FA-03 RESERVOIR FISH STRANDING AND TRAPPING RISK ASSESSMENT INTERIM REPORT

SKAGIT RIVER HYDROELECTRIC PROJECT FERC NO. 553

Seattle City Light

Prepared by:
Four Peaks Environmental Science & Data Solutions and
Blue Coast Engineering

March 2022
Initial Study Report

TABLE OF CONTENTS

List of Figures

List of Tables

List of Acronyms and Abbreviations

ACS.....adaptive cluster sampling
City Light.....Seattle City Light
CoSD.....City of Seattle datum
DEM.....digital elevation model
FERC.....Federal Energy Regulatory Commission
GIS .....Geographic Information System
GNSS .....Global Navigation Satellite System
GPS .....Global Positioning System
ISR .....Initial Study Report
km .....kilometer
LiDAR.....Light Detection and Ranging
LP.....licensing participant
NAVD 88.....North American Vertical Datum of 1988
NPS .....National Park Service
PME .....protection, mitigation, and enhancement
Project .....Skagit River Hydroelectric Project
QC.....quality control
RSP .....Revised Study Plan
SAGA.....System for Automated GIS Analysis
SR.....State Route
SRS .....stratified random sampling
USGS .....U.S. Geological Survey
USR.....Updated Study Report
WSE .....water surface elevation

This page intentionally left blank.

1.0 INTRODUCTION

The FA-03 Reservoir Fish Stranding and Trapping Assessment (Stranding and Trapping Assessment) is being conducted in support of the relicensing of the Skagit River Hydroelectric Project (Project), Federal Energy Regulatory Commission (FERC) No. 553, as identified in the Revised Study Plan (RSP) submitted by Seattle City Light (City Light) on April 7, 2021 (City Light 2021). On June 9, 2021, City Light filed a "Notice of Certain Agreements on Study Plans for the Skagit Relicensing" (June 9, 2021 Notice)[1] that detailed additional modifications to the RSP agreed to between City Light and supporting licensing participants (LP) (which include Swinomish Indian Tribal Community, Upper Skagit Indian Tribe, National Marine Fisheries Service, National Park Service [NPS], U.S. Fish and Wildlife Service, Washington State Department of Ecology, and Washington Department of Fish and Wildlife). The June 9, 2021 Notice included agreed to modifications to the Stranding and Trapping Assessment.

In its July 16, 2021 Study Plan Determination, FERC approved the Stranding and Trapping Assessment with modifications. Specifically, FERC recommended removing the placeholder from the study plan (as described in the June 9, 2021 Notice) requiring City Light to potentially expand the scope of the study in 2022 to include field studies in the Canadian portion of Ross Lake. This determination was based upon FERC's conclusion that it had no authority to require City Light to implement studies in Canada. Notwithstanding, City Light is implementing the Stranding and Trapping Assessment as proposed in the RSP with the agreed modifications described in the June 9, 2021 Notice.

This interim report on the 2021 study efforts is being filed with FERC as part of City Light's Initial Study Report (ISR). City Light will perform additional work for this study in 2022 and include a report in the Updated Study Report (USR) in March 2023.

[1] Referred to by FERC in its July 16, 2021 Study Plan Determination as the "updated RSP."

2.0 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 outlined in the RSP include:

- Identify and map focal areas through a desktop Geographic Information System (GIS) analysis of existing elevation and topo bathymetric 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.

Additional objectives that were described in the June 9, 2021 Notice and which were agreed to on an "if needed" basis during a subsequent consultation with LPs on October 20, 2021 include:

- Finding a reservoir drawdown rate that avoids, limits, or greatly reduces stranding of fish and juvenile amphibians; and
- Identifying reservoir elevations that prove problematic for trapping of fish and juvenile amphibians.

In addition, the June 9, 2021 Notice identified four clarifications related to implementation of this Stranding and Trapping Assessment:

- City Light to hold technical meetings with the LPs to review initial information to assess adequacy of that information (related to the spatial scale of data) in informing stranding evaluation (including tree well size) and to guide representative sampling in Q4 2021 and in 2022.
- Review 2021 sampling in the U.S. for risk assessment to refine and inform the expansion to Canadian drawdown zone in 2022.
- LPs requested that the study results inform the development of protection, mitigation, and enhancement (PME) measures inclusive of a reservoir drawdown rate that avoids, limits, or greatly reduces stranding of fish and juvenile amphibians and identifies reservoir elevations that prove problematic for trapping of fish and juvenile amphibians. City Light and the LPs recognize that the study plan report will not include proposed PME measures related to stranding. Such PME measures will be developed as part of the license application.
- City Light will clarify the study to provide for opportunistic surveys if maintenance drawdowns or lowering of reservoirs beyond normal operations occurs.

[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. Normal operations are further defined in Section 3.0 of this report.

3.0 STUDY AREA

The study area includes Ross, Diablo, and Gorge lakes, within the U.S. and Canada, and specifically targets the varial zone at which stranding and trapping risks could occur under normal Project operations (Figure 3.0-1). The GIS analysis area extends into the portion of Ross Lake in Canada approximately 1.4 kilometers (km) north of the Canada-U.S. border (outside of the Project Boundary). The initial field survey area includes the Project reservoirs within the U.S. only.

