FA-01 WATER QUALITY MONITORING
REVISED STUDY PLAN

SKAGIT RIVER HYDROELECTRIC PROJECT
FERC NO. 553

Seattle City Light

April 2021
RSP

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List of Acronyms and Abbreviations

1-DMax......................1-day maximum temperature
7-DADMax ....7-day average of daily maximum temperature
µg/L...........................microgram per liter
cfs..............................cubic feet per second
CFU...........................colony-forming units
City Light...................Seattle City Light
CoSD..........................City of Seattle (Vertical) Datum
CWA ....Clean Water Act
Ecology ....Washington State Department of Ecology
EFH ....Essential Fish Habitat
ELC ....Environmental Learning Center
ESA ....Endangered Species Act
FARWG ....Fish and Aquatics Resource Work Group
FERC..........................Federal Energy Regulatory Commission
FLA ....Final License Application
FPA ....Federal Power Act
FSA ....Fisheries Settlement Agreement
ILP.............................Integrated Licensing Process
ISR ....Initial Study Report
L ....liter
LP..............................licensing participant
mg ....milligram
mg/L..........................milligram per liter
mL.............................milliliter
MPN..........................most probable number
mS/cm ....microsiemens per centimeter
NAVD 88...................North American Vertical Datum 1988
NHPA.........................National Historic Preservation Act
NMFS.........................National Marine Fisheries
NPS ....National Park Service
NTU ....nephelometric turbidity units

PAD............................Pre-Application Document
PRM...........................Project River Mile
Project.........................Skagit River Hydroelectric Project
PSP.............................Proposed Study Plan
QAPP..........................Quality Assurance Program Plan
RLNRA......................Ross Lake National Recreation Area
RM.............................river mile
RSP............................Revised Study Plan
RWG..........................Resource Work Group
SEEC..........................Skagit Environmental Endowment Council
SOP............................standard operating procedure
TDG...........................total dissolved gas
TSS.............................total dissolved solids
U.S.C..........................United States Code
USFS..........................U.S. Forest Service
USFWS......................U.S. Fish and Wildlife Service
USGS.........................U.S. Geological Survey
USIT...........................Upper Skagit Indian Tribe
USR............................Updated Study Report
WAC..........................Washington Administrative Code
WDFW.......................Washington Department of Fish and Wildlife
WRIA.........................Water Resources Inventory Area

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1.0 INTRODUCTION

1.1 General Description of the Project

The Skagit River Hydroelectric Project (Project), licensed to The City of Seattle, Washington, and operated through its publicly-owned electric power utility Seattle City Light (City Light), is located in northern Washington State and consists of three power generating developments on the Skagit River – Ross, Diablo, and Gorge – and associated lands and facilities. The Project generating facilities are in the Cascade Mountains of the upper Skagit River watershed, between Project River Miles (PRM) 94.7 and 127.9 (U.S. Geological Survey [USGS] RMs 94.2 and 127).[1] Power from the Project is transmitted via two 230-kilovolt powerlines that span over 100 miles and end just north of Seattle at the Bothell Substation. The Project also includes two City Light-owned towns, an Environmental Learning Center (ELC), several recreation facilities, and several parcels of fish and wildlife mitigation lands.

Project generating facilities are all located in Whatcom County, although Ross Lake, the most upstream reservoir, crosses the U.S.-Canada border and extends for about one mile into British Columbia at normal maximum water surface elevation. Gorge Powerhouse, the most downstream facility, is approximately 120 miles northeast of Seattle and 60 miles east of Sedro-Woolley, the nearest large town. The closest town is Newhalem, which is part of the Project and just downstream of Gorge Powerhouse. The primary transmission lines cross Whatcom, Skagit, and Snohomish counties; the fish and wildlife mitigation lands are in the same counties.

The Project Boundary is extensive, spanning over 133 miles from the Canadian border to the Bothell Substation just north of Seattle, Washington. In addition, there are "islands" of fish and wildlife mitigation lands and recreation facilities within the Skagit, Sauk, and South Fork Nooksack watersheds that are also within the Project Boundary. Project generating facilities are entirely within the Ross Lake National Recreation Area (RLNRA), which is administered by the National Park Service (NPS) as part of the North Cascades National Park Complex. The RLNRA was established in 1968 in the enabling legislation for North Cascades National Park to provide for the "public outdoor recreation use and enjoyment of portions of the Skagit River and Ross, Diablo, and Gorge lakes." The legislation maintains the Federal Energy Regulatory Commission's (FERC) jurisdiction "in the lands and waters within the Skagit River Hydroelectric Project," as well as hydrologic monitoring stations necessary for the proper operation of the Project (16 United States Code [U.S.C.] § 90d-4; Public Law 90-544. Sec. 505 dated October 2, 1968, as amended by Public Law 100-668. Sec. 202 dated November 16, 1988).

1.2 Relicensing Process

The current FERC license for the Project expires on April 30, 2025, and City Light will apply for a new license no later than April 30, 2023. City Light formally initiated the relicensing process by filing a Notice of Intent and Pre-Application Document (PAD) with FERC on April 27, 2020 (City Light 2020a). The PAD includes descriptions of the Project facilities, operations, license

[1] City Light has developed a standard Project centerline and river mile system to be used throughout the relicensing process, including the study program, to replace the outdated USGS RM system. Given the long-standing use of the USGS RM system, both it and the Project River Mile (PRM) system are provided throughout this document. For further details see Section 7.0 of the main body RSP.

requirements, and Project lands as well as a summary of the extensive existing information available on Project area resources and early consultation on potential resource issues to be addressed during the relicensing. The PAD also includes an outline of the goals and objectives of this study.

The relicensing process includes the timeframes and deadlines specified in FERC's Integrated Licensing Process (ILP), including consultation with interested agencies and Indian tribes related to study plans, study results, and subsequent analysis of results and effects analysis through the filing of the Final License Application (FLA). FERC's process includes steps to satisfy the various statutory authorities identified in the Federal Power Act (FPA) (e.g., Sections 4(e), 10(j), 10(a)). Other related regulatory processes including Washington State Department of Ecology's (Ecology) Section 401 water quality certification process, the U.S. Fish and Wildlife Service's (USFWS) and National Marine Fisheries Service's (NMFS) Section 7 Endangered Species Act (ESA) consultation, NMFS's oversight of Essential Fish Habitat (EFH), as defined by the Magnuson Stevens Fishery Conservation and Management Act, and consultation pursuant to Section 106 of the National Historic Preservation Act (NHPA) will continue following filing of the FLA. With the filing of the PAD, City Light requested that FERC designate City Light as FERC's non-federal representative for purposes of initiating and conducting day-to-day consultation under ESA Section 7 and NHPA Section 106, which was granted by FERC in its June 26, 2020 Notice of Intent to File License Application for a New License and Commencing Pre-Filing Process.

1.3 Study Plan Development

In 2019-2020, City Light convened a number of Resource Work Groups (RWGs) to engage agencies and other licensing participants (LPs) in a Study Plan Development Process, which provided LPs and City Light the opportunity to submit forms that identified potential resource issues, their potential connection to the Project, information or studies requested, a rationale for studying the issues, and how the information collected by the study could be used to support relicensing. Table 5.1-2 of the PAD provides a summary of all the issue forms submitted during this 2019-2020 process.

Section 5 of the PAD lists the resource studies and management plans proposed by City Light to address select (but not all) issues identified as part of the Study Plan Development Process. While acknowledging the broad interests of LPs, City Light focused its initial draft study plans contained in the PAD on information gaps that were most likely to inform license conditions by a study of potential Project effects. City Light developed 24 study proposals, including a Water Quality Monitoring study plan.

On April 10, 2020, City Light released the FA-01 Water Quality Monitoring Draft Study Plan for LP review and comment. On May 5, 2020, the draft study plan was discussed at a Fish and Aquatic Resource Work Group (FARWG) meeting. City Light reviewed all comments received and released a revised version of the draft study plan on June 16, 2020. The revised draft was discussed on June 24, 2020 at a FARWG meeting. Written comments were received from NPS, Ecology, Washington Department of Fish and Wildlife (WDFW), USFWS, Upper Skagit Indian Tribe, and NMFS and responded to in an attachment to this study plan. A Status Draft of the study plan was provided to LPs on August 6, 2020.

City Light is filing this study plan with FERC as part of its Revised Study Plan (RSP). It is an update to the version that was filed with the Proposed Study Plan (PSP) on December 8, 2020 (City Light 2020b) and incorporates additional consultation with LPs prior to the filing date.

This study plan addresses, with modifications, elements of the following study requests, as explained in Section 6 of the RSP: Ecology-01 Water Quality Study, NMFS-01 Water Quality, NPS-02 Skagit Project Water Quality Assessment and Modeling, USFWS-03 Skagit Project Water Quality Assessment and Modeling, USIT-07 Water Quality Impacts above and below SCL Project Infrastructure, and WDFW-17 Water Quality Impacts above and below SCL Project Infrastructure.

PSP comments to this study plan were submitted by American Rivers/Trout Unlimited, Ecology, NMFS, NPS, Sauk-Suiattle Indian Tribe, Swinomish Indian Tribal Community, USFWS, and Upper Skagit Indian Tribe . City Light has addressed the specific comments and suggested edits in this study plan and responded to comments in the PSP comment/response table appended to the main body of the RSP. Modifications made to the study plan in response to comments and since the PSP include adding a total of 13 water quality monitoring locations, which include additional temperature, dissolved oxygen, pH, turbidity, total suspended solids, fecal coliform, total dissolved gas, and benthic macroinvertebrate sampling locations. Parameters to be measured at the new locations vary and are detailed in Table 2.6-1 of this study plan and shown in a mapbook attached to the study plan. Additionally, sampling periods for some monitoring locations were extended so that all sampling occurs over a two-year period—though the water quality monitoring record for some of these locations covers many parameters studied extensively prior to this formal FERC study period.

The study design described in Section 2.6 of this study plan is structured to identify water quality data collection which, along with abundant existing water quality information, will support the license application, including the application to Ecology for certification of the Project under Section 401 of the Clean Water Act (CWA). A licensee must receive a water quality certification, or a waiver thereof, before FERC can issue an operating license. The study will also provide data of value to FERC, other resource agencies, Indian tribes, and other LPs on water quality within the study area (see Section 2.5 of this study plan).

Following completion of relicensing studies, an integrated environmental analysis will specifically address links across resource areas. Data collected as part of the Water Quality Monitoring Study, along with existing water quality information, may also be applicable to other resource areas. City Light will work with LPs to review and integrate information from related studies as part of the ILP process in support of its license application filing.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

As noted above, this study plan has been designed to collect water quality data, which along with existing water quality information, is intended to support Ecology's certification of the Project under Section 401 of the CWA and the data needs of FERC, while also addressing other data needs of City Light, resource agencies, Indian tribes, and other LPs in the context of FERC relicensing. The goal of this study is to monitor water quality parameters for which existing information is insufficient to characterize conditions within the study area. A summary of existing data is presented in Section 2.3 (including Table 2.3-1). City Light proposes to direct resources toward the collection of data needed to characterize parameters that currently are not well understood. The water quality parameters listed below will be monitored in the identified waterbodies during the relicensing study period.

Specific objectives of this study are listed below (sampling design and timeframes, which vary by waterbody and parameter, are provided in the Methods section of this plan). For all parameters, data collection will take place over a two-year period.

- Provide a summary and analysis of all relevant existing water quality information identified in Table 2.3-1, other City Light data (e.g., ongoing data collection in tributaries), and data obtained from the NPS and other reputable sources.
- Characterize background levels of turbidity and total suspended solids (TSS) in Ross, Diablo, and Gorge lakes.
- Measure temperature, dissolved oxygen, pH, turbidity, and TSS at one location in the Skagit River upstream of Ross Lake.
- Measure turbidity and TSS at the mouths of select tributaries to Ross (Big Beaver and Ruby creeks) and Diablo (Thunder Creek) lakes to characterize conditions during periods of reservoir drawdown.
- Measure turbidity and TSS at transects positioned parallel to the shoreline at three locations in Ross Lake to characterize conditions adjacent to areas of shoreline erosion during reservoir drawdown when erosional faces of the littoral fringe are exposed.
- Measure fecal coliform levels at targeted locations in Ross and Diablo lakes.
- Measure temperature, dissolved oxygen, and pH in Diablo and Gorge lakes.
- Continuously measure total dissolved gas (TDG) in the Diablo Dam tailrace and Gorge Lake forebay.
- Continuously monitor temperature, dissolved oxygen, TDG, and turbidity at three locations in the Gorge bypass reach.
- Continuously measure temperature, dissolved oxygen, pH, TDG, and turbidity below Gorge Powerhouse. Sample TSS during periods when turbidity levels below Gorge Powerhouse are considered elevated.
- Continuously measure temperature by installing probes at six locations in the Skagit River between Gorge Powerhouse and downstream of the Baker River confluence.

- Sample benthic macroinvertebrates in riffle habitat at six locations in the Skagit River between Gorge Powerhouse and downstream of the Baker River confluence.
- Continuously measure temperature at one location in the lower Sauk River.
- Sample benthic macroinvertebrates in riffle habitat at one location in the lower Sauk River.

2.2 Resource Management Goals

The study will provide information for resource agencies and Indian tribes with jurisdiction in the Project vicinity to address their respective goals and objectives for resource management. Resource management goals were provided by LPs in their study requests identified in Section 1.3 of this study plan.

2.2.1 Applicable Numeric Water Quality Standards and Designated Uses

In the State of Washington, surface waters are protected by a three-part approach, namely numeric and narrative criteria, designated uses, and an antidegradation policy. Numeric as well as narrative criteria both support and protect the designated uses identified in Washington Administrative Code (WAC) 173-201A-200. Numeric water quality criteria for the Project vicinity are shown in Table 2.2-1, some of which differentiate between lakes/reservoirs and stream reaches defined by Ecology (WAC 173-201A-600) as follows: "[R]eservoirs with a mean detention time greater than fifteen days are to be treated as a lake for use designation[.]" By this definition, riverine water quality criteria (Table 2.2-1) apply to Diablo (detention time = 9.4 days) and Gorge (detention time = 0.8 days) lakes. Ross Lake, with a detention time of 189.4 days, is subject to the lake criteria identified in Table 2.2-1. Ecology has identified supplemental spawning and incubation criteria for specific reaches within Water Resources Inventory Area (WRIA) 4 (Figure 2.2-1). The Skagit River from Gorge Dam PRM 97.2 (USGS RM 96.6) downstream to Gorge Powerhouse (i.e., Gorge bypass reach) has a special condition status under State water quality standards (WAC 173-201A-600): Water temperatures are not to exceed 21 ºC as a result of anthropogenic activities. City Light will work with Ecology to understand how the narrative criteria apply to the Project and will identify an approach to providing the information needed for Ecology to make a determination regarding its reasonable assurance that water quality criteria will be met at and immediately downstream of the Project.

Table 2.2-1. Water quality criteria for the Project vicinity (see also Figure 2.2-1).

Parameter	Water Quality Criteria
Fecal Coliform	Not to exceed a geometric mean value of 100 colony-forming units (CFU) or most probable number (MPN)/100 milliliter (mL) with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained for calculating the geometric mean value exceeding 200 CFU or MPN/100 mL.
E. coli	*E. coli* organism levels within an averaging period must not exceed a geometric mean value of 100 CFU or MPN per 100 mL, with not more than 10 percent of all samples (or any single sample when less than ten sample points exist) obtained within the averaging period exceeding 320 CFU or MPN per 100 mL.
Dissolved Oxygen	Lowest 1-Day Minimum: Char Spawning and Rearing: 9.5 milligrams per liter (mg/L) Salmon and trout spawning, core rearing, and migration: 9.5 mg/L

Parameter	Water Quality Criteria
	For lakes/reservoirs, human actions considered cumulatively may not decrease the dissolved oxygen concentration more than 0.2 mg/L below natural conditions.
Temperature	Maximum 7-day average of daily maximum temperature (7-DADMax): Char Spawning and Rearing: 12 degrees Celsius (°C)(53.6°F) Salmon and trout spawning (Sept. 1 to June 15): 13°C (55.4°F) Core summer salmonid habitat: 16°C (60.8°F)
	Skagit River from Gorge Dam to Gorge Powerhouse (Gorge bypass reach). Temperature shall not exceed a 1-day maximum temperature (1-DMax) of 21°C due to human activities. When natural conditions exceed a 1-DMax of 21°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 $t = 34/(T + 9)$.
	For lakes/reservoirs, human actions considered cumulatively may not increase the 7-DADMax temperature more than 0.3°C (0.54°F) above natural conditions.
Total Dissolved Gas	Not to exceed 110 percent of saturation at any point of sample collection.
pH	Within 6.5 to 8.5 pH units with human caused variation of: Less than 0.2 units for char and salmon and trout spawning, core rearing, and migration.
Turbidity	Shall not exceed either a 5 nephelometric turbidity unit (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.

Source: WAC 173-201A-200.

Designated uses for protection in fresh surface waters that are relevant to the Project are shown in Table 2.2-2.

Table 2.2-2. Designated uses of water in the Skagit River and designated Water Resource Inventory Area (WRIA) 4 tributaries.

	Aquatic Life Uses						Recreational Uses			Water Supply Uses				Misc. Uses				
Water Body	**Char Spawning/Rearing**	**Core Summer Habitat**	**Spawning/Rearing**	**Rearing/Migration Only**	**Redband Trout**	**Warm Water Species**	**Ex Primary Contact**	**Primary Contact**	**Secondary Contact**	**Domestic Water**	**Industrial Water**	**Agricultural Water**	**Stock Water**	**Wildlife Habitat**	**Harvesting**	**Commerce/Navigation**	**Boating**	**Aesthetics**
Skagit River and all tributaries upstream of Skiyou Slough except designated tributaries		✓	✓[2]				✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Designated WRIA 4 tributaries[1]	✓						✓			✓	✓	✓	✓	✓	✓	✓	✓	✓

1 Bacon Cr, Big Beaver Cr, Cascade R, Diobsud Cr, Goodell Cr, Hozomeen Cr, Illabot Cr, Lightning Cr, Little Beaver Cr, Newhalem Cr., Rocky Cr, Ruby Cr, Sauk R, Silver Cr, Stetattle Cr,, Thunder Cr.

2 See supplemental spawning and incubation map (Figure 2.2-1).

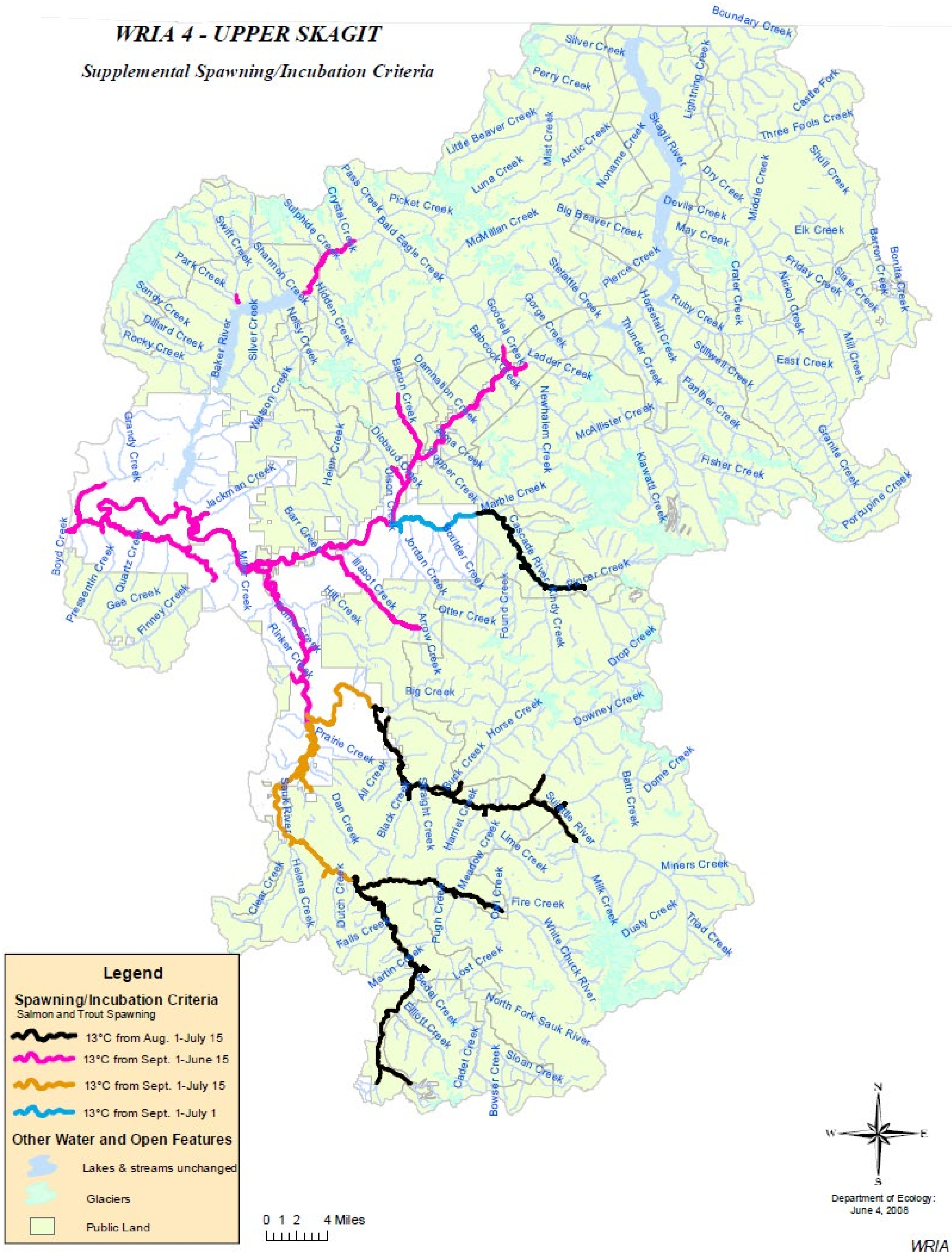

Figure 2.2-1. Supplemental spawning and incubation protection temperature criteria for WRIA 4 Upper Skagit River basin.

2.3 Background and Existing Information

At nearly 23 miles long, Ross Lake is the largest reservoir in western Washington. The reservoir has a surface area of 11,680 acres and a storage volume of 1,435,000 acre-feet at the normal maximum water surface elevation of 1,608.76 feet North American Vertical Datum 1988 (NAVD 88) (1,602.5 feet City of Seattle Datum (CoSD)].[2] Between 1991 and 2018, the average low water surface elevation ranged from 1,453.36 feet NAVD 88 (1,467.1 feet CoSD) (in April) to 1,591.06 feet NAVD 88 (1,584.8 feet CoSD) (in August). Ross Lake has a detention time of 189.4 days (Connor 2019). Ross Lake is the primary storage reservoir for the Project and is drawn down in winter to capture water from spring runoff and to provide downstream flood control. City Light typically begins drawing down the reservoir shortly after Labor Day. Spills are infrequent at Ross Dam due to the reservoir's large storage capacity. Spills are typically associated with gate testing, are of short duration, and average only a few cubic feet per second (cfs). From 2014–2018, Ross Dam spilled 20 times. Eleven of these spills occurred in August 2015 during the Goodell Creek Wildfire, which disrupted Project operations and transmission. In 2014, 2016, 2017, and 2018, average spills ranged from <1–5 cfs per day. Average spills were higher (i.e., 1,540 cfs) in 2015 because the fire disrupted operations.

Diablo Lake has a surface area of approximately 770 acres and gross storage of 50,000 acre-feet at a normal maximum water surface elevation of 1,211.36 feet NAVD 88 (1,205 feet CoSD). During summer, the reservoir's major tributary, Thunder Creek, carries a heavy load of very fine, suspended glacier-generated sediment, also known as glacial flour, which gives the lake a notable turquoise color. Diablo Lake has a detention time of 9.4 days (Connor 2019). The primary function of the Diablo Development is to reregulate flows between the Ross and Gorge developments. The reservoir typically fluctuates 4-5 feet daily, although drawdowns of 10-12 feet occur occasionally, as needed for construction projects or maintenance. Because of its role as a reregulation facility, Diablo Dam spills more frequently than any of the other Project facilities. Spill typically occurs during periods of high runoff, particularly during the spring or early summer. However, Diablo Dam also spills on the rare occasion that units are off-line at the Diablo Powerhouse or when additional water is needed to meet flow requirements downstream of Gorge Powerhouse.

Gorge Lake is 4.5 miles long. At the normal maximum water surface elevation of 881.51 feet NAVD 88 (875 feet CoSD), the reservoir has a surface area of 240 acres and gross storage of 8,500 acre-feet. Gorge Lake has a detention time of 0.8 days (Conner 2019). Because of Gorge Lake's relatively low storage volume, unplanned spills at the dam can occur any time inflow exceeds generation capacity. In addition, because flows from the Gorge Development are critical for fish production and protection in the Skagit River downstream of Gorge Powerhouse, water from Gorge Lake is spilled into the Gorge bypass reach if flows through Gorge Powerhouse are insufficient to meet downstream flow requirements specified under the 2013 Revised Fisheries Settlement Agreement (FSA) for salmon or steelhead spawning or rearing.

[2] City Light is in the process of converting Project information from its older vertical elevation datum (CoSD) to the more current and standardized elevation datum (NAVD 88). As such, elevations are provided relative to both data throughout this RSP. The conversion factor between CoSD and NAVD 88 varies depending on location. A table converting elevation values of common benchmarks, staff gages, and key Project features from CoSD to NAVD 88 and a map of the same features are appended to this RSP, both of which have been updated since the Pre-Application Document (PAD).

The reach of the Skagit River between Gorge Dam and Powerhouse is referred to as the bypass reach and is approximately 2.5 miles long. Under the current Project license, City Light is not required to release any flow into the Gorge bypass reach (FERC 1995). The flow and non-flow measures incorporated into the FSA were determined by signatories to the settlement to resolve the effects of the absence of flows and to obviate any need for flow releases in the bypass reach (City Light 1991). FERC, in its order accepting the settlement agreement, issuing new license, and terminating the proceeding (FERC 1995), concurred with the proposed action to continue interim agreement flow measures and to add non-flow enhancement measures in the Skagit River below Gorge Powerhouse to address continued habitat loss in the bypass reach because "river flows from the powerhouse are of far more value to the anadromous fishery." Under the current license, flows in the bypass reach are limited to accretion flow, spill-gate seepage, tributary input, and precipitation runoff, except when water is being spilled at Gorge Dam.

From 1991 through 2012, flow releases to the mainstem Skagit River downstream of Gorge Powerhouse were dictated by the current Project license (FERC 1995), which fully incorporates the measures included in the Flow Plan of the FSA (City Light 1991). The primary purpose of the Flow Plan is to minimize the effects of Project operations on salmonids by providing spawning flows and protecting redds, fry, and yearlings. The Project license was amended in 2013 to incorporate a Revised FSA Flow Plan (City Light 2011) that included four measures City Light had been implementing voluntarily since 1995 to further reduce Project effects on steelhead and salmon. The FSA Flow Plan, as amended, is described in Section 3.5.2 of the PAD.

City Light possesses a large number of data files and accompanying data collection descriptions for the Project reservoirs (Table 2.3-1).[3] Table 2.3-1 also includes an account of existing data collected in the mainstem Skagit River downstream of the Project near Marblemount, which is located in the Project vicinity at PRM 78.3 (USGS RM 78). Parameters for which multiple years of recent data have been collected are considered to be adequately represented by existing information, and data collection proposed in this study plan will fill data gaps identified in the body of existing information. A portion of the existing information is presented and discussed in Section 4.4 of the PAD, and a complete presentation of all relevant existing information will be provided in the Water Quality Monitoring Study report filed with FERC (with the Initial Study Report [ISR]).

In addition to existing data for the Project reservoirs and the Skagit River downstream of the Project, City Light has continuously measured temperature (or funded temperature measurement) for many years in tributaries to the reservoirs and, more recently, in tributaries flowing into the Skagit River downstream of the Project. NPS has also collected temperature data in tributaries to Project reservoirs. Ongoing temperature data collection efforts being conducted in tributaries to the Project reservoirs are identified in an attachment to this study plan.

In addition to the information shown in Table 2.3-1 below and Tables 2 and 3 attached to this study plan, City Light will obtain and summarize pertinent water quality data collected by other entities in the Project reservoirs, tributaries to the reservoirs, and the Skagit River below the Project. (For

[3] The NPS's study request, NPS-02: Skagit Project Water Quality Assessment and Modeling, Attachment 1, includes a table of existing data, which includes additional data files for the Project reservoirs. City Light will coordinate with the NPS to procure all files and summarize relevant data in the Water Quality Monitoring Study report.

example, City Light is aware of relevant information collected by the NPS, USGS, U.S. Forest Service [USFS], and WDFW).

The agencies and City Light collect data according to quality assurance and control protocols that may differ among entities but are all valid. These protocols will be summarized for comparison to Ecology's standard operating procedures (SOPs), and any differences will be identified for consideration of their significance in the ISR. Specifically, City Light will assess and report on these quality control procedures implemented in the collection of existing water quality data by the agency stewards of those data.

All reliable existing data will be assessed and used to evaluate thermal regimes above and below the Project. Temperature data will be evaluated in tandem with abundant fish-related information, including size-at-age data and data pertaining to the timing of life-history events. These data will inform the evaluation of potential sublethal effects on fish downstream of the Project, as well as the consideration of fish species' introductions above the dams

Table 2.3-1. Summary of existing water quality data collected since 1991[1], Skagit River Hydroelectric Project and Skagit River to Marblemount.

		Timeframe			Data Type		
Parameter	Collection Location	Year Collected	Month(s) Collected	Sampling Approach	Continuous	Discrete	Entity Collecting Data
Ross Lake							
Temperature (°C)	Little Beaver	2015	Jun, Jul, Sep, Oct, Nov	Profile		X	City Light, NPS
		2016	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2017	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2018	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2017	Jun–Dec	Surface, Middle, & Bottom	X		
		2018	Jun–Nov	Surface, Middle, & Bottom	X		
	Skymo	2015	Jun, Jul, Sep, Oct, Nov	Profile		X	
		2016	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2017	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2018	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2017	Jun–Dec	Surface, Middle, & Bottom	X		
		2018	Jun–Nov	Surface, Middle, & Bottom	X		
	Pumpkin Mountain	2015	May, Jun, Jul, Sep, Oct, Nov	Profile		X	
		2016	May, Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2017	May, Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2018	May, Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	

		Timeframe			Data Type		
Parameter	**Collection Location**	**Year Collected**	**Month(s) Collected**	**Sampling Approach**	**Continuous**	**Discrete**	**Entity Collecting Data**
		2017	Jun–Dec	Surface, Middle, & Bottom	X		
		2018	May–Dec	Surface, Middle, & Bottom	X		
		2019	Jan–Feb[2]	Surface, Middle, & Bottom	X		
	Log Boom	2000	Sep–Dec	Surface	X		City Light
		2001	Jan–Feb; Sep–Dec	Surface	X		
		2002	Jan–Mar	Surface	X		
		2003	Aug–Dec	Surface	X		
		2004	Jan–Aug; Nov–Dec	Surface	X		
		2005	Jan–Dec	Surface	X		
		2006	Jan–Dec	Surface	X		
		2007	Jan–Oct	Surface	X		
		2008	Sep–Dec	Profile	X		
		2009	Jan–Dec	Profile	X		
		2010	Jan–Feb	Profile	X		
		2014	Nov–Dec	Profile	X		
		2015	Jan–Dec	Profile	X		
		2016	Jan–Mar; Nov–Dec	Profile	X		
		2017	Jan–Sep	Profile	X		
	Hozomeen	2017	Jun–Oct	Surface & Bottom	X		NPS
		2018	Jun–Oct	Surface & Bottom	X		
Dissolved oxygen (mg/L)	Little Beaver	2015	Jun, Jul, Sep, Oct, Nov	Profile		X	City Light

		Timeframe			Data Type		
Parameter	Collection Location	Year Collected	Month(s) Collected	Sampling Approach	Continuous	Discrete	Entity Collecting Data
		2016	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	NPS
		2017	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2018	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
	Skymo	2015	Jun, Jul, Sep, Oct, Nov	Profile		X	
		2016	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2017	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2018	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
	Pumpkin Mountain	2015	May, Jun, Jul, Sep, Oct, Nov	Profile		X	
		2016	May, Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2017	May, Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2018	May, Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
pH	Little Beaver	2015	Jun, Jul, Sep, Oct, Nov	Profile		X	City Light, NPS
		2016	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2017	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2018	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
	Skymo	2015	Jun, Jul, Sep, Oct, Nov	Profile		X	
		2016	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2017	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2018	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
	Pumpkin Mountain	2015	May, Jun, Jul, Sep, Oct, Nov	Profile		X	
		2016	May, Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2017	May, Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2018	May, Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	

		Timeframe			Data Type		
Parameter	**Collection Location**	**Year Collected**	**Month(s) Collected**	**Sampling Approach**	**Continuous**	**Discrete**	**Entity Collecting Data**
Nutrients	Little Beaver	2017	Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	NPS
		2018	Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
	Skymo	2017	Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
		2018	Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
	Pumpkin Mountain	2017	May, Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
		2018	May, Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
Chlorophyll *a* (µg/L)	Little Beaver	2015	Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	NPS
		2017	Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
		2018	Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
	Skymo	2015	Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
		2017	Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
		2018	Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
	Pumpkin Mountain	2015	May, Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
		2017	May, Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
		2018	May, Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
Dissolved Organic Carbon (mg/L)	Little Beaver	2017	Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	NPS
		2018	Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
	Skymo	2017	Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
		2018	Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
	Pumpkin Mountain	2017	May, Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
		2018	May, Jun, Jul, Aug, Sep, Oct, Nov	Surface		X	
Turbidity (NTU)	Log Boom	2016	Aug	Profile		X	City Light

		Timeframe			Data Type		
Parameter	**Collection Location**	**Year Collected**	**Month(s) Collected**	**Sampling Approach**	**Continuous**	**Discrete**	**Entity Collecting Data**
Specific conductance (mS/cm)	Little Beaver	2015	Jun, Jul, Sep, Oct, Nov	Profile		X	City Light, NPS
		2016	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2017	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2018	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
	Skymo	2015	Jun, Jul, Sep, Oct, Nov	Profile		X	
		2016	Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
			Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
			Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
	Pumpkin Mountain	2015	May, Jun, Jul, Sep, Oct, Nov	Profile		X	
		2016	May, Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2017	May, Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
		2018	May, Jun, Jul, Aug, Sep, Oct, Nov	Profile		X	
Mercury[3]		2007, 2012, 2015	Summer–Fall	Fish tissue[4]		X	Ecology
PCBs[3]		2007, 2012, 2015	Summer–Fall	Fish tissue		X	Ecology
Copper[3]		2007, 2012, 2015	Summer–Fall	Fish tissue		X	Ecology
Selenium[3]		2007, 2012, 2015	Summer–Fall	Fish tissue		X	Ecology
Zinc[3]		2007, 2012, 2015	Summer–Fall	Fish tissue		X	Ecology
Zooplankton	Little Beaver	2015	Jun, Jul, Aug, Sep, Oct, Nov	Horizontal Tow		X	NPS
		2016	Jun, Jul, Aug, Sep, Oct, Nov	Horizontal Tow		X	
		2017	Jun, Jul, Aug, Sep, Oct, Nov	Horizontal Tow		X	
		2018	Jun, Jul, Aug, Sep, Oct, Nov	Horizontal Tow		X	
	Skymo	2015	Jun, Jul, Aug, Sep, Oct, Nov	Horizontal		X	

		Timeframe			Data Type		
Parameter	Collection Location	Year Collected	Month(s) Collected	Sampling Approach	Continuous	Discrete	Entity Collecting Data
				Tow			
		2016	Jun, Jul, Aug, Sep, Oct, Nov	Horizontal Tow		X	
		2017	Jun, Jul, Aug, Sep, Oct, Nov	Horizontal Tow		X	
		2018	Jun, Jul, Aug, Sep, Oct, Nov	Horizontal Tow		X	
	Pumpkin Mountain	2015	Jun, Jul, Aug, Sep, Oct, Nov	Horizontal Tow		X	
		2016	May, Jun, Jul, Aug, Sep, Oct, Nov	Horizontal Tow		X	
		2017	May, Jun, Jul, Aug, Sep, Oct, Nov	Horizontal Tow		X	
		2018	May, Jun, Jul, Aug, Sep, Oct, Nov	Horizontal Tow		X	
Diablo Lake							
Temperature (°C)	Log Boom/Forebay	2008	Aug–Dec	Surface	X		City Light, NPS
		2009	Jan–Aug	Surface	X		
		2014	See footnote[2]				
		2015	See footnote[2]				
		2016	Nov–Dec	Profile	X		
		2017	Jan–Sep	Profile	X		
	Thunder Arm	2018	Jun–Dec	1-, 15-, and 28-m depths	X		
		2019	Jan–Aug	1-, 15-, and 28-m depths	X		
	Thunder Arm	2018	Jun, Jul, Aug, Sep	Profile		X	
		2019	Jun, Aug, Oct[2]	Profile		X	
	Mid-Lake Buoy	2018	Jul, Aug, Sep	Profile		X	

		Timeframe			Data Type		
Parameter	**Collection Location**	**Year Collected**	**Month(s) Collected**	**Sampling Approach**	**Continuous**	**Discrete**	**Entity Collecting Data**
		2019	Jun, Aug, Oct	Profile		X	
	Forebay	2018	Jul, Aug, Sep	Profile		X	
		2019	Jun, Aug, Oct	Profile		X	
Dissolved oxygen (mg/L)	Thunder Arm	2018	Jun, Jul, Aug, Sep	Profile		X	
		2019	Jun, Aug, Oct	Profile		X	
	Mid-Lake Buoy	2018	Jul, Aug, Sep	Profile		X	
		2019	Jun, Aug, Oct	Profile		X	
	Forebay	2018	Jul, Aug, Sep	Profile		X	
		2019	Jun, Aug, Oct	Profile		X	
pH	Thunder Arm	2018	Jun, Jul, Aug, Sep	Profile		X	
		2019	Jun, Aug, Oct	Profile		X	
	Mid-Lake Buoy	2018	Jul, Aug, Sep	Profile		X	
		2019	Jun, Aug, Oct	Profile		X	
	Forebay	2018	Jul, Aug, Sep	Profile		X	
		2019	Jun, Aug, Oct	Profile		X	
Specific conductance (mS/cm)	Thunder Arm	2018	Jun, Jul, Aug, Sep	Profile		X	
		2019	Jun, Aug, Oct	Profile		X	
	Mid-Lake Buoy	2018	Jul, Aug, Sep	Profile		X	
		2019	Jun, Aug, Oct	Profile		X	
	Forebay	2018	Jul, Aug, Sep	Profile		X	
		2019	Jun, Aug, Oct	Profile		X	
Gorge Lake							
Temperature (°C)	Log Boom	2014	See footnote[2]				City Light, NPS
		2015	See footnote[2]				
		2016	Nov–Dec	Profile	X		
		2017	Jan–Jul	Profile	X		
		2018	See footnote[2]				

		Timeframe			Data Type		
Parameter	Collection Location	Year Collected	Month(s) Collected	Sampling Approach	Continuous	Discrete	Entity Collecting Data
		2019	See footnote[2]				
Skagit River downstream of the Project							
Temperature (°C)[5]	Newhalem	2007–Ongoing	All	Surface	X		USGS
Total dissolved gas (percent saturation)	Below Gorge Powerhouse	1997	Jul	Surface		X	City Light
Skagit River at Marblemount[6]							
Temperature (°C) 7DADMax	Marblemount	2002–2009	Jun–Sep[7]	Surface	X		Ecology
Temperature (°C) Daily grab sample		2009–Ongoing	Jan–Dec	Surface		X	Ecology
Dissolved oxygen (mg/L)		2009–Ongoing	Jan–Dec	Surface		X	Ecology
pH		2009–Ongoing	Jan–Dec	Surface		X	Ecology
Turbidity (NTU)		2009–Ongoing	Jan–Dec	Surface		X	Ecology
Ammonia (mg/L)		2009–Ongoing	Jan–Dec	Surface		X	Ecology
Total phosphorous (mg/L)		2009–Ongoing	Jan–Dec	Surface		X	Ecology
Fecal coliform (CFU/100 mL)		2009–Ongoing	Jan–Dec	Surface		X	Ecology
Metals[8]		1994	May, Jul, Sep, Nov	Surface		X	Ecology
		1995	Jan, Mar	Surface		X	Ecology

1 The period 1991–2019 encapsulates the timeframe beginning with the finalization of the Settlement Agreement and ending with the most recent year.
2 City Light is following up to determine if data (or additional data) are available for the period and timeframe shown in this cell of the table.
3 See Seiders and Deligeannis (2018).
4 Bull Trout, Rainbow Trout, Redside Shiner
5 USGS (2019a) https://waterdata.usgs.gov/usa/nwis/uv?12178000
6 USGS (2019b) https://apps.ecology.wa.gov/eim/search/SMP/RiverStreamSingleStationOverview.aspx?ResultType=RiverStreamOverviewList&StudyMonitoringProgramUserId=RiverStream&StudyMonitoringProgramUserIdSearchType=Equals&LocationUserIds=04A100&LocationUserIdSearchType=Equals.
7 Measurement within this overall timeframe varies by year.
8 Arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc; source Ecology (2019); see URL provided in table footnote number 5.

2.4 Project Operations and Effects on Resources

The Skagit River drains mountainous and, in some cases, glacial areas located mainly within national park and wilderness areas; water flowing through the Project remains clean and cold throughout the year. Existing information indicates that water quality in the Project reservoirs is in compliance with Ecology’s relevant numeric criteria. The few 303(d) listings for WRIA 4, which includes the Project and its vicinity, are applicable to reaches that unaffected by the Project, reflecting the good baseline water quality measured within and downstream of the Project Boundary. Moreover, data collected by Ecology indicate that water quality in the Skagit River downstream of the Project (measured at Marblemount and discussed in Section 4.4.5 of the PAD) also complies with Ecology’s numeric criteria. City Light is aware of no data indicating that the designated uses shown in Table 2.2-2 are adversely affected by the Project’s operation.

Although there is a large body of existing water quality information for the Project (e.g., Table 2.3-1 and attached tables 2 and 3), targeted data collection is proposed to address water quality parameters for which existing information is limited. Existing data, combined with data collected during this proposed study and other qualified ongoing efforts, will be used to inform the Section 401 certification process overseen by Ecology, as well as FERC’s issuance of a new license for the Project.

2.5 Study Area

The study will be conducted from the upper Skagit River inflow just north of the U.S. Canada Border, through Ross (within the United States), Diablo, and Gorge lakes, the Gorge bypass reach, and in the Skagit River downstream to just below the Baker River confluence, and in the lower Sauk River (Figure 2.5-1). Approximate locations of the proposed water quality sampling/measurement sites and the rationale for their locations are discussed in Section 2.6 of this study plan. (See Table 2.6-1 and the attached mapbook that shows locations of sampling sites, by parameter.)

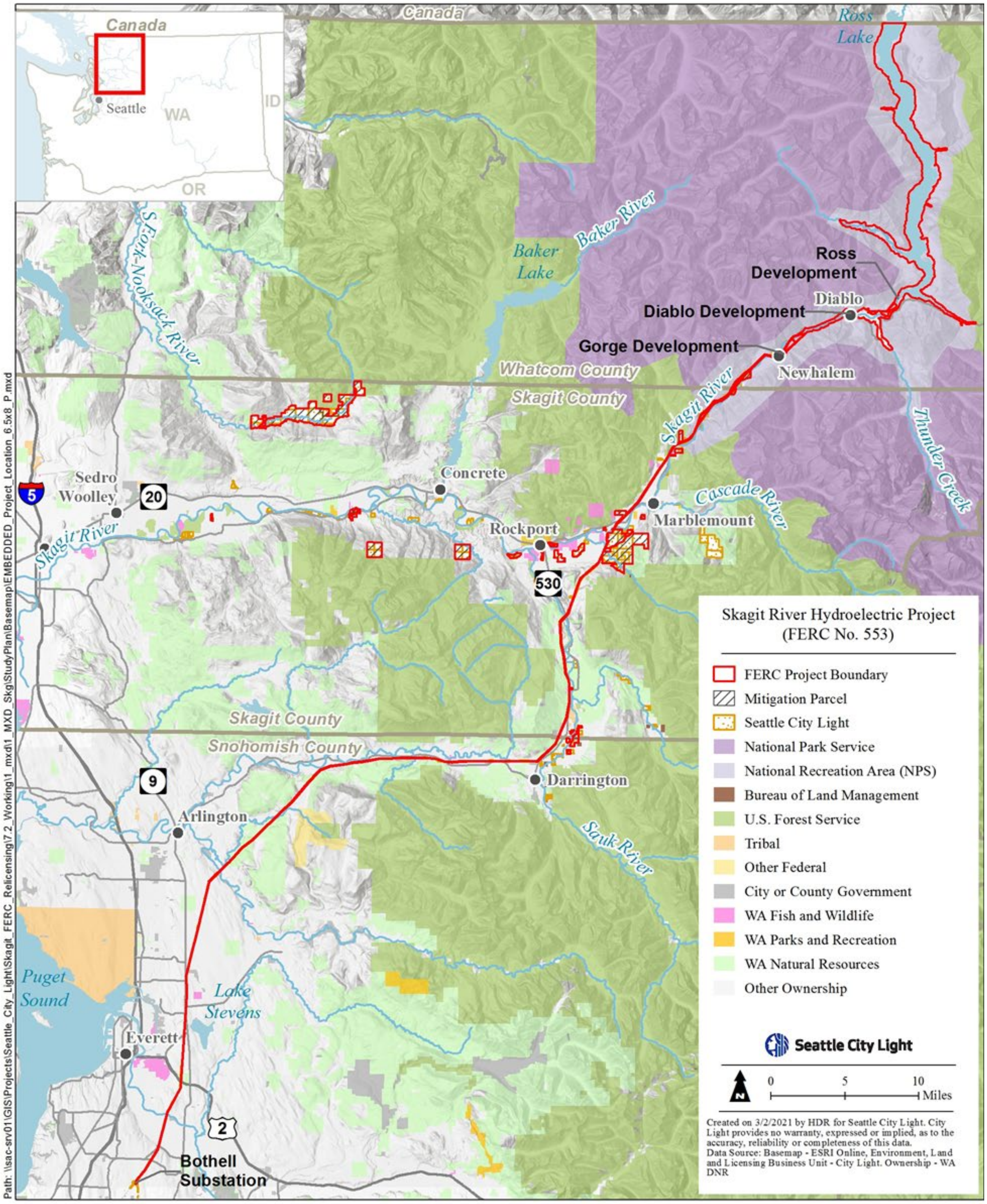

Figure 2.5-1. Location map of the Skagit River Project.

2.6 Methodology

The approach to water quality data collection, by location and parameter, is outlined below. The proposed parameters and locations were selected to augment the body of existing data summarized in Table 2.3-1 and existing water quality data for tributaries to Project reservoirs and the lower Skagit River. In addition to new water quality data being collected as part of this study, all reliable, pertinent existing information will be summarized in the Water Quality Monitoring Study report that will be filed with FERC. A Quality Assurance Program Plan (QAPP) is attached to this study plan. The QAPP details technical elements of field sampling and measurement, laboratory protocols, chain-of-custody procedures, and data management. Table 2.6-1 provides an overview of parameters to be measured or sampled along with proposed sampling locations, sampling timing and durations, and approach to data collection. A mapbook showing the proposed locations of all data collection sites is attached to this study plan.

Table 2.6-1. Summary of parameters to be measured or sampled along with proposed sampling locations, sampling periods and frequencies, and approach to data collection.

Parameter	Location	Approximate Lat./Lon.	Sampling Period	Frequency	Sampling Approach
Upper Skagit River					
Temperature (°C)	Upper Skagit River at Swing Bridge[4]	49.01927/-121.06065	Jun 2021–May 2023	Monthly	Grab Sample (1 m)
DO (mg/L)					
pH					
Turbidity (NTU); TSS (mg/L)					
Ross Lake					
Turbidity (NTU); TSS (mg/L)	Little Beaver[5]	48.9274/-121.0625	Jun 2021–May 2023	Monthly	Grab Sample (1 m and ≤ 5 m)
	Skymo[6]	48.8547/-121.0308			Grab Sample (1 m and 5 m)
	Pumpkin Mountain[7]	48.7904/-121.0496			
	Big Beaver Creek Confluence[8]	48.77418/-121.06419	2021–2023	Fall, Winter, and Spring during Drawdown	Grab Sample (surface and 5 m)
	Ruby Creek Arm[9]	48.73004/-121.02532			
	Ross Lake Shoreline Erosional Area North[10]	48.94838/-121.08508			100 m Transect, 5 m from Shoreline;
	Ross Lake Shoreline Erosional Area Central[11]	48.89389/-121.04398			

[4] Coincident with established acoustic receiver placement at Swing Bridge (i.e., Acoustic Station RLK05), in Canadian Skagit River at confluence with reservoir.
[5] Coincident with established water quality monitoring station used by NPS, with (SEEC funding.
[6] Coincident with established water quality monitoring station used by NPS, with SEEC funding.
[7] Coincident with established water quality monitoring station used by NPS, with SEEC funding.
[8] Coincident with Big Beaver Confluence zone where fish tagging is annually conducted for ongoing Bull Trout acoustic monitoring study for entrainment and habitat use.
[9] Coincident with established acoustic long line receiver placement within Ruby Arm (i.e., Acoustic Station RLK01); coordinates approximate centroid of transect.
[10] Coincident with established acoustic long line receiver placement, south of Silver Creek mouth (i.e., Acoustic Station RLK10), west bank; coordinates approximate centroid of transect.
[11] Coincident with established acoustic long line receiver placement, south of Desolation Peak trailhead (i.e., Station RLK07), east bank; coordinates approximate centroid of transect.

Parameter	Location	Approximate Lat./Lon.	Sampling Period	Frequency	Sampling Approach
	Ross Lake Shoreline Erosional Area South[12]	48.76682/-121.04427			5 Surface Grab Samples Collected Every 25 m along Transect
Fecal coliform	Hozomeen	TBD	Jun–Sep 2021, Jun–Sep 2022	Monthly (total of 8 collections over 2 years)	Grab Sample Surface
	Ross Lake Resort[13]	48.73890/-121.06072			
	Little Beaver Boat Access Camp	48.917841, -121.126283			
	Lightning Creek Boat Access Camp	48.876296, -121.011004			
	Big Beaver Boat Access Camp	48.774879, -121.066489			
Diablo Lake					
Temperature (°C)	Upstream End[14] and Forebay[15]	48.72961/-121.07244 48.71489/-121.13171	Jun 2021–May 2023	Monthly	Vertical profile at 2-m intervals
DO (mg/L)					
pH					
Turbidity (NTU); TSS (mg/L)	Upstream End and Forebay	48.72961/-121.07244 48.71489/-121.13171	Jun 2021–May 2023	Monthly	Grab Sample (1m and 5 m)
	Thunder Creek Confluence at Bridge/Colonial Creek Campground[16]	48.69101/-121.09552	2021–2023	Fall, Winter, and Spring	100 m Transect, 5 Surface Grab Samples Collected Every 25 m along Transect Moving Upstream
Fecal coliform	Thunder Creek Confluence at Bridge/Colonial Creek Campground	48.69101/-121.09552	Jun–Sep 2021, Jun–Sep 2022	Monthly (total of 8 collections over 2 years)	Grab Sample Surface

[12] Coincident with established acoustic long line receiver placement south of Big Beaver Creek confluence (i.e., Acoustic Station RLK02), west bank, opposite Roland Point

[13] Coincident with established acoustic receiver placement along eastern side of resort boom (i.e., Acoustic station RFB02)

[14] Coincident with established acoustic receiver placement at northwest corner of boathouse just downstream of Ross Powerhouse discharge (i.e., Acoustic station DLK06)

[15] Coincident with established acoustic receiver placement at Diablo Dam intake, along northern side of forebay boom (i.e., Acoustic Station DLK10)

[16] Coincident with established acoustic receiver location at Thunder Arm Bridge (i.e., Acoustic Station DLK07), adjacent to Colonial Creek Campground. Coordinates represent downstream terminus of transect.

Parameter	Location	Approximate Lat./Lon.	Sampling Period	Frequency	Sampling Approach
	Environmental Learning Center[17]	48.71690/-121.11940	Jun–Sep 2021, Jun–Sep 2022	Monthly (total of 8 collections over 2 years)	Grab Sample Surface
Gorge Lake					
Temperature (°C)	Upstream End[18] and Forebay[19]	48.71188/-121.14317 48.69777/-121.20672	Jun 2021–May 2023	Monthly	Vertical profile at 2-m intervals
DO (mg/L)					
pH					
Turbidity (NTU); TSS (mg/L)	Upstream End and Forebay	48.71188/-121.14317 48.69777/-121.20672	Jun 2021–May 2023	Monthly	Grab Sample (1 m and 5 m)
TDG (% saturation)	Below Diablo Dam	48.71188/-121.14317	Jun 2021–May 2023	Continuous	Below compensation depth
	Gorge Lake Forebay	48.69777/-121.20672			
Gorge Bypass Reach					
Temperature (°C)	Below Gorge Dam in Plunge Pool	-	Jun 2021–May 2023	Continuous	1 m Depth
DO (mg/L)					
Turbidity (NTU)					
Temperature (°C)	≈ 1.5 Miles above Gorge Powerhouse	-			
DO (mg/L)					
Turbidity (NTU)					
Temperature (°C)	≈ 0.6 miles above Gorge Powerhouse	-			
DO (mg/L)					
Turbidity (NTU)					
TDG (% saturation)	Below Gorge Dam in Plunge Pool	-	Jun 2021–May 2023	Continuous	Below compensation depth[20]
	≈ 1.5 Miles above Gorge Powerhouse	-			

[17] Coincident with established acoustic receiver placement offshore of Environmental Learning Center and Diablo Boathouse (i.e., Acoustic Station DLK02)
[18] Coincident with established uppermost acoustic monitoring station in Gorge reservoir (i.e. Acoustic Station GLK07), opposite bank from Reflector Bar.
[19] Coincident with established lowermost downstream acoustic monitoring station in Gorge inner forebay, (i.e., Acoustic Station GLK11), along southern log boom just above penstock intake.
[20] The depth at which the sum of hydrostatic and atmospheric pressure exceeds the gas pressure of TDG-supersaturated water.

Parameter	Location	Approximate Lat./Lon.	Sampling Period	Frequency	Sampling Approach
	~0.6 miles above Gorge Powerhouse	-			
Skagit River downstream of Gorge Powerhouse					
Temperature (°C)	Immediately Below Gorge Powerhouse, right bank	-	Jun 2021–May 2023	Continuous	2 m Depth
DO (mg/L)					
pH					
Turbidity (NTU)					
TDG (% saturation)					
TSS (mg/L)	Immediately Below Gorge Powerhouse	-	Jun 2021–May 2023	As needed	1 m Depth
Temperature (°C)	PRM 91.6 (USGS RM 91.1)	-	Jun 2021–May 2023	Continuous	1 m Depth
	PRM 85.9 (USGS RM 85.6)				
	PRM 75.6 (USGS RM 75.4)				
	PRM 69.3 (USGS RM 69.1)				
	PRM 60.8 (USGS RM 60.6)				
	PRM 54.5 (USGS RM 54.3)				
Benthic Macroinvertebrate	PRM 91.6 (USGS RM 91.1)	-	Jul and Sep 2021, Jul and Sep 2022	Discrete	Streambed
	PRM 85.9 (USGS RM 85.6)				
	PRM 75.6 (USGS RM 75.4)				
	PRM 69.3 (USGS RM 69.1)				
	PRM 60.8 (USGS RM 60.6)				
	PRM 54.5 (USGS RM 54.3)				
Sauk River					
Temperature (°C)	RM 2.8	-	Jun 2021–May 2023	Continuous	1 m Depth
Benthic Macroinvertebrate	RM 2.8	-	Jul and Sep 2021, Jul and Sep 2022	Discrete	Streambed

2.6.1 Upper Skagit River

2.6.1.1 Temperature, Dissolved Oxygen, and pH

Temperature (°C), dissolved oxygen (mg/L and percent saturation),[21] pH, turbidity (nephelometric turbidity units, NTU), and TSS (milligram/liter [mg/L]) will be measured at a depth of 1 m in the upper Skagit River at Swing Bridge (see attached mapbook), using a Hydrolab® multiparameter sonde with depth probe or equivalent equipment. Sampling will be conducted once per month from June 2021–May 2023, as access permits. At this location, the river is fully mixed, so a surface water sample (i.e., 1 m) will be representative of conditions throughout the water column.

2.6.2 Ross Lake

2.6.2.1 Turbidity and Total Suspended Solids

City Light proposes to collect data from June 2021–May 2023[22] to establish background turbidity (NTU) levels within Ross Lake. Sampling will be conducted once per month, at three locations in the reservoir: Pumpkin Mountain, Skymo, and Little Beaver (see attached mapbook). These locations are representative of conditions in the downstream, middle, and upstream ends of the reservoir, respectively, and are used by the NPS in its water quality sampling program funded by the Skagit Environmental Endowment Council (SEEC). Measurements will be made at depths of 1 m and ≤ 5 m[23]. Samples for the measurement of TSS (mg/L) will be collected at the same locations and times as turbidity. TSS samples will be collected according to Ecology's SOPs (attached to this study plan) and sent to an accredited laboratory for analysis. The sampling approach is designed to measure turbidity/TSS during all times of year to characterize background conditions during minimum water surface elevation in winter, reservoir refill in spring, normal maximum water surface elevation during summer, and reservoir drawdown in fall.

Turbidity will also be measured at the Big Beaver Creek confluence and in the Ruby Creek arm of the reservoir during fall, winter, and spring 2021-2023, six times in total, to characterize conditions when the reservoir is drawn down (TSS samples will be collected when turbidity is measured) (see attached mapbook). At both locations, grab samples will be collected at the surface and at a depth of 5 m. The exact timing of the sampling will be identified (in consultation with LPs) in response to ambient conditions, i.e., to characterize conditions when turbidity is thought by LPs to potentially influence fish access to tributaries.

City Light will also measure turbidity and TSS during drawdown conditions along three 100-m transects positioned parallel to the lakeshore (5 m from the shoreline) in three areas where active shoreline erosion is occurring: Ross Lake Shoreline Erosional Area North, Ross Lake Shoreline Erosional Area Central, and Ross Lake Shoreline Erosional Area South (see attached mapbook). Measurements will be made at all three transects during fall, winter, and spring 2021–2023 (six

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[21] Atmospheric pressure will be measured along with dissolved oxygen.

[22] The Updated Study Report (USR) is to be filed by March 2023. City Light recognizes that any data collected beyond December 2022 are not likely to be included in the USR; all data from the June 2012–May 2023 period will be made available to Ecology and other LPs and incorporated to the extent possible into the application for Section 401 certification of the Project.

[23] Water at the Little Beaver site is sometimes less than 5 m deep.

times total). During each sampling event, five measurements will be made, i.e., one every 25 m along the transect. TSS samples will be collected when turbidity is measured.

2.6.2.2 Fecal Coliform

City Light proposes to collect samples to measure fecal coliform monthly from June–September 2021 (the period of year when recreational use is heaviest) and again from June–September 2022 at the following locations, chosen because they experience relatively high levels of human use: Hozomeen, Ross Lake Resort, and at three boat access camps managed by the NPS, i.e., Little Beaver, Lightning Creek, and Big Beaver (see attached mapbook). Surface samples will be collected according to Ecology's SOPs (attached to this study plan) and sent to an accredited laboratory for analysis.

2.6.3 Diablo Lake

2.6.3.1 Temperature, Dissolved Oxygen, and pH

Temperature (°C), dissolved oxygen (mg/L and percent saturation), and pH will be measured at 2-m intervals along vertical profiles at the upper end of Diablo Lake and in the Diablo Lake forebay using a Hydrolab® multiparameter sonde with depth probe or equivalent equipment (see attached mapbook). Sampling will be conducted once per month from June 2021–May 2023.

2.6.3.2 Turbidity and Total Suspended Solids

Turbidity (NTU) and TSS (mg/L) will be measured/sampled at the upper end of Diablo Lake and in the Diablo Lake forebay (see attached mapbook); measurements will be made and grab samples will be collected at depths of 1 m and 5 m.

Turbidity will also be measured along a 100-m transect in the Thunder Creek Arm at the bridge near Colonial Creek Campground (see attached mapbook). Measurements will be made during fall, winter, and spring 2021–2023, six times in total, to characterize conditions when the reservoir is drawn down. During each sampling event, five measurements will be made, i.e., one every 25 m along the transect. TSS samples will be collected when turbidity is measured.

2.6.3.3 Fecal Coliform

Fecal coliform samples will collected monthly from June–September 2021 (the period of year when recreational use is heaviest) and again from June–September 2022 near Colonial Creek Campground and near the ELC (see attached mapbook). Samples will be collected according to Ecology's SOPs (attached to this study plan) and sent to an accredited laboratory for analysis.

2.6.4 Gorge Lake

2.6.4.1 Temperature, Dissolved Oxygen, and pH

Temperature (°C), dissolved oxygen (mg/L and percent saturation), and pH will be measured at 2-m intervals along vertical profiles at the upper end of Gorge Lake and in the Gorge Lake forebay (see attached mapbook) using a Hydrolab® multiparameter sonde with depth probe or equivalent equipment. Sampling will be conducted once per month from June 2021–May 2023.

2.6.4.2 Turbidity and Total Suspended Solids

Turbidity (NTU) and TSS (mg/L) will be measured at the upper end of Gorge Lake and in the Gorge Lake forebay (see attached mapbook); measurements will be made and samples will be collected at depths of 1 m and 5 m.

2.6.4.3 Total Dissolved Gas

TDG (percent saturation) will be measured at two monitoring locations: downstream of Diablo Dam below the compensation depth[24] and in the Gorge Lake forebay (see attached mapbook) using a Hydrolab® TDG sensor or equivalent equipment. TDG will be measured continuously from June 2021–May 2023.

2.6.5 Gorge Bypass Reach[25]

2.6.5.1 Temperature and Dissolved Oxygen

Temperature (°C) and dissolved oxygen (mg/L and percent saturation) will be measured continuously from June 2021–May 2023 at three locations in the Gorge bypass reach using a Hydrolab® multiparameter sonde or equivalent equipment: i.e., near Gorge Dam, approximately 1.5 miles upstream of Gorge Powerhouse, and approximately 0.6 miles upstream of Gorge Powerhouse that stays wet throughout the year (see attached mapbook).

2.6.5.2 Turbidity

Turbidity (NTU) will be measured continuously using a Hydrolab® multiparameter sonde or equivalent equipment. Measurements will be made at the same locations as temperature and dissolved oxygen (above) from June 2021–May 2023.

2.6.5.3 Total Dissolved Gas

TDG (percent saturation) will be measured continuously below the compensation depth using a Hydrolab® multiparameter sonde or equivalent equipment. Measurements will be made at the same locations as temperature and dissolved oxygen (above) from June 2021–May 2023. Sampling continuously will allow for the opportunistic measurement of TDG under spill conditions as they occur. Also, TDG will be monitored during controlled flow releases from Gorge Dam of approximately 50, 500, and 1,200 cfs (i.e., releases made to develop the Skagit River Gorge Bypass Reach Hydraulic and Instream Flow Model).

2.6.6 Skagit River below Gorge Powerhouse

2.6.6.1 Temperature, Dissolved Oxygen, and pH

Temperature (°C), dissolved oxygen (mg/L and percent saturation), and pH will be measured continuously from June 2021–May 2023 in the Gorge Powerhouse tailrace (see attached mapbook) using a Hydrolab® multiparameter sonde or equivalent.

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[24] The depth at which the sum of hydrostatic and atmospheric pressure exceeds the gas pressure of TDG-supersaturated water.

[25] A RWG meeting will be held in May/June 2021 to review sampling locations proposed in this RSP and to discuss the need for benthic macroinvertebrate sampling and other productivity sampling in the bypass reach.

Temperature (°C) will be measured continuously from June 2021–May 2023 with probes installed at three stage/discharge gage stations established in the Skagit River downstream of Gorge Powerhouse for the Instream Flow Model Development Study and at three sites between Marblemount and just below the Baker River confluence. Temperature measurement stations will be located at (1) PRM 91.6 (USGS RM 91.1), (2) PRM 85.9 (USGS RM 85.6), (3) PRM 75.6 (USGS RM 75.4), (4) PRM 69.3 (USGS RM 69.1), (5) PRM 60.8 (USGS RM 60.6), and (6) PRM 54.5 (USGS RM 54.3) (see attached mapbook).

2.6.6.2 Turbidity and TSS

Turbidity (NTU) will be measured continuously from June 2021–May 2023 in the Gorge Powerhouse tailrace (see attached mapbook) using a Hydrolab® multiparameter sonde or equivalent. TSS (mg/L) will be sampled opportunistically during any periods when turbidity levels are considered elevated.

2.6.6.3 Total Dissolved Gas

TDG (percent saturation) will be measured continuously from June 2021–May 2023 in the Gorge Powerhouse tailrace (see attached mapbook) using a Hydrolab® multiparameter sonde or equivalent.

2.6.6.4 Benthic Macroinvertebrates

Benthic macroinvertebrates (an index of secondary productivity) will be sampled near the six continuous temperature monitoring locations identified above (i.e., PRMs 91.6, 85.9, 75.6, and 69.3, 60.8, and 54.5) (see attached mapbook) during two periods over two years (for a total of four sampling events): July and September 2021 and again in July and September 2022. At each location, benthic macroinvertebrates will be collected with a D-frame kicknet (with an area of 1 ft^2) over a site length of 2 bankfull widths or more. Eight, 1-ft^2 kicknet samples will be taken in multiple riffles at each location during a given sampling period to obtain a single 8-ft^2 composite sample. Kicknet samples will be collected and processed according to the relevant field sampling, preservation, data reporting, records management, and quality assurance and quality control methods described in Ecology's SOPs EAP073 included in the QAPP attached to this study plan.

2.6.7 Sauk River

2.6.7.1 Temperature and Benthic Macroinvertebrates

Temperature (°C) will be measured continuously from June 2021–May 2023 with a probe installed at RM 2.8 in the lower Sauk River (see attached mapbook). Benthic macroinvertebrates will be sampled at RM 2.8 during two periods over two years (a total of four sampling events): July and September 2021 and again in July and September 2022. The sampling approach will be the same as that described for the lower Skagit River (above).

2.6.8 Analysis and Reporting

An interim monitoring report will be filed in March 2022 (with the ISR), and a final study report will be filed in March 2023 (with the USR) (see Section 2.8 of this study plan). As noted in Section 2.6.1 of this study plan, data collected beyond December 2022 are unlikely to be incorporated into the USR; however, these data will be made available to Ecology and other LPs and incorporated to the extent possible into the application for Section 401 certification of the Project. The final monitoring report will include:

- A description of the study methodology;
- Maps showing all data collection locations;
- A summary and analysis of existing data sources included in Table 2.3-1, reservoir tributary temperature data, Skagit River tributary data, and additional data of suitable quality provided by other entities;
- Summary figures and tables of water quality and benthic macroinvertebrate data collected; and
- A parameter-specific evaluation of results against Ecology's numeric and narrative criteria.

2.7 Consistency with Generally Accepted Scientific Practice

Methods for data collection, handling, and analysis are in accordance with Ecology guidance and associated SOPs as detailed in the QAPP attached to this study plan.

2.8 Schedule

Periodic progress reports on fieldwork will be provided to Ecology and LPs.

- Draft QAPP submitted to Ecology for review – Fall 2020
- RWG meeting to review sampling locations proposed in this RSP and to discuss the need for benthic macroinvertebrate sampling and other productivity sampling in the bypass reach – May/June 2021
- Fieldwork – June 2021 to May 2023
- Data Analysis – August 2021 to August 2023
- ISR – March 2022
- USR – March 2023

2.9 Level of Effort and Cost

The initial estimate for implementation and reporting associated with this study is approximately $450,000.

3.0 REFERENCES

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WATER QUALITY MONITORING REVISED STUDY PLAN

ATTACHMENT A

CITY LIGHT RESPONSES TO LP COMMENTS ON THE STUDY PLAN PRIOR TO PSP

Table 1. City Light responses to LP comments on the study plan prior to PSP.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
1.	Ashley Rawhouser (NPS)	05/11/2020	General Comment, Title Page	General Comments NPS: 1) The study plans should stand alone as an independent documents. When referencing the PAD or the original Issue Forms submitted by the LPs a summary of the pertinent information should be provided.	1) City Light agrees that the study plans should be stand-alone documents, but there are limits to what can reasonably be presented in a background or existing information section. The PAD contains much information, which is often detailed and nuanced. A summary in this study plan would not be representative of the material, and reproducing the content of the PAD would make the plan unwieldy. City Light continues to believe that the best approach is for LPs to reference the PAD (Note" any additional information located by City Light but not presented in the PAD will be summarized in the Water Quality Monitoring Study report). 2) City Light has removed references to the issue forms from this study plan (consistent with the approach taken in other study plans). Text has been added to Section 1.3 to better explain the role of the issue forms in contributing to City Light's suite of study proposals. Notwithstanding the restructuring of how issue forms are represented in study plans, City Light acknowledges that not every element of water quality sampling identified in issue forms is addressed in the proposed study design. The principal focus of this study as drafted is to address water quality data gaps needed for 401 water quality certification of the Project. City Light has demonstrated commitment to long-term monitoring of other elements requested in issue forms and will continue to do so through the partnerships we maintain with LPs in

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
					ongoing and future monitoring of water quality trends, including such metrics that are not typically conditioned to licenses (e.g., benthos sampling or reservoir phytoplankton), but for which long-term trend monitoring is useful for understanding effects of climate change and other environmental and operational factors at play in the watershed. City Light sees these commitments as largely falling outside of the 401 water quality certification process and best identified and prioritized through a longer term strategic management plan that could be coordinated with LPs and agreed to as part of license conditions beyond the two-year FERC study time frame. Long term strategic sampling, in coordination with City Light's climate resilience strategy, and incorporating a shared data management approach with LPs, is in keeping with City Light's environmental stewardship ethos. City Light would welcome furthering such an approach following license issuance in an independent working group that is expressly focused on strategically prioritized long-term trend monitoring of appropriate water quality metrics.
2.	Monika Kannadaguli (Ecology)	05/13/2020	Section 1.1, General Description of the Project	"The Project generating facilities are in the Cascade Mountains of the upper Skagit River watershed, between river miles (RM) 94 and 127. Power from the Project is transmitted via two 230-kilovolt ~~powerlines~~power lines that span over 100 miles and end just north of Seattle at the Bothell Substation."	In its documents, including the PAD, City Light consistently uses "powerlines;" the unedited version has been retained in this and other study plans.
3.	Brock Applegate (WDFW)	05/11/2020	Section 1.2, Relicensing Process	"This study plan reflects the RWG consultation ~~effort~~, and City Light will continue to engage the RWG structure in the preparation of the Proposed and Revised Study Plans (18 Code of	Section 1.2 and 1.3 were redrafted to better describe the 2019 collaborative process. Formal consultation does not begin until after the PAD is officially submitted. Although the informal

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				Federal Regulations [CFR] §§ 5.11-5.13), and through the relicensing process generally." **New comment provided on 06/24/2020:** WDFW does not consider the process as collaborative when the licensee tells the Licensing Participants (LP) to take their issues to FERC. SCL management would not select the collaborative licensing process, the Alternative Licensing Process, which most, if not all, licensing participants preferred. SCL can select the licensing process they prefer, but the ILP operates in consultation, not collaboration when SCL chooses to separate the licensing process from the settlement agreement process. I would agree that we did collaborate during the collection of study issues.	2019 process leading up to the development of draft study plans did not result in consensus regarding all issues raised by LPs, City Light views this process as a collaborative effort (i.e., the action of working together). **Response to comment provided on 06/24/2020:** City Light appreciates your agency's input and looks forward to working with you to address resource issues during the relicensing proceeding.
4.	Judy Neibauer (USFWS)	05/13/2020	Section 1.2, Relicensing Process	"This study plan reflects the RWG consultation, and City Light will continue to engage the RWG structure in the preparation of the Proposed and Revised Study Plans (18 Code of Federal Regulations [CFR] §§ 5.11-5.13), and through the relicensing process generally." Mention here that this information will help inform NEPA, the BA for ESA consultation, and the information needed for Section 10j for the Fish and Wildlife Coordination Act....similar to your other study plans....	See revisions to Section 1.3.
5.	Ashley Rawhouser (NPS)	05/11/2020	Section 1.3 Study Plan Development	In general, NPS believes the study plans should standalone as independent documents that contain enough detail so they could be replicated by an uniformed "outside" party.	City Light agrees that study methods must be clearly stated so that the study could be replicated, and such clarity will be provided as the study plan and its associated QAPP are finalized. A draft QAPP will be included in City Light's Proposed Study Plan (PSP), at which time LPs can provide comments on the QAPP.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
					The QAPP will describe the technical aspects of all field, laboratory, and data management aspects of the study, including the frequency of instrument calibrations.
6.	Judy Neibauer (USFWS)	05/13/2020	Section 1.3 Study Plan Development	Yes. My experiences with the Chelan PUD FERC study plans are the if the words are not accurate in the studies, they continually are brought up and argued about what was meant or what was supposed to be studied….Please make studies clear so that FERC and working groups will understand them. (See Comment #5)	See Comment Response #5.
7.	Ashley Rawhouser (NPS)	05/11/2020	Section 1.3 Study Plan Development	"Resource issues to be addressed in part by this study in combination with existing information are identified in the following issue forms: (1) FA10 Reservoir Turbidity; (2) FA14 Water Quality Monitoring; and (3) FA15 Water Quality Data." Please briefly describe or outline the issues to ensure we are all on the same page. Additional NPS issue forms that relate to this study plan but are not listed: FA-08 and FA-05 Current NPS issues include: 1) The proposed development of pumped storage will likely change water temperatures, thermal stratification, dissolved oxygen concentrations, nutrient concentrations, and turbidity in all three reservoirs and downstream in the Skagit River. These changes will have cascading effects on the biological communities and food webs in these waterbodies. In order to assess the impacts associated with this proposed development, existing water quality conditions	See Comment Response #1.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				need to be established. These data will also be needed to develop a hydrodynamic model that will be used to evaluate changes in reservoir water circulation, stratification, and the water quality characteristics of project's powerhouses outflows. 2) Sustained (maximum 7-day average) water temperatures routinely exceed 20°C in July, August, and September in Ross Reservoir and may inhibit the fall spawning migration of Bull Trout and Dolly Varden and reduce the amount of suitable habitat for foraging and rearing for these species. 3) The primary inflow to Diablo, Gorge, and the Skagit River at Newhalem is from the hypolimnetic releases from the reservoirs above. This is likely depressing water temperatures in these waterbodies reducing invertebrate productivity and the growth of native fish species. 4) Due to impoundment, nutrients are likely sequestered in the reservoirs through biological uptake and deposition into lake sediments rather than flowing downstream. This is potentially reducing invertebrate productivity and the growth of native fish downstream in Diablo, Gorge, and the Skagit River below the Newhalem Powerhouse. 5) The Bypass Reach is currently dewatered due to hydroproject operations an only receives limited inflow from dam leakage and small intermittent tributaries. 6) Increased turbidity during seasonal drawdowns may impair migration and foraging of native Bull Trout, Dolly Varden, and Rainbow Trout.	

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				7) Accumulation of heavy metals in reservoir sediment, primarily Ross, and subsequent uptake into the food web and fish tissue related to historic and active placer mining in the BC portion of the Skagit River and the Ruby Creek watershed.	
8.	Brock Applegate (WDFW)	05/11/2020	Section 1.3 Study Plan Development	I agree with Ashley. SCL should make more specific details on which part of these studies that they will cover in this study. (See Comment #7)	See Comment Response #1.
9.	Judy Neibauer (USFWS)	05/13/2020	Section 1.3 Study Plan Development	"Resource issues to be addressed in part by this study in combination with existing information are identified in the following issue forms: (1) FA10 Reservoir Turbidity; (2) FA14 Water Quality Monitoring; and (3) FA15 Water Quality Data." Describe her the issues, and how this study addressed what data gaps. Link to additional studies like erosion, sedimentation, operational flow models, geomorphology or landforms. You will want to know if some areas are naturally high in turbidity or not. You will want to know if exceedances occur under a range of operational flows. You will want to compare conditions upstream in reservoirs to downstream areas to determine sources of water quality issues. Doing this may help establish additional monitoring locations for data collection. As well, link to the Baker River WQ data to determine how far downstream effect can be observed and for cumulative effects……	See Comment Response #1 regarding issue forms. An integrated environmental analysis will specifically address links across resource areas. The FERC process schedule positions the integrated environmental analysis subsequent to the completion of the study program and prior to the filing of a Project License Application. City Light will work with RWGs to integrate information from related studies as part of the ILP process. City Light has added language to Section 1.3 to better describe potential linkages between studies being implemented during relicensing. City Light plans to collect data over a range of flows, as discussed in the methods section. City Light acknowledges the need to consider data from downstream locations and will assess the nature of the Project's contribution to cumulative effects downstream of the Sauk River confluence using existing available information as part of the relicensing process.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
					This would include not only Baker River data but data from other sources as well.
10.	Monika Kannadaguli (Ecology)	05/13/2020	Section 2.1 Study Goals and Objectives	“City Light proposes to direct resources toward the collection of data needed to characterize parameters that are not currently well understood.” I do not see any future proposal or past data for sediment sampling behind Ross Dam. There are known sources of mining and superfund sites upstream of Ross dam. I understand that these sites are not part of SCL project but stormwater discharged from these sites have potential to impact sediment quality downstream. Accumulation of sediments behind Ross dam is a project impact. Was there any data collected in the past to monitor the sediment quality behind Ross dam.	City Light questions whether toxic substances buried in sediment behind Ross Dam are likely to be mobilized during current or potential future Project operations—although the potential for the release of toxics will be explored during the integrated analysis of potential Project effects conducted during the ILP. Rather than sampling sediments that have accumulated at depth, City Light believes that existing/ongoing fish tissue data provide a better indicator of the potential effects of toxics in Ross Lake integrated over time in a biologically meaningful way. Fish tissue samples collected by Ecology in Ross Lake do not indicate toxics-related issues, as explained below. Seiders and Deligeannis (2018) evaluated data from tissue samples taken from 70 Rainbow Trout and native char collected by NPS, which were analyzed for chlorinated pesticides, PCBs, PBDEs, and metals. Concentrations of chlorinated pesticides and PCBs were low “and comparable to levels seen in waterbodies deemed to have little apparent human impact (Johnson et al, 2010, 2013, as cited in Seiders and Deligeannis 2018).” Seiders and Deligeannis (2018) state: “The concentrations of metals in the 2015 samples appear to be typical. Levels of copper were within or slightly above ranges (0.37-2.18

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
					mg/kg, respectively) found in other studies in Washington (Energy, 2012; EPA). Concentrations of mercury in 2015 (0.147-0.600 mg/kg) seem typical for the size, age, and trophic level for the native char and rainbow trout that were analyzed. Levels of selenium were detected just above the reporting limit and were within a guideline of 3 mg/kg for the protection of piscivorous wildlife (MacDonald, 1994). Concentrations of zinc were also similar to the median value (8.2 mg/kg) for fish fillets across Washington as reported by Serdar and Johnson (2006)...The 2015 sample results should serve as a good baseline for future comparisons." In addition, City Light has recently become aware of additional toxics data collected in the Skagit River at the US-Canada border (data collected by the USGS, Washington Water Science Center). Dissolved and whole metals are collected periodically, and bed sediment and Rainbow Trout liver and fillet metals are collected annually. These data are not included in Table 2.3-1 because they reflect conditions in an area outside the range of Project impacts (except perhaps fish tissue metals levels given that fish migrate between the reservoir and tributaries). The data will be briefly summarized in the Water Quality Monitoring Study report filed with FERC.
11.	Judy Neibauer (USFWS)	05/13/2020	Section 2.1 Study Goals and Objectives	"The water quality parameters listed below will be monitored in the identified waterbodies during the relicensing study period." Something that is coming to light with climate	Climate change will be addressed as part of the cumulative effects analysis that will be conducted as part of FERC's NEPA process. Under current conditions, however, Ross Lake

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				change is increasing issues with blue green algae. In some bull trout streams, even tho cold, we are seeing changes in type and amounts of algae. In terms of nutrients, this should be part of a long term monitoring program to be able to detect WQ issues related to algae invasions. Climate change will increase these events in some locations…….There are likely key locations both above and below reservoirs, downstream to the mouth, that would provide data some early warning data, to a potentially hazardous problem for both fish, wildlife, and people….	is considered oligotrophic. Nuisance cyanobacteria (aka blue-green algae) issues in a reservoir with such low nutrient concentrations are highly unlikely. Although tributaries upstream of the Project are important, conditions in these tributaries are outside the range of the Project's impacts and the scope of this proposed study. Nevertheless, the Water Quality Monitoring Study report will include a description of algae data collected annually in the Skagit River at the US-Canada border. Regarding the suggested expansion of the spatial scope of this analysis, City Light plans to assess the nature of the Project's contribution to cumulative effects (as required by the NEPA process) downstream of the Sauk River confluence using existing available information. Water quality effects from the Project in the lower reaches of the Skagit River and Puget Sound, given the numerous inflows and complex array of factors contributing to existing environmental conditions in these areas, will be extremely unlikely to be discernible. The proposed study is focused on filling data gaps in our current understanding of water quality conditions in the areas influenced by the Project. An expansion of scope as proposed is not warranted based on the extensive existing information indicating water quality criteria are being met in the reaches directly affected by the Project.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
12.	Monika Kannadaguli (Ecology)	05/01/2020	Section 2.1 Study Goals and Objectives	"Specific objectives of this study include the following:" What are the locations for conducting baseline monitoring?	Initial proposed locations for data collection are identified in the Methods section of the study plan. However, locations may be modified/refined in consultation with Ecology and other LPs.
13.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.1 Study Goals and Objectives	"Specific objectives of this study include the following:" A water quality evaluation should evaluate nutrient (N/P) ratios as well to examine evidence for cultural oligotrophication of the systems. Should also be expanded to biological monitoring (phytoplankton, zooplankton, and benthic macroinvertebrates) All 3 reservoirs should be included in this.	City Light understands cultural oligotrophication to be the result of a loss of nutrients, phosphorus in particular, from watersheds. If there is nutrient depletion due to upstream land uses, it does not constitute a Project effect. City Light believes existing information is sufficient to characterize the zooplankton communities of Ross Lake (see PAD and Table 2.3-1 of this study plan). Benthic macroinvertebrates, while critical to a functioning ecosystem, are unlikely to serve as the basis for PMEs, and City Light questions the need for potentially costly and time consuming (mostly due to sample processing) data collection that is unlikely to be used to formulate eventual license conditions. However, sampling macrobenthos could be undertaken as part of long-term monitoring, as explained in Comment Response #1).
14.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.1 Study Goals and Objectives	"Specific objectives of this study include the following:" Additional objective: Characterize suspended sediment in tributary inflows, within reservoirs, and downstream of the project.	The objectives and corresponding methods have been revised to include measurement of total suspended solids (TSS) at the locations and times associated with turbidity measurements in Project reservoirs. However, TSS in tributaries reflects watershed conditions of those tributaries, not a Project effect, by which these studies are parameterized.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
15.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.1 Study Goals and Objectives	"Specific objectives of this study include the following:" The PAD and this study plan do not adequatly summarise the existing data and ID data gaps. As such, the list provided below needs to be expanded in terms of geographic and temporal scope and interms of the parameters measured. The current objectives do not address the issues identified by NPS in the previous comment. Revising the objectives is probably better accomplished outside of the bubble format.	Table 2.3-1 has been modified to add more specificity regarding where data were collected and whether parameters are/were continuously or discretely monitored. This more detailed treatment sheds light on data gaps and City Light's data collection objectives to fill those gaps. In addition, City Light is in the process of organizing all its data files, which will be provided to LPs so that they can verify that existing data are suitable for characterizing water quality in the Project Area.
16.	Judy Neibauer (USFWS)	05/13/2020	Section 2.1 Study Goals and Objectives	1st Bullet – Edits in red text "Specific Objectives of this study include the following: ▪ Characterize background levels of turbidity in the Skagit River, Ross Lake, Diablo Lake, and Gorge Lake at a range of operational flows."	The objective and corresponding methods have been revised to include turbidity measurements in Diablo and Gorge lakes. The study plan already includes turbidity measurements in the Skagit River immediately downstream of Gorge Powerhouse.
17.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.1 Study Goals and Objectives	2nd Bullet – Comment "Measure fecal coliform levels at targeted locations in Ross Lake." Should include all recreational use facilities in the project boundary. (i.e. Diablo, George, and others)	City Light welcomes LP input regarding specific evidence that suggests a given recreation site should be added to what is proposed under this objective. City Light is aware of no evidence to suggest that bacteria levels are a problem anywhere in the Project area. The sampling proposed in this study plan is meant to screen some of the higher-use areas to see if there are any indications of problems. Sampling at every site would be excessive and not warranted based on the quality of water in the Project area. The bacterial monitoring as proposed takes a risk-based approach wherein

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
					sites selected for sampling experience the highest recreational use and hence qualitatively would have the highest likelihood of bacterial contamination.
18.	Judy Neibauer (USFWS)	05/13/2020	Section 2.1 Study Goals and Objectives	2nd Bullet – Comment "Measure fecal coliform levels at targeted locations in Ross Lake." Add in sites at additional recreational sites, or future new rec sites (i.e. rafting) along the mainstem Skagit River, or where there are sites in adjacent tribs that could be affecting downstream waters Specifically add in mining sites (Ruby) that could send elevated WQ parameters into reservoirs. Would need to know if issues are within SCL or adjacent/ but cumulative issues.	Bacteria levels in the tributaries upstream of the Project boundary and in the Skagit River downstream of the boundary do not constitute Project effects. Moreover, activities such as rafting are transitory in nature and sampling would be unlikely to capture the effects of such recreation. Also, results of monthly fecal coliform measurements in the Skagit River at Marblemount, 2009-2018, are well below Ecology's criteria, indicating that overall conditions are suitable downstream of the Project. Mining sites in the Ruby Creek drainage are well outside of the Project Boundary, are not affected by Project actions, and have been thoroughly investigated by Ecology for their potential effects on reservoir fish and water quality. See Comment Response #10.
19.	Judy Neibauer (USFWS)	05/13/2020	Section 2.1 Study Goals and Objectives	3rd Bullet – Edits in red text "Specific Objectives of this study include the following: ▪ Measure dissolved oxygen and pH along vertical profiles in Gorge, Diablo, and Ross Lake."	The text has been edited to include Diablo and Gorge Lake in a single objective as requested. City Light believes that existing dissolved oxygen and pH data are sufficient to characterize conditions in Ross Lake.
20.	Brock Applegate (WDFW)	05/11/2020	Section 2.1 Study Goals and Objectives	4th Bullet – Comment "Measure total dissolved gas below Diablo Dam during spill events."	Spills are infrequent at Ross Dam due to Ross Lake's large storage capacity. Spills at Ross Dam are typically associated with gate testing, are of short duration, and average only a few

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				Does SCL have the total dissolved gas below Ross Dam or a reason not to collect the information? **New comment provided on 06/24/2020:** If you spill, even in small amounts, SCL has a "little" potential for adverse impacts.	cfs. In most years, there is no spill from Ross Lake. As such, there is no potential for adverse impacts due to elevated TDG levels downstream of Ross Dam. **Response to comment provided on 06/24/2020:** Whether sufficient gas is entrained to result in elevated TDG concentrations depends on the volume of water spilled relative to the volume of the receiving water. If spills at Ross Dam are typically only a few cfs, any effect would be diluted in the receiving water and would be very unlikely to translate into potential harmful impacts on fish or other aquatic biota. However, your objection to the use of absolute language is appreciated. Rather than state that "there is no potential for adverse impacts…," City Light provides the following restatement: "As such, adverse impacts are highly unlikely..."
21.	Judy Neibauer (USFWS)	05/13/2020	Section 2.1 Study Goals and Objectives	5th Bullet – Edits in red text and comment "~~Measure dissolved oxygen and pH along vertical profiles in Gorge Lake~~" Just use one bullet for all the lakes, need to have Ross in here, if you already are monitoring that, just say that and discuss how you will add that to new data. Put current data within background or existing information section.	See Comment Responses #1 and #19.
22.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.1 Study Goals and Objectives	6th Bullet – Comment "Measure temperature and dissolved oxygen in the Gorge bypass reach." And further downstream until effects of	Temperature (°C) will be measured continuously with probes installed at riverine nodes established in the Skagit River downstream of the Gorge Powerhouse as part of the Operations Model Study.

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				hypolimnetic release are dissipated.	Dissolved oxygen will be collected at two locations in the Gorge Bypass reach and just below Gorge Powerhouse and at Marblemount (also there are historical data at Marblemount). City Light believes these measurements will be sufficient without the need for additional sites downstream of the Project.
23.	Judy Neibauer (USFWS)	05/13/2020	Section 2.1 Study Goals and Objectives	6th Bullet – Comment "Measure temperature and dissolved oxygen in the Gorge bypass reach" It seems that this reach has rarely been studied with it dewatering. I suggest that monitoring of turbidity, and possibly other nutrients should be added to understand its baseline conditions.	Field observations to date show that water clarity is high in the bypass reach nearly all the time, so turbidity measurements do not appear necessary. There are no large tributaries to the bypass reach, so sediment and nutrient loading are minimal. City Light continues to believe that the proposed collection of temperature, dissolved oxygen, and TDG data will provide the information necessary and relevant for assessing Project impacts.
24.	Ashley Rawhouser (NPS)	05/13/2020	Section 2.2 Resource Management Goals	"**2.2 Resource Management Goals**" I think it would be beneficial for SCL and LPs develop a set of RM questions this study will answer. This, as a starting point, would inform the objectives, scope, and methods to be used.	Thank you for your comment. City Light identifies its goals in Section 2.2. The second part of this section is intended to represent agency management goals, and City Light invites LP input. If NPS has specific resource management goals it believes are relevant for inclusion, please provide them to City Light for consideration.
25.	Judy Neibauer (USFWS)	05/13/2020	Section 2.2 Resource Management Goals	"**2.2 Resource Management Goals**" According to guidelines for the ILP…this section should also include information about public input considerations…maybe you have this somewhere already… see- https://www.ferc.gov/industries/hydropower/gen-info/guidelines/guide-study-criteria.pdf	Thank you. City Light is aware of these study request guidelines. Also, it is worth noting that the criteria pertain to "public interest," not public "input."
26.	Judy Neibauer (USFWS)	05/13/2020	Section 2.2 Resource	"The proposed study will provide information, which in combination with existing data, will be	See Comment Responses #9 and #11.

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			Management Goals	used to characterize water quality within the study area and allow resource agencies with jurisdiction over water or aquatic resources to analyze any Project effects related to water quality." I suggest you extend the scope to the full basin, maybe you have existing data elsewhere, You should discuss it and show how you will add it into the study, and augment with new data. Link to the geopmorphology, landform, and operational studies to understand where addition key areas are from a hyporheic standpoint. That would be important refugia sites for monitoring temperatures over time. Please see our critical habitat rule that has 9 PCEs that need to be maintained. These were developed in 2010. Water quality and temperatures are included. Other PCEs protect key regugia. This study should be designed with these PCEs in mind as well, Describe other agency resource goals here as well	7-DADMax water temperatures in the Skagit River between the Project and the Sauk River are cool year round (rarely >14 °C), so unlike many systems where water becomes warm, thermal refugia between the Project and the Sauk River confluence are not a significant issue.
27.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3 Background and Existing Information	"Between 2009 and 2018, the average low water surface elevation was 1,535 feet." Describe over the course of the current license.	The text was revised as follows: "Between 1991 and 2018, the average low water surface elevation ranged from 1,467.1 feet (in April) to 1,584.8 feet (in August)."
28.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3 Background and Existing Information	"Under normal operations at both the Gorge and Diablo developments there is a short section of free-flowing river between the Diablo tailrace and the upper end of Gorge Lake." This is an unnecessary qualifier. It speaks in contrast to the cultural impact felt by the Upper Skagit Tribe.	The word "short" has been deleted from this sentence.

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29.	Monika Kannadaguli (Ecology)	05/01/2020	Section 2.3 Background and Existing Information	"Because of Gorge Lake's relatively low storage volume, unplanned spills at the dam can occur any time inflow exceeds generation capacity. In addition, because flows from the Gorge Development are critical for fish production and protection in the Skagit River, water from Gorge Lake is spilled into the Gorge bypass reach if flows through Gorge Powerhouse are insufficient to meet downstream flow requirements specified under the 2013 Revised Fisheries Settlement Agreement (FSA) for salmon or steelhead spawning or rearing." What flows are you targeting to meet? What is the threshold for spill? Where is this measured in the system?	City Light is required by the existing FSA to release targeted flows to protect and enhance, as possible, spawning, incubation, and rearing of the different life stages and species of salmonids using habitats downstream of the Gorge Powerhouse. Descriptions in the PAD (Section 3.5.2) describe these parameters under the existing license. (These descriptions will also be included in the license application). The "threshold" for spill depends on a number of interacting factors, and a description of operations at this level seems beyond the scope of this section. Instead, the operations model, which is being developed, and eventually will be run, with input from LPs, will provide the operational characterizations needed to complete the integrated effects analysis.
30.	Monika Kannadaguli (Ecology)	05/01/2020	Section 2.3 Background and Existing Information	"Because of Gorge Lake's relatively low storage volume, unplanned spills at the dam can occur any time inflow exceeds generation capacity. In addition, because flows from the Gorge Development are critical for fish production and protection in the Skagit River, water from Gorge Lake is spilled into the Gorge bypass reach if flows through Gorge Powerhouse are insufficient to meet downstream flow requirements specified under the 2013 Revised Fisheries Settlement Agreement (FSA) for salmon or steelhead spawning or rearing." Does this mean downstream of the dam or downstream of the gorge powerhouse	The FSA stipulates flow targets for the river downstream of Gorge Powerhouse, per Comment Response #29. Text revised accordingly for clarity.
31.	Jon-Paul Shannahan	05/11/2020	Section 2.3 Background and	"The reach of the Skagit River between Gorge Dam and Powerhouse is referred to as the	Previous documents state that the bypass reach is 2.7 miles long. Current calculations by City

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	(Upper Skagit Indian Tribe)		Existing Information	bypass reach and is about 2.5 miles long." This needs to be measured and standardized in all documents.	Light, made in 2019, reveal the bypass to be 2.5 miles long. This vetted number was used consistently throughout the PAD and study plans.
32.	Brock Applegate (WDFW)	05/11/2020	Section 2.3 Background and Existing Information	"The reach of the Skagit River between Gorge Dam and Powerhouse is referred to as the bypass reach and is about 2.5 miles long." Why do we have all this fish passage information in the water quality study? Can we input this fish passage data in the instream flows study where SCL will need to describe which species uses what part of the bypass reach for which habitat? See the Habitat Suitability Curves (HSC) Section of the Instream Flow Study Plan.	Most of this paragraph consists of a general description of the bypass reach, which is relevant. However, City Light agrees that the statement relating to fish passage is not germane to the water quality study plan and has removed the last sentence from the paragraph.
33.	Monika Kannadaguli (Ecology)	05/01/2020	Section 2.3 Background and Existing Information	"Under the current Project license, City Light is not required to release any flow into the Gorge bypass reach." Please add specific document reference here (and web link or SharePoint link) Which condition in the previous FERC license says that City light is not required to release any flow into the Gorge bypass reach. ……..	"FERC (1995)" has been added to this statement. See pages 43, 44, 49, and 50 of the FERC Environmental Assessment (1995). Online link: http://www.seattle.gov/light/skagit/Relicensing/default.htm
34.	Judy Neibauer (USFWS)	05/13/2020	Section 2.3 Background and Existing Information	"Under the current Project license, City Light is not required to release any flow into the Gorge bypass reach." If you are doing studies for safety and recreation. Link to them, and include the monitoring of WQ data at the same time….	See Comment Response #9. Thank you for your suggestion regarding linking studies. In implementing the final approved study plans, City Light will be reviewing all opportunities for efficiencies that do not compromise the objectives or methods of individual studies.

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35.	Monika Kannadaguli (Ecology)	05/01/2020	Section 2.3 Background and Existing Information	"Much of this reach is upstream of several natural barriers to anadromous fish passage; the most downstream of these barriers is located 0.6 miles upstream of Gorge Powerhouse at about RM 95 (Smith and Anderson 1921; Envirosphere 1989)." We will need to work on this. I am not hearing same conclusion from the other stakeholders.	See Comment Responses #32 (this sentence has been deleted from the Water Quality Monitoring Study Plan) and #33. This statement is, however, based on a number of sources in the record (see the PAD and FERC (1995)). Nevertheless, City Light understands and appreciates the importance of the questions regarding passage and habitat conditions in the bypass reach, and its potential value as a transit and/or spawning/rearing environment under different flow conditions. The subject of potential passage of salmonids upstream of documented barriers in the bypass reach (Envirosphere 1989) and the options for how best to consider the functional values of the habitat therein will be addressed at length during the ILP. It will constitute a major element of the integrated analysis of potential Project effects and be addressed thoroughly in the License Application and its supporting documentation.
36.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.3 Background and Existing Information	"Much of this reach is upstream of several natural barriers to anadromous fish passage; the most downstream of these barriers is located 0.6 miles upstream of Gorge Powerhouse at about RM 95 (Smith and Anderson 1921; Envirosphere 1989)." Presumed velocity	See Comment Responses #32 (this sentence has been deleted from the Water Quality Monitoring Study Plan), #33, and #35.
37.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3 Background and Existing Information	"Much of this reach is upstream of several natural barriers to anadromous fish passage; the most downstream of these barriers is located 0.6 miles upstream of Gorge Powerhouse at about	See Comment Responses #32 (this sentence has been deleted from the Water Quality Monitoring Study Plan), #33, and #35.

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				RM 95 (Smith and Anderson 1921; Envirosphere 1989).” Where in Smith and Anderson is this particular “barrier” described?	
38.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3 Background and Existing Information	“Much of this reach is upstream of several natural barriers to anadromous fish passage; the most downstream of these barriers is located 0.6 miles upstream of Gorge Powerhouse at about RM 95 (Smith and Anderson 1921; Envirosphere 1989).” Envirosphere 1989 describes that flows of 1000 cfs create conditions that allow passage of several salmonid species.	See Comment Responses #32 (this sentence has been deleted from the Water Quality Monitoring Study Plan), #33, and #35.
39.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3 Background and Existing Information	“The primary purpose of the Flow Plan was to minimize past ~~the~~ effects of Project operations on redd protection and fry stranding on salmon and steelhead.” Downstream of the Gorge Powerhouse	City Light feels that the minimizing of Project effects due to flow releases is ongoing, and hesitates to use the word “past.” The second proposed text edit has been accepted with modification, i.e., “The primary purpose of the Flow Plan is to minimize the effects of Project operation on salmonids by providing spawning flows and protecting redds, fry, and yearlings.”
40.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.3 Background and Existing Information	“Much of this reach is upstream of several natural barriers at certain flows (partial barriers) to anadromous fish passage; the most downstream of these barriers is located 0.6 miles upstream of Gorge Powerhouse at about RM 95 (Smith and Anderson 1921; Envirosphere 1989).” Delete. Not pertenent for this study plan.	Agreed. Text deleted.

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41.	Brock Applegate (WDFW)	05/11/2020	Section 2.3 Background and Existing Information	"Much of this reach is upstream of several natural barriers at certain flows (partial barriers) to anadromous fish passage; the most downstream of these barriers is located 0.6 miles upstream of Gorge Powerhouse at about RM 95 (Smith and Anderson 1921; Envirosphere 1989)." Many fish, definitely steelhead, routinely make their way over or around this barrier, when the pool depth below the partial barrier becomes so deep. More fish passage will occur if we have more flow within the bypass reach. **New comment provided on 06/24/2020:** Please insert this paragraph into the Fish Passage Study Plan.	See Comment Responses #32 (this sentence has been deleted from the Water Quality Monitoring Study Plan), #33, and #35. **Response to comment provided on 06/24/2020:** Thank you for your comment. Additional discussions regarding the issue of Project fish passage are anticipated and City Light welcomes discussion of the proposed characterization at that time.
42.	Judy Neibauer (USFWS)	05/13/2020	Section 2.3 Background and Existing Information	"Much of this reach is upstream of several natural barriers at certain flows (partial barriers) to anadromous fish passage; the most downstream of these barriers is located 0.6 miles upstream of Gorge Powerhouse at about RM 95 (Smith and Anderson 1921; Envirosphere 1989)." Bull trout, lamprey, and other species may be able to manipulate cascades, etc…that allow passage at certain flows. I have surveyed lots of barriers, snorkeled and seen bull trout jump and slither over many obstacles. This seems important for a fish passage study, but WQ should be measured in these areas.	See Comment Responses #32 (this sentence has been deleted from the Water Quality Monitoring Study Plan), #33, and #35.
43.	Judy Neibauer (USFWS)	05/13/2020	Section 2.3 Background and Existing Information	"The primary purpose of the Flow Plan was to minimize the effects of Project operations on salmon and steelhead."	See Comment Response #35. Bull trout will be considered.

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				We now know lots more about what bull trout do, and they are anadromous here, so when we are developing instream flows, we will need to include bull trout and their prey species. As well consider their Critical Habitat parameters now too	
44.	Monika Kannadaguli (Ecology)	05/13/2020	Section 2.3 Background and Existing Information	**"**Table 2.3-1. Summary of existing water quality data collected since 1991[1], Skagit River Hydroelectric Project.**"** Please elaborate this table to clarify for which parameters there is continuous data available. If a specific parameter is measured only for a few months in any year, please clarify that.	Table 2.3-1 has been modified to add more specificity regarding where and when data were collected and whether they were continuously or discretely monitored. Also, please note that an objective has been added to the study plan that specifies that City Light will provide a complete summary of all pertinent water quality data in the Water Quality Monitoring Study report (City Light has become aware of additional information since the time the PAD was drafted). In addition to the information shown in Table 2.3-1, City Light will also summarize select inflow water quality information, which may be useful for informational purposes. For example, City Light is gaining access to water quality data collected in the Skagit River at the US-Canada border (data collected by USGS, Washington Water Science Center). Temperature, dissolved oxygen, pH, conductivity, and FDOM data are collected continuously at this location; samples for nutrients, major ions, and dissolved and whole metals are collected periodically; bed sediment, algae, snail, and Rainbow Trout liver and fillet metals data are collected annually. These data are not included in Table 2.3-1, however, because they reflect conditions in an area outside the range of Project impacts (except

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					perhaps fish tissue metals levels given that fish migrate between the reservoir and tributaries). The data will be briefly summarized in the Water Quality Monitoring Study report filed with FERC.
45.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3 Background and Existing Information	**"Parameters for which multiple years of recent data have been collected are considered to be adequately represented by existing information."** **The specific years should be assessed to describe relevant environmental conditions and project-related actions (e.g. summer drought, 10-year flood event, large spills or drawdowns, etc.), then determine whether additional years of data need to be collected.**	See Comment Response #44. Datasets in many cases are extensive, i.e., collected over a long enough period to account for environmental and operational variability; these variations will be summarized in the final report of the results from the study. In instances where the data collection period is shorter, City Light has proposed to collect additional data to bolster the existing record. City Light believes that the proposed study design, as revised per LP comments, plus existing information should enable characterization of water quality conditions within and downstream of the Project with high confidence and low uncertainty.
46.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3 Background and Existing Information	**"**Table 2.3-1. Summary of existing water quality data collected since 1991[1], Skagit River Hydroelectric Project.**"** **Include maps or more detailed descriptions of specific locations (e.g. where in Ross Reservoir has temperature been collected surface at depth, how many locations?), frequency of sampling etc.**	See Comment Response #44.
47.	Ashley Rawhouser (NPS)	05/11/2020	Section 2.3 Background and Existing Information	**"**Table 2.3-1. Summary of existing water quality data collected since 1991[1], Skagit River Hydroelectric Project.**"** For SCL data, NPS will need to review field sampling protocols, that data that were collected, associated metadata, and QAQC	City Light will provide LPs access to all relevant City Light water quality data files. Ecology's data are available at: Freshwater Information Network, Environmental Information Management System. [Online] URL:

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				documentation to determine their usefulness. Assuming that WA DOE and USGS have QAPPs (or similar) in place. Please provide the appropriate citations for data associated with these agencies.	https://apps.ecology.wa.gov/eim/search/SMP/RiverStreamSingleStationOverview.aspx?ResultType=RiverStreamOverviewList&StudyMonitoringProgramUserId=RiverStream&StudyMonitoringProgramUserIdSearchType=Equals&LocationUserIds=04A100&LocationUserIdSearchType=Equals. USGS's data are available at: https://waterdata.usgs.gov/usa/nwis/uv?12178000
48.	Judy Neibauer (USFWS)	05/13/2020	Section 2.3 Background and Existing Information	"Table 2.3-1. Summary of existing water quality data collected since 1991[1], Skagit River Hydroelectric Project." Thanks for providing. It looks like there are some data gaps, and that with contamination of lakes from acidic rain/snow these days….it seem you might want to collect baseline data in Diablo and Gorge Lakes to understand if conditions are similar downstream. As well, having WQ sampling information from Canada seem important. It would be great to develop a MOU with Canada to share data. Looks like you may need to include additional data or add sampling sites downstream of Marblemount….See my previous comment about sampling turbidity and fecal coliform at key recreational sites.	City Light has developed objectives/methods for the collection of water quality data to fill the gaps identified in the table. Baseline data will be collected from all three reservoirs. Also please See Comment Response #47. City Light agrees; it would be great to access data from sources in Canada. City Light is proposing to collect data on potential bacterial contamination at recreational sites in Ross Lake, at locations within the Project area where recreation is deemed most concentrated. Results of monthly fecal coliform measurements in the Skagit River at Marblemount, 2009-2018 are well below Ecology's criteria. City Light believes data collected at Marblemount are sufficient for understanding potential Project effects on water quality in the river downstream of the Project. Data from sources downstream of the Sauk River will be incorporated into the cumulative effects

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					analysis conducted to satisfy NEPA requirements.
49.	Monika Kannadaguli (Ecology)	05/13/2020	Section 2.3 Background and Existing Information	**"**Table 2.3-1. Summary of existing water quality data collected since 1991[1], Skagit River Hydroelectric Project.**"** Please add baseline monitoring locations to this table. What all parameters were measured and for how long?	Table 2.3-1 has been revised to provide the requested information.
50.	Monika Kannadaguli (Ecology)	05/01/2020	Section 2.3 Background and Existing Information	"**Existing Data (years collected)**" Data collection dates provided here does not match with the information provided in the summary tables.	City Light has become aware of additional data since the original "summary table" was provided to Ecology in 2019. Please consider the table contained in this study plan to be the most up-to-date/definitive.
51.	Monika Kannadaguli (Ecology)	05/13/2020	Section 2.3 Background and Existing Information	"2000–2002; 2008; 2010; 2012–2018" Is this all continuous data monitoring?	See Comment Response #44.
52.	Monika Kannadaguli (Ecology)	05/13/2020	Section 2.3 Background and Existing Information	"Zinc (tissue)" Was there any sediment monitoring for Metals by SCL?	See Comment Response #10.
53.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.3 Background and Existing Information	Last row of Table 2.3.1 "Metals[3] 1994-1995 Ecology" Macro-invertebrate from NewHalem/gorge Powerhouse and Marblemount	City Light is uncertain how to interpret this comment but presumes that Mr. Shannahan is providing notification that data exist that City Light is unaware of. Please provide a full reference so that we can consider the relevancy of the results. City Light's review of Ecology files from Marblemount revealed no BMI data (see: https://apps.ecology.wa.gov/eim/search/SMP/RiverStreamSingleStationOverview.aspx?

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					ResultType=RiverStreamOverviewList&StudyMonitoringProgramUserId=RiverStream&StudyMonitoringProgramUserIdSearchType=Equals&LocationUserIds=04A100&LocationUserIdSearchType=Equals). Similarly, City Light is unaware of BMI data from Newhalem. City Light will attempt to locate and obtain these BMI data and incorporate them into the Water Quality Monitoring Study report. City Light is aware of BMI data collected by Ecology in six Skagit River basin tributary streams within WRIA 4: Bacon, Diobsud, Finney, Illabot, Jackman, and Presentin creeks, and BMI data collected by the NPS in Stetattle Creek (these data are addressed in the PAD).
54.	Ashley Rawhouser (NPS)	05/11/2020	Section 2.3 Background and Existing Information	"3. Arsenic, cadmium, chromium, copper, lead, mercury, nickel, zinc." Citation needed.	Citation provided.
55.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.4 Project Operations and Effects on Resources	"Project operations have minimal effects on water quality in the Project reservoirs and Skagit River, as shown by the data reported in the PAD. For a summary of available water quality information by water quality parameter and Ecology's water quality criteria, see Section 4.4.5.2, *Existing Water Quality in the Project Vicinity*, of the PAD. The Skagit River drains mountainous and, in some cases, glacial areas located mainly within national park and wilderness areas; water flowing through the Project remains clean and cold throughout the year. The few 303(d) listings for Water Resources Inventory Area (WRIA) 4, which	City Light acknowledges that potential Project effects on water quality will be further assessed in consultation with LPs during the ILP. The license application will provide a summary of such assessments.

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				includes the Project vicinity, are applicable to reaches that are not affected by the Project, reflecting the good baseline water quality measured within and downstream of the Project Boundary. Moreover, water quality data collected by Ecology confirm the high quality of water in the Skagit River downstream of the Project (measured at Marblemount and discussed in Section 4.4.5 of the PAD)." Studies, analyses, and subsequent negotiations will determine the extent to which the project impacts water quality.	
56.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.4 Project Operations and Effects on Resources	"Project operations have minimal effects on water quality in the Project reservoirs and Skagit River, as shown by the data reported in the PAD." PAD summary is insufficient.	See Comment Response #55.
57.	Judy Neibauer (USFWS)	05/13/2020	Section 2.4 Project Operations and Effects on Resources	"Project operations have minimal effects on water quality in the Project reservoirs and Skagit River, as shown by the data reported in the PAD." Need to monitor Turbidity when turbidity is happening during storm events, while reservoirs are drawn down or shorelines intercept key erosional areas…link to erosion, sedimentation, geomorphology study data to identify key locations Also see my comment above where there looks like there have been data gaps in you data described in the table.	See Comment Responses #9 and #44. Following the first year of sampling, City Light will consult with Ecology and other LPs regarding the need for additional fieldwork.
58.	Brock Applegate (WDFW)	05/11/2020	Section 2.4 Project Operations and	"The Skagit River drains mountainous and, in some cases, glacial areas located mainly within national park and wilderness areas; water	City Light has recently become aware of additional water quality data collected in the Skagit River at the US-Canada border (data

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			Effects on Resources	flowing through the Project remains clean and cold throughout the year." Some salmonids may have issues with too cold of water for fish growth. Can SCL look at temperature above the project in the Skagit River? The lack of nutrients in the water can lead to a lack of productivity.	collected by USGS Washington Water Science Center). Temperature has been collected continuously, and sampling for nutrients is conducted periodically. These data will be summarized in the Water Quality Monitoring Study report.
59.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.4 Project Operations and Effects on Resources	"The few 303(d) listings for Water Resources Inventory Area (WRIA) 4, which includes the Project vicinity, are applicable to reaches that are not affected by the Project, reflecting the good baseline water quality measured within and downstream of the Project Boundary. Moreover, water quality data collected by Ecology confirm the high quality of water in the Skagit River downstream of the Project (measured at Marblemount and discussed in Section 4.4.5 of the PAD)." Yes many of the water quality metrics meet numeric standards, however water quality must also comply with designated uses narratives. Skagit downstream of Newhalem can potentially have water that is too cold for supporting salmonid productivity prior to thermal mixing of downstream tributaries. Fish use (spawning data and yearling stream use) should be compared to other locations downstream, to measure degree of which this is a problem. Has there been studies measuring macroinvertebrate diversity and abundance to support stream life histories of native fish in section between Marblemount and Gorge Power House? Upper Skagit Indian Tribe would like this metric (macro-invertebrates) measured under this study plan.	Water temperatures in the Skagit River downstream of Newhalem within the FERC Project boundary meet applicable beneficial use standards and City Light is not aware of any evidence that salmonid productivity is adversely affected by temperature in this reach. Macroinvertebrate diversity and abundance data, while interesting, are costly to process, and the results of BMI studies are rarely used to formulate PMEs in the context of relicensing. City Light intends to work with Ecology and other LPs to assess Project impacts based on the parameters identified in this study plan, as revised, and are receptive to considering how macroinvertebrate sampling could be incorporated as a metric for long-term trend monitoring under the new license. See Comment Response #1.

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60.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.4 Project Operations and Effects on Resources	"The existing data, combined with that collected during this proposed study, will be used to inform the Section 401 certification process overseen by Ecology as well as FERC's issuance of a new license for the Project." expanding the water quality sampling to include a full limnological analysis would bolster the strength of the proposed study and allow for additional evaluations to be considered.	City Light believes existing information, in combination with the limnological analyses proposed for the parameters for which we have data gaps, will provide a comprehensive picture of water quality conditions within and downstream of the Project. The collection of limnological data for parameters for which extensive records exist diverts resources.
61.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.5 Study Area	"The study will be conducted in Ross (within the United States), Diablo, and Gorge lakes, the Gorge bypass reach, and in the Skagit River immediately below the Gorge Powerhouse (Figure 2.5-1)." It will be necessary to monitor tributaries flowing into reservoirs to gain a baseline of water quality conditions upstream of the project. Project-related effects extend beyond the area immediately downstream of the Gorge bypass (e.g. cold temperature from hypolimnetic release), in some cases down to Puget Sound (e.g. suspended sediment load), and it will be necessary to extend sampling to these areas to determine when project-related effects become adequately dissipated by tributary inflows or environmental conditions.	Water quality in tributaries is driven by non-Project related causes, primarily land uses and climate, and as a result is beyond the scope of this study and the FERC relicensing process. However, water quality data collected in the Skagit River at the US-Canada border (data collected by USGS Washington Water Science Center) will be summarized in the Water Quality Monitoring Study report. Regarding sampling to Puget Sound, please See Comment Response #11.
62.	Brock Applegate (WDFW)	05/11/2020	Section 2.5 Study Area	"The study will be conducted in Ross (within the United States), Diablo, and Gorge lakes, the Gorge bypass reach, and in the Skagit River immediately below the Gorge Powerhouse (Figure 2.5-1)." Work with Canada to get some information from them or permission to look at temperatures	See Comment Response #48. City Light disagrees that the Project affects water quality upstream of the high-water mark of Ross Lake.

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				in the Skagit River above the project. The true effects area above the Project extends above the Ross Reservoir.	
63.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.5 Study Area	"All sampling locations within the Project reservoirs, Gorge bypass reach, and immediately below the Gorge Powerhouse are affected by Project operations." The geographic scope needs to be expanded. The influence and attenuation of cold water released from the hypolimnion of the reservoirs needs to be evaluated. As does the sequestration of fine sediments and nutrients in the reservoirs. NPS welcomes additional conversations with SCL on these issues.	Temperature data available for the USGS Newhalem gage and Ecology's monitoring station at Marblemount provide a reasonable characterization of temperature trends in the reach directly affected by the Project. Project effects would be difficult to discern in the lower reaches of the Skagit River and Puget Sound given the complex array of factors contributing to existing environmental conditions in these areas. City Light plans to assess the nature of the Project's contribution to cumulative effects downstream of the Sauk River confluence using existing available information as part of the NEPA process. City Light is aware of no evidence indicating that there are nutrient-related adverse effects on biota in the Skagit River downstream of the Project. However, City Light welcomes LP input regarding specific aquatic habitat issues associated with nutrients, and the information upon which LPs base their concerns.
64.	Judy Neibauer (USFWS)	05/13/2020	Section 2.5 Study Area	"All sampling locations within the Project reservoirs, Gorge bypass reach, and immediately below the Gorge Powerhouse are affected by Project operations." I agree, Need to include areas down to the mouth and estuary, and or include data you already have…..There is a need to establish a baseline, determine if key nutrients are lacking due to blockage at dams/in reservoirs and understand what comes in from Canada and or	See Comment Responses #11, #44, #48, and #63.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				the Baker River system to effect WQ for cumulative effects or aggregated effects analysis…	
65.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6 Methodology	"2.6 Methodology" Measure suspended sediment load in tributaries flowing into reservoirs. The reservoirs sequester suspended sediment, thereby interrupting downstream transport. Suspended sediment is important for delta formation and habitat conditions in Skagit Bay. The large watershed area cut-off by the project is reducing the fine sediment load delivered to Skagit Bay.	Sediment conditions below the Sauk River confluence and delta formation are being addressed in the geomorphology cumulative effects analysis. Also See Comment Response #11.
66.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.6 Methodology	"2.6 Methodology" NPS will provide comments on the sample frame and methods when the objectives of the study are finalized.	City Light welcomes any and all input during the established review period for this study plan.
67.	Curtis Clement (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.1 Methodology	"City Light proposes to collect data during one field season to establish background turbidity (nephelometric turbidity units, NTUs) levels within Ross Lake." Will these measurements be near the inlet bays or along the center of the reservoir in line with these inlets? Also, please specify whether these are surface measurement or if they will be water column profiles of turbidity.	City Light proposes to measure turbidity at the reservoir's surface and at a depth of 5 m. Unless otherwise guided by Ecology and other LPs, City Light plans to conduct the measurements at the following coordinates: Pumpkin Mountain (48.7904, -121.0496), Skymo (48.8547, -121.0308), and Little Beaver (48.9274, -121.0625). City Light plans to conduct mid-reservoir sampling at these locations.
68.	Judy Neibauer (USFWS)	05/13/2020	Section 2.6.1 Methodology	"City Light proposes to collect data during one field season to establish background turbidity (nephelometric turbidity units, NTUs) levels within Ross Lake." If the events that cause storm turbidity do not happen you may need to expand the	See Comment Response #57.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				timeline….plan for additional year as necessary to capture these events.	
69.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.6.1 Methodology	"Sampling will be conducted once per month using a Hydrolab® multiparameter sonde or equivalent, at three general locations in the reservoir: Pumpkin Mountain (48.7904, -121.0496), Skymo (48.8547, -121.0308), and Little Beaver (48.9274, -121.0625)." The sonde should be calibrated before each sampling event, and a proof of calibration log should be provided.	See Comment Response #5.
70.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.6.1 Methodology	"Sampling will be conducted to characterize turbidity during minimum water surface elevation in winter, reservoir refill in spring, normal maximum water surface elevation during summer, and reservoir drawdown in fall." Is monthly sampling frequency sufficient to capture temporal variability during the drawdown/refill?	City Light believes monthly sampling is suitable to capture temporal variability during drawdown and refill, as these processes take several months in Ross Lake—the primary reservoir where the potential for exposed shorelines to generate turbidity from erosion will be greatest., City Light proposes to consult with Ecology and other LPs to determine if additional turbidity monitoring is warranted after the results from the first year of sampling are shared
71.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.6.1 Methodology	"City Light proposes to collect fecal coliform data four times during one summer field season at the following locations, chosen because they experience relatively high levels of human use…" All recreation sites should be evaluated for fecal coliform, regardless of use level. Even moderate levels of use can cause fecal coliform commination IF the facilities are not functioning properly.	See Comment Response #17. Sampling at every recreation site is unwarranted for an initial screening to determine if a problem may exist with fecal coliform levels in Ross Lake. Additional sampling can be considered following review of initial results from the sampling at the proposed sites where highest probability for contamination exists. It should be recognized that facility maintenance at these sites is not under the purview of City Light.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
72.	Brock Applegate (WDFW)	05/11/2020	Section 2.6.1 Methodology	"City Light proposes to collect fecal coliform data four times during one summer field season during the heaviest use by recreationists at the following locations, chosen because they experience relatively high levels of human use (exact sampling locations will be identified in consultation with Ecology): Hozomeen, Ross Lake Resort, and at three boat access camps managed by the NPS (the camps to be sampled will be determined in consultation with Ecology and the NPS)."	The text has been edited to state: "City Light proposes to collect fecal coliform data four times during one summer field season, when recreational use is heaviest, at the following locations…"
73.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.6.2 Diablo Lake	**"2.6.2 Diablo Lake"** Sampling should be conducted in the "middle" of the reservoir as well.	Please recall that detention time in Diablo Lake is only 9.4 days, so there is little potential for water quality in the center of the reservoir to be substantially different from that at the inflow and outflow points. Sampling at the upper and lower ends of Diablo Lake will be sufficient to characterize conditions in the reservoir relative to water quality numeric and narrative standards, i.e., City Light believes sampling near the inflow and outflow point will reveal any changes taking place within the waterbody to determine if additional sample sites are needed in the middle of the reservoir or elsewhere.
74.	Judy Neibauer (USFWS)	05/13/2020	Section 2.6.2 Diablo Lake	**"2.6.2 Diablo Lake"** Sample turbidity here as well, esp in Storm events; Baseline nutrient levels should be monitored to see if Nutrients are passing between Ross Lake, Diablo Lake, and Gorge Lake. And to see if there are certain operation events that either allow them to pass or not….. Since this license will be long term, and climate change is causing strange elevated levels in	Sampling turbidity in Ross Lake and at the Gorge Powerhouse will suffice to bracket inflow and outflow conditions. City Light is aware of no evidence to suggest that nutrient levels in Diablo Lake are impaired by Project operations, so the sampling proposed in this comment seems excessive. However, City Light welcomes input regarding information LPs have for adverse effects on

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				algae, establish a baseline to help determine if and when this becomes an issue to fish, wildlife, and people. Develop monitoring program for acidity, with pcbs and other contaminants within wilderness lakes, please monitor each of the lake to establish if this is an issue currently, and or may become an issue in the future. This will help with any aggregated / cumulative effects analysis	biota related to nutrient levels in any of the Project reservoirs or downstream. Regarding toxics, please See Comment Response #10. There is no evidence suggesting toxicants, including PCBs, are affecting water quality and/or resources of concern.
75.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.6.2 Diablo Lake	"Dissolved oxygen (milligram/liter [mg/L]) and pH vertical profile measurements will be made at the upper end of Diablo Lake and in the Diablo Lake forebay using a Hydrolab® multiparameter sonde with depth probe or equivalent equipment." Temperature and other hydrolab capabilities should be collected. Temperature is of particular importance, however. Sonde should be calibrated before each event.	The scope has been revised to include temperature as one of the parameters to be monitored along vertical profiles in Diablo Lake. Regarding calibration, please See Comment Response #5.
76.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.6.3 Gorge Lake	"**2.6.3 Gorge Lake**" Sampling locations in the "middle" of the reservoir as well. This is needed to gain an understanding of the physical characteristics throughout the entire reservoir.	See Comment Response #73. Also, please recall that detention time in Gorge Lake is only 0.8 days and water is thoroughly mixed
77.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.6.3 Gorge Lake	"Dissolved oxygen (mg/L) and pH vertical profile measurements will be made at the upper end of Gorge Lake and in the Gorge Lake forebay using a Hydrolab® multiparameter sonde with depth probe or equivalent equipment."	The scope has been revised to include temperature as one of the parameters to be monitored along vertical profiles in Gorge Lake.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				Temperature and other hydrolab capabilities should be collected. Temperature is of particular importance, however.	
78.	Judy Neibauer (USFWS)	05/13/2020	Section 2.6.3 Gorge Lake	"Sampling will be conducted once per month from June through September during a single field season to document conditions during the warmest time of year." Establish network of temperature monitoring to understand thermal changes that happen in the draw down zones within and adjacent to bull trout spawning streams at a variety of reservoir elevations…similarly, determine if there are tributaries below the dam, where barriers may form at intersections with the mainstem….due to thermal conditions….and include these areas as Temperature sampling sites.	See Comment Response #77. Gorge Lake, is usually kept at or near normal maximum water surface elevation to provide maximum head for Gorge Powerhouse. As a result there is little or no drawdown zone in this waterbody. Moreover, detention time in Gorge Lake is only 0.8 days, so water does not reside long enough in the reservoir to undergo significant changes. Temperatures in Gorge Lake are cool, rarely above 14°C. Based on these characteristics, City Light can see no justification for the requested temperature sampling in Gorge Lake. City Light is unaware of any evidence that there are thermal barriers to tributaries in the reach of the Skagit River downstream of the Project. However, City Light welcomes LP input regarding specific information that indicates that thermal barrier issues occur at the mouths of tributaries. Elevated temperatures within tributaries that affect bull trout stream access are outside the Project's range of effects.
79.	Judy Neibauer (USFWS)	05/13/2020	Section 2.6.4 Gorge Bypass Reach	"**2.6.4 Gorge Bypass Reach**" Consider adding in monitoring of WQ during recreational safety study, when water levels are at varying depths in this bypass reach.	City Light will work with LPs and its technical consultants to determine if there is any potential benefit to conducting the Level Three: Multiple Flow Evaluation during the time that water quality parameters are being measured.
80.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.4 Gorge Bypass Reach	"Temperature (°C) and dissolved oxygen (mg/L) will be measured during a single field season at two locations in the Gorge bypass reach….."	See Comment Responses #11 and #65.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				Include suspended sediment load. See comment above related to Skagit Bay.	
81.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.6.4 Gorge Bypass Reach	"Temperature (°C) and dissolved oxygen (mg/L) will be measured during a single field season at two locations in the Gorge bypass reach using a Hydrolab® multiparameter sonde or equivalent equipment: i.e., near Gorge Dam and in the reach downstream ~~of the fish barrier~~ located 0.6 miles upstream of Gorge Powerhouse that stays wet throughout the year." In the plunge pool	Edit accepted.
82.	Monika Kannadaguli (Ecology)	05/01/2020	Section 2.6.4 Gorge Bypass Reach	"Sampling will be conducted once per month from June through September to document conditions during the warmest time of year." Why not continuous data collection? There are other equivalent or even smaller facilities that are collecting continuous Temp data .	City Light has revised the study plan to state that temperature and dissolved oxygen data will be collected continuously from June through September in the Gorge Bypass Reach.
83.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.6.4 Gorge Bypass Reach	"Sampling will be conducted once per month from June through September to document conditions during the warmest time of year" Sampling should also take place during spill events. Recommend sampling to cover April through end of December	Section 2.6.4, Gorge Bypass Reach, has been revised to include opportunistic temperature, dissolved oxygen, and turbidity monitoring during spill events. Continuous monitoring of turbidity in the bypass reach, outside of spill events, is unwarranted, as base flows through the bypass reach are nominal, water clarity is excellent, and sources of fine sediments that could be suspended to generate turbidity above water quality standards under such base flow conditions are negligible.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
84.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.6.6 Skagit River below Gorge Powerhouse	"Dissolved oxygen (mg/L), pH, and turbidity (NTU) will be measured continuously for approximately one year in the Gorge Powerhouse tailrace using a Hydrolab® multiparameter sonde or equivalent." Would like to see plan for measuring temperature below project to at least Marblemount.	Temperature (°C) will be measured continuously with probes installed at riverine nodes established in the Skagit River downstream of the Gorge Powerhouse as part of the Operations Model Study.
85.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.8 Schedule	NPS suggests establishing a smaller WQ RWG to develop the sample frame and methods. The schedule should include milestones for consulting with LPs.	The purpose of this study plan review process is to have a dialogue with LPs regarding scope and timeframe of this proposed study; each existing RWG has the ability to decide if additional meetings are needed. City Light sees no need for a separate Water Quality RWG at this time.
86.	Judy Neibauer (USFWS)	05/13/2020	Section 2.8 Schedule	"**2.8 Schedule**" ▪ Consider expanding this to two years of sampling at least esp. if this year is a drought year, or exceptionally cold year….so you can capture key events, ….	See Comment Response #57.
87.	Brock Applegate (WDFW)	05/11/2020	Section 2.8 Schedule	▪ Field Work – January to December 2021 ▪ Analysis – February 2021 to January 2022 ▪ Final Initial Study Report (ISR) – March 2022 ▪ IRS Meeting -- 2022	Thank you for your comment. The schedule reflects the timeline for this study only, not the larger ILP process.
88.	Monika Kannadaguli (Ecology)	05/13/2020	Section 3.0, References	Please update this list.	References have been updated.
89.	Steve Copps (NMFS)	05/11/2020	Section 2.1 Study Goals and Objectives	The listed objectives are actions pursuant to CWA Sec. 401 compliance. We suggest adapting the broad objectives of the CWA and other water quality objectives related to salmonid recovery to fit the context of the study within the Skagit river system. Species specific	As noted in Section 2.1, this study plan is "designed to collect water quality data, which along with existing water quality information, is intended to support [not only] Ecology's certification of the Project under Section 401 of the CWA, and the data needs of FERC,

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				consideration should be made for both lethal and sublethal effects.	[but]…also…other data needs of resource agencies, tribes, and other LPs in the context of FERC relicensing (underline added). Review of the available Project water quality information collected over numerous years indicates water quality within the Project Boundary and downstream of the Project is very good, i.e., in compliance with Ecology's criteria, which have been established to protect beneficial uses, including the suitability of habitat for anadromous and non-anadromous salmonids. Existing information indicates no adverse effects of water quality on fish species within and downstream of the Project Boundary; data collected in this study will be used to further evaluate compliance with Ecology's criteria which City Light believes provide water quality conditions that are conducive to salmonid recovery. In addition, the relicensing process includes opportunities to modify the scope of the Water Quality Monitoring Study if additional information needs are identified. .
90.	Steve Copps (NMFS)	05/11/2020	Section 2.2 Resource Management Goals	Fully describe the linkages to other study plans with sufficient detail to understand the nature of each specific link and how the information will be synthesized to inform relicensing.	City Light has added language to Section 1.3 to address potential linkages between studies being implemented during relicensing. Also, please see Comment Response #9. City Light welcomes further discussion on requested information on study linkages and will consider adding additional information to the PSP filing to expand upon how the information will be synthesized to inform relicensing.
91.	Steve Copps (NMFS)	05/11/2020	Section 2.2 Resource Management Goals	Describe how the study will inform the relicensing process both substantively and procedurally (e.g., how will the information be used to assess alternative management scenario effects on water quality).	Please see Comment Response #9. As noted in the Operations Model Study Plan, simulation of various potential Project operation scenarios considered during the relicensing process (i.e., during the comprehensive resource analysis that

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
					will occur after studies are completed in support of license application development) will aid in decision-making regarding the effects of various operating scenarios on water allocation, flood control, fish and wildlife habitat, instream flows, reservoir levels, wetland and floodplain connectivity, recreation, hydropower generation, and other matters [e.g., water quality] affected by flow releases from the Project. City Light will work with all LPs to develop these scenarios and consult during the assessment of potential Project effects associated with each scenario.
92.	Steve Copps (NMFS)	05/11/2020	Section 2.2 Resource Management Goals	Describe in more detail the purpose of conferring with other agencies and tribes.	Please see revisions made to Section 1.2 of this study plan.
93.	Steve Copps (NMFS)	05/11/2020	Section 2.2 Resource Management Goals	Consider combining the study plan with another appropriate study (e.g., Operations Model).	Please see Comment Response #90 and #91. Different technical skills are necessary to implement individual study plans, therefore these study plans and reports will remain separate. Results of studies will be considered comprehensively, along with other available information, to complete a comprehensive resource analysis in support of the license application.
94.	Steve Copps (NMFS)	05/11/2020	Section 2.5 Study Area	The geographic scope should be consistent with project effects on water quality. At a minimum, the study plan should justify the proposed scope.	Project effects on water quality have not been identified; City Light believes that combined with extensive existing information, the scope of the study will fully characterize water quality in the Project area. Please see Comment Response #11. If NMFS has specific water quality data needs that it believes are not included in the current study scope, City Light welcomes additional comment from NMFS.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
95.	Steve Copps (NMFS)	05/11/2020	Section 2.6, Methodology	The proposed sample sample sizes appear to be insufficient. The revised plan should describe in detail the rationale for low sampling rates, it would seem that continuous measurement technology would be more appropriate to understand the influence of water quality on aquatic species throughout multiple life history stages.	Please see revisions to Sections 2.1, 2.3, and 2.6, including revisions to Table 2.3-1.
96.	Steve Copps (NMFS)	05/11/2020	Section 2.8 Schedule	There appears to be an excessive amount of time for analysis given the objective of the draft plan.	Please see the revised study schedule included in Section 2.8. The analysis period extends through the sampling period to acknowledge interim data processing, and the end date only extends two months beyond the end of field data collection.

WATER QUALITY MONITORING REVISED STUDY PLAN

ATTACHMENT B

LOCATIONS OF ONGOING TEMPERATURE MONITORING BEING CONDUCTED BY CITY LIGHT

Table 2. Locations of ongoing temperature monitoring being conducted by City Light as part of other studies and current license implementation.

Thermistor Serial No.	Location
11011546	Sumalo River
10706123	Upper Skagit River Left (wetted) Channel
11011549	Klesilkwa River
9646449	Upper Skagit River 26 Mile Bridge
11011547	Upper Skagit River at Brown Sign
11011571	Upper Skagit River at Nepopekum Day Use
9846470	Upper Skagit River at Swing Bridge
9846463	Ruby Creek Upper
9846454	Big Beaver Creek Mouth
1021142	Ruby Creek Mouth
9846445	Ross Lake 2nd Boom Yellow Line 3 ft
11011548	Ross Lake 2nd Boom Yellow Line 13.5 ft
10248300	Ross Lake 2nd Boom Yellow Line 23.5 ft
9866511	Ross Lake 2nd Boom Yellow Line 34.5 ft
9846451	Ross Lake 2nd Boom Yellow Line 46.5 ft
10248287	Ross Lake 2nd Boom Yellow Line 58 ft
11011564	Ross Lake 2nd Boom Yellow Line 68 ft
10248310	Ross Lake 2nd Boom Yellow Line 91 ft
9846447	Ross Lake 2nd Boom Yellow Line 114.5 ft
11011576	Ross Lake 2nd Boom Yellow Line 137.5 ft
9866514	Ross Lake 2nd Boom Yellow Line 161.5 ft
10219838	Ross Lake Spillway Boom Lead Line 5 ft
10586804	Ross Lake Spillway Boom Lead Line 15 ft
10420842	Ross Lake Spillway Boom Lead Line 30 ft
10219842	Ross Lake Spillway Boom Lead Line 45 ft
10582876	Ross Lake Spillway Boom Lead Line 60 ft
10582878	Ross Lake Spillway Boom Lead Line 75 ft
10420857	Ross Lake Spillway Boom Lead Line 90 ft
10221515	Ross Lake Spillway Boom Lead Line 105 ft
10420862	Ross Lake Spillway Boom Lead Line 125 ft
10586801	Ross Lake Spillway Boom Lead Line 150 ft
10420858	Diablo Lake on Thunder Creek VR2W
10706111	Diablo Lake on Thunder Bridge VR2W
10706109	Diablo Lake on Thunder Arm Boom VR2W
10706112	Diablo Lake at Ross Powerhouse VR2W
10706113	Diablo Lake at Buster Brown Bay Work Float VR2W
10586794	Diablo Lake Log Boom 125 ft
10219817	Diablo Lake Log Boom 100 ft
10586809	Diablo Lake Log Boom 85 ft
10420847	Diablo Lake Log Boom 75 ft

Thermistor Serial No.	Location
10420846	Diablo Lake Log Boom 65 ft
9846469	Diablo Lake Log Boom 55 ft
10586796	Diablo Lake Log Boom 45 ft
10420835	Diablo Lake Log Boom 35 ft
10420855	Diablo Lake Log Boom 25 ft
10219834	Diablo Lake Log Boom 15 ft
10706110	Diablo Lake Log Boom 5 ft
10420838	Gorge Lake at Reflector Bar VR2W
10582882	Gorge Lake at Diablo Powerhouse VR2W
10420837	Gorge Lake at Diablo u/s Stetattle Cr (Dolly Hole)
10582875	Stetattle Creek Mouth
10420832	Gorge Lake Boat Launch VR2
10586793	Gorge Lake Powerline VR2
11011577	Gorge Lake Midway VR2
9846458	Gorge Lake Log Boom 80 ft
10248285	Gorge Lake Log Boom 70 ft
10248288	Gorge Lake Log Boom 60 ft
9846448	Gorge Lake Log Boom 50 ft
9866532	Gorge Lake Log Boom 40 ft
10248311	Gorge Lake Log Boom 30 ft
9846466	Gorge Lake Log Boom 20 ft
9866530	Gorge Lake Log Boom 10 ft
9846453	Skagit River at Newhalem VR2W

WATER QUALITY MONITORING REVISED STUDY PLAN

ATTACHMENT C

LOCATIONS OF ONGOING NPS TEMPERATURE MEASUREMENT IN TRIBUTARIES TO PROJECT RESERVOIRS

Table 3. Streams in which the NPS (under contract to City Light) maintains and downloads water temperature loggers.

Stream	Drainage
Silver Creek	Ross Lake
Little Beaver Creek near Perry Creek	Ross Lake
Upper Little Beaver Creek	Ross Lake
Big Beaver Creek below Luna Camp	Ross Lake
Big Beaver Creek below McMillan Creek	Ross Lake
Lightning Creek below Three Fools Creek	Ross Lake
Panther Creek	Ross Lake
Upper Granite Creek	Ross Lake
Hozomeen Creek	Ross Lake
Canyon Creek	Ross Lake
Thunder Creek, mid-drainage	Diablo Lake
Thunder Creek, upper drainage	Diablo Lake
Thunder Creek near McAllister Creek	Diablo Lake
Thunder Creek, Fisher Creek	Diablo Lake
Thunder Creek, West Fork	Diablo Lake
Bacon Creek	Gorge Dam to Sauk River
Diobsud Creek	Gorge Dam to Sauk River
Goodell Creek	Gorge Dam to Sauk River
Rocky Creek	Gorge Dam to Sauk River
Illabot Creek, upper watershed	Upper Skagit River
Boulder Creek	Cascade River
Upper Cascade River near Marble Creek	Cascade River
Baker River	Upper Baker River
Hidden Creek	Upper Baker River

WATER QUALITY MONITORING REVISED STUDY PLAN

ATTACHMENT D

WATER QUALITY SAMPLING LOCATION MAPS

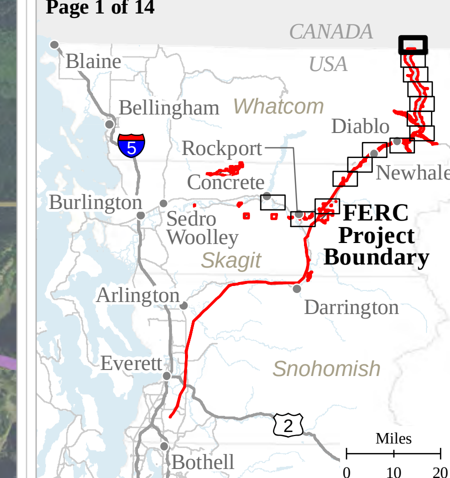
WQ MONITORING STUDY SAMPLING LOCATIONS (FA-01)

- FERC Project Boundary
- Mitigation Parcel
- Seattle City Light
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Water Quality Stations for Study

N

0 1,000 2,000 Feet

Page 1 of 14



Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

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Data Source: Environment, Land and Licensing Business Unit - city Light, Aerial - 2019 NAIP

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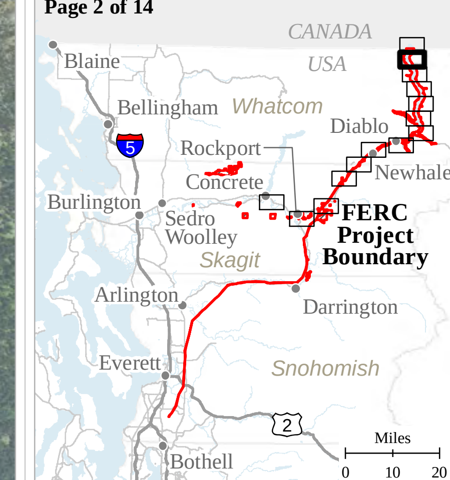
WQ MONITORING STUDY SAMPLING LOCATIONS (FA-01)

- FERC Project Boundary
- Mitigation Parcel
- Seattle City Light
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Water Quality Stations for Study

N

0 1,000 2,000 Feet



Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

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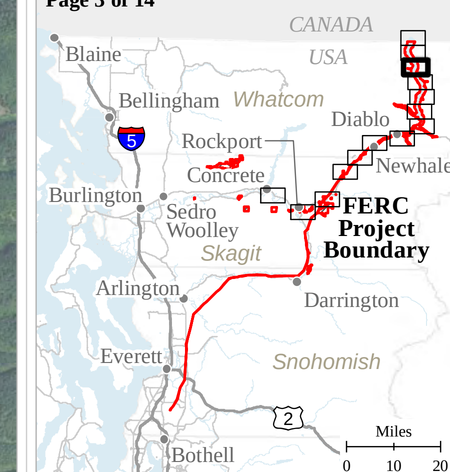
WQ MONITORING STUDY SAMPLING LOCATIONS (FA-01)

FERC Project Boundary
Mitigation Parcel
Seattle City Light
Project River Miles (PRM)
National Park / National Recreation Area Boundary
Water Quality Stations for Study

0 1,000 2,000 Feet



Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

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WQ MONITORING STUDY SAMPLING LOCATIONS (FA-01)

FERC Project Boundary
Mitigation Parcel
Seattle City Light
Project River Miles (PRM)
National Park / National Recreation Area Boundary
Water Quality Stations for Study

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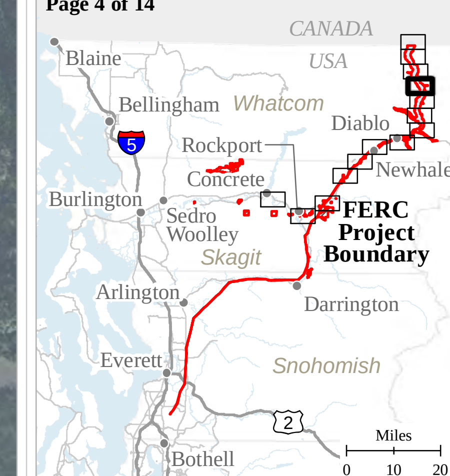

Seattle City Light

SKAGIT RIVER HYDROELECTRIC PROJECT (FERC NO. 553)

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WQ MONITORING STUDY SAMPLING LOCATIONS (FA-01)

- FERC Project Boundary
- Mitigation Parcel
- Seattle City Light
- Project River Miles (PRM)
- National Park / National Recreation Area Boundary
- Water Quality Stations for Study

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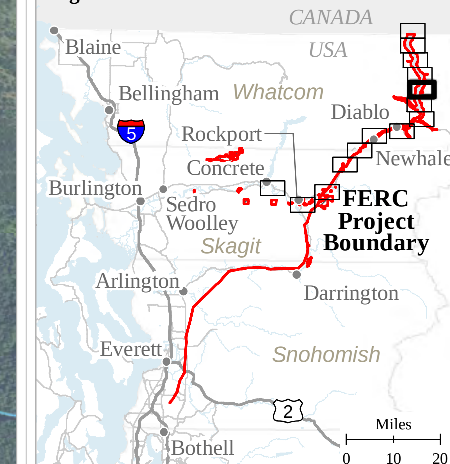

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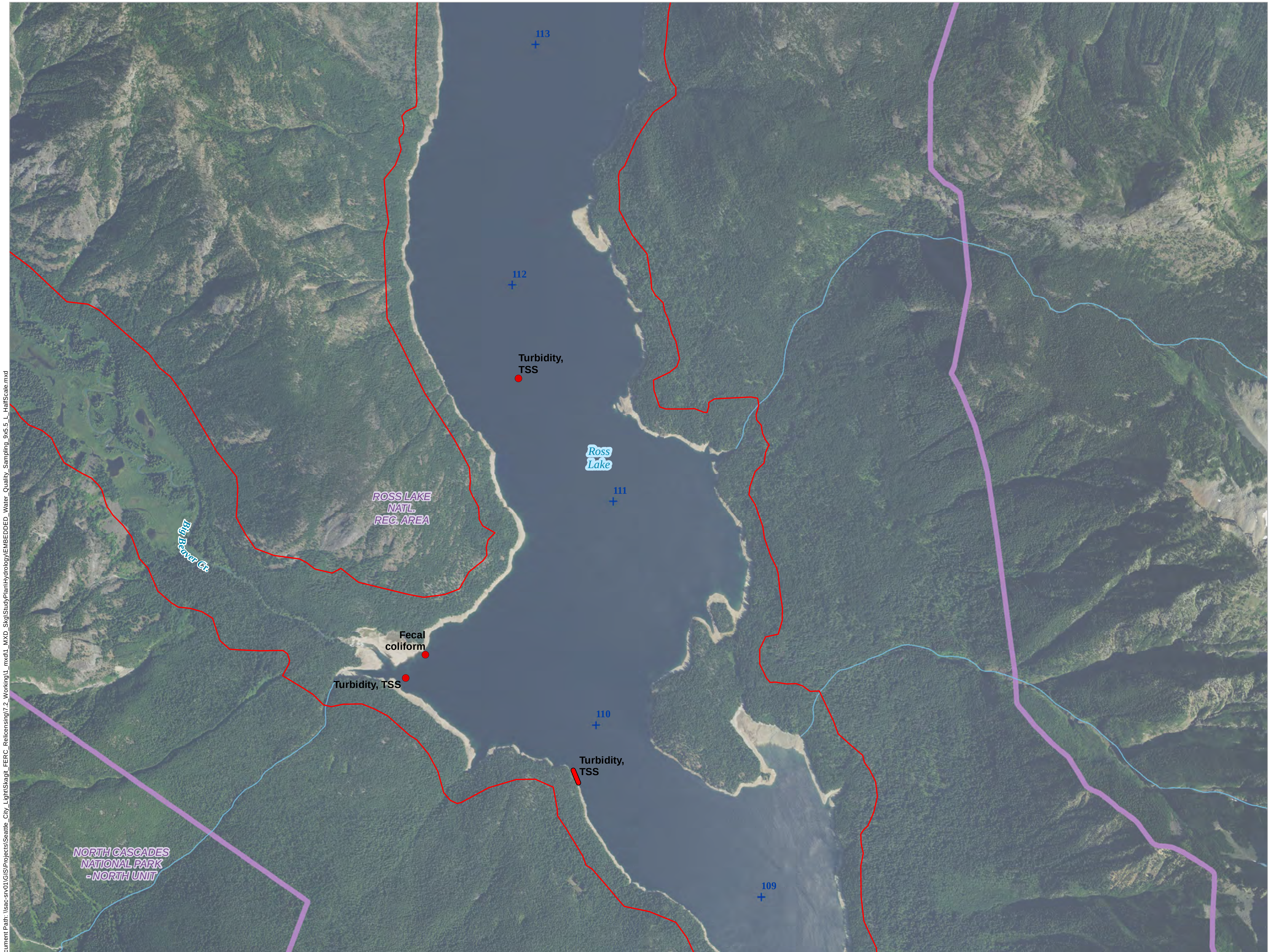

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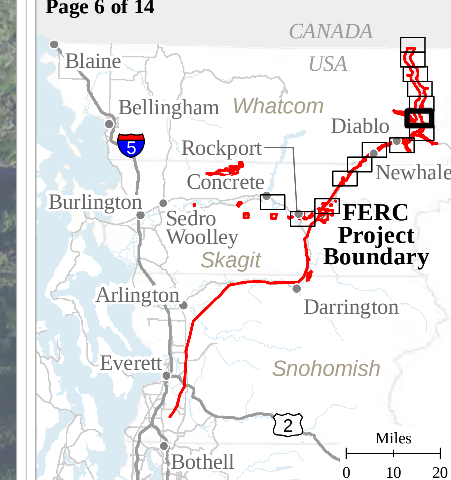

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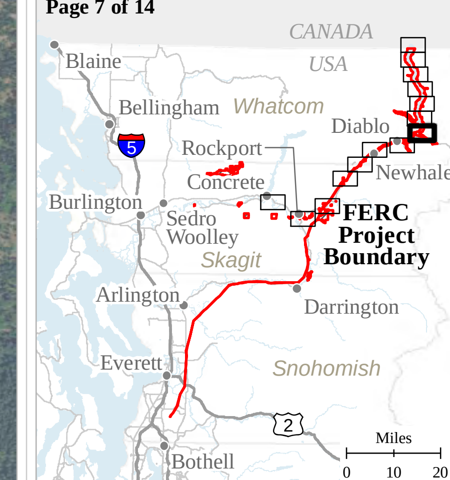

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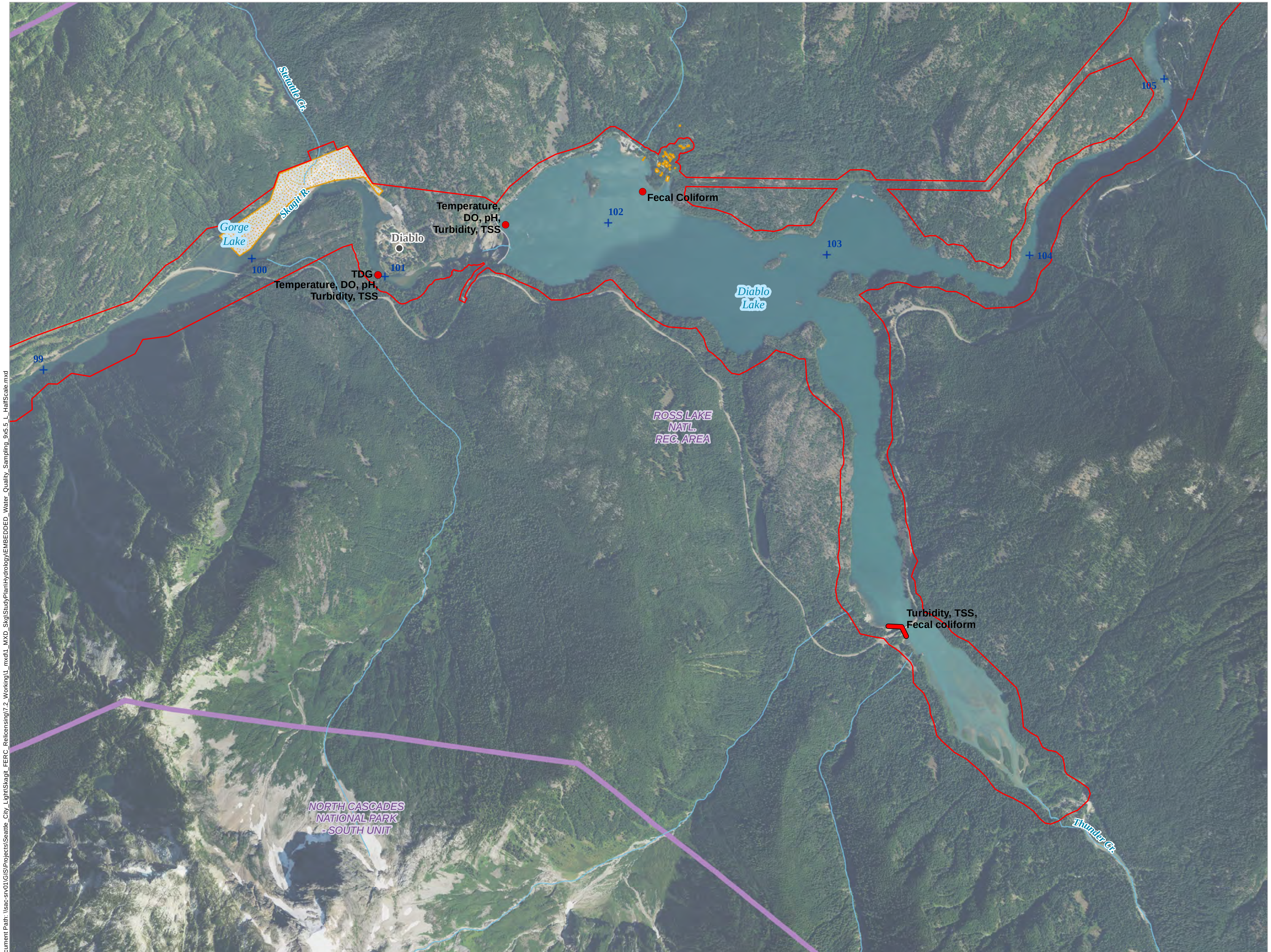

FERC Project Boundary

Mitigation Parcel

Seattle City Light

Project River Miles (PRM)

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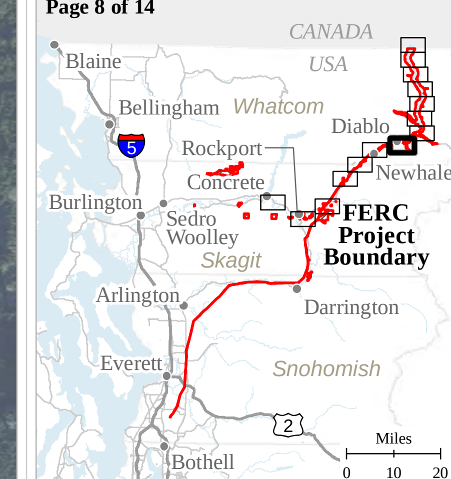

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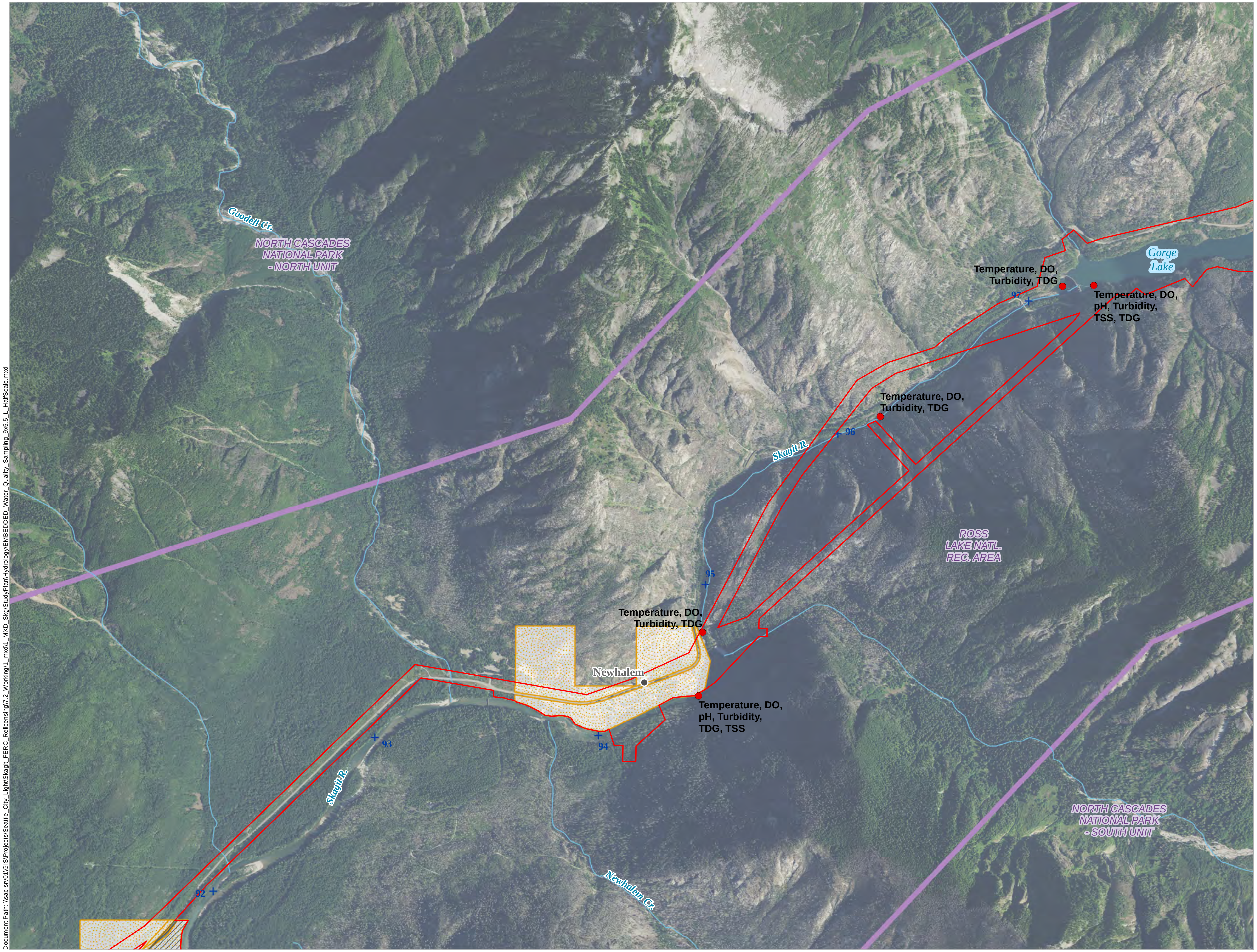

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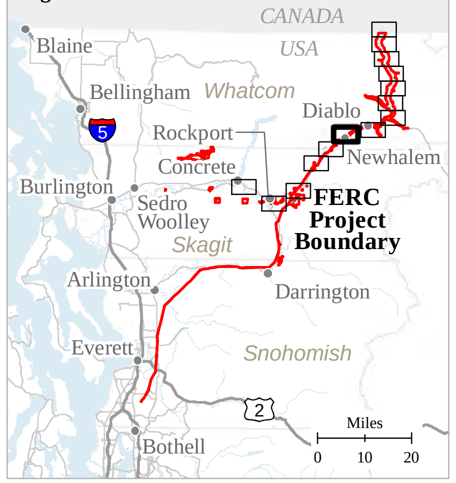

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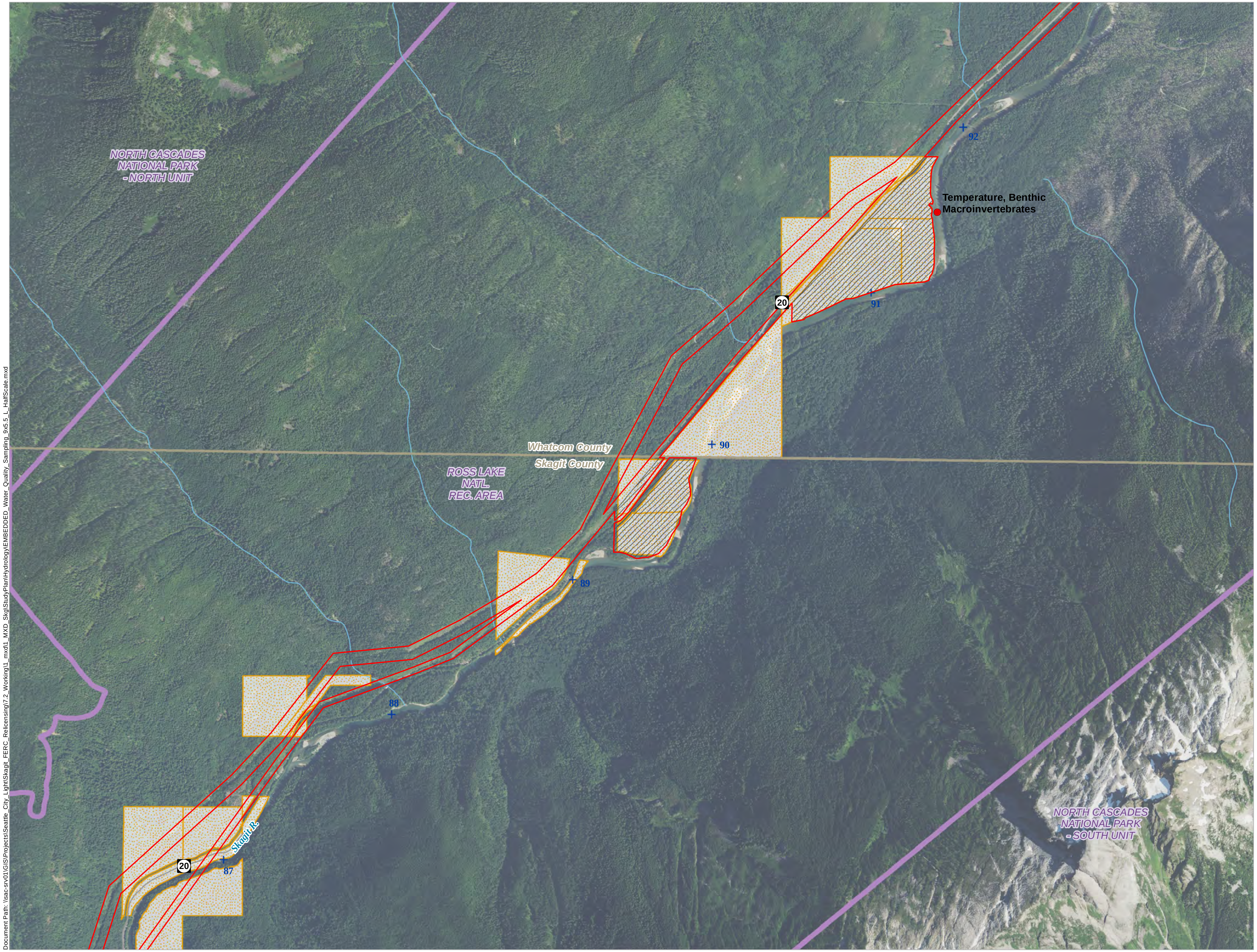

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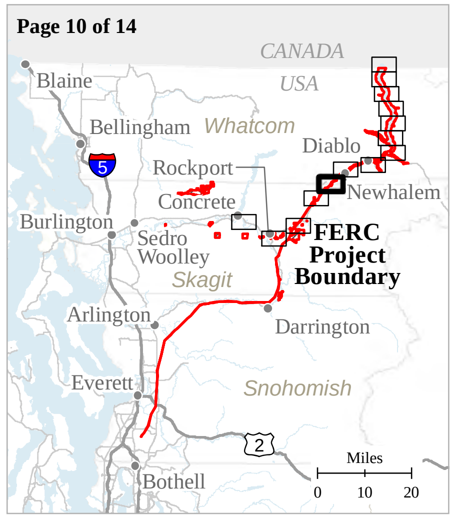

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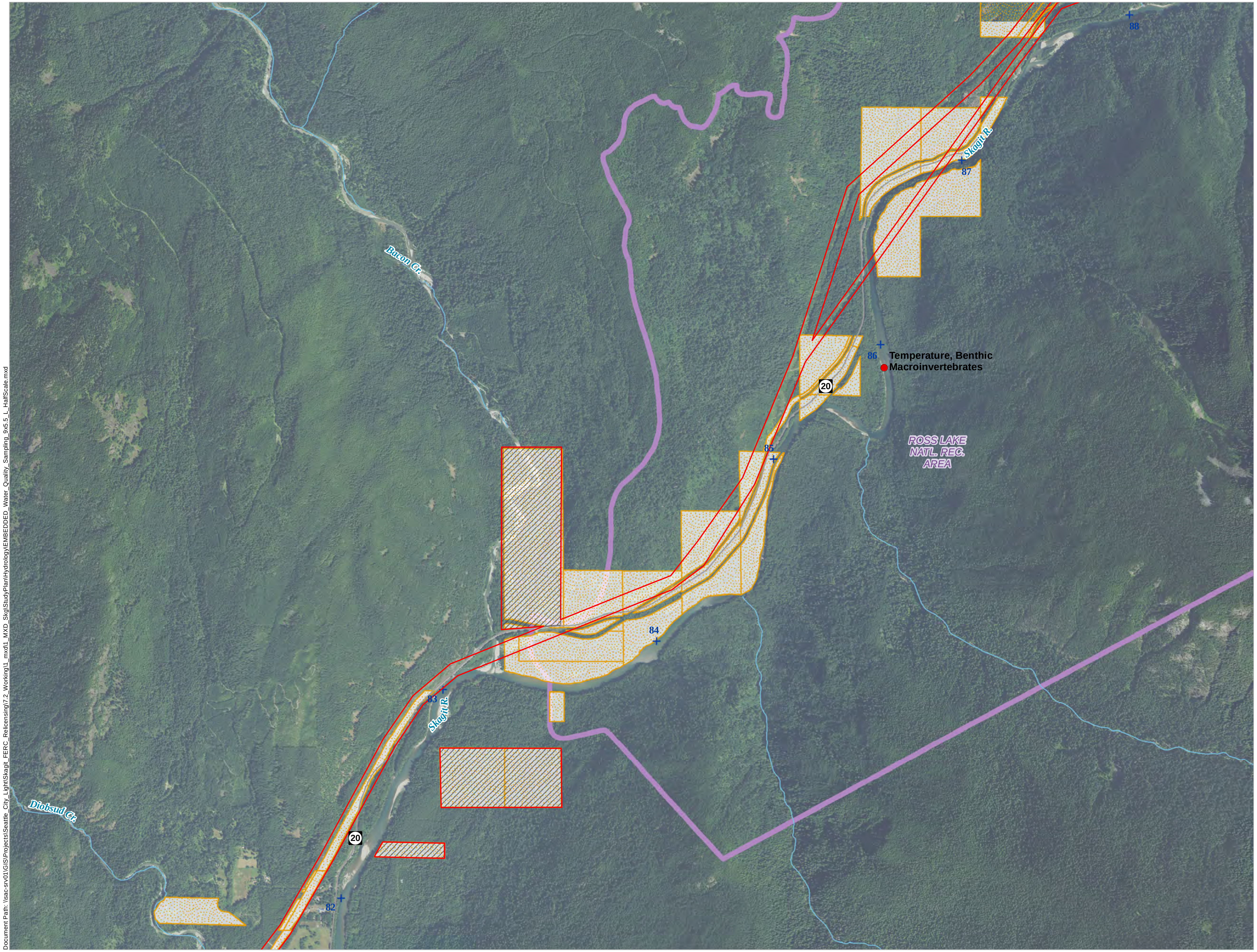

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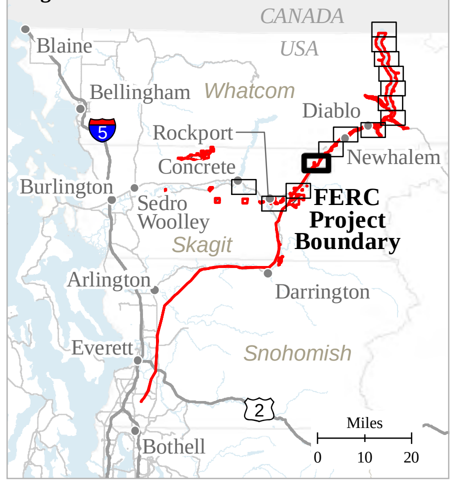

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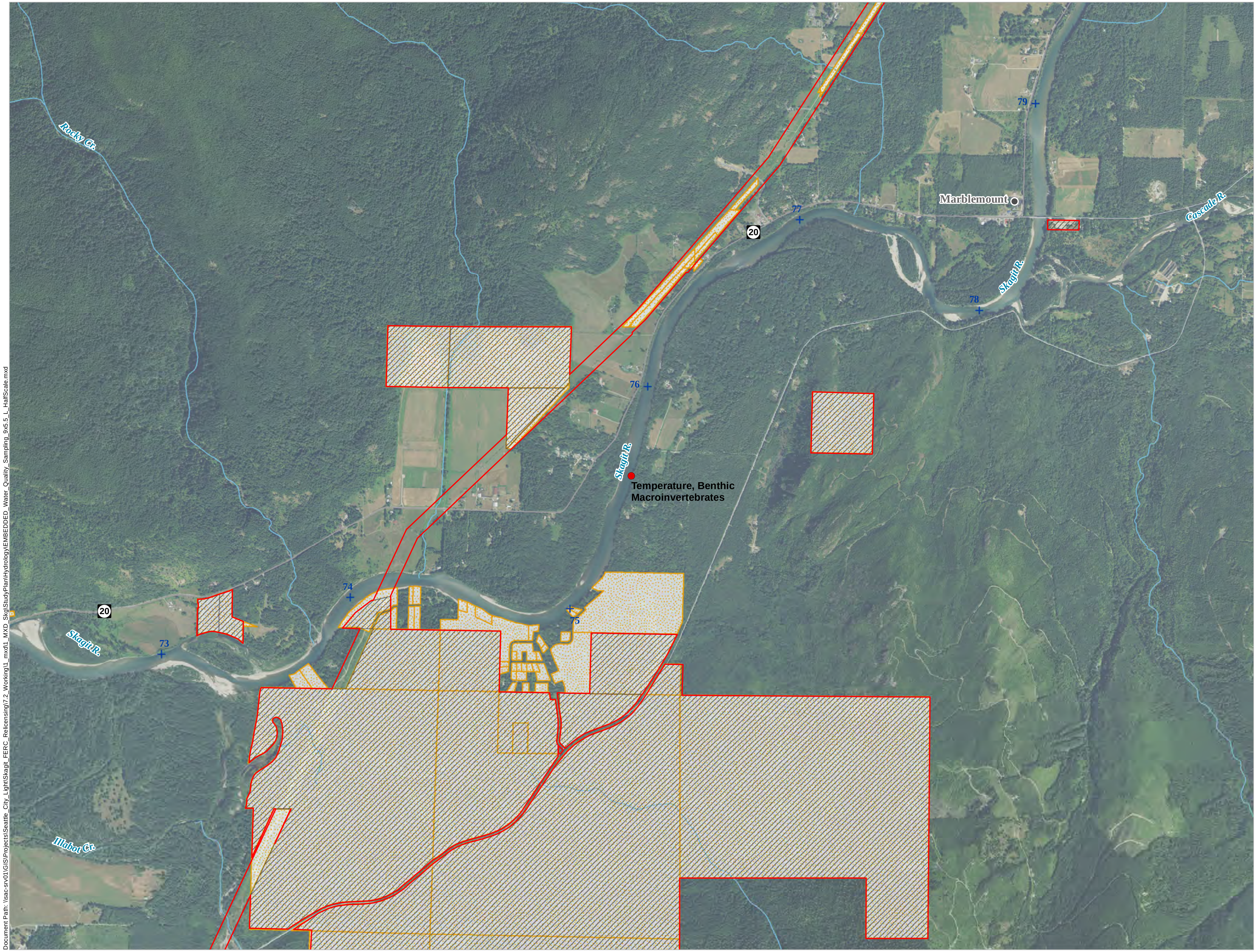

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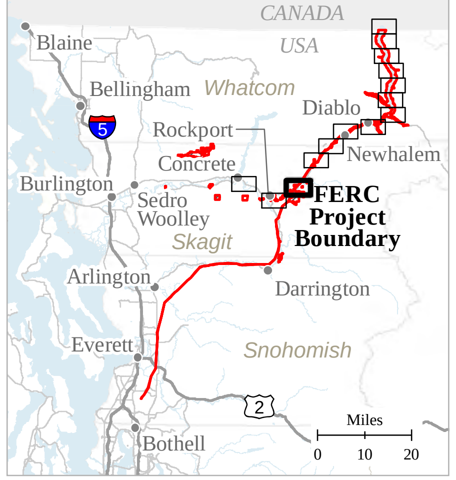

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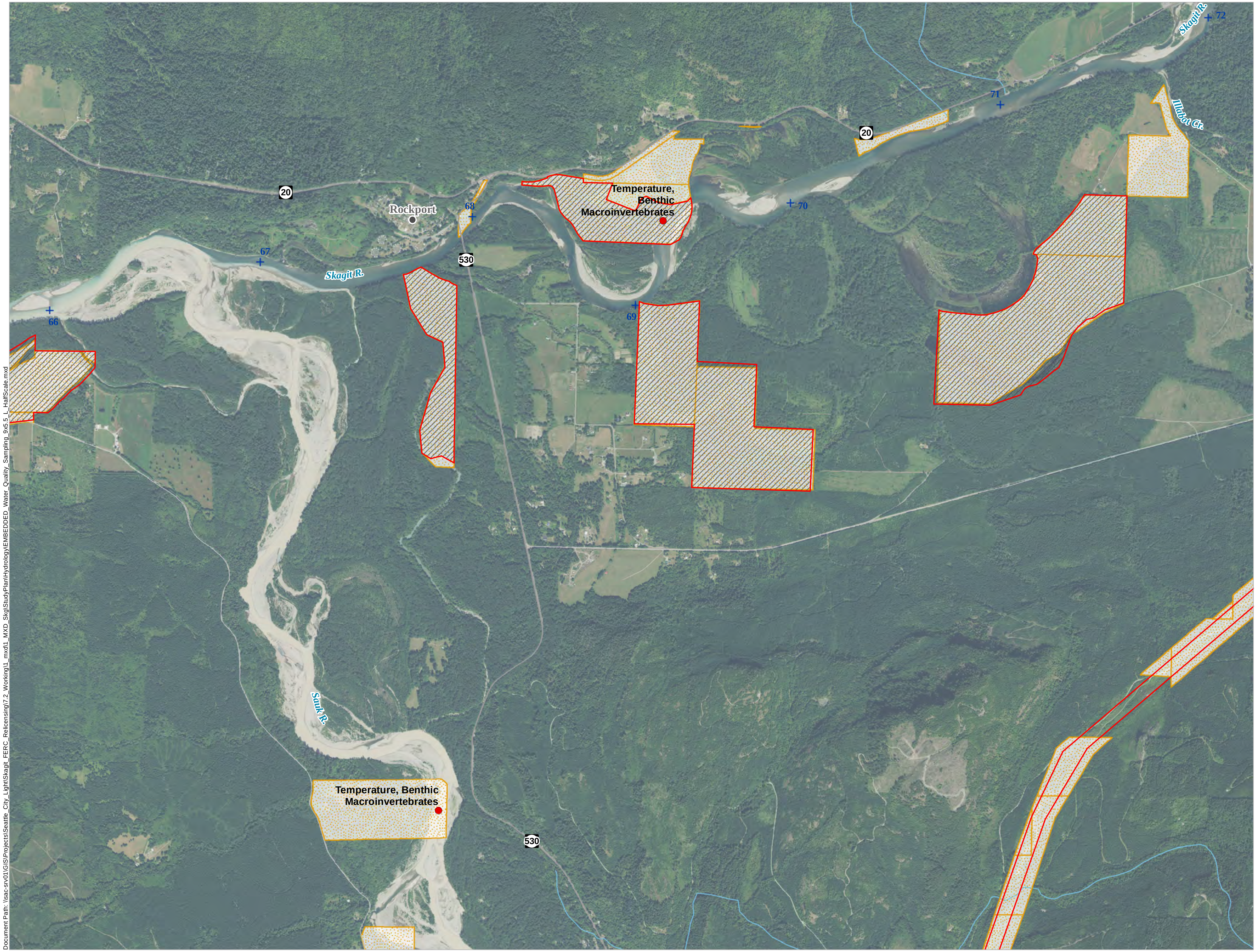

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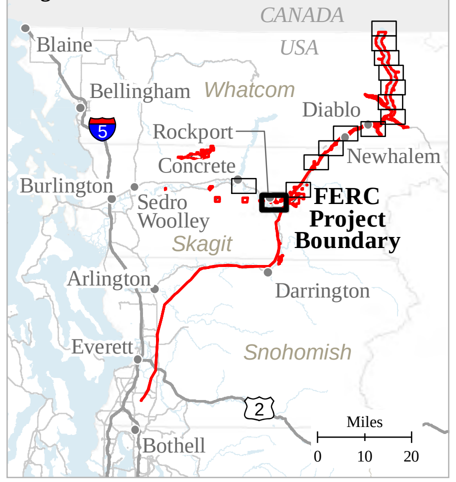

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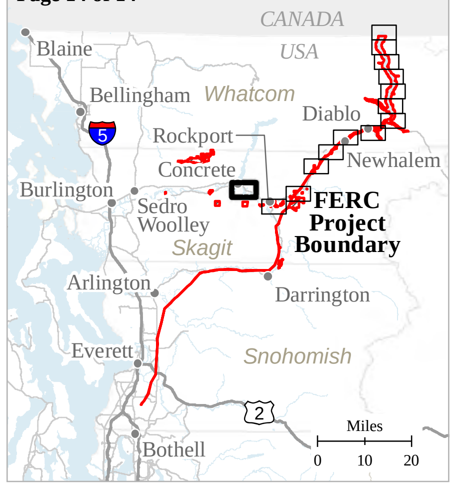

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WATER QUALITY MONITORING REVISED STUDY PLAN

ATTACHMENT E

QUALITY ASSURANCE PROGRAM PLAN

QUALITY ASSURANCE PROJECT PLAN

FOR THE WATER QUALITY MONITORING REVISED STUDY PLAN

SKAGIT RIVER HYDROELECTRIC PROJECT FERC NO. 553

Seattle City Light

April 2021

Quality Assurance Project Plan (QAPP)
Seattle City Light Skagit River Hydroelectric Project

REVISION 0

December 2020

		HDR			Seattle City Light
Rev No.	**Date**	**Preparer**	**Reviewer**	**Approver**	**Reviewer and Approver**
Rev 0	7/27/20	Chad Wiseman	HDR	Jenna Borovansky	Jeff Fisher
Rev 1					
Rev 2					

Approved by:

Jeff Fisher, Seattle City Light, Technical Lead — Date

Jenna Borovansky, HDR, Project Manager — Date

TBD, Study Lead — Date

Chad Wiseman, HDR, QA Officer — Date

DISTRIBUTION LIST

This document will be distributed to the key personnel listed below and will be provided as an attachment to relevant study plans and reports and provided upon request.