Under the current Project license, Ross Lake normal maximum water surface elevation (WSE) and minimum WSE (authorized by current license) are 1,608.76 feet North American Vertical Datum of 1988 (NAVD 88; 1,602.5 feet City of Seattle datum [CoSD][3]) 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). The varial zone below the normal maximum WSE to the seasonal drawdown level comprises the study area of Ross Lake.

Diablo Lake may fluctuate 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). Occasionally, 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) under normal operations. Drawdowns of 10 to 12 feet to about elevation 1,200 (1,193.64 feet CoSD) feet NAVD 88 also occur as needed for construction projects or maintenance. The varial zone exposed during typical (normal) fluctuations constitutes the primary study area of Diablo 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). Under normal operations the lake may be operated as low as 870 feet NAVD 88, on occasion. Drawdowns of 50 feet or more are occasionally needed for spill gate maintenance or inspection. The varial zone exposed during typical (normal) fluctuations constitutes the primary study area of Gorge Lake.

[3] As described in Section 2.3.1 of the RSP, the CoSD requires a conversion to NAVD 88 in order to be comparable with elevations measured and presented elsewhere in analyses and discussions surrounding Project relicensing. To convert to NAVD 88, 6.26 feet must be added to Ross Lake WSE in CoSD, 6.36 feet added to Diablo Lake WSE, and 6.51 feet added to WSE for Gorge Lake.

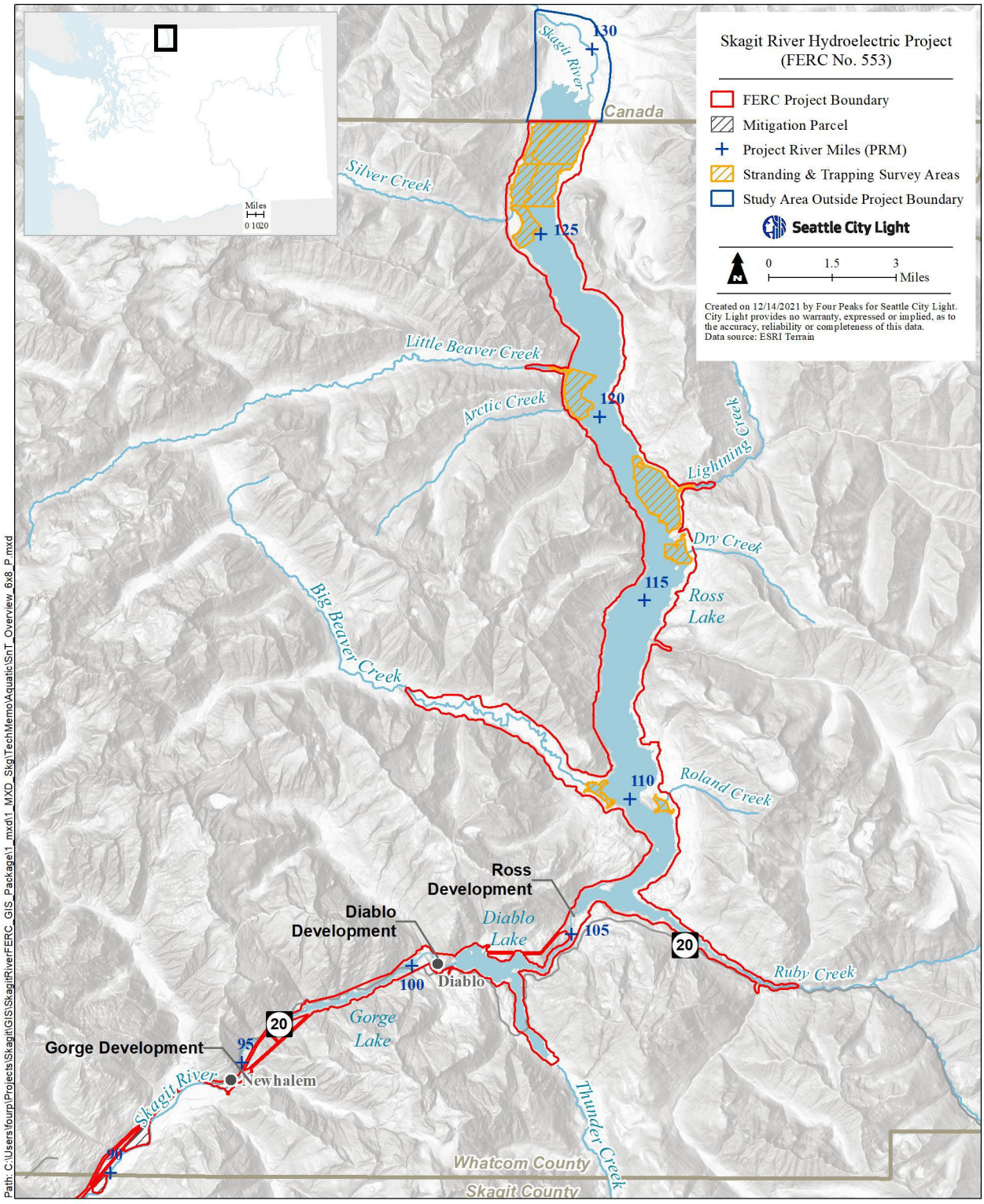

Figure 3.0-1. Overview of proposed study area.

4.0 METHODS

The Stranding and Trapping Assessment study includes four distinct tasks: (1) field reconnaissance; (2) a desktop analysis of the study area to identify potential areas of fish stranding and trapping risk; (3) field surveys at selected areas to test the results of the desktop analysis; and (4) an update to the desktop analysis, if necessary.

4.1 Reconnaissance Surveys

A total of three reconnaissance field surveys were conducted on Ross Lake during the 2020 and 2021 drawdown cycle—in December 2020, March 2021, and April 2021 to capture various points in the drawdown cycle. Additionally, one opportunistic reconnaissance survey was conducted in Diablo Lake in September 2020 to capitalize on an unplanned drawdown beyond the normal operations of that reservoir.

These reconnaissance efforts served four main purposes associated with optimizing the formal field program planned for 2021-2022 (2021-2022 Ross Lake drawdown cycle, the 2022 Gorge and Diablo lakes quarterly sampling, and opportunistic sampling of reservoir drawdown events below the range of normal operations, as defined by the study):

(1) Identify areas around project reservoirs with high concentrations of potential stranding or entrapment habitat (e.g., tree wells, low-slope areas), including refining the boundaries that define these areas;

(2) Refine the methodology for spatial sampling and field surveying;

(3) Identify shoreline access issues and other logistical challenges for each lake; and

(4) Optimize the sequence of sampling study zones, both throughout the season and within each survey.

4.1.1 Ross Lake Reconnaissance

Reconnaissance field surveys on Ross Lake were conducted between December 2020 and April 2021, a period spanning most of the 2020-2021 reservoir drawdown and the beginning of reservoir refill. Consequently, WSE in Ross Lake varied by more than 80 feet over this period (Figure 4.1-1).

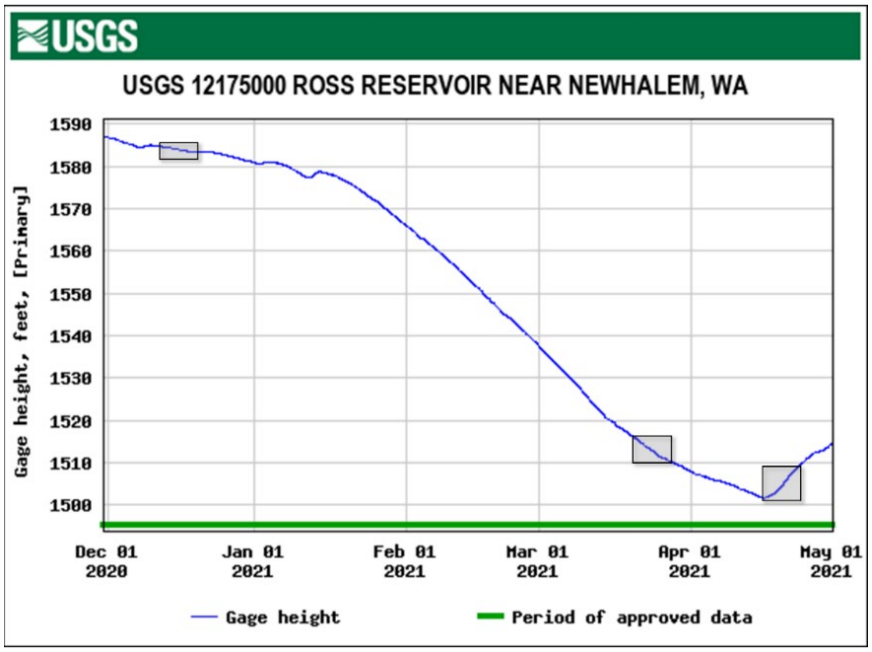

Figure 4.1-1. Ross Reservoir (i.e., Ross Lake) WSE (feet above CoSD) from December 2020 through April 2021. Shaded rectangular boxes indicate approximate periods of reconnaissance surveys (USGS 2021).

Ross Lake reconnaissance surveys focused on areas around Ross Lake that were identified as having a known or hypothesized high potential risk of stranding and trapping, based on input from LPs, preliminary desktop analyses, and prior experience of City Light staff, including iterative development of these areas based on observations during the reconnaissance efforts. The areas identified by these processes included locations where stranding and trapping had been observed previously by LPs or City Light staff or contractors, locations where existing information on topographic slope and bathymetry in exposed areas suggested potential for stranding and trapping, and locations that were considered likely stranding and trapping risk areas based on best professional judgment and past findings in other systems (e.g., areas close to a tributary outflow). Both the identification of these meso-scale focus areas and the precise delineation of their respective boundaries were iteratively refined through the reconnaissance period; for example, to account for feedback provided during consultation with LPs on October 20, 2021, and from review of empirical data collected during the reconnaissance surveys on Ross Lake.