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Jenna Borovansky	HDR, Inc.	Consultant Team Project Manager	600 University Street, Suite 500 Seattle, WA 98101-4132 (206) 826-4696 Jenna.Borovansky@hdrinc.com
TBD	TBD	Study Lead	
Chad Wiseman	HDR, Inc.	QA Officer	905 Plum Street SE #200 Olympia, WA 98501 (360) 570-4427 Chad.Wiseman@hdrinc.com
TBD	ALS (TSS and fecal coliform)	Laboratory Manager	8620 Holly Drive, Suite 100 Everett, WA 98208
Gary Lester	EcoAnalysts, Inc. (benthic macroinvertebrates)	Laboratory Manager	4729 NE View Drive PO Box 216 Port Gamble, WA 98364

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List of Acronyms and Abbreviations

ASTM	American Society for Testing and Materials
CFR	Code of Federal Regulations
City Light	Seattle City Light
C°	degrees Celsius
CRT	Certified Reference Thermometer
CWA	Clean Water Act
DO	dissolved oxygen
DQO	data quality objective
Ecology	Washington Department of Ecology
ELC	Environmental Learning Center
EPA	U.S. Environmental Protection Agency
FERC	Federal Energy Regulatory Commission
GPS	Global Positioning System
m	meter
mg/L	milligrams per liter
NIST	National Institute of Standards and Technology
NPS	National Park Service
NTU	nephelometric turbidity units
PARCC	precision, accuracy, representativeness, completeness, and comparability
PRM	Project River Mile
Project	Skagit River Hydroelectric Project
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
RL	reporting limit
RLNRA	Ross Lake National Recreation Area
RM	river mile
RSD	relative standard deviation
SOP	Standard Operating Procedure
TDG	total dissolved gas
TSS	total suspended solids
U.S.C.	United States Code

USGS .........................U.S. Geological Survey

1.0 BACKGROUND

The Skagit River Hydroelectric Project (Project), licensed to The City of Seattle, Washington, and operated through its publicly-owned electric power utility Seattle City Light (City Light), is located in northern Washington State and consists of three power generating developments on the Skagit River – Ross, Diablo, and Gorge – and associated lands and facilities. The Project generating facilities are in the Cascade Mountains of the upper Skagit River watershed, between Project River Miles (PRM) 94.7 and 127.9 (U.S. Geological Survey [USGS] RMs 94.2 and 127).[1] Power from the Project is transmitted via two 230-kilovolt powerlines that span over 100 miles and end just north of Seattle at the Bothell Substation. The Project also includes two City Light-owned towns, an Environmental Learning Center (ELC), several recreation facilities, and several parcels of fish and wildlife mitigation lands.

Project generating facilities are all located in Whatcom County, although Ross Lake, the most upstream reservoir, crosses the U.S.-Canada border and extends for about one mile into British Columbia at normal maximum water surface elevation. Gorge Powerhouse, the most downstream facility, is approximately 120 miles northeast of Seattle and 60 miles east of Sedro-Woolley, the nearest large town. The closest town is Newhalem, which is part of the Project and just downstream of Gorge Powerhouse. The primary transmission lines cross Whatcom, Skagit, and Snohomish counties; the fish and wildlife mitigation lands are in the same counties.

The Project Boundary is extensive, spanning over 133 miles from the Canadian border to the Bothell Substation just north of Seattle, Washington. In addition, there are “islands” of fish and wildlife mitigation lands and recreation facilities within the Skagit, Sauk, and South Fork Nooksack watersheds that are also within the Project Boundary. Project generating facilities are entirely within the Ross Lake National Recreation Area (RLNRA), which is administered by the National Park Service (NPS) as part of the North Cascades National Park Complex. The RLNRA was established in 1968 in the enabling legislation for North Cascades National Park to provide for the “public outdoor recreation use and enjoyment of portions of the Skagit River and Ross, Diablo, and Gorge lakes.” The legislation maintains the Federal Energy Regulatory Commission’s (FERC) jurisdiction “in the lands and waters within the Skagit River Hydroelectric Project,” as well as hydrologic monitoring stations necessary for the proper operation of the Project (16 United States Code [U.S.C.] § 90d-4; Public Law 90-544. Sec. 505 dated October 2, 1968, as amended by Public Law 100-668. Sec. 202 dated November 16, 1988).

The current FERC license for the Project expires on April 30, 2025, and City Light will apply for a new license no later than April 30, 2023. A licensee must receive a water quality certification before FERC can issue an operating license (or the state regulatory agency can waive certification). A study plan has been designed to collect water quality data, which along with existing water quality information, will support the license application, including the application to Washington Department of Ecology (Ecology) for certification of the Project under Section 401 of the Clean Water Act (CWA). This Quality Assurance Project Plan (QAPP) includes the field data collection

[1] City Light has developed a standard Project centerline and river mile system to be used throughout the relicensing process, including the study program, to replace the outdated USGS RM system. Given the long-standing use of the USGS RM system, both it and the Project River Mile (PRM) system are provided throughout this document. For further details see Section 7.0 of the main body RSP.

methods, laboratory methods, and quality assurance methods to ensure that data collected for this Project are accurate, usable, and repeatable.

2.0 PROJECT PLAN

2.1 Project Goal

In most cases, a licensee must receive a water quality certification before FERC can issue an operating license for a hydroelectric project. As noted above, the FA-01 Water Quality Monitoring Study Plan (study plan) has been designed to collect water quality data, which along with existing water quality information, will support the license application, including the application to the Washington Department of Ecology (Ecology) for certification of the Project under Section 401 of the CWA.

The proposed study will provide information, which in combination with existing data, will be used to characterize water quality within the study area and allow resource agencies with jurisdiction over water or aquatic resources to analyze Project effects related to water quality.

This QAPP has been developed to provide guidance and quality assurance for water quality sampling and analyses required by the FERC-approved Water Quality Monitoring Study Plan in support of the Project's FERC relicensing.

2.2 Decisions or Outcomes

The collected data will characterize the physical and/or chemical state of surface water in the study area, as defined in the study plan. The data will be filed with FERC in the Initial Study Report and in other subsequent relicensing documents, as needed, and will be suitable to compare to applicable regulatory standards and criteria. Additional information regarding study objectives, methods, and reporting can be found in the study plan.

2.3 Study Area

The study will be conducted from the upper Skagit River inflow just north of the U.S. Canada Border, through Ross (within the United States), Diablo, and Gorge lakes, the Gorge bypass reach, and in the Skagit River downstream to just below the Baker River confluence, and in the lower Sauk River (see Figure 2.5-1 in the study plan). Approximate locations of the proposed water quality sampling/measurement sites are included in Section 5 of this QAPP and shown in the mapbook attached to the study plan.

2.4 Project Constraints

Data collection may be constrained by site access during winter snow events. High river flows may also at times affect in situ sampling and sonde maintenance.

3.0 ORGANIZATION AND SCHEDULE

3.1 Involved Parties and Roles

This QAPP has been prepared for the Water Quality Monitoring Study component(s) of the Project's FERC-approved relicensing studies. Within this QAPP are descriptions of methods, procedures, and practices that will be used to assure and control the quality of water quality data.

Key personnel who will be involved in the study are listed in Table 1. City Light's Technical Lead, with assistance from HDR, will be responsible for ensuring that all aspects of the Water Quality Monitoring Study are addressed, including the organization of field staff, scheduling of sampling days, field quality assurance/quality control (QA/QC), coordination with the off-site laboratory, and reporting. Laboratory analytical services will be provided by ALS[2] and EcoAnalysts.[3]

Table 1. List of key personnel on the study team.

Title	Name	Affiliation
Technical Lead	Jeff Fisher	Seattle City Light
Study Lead	TBD	TBD
Field Coordinator	TBD	TBD
QA Officer	Chad Wiseman	HDR, Inc.
Laboratory Manager	TBD	Edge Analytical
Laboratory Manager	Gary Lester	EcoAnalysts

The Study Lead is responsible for monitoring and verifying implementation of the QA/QC procedures found in this QAPP. Key personnel assigned to the Project will have reviewed the QAPP and will be instructed by the Study Lead regarding the requirements of the QA/QC program. The Study Lead will work directly with the Field Coordinator or other designee and Laboratory Manager(s) to ensure that the QAPP objectives are being met.

The Study Lead is also responsible for keeping the QAPP up to date. Modifications may be identified by any member of the study team. Exceptions or modifications to the content of this document will be formalized in the Revision Log following the title page. Revised versions of the QAPP (if they are necessary) will be available to study personnel and attached to subsequent reports. Variances from and non-conformances with the QAPP will be documented in applicable reports.

The QA Officer is familiar with the study, but not involved in day-to-day implementation. The QA Officer is versed in water quality field sampling and laboratory procedures. The QA Officer will review the study's intermediate and final products, and work with the Study Lead to ensure they are of high quality when complete.

[2] https://www.alsglobal.com/en/locations/americas/north-america/usa/washington/everett-environmental
[3] https://www.ecoanalysts.com/

3.1.1 Organizational Chart and Responsibilities

The organizational chart for implementation of the Water Quality Monitoring Study is presented in Figure 1.

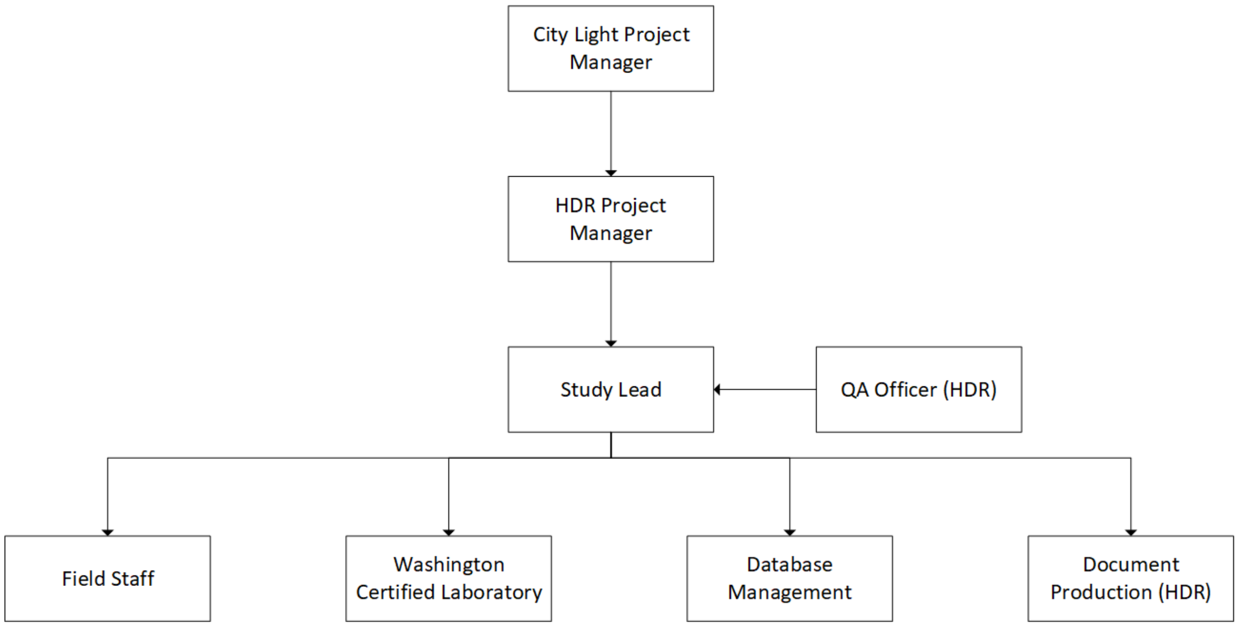

Figure 1. Organizational chart.

3.2 Project Schedule

The following schedule is anticipated, presuming approval of the Water Quality Study Plan by FERC in early 2021[4]:

- Field Work – June 2021 to May 2023
- Analysis – August 2021 to August 2023
- File Initial Study Report – March 2022
- File Updated Study Report – March 2023

4.0 QUALITY OBJECTIVES

Data quality objectives (DQO) are a set of performance or acceptance criteria that the collected data should achieve to minimize the possibility of either making a decision error or failing to keep uncertainty in estimates to within acceptable levels. DQOs are defined in terms of five parameters: precision, accuracy, representativeness, completeness, and comparability (PARCC) and differ with different measurement techniques.

[4] The schedule identified herein reflects anticipated dates for a FERC-approved study. However, early data collection is taking place during fall and winter of 2020-2021. The procedures outlined in this QAPP were/will be adhered to for data collection conducted in fall and winter of 2020-2021.

DQOs for this Water Quality Monitoring Study are presented in Tables 2 and 3.

Table 2. DQOs, by measurement type and sampling event.

Precision	Accuracy	Representativeness	Completeness	Comparability
Field Measurements Temperature, pH, dissolved oxygen (DO), turbidity, total dissolved gas (TDG)				
Successive measurements are within precision limits	Within accuracy limits as compared to standards or calibrated meter	Sample locations, sampling frequency and analytical methods follow study plan.	90%	Sensor range includes expected range of conditions in the Study Area
Analytical Laboratory Analyses Fecal Coliform and Total Suspended Solids (TSS)				
Field duplicates within10%; Laboratory QA/QC meets method requirements.	Laboratory QA/QC meets method requirements.	Sample locations, sampling frequency and analytical methods follow study plan.	90%	Meets Reporting Limits.

Table 3. Field measurement methods and quality objectives.

Parameter	Units	Method	Range	Accuracy	Precision
Temperature	Degrees Celsius (˚C)	SM2550	0- 50	0.2	0.35
pH	units	SM4500H	0- 14	0.5	0.2
DO	Milligrams per liter (mg/L)	ASTM D888C	0- 60	0.5	0.3
Turbidity	Nephelometric turbidity units (NTU)	SM2130	0- 3,000	5%	5%
TDG	% Saturation	SM 2810B	100 - 140	1%- or 5-mm Hg	1%- or 5-mm Hg

Precision is a measure of the reproducibility of analyses under a given set of conditions. Precision describes how well repeated measurements agree. The precision of field measurements will be evaluated by comparing successive measurements against one another in a controlled environment. The precision of analytical results will be evaluated by comparing duplicate samples and calculating the relative standard deviation (RSD) for those samples. The RSD is the ratio of the standard deviation and the mean, expressed as a percentage.

Precision will be determined through the use of field duplicates, laboratory matrix spike/matrix spike duplicates, and laboratory duplicate quality control samples.

Accuracy is a measure of the bias that exists in a measurement system. In other words, accuracy describes how close an analytical measurement is to its "true" value. For analytical samples, accuracy is typically measured by analyzing a sample of known concentration (prepared using analytical-grade standards) and comparing the analytical result with the known concentration. For bacteria samples, accuracy is evaluated by comparing results to a laboratory reference sample.

Representativeness is the degree that sampling data accurately and precisely depict selected characteristics. The representativeness of the data is mainly dependent on the sample design, such as locations (spatial), sampling frequency (temporal), and sample collection procedures, as well as analytical constituents and methods. The study plan presents the study design.

Completeness, which is expressed as a percentage, is calculated by subtracting the number of rejected and unreported results from the total planned results and dividing by the total number of planned results. Estimated results do not count against completeness because they are considered usable as long as any limitations are identified. Results rejected because of out-of-control analytical conditions, severe matrix effects, broken or spilled samples, or samples that could not be analyzed for any other reason are subtracted from the total planned number of results to calculate completeness. Although regulations currently do not require a specific percentage of data completeness, it is expected that the measurement techniques selected for use in this study are capable of generating data that is of 90 percent or greater completeness for field and laboratory analyses.

Comparability is the degree of confidence with which one data set can be compared to another. A broad spectrum of field and analytical constituents has been selected to characterize water quality, and the use of approved/documented field and analytical methods will ensure that results adequately represent the true concentrations of constituents within the study area. The comparability of field measurements is ensured by using calibrated water quality meters and sensors that have a measurement range bracketing expected field conditions. The comparability of analytical sample results is ensured by using methods with reporting limits (RL) of adequate sensitivity to generate useful data for the purposes of this study. Selection of appropriate RLs was based on specifications in the U.S. Environmental Protection Agency's (EPA) 40 Code of Federal Regulations (CFR) 136 (EPA 2011), water quality objectives and standards, and the capabilities of commercial laboratories.

5.0 SAMPLING PROCESS DESIGN

The proposed parameters and locations were selected to augment the body of existing data identified in the Water Quality Monitoring Study Plan. Sample locations were chosen to be representative of conditions throughout the study area. Table 4 lists the proposed sample locations and analytical parameters for the study.

Table 4. Sample process design.

Location	Sample Identification	Sample Frequency	Sample Type	Temperature (C°)	Dissolved Oxygen (mg/L)	pH (units)	Turbidity (NTU)	Total Suspended Solids (mg/L)	Total Dissolved Gas (% Saturation)	Fecal Coliform (CFU)	Benthic Macroinvertebrates
Upper Skagit River											
Upper Skagit River at Swing Bridge	UPSKAGIT1	Monthly (Jun 2021–May 2023)	Grab	1 meter (m)	1 m	1 m	1 m	1 m			
Ross Lake											
Pumpkin Mountain	ROSS1	Monthly (Jun 2021–May 2023)	Grab				1m, 5 m	1m, 5 m			
Skymo	ROSS2	Monthly (Jun 2021–May 2023)	Grab				1 m, 5 m	1 m, 5 m			
Little Beaver	ROSS3	Monthly (Jun 2021–May 2023)	Grab				1 m, ≤ 5 m	1 m, ≤ 5 m			
Big Beaver Creek Confluence	BBEAVER1	Fall, Winter, Spring 2021–2023	Grab				Surface, 5 m	Surface, 5 m			
Ruby Creek Arm	RUBY1	Fall, Winter, Spring 2021–2023	Grab				Surface, 5 m	Surface, 5 m			
Ross Lake Shoreline Erosional Area North	ROSS4	Fall, Winter, Spring 2021–2023	Grab				100 m transect; 5 surface samples	100 m transect; 5 surface samples			
Hozomeen	ROSS7	Four events (Jun 2021–Sep 2021) Four events (Jun 2022–Sep 2022)	Grab							Surface	
Ross Lake Resort	ROSS8	Four events (Jun 2021–Sep 2021) Four events (Jun 2022–Sep 2022)	Grab							Surface	
Little Beaver Boat Access Camp	ROSS9	Four events (Jun 2021–Sep 2021) Four events (Jun 2022–Sep 2022)	Grab							Surface	
Lightning Creek Boat Access Camp	ROSS10	Four events (Jun 2021–Sep 2021) Four events (Jun 2022–Sep 2022)	Grab							Surface	
Big Beaver Boat Access Camp	ROSS11	Four events (Jun 2021–Sep 2021) Four events (Jun 2022–Sep 2022)	Grab							Surface	
Diablo Lake											
Upper End of Diablo Lake	DIABLO1	Monthly (Jun 2021–May 2023)	Grab	Vertical Profile (2 m)	Vertical Profile (2 m)	Vertical Profile (2 m)	1m, 5 m	1m, 5 m			
Diablo Lake Forebay	DIABLO2	Monthly (Jun 2021–May 2023)	Grab	Vertical Profile (2 m)	Vertical Profile (2 m)	Vertical Profile (2 m)	1m, 5 m	1m, 5 m			
Thunder Creek Confluence at Bridge/Colonial Creek Campground	DIABLO3	Fall, Winter, Spring 2021–2023	Grab				100 m transect; 5 surface samples	100 m transect; 5 surface samples			

Location	Sample Identification	Sample Frequency	Sample Type	Temperature (C°)	Dissolved Oxygen (mg/L)	pH (units)	Turbidity (NTU)	Total Suspended Solids (mg/L)	Total Dissolved Gas (% Saturation)	Fecal Coliform (CFU)	Benthic Macroinvertebrates
Thunder Creek Confluence at Bridge/Colonial Creek Campground	DIABLO4	Four events (Jun 2021–Sep 2021) Four events (Jun 2022–Sep 2022)	Grab							Surface	
Environmental Learning Center	DIABLO5	Four events (Jun 2021–Sep 2021) Four events (Jun 2022–Sep 2022)	Grab							Surface	
***Gorge Lake*[2]**											
Upper End of Gorge Lake	GORGE1	Monthly (Jun 2021–May 2023)	Grab	Vertical Profile (2 m)	Vertical Profile (2 m)	Vertical Profile (2 m)	1m, 5 m	1m, 5 m			
Gorge Lake Forebay	GORGE2	Monthly (Jun 2021–May 2023)	Grab	Vertical Profile (2 m)	Vertical Profile (2 m)	Vertical Profile (2 m)	1m, 5 m	1m, 5 m			
Below Diablo Dam	GORGE3	Jun 2021–May 2023	Continuous						Below Compensation[5] Depth		
Gorge Lake Forebay	GORGE4	Jun 2021–May 2023	Continuous						Below Compensation Depth		
Gorge Bypass Reach											
Below Gorge Dam in plunge pool	BYPASS1	Jun 2021–May 2023	Continuous	1 m	1 m		1 m		Below Compensation Depth		
≈ 1.5 miles above Gorge Powerhouse	BYPASS2	Jun 2021–May 2023	Continuous	1 m	1 m		1 m		Below Compensation Depth		
≈ 0.6 miles above Gorge Powerhouse	BYPASS3	Jun 2021–May 2023	Continuous	1 m	1 m		1 m		Below Compensation Depth		
Skagit River Downstream of Gorge Powerhouse											
Immediately Below Gorge Powerhouse	PHOUSE1	Jun 2021–May 2023	Continuous	2 m	2 m	2 m	2 m		2 m		
Immediately Below Gorge Powerhouse	PHOUSE2	Opportunistically Jun 2021–May 2023	Grab					1 m			
Locations Downstream of Gorge Powerhouse, (6) (PRMs 91.6, 85.9, 75.6, 69.3, 60.8, and 54.5)	SKAGIT2–4	Jun 2021–May 2023	Continuous	1m							
Locations Downstream of Gorge Powerhouse, (6) (PRMs 91.6, 85.9, 75.6, 69.3, 60.8, and 54.5)	SKAGIT5–7X	Jul and Sep 2021; Jul and Sep 2022	Grab								Streambed
Sauk River											
RM 2.8	SAUK1	Jun 2021–May 2023	Continuous	1 m							

[5] The depth at which the sum of hydrostatic and atmospheric pressure exceeds the gas pressure of TDG-supersaturated water.

Location	Sample Identification	Sample Frequency	Sample Type	Temperature (C°)	Dissolved Oxygen (mg/L)	pH (units)	Turbidity (NTU)	Total Suspended Solids (mg/L)	Total Dissolved Gas (% Saturation)	Fecal Coliform (CFU)	Benthic Macroinvertebrates
RM 2.8	SAUK2	Jul and Sep 2021; Jul and Sep 2022	Grab								Streambed

6.0 SAMPLING PROCEDURES

Data will be obtained in the field and in the laboratory. Samples will be collected in accordance with Ecology's Standard Operating Procedures (SOP) included in Appendix A. The field sampler will maintain a field notebook and will note relevant conditions during each sampling event on the field data sheet. At a minimum, the following information pertaining to each sample will be recorded: date, time, name(s) of people collecting samples, units of measurements, depth, Global Positioning System (GPS) coordinates for the sample site, and river flow.

Gloves and other appropriate personal protective equipment will be worn during sample and data collection activities consistent with the methodologies appropriate for the analyte in question, as summarized in Tables 3 and 5. Observations of any field conditions that could affect sample results will be recorded in the field notebook, such as the concentrated presence of domestic animals or wildlife. Digital photo documentation of sampling conditions may also be performed. All field notes will be clearly written in a format that can be reproduced (i.e., scanned [pdf]) and entered into electronic format (Word or Excel).

Table 5. Analytical sample container, sample preservation, and holding time requirements.

Analytical Parameter	Units	Method	Reporting Limit	Concentration Range of Interest	Container	Sample Preservation	Holding Time
TSS	mg/L	SM2540-D	1.0	0 - 50	Polyethylene or Glass	Cool, 4°C	7 days
Fecal Coliforms	CFU/100ml	SM9222-D	1	0 - 200	Polyethylene or Glass	Cool, 4°C, 0.008% $Na_2S_2O_3$	6-24 hours

6.1 Data Collections *In Situ*

The field measurement equipment that will be used during this Project includes the following (or a suitable equivalent):

- Multi-parameter water quality sondes (e.g., Hydrolab® DataSonde 5) will be used to measure water temperature, DO, pH, turbidity, and TDG.
- Water temperature data loggers (e.g., Onset Water Temp Pro) will be used to measure continuous water temperature.

Multi-parameter water quality sondes will be calibrated, deployed, and post-checked consistent with Ecology SOP EAP129 and EAP002 (Appendix A). Sondes will be used to measure instantaneous vertical profiles in Diablo and Gorge Lakes, using a long-line data cable. Sondes will also be used for continuous and unattended data collection in the Gorge Bypass Reach and downstream of the Gorge Powerhouse. When used for unattended data collection, the sondes will be deployed in a protective housing that will minimize risk of vandalism or theft. Sondes will be deployed as deep as practical, to best represent river conditions, and to minimize risk of the probes going dry with changing flows. Sondes used to measure TDG will be deployed below the applicable compensation depths. Data will be downloaded and post-processed consistent with Ecology SOP EAP130 (Appendix A).

Continuous water temperature data loggers will be calibrated, deployed, post-checked, and post-processed consistent with Ecology SOP EAP080 (Appendix A). Data loggers will be used for continuous and unattended water temperature measurements downstream of the Gorge Powerhouse. Water temperature data loggers will be fixed to a structure, such as a bridge piling, boulder, or rebar that has been driven into the riverbed.

Prior to each use, the sonde instruments will be calibrated using manufacturer's recommended methods, checked at least monthly for drift, and recalibrated if not meeting accuracy requirements. Any variances will be noted on the field data sheet and final report. Non-disposable sampling equipment will be thoroughly cleaned between sampling sites.

Any field-collected data that are not already in electronic format (Excel) will be hand entered into an electronic format and checked by a second party.

6.2 Sample Collection for Laboratory-Determined Analytes

Surface water samples will be collected in the field for subsequent TSS and fecal coliform determination in a qualified laboratory. Surface samples will be collected using a grab sampling technique, consistent with the "Stream Side" or "Extension Pole" method in Ecology SOP EAP034 (Appendix A). Surface samples collected from a boat will be collected via the "Extension Pole" method. Each laboratory sample will be collected using laboratory-supplied clean containers. Sample identification will include the site ID and depth interval (e.g., BYPASS1), date and time collected, and the sampler. The sample bottles will be transported to the sampling location in clean resealable plastic bags (e.g., Ziploc®). With the bottles in position for direct filling, the field sampler will don clean nitrile gloves and fill the bottles by directly submerging the sample bottles in the river. The bottles will be returned to the plastic bag, and resealed.

6.3 Sample Handling and Custody

A chain-of-custody record will be maintained with the laboratory samples at all times. A chain-of-custody form that identifies the sample bottles, date and time of sample collection, and analyses requested will be initiated at the time of sample collection and prior to sample shipment or release. Identification information for each sample will be consistent with the information entered in the field notebook. The samples will be transported or shipped to the analytical lab in insulated containers within the appropriate holding time and will be accompanied by the chain-of-custody form. If shipment is needed, the samples will be packaged and shipped in accordance with U.S. Department of Transportation standards. The original chain-of-custody will be given to the lab with the samples and a copy will be retained by the field staff for their records. Once received by the laboratory, a sample receipt and storage record will be generated. The laboratory will perform all analyses within the constituent- or method-specific holding times. After analyses are conducted, all samples will be disposed of in accordance with federal, state, and local requirements.

6.4 Analytical Methods for TSS and Fecal Coliform

TSS and fecal coliform concentrations will be measured with standard methods by ALS, as specified in Table 5. Containers, preservatives, holding times, and QA/QC requirements are specified in the analytical methods and/or in the laboratory's standard operating procedures. Analytical methods are preferentially EPA or American Society for Testing and Materials (ASTM) methods and are detailed in the laboratory's quality assurance manual.

Samples will be preserved on ice upon sample collection. Fecal coliform samples will have sodium thiosulfate preservative in the containers provided by the laboratory and must not be overfilled. Samples will be transported to the laboratory the same day to meet the fecal coliform holding time.

For each analyte, the laboratory must be able to achieve target reporting limits and method detection limits that will allow consistency with study plan and data quality objectives. Reporting limits are defined to detect small changes in concentration relative to background.

6.5 Benthic Macroinvertebrates

Benthic macroinvertebrates will be sampled by qualified personnel according to the protocol described in SOP (EAP073) included in Appendix A. At each sampling location, benthos will be collected in accordance with the SOP (shown in Table 6); see the SOP for more detailed explanation of the monitoring elements shown in Table 6.

Table 6. Sampling protocol for benthic macroinvertebrates.

Monitoring Element	Equipment and Procedural Specifications
Sampling Device	D-frame kicknet
Net Mesh Size	500 µm
Site Length	Two bankfull widths or more
Sample Area	8 ft^2 to create a single composite sample
Station	Multiple riffles
Time to Suspend Sediment	30-120 seconds
Sample	Targeted riffle composite
Sampling Season	July 1–October 15
Subsample Goal	500+ organisms
Taxonomic Resolution	Lowest practical

7.0 QUALITY CONTROL

7.1 *In Situ* Data Collection

Quality control measures for *in situ* water quality meters are described in the SOPs included in Appendix A. Water temperature data loggers will be checked before and after deployment by comparing the temperature data loggers to a Certified Reference Thermometer (CRT) traceable to the National Institute of Standards and Technology (NIST). Sonde performance will be assessed with calibration checks before and after deployment, according to the manufacturer's specifications. Instrument accuracy is also documented during servicing once a month, by comparing against standard reference materials or a second calibrated meter.

7.2 Sample Collection

QA/QC activities for sampling processes include the collection of field duplicates and field blanks for TSS and fecal coliform testing. The number of duplicates and blanks should be one per field visit.

7.3 Analytical Laboratory

ALS, which has been selected to provide analytical support for the TSS and fecal coliform elements of this study, has appropriate facilities to store, prepare, and process samples and appropriate instrumentation and staff to provide data of the required quality within the time period dictated by the study. ALS has a quality assurance plan in place and will adhere to standard protocols for accuracy, precision, instrument bias, and analytical bias.

The laboratory's deliverable (i.e., data package) will include information documenting its ability to conduct the analyses with the required level of data quality. Such information may include results from inter-laboratory calibration studies, control charts, summary data from internal QA/QC checks, and results from analyses of certified reference materials. Additionally, the laboratory will report any inconsistencies or problems associated with any sample run(s) to HDR, which will document the situation as a variance or non-conformance, as appropriate (e.g., contaminated reagents, equipment malfunction, lost or broken sample bottles upon receipt).

7.4 Macroinvertebrates

Quality control measures for benthic macroinvertebrate samples are described in the relevant SOP (EAP073) included in Appendix A. Benthic macroinvertebrate samples will be processed and analyzed by EcoAnalysts.

8.0 DATA MANAGEMENT PROCEDURES

Field and laboratory data will be entered and maintained in Excel spreadsheets. The contract laboratory will provide an electronic data deliverable and an electronic narrative that includes, at a minimum, Level II documentation.

Throughout the relicensing, the original field notebooks and forms, equipment maintenance and calibration documentation, chain-of-custody forms, laboratory reports, and data verification records will be stored at the HDR office at 905 Plum Street SE, Suite 200, Town Square 3, Olympia, WA 98501-1516. Records will be transferred to City Light upon license receipt or earlier, at City Light's discretion.

9.0 AUDITS AND REPORTS

Periodic assessments will be conducted to ensure that data collection is conducted according to requirements presented in this QAPP. The Study Lead will have the primary responsibility for assessing compliance with the QAPP requirements pertaining to sample collection and handling procedures, field analytical procedures, laboratory analytical procedures, and communicating study status to the QA Officer and Project Manager. The QA Officer or his designee will conduct reviews of field sampling and analysis procedures at the beginning of each field season. The reviews may be performed at a demonstration site or involve accompanying sampling personnel to determine whether sampling activities are being conducted in accordance with the QAPP and study plan. Laboratory analyses will be assessed through evaluating results of QC samples and compliance with DQOs.

If a non-conformance is identified, the QA Officer and/or Study Lead will notify the Project Manager immediately. The Project Manager, QA Officer, and Study Lead will discuss the observed discrepancy with the appropriate person responsible for the activity to determine whether the information collected can still be considered accurate, what the cause(s) were leading to the deviation, how the deviation might impact data quality, and what corrective actions might be considered. The QA Officer and Study Lead will then follow up to ensure that corrective actions have been implemented.

10.0 DATA VERIFICATION AND VALIDATION

Documentation of review, verification, and/or validation will be maintained in the Project file. All data will be reviewed and verified. In brief, following the field sampling and laboratory analyses, which includes the laboratories' own QA/QC analyses, HDR will subject all data to QA/QC procedures including, but not limited to: spot-checks of transcription; review of electronic data submissions for completeness; comparison of results to field blank results; and identification of any data that seem inconsistent (Appendix B). If any inconsistencies are found, HDR will consult with the laboratory to identify any potential sources of error before concluding that the data are correct.

All verified chemical detections, including data whose results are "J" qualified, will be used for this assessment. Should the laboratory need to re-extract samples and rerun the sample under different calibration conditions, the data identified by the laboratory as the most certain will be used. If field-sampling conditions, as measured by the field blank, indicate that samples have been corrupted, HDR will identify the data accordingly.

All Onset Water Temp Pro data will be reviewed, and anomalous data may be identified by reviewing a plot of the water temperature results and by comparing any questionable results to ambient monitoring temperature data, flow information, and field notes. Identified data anomalies then may be deleted from the record, provided the reason has been noted.

Handheld multi-parameter meter field data will be processed through a QA/QC procedure as follows. Data from time periods with anomalous patterns or uncharacteristic spikes will be identified and not accepted. Field monitoring data will be compared to the field and laboratory instrument calibration records. Full documentation of QA/QC procedures and reasons for not accepting any data will be provided in the initial and final study reports.

11.0 DATA QUALITY (USABILITY) ASSESSMENT

It is important that the data collected during this study are accurate, precise, representative, and complete, and can, therefore, be used to characterize water quality within the Project area. These data requirements will be assessed by ensuring that DQOs are met throughout the study.

After each discrete sampling event, the Study Lead will evaluate if the DQOs have been met. If the impact of the QC failure on data quality is minimal, the data will be flagged and included in the database. If a greater impact is found, the Study Lead will work with the QA Officer to determine the next steps. Data that do not meet the DQOs will be evaluated to determine the cause of the problem and whether corrective actions can be implemented so that DQOs are met in the future. At the end of the monitoring program, the data generated under this project will be given to City Light.

12.0 REFERENCES

United States Environmental Protection Agency (EPA). 2011. Guidelines Establishing Test Procedures for the Analysis of Pollutants. Title 40 Code of Federal Regulations, Pt. 136. 2011 ed.

QUALITY ASSURANCE PROJECT PLAN

APPENDIX A

STANDARD OPERATING PROCEDURES

Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedure for Monitoring Total Dissolved Gas in Freshwater

Version 1.0

Author – Paul Pickett
Date -

Reviewer – Karol Erickson, Water Quality Studies Unit Supervisor
Date -

QA Approval – Bill Kammin, Ecology QA Officer
Date -

EAP002

APPROVED: 7/10/2006

Recertified: May 7, 2010

Signatures on File

Please note that the Washington State Department of Ecology's Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Ecology use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. Distribution of these SOPs does not constitute an endorsement of a particular procedure or method.

Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the Department of Ecology.

Although Ecology follows the SOP in most instances, there may be instances in which Ecology uses an alternative methodology, procedure, or process.

SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)
05/7/10	1.0	Recertified	All	Kammin

Environmental Assessment Program

Standard Operating Procedure for Monitoring Total Dissolved Gas in Freshwater

1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program (EAP) Water Quality Studies Unit Standard Operating Procedure (SOP) for Monitoring Total Dissolved Gas (TDG) in Freshwater.

2.0 Applicability

2.1 This SOP should be followed for all monitoring of TDG in freshwater. It includes procedures for spot measurements and long-term continuous monitoring of TDG pressure, and the measurement of barometric pressure data to allow calculations of TDG as percent of saturation.

3.0 Definitions

3.1 Total Dissolved Gas: the amount of gases, typically the constituents of air, dissolved in water. Usually measured as pressure (e.g. mm Hg) or percent of saturation relative to ambient barometric pressure.

3.2 Compensation Depth: the depth in a water column at which the total dissolved gas pressure is equal to the hydrostatic pressure. As a rule of thumb, this corresponds to roughly 1 meter for every 10 percent of saturation above 100%.

3.3 Aerated Zone: the area below a dam's spill, waterfall, or other plunging stream of water where bubbles are entrained in the water column and TDG is crossing the air-water interface of the bubbles either into or out of solution.

4.0 Personnel Qualifications/Responsibilities

4.1 Training in the use of Hydrolab® equipment, including the Standard Operating Procedures for use of Hydrolab® equipment.
4.2 Trained in safety procedures for work on or over the water.

5.0 Equipment, Reagents, and Supplies

5.1 Equipment

5.1.1 A Hydrolab® meter fitted with a TDG sensor.
5.1.2 Spare membrane for TDG sensor
5.1.3 Calibration kit with NIST pressure sensor, bulb hand air pump, fittings and tubes, modified calibration cap, and tools.
5.1.4 Laboratory barometer
5.1.5 Portable digital barometer (optional)

5.2 Supplies

5.2.1 Selzer water (USGS standard is Schweppe's Club Soda)

6.0 Summary of Procedure

6.1 Overview

6.1.1 TDG, simply stated, is air dissolved in water. The dynamics of TDG are governed by gas laws such as Henry's Law and Boyle's Law (Colt, 1984) Supersaturated TDG is most commonly caused by air forced into solution by hydrostatic pressures when a stream of water with entrained air bubbles plunges to depth.

6.1.2 TDG levels can also be affected by a variety of environmental conditions:

6.1.2.1 Primary biological productivity, which changes dissolved oxygen levels, since DO is one component of TDG.

6.1.2.2 Changing water temperatures, which directly change TDG pressures and percent saturation in accordance with gas laws.

6.1.2.3 High winds, and shallow, turbulent flow can increase the rate of gas exchange. Supersaturated TDG is constantly seeking equilibrium with the atmosphere through the air-water interface, but under calm conditions with laminar flow and deep water (such as in reservoir with little wind), that exchange is very slow. A vigorous set of rapids or cascades can allow a rapid return of supersaturated waters to equilibrium.

6.1.2.4 Changes in barometric pressure change TDG levels relative to the standards, since TDG water quality criteria are expressed in terms of percent of saturation relative to ambient barometric pressure. This also means that evaluation of criteria requires measurement or estimation of the absolute barometric pressure at the location being monitored.

6.1.2.5 All TDG monitoring is conducted by field measurements with specialized meters. Various manufacturers provide TDG meters, but all use diffusion membrane methods equivalent to Standard Method 2810 (APHA *et al.*, 1998). Ecology owns several Hydrolab® meters outfitted with TDG sensors. Other meter models are sold by Common Sensing (the original developer of TDG meters) and In-Situ (who bought Alpha Designs, the source of replacement TDG membranes for the Hydrolab® meters). Prior to development of field measurement methods, dissolved gas was measured in the laboratory using a blood gas analyzer, but this method is now rarely used.

Figure 1. TDG sensor and membrane

6.1.2.6 The basic principle behind TDG monitoring is that dissolved gas diffuses through thin silastic tubing wound around a base, and the pressure exerted through the membrane is measured by a pressure sensor. The pressure sensors are quite robust and accuracy is quite stable (they reportedly are the same as those used in automobile engines for emission control). The membrane, however, is delicate and usually the source of any monitoring challenges. Membranes need to be intact, dry inside, and clean. This requires some attention to equipment maintenance and handling.

6.1.2.7 Good TDG measurements require three elements unique to the method: proper meter placement, diligent care of the membrane, and patience:

6.1.2.7.1 For proper functioning of the membrane, meters need to be placed below the compensation depth and outside any aerated zones. Membranes placed in shallow supersaturated water or in bubbly conditions may produce inaccurate readings. Because monitoring often occurs during high flow periods, rapid water velocities, high turbulence, and dynamic water elevations create challenging deployment logistics.

6.1.2.7.2 Periodic cleaning and calibration will help insure membranes are performing properly. During continuous monitoring deployment, maintenance about every two weeks is optimal, but monthly maintenance is adequate.

6.1.2.7.3 Membranes can take 15-20 minutes to equilibrate to changing conditions, so plenty of time needs to be allowed for calibration and for properly equilibrated spot measurements. Bring a book, a laptop to check email, a radio or music player, or just enjoy the scenery!

6.1.2.8 Like all environmental monitoring, a Quality Assurance Project Plan should be developed for TDG monitoring. Examples developed by Ecology are cited in the References (Ecology 2002; 2003; 2004). Ecology's TDG data quality procedures are modeled on the methods developed by the U.S. Geological Survery (Tanner and Johnston, 2001).

6.2 Calibration

6.2.1 Calibration procedures follow the outline provided in Section A.1. of Appendix A. Other parameters measured by the Hydrolab® meter should also be calibrated, especially temperature and dissolved oxygen because of their close relationship to TDG pressure. See the SOPs for Hydrolab® use for instructions on these parameters.

6.2.2 Calibrate the pressure sensor without membrane

6.2.2.1 Take a meter reading with pressure sensor open to ambient air, and compare to the barometric pressure (BP) using the laboratory standard barometer.

6.2.2.2 Attach the fitting to the pressure sensor that connects through tubing and a tee fitting to the NIST pressure gage and the bulb.

6.2.2.3 Pump up the pressure on the bulb until the NIST meter shows 100 mm Hg and record the meter reading and lab BP+100. Repeat for +200 and +300 mm Hg.

6.2.2.4 If any readings are greater than 2 mm Hg different from the lab BP standard, calibrate the meter at ambient BP and ambient BP+200.

6.2.3 Test Hydrolab® meter with dry membrane

6.2.3.1 Attach the dry TDG membrane, then put on a calibration cup with the special cap with tubing.

6.2.3.2 Record a meter reading with the chamber open to ambient BP.

6.2.3.3 Add 200 mm Hg pressure to the chamber (make sure all seals are tight!) and record meter reading. Readings should agree within 2 mm Hg.

6.2.4 Test Hydrolab® meter in Club Soda

6.2.4.1 Remove the calibration cup and put the sensor guard on the meter.

6.2.4.2 Place the probe in a beaker and fill with Club Soda. Watch the readings and record the high reading. TDG should rise from ambient to over 1000 mm Hg (for fresh soda) in about 40 to 60 seconds, and then start to drop.

6.2.4.3 Remove the probe from the Club Soda. Watch the readings and record the low reading. TDG should drop to slightly below ambient BP (effect of evaporation on the membrane) in about 1 to 3 minutes, then begin to rise.

6.2.4.4 If the TDG readings in Club Soda rise or fall too quickly or too slowly, or if the readings don't rise as high as expected or don't fall below ambient, replace the TDG membrane and repeat 6.22 and 6.23. (This is why it's always good to have a spare membrane or two!)

6.2.4.5 The problem membrane can be washed in distilled water, dried thoroughly (at least 24 hours) and then retested. Moisture inside the membrane will cause problems. Membranes can also develop tiny splits or pinholes, in which case they need to be refurbished (rewound with new silastic tubing).

6.2.4.6 If the TDG meter and membrane passes all tests, it is ready to go. Dry the membrane and visually inspect for flaws or internal moisture. Remove the sensor guard and replace calibration cup for transport. TDG membranes are best stored dry when not in use.

6.3 Barometric pressure measurement methods

6.3.1 Obtaining BP measurements that coincide with your TDG pressure readings can be problematic. Ideally a continuous data-logging barometer would be installed adjacent to the deployment location, but Ecology has not found the high cost to be justified by the limited need, and several alternative methods should work adequately.

6.3.2 For spot measurements, the meter itself can work as a barometer. Remove the membrane at the monitoring location and take a reading with only the pressure sensor. The disadvantage of this method is that any handling of the membrane increases the chance of membrane damage.

6.3.3 A hand-held digital barometer of acceptable accuracy serves well for spot readings. (The Quality Assurance Project Plan should specify MQOs for barometer readings.) EAP has some analog (aneroid) barometers, but they have been found to be very sensitive to temperature changes and often provide inaccurate readings in field conditions. Barometer readings can be checked with paired readings with the meter and laboratory barometer during calibration.

6.3.4 For continuous deployment, a meteorological station in the vicinity is needed which records continuous BP. BP tends not to vary on fine spatial scales (within a mile or two), but on regional scales significant differences can occur, especially when BP is dynamic such as during an approaching low front. Ideally you should visit the meteorological station during field surveys and take a spot BP reading on-site for paired comparison. Spot BP readings at the deployment site can then be compared to the meteorological station data, and a regression developed to predict BP at the deployment site from the meteorological station time series. BP varies linearly with altitude, so a first-order linear regression usually works well.

6.4 Spot measurements

6.4.1 The trick to taking spot TDG measurements is to get the meter below the compensation depth and keep it there long enough for a stable reading. The main approaches to accomplish this are:

6.4.1.1 Find a quiet spot where the water is connected to the river but currents are slow, such as an eddy or below an obstruction.

6.4.1.2 Take readings while drifting in a boat.

6.4.1.3 Attach a heavy weight on a short cable with the meter at the end of a rope. Ecology has a cable and weight for this purpose.

6.4.2 Modify the attached form A-3 in Appendix A for the spot readings you plan to collect. When you reach the site, take a BP reading, then lower the meter into the water to an appropriate depth. Monitor the TDG readings until they are stable (less than 1 mm Hg change in 2 minutes). Check the depth to make sure the meter is below the compensation depth (divide the BP by 10, then allow 1 meter for each increment of BP/10 that the TDG reading is above the BP). Record your reading (electronically and in the field book).

6.5 Continuous monitoring deployment

6.5.1 Continuous deployment requires the selection of a location that meets several criteria:

6.5.1.1 Accessible for maintenance;
6.5.1.2 In a representative location;
6.5.1.3 Below the compensation depth for all flows and water surface elevations
6.5.1.4 Will stay in place during high flows; and
6.5.1.5 Protected from damage from debris or movement of the meter itself

6.5.2 A number of approaches have been used around the state. A few are listed here:

Figure 2. TDG continuous monitoring deployment with a PVC pipe mounted from a bulkhead.

6.5.2.1 Install a PVC pipe on a dock, bulkhead, abutment, or other permanent structure, so the meter is 5 meters below low water and the top is accessible from the structure. This is the most ideal kind of deployment for easy access and dependable readings. It is best if the site has secure access.

6.5.2.2 Install a PVC pipe along the river bottom with the end anchored in the channel and the top accessible on the shore. It’s challenging to find a location for this kind of deployment where the end is deep enough and won’t wash away and the top is in a secure location

6.5.2.3 Put the meter in a protective PVC case and attach to an anchor, which is lowered from a boat or dock. This works best in low velocities, with an anchor heavy enough to stay in place or attached to a structure. An anchor made of a piece of flat steel tends to stay put better than a concrete anchor. At higher velocities you don’t want the anchor to move or the meter to bang on the bottom. You could build a custom anchor with a clamp or attached housing for the meter. An alternative to attaching the meter directly to the anchor is to put the meter on a small buoy that is pulled below the surface but keeps the meter off the bottom. The usual security problems exist for buoy deployments in areas with public access.

Figure 3. Anchor and PVC housing deployed from a dock for continuous TDG monitoring.

6.5.2.4 If you have the time, funds, and aptitude to rig a custom deployment, you could rig a cable out to an anchor and then suspend the meter in a housing that hangs from the cable on pulleys. To deploy or retrieve the meter you put tension on the cable and then lower or raise the meter with a second rope.

6.5.3 When you first deploy the meter, take a second meter and take a paired reading before deployment. At intervals of 2-4 weeks, bring a second calibrated meter, take a paired reading, and then swap the meters. If you have another meter for spot readings, a three-way replicate reading is even better. If an extra meter is unavailable, the meter can be retrieved, milked for data, recalibrated, and redeployed in the field. Form A-3 can be adapted to guide this field work and record data.

6.6 Post-calibration and maintenance

6.6.1 Post-calibration follows most of the same steps as calibration (Section 6.2). Form A-2 is provided in Appendix A to guide post-calibration.

6.6.2 After post-calibration, the TDG membrane should be removed, the solid cap placed on the pressure sensor, and the membrane allowed to dry thoroughly. The TDG membrane should then be stored in a sealed container with a moisture absorbent packet.

6.6.3 Damaged TDG membranes can be refurbished for about half the cost of buying an entirely new membrane. Sometimes a membrane that is functioning poorly will work fine after being cleaned and thoroughly dried, so this is worth trying before paying for refurbishment.

7.0 Records Management

7.1 The standardized recording sheets provided in Appendix A should be modified as appropriate for the specific needs of the project and used for calibration and field QA procedures. Care should be taken to record times, barometric pressures, field conditions and other relevant information at frequent intervals.

8.0 Quality Control and Quality Assurance

8.1 QA/QC procedures are described in the procedures above, and will be addressed thoroughly on a project-by-project basis in the QAPP for the project. See References for examples of TDG QAPPs.

9.0 Safety

9.1 All appropriate safety procedures to the installation method employed should be followed for working off of docks, bridges, or boats, and for deploying and retrieving remote moorings with buoy and anchors.

9.2 Installation of mounted tubes or other deployment should follow safety procedures for use of tools and work over water.

9.3 For further field health and safety measures refer to the Environmental Assessment Program (EAP) Safety Manual .

10.0 References

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Appendix A

Laboratory and Field Data Sheets

A.1. HYDROLAB CALIBRATION PROCEDURES (To be done prior to survey)

Hyrolab #______________ Lab barometer ID ___________
TDG sensor #___________ Date barometer last calib. ___________
Survey location _______ Today's date ___________
Survey Date _________ Checked by ___________

1. CALIBRATE TDG WITH DIGITAL PRESSURE GAUGE (MEMBRANE OFF).

Lab BP ________ mm Hydrolab ambient pressure ________ mm Time __________
Baro+100mm: expected/measured ________ /________
Baro+200mm: expected/ measured ________ /________
Baro+300mm: expected/ measured ________ /________

If any readings are >2 mm off, do a 2-point calibration at BP and BP+200 mm and note below.
Calibration BP: calibrated/measured ________ /________
BP+200mm: calibrated/ measured ________ /________

2. INSTALL DRY MEMBRANE AND TEST HYDROLAB WITH PRESSURE GAGE AND CHAMBER.

Lab BP + 200mm = ______ mm
Before applying 200 mm pressure Hydrolab pressure ________ mm Time _______
After applying pressure Hydrolab pressure ________ mm Time _______

3. INSTALL SENSOR GUARD AND TEST HYDROLAB WITH CLUB SODA.

Before soda test Hydrolab pressure ________ mm * Time _______
High pressure, soda test Hydrolab pressure ________ mm Time _______
Low pressure, after soda test Hydrolab pressure ________ mm Time _______

4. CHECK MEMBRANE FOR INTERNAL MOISTURE AFTER THE OUTSIDE HAS HAD TIME TO DRY.

A.2. HYDROLAB TDG POST-CALIBRATION PROCEDURES (To be done at the conclusion of a survey.)

Today's date ___________ Checked by ___________

1. TEST LOW CALIBRATION WITH MEMBRANE ATTACHED.

Lab BP _________ mm Hydrolab Pressure ________ mm Time _______

2. TEST HYDROLAB WITH DIGITAL PRESSURE GAGE AND PRESSURE CHAMBER.

Lab BP + 200mm = ______ mm
Before applying 200 mm pressure Hydrolab pressure ________ mm Time _______
After applying pressure Hydrolab pressure ________ mm Time _______

3. TEST HYDROLAB WITH CLUB SODA.

Before soda test Hydrolab pressure ________ mm Time _______
High pressure, soda test Hydrolab pressure ________ mm Time _______
Low pressure, after soda test Hydrolab pressure ________ mm Time _______

(If the unit does not perform well on #1-3 above, re-evaluate the corresponding site record.)

Remove TDG membrane, clean the membrane, air dry, store with desiccator.
Allow TDG sensor to air dry for at least 24 hours.

A.3. HYDROLAB TDG FIELD INSPECTION/CALIBRATION SHEET

Deployment/Retrieval Procedures

Project: ___________ Date: ___________ Personnel: __________________________________

Weather: ______________________________ Air temperature: ______ °C

Observed river conditions (flow, spill, etc.): ____

Barometer ID ____________ Date last cal.__________ Survey meter #:________

1. Spot reading at:_______________________________**.** Start time:_____; Site conditions:______________________

BP:______; Depth:_____; TDG:______; DO:____; pH:_____; Cond:______; Temp:______;

2. Paired readings at deployment site:_____________________________**.** Site conditions:_____________________

Start time:________ Bar Press:____________

Meter #:___; Time:___; Depth:_____; TDG:______; DO:____; pH:_____; Cond:______; Temp:______;

Meter #:___; Time:___; Depth:_____; TDG:______; DO:____; pH:_____; Cond:______; Temp:______;

After a minimum of 15 minutes, if both Hydrolab readings have not changed 1 mm./2 min, or if meters are changing but difference is constant:

___________ mm (DS#____) - ____________ mm (DS#____) = ___________ mm Time: ________

IF Difference is > 10 mm, do A and B

A. Test both Datasondes with club soda:

DS#____ ; TDG:___________ mm Time: ________

DS#____; TDG:___________ mm Time: ________

B. Test both Datasondes with pressure gage and chamber:

DS#____: ambient___________ mm; plus 200mm__________ mm Time: ________

DS#____: ambient___________ mm; plus 200mm__________ mm Time: ________

IF DATASONDE FAILS EITHER TEST, REPLACE MEMBRANE AND RETEST, OR DO NOT USE.

Old meter retrieval time:_____, new meter deployment time:_____. End time:_______ BP:___________

3. Spot reading at:______________________________**.** Start time:_____; Site conditions:_______________________

BP:______; Depth:_____; TDG:______; DO:____; pH:_____; Cond:______; Temp:______

4. Spot reading at:______________________________**.** Start time:_____; Site conditions:_______________________

BP:______; Depth:_____; TDG:______; DO:____; pH:_____; Cond:______; Temp:______

DEPARTMENT OF
ECOLOGY
State of Washington

Standard Operating Procedure EAP034, Version 1.5

Collection, Processing, and Analysis of Stream Samples

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Purpose of this document

The Department of Ecology develops Standard Operating Procedures (SOPs) to document agency practices related to sampling, field and laboratory analysis, and other aspects of the agency's technical operations.

Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedures for the Collection, Processing, and Analysis of Stream Samples

Version 1.5

Author - William J. Ward
Date - 11/23/16

Reviewer - Brad Hopkins
Date - 11/23/16

QA Approval - William R. Kammin, Ecology Quality Assurance Officer
Date – 7/20/2016

EAP034

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For the internet version, signatures are on file

Please note that the Washington State Department of Ecology's Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Ecology use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. Distribution of these SOPs does not constitute an endorsement of a particular procedure or method.

Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the Department of Ecology.

Although Ecology follows the SOP in most instances, there may be instances in which Ecology uses an alternative methodology, procedure, or process.

SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)
2/9/2007	1.1	Editorial; formatting	All	Bill Ward
3/7/2007		Comments	All	Dave Hallock
5/9/2007	1.2	Edits based on comments	All	Bill Ward
6/19/07		Comments	All	Bill Kammin
8/6/07	1.3	Edits based on comments	All	Bill Ward
9/28/07		Comments	All	Dave Hallock
9/28/07	1.3	Edits based on comments	All	Bill Ward
9/4/12	1.4	Edits based on Dave Hallock and TCT workgroup comments	All	Bill Ward
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Environmental Assessment Program

Standard Operating Procedure for the Collection and Processing of Stream Samples

1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for the collection, preservation, measurement, and analyses of water quality at Freshwater Ambient Monitoring stations.

1.2 It describes the general stream monitoring procedures used for run preparation, sample collection, measurement, processing, preservation, and shipment. The document also addresses quality assurance and quality control procedures.

1.3 The standard set of samples collected, measured, or processed include: temperature, pH, conductivity, dissolved oxygen, turbidity, total suspended solids, fecal coliform bacteria, ammonia, nitrate plus nitrite, total nitrogen, total phosphorus, soluble reactive phosphorus, metals, and stage height. Program SOP methods for Instantaneous Temperature (EAP011), Dissolved Oxygen (EAP023), Metals (EAP029), Fecal Coliform Bacteria (EAP030), pH (EAP031), Conductivity (EAP032), and Invasive Species (EAP070) are also included.

1.4 Other samples that may also be collected and processed on a special study request basis include: alkalinity, dissolved organic carbon (DOC), total organic carbon (TOC), filtered total phosphorus, filtered total nitrogen, Nitrogen Isotope, chlorophyll, and suspended sediment concentration (SSC).

1.5 All Ambient stations are typically monitored once a month and dissolved metals are also monitored every other month at only a few stations.

2.0 Applicability

2.1 This SOP is intended for long term ambient stream monitoring.

3.0 Definitions

3.1 Dissolved Oxygen (DO) – The concentration of dissolved oxygen (mg/L) in a water sample.

3.2 Conductivity –A measure of the ability of water to carry an electrical current. It is dependent upon the concentrations and types of dissolved ions and the water temperature. In general, a greater concentration of ions in the water will lead to a larger conductivity value.

3.3 Ecology – Washington State Department of Ecology.

3.4 EAP – Environmental Assessment Program.

3.5 EIM – Environmental Information Management System. A searchable database developed and maintained by the Washington State Department of Ecology.

3.6 Fecal coliform – A group of bacteria that inhabit the intestinal tract of warm-blooded animals and remain viable in freshwater for a variable period of time. The presence of fecal coliform bacteria in water indicates fecal contamination of the water by a warm-blooded animal; harmful bacteria and viruses associated with fecal contamination may also be present.

3.7 Field Logbook – A weather resistant logbook containing “Rite in the Rain” ® writing paper used to document any and all field activities, sample data, methods and observations for each and all sample sites.

3.8 µmhos – micro mhos (mho = 1/ohm = 1 Siemen) per centimeter

3.9 MEL – Manchester Environmental Laboratory

3.10 MQO’s – Measurement Quality Objectives

3.11 MSDS – Material Safety Data Sheets provides both workers and emergency personnel with the proper procedures for handling or working with a particular substance. MSDS’s include information such as physical data (melting point, boiling point, flash point, etc.), toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment and spill/leak procedures.

3.12 OC – Operations Center. The location of the program field equipment, boats, walk-in cooler and shop (where technicians repair or fabricate the equipment).

3.13 pH – A measure of the acidity or alkalinity of a solution, numerically equal to 7 for neutral solutions, increasing with increasing alkalinity and decreasing with increasing acidity. The pH scale ranges from 0 to 14.

3.14 Run – Monthly scheduled sampling event (usually lasting 2-4 days).

4.0 Personnel Qualifications/Responsibilities

4.1 Field operations require training specified in EAP's Field Safety Manual (Ecology, 2015) such as First Aid, CPR, and Defensive Driving.

4.2 Because the procedure requires the use of hazardous materials, training is required as per the Ecology Chemical Hygiene Plan and Hazardous Material Handling Plan (Section 1) (WA State Department of Ecology 2011), which includes Laboratory Safety Orientation, Job-Specific Orientation and Chemical Safety Procedures. The Standard Operating Procedures in Section 16 of the Chemical Hygiene Plan and Hazardous Material Handling Plan for handling chemicals must also be followed.

5.0 Equipment, Reagents, and Supplies

5.1 Bridge sampler (based on design presented in Figure 4500-0:1 of the 20th Edition of Standard Methods), 1 L Funnel, or Kemmerer/Van Dorn samplers
5.2 Sampling ropes 1 @ 10 ft., 1 @ 35 ft. and 2 @ 55 ft.
5.3 Extension pole with bottle clamp
5.4 1-L funnel with tubing
5.5 Field Logbook or Field Data Report Form
5.6 Meter Calibration Log Form
5.7 Ambient Run Checklist
5.8 Sample tags
5.9 Sample coolers
5.10 Sample bottles
5.11 Cube ice
5.12 Gel-Ice (Blue Ice)
5.13 250 mL 10% HCl
5.14 Bacteria sampler
5.15 Long-line thermistor
5.16 Red-liquid thermometer
5.17 Weighted measuring tape
5.18 USGS gage keys
5.19 Peristaltic pump and filter holder
5.20 Hach PHC electrode
5.21 Hach pH 4, 7, & 10 Buffers.
5.22 Hach pH electrode filling solution.
5.23 pH 7 QC buffer (from another manufacturer - not Hach).
5.24 Hach 4-cell Conductivity electrode

Bridge Sampler
W/sample bottles

Bacteria Sampler
W/sample bottle

5.25 2 –100 µmhos/cm conductivity standards

5.26 2 – 1 L nutrient grab sample bottles[1] (marked up with black permanent ink and MSDS sticker)

5.27 1 – 1 L pH and conductivity grab sample bottle (marked w/red or green permanent ink)

5.28 DO box that has the following supplies:

5.29 300 mL BOD bottles (enough for the Run plus two spares)

5.30 Glass BOD stoppers

5.31 Plastic BOD bottle caps

5.32 3 mL graduated disposable transfer pipettes (one dedicated to each reagent)

5.33 Manganous sulfate monohydrate reagent bottle with MSDS sticker

5.34 Alkali-iodine-azide reagent bottle with MSDS sticker

5.35 Deionized water (DI water) used to rinse sampling bottles and equipment.

5.36 2-750 mL (or 500mL) plastic DI wash bottles

5.37 Metals sampling supplies:

5.38 Hand vacuum pump with hose and pressure gage

5.39 500mL Teflon FEP bottles pre-filled with de-ionized water by the lab

5.40 125 mL narrow mouth poly bottle containing H2S04 preservative for hardness sample disposable 0.45 micron cellulose acetate filter unit (pre-cleaned)

5.41 Small Teflon vials containing 5 ml concentrated nitric acid preservative

5.42 Powder-free vinyl or nitrile disposable gloves

5.43 Baking Soda

5.44 Eyewash Stations

5.45 Digital Camera

6.0 Summary of Procedure

6.1 Annual Run Preparation. This process typically begins in the winter (several months ahead of the sampling schedule).

6.1.1 The first objective is to work with the regional watershed leads and other Ecology staff to prioritize and select new Basin Stations and metals sample stations[2] (see Attachment A for draft station selection guidance).

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[1] These should contain about 200 mL of 10% HCL solution that is replaced every other Run

[2] These are sampled every other month.

6.1.2 The next objective is to complete the "RunOrder" table in the "R&SNewWYPlanning" database. Then, notify the Ambient Database Administrator that the RunOrder table has been updated and he will use the database to generate the following documents: (1) Lab # (assigns lab numbers for each of the run stations), (2) Bottle Order (details the sample bottle needs, delivery, and pickup schedules for each Ambient Monitoring Run).

6.1.3 The administrator will then forward the finalized Lab # and Bottle Order documents to the Manchester Environmental Laboratory (MEL) and post them on the Y drive.

6.1.4 The final objective is to draft and post the following two run documents on the Y drive (Y:\ambient) under the appropriate water year folder (WY__ Docs) and run name by mid-September: (1) Run Times (details the planned daily time schedule) and (2) Run Directions (details driving and sample location directions).

6.2 Monthly Run Preparation. This should begin one week in advance of a run and requires: the completion and posting of a Field Work Plan & Contact Person Form, making sample tags, printing out the Field Data Report Form and the Lab Analyses Required Form (LAR), pre-booking air shipment(s), forward the air shipment confirmation e-mail(s) to the courier, and make hotel reservations.

6.2.1 Samplers should always prepare for a Run through the use of a Run Checklist (see Attachment B) to ensure that all of the necessary tasks, sampling equipment, supplies, sample containers, and safety gear have been dealt with or loaded in the van. *Note: Run sample bottles should have been delivered to the OC bottle storage room (or the designated regional location) by the lab courier the Wednesday before the scheduled run. The lab courier should be contacted if they are not there or the order is incorrect.*

6.2.2 Verify that the conductivity (and if needed DO electrode) soaks in tap or DI water (replace water monthly).

6.2.3 Field Work Plan & Contact Person Form.

6.2.3.1 Samplers must complete and post the Field Work Plan & Contact Person Form on SharePoint, along with links to the Run Directions and Run Times documents before beginning a run.

6.2.3.2 The information on the form enables family and program staff to call a sampler in case of an emergency or conduct a search if there was a mishap.

6.2.3.3 If plans change (lodging, cell phone number, etc.) the sampler must contact a supervisor or the section secretary to have the information revised.

6.2.3.4 If the sampler fails to check in with the contact person, then the contact person needs to notify the supervisor to begin efforts to locate the sampler. *Note: Van cell phones need to be kept on during work hours to allow the lab courier or other staff to get shipment information or to discuss other program related needs.*

6.2.4 Make Sample Tags

6.2.4.1 Use the River and Stream Data Management Database to print the sample tag labels for the Run.

6.2.4.2 Stick the labels to the Rite in the Rain sample tags provided by MEL.

6.2.4.3 Rubber band the labeled tags by station and by the planned sampling order.

6.2.5 Print Out Field Forms.

6.2.5.1 Use the River and Stream Management Database to generate the Field Data Report (FDR) and the Lab Analysis Request (LAR) forms.

6.2.5.2 Check the accuracy of the pre-entered information (run date, sampler…) on the forms before printing them (see Attachment C - Example FDR and LAR Forms).

6.3 Day One Procedures

6.3.1 Refill the DI water containers (2 L bottles and 5 gallon carboy*). Note: this task may also be done at the end of the Run if a DI water source is not available at the satellite office operation center.*

6.3.2 Turn on the cell phone.

6.3.3 Put several scoops of ice into each sample cooler needed for the Run day and set the coolers into the van. If on a multiple day Run that includes an overnight stay, then consolidate the ice needed into a cooler for each day and top the cooler(s) off with several frozen Gel-Ice. If shipping by air cargo, pack one cooler with gel ice.

6.3.4 Calibrate check the van barometer using the OC digital barometer located in the wet lab (or by another means such as a local weather station - but note that weather stations report BP corrected to sea level which must be converted back to absolute pressure). Adjust the van barometer to be within 0.10 in Hg (inches mercury) when needed (and if possible).

6.3.5 Check the calibration of the long-line thermistor to the NIST reference Onset HOBO U14 digital Thermometer, complete the calibration check log to determine if it can be used, and also note the results on the electrode Calibration Log Form.

6.3.6 Empty and refill the dedicated 4, 7, and 10 Hach pH buffer calibration bottles with fresh buffer solution that are the same temperature and at least 15°C.

6.3.7 Replace the pH electrode filling solution, rinse electrode with DI water, carefully re-attach the half-filled electrode soaker bottle, plug the fill hole, and store the electrode upright.

6.3.8 Empty and refill the QC 7 pH buffer and conductivity standard bottles.

6.3.9 Clean the conductivity electrode cells with a Q-Tip, rinse area with DI water, and store electrode in DI or tap water.

6.3.10 Verify that the meter times are in Pacific Standard Time and within 3 minutes to a cell phone or to the Naval Atomic Clock time.

6.3.11 Clean the inside of the filter stand apparatus by removing the hard plastic support from the base and cleaning underneath with a brush, if necessary. Re-assemble and pump (cycle) 10 % HCL through it followed by at least a 10 second flush with DI water from the 2 L storage bottle located in the sink.

6.4 Daily Pre-Departure Procedures

6.4.1 pH Electrode Calibration (Hach PHC electrode).

6.4.1.1 Clear the junction. Remove the filling-hole cap, and slowly pull the attached electrode soaker bottle down the electrode in half-inch increments until there is a noticeable drop in the volume of the electrode filling solution.

6.4.1.2 Remove the electrode storage bottle and top off the electrode fill chamber with filling solution.

6.4.1.3 Calibrate electrode following the electrode instruction manual for a three-point calibration (Note: Hach 4, 7, and 10 buffers must be used).

6.4.1.4 Check the calibration accuracy by reading the QC7 buffer.

6.4.1.5 Record all the calibration information on the calibration sheet. Then reattach the electrode storage bottle and store the electrode upright.

6.4.2 Conductivity Electrode Calibration (Hach CDC electrode).

6.4.2.1 Rinse the electrode with DI water and set it in fresh 100 umhos/cm conductivity standard. *Note: the conductivity standard is easily contaminated. Keep it tightly capped and avoid diluting it with DI or stream sample water. Also note: the accuracy of freshly opened standard can be affected if unused for over 15 days.*

6.4.2.2 Check the meter settings to ensure the meter reads in the non-linear function (nLF) mode for temperature compensation and the reference temperature setting is 25˚C.

6.4.2.3 Measure the 100 standard. If the result is within the acceptable range of ± 2 umhos of the standard (>98 and <102), then record the initial result and cell constant, sample ID number, and skip the following calibration steps. If the result is beyond the acceptable range, then remeasure a freshly opened standard. If this next result is beyond the acceptable range, then follow the calibration steps below.

6.4.2.4 Calibrate the electrode according to the electrode instruction manual.

6.4.2.5 Record the conductivity standard concentration, the electrode ID number, the initial and final cell constants, the sample ID number, and any other required information on the Electrode Calibration Log Form (see Attachment D).

6.4.2.6 Store the conductivity electrode in DI, tap, or stream sample water at all times. (Do not store with the pH electrode).

6.4.3 Pre-Sample Collection Preparations.

6.4.3.1 Insert a new filter into the filter stand and wet the new filter with DI water to help keep it in place. Reassemble the filter apparatus and turn the filter pump on for 10 seconds to further flush the apparatus.

6.4.3.2 Select an empty BOD bottle from the DO box, record its number on the Field Data Report Form, set it in the bridge sampler bucket, and secure the bucket lid.

6.4.3.3 Consolidate the 10% HCl solution from the two dedicated 1 L nutrient grab sample bottles (marked up with black permanent ink) into one of the bottles, triple rinse the empty bottle with DI water, and secure it in a bridge sampler bottle holder location.

6.4.3.4 Rinse a dedicated 1 L pH and conductivity grab sample bottle (marked with red or green permanent ink) with DI water and secure it in another bridge sampler bottle holder location.

6.4.3.5 Secure clean 1 L TSS and 0.5 L general chemistry (mostly used for turbidity analysis) sample bottles in the remaining bridge sampler bottle holder locations.

6.4.3.6 Secure a bacteria sample bottle in the bacteria sampler.

6.5 Sample Collection Procedures.

6.5.1 Deploy the Long-line thermistor (LLT) electrode and if warranted do a stream height reference point (RP) measurement.

6.5.2 Use one of the following three basic sample collection methods: bridge sampler (mostly used to collect samples from bridges), hand dip, and extension pole. *Note: Always survey the sample location for hazards (such as boating traffic or floating woody debris) that must be avoided when using the sampling gear. Also, if necessary, put on a high-visibility safety vest, turn on the amber strobe beacon light or vehicle emergency flashers, and put out the traffic cones and warning signs.*

6.5.3 Bridge Sampler Method. Carry the sampling gear to sample at the station (e.g., bridge sampler, sample bottles, bacteria sampler, sample ropes, and long-line thermistor) onto the bridge to a well-mixed location such as the main part of the channel where representative stream samples may be collected.

6.5.3.1 Lower the thermistor electrode into the water and let it equilibrate for at least two minutes while completing some of the other sampling tasks.

6.5.3.2 If called for, measure the stream stage height[3] and record the result in the Yellow Field Logbook (Flow Book). Also, record the weighted measuring tape correction factor or check bar measurements. *Note: The keys to the gage houses and wire weight gage boxes are located on the key ring stored in the van above the sampling ropes.*

6.5.3.3 Attach the sampling rope to the bridge sampler[4], remove all the bottle caps, and set the caps aside where they can remain clean.

6.5.3.4 Carefully lower the bridge sampler to the water surface, taking care to not dislodge any bridge debris onto it. Allow the bottom of the sampler to touch the water surface, and then raise the sampler off the water for a few moments to allow any debris from the bottom of the sampler to drop off and float away. Then rapidly lower the sampler about 0.5 meters to submerge it. *Note: This minimizes the sampling of surface film and any debris from the bottom of the sampler*.

6.5.3.5 When the bubbles from the bridge sampler bucket vent tube stop (bucket is full), retrieve the sampler taking care not to dislodge bridge debris into it. If a swift current carries the sampler downstream (before it can completely fill), then pull the sampler above the water, allow it to swing upstream, and then drop it back into the water. This action may need to be repeated a few times until the bucket is full.

6.5.3.6 Set the bridge sampler aside and replace the bottle caps.

6.5.3.7 *Note: If alkalinity or other special study grab samples are needed, then collect them using the bridge or bacteria sampler. Also note: A sample bottle may be added to the bridge sampler through the use of a rubber tie down strap*.

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[3] Stream stage height measurements are obtained at some stations from a reference point (RP) by using a weighted measuring tape, a USGS weighted wire gage, or a staff gage.

[4] The bridge sampler with sample bottle holders can simultaneously collect DO, turbidity, total suspended solids, pH, conductivity, and nutrient samples.

6.5.3.8 Memorize or record the water temperature, push the meter hold button to lock the result, retrieve the thermistor electrode, and set the thermistor aside.

6.5.3.9 Attach the sampling rope to the bacteria sampler, remove the aluminum foil-covered stopper or cap from the bacteria bottle, and place the aluminum foil-covered stopper or cap where contamination can be avoided.

6.5.3.10 Move a few feet over from the location where the bridge sampler was retrieved and carefully lower the bacteria sampler to the water surface, taking care to not dislodge bridge debris or the bridge sampler retrieval water onto it. Allow the bottom of the sampler to touch the water surface, and then raise the sampler off the water for a few moments to allow any debris from the bottom of the sampler to drop off and float away. *Note: This minimizes the sampling of any debris from the bottom of the sampler.*

6.5.3.11 Lower the sampler part way into the water but do not submerge the lip of the sample bottle. Allow the current to re-orient the sampler so the sample bottle is on the upstream side of the sampler. Then rapidly lower the sampler about 0.5 meters to completely submerge it. *Note: This minimizes the sampling of surface film and prevents contamination from the bacteria sampler.*

6.5.3.12 Retrieve the bacteria sampler taking care to not dislodge bridge debris onto it.

6.5.3.13 Carefully replace the aluminum foil-covered stopper or cap in a way that avoids contamination to the inside of the bottle.

6.5.3.14 Return to the van with all the sampling gear.

6.5.4 Stream Side (1-L Funnel and hand dip) Method. This method is typically used to collect samples within reach of the water surface when standing in or near the stream.

6.5.4.1 Carry the funnel, thermistor, and any needed sample bottles using vest pockets and an empty bucket to a well-mixed location such as the deepest part of the active channel or another location where a representative sample may be collected. *Note: Do not contaminate the sample location by wading upstream of it or collect a sample from an eddy.*

6.5.4.2 Put the thermistor electrode in the water and let it equilibrate for at least two minutes while completing some of the other sampling tasks.

6.5.4.3 If called for, measure the stream stage height[5] and record the measurement in the Yellow Field Logbook (Flow Book). Also, record the weighted measuring tape correction factor or check bar measurements. *Note: The keys to the gage houses and wire weight gage boxes are located on the key ring stored in the van above the sampling ropes (or within view of driver).*

6.5.4.4 Rinse the funnel in the stream.

6.5.4.5 Invert the funnel or orient the open end of the funnel upstream and slowly submerge it until it and the funnel tubing completely fills avoiding any entrainment of air bubbles. Pinch the end of the funnel tubing and remove the funnel (top end first) from the water.

6.5.4.6 Insert the end of the funnel tubing into the bottom of a BOD bottle, allow the funnel to overfill the bottle until it is nearly empty, and then quickly withdraw the tubing (do not use any samples that were aerated by the final discharge from the funnel). Insert the glass stopper in the BOD bottle and cap it.

6.5.4.7 Hold the base of one of the sample bottles with one hand and remove the bottle cap. Then invert the bottle, reach upstream, and plunge the bottle into the water about 15 cm (6 inches), and then tip the bottle mouth up toward the water surface. Allow the bottle to fill, take it out of the water, replace the cap, and repeat the bottle filling process to fill the remaining sample bottles. *Note: The pH/conductivity bottle should be filled completely; the other bottles should be filled to the shoulder*.

6.5.4.8 Memorize, push the meter hold button, or record the water temperature, and retrieve the thermistor electrode.

6.5.4.9 Return to the van with all the sampling gear.

6.5.5 Extension Pole Method. This method is typically used to reach a more representative or undisturbed sample location from the stream bank or to sample a shallow stream from a bridge.

6.5.5.1 Carry the extension pole, funnel, thermistor, and needed sample bottles using vest pockets and an empty bucket to a well-mixed location such as the deepest part of the active channel or another location where a representative sample may be collected. Do not contaminate the sample location by wading upstream of it.

6.5.5.2 Put the thermistor electrode in the water and let it equilibrate for at least two minutes while completing some of the other sampling tasks.

[5] Stream stage height measurements are obtained at some stations from a reference point (RP) by using a weighted measuring tape, a USGS weighted wire gage, or a staff gage.

6.5.5.3 If called for, measure the stream stage height[6] and record the measurement in the Yellow Field Logbook (Flow Book). Also, record the weighted measuring tape correction factor or check bar measurements. *Note: The keys to the gage houses and wire weight gage boxes are located on the key ring stored in the van above the sampling ropes.*

6.5.5.4 Secure one of the sample bottles in the extension pole clamp (Collect the FC sample last[7]), remove the cap from the bottle, and place the cap where contamination can be avoided.

6.5.5.5 Use the extension pole to position the bottle just over the desired sample location.

6.5.5.6 Invert the bottle and in one quick motion plunge the mouth of the bottle into the water about 15 cm (6 inches) and then tip the bottle mouth toward the water surface. Wait until the bottle has filled, then take it out of the water, replace the cap, and remove the bottle from the clamp.

6.5.5.7 Repeat this bottle filling process to fill the remaining grab samples.

6.5.5.8 The DO sample must be collected following 1L funnel procedure noted in 6.4.2 above or in combination with the extension pole.

6.5.5.9 Memorize, push the meter hold button, or record the water temperature, and retrieve the thermistor electrode.

6.5.5.10 Return to the van with all the sampling gear.

6.6 <u>Field Processing Procedure</u>. Field processing fulfills three essential purposes: to preserve (fix) the DO sample, to prepare the individual samples for shipment to the lab, and to obtain field measurements for conductivity, pH, and barometric pressure. The typical field processing consists of the following procedure:

6.6.1 Put all the sampling gear into the van.

6.6.2 Tag the fecal coliform sample with the appropriate tag and place it in a cooler of ice.

6.6.3 Remove the BOD bottle from the bridge sampler bucket.

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[6] Stream stage height measurements are obtained at some stations from a reference point (RP) by using a weighted measuring tape, a USGS weighted wire gage, or a staff gage.

[7] Collect the FC sample first in really slow moving streams. This avoids the potential of having the other sampling gear contaminate the sample location for the bacteria sample.

6.6.4 Remove the bottle stopper and fix the sample by adding two milliliters of manganous sulfate reagent followed by two milliliters of alkaline-azide reagent using the disposable pipettes reserved for each reagent. Add these reagents by dispensing them onto the inside neck of the bottle near the top of the sample (do not immerse the tip of the pipette). This should avoid splashing and entraining air bubbles into the sample and prevent any contamination of the reagents.

6.6.5 If necessary, tap the side of the BOD bottle to dislodge any air bubbles clinging to the inside of the bottle. Then insert a glass stopper in the BOD bottle and tip it to discard the displaced water.

6.6.6 Replace the stopper and invert the bottle a few times to mix the reagents into the sample.

6.6.7 Add a few milliliters of water around the stopper to form a water seal and cover the bottle top with a plastic BOD bottle cap.

6.6.8 Place the fixed sample into the DO box. Note: samples must be analyzed within four days.

6.6.9 Get into the van and record the sample time and the stream temperature on the Field Data Report Form. (Be sure to record exact sample times at Hydrolab stations.)

6.6.10 Remove the pH and conductivity grab sample bottle (marked with red or green permanent ink), rinse the pH and specific conductivity measurement cups and electrodes with sample water, and gently over fill the pH and conductivity measurement cups with the sample water. *Note: excessive agitation of the sample water will affect pH.*

6.6.11 Unplug the pH electrode fill hole and carefully remove the pH electrode soaker bottle, rinse the electrode with DI water, and put it in the pH measurement sample cup. Turn on the meter and gently stir the pH electrode for several seconds every half minute (or so) for three to five minutes while completing some of the other field processing tasks.

6.6.12 Open a 125mL preserved nutrient bottle (contains 0.25 mL of sulfuric acid) and a 125 mL preserved nutrient bottle (contains 0.25 mL of hydrochloric acid) set them in the sink bottle holders[8]. Avoid contact with the acid. Shake the 1 L nutrient sample to ensure it is thoroughly mixed and fill each of the preserved nutrient bottles to the bottle shoulder. Cap the bottles and tip them to mix the acid into the samples and set them aside. Also fill a Hardness sample bottle if Metals samples are to be collected at the station. *Note: special study samples such as dissolved organic carbon (DOC), total organic carbon (TOC), filtered total phosphorus, and filtered total nitrogen samples should also be sub-sampled out of the nutrient grab sample and processed at this time*.

[8] Make sure there are a few drops of acid in each bottle.

6.6.13 Turn on the filter pump and put the intake hose in the remaining 1 L nutrient sample. Allow the filtered sample water to run through the filter apparatus for 10-15 seconds to ensure that the DI water has been purged from it. Then fill a 125-mL amber bottle (no preservative) to the shoulder with filtered sample water, cap it, and set it aside.

6.6.14 Remove the intake hose from the 1 L nutrient sample bottle and rinse hose exterior with DI water. Then put the hose in DI water and let the pump run for 10-15 seconds to flush the interior of the filter apparatus.

6.6.15 Gently stir the pH sample with the pH electrode for several seconds prior to and during the time it takes for the meter to indicate a stable sample measurement. Repeat this process until consecutive stable readings are within 0.02 pH units. Record the result and the sample temperature on the Field Data Report Form. *Note: This process may take several minutes and gradual sample temperature changes may alter the pH or prolong the time it takes to obtain a stable result.*

6.6.16 If a Hach PHC281 electrode initial measurement is < 6.5 pH units, then clear the junction and remeasure the sample (not a current method for other Hach pH electrodes).

6.6.17 If the pH result equals 6.5 or less or 8.5 or higher, then check the calibration of the pH meter using the closest buffer (7 or 10). Record the calibration check result on the Field Data Report Form and if necessary, recalibrate meter, and re-measure the sample[9].

6.6.18 Check the calibration of the pH meter after the first, middle, and last station of the day using the QC 7 pH buffer. Record the check result on the Field Data Report Form and the Calibration Log Form. If necessary, recalibrate meter, and re-measure the sample.

6.6.19 Record the conductivity result on the Field Data Report Form or in the Field Logbook. The meter displays results to the nearest tenth, so round the result to the nearest whole number. If the tenths digit > 0.5, then round up; if it is < 0.5, then round down; and if it is = to 0.5 round to the nearest even number. For example, a conductivity result of 103.5 would be rounded to 104 and a result of 62.5 would be rounded to 62.

6.6.20 Record the barometric pressure, stream stage height, and any other measurements on the Field Data Report Form. Then record any weather or unusual site specific observations, and equipment issues (spend some time on this as these narrative observations can help explain any anomalous data on the form).

[9] If the difference between the pH meter result and the standard is greater than or equal to 0.10 pH units then recalibrate the meter, if the difference between the pH meter result and the standard is greater than or equal to 0.15 pH units, then recalibrate the meter, re-read the sample, and "J" data since last calibration check.

6.6.21 ***Note: if you observe any unusual or suspicious looking colored water in or entering the stream, or other potential environmental hazards (drums, dead animals, or new invasive plants or benthic macro invertebrates), then take some pictures and make notes about the observation and your exact location. If the suspicious looking colored water or potential environmental hazard is dangerous, then do not approach*!**

6.6.22 ***If the suspicious looking colored water is obviously not dangerous, then take some precautions and collect two water samples (500mL bacteria and 1L - TSS) to send to the lab. Also, if warranted, collect any potential new invasive plant samples for later identification. Send to Jenifer Parsons (Program plant specialist) or other agency staff that can do the identification*.**

6.6.23 ***In addition, immediately report these observations to the appropriate Ecology contacts (Ecology's Spills Hotline, regional office staff, and/or watershed lead) and indicate that there are samples being sent to the Manchester Lab for potential analysis if it is warranted.***

6.6.24 Label the all sample bottles with the appropriate sample tags, double check the station ID on the tag, and place them in ice in a cooler.

6.6.25 Remove and discard the used filter from the filter apparatus, rinse the inside of the apparatus with DI water, and insert a new filter.

6.6.26 Wet the new filter with DI water to keep it in place, reassemble the filter apparatus, and then turn the filter pump on for 10-15 seconds to flush the apparatus with DI water.

6.6.27 Select an empty BOD bottle from the DO sample box, record its number on the Field Data Report Form, place it in the stainless bridge sampler bucket, and secure the bucket lid.

6.6.28 Rinse the used nutrient sample bottle with DI water and pour the 10% acid solution from the spare bottle into the newly rinsed bottle. Cap it, shake it, and set it aside in the sink to soak until the next station.

6.6.29 Triple rinse the newly emptied nutrient sample bottle with DI water, and secure it in a bridge sampler bottle holder location.

6.6.30 Rinse the dedicated 1 L pH and conductivity grab sample bottle with DI water and secure it in another bridge sampler bottle holder location.

6.6.31 Secure clean 1 L and 0.5 L sample bottles in the remaining bridge sampler bottle.

6.6.32 Rinse electrode with DI water, carefully re-attach the quarter-filled electrode soaker bottle, plug the fill hole, and store the electrode upright.

6.6.33 Decontaminate all field gear and equipment following the "Standard Operating Procedures to Minimize the Spread of Invasive Species" (Parsons, et. al, 2012).

6.6.34 Repeat the Sample Collection and Processing Procedures (see procedures 6.4, and 6.5 above) at the rest of the sampling stations. *Note: the calibration of the pH meter must be checked against a QC 7 pH buffer (not used for calibration purposes) after the first, middle, and last stations of the day. The conductivity meter needs to be checked after the last station of the day. Record the results on the Field Data Report Form and on the Meter Calibration Log Form.*

6.7 Metals Sampling Procedure. If called for, return to the sample location, and collect the metals samples[10] .

6.7.1 This sampling procedure generally follows EPA Method 1669. Samples are collected as single grabs in a 500ml Teflon FEP bottle using the stainless steel metals sampler or by hand. Care must be used at all times when collecting and processing metals samples to avoid contaminating the inside of the sample bottle or cap with debris and to minimize the contact with ambient air.

6.7.2 Metals samples should be processed (filtered, preserved, and placed on ice) within 15 minutes after having been collected. If the metals processing requirement was not met then make a note to the lab on the field sheet (and in the remarks) indicating how long it took to process the sample. The lab may "J" qualify the data. Note: the holding time prior to analysis for all metals, except mercury, is six months and the holding time for mercury is 28 days.

6.7.3 Metals Sampler Method. This method is typically used to collect samples from a bridge or from the stream bank through the use of a rope.

6.7.3.1 Move to a well-mixed location such as the deepest part of the active channel where a representative sample may be collected.

6.7.3.2 Invert the Teflon sample bottle, remove the cap, and rinse the sampler with the "ultra-pure" water that empties out of the bottle.

6.7.3.3 After the bottle empties, set the sampler down and replace the bottle cap.

6.7.3.4 Then fit the sample bottle into the base of the stainless steel metals sampler.

6.7.3.5 Completely loosen the bottle cap while it is kept on the bottle opening. Gently lower the sampler lifting arm hose-clamp over the cap and then tighten the clamp to secure it.

6.7.3.6 Attach the sampling rope.

[10] Metals samples are collected at a few selected stations every other month.

6.7.3.7 Move to a well-mixed location such as the deepest part of the active channel where a representative sample may be collected.

6.7.3.8 Check to make sure the sampler lifting arm can move up freely.

6.7.3.9 Carefully lower the sampler to the water surface, taking care to not dislodge bridge debris onto it. Allow the bottom of the sampler to touch the water surface, and then raise the sampler off the water for a few moments to allow any debris from the bottom of the sampler to drop off and float away. *Note: This minimizes the sampling of any debris from the bottom of the sampler.*

6.7.3.10 Lower the sampler about 15 cm (6 inches) into the water. Allow the current to re-orient the sampler so the sample bottle is on the upstream side of the sampler. Then rapidly lower the sampler about 0.5 meters to completely submerge it. This minimizes the sampling of surface film. *Note: At about 25 cm under the water surface, the sampler should automatically raise the bottle cap and allow the bottle to fill. Also, it may take more than 45 seconds for the bottle to fill.*

6.7.3.11 Retrieve the filled bottle taking care to not dislodge bridge debris onto it or the sampler.

6.7.3.12 Hold the bottle cap down on the bottle opening, carefully loosen the lifting arm hose-clamp, screw on the cap until it is tight, remove and tag the bottle, and place the bottle back in the Ziploc bags that it shipped in.

6.7.3.13 Repeat the procedure to obtain a second metals sample.

6.7.3.14 Put on a pair of gloves from the special Hg metals bottle bag and repeat procedures 6.7.3.1 – 6.7.3.4 to secure the bottle in the sampler.

6.7.3.15 Remove the gloves and follow procedures 6.7.3.5 – 6.7.3.10 to collect the sample.

6.7.3.16 Put on another pair of the gloves, hold the bottle cap down on the bottle opening, carefully loosen the lifting arm hose-clamp, screw on the cap until it is tight, remove and tag the bottle, and place it back in the Ziploc bags that it was shipped in. ***Note: Do not acidify this sample.***

6.7.3.17 Return to the van with the samples and sampling gear.

6.7.4 Hand Dip Method. This method is typically used to collect samples from a small or shallow stream, or near the bank of a large stream.

6.7.4.1 Move to a well-mixed location such as the deepest part of the active channel or another location where a representative sample may be collected. *Note: Do not contaminate the sample location by wading upstream of it or collect a sample from an eddy.*

6.7.4.2 Grab the base of the sample bottle with one hand, invert the Teflon sample bottle, remove the cap, and let the "ultra-pure" water empty out of the bottle.

6.7.4.3 Reach upstream and plunge the bottle into the water about 15 cm (6 inches) and then tip the bottle mouth up toward the water surface.

6.7.4.4 Allow the bottle to fill and then take it out of the water.

6.7.4.5 Replace the cap in a way that avoids contamination to the inside of the bottle and place the bottle in the Ziploc bag it shipped in.

6.7.4.6 Repeat procedure 6.7.4.1 – 6.7.4.6 to obtain a second metals sample.

6.7.4.7 Put on two pair of gloves from the special metals bottle bag, remove the cap, collect the New Hg Metals sample, remove one pair of the gloves, replace the cap, tag the bottle with the new Hg tag, and place it back in the Ziploc bags it shipped in. ***Note: Do not acidify this sample or set the cap down.***

6.7.4.8 Return to the van with the samples and sampling gear.

6.7.5 Extension Pole Method. This method is typically used to reach a more representative or undisturbed sample location from the stream bank or slow moving stream.

6.7.5.1 Secure the metals sample bottle in the extension pole clamp.

6.7.5.2 Move to a well-mixed location where a representative sample may be reached with the pole. Note: Do not contaminate the sample location by wading upstream of it and do not collect a sample from an eddy.

6.7.5.3 Invert the Teflon sample bottle, remove the cap, and let the "ultra-pure" water empty out of the bottle. Also, put the cap into the Ziploc bag the bottle shipped in and put the bag in a location that will prevent contamination to the inside of the cap.

6.7.5.4 Position the bottle over the desired sample location.

6.7.5.5 Invert the bottle and in one quick motion plunge the mouth of the bottle into the water about 15 cm (6 inches). Then slowly move the bottle upstream with the bottle mouth tipped toward the water surface until the bottle has filled.

6.7.5.6 Take the filled bottle out of the water and then replace the bottle cap in a way that avoids contamination to the inside of the cap and bottle.

6.7.5.7 Repeat the procedure to obtain the second metals sample.

6.7.5.8 Put on two pairs of gloves from the special new Hg metals bottle bag, remove the cap, collect the New Hg Metals sample, remove one pair of gloves, replace the cap, tag the bottle with the new Hg tag, and place it back in the Ziploc bags that it shipped in. ***Note: Do not acidify this sample or set the cap down.***

6.7.5.9 Return to the van with the samples and sampling gear.

6.8 Metals Field Processing Procedure.

6.8.1 Total Recoverable Metals and Total Mercury.

6.8.2 Close the vehicle door to minimize drafts

6.8.3 Put on powder-free vinyl or nitrile disposable gloves.

6.8.4 Remove the disposable filter unit from the large Ziploc bag and set the bag and filter unit aside.

6.8.5 Unscrew the cap from the first sample bottle (but leave it on the bottle).

6.8.6 If necessary, gently squeeze the side of the sample bottle to displace about 5 ml of sample to make room for the Nitric acid preservative.

6.8.7 Carefully uncap the small Teflon vial containing 1:1 Nitric acid, lift the cap from the sample bottle and add the acid to the sample. Screw the cap on the sample and then re-cap the empty Nitric acid vial.

6.8.8 Attach the Total Metals and Total Recoverable Mercury sample tag to the sample bottle.

6.8.9 Place the tagged sample in its original Ziploc bag along with the empty (capped) Teflon vial, eliminate air from the Ziploc bag, seal it and then put it in the large Ziploc bag that contained the filter unit.

6.8.10 Dissolved Metals.

6.8.10.1 Attach the hand pump (or peristaltic pump) hose to the metals filter unit.

6.8.10.2 Remove the cap from the second sample bottle; lift up one side of the filter unit lid about 3 cm (1 inch), and pour the sample into the top of the unit. Note: Avoid touching or contaminating the inside of the filter unit.

6.8.10.3 Cap the empty sample bottle and put it into the large Ziploc bag that also contains the tagged total metals sample.

6.8.10.4 Hold onto the filter unit with one hand and use the other hand to squeeze and release the hand pump lever (or turn on the peristaltic pump on the lowest setting) to create a vacuum no greater than 20 PSI[11] to filter the sample.

6.8.10.5 Filter as much of the collected sample as possible (at least half).

6.8.10.6 Empty "ultra-pure" water from an unused Teflon bottle and set the cap on the bottle opening.

6.8.10.7 Unscrew the bottom of the filter apparatus, remove the cap from the top of the unused Teflon sample bottle (do not set the cap down), pour the filtered sample into the Teflon bottle, and set the cap on the bottle opening.

6.8.10.8 Carefully uncap the small Teflon vial containing 1:1 Nitric acid, lift the cap off the bottle containing the filtered sample, and add the acid to the sample. Screw the cap on the sample and then re-cap the Nitric acid vial.

6.8.10.9 Attach the Dissolved Metals sample tag to the sample bottle.

6.8.10.10 Place the tagged sample in its original Ziploc bag along with the empty (capped) Teflon vial.

6.8.10.11 Eliminate air from the Ziploc bag, seal it, and put it in the large Ziploc bag that contains the tagged total metals sample and the empty Teflon bottle.

6.8.10.12 Eliminate air from the large Ziploc bag and place the bagged samples on ice in a cooler.

6.8.11 Field Processing – New Hg Metals

6.8.11.1 Put it in the large Ziploc bag that contains the: tagged total metals sample, dissolved metals sample, and the empty Teflon bottle.

6.9 Quality Assurance / Quality Control Sampling Procedures. Stations for Quality Assurance / Quality Control (QA/QC) samples are assigned at random prior to the water year. A typical Run has two field blank stations and ten field replicate/field split stations per year. One QA sample station is assigned per Run per month. This sampling follows the regular sampling process for the station.

6.9.1 Field Replicate/Field Split Samples[12].

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[11]Any peristaltic pumps used for metals filtering must be checked to verify that the lowest setting will not create a vacuum greater than 20PSI.

[12] Replicate samples are collected after the normal set of samples have been collected, processed, and the sampling equipment has been set up to sample another station. The QA_-1 samples are used to assess variability from short-term instream processes and field and lab processing. The QA_-2 samples are used assess variability from only the field and lab processing.

6.9.1.1 Repeat the normal sample collection and processing procedures (See sections 6.4 and 6.5) to collect a second set of field grab samples at the station. Then collect two samples out of the of the same 1 L nutrient grab sample (instead of one set). ***Note: the split samples for the station are usually just nutrient samples, but they may also include non-nutrient samples such as hardness, TOC, and DOC.***

6.9.1.2 Label the first set of collected samples with the QA_-1 (field replicate) tags and label the second samples with the QA_-2 (field split) tags. ***Note: There is no need to split any sample that is collected directly in the bottle and sent to the lab. Also note that the QA_-3 tags is are to be used if any QA samples are collected at a station other than the station associated with the QA_-1 and QA_-2 samples.***

6.9.2 True Process Field Blank Samples. The purpose of this procedure is to subject the blank samples to all the typical sample collection contamination sources.

6.9.2.1 Do not collect fecal coliform or DO samples, or take any pH or temperature measurements.

6.9.2.2 Load the bridge sampler with all the normal plastic sample bottles (TSS, general chemistry, nutrient, and pH/conductivity). Go to the sample site, remove the bottle caps, and set the caps in the typical location you would use at that site (such as on the road or bridging). Lower the bridge sampler to the water surface (do not immerse anything into the stream), retrieve the sampler, and cap the bottles.

6.9.2.3 Return to the van and fill all the containers except the stainless bucket with the Lab provided DI water.

6.9.2.4 Fill the conductivity measurement cup with water from the pH/conductivity grab sample bottle, allow the conductivity electrode to stabilize, and record the measurement.

6.9.2.5 Go through the normal process of obtaining the preserved nutrient bottle samples and filtered nutrient samples from the nutrient grab sample bottle.

6.9.2.6 Label the bottles with the appropriate QA_-1 tags, place them in ice in a cooler, and note the time and conductivity measurement on the Field Data Report Form.

6.9.3 True Process Field Metals Blank Samples[13].

6.9.3.1 Load the sampler with a metals bottle (do not empty the special "ultra-pure" DI water out of the bottle). Go to the sample site, remove the bottle cap, and put the cap in a dry Ziploc bag to avoid any contamination. Lower the Metals Sampler to the water surface (do not immerse anything into the stream), retrieve the sampler, and cap the bottle.

[13] One Metals blank is collected per Run per year.

6.9.3.2 Return to the van and follow the Dissolved Metals processing procedure (see procedure 6.8.10) and filter the ultra-pure de-ionized water from the sample bottle. Then pour the filtered DI water sample back into the same bottle the water came from, cap it, label it with a QA_-1 tag and place it on ice.

6.10 <u>End of Day QC Procedures.</u>

6.10.1 Check the calibration of the pH electrode using the QC 7 pH buffer. Record the result on the Field Data Report Form and the electrode calibration form and if necessary, recalibrate meter, and re-measure the last sample.

6.10.2 Rinse electrode with DI water, carefully re-attach the quarter-filled electrode soaker bottle, plug the fill hole, and store the electrode upright.

6.10.3 Check the calibration of the conductivity electrode. Record the result on the electrode calibration form Form. If the conductivity measurement is not within 5 µmhos/cm of the standard then troubleshoot the meter and if necessary re-measure all of the samples using the general chemistry sample.

6.10.4 Review the information recorded on the Field Data Report Form for completeness.

6.10.5 Use a pen to fill out the Lab Analysis Required Form (LAR). The information required includes: sample times, field contact phone number, relinquished by, relinquish time, relinquished to “Walk in cooler”, if necessary, number of coolers, and any helpful comments. Initial and date any changes made to the form in ink.

6.11 <u>OC Walk-in Cooler Shipping Procedures</u>.

6.11.1 Drain the ice water from the sample cooler(s), top the samples off with a couple scoops of ice, and set the cooler(s) in the walk-in cooler. Put a tag on the handle of the cooler indicating it goes to MEL to make identification easier.

6.11.2 Put in the completed LAR in the courier’s inbox tray located near the walk-in cooler.

6.12 <u>Greyhound or motor freight (truck) Shipping Procedures.</u> ***Note: If possible, avoid shipping on Greyhound, because this method can delay the receipt of the samples by the lab***.

6.12.1 Fold the completed LAR, put it in a plastic sandwich bag, and tape the bag under the sample cooler lid.

6.12.2 Drain the coolers of ice water, and top them off with some additional ice or frozen Gel-Ice (Blue-Ice). *Note: do not overload the cooler with Gel-Ice because this can freeze the samples. Also, all sample coolers used to ship samples must be in good condition and not leak.*

6.12.3 Tape the cooler drain plug and lid using ¾ or 1 inch reinforced tape. It works best to tape over the drain plug first and then wrap tape twice around that end of the cooler and cooler lid.

6.12.4 Check the sample cooler(s) in at the package service counter of the shipper and provide Ecology's account number along with any other necessary information.

6.12.5 If the shipper indicates any problems with the shipment schedule, then notify the courier.

6.13 <u>Airfreight Shipping Procedures</u>. GoldStreak – Alaska Airlines/Horizon Air Cargo is the current provider of this service for the sample cooler shipments. *Note: The airline may require a 24 hour advance notification procedure. The shipment can be booked online the week before the run.*

6.13.1 Fold the completed LAR, put it in a plastic sandwich bag, and tape the bag under the lid of an empty (dry) sample cooler lid of a cooler that is in good condition and will not leak. Tape the cooler drain plug using ¾ or 1 inch reinforced tape.

6.13.2 Transfer the iced samples into the empty (dry) sample cooler and be sure that the all the sample container lids are tight.

6.13.3 Top off the samples with several frozen Gel-Ice. The amount of Gel-Ice may need to be increased during hot weather to ensure that the samples remain at or below 4° C during shipment. If the Gel-Ice were frozen or kept frozen with dry ice, then use only a few of them to top off the samples[14].

6.13.4 Hold off taping the cooler(s), but take the tape with you so it can be done after check-in and TSA inspection.

6.13.5 Check the sample cooler(s) in at the airline airfreight office or ticket counter. They will need Ecology's Customer ID number, your personal and Ecology ID, and possibly other necessary information. Request that they attach a Keep Cool Sticker to the cooler lid or side and have the officer from the Transportation Security Administration (U.S. Department of Homeland Security) tape the cooler lids down after the cooler contents have been inspected. If possible watch the process to be sure they remember to secure the cooler lids down with tape. *Note: The process allowed to get the cooler lids secured with tape varies at each airport. Some airport staff will let us tape the coolers using our tape, others will tape them using our or their tape (ask if you can watch for chain-of-custody reasons), and sometimes they will tape the lids but not allow you to watch.*

6.13.6 Contact the lab courier with any changes to the planned air shipment and the **air waybill number** (already noted in the forwarded airline confirmation) after the cooler(s) have been shipped.

[14] Dry ice freezes Gel-Ice colder and some samples could be frozen if several of them are used.

6.14 End of Day Procedures

6.14.1 Call the contact person noted on the Field Work Plan & Contact Person Form.

6.14.2 Lift the tube out of the DI water for the filter apparatus, lay the tube across the top of the apparatus, turn on the pump, and pump the filter apparatus dry.

6.14.3 Move the meters, electrodes, a filled DI water wash bottle, pH buffers, and conductivity standard into a heated room (hotel room, regional lab, or operation center).

6.14.4 If the overnight air temperatures will be at or below freezing, then also move the DI water, and DO box containing DO samples into a heated room to prevent freezing or loss to breakage.

6.15 DO Laboratory Analysis - *Note: Save all Winkler chemical waste resulting from any analysis (in a pail or bucket) for treatment (See 6.15.7 Winkler Waste Treatment and Disposal Methods). Also Note: the titration procedures are also documented in a Winkler training video in the Training area of EAP SharePoint.*

6.15.1 Initial Cleaning Procedure:

6.15.1.1 Put on a plastic apron and Nitrile gloves.

6.15.1.2 Thoroughly rinse the flask and stir bar with deionized water.

6.15.1.3 Check and if necessary fill the Potassium bi-iodate dispenser and starch squirt bottle.

6.15.1.4 Fill the Sodium thiosulfate reservoir and loosen the reservoir cap. *Note: it is best to do this a few hours before the titrations, so the solution may reach room temperature and there are no chemical reaction delays during the titration process.*

6.15.1.5 Open the volumetric burette stopcock to a fill position.

6.15.1.6 Raise and lower the sodium thiosulfate storage bottle reservoir above and below the volumetric burette a few times to flush the burette and to mix the sodium thiosulfate in the reservoir.

6.15.1.7 Clamp the reservoir onto the workstation lab-frame above the volumetric burette.

6.15.1.8 Set a small beaker under the burette tip and turn the stopcock to the drain position to dispense the old thiosulfate from the burette but not the burette tip. Refill the burette and then drain it a second time to also rid any old thiosulfate from the tip. Avoid empting the burette tip, because the resulting air bubble is difficult to eliminate.

6.15.2 Titration Procedure:

6.15.2.1 Remove the plastic cap from the BOD bottle.

6.15.2.2 Pour off the water seal and invert the bottle several times to mix the floc.

6.15.2.3 Allow the floc to settle to the lower half of the bottle.

6.15.2.4 Put on the face shield.

6.15.2.5 Remove the bottle-top sulfuric acid dispenser from the acid storage cabinet. The dispenser should already be pre-set to dispense 2 mL of acid.

6.15.2.6 Remove the glass stopper of the BOD bottle. Dispense 2 mL of the acid into the DO sample and put the acid bottle back into the cabinet. ***Note: Concentrated sulfuric acid is a very dangerous chemical and should be handled very carefully. Never add water to it and always immediately rinse and dispose of gloves that get any acid on them.***

6.15.2.7 Re-stopper the BOD bottle and invert it several times over the sink until the precipitate has completely dissolved. The sample should have a clear yellowish color. If some floc remains in BOD bottle, then invert the bottle several times to mix the floc and allow 5-6 minutes for the precipitate to dissolve. If the floc still has not dissolved then add a few drops of sulfuric acid from the sulfuric acid dispenser until floc completely dissolves.

6.15.2.8 Slide a magnetic stir bar into an empty 500 mL Erlenmeyer flask.

6.15.2.9 Fill a 203 mL volumetric flask[15] with the DO sample, transfer the sample to the Erlenmeyer flask, and set the flask in the sink.

6.15.2.10 Refill the volumetric burette with sodium thiosulfate (make sure the sodium thiosulfate escapes from the top nipple).

6.15.2.11 Place the Erlenmeyer flask containing the sample on the magnetic stirrer and turn on the stirrer to the lowest setting.

6.15.2.12 Titrate the sample with the Sodium thiosulfate from the volumetric burette until it turns to a pale yellow color.

6.15.2.13 Squirt 1 to 2 mL of the starch solution into the sample. Note: the addition of the starch solution earlier than this can cause a less distinct titration endpoint or overshooting the end point.

[15] This is a slight modification of azide modification method presented in SM 20th Edition, 1998, which calls for the addition of 1 mL of manganous sulfate and alkali-iodine azide instead of 2 mL. The excess reagents are accounted for by using 203mL volumetric flasks rather than 201mL flasks.

6.15.2.14 Continue the titration process by adding the sodium thiosulfate by quickly twisting the burette stopcock past the discharge point (or by slowly adding individual drops) until the purple color of the sample just disappears. This is the titration end point[16] and it should be sharp and distinct[17]. Care should be taken to avoid an end point overrun.

6.15.2.15 Check the titration end point of any sample that was possibly overrun by adding a drop of bi-iodate from a 3 mL graduated disposable transfer pipette to the titrated sample. If the end point is correct, a faint purple color should reappear. If more than one drop of bi-iodate is required to get a faint purple color, then the end point was overrun and a Back-Titration needs to be done to correct the result (see 6.14.3 – Back-Titration).

6.15.2.16 Record the titration result or corrected titration result in the proper column on the Field Data Report Form or in the field notes as mg/L of DO[18]. If the value is between the 0.1 mL marks on the burette, round the even numbers down and the odd numbers up (e.g., 10.25 to 10.2 and 10.35 to 10.4).

6.15.3 Back-Titration Procedure

6.15.3.1 Back-titrate an overrun end point sample using bi-iodate drops from a 3 mL graduated disposable transfer pipette (1 drop = 0.05 mg/L). Correct the final value[19] if the back-titration requires fewer than or equal to 8 drops and record the result without qualification[20]. If the back-titration requires more than 8 drops but less than or equal to 20, correct the final value and record the result with a "J" qualification (twenty drops are equivalent to 1 mg/L). If the back-titration requires more than 20 drops, do not record a result, but make a comment on the Field Data Report Form indicating the titration error[21].

6.15.3.2 If a graduated burette or pipette is available, then carefully back-titrate to the overrun end point sample using a measured quantity of bi-iodate and subtract the amount used to correct the final result.

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[16] The volume of sodium thiosulfate used to titrate 203 mL of a sample equals the DO of the sample in mg/L.
[17] If the end point was not sharp and distinct or the sample contains purple flakes, then replace the starch solution (it may have gone bad – this is rare). Record the result with a "J" qualification to indicate the result is an estimate and note that the starch was bad and was replaced on the Field Data Report Form.
[18] The mL of Sodium thiosulfate used to analyze a 200mL sample with this method is equal to the DO concentration in mg/L.
[19] The corrected final value is the final value - (number of drops used x 0.05 mg/L). For example, if 8 drops were used and the final value was 10.3 mg/L, then the corrected final value is 9.9 mg/L (10.3 mg/L - (8 x 0.05 mg/L or 0.4 mg/L)).
[20] Justification: Our MQOs specify 0.2 mg/L; 8 drops is equivalent to 0.4 mg/L which leaves a generous allowed error of 50% for miscounting, imprecise drop size, etc. to still be within MQOs.
[21] Justification: Results with a potential error of 50% of 1 mg/L, or 0.5 mg/L, should not be recorded at all.

6.15.4 Sodium Thiosulfate Normality Check. The test is done to verify the strength of the Sodium Thiosulfate solution and get a data correction factor. The normality check result should almost always be between 9.95 and 10.05 mL if the Sodium Thiosulfate has been stored properly. The result should also be very similar to those that others have recently recorded in the Titration Log.

6.15.4.1 After the first sample has been titrated to its end point, add exactly 10 mL of the bi-iodate standard using: a 10 mL volumetric burette, w/3-way stopcock, 10 mL bottle-top dispenser, or glass volumetric pipette. Rinse the inside wall of flask with starch solution to ensure that none of the standard is on it and re-titrate.

6.15.4.2 Repeat this procedure mid-way through the batch of samples to be titrated.

6.15.5 Record the volume of the sodium thiosulfate needed for each normality check on the field notebook or worksheet and on the titration log located next to the titration station (The average of the two normality checks is used as a correction factor for the field data). *Note: These normality checks should be very close, within 0.2 mL. If they are not, then do at least two more until you have three consecutive results (within 0.2 mL of each other) to use to calculate a correction factor*.

6.15.5.1 If you get less than a 9.95 mL result, then repeat the normality check on another sample but do the following first:

6.15.5.2 Eliminate air from the tip of the Potassium Biiodate bottle-top dispenser to ensure it dispenses a 10.0 mL.

6.15.5.3 Gently dispense the Potassium Biiodate into the titrated solution in the bottom of the Erlenmeyer flask and avoid getting any on the inside flask wall,

6.15.5.4 Rinse the inside flask wall with starch solution to ensure that all of the Potassium Biiodate is in the titrated solution, and eliminate Sodium Thiosulfate drops/residue from the outside of the refillable burette tip and tube connection.

6.15.6 Correcting Titration End Point Results with Normality Check (NC) Results[22].

6.15.6.1 Note: If using the ambient database, these corrections will be done automatically; simply enter the mL of thiosulfate needed into the database “correction factor” field.

6.15.6.2 Divide the average of the two or more normality check results into 10 to get the correction factor (10/NC avg.), and then multiply the measured result by the correction factor (CF) to get the corrected result (Corrected DO = measured DO × CF).

6.15.6.3 For example, if the average of the normality checks was 9.9 mL and the sample titration result was 11.5 mL, then:

[22] The Ambient database automatically does this.

6.15.6.4 Correction Factor Multiplier = (10/NC avg.) = (10/9.9 mL) = 1.01CF

6.15.6.5 Corrected Result = (measured DO × CF) = (11.5 mL × 1.01CF) = 11.6 mL. *Note: The corrected result is the volume, in mL, of sodium thiosulfate used to titrate a 200mL sample. This volume is equivalent to the concentration of DO in mg/L.*

6.15.7 Waste Treatment Procedures. Follow procedure depicted in Figure 4 below, record final pH on the Winkler Waste Treatment Record (Attachment E), and rinse the treated waste down the drain with copious amounts of tap water.

Figure 4. Winkler Waste Treatment.

6.15.8 Lab Clean Up Procedure

6.15.8.1 Move the sodium thiosulfate reservoir back to its storage area on the counter.

6.15.8.2 Open the volumetric burette stopcock to a fill position (this allows the thiosulfate in the volumetric burette to return to the reservoir).

6.15.8.3 Tighten the reservoir cap, drain thiosulfate from the burette to a level just above the stopcock (leave thiosulfate in the tip), and leave the stopcock in a closed position.

6.15.8.4 Thoroughly rinse the used flasks and stir bar(s), and give them a final rinse them with DI water.

6.16 End of Run Procedures.

6.16.1 Brush and DI rinse the pH and conductivity sample cups and store them upside down.

6.16.2 DI rinse the filter apparatus and pump the lines dry.

6.16.3 Rinse the conductivity electrode with DI water.

6.16.4 Store the meter(s), electrodes, pH buffers, and conductivity standards in a warm and dry area in the regional lab or operation center.

6.16.5 Refill the manganous sulfate monohydrate and alkali-iodine-azide reagent containers in the DO box.

6.16.6 Empty the van of trash and vacuum it out.

6.16.7 Top off the gas tank (tank must be at least ¾ full).

6.16.8 If warranted, get the van oil changed.

6.16.9 Turn any malfunctioning equipment into the Operation Center Technician along with a completed Equipment Problem Report Form for repair at the end of each Run. Malfunctioning equipment may result in unsafe sampling conditions and lost sampling opportunities.

6.16.10 Enter the field data results and comments into our Access-based database, review the entries for accuracy, and turn in the printout of the Run Field Data sheet along with the other documentation to the database manager. *Note: The run isn't considered complete until the field data have been entered and finalized in the database. This means that normally you would do the run, analyze the DO samples, clean up your gear, and enter data before doing any other non-run-related tasks.*

7.0 Records Management

7.1 All hardcopy documentation of the data, such as completed Field Logbook and Field Data Report Forms are kept and maintained by the project lead. These documents are organized in binders or in expanding files. After about six years, hardcopies are boxed and moved to EAP archives.

7.1.1 The data are entered into our Access-based database, reviewed and verified following the Quality Control and Quality Assurance procedures, uploaded into EIM, and posted on our webpage www.ecy.wa.gov/programs/eap/fw_riv/.

8.0 Quality Control and Quality Assurance Section

8.1 The data QA program for field sampling consists of three parts: (1) adherence to the SOP procedures for sample/data collection and periodic evaluation of sampling personnel, (2) consistent instrument calibration methods and schedules, and (3) the collection of a field quality control (QC) sample during each sampling run. Our QA program is described in detail in Hallock and Ehinger (2003) and Hallock (2012).

8.2 The field QC samples are collected as a duplicate (sequential) field sample. This consists of the collection of an additional sample approximately 15-20 minutes after the initial collection at a station. This sample represents the total variability due to short-term, in-stream dynamics, sample collection and processing, and laboratory analysis.

8.3 The annual field QC metals sample is a filtered field blank sample. This sample captures potential contamination from sample processing and laboratory analysis.

8.4 A two-tiered system is used to evaluate data quality of individual results based on field QC. The first tier consists of an automated evaluation of the data. Results exceeding pre-set limits are flagged. The second tier QC evaluation is a manual review of the data flagged in the first tier. Data are then coded from 1 through 9 (1 = data meets all QA requirements, 9 = data are unusable). Criteria for assigning codes are discussed in more detail in Hallock and Ehinger (2003) and Hallock (2012). We do not routinely use or distribute data with quality codes greater than 4.

8.4.1 The overall quality of data collected during the sampling year are evaluated in our annual reports (e.g., Hallock, 2011)

9.0 Safety

9.1 Safety is the primary concern when collecting samples. Since most sample sites are located on highway bridges, road and pass conditions should always be checked before departure (especially in winter). If roadside hazards, weather, accidents, construction, etc. make sample collection dangerous, then skip that station. Note the reason on the Field Data Report Form and notify your supervisor of the hazard when you return to the office. If the hazard is a permanent condition, relocation of the station may be necessary. Review Ecology's Safety Program Manual periodically to assist with these safety determinations.

10.0 References

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10.4 EPA, 1996. Method 1669, Sampling Ambient Water for Trace Metals at EPA Water Quality Criteria Levels. Washington, D.C.

10.5 Hallock, D., 2007. Addendum to Quality Assurance Monitoring Plan: Stream Ambient Water Quality Monitoring: Correction of Objectives, Responsibilities, and Addition of Analytes. Washington State Department of Ecology, Olympia, WA. 11 pp. Publication No. 03-03-200Add2.
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Attachment A – Draft Station Selection Guidance

Draft Water Year Planning and Basin Station Selection Guidance

We have had problems with final station selection not happening until late September or even into October, after the new Water Year has already begun. As a result, scoping gets neglected, location metadata collection may be sloppy or overlooked, samples may be missed, stations get moved after sampling has begun, and data management is convoluted, which risks data being compromised.

Sometimes there are legitimate reasons for delaying station selection, but too often the reason is that we are all too busy with other things. To help shepherd the station selection process, this document includes some milestones for preparing the ambient runs for a new water year, as well as some guidance for identifying suitable basin stations.

Milestones

Date	Task
June	Ambient regional staff will work with stakeholders (regions, TMDL staff, TMDL effectiveness staff, watershed leads, local governments, etc.) and each other to develop a list of basin stations for the coming water year. (See selection criteria, below.) Identify any supplemental parameters (and funding sources), metals stations, flow-critical stations, etc. to the ambient coordinator. (Some scoping at questionable stations may be required at this time.)
Late July	Ambient regional staff will submit lists of basin stations (final, pending scoping) directly to stakeholders and, via the ambient coordinator to the flow group and EAP managers. Include supplemental parameters, reasons for sampling each station, etc. Also include any proposed stations that were not selected, and the reason they were not selected.
August	Ambient staff will scope basin stations. Look for safe parking and bridge access, safe and representative (e.g., well-mixed) bank sample location. Consider high-flow conditions (and high-tide condition, where applicable). Record cross-section temperatures and conductivities. Take notes for developing run directions (road names, etc.). Take photographs (upstream and downstream) and GPS coordinates (NAD83). The ambient coordinator will provide a sampling schedule for the upcoming water year to MEL and the flow group. The flow group will identify stations where flows may not be available.
Late August	Ambient regional staff will submit the final list of basin stations directly to stakeholders and, via the ambient coordinator to the flow group and EAP managers. Ambient regional staff will indicate the availability of flows at stations where flows are not expected.
Early September	Ambient staff will plan the new water year run. Enter day/order/lab number information, parameters for each station, the coming year's sampling schedule, etc., into a temporary database, complete run directions, etc.
Mid September	Database administrator will submit required reports to MEL.
Late September	Ambient staff must enter September field data on time (the Thursday after the run). After the last run is entered, the database administrator will switch the database over to the new water year's schedule.
October 1	New water year begins.

[*NOTE: Ambient regional staff includes all ambient staff responsible for the Runs in each of the four Ecology regions (currently six Runs) and the database administrator/coordinator.*

Sampling Design

Our standard monitoring design consists of monthly sampling for the constituents listed in the table, below. We are usually willing to collect additional constituents when the analysis is funded by a stakeholder.

Our funding is sufficient to sample a total of 82 stations (plus quality control samples). We have divided these into 62 long-term stations that we monitor every year and 20 basin stations that can change from year to year. If logistics allow, we are usually happy to monitor additional basin stations, provided a stakeholder funds the analyses. (Lab analyses for standard constituents at one station for a year costs $1,320.) We may also establish a series of additional stations in cases where a stakeholder has been able to fund staff time and travel, as well as analyses.

Standard Constituents		
Ammonia	nitrate plus nitrite	phosphorus, total
conductivity	nitrogen, total	suspended solids, total
fecal coliform bacteria	oxygen	temperature
flow (at most stations)	ph	turbidity
metals & hardness (bimonthly, 12 stations)	Phosphorus, soluble reactive	

Basin Station Selection Criteria

Ideally, basin stations will be selected with the consensus of all stakeholders. But if there are too few stations identified by early July, ambient monitoring staff may need to identify additional stations. Conversely, if too many stations are identified, ambient staff will need to prune the list or get commitments from stakeholders to fund the extra stations. Ambient staff will also need to decide if proposed stations meet our basic requirements.

Basin Station Selection Criteria

- Category "5" (303(d) listed. (See www.ecy.wa.gov/programs/wq/303d/.)
- Category "2" (Needs more data. See www.ecy.wa.gov/programs/wq/303d/.)
- Support Ecology's permitting system (See https://fortress.wa.gov/ecy/wqreports/public/f?p=110:300:3631029519474507::::.)
- Never been there, suspect impairment (See www.ecy.wa.gov/programs/eap/fw_riv/)
- Never been there, need to broaden coverage (especially in supplemental spawning areas)
- Supplement local efforts
- Pre-TMDL
- Contribute to an active TMDL
- Post-TMDL/effectiveness

Basic Requirements

- Safe to park, access bridge/bank, and sample (see EAP Safety Manual, 2012), Working near traffic and from bridges, Working in Rivers and Streams, and Fall Protection, among others; remember, you must be able to park and sample outside the fog line.)
- Stream flows in one direction (i.e., no tidal influence)
- Representative samples can be collected (well-mixed, no upstream tributary or other source)
- Active stream flow gage recommended but not required (see https://fortress.wa.gov/ecy/wrx/wrx/flows/regions/state.asp)

Metals Stations

- Permit writers want data *upstream* of their facilities, even if no problems are expected
- Basin stations where we don't have data

Attachment B – Run Checklist

Pre-Run Preparation
- ___ Hotel Reservations
- ___ Pre-Booked Air Shipment
- ___ Field Work Plan in SharePoint
- ___ Sample Tags
- ___ Meter Calibration Log Form
- ___ Lab Analysis Report Forms
- ___ Field Data Report Forms
- ___ Waterproof Field Notebook
- ___ Run Directions Binder
- ___ Van Binder and keys
- ___ Cell Phone
- ___ Gas Van
- ___ Sample Bottles
- ___ Submit Timesheet
- ___

Standards & Sampling Supplies
- ___ pH 4, 7, & 10 Buffers
- ___ pH Probe Filling & Storage Solutions
- ___ Conductivity Standard
- ___ Filters
- ___ Pipettes
- ___ Deionized Water
- ___ D.O. Reagents
- ___ 250 mL 10% HCl
- ___ Disposable Powder Free Gloves
- ___ Soak Probes in Tap Water
- ___ Tape
- ___ Scissors
- ___ Bags for small bottles
- ___ Clipboard
- ___ Baking Soda
- ___ Flagging

Sampling Equipment
- ___ Gage & Gate Keys
- ___ Stainless D.O. Bucket Sampler
- ___ Fecal Coliform Sampler
- ___ Metals Sampler
- ___ Weighted Measuring Tape
- ___ Ropes
- ___ D.O. Sample Box
- ___ Filter Apparatus
- ___ Hand Vacuum Pump with Hose
- ___ Map/Gazetteer/Thomas Guide pages
- ___ Gloves
- ___ Knee Boots
- ___ Rain Gear

Van/Safety Equipment
- ___ Yellow Hazard Beacon
- ___ Flares or Reflectors
- ___ Tire Chains
- ___ Jumper Cables
- ___ Tool Chest
- ___ Flashlight
- ___ Shovel
- ___ Safety Vests
- ___ Hardhats
- ___ First Aid Kit
- ___ Foil Blanket
- ___ Emergency Eyewash
- ___ Hand Towels
- ___ Hand Truck?
- ___ Step Ladder?

Personal Gear
- ___ Sun Glasses
- ___ Watch
- ___ Extra Clothing
- ___ Hat
- ___ 2 Gallons Drinking Water

Meters/Instruments
- ___ pH Electrode
- ___ Conductivity Electrode
- ___ Long-line Thermistor
- ___ Barometer
- ___ Camera (and GPS?)
- ___ Meter Manuals
- ___
- ___

Pre-Departure Preparation
- ___ Check Road Conditions
- ___ Acid Wash Filter Apparatus
- ___ Calibrate Check Barometer[1]
- ___ Change pH Probe Solution
- ___ Clean conductivity cells
- ___ Change pH & Conductivity standards
- ___ Calibrate Conductivity Electrode[1]
- ___ Calibrate pH Electrode[1]
- ___ Check Thermistor Calibration[1]
- ___ Load Ice Chests, Gel-Ice, and Ice
- ___
- ___
- ___

[1]Enter Observations on Meter Calibration Log Form

Attachment C-1 Example FDR Form

Sampler: Bill Ward

SRM FIELD DATA REPORT FORM

Date: 9/17/2012

Page 1 of 2

Station	Station Name	Time	Temp ºC	DO mg/L	DO #	Temp pH	True Meter	Cond uS/cm	Press in.Hg	Stage Height	ChkBr/ Corr.	Comments
23A160	Chehalis R @ Dryad											
24B090	Willapa R nr Willapa											
24F070	Naselle R nr Naselle											
25F060	Mill Cr nr mouth											
25E060	Abernathy Cr nr mouth											
25D050	Germany Cr @ mouth											
QAS-1	Quality Control Sample											
QAS-2	Quality Control Sample											

WEATHER, etc:

Bi-Iodate: 10.0/10.0 Thiosulfate: _____/_____

Attachment C-2, Example FDR Form

Laboratory Analyses Required

Project Name: **SRM - 1209005**

SIC: **DWF03** Program: **EAP**

Send Results to: **David Hallock** Mail Stop: **47600** ☑ Monitoring Reference QAPP: **0503202 and Addendum**

Date (Year 12) mm dd	Time (Military, e.g., 1625)	Field Station ID	Manchester Lab Sample Number	Matrix Code	Source Code	General Chemistry: RUNS parameter group*	Conductivity	Turbidity	Total Suspended Solids	Ammonia	Nitrate-Nitrite	Total Pers. Nitrogen	Total Phosphorus TP8	Orthophosphate Mix 11	TOC	DOC	Chlorophyl	Suspend. Sed. Conc.				Micro: Fecal Coliform (MF)				Metals: Met Amb parameter Tot	MetAmb Prameter Dis	Hardness	Total Mecury Only			
09 17		23A160	-01	10	12	X	X	X	X	X	X	X	X	X		X						X										Chehalis R @ Dryad
09 17		24B090	-02	10	12	X	X	X	X	X	X	X	X	X		X						X										Willapa R nr Willapa
09 17		24F070	-03	10	12	X	X	X	X	X	X	X	X	X		X						X										Naselle R nr Naselle
09 17		25F060	-04	10	12	X	X	X	X	X	X	X	X	X	X	X		X				X										Mill Cr nr mouth
09 17		25E060	-05	10	12	X	X	X	X	X	X	X	X	X	X	X		X				X										Abernathy Cr nr mouth
09 17		25D050	-06	10	12	X	X	X	X	X	X	X	X	X	X	X		X				X										Germany Cr @ mouth
			-	10	12																											
			-	10	12																											
09 17		QAS-1	-12	10	12	X		X	X	X	X	X	X	X	X	X		X				X										Quality Control Sample
09 17		QAS-2	-13	10	12					X	X	X	X	X	X	X																Quality Control Sample

<u>Project Officer</u>

Name: **David Hallock**

Phone: **3604076681**

<u>Sampler</u>

Name: **Bill Ward**

Field Phone #:_______________

Chain of Custody Record					
Relinquished by	Received by	Date	Hr	Mn	Comments (temp, preserv, No. of coolers, etc.)
		09/17/12			Shipped _______ coolers.

Comments:____

* RUNS Parameter Group: Turb, TSS, NH3, NO2+NO3, TPN, FCMF.

Attachment D- Electrode Calibration Log Form

Electrode Calibration and QC Checks					**Draft version 1.1**
Date (dd/mm/yy)	Time	Run	Sampler(s)		
Thermistor #	a) HOBO Logger/Thermometer (º		Van pressure (Pre-cal.)		
Meter #	b) Thermistor (ºC)		Lab pressure		
pH Elect. #	Correction (a minus b)		LDO Electrode pressure		
Cond Elect. #	Was that corr. expected?	Y/N	Adjusted?	Y/N	
LDO Elect. #	Comments:				

pH Electrode Calibration[a]						**Calib. Millivolts (Mv)**				
Date/Time	**Slope**	**%**	**Offset**	**r2**	**Temp °C**	**4**	**7**	**10**	**QC 7 True**	**QC7 reading**

LDO Electrode	**Pre calibration[b]**			**Calibration[c]**				**Post calibration**		
Date/Time	1) Expected mg/L (USGS)	2) Reading mg/L	Diff of 1 & 2d	**Slope**	**Offset**	**Temp**	**inHg**	1) Expected mg/L (USGS)	2) Reading mg/L	Diff of 1 & 2

Conductivity Electrode Calibration[d]					
Date/Time	Initial Cell Constant	Initial Reading	Final Cell Constant	MV W/O temp corr.	Final Standard Reading

Temp˚C	Hach pH7	Hach pH10	NIST pH7	NIST pH 10
8	7.08	10.19	7.07	10.21
10	7.07	10.17	7.06	10.18
12	7.06	10.14	7.05	10.16
14	7.05	10.12	7.04	10.13
16	7.04	10.1	7.03	10.11
18	7.03	10.08	7.02	10.08
20	7.02	10.05	7.01	10.06
22	7.01	10.03	7.01	10.04
24	7	10.01	7	10.02
26	7	10	6.99	10.01

Daily Electrode QC Check Day #1[e]					
Date:	**Sample ID**	**Time**	**True pH**	**Reading**	**Recal?**
pH QC Check #1					Y/N
pH QC Check #2					Y/N
pH QC Check #3					Y/N
pH QC Check #4					Y/N
End day QC check Cond Stand 100, Reading _____________					µS/cm

Comments

Daily Electrode QC Check Day #2[e]					
Date:	**Sample ID**	**Time**	**True pH**	**Reading**	**Recal?**
pH QC Check #1					Y/N
pH QC Check #2					Y/N
pH QC Check #3					Y/N
pH QC Check #4					Y/N
End day QC check Cond Stand 100, Reading _____________					µS/cm

Daily Electrode QC Check Day #3[e]					
Date:	**Sample ID**	**Time**	**True pH**	**Reading**	**Recal?**
pH QC Check #1					Y/N
pH QC Check #2					Y/N
pH QC Check #3					Y/N
pH QC Check #4					Y/N
End day QC check Cond Stand 100, Reading _____________					µS/cm

Footnotes

[a] *See bottom right corner for expected ranges.*

[b] *See O_2 Solubility Table below.*

[c] *Recalibrate if difference is ± 0.1 mg/L.*

[d] *If electrode conductivity is >± 5µs/cm, recalibrate, re-read sample, & "J" data since last calibration.*

[e] *If electrode pH is >± 0.10 units, recalibrate; if > ± 0.15 units, recalibrate, re-read sample, & "J" data since last calibration*

LDO Electrode QC Check Post Run						
Date/time	Sample ID	Van Pressure	Meter Pressure	1) Expected mg/L	2) Reading mg/L	Diff of 1 & 2

Slope #: -57.5 to -58.8 (<0.7)	pH4: 165 to 178 (<5)
Slope %: 98 to 100	pH7: -5 to +6 (<5)
Slope r^2: >0.9995	pH10: -168 to +179 (<5)
Offset: -3 to +8 (<4)	Cond: 0.375 to 0.425 (<0.02)

Winkler Waste Treatment Record

Name	Date	Volume	Initial pH	pH after treatment

Measure and record waste volume and initial pH. Then sprinkle in about two tablespoons of Baking Soda per ½ gallon (or one scoop), stir it to mix, wait about five minutes, and then re-measure and record the final pH.

DEPARTMENT OF
ECOLOGY
State of Washington

Standard Operating Procedure EAP073, Version 2.3

Minimum Requirements for the Collection of Freshwater Benthic Macroinvertebrates in Streams and Rivers

April 2019
Publication 19-03-211

Purpose of this document

The Washington State Department of Ecology develops Standard Operating Procedures (SOPs) to document agency practices related to sampling, field and laboratory analysis, and other aspects of the agency's technical operations.

Publication Information

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Environmental Assessment Program
Standard Operating Procedure EAP073
Version 2.3

Minimum Requirements for the Collection of Freshwater Benthic Macroinvertebrates in Streams and Rivers

Original Author – Chad Larson
Date –

Original Reviewer –
Date –

Current Author –
Date –

Current Reviewers – Brandee Era-Miller, Glenn Merritt, Meghan Rosewood-Thurman, and Brian Engeness
Date –

QA Approval – Arati Kaza, Ecology Quality Assurance Officer
Approved Date – 10/2/2018

Recertified Date – 10/2/2018

SIGNATURES AVAILABLE UPON REQUEST

Please note that the Washington State Department of Ecology's Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Ecology use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. Distribution of these SOPs does not constitute an endorsement of a particular procedure or method.

Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the Department of Ecology.

Although Ecology follows the SOP in most instances, there may be instances in which the Ecology uses an alternative methodology, procedure, or process.

SOP Revision History

Revision Date	Revision History	Summary of changes	Sections	Reviser(s)
April 2015	2.0	Version has changed because the scope of the SOP has been changed to incorporate more streams. Current version distinguishes between narrow and wide protocols.	throughout	Chad Larson
12/14/2016	2.1	Update cover page and footer; Recertify	all	Bill Kammin
12/28/2017	2.2	Updated Glossary terms, updated formatting, added footers, general edits; Changed ETOH application for clarity	all	Meghan Rosewood-Thurman
10/2/2018	2.3	Minor edits	all	Kaza, Gries
4/16/19	2.3	format and copy edit for web publication	all	J. Ponzetti

1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for the collection of freshwater benthic macroinvertebrate (BMI) data. Collection of BMI in wadeable streams and rivers (<25 m average bankfull width) and larger rivers (≥25 m average bankfull width) using narrow and wide protocols, respectively, is discussed.

1.2 This document provides minimum requirements for the standardized methods of collecting and preserving aquatic insects, as well as for the taxonomic identification and reporting of the contents of BMI samples.

1.3 The methods described here are compatible with those used by other federal and state agencies in the Pacific Northwest Region (Hayslip 2007). Data collected using these methods allows us to share data with other agencies, thereby allowing for more efficient use of time in the field and potentially more extensive sampling of the streams and rivers in Washington.

2.0 Applicability

2.1 The procedures outlined here are used by EAP staff when collecting macroinvertebrates during a data collection event (DCE) from rivers and streams in Washington State.

2.2 To allow for comparable results, any data submitted for analysis using Ecology's bioassessment models by outside entities should be conducted in this manner.

2.3 The methods outlined here are employed by several of EAP's programs conducting status and trends monitoring for the state. These include the Watershed Health Monitoring (WHM), Ambient Freshwater Biological Monitoring (BIO), and Sentinel programs (SEN).

2.4 These methods also pertain to biological assessment conducted for potential regulatory purposes, i.e., directed studies (e.g., TMDL studies) or outside entities assessing sites for potential listing on the state's 303(d) list for "biological impairment" (see Ecology's Water Quality Program Policy 1-11: Bioassessment).

3.0 Definitions

3.1 DCE: The *data collection event* is the sampling event for the given protocol. Data for a DCE are indexed using a code that includes the site ID followed by the year, month, day, and the time (military) for the start time of the sampling event. For example: WAM06600-000222-DCE-YYYY-MMDD-HH:MM. One DCE should be completed within one working day, lasting 4 to 6 hours, on average.

3.2 D-frame kicknet (Fig. 1): A lightweight, packable net used for the collection of aquatic macroinvertebrates, composed of a 3- to 4-foot pole with a D-shaped frame attached to the bottom, such that the flat side can be placed against the substrate. The frame is 1 foot wide and 1 foot tall. A 500-micron mesh net is attached to the frame. With the ability to be deployed across most substrate types, this is the required sampling device for status and trends monitoring.

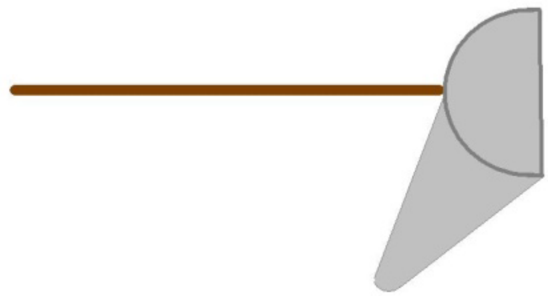

Figure 1: D-frame kicknet.

3.3 EAP: Environmental Assessment Program

3.4 Ecology: Washington State Department of Ecology

3.5 EIM: The Environmental Information Management System is the Department of Ecology's main database for environmental monitoring data. EIM contains records on physical, chemical, and biological analyses and measurements. Supplementary information about the data (metadata) is also stored, including information about environmental studies, monitoring locations, and data quality. The "search by map" feature enables plotting coordinates over orthophotographic imagery.

3.6 Hess sampler: A cylindrical mesh frame that is open on either end to allow access to bottom substrates through the top of the cylinder (Fig. 2). This cylinder has a 500-micron mesh net attached to part of the wall for sample collection. This sampler prevents escape of sample organisms and prevents outside materials and organisms from drifting into the net.

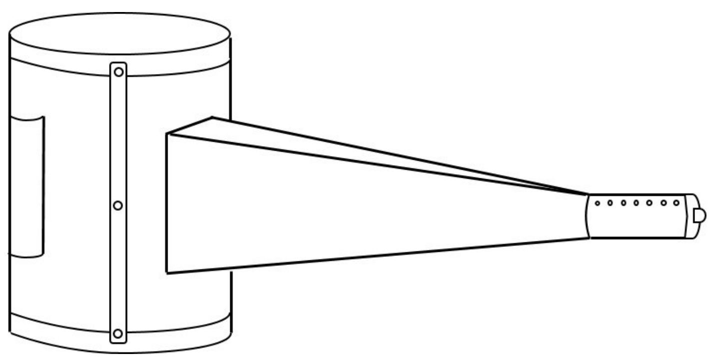

Figure 2. Hess sampler.

3.7 Narrow protocol: The set of Watershed Health Monitoring SOPs that describe data collection at wadeable sites with an average bankfull width of less than 25 m at the index station.

3.8 Narrow protocol sampling stations: Sampling occurs in a zigzag sequence (Table 1) when moving upstream.

Table 1. Pre-determined station locations on each transect of a standard stream site.

Station	% Transect Distance Left to Right
1	25
2	50
3	75
4	50
5	25
6	50
7	75
8	50

3.9 Reach-wide composite sample: The reach-wide sample is composited from eight predefined stations (Table 1). Each station is located on a separate transect and selected without regard to whether it is in a pool, riffle, or other habitat type. Sampling from multiple dispersed locations provides a representative sample.

3.10 SDS: Safety Data Sheets (previously Material Safety Data Sheets or MSDS) provide both workers and emergency personnel with the proper procedures for handling or working with a particular substance. An SDS includes information such as physical data (melting point, boiling point, flash point, etc.), toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment, and spill/leak procedures.

3.11 Station: Any location within the site where an observation is made or part of a sample is collected. For SOP EAP073 and SOP EAP111 (Larson and Collyard 2019), eight out of the eleven transects are randomly selected for periphyton and macroinvertebrate sampling. Table 1 defines the sampling path within the stream or river.

3.12 Substrate: The material that rests on the bottom of the stream.

3.13 Surber sampler – A net used for sampling aquatic insects, composed of a 12 × 12 inch square frame with a 500-micron mesh net attached. It has another 12 × 12 inch square frame that sits on the substrate to border your sampling area (Fig. 3).

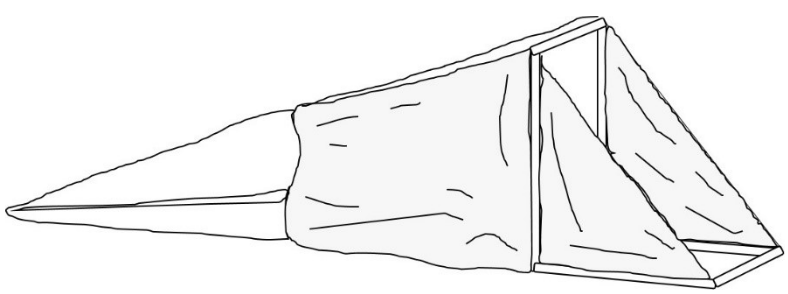

Figure 3. Surber sampler.

3.14 Targeted riffle sampling: A targeted sample represents sampling a single habitat type from a stream reach that extends at least twice its bankfull width. A targeted sample is composed of 8 feet of surface area sampled across multiple riffles or pools. Targeted sampling from a single habitat type can help to reduce the variation in the data and to provide a clear response signal. Individual directed studies may decide on the utility of using targeted riffle sampling; however, projects involved in status and trends monitoring employ only reach-wide composite sampling.

3.15 Transect: A straight line along which observations and/or measurements are made. This line spans the stream channel and is perpendicular to the direction of flow.

3.16 Wide protocol: The set of SOPs for collecting data and samples at non-wadeable sites or sites wider than 25 m bankfull width. It is an abbreviated version of the narrow protocol.

3.17 Wide protocol sampling stations: Sampling at each of the eight transects occurs on the side of the stream or river where habitat is also surveyed. At each of the selected transects, a sample is collected from a representative portion (as much as practical) of a littoral zone extending 10 m into the stream/river from the wetted bank and 10 m upstream and downstream, respectively from the transect. The sample should also be collected in an area shallow enough to deploy the kicknet and in an area away from backwaters, eddies, or other edge habitat.

4.0 Personnel Qualifications/Responsibilities

4.1 For collection of the sample, personnel should at a minimum review the Quality Assurance Monitoring Plans for the status and trends monitoring programs (e.g., Ambient Biological Monitoring (Adams 2010), WHM) and the training tutorial Sampling Macroinvertebrates in Wadeable Streams in Washington State (EAP 2010). Alternatively, they may receive formal training from staff who have themselves been formally trained. EAP has been holding formal training sessions for watershed health monitoring during June of each year. These sessions are open to the public.

4.2 For taxonomic analysis of the sample, the personnel should be certified for identification of Western United States taxa to the genus or species level by the Society for Freshwater Science (http://www.nabstcp.com/). Sample identification and enumeration should be to the lowest practical level as outlined in Quality Assurance Monitoring Plan: Ambient Biological Monitoring in Rivers and Streams: Benthic Macroinvertebrates and Periphyton (Adams 2010).

4.3 All staff must comply with the requirements of the EAP Safety Manual (EAP 2017). A full working knowledge of the procedures in Chapter 1 is expected.

4.4 All staff must be familiar and comply with the requirements of Ecology's Chemical Hygiene Plan and Hazardous Materials Management Plan (EAP 2018).

4.5 Field staff must be trained annually to minimize the spread of invasive species. See SOP EAP070 (Parsons et al. 2018).

4.6 Read this standard operating procedure and discuss any questions with your supervisor or task team leader.

4.7 Read the Safety Data Sheets (SDS) for ethanol before beginning the sorting/taxonomic procedures. The SDSs are available in the Ecology Headquarters benthic laboratory and on the Ecology's internal QA website. Use proper protective clothing and equipment as indicated.

4.8 Immediately report to your supervisor any symptoms or reactions that might be related to ethanol exposure.

5.0 Equipment, Reagents, and Supplies

5.1 Wide-mouth polyethylene jar (128 oz or 3.8 L is a recommended size)

5.2 D-Frame kicknet (pre-cleaned of organisms) with these characteristics:

- Frame mouth that is 1 ft (30.5 cm) wide by 1 ft tall
- 500-µm mesh net

5.3 95% ethanol (3:1 ratio by volume for each part sample)

5.4 Label (waterproof) for jar exterior

5.5 Label (waterproof) for jar interior

5.6 Soft-lead pencil

5.7 Clear tape

5.8 Electrical tape

5.9 Pocket knife

5.10 Wading gear (pre-cleaned of organisms)

6.0 Summary of Procedure

6.1 Details of the procedure are determined by the purpose for monitoring (Table 2).

Table 2. Details of benthic sampling based on monitoring purpose.

Monitoring purpose	Status & Trends (narrow protocols)	Status & Trends (wide protocols)	Regulatory
Device	D-frame kicknet	D-frame kicknet	D-frame kicknet, or Surber, or Hess
Mesh	500 µm	500 µm	500 µm
Site length	20 bankfull widths (150–500 m)	20 bankfull widths (150–2000 m)	2 bankfull widths (or more)
Sample area	8 ft^2	8 ft^2	8 ft^2
Station distribution	8 transects, 4 margins + 4 central	8 transects, littoral zone on side of stream where habitat is surveyed	Multiple riffles or 8 transects
Time to suspend	30 seconds	30 seconds	30–120 seconds
Sample	Reach-wide composite	Reach-wide composite	Reach-wide or targeted-riffle composite
Season	July 1–Oct 15	July 1–Oct 15	July 1–Oct 15
Subsample goal	500+ organisms	500+ organisms	500+ organisms
Taxonomic resolution	lowest practical	lowest practical	lowest practical

6.2 Field Sampling

6.2.1 For status and trends monitoring purposes (e.g., WHM), the sampling season extends from July 1 to October 15. For regulatory monitoring purposes, sampling should be conducted during the same period.

6.2.2 Samples should be collected with a device that uses 500 micron mesh, including D-frame kicknets, Surber samplers, or Hess samplers. Samples collected for status and trends monitoring (i.e., WHM, Ambient Stream Biological Monitoring, and Sentinel programs) should use a D-frame kicknet.

6.2.3 Samples should be collected from 8 square feet of stream bottom surface area and composited in the same jar. These samples should come from multiple locations across the study site.

6.2.4 Samples taken for the purpose of monitoring status and trends of stream health (e.g., WHM) should be composited (regardless of habitat) from 8 randomly selected transects dispersed across a site at least 150 m long. See the WHM SOP for Verification and Layout (in production) or Adams (2010) for a description of the site layout procedures.

6.2.5 Samples taken for the purpose of regulatory assessment should be composited from 8 feet of surface area taken from multiple fast-water habitats in the study reach. Aliquots may be from either turbulent (e.g., riffles) or non-turbulent habitat (e.g., glides), as long as flow is sufficient to carry organisms into the net.

6.3 Fast-water Aliquots

6.3.1 Place the sampling device firmly against the stream bottom, facing the flow of water. Eliminate gaps under the frame with the opening of the collection net.

6.3.2 Identify the surface area to be sampled. Gently scrub large substrate particles (larger than 5 cm in diameter) in front of the sampling device to remove any organisms that cling to the substrates; allow the flow to carry them into the mesh.

6.3.3 After each particle in the sample surface area is cleaned, inspect it for any remaining organisms, and then set it outside of the sample area.

6.3.4 Suspend the substrate into the water column from the specified surface area and allow the flow of the water to carry the BMI into the mesh. This may be accomplished by kicking or using a trowel, for a minimum of 30 seconds, to stir up and suspend the substrate in front of the net.

6.4 Slack-water Aliquots

6.4.1 If flow is unable to carry the BMIs into the mesh, visually inspect the stream bottom for any heavy or large organisms, such as mussels and snails, and place them in the sample jar.

6.4.2 Pick up any loose rocks or large substrate particles and scrub them over the net, allowing the organisms to fall into the mesh, and then set aside.

6.4.3 After scrubbing, vigorously kick the remaining finer substrate within your sampled surface area and drag the net repeatedly (for 30–120 seconds) through the disturbed area just above the bottom.

6.4.4 Move the net all the time so the organisms remain trapped in the net and do not escape; continue kicking.

6.4.5 On completion of sampling, remove the net from the water with a quick upward/upstream motion to wash the organisms to the bottom of the net.

6.4.6 Wash the contents of the net down to the bottom for ease of placing the sample aliquot into a jar. Remove relatively large debris, i.e., pieces of wood or rocks, from the net following inspection for attached invertebrates.

6.4.7 Place the aliquots in the jar.

6.4.8 Carefully inspect the mesh itself and remove any remaining organisms that may be stuck to the net. Adding a small amount of ethanol to the jar prior to sample collection helps to reduce the number of organisms sticking to the net and minimizes sample degradation during the sampling event.

6.4.9 Add 95% non-denatured ethanol to equal 2/3 of the volume of the total sample and add a label printed on waterproof paper to the contents of the jar. Sufficient ethanol is necessary to preserve the contents of the jar until taxonomic enumeration.

6.4.10 Existing water in the jar should not dilute the concentration of ethanol below 70%, so if, for example, approximately 100 mL of water is in the jar, add 300 mL of ethanol (ratio is 3:1).

6.4.11 Seal the jar securely, wrap the lid with electrical tape at the junction with the bottle, and affix a second label printed on waterproof paper to the outside of the jar. Contents are now ready to be delivered to the taxonomist for identification and enumeration.

6.4.12 Minimize the risk of spreading invasive species.

6.4.13 Before sampling in another stream or river, treat boots, boats, and nets according to SOP EAP070 Environmental Assessment Procedure 01-15 (Parsons et al. 2018).

7.0 Data Reporting

7.1 At a minimum, a target of 500 organisms should be identified by the lab for each sample. There are occasional situations that lead to fewer than 500 organisms per sample and do not meet this target. In these cases, the lab should identify the entire sample. Acceptance of smaller count (<500 organisms identified) data into our database for assessment purposes will be allowed at Ecology's discretion.

7.2 Each organism should be identified to the "lowest practical level." Lowest practical level is generally to genus or species, unless the specimen is underdeveloped or has been damaged, preventing identification to this level. Adams (2010) outlined the standard taxonomic effort employed by EAP's status and trends monitoring projects (see appendices G & H in Adams [2010]).

7.3 Lab data reported should include at a minimum:

7.3.1 Lab name/taxonomist

7.3.2 Integrated Taxonomic Information System (ITIS) taxa number

7.3.3 Scientific name of taxa

7.3.4 Collection date

7.3.5 Sampling device

7.3.6 Habitat sampling scheme (reach wide or targeted)

7.3.7 Protocol used (narrow or wide)

7.3.8 Number of organisms identified

7.3.9 Density of taxa per meter square

7.3.10 Number of taxa by life stage

7.3.11 Report number of damaged taxa and indicate if unable to identify to lowest level

7.3.12 Report taxa uniqueness for nonspecific identifications (to estimate diversity)

8.0 Records Management

8.1 List every sample on a chain of custody form submitted to the taxonomist. This form should include location, date, and sampling information.

8.2 The taxonomist will submit data to Ecology's EIM database (ecology.wa.gov/Research-Data/Data-resources/Environmental-Information-Management-database) or to Puget Sound Stream Benthos (http://pugetsoundstreambenthos.org/default.aspx). Arrangements should be made with King County DNR to give permissions for the taxonomist to submit data to the Puget Sound Stream Benthos website.

9.0 Quality Control and Quality Assurance Section

9.1 Field Quality Assurance

9.1.1 *Visit precision* measures variability in the sampling method and is related to the variability of collecting a composite sample in a reach. Visit precision is estimated by collecting side-by-side duplicate composite samples of the invertebrate communities within the same reach during the same day at 10% of the reaches sampled annually. Visit precision is calculated using the relative standard deviation (RSD) from two replicate composite samples and should be <20% in reference streams when using the taxa richness metric.

9.1.2 For additional information see the Quality Assurance Monitoring Plan for Ambient Biological Monitoring in Rivers and Streams: Benthic Macroinvertebrates and Periphyton, Appendix C (Adams 2010). https://fortress.wa.gov/ecy/publications/summarypages/1003109.html.

9.1.3 Macroinvertebrate Sorting Efficiency

9.1.4 Quality control procedures for initial sample processing and subsampling involves checking *sorting efficiency*. These checks are conducted on 10% of the samples by independent observers who microscopically re-examine the sorted substrate from each sample.

9.1.5 All organisms that were missed are counted. Sorting efficiency is evaluated by applying the following calculation:

$$SE = n_1 / n_2 \times 100$$

where SE is the sorting efficiency expressed as a percentage, n_1 is the total number of specimens in the first sort, and n_2 is the total number of specimens in the first and second sorts combined.

9.1.6 Sorting efficiency is recorded on each bench sheet by the person or lab enumerating the sample. If 95% sorting efficiency is not achieved for a given sample, a failure is recorded on the bench sheet and in the database.

9.1.7 The sorted portion of that sample is then completely resorted before the sorting efficiency test is repeated for that sample.

9.1.8 Sorting efficiency statistics for each technician and for the entire laboratory are reviewed monthly.

9.1.9 Sorting efficiency for each sample in a project is reported to the client in the technical summary document. Technicians who do not maintain the target sorting efficiency are given remedial training, and larger portions of the samples they process are examined for the sorting efficiency test until they are able to maintain the target sorting efficiency.

9.1.10 A second evaluation of the subsampling process is applied to a small proportion of samples processed in each month; typically, one sample per week is subjected to the following test of *precision of the subsampling process*.

9.1.11 The procedure is only applied to samples where the target number of organisms was achieved in less than half of the Caton grids. A sample is randomly selected, and a second subsample is resorted from the unprocessed sample remnant.

9.1.12 A second technician performs this sort. The resulting subsample is identified, and Bray-Curtis similarity index is calculated for the results of both subsamples.

9.1.13 Results that are less than 90% similar would indicate the need for more thorough distribution of sample materials in the subsampling tray or more special attention given to easily missed taxa when sorting (i.e., increased magnification).

9.2 Taxonomic Accuracy and Precision

9.2.1 Taxonomic misidentification results in inadequate biological characterization of a stream. Errors in identification should be less than 5% of the total taxa in the sample. Re-identification of samples is conducted for 10% of the total number of samples in each year.

9.2.2 Secondary identification is conducted by experienced taxonomists in order to maintain confidence in the data set. Difficult taxa should be sent to museum curators whose specialty includes members of the order in question.

9.2.3 Voucher collections are maintained by the Orma J. Smith Museum of Natural History in Caldwell, Idaho. A voucher collection should be prepared from the set of samples for the year and shipped to the address below:

The Orma J. Smith Museum of Natural History
College of Idaho
2112 Cleveland Blvd.
Caldwell, ID 83605-4432

10.0 Safety

10.1 Field Safety

10.1.1 All field staff must comply with the requirements of the EA Safety Manual (EAP 2019).

10.1.2 Sampling will not take place if the stream is not safe to enter.

10.1.3 Fieldwork should be conducted by a team of two people at a minimum to ensure the safety of the sampler.

10.1.4 If a given sampling location within a study site/reach appears unsafe (e.g., too deep, too steep, or covered with loose material, such as a logjam), it may be shifted to allow sampling in a nearby portion of the same or similar habitat conditions as the one avoided.

10.1.5 Proper field gear should be worn, including shoes with adequate lugging, felting, or studs to allow for traction on slick surfaces.

10.2 Chemical Safety

10.2.1 All employees should read this standard operating procedure and discuss any questions with her/his supervisor or task team leader.

10.2.2 Ethanol should be kept in small quantities in a tightly sealed container out of direct sunlight.

10.2.3 Read all relevant Material Safety Data Sheets (MSDS) before beginning this procedure. The MSDS are available in the Ecology benthic laboratory located at the EAP Operations Center and on Ecology's internal Quality Assurance website.

10.2.4 Report to supervisor immediately any symptoms or reactions that might be related to ethanol exposure.

11.0 References

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DEPARTMENT OF ECOLOGY
State of Washington

Standard Operating Procedure EAP080, Version 2.1

Continuous Temperature Monitoring of Freshwater Rivers and Streams

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Purpose of this document

The Department of Ecology develops Standard Operating Procedures (SOPs) to document agency practices related to sampling, field and laboratory analysis, and other aspects of the agency's technical operations.

Washington State Department of Ecology

Environmental Assessment Program

Standard Operating Procedures for Continuous Temperature Monitoring of Freshwater Rivers and Streams.

Version 2.1

Author – William J. Ward
Date –

Reviewers: Dan Sherratt and Dave Hallock

QA Approval - William R. Kammin, Ecology Quality Assurance Officer
Date – 10/26/2011

EAP080

APPROVED: 10/26/2011

Recertified: 2/27/15
Updated and Recertified: 3/25/2015
Updated and Recertified: 3/25/2018

Signatures on File

Please note that the Washington State Department of Ecology's Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Ecology use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. Distribution of these SOPs does not constitute an endorsement of a particular procedure or method.

Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the Department of Ecology.

Although Ecology follows the SOP in most cases, we occasionally encounter situations where an alternative methodology, procedure, or process is warranted.

SOP Revision History

Revision Date	Rev number	Summary of changes	Sections	Reviser(s)
4/12/10		First draft updating and incorporating existing 2003 Continuous Temperature Protocols with the 2008 TMDL SOP.	All	W. Ward
		Draft addressing Dan Sherratt and Dave Hallock comments	All	W. Ward
		Draft addressing James Kardouni comments	All	W. Ward
	1.0	Final draft		
10/26/2011	1.0	Editorial cleanup	All	B. Kammin
3/25/15	2.0	Minor editorial updates and recertified	All	W. Ward
3/25/2015	2.0	QA approval	All	B. Kammin
3/25/2018	2.1	Minor editorial updates	5, 6, & 10	W. Ward
3/25/2018		Recertified	All	T. Gries

Standard Operating Procedures for Continuous Temperature Monitoring of Fresh Water Rivers and Streams.

1.0 Purpose and Scope

This Standard Operating Procedure (SOP) details a methods used by the Department of Ecology (Ecology) to collect continuous temperature monitoring data. It may also contain methods that other entities would find useful for their monitoring work.

The scope of the continuous temperature monitoring program currently focuses on summer (June-September) stream temperatures, but will be expanded to year-round as resources allow.

The intended purpose of the continuous temperature monitoring program is to collect diel stream temperature data that may be used to expand the interpretation of a station's ambient monitoring results and to determine its compliance with state water quality standards. The continuous temperature results are assessed using Ecology's policy for identifying impairments under the federal Clean Water Act (Section 303(d)), which requires stream temperature to be measured on consecutive days in order to apply the criterion.

2.0 Applicability

The Standard Operating Procedures (SOP) will be followed for the installation and maintenance of continuous temperature ambient monitoring stations. These protocols reflect in part those outlined in the TFW Stream Temperature Survey Manual (Schuett-Hames et al., 1999), Continuous Temperature Sampling Protocols for the Environmental Monitoring and Trends Section (https://fortress.wa.gov/ecy/publications/summarypages/0303052.html) (Ward, 2003), Measuring Stream Temperature with Digital Data Loggers (USFS, 2005), and Standard Operating Procedures for continuous temperature monitoring of fresh water rivers and streams conducted in a Total Maximum Daily Load (TMDL) project for stream temperature (Bilhimer and Stohr, 2008).

3.0 Definitions

3.1 7DAD*Max*, 7-day average of the daily maximum temperature
3.2 *EAP*, Ecology's Environmental Assessment Program
3.3 *EIM*, Ecology's Environmental Information Management database for environmental data
3.4 *EPA*, US Environmental Protection Agency
3.5 *GIS*, Geographical Information System

3.6 *GPS*, Global Position System
3.7 *NIST*, National Institute of Standards and Technology
3.8 *PST*, Pacific Standard Time
3.9 *PDT*, Pacific Daylight savings Time
3.10 *QAPP*, Quality Assurance Project Plan

4.0 Personnel Qualifications/Responsibilities

4.1 Field operations require training specified in EAP's Field Safety Manual (Ecology, 2016), such as First Aid, CPR, and Defensive Driving.

4.2 Typical Job Class performing SOP: Natural Resource Scientist 1/2/3, Environmental Engineer 1/2/3/4/5, Environmental Specialist 1/2/3/4/5, Administrative Intern 1/2/3.

5.0 Equipment, Reagents, and Supplies

5.1 *General Field Equipment:*

5.1.1 See Attachment A for a list of the typical equipment and supplies that may be used to deploy temperature loggers.

5.2 *Specialized Field Equipment*[1].

5.2.1 Rebar Pounder (see design specifications in Attachment B)
5.2.2 PVC Shade Device (see design specifications in Attachment B)
5.2.3 Onset Tidbit© v2 Temp Logger, (#UTBI-001), +/- 0.2°C
5.2.4 Onset Hobo© Water Temp Pro v2, (#U22-001), -20°C to +50°C, +/- 0.2C
5.2.5 Onset StowAway Tidbits©, -5°C to +37°C model, +/- 0.2°C (no longer available)
5.2.6 Onset StowAway Tidbits©, -20°C to +50°C model, +/- 0.4°C (no longer available)
5.2.7 Spirit-filled thermometer or long-line thermistor with an accuracy of +/-0.2ºC
5.2.8 PC communication cables or optic shuttles specific for each instrument type

6.0 Summary of Procedure

6.1 *Pre-Deployment Run Preparation*

6.1.1 Assemble equipment. Use a checklist to ensure that all of the necessary preparation tasks, equipment, supplies, and safety gear are completed (See Attachment A for the Continuous Temperature Sampling Checklist).

6.1.2 Calibration Checks. All temperature loggers must be calibration checked both pre- and post-study to document instrument accuracy specifications.

[1] The specialized equipment listed does not represent an endorsement by Ecology. Other equipment may be used if it meets the project QA/QC requirements for accuracy and reliability.

6.1.2.1 The calibration checks are done using test-bath temperatures that bracket the intended monitoring range (near 20 and 0ºC). The bath temperatures must be verified with a NIST traceable or calibrated reference thermistor, thermocouple, or thermometer (NIST thermometer)[2]. *Note: This procedure is also used to determine correction factors (if required) for the field thermistor and thermometer measurements.*

6.1.2.2 A calibration-check test-bath method that can maintain a constant temperature is essential to obtain excellent test results. The one described below has worked very well for us. In addition, we have also had great success utilizing a 20-gallon aquarium with a two-bay Hatch Box design and a recirculation pump.

6.1.2.3 Place one open cooler half full of water overnight in a walk-in cooler or room that has a constant air temperature near 0ºC and two coolers (setup similarly) in a room with a temperature near 20ºC. *Note: Test baths done in rooms that have the target temperature ensure stable bath temperatures and the overall quality of the test.*

6.1.2.4 Program the temperature loggers for the test start time and up to a five-minute logging interval (a one- to two-minute interval is preferred). String the loggers together to facilitate their transfer into each water bath.

6.1.2.5 Put the programmed temperature loggers in the near 0 ºC test bath overnight.

6.1.2.6 Twenty minutes before the start of the test, place the NIST thermometer in the water bath oriented to easily view the scale increments. Then, gently stir the water to help ensure a uniform water temperature.

6.1.2.7 Gently stir the water bath again a few minutes before test and just after reading and recording the NIST thermometer temperature.

6.1.2.8 Record 10 relatively constant and consecutive NIST thermometer comparison measurements on the Calibration Check Form (See Attachment C1 for blank form and Attachment C2 for an example of a used form) when the logger records the water bath temperature. If the logger has a two-minute sampling interval, it may take twenty minutes to obtain the 10 NIST measurements.

6.1.2.9 Dewater and transfer the strings of temperature loggers, thermometers, and thermistor probes to one of the room temperature (near 20ºC) water baths. Gently stir the transition water bath and allow the loggers to soak there for several minutes. Then transfer them to the other room temperature water bath for a few minute soak. *Note: this two-step process helps minimize the temperature changes in the final water bath.*

6.1.2.10 Repeat the process noted above to obtain ten relatively constant NIST thermometer comparison measurements the final water bath.

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[2] All NIST reference thermistors, thermocouples, and thermometers, used for this test, need to have an annual three-point (near 0, 10, 20°C) calibration check against the Lacey Operations Center NIST or be sent in for an Accredited Calibration Certificate.

6.1.2.11 Download the temperature loggers as soon as possible after the test to shut them off and minimize battery life impacts.

6.1.2.12 Calculate the mean absolute value of the difference between the temperature logger measurements and the NIST thermometer for each water bath with spreadsheet software or by hand. Water-temperature loggers that have a mean difference greater than 0.2°C in one or both water baths have failed the test and cannot be used unless they pass a follow-up test.

6.1.3 Launch temperature loggers. Adjust the computer clock settings to Pacific Standard Time (PST) and also make sure that it will not automatically adjust to Daylight Savings Time (DST). Then adjust the clock time to the atomic clock (e.g., https://www.time.gov). These necessary steps ensure that all the data will be in PST year-round and that all loggers will monitor at exactly the same time.

6.1.4 Program the temperature loggers for a delayed launch that starts at least one hour before the first planned deployment time of the season and at a 30- (or 15-) minute monitoring interval (on the hour and half hour).

6.2 *Stream temperature logger site selection methods*

6.2.1 Deploy temperature loggers in the active and well-mixed part of the stream (or as close as possible to it) to ensure representative temperatures (based on flow volume) are recorded throughout the entire deployment period. The preferred location in these areas is against an instream landmark or other submerged structure that can help hide the logger and minimize the loss to vandalism or high-flow events and also where direct sunlight may be avoided. *Note: avoid deployment locations near popular swimming holes and fishing access points where there is a much higher chance of logger discovery and loss to vandalism.*

6.2.2 Ideal deployment locations are typically at the upstream outside edge or downstream inside edge of the river bends or in the middle of riffles of low flow and wadeable streams (see Figure 1 below).

6.2.3 Temperature logger locations should never be in eddies or pools or locations where these conditions may develop during low flows. In addition, locations just downstream of tributaries, stream-side wetland areas, point-source discharges, and potential hillside groundwater seeps should also be avoided because these conditions may seasonally bias the recorded temperatures. Consider locations either on the opposite side of the stream or upstream of these conditions.