These reconnaissance focus areas represent early risk screening "strata." Within these strata, which represent a substantial area of survey within Ross Lake in particular, the adaptive cluster sampling (ACS) approach (defined further in Section 4.3 of this study report) was evaluated for application later in 2021 and in 2022 after the digital elevation model (DEM) results described in Section 4.2 are complete. The results of these surveys also informed the desktop analysis described in Section 4.2 of this study report.

The first reconnaissance survey in Ross Lake was conducted on December 17-18, 2020, when Ross Lake WSE measured at U.S. Geological Survey (USGS) station 12175000 was approximately 1,590.26 feet NAVD 88 (1,584 feet CoSD, Figure 4.1-2A). On December 17, 2020, crews surveyed the northern part of the eastern shore of the lake, north of the Hozomeen Fish

Camp. On December 18, 2020, crews surveyed the northern part of the western shore of the lake, beginning opposite Hozomeen Fish Camp, then surveyed around the mouth of Big Beaver Creek and dispersed shoreline areas along the southern end of the lake. During this visit, crews evaluated the logistics of sampling 10 percent of the dewatered varial zone and tested field-based delineation of 25-meter quadrats. Within each quadrat, crews visually searched for evidence of stranded or trapped fish, including dead fish, fish remains, and topographic features that were holding water.

A second reconnaissance survey in Ross Lake was conducted on March 24, 2021, when Ross Lake WSE measured at the USGS gage was approximately 1,519.26 to 1,520.26 feet NAVD 88 (1,513 to 1,514 feet CoSD, Figure 4.1-2B). The varial zone was surveyed around the mouths of Roland Creek, Big Beaver Creek, and Lightning Creek, around Lost Lake, and within the Ruby Arm where Ruby Creek flows into Ross Lake.

A third and final reconnaissance survey in Ross Lake was conducted on April 20, 2021, when Ross Lake WSE measured at the USGS gage was approximately 1,511.26 feet NAVD 88 (1,505 feet CoSD, Figure 4.1-2C). On this date, the crew attempted to survey the north end of the lake, but water level was too low and conditions were too shallow to safely proceed past the approximate location of Jack Point in the boat. The crew attempted passage using a smaller motorized raft, but the current was too strong to pass and no further attempts were made. The crew then resampled areas around the mouth of Lightning Creek and around Lost Lake using randomly selected starting locations as part of the stratified random sampling (SRS) plan. Next, the crew surveyed the varial zone along both the south and north sides of the mouths of Little Beaver Creek and Arctic Creek.

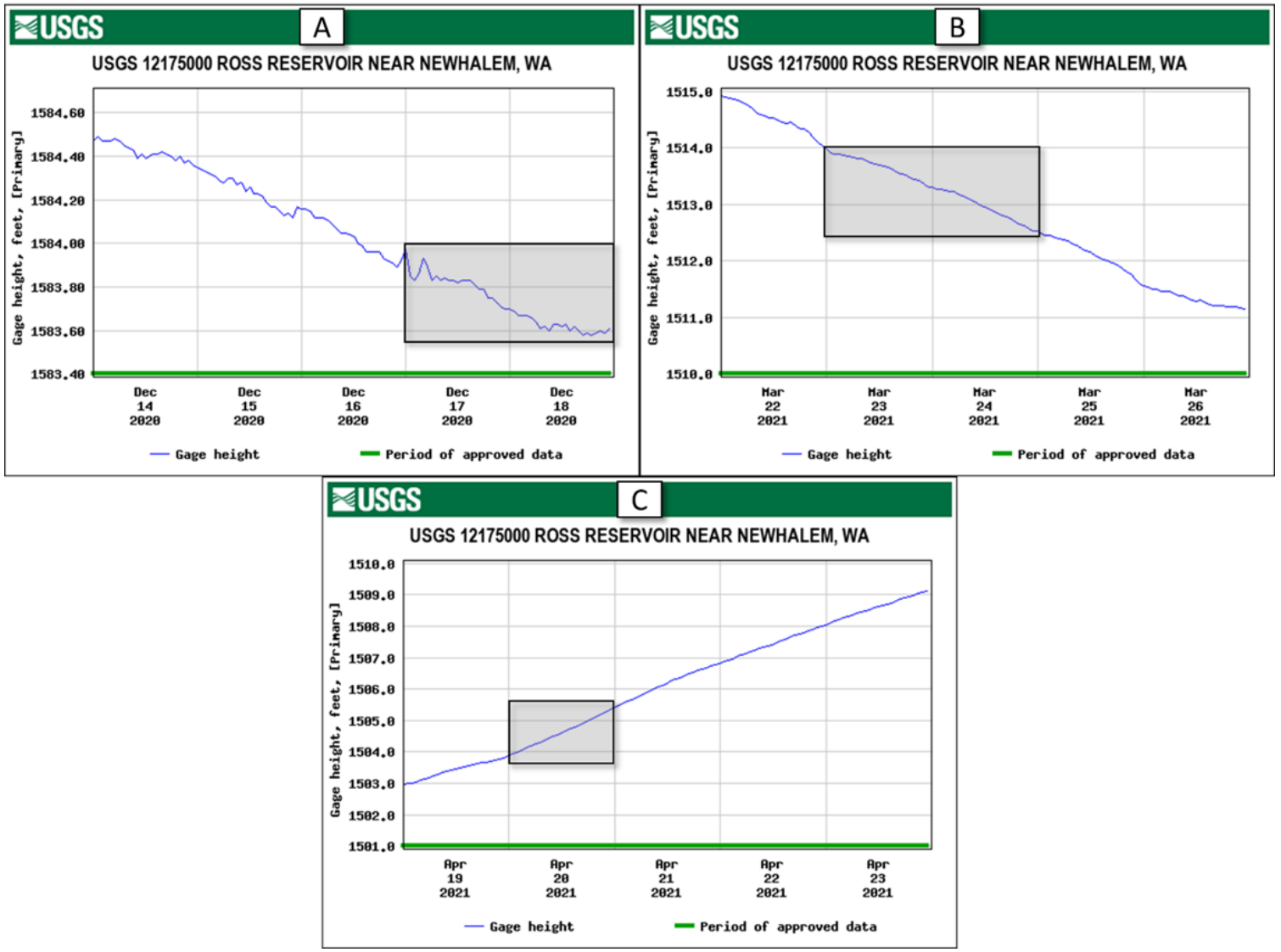

Figure 4.1-2. **Ross Reservoir (i.e., Ross Lake) WSE (feet above CoSD) from December 17-18, 2020 (A), March 23-24, 2021 (B), and April 20-21, 2021 (C). Shaded rectangular boxes indicate approximate periods of reconnaissance surveys (USGS 2021).**

4.1.2 Opportunistic Diablo Lake Reconnaissance

On September 16-17, 2020, Diablo Lake was opportunistically surveyed for stranded or trapped fish during an unplanned drawdown for previously unscheduled maintenance. During this event the reservoir was drawn down nearly 6 feet (7 feet from normal maximum WSE), to a WSE of approximately 1,202.36 to 1,207.36 feet NAVD 88 (1,196 to 1,201 feet CoSD) as measured at USGS station 12176500 near Newhalem, Washington (Figure 4.1-3).

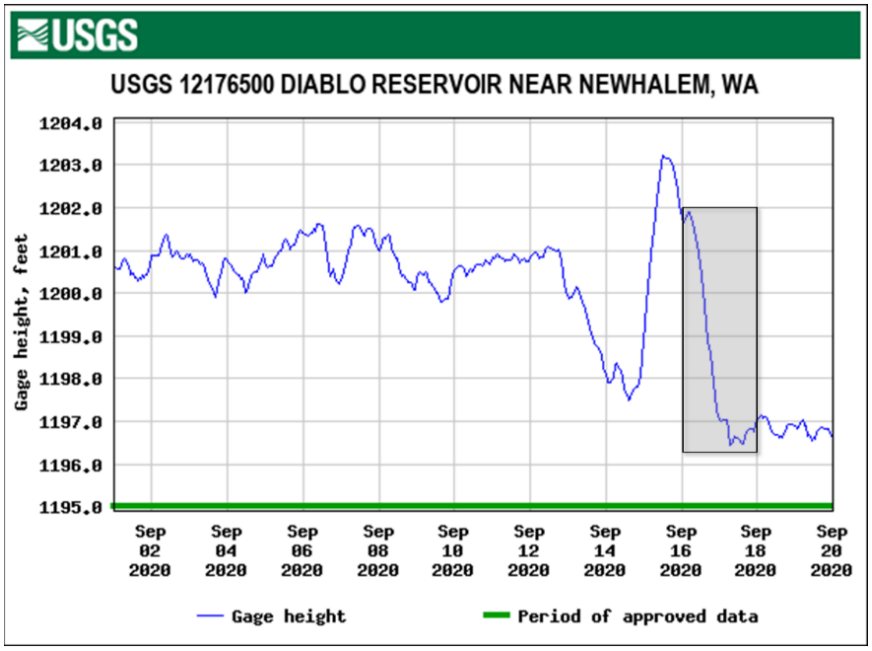

Figure 4.1-3. Diablo Reservoir (i.e., Diablo Lake) WSE (feet above CoSD) during mid-September 2020. Shaded rectangular box indicates approximate period of reconnaissance survey (USGS 2020).

Sampling around Diablo Lake began between 07:30 and 09:00 on each day. Sampled locations included areas upstream (south) of the State Route (SR) 20 bridge, including sites in Thunder Arm around the mouth of Colonial Creek.

4.2 Desktop Analysis

The desktop analyses include three components, as described in Section 2.6.2 of the RSP: (1) assembly and analysis of DEMs of reservoir shoreline and bed topography to inventory potential stranding and trapping areas; (2) an analysis of reservoir WSE 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 and trapping risk under normal operations may be present in the study area. These components are discussed in more detail in the sections below.