6.2.4 Deployment depth locations should not be on the stream bottom where the loggers may record groundwater inflow, but deep enough that they do not become exposed to air during a low-flow period. The basic deployment location depth goal is six (6) inches (<0.5 ft) off the stream bottom in smaller streams and wadeable locations and, if possible, at about one half of the water depth in the large streams (Schuett-Hames et al., 1999). *Note: Locating temperature loggers near the stream bottom may be necessary in small streams to ensure that the logger remains submerged during low flows.*

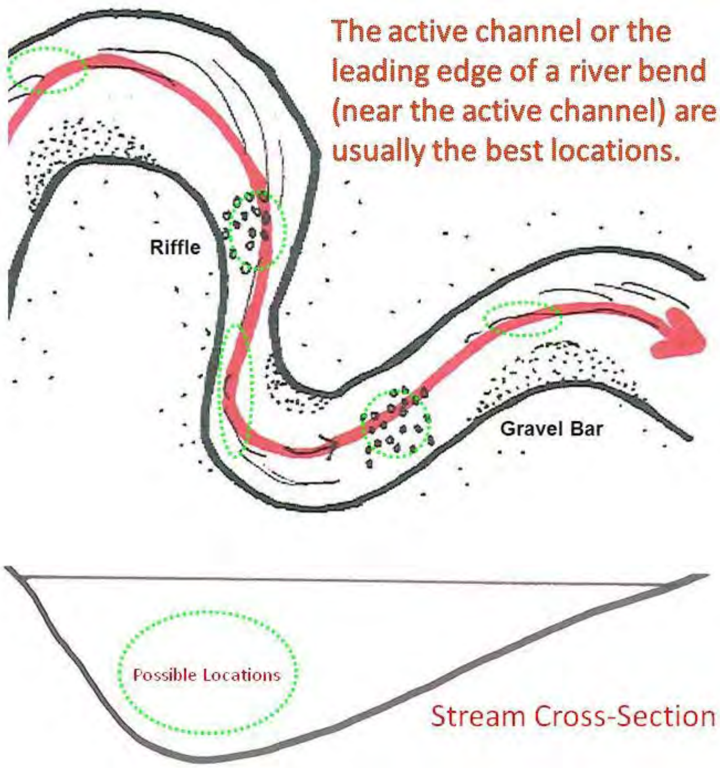

Figure 1. Potential Temperature Logger Deployment Locations

6.2.5 The representativeness of the temperature logger deployment location should be verified by measuring several points in and near the vicinity of the logger and the temperature of the well-mixed part of the stream. If the stream can be easily waded, then a simple cross sectional temperature survey could also be done. Review the survey results, and consider another deployment location, if necessary, to help ensure that the logger will record representative results.

6.3 *Stream temperature logger deployment options*

6.3.1 Record the water-temperature-logger serial numbers on the survey form. (See Attachment D1 for blank form and Attachment D2 for an example).

6.3.2 Pre-assemble the water-temperature logger with a camouflage-painted PVC shade device cover (See fig.2 below and design in Attachment B) that helps hide the logger and prevent any bias from indirect solar radiation.

6.3.3 Avoid low-flow and direct-sunlight temperature logger deployment locations. If the temperature logger needs to be deployed in these locations, then a white PVC shade cover must be used to prevent any solar-biased temperature results (USFS, 2005).

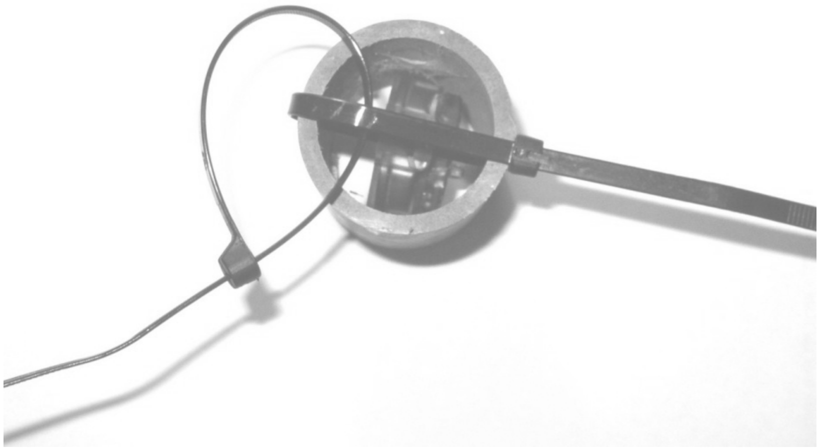

Figure 2. Assembled Temperature Logger and PVC Cover

6.3.4 Place a thermometer or thermistor as close as possible to the identified deployment location and record the measurement after the logger has been deployed. Consider one the use of one of the following deployment methods:

6.3.5 Rebar Deployments. This option is typically used in small- and medium-sized streams to create a suitable temperature logger attachment location in or as near as possible to the active part of the stream. In most cases, this method is best used against the active-part-of-the-stream side of a large landmark rock or log.

6.3.6 Choose a two-to-three-foot length of rebar that can be driven deep enough into the streambed to stay in place during high streamflow events and provide an attachment location that is six inches to one-half of the expected total stream depth during the seasonal low-flow period.

6.3.7 Insert the rebar into the open end of the rebar pounder and use a 4# engineering hammer (or an alternative) to hammer the rebar into the streambed by striking the heavy steel head of the pounder. Hammer all but eight inches of the rebar into the streambed[3].

6.3.8 Leave the rebar pounder on the rebar, and document the water-temperature logger location with photographs.

6.3.9 Remove the rebar pounder and attach the temperature logger assembly to the rebar about 6 inches off the bottom (or mid-water depth) with a cable tie. *Note: In fast-flowing locations an additional cable tie should be attached to the rebar just above the temperature logger assembly attachment point to prevent its loss should the second cable tie loosen on the rebar (or attach the assembly using a small gage wire).*

[3] If a mid-stream depth is desired, then leave more rebar exposed.

6.3.10 Large Rock, Tree Root, or woody debris deployments. This option uses existing instream structures such as large rocks or boulders, woody debris, or roots that are located in or extend into the desired location in the active part of the stream. Attach the water-temperature logger to these structures with cable ties or wire, or to cable or heavy wire that may be used to create the location near the base of these structures.

6.3.11 Photographs of the location using a visual marker (such as the rebar pounder, hammer handle, nearby flagging, or pointing with a finger) are essential to help relocate loggers installed by this method.

6.3.12 Anchor deployments. This option can be used where stable large woody debris is not available or where near-surface bedrock or other consolidated sediments prohibit rebar use. The basic approach is to attach the water-temperature-logger assembly to a heavy weight (i.e., rock, brick, concrete block, wadded up piece of chain, or rebar) that may be set in the desired water-temperature-logger location.

6.3.13 It is also advisable that the heavy object be cabled or chained to something on the nearest bank (or other stable instream structure) to prevent loss during a possible high flow event (*Note: rusty chain use may deter logger loss to vandalism more than a shiny cable*). The heavy weight may be encouraged into the desired deployment location using a stick or boat hook (or similar device). *Note: this is not considered a viable option in locations with a significant groundwater inflow.*

6.3.14 Streamside or pile deployments. A long protective PVC or metal pipe housing may be used to establish a deployment location along deep rivers or at wildly fluctuating streams. The pipe can be fastened to a piling, pier, or anchored to large rocks and trees on the stream bank with the lower end extended into the active part of the stream. The upper end of the pipe should be secured with a threaded or locking cap to discourage casual vandalism. The lower end of the pipe should be perforated to allow streamflow around the logger and also be blocked with a diagonal bolt (or similar device) to prevent logger loss out that end. The logger in a protective cover needs to be kept at the lower pipe end with a weighted cord, length of PVC pipe, or any other method that also allows retrievals and deployments to be made through the upper capped end (see Figure 3 example below).

6.3.15 Buoy or dock deployments. This option may be useful where no pilings are available or where a string of thermistors is desired to monitor stratified conditions. One issue with this type of deployment option is the high vandalism potential. This potential increases dramatically when establishing a new floating structure, so it is best to use existing structures if permission can be obtained.

6.3.16 Aquatic Invasive Species. Clean all field equipment that contacted water following procedures in Parsons, et al., (EAP070) and Ward, et al., (EAP071).

Figure 3. Deployment method using a length of PVC pipe

6.4 *Air temperature logger deployment methods*

6.4.1 Use temperature loggers that can record the maximum expected temperature for the deployment location. If you are locating loggers in an area where the summer air temperatures can exceed 100ºF (37ºC), then use an air thermistor that has the higher temperature range setting.

6.4.2 Record the air-temperature-logger serial numbers on the survey form.

6.4.3 Pre-assemble the air-temperature logger with a PVC shade device cover. The pre-assembly should be done before beginning the process to install the logger (See Figure 2 above).

6.4.4 These temperature loggers need to be located within the same microclimate of the water logger. Ideal locations are one to three meters into the riparian zone (Schuett-Hames et al., 1999) and about four to eight feet above the ground (USFS, 2005). Avoid placing them in areas that are not representative of streamside conditions at your location or where they will be severely impacted from solar radiation. The north side of a shrub or tree trunk should work well in most locations, especially those with limited streamside vegetation choices[4].

6.4.5 One air-temperature logger should be deployed near every water-temperature-logger location. However, if the vegetation and streamside conditions are similar, then one air-temperature logger may be used to cover several nearby water-temperature loggers. *Note: Air loggers deployed for Total Maximum Daily Load studies (*Bilhimer and Stohr, 2008) *must be within approximately 0.5 mile of the most distant water logger.*

[4] Do not use weeping willows, as they can secrete fluid during hot weather and create error in the air temperature results.

6.5 *Documentation Procedures*

6.5.1 Record all the field data and deployment location information on the Continuous Temperature Station Survey Form (See example in Attachment D-1) or by a similar method. Be sure to note the station number and name, temperature logger ID numbers, and air- and water-temperature measurements, and any other useful narrative observations, especially those useful for finding the location (e.g. – “upstream of largest boulder on right bank”).

6.5.2 Also, record all observation times in PST (or note when they are DST, so they may be converted to PST later), and use a timepiece that has been calibrated to the atomic clock (or use the cell-phone time).

6.5.3 Further, draw a map and describe the general area, noting the temperature-logger locations, logger installation technique, and any landmark references such as a unique rock, log, root, flagging, or tree (See example in Attachment D-2). *Note: if possible, draw the map with north being toward the page top or denote the direction of north on the drawing*.

6.5.4 Take upstream and downstream photographs of the water-temperature-logger location that includes useful and easily identifiable landmark tree(s), flagging, or boulder. It is also important that the photographs include some visual marker (such as the rebar pounder, hammer handle, or pointing with a finger) to use along with the information on the survey form to help relocate and retrieve it in the future (See Fig 4 below).

6.5.5 Measure and record: the total water depth (water depth), distance from the logger to the streambed (height), distance from water surface to the logger (deployment depth), and the stream temperature on the survey form.

Figure 4. Photo showing the water-temperature-logger deployment location.

6.5.6 Record the temperature logger GPS coordinate location (or note the logger location on an accurate map and determine the coordinates later).

6.6 *Mid-deployment checks*

6.6.1 If possible, periodically visit the temperature-logger location during the deployment period to get mid-deployment temperature-check data and to make sure that it remains submerged and in a representative location. If the logger needs to be moved or is missing and needs to be replaced, then take the appropriate action and enter new remarks and notes on the survey form. *Note: consider taking replacement loggers and deployment equipment along when doing these checks to help expedite to process.*

6.7 *Retrieval Procedures*

6.7.1 Measure and record the stream temperature and surface depth of the water-temperature logger (retrieval depth), and record the results on the field form. Also, measure and record the distance from the streambed up to the logger, and note any differences between the result and what was recorded during deployment.

6.7.2 If the stream may be easily waded, then also consider doing a cross-sectional survey of the stream temperature. The survey results may help determine if the stream-temperature logger measured representative temperatures and show any cross-sectional temperature differences.

6.7.3 Remove all rebar, cement blocks, or other deployed equipment at the end of the study.

6.7.4 Aquatic Invasive Species. Clean all field equipment that contacted water following the procedures in Hallock, et al., 2010 (EAP070).

6.8 *Downloading Procedures*

6.8.1 Gently clean the temperature loggers with a soft wet cloth to remove any biofouling or sediment that may affect its ability to communicate optically during the downloading process. The preferred method is to use water and a soft cloth or soft-bristled brush. Note: avoid using any method that can scratch the logger optic communication area.

6.8.2 Set the computer clock to atomic clock time for the Pacific Time Zone before downloading any temperature loggers. Then follow the manufacturer's downloading procedures, and save the data in text files that may be opened in Excel or another type of spreadsheet software.

7.0 Records Management

7.1 Continuous Temperature Survey Forms are used to document the deployment and retrieval information for a station. Filled-out field forms are organized and stored in binders to use for long-term recordkeeping.

7.2 Use Ecology's FMU Access® Data Logger Database developed by Dave Hallock, to manage, store, export, and upload data summaries to Ecology's Environmental Information Management System (EIM). *Note: the database is available to interested agencies and organizations upon request.*

8. 0 Quality Control and Quality Assurance Section

8.1 *Temperature Logger Post-Deployment Accuracy Check.* Verify the accuracy of the retrieved temperature loggers by conducting a post-deployment calibration check (Refer to Calibration Check procedure, 6.1.2, above).

8.1.1 If the mean absolute value of the temperature difference for a logger in each water bath, compared against the NIST certified thermometer, is equal to or less than the manufacturer stated accuracy (i.e. usually ±0.2°C for a water-temperature logger or ±0.4°C for an air temperature logger), then a second check should be performed.

8.1.2 If a second calibration check result confirms a consistent bias above the stated accuracy, then the raw data should be adjusted by the mean difference of the pre- and post-calibration check results to correct for the logger bias (Schuett-Hames et al., 1999).

8.2 *Data Proofing Procedures.* Data from temperature loggers that met the calibration-check accuracy requirement are proofed and QC checked using *Ecology's FMU Access® Data* Logger Database. This database allows the information recorded on the Continuous Temperature Data Report Form (deployment/retrieval times and temperatures) and available climatic and flow data to be used to proof, edit, run automated QC checks, store, summarize, report, and export the finalized data (to text files, Microsoft® Excel, or to Ecology's Environmental Information Management (EIM) system Excel template).

8.2.1 *Note: all identified anomalous data may be omitted from the data set, provided that the justification remark(s) is inserted on the station Continuous Temperature Station Survey Form and in the electronic record for the data. Similarly, all explainable climatic caused data spikes (i.e. - rain events) should also be noted in these same two records.*

8.2.2 All data will be assigned a measurement accuracy value based on the pre- and post-deployment calibration check results.

9.0 Safety

Safety is the primary concern when deploying temperature loggers. Proper fieldwork safety procedures are outlined in the Environmental Assessment Program Safety Manual (Ecology, 2016). A minimum of two people are required when streams are waded. One can deploy the stream temperature loggers, and the other can assist from shore. If streamside hazards such as high flow, weather, and debris make the temperature logger deployment dangerous, then an alternate location, different deployment method, or different deployment time should be considered.

9.1 Material Safety Data Sheets (MSDSs) for all chemicals used in EAP field sampling or analytical procedures can be found at the following SharePoint link: http://teams/sites/EAP/QualityAssurance/ChemicalSafetyDataSheets/Forms/AllItems.aspx.

Also, binders containing MSDSs can be found in all field vehicles, vessels, Ecology buildings, or other locations where potentially hazardous chemicals may be handled. EAP staff following Ecology SOPs are required to familiarize themselves with these MSDSs and take the appropriate safety measures for these chemicals.

10.0 References

10.1. Bilhimer, D. and Stohr, A., 2008. Standard Operating Procedures for Continuous Temperature Monitoring of Freshwater Rivers and Streams Conducted in a Total Maximum Daily Load (TMDL) Project for Stream Temperature, Version 2.2. Washington State Department of Ecology, SOP Number EAP044. ecology.wa.gov/Quality.

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10.3. Environmental Assessment Program, 2016. Environmental Assessment Program Safety Manual.

10.4. Hallock, D. 2010. Standard Operating Procedures to Minimize the Spread of Invasive Species from Areas of Extreme Concern. EAP070. https://fortress.wa.gov/ecy/publications/SummaryPages/1803201.html.

10.5. Schuett-Hames, D., A. E. Pleus, E. Rashin, and J. Matthews, 1999. TFW Monitoring Program Method Manual for the Stream Temperature Survey. Washington State Department of Natural Resources and NW Indian Fisheries Commission publication #TFW-AM9-99-005.

10.6. Ward, W., 2003. Continuous Temperature Sampling Protocols for the Environmental Monitoring and Trends Section. Washington State Department of Ecology, Olympia, WA. https://fortress.wa.gov/ecy/publications/summarypages/0303052.html.

Attachment A

This Attachment contains the checklist used to prepare for temperature logger deployments.

Continuous Temperature Sampling Checklist

Pre-Deployment Preparation

_____ Determine Number of Stations
_____ Determine Deployment Equipment Needs
_____ Obtain or Make Deployment Equipment
_____ Check Calibration of:
_____ • Temperature Loggers
_____ • Thermometer
_____ • Thermistor
_____ Plan Deployment Schedule
_____ Schedule Field Assistance
_____ Program Temperature Loggers
_____ Make Motel Reservations
_____ Fill out Field Work Plan and Contact Person Designation Form
_____ Gas Van

Van/Safety Equipment

_____ Tire Chains
_____ Yellow Hazard Beacon
_____ Flashlight
_____ Tool Chest
_____ Jumper Cables
_____ Flares/Reflectors
_____ First Aid Kit
_____ Foil Blanket
_____ Orange Vests
_____ 2 Gallons Drinking Water
_____ Hand Towels
_____
_____

Sampling Equipment and Supplies

_____ Programmed Temperature Loggers
_____ Continuous Temperature Survey Forms
_____ Thermometer
_____ Thermistor
_____ Compass
_____ Maps
_____ Watch
_____ Camouflaged PVC Pipe
_____ Cable Ties
_____ Rebar Pounder
_____ 3/8 inch x 2 – 3 Ft. Rebar Pieces
_____ 4# Hammer
_____ Several lengths of Chain or cable
_____ Pyramid Blocks
_____ Small Wire Cutters
_____ 6' Pole W/Hook
_____ Knife
_____ Hand Trimmer
_____ Machete
_____ Survey Flagging
_____ Digital Camera
_____ Duct Tape

Personal Gear

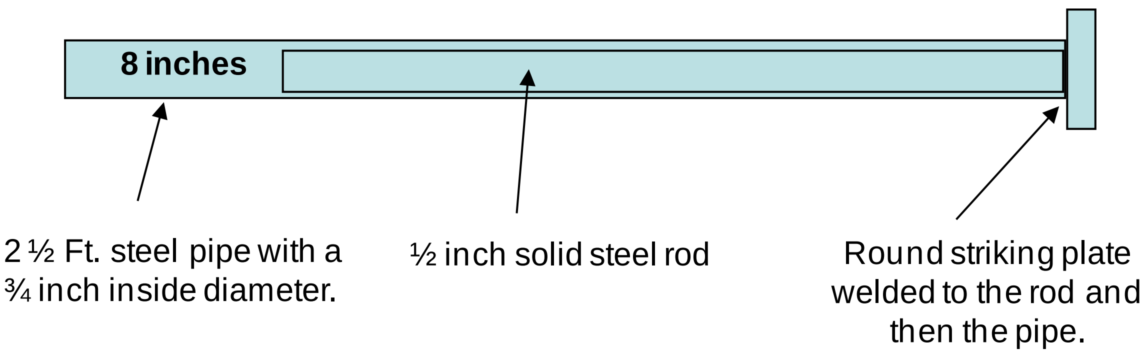
_____ Rain Gear
_____ Knee Boots
_____ Waders
_____ Watch
_____ Gloves
_____ Extra Clothing
_____ Hat
_____
_____
_____

Attachment B

This attachment contains the design specifications for the equipment that is made “in-house.” These designs have been created to meet specific needs for past field studies and can be modified as needed. The equipment to make these includes: power saws, drill press, and other hand tools. The rebar pounder is manufactured by a contracted welder.

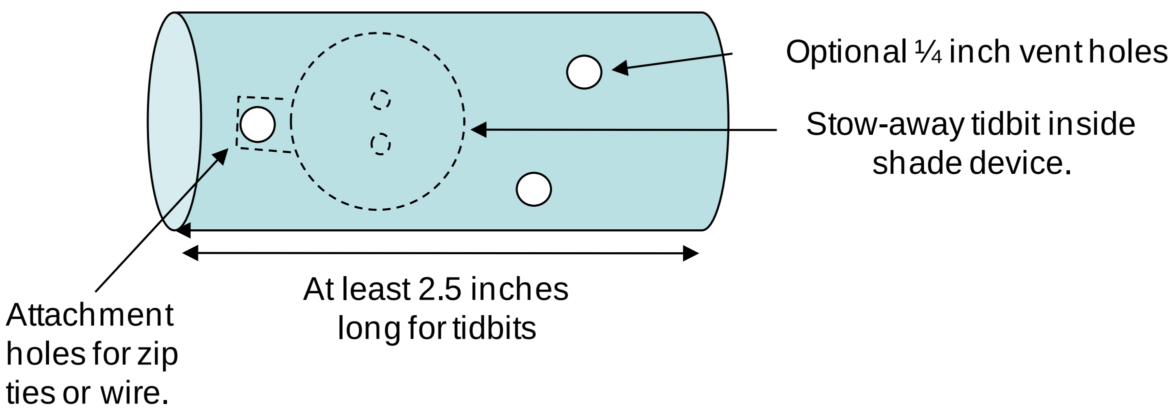
Rebar Pounder Design

Used to drive #4 (½ inch) rebar sections (2-4ft in length) into the streambed to establish an instream thermistor attachment location. The rebar is inserted in the hollow end and a heavy hammer is used to pound on the striking plate.

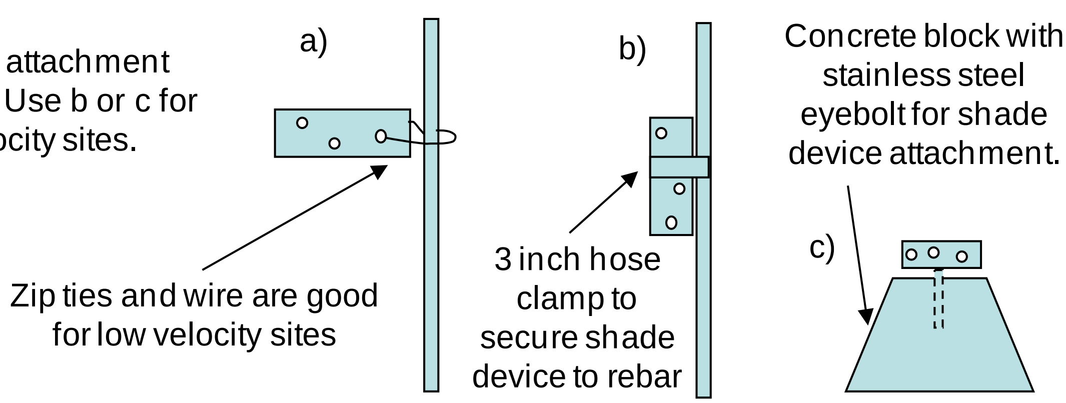


PVC Shade Device

This is typically made from 1.5 inch (inside diameter) PVC pipe. It should completely cover the thermistor to prevent solar radiation absorption. This design may be used for both instream and air thermistors.



Possible attachment options. Use b or c for high velocity sites.



Attachment C.

C-1. Temperature Logger Calibration Check Form – Blank Form.

C-2. Temperature Logger Calibration Check Form – Filled Out Form.

C-1. Temperature Logger Calibration Check Form – Blank Form.

Date: __________

Temperature Logger Calibration Check Form

Technicians:

____

	Time	NIST SN-	Thermistor #	Red Liquid SN-	SN-	SN-
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

	Time	NIST SN-	Thermistor #	Red Liquid SN-	SN-	SN-
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						
14						
15						

C-2. Temperature Logger Calibration Check Form - Filled Out Form.

Date: 5/4/09

Temperature Logger Calibration Check Form

Technicians: W/FRD

	Time	NIST SN- 70409	Thermistor # SLLT-1	Red Liquid SN- 8N935	RED LIQUID SN- 8N911	SN-
1	08:30	4.3	4.2	4.3	4.3	
2	:32	4.3	4.2	4.3	4.3	
3	:34	4.3	4.2	4.3	4.3	
4	:36	4.3	4.2	4.3	4.3	
5	:38	4.3	4.2	4.3	4.3	
6	:40	4.3	4.2	4.3	4.3	
7	:42	4.3	4.2	4.3	4.3	
8	:44	4.3	4.2	4.3	4.3	
9	:46	4.3	4.2	4.3	4.3	
10	:48	4.3	4.2	4.3	4.3	
11	:50	4.3	4.2	4.3	4.3	
12	:52					
13						
14						
15						

	Time	NIST SN- 70409	Thermistor # SLLT-1	Red Liquid SN- 8N935	RED LIQUID SN- 8N911	SN-
1	09:14	21.0	21.0	21.0	20.9	
2	09:16	21.05	21.0	21.1	20.9	
3	:18	21.1	21.1	21.1	21.0	
4	:20	21.1	21.1	21.1	21.0	
5	:22	21.1	21.1	21.1	21.0	
6	:24	21.1	21.1	21.1	21.0	
7	:26	21.1	21.1	21.1	21.0	
8	:28	21.1	21.1	21.1	21.0	
9	:30	21.1	21.1	21.1	21.0	
10	:32	21.1	21.1	21.1	21.0	
11	:34	21.1	21.1	21.1	21.0	
12	:36	21.1	21.1	21.1	21.1	
13						
14						
15						

Good

Attachment D

This section contains a blank and filled out example of the Continuous Temperature Survey Form that should be used for Ambient Monitoring - continuous temperature logger deployments. The form must be printed on waterproof paper and all completed ones need to be organized and stored in binders for archival purposes.

D-1. Blank Survey Form

D-2. Filled-out Survey Form

D-1. Blank Survey Form

Continuous Temperature Survey Form

Station #: ___________ **Station Name:** ___________________________ **Samplers:** ________________________

Interval Frequency 00:30

Water Temperature Logger

I.D. # ________________

Water Depth ______ **ft** **Deployment Depth** ______ **ft**

Height (Abv Bottom) ______ **ft** **Retrieval Depth** ______ **ft**

Air Temperature Logger

I.D. # ________________

Height (Abv Stream) ______ **ft**

Date	Time	Water Temp	Air Temp	Weather/ Comments

Air Temperature Logger Location:

Water Temperature Logger Location:

D-2. Filled-out Survey Form

Continuous Temperature Survey Form

Station #: 08C110 **Station Name:** CEDAR NR LANDSBURG **Samplers:** WARD/MYERS

Interval Frequency 00:30

Water Temperature Logger

I.D. # 457373

Water Depth 1.5 **ft** **Deployment Depth** 1.0 **ft**

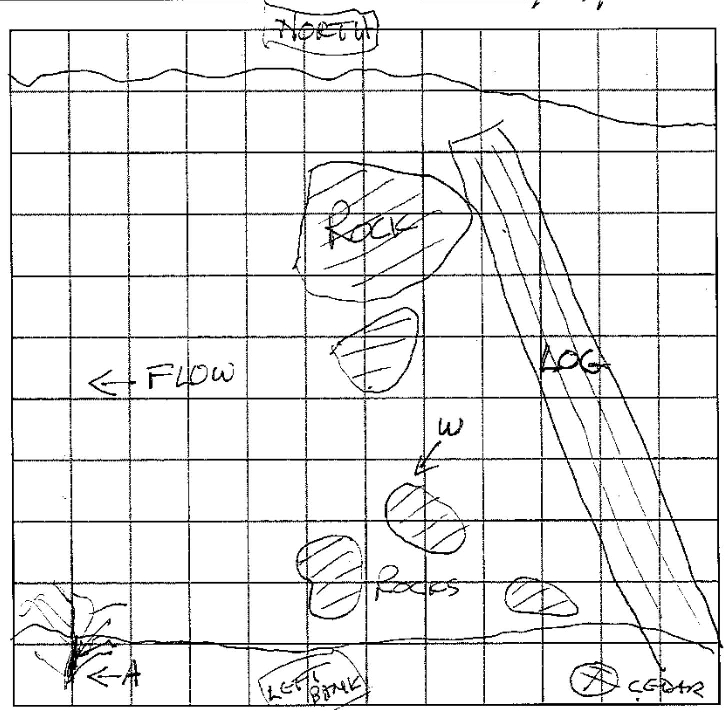
Height (Abv Bottom) 0.5 **ft** **Retrieval Depth** 0.7 **ft**

Air Temperature Logger

I.D. # 457375

Height (Abv Stream) 6 **ft**

Date	Time	Water Temp	Air Temp	Weather/ Comments
6/25	11:40	11.8	12.5	OVERCAST
9/24	10:20	12.3	·	PARTLY SUNNY



Air Temperature Logger Location: ON VINE MAPLE ~ 3.5' OFF GROUND, TREE IS LOCATED ~ 15' DOWNSTREAM OF WATER LOGGER LOCATION (ORANGE FLAGGING). LOGGER IS ON BANK SIDE OF TREE.

Water Temperature Logger Location: ON REBAR INSTALLED ON THE STREAM/UPSTREAM CORNER OF THE FIRST OF TWO LARGE ROCKS (>3.5' DIAMETER) BELOW LARGE LOG (~ 9' FROM LOG). NEAR LEFT BANK.

Standard Operating Procedure EAP129, Version 1.0

Short-term Continuous Data Collection with a Multiparameter Sonde, Part 1: Field Procedures

December 2019
Publication 19-03-229
[Approved 2019]

Purpose of this Document

The Washington State Department of Ecology develops Standard Operating Procedures (SOPs) to document agency practices related to sampling, field and laboratory analysis, and other aspects of the agency's technical operations.

Publication Information

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https://fortress.wa.gov/ecy/publications/SummaryPages/1903229.html. [Approved 2019.]

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Date – 5/31/2018

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Approval Date – 5/14/2019

SIGNATURES AVAILABLE UPON REQUEST

SOP Revision History

Revision Date	Revision History	Summary of changes	Sections	Reviser(s)
5/30/2018	1.0	Original draft completed	All	Nuri Mathieu
5/31/2018	1.0	Reviewed and contributed	All	Tighe Stuart; Eiko Urmos-Berry

1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for short-term (less than 6 months) continuous data collection using a deployed (unattended) multiparameter sonde. This SOP is intended for a variety of types of water quality studies, including Total Maximum Daily Load (TMDL), effectiveness monitoring, toxic loading, and other focused water quality studies.

1.2 Deploying sondes in the aquatic environment requires careful planning, routine dedicated maintenance, and thorough review of data record for usability and quality.

1.3 For long-term (greater than 6 months) or high-flow-conditions sonde deployment, consider requesting the Freshwater Monitoring Unit’s assistance with installing a long-term deployment station.

1.4 For deployment in an estuarine or marine environment, consider requesting the Marine Monitoring Unit’s assistance with selecting appropriate equipment and installing a deployment station.

1.5 Several of the methods and information presented in this SOP were taken or adapted from the USGS techniques and methods 1D-3: Guidelines and Standard Procedures for Continuous Water Quality Monitors: Station Operation, Record Computation, and Data Reporting (Wagner et al., 2006).

2.0 Applicability

2.1 This document should be used for deploying sondes in freshwater rivers, streams, and other waterbodies for project-level water quality assessments of limited duration.

3.0 Definitions

3.1 ABS — Acrylonitrile butadiene styrene, a type of plastic.

3.2 Fouling — the accumulation of unwanted material on solid surfaces to the detriment of function. The fouling materials can consist of either living organisms (biofouling) or a non-living substance (inorganic and/or organic).

3.3 Sonde — an instrument probe that transmits or logs information about its surroundings underground, under water, in the atmosphere, etc.

3.4 Thalweg — the line that connects the lowest points in a valley or river channel and, thus, the line of fastest flow or deepest water along a river's course.

4.0 Personnel Qualifications/Responsibilities

4.1 In general, field staff should be trained in safety procedures for work in streams. Ecology field staff must undergo annual training and certification for safety, invasive species decontamination, and heat stress.

4.2 Job classifications that typically perform this work: Natural Resource Scientist 1/2/3, Environmental Engineer 1/2/3, Environmental Specialist 1/2/3/4/5, Hydrogeologist 1/2/3/4.

5.0 Equipment, Reagents, and Supplies

5.1 Multiparameter sonde — Currently, EAP staff conducting water quality studies use three different types of sondes:

5.1.1 Hydrolab® Series 4 and 5 Datasondes and Minisondes.

5.1.2 Hydrolab® HL4/HL7 Multiparameter Sonde.

5.1.3 YSI® EXO 1/2/3 Multiparameter sonde.

5.2 Short-term sonde deployment tube. Schedule 40 or 80 PVC with holes drilled at one end for flow (Figure 2).

5.3 ABS bottom plates with large u-bolts and holes for staking (Figure 2).

5.4 Rebar or construction stakes 24 to 48 inches long.

5.5 Galvanized or stainless steel hardware (bolts, nuts, pipe clamps, stops/ferrules).

5.6 ¼-inch (or larger) cable or chain in various lengths (optional).

5.7 Life Vest/Personal floatation device (PFD).

5.8 Hip or Chest Waders.

5.9 Padlocks (optional).

5.10 Galvanized or stainless steel strut channel (optional).

5.11 Heavy duty deployment tube. Galvanized metal pipe with holes drilled at one end for flow (optional).

5.12 Concrete blocks, such as cinder or pier blocks (optional).

5.13 12V Hydrolab external battery in carrying case (if using).

5.14 Ammo box for external battery (if using).

5.15 Hydrolab underwater connection cable (if using external battery).

5.16 "Split" cable for connecting underwater connection cable to external battery (if using).

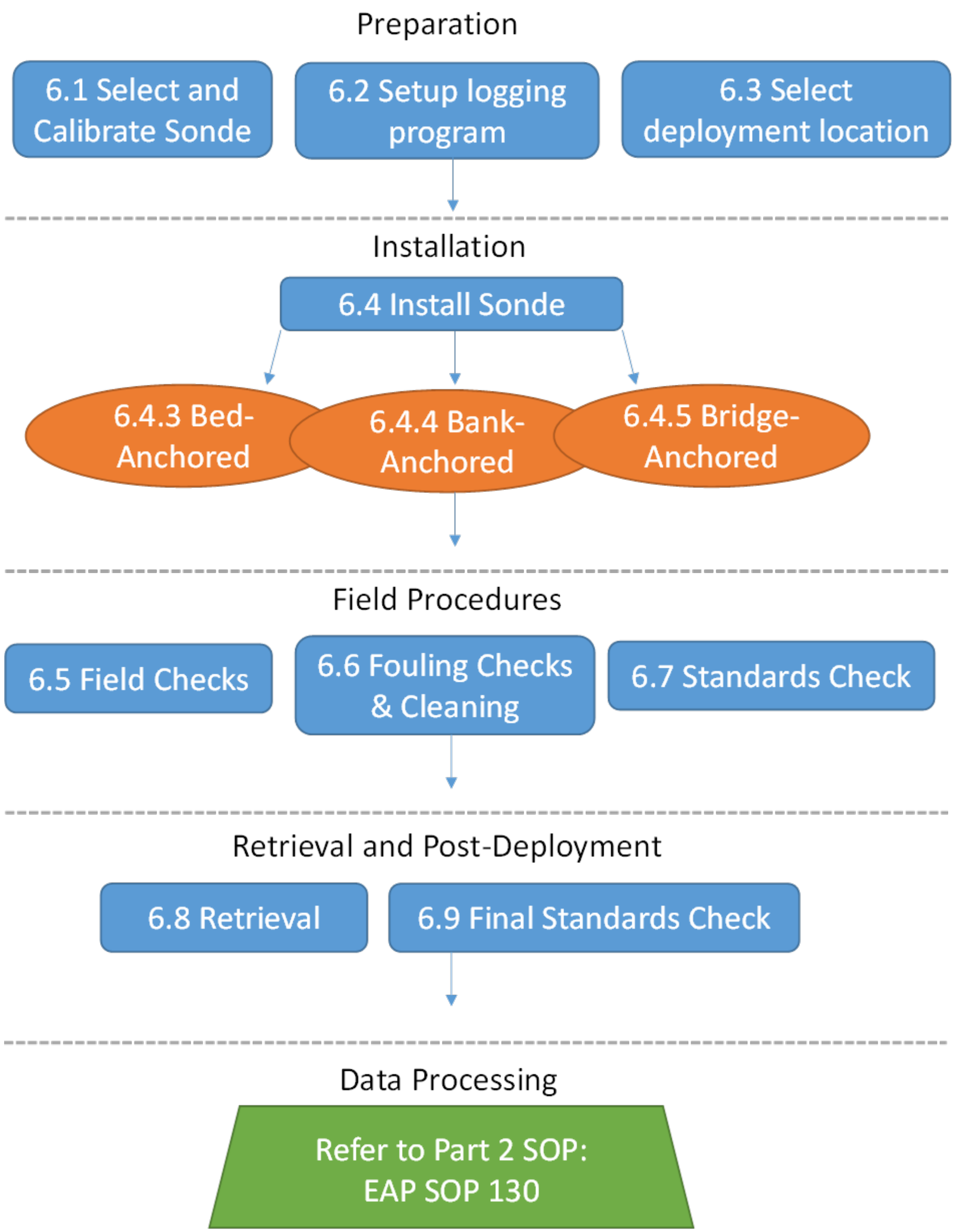

Figure 1. Summary of SOP for Field Procedures

6.0 Summary of Procedure

6.1 Pre-deployment sonde maintenance, calibration, and selection. In general, follow maintenance and calibration procedures outlined in EAP SOP 033 (Anderson, 2016).

6.1.1 Check sonde repair and maintenance history located on the EAP SharePoint site in the "Sonde repair status" spreadsheet in the Hydrolab Reservations SharePoint library. Choose a sonde/s with sensors that are in good repair and equipped with the parameters necessary to meet project objectives.

6.1.2 Designate which sondes will be used for deployment and which will be used to collect instantaneous field checks. For pH and DO in particular, assign sondes with newer sensors to locations that are critical to the study.

6.1.3 For pH, the Hydrolab sondes employ a reference probe that is installed in a separate port from the glass-bulb sensor. These reference probes require dedicated maintenance including routinely replacing the Teflon screw-on junction and replenishing reference electrolyte. For deployments of longer than 5 days, or deployments in low-ionic-strength waters, additional salt crystal pellets can be added to the electrolyte solution.

6.1.4 After replacing electrolyte solution or Teflon junction, it is very important to soak the sensors in tap or clean ambient water BEFORE calibrating the sonde. Ideally, the sonde should be set to log once every 15 minutes over the course of an overnight soak. Alternatively, if short on time or you forget to log overnight, then the sonde should be powered on for at least 15 minutes consecutively in the soaking solution before calibration.

6.2 Pre-deployment sonde setup for unattended logging

6.2.1 Deployments can be setup using either the handheld display unit (handheld) or a computer with the corresponding software installed. The internal logging setup for each of the different multiparameter sondes requires the same basic information including start time, log interval, and site or filename. The manuals for the sondes and handhelds provide more detailed information.

6.2.2 For water quality deployments that include pH and DO measurements, **a logging interval of 15 minutes is recommended**. For all other parameters, a maximum interval of 1 hour is recommended.

6.2.3 To maximize battery and sensor life, it is recommend to start/activate/enable internal logging files in the field immediately prior to deployment. Alternately, if the relative deployment time can be anticipated, the log file may be setup for a delayed start. Another alternative is to activate logging in advance, but leave the sonde disconnected from power until installation in the field. Upon connection to power, logging will commence.

6.2.4 The sondes can also be connected to an external data logger with the appropriate adapters and settings. The sondes can be configured with specific parameters in a specific order (assigned to channels). The parameters and order must match the data logger exactly.

6.2.5 Logging setup information specific to the YSI EXO 1/2/3

6.2.5.1 On the Exo Handheld, the ⚙ (gear) symbol leads to the deployment settings

6.2.5.2 The Exo sondes allow the user to setup the deployment up for a specified time zone. It is recommended that all deployments be setup in Pacific Standard Time (PST), which is always 8 hours behind the Coordinated Universal Time (UTC -0800). It is also acceptable to set the sonde to UTC time and correct to PST when processing the data. Both PST and UTC time avoid data-management issues in the data recorded during daylight savings transitions, such as two duplicate times in a row (in the fall) and skipping ahead 2 hours (in the spring). Record the time zone setting for each sonde after deployment setup is completed. It is also important that field staff record the time zone associated with measurements collected in the field.

6.2.5.3 The Exo sondes allow for an averaging duration to be specified. If pH is being collected for the study, it is important to set an averaging duration other than zero. Two to 3 minutes is suggested. The reason for this is that if the average duration is set to zero (default), only an instantaneous measurement will be collected at each measurement interval. The pH probe will likely not have adequate warmup time to equilibrate, and biased pH data could result. Note that after deployment, it is important to set the averaging duration back to zero for calibration post-checks, to get quick response to each standard/buffer.

6.2.6 Logging setup information specific to the Hydrolab HL4

6.2.6.1 The Hydrolab sondes require that the user enter a sensor warmup time, or how long the sensors will be powered on before collecting a measurement. **A minimum warmup time of 30 seconds is recommended (2-minute warmup if collecting pH)** to allow enough time for sensors to equilibrate to the water without draining battery power excessively. The warmup time must be smaller than the logging interval.

6.2.6.2 An HL4 with a fresh D battery can log for about a week with 15-minute interval and 30-second sensor warmup time; or about 2 days with a 2-minute sensor warmup time.

6.2.7 Logging setup information specific to the Hydrolab Series 4/5

6.2.7.1 As with the HL4, a warmup time of 30 seconds (or 2 minutes if collecting pH) should be used.

6.2.7.2 Similar to HL4, an MS5 with 8 fresh AA batteries can log for about a week with 15-minute interval and 30-second sensor warmup time; or about 2 days with a 2 minute sensor warmup time. This can be significantly extended by using a 12V external battery.

6.2.7.3 ***Important:*** When setting up a log file using HYDRAS3LT, parameters from the "parameters in sonde list" must be selected and added to the "parameters in log file" list, and then "update settings" must be selected. The sonde will NOT automatically log all equipped parameters/sensors.

6.2.7.4 ***Important:*** When setting up a log file using HYDRAS3LT, after configuring logging settings and parameters, **ENABLE** must be selected in order for the deployment to be activated. By default, the log file is disabled until this step is completed.

6.2.7.5 ***Important:*** When setting up log file using terminal mode (via HyperTerminal, Tera Term, or similar), it is important to add all parameters to the scrolling display before creating the log file. The log file will include all parameters displayed at the time the file is created. It is not necessary to do a separate "enable" step when using terminal mode; logging will be armed as soon as file is created.

6.3 Site selection and preparation

6.3.1 The most important step of deployment is selecting a location that is representative, accessible, safe, and relatively private.

6.3.2 To ensure a well-mixed, representative river deployment location, select a spot with adequate but not turbulent velocity (ideally ~1 ft/sec) that is located in the thalweg or main channel of flow and is not influenced by poorly mixed sources.

6.3.3 Good reconnaissance of the deployment location (both in the field and with GIS/aerial photography) is necessary to ensure there are no tributaries, outfalls, or groundwater seepage immediately upstream. As a general rule, equipment should be deployed upstream of bridge crossings to avoid influence from roadside drainage ditches and also upstream of recreational wading/swimming.

6.3.4 A location that is accessible, safe, and private can be difficult to locate and may require obtaining permission from a landowner to access private property.

6.3.5 Section 9.0 and the EAP Safety Manual contain guidelines for assessing site safety.

6.3.6 In some cases, public access with high visibility and recreational activity is the only option for deployment. In this case, make sure to deploy the sonde during a period of low activity such as early morning. Choose a location in the stream that is difficult to access without waders and is not suited to recreation. (Avoid swimming holes, shallow sandy areas, and within a ~50 foot radius of trail or bridge access.)

6.3.7 Deployment may require physical removal of interference and minor alterations of the streambed. Be mindful not to disturb fish and wildlife habitat, keeping impacts on the stream bed and riparian area to a minimum.

6.3.8 Representativeness cross-section surveys

6.3.8.1 If it is unclear whether the deployment location is representative, then a cross-section survey of spot measurements should be taken across the width of the channel. The cross-section should include, at a minimum, measurements at the desired deployment location, within several feet of both banks, and in the thalweg (if different from the deployment location).

6.3.8.2 For deeper or vertically-stratified rivers and streams, vertical profiles of spot measurements should be made at the deployment location and in the thalweg or deepest location nearby. At a minimum, profile measurements should be taken just below the water surface, at the deployment depth and near the streambed, with measurements at other levels to provide a representative profile.

6.3.8.3 For larger rivers or waterbodies, it may be necessary to determine an area-weighted mean for sonde parameters. This can be accomplished by taking equal width and depth increment measurements at the deployment transect. See USGS protocols, including Webb et al. (1999) and Wilde and Radtke (2005) for area-weighted measurements and calculations. Mathieu (2016) provides an example of area-weighted measurement and calculation for salinity.

6.3.8.4 If the sonde cannot be safely deployed in the most representative location, the data may be adjusted for location bias following procedures in Part 2 of this SOP, provided there are at least 3 area-weighted measurements to determine the adjustment factor.

6.4 Installation of sonde

6.4.1 There are three general types of sonde installations: bed-anchored, bank-anchored and bridge anchored, with several modifications within each type. Additional methods for sonde installation (not covered by this SOP) are available including boom-arm and flow-through monitoring installations.

6.4.1.1 Boom-arm installations are possible with assistance from the Freshwater Monitoring Unit's long-term deployment staff. These deployments allow the sonde deployment tube some flexibility of movement in the water column to avoid damage from flood debris.

6.4.1.2 Flow-through monitoring stations are typically the most expensive and require additional housing and justification; installation of these stations should be addressed in a project-specific QAPP, and are generally not applicable to short-term deployments.

6.4.2 Select the installation type that is best for your site and study objectives. Bed-anchored stations are often the best choice for very short deployments (two weeks or less) during stable flow conditions. Bank-anchored installations provide more security for multiple month or wet season deployments. Bridge-anchored installations may be the best choice if the waterbody is deep and the thalweg is limited to the center of the channel. Table 1 provides a list of advantages and disadvantages for each installation type.

Installation Type	Advantages	Disadvantages
Bed-anchored	• Less exposure to vandalism • Easily relocated • More locations suitable • Can be located anywhere across the transect • No/little permitting	• Susceptible to sedimentation. • Susceptible to debris damage • Servicing sensors limited during high water/flooding • Vandalism more likely to result in damage or loss • Not suitable for non-wadeable stream depth or substrate
Bank-anchored	• Sensors can be serviced during all conditions • Less susceptible to debris damage • Vandalism less likely to result in damage or loss* • Suitable for non-wadeable stream depth or substrate	• May require two installations (high and low flow). • More exposure to vandalism • Difficult to relocate • Fewer locations suitable • Must be located near bank • May require additional permitting. • May require private access.
Bridge-anchored	• Can be located anywhere across the transect • Easy to adjust depth • Sensors can be serviced during all conditions • Less susceptible to debris damage • Can be deployed at public access. • Suitable for non-wadeable stream depth or substrate.	• Fewer locations suitable • Requires additional permitting or permissions. • Additional traffic management and safety precautions required.

Table 1. Advantages and disadvantages for bed-, bank-, and bridge-anchored sonde installations

* If deployed in galvanized metal pipe attached to strut channel.

6.4.3 Bed-anchored installations

6.4.3.1 Bed-anchored installations require attachment to stream substrate or an object permanently embedded in the streambed (such as an abandoned piling, large tree, or boulder). Bed installations require wadeable stream access to the deployment location.

6.4.3.2 Bed deployments typically involve placing the sonde inside a deployment tube and attaching to rebar driven into the substrate. Concrete blocks, natural substrate, and large woody debris can be used to keep the sonde suspended above the bed. Pipe clamps, u-bolts, chain, braided steel cable with thimbles and cable clamps, concrete anchors, and heavy duty plastic ties are used to attach and anchor the sonde.

6.4.3.3 Bottom plates made from ABS, with holes drilled for rebar and u-bolts, provide an effective deployment platform. Figure 2 illustrates an example bed deployment configuration and Figure 3 depicts two examples of deployment.

6.4.3.4 The deployment tube may also be attached to abandoned pilings vertically with pipe clamps, cable, chain, rope, or webbing.

6.4.3.5 If changes in flow are expected, installations should be anchored at multiple points.

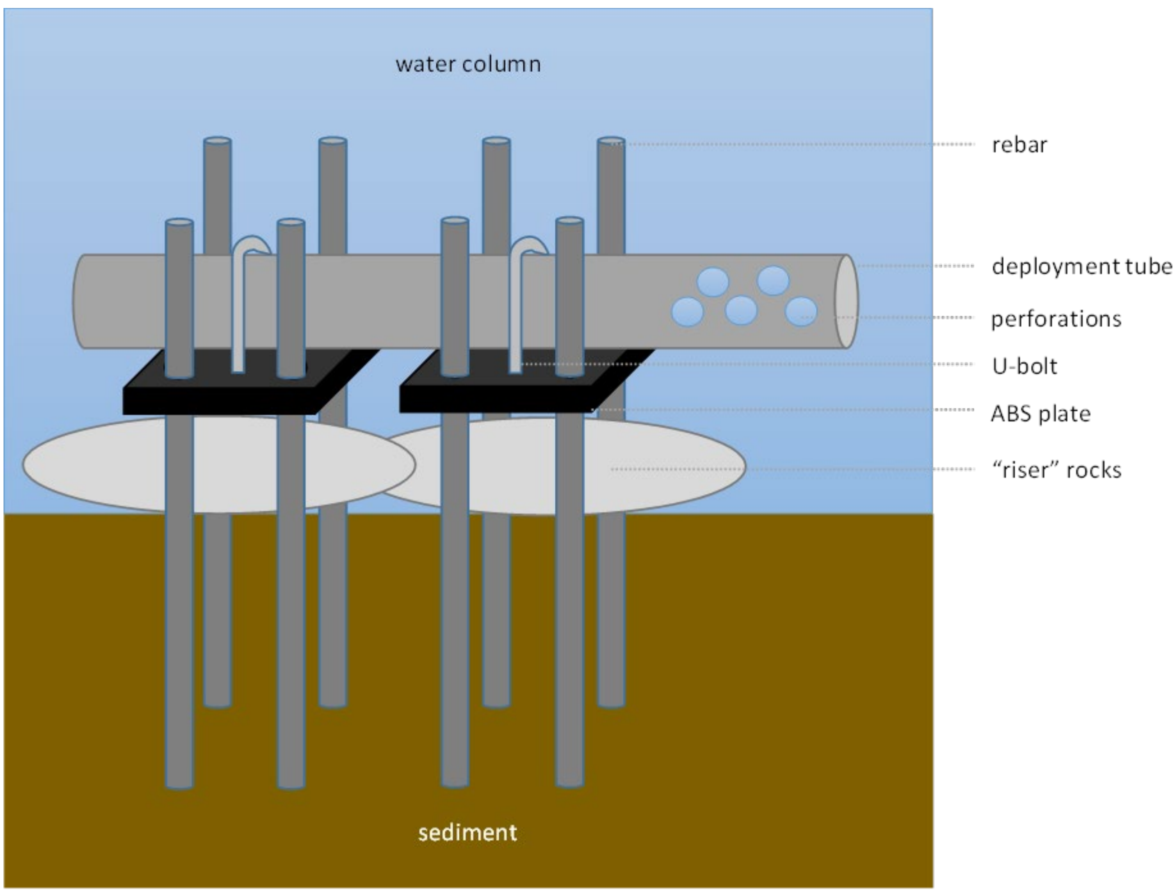

Figure 2. Bed anchored sonde installation using rebar, u-bolts, ABS plates, and PVC deployment tube.

Figure 2. Examples of bed-anchored installations.

6.4.4 Bank-anchored installations

6.4.4.1 Bank-anchored installations range from more involved (such as galvanized metal pipe housing with strut channel anchors: Figure 4) to relatively simple (such as using a chain or cable to anchor a PVC deployment tube to a large tree).

6.4.4.2 Bank-anchored stations provide access during a wide variety of flow conditions and the additional security of being able to anchor to permanent objects on the bank, riparian area, or floodplain.

6.4.4.3 Typically these deployments work best on the outer bank of a river bend where the thalweg, good velocity, and adequate depth are accessible during a wider range of conditions.

6.4.4.4 If possible, the deployment tube should be configured in such a way that the angle or depth can be adjusted as flow conditions change.

Figure 3.Examples of strut-channel (left) and simple rebar (right) bank-anchored installations.

6.4.5 Bridge-anchored installations

6.4.5.1 Bridge-anchored installations may be suspended from bridge railing/barrier or attached to bridge piers/pilings.

6.4.5.2 Bridge deployments should be installed downstream of a bridge piling to protect the sonde from debris damage. The depth of the sonde should be checked and adjusted at least monthly and may need more frequent adjustments during periods of rapidly changing water levels.

6.4.5.3 Before deploying the sonde from a bridge, permission must be obtained from the transportation/engineering department of the jurisdiction responsible for maintaining the bridge.

6.4.6 External battery power

6.4.6.1 Deployments of longer than 2 weeks typically require an external source of power to avoid frequent site visits and protect against data loss.

6.4.6.2 A variety of external power options are available based on the sonde manufacturer and deployment situation.

6.4.6.3 The Hydrolab HL4 and EXO sondes require the sonde be connected to a communications module and external data logger in order to utilize an external power source. Figure 5 shows the external battery options and associated adapters that can be connected to the Series 5 Hydrolab via a field cable.

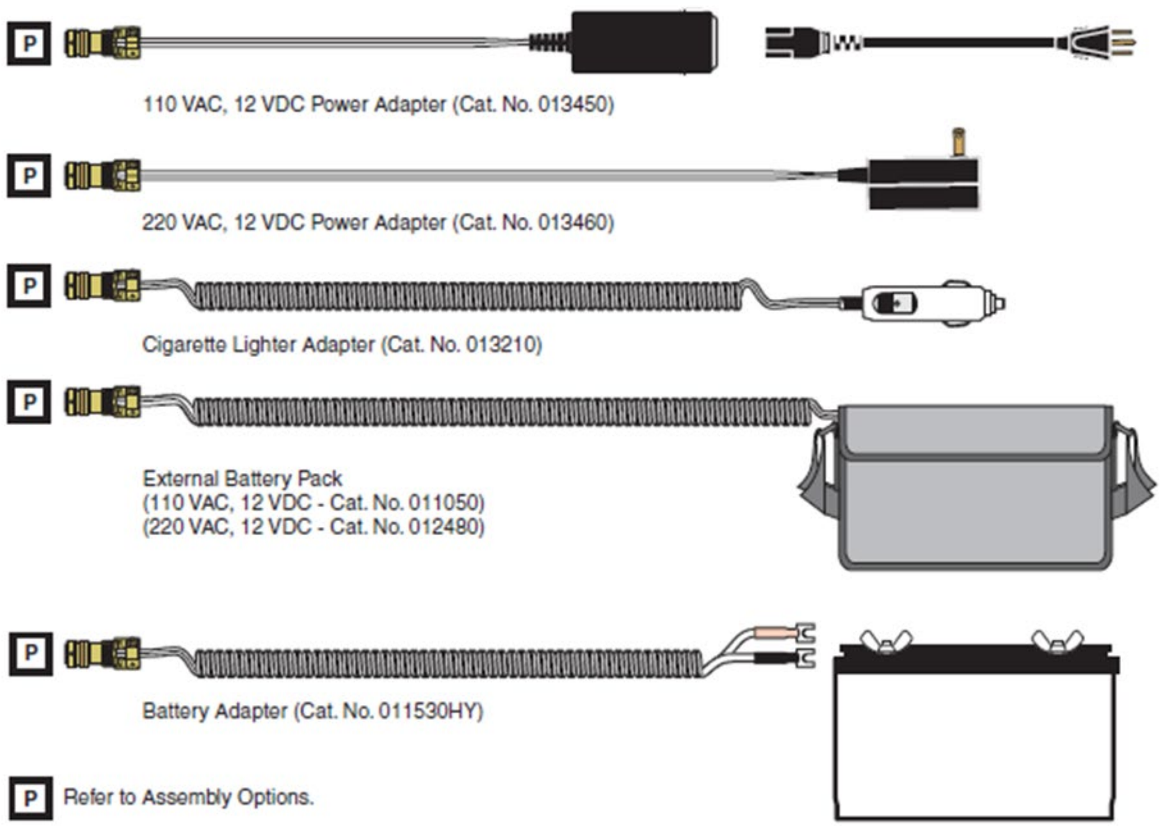

Figure 4. Series 5 Hydrolab external power options (taken from user manual).

6.4.6.4 12-volt DC batteries of varying sizes, stored in waterproof electrical boxes, are typically used to extend the amount of time between site visits.

6.4.7 Rapid deployment module

6.4.7.1 Typically real-time data transmission via telemetry only occurs at long-term-monitoring deployments. However, rapid-deployment telemetry modules can be set up to meet this need for short-term deployments.

6.4.7.2 A small waterproof electrical box is used to house the necessary equipment, including the data logger, data-collection platform radio set (DCPRS), battery, and extra communications cable.

6.4.7.3 PVC is used to cover the cable between the stream and housing. For these short-term deployments, housing can be installed closer to sensor (doesn't need to accommodate as wide of a range of flows).

6.4.7.4 Data is transmitted via the Geostationary Operational Environmental Satellite (GOES) network to Ecology's long-term continuous data management system.

6.5 Performing field checks

6.5.1 Field-check measurements using a separate calibrated sonde or instrument of comparable quality are collected upon deployment, mid-deployment, and at retrieval to help assess the data quality of the deployment measurements.

6.5.2 A list of acceptable field check instruments is maintained in the Programmatic Water Quality Impairment QAPP (McCarthy and Mathieu, 2017).

6.5.3 Upon deployment, the sonde should be allowed at least 5 minutes to equilibrate in the stream. If a logged measurement occurs less than 5 minutes after deployment, then the field check should be collected near the second logged measurement time. For example, if the sonde is deployed at 8:56 and set up to log every 15 minutes starting at 9:00, then the field-check measurement should be collected closer to the 9:15 logged measurement. This initial field check is important for assessing potential drift issues with the sensors.

6.5.4 At least one field check must be collected mid-deployment, unless the deployment is less than 48 hours. The mid-deployment field check can be collected as part of a fouling check (see Section 6.6).

6.5.5 It is recommended to locate the field check sonde as close to the deployed sonde sensors as possible (Figure 6) and to record field checks as close to the logged measurement time on the deployed sonde as possible.

6.5.6 A final field check must always be collected upon retrieval of the deployed instrument. This is the most important field check to collect.

6.5.7 If dissolved oxygen is being measured, a Winkler sample should be collected with each field check as an additional quality check on DO. If a fouling check is being conducted, the Winkler should be collected immediately after the fouling check.

Figure 5. Example of side-by-side field check on a deployed sonde.

6.6 Sonde cleaning and fouling checks

6.6.1 Cleaning of the sonde/sensors and a fouling check should be completed during site visits when a sonde has been left unattended for a period of 1 week or longer and upon instrument retrieval for any deployment of 1 week or longer. More frequent cleaning and fouling checks may be necessary in very eutrophic conditions or during periods of sedimentation.

6.6.2 Fouling check procedure.

6.6.2.1 Conduct site inspection for damage, obstructing debris, sedimentation, and general observations. Record all observations.

6.6.2.2 Upon arriving at the site, immediately place the field-check sonde/instrument in the water near the deployed sonde and power on the handheld. This will allow the field check instrument the appropriate warmup time.

6.6.2.3 **<u>If there is NOT a cable permanently attached to the deployed sonde</u>**, allow the sonde to log one final reading, and then record the pre-cleaning field-check readings at or near the same time.

6.6.2.4 **<u>If there is a cable permanently attached to the sonde</u>**, attach a second handheld to the deployed communications cable and power on the handheld. Allow the appropriate sensor warmup time (2 minutes for pH, 30 seconds for all other parameters), record the deployed sonde readings, and then record the pre-cleaning field check readings at or near the same time.

6.6.2.5 After the pre-cleaning measurements have been completed, immediately remove sonde from the deployment tube, and thoroughly clean sensors following sensor cleaning procedure in 6.6.3. Clean and flush the deployment tube after removing sonde. Figure 7 depicts two examples of sensors with fouling post-deployment.

6.6.2.6 Return the sonde to the same deployment location, allow parameters to stabilize, and record post-cleaning readings and time.

6.6.2.7 At the same time or immediately after, record post-cleaning readings and time from the field check instrument. Take measurement as near to the deployed sonde as possible.

6.6.2.8 Finally, after cleaning is completed collect a Winkler sample (See EAP SOP #023; Ward, 2016) as an additional check on DO.

6.6.2.9 At the end of the fouling check you should have four sets of measurements: 1) deployed sonde pre-cleaning, 2) field check pre-cleaning, 3) deployed sonde post-cleaning, and 4) field check post-cleaning.

6.6.2.10 Make note of any rapid changes in the parameters on the field-check instrument. The pre- and post-cleaning field check readings are used to determine any change in the parameters not associated with fouling. For example, if the stream temperature is warming rapidly.

Figure 6.Sensor fouling due to sedimentation/debris accumulation (top) and eutrophic conditions (bottom).

6.6.3 Sensor cleaning procedure.

6.6.3.1 In general, always follow individual manufacturer's guidelines for cleaning the sonde and attached sensors.

6.6.3.2 After removing the sonde, the deployment tube or apparatus should be flushed with a bucket of water to remove sediment buildup and scrubbed with a hard-bristled brush attached to a long handle or pole.

6.6.3.3 The electrical connector pins of the sonde, cables, and handhelds should be dry and free of debris prior to connecting and powering on. A small container of compressed air is helpful for drying and cleaning connectors.

6.6.3.4 The bodies of the sonde and individual sensors can be carefully scrubbed with a soft-bristled brush or toothbrush and ambient or DI water.

6.6.3.5 The sensor membranes, bulbs, cells, and any other "working parts" should be cleaned with a damp, lint-free cotton swab and DI water, unless otherwise specified by the manufacturer.

6.6.3.6 For turbidity sensors, Wagner et al. (2006) recommends: "the optic lens should be carefully cleaned with alcohol by using a soft cloth to prevent scratching (or as recommended by the manufacturer), rinsed three times with turbidity-free water, and carefully dried. If the readings are unusually high or erratic during the sensor inspection, entrained air bubbles may be present on the optic lens and must be removed."

6.7 Mid-deployment standards check

6.7.1 After cleaning is completed, if the deployed sensors deviate from the field checks by greater than the thresholds identified in Table 2, then the sensors should be checked against NIST-certified standards. A standards check is only necessary for the individual parameters that exceed their respective threshold, not for the entire sonde.

Table 1. Deviation thresholds (field check vs. deployed sonde) which trigger a standards check.

Parameter	Deviation Threshold (Field check vs Deployed sonde)	Bias MQO from Programmatic QAPP
Specific Conductance	± 10%	± 10%
pH	± 0.2	± 0.2
DO	± 0.5 mg/L	± 0.5 mg/L
Turbidity	± 10% or 1 NTU/FNU**	± 10%

** whichever is greater.

6.7.2 If the deployed sensors (except for DO) deviate from the standards by greater than the thresholds identified in Table 3, then the sensors should be recalibrated. Recalibration is only necessary for the individual parameters that exceed their respective thresholds, not for the entire sonde.

6.7.3 For DO, if the difference between the deployed and field check values exceeds 0.5 mg/L (Table 2), then a saturation check should be performed on both the deployed and field check instrument. In general, recalibration of DO is not recommended in the field. The Winkler samples, mid-deployment saturation checks, and post-deployment saturation checks can be used during data processing to assess, and potentially adjust for, bias.

Table 2. Deviation thresholds (standards vs. deployed sonde) which trigger recalibration.

Parameter	Deviation Threshold (Standards vs Deployed sonde)	MQO from Programmatic QAPP
Specific Conductance	± 10%	± 10%
pH	± 0.2	± 0.2
DO	± 0.5 mg/L	± 0.5 mg/L
Turbidity	± 10% or 1 NTU/FNU**	± 10%

** whichever is greater

6.7.4 The temperature of standards/buffers used for calibration can change rapidly in the field due to differences between the ambient, vehicle, and overnight storage temperatures. Pay close attention to temperature readings during calibration and only enter the temperature-adjusted calibration value immediately before calibrating. Note any rapid temperature changes in the buffer on the calibration form or field log book.

6.7.5 If possible, the buffers and sonde should be kept out of direct sunlight during field calibration to avoid temperature changes due to direct solar radiation.

6.7.6 Two options are available for saturation field checks on DO: 1) a small aquarium bubbler can be setup in a small open-top container of water and the sonde placed inside or 2) a bottle of water that has equilibrated to ambient air temperature may be shaken for 40 seconds and then poured into the sonde's calibration cup. See SOP EAP033 (Anderson, 2016) for further detail.

6.7.7 DO saturation field checks require the local barometric pressure. This can be measured in the field with a barometer or can be obtained from a local weather station. The YSI Exo Handheld is equipped with a barometer, and DO saturation can be viewed in %EU mode to obtain readings automatically corrected to the live barometric pressure reading. Most weather stations report the barometric pressure adjusted to sea level. These values must be adjusted for the site elevation using the equation:

$$\text{Pressure at sea level in mmHg} = (\text{Site Elevation} \times 0.0254)$$

6.7.8 During DO saturation field checks, record the DO in mg/L, water temperature, and specific conductance of the water at saturation. The temperature and specific conductance readings can be used to calculate the theoretical DO at saturation in mg/L using the USGS DO saturation tables (https://water.usgs.gov/software/DOTABLES/).

6.7.8.1 The DO tables can be printed out and used in the field for reference.

6.7.8.2 The sonde and theoretical DO values, in mg/L, at saturation can be compared to assess the potential error in mg/L. This information is useful during the data-processing stage.

6.8 Retrieval of sonde and deployment equipment

6.8.1 After collecting the final field, fouling, and Winkler checks, the sonde should be removed from the water and fitted with the sensor storage cup. A small amount of tap or site water should be placed in the storage cup to protect the sensors against damage or drift.

6.8.2 The data should be downloaded, backed-up, and visually checked before leaving the site. Data quality or logging issues may require re-deployment of the same or a different sonde.

6.8.3 Disturbance of the streambed and riparian area should be minimized upon station removal. All materials (rebar, strut channel, concrete blocks, etc.) brought to the site for installation must be removed from the site. The stream and surrounding areas should be restored to their pre-deployment condition, to the extent possible.

6.9 Post deployment reference checks

6.9.1 Both the deployed and field instruments should be checked against reference materials upon retrieval. This is similar to the pre-deployment calibration procedure; however, the sensors should **NOT** actually be calibrated to reference values. This is particularly important for 2- or 3-point calibrations, such as pH, where the second and third readings are affected by the first calibration point.

6.9.2 The purpose of the post-check is to assess the sensors for potential drift or bias issues, NOT to recalibrate the sonde for subsequent data collection.

7.0 Records Management

7.1 Field measurements and observations recorded in a field notebook should be checked for errors and omissions before leaving each site and then entered into the appropriate discharge spreadsheet as soon as possible upon return from the field.

7.2 Electronically recorded measurements should be saved to another device (e.g. usb drive, tablet, or laptop) as soon as possible (preferably in the field) and entered/imported into the project database as soon as possible upon return from the field.

7.3 For Ecology staff, the raw data files should be saved to network drive in order to ensure routine backup of files.

8.0 Quality Control and Quality Assurance

8.1 QA/QC procedures will be addressed thoroughly on a project-by-project basis in the Quality Assurance Project Plan (QAPP) for the project.

8.2 In the absence of a project specific QAPP, QA/QC procedures and objectives should follow those outlined in Section 6 of this SOP, in the Programmatic Water Quality Improvement QAPP (McCarthy and Mathieu, 2017), and in the Part 2 Data Processing SOP.

9.0 Safety

9.1 Wading streams is one of the most dangerous activities undertaken by field staff especially during higher flows. Two people are required at all times when streams are to be waded. Life jackets are to be worn if there is any chance of being pushed downstream or being submerged after falling into the water. Life jackets should also be worn when new sites are being established and when stream conditions to be encountered are unknown.

9.2 Assess whether or not the velocity and depth of the stream are low enough to safely wade across it. As a rule of thumb: **Do NOT wade in flowing water when the product of depth (in feet) and velocity (in feet per second) equals 10 or greater.** For example, if the stream is estimated to be 3 feet deep and have a velocity of 4 ft/s, do **NOT** wade across the stream. This is only a general rule; take extra precautions where the substrate is unstable (slippery or moving), water visibility is impaired (high turbidity or glare), or other challenges are present.

9.3 If there is any chance of the streamflow being strong enough to potentially cause injury (by being swept downstream into rocks or other dangerous settings, drowning, hypothermia, etc.), do not consider wading in the stream. When in doubt, err on the side of safety.

9.4 For further field health and safety measures refer to Environmental Assessment Program's Safety SharePoint site.

10.0 References

10.1 Environmental Assessment Program (EAP), 2019. *Environmental Assessment Program Safety Manual*. Washington State Department of Ecology. Revised 03/19

10.2 Anderson, P. 2016. Standard Operating Procedure EAP033: Hydrolab® DataSonde®, MiniSonde®, and HL4 Multiprobes. Environmental Assessment Program, Washington State Department of Ecology, Olympia.
ecology.wa.gov/quality

10.3 Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 pp. + 8 attachments.
http://pubs.water.usgs.gov/tm1d3

10.4 Ward, W.J, 2016. Standard Operating Procedure EAP023: Collection and Analysis of Dissolved Oxygen (Winkler Method). Environmental Assessment Program, Washington State Department of Ecology, Olympia.
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10.5 Webb, W.E., Radtke, D.B., and Iwatsubo, R.T., 1999. Surface-water sampling: Collection methods at flowing-water and still-water sites: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Chapter A6, Section 4.1.
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10.6 Wilde, F.D., and Radtke, D.B., 2005. General information and guidelines: U.S. Geological Survey Techniques of Water-Resources Investigations, Book 9, Chapter A6, Section 6.0, 36 pp.
http://pubs.water.usgs.gov/twri9A6

Standard Operating Procedure EAP130, Version 1.0

Short-term Continuous Data Collection with a Multiparameter Sonde, Part 2: Data Processing

December 2019
Publication 19-03-230
[Approved 2019]

Purpose of this Document

The Washington State Department of Ecology develops Standard Operating Procedures (SOPs) to document agency practices related to sampling, field and laboratory analysis, and other aspects of the agency's technical operations.

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SIGNATURES AVAILABLE UPON REQUEST

Please note that the Washington State Department of Ecology's Standard Operating Procedures (SOPs) are adapted from published methods, or developed by in-house technical and administrative experts. Their primary purpose is for internal Ecology use, although sampling and administrative SOPs may have a wider utility. Our SOPs do not supplant official published methods. Distribution of these SOPs does not constitute an endorsement of a particular procedure or method.

Any reference to specific equipment, manufacturer, or supplies is for descriptive purposes only and does not constitute an endorsement of a particular product or service by the author or by the Department of Ecology.

Although Ecology follows the SOP in most instances, there may be instances in which the Ecology uses an alternative methodology, procedure, or process.

SOP Revision History

Revision Date	Revision History	Summary of changes	Sections	Reviser(s)
6/12/2018	1.0	Original draft completed	All	Nuri Mathieu
6/30/2018	1.0	Review and major contributions	All	Tighe Stuart;
7/30/2018	1.0	Reviewer	All	Nuri Mathieu
5/14/2019	1.0	Approval	All	Arati Kaza

1.0 Purpose and Scope

1.1 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for the preparation of technical SOPs.

1.2 This document is the Environmental Assessment Program (EAP) Standard Operating Procedure (SOP) for processing, reviewing, and finalizing short-term (less than 6 months) continuous data sets collected using a deployed multi-parameter sonde. This SOP is intended for a variety of types of water quality studies, including Total Maximum Daily Load (TMDL), effectiveness monitoring, toxic loading, and other focused water quality studies.

1.3 For data collection procedures associated with this SOP see Part 1, SOP EAP129.

1.4 Several of the methods and information presented in this SOP were taken or adapted from the USGS techniques and methods 1D-3: *Guidelines and Standard Procedures for Continuous Water Quality Monitors: Station Operation, Record Computation, and Data Reporting* (Wagner et al., 2006).

2.0 Applicability

2.1 This document should be used for processing data from sondes deployed in freshwater rivers, streams, and other waterbodies for project-level water quality assessments of limited duration (less than 6 months). Deployments of great than 6 months involve a larger dataset and a more dynamic range of deployment conditions. These long-term deployments should be conducted in consultation with EAP's freshwater monitoring unit.

3.0 Definitions

3.1 Data adjustment — raw data values changed based on a factor or equation that accounts for observed bias or drift.

3.2 Fouling — the accumulation of unwanted material on solid surfaces to the detriment of function. The fouling materials can consist of either living organisms (biofouling) or a non-living substance (inorganic and/or organic).

3.3 Instrument Drift — a change in the accuracy of an instrument's measurements over time.

3.4 RMSE — Root Mean Squared Error, the square root of the average of the differences between two measurements.

3.5 Sonde — an instrument probe that transmits or logs information about its surroundings underground, under water, in the atmosphere, etc.

4.0 Personnel Qualifications/Responsibilities

4.1 Staff must be trained in processing, reviewing, and adjusting water quality sensor data.

4.2 Job classifications that typically perform data processing work: Natural Resource Scientist 1/2/3, Environmental Engineer 1/2/3, Environmental Specialist 1/2/3/4/5, Hydrogeologist 1/2/3/4. Entry-level staff should not perform data review or adjustment without oversight from experienced senior staff.

5.0 Equipment, Reagents, and Supplies

5.1 Computer with data processing software such as Microsoft Excel/Access, R, Hydstra, Aquarius, etc.

6.0 Summary of Procedure

6.1 Reviewing and qualifying the field-check instrument data

6.1.1 The first step in processing the continuous data from the deployed sonde is to make sure that the field-collected "check" data used to assess it is of acceptable quality.

6.1.2 For all parameters except dissolved oxygen (DO), the post-check results (see SOP EAP129, Part 1; section 6.9) are used to calculate the difference between the field-check instrument values and reference material values.

6.1.3 The calculated differences are compared to the criteria in table 1 and used to assign a data-quality rating for data collected with each field-check instrument. When multiple reference checks are conducted, the larger of the two differences should be used to assign the rating. For example, if the instrument was 0.15 pH units high, compared to the pH 7 buffer, and 0.22 units high, compared to the pH 10 buffer, then the instrument pH should be assigned a quality rating of "Qualify" based on the 0.22 value.

Table 1. Measurement quality objectives for field-check instruments using post-check data

Measured field parameter	Post-check Reference	Accept	Qualify as Estimate	Reject
Water temperature	NIST-certified Thermometer	≤ ± 0.2°C	> ± 0.2 – 0.8°C	> ± 0.8°C
Specific conductance[a]	NIST-certified Buffer/s	≤ ± 10%	> ± 10 – 20%	> ± 20%
pH	NIST-certified Buffers (2-3pt)	≤ ± 0.2 units	> ± 0.2 – 0.8 units	> ± 0.8 units
Turbidity	NIST-certified Buffer/s	≤ ± 1.0 units or ≤ ± 10% [b]	> ± 1.0 – 2.0 units or > ± 10 – 20% [b]	> ± 2.0 units or > ± 20% [b]

[a] *Except for zero-check*
[b] *Whichever is greater*

6.1.4 For DO, it is recommended that field checks be assessed and, if necessary, adjusted (see section 6.5) based on regression with Winkler samples. Winkler-adjusted DO field checks can be rated based on the degree of agreement between the adjusted values and the Winkler samples (Table 2). In the absence of “accepted” Winkler data, the field-check instrument should be rated based on the percent saturation post-check (Table 2).

6.1.5 For large short-term surveys with many deployed sondes and one field-check sonde, a good approach is to collect a large number (e.g. 10+) of Winklers alongside the check sonde, across a range of values. This provides a strong basis for bias correction of the check sonde. A minimum of 5 Winklers are required to adjust field-check data.

6.1.6 Using the Winkler-adjusted field checks to assess the deployed instruments combines the accuracy and standardization of Winkler samples with the precision of optical DO sensors (Figure 1).

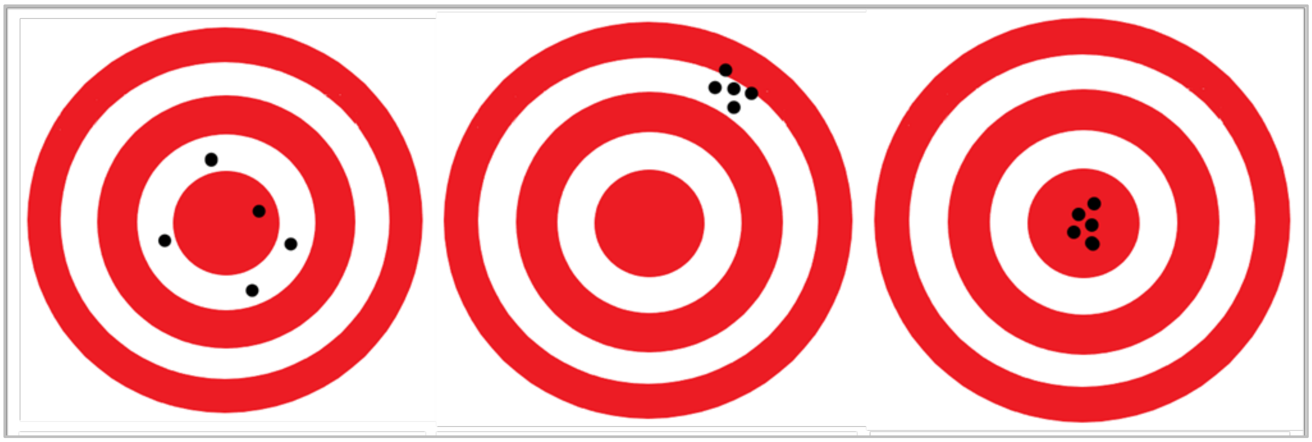

Figure 1. Illustration of accuracy vs. precision, as applied to Winkler and optical DO methods
Additional text describing Figure 1:

Left: The chemical basis of Winkler samples ensures they are generally accurate, but they are not precise, often having up to 0.3 mg/L error.

Middle: Optical DO probe results are very precise, down to a few hundredths of a mg/L. However, they can be inaccurate (biased) up to 1 mg/L off because of inherent problems with saturation calibrations.

Right: Applying a bias correction to optical DO probe results using several Winkler results provides a way to be both precise and accurate.

Table 2. Dissolved Oxygen measurement quality objectives for field-check instruments equipped with optical DO probes, post adjustment.

Measured field parameter	Quality Rating Method Preference	Post-check Reference	Accept	Qualify as Estimate	Reject
Dissolved Oxygen	Primary	Winkler samples	≤ ± 0.5 mg/L	> ± 0.5 – 1.0 mg/L	> ± 1.0 mg/L
Dissolved Oxygen	Secondary	Saturation Check	≤ ± 5%	> ± 5 – 15%	> ± 15%

6.1.7 Winkler data quality is assessed by collecting replicate samples in the field and by performing sodium thiosulfate normality checks with potassium bio-iodate during titration.

6.1.8 If the normality check is off by greater than ±0.2 mg/L, then an attempt will be made to correct the problem (i.e. replace the thiosulfate, check equipment, etc.). A second normality check will then be performed. If the problem is corrected (check now <±0.2 mg/L), then the Winkler samples titrated prior to that normality check may be adjusted by the offset (difference between first and second check). If the second normality check is greater than ±0.2 (problem not corrected), then the Winkler samples will be qualified as estimates. If the second check is greater than ±0.8, the Winkler samples will be rejected.

6.1.9 The programmatic QAPP (McCarthy and Mathieu, 2017) states that the median absolute difference for DO Winkler replicate pairs should be less than 0.2 mg/L.

6.2 <u>Preliminary data rejection and removal</u>

6.2.1 The first step in reviewing a time series raw data file for a deployed sonde is to remove all measurements where the sonde was not deployed in the water column or had not yet equilibrated. If the log file was not enabled/disabled in the field (or power was supplied early), then there may be numerous measurements on either end of the record.

6.2.2 Deployment, retrieval, and site-visit times should be used to remove data points where the sonde was out of water. If field activity time is missing, specific conductance values at or near zero can be used to identify times when the sonde was out of the water. As a general rule, any measurements logged near-in-time to placing the sonde in the water should be removed if they are out of line with other measurements in the record. All removed data should be documented in the project files.

6.2.3 pH may take multiple log intervals to equilibrate. Additional values may be removed from the beginning of the pH time series record based on visual review.

6.2.4 Figure 2 provides an example of data points removed from the raw data file that were collected prior to deployment and after retrieval.

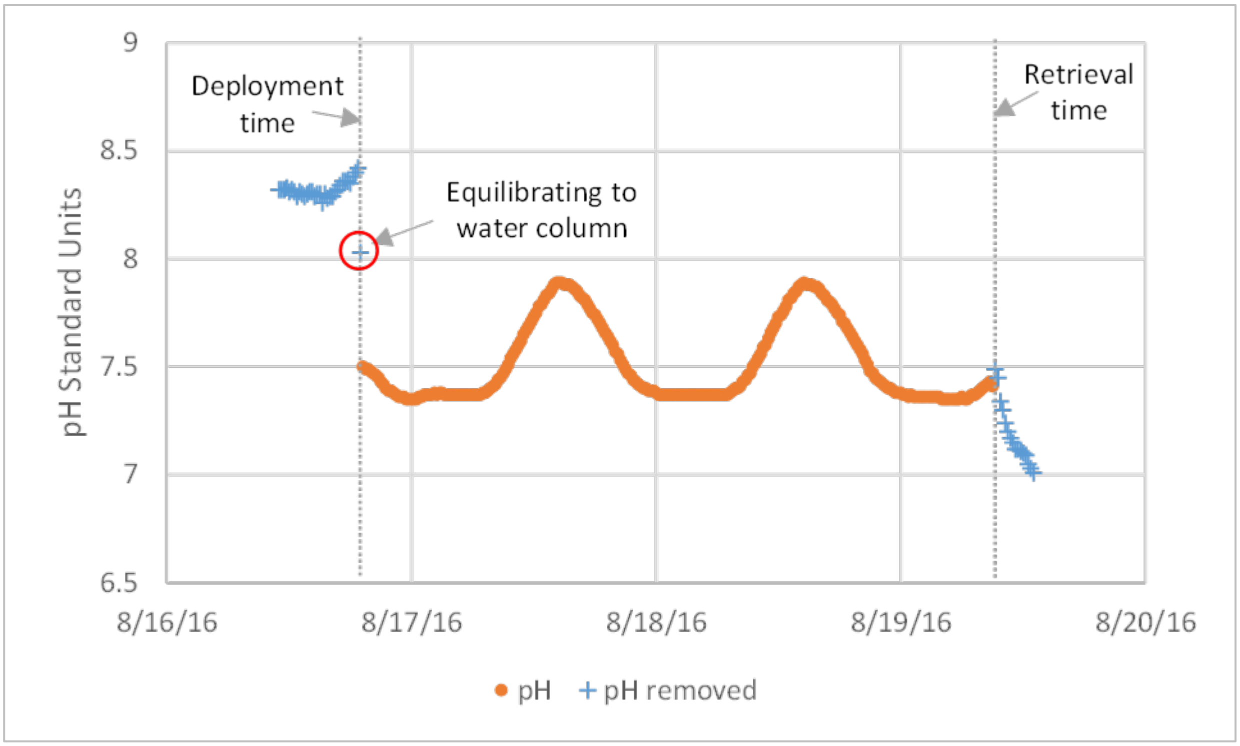

Figure 2. Example of preliminary data removal prior to deployment and after retrieval.

6.2.5 In some cases, temporary interference or fouling may create artificial noise in the data record. Data filters and/or manual review may be used to remove or qualify spurious data points. This level of data processing requires careful review and thorough documentation of any rejected data in the project files.

6.2.6 Figure 3 provides an example of specific-conductance data processing to remove unexplained noise in the data. First, a rate of change filter is applied, and, then, additional noise is removed manually by visual review. The daily signal is retained, and the average of the data changes by 1.1% between raw and processed data.

6.2.7 Removal or rejection of noisy data points should be thought of as a conservative process, whereby data with less certainty associated to it is not reported.

6.2.8 Do not perform data averaging or smoothing to remove noise on continuous sonde data.

6.2.9 Only noise that appears randomly distributed should be removed. Continuous "spikes" in the data should NOT be removed, as they likely represent real discrete changes in water quality due to a temporary discharge or condition. If it is unclear whether the noise is random, qualify, rather than reject the data.

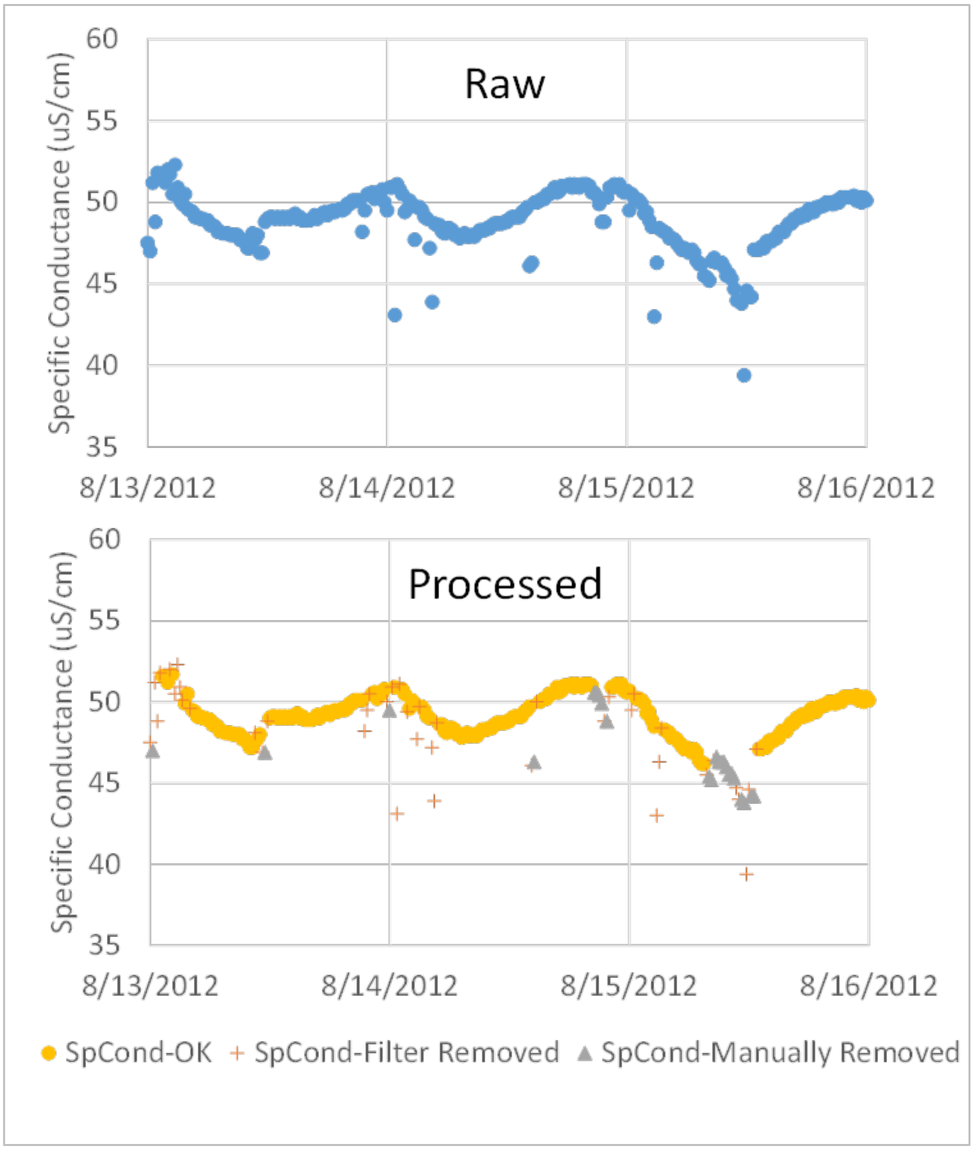

Figure 3. Example of removal of unexplained noise in the data record

6.2.10 When a sonde experiences extreme fouling, sediment burial, or major interference, part of the data file may be salvaged, if a specific fouling or interference event can be identified. Figure 4 provides an example where Sonde A was found buried in sediment following a large storm event. Flow data from a gage in the watershed and water quality data from the nearby unburied Sonde B were used to identify the time of burial. Only results after the identified burial event were removed from the final record.

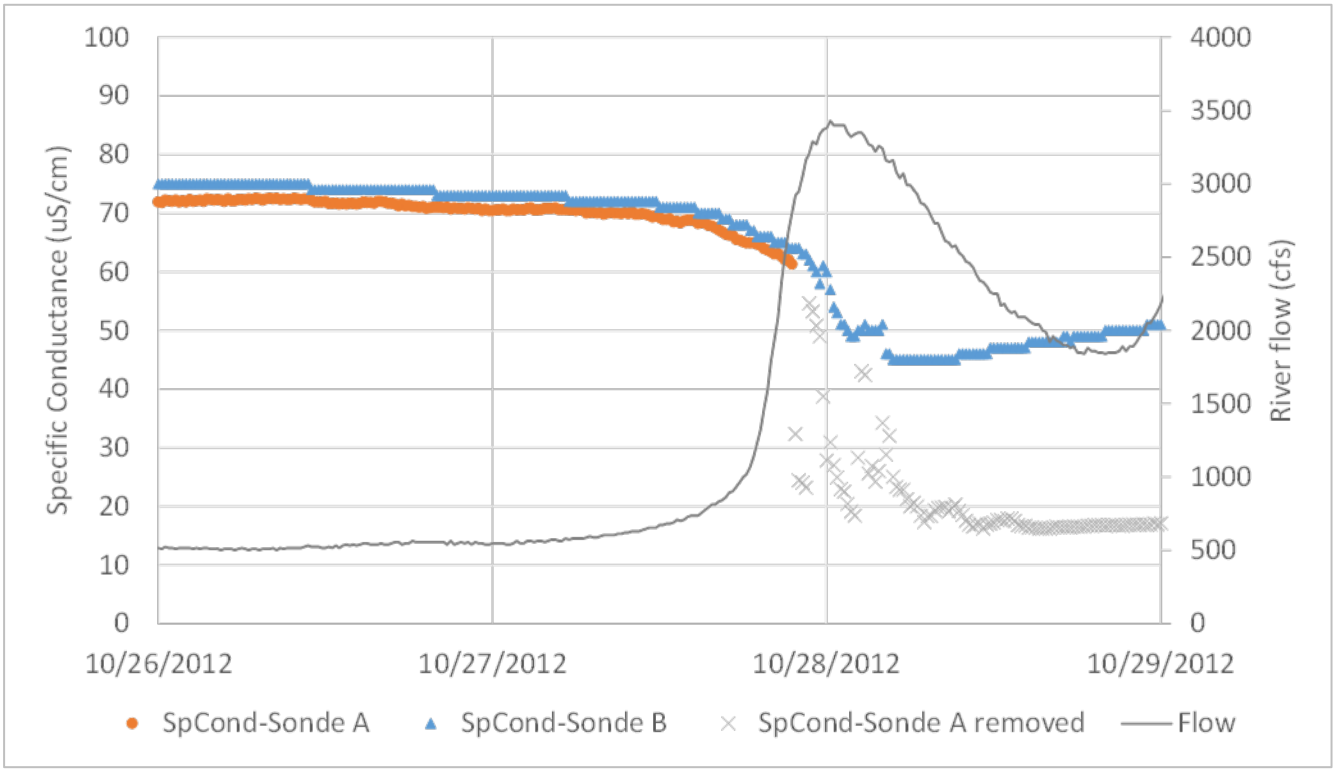

Figure 4. Example of data removed due to sediment deposition during a runoff event.

6.2.11 A log of all removed data (including dates, times, and justification for removal) should be kept with the project files.

6.2.12 In EIM, observations should be entered for data removed/rejected mid-deployment. It is not necessary to enter observations into EIM for data removed from either the beginning or end of the record. See EIM time series data entry guidance for additional detail.

6.3 Fouling adjustments

6.3.1 Fouling adjustments are necessary when fouling checks (see EAP SOP 129, Part 1 section 6.7), collected before and after cleaning, reveal a bias due to sensor fouling. Fouling adjustments should be reviewed and completed before any other type of data adjustment.

6.3.2 Fouling adjustments, while rare, are applied as a drift correction that is a linear interpolation based on the start time, zero, the stop time and the final offset due to fouling.

$$\text{The final fouling offset} = (\mathrm{DS}_{\mathrm{post}} - \mathrm{DS}_{\mathrm{pre}}) + (\mathrm{FC}_{\mathrm{pre}} - \mathrm{FC}_{\mathrm{post}})$$

Where DS= Deployed Sonde Value; FC = Field-check Value; Pre/Post= Before/after cleaning.

6.3.3 Changes in the "clean" field-check instrument values, before and after the deployed sonde cleaning, are used to separate the "true" changes in water chemistry that elapsed while the deployed sonde was being cleaned from the changes in the deployed sonde readings due to removal of fouling.

6.3.4 Figure 5 illustrates a minor drift-fouling adjustment of DO data based on a final fouling offset of 0.15. The fouling offset was calculated as (8.73 - 8.60) + (8.79 – 8.77).

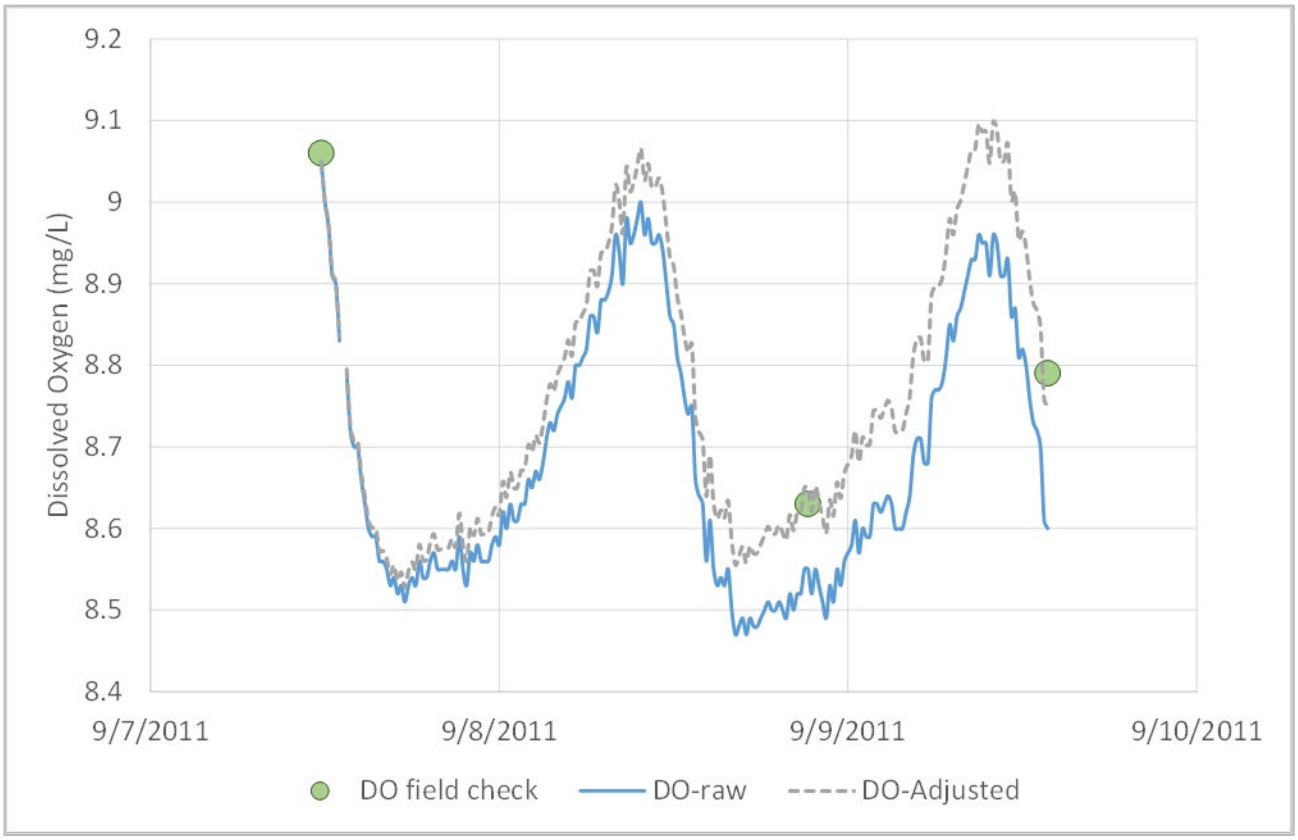

Figure 5. Example of a minor drift-fouling adjustment of DO data based on a final fouling offset

6.4 Determining final adjustment period

6.4.1 The period of adjustment may be different for each parameter. For fouling, the adjustment period will always be limited to in between cleanings. For final adjustments (section 6.5), the period ends when the sonde is recalibrated. This typically coincides with retrieval on short deployments, but not always.

6.4.2 For optical DO sensors, it is recommended to not recalibrate the deployed sensor, if it continues to meet the QAPP specific MQO, until the end of a project. The deployed sensors measurements can then be compared to a larger number of Winkler samples and field-check measurements. Bias or regression adjustments are then made on a larger period of data, based on a larger sample size of quality checks.

6.5 Weight of evidence adjustment based on quality checks

6.5.1 Once the steps of data removal/rejection and fouling review/adjustments have been completed, the final data quality review and adjustment (if applicable) process is started.

6.5.2 All the available information should be used in evaluating whether or not a data adjustment is warranted. A weight-of-evidence approach is used that considers the following information:

- Post-deployment checks against NIST reference.
- Post-deployment checks against other reference (for example air-saturated water).
- Field checks using instrument with “Accept” quality rating (see Table 1 and 2).
- Field checks from Winkler samples with “Accept” quality rating (DO only).
- Deployed measurement values at a nearby location on the same waterbody. *Note: Use caution when considering nearby data; if there are significant inflows, significant biological productivity, or long residence times between the two sites, then this approach is not warranted.*
- Consideration of physical, biological, or chemical processes (for example DO appears supersaturated at all times).
- Field observations (for example, debris accumulated on deployment tube).
- Field-check instruments or DO Winkler samples with a “Qualify” rating are generally not used in the weighing of evidence for adjustments.
- Field-check instruments or DO Winkler samples with a “Reject” rating should never be used in the weighing of evidence for adjustments.

6.5.3 Typically, choose the adjustment that results in the smallest residuals and bias between the adjusted values and QC checks (post and field checks). Best professional judgement and visual review are necessary to confirm the adjustment.

6.5.4 **If the evidence is weak or inconclusive, do not adjust the data**.

6.5.5 There are three primary types of data adjustments:

6.5.5.1 Bias offset: Data are typically adjusted by the average difference between the QC checks and deployed sonde. The majority of QC checks must show bias to use this method. An adjustment for representativeness may also be made, based on the average difference from cross-section surveys or area weighted mean measurements (see SOP EAP129, Part 1).

6.5.5.2 Regression (slope + offset): Data are adjusted using regression, typically linear, between QC checks and deployed sonde. This accounts for both a slope and offset adjustment. The regression must have at least 5 data points and an R^2 value of >0.95 to use for adjustment. Use extreme caution when extrapolating regressions beyond the range of the QC checks.

6.5.5.3 Calibration Sensor Drift: Data are adjusted using linear regression with time from calibration or deployment to post check or retrieval. The majority of QC checks, particularly post checks, must confirm the pattern of drift (the drift-adjusted sonde values should more closely match most of the QC checks). This adjustment is applied in a manner similar to a fouling-drift correction (Figure 4); however in this case, rather than fouling, the drift is due to a sensor degrading, losing power, or not holding a calibration over time.

6.5.6 Table 3 and Figure 6 provide an example of a bias adjustment of 7.1% applied to a specific-conductance deployment based on the average bias from both field and buffer post checks. Table 4 shows the adjusted values and the associated reduction in bias (from 7.1% to -0.4%) and the RMSE (From 7.4% to 2.1%), compared to the QC checks.

Table 3. Example of bias in a deployed sonde, compared to buffer and accepted field checks.

Date & Time	SpCond Deployed	QC type	SpCond QC	Field-check rating	% Difference
9/24/2012 12:40	66.9	Field Check	70.2	Accept	4.7%
9/25/2012 11:00	66.0	Field Check	72.9	Accept	9.5%
9/25/2012 16:40	65.2	Field Check	71.7	Accept	9.1%
9/27/2012 11:40	69.0	Field Check	73.7	Accept	6.4%
9/28/2012 10:00	94.0	Buffer Check (Post)	100		6.0%
Average QC Difference (Bias) =					7.1%
RMSE QC Difference =					7.4%

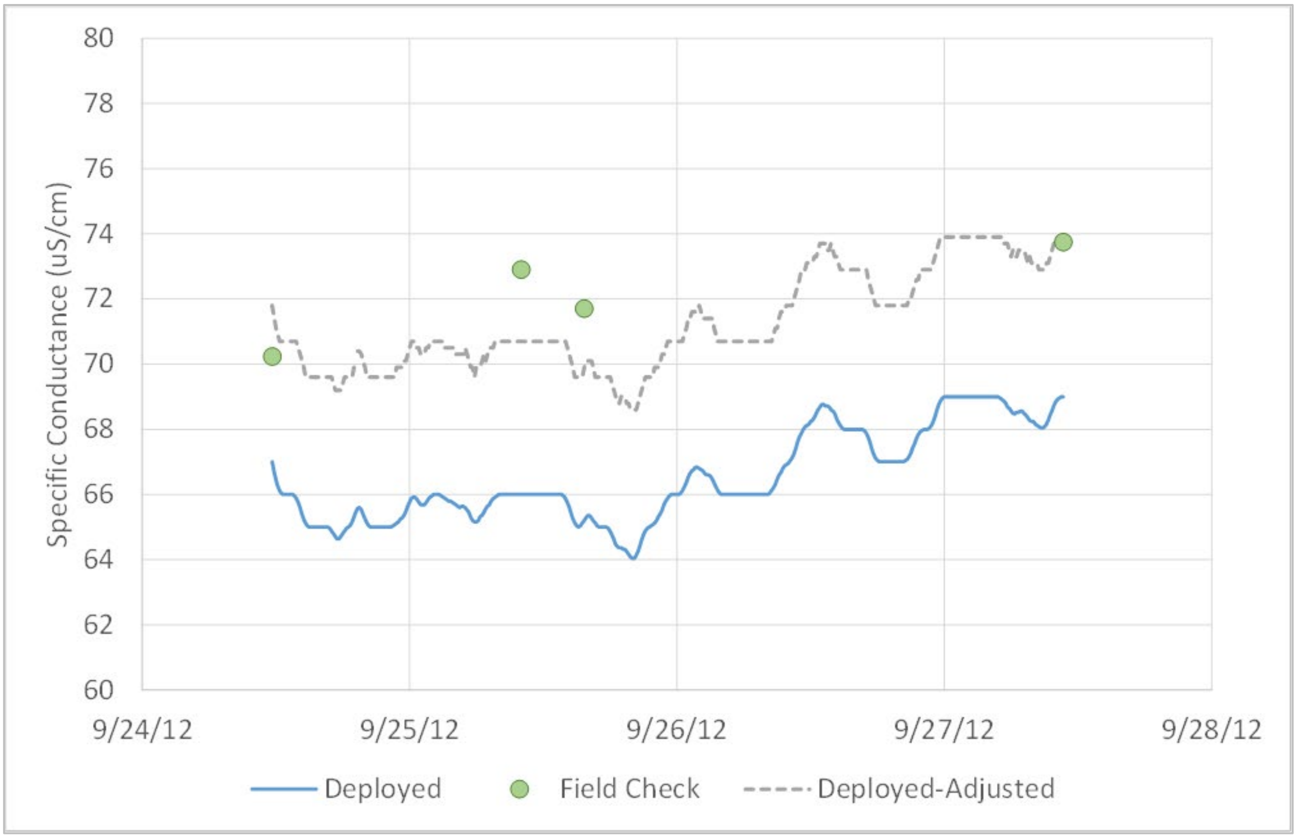

Figure 6. Example of bias adjustment.

Table 4. Adjusted deployment data and residuals/fit with quality checks.

Date & Time	SpCond Adjusted	QC type	SpCond QC	Field-check rating	% Difference
9/24/2012 12:40	71.8	Field Check	70.2	Accept	2.2%
9/25/2012 11:00	70.7	Field Check	72.9	Accept	-3.0%
9/25/2012 16:40	69.9	Field Check	71.7	Accept	-2.5%
9/27/2012 11:40	73.9	Field Check	73.7	Accept	0.2%
9/28/2012 10:00	101.0	Buffer Check (Post)	100		1.0%
Average QC Difference (Bias) =					-0.4%
RMSE QC Difference =					2.1%

6.5.7 If any data are adjusted, detailed documentation of the QC data and justification for adjustment must be retained with the project files.

6.6 Final data quality ratings and data qualifiers

6.6.1 The final deployed sonde data, adjusted or not, is assigned a quality rating by comparing the final RMSE QC difference to the criteria in Table 5. For example, the adjusted data from Table 4 would receive an "Accept" quality rating, based on an RMSE of less than 10%, post-adjustment (2.1% RMSE).

6.6.2 The RMSE is the square root of the average of the squared residuals between the final deployed data and the QC check (both field and post check). For specific conductance, the RMSE is calculated with the square of the percent difference, instead of the residual.

Table 5. Final data quality ratings based on the RMSE between quality checks and adjusted/final deployed readings.

Measured field parameter	Accept	Qualify as estimate	Reject
Water temperature	≤ ± 0.2°C	> ± 0.2 – 0.8°C	> ± 0.8°C
Specific conductance	≤ ± 10%	> ± 10 – 20%	> ± 20%
Dissolved Oxygen	≤ ± 0.5 mg/L	> ± 0.5 – 1.0 mg/L	> ± 1.0 mg/L
pH	≤ ± 0.2 units	> ± 0.2 – 0.5 units	> ± 0.8 units
Turbidity	≤ ± 1.0 units or ≤ ± 10%	> ± 1.0 – 2.0 units or > ± 10 – 20%	> ± 2.0 units or > ± 20%

For "or" criteria, use whichever is greater.

6.6.3 Bias adjustments can typically be applied with more confidence, compared to fouling/calibration drift or slope adjustments where the linear relationship cannot be confirmed between quality checks. For this reason, adjusted data where a drift or slope adjustment exceeds the thresholds in Table 6 should be qualified as estimates, regardless of whether or not the final RMSE meets accept criteria.

Table 6. Threshold for when to qualify data based on drift or slope adjustment applied

Measured Field parameter	Drift or slope adjustment threshold for qualifying data
Water temperature	> 0.4°C
Specific conductance	> ± 20%
Dissolved Oxygen	> ± 1.0 mg/L
pH	> ± 0.4 units
Turbidity	> ± 2.0 units or > ± 20% [c]

6.6.4 Adjusted data from a deployed sonde should be designated as adjusted in the EIM database (See section 6.7 data reporting).

6.7 Data Reporting

6.7.1 Table 7 contains names, method codes, units, and digit conventions for continuous deployment data reporting.

Table 7. Reporting units and conventions for continuous data parameters.

EIM Parameter Name or Alias	Reporting Unit/s	EIM Method Code	Reporting Conventions
Temperature, water	°C	TEMPTHERM	To nearest 0.01 °C.
Specific conductance	µS/cm	CONDMETER	<1 to the nearest 0.01 1-100 to the nearest 0.1 > 100 to the nearest whole number
pH	pH	PHMETER	to the nearest 0.01
Dissolved Oxygen	mg/L	DO-OPTICAL DO-CLARK[1]	to the nearest 0.01
Turbidity	FNU/NTU	TURBM	0–10, to nearest 0.1 10–100, to nearest 1 >100, to nearest 10

[1] *Most sensors used by EAP are optical LDO technology (EIM method code = DO-OPTICAL), a few Clark-cell technology sensors are actively maintained (DO-CLARK). Only optical sensors should be used for field-check instruments.*

6.7.2 Dissolved oxygen percent saturation from deployed sondes is generally not reported in EIM. For this data type, temperature, specific conductance, and elevation data are available in EIM. These data can be used to calculate the percent saturation outside of the database.

6.7.3 The EIM help center provides specific guidance on how to enter adjusted time-series data into EIM. Table 8 summarizes this guidance in the context of this SOP. Time-series data is entered into EIM using a specific template and the associated help document.

6.7.4 It is recommended to enter information specific to the data adjustment into EIM Result comment field (see Table 8 comment example).

Table 8. EIM data entry guidelines for adjusted and non-adjusted time-series data from short term deployments.

Final Data Quality Rating	Result Data Qualifier[1]	Result Data Qualifier Description	Comment (Example)[2]
Non- Adjusted Data			
Accept	-	-	-
Qualify	EST	Measurement value reported is estimated. See comment for additional detail.	RMSE >0.5 mg/L based on data quality checks; reported result is an estimate and should be used with caution.
Adjusted Data			
Accept	IA	Instrument result adjusted; reported result meets study objectives	Result Value adjusted for linear instrument drift identified post deployment.
Qualify	EST	Measurement value reported is estimated. See comment for additional detail.	Result Value adjusted; considerable instrument drift during deployment, reported result is an estimate and should be used with caution.

[1] (Column S in Time-Series Result Template)
[2] (Column U in Time-Series Result Template)

7.0 Records Management

7.1 All original data files should be retained in their raw electronic form (.csv, .txt, etc.) in one data folder or database.

7.2 A “final” file or database should be retained for each deployment that includes at a minimum: final data after processing and/or adjustment, any field check or buffer check data associated with the deployed sonde, and any factors or equations used to adjust the data.

7.3 Any information used to review or adjust data should be retained with the project files.

7.4 All files and databases should be stored on a network drive that is routinely automatically backed up.

8.0 Quality Control and Quality Assurance

8.1 The quality control and assurance guidelines are embedded throughout Section 6 in the order that they are encountered during data processing.

8.2 Specific QA/QC criteria are included in tables 1, 2, 5, and 6.

8.3 The Part 1 SOP includes field procedures related to data quality.

8.4 Additional applicable quality assurance guidelines can be found in the programmatic QAPP for water quality impairment studies (McCarthy and Mathieu, 2017)

9.0 Safety

9.1 For further field health and safety measures refer to the EAP Safety Manual (EAP, 2019).

10.0 References

10.1 Environmental Assessment Program (EAP), 2019. Environmental Assessment Program Safety Manual. Washington State Department of Ecology. Revised 03/19.

10.2 McCarthy, S. and N. Mathieu, 2017. Programmatic Quality Assurance Project Plan: Water Quality Impairment Studies. Washington State Department of Ecology, Olympia, WA. https://fortress.wa.gov/ecy/publications/SummaryPages/1703107.html.

10.3 Wagner, R.J., Boulger, R.W., Jr., Oblinger, C.J., and Smith, B.A., 2006, Guidelines and standard procedures for continuous water-quality monitors—Station operation, record computation, and data reporting: U.S. Geological Survey Techniques and Methods 1–D3, 51 p. + 8 attachments; http://pubs.water.usgs.gov/tm1d3.

QUALITY ASSURANCE PROJECT PLAN

APPENDIX B

DATA REVIEW AND VERIFICATION CHECKLIST

This checklist should be used to document data review verification of data generated through implementation of the FERC-approved study plan.

GENERAL

- For each sampling event, samples have been collected and analyzed at all locations and for all analyses specified in the study plan.
- For each sample and analyses, the Project file contains records, field notes, chain-of-custody, and analytical results, including quality assurance documentation (hardcopy and electronic).

FIELD DATA

- Field notes and/or data sheets include date, time of sample collection, field sampling staff, time arrived at site, time left site, site identification, description of site conditions (weather), field parameters, reservoir level or flow information (measured or estimated), sample collection procedures, and call-out quality assurance samples collected. If mistakes are found on the field data sheet, changes can be made by crossing out the mistake and marking the change with a date of change, initials, and reason for change.
- Documentation of field equipment calibration is in the field notes and/or Project records.
- Field data entered into Excel have been checked by a second party.

LABORATORY REPORT

- Field duplicates, blanks, and rinsates were submitted to the laboratory at the frequency specified in the study plan.
- Any constituents found in blanks or rinsates are discussed in the final report.
- Any duplicate concentrations that differ by more than 10 percent are discussed in the final report.
- Samples were received by the laboratory intact and analyzed within method and/or study specified holding times.
- Laboratory reports are accurate with respect to sample IDs, analyses, reporting/detection limits, units, column labels, footnotes, and titles. Have lab re-issue report with corrections if there are inconsistencies.
- Check that non-detects are always reported in the same manner using consistent notation. For example, either "ND" or "<." Have lab re-issue report with corrections if there are inconsistencies.
- If observed, "J" qualified data and/or elevated detection limits are discussed in the final report.

FA-02 INSTREAM FLOW MODEL DEVELOPMENT
REVISED STUDY PLAN

SKAGIT RIVER HYDROELECTRIC PROJECT
FERC NO. 553

Seattle City Light

April 2021
RSP

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List of Acronyms and Abbreviations

ADCP.........................acoustic doppler current profiler
AWS...........................area weighted suitability
cfs...............................cubic feet per second
City Light...................Seattle City Light
Ecology ....Washington State Department of Ecology
EFH............................Essential Fish Habitat
ELC............................Environmental Learning Center
ESA............................Endangered Species Act
ESH............................Effective Spawning Habitat (model)
FARWG.....................Fish and Aquatics Resource Work Group
FEMA ....Federal Emergency Management Agency
FERC..........................Federal Energy Regulatory Commission
FLA............................Final License Application
FPA ....Federal Power Act
FSA ....Fisheries Settlement Agreement
GIS ....Geographic Information System
HEC-RAS ....Hydrologic Engineering Center River Analysis System
HSC............................Habitat Suitability Criteria
IFIM ....Instream Flow Incremental Method
ILP..............................integrated licensing process
ISR ....Initial Study Report
LiDAR........................Light Detection and Ranging
LP...............................licensing participant
NHPA.........................National Historic Preservation Act
NMFS.........................National Marine Fisheries Service
NPS ....National Park Service
PAD............................Pre-Application Document
PHABSIM..................Physical Habitat Simulation
PRM ....Project River Mile
Project ....Skagit River Hydroelectric Project
PSP.............................Proposed Study Plan

RLNRA......................Ross Lake National Recreation Area
RM ....river mile
RSP ....Revised Study Plan
RTK............................real-time kinematic
RWG ....Resource Work Group
SR...............................State Route
SRSC..........................Skagit River System Cooperative
USACE ......................U.S. Army Corps of Engineers
U.S.C..........................United States Code
USFS ..........................U.S. Forest Service
USFWS ......................U.S. Fish and Wildlife Service
USGS .........................U.S. Geological Survey
USIT...........................Upper Skagit Indian Tribe
USR............................Updated Study Report
WDFW.......................Washington Department of Fish and Wildlife
WUA ....weighted usable area

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1.0 INTRODUCTION

1.1 General Description of the Project

The Skagit River Hydroelectric Project (Project), licensed to The City of Seattle, Washington, and operated through its publicly-owned electric power utility Seattle City Light (City Light), is located in northern Washington State and consists of three power generating developments on the Skagit River – Ross, Diablo, and Gorge – and associated lands and facilities. The Project generating facilities are in the Cascade Mountains of the upper Skagit River watershed, between Project River Miles (PRM) 94.7 and 127.9 (U.S. Geological Survey [USGS] RMs 94.2 and 127).[1] Power from the Project is transmitted via two 230-kilovolt powerlines that span over 100 miles and end just north of Seattle at the Bothell Substation. The Project also includes two City Light-owned towns, an Environmental Learning Center (ELC), several recreation facilities, and several parcels of fish and wildlife mitigation lands.

Project generating facilities are all located in Whatcom County, although Ross Lake, the most upstream reservoir, crosses the U.S.-Canada border and extends for about one mile into British Columbia at normal maximum water surface elevation. Gorge Powerhouse, the most downstream facility, is approximately 120 miles northeast of Seattle and 60 miles east of Sedro-Woolley, the nearest large town. The closest town is Newhalem, which is part of the Project and just downstream of Gorge Powerhouse. The primary transmission lines cross Whatcom, Skagit, and Snohomish counties; the fish and wildlife mitigation lands are in the same counties.

The Project Boundary is extensive, spanning over 133 miles from the Canadian border to the Bothell Substation just north of Seattle, Washington. In addition, there are “islands” of fish and wildlife mitigation lands and recreation facilities within the Skagit, Sauk, and South Fork Nooksack watersheds that are also within the Project Boundary. Project generating facilities are entirely within the Ross Lake National Recreation Area (RLNRA), which is administered by the National Park Service (NPS) as part of the North Cascades National Park Complex. The RLNRA was established in 1968 in the enabling legislation for North Cascades National Park to provide for the “public outdoor recreation use and enjoyment of portions of the Skagit River and Ross, Diablo, and Gorge lakes.” The legislation maintains the Federal Energy Regulatory Commission’s (FERC) jurisdiction “in the lands and waters within the Skagit River Hydroelectric Project,” as well as hydrologic monitoring stations necessary for the proper operation of the Project (16 United States Code [U.S.C.] § 90d-4; Public Law 90-544. Sec. 505 dated October 2, 1968, as amended by Public Law 100-668. Sec. 202 dated November 16, 1988).

1.2 Relicensing Process

The current FERC license for the Project expires on April 30, 2025, and City Light will apply for a new license no later than April 30, 2023. City Light formally initiated the relicensing process by filing a Notice of Intent and Pre-Application Document (PAD) with FERC on April 27, 2020 (City Light 2020a). The PAD includes descriptions of the Project facilities, operations, license

[1] City Light has developed a standard Project centerline and river mile system to be used throughout the relicensing process, including the study program, to replace the outdated USGS RM system. Given the long-standing use of the USGS RM system, both it and the Project River Mile (PRM) system are provided throughout this document. For further details see Section 7.0 of the main body RSP.

requirements, and Project lands as well as a summary of the extensive existing information available on Project area resources and early consultation on potential resource issues to be addressed during the relicensing.

The relicensing process includes the timeframes and deadlines specified in FERC's Integrated Licensing Process (ILP), including consultation with interested agencies and Indian tribes related to study plans, study results, and subsequent analysis of results and effects analysis through the filing of the Final License Application (FLA). FERC's process includes steps to satisfy the various statutory authorities identified in the Federal Power Act (FPA) (e.g., Sections 4(e), 10(j), 10(a)). Other related regulatory processes including Washington State Department of Ecology's (Ecology) Section 401 water quality certification process, the U.S. Fish and Wildlife Service's (USFWS) and National Marine Fisheries Service's (NMFS) Section 7 Endangered Species Act (ESA) consultation, NMFS's oversight of Essential Fish Habitat (EFH), as defined by the Magnuson Stevens Fishery Conservation and Management Act, and consultation pursuant to Section 106 of the National Historic Preservation Act (NHPA) will continue following filing of the FLA. With the filing of the PAD, City Light requested that FERC designate City Light as FERC's non-federal representative for purposes of initiating and conducting day-to-day consultation under ESA Section 7 and NHPA Section 106, which was granted by FERC in its June 26, 2020 Notice of Intent to File License Application for a New License and Commencing Pre-Filing Process.

1.3 Study Plan Development

In 2019-2020, City Light convened a number of Resource Work Groups (RWG) to engage agencies and other licensing participants (LP) in a Study Plan Development Process, which provided LPs and City Light the opportunity to submit forms that identified potential resource issues, their potential connection to the Project, information or studies requested, a rationale for studying the issues, and how the information collected by the study could be used to support relicensing. Table 5.1-2 of the PAD provides a summary of all the issue forms submitted during this 2019-2020 process.

Section 5 of the PAD lists the resource studies and management plans proposed by City Light to address select (but not all) issues identified as part of the Study Plan Development Process. While acknowledging the broad interests of LPs, City Light focused its initial draft study plans contained in the PAD on information gaps that were most likely to inform license conditions by a study of potential Project effects. City Light developed 24 study proposals, including this Instream Flow Model Development study plan.

On April 10, 2020, City Light released the FA-02 Instream Flow Model Development Draft Study Plan for LP review and comment. On May 5, 2020, the draft study plan was discussed at a Fish and Aquatic Resource Work Group (FARWG) meeting. City Light reviewed all comments received and released a revised version of the draft study plan on June 17, 2020. The revised draft was discussed on June 24, 2020 at a FARWG meeting. Written comments were received from the Upper Skagit Indian Tribe, Washington Department of Fish and Wildlife (WDFW), USFWS, NPS, Skagit River System Cooperative (SRSC), and NMFS and responded to in an attachment to this study plan. A Status Draft of the study plan was provided to LPs on August 6, 2020.

City Light is filing this study plan with FERC as part of its Revised Study Plan (RSP), an update to the version that was filed with the Proposed Study Plan (PSP) on December 8, 2020 (City Light 2020b) and incorporating additional consultation with LPs prior to the filing date. This study plan addresses, with modifications, elements of the following study requests, as explained in Section 6 of the RSP: Ecology-02 Instream Flow Study, NMFS-02 Geomorphology and Aquatic Habitat, NPS-13 Impact of the Operations of Skagit Hydroelectric Project (#553) on Process Flows of Water, Wood and Sediment Below Gorge Dam, USFWS-13 Impact of the Operations of Skagit Hydroelectric Project (#553) on Process Flows of Water, Wood, and Sediment below Gorge Dam, USFWS-15 Geomorphology and Aquatic Habitat Complexity Study, USIT-08 Geomorphology and Anadromous Salmonid Habitat, WDFW-05 Geomorphology and Anadromous Salmonid Habitat, and WDFW-08 Impact of the Operations of Skagit Hydroelectric Project (#553) on Process Flows of Water, Wood and Sediment Below Gorge Dam.

PSP comments to this study plan were submitted by American Rivers/Trout Unlimited, Ecology, NMFS, NPS, Sauk-Suiattle Indian Tribe, Upper Skagit Indian Tribe, and USFWS. City Light has addressed the specific comments and suggested edits in the study plan and responded to comments in the PSP comment/response table appended to the main body of the RSP. Modifications made to the study plan in response to comments and since the PSP include updating details regarding fieldwork that has been completed, updating the fish species list, and providing details for a process to identify and evaluate alternative flow management scenarios.

Project operations result in the release of flows to the Skagit River at the Gorge Powerhouse and Gorge Dam. Through coordination with the U.S. Army Corps of Engineers (USACE), Project operations reduce downstream flood risk. Through a variety of pathways, and in combination with non-Project related cumulative effects, the Project's flow releases also affect the availability and suitability of spawning, incubation, and rearing habitat for anadromous salmonids. The development of hydraulic models will provide detailed information on the hydraulic characteristics of flows in the Skagit River (discharge, flow depth and velocity, and their spatial and temporal variations) and will be useful when considering potential alternative Project operations, particularly related to effects on fish habitat. This study is intended to describe the development of an instream flow model for the Skagit River in the reach between Gorge Powerhouse and the confluence with the Sauk River. The Instream Flow Model will consist of a numerical hydraulic model that produces hydraulic outputs (i.e., depth and velocity grids) that can be further analyzed or synthesized in a Geographic Information System (GIS) to assess changes in habitat suitability under alternative Project operations. The model may contribute to addressing some of the issues identified in the summary provided in Table 5.3-1 of the PAD (City Light 2020).

The hydraulic model to be developed as described in this study plan will be one of the tools contributing to an integrated analysis of Project effects on environmental resources. Studies that may ultimately be linked, either directly or indirectly, to the findings of this study include: (1) FA-01 Water Quality Monitoring Study (i.e., the relationship between water quality and flows with respect to fish habitat suitability); (2) GE-04 Skagit River Geomorphology between Gorge Dam and the Sauk River Study (e.g., substrate mapping, etc.); (3) OM-01 Operations Model Study (i.e., upstream hydraulic boundary condition); (4) Wetlands Assessment (i.e., in terms of potential river-wetlands connectivity); (5) TR-01 Vegetation Mapping Study (i.e., cover types); (6) FA-05 Skagit River Gorge Bypass Reach Hydraulic and Instream Flow Model Development Study; and (7) landform mapping (being conducted by the NPS). More needs to be learned within each respective study area before it is clear if and how study results will meaningfully inform comprehensive environmental analysis. City Light will work with LPs to review and integrate information from related studies as part of the ILP process in support of City Light's license application filing.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

The goal of the Instream Flow Model Development Study is to develop an updated flow-habitat evaluation tool for the Skagit River between the Gorge Powerhouse and the confluence with the Sauk River.

Specific objectives include:

- Develop, calibrate, and validate a numerical hydraulic model of the Skagit River for the reach between the Gorge Powerhouse and the confluence with the Sauk River.
- Integrate hydraulic model outputs and observed characteristics of substrate and cover with biological (species, life stages, periodicities) and physical (depth and velocity) criteria used in the current flow-habitat evaluation tool, including modifications from additional data sources as appropriate, to develop updated flow-habitat relationships for the reach of the Skagit River between the Gorge Powerhouse and the confluence with the Sauk River.

Once the study is complete (i.e., the model has been developed), the flow-habitat model will be used to investigate and inform the evaluation of flows and habitat in the Gorge Powerhouse to Sauk River reach to continue supporting mainstem Skagit River fish habitat during the new FERC license term and to support additional discussions regarding hydraulic conditions and aquatic habitat, including migration habitat.

2.2 Resource Management Goals

City Light's goal for the proposed study is to develop updated flow-habitat relationships to potentially inform flow management in the Skagit River between the Gorge Powerhouse and the confluence with the Sauk River.

The study will provide information for resource agencies and Indian tribes with jurisdiction in the Project vicinity to address their respective goals and objectives for resource management. Resource management goals were provided by LPs in their study requests identified in Section 1.3 of this study plan. For example, NMFS, USFWS, WDFW, the Upper Skagit Indian Tribe, the Sauk-Suiattle Indian Tribe, and the Swinomish Indian Tribal Community all have certain management responsibilities for anadromous salmonids and their prey species, wildlife, and plants in the Skagit River basin and its tributaries. Other agencies have responsibilities for adjacent land management.

The flow-habitat model will serve as a tool to analyze current conditions and alternative scenarios during the relicensing process. Additionally, the hydraulic model may be used to support the assessment of alternative scenarios or future proposals involving potential off-channel and floodplain restoration projects to benefit salmonid spawning and rearing in the study reach.

2.3 Background and Existing Information

Detailed information is required on hydraulic conditions and their spatial and temporal variation in the Skagit River between Gorge Powerhouse and the confluence with the Sauk River to support evaluation of flows for the management of Skagit River fish habitat.

Flows downstream from Gorge Powerhouse are managed under the current Project license in accordance with the Revised Fisheries Settlement Agreement (FSA) (City Light 2011) which, amongst other things, provides comprehensive detailed requirements for management of Skagit River releases for the protection of anadromous fish. The Revised FSA provides requirements for protection of Chinook, Pink, and Chum salmon and for steelhead for all life stages. It includes requirements for flow management for all spawning and incubation periods, restrictions on riverine ramping rates, and specification of minimum flows. Current flow management requirements per the Revised FSA are summarized in Section 3.5.2 of the PAD.

Flow management under the current Project license in accordance with the Revised FSA is supported by City Light's Effective Spawning Habitat (ESH) model. In summer 2015, the ESH model was unable to account for low flows, resulting in the inability to inform, with high reliability, minimum flows for redd incubation during this time period. This model was developed using a small number of river channel cross sections dating from the 1970s to characterize hydraulic conditions. Changes in channel geometry and habitat conditions have occurred over time, and an updated model will reflect both current channel conditions and river hydraulics over a broader range of hydrologic conditions.

Recent hydraulic models are available for portions of the river reach between the Gorge Powerhouse and the Sauk River. Significantly, a detailed two-dimensional hydraulic model was recently developed for an approximately 7-mile reach of the river, extending from just upstream of the confluence with Illabot Creek to a point about 1.5 miles downstream of the confluence with the Sauk River (Natural Systems Design 2019). The model, developed using the RiverFlow2D software (Hydronia LLC 2018), was applied to investigate habitat restoration measures in the Barnaby Reach, which encompasses the mainstem of the Skagit River and its associated floodplain from the confluence with Illabot Creek to the Sauk River. The potential use of this model, and the topographic and bathymetric data on which it is based, is discussed further in Section 2.6 of this study plan.

A two-dimensional hydraulic model was also developed in 2012 for an approximately 4.5-mile reach of the river near the confluence with Illabot Creek for use in the analysis and design of riverbank stabilization measures to protect highway State Route (SR) 20 from erosion (Northwest Hydraulic Consultants 2012). Most of this model is within the domain of the Barnaby Reach model developed in 2019. Additional output provided by the 2012 model, upstream of the Barnaby Reach domain, appears to be based on outdated bathymetric survey data that may not adequately characterize current terrain conditions.

The Seattle District of the USACE recently (circa 2016) developed an updated Hydrologic Engineering Center River Analysis System (HEC-RAS) hydraulic model of the Skagit River from Skagit Bay to Newhalem by combining and recalibrating two pre-existing HEC-RAS models: a two-dimensional model of the Skagit River delta downstream from Sedro-Woolley, and a second one-dimensional model upstream from Sedro-Woolley to Newhalem. The USACE HEC-RAS model is one component of the Corps Water Management System, which supports decision-making for flood control operations within the Skagit River basin. The one-dimensional model of the upper Skagit, upstream from the Sauk River, is based on outdated channel cross-section data, including data from the Federal Emergency Management Agency (FEMA) surveys of the 1970s. The model calibration focused on high flow events but also attempted to reproduce stage-discharge ratings at key USGS streamflow gages, including that at Marblemount. Poor model calibration at Marblemount was attributed to a lack of reliable upstream channel data.

A variety of hydrologic, topographic, and bathymetric data are available to support development of hydraulic models of the study reach, which in turn would provide the hydraulic data needed to update the ESH model, and to potentially inform other related studies:

- Topographic and Bathymetric Data. Light Detection and Ranging (LiDAR) data covering the proposed hydraulic model extents (see Section 2.5 of this study plan) were acquired in 2017 and 2018 (Quantum Spatial 2017; Quantum Spatial 2018). The LiDAR generally provides high quality topographic and bathymetric data; however, there are some gaps or voids in the channel bathymetry data because of limitations imposed by water depth, turbulent aerated water, vegetation cover, and/or channel bed conditions. These voids will need to be filled using ground-based surveys or other techniques as described in more detail in Section 2.6 of this study plan.
- Hydrologic Data. The USGS operates water level and discharge gaging stations on the mainstem Skagit River and several of its larger tributaries. Currently active USGS gages in the area between Gorge Dam and the Sauk River are listed in Table 2.3-1 and locations shown in Figure 2.5-1. Historical data are also available from now-discontinued gages listed in Section 4.4.2 of the PAD. The PAD also provides monthly minimum, average, and maximum outflows from Ross, Diablo, and Gorge lakes for the period 1991–2018.

Table 2.3-1. Active USGS stream gages in the area between Gorge Dam and the Sauk River (see Figure 2.5-1 for gage locations).

Gage ID	Name	Period of Record	Drainage Area (sq. mi.)
12178000	Skagit River at Newhalem, WA	Dec 1908 to May 1914 Oct 1920 to present	1,175
12178100	Newhalem Creek near Newhalem, WA	Feb 1961 to present	27.9
12179900	Bacon Creek below Oakes Creek near Marblemount, WA	Aug 1943 to Sep 1950 Oct 1998 to present	49.7
12181000	Skagit River at Marblemount, WA	Sep 1943 to Jul 1944 Oct 1946 to Sep 1951 May 1976 to present	1,381
12182500	Cascade River at Marblemount, WA	Oct 1928 to Oct 1979 Jun 2006 to present	172
12184700	Skagit River near Rockport, WA[1]	Oct 2015 to present	1,655
12189500	Sauk River near Sauk, WA	Jul 1928 to present	714

1 Gage height only.

2.4 Project Operations and Effects on Resources

The Project's flow releases affect the availability and suitability of spawning, incubation, and rearing habitat for anadromous salmonids. Information on the hydraulic characteristics of flows in the Skagit River (discharge, depth, and velocity, and their spatial and temporal variations) will describe these influences and may inform alternative scenarios of future Project operations involving flow management, particularly as related to fish habitat.

2.5 Study Area

The study area extends from Gorge Powerhouse at about PRM 94.7 (USGS RM 94.2) downstream to a suitable location a short distance downstream from the confluence with the Sauk River, at approximately PRM 65.2 (USGS RM 65) (Figure 2.5-1). The total reach length is approximately 29 miles.

The downstream study limit, and downstream limit of the hydraulic modeling, below the confluence with the Sauk River, will be selected to allow the model to correctly account for the influence of the Sauk on conditions on the Skagit upstream from the Sauk, and to ensure a robust downstream boundary for hydraulic modeling. For the purpose of this study plan, it is assumed that the downstream study limit coincides with the downstream extent of the existing RiverFlow2D hydraulic model developed for the Barnaby Reach restoration project discussed further in Section 2.6.1.1 of this study plan.

The focus of the hydraulic model between Gorge Powerhouse and the Sauk River confluence will be on the in-channel portion of the mainstem Skagit River corridor and any side channels identified by the study team as having significant habitat value; however, the model will also include, in lesser detail, the overbank floodplain out to the valley side walls.

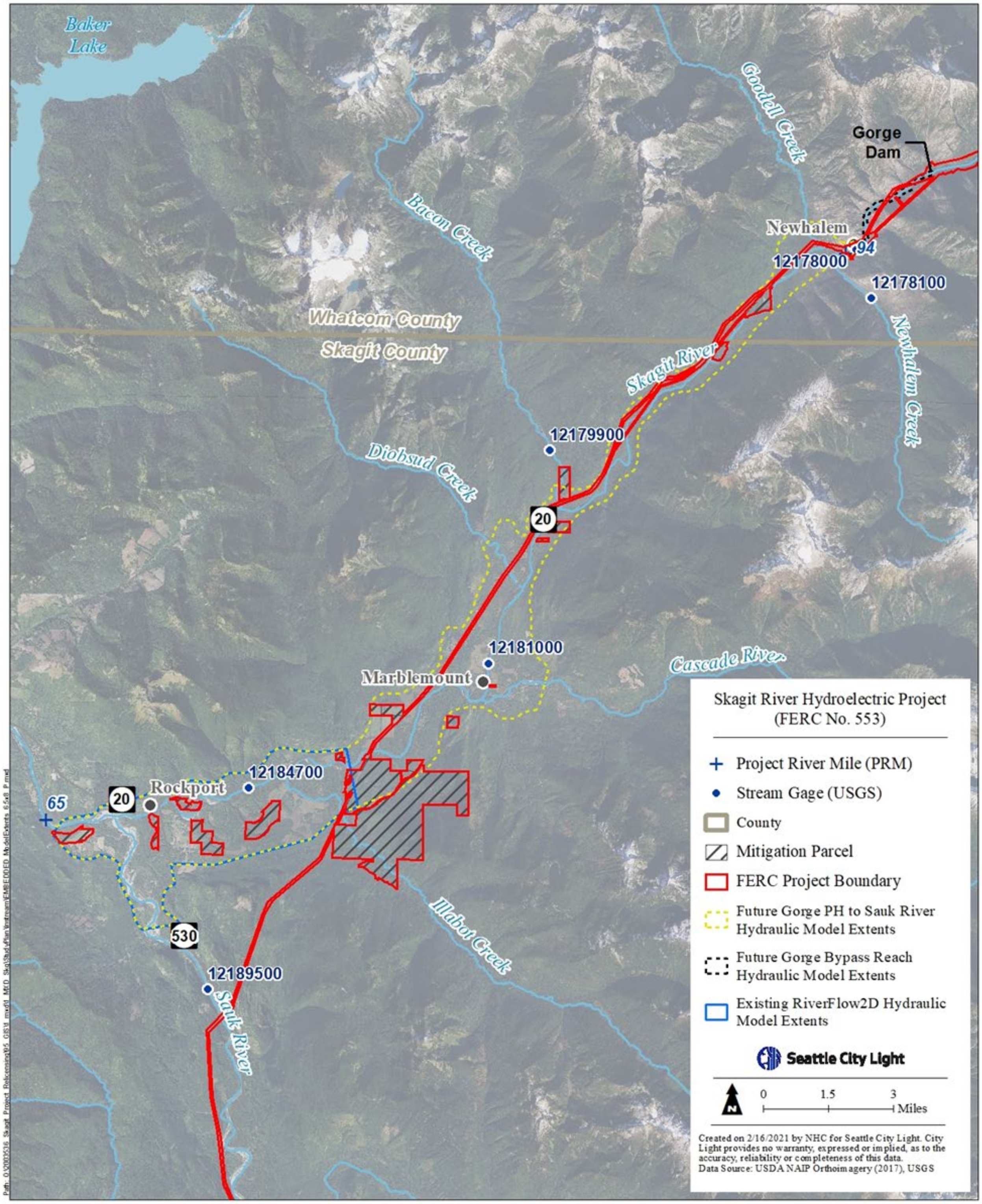

Figure 2.5-1. Overview of study area.

2.6 Methodology

An unsteady flow hydraulic model will be developed for the study area using the USACE HEC-RAS modeling platform (USACE 2016).

2.6.1 Gorge Powerhouse to Sauk River Confluence Model

2.6.1.1 Hydraulic Model Selection and Overview of Model Development

A two-dimensional unsteady flow hydraulic model will be developed for the Gorge Powerhouse to Sauk River reach using the USACE HEC-RAS modeling platform (USACE 2016). The model will extend from the Gorge Powerhouse at PRM 94.7 (USGS RM 94.2) to just downstream from the confluence with the Sauk River at PRM 65.2 (USGS RM 65), for a total reach length of approximately 29 miles.

Model development will take advantage of previous hydraulic modelling efforts to the extent appropriate. In particular, the proposed model will build on previous model development for the Barnaby Reach restoration project (Natural Systems Design 2019) discussed in Section 2.3 of this study plan.

The Barnaby Reach model is a RiverFlow2D model (Hydronia 2018) covering the approximately 7 lowest miles of the study reach from just upstream of Illabot Creek to the downstream end of the study area, approximately 1.5 miles below the confluence with the Sauk River. The model was developed at a sufficiently fine-scale resolution for investigating restoration measures in the Barnaby Reach. The bathymetry and topography for two-dimensional hydraulic models are described using a mesh or wireframe. The model mesh for the Barnaby Reach RiverFlow2D model comprises approximately 800,000 triangular elements.

In developing this study plan, two hydraulic model options were considered as follows:

(1) Extend the existing Barnaby Reach model upstream to the Gorge Powerhouse using RiverFlow2D.

(2) Develop a new HEC-RAS 2D model of the entire study reach, taking advantage of the bathymetric data and calibration data for the Barnaby Reach from the RiverFlow2D model.

The following factors were considered in selecting a model platform:

- Efficiency of model development (recognizing the availability of the Barnaby Reach RiverFlow2D model);
- Model resolution required to meet study objectives (discussed further in Section 2.6.1.3);
- Speed of model execution;
- Integration with other model platforms (for example, Project operations models);
- Availability of model support and model maintenance;
- Availability of visualization tools and software features for analysis, synthesis and display of model output;

- Efficiency with which metrics of interest for Project flow management can be generated from model output;
- Acceptance by the engineering community and both governmental and non-governmental institutions; and
- Size of user community (which relates to the pool of expertise available for model updates and application).

A qualitative comparison of the RiverFlow2D and HEC-RAS 2D modeling platforms for the above attributes is provided in Table 2.6-1. A two-dimensional HEC-RAS (Version 5) model of the full study reach was determined, after considering the above selection factors, to provide the best tool to meet study objectives, and the best modeling platform for adoption over the term of the next license. Ecology and WDFW approved the use of a two-dimensional HEC-RAS 2D model, as indicated in their August 14, 2020 email correspondence with City Light.[2]

Model development involves the following tasks, described in the following sub-sections:

- Processing model topographic data;
- Developing model geometry;
- Analyzing model boundary conditions;
- Field monitoring to obtain discharge and water level data to support model calibration and validation;
- Model configuration, calibration and validation; and
- Model application and analysis of model output.

[2] August 14, 2020 email from James M. Pacheco (Ecology) to Erin Lowery (City Light).

Table 2.6-1. Qualitative comparison of RiverFlow2D and HEC-RAS 2D.

Attribute	RiverFlow2D	HEC-RAS 2D
Efficiency of model development (recognizing the availability of the Barnaby Reach RiverFlow2D model).	+	+
Model resolution required to meet study objectives.	+	+
Speed of model execution.	++	+
Integration with other model platforms (for example, Project operation models).	+	+
Availability of model support and model maintenance.	++	+
Availability of visualization tools and software features for analysis, synthesis and display of model output.	+	+++
Efficiency with which metrics of interest for Project flow management can be generated from model output.	+	+
Acceptance by the engineering community and both governmental and non-governmental institutions.	+	++
Size of user community (which relates to the pool of expertise available for model updates and application).	+	+++

2.6.1.2 Model Topographic Data

A three-dimensional terrain model of the reach spanning from Gorge Powerhouse to approximately 1.5 miles downstream of the Sauk River confluence (~29 RMs) will be developed from a combination of topobathymetric LiDAR, standard LiDAR, boat-based bathymetric (sonar) surveys, and terrain data from the existing hydraulic model of the Barnaby Reach of the Skagit River.

The following LiDAR sources will be relied on:

- Quantum Spatial topobathymetric LiDAR ("green LiDAR") contracted by City Light; acquired April 25 and 26, 2018 (Quantum Spatial 2018).

Covers ~4,000 acres (~18 RMs) of Skagit River between Gorge Powerhouse and Barnaby Slough reach

- Quantum Spatial topobathymetric LiDAR ("green LiDAR") contracted by the SRSC; acquired April 21, 2017 (Quantum Spatial 2017a).

Covers ~11,000 acres of the Barnaby Slough reach (~10 RMs)

- Quantum Spatial topographic LiDAR contracted by USGS; acquired March 2016 – September 2016 (Quantum Spatial 2017b).

Covers ~3.6 million acres of western Washington.

The 2016 LiDAR (Quantum Spatial 2017b) will supplement any floodplain data not acquired in the more limited topobathymetric datasets. A very coarse preliminary hydraulic model of the reach of interest, constructed to test the sensitivity of HEC-RAS model simulation times to cell size, indicates there may be several such floodplain areas (Figure 2.6-1), depending upon the flows simulated. As noted in Section 2.5 of this study plan, while the focus of this study will be on the in-channel portion of the mainstem Skagit River, the model will also include, in lesser detail, the overbank floodplain out to the valley side walls. The lateral extent of the model will be informed by review of data from the landform mapping study.

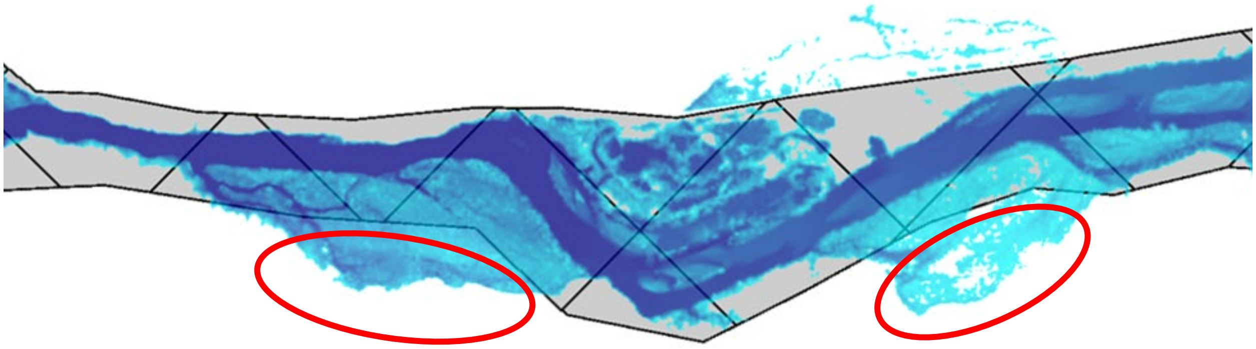

Figure 2.6-1. Coarse HEC-RAS model illustrates floodplain beyond limits of topobathymetric LiDAR (32,000 cfs, corresponding to an approximately 4-year peak flow for the Skagit River at Marblemount).

In addition to areas outside the topobathymetric data extents, areas within the wetted channel exist that are not defined in the topobathymetric rasters. This can occur for reasons such as turbid water, deep water, turbulent aerated water, vegetation cover, and/or a non-reflective channel bottom. These areas, which occur throughout the entire reach and are important to capture for flow conveyance and channel habitat assessment purposes, will be surveyed, subject to safety considerations, using traditional echo-sounding methods from a boat.

A spatial coverage delineating areas where the channel bottom was not measured (examples are shown in Figure 2.6-2) will be loaded onto a laptop running Hypack (hydrographic survey software) linked to a survey grade real-time kinematic (RTK)-GPS and a dual-frequency, single-beam echosounder or an acoustic Doppler current profiler (ADCP). The RTK operation will rely on RTK base stations broadcasting differential corrections. Areas to be surveyed by boat will be somewhat larger than gaps in the topobathymetric LiDAR coverage to provide some degree of overlap between the boat-based bathymetry and LiDAR and to identify and reconcile possible differences between the two data sources.

Where bathymetric surveys cannot be performed safely by boat, most notably in the approximately 1-mile reach known as Shovel Spur rapids, voids will be filled using interpolated terrain data produced by Quantum Spatial (Quantum Spatial 2018).

Boat-based survey bathymetry of voids and interpolated terrain data will be spliced into the topobathymetric LiDAR to create a complete three-dimensional terrain of the modeled reach.

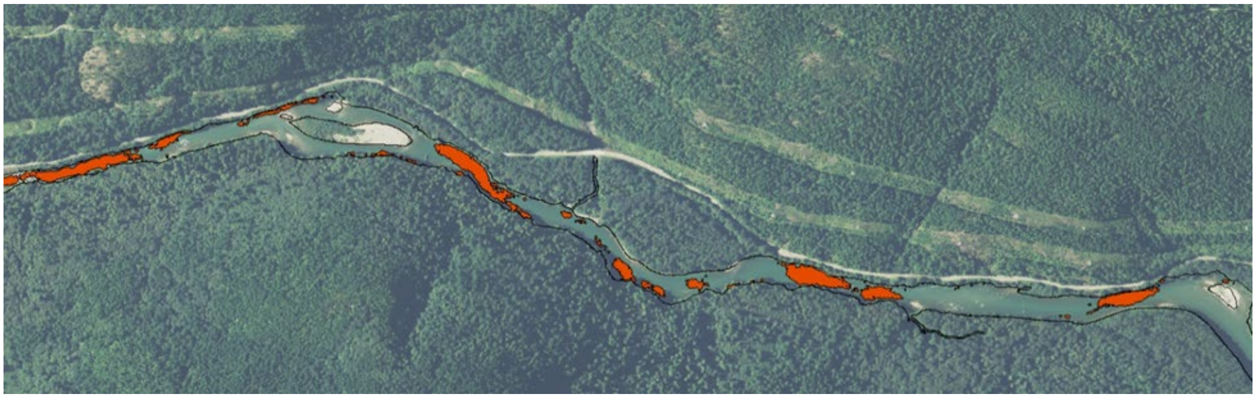

Figure 2.6-2. Red color indicates examples of areas where channel bottom was not mapped with topobathymetric LiDAR.

The SRSC recently commissioned studies to evaluate measures to restore habitat conditions for fish and wildlife in the Barnaby Reach of the Skagit River (see also Section 2.3 of this study plan). As part of those efforts, a two-dimensional RiverFlow2D hydraulic model was built of approximately 7 miles of the Skagit River and its floodplain in 2019. The model topographic sources included Quantum Spatial's 2017 topobathymetric LiDAR (Quantum Spatial 2017a) supplemented with channel bathymetry collected via various methods in 2013 and 2014. SRSC's consultant merged the topography datasets and interpolated to fill in remaining data gaps. This developed terrain will be used as-is and joined with the composite terrain to be developed upstream of the Barnaby Slough reach.

The final composite terrain will be imported into HEC-RAS to define the riverbed and surrounding floodplain. The modeled domain will be one reach with boundary conditions as discussed in Section 2.6.2.4.

2.6.1.3 Model Geometry Development

A two-dimensional model mesh will be developed using tools in the HEC-RAS Mapper editor and "draped" over the final composite terrain. The mesh consists of cells, or elements, whose size, shape and orientation are refined as needed to simulate hydraulic conditions. The model cell size will be determined considering simulation run time (fewer cells equates to faster run times), resolution in areas of interest for habitat evaluation (more cells equates to finer resolution and slower run times) and calibration to observed velocities, depths and discharges. A relatively coarse mesh will be used to represent floodplain areas. The final mesh geometry and associated simulation time step will balance achieving good numerical accuracy at the desired resolution while minimizing computation time.

"Breaklines" will be added to the model mesh to ensure geometric features that affect river hydraulics (for example, raised roads) are adequately represented. Skagit River bridge crossings at Marblemount and Rockport will be included in the model.

Hydraulic roughness zones will be delineated representing land use and land surface classes found in the reach such as active riverbed, typically exposed channel bars, forested floodplain, and pasture. The results of the landform mapping study being conducted by the NPS will be reviewed in delineating roughness zones. Initial roughness coefficients will be assigned based on professional judgement and published values (e.g., Barnes 1967) and then refined during model calibration.

2.6.1.4 Model Boundary Conditions

Boundary conditions, representing hydrologic inputs to the proposed model, will be specified by: mainstem flows from the USGS gage Skagit River at Newhalem (as regulated by the Project), tributary inflows to the study reach from both gaged and ungaged tributaries, and flows from the USGS gage Sauk River near Sauk. The currently active gages that will be relied upon to provide these inputs are listed in Table 2.3-1. Active gage locations are shown in Figure 2.5-1. Gaged data will be downloaded from the USGS National Water Information System web site and reviewed for reliability, consistency, and accuracy. Ungaged tributary inflows between the mainstem Newhalem and Marblemount gages, and between the Marblemount gage and the confluence with the Sauk River, will be estimated from the gaged tributary flows using data from both the active gages and the historical discontinued gages. Ungaged tributaries include, for example, Goodell Creek, Diobsud Creek, and Illabot Creek.

City Light staff have observed that the study reach between the USGS Newhalem and Marblemount gages may experience some flow depletion under extreme low flows, as occurred in the summer of 2015. Available hydrologic and groundwater data will be reviewed to develop a better understanding of the significance of channel losses, to the extent possible. If necessary, consideration will be given to accounting for such losses in the hydraulic model by modifying the tributary inflows.

A stage or normal flow condition will be used to specify the model's downstream boundary, downstream from the confluence with the Sauk River.

2.6.1.5 Field Monitoring

A field monitoring program has acquired water level and concurrent discharge data throughout the study reach for use in hydraulic model calibration and validation. Additional detailed monitoring at select transects has also been conducted as described below. The goal of the monitoring program was to acquire model calibration data at three discharges covering the range of discharges and hydraulic conditions of primary interest to fisheries management. For planning purposes, target discharges were assumed to range from about 2,000 cfs to 6,000 cfs at Newhalem, with the exact magnitude of flows determined by hydrologic conditions and scheduled Project releases at the time of monitoring. Monitoring was also conducted for one high flow event. Given that high flow events are unpredictable, monitoring of the high flow event was conducted on an opportunistic basis.

Six automatic water level recorders were installed over a six-month period from June through November 2020 at key locations throughout the study reach to supplement stage data available from the three mainstem Skagit River USGS gages at Newhalem, Marblemount, and Rockport and from a mainstem stage gage approximately 1 mile upstream from the Sauk River confluence operated by the SRSC. Water levels are being recorded continuously at 15-minute intervals.

The locations for the automatic water level recorders were selected considering hydraulic model requirements, locations of existing mainstem gages, locations of tributary inflows, local hydraulic conditions, and access. The gages were installed by and are being maintained by the USGS under agreement with City Light. One of the gages was installed at the former location of the USGS gage Skagit River above Alma Creek, with the goal of reestablishing a stage-discharge rating and, hence, having the ability to obtain continuous stage and discharge data at this location. The installation of these gages was identified by City Light as an early action item to ensure the gages were in place to capture any high flow events in the late spring/early summer 2020 snowmelt runoff period or during fall/early winter rainfall events to support hydraulic model development and calibration starting in spring 2021. The locations of the gages are shown in Figure 2.6-3.

In addition to continuous gaging, river water surface profiles for the majority of the 29-mile reach were surveyed for discharges of 2,400, 4,200, and 6,700 cfs at Newhalem. The surveys were conducted in August 2020, October 2020, and March 2021, respectively. Certain reaches were not surveyed due to safety concerns (e.g. the Shovel Spur rapid) or because of access difficulties. Surveys were conducted using a boat-mounted echosounder continuously recording water surface elevation while the Project discharges at Gorge Powerhouse were held approximately constant. A smoothing filter will be applied to the raw water surface elevation data to produce water surface profiles suitable for use in model calibration (see Section 2.6.1.6 of this study plan). Skagit River discharges were measured concurrent with the water surface profile surveys at multiple locations along the study reach. Discharges were determined as part of more detailed transect monitoring (discussed below) using an ADCP mounted to a jet boat, augmented by a conventional current meter or handheld acoustic doppler velocimeter in areas too shallow for boat operation. Inflows at several ungaged tributaries (for example, Goodell, Diobsud, and Illabot Creeks) were also measured.

A water surface profile was also surveyed for a high flow event in November 2020. This event produced a peak flow of 12,200 cfs at Newhalem and 25,300 cfs at Marblemount (approximately 1.5-year and 2.5-year return periods respectively). In this case, high water marks were identified on land at multiple locations along the study reach and high water mark elevations were then determined using conventional survey methods.

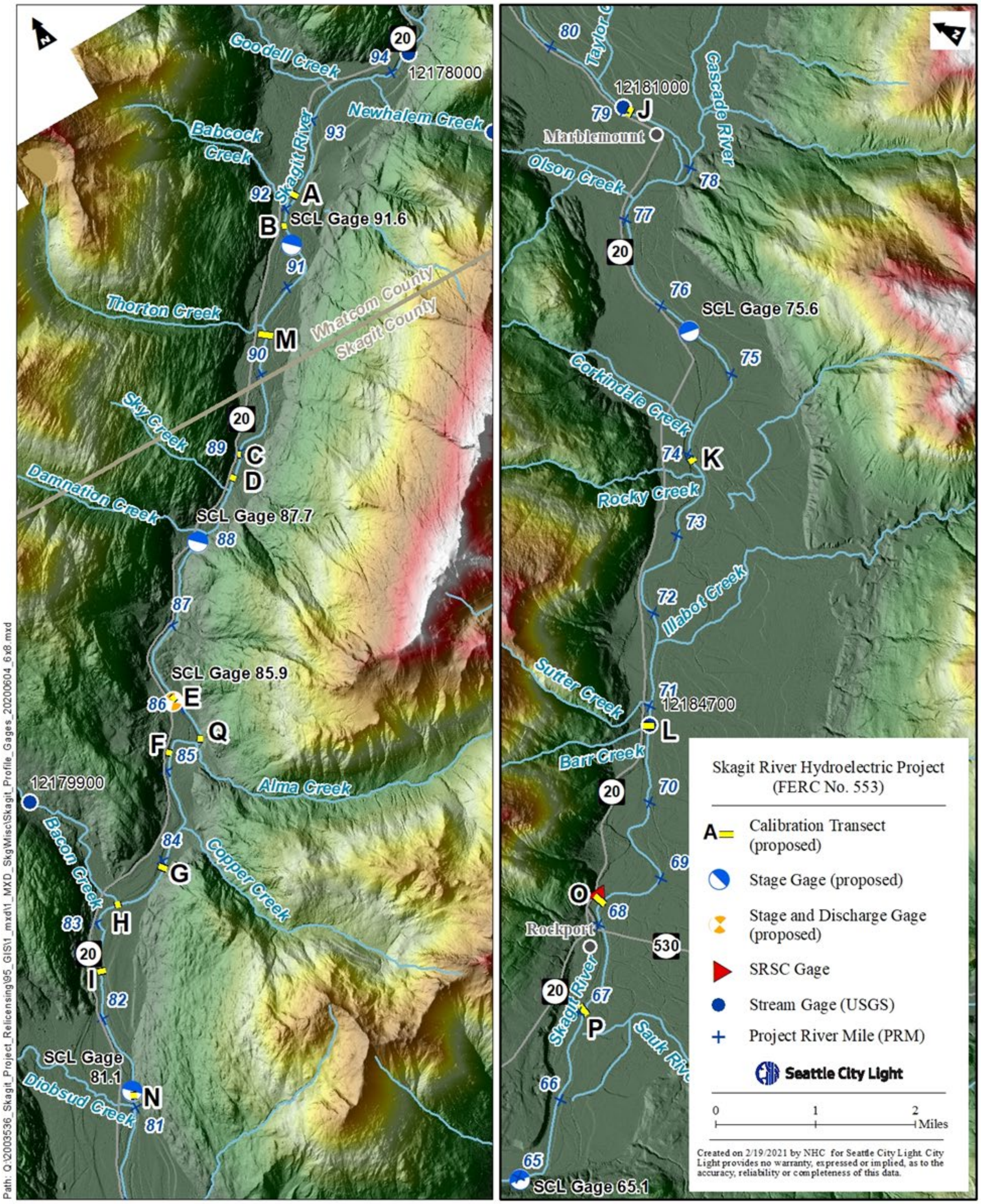

Figure 2.6-3. Stage and discharge gage locations.

Substrate Mapping

The results of substrate mapping will provide input for fish habitat modeling, be used to refine estimates of hydraulic roughness and to aid in hydraulic model calibration. Substrate will be classified visually according to the size codes identified in the WDFW/Ecology Instream Flow Study Guidelines (Beecher et al. 2016) (Table 2.6-2).

Table 2.6-2. Substrate size-classes.

Substrate Code	Type of Substrate
1	Silt, Clay, or Organic
2	Sand
3	Small Gravel (0.1-0.5")
4	Medium Gravel (0.5-1.5")
5	Large Gravel (1.5-3.0")
6	Small Cobble (3.0-6.0")
7	Large Cobble (6.0-12")
8	Boulder (>12")
9	Bedrock

Substrate polygons will be delineated throughout the study reach, with additional effort focused on high-value areas. Substrate mapping will be performed using map tiles developed from high-resolution aerial imagery (Quantum 2018; Skagit County 2015) and loaded into ArcGIS Collector on differential GNSS-enabled iPads. Substrate information will be recorded in Collector by electronically delineating polygons of homogeneous substrate facies (natural breaks) directly onto the map tiles and assigning each polygon a substrate code. Substrate codes will use the format “ab.c” where “a” is the component code for dominant particle size (particle size will be assigned based on the particle’s intermediate axis), “b” is the component code for the subdominant particle size, and “c” is tenths of cell area covered by dominant (50 percent or greater) substrate type. For example, the code 46.8 indicates 80 percent medium gravel and 20 percent small cobble, in accordance with the table above (Beecher et al. 2016).

Field teams will be trained prior to mapping so that substrate coding is accurately and uniformly applied. Initially, crew members will “calibrate” their visual assessments of particle size using a gravelometer or ruler. Regular calibration checks will be conducted as needed, such as when crews encounter a significant change in substrate conditions or if/when mapping is resumed after breaks in fieldwork.

Cover Mapping

Cover mapping, which will provide input for fish habitat modeling, will be conducted based on the codes identified in the WDFW/Ecology Instream Flow Study Guidelines (Beecher et al. 2016) (Table 2.6-3). The guidelines include nine cover criteria, eight of which (i.e., 00.2–00.9) will be mapped and used for modeling fish habitat. Undercut banks (00.1 in Table 2.6-3) likely constitute a small fraction of the overall rearing cover in a river the size of the Skagit, and exclusion of this cover type will have little influence on the 2D model’s output. As a result, undercut banks will be omitted from the cover mapping exercise.

Table 2.6-3. Generic cover/substrate codes and preference values.

Cover Code	Type of Cover	Preference Values: Salmon and Trout Rearing: Juvenile and Resident Adult	Whitefish Rearing: Juvenile	Whitefish Rearing: Adult
00.1	Undercut Bank	1.00	1.00	1.00
00.2	Overhanging Vegetation Near or Touching Water	1.00	1.00	1.00
00.3	Rootwad (Including Partly Undercut	1.00	1.00	1.00
00.4	Log Jam/Submerged Brush Pile	1.00	1.00	1.00
00.5	Log(s) Parallel to Bank	0.80	0.80	0.80
00.6	Aquatic Vegetation	0.80	0.80	0.80
00.7	Short (<1') Terrestrial Grass	0.10	0.10	0.10
00.8	Tall (<3') Dense Grass	0.70	0.70	0.10
00.9	Vegetation > 3 Vertical ft above SZF	0.20	0.20	0.20

Available remote sensing data packages will be used for initial delineation of cover types, and field mapping will be conducted as needed to supplement the remote sensing analysis. Mapping of overhanging vegetation will be based on available remote sensing data, augmented by a rapid refinement field effort to ensure that results comply with definitions in the Guidelines and to reduce the potential for overestimation. Initial delineation of large wood will be based on aerial imagery. However, rootwads, submerged brush piles, and other large wood elements that cannot be delineated from aerial imagery will be mapped in the field. Estimates of aquatic vegetation abundance and distribution can be derived largely from existing infrared imagery. Although there is likely little aquatic vegetation in the main channel, some targeted mapping will be used to supplement what is derived from infrared imagery. Short (<1 ft) terrestrial grass, tall (<3 ft) dense grass, and vegetation >3 vertical feet above stage at zero flow will be delineated using LiDAR and infrared imagery. Information from multiple remote sensing packages will be combined to produce a map of these terrestrial vegetation cover types.

Data Collection at Transects

Detailed monitoring of depth, velocity, and discharge was performed at 17 transects distributed throughout the study reach. The transects were selected to represent the range of habitat types (i.e., range of hydraulic conditions) in the study reach: riffles, pools, meander bends, split channels, etc. The number and location of these transects, shown in Figure 2.6-3, were established in consultation with Ecology, WDFW, Upper Skagit Indian Tribe, and SRSC. To allow hydraulic model development to be completed early in the relicensing process, City Light conducted monitoring of transect data and water surface profiles in the late summer and fall of 2020 and in late winter of 2020/2021. Monitoring of low flows was performed during the week of August 24, 2020, with a discharge at Newhalem of about 2,400 cfs. Monitoring under moderate flow conditions was performed during the week of October 19, 2020 with a discharge at Newhalem of about 4,200 cfs. Monitoring for flows at the high end of the range of interest was performed during the week of March 1, 2021 with a discharge at Newhalem of about 6,700 cfs.

2.6.1.6 Model Calibration and Validation

The hydraulic model will be calibrated and validated against the discharge, velocity, and water level data acquired during the field monitoring program, as well as data collected for the Barnaby Reach project, and data available from the existing USGS gauges at Newhalem, Marblemount and Rockport. Model calibration will be accomplished by first adjusting model coefficients and model mesh to match observed velocities and water levels at about 12 of the 17 transects. Data from the remaining transects will be reserved for use in model validation. The model calibration process will then be extended to match water levels both spatially and temporally at the water level monitoring stations and from the continuous water surface profiles. As part of the calibration process, sensitivity analyses will be conducted by modifying channel roughness coefficients (Manning's "n" values) over a range of conditions and recording how the model results are affected. Similar analyses will be conducted to determine the sensitivity of model results to model mesh size.

2.6.1.7 Development of Habitat Suitability Criteria

Habitat suitability criteria (HSC) define the range of microhabitat variables that are suitable for a species and life stage of interest. HSC provide the biological criteria input to a habitat model that combines the physical habitat data and the HSC into habitat suitability calculations over a range of simulation flows. Variables typically defined with HSC include depth, velocity, substrate, and instream cover. HSC values range from 0.0 to 1.0, indicating habitat conditions that are unsuitable to optimal, respectively.

Under the current Project license, flows downstream of the Gorge Powerhouse are managed in support of mainstem Skagit River anadromous fish production. The current flow plan is detailed in the Revised FSA (City Light 2011). The approach to managing flows for spawning, incubation, and rearing was initially developed by conducting an Instream Flow Incremental Method (IFIM) analysis using Physical Habitat Simulation (PHABSIM), which modeled nine species and 26 life stages of sport fishes in the Skagit River. To optimize the model for instream flow planning, LPs agreed to focus on spawning and incubation criteria for Chinook, Pink, and Chum salmon, and steelhead (Crumley and Stober 1984 Vol. I). When the FSA was updated, target flows for stream-type rearing salmonids were also included. The resulting model is referred to as the ESH model. Inputs to the model for these four species were developed using Skagit River specific data where appropriate, which indicated that these species use deeper water, higher velocities, and larger substrate than are reported in the literature. In this way, the usable area of the river was adjusted in the model to account for this Skagit-specific information as suggested by Bovee (1978). The model produced a range of flows, creating usable spawning habitat and an associated incubation flow for each spawning flow. These mainstem flows incorporate tributary inputs based on observed exceedance flows, and are referenced to the USGS gage at Newhalem. The model also incorporates flow program rules (i.e., ramp rates) to protect against fry stranding and trapping.

In practice, the output of the model will provide a season-long, flexible guideline for instream flows and will: (1) be adjustable based on natural variability of flows; (2) meet biological (spawning, incubation, rearing, and migration) requirements; and (3) protect fry from stranding and trapping, while supporting Project energy generation needs. Post-implementation analysis of the ESH model indicated an increase in mainstem salmon production (i.e., adult escapement) compared to pre-flow plan productivity (Connor and Pflug 2004).

The study proposes to review the existing river-specific habitat information and other flow program rules that support implementation of the current ESH model. ESH model documentation will also be reviewed, and existing species, life stage, periodicity information and associated HSC, and other rules will be compiled and updated to reassess relationships between fish habitat and flow for the target species[3]. Existing information will be substantiated or updated, and data gaps and/or data issues (e.g., inaccurate, outdated) will be identified. Data gaps or data issues will be addressed using available regional information compiled from literature sources and agency documents (e.g., NMFS Recovery Plan, etc.) appropriate to the study reach. As necessary, updated HSC curves will be developed for each species and life stage of interest.

HSC curves and periodicity information, in combination with a calibrated and validated hydraulic model, will allow for detailed analyses of the amount, timing, and location of suitable habitat under a range of discharges for species and life stages of interest. This could, for example, include development of stage-discharge ratings at locations of interest, analysis of discharge wetted-area relationships, integration of model depth and velocity results with habitat data in an IFIM type of analysis to produce habitat-discharge relationships for species and life stages of interest. Model results will be output directly from HEC-RAS and analyzed or synthesized further in GIS. For example, HEC-RAS model results will be output as depth and velocity grids. These will be analyzed in conjunction with substrate/cover grids and HSC curves using GIS scripts to compute usable area. Animation of model results with HEC-RAS RAS Mapper will be used to help visualize spatial and temporal variations in hydraulic and habitat conditions.

2.6.2 Workshop Consultation, Scenario Evaluation and Report Preparation

2.6.2.1 Workshop Consultation

A series of five consultation workshops will be held with LPs during model development to solicit input and feedback as follows:

- An initial workshop to discuss the overall program for instream flow model development, including:
  - velocity, stage, and discharge monitoring for hydraulic model calibration;
  - hydraulic model calibration goals and model resolution or mesh size;
  - review/discussion of existing relevant biological and habitat metrics (i.e., the basis for the current ESH model) for model input, potential data gaps, and information sources; and
  - hydraulic model outputs needed to inform the development of guidelines for future fisheries management.
- A second workshop to review and discuss proposed updates to relevant biological and habitat metrics based on discussions and input from the initial workshop;
- A mid-point workshop to present information on hydraulic model construction, including terrain data, model geometry, and model boundary conditions;

[3] Initial species and life stages for HSC development and updates will be those identified in the current ESH model. As part of the model workshops, City Light will collaborate with LPs regarding additional species and life stage HSC to be considered as part of the instream flow model.

- A workshop toward the end of the study to present and discuss the results of hydraulic model calibration and integration with biological/aquatic habitat data; and
- A final workshop to present final model calibration results and to discuss future model application.

The workshop topics identified above are typical model development milestones that benefit from LP consultation. Additional workshops and/or ad hoc discussions to discuss field data collection, model calibration, and other topics of interest to LPs related to the study may be scheduled in consultation with LPs.

2.6.2.2 Evaluation of Alternative Flow Scenarios

The process and schedule for identifying and evaluating flow management scenarios is considered a subsequent step to completing this Instream Flow Model Development Study. It is briefly described herein and in Section 2.8 of this study plan.

Upon completion (i.e., model development, calibration, validation, incorporation of HSC evaluation interface), the Instream Flow Model will be capable of evaluating alternative Project flow scenarios developed by City Light and/or LPs for the Skagit River between the Gorge Powerhouse and the Sauk River confluence. This Instream Flow Model is intended to be integrated into a broader suite of models that include the Gorge Bypass Reach Instream Flow Model and the Operations Model. A framework for evaluating alternative Project flow scenarios will be conducted in coordination with other Project models and available resource study information. A model output template will be developed to provide consistent information on modeling results for each of the scenarios identified.

The consultant developing the models will maintain the model runs and a record of results of flow scenarios evaluated. Model outputs will be summarized to track key interest areas and to compare the system response to changes in Project operations. Examples of potential flow scenarios include but may not be limited to: geomorphic process flows, spawning and rearing flows, trapping and stranding protection flows, and minimum instream flows.

It is important to note that simulation models are decision support tools and are not intended to simulate or predict exact future conditions on a daily or annual basis. The models are tools for comparisons of different scenarios.

2.6.2.3 Reporting

A technical report will be prepared documenting instream flow model development, including evaluation of existing information, field data collection, model calibration and validation, and development and integration of biological/physical inputs.

2.7 Consistency with Generally Accepted Scientific Practice

HEC-RAS is widely recognized and accepted throughout the engineering and scientific community for riverine hydraulic modeling. The proposed study methodology for hydraulic model development is consistent with the approach used for similar work.

2.8 Schedule

The schedule for completion of the Instream Flow Model is determined both by the overall schedule for Project relicensing and the needs for hydraulic modeling input by other studies. The schedule proposed for the Skagit River Geomorphology Between Gorge Dam to Sauk River Study Plan, for example, assumes the availability of a hydraulic model by fall 2021.

The proposed study schedule for hydraulic model development is as follows:

- Planning, permitting, acquisition and installation of stage recorders – April to October 2020
- Opportunistic monitoring of stage and discharge data for high flow events – July 2020 to July 2021
- Monitoring of stage, velocity, and discharge data for controlled flows of primary interest for fisheries management and conducting substrate and cover mapping – August 2020 to July 2021
- Supplementary bathymetric surveys – October[4] to November 2020 and March to April 2021, as flows safely allow
- Review and development of HSC – April to July 2021
- Hydraulic model development and calibration – May to November 2021
- Model Workshops
  - Workshop 1: Instream Flow Model Development Program Overview – April 2021
  - Workshop 2: Biological and Habitat Metrics – July 2021
  - Workshop 3: Hydraulic Model Construction – July/August 2021
  - Workshop 4: Hydraulic Model Calibration and Biological/Habitat Integration – September 2021
  - Workshop 5: Final Calibration and Model Application – November 2021
- Final Report (Initial Study Report [ISR]) – March 2022
- Alternative Scenario Identification and Evaluation Process – see below for schedule details
- Final Report (Updated Study Report [USR]) March 2023

Alternative Scenario Identification and Evaluation Process:

- Preliminary modeling tools and relicensing study results available for use – January 2022
- Alternative scenario identification and evaluations, review results, modify scenarios and discuss with LPs – January – September 2022
- As needed, continued alternative scenario evaluations and discussions – September 2022 to March 2023

[4] Surveys to fill voids in the bathymetric data were initiated in October 2020. Approximately 30 percent of the required data were collected before surveys had to be suspended due to unsafe conditions. The remaining data will be collected in March or April 2021.

2.9 Level of Effort and Cost

The initial estimate for development of the modeling tool associated with this study is approximately $1,100,000.