4.2.1 Analysis of DEMs for Stranding and Trapping Risk

Of the three reservoirs in the Project Area, only Ross Lake has a complete DEM of the topography and bathymetry within the varial zone. As a result, only Ross Lake has been analyzed. Gorge and

Diablo lakes will be analyzed after bathymetric data collection (currently in progress by City Light) is complete.

Identifying and analyzing areas presenting a stranding and trapping risk around Ross Lake began by performing a quality assurance test of the existing Ross Lake DEM that was developed from the 2018 Light Detection and Ranging (LiDAR) flight (Quantum Spatial 2018a; 2018b). The Ross Lake DEM was then analyzed to identify and quantify (1) areas with gradient profiles indicating stranding risk and (2) areas draining to isolated pools indicating trapping risk. These analyses included five distinct steps, detailed below.

First, the DEM was clipped to include only elevations between normal maximum WSE of 1,608.76 feet NAVD 88 (1,602.5 feet CoSD) and 1,494.26 feet NAVD 88 (1,488 CoSD) WSE during the LiDAR flight used to develop the data for the DEM. This was accomplished within the ArcGIS tool Analysis > Clip.

Second, using standard GIS tools within the ArcGIS Spatial Analyst toolbox, each 3-foot square grid cell (i.e., 9-square-foot area) within the existing DEM was analyzed to determine its slope. Each cell was characterized by benchmark slopes identified by Bell et al. (2008) as associated with salmonid stranding potential in reservoir environments, consisting of (1) slope less than 4 percent (low slope); (2) between 4 and 6 percent (moderate slope); or (3) greater than 6 percent (steep slope). The slope of each individual cell was then compared with adjacent (neighboring) cells. To eliminate overly granular slope classification, low slope areas were identified as the union of two or more adjacent or diagonal cells (18 square feet) with low slope, in keeping with the approach described in the RSP (City Light 2021). Polygons were then generated to enclose low slope areas less than 4 percent and moderate slope areas between 4 and 6 percent.

Third, trapping hazards were identified by querying the Ross Lake DEM for sinks that met the criteria of being greater than 108 square feet in area and deeper than 12 inches compared to the surrounding surface. These criteria were based on reported LiDAR resolution, and are presumed to accurately capture areas with high risk of stranding and trapping, because of the clustering nature of these features that was observed during reconnaissance surveys and preliminary desktop GIS analyses. This querying was done using a two-step process that began by identifying sinks that were at least 12 inches deep, and then retaining only those 12-inch-deep sinks with area greater than or equal to 108 square feet. Identifying sinks involved detecting depressions using the sink-filling algorithm (Terrain Analysis > Fill Sinks) (Wang and Liu 2006) within the System for Automated GIS Analysis (SAGA) v7.9.1 (Conrad et al. 2015), and then extracting the sinks as the difference between the filled DEM and the unfilled DEM, using the ArcGIS tool Image Analyst > Raster Calculation. Next, only those sinks that were greater than 12 inches were retained, using the ArcGIS tool Spatial Analyst > Conditional. Sinks were converted from binary rasters to polygons, using the ArcGIS tool Conversion > Raster to Polygon (with the "simplify" option selected). Finally, these polygons were queried to include only those areas greater than or equal to 108 square feet, using the ArcGIS tool Select by Attributes, and a sink edge elevation was assigned to each using the ArcGIS tool Analysis > Spatial Join to join the sink polygons with the contours from the DEM.

Fourth, these low-slope and sink areas around Ross Lake were mapped and evaluated visually to inventory reservoir reaches exhibiting high concentrations of potential stranding and trapping areas.

Fifth, low slope and sink areas were manually adjusted to remove features that are contiguous with the mainstem thalweg at full drawdown. This step was necessary to account for a data gap relating WSE among locations around Ross Lake across the range of reservoir stage. Ross Lake WSE is reported from measurements collected at a single location (near the dam). However, WSE along the length of Ross Lake is neither flat nor uniformly sloped at all reservoir stages. At normal maximum WSE, the reservoir water surface is essentially flat. However, as it is drawn down, the reservoir becomes increasingly steeper, and its profile approaches that of a free-flowing river. The degree to which WSE varies and the relationship among WSE measured at different points around the lake across the range of reservoir stage is unknown. However, data visualizations and preliminary analyses indicate that, at full drawdown, WSE in the lower reservoir may be 40 to 90 feet lower than WSE in the upper reservoir.[4] This means that as the reservoir is drawn down, the water elevation, and thus the elevation of exposed varial zone around the lake, increasingly varies across the length of the lake. For a set of features at the same elevation around the lake, those features that are closer to Ross Dam will be exposed earlier during drawdown, i.e., at higher WSE as measured at the dam gage. Features further upstream the reservoir at that same elevation will not be exposed until the reservoir has drawn down more. This means that the DEM clipping described at the beginning of this section may inadvertently include features that are never dewatered, such as flow paths that were adjacent and contiguous to the mainstem thalweg of the Skagit River, and which are now submerged within Ross Lake at even full drawdown. The result of this would be an overestimation of the total amount of stranding and trapping area, and an overestimation of risk at a given WSE. The manual editing of the identified areas has partially corrected for this data gap, and work is ongoing to further resolve this issue.

As described in Section 4.1 of this study report, this desktop analysis was conducted iteratively with the Ross Lake reconnaissance surveys to ensure that areas identified in the field as having a high potential risk of stranding and trapping were also identified using the GIS analyses.

4.2.2 Analysis of Reservoir Drawdown

The purpose of the WSE analysis is to characterize the time series of WSEs in the reservoir at daily, monthly, annual, and decadal time scales. The results from this analysis will be used to plan field surveys—by identifying consistent WSE and patterns in drawdown that occur at certain periods of the year—and to characterize the GIS-based assessment of stranding and trapping risk, which will be completed and documented in the USR, by identifying the timing, frequency, and duration of risk associated with dewatered stranding and trapping features. The historical WSE analysis for Ross Lake is complete. A similar WSE analysis will be conducted for Gorge and Diablo lakes after City Light completes collection of and makes available additional bathymetry to address data gaps as identified in the RSP (City Light 2021). That work will be documented in the USR due no later than March 2023.

The WSE analysis was completed to characterize the frequency of WSEs in the reservoir. The results from this analysis will be used to plan field surveys and to characterize the GIS-based assessment of stranding and trapping risk, which will be completed and documented in the USR.

Records of hourly and daily gage height were obtained for Ross Lake from the USGS website (USGS 2021) for the period of January 1, 2011, through June 9, 2021, as specified in the RSP

[4] These analyses are in process and have not yet been field verified.

(City Light 2021). As described above in Section 3.0, the gage height was converted from CoSD to NAVD 1988 by adding 6.26 feet to the gage readings. All data were collated and then screened for data gaps and outliers. The longest notable data gaps were two days (2) and one day (1). No outliers were identified above or below the licensed operating WSE (1,480.76 NAVD 88 [1,474.5 feet CoSD] to 1608.76 feet NAVD 88 [1,602.5 feet CoSD]) (City Light 2021).

Next, frequency of occurrence and percent exceedance curves were calculated for the hourly dataset using 1-foot bin sizes between the minimum and maximum WSE recorded in Ross Lake over the period considered. After binning the data records into 1-foot bins, the frequency distribution and percentiles were determined in order to calculate frequency of occurrence and percent exceedance curves (Helsel et al. 2020). Bulk statistics (minimum, maximum, mean, median, range, variance) were also calculated for the dataset. Data operations (calculation of frequency of occurrence, percent exceedance, and bulk statistics) were completed for the full dataset (2011 to 2021) and by month of year and week of year.

4.2.3 Native Species Life Stage and Periodicity Analysis

Each of the Project reservoirs support native Bull Trout, Dolly Varden, and Rainbow Trout. 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 seasonal use of those habitats where stranding and trapping might occur. At present, site-specific 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 consider the general life cycles of the native fish based upon relevant literature and professional judgment of biologists working in the study area to infer their life-stage-specific temporal susceptibility.

Rainbow Trout typically spawn from late March through April, but 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. Trapping of rearing sub-adult and adult Rainbow Trout from changes in reservoir WSE is possible, though less likely.

Dolly Varden and Bull Trout, both char species, spawn in the autumn over a period of declining ambient temperatures. Spawning commences when water temperatures decline to about 8º C, typically starting in late September into November depending on the temperature regime of the tributary location. Char fry 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. However, young-of-the-year for both species are typically obligate stream dwellers, and emigration into lentic reservoir habitats at fry stages is less likely.

Because none of these native species is known to spawn in the lentic habitats of the Project reservoirs (documented spawning occurs in lotic habitats within reservoir tributaries instead) the likelihood of trapping or stranding spawning char and trout is anticipated to be low. Spawning age

fish would be on tributary spawning grounds, which would not be susceptible to the effects of reservoir fluctuations or drawdown.

Stranding and trapping risks are expected to be highest for early emergent fry and young of the year of Rainbow Trout, 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.

As described above, the periodicity analysis for this study is still in process. Periodicity analyses for all Project species of interest are being developed in collaboration with LPs for complementary studies.

4.3 Sampling Design and Field Surveys

All surveys have and will continue to be conducted in the normal operating range for each reservoir (see Section 3.0 for a definition of these ranges). Crews will also continue to conduct opportunistic surveys in Diablo and Gorge lakes if maintenance drawdowns or lowering of reservoirs beyond normal operations occurs during the study period when these areas may be accessed safely.

4.3.1 Ross Lake Sampling Design

As summarized in Section 4.1.1 of this study report, eight sampling areas within Ross Lake were identified for field survey in the 2021/22 field season: Mile 1,[5] Mile 2, Silver Creek,[6] Arctic Creek/Little Beaver Creek, Lost Lake/Lightning Creek, Dry Creek, Big Beaver Creek, and Roland Creek (Figure 3.0-1). These areas were iteratively defined, based on field reconnaissance results (described in Section 5.1 of this study report), preliminary analyses of reservoir elevation data, and input from LPs. Because these sampling areas are substantial in size, field surveys subsampled each, using a multi-step process to randomly sample strata within each (described in more detail in Section 5.1 of this study report). Including the delineation of the sampling areas themselves, this process involved five broad steps, each comprising multiple components (Figure 4.3-1). The first three steps were completed once, and results were retained for the remainder of the study. The last two steps were completed immediately before each field survey.