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INSTREAM FLOW MODEL DEVELOPMENT
REVISED STUDY PLAN

ATTACHMENT A

CITY LIGHT RESPONSES TO LP COMMENTS ON THE STUDY PLAN PRIOR TO PSP

Table 1. City Light responses to LP comments on the study plan prior to PSP.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
1.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	General Comments Title Page	Although instructed by SCL staff at the Fish and Aquatics Technical work group on 5/520 that the Utility is no longer accepting scope or scale comments- the discrepancy between tribal resource management goals and study plan draft require additional comments to scope and scale be considered.	Thank you for your comment. Although City Light believes the scope of the study plan is appropriate to develop the information needed to assess potential Project effects, City Light looks forward to continuing discussions on this and other study plans and encourages LPs to submit study plan comments and/or submit additional study requests to FERC as part of the formal relicensing process for issues that remain unresolved through the current consultations and study plan review process. City Light remains committed to continued collaboration with LPs regularly throughout the ILP process.
2.	Brock Applegate (WDFW)	05/05/2020	Section 1.2 Relicensing Process	"This study plan reflects the RWG consultation~~effort~~, and City Light will continue to engage the RWG structure in the preparation of the Proposed and Revised Study Plans (18 Code of Federal Regulations [CFR] §§ 5.11-5.13), and through the relicensing process generally." Please use language from Revised Sedimentation and Operations Model Study Plans. **New comment provided on 06/24/2020:** WDFW does not consider the process as collaborative when the licensee tells the Licensing Participants (LPS) to take their issues to FERC. SCL management would not select the collaborative licensing process, the Alternative Licensing Process, which most, if not all, licensing participants preferred. SCL can select the licensing process they prefer, but the ILP	Section 1.2 and 1.3 were redrafted to better describe the 2019 process. Formal consultation does not begin until after the PAD is officially submitted. Although LP consultation leading up to the development of draft study plans did not result in consensus regarding all issues raised by LPs, City Light views this process as a collaborative effort (i.e., the action of working together). **Response to comment provided on 06/24/2020:** City Light appreciates your agency's input and looks forward to working with you to address resource issues during the relicensing proceeding.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				operates in consultation, not collaboration when SCL chooses to separate the licensing process from the settlement agreement process. I would agree that we did collaborate during the collection of study issues.	
3.	Judy Neibauer (USFWS)	05/13/2020	Section 1.2 Relicensing Process	"This study plan reflects the RWG consultation, and City Light will continue to engage the RWG structure in the preparation of the Proposed and Revised Study Plans (18 Code of Federal Regulations [CFR] §§ 5.11-5.13), and through the relicensing process generally." Mention here that this information will help inform NEPA, the BA for ESA consultation, and the information needed for Section 10j for the Fish and Wildlife Coordination Act....similar to your other study plans....	Section 1.2 has been edited to identify elements of the relicensing process, such as those noted by USFWS.
4.	Brock Applegate (WDFW)	05/05/2020	Section 1.2 Relicensing Process	"This study will develop numerical hydraulic models of the Skagit River in the reach between Gorge Dam and the confluence with the Sauk River." Flows have effects on aquatic habitat all the way to the estuary.	City Light intends to assess the nature of the Project's contribution to cumulative effects downstream of the Sauk River confluence using existing available information as part of the relicensing process.
5.	Ashley Rawhouser (NPS)	05/13/2020	Section 1.3 Study Plan Development	"This study will develop numerical hydraulic models of the Skagit River in the reach between Gorge Dam and the confluence with the Sauk River." Concur with WDFW and USFWS study area should extend to Puget Sound.	See Comment Response #4.
6.	Judy Neibauer (USFWS)	05/13/2020	Section 1.3 Study Plan Development	"The models may contribute to addressing a variety of issues identified in the issue forms listed in Table 5.3-1 of the PAD (City Light 2020)."	See Comment Response #4. The FERC process schedule positions an integrated environmental analysis subsequent to

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				I agree we will need to understand effects of operations on flow effects down to the estuary for a variety of reasons...aquatic species, riparian habitat, floodplain connectivity, etc. I would also like to understand how operations that alter the reservoirs daily for about 4-5 feet, and then on maintenance or flood flow events that alter the reservoir elevations up to 50 feet might affect downstream resources. Monitoring instream flows to depict what happens all the way downstream, will be important for ESA consultation.	the completion of the study program and prior to the filing of a Project License Application. The integrated environmental analysis will address cross-resource linkages and issues. The information resulting from the study program is intended to inform consultation with LPs including USFWS during future steps within the process. City Light has added language to Section 1.3 to address potential linkages between studies.
7.	Judy Neibauer (USFWS)	05/13/2020	Section 1.3 Study Plan Development	"The models may contribute to addressing a variety of issues identified in the issue forms listed in Table 5.3-1 of the PAD (City Light 2020)." Describe if you will use existing data, other data or links to other study plans here such as geomorphology, operational flows model, etc to help establish timeframes and locations for monitoring stream flow and establishing "instream flows"	Section 1.3 was redrafted to better describe the 2019 process including the rationale supporting City Light's initial draft study plan proposal. See Comment Response #6.
8.	Stan Walsh (SRSC)	05/11/2020	Section 2.1 Study Goals and Objectives	"**2.1 Study Goals and Objectives**" An Instream Flow Study needs to be as comprehensive as possible and go beyond development of a flow model to be used later in relicense. The study plan needs to identify how the model will be used and what other studies it will be integrated with including the geomorphology study and riparian vegetation study. While many model runs may be developed by an instream flow study group a number of examples should be included in the	See Comment Response #6. The scope of the study is the development, calibration and validation of the model. Subsequent phases of the relicensing process are intended to analyze cross-resource issues and to compare alternative scenarios to existing conditions.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				study plan that goes into the PSP in the ILP process.	
9.	Brock Applegate (WDFW)	05/05/2020	Section 2.1 Study Goals and Objectives	"The primary goal of the Instream Flow Model Development Study is to develop an updated flow/habitat management and evaluation tool for the Skagit River between the Gorge Powerhouse and the confluence with the Sauk River." SCL should extend your geographic scope. The effects of the Project continue downstream in some manner. With a estuary that needs more sediment and a change in timing, a reduction in magnitude and duration of process flows, SCL has cumulatively affected the downstream Skagit River with other users.	See Comment Response #4.
10.	Stan Walsh (SRSC)	05/11/2020	Section 2.1 Study Goals and Objectives	"The primary goal of the Instream Flow Model Development Study is to develop an updated flow/habitat management and evaluation tool for the Skagit River between the Gorge Powerhouse and the confluence with the Sauk River." There are several flow impacts that extend below the Sauk River confluence that need to be studied including but not limited to middle river spawning and incubation (including timing), flood plain connectivity, habitat flows, downramp rates and amplitudes. Additionally flow impacts combined with geomorphic impacts including disrupted bedload, fine sediment delivery to the Skagit Bay front, LWD disruption to the middle Skagit may be limiting salmonid habitat below the Sauk River.	See Comment Response #4.
11.	Judy Neibauer (USFWS)	05/13/2020	Section 2.1	"The primary goal of the Instream Flow Model Development Study is to develop an updated	See Comment Response #4.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
			Study Goals and Objectives	flow/habitat management and evaluation tool for the Skagit River between the Gorge Powerhouse and the confluence with the Sauk River." I suggest you extend the scope of the study to include the full basin	
12.	Brock Applegate (WDFW)	05/05/2020	Section 2.1 Study Goals and Objectives	"A second~~ary~~ goal is to describe current hydraulic conditions in the Skagit River between Gorge Dam and the Gorge Powerhouse (i.e., Gorge bypass reach) through the development of a numerical hydraulic model for this reach." **New comment provided on 06/24/2020:** SCL does not understand the request from WDFW. Please see below. WDFW recommended that SCL combine the bypass reach with this instream flow model effort in the downstream reach, not put it in a separate study plan.	City Light understands the requests from WDFW and other LPs for a study plan that focuses on information necessary in the bypass reach and welcomes discussion on the best way to address this in a separate study plan at future RWG meetings. City Light agrees that it may be best to discuss these information needs separate from the existing instream flow study plan, and has removed related text from this study plan. **Response to comment provided on 06/24/2020:** See Comment Responses #12 and #120. Although separate models are proposed for the bypass reach and the Gorge Powerhouse to Sauk River reach, the models will be configured to allow easy interface with outflow from the bypass reach model providing input at the upstream end of the Gorge Powerhouse to Sauk River model. The principal technical reason for developing separate but linkable models is the much finer resolution (and hence longer computational times) required of the bypass reach model given the different physical characteristics of the two reaches.
13.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.1 Study Goals and Objectives	"A secondary goal is to describe current hydraulic conditions in the Skagit River between Gorge Dam and the Gorge Powerhouse	See Comment Response #12.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				(i.e., Gorge bypass reach) through the development of a numerical hydraulic model for this reach." Upper Skagit Indian Tribe views this goal as of equal importance to the primary goal stated above.	
14.	Stan Walsh (SRSC)	05/11/2020	Section 2.1 Study Goals and Objectives	"A secondary goal is to describe current hydraulic conditions in the Skagit River between Gorge Dam and the Gorge Powerhouse (i.e., Gorge bypass reach) through the development of a numerical hydraulic model for this reach." This should include looking at habitat potential in the bypass reach.	See Comment Response #12.
15.	Brock Applegate (WDFW)	05/11/2020	Section 2.1 Study Goals and Objectives	"Specific objectives include: ▪ Develop, calibrate, and validate a numerical hydraulic model of the Skagit River for the reach between the Gorge Dam~~Powerhouse~~ and the confluence with the Sauk River. ▪ Integrate hydraulic model outputs with biological (species, life stages, periodicities, etc.) and physical (depth, velocity) criteria used in the current flow/habitat management tool to develop updated flow/habitat relationships for the reach between the Gorge Dam~~Powerhouse~~ and the confluence with the Sauk River. ▪ Develop, calibrate, and validate a numerical hydraulic model for the Skagit River for the Gorge bypass reach to describe current hydraulic conditions in this reach." SCL should develop hydraulic models and use fish habitat suitability curves in both reaches. I understand the need to divide the reaches out	See Comment Response #12. This study plan now only refers to the study reach downstream of the Gorge Powerhouse. **Response to comment provided on 06/24/2020:** See Comment Responses #12, #120, and #143.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				because of the water supply, but they should receive equal treatment in the process of obtaining instream flows. **New comment provided on 06/24/2020:** Please see my comment on #12. Combine the study areas, not separate them.	
16.	Curtis Clement (Upper Skagit Indian Tribe)	05/07/2020	Section 2.1 Study Goals and Objectives	1st Bullet – Comment "Specific objectives include: ▪ Develop, calibrate, and validate a numerical hydraulic model of the Skagit River for the reach between the Gorge Powerhouse and the confluence with the Sauk River." The project affects the river all the way to the sound. Why doesn't SCL want to examine what the impacts might be below the Sauk? If mitigation is to be done upstream of the Sauk, that mitigation will always have impacts downstream, it would only be logical to investigate what that impact might be. This model is the perfect time and place to make that investigation. It's only going to help design better mitigation upstream.	See Comment Response #4.
17.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.1 Study Goals and Objectives	1st Bullet – Comment "Specific objectives include: ▪ Develop, calibrate, and validate a numerical hydraulic model of the Skagit River for the reach between the Gorge Powerhouse and the confluence with the Sauk River."	See Comment Response #4.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				As Curtis states, this study needs to cover the entire Skagit River to Puget Sound. See our previous comments for a more thorough justification of this study need (e.g. Wetland and Vegetation Mapping study plans).	
18.	Jon Riedel (NPS)	05/13/2020	Section 2.1 Study Goals and Objectives	1st Bullet – Comment "Specific objectives include: ▪ Develop, calibrate, and validate a numerical hydraulic model of the Skagit River for the reach between the Gorge Powerhouse and the confluence with the Sauk River." Suggest this be integrated with 2 geomorphology mapping projects: landform mapping and habitat characterization. Specifically, model domain should be designed with reach scale geomorphology and landforms in mind.	As part of study planning, existing information such as the referenced landform mapping and habitat characterization will be assessed for utility. The study team is also coordinating with the geomorphology and vegetation mapping study team to ensure that data collection and analyses under that study inform model development.
19.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.1 Study Goals and Objectives	2nd Bullet – Comment "Specific objectives include: ▪ Integrate hydraulic model outputs with biological (species, life stages, periodicities, etc.) and physical (depth, velocity) criteria used in the current flow/habitat management tool to develop updated flow/habitat relationships for the reach between the Gorge Powerhouse and the confluence with the Sauk River." Additional criteria should be integrated:	All of these data will be collected as part of the vegetation mapping and geomorphology studies. This study is intended to develop the hydraulic model that will be combined with the results of other studies in order to model fish habitat and potential use. Additional data collection can be discussed during the LP workshops which are a part of this study plan.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				1) Habitat units/types (e.g. pool, riffle, bank, bar, backwater, side-channel, off-channel). 2) Instream cover (e.g. large woody debris, vegetated bars) 3) Substrate composition (e.g. spawning suitability, cover for juveniles) Field studies should document these metrics, if not already collected in other studies.	
20.	Stan Walsh (SRSC)	05/11/2020	Section 2.1 Study Goals and Objectives	2nd Bullet - Comment "Specific objectives include: ▪ Integrate hydraulic model outputs with biological (species, life stages, periodicities, etc.) and physical (depth, velocity) criteria used in the current flow/habitat management tool to develop updated flow/habitat relationships for the reach between the Gorge Powerhouse and the confluence with the Sauk River." Including modifications from additional data sources	Text has been revised as suggested.
21.	Stan Walsh (SRSC)	05/11/2020	Section 2.1 Study Goals and Objectives	2nd Bullet – Comment "Specific objectives include: ▪ Integrate hydraulic model outputs with biological (species, life stages, periodicities, etc.) and physical (depth, velocity) criteria used in the current flow/habitat management tool to develop updated flow/habitat relationships for the reach between the Gorge Powerhouse and the confluence with the Sauk River."	See Comment Responses #4, #6, and #8.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				See second comment in this section (See Comment #10)	
22.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.1 Study Goals and Objectives	3rd Bullet – Comment "Specific objectives include: ▪ Develop, calibrate, and validate a numerical hydraulic model for the Skagit River for the Gorge bypass reach to describe current hydraulic conditions in this reach." This reach should not be treated separately, or SCL should justify why it is being treated separately. The Gorge bypass reach has the same study needs as the rest of the Skagit River within and below the project boundary.	See Comment Response #12.
23.	Stan Walsh (SRSC)	05/11/2020	Section 2.1 Study Goals and Objectives	3rd Bullet – Comment "Specific objectives include: ▪ Develop, calibrate, and validate a numerical hydraulic model for the Skagit River for the Gorge bypass reach to describe current hydraulic conditions in this reach." Need to include reference to Unsteady flow model development – see below.	See Comment Response #12. The hydraulic model proposed is an unsteady flow model. The study plan has been edited to indicate this.
24.	Brock Applegate (WDFW)	05/05/2020	Section 2.1 Study Goals and Objectives	"Once the study is complete (i.e., the models have been developed), the flow/habitat models will be used to investigate and inform the evaluation of flows and habitat in the Gorge Dam~~Powerhouse~~ to Sauk River reach to continue supporting ~~mainstem~~Skagit River fish production during the new FERC license term and to support additional discussions regarding	See Comment Response #12. **Response to comment provided on 06/24/2020:** See Comment Responses #12 and #120.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				hydraulic conditions and fish and aquatic habitat, including migration habitat, in the Skagit River in the Gorge bypass reach." **New comment provided on 06/24/2020:** SCL will need to consider the entire fish population, not just the population in the mainstem or below the powerhouse.	
25.	Judy Neibauer (USFWS)	05/13/2020	Section 2.1 Study Goals and Objectives	"Once the study is complete (i.e., the models have been developed), the flow/habitat models will be used to investigate and inform the evaluation of flows and habitat in the Gorge Dam to Sauk River reach to continue supporting Skagit River fish production during the new FERC license term and to support additional discussions regarding hydraulic conditions and fish and aquatic habitat, including migration habitat, in the Skagit River in the Gorge bypass reach." Link to the operational plan, reservoir information, so that when you are sampling downstream and looking at stream flows, you understand what effects are occurring to water levels in the reservoirs...i.e., are tributaries left disconnected or exposed, is there stranding occurring at all, etc...The upstream reservoirs levels and downstream flows information gathered in both areas will need to be combined, to understand the level of risk to both upstream and downstream resources when developing instream flow parameters.	The Instream Flow Model is designed to be operated in tandem with the Operations Model. Post-study analysis of potential Project effects and evaluation of potential alternative operating scenarios using the Instream Flow Model will include linkages to the Operations Model.
26.	Stan Walsh (SRSC)	05/11/2020	Section 2.1 Study Goals and Objectives	"Once the study is complete (i.e., the models have been developed), the flow/habitat models will be used to investigate and inform the evaluation of flows and habitat in the Gorge	Text has been revised as suggested.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				Powerhouse to Sauk River reach to continue supporting mainstem Skagit River fish production during the new FERC license term and to support additional discussions regarding hydraulic conditions in the Skagit River in the Gorge bypass reach." Should be fish habitat rather than production	
27.	Stan Walsh (SRSC)	05/11/2020	Section 2.2 Resource Management Goals	"City Light's goal for the proposed study is to develop an updated flow/habitat management tool to re-examine flow management in the portion of the Skagit River affected by Project operations between the Gorge Powerhouse and the confluence with the Sauk River to evaluate whether flows as currently regulated by the Project continue to support mainstem Skagit River fish production, and identify where changes may be needed." See second comment section 2.1 (See Comment #10)	See Comment Responses #4, #6, and #8.
28.	Stan Walsh (SRSC)	05/11/2020	Section 2.2 Resource Management Goals	"City Light's goal for the proposed study is to develop an updated flow/habitat management tool to re-examine flow management in the portion of the Skagit River affected by Project operations between the Gorge Powerhouse and the confluence with the Sauk River to evaluate whether flows as currently regulated by the Project continue to support mainstem Skagit River fish production, and identify where changes may be needed." This statement suggests the study will be evaluating fish production – which it is not. Suggest rephrasing to "…provide the quantity	Text has been revised as suggested.

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				and quality of fish habitat in the mainstem Skagit River necessary to sustain healthy fish populations of key species	
29.	Brock Applegate (WDFW)	05/11/2020	Section 2.2 Resource Management Goals	"City Light's goal for the proposed study is to develop an updated flow/habitat management tool to re-examine flow management in the portion of the Skagit River affected by Project operations between the Gorge Dam~~Powerhouse~~ and the estuary ~~confluence with~~of the Skagit~~auk~~ River to evaluate whether flows as currently regulated by the Project continue to support ~~mainstem~~ Skagit River fish production, and identify where changes may be needed." SCL should try to identify their partial effects that grow less down the river in SCL's effects analysis.	These edits have not been accepted. See Comment Response #4.
30.	Brock Applegate (WDFW)	05/11/2020	Section 2.2 Resource Management Goals	"City Light's goal for the proposed study is to develop an updated flow/habitat management tool to re-examine flow management in the portion of the Skagit River affected by Project operations between the Gorge Dam~~Powerhouse~~ and the estuary ~~confluence with~~of the Skagit~~auk~~ River to evaluate whether flows as currently regulated by the Project continue to support ~~mainstem~~ Skagit River fish production, and identify where changes may be needed." WDFW recommends that SCL take migration of fish upstream into and downstream from tributaries into account when the LPs consider instream flows. Tributary fish production should include fish passage in and out of the tributaries as well.	See Comment Response #12. Regarding connectivity of the mainstem Skagit River and associated tributaries (between Gorge Dam and the Sauk River), City Light is not aware of any existing connectivity issues but is interested in exploring these concerns with LPs if there is evidence of issues at such locations. While identification and development of PMEs (i.e., instream flows) for the next license is a phase of relicensing subsequent to the study program, City Light anticipates and is committed to working with LPs during this phase of the ILP to ensure tributary connectivity.
31.	Judy Neibauer (USFWS)	05/13/2020	Section 2.2 Resource	"National Marine Fisheries Service (NMFS), US Fish and Wildlife Service,(USFWS),	Edits accepted.

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			Management Goals	Washington Department of Fish and Wildlife (WDFW), the Upper Skagit Indian Tribe, the Sauk-Suiattle Indian Tribe, and the Swinomish Indian Tribal Community all have management responsibilities for anadromous salmonids and their prey species, wildlife and plants ~~salmon and steelhead~~ in the ~~lower~~ Skagit River basin and its tributaries. Other agencies have responsibilties for adjacent land management." The US Fish and Wildlife Service also has responsibilities for anadromous fish. We would also like you to include other fish species in development of instream flow models for management. Pacific Lamprey, bull trout, Whitefish, cutthroat, etc and other species that may contribute to prey base...per our Critical Habitat PCE 3	The current ESH model incorporates the needs of 9 salmonid species (including cutthroat trout and mountain whitefish) and 26 associated life stages and this biological/habitat information including other rules/constraints to protect fisheries resources (e.g., ramp rates, etc.) will serve as the initial biological inputs for the Instream Flow Model. Additional discussions regarding refinements of biological model inputs is anticipated to occur at model workshops identified in Section 2.6.2.
32.	Judy Neibauer (USFWS)	05/13/2020	Section 2.2 Resource Management Goals	"National Marine Fisheries Service (NMFS), US Fish and Wildlife Service,(USFWS), Washington Department of Fish and Wildlife (WDFW), the Upper Skagit Indian Tribe, the Sauk-Suiattle Indian Tribe, and the Swinomish Indian Tribal Community all have management responsibilities for anadromous salmonids and their prey species, wildlife and plants in the Skagit River basin and its tributaries. Other agencies have responsibilties for adjacent land management. I suggest you extend the scope to the full basin, Please see our critical habitat rule that has 9 PCEs that need to be maintained. These were developed in 2010. Of importance to note is PCE 1 to maintain seeps, springs, ground water, subsurface water like Hyporheic areas; as well	See Comment Responses #4, #6, and #25.

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				as the other 8 PCES that are linked to stream flow and reservoir levels in one way or another. If you need to link to other model already completed you can show how you might do that in this model or additional studies. Link to the geomorphology, landform, and operational studies to understand where addition key areas are from a hyporheic standpoint. Understanding where and how these hyporheic areas are, will help identify key refugia within the river channels so that you can accommodate instream flows to protect them. These areas provide for forage, overwintering, cool water refugia, spawning....within the larger water bodies.	
33.	Judy Neibauer (USFWS)	05/13/2020	Section 2.2 Resource Management Goals	"National Marine Fisheries Service (NMFS), US Fish and Wildlife Service,(USFWS), Washington Department of Fish and Wildlife (WDFW), the Upper Skagit Indian Tribe, the Sauk-Suiattle Indian Tribe, and the Swinomish Indian Tribal Community all have management responsibilities for anadromous salmonids and their prey species, wildlife and plants in the Skagit River basin and its tributaries. Other agencies have responsibilties for adjacent land management. You should mention that we now have listed critical habitat and populations since the issuance of the last license and fish settlement agreement. The goal here would be to look at stream flow and develop a new set of instream flows that reduce impacts to species and habitats. You could even list or link to our Critical habitat PCEs for listed species or to the Mag Stevens or other resource management goal for other agencies...such as the USFS	See Comment Response #6.

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				standards and guides that address Key watersheds and the Aquatic Conservation Strategy...	
34.	Judy Neibauer (USFWS)	05/13/2020	Section 2.2 Resource Management Goals	National Marine Fisheries Service (NMFS), US Fish and Wildlife Service,(USFWS), Washington Department of Fish and Wildlife (WDFW), the Upper Skagit Indian Tribe, the Sauk-Suiattle Indian Tribe, and the Swinomish Indian Tribal Community all have management responsibilities for anadromous salmonids and their prey species, wildlife and plants in the Skagit River basin and its tributaries. Other agencies have responsibilties for adjacent land management. not just looking at instream flow for anadromous salmon, will need to include other resources, per my additional language suggestion...	See Comment Response #31.
35.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.2 Resource Management Goals	"The flow/habitat model will serve as a tool to analyze current conditions and alternative scenarios during the relicensing process. Additionally, the hydraulic model may be used to support the assessment, planning and design of potential off-channel and floodplain restoration projects that enhance juvenile salmonid rearing opportunities in this reach." The model should also be capable of handling predicted geomorphic changes under additional potential mitigation alternatives: 1) Process flows to create and sustain fluvial habitats 2) Sediment and wood reintroduced below the dams	See Comment Responses #6 and #8. The primary purpose of the hydraulic model will be to investigate and inform the evaluation of flow/habitat relationships in support of mainstem Skagit River aquatic habitat protection and fish production. The model will have the flexibility that it could be modified or adapted for a range of other applications and interests. The proposed model will not simulate sediment transport or geomorphic change. However basic hydraulic model outputs (discharge, water depth, velocity, shear stress) can be used to support analysis of sediment transport and geomorphic change and will be used to support the geomorphology study.

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36.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.2 Resource Management Goals	"The flow/habitat model will serve as a tool to analyze current conditions and alternative scenarios during the relicensing process." Need the tool to assess Steelhead kelt migration flows, juvenile migration flows and stream life history flows for rearing, growth and survival.	The current model accounts for juvenile migration and rearing. Steelhead kelts were not included in the current model. See Comment Response #31. Additional discussions regarding refinements of biological model inputs is anticipated to occur at model workshops identified in Section 2.6.2.
37.	Stan Walsh (SRSC)	05/11/2020	Section 2.2 Resource Management Goals	"The flow/habitat model will serve as a tool to analyze current conditions and alternative scenarios during the relicensing process." Should include other study linkages (geomorphology, riparian vegetation) and some specifics such as floodplain connectivity and hyporheic flows for riparian vegetation.	See Comment Responses #6, #8, and #35.
38.	Stan Walsh (SRSC)	05/11/2020	Section 2.2 Resource Management Goals	"City Light will confer with resource agencies and tribes that are interested in participating in development of this study proposal, and language identifying specific management goals relevant to this study proposal is anticipated." Will these conferences result in a revised study plan for the PSP?	Consultation on City Light's draft study plans with LPs is intended to result in a revised study plan that would be included in the PSP filing in December 2020. City Light also encourages LPs to submit study plan comments on the PSP and/or submit additional study requests to FERC as part of the formal relicensing process for issues that cannot be resolved prior to PSP submission.
39.	Brock Applegate (WDFW)	05/11/2020	Section 2.3 Background and Existing Information	Detailed information is required on hydraulic conditions and their spatial and temporal variation in the Skagit River between Gorge Dam~~Powerhouse~~ and the estuary ~~confluence with~~ in the Skagit~~auk~~ River to support management of flows for Skagit River fish production.	These edits have not been accepted. See Comment Responses #4 and #12.
40.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3 Background and Existing Information	"The Revised FSA provides requirements for protection of Chinook, Pink, and Chum salmon and for steelhead for all life stages."	City Light will be assessing Project effects on rearing habitat and geomorphology as part of our effects analysis. In order to assess the effect of the Project on geomorphology, including

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				Perhaps this was the original intent, but subsequent scientific evidence indicates that all life stages are not adequately protected. The Skagit Chinook Recovery Plan identifies juvenile rearing habitat as a key limiting factor basin-wide in the Skagit. An overarching cause is interrupted fluvial habitat forming processes, which includes impacts from hydroelectric projects. The new instream flow study, in combination with the geomorphic study, needs to address interruptions to geomorphic processes that create and sustain rearing habitats for Chinook.	rearing habitat, we will first need to determine the existing conditions. We can then determine how the Project affects the specific metrics which you listed in your comment. It will require that we integrate the results of several other studies in order to conduct this analysis. The hydraulic model and instream flow related habitat metrics are just one piece of that puzzle.
41.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3 Background and Existing Information	"Changes in channel morphology and habitat conditions have occurred over time and an updated model will reflect both current channel conditions and river hydraulics over a broader range of hydrologic conditions." Will the model reflect expected future changes to channel conditions?	See Comment Response #6. The model is intended to describe the existing environmental conditions with regards to flows and aquatic habitat to support fish production. As part of an integrated environmental analysis (subsequent to the relicensing study program) the model will support an analysis of Project effects, assess cross-resource linkages and compare alternative scenarios to the existing condition. Within this analysis framework, the model may be used to inform estimates of potential future changes to channel conditions under alternative operational (flow) scenarios that could be implemented in the future.
42.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3 Background and Existing Information	"Additional data provided by the 2012 model, upstream of the Barnaby Reach domain, is based on outdated bathymetric survey data that may not accurately characterize current terrain conditions." This speaks to the need to incorporate predicted geomorphic changes over the course of the	See Comment Response #41. Note that the proposed 2D HEC-RAS model would be relatively easy to update with new terrain data as they become available.

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				license period, or to develop a model that can be used to adaptively manage over the course of the new license.	
43.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3 Background and Existing Information	"The one-dimensional model of the upper Skagit, upstream from the Sauk River, is based on outdated channel cross-section data, including data from the Federal Emergency Management Agency (FEMA) surveys of the 1970s." It is also inadequate because it is a 1-D model. A 2-D model is needed to assess complex channel and floodplain habitats.	Agreed.
44.	Brock Applegate (WDFW)	05/11/2020	Section 2.3 Background and Existing Information	"The one-dimensional model of the upper Skagit, upstream from the Sauk River, is based on outdated channel cross-section data, including data from the Federal Emergency Management Agency (FEMA) surveys of the 1970s." WDFW assumes that SCL will update the channel cross-section data.	The model geometry will be developed from LiDAR data collected between 2016 and 2018 supplemented by new bathymetric surveys as described in study plan sections 2.6.2.2 and 2.6.2.3. The 1970s era cross-section data will not be used.
45.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.3 Background and Existing Information	"There are no existing hydraulic models for the Gorge bypass reach. Under existing conditions, this 2.5-mile-long reach of the Skagit River flows through a steep, confined canyon that is characterized by bedrock and large boulder substrate." Please measure and site consistently across study plans	Previous documents note that the bypass reach is 2.7 miles long. Current calculations by City Light, made in 2019, reveal the bypass to be 2.5 miles long. This vetted number was used consistently throughout the PAD.
46.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3 Background and Existing Information	"Aquatic habitat in the Gorge bypass reach is mainly limited by minimal natural flow inputs derived from seepage under Gorge Dam, groundwater accretions, and from four	See Comment Response #12.

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				ephemeral (non-fish bearing) streams, which do not provide a fully wetted channel (Envirosphere 1988)." Incorrect. It is mainly limited by Gorge Dam flow diversions and disrupted sediment and wood transport.	
47.	Curtis Clement (Upper Skagit Indian Tribe)	05/07/2020	Section 2.3 Background and Existing Information	"Development of a hydraulic model will support additional analyses regarding hydraulic conditions in the Gorge bypass." Needs elaboration as to how it will support analysis of a reach that is upstream of where the model will begin.	See Comment Response #12. The sentence quoted refers to development of a hydraulic model of the bypass reach which has now been removed.
48.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3 Background and Existing Information	"Development of a hydraulic model will support additional analyses regarding hydraulic conditions in the Gorge bypass." For below the Sauk, there may be a 2-D model developed for the Skagit River between Day Creek and Sedro-Woolley (project currently being proposed under the RCO Salmon Recovery Funding Board program).	Thank you for the information.
49.	Brock Applegate (WDFW)	05/11/2020	Section 2.3 Background and Existing Information	"Aquatic habitat in the Gorge bypass reach is mainly limited by minimal natural flow inputs derived from seepage under Gorge Dam, groundwater accretions, spill from Gorge Dam, and from four ephemeral (non-fish bearing) streams, which do not provide a fully wetted channel (Envirosphere 1988), when SCL does not spill."	See Comment Response #12.
50.	Stan Walsh (SRSC)	05/11/2020	Section 2.3 Background and Existing Information	"Development of a hydraulic model will support additional analyses regarding hydraulic conditions in the Gorge bypass."	See Comment Response #12.

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				Should include habitat potential in the bypass reach	
51.	Judy Neibauer (USFWS)	05/13/2020	Section 2.3 Background and Existing Information	"Aquatic habitat in the Gorge bypass reach is mainly limited by minimal natural flow inputs derived from seepage under Gorge Dam, groundwater accretions, spill from Gorge Dam, and from four ephemeral (non-fish bearing) streams, which do not provide a fully wetted channel (Envirosphere 1988), when SCL does not spill." Linking up to geomorphology, operational modeling, and landform study information may show that there is other ground water, seeps, springs that are important. Please link to that information.	See Comment Responses #6 and #25.
52.	Judy Neibauer (USFWS)	05/13/2020	Section 2.3 Background and Existing Information	"Development of a hydraulic model will support additional analyses regarding hydraulic conditions in the Gorge bypass." Please think about including a 3-d model development that will greatly assist in showing and helping to develop alternatives for flow management in the future	See Comment Response #12. While a 3-D model would allow detailed examination of hydraulic conditions at certain specific locations (e.g. at a plunge pool), it would not be feasible to apply at the scale of the bypass reach as a whole.
53.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3 Background and Existing Information	"Topographic and bathymetric data. LiDAR data covering the proposed hydraulic model extents (see Section 2.5 of this study plan) were acquired in 2017 and 2018 (Quantum Spatial 2017; Quantum Spatial 2018). The LiDAR generally provides high quality topographic and bathymetric data, however there are some gaps or voids in the channel bathymetry data because of limitations imposed by water depth and/or channel bed conditions. These voids will need to be filled using ground-based surveys as	See Comment Response #4.

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				described in more detail in Section 2.6 of this study plan." Data needs for below the Sauk must be addressed.	
54.	Judy Neibauer (USFWS)	05/13/2020	Section 2.3 Background and Existing Information	"The PAD also provides monthly minimum, average, and maximum outflows from Ross, Diablo, and Gorge lakes for the period 1991–2018. During the study, opportunistic flows may need to be take during certain times of the year or during changes in operations. Please consider adding some number of opportunistic flow recording sites to capture events that will collect data that represents the range of changes that may occur during operations.	The field monitoring program proposed in study plan section 2.6.2.5 includes installation of automatic water level recorders. These, in conjunction with existing flow gauging stations, will collect data within the study reach which reflects operational changes during the monitoring period.
55.	Jon Riedel (NPS)	05/13/2020	Section 2.4 Project Operations and Effects on Resources	"Project operations regulate flows in the Skagit River downstream from Gorge Dam, reducing downstream flood risk, altering geomorphic processes, and influencing, through a variety of pathways, the availability and suitability of spawning, incubation, and rearing habitat for anadromous salmonids." And at various spatial and temporal scales. The project has a particularly large impact on the long-duration spring flood, when Ross Lake is being filled with snow melt runoff. This is a geomorphically/habitat key flow event.	Comment acknowledged. The Geomorphology between Gorge Dam and the Sauk River Confluence study will also help to address effects of peak flow events on geomorphology and aquatic habitat including peak flow magnitude, frequency, timing, and duration.
56.	Brock Applegate (WDFW)	05/11/2020	Section 2.4 Project Operations and Effects on Resources	"Project operations regulate flows in the Skagit River downstream from Gorge Dam, reducing downstream flood risk, altering geomorphic processes, and influencing, through a variety of pathways, the availability and suitability of	See Comment Response #31.

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				spawning, incubation, and rearing habitat for anadromous salmonids." SCL affects many more species than just anadromous salmonid species. The project affects all aquatic habitat and species, including macroinvertebrate populations, resident trout, other fish species, and other organisms.	
57.	Stan Walsh (SRSC)	05/11/2020	Section 2.4 Project Operations and Effects on Resources	"Project operations regulate flows in the Skagit River downstream from Gorge Dam, reducing downstream flood risk, altering geomorphic processes, and influencing, through a variety of pathways, the availability and suitability of spawning, incubation, and rearing habitat for anadromous salmonids." And resident	See Comment Response #31.
58.	Judy Neibauer (USFWS)	05/13/2020	Section 2.4 Project Operations and Effects on Resources	"Information on the hydraulic characteristics of flows in the Skagit River (discharge, flow depth and velocity, and their spatial and temporal variations) will describe these influences and inform future Project operations for flow management, particularly as related to fish production." Consider adding a section here about past operations and the effects on stream flows and resources dependent upon stream flow, and describe what the current instream flows are designed to meet, and SCL's overall general management to meet instream flows and a abilities to meet them	The PAD contains much information, which is often detailed and nuanced. A summary in this study plan would not be representative and reproducing the content of the PAD in this study plan would make it cumbersome and lengthy. City Light continues to believe that the best approach is to simply reference the PAD, to which all LPs have access.
59.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.5 Study Area	"The study area, which is defined by the proposed limits of hydraulic modeling, will extend from Gorge Dam at about RM 96.5 downstream to a suitable location a short	See Comment Response #4.

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				distance downstream from the confluence with the Sauk River, at approximately RM 65 (Figure 2.5-1). The total reach length is approximately 31.5 miles." Extend to Puget Sound. See previous comments.	
60.	Brock Applegate (WDFW)	05/11/2020	Section 2.5 Study Area	"The study area, which is defined by the proposed limits of hydraulic modeling, will extend from Gorge Dam at about RM 96.5 downstream to a suitable location a short distance downstream from the confluence with the Sauk River, at approximately RM 65 (Figure 2.5-1)." SCL should consider the effects of the flow model out of the Skagit River and estuary and into the Sound. The Project has population effects on anadromous salmonid populations and those species dependent on them, like orcas.	See Comment Response #4.
61.	Stan Walsh (SRSC)	05/11/2020	Section 2.5 Study Area	"The total reach length is approximately 31.5 miles." See second comment section 2.1 (See Comment #10)	See Comment Responses #4, #6, and #8.
62.	Stan Walsh (SRSC)	05/11/2020	Section 2.5 Study Area	"As discussed further in subsequent sections of this study plan, two separate but linkable hydraulic models will be developed: a model of the Gorge bypass reach; and a model of the reach from Gorge Powerhouse to the confluence with Sauk River (i.e., the reach of primary interest for fisheries production)." Fish habitat within the bypass reach should also be evaluated	See Comment Response #12.

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63.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.5 Study Area	"The focus of the hydraulic model between Gorge Powerhouse and the Sauk River confluence will be on the in-channel portion of the mainstem Skagit River corridor, and any side channels identified by the study team as having significant habitat value; however, the model will also include, in lesser detail, the overbank floodplain out to the valley side walls." This needs to be justified. Are floodplain habitat conditions being more fully addressed in a different study? We have commented on this repeatedly, so I will keep it brief here. Floodplain habitats are key for salmonids. The project impacts floodplain habitats. The study needs to address these impacts adequately.	The primary purpose of the hydraulic model will be to investigate and inform the evaluation of flow/habitat relationships in support of mainstem aquatic habitat protection and fish production. The model will simulate mainstem water surface profiles to evaluate potential for floodplain connectivity and will also simulate floodplain inundation but at a relatively coarse level. The model will however have the flexibility to allow future modification or refinement to analyze floodplain connectivity in more detail.
64.	Stan Walsh (SRSC)	05/11/2020	Section 2.5 Study Area	"The focus of the hydraulic model between Gorge Powerhouse and the Sauk River confluence will be on the in-channel portion of the mainstem Skagit River corridor, and any side channels identified by the study team as having significant habitat value; however, the model will also include, in lesser detail, the overbank floodplain out to the valley side walls. The focus of the bypass reach hydraulic model will be on the in-channel portion of the reach." While LiDAR can provide high quality topographic data, there are "some gaps or voids in the channel bathymetry data because of limitations imposed by water depth and/or channel bed conditions"(Section 2.3). While voids are proposed to be filled by ground-based surveys, the merging of these data sets may be problematic. Validation of the resulting bathymetric data set should be included as a	The process of merging bathymetric data from the Green LiDAR with that from ground-based surveys will include reconciling differences between the two data sources and expanding the area of ground-based surveys where necessary to minimize edge discontinuities. Discontinuities may arise for example because of changes in channel geometry since the 2018 LiDAR flight. While an important consideration, we do not expect this to be a major issue given the relative stability of the channel. The data sources and details of merging data from the various data sources to develop the model terrain will be documented in the study report.

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				study component. The accuracy of wetted channel areas defined by green LiDAR, and areas of data merging between green LiDAR and ground-based surveys should be systematically reported since those areas may describe important aquatic habitat.	
65.	Brock Applegate (WDFW)	05/11/2020	Section 2.5 Study Area	"The focus of the bypass reach hydraulic model will be on the in-channel portion of the reach." The instream flow model should demonstrate the effects of process flows that may envelop the floodplain for consideration during relicensing conditions.	See Comment Response #8. Evaluation of alternative flow scenarios such as process flows is a subsequent step to the study program.
66.	Judy Neibauer (USFWS)	05/13/2020	Section 2.5 Study Area	"The focus of the bypass reach hydraulic model will be on the in-channel portion of the reach." See my previous comment above…but will need to understand how the floodplain, wetlands, seeps, springs also function under different management scenarios. Please include, at the least, the channel migration zone. See our Critical Habitat rules, we will need to understand how SCL impacts elements of critical habitat. Either include data you already have, link to existing data, or add key questions and data collection into this model or a new study. Will need to pull in reservoir levels at periods you are looking at to be able to compare to what is going on upstream above the dams also at similar flows. Will need to understand how operational flow impact adjacent land, tributaries, managed/purchased lands, and transmission	See Comment Responses #6, #12, #32, and #38.

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				corridors…….there may be the need to pull these areas in or have some type of monitoring here to understand impacts to stream flows…. (See Comment #58)	
67.	Judy Neibauer (USFWS)	05/13/2020	Section 2.6 Methodology	"Two separate but linkable hydraulic models will be developed for the study area using the USACE HEC-RAS modeling platform (USACE 2016)." Expand scope and provide details here about how to link to other existing models you mentioned on the phone call. Describe you would incorporate these existing models to tell the story for hydrology and streamflow, and use that to help set instream flow for the whole basin. Describe here how you will pull in reservoir elevation and other information here to help set up instream flows to minimize impacts both above and below dams….	See Comment Responses #6, #12, and #25.
68.	Curtis Clement (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.1 Gorge Bypass Reach Model	"The methodology we adopt for development of the Gorge bypass reach model will be similar in concept to that described in Section 2.6.2 below on development of the hydraulic model from Gorge Powerhouse to the Sauk River confluence, but will differ in detail and will be informed by further development of modeling objectives for the reach." When will LPs be able to review these specifics? How will this DEM developed? Where will discharge, stage heights and water level profiles come from for calibration and validation? If not until sometime during the downstream model,	Section 2.6.1 has been removed from the study plan. See Comment Response #12.

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				will LPs be consulted as details are formulated? This reach needs fish in it, every reach is critical to salmon recovery, more so now than at any other time.	
69.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.1 Gorge Bypass Reach Model	"The methodology we adopt for development of the Gorge bypass reach model will be similar in concept to that described in Section 2.6.2 below on development of the hydraulic model from Gorge Powerhouse to the Sauk River confluence, but will differ in detail and will be informed by further development of modeling objectives for the reach." Curtis is correct, the time has come for SCL to better explain the separate treatment of these river sections.	Section 2.6.1 has been removed from the study plan. See Comment Response #12.
70.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.1 Hydraulic Model Selection and Overview of Model Development	"A model at this resolution is not necessary for reach-wide evaluation of hydraulic conditions to support flow management as proposed under this study plan." Model mesh size for this study needs discussion and needs to be sufficient to evaluate habitat conditions across a wide range of flows and include flood plain connection	This subsection is now 2.6.1.1. The model computational mesh size will be varied as needed to represent spatial variations in both hydraulic and habitat conditions and considering the primary in-channel focus of the model. The sensitivity of model results to mesh size will be tested with selection of mesh size a balance between achieving good numerical accuracy at the relevant scale while minimizing computational time. Mesh size selection will be discussed at a consultation workshop.
71.	Jon Riedel (NPS)	05/13/2020	Section 2.6.2.1 Hydraulic Model Selection and Overview of Model Development	"A model at this resolution is not necessary for reach-wide evaluation of hydraulic conditions to support flow management as proposed under this study plan." But wouldn't it be to assess influence of project at habitat scale?	This subsection is now 2.6.1.1. See Comment Response #70.

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72.	Rick Hartson (Upper Skagit Indian Tribe)	05/11/2020	Section 2.6.2.1 Hydraulic Model Selection and Overview of Model Development	"In developing this study plan, two hydraulic model options were considered as follows: (1) Extend the existing Barnaby Reach model upstream to the Gorge Powerhouse using RiverFlow2D. (2) Develop a new HEC-RAS model of the entire study reach, taking advantage of the bathymetric data and calibration data for the Barnaby Reach from the RiverFlow2D model. The following factors were considered in selecting a model platform: ▪ Ease of model development (recognizing the availability of the Barnaby Reach RiverFlow2D model); ▪ Model resolution required to meet study objectives; ▪ Speed of model execution; ▪ Ease of integration with other model platforms (for example, Project operation models); ▪ Availability of model support and model maintenance; ▪ Availability of visualization tools and software features for analysis, synthesis and display of model output; ▪ Ease with which metrics of interest for Project flow management can be generated from model output; ▪ Acceptance by the engineering community and both governmental and non-governmental institutions; and ▪ Size of user community (which relates to the pool of expertise available formodel updates and application)."	This subsection is now 2.6.1.1. A table providing a qualitative comparison of the HEC-RAS and RiverFlow2D platforms has been added.

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				This list is not helpful. Upper Skagit Indian Tribe is requesting a table that describes the relevant characteristics of each model for each of these factors in terms of SCL's determined relicensing needs.	
73.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.2.1 Hydraulic Model Selection and Overview of Model Development	"The following factors were considered in selecting a model platform: ▪ Model resolution required to meet study objectives;" This has not been adequately discussed. What is the resolution of the Barnaby model and how did SCL determine the relevant resolution for its purposes?	This subsection is now 2.6.1.1. See Comment Response #70. The Barnaby model which extends over a reach length of approximately 8 miles and covers about 7,750 acres uses a model mesh comprised of just under 800,000 triangular elements for an average element area of about 400 square feet with a finer mesh along the main channel and side channels and a coarser mesh elsewhere.
74.	Jon Riedel (NPS)	05/13/2020	Section 2.6.2.1 Hydraulic Model Selection and Overview of Model Development	"The following factors were considered in selecting a model platform:" I understand this model platform has a sediment routing function. But is it appropriate for Skagit conditions?	This subsection is now 2.6.1.1. The current 2-D HEC-RAS code proposed for use in this study does not support sediment transport modeling. Sediment transport modeling is available in the 1-D implementation of HEC-RAS and the USACE plans to release a version of the 2-D code with sediment transport modeling in the future. We have not evaluated the suitability of the 1-D HEC-RAS code for sediment transport modeling for Skagit River conditions. We note that suitability of a particular model would depend on multiple factors including scale of modeling, issues to be addressed, etc. We are not proposing to model sediment transport at this time.
75.	Brock Applegate (WDFW)	05/11/2020	Section 2.6.2.1 Hydraulic Model Selection and Overview of	8th Bullet – Comment	This subsection is now 2.6.1.1. City Light intends to continue consultation on its draft study plans with LPs which includes Ecology.

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			Model Development	"Acceptance by the engineering community and both governmental and non-governmental institutions; and" Did SCL consult with the Department of Ecology on these models? From the RWG meetings, the hydrologist from the Department of Ecology did not seem aware of your model selections. WDFW recommends that you consult with the Department of Ecology. I would highlight this bulleted item until SCL does.	
76.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.1 Hydraulic Model Selection and Overview of Model Development	"A two-dimensional HEC-RAS (Version 5) model of the full study reach was determined, after considering the above selection factors, to provide the best tool to meet study objectives, and the best modeling platform for adoption over the term of the next license." Two -dimensional HEC-RAS is often used to describe reach-level hydraulic conditions. Use of the HEC-RAS model to describe depth and velocities at a scale relevant to HSC should be confirmed before proceeding. Once this occurs, HEC-RAS 2D may be a valuable tool for assessing the relationships between flow and fish habitat. However, it may not be the most efficient tool for assessing the effects of downramping from flow releases at the Gorge Powerhouse. Downramping pulses from Gorge Powerhouse will travel downstream and attenuate as they combine with flows from downstream tributaries. Rather, an unsteady flow model with a time step of 1-hour is recommended to assess	This subsection is now 2.6.1.1. The 2-D HEC-RAS model proposed is an unsteady flow model which will be run at a sub-hour time step. The model will be capable of adequately representing the river's response to downramping. While a 1-D model would certainly be more efficient in terms of computational effort if we were only looking at downramping issues, a single 2-D model (as opposed to parallel 1-D and 2-D models) is believed to be a more efficient approach for the study as a whole. Discharge, depth and velocity monitoring and model calibration will be performed under flow conditions relevant to HSCs. The current license includes requirements for periodic validation of fry stranding mitigation measures. Monitoring data indicates that the fry stranding rate has declined since the rate was first assessed in the '80s. The current flow program/ESH model incorporates stranding and

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				the effects of downramping. Instead of using HEC-RAS 2D, it may be more efficient to develop a parallel HEC-RAS 1D model for routing unsteady flows through the study reach, especially if flows are modeled with a 1-hour time step for multiple years of operation. Downramping may result in stranding and trapping of fry and this study should also assess the potential for this to occur under current and proposed future operations. The areas encompassed by the upper and lower extent of the ramping cycle are termed the varial zone and represent areas most susceptible to stranding and trapping. These areas are found along the channel margins which are frequently used by fry and juvenile fish. The areas are also generally devoid of invertebrate production thereby potentially affecting food availability for younger fish. Areas most likely to be influenced by this should be identified as part of the initial workshop and study methods subsequently defined.	trapping rules. Per Comment Response #31, these biological inputs will be incorporated into the new model to support additional discussions on refining biological inputs and to ensure the new model can support an integrated environmental analysis to address the issue of stranding and trapping under current conditions. The information is intended to further inform potential actions to continue addressing stranding and trapping in the reach between the Gorge Powerhouse and Sauk River under a new license.
77.	Judy Neibauer (USFWS)	05/13/2020	Section 2.6.2.2 Model Topographic Data	"A three-dimensional terrain model of the reach spanning from Gorge Powerhouse to approximately 1.5 miles downstream of the Sauk River confluence (~29 RMs) will be developed from a combination of topobathymetric LiDAR, standard LiDAR, boat-based bathymetric (sonar) surveys, and terrain data from the existing hydraulic model of the Barnaby Reach of the Skagit River." Discuss how you might link to landform, geomorphology, and operational flows to help develop the information that may help	This subsection is now 2.6.1.2. See Comment Responses #6 and #25.

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				determine key refugia, wetlands, springs, seeps, and hyporheic areas so that instream flow will maintain these features too.	
78.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.2.2 Model Topographic Data	"The 2016 LiDAR (Quantum Spatial 2017b) will supplement any floodplain data not acquired in the more limited topobathymetric datasets. A very coarse preliminary hydraulic model of the reach of interest, constructed to test the sensitivity of HEC-RAS model simulation times to cell size, indicates there may be several such floodplain areas (Figure 2.6-1), depending upon the flows simulated. As noted in Section 2.5 of this study plan, while the focus of this study will be on the in-channel portion of the mainstem Skagit River, the model will also include, in lesser detail, the overbank floodplain out to the valley side walls." As commented earlier, the floodplain needs to be assessed in greater detail. These preliminary results indicate the importance of understanding habitat conditions outside of the channels, even in relatively narrow reaches that may be considered to have minimal floodplain habitat.	This subsection is now 2.6.1.2. See Comment Response #63.
79.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.3 Model Geometry Development	"The mesh consists of cells, or elements, whose size, shape and orientation are refined as needed to simulate hydraulic conditions. The model cell size will be determined considering simulation run time (fewer cells equates to faster run times), resolution in areas of interest for habitat evaluation (more cells equates to finer resolution and slower run times) and calibration to observed discharges." Mesh size is a critical component of aquatic habitat evaluation. Larger cells (i.e., coarser	This subsection is now 2.6.1.3. See Comment Response #70.

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				mesh) can be used in overbank areas to reduce run time, but smaller cells (i.e., finer mesh) should be concentrated along shorelines, in-water woody debris, side channels and sloughs. Cell size should be fine enough in areas of important salmonid habitats to depict the velocity gradient, cover distribution, and depth variations described in the HSC. In one-dimensional PHABSIM studies, it is common practice to require a minimum of 20 cells for each transect. This "rule of thumb" originated from the USGS requirement of 20 cells for an accurate flow measurement from wading. This can be used to calculate the cell size needed for habitat modeling. More cells will be needed per river mile at the upstream end of the study reach where the river is narrower. Similarly, fewer cells will be needed per river mile at the downstream end of the study reach where the river is wider.	
80.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.2.3 Model Geometry Development	"A relatively coarse mesh will be used to represent floodplain areas." This makes sense, assuming there is close coordination with LPs and an iterative approach to allow identification of key floodplain areas where mesh resolution should be made finer.	This subsection is now 2.6.1.3. See Comment Response #63. The primary focus of the study will be the mainstem river. The model will have the flexibility to allow users to refine the mesh for other areas of interest as the need arises in future potential applications.
81.	Jon Riedel (NPS)	05/132020	Section 2.6.2.3 Model Geometry Development	"A relatively coarse mesh will be used to represent floodplain areas." Even if the floodplain has a lot of side channels?	This subsection is now 2.6.1.3. See Comment Responses #63 and #80.

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82.	Jon Riedel (NPS)	05/132020	Section 2.6.2.3 Model Geometry Development	""Breaklines" will be added to the model mesh to ensure geometric features that affect river hydraulics (for example, raised roads) are adequately represented. Skagit River bridge crossings at Marblemount and Rockport will be included in the model." This would be another good place to link with landforms and geomorphic reaches. See comment above.	This subsection is now 2.6.1.3. See Comment Response #18.
83.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.2.3 Model Geometry Development	"Hydraulic roughness zones will be delineated representing land use and land surface classes found in the reach such as active riverbed, typically exposed channel bars, forested floodplain, and pasture. The results of the landform mapping study being conducted by the NPS will be reviewed in delineating roughness zones. Initial roughness coefficients will be assigned based on professional judgement and then refined during model calibration." Need to address this for below the Sauk, in particular need to consider assumed or potential changes in land use over the course of the license. Alternatively, develop a model that can be used throughout the license term in an adaptive management framework.	This subsection is now 2.6.1.3. See Comment Responses #4 and #41.
84.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.4 Model Boundary Conditions	"Ungaged tributary inflows between the mainstem Newhalem and Marblemount gages, and between the Marblemount gage and the confluence with the Sauk River, will be estimated from the gaged tributary flows using data from both the active gages and historic discontinued gauges. Ungaged tributaries include, for example, Goodell Creek, Diobsud Creek, and Illabot Creek."	This subsection is now 2.6.1.4. Agreed.

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				For unsteady flow modelling of downramping events, tributary inflows should be estimated on an hourly basis. There should be a smooth transition from one day to the next to avoid the creation of artificial downramping from the tributary inflow.	
85.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.2.4 Model Boundary Conditions	"Ungaged tributary inflows between the mainstem Newhalem and Marblemount gages, and between the Marblemount gage and the confluence with the Sauk River, will be estimated from the gaged tributary flows using data from both the active gages and historic discontinued gauges." Has SCL compiled a list of known sources? This should be included in the study plan.	This subsection is now 2.6.1.4. A list of active and historic discontinued gauges will be compiled at the start of the study along with pertinent information such as period of record, parameters recorded, and drainage area.
86.	Curtis Clement (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.2.4 Model Boundary Conditions	"Ungaged tributaries include, for example, Goodell Creek, Diobsud Creek, and Illabot Creek." Upper Skagit Indian Tribe has stage data for Goodell and Diobsud but not enough discharge measurements to make a rating curve. We have previously offered to share these data, and the offer stands to support this effort.	This subsection is now 2.6.1.4. Thank you for this information.
87.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.2.4 Model Boundary Conditions	"Ungaged tributaries include, for example, Goodell Creek, Diobsud Creek, and Illabot Creek." Several years of gage data exist for Illabot that should be incorporated. I believe SRSC is the data steward.	This subsection is now 2.6.1.4. Thank you for this information.
88.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.4 Model Boundary Conditions	"City Light staff have observed that the study reach between the USGS Newhalem and Marblemount gages is apparently affected by	This subsection is now 2.6.1.4. The approach to be considered for simulating

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				channel losses under some conditions. Channel losses were specifically noted following the extreme low flows of summer 2015. Hydrologic and groundwater data will be reviewed to develop a better understanding of the causes and significance of channel losses. If necessary, consideration will be given to accounting for such losses in the hydraulic model by modifying the tributary inflows." While flow gains and losses can be incorporated in to the hydraulic model by modifying tributary inflows, how will the influence of channel gains and losses both in-channel and floodplain groundwater accretion be incorporated in the salmon and steelhead spawning and juvenile rearing habitat modeling components?	losses to groundwater in the mainstem Skagit is by decreasing tributary inflows. We recognize that this does not represent reality; it is simply a means to account for mainstem losses given limited options for simulating such losses in HEC-RAS (and most other riverine hydraulic modeling codes) and ensuring reliable simulation of mainstem low flows. Habitat modeling for this study will rely on traditional habitat suitability curves tied to velocity, depth and substrate. The velocity and depth, as determined by the hydraulic model, are a function of total discharge only and do not consider the source of flow (whether surface or groundwater).
89.	Jon Riedel (NPS)	05/13/2020	Section 2.6.2.4 Model Boundary Conditions	"Channel losses were specifically noted following the extreme low flows of summer 2015." Landform map will help with this. There is a very coarse fill in the valley below Bacon Creek, and particularly from Diobsud Creek to Marblemount.	This subsection is now 2.6.1.4. Thank you for this information.
90.	Curtis Clement (Upper Skagit Indian Tribe)	05/07/2020	Section 2.6.2.4 Model Boundary Conditions	"If necessary, consideration will be given to accounting for such losses in the hydraulic model by modifying the tributary inflows." Are you suggesting that the tributaries will also be losing and will need to be adjusted, or, that you will simulate losses in the Skagit by decreasing flows in the tributaries? If the latter is required, it may suggest other parameters are not properly accounted for and should be revisited rather than forcing the results. For example, hydraulic conductivity of substrate	This subsection is now 2.6.1.4. See Comment Response #88.

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				and floodplain, water withdrawals from ET and domestic use or the modeled area is insufficient causing boundary effects. I don't know all the parameters that are required for HEC-RAS, those are just to illustrate my point.	
91.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.2.5 Field Monitoring	"The goal of the monitoring program will be to acquire calibration data at two or three discharges covering the range of discharge conditions of primary interest to fisheries management (assumed to range from about 2,000 cfs to 6,000 cfs at Newhalem), plus one high flow discharge." This study plan almost completely overlooks an extremely important aspect of this model development. There needs to be considerable thought put into the flows that will be used for model runs. Modeled flows should consider pre-project hydrology, current license hydrology, and potential mitigation flows. High flow events need to be considered, for instance those that temporarily connect off-channel habitats during the spring Chinook outmigration. This speaks to the need to better incorporate floodplain habitat impacts into this study, and coordinate the selection of flows with model development.	This subsection is now 2.6.1.5. See Comment Responses #6 and #41. FERC's baseline is the existing condition. Modeling potential mitigation flows is a subsequent step to this model development study. The purpose of this study is to develop a new model to support continued protection of fish/aquatic habitat to support healthy fish populations. The proposed range of flows targeted for hydraulic model calibration was determined from a review of current license hydrology. Actual calibration flows will depend on conditions experienced during the monitoring period and may cover a wider range than that currently assumed. High flow events are proposed to be captured opportunistically. Again, the size of high flow events used in model calibration will depend on the conditions experienced in the monitoring period. To the extent possible, flows targeted for use in model calibration will be such as to allow the model to be applied with confidence to potential mitigation flows and other flow scenarios subsequent to model development.
92.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.5 Field Monitoring	"The goal of the monitoring program will be to acquire calibration data at two or three	This subsection is now 2.6.1.5.

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				discharges covering the range of discharge conditions of primary interest to fisheries management (assumed to range from about 2,000 cfs to 6,000 cfs at Newhalem), plus one high flow discharge. Given that high flow events are unpredictable, monitoring of a high flow event will be on an opportunistic basis." Model calibration at a high flow condition will be valuable for analyzing gravel transportation. The Skagit River at Newhalem currently does not receive gravel as a result of gravel storage in the three upstream reservoirs. From 1930 to 1936 (before the construction of Ross Dam), Diablo Reservoir accumulated a total of 358 acre-feet of sediment deposits over this 6-year period (U.S. Soil Conservation Service 1950). The proposed hydraulic model should be used to assess the risk of scour from existing gravel patches and scour from areas where additional gravel may be added.	See Comment Response #35.
93.	Jon Riedel (NPS)	05/13/2020	Section 2.6.2.5 Field Monitoring	"The goal of the monitoring program will be to acquire calibration data at two or three discharges covering the range of discharge conditions of primary interest to fisheries management (assumed to range from about 2,000 cfs to 6,000 cfs at Newhalem), plus one high flow discharge." This ties in with my comment on scale and integration with sediment transport. I would hope that 'geomorpphically significant' flows could also be modeled, such as the spring event with a long duration and a fall peak flow event (100 year) that would examine impact of water storage in Ross Lake.	This subsection is now 2.6.1.5. See Response Comment #8.

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94.	Judy Neibauer (USFWS)	05/13/2020	Section 2.6.2.5 Field Monitoring	"Given that high flow events are unpredictable, monitoring of a high flow event will be on an opportunistic basis." Please link the dates and times when monitoring takes place to reservoir elevations to determine how reservoirs change with instream flows. We will need to consider effects in both areas when finalizing any instream flow requirements. Could you have water level recorders in the reservoir?	This subsection is now 2.6.1.5. See Comment Responses #6 and #25.
95.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.5 Field Monitoring	"Up to six automatic water level recorders will be installed at key locations throughout the study reach to supplement stage data available from the three mainstem Skagit River USGS gages at Newhalem, Marblemount, and Rockport and a mainstem stage gage approximately one mile upstream from the Sauk River confluence operated by the SRSC." Locations of the six new water level recorders should be selected in collaboration with the stakeholders. Vertical survey control should be established at all 10 sites using RTK-GPS to ensure that the water surfaces are measured with a datum consistent with the vertical datum used for the hydraulic model (NAVD 88).	This subsection is now 2.6.1.5. Locations for the automatic level recorders have been selected considering hydraulic model requirements, locations of existing mainstem gauges, locations of tributary inflows, local hydraulic conditions, and access. The gauges are being installed and maintained by the USGS under agreement with City Light. Installation is expected to be complete by mid-June. The installation of these gages was identified by City Light as an early action item to ensure that gauges were in place to capture any high flow events in the late spring/early summer 2020 snowmelt freshet necessary to support hydraulic model development and calibration starting in spring 2021. The study plan has been revised to reflect the current status and gauge locations.
96.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.5 Field Monitoring	"The river will be driven with the boat continuously recording water surface elevation while the Project discharges at Gorge Powerhouse are more or less constant. A smoothing filter will be applied to the raw water surface elevation data to produce water surface	This subsection is now 2.6.1.5. The model geometry will reflect split channels, perched side channels etc. However, it is correct that model calibration will be to longitudinal water surface profiles along the main or dominant channel and will in general not

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				profiles suitable for use in model calibration (see Section 2.6.1.6)." It appears that the intent of the boat measurements and smoothing filter are to develop a longitudinal water surface profile. However, water surface elevations vary horizontally across the Skagit River channel. Split channels, multiple channels, perched side channels, and even the inside and outside of a bend can cause significant variations in water surface elevations at a given flow. Those horizontal variations also change in response to changes in mainstem flow. How will those horizontal variations be addressed in the hydraulic and habitat models? Smoothing the horizontal component of water surface elevations can drastically alter the predicted magnitude and frequency of dewatering and inundation of critical shallow water habitats. As described in Section 2.6.2.6, "Model calibration will be accomplished by adjusting model coefficients and model mesh to match water levels both spatially and temporally at the water level monitoring stations and the continuous water surface profiles." This process will address longitudinal water surface profiles but ignore important horizontal variations in water surface elevations.	account for cross-channel variations in water surface elevations. The proposed monitoring program will be expanded to provide more detailed monitoring of selected areas to improve hydraulic/habitat model linkages. Cross-channel variations in water surface elevations in these areas will be monitored and considered in model calibration. See Comment Response #97.
97.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.5 Field Monitoring	"Skagit River discharges will be measured concurrent with the water surface profile surveys at up to four locations along the study reach." Skagit River discharges should be measured at the six locations where water level recorders are	This subsection is now 2.6.1.5. The proposed monitoring program will be expanded to provide more detailed monitoring of selected areas or reference reaches to improve hydraulic/habitat model linkages. Monitoring will include depth, velocity and discharge. The

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				installed when flow releases from Gorge Powerhouse are 2,000, 4,000 and 6,000 cfs.	exact number and location of these reference reaches remain to be determined but are expected to be in reasonable proximity to the automatic water level recorders currently planned for installation. See Comment Response #95.
98.	Curtis Clement (Upper Skagit Indian Tribe)	05/07/2020	Section 2.6.2.5 Field Monitoring	"The need for measuring discharges at the locations of the USGS Newhalem and Marblemount gages will be determined following review of the current stage-discharge ratings developed by the USGS at those locations." Please specify the criteria used to make this decision. Doing so will reveal potential biases in discharge of the other measurements, why would this check be omitted?	This subsection is now 2.6.1.5. The USGS actively maintains the stage-discharge ratings at the Newhalem and Marblemount gage sites. If those ratings are well defined and stable, with little shift over time and with direct discharge measurements close to the rating, then discharges at those sites will be determined from the observed stage and the current stage-discharge rating. This will allow resources to be directed to other monitoring sites.
99.	Curtis Clement (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.2.6 Model Calibration and Validation	"2.6.2.6 Model Calibration and Validation" What are criteria being used to consider the model validated? Some percentage to the measured flows, smallest possible R^2 achieved for all years of modeled runs, most similar R^2 between the calibration runs and validation runs, other? What is the goal for this?	This subsection is now 2.6.1.6. Various metrics will be used to assess model performance. These will include various statistics of absolute error in simulated water surface profiles (maximum, mean and variance), fit to USGS stage-discharge ratings at the Newhalem and Marblemount gages, absolute and relative error between simulated and observed velocities, and others. Quantitative goals for these metrics have not been set; they will be discussed at a consultation workshop.
100.	Jon Riedel (NPS)	05/13/2020	Section 2.6.2.6 Model Calibration and Validation	"2.6.2.6 Model Calibration and Validation" Will model be calibrated at USGS gages?	This subsection is now 2.6.1.6. Yes, the model will be calibrated to data at the USGS gage sites in addition to other locations.

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101.	Brock Applegate (WDFW)	05/05/2020	Section 2.6.2.7 Development of Biological and Aquatic Habitat Information	"Habitat Suitability Criteria (HSC) define the range of microhabitat variables that are suitable for a species and life stage of interest." SCL will need to know which species uses which habitat in the bypass reach, hence WDFW's request for a fish barrier survey.	This subsection is now 2.6.1.7. See Comment Response #12.
102.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.7 Development of Biological and Aquatic Habitat Information	"Habitat Suitability Criteria (HSC) define the range of microhabitat variables that are suitable for a species and life stage of interest. HSC provide the biological criteria input to a habitat model which combines the physical habitat data and the HSC into habitat suitability calculations over a range of simulation flows. Variables typically defined with HSC may include depth, velocity, and instream cover or substrate. HSC values range from 0.0 to 1.0, indicating habitat conditions that are unsuitable to optimal, respectively. Usable area, also referred to as weighted usable area (WUA) or area weighted suitability (AWS), is defined as the sum of stream surface area within a nodal area model domain or stream reach, weighted by multiplying the area by the index for each habitat suitability parameter." The HEC-RAS 2D model can be used to calculate depth and velocity. However, there is no discussion on how instream cover or substrate will be mapped. The HEC-RAS 2D does not have a module for calculation of weighted usable area. Will a separate model be constructed to perform these calculations?	This subsection is now 2.6.1.7. Substrate mapping will be developed in coordination with the geomorphology study. Substrate data for areas where detailed monitoring is conducted (See Comment Response #97) will be collected in conjunction with that monitoring under the instream flow model study. Cover data will be developed in coordination with the geomorphology study and vegetation mapping study, generally consistent with Ecology guidance on cover types. HEC-RAS model results will be output as depth and velocity grids. These together with substrate and cover grids and habitat suitability curves will be analyzed using GIS scripts to compute weighted usable area. Since the purpose of this study is develop a tool to support flow management to protect habitat, habitat modeling will rely on the traditional determinants of depth, velocity, cover and substrate. While we acknowledge that other factors, including those listed in the comment, may affect habitat quality, it is not clear how they would be used to inform development of and are beyond the scope of the flow management tool.

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				Although depth, mean velocity, and substrate composition have traditionally been considered determinants in habitat selection, different species and life stages of fish may cue on different variables including availability of escape cover, water quality (temperature, dissolved oxygen, pH, turbidity), presence of groundwater upwelling/downwelling, etc. Numerous other habitat components could influence distribution and site selection including competition, predation, feeding behavior, seasonal and diurnal movement, etc. Will this study consider these other elements? If no - why not? If so - how will these be addressed? See additional comment on groundwater below.	
103.	Judy Neibauer (USFWS)	05/13/2020	Section 2.6.2.7 Development of Biological and Aquatic Habitat Information	"The approach to managing flows for spawning, incubation, and rearing was initially developed by conducting an Instream Flow Incremental Method (IFIM) analysis using Physical Habitat Simulation (PHABSIM) which modeled nine species and 26 life stages of sport fishes in the Skagit River." Will need to think about critical habitat primary constituent elements…. Need to include bull trout and other anadromous species…i.e., lamprey, cutthroat, whitefish, sculpins…other species considered as preybase too….sc	This subsection is now 2.6.1.7. See Comment Responses #31 and #36.
104.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.7 Development of Biological and Aquatic Habitat Information	"To optimize the model for instream flow planning, LPs agreed to focus on spawning and incubation criteria for Chinook, Pink, and Chum salmon, and steelhead (Crumley and Stober 1984 Vol. I)."	This subsection is now 2.6.1.7. Thank you for the comment. We will include this suggestion and other considerations that are developed during the LP workshops.

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				However, the 2020 PAD (page 4-133) states that Coho Salmon are native to the Skagit River and may spawn in side-channel and slough areas along the mainstem channel. These off-channel areas are particularly susceptible to impacts from flow management and should be considered in this study.	
105.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.2.7 Development of Biological and Aquatic Habitat Information	"Inputs to the model for these four species were developed using Skagit River specific data which indicated that these species use deeper water, higher velocities, and larger substrate than is reported in the literature." Additional criteria should be integrated: 1) Habitat units/types (e.g. pool, riffle, bank, bar, backwater, side-channel, off-channel). 2) Instream cover (e.g. large woody debris, vegetated bars) 3) Substrate composition (e.g. spawning suitability, cover for juveniles) Field studies should document these metrics, if not already collected in other studies.	This subsection is now 2.6.1.7. See Comment Response #19. Our response to comment #19 covers most of these items except the habitat units. We will not be delineating habitat units, since delineating these features is subject to professional judgment and are often difficult to quantify using models. However, the proposed approach, which is an update of the current ESH model, does include a suite of HSCs which include depth, velocity, and substrate. By taking this approach, we can infer habitat types and, through post processing in GIS, create spatial analytical tools which will allow professionals in the basin to delineate habitat types. The proposed approach in this study plan aligns with WDFW and Ecology guidance. Any additional work to map or quantify aquatic habitat can be discussed during the LP workshops and during model optimization.
106.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.7 Development of Biological and Aquatic Habitat Information	"The resulting model is referred to as the ESH model. Inputs to the model for these four species were developed using Skagit River specific data which indicated that these species use deeper water, higher velocities, and larger substrate than is reported in the literature."	This subsection is now 2.6.1.7. The intent of this study is to develop a new model using as many inputs from the existing ESH model as possible. Our overall goal is to develop a model that is transparent, integrates with operations, and is updateable. The old

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				The Effective Spawning Habitat (ESH) model does not appear to be well documented, other than what is provided in the FSA. Moreover, the model should be made available in a format useable by others so that its' assumptions and algorithms can be tested/verified first, before it is refined with new information and applied in evaluating proposed future operations..	model is none of those things. We can only update the outputs which is why we are taking the proposed approach. Also See Comment Responses #31, #36, and #104.
107.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.2.7 Development of Biological and Aquatic Habitat Information	"The study proposes to utilize the existing site-specific habitat information that supports implementation of the current ESH model." See previous comments regarding the need to incorporate Skagit Chinook Recovery Plan emphasis on juvenile rearing habitat and the importance of fluvial process and habitat forming flows.	This subsection is now 2.6.1.7. Comment acknowledged. See Comment Responses #31 and #106. Development of habitat information will start with the use existing HSC/HSI information from the current ESH model. These data may be updated and/or refined based upon more recent available information as appropriate and will be discussed during model workshops. This would include consideration of the Skagit Chinook Recovery Plan.
108.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.7 Development of Biological and Aquatic Habitat Information	"The study proposes to utilize the existing site-specific habitat information that supports implementation of the current ESH model." The proposed study plan proposes to utilize probability-of-use criteria developed as part of the 1975-1984 Skagit River instream flow studies (Crumley and Stober 1984). These criteria were developed using a combination of site-specific data collected through fish sampling, literature sources, and through refinement based on the professional judgment of project biologists. Although the methods used in developing the habitat utilization model (probability of use criteria) appear robust, habitat models that have been adjusted for site-	This subsection is now 2.6.1.7. Comment acknowledged. See Comment Responses #31 and #106. We will be incorporating all the relevant input data that is available from the existing model and as suggested by Ecology and LPs during consultations and workshops. If data gaps exist, we can reduce uncertainty through a well-designed adaptive management program.

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				specific habitat availability (e.g., preference curves) are generally considered to more accurately reflect habitat preference (Bovee 1986).	
109.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.7 Development of Biological and Aquatic Habitat Information	"As such, ESH model documentation will be reviewed and existing species, life stage, periodicity information and associated HSC will be compiled to support flow-fish habitat analyses. Existing information will be reviewed for completeness and accuracy." The HSC variables of depth, velocity, instream cover, and substrate define expected fish response to gradations in hydraulic variables. The size of mesh, merging of LiDAR and ground-based measurements, hydraulic model predictions of horizontal (i.e., cross-channel) variations in velocity and water surface elevations do not appear to be accurate enough to depict changes in habitat using HSC. Validation of hydraulic predictions must be conducted in important spawning and rearing habitats. Accurate predictions must be demonstrated early in the process and measures to address any inadequacies identified in the next draft of the study plan. Developing habitat use models based on professional opinion relies on those most knowledgeable to define species habitat needs; however personal, geographical, and knowledge-based biases may influence the accuracy of this approach (Galbraith et al. 2016). In addition to depth, velocity, substrate, and	This subsection is now 2.6.1.7. See Comment Responses #70, #88, #96. #97, and #102. The hydraulic model will be validated against hydraulic data (depth, velocity and discharge) for selected spawning and rearing habitats. Hydraulic model development, calibration and validation will take place as part of the study itself and not as part of study plan process. We agree that surface-groundwater exchange can be important in off-channel areas. Since the purpose of this study is development of a flow management tool to support mainstem fish habitat, surface-groundwater exchange processes will not be evaluated here but would be considered in the evaluation of potential future off-channel mitigation measures.

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				cover, factors such as groundwater inflow – temperature gradients and other water quality parameters, and food availability should be evaluated as potential determinants of habitat suitability. In many river systems, the exchange of groundwater and surface water is part of the natural process in off-channel areas (side channels and sloughs). The surface-groundwater exchange (i.e., upwelling and downwelling) alters thermal and chemical regimes creating unique habitat areas that are often utilized by both spawning and rearing salmonids. For this, consideration should be given to completing a thermal imaging (Forward Looking Infrared -= FLIR) survey of the entire project reach to identify groundwater inputs and areas of thermal refugia.	
110.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.7 Development of Biological and Aquatic Habitat Information	"Data gaps and/or data issues (e.g., inaccurate, outdated, etc.), if any, will be identified. Data gaps or data issues will be addressed using available regional information compiled from literature sources and agency documents (e.g., NMFS Recovery Plan, etc.) appropriate to the study reach." This may be OK for most species and life stages but some life stages (e.g. juvenile rearing) may require additional field data collection to more fully understand temporal and spatial habitat use. For example, recent survey information suggests steelhead juvenile numbers are trending lower than in the past and there is no obvious reason for this. Also – whitefish numbers also seem to be in decline, again with	This subsection is now 2.6.1.7. See Comment Response #97. Part of the instream flow determination process is a step of optimizing flows to meet biological needs based on hydrological conditions. Therefore, it is inherently a process where decisions by natural resources managers are necessary to finalize the seasonal flow ranges. Some of this can be developed during the LP workshops and also in discussions with resources managers. In the current model, there are provisions for Stream-Type juvenile rearing, fry emergence, and fry outmigration. We anticipate that we will refine these flow

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				no apparent reason. Although studies have demonstrated a positive effect of the flow operations on returns of adult Chinook, Pink and Chum salmon (Connor and Pflug 2004), such increases were largely attributed to reductions in redd dewatering and provision of a more stable incubation environment. The rearing life stage in instream flow studies is often assumed to be provided for as long as habitats for spawning and incubation are provided. This was the case for the current operations of the Skagit Project with the provision of flows focused on protection of salmon and steelhead spawning and incubation habitats. Fry habitats for salmon and steelhead were assumed protected via downramping restrictions, as were those for salmon and steelhead yearlings. Flow operations specifically directed toward provision and protection of juvenile/yearling rearing habitats were largely absent from the FSA and should be evaluated as part of this study. Consideration should be given to establishing 3-4 (or more) Focus Areas located in areas either known to or likely to provide substantial rearing habitats in the river. These will likely include sloughs, side channels and backwater areas with slow moving waters. These areas would be the focus of more detailed study specifically for evaluating flow-rearing habitat relationships that can be used in assessing project effects.	standards during the optimization process. Part of the model development will include identifying reference reaches, or focus areas, for mainstem habitat use. This will include adjacent side channels. We will be selecting these reaches in coordination with natural resources managers familiar with the Skagit River.
111.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.7 Development of Biological and	"HSC curves will be developed for each species and life stage of interest."	This subsection is now 2.6.1.7. See Comment Response #31.

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			Aquatic Habitat Information	This should be addressed and discussed during the initial workshop.	City Light agrees. Model inputs will be part of the LP workshops.
112.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.2.7 Development of Biological and Aquatic Habitat Information	"HSC curves and periodicity information in combination with a calibrated and validated hydraulic model will allow for detailed analyses of the amount, time, and location that suitable habitat will be available under a range of discharges for species and life stages of interest. This could, for example, include development of stage-discharge ratings at locations of interest, analysis of discharge wetted-area relationships, integration of model depth and velocity results with habitat data in an IFIM type of analysis to produce habitat-discharge relationships for species and life stages of interest. Model results can be output directly from HEC-RAS and analyzed or synthesized further in Geographic Information System (GIS). Animation of model results with HEC-RAS RAS Mapper will be used to help visually understand spatial and temporal variations in hydraulic and habitat conditions." Recent climate change has resulted in warmer water temperatures, changing precipitation patterns, and altering stream flows (timing, magnitude, and duration of hydrological event). It is assumed that the periodicity of habitat use (spawning, incubation, migration, etc.) by individual species and life stage in the Skagit River has adapted in response to these changes. Applying result of the habitat modeling to particular time periods will need to be adjusted and account for changes in the timing of habitat use	This subsection is now 2.6.1.7. See Comment Response #31. We are proposing to start with HSC information in the existing ESH model and update with appropriate regional information, as necessary. This will be presented and discussed in the workshops.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
113.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.3 Consultation and Report Preparation	1st Bullet – Comment "An initial workshop to discuss the overall program for hydraulic model development, including stage and discharge monitoring for model calibration, the linkages between hydraulic conditions and relevant biological and habitat metrics, and the hydraulic model outputs required to inform fisheries management decisions;" The initial workshop should focus more than on just the hydraulic model development but also the proposed approach for defining biological data.	This subsection is now 2.6.2. See Comment Responses #31, #111 and #112. Edits have been made to elaborate upon workshop topics.
114.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.3 Consultation and Report Preparation	1st Bullet – Comment "An initial workshop to discuss the overall program for hydraulic model development, including stage and discharge monitoring for model calibration, the linkages between hydraulic conditions and relevant biological and habitat metrics, and the hydraulic model outputs required to inform fisheries management decisions;" This should include an unsteady flow model	This subsection is now 2.6.2. The proposed 2-D HEC-RAS model is an unsteady flow model.
115.	Stan Walsh (SRSC)	05/11/2020	Section 2.6.3 Consultation and Report Preparation	2nd Bullet – Comment A mid-point workshop to present information on hydraulic model construction, including discussion of biological/aquatic habitat information development, terrain data, model geometry, and model boundary conditions; This seem like too much to cover in one	This subsection is now 2.6.2. An additional workshop to discuss biological data will be included in the study plan.

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				workshop. Suggest a separate workshop to go over the biological data to be collected and the EFH model. This should be preceded by release of a user friendly version of the EFH model, and model documentation	
116.	Stan Walsh (SRSC)	05/11/2020	Section 2.7 Consistency with Generally Accepted Scientific Practice	"HEC-RAS is widely recognized and accepted throughout the engineering and scientific community for riverine hydraulic modeling." Revise this section consistent with revisions above	It is not clear what revision is being requested here.
117.	Judy Neibauer (USFWS)	05/13/2020	Section 2.8 Schedule	"The schedule proposed for the Gorge Dam to Sauk River Geomorphology study plan, for example, assumes the availability of a hydraulic model by fall 2021." You may need an additional year if flows don't happen I suggest thinking about a longer study period of 2 years or more.	Thank you for your comment. The ILP provides the opportunity for comment on the final report submitted in the ISR and discussed at the ISR meeting; if any components of the study goals and objectives are not met in the first year, or there are anomalous conditions, any party may propose additional work or request additional study per FERC ILP regulations.
118.	Stan Walsh (SRSC)	05/11/2020	Section 2.8 Schedule	"The proposed study schedule for hydraulic model development is as follows:" Data acquisition and review and ESH refinement should be in the schedule	Additional detail has been added to the study schedule.
119.	Brock Applegate (WDFW)	05/11/2020	Section 2.8 Schedule	▪ Final Initial hydraulic model development report – March 2022 ▪ Study Meeting for the Final Initial Study Report-- 2022	Thank you for your comment. The schedule reflects the timeline for this study only, not the larger ILP process.
120.	Steve Copps (NMFS)	05/11/2020	Section 1.3 Study Plan Development	This section provides an excellent description of relevant project effects and how the proposed study would inform the relicensing process relative to those effects. It may serve as a model for authors of other study plans to describe the basic rationale for a specific plan.	Thank you for the comment.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
121.	Steve Copps (NMFS)	05/11/2020	Section 1.3 Study Plan Development	The section indicates that the proposed study plan will contribute to a variety of issues identified for study in the PAD. Those linkages should be made explicit both within this study plan and in a broader analysis of linkages between all study plans. For example, there are clear linkages to the geomorphology draft study plan that should be drawn out with enough detail to foster a clear understanding of the relationship between the two plans.	City Light has added language to Section 1.3 to address potential linkages between studies being implemented during relicensing. Also, the linkages between instream flow modeling and geomorphology are made in a number of locations in Section 2 of this study plan. Also, please See Comment Responses #6 and #18.
122.	Steve Copps (NMFS)	05/11/2020	Section 2.1 Study Goals and Objectives	Similar to the above comment, the objectives are nicely laid out and may serve as a model for authors of other study plans.	Thank you for the comment.
123.	Steve Copps (NMFS)	05/11/2020	Section 2.1 Study Goals and Objectives	Section 2.4 cites data collected in the 1970s. An objective should be added to characterize channel changes since that time.	The purpose of this study is the development of a model for existing conditions. The study is not intended to characterize channel changes over time. Use of historic channel geometry data to characterize channel changes over time will be considered in the Skagit River Geomorphology between Gorge Dam and Sauk River study plan. (See Section 2.6.2).
124.	Steve Copps (NMFS)	05/11/2020	Section 2.1 Study Goals and Objectives	Additional detail should be provided on how the model will be used to support the relicensing process. Can the models be used in a decision making context to develop and understand impacts associated with alternative management scenarios?	See Comment Responses #6 and #8.
125.	Steve Copps (NMFS)	05/11/2020	Section 2.1 Study Goals and Objectives	NMFS is concerned about the abbreviated geographic scope of the proposal.	See Comment Response #4.
126.	Steve Copps (NMFS)	05/11/2020	Section 2.2 Resource Management Goals	Add USFWS to the second paragraph.	Text has been revised as suggested.

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127.	Steve Copps (NMFS)	05/11/2020	Section 2.3 Background and Existing Information	The section includes information that should be linked to the geomorphology study plan. For example, the section describes a recently developed 2-dimensional hydraulic model for the Illabot to Sauk reach that is an appropriate linkage.	The referenced 2-D model of the Illabot to Sauk reach was developed for the Barnaby Reach restoration project. Review of geomorphology studies undertaken for that project is included in the Skagit River Geomorphology between Gorge Dam and Sauk River study plan.
128.	Steve Copps (NMFS)	05/11/2020	Section 2.6 Methodology	This section should better describe the methods for the bypass reach and make clear distinctions from how the other river sections will be modeled. The different approaches should be described in terms of how the model outputs will improve our understanding of project effects on fish and their ecological connections.	See Comment Response #12.
129.	Brock Applegate (WDFW)	06/23/2020	Section 1.3 Study Plan Development	"This study will develop an instream flow model of the Skagit River in the reach between Gorge Powerhouse and the confluence with the Sauk River." Where did the bypass reach go? Will SCL address instream flow in the bypass reach for the proposed study plan document? I can't think of a greater project effect than on the bypass reach.	See Comment Response #12. City Light will develop an effective model for the bypass reach, and will consult with LPs on its development and application. As with the river downstream of the powerhouse, alternative operating scenarios will be evaluated for the Gorge bypass reach during the integrated resource analysis that will be conducted during the ILP.
130.	Brock Applegate (WDFW)	06/23/2020	Section 1.3 Study Plan Development	"This study will develop an instream flow model of the Skagit River in the reach between Gorge Powerhouse and the confluence with the Sauk River." Most LPs asked for an increase in study area from the Dam to the estuary. Why did we get a reduction in study area from the powerhouse to the Sauk confluence?	See Comment Responses #4, #12, and #129.
131.	Brock Applegate (WDFW)	06/23/2020	Section 2.1 Study Goals and Objectives	"The goal of the Instream Flow Model Development Study is to develop an updated flow/habitat management and evaluation tool for the Skagit River between the Gorge	See Comment Responses #4, #12, and #129.

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				Powerhouse and the confluence with the Sauk River." What will SCL do about the bypass reach? Can we analyze the effects of our selected flows downstream to the estuary?	
132.	Brock Applegate (WDFW)	06/23/2020	Section 2.1 Study Goals and Objectives	"The goal of the Instream Flow Model Development Study is to develop an updated flow/habitat management and evaluation tool for the Skagit River between the Gorge Powerhouse and the confluence with the Sauk River." I think most LPs wanted to combine the bypass reach with the downstream flow model not remove it from the study plan altogether.	See Comment Responses #12 and #129.
133.	Brock Applegate (WDFW)	06/23/2020	Section 2.1 Study Goals and Objectives	"Once the study is complete (i.e., the model has been developed), the flow/habitat models will be used to investigate and inform the evaluation of flows and habitat in the Gorge Powerhouse to Sauk River reach to continue supporting mainstem Skagit River fish habitat during the new FERC license term and to support additional discussions regarding hydraulic conditions and aquatic habitat, including migration habitat." Please include rearing habitat as well.	As noted in Section 2.6.1.7 of the study plan, the study proposes to utilize the existing site-specific habitat information and other flow program rules that support implementation of the current ESH model. The output of the ESH model provides a season long, flexible guideline for instream flows and is adjustable based on natural variation, meets biological (<u>spawning, incubation, rearing, and migration</u>) requirements, protects against fry stranding and trapping, and supports Project generation needs.
134.	Brock Applegate (WDFW)	06/23/2020	Section 2.2 Resource Management Goals	"City Light's goal for the proposed study is to develop an updated flow/habitat management tool to re-examine flow management in the portion of the Skagit River affected by Project operations between the Gorge Powerhouse and the confluence with the Sauk River to evaluate whether flows as currently regulated by the Project continue to provide the quantity and	See Comment Response #4.

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				quality of fish habitat in the mainstem Skagit River necessary to sustain healthy populations of key species, and identify where changes may be needed." Why not measure the effects all the way down the river?	
135.	Brock Applegate (WDFW)	06/23/2020	Section 2.3 Background and Existing Information	"Detailed information is required on hydraulic conditions and their spatial and temporal variation in the Skagit River between Gorge Powerhouse and the confluence with the Sauk River to support management of flows for Skagit River fish production." Doesn't the rest of the river require detailed information, like the bypass reach?	See Comment Responses #4, #12, and #129.
136.	Brock Applegate (WDFW)	06/23/2020	Section 2.5 Study Area	"The study area, which is defined by the proposed limits of hydraulic modeling, will extend from Gorge Powerhouse at about RM 94 downstream to a suitable location a short distance downstream from the confluence with the Sauk River, at approximately RM 65 (Figure 2.5-1)." WDFW disagrees with the limited study area. Why would SCL not include the bypass reach besides the need to continue down the entire river?	See Comment Responses #4, #12, and #129.
137.	Brock Applegate (WDFW)	06/23/2020	Section 2.5 Study Area	"The focus of the hydraulic model between Gorge Powerhouse and the Sauk River confluence will be on the in-channel portion of the mainstem Skagit River corridor, and any side channels identified by the study team as having significant habitat value; however, the model will also include, in lesser detail, the	Fish habitat will be considered for the in-channel portion of the mainstem Skagit River and for side channels with significant habitat values where hydraulic conditions are determined by mainstem flows and water levels. The Skagit River floodplain will be modeled at a relatively coarse level. Floodplain habitat values will not be considered in this study,

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				overbank floodplain out to the valley side walls." Wouldn't we want to consider these areas for fish habitat?	however the hydraulic model will be capable of refinement to support future assessment of floodplain habitat values as needed. See also Comment Response #63.
138.	Brock Applegate (WDFW)	06/23/2020	Section 2.6 Methodology	"An unsteady flow hydraulic model will be developed for the study area using the USACE HEC-RAS modeling platform (USACE 2016)." The Washington State Instream Flow Study Guidelines does not support HEC-RAS. HEC-RAS has a depth calibrated model without velocity that estimates velocity with a mass balance calculation. HEC-RAS does not refine velocity estimates with data collected on the river, like PHABSIM. DOE and WDFW will continue to consult with SCL to approve HEC-RAS or recommend other flow models.	Thank you for your comment. City Light continues to consult with WDFW and Ecology regarding their concerns and has revised the study plan to include velocity monitoring and calibration to these data.
139.	Brock Applegate (WDFW)	06/24/2020	Section 2.6.1.1 Hydraulic Model Selection and Overview of Model Development	"Field monitoring to obtain discharge and water level data to support model calibration and validation" Model does not collect velocity information during field monitoring like other models.	As noted in Section 2.6.1.5, detailed monitoring of hydraulic conditions will be performed in selected areas (i.e., reference reaches) representative of important habitat in the overall study reach. Monitoring will include depth, velocity and discharge.
140.	Brock Applegate (WDFW)	06/24/2020	Section 2.6.1.1 Hydraulic Model Selection and Overview of Model Development	**Table 2.6-1 Qualitative comparison of RiverFlow2D and HEC-RAS 2D.** "Acceptance by the engineering community and both governmental and non-governmental institutions" Your governmental institution that issues your 401 Certification has not approved your model yet.	Thank you for your comment. City Light looks forward to continued consultation with WDFW and Ecology on the model.

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141.	Brock Applegate (WDFW)	06/24/2020	Section 2.7 Consistency with Generally Accepted Scientific Practice	"HEC-RAS is widely recognized and accepted throughout the engineering and scientific community for riverine hydraulic modeling." So far, we have seen HEC-RAS used for hydraulic modeling but not instream flow modeling. DOE has asked for examples of HEC-RAS use in instream flow modeling	Thank you for your comment. City Light looks forward to continued consultation with WDFW and Ecology on the model.

FA-03 RESERVOIR FISH STRANDING AND TRAPPING RISK ASSESSMENT
REVISED STUDY PLAN

SKAGIT RIVER HYDROELECTRIC PROJECT
FERC NO. 553

Seattle City Light

April 2021
RSP

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List of Acronyms and Abbreviations

ACS .... adaptive cluster sampling
City Light .... Seattle City Light
CoSD .... City of Seattle (Vertical) Datum
DEM .... digital elevation model
Ecology .... Washington State Department of Ecology
EFH .... Essential Fish Habitat
ELC .... Environmental Learning Center
ESA .... Endangered Species Act
FARWG .... Fish and Aquatics Resource Work Group
FERC .... Federal Energy Regulatory Commission
FLA .... Final License Application
FPA .... Federal Power Act
GIS .... Geographic Information System
ILP .... Integrated Licensing Process
ISR .... Initial Study Report
LiDAR .... Light Detection and Ranging
LP .... licensing participant
NAVD 88 .... North American Vertical Datum of 1988
NHPA .... National Historic Preservation Act
NMFS .... National Marine Fisheries Service
NPS .... National Park Service
PAD .... Pre-Application Document
PRM .... Project River Mile
Project .... Skagit River Hydroelectric Project
PSP .... Proposed Study Plan
RLNRA .... Ross Lake National Recreation Area
RM .... river mile
RSP .... Revised Study Plan
RWG .... Resource Work Group
SR .... State Route
UAV .... unmanned aerial vehicle

USFWS ......................U.S. Fish and Wildlife Service
USGS .........................U.S. Geological Survey
USR............................Updated Study Report
WDFW.......................Washington Department of Fish and Wildlife

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1.0 INTRODUCTION

1.1 General Description of the Project

The Skagit River Hydroelectric Project (Project), licensed to The City of Seattle, Washington, and operated through its publicly-owned electric power utility Seattle City Light (City Light), is located in northern Washington State and consists of three power generating developments on the Skagit River – Ross, Diablo, and Gorge – and associated lands and facilities. The Project generating facilities are in the Cascade Mountains of the upper Skagit River watershed, between Project River Miles (PRM) 94.7 and 127.9 (U.S. Geological Survey [USGS] RMs 94.2 and 127).[1] Power from the Project is transmitted via two 230-kilovolt powerlines that span over 100 miles and end just north of Seattle at the Bothell Substation. The Project also includes two City Light-owned towns, an Environmental Learning Center (ELC), several recreation facilities, and several parcels of fish and wildlife mitigation lands.

Project generating facilities are all located in Whatcom County, although Ross Lake, the most upstream reservoir, crosses the U.S.-Canada border and extends for about one mile into British Columbia at normal maximum water surface elevation. Gorge Powerhouse, the most downstream facility, is approximately 120 miles northeast of Seattle and 60 miles east of Sedro-Woolley, the nearest large town. The closest town is Newhalem, which is part of the Project and just downstream of Gorge Powerhouse. The primary transmission lines cross Whatcom, Skagit, and Snohomish counties; the fish and wildlife mitigation lands are in the same counties.

The Project Boundary is extensive, spanning over 133 miles from the Canadian border to the Bothell Substation just north of Seattle, Washington. In addition, there are "islands" of fish and wildlife mitigation lands and recreation facilities within the Skagit, Sauk, and South Fork Nooksack watersheds that are also within the Project Boundary. Project generating facilities are entirely within the Ross Lake National Recreation Area (RLNRA), which is administered by the National Park Service (NPS) as part of the North Cascades National Park Complex. The RLNRA was established in 1968 in the enabling legislation for North Cascades National Park to provide for the "public outdoor recreation use and enjoyment of portions of the Skagit River and Ross, Diablo, and Gorge lakes." The legislation maintains the Federal Energy Regulatory Commission's (FERC) jurisdiction "in the lands and waters within the Skagit River Hydroelectric Project," as well as hydrologic monitoring stations necessary for the proper operation of the Project (16 United States Code [U.S.C.] § 90d-4; Public Law 90-544. Sec. 505 dated October 2, 1968, as amended by Public Law 100-668. Sec. 202 dated November 16, 1988).

1.2 Relicensing Process

The current FERC license for the Project expires on April 30, 2025, and City Light will apply for a new license no later than April 30, 2023. City Light formally initiated the relicensing process by filing a Notice of Intent and Pre-Application Document (PAD) with FERC on April 27, 2020 (City Light 2020a). The PAD includes descriptions of the Project facilities, operations, license

[1] City Light has developed a standard Project centerline and river mile system to be used throughout the relicensing process, including the study program, to replace the outdated USGS RM system. Given the long-standing use of the USGS RM system, both it and the Project River Mile (PRM) system are provided throughout this document. For further details see Section 7.0 of the main body RSP.

requirements, and Project lands as well as a summary of the extensive existing information available on Project area resources and early consultation on potential resource issues to be addressed during the relicensing. The PAD also includes an outline of the goals and objectives of this study.

The relicensing process includes the timeframes and deadlines specified in FERC's Integrated Licensing Process (ILP), including consultation with interested agencies and Indian tribes related to study plans, study results, and subsequent analysis of results and effects analysis through the filing of the Final License Application (FLA). FERC's process includes steps to satisfy the various statutory authorities identified in the Federal Power Act (FPA) (e.g., Sections 4(e), 10(j), 10(a)). Other related regulatory processes including Washington Department of Ecology's (Ecology) Section 401 water quality certification process, the U.S. Fish and Wildlife Service's (USFWS) and National Marine Fisheries Service's (NMFS) Section 7 Endangered Species Act (ESA) consultation, NMFS's oversight of Essential Fish Habitat (EFH), as defined by the Magnuson Stevens Fishery Conservation and Management Act, and consultation pursuant to Section 106 of the National Historic Preservation Act (NHPA) will continue following filing of the FLA. With the filing of the PAD, City Light requested that FERC designate City Light as FERC's non-federal representative for purposes of initiating and conducting day-to-day consultation under ESA Section 7 and NHPA Section 106, which was granted by FERC in its June 26, 2020 Notice of Intent to File License Application for a New License and Commencing Pre-Filing Process.

1.3 Study Plan Development

In 2019-2020, City Light convened a number of Resource Work Groups (RWG) to engage agencies and other licensing participants (LP) in a Study Plan Development Process, which provided LPs and City Light the opportunity to submit forms that identified potential resource issues, their potential connection to the Project, information or studies requested, a rationale for studying the issues, and how the information collected by the study could be used to support relicensing. Table 5.1-2 of the PAD provides a summary of all the issue forms submitted during this 2019-2020 process.

Section 5 of the PAD lists the resource studies and management plans proposed by City Light to address select (but not all) issues identified as part of the Study Plan Development Process. While acknowledging the broad interests of LPs, City Light focused its initial draft study plans contained in the PAD on information gaps that were most likely to inform license conditions by a study of potential Project effects. City Light developed 24 study proposals, including this FA-03 Reservoir Fish Stranding and Trapping Risk Assessment (Stranding and Trapping Assessment) Study Plan.

On April 10, 2020, City Light released the Stranding and Trapping Assessment Draft Study Plan for LP review and comment. On May 5, 2020, the draft study plan was discussed at a Fish and Aquatic Resource Work Group (FARWG) meeting. City Light reviewed all comments received and is releasing this plan as the revised version of the draft study plan. The revised draft will be discussed at a FARWG meeting. Written comments were received from Upper Skagit Indian Tribe, NPS, Washington Department of Fish and Wildlife (WDFW), USFWS, and NMFS and responded to in an attachment to this study plan. A Status Draft of the study plan was provided to LPs on August 6, 2020.

City Light is filing this study plan with FERC as part of its Revised Study Plan (RSP), an update to the version that was filed with the Proposed Study Plan (PSP) on December 8, 2020 (City Light 2020b) and incorporating additional consultation with LPs prior to the filing date.

No formal study requests related to this study were filed with FERC.

PSP comments to this study plan were submitted by USFWS. City Light has addressed the specific comments and suggested edits in the study plan and responded to comments in the PSP comment/response table appended to the main body of the RSP. Modifications made to the study plan in response to comments and since the PSP include changes to the schedule based on availability of bathymetry data collection.

This study plan has been designed to assess the risk of fish stranding and trapping in the study area and inform related littoral and riparian habitat issues raised during the 2019-2020 Study Plan Development Process.

Following completion of relicensing studies, an integrated environmental analysis will specifically address links across resource areas. Data collected as part of the Stranding and Trapping Assessment, along with existing information, may also be applicable to other resource areas. Studies that may ultimately be linked, either directly or indirectly, to the findings of this study include FA-02 Instream Flow Model Development Study, OM-01 Operations Model Study, and sediment deposition and erosion studies. Results from the Stranding and Trapping Assessment may provide habitat data for TR-08 Special-status Amphibians Study. More needs to be learned within each respective study area before it is clear if and how study results will meaningfully inform comprehensive environmental analysis. City Light will work with LPs to review and integrate information from related studies as part of the ILP process in support of its license application filing.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

The goal of the Stranding and Trapping Assessment is to assess the risk of native fish species stranding and trapping within the study area under normal Project operations.[2] Native fish species within Project reservoirs include resident Rainbow Trout (*Oncorhynchus mykiss*), Bull Trout (*Salvelinus confluentus*) and Dolly Varden (*Salvelinus malma*).

Specific objectives include:

- Identify and map focal areas through a desktop Geographic Information System (GIS) analysis of existing elevation and topobathymetric data where stranding and trapping risk to native fish species may occur;
- Undertake field surveys of fish stranding and trapping at select risk areas to confirm or refute the results of the desktop analysis methods; and
- As needed, update the desktop analysis based on field results.

Results and/or tools from this study may be used to evaluate Project effects in the license application.

2.2 Resource Management Goals

The study will provide information for resource agencies, Indian tribes, and First Nations with jurisdiction in the Project vicinity to address their respective goals and objectives for resource management.

2.3 Background and Existing Information

No stranding or trapping information is available for any of the reservoirs under normal Project operations. Project operations may strand or trap native fish in Ross, Diablo, or Gorge lakes due to reservoir drawdowns and/or surface elevation fluctuations. Reservoir drawdowns or fluctuations occur during normal operations to support flood control, fish protection, recreation, and power generation.

Per current licensing requirements, occasional assessments of fish stranding and trapping have occurred in Gorge and Diablo lakes (by City Light and LPs) during scheduled drawdowns outside of normal operations for maintenance activities and infrastructure testing (e.g., spillways, etc.) but no information exists for Ross Lake under these circumstances.

In April 2019, drawdown of Gorge Lake to about 830 feet North American Vertical Datum of 1988 (NAVD 88) [3] (823.49 feet City of Seattle Datum (CoSD)) for spill gate testing resulted in

[2] For purposes of this study, "normal operations" are defined as typical operations to support flood control, fish protection, recreation, and power generation and do not include drawdowns for maintenance or infrastructure testing.
[3] City Light is in the process of converting Project information from its older vertical elevation datum (CoSD) to the more current and standardized elevation datum (NAVD 88). As such, elevations are provided relative to both data throughout this RSP. The conversion factor between CoSD and NAVD 88 varies depending on location. A table

stranding and trapping of native fish in the vicinity of the State Route (SR) 20 causeway crossing of Gorge Lake. City Light is preparing a report on this stranding and trapping event. However, genetic analysis conducted by the WDFW Molecular Genetics Lab confirmed that samples of stranded char appear to be primarily Dolly Varden with a low level (≈ 5 percent) of hybridization with Bull Trout and Brook Trout, and Gorge Lake Brook Trout samples were identified correctly in the field (Small et al. 2020a). Stranded Rainbow Trout were native origin fish (Small et al. 2020b).

Native fish species in the Project reservoirs include Rainbow Trout, Bull Trout, and Dolly Varden. Bull Trout are listed as "threatened" under the ESA. Section 2.6.2.4 of this study plan discusses life stage information (e.g., fry, juvenile, adult, etc.) of each native species and timing of the presence of those life stages in reservoirs during periods of Project operations when there is a risk of trapping or stranding.

2.3.1 Description of Reservoir Operations

City Light reports to CoSD all water level data currently collected at the Project reservoirs and key water surface elevations cited in the current Project license. All elevations in this and subsequent sections of the study plan are given relative to NAVD 88 and, in most instances, also to CoSD, using the conversions provided below. All Light Detection and Ranging (LiDAR) data discussed in the study plan are reported to NAVD 88.

- Ross Lake: NAVD 88 = CoSD + 6.26 feet
- Diablo Lake: NAVD 88 = CoSD + 6.36 feet
- Gorge Lake: NAVD 88 = CoSD + 6.51 feet

2.3.2 Ross Lake

Under the current Project license, Ross Lake normal maximum water surface elevation and minimum water surface elevation (authorized by current license) are 1,608.76 feet NAVD 88 (1,602.5 feet CoSD) and 1,480.76 feet NAVD 88 (1,474.5 feet CoSD), respectively. Water surface elevations are typically maintained between a normal maximum of 1,608.76 feet NAVD 88 (1,602.5 feet CoSD) during summer and 1,541.26 feet NAVD 88 (1,535 feet CoSD) during fall and winter (a difference of 67 feet). Ross Lake is maintained close to its normal maximum water surface elevation from 31 July through Labor Day and then drawn down for flood control and power generation through the fall and winter months, typically reaching its annual low elevation in mid-April. The reservoir is then refilled during the spring/early summer freshet back to its normal maximum by 31 July. The annual drawdown is typically between about 60 and 80 feet but has been as much as 120 feet.[4] A sample of daily water surface elevation data from 2010 through 2018 is shown in Figure 2.3-1.

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converting elevation values of common benchmarks, staff gages, and key Project features from CoSD to NAVD 88 and a map of the same features are appended to this RSP, both of which have been updated since the Pre-Application Document (PAD).

[4] The lowest licensed water surface elevation for Ross Lake is 1,480.76 feet NAVD 88 (1,474.5 feet CoSD), 128 feet below normal maximum water surface elevation, which has occurred only once in the current license period (in April 1999). Between 2009 and 2018, the average low water surface elevation was 1,541.26 feet NAVD 88 (1,535 feet CoSD), a difference of 67 feet.

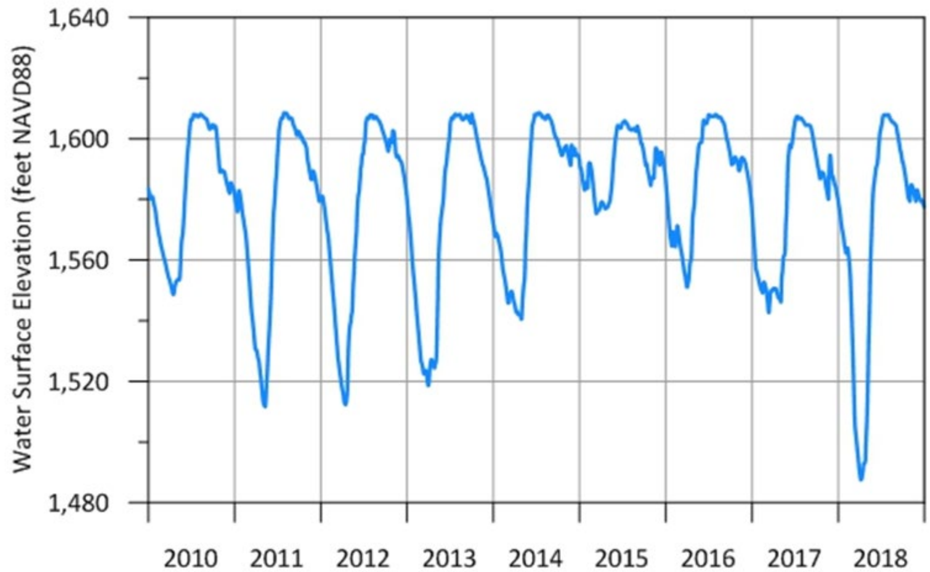

Figure 2.3-1. Ross Lake daily water surface elevations (2010-2018).

2.3.3 Diablo Lake

The primary function of Diablo Lake is to reregulate flows between the Ross and Gorge developments. The lake typically fluctuates 4 to 5 feet daily for a typical operating range between about 1,206 and 1,211 feet NAVD 88 (between about 1,199.64 and 1,204.64 feet CoSD), although under normal operations the lake may be operated as low as elevation 1,203 or 1,204 feet NAVD 88 (1,196.64 and 1,197.64 feet CoSD) on occasion, and drawdowns of 10 to 12 feet to about elevation 1,200 (1,103.64 feet CoSD) feet NAVD 88 occur occasionally as needed for construction projects or maintenance. There is little seasonal variation in water surface elevations. A sample of hourly water surface elevation data for April 2014 through June 2014 is shown in Figure 2.3-2.

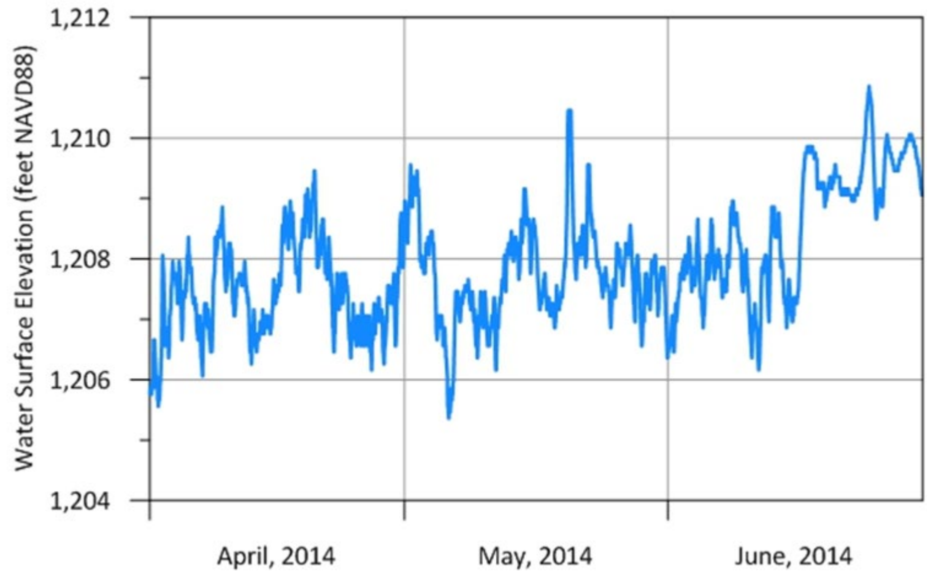

Figure 2.3-2. Diablo Lake hourly water surface elevations (April – June 2014).

2.3.4 Gorge Lake

The primary function of Gorge Lake is to regulate downstream flows for fish protection. Gorge Lake typically fluctuates 3 to 5 feet daily for a typical operating range between about 876 and 880 feet NAVD 88 (between about 869.49 and 873.49 feet CoSD), although under normal operations the lake may be operated as low as 870 feet NAVD 88 on occasion, and drawdowns of 50 feet or more are occasionally needed for spill gate maintenance or inspection. A sample of hourly water surface elevation data for April 2014 through June 2014 is shown in Figure 2.3-3.

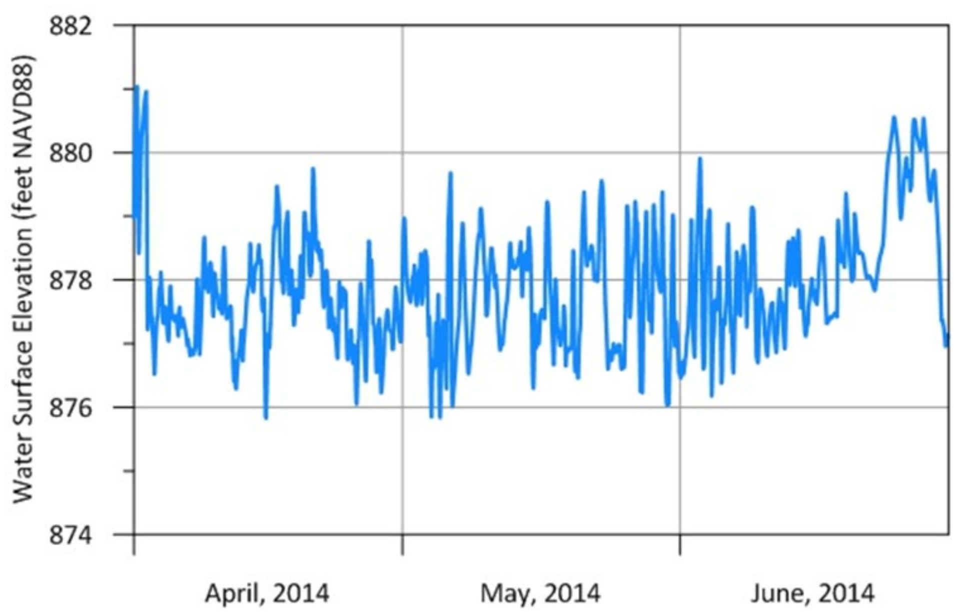

Figure 2.3-3. Gorge Lake hourly water surface elevations (April – June 2014).

City Light's current monthly operations plan states that if the water surface elevation of Gorge Lake is drawn down below 867 feet CoSD (873.51 feet NAVD 88), City Light's Project Fish Biologists will be contacted within 48 hours to conduct a stranding/entrapment assessment at known locations where stranding may occur.

2.3.5 Existing Data

A variety of topographic and bathymetric data are available to support development of digital elevation models (DEM) for use in identifying isolated pools and areas with minimal topographic relief which present the greatest risk for stranding and trapping within the study area. These data comprise:

- Topographic data: Standard LiDAR data were acquired for all three reservoir areas in 2016/2017 (Quantum Spatial 2017) and for Ross Lake in 2018 (Quantum Spatial 2018a). Standard LiDAR data provide topography for shoreline areas above the reservoir water surface elevation at the time of data acquisition. The 2018 Ross Lake LiDAR data were acquired on 25/26 April 2018 at a time when the lake was at a very low water surface elevation (water surface elevation of about 1,494 feet NAVD 88 or 1,487.74 feet CoSD) and hence provides topographic data for almost the entire area of the reservoir presenting a possible stranding/trapping risk. The 2016/2017 data provides no additional information for Ross Lake and limited information on shoreline topography for Gorge and Diablo. The exact extent of shoreline topography from the 2016/2017 LiDAR is discussed further in Section 2.6.2.1 of this study plan.
- Topobathymetric data: Topobathymetric (aka Green) LiDAR data were acquired for portions of Gorge and Diablo lakes on 25/26 April 2018 (Quantum Spatial 2018b). Because of its ability to penetrate water to some (limited) depth, the 2018 Green LiDAR provides somewhat greater coverage of topographic and bathymetric data than the 2016/2017 Standard LiDAR. The exact extent of shoreline topography and bathymetry from the 2018 Green LiDAR is also discussed further in Section 2.6.2.1 of this study plan.

The 2017 and 2018 standard LiDAR data have an absolute Non-vegetated Vertical Accuracy of 0.263 and 0.201 feet respectively with 95 percent confidence. The topobathymetric LiDAR data have a vertical accuracy of 0.366 feet with 95 percent confidence for submerged bathymetric check points. Full details of the LiDAR resolution and accuracy assessments can be found in the LiDAR technical data reports (Quantum Spatial 2017, 2018a, and 2018b).

Reservoir water surface elevation data under current Project operations are available from both the USGS and City Light. The USGS reports daily (end of day) water surface elevations. More detailed hourly data are available from City Light. Given the time scales over which the reservoir water surface elevations vary, daily data are suitable for analysis of Ross Lake water surface elevations, while hourly data are necessary for analysis of Gorge and Diablo lakes water surface elevations. Hourly and daily water surface elevation data from Ross Lake will be reviewed to confirm that the daily data adequately characterize Ross Lake water level fluctuations relevant to the evaluation of stranding and trapping risk. Summaries of monthly and annual maximum, average and minimum water surface elevations for Ross Lake, Diablo Lake, and Gorge Lake are provided in Table 3.5-1, Table 3.5-3 and Table 3.5-6 of the PAD, respectively.

2.4 Project Operations and Effects on Resources

Project operations may strand or trap native fish in Ross, Diablo, or Gorge lakes due to reservoir drawdowns and/or surface elevation fluctuations. Reservoir drawdowns or fluctuations occur to support flood control, fish protection, recreation, and power generation. Although reservoir drawdowns are also conducted for maintenance or FERC-required infrastructure testing, these operations occur less frequently, are not anticipated to occur during the study period, and are, therefore, not included in the definition of normal Project operations for the purposes of this study.

2.5 Study Area

The proposed study area includes Ross, Diablo, and Gorge lakes, within the U.S., at elevations below which stranding and trapping risks could be elevated under normal Project operations (Figure 2.5-1). If analysis of existing information and field data collected in the U.S. indicates that City Light needs information from portions of Ross Lake in Canada to adequately address the objectives of this study, then City Light will explore the feasibility of field data collection in Canada (i.e., outside of the FERC Project Boundary).

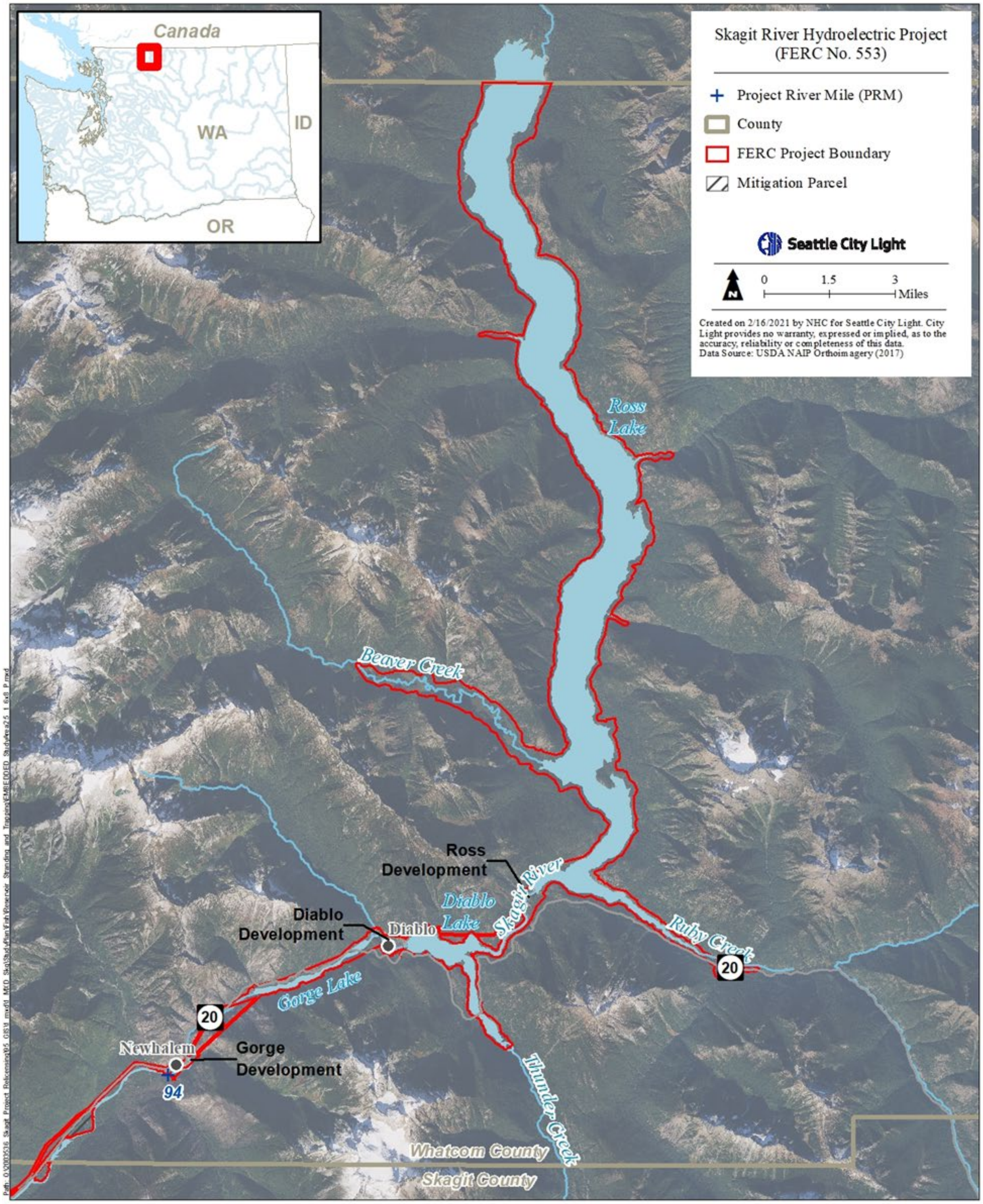

Figure 2.5-1. Overview of proposed study area.[5]

2.6 Methodology

The study includes two phases: (1) field reconnaissance and a desktop analysis of the study area to identify potential areas of fish stranding and trapping risk; and (2) field surveys at selected areas to validate results of the desktop analysis and to update the desktop analysis, as necessary.

2.6.1 2020-2021 Ross Lake Reconnaissance

A total of three reconnaissance level field surveys will be conducted during the 2020/21 Ross Lake drawdown cycle. The reconnaissance effort is intended to provide an initial assessment of entrapment habitat associated with tree stumps (i.e., tree wells) because little is currently known about mechanisms that form this type of habitat in Ross Lake. Information on locations, numbers, and approximate sizes of tree wells, and physical factors (e.g., slope, aspect, or exposure to wave action) associated with the formation of tree wells will be collected. In addition to tree well trapping conditions, reconnaissance will examine other low-slope potential stranding zones. If stranding or trapping is observed during reconnaissance, such observations will be useful for refining understanding of the periodicity of reservoir habitat use by life stage(s) of the primary species of interest in this study.

Because the DEM model will not have been developed by the time 2020/21 drawdown reconnaissance surveys need to be conducted, existing information will be used to target areas for examination. Specifically, field surveys will focus on areas where stranding and trapping may have been previously observed, where existing information on topographic slope and bathymetry in exposed areas is qualitatively representative of the slope delineations to be refined in the 2021 desktop analysis, and areas—based on best professional judgment and past findings in other systems—that are likely stranding and trapping risk areas (e.g., proximity to a tributary stream or margins of the mainstem influent).[6] These reconnaissance focus areas will represent, in essence, early risk screening "strata." Within these strata, which are expected to represent a significant area of survey within Ross Lake in particular, City Light will test the adaptive cluster sampling approach (defined further in Section 2.6.3 of this study plan) for application later in 2021 and in 2022 after the DEM results can be considered. The results of these surveys will also help to inform the desktop analysis described in Section 2.6.2 below.

2.6.2 Desktop Analysis

The desktop analysis includes (1) assembly and analysis of DEMs of reservoir shoreline and bed topography to inventory potential stranding and trapping areas, (2) an analysis of reservoir water surface elevation data to document the frequency and period of time over which trapping pools are formed and areas of low slope terrain are exposed in drawdown zones, and (3) an analysis of native species life stage and periodicity information to identify when life stages susceptible to stranding

[5] Figure 2.5-1 depicts the Project Boundary encompassing the generation facilities. The study area is the portion of Project reservoirs (i.e., Ross, Diablo and Gorge) at risk of native fish species stranding and trapping under normal operations (defined in Section 2.1 of this study plan). If analysis of existing information and field data collected in the U.S. indicate that information from Ross Lake within Canada is needed to adequately address the objectives of this study, City Light will explore the feasibility of field data collection within Canada (i.e., outside of the FERC Project Boundary).
[6] Reconnaissance methods are under development and will be finalized prior to field efforts.

and trapping risk under normal operations may be present in the study area. The life stage periodicity analysis may also inform appropriate periods for field sampling.

2.6.2.1 Inventory of Areas Presenting Stranding and Trapping Risk

Developing an inventory of areas presenting a stranding and trapping risk will involve assembling and analyzing DEMs to identify and quantify areas with gradient profiles indicating stranding risk and areas draining to isolated pools indicating trapping risk. The DEMs will be developed from available LiDAR data, supplemented for Gorge Lake and Diablo Lake by bathymetric data to be collected as part of this study.

Ross Lake DEM

The 2018 Standard LiDAR at Ross Lake (Quantum Spatial 2018a) (Figure 2.6-1) was flown at a water surface elevation of 1,494 feet NAVD 88 (1,487.74 feet CoSD), which is substantially lower than the water surface elevation during acquisition of the 2016/2017 Standard LiDAR. Therefore, only the 2018 data will be used when evaluating trapping/stranding issues in Ross Lake. Given Ross Lake's typical annual minimum water surface elevation of about 1,541 feet NAVD 88 (1,534.74 CoSD), the 2018 LiDAR will readily quantify the terrain slope and isolated pools with potential for stranding and trapping.

Diablo Lake DEM

The only available LiDAR data providing complete coverage around Diablo Lake is the 2016/2017 Standard LiDAR, which was flown at a water surface elevation of approximately 1,208 feet NAVD 88 (1,201.64 feet CoSD) (Quantum Spatial 2017). With a minimum water surface elevation under normal operations of about 1,203 feet NAVD 88 (1,196.64 feet CoSD), there will remain a narrow band of shoreline surrounding the lake within the normal operating range where the slope cannot be quantified and where isolated pools cannot be identified from the Standard LiDAR. Green LiDAR was acquired on Thunder Arm, which is the inundated reach of Thunder Creek that enters Diablo Lake from the south (Quantum Spatial 2018b) (Figure 2.6-2). The Green LiDAR coverage was obtained at a water surface elevation of approximately 1,208 feet NAVD 88 (1,201.64 feet CoSD), which is similar to the water surface elevation during acquisition of the 2016/2017 LiDAR. Quantum Spatial reports confidence in underwater laser returns as low as elevation 1,193 feet NAVD 88 (1,186.64 feet CoSD) for a maximum depth underwater of about 15 feet. This allows for quantifying the shoreline terrain slope approximately 35 feet from the lakeshore and quantifying slope and isolated pools in Thunder Arm near the SR 20 crossing where most of the lakebed surface is revealed (Figure 2.6-3). Any areas of the lakebed not colored in dark blue on Figure 2.6-3 are not quantifiable with the available Green LiDAR. As part of the study, additional bathymetric data will be collected in areas within the normal operating range where LiDAR is unavailable to support the desktop analysis. These data will be obtained by boat or autonomous underwater vehicle using traditional echo-sounding methods and will allow for quantifying shoreline terrain down to an elevation of approximately 1,200 feet NAVD 88 (1,193.64 feet CoSD). The Diablo Lake water level has dropped below 1,200 feet NAVD 88 only once since hourly water level records began in 1997 (approximately 1,199.4 feet NAVD 88 in 2017). Except for Thunder Arm, the shoreline of Diablo Lake is relatively steep and the potential for stranding and trapping outside Thunder Arm is likely low.

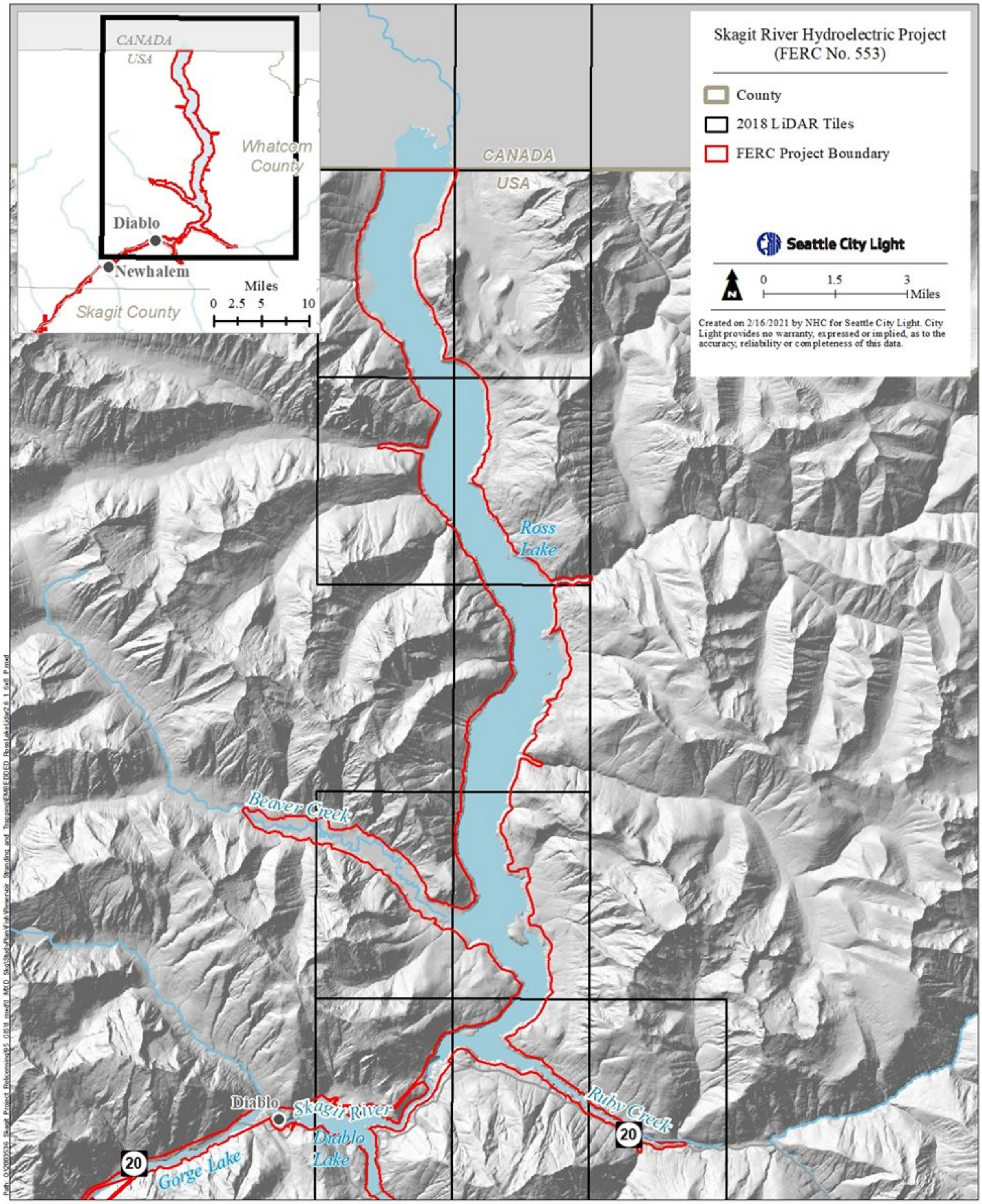

Figure 2.6-1. **Extents of 2018 LiDAR of Ross Lake.**

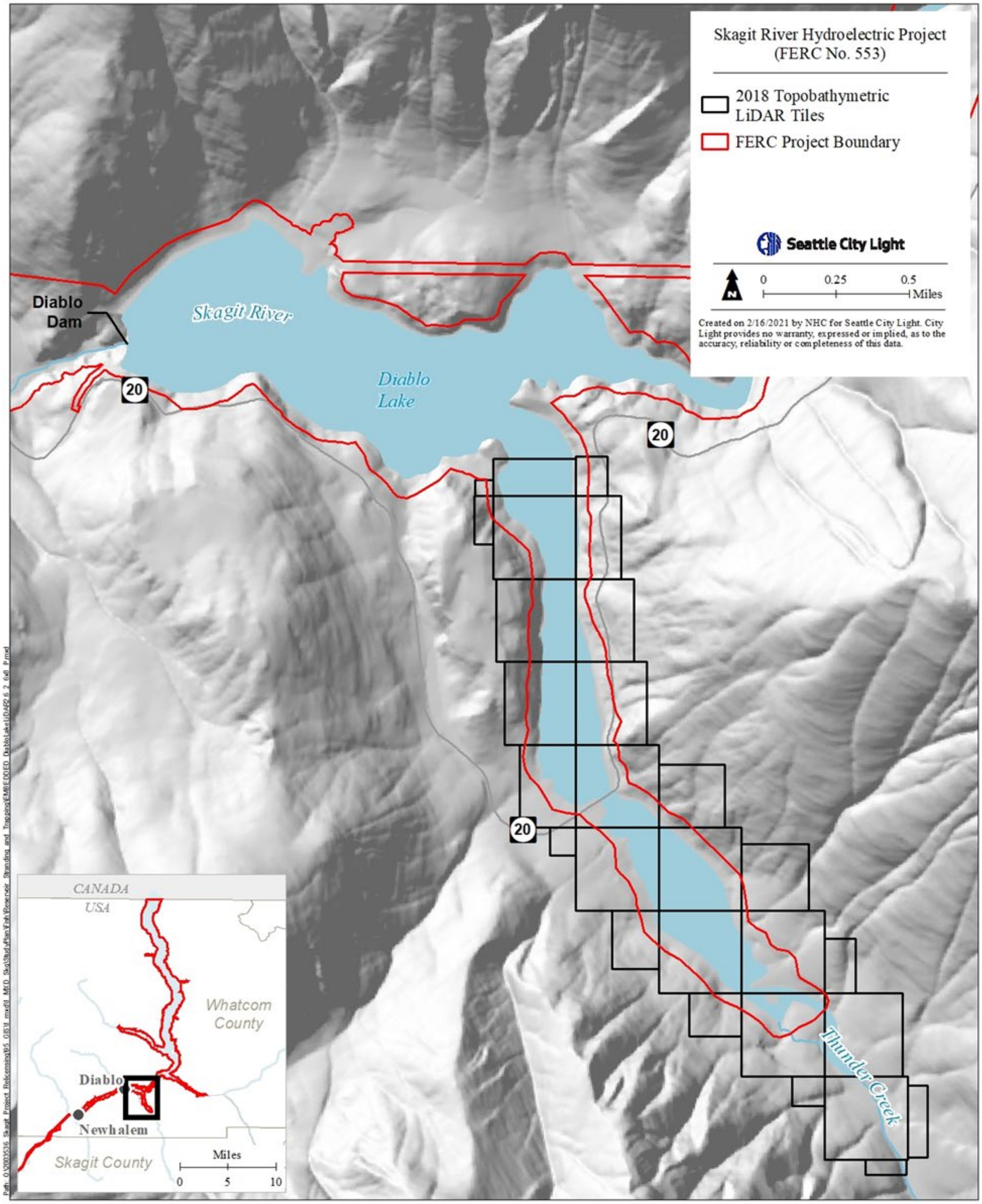

Figure 2.6-2. Extents of 2018 topobathymetric (Green) LiDAR around Diablo Lake.

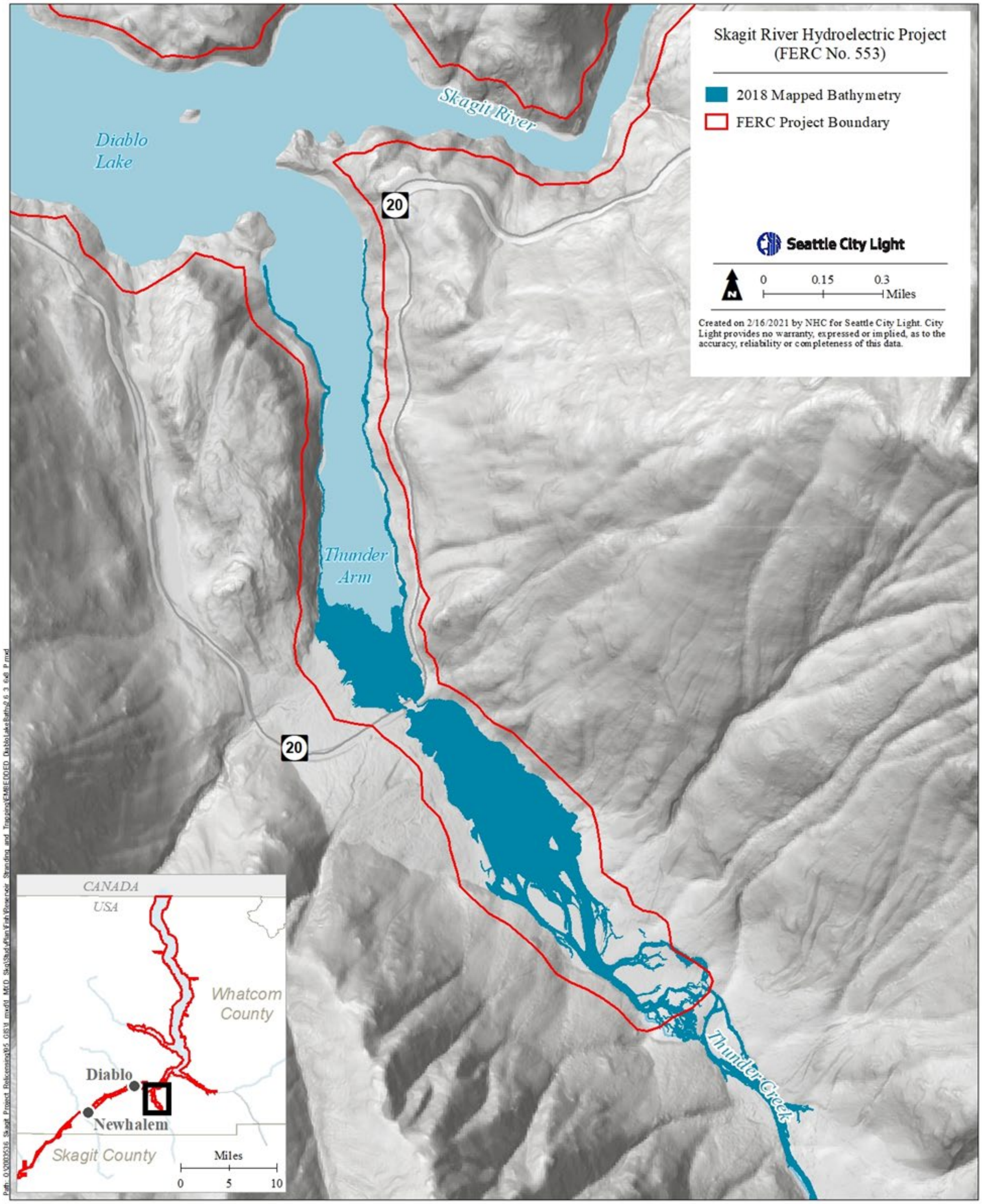

Figure 2.6-3. Dark blue color illustrates shoreline and bed area in Thunder Arm of Diablo Lake that is quantified in the topobathymetric (Green) LiDAR.

Gorge Lake DEM

The only available LiDAR data providing complete coverage around Gorge Lake is the 2016/2017 Standard LiDAR which was flown at a water surface elevation of approximately 876.6 feet NAVD 88 (870.09 feet CoSD) (Quantum Spatial 2017). With a minimum water surface elevation under normal operations of about 870 feet NAVD 88, there will remain a narrow band of shoreline surrounding the lake within the normal operating range where the slope cannot be quantified and where isolated pools cannot be identified from the Standard LiDAR. Green LiDAR was also acquired at the Stetattle Creek confluence with Gorge Lake upstream to Diablo Dam (Quantum Spatial 2018b) (Figure 2.6-4). The Green LiDAR was flown at a water surface elevation of 876 feet NAVD 88 (869.49 feet CoSD), which is similar to the water surface elevation during acquisition of the 2016/2017 Standard LiDAR. Quantum Spatial reports confidence in underwater laser returns as low as elevation 869 feet NAVD 88 (862.49 feet CoSD) near the SR 20 causeway, for a maximum depth underwater of 7 feet. This allows quantifying by LiDAR approximately 10–50 feet of the shoreline lakebed south of the causeway and much of the lakebed slope and isolated pools presenting a trapping risk north of the SR 20 crossing (Figure 2.6-5). Any areas of the riverbed not colored in dark blue on Figure 2.6-5 are not quantifiable with the available LiDAR. As part of the study, the LiDAR data for Gorge Lake will be supplemented by data from a bathymetric survey conducted by boat or autonomous underwater vehicle using traditional echo-sounding methods. The bathymetric survey will map lakebed terrain down to an elevation of approximately 800 feet NAVD 88 (793.49 feet CoSD), which would encompass the lowest water levels seen in the proposed period of analysis since 2011, including those associated with maintenance drawdowns.

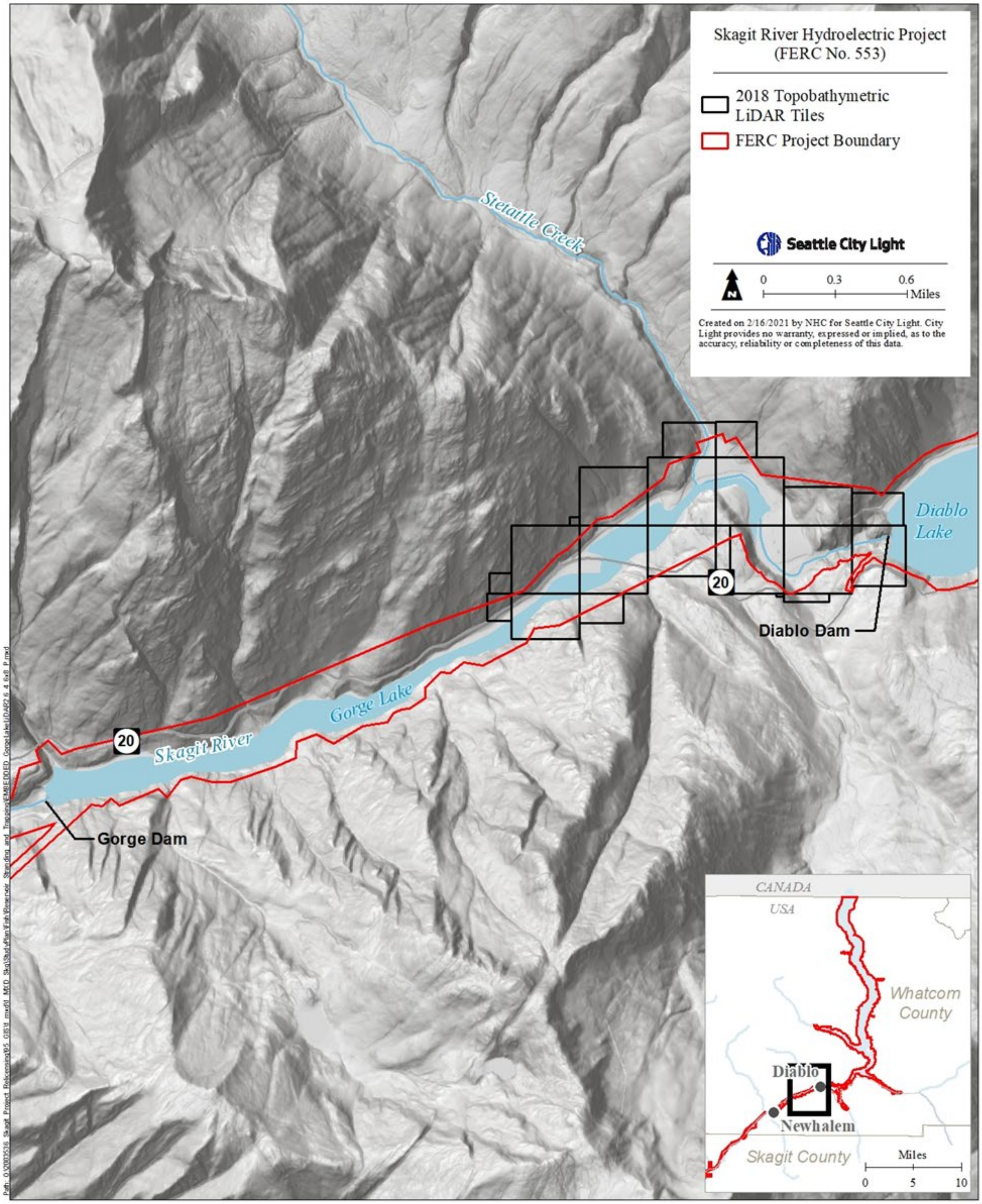

Figure 2.6-4. Extents of 2018 topobathymetric (Green) LiDAR around Gorge Lake.

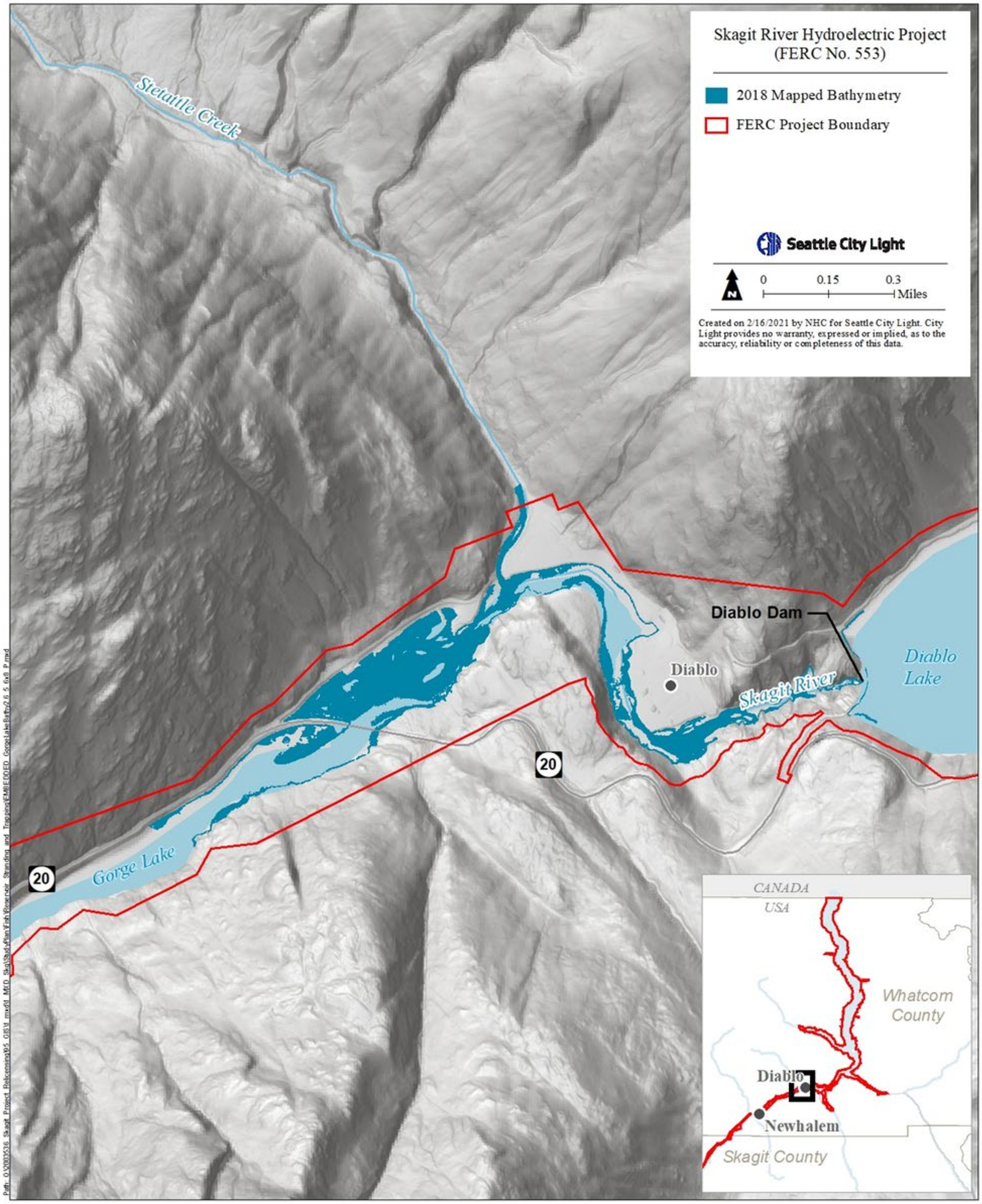

Figure 2.6-5. **Dark blue color illustrates shoreline and bed area of Gorge Lake that is quantified in the topobathymetric (Green) LiDAR.**

2.6.2.2 Analysis of DEMs for Stranding and Trapping Risk

Evaluation of potential stranding and trapping risk in the study area will be performed with standard GIS tools from the ArcGIS Spatial Analyst toolbox supplemented by custom scripts to facilitate analysis. Terrain slopes will be computed for each DEM cell (likely 3-foot square cells) and labeled as having a slope less than 4 percent; between 4 percent and 6 percent; or greater than 6 percent. The benchmark slopes were previously identified by Bell et al. (2008) as associated with salmonid stranding potential in reservoir environments. These slopes are significantly steeper than the very shallow slopes associated with salmonid fry stranding from boat wakes or stranding in floodplains on unregulated systems on a declining hydrograph (Ackerman et al. 2002; Sommer et al. 2005). However, they are relevant to trapping risks in reservoir systems where stream velocity cues (rheotactic) will be relatively lacking and rapid drawdowns have potential to create ponding. Rheotaxis is useful to orient fish for egress from stranding-risk areas when depths decrease gradually, which occurs more often under normative flow regimes. Cells with slopes inconsistent with a sufficient number of neighboring cells will be aggregated to eliminate overly granular slope classification and remain true to the purpose of this analysis, which is to identify areas of low slope presenting a stranding risk. Exposed lakebed slope/area statistics will be summarized by water surface elevation and a map will be produced illustrating the exposed low-gradient areas within the range of water surface elevations for which the DEMs have been developed for each reservoir.

To identify trapping hazards, the lake shoreline and lakebed DEMs will be queried for isolated pools, or “sinks” in GIS terminology. With consideration of the accuracy of the LiDAR data, sinks will initially be defined as spatially connected cells surrounded by a ring of higher elevation cells that hold water to a minimum depth of 12 inches. Sinks with a minimum depth of less than 12 inches will generally be classified by the DEM analysis as low slope terrain presenting a stranding (rather than trapping) risk, hence there may be some misclassification of stranding and trapping risk classifications. The minimum depth used to identify sinks will be revisited following field verification of the results of the DEM analysis.

Given the resolution of the LiDAR data, a minimum sink area of 108 square feet will be assumed for the purposes of identifying and quantifying sinks. This would represent 12 contiguous, 3-foot square cells in the DEM. As with stranding hazards, the number and area of these sinks will be summarized by reservoir water surface elevation and a map produced illustrating the sinks within the range of water surface elevations for which the DEMs have been developed.

The maps depicting low slope terrain and isolated pools/sinks will be overlaid to identify the areas with the highest potential for fish stranding or trapping for a given reservoir water surface elevation.

The 2020/21 drawdown field reconnaissance (see Section 2.6.1 of this study plan) also offers an opportunity to verify high-risk areas identified by the DEM analysis are experiencing high stranding or trapping rates. Similarly, the field reconnaissance will identify areas that were *not* identified by the DEM but where stranding or trapping did occur.

2.6.2.3 Analysis of Reservoir Drawdown

Trapping and stranding risk areas will be estimated from the frequency with which isolated trapping pools are formed and the frequency with which low gradient stranding areas become exposed. The reservoir elevation data will also be analyzed to characterize reservoir drawdown rates.

Analyses for Gorge and Diablo lakes will be performed using the record of hourly water surface elevation data since 2011 under current Project operations. As discussed in Section 2.3 of this study plan, water surface elevations in Gorge and Diablo lakes commonly fluctuate within their normal operating ranges daily. The reservoir water surface elevation data will be analyzed in conjunction with the inventory of areas presenting a potential risk to determine the frequency of formation of isolated trapping pools and exposure of low gradient stranding areas by reservoir elevation. Since Gorge and Diablo lakes elevations fluctuate daily, the duration of time that trapping pools remain isolated will be determined. The reservoir elevation data will also be analyzed to characterize reservoir drawdown rates under normal Project operations, classified by time of day and month or season.

Analysis for Ross Lake will be similar to that for Gorge and Diablo, except that the analysis will be performed using the record of daily (end of day) water surface elevation data since 2011. As discussed in Section 2.3 of this study plan, water surface elevations in Ross Lake fluctuate seasonally. Hourly and daily water surface elevation data from Ross Lake will be reviewed to confirm that the daily data adequately characterize Ross Lake water level fluctuations relevant to the evaluation of stranding and trapping risk. Gorge and Diablo lakes water surface elevation data will be analyzed in conjunction with the inventory of areas presenting a potential risk to determine the frequency of formation of isolated trapping pools and exposure of low gradient stranding areas.

2.6.2.4 Native Species Life Stage and Periodicity Analysis

As referenced above, each of the Project reservoirs support native Bull Trout, Dolly Varden, and Rainbow Trout. While the early life stages of these native species (i.e., emergent fry and young of the year parr) are most susceptible to stranding because of their low velocity tolerance and associated use of shallow and slow waters, defining risks to all life stages of native species under normal operations requires the overlay of temporal operations on reservoir elevations and an understanding of the corresponding phenology of the use of those habitats where trapping and stranding might occur. At present, knowledge at this level of resolution is limited, so predictions of which species and life stage will be most susceptible to stranding or trapping over an annual or seasonal operations cycle will take into account the general life cycles of the native fish to infer their life-stage-specific temporal susceptibility.

Rainbow Trout are spring spawners, typically spawning from late March through April, but potentially extending well into May or June in systems with cooler water temperatures. Spawning and incubation of the resultant eggs and sac-fry occur over a period of rising water temperatures. Young of the year rainbow trout fry typically emerge from June onwards through July, with susceptible young of the year present through the remainder of the calendar year, with increasing size. Changes in reservoir elevation trapping rearing sub-adult and adult rainbow trout are possible, though less likely.

Dolly Varden and Bull Trout, both char species, spawn in the autumn, over a period of declining ambient temperatures, with spawning commencing when water temperatures decline to about 8 ºC, typically starting in late September into November, depending on the tributary location's temperature regime. Fry of these char species typically emerge from February through March, so stranding and trapping risks for these species are likely highest during this early emergence period through the first few months of early rearing in the spring.

Because none of these native species is known to spawn in the lentic habitats of the Skagit River Project reservoirs—with spawning known to occur in reservoir tributaries—the likelihood of trapping or stranding spawning char is anticipated to be low (as it is with spawning Rainbow Trout). Spawning age fish would be on tributary spawning grounds which would not be susceptible to the effects of reservoir fluctuations or drawdown. In sum, trapping and stranding risks are highest for early emergent fry and young of the year of Rainbow and Bull Trout and Dolly Varden, and the early life stages of these species would be present from February through the summer months. Trapping risks could extend beyond summer months for parr and older sub-adults.

2.6.3 Sampling Design, Field Surveys, and Desktop Analysis Updates

2.6.3.1 2021/22 Sampling Design

Based on field reconnaissance results described in Section 2.6.1, inventory from Section 2.6.2.1, and analysis of reservoir elevation data in Sections 2.6.2.2 and 2.6.2.3 of this study plan, study area zones within each of the three Project reservoirs will be identified for field survey in the 2021/22 field season. Because the areas identified may be substantial, particularly in Ross, subsampling of these study zones for further field survey will be required. A subsample of quadrats corresponding to the resolution of DEM cells will be randomly selected initially from a grid overlay of the key study area zones for initial survey.

An adaptive cluster sampling (ACS) approach will be employed within these study area zones (Thompson 1992). Observations of stranding or trapping, to the extent they may occur, are expected to be highly clustered and not randomly dispersed; therefore, traditional lineal or randomly selected quadrate-based survey has a high likelihood of underestimating observations. That is, traditional randomly selected quadrats will often contain no animals if the habitat use by the species is typically clustered. As such, sampling clusters in a non-random way is needed. Per Thompson (1992), "Adaptive cluster sampling begins in the usual way with an initial sample of quadrats selected by simple random sampling with replacement, or simple random sampling without replacement. When one of the selected quadrats contains the organism of interest, additional quadrats in the vicinity of the original quadrat are added to the sample." The method is akin to hunting for mushrooms--when a forager finds one of a desired species, effort is typically increased in the immediate area of the finding because a higher density of the species is likely.

ACS can result in higher sampling efficiency and higher rates of detecting rare species in comparison to conventional sampling designs, but several assumptions are inherent to its application. First, a quadrat for ACS survey (e.g., quadrat x) is selected only if it contains at least one organism of the study focus (i.e., $y = 1$) (In this case, an observation of a trapped or stranded fish within the quadrat survey area). Next, adjacent quadrats (the 'quadrat neighborhood') are examined for the presence of trapped or stranded fish; these quadrats will have one side in common with quadrat x. Some of these quadrats will contain additional organisms, whereas others will be empty. The empty quadrats do not satisfy the initial selection of a quadrat, and are considered "edge quadrats." Based on ACS, neighborhoods will expand until there are no further observations in edge quadrats; the collective of adjoining "neighborhoods" is termed a "network," where the random selection of any one of the quadrats in the neighborhood would result in all quadrats being included in the network to be sampled.

In Figure 2.6-6,[7] a 400-cell (20 x 20) sample grid is represented. Initially, a random sample of 10 cells was selected for survey. Using ACS, additional adjacent grids are examined, yielding a sample matrix of 37 cells total (in this example), with three sample networks, per the definition above. Simply calculating the mean of all 37 quadrats would result in an estimator that would bias high.

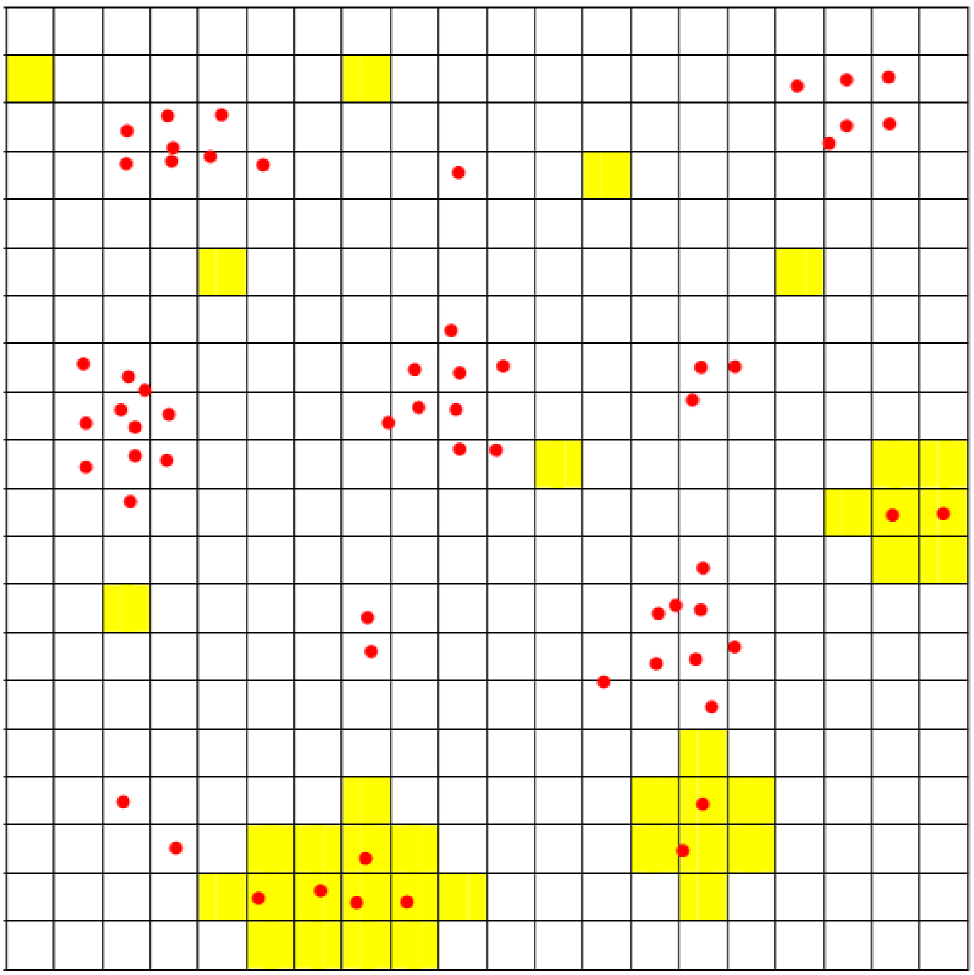

Figure 2.6-6. **A 20-by-20 traditional sampling grid, overlaid with representation of subsequently applied adaptive cluster sampling revealing three distinct networks from which abundance estimates can be calculated.**

The following sequential procedures are followed to avoid bias and reach estimates of abundance (Thompson 1992).

(1) Calculate the average abundance of each of the networks:

[7] From http://projects.nri.org/ecorat/docs/Adaptive_sampling_protocol.pdf, (no author attribution).

$$w_i = \frac{\sum_k y_k}{m_i}$$

Where

wi = The average abundance of organism y in the *i*-th network
y_k = Abundance of the organism in each of the k-quadrats in the i-th network
mi = Number of quadrats in the *i*-th network.

(2) Calculate the estimator of mean abundance:

$$\bar{x} = \frac{\sum_i w_i}{n}$$

Where

$\bar{x}$ = Unbiased estimate of mean abundance from adaptive cluster sampling
n = Number of initial sampling units selected via random sampling

(3) Calculate the variance of the mean abundance estimate, where samples are selected without replacement:[8]

$$\hat{\text{var}}(\bar{x}) = \frac{(N-n)\sum_{i=1}^{n}(w_i - \bar{x})^2}{Nn(n-1)}$$

In the hypothetical example represented in Figure 2.6-6, 10 quadrats were initially sampled, seven contained no observations of stranded fry, while three did. These three quadrats became three networks from subsequent ACS sampling.

So, the mean estimator (2):

$$\bar{x} = \frac{\sum_i w_i}{n}$$

Would be calculated as:

(2/7 + 2/8 + 5/15 + 0/1 +0/1 +0/1 + 0/1 + 0/1 + 0/1 + 0/1)/10, = 0.0869 stranded fry/quadrat.

[8] For the reservoir stranding and trapping risk assessment, it is assumed sampling will occur without replacement.

The variance of the mean (3), would then be calculated as follows:

$$\hat{\text{var}}(\bar{x}) = \frac{(N-n)\sum_{i=1}^{n}(w_i-\bar{x})^2}{Nn(n-1)}$$

$$= \frac{(400-10)\left[\left(\frac{2}{7}-0.0869\right)^2+\left(\frac{2}{8}-0.0869\right)^2+....\right]}{(400)(10)(10-1)}$$

$$= 0.0019470$$

Confidence limits for the estimates of the mean are calculated using Equation (4):

$$\bar{x} \pm t_{\alpha}\sqrt{\hat{\text{var}}(\bar{x})}$$

2.6.3.2 Field Data Collection

During each survey, field crews will collect data in pools and low gradient areas where trapping or stranding are observed. Data to be collected from pools where trapping is observed would include:

- Water temperature;
- Dissolved oxygen concentration;
- Turbidity;
- Maximum pool depth and approximate pool surface area;
- Visual characterization of sediment grain size to qualify dominant and subdominant substrates and their relative proportions;
- Number and condition of trapped fish by species and life stage;[9]
- Distance from instream cover (e.g., large woody debris, boulder scour pool);
- Presence of canopy cover (y/n); and
- Presence of macroinvertebrates (y/n).

[9] Native (i.e., Bull Trout and Dolly Varden) and non-native (Brook Trout) char species are present in the study area. Differentiation between and identification of native char species can be difficult. While rare, hybrids between the two native species and hybrids between Brook Trout and Dolly Varden can also create confusion when attempting to identify or differentiate char species. Brook Trout can be identified by distinct vermiculation on the dorsal surface and dark bands across the dorsal fin. Field differentiation of native char species will be based on size and head morphology, eye orientation, maxilla length, and mouth position features (Cavender 1978, McPhail and Taylor 1995). If native char species cannot be differentiated during field sampling (i.e., Bull Trout versus Dolly Varden), genetic samples will be taken from a subsample of questionable species.

Data collected from low gradient areas where stranding is observed would include:

- Area surveyed over which stranding was observed;
- Field measured slope of area;
- Unusual hydraulic conditions (e.g. unique eddies that concentrate fish);
- Visual characterization of dominant and subdominant substrate;
- Presence of macrophytes;
- Closest distance to instream cover;
- Reservoir drawdown rate at time of field survey, when area became exposed; and
- Number of stranded fish by species and life stage.[10]

Additional actions at each sampling location:

- Photographs and field notes will be taken to document conditions;
- Location will be recorded by GPS;
- Indications of predation will be noted; and
- Common predators present in the area prior to conducting surveys will be noted.

Field surveys for Gorge Lake and Diablo Lake will be conducted quarterly during the study (total of four surveys) with the reservoirs in their typical operating range. Exact timing will be determined following further consideration of fish species and life stages of primary concern, as well as limitations due to timing of bathymetric data collection which requires stable reservoir elevations that occur during the summer. If conditions allow, one additional field survey for each of the two reservoirs (Gorge and Diablo) may be undertaken on an opportunistic basis if the reservoirs are drawn down below their typical operating range for maintenance or other reasons.

Field surveys for Ross Lake will be conducted three times during the 2021/2022 drawdown cycle. The surveys will cover the full range of drawdown and will take place at the following approximate times:

- October or November 2021, with the water surface elevation drawn down 10 to 20 feet, to elevations of 1,598 to 1,588 feet NAVD 88 (1,591.74 feet to 1,581.74 feet CoSD).
- January or February 2022, with the water surface elevation drawn down 30 to 40 feet, to elevations of 1,578 to 1,568 feet NAVD 88 (1,571.74 feet to 1,561.74 feet CoSD).
- April 2022, with the reservoir elevation close to its minimum and the water surface elevation drawn down 50 feet or more, to an elevation of 1,558 feet NAVD 88 (1,551.74 feet CoSD) or lower.

[10] In the event of findings of significant stranding and/or trapping, total counts may not be possible or practical, and subsampling would be pursued as appropriate.

Each of the surveys in Ross Lake will focus on recently exposed low gradient areas or recently formed pools as Ross Lake is drawn down through the fall and winter months. The exact timing of surveys will depend on actual Project operations and will be adjusted if needed based on the inventory prepared under Section 2.6.2.1 of this study plan.

As appropriate, data collected during field sampling may be used to update the evaluation parameters used in the desktop analysis.

2.6.4 Analysis and Reporting

A monitoring report will be prepared at the end of the 2021 field program. This will be followed by a final study report at the conclusion of the program (see Section 2.8 of this study plan). Per methods identified in Section 2.6.3 of this study plan, final reporting will estimate mean stranding and trapping within the areas examined in the field over the time periods of study, by species and life stage (as possible). In addition, the final study report will also include the following:

- A description of the methodology employed;
- Field conditions at the time of survey (to include a summary of reservoir elevations and drawdown rates in the periods preceding each field survey);
- A summary of the empirical data collected in field surveys on fish stranding and trapping; and
- Summary text and figures of the areas presenting a high, medium, and/or low stranding and trapping risk by species and life stage, as estimated from the DEM and field survey validation.

Data collected will be analyzed to test relevant hypotheses (e.g., H_o: normal operating ranges do not cause an increase in stranding; slopes greater than 6 percent cause no increase in stranding risk; distance from cover has no bearing on trapping risks, etc.). To the degree that multiple factors are recognized as influencing trapping or stranding risks, multiple regression will likely be used to evaluate the relative influence of each factor. A data management approach including hypotheses to be tested and the statistical methods that will be applied and included in the Initial Study Report (ISR).

2.7 Consistency with Generally Accepted Scientific Practice

The methodology described in Section 2.6 of this study plan considered other investigations of fish stranding and trapping in the western U.S. and western Canada (e.g., Bell et al. 2008; Sykes 2012) and the need to apply an ACS approach to better sample populations of a species for which clustering is likely (Thompson 1992).

2.8 Schedule

The Stranding and Trapping Assessment includes Ross Lake reconnaissance surveys, data collection to address LiDAR data gaps, office assembly and analysis of DEMs derived from LiDAR and other topobathymetric data, GIS-based assessment to identify potential risk areas, a single season of field validation surveys, and analysis and reporting of field survey results including updates to the GIS-based assessment, as appropriate. The proposed study schedule is as follows:

- Ross Lake field reconnaissance – December 2020 to April 2021
- Bathymetry data collection for Gorge and Diablo lakes – July to August 2021
- Assembly and analysis of DEMs – August to September 2021
- Field surveys 2021
  - Gorge and Diablo lakes Q3 and Q4 surveys – September to December 2021 (depending on when DEM analysis is complete, only Q4 may be completed)
  - Ross Lake survey 1 – October to December 2021
- Field surveys 2022
  - Gorge and Diablo lakes Q1, Q2, and Q3 surveys (if Q3 is not completed in 2021) – January to September 2022
  - Ross Lake surveys 2 and 3 – January to April 2022
- Report Year 1 (ISR) – March 2022
- Post-field analysis – May to June 2022
- Final Study Report (Updated Study Report [USR]) – March 2023

2.9 Level of Effort and Cost

The initial estimate for implementation and reporting associated with this study is approximately $465,000.

3.0 REFERENCES

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RESERVOIR FISH STRANDING AND TRAPPING RISK ASSESSMENT
REVISED STUDY PLAN

ATTACHMENT A

CITY LIGHT RESPONSES TO LP COMMENTS ON THE STUDY PLAN PRIOR TO PSP

Table 1. City Light responses to LP comments on the study plan prior to PSP.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
1.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	General Comments, Title Page	Although instructed by SCL staff at the Fish and Aquatics Technical work group on 5/520 that the Utility is no longer accepting scope or scale comments- the discrepancy between issue form and study plan draft require additional comments to scope and scale. The 2019 Study Issue Form included downstream of Gorge Dam and Powerhouse, Upper Skagit Indian Tribe is requesting this downstream area (and by-pass) be included in the assessment of stranding and trapping from project operations.	Thank you for your comment. Although the 2019 voluntary process leading up to the development of draft study plans did not result in consensus and inclusion of all LP issues into City Light's proposed draft study plan, City Light believes the scope of the study plan is appropriate to support the relicensing process by providing information to assess potential Project effects. City Light looks forward to continuing discussions on this and other study plans as time allows and also encourages LPs to submit study plan comments and/or submit additional study requests to FERC as part of the formal relicensing process. City Light remains committed to continued collaboration and consultation with LPs regularly throughout the ILP process. City Light acknowledges these issues were raised in 2019. Once complete, hydraulic models (described in other study plans) for the bypass reach and the reach below the Gorge Powerhouse (to the Sauk River) will be able to support additional analysis to assess stranding and trapping resulting from Project flows. This study is focused on stranding and trapping risk related to Project operations in reservoirs.
2.	Ashley Rawhouser (NPS)	05/12/2020	General Comments, Title Page	The NPS requests that Study Plans stand alone as independent documents. When information is cited in the study plan a summary of the pertenent information in the PAD should be provided for the reader. The current document leaves room for too much uncertainty to provide and adequate review.	The PAD contains much information, which is often detailed and nuanced. A summary in this study plan would not be representative and reproducing the content of the PAD in this study plan would make it cumbersome and lengthy. City Light continues to believe that the best

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
					approach is to reference the PAD, to which all LPs have access.
3.	Brock Applegate (WDFW)	05/05/2020	Section 1.2 Relicensing Process	"This study plan reflects the RWG consultation~~effort~~, and City Light will continue to engage the RWG structure in the preparation of the Proposed and Revised Study Plans (18 Code of Federal Regulations [CFR] §§ 5.11-5.13), and through the relicensing process generally." I would recommend the language in the two revised studies, the Sediment Deposition and Operation Models Study Plans	Section 1.2 and 1.3 were redrafted to better describe the 2019 process. Formal consultation does not begin until after the PAD is officially submitted. Although the informal 2019 process leading up to the development of draft study plans did not result in consensus regarding all issues raised by LPs, City Light views this process as a collaborative effort (i.e., the action of working together).
4.	Judy Neibauer (USFWS)	05/12/2020	Section 1.3 Study Plan Development	"This study will assess the risk of fish stranding and trapping in the study area and address reservoir stranding and littoral and riparian habitat issues raised during the 2019 Study Plan Development Process." This work will also help inform NEPA and the FWCA…see other language in other study plans (i.e. Operationsl model, sediment study, etc.) for this section….	Section 1.2 was redrafted to identify the regulatory processes addressed during relicensing. The study program and subsequent integrated environmental analysis and NEPA document will provide the information necessary for LPs to execute their statutory responsibilities under the Federal Power Act. The integrated environmental analysis will address cross-resource linkages and issues. The information resulting from the study program will inform an analysis of Project effects, ongoing consultation with LPs, and development of the Project License Application, which will include appropriate Protection, Mitigation and Enhancement measures (PMEs). The FERC process schedule positions the integrated environmental analysis subsequent to the completion of the study program and prior to the filing of a Project License Application.
5.	Judy Neibauer (USFWS)	05/12/2020	Section 1.3 Study Plan Development	"Relevant issue forms include:" Describe if you will use other study data (i.e. from the operational flow study to help look at	City Light has added language to Section 1.3 to address potential linkages between studies being implemented during relicensing. The integrated environmental analysis (See Comment

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				certain stranding/and or entrainment issues, riparian and littoral habitat, and productivity in a variety of flow conditions, from high spring flows to low low flows. Fish stranding, productivity, and riparian/littoral habitat can be affected and changed during a number of events throughout the year.	Response #4) will address cross-resource linkages and issues.
6.	Judy Neibauer (USFWS)	05/12/2020	Section 2.0 Study Plan Elements	"**2.0 STUDY PLAN ELEMENTS**" I found a great source that identifies what Study Guide Criteria should be addressed in these study plans. Maybe you have seen it, but here is the link… https://www.ferc.gov/industries/hydropower/gen-info/guidelines/guide-study-criteria.pdf …sorry if you already have discussed this.	City Light appreciates the input.
7.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.1 Study Goals and Objectives	"The goal of the Reservoir Fish Stranding and Trapping Risk Assessment Study is to assess the risk of native fish species stranding and trapping within the study area under normal Project operations." The goal should be to quantify the actual harm done to fish, not the risk of harm.	The purpose of the study is not to undertake an investigation of harm to fish due to reservoir water level fluctuations but to assess the risk of stranding and trapping due to such fluctuations at a level of detail appropriate to identify the potential need and scope of future measures to address reservoir stranding and trapping. Stranding and trapping are recognized mechanisms of potential harm at the outset, hence, the intent is to better understand the risks of stranding and trapping.
8.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.1 Study Goals and Objectives	"The goal of the Reservoir Fish Stranding and Trapping Risk Assessment Study is to assess the risk of native fish species stranding and trapping within the study area under normal Project	City Light is aware of only one such event and is completing a review of the circumstances and the appropriate BMPs to prevent a repeat. At this time, reservoir operations beyond those defined as "normal operations" in the study plan are not anticipated during the study period. City Light does not support artificially creating reservoir

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				operations[11].” Regarding footnote 1, how will drawdowns for maintenance or infrastructure testing be studied? Previous drawdowns for maintenance or infrastructure testing have resulted in substantial amounts of fish killed during each drawdown event, and these impacts need to be quantified. I personally observed thousands of dead stranded fish during a recent maintenance-related drawdown in Gorge Reservoir.	elevations which simulate larger drawdowns at the scale of maintenance or infrastructure testing given the significant impacts to the Project and the risk for fish mortality. However, the proposed plan has allocated resources to conduct sampling opportunistically should those conditions occur during the study period. Further, the risk assessment results from this study will likely inform efforts for fish recovery for future maintenance actions.
9.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.1 Study Goals and Objectives	“The goal of the Reservoir Fish Stranding and Trapping Risk Assessment Study is to assess the risk of native fish species stranding and trapping within the study area under normal Project operations.” NPS requests that either as part of this study or the Amphibian Study the impacts of reservoir drawdowns on amphibian communities be study.	Pools that are formed in drawdown zones will be assessed for special-status amphibians under the Amphibian Study. Incidental observations of amphibians will also be recorded if observed during field surveys under the Reservoir Fish Stranding and Trapping Risk Assessment Study in support of the Amphibian Study.
10.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.1 Study Goals and Objectives	“The goal of the Reservoir Fish Stranding and Trapping Risk Assessment Study is to assess the risk of native fish species stranding and trapping within the study area under normal Project operations.” What is the study area? Please describe. The study area should include the Ross in BC as well as the length of the Skagit River in BC that is influenced by Ross Reservoir elevations. McPhail documented char fry in distributary	Please refer to Section 2.5 for a description of the study area. City Light is currently exploring its abilities and obligations within the FERC process regarding any interactions with information sources in Canada.

[11] For purposes of this study, “normal operations” are defined as typical operations to support flood control, fish protection, recreation and power generation and does not include drawdowns for maintenance or infrastructure testing.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				channels of the Skagit during his investigations.	
11.	Brock Applegate (WDFW)	05/05/2020	Section 2.1 Study Goals and Objectives	"The goal of the Reservoir Fish Stranding and Trapping Risk Assessment Study is to assess the risk of native fish species stranding and trapping within the study area under normal Project operations." If you have planned maintenance and infrastructure testing, SCL should have the ability to avoid trapping and stranding or mitigate.	See Comment Response #8.
12.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.1 Study Goals and Objectives	"The goal of the Reservoir Fish Stranding and Trapping Risk Assessment Study is to assess the risk of native fish species stranding and trapping within the study area under normal Project operations." Please quantify what normal project operations are for each reservoir in terms of magnitude/amplitude, frequency, duration (in terms of hours), timing, and rate of change each reservoir drops on an average annual basis during the period of the current license. This should also include future opertational senarios that may be proposed as part o the new license including pumped storage. This peice of info should be included in the study plan. Please do not refer the reader to the PAD.	Please refer to Section 2.3 of the study plan for background information. Reservoir water level variations during the period since 2011 when the revised fisheries settlement agreement was adopted, will be analyzed as part of the study (see Section 2.6.2.3). The range of water levels experienced under normal operation has been clarified in Section 2.3.3 and 2.3.4. Future operational scenarios are unknown at this time. Analysis of potential scenarios is a part of the integrated environmental analysis noted in Comment Responses #4 and #5.
13.	Judy Neibauer (USFWS)	05/12/2020	Section 2.1 Study Goals and Objectives	"Native fish species within Project reservoirs include resident Rainbow Trout (*Oncorhynchus mykiss*), Bull Trout (*Salvelinus confluentus*) and Dolly Varden (*Salvelinus malma*)." Please consider other fish species that may provide a prey base. The study should look at any fish species stranded, including redside	The study is designed to ensure field sampling activities target periods of time when native species (not prey species such as non-native, introduced redside shiner) may be subject to stranding and trapping risk in reservoirs. However, during field sampling, data will be collected on all fish species encountered. There is no evidence indicating that the prey species

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				shiner, sculpin, etc. Expand the scope – Please include alluvial areas of adjacent reservoir tributaries where stranding could also occur during drawdown. What study do you have to look at for stranding downstream of dams. There may be areas downstream of dams that have reduced flow, when you are filling/holding water in reservoirs that affect fish and wildlife, riparian areas, and connectivity/refugia habitat. Please include in this study or add another study downstream.	base (e.g., redside shiner) is being negatively impacted by the Project. The areas of tributary junctions with Project reservoirs at full pool are considered within the study area since these areas can become dewatered during operations and are subject to stranding and trapping risk. Tributary reaches upstream of full pool are not included in this study. Regarding stranding downstream of dams, See Comment Response #1.
14.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.1 Study Goals and Objectives	"Native fish species within Project reservoirs include resident Rainbow Trout (*Oncorhynchus mykiss*), Bull Trout (*Salvelinus confluentus*) and Dolly Varden (*Salvelinus malma*)." We currently lack information about the distribution and timing of fish in the reservoirs. What sources of information will you use to fill this gap?	City Light concurs that periodicity information is currently limited, hence the referral to basic life history information as detailed by Quinn (2004). Sources of spatially and temporally incomplete information include: spawning ground survey, snorkel survey, and temperature monitoring data from tributaries and the Canadian mainstem. These data can be used to infer approximate fry emergence and outmigration timing of juveniles into the reservoirs. In addition, during 2020 reconnaissance, as described in Section 2.6.1, any observations of trapped or stranded fish will further refine periodicity with site specific information.
15.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.1 Study Goals and Objectives	"Specific objectives include:" These study objectives do not address productivity. To address productivity, some sort of primary or secondary productivity analysis needs to be conducted in conjunction with fish surveys.	The overall goal of this study is to estimate trapping and stranding risk due to reservoir operations. Conducting studies which quantify trophic dynamics is beyond the scope of the proposed study; which is looking at trapping and stranding risk. However, the ongoing Food Web study is quantifying trophic dynamics at the population scale which may be informative for

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
					assessing productivity. Also See Comment Response #7.
16.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.1 Study Goals and Objectives	"Specific objectives include:" The study objectives do not address the population-level impact. The study should consider the fish populations in each reservoir, and the risk to population viability and genetic structure.	See Comment Responses #4, #5, and #7.
17.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.1 Study Goals and Objectives	"Specific objectives include:" The objective below read more like goals. Objectives should have a quanitifable componnet.	City Light believes the terminology used in the Section 2.1 is appropriate. Quantifiable components of the objectives are described later in the study plan, for example under Section 2.6.2 for the desktop analysis.
18.	Brock Applegate (WDFW)	05/11/2020	Section 2.1 Study Goals and Objectives	I agree with Ashley. SCL should quantify the drawdown rate of the reservoir. SCL has listed a few goals instead of objectives. (See Comment #12 and #17)	Please refer to Section 2.6.1.3 of the study plan. Drawdown rates for each reservoir will be quantified as part of the desktop analysis.
19.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.1 Study Goals and Objectives	1st Bullet – Comment "Conduct a desktop analysis (using existing data and as needed, additional topobathymetric data) to identify areas where, the frequency with which, and the time periods when (using available fish life-stage periodicity information) there is a risk of stranding and trapping of native fish species in the study area under normal Project operations;" Expanding the desktop analysis to include all Project operations, even ones outside of "normal" is needed to fully understand the impact of the Project on salmonids during drawdowns.	See Comment Response #8 and #12

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20.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.1 Study Goals and Objectives	2nd Bullet – Comment "Undertake field surveys of fish stranding and trapping at selected areas within the study area, to field validate results of the desktop analysis; and" The field surveys should do more than validate the existence of stranding risk. Rather, they should quantify the number of fish killed during the various project-related reservoir fluctuations.	Please refer to Section 2.6.3 of the study plan. The number and condition of fish by species and lifestage will be quantified at reservoir stranding and trapping areas sampled during field surveys.
21.	Brock Applegate (WDFW)	05/11/2020	Section 2.1 Study Goals and Objectives	"Top Objective: Find Reservoir Drawdown rates and minimum reservoir elevations that avoid trapping and stranding of native fish for all three reservoirs" We already know that we have a problem in Gorge Lake, so why not find the drawdown rate in that reservoir. Does SCL have other mitigation proposals for Gorge Reservoir?	These edits have not been accepted. See Comment Responses #4 and #5. Stranding and trapping information collected during the 2019 Gorge Lake maintenance drawdown will be evaluated as part of the integrated environmental analysis (See Comment Response #4) and will support the development of measures to address Project reservoir stranding and trapping in the new FERC license.
22.	Judy Neibauer (USFWS)	05/12/2020	Section 2.1 Study Goals and Objectives	"Top Objective: Find Reservoir Drawdown rates and minimum reservoir elevations that avoid trapping and stranding of native fish for all three reservoirs" Include areas in the study to look at when flows are high, and water levels drop and when water levels are low, and stranding may occur in low rain/snow drought types years…….	Please refer to Section 2.5 for a description of the study area. The ILP provides the opportunity for comment on the final report submitted in the ISR and discussed at the ISR meeting; if any components of the study goals and objectives are not met in the first year, or there are anomalous conditions, any party may propose additional work or request additional study per FERC ILP regulations.

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23.	Brock Applegate (WDFW)	05/11/2020	Section 2.1 Study Goals and Objectives	2nd Bullet – Red Text Edits and Comment "Undertake field surveys of fish stranding and trapping at selected areas within the study area, to field validate results of the desktop analysis and find a safte drawdown rate; and" Will you validate that you have fish mortality? How will you validate the desktop analysis?	These edits have not been accepted. See Comment Responses #4 and #5. Field sampling will identify and enumerate condition, species (if possible) and life stages of stranded and trapped fish. These data will be used to validate and if necessary, update the desktop analysis tool.
24.	Judy Neibauer (USFWS)	05/12/2020	Section 2.1 Study Goals and Objectives	"Results and/or tools from this study may be used to evaluate Project effects in the license application and arrive at a drawdown rates, and a refill and spill plans, to mitigate those effects." There may be stranding, flooding, due to high or low flows, there may be mitigation needed on both ends.	Thank you for your comment. See Comment Responses #4 and #5.
25.	Brock Applegate (WDFW)	05/11/2020	Section 2.1 Study Goals and Objectives	"Results and/or tools from this study may be used to evaluate Project effects in the license application and arrive at a drawdown rates, and a refill and spill plans, to mitigate those effects." Why not complete this task while SCL has crews in the field?	These comments have not been accepted. See Comment Responses #4 and #5. Evaluation of Project effects and the development of PMEs to address effects is a subsequent step to the study program.
26.	Judy Neibauer (USFWS)	05/12/2020	Section 2.2 Resource Management Goals	**"2.2 Resource Management Goals"** According to guidelines for the ILP…this section should also include information about public input considerations…maybe you have this somewhere already… see-https://www.ferc.gov/industries/hydropower/gen-info/guidelines/guide-study-criteria.pdf	City Light appreciates the input. Also, it is worth noting that the criteria pertain to "public interest," not public "input."
27.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.2 Resource	**"2.2 Resource Management Goals"**	Thank you for your comment. City Light identifies its goal in Section 2.2. The second part of this section is intended to represent agency

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			Management Goals	BCHydro includes a series of management questions as part of their studies. I think working on a mutually agreed to set of questions would help to clarify the scope and objectives for the study. See: https://www.bchydro.com/content/dam/BCHydro/customer-portal/documents/corporate/environment-sustainability/water-use-planning/southern-interior/clbmon-4-yr2-2018-10-29.pdf	management goals and invites LP input. If NPS has specific resource management goals it believes are relevant for inclusion, please provide them to City Light for consideration.
28.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.2 Resource Management Goals	"City Light's goal for the proposed study is to improve understanding of the factors influencing fish stranding and trapping risk within the study area under normal Project operations." Goals should include quantifying the actual harm done to fish populations. This should include all operations, including those for maintenance and infrastructure.	See Comment Responses #7 and #8.
29.	Brock Applegate (WDFW)	05/11/2020	Section 2.2 Resource Management Goals	"City Light's goal for the proposed study is to improve understanding of the factors influencing fish stranding and trapping risk within the study area under normal Project operations." The factors include the rate of drawdown and the elevation of the reservoir and whether SCL observes fish trapping and stranding during the rates and elevation at problem spots identified by the desktop analysis.	Thank you for your comment.
30.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.3 Background and Existing Information	"No stranding or trapping information is available for any of the reservoirs under normal Project operations." Please define what you are considering standing	Please refer to Section 2.6 of this study plan for more information.

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				and trapping. You requested this for the NPS Gorge Stranding report.	
31.	Judy Neibauer (USFWS)	05/12/2020	Section 2.3 Background and Existing Information	"No stranding or trapping information is available for any of the reservoirs under normal Project operations." See my comment above about stranding below dams, Include areas below dams in this study or design an additional study.	See Comment Response #1.
32.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.3 Background and Existing Information	"No stranding or trapping information is available for any of the reservoirs under normal Project operations." Concur. It is unclear if SCL intendeds to conduct stranding and entrapment surveys below Gorge Dam as part of the voluntary collaborative process. If SCL intends to do this noting that here would be appropriate.	See Comment Response #1.
33.	Judy Neibauer (USFWS)	05/12/2020	Section 2.3 Background and Existing Information	"No stranding or trapping information is available for any of the reservoirs under normal Project operations." Describe what are normal operations here.	Please refer to footnote in Section 2.3 for this study's definition of normal Project operations.
34.	Brock Applegate (WDFW)	05/11/2020	Section 2.3 Background and Existing Information	"Project operations may strand or trap native fish in Ross, Diablo, or Gorge lakes due to reservoir drawdowns and/or surface elevation fluctuations under a variety of flows. Reservoir drawdowns or fluctuations occur during normal operations to support flood control, fish protection, recreation, and power generation." Unless SCL did not operate under normal operating conditions, SCL has already stranded or trapped fish in Gorge Reservoir.	Thank you for your comment. The event described is not considered normal operations as defined in this study plan. See Comment Response #8.

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35.	Judy Neibauer (USFWS)	05/12/2020	Section 2.3 Background and Existing Information	"Project operations may strand or trap native fish in Ross, Diablo, or Gorge lakes due to reservoir drawdowns and/or surface elevation fluctuations under a variety of flows." Can you list those reservoir elevations where stranding may occur, from existing information?	Reservoir elevations where stranding or trapping may occur will be determined from analysis of topobathymetric data as described in Section 2.6.2.2 and subject to validation in the field surveys as described in Section 2.6.3. We cannot list the reservoir elevations where stranding and trapping may occur at present, as that is the focus of the study—to define those elevations (and associated reservoir locations) where risks are elevated.
36.	Brock Applegate (WDFW)	05/11/2020	Section 2.3 Background and Existing Information	"Per current licensing requirements, occasional assessments of fish stranding and trapping have occurred in Gorge and Diablo lakes (by City Light and LPs) during scheduled drawdowns outside of normal operations for maintenance activities and infrastructure testing (e.g., spillways, etc.) but no information exists for Ross Lake under these circumstances." WDFW and other LPs will also want to know of stranding and trapping outside of normal operations as well. From an effects analysis, SCL has impacted fish with either scenario, normal or not normal operations.	See Comment Responses #4, #5, and #8.
37.	Judy Neibauer (USFWS)	05/12/2020	Section 2.3 Background and Existing Information	"Per current licensing requirements, occasional assessments of fish stranding and trapping have occurred in Gorge and Diablo lakes (by City Light and LPs) during scheduled drawdowns outside of normal operations for maintenance activities and infrastructure testing (e.g., spillways, etc.) but no information exists for Ross Lake under these circumstances." Agreed. I would also like to know about all species collected and harmed in these events, how many times it happens, and across what flows does this occur.	See Comment Responses #4, #5, #8, and #20.

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				(See Comment #36)	
38.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.3 Background and Existing Information	"Per current licensing requirements, occasional assessments of fish stranding and trapping have occurred in Gorge and Diablo lakes (by City Light and LPs) during scheduled drawdowns outside of normal operations for maintenance activities and infrastructure testing (e.g., spillways, etc.) but no information exists for Ross Lake under these circumstances." Lost lake assessments?	Per the white paper prepared with data collected by City Light during 2016 and 2017 it does not appear that fish isolated in Lost Lake are at risk of mortality. Based on the results of that assessment, it is unlikely that additional data collection at Lost Lake would change those results and exposure of Lost Lake is not anticipated during the proposed study period. The NPS also collected data at Lost Lake. These data have not yet been made available to the FCC/NCC and therefore were not included in the white paper.
39.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3 Background and Existing Information	"In April 2019, drawdown of Gorge Lake to about 830 feet North American Vertical Datum of 1988 (NAVD 88)[2] (823.49 feet CoSD) for spill gate testing resulted in stranding and trapping of native fish in the vicinity of the State Route (SR) 20 causeway crossing of Gorge Lake. A report on this stranding and trapping event is currently under preparation by City Light." Clarify whether the April 2019 drawdown was for maintenance, and whether the study proposes to examine these types of events.	The April 2019 drawdown of Gorge Lake was for FERC-mandated gate testing. The study proposes to investigate trapping and stranding under "normal Project operations" (see footnote 1, Section 2.1) and which does not include drawdown for testing. Also See Comment Response #8.
40.	Judy Neibauer (USFWS)	05/12/2020	Section 2.3 Background and Existing Information	"Native fish species in the Project reservoirs include Rainbow Trout, Bull Trout, and Dolly Varden. Bull Trout are listed as "threatened" under the Endangered Species Act (ESA)." I am interested in any potential prey species as well…not just the listed ESA species.	See Comment Response #13.

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41.	Ashley Rawhouser (NPS)	05/13/2020	Section 2.3 Background and Existing Information	"Native fish species in the Project reservoirs include Rainbow Trout, Bull Trout, and Dolly Varden. Bull Trout are listed as "threatened" under the Endangered Species Act (ESA)." Concur. All fish species should be included. (See Comment #40)	See Comment Response #13.
42.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.3 Background and Existing Information	"Lifestage information (e.g., fry, juvenile, adult, etc.) of each native species and timing of their presence in reservoirs during periods of Project operations where there is a risk of trapping or stranding are discussed in more detail in Section 2.6.1.4 of this study plan." Could not find this section in the document. Where is section 2.6.1.4?	Section 2.6.2.4 is located on page 2-19 of the study plan.
43.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3.2 Ross Lake	"**Figure 2.3-1 Ross Lake daily water surface elevations (2010-2018).**" Show this data for the entire current license period.	The period 2010-2018 is representative of Ross Lake seasonal water level variations over the current license period and covers the period since adoption of the revised fisheries settlement agreement in 2011 proposed for analysis. Thus, City Light views the period of record proposed as applicable and appropriate because it represents the most current operational regime following the 2011 FSA. The use of earlier data would not be particularly germane to understanding risks of the current operational regime. Water surface elevation data for the full period of record can be readily seen on the USGS NWIS website.
44.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3.3 Diablo Lake	"The lake typically fluctuates 4 to 5 feet daily for a typical operating range between about 1,206 and 1,211 feet NAVD 88 (between about 1,199.64 and 1,204.64 feet CoSD), although drawdowns of 10 to 12 feet occur occasionally	We have not determined the number of times Diablo Lake water levels fell below 1,206 ft NAVD88, but water levels were below 1,206 ft NAVD88 approximately 8% of the time in the period from January 2011 through December

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				as needed for construction projects or maintenance." How often do drawdowns below the typical operating range occur?	2018. In the same period, there were a total of 8 instances where the lake level dropped below 1,202 ft NAVD88 for one hour or more. Also See Comment Response #45.
45.	Judy Neibauer (USFWS)	05/12/2020	Section 2.3.3 Diablo Lake	"A sample of hourly water surface elevation data for April 2014 through June 2014 is shown in Figure 2.3-2." Can you apply bathymetry to these 4-5 feet fluctuations to see if there are certain areas that pop out as key stranding areas? How often does construction and maintenance flows happen? Can you also use bathometry to show where stranding, key productivity issues, and littoral issues may occur with the 10 -12 foot drops. I imagine that during the maintenance flows, there could be stranding downstream once flows stop or are reduced. Similar question as above, can you apply stream bed elevation models to look at where key stranding areas might be below the dams. Please include areas below the dams in this study or another study to look at stranding/ riparian/ and productivity issues down there.	Bathymetric data along the Diablo Lake shoreline will be developed as described in Section 2.6.2.1. Analysis of bathymetric data to identify potential stranding areas will be performed as described in Section 2.6.2.2. Note that because of limited LiDAR coverage of Diablo Lake shoreline, LiDAR data will be supplemented by bathymetric data collected along the shoreline by sonar. Data to be collected will allow analysis of bathymetry down to elevations of 1,200 feet NAVD88 or lower in most places. This would allow analysis of stranding and trapping risk for water level fluctuations of the order of 10 to 12 feet. The Diablo Lake water level has dropped below 1,200 feet NAVD88 only once since records of hourly water levels began in 1997 - the lake level dropped to approximately 1199.4 feet NAVD88 in 2017. Productivity and riparian habitat issues will not be investigated in this study. Regarding stranding below the dams, please See Comment Response #1.
46.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.3.4 Gorge Lake	Upper Skagit Indian Tribe would like an assessment of stranding and trapping in by-pass reach under existing conditions. Spill can trap and isolate fish species, the lower 0.6 miles in the by-pass are hydrologically connected to mainstem but daily/hourly ramping is currently unknown- so extent of mortality here is a data	See Comment Response #1.

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				gap.	
47.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.3.4 Gorge Lake	"Gorge Lake typically fluctuates 3 to 5 feet daily for a typical operating range between about 876 and 880 feet NAVD 88 (between about 869.49 and 873.49 feet CoSD) , but drawdowns of 50 feet are occasionally needed for spill gate maintenance or inspection." How often do drawdowns below the typical operating range occur?	We have not determined the number of times Gorge Lake water levels fell below 876 ft NAVD88, but water levels were below 876 ft NAVD88 approximately 10% of the time in the period from January 2011 through December 2018. In the same period, there were a total of 6 instances where the lake level dropped below 870 ft NAVD88 for one hour or more. Note that the study plan has been revised to include a complete bathymetric survey of Gorge Lake, down to elevations of approximately 800 ft NAVD88, which would encompass the lowest water levels seen in the proposed period of analysis (2011 – present), including those associated with maintenance drawdowns.
48.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.3.4 Gorge Lake	"A sample of hourly water surface elevation data for April 2014 through June 2014 is shown in Figure 2.3-3." Actions are taken to prepare for large flood events what is the typical draw down of Gorge in preparation of these significant storms?	Drawdown of Gorge Lake in anticipation of severe storms varies. The pool level was drawn down to approximately 866.5 ft NAVD88 in anticipation of severe storms in November 2015. More recently such drawdown has been restricted to an elevation of approximately 871.5 ft NAVD88.
49.	Judy Neibauer (USFWS)	05/12/2020	Section 2.3.4 Gorge Lake	"A sample of hourly water surface elevation data for April 2014 through June 2014 is shown in Figure 2.3-3." See comment above about using bathometry to help located sample sites or develop information for key stranding areas, issues with productivity, and littoral habitat.	Shoreline and lake-bed topography will be developed from a combination of standard and Green LiDAR and data from bathymetric surveys to identify areas of stranding and trapping risk as described in Section 2.6.2.1. Productivity and littoral habitat issues will not be investigated in this study.
50.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.3.4 Gorge Lake	"City Light's current monthly operations plan states that if the water surface elevation of Gorge Lake is drawn down below 867 feet CoSD (873.51 feet NAVD 88), City Light's Project	Thank you for your comment. Development of future measures to address the potential for stranding and trapping in Project reservoirs is a subsequent phase in the ILP process (See

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				Fish Biologists will be contacted within 48 hours to conduct a stranding/entrapment assessment at known locations where stranding may occur." Seems completely inadequate for monitoring impacts to fishery resources, notification should be made prior to these actions.	Comment Responses #4 and #5). Note also that the monthly operations plan sets the minimum requirement and depending upon seasonal risk and other factors, City Light responds/puts in place preventative measures as circumstances allow. City Light is open to discussion regarding modification of these procedures.
51.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.3.5 Existing Data	"**2.3.5 Existing Data**" Describe the resolutaion and accuracy of these data.	The 2018 standard LiDAR has a reported absolute non-vegetated vertical accuracy of 0.2 feet with 95% confidence and a resolution of 8 pulses/square meter. The 2018 Green LiDAR has a reported absolute accuracy of 0.4 feet with 95% confidence for bathymetric (i.e. submerged) surfaces and a resolution of 6 pulses/square meter. The 2017 standard LiDAR has an absolute non-vegetated vertical accuracy of 0.3 feet with 95% confidence and a resolution of 8 pulses/square meter. Information on vertical accuracy will be included in the text of the study plan.
52.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.3.5 Existing Data	"More detailed hourly data are available from City Light. Given the time scales over which the reservoir water surface elevations vary, daily data are suitable for analysis of Ross Lake water surface elevations, while hourly data are necessary for analysis of Gorge and Diablo lakes water surface elevations." To allow a comparision of the risk among all of the reservoirs hourly data should be used for the entire project. Even though the magnitude of hourly flucuations is likely lower in Ross (than in GOrge or Diablo) Ross has a much larger area of low gradient habitat that is impacted my smaller changes in reservoir elevation changes.	Hourly Ross Lake fluctuations will be checked to ensure that daily elevation data adequately identify stranding and trapping risk. We note also that hourly water level data from Ross often show high variability because of the effects of wind-driven waves. This noise is less evident in the daily record.

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53.	Brock Applegate (WDFW)	05/11/2020	Section 2.3.5 Existing Data	I agree with Ashley. SCL will need hourly rate of change for Ross Reservoir to describe drawdown rates that cause stranding and trapping. Why would SCL want to compare the reservoirs with different units of measurements? (See Comment #52)	See Comment Response #52.
54.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.3.5 Existing Data	"Summaries of monthly and annual maximum, average and minimum water surface elevations for Ross Lake, Diablo Lake, and Gorge Lake are provided in Table 3.5-1, Table 3.5-3 and Table 3.5-6 of the PAD, respectively." The study plans should stand alone. Please include pertenent information in this document.	See Comment Response #2.
55.	Judy Neibauer (USFWS)	05/12/2020	Section 2.3.5 Existing Data	"Summaries of monthly and annual maximum, average and minimum water surface elevations for Ross Lake, Diablo Lake, and Gorge Lake are provided in Table 3.5-1, Table 3.5-3 and Table 3.5-6 of the PAD, respectively." Expand scope-You will need to look at areas downstream for potential stranding/productivity/riparian issues….separate study? Add here? Or do you already have existing information.	See Comment Responses #1, #4, and #5.
56.	Judy Neibauer (USFWS)	05/12/2020	Section 2.4 Project Operations and Effects on Resources	"**2.4 Project Operations and Effects on Resources**" Can you link to issues and how the study goals and objective will address data gaps here.	See Comment Responses #4 and #5.
57.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.4 Project Operations and	"Project operations may strand or trap native fish in Ross, Diablo, or Gorge lakes due to reservoir drawdowns and/or surface elevation fluctuations."	Thank you for your comment. For the purposes of this assessment, stranding denotes mortality. Trapping, however, may not result in mortality as other factors may play a role in fish surviving

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			Effects on Resources	Causing mortality	a particular event including but not limited to size and depth of trapping pool and amount of time a pool exists before potentially being reinundated.
58.	Judy Neibauer (USFWS)	05/12/2020	Section 2.4 Project Operations and Effects on Resources	"Project operations may strand or trap native fish in Ross, Diablo, or Gorge lakes and associated alluvial areas of adjacent tributaries due to reservoir drawdowns and/or surface elevation fluctuations." And downstream in riverine areas	See Comment Response #1.
59.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.4 Project Operations and Effects on Resources	"Project operations may strand or trap native fish in Ross, Diablo, or Gorge lakes and associated alluvial areas of adjacent tributaries due to reservoir drawdowns and/or surface elevation fluctuations." See previous copmment.	See Comment Response #1.
60.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.4 Project Operations and Effects on Resources	"Reservoir drawdowns or fluctuations occur to support flood control, fish protection, recreation and power generation." Downstream	See Comment Response #1.
61.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.4 Project Operations and Effects on Resources	"While reservoir drawdowns are also made for maintenance or FERC-required infrastructure testing, these operations occur less frequently, are not anticipated to occur during the study period and are, therefore, not included in the definition of normal Project operations for the purposes of this study." These should be included in analysis as they can be an additional source of stranding mortality.	See Comment Response #8.

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62.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.4 Project Operations and Effects on Resources	"While reservoir drawdowns are also made for maintenance or FERC-required infrastructure testing, these operations occur less frequently, are not anticipated to occur during the study period and are, therefore, not included in the definition of normal Project operations for the purposes of this study." This is not adequate reason to exclude from the study. If these operations will occur during the next license period, the impacts need to be understood.	See Comment Response #8.
63.	Brock Applegate (WDFW)	05/05/2020	Section 2.4 Project Operations and Effects on Resources	"While reservoir drawdowns are also made for maintenance or FERC-required infrastructure testing, these operations occur less frequently, are not anticipated to occur during the study period and are, therefore, not included in the definition of normal Project operations for the purposes of this study." SCL should focus on drawdown rate and not why they will drawdown the reservoir. WDFW recommends that SCL find rates change of drawdown and elevations of reservoirs that SCL will strand and trap fish.	Identification of the drawdown rates of the reservoirs, within normal Project operations as defined in the study plan, and the associated reservoir elevations where there is stranding and trapping risk is a component of the study. Please see Section 2.6.2.3. Thank you for the recommendation.
64.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.5 Study Area	"**2.5 Study Area**" Issue Form also requested an evaluation of the current downstream (Below Gorge Dam and Powerhouse) stranding methodology, to better quantify downstream impacts to listed species. Is SCL not considering this area of study? Upper Skagit Indian Tribe is requesting downstream river stranding and trapping be reevaluated as part of this study. See comments about additional request for downstream area and by-	See Comment Response #1.

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				pass reach.	
65.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.5 Study Area	"The study area includes Ross, Diablo, and Gorge lakes at elevations below which stranding and trapping risks could be elevated, under normal Project operations (Figure 2.5-1)." Include all reservoir elevations from full pool to minimum pool. Trapping and stranding risk could be elevated anywhere that project operations affect reservoir elevation.	See Comment Response #8.
66.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.5 Study Area	"The study area includes Ross, Diablo, and Gorge lakes at elevations below which stranding and trapping risks could be elevated, under normal Project operations (Figure 2.5-1)." More detailed description needed. Are you going to assess stranding up Big Beaer Ck? The Canadian portion of the reservoir needs to be included. Early sudy by McPhail documented char in distriburay channels of the Skagit River near Hozomeen. Additionally, this is an area where the frequency of dewatering is likely to be very high given the gradient of the reservoir bed in this location.	Inundated areas of tributary mouths below full pool reservoir elevations are included in the study area. However, upstream portions of tributaries outside of the reservoirs influence on stranding and trapping are not included. Regarding the inclusion of the Canadian portion of the reservoir, See Comment Response #10.
67.	Judy Neibauer (USFWS)	05/12/2020	Section 2.5 Study Area	Agreed. Also see my comments above to include alluvial areas or inundated areas of tributaries where stranding can occur. Some areas that are backed up into tributaries may be outside of the FERC boundary. Link to the geomphology studies to determine where the upper edge of influence is in adjacent tributaries. As well, areas below the dams should be included. (See Comment #66)	See Comment Responses #1, #4, #5, and #66.

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68.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.5 Study Area	"**Figure 2.5-1 Overview of study area**" Have new lidar for Canadian section of Skagit, the interface between Skagit river and Reservoir should be assessed through new or existing trans-boundary management agreements or partnerships.	See Comment Response #10. The 2018 LiDAR coverage of Ross Lake extends into Canada and covers all areas of Ross Lake below its normal maximum water surface elevation. Please see Figure 2.6-1.
69.	Brock Applegate (WDFW)	05/05/2020	Section 2.6 Methodology	"The study includes two phases: (1) a desktop analysis of the study area to identify potential areas of fish stranding and trapping risk; and (2) field surveys at selected areas to validate results of the desktop analysis and to update the desktop analysis, as necessary. (3) Identify drawdown rate for each reservoir that avoids stranding and reservoir elevations that avoid trapping."	See Comment Responses #4 and #5. Please note that analysis of actual drawdown rates under normal Project operations is a component of the desktop analysis. Drawdown rates preceding field surveys will also be determined. Section 2.6.4 will be edited to include reporting of drawdown rates.
70.	Brian Lanouette (Upper Skagit Indian Tribe)	05/11/2020	Section 2.6.1 Desktop Analysis	"**2.6.1 Desktop Analysis**" Desktop analysis should also include analysis of passage (ie. Low/no flow passage barriers) to tributary spawning locations, particularly as native char migrate and spawn during the drawdown period. OR covered in reservoir sediment study	City Light currently mitigates for potential effects on fish migration/passage resulting from sediment and woody debris deposition in Project reservoirs, and intends to continue the effort. The 1991 Settlement Agreement stipulates that City Light is to survey for and remove transitory barriers to spawning migration in tributaries to Project reservoirs. City Light has agreed to expand the annual barrier surveys and barrier removal efforts beginning in 2020 following NCC approval.
71.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.6.1 Desktop Analysis	"The desktop analysis includes assembly and analysis of DEMs of reservoir shoreline and bed topography to inventory potential stranding and trapping areas, an analysis of reservoir water surface elevation data to document the frequency and period of time over which trapping pools are formed and areas of low slope terrain are exposed in drawdown zones, and an analysis of native species lifestage and periodicity information to identify when	See Comment Response #14.

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				lifestages susceptible to stranding and trapping risk under normal operations may be present in the study area. The lifestage periodicity analysis may also inform appropriate periods for field sampling." This is a key component of the study and more detail is needed. See previous comment of lack of info on distribution and timing of fish in the reservoirs. Please cite ans summarize the inormation you are planning to use.	
72.	Brock Applegate (WDFW)	05/11/2020	Section 2.6.1 Desktop Analysis	I agree with Ashley. SCL may need to conduct other studies to understand fish distribution and timing in the reservoirs. (See Comment #71)	See Comment Response #14.
73.	Judy Neibauer (USFWS)	05/12/2020	Section 2.6.1 Desktop Analysis	I also agree (See Comment #71)	See Comment Response #14.
74.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.6.1 Desktop Analysis	"The desktop analysis includes assembly and analysis of DEMs of reservoir shoreline and bed topography to inventory potential stranding and trapping areas, an analysis of reservoir water surface elevation data to document the frequency and period of time over which trapping pools are formed and areas of low slope terrain are exposed in drawdown zones, and an analysis of native species lifestage and periodicity information to identify when lifestages susceptible to stranding and trapping risk under normal operations may be present in the study area. The lifestage periodicity analysis may also inform appropriate periods for field sampling." More detail is needed, This should be written so	See Comment Response #14.

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				that the work could be replicated by somebody unfamiliar with project.	
75.	Judy Neibauer (USFWS)	05/12/2020	Section 2.6.1 Desktop Analysis	I agree, esp. since the license will be for a long term and we may not be around to work on it then… (See Comment #74)	See Comment Response #74.
76.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.1.1 Inventory of Areas Presenting Stranding and Trapping Risk	"2.6.1.1 Inventory of Areas Presenting Stranding and Trapping Risk" Study should assess the entire drawdown zone. Comments on multiple previous study plans expressed the need for full bathymetric coverage in the three reservoirs. Such data would be relevant here.	See Comment Response #8.
77.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.6.1.1 Inventory of Areas Presenting Stranding and Trapping Risk	"Developing an inventory of areas presenting a stranding and trapping risk will involve assembling a DEM of each of the three reservoirs and then analyzing the DEMs to identify and quantify areas with gradient profiles (see Section 2.6.1.2 in this study plan) indicating stranding risk and areas draining to isolated pools indicating trapping risk." Section 2 is blank.	Section 2.6.2.2 is located on page 2-18 of the study plan.
78.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.1.1 Inventory of Areas Presenting Stranding and Trapping Risk	"**Figure 2.6-1 Extents of 2018 LiDAR of Ross Lake**" How will the study address tributaries not covered by the 2018 lidar, such as Beaver Creek?	See Comment Response #66. The 2018 LiDAR covers the area where Beaver Creek enters Ross Lake below the Ross Lake normal maximum water surface elevation. The study is intended to assess stranding and trapping in Ross Lake and does not extend to tributaries above the lake's normal maximum water surface elevation.

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79.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.1.1 Inventory of Areas Presenting Stranding and Trapping Risk	"**Diablo Lake DEM**" With the exception of Thunder Arm, the shoreline of Diablo Lake is relatively steep and the potential for stranding and trapping outside Thunder Arm is likely low. This needs to be confirmed with topobathymetric data collection and field verification.	Agreed. Topobathymetric data of the Diablo Lake shoreline will be collected. The description of shoreline bathymetric data collection efforts at Diablo Lake will be revised. See Comment Response #45.
80.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.1.1 Inventory of Areas Presenting Stranding and Trapping Risk	"**Gorge Lake DEM**" "Any areas of the riverbed not colored in dark blue on Figure 2.6-5 are not quantifiable with the available LiDAR." Study should assess the entire drawdown zone. Comments on multiple previous study plans expressed the need for full bathymetric coverage in the three reservoirs. Such data would be relevant here.	See Comment Response #8. The study plan will be revised to include bathymetric survey of Gorge Lake.
81.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.1.1 Inventory of Areas Presenting Stranding and Trapping Risk	"**Gorge Lake DEM**" "From review of the available Standard and Green LiDAR it appears that topographic data to support the desktop analysis are available for essentially all areas within the normal operating range of Gorge Lake plus additional areas of known trapping risk in the vicinity of the SR 20 crossing." These areas are known to cause fish mortality because they are easily accessible. Within a short walk from SR20 or the Gorge boat ramp, thousands of stranded dead fish have been observed during previous maintenance	Comment acknowledged. The intent of the study is to assess stranding and trapping risk (including mortality where observed during field sampling) in less easily observable locations.

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				drawdowns. The study needs to identify mortality that occurs in less easily observable places within the reservoirs.	
82.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.6.1.2 Analysis of DEMs for Stranding and Trapping Risk	"Evaluation of potential stranding and trapping risk in the study area will be performed with standard GIS tools. Terrain slopes will be computed for each DEM cell (likely 3-foot square cells) and then labeled as having a slope less than 4 percent, between 4 percent and 6 percent, and greater than 6 percent." This is pretty vague. The study plan should provide enought detail for all methods so that an uniformed outside party could replicate and verify the study.	GIS analysis will be conducted primarily using the Spatial Analyst tool set. Text has been added to the study plan.
83.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.6.1.2 Analysis of DEMs for Stranding and Trapping Risk	"Evaluation of potential stranding and trapping risk in the study area will be performed with standard GIS tools. Terrain slopes will be computed for each DEM cell (likely 3-foot square cells) and then labeled as having a slope less than 4 percent, between 4 percent and 6 percent, and greater than 6 percent." This will miss a considerable amount of high risk habitat and greatly underestimate the amount of habitat that poses a risk.	It is not clear why the proposed approach relying on 3-foot square DEM cells to evaluate slope will "miss a considerable amount of high risk habitat". Three foot square DEM cells are actually quite small at the physical scale of the Project reservoirs, and GIS analysis of the DEM should pick up the great majority of low gradient stranding areas and a substantial number of potential trapping area depressions from which to gage risks. It is acknowledged that identification of small depressions such as tree wells via GIS analysis presents a challenge. The significance of tree wells or other small depressions as a trapping risk and the ability to identify those depressions will be assessed during the 2020 reconnaissance described in Section 2.6.1 and the approach to analysis adjusted accordingly as necessary.
84.	Judy Neibauer (USFWS)	05/12/2020	Section 2.6.1.2 Analysis of DEMs for	Agreed. (See Comment #83)	See Comment Response #83.

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			Stranding and Trapping Risk		
85.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.1.2 Analysis of DEMs for Stranding and Trapping Risk	"Cells whose slope is inconsistent with a sufficient number of neighboring cells will be aggregated to eliminate overly granular slope classification and remain true to the purpose of this analysis which is to identify areas of low slope presenting a stranding risk." This needs to be field-verified. The analysis risks missing small isolated stranding pools, which cumulatively may create substantial harm.	The results of the desktop analysis will be field-verified.
86.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.6.1.2 Analysis of DEMs for Stranding and Trapping Risk	"Sinks consist of spatially connected cells surrounded by a ring of higher elevation cells that hold water to a minimum depth of 12 inches." This scale (12") is likely to greatly underestimate "sink" habitat.	The 12-inch minimum depth is a conservative estimate of minimum depth for which sinks could be reliably identified from LiDAR considering LiDAR accuracy (See Comment Response #51) and ground conditions. Field verification of LiDAR analysis will be conducted during the study and may allow use of a smaller minimum depth to identify sinks. Sinks with lower "rims" will generally be classified by the GIS analysis as low slope terrain presenting a stranding rather than trapping risk. There may therefore be some misclassification of trapping and stranding.
87.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.6.1.2 Analysis of DEMs for Stranding and Trapping Risk	"To identify trapping hazards, the lake shoreline and lake bed DEMs will be queried for isolated pools, or "sinks" in GIS terminology. Sinks consist of spatially connected cells surrounded by a ring of higher elevation cells that hold water to a minimum depth of 12 inches." Is this deep enough to ensure stranding mortality will not occur?	See Comment Response #86. Analysis for "sinks" is an approach to identify trapping hazards, not stranding hazards as identified in the comment.

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88.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.1.2 Analysis of DEMs for Stranding and Trapping Risk	"To identify trapping hazards, the lake shoreline and lake bed DEMs will be queried for isolated pools, or "sinks" in GIS terminology. Sinks consist of spatially connected cells surrounded by a ring of higher elevation cells that hold water to a minimum depth of 12 inches." Why is there a depth minimum? Small pools with depth less than 12 inches can strand fish, and these may create a substantial cumulative harm.	See Comment Response #86.
89.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.1.2 Analysis of DEMs for Stranding and Trapping Risk	"Given the resolution of the underlying LiDAR data, a minimum sink area of 108 square feet will be assumed for the purposes of identifying and quantifying sinks. This would represent 12 contiguous 3-foot square cells in the DEM." This needs to be field-verified. The analysis risks missing small isolated stranding pools, which cumulatively may create substantial harm.	See Comment Response #86.
90.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.6.1.2 Analysis of DEMs for Stranding and Trapping Risk	"The separate maps of low slope terrain and isolated pools or sinks will be overlaid to identify the areas with the highest potential for fish stranding or trapping for a given reservoir water surface elevation." Please simply and clearly state the minimum surface area and depths of the various stnading habitats you anticipate being able to detect and map with the LiDAR and GIS analysis.	We expect to be able to identify low gradient areas presenting a potential stranding risk as small as 9 square feet (i.e. on the scale of a single 3-foot by 3-foor DEM cell). Considering ground conditions and LiDAR accuracy, we also expect to be able to reliably identify areas representing a trapping risk as small as 108 square feet (representing 12 contiguous DEM cells) and having a minimum depth of 12 inches. Field verification of LiDAR analysis will be conducted during the study and may allow identification of sinks with smaller minimum areas and smaller minimum depths. Please also See Comment Response #86.

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91.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.6.1.3 Analysis of Reservoir Drawdown	"2.6.1.3 Analysis of Reservoir Drawdown" Please desribe the quantifiable atrributes of the drawdowns you are ascribing risk to.	Drawdown for each reservoir will be quantified by rate of drawdown (inches/hour), classified by time of day and month or season.
92.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.6.1.3 Analysis of Reservoir Drawdown	"Actual trapping and stranding risk will be determined by the frequency with which isolated trapping pools are formed and the frequency with which low gradient stranding areas become exposed." More detail is needed. How will this be calculated? How will risk be ascribed?	Frequency of formation of trapping pools or exposure of low gradient areas will be determined from analysis of variation in hourly (or daily for Ross Lake) water levels as described in Section 2.6.2.3.
93.	Brock Applegate (WDFW)	05/11/2020	Section 2.6.1.3 Analysis of Reservoir Drawdown	"The reservoir elevation data will also be analyzed to characterize reservoir drawdown rates." Will SCL conduct surveys in the reservoir to confirm the drawdown rates?	Reservoir drawdown rates will be determined from the water level data routinely collected, and validated by the USGS, at Project reservoirs. Field surveys to confirm drawdown rates are not proposed at this time since data verification is already routinely conducted.
94.	Judy Neibauer (USFWS)	05/12/2020	Section 2.6.1.3 Analysis of Reservoir Drawdown	"The reservoir elevation data will also be analyzed to characterize reservoir drawdown rates." This will be important to determine accurate drawdown rates to minimize effects. So that we can associate a risk level to the rates.	Agree. Thank you for your comment.
95.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.6.1.3 Analysis of Reservoir Drawdown	"Analysis for Gorge and Diablo lakes will be performed using the record of hourly water surface elevation data since 2011 under current Project operations" Does that cover typical maintenance and testing that the project has currently under the license provisions. If not would suggest a longer study period to ensure we have variability of flows covered by license.	See Comment Response #8. The period since 2011 adequately describes existing, normal operations. This period is most representative of current Project operations as it reflects operational changes since the 2011 amendment to the Fisheries Settlement Agreement.

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96.	Brock Applegate (WDFW)	05/11/2020	Section 2.6.1.3 Analysis of Reservoir Drawdown	"Analysis for Ross Lake will be similar to that for Gorge and Diablo, except that the analysis will be performed using the record of daily (end of day) water surface elevation data since 2011. As discussed in Section 2.3 of this study plan, water surface elevations in Ross Lake fluctuate seasonally." Unfortunately, SCL may miss drawdown rates of the Ross Reservoir that would strand fish, especially in low slope areas.	See Comment Response #52.
97.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.1.3 Analysis of Reservoir Drawdown	"Analysis for Ross Lake will be similar to that for Gorge and Diablo, except that the analysis will be performed using the record of daily (end of day) water surface elevation data since 2011." Run a subset of hourly fluctuations to ensure that daily elevations adequately identify the stranding risks.	See Comment Response #52.
98.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.1.3 Analysis of Reservoir Drawdown	"Analysis for Ross Lake will be similar to that for Gorge and Diablo, except that the analysis will be performed using the record of daily (end of day) water surface elevation data since 2011." Also include assessment of pre-2011 water surface elevations.	The period since 2011 was selected for analysis as representative of current normal Project operations. See Comment Response #95.
99.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.6.1.4 Native Species Lifestage and Periodicity Analysis	"2.6.1.4 Native Species Lifestage and Periodicity Analysis" While generally correct, this section, with the exception of the last paragraph, should be bracketed very large error bars. Until we know more about the timing and distribution of fish in the tributaries and littoral habitats of the reservoirs we should assume that fish of all ages, size classes and species are present yearround in	See Comment Response #14.

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				all habitats. As we gather more data we can refine the risk assessment to involve timing. Case in point: the large number of RBT <~40mm killed in the last Gorge Reservoir stranding event.	
100.	Brock Applegate (WDFW)	05/11/2020	Section 2.6.1.4 Native Species Lifestage and Periodicity Analysis	I agree with Ashley. We need the information on fish and the littoral habitats before we can finish this analysis. Otherwise, SCL has a best guess, which leads to possible large errors. (See Comment #99)	See Comment Response #14.
101.	Judy Neibauer (USFWS)	05/12/2020	Section 2.6.1.4 Native Species Lifestage and Periodicity Analysis	"2.6.1.4 Native Species Lifestage and Periodicity Analysis" Understanding and having a genetic baseline to understand what populations are more succeptible to operational effects, including stranding will be important. We will need to be able to understand what local populations, and life history stages are most susceptible. In some streams bull trout juveniles may outmigrate between one and two…while in other, perhaps cloder tributaries they may migrate later around 3-4 to the reservoir. Also, under standing how they use littoral habitat as juveniles or sub-adults may help determine high risk areas, operational measures, and future restoration need to mitigate impacts. Having a long term pit tag study to monitor a subset of each population through a longer time period than telemetry will assist with long term adaptive management. Having a longer term pit tag study….would help	See Comment Responses #4 and #5. Thank you for this information and these suggestions. We intend to address gaps in periodicity information to inform the study through the exercise outlined in Comment Response #14. Pit tagging is beyond the temporal scope of the study and would require several years of data from which to draw refined conclusions. Lack of refined site-specific periodicity information, over the time period of this study should have limited bearing on the risk assessment results because multiple field checks will be conducted over time in this study, following the desk top analysis, which should capture the periods in which the most vulnerable salmonid life stages could occur in stranding and trapping areas.

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				with understanding what time these fish return to spawning tributaries and use larger bodies of water,…and how they may dip in and out for foraging …over the course of their lifetime…will also help to understand key time periods where bull trout are susceptible to drawdown or long term maintenance flows….	
102.	Judy Neibauer (USFWS)	05/12/2020	Section 2.6.1.4 Native Species Lifestage and Periodicity Analysis	"While the early life stages of these native species (i.e., emergent fry and young of the year parr) will be physically most susceptible to stranding because of their low velocity tolerance and associated use of shallow and slow waters, defining risks to all life stages of native species under normal operations requires the overlay of temporal operations on reservoir elevations and an understanding of the corresponding phenology of the use of those habitats where trapping and stranding might occur." Need ing information on potentially all fish species, that would serve as a preybase, also non native species, including brook trout, to understand numbers and distributions…	See Comment Response #13.
103.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.1.4 Native Species Lifestage and Periodicity Analysis	"At present, knowledge at this level of resolution is limited, so predictions of which species and life stage will be most susceptible to stranding or trapping over an annual or seasonal operations cycle will take into account the general life cycles of the native fish to infer their life stage specific temporal susceptibility." Field studies are warranted.	See Comment Response #14.
104.	Brock Applegate (WDFW)	05/11/2020	Section 2.6.1.4 Native Species Lifestage and Periodicity Analysis	"At present, knowledge at this level of resolution is limited, so predictions of which species and life stage will be most susceptible to stranding or trapping over an annual or seasonal operations cycle will take into account the	See Comment Response #14.

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				general life cycles of the native fish to infer their life stage specific temporal susceptibility.” Should SCL gather this information instead of guess?	
105.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.1.4 Native Species Lifestage and Periodicity Analysis	“Changes in reservoir elevation trapping rearing sub-adult and adult rainbow trout are possible though less likely.” The mortality of older fish is likely of greater impact. For instance, older fish have higher survival and fecundity and lower energetic requirements per unit body mass.	Comment acknowledged. We concur that the consequences of trapping or stranding sub-adult and adult fish are greater than younger fish. The text simply references likelihood, not consequences.
106.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.6.1.4 Native Species Lifestage and Periodicity Analysis	“Because none of these native species are known to spawn in the lentic habitats of the Skagit Project reservoirs—with spawning known to occur in reservoir tributaries—the likelihood of trapping or stranding spawning char is extremely low (as it is with spawning rainbow trout).” Access to the tributary spawning locations should be assessed.	See Comment Response #70. Access to tributary spawning locations by native species is routinely assessed as part of the reservoir tributary barrier removal program under the current license.
107.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.6.1.4 Native Species Lifestage and Periodicity Analysis	“Because none of these native species are known to spawn in the lentic habitats of the Skagit Project reservoirs—with spawning known to occur in reservoir tributaries—the likelihood of trapping or stranding spawning char is extremely low (as it is with spawning rainbow trout).” NPS has documented native char spawning in the drawdown zone of Diablo Lake near Colonial Creek.	Thank you for your comment. Please provide this information to City Light to better inform the relicensing process.

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108.	Brock Applegate (WDFW)	05/11/2020	Section 2.6.1.4 Native Species Lifestage and Periodicity Analysis	"Because none of these native species are known to spawn in the lentic habitats of the Skagit Project reservoirs—with spawning known to occur in reservoir tributaries—the likelihood of trapping or stranding spawning char is extremely low (as it is with spawning rainbow trout)." WDFW feels like SCL has some data to collect, with disagreements on fish use. I agree with NPS, SCL has refused to move forward with littoral habitat studies, although they know very little.	City Light looks forward to the documentation of and is unaware of any littoral spawning char occurring in the reservoirs in the decades of operations there. Hence, adverse effects to littoral spawning habitat under existing conditions of reservoir drawdown are equivocal. See also Comment Responses #4 and #5.
109.	Ashley Rawhouser (NPS)	05/08/2020	Section 2.6.1.4 Native Species Lifestage and Periodicity Analysis	Because none of these native species are known to spawn in the lentic habitats of the Skagit Project reservoirs—with spawning known to occur in reservoir tributaries—the likelihood of trapping or stranding spawning char is extremely low (as it is with spawning rainbow trout). NPS disagrees with statement. An assessment of spawning in littoral habitats has never been completed. What data are SCL using to support this statement?	See Comment Response #108.
110.	Judy Neibauer (USFWS)	05/12/2020	Section 2.6.1.4 Native Species Lifestage and Periodicity Analysis	"Spawning age fish would be on tributary spawning grounds which would not be susceptible to the effects of reservoir fluctuations or drawdown." You could end up with inundated redds within affected tributaries, if water is held high during spawning…of visa versa if for some reason you drop it low there could be some dewatered redds…depends on the timing of spawning and operational flow changes.	Operations result in near full pool elevations in the early autumn when native char ascend tributaries to spawn, above the influence of water level elevations in the tributaries. Hence, redd de-watering or inundation in tributaries are not issues affected by the Project.

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111.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"**2.6.2 Field Surveys and Desktop Analysis Updates**" Funding should be provided to interested LPs to collect data and/or indepently verify field data collection. Similiar to current FSA.	City Light will remain in communication with LPs regarding study field programs should they be interested in participating/verifying using their own resources.
112.	Ashley Rawhouser (NPS)	05/13/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"**2.6.2 Field Surveys and Desktop Analysis Updates**" All char should be IDed genetically. All fish mortalities should be preserved and sent to NPS or an agreed to 3rd party for additional analysis that may support other studies.	Char mortalities will be sampled for genetic analysis, guided by a statistically defensible subsampling method whereas analyzing all individuals is impractical or unwarranted. Final sample disposition subject to permit conditions, and/or data sharing for aligned research is negotiable.
113.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"Based on the inventory from Section 2.6.1.1 of this study plan and analysis of reservoir elevation data in Sections 2.6.1.2 and 2.6.1.3 of this study plan, key areas of the study area in each of the three Project reservoirs will be identified as candidate sites for field surveys of fish stranding and trapping." Evaluation of study sites should also be made from on the ground evaluations to ensure the desktop analysis did not miss anything. This will also corroborate the desktop analysis.	Thank you for your comment. Field surveys to validate the desktop analysis are planned.
114.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"Based on the inventory from Section 2.6.1.1 of this study plan and analysis of reservoir elevation data in Sections 2.6.1.2 and 2.6.1.3 of this study plan, key areas of the study area in each of the three Project reservoirs will be identified as candidate sites for field surveys of fish stranding and trapping." It is unclear how these areas are define/determined.	Field surveys will focus on areas which have been identified from the desktop analysis as presenting a risk of stranding and trapping under normal Project operations. The full suite of areas that may represent conditions where stranding or trapping risks are elevated cannot be known until the digital elevation model is completed. Following which, we anticipate randomly sampling a subset of areas in the field within each strata, per a stratified/random experimental design. Survey areas would be randomly

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					assigned within each strata and field validation would verify or refute stranding and/or trapping conditions, with additional habitat data collected (per Section 2.6.3 of the study plan) to improve our understanding of other physical conditions—beyond elevation and slope, that might influence stranding or trapping. This sampling, to be conducted in 2021, would also be informed by 2020 reconnaissance during Ross Lake drawdown.
115.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"For each reservoir, a number of isolated pools, and areas of low gradient terrain will be selected for sampling." Dewatered areas where stranding mortalities were likely to have occurred should also be assessed.	Assessing stranding areas in addition to trapping areas is also a planned component of the field program.
116.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"For each reservoir, a number of isolated pools, and areas of low gradient terrain will be selected for sampling." What is the method for selecting sample sites? Include systematic transect surveys to validate GIS model and identify stranding in de-watered areas.	See Comment Response #114.
117.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"For each reservoir, a number of isolated pools, and areas of low gradient terrain will be selected for sampling." This is pretty vague. More detail needed as this is critical to verify the desktop analysis. How much area will be surveyed to verify desktop analysis and how will the accuracy and prescision of the desk top analysis be quantified?	See Comment Response #114.

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118.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"Selection of sampling locations will consider: accessibility and sampling logistics; safety concerns; frequency of formation of isolated pools or exposure of low gradient areas; and degree to which the pool or low gradient areas are representative of similar features throughout the reservoir drawdown zones." Upper Skagit Indian Tribe would like to consult on location selection, but will recommend inclusion of the life stage and periodicity analysis plus field verification mentioned above.	Thank you for your comment. See Comment Response #14 and #114.
119.	Judy Neibauer (USFWS)	05/12/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"Selection of sampling locations will consider: accessibility and sampling logistics; safety concerns; frequency of formation of isolated pools or exposure of low gradient areas; and degree to which the pool or low gradient areas are representative of similar features throughout the reservoir drawdown zones." Might want to included riffle habitat with pocket water, especially if in rearing habitat for bull trout. In some streams bull trout are stranded within riffle habitat as water levels drop through summer months Check in with WDFWto see if their Large Lakes crews could be available or assistance in survey methods and field help.	Thank you for your comment. Sampling locations will primarily be driven by the desktop analysis which considers slope and other topobathymetric features and may also include additional information resulting from the 2020 reconnaissance effort. This does not preclude the potential for riffle habitat to be captured in this analysis. Although note that Ross Lake is full during summer months to support recreation activities.
120.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"Data to be collected at each sampled pool will include:" Data collection should include: • Presence of macroinvertebrates • Collection of all mortalities found.	With regard to collection of all mortalities, please See Comment Response #112. If macroinvertebrates are readily observed, this can be noted in field notes. However, this is not a macroinvertebrate diversity or productivity study.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
121.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	7th Bullet – Comment "Number and condition of trapped fish by species and life stage," Field identification of native char species (i.e. Dolly Varden vs. Bull Trout) should not be considered. This is not an accurate method for differentiating the species. Genetic sampling should be used as the stand alone method for differentiating the two.	Field identification of char species is feasible and recommended. Bull Trout and Dolly Varden have distinct morphologies which makes field identification possible by a properly trained person. The paper which describes the differences between Bull Trout and Dolly Varden was published in 1978. And has since been validated using genetic techniques. Therefore, if field crews are properly trained, they can positively identify char species based on non-invasive observational techniques. The only caveat is hybrids between the two native char species. However, those are rare and would not invalidate a field observation based approach. Also See Comment Response #112.
122.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	7th Bullet – Comment "Number and condition of trapped fish by species and life stage," Conduct repeated visits to infer predation.	While observations of mortalities and trapped live fish will be recorded during field survey, this is not a study to quantify fish mortality *per se*. It's a study to assess risk of operations to strand and trap fish to help manage future mortality as opposed to conducting a detailed accounting of every fish potentially affected by drawdown operations. Per Section 2.6.3, indications of predation during field visits is proposed.
123.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	7th Bullet – Comment "Number and condition of trapped fish by species and life stage[4]," Where is this footnote?	Footnote 4 is located at the bottom of page 2-20 of the study plan.
124.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	14th Bullet – Comment "Presence of macrophytes"	If macrophytes are present on such plots, and fish are also found stranded, if entangled, this would be noted.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				Survey plots to identify fish entangled in macrophytes.	
125.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	17th Bullet – Comment "Number of stranded fish by species and life stage" All mortalities should be collected and genetic analysis conducted to determine species.	See Comment Response #112.
126.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	20th Bullet – Comment "Indications of predation will be noted." Note common predators in area prior to conducting survey	Thank you for this suggestion, which will be actioned and text has been added to the study plan in Section 2.6.3.
127.	Brian Lanouette (Upper Skagit Indian Tribe)	05/04/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"Field surveys for Gorge Lake and Diablo Lake will be conducted quarterly during the study with the reservoirs in their typical operating range." More frequent sampling, and sampling based on lowest drawdown times should occur.	Please See Comment Responses #7 and #122. City Light believes that proposed sampling effort is sufficient to support the risk assessment approach. For Gorge and Diablo lakes, the intent is to sample as close to the lowest point within the normal operating range. The objective of the field surveys is to field validate the desktop analysis. By sampling quarterly, we gain a temporal perspective in addition to the spatial component we are validating. At which point we will have enough information to inform an analysis of effects, potential PME measures, and/or additional studies that may be required.
128.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"Field surveys for Gorge Lake and Diablo Lake will be conducted quarterly during the study with the reservoirs in their typical operating range. Exact timing will be determined following further consideration of fish species and life stages of primary concern. The same pools or low gradient areas will be sampled in	As a risk assessment screening study, quarterly sampling as envisioned for Diablo and Gorge allows for an investigation that will capture periodicities of early life stages as well as sub-adult and adult fish of each salmonid species that are the subject of this study. To the extent that night drawdowns occur during these periods

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				each survey. If conditions allow, one additional field survey for each of the two reservoirs (Gorge and Diablo), may be undertaken on an opportunistic basis if the reservoirs are drawn down below their typical operating range for maintenance or other reasons." Since we don't much about the timing and distribution of fish in the littoral habitats and when our migration occurs from tribs quartly sampling is not frequent enough. Timing of surveys should be based on different reservoir elevation and time of day. Right now, we don't know if night drawdowns entrap and kill more fish than daytime draw downs.	of study, we will endeavor to sample at such time to address this gap.
129.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"Field surveys for Ross Lake will be conducted three times during the 2021/2022 drawdown cycle. The surveys will cover the full range of drawdown and will take place at the following approximate times: ▪ October or November 2021, with the water surface elevation drawn down 10 to 20 feet, to elevations of 1,598 to 1,588 feet NAVD 88 (1,591.74 feet to 1,581.74 feet CoSD). ▪ January or February 2022, with the water surface elevation drawn down 30 to 40 feet, to elevations of 1,578 to 1,568 feet NAVD 88 (1,571.74 feet to 1,561.74 feet CoSD). ▪ April 2022, with the reservoir elevation close to its minimum and the water surface elevation drawn down 50 feet or more, to an elevation of 1,558 feet NAVD 88 (1,551.74 feet CoSD) or lower."	Analysis of reservoir elevation data is described in Section 2.6.2.3. The desktop analysis will identify entrapment areas such as those described but will not analyze the potential impact on trapping risk of water level variations in the Skagit River at the head of Ross Lake (as opposed to Ross Lake itself) during spring runoff.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				NPS would like to discuss the frequency and timing of Ross surveys. We have observed fish being pushed into entrapment habitats on the rising limb of the Skagit Rivers hydrograph during string runoff. This is also complicated by reservoir level flucuations. Part of this study plan should include an analysis all reservoir levels flucuation rates, amplitude, timing, and duration.	
130.	Judy Neibauer (USFWS)	05/12/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"Field surveys for Ross Lake will be conducted three times during the 2021/2022 drawdown cycle. The surveys will cover the full range of drawdown and will take place at the following approximate times:" You may want to focus on high flows, when areas are at full pool, then water begins to drop…not sure the timing is the same in every reservoir…but it sounds like full pool could vary daily by 5 or more feed in different reservoirs. It would be good to have some survey effort in each reservoir during these types of reservoir level changes also.	Pool elevations for Gorge Lake and Diablo Lake vary daily by from 3 to 5 feet or more, as described in Section 2.4. The pool elevation for Ross Lake varies seasonally, with the daily variation in water level typically less than one foot. The surveys have been designed considering the different operating characteristics of the three reservoirs.
131.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"If conditions allow, one additional field survey for each of the two reservoirs (Gorge and Diablo), may be undertaken on an opportunistic basis if the reservoirs are drawn down below their typical operating range for maintenance or other reasons." This needs to be included, or some other method developed to assess the impact of drawdowns outside the typical operating range.	See Comment Response #8.
132.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	05/11/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"Field surveys for Ross Lake will be conducted three times during the 2021/2022 drawdown cycle. The surveys will cover the full range of	See Comment Response #10.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				drawdown and will take place at the following approximate times: ▪ October or November 2021, with the water surface elevation drawn down 10 to 20 feet, to elevations of 1,598 to 1,588 feet NAVD 88 (1,591.74 feet to 1,581.74 feet CoSD). ▪ January or February 2022, with the water surface elevation drawn down 30 to 40 feet, to elevations of 1,578 to 1,568 feet NAVD 88 (1,571.74 feet to 1,561.74 feet CoSD). ▪ April 2022, with the reservoir elevation close to its minimum and the water surface elevation drawn down 50 feet or more, to an elevation of 1,558 feet NAVD 88 (1,551.74 feet CoSD) or lower." Need to coordinate with BC Canadian fishery agencies to assess upper reservoir stranding and trapping.	
133.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	"Each of the surveys for Ross Lake will focus on low gradient areas recently exposed or pools recently formed as Ross Lake is drawn down through the fall and winter months." The focus on low gradient habitat and exclusion of higher gradient habitat is not warrented at this time. Ross contains a siginifcant amount of entrapment habitat assocaited with stumps on higher gradient habitat.	Analysis of the DEM will identify areas (strata) for subsequent field verification and sampling on the basis of slope. The 2020 reconnaissance will provide an initial assessment of the amount of potential entrapment habitat associated with tree stumps (i.e. tree wells) as a function of slope and may serve to resolve concerns regarding the potential for entrapment in tree wells in higher gradient terrain. Anecdotal experience indicates that the flatter areas in reservoirs appear to generate more tree wells. Findings from the 2020 reconnaissance, discussed in Section 2.6.1, will also inform design of the formal 2021 sampling program.
134.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.3 Analysis and Reporting	"**2.6.3 Analysis and Reporting**" The analysis should quantify the number of fish	See Comment Responses #7 and #122.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				killed during the various project-related reservoir fluctuations. As scoped, it seems to focus on identifying areas of stranding risk. This will not be adequate to assess the risk to reservoir fish populations in terms of abundance, productivity, viability.	
135.	Judy Neibauer (USFWS)	05/12/2020	Section 2.6.3 Analysis and Reporting	"**2.6.3 Analysis and Reporting**" Clearly lay out study questions, methods, analysis, and report format in this section.	The requested details will be developed in the course of the study. Please also See Comment Response #136.
136.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.6.3 Analysis and Reporting	"A description of the methodology employed," NPS needs this information as part of the study plan in order to support it.	The basic methodology is as described in Section 2.6 of the study plan. The methodology will be further developed in the course of the study, informed in part by the findings of the 2020 reconnaissance.
137.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.6.3 Analysis and Reporting	"Data collected will be interrogated to test relevant hypotheses (e.g., H_o: normal operating ranges do not cause an increase in stranding; slopes greater than 6 percent cause no increase in stranding risk; distance from cover has no bearing on trapping risks, etc.). To the degree that multiple factors are recognized as influencing trapping or stranding risks, multiple regression will likely be used to further our understanding of the relative variation influenced by each factor. A full data management plan, including hypotheses to be tested and the statistical methods that will be applied will be developed in advance of data collections." Proposed analysis methods should be described as part of this study plan.	City Light continues to work on refining the data management and statistical methods to be applied for the study to ensure they are robust and defensible, and will update the study plan with additional details prior to the finalization and filing with FERC as part of the PSP.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
138.	Rick Hartson (Upper Skagit Indian Tribe)	05/08/2020	Section 2.6.3 Analysis and Reporting	"A full data management plan, including hypotheses to be tested and the statistical methods that will be applied will be developed in advance of data collections." Include power analysis to ensure adequate sample size for field verification and transect surveys.	A power analysis to ensure adequate sampling to meet study objectives will be a part of the detailed information as described in Comment Response #137.
139.	Ashley Rawhouser (NPS)	05/12/2020	Section 2.8 Schedule	"**2.8 Schedule**" Schedule will need to be revised pending RWG agreement on objectives, scope, and methods.	Comment acknowledged. As appropriate, the schedule will be revised based upon agreements resulting from this 2020 voluntary study plan review process with LPs.
140.	Judy Neibauer (USFWS)	05/12/2020	Section 2.8 Schedule	2nd Bullet – Comment "Field Surveys – January 2021 to April 2022" Allow for opportunistic surveying outside of timeframes when flows allow for key collection of data during both high and low flow events. Might need additional year or two to be able to incorporate flows necessary to do the study…??	Thank you for the comment. The ILP provides the opportunity for comment on the final report submitted in the ISR and discussed at the ISR meeting; if any components of the study goals and objectives are not met in the first year, or there are anomalous conditions, any party may propose additional work or request additional study per FERC ILP regulations. Note also that the study allows for opportunistic sampling of Gorge and Diablo reservoirs under conditions outside of normal operations (as defined in the study plan)if they should occur during the study period.
141.	Brock Applegate (WDFW)	05/11/2020	Section 2.8 Schedule	Added 4th bullet "Initial Study Report Meeting-- 2022"	Thank you for your comment. The schedule reflects the timeline for this study only, not the larger ILP process.
142.	Steve Copps (NMFS)	05/11/2020	Section 1.3 Study Plan Development	Add Fish Passage and Sediment Deposition to the list of linked issues.	Section 1.3 has been revised and linkages to issue forms is no longer included as part of this section. Text has been added to this section to indicate that sediment deposition studies are potentially linked to this study.
143.	Steve Copps (NMFS)	05/11/2020	Section 1.3	Fully describe the linkages to other study plans with sufficient detail to understand the nature of	Please see additional text added to section 1.3.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
			Study Plan Development	each specific link and how the information will be synthesized to inform relicensing.	
144.	Steve Copps (NMFS)	05/11/2020	Section 2.1 Study Goals and Objectives	Anadromous fish should be added to the list of species to adequately describe stranding and trapping risks under a new license.	This study is focused on reservoir stranding and trapping upstream of where anadromous fish can access under existing conditions.
145.	Steve Copps (NMFS)	05/11/2020	Section 2.1 Study Goals and Objectives	Additional detail should be provided on how the risk assessment will be used to support the relicensing process. Can the assessment be used in a decision making context to develop and understand impacts associated with alternative management scenarios?	See Comment Response #4. Yes, information from this risk assessment is intended to support a subsequent analysis of Project effects and the development of potential actions to address effects, including alternative management scenarios as appropriate
146.	Steve Copps (NMFS)	05/11/2020	Section 2.2 Resource Management Goals	Define “normal project operations.”	Normal Project operations are defined in Section 2.1 (see footnote #1).
147.	Steve Copps (NMFS)	05/11/2020	Section 2.4 Project Operations and Effects on Resources	In the absence of conducting research during drawdowns, the study plan should consider alternative strategies to minimize the risk of trapping and stranding (e.g., rescue).	The study results are intended to inform the development of alternative strategies to mitigate or minimize the risk of stranding and trapping. Rescue, for example, may be one of many strategies evaluated for utility in decreasing risk.
148.	Steve Copps (NMFS)	05/11/2020	Section 2.5 Study Area	Low reservoir stage is a good opportunity to examine the full pool extent in dry conditions to assess problems, especially with tributary junctions. Given the objective of determining when and at what elevations strandings occur, the study area should not be limited to elevations below which strandings would occur.	The study proposes to evaluate stranding and trapping risk under normal operations however allowance is made for opportunistic sampling under larger reservoir drawdowns should those occur during the study period. See also Comment Response #8.
149.	Steve Copps (NMFS)	05/11/2020	Section 2.6.1.1 Diablo Lake DEM	New LiDAR information will be necessary as the 2016/17 data will not provide the level of minimum pool elevation data needed to inform when stranding and blocking would occur.	The 2016/2017 LiDAR data for Diablo Lake will be supplemented by bathymetric data to be collected by boat. Section 2.6.2.1 has been revised.
150.	Steve Copps (NMFS)	05/11/2020	Section 2.6.1.1 Diablo Lake DEM	It would be useful to understand the scale of green LiDAR data to know if the resolution is	See Comment Response #51.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				adequate to detected isolated pools and blockages.	
151.	Steve Copps (NMFS)	05/11/2020	Section 2.6.1.1 Diablo Lake DEM	Please include an image of green LiDAR imagery at Stetattle creek.	Please see Figure 2.6-5. This figure shows the extent of green LiDAR coverage where Stetattle Creek enters Gorge Lake.
152.	Steve Copps (NMFS)	05/11/2020	Section 2.6.1.2 Analysis of DEMs for Stranding and Trapping Risk	Please expand discussion of slope percentages to ensure the study will not miss sudden changes in gradient. For example, sediment type.	Changes in gradient will be detectable from the LiDAR data. See Comment Response #51 regarding accuracy and resolution of LiDAR.
153.	Steve Copps (NMFS)	05/11/2020	Section 2.6.1.2 Analysis of DEMs for Stranding and Trapping Risk	The study should address the potential for trapping in less than 12-inch depth.	See Comment Response #86.
154.	Steve Copps (NMFS)	05/11/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	Describe selection criteria.	See Comment Response #114.
155.	Steve Copps (NMFS)	05/11/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	Add tributary junctions to sampling sites.	See Comment Response #13.
156.	Steve Copps (NMFS)	05/11/2020	Section 2.6.2 Field Surveys and Desktop Analysis Updates	Describe how “distance from cover has no bearing on trapping risks.” If true, cover may influence survival of trapped fish.	Whether “distance from cover has no bearing on trapping risks” is one of several hypotheses which may be tested, as described in Section 2.6.4. We agree that cover may influence survival of trapped fish.
157.	Steve Copps (NMFS)	05/11/2020	Section 2.8 Schedule	The schedule should be amended to include foreseeable utility of the risk assessment to inform decision making in the relicensing process.	See Comment Response #147.

FA-04 FISH PASSAGE TECHNICAL STUDIES PROGRAM
REVISED STUDY PLAN

SKAGIT RIVER HYDROELECTRIC PROJECT
FERC NO. 553

Seattle City Light

April 2021
RSP

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List of Acronyms and Abbreviations

cfs...............................cubic feet per second
City Light...................Seattle City Light
Ecology ....Washington State Department of Ecology
ELC ....Environmental Learning Center
ESA ....Endangered Species Act
FERC..........................Federal Energy Regulatory Commission
FTE ....full-time equivalent
HEC-RAS ....Hydrologic Engineering Center River Analysis System
ISR ....Initial Study Report
LP...............................licensing participant
NMFS.........................National Marine Fisheries Service
NPS ....National Park Service
O&M..........................operations and maintenance
OPCC.........................Opinions of Probable Construction Costs
PAD............................Pre-Application Document
PRM ....Project River Mile
Project ....Skagit River Hydroelectric Project
PSP.............................Proposed Study Plan
RLNRA......................Ross Lake National Recreation Area
RM ....river mile
RSP ....Revised Study Plan
RWG ....Resource Work Group
U.S.C..........................United States Code
USFS ..........................U.S. Forest Service
USFWS ......................U.S. Fish and Wildlife Service
USGS .........................U.S. Geological Survey
USIT...........................Upper Skagit Indian Tribe
USR............................Updated Study Report
WDFW.......................Washington Department of Fish and Wildlife

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1.0 INTRODUCTION

1.1 General Description of the Project

The Skagit River Hydroelectric Project (Project), licensed to The City of Seattle, Washington, and operated through its publicly-owned electric power utility Seattle City Light (City Light), is located in northern Washington State and consists of three power generating developments on the Skagit River – Ross, Diablo, and Gorge – and associated lands and facilities. The Project generating facilities are in the Cascade Mountains of the upper Skagit River watershed, between Project River Miles (PRM) 94.7 and 127.9 (U.S. Geological Survey [USGS] RMs 94.2 and 127).[1] Power from the Project is transmitted via two 230-kilovolt powerlines that span over 100 miles and end just north of Seattle at the Bothell Substation. The Project also includes two City Light-owned towns, an Environmental Learning Center (ELC), several recreation facilities, and several parcels of fish and wildlife mitigation lands.

Project generating facilities are all located in Whatcom County, although Ross Lake, the most upstream reservoir, crosses the U.S.-Canada border and extends for about one mile into British Columbia at normal maximum water surface elevation. Gorge Powerhouse, the most downstream facility, is approximately 120 miles northeast of Seattle and 60 miles east of Sedro-Woolley, the nearest large town. The closest town is Newhalem, which is part of the Project and just downstream of Gorge Powerhouse. The primary transmission lines cross Whatcom, Skagit, and Snohomish counties; the fish and wildlife mitigation lands are in the same counties.

The Project Boundary is extensive, spanning over 133 miles from the Canadian border to the Bothell Substation just north of Seattle, Washington. In addition, there are "islands" of fish and wildlife mitigation lands and recreation facilities within the Skagit, Sauk, and South Fork Nooksack watersheds that are also within the Project Boundary. Project generating facilities are entirely within the Ross Lake National Recreation Area (RLNRA), which is administered by the National Park Service (NPS) as part of the North Cascades National Park Complex. The RLNRA was established in 1968 in the enabling legislation for North Cascades National Park to provide for the "public outdoor recreation use and enjoyment of portions of the Skagit River and Ross, Diablo, and Gorge lakes." The legislation maintains the Federal Energy Regulatory Commission's (FERC) jurisdiction "in the lands and waters within the Skagit River Hydroelectric Project," as well as hydrologic monitoring stations necessary for the proper operation of the Project (16 United States Code [U.S.C.] § 90d-4; Public Law 90-544. Sec. 505 dated October 2, 1968, as amended by Public Law 100-668. Sec. 202 dated November 16, 1988).

1.2 Relicensing Process

The current FERC license for the Project expires on April 30, 2025, and City Light will apply for a new license no later than April 30, 2023. City Light formally initiated the relicensing process by filing a Notice of Intent and Pre-Application Document (PAD) with FERC by April 27, 2020 (City Light 2020a). The PAD includes descriptions of the Project facilities, operations, license

[1] City Light has developed a standard Project centerline and river mile system to be used throughout the relicensing process, including the study program, to replace the outdated USGS RM system. Given the long-standing use of the USGS RM system, both it and the Project River Mile (PRM) system are provided throughout this document. For further details see Section 7.0 of the main body RSP.

requirements, and Project lands as well as a summary of the extensive existing information available on Project area resources and early consultation on potential resource issues to be addressed during the relicensing.

In 2019-2020, City Light convened a series of Resource Work Groups (RWG) to engage agencies and other licensing participants (LP) in the Study Plan Development Process. Discussions with LPs continued in early 2021 with a series of topic-based discussions following filing of the Proposed Study Plan (PSP) on December 8, 2020 (City Light 2020b). This study plan reflects RWG and LP discussion and study requests and comments submitted by LPs.

1.3 Study Plan Development

As part of the Study Plan Development Process, National Marine Fisheries Service (NMFS) and other LPs have requested studies to assess the biological, physical, and engineering feasibility of fish passage at Project dams. In response to these requests, City Light proposes to conduct the FA-04 Fish Passage Technical Studies Program (Fish Passage Study) as described in this study plan.

City Light is filing this study plan with FERC as part of its Revised Study Plan (RSP). City Light has amended its proposed Fish Passage Study Plan in response to comments provided by LPs. The Fish Passage Study–while continuing to include the assessment of the bypass reach as a potential barrier (full, partial, or no barrier) to adult migratory fish species and the investigation of upstream and downstream fish passage at Gorge Dam–has been expanded to include the development and study of fish passage alternatives at the Diablo and Ross developments. Both the passage barrier assessment work and the fish passage facilities investigations will be initiated in parallel during the first year of study, i.e., the phased approach included in the PSP study plan has been amended to have both tasks being performed concurrently.

This study plan addresses with modifications, elements of the following study requests, as explained in Section 6 of the RSP: (1) assessment of potential upstream fish passage barriers in the Gorge bypass reach (Washington Department of Fish and Wildlife [WDFW]-01 Evaluation of Fish Barriers and Fish Species in the Bypass Reach); (2) feasibility analysis of anadromous and resident fish passage facilities (NMFS-04 Feasibility Analysis of Fish Passage, NPS-01 Feasibility Analysis of Anadromous and Resident Fish Passage, U.S. Fish and Wildlife Service [USFWS]-01 Feasibility Analysis of Fish Passage at the Skagit River Hydroelectric Project, Upper Skagit Indian Tribe [USIT]-01 Feasibility Analysis of Fish Passage at the Skagit River Hydroelectric Project, and WDFW-02 Feasibility Analysis of Fish Passage at the Skagit River Hydroelectric Project); and (3) evaluating fish habitat and potential fish productivity upstream of Gorge Dam, with emphasis on ESA-listed salmonids (NMFS-03 Quantifying Habitat and Production Potential of Chinook and Coho Salmon and Steelhead above Ross Dam, NPS-08 Quantifying the Productivity Potential of Reservoir Tributary Habitat, USFWS-02 Quantifying the Habitat and Production Potential of ESA-Listed Salmon, Steelhead, and Bull Trout above Dams, USIT-02 Quantifying Habitat and Production Potential of ESA-listed Chinook Salmon, Steelhead, Bull Trout, Coho Salmon, and Sockeye Salmon above Gorge Dam, and WDFW-03 Quantifying Habitat and Production Potential of ESA-listed Chinook Salmon, Steelhead, Bull Trout, Coho Salmon, and Sockeye Salmon above Gorge Dam).

PSP comments to this study plan were submitted by American Rivers/Trout Unlimited, American Whitewater, Ecology, NMFS, North Cascades Institute, NPS, Sauk-Suiattle Indian Tribe, Skagit

County Board of Commissioners, Swinomish Indian Tribe of Indians, Upper Skagit Indian Tribe, USFWS, and WDFW. City Light has addressed the specific comments and suggested edits in the study plan and responded to comments in the PSP comment/response table appended to the main body of the RSP. Modifications made to the study plan in response to comments and since the PSP include eliminating the phased approach to studying fish passage (i.e., the barrier assessment is now being conducted in parallel with the engineering component of the study), relocating the tributary habitat assessment to a new study plan, FA-07 Reservoir Tributary Habitat Assessment, expanding the study to include all three Project developments, and adding technical workshops.

With the expansion of the Fish Passage Study scope to incorporate the Diablo and Ross developments, the study of tributary habitat suitability has also increased to include Thunder Creek upstream of Diablo Dam, eight[2] tributaries to Ross Lake, and the mainstem Skagit River in Canada. For the RSP, the scope of the tributary habitat assessment is now described in a separate study plan, titled FA-07 Reservoir Tributary Habitat Assessment.

[2] Tributaries to be evaluated include: (1) Stetattle Creek (tributary to Gorge Lake); (2) Thunder Creek (tributary to Diablo Lake); and (3) nine tributaries to Ross Lake, i.e., Canyon, Little Beaver, Big Beaver, Hozomeen, McMillan, Devils, Granite and Three Fools creeks and the upper Skagit River.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

The purpose of the Fish Passage Study is to investigate biological, physical, operational, and engineering factors involved when considering the potential to provide safe, timely, and effective fish passage at any or all of the three Project developments. Five target species have provisionally been identified for evaluation: steelhead; Chinook, Coho, and Sockeye salmon; and Bull Trout. Consideration may also be given to other species, if identified in collaboration with the fish management agencies and Indian tribes. The study will include the development of concept-level upstream and downstream passage facilities that may involve alternatives at each development and/or for the system of all three developments as a whole. Planning-level concepts will consider both volitional (non-directive) and directive fish passage strategies where applicable. Upstream and downstream passage concepts will be configured to accommodate unique physical, operational, and site constraints of the existing facilities and overall Project reach. All concepts will be developed consistent with the engineering principles, criteria, and guidelines contained in NMFS (2011), WDFW (2000a, 2000b), and Bell (1991), to the extent practicable. Other factors affecting technical viability, Project modifications, and/or potential biological limitations of each alternative will be identified. Upon completion of concept-level fish passage facility options, planning level opinions of probable construction costs appropriate to reconnaissance level investigations will be completed consistent with the AACE Cost Estimate Classification System, Class 5 standardized guidelines (AACE 2003). The goal of engineering assessment of fish passage options is to determine if specific conceptual scenarios are constructable and at what cost, within the standards of accuracy provided in AACE (2003).

The study also will include a field investigation to characterize potential upstream passage barriers identified by Envirosphere (1989) in the Gorge bypass reach as requested by WDFW. The field investigation will be supplemented by hydraulic modeling[3] to evaluate potential ranges of flow under which potential barriers in the bypass reach may be passable by the target species being considered.

Tributary Habitat Study Integration: Results of the Fish Passage Study will be integrated with results of the Reservoir Tributary Habitat Assessment and, as appropriate, other studies conducted during relicensing to identify constraints and assess benefits and risks of providing fish passage and access to habitats upstream of the Project dams, consistent with the approach recommended in Anderson et al. (2014). The results of the Fish Passage Study and/or the Reservoir Tributary Habitat Assessment may include the identification of next steps or additional studies that are warranted to further evaluate factors which may affect the efficacy of providing safe, timely, and effective fish passage at the Project, such as those referenced in NMFS's study plan request in Sections 3.4.5 and 3.4.7 (e.g., juvenile reservoir transit and mortality) and those raised in Anderson et al. (2014).

Fish Passage Technical Workshops: This study is intended to include a rigorous assessment of the technical factors influencing the viability and potential effectiveness of fish passage at the

[3] A hydraulic model is being developed per the FA-05 Skagit River Gorge Bypass Reach Hydraulic and Instream Flow Model Development (Bypass Instream Flow Model Development) Study Plan. The hydraulic model will provide input to this study, as described in this plan.

Project developments. To this end, the study plan identifies a series of Technical Workshops that will include full and active involvement of resource agency and tribal biologists and engineers who have specific fish passage or related experience. The scope of work and sequence summarized below includes a logical series of steps and workshops intended to build consensus and reach agreement before proceeding to the next step.

Fish Passage Independent Expert Panel: To further ensure scientific and engineering rigor, City Light is proposing the formation of a three-member Fish Passage Independent Expert Panel (Expert Panel), which would be available to review reports and provide advisory opinions. The makeup of the Expert Panel will be determined in collaboration with LPs. City Light currently envisions that one member of the panel be selected by LPs, a second by City Light, and the third by the two previously selected panel members, but City Light is open to other options for the makeup of the Expert Panel.

NMFS Fish Passage Engineer: A fish passage engineer from NMFS will be invited to participate as an integral member of the team executing the Fish Passage Study. The NMFS member of the execution team will directly participate in the early review of the Conceptual Design Criteria Document, Fish Passage Concept Development Report, and Fish Passage Assessment Report discussed later in this study plan. Feedback obtained from the NMFS member will be incorporated into each of the study elements. The NMFS fish passage engineer will be included in study-related meetings or teleconferences with City Light and its consultants as an integral part of study plan implementation.

2.2 Resource Management Goals

The study will provide information for resource agencies and Indian tribes with jurisdiction in the Project vicinity to address their respective goals and objectives for resource management. Resource management goals were provided by LPs in their study requests identified in Section 1.3 of this study plan.

2.3 Background and Existing Information

Historical distributions of salmonid species in the Skagit River, particularly in the reach now occupied by the Project, have been influenced by large-scale geological phenomena. Both local and regional drainage patterns in the Skagit River basin have been altered by glaciation (Riedel et al. 2007). The North Cascade Range and Puget Lowlands were inundated by the south-flowing Cordilleran Ice Sheet during the Fraser Glaciation 35 to 11.5 thousand years ago. The Cordilleran Ice Sheet that advanced into the area from the north was greater than one mile thick at Ross Lake and the Puget Lowland (Armstrong et al. 1965; Porter and Swanson 1998). Glacial ice dams blocked the northerly flowing Skagit River and created lakes that drained to the south, forming deep canyons. After the ice sheet retreated, the Skagit River and nearby creeks were redirected to flow south in their current configuration (Riedel et al. 2012). Prior to this redirection, the upper Skagit River is thought to have been a tributary to the Fraser River (Riedel et al. 2007).

Smith (2019) indicated that Bull Trout populations in the Upper Skagit Core area are the result of a founding population from the Fraser River. Smith (2019) based this conclusion on an analysis of mitochondrial haplotypes of Bull Trout from the Fraser and Skagit rivers, and low allelic richness of upper Skagit Bull Trout indicating a founder effect. Smith (2019) suggests that the most likely mechanism for dispersal into the Skagit River above the current location of Gorge Dam is through the upper Skagit River from the Fraser River; the findings of Riedel et al. (2007) corroborate this conclusion regarding the origin of upper Skagit River salmonids. This is consistent with the fact that Bull Trout and Rainbow Trout below Gorge Dam are genetically distinct from those in the upstream reservoirs (Smith 2010; Small et al. 2016), and Dolly Varden only occur upstream of the Skagit River Gorge. Rainbow Trout in Stetattle Creek are also genetically distinct from steelhead in the Skagit River (Kassler and Warheit 2012, as cited in Pflug et al. 2013). These genetic differences coupled with the geologic history of the basin strongly suggest that salmonids in the upper Skagit River basin originated in the Fraser River.

Downen (2014) agrees that compelling evidence exists to support the hypothesis that the upper Skagit River once flowed into the Fraser River and states that native char (Dolly Varden and Bull Trout) and Rainbow Trout in the upper Skagit River basin may have originated in the Fraser River. As described in Downen (2014), a recent analysis conducted by the Washington Department of Fish and Wildlife (WDFW; Kassler and Warheit 2012, as cited in Pflug et al. 2013) found that Rainbow Trout in Ross, Diablo, and Gorge lakes are similar to each other, supporting the agency's management of these fish as a single population. However, they are genetically distinct (cluster separately) from steelhead in the lower Skagit River watershed and from other headwater resident Rainbow Trout populations (Pflug et al. 2013). Prior to the construction of Ross Dam, gene flow from the upper Skagit into the lower Skagit was likely only one-way (upstream to downstream) following the redirection of the Skagit River's flow to the south approximately 15,000 years ago (Downen 2014).

The Skagit River Gorge (the gorge) is a narrow section of the Skagit River that begins just upstream of Newhalem, where the river flows through a confined canyon with steep rock walls. Following the geologic connection of the upper and lower Skagit River basins (as described above) after the glacial retreat, the Skagit River flowed south through this gorge through high drops and cascades. There is currently a lack of agreement between City Light and LPs regarding historical anadromous fish use of the Skagit River watershed upstream of the present location of the Gorge Powerhouse.

2.4 Project Operations and Effects on Resources

With construction of the Project, water in the Skagit River was diverted at Gorge Dam into a tunnel to Gorge Powerhouse, bypassing the Gorge except during spill events. This 2.5-mile section from the dam to the powerhouse is now known as the Gorge bypass reach. Under the current Project license, City Light is not required to release any flow into the Gorge bypass reach (FERC 1995). Flows in the bypass reach are limited to accretion, spill-gate seepage, tributary input, and precipitation runoff, except when water is being spilled at Gorge Dam.

2.5 Study Area

The Fish Passage Study area encompasses the Project from the Gorge powerhouse to the upstream end of the Ross Reservoir, thereby including all of the Gorge, Diablo, and Ross developments (Figure 2.5-1).

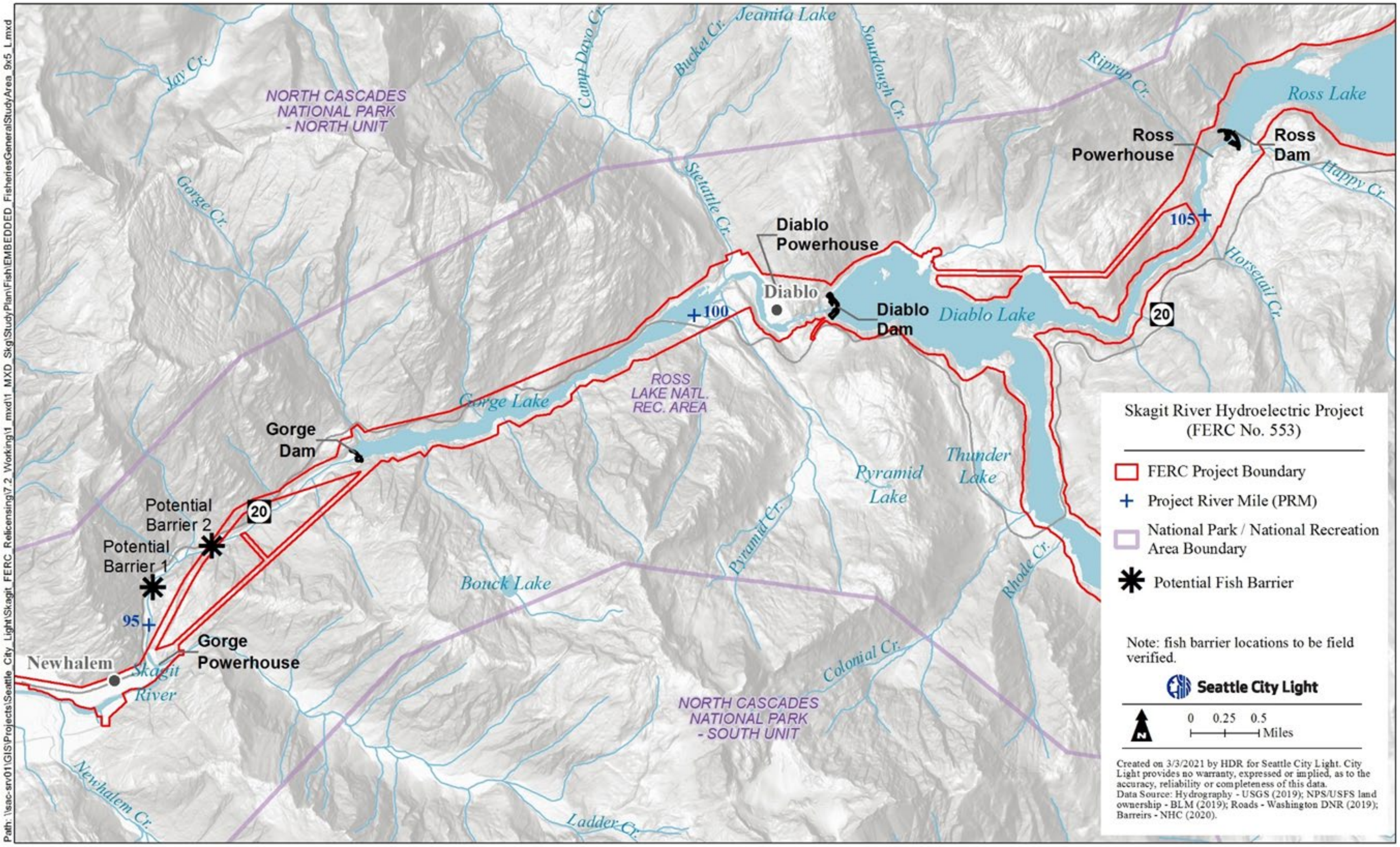

Figure 2.5-1. Study Area for the Fish Passage Study.

2.6 Methodology

2.6.1 Fish Passage Facilities Alternatives Assessment

As described below, City Light envisions a three-stage process for assessing the feasibility of upstream and downstream fish passage at the Project, i.e., the development, in consultation with LPs, of: (1) fish passage conceptual design criteria; (2) fish passage concept-level designs; and (3) a fish passage feasibility assessment. As stated above, City Light will work with a NMFS fish passage engineer as an integral member of the team executing this study. The NMFS engineer will be asked to participate in the early review of the Conceptual Design Criteria Document, Fish Passage Concept Development Report, and Fish Passage Assessment Report discussed below. Feedback obtained from the NMFS engineer will be incorporated into each of the study elements, and the engineer will be included in study-related meetings and/or teleconferences with City Light and its consultants as a part of study implementation team.

2.6.1.1 Fish Passage Conceptual Design Criteria

City Light proposes to conduct three technical workshops with LPs to develop a Fish Passage Conceptual Design Criteria Document. Dates associated with the milestones identified herein are provided in Section 2.9 of this study plan. As part of the assessment process (described below), City Light will gather and present information related to the biological performance of fish passage facilities that have been completed at high-head dams in the Pacific Northwest, along with other relevant site-specific information.

- Workshop 1: The purposes of Workshop 1 are to: (1) review the final study plan and schedule; (2) organize technical biological and engineering teams; (3) finalize a list of species to be considered; (4) establish communication channels; (5) discuss the make-up of the proposed Expert Panel and its formation; (6) discuss criteria to be applied to the barrier assessment study in the bypass reach; and, if possible (7) conduct a site visit to each Project development. Following the Workshop, City Light will assemble the Expert Panel, based on guidance received from LPs during the workshop.

- Workshop 2: Prior to Workshop 2, City Light will issue a preliminary draft Fish Passage Conceptual Design Criteria Document for the LPs' review. The Fish Passage Conceptual Design Criteria Document will include maps and drawings of existing facilities, reservoir rule curves and operating limits, historical operations data, debris accumulation information, and data on thermal regimes of the reservoirs. To the extent practical, a draft list of concept-level passage alternatives will also be issued in advance of the Workshop. The purpose of Workshop 2 will be to discuss the design basis and criteria needed to develop upstream and downstream passage alternatives to the concept level. Draft criteria will be accompanied by a description of the information needed to proceed to the next phase of study. While much of the proposed design criteria and engineering principles will be based on NMFS (2011) and WDFW (2000a, 2000b) guidelines and Bell (1991), additional information will be needed from workshop participants to ensure each concept will be consistent with safe, timely, and effective fish passage requirements. At this workshop, City Light will update LPs regarding progress made gathering biological performance information on Pacific Northwest fish passage facilities. For each fish species under consideration, the following factors will be discussed: (1) estimated adult and juvenile run sizes; (2) adult and juvenile run timing; (3) upstream and downstream passage efficiency requirements; and (4) other design criteria necessary to assist with the layout and configuration of concept-level alternatives.

- Workshop 3: Prior to Workshop 3, City Light will release a revised draft Fish Passage Conceptual Design Criteria Document and a revised list of potential fish passage concept alternatives. At the workshop, City Light and LPs will discuss the LPs' comments on and appropriate revisions to the draft document. If desired by the LPs, the draft document can be submitted to the Expert Panel for review and feedback.

Following Workshop 3, City Light will finalize the Fish Passage Conceptual Design Criteria Document. With the completion of this document and approval of the list of conceptual alternatives to be evaluated, City Light will proceed with the development of concept layouts and configurations for alternative fish passage scenarios. If desired by the LPs, the final document can also be submitted to the Expert Panel for review and feedback.

2.6.1.2 Fish Passage Concept Development

Following finalization of the Fish Passage Conceptual Design Criteria Document, City Light will proceed with developing concept-level upstream and downstream fish passage alternatives and their estimated costs. City Light will develop functional site layouts, process descriptions and diagrams, facility sizing, general design parameters, expected fish capture and survival efficiencies, and opinions of probable costs for select fish passage alternatives. Generally, the work undertaken to develop the Fish Passage Concept Development Report will include:

- Complete concept-level facility layouts and configurations of fish passage and auxiliary structures for each alternative in accordance with the requirements contained in the Fish Passage Conceptual Design Criteria Document, including necessary construction requirements (e.g., cofferdams), modifications to existing Project structures, and features needed for fish passage operations and maintenance (O&M) purposes (e.g., permanent access facilities).
- Prepare a list of potential facility operational changes that may be associated with construction or operations of the fish passage facilities.
- Develop an estimate of reasonably expected performance of the facilities consistent with site characteristics identified in the Fish Passage Conceptual Design Criteria Document and/or prepare a list of additional information needed to provide such estimates;
- Develop site layouts and constructability to the level consistent with generally accepted engineering practice for planning/reconnaissance level studies (e.g., U. S. Bureau of Reclamation 2012; U.S. Army Corps of Engineers (USACE) 2000; USACE 1999; AACE 2003);
- Prepare an estimate for the annual O&M costs associated with each fish passage concept;
- Hold Workshops 4 and 5 to review progress during the concept development work (see Section 2.9 of this study plan for workshop schedule); and
- Prepare draft and final Fish Passage Concept Development reports, which can be provided to the Expert Panel for review if desired by the participant team.

Order of magnitude Opinions of Probable Construction Costs (OPCC) will be developed for potential upstream and downstream fish passage facility alternatives. Cost estimates will be based on anticipated labor, equipment, and materials required to construct each facility. The overall level of detail will be commensurate with a Class-5 cost estimating classification per AACE International (AACE 2003). OPCC will be based on available vendor cost data from similar projects in the region to the extent they are available. An appropriate percent contingency will be added to cost estimates to account for undefined design items and unforeseen construction challenges that cannot reasonably be anticipated at a conceptual level of design. Taxes, to the extent they can be foreseen, will be accounted for in estimates. Additional cost uncertainty will be addressed by presenting a range of OPCC, i.e., high (+40 percent) and low (-25 percent) estimates for each facility.

O&M costs will include annual costs expected to be incurred continuously over the life of the facility. Operational costs are based on the anticipated annual period of operation, required staffing, and resources and equipment required to operate the facility in a manner that achieves the facility's intended objectives. Maintenance costs are those associated with maintaining the proper function and longevity of the system's components. Maintenance includes painting, lubrication of moving parts, repair of damage, replacement of broken or non-functional parts, and periodic inspection. The annual level of effort required to operate and maintain a facility will be estimated using full-time equivalents (FTE) for required personnel. Non-labor costs, such as electricity or fuel, will be estimated based on calculated usage requirements for specified equipment and vehicles.

2.6.1.3 Fish Passage Assessment

Based on the results of the Fish Passage Concept Development Report and any Expert Panel input, City Light will identify fish passage concepts that appear viable and that are consistent with the requirements of the Fish Passage Conceptual Design Criteria Document. Each technical option for facilitating fish passage above Gorge Dam will be evaluated in three ways: (1) its ability to be engineered, constructed, and operated in the context of site geology, existing Project and non-Project structures, site hydrology, reservoir and riverine operations, and safety requirements (i.e., technical feasibility); (2) its ability to operate without significantly interfering with existing Project and non-Project uses; and (3) the facility's ability to meet customary performance standards established for similar facilities, such as facility collection efficiency, survival through the passage facility, and overall Project-wide passage effectiveness. Habitat availability and quality upstream of the Project dams, based on the results of the Reservoir Tributary Habitat Assessment, will also influence whether a passage alternative would benefit anadromous fish populations.

Based on the outcome of the technical engineering assessment described above, City Light, in consultation with LPs, will identify any next steps or additional studies that may be needed in accordance with planning recommendations put forward in Anderson et al., (2014) and potential additional information as identified in the NMFS-04 Feasibility Analysis of Fish Passage study request (Sections 3.4.5 and 3.4.7). Potential additional studies could include: (1) juvenile route selection studies in Ross Lake; (2) reservoir juvenile transit/mortality studies; (3) potential effects of and on resident fish populations (e.g., disease transmission, competition, genetic introgression); (4) demographic factors such as effects on source populations (i.e., source/sink dynamics); and/or

(5) further engineering investigations or hydrodynamic modeling needed to validate concept viability.

When evaluating the potential for fish passage, consideration should be given to the question of whether the target species are being introduced to wholly new habitat and what bearing this may have, if any, on the potential for fish passage to increase the target species' population sizes. Existing information on fish genetics and the historical extent of anadromous fish distributions in the Skagit River indicate that anadromous salmonids may not have had access to reaches upstream of the current location of Diablo Dam (see Section 2.3 of this study plan).

Draft and Final Fish Passage Assessment Reports will be prepared and provided to LPs for review (see Section 2.9 of this study plan). These reports will also be submitted to the Expert Panel, if desired by City Light or LPs.

2.6.2 Field Investigation of Potential Barriers

A field investigation will be conducted to characterize and document the physical structure of the potential upstream passage barriers identified by Envirosphere (1989) in the Gorge bypass reach and to assess the degree to which the barriers may be passable by one or more of the target species. City Light intends to invite LPs to participate in the fieldwork for this investigation, if doing so is considered safe and practicable.

The following information will be recorded at both barriers identified by Envirosphere (1989) during controlled flow releases from Gorge Dam of about 50, 500, and 1,200 cubic feet per second (cfs) (i.e., calibration flows for the bypass reach hydraulic model).

- GPS coordinate points;
- Effective height of each barrier;
- Gradient/slope of the barrier measured with a range finder and hand level;
- Maximum and average depths of the plunge pool at the base of the barrier;
- A characterization of conditions at the apex of the barrier, which will include velocity measurements at the three flows identified above;
- Maximum and average depth of the landing zone on the upstream side of the barrier;
- Description of leap conditions and presence of obstacles;
- Assessment and documentation of adjacent channel features that might be inundated and provide alternative hydraulic pathways at higher flows; and
- Additional channel features and structure that influence hydraulic complexity and are needed for input to computer modeling methodologies.

A fish's potential to successfully ascend a physical feature will be evaluated by comparing the physical and simulated hydraulic characteristics of each feature to the swimming and/or leaping capabilities of each of the target salmonid species. Swimming and leaping capabilities for each species will be estimated using biometric and laboratory data available from the literature such as Bell (1991), Katopodis and Gervais (2016), and Hunter and Mayor (1986). Leaping ability, if a leap barrier exists, will be approximated using mathematical relationships outlined in Powers and Orsborn (1985). Results from these calculations will provide estimated leap heights and leap spans over a range of trajectory angles for each salmonid species. The threshold for total barriers will be based on the maximum estimated leap-height calculated for a trajectory of 85 degrees. For this evaluation, the anticipated burst speed and resulting leap height will be adjusted using the dimensionless length factors and condition coefficients presented in Hunter and Mayor (1986) and, as appropriate, updated guidance from WDFW (2019). The evaluation will be based on available information regarding potential size-class distribution and estimated travel time between a fish's entry into the mainstem Skagit River and its arrival at the Gorge bypass reach.

A given channel feature in the bypass reach will be classified as a total barrier if it is judged to have a measured effective leap height greater than the calculated maximum leap-height or to exceed the burst swim speed and endurance capabilities for all species under all hydraulic conditions.

A feature will be classified as a partial and/or temporal barrier, rather than total barrier, if a barrier exists to a particular target species of adult salmonid, or if it appears to form an impediment to upstream salmonid passage during a certain range of flows.

Final classification will be subject to observation and hydraulic modeling (see below) to provide a more rigorous assessment of the provisional conclusions made during the field investigation and to identify the flows under which the barrier may be passable by the target salmonid species. For example, a feature could exhibit an effective barrier height, a horizontal leap distance, and water velocities that appear negotiable to the target salmonid species but could have a low pool depth, obstructions at the leaping or landing zones, or high levels of turbulence that could inhibit passage over some range of flows. Visual observation will be accomplished through the use of time-lapse cameras. Monitoring cameras will be set up at both barriers, and conditions will be documented under the controlled releases identified in the Bypass Instream Flow Model Development Study Plan, i.e., 50, 500, and 1,200 cfs, and any operational- or maintenance-related spill releases that may occur during the study period. Water velocities will be measured at the apex of the barriers under the controlled releases identified above, if feasible and safe.

2.6.3 Hydrodynamic Modeling

Computer aided two-dimensional (2-D) hydrodynamic modeling will be conducted to estimate the flow range(s) under which upstream passage of the target species would be possible. Results from this model will be used to compare simulated flow depth, velocity and distance to adjacent holding areas with a fish species' swimming speeds and anticipated time to exhaustion (endurance). Pathways and corresponding ranges of flow that appear to allow for upstream navigation, and those that do not, will be reported.

2.7 Reporting

As discussed above and shown in the following schedule, City Light would produce: (1) Draft and Final Fish Passage Conceptual Design Criteria Documents; (2) Draft and Final Fish Passage Concept Development Reports; and (3) Draft and Final Fish Passage Assessment Reports. City Light will also provide a Fish Passage Barrier Assessment in the Initial Study Report (ISR)that summarizes the results of the field investigation of potential upstream passage barriers and pertinent results of hydrodynamic modeling in the Gorge bypass reach.

2.8 Consistency with Generally Accepted Scientific and Engineering Practice

Concept-level upstream and downstream passage alternatives will be developed by qualified personnel. The design, function, and performance of fish passage facilities would be consistent with relevant guidance, i.e., NMFS (2011), WDFW (2000a, 2000b), Bell (1991), bioengineering principles for the target salmonid species, and relevant standards of practice for similar engineered projects.

The application of methods and biometric data applicable to the barrier assessment would be as outlined in Bell (1991), Powers and Orsborn (1985), Hunter and Mayor (1986), and Katopodis and Gervais (2016), and updated guidance from WDFW (2019), along with the corresponding field measurements and observations proposed in this plan, constitute a standard approach to assessing the degree to which channel features constitute barriers to upstream salmonid migration.

Hydrologic Engineering Center River Analysis System (HEC-RAS) is widely recognized and accepted throughout the engineering and scientific community for riverine hydraulic modeling. The proposed application of HEC-RAS 2D for characterizing the hydraulics of channel features that may be barriers to upstream migration is consistent with approaches undertaken in similar situations.

2.9 Schedule

A provisional schedule for conducting the Fish Passage Study elements follows:

- Conduct field investigation to characterize channel features in the Gorge bypass reach considered to be potential upstream fish passage barriers – May to July 2021.
- Assess the extent to which these channel features constitute passage barriers to upstream passage of one or more of the target species – July 2021.
- Conduct hydraulic modeling (i.e., as part of the Bypass Instream Flow Model Development Study) to identify the flow ranges under which each of the target species may be able to pass the barriers – November 2021 to February 2022.
- Fish Passage Conceptual Design Criteria Document – June 2021 to January 2022
  - Workshop 1: June 2021
  - Preliminary draft Fish Passage Conceptual Design Criteria Document: September 2021
  - Workshop 2: September 2021
  - Revised draft Fish Passage Conceptual Design Criteria Document: November 2021
  - Workshop 3: December 2021
  - Final Fish Passage Conceptual Design Criteria Document: January 2022

- Fish Passage Concept Development Report – January 2022 to May 2022
  - Draft Fish Passage Concept Development Report: March 2022
  - Workshop 4: March 2022
  - Final Fish Passage Concept Development Report: June 2022
  - Workshop 5: July 2022
- ISR – March 2022
- Fish Passage Assessment Report – July 2022 to December 2022
  - Draft Fish Passage Assessment Report: August 2022
  - Final Fish Passage Assessment Report: December 2022
- Updated Study Report (USR) – March 2023

2.10 Level of Effort and Cost

The initial estimate for implementation and reporting associated with this study is approximately $800,000. This cost estimate does not include hydraulic modeling of partial barriers to fish passage, which is included in the FA-05 Skagit River Gorge Bypass Reach Hydraulic and Instream Flow Model Development Study.

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FA-05 SKAGIT RIVER GORGE BYPASS REACH HYDRAULIC AND INSTREAM FLOW MODEL DEVELOPMENT
REVISED STUDY PLAN

SKAGIT RIVER HYDROELECTRIC PROJECT
FERC NO. 553

Seattle City Light

April 2021
RSP

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List of Acronyms and Abbreviations

2-D ....two-dimensional
cfs..............................cubic feet per second
City Light..................Seattle City Light
Ecology ....Washington State Department of Ecology
ELC ....Environmental Learning Center
ESH ....Effective Spawning Habitat (model)
FEMA ....Federal Emergency Management Agency
FERC..........................Federal Energy Regulatory Commission
GIS ....Geographic Information System
GNSS ....Global Navigation Satellite System
HEC-RAS ....Hydrologic Engineering Center River Analysis System
HSC...........................habitat suitability criteria
IFIM ....Instream Flow Incremental Method
ILP.............................Integrated Licensing Process
LiDAR........................Light Detection and Ranging
LP ....licensing participant
NMFS.........................National Marine Fisheries Service
NPS ....National Park Service
PAD...........................Pre-Application Document
PRM ....Project River Mile
Project ....Skagit River Hydroelectric Project
PSP ....Proposed Study Plan
RLNRA ....Ross Lake National Recreation Area
RM ....river mile
RSP ....Revised Study Plan
RWG ....Resource Work Group
UAV ....unmanned aerial vehicle
USACE ......................U.S. Army Corps of Engineers
U.S.C..........................United States Code
USFWS ......................U.S. Fish and Wildlife Service
USGS .........................U.S. Geological Survey

WDFW......................Washington Department of Fish and Wildlife

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1.0 INTRODUCTION

1.1 General Description of the Project

The Skagit River Hydroelectric Project (Project), licensed to The City of Seattle, Washington, and operated through its publicly-owned electric power utility Seattle City Light (City Light), is located in northern Washington State and consists of three power generating developments on the Skagit River – Ross, Diablo, and Gorge – and associated lands and facilities. The Project generating facilities are in the Cascade Mountains of the upper Skagit River watershed, between Project River Miles (PRM) 94.7 and 127.9 (U.S. Geological Survey [USGS] RMs 94.2 and 127).[1] Power from the Project is transmitted via two 230-kilovolt powerlines that span over 100 miles and end just north of Seattle at the Bothell Substation. The Project also includes two City Light-owned towns, an Environmental Learning Center (ELC), several recreation facilities, and several parcels of fish and wildlife mitigation lands.

Project generating facilities are all located in Whatcom County, although Ross Lake, the most upstream reservoir, crosses the U.S.-Canada border and extends for about one mile into British Columbia at normal maximum water surface elevation. Gorge Powerhouse, the most downstream facility, is approximately 120 miles northeast of Seattle and 60 miles east of Sedro-Woolley, the nearest large town. The closest town is Newhalem, which is part of the Project and just downstream of Gorge Powerhouse. The primary transmission lines cross Whatcom, Skagit, and Snohomish counties; the fish and wildlife mitigation lands are in the same counties.

The Project Boundary is extensive, spanning over 133 miles from the Canadian border to the Bothell Substation just north of Seattle, Washington. In addition, there are "islands" of fish and wildlife mitigation lands and recreation facilities within the Skagit, Sauk, and South Fork Nooksack watersheds that are also within the Project Boundary. Project generating facilities are entirely within the Ross Lake National Recreation Area (RLNRA), which is administered by the National Park Service (NPS) as part of the North Cascades National Park Complex. The RLNRA was established in 1968 in the enabling legislation for North Cascades National Park to provide for the "public outdoor recreation use and enjoyment of portions of the Skagit River and Ross, Diablo, and Gorge lakes." The legislation maintains the Federal Energy Regulatory Commission's (FERC) jurisdiction "in the lands and waters within the Skagit River Hydroelectric Project," as well as hydrologic monitoring stations necessary for the proper operation of the Project (16 United States Code [U.S.C.] § 90d-4; Public Law 90-544. Sec. 505 dated October 2, 1968, as amended by Public Law 100-668. Sec. 202 dated November 16, 1988).

1.2 Relicensing Process

The current FERC license for the Project expires on April 30, 2025, and City Light will apply for a new license no later than April 30, 2023. City Light formally initiated the relicensing process by filing a Notice of Intent and Pre-Application Document (PAD) with FERC on April 27, 2020 (City Light 2020a). The PAD includes descriptions of the Project facilities, operations, license

[1] City Light has developed a standard Project centerline and river mile system to be used throughout the relicensing process, including the study program, to replace the outdated USGS RM system. Given the long-standing use of the USGS RM system, both it and the Project River Mile (PRM) system are provided throughout this document. For further details see Section 7.0 of the main body RSP.

requirements, and Project lands as well as a summary of the extensive existing information available on Project area resources and early consultation on potential resource issues to be addressed during the relicensing.

In 2019-2020, City Light convened a series of Resource Work Groups (RWG) to engage agencies and other licensing participants (LP) in the Study Plan Development Process. Discussions with LPs continued in early 2021 with a series of topic-based discussions following filing of the Proposed Study Plan (PSP) on December 8, 2020 (City Light 2020b). This study plan reflects RWG and LP discussion and study requests and comments submitted by LPs.

1.3 Study Plan Development

As part of the Study Plan Development Process, LPs expressed concern about the Project's potential effects on fish habitat and fish passage in the Gorge bypass reach (defined as the reach between Gorge Dam to Gorge Powerhouse). Table 5.1-2 of the PAD provides a summary of all the issue forms submitted during this 2019 process. Section 5 of the PAD lists the resource studies and management plans proposed by City Light to address select (but not all) issues identified as part of the Study Plan Development Process. While acknowledging the interests of LPs, City Light focused its initial draft study plan proposal in the PAD on information gaps that were needed to directly inform license conditions and that were focused on potential Project effects.

To address LPs' concerns about the Project's potential effects on fish habitat and fish passage in the Gorge bypass reach of the Skagit River, City Light proposes to conduct this FA-05 Skagit River Gorge Bypass Reach Hydraulic and Instream Flow Model Development Study (Bypass Instream Flow Model Development Study).

City Light is filing this study plan with FERC as part of its Revised Study Plan (RSP), an update to the version that was filed with the PSP and incorporating additional consultation with LPs prior to the filing date. This study plan addresses, with modifications, elements of the Evaluation of Fish Barriers and Fish Species in the Bypass Reach Study request submitted by the Washington Department of Fish and Wildlife (WDFW-01) and also addresses, with modifications, elements of the Instream Flow Study request submitted by Washington State Department of Ecology (Ecology-02), as explained in Section 6 of the RSP.

PSP comments to this study plan were submitted by American Whitewater, Ecology, Upper Skagit Indian Tribe, U.S. Fish and Wildlife Service (USFWS), and WDFW. City Light has addressed the specific comments and suggested edits in the study plan and responded to comments in the PSP comment/response table appended to the main body of the RSP. Modifications made to the study plan in response to comments and since the PSP include updating the fish species list and providing details for a process to identify and evaluate alternative flow management scenarios. Language conditioning the monitoring and detailed hydraulic modeling of fish passage barriers on a determination of fish passage potential has also been removed.

Project operations result in the release of flows to the Skagit River at the Gorge Powerhouse and Gorge Dam. Through coordination with the U.S. Army Corps of Engineers (USACE), Project operations reduce downstream flood risk. Through a variety of pathways, the Project's flow releases also affect the availability and suitability of spawning, incubation, and rearing habitat for anadromous salmonids and long-term geomorphic processes. The development of hydraulic models will provide detailed information on the hydraulic characteristics of flows in the Skagit River (discharge, flow depth and velocity, and their spatial and temporal variations) and will be useful when considering potential alternative Project operations, particularly related to effects on fish habitat. This study plan describes the proposed development of an instream flow model for the reach between Gorge Dam and Gorge Powerhouse. The Instream Flow Model will consist of a numerical hydraulic model that produces hydraulic outputs (i.e., depth and velocity grids) that can be further analyzed or synthesized in a Geographic Information System (GIS) to assess changes in habitat suitability under alternative Project operations. The model will also provide hydraulic data to support an evaluation of potential fish passage barriers in this reach.

Following completion of relicensing studies, an integrated environmental analysis will specifically address links across resource areas. Studies that may ultimately be linked, either directly or indirectly, to the findings of this study include: (1) FA-04 Fish Passage Technical Studies Program (Fish Passage Study); (2) FA-01 Water Quality Monitoring Study (i.e., the relationship between water quality and flows with respect to fish habitat suitability); (3) GE-04 Skagit River Geomorphology between Gorge Dam and the Sauk River Study (Geomorphology Study)(e.g., substrate mapping, etc.); (4) OM-01 Operations Model Study (i.e., upstream hydraulic boundary condition); (5) FA-02 Instream Flow Model Development (i.e., for the reach between Gorge Powerhouse and the Sauk River confluence); (6) RA-02 Gorge Bypass Reach Safety and Whitewater Boating Assessment; and (7) CR-03 Gorge Bypass Reach Cultural Resources Survey. More needs to be learned within each respective study area before it is clear if and how study results will meaningfully inform comprehensive environmental analysis. City Light will work with LPs to review and integrate information from related studies as part of the ILP process in support of City Light's license application filing.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

The goal of the Bypass Instream Flow Model Development Study is to develop a flow/habitat evaluation tool for the Gorge bypass reach (defined as the reach between Gorge Dam and Gorge Powerhouse) and to develop hydraulic data necessary to support an evaluation of fish passage at two locations in the bypass reach.

Specific objectives include:

- Develop and calibrate a numerical hydraulic model (or models) of the bypass reach.
- Integrate hydraulic model outputs and observed characteristics of substrate and cover with biological (fish species, life stages, periodicities) and physical (depth, velocity) criteria to develop flow-habitat relationships for the bypass reach.
- Apply the model to provide hydraulic data to support the evaluation of fish passage, particularly at two previously identified potential upstream passage barriers (Envirosphere 1989) within the bypass reach located approximately 0.6 and 1.3 miles upstream from Gorge Powerhouse.

Once the study is complete (i.e., the model has been developed), the flow/habitat model will be used to support additional discussions regarding hydraulic conditions and aquatic habitat within the bypass reach, the potential for fish passage at bypass reach potential barriers and, through integration with results from the Instream Flow Model Development Study,[2] evaluation of instream flows in the mainstem Skagit River between Gorge Dam and the Sauk River.

2.2 Resource Management Goals

The study will provide information for resource agencies and Indian tribes with jurisdiction in the Project vicinity to address their respective goals and objectives for resource management. Resource management goals were provided by LPs in their study requests identified in Section 1.3 of this study plan.

2.3 Background and Existing Information

The bypass reach is the 2.5-mile reach between Gorge Dam and Gorge Powerhouse, which is largely dewatered for much of the time under existing conditions as a result of Skagit River flows being diverted at Gorge Dam into a tunnel for power generation. The river in this reach flows in a steep (average slope approximately 1.6 percent) confined channel with lower gradient run and riffle sections interspersed with higher gradient boulder cascade and plunge pool sections (Envirosphere 1989). The substrate in the reach is dominated by boulders and cobbles with sand and gravel in pools.

[2] The Instream Flow Model Development study will develop an instream flow model for the mainstem Skagit River from Gorge Powerhouse to the confluence with the Sauk River.

Under existing conditions, flows in the bypass reach are limited to seepage from the spill gates at Gorge Dam, seepage under the dam, groundwater accretion, inflows from four small ephemeral tributaries, and occasional spill from Gorge Dam.

Discharge data for the bypass reach are available from limited measurements of baseflow, including those made in summer and fall 1989 (Envirosphere 1989) discussed further below, and records of spill from Gorge Dam. Records of spill from Gorge Dam are available starting in January 1997. As reported in Section 4.5.2.4 of the PAD (City Light 2020), under existing conditions, flows of several hundred to over 20,000 cubic feet per second (cfs) occur in the bypass reach during planned and unplanned spill events at Gorge Dam. These spill events are most often the result of inflows to Gorge Lake exceeding Gorge Powerhouse capacity but may also be the result of a load rejection, emergency shutdown of flow diversion, or the release of water during Gorge Powerhouse maintenance periods. During maintenance or emergency shutdown periods, water is routed through the Gorge bypass reach to maintain instream flow requirements in the Skagit River downstream from Newhalem. Between January 1, 1997 and April 16, 2019, there were 634 days (approximately 8 percent of the time) when Gorge Dam was spilling water into the bypass reach, with a daily average spill (for days when spill was occurring) of about 1,900 cfs.

Records of discharge in the bypass reach for pre-Project conditions are available from USGS gage Skagit River at Newhalem (USGS gage 1217800) for the periods December 1908 to May 1914 and October 1920 to September 1924, when diversion of flow for power generation began.

A study of hydraulic conditions, fish habitat characteristics, and fish populations in the bypass reach was conducted in 1989 (Envirosphere 1989). Baseflows were measured in early summer, mid-summer, late summer, and early fall at three locations: at the upper and lower ends of the bypass reach and at an intermediate location. The largest measured baseflows (in late June) were 10 cfs at the upper end of the bypass reach and 15 cfs at the lower end. Low flows of 1.5 cfs and 2 cfs were reported during August and early September for the upper and lower ends of the bypass reach, respectively.

Channel cross-sections were surveyed at a total of 17 transects through the bypass reach. Water surface elevations at those transects were measured during baseflow conditions and for controlled releases from Gorge Dam of 50 cfs, 500 cfs and 1,000 cfs. The channel cross-section data and observed water surface elevation data were used to determine the variation of hydraulic geometry with discharge (including wetted width, depth, and cross-section average velocity) at each transect.

A fish barrier analysis and fish habitat survey were also conducted. Two potential fish barriers were identified, i.e., at 0.6 miles and 1.3 miles upstream from Gorge Powerhouse. Both barriers were classified using the Powers and Orsborn (1985) classification as boulder cascade barriers. The first (at 0.6 miles) and more severe of the two barriers is described (Envirosphere 1989) as a "9-ft vertical drop in elevation over a large granitic block." The 1989 fish barrier analysis indicated that passage of this barrier by steelhead trout and Chinook Salmon may be possible under a certain range of flow conditions but that other anadromous fish (Pink, Coho and Chum Salmon) "could not negotiate this barrier." The analysis found that fish passage at this barrier would be limited at low flows by plunge pool depth from which to leap, and also concluded that "the presence of velocity barriers at high flows is a definite possibility in the confined bedrock and boulder sections of the bypass reach." The second boulder-cascade series (at 1.3 miles) was characterized as a velocity barrier of less restrictive conditions (Envirosphere 1989).

The 1989 fish habitat survey comprised transect-based quantification of habitat variables (depth and velocity under baseflow conditions, substrate type, and cover) for selected habitat units (shallow pools, deep pools and riffles/runs). The survey found excellent habitat associated with deep pools and large substrate even under existing summer baseflow conditions, noting that "habitat in the Gorge bypass reach is mainly limited by flows which do not provide a fully wetted channel."

Fish survey results in the bypass reach (Envirosphere 1989; Upper Skagit Indian Tribe 2016) and Bull Trout genetics studies (Smith 2010; Small et al. 2016) support the conclusion that the lowermost barrier 0.6 miles upstream of the powerhouse historically blocked the upstream movement of salmon and Bull Trout in the Skagit River. In 2016, live steelhead, steelhead redds, and Coho Salmon fry were seen below the lowermost barrier, whereas juvenile Rainbow Trout were found throughout the bypass reach (Upper Skagit Indian Tribe 2016).[3] Further field reconnaissance on October 24, 2019 by a team of City Light, WDFW, Upper Skagit Indian Tribe, and NPS biologists observed no adult steelhead anywhere in the bypass reach (as expected given their spring spawning behavior), but three schools of live Coho Salmon, several Pink Salmon carcasses and redds, and one Chinook Salmon carcass and redd were observed below the lowermost barrier. In contrast, several juvenile Rainbow Trout, Brook Trout, and native char were angled or electrofished upstream of the second barrier (located about 1.3 miles upstream of the powerhouse). Under some flow conditions small numbers of steelhead may have historically been able to move upstream of these barriers (Smith and Anderson 1921; Envirosphere 1989; NMFS 2012; NMFS 2018). During the previous Project relicensing, City Light assessed historical records containing WDFW accounts in the Project vicinity (Envirosphere 1988). From review of the historical records, Envirosphere concluded that, "Some historical evidence suggests that small runs of steelhead trout migrated as far as Stetattle Creek..."

High quality topographic and bathymetric data (Quantum Spatial 2017, 2018) are available to support development of hydraulic models of the bypass reach, which in turn would provide the hydraulic data needed to analyze instream flows and to support use of the hydraulic model to assess potential fish passage barriers. City Light also has a bathymetric map of the plunge pool below Gorge Dam.

[3] Surveys of the bypass reach were conducted on May 9 and June 17, 2016. The May 2016 survey extended from Gorge Powerhouse to about 1.5 miles upstream in the bypass reach. During the survey, snorkelers recorded the number of fish, by species and size-class, and redds in each distinct habitat area. Four adult steelhead and four steelhead redds were observed, all downstream of the barrier located 0.6 miles upstream of the powerhouse. No adult steelhead or redds were observed upstream of the barrier. Numerous Coho Salmon fry were observed in the bypass reach up to about 0.6 miles upstream of the powerhouse; no Coho fry were observed above the [at least partial] barrier located 0.6 miles above the powerhouse. Seven juvenile Rainbow Trout/steelhead were observed in pools below and within the fish passage barrier at 0.6 miles upstream of the Gorge Powerhouse, and five juvenile Rainbow Trout/steelhead were observed in a pool located immediately upstream of the barrier; these fish likely originated in Gorge Lake and were passed downstream during a spill event (Connor 2016). During the June 2016 survey, no steelhead or additional steelhead redds were observed; juvenile Rainbow Trout/steelhead and one Eastern Brook Trout were observed above the barrier in June.

2.4 Project Operations and Effects on Resources

Project operations downstream of Gorge Dam reduce downstream flood risk and affect the availability and suitability of spawning, incubation, and rearing habitat for anadromous salmonids. Project operations may also affect fish passage within the bypass reach for certain species and life stages. Information on the hydraulic characteristics of flows in the bypass reach (discharge, flow depth and velocity, and their spatial and temporal variations) will be used to assess Project effects and may inform the development of alternative scenarios for future Project operations, including flow releases into the bypass, particularly as they pertain to fish habitat.

2.5 Study Area

The study area extends from Gorge Dam at about PRM 97.2 (USGS RM 96.6) downstream to the USGS Skagit River at Newhalem gage (USGS gage 12178000), approximately 0.5 miles downstream from Gorge Powerhouse at PRM 94.3 (USGS RM 93.7) (Figure 2.5-1). Reach length is approximately 2.9 miles.

The downstream limit of hydraulic modeling, i.e., the USGS Skagit River at Newhalem gage, was selected to allow use of the stage-discharge rating at the gage site as a robust downstream model boundary condition and to overlap with the Gorge Powerhouse to Sauk River hydraulic model proposed under Instream Flow Model Development Study Plan.

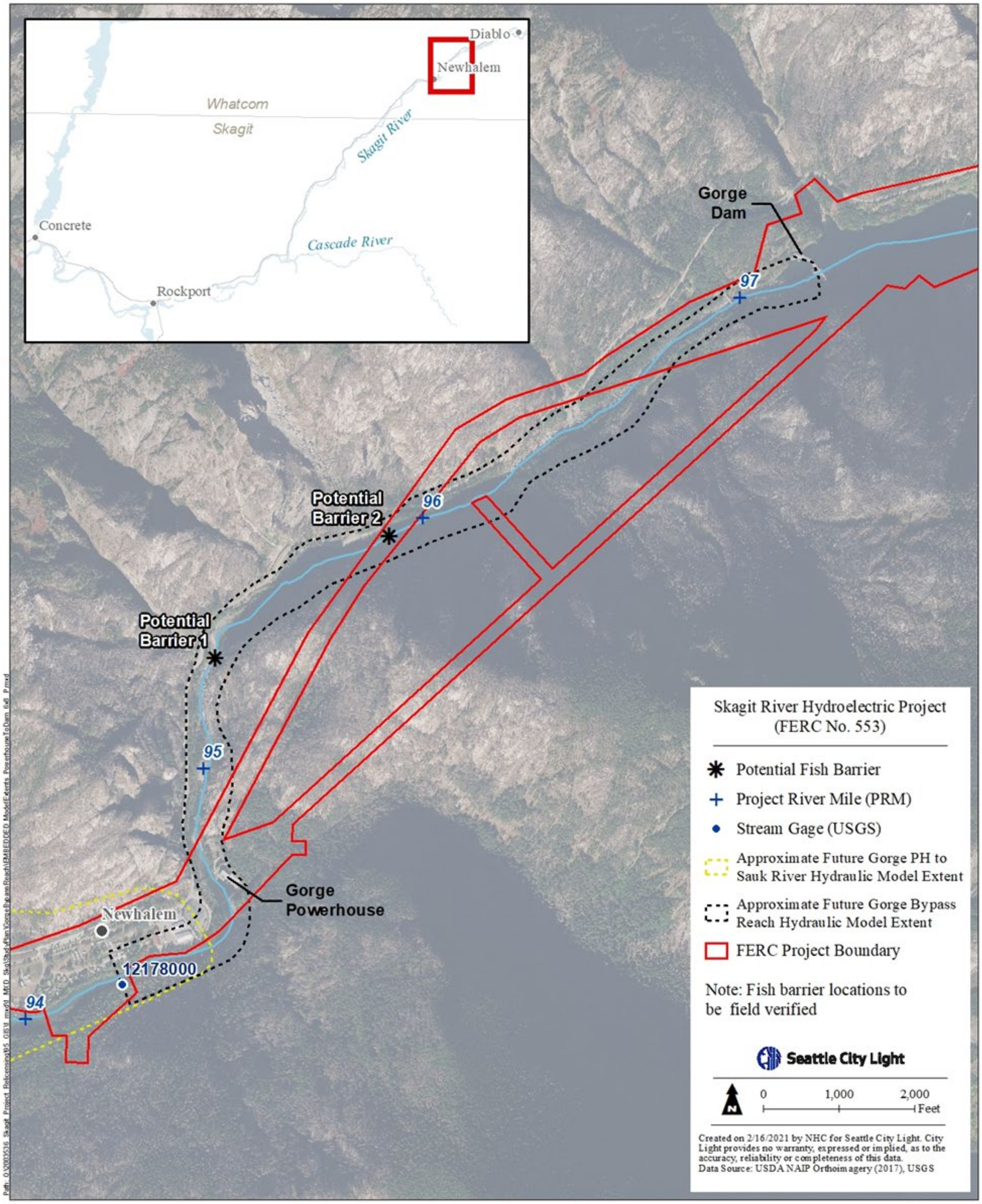

Figure 2.5-1. Overview of study area.

2.6 Methodology

The proposed work will involve developing and calibrating a two-dimensional hydraulic model, as well as applying the model to analyze instream flows and to provide hydraulic data in support of an evaluation of fish passage, focusing on the two potential barriers discussed in Section 2.3 and shown in Figure 2.5-1 of this study plan.

2.6.1 Hydraulic Modeling for Instream Flow Analysis and Evaluation of Fish Passage

2.6.1.1 Hydraulic Model Selection and Overview of Model Development

A two-dimensional unsteady flow hydraulic model will be developed for the bypass reach using the U.S. Army Corps of Engineers (USACE) HEC-RAS modeling platform (USACE 2016). The model will extend from Gorge Dam at about PRM 97.2 (USGS RM 96.6) downstream to the USGS Skagit River at Newhalem gage (USGS gage 12178000), approximately 0.5 miles downstream of Gorge Powerhouse at PRM 94.3 USGS RM 93.7), for a total reach length of approximately 2.9 miles.

The following factors were considered in selecting a model platform:

- Ease of integration with the proposed HEC-RAS two-dimensional (2-D) model of the downstream reach from Gorge Powerhouse to the Sauk River confluence (see the Instream Flow Model Development Study Plan) and with the Operations Model (see the Operations Model Study Plan);
- Efficiency with which metrics of interest for instream flow analysis and evaluation of potential fish passage barriers can be generated by the model;
- Efficiency of model development;
- Model resolution required to meet study objectives;
- Speed of model execution;
- Availability of model support and model maintenance;
- Availability of visualization tools and software features for analysis, synthesis, and display of model output;
- Acceptance by the engineering community and both governmental and non-governmental institutions; and
- Size of user community (which relates to the pool of expertise available for model updates and application).

Model development will involve the following tasks, described in the following sub-sections:

- Processing of model topographic data;
- Development of model geometry;
- Analysis of model boundary conditions;
- Field monitoring to obtain discharge and water level data to support model calibration;

- Mapping of substrate and cover;
- Model configuration and calibration; and
- Model application and analysis of model output.

2.6.1.2 Model Topographic Data

A three-dimensional terrain model of the reach from Gorge Dam to the USGS Skagit River at Newhalem gage (USGS gage 12178000) will be developed from a combination of topobathymetric Light Detection and Ranging (LiDAR) and standard LiDAR.

LiDAR data covering the proposed hydraulic model extents were acquired in 2016 and 2018 (Quantum Spatial 2017; Quantum Spatial 2018) as follows:

- Quantum Spatial topobathymetric LiDAR ("green" LiDAR) contracted by City Light; acquired April 25 and 26, 2018 (Quantum Spatial 2018).
- Quantum Spatial topographic LiDAR ("standard" LiDAR) contracted by USGS; acquired March 2016–September 2016 (Quantum Spatial 2017).

The 2018 topobathymetric LiDAR data have an absolute Non-vegetated Vertical Accuracy of 0.182 feet with 95 percent confidence and a vertical accuracy of 0.366 feet with 95 percent confidence for submerged bathymetric check points. The 2016 standard LiDAR data have an absolute Non-vegetated Vertical Accuracy of 0.263 feet with 95 percent confidence. Full details of the LiDAR resolution and accuracy assessments can be found in the LiDAR technical data reports (Quantum Spatial 2017, 2018).

The 2018 topobathymetric LiDAR provides high resolution topographic and bathymetric data and orthophotos for almost the entire study area. There are, however, several locations where topobathymetric voids exist in the data, either because of turbid water, deep water, aerated water, vegetation cover, and/or a non-reflective channel bottom, which prevents adequate laser returns. These voids in the bathymetric data are located at:

- One deep pool approximately 1.4 miles upstream of Gorge Powerhouse;
- The Gorge Powerhouse tailrace; and
- A short stretch of deep water between the Gorge Powerhouse and the USGS Skagit River at Newhalem gage.

Each of these voids will be filled using interpolated terrain data produced by Quantum Spatial (Quantum Spatial 2018).

The topobathymetric LiDAR in the vicinity of the deep pool 1.4 miles upstream from Gorge Powerhouse provides channel bed elevations in water depths up to approximately 25 feet. The coverage void at this pool (water depth greater than 25 feet under base flow conditions) will not be surveyed due to difficult access, but given the depth of water at this location, use of interpolated terrain data will have no impact on hydraulic model results or instream flow analysis. The void in the immediate vicinity of the Gorge Powerhouse tailrace will be not be surveyed because it is unsafe to do so, but it will be filled by interpolation from surrounding bathymetry. The void in deep water downstream from Gorge Powerhouse will not be surveyed either because of difficult access, but it too will be filled by interpolation.

There are several locations where the 2018 LiDAR may not extend far enough to provide complete coverage of the left bank of the bypass reach for modeling high flows. Where this is the case, left bank topographic data coverage will be extended as needed using the 2016 LiDAR data (Quantum Spatial 2017). Use of this less detailed topographic information will have a negligible effect on hydraulic model results and instream flow analysis.

The final composite terrain will be imported into HEC-RAS to define the river channel. The modeled domain will be one reach with boundary conditions as discussed in Section 2.6.1.4 of this study plan.

2.6.1.3 Model Geometry Development

A two-dimensional model mesh will be developed using tools in the HEC-RAS Mapper editor and "draped" over the final composite terrain. The mesh consists of cells, or elements, whose size, shape, and orientation are refined as needed to simulate hydraulic conditions. The model cell size will be determined considering simulation run time (fewer cells equates to faster run times), and resolution in areas of interest for habitat and fish passage evaluation (more cells equates to finer resolution and slower run times). Several meshes will be developed with cells ranging in size from 1 to 5 feet and coupled with a narrow range of appropriate computation time steps. This consistency sensitivity analysis will allow for understanding how cell size and computational time-step affect model results. The final mesh geometry and associated simulation time step will balance achieving numerical accuracy at the desired resolution with minimizing computation time.

Hydraulic roughness zones will be delineated from an initial assessment of channel bed substrate and observed vegetation. Initial roughness coefficients will be assigned based on professional judgement and published values (e.g. Barnes 1967) and then refined during model calibration.

2.6.1.4 Model Boundary Conditions

Hydrologic inputs to the proposed model will be specified by flow releases from Gorge Dam, local tributary inflows between Gorge Dam and the USGS Skagit River at Newhalem gage, and discharge from Gorge Powerhouse. Ungaged tributary inflows between Gorge Dam and the USGS Skagit River at Newhalem gage will be estimated using data from the USGS Newhalem Creek near Newhalem gage (USGS gage 12178100) and data collected during field monitoring (see Section 2.6.1.5 of this study plan).

The published stage-discharge rating for the USGS Skagit River at Newhalem gage will be used to specify the model's downstream boundary.

2.6.1.5 Field Monitoring

A field monitoring program will acquire water level, discharge, and velocity data for use in hydraulic model calibration and to support an analysis of fish passage potential.

Model calibration for the purposes of instream flow modeling will rely on water surface profile data for the study reach and water surface elevation, velocity, and discharge data at select transects.

Water surface profiles for the 2.9-mile study reach will be acquired, subject to safety considerations, by marking and surveying profiles under existing base flow conditions (with no spill from Gorge Dam) and during controlled releases from Gorge Dam of approximately 50, 500, and 1,200 cfs. These target flows are similar to those used in the 1989 study of the bypass reach (Envirosphere 1989), but with a somewhat larger flow at the high end. The high-end flow is approximately the 90-percent exceedance flow (i.e. the flow exceeded 90 percent of the time) from analysis of pre-Project discharge data.

Detailed data on water surface elevations, velocities, and discharge will also be collected during baseflow conditions and, subject to safety considerations, at each of the controlled releases, at a maximum of four transects representative of the range of hydraulic conditions in the bypass reach. Transect locations will be determined in consultation with LP natural resource managers familiar with the river.

Additional water surface elevation and velocity data will be collected in the vicinity of the potential fish passage barriers to refine the model calibration at those locations.

Up to twelve automatic water level recorders will be installed at key locations throughout the two potential fish barrier sections. Up to six water level recorders will be installed at the lower potential fish barrier (Potential Barrier 1 in Figure 2.5-1), and up to six at the upper potential barrier (Potential Barrier 2 in Figure 2.5-1). The instruments will be placed in the plunge pool below each barrier and at key locations in the principal pathways through each barrier section. These instruments will provide information on plunge pool depth below each barrier and water surface profiles through each barrier for the full range of flows experienced during the monitoring period for use in both hydraulic model calibration and to provide data for direct evaluation of fish passage potential. Exact locations for these instruments will be determined in consultation with LPs and study team fish passage specialists.

Water surface elevation and velocity data will also be collected during baseflow conditions and, subject to safety considerations, at each of the controlled releases at select locations upstream from and within the fish passage barrier sections. Locations for monitoring will be determined in consultation with LPs and study team fish passage specialists.

If possible, documentation of flow conditions within the potential passage barriers will be collected in the form of nadir (i.e., downward facing) and oblique photos from an Unmanned Aerial Vehicle (UAV) to support the fish passage evaluation. These photos will be processed in conjunction with local survey ground control to provide detailed water surface elevation data (water's edge elevation data) through the barrier sections.

Substrate Mapping

The results of substrate mapping will provide input for fish habitat modeling, will be used to refine estimates of hydraulic roughness, and will aid in hydraulic model calibration. Substrate will be classified visually according to the size codes identified in the WDFW/Ecology Instream Flow Study Guidelines (Beecher et al. 2016) (Table 2.6-1).

Table 2.6-1. Substrate size-classes.

Substrate Code	Type of Substrate
1	Silt, Clay, or Organic
2	Sand
3	Small Gravel (0.1-0.5")
4	Medium Gravel (0.5-1.5")
5	Large Gravel (1.5-3.0")
6	Small Cobble (3.0-6.0")
7	Large Cobble (6.0-12")
8	Boulder (>12")
9	Bedrock

Substrate polygons will be delineated throughout the study reach with additional effort focused on high-value areas. Substrate mapping will be performed using map tiles developed from high-resolution aerial imagery (Quantum 2018; Skagit County 2015) and loaded into ArcGIS Collector on differential Global Navigation Satellite System (GNSS)-enabled iPads. Substrate information will be recorded in Collector by electronically delineating polygons of homogeneous substrate facies (natural breaks) directly onto the map tiles and assigning each polygon a substrate code. Substrate codes will use the format “ab.c” where “a” is the component code for dominant particle size (particle size will be assigned based on the particle’s intermediate axis), “b” is the component code for the subdominant particle size, and “c” is tenths of cell area covered by dominant (50 percent or greater) substrate type. For example, the code 46.8 indicates 80 percent medium gravel and 20 percent small cobble, in accordance with the table above (Beecher et al. 2016).

Field teams will be trained prior to mapping so that substrate coding is accurately and uniformly applied. Initially, crew members will “calibrate” their visual assessments of particle size using a gravelometer or ruler. Regular calibration checks will be conducted as needed, such as when crews encounter a significant change in substrate conditions or if/when mapping is resumed after breaks in fieldwork.

Cover Mapping

Cover mapping, which will provide input for fish habitat modeling, will be conducted based on the codes identified in the WDFW/Ecology Instream Flow Study Guidelines (Beecher et al. 2016) (Table 2.6-2). The guidelines include nine cover criteria, eight of which (i.e., 00.2–00.9) will be mapped and used for modeling fish habitat. Undercut banks (00.1 in Table 2.6-2) constitute a small fraction of the overall potential rearing cover in a river the size of the Skagit, particularly in the high-gradient channel in the Gorge, and exclusion of this cover type will have little influence on the 2-D model’s output. As a result, undercut banks will be omitted from the cover mapping exercise.

Table 2.6-2. Generic cover/substrate codes and preference values.

Cover Code	Type of Cover	Preference Values: Salmon and Trout Rearing: Juvenile and Resident Adult	Whitefish Rearing: Juvenile	Whitefish Rearing: Adult
00.1	Undercut Bank	1.00	1.00	1.00
00.2	Overhanging Vegetation Near or Touching Water	1.00	1.00	1.00
00.3	Rootwad (Including Partly Undercut	1.00	1.00	1.00
00.4	Log Jam/Submerged Brush Pile	1.00	1.00	1.00
00.5	Log(s) Parallel to Bank	0.80	0.80	0.80
00.6	Aquatic Vegetation	0.80	0.80	0.80
00.7	Short (<1') Terrestrial Grass	0.10	0.10	0.10
00.8	Tall (<3') Dense Grass	0.70	0.70	0.10
00.9	Vegetation > 3 Vertical ft. above SZF	0.20	0.20	0.20

Available remote sensing data packages will be used for initial delineation of cover types, and field mapping will be conducted as needed to supplement the remote sensing analysis. Mapping of overhanging vegetation will be based on available remote sensing data, augmented by a rapid refinement field effort to ensure that results comply with definitions in the Guidelines and to reduce the potential for overestimation. Initial delineation of large wood will be based on aerial imagery. However, rootwads, submerged brush piles, and other large wood elements that cannot be delineated from aerial imagery will be mapped in the field. Estimates of aquatic vegetation abundance and distribution can be derived largely from existing infrared imagery. Although there is likely little aquatic vegetation in the main channel, some targeted mapping will be used to supplement what is derived from infrared imagery. Short (<1 ft) terrestrial grass, tall (<3 ft) dense grass, and vegetation >3 vertical feet above stage at zero flow will be delineated using LiDAR and infrared imagery. Information from multiple remote sensing packages will be combined to produce a map of these terrestrial vegetation cover types.

2.6.1.6 Hydraulic Model Calibration

The hydraulic model will be calibrated with the discharge, velocity, and water level data acquired during the field monitoring program. Model calibration will be an iterative process in which model parameters are first adjusted to match observed water levels from the continuous water surface profiles. The model calibration process will then be extended, with further parameter (or possibly, though unlikely, terrain) adjustments as needed, to match observed water levels and velocities at transect locations and, if hydraulic modeling is required to evaluate potential fish passage, at the fish passage barriers. Model visualization tools will be used to compare model results against UAV imagery.

As part of the calibration process, sensitivity analyses will be conducted by modifying channel roughness coefficients (Manning's "n" values) over a range of conditions and recording how the model results are affected.

2.6.1.7 Development of Habitat Suitability Criteria

Habitat suitability criteria (HSC) define the range of microhabitat variables that are suitable for a species and life stage of interest. HSC provide the biological criteria input to a habitat model that combines the physical habitat data and the HSC into habitat suitability calculations over a range of simulated flows. Variables typically defined with HSC include depth, velocity, substrate, and instream cover. HSC values range from 0.0 to 1.0, indicating habitat conditions that are unsuitable to optimal, respectively. For the species of interest in the bypass reach, HSC curves and periodicity information developed as part of the Instream Flow Model Development Study (see Section 2.6.1.7 of the Instream Flow Model Development Study Plan) may be used.[4]

HSC curves and periodicity information in combination with the calibrated hydraulic model will allow for detailed analyses of the amount, timing of availability, and location of suitable habitat under a range of discharges for species and life stages of interest. Model depth and velocity results will be integrated with habitat data in an IFIM type analysis to produce flow/habitat relationships for species and life stages of interest. Hydraulic model results will be output directly from HEC-RAS and analyzed or synthesized further in a Geographic Information System (GIS). For example, HEC-RAS model results will be output as depth and velocity grids. These will be analyzed in conjunction with substrate/cover grids and HSC curves using GIS scripts to compute usable area. Animation of hydraulic model results with HEC-RAS RAS Mapper and display of composite usable area in GIS will be used to help visualize spatial and temporal variations in hydraulic and habitat conditions.

2.6.1.8 Hydraulic Data for Fish Passage Analysis

The calibrated hydraulic model will be run for a range of flows determined in consultation with LPs and study team fish passage specialists to generate hydraulic data to support the fish passage evaluation. The evaluation of fish passage will be conducted as part of the Fish Passage Study.

Hydraulic metrics for fish passage evaluation will be determined in consultation with the fish passage specialists. Basic metrics will include plunge pool depth, difference in water surface elevation between the upstream water surface and plunge pool, and depth and velocity of flow in pathways approaching and through the barriers.

2.6.2 Workshop Consultation, Scenario Evaluation, and Report Preparation

2.6.2.1 Workshop Consultation

A series of five consultation workshops will be held to apprise LPs of progress on model development and to solicit feedback and input from LPs as follows:

- An initial workshop to discuss the overall program for instream flow model development and, if required, generation of hydraulic data for fish passage evaluation, including:
  - Velocity, stage, and discharge monitoring for hydraulic model calibration;
  - Hydraulic model calibration goals and model resolution or mesh size;

[4]As part of the model workshops, City Light will collaborate with LPs regarding the species and lifestages HSC for the bypass reach instream flow model.

- Review/discussion of existing relevant biological and habitat metrics for model input, potential data gaps, and information sources; and
- Hydraulic model outputs required to develop flow-habitat relationships and to support fish passage analysis.

- A second workshop to review and discuss proposed updates to relevant biological and habitat metrics based on discussions and input from the initial workshop.
- A mid-point workshop to present information on hydraulic model construction, including terrain data, model geometry, and model boundary conditions;
- A workshop toward the end of the study to present and discuss the results of hydraulic model calibration, integration with biological/aquatic habitat data, the suite of simulation runs proposed to develop flow-habitat relationships, and to generate hydraulic data for fish passage analysis; and
- A final workshop to present final model simulation results.

2.6.2.2 Evaluation of Alternative Flow Scenarios

The process and schedule for identifying and evaluating flow management scenarios is considered a subsequent step to completing this Bypass Reach Instream Flow Model Development Study. It is briefly described herein and in Section 2.8 of this study plan.

Upon completion (i.e., model development, calibration, validation, incorporation of HSC evaluation interface), the Instream Flow Model will be capable of evaluating alternative Project flow scenarios developed by City Light and/or LPs for the Skagit River between the Gorge Dam and the Gorge Powerhouse. This Instream Flow Model is intended to be integrated into a broader suite of models that include the Instream Flow Model from Gorge Powerhouse to Sauk River and OM-01 Operations Model. A framework for evaluating alternative Project flow scenarios will be conducted in coordination with other Project models and available resource study information. A model output template will be developed to provide consistent information on modeling results for each of the scenarios identified.

The consultant developing the models will maintain the model runs and a record of results of flow scenarios evaluated. Model outputs will be summarized to track key interest areas and to compare the system response to changes in Project operations. Examples of potential flow scenarios include but may not be limited to: geomorphic process flows, spawning and rearing flows, trapping and stranding protection flows, and minimum instream flows.

It is important to note that simulation models are decision support tools and are not intended to simulate or predict exact future conditions on a daily or annual basis. The models are tools for comparisons of different scenarios.

2.6.2.3 Reporting

A technical report will be prepared to document model development and application, including evaluation of existing information, field data collection, model calibration, development and integration of biological/physical inputs, flow-habitat relationships, and a summary of pertinent fish passage hydraulic data.

2.7 Consistency with Generally Accepted Scientific Practice

HEC-RAS is widely recognized and accepted throughout the engineering and scientific community for hydraulic modeling. The proposed study methodology for hydraulic model development and application is consistent with the approach used for similar work.

2.8 Schedule

The proposed study schedule for the Bypass Instream Flow Model Development Study is as follows:

- Planning, permitting, acquisition, and installation of stage recorders – March to May 2021
- Monitoring for controlled releases from Gorge Dam and conducting substrate and cover mapping – June to September 2021
- Hydraulic model development and calibration – May to September 2021
- Hydraulic model application to develop flow-habitat relationships and to generate hydraulic data for fish passage evaluation – October 2021
- Model Workshop Tentative Schedule
  - Workshop 1: Instream Flow Model Development Program Overview – April 2021
  - Workshop 2: Biological and Habitat Metrics – July 2021
  - Workshop 3: Hydraulic Model Construction – July/August 2021
  - Workshop 4: Hydraulic Model Calibration and Biological/Habitat Integration – September 2021
  - Workshop 5: Final Calibration and Model Application – November 2021
- Final Report (Initial Study Report [ISR]) – March 2022
- Alternative Scenario Identification and Evaluation Process – see below for schedule details
- Final Report (Updated Study Report [USR]) March 2023

Alternative Scenario Identification and Evaluation Process:

- Preliminary modeling tools and relicensing study results available for use – January 2022
- Alternative scenario identification and evaluations, review results, modify scenarios and discuss with LP – January to September 2022
- As needed, continued alternative scenario evaluations and discussions – September 2022 to March 2023

2.9 Level of Effort and Cost

The initial estimate for development of the modeling tool associated with this study is approximately $477,000.

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FA-06 RESERVOIR NATIVE FISH GENETICS BASELINE
REVISED STUDY PLAN

SKAGIT RIVER HYDROELECTRIC PROJECT
FERC NO. 553

Seattle City Light

April 2021
RSP

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List of Acronyms and Abbreviations

AMOVA ....Analysis of Molecular Variance
ASCII ....American Standard Code for Information Interchange
CFR ....Code of Federal Regulations
City Light ....Seattle City Light
N_e ....effective population size
ELC ....Environmental Learning Center
Expert Panel ....Salmonid Genetics Expert Panel
FERC..........................Federal Energy Regulatory Commission
FIS ....inbreeding coefficient
F_{ST} ....genetic divergence
G_{IS} ....inbreeding coefficient
HWE ....Hardy-Weinberg equilibrium
ILP.............................Integrated Licensing Process
ISR ....Initial Study Report
LP ....licensing participant
NPS ....National Park Service
PAD............................Pre-Application Document
PRM ....Project River Mile
Project ....Skagit River Hydroelectric Project
PSP.............................Proposed Study Plan
RLNRA ....Ross Lake National Recreation Area
RM ....river mile
RSP ....Revised Study Plan
Rxy ....relatedness
SNP ....single nucleotide polymorphism
U.S.C..........................United States Code
USFWS ......................U.S. Fish and Wildlife Service
USGS .........................U.S. Geological Survey
USR............................Updated Study Report
WDFW ....Washington Department of Fish and Wildlife

1.0 INTRODUCTION

1.1 General Description of the Project

The Skagit River Hydroelectric Project (Project), licensed to The City of Seattle, Washington, and operated through its publicly-owned electric power utility Seattle City Light (City Light), is located in northern Washington State and consists of three power generating developments on the Skagit River – Ross, Diablo, and Gorge – and associated lands and facilities. The Project generating facilities are in the Cascade Mountains of the upper Skagit River watershed, between Project River Miles (PRM) 94.7 and 127.9 (U.S. Geological Survey [USGS] RMs 94.2 and 127).[1] Power from the Project is transmitted via two 230-kilovolt powerlines that span over 100 miles and end just north of Seattle at the Bothell Substation. The Project also includes two City Light-owned towns, an Environmental Learning Center (ELC), several recreation facilities, and several parcels of fish and wildlife mitigation lands in Whatcom, Skagit, and Snohomish counties.

Project generating facilities are all located in Whatcom County, although Ross Lake, the most upstream reservoir, crosses the U.S.-Canada border and extends about one mile into British Columbia at normal maximum water surface elevation. Gorge Powerhouse, the most downstream facility, is approximately 120 miles northeast of Seattle and 60 miles east of Sedro-Woolley, the nearest large town. The closest town is Newhalem, which is part of the Project and just downstream of Gorge Powerhouse. The primary transmission lines cross Whatcom, Skagit, and Snohomish counties.

The Project boundary is extensive, spanning over 133 miles from the Canadian border to the Bothell Substation just north of Seattle, Washington. In addition, there are “islands” of fish and wildlife mitigation lands and recreation facilities within the Skagit, Sauk, and South Fork Nooksack watersheds that are also within the Project boundary. Project generating facilities are entirely within the Ross Lake National Recreation Area (RLNRA), which is administered by the National Park Service (NPS) as part of the North Cascades National Park Complex. The RLNRA was established in 1968 through legislation for North Cascades National Park to provide “public outdoor recreation use and enjoyment of portions of the Skagit River and Ross, Diablo, and Gorge lakes” for the public. The legislation maintains the Federal Energy Regulatory Commission’s (FERC) jurisdiction “in the lands and waters within the Skagit River Hydroelectric Project,” as well as hydrologic monitoring stations necessary for the proper operation of the Project (16 United States Code [U.S.C.] § 90d-4; Public Law 90-544. Sec. 505 dated October 2, 1968, as amended by Public Law 100-668. Sec. 202 dated November 16, 1988).

1.2 Relicensing Process

The current FERC license for the Project expires on April 30, 2025, and City Light will apply for a new license no later than April 30, 2023. City Light formally initiated the integrated licensing process (ILP) by filing a Notice of Intent and Pre-Application Document (PAD) with FERC on April 27, 2020 (City Light 2020a). The PAD includes descriptions of the Project facilities,

[1] City Light has developed a standard Project centerline and river mile system to be used throughout the relicensing process, including the study program, to replace the outdated USGS RM system. Given the long-standing use of the USGS RM system, both it and the Project River Mile (PRM) system are provided throughout this document. For further details see Section 7.0 of the main body RSP.

operations, license requirements, and Project lands as well as a summary of the extensive existing information available on Project area resources and early consultation on potential resource issues to be addressed during the relicensing.

In 2019-2020, City Light convened a series of Resource Work Groups (RWG) to engage agencies and other licensing participants (LP) in the Study Plan Development Process. Discussions with LPs continued in early 2021 with a series of topic-based discussions following filing of the Proposed Study Plan (PSP) on December 8, 2020 (City Light 2020b). This study plan reflects RWG and LP discussion and study requests and comments submitted by LPs.

1.3 Study Plan Development

LPs filed comments on the PAD and study requests on October 24, 2020. As part of study request submittals, LPs submitted study requests aimed at collecting baseline genetics information in Project reservoirs. The PSP included a commitment to consult with LPs on the formulation of this FA-06 Reservoir Native Fish Genetics Baseline Study Plan in response to LPs' study requests.

On February 24, 2021, City Light released the Reservoir Native Fish Genetics Baseline Draft Study Plan for LP review and comment. City Light is filing this study plan with FERC as part of its Revised Study Plan (RSP), incorporating additional consultation with LPs prior to the filing date.

This study plan addresses, with modifications, elements of the following study requests, as explained in Section 6 of the RSP: NPS-05 Population Structure of Native Fish in the Project Area, U.S. Fish and Wildlife Service (USFWS)-06 Population Structure of Native Fish in the Project Area, and Washington Department of Fish and Wildlife (WDFW)-15 Habitat Use and Population Dynamics of Reservoir Fish. LPs requested that City Light conduct a study to describe the genetic population structures of Bull Trout (*Salvelinus confluentus*), Rainbow Trout (*Oncorhynchus mykiss*); and Dolly Varden (*Salvelinus malma*); develop a genetic baseline that can be used to document population responses to fish passage; and assess the health and viability of fish populations in each reservoir. These objectives are aimed at developing baseline information needed to inform management decisions. Although there is adequate existing information[2] (18 Code of Federal Regulations [CFR] § 5.9(b)(4)) for characterizing fish genetics for the purposes of relicensing the Project, City Light acknowledges a shared interest in developing a more in-depth genetics baseline for native salmonid species in Project reservoirs to inform longer-term fish management objectives.

PSP comments to this study plan were submitted by NPS, Upper Skagit Indian Tribe, and WDFW. City Light has addressed the specific comments and suggested edits in the study plan and responded to comments in the PSP comment/response table appended to the main body of the RSP. Modifications made to the study plan in response to comments and since the PSP include clarification of study goals and analyses and field data collection.

[2] Anthony and Glesne 2014; Downen 2004; Kassler and Warheit 2012; McPhail and Taylor 1995; Myers et al. 1998; Pflug et al. 2013; Ruckelshaus et. 2006; Small et al. 2016; Small et al. 2020a; Small et al. 2020b; Smith 2010; Smith 2019.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

The goals of this two-year study are to characterize baseline population genetic structure for three native salmonid species; Bull Trout, Rainbow Trout, and Dolly Varden (target species) in Project reservoirs, and provide the basis necessary to inform the planning of long-term (i.e., over the next Project license term) reservoir fish management objectives. The study will be conducted in consultation with a Salmonid Genetics Expert Panel (Expert Panel), per Section 2.5.1 of this study plan. City Light will convene an Expert Panel composed of resource agency specialists and/or experts from academia with regional expertise on the genetics of the three target species. Specifically, the goals of this study are to:

- Determine the population genetic structure of within and among target species populations and assess whether management actions are necessary for genetic sustainability.
- Determine the number of fish populations, for each target species, within and among the Project reservoirs.
- Estimate the effective population size (N_{e}) for each target species and reservoir.
- Identify topics and/or management objectives to be considered in the reservoir fish and aquatics management plan.

Specific objectives to meet these study goals are listed below.

Year 1

- City Light will convene an Expert Panel in consultation with LPs.
- Review, compile, and analyze target species genetics data collected by multiple researchers in the Project reservoirs.
    - Acquire and consolidate existing genetics data[3] for Bull Trout, Rainbow Trout, and Dolly Varden.
    - Create a single, standardized datafile for each species that compiles genotypes from existing studies.
- Use the standardized datafiles to evaluate baseline genetic metrics for Bull Trout and Rainbow Trout.
    - Calculate within- and among-population summary statistics using consistent methods for Bull Trout and Rainbow Trout.
    - Estimate relatedness for Bull Trout and Rainbow Trout and report the statistical distribution of this metric by species and reservoir.
    - Estimate the power (false detection rate) of genetic markers currently in use to identify relationships (e.g., parent-offspring pairs, full-sibling-unrelated pairs).

[3] Small et al. 2013, 2016, 2020b; Smith 2010; Pflug et al. 2013.

- Identify the availability of relevant existing genetic samples and coordinate target fish species sampling being conducted opportunistically by other relicensing studies and current license field activities.
- Expert Panel review of Year 1 study results and assistance in development of Year 2 study program.

Year 2

- Continue data collection to address heterozygosity, within- and among-population variance, and relatedness for Dolly Varden in Project reservoirs.
- Gather additional data needed to estimate N_e for each population of Bull Trout, Rainbow Trout, and Dolly Varden.
  - Gather age metadata needed to estimate Ne, either from existing scale samples or from fish collected during the ILP study period.

2.2 Resource Management Goals

The study will provide information for resource agencies, Indian tribes, and First Nations with jurisdiction in the Project vicinity to address their respective goals and objectives for resource management. Resource management goals were provided by LPs in their study requests identified in Section 1.3 of this study plan. Results of the study will be used to inform the development of a future reservoir fish and aquatics management plan. Resource management goals were provided by LPs in their study requests identified in Section 1.3 of this study plan.

2.3 Background and Existing Information

Both local and regional drainage patterns in the Skagit River basin have been altered by glaciation (Riedel et al. 2007). The North Cascade Range and Puget Lowlands were inundated by the south-flowing Cordilleran Ice Sheet during the Fraser Glaciation 35 to 11.5 thousand years ago. The Cordilleran Ice Sheet that advanced into the area from the north was greater than 1 mile thick at Ross Lake and the Puget Lowland (Armstrong et al. 1965; Porter and Swanson 1998). Glacial ice dams blocked the northerly flowing Skagit River and created lakes that drained to the south, forming deep canyons. After the ice sheet retreated, the Skagit River and nearby creeks were redirected to flow south in their current configuration (Riedel et al. 2012). Prior to this redirection, the upper Skagit River is thought to have been a tributary to the Fraser River (Riedel et al. 2007).

Several studies suggest that Bull Trout, Rainbow Trout, and Dolly Varden likely originated from founding populations in the Fraser River at the time the upper Skagit River was a tributary to the Fraser River (Smith 2019; Downen 2014; Riedel et al. 2007). Smith (2019) based this conclusion on an analysis of mitochondrial haplotypes of Bull Trout from the Fraser and Skagit Rivers, and low allelic richness of Upper Skagit Bull trout indicating a founder effect. Therefore the most likely mechanism for dispersal into the Skagit River above the current location of Gorge Dam is through the upper Skagit River from the Fraser River; this pathway is corroborated by Riedel et al. (2007). Native char (Dolly Varden and Bull Trout) and Rainbow Trout in the upper Skagit River basin are thought to have originated from the Fraser River by Downen (2014).

Past research also indicates that Bull Trout and Rainbow Trout below Gorge Dam are genetically distinct (i.e., cluster separately) from those in the upstream reservoirs (Smith 2010; Pflug et al. 2013; Small et al. 2016), and Dolly Varden are only found upstream of the Skagit River Gorge. Rainbow Trout in Stetattle Creek are also genetically distinct from steelhead in the Skagit River (Kassler and Warheit 2012, as cited in Pflug et al. 2013). Prior to the construction of Ross Dam, opportunity for gene flow from the upper Skagit into the lower Skagit was likely one-way (upstream to downstream) (Downen 2014) due to high drops and cascades through the Skagit River Gorge, following the redirection of the Skagit River's flow to the south approximately 15,000 years ago. These genetic differences, coupled with the geologic history of the basin, support the conclusion that salmonids in the upper Skagit River basin originated in the Fraser River and that populations within the reservoirs are likely distinct from those below the Project.

2.4 Study Area

The proposed study area includes the Project reservoirs (i.e., Gorge, Diablo and Ross lakes in the U.S.) and will include associated reservoir tributaries, as appropriate (Figure 2.4-1).

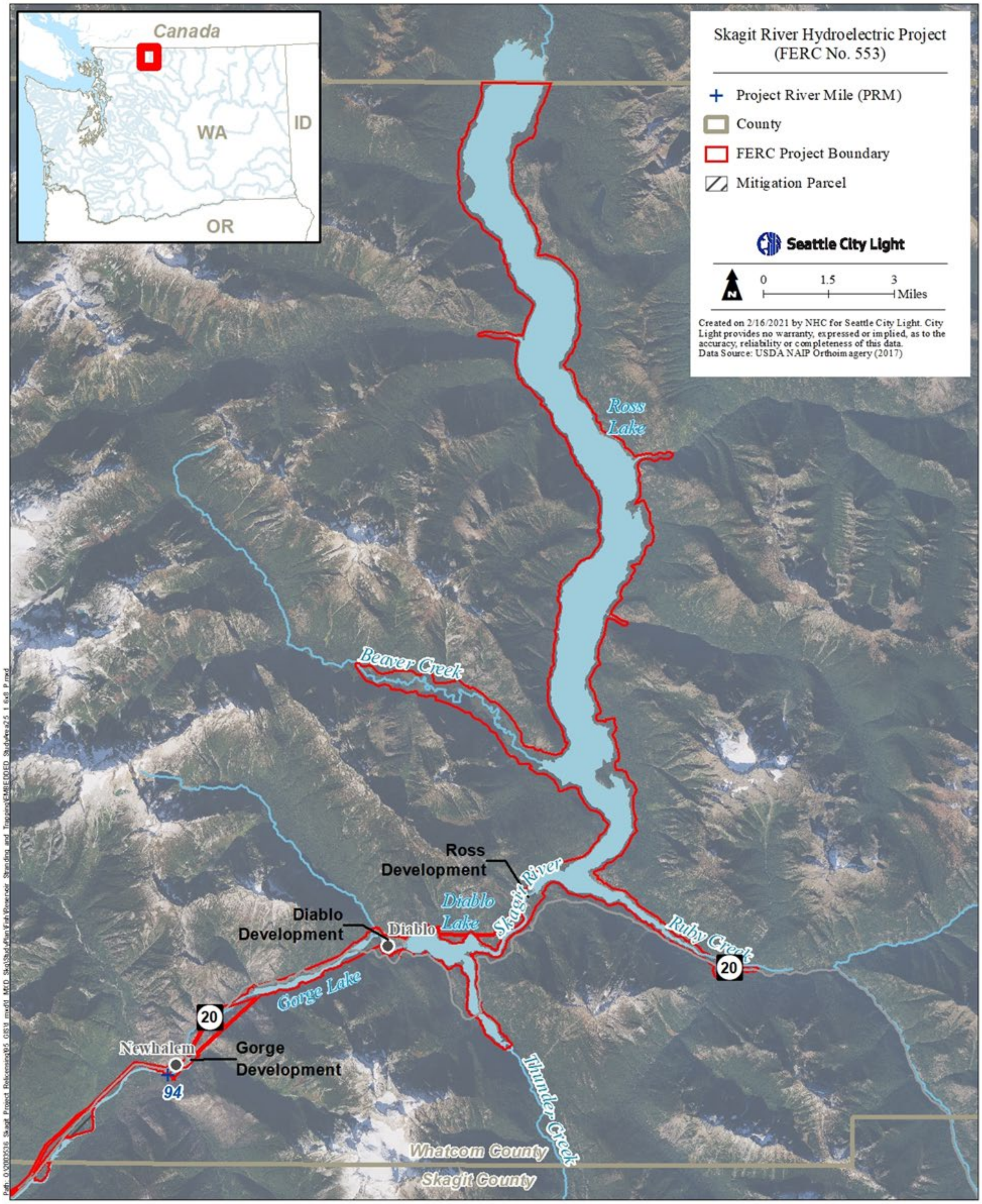

Figure 2.4-1. Overview of proposed study area.

2.5 Methodology

City Light proposes to conduct a two-year study as described below. Year 1 will be dedicated to obtaining, standardizing, and vetting existing data in consultation with the Expert Panel (see Section 2.5.1 of this study plan), to evaluate the current understanding of salmonid baseline population genetics in the Project reservoirs. During Year 2, City Light will begin to fill known data gaps, as described below, and other potential gaps identified in consultation with the Expert Panel.

2.5.1 Salmonid Genetics Expert Panel

City Light will convene, in consultation with LPs, an Expert Panel consisting of three to five members. Members of the Expert Panel selected by City Light will be resource agency specialists and/or experts from academia with experience working in the Skagit River watershed and/or regional expertise on the genetics of the three native salmonid species. Potential members may include geneticists from University of British Columbia, USFWS, WDFW, Northwest Indian Fisheries Commission, and NMFS. The purpose of the Expert Panel is to provide input and recommendations to inform City Light's study approach and decisions at specific milestones.

City Light proposes to consult with the Expert Panel at three milestones during the execution of this study:

- Meeting 1: review and provide input on City Light's proposed approach to compiling a standardized datafile from existing salmonid genetics datasets for each species and applying the standardized data to address City Light's proposed analyses. The Expert Panel will also support the development of standard sampling and quality assurance protocols to be implemented by field crews in Year 1 (ongoing license and other relicensing study activities to opportunistically collect target species samples) and in Year 2 (additional field sampling to address identified Year 1 data gaps).
- Meeting 2: discuss Year-1 study results and provide recommendations on baseline genetics data gaps that may be evaluated during Year 2.
- Meeting 3: discuss the draft results of the two-year study and recommend potential topics to be addressed in a long-term reservoir fish and aquatics management plan.