[5] The "Mile 1" and "Mile 2" sampling areas refer to the varial zone shoreline areas of Ross Lake that are one mile and two miles south of the Canadian Border, respectively.

[6] Sampling areas named for creeks refer to the mouth of these creeks, where they flow into Ross Lake.

Figure 4.3-1. Process diagram for identification of stratified randomized sampling starting locations.

4.3.1.1 Stratified Adaptive Cluster Sampling Process

First, eight sampling areas around Ross Lake were defined based on whether they met any of the following three criteria:

(1) Site of previous observation of stranding or trapping;

(2) Site identified as high-risk during reconnaissance, based on observation of high concentration of tree wells or other depressional areas, or of large areas of low slope shoreline; and

(3) Site identified during preliminary GIS analyses as potentially containing large concentrations of low slope or depressional areas.

Second, the varial zone was defined and a grid of quadrats was developed to uniquely identify locations around Ross lake. The lower bound of the varial zone was placed at 1,494.56 feet NAVD 88 (1,500.3 CoSD), which was the WSE at the time of the 2018 LiDAR flight. The upper bound was placed at 1,608.76 feet NAVD 88 (1,602.5 CoSD), which is the maximum licensed elevation. A map of the Ross Lake varial zone was then overlaid with a grid of 25-meter-square (625 square meter) cells (quadrats). Each quadrat was then assigned a unique alphanumeric identifier (Figure 4.3-2).

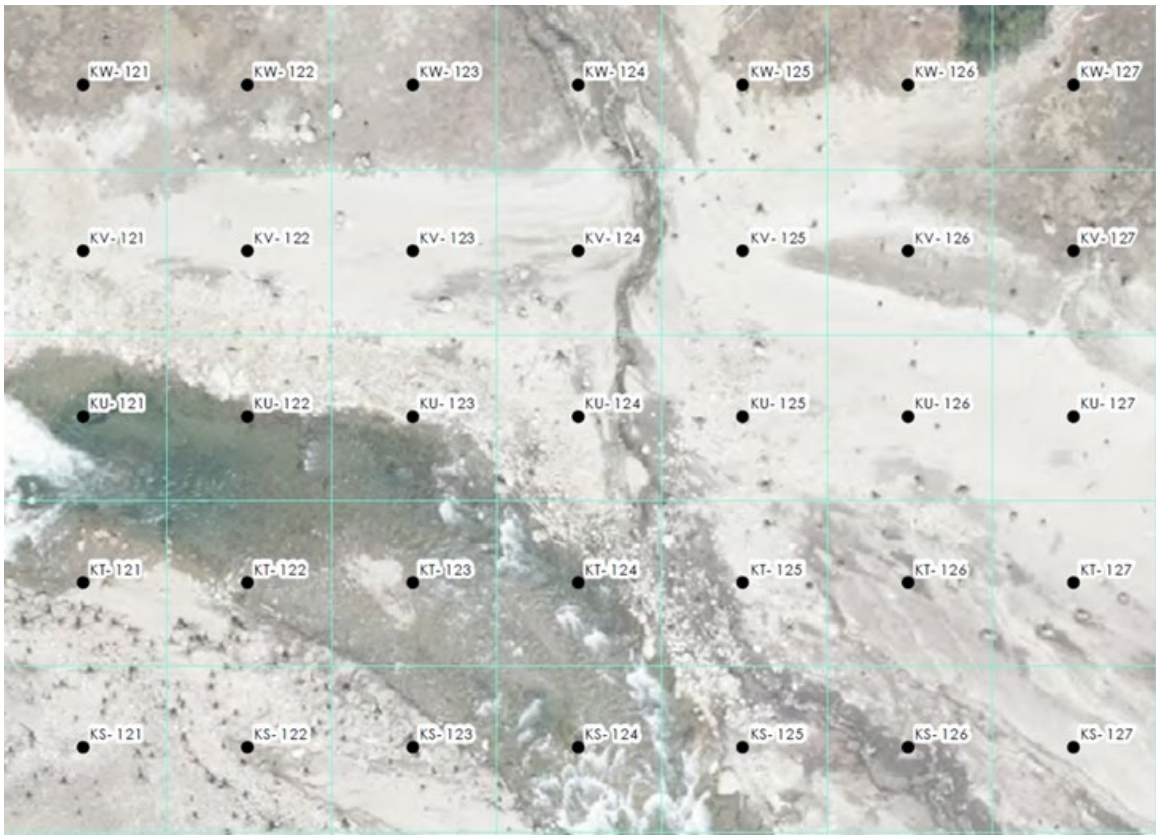

Figure 4.3-2. Area around mouth of Big Beaver Creek, showing overlaid 25-meter quadrats that are each assigned an alphanumeric identifier.

Third, low