2.5.2 Year-1 Tasks

2.5.2.1 Consolidation of Existing Genetics Information

City Light plans to request relevant data sets in an American Standard Code for Information Interchange (ASCII) format, with accompanying metadata describing the genetic samples, loci, etc. Fundamentally, genetic analysis begins with tabulating the identity of genetic variants (alleles) at defined locations in the genome (i.e., genetic markers, or loci) and estimating the frequencies of those alleles present within physical collections (organisms sampled). The quantity of samples required for any study should, at a minimum, be sufficient for estimating allele frequencies.

Existing native salmonid genetics data were collected over time by multiple researchers in the Project reservoirs. After consulting with the Expert Panel and LPs on a proposed approach, City Light will work with the primary researchers to obtain and compile the existing native salmonid genetics information and unify existing (microsatellite) datasets for Bull Trout, Dolly Varden, and Rainbow Trout to facilitate a common analysis of the baseline genetics metrics identified in subsequent sections of this plan. Table 2.5-1 provides a basic description of the datasets to be consolidated.

Table 2.5-1. Datasets proposed for inclusion in the standardized database.

Species of Interest	Reference	Notes
Rainbow Trout	Pflug et al. 2013	Above Gorge Dam - *O. mykiss* from Ross Lake, Diablo Lake, Dry Creek, Roland Creek, and Stetattle Creek
	Pflug et al. 2013	Below Gorge Dam - Skagit River natural-origin *O. mykiss*
Bull Trout (excluding hybrids)	Smith 2010	
	Small et al. 2013	Year 1 data relevant to the Project reservoirs
	Small et al. 2016	
	Small et al. 2020b	
Dolly Varden (excluding hybrids)	Small et al. 2013	Year 1 data relevant to the Project reservoirs
	Small et al. 2016	
	Small et al. 2020b	

2.5.2.2 Conduct Baseline Analyses Using Standardized Database

Heterozygosity and Population Variance of Bull Trout and Rainbow Trout

City Light will calculate heterozygosity and within- and among-population variance using consistent methods for Bull Trout and Rainbow Trout.

Previous reports have generally treated each reservoir as a distinct population. This interpretation of the data will be investigated through exploratory visualization of individual-based data and genetic principal component analysis (e.g., Jombart et al. 2010), where the number (k) of groups determined from k-means clustering should equal the number of Project area reservoirs (i.e., three). If this is not observed, alternative population subdivisions will be explored. Additional or alternative analysis, such as STRUCTURE analysis, can also be performed.

By default, all population collections will be combined and considered a single population, unless statistically significant departures from Hardy-Weinberg equilibrium (HWE) are observed. A common implementation of HWE test is Guo and Thompson (1992) Markov-chain random walk extension of Fisher's (2-allele) classical exact test. Departures from HWE will also be quantified using F_{IS} statistic observed from analysis of molecular variance (AMOVA, see below), which is equivalent to Weir and Cockerham (1984) small f statistics. Hypothesized populations will also be analyzed for evidence of linkage disequilibrium (i.e., non-independence of alleles at different loci). Given gametic phase is unknown for previously reported data, linkage disequilibrium between a pair of loci is tested using a likelihood-ratio test, whose empirical distribution is obtained by a permutation procedure (e.g., Excoffier and Slatkin 1998). Lastly, population classifications will be evaluated using observed allelic distributions. Equivalency of allelic distributions across populations is commonly tested for by using contingency table analysis described by Raymond and Rousset (1995).

With populations defined given empirical analysis of genotype data, population diversity summary statistics will be calculated and compared. Gene diversity, the expected frequency of heterozygotes within a population assuming HWE, will be estimated following the sampling bias correction method described be Nei (1987). The observed heterozygosity (average frequency) will also be estimated. The degree of deviation from HWE (observed and expected heterozygosity; inbreeding coefficient) can be estimated using heterozygosity (e.g., G_{IS}; Nei 1987), although it is recommended that the least-squares based estimator (F_{IS}) be used from an AMOVA framework (Excoffier et al. 1992; Yang 1998). The AMOVA framework estimates hierarchical f statistics for any number of desired levels (e.g., within individuals, within populations, among populations). Population differentiation, the observation that individuals within a population are more similar to each other than are individuals from different populations, is captured within f statistics. There are many formulations of the population differentiation variance component measure (i.e., relative correlations among gametes), although a common implementation is a form of the fixation index (e.g., F_{ST}). Pairwise estimates of F_{ST} will be estimated (Weir and Goudet 2017) and used as a measure of population divergence, with statistical significance calculated following likelihood-ratio tests (Goudet et al. 1996). Further, given the Euclidean nature of F_{ST} "distance", the underlying matrix can be visualized using Principal Coordinate Analysis. Nonetheless, it is recommended that individual-based analysis of genetic principal component be revisited following characterization of populations.

Lineage Relationships

While correlations among alleles estimated within and among populations (e.g., f statistics) attempt to account for relatedness and population genetic structure, the underlying pedigrees for sampled fish are unknown. Directly documenting relatedness among individuals is a useful measure to evaluate, over time, the genetic structure and integrity of a population. Parentage can determine whether fish move between reservoirs and subsequent survival, as well as gage reproductive success within reservoirs. There are many formulations for estimating relatedness. It is recommended that Queller and Goodnight (1989) Rxy estimator be used for Bull Trout and Rainbow Trout populations, as Rxy is statistically unbiased. City Light will estimate the power (false detection rate) of genetic markers currently in use to identify relationships among Bull Trout and Rainbow Trout (e.g., parent-offspring pairs, full-sibling-unrelated pairs).

2.5.2.3 Availability of Existing Samples and Coordination of Sampling with Ongoing Activities

City Light will identify the availability of any existing genetic samples from past studies (e.g., unanalyzed samples from past studies, archived samples from fieldwork in Project reservoirs, samples used in previous analyses for which a partial sample may still be available for additional analyses, etc.). City Light will also coordinate target fish species sampling being conducted opportunistically by other relicensing studies and current license field activities. Other ongoing and relicensing study activities where sampling may be conducted opportunistically in Year 1 include but are not limited to the USGS Food Web Study, the Acoustic Telemetry Monitoring Program, and FA-03 Reservoir Fish Stranding and Trapping Risk Assessment. A summary of these available samples will help to identify information data gaps and inform the scope of additional data collection activities in Year 2 of the study.

2.5.3 Year-2 Tasks

2.5.3.1 Additional Baseline Genetics Data Collection and Analyses

Heterozygosity and Population Variance of Dolly Varden

If sufficient data exist, then population analyses described above for Bull Trout and Rainbow Trout will be performed for Dolly Varden in the Project vicinity. However, if initial review of existing data suggests that base condition genetic diversity has not been adequately characterized for Dolly Varden[4] The initial characterization of data inadequacy will be confirmed given the data compiled (Table 2.5-1). If insufficient data are available for Dolly Varden, recommendations for future data acquisition will be made. A proposed field sampling plan for Year 2 tissue collection will be proposed in consultation with LPs.

Effective Population Size

If age metadata are available for datasets compiled (Table 2.5-1), then City Light will estimate effective population size (N_e) for annual cohorts of Bull Trout, Dolly Varden, and Rainbow Trout where it is possible to do so. The effective population size will be estimated using the mathematical relationship between linkage disequilibrium and N_e following Waples (2006). If data are inadequate, recommendations for future data acquisition will be made. The baseline values of N_e will serve as reference points against which to evaluate trends over time during the next license period. This trend monitoring is likely to be a component of a future reservoir fish and aquatics management plan (see below). City Light will collect age metadata to enable the estimate of N_e, either from existing scale samples or hard parts from fish collected during the ILP study period. City Light will coordinate with individuals conducting fish studies in the reservoirs during the ILP to ensure that appropriate incidental fish data are collected during their respective field activities.

2.5.3.2 Synthesis of Results to Inform Management Plan

City Light will consult with the Expert Panel and LPs to review and discuss the results of the preceding analyses to inform the development of genetic objectives to be considered within a future long-term Skagit Project reservoir fish and aquatics management plan. Although the scope and structure of the management plan are yet to be determined, some topics that are likely to be addressed include:

(1) Monitoring the maintenance and distribution of genetic diversity;

(2) Monitoring at intervals to measure trends in N_e;

(3) Assessment of native species' origins;

(4) Potentially updating genetic technologies (single nucleotide polymorphisms [SNP] versus microsatellites, etc.); and

[4] Dolly Varden in Project reservoirs constitute trapped populations; fish cannot interact with populations outside the Project vicinity. This has implications for the species' genome(s) in the reservoirs and how this species may need to be managed over the long-term.

(5) The extent and potential population effects[5] of hybridization among native char and Brook Trout.

2.6 Reporting

A draft report providing Year-1 results will be provided to the Expert Panel prior to Meeting 2 (see Section 2.5.1 and 2.8 of this study plan). The report will contain:

(1) A summary of the process undertaken to create the standardized database (see Section 2.5.2 of this study plan);

(2) The results of Year-1 analyses and the degree to which the findings conform to the conclusions of previously conducted studies; and

(3) Additional findings, if any, gleaned from the standardized database that may not have been previously reported.

After receiving Expert Panel input, the report will be revised and submitted to FERC as part of the initial study report (ISR). A draft report providing the Year-2 results will be provided to the Expert Panel prior to Meeting 3 (see Section 2.5.1 and 2.8). After receiving Expert Panel input, the report will be revised and submitted to FERC as part of the Updated Study Report (USR). Any Expert Panel recommendations not adopted by City Light will be documented in the ISR and USR, along with City Light's rationale for not adopting the recommendations.

2.7 Consistency with Generally Accepted Scientific Practice

The existing genetics information that would be used to develop the standardized database is associated with articles published in scientific journals or studies conducted by members of academic organizations or resource agency specialists. As a result, City Light considers the information to be reliable. Any analyses conducted to further document genetic baseline conditions of Project area fish populations would be based on well-established methods viewed as best practices. It is presumed that existing fish tissue samples, collected either by City Light or resource agency biologists, are suitably documented so that they would provide a reliable basis for analysis. Fish tissue and corresponding age-related data collected in the reservoirs during the ILP study period would be obtained by trained field personnel who would adhere to all necessary quality assurance measures for preservation of samples and reliability of records.

2.8 Schedule

- Meeting 1 with Expert Panel to review proposed Year-1 approach – June 2021
- Year-1 consolidated data analyses, and report writing – June – December 2021
- Meeting 2 with Expert Panel to review Year-1 results and verify next steps – December 2021
- ISR – March 2022
- Year-2 information gathering, fieldwork, analyses, and report writing – May – December 2022

[5] Existing information shows that hybridization between Brook Trout and native char occurs, but population level effects are unknown.

- Meeting 3 with Expert Panel to evaluate results and identify objectives for the future reservoir fish and aquatics management plan – October/November 2022
- USR – March 2023

2.9 Level of Effort and Cost

The initial estimate for analysis and reporting associated with this study plan is approximately $115,000.

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FA-07 RESERVOIR TRIBUTARY HABITAT ASSESSMENT
REVISED STUDY PLAN

SKAGIT RIVER HYDROELECTRIC PROJECT
FERC NO. 553

Seattle City Light

April 2021
RSP

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List of Acronyms and Abbreviations

cfs ....cubic feet per second
CDMetaPOP ....Cost-Distance Meta-POPulation
City Light ....Seattle City Light
DEM ....Digital Elevation Model
Ecology ....Washington State Department of Ecology
ELC ....Environmental Learning Center
ESA ....Endangered Species Act
FERC ....Federal Energy Regulatory Commission
FTE ....full-time equivalent
GE ....growth efficiency
HEC-RAS ....Hydrologic Engineering Center River Analysis System
ISR ....Initial Study Report
LP ....licensing participant
NMFS ....National Marine Fisheries Service
NPS ....National Park Service
O&M ....operations and maintenance
OPCC ....Opinions of Probable Construction Costs
PAD ....Pre-Application Document
PRM ....Project River Mile
Project ....Skagit River Hydroelectric Project
PSP ....Proposed Study Plan
RLNRA ....Ross Lake National Recreation Area
RM ....river mile
RSP ....Revised Study Plan
RWG ....Resource Work Group
U.S.C. ....United States Code
USFS .........................U.S. Forest Service
USFWS .....................U.S. Fish and Wildlife Service
USGS ........................U.S. Geological Survey
USIT ....Upper Skagit Indian Tribe
USR ....Updated Study Report

WDFW......................Washington Department of Fish and Wildlife

1.0 INTRODUCTION

1.1 General Description of the Project

The Skagit River Hydroelectric Project (Project), licensed to The City of Seattle, Washington, and operated through its publicly-owned electric power utility Seattle City Light (City Light), is located in northern Washington State and consists of three power generating developments on the Skagit River – Ross, Diablo, and Gorge – and associated lands and facilities. The Project generating facilities are in the Cascade Mountains of the upper Skagit River watershed, between Project River Miles (PRM) 94.7 and 127.9 (U.S. Geological Survey [USGS] RMs 94.2 and 127).[1] Power from the Project is transmitted via two 230-kilovolt powerlines that span over 100 miles and end just north of Seattle at the Bothell Substation. The Project also includes two City Light-owned towns, an Environmental Learning Center (ELC), several recreation facilities, and several parcels of fish and wildlife mitigation lands.

Project generating facilities are all located in Whatcom County, although Ross Lake, the most upstream reservoir, crosses the U.S.-Canada border and extends for about one mile into British Columbia at normal maximum water surface elevation. Gorge Powerhouse, the most downstream facility, is approximately 120 miles northeast of Seattle and 60 miles east of Sedro-Woolley, the nearest large town. The closest town is Newhalem, which is part of the Project and just downstream of Gorge Powerhouse. The primary transmission lines cross Whatcom, Skagit, and Snohomish counties; the fish and wildlife mitigation lands are in the same counties.

The Project Boundary is extensive, spanning over 133 miles from the Canadian border to the Bothell Substation just north of Seattle, Washington. In addition, there are “islands” of fish and wildlife mitigation lands and recreation facilities within the Skagit, Sauk, and South Fork Nooksack watersheds that are also within the Project Boundary. Project generating facilities are entirely within the Ross Lake National Recreation Area (RLNRA), which is administered by the National Park Service (NPS) as part of the North Cascades National Park Complex. The RLNRA was established in 1968 in the enabling legislation for North Cascades National Park to provide for the “public outdoor recreation use and enjoyment of portions of the Skagit River and Ross, Diablo, and Gorge lakes.” The legislation maintains the Federal Energy Regulatory Commission’s (FERC) jurisdiction “in the lands and waters within the Skagit River Hydroelectric Project,” as well as hydrologic monitoring stations necessary for the proper operation of the Project (16 United States Code [U.S.C.] § 90d-4; Public Law 90-544. Sec. 505 dated October 2, 1968, as amended by Public Law 100-668. Sec. 202 dated November 16, 1988).

1.2 Relicensing Process

The current FERC license for the Project expires on April 30, 2025, and City Light will apply for a new license no later than April 30, 2023. City Light formally initiated the relicensing process by filing a Notice of Intent and Pre-Application Document (PAD) with FERC by April 27, 2020 (City Light 2020a). The PAD includes descriptions of the Project facilities, operations, license

[1] City Light has developed a standard Project centerline and river mile system to be used throughout the relicensing process, including the study program, to replace the outdated USGS RM system. Given the long-standing use of the USGS RM system, both it and the Project River Mile (PRM) system are provided throughout this document. For further details see Section 7.0 of the main body RSP.

requirements, and Project lands as well as a summary of the extensive existing information available on Project area resources and early consultation on potential resource issues to be addressed during the relicensing.

In 2019-2020, City Light convened a series of Resource Work Groups (RWG) to engage agencies and other licensing participants (LP) in the Study Plan Development Process. Discussions with LPs continued in early 2021 with a series of topic-based discussions following filing of the Proposed Study Plan (PSP) on December 8, 2020 (City Light 2020b). This study plan reflects RWG and LP discussion and study requests and comments submitted by LPs.

1.3 Study Plan Development

As part of the Study Plan Development Process, LPs expressed concern about the Project's potential effects on fish passage in the Skagit River, which, if it were to be implemented, would result in the introduction of anadromous salmonids into the Skagit River basin upstream of Gorge Dam. Related to this, LPs requested an assessment of the habitat capacity of tributaries to the Project reservoirs. To address LPs' concerns, City Light proposes to conduct this FA-07 Reservoir Tributary Habitat Assessment.

City Light is filing this study plan with FERC as part of its Revised Study Plan (RSP), based on consultation with LPs prior to the filing date. This study plan addresses, with modifications, elements of the following study requests, as explained in Section 6 of the RSP: National Marine Fisheries Service (NMFS)-03 Quantifying Habitat and Production Potential of Chinook and Coho Salmon and Steelhead above Ross Dam, NPS-08 Quantifying the Productivity Potential of Reservoir Tributary Habitat, U.S. Fish and Wildlife Service (USFWS)-02 Quantifying the Habitat and Production Potential of ESA-Listed Salmon, Steelhead, and Bull Trout above Dams, Upper Skagit Indian Tribe (USIT)-02 Quantifying Habitat and Production Potential of ESA-listed Chinook Salmon, Steelhead, Bull Trout, Coho Salmon, and Sockeye Salmon above Gorge Dam, and Washington Department of Fish and Wildlife (WDFW)-03 Quantifying Habitat and Production Potential of ESA-listed Chinook Salmon, Steelhead, Bull Trout, Coho Salmon, and Sockeye Salmon above Gorge Dam.

Because this is the first draft of the study plan, there are no relevant PSP comments.

Results of this study, in combination with other studies and existing information, are intended to provide input necessary for evaluating the potential feasibility of establishing fish passage at one or more of the Project developments.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

The goal of this study is to evaluate the availability and production potential of habitat for Chinook Salmon (*Oncorhynchus tshawytscha)*, Coho Salmon (*O. kisutch*), Sockeye Salmon (*O. nerka*), and steelhead (*O. mykiss*) (collectively the target species) in select tributaries to Project reservoirs. Tributaries to be evaluated include (1) Stetattle Creek (tributary to Gorge Lake); (2) Thunder Creek (tributary to Diablo Lake); and (3) nine tributaries to Ross Lake, i.e., Canyon, Little Beaver, Big Beaver, Hozomeen, McMillan, Devils, Granite, and Three Fools creeks and the upper Skagit River. These tributaries were identified by NMFS in its Study Request 3 as those that are "…reasonably large enough to support populations of anadromous fishes…"

Results of this Reservoir Tributary Habitat Assessment will be integrated with results of the FA-04 Fish Passage Technical Studies Program (Fish Passage Study) and, as appropriate, other studies conducted during relicensing to identify constraints and assess benefits and risks of providing fish passage and access to habitats upstream of the Project dams, consistent with the approach recommended in Anderson et al. (2014). The results of the Reservoir Tributary Habitat Assessment and/or the Fish Passage Study may include the identification of next steps or additional studies that are warranted to further evaluate the feasibility and efficacy of fish passage (e.g., juvenile reservoir transit and mortality) and to address other concerns raised in Anderson et al. (2014) as determined appropriate.

Specific objectives of this study are listed below:

(1) Apply the NetMap Intrinsic Potential model (e.g., Burnett et al. 2007) to map and characterize the extent of potential spawning and rearing habitat for the target species within tributaries based on geomorphic habitat suitability measures.

(2) Use physical habitat variables to estimate juvenile rearing habitat capacity, i.e., productivity potential, (e.g., Cooper et al. 2020) for the target species within potentially suitable reaches identified by Intrinsic Potential modeling.

(3) Evaluate the results of Objective 2 in the context of results from the Factors Limiting Native Salmonids above Skagit River Dams study (Food Web Study) (Beauchamp, in development).

2.2 Resource Management Goals

The study will provide information for resource agencies, Indian tribes, and First Nations with jurisdiction in the Project vicinity to address their respective goals and objectives for resource management. Resource management goals were provided by LPs in their study requests identified in Section 1.3 of this study plan.

2.3 Background and Existing Information

Resident fish species that have been documented upstream of Gorge Dam include Bull Trout (*Salvelinus malma*), Dolly Varden (*Salvelinus malma*), Cutthroat Trout (*Oncorhynchus clarkii)*, Rainbow Trout (*Oncorhynchus mykiss*), Brook Trout (*Salvelinus fontinalis*), and Redside Shiner

(*Richardsonius balteatus*).These species occur in all three Project reservoirs and some of the reservoirs' tributaries.

2.4 Project Operations and Effects on Resources

The vast majority of the tributary habitat to be assessed as part of this study is upgradient of the area of Project effects, except potentially in the regions of the tributary inflows to Project reservoirs.

2.5 Study Area

The study will be conducted in the following tributaries to the Project reservoirs: (1) Stetattle Creek (tributary to Gorge Lake); (2) Thunder Creek (tributary to Diablo Lake); and (3) nine tributaries to Ross Lake, i.e., Canyon, Little Beaver, Big Beaver, Hozomeen, McMillan, Devils, Granite, and Three Fools creeks and the upper Skagit River (Figure 2.5-1).

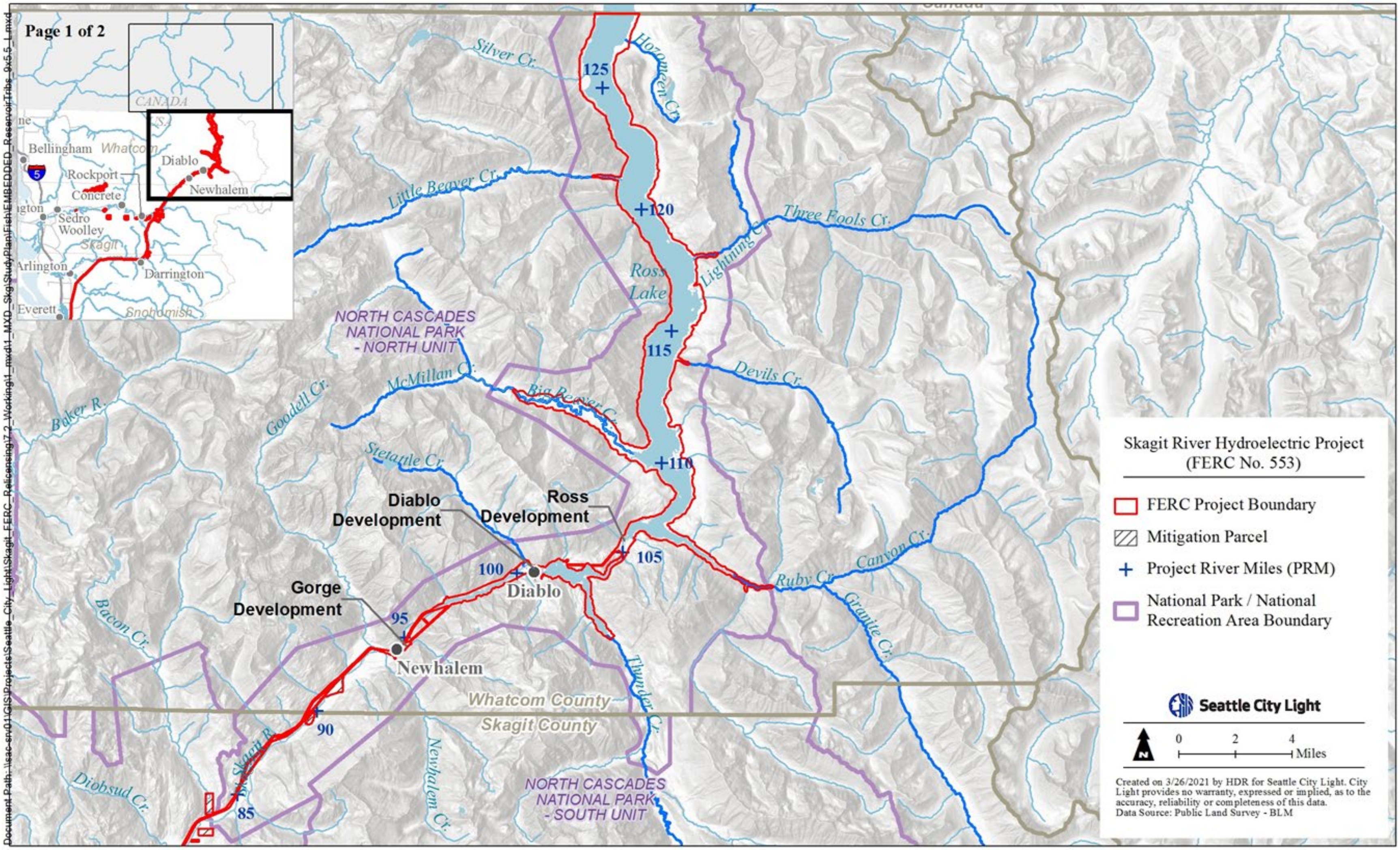

Figure 2.5-1. General study area for the Reservoir Tributary Habitat Assessment in the U.S. (page 1 of 2).

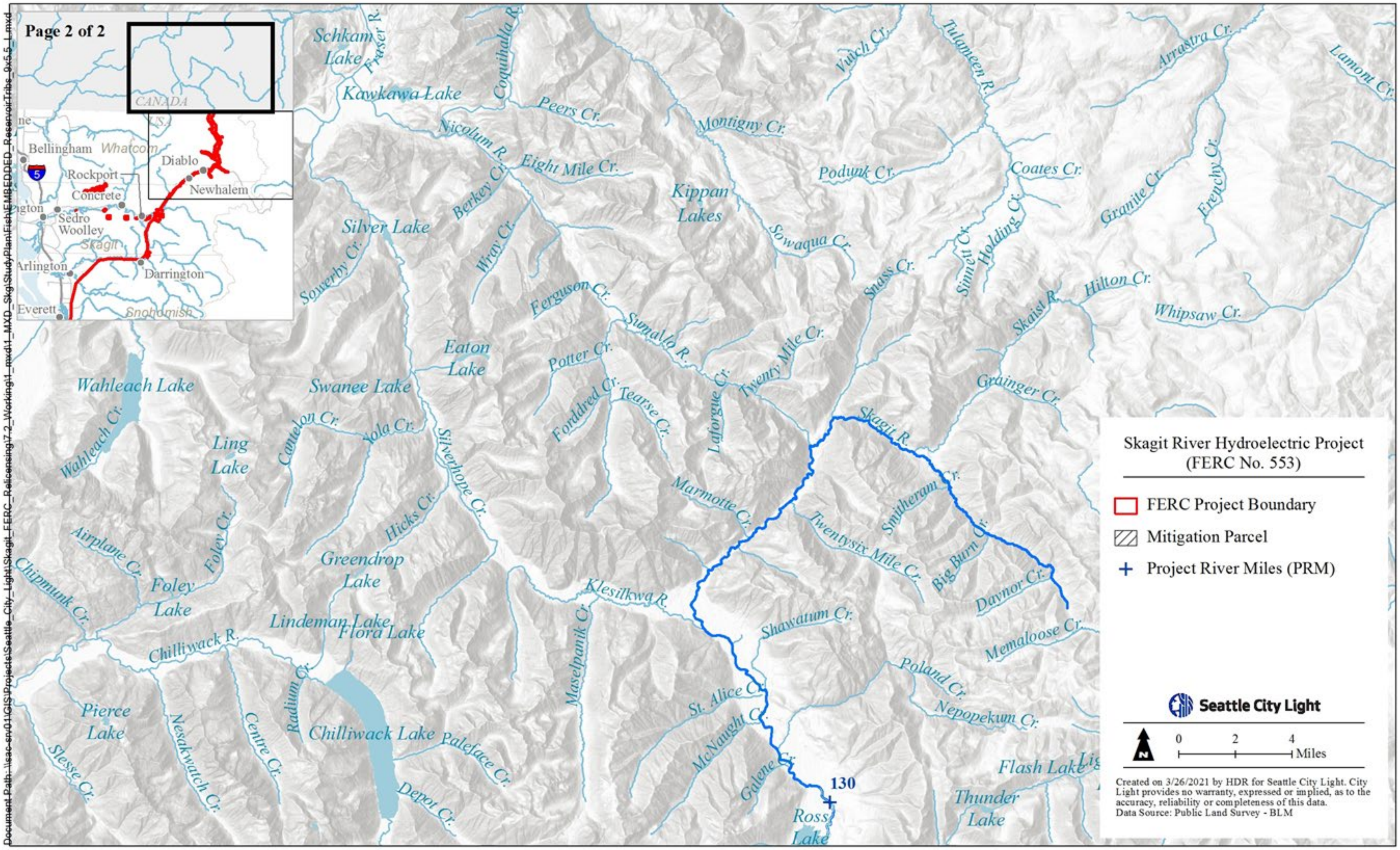

Figure 2.5-1. General study area for the Reservoir Tributary Habitat Assessment in Canada (page 2 of 2).

2.6 Methodology

2.6.1 Intrinsic Potential Modeling

Limits to the extent of habitat will be identified using the NetMap Intrinsic Potential model, which predicts salmonid habitat availability in a GIS using a 10-m resolution Digital Elevation Model (DEM)[2] to calculate stream slope, valley confinement, and drainage area as limiting factors to suitable habitat, as defined by NMFS (2016). Intrinsic Potential modeling can be used to estimate both the amount and location of habitats that are geomorphically suitable for spawning or rearing. The results of the Intrinsic Potential modeling will be refined based on the locations of known barriers to upstream fish migration.

2.6.2 Estimating Juvenile Salmonid Rearing Capacity

Parr capacity will be characterized using spatial analysis to quantify and characterize tributaries upstream of the Project dams to create a data collection and extrapolation framework, which will be followed by ground-based surveys of accessible salmonid rearing habitat (e.g., Cooper et al. 2020), as needed to augment existing habitat data. Habitat data collected in the field will serve as inputs to a juvenile capacity estimation tool (e.g., the Unit Characteristic Method, Cramer and Ackerman 2009a, 2009b), adapted as necessary to relate habitat conditions to parr density for the target species, i.e., using surrogate parr densities from local watersheds to the extent feasible. The approach used to estimate juvenile capacity will be adjusted to local conditions to account for site-specific hydrology, climate conditions, and geomorphology. Parr densities will be calculated at the habitat-unit scale and extrapolated to reach and watershed scales.

The reaches selected for production potential analysis (based on Intrinsic Potential modeling results) will be classified into categories (reach types) based on gradient and drainage area. The frequency (stream-miles) of each reach type will be used to assign a proportional number of sites within which to conduct ground-based habitat surveys. After specific field survey sites are selected, habitat data will be collected under low-flow conditions (July – September). Habitat data collected during surveys will be extrapolated to characterize habitat in corresponding reaches (of the same type) that are not surveyed. Habitat surveys in tributaries will be conducted according to the USFS's Region 6 Stream Inventory Handbook (USFS 2012) or a comparable method. Each habitat unit will be classified as a pool, riffle, cascade, flatwater, or dry unit and measured for wetted surface area. Other habitat variables measured will include instream large woody debris, instream cover, streambed substrate composition and embeddedness, canopy cover, discharge, and temperature.

2.6.3 Linkages to the Food Web Study

The results of the Intrinsic Potential model and assessment of production potential can be interpreted in tandem with bioenergetics results conducted as part of the Food Web Study, which is currently being conducted in the Project vicinity, outside the context of FERC relicensing (Beauchamp, in development). The physical habitat assessment will generate the template upon

[2] NetMap coverage for tributaries in the U.S. is at 10-m pixel resolution; 20-m pixel resolution is available for the upper Skagit drainage in Canada.

which thermal and biotic factors can be overlaid to account for the influences of temperature variability and food supply on salmonid production capacity.

When lakes or reservoirs are available, ocean- and stream-type Chinook Salmon frequently use them as freshwater rearing habitat, whereas steelhead tend to remain in streams and Coho Salmon use both streams and transition-zones between lotic and lentic habitats. Sockeye Salmon is a nearly obligate lake-rearing species. Some or all of the rearing capacity for juvenile Chinook and Sockeye would be influenced by seasonal patterns of thermal stratification and prey availability in the reservoirs. These phenomena can be addressed through bioenergetics evaluations.

Bioenergetics simulations can be used to predict growth performance of juvenile salmonids in tributaries where temperature, fish size-at-age, and invertebrate drift data were collected together, thereby providing a diagnostic tool for assessing the importance of these factors as they influence growth. Bioenergetics modeling of salmonid growth in specific tributaries provides a useful diagnostic tool for evaluating growth potential for anadromous salmonids added to the system. Conventional bioenergetics modeling approaches can predict the carrying capacity of lakes for a suite of pelagic consumers like Sockeye or Chinook salmon in additional to existing residents like Redside Shiners (Beauchamp et al. 1995; Hansen et al. 2016; Sorel et al. 2017). For tributary rearing fish, this bioenergetics approach cannot explicitly predict carrying capacity for drift feeding salmonids without a substantial increase in data collection that is frequently technically infeasible. However, the bioenergetics approach can directly address the question of whether there is sufficient production capacity to support anadromous salmonids, given the existing fish community and growth performance of fish in that specific system (tributary or lake).

Juvenile Rainbow Trout (ages 1-3) provide an obvious preview of potential growth for juvenile steelhead, but they are also useful partial surrogates for evaluating the niche available for extended stream rearing by juvenile Chinook or Coho salmon. Based on size-at-age (back-calculated size-at-annulus on scales) and seasonal length-weight relationships observed for juvenile Rainbow Trout of different sizes in specific tributaries, bioenergetics model simulations can incorporate empirical data on diet, thermal regime, and energy content of the composite diet and consumers to generate output variables that serve as useful diagnostics to evaluate growth performance of the existing population. Then if growth is limiting, the key processes limiting growth can be evaluated such as: temporal food supply and its corresponding energetic quality of the diet; thermal suppression of growth (too cold or hot for inordinately long periods); or body size (i.e., has the fish outgrown the capacity to thrive in that environment given allometric effects of body mass on metabolism and feeding capacity).

The bioenergetics model operates on a daily time-step to incorporate temporal changes in thermal experience, diet composition, and predicted body mass to generate estimates of: daily consumption of each prey type, daily change in body mass, and an average feeding rate averaged over the entire simulation period expressed as %Cmax (the percentage of the theoretical maximum consumption for a species, given its current body mass and thermal experience). In addition, the growth efficiency (GE) of the consumer over the simulation period can be computed as the mass gained (or lost) divided by the mass of food consumed over the simulation period.

Collectively, %Cmax, GE, and final weight at age-1, -2 and age-3 annuli provide insightful metrics for how the current resident salmonids perform and allow some inference about whether there is additional capacity to support anadromous salmonids to successful smolt size at the appropriate ages. These size-at-annulus and weight-at-annulus estimates can be compared to the actual sizes of successful wild steelhead smolts from the anadromous portion of the Skagit River (Thompson and Beauchamp 2016) and for Chinook and Coho smolts from smolt trapping data and/or supplementary analyses on size-selective mortality during marine life stages (e.g., Gamble et al. 2018 for subyearling Chinook, unpublished data for yearling Coho). Additionally, if the relevant age classes of Rainbow Trout exhibit relatively high values for growth (attain successful smolt size at appropriate age), GE (≈10-20 percent for juvenile salmonids) and %Cmax (>0.40 for juvenile salmonids feeding on a primarily invertebrate diet), then their growth suggests that significantly more consumers with relatively low diet overlap could be accommodated. However, values of any of these metrics that were already substantially lower would suggest high vulnerability to competitive effects and density-dependent declines in growth compared to current observed performance.

2.6.3.1 Food Web Study Workshop

City Light believes that the development of a process to integrate the results of the physical habitat and bioenergetics assessments would be enhanced by consultation with LPs and proposes to schedule a workshop involving the author of the Food Web Study (David Beauchamp, PhD). During the workshop, determinations can be made about how best to bring together the conclusions of the bioenergetics study and results of the habitat analyses to evaluate the fates of anadromous salmonids potentially released into the basin above the Project. In addition, City Light believes the workshop would provide an opportunity to discuss how the bioenergetics results will be used to address reservoir-related issues raised in LP study requests. For example, NMFS identified the following issues in its study request:

- Seasonal and size-structured trophic interactions within the reservoir food webs and the relative influences of seasonal changes in food supply, competition, and predation as potential limits to the production of anadromous salmonids.
- Integration of production estimates in tributaries and reservoir production analyses.
- Assessment of potential production bottlenecks to salmon and steelhead productivity in reservoirs.

In the event data gaps are identified at the workshop, City Light will adjust the study scope to fill these data gaps in the second year of study.

2.6.3.2 Integration of the Food Web Study

The ongoing Food Web Study is being expanded to conduct bioenergetic simulations in tributaries that have not already been modeled. These simulations will be based on available information, potentially extrapolating from existing salmonid diet or stream temperature data to simulate streams for which data are unavailable. Limited field sampling may be conducted to derive targeted data inputs for the highest priority uncertainties. Other data gaps may be filled by developing supportable assumptions using data from other nearby tributaries.

The highest priority is collecting size-at-age data for rainbow trout (fork length, weight, and scale-based back-calculations to fork length-at-annulus for all previous ages). Size-at-age data would provide a valuable record of stage-specific growth within tributaries, from which bioenergetics modeling could be used to assess potential constraints on growth and the timing and relative magnitude of bottlenecks during the juvenile rearing life stage. Drift sampling in reaches where fish sampling occurs would be valuable for providing an indicator of stream productivity. Where gaps in temperature data exist, temperature loggers could be deployed in tributaries where there is uncertainty about thermal regimes; loggers should be deployed from early spring through early fall to provide empirical data to support evaluations of growth potential.

2.6.4 Foundation for Potential Subsequent Analyses

As noted in Section 2.1, results of the Reservoir Tributary Habitat Assessment will be integrated with results of other studies conducted during relicensing to provide a foundation for identifying constraints and assess benefits and risks of providing fish passage and access to habitats upstream of the Project dams, consistent with the approach recommended in Anderson et al. (2014). A variety of other factors would require evaluation to develop a comprehensive assessment of the potential outcome of introducing anadromous fish into the basin upstream of the Project dams. Bull Trout, which are abundant in the reservoirs, can prey heavily on juvenile anadromous salmonids as they rear in or outmigrate through reservoirs. Other factors that would influence the evaluation of instituting fish passage include potential effects of and on resident fish populations (e.g., disease transmission, competition, genetic introgression) and demographic factors such as effects on source populations (i.e., source/sink dynamics). Next steps or additional studies may be warranted to further evaluate the feasibility and efficacy of fish passage (e.g., juvenile reservoir transit and mortality).

Potential future efforts could include but not be limited to parameterization and use of a Cost-Distance Meta-POPulation (CDMetaPOP) model (or other comparable modeling tool) for the target species. CDMetaPOP is a spatially explicit, individual-based model derived from CDPOP (Landguth and Cushman 2010). The model, which was developed for species living in dynamic riverine landscapes, is suitable for application in situations where the spatial arrangement of habitats, habitat-specific demographics, and behavior describing the dispersal of species can be defined (Landguth et al. 2017). CDMetaPOP can simulate a range of spatially explicit processes and accommodate simulations involving up to hundreds of thousands of individuals to support assessment of population genetic responses to simulated scenarios. Estimates of production potential derived from this study, along with other relevant data and vetted assumptions, would serve as input to the model.

2.7 Reporting

The reporting schedule is shown in Section 2.9. The draft report will contain the results of Intrinsic Potential modeling, a description of plans for conducting habitat assessments in tributaries, and a summary of the outcome of the Food Web Study Workshop. The final report will integrate production estimates from tributaries and relevant bioenergetics study results to develop a synthesis, which will include potential production estimates and constraints on target species' productivity.

2.8 Consistency with Generally Accepted Scientific Practice

Intrinsic Potential modeling is a widely used and accepted method for establishing the extent of salmonid habitat in streams, including low-order tributaries such as many of those that flow into the Project reservoirs.

Habitat surveys in tributaries will be conducted according to the USFS's Region 6 Stream Inventory Handbook (USFS 2012) or a comparable method. Selection of a vetted and routinely applied survey method constitutes an industry-standard approach.

Estimates of carrying capacity will be based on scientifically accepted techniques that have been applied successfully in other locations and refined for site-specific application in consultation with LPs.

The approach to conducting the ongoing Food Web Study is a widely used and accepted method for evaluating seasonal and size-structured food web interactions to identify factors that limit recruitment or production of native salmonids.

2.9 Schedule

A provisional, basic schedule for conducting the Reservoir Tributary Habitat Assessment is as follows:

- Intrinsic Potential modeling – June through September 2021
- Identifying Reaches for ground-based habitat surveys – October 2021
- Food Web Study Workshop – July 2021
- Draft Report (Initial Study Report [ISR]) – March 2022
- Conduct ground-based habitat surveys in target reaches – July through September 2022
- Develop estimates of production potential for study tributaries – October through December 2022
- Final Report (Updated Study Report [USR]) – March 2023

2.10 Level of Effort and Cost

The initial estimate for implementation and reporting associated with this study is approximately $225,000. This estimate does not include costs associated with the Food Web Study implementation.

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FA-08 FISH ENTRAINMENT
REVISED STUDY PLAN

SKAGIT RIVER HYDROELECTRIC PROJECT
FERC NO. 553

Seattle City Light

April 2021
RSP

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List of Acronyms and Abbreviations

ADCP.........................Acoustic Doppler Current Profiler
BO.............................Biological Opinion
City Light...................Seattle City Light
ELC...........................Environmental Learning Center
EPRI..........................Electric Power Research Institute
FERC..........................Federal Energy Regulatory Commission
GIS............................Geographic Information System
GPS...........................Global Positioning System
ILP.............................Integrated Licensing Process
ISR............................Initial Study Report
LP..............................licensing participant
NMFS.........................National Marine Fisheries Service
NPS...........................National Park Service
PAD...........................Pre-Application Document
PRM..........................Project River Mile
Project........................Skagit River Hydroelectric Project
PSP............................Proposed Study Plan
RLNRA......................Ross Lake National Recreation Area
RM............................river mile
RSP...........................Revised Study Plan
RTE...........................rare, threatened, and endangered
RWG.........................Resource Work Group
USFWS......................U.S. Fish and Wildlife Service
USGS.........................U.S. Geological Survey
WDFW.......................Washington Department of Fish and Wildlife

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1.0 INTRODUCTION

1.1 General Description of the Project

The Skagit River Hydroelectric Project (Project), licensed to The City of Seattle, Washington, and operated through its publicly-owned electric power utility Seattle City Light (City Light), is in northern Washington State and consists of three power generating developments on the Skagit River – Ross, Diablo, and Gorge – and associated lands and facilities. The Project generating facilities are in the Cascade Mountains of the upper Skagit River watershed, between Project River Miles (PRM) 94.7 and 127.9 (U.S. Geological Survey [USGS] RMs 94.2 and 127).[1] Power from the Project is transmitted via two 230-kilovolt powerlines that span over 100 miles and end just north of Seattle at the Bothell Substation. The Project also includes two City Light-owned towns, an Environmental Learning Center (ELC), several recreation facilities, and several parcels of fish and wildlife mitigation lands.

Project generating facilities are all located in Whatcom County, although Ross Lake, the most upstream reservoir, crosses the U.S.-Canada border and extends for about one mile into British Columbia at normal maximum water surface elevation. Gorge Powerhouse, the most downstream facility, is approximately 120 miles northeast of Seattle and 60 miles east of Sedro-Woolley, the nearest large town. The closest town is Newhalem, which is part of the Project and just downstream of Gorge Powerhouse. The primary transmission lines cross Whatcom, Skagit, and Snohomish counties; the fish and wildlife mitigation lands are in the same counties.

The Project Boundary is extensive, spanning over 133 miles from the Canadian border to the Bothell Substation just north of Seattle, Washington. In addition, there are "islands" of fish and wildlife mitigation lands and recreation facilities within the Skagit, Sauk, and South Fork Nooksack watersheds that are also within the Project Boundary. Project generating facilities are entirely within the Ross Lake National Recreation Area (RLNRA), which is administered by the National Park Service (NPS) as part of the North Cascades National Park Complex. The RLNRA was established in 1968 in the enabling legislation for North Cascades National Park to provide for the "public outdoor recreation uses and enjoyment of portions of the Skagit River and Ross, Diablo, and Gorge lakes." The legislation maintains the Federal Energy Regulatory Commission's (FERC) jurisdiction "in the lands and waters within the Skagit River Hydroelectric Project," as well as hydrologic monitoring stations necessary for the proper operation of the Project (16 United States Code [U.S.C.] § 90d-4; Public Law 90-544. Sec. 505 dated October 2, 1968, as amended by Public Law 100-668. Sec. 202 dated November 16, 1988).

1.2 Relicensing Process

The current FERC license for the Project expires on April 30, 2025, and City Light will apply for a new license no later than April 30, 2023. City Light formally initiated the integrated licensing process (ILP) by filing a Notice of Intent and Pre-Application Document (PAD) with FERC on April 27, 2020 (City Light 2020a). The PAD includes descriptions of the Project facilities,

[1] City Light has developed a standard Project centerline and river mile system to be used throughout the relicensing process, including the study program, to replace the prior USGS RM system. Given the long-standing use of the USGS RM system, both it and the Project River Mile (PRM) system are provided throughout this document. For further details see Section 7.0 of the main body RSP.

operations, license requirements, and Project lands as well as a summary of the extensive existing information available on Project area resources and early consultation on potential resource issues to be addressed during the relicensing.

In 2019-2020, City Light convened a series of Resource Work Groups (RWG) to engage agencies and other licensing participants (LP) in the Study Plan Development Process. Discussions with LPs continued in early 2021 with a series of topic-based discussions following filing of the Proposed Study Plan (PSP) on December 8, 2020 (City Light 2020b). This study plan reflects RWG and LP discussion and study requests and comments submitted by LPs.

1.3 Study Plan Development

City Light is filing this FA-08 Fish Entrainment Study Plan with FERC as part of its Revised Study Plan (RSP). This study plan addresses, with modifications, elements of the following study requests, as explained in Section 6 of the RSP: NPS-07 Evaluating Existing Fish Passage and Entrainment, U.S. Fish and Wildlife Service (USFWS)-08 Evaluating Existing Fish Passage and Entrainment through the Skagit Hydroelectric Project Dams and Appurtenant Facilities, Upper Skagit Indian Tribe USIT-03 Evaluating Existing Fish Passage: Spill and Entrainment through Ross, Diablo, Gorge Dams and Appurtenant Facilities through the Project Area at the Skagit River Hydroelectric Project, and Washington Department of Fish and Wildlife (WDFW)-04 Evaluating Existing Fish Passage: Spill and Entrainment through Ross, Diablo, Gorge Dams and Appurtenant Facilities through the Project Area at the Skagit River Hydroelectric Project.

Because this is the first draft of the study plan, there are no relevant PSP comments.

City Light proposes a desktop assessment of fish entrainment and impingement as part of the RSP. Desktop analysis of entrainment and impingement at hydroelectric facilities is an approach that has been widely accepted by state and federal agencies and is considered a useful predictive tool in lieu of field studies (USFWS 2019).

Results of this assessment will be used to inform an integrated environmental analysis and to identify links across resource areas. Data collected as part of the Fish Entrainment Study, along with existing information, may also be applicable to other resource areas. The FA-04 Fish Passage Technical Studies Program may ultimately be linked, either directly or indirectly, to the findings of this study. More needs to be learned within each respective study area before it is clear how study results will best inform comprehensive environmental analysis. City Light will work with LPs to review and integrate information from related studies as part of the ILP process in support of its license application filing.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

Fish that reside in the Project reservoirs may be susceptible to impingement on trash racks, or entrainment through operating turbines or other non-turbine flow pathways (e.g., bypass channels, spillways, etc.). The goals of this desktop study are to evaluate fish entrainment and impingement at the Ross, Diablo, and Gorge developments and the potential effect on the Skagit River fish community.

Specific objectives to meet this goal are provided below.

- Describe the physical characteristics of the Project powerhouses and intake structures, including locations, dimensions, turbine specifications, and trash rack spacing.
- Summarize water quality characteristics in the vicinity of the Project intake structures using existing data or data being collected as part of the FA-01 Water Quality Monitoring Study.
- Estimate intake velocities at each of the intake structures at Ross, Diablo, and Gorge dams.
- Describe the fish community and compile a target species list for entrainment and impingement analyses.
- Characterize the risk of impingement to target species based on Project development intake velocities, trash rack bar spacing, and target species life history information and estimated swim speeds.
- Characterize the risk of turbine and non-turbine (e.g., spillway or bypass) entrainment to target species based on body size, life stage, periodicity, habitat requirements, and Project operations (i.e., velocities, spill versus generation).
- Conduct a literature review and desktop analysis of historical turbine entrainment and entrainment survival studies to estimate turbine entrainment and entrainment survival at Project developments.
- Characterize probability of passage and survival for target species at the Project developments (turbine and spillway passage) using site-specific physical and operational parameters, estimated non-turbine (spillway) entrainment mortality rates, and the USFWS Turbine Blade Strike Analysis Model (USFWS 2020).
- Provide a qualitative summary of entrainment and impingement potential for target species at the Project developments based on physical and operational information, turbine and non-turbine entrainment and mortality rates, comparison of burst swim speeds to intake velocity, body size exclusion, and species and life stage periodicity.

2.2 Resource Management Goals and Project Nexus

The study will provide information for resource agencies, Indian tribes, and First Nations with jurisdiction in the Project vicinity to address their respective goals and objectives for resource management. Resource management goals were provided by LPs in their study requests identified in Section 1.3 of this study plan.

2.3 Project Operations and Potential Effects on Resources

2.3.1 Background

City Light proposes this study to evaluate potential direct effects of Project operations on reservoir fish populations. Downstream fish passage through hydroelectric dams via water intakes and turbine and non-turbine flow pathways (e.g., bypass channels, spillways, etc.) may cause injury or mortality regardless of pathway traveled. Entrainment injuries and mortalities can result from fish becoming impinged against trash racks, encountering the turbine blades or other mechanical components or natural structures during passage over the spillway ("spillway entrainment"), and/or pressure changes and cavitation.

The potential for fish to become entrained or impinged at a hydroelectric facility depends on a variety of factors such as fish life history, size, and swimming ability; water quality; operating regimes (i.e., generation versus spill); inflow; and intake/turbine configurations (Cada et al. 1997). Impingement may occur when a fish does not pass through the trash rack but is instead held against (impinged) the racks due to forces created by the intake velocities. Entrainment of fish can occur at intake structures or via non-turbine pathways (i.e., spillways or bypass channels).

A gradient of fish entrainment potential exists both temporally and spatially at Project developments. Smaller-sized fish may be in higher abundances during certain portions of the year, thus increasing their potential for entrainment. In addition, diurnal and seasonal movements of both small and large fish may bring them in closer proximity to intake structures or spillways. Physical and operational characteristics of a project, including trash rack bar spacing[2], intake velocities, intake depth, thermal stratification in the reservoir, intake proximity to feeding and rearing habitats, and frequency of generation versus spill can also affect the potential for a fish to become entrained. These factors and several others are used to make general assessments of entrainment and impingement potential at hydroelectric projects using a desktop study approach.

Fish may suffer immediate or latent mortality during entrainment through a hydropower development. This could be caused by several factors related to mechanical injuries, shear stress, pressure changes, cavitation (the formation of gas bubbles in areas of low pressure, such as downstream of a turbine blade), and/or turbulence (Odeh 1999; Cada et al. 1997). Immediate mortalities typically occur from mechanical injuries, where blade strikes can completely sever fish or cause blunt force trauma. Other physical injuries such as grinding, abrasions, and cuts may make fish more susceptible to disease and predation, thus causing latent mortality. Fish with open wounds and abrasions are more susceptible to bacterial and viral diseases due to loss of their skin's mucous layer, while physical injuries may limit fish mobility and predator avoidance (Jenkins and Burkhead 1993).

Pressure changes may cause injuries or latent mortality. Shear stress, or parallel surface pressure, can also lead to latent or immediate mortalities. Injuries sustained from shear stress could include the removal of skin mucous and loss of eyeballs and mouth parts (Cada et al. 1997). Turbulence occurs at different scales while a hydroelectric turbine is operating, often leading to pressure and shear-stress-related injuries. However, turbulence may also disorient fish after passage, potentially

[2] Gorge Dam currently has trash racks with 3.5-inch clear spacing, Ross Dam has trash racks with 3.5-inch clear spacing, and Diablo Dam currently has trash racks with 2.5- to 2.75-inch clear spacing.

creating higher predation potential. Cavitation is another form of injury that can cause latent or immediate mortality. These types of pressure-related injuries occur most often at dams with >100 feet (ft) of head; the majority of injuries/mortalities occurring at hydropower projects with <100 ft of head is from blade strike (Franke et al. 1997).

2.3.2 Existing Information

The Project's intake structures and spillways are unscreened and, as a result, fish rearing in or migrating through the Project reservoirs could be entrained into the Project's intakes and turbines or entrained through the Project's spillways during spill events. As described in Section 2.3.1 of this study plan, fish that become entrained into these facilities may survive and add to the fish populations located downstream of the powerhouse, or suffer mortality, injury, or be preyed upon.

Although a species-specific assessment of entrainment and impingement at Project facilities has not previously been performed, some generalizations can be made. Turbine intake depths at Ross, Diablo, and Gorge dams are approximately 110, 88, and 52 feet (City Light 2020b), respectively. Entrainment of smaller-bodied species and early life-stage salmonids is unlikely because they do not frequently occupy these depths and as resident species, they do not actively seek deep water exits from the reservoirs. Larger-bodied species and life-stages typically have sufficient burst swim speeds to avoid impingement or entrainment at the intakes.

Spills are infrequent at Ross Dam due to the large reservoir storage capacity, and are typically associated with gate testing, are of short duration, and average only a few cfs. Over the past five years (2014-2018), Ross Dam has spilled 20 times; 11 of these occurred in August 2015 during the Goodell Creek Wildfire, which disrupted Project operations and transmission (City Light 2020a). Ross Dam has large reservoir storage capacity; therefore, spills are infrequent. When spills do occur, they are usually associated with gate testing, short in duration, and average a few cubic feet per second (cfs) per event. As such, spillway entrainment at Ross Dam is likely to be rare.

Spillway use at Diablo Dam occurs about 30 days per year, on average, typically during periods of high runoff in spring and early summer or when powerhouse units are offline or additional flow is needed to meet fish protection flows downstream of Gorge Powerhouse. Therefore, the risk of spillway entrainment at Diablo Dam is low and limited to the short duration window when spills may occur.

Spill at Gorge Dam occurs when inflow exceeds the generating capacity of the powerhouse or if flow is needed to meet fisheries protection flows downstream of Gorge Powerhouse. Based on recent records, spills occur between 14 and 61 days per year. As such, spillway entrainment risk would be low and limited to when spills may occur.

Entrainment was not studied as part of the previous Project relicensing; however, City Light conducted a non-species-specific desktop risk assessment (City Light 2011) of entrainment related mortality risk based on fish size. Estimated entrainment related injury rates were well below what would result in population-level effects. Additionally, when City Light submitted its 2011 application for a non-capacity amendment of the license (for the construction of a second power tunnel between Gorge Dam and Powerhouse), the USFWS requested additional information to address potential impacts of entrainment on Bull Trout (*Salvelinus confluentus*) at Skagit River

Project facilities. Bull Trout was not an ESA-listed species at the time of the previous relicensing but was listed by the time of the amendment application.

As a component of its Biological Opinion (BO) associated with the addition of the second power tunnel at the Gorge Development, USFWS (2013) analyzed the potential effects of entrainment on the Bull Trout population in Gorge, Diablo and Ross lakes. Results of the analysis indicated that Bull Trout that pass through the Skagit Project facilities may be injured, killed, or otherwise impacted such that they are temporarily more vulnerable to predation due to disorientation and stress. Further, the BO assumed that Bull trout would continue to be entrained at the intakes and spillways of all three dams for the remainder of the license period (2012 to 2025).

Entrainment at Gorge, Diablo, and Ross dams may potentially occur whenever generation is underway, which is almost constant on a year-round basis. During short periods of planned and un-planned plant outages, water does not typically flow through the intake structures (USFWS 2013). During periods of infrequent plant outages, turbine entrainment would not take place; however, spill entrainment would occur during periods of plant outages or flooding. On an annual basis, the Project dams spill 1 to 2 percent of the time; with spill flows and duration varying greatly, ranging from a few hundred to a few thousand cfs and for as short as an hour to several days or weeks at a time depending on the circumstances.

The potential for Bull Trout passage during spill events is a function of which spillway is open and passing flow, combined with the time of year relative to Bull Trout life history, and movement patterns both laterally and vertically in the water column (USFWS 2013). The risk of spill passage injury or mortality is a function of the conditions that would be experienced by the fish during the passage and upon reintroduction to the river in the tailrace below each dam. It is expected that the greatest impact on fish passing through spill would occur upon entrance of the plunging flow into the tailrace.

Entrainment of Bull Trout at the Project dam intake structures has not been previously evaluated, but USFWS assumed that some Bull Trout are entrained annually at the power intakes of all three dams. However, results of a multiple-year acoustic tracking study in Ross Lake by City Light strongly suggest that the number of Bull trout entrained at the Project intakes is small. The Bull Trout in Ross Lake were observed near intake structures for a relatively small percentage of time and avoided being entrained into the intake tunnel; thus, Bull trout appear behaviorally and physically able to avoid entrainment during those periods when they are near the intakes (USFWS 2013).

Between 2013 and 2018, City Light documented two tagged Bull Trout being entrained at the Diablo Dam intakes; however, both fish survived passage through the turbines as evidenced by their continued movements (via the acoustic tags) following each event. Both fish were relatively large, measuring over 500 mm in length. In 2016, the overall acoustic-tagged Bull Trout passage rate at Diablo Dam was 25 percent (1 of 4 active tags present in Diablo Lake), and in 2018 it was 9 percent (1 of 11 active tags present in Diablo Lake). These findings demonstrate that Bull Trout can survive passage through the Diablo Powerhouse.

Based on the results of these studies, it is apparent that Bull Trout entrainment is relatively uncommon at Ross and Gorge dams (via the intake routes); however, it may be more common at

Diablo Dam as evidenced by the successful passage of Bull Trout (via a turbine intake route) in two of six years. Passage over the spillways at Ross Dam appears to be relatively rare given the limited number of spill events that occur at this facility. Spillway passage is assumed to be more common at Diablo and Gorge dams, although only one Bull Trout was documented (via acoustic telemetry) to pass over the Gorge Dam spillway during the six-year study. No tagged Bull Trout were documented passing over Diablo Dam spillway, although Bull Trout entrainment was estimated via the spill duration method for the purposes of annual entrainment estimation as required by USFWS's Biological Opinion (USFWS 2013).

Under its current Section 10 USFWS permit and NPS research permit, City Light has received approval to tag Bull Trout, Rainbow Trout, Dolly Varden (*Salvelinus malma*), and Brook Trout (*Salvelinus frontalis*) in Project reservoirs to further inform understanding of interspecies interactions, behavior, and entrainment risk. Ongoing tracking of these fish will provide additional information on entrainment and entrainment risk of these species.

2.4 Study Area

The study area includes those locations nearest the existing intake structures within the impoundments upstream of the Ross, Diablo, and Gorge developments, the respective powerhouses, and the immediate tailraces. The proposed study area is shown in Figure 2.4-1.

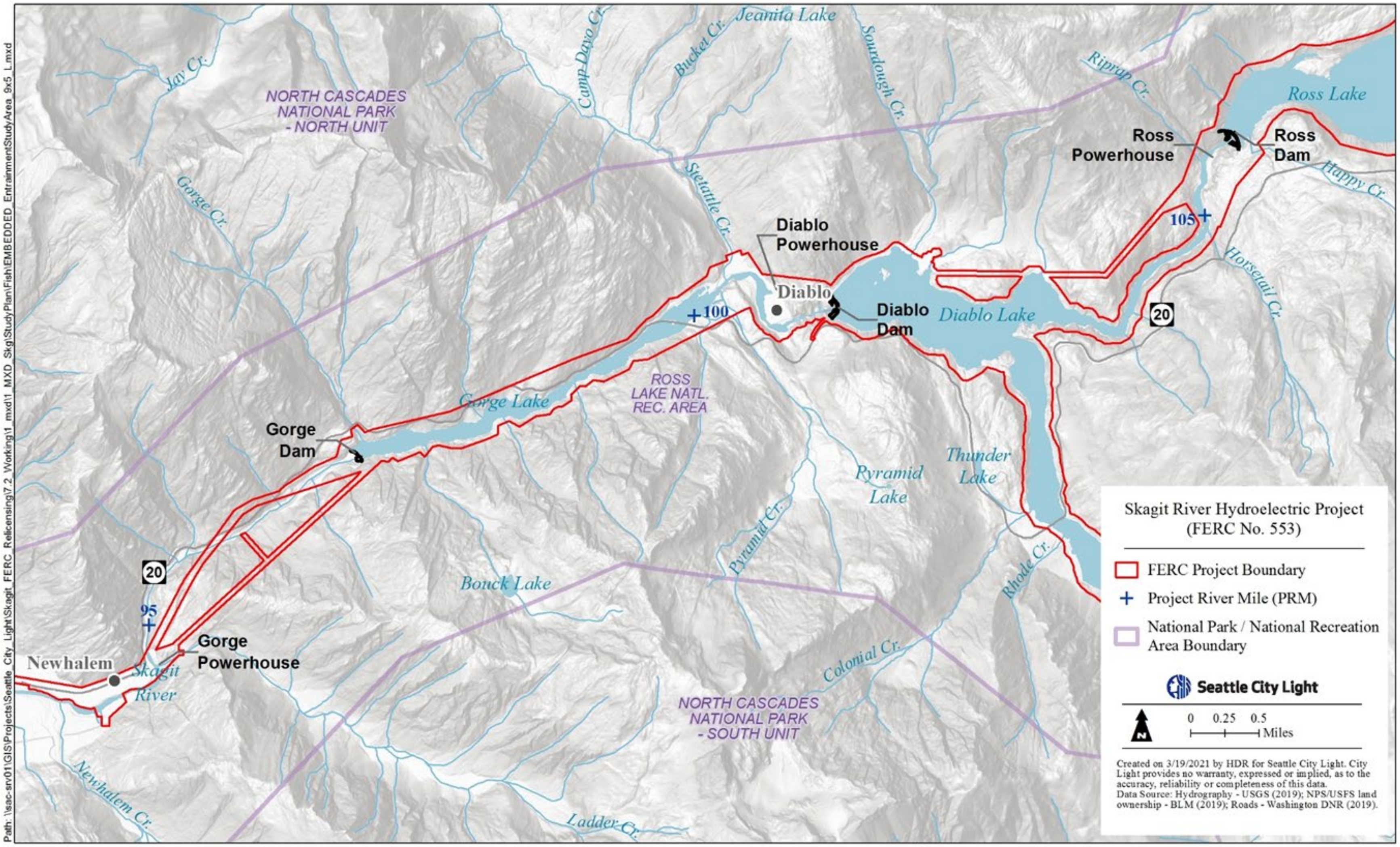

Figure 2.4-1. **Study area.**

2.5 Methodology

A desktop evaluation of the potential for fish entrainment, impingement, and mortality will be performed based on the objectives described in Section 2.1 of this study plan. This evaluation will utilize existing fish community information, hydrology data, and structural/operational characteristics of the Project facilities to characterize turbine and non-turbine entrainment and mortality for select or target species. In order to accomplish these objectives, the following tasks will be completed.

2.5.1 Determine the Physical and Water Chemistry Characteristics of the Structures and Surrounding Areas that may influence Entrainment, Impingement, and Mortality

City Light will summarize the physical and operational data for the Project facilities including pool surface area, volume, average depth, and retention time. Maps and available drawings of the dams and powerhouses may be reviewed to gather information related to total head; intake depth and size; the number, type, orientation, and clear spacing of trash racks; and other relevant powerhouse/turbine/spillway specifications necessary to perform a desktop fish entrainment and survival study. Much of the physical and operational data are summarized in the PAD, although further review of Project design drawings may be necessary.

Existing water quality profile data, or that being collected as part of the FA-01 Water Quality Monitoring Revised Study Plan, will be used to describe forebay water quality conditions (such as stratification) and their potential influence on fish occurrence in the forebay near the spillway or intake structure.

2.5.2 Estimate Intake Velocities at Project Facility Intake Structures

Velocity at the intake structure is an important component for evaluating entrainment and impingement risk. City Light proposes to perform desktop calculations of intake velocities at Project intake structures. Approach (i.e., normal) and open-space velocities will be calculated following guidance from the U.S. Fish and Wildlife Service Fish Passage Engineering Design Criteria (USFWS 2019) and facility-specific generation rates. It is assumed that fish in the vicinity of spillway gates will enter the spillway and be passed downstream, therefore velocity will not be estimated for the spillway pathway.

2.5.3 Describe the Species Composition of the Existing Fish Community and Develop a Target Species List

Existing fisheries information will be used to describe the fish community that may be susceptible to impingement and entrainment. An initial target species list includes the three native salmonid species present in reservoirs (Rainbow Trout, Dolly Varden, and Bull Trout). A final list of target species to be evaluated will be developed in consultation with LPs. The "target species" will be evaluated for potential for entrainment and impingement based on swim speed, behavior, habitat preferences, life stages, and other life history characteristics. Risk assessment of impingement and entrainment will also consider seasonal, diel, or temperature behavior changes in fish species.

2.5.4 Assess the Potential for Trash Rack Exclusion and/or Impingement

Information gathered as part of tasks described in Sections 2.6.1 – 2.6.3 of this study plan will be used to assess the potential for trash rack exclusion and vulnerability to impingement/entrainment. This will incorporate the trash rack clear spacing, intake velocities, swimming speeds, and body scaling factors. Body scaling factors (documented body width to body length proportions) will be calculated from empirical data to determine minimum lengths of target species physically excluded from the trash rack spacing. Such exclusions will be factored into the individual entrainment and mortality estimates.

2.5.5. Determine Monthly Entrainment Rates

A literature review of entrainment field studies conducted at other hydroelectric projects with comparable physical and operational characteristics (i.e., hydraulic capacity, turbine-type, trash rack spacing, number of turbine blades, reservoir size, usable storage, plant capacity, intake velocity at trash racks, regional characteristics, etc.) will be performed to compile entrainment rates for target species. Sources of entrainment information may include (but is not limited to) existing entrainment databases (e.g., Stone & Webster Environmental Services 1992; FERC 1995; EPRI 1997) or entrainment studies conducted at other facilities in the region. Monthly entrainment rates for turbine and non-turbine (i.e., spillway) pathways will be estimated for each of the target species, or surrogate representatives available in the literature.

2.5.6 Calculate Turbine and Spillway Mortality

A literature review of turbine mortality field studies conducted at other hydroelectric projects with comparable physical and operational characteristics (i.e., reservoir size, usable storage, plant capacity, operating mode, average velocity at trash racks, trash rack spacing, etc.) will be performed to compile fish survival rates applicable to the Project developments. Turbine survival information will include the comprehensive Turbine Entrainment and Survival Database - Field Tests prepared by EPRI (1997), and will consider other relevant information as identified during the study.

While injuries and mortalities can result from mechanisms including extreme pressure changes, shear stress, water turbulence, cavitation, and grinding, the greatest opportunity for fish mortality through a facility lies in potential contact with the turbine runner blades (Deng et al. 2005). The most direct cause of injury and mortality to entrained fish is caused by mechanical mechanisms, such as leading-edge strikes by turbine blades, gap grinding, abrasion, wall strike, or mechanical chop (Franke et al. 1997). Estimates of survival for each target species based on the blade strike analysis and literature review findings will be developed, and these survival estimates will be applied to the entrainment estimates for overall Project assessments.

In addition to the literature review, fish entrainment and mortality through Project developments will be modeled using the USFWS Turbine Blade Strike Analysis model. This evaluation uses the most recent version of the Turbine Blade Strike Analysis Model (USFWS 2020) created by the USFWS, which is a probabilistic Excel-based Visual Basic for Applications implementation of the methods outlined by Franke et al. (1997) for evaluating fish mortalities due to turbine entrainment, as well as through non-turbine routes. This tool allows for the estimation of turbine passage and mortality (blade strikes) based on site-specific information (i.e., turbine type, number of units, bar rack spacing, etc.) and length distribution for target species used in this impingement and entrainment assessment. Using the model, fish can be subjected to up to 20 passage routes, including three turbine types, and non-turbine pathways (i.e., bypasses or spillways, which are prescribed a selection probability and estimated mortality rate) incorporating the Franke et al. (1997) equations into a Monte Carlo simulation that produces a probabilistic model result for turbine and non-turbine mortality.

2.5.7 Qualitative Summary of Entrainment Potential at Project Developments

The following factors will be combined to produce a qualitative entrainment potential rating for target species at the Project developments, including:

- Entrainment rates (turbine) and associated mortality for each target species developed for turbine and non-turbine pathways;
- Facility-specific generation and spill rates;
- Comparison of burst swim speed versus intake velocity for likelihood of intake avoidance;
- Body-size-based exclusion; and
- Life history characteristics, such as migratory behavior, habitat preferences, spawning behavior/requirements, and early life stage periodicity.

2.6 Analysis and Reporting

A draft (initial) and updated (final) technical report on the results of the literature review, desktop calculations of intake velocity, quantitative and qualitative assessment of impingement and entrainment, and resulting recommendations will be prepared for this study.

2.7 Consistency with Generally Accepted Scientific Practice

The proposed methods for this study are consistent with accepted professional practices. Desktop analysis of entrainment and impingement at hydroelectric facilities is an approach that has been widely accepted by state and federal agencies and is considered a useful predictive tool in lieu of field studies (USFWS 2019). In addition, the proposed methods for this study are consistent with FERC study requirements under the ILP. No alternative approaches to this study are necessary.

2.8 Schedule

- Literature review – June 2021 – March 2022
- Draft Report (Initial Study Report [ISR]) – March 2022
- Desktop impingement and entrainment evaluation – March – October 2022
- Final Report (Updated Study Report [USR]) – March 2023

2.9 Level of Effort and Cost

City Light estimates that this study will cost approximately $85,000 to complete.

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GE-01 RESERVOIR SHORELINE EROSION
REVISED STUDY PLAN

SKAGIT RIVER HYDROELECTRIC PROJECT
FERC NO. 553

Seattle City Light

April 2021
RSP

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List of Acronyms and Abbreviations

ARMMP.....................Archaeological Resources Mitigation and Management Plan
B&W..........................black and white
City Light...................Seattle City Light
ELC............................Environmental Learning Center
FEMA ....Federal Emergency Management Agency
FERC..........................Federal Energy Regulatory Commission
ft.................................feet
GIS.............................Geographic Information System
ISR.............................Initial Study Report
LiDAR........................Light Detection and Ranging
LP...............................licensing participant
NAIP..........................National Agriculture Imagery Program
NPS............................National Park Service
PAD............................Pre-Application Document
PRM...........................Project River Mile
Project........................Skagit River Hydroelectric Project
PSP.............................Proposed Study Plan
RLNRA......................Ross Lake National Recreation Area
RM.............................river mile
RSP............................Revised Study Plan
RTE............................rare, threatened, and endangered
RWG..........................Resource Work Group
TRREWG...................Terrestrial Resources and Reservoir Erosion Work Group
U.S.C..........................United States Code
USFS..........................U.S. Forest Service
USFWS......................U.S. Fish and Wildlife Service
USGS.........................U.S. Geological Survey
USR............................Updated Study Report
WDFW.......................Washington Department of Fish and Wildlife

1.0 INTRODUCTION

1.1 General Description of the Project

The Skagit River Hydroelectric Project (Project), licensed to The City of Seattle, Washington, and operated through its publicly-owned electric power utility Seattle City Light (City Light), is located in northern Washington State and consists of three power generating developments on the Skagit River – Ross, Diablo, and Gorge – and associated lands and facilities. The Project generating facilities are in the Cascade Mountains of the upper Skagit River watershed, between Project River Miles (PRM) 94.7 and 127.9 (U.S. Geological Survey [USGS] RMs 94.2 and 127).[1] Power from the Project is transmitted via two 230-kilovolt powerlines that span over 100 miles and end just north of Seattle at the Bothell Substation. The Project also includes two City Light-owned towns, an Environmental Learning Center (ELC), several recreation facilities, and several parcels of fish and wildlife mitigation lands.

Project generating facilities are all located in Whatcom County, although Ross Lake, the most upstream reservoir, crosses the U.S.-Canada border and extends for about one mile into British Columbia at normal maximum water surface elevation. Gorge Powerhouse, the most downstream facility, is approximately 120 miles northeast of Seattle and 60 miles east of Sedro-Woolley, the nearest large town. The closest town is Newhalem, which is part of the Project and just downstream of Gorge Powerhouse. The primary transmission lines cross Whatcom, Skagit, and Snohomish counties; the fish and wildlife mitigation lands are in the same counties.

The Project Boundary is extensive, spanning over 133 miles from the Canadian border to the Bothell Substation just north of Seattle, Washington. In addition, there are "islands" of fish and wildlife mitigation lands and recreation facilities within the Skagit, Sauk, and South Fork Nooksack watersheds that are also within the Project Boundary. Project generating facilities are entirely within the Ross Lake National Recreation Area (RLNRA), which is administered by the National Park Service (NPS) as part of the North Cascades National Park Complex. The RLNRA was established in 1968 in the enabling legislation for North Cascades National Park to provide for the "public outdoor recreation use and enjoyment of portions of the Skagit River and Ross, Diablo, and Gorge lakes." The legislation maintains the Federal Energy Regulatory Commission's (FERC) jurisdiction "in the lands and waters within the Skagit River Hydroelectric Project," as well as hydrologic monitoring stations necessary for the proper operation of the Project (16 United States Code [U.S.C.] § 90d-4; Public Law 90-544. Sec. 505 dated October 2, 1968, as amended by Public Law 100-668. Sec. 202 dated November 16, 1988).

1.2 Relicensing Process

The current FERC license for the Project expires on April 30, 2025, and City Light will apply for a new license no later than April 30, 2023. City Light formally initiated the relicensing process by filing a Notice of Intent and Pre-Application Document (PAD) with FERC on April 27, 2020 (City Light 2020a). The PAD includes descriptions of the Project facilities, operations, license

[1] City Light has developed a standard Project centerline and river mile system to be used throughout the relicensing process, including the study program, to replace the outdated USGS RM system. Given the long-standing use of the USGS RM system, both it and the Project River Mile (PRM) system are provided throughout this document. For further details see Section 7.0 of the main body RSP.

requirements, and Project lands as well as a summary of the extensive existing information available on Project area resources and early consultation on potential resource issues to be addressed during the relicensing. The PAD also includes an outline of the goals and objectives of this study.

In 2019-2020, City Light convened a series of Resource Work Groups (RWG) to engage agencies and other licensing participants (LP) in the Study Plan Development Process. Discussions with LPs continued in early 2021 with a series of topic-based discussions following filing of the Proposed Study Plan (PSP) on December 8, 2020 (City Light 2020b). This study plan reflects RWG and LP discussion and study requests and comments submitted by LPs.

1.3 Study Plan Development

Ongoing shoreline erosion at Project reservoirs (Ross, Diablo, and Gorge lakes) has the potential to affect the following resources: terrestrial vegetation, including rare, threatened, and endangered (RTE) plant communities; wildlife habitat; aquatic resources; cultural resources; and recreation resources along the shoreline. An inventory of shoreline erosion areas was completed in the late 1980s for the current Project license (Riedel 1990), and erosion control measures and shoreline erosion monitoring at selected sites have taken place annually since 1995. This study will: (1) review available information; (2) update the previous shoreline erosion inventory; (3) assess the current status of previously identified areas of shoreline erosion and the effectiveness of existing erosion control measures; (4) identify any new erosion sites; and (5) provide information that will be used to evaluate the effects of Project-related shoreline erosion on resources of concern. At least five issue forms from the 2019 collaborative process are directly or indirectly linked to the results of this study: (1) TE06 Reservoir Erosion; (2) TE07 Shoreline Erosion; (3) FA10 Reservoir Turbidity; (4) CR02 Erosion Monitoring Plan; and (5) CR07 Ross Lake Geomorphology Study and Monitoring. Information from this study will inform CR-02 Cultural Resources Survey and the Archeological Resources Mitigation and Management Plan (see Schalk et al. 2011 for current ARMMP). Note that reservoir sedimentation at resource areas of concern will be addressed in the GE-03 Sediment Deposition in Reservoirs Affecting Resource Areas of Concern Study.

On March 13, 2020, City Light released the GE-01 Reservoir Shoreline Erosion Draft Study Plan for LP review and comment. On March 17, 2020, the draft study plan was discussed at a Terrestrial Resources and Reservoir Erosion Work Group (TRREWG) meeting. City Light reviewed all comments received and released a revised version of the draft study plan on April 29, 2020. The revised draft was discussed on May 6, 2020 at a TRREWG meeting. The revised draft study plan was also provided to the Fish and Aquatics Resource Work Group (FARWG) on June 19, 2020 for review. Written comments were received from Washington Department of Fish and Wildlife (WDFW), U.S. Fish and Wildlife Service (USFWS), NPS, and Upper Skagit Indian Tribe and responded to in an attachment to this study plan. A Status Draft of the study plan was provided to LPs on August 6, 2020.

City Light is filing this study plan with FERC as part of its Revised Study Plan (RSP), an update to the version that was filed with the PSP and incorporating additional consultation with LPs prior to the filing date. No formal study requests related to this study were filed with FERC.

PSP comments to the study plan were submitted by the Upper Skagit Indian Tribe and USFWS. City Light has addressed the specific comments and suggested edits in this study plan and responded to comments in the PSP comment/response table appended to the main body of the RSP. Modifications made to the study plan in response to comments include adding reference to the Skagit ARMMP and clarification of the area assessed.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

The goals of the Reservoir Shoreline Erosion Study are to characterize existing areas of erosion along Project reservoir shorelines and to identify any Project-related factors resulting in erosion at each locale. The study results will facilitate City Light's development of erosion control or monitoring measures, as needed where Project-related erosion is affecting resources of concern.

Specific objectives include:

- Update and review each reservoir erosion site identified in the 1990 reservoir erosion inventory as well as any newly-identified reservoir erosion sites to identify ongoing areas of reservoir erosion along the shorelines of Ross Lake, Diablo Lake, and Gorge Lake.
- Identify types of erosion and factors (Project and non-Project) contributing to erosion at each location to help categorize areas with similar erosion patterns and rates.
- Estimate shoreline erosion rates to the extent possible at representative un-monitored sites based on existing measured erosion rates, aerial photographs and Light Detection and Ranging (LiDAR), and on-site evidence to better understand erosion rates and processes.
- Correlate existing erosion rate data collected at monitoring sites during the current Project license term and data collected at previously un-monitored sites (see previous bullet) with erosion site characteristics (e.g., underlying geology, slope, aspect, shoreline height, landform, type of erosion) to extrapolate and help estimate ongoing erosion rates at unmeasured sites.
- Evaluate the condition and effectiveness of existing shoreline erosion control measures.

2.2 Resource Management Goals

City Light's goal is to gain a current understanding of areas of reservoir shoreline erosion and of the effectiveness of existing erosion control measures. This information will be used during the relicensing process to assess the potential for Project-related shoreline erosion to affect resources of concern.

The study will provide information for resource agencies and Indian tribes with jurisdiction in the Project vicinity to address their respective goals and objectives for resource management.

2.3 Background and Existing Information

An inventory of shoreline conditions was completed for the current Project license (Riedel 1990). Shorelines along the three Project reservoirs (Ross, Diablo, and Gorge lakes) are composed of a variety of materials based on the underlying geology and soils materials (Table 2.3-1). The majority of shoreline length on all three reservoirs consists of stable bedrock and talus as well as stable SR 20 road fill along Gorge Lake. Colluvium comprises another large portion of lake shorelines and can be unstable on steep slopes, but is thin, resulting in limited erosion volumes or shoreline retreat if bedrock is encountered. Lodgement till on shorelines in Ross and Diablo lakes is generally consolidated and can be stable, but in some areas till is unconsolidated and erodible. Less stable deposits (outwash, unconsolidated areas of alluvial fan, alluvium, and landslide deposits) are subject to erosion.

Table 2.3-1. Length (feet [ft]) and percentage of shoreline composed of various materials.

Material	Ross Lake	Diablo Lake	Gorge Lake
Bedrock	95,670 (33%)	38,090 (48%)	19,195 (40%)
Talus	18,440 (6%)	5,250 (7%)	8,365 (17%)
Colluvium	56,675 (20%)	8,990 (11%)	1,970 (4%)
Undifferentiated	0	985 (1%)	655 (1%)
Glacial Till	67,750 (23%)	8,840 (12%)	0
Outwash	8,675 (3%)	0	0
Alluvial Fan	28,740 (10%)	8,775 (11%)	7,710 (16%)
Alluvium	2,295 (<1%)	1,805 (2%)	1,970 (4%)
Landslide	2,625 (<1%)	0	0
Fill	5,415 (2%)	6,238 (8%)	8,040 (17%)
Total	**286,285**	**75,973**	**47,905**

Source: Riedel 1990.

Lake shorelines are subject to erosion from natural processes (e.g., waves, currents, freeze-thaw action, mass movements groundwater, and overland flow), as well as other factors (e.g., recreational use/trampling). Fluctuation of reservoir levels as part of Project operations contribute to lake shoreline erosion by focusing wave energy on different parts of the bank and exposing areas within the drawdown zone to wave action, freeze-thaw, and overland flow and can affect mass movements (Riedel 1990). During reservoir drawdown and filling, previously eroded material is transported downslope and deposited in lower elevations of the reservoirs.

As part of the 1990 shoreline condition inventory (Riedel 1990), information on bank material, bank slope, bluff height, sediment thickness, site aspect, and evidence of slope instability were recorded. Each eroding site was classified based on erosion type and extent using the following criteria:

- Class I – over 1,000 cubic feet of mass movement had or could occur.
- Class II – less than 1,000 cubic feet of mass movement had or could occur with bluffs over 3-5 feet.
- Class III – less than 1,000 cubic feet of mass movement had or could occur with bluffs less than 3-5 feet.

Shoreline conditions at Ross, Diablo, and Gorge lakes varied considerably at the time of the 1990 report (Table 2.3-2). Approximately 26 percent of the Ross Lake shoreline was eroding to some extent, with 2 percent of the shoreline in Class I sites, 14 percent in Class II sites, and 10 percent in Class III sites. Most of the erosion sites were located in the southern 17 miles of the reservoir where colluvium and glacial sediments occur on steep valley slopes. Bluff sites at the Class I areas ranged from 5 to over 50 feet in height. Dominant processes affecting erosion were waves (wind waves and boat waves) undercutting the base of bluffs; at some sites, freeze-thaw activity or groundwater seepage contributed to instability.

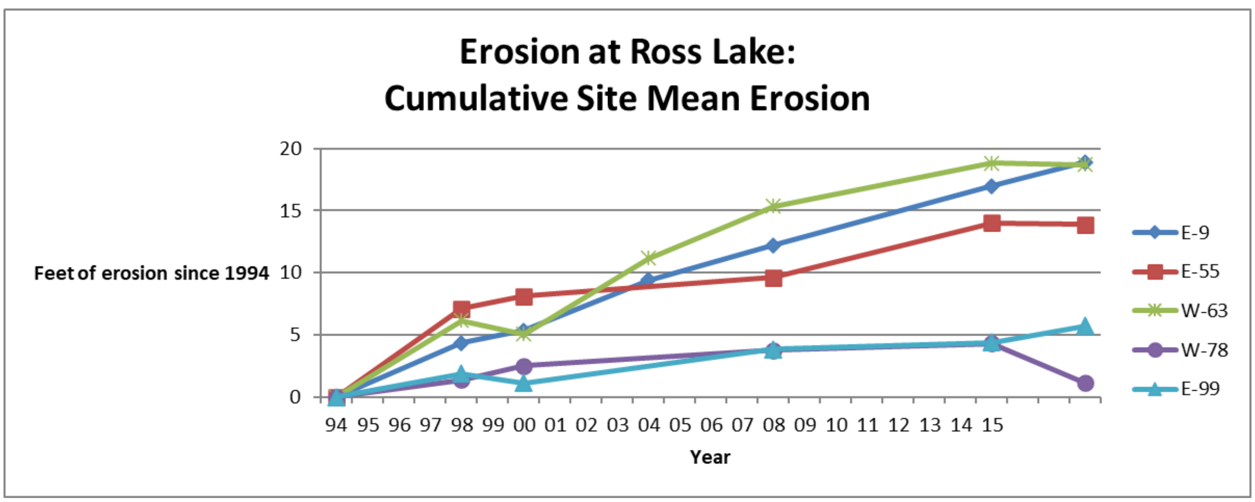
Table 2.3-2. Number of erosion sites and length (ft) and percentage of total shoreline eroding in 1990.

Erosion Class	Ross Lake	Diablo Lake	Gorge Lake
Class I	34 sites; 6,529 ft; 2%	5 sites; 1,801 ft; 2%	3 sites; 312 ft; <1%
Class II	719 sites; 40,072 ft; 14%	17 sites; 2,310 ft; 3%	3 sites; 341 ft; <1%
Class III	390 sites; 29,878 ft; 10%	56 sites; 3,927 ft; 5%	11 sites; 272 ft; <1%
Total	**1,143 sites; 76,479 ft; 26%**	**78 sites; 8,038 ft; 10%**	**17 sites; 925 ft; 2%**

Source: Riedel 1990.

At Diablo Lake, 10 percent of the shoreline was eroding; much of the lake perimeter consists of relatively stable material (e.g., bedrock and talus). The eroding areas were glacial till and colluvium; wave action was the primary cause of erosion. The Gorge Lake shoreline is composed of very stable material; only 2 percent of the shoreline was eroding, primarily mass wasting due to waves undercutting areas of erodible material.

NPS has monitored five bank erosion sites (22 total transects) as part of the Erosion Control Plan (Ebasco Environmental and NPS 1990). The most recent monitoring occurred in 2018. Each of the five sites monitored has a different rate of erosion because of varying bank material, aspect, and slope (NPS personal communication 2020; Figure 2.3-1). The greatest total amount of bank recession is at three sites with thick glacial deposits (E9, E55, and W63), where erosion has claimed an average of 14 to 19 feet of the bank in 24 years. Relatively low rates of erosion were observed at the other two sites with an average of less than 6 feet of erosion in 24 years. The majority of the 22 transects had less than 10 feet of erosion over the 24-year monitoring period; the transect with the highest erosion rate had nearly 65 feet of bank retreat. Site E99 is a rocky slope with colluvial soils, while site W78 has a shoreline composed of very dense glacial till.



Source: NPS personal communication 2020.

Figure 2.3-1. Total mean distance of bank recession 1994–2018 at Ross Lake monitoring sites.

2.4 Project Operations and Effects on Resources

The Skagit River Project contains three Project reservoirs: Ross Lake, Diablo Lake, and Gorge Lake. The shorelines of these reservoirs include areas subject to erosion that may be influenced by Project operations. Erosion mechanisms and causes include wind/boat wave action at the water/land interface; rainsplash erosion, overland flow, streamflow, groundwater, and freeze-thaw. Shoreline erosion has the potential to affect terrestrial vegetation including RTE plant communities along the shoreline, wetlands, riparian areas, cultural resources, wildlife or aquatic habitat, and recreation resources (e.g., trails and campgrounds). Erosion monitoring by the NPS has documented up to 0.85 feet/year of bank retreat since 1994, with the maximum rate at one transect of up to 2.5 feet/year (Figure 2.3-1). Erosion control measures have been installed at some of the erosion sites identified during the current Project license and additional erosion control measures, maintenance and modifications to existing measures may be needed during the next license period. Information on the current status of shoreline erosion will be used to inform appropriate shoreline erosion protection measures where resources of concern are affected.

2.5 Study Area

The Reservoir Shoreline Erosion Study area includes shorelines at and near normal maximum water surface elevation of Ross Lake (within waters of the United States), Diablo Lake, and Gorge Lake, and riverine sections between the three lakes (Figure 2.5-1). All of these shorelines are within the FERC Project Boundary.

There are locations along the shorelines, primarily adjacent to Project facilities, where past large rockfall or mass wasting features/hazards exist and have been documented as part of previous dam safety analyses. Rockfall and mass wasting features will be identified as part of the current (reservoir shoreline erosion) study but will be analyzed in more detail as part of the Erosion and Geologic Hazards at Project Facilities and Transmission Line Corridor Study.

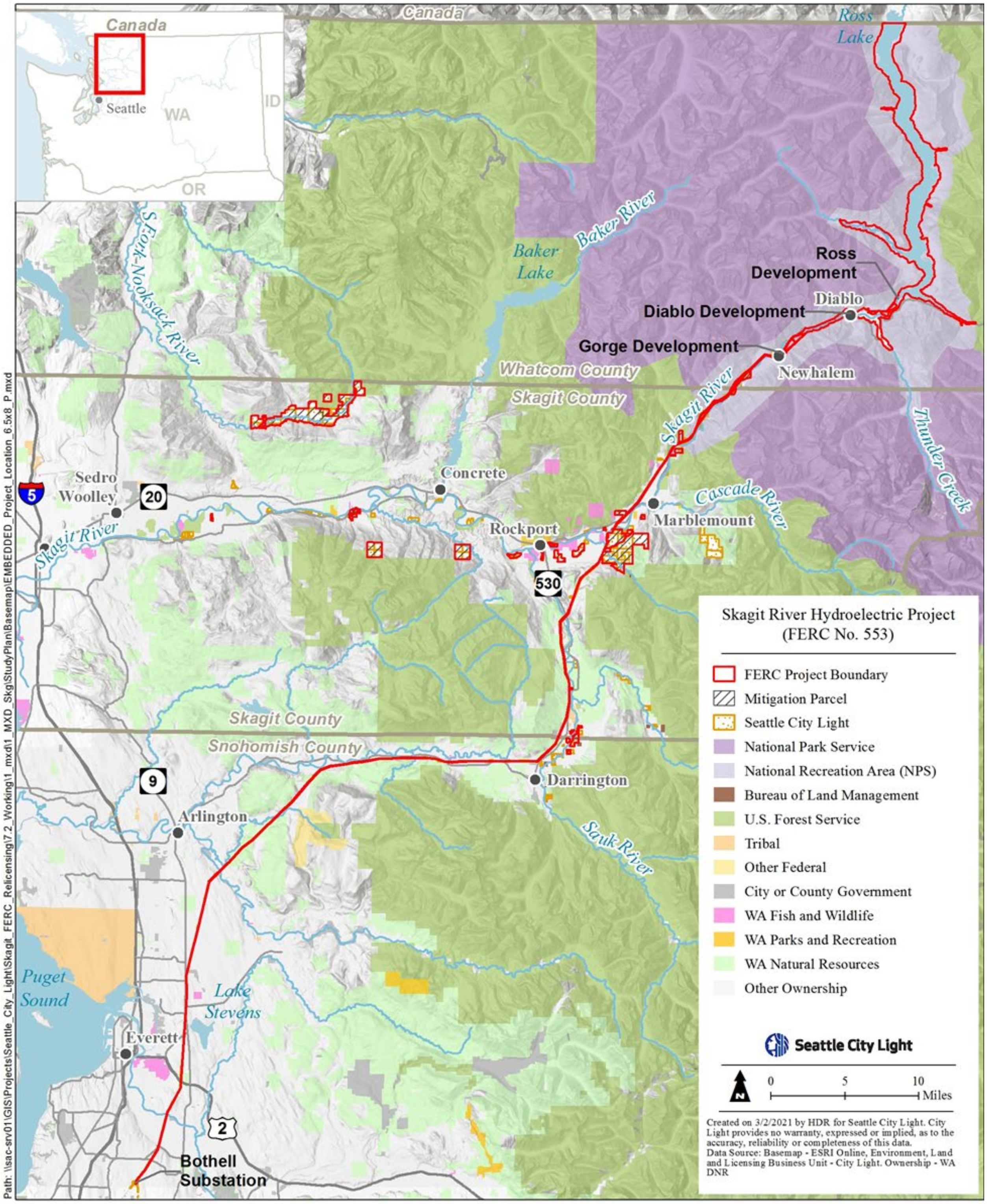


Figure 2.5-1. Location map of the Skagit River Project.

2.6 Methodology

The Reservoir Shoreline Erosion Study will include pre-field analysis of existing information, one season of field work to inventory existing areas of shoreline erosion, and post-field analysis and report writing.

2.6.1 Analysis of Existing Information

Existing reports, maps, aerial photographs, LiDAR data, and NPS erosion data will be compiled and pre-field analyses will be conducted. These analyses include:

- Compile relevant existing reservoir erosion information from NPS, LiDAR, landform mapping, geologic mapping, and aerial photographs for the reservoir erosion study area.
- Digitize erosion areas from the 1990 reservoir erosion inventory to create a Geographic Information System (GIS) database so that past sites can be accurately identified during the field inventory and compared to new sites.
- Review existing NPS landform mapping and update landforms along reservoir shorelines if necessary, based on existing LiDAR. Update large shoreline landslide mapping from existing current LiDAR and aerial photographs as needed (see Table 2.6-1 for list of recent LiDAR and aerial photography available).
- If resolution is sufficient, estimate shoreline bank retreat rates using historic and current aerial photographs and/or LiDAR. Relevant aerial photographs of appropriate scale available through the NPS to be considered for the analysis are listed in Table 2.6-1 (Hampton and Griggs 2004). Note that only a few of the aerial photograph years will be selected for the analysis.
- Prepare base maps to use for field inventory (laminated high-resolution prints of aerial photographs with past erosion areas identified).

Table 2.6-1. Available aerial photographs and LiDAR.

Date	Image Type	Scale	Notes
1947	black and white (B&W) stereo photos	1:27,700	U.S. Forest Service (USFS)
1950	B&W stereo photos	1:24,000	USFS
1974	Orthophoto quads	1:24,000	Basis for 7.5-minute topo series
1990	Orthophoto quads, 1-2m res.	1:24,000	Update to 7.5-minute series various quads
1992	Orthophoto quads, 1-2m res.	1:24,000	Update to 7.5-minute series various quads
1993	Orthophoto quads, 1-2m res.	1:24,000	Update to 7.5-minute series various quads
1998	Orthophoto quads, 1-2m res.	1:24,000	Update to 7.5-minute series various quads
1998	True color stereo photos	1:12,000	NPS
1999	10” x 10” prints	1:7,200	Walker Wheeler/NPS – working on georeferencing
2006	True Color National Agriculture Imagery Program (NAIP) hi-resolution	1m	Digital
2009	True Color NAIP hi-res.	1m	Digital
2011	True Color NAIP hi-res.	1m	Digital
2015	True Color NAIP hi-res.	1m	Digital
2015	True Color NAIP hi-res.	1m	Digital
2017	True Color NAIP hi-res.	1m	Digital
2018	4 band RGB-NIR	6 inch	Digital
LiDAR			
2006	LiDAR	Digital	North Puget (USGS) – partial coverage
2016	LiDAR	Digital	3DEP – ff partial coverage
2017	LiDAR	Digital	North Puget
2018	LiDAR	Digital	Seattle City Light – topobathymetry – partial coverage

Source: NPS staff.
Note: additional aerial photograph or LiDAR data may be available and will be used if available.

2.6.2 Field Inventory

A field inventory will be conducted to identify the current status of erosion areas along the shorelines of Ross, Diablo, and Gorge lakes. The inventory will be conducted by boat and foot under near normal maximum water surface elevation conditions. Erosion locations will be mapped on recent aerial photograph base maps; a map showing erosion areas identified during the current Project license inventory (Riedel 1990) will be available for comparison and GPS equipment will be used if feasible to supplement location mapping. CL has found that Trimble GeoXH GPS units are useful in the many parts of the reservoirs.

A unique identifier will be assigned to each erosion site and relevant characteristics will be collected, such as eroding length and bank height (or area as appropriate); disturbed and undisturbed bank gradient; bank composition/grain size; geology; type of erosion process; aspect; vegetation characteristics; factors that appear to be affecting erosion; any evidence of seepage/groundwater; condition, type, and effectiveness of any stabilization measures; and any evidence of recent erosion (e.g., fresh tree fall, fresh soil at base of bluff). Evidence of total erosion or bank retreat rate since reservoir operations began (e.g., exposed tree stumps, bulkheads, or anchors) will be documented and measured if possible. A photograph will be taken of each erosion site. If possible, photographs will be compared to representative photos from the 1990 inventory. A draft field form is attached to this study plan.

Erosion processes will be determined by field observations and by applying site-appropriate geology, geomorphology, and hydrology principles. Field methods for estimating erosion rates will vary depending on site and erosion characteristics and may include projecting the slope aspect of the original topography, estimating the age and type of vegetation on past failed slopes, and measuring root exposure of tree stumps, or exposure of bulkheads, or anchors (Riedel 1990; City Light 2009; Federal Emergency Management Agency [FEMA] 2018; Hampton and Griggs 2004).

A field inventory and assessment of existing erosion control measures will also be made and will include location, type, condition, effectiveness, and maintenance/repair needs. (Some of this information may already be available from recent NPS surveys.) A photograph will be taken of each erosion control site. These photos will be compared to photos of the erosion control sites taken by the NPS as part of its erosion control program.

2.6.3 Data Analysis and Report Preparation

Field data will be entered into an Excel file or database and erosion locations will be digitized into GIS as line or polygon features as appropriate for each site. Data on erosion site characteristics will be compiled and summarized. Shoreline maps identifying existing erosion sites will be prepared.

A technical report will be prepared describing analysis and field inventory methods and study results. The report will include a narrative describing the geologic, soil, and landform setting relevant to shoreline erosion, an overview of Project-related lake surface elevation fluctuations, and information on areas of reservoir shoreline erosion and erosion control measures.

Specific study and report products include:

- GIS-based map of shoreline erosion areas at Ross, Diablo, and Gorge lakes to allow overlays of erosion sites with resources of concern.
- An Excel database linked to the GIS data with erosion-related characteristics and factors contributing to erosion at each identified erosion site.
- A list of the current condition/effectiveness of existing erosion control measures.
- Compilation of available data about factors contributing to shoreline erosion (for example, reservoir water level fluctuations, wind waves, recreation use).
- An analysis of erosion rates over the term of the current Project license where possible based on existing NPS erosion monitoring results and aerial photograph, LiDAR, and site-based erosion rates using an Excel spreadsheet. Changes in rates through time will be discussed as possible based on data availability.

- The erosion rate data will be used to inform an analysis of associations between relevant site characteristics (e.g., geology, slope, aspect, groundwater, erosion type) and erosion severity/rate to aid in erosion control planning at sites with resources of concern using Pivot Tables within the Excel database.
- A discussion of Project-related factors contributing to reservoir shoreline erosion.

2.7 Consistency with Generally Accepted Scientific Practice

The methods described above were prepared by a Washington State Licensed Engineering Geologist. Field methods are consistent with those used during the reservoir erosion inventory during the current Project license period. Methods for determining erosion processes and rates in lake settings are similar to those used for analysis of reservoir shoreline erosion during licensing studies at the Boundary Hydroelectric Project (City Light 2009), the Pelton Round Butte Hydroelectric Project (Dubé 2005), and the Cowlitz Hydroelectric Project (Harza Engineering Company 2000) as well as shoreline erosion studies at other lakes (Hampton and Griggs 2004; FEMA 2018).

2.8 Schedule

The Reservoir Shoreline Erosion Study includes pre-field office analysis of existing information, one season of field work on the reservoirs during near normal maximum water surface elevation conditions (summer), post-field data analysis and report preparation. Quarterly progress reports will be prepared.

- Pre-field Analysis – March to June 2021
- Field Work – June to August 2021
- Post-field Analysis – August 2021 to February 2022
- Draft Report (Initial Study Report [ISR]) – March 2022
- Final Report (Updated Study Report [USR] – March 2023

2.9 Level of Effort and Cost

The initial estimate for implementation and reporting associated with this study is approximately $120,000.

3.0 REFERENCES

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RESERVOIR SHORELINE EROSION REVISED STUDY PLAN

ATTACHMENT A

DRAFT RESERVOIR EROSION FIELD FORM

Skagit Hydroelectric Project Reservoir Erosion Field Form

DRAFT

Site ID ____________________

Reservoir ____________________

Location ____________________

Date/Time ____________________

Surveyors ____________________

Former Site ID ____________________

Erosion Type
- ❑ Undercut bank
- ❑ Slumping
- ❑ Raveling
- ❑ Rills/gullies
- ❑ Trampling
- ❑ ____________

Seepage? Y / N

Shore Area Affected
- ❑ Shore above high water
- ❑ Drawdown zone
- ❑ ____________

Dimensions of eroding area (ft)
- Shoreline length ____________
- Bank height ____________
- Dist. from shore ____________
- Area (sq ft) ____________
- Disturbed slope gradient (%) ____________
- Undisturbed slope gradient (%) ____________

Geology/Soils
- ❑ Bedrock
- ❑ Talus
- ❑ Colluvium
- ❑ Till
- ❑ Outwash
- ❑ Alluvial Fan
- ❑ Alluvium
- ❑ Fill
- ❑ ____________

Piping? Y / N

Gleyed soils? Y / N

Evidence of erosion rate/activity
- Exposed roots/stump depth (ft) ____________
- Fresh tree fall (#, decay class) ____________
- Fresh soil ____________
- Stabilized (rationale) ____________

Vegetation

Type ____________________

Tree diameter (dbh): ____________________

Condition: heathy dead unhealthy beaver

Age ____________________

% Bare soil ____________________

LWD: On Bank ______ In water ________

Percent Cover:	Trees	Shrub	Herb	Other
Disturbed	______	_____	_______	______
Undisturbed	______	_____	_______	______

Comments/Sketch

Factors Affecting Erosion
- ❑ Reservoir fluctuations
- ❑ Wave action
- ❑ Recreation use
- ❑ Stream erosion
- ❑ Shoreline Development
- ❑ Road Runoff
- ❑ ____________

RESERVOIR SHORELINE EROSION REVISED STUDY PLAN

ATTACHMENT B

CITY LIGHT RESPONSES TO LP COMMENTS ON THE STUDY PLAN PRIOR TO PSP

Table 1. City Light responses to LP comments on the study plan prior to PSP.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
1.	Brock Applegate (WDFW)	04/17/2020	Section 1.2 Relicensing Process	1st Paragraph – Add: consultation Delete: effort	Change made in different location of sentence and paragraph. Text modified to include discussion and consultation.
2.	Judy Neibauer (USFWS)	04/17/2020	Section 1.3 Study Plan Development	Might want to say somewhere in here or in the Study Plan Development section…that information will be used for ESA consultation and to meet the Fish and Wildlife Coordination Act components of FERC (i.e. Section 10j in the FERC process)	City Light acknowledges the need for consultation with USFWS related to its regulatory responsibilities as required in the FERC process and that the information resulting from the study program is intended to inform consultation with USFWS during future steps within the process. A comprehensive resource effects analysis will be developed and integrated during the preparation of the Draft License Application (DLA). License participants will have an opportunity to consider effects of reservoir shoreline erosion, if warranted, on other resources in their review of the DLA in the National Environmental Policy Act (NEPA) process.
3.	Jon Riedel (NPS)	04/06/2020	Section 1.3 Study Plan Development	Given well-documented erosion, would it not be more accurate to say ‘is’ affecting these resources? It hasn’t stopped.	Thank you for your comment, no changes were made. City Light has summarized existing information on documented erosion in the PAD. The focus of the study is to evaluate ongoing Project-related factors resulting in erosion.
4.	Brock Applegate (WDFW)	04/17/2020	Section 1.3 Study Plan Development	1st Paragraph – Delete: the potential to Add: affected some, if not all, the	Thank you for your comment. No edits made to “the potential to” - See response to Comment #3. No edits made to “affected some, if not all, the”

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				Add: wildlife,	Edit made: “Wildlife” City Light welcomes any information that licensing participants may provide that will inform analysis of potential Project-related effects on wildlife due to reservoir shoreline erosion.
5.	Ashley Rawhouser (NPS)	03/17/2020	Section 1.3 Study Plan Development	1st Paragraph – Add: “aquatic resources”	Thank you for your comment. Edit made: “aquatic resources”
6.	Jon Riedel (NPS)	04/06/2020	Section 1.3 Study Plan Development	Will there be a separate study plan for below full pool erosion of CR? If not, this is a major issue because there is clear evidence of continued erosion of intact cultural resource bearing sediments in drawdown.	No edits made. A study plan is not needed to complete this work. Continued erosion of intact cultural resource-bearing sediments below full pool is a known continued Project effect which is already addressed in the Archaeological Mitigation and Management Plan (ARMMP) and other confidential cultural resource documents and is anticipated to continue into the next license period. The ARMMP will be updated, in consultation with cultural resources leads for City Light, the NPS, affected tribes and DAHP, with new strategies for monitoring erosion and identifying viable mitigation measures. In addition, a comprehensive resource effects analysis will be developed and integrated during the preparation of the Draft License Application (DLA). License participants will have an opportunity to consider effects of reservoir shoreline erosion, on other resources in their review of the DLA in the National Environmental Policy Act (NEPA) and Section 106 processes.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
7.	Ashley Rawhouser (NPS)	03/17/2020	Section 1.3 Study Plan Development	1st Paragraph – Add: (6) assess cumulative impacts to aquatic reources (E.g. water quality, fish and amphibian habitat, invertebrate communities)	Thank you for the comment. No edits were made. A comprehensive resource effects analysis will be developed and integrated during the preparation of the Draft License Application (DLA). License participants will have an opportunity to consider effects of reservoir shoreline erosion, on other resources in their review of the DLA in the National Environmental Policy Act (NEPA) process.
8.	Jon Riedel (NPS)	04/06/2020	Section 1.3 Study Plan Development	Good to see this was added. Other considerations: shoreline development or lack of (beaches)? no large wood accumulation? no riparian vegetation?	Thank you for the comment. No edits were made. See response to Comment #7. Shoreline and beach development (or lack) will be addressed.
9.	Jon Riedel (NPS)	04/06/2020	Section 1.3 Study Plan Development	One other item to address, and maybe you do in a different SP, is to link erosion and valuable resources listed above.	See response to Comment #7.
10.	Judy Neibauer (USFWS)	04/17/2020	Section 1.3 Study Plan Development	As the reservoirs lower, additional shoreline and stream channels are exposed to air, wind, and water. Please expand the study to include areas within the reservoir bed that may be impacting aquatic and riparian habitats. I supplied comments in the sediment deposition and geomorphology documents about this as well. You should show the linkages to those documents. Because of erosion on shorelines and or exposed bed/banks…there may be key depositional areas from areas of erosion. Also because of the geomorphology, there may be areas that are higher at risk from erosion and deposition that may affect aquatic and riparian habitats.	This study plan addresses reservoir shoreline erosion, at or near full pool levels. See response to Comment #7.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				These erosional areas can affect lake water quality and possibly form barriers to movement and foraging…storm driven erosion create large areas of turbidity out for some distance into reservoirs. Erosion and turbidity at edges of stream banks, that are part of the reservoir bed, when the reservoir is lowered, can also have effects Please include analysis of these areas to be able to understand impacts to critical habitat, bull trout, and their prey species.	
11.	Rick Hartson (Upper Skagit Indian Tribe)	04/17/2020	Section 2.1 Study Goals and Objectives	Absent conflicting evidence, all shoreline erosion should be assumed caused by project-related factors. Without the project, there would be no reservoir shoreline, hence no shoreline erosion. The location and timing of erosion is driven by reservoir storage and operations. **New comment from Brock Applegate (WDFW) provided on 05/06/2020:** WDFW totally disagrees with this statement. Ongoing operations of the project cause the fluctuation of the reservoir and the erosion. I can't think any more direct impact by ongoing project operations than the fluctuation of the reservoir.	Thank you for your comment, no changes were made. The FERC baseline is existing conditions, and therefore pre-dam conditions are not considered in this study plan. The focus of the study is to evaluate ongoing Project-related factors resulting in erosion. **Response to comment provided on 05/06/2020:** Comment noted.
12.	Judy Neibauer (USFWS)	04/17/2020	Section 2.0 Study Plan Elements	I found a great source that identifies what Study Guide Criteria should be addressed in these study plans. Maybe you have seen it, but here is the link…I think you mention it in the PAD too…	City Light appreciates the input.
13.	Judy Neibauer (USFWS)	04/17/2020	Section 2.1 Study Goals and Objectives	You should show how you will link to the other studies geomorphology, sediment deposition, operational flows, etc, Not sure	See response to Comment #7.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				where you are going to put this. But maybe either in the goals and objectives or back ground information sections. It would help show how you will use old vs new data, and show how these things fit with the issues and questions you are asking.	
14.	Brock Applegate (WDFW)	04/17/2020	Section 2.1 Study Goals and Objectives	1st Bullet – Add: and review each site of	Edit made.
15.	Jon Riedel (NPS)	04/06/2020	Section 2.1 Study Goals and Objectives	Will this be site by site review of 1990 conditions?	Yes. Each of the sites identified in the 1990 erosion study will be re-evaluated.
16.	Judy Neibauer (USFWS)	04/17/2020	Section 2.1 Study Goals and Objectives	Include some kind of measurement of storm/wind driven erosion as it can have large effects for quite some distance out into reservoirs (foraging, turbidity barriers, etc) You should study erosion as the reservoir is lowered and filled, for certain flow scenarios. Include erosion study area out into the reservoir bed at junctions of tributaries. Please see my comment in sediment deposition study about potential for the edges of streams to erode or slough as the reservoir draws down, creating turbidity and trapping and stranding fish or other wildlife…	See response to Comment #10.
17.	Ashley Rawhouser (NPS)	03/17/2020	Section 2.1 Study Goals and Objectives	Bulleted list – Add: Evaluate the potential impacts of ongoing erosion and erosion control measures to aquatic resources. **New comment from Brock Applegate (WDFW) provided on 05/06/2020:** WDFW disagrees. The fluctuation of the reservoir cause by ongoing operations limits	Thank you for your comment. City Light is unaware of any specific Project-related adverse effects due to reservoir shoreline erosion or erosion control measures that are affecting fish in the reservoirs, i.e., the status of reservoir fish populations does not indicate that there is a habitat-related issue. However, City Light welcomes LP input regarding specific aquatic habitat issues, i.e., issues

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				fish habitat by reducing the amount of littoral vegetation and riparian habitat, which adds structure and food to the water.	identified by LPs regarding erosion or erosion control at a specific location within one of the reservoirs and the associated documentation or anecdotal evidence for a specific adverse effect on a fish species/life-stage. **Response to comment provided on 05/06/2020:** Comment noted.
18.	Ashley Rawhouser (NPS)	03/17/2020	Section 2.1 Study Goals and Objectives	Bulleted list – Add: Compare erosion rates in reservoirs to natural lakes of similar size and geomorphology.	Comparison of erosion rates at Skagit River Project reservoirs with other reservoirs would be of academic interest, but is not apparent how this could be used in the FERC process to understand Project effects or to evaluate PME measures.
19.	Brock Applegate (WDFW)	04/17/2020	Section 2.1 Study Goals and Objectives	I agree with Ashley, SCL should try to understand the effects of the fluctuating reservoir due to ongoing project operations.	See response to Comment #18.
20.	Judy Neibauer (USFWS)	04/17/2020	Section 2.1 Study Goals and Objectives	I agree too.	See response to Comment #18.
21.	Judy Neibauer (USFWS)	04/17/2020	Section 2.2 Resource Management Goals	According to guidelines for the ILP…this section should also include Information about public input/interest considerations…Maybe you have this somewhere else? See this link: https://www.ferc.gov/industries/hydropower/gen-info/guidelines/guide-study-criteria.pdf	See response to Comment #12.
22.	Judy Neibauer (USFWS)	04/17/2020	Section 2.2 Resource Management Goals	Expand this section to include resource management goals that this study could help address. Maybe you can gleen them from the issue forms? Other agencies/ tribes and esp the Park Service may have some resource	City Light appreciates the input. The intent of this section is for agencies to provide feedback on their goals related to the study. Because FERC's jurisdiction is limited to the

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				management goals for this section. Also, is there any kind of transboundary agreement with Canada? Seems like they might have some input here too.	U.S., any transboundary coordination is outside of the scope of this study plan.
23.	Judy Neibauer (USFWS)	04/17/2020	Section 2.3 Background and Existing Information	Good information in here already…This section looks like you could link up to key questions and goals and objectives above to show what the existing information will address. Maybe some kind of a summary paragraph? This is where you could possibly use a table to help with that	City Light appreciates the input. No changes were made to the study plan. Feedback on organization will be taken into consideration on development of the study report.
24.	Jon Riedel (NPS)	04/06/2020	Section 2.3 Background and Existing Information	Still worth noting we are losing 1.5 acre of land a year. So it is a big problem.	Thank you for your comment and reference to land loss. This will be evaluated for the new license. This information is included in the PAD, no revision to text necessary.
25.	Jon Riedel (NPS)	04/06/2020	Section 2.3 Background and Existing Information	Or distance of retreat if bedrock encountered.	Thank you for the clarification; text edited for clarity.
26.	Rick Hartson (Upper Skagit Indian Tribe)	04/17/2020	Section 2.3 Background and Existing Information	Not an appropriate term. The project resulted in creation of reservoirs; there were no natural lentic systems prior to the hydro project.	Thank you for your comment. Text has been edited to remove “Lake”.
27.	Rick Hartson (Upper Skagit Indian Tribe)	04/17/2020	Section 2.3 Background and Existing Information	Not an appropriate term because the reservoirs are not natural features.	Thank you for your comment. Terminology is used to reflect that natural processes still occur.
28.	Bob Mierendorf (Upper Skagit Indian Tribe)	04/17/2020	Section 2.3 Background and Existing Information	Need to add the slope gradient of the landform.	This list was attempting to convey types of erosion processes that result in erosion; slope gradient is an underlying condition that affects rate of erosion and is included in the methods and assessment process (see Section 2.6.2).

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
29.	Jon Riedel (NPS)	04/06/2020	Section 2.3 Background and Existing Information	This is inaccurate. Lodgement till may be more stable than other bank material but it is eroding, albeit more slowly.	Thank you for the clarification; text will be revised.
30.	Judy Neibauer (USFWS)	04/17/2020	Section 2.3 Background and Existing Information	When is this measured, at full pool or low pool? You might want to conduct analysis's at different flow scenarios, including climate change scenarios, so we can determine duration of exposure/erosion… in different flow scenarios.	The shoreline lengths in this table from the 1990 report are at full pool. The objective of this study plan is to evaluate shoreline erosion at near full pool levels.
31.	Jon Riedel (NPS)	04/06/2020	Section 2.3 Background and Existing Information	I don't think this is uncertain. Look at the literature and the 1990 report! This is what makes the process of bank retreat un-natural. While erosion is natural erosion on a reservoir is different than a natural lake with a more- stable water level.	Text revised to clarify. See also response to Comment #26.
32.	Brock Applegate (WDFW)	04/17/2020	Section 2.3 Background and Existing Information	WDFW agrees with this statement. The fluctuations of reservoirs causes erosion, removes and precludes native vegetation and habitat, and promotes reed canarygrass.	See response to Comment #31.
33.	Jon Riedel (NPS)	04/06/2020	Section 2.3 Background and Existing Information	Movement of eroded sediment (particularly fines) is widespread and significant in volume. I would say ' are', not 'can'.	Text revised to clarify.
34.	Judy Neibauer (USFWS)	04/17/2020	Section 2.3 Background and Existing Information	I agree. See my comments in the deposition study…where I mention linking up to this plan, since erosion can lead to deposition. Link to sedimentation study.	See response to Comment #7.
35.	Judy Neibauer (USFWS)	04/17/2020	Section 2.3 Background and Existing Information	Sorry, since I am new here…I have some questions and thoughts. Not sure what you all have previously discussed. Sorry if these are repeated questions…. Was this 1990 study done at low pool or only high pool? Was any part of the lake bed included in the study to be able to determine if certain areas of the reservoir erode more than other areas, esp. around edges/mouths of	The 1990 study was done at mid pool elevation based on conversations with Jon Riedel (NPS). A comprehensive resource effects analysis will be developed and integrated during the preparation of the Draft License Application (DLA). License participants will have an opportunity to consider effects of reservoir

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				key fish bearing tributaries? Can you overlay with geology to help see how erosion areas line up with land types?	shoreline erosion, on other resources in their review of the DLA in the National Environmental Policy Act (NEPA) process. This study includes methods that will overlay erosion areas with geology and landforms (See Section 2.6).
36.	Jon Riedel (NPS)	04/06/2020	Section 2.3 Background and Existing Information	You mean bedrock?	Bedrock and talus; text revised to clarify.
37.	Jon Riedel (NPS)	04/06/2020	Section 2.3 Background and Existing Information	Soils is unstable because it is being undercut by waves.	Text revised to clarify.
38.	Rick Hartson (Upper Skagit Indian Tribe)	04/17/2020	Section 2.3 Background and Existing Information	What proportion of the known eroding and erodible shoreline is being monitored? This study plan should assess all potentially erodible shorelines, at least remotely, to determine the extent of impact at a project-wide scale.	Twenty five (25) erosion control sites along approximately 0.3 total miles of shoreline are visually monitored by the NPS to determine if erosion control measures are functioning. NPS also monitors erosion at five unprotected locations in Ross Lake with varying bank material, aspect and slope. All areas of shoreline at near full pool levels will be assessed using remote sensing (to the extent possible) and field inventory methods. See Section 2.6
39.	Jon Riedel (NPS)	04/06/2020	Section 2.3 Background and Existing Information	Have data from 2018.	Thank you for providing the updated information; the new graph has been inserted.
40.	Jon Riedel (NPS)	04/06/2020	Section 2.3 Background and Existing Information	Note E9 is average. Erosion at crest is much higher (65 ft. since 1994).	Thank you for clarifying. Text has been revised to clarify
41.	Rick Hartson (Upper Skagit Indian Tribe)	04/17/2020	Section 2.4 Project Operations and Effects on Resources	See comment above. All erosion should be assumed a project impact.	See response to Comment #11. **Response to comment provided on 05/06/2020:**

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				New comment from Brock Applegate (WDFW) provided on 05/06/2020: The ongoing operation of the project causes fluctuations and erosion, the most direct effect of project operations.	Comment noted.
42.	Jon Riedel (NPS)	04/06/2020	Section 2.4 Project Operations and Effects on Resources	Same comment as above. There is no erosion without the project water lapping on the steep mountain slopes covered with unconsolidated glacial drift and colluvium.	See response to Comment #3. No revisions made.
43.	Rick Hartson (Upper Skagit Indian Tribe)	04/17/2020	Section 2.4 Project Operations and Effects on Resources	Fisheries and aquatic resources, including water quality impacts due to turbidity and physical disruptions to littoral and riparian habitats.	See response to Comment #7.
44.	Judy Neibauer (USFWS)	04/17/2020	Section 2.4 Project Operations and Effects on Resources	1st Paragraph - Add: wetlands, riparian areas	Thank you for the clarification. Text added.
45.	Brock Applegate (WDFW)	04/17/2020	Section 2.4 Project Operations and Effects on Resources	1st Paragraph – Add wildlife, aquatic resources and habitat, Add: maintenance and	Thank you for the clarification. Text added.
46.	Jon Riedel (NPS)	04/06/2020	Section 2.4 Project Operations and Effects on Resources	Check this, we have a site with 65 ft in 26 years, or 2.5 ft/year. Using averages minimizes severity of problem. SP should mention loss of 1.5 acres year on Ross.	Thank you for this clarification. Text revised to clarify rates. For the last comment, please see response to Comment #24.
47.	Jon Riedel (NPS)	04/06/2020	Section 2.4 Project Operations and Effects on Resources	And maintenance, specifically of scour protection, but also vegetation and ends of walls.	Thank you for this clarification. Text revised to clarify.
48.	Judy Neibauer (USFWS)	04/17/2020	Section 2.4 Project Operations and Effects on Resources	As I mentioned before…You might include a table that shows how you will answer key questions/issues with new both old and new study information so you can show how you	Many of these will be included in the study results in the study report.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				will analyzing effects of operations. Include erosion at different operation scenarios, by geology/land form type if possible so you can look at risk within certain areas.	A comprehensive resource effects analysis will be developed and integrated during the preparation of the Draft License Application (DLA). License participants will have an opportunity to consider effects of reservoir shoreline erosion, on other resources in their review of the DLA in the National Environmental Policy Act (NEPA) process.
49.	Rick Hartson (Upper Skagit Indian Tribe)	04/17/2020	Section 2.4 Project Operations and Effects on Resources	Including potential identification of new erosion sites.	Yes, as described in Section 2.6.
50.	Rick Hartson (Upper Skagit Indian Tribe)	04/17/2020	Section 2.5 Study Area	The entire reservoir shoreline should be assessed for evidence of erosion, at least with remote sensing methods. Erosion should be assessed throughout the entire drawdown zone, not limited to at or near the normal maximum water surface elevation. Fish may be impacted by turbidity at all reservoir elevations. Cultural resources may be present at any elevation. It is necessary to document the extent of erosion to assess potential for resource impacts.	See response to Comments #7, #10 and #38.
51.	Judy Neibauer (USFWS)	04/17/2020	Section 2.5 Study Area	Expand the study to incorporate least moderate and low pool elevations. It seems like you might want to look at erosion at a various number of elevation, not just maximum height. I have seen storms cause erosion at both mid and low pools where more sediments are exposed and where streams intersect with the sediments on the reservoir bottom as they flow across sand/silt to the low pool. Are there any recreation trails, horse, bike, or motorcycle, along reservoir bed that cross	See response to Comment #10.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				fish bearing tributaries? Not sure if you can do that up there…but if so, you may want to include some of those sites too.	
52.	Brock Applegate (WDFW)	04/17/2020	Section 2.5 Study Area	2nd Paragraph – Add: NPS has Delete: have been Add: these areas Add: SCL should have NPS conduct the study or should include NPS as a required part of the data gathering to maintain consistency.	See response to Comment #53. Edits not accepted.
53.	Jon Riedel (NPS)	04/06/2020	Section 2.5 Study Area	This SCL analysis relied on published NPS data. See upper Skagit landform report, which identified these features. SCL did not contribute to the landform mapping effort. For the sake of consistency and reliability, the NPS should be the party tasked with revisiting the landform map now that Lidar is available.	Thank you for clarifying. City Light will consider the most efficient means to implement the study and is willing to discuss the landform mapping with NPS.
54.	Judy Neibauer (USFWS)	04/17/2020	Section 2.5 Study Area	Thanks for mentioning and linking to the other study here…Will you also at some point summarize upper (above the dams) and lower erosion areas together? You could mention this somewhere in here or link to the downstream erosion information/or new geomorphology study. Tying these two areas together will help understand effects in the basin…maybe mention that here or in the background information also.	The license application will summarize results of all studies related to erosion in the Project Boundary. See response to Comment #48.
55.	Bob Mierendorf (Upper Skagit Indian Tribe)	04/17/2020	Section 2.6.1 Analysis of Existing Information	One additional analysis should be added to this list: Coordinate with the CRWG to determine the co-occurrence of erosion sites and cultural resource sites. These data will	See response to Comment #6.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				inform several CRWG studies and needs.	
56.	Jon Riedel (NPS)	04/06/2020	Section 2.6.1 Analysis of Existing Information	Why not other reservoirs in region, as did Riedel 1990? We also have a lot of site measurements, thickness, material type etc. that were not included in the Existing Conditions Report.	See response to Comment #18.
57.	Jon Riedel (NPS)	04/06/2020	Section 2.6.1 Analysis of Existing Information	See earlier comment. NPS should update landforms.	See response to Comment #53.
58.	Brock Applegate (WDFW)	04/17/2020	Section 2.6.1 Analysis of Existing Information	3rd Bullet point – Add: have NPS	Edits removed. See response to Comment #53.
59.	Jon Riedel (NPS)	04/06/2020	Section 2.6.1 Analysis of Existing Information	Unlikely that the airphotos will be of a sufficiently large scale, or offer a clear, un-shaded view of shoreline..	Agree, this is discussed in the methods.
60.	Rick Hartson (Upper Skagit Indian Tribe)	04/17/2020	Section 2.6.1 Analysis of Existing Information	If lidar analysis is not currently possible, this study should ensure a first time step will be collected so that future monitoring can assess shoreline erosion across the entire project area.	LiDAR data has already been acquired.
61.	Judy Neibauer (USFWS)	04/17/2020	Section 2.6.2 Field Inventory	See my comment above about expanding survey to include multiple operations scenarios, by including moderate and low elevations scenarios, and areas around fish bearing tributaries, especially where silts and sandy banks become exposed at lower flows.	See response to Comment #10.
62.	Jon Riedel (NPS)	04/06/2020	Section 2.6.2 Field Inventory	Unlikely that it will be accurate enough. NPS has hard copies of site maps on 7.5 minute quads.	Yes, text acknowledges GPS may or may not be helpful.
63.	Judy Neibauer (USFWS)	04/17/2020	Section 2.6.1 Analysis of Existing Information	Is there any existing turbidity information?	See response to Comment #10.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
64.	Jon Riedel (NPS)	04/06/2020	Section 2.6.2 Field Inventory	Why not use old numbering system?	Numbering system will be developed during study implementation and will take into account existing numbering.
65.	Brock Applegate (WDFW)	04/17/2020	Section 2.6.2 Field Inventory	I agree. SCL should remain consistent with last study.	See response to Comment #64.
66.	Ashley Rawhouser (NPS)	03/17/2020	Section 2.6.2 Field Inventory	Will this sych up with the vegeation map? What spatial extent (with 5m, 10m ? of active erosion)	The intent of noting vegetation type in this context is to get a general idea of type and density of any existing vegetation within eroding areas (e.g., trees, shrubs, annual vegetation) to help determine site erosion activity level. See the field form (Appendix) for details. This is not intended to synchronize with vegetation mapping undertaken as part of other studies.
67.	Brock Applegate (WDFW)	04/17/2020	Section 2.6.2 Field Inventory	What kind of vegetation and habitat does the fluctuating reservoirs preclude? **New comment provided on 05/06/2020:** The ongoing operation precludes the establishment of habitat and SCL should consider it an impact.	See response to Comment #10. The current License allows Project reservoirs to fluctuate within set ranges up to normal full pool elevations; quantity and quality of vegetative habitat below normal full pool is considered part of existing conditions and therefore not proposed for study here. **Response to comment provided on 05/06/2020:** Comment noted.
68.	Ashley Rawhouser (NPS)	03/17/2020	Section 2.6.2 Field Inventory	2nd Paragraph – Add: type Add: potential for and amount of large woody debris recruitment,	An analysis of large woody debris recruitment is not an objective of this study. Edits not accepted.
69.	Jon Riedel (NPS)	04/06/2020	Section 2.6.2 Field Inventory	You mean distance and then assumed rate based on when waters initially flooded site?	Yes, text revised to clarify.
70.	Jon Riedel (NPS)	04/06/2020	Section 2.6.2 Field Inventory	Should digitize old photos and compare sites, at a representative many.	If old photos and locations are available, this can be considered for representative

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
					locations that can be located during the current field inventory. Text added to clarify.
71.	Ashley Rawhouser (NPS)	03/17/2020	Section 2.6.2 Field Inventory	2nd Paragraph – Add: existing slope aspect above and below highwater line, Add: and type	Text will be revised to clarify.
72.	Jon Riedel (NPS)	04/06/2020	Section 2.6.2 Field Inventory	Note table in Riedel (1990) where we also used recession from anchors and dock bulkheads.	Good suggestion, added to methods. Thank you.
73.	Ashley Rawhouser (NPS)	03/17/2020	Section 2.6.2 Field Inventory	3rd Paragraph – Add: and restoration opportunities to improve conditions for aquatic resources	Any restoration opportunities identified will be discussed in the license application.
74.	Jon Riedel (NPS)	04/06/2020	Section 2.6.2 Field Inventory	And compared to 1990 photos? The old images need to be digitized.	See response to Comment #70.
75.	Jon Riedel (NPS)	04/06/2020	Section 2.6.2 Field Inventory	One item missing is what the erosion threatens. This should be recorded in field (e.g nesting tree, rare plants/communities, dock bulkheads, trails, etc.).	The analysis of potential effects of shoreline erosion on other resources will be conducted in the license application. If other resource effects are readily visible during the field work, it will be noted on the field form (for example, erosion of a trail or camping area).
76.	Curtis Clement (Upper Skagit Indian Tribe)	04/08/2020	Section 2.6.2 Field Inventory	This study is an opportunity to use photogrammetry or some form of laser scanning to form a new 3D digital data set that can be redone in the future to quantify Slope and volume changes.	Any monitoring methods identified will be discussed in the license application.
77.	Bob Mierendorf (Upper Skagit Indian Tribe)	04/17/2020	Section 2.6.3 Data Analysis and Report Preparation	It was good up in Sec. 1.3 that this plan was linked to CR-02, but the Upper Skagit Indian Tribe would like to see an explicit statement somewhere in the methodology that encourages coordination with the CRWG in cases where erosion and cultural sites co-occur.	See response to Comment #10.
78.	Judy Neibauer (USFWS)	04/17/2020	Section 2.6.3	See my comment above about including a table that can be referenced here to show	See response to Comment #23.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
			Data Analysis and Report Preparation	what key questions/issues are being answered with existing or new data.	
79.	Ashley Rawhouser (NPS)	03/17/2020	Section 2.6.3 Data Analysis and Report Preparation	What scale?	The maps in the study report will be prepared from GIS data; this data will be available when the report is finalized so that interested parties can produce maps at any scale they need.
80.	Jon Riedel (NPS)	04/06/2020	Section 2.6.3 Data Analysis and Report Preparation	Need to look at erosion within drawdown, and compare locations of net erosion/deposition with lake level curves. Based on a few measurements, it seems most erosion occurring above 1550 ft. with net deposition below.	This goal of this study is to address reservoir shoreline erosion.
81.	Curtis Clement (Upper Skagit Indian Tribe)	04/08/2020	Section 2.6.3 Data Analysis and Report Preparation	A full pool, low pool and transition erosion rate should be included to really understand project impacts. Expand the timing of the field season to accommodate.	See the response to Comments #9 and #86.
82.	Ashley Rawhouser (NPS)	03/17/2020	Section 2.6.3 Data Analysis and Report Preparation	6th Bullet – Add: , LWD recruitment, shoreline and littoral habitat, water quality	The analysis of potential effects of shoreline erosion on other resources will be conducted in the license application.
83.	Jon Riedel (NPS)	04/06/2020	Section 2.7 Consistency with Generally Accepted Scientific Practice	Suggest you use these sites to compare and contrast problems on Skagit reservoirs. Geology of many reservoirs is very similar from northwestern Montanan through Idaho to Washington.	See response to Comment #18.
84.	Jon Riedel (NPS)	04/06/2020	Section 2.8 Schedule	This is too late to start, lake may be at or close to full pool for much of this time. And the survey needs to look at conditions below OHW mark. A big gap in this analysis is looking to see if any kind of beach platform has formed out of eroded materials that could absorb some wave energy.	The intent of this study is to look at shorelines near full pool. Beach platform development should be visible just below the water line, or by utilizing aerial photographs/LiDAR data.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
85.	Bob Mierendorf (Upper Skagit Indian Tribe)	04/17/2020	Section 2.8 Schedule	This is an excellent example of the need to coordinate with the CRWG because beach platforms may be covering some parts of cultural resources sites.	See response to Comment #10.
86.	Brock Applegate (WDFW)	04/17/2020	Section 2.8 Schedule	Bulleted list – Add: • Initial Study Report (ISR) – March 2022 • ISR Meeting • Study Plan Modification Request (if needed). For example, SCL may need additional collection of data below OHW mark the following winter and spring. • Field Work -- September 2022 to March 23 (if needed) • Final Report – Summer 2022/2023 **New comment provided on 05/06/2020:** These two ILP milestones will occur. How about adding them to the schedule?	Thank you for the comment; City Light acknowledges the ILP milestones provided. The ILP will provide the opportunity for comment on the final report submitted in the ISR and discussed at the ISR meeting; if any components of the study goals and objectives are not met in the first year, or there are anomalous conditions, any party may propose additional work or request additional study per FERC ILP regulations. No changes were made to the schedule in the draft study plan as City Light intends to complete the study within one year and wants to be clear with FERC and LPs on the proposed schedule. City Light believes that it will be beneficial to all parties to have complete information from the studies as soon as possible to inform development of management proposals and cross resource analysis. **Response to comment provided on 05/06/2020:** Thank you for your comment. The schedule reflects the timeline for this study only, not the larger ILP process.
87.	Bob Mierendorf (Upper Skagit Indian Tribe)	04/17/2020	Section 3.0 References	Insert this reference: Schalk, Randall F., with Carolyn D. Dillian, Robert R. Mierendorf, and Beth Blattenberger 2011, Archeological Resources Mitigation and Management Plan for Upper Skagit	Reference not needed; see response to Comment #10.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				River Valley Archaeological District. Prepared pursuant to Federal Energy Regulatory Commission License 553 for the Skagit River Hydroelectric Project.	
88.	Jon Riedel (NPS)	04/06/2020	Attachment A Draft Reservoir Erosion Field Form	Should use original NPS site numbers for consistency and comparison.	See response to Comment #64.

GE-02 EROSION AND GEOLOGIC HAZARDS AT PROJECT FACILITIES AND TRANSMISSION LINE RIGHT-OF-WAY REVISED STUDY PLAN

SKAGIT RIVER HYDROELECTRIC PROJECT
FERC NO. 553

Seattle City Light

April 2021
RSP

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List of Attachments

List of Acronyms and Abbreviations

CFR............................Code of Federal Regulations
City Light...................Seattle City Light
CMZ...........................Channel Migration Zone
DNR...........................Washington Department of Natural Resources
DOGAMI...................Oregon Department of Geology and Mineral Industries
Ecology......................Washington State Department of Ecology
ELC............................Environmental Learning Center
FERC..........................Federal Energy Regulatory Commission
GIS.............................Geographic Information System
LiDAR........................Light Detection and Ranging
ISR.............................Initial Study Report
LP...............................licensing participant
NPS............................National Park Service
O&M..........................operations and maintenance
PAD............................Pre-Application Document
PME...........................protection, mitigation, and enhancement
PRM...........................Project River Mile
Project........................Skagit River Hydroelectric Project
PSP.............................Proposed Study Plan
RLNRA......................Ross Lake National Recreation Area
RM.............................river mile
RMAP........................Road Maintenance and Abandonment Plan
ROW..........................right-of-way
RSP............................Revised Study Plan
RTE...........................rare, threatened, and endangered
RWG..........................Resource Work Group
SSIT...........................Sauk-Suiattle Indian Tribe
TRREWG...................Terrestrial Resources and Reservoir Erosion Work Group
U.S.C..........................United States Code
USDA.........................U.S. Department of Agriculture
USGS.........................U.S. Geological Survey

USR............................Updated Study Report

WDFW.......................Washington Department of Fish and Wildlife

WGS............................Washington Geologic Survey

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1.0 INTRODUCTION

1.1 General Description of the Project

The Skagit River Hydroelectric Project (Project), licensed to The City of Seattle, Washington, and operated through its publicly-owned electric power utility Seattle City Light (City Light), is located in northern Washington State and consists of three power generating developments on the Skagit River – Ross, Diablo, and Gorge – and associated lands and facilities. The Project generating facilities are in the Cascade Mountains of the upper Skagit River watershed, between Project River Miles (PRM) 94.7 and 127.9 (U.S. Geological Survey [USGS] RMs 94.2 and 127).[1] Power from the Project is transmitted via two 230-kilovolt powerlines that span over 100 miles and end just north of Seattle at the Bothell Substation. The Project also includes two City Light-owned towns, an Environmental Learning Center (ELC), several recreation facilities, and several parcels of fish and wildlife mitigation lands.

Project generating facilities are all located in Whatcom County, although Ross Lake, the most upstream reservoir, crosses the U.S.-Canada border and extends for about one mile into British Columbia at normal maximum water surface elevation. Gorge Powerhouse, the most downstream facility, is approximately 120 miles northeast of Seattle and 60 miles east of Sedro-Woolley, the nearest large town. The closest town is Newhalem, which is part of the Project and just downstream of Gorge Powerhouse. The primary transmission lines cross Whatcom, Skagit, and Snohomish counties; the fish and wildlife mitigation lands are in the same counties.

The Project Boundary is extensive, spanning over 133 miles from the Canadian border to the Bothell Substation just north of Seattle, Washington. In addition, there are "islands" of fish and wildlife mitigation lands and recreation facilities within the Skagit, Sauk, and South Fork Nooksack watersheds that are also within the Project Boundary. Project generating facilities are entirely within the Ross Lake National Recreation Area (RLNRA), which is administered by the National Park Service (NPS) as part of the North Cascades National Park Complex. The RLNRA was established in 1968 in the enabling legislation for North Cascades National Park to provide for the "public outdoor recreation use and enjoyment of portions of the Skagit River and Ross, Diablo, and Gorge lakes." The legislation maintains the Federal Energy Regulatory Commission's (FERC) jurisdiction "in the lands and waters within the Skagit River Hydroelectric Project," as well as hydrologic monitoring stations necessary for the proper operation of the Project (16 United States Code [U.S.C.] § 90d-4; Public Law 90-544. Sec. 505 dated October 2, 1968, as amended by Public Law 100-668. Sec. 202 dated November 16, 1988).

1.2 Relicensing Process

The current FERC license for the Project expires on April 30, 2025, and City Light will apply for a new license no later than April 30, 2023. City Light formally initiated the relicensing process by filing a Notice of Intent and Pre-Application Document (PAD) with FERC on April 27, 2020 (City Light 2020a). The PAD includes descriptions of the Project facilities, operations, license

[1] City Light has developed a standard Project centerline and river mile system to be used throughout the relicensing process, including the study program, to replace the outdated USGS RM system. Given the long-standing use of the USGS RM system, both it and the Project River Mile (PRM) system are provided throughout this document. For further details see Section 7.0 of the main body RSP.

requirements, and Project lands as well as a summary of the extensive existing information available on Project area resources and early consultation on potential resource issues to be addressed during the relicensing. The PAD also includes an outline of the goals and objectives of this study.

In 2019-2020, City Light convened a series of Resource Work Groups (RWG) to engage agencies and other licensing participants (LP) in the Study Plan Development Process. Discussions with LPs continued in early 2021 with a series of topic-based discussions following filing of the Proposed Study Plan (PSP) on December 8, 2020 (City Light 2020b). This study plan reflects RWG and LP discussion and study requests and comments submitted by LPs.

1.3 Study Plan Development

There are a variety of erosion and drainage concerns associated with ongoing Project operations and maintenance (O&M) as well as naturally occurring geologic hazards; these can potentially affect Project facilities, aquatic habitat, terrestrial and riparian habitat, cultural and recreation resources, and water quality. This study will identify and evaluate the interaction of Project facilities and operations with erosion/drainage and geologic hazards. The data from this study will be available to evaluate potential effects on other resources. This study plan directly addresses issues identified in the following issue forms: (1) TE08, Road and Townsite Erosion; (2) TE14; Geologic Hazards; (3) TE15, Roads and Drainage; and (4) FA23, Transmission Line Stream Crossing Habitat.

On June 12, 2020, City Light released the GE-02 Erosion and Geologic Hazards at Project Facilities and Transmission Line Right-of-Way Draft Study Plan for LP review and comment. On June 23, 2020, the draft study plan was discussed at a Terrestrial Resources and Reservoir Erosion Work Group (TRREWG) meeting. City Light reviewed all comments received and is releasing this plan as the revised version of the draft study plan. The revised draft will be discussed at a TRREWG meeting. Written comments were received from NPS, Washington Department of Fish and Wildlife (WDFW), and the Upper Skagit Indian Tribe and responded to in an attachment to this study plan. A Status Draft of the study plan was provided to LPs on August 6, 2020.

City Light is filing this study plan with FERC as part of its Revised Study Plan (RSP), an update to the version that was filed with the PSP and incorporating additional consultation with LPs prior to the filing date. The Sauk-Suiattle Indian Tribe submitted the following study request pertaining to aquatic habitat and a riparian zone within the transmission line right-of-way (ROW): SSIT-02 Impacts of Transmission Line Right of Way (ROW) on Aquatic Habitat and Riparian Zone for the Skagit River Hydroelectric Project. This study plan addresses some of the elements identified in the Sauk-Suiattle Indian Tribe's study request, as explained in Section 6 of the RSP.

PSP comments to this study plan were submitted by the Sauk-Suiattle Indian Tribe, Stillaguamish Tribe of Indians, Upper Skagit Indian Tribe, and USFWS. City Light has the specific comments and suggested edits in the study plan and responded to comments in the PSP comment/response table appended to the main body of this RSP. Modifications made to the study plan in response to comments include updating methods for study road-stream crossing culvert assessments.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

The goals of the Erosion and Geologic Hazards at Project Facilities and Transmission Line Right-Of-Way Study are two-fold: (1) to characterize where Project O&M activities are affecting erosion, mass wasting, and runoff that could affect terrestrial; aquatic; fisheries; riparian; rare, threatened, and endangered (RTE) plants; or cultural resources; and (2) to determine where existing erosion, mass wasting, and channel migration/bank erosion have the potential to affect Project facilities. This study plan includes both elements to inform the FERC relicensing process and broader background information that will help inform long-term geologic hazard planning at Project facilities.

Specific objectives include:

- Identify, map, inventory, and characterize areas of erosion, runoff, mass wasting, and culvert conditions that are affected by Project facilities, townsites, transmission towers, and study roads. (Goal 1)
- Identify where Project maintenance activities (e.g., road grading, ditch maintenance, vegetation management, streambank protection) along the transmission line ROW and study roads have the potential to cause erosion or sedimentation or altered hydrologic connectivity to water bodies. (Goal 1)
- Identify the current instream and riparian habitat conditions immediately upstream and downstream of transmission line stream crossings where channel migration, bank erosion, or mass wasting are affected by Project operations. (Goal 1)
- Identify mass wasting (landslide, rockfall) and channel erosion hazards (e.g., channel migration, bank erosion) that could affect Project facilities, transmission towers, or study roads. (Goal 2)
- Characterize study road-stream crossing structures so that hydraulic capacity, erosion, and biological effects (e.g., fish passage) can be assessed. (Goals 1 and 2)

This information will be available to inform license application preparation to evaluate how Project O&M affects slope stability and erosion and how water quality, aquatic, riparian, terrestrial, and cultural resources may be affected. The information will be used to inform the relicensing and long-term geologic hazard planning at the Project facilities.

2.2 Resource Management Goals

The study will provide information for resource agencies and Indian tribes with jurisdiction in the Project vicinity to address their respective goals and objectives for resource management. Resource management goals were provided by LPs in their study requests identified in Section 1.3 of this study plan.

2.3 Background and Existing Information

2.3.1 Mass Wasting (Landslide and Rockfall)

Steep topography, narrow valleys, and heavy precipitation combine to produce mass wasting hazards within the North Cascades region of the Skagit River Project. In the Puget Lowland region, slopes over-steepened by valley glacier migration coupled with heavy precipitation contribute to mass wasting along the southern portion of the alignment corridor. Valley walls produce snow avalanches, rock falls, debris avalanches, shallow-rapid landslides, deep-seated landslides, and debris torrents. Shallow-rapid landslides along steep slopes, slower soil slumps and creep, and large, deep-seated landslides have been mapped and compiled in some areas of the Project Boundary by the National Park Service and Washington Department of Natural Resources (DNR) (Riedel et al. 2012; Washington DNR 2019). Stability assessments have been prepared for some areas near Project facilities (see list of available reports in Section 2.3.4 of this study plan).

2.3.2 Erosion and Drainage at Project-related Roads and Townsites

Erosion and drainage issues at Project-related roads along twelve transmission line access roads between Ross Dam and Bacon Creek and paved roads in Diablo and Newhalem were inventoried for the current license period (Riedel 1990). No erosion issues were identified at that time along paved roads. Several sites were identified where culverts were subject to plugging, small intermittent streams/seeps were causing erosion concerns, or small mass movements were related to roads.

Study roads are used to access Project facilities such as dams, powerhouses, mitigation lands, and transmission line towers. While information on road and culvert conditions exists in databases and files of various entities (see Section 2.3.4 of this study plan), this study will provide a comprehensive compilation of data available on the condition of study roads, erosion and runoff issues, or culvert conditions.

2.3.3 Transmission Line Right-Of-Way and Tower Maintenance

City Light performs routine road maintenance and vegetation clearing along the transmission line ROW to ensure access for emergency and scheduled repairs and to meet North American Electric Reliability Corporation reliability standards for clearances of energized conductors and has records of types of procedures and frequency. In addition to routine maintenance, transmission towers have been moved or redesigned and/or bank protection has been added at five locations to protect against erosion caused by river or stream migration. These include the Boulder River, French Creek, Skagit River near Corkindale Creek (to protect from bank erosion), Diobsud Creek (removal of a log jam and addition of an engineered log jam), and the Sauk River. Reports pertaining to the Boulder River and French Creek work are available (see Section 2.3.4 of this study plan). Relocating transmission line towers and installing bank protection measures can result in effects to natural or cultural resources. A Geographic Information System (GIS)-based road inventory recently developed by City Light will be used as basis for assessing O&M activity locations in this study.

2.3.4 Existing Reports, Data, and Resources

City Light will review the following data sources to inform this study:

- Washington Department of Natural Resources. 2019. Landslide Compilation Geodatabase. https://www.dnr.wa.gov/programs-and-services/geology/geologic-hazards/landslides.
- Riedel, J., S. Brady, S. Dorsch, N. Bowerman, and J. Wenger. 2012. Geomorphology of the Upper Skagit watershed: Landform mapping at North Cascades National Park Service Complex, Washington. Natural Resource Technical Report NPS/NCCN/NRTR—2012/568. National Park Service, Fort Collins, Colorado.
- Haugerud, R. and R. Tabor. 2009. Geologic map of the North Cascade Range, Washington. U.S. Geological Survey.
- Dragovich et al. 2002. Geologic Map of Washington – Northwest Quadrant. Washington State Department of Natural Resources.
- Dragovich, J. D., L.A. Gilbertson, W.S. Lingley, Jr., M. Polenz, and J. Glenn. 2002. Geologic map of the Darrington 7.5-minute quadrangle, Skagit and Snohomish Counties, Washington: Washington Division of Geology and Earth Resources Open File Report 2002-7, 1 sheet, scale 1:24,000.
- Dragovich, J. D., L.A. Gilbertson, W.S. Lingley, Jr., M. Polenz, and J. Glenn. 2002. Geologic map of the Fortson 7.5-minute quadrangle, Skagit and Snohomish Counties, Washington: Washington Division of Geology and Earth Resources Open File Report 2002-6, 1 sheet, scale 1:24,000.
- Dragovich, J.D., B.W. Stanton, W.S. Lingley, Jr., G.A. Griesel, and M. Polenz. 2003. Geologic map of the Mount Higgins 7.5-minute quadrangle, Skagit and Snohomish Counties, Washington: Washington Division of Geology and Earth Resources Open File Report 2003-12, 1 sheet, scale 1:24,000.
- Dragovich, J.D., B.W. Stanton, W.S. Lingley, Jr., G.A. Griesel, M. Polenz. 2003. Geologic map of the Oso 7.5-minute quadrangle, Skagit and Snohomish Counties, Washington: Washington Division of Geology and Earth Resources Open File Report 2003-11, 1 sheet, scale 1:24,000.
- Minard, J.P. 1985. Geologic map of the Arlington East quadrangle, Snohomish County, Washington: U.S. Geological Survey Miscellaneous Field Studies Map MF-1739, 1 sheet, scale 1:24,000.
- Minard, J.P. 1985. Geologic map of the Lake Stevens quadrangle, Snohomish County, Washington: U.S. Geological Survey Miscellaneous Field Studies Map MF-1742, 1 sheet, scale 1:24,000.
- Minard, J.P. 1985. Geologic map of the Snohomish quadrangle, Snohomish County, Washington: U.S. Geological Survey Miscellaneous Field Studies Map MF-1745, 1 sheet, scale 1:24,000.
- Minard, J.P. 1985. Geologic map of the Everett 7.5-minute quadrangle, Snohomish County, Washington: U.S. Geological Survey Miscellaneous Field Studies Map MF-1748, 1 sheet, scale 1:24,000.

- Minard, J.P. 1985. Geologic map of the Bothell quadrangle, Snohomish and King Counties, Washington. U.S. Geological Survey Miscellaneous Field Studies Map MF-1747, 1 plate, scale 1:24,000.
- R. Tabor et al. 2002. Geologic Map of the Sauk River 30- by 60-Minute Quadrangle, Washington. U.S. Geological Survey.
- R. Tabor et al. 2003. Geologic map of the Mount Baker 30- by 60-minute quadrangle, Washington. U.S. Geological Survey.
- United States Department of Agriculture (USDA) et al. 2012. Soil survey of North Cascades National Park Complex, Washington.
- United States Department of Agriculture (USDA) – Soil Conservation Service. 1983. Soil Survey of Snohomish County Area, Washington.
- United States Department of Agriculture (USDA) – Soil Conservation Service. 1989. Soil Survey of Skagit County Area, Washington.
- Whatcom County. 2006. Whatcom County Geologically Hazardous Areas Map. http://www.whatcomcounty.us/DocumentCenter/View/1837/Geologically-Hazardous-Areas-PDF?bidId=.
- Snohomish County Department of Planning and Development Services. Landslide Hazard Areas. 2015. http://www.snoco.org/docs/scd/PDF/PDS_CAR/Landslide%20Hazard%20Areas_CW_10_2_INDEX.pdf.
- Shannon & Wilson. 1999. Rock Discontinuity and Geological Reconnaissance Report, Diablo Dam Powerhouse Rock Slope. August 1999.
- Golder Associates. 2014. Ross Dam Powerhouse Slope Stability Evaluation and Cross Over Audit Evaluation. June 6, 2014.
- Strauch et al. 2018. A hydroclimatological approach to predicting regional landslide probability using Landlab.
- Strauch et al. 2019. A new approach to mapping landslide hazards: a probabilistic integration of empirical and physically based models in the North Cascades of Washington, USA.
- Riedel, J. 1990. Skagit River Project Report on Existing Conditions of Reservoir and Streambank Erosion.
- Seattle City Light (City Light). 2018. Skagit River LiDAR.
- United States Geological Survey Western Washington 3DEP LiDAR. 2016/2017. http://lidarportal.dnr.wa.gov/.
- NPS Skagit River Channel Migration Zone GIS shapefile.
- Skagit County Channel Migration Mapping (Skagit County Shoreline Master Plan 2016).
- Sauk River Migration Analysis (Skagit River System Cooperative).
- Boulder River Channel Migration Analysis (Hererra and Stillwater 2016).
- French Creek Channel Migration Analysis (Stillwater 2014).

- Goodell Creek Alluvial Fan Restoration Project Feasibility Study (Herrera 2017).
- Road Maintenance and Abandonment Plans (RMAP) for mitigation lands and transmission line right-of-way lands under Washington DNR Forest Practice Regulations.
- Skagit System Cooperative fish passage database at road culverts (GIS database - in preparation).
- WDFW database on fish passage at road culverts (https://geodataservices.wdfw.wa.gov/hp/fishpassage/index.html).
- Developing a GIS-based geospatial decision support tool for assessing climate change impacts on flood risks in northern Cascadia road networks (Strauch et al. 2018b).
- Burns, W.J. and K.A. Mickelson. 2016. Protocol for deep landslide susceptibility mapping: Oregon Department of Geology and Mineral Industries Special Paper 48, 63 p.
- Burns, W.J., I.P. Madin, and K.A. Mickelson. 2012. Protocol for Shallow-Landslide Susceptibility Mapping: Oregon Department of Geology and Mineral Industries Special Paper 45, 32 p.
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2.4 Project Operations and Effects on Resources

O&M at Project facilities and study roads could result in potential erosion and drainage issues, particularly if appropriate Best Management Practices are not followed. Erosion, bank armoring, and drainage can affect water quality, aquatic/fish resources, cultural resources, and terrestrial resources. Additionally, geologic hazards such as mass wasting and channel migration can affect Project facilities and/or be affected by Project operations. Maintenance or measures to protect Project facilities from mass wasting or channel migration could affect fisheries, riparian, cultural, or terrestrial resources.

2.5 Study Area

The Erosion and Geologic Hazards study area will cover land within the Project Boundary from Ross Dam to the Bothell Substation (Figure 2.5-1) including:

- Project dams and powerhouses;
- Project townsites;
- Study roads;
- Transmission line ROW; and
- Fish and wildlife mitigation lands.

Note that erosion and mass wasting areas along Project reservoir shorelines (Ross, Diablo, and Gorge lakes) are not included within this study area, as they are covered in the Reservoir Shoreline Erosion Study Plan. However, areas around Project-related facilities near Diablo Dam are included in this study area (e.g., Skagit Tour Dock, Ferry Landing, Boat House, City Light Boat Launch, and City Light Dry Dock).

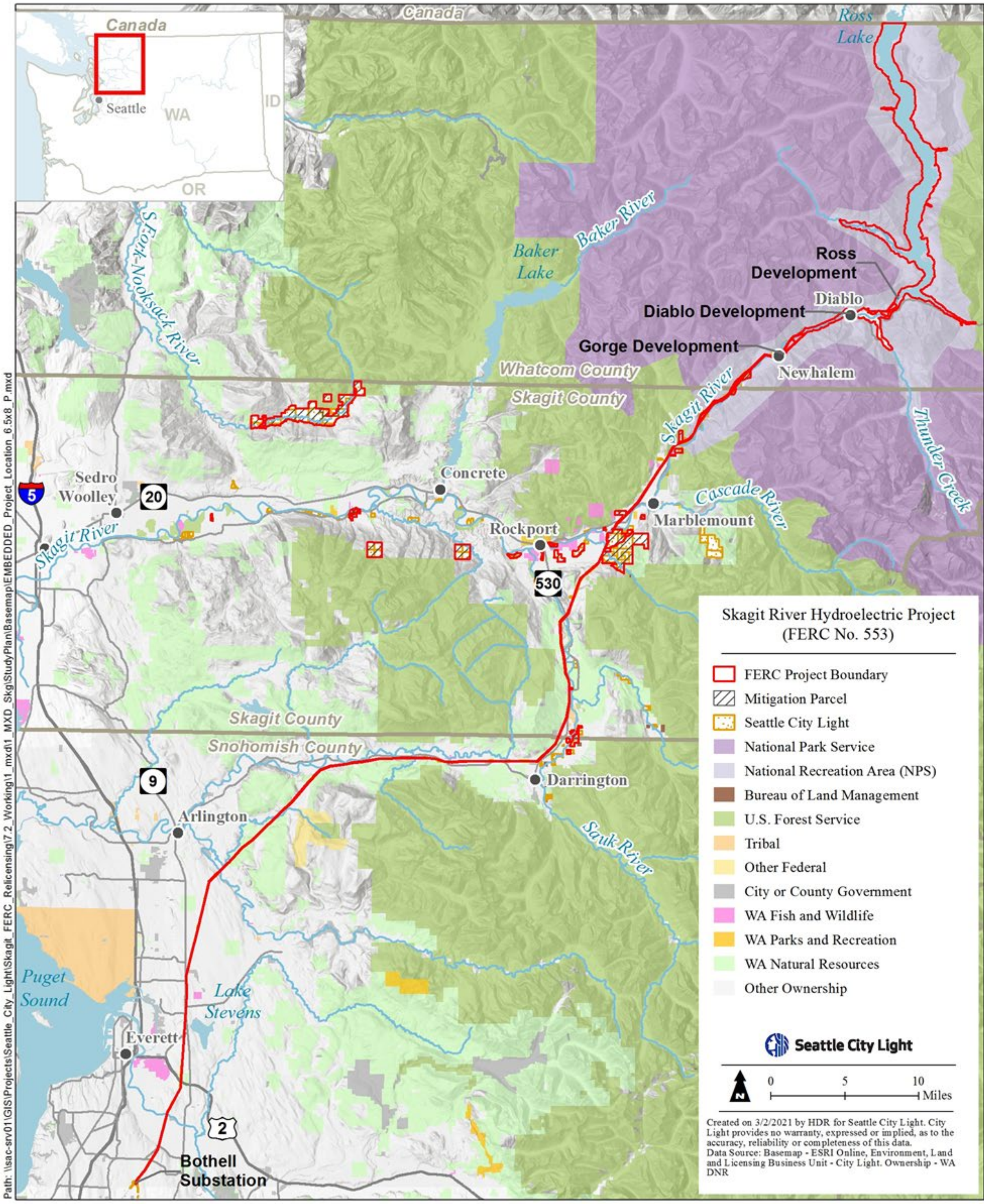

Figure 2.5-1. Location map of the Skagit River Project.

2.6 Methodology

2.6.1 Mass Wasting Hazards

The mass wasting portion of the study will provide: (1) a digital inventory (Inventory) of existing mass wasting features (e.g., landslide and rockfall) within the study area that could affect and/or be affected by City Light facilities and operations; and (2) an initial assessment of susceptibility of slopes to the dominant types of mass wasting within the Project Boundary based primarily on existing mass wasting features, slope characteristics, and local geology. The Inventory focuses on known occurrences of mass wasting, types of mass wasting processes, approximate magnitude of historical landslide/rockfall volumes, and other attributes useful for analyzing areas susceptible to mass wasting. An understanding of the susceptibility of the terrain to specific types of landslides, and their historic magnitudes, is the basis for mapping hazard zones. Hazard zonation will also help provide some regional context for previous site-specific studies.

2.6.1.1 Compile and Review Existing Information

The analysis of mass wasting hazards will include the compilation of reports, published maps, existing geospatial data, and similar studies that are relevant to the identification of unstable slopes in the study area (see existing resources list in Section 2.3.4 of this study plan). The existing information will be useful for establishing data points for regional hazard study and susceptibility analyses. Where appropriate, mass wasting features identified and mapped in the existing studies will be integrated into the Inventory being developed for this study.

Subsurface geotechnical and geologic explorations are particularly useful for the study of *individual*, deep-seated landslides, but implementing subsurface information databases for *regional* hazard study is not necessary for this analysis because the analysis is a regional hazard study. Information on existing explorations will not be reviewed as part of this study.

2.6.1.2 Identification of Existing Hazards

Mass wasting features in the study area will be mapped and inventoried based on a visual interpretation of LiDAR-derived topographic imagery and aerial photos and review of existing information. The results of the Inventory will be compiled into a GIS database. The GIS database will be the primary input data for analyzing susceptibility of the terrain to the main types of mass wasting processes.

There are existing, generally accepted protocols from state agencies in Washington and Oregon for compiling mass wasting feature inventories, for extending the inventories for susceptibility analysis, and for developing hazard maps based on integrating the Inventory with other information in GIS. The Washington Geologic Survey (WGS) of Washington DNR developed a protocol for identification, characterization, mapping, and inventorying recent and historical landslides (Slaughter et al. 2017) by mapping the following geomorphic features:

- Landslide deposits;
- Landslide headscarps, flank scarps, and internal scarps;
- Fan deposits;
- Rockfall deposits and scarps; and

- Recent landslides (typically under 50 years since occurrence).

In addition to mapping the features listed above, information on material, movement type, confidence in identification, and a general relative age of movement (e.g., pre-historic, historic, active) will be interpreted using LiDAR and aerial imagery and added to the Inventory. Several LiDAR datasets exist for the study area (e.g., U.S. Geological Survey 2016/17; City Light 2018) and will be integrated for complete coverage. Geometric parameters for slope angle, headscarp height (used to differentiate shallow and deep-seated landslides), average internal scarp distance, and landslide movement direction will also be measured from a LiDAR elevation model and added to the Inventory; these measurements will be used to calculate landslide failure depth and landslide deposit volume. Observations that do not fit within the existing protocol, such as specific details pertinent to landslide age, will be added as notes in the Inventory. Mass wasting hazards identified in previous studies (Riedel et al. 2012; Whatcom County 2006; Snohomish County 2015; Shannon & Wilson 1999; Golder Associates 2014; Washington DNR 2019; Skagit County 2016; and R2 Resource Consultants, Inc. 2015) will be used to guide mapping and may be integrated into the Inventory as appropriate. Applying the Slaughter et al. (2017) mapping protocol to previously identified mass wasting features will allow those previous efforts to be updated and included in a consistent Inventory.

Landslide Susceptibility Analysis

The Inventory will be used to interpret the types and magnitudes of hazards in the landscape between existing landslides. Landslide susceptibility describes the propensity, or likelihood, of slopes to fail. Susceptibility analysis is effective for mapping mass wasting hazards in terrain that may affect the study area but that does not exhibit mappable mass wasting features. The mass wasting inventory mapping protocol (Slaughter et al. 2017) is based on a similar protocol (Burns and Madin 2009) developed by the Oregon Department of Geology and Mineral Industries (DOGAMI). DOGAMI also developed methods for susceptibility analysis (Burns et al. 2012; Burns and Mickelson 2016) that will be used in this study and use the LiDAR-based Inventory as part of the input data.

Landslide susceptibility will be described and quantified using three approaches that vary in detail depending on the type of mass wasting process being analyzed:

- Spatial analysis of landslide/rockfall density from the Inventory;
- Spatial analysis of the slope failure factor of safety; and
- Spatially distributed weighted sums of mapped variables, such as geologic units, susceptible geologic contacts, landforms, soil cohesion, slope angle and aspect, and geologic structure.

Shallow and deep-seated landslide susceptibility and rockfall susceptibility will be analyzed using these three approaches. Debris flow susceptibility analysis does not follow these methods, typically focusing on identifying landforms related to debris flow-type processes. As described below, City Light will use that methodology for its debris flow susceptibility analysis.

Shallow Landslides

The shallow landslide susceptibility analysis approach (Burns et al. 2012) will integrate the shallow landslides in the Inventory, a simplified factor-of-safety analysis using a LiDAR Digital

Elevation Model and geotechnical parameters developed from published information. The work of Strauch et al. (2018, 2019) on hydroclimatological and probabilistic modeling of shallow landslide susceptibility overlaps with and is nearby the study area, and is a useful reference.

Deep-Seated Landslides

Deep-seated landslide susceptibility analysis will require more information on geologic conditions, such as soil and rock characteristics and geologic structure. Burns and Mickelson (2016) describe a GIS-based weighted sum approach to analyze for deep-seated landslide susceptibility using inputs, including:

- The mass wasting feature Inventory;
- Published geologic maps (geologic units, generalized rock and soil characteristics, and orientation measurements of geologic structures);
- Previous rockfall studies where discontinuity mapping was performed; and
- LiDAR-derived slope angle and slope azimuth maps.

Some of the published methods will be adapted for this study. For example, the WGS and Section 16 of the Washington Forest Practices Board Manual (Washington DNR 2016) recommend that deep-seated landslides are defined as those that failed at depths greater than 10 feet, not 15 feet, as indicated by Burns and Mickelson (2016).

Rockfall

The methods for analyzing deep-seated failures will be adapted for analyzing rockfall susceptibility. Rockfall susceptibility analysis will be limited to areas identified from LiDAR and aerial photo observations as being exposed rock faces or relatively unweathered rock with a veneer soil mantle. Areas where known rockfall have occurred will be identified. The application of engineering geologic data in this analysis will emphasize the findings of previous rockfall studies, discontinuity mapping, and kinematic failure analyses.

Debris Flow

Debris flow hazards occur when shallow landslides propagate into steep channelized streams called “chutes.” Debris fans commonly form at the base of chutes and are indicative of episodic debris flow activity. Geomorphologic mapping and landform classifications were performed for parts of the study area (Riedel et al. 2012) and will be useful for identifying debris fans. These geomorphic features produced by debris flows will be included in the Inventory for this Project.

However, fans can originate from different depositional processes that impart different levels of potential hazard. There are several empirical calculations used to differentiate between alluvial- and debris-flow-dominated fans. WGS (Slaughter et al. 2017) recommends combining the Melton Ratio (Melton 1965) and the Relative Relief Ratio (Wilford et al. 2004) to classify fans in order of increasing hazard: alluvial flow, debris flood, and debris flows. These ratios describe numerical relationships between watershed parameters; the former is the watershed area divided by the square root of the watershed area, and the latter refines the former by factoring in watershed length.

Quality Control and Compilation of Results

Based on experience of mapping landslides in the region, the landslide features tracked in the inventory are anticipated to contain more deep landslides than shallow landslides. The more severe shallow landslide hazards and risks are more likely related to debris flows. The results of the susceptibility analyses will be classified into three relative hazard classes: high, moderate, and low.

Since multiple data sources will be integrated into the susceptibility analysis, varying levels of data quality could affect the analysis results. Because recent high-quality LiDAR is available for all of the study area and anticipated mapping areas, these data are not considered a significant limiting factor in the analysis.

Field Verification

Field verification may be used at select locations near Project features if additional detail is needed to verify mass wasting hazards.

2.6.1.3 Overlay of Existing Hazards and Project Facilities, Transmission Towers, and Study Roads

The proximity of hazard zones and existing landslides to Project facilities will be used to help understand risks associated with mass wasting processes to and from Project features. While a formal risk assessment is not part of this study, by overlaying the Project facilities on the hazard zonation map, a basic picture of the proximity and severity of hazards to facilities can be drawn, and some of the related elements of risk inferred.

Study Results and Deliverables

The study results will be summarized in a report and GIS products and maps, including:

- GIS database (Inventory) of mass wasting features containing polygon and polyline features and associated attribute tables;
- GIS layers containing results of susceptibility analysis in the form of a hazard zonation map: Each hazard class will have a unique description related to the type of mass wasting process, and each hazard zone will have a unique symbology in the hazard map;
- A suite of maps that cover the Project ROW and include mass wasting features from the Inventory, previously mapped features from existing studies, and the City Light Project facilities;
- Guidance on the use of the GIS products and maps; and
- Summary of results that indicate areas of special concern, i.e., areas of high hazards or potentially unstable mass wasting features near Project infrastructure.

2.6.2 Erosion and Runoff from Project-related Townsites and Study Roads

The analysis of erosion and runoff from Project-related townsites and study roads will include compiling existing data and GIS layers; a pre-field analysis of roads and stream connectivity; a field inventory of road, culvert, and townsite erosion and runoff conditions; and a post-field summary and analysis.

2.6.2.1 Collect Existing Information

The following existing information and data will be collected for use as part of the analysis:

- Road, townsite, and stream sites identified in 1990 erosion inventory will be re-assessed (Riedel 1990);
- Recent LiDAR data and aerial photographs;
- Geology and soils GIS layers;
- Stream and wetland GIS layers;
- Study roads GIS layer (including any available attributes such as width, surfacing, culvert locations);
- RMAP information, where available;
- Available City Light road maintenance records;
- Townsite road and drainage layer; snow dump locations; and
- Existing culvert fish passage information (including https://geodataservices.wdfw.wa.gov/hp/fishpassage/index.html; Skagit System Cooperative fish passage database at road culverts; and other available data such as from NPS).

2.6.2.2 Study Roads

The analysis of erosion and sedimentation along study roads[2] will consider:

- Erosion (surface erosion, gullying, and mass wasting);
- Hydrologic connectivity; and
- Culvert and drainage structure characteristics and condition, and data to assess fish passage suitability at fish-bearing stream crossings where passage information is outdated.

A pre-field GIS assessment of potential erosion, fish passage, and hydrologic connectivity will be made based on study roads and stream/wetland crossings. For wildlife mitigation lands, information on road and culvert status will be summarized from existing RMAPs supplemented by field assessments. Available City Light road maintenance records will be consulted to assist in identifying locations with potential chronic road issues. Locations where roads cross fish-bearing streams (Washington DNR stream designation, SalmonScape) will be identified and cross-referenced with existing culvert fish passage information to help determine if additional field data collection is necessary to assess passage.

A field inventory of study road and culvert conditions will be made using methods similar to those developed for the Cedar River watershed (Seattle Public Utilities 2005) and the Boundary

[2] Study roads are currently being inventoried by City Light and will include private roads that are owned and/or maintained by City Light to access Project facilities. Roads maintained by Washington State Department of Transportation are not considered Project-related roads.

Hydroelectric Project relicensing. WDFW culvert assessment screening protocol data (WDFW 2019) will be collected on culverts at fish-bearing stream crossings where barrier assessments have not been made by other entities. Information will be collected on:

- Hydrologic connectivity of each road segment/drainage structure (road drainage to streams or wetlands);
- Road condition (tread, cutslope, surfacing, width, gradient, configuration, length hydrologically connected, any erosion or mass wasting issues, fish passage issues, oversteepened sidecast or fillslopes, etc.);
- Culvert condition (diameter, length, plugged, crushed, shotgun, stream crossing or cross-drain culvert, etc.).; and
- Bridge condition (length, width); and condition information on any fords or other non-culvert stream crossings.

Field work at study roads will identify each drainage structure (e.g., culvert, bridge, ford). For each drainage structure, a GPS point will be collected (or marked on map if there is no GPS coverage). The Washington DNR stream typing map will be consulted to determine if the crossing has been previously mapped as a stream and the water type (e.g., F, N, U). Each crossing will be assessed in the field to identify if it is or is not a stream and its potential for fish-bearing for a length equivalent to approximately 10 bankfull widths upstream and downstream of the immediate zone of influence of the crossing structure as follows. (Note that stream/fish-bearing potential may be different upstream and downstream from a structure, and each will be assessed and noted separately.):

- If there is a defined bed and banks and water-washed sediment, the crossing will be considered a stream.
- If the crossing is a stream and is not mapped as a Type F on the Washington DNR stream typing map, the potential for fish use will be noted if the stream has a scour width of over 2 feet and a gradient less than 20 percent. If the scour width is less than 2 feet or the gradient is over 20 percent, it will be marked as not potentially fish-bearing.

Fish passage attributes will be collected at Washington DNR designated fish-bearing stream crossings and at any field-identified crossings identified as potentially fish-bearing upstream and downstream from the crossing where recent (less than 5 years old) passage data is unavailable. Data will be collected to complete a Level A or B fish passage assessment as appropriate based on Washington DNR 2019 (see decision tree in Washington DNR 2019 to identify if Level A or B is necessary).

During fieldwork, City Light will note any presence of springs and seeps along the project roads based on evidence of surface water and vegetation that thrive in wet soil conditions (sedges, horsetail, etc.).

Field data will be compiled and analyzed. Surface erosion and hydrologic connectivity will be assessed using the Washington Road Surface Erosion Model (Dubé et al. 2004; https://www.dnr.wa.gov/washington-road-surface-erosion-model). Tables will be developed listing road segments with major erosion issues, gullying or mass wasting issues, or culvert issues.

These segments will be flagged to help identify priorities for assessing potential effects to terrestrial, aquatic, and cultural resources as part of relicensing.

Work products will include the following: a map and assessment of hydrologic connectivity, erosion issues, and culvert condition/fish passage along study roads; an estimate of average annual sediment delivery to streams; a table summarizing road/culvert locations with erosion issues or fish passage concerns; report sections summarizing assessment; and a GIS database with roads and culvert conditions.

2.6.2.3 Project Townsites

The analysis of Project townsites will consider:

- Runoff and stormwater outfalls;
- Erosion (surface erosion, gullying);
- Bank armoring along the Skagit River in Project townsites; and
- Hollywood levee erosion (e.g., along Stetattle Creek).

A pre-field assessment of Project townsites will be made based on mapped townsite facilities (roads, structures, drainage) along with proximity to rivers and streams. The townsites will be visited in the field to visually assess areas of erosion and runoff.

Work products will include the following: a map and assessment of runoff or erosion issues at Project townsites and a table listing any issues. The work products will be available during license and protection, mitigation, and enhancement (PME) measure development to assess effects on other resources.

2.6.3 Channel Migration and Stream Crossings

Existing data, reports, and GIS layers pertaining to channel migration at locations where study roads or the Project transmission line crosses streams within the study area will be compiled. Existing LiDAR data and aerial photographs of these stream crossings will also be collected.

2.6.3.1 Channel Migration Analysis

Channel migration can occur along streams and rivers located within a wide valley bottom or along streams with high erosive power or high bedload (e.g., alluvial fans). Existing topography and the Washington State Department of Ecology (Ecology) Channel Migration Zone (CMZ) Screening Tools (Legg and Olson 2015) were used to determine an initial list of streams and rivers that cross the Project Boundary where channel migration may occur that could affect Project facilities, Project-related transmission towers, or study roads. These include but are not limited to:

- Ladder Creek;
- Goodell Creek;
- Thornton Creek;
- Damnation Creek;

- Bacon Creek;
- Diobsud Creek;
- Babcock Creek;
- Skagit River;
- Illabot Creek;
- Sauk River;
- Stillaguamish River;
- Squire Creek;
- French Creek (Stillwater 2014);
- Boulder River (Hererra and Stillwater 2016);
- Montague Creek;
- Jim Creek;
- Siberia Creek; and
- Snohomish River.

This list of streams will be further refined during the study to determine if channel migration may affect Project-related transmission towers, facilities, and study roads based on topography and proximity of facilities to the potential CMZ (e.g., if the transmission line crosses a stream but there are no towers within the potential CMZ, channel migration would not affect the facility). Any existing CMZs for these streams will be used as part of this analysis. If existing CMZs for streams on the refined list (streams where facilities may be affected by channel migration) are not available, a CMZ will be delineated within the study area and 500 feet upstream and downstream of the study area boundary using methods in Rapp and Abbe (2003) and/or Washington DNR (2004).

Work products will include the following: CMZ GIS-based map and report sections analyzing potential channel migration effects on Project-related transmission towers, facilities, and study roads.

2.6.3.2 Compilation of Transmission Line Maintenance Procedures near Stream Crossings

Routine maintenance such as vegetation clearing and road maintenance under transmission line ROW has the potential to affect riparian vegetation and streambank stability. A list of maintenance procedures used near each transmission line stream crossing will be compiled to help identify the potential for resource affects. Locations where bank armoring has been installed at transmission line crossings/tower locations will also be identified.

Work products include the following: a list of maintenance procedures used near transmission line stream crossings and a GIS-based map showing affected stream crossing locations.

2.6.3.3 Stream/Riparian/Bank Condition at CMZ and Transmission Line Maintenance Locations

Information on aquatic habitat, bank conditions, and riparian habitat will be collected at streams where:

- The assessment of channel migration (Section 2.6.3.1 of this study plan) indicates that channel migration could affect Project-related facilities or transmission towers, or study roads; or
- At transmission line stream crossings where maintenance procedures affect aquatic or riparian resources.

Some of these data may be available from the Vegetation Mapping, Wetland Assessment, or Geomorphology between Gorge Dam and Sauk River studies. Collected data can be used during license application and PME development to assist with the analysis of potential risks to and conflicts with these resources and the development of appropriate PMEs and management plans.

The following habitat conditions will be collected during a field inventory at the selected locations where existing information is unavailable. Field data will be collected at the transmission line crossing and for a distance of 10 bankfull channel widths upstream and downstream from the crossing ROW zone to provide context of local habitat conditions.

- Aquatic habitat (habitat type, dominant/subdominant substrate, large woody debris, stream bank material, bank erosion; bankfull width; any hydromodifications); and
- Riparian habitat (vegetation type, average tree size class, average tree density, understory species, invasive plants).

Work products will include the following: report sections summarizing aquatic habitat and riparian conditions at selected stream crossing locations and a GIS-based map of locations.

2.7 Consistency with Generally Accepted Scientific Practice

The mass wasting and rockfall hazard analysis described above will be performed by or under supervision of a Washington State Licensed Engineering Geologist who specializes in mass wasting assessments. The methods described are similar to those used by geologists within Washington State to identify mass wasting and rockfall hazards. Road erosion and runoff data collection and analyses will use Washington DNR methods (Dubé et al. 2004). Channel migration analysis will be done using published methods developed by Ecology and DNR (Rapp and Abbe 2003; Washington DNR 2004) by or under supervision of a Washington State Licensed Engineering Geologist who specializes in geomorphology.

2.8 Schedule

This study will include pre-field analysis, one year of field work, post field analysis, and a draft and final report.

- Pre-field Analysis – January to June 2021
- Field Work – April to November 2021

- Post-field Analysis – October to December 2021
- Draft Report (Initial Study Report [ISR]) – March 2022
- Final Report (Updated Study Report [USR]) – March 2023

2.9 Level of Effort and Cost

The initial estimate for implementation and reporting associated with this study is approximately $450,000.

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EROSION AND GEOLOGIC HAZARDS AT PROJECT FACILITIES AND TRANSMISSION LINE RIGHT-OF-WAY REVISED STUDY PLAN

ATTACHMENT A

CITY LIGHT RESPONSES TO LP COMMENTS ON THE STUDY PLAN PRIOR TO PSP

Table 1. City Light responses to LP comments on the study plan prior to PSP.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
1.	Jon Riedel (NPS)	07/02/2020	Title Page	Good plan is just needs a little clarification.	Thank you for your comment.
2.	Brock Applegate (WDFW)	07/07/2020	Section 2.1 Study Goals and Objectives	2nd paragraph, 3rd bullet – Add: and possible fish passage issues *immediately* in, *upstream*, (italicized language is existing)	No edits made. City Light is not clear how a transmission line crossing could impact fish passage. City Light would appreciate any information on fish passage impacts due to transmission line crossings.
3.	Jon Riedel (NPS)	07/02/2020	Section 2.3 Background and Existing Information	Are there no hazards from over-steepened ice sheet deposits in Puget Lowland?	Text revised to include the following: "In the Puget Lowland region, slopes over-steepened by valley glacier migration coupled with heavy precipitation contribute to mass wasting along southern portion of the alignment corridor."
4.	Brock Applegate (WDFW)	07/07/2020	Section 2.3 Background and Existing Information	Did these streams contain fish?	No formal assessment was completed when the original erosion control plan was prepared. Based on review of SalmonScape, it appears that the stream segments noted in the plan are not known to support salmonids. Presence of resident fish is unknown.
5.	Brock Applegate (WDFW)	07/07/2020	Section 2.3 Background and Existing Information	Please add if the stream contains fish.	This study will not determine fish presence (Washington DNR stream typing will be used for fish/non fish determinations) but will provide information useful for assessing effects of Project operation and maintenance on habitat conditions for fish and identifying PMEs. During PME implementation, some sites might warrant follow-up fish presence surveys.
6.	Jon Riedel (NPS)	07/02/2020	Section 2.3 Background and Existing Information	Will the study examine the impact of certain road maintenance practices? Particularly concerned about side casting and building of fill turnarounds on steep slopes.	Yes, City Light will be examining road management practices. Project-related roads and potential effects will be included; as stated in Section 2.3.2 "…this study will provide a comprehensive compilation of data available on the condition of Project-related roads, erosion and

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
					runoff issues, or culvert conditions." Text has been added to Section 2.6.2.2 to clarify.
7.	Brock Applegate (WDFW)	07/07/2020	Section 2.3 Background and Existing Information	4th paragraph – Add: , including fish passage	No edits made. City Light includes fish passage as part of the natural resources category.
8.	Jon Riedel (NPS)	07/02/2020	Section 2.3 Background and Existing Information	Joe also mapped Darrington Quad, but not sure if line crosses it.	Thank you for your comment. City Light has revised to add all relevant geologic maps (10 at 24K and 100K scale for full coverage, retrieved via WGS portal) to Section 2.3.4 and to References section.
9.	Jon Riedel (NPS)	07/02/2020	Section 2.4 Project Operations and Effects on Resources	Mention maintenance of rip-rap along riverbanks in towns?	Agree, edits made in Sections 2.4 and 2.6.2.3.
10.	Brock Applegate (WDFW)	07/07/2020	Section 2.4 Project Operations and Effects on Resources	I agree with Jon. Rip-rap reduces and degrades aquatic habitat and armors the bank.	See response to Comment #9.
11.	Brock Applegate (WDFW)	07/07/2020	Section 2.4 Project Operations and Effects on Resources	1st paragraph – Add: bank armoring,	Agree, edit accepted.
12.	Jon Riedel (NPS)	07/02/2020	Section 2.6 Methodology	Wouldn't you use that information if you found a deep-seated landside that threatened a project or other facility?	Text revised to the following (italics indicate addition): "*Where appropriate, mass wasting features identified and mapped in the existing studies* will be integrated into the Inventory being developed for this study."
13.	Jon Riedel (NPS)	07/02/2020	Section 2.6 Methodology	Clarify what you mean by relative? Will you attempt to quantify age of individual landslides when possible using radiocarbon,	The relative age refers to general age of movement (e.g., pre-historic, historic, active), as can be estimated from geomorphic features on LiDAR

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				air photos or volcanic ash?	imagery, freshness of those features and deformation of human-made features such as roads, walls, etc., observed in air photos. Text revised to the following (italics indicate addition): "In addition to mapping the features listed above, information on material, movement type, confidence in identification, and *a general* relative age of movement *(e.g., pre-historic, historic, active)* will be interpreted using LiDAR *and aerial imagery* and added to the Inventory.
14.	Jon Riedel (NPS)	07/02/2020	Section 2.6 Methodology	Can you give examples of each type? (e.g. debris flows for shallow, and debris avalanches and slumps for deep seated.	Debris flows are addressed subsequently in Section 2.6.
15.	Jon Riedel (NPS)	07/02/2020	Section 2.6 Methodology	Do you mean debris cones? We distinguish between debris cones and fans and alluvial fans based on several morphometric characteristics, but the most important are basin size, stream gradient, and the slope of the debris accumulation: debris cone >10 degrees, debris fan, 5-10 and alluvial fan <5.	City Light would appreciate more information on the method you reference as it sounds like it might be beneficial to consider adding to the approach. While the methodology and parameters are similar, our method does not account for the debris slope. City Light would like to consider possibly adding this method to the study as it may be useful and a good comparison to the Wilford and Melton methods.
16.	Jon Riedel (NPS)	07/02/2020	Section 2.6 Methodology	Can you assign probability?	Following the approach we propose, we cannot assign probability but rather a relative likelihood of occurrence. Assigning probability would require more sophisticated modeling and perhaps a site-specific risk assessment study. This is outside the scope for this study.
17.	Jon Riedel (NPS)	07/02/2020	Section 2.6 Methodology	Which is it?	Text revised to reflect that high-quality LiDAR is available for all of the study area
18.	Jon Riedel (NPS)	07/02/2020	Section 2.6 Methodology	Note previous comment on rip rap along river in towns.	See response to Comment #9; text revised to include rip rap in Section 2.6.2.3.
19.	Jon Riedel (NPS)	07/02/2020	Section 2.6 Methodology	Should systematically review conditions at 16 sites identified in current license in RLNRA.	Agree, these will be re-assessed; text revised to include this in Section 2.6.2.1.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
20.	Jon Riedel (NPS)	07/02/2020	Section 2.6 Methodology	Need to assess threat to SR20 and other roads from mass wasting in NRA. This is an ongoing issue.	Issues stemming from Project-related roads will be assessed, including if Project roads affect SR20. SR20 is a State-operated highway; issues originating from SR20 are not included in this study.
21.	Brock Applegate (WDFW)	07/07/2020	Section 2.6 Methodology	2nd paragraph; 2nd bullet - Add: and fish migration	The proposed addition is not necessary as the 3rd bullet discusses documenting conditions relating to fish passage. No edits made.
22.	Brock Applegate (WDFW)	07/07/2020	Section 2.6 Methodology	3rd paragraph - Delete: and Add: fish passage, and	Edit accepted. Pre-field analysis will include review of existing GIS data on fish distribution and culverts to identify which stream segments crossed by Project roads are known to be fish-bearing.
23.	Brock Applegate (WDFW)	07/07/2020	Section 2.6 Methodology	1st paragraph; 1st bullet - Add: fish passage issues,	Edit accepted.
24.	Brock Applegate (WDFW)	07/07/2020	Section 2.6 Methodology	These issues can lead to fish passage problems.	Comment noted.
25.	Jon Riedel (NPS)	07/02/2020	Section 2.6 Methodology	Specifically call out erosion problem along townsites on RB Skagit River	See response to Comment #9; text revised.
26.	Jon Riedel (NPS)	07/02/2020	Section 2.6 Methodology	Note Goodell restoration study looked at towers on RB of creek.	Thank you for the information, we will review that report.
27.	Brock Applegate (WDFW)	07/07/2020	Section 2.6 Methodology	1st paragraph - Add: fish passage,	See response to Comment #2. City Light would appreciate any information on fish passage impacts due to transmission line crossing.
28.	Brock Applegate (WDFW)	07/07/2020	Section 2.6 Methodology	3rd paragraph; 3rd bullet - Add: Any fish passage problems	See response to Comment #2. City Light would appreciate any information on fish passage impacts due to transmission line crossing.
29.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.1 Study Goals and Objectives	New objective: assess impact of bank protection, channel and floodplain fill, and riparian vegetation removal on fluvial geomorphic processes that create and sustain fish habitat. Assess impact to quantity and quality of fish habitat.	Information on bank protection and riparian vegetation removal on fluvial geomorphic processes will be collected in specific locations (see second and third objectives). Assessing impacts is outside the scope of this study plan, but will be included in the DLA.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
					Channel and floodplain fill cannot be measured due to lack of pre- and post-fill project data.
30.	Brian Lanouette (Upper Skagit Indian Tribe)	07/13/2020	Section 2.1 Study Goals and Objectives	The previous paragraph mentions the impacts on fisheries aquatic, and cultural resources, but those are not present in specific objectives. This inconsistency needs to be addressed by including those impacts in specific objectives. I included one such example.	No edits made. The resources are listed in the above goals, which apply to the objectives. The specific objectives relate to the information that will be collected as part of this study. That information will be used in the DLA to assess cumulative effects to resources. Assessment will consist of an overlay of erosion information with any sensitive resource locations in the DLA (cultural, aquatic, fishery, etc.).
31.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.1 Study Goals and Objectives	Maintenance activities include road repair needed due to improperly placed fill, altered drainage patterns, and flood damage.	Thank you for your comment. City Light will include all Project maintenance activities that have potential to cause erosion or sedimentation.
32.	Brian Lanouette (Upper Skagit Indian Tribe)	07/13/2020	Section 2.1 Study Goals and Objectives	2nd bullet - Add: "that may impact aquatic, fishery, and cultural resources"	See response to Comment #30.
33.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.1 Study Goals and Objectives	Assess potential to alter drainage patterns and delivery of surface runoff to streams. Assess potential to alter risk of road damage or failure.	An assessment of the potential for Project-related roads to deliver runoff/sediment and road-related erosion issues will be included in the analysis, and is included in the methods. Text added: "or altered hydrologic connectivity to water bodies"
34.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.1 Study Goals and Objectives	All crossings in fish-bearing waters assessed for passage for all species at all life stages. Quantify fish habitat upstream of all crossings.	Quantifying fish habitat upstream of all crossings is beyond the scope of this study. Level A fish passage at culverts in fish-bearing waters (per Washington DNR stream typing) will be assessed using WDFW 2019 (Washington Department of Fish and Wildlife. 2019. Fish Passage Inventory, Assessment, and Prioritization Manual. Olympia, Washington) at locations where existing culvert assessments are inadequate.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
35.	Brian Lanouette (Upper Skagit Indian Tribe)	07/13/2020	Section 2.2 Resource Management Goals	Prevent degradation of aquatic habitat, prevent loss of aquatic, cultural, and fishery resources. Are examples. Fish passage is another goal that can be addressed.	Thank you for your comment. Text revised to include stated goals.
36.	Brian Lanouette (Upper Skagit Indian Tribe)	07/13/2020	Section 2.3 Background and Existing Information	*In response to Comment #4* Agree with Brock. Even intermittent streams can be important for fish temporary usage, for example- they can contribute to Bull Trout Foraging, Migrating, and Overwintering (FMO) habitat. Therefore, they should not be discounted.	City Light is not assessing fish usage. City Light will only assess fish passage at streams that have been typed already (per Washington DNR stream typing). Sediment and erosion will be addressed at all crossings. Also see response to Comment #4.
37.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.3 Background and Existing Information	Field assessment of project culverts, and other crossing types, needs to be conducted. Passage conditions change over time.	We will assess existing data to determine if additional data needs to be collected to appropriately update condition information.
38.	Brian Lanouette (Upper Skagit Indian Tribe)	07/13/2020	Section 2.3 Background and Existing Information	*In response to Comment #5* Or if fish use the stream even for brief portions of the season/year (see my previous comment).	See response to Comment #5.
39.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.3 Background and Existing Information	Or protected with bank hardening.	Thank you for your comment. Emergency and/or temporary measures may be necessary to protect infrastructure.
40.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.3 Background and Existing Information	And installing bank protection measures	Text revised.
41.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.3 Background and Existing Information	Field assessment of project culverts, and other crossing types, needs to be conducted. Data was originally collected over 20 years ago and passage conditions often change over this time period. The purpose of the database cited here is to update past crossing assessments.	Thanks for clarification. We will assess existing data to determine if additional data needs to be collected.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
42.	Brian Lanouette (Upper Skagit Indian Tribe)	07/13/2020	Section 2.4 Project Operations and Effects on Resources	This evaluation is lacking on how Project operational effects on cultural resources, fishery resources, and water quality will be evaluated. More information on evaluating these components needs to be added for this plan to be in a complete state.	Assessment of effects on resources will occur in the DLA.
43.	Curtis Clement (Upper Skagit Indian Tribe)	07/13/2020	Section 2.4 Project Operations and Effects on Resources	Placement of transmission towers and roads in alluvial fans impedes channel migration and other fluvial processes that are beneficial to fish.	Thanks, comment noted. We will evaluate risk to Project-related infrastructure as part of assessment and information will help inform development of a management plan.
44.	Brian Lanouette (Upper Skagit Indian Tribe)	07/13/2020	Section 2.4 Project Operations and Effects on Resources	What components of water quality will be addressed? So far all I see is sediment. I agree erosion and bank armoring can impact water quality beyond sediment- Therefore, other components of water quality such as nutrient spiraling dynamics should be addressed.	Assessing potential water quality problems is beyond the scope of this study. Potential water quality concerns will be addressed as part of the DLA.
45.	Brian Lanouette (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	Will the existing data be QA/QC'd? Will its accuracy or applicability be ground truthed with some on the ground observations?	Yes, see QC section below. Field work will be conducted if possibility of mass wasting impacting Project infrastructure if existing information is not available
46.	Curtis Clement (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	Kind of an odd statement for this section. Maybe true but don't let this belief bias your results. Deep seated landslide create opportunities for shallow on the toe and head scarps, plus debris flows are not always apparent in LiDAR or in the field, unless a chute is developed but that isn't always the case.	Thank you for your comment.
47.	Curtis Clement (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	Please specify how the need for field verification will be determined. Are there criteria or will it be some random subset. My advice is don't just go off of LiDAR, if slope failure can't be verified on aerial imagery, the feature needs verification.	As described in Sections 2.6.1.1 and 2.6.1.2, mass wasting sites will be identified from a combination of existing reports/information and analysis of LiDAR and aerial photography. If mass wasting features are identified that are associated with Project assets, they will be field checked.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
48.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	All crossings in fish-bearing waters should be field assessed for passage condition; recent surveys (e.g. within 10 years) may suffice, but conditions change over time necessitating updated passage assessments.	Please see response to Comments #4 and #5.
49.	Curtis Clement (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	Please clarify what this means	Text revised to reflect that "tagged" = "identified".
50.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	Include assessment of impacts to fluvial geomorphic process, creation and maintenance of fish habitats, this includes channel and floodplain habitat condition.	Please see response to Comment #29.
51.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	The Project affects channel migration, not the other way around as it's currently written. This may sound like semantics, but it's an important concept to understand USIT's perspective on Project-related impacts.	Comment noted. The flow/geomorphic effects of the Project on channel migration are included in other studies.
52.	Curtis Clement (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	On Goodell alluvial fan	Thank you for your comment.
53.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	And channel migration rate and relic channel locations.	Thank you for your comment.
54.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	Where would these come from?	CMZs are sometimes developed for county shoreline management documents or individual projects along streams. NPS has developed a CMZ for the Skagit River.
55.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	Hydromodifications (e.g. bank armoring) should be identified, field inventoried, if necessary, for existing and newly developed CMZ's. The impact of hydromodifications on CMZ extent should be assessed, as should the potential for removal or restoration during the term of the license.	Ecology's CMZ delineation methodology includes analysis of hydromodified features. Potential alterations to hydromodifications can be included in PMEs.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
56.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	1st paragraph - Add: "water quality,"	No edits made. Assessing potential water quality problems is beyond the scope of this study. Potential water quality concerns will be addressed as part of the DLA.
57.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	At minimum this should include all fish-bearing streams. Also, develop an approach to determine when maintenance activities along non-fish bearing streams will have the potential to affect downstream conditions in fish-bearing streams.	As stated in the methods, this assessment will take place at locations where maintenance procedures have the potential to affect streams. These may or may not be fish bearing. City Light will address potential impacts of maintenance activities in the DLA. A management plan will include updated treatments to minimize effects of maintenance activities.
58.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	Cite the data collection methods that will be used.	Specific data collection methods will be determined based on stream size prior to initiating field work.
59.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	There should also be a comparison to reference reaches, to account for non-Project related impacts to stream habitat condition.	City Light suggests a control/impact type comparison requiring 'reference' reaches is not appropriate for the methodology proposed here.
60.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	Measure hydromodifications, including bank armor, channel and floodplain fill. Measure bankfull width and floodplain width.	We can include bankfull and floodplain width, and length of hydromodification, but others cannot be done without additional information would need pre- and post-Project topography to do this. Edits made to reflect this.
61.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	Tree species, or at minimum differentiate between hardwood and conifer.	Thank you for your comment. We will review what information currently exists. We will review standardized existing protocols and how data will be used.
62.	Rick Hartson (Upper Skagit Indian Tribe)	07/13/2020	Section 2.6 Methodology	2nd bulleted list, 4th bullet - Add: "Any water quality problems"	Assessing water quality is beyond the scope of this study.

GE-03 SEDIMENT DEPOSITION IN RESERVOIRS AFFECTING RESOURCE AREAS OF CONCERN
REVISED STUDY PLAN

SKAGIT RIVER HYDROELECTRIC PROJECT
FERC NO. 553

Seattle City Light

April 2021
RSP

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List of Acronyms and Abbreviations

City Light .... Seattle City Light
cu yds .... cubic yards
DEM .... digital elevation model
Ecology .... Washington State Department of Ecology
ELC .... Environmental Learning Center
FARWG .... Fish and Aquatics Resource Work Group
FERC.......................... Federal Energy Regulatory Commission
GPS .... Global Positioning System
ISR .... Initial Study Report
LP .... licensing participant
LiDAR........................ Light Detection and Ranging
m .... meter
N/m^2 .... Newton/square meter
NAIP .... National Agriculture Imagery Program
NMFS......................... National Marine Fisheries Service
NPS .... National Park Service
sq mi........................... square mile
PAD............................ Pre-Application Document
PRM .... Project River Mile
Project .... Skagit River Hydroelectric Project
PSP .... Proposed Study Plan
RLNRA .... Ross Lake National Recreation Area
RM .... river mile
RSP .... Revised Study Plan
RWG .... Resource Work Group
USACE .... U.S. Army Corps of Engineers
U.S.C.......................... United States Code
USFS .... U.S. Forest Service
USFWS .... U.S. Fish and Wildlife Service
USGS .... U.S. Geological Survey
WDFW .... Washington Department of Fish and Wildlife

yr ....year

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1.0 INTRODUCTION

1.1 General Description of the Project

The Skagit River Hydroelectric Project (Project), licensed to The City of Seattle, Washington, and operated through its publicly-owned electric power utility Seattle City Light (City Light), is located in northern Washington State and consists of three power generating developments on the Skagit River – Ross, Diablo, and Gorge – and associated lands and facilities. The Project generating facilities are in the Cascade Mountains of the upper Skagit River watershed, between Project River Miles (PRM) 94.7 and 127.9 (U.S. Geological Survey [USGS] RMs 94.2 and 127).[1] Power from the Project is transmitted via two 230-kilovolt powerlines that span over 100 miles and end just north of Seattle at the Bothell Substation. The Project also includes two City Light-owned towns, an Environmental Learning Center (ELC), several recreation facilities, and several parcels of fish and wildlife mitigation lands.

Project generating facilities are all located in Whatcom County, although Ross Lake, the most upstream reservoir, crosses the U.S.-Canada border and extends for about one mile into British Columbia at normal maximum water surface elevation. Gorge Powerhouse, the most downstream facility, is approximately 120 miles northeast of Seattle and 60 miles east of Sedro-Woolley, the nearest large town. The closest town is Newhalem, which is part of the Project and just downstream of Gorge Powerhouse. The primary transmission lines cross Whatcom, Skagit, and Snohomish counties; the fish and wildlife mitigation lands are in the same counties.

The Project Boundary is extensive, spanning over 133 miles from the Canadian border to the Bothell Substation just north of Seattle, Washington. In addition, there are "islands" of fish and wildlife mitigation lands and recreation facilities within the Skagit, Sauk, and South Fork Nooksack watersheds that are also within the Project Boundary. Project generating facilities are entirely within the Ross Lake National Recreation Area (RLNRA), which is administered by the National Park Service (NPS) as part of the North Cascades National Park Complex. The RLNRA was established in 1968 in the enabling legislation for North Cascades National Park to provide for the "public outdoor recreation use and enjoyment of portions of the Skagit River and Ross, Diablo, and Gorge lakes." The legislation maintains the Federal Energy Regulatory Commission's (FERC) jurisdiction "in the lands and waters within the Skagit River Hydroelectric Project," as well as hydrologic monitoring stations necessary for the proper operation of the Project (16 United States Code [U.S.C.] § 90d-4; Public Law 90-544. Sec. 505 dated October 2, 1968, as amended by Public Law 100-668. Sec. 202 dated November 16, 1988).

1.2 Relicensing Process

The current FERC license for the Project expires on April 30, 2025, and City Light will apply for a new license no later than April 30, 2023. City Light formally initiated the relicensing process by filing a Notice of Intent and Pre-Application Document (PAD) with FERC on April 27, 2020 (City Light 2020a). The PAD includes descriptions of the Project facilities, operations, license

[1] City Light has developed a standard Project centerline and river mile system to be used throughout the relicensing process, including the study program, to replace the outdated USGS RM system. Given the long-standing use of the USGS RM system, both it and the Project River Mile (PRM) system are provided throughout this document. For further details see Section 7.0 of the main body RSP.

requirements, and Project lands as well as a summary of the extensive existing information available on Project area resources and early consultation on potential resource issues to be addressed during the relicensing.

1.3 Study Plan Development

In 2019-2020, City Light convened a number of Resource Work Groups (RWG) to engage agencies and other licensing participants (LP) in a Study Plan Development Process, which provided LPs and City Light the opportunity to submit forms that identified potential resource issues, their potential connection to the Project, information on studies requested, a rationale for studying the issues, and how the information collected by the study could be used to support relicensing. Table 5.1-2 of the PAD provides a summary of all the issue forms submitted during this 2019-2020 process.

Section 5 of the PAD lists the resource studies and management plans proposed by City Light to address select (but not all) issues identified as part of the Study Plan Development Process. While acknowledging the broad interests of LPs, City Light focused its initial draft study plans contained in the PAD on information gaps that were most likely to inform license conditions by a study of potential Project effects. City Light developed 24 study proposals, including this Sediment Deposition in Reservoirs Affecting Resource Areas of Concern Study Plan.

On March 13, 2020, City Light released the GE-03 Sediment Deposition in Reservoirs Affecting Resource Areas of Concern Draft Study Plan for LP review and comment. On March 31, 2020, the draft study plan was discussed at a Fish and Aquatic Resource Work Group (FARWG) meeting. City Light reviewed all comments received and released a revised version of the draft study plan on April 28, 2020. The revised draft was discussed on May 5, 2020 and June 2, 2020 at FARWG meetings. Written comments were received from National Marine Fisheries Service (NMFS), U.S. Forest Service (USFS), Washington Department of Fish and Wildlife (WDFW), NPS, U.S. Fish and Wildlife Service (USFWS), and the Upper Skagit Indian Tribe and responded to in an attachment to this study plan. A Status Draft of the study plan was provided to LPs on August 6, 2020.

City Light is filing this study plan with FERC as part of its Revised Study Plan (RSP), an update to the version that was filed with the Proposed Study Plan (PSP) on December 8, 2020 (City Light 2020b) and incorporating additional consultation with LPs prior to the filing date.

Three LPs submitted study requests related to potential backwater effects on tributaries to Project reservoirs: NPS-10 Impact of the Operation of Skagit Hydroelectric Project (#553) Backwater on Major Streams and its Influence on Habitat Quality, USFWS-09 Impact of the Operation of Skagit Hydroelectric Project (#553) Backwater on Major Streams and its Influence on Habitat Quality, and WDFW-11 Impact of the Operation of Skagit Hydroelectric Project (#553) Backwater on Six Major Streams Tributary to Ross Lake and its Influence on Habitat Quality. The LPs requested information on eight tributaries entering Project reservoirs: Big Beaver, Little Beaver, Skagit River, Lightning Creek, Devils Creek, and Ruby Creek that enter Ross Lake; Thunder Creek that enters Diablo Lake; and Stetattle Creek that enters Gorge Lake.

The purpose of this study plan is to study sediment accumulations and backwater effects in three of the tributaries requested by the LPs (Skagit River where it enters Ross Lake, Thunder Creek on

Diablo Lake, and Stetattle Creek on Gorge Lake), i.e., locations of documented effects on recreation or Project operations due to deposition within reservoir delta deposits. City Light thinks it is unnecessary to collect information on the remaining five tributaries for the reasons provided in Section 6 of the RSP.

PSP comments to this study plan were submitted by American Rivers/Trout Unlimited, NPS, Upper Skagit Indian Tribe, and USFWS. City Light responded to comments in the PSP comment/response table appended to the main body of the RSP. No modifications were made to the study plan in response to comments.

City Light understands that deposition in four particular areas (Hozomeen inlet at the head of Ross Lake, Sourdough inlet in Diablo Lake, Thunder inlet in Diablo Lake, and Stetattle Creek delta in Gorge Lake) is or may be affecting recreational resources or Project operations. Ongoing sediment deposition in Project reservoirs is known to affect recreational resources (boat launches and docks), operational facilities (docks and landings), and/or power generation at two locations, and it might have similar effects at two additional locations. Deposition is an ongoing process that will continue over the term of the new license. Information on these four locations is as follows:

- Ross Lake: Hozomeen inlet, formed by the Skagit River flowing into Ross Lake, has affected the Hozomeen Public Boat Launch ("Hozomeen Launch") and Winnebago Flats Dock and Launch ("Winnebago Flats Launch"). NPS performed an environmental assessment (NPS 1999) to improve the recreational facilities at Hozomeen Campground Lower Boat Launch Area ("Government Dock Launch Area" by NPS). Three alternatives were considered; the third alternative to extend "Government Dock" was determined to be not economically feasible due to long-term maintenance needed to properly identify, buoy, and dredge a channel that would access the launch. Though not explicitly stated, it is hypothesized that the depositional environment at the north end of Ross Lake influences access to both boat launches.
- Diablo Lake: Sediment from Sourdough Creek is potentially affecting the City Light Boat Launch, City Light Boat House, West Ferry Landing, and Environmental Learning Center Canoe and Kayak dock. Sediment from a small, unnamed tributary to the east of Sourdough Creek may also be affecting the City Light Dry Dock.
- Diablo Lake: Deposition in Thunder Arm is affecting the ability of boats to launch from Colonial Creek Boat Launch/Dock. City Light in the past has used the beach access area on the north side of the campground adjacent to the existing NPS boathouse for loading and unloading large equipment such as transformers. Access needs to be maintained for equipment that cannot be transported on the Diablo Dam road for future operation of Ross Dam and Powerhouse.
- Gorge Lake: Deposition where Stetattle Creek enters Gorge Lake is reducing power generation by raising the Diablo Powerhouse tailwater elevation and affecting the Gorge Lake Campground Boat Launch and Dock. The delta deposit that has formed at the outlet of Stetattle Creek is used for whitewater training and instruction and long-term effects upon this use should be evaluated.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

The goal of the Sediment Deposition Study is to evaluate the effects of deposition on four specific locations within Ross, Diablo, and Gorge lakes with identified recreational resources and/or Project operations impacts. The study will develop an understanding of the physical conditions (rate of deposition, grain size of deposits) under which deposition occurs at the four locations. Specific objectives are as follows:

- Describe and map the location and history of sediment deposition in the:
  - Hozomeen inlet in Ross Lake; i.e., the large arm of upper Ross Lake that has sediment contributed by the Skagit River;
  - Sourdough Creek inlet in Diablo Lake; i.e., the small arm of Diablo Lake into which Sourdough Creek flows;
  - Thunder Arm in Diablo Lake; i.e., the large arm within Diablo Lake into which Thunder Creek, Colonial Creek, and Rhode Creek flow; and
  - Stetattle Creek delta in Gorge Lake (i.e., the sediment deposited at the mouth of Stetattle Creek where it enters Gorge Lake) and the sediment deposited between Stetattle Creek and the State Highway 20 bridge crossing.
- Determine rate and grain size of sediment input, quantify total volume of sediment deposition in the four inlets and deltas, and estimate rate and patterns of deposition.
- Identify likely future zones and patterns of deposition with respect to recreational resources and operational impacts.

2.2 Resource Management Goals

The study will provide information for resource agencies and Indian tribes with jurisdiction in the Project vicinity to address their respective goals and objectives for resource management. Resource management goals were provided by LPs in their study requests identified in Section 1.3 of this study plan.

Several agencies and Indian tribes have resource management goals related to sediment conditions in the Project reservoirs and/or the Skagit River. These include USFWS, NMFS, Washington State Department of Ecology (Ecology), NPS, WDFW, Upper Skagit Indian Tribe, Sauk-Suiattle Indian Tribe, and Swinomish Indian Tribal Community.

2.3 Background and Existing Information

Delta formation and deposition in specific areas of Project reservoirs affect access to/from certain recreational facilities (boat launches and docks), operational facilities (docks and landings), and/or power generation. Studies and potential methods to address concerns have been proposed during the current license period, but specific actions have not been undertaken. This study will build on information from previous studies to develop a better understanding of the impacts of inlet and delta deposition within the four identified areas of concern. Existing information and documentation contributing to the understanding of sediment deposition rates and processes in the areas of concern includes:

- As-built documentation, historical topography and available bathymetry for Sourdough Creek inlet within Diablo Lake, Thunder Arm within Diablo Lake, and the Hozomeen inlet at the north end of Ross Lake.
- LiDAR and green LiDAR are available for areas within the Project Boundary.
- Current and historical aerial photographs are available to determine changes to the spatial extent of the deposits over time.
- Improvement of Recreational Facilities, Hozomeen Campground Lower Boat Launch Area (NPS 1999).
- Diablo Powerhouse Tailwater Remediation: Stetattle Creek Delta Geomorphology Report – A study is currently being conducted (Watershed GeoDynamics, In Prep) to determine the pattern and rates of deposition of the Stetattle Creek delta. This study will evaluate sediment supply, particle size distribution, and lateral and vertical extent of the deposit. It will also provide suggestions for long-term resolution for both the boat launch ingress and egress and for mitigating the effects on Diablo Powerhouse tailrace. The Stetattle Creek Delta results will be incorporated into this study, and methods will be used as a model for other areas of concern.
- Report on Existing Conditions of Reservoir and Streambank Erosion (Riedel 1990).
- Skagit Hydroelectric Project Erosion Control Plan (Riedel et al. 1991).
- Geomorphology of a Cordilleran ice sheet drainage network through breached divides in the North Cascades Mountains of Washington and British Columbia, Geomorphology (Riedel et al. 2007).
- Deposition of Mount Mazama Tephra in a Landslide-Dammed Lake on the Upper Skagit River, Washington, USA. In Volcaniclastic Sedimentation in Lacustrine Settings (Riedel et al. 2009).
- Geomorphology of the Upper Skagit watershed: Landform mapping at North Cascades National Park Service Complex, Washington (Riedel et al. 2012).
- NPS Erosion Control and Revegetation Completion Reports (2016, 2018).
- Regional estimates of watershed sediment input have been developed by the Army Corps of Engineers (USACE 2008). A comprehensive assessment and inventory of sediment sources and yield does not exist for the Skagit River basin (USACE 2008). Annual sediment budgets for ten Skagit River sub-basins were developed by Paulson (1997) but estimates of sediment yield were based on drainages tributary to the Skagit below Gorge Dam (e.g., drainages managed for timberland in the Baker River and middle Skagit River areas). An estimate of sediment accumulation of 85 cu yd/sq mi/yr based on comparisons of bathymetry in the reservoir in Gorge Lake was made by the U.S. Soil Conservation Service (1950) for the period 1930-1936. There are glaciated areas (areas covered by glacial ice) within the Thunder Arm drainage area; Nichols (2006) estimated the glaciated areas would produce 2,600 tons/sq mi/yr or around 1,900 cu yd/sq mi/yr. The estimated 0.8–3.8 million tons/yr sediment yield equates to 530–2,500 tons/sq mi/yr from the 1,500 sq mi of the Skagit basin that is not regulated by dams. This Skagit River range is consistent with the regional range of 830–2,500 tons/sq mi/yr

of sediment from glacier-fed rivers compiled by R2 Resource Consultants (2004) for Puget Sound Energy. These values have not been adjusted for climate change; literature will be reviewed by City Light as to the effects of climate change on sediment supply.

2.4 Project Operations and Effects on Resources

Sediment supply (non-Project related) from tributaries results in deposition within Project reservoirs. The deposition affects access to/from recreational facilities (boat launches and docks), and operational facilities (docks and landings), access to Ross Dam and Reservoir for ongoing operations and maintenance, and/or power generation associated with the Project. The data obtained with the methods identified below will be used to analyze potential future deposition volumes and patterns to help develop methods to manage sediment deposition at the areas of resource concern through the term of the new license.

2.5 Study Area

This study includes portions of the Skagit River inlet (Ross Lake), Sourdough Creek inlet (Diablo Lake), Thunder Arm (Diablo Lake), and Stetattle Creek delta (Gorge Lake) (Figure 2.5-1). The study area includes inlets/delta at four locations with identified recreational or operational impacts in the Project Boundary:

- Hozomeen inlet at the head of Ross Lake – recreational resource: Hozomeen and Winnebago Flats boat launches;
- Sourdough inlet in Diablo Lake – City Light resources: City Light Boat Launch, City Light Boat House, City Light Dry Dock; recreational resources: West Ferry Landing, Environmental Learning Center Canoe and Kayak Dock;
- Thunder inlet in Diablo Lake – recreational resource: Colonial Creek Boat Launch/Dock; and
- Stetattle Creek delta in Gorge Lake – recreational resource: whitewater training and instruction, Gorge Lake Campground Boat Launch and Dock; operational resource: City Light Diablo Powerhouse Tailrace.

Figures 2.5-2 to 2.5-4 show the extent of the depositional area that will be investigated for three study locations. Figure 2.5-5 is included to show the Stetattle Creek site that is being investigated in an ongoing study (Watershed GeoDynamics, In Prep). Each figure includes the location of the resource(s) of concern. Figure 2.5-2 also includes an area south of the boat launches in case, upon field review, the area has substantially more deposition that could affect the boat launch depositional environment than is visible from the aerial photographs. In addition to the deposition zones shown in the figures, the watersheds of each of the creeks will be included in the study area to help estimate current/future sediment inputs based on watershed area, geology, and extent of glacial cover.

Note that the Skagit River inlet includes areas within Canada (Figure 2.5-2). The study area within Canada will primarily be evaluated using remote sensing data (LiDAR, aerial photographs); field work will be conducted only if necessary, such as because of unavailability of adequately representative sampling locations within the U.S.

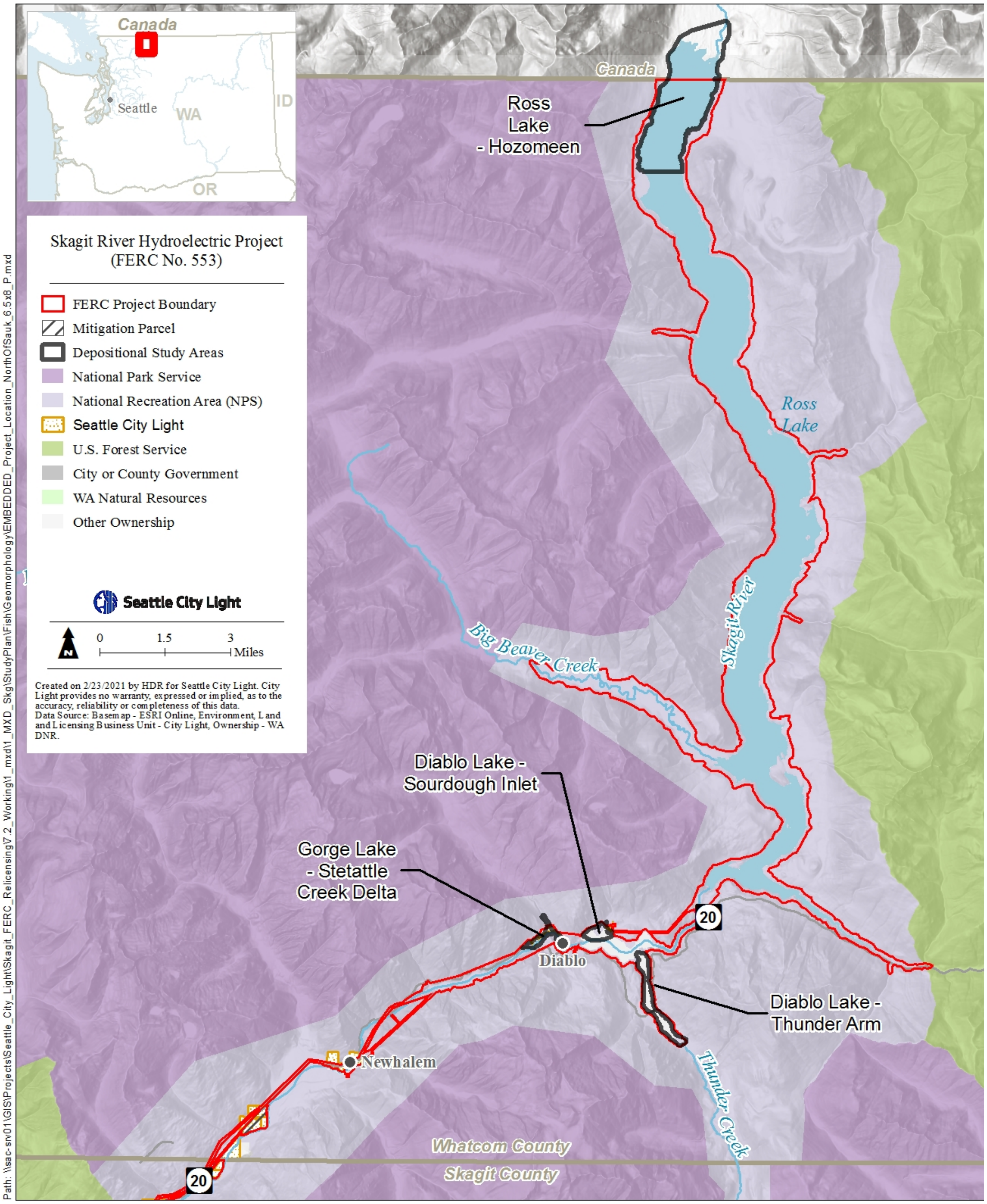

Figure 2.5-1. Overview of study area.

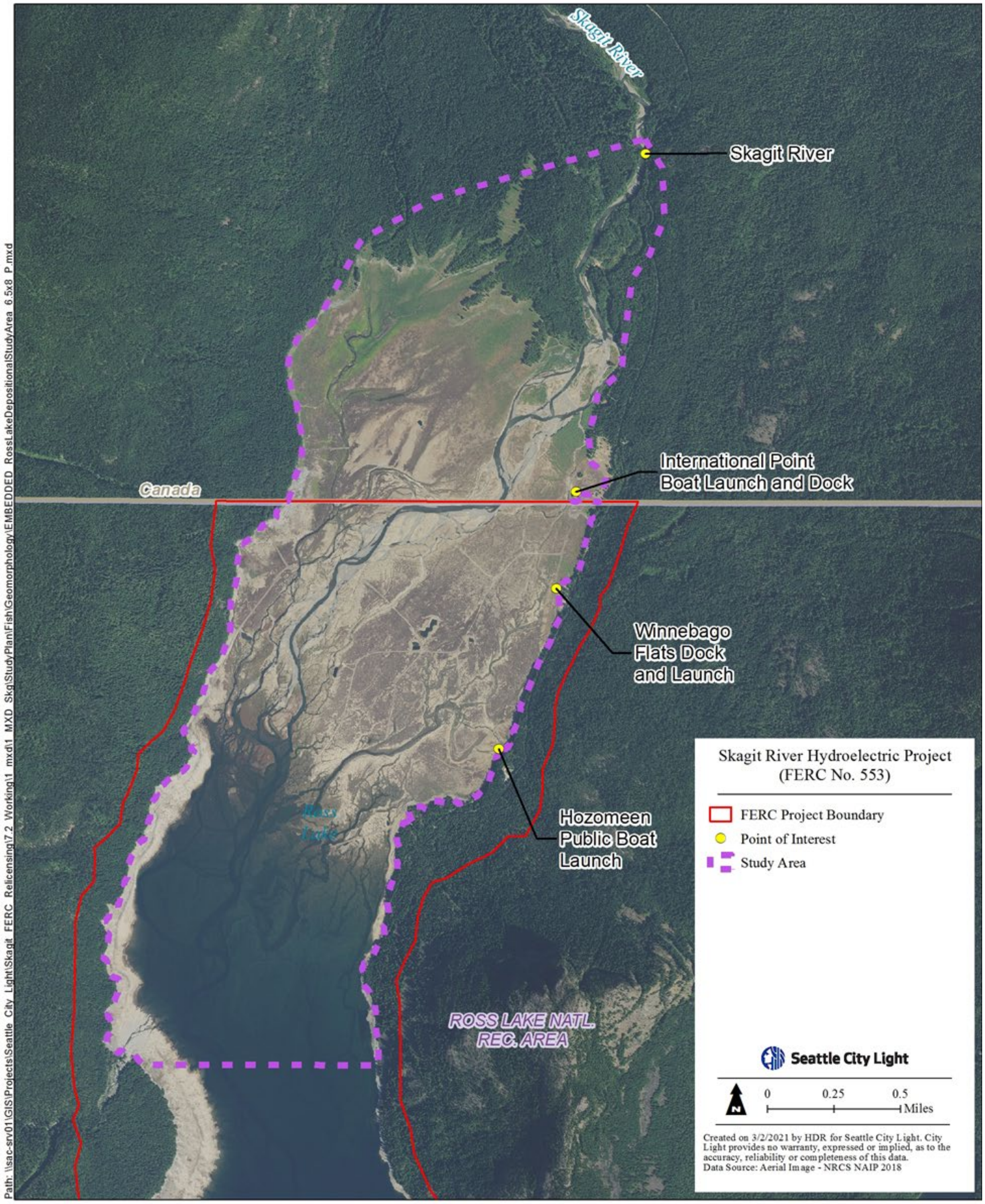

Figure 2.5-2. Study area – Ross Lake - Hozomeen inlet with Winnebago Flats Dock and Launch and Hozomeen Public Boat Launch.[2]

[2] Note: areas within Canada (outside of FERC Project Boundary) will be evaluated primarily using remote sensing methods.

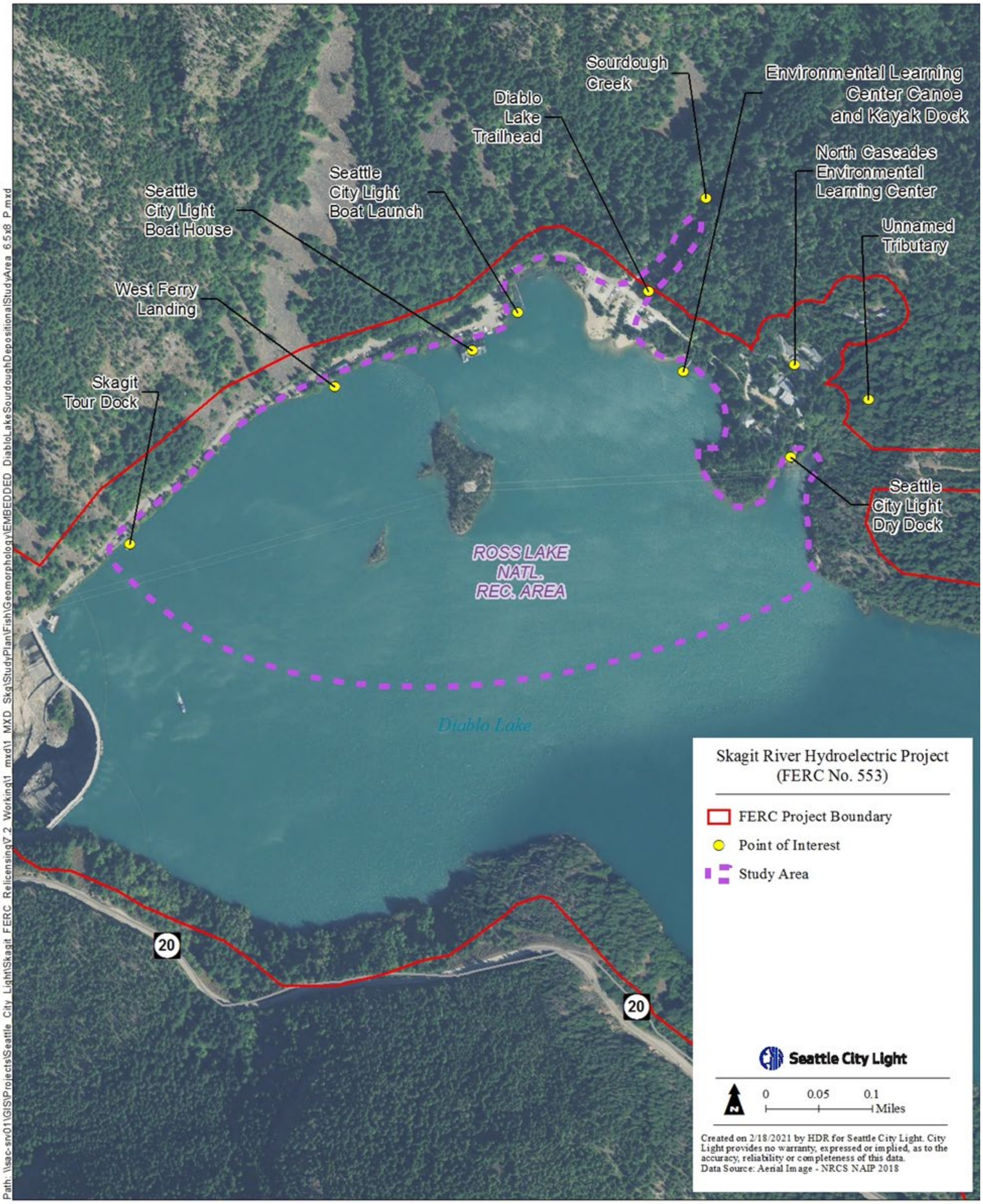

Figure 2.5-3. Study area – Diablo Lake – Sourdough Creek inlet with City Light Boat Launch, City Light Boat House, City Light Dry Dock, West Ferry Landing, Environmental Learning Center Canoe and Kayak Dock and Skagit Tour Dock.

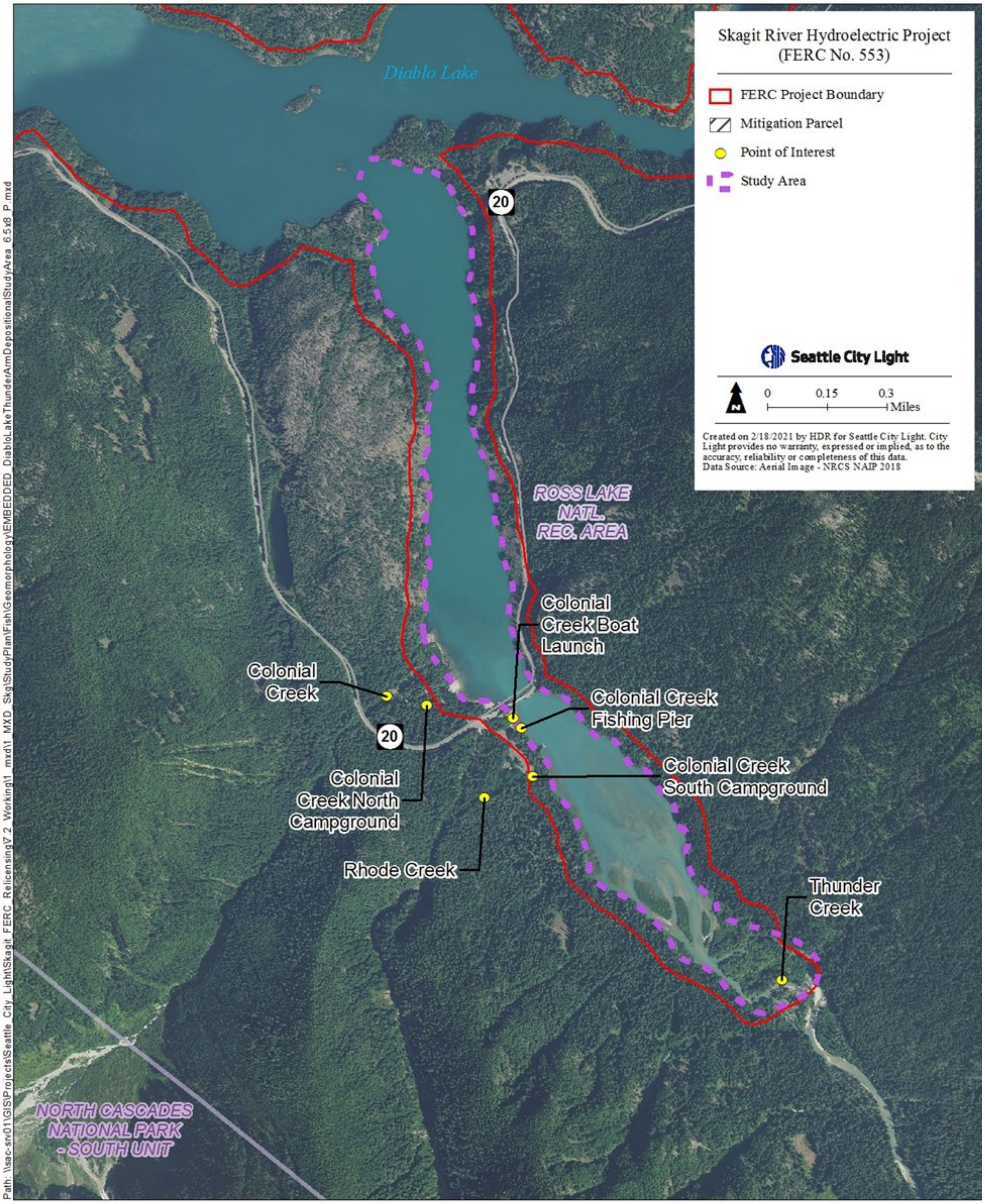

Figure 2.5-4. **Study area – Diablo Lake –Thunder Arm inlet, with Colonial Creek Boat Launch/Dock.**

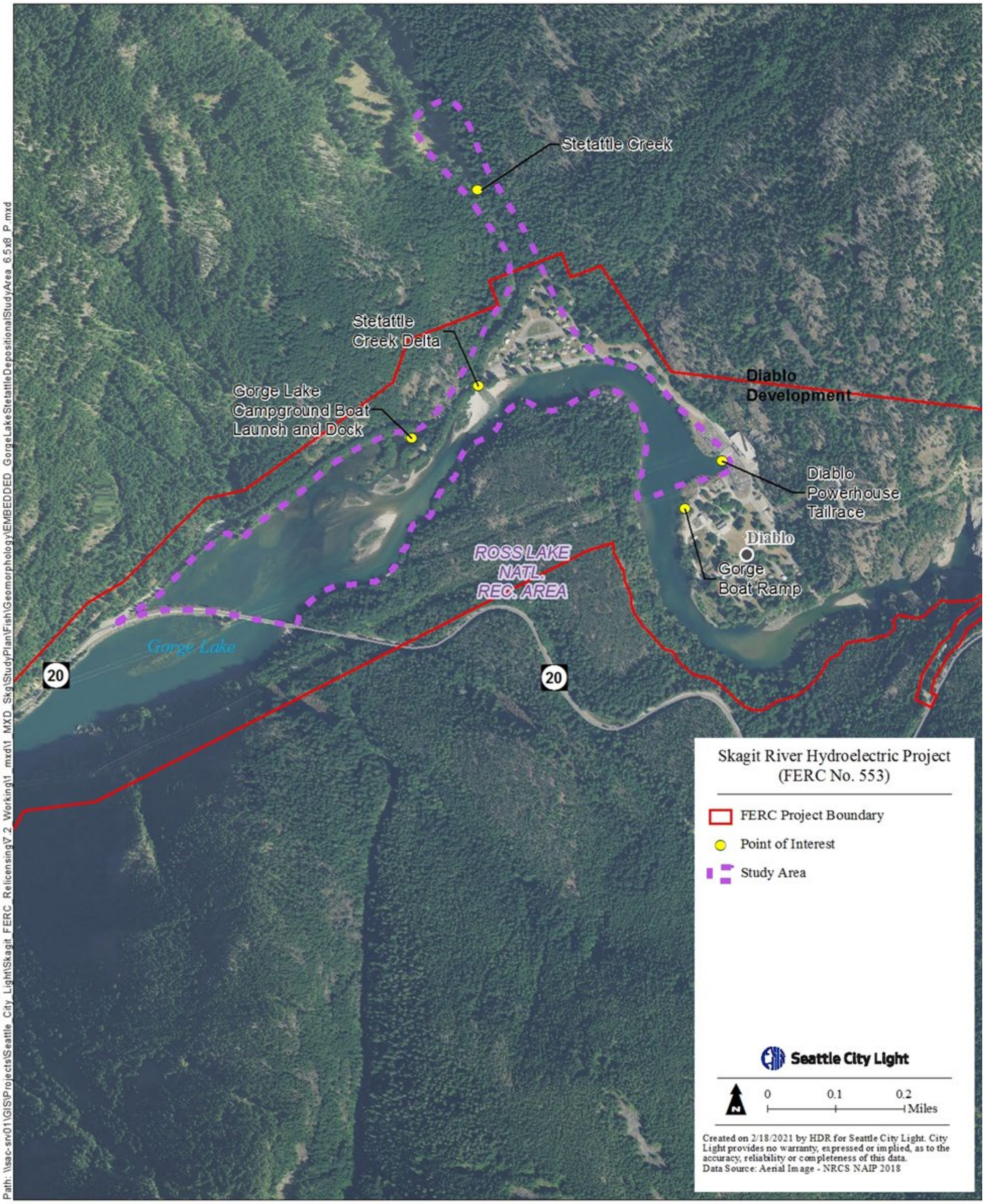

Figure 2.5-5. **Study area – Gorge Lake - Stetattle Creek delta, with Gorge Lake Campground Boat Launch and Dock, Stetattle delta deposit, and Diablo Powerhouse tailrace (Watershed GeoDynamics, In Prep)**

2.6 Methodology

2.6.1 Compile and Assess Existing Information

Existing information on the study area will be compiled (see Section 2.3 of this study plan). These data will be used to develop initial estimates of sediment input/deposition and rates of inlet/delta sedimentation through time.

- Historical and recent topography, LiDAR, and green LiDAR will be used to evaluate total deposit volume within each delta study site (Table 2.6-1).
- Current and historical aerial photos will be used to supplement the LiDAR data and to determine the changes of the deltas/deposits over time (Table 2.6-1). Historical aerials will be georeferenced as needed. The photos that will be included in the analysis are a subset of those years available using photos that are likely to be complete and of a resolution sufficient for the task. The photos used may change as quality and coverage is evaluated: initially, it is proposed that the years 1950, 1978, 1990, 2006, and, most recently, 2018/2019 be used to evaluate change over time. Aerial photographs from different years may be substituted or included if higher quality aerial photographs are located.
- Basin sediment yields will be developed using two methods:
  - Average annual sediment budgets for 10 Skagit River sub-basins developed by Paulson (1997), estimates reported in USACE 2008, and any other pertinent references will be used as appropriate based on a comparison of basin geology/geomorphology for the Sourdough, Thunder, and Hozomeen (Skagit River) watershed drainages to develop average annual sediment inputs on a per-acre basis.
  - Estimates for glaciated areas (e.g., Nichols 2006 and any other pertinent references) will be used for glaciated areas (areas covered by glacial ice) of tributary watersheds.
  - The historical aerial photographs used for the delta/deposition analysis will also be used to note and, if possible, to track through time any large sediment sources, such as landslides, rockslides, or other erosion areas within the Sourdough Creek and Thunder Creek watersheds that should be taken into account for sediment input budgeting purposes.

Table 2.6-1. Project area aerial photograph inventory and remote sensing resources.

Date	Image Type	Scale	Notes
Orthophotos			
1947	Orthophoto quads	1:62:500	
1950	Orthophoto quads	1:62:500	Basis for 15' topo series
1974	Orthophoto quads	1:24,000	Basis for 7.5' topo series
1990	Orthophoto quads, 1-2m res.	1:24,000	Update to 7.5 minute series various quads
1992	Orthophoto quads, 1-2m res.	1:24,000	Update to 7.5 minute series various quads
1993	Orthophoto quads, 1-2m res.	1:24,000	Update to 7.5 minute series various quads
1998	Orthophoto quads, 1-2m res.	1:24,000	Update to 7.5 minute series various quads
Hard Copy Stereoscopic Photographs			
1947	B&W stereo photos	1:27,700	U.S. Forest Service (USFS)
1950s	B&W stereo photos	1:24,000	USFS
8/9-1956	B&W stereo photos	1:24,000	EBK series USFS (NPS incomplete set)
1957	Unclear	1:47,200	VRL series USGS (no NPS set)
1958	Unclear	1:49,000	VSA series USGS (no NPS set)
1963/64	B&W (?) stereo	1:12,000	EMM series USFS (NPS incomplete set)
1973	B&W (?) stereo	?	VCAG series USGS (no NPS set)
1978	True color stereo photos	1:24,000	NPS
1998	True color stereo photos	1:12,000	NPS
Hard Copy Stereoscopic Photographs - Pairs			
1984	Color, Hi- res. CIR min. overlap	1:10,000	NPS prints 3 ft x 3 ft
1990	Hi -res. B&W min. overlap	1:10,000	NPS prints 3 ft x 3 ft
National Agriculture Imagery Program (NAIP) Orthorectified Digital Imagery			
2006	True Color NAIP hi-resolution	1m	Digital
2009	True Color NAIP hi-res.	1m	Digital
2011	True Color NAIP hi-res.	1m	Digital
2015	True Color NAIP hi-res.	1m	Digital
2015	True Color NAIP hi-res.	1m	Digital
2017	True Color NAIP hi-res.	1m	https://viewer.nationalmap.gov/basic
LiDAR			
2018	Ross Lake	0.5m or 1ft	USGS QL1 standards
2018	Gorge and Diablo Lake Green LiDAR	0.5m or 1ft	USGS QL1 standards
2017	Skagit Topobathy	0.5m or 1ft	USGS QL1 standards
Digital Elevation Models/topographic maps			
2017	Western Washington	0.5m or 1ft	3DEP North

2.6.2 Field Data Collection

New data to be collected in the field for the areas of concern (within the U.S.) include bathymetry and distribution and grain size of inlet and delta deposits. Field data are not currently proposed to be collected within Canada. If analysis of available information and proposed fieldwork in the U.S. identify data gaps that must be filled to meet the objectives of the study, City Light will explore the feasibility of field data collection within Canada (outside the Project Boundary).

2.6.2.1 Bathymetry

Bathymetry data will be collected in inlets in Ross and Diablo lakes during high water level in the areas generally defined within Figures 2.5-2 to 2.2-4, excluding riverine environments and areas too shallow for bathymetry. Bathymetry data will be collected during high water level for Ross Lake; June through September generally has the maximum water level. Diablo Lake normally has only a 4- to 5-foot variation in water level, but every attempt will be made to accomplish the bathymetry within the Sourdough Creek and Thunder Arm study areas at the highest water level. Some bathymetry data have been collected for part of the Thunder Arm inlet; these data will be supplemented to cover the entire study area. The area for the bathymetry and sediment deposition analysis has been extended upstream and downstream of the recreational issues of concern (e.g., boat launch) because it is important to understand upstream and downstream controls. For example, the Colonial Creek delta may influence deposition at the Colonial Creek Boat Launch/Dock in the Thunder Arm of Diablo Lake. Data have already been collected for the Stetattle Creek delta in Gorge Lake (Figure 2.5-5) (Watershed Dynamics, In Prep).

2.6.2.2 Sediment Transport and Deposition Zones

The reservoir can act as a base level that influences inlet and delta deposition and riverine sediment transport. Upstream of the reservoirs, there is a point where the reservoir level does not affect riverine transport of sediments, such as an inflection point where the gradient changes from flat and depositional to steeper with more transport-dominated processes. This location will be established by evaluating LiDAR and field evidence. Evaluation of the change in slope can be used to evaluate changes in transport processes (Richards 1982).

An estimate of flow competence within and above the zone of reservoir influence will be made by measuring a cross section, particle size, and slope within the lower gradient depositional zone between the reservoir and the inflection point, and above the inflection point. Flow competence (the point at which the particle of interest, e.g., median particle is just mobile, or “incipient motion”) will be estimated using river gradient, particle size (Wolman pebble count; Wolman 1954), and hydraulic radius of a cross section. These variables will be measured both above and below the inflection point. Incipient motion occurs when critical shear stress on a particle exceeds bed shear stress. Bed shear stress (a function of the hydraulic radius-slope product) will be obtained as output from WinSXPRO, a cross section analyzer (Hardy et al. 2005). Bed shear stress (τ) is expressed as an average force (Newton/square meter [N/m^2]) over the transect width and will be averaged for the entire cross section at bankfull and flood-prone (i.e., elevation of water at twice the maximum bankfull depth) elevations. The shear stress required to initiate motion for a given particle size will be established using the Shield’s relationship that defines the critical shear stress (τ^*_{ci}, the shear stress threshold at which incipient motion occurs). Shield’s relationship for critical shear stress is defined as $\tau^*_{ci} = \beta\ (\gamma_s - \gamma)\ D_x$, where β = Shield’s parameter (dimensionless critical shear stress), γ = specific weight of the fluid, γ_s = specific weight of the sediment[3], and D_x = particle diameter of interest (i.e., D_{16}, D_{50}, and D_{84}, in mm). Recent research has shown the parameter to range between 0.033 and 0.21 (Bunte et al. 2013). A matrix of the flow at which the D_{50} (median particle) and D_{84} (particle distribution of which 84 percent are finer) are mobile will be presented, using different estimates of Shield's parameter.

This information will be used to inform long-term input and influence from upstream and non-Project sediment upon sediment management in the areas of concern.

2.6.2.3 Mapping of Inlet Area Deposits

Laminated aerial photographs pertinent to the study area or a field computer loaded with aerial photographs will be used to map polygons around distinct units within the inlet areas of like-sized particles or "facies," while in the field.

Exposed Sediments

For the area exposed during drawdown (usually March–April for minimum pool level) for the U.S. portion of the Hozomeen inlet in Ross Lake, it will be possible to directly assess the particles and to establish particle size. Within exposed deposits, surficial particle size estimates will be evaluated by compiling a facies map. Facies are groupings of like particles that reflect the conditions and environment of deposition and that serve to distinguish sections of deposits. A facies may consist of, for example, a mixture of poorly sorted grains that is consistent over the entire patch. Facies maps are useful as descriptors of current conditions to capture reach-wide variations in surface size (Kondolf and Piègay 2003). Delineation of the surface bed texture will be separated into distinct units by dominant and sub-dominant grain-size classes (Level I, Buffington and Montgomery 1999). Each patch that represents a facies must have a minimum size of 1,000 ft^2 to be considered a separate facies (approximately 10 meter [m] x 10 m as suggested in Pasternack 2012). Polygons will be drawn around the facies on laminated aerial photographs or a Global Positioning System (GPS)-enabled tablet to provide a visual representation of the variability and distribution of particles.

It is expected that the alluvial fan at the mouth of Sourdough Creek (i.e., the steep delta-shaped deposit external to the mean high water mark of Diablo Lake) can be walked and sampled, along with the shallow inundated sections at the upper end of Thunder Arm and in the U.S. portions of the Hozomeen inlet, and within the riverine zone of Sourdough Creek, Thunder Creek, and the Skagit River upstream of Ross Lake. The small tributary that may be affecting the City Light Dry Dock will also be assessed for sediment supply and type of sediment transported to the reservoir. There may be shallow inundated areas that are too fine-grained and saturated to walk but not deep enough to use a shallow-draft boat; these areas may need to be estimated using aerial imagery.

Sub-Aqueous Sediments

For those areas that are perennially inundated, there are two methods for determining particle size. For the areas over 1.5 feet deep, an inflatable kayak or Johnboat will be used to deploy a petit

[3] Specific weight of water is based on water temperature (e.g., a water temperature of 7.2C has a specific weight of 9,732 N/m^3; specific weight of sediment is based on the particle size (e.g., a D_{90} of 128 mm has a specific weight of 19,322 N/m^3 [Vanoni 1975 p. 40]

PONAR grab sampler. This device can be used to sample particles that cannot be reached by wading. An estimate of the dominant particle size from each sample will be documented. If the site can be waded, visual or tactile estimations of particle size will be documented. Polygons will again be drawn around like-particles.

2.6.3 Analysis

Deliverables will include:

- The in-progress sediment study report for the Stetattle Creek delta in Gorge Lake (Watershed Dynamics, In Prep).

For the three study areas where new data will be collected (e.g., Sourdough Creek, Thunder Arm, inlet, and Hozomeen inlet), deliverables will include:

- A summary report that sets out methods, results, and conclusions.
- Current bathymetry with data tied to mean high-water elevation.
- A digital elevation model (DEM) of study areas developed from bathymetry and existing topography below and outside of mean high-water level.
- A shaded relief map of accumulation of sediments within the study areas below the mean high-water level. Increments of relief will be determined based on the variability and resolution of the data.
- An estimate of total volume of sediment accumulated within the areas of concern.
- A calculation of sediment volume/year deposit within study areas based on the 1952 Ross Dam construction and the 1936 Diablo Dam construction or the latest bathymetry/topographic data available for comparison.
- An estimate of sediment input to the areas of concern by grain size category.
- A qualitative assessment of future deposition and patterns.
- Facies maps of three areas of concern: Sourdough Creek inlet, Thunder Arm, and Hozomeen inlet.
- Location where riverine processes become affected by reservoir level.
- An estimate of sediment mobility in the tributary below and above the inflection point where transport processes change from transport-dominated to deposition affected by the reservoir level in Sourdough Creek, Thunder Creek, and the Skagit River above the Hozomeen inlet.

2.7 Consistency with Generally Accepted Scientific Practice

A comparison of the earliest known original and current topographies to determine changes in sediment deposition location and character is a common component of relicensing studies. Methods vary depending on available data, but estimating changes in sediment deposits is critical to managing Project facilities; methods used herein are similar to those used in other reservoir studies (e.g., Dendy et al. 1973; Kondolf and Piegay 2003; studies summarized in Minear and Kondolf 2009) and relicensing efforts (e.g., Stillwater Sciences 2001; Merced Irrigation District 2011).

Particle size analyses, i.e., facies mapping of deposits and channel morphology studies, are also common assessments used in relicensing studies (e.g., Yuba County Water Agency 2012; 2013; Nevada Irrigation District 2011; Merced Irrigation District 2011).

2.8 Schedule

- Pre-field analysis – March 2020 to March 2021
- Fieldwork – March to September 2021
- Post-field analysis – April to December 2021
- Final Report (Initial Study Report [ISR]) – March 2022

2.9 Level of Effort and Cost

The initial estimate for implementation and reporting associated with this study is approximately $140,000.

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SEDIMENT DEPOSITION IN RESERVOIRS AFFECTING RESOURCE AREAS OF CONCERN
REVISED STUDY PLAN

ATTACHMENT A

CITY LIGHT RESPONSES TO LP COMMENTS ON THE STUDY PLAN PRIOR TO PSP

Table 1. City Light responses to LP comments on the study plan prior to PSP.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
1.	Steve Copps, Jim Myers, and David Price (NMFS)	04/13/2020	General Comments	Each plan suffers from an abbreviated scope and lack of clarity in guiding hypotheses and the questions the studies are designed to answer. From NMFS' perspective, the study plans should clearly state the anticipated utility of the proposed research in understanding the past, current, and future effects of the project on ESA-listed salmonids, Critical Habitat, Essential Fish Habitat, and Treaty Trust Responsibilities. Fish habitat includes a diverse assemblage of aquatic and terrestrial species that are affected in time and space by the operations at the dams. Further, the study plans should clearly state the anticipated utility of proposed research in understanding the status quo, assessing ongoing project effects, and predicting the effects of future management plan scenarios under a new license, including climate change scenarios.	City Light acknowledges the need for consultation with NMFS related to its regulatory responsibilities as required in the FERC process and that the information resulting from the study program is intended to inform consultation with NMFS during future steps within the process. The FERC process schedule positions the integrated environmental analysis subsequent to the completion of the study program and prior to the filing of a Project License Application. City Light currently manages and investigates existing depositional features and over the course of the relicensing will identify appropriate PME measures in consultation with LPs.
2.	Steve Copps, Jim Myers, and David Price (NMFS)	04/13/2020	General Comments	The study plans should describe in detail how they will inform our collective understanding of fish and aquatic habitat and ecology. To that end, the study plans should be forward thinking in connecting the anticipated results between these and other study plans. The connections between study plans should be made explicit now to ensure researchers are thinking ahead about the utility of their data from both technical and analytical perspectives and so that plans and associated cost estimates fully reflect foreseeable tasks. Explicitly making these connections will also assist NMFS and other LPs understand exactly how our data needs will be met through multiple study plans.	The integrated environmental analysis referred to in Comment #1 will specifically address links across resource areas. City Light will work with the RWGs to integrate information from related studies as part of the ILP process.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
3.	Steve Copps, Jim Myers, and David Price (NMFS)	04/13/2020	General Comments	The geographic and temporal scopes of the draft Geomorph and Operations Model study plans are insufficient. The Geomorph study should be extended to include the full extent of project effects on geomorphic processes. That includes at a minimum, downstream to Puget Sound and upstream through the bypass reach and Stetattle Creek where the project precludes a known population of ESA-listed steelhead from migrating and spawning. The Geomorph and Operations Model draft study plans should be developed to improve our collective understanding of historical processes (including pre-dam conditions) so that they can be compared to the status quo and future management scenarios. **New comments from Brock Applegate (WDFW) provided on 05/05/2020:** SCL current operation of the project does not allow fish passage between the reservoirs or upstream to Stetattle Creek. In addition, SCL refused to study fish barriers in the bypass reach or acknowledge that at the very least, steelhead can migrate to the plunge pool below Gorge Dam. With additional flow, WDFW expects more upstream fish passage to Gorge Dam, through the partial fish barriers described in the Envirosphere report. SCL would not write a study plan, but only looked at the possibility of fish in the bypass reach with only limited amounts of surveys and no study plan.	Please refer to the Geomorphology and Operations Model study plans for City Light's respective responses for those studies. The FERC baseline is existing conditions, and therefore pre-dam conditions are not considered in this study plan. Project effects would more than likely be indiscernible in the lower reaches of the Skagit River and Puget Sound given the complex array of factors contributing to existing environmental conditions in the lower reaches of the Skagit River. City Light plans to assess the nature of the Project's contribution to cumulative effects downstream of the Sauk River confluence using existing available information as part of the relicensing process. **Response to comments provided on 05/05/2020:** Thank you for your comment. Additional discussions regarding the issue of Project fish passage are anticipated and City Light welcomes discussion of this issue with LPs in the future.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
4.	Steve Copps, Jim Myers, and David Price (NMFS)	04/13/2020	General Comments	The draft Sediments Deposition study plan should consider the effects of project operations on biological processes including fish movement between the reservoir and tributaries. **New comment from Brock Applegate (WDFW) provided on 05/05/2020:** SCL did not answer the question of fish passage to Stetattle Creek or between the reservoirs.	City Light currently mitigates for potential effects on fish migration/passage resulting from sediment and woody debris deposition in Project reservoirs, and intends to continue the effort. The 1991 Settlement Agreement stipulates that City Light is to survey for and remove transitory barriers to spawning migration in tributaries to Project reservoirs. City Light has agreed to expand the annual barrier surveys and barrier removal efforts beginning in 2020 following NCC approval. **Response to comment provided on 05/05/2020:** See response to Comment #3.
5.	Steve Copps, Jim Myers, and David Price (NMFS)	04/13/2020	General Comments	The draft study plans would benefit from collaboration within the FA Group to harmonize LP comments and explore opportunities for improving efficiency and utility of the anticipated results in meeting the needs of all License Participants. **New comment from Brock Applegate (WDFW) provided on 05/05/2020:** SCL informs LPs that if they want fish passage and other study plans that the other 99% of the LPs want, "Go to FERC with your study plan request." This response does not equal collaboration. Although the identification of study issues forms felt collaborative, the process to bin and prioritize did not. The LPs have consulted on the creation of the current study plans. WDFW respects and appreciates the consultation on study plans and SCL's prerogative to do so, but the LPs would not call the current study plan creation as collaborative.	The requested collaboration is underway, as evidenced by the 2019-2020 voluntary study identification process, including this study plan and associated comment-response effort. Moreover, City Light will continue collaboration with LPs regularly throughout the ILP process. **Response to comment provided on 05/05/2020:** City Light appreciates your agency's input and looks forward to working with you to address resource issues during the relicensing proceeding.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				SCL did not choose the collaborative licensing process, the Alternative Licensing Process (ALP). WDFW remains fine with the status of study plan consultation, but SCL has chose something different than 100% collaboration.	
6.	USFS	04/14/2020	General Comments	It is not stated in the draft study plan how the methods and measures for analysis will result in a better understanding of project effects on sediment depositional dynamics, and more importantly on aquatic habitats. **New comment from Brock Applegate (WDFW) provided on 05/05/2020:** Sediment deposition in the reservoirs and below the project has affected upstream fish migration. WDFW does not need population effects for SCL to violate State law. If you have fish passage blockage, SCL has violated State law. With that said, WDFW looks forward to working with SCL to find solutions to fish passage problems.	The data collected as part of this study plan will be used, in conjunction with data on Project reservoir elevation fluctuations, to help understand Project effects on sediment deposition in the areas identified in the study plan. Regarding aquatic habitat, City Light is unaware of any Project-related adverse effects due to sediment deposition that are affecting fish in the reservoirs, i.e., the status of reservoir fish populations does not indicate that there is a habitat-related issue. However, City Light welcomes LP input regarding specific aquatic habitat issues associated with sediment deposition in the reservoirs, and the associated information for such adverse effects on any fish species/life-stage. **Response to comment provided on 05/05/2020:** City Light appreciates your agency's input and looks forward to working with you to address resource issues during the relicensing proceeding.
7.	USFS	04/14/2020	General Comments	The draft study plan cites FA44 and FA45 as issues the study will address but there is no specific goal/objective for evaluating project effects on sediment deposition dynamics and consequent impacts to aquatic habitat, no methods to evaluate those impacts, and no	References to these issue forms have been deleted from this study plan, and text has been added to Section 1.3 to better explain the role of the issue forms in contributing to City Light's suite of study proposals.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				measures for analysis that will develop conclusions on those likely impacts.	With regard to effects of sediment deposition at tributary mouths on fish passage/migration or aquatic habitat, see responses to Comments #4 and #6 and #10.
8.	USFS	04/14/2020	General Comments	This study plan appears to address the data gap and resource impacts identified in RA01 Recreation and Visitor Use.	Yes, this study is intended to address a data gap which was first brought forward in the Recreation and Aesthetics RWG. Subsequent discussions among the geomorphology subgroup did not identify additional locations at that time where sediment deposition was identified as an impact to biological resources. Per comment response #4 and #10, City Light sees an opportunity to address potential sediment deposition issues in other areas through direct management action by expanding the current reservoir tributary barrier removal program.
9.	Brock Applegate (WDFW)	04/13/2020	Section 1.2 Relicensing Process	"This study plan reflects the RWG consultation ~~effort~~, and City Light will continue to engage the RWG structure in the preparation of the Proposed and Revised Study Plans….." **New comment provided on 05/05/2020:** When Seattle City Light constantly tells the LPs to "take their study plan request to FERC," the LP does not feel like they have collaborated. WDFW agrees to disagree, but also realizes that SCL have every right to pick their licensing and consultation process.	Section 1.2 and 1.3 were redrafted to better describe the 2019 process. Formal consultation does not begin until after the PAD is officially submitted. Although the informal 2019 process leading up to the development of draft study plans did not result in consensus regarding all issues raised by LPs, City Light views this process as a collaborative effort (i.e., the action of working together). **Response to comment provided on 05/05/2020:** Thank you for your comment.
10.	Jon Riedel (NPS)	03/27/2020	Section 1.3 Study Plan Development	What about Big Beaver. There is a massive sand delta there that is a major source of fine sediment. Is it being transported to dam? Affecting turbidity? Prone to collapse? Filling river channel when lake down?	Understanding tributary delta sediment deposits that may impact natural resources is a shared interest of City Light. We see opportunity to incorporate information gathering into the current tributary delta barrier removal program and possibly identify a management PM&E

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				New comment from Brock Applegate (WDFW) provided on 05/05/2020: LPs have also brought up sedimentation concerns for natural resources as well, but SCL has only moved forward with these particular spots that have recreation and facility concerns.	measure in subsequent consultation associated with relicensing. The focal areas of this proposed study are based on the issues identified by LPs from sediment deposition concerns around specific recreational resource assets. Turbidity is being addressed as part of the Water Quality Study as part of actions to fill data gaps on existing conditions in Ross Lake. **Response to comment provided on 05/05/2020:** Thank you for your comment. Please refer to specific comments in this table related to natural resource concerns from LPs and City Light has provided responses to specific issues identified; if WDFW has specific resource issues it believes are not captured, City Light welcomes further discussion.
11.	Brock Applegate (WDFW)	04/13/2020	Section 1.3 Study Plan Development	WDFW feels like SCL should focus on the Big Beaver Creek and wetlands. Although the sediment may or may not affect reed canarygrass population in the area, sediment aggradation could affect fish habitat and passage. SCL should make this area, an area of focus for aquatic restoration activities and wetland mitigation. SCL should address sediment issues in other area besides those listed in this study plan. SCL should do a sediment budget model to describe how much sediment the Project cuts off, does not transport downstream, and stores.	City Light believes that quantifying the rates of sediment by the Project is not necessary to mitigate for potential Project impacts on downstream resources. Rather, during relicensing, City Light plans to work with LPs to gather information and develop tools to support current and future environmental resource objectives in the Skagit River downstream of the Project (i.e., Gorge Dam to Sauk River). This will include addressing limiting factors to fish populations by continuing, and possibly modifying, City Light's instream flow program and identifying and implementing active habitat restoration and effectiveness monitoring. City Light hopes to collaborate with LPs to take a resource-benefit

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
					approach, e.g., identifying locations in the Skagit River below the Project and then targeting eventual PME measures to improve ecological function at those locations. Ongoing wood management activities will also provide information on wood inputs to the reservoirs. With regard to effects of sediment deposition at tributary mouths on fish passage/migration or aquatic habitat, see responses to Comments #4 and #6 and #10. Regarding the comment on reed canarygrass, the Invasive Plant Inventory will address reed canarygrass distribution.
12.	Brock Applegate (WDFW)	04/13/2020	Section 1.3 Study Plan Development	SCL should also address aggradation of sediment at the tributaries to all the reservoirs with fish. SCL should evaluate fish passage in the spring for spawning resident trout and the fall for spawning char. Fish barriers often occur when the reservoir elevation drops. Sediment often drops out of the creek when it flows into the reservoir or backwater caused by it, which increases the aggradation and possible fish passage blockages. **New comment provided on 05/05/2020:** See my response to your response on # six.	See responses to Comments #4 and #6 and #10. **Response to comment provided on 05/05/2020:** See response to Comment #10.
13.	Judy Neibauer (USFWS)	04/13/2020	Section 1.3 Study Plan Development	"Ongoing sediment deposition in Project reservoirs is known to affect recreational resources (boat launches and docks), fish and wildlife resources, operational facilities (docks and landings), and/or power generation at two locations, and potentially may have similar effects at two additional locations."	See responses to Comments #4, #6, and #10. With regard to wildlife, City Light is proposing to conduct studies to assess potential Project effects on wildlife. City Light is also providing baseline information on vegetation throughout the Project area, i.e., Vegetation Mapping, Wetlands Assessment.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				Please include more locations and additional objectives in this study. You may need to link to the geomorphology, and operation studies for additional information to inform sediment deposition in reservoirs. Also see my comments in the Geomorphology study where I mentioned to add geomorphology assessments above the dams. Understanding if there are naturally higher sediments coming down from tributaries will help to in determining operational effects. Sedimentation in reservoirs are known to cause effects to aquatic and wildlife species and habitats. Sediments deposit at most of the larger tributaries, where they connect with reservoirs. This may occur at multiple reservoir elevations bands, creating sediment deposition where ever the mouth of the stream has intersected with the reservoir. Additionally, aggradation of substrates/sediments can occur in many of the reservoir tributaries due to the effect of the reservoir slowing down the energy of the stream and causing aggradation of larger and smaller substrate upstream from the reservoir some distance upstream. Turbidity and sediment deposition in the reservoirs also happens due to wind/rain action lapping at the exposed shorelines/sediments on the reservoir beds, and can be extreme. Turbidity can extend many yards out into the reservoir. This can cause effects to foraging/migrating fish, depending on the time	City Light welcomes any information that licensing participants may provide that will inform Project related effects on wildlife due to sedimentation. **Response to comment provided on 05/05/2020:** Thank you for your comment. Please see responses to Comments #10 and #13.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				of year, but especially during juvenile out migration and adult spawning migrations. **New comment from Brock Applegate (WDFW) provided on 05/05/2020:** SCL has other areas to address sedimentation than just recreation facilities.	
14.	Jon Riedel (NPS)	03/27/2020	Section 1.3 Study Plan Development	1st Bullet – Comment "Hozomeen inlet" Never heard this term before.	This term was used to better describe the location.
15.	Brock Applegate (WDFW)	04/13/2020	Section 1.3 Study Plan Development	4th Bullet – Add red text "The delta deposit that has formed at the outlet of Stetattle Creek is used for whitewater training and instruction and long-term effects upon this use should be evaluated, along with containing spawning habitat for rainbow trout."	Effects on recreational resources will be included in recreation resource studies and the license application. Rainbow trout continue to have access to spawning habitat in Stetattle Creek and City Light is not aware of any information on impediments to passage or habitat use of the Stetattle Creek delta area by rainbow trout. See responses to Comments #4 and #6.
16.	Rick Hartson (Upper Skagit Indian Tribe)	04/11/2020	Section 1.3 Study Plan Development	1st Paragraph – Comment The study should consider sediment deposition across the entire reservoir system. The project has been in place for over a century, over which time sediment deposition may have reduced reservoir storage capacity. It is important to determine if, and to what extent, this may be impacting operational flexibility, including instream flows, fisheries and aquatic resources. Additionally, measuring total sediment deposition would provide important information for the geomorphic assessment, for example the ability to estimate average annual sediment input.	See responses to Comments #1, #6, and #11.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
17.	Rick Hartson (Upper Skagit Indian Tribe)	04/13/2020	Section 1.3 Study Plan Development	Bullets 1 through 4 – Comment Additional locations should include all fish-bearing tributaries to determine impacts to fish passage that have already occurred and that are expected to continue, increase, or manifest over the course of the next license term. Passage may be interrupted due to sedimentation patterns associated with reservoir operations. Specific impacts may include lack of channel definition resulting in diffuse flows with water too shallow to allow normal fish passage, loss of surface flow as water infiltrates depositional features, or physical blockages created by wood and other debris that gets deposited as reservoirs are drawn down.	See response to Comment #4.
18.	Bob Mierendorf (Upper Skagit Indian Tribe)	04/13/2020	Section 1.3 Study Plan Development	1st Bullet – Comment The Hozomeen inlet is archaeologically and culturally significant to the Upper Skagit Indian Tribe, which is concerned that sedimentation may be affecting some in the cluster of archaeological sites documented in this area (see 2011 Archaeological Resources Mitigation and Management Plan).	Effects on cultural resources are being addressed in the Historic Properties Management Plan.
19.	Rick Hartson (Upper Skagit Indian Tribe)	04/11/2020	Section 1.3 Study Plan Development	Last Paragraph - Comment Geomorphology study needs could be addressed related to average annual sediment input rate. Reservoir fishery study needs could be addressed by understanding fish passage impacts into tributaries. See above comments.	See responses to Comments #4 and #10 and #11.
20.	Judy Neibauer (USFWS)	04/13/2020	Section 1.3 Study Plan Development	"Issues to be addressed by this study are identified in the following issue forms: (1) FA44 Sediment Deposition within Reservoirs that Affect Resources of Concern; (2) FA45	See responses to Comments #6 and #13.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				Bathymetry and Sediment Deposition within Reservoirs; and (3) RA01 Recreation and Visitor Use.” Include additional objectives to identify other Resources of Concern. At the least it should also include fish and wildlife, and I also added it above.	
21.	Judy Neibauer (USFWS)	04/13/2020	Section 1.3 Study Plan Development	“Issues to be addressed by this study are identified in the following issue forms: (1) FA44 Sediment Deposition within Reservoirs that Affect Resources of Concern; (2) FA45 Bathymetry and Sediment Deposition within Reservoirs; and (3) RA01 Recreation and Visitor Use.” Link bathymetry to operations modeling to determine if there are shallow areas or areas of potential barriers that develop within the reservoirs during drawdown. This can also inform the future fish passage study.	See response to Comment #4.
22.	Judy Neibauer (USFWS)	04/13/2020	Section 1.3 Study Plan Development	Issues to be addressed by this study are identified in the following issue forms: (1) FA44 Sediment Deposition within Reservoirs that Affect Resources of Concern; (2) FA45 Bathymetry and Sediment Deposition within Reservoirs; and (3) RA01 Recreation and Visitor Use. This study should also be used to help inform the Fish and Wildlife Coordination Act components of FERC (i.e. Section 10j in the FERC process).	See response to Comment #7. The study program and subsequent integrated effects analysis and NEPA document will provide the information necessary for LPs to execute their statutory responsibilities under the Federal Power Act.
23.	USFS	04/14/2020	Section 1.3 Study Plan Development	***The FS recommends*** only including those issues, and referencing those issue forms, that are explicit goals and/or objectives of this study	See responses to Comments #4, #6, and #7.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				plan. If methods are not designed to study the specific data gaps identified in the issue forms, then issues should not be included here. Alternatively, describe in sufficient detail how conclusions drawn from this study plan will inform project effects on the issues brought forward in this paragraph. In particular, there is no mention of aquatic habitat impacts from sediment deposition, yet that measure seems a priority in both FA issue forms (as described by LP comments). ***The FS recommends*** including study design methods, or include an interpretation of the data collected from proposed methods, that is specific to project effects on aquatic habitat as described in the issue forms for FA44 and FA45. Alternatively, focus on solely issues of RA01 Recreation and Visitor Use.	
24.	Judy Neibauer (USFWS)	04/13/2020	Section 2.0 Study Plan Elements	I found a great source that identifies what Study Guide Criteria should be addressed in these study plans. Maybe you have seen it, but here is the link… https://www.ferc.gov/industries/hydropower/gen-info/guidelines/guide-study-criteria.pdf	City Light appreciates the input.
25.	Ashley Rawhouser (NPS)	04/13/2020	Section 2.1 Study Goals and Objectives	1st Bullet – Comments In general, the scope of this study is too limited in both geographic extent and in terms of the resources that are potentially impacted. This appears to initiate a piece meal approach to dealing with sedimentation issues related to the dams and this will likely create confusion for	See response to Comment #11.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				LP's, FERC, and SCL down the road. NPS identified the need to develop updated bathymetric maps covering all the reservoir as a baseline piece of information needed early in the process. And that these maps will be needed to address multiple issues. As such, the limited scope of the study is problematic and needs to be expanded. Why aren't the forebays of the dams and the confluences of a tributaries with the reservoirs part of the scope?	
26.	Judy Neibauer (USFWS)	04/13/2020	Section 2.1 Study Goals and Objectives	I agree the goal and objectives seems limited. Either expand this study or add a new study to look at fish and wildlife habitat issues related to sedimentation, deposition, and turbidity, related effects from operations. You may also want to link to the geomorphology study data you will be collecting.	See responses to Comments #4, #6, #10, and #13.
27.	Jon Riedel (NPS)	03/27/2020	Section 2.1 Study Goals and Objectives	4th Bullet – Comment Note problems with deposition by 3 streams; Thunder Colonial and Rhode. Rhode cr primary source of sediment to boat launch.	All three tributaries will be analyzed as part of this study.
28.	Judy Neibauer (USFWS)	04/13/2020	Section 2.1 Study Goals and Objectives	5th Bullet – Comment "Stetattle Creek delta in Gorge Lake (i.e., the sediment deposited at the mouth of Stetattle Creek where it enters Gorge Lake) and the sediment deposited between Stetattle Creek and the State Highway 20 bridge crossing." I am guessing that there is a much larger list of tributaries that contribute to migratory and resident fish spawning, rearing, and foraging, that are in need of assessment. Please add key	See responses to Comments #4 and #6. Also see responses to comments in the Geomorphology Study Plan.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				fish bearing tributaries, their intersections with the reservoir at multiple locations, and some distance upstream where aggradation/deposition may occur. See my comments in the geomorphology study to add areas above the dams and in tributaries. This will help to determine if depositions are partly natural or caused by the lowering and raising of the reservoirs. You will likely want to link to the geomorphology study.	
29.	Judy Neibauer (USFWS)	04/13/2020	Section 2.1 Study Goals and Objectives	Added 7th Bullet "Identify where there are likely aggradation and depositional areas are within tributaries that are and will continue to be connectivity issues for aquatic and wildlife species and or are problem areas in need of restoration."	See responses to Comments #4, #6, and #13.
30.	Brock Applegate (WDFW)	04/13/2020	Section 2.1 Study Goals and Objectives	8th Bullet – Add red text "Identify likely future zones and patterns of deposition with respect to natural resources, recreational resources, and operational impacts."	City Light chose not to adopt this edit, because the focus of this study is to address recreational resources and operations areas. Assessment of potential Project impacts on other resources will be reviewed with LPs during the ILP and in some cases addressed through management measures. Please see responses to Comments #4, #6, #10 and #13.
31.	Brock Applegate (WDFW)	04/13/2020	Section 2.1 Study Goals and Objectives	8th Bullet – Comment The manipulation of this sediment may cause fish and wildlife impacts. Please explain the environmental effects as the NEPA documentation will require.	As required by the ILP schedule, the NEPA analysis, follows the study phase of the process. FERC's NEPA document will address Project effects and effects associated with implementing potential PMEs. If PMEs are identified that involve the manipulation of sediment, an environmental analysis of that action would occur at that time.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
32.	Rick Hartson (Upper Skagit Indian Tribe)	04/12/2020	Section 2.1 Study Goals and Objectives	1st Paragraph – Comment "The goal of the Reservoir Deposition Affecting Resource Areas of Concern Study is to evaluate the effects of deposition on four specific recreational resources and operations areas within Ross, Diablo, and Gorge lakes." See previous comments regarding need to expand study scope to entire reservoir system, and aquatic resources.	See responses to Comments #4 and #6 and #10. Also, recreation impacts resulting from sedimentation deposition are not occurring universally, so this study is focused on areas of known impact.
33.	Curtis Clement (Upper Skagit Indian Tribe)	04/13/2020	Section 2.1 Study Goals and Objectives	1st Bullet – Comment This study will be using some existing sediment budgets as a starting point to understand potential sediment input. SCL should use the data they collect at these sites and develop new sediment budgets for each of these basins for comparisons. The budgets described were developed in areas within entirely different geologic domains and different forest practices. Additionally, the sub-basins listed here are not that similar in size, overall aspect or level of glaciation; even if they are at least in the same geologic domain. This study should include development of new sediment budgets based on collected data for each of these basins.	Data from previous sediment input budgets in the Skagit River basin will be used as just one tool to help evaluate sediment input from the listed watersheds. Data collected from each basin and delta deposit will also be used to evaluate sediment input at each location.
34.	Rick Hartson (Upper Skagit Indian Tribe)	04/13/2020	Section 2.1 Study Goals and Objectives	6th Bullet – Comment The study should differentiate between natural pre-project depositional features and sediment deposits that started occurring as a result of the project.	Traces of submerged natural depositional features will likely be difficult to detect and measure in a meaningful way. The goal of this study is to estimate depositional rates in the recreational resource areas of concern under existing conditions rather than address specific pre-Project features. See response to Comment #1.

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35.	Rick Hartson (Upper Skagit Indian Tribe)	04/11/2020	Section 2.1 Study Goals and Objectives	7th Bullet – Comment "Identify likely future zones and patterns of deposition with respect to recreational resources and operational impacts." And fishery and aquatic resources.	See responses to Comments #4 and #6.
36.	USFS	04/14/2020	Section 2.1 Study Goals and Objectives	***The FS recommends*** modifying the goal of the study plan to include some measure of project effect on aquatic habitats as a result of reservoir sediment deposition. Aquatic habitats are a resource of concern, and are identified in issue forms FA44 and FA45. ***The FS recommends*** clarifying the goal statement to ensure the study plan is to *"…evaluate* ***project effects*** *of* ***sediment deposition****…"* The results of the study should provide SCL and LPs an ability to distinguish the naturally occurring depositional patterns versus those created by project operations. ***The FS recommends*** including an evaluation of all tributary confluences that have known benefit to aquatic organisms and their habitats. This evaluation could possibly be extrapolated from the data being collected as part of the proposed study design given that the proposed study area is quite large. Effects of project operation on tributary/reservoir confluence habitat is a data gap and could be addressed in this study design.	See responses to Comments #1, #6, and #34.
37.	Brock Applegate (WDFW)	04/13/2020	Section 2.2 Resource Management Goals	Add red text "City Light will confer with resource agencies and tribes that are interested in participating in	See responses to Comments #1 and #2.

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				development of this study proposal, and language identifying specific management goals and possible environmental effects relevant to this study proposal is anticipated."	
38.	Judy Neibauer (USFWS)	04/13/2020	Section 2.2 Resource Management Goals	According to guidelines for the ILP…this section should also include Information about public input considerations…Maybe you have this somewhere else? See this link: https://www.ferc.gov/industries/hydropower/gen-info/guidelines/guide-study-criteria.pdf	See response to Comment #24. Also, it is worth noting that the criteria pertain to "public interest," not public "input".
39.	Rick Hartson (Upper Skagit Indian Tribe)	04/11/2020	Section 2.2 Resource Management Goals	1st Paragraph – Comment Upper Skagit Indian Tribe is interested in evaluating sediment deposition across the entire reservoir system, and the associated impacts on cultural, fishery, and aquatic resources.	See responses to Comments #4, #6, and #18.
40.	Judy Neibauer (USFWS)	04/13/2020	Section 2.2 Resource Management Goals	"City Light is interested in evaluating the effects of deposition in the four identified areas of concern in order to inform the relicensing process." This should be expanded to include other goals and objectives… see above comments	See responses to Comments #6, #10, #11, #13, and #18.
41.	Rick Hartson (Upper Skagit Indian Tribe)	04/13/2020	Section 2.2 Resource Management Goals	2nd Paragraph – Comment As currently scoped, it appears the study is not adequate to address Upper Skagit Indian Tribe's specific management goals. The study scope should include the entire reservoir system so that system-wide impacts can be understood and addressed. For example, see earlier comments related to average annual sediment input rate, tributary fish passage, and reservoir storage capacity.	Although addressing specific, relevant management goals is at times an objective of resource studies, not all agency and Tribal management goals pertain to the FERC relicensing study program. As the ILP unfolds, City Light will work with LPs to identify and address management goals that intersect with relicensing. See responses to Comments #4 and #11.

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42.	Judy Neibauer (USFWS)	04/13/2020	Section 2.2 Resource Management Goals	Add in any other agency resource management goals? NPS? WDFW? See your other study plans, you mention there might be other agency resource management goals. You could list them here too…	Edits have been made so that the content of the referenced section is consistent with that of other City Light study plans.
43.	Judy Neibauer (USFWS)	04/13/2020	Section 2.3 Background and Existing Information	"Delta formation and deposition in specific areas of Project lakes affects access to/from certain recreational facilities (boat launches, docks), operational facilities (docks and landings), aquatic and wildlife species and habitats, and/or power generation." This is a section where maybe you add a paragraph showing how previous issues, and current information/data will be used in the assessments and effects analysis of aquatic habitats…you could put that in a table that links the office data with the field data, issues, and key questions. See my comments in this section in the geomorphology study too Link to the shoreline erosion study, the geomorphology study, and operational model study…there are likely overlaps with these studies where data from each could inform the other.	See responses to Comments #2, #6, and #13.
44.	Judy Neibauer (USFWS)	04/13/2020	Section 2.3 Background and Existing Information	"Existing information that contributes to the understanding of sediment deposition rates and processes in the areas of concern includes:" Include major tributaries and deposits within the reservoir beds in these assessments. You will need to that identify fish passage issues, upstream tributary habitat conditions, and	See responses to Comments #4, #6, and #10. Thank you for the interesting reference to another reservoir system, likely with different dynamic processes affecting the transport of sediment and fish behavior. City Light is not aware of evidence that salmonids are being

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				aggradation of substrates/sediments. Information about depositions (i.e. in rivers/tributaries and in reservoirs) and including areas of wind driven turbidity and deposition; will be needed to assess current and future operational effects from the lowering and raising reservoirs. There is evidence that shows operational effects occur within the reservoir beds to bull trout from such things as predation and poor habitat. As reservoirs lower, and migratory bull trout are located within the small river channels/braided channels while migrating to and from spawning tributaries. Predation occurs due to the lack of cover and sediments that form stream banks in the reservoir bed. Edges of the stream banks (i.e. within the reservoir bed) can collapse and bury migratory bull trout that may be hiding or holding in the reservoir portion of the stream. An example of this occurred in an Idaho BOR reservoir in the N. Fork Boise system, where they found a dead bull trout that had a radio tag and was buried in 20 cm of the collapsed sandy stream banks within the reservoir bed. I am not sure where this effect falls out yet (passage, habitat, sediment deposition?)…but it was a combination of sediment deposition in the reservoir beds and the operational drawdowns that likely caused this effect. The study was conducted by USBOR. And here is the reference. Salow and Hostettler 2004. There are also studies in the Yakima basin, within bull trout spawning habitat associated with reservoirs where sediment deposition at stream junctions, within tributaries, and within	buried in sediments near the mouths of tributaries in the Skagit system, nor that predation on bull trout is linked to Project effects on sedimentation in the reservoirs. City Light and LPs will be able to explore potential impacts on fish and aquatic resources to a greater degree during the ILP (Please also see the response to Comment #6.). Habitat conditions in the tributaries, above the influence of the reservoirs' high-water marks, are outside the range of the Project's effects.

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				reservoir beds, impact passage and aquatic habitats and as well…facilitates predation.	
45.	Brock Applegate (WDFW)	04/13/2020	Section 2.3 Background and Existing Information	5th Bullet – Add red text "It will also provide suggestions for long term resolution for both the boat launch ingress and egress, and mitigating the effects upon Diablo Powerhouse tailrace and fish habitat."	See response to Comment #6 If future sediment manipulation is identified as a mitigation measure, effects of that measure on fish habitat will be evaluated as part of the planning process.
46.	Jon Riedel (NPS)	03/27/2020	Section 2.3 Background and Existing Information	12th Bullet – Comment "Regional estimates of watershed sediment input have been developed by Army Corps of Engineers (USACE 2008)" There is more: Chilliwack, Goodell, Newhalem (?) 1039 1936 estimate of sediment volume for Diablo Reservoir (SCL study).	Thank you for the additional references. Text has been revised.
47.	Jon Riedel (NPS)	03/27/2020	Section 2.3 Background and Existing Information	12th Bullet – Comment "Annual sediment budgets for ten Skagit River sub-basins were developed by Paulson (1997)….." On heavily managed timberlands.	Agreed. The conditions in different watersheds will be considered as part of this analysis to aid in determining if referenced studies are applicable. Text has been revised.
48.	Rick Hartson (Upper Skagit Indian Tribe)	04/11/2020	Section 2.3 Background and Existing Information	1st Paragraph – Comment "Delta formation and deposition in specific areas of Project lakes affects access to/from certain recreational facilities (boat launches, docks), operational facilities (docks and landings), and/or power generation." Reservoirs is appropriate term. Lentic systems did not exist here prior to the project.	Agreed, text edited accordingly.

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49.	Rick Hartson (Upper Skagit Indian Tribe)	04/11/2020	Section 2.3 Background and Existing Information	1st Paragraph – Comment "Delta formation and deposition in specific areas of Project lakes affects access to/from certain recreational facilities (boat launches, docks), operational facilities (docks and landings), and/or power generation." Reiterating need to broaden scope of study and assessment of resource impacts. See previous comments.	See responses to Comments #4, #6, and #13.
50.	Rick Hartson (Upper Skagit Indian Tribe)	04/11/2020	Section 2.3 Background and Existing Information	1st Bullet – Comment "As-built documentation, historical topography and available bathymetry for Sourdough Creek inlet within Diablo Lake, Thunder Arm within Diablo Lake, and the Hozomeen inlet at the north end of Ross Lake." Has access to these as-built documents been granted to LPs? If not, Upper Skagit Indian Tribe requests access to the documents to foster a shared understanding between SCL and LPs.	As-built documents may be subject to confidentiality requirements. City Light will share materials related to as-built documents to the extent permitted by law.
51.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/12/2020	Section 2.3 Background and Existing Information	5th Bullet – Comment "This study will evaluate sediment supply, particle size distribution, and lateral and vertical extent of the deposit." The study should also assess what restoration of the historic alluvial fan would do for project operations and fishery resources as relating to passage and access to Stetattle Creek to the Skagit River inside Gorge reservoir- as this is the only free flowing section of the Skagit in the project area. Study should assess historical	See response to Comment #1.

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				extend of gravel and sediment bar as compared to rate of change from project operations.	
52.	Curtis Clement (Upper Skagit Indian Tribe)	04/13/2020	Section 2.3 Background and Existing Information	12th Bullet – Comment "Annual sediment budgets for ten Skagit River sub-basins were developed by Paulson (1997)…" These results were from active industrial forests at a time when current forest practices were just being put into place. Expect that these budgets will be different than they are now for the same basins, certainly different than basins upstream of Gorge powerhouse.	See response to Comment #47.
53.	Curtis Clement (Upper Skagit Indian Tribe)	04/13/2020	Section 2.3 Background and Existing Information	12th Bullet – Comment "…Nichols (2006) estimated the glaciated areas would produce 2,600 tons/square…." Is this personal communication based on the USACE 2008 regional study? This is very unclear where this comes from and how it fits in with the numbers below. It gives a number that is close to the high range of the regional estimate, but there is no information for where it falls within a range for glaciated areas. Is 2,600 the mean, the low end or the high end of what is produced from glaciated areas?	Yes. This reference is reported in the USACE (2008) regional study; the reference has been edited to clarify the source. A more detailed description and analysis of various sediment supply rates reported for appropriate watersheds in the vicinity of the study area will be provided in the study report.
54.	Curtis Clement (Upper Skagit Indian Tribe)	04/13/2020	Section 2.3 Background and Existing Information	12th Bullet – Comment "….R2 Resources (2004) for Puget Sound Energy." The Baker area and middle Skagit are substantially different geology than what exists	See response to Comment #47.

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				upstream of Gorge powerhouse, as are the forest practices.	
55.	USFS	04/14/2020	Section 2.3 Background and Existing Information	Existing information provided in this section does not include information about project operation effects on sediment deposition in aquatic habitats in the three reservoirs. This study is a good opportunity to resolve that data gap.	See responses to Comments #4 and #6.
56.	Judy Neibauer (USFWS)	04/13/2020	Section 2.4 Project Operations and Effects on Resources	This is a section described in the study plan guidelines I shared earlier…Here you can talk about how the results from the Project will affect the resources. This section could link up to the goals and objectives above and share how the information will be used to assess effects. You can describe here where the data gaps are that this study will address. This section just seems like it lacks description, and looks more like a general statement/paragraph, without the details of how the data will be used to address the effects…Maybe add information showing how data will be used in the effects analysis…you could put that in a table too.	See responses to Comments #1 and #24.
57.	Judy Neibauer (USFWS)	04/13/2020	Section 2.4 Project Operations and Effects on Resources	"Sediment supply (non-Project related) from tributaries results in deposition within Project reservoirs. The deposition affects access to/from recreational facilities (boat launches, docks); aquatic and wildlife habitat; and operational facilities (docks and landings);" Effects likely occur to aquatic and wildlife populations and habitat, as previously mentioned. Need to add this here. Or show how you are addressing fish and wildlife issues elsewhere.	See responses to Comments #4, #6, and #13.

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58.	Brock Applegate (WDFW)	04/13/2020	Section 2.4 Project Operations and Effects on Resources	"The data obtained with the methods identified below will be used to analyze potential future deposition volumes and patterns to help develop methods to manage sediment deposition at the areas of resource concern and develop mitigation for any fish and wildlife impacts through the term of the new license."	See responses to Comments #6 and #13.
59.	Rick Hartson (Upper Skagit Indian Tribe)	04/11/2020	Section 2.4 Project Operations and Effects on Resources	"The deposition affects access to/from recreational facilities (boat launches, docks), and operational facilities (docks and landings); access to Ross Dam and Reservoir for ongoing operations and maintenance; and/or power generation associated with the Project." The deposition affects cultural, fisheries, and aquatic resources. See previous comments.	See responses to Comments #4, #6, and #18.
60.	USFS	04/14/2020	Section 2.4 Project Operations and Effects on Resources	***The FS recommends*** a clear statement of **project effect** on sediment deposition dynamics and their subsequent impact on aquatic/recreational resources. Identify the clear project effect of operations management on depositional patterns, and include the "potential" impacts to aquatic habitats that this study will address. Alternatively, remove FA44 and FA45 as issues to be addressed and focus solely on recreation impacts. ***The FS recommends*** modifying the following statement "…The data obtained with the methods identified below will be used to analyze future deposition volumes and patterns to help develop methods to manage sediment deposition at the areas of resource concern…" I'm hoping that we all agree that sediment transport and deposition from tributaries will not cease to occur in the future!	See responses to Comments #6 and #7.

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61.	Brock Applegate (WDFW)	04/13/2020	Section 2.5 Study Area	SCL should include Big Beaver Creek and all other tributaries that may have fish passage blockages due to sedimentation when the tributary flow arrives at the reservoir or the backwater cause by it.	See responses to Comment #4.
62.	Judy Neibauer (USFWS)	04/13/2020	Section 2.5 Study Area	Agreed. Also see my previous comments about expanding this study to include tributaries and reservoir beds. Rationale: Deposition likely occurs at multiple locations along the lower reaches of tributaries. This may depend where the reservoir elevation levels intersect along the stream. Deposition also can occur long distances out into the reservoir from the tributary mouths and from erosion of exposed reservoir shorelines/beds by wind and rain storm events. Also, aggradation and deposition of larger substrate and smaller sediments have likely occurred some distance upstream from the location of the reservoir bed to some type of reach break or point of inflection in the tributary stream channels. These distances upstream might be unique to geomorphology and land types.	Comment acknowledged. All elements of deposition will be addressed to assess potential Project impacts on the target resources identified in the study plan.
63.	Rick Hartson (Upper Skagit Indian Tribe)	04/11/2020	Section 2.5 Study Area	Upper Skagit Indian Tribe believes the study area should encompass the entire reservoir system. See previous comments.	See response to Comment #11.
64.	USFS	04/14/2020	Section 2.5 Study Area	***The FS recommends*** including all of the tributary/reservoir confluences where aquatic habitat impacts are likely to occur from project effects. This could be completed in the same fashion as the study area in Canada with remote sensing data. Field work could be limited to those areas where remote sensing data is insufficient.	See responses to Comments #4 and #6.

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65.	Jon Riedel (NPS)	03/27/2020	Figure 2.5-4	"Study area – Diablo Lake –Thunder Arm inlet, with Colonial Creek Boat Launch/Dock." Show Rhode Creek, a major source of sediment for boat launch.	Map revised to show Rhode Creek.
66.	Bob Mierendorf (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6 Methodology	Given expectations about collaboration and cross-resource coordination, this Methodology needs to explicitly include a statement about consultation with other working groups, particularly the CRWG.	City Light will work with RWGs so that information from all related studies will be integrated in the context of the ILP process.
67.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.1 Compile and Assess Existing Information	Compile geomorphology, geology land types to assist in determining natural levels of deposition within tributaries and at mouths of tributaries. .See my comments about adding in areas above. Possibly assign a high, moderate, low risk to tributaries for their natural levels of deposition, while using geology/ landform to help sort them. You can use that condition risk as a base to start from to help determine operational effects. I am just thinking out loud here, but you will need to determine levels of natural deposition and baseline conditions to be able to show operational effects at points of deposition. This will also inform any type of maintenance or restoration needed in the future.	See response to Comment #1.
68.	Curtis Clement (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.1 Compile and Assess Existing Information	4th Bullet – Comment "Average annual sediment budgets for ten Skagit River sub-basins developed by Paulson (1997; USACE 2008)…." These will be good sanity checks and initial starting point but SCL is going through a lot of	The conditions in different watersheds will be considered as part of this analysis to aid in determining if referenced studies are applicable. One objective of the study is to determine sediment inputs from each watershed; a variety of methods are described to do this. Text revised to clarify.

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				trouble just to use these two already developed budgets anyway. Why not develop a sediment budget based on all the data being collected in each specific basin, each of which can more directly apply to other basins in the project?	
69.	Curtis Clement (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.1 Compile and Assess Existing Information	4th Bullet – Comment "Estimates for glaciated areas (Nichols 2006) will be used for glaciated areas of tributary watersheds." It was only 1 estimate.	Agreed. Thank you for the clarification. Text revised.
70.	Curtis Clement (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.1 Compile and Assess Existing Information	4th Bullet – Comment "Estimates for glaciated areas (Nichols 2006) will be used for glaciated areas of tributary watersheds." Again, where did this estimate come from? It is also unclear how this will be used. Thunder creek is glacially fed but not all of it is a "glaciated area." How will this study define glaciated area? How will the yield/acre for glaciated areas be incorporated?	The area of a specific watershed that is covered by glacial ice will be used to help estimate the amount of sediment coming from that erosional process (this is what is meant by "glaciated area"). Estimates of sediment production from other glaciated areas in the Pacific Northwest may also be used as appropriate. Text revised for clarity.
71.	USFS	04/14/2020	Section 2.6.1 Compile and Assess Existing Information	***The FS requests*** review of the methods in Nichols 2006 that will be used for glaciated areas of tributary watersheds. We were unsuccessful finding it in the archived materials on the HDR sharepointe site.	References will be made available to LPs.
72.	Jon Riedel (NPS)	03/27/2020	Section 2.6.2.1 Bathymetry	How will you measure? At spots, continuous swath?	The specifics of the bathymetry analysis will be selected based on the most appropriate technology to obtain the needed data at each site.

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73.	Curtis Clement (Upper Skagit Indian Tribe)	04/11/2020	Section 2.6.2.1 Bathymetry	"Bathymetry data…." Multibeam, singlebeam, vessel mounted with IMU or handheld unit, or a wading rod? LiDAR? What method to be used?	See response to Comment #72
74.	Rick Hartson (Upper Skagit Indian Tribe)	04/11/2020	Section 2.6.2.1 Bathymetry	"Some bathymetry data have been collected for part of the Thunder Arm inlet; these data will be supplemented to cover the entire study area." What is the source and year of data collection? Is there need to consider whether additional deposition has occurred since this data was collected?	Green LiDAR was flown in April of 2018 for Diablo Lake by Quantum Spatial. These data should be recent enough to support the study.
75.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.2.1 Bathymetry	Why not cover other areas of Gorge Lake? It seems that should be looked as well. Besides in tributaries, you will need to understand if there are any in-reservoir passage barriers at certain operational flows. Does current bathymetry cover the whole lake?	There is no evidence of in-reservoir passage barriers in Gorge Lake. See response to Comment #4.
76.	USFS	04/14/2020	Section 2.6.2.1 Bathymetry	***The FS recommends*** a description of how the bathymetry will be collected. There was mention of using existing bathymetry for a part of Thunder Arm inlet. To avoid discrepancies in volumetric estimates across time, all bathymetric data should be collected at the same time.	The specifics of the bathymetry analysis will be selected based on the most appropriate technology to obtain data at each site. The date that each set of bathymetric data was collected will be accounted for during data analysis.
77.	Jon Riedel (NPS)	03/27/2020	Section 2.6.2.2 Sediment Transport and Deposition	"Evaluation of the change in slope can be used to evaluate changes in transport processes (Richards 1982)." At Lake Chelan we developed a 1-D backwater model to quantify this, and it went >0.25 miles upstream..	City Light agrees that changes in slope can be due to numerous factors; these will be assessed during the analysis. Text revised for clarity.

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				Change in slope may be due to underlying geology and reach scale geomorphology. See glacial lake Skagit in Riedel 2017.	
78.	Brock Applegate (WDFW)	04/13/2020	Section 2.6.2.2 Sediment Transport and Deposition	I agree with Jon. Other things can affect a change in slope besides the end of sediment transport. SCL should explain how they will address this possible problem.	See response to Comment #77.
79.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.2.2 Sediment Transport and Deposition	"Evaluation of the change in slope can be used to evaluate changes in transport processes (Richards 1982)." Slope might be a good first cut, but there may be other geomorphic / terrain features or flow processes (glacial dominated vs spring fed systems) that cause reservoir effect to go further upstream. Utilize geomorphic study and geology or land type data to help determine distances of influence upstream in tributaries. You will likely need to use landform, geomorphology, aerial photo interpretation to assist in depicting distances upstream where operational effects dissipate. Separately, you may need to do some reservoir bed surveys along key tributaries to look for connectivity issues.	See response to Comment #77.
80.	Curtis Clement (Upper Skagit Indian Tribe)	04/11/2020	Section 2.6.2.2 Sediment Transport and Deposition Zones	3rd Paragraph – Comment "This information will be used to inform long-term input and influence from upstream and non-project sediment upon sediment management in the areas of concern." Also to inform downstream geomorphology study and potential management goals, such as sediment enrichment.	See response to Comment #11.

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81.	USFS	04/14/2020	Section 2.6.2.2 Sediment Transport and Deposition	***The FS recommends*** evaluating other mechanisms of slope change like underlying geology or reach scale geomorphic controls. How these natural controls modify the geographic scope of project effects will be important to address either quantitatively or qualitatively in the results.	See response to Comment #77.
82.	Curtis Clement (Upper Skagit Indian Tribe)	04/10/2020	Section 2.6.2.3 Mapping of Inlet Area Deposits, Exposed Sediments	1st Paragraph – Comment "….1000 ft^2 to be considered a separate facies (approximately 10 meter [m] x 10 m…" Did you mean 100 square feet or 1000 square feet?	1,000 square feet as stated in the methods.
83.	Curtis Clement (Upper Skagit Indian Tribe)	04/11/2020	Section 2.6.2.3 Mapping of Inlet Area Deposits, Exposed Sediments	2nd Paragraph – Comment "There may be shallow inundated areas that are too fine-grained and saturated to walk nor deep enough to use a shallow-draft boat so these areas may need to be estimated using aerial imagery." This would be a good opportunity to use green lidar, which has been discussed for use in other study plans.	Thank you for the comment. City Light agrees and would use existing green LiDAR as available.
84.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.2.3 Mapping of Inlet Area Deposits, Exposed Sediments	Wind driven erosion, turbidity, an deposition can occur in a number of locations. Examine wind patterns from storms and runoff patterns of tributaries, to help assess effects within reservoirs. I have seen wind and rain driven muddy waters, several hundred yards off of reservoir shorelines many times. There may be a depositional area some distance out where the accumulations from these wind/rain events occur.	See response to Comment #10. However, there is no plan to attempt to map out turbidity plumes associated with individual depositional features, plumes that are likely of short duration and localized, and therefore unlikely to have significant effects on aquatic resources over time.

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				The turbidity caused from shoreline/reservoir bed sediments, can affect foraging and swimming abilities, contribute to predation, degrade refugia habitat… among other issues….especially, if events occur near key holding/forage habitat and at mouths of tributaries and during juvenile outmigration or adult spawning migration.	
85.	USFS	04/14/2020	Section 2.6.2.3 Mapping of Inlet Area Deposits, Exposed Sediments	***The FS recommends*** including bedload core sampling as part of the field data collection effort as a measure of project effect on fine sediment volume in suitable spawning habitat for individual fish species. A random sub-sample across tributary/reservoir confluences can be collected during other field reconnaissance.	See response to Comment #6.
86.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.3 Analysis	"For the three study areas where new data will be collected (e.g., Sourdough Creek Thunder Arm, inlet, and Hozomeen inlet):" May need to include other areas per previous comments	See responses to Comments #6, #11, and #13 and parts of #1.
87.	Jon Riedel (NPS)	03/27/2020	Section 2.6.3 Analysis	3rd Bullet – Comment "Current bathymetry with data tied to mean high water elevation." What will error be in the estimate?	Error estimates will be developed as part of data analysis during the study.
88.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.3 Analysis	4th Bullet – Comment DEM of study areas developed from bathymetry and existing topography below and outside of mean high water level. Aerial photo analysis, may help identify	The locations to be studied have been identified with specificity. City Light does not intend to expand the analysis to characterize conditions at a large number of tributary mouths. See responses to Comments #6, #11, and #13 and parts of #1.

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				locations of key tributaries with sediment deposition, and determining wind and bank erosion, turbidity, and deposition risk areas?	
89.	Jon Riedel (NPS)	03/27/2020	Section 2.6.3 Analysis	7th Bullet – Comment "Calculated sediment volume/year deposit within study areas based on 1952 Ross Dam construction and 1936 Diablo Dam construction or the latest bathymetry/topographic data available for comparison." These are 25 ft contour maps, so the estimate would have a large error.	See response to Comment #87.
90.	Jon Riedel (NPS)	03/27/2020	Section 2.6.3 Analysis	12th Bullet – Comment "Estimate of sediment mobility in the tributary below and above the inflection point where transport processes change from transport-dominated to deposition affected by the reservoir level in Sourdough Creek, Thunder Creek, and the Skagit River above the Hozomeen inlet." Why just these tributaries? There are many other large ones influenced by reservoir backwater – e.f. Devils. Ruby, Lightning, L. Beaver.	These tributaries were identified due to specific, known recreation and operations related concerns, i.e., to obtain information required to complete a specific effects assessment.
91.	Brock Applegate (WDFW)	04/13/2020	Section 2.6.3 Analysis	12th Bullet – Comment I agree with Jon. SCL should develop a sediment budget for the entire Project area, but at the very least address and study those areas that may have fish and wildlife impacts due to sediment aggradation. How will SCL address possible fish passage barriers and loss and degradation of aquatic habitat in those areas?	See responses to Comments #4, #6, and #13.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
92.	Brock Applegate (WDFW)	04/13/2020	Section 2.6.3 Analysis	13th Bullet - Added a new bullet "Description of habitat of fish and wildlife described by type, quality, and quantity and possible impacts by any recommended projects or management generated by this study plan."	See responses to Comments #6 and #13. Potential impacts associated with any proposed projects or management actions will be assessed as part of the planning process for those actions.
93.	Curtis Clement (Upper Skagit Indian Tribe)	04/10/2020	Section 2.6.3 Analysis	7th Bullet – Comment "Calculated sediment volume/year deposit within study areas based on 1952 Ross Dam construction and 1936 Diablo Dam construction or the latest bathymetry/topographic data available for comparison." The intention here is not clear. If you are talking about using contours from those times I am skeptical that you will be able to capture the changes in volume simply because of the resolution of surveys from that time. More recent data needs to be included to support whether certain depositional features did or did not already exist.	See response to Comment #89.
94.	Rick Hartson (Upper Skagit Indian Tribe)	04/11/2020	Section 2.6.3 Analysis	8th Bullet – Comment "Estimate of sediment input to the areas of concern." Reported by size class?	Total sediment input will be estimated; estimates by size class will be made, if possible, from data collected as part of the study. Text revised to clarify.
95.	USFS	04/14/2020	Section 2.6.3 Analysis	***The FS recommends*** a review of the goals and objectives of this study plan, the issues identified to be addressed, and whether the analysis will result in conclusions of how project operations effects sediment deposition and consequent aquatic habitat impacts.	See responses to Comments #4, #6, and #7.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				The FS did not identify a clear study goal (section 2.1) specific to sediment depositional impacts to aquatic habitat, nor was an explicit design feature in the methods (section 2.6) meant to address aquatic habitats impacts, and there appears to be no specific measure of aquatic habitat degradation due to project effect (section 2.6.3). ***The FS recommends*** this study plan focus on recreation impacts as it does not appear to be directed at aquatic habitat concerns as described in FA44 and FA45.	
96.	USFS	04/14/2020	Section 2.7 Consistency with Generally Accepted Scientific Practice	***The FS recommends*** review of Nichols 2006.	Thank you for your comment.
97.	Brock Applegate (WDFW)	04/13/2020	Section 2.8 Schedule	Edited or added the following bullets: ▪ Initial Study ~~Final~~ Report (ISR)– March 2022 ▪ ISR Study Meeting ▪ Requests for study plan modification (if needed) ▪ Second Season of Field Work and studies (if needed) ▪ Post-field analysis (if needed)– April to December 2022 ▪ Final Study Report (if needed)—March 2023 **New comment provided on 05/05/2020:** I agree with the reasoning of SCL other than SCL will conduct a study meeting. How about adding below? - Final report of the Initial Study Report (ISR)	Thank you for the comment; City Light acknowledges the ILP milestones provided. The ILP provides the opportunity for comment on the final report submitted in the ISR and discussed at the ISR meeting; if any components of the study goals and objectives are not met in the first year, or there are anomalous conditions, any party may propose additional work or request additional study per FERC ILP regulations. No changes were made to the schedule in the draft study plan as City Light intends to complete the study within one year and wants to be clear with FERC and LPs on the proposed schedule. City Light believes that it will be beneficial to all parties to have information from the studies available as soon as possible to

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				- ISR Study Meeting - Request for study plan modification (if needed) SCL will have a study meeting. Why not list the meeting?	inform development of management proposals and cross resource analysis. **Response to comment provided on 05/05/2020:** Thank you for your comment. The schedule reflects the timeline for this study only, not the larger ILP process.
98.	USFS	04/14/2020	Section 2.9 Level of Effort and Cost	***The FS recommends*** a breakdown of likely costs for each phase (described in section 2.8).	City Light is open to discussions with LPs regarding the need for the additional information that is being requested. Costs will be updated through subsequent drafts of the study plan.

GE-04 SKAGIT RIVER GEOMORPHOLOGY BETWEEN GORGE DAM AND THE SAUK RIVER
REVISED STUDY PLAN

SKAGIT RIVER HYDROELECTRIC PROJECT
FERC NO. 553

Seattle City Light

April 2021
RSP

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List of Acronyms and Abbreviations

2-D ....two-dimensional
CFR ....Code of Federal Regulations
City Light ....Seattle City Light
dbh.............................diameter at breast height
Ecology ....Washington State Department of Ecology
EFH ....Essential Fish Habitat
ELC ....Environmental Learning Center
ESA ....Endangered Species Act
FARWG ....Fish and Aquatics Resource Work Group
FERC..........................Federal Energy Regulatory Commission
FLA ....Final License Application
FPA ....Federal Power Act
GIS ....Geographic Information System
IHA ....Indicators of Hydraulic Alteration
ILP.............................integrated licensing process
ISR ....Initial Study Report
LiDAR........................Light Detection and Ranging
LP...............................licensing participant
LRMP.........................Land and Resource Management Plan
LWD ....large woody debris
NAIP ....National Agriculture Imagery Program
NHPA.........................National Historic Preservation Act
NMFS.........................National Marine Fisheries Service
NPS ....National Park Service
PAD............................Pre-Application Document
PRM ....Project River Mile
Project ....Skagit River Hydroelectric Project
PSP.............................Proposed Study Plan
RLNRA ....Ross Lake National Recreation Area
RM ....river mile
RSP ....Revised Study Plan

RWG ....Resource Work Group
USACE ......................U.S. Army Corps of Engineers
U.S.C. ....United States Code
USFS ..........................U.S. Forest Service
USFWS ......................U.S. Fish and Wildlife Service
USGS .........................U.S. Geological Survey
USIT ....Upper Skagit Indian Tribe
USR ....Updated Study Report
WDFW ....Washington Department of Fish and Wildlife
WSDOT ....Washington State Department of Transportation

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1.0 INTRODUCTION

1.1 General Description of the Project

The Skagit River Hydroelectric Project (Project), licensed to The City of Seattle, Washington, and operated through its publicly-owned electric power utility Seattle City Light (City Light), is located in northern Washington State and consists of three power generating developments on the Skagit River – Ross, Diablo, and Gorge – and associated lands and facilities. The Project generating facilities are in the Cascade Mountains of the upper Skagit River watershed, between Project River Miles (PRM) 94.7 and 127.9 (U.S. Geological Survey [USGS] RMs 94.2 and 127).[1] Power from the Project is transmitted via two 230-kilovolt powerlines that span over 100 miles and end just north of Seattle at the Bothell Substation. The Project also includes two City Light-owned towns, an Environmental Learning Center (ELC), several recreation facilities, and several parcels of fish and wildlife mitigation lands.

Project generating facilities are all located in Whatcom County, although Ross Lake, the most upstream reservoir, crosses the U.S.-Canada border and extends for about one mile into British Columbia at normal maximum water surface elevation. Gorge Powerhouse, the most downstream facility, is approximately 120 miles northeast of Seattle and 60 miles east of Sedro-Woolley, the nearest large town. The closest town is Newhalem, which is part of the Project and just downstream of Gorge Powerhouse. The primary transmission lines cross Whatcom, Skagit, and Snohomish counties; the fish and wildlife mitigation lands are in the same counties.

The Project Boundary is extensive, spanning over 133 miles from the Canadian border to the Bothell Substation just north of Seattle, Washington. In addition, there are “islands” of fish and wildlife mitigation lands and recreation facilities within the Skagit, Sauk, and South Fork Nooksack watersheds that are also within the Project Boundary. Project generating facilities are entirely within the Ross Lake National Recreation Area (RLNRA), which is administered by the National Park Service (NPS) as part of the North Cascades National Park Complex. The RLNRA was established in 1968 in the enabling legislation for North Cascades National Park to provide for the “public outdoor recreation use and enjoyment of portions of the Skagit River and Ross, Diablo, and Gorge lakes.” The legislation maintains the Federal Energy Regulatory Commission’s (FERC) jurisdiction “in the lands and waters within the Skagit River Hydroelectric Project,” as well as hydrologic monitoring stations necessary for the proper operation of the Project (16 United States Code [U.S.C.] § 90d-4; Public Law 90-544. Sec. 505 dated October 2, 1968, as amended by Public Law 100-668. Sec. 202 dated November 16, 1988).

1.2 Relicensing Process

The current FERC license for the Project expires on April 30, 2025, and City Light will apply for a new license no later than April 30, 2023. City Light formally initiated the relicensing process by filing a Notice of Intent and Pre-Application Document (PAD) with FERC on April 27, 2020 (City Light 2020a). The PAD includes descriptions of the Project facilities, operations, license

[1] City Light has developed a standard Project centerline and river mile system to be used throughout the relicensing process, including the study program, to replace the outdated USGS RM system. Given the long-standing use of the USGS RM system, both it and the Project River Mile (PRM) system are provided throughout this document. For further details see Section 7.0 of the main body RSP.

requirements, and Project lands as well as a summary of the extensive existing information available on Project vicinity resources and early consultation on potential resource issues to be addressed during the relicensing. The PAD also includes an outline of the goals and objectives of this study.

The relicensing process includes the timeframes and deadlines specified in FERC's integrated licensing process (ILP), including consultation with interested agencies and Indian tribes related to study plans, study results, and subsequent analysis of results and effects analysis through the filing of the Final License Application (FLA). FERC's process includes steps to satisfy the various statutory authorities identified in the Federal Power Act (FPA) (e.g., Sections 4(e), 10(j), 10(a)). Other related regulatory processes including Washington State Department of Ecology's (Ecology) Section 401 water quality certification process, the U.S. Fish and Wildlife Service's (USFWS) and National Marine Fisheries Service's (NMFS) Section 7 Endangered Species Act (ESA) consultation, NMFS's oversight of Essential Fish Habitat (EFH), as defined by the Magnuson Stevens Fishery Conservation and Management Act, and consultation pursuant to Section 106 of the National Historic Preservation Act (NHPA) will continue following filing of the FLA. With the filing of the PAD, City Light requested that FERC designate City Light as FERC's non-federal representative for purposes of initiating and conducting day-to-day consultation under ESA Section 7 and NHPA Section 106, which was granted by FERC in its June 26, 2020 Notice of Intent to File License Application for a New License and Commencing Pre-Filing Process.

1.3 Study Plan Development

In 2019-2020, City Light convened a number of Resource Work Groups (RWG) to engage agencies and other licensing participants (LP) in a Study Plan Development Process, which provided LPs and City Light the opportunity to submit forms that identified potential resource issues, their potential connection to the Project, information or studies requested, a rationale for studying the issues, and how the information collected by the study could be used to support relicensing. Table 5.1-2 of the PAD provides a summary of all the issue forms submitted during this 2019-2020 process.

Section 5 of the PAD lists the resource studies and management plans proposed by City Light to address select (but not all) issues identified as part of the Study Plan Development Process. While acknowledging the broad interests of LPs, City Light focused its initial draft study plans contained in the PAD on information gaps most likely to inform license conditions by a study of potential Project effects. City Light developed 24 study proposals, including this Geomorphology between Gorge Dam and the Sauk River Study Plan.

On March 13, 2020, City Light released the GE-04 Skagit River Geomorphology Between Gorge Dam and the Sauk River Draft Study Plan for LP review and comment. On March 31, 2020, the draft study plan was discussed at a Fish and Aquatic Resource Work Group (FARWG) meeting. City Light reviewed all comments received and released a revised version of the draft study plan on June 16, 2020. The revised draft was discussed on June 24, 2020 at a FARWG meeting. Written comments were received from NMFS, U.S. Forest Service (USFS), NPS, USFWS, Washington Department of Fish and Wildlife (WDFW), Upper Skagit Indian Tribe, Skagit River Systems Cooperative, and Sauk-Suiattle Indian Tribe and responded to in an attachment to this study plan. A Status Draft of the study plan was provided to LPs on August 6, 2020.

City Light is filing this study plan with FERC as part of its Revised Study Plan (RSP), an update to the version that was filed with the Proposed Study Plan (PSP) on December 8, 2020 (City Light 2020b) and incorporating additional consultation with LPs prior to the filing date.

Six LPs submitted a total of 14 study requests related to geomorphology and aquatic habitat in the Skagit River and regarding Project effects on sediment, instream large wood, process flows, and/or floodplain connectivity/off-channel aquatic habitat: Ecology-02 Instream Flow Study, NMFS-02 Geomorphology and Aquatic Habitat, NPS-11 Impact of Operations of Skagit Hydroelectric Project (#553) on Sediment Capture Within Reservoirs and Sediment Recovery Below Gorge Dam and Its Influence on Endangered Species Habitat, NPS-12 Impact of the Operations of Skagit Hydroelectric Project (#553) on Sediment Storage, Stability and Transport on Skagit River and its Influence on Endangered Species Habitat, NPS-13 Impact of the Operations of Skagit Hydroelectric Project (#553) on Process Flows of Water, Wood and Sediment Below Gorge Dam, USFWS-11 Impact of Operations of Skagit Hydroelectric Project (#553) on Sediment Capture Within Reservoirs and Sediment Recovery Below Gorge Dam and Its Influence on Endangered Species Habitat, USFWS-12 Impact of the Operations of Skagit Hydroelectric Project (#553) on Sediment Storage, Stability and Transport on Skagit River and its Influence on Endangered Species Habitat, USFWS-13 Impact of the Operations of Skagit Hydroelectric Project (#553) on Process Flows of Water, Wood, and Sediment below Gorge Dam, USFWS-15 Geomorphology and Aquatic Habitat Complexity Study, USIT-08 Geomorphology and Anadromous Salmonid Habitat, WDFW-05 Geomorphology and Anadromous Salmonid Habitat, WDFW-08 Impact of the Operations of Skagit Hydroelectric Project (#553) on Process Flows of Water, Wood and Sediment Below Gorge Dam, WDFW-09 Wood Budget, Inventory and Assessment, and WDFW-10 Impact of Operations of Skagit Hydroelectric Project (#553) on Sediment Capture Within Reservoirs and Sediment Recovery Below Gorge Dam and Its Influence on Endangered Species Habitat.

PSP comments to this study plan were submitted by American Rivers/Trout Unlimited, Ecology, NMFS, NPS, Sauk-Suiattle Indian Tribe, Swinomish Indian Tribal Community, Upper Skagit Indian Tribe, and USFWS. City Light has addressed the specific comments and suggested edits in the study plan and responded to comments in the PSP comment/response table appended to the main body of the RSP. Modifications made to the study plan in response to comments and since the PSP include investigating flows that result in geomorphic /habitat changes (process flows), using Indicators of Hydraulic Alteration (IHA) software package to investigate the timing and duration of different types of high flow events, assessing the potential for fish passage blockages at tributary junctions due to shallow water conditions, and analyzing sediment and large wood transport between Gorge Dam and the Sauk River confluence.

This Skagit River Geomorphology between Gorge Dam and the Sauk River Study Plan addresses, with modifications, many of the elements identified in the study requests listed above, as explained in Section 6 of the RSP. Project operations alter peak flow magnitude, duration, and timing in the Skagit River downstream of Gorge Dam, thereby altering geomorphic processes that may affect aquatic habitat and cultural resources through the alteration in flow, sediment, and large woody debris (LWD). Geomorphic processes affect aquatic habitat by influencing substrate size and quality, large wood dynamics, main channel and side channel habitat abundance and diversity, and side channel, wetland, and floodplain connectivity. Information to be collected in this study on geomorphic processes, aquatic habitat for a number of fish species including anadromous, migratory, and resident salmonids, large wood, and sediment in the Skagit River between Gorge Dam and the Sauk River confluence is needed to improve the understanding of how Project operations influence aquatic species and their habitat and cultural resources over the next license term.

2.0 STUDY PLAN ELEMENTS

2.1 Study Goals and Objectives

The study goals of the Skagit River Geomorphology between Gorge Dam and the Sauk River Study (Geomorphology Study) are to characterize the current condition of aquatic habitat in the reach and to characterize how Project-related changes in peak flows affect geomorphic processes, which will be used to evaluate the Project's contribution to cumulative effects in the reach.

Specific objectives include:

- Use aerial photograph and LiDAR data and collect field data noting current conditions and changes to document:
  - Baseline channel configuration and migration patterns;
  - Distribution of aquatic habitat types, characteristics, and availability;
  - Side channels and off-channel habitat, including hydraulically connected wetlands;
  - Substrate size and distribution;
  - Sediment sources and delivery mechanisms; and
  - Large wood input, transport, and retention.
- Determine flow rates that result in redd scour to help guide management of peak flow releases from Gorge Dam and Powerhouse.
- Investigate flows that result in geomorphic/habitat changes (process flows) for the following processes:
  - Mobilize deposits at tributary mouths along the mainstem Skagit River;
  - Mobilize river bed and bars;
  - Erode river banks and result in channel migration;
  - Instigate side channel development/maintenance; and
  - Hydraulically connect side channel and off-channel habitat.

2.2 Resource Management Goals

The study will provide information for resource agencies and Indian tribes with jurisdiction in the Project vicinity to address their respective goals and objectives for resource management. Resource management goals were provided by LPs in their study requests identified in Section 1.3 of this study plan.

2.3 Background and Existing Information

Aquatic habitat in the Skagit River supports numerous anadromous, migratory, and resident fish species as well as other aquatic organisms. Geomorphic processes affect components of aquatic and riparian habitat, including substrate size, quantity and quality; large wood dynamics, and main channel and side channel habitat diversity. Floodplain connectivity—both hydraulic and geomorphic—is also important for aquatic and terrestrial biota and riparian ecosystem dynamics. Information on floodplain and riparian vegetation, wetlands, and landform mapping being conducted in other Skagit licensing studies will provide baseline information helpful to the analysis of geomorphic and aquatic habitat conditions considered in this study plan.

Detailed information on aquatic habitats downstream of Gorge Dam is needed to improve the understanding of current spawning and rearing capacity for all salmonid species using the habitat, and how these factors could be predicted to change over the next license term. Additional information is also needed to establish gravel quantities and quality on a spatial scale, gravel mobilization and redd scour flows in primary spawning areas, and changes to river geometry that may occur through time. Data on existing river conditions downstream of Gorge Dam are needed to enable tracking changes to:

- Channel configuration and migration patterns;
- Aquatic habitat types, characteristics, and availability;
- Side channels (existing channels, formation and maintenance processes);
- Substrate size and distribution; and
- Large wood (existing; potential input, transport, and retention processes).

Other land use practices such as timber harvest, road construction, and bank protection downstream of Gorge Dam also influence geomorphic processes and the suitability of aquatic habitat. Evaluating the relative influence of different natural and human-induced processes will aid in the understanding of existing river conditions.

City Light surveys anadromous fish spawning locations throughout the year and records location, water depth, and species. These data can provide information on preferred spawning locations and habitat to help guide gravel scour monitoring. Flow data in the reach is available at several USGS gage locations to help analyze the interaction between peak flows and geomorphic processes. Historic and recent aerial photographs and recent LiDAR data are available to aid in mapping channel configuration, large wood, and sediment dynamics.

Existing information providing a basis for understanding geomorphic processes in the Skagit River includes:

- A baseline fluvial geomorphology report was prepared for the Skagit River basin (Gorge Powerhouse to estuary) by the U.S. Army Corps of Engineers (USACE) that includes an estimated sediment input budget based on basin sediment budgets and suspended load data and a description of fluvial geomorphic reaches (USACE 2008).
- Channel incision was identified as a potential issue during the Skagit River Project's last relicensing in the early 1990s. Analysis of USGS gage records at that time showed incision at the Alma gage (no longer in service) and little variation to 0.4 feet of aggradation at the Newhalem gage (Riedel 1990).
- The WRIA Limiting Factors Assessment for the Skagit River (Smith 2003) identifies types of habitat/conditions that are limiting fish production in the river. Information on substrate

quality, streambed stability and LWD are listed as data gaps in the upper Skagit River (Newhalem to Sauk River confluence).

- The Skagit Watershed Council produced Geographic Information System (GIS)-based analyses of relative sediment input, riparian conditions, and bank hardening areas in the Skagit River system (Beamer et. al 2000). This information was used for a reach assessment of the Middle Skagit River (Sauk River confluence to Sedro-Woolley) that analyzed potential areas for targeting habitat restoration based on habitat, geomorphology, and land uses (Smith et al. 2011).
- A sediment budget of the Middle Skagit River (Rockport to Sedro-Woolley) was developed by Rothleutner (2017) and included an analysis of historical channel migration rates and sediment input from river meandering. GIS-based methods used for this analysis could be used in other river reaches to estimate sediment input from bank erosion and channel migration.
- The Skagit Watershed Council commissioned a report on LWD in the Skagit River system (Natural Systems Design 2017) that identified LWD as a potential limiting factor in the Skagit Chinook Recovery Plan. The report also included a summary of existing factors affecting LWD recruitment and potential methods to analyze/inventory LWD in the watershed.
- Geomorphology, hydrology, and hydraulics studies undertaken for the Barnaby Reach restoration project provide detailed information on the Skagit River channel, off-channel areas, and floodplain in the area just upstream of the Sauk River confluence (Skagit River System Cooperative and Natural Systems Design 2019).
- Suspended sediment monitoring by the USGS on the lower Skagit River (Curran et al. 2016) and Sauk River (Jaeger et al. 2017).

2.4 Project Operations and Effects on Resources

Project operations alter peak flow magnitude, duration, and timing in the Skagit River downstream of Gorge Dam, thereby altering geomorphic processes that may affect aquatic habitat through the alteration in flow, sediments, and LWD. Geomorphic processes affect aquatic habitat by influencing key habitat forming elements, such as: substrate size, amount, and quality; key pools, large wood dynamics, main channel and side channel habitat diversity, streambank condition, riparian vegetation, tributary and floodplain connectivity, including side channel and hydraulically connected wetlands.

2.5 Study Area

The primary study area includes areas where new information will be collected in the Skagit River and tributary junctions between Gorge Dam and the Sauk River confluence (Figures 2.5-1 through 2.5-3). This study will also compile existing relevant geomorphic information on the Skagit River downstream from the Sauk River confluence, which will be used to evaluate the Project's contribution to cumulative effects in that reach, but will not collect any new information downstream from the Sauk River confluence.

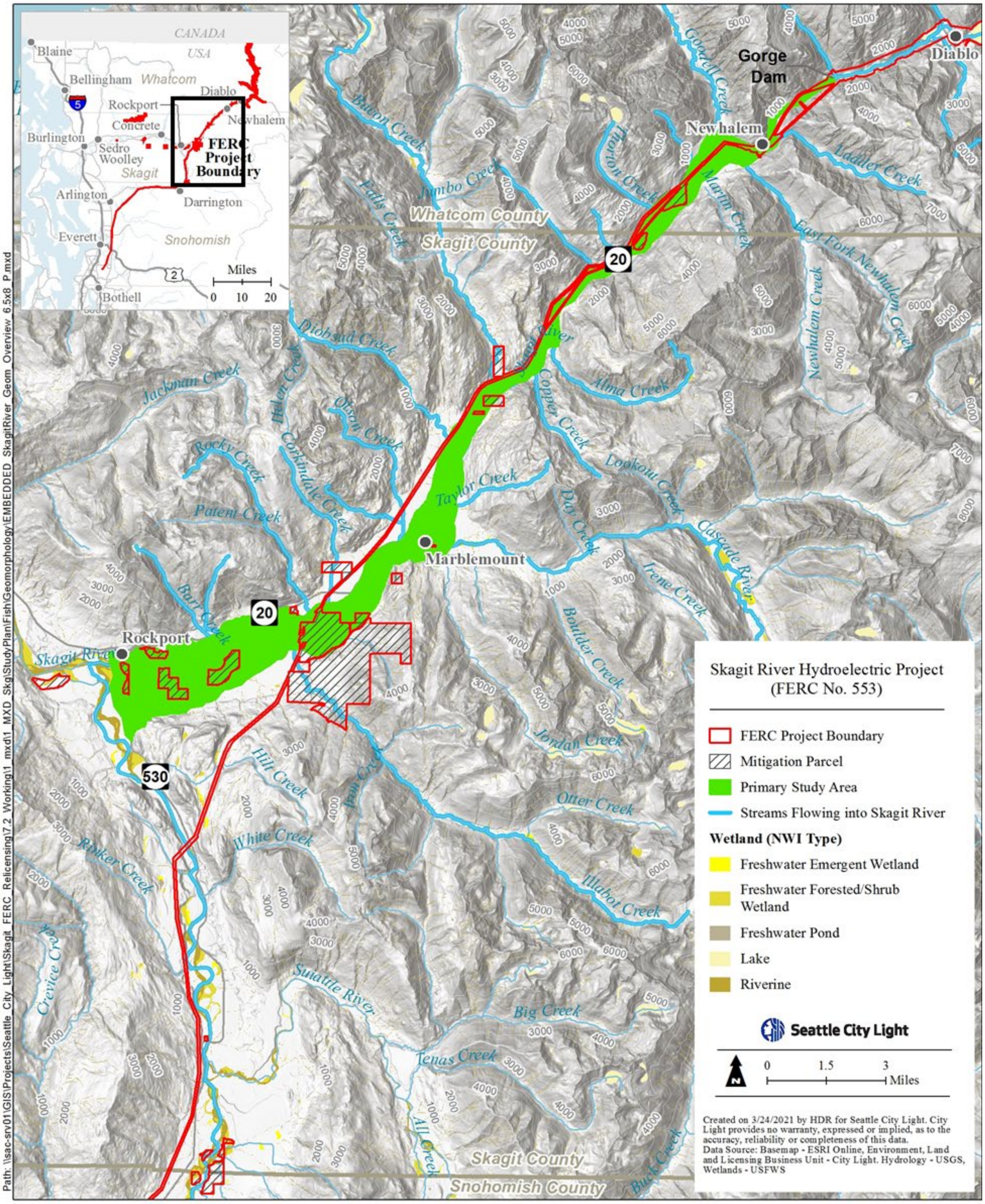

Figure 2.5-1. **Overview of study area: Gorge Dam to Sauk River confluence.**

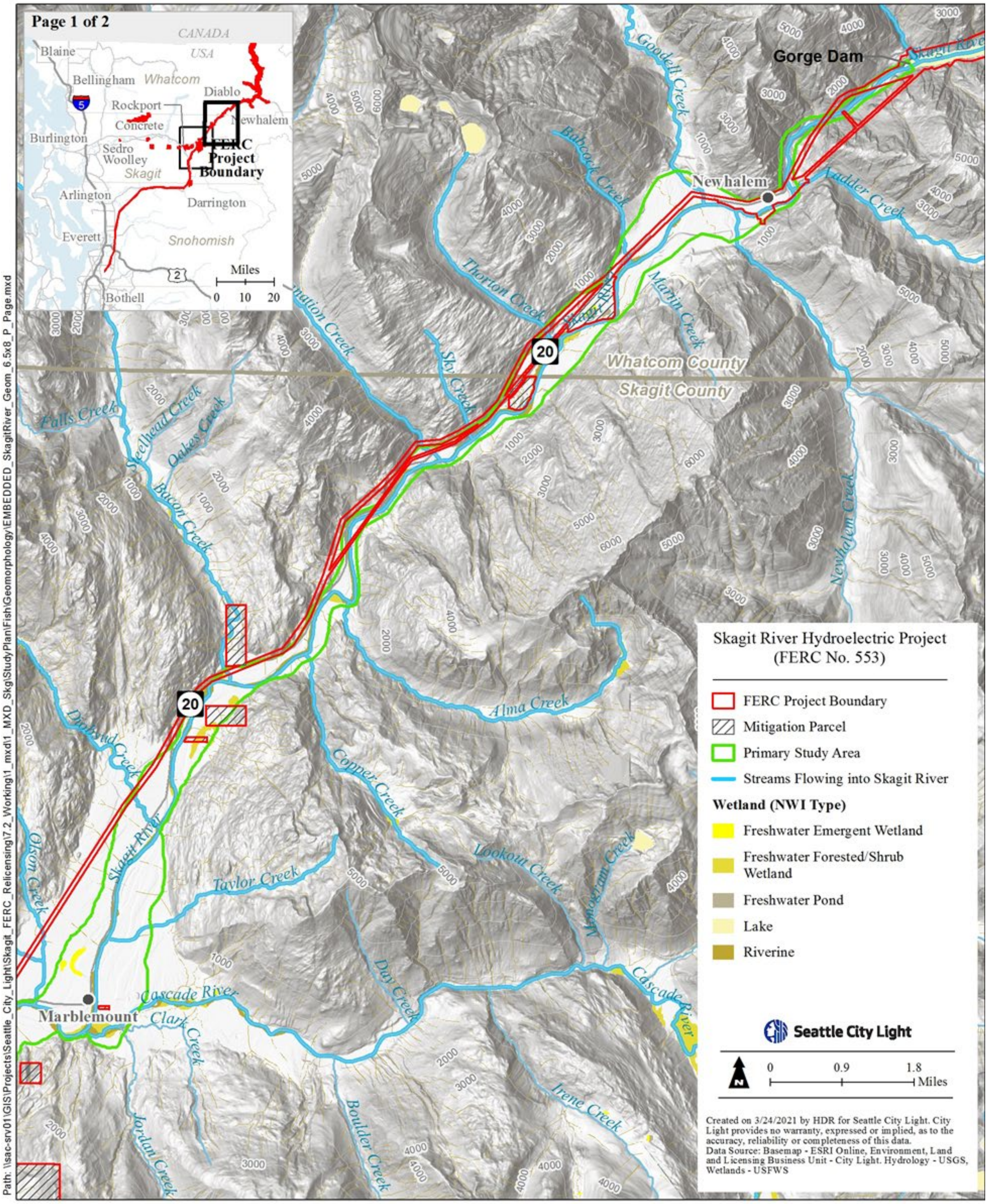

Figure 2.5-2. Northern portion of study area: Gorge Dam to Marblemount.

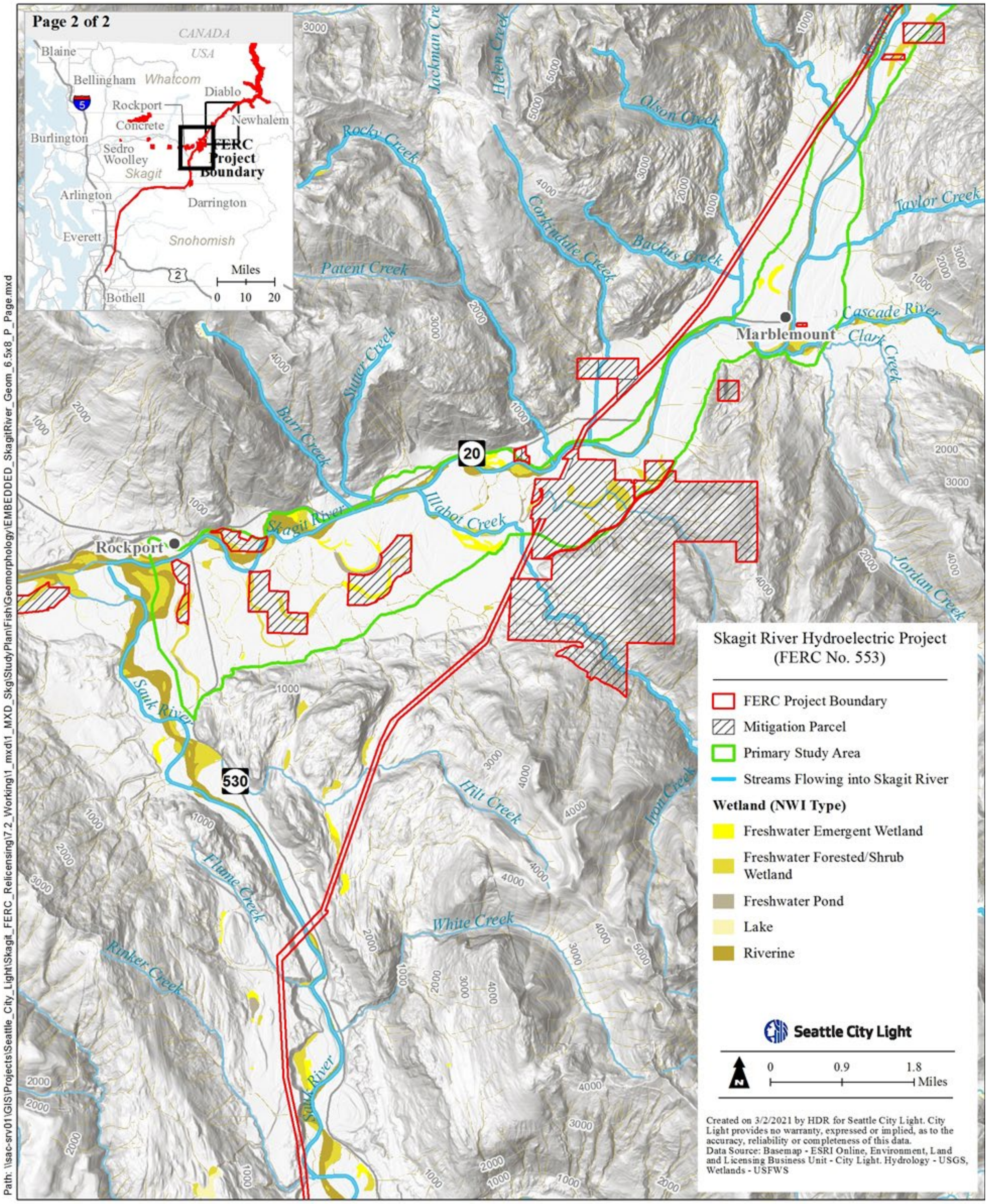

Figure 2.5-3. Southern portion of study area: Marblemount to Sauk River confluence.

2.6 Methodology

The Skagit River Geomorphology from Gorge Dam to the Sauk River Study will include pre-field analysis of existing information, one season of field work to inventory current geomorphic conditions in the Skagit River, three years of redd scour monitoring,[2] two years of scour monitoring at tributary junctions and river bars, sediment transport modeling, and post-field analysis and report writing. Work below is described by geomorphic/habitat topic, but information on multiple topics will be collected during a single field effort for efficiency, and the analysis and reporting will include a synthesis of geomorphic processes among the different topics.

2.6.1 Collect Existing Information

Existing reports, maps, aerial photographs, LiDAR data, peak flow data, and habitat/redd survey data will be compiled (see Table 2.6-1 for available aerial and LiDAR data sets). Up to seven sets of aerial photographs will be chosen from available coverage at approximately decadal scale for use in analysis of planimetric geomorphic changes under existing flow conditions. These will be related to topographic changes determined by evaluation of geomorphic change between LiDAR surfaces. Pre-field analyses will be conducted using this data as described by topic in the following sections. A comprehensive set of base maps will be prepared for field inventory between Gorge Dam and the Sauk River confluence (a set of laminated high-resolution copies of aerial photographs and a set of laminated copies of visualization detrended LiDAR topography data). Geomorphic reaches will be delineated based on consideration of several factors, such as gradient, confinement, tributary junctions, and landform mapping (being conducted by NPS). These reaches will be used to help group and analyze geomorphic data.

Available reports on Skagit River geomorphology downstream from the Sauk River confluence will be summarized. An annotated bibliography will be prepared, and a summary of geomorphic conditions will be written for inclusion in the study report.

USGS gage records from the Skagit River will be collected from the USGS gage site for use in the IHA software package.

[2] A pilot scour monitoring study started in September 2019; it is anticipated the scour monitoring study will be expanded to include new areas and continue through September 2022.

Table 2.6-1. Available aerial photograph and LiDAR Data.

Date	Image Type	Scale	Notes
Orthophotos			
1947	Orthophoto quads	1:62:500	
1950	Orthophoto quads	1:62:500	Basis for 15' topo series
1974	Orthophoto quads	1:24,000	Basis for 7.5' topo series
1990	Orthophoto quads, 1-2m res.	1:24,000	Update to 7.5 minute series various quads
1992	Orthophoto quads, 1-2m res.	1:24,000	Update to 7.5 minute series various quads
1993	Orthophoto quads, 1-2m res.	1:24,000	Update to 7.5 minute series various quads
1998	Orthophoto quads, 1-2m res.	1:24,000	Update to 7.5 minute series various quads
Hard Copy Stereoscopic Photographs			
1947	Black B&W stereo photos	1:27,700	USFS
1950s	B&W stereo photos	1:24,000	USFS
8/9-1956	B&W stereo photos	1:24,000	EBK series USFS (NPS incomplete set)
1957	Unclear	1:47,200	VRL series USGS (no NPS set)
1958	Unclear	1:49,000	VSA series USGS (no NPS set)
1963/64	B&W (?) stereo	1:12,000	EMM series USFS (NPS incomplete set)
1973	B&W (?) stereo	?	VCAG series USGS (no NPS set)
1978	True color stereo photos	1:24,000	NPS
1998	True color stereo photos	1:12,000	NPS
Hard Copy Stereoscopic Photographs - Pairs			
1984	Color, Hi- res. CIR min. overlap	1:10,000	NPS prints 3 feet x 3 feet
1990	Hi -res. B&W min. overlap	1:10,000	NPS prints 3 feet x 3 feet
2006	True Color National Agriculture Imagery Program (NAIP) hi-resolution	1m	Digital
2009	True Color NAIP hi-res.	1m	Digital
2011	True Color NAIP hi-res.	1m	Digital
2015	True Color NAIP hi-res.	1m	Digital
2015	True Color NAIP hi-res.	1m	Digital
2017	True Color NAIP hi-res.	1m	https://viewer.nationalmap.gov/basic
2006	True Color NAIP hi-resolution	1m	Digital
2009	True Color NAIP hi-res.	1m	Digital
2011	True Color NAIP hi-res.	1m	Digital
LiDAR			
2005	LiDAR	digital	Puget Lowlands – partial coverage
2006	LiDAR	digital	North Puget (USGS)
2009	LiDAR	digital	North Cascades – partial coverage
2017	LiDAR	digital	Skagit River topobathymetry – partial coverage
2017	LiDAR	digital	North Puget
2018	LiDAR	digital	Seattle City Light topobathymetry

2.6.2 Geomorphic Change

The analysis of geomorphic change includes two primary metrics: channel migration and channel incision. Changes in active channel width, sinuosity, and braiding intensity will also be analyzed. Tasks will include the following:

Mapping will be conducted of active channel areas as polygons on current (2019) and up to six historical geo-referenced aerial photographs (seven total sets of aerials). Active channels include areas within the river where the combination of sediment transport intensity and hydroperiod prevent establishment of vegetation. Wetted areas will be digitized separately from unvegetated areas (bars), and each polygon will be coded as wetted or unvegetated bar.

Channel migration rates will be calculated by summing the difference in new channel planform area between aerial photograph years and dividing by reach length. Migration rates will be calculated for each bank of the river separately. Channel migration rates will be compared to peak flow conditions and changes to sediment inputs and large wood loading to determine conditions that contribute to bank erosion and channel migration. Channel migration history over the existing license period will be visualized by calculating historic channel occupancy maps and maps illustrating historic channel positions. Bank protection will be taken into account when analyzing channel migration.

Sediment input from channel migration will be estimated based on the methods used by Rothleutner (2017) in the middle Skagit River to allow direct comparison and, for the more recent period with available LiDAR data, by comparing geomorphic change between LiDAR surfaces. This task will be coordinated with the bank material sampling undertaken as part of the landform mapping study to assess grain size of eroded bank material.

Locations and character of bank protection will be mapped between Gorge Dam and the Sauk River to update information in Beamer et al. (2000). This will be coordinated with other field efforts (e.g., landform mapping study or aquatic habitat mapping) and any other updated hydromodification data from other sources.

A visual estimate of percent boulder, cobble, gravel, sand, and fines (silt/clay) will be made for exposed/eroding riverbanks, and the locations will be mapped. This information will be used along with the channel migration analysis to estimate sediment input from bank erosion.

Active channel width, sinuosity, and braiding intensity will be calculated for appropriate geomorphic reaches (reaches with similar confinement characteristics) based on the active channel mapping. Changes through time will be tracked.

An analysis of USGS gage rating curve changes during the term of the current license (from 1990 to present) will be made at the Skagit River at Newhalem (USGS 12178000), Skagit River at Marblemount (USGS 12181000), Skagit River near Rockport (USGS 12184700) gages to evaluate potential channel incision or aggradation. These data will be combined with rating curve change analysis from the previous licensing studies (Riedel 1990). If feasible, historic cross-section data at other locations between the Gorge Dam and the Sauk River will be compared with available Green LiDAR data to evaluate channel changes at locations between gages.

The Relative Elevation Map based on current LiDAR data (developed as part of a landform mapping study being conducted by the National Park Service) will be used to analyze channel evolution stage between Gorge Dam and the Sauk River based on the Stream Evolution Model in Cluer and Thorne (2013).

2.6.3 Aquatic Habitat

An inventory of the current status of aquatic habitat in the Skagit River between Gorge Dam and the Sauk River will be made using both remote sensing and field methods. This work will be coordinated with data collected in the FA-02 Instream Flow Model Development Study and the FA-05 Skagit River Gorge Bypass Reach Hydraulic and Instream Flow Model Development Study (Bypass Hydraulic Model Development Study).

An initial map of aquatic habitat types will be made based on recent (2019) georeferenced aerial photographs and green LiDAR (e.g., riffle, pool, glide, cascade, side channels as visible – see Section 2.6.4 of this study plan for more detail on side channels). Habitat units will be digitized from 2019 aerial/LiDAR data to obtain a GIS layer. Data fields obtained from the GIS analysis will include habitat type, average depth (from green LiDAR), and average wetted width. Estimates of average bankfull width and depth will be made based on the green LiDAR and results from the 2D hydraulic model (Instream Flow Model Development Study). Pool depths that were not able to be determined from the green LiDAR data will be field verified as part of the Instream Flow Model Development Study and the Bypass Hydraulic Model Development Study as described in those study plans. Field information on cover and dominant/subdominant substrate size will also be collected as part of the Instream Flow Model Development Study and the Bypass Hydraulic Model Development Study for the reach between Gorge Dam and the Sauk River and will be used to characterize each aquatic habitat unit using GIS.

An assessment of the potential for fish passage blockages at tributary junctions due to shallow water conditions will be made during low flow conditions. Thalweg water depths will be measured at tributary junction fans from the confluence with the Skagit River to a point 500 feet upstream of the confluence. The water depths will be compared to minimum water depths required for upstream adult migrants.

Summary tables showing the amount (square feet) and characteristics of aquatic habitat will be prepared and synthesized with substrate, large wood, and side channel data collected as described in the following sections.

2.6.4 Side Channels and Off-Channel Habitat

An inventory will be taken of the current status of side channels and off-channel habitat in the Skagit River floodplain between Gorge Dam and the Sauk River. The inventory will be made using a combination of remote sensing and field methods.

An initial map of side channels and off-channel habitat will be made based on recent (2019) georeferenced aerial photographs and green LiDAR in coordination with the NPS landform mapping project currently underway and the Wetland Assessment Study. Side channels will be digitized from 2019 aerial/LiDAR data to obtain a GIS layer. Data fields obtained from the GIS analysis will include side channel type (overflow side channel [perennial and seasonal] wall-based channel, groundwater-fed channel) and area. A Relative Elevation Map, which shows relative elevations above/below river water surface, will be used to help delineate side channels and off-channel areas.

The initial map of side channels having significant habitat value (as defined in the Instream Flow Model Development Study) will be refined and field-checked during low-flow conditions as part of the Instream Flow Model Development Study. The field inventory will include collecting information on side channel characteristics not available from aerial photographs, such as inlet and outlet characteristics, dominant/subdominant substrate, and cover.

Information on off-channel habitat will be collected from aerial photographs/LiDAR and field data collected as part of the Wetland Assessment. In addition, the 2D hydraulic model being developed as part of the Instream Flow Model Development Study will be used to help assess side channel/off-channel connectivity under selected flows. (Flows will be determined based on a peak flow frequency analysis.)

If possible (depending upon visibility of side channels on aerial photographs), side channel formation and changes through time over the period of the current license will be mapped and correlated with peak flow conditions (magnitude and duration) between aerial photographs chosen for the geomorphic change analysis to help determine how side channels form and/or are maintained under existing peak flow conditions.

A summary of the amount and quality of side channel habitat will be made. Information on side channel formation and changes over time will be used to evaluate the ability of existing peak flow conditions to create and maintain side channels.

2.6.5 Substrate/Sediment

An inventory of the current status of substrate in the Skagit River, side channels, tributary junctions, and unvegetated bars between the Gorge Dam and the Sauk River will be made. The inventory will be made using both remote sensing and field methods and will be coordinated with the landform mapping project currently underway.

Field data on dominant/subdominant substrate size between Gorge Dam and the Sauk River will be collected as part of the Instream Flow Model Development Study and the Bypass Hydraulic Model Development Study.

Wolman pebble counts (100 surficial particles) and sub-surface samples (Church et al. 1987) will be collected at locations representative of bedload transport (e.g., top end of point bars or upper end of mid-channel bars) during low flow conditions. Sample spacing will depend upon the availability of appropriate bars and will be stratified by geomorphic reach, with the aim of one sample per river mile. Pebble counts will also be made at tributary confluences to characterize the grain size of current sediment contributed from tributaries. Data from the landform mapping study currently underway will be used to assess the grain size of sediment sourced from riverbank erosion. Surface and sub-surface substrate size will be compared at sample locations to help determine the extent of any armoring.

Tributary deltas and unvegetated bars will be mapped on a series of up to seven historical to recent aerial photographs to enable tracking of their sizes and conditions over time and to assess the ability of current peak flow regimes to distribute incoming sediment (see Section 2.6.2 of this study plan).

An analysis of initiation of gravel transport at key/representative spawning locations, tributary confluences, and river bars using scour monitors and accelerometers will be made to help determine the flow rate that initiates movement or results in substrate movement as well as scour (to redd depth in redds). A pilot redd scour monitoring project was initiated at three locations during August 2019 to help determine the feasibility of using various scour monitor/accelerometer techniques in the Skagit River. Details of the field methods are attached to this study plan. Scour monitoring was expanded to include a total of 10 other critical spawning areas in August 2020. Additional scour monitors/accelerometers will be installed at select river bar and tributary deltas in August 2021 to help identify initiation of transport and scour depths in those features. Scour monitoring will be continued through the fall of 2022 to allow monitoring of several high flow seasons since high flow events are unpredictable. Locations for additional scour monitors and accelerometers will be discussed during the coordination meetings proposed as part of sediment transport modeling studies discussed in an attachment to this study plan.

USGS (in cooperation with Washington State Department of Transportation [WSDOT]) installed hydrophones at Marblemount and Car Body Hole in fall 2020 to record acoustical signals of bedload movement, and it intends to collect bedload transport data during high flow conditions. These data will be available to City Light and used to augment information collected from the scour monitors/accelerometers to help determine flows that initiate bedload movement as well as bedload transport rates as feasible.

Summary tables and graphs showing area of different substrate sizes, median surface and sub-surface grain size (from sample locations) and showing proportion of bedrock, boulder, cobble, gravel, sand, and fines longitudinally along the length of the study reach will be prepared. Summary tables of these same parameters for tributary inputs will also be made. Maps showing the changes in gravel bar/tributary confluence deposits through time will be prepared to help correlate any changes in gravel bar or delta growth/movement with peak flows. An analysis of flow levels that initiate substrate movement and scour depths at river bars, tributary deltas, and spawning areas will be made using the representative scour monitoring data. These data will be used along with the hydraulic modeling (see Instream Flow Model Development Study) to extrapolate the results to other areas of the study reach based on substrate size and modeled hydraulic conditions.

2.6.6 Large Wood

An inventory of the current status of large wood in the Skagit River between Gorge Dam and the Sauk River, including tributary mouths, will be conducted using both remote sensing and field methods. The inventory will be coordinated with the cover mapping conducted for the Instream Flow Model Development Study and the Bypass Hydraulic Model Development Study.

An initial inventory of large wood will be made using current (2019) filtered LiDAR cross referenced to concurrent aerial photographs (similar to methods described in Abalharth et al. 2015). LiDAR will be used to delineate large wood and jams. Delineated wood and jams will be cross referenced with aerial photographs to verify features and to collect additional information such as root wad (Y/N), function, and member of log jam (Y/N). Data will be entered into the GIS coverage, and volume of wood will be calculated if possible.

Current large wood will be field inventoried during low flow conditions by boat or foot in coordination with the aquatic habitat inventory. Pieces of large wood over 25 feet in length and 12 inches in diameter will be tallied in each aquatic habitat unit (see Section 2.6.3 of this study plan) in binned categories. In addition, more detailed information on large wood (over 25 feet in length and 12 inches diameter) within ten 0.5-mile-long representative detailed wood inventory reaches will be collected. In these detailed wood inventory reaches, a GPS point will be taken on each large wood piece, and information on length, diameter at breast height (dbh), orientation, root wad (Y/N), single log (Y/N), jam (Y/N), source, decay class; species, mobility, habitat/geomorphic function will be collected for use in determining wood dynamics.

An inventory of large wood on up to seven sets of historical aerial photographs (assuming resolution is appropriate) over the term of the last license will be made, with wood digitized as line features to help determine large wood mobility and loading to correlate with peak flows between aerial photograph series.

Work products will include:

- Summary tables/graphs showing existing large wood loading metrics along the river;
- Summary of any changes to large wood loading and sources over the term of the current license based on historical aerial photographs correlated with peak flow conditions; and
- Evaluation of the potential for future large wood loading from tributaries and bank erosion based on tributary inputs, bank erosion rates, and riparian vegetation type and size (linked to channel migration analysis in Section 2.6.2 of this study plan, the TR-01 Vegetation Mapping Study, and Landform Mapping Study in floodplain).

2.6.7 Process Flows

High flow events of a variety of magnitude and durations help to support a geomorphic processes and habitat values and are often referred to as “process flows.” Based on the information and analysis described above, and in this section, flows associated with the following processes will be investigated:

- Flows that mobilize river bar deposits;
- Flows that mobilize deposits at major tributary mouths;
- Flows that erode river banks and contribute to channel migration;
- Flows that instigate side channel development/maintenance; and
- Flows that hydraulically connect side channel and off-channel habitat.

The water depth, velocity, and shear stress output from the two-dimensional (2-D) unsteady flow hydraulic model developed as part of the Instream Flow Model Development Study will help analyze initiation of bedload movement at river bars, tributary mouths, and riverbanks. The scour monitor, accelerometer, and hydrophone data will be used in conjunction with the hydraulic model results and sediment transport modeling to determine flows that initiate substrate movement at different locations. The hydraulic model results will also be used to help estimate flows that connect different side channel and off-channel habitat units to the main channel flow.

The IHA software package will be used to investigate the timing and duration of different types of high flow events under unmanaged conditions to inform the development of potential process flow scenarios that can be analyzed as part of license application development.

2.6.8 Transport of Sediment and Large Wood

An analysis of the transport of sediment and large wood in the Skagit River between Gorge Dam and the Sauk River confluence will be undertaken to address study requests submitted by LPs, specific NMFS-02 Geomorphology and Aquatic Habitat study request. Proposed methods for these analyses are attached to this study plan and additional details will be developed in consultation with LPs through a series of workshops to select specific methods and locations for more intense study (e.g., focus areas).

2.6.9 Data Analysis and Report Preparation

A technical report will be prepared describing field inventory and analytical methods and study results. The report will include a narrative describing each of the aquatic habitat/geomorphic topic areas listed in the previous sections and their results, as well as a synthesis of the interactions between these processes and conditions.

Specific study and report products include:

- A description of the geomorphic setting and brief summary of relevant previous geomorphic studies conducted in the Skagit River between Gorge Dam and the Skagit River estuary, including a summary of relevant information from the landform mapping study (undertaken by NPS and in progress);
- A summary of geomorphic change (planform change, channel migration, and channel elevation change) over the term of the current license and correlation with peak flows/geomorphic disturbances;
- GIS-based maps, summary tables and analyses of aquatic habitat, side channels, substrate, and large wood as described in previous sections;
- An analysis of initiation of substrate movement and scour in monitored areas (river bars, tributary confluence deposits, and adjacent to redds) with peak flow conditions;
- Extrapolation of measured substrate movement with mapped grain size and computed shear stress to other locations using the 2-D Hydraulic Model (Instream Flow Model Development Study);
- An analysis of current side channel conditions and side channel formation/maintenance processes, as well as an assessment of hydrologic connectivity to the mainstem Skagit River at a variety of flows;
- An analysis to evaluate current amount and quality of spawning and rearing habitat for all salmonid species within the study area;

- An estimate of potential future loading of large wood and gravel/cobble in the Skagit River between Gorge Dam and the Sauk River confluence;
- An assessment of the potential for fish passage issues due to water depth at tributary confluences;
- IHA results for unmanaged conditions to help inform the timing and duration of high flow processes;
- Monitoring, modeling results, and discussion of sediment and wood transport analysis (see proposed methodology for additional monitoring and modeling attached to this study plan); and
- Synthesis of the interaction among flow, sediment loading, large wood input, channel migration/side channel formation, floodplain connectivity and aquatic habitat.

2.7 Consistency with Generally Accepted Scientific Practice

The methods described above were prepared by a Washington State Licensed Engineering Geologist and are consistent with remote sensing and field inventory methods used in other parts of the Skagit River and in other large river systems (Abalharth et al. 2015; Church et al. 1987; Cluer and Thorne 2013; Rothleutner 2017; Skagit River System Cooperative and Natural Systems Design 2019; Smith et al. 2011; USACE 2008).

2.8 Schedule

The Geomorphology Study includes pre-field office analysis of existing information, one season of field work in the river during the late summer low-flow period (summer), post-field data analysis, and report preparation. Workshops to identify additional field scour monitoring locations and other data gathering efforts associated with the Sediment Transport and Large Wood Proposed Monitoring and Transport Studies described in the attachment to this study plan will be initiated in June 2021.

- Scour monitoring – August 2019 to July 2022
- Pre-field Analysis – April to June 2021
- Workshops (as needed) – June to December 2021
- Field Work – January to September 2021 (depending on flows)
- Post-field Analysis – Summer 2021 to Winter 2021-2022
- Initial Study Report (ISR) – March 2022
- Final Report (Updated Study Report [USR]) – March 2023

2.9 Level of Effort and Cost

The initial estimate for implementation and reporting associated with this study is approximately $565,000. Estimated cost for the proposed sediment transport and large wood modeling is an additional $1.5 million.

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SKAGIT RIVER GEOMORPHOLOGY BETWEEN GORGE DAM AND THE SAUK RIVER
REVISED STUDY PLAN

ATTACHMENT A

CITY LIGHT RESPONSES TO LP COMMENTS ON THE STUDY PLAN PRIOR TO PSP

Table 1. City Light responses to LP comments on the study plan prior to PSP.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
1.	Steve Copps, Jim Meyers, and David Price (NMFS)	04/13/2020	General Comments	Each plan suffers from an abbreviated scope and lack of clarity in guiding hypotheses and the questions the studies are designed to answer. From NMFS' perspective, the study plans should clearly state the anticipated utility of the proposed research in understanding the past, current, and future effects of the project on ESA-listed salmonids, Critical Habitat, Essential Fish Habitat, and Treaty Trust Responsibilities. Fish habitat includes a diverse assemblage of aquatic and terrestrial species that are affected in time and space by the operations at the dams. Further, the study plans should clearly state the anticipated utility of proposed research in understanding the status quo, assessing ongoing project effects, and predicting the effects of future management plan scenarios under a new license, including climate change scenarios.	City Light acknowledges the need for consultation with NMFS related to its regulatory responsibilities as required in the FERC process and that the information resulting from the study program is intended to inform consultation with NMFS during future steps within the process. The FERC process schedule positions an integrated environmental analysis subsequent to the completion of the study program and prior to the filing of a License Application. City Light currently manages and investigates many aspects of aquatic species conditions in the study area and over the course of the relicensing will identify appropriate PME measures in consultation with LPs.
2.	Steve Copps, Jim Meyers, and David Price (NMFS)	04/13/2020	General Comments	The study plans should describe in detail how they will inform our collective understanding of fish and aquatic habitat and ecology. To that end, the study plans should be forward thinking in connecting the anticipated results between these and other study plans. The connections between study plans should be made explicit now to ensure researchers are thinking ahead about the utility of their data from both technical and analytical perspectives and so that plans and associated cost estimates fully reflect foreseeable tasks. Explicitly making these connections will also assist NMFS and other LPs understand exactly how our data needs will be met through multiple study plans.	The integrated environmental analysis referred to in Comment #1 will specifically address links across resource areas. City Light will work with the RWGs to integrate information from related studies as part of the ILP process.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
3.	Steve Copps, Jim Meyers, and David Price (NMFS)	04/13/2020	General Comments	The geographic and temporal scopes of the draft Geomorph and Operations Model study plans are insufficient. The Geomorph study should be extended to include the full extent of project effects on geomorphic processes. That includes at a minimum, downstream to Puget Sound and upstream through the bypass reach and Stetattle Creek where the project precludes a known population of ESA-listed steelhead from migrating and spawning. The Geomorph and Operations Model draft study plans should be developed to improve our collective understanding of historical processes (including pre-dam conditions) so that they can be compared to the status quo and future management scenarios.	Please refer to the Operations Model study plan for City Light's responses for that study. The FERC baseline is existing conditions, and therefore pre-dam conditions are not considered in this study plan. As noted in Section 2.1, the upper end of the Study Area is bounded by Gorge Dam, i.e., the Gorge bypass reach is included in the study area. Note that the few steelhead that occasionally made it to Stetattle Creek did not constitute a population but rather an intermittent spawning aggregation. Project effects would more than likely be indiscernible in the lower reaches of the Skagit River and Puget Sound given the complex array of factors contributing to existing environmental conditions in the lower reaches of the Skagit River, and the extremely limited time available to these studies. City Light plans to assess the nature of the Project's contribution to cumulative effects downstream of the Sauk River confluence using existing available information as part of the relicensing process, and nonetheless remains open to discussion of evidence of effects that should be evaluated herein. Note that to support this assessment, existing information downstream of the Sauk River confluence will be compiled and analyzed as part of this study.
4.	Steve Copps, Jim Meyers, and David Price (NMFS)	04/13/2020	General Comments	The draft study plans would benefit from collaboration within the FA Group to harmonize LP comments and explore opportunities for improving efficiency and	The requested collaboration is underway, as evidenced by the 2019-2020 voluntary study identification process, including this study plan and associated comment-response effort.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				utility of the anticipated results in meeting the needs of all License Participants.	Moreover, City Light will continue collaboration with LPs regularly throughout the ILP process.
5.	USFS	04/13/2020	General Comments	Quantification of sediment (bedload) and wood arrest by project operation and consequent downstream resource impacts. This is a significant omission and is a clear project effect on downstream resources now and into the new license.	City Light believes that quantifying the rates of sediment and wood retention by the Project is not necessary to mitigate for potential Project effects on downstream resources. Rather, during relicensing, City Light will work with LPs to gather information and develop tools to inform our understanding of existing conditions that may or may not support current and future environmental resource objectives in the Skagit River downstream of the Project (i.e., Gorge Dam to Sauk River.) These studies should expand our understanding of the limiting factors to fish populations that could be further addressed through the implementation of the current (or modified) instream flow program, through identifying and implementing active restoration projects that address these limiting factors in a strategic manner (e.g., reflective of Skagit River Chinook, steelhead and bull trout recovery plans), and through effectiveness monitoring from which appropriate adaptive management measures can be identified and actioned upon. City Light, favors this type of resource benefit management approach (i.e., identifying locations in the Skagit River below the Project and then targeting eventual PME measures to improve ecological function at those locations) and looks forward to further discussions with all LPs for means to explore this approach in concert with meeting their resource management objectives.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
					Also note that the reservoir sedimentation study at reservoir locations with specific resource related concerns, and the shoreline erosion study will provide some information of relevance to the stated concern. Ongoing wood management activities will also provide information on wood inputs to the reservoirs.
6.	USFS	04/13/2020	General Comments	Evaluation of geomorphic change as a result of project effect. The study plan attempts to study the existing condition without isolating the project effect on the resource of concern.	See Comment Responses #1 and #5.
7.	USFS	04/13/2020	General Comments	Address the geomorphic change downstream as a consequence of the range of flows released by the project not just peak flows. It seems imprudent to omit nearly the entire range of flow conditions from analysis when attempting to study project effects on downstream resources.	High flows (rather than moderate or low flows) are the driver of geomorphic processes; text was revised to clarify that the magnitude and duration of high flows will be considered during the analysis.
8.	USFS	04/13/2020	General Comments	**The FS recommends** the title be modified to include the remainder of the Skagit River to the terminus or delta (including the bypass reach). This will enable SCL to sufficiently capture all of the fluvial geomorphic direct, indirect, and cumulative effects from project operations on physical habitats in the Skagit River. Including all areas of likely effects will inform the development of license requirements and assist the Forest Service (FS) analysis of Forest Plan consistency1,2 and Wild and Scenic River Act (WSRA) section 7 determination 3 needed during the relicense process.	See Comment Response #3.
9.	Jon Riedel (NPS)	03/31/20201	Section 1.1 General Description of the Project	"The Project also includes two City Light-owned towns, an Environmental Learning Center, several recreation facilities, and several parcels of fish and wildlife mitigation lands."	Roads associated with the Project are included in the Project Area; issues related to roads will be included in the Erosion and Geologic Hazards study plan.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				Mention all of the roads associated with the project?	
10.	Judy Neibauer (USFWS)	04/13/2020	Section 1.2 Relicensing Process	"The PAD also includes an outline of the goals and objectives of this study." You should mention that this data will help to collect data for other analysis such as: NEPA, ESA, and the Fish and Wildlife Coordination Act (see Section 10j of the FERC regulations). The FWCA process is combined in the ILP process and comes into play later.	Section 1.2 has been edited to identify elements of the relicensing process, such as those noted by USFWS.
11.	Brock Applegate (WDFW)	04/12/2020	Section 1.2 Relicensing Process	"This study plan reflects consultation from the RWG effort,…."	Section 1.2 and 1.3 were redrafted to better describe the 2019 process. Formal consultation does not begin until after the PAD is officially submitted. Although the informal 2019 process leading up to the development of draft study plans did not result in consensus regarding all issues raised by LPs, City Light views this process as a collaborative effort (i.e., the action of working together).
12.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 1.2 Relicensing Process	"This study plan reflects the RWG effort, and City Light will continue to engage the RWG structure in the preparation of the Proposed and Revised Study Plans…" This study plan might reflect the RWG effort, but falls critically short of addressing the need identified by the RWG on scope (spatial scale), and complexity of the issues across resources of concern.	See Comment Response #3. City Light acknowledges that the proposed study plan does not incorporate all issues discussed during the 2019 RWG effort (i.e., study elements where consensus could not be achieved were not included). The proposal reflects City Lights view of geomorphology issues that may warrant study under the Project FERC relicensing process. During subsequent stages of the ILP, City Light and LPs will be able to explore potential effects on resources to a greater degree and will work with the RWGs to integrate information from related studies. See also Comment Responses #1 and #2.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
13.	Brock Applegate (WDFW)	04/12/2020	Section 1.3 Study Plan Development	"Project operations reduce ~~alter~~ peak flows by magnitude and duration and alter the flow period timing in the Skagit River downstream of Gorge Dam, thereby altering geomorphic processes that may affect aquatic habitat and cultural resources through the reduction in flow, sediment, and LWD. Geomorphic processes affect aquatic habitat by influencing substrate size and quality; large wood dynamics, main channel and side channel habitat abundance and diversity, and side channel, wetland, and floodplain connectivity. Information on geomorphic processes, aquatic habitat for a number of fish species including anadromous, migratory, and resident salmonids, large wood, and sediment in the Skagit River between Gorge Dam and the Sauk River confluence and downstream to the estuary is needed to improve the understanding of how Project operations may influence aquatic species and their habitat and cultural resources over the next license term."	See Comment Response #7 regarding flows and #3 regarding spatial scope of analysis. Text accepted with minor modification (i.e., "alter" was retained).
14.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 1.3 Study Plan Development	"Project operations alter ~~peak~~ flows in the Skagit River downstream" The continued use of Peak flows creates an appearance that aquatic resources are only impacted via lack of peak flow. However, smaller events or the duration of these events also need to be evaluated for impacts to aquatic resources of concern. Basic operations have also disrupted sediment, bedload, and LWD from downstream habitats and processes.	See Comment Response #7 regarding flows and #5 and #6 regarding quantification of sediment and LWD retention by the reservoirs.
15.	Rick Hartson (Upper Skagit Indian Tribe)	04/13/2020	Section 1.3 Study Plan Development	"Project operations alter peak flows in the Skagit River Downstream"	See Comment Response #7 regarding flows and #5 and #6 regarding quantification of sediment and LWD retention by the reservoirs.

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				Also disrupt sediment and LWD transport by storing in reservoirs. Understanding the project impacts on geomorphology requires accounting for the interaction between sediment, LWD, and habitat-forming flows. A wide range of flows, not just peak flows and the duration of these flows, affect connectivity to floodplain habitats (e.g. wetlands, relic channels, side channel) and wetted area of channel habitats (e.g. bank, bar, backwater, side channel).	
16.	Rick Hartson (Upper Skagit Indian Tribe)	03/30/2020	Section 1.3 Study Plan Development	"Geomorphic processes affect aquatic habitat by influencing substrate size and quality; large wood dynamics, main channel and side channel habitat abundance and diversity, and floodplain connectivity." Functioning PNW rivers provide spawning habitats that are protected from scour during high flow events (e.g. side channels, groundwater fed floodplain channels, meander bends). Need to consider interaction between sediment mobility and hydraulics of simplified channels, where the project may be simplifying channel geomorphology and increasing redd scour.	A synthesis discussion integrating the flow, sediment, large wood, aquatic habitat, channel migration, and side channel dynamics based on existing information as well as data gathered as part of this study will be included in the study report (see Section 2.6.7). City Light will use this information in a forward-looking manner, by evaluating potential future scenarios relative to existing conditions, to help develop appropriate PMEs.
17.	Rick Hartson (Upper Skagit Indian Tribe)	03/30/2020	Section 1.3 Study Plan Development	"Geomorphic processes affect aquatic habitat by influencing substrate size and quality; large wood dynamics, main channel and side channel habitat abundance and diversity, and floodplain connectivity." High flows interact with LWD in habitat-forming processes. The project impacts both high flow and the abundance of LWD	See Comment Response #16 for synthesis discussion.

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				downstream of the dams, thus the study needs to account for this interaction to understand the extent of impacts.	
18.	Rick Hartson (Upper Skagit Indian Tribe)	03/30/2020	Section 1.3 Study Plan Development	"Geomorphic processes affect aquatic habitat by influencing substrate size and quality; large wood dynamics, main channel and side channel habitat abundance and diversity, and floodplain connectivity." Also affect channel migration and formation of floodplain habitats. The study needs to explicitly consider habitat forming processes, not simply presence of habitats during a given snapshot in time.	See Comment Response #16 for synthesis discussion.
19.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 1.3 Study Plan Development	"Information on geomorphic processes, aquatic habitat for anadromous salmonids, large wood, and sediment in the Skagit River between Gorge Dam and the Sauk River confluence is needed to improve the understanding of how Project operations ~~may~~ influence aquatic habitat for anadromous salmon and cultural resources over the next license term." Essential fish Habitat, as defined by the Magnuson Stevens Fishery Conservation and Management Act.	See Comment Response #10. EFH is included with other statutory authorities in Section 1.2.
20.	Rick Hartson (Upper Skagit Indian Tribe)	03/30/2020	Section 1.3 Study Plan Development	"Information on geomorphic processes, aquatic habitat for anadromous salmonids, large wood, and sediment in the Skagit River between Gorge Dam and the Sauk River confluence is needed to improve the understanding of how Project operations influence aquatic habitat for anadromous salmon and cultural resources over the next license term." This term will limit collaborative opportunities	See Comment Responses #3 and #5. City Light currently transports woody debris from Project reservoirs to the lower Skagit River to benefit aquatic habitat. As summarized in Section 5.0 of the PAD, a management plan will be developed over the course of the relicensing process to outline wood management and will include

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				if it does not include materials affected by the reservoirs. The lack of an operation is relevant here. Namely, the lack of a program to transport LWD and sediment downstream of the dams. Also, reservoir storage inundates Skagit River and tributary floodplains, thereby preventing the growth of forests and a source of LWD recruitment.	information on the process for transporting trapped wood downstream.
21.	USFS	04/13/2020	Section 1.3 Study Plan Development	**The FS recommends** modify the following statement to clearly identify project effects on the full range of natural flow conditions, sediment transport, and large wood recruitment and transport. Statement: **Project operations reduce peak flows by magnitude and duration and alter the flow period timing in the Skagit River downstream of Gorge Dam.** **The FS recommends** only including those issues, and referencing those issue forms, that are explicit goals and/or objectives of this study plan. If methods are not designed to study the specific data gaps identified in the issue forms, then issues should not be included here. Alternatively, describe in sufficient detail how conclusions drawn from this study plan will inform project effects on the issues brought forward in this paragraph.	See Comment Response #7 regarding flows and #11 regarding references to issue forms.
22.	Jon Riedel (NPS)	03/31/2020	Section 1.3 Study Plan Development	"Project operations reduce peak flows by magnitude and duration and alter the flow period timing in the Skagit River downstream of Gorge Dam, thereby altering geomorphic processes…." Really should mention major project impact of eliminating sediment (bed load) and LWD,	See Comment Response #7 regarding flows. See Comment Responses #5, #6, and #20.

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				which along with flow period alteration have major geomorphic impacts. Further it is not just peak flow but duration, particularly for spring flood.	
23.	Judy Neibauer (NPS)	04/13/2020	Section 1.3 Study Plan Development	"Information on geomorphic processes, aquatic habitat for…." I wasn't involved in the early development of this study…but I am thinking that understanding where the key upwelling/hyporheic areas are, would be important to add. Overlaying geomorphology with temperatures can help indicate/find key hyporheic areas and pools that are used for refugia, forage, spawning etc. If there is any FLIR data out there to utilize, it would be worth finding. You can overlay that with Lidar/geomorphology information to help show the upwelling/cool water location that are indicative of hyporheic areas. The effects from project operations to these refugia areas would be important to know. It seems that this would be the place for collecting that type of information.	This study does not include water temperature. However, temperature data are collected at the Newhalem USGS gage, and Ecology has and continues to collect temperature data at Marblemount. As discussed in the PAD, available data indicate that water temperature is in compliance with Ecology criteria in the reach downstream of the Project. 7-DADMax water temperatures in the Skagit River between the Project and the Sauk River are cool year round (rarely >14 °C).
24.	Judy Neibauer (USFWS)	04/13/2020	Section 1.3 Study Plan Development	"Information on geomorphic processes, aquatic habitat for ~~anadromous salmonids~~ a number of fish species including anadromous, migratory, and resident salmonids, large wood, and sediment in the Skagit River between Gorge Dam and the Sauk River confluence and downstream to the estuary is needed to improve the understanding of how Project operations may influence aquatic species and their habitat ~~for anadromous salmon~~ and cultural resources over the next license term."	Edits accepted.

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25.	Judy Neibauer (USFWS)	04/13/2020	Section 1.3 Study Plan Development	"Information on geomorphic processes, aquatic habitat for a number of fish species including anadromous, migratory, and resident salmonids…." Should include other fish species in this statement as well. We will need to think about bull trout and their prey species, and other resident fish.	See Comment Response #24.
26.	Brock Applegate (WDFW)	04/13/2020	Section 1.3 Study Plan Development	I agree with Judy, we should consider all aquatic species. (See Comment #17)	See Comment Response #24.
27.	Judy Neibauer (USFWS)	04/13/2020	Section 1.3 Study Plan Development	"Information on geomorphic processes, aquatic habitat for a number of fish species including anadromous, migratory, and resident salmonids, large wood, and sediment in the Skagit River between Gorge Dam and the Sauk River confluence and downstream to the estuary is needed to improve the understanding of how Project operations may influence aquatic species and their habitat…" I would imagine you are thinking about applying the information gained by this geomorphic study to aquatic species…not just anadromous salmon…hence the addition here. At some point you may need to make a distinction between habitat types…and we also have "listed critical habitat" under the ESA Critical habitat rules. If this information will help qualify conditions of critical habitat, you may want to point that out somewhere.	See Comment Response #24.
28.	Brock Applegate (WDFW)	04/13/2020	Section 1.3, Study Plan Development	"….(8) FA35, Process Flows,…" Many LPs question whether this study will identify the process flows, which SCL will	See Comment Responses #1 and #11.

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				need for the flow model. If we can't identify the process flows, please remove FA35 and FA 36 from the list.	
29.	Jon Riedel (NPS)	03/31/2020	Section 1.3 Study Plan Development	"….(13) FA47, Sediment Budget and Storage, Stability, and Transport in Skagit River Downstream of Gorge Dam." Glad to see you at least acknowledge these issue statements, even if this SP does not address them. This remains a large issue with a huge data gap. NPS will want to know how SCL will address.	Thank you for your comments. See Comment Responses #5, #6, and #11.
30.	Brock Applegate (WDFW)	04/13/2020	Section 1.3 Study Plan Development	I agree with John. This study plan will not address sediment budget or storage in and transport around the reservoirs. Why include this Study Issue Identification Form in the list when it does not address it in the Study Plan? (See Comment #21)	See Comment Responses #5, #6, and #11.
31.	Ashley Rawhouser (NPS)	03/25/2020	Section 2.1 Study Goals and Objectives	"The study goals of the Skagit River Geomorphology between Gorge Dam and the Sauk River study are…." Can SCL provide the rationale (written) for why the study doesn't include 1) the Bypass Reach and 2) the Skagit River below the Sauk confluence. If possible please provide citations to support the proposed study area.	See Comment Response #3.
32.	Brock Applegate (WDFW)	04/12/2020	Section 2.1 Study Goals and Objectives	WDFW would like to see an explanation why SCL did not include downstream of the Sauk confluence in this study plan beyond the collection of literature. Most LPs realize a reduction in effects below the Sauk confluence, but SCL should make some attempt to understand their impacts below the Sauk. No other LP accepts the explanation by SCL of no	See Comment Response #3.

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				effects or too complicated to calculate the effects. SCL has some sort of effect downstream of the Sauk confluence. (Response to Comment #23)	
33.	Judy Neibauer (USFWS)	04/13/2020	Section 2.1 Study Goals and Objectives	Include areas upstream of the dam as well as downstream to the mouth/estuary, and also include some distance upstream into fish bearing tributaries that are connected to both the river and to the reservoir (at least key tributaries used for spawning and foraging)… There is likely some distance upstream in the tributaries where effects are observed. Rational: Actions associated with operations such as releasing flows, cause streams/ rivers/ and reservoir movements up and down, and these flow changes or reservoir elevation changes generally change tributary processes (i.e., they slow or hasten the rate of flow in the tributary itself, and change the point at which the waterways connect to the main Skagit River or reservoirs. Hence, affecting the geomorphology at intersection of the mouths of the tributaries…can be a big deal for connectivity. Adding these areas and assessing the geology/gradients/ flow regimes, etc… can help inform what is natural processes vs operational effects.	See Comment Response #3. Regarding reservoir connectivity, habitat conditions in the reservoir tributaries, above the influence of the reservoirs' high-water marks, or in tributaries that flow into the Skagit River, are outside the range of the Project's effects. City Light currently mitigates for potential effects on fish migration/passage (i.e., connectivity) resulting from sediment and woody debris deposition in Project reservoirs, and intends to continue the effort. The 1991 Settlement Agreement stipulates that City Light is to survey for and remove transitory barriers to spawning migration in tributaries to Project reservoirs. City Light has agreed to expand the annual barrier surveys and barrier removal efforts beginning in 2020 following NCC approval. Regarding tributary connectivity between Gorge Dam and the Sauk River, City Light is not aware of any connectivity issues due to geomorphic processes downstream of Gorge Dam. However, the Relative Elevation Model (REM) that is being developed for this reach will help address this concern as part of the license application process.
34.	Rick Hartson (Upper Skagit Indian Tribe)	04/13/2020	Section 2.1 Study Goals and Objectives	"The study goals of the Skagit River Geomorphology between Gorge Dam and the Sauk River study are to characterize the current condition of aquatic habitat in the reach, and to	See Comment Response #3.

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				characterize how Project-related changes in peak flows affect geomorphic processes in the reach." See Upper Skagit Indian Tribe comments on Vegetation Mapping and Wetland Mapping studies from TR&RE RWG. These were detailed comments that present evidence of project impacts below the Sauk confluence and the importance of understanding this in terms of EFH for salmonids, including for ESA-listed species.	
35.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.1 Study Goals and Objectives	"The study goals of the Skagit River Geomorphology between Gorge Dam and the Sauk River study are to characterize the current condition of aquatic habitat in the reach, and to characterize how Project-related changes in peak flows affect geomorphic processes in the reach." CC: Suggesting mitigation for effects upstream without having a better understanding of what is downstream is dangerous because everything downstream has adjusted to previous conditions before mitigation.	See Comment Responses #1, #2, and #3.
36.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.1, Study Goals and Objectives	"The study goals of the Skagit River Geomorphology between Gorge Dam and the Sauk River study are to characterize the current condition of aquatic habitat in the reach, and to characterize how Project-related changes in peak flows affect geomorphic processes in the reach." CC: Understanding the current condition is important but is SCL intention to keep things as they are for the future license or to improve	Subsequent to completion of the study program, there are steps in the relicensing process intended to determine what PMEs will be formulated, including how the Project will be operated during the next license term (See Comment Responses #1 and #2). City Light is proud of its stewardship of the river and the current flow regime, i.e., as required by the FSA, has been beneficial to anadromous and resident salmonids in the Skagit River. City Light's goal is to continue to benefit aquatic

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				things during the future license? If the goal is to bring salmon back we need to be studying how to reverse project impacts; not keep them status quo.	resources, which may involve the reshaping of the flow release schedule (among other things). However, City Light respectfully requests that LPs recognize that City Light's obligation in the context of the FERC process is to mitigate for ongoing Project effects.
37.	Rick Hartson (Upper Skagit Indian Tribe)	04/13/2020	Section 2.1 Study Goals and Objectives	"The study goals of the Skagit River Geomorphology between Gorge Dam and the Sauk River study are to characterize the current condition of aquatic habitat in the reach, and to characterize how Project-related changes in peak flows affect geomorphic processes in the reach." Also, disrupted LWD and sediment transport. And disrupted formation of floodplain forests under reservoirs (see earlier comment).	See Comment Responses #5 and #6.
38.	Brock Applegate (WDFW)	04/12/2020	Section 2.1 Study Goals and Objectives	"Project-related changes in peak flows affect geomorphic processes in the reach." How will SCL accomplish this statement without the use of a sediment budget?	See Comment Responses #5 and #6.
39.	Rick Hartson (Upper Skagit Indian Tribe)	03/30/2020	Section 2.1 Study Goals and Objectives	"Specific objectives include:" New objective: Determine peak flow magnitudes and duration curves that support natural fluvial processes and habitat-formation to help guide management of peak flow releases from Gorge Dam and Powerhouse, and to help determine potential issues related to floodplain development.	See Comment Responses #1, #2, and #6. City Light is not addressing this with the objectives of this study plan but acknowledges that evaluating appropriate peak flow releases for the next license term will be a topic addressed during later stages of the formal ILP. Note also that evaluating floodplain development and associated regulations are beyond the scope of the relicensing process and study program.
40.	Rick Hartson (Upper Skagit Indian Tribe)	03/30/2020	Section 2.1 Study Goals and Objectives	1st Bullet – Comment "Use aerial photograph and LiDAR data and collect field data to document current	See Comment Responses #3 and #6. Edits made to use sub-set of all available historical aerial photographs/maps.

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				conditions and changes over the period of the current license to document:" Not adequate to understand disruption to fluvial process. Impacts were likely already in place at start of current license. Need to have historic condition as a reference against which to estimate the ongoing disruption to fluvial and habitat-forming processes. Then, account for non-project interacting factors that impact fluvial process, then we can isolate and identify the impacts caused by the project.	
41.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.1 Study Goals and Objectives	2nd Bullet – Comment "Baseline channel configuration and migration patterns;" CC: How far back is SCL planning to look? Why not include older topo maps? There is valuable information back to 1899 that could be used to track changes to the rate of migration that would be indicative of project effects since the beginning.	See Comment Responses #3 and #6.
42.	Rick Hartson (Upper Skagit Indian Tribe)	03/30/2020	Section 2.1 Study Goals and Objectives	2nd Bullet – Comment "Baseline channel configuration and migration patterns;" Pre-project. GLO maps may provide a resource.	See Comment Responses #3 and #6.
43.	Rick Hartson (Upper Skagit Indian Tribe)	03/30/2020	Section 2.1 Study Goals and Objectives	4th Bullet - Comment "Side channels and off-channel habitat;" Wetlands and other floodplain habitats that only have surface connectivity to channels during high flows.	The *Study Goals and Objectives* include side channels and off-channel habitat. Wetlands are being addressed in a separate study plan in TRREWG; information from that study will be integrated with information from this geomorphology study after the relicensing

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					study program is completed and described in the license application.
44.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.1 Study Goals and Objectives	6th Bullet – Comment Large wood input, transport, and retention. Wood budget for system?	An analysis of wood loading and mobility for current conditions will be developed based on an analysis of wood on aerial photographs as described in Section 2.6.6.
45.	Rick Hartson (Upper Skagit Indian Tribe)	03/30/2020	Section 2.1 Study Goals and Objectives	7th Bullet – Comment "Determine flow rates that result in redd scour to help guide management of peak flow releases from Gorge Dam and Powerhouse." Spatially explicit scour risk to account for hydraulic heterogeneity (e.g. refuge in side channels and groundwater fed floodplain channels).	The combination of the redd scour measurements and the hydraulic model developed for the Instream Flow Study can be used to extrapolate measured scour to other areas of the modeled channel.
46.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.1 Study Goals and Objectives	7th Bullet – Comment "Determine flow rates that result in redd scour to help guide management of peak flow releases from Gorge Dam and Powerhouse." The first issue should be to understand what flows currently result in redd scour, across the current available habitat and for all native salmonids downstream of project area. Scour to pink redds is fundamently different than scour to Steelhead redds based on species specific spawning locations (depth, substrate size, channel location etc.) and timing. Upper Skagit Indian Tribe is requesting scour assessments specific to each anadromous salmonid species present in the Skagit. As noted multiple times project operations have not passed wood, sediments nor bed load which may bias these	The pilot Redd scour monitor locations cover Pink, Chum, Chinook, and steelhead spawning locations; the expanded monitoring locations will cover all mainstem spawning species. See Comment Responses #5, #6, and #20. Future instream flow recommendations will be developed as part of the license application and include consideration of many resources.

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				results. Managing flows from the project require a much deeper and wider dive than redd scour to assess future recommendations for downstream flows, suggest removing this reference.	
47.	Judy Neibauer (USFWS)	04/13/2020	Section 2.1 Study Goals and Objectives	"Project-related changes in peak flows affect geomorphic processes in the reach." Include gathering of data for locations of key hyporheic/upwelling areas. This can lead to finding out about potential spawning, foraging, and rearing habitat. I would like to suggest you add a component to the objectives that looks at geology and temperature patterns (glacial till deposits or where fault lines of land forms are that could be overlaid with temperature data like FLIR or other data)… These types of data linked together may provide knowledge for effects to aquatic refugia…such as key locations for spawning, foraging, overwintering, or key holding habitat that might be cooler than surrounding waters. Understanding key hyporheic or upwelling areas, will help with understanding how operational flows affect these types of refugia.	See Comment Response #23.
48.	Judy Neibauer (USFWS)	04/13/2020	Section 2.1 Study Goals and Objectives	Specific objectives include: These objectives seem a bit limited. You might think about putting in the key questions you are going to answer. If you are collecting aquatic habitat data there are generally more objectives that you have listed here…i.e., Are there enough key pools? Is there enough key wood for cover and forming pools, stabilizing channel? Are there too many sediments mixed	See Comment Responses #1, #2, and #6.

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				with the spawning substrates? Also, show how you will be using data gathered in the office vs the field, and link the data to the questions you will be answering. In the Existing Information section below, you can show the data you already have and the questions it answers. Doing something like this… might help partners understand what this study will pulling together in the office vs that field and how it links to the issues.	
49.	Brock Applegate (WDFW)	04/12/2020	Section 2.1 Study Goals and Objectives	5th Bullet – Add red text "Side channels and off-channel habitat, including hydraulically connected wetlands;"	Thank you. These edits have been incorporated.
50.	Jon Riedel (NPS)	03/31/2020	Section 2.1 Study Goals and Objectives	6th Bullet - Comment "Substrate size and distribution; sediment sources and delivery mechanisms; and…" You mean, specifically, tributaries? I thought Issue Statement was for 'sediment budget'?	The intention is to look at substrate size, distribution, existing sediment sources and delivery mechanisms in the mainstem Skagit and at the mouths of tributaries.
51.	Jon Riedel (NPS)	03/31/2020	Section 2.1 Study Goals and Objectives	7th Bullet - Comment "Determine flow rates that result in redd scour to help guide management of peak flow releases from Gorge Dam and Powerhouse." Isn't it flow peak discharge as well as rate (ramping)? And duration is also critical for geomorphology. Lack of sustained peak flow is allowing tributary deposits to accumulate in main channel and narrow Skagit River.	Agree discharge and duration are important – See Comment Response #7. Changes to the Skagit River at tributary junctions will be assessed as part of this study (See Section 2.6.2).
52.	USFS	04/13/2020	Section 2.1	The first paragraph on pg 2-1 does not identify a clear resource issue and associated project	See Comment Responses #1, #2, #5, #6, and #20.

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			Study Goals and Objectives	effect. The Goal of the study should be "**Evaluate the <u>project effects</u> on geomorphic conditions between Gorge Dam and the Skagit River terminus or delta (including the bypass reach)".** This will enable SCL to sufficiently capture all of the fluvial geomorphic direct, indirect, and cumulative effects from project operations on physical habitats in the Skagit River. Including all areas of likely effects will inform the development of license requirements and assist the Forest Service (FS) analysis of Forest Plan consistency1,2 and Wild and Scenic River Act (WSRA) section 7 determination 3 needed during the relicense process. Objectives of the study would be to measure those effects (quantitatively or qualitatively) on specific issues identified in the issue forms described in Section 1.3. **The FS recommends** including two quantifiable measures of downstream effects on the geomorphic condition of the Skagit River that appear to be missing from the objectives. 1) Quantify anticipated wood loading above Gorge Dam for the period of the new license, based on methods described in the study plan but applied to the upper basin above Gorge Dam, as a measure of wood transport loss to downstream habitat due to project effects. 2) Quantify anticipated bedload volume above Gorge Dam for the period of the new license, based on methods described in the study plan but applied to the upper basin above Gorge	

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				Dam as a measure of sediment transport loss to downstream habitat due to project effects. The loss of both large wood and bedload volume over the period of the new license is an indirect project effect on all downstream Skagit River geomorphic condition and subsequent physical habitat formation for aquatic species. Objectives identified in this section provide a thorough description of the existing condition, and snapshots of the period of the current license, but it is unclear how the product from this study plan will be tied to project effects during the new license period. **The FS recommends** adding a summary at the end of Section 2.1 of how each objective will meet the stated goal.	
53.	Judy Neibauer (USFWS)	04/13/2020	Section 2.2 Resource Management Goals	According to guidelines for the ILP…this section should also include Information about public input considerations…Maybe you have this somewhere else? See this link: https://www.ferc.gov/industries/hydropower/gen-info/guidelines/guide-study-criteria.pdf	City Light appreciates the input. Also, it is worth noting that the criteria pertain to "public interest," not public "input."
54.	Judy Neibauer (USFWS)	04/13/2020	Section 2.2 Resource Management Goals	"This information will be used during the licensing process to inform Project effects on the geomorphic conditions through this reach of the Skagit River and identify potential protection, mitigation and enhancement measures, as appropriate." Think about rewording this to say you are not just looking at effects to the geomorphic conditions…but setting a baseline to establish how the changes to geomorphic	See Comment Response #6.

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				conditions/processes effect the fish, aquatic, and riparian resources.	
55.	Jon Riedel (NPS)	03/31/2020	Section 2.2 Resource Management Goals	"This information will be used during the licensing process to inform Project effects on the geomorphic conditions through this reach of the Skagit River and identify potential protection, mitigation and enhancement measures, as appropriate." How will SCL know how to design mitigation for loss of bed load if there is no idea how much is being cut-off by dams? How would SCL understand dynamic nature of bed load transport and storage without basic modeling? The lack of gravel from the upper basin has many effects below the project, including influence on channel stability, bank erosion, and introduction of gravel from these sources. It also would influence floodplain connectivity.	See Comment Responses #5 and #6.
56.	Brock Applegate (WDFW)	04/12/2020	Section 2.2 Resource Management Goals	I agree with and cannot describe it better than Jon. I would only add that the reach in question does not operate in a vacuum. SCL has effects above the Project from the lack of transport of sediment and large woody debris. SCL has effects below the Project like disconnected channels and wetlands and a shrinking estuary. I agree that the SCL has a smaller effect the farther we go downstream, but the Project still have some effect. How does SCL intend on answering salmonid population questions or mitigation for such when it won't collect the information for the entire river? (See Comment #35)	See Comment Responses #3, #5, #6, and #20.
57.	Judy Neibauer (USFWS)	04/13/2020	Section 2.2 Resource	I also agree see my other comment above about study area. It is highly likely that there are some	See Comment Response #3 and #33.

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			Management Goals	effects out into the estuary…as well as effects above the dams. In general, in most systems where there are dams, the tributaries are also affected some distance upstream (i.e., from operational flows, reservoir levels). (See Comments #35 and #25?)	Habitat conditions in tributaries upstream of the dams are not within the scope of this study but are addressed in the Reservoir Deposition study plan. City Light is unaware of any Project-related adverse effects on aquatic habitat in the lowest reaches of tributaries to the Skagit River downstream of the Project. However, City Light welcomes LP input regarding specific aquatic habitat issues associated with geomorphic alteration, and the associated site-specific information that serves as the basis for raising the issues.
58.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.2 Resource Management Goals	Suggestion for Goal Statement that may help bridge difference of LPs approach and Utilities approach: The Shared resource management goals are to understand how Project past's and current operations have affected existing Essential Fish Habitat, and geomorphic processes through and below project area. If the goal is to just know what existing aquatic habitat conditions currently exists then we bias that understanding by not identifying what the projects impacts are to those resources.	The FERC baseline is existing conditions, and therefore ongoing effects, not past effects, are the focus of this study plan (see also comment response #6). In addition, this study plan addresses conditions from Gorge Dam to the Sauk River. Other study plans are currently aimed at assessing conditions in the Project reservoirs. Also, it is important to emphasize that this study constitutes the first phase of investigation, and studies and LP consultation will continue during the ILP process.
59.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.2 Resource Management Goals	"This information will be used during the licensing process to inform Project effects on the geomorphic conditions through this reach of the Skagit River and identify potential protection, mitigation and enhancement measures, as appropriate." CC: What is the metric for this and when does this come into play? How will the need to enhance or mitigate be determined if current conditions between Gorge and Sauk are all that	See Comment Responses #1, #2, #5, and #6.

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				are assessed? Why is there no study currently being planned for to address mitigation or enhancement based on quantifying how much sediment and LWD is being cut-off by the dams?	
60.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.2 Resource Management Goals	"City Light will confer with resource agencies and tribes that are interested in participating in development of this study proposal, and language identifying specific management goals relevant to this study proposal is anticipated." When and how? The current path on this study plan was for LP's to ask clarifying questions, which directly stymied a robust dialogue of scientific inquiry to tease out Projects impacts on current existing habitats and processes. The statement also implies the utility has created the study plan without input, but a more accurate statement would acknowledge the contributions to date, and limited use and interpretation by the utlity, with additional work to move towards an agreed to study plan. Suggest the creation and facilitated support of hydro-geomorph sub group.	Although the informal 2019 process leading up to the development of draft study plans did not result in consensus regarding all issues raised by LPs, City Light views this process as a collaborative effort (i.e., the action of working together). See Comment Responses #1, #2, #11, and #12.
61.	USFS	04/13/2020	Section 2.2 Resource Management Goals	**The FS recommends** changing the goal statement "City Light's resource management goals are to gain a current understanding of existing aquatic habitat conditions related to geomorphic processes in the Skagit River between Gorge Dam and the Sauk River confluence." to better align with federal, state, and tribal resource management goals. An appropriate change would be **"City Light's resource management goals are to gain an understanding of project effects on**	See Comment Response #3 regarding spatial scope. Section 2.2, Resource Management Goals, was modified to include the USFS management documents.

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				geomorphic conditions between Gorge Dam and the Skagit River terminus or delta (including the bypass reach)". This will enable SCL to sufficiently capture all of the fluvial geomorphic direct, indirect, and cumulative effects from project operations on physical habitats in the Skagit River. Including all areas of likely effects will inform the development of license requirements and assist the Forest Service (FS) analysis of Forest Plan consistency1,2 and Wild and Scenic River Act (WSRA) section 7 determination 3 needed during the relicense process. **The FS recommends** maintaining consistency throughout the suite of study plans by referencing the following FS management planning documents: 1990 Mt. Baker Snoqualmie National Forest Land and Resource Management Plan (LRMP) 1994 Record of Decision - Standards and Guidelines for Management of Habitat for Late-Successional and Old-Growth Forest Related Species Within the Range of the Northern Spotted Owl - Attachment A to the Record of Decision for Amendments to Forest Service and Bureau of Land Management Planning Documents Within the Range of the Northern Spotted Owl. 1983 Skagit River Management Plan Volume II.	

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62.	Judy Neibauer (USFWS)	04/13/2020	Section 2.3 Background and Existing Information	"Aquatic habitat in the Skagit River supports numerous anadromous, migratory, and resident fish species as well as other aquatic organisms. Geomorphic processes affect components of aquatic and riparian habitat, including substrate size, quantity and quality; large wood dynamics, and main channel and side channel habitat diversity." The term "resident" can take many forms….in the FERC world and policy world…"resident" may mean all fish but salmon. In the biological world resident means fish that stay in their stream they were born in. In the Skagit we have bull trout that exhibit all life history forms (anadromous, adfluvial, riverine, and resident). If you add the word migratory here (i.e., fish that are staying in freshwater and moving between lakes/reservoirs/rivers/streams), that may insure you are covering and discussing these forms of fish more appropriately. Today, with all the new telemetry and PIT tag data, we know there are more life forms that act differently and use different habitat than a true "resident" fish. In the bull trout world, we may have anadromous bull trout spawning with riverine migrants, or even resident sized fish. This Project might be an opportunity to begin discussing native fish assemblages and insuring that when we talk about anadromous fish, we also mean bull trout. And that when we talk about steelhead, we talk about resident or riverine forms….Not sure how to do this yet, but it could start with definitions and or usage of the terms salmon, steelhead, bull trout when	Edits accepted.

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				we talk about habitat they exist in.	
63.	Judy Neibauer (USFWS)	04/13/2020	Section 2.3 Background and Existing Information	"Aquatic habitat in the Skagit River supports numerous anadromous, migratory, and resident fish species as well as other aquatic organisms. Geomorphic processes affect components of aquatic and riparian habitat, including substrate size, quantity and quality; large wood dynamics, and main channel and side channel habitat diversity." Geomorphic studies can be used to look at a large array of aquatic and riparian habitat information, all generally important to addressing the effects of operations. Thus, I add riparian habitat here, because changes to channels, effect riparian vegetation, that in turn effects macroinvertebrates, overhanging cover, LWD, undercut bank cover, and energy dispersion of the channel… and these are all important to assess aquatic habitat. I am guessing, that perhaps the vegetation mapping can link up to the geomorphology study data, to help determine changes in riparian vegetation types?... Overall, this seems like a good section of the document to describe the linkages to other studies where you will use additional data from this study to identify effects?	Edits accepted.
64.	Rick Hartson (Upper Skagit Indian Tribe)	03/30/2020	Section 2.3 Background and Existing Information	"Aquatic habitat in the Skagit River supports numerous anadromous and resident fish species as well as other aquatic organisms." And habitats that may be considered terrestrial. For example, floodplain terraces and wetlands that may only have surface connections to main	See Comment Response #63.

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				channels during high flows. Wetlands can support direct use by juvenile salmonids. Inundation of forested floodplain terraces supports aquatic productivity via terrestrial subsidies. There must be thorough coordination among this geomorphic study and the Wetland and Vegetation Mapping studies in the TR&RE RWG.	
65.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.3 Background and Existing Information	Essential Fish Habitat, might capture the complexity of habitat types fish biologist are concerned with- which includes both aquatic and terrestrial, plus seasonal habitat types across the floodplain.	EFH is included with other statutory authorities in Section 1.2.
66.	Rick Hartson (Upper Skagit Indian Tribe)	03/30/2020	Section 2.3 Background and Existing Information	"Additional information is also needed to establish gravel quantities and quality on a spatial scale, gravel mobilization and redd scour…" Spatially-explicit redd scour. Use of 2-D model would help identify hydraulic refuges, such as those associated with side channels, meander bends, vegetated islands, and log jams.	The purpose of the study is to collect information to understand the existing environment and identify potential limiting factors associated with hydro-operations. This information in combination with information from other studies including the hydraulic model can be used to support the development of PMEs to address Project effects.
67.	Jon Riedel (NPS)	03/31/2020	Section 2.3 Background and Existing Information	"Additional information is also needed to establish gravel quantities and quality on a spatial scale, gravel mobilization and redd scour flows in primary spawning areas, and changes to river geometry that may occur through time." Is there a basin-wide scale? Or, just tributaries?	The Study Area includes the mainstem and tributary mouths.
68.	Brock Applegate (WDFW)	04/12/2020	Section 2.3 Background and Existing Information	"Additional information is also needed to establish gravel quantities and quality on a spatial scale, gravel mobilization and redd scour flows in primary spawning areas, and	See Comment Responses #1 and 6.

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				changes to river geometry that may occur through time.” Do primary spawning areas change from year to year? If so, we many need to develop an adaptive management plan, when we finish this study to monitor scour, if the spawning areas move in the river.	
69.	Rick Hartson (Upper Skagit Indian Tribe)	03/30/2020	Section 2.3 Background and Existing Information	▪ Channel configuration and migration patterns; ▪ Aquatic habitat types, characteristics, and availability; ▪ Side channels (existing channels, formation and maintenance processes); ▪ Substrate size and distribution; and ▪ Large wood (existing; potential input, transport, and retention processes). See previous comments to ensure these are adequately understood.	Thank you. Comment noted.
70.	Rick Hartson (Upper Skagit Indian Tribe)	03/30/2020	Section 2.3 Background and Existing Information	“These data can provide information on preferred spawning locations and habitat to help guide gravel scour monitoring.” Scour monitoring should allow comparison to a reference river system or reconstruction of historic conditions to help understand whether the current system has adequate heterogeneity and hydraulic refuge to provide natural redd protection under a variety of flows. Depending on the timing, there may be a conflict between habitat-forming flows and redd protection. The geomorphology study should help determine whether this conflict may arise, and, if so, how we can accommodate both redd protection and	See Comment Responses #1, #3, #6, and #36.

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				habitat-forming flows (i.e. we need understand how we can best mimic a natural PNW river that supports all necessary salmonid life-stages and species).	
71.	Rick Hartson (Upper Skagit Indian Tribe)	03/30/2020	Section 2.3 Background and Existing Information	"Existing information that provides a basis for understanding geomorphic processes in the middle and lower Skagit River includes:" These will be valuable resources, but the geomorphic study needs to be comprehensive from Gorge Dam downstream to the Skagit delta/estuary (other comments in this study plan as well as in Vegetation and Wetland Mapping plans in TR&RE RWG).	See Comment Response #3.
72.	Jon Riedel (NPS)	03/31/2020	Section 2.3 Background and Existing Information	3rd Bullet - Comment "Side channels (existing channels, formation and maintenance processes);" Need to link this, and other data, with landform maps. There is some overlap here, making it critical that we work together on the side channels.	Yes, the intention is to use landform mapping the NPS is preparing. Text revised to clarify.
73.	Jon Riedel (NPS)	03/31/2020	Section 2.3 Background and Existing Information	Other land use practices such as timber harvest, road construction, and bank protection downstream of Gorge Dam also influence geomorphic processes and the suitability of aquatic habitat. Note there are few of these impacts above Bacon Creek. Should add other hydro projects to list of land use?	Thank you for your comment. Other hydro projects will be included in the cumulative effects analysis.

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74.	Brock Applegate (WDFW)	04/12/2020	Section 2.3 Background and Existing Information	Thanks Jon, SCL has another hydroelectric project at Newhalem Creek. (See Comment #44)	See Comment Response #73.
75.	Judy Neibauer (USFWS)	04/13/2020	Section 2.3 Background and Existing Information	If there are existing SCL facilities/projects or other types of issues/ongoing actions, they should be included in the background, including any habitat conditions that may be altered as a result.. (i.e., Newhalem Dam, storage areas/access roads, transmission corridors, conservation lands, hatcheries, road/culvert issues). The background information will help develop baseline conditions and capture the past and current conditions and show why you might need to study. Collecting the information in these areas becomes important, and helps USFWS, NMFS, and FERC/ SCL to compare any ongoing or new effects to the baseline and may help out SCL to determine their levels of effects. (See Comment #44)	See Comment Response #73.
76.	Brock Applegate (WDFW)	04/12/2020	Section 2.3 Background and Existing Information	"Evaluating the relative influence of different natural and human-induced processes will aid in the understanding of existing river conditions." These kind of evaluation would help with your effects analysis below the Sauk confluence as well.	Thank you for your suggestion.
77.	Judy Neibauer (USFWS)	04/13/2020	Section 2.3 Background and Existing Information	"Evaluating the relative influence of different natural and human-induced processes will aid in the understanding of existing river conditions." Do you have locations of key refugia for bull trout already? You should mention that in here	See Comment Response #1. Also, City Light will work with USFWS in the context of the Section 7 Consultation associated with the relicensing to address effects on Bull Trout.

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				somewhere. Understanding how key refugia and populations change with operations will be important for the effects analysis. We will be looking at effect to bull trout and bull trout critical habitat both above the dams, in tributaries, within SCL owned lands, transmission corridors, and below the dam out into the estuary.	
78.	Judy Neibauer (USFWS)	04/13/2020	Section 2.3 Background and Existing Information	Understanding how SCL's portion of the impacts (i.e. dam operations, and management, of other areas including transmission line corridors) is a key goal and should be described in effects assessments. Gathering data to help parse this out will be important. You might include a description of other land management issues…dredging, land use, forest practices, irrigation, fishing, to name a few… (See Comment #48)	See Comment Response #73.
79.	Brock Applegate (WDFW)	04/12/2020	Section 2.3 Background and Existing Information	"City Light surveys anadromous fish spawning locations throughout the year and records location, water depth, and species." Will this continue into the next license? I assume we will have a good grasp on the location of excellent spawning areas and possible spawning area changes to look at redd scour flows throughout the life of the license, if necessary.	While the identification and development of PMEs for the next license is a phase of relicensing subsequent to the study program, City Light anticipates and is committed to working with LPs during the ILP to identify monitoring and protective flow releases for the new license term.
80.	Jon Riedel (NPS)	03/31/2020	Section 2.3 Background and Existing Information	"Historic and recent aerial photographs and recent LiDAR data are available to aid in mapping channel configuration, large wood, and sediment dynamics." Since you are not modeling, how will you address sediment dynamics? At specific points with instruments? Here again, the data	See Comment Response #6. Links to landform mapping and geomorphic reach breaks have been added to the text throughout the study plan.

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				collection and analyses need to be linked to specific geomorphic reaches identified in the landform mapping. SCL has an early version of the reach breaks, but they are being revised as we map.	
81.	Jon Riedel (NPS)	03/31/2020	Section 2.3 Background and Existing Information	"Existing information that provides a basis for understanding geomorphic processes in the middle and lower Skagit River includes:" Should mention landform mapping at 1:6000 scale currently being conducted?	See Comment Response #72.
82.	Judy Neibauer (USFWS)	04/13/2020	Section 2.3 Background and Existing Information	"Existing information that provides a basis for understanding geomorphic processes in the middle and lower Skagit River includes:" See my previous comment on expanding study area. Here I don't see you are gathering information in tributaries below or above the dams to determine areas affected. Effects likely travels some distance upstream of the influence of the Skagit River or Reservoirs. This might be unique in certain tributaries based on land types. We will need information in these areas above and below the dams, within reservoirs, and some distance upstream in the tributaries to assess effects from operational flows. There may also be different levels of effects in reservoir tributaries, from where they enter the reservoir at the highest flows, to where they enter the reservoir at average flows, to where they enter the reservoir at lowest flows.	See Comment Responses #3 and #57.
83.	Jon Riedel (NPS)	03/31/2020	Section 2.3 Background and Existing Information	5th Paragraph, 1st Bullet – Comment "A baseline fluvial geomorphology report was prepared for the Skagit River basin (Gorge Powerhouse to estuary) by the U.S. Army	Agree – this will be appropriate for some of the small watersheds we are looking at. The geology, topography, land use, etc. conditions in each watershed will be taken into account

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				Corps of Engineers (USACE) that includes an estimated sediment input budget based on basin sediment budgets and suspended load data and a description of fluvial geomorphic reaches (USACE 2008). This report relies largely on the work of Paulson, which is focused on logged areas in NF.	when using data from sediment budgets prepared for other areas.
84.	Jon Riedel (NPS)	03/31/2020	Section 2.3 Background and Existing Information	5th Paragraph, 2nd Bullet – Comment "Channel incision was identified as a potential issue during the Skagit Project's last relicensing in the early 1990s. Analysis of USGS gage records at that time showed incision at the Alma gage (no longer in service) and little variation to 0.4 feet of aggradation at the Newhalem gage (Riedel 1990)." Hasn't USGS (Anderson) recently revisited this?	The USGS provided a draft analysis at a geomorphology workgroup meeting; a finalized analysis will be prepared as part of this study.
85.	Brock Applegate (WDFW)	04/12/2020	Section 2.3 Background and Existing Information	5th Paragraph, 8th Bullet – Comment "Suspended sediment monitoring by the USGS on the lower Skagit River (Curran et al. 2016) and Sauk River (Jaeger et al. 2017)." SCL should think about a reproduction of this study in the study reach with the same protocol.	There will be turbidity monitoring just below the Gorge Powerhouse, which should reveal the times when system-wide water clarity issues are occurring. If the suggestion to conduct suspended sediment monitoring is for sediment budgeting purposes, See Comment Response #6.
86.	USFS	04/13/2020	Section 2.3 Background and Existing Information	***The FS recommends*** modify this section to include a clear statement of what the data gap is that the study plan is to address. The below problem statement address the data gap need, but it is unclear in the study plan methods how this study plan will address this issue.	See Comment Responses #1 and #2.

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				"Detailed information on aquatic habitats downstream of Gorge Dam is needed to improve the understanding of current spawning and rearing capacity for all salmonid species using the habitat, and how these factors could be predicted to change over the next license term." ***The FS recommends*** that this section describe the background and existing information on each issue described in section 1.3. Providing the background and existing information of each issue will draw out where data gaps are and how this study plan can best be developed to address them. This section may be a good place to link other study plans intended to provide additional information on issues that may inform conclusions of this study plan.	
87.	Jon Riedel (NPS)	03/31/2020	Section 2.4 Project Operations and Effects on Resources	"Project Operations and Effects on Resources" And sediment? Gravel? LWD? Duration?	See Comment Response #88.
88.	Brock Applegate (WDFW)	04/12/2020	Section 2.4 Project Operations and Effects on Resources	"Project operations ~~alter~~ reduce peak flows in duration and magnitude and alter flow period timing in the Skagit River downstream of Gorge Dam, thereby altering geomorphic processes that may affect aquatic habitat through the reduction in flow, sediment, and LWD. Geomorphic processes affect aquatic habitat by influencing key habitat forming elements, such as: substrate size, amount, and quality; key pools, large wood dynamics, main channel and side channel habitat diversity, streambank condition, riparian vegetation, tributary and floodplain connectivity, including	The term "reduce" was rejected because the term alter provides for a wider and more varied scope of changes. Other edits accepted.

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				side channel and hydraulically connected wetlands."	
89.	Judy Neibauer (USFWS)	04/13/2020	Section 2.4 Project Operations and Effects on Resources	"Project operations reduce peak flows in duration and magnitude and alter flow period timing in the Skagit River downstream of Gorge Dam, thereby altering geomorphic processes that may affect aquatic habitat through the reduction in flow, sediment, and LWD. Geomorphic processes affect aquatic habitat by influencing key habitat forming elements, such as: substrate size, amount, and quality; key pools, large wood dynamics, main channel and side channel habitat diversity, streambank condition, riparian vegetation, tributary and floodplain connectivity, including side channel and hydraulically connected wetlands."	Edits accepted.
90.	Rick Hartson (Upper Skagit Indian Tribe)	03/30/2020	Section 2.4 Project Operations and Effects on Resources	"Project operations alter peak flows in the Skagit River downstream of Gorge Dam, thereby altering geomorphic processes that may affect aquatic habitat." See other comments. The transport of LWD and sediment is impacted, as is the recruitment of LWD above the dams.	See Comment Responses #5 and #6.
91.	Judy Neibauer (USFWS)	04/13/2020	Section 2.4 Project Operations and Effects on Resources	This is a section described in the study plan guidelines which I shared earlier…It mentions this is where you get to talk about how the results from the Project will affect the resources. This section could link up to the goals and objectives above and show how the information will be used to assess effects. Currently, this just seems like a general statement/paragraph, without the details of how the data will be used.	See Comment Responses #1 and #2.

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92.	USFS	04/13/2020	Section 2.4 Project Operations and Effects on Resources	**The FS recommends** modifying this section to include the project effects on the complete range of natural flow conditions, sediment transport, and large wood recruitment and transport both above the dams and downstream to the Skagit River delta (as described above).	See Comment Responses #3, #6, and #20.
93.	Ashley Rawhouser (NPS)	03/25/2020	Section 2.5 Study Area	See previous related comment. (See Comment #23)	See Comment Response #23.
94.	Brock Applegate (WDFW)	04/12/2020	Section 2.5 Study Area	Please explain why SCL will not pursue the collection of new information below the Sauk River confluence to the estuary.	See Comment Responses #3.
95.	Judy Neibauer (USFWS)	04/13/2020	Section 2.5 Study Area	Please see my comment above, I agree with folks about expanding the study both above and below the dams, and also I think it should gather information in affected tributaries for some distance upstream …as well as your conservation land areas, and across your transmission lines/roads, see my previous comments. (See Comment #25)	See Comment Responses #3 and #57. Please see the Sediment Deposition in Reservoirs study plan for City Light's responses regarding tributaries to the Project reservoirs.
96.	Brock Applegate (WDFW)	04/12/2020	Section 2.5 Study Area	In consideration of the historic fish passage to Stetattle Creek, SCL should consider the geomorphology currently and historically from Diablo Canyon and downstream.	See Comment Response #3.
97.	Rick Hartson (Upper Skagit Indian Tribe)	03/30/2020	Section 2.5 Study Area	Need to continue the full study downstream to the Skagit delta/estuary. Also, study area needs clarification regarding lateral boundaries. The study area should encompass the FEMA 100-year floodplain (see FEMA NFIP BiOp for Puget Sound, 2008). The FEMA 100-year floodplain should be determined in the absence of project-related flood control (see Upper Skagit Indian Tribe's Regulatory Floodplain Issue Form). This approach for mapping the floodplain attempts to directly relate	See Comment Responses #3, #5, and #20. Lateral boundaries to study area have been adjusted. The study area includes the NPS-mapped channel migration zone along the Skagit River upstream from the Sauk River. The study area was extended upstream from the NPS-mapped channel migration zone to Gorge Dam and includes the entire valley bottom in the extended portion of the study area.

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				information requests to ongoing project operations. The study area should be expanded beyond the 100-year floodplain where geomorphic assessment suggests a possibility for bank erosion and channel meandering over the course of the relicense period (see earlier comment for justification, including reference to comments in Vegetation Mapping and Wetland Mapping studies from TR&RE RWG). See previous comments regarding lost floodplain forests and LWD recruitment due to reservoir operations that prevent tree growth in Skagit River and tributary floodplains upstream of the dams. The study area should include all floodplains between low pool and high pool in the reservoirs. The area between low pool and high pool should also consider landslide-prone areas that may provide sediment and LWD to the floodplain via mass-wasting events. Also, agree with Ashley that Gorge bypass should be included in this study. There is potential for well over a mile of high quality rearing habitat (e.g. see Additional Information Request #4 from current license). The geomorphic study will also help assess fish passage. Though it is clear that anadromous fish can reach Gorge Dam, understanding how LWD and sediment retention impact hydraulic roughness will help determine the range of flows under which passage is possible, as well as species-specific requirements (e.g. can Chum salmon, with the poorest jumping ability	Fish passage issues related to the Gorge bypass reach are being discussed as part of continuing discussions and will be addressed during later phases of the ILP, when a synthesis of information across resource areas is conducted to evaluate Project effects and appropriate PMEs.

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				of anadromous Skagit salmonids, reach Gorge Dam?).	
98.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.5 Study Area	Note the Upper Skagit Indian Tribe dissatisfaction of project area and scope. With that as our primary concern, a secondary comment is will the study acknowledge if there are data gaps from this compilation, and once compiled will the reports/data be analyzed for project ongoing impacts to aquatic resources and the processes that maintain and sustain them?	See Comment Response #3. Data gaps relevant to a cumulative effects analysis will be identified for geomorphic information downstream from the Sauk River. The compiled information will be used for a cumulative effects analysis that will consider effects to geomorphic processes and aquatic habitat.
99.	USFS	04/13/2020	Section 2.5 Study Area	**The FS recommends** modifying the geographic scope to encompass all potential direct, indirect, and cumulative project effects on natural resources. This would include the bypass reach and the Skagit River down to the terminus or delta. The FS recommends modifying the second statement regarding compiling information below the Sauk to "…This study will also compile **historically** relevant geomorphic information on the Skagit River downstream from the Sauk River confluence but will not collect any new **field data** downstream from the Sauk River confluence".	See Comment Response #3. The FERC baseline is existing conditions, and therefore historical conditions are not being addressed in this study plan.
100.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section, 2.6 Methodology	"Figure 2.5-1 Overview of study area: Gorge Dam to Sauk River confluence." Upper Skagit Indian Tribe questions why the entire by pass reach is not in project boundary. Could SCL explain the odd delineation from their perspective or records?	See Comment Response #3.
101.	Jon Riedel (NPS)	03/31/2020	Section, 2.6 Methodology	"The Skagit River Geomorphology from Gorge Dam to the Sauk River Study will include pre-	Comment is acknowledged. City Light is confident it has the resources to ensure that the

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				field analysis of existing information, one season of field work…" Concerned that this is too short of a time, particularly since it overlaps with the reservoir erosion field data collection in summer 2021.	study program can be executed successfully within the identified period of time. Note however, that the ILP includes steps for LPs, City Light and FERC to assess the need for additional study information during the 2 year relicensing study window.
102.	Brock Applegate (WDFW)	04/12/2020	Section, 2.6 Methodology	I agree with Jon. SCL will also depend on one season to collect information at specific flows. SCL may not receive those specific flows. SCL may rely too heavily on the green Lidar and aerial photographs to get some information, like pool depth. SCL may need additional field work to retrieve information not obtainable by green Lidar and aerial photographs. (See Comment #67)	See Comment Response #101. In areas where pool depth is not reliable using green LiDAR, depth data will be collected as part of the Instream Flow Model Development Study. Text revised to clarify in more detailed methods - Section 2.6.3.
103.	Judy Neibauer (NPS)	04/13/2020	Section, 2.6 Methodology	Collection of data: Do you mean you are collecting data on existing conditions? If yes, you would likely need to do some additional sampling to understand the layers of sediments/bedload deposited from prior to and during project operations to be able to see what has been changing,. Collecting this information would help you to be able to see how processes will change into the future with continued or changed operations.	Surficial sediment gradation and subsurface sampling methods are described in Sections 2.6.3 and 2.6.5.
104.	Brock Applegate (WDFW)	04/12/2020	Section, 2.6 Methodology	"The Skagit River Geomorphology from Gorge Dam to the Sauk River Study will include pre-field analysis of existing information, one season of field work to inventory current geomorphic conditions in the Skagit River, three years of scour monitoring[3], and post-field analysis and report writing."	See Comment Response #68.

[3] A pilot scour monitoring study started in September 2019; it is anticipated the scour monitoring study will be expanded to include new areas and continue through September 2022.

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				If the greatest concentration of redds change over the decades, SCL will need to continue this scour monitoring throughout the license.	
105.	Judy Neibauer (USFWS)	04/13/2020	Section, 2.6 Methodology	Agreed. This may be a long term management plan type of monitoring need. (See Comment #70)	See Comment Response #68.
106.	USFS	04/13/2020	Section, 2.6 Methodology	**The FS recommends** identifying contingencies or adaptive management in field schedule duration and intensity. Field schedule in draft study plan does not account for field data collection efforts needed above the dams to study sediment and large wood budgets, and does not include data collection effort in the bypass reach.	See Comment Responses #3, #5, and #20.
107.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.1 Collect Existing Information	Is there FLIR data analysis conducted in the Skagit? Please add this or another type of temperature information to your study…. this type of information overlaid with geomorphology /Lidar data could help to depict hyporheic areas within the channels. Finding these areas could be key to finding refugia…areas that fish and their prey may use for refuge, foraging, and spawning. Long term temperature monitoring may be needed and might be part of a long term management plan.	See Comment Response #23.
108.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.1 Collect Existing Information	See my comment above about expanding geomorphic analysis upstream and into adjacent tributaries to be able to depict how operations are/will affect sediment/bedload transport…This will inform operational effects to passage, habitat quality, quantity, flows, and refugia in these areas of intersection between tributaries and the river or reservoirs.	See Comment Responses #3 and #57. Please see the Sediment Deposition in Reservoirs study plan for City Light's responses regarding tributaries to the Project reservoirs.

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109.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.1 Collect Existing Information	"An annotated bibliography will be prepared, and a summary of geomorphic conditions will be written for inclusion in the study report." Primary concern study does not match Upper Skagit Indian Tribe expectations for geographic scope. Secondarily need to ensure study report does not simply describe what is there as a baseline. Upper Skagit Indian Tribe has been requesting an understanding of how project operations affect EFH and processes that create and maintain salmonid productivity.	See Comment Responses #3 and #6. EFH is included with other statutory authorities in Section 1.2.
110.	Brock Applegate (WDFW)	04/12/2020	Section 2.6.2 Geomorphic Change	"The analysis of geomorphic change includes two primary metrics: channel migration and channel incision." Bank armoring may retard or stop channel incision and migration. Please take bank armoring into account during the analysis or change the analysis area.	Bank armoring will be taken into account during the analysis of channel migration. Text revised to clarify.
111.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.2 Geomorphic Change	"This analysis will consider change in these metrics over the term of the existing license to inform likely changes over the term of the new license." You should include a measurement that helps look at bedload movement, to determine the average sized particles moving…or not moving. This will help inform what particles are moving through the system, and where they are causing changes in key habitat (i.e. spawning, refugia, pools, etc.). This would also help inform future restoration needs.	See Comment Responses #1, #2, #5, and #6. The scour monitoring in conjunction with the 2-D hydraulic model developed as part of the instream flow study will provide information on bedload movement.
112.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.2 Geomorphic Change	"Channel migration rates will be compared to peak flow conditions and changes to sediment inputs and large wood loading to determine	See Comment Responses #1, #2, and #3.

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				conditions which contribute to bank erosion and channel migration." Need to establish a number of flow scenarios to look at how the channel has changed. For the effects analysis you will need to think about climate change scenarios and how operational flows change in the future. Including scenarios with climate effects added. I would expect you would need to stablish a baseline of flows from the earliest years of data collection and look to find the number of peak, base, and low flows and their duration…over time so that you can use the information to help define their intervals….. This will help SCL figure out at what flows channels seem to change to develop habitat, maintain habitat, and degrade habitat and how often this may occur. Link this study to the Land type/Geological mapping: Because of the geomorphic processes and land types, channels will react differently depending where you are in the landscape. Summarizing data by reach type or some type of a method that makes sense based on location is a normal part of looking at geomorphology data. You might look at some of the Forest Practices watershed analysis tools used in years past to delineate data. You may choose to delineate it by water bodies… tributary/river/reservoir….and by something similar to Source, Transport, and Depositional reaches. By doing this categorizing of data, you can adequately combine data and tally the data in a way so that you are not mixing apples and oranges…	Please see the Sediment Deposition in Reservoirs At Areas of Resource Concern study plan for City Light's responses regarding tributaries to the Project reservoirs. Geomorphic reaches will be developed early in the study as a way to group and analyze data collected. Text added to clarify in Section 2.6.1.

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				Expand the study to include the areas I have mentioned previously (above the dams, in to tributaries, and out to the estuary/mouth)…	
113.	Jon Riedel (NPS)	03/31/2020	Section 2.6.2 Geomorphic Change	"Active channel width, …." Will be measured, not calculated?	Active channel width will be calculated based on mapping/digitizing of active channels on the referenced series of aerial photographs.
114.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.2 Geomorphic Change	"Changes through time will be tracked." See my previous comments. Include areas of tributaries that are affected by river and reservoir flows/levels. As mentioned earlier…. The stream channels within tributaries are altered some distance upstream of the mouths…by flows in mainstem rivers. Tributary channels that enter in reservoirs are also altered some distance upstream as reservoir levels are raised and lowered. We visually can see this at the mouths of streams, but depending upon the geomorphology of the tributaries and the operations that alter the flow and water levels….you can walk some distance up these tributaries to see the changes that can travel upstream. These changes in processes can cause either aggrading or degrading the channels that may contribute to degrading aquatic habitat and vegetation, and fish populations. Some stream channels can go subsurface causing a disconnection in the surface water. What do you mean when you say changes will be tracked through time….annually, periodically, etc.?	This study area includes the Skagit River downstream of Gorge Dam (to Sauk River), so analysis of tributaries entering reservoirs is outside of this study area. Tributary mouths that enter the Skagit River from Gorge Dam to the Sauk River are part of the study area for this study. The junction of tributaries and mainstem rivers are very dynamic environments. City Light is not aware of locations in this study area where tributaries go subsurface or result in passage barriers, but is interested in exploring these concerns with LPs if there is evidence of such locations. Changes will be tracked through time at intervals determined by the sets of historic aerial photographs chosen for the analysis (see second paragraph in Section 2.6.2).

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115.	Jon Riedel (NPS)	03/31/2020	Section 2.6.2 Geomorphic Change	"An analysis of USGS gage rating curve changes during the term of the current license (from 1990 to present) will be made at the Skagit River at Newhalem (USGS 12178000), Skagit River at Marblemount (USGS 12181000), Skagit River near Rockport (USGS 12184700) gages to evaluate potential channel incision or aggradation." Duration and timing of events also key impact and not just peaks.	Agree.
116.	Brock Applegate (WDFW)	04/12/2020	Section 2.6.2 Geomorphic Change	I agree with Jon. Please consider timing, magnitude, and duration of the flows. (See Comment #80)	See Comment Response #115.
117.	Jon Riedel (NPS)	03/31/2020	Section 2.6.2 Geomorphic Change	If feasible, historic cross-section data at other locations between the Gorge Dam and the Sauk River will be compared with available Green LiDAR data to evaluate channel changes at locations between gages. FEMA floodplain study and cross sections below Bacon Creek.	Thank you for the suggestion.
118.	Jon Riedel (NPS)	03/31/2020	Section 2.6.2 Geomorphic Change	"The Relative Elevation Map based on current LiDAR data….." We are developing these by reach in landform mapping, and using them more as a tool than an end-product (i.e. changing vertical scale makes a big difference).	Thank you for the clarification.
119.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.2 Geomorphic Change	"The analysis of geomorphic change includes two primary metrics: channel migration and channel incision." Will channel incision include a stream bed armoring assessment? Concern here is has the	Streambed armoring will be assessed by comparing surface and sub-surface grain size. See Comment Response #33.

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				longevity of lack of sediment and bed load transport locked the Skagit to a perpetual incised state? How will floodplain, side channel and tributary seasonal connectedness be measured? Concern is a potential loss of connectivity given incised channel forms along the mainstem?	
120.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.2 Geomorphic Change	"Map active channel areas as polygons on current (2019) and up to five historical geo-referenced aerial photographs." How will tributary junctions be addressed? What tributaries and how far up will these be mapped? Floodplain reach mapped or defined by?	All tributaries with channels visible on aerial photographs will be mapped within the study area.
121.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.2 Geomorphic Change	"Channel migration rates will be calculated by summing the difference in new channel planform area between aerial photograph years and dividing by reach length." CC: How will you identify sites to perform the calculation? LP's need to be able to weigh in on this.	The intention is to calculate migration rates by geomorphic reach and analyze all areas of river (not just a few specific sites). Geomorphic reaches will be developed as part of the study using channel metrics and landform mapping (NPS).
122.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.2 Geomorphic Change	"Channel migration rates will be calculated by summing the difference in new channel planform area between aerial photograph years and dividing by reach length." CC: This reach average method can be misleading if meanders aren't growing but rather just translating downstream or if an active channel moves because the planform area can actually stay steady even though there has been significant migration. The motion of individual meanders need to be taken into account.	The migration analysis will be performed for each bank of the river to help differentiate movement of meanders. Text revised to clarify.

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123.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.2 Geomorphic Change	"Channel migration history over the existing license period will be visualized by calculating historic channel occupancy maps and maps illustrating historic channel positions." CC Will you take into consideration whether channel migration occurred over time by continual bank erosion or whether it occurred due to some event causing avulsion? The average rate over time might calculate the same but the mechanics and impacts are very different.	If it is apparent from the aerial photograph record that migration is progressing via avulsion that will be noted.
124.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.2 Geomorphic Change	"Locations and character of bank protection will be mapped between the Gorge Dam and the Sauk River to update information in Beamer et al. (2000)." Upper Skagit Indian Tribe has a data set on all chinook bearing tributaries and along the Skagit. The methodology used a rapid watershed visual mapping assessment. Please contact Rick h for data and reports.	Thank you for the information; it will be very helpful and included in the analysis.
125.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.2 Geomorphic Change	"An analysis of USGS gage rating curve changes during the term of the current license (from 1990 to present) will be made at the Skagit River at Newhalem (USGS 12178000), Skagit River at Marblemount (USGS 12181000), Skagit River near Rockport (USGS 12184700) gages to evaluate potential channel incision or aggradation." The impact of sediment and wood began as early as the 1918/19 with the building of the first dam at gorge, using a truncated data set may obscure project ongoing impacts.	See Comment Responses #1, #3, #5, and #6.

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126.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.2 Geomorphic Change	"The Relative Elevation Map based on current LiDAR data (developed as part of landform mapping study being conducted by the National Park Service) will be used to analyze channel evolution stage between Gorge Dam and the Sauk River based on the Stream Evolution Model in Cluer and Thorne (2013)." CC By this do you mean the river stage at which channels evolve?	The Cluer and Thorne (2013) paper identifies an idealized progression that occurs along some river channels in response to disturbance. The paper is available in the reference section on SharePoint.
127.	USFS	04/13/2020	Section 2.6.2 (Geomorphic Change) through 2.6.6 (Large Wood)	**The FS recommends** that the two primary metrics to be used for evaluating project effects on downstream geomorphology be the quantification of sediment (bedload) and large wood arrested by the project. Using this analysis, develop a range of scenarios of effects to geomorphic condition downstream of the project under a range of flow conditions from the USGS historical record. The mapping of channel migration zone (CMZ) across the range of historical aerial photos is useful for evaluating human-induced and natural effects to CMZ migration rates for the area of interest, but is too coarse to isolate those effects from only the project. The purpose of the study plan should address data gaps in how project operation contributes to downstream resource impacts. It is unclear how this mapping exercise achieves that objective. The analysis of USGS rating curve changes is useful but shouldn't be limited to the period of the existing license but include the entire period of record. As mentioned above, depending on which USGS station is analyzed the ability to	See Comment Responses #3 and #5. Channel migration is influenced by a number of Project and non-Project factors. It may not be possible to differentiate among these, but the analysis is still useful to identify rates of channel migration.

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				detect (and isolate) project effects will be extremely difficult to immeasurable.	
128.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.3 Aquatic Habitat	"An inventory of the current status of aquatic habitat in the Skagit River between the Gorge Dam and the Sauk River will be made using both remote sensing and field methods." I am excited you will be using LiDAR to help make assessments. Think about adding a summary of current and new information in a table ….to show what data you are pulling from existing sources, how you will use it and what additional data you will be collecting. Show the key questions it will answer and issues it addresses. Habitat affected by the Project operations would include habitat in streams not just in this study area …but in the rivers/ tributaries, reservoirs, and in streams along the transmission corridors/access roads or conservation lands. Will you be surveying side channels similarly? Aquatic data can also be grouped by reach types, depending on geology…a pool in one reach may not be similar to a pool in another reach. See my previous comments about this. Using geomorphology/geology and precipitation zones can help design your reach breaks, this will help you look at how you will organize your data so that you can compare it correctly. If you already have data for these areas mention	Thank you for your suggestions on study plan formatting but the format of study plans is standardized for the Project. Streams along the transmission corridor are addressed in a separate study plan. Side channel methods are discussed in Section 2.6.4. Geomorphic reach breaks will be determined as part of study implementation based on a number of factors as discussed in Section 2.6.1.

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				it in the section above where you previously talked about existing data, if its aquatic habitat related, bring it forward here to show how you will use it in combination with field data.	
129.	Jon Riedel (NPS)	03/31/2020	Section 2.6.3, Aquatic Habitat	"An initial map of aquatic habitat type will be made based on recent (2019) georeferenced aerial photographs and green LiDAR…" This data is poor in pools and deep cutbanks. Pool depths will have to be measured in field.	See Comment Response #102.
130.	Brock Applegate (WDFW)	04/12/2020	Section 2.6.3 Aquatic Habitat	Yes, SCL may need more than one season of study because of the extra field work that SCL may need to conduct due to the decrease in accuracy of data for cutbanks and pool depths. WDFW and NPS have found several problems that might occur to trigger a fieldwork season in 2022 and SCL should remain open to the possibility. (See Comment #86)	See Comment Response #101.
131.	Brock Applegate (WDFW)	04/12/2020	Section 2.6.3 Aquatic Habitat	"Data fields obtained from the GIS analysis will include habitat type, average depth (from green LiDAR),…" SCL may want to set aside more time for fieldwork. SCL may need more time to acquire information for pool depths.	See Comment Response #101.
132.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.3 Aquatic Habitat	"The initial map will be refined and field-checked during a walk/float of the river from Gorge Dam to Gorge Powerhouse (foot survey) and between Gorge Powerhouse to the Sauk River confluence (foot/boat survey as appropriate) during low flow conditions." Study proposed limited field time, and how will floodplain and side channels be addressed given difficulty mapping from aerial photographs and limited time for field	See Comment Response #101. LiDAR will be very useful for mapping side channels on the floodplain.

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				verification?	
133.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.3, Aquatic Habitat	"The field inventory will use standard methods…" What type of standard methods or habitat survey will be done? Describe here if it will be detailed like a Hankin –Reeves type survey the USFS uses, or if it will be more of a geomorphic reach assessment. Identify details here so that people know what the data can be used for in terms of assessing affects to aquatic species. If you collect only geomorphic reach scale data, you might miss some of the important information (wood, pools, temperatures, depth, substrate type, undercut banks, riparian vegetation, etc.) which are key indicators used to assess effects… Additional field methods might need to be applied, such as more pebble counts, McNeil core sediment sampling, deploying thermographs, etc. to determine quality of pools and key habitats….	Details of specific aquatic habitat inventory methods will be discussed with LPs to determine appropriate methods for use in a large non-wadable river like the Skagit. McNeil cores are not proposed to conduct the sub-surface sampling because the sample size would be too small considering the size of substrate in the Skagit River. This study does not include water temperature. However, temperature data are collected by USGS at Newhalem, and Ecology has and continues to collect temperature data at Marblemount. As discussed in the PAD, data indicate that water temperature is in compliance with Ecology criteria in the reach downstream of the Project.
134.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.3 Aquatic Habitat	The field inventory will use standard methods to field verify habitat typing and collect information not available from aerial photographs. Please provide reference to standard methods	See Comment Response #133.
135.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.3 Aquatic Habitat	"Field data will include average bankfull width, cover, and if visible (dependent upon turbidity and water depth) dominant/subdominant substrate particle size (e.g., bedrock, boulder, cobble, gravel, sand, fines), and embeddedness."	The same types of data will be collected in all side channels. Chum channel locations are known and can be assessed separately if needed.

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				How will the "Chum channels" man made mitigation sites- be measured or identified against natural aquatic systems?	
136.	Jon Riedel (NPS)	03/31/2020	Section 2.6.4, Side Channels	"The inventory will be made using both remote sensing and field methods." Landform mapping is also addressing this. Need to coordinate to reduce duplication and make products comparable.	Agree – text revised to clarify.
137.	Jon Riedel (NPS)	03/31/2020	Section 2.6.4 Side Channels	"Data fields obtained from the GIS analysis will include side channel type (overflow side channel, [perennial and seasonal], wall-based channel, groundwater-fed channel) and area." These are not the units, or at least descriptions, you shared previously and which the landform mapping is using.	City Light will continue to coordinate on side channel typing.
138.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.4 Side Channels	"If possible (depending upon visibility of side channels on aerial photographs), side channel formation and changes through time over the period of the current license will be mapped and correlated with peak flow conditions between aerial photographs to help determine how side channels form and/or are maintained under existing peak flow conditions." What does peak mean here – do we need that detail or correlated with flow conditions…	City Light has revised text to clarify (magnitude and duration of high flows).
139.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.4 Side Channels	"A summary of the amount and quality of side channel habitat will be made." Glad to see that the quality of side channels will be reviewed. Will you be conducting the same aquatic habitat surveys in the side channels as in the mainstem?	Habitat methods for side channels will be similar to aquatic habitat methods as described in the study plan. Effects of hyporheic flows are not addressed in this study plan. See Comment Response #23.

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				Is seems that type of information in side channels would be needed to assess the operational effects on the type of habitat within the side channels. Some side channel habitat is similar to the mainstem habitat…and should be treated as aquatic habitat in aquatic surveys….and some side channels could become the mainstem in some years…You may need to determine they types of side channels you will gather aquatic information on, Maybe aerial photos could help with this. Assessing and understanding the hyporheic areas associated with these channels is important and can help determine if they are key forage, rearing, refugia type areas. The effects of operational flows in these areas will be important to know.	Effects of operation and PME measures would be addressed as part of the license application. This is a subsequent step to the study program.
140.	Jon Riedel (NPS)	03/31/2020	Section 2.6.5 Substrate / Sediment	"An initial map of dominant/subdominant substrate size will be made if visible on recent (2019) georeferenced aerial photographs." Doubt you can do this with scale of aerial phots – and not just historic small scale ones but also recent large scale NAIP images with a 1m resolution. This is another product that should be linked to landform mapping, which is just noting whether or not bars are gravel vs. sand.	Agree – the methods acknowledge it may not be possible. Links to landform mapping are included in this section of the methods.
141.	Brock Applegate (WDFW)	04/12/2020	Section 2.6.5 Substrate / Sediment	"An initial map of dominant/subdominant substrate size will be made if visible on recent (2019) georeferenced aerial photographs." SCL should tell us how they will accomplish these tasks as it sounds like the photographs lack the detail to detect substrate size.	See Comment Response #140.

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142.	Brock Applegate (WDFW)	04/12/2020	Section 2.6.5 Substrate / Sediment	"The initial substrate map will be refined and field-checked during a walk/float of the river from Gorge Dam to Gorge Powerhouse (foot survey) and between Gorge Powerhouse to the Sauk River confluence (foot/boat survey as appropriate) during low flow conditions." Will SCL have enough time in one season to collect, verify, and proof other information gathered from Green lidar and aerial photographs?	See Comment Response #101.
143.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.5 Substrate / Sediment	"An inventory of the current status of substrate in the Skagit River, side channels, tributary deltas, and unvegetated bars between the Gorge Dam and the Sauk River will be made. The inventory will be made using both remote sensing and field methods and will be coordinated with the landform mapping project currently underway. An initial map of dominant/subdominant substrate size will be made if visible on recent (2019) georeferenced aerial photographs. Substrate size categories include bedrock, boulder, cobble, gravel, sand, and fines. Substrate polygons will be digitized to produce a GIS layer. Minimum polygon size will be 1,000 square feet. The initial substrate map will be refined and field-checked during a walk/float of the river from Gorge Dam to Gorge Powerhouse (foot survey) and between Gorge Powerhouse to the Sauk River confluence (foot/boat survey as appropriate) during low flow conditions."	An analysis of armoring will be made based on results of sediment armor/sub-armor sampling.

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				Will an assessment of armoring be conducted with these data?	
144.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.5 Substrate / Sediment	"Wolman pebble counts (100 surficial particles) and sub-surface samples (Church et al. 1987) will be collected at locations representative of bedload transport (e.g., top end of point bars or upper end of mid-channel bars) during low flow conditions." Could identify in each of these methods sections, the questions you will be answering? That might help understand what it is you are measuring, and how the information will answer the questions for future assessments. It is not clear here in the substrate/sediment section everything you will be answering. Pebble counts are a great first cut way of seeing red flags and areas of deposition. However, using pebble counts across habitat types and not just at bars would help to also determine the quality of a range of habitat types. See the Hankin-Reeves type surveys the USFS uses as an example tool to use to assess sedimentation across all habitat types and by reach type. This section seems like you are limiting the collection of substrate/sediment data. Will you do different pebble counts or combine additional counts from the Aquatic survey? If you will want to determine how impacted spawning areas are…you might utilize some other tool like the McNeil core sampler transects.	See Comment Responses #1 and #2 regarding the integration of information in the ILP process. As described in Section 2.6.3, dominant and sub-dominant substrate will be collected within habitat units. McNeil cores are too small to use to sample the large substrate in the Skagit River.
145.	Jon Riedel (NPS)	03/31/2020	Section 2.6.5 Substrate / Sediment	"Sample spacing will depend upon the availability of appropriate bars, with the aim of one sample per river mile."	Gravel sampling will be stratified by geomorphic reach, which will take into account landform mapping, tributaries, and other channel metrics– text will be revised to clarify.

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				This seems very coarse based on initial landform mapping results (i.e more than one gravel bar per mile). There is also a lot of variability with tributary inflows and changes in reach scale geomorphology. Sampling frequency should be linked to reaches identified in landform mapping.	The 1 sample/river mile is based on an initial look at gravel bars on aerial photographs; this can be adjusted if needed based on the results of the initial mapping and landform mapping.
146.	Brock Applegate (WDFW)	04/12/2020	Section 2.6.5 Substrate / Sediment	I agree with Jon. Sampling spacing should depend on landform changes. We should have another sample for each change in geomorphological landform, instead of set on a specific distance. (See Comment #97)	See Comment Response #145.
147.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.5 Substrate / Sediment	I agree. If not appropriate reaches you may be comparing data not representative of the different land types…which could skew data (i.e. if in a sandstone reach vs a bedrock vs a glacial till type reach); and it would be like comparing apples and oranges. (See Comment #97)	See Comment Response #145.
148.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.5 Substrate / Sediment	"Sample spacing will depend upon the availability of appropriate bars, with the aim of one sample per river mile." Sampling appears limited in scope.	See Comment Response #145.
149.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.5 Substrate / Sediment	"Tributary deltas and unvegetated bars will be mapped on a series of up to five historical to recent aerial photographs to enable tracking their size and condition over time and assess ability of the current peak flow regimes to distribute incoming sediment (see Section 2.6.2 above)." How far up tributaries and which ones will be surveyed? If sediment appears unchanged between time series then that might imply no	Tributaries visible on aerial photographs will be mapped within the study area. It is true that unchanging sediment between aerial photograph series could imply that they were deposited, transported, and re-deposited, but it is unlikely that this sequence would result in deposits that are totally similar between the two periods. The sequence of high flows between aerial photograph periods will help to analyze the potential for this occurring.

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				sediment inputs but what if they were dropped, washed away and filled between photo periods, seems like this might need a change in approach?	
150.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.5 Substrate / Sediment	"An analysis of initiation of gravel transport at key/representative spawning locations using scour monitors and accelerometers will be made to help determine the flow rate that initiates movement or results in substrate scour to redd depth." See comments above about species specific spawning sites and risk from scour.	See Comment Response #46.
151.	Brock Applegate (WDFW)	04/12/2020	Section 2.6.6 Large Wood	An inventory of the current status of large wood in the Skagit River between the Gorge Dam and the Sauk River including tributary mouths will be made using both remote sensing and field methods. Why not consider remote sensing down to the estuary?	See Comment Response #145.
152.	Judy Neibauer (USFWS)	04/13/2020	Section 2.6.6 Large Wood	Since the Project is in the headwaters of the Skagit, effects to instream and riparian area LWD have likely occurred through time and will continue with the new license. Looking at operational effects across the Project seems like something needed. If you have other data, you should describe it in the existing information section above, and bring it forward here to show how you will be linking any new data collected in the field work. If no existing data is available, this study should include those areas lacking information. The Project occurs both above and below dams, affect some areas upstream in adjacent tributaries, affect streams in transmission	See Comment Response #20.

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				corridors, and on conservation lands. These areas should be included in this study to see how aquatic and riparian habitat is changed through time, how habitat is altered at high/low flows, and how riparian areas may be affected during low flows, especially for extended low flow periods or low reservoir levels. You should include an analysis for operational effects to existing in-channel wood, and future wood in riparian areas, and including climate change scenarios. Understanding how much wood is out there, how wood is interacting with the channel at certain flow levels, and what the future recruitment is like, is key to understanding aquatic habitat effects. Maybe you are already doing this type of wood assessment. But this updated information could be used to help with new restoration designs on reservoir shorelines, in tributaries, or in rivers in the Project area. A restoration goal may be to collect woody debris to be used at certain locations where data shows operations may have impacted in-channel or future wood.	
153.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.6 Large Wood	"An inventory of the current status of large wood in the Skagit River between the Gorge Dam and the Sauk River including tributary mouths will be made using both remote sensing and field methods." CC: Please include an inventory of LWD that has been intentionally passed or moved into the river as per the LWD management plan.	See Comment Response #20.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
154.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.6 Large Wood	"An initial inventory of large wood will be made using current (2019) filtered LiDAR cross referenced to concurrent aerial photographs (similar to methods described in Abalharth et al. 2015). LiDAR will be used to delineate large wood and jams. Delineated wood and jams will be cross referenced with aerial photographs to verify features and collect additional information such as root wad (Y/N), function, and member of log jam (Y/N). Data will be entered into the GIS coverage and volume of wood will be calculated if possible." Yearling Phase one report has method and results of large wood jams, and should be utilized for rate of change or inventory assessments. Includes Newhalem down to hyw 9 Bridge in Sedro-Wolley.	Thank you for the additional information.
155.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.6 Large Wood	"LiDAR will be used to delineate large wood and jams. Delineated wood and jams will be cross referenced with aerial photographs to verify features and collect additional information such as root wad (Y/N), function, and member of log jam (Y/N)." CC: Persistence of single LWD or log jams should also be determinable and useful information. How many years has any particular log jam been in place?	Yes, it is intended to look at this type of data if possible depending upon the resolution of the aerial photographs.
156.	Jon-Paul Shannahan (Upper Skagit Indian Tribe)	04/13/2020	Section 2.6.6 Large Wood	"Work products will include:" Wood budget for below Diablo dam? Also a table describing the quantity of LWD passed at New Halem Ponds over last license, it should include timeframe of events. Another estimate should be made for amount released through Gorge dam as part of maintenance operations.	See Comment Response #153.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
157.	Jon Riedel (NPS)	03/31/2020	Section 2.6.7 Data Analysis and Report Preparation	1st Bullet – Comment "A description of the geomorphic setting and brief summary of relevant previous geomorphic studies conducted in the Skagit River between Gorge Dam and the Skagit River estuary." Link with landform mapping, which should be available in draft form by the time you are starting this study.	Agree, text revised to clarify.
158.	Jon Riedel (NPS)	03/31/2020	Section 2.6.7 Data Analysis and Report Preparation	4th Bullet – Comment "An analysis of initiation of substrate movement and redd scour in monitored areas (adjacent to redds) with peak flow conditions." This will be a Swiss cheese approach. With no continuous modeling you will conduct spot measures of sediment entrainment, but what about deposition and storage? Some of the gravel bars, spawning beds may be transitory features.	See Comment Responses #5 and #6.
159.	Brock Applegate (WDFW)	04/12/2020	Section 2.6.7 Data Analysis and Report Preparation	4th Bullet – Comment I agree with Jon. If SCL doesn't complete the sediment budget model, they cannot predict future spawning habitat where they needs to measure redd scour. Without a prediction tool, you will need to measure redd scour throughout the license, hence SCL should have a monitoring and adaptive management plan for the license that addresses redd scour. (See Comment #103)	See Comment Responses #5 and #6.
160.	Jon-Paul Shannahan	04/13/2020	Section 2.6.7 Data Analysis	6th Bullet – Comment	Text revised to add "quality".

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
	(Upper Skagit Indian Tribe)		and Report Preparation	"An analysis to evaluate current amount of spawning and rearing habitat for all salmonid species within the study area." CC: and Quality	
161.	USFS	04/13/2020	Section 2.6.7 Data Analysis and Report Preparation	The FS recommends that final report conclusions provide a clear nexus between project effects and downstream resource impacts (if any). The current products identified in the draft study plan describe work products that summarize existing condition, due in large part to effects of all human-induced impacts and natural processes. The report should focus on the project effects on downstream geomorphic conditions. The FS recommends having a table in this section describing remaining data gaps not addressed, issues identified for resolution but unable to resolve, and preliminary next steps.	See Comment Responses #1, #2, and #6.
162.	Jon Riedel (NPS)	03/31/2020	Section 2.8 Schedule	3rd Bullet – Comment "Field Work – January to September 2021 (depending on flows)" This is ambitious, You have a large field area, and limited low flow periods for field work. The summer part of this field season also overlaps with reservoir erosion field season. Will you have multiple crews?	See Comment Response #101.
163.	Brock Applegate (WDFW)	04/12/2020	Section 2.8 Schedule	3rd Bullet – Comment and Schedule Comments I agree with Jon. See additions to the schedule.(See Comment #106) Initial Study ~~Final~~ Report (ISR) – March 2022	See Comment Response #101. Thank you for the comment; City Light acknowledges the ILP milestones provided. The ILP provides the opportunity for comment on the final report submitted in the ISR and

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				ISR Meeting Request for study plan modification (if needed) Next season of Field Work and Studies (if needed)—January to September 2022 Post-field Analysis (if needed) – Summer 2022 to Winter 2022–2023 Final Study Report (if needed)- March 2023	discussed at the ISR meeting; if any components of the study goals and objectives are not met in the first year, or there are anomalous conditions, any party may propose additional work or request additional study per FERC ILP regulations. No changes were made to the schedule in the draft study plan as City Light intends to complete the study within one year. City Light believes that it will be beneficial to all parties to have information from the studies available as soon as possible to inform development of management proposals and cross resource analysis. The schedule reflects the timeline for this study only, not the larger ILP process.
164.	USFS	04/13/2020	Section 2.8 Schedule	The FS Recommends modifying the intensity of field work necessitated by including field data collection above the dams and in the bypass reach. If infeasible to increase data collection effort, then request omitting much of the evaluation of existing condition and focus on quantifying known project effects (sediment and wood) arrested by project operation.	See Comment Responses #3, #5, and #6.
165.	Stan Walsh (SRSC)	03/30/2020	Section 2.1 Study Goals and Objectives	"**2.1 Study Goals and Objectives**" The study plan does not address disruption of bedload and LWD by the project which is an area of study identified by multiple agencies and tribes. SRSC request the study proposal be modified to include a) An estimate of bedload and LWD annually disrupted by the project b) Model routing of the estimated	See Comment Response #5. Regarding "modeling multiple levels of bedload augmentation", this would be a subsequent step to this study. See Comment Response #2.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				bedload through the Skagit River under multiple flow regimes in conjunction with the instream flow study c) Model estimated LWD distribution through the Skagit River under multiple flow regimes in conjunction with the instream flow study d) Model multiple levels of bedload augmentation under multiple flow regimes in conjunction with the instream flow study	
166.	Stan Walsh (SRSC)	04/13/2020	Section 2.1, Study Goals and Objectives	"The study goals of the Skagit River Geomorphology between Gorge Dam and the Sauk River study are to characterize the current condition of aquatic habitat in the reach, and to characterize how Project-related changes in peak flows affect geomorphic processes in the reach." The Scope of the study needs to be extended to below the Sauk River. Specific project impacts that need analysis below the Sauk are disruption of fine sediment delivery to the estuary and bay front and disruption of LWD transport to the middle Skagit River	See Comment Response #3.
167.	Stan Walsh (SRSC)	03/19/2020	Section 2.1, Study Goals and Objectives	"The study goals of the Skagit River Geomorphology between Gorge Dam and the Sauk River study are to characterize the current condition of aquatic habitat in the reach, and to characterize how Project-related changes in peak flows affect geomorphic processes in the reach." It is likely not just peak flows that influence geomorphology but the entire flow regime and	See Comment Response #7. Text has been revised.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				specifically duration of high flow events, numerous flow regimes need to be evaluated for their effect on geomorphology in conjunction with the flow model	
168.	Stan Walsh (SRSC)	03/19/2020	Section 2.1, Study Goals and Objectives	1st Bullet - Comment "Use aerial photograph and LiDAR data and collect field data to document current conditions and changes over the period of the current license to document:" The study needs to look over longer period than the current license. The flow conditions of the current license may be maintaining an already adverse condition that is a direct effect of the ongoing operation of the project.	See Comment Response #3.
169.	Stan Walsh (SRSC)	03/19/2020	Section 2.1, Study Goals and Objectives	Suggested New Bullet A specific objective of the flow study should be to implement a-d listed in the first comment in this section.	See Comment Response #5.
170.	Stan Walsh (SRSC)	03/19/2020	Section 2.3 Background and Existing Information	"City Light surveys anadromous fish spawning locations throughout the year and records location, water depth, and species." Only steelhead are recorded for all redds, for salmon species only the shallowest redds at risk of dewater at minimum flows are marked comprehensively	Thank you for the clarification.
171.	Stan Walsh (SRSC)	04/13/2020	Section 2.3 Background and Existing Information	"This information was used for a reach assessment of the Middle Skagit River (Sauk River confluence to Sedro-Woolley) that analyzed potential areas to target habitat restoration based on habitat, geomorphology, and land uses (Smith et al. 2011)."	Thank you for your comment. The Upper Skagit Indian Tribe 2010 bank hardening data will be collected and used in the analysis if available.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				For the Middle Skagit River Assessment an updated inventory of bank hardening was conducted by the Upper Skagit Indian Tribe in 2010.	
172.	Stan Walsh (SRSC)	04/13/2020	Section 2.3 Background and Existing Information	"Geomorphology, hydrology, and hydraulics studies undertaken for the Barnaby Reach restoration project provide detailed information on the Skagit River channel, off-channel areas, and floodplain in the area just upstream of the Sauk River confluence (Skagit River System Cooperative and Natural Systems Design 2019)." This document seems out of place in this section as the Barnaby Reach is above the Sauk River.	You are correct. Text revised.
173.	Stan Walsh (SRSC)	03/19/2020	Section 2.4 Project Operations and Effects on Resources	"Project operations alter peak flows in the Skagit River downstream of Gorge Dam, thereby altering geomorphic processes that may affect aquatic habitat." See comment on range of flows in Sec 2.1	See Comment Response #7.
174.	Stan Walsh (SRSC)	03/19/2020	Section 2.5 Study Area	"This study will also compile existing relevant geomorphic information on the Skagit River downstream from the Sauk River confluence but will not collect any new information downstream from the Sauk River confluence." See comment on study below the Sauk River confluence in Sec 2.1	See Comment Response #3.
175.	Stan Walsh (SRSC)	03/24/2020	Section 2.6.2 Geomorphic Change	"This analysis will consider change in these metrics over the term of the existing license to inform likely changes over the term of the new license."	See Comment Response #3.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				Geomorphic changes likely occurred as a result of ongoing project operations prior to 1995 that the current license continues to maintain or exasperate. Continued disruption of bedload needs to be analyzed as requested in Sec 2.1	
176.	Stan Walsh (SRSC)	03/24/2020	Section 2.6.2 Geomorphic Change	"Channel migration history over the existing license period will be visualized by calculating historic channel occupancy maps and maps illustrating historic channel positions." See comment on study period in Sec. 2.1	See Comment Response #3.
177.	Stan Walsh (SRSC)	03/24/2020	Section 2.6.2 Geomorphic Change	"Locations and character of bank protection will be mapped between the Gorge Dam and the Sauk River to update information in Beamer et al. (2000)." Also include Upper Skagit Indian Tribe inventory of bank armor 2013	Thank you for your comment; Upper Skagit Indian Tribe bank protection inventory will be obtained and used in the analysis if available.
178.	Stan Walsh (SRSC)	03/30/2020	Section 2.6.2 Geomorphic Change	"An analysis of USGS gage rating curve changes during the term of the current license (from 1990 to present) will be made at the Skagit River at Newhalem (USGS 12178000), Skagit River at Marblemount (USGS 12181000), Skagit River near Rockport (USGS 12184700) gages to evaluate potential channel incision or aggradation." Gage locations are chosen for their stability and are not generally representative of the reaches where they are located. Translation of incision/aggradation at the gage sites to other areas of the Skagit would seem to be too tenuous to be useful.	Comment noted and will be included in study report discussion of channel change analysis. Other non-USGS cross sections will also be used if possible.
179.	Stan Walsh (SRSC)	03/30/2020	Section 2.6.4 Side Channels	"Data fields obtained from the GIS analysis will include side channel type (overflow side	Backwater side channels are included as overflow side channels; the classification of

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				channel, [perennial and seasonal], wall-based channel, groundwater-fed channel) and area." This inventory should include backwater channels.	side channel types is worthwhile of continued discussion as there are several different classification schemes available.
180.	Stan Walsh (SRSC)	04/13/2020	Section 2.6.4 Side Channels	"If possible (depending upon visibility of side channels on aerial photographs), side channel formation and changes through time over the period of the current license will be mapped and correlated with peak flow conditions between aerial photographs to help determine how side channels form and/or are maintained under existing peak flow conditions." Side channel connectivity is often difficult to ascertain from aerial photos. Connectivity needs to be look at over a wide range of flows in conjunction with the flow study. Connectivity also needs to be modeled with bedload disruption analysis and bedload augmentation scenarios.	Connectivity on historic aerials is difficult and is acknowledged in the methods statement. Use of the instream flow study model to analyze side channel connectivity may be explored as part of the integrated environmental analysis noted in Comment Response #2.
181.	Stan Walsh (SRSC)	03/30/2020	Section 2.6.5 Substrate/Sedime nt1	"Sample spacing will depend upon the availability of appropriate bars, with the aim of one sample per river mile." Spacing should be determined by reach but one-mile spacing seems sparse	See Comment Response #145.
182.	Stan Walsh (SRSC)	04/13/2020	Section 2.6.5 Substrate/Sedime nt1	"Tributary deltas and unvegetated bars will be mapped on a series of up to five historical to recent aerial photographs to enable tracking their size and condition over time and assess ability of the current peak flow regimes to distribute incoming sediment (see Section 2.6.2 above)." If aerial photos are used to estimate quantity, it	Agree, this will be included as part of the analysis of data.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				will be important to investigate the flow conditions at the time of each photo and use that information to "normalize" the measurements so comparisons can be made.	
183.	Stan Walsh (SRSC)	03/30/2020	Section 2.6.5 Substrate / Sediment	"If scour monitoring devices deployed are successful at measuring scour in the river, scour monitoring will be expanded to other critical spawning areas and continued through the fall of 2022 to allow monitoring of several high flow seasons since high flow events are not predictable." How will this be addressed if scour flows do not occur in the two-year study window?	Scour monitors were deployed at several locations in fall 2019 and will be continued through fall 2022, allowing for 3 high flow seasons. A high flow occurred after the 2019 deployment that we anticipate will provide some data for the analysis.
184.	Stan Walsh (SRSC)	03/30/2020	Section 2.6.6 Large Wood	"**2.6.6 Large Wood**" See comment in Sec. 2.1 on LWD transport disruption by the project.	See Comment Response #5.
185.	Stan Walsh (SRSC)	03/30/2020	Section 2.6.6 Large Wood	"In these detailed wood inventory reaches, a GPS point will be taken on each large wood piece and information on length, diameter at breast height (dbh), orientation, root wad (Y/N), single log (Y/N), jam (Y/N), source, decay class; species, mobility, habitat/geomorphic function will be collected for use in determining wood dynamics." Consider a couple categories of jams to get at stability	Thank you for your comment. Additional details on jams will be collected.
186.	Stan Walsh (SRSC)	03/30/2020	Section 2.6.6 Large Wood	"An inventory of large wood on up to five additional sets of historical aerial photographs (assuming resolution is appropriate) over the term of the last license will be made, with wood digitized as line features to help determine large wood mobility and loading to correlate	See Comment Response #3.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
				with peak flows between aerial photograph series." See comment on study period in Sec. 2.1	
187.	Stan Walsh (SRSC)	04/13/2020	Section 2.6.6 Large Wood	"An inventory of large wood on up to five additional sets of historical aerial photographs (assuming resolution is appropriate) over the term of the last license will be made, with wood digitized as line features to help determine large wood mobility and loading to correlate with peak flows between aerial photograph series." Resolutions of older photographs may make comparisons with current conditions difficult. How will this be addressed? More modern color photos may over-represent current conditions compared to past photo resolution.	Yes, the difficulty in resolution on older aerial photographs is acknowledged in the text. This will be discussed in the report based on the actual resolution of chosen photo sets.
188.	Stan Walsh (SRSC)	03/30/2020	Section 2.6.7 Data Analysis and Report Preparation	2nd Bullet – Comment A summary of geomorphic change (planform change, channel migration, and channel elevation change) over the term of the current license and correlation with peak flows/geomorphic disturbances. See comment on time period of analysis in Sec. 2.1	See Comment Response #3.
189.	Stan Walsh (SRSC)	03/30/2020	Section 2.6.7 Data Analysis and Report Preparation See comment on geographic scope in Sec. 2.1	7th Bullet – Comment Estimate potential future loading of large wood and gravel/cobble in the Skagit River between Gorge Dam and the Sauk River confluence. See comment on geographic scope in Sec. 2.1	See Comment Response #3.

No.	Commenting Individual (Organization)	Date	Study Plan Section	Comment	Response
190.	Sauk-Suiattle	06/22/2020	Section 2.1 Study Goals and Objectives	"Use aerial photograph and LiDAR data and collect field data to document current conditions and changes to document:" It might be good to stress which data are corroborated by ground-truthing, or indeed which data are collected in the field (vs only through labwork via Lidar). If the method of collecting data is mostly remote sensing, then the hypothesis may need amending to suggest that, say, "distribution of aquatic types" as perceived remotely. Or perhaps just agree on definitions that are used, which may be interesting as an exercise, anyway. (this following up on the 6/22 CRWG conversation with Kathie Dube et al.) -slobo	Thank you for your comment. The detailed methods sections specify remote sensing and field verification for each component.
191.	Brock Applegate (WDFW)	06/24/2020	Section 2.5 Study Area	SCL has effects downstream of the Sauk confluence. The biggest impact would include hydrology and the change of timing, duration, and magnitude of process flows and the reduction in flood plain. The loss of flood plain has led to less connectivity of fish habitat. Additionally, the river suffers from a reduction in sediment and wood, which has reduced the size of the estuary. The Project holds back large amount of sediment at the upstream end Ross Lake dam and other tributaries that feed into the reservoir system. Please expand your study area to analyze effects by the project for the entire river. Fish populations and orcas will need this more ecosystem approach to effects analysis, along with information collected downstream of the Sauk confluence to address it.	See Comment Responses #3 and #5.

SKAGIT RIVER GEOMORPHOLOGY BETWEEN GORGE DAM AND THE SAUK RIVER
REVISED STUDY PLAN

ATTACHMENT B

SCOUR MONITOR PILOT PROJECT – INSTALLATION NOTES MEMO

Memo

Date:	October 7, 2019
Project:	Skagit River Project FERC Relicensing
To:	Erin Lowery, Seattle City Light
From:	Kathy Dubé, Watershed GeoDynamics
Subject:	Scour Monitor Pilot Project – Installation Notes

Scour monitors were installed at three locations in the Skagit River between RM 77.5 and 82.5 on August 22 and 23, 2019. The purpose of the installation was to test scour monitor and accelerometer equipment to determine:

- Which types of equipment are most suitable in the mainstem Skagit River;
- Best methods for installation (e.g., equipment, locations, crew size, time required) as well as any limitations of equipment or installation methods;
- Flows that initiate substrate movement in areas near Chinook redds; and
- Flows that scour substrate to Chinook redd depth.

1.0 EQUIPMENT

Three types of scour monitors/accelerometers were constructed for use: sliding bead and golf ball scour monitors as described in Shuett-Hames et al. (1999); and 2-array accelerometers as described in Gendazak et al (2013).

1.1 Sliding Bead Scour Monitors

Sliding bead scour monitors are the smallest monitors constructed and use ¾ inch steelhead Corkies strung on 3/32 inch stainless steel aircraft cable (Figure 1). The advantages of these monitors are ease of installation and the ability to measure finer scale scour since each bead is ¾ inches in diameter. The main disadvantage is that the Corkies are not as durable as the larger plastic balls used in the golf ball monitors.

1.2 Golf Ball Scour Monitors

Golf ball monitors are similar in design to the sliding bead monitors but use plastic perforated heavy-duty golf balls in place of the Corkies (Figure 2). Drill a small pilot hole into the wooden anchor dowel to insert the thin metal rod during installation. The golf balls are approximately 1.7 inches in diameter, so they record scour at a coarser scale than the Corkies. The golf ball monitors require use of a larger diameter installation pipe which is more difficult to pound into the substrate than the smaller diameter sliding bead inserter.

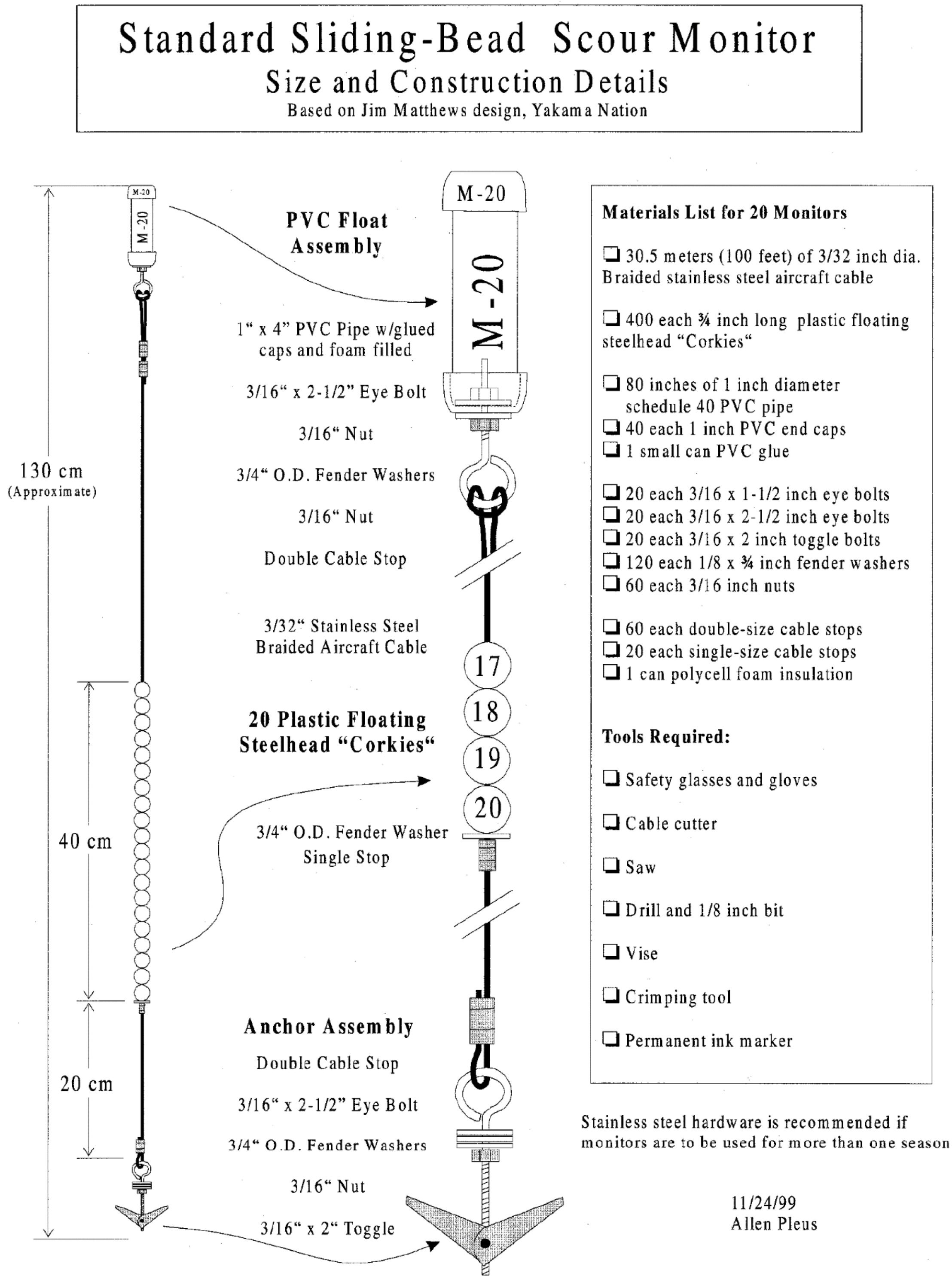

Figure 1. Sliding bead scour monitor design. Source: Schuett-Hames et al. 1999.

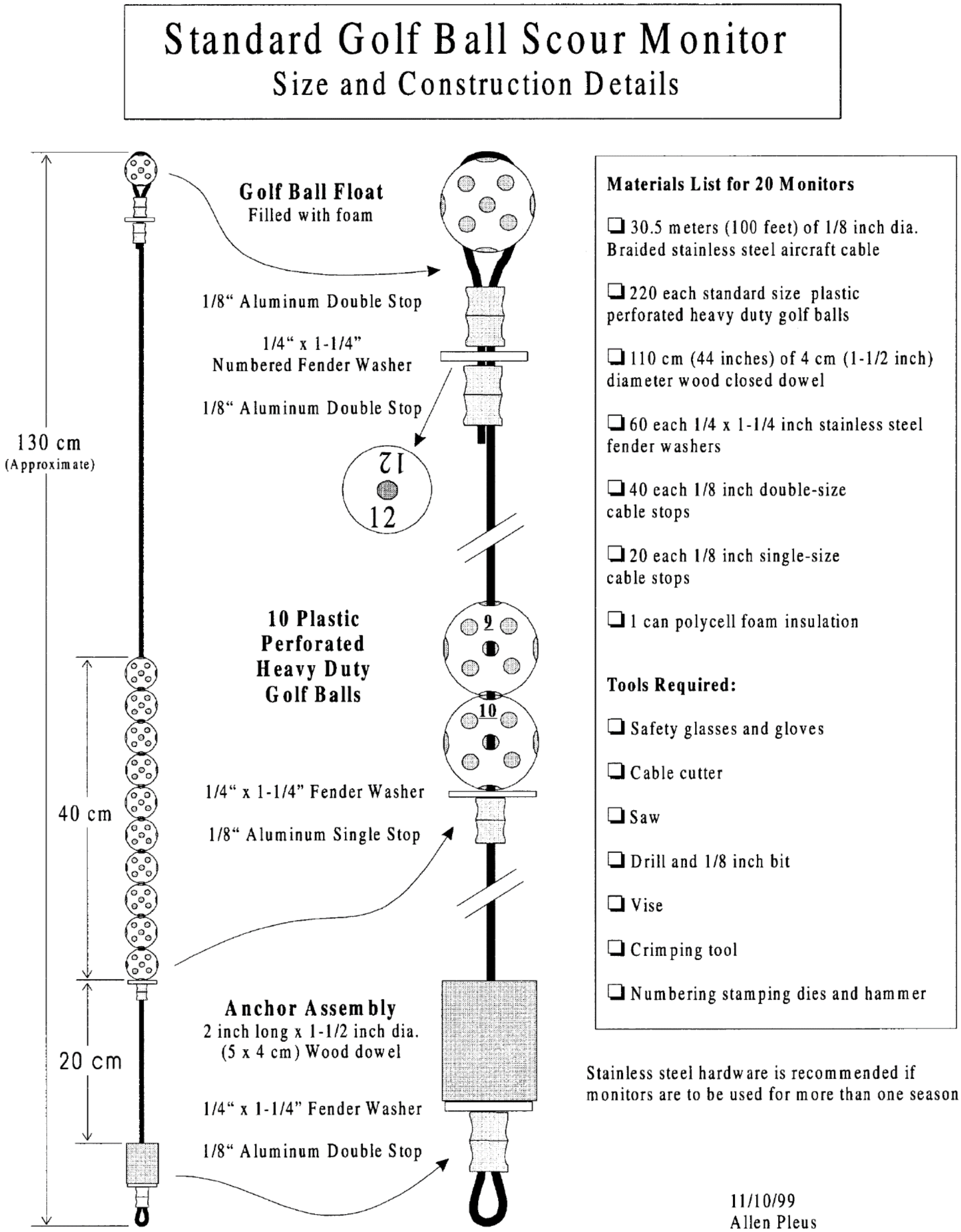

Figure 2. Golf ball scour monitor design. Source: Schuett-Hames et al. 1999.

1.3 Accelerometer Arrays

Arrays of two accelerometers were constructed using a design modified from Gendazak et al. 2013 (Figure 3). Accelerometers measure x-y-z orientation at given time steps and thus record the time when movement takes place (which can be correlated with flow at that time), but they do not record precise scour depths. Hobo Pendant G® accelerometers were inserted into 4-inch lengths of 1.5-inch diameter PVC pipe. A piece of 1/8 inch stainless steel aircraft cable was threaded through a hole drilled through the PVC pipe, through the eye on the accelerometer, and then crimped in place with a double cable stop. The other end of the airline cable was threaded through a piece of wooden dowel anchor similar to that used for the golf ball scour monitors. Drill a small pilot hole into the wooden anchor dowel to insert the thin metal rod during installation. Each accelerometer was wrapped in plastic wrap prior to inserting into the pipe, and spray foam was sprayed into each pipe so that the accelerometer would not move unless the entire pipe assembly moved. Two accelerometer pipe set ups were threaded through each dowel, with one set at 10 inches from the dowel and the other set at 17 inches from the dowel. The result was two independent cables with accelerometers set 7 inches apart from each other. This allowed for the accelerometers to be inserted into the gravel with the top accelerometer measuring movement of surface substrate (initiation of movement) and the bottom accelerometer measuring movement of material 7 inches below the surface (average Chinook redd depth). The accelerometers were set to begin recording on September 1, 2019 at 30-minute intervals (at timestamp GMT-8). This allows for 1.2 years of record to be stored before the onboard memory fills. Accelerometers require the use of the larger-diameter installation pipe. An inserter for the Golf Ball Monitors and Accelerometer Arrays was fabricated based on Figure 4, provided by Andy Gendazak. This inserter is available for use on future scour monitor installations.

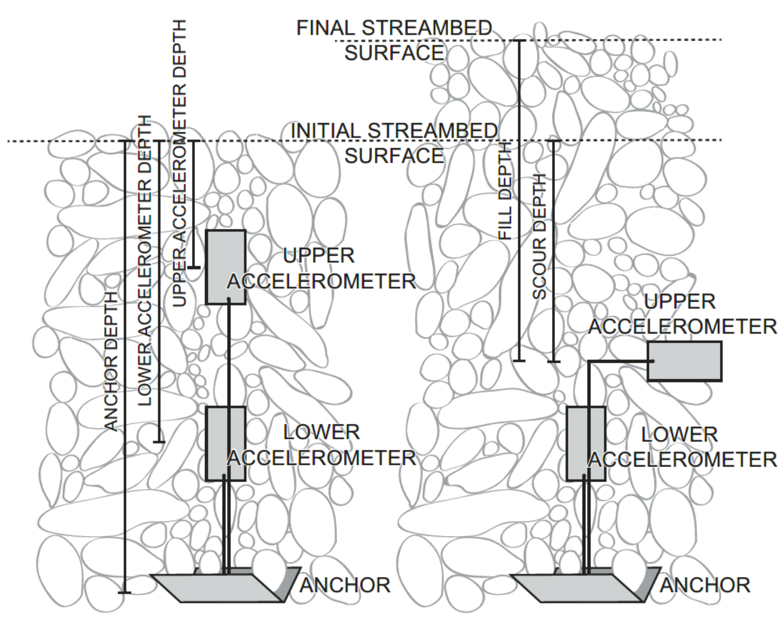

Figure 3. Gendazak Accelerometer Array general design (the anchor was modified for the present project – similar to golf ball anchor). Source: Gendazak et. al 2013.

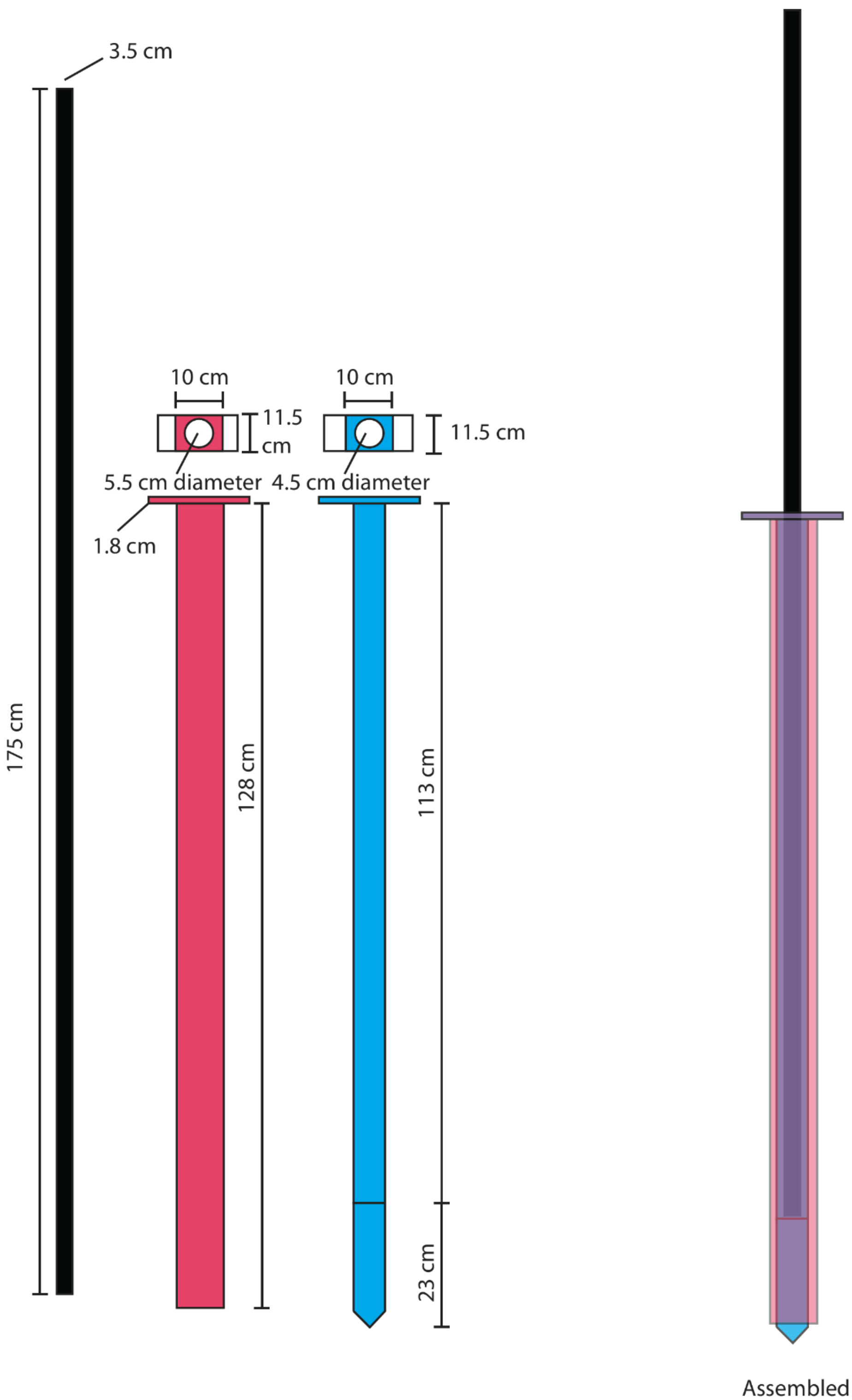

Figure 4. Golf Ball and Accelerometer Inserter Design – stainless steel pipe, mild steel pounding rod. Source; Gendazak, personal communication.

2.0 INSTALLATION METHODS

The following equipment is needed to install the monitors:

- Scour monitors and accelerometer arrays (2 of each type were installed at each site in 2019); 5-gallon buckets work great to keep them semi-organized
- Large inserter (fabricated 2 pipe inserter with steel pounding rod) – check for damage to outside pipe and determine if repairs are needed or a second outside pipe should be brought in case of damage from large cobbles. Mark pipe with insertion depth prior to pounding into substrate.
- Small inserter pipe and straight joints (bring several of each, see if Newhalem shop can repair threads if needed)
- Thin metal rods for inserting (bring 2-3)
- Long wooden dowels with small pilot hole drilled to fit thin metal rod for inserting
- Alligator clips on a 2 ft line with flagging so they don’t get lost (bring several – for small inserter)
- Small hinge clips on 2 ft line with flagging so they don’t get lost (bring several – for large inserter)
- Small and large sledgehammers
- 100-foot fiberglass tape marked in tenths of a foot; compass
- Trimble GPS, handheld GPS as backup
- Waterproof Camera
- Gravelometer
- Field book and pebble count data sheets
- Pencils, large Sharpies
- Copies of permits
- Personal Safety Gear: PFD, safety glasses, hearing protection, work gloves, waders, rain gear, sunscreen, food, water, hats, extra clothes

At each site, determine locations to install monitors. Keep in mind locations where Chinook are known to spawn, substrate size, water depth, and space different types of monitors/accelerometers to cover area.

To install monitors, make sure inserter is marked with installation depth prior to starting (use a Sharpie when inserter is dry). Place inserter at desired location and pound into gravel to marked depth. With large inserter, make sure to take turns. Hold inserter in a vertical position until it can stand upright without support. Sometimes inserters will tilt as they work their way around large cobbles. Try to pull the inserter vertical after it has worked around cobbles. If inserter “bounces” for many hits and does not go into substrate it is likely that it has hit a boulder and a new location will be needed.

After the inserter is pounded in to the marked depth, remove the pounder and center pipe leaving the outside pipe in the substrate. Test depth of hole inside pipe with the long wooden dowel to make sure that fine sediment/sand is not blocking the bottom of the pipe – pound inserter in farther if necessary. Prepare the scour monitor or accelerometer – put a clip on the sliding bead/golf ball cable to keep balls from sliding up cable when it is inserted. Tie thin string onto accelerometer pipes to keep vertical. Place end of thin metal rod into pilot hole in dowel or toggle and insert into pipe, making sure to hold onto string attached to clip or accelerometers. When the metal rod is all the way into the pipe, put the long wooden dowel onto the end (in pilot hole) and push in as far as possible. Once monitor is pushed all the way into pipe, hold the dowel and string steady and have another person slowly and carefully remove the pipe while pushing down on the dowel. Note that this can be tricky, go slow and push or pound gently on the rod/dowel if needed (pounding too hard will push metal rod through dowel – a bad thing). After pipe is removed, check on beads/balls/accelerometers to make sure they are the appropriate depth below riverbed. Fill in top of hole with gravel/fines as needed so beads don't pop up. Record burial depth for each monitor. Attach float if using.

Take a GPS Point with the Trimble at each monitor location and label with monitor designation in notes field.

Measure distance between each monitor and all other monitors as well as any distinctive locations on shore (trees, large boulders, bridge piers, etc.). Draw a sketch with distances in field book.

Take photographs of each site looking upstream, downstream, and at monitors.

Do a Wolman pebble count of 100 particles (use gravelometer) making sure to cover area representative of substrate where monitors are located.

Check inserters after each installation to make sure ends (top and bottom) are not too mangled so that scour monitor/accelerometers will fit through; replace or repair as needed.

Double check before leaving each site to make sure you've got all equipment

3.0 INSTALLATION LOCATIONS

Sites were chosen for the pilot project installation based on areas where Chinook are known to spawn, and where permits could be obtained given the time constraints in 2019. Scour monitors were installed at three locations in the Skagit River: downstream of Bacon Creek, upstream, and just downstream of the Cascade River confluence (Figure 5). Flows during installation were 2,470-2,540 cfs at the Marblemount gage.

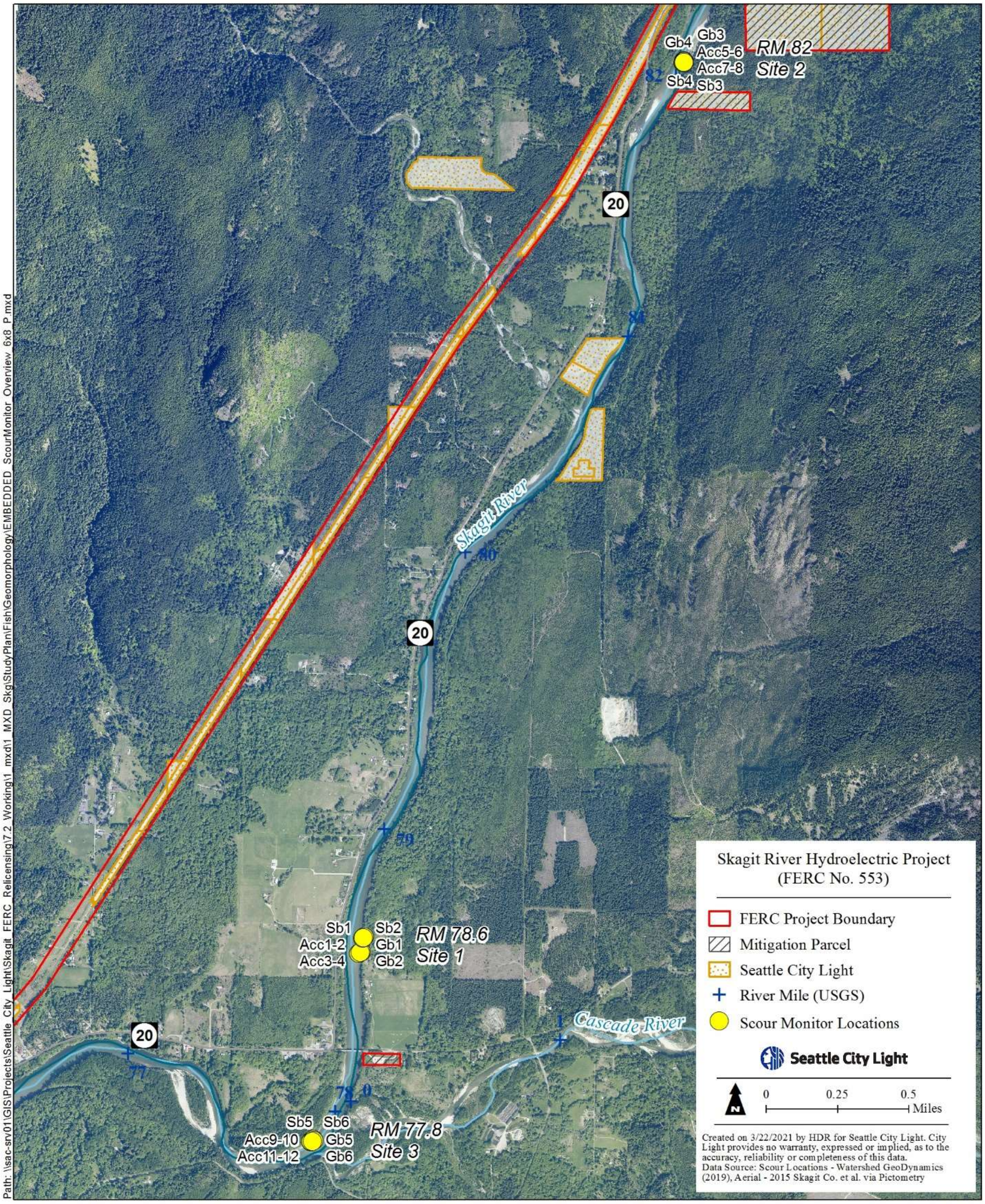

Figure 5. 2019 scour monitor installation locations.

3.1 RM 82 Left Bank Moses Bar Site 2

The site at RM 82 is the downstream end of a left bank bar. This bar is disconnected from the bank at the downstream end by a channel that flows at high discharge levels but was a backwater channel during placement. Monitor placement is summarized in Table 1 and shown in Figure 6.

Table 1. RM 82 Moses Bar monitors.

Monitor Designation	Initial Burial Depth
GB 3 (Golf Ball)	3 inches (one cobble depth)
GB 4 (Golf Ball)	3 inches (one cobble depth)
SB 3 (Sliding Bead)	4 beads floating
SB 4 (Sliding Bead)	3 inches (one cobble depth)
Acc 5-6 (Accelerometer)	4 inches
Acc 7-8 (Accelerometer)	3 inches (one cobble depth)

RM 82 site looking downstream (left) and upstream (right).

Figure 6a. RM 82 Left Bank Moses Bar Site 2 – 2019 scour monitor locations.

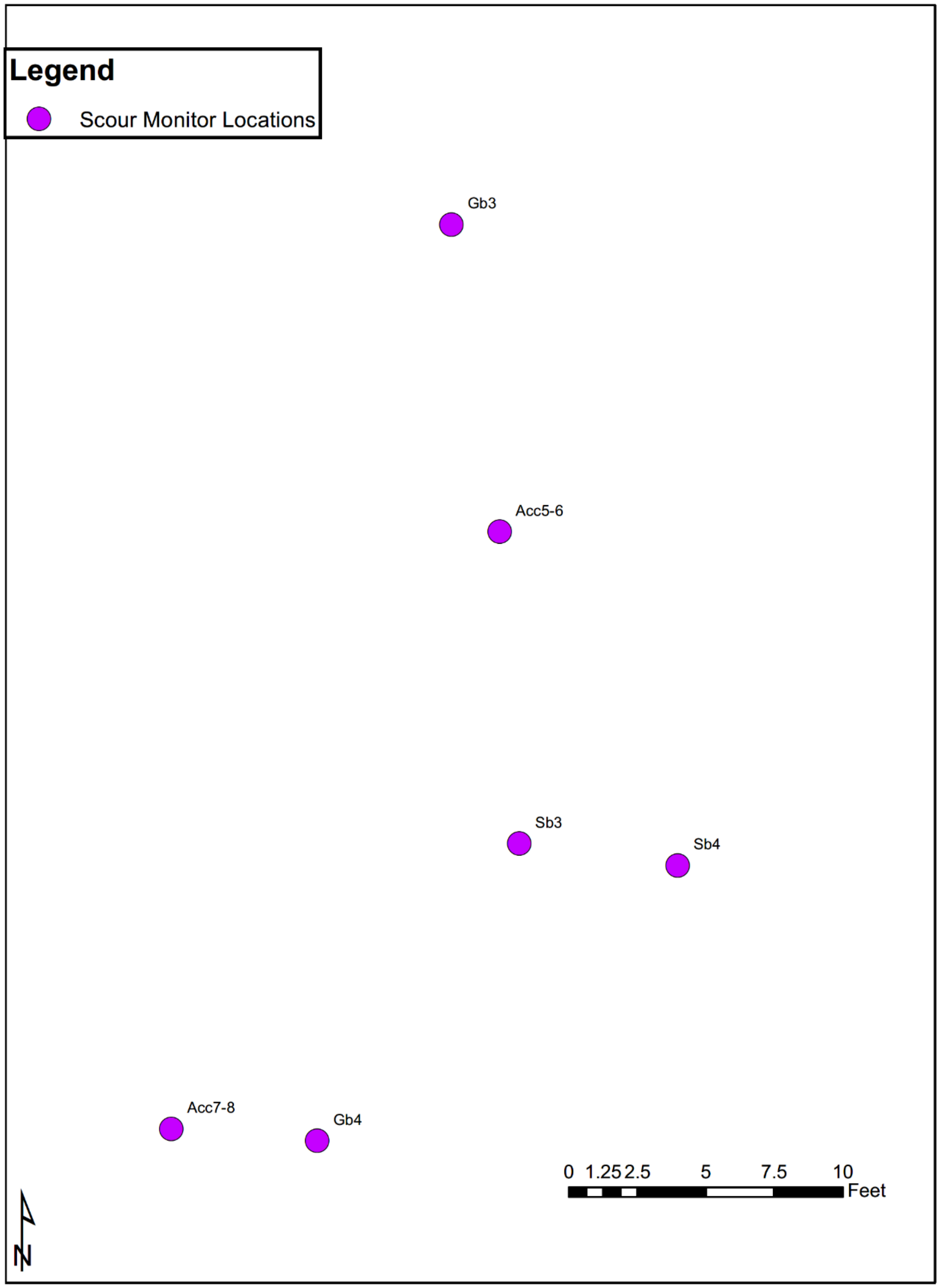

Figure 6b. RM 82 Left Bank Moses Bar Site 2 – 2019 scour monitor locations.

3.2 RM 78.6 Left Bank Channel Upstream of Cascade River Road Bridge Site 1

The RM 78.6 location is upstream from the Cascade River boat launch and bridge in a left bank low flow channel. The channel was separated from the main flow by a bar during monitor placement but is part of the main channel during higher flows. A lower (downstream) and an upper (upstream) grouping of monitors was placed at this location. Monitor placement is summarized in Table 2 and shown in Figure 7.

Table 2. RM 78.6 Upstream of Cascade Road Bridge monitors.

Monitor Designation	Initial Burial Depth
GB 1 (Golf Ball)	1 inch
GB 2 (Golf Ball)	5 inches
SB 1 (Sliding Bead)	1 inch
SB 2 (Sliding Bead)	2 inches
Acc 1-2 (Accelerometer)	3 inches (one cobble depth)
Acc 3-4 (Accelerometer)	5 inches

RM 78.6 lower site looking downstream (left) and upstream (right).

RM 78.6 upper site looking downstream (left) and toward main channel (right).

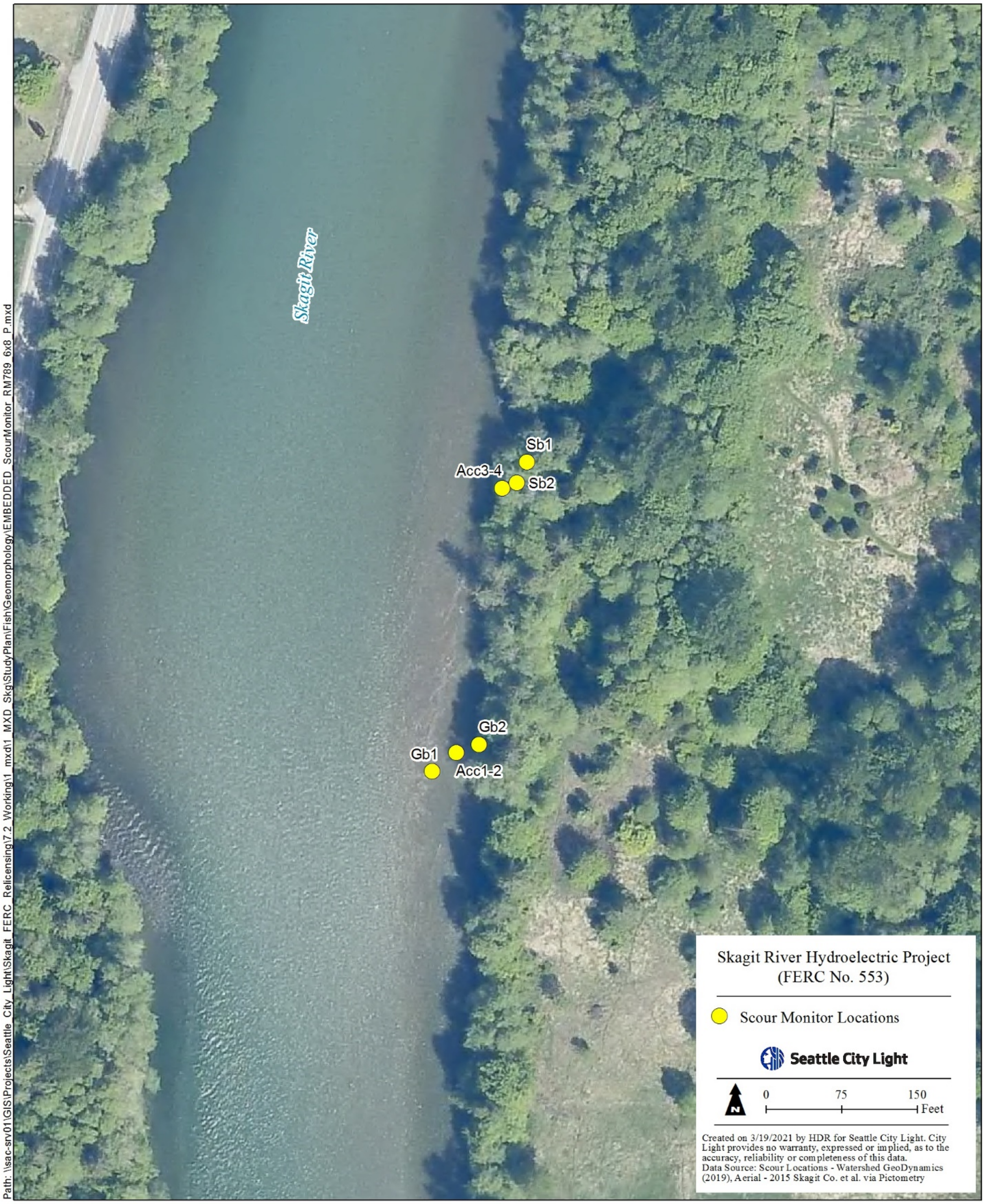

Figure 7a. RM 78.6 Left Bank Bar upstream of Cascade River Road Bridge Site 1 – 2019 scour monitor locations.

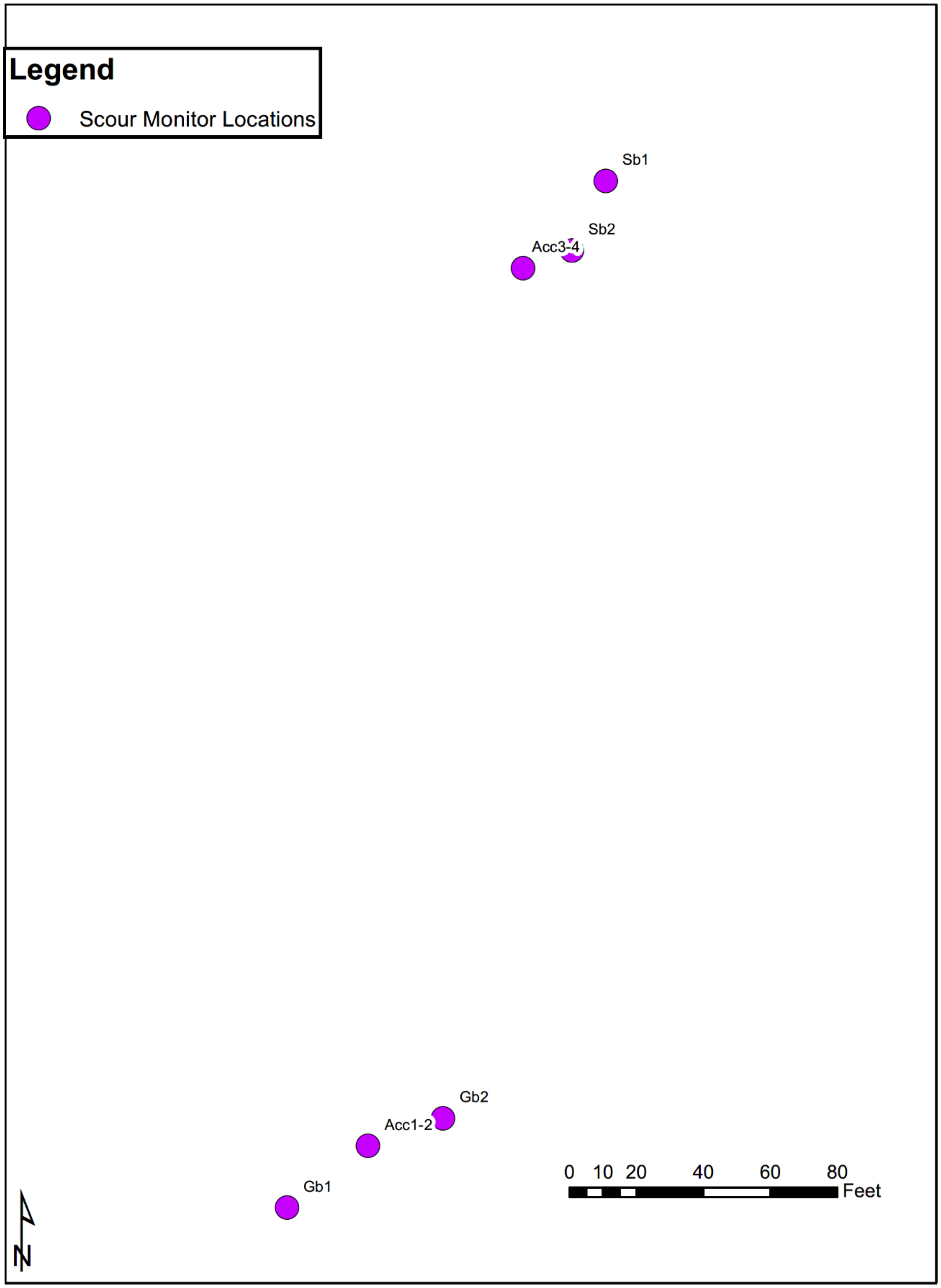

Figure 7b. RM 78.6 Left Bank Bar upstream of Cascade River Road Bridge Site 1 – 2019 scour monitor locations.

3.3 RM 77.8 Right Bank Bar at Cascade River Confluence Site 3

The RM 77.8 site is on a right bank bar across the mainstem Skagit River from the mouth of the Cascade River. The site likely is influenced by the sediment input from the Cascade River; the substrate was much looser and easier to install monitors than the two upstream sites. Monitor placement is summarized in Table 3 and shown in Figure 8.

Table 3. RM 77.8 Cascade Confluence Bar monitors.

Monitor Designation	Initial Burial Depth
GB 5 (Golf Ball)	4 inches
GB 6 (Golf Ball)	3 inches (one cobble depth)
SB 5 (Sliding Bead)	3 inches (one cobble depth)
SB 6 (Sliding Bead)	3 inches (one cobble depth)
Acc 9-10 (Accelerometer)	3 inches (one cobble depth)
Acc 11-12 (Accelerometer)	3 inches (one cobble depth)

RM 77.8 lower site looking downstream (left) and upstream (right).

Figure 8a. RM 77.8 Right Bank Bar at Cascade River Confluence Site 3 - 2019 Scour Monitor Locations.

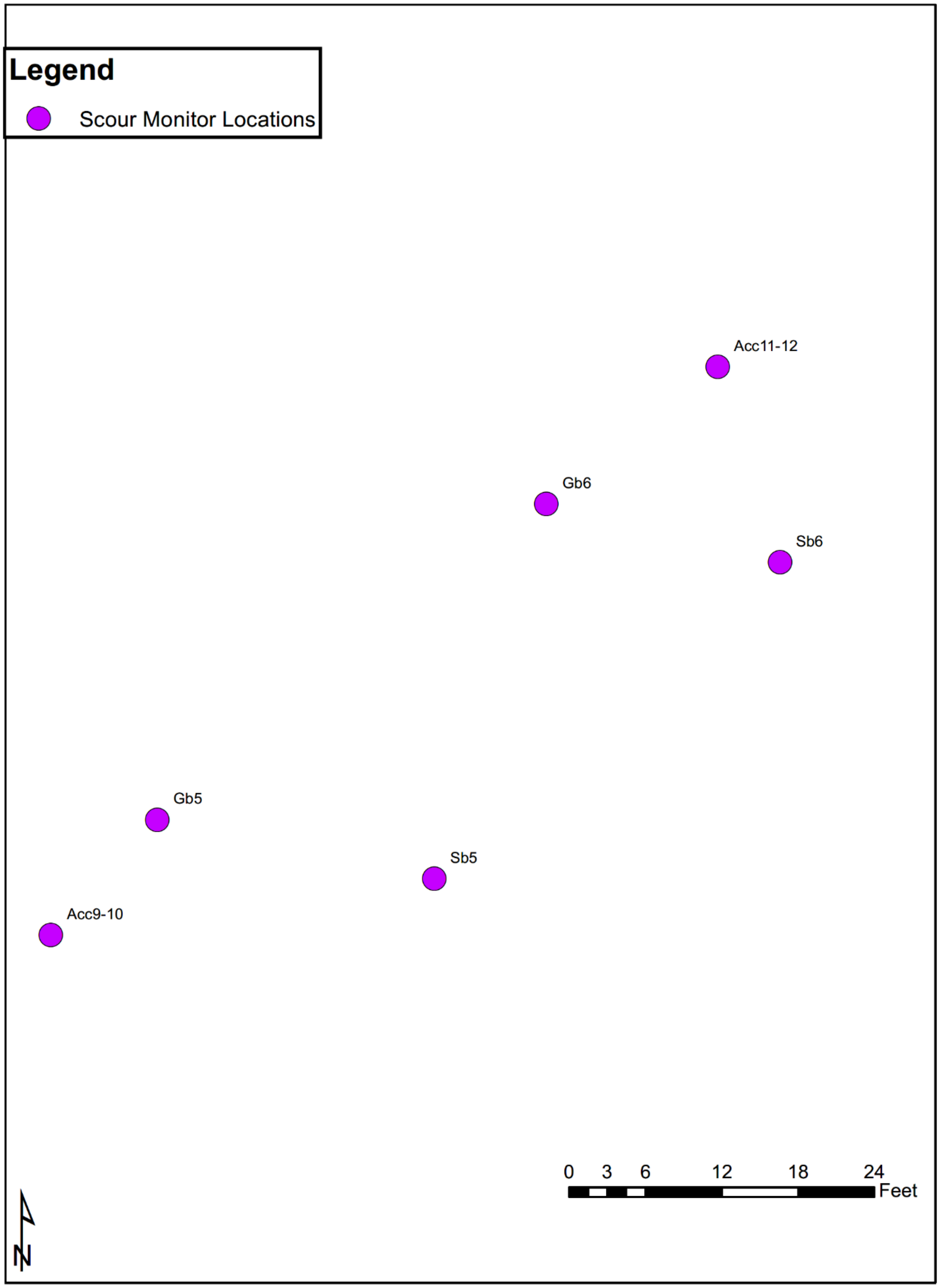

Figure 8b. **RM 77.8 Right Bank Bar at Cascade River Confluence Site 3 - 2019 Scour Monitor Locations.**

3.4 Substrate Texture at 2019 Scour Sites

Surficial substrate texture for each of the scour monitor sites is shown in Figures 9 and 10. All sites were dominated by coarse gravel and cobble particles, with the two sites just upstream and downstream of the Cascade River confluence having a finer texture than the upstream-most site.

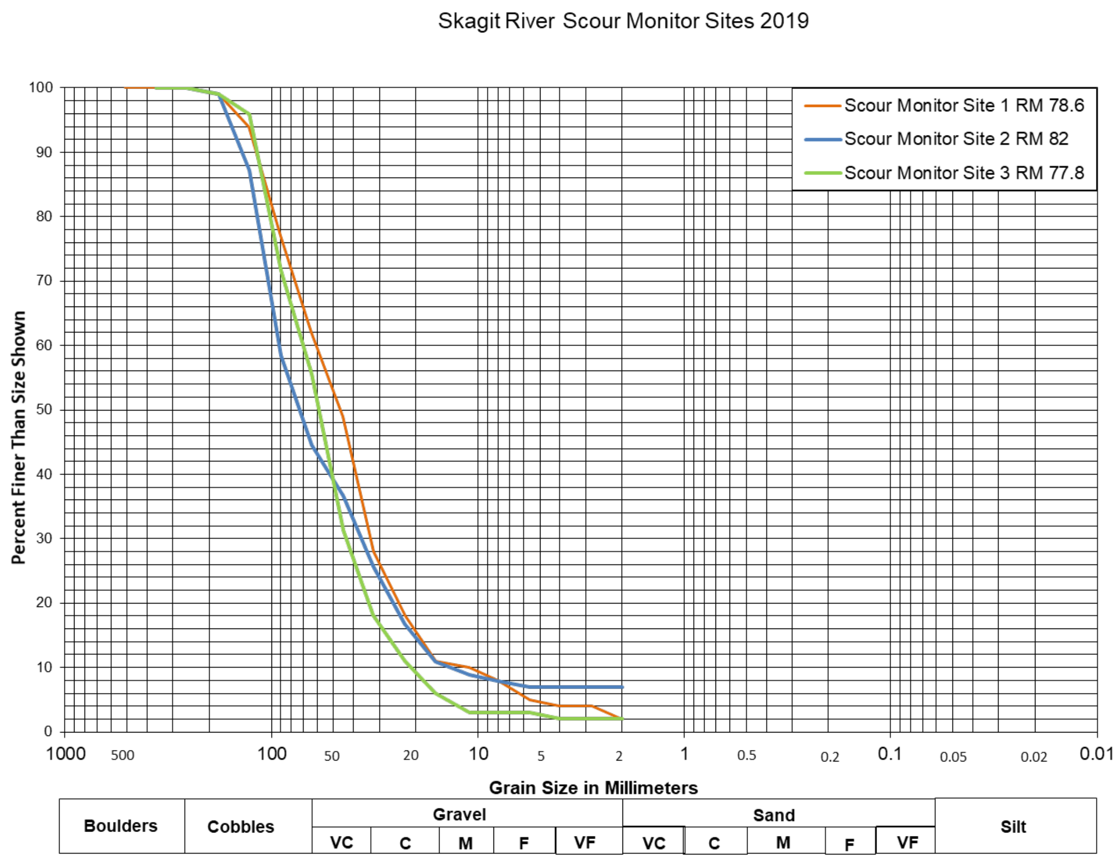

Figure 9. Substrate texture, percent finer, at 2019 scour monitor locations.

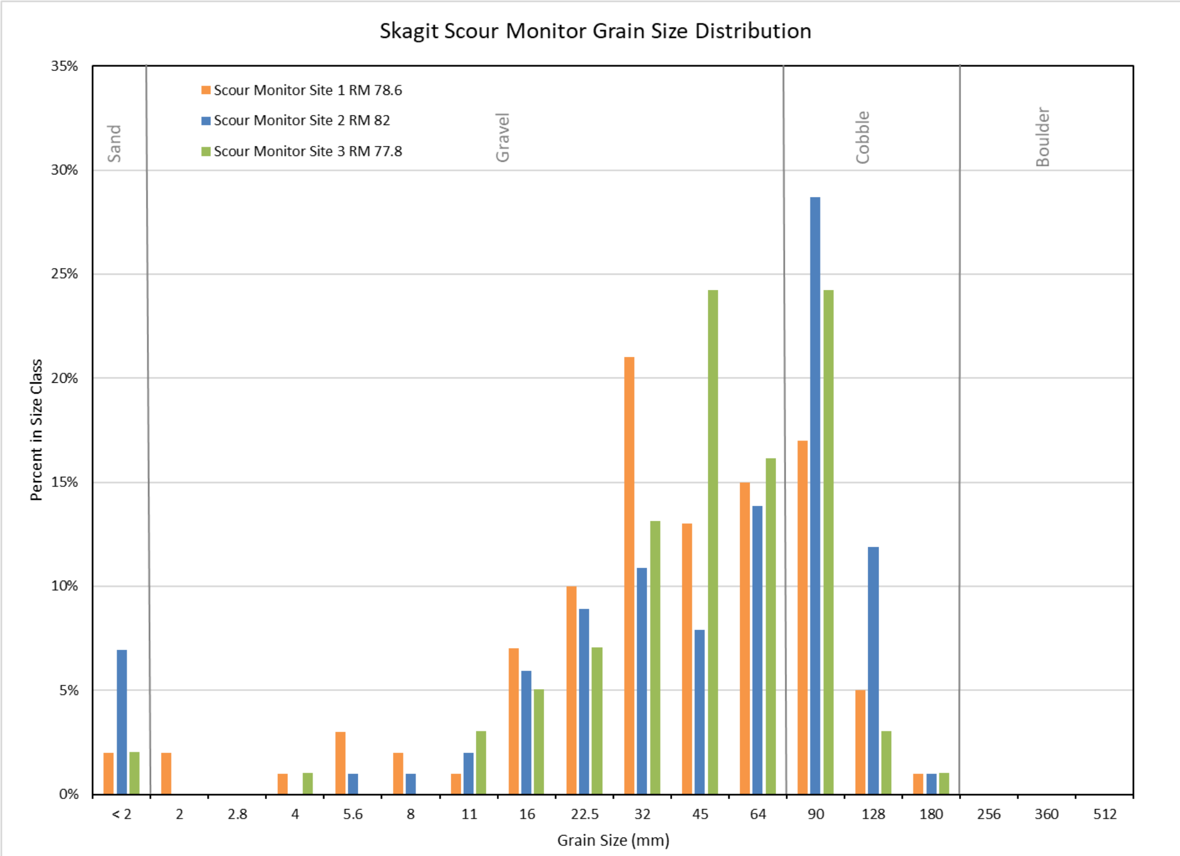

Figure 10. Substrate texture, grain size distribution, at 2019 scour monitor locations.

4.0 PLANS FOR DATA COLLECTION

If flow and water clarity is suitable, the scour monitor and accelerometer installations will be visually checked by Erin Lowery during weekly spawner surveys to determine if monitors appear to be in place and if any beads/golf balls appear to have moved.

Scour monitors and accelerometers will be relocated as soon as flows are low enough during the summer/fall of 2020. If scour monitors are buried, the depth of fill on top of the monitor will be recorded; if beads have moved from the vertical position, the number of beads/golf balls will be recorded to determine scour depth. Scour monitors can be left in place if there has been little scour or can be pulled and reset. Accelerometer arrays will need to be removed from the gravel and cut out of the pipe to allow data to be downloaded using the HOBO software. The accelerometers can be re-deployed after data is downloaded, and re-inserted into the pipes and re-installed, or inserted into new pipe arrays if the old arrays are damaged or rusted.

Data on any scour/fill and timing will be compiled and correlated to flow recorded at the Newhalem and Marblemount gages.

5.0 RECOMMENDATIONS FOR FUTURE INSTALLATIONS

Based on the fall 2019 installation trip, we have the following recommendations:

- Allow time to obtain the necessary permits or waivers depending upon installation locations chosen
- Bring extra installation equipment if available, particularly clips and small inserter pipes to allow for damage
- Install during the lowest flows possible
- A four-person crew is optimal to allow 3 people to pound the inserters into the ground while a fourth person gets the monitors set up
- Allow 3-4 hours per site for installation and travel time between sites; staying on site is recommended instead of driving to and from Seattle each day
- Some installation locations may be accessible by foot but consider that heavy equipment needs to be carried to each site
- Use Trimble to locate each monitor accurately to aid in recovery and locating during spawner surveys
- Triangulate between each monitor and, if possible, shore locations such as trees to aid in recovery
- Decide if floats should be used for scour monitors (golf ball or sliding bead) based on any loss of equipment (vandalism)

6.0 REFERENCES

Gendaszek, A.S., C.S. Magirl, C.P. Konrad, C.R. Czuba, and C.P. Konrad. 2013. The Timing of Scour and Fill in a Gravel-bedded River Measured with Buried Accelerometers. Journal of Hydrology Vol. 495 pp. 186-196.

Schuett-Hames, D., R. Conrad, A. Pleus, and K. Lautz, 1999. TFW Monitoring Program Method Manual for the Salmonid Spawning Gravel Scour Survey. Prepared for the Washington State Department of Natural Resources under the Timber, Fish, and Wildlife Agreement. TFW-AM9-99-008; DNR #110. December. Available at: http://file.dnr.wa.gov/publications/fp_tfw_am9_99_008.pdf.

SKAGIT RIVER GEOMORPHOLOGY BETWEEN GORGE DAM AND THE SAUK RIVER
REVISED STUDY PLAN

ATTACHMENT C

SEDIMENT TRANSPORT AND LARGE WOOD PROPOSED MONITORING AND TRANSPORT STUDIES

1.0 INTRODUCTION

This attachment describes proposed methods to analyze the transport of sediment and large wood in the Skagit River between Gorge Dam and the Sauk River confluence in response to NMFS-02 Geomorphology and Aquatic Habitat study request. Several LPs have requested development of tools such as transport models or transport studies to help in the analysis of potential protection, mitigation, and enhancement (PME) measures to balance the input of water, wood, and sediment downstream from the Project, with the ultimate goal of enhancing aquatic and riparian habitat.

2.0 GOALS AND OBJECTIVES

The following are goals and objectives of these additional analyses:

- Develop a calibrated sediment transport model with the purpose of answering the following questions:
  - What flows (magnitude and duration) are needed to transport and/or deposit sediment in the following habitat/geomorphic areas (focus areas):
    - Tributary junctions
    - Side channel/off-channel habitat (e.g., connect, clean out, or create these habitats)
    - Channel migration (e.g. what flows result in bank erosion)
    - Rearing habitat
    - Spawning habitat
    - River bars
- How would any sediment added to the Skagit River as part of PMEs be routed through river and how far downstream would effects be noticeable?
- Quantify/characterize large wood removed from reservoirs (this information is currently being compiled as part of the proposed Wood Management Plan)
- Determine the fate of reservoir wood added to the Skagit River downstream from Gorge Powerhouse

The above information and tools (e.g., models) would be used as part of the license application and PME development process to assess potential flow regimes, gravel, or wood augmentation plans for the new license.

3.0 METHODS

The following are suggested approaches to meet the goals and objectives.

3.1 Workshop to Discuss Methodology and Select Focus Areas

A series of workshops will be held with licensing participants to work out details of methodology and to select specific focus areas for more detailed study. It is recommended that technical experts in geomorphology/aquatic habitat/modeling from LPs attend the workshop so that the discussions can be focused on details of methodologies (similar to the geomorphology subgroup that met at the beginning of the licensing meetings). The initial Workshop is proposed for June 2021, with the subsequent workshop schedule to be determined in collaboration with LPs.

3.2 Sediment Transport Models/Sediment Augmentation

In order to answer questions posed in the goals and objectives, two different types of sediment transport models are needed. A two-dimensional (2-D) sediment transport model is needed to assess flows that move and re-distribute substrate at focus areas, and a one-dimensional (1-D) sediment transport model is needed to determine how sediment is routed through the river.

3.2.1 2-D Sediment Transport Model

The HEC-RAS 2-D hydraulic model being developed for the FA-02 Instream Flow Model Development Study will be used as a basis for the 2-D sediment transport modeling by applying the sediment transport algorithms at focus areas. This will provide details on how sediment will move/accumulate at a scale where changes to aquatic and riparian habitat can be analyzed. The model could also be used to simulate localized effects of log jams/wood accumulations by adding obstructions in model mesh.

Mobile bed capabilities in HEC-RAS 2D are new as of the December 2020 release of Version 6.0, which is currently only in ‘beta’ status; thus, the HEC-RAS sediment transport model will require additional testing and debugging. The HEC-RAS model is suggested for sediment transport modeling for consistency with the hydraulic model being used for the Project. In order to compare HEC-RAS sediment transport results with other models that have been in use for a longer time, an SRH-2D model will be developed for one test focus area. Assuming HEC-RAS model performs satisfactorily, it will be applied to the other focus areas.

Model simulations will be run for a flow range of 5,000 cfs to 40,000 cfs based on the currently available flow data for calibration of the hydraulic model. An estimated 10 to 20 simulation will be run to test sensitivity on sediment boundary conditions (clearwater, low, and high inputs) as part of model calibration.

3.2.1.1 Focus Area Selection

Focus areas will be selected in consultation with LPs at a workshop and cover the following types of locations:

- Tributary junction
- Side channel/off-channel habitat
- Rearing habitat
- Spawning habitat
- River bar
- Channel migration area (note that channel migration will be analyzed through a combination of aerial photograph/LiDAR analysis supplemented by hydraulic model results of shear stress compared to bank composition rather than explicitly in a sediment transport model)

Focus areas are anticipated to be approximately 0.25 to 1 mile long depending on the type of habitat/process to be modeled. It is anticipated that focus areas can cover multiple habitat types – for example, many spawning areas and some rearing occurs in the vicinity of river bars, so one focus area could cover a bar/rearing/spawning area analysis. This would provide for a more holistic approach to potential habitat changes that could be completed through future PME measures.

Bacon Creek is one recommended focus area (tributary junction location) because it has a USGS gage which makes F flow records are readily available. In addition, bedload transport can readily be measured at the bridge crossing, and there is a large deposit of sediment at the mouth of the creek.

3.2.1.2 Model Input Data

The following input data are available under the current study program for the Gorge Dam to Sauk River confluence:

- 2-D hydraulic model will include substrate and flow information
- Pebble counts and sub-surface sampling already included in GE-04
- River bank composition already included in GE-04
- Hydrograph (2 locations in mainstem) and bedload being collected by WSDOT/USGS
- Scour monitor/accelerometer data at spawning bed, tributary mouths, and river beds
- 2018 green LiDAR and supplemental bathymetry information for Skagit River from Gorge Dam to Sauk

The following additional calibration data would need to be collected in order for the 2-D model to be calibrated enough to be useful:

- Re-do the green LiDAR (and aerial photographs) in August 2021 and, if a high enough flow occurs to move sediment again in August 2022.
- Add scour monitors, hydrophones, and bedload transport sampling in focus area tributaries upstream from confluence areas to determine tributary flows that initiate transport and transport volumes.
- Tag/monitor movement and fate of gravel/cobble deposits at mouths of Ladder Creek, Newhalem Creek, and Goodell Creek as a surrogate for adding gravel to river and tracking it. There is essentially no input of gravel/bedload (or very limited amounts) upstream from these tributaries, so the deposits at these tributary mouths can be used as an analogue for sediment augmentation, allowing the analysis to proceed within the 2-year relicensing timeframe without the need for the time to obtain permits/infrastructure, etc. to add supplemental sediment gravel at an artificial location which would likely take longer than the allotted time for the FERC study process.[4]

[4] Wood and bedload movement are extremely episodic, so it is possible (even likely) that there would be no/little movement of the tagged sediment and wood within the 2-year study timeframe. For this reason, this study element

3.2.2 1-D Sediment Transport Model

The 2-D sediment transport modeling will help answer questions about localized effects on aquatic/riparian habitat but it will not route sediment through the river. In order to address the goal of determining how any added sediment would be routed through the system (e.g., to answer questions about how far downstream any sediment augmentation would be noticeable) then a separate 1-D sediment transport model would be required. A HEC-RAS 1-D model or other 1-D transport model could be developed and used for this purpose. No additional field data collection (hydraulic or sediment) is anticipated, but there would be a separate effort required to develop and calibrate the model. The 1-D model could also provide insights on possible sediment attenuation in the Newhalem area and could possibly inform effectiveness of augmentation activities.

3.2.3 Flow/Sediment/Wood Augmentation Scenarios

Scenarios of various flow/sediment augmentation (and effects of added obstructions like engineered log jams) would be run through the model(s) to help answer questions posed in goals and objectives above as part of license application and PME development after the study plan implementation and reports are completed.

3.3 Wood Transport Augmentation and Tracking

There are no known wood transport models that are in general use; there are some in the experimental stage. In order to meet the goal of determining how large wood moves through the Skagit River, the analysis of wood movement on historical/recent aerial photographs in the main study plan will be supplemented with a program to tag large wood in the river.

3.3.1 Tracking Movement of Added Wood

The wood that is stockpiled at the Agg Ponds and wood ready to be transported from Ross Lake will be tagged (metal tags or radio tags) and added to the Skagit River at the Agg Pond boat launch. This wood will be observed and when it disperses, a survey of the fate of the wood will be made (note that it may not be possible to re-locate all wood pieces). The wood available for adding to the river is relatively small due to the constraints of the transport system to get it from Ross Lake to the boat launch. If the fate of larger wood is of interest, additional larger "natural" logs could be tagged that are already in the river system.

3.3.2 Tracking Movement of Wood via Aerial Photographs

Large wood will be digitized from the 2021 and 2022 LiDAR/aerial photographs within the study area to provide information on individual wood piece and log jam movement from year to year. This will supplement the aerial photograph wood tracking in the main study plan.

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should be viewed as the start of a wood/sediment study and monitoring program that would extend into the term of the new license and likely move into management/monitoring plan status.

4.0 ESTIMATED COSTS

Cost estimate to complete all of the items in the study plan (1-D and 2-D sediment transport model development, data collection, and large wood tracking) is approximately $1.5 million (assuming four total focus areas requiring 2-D model development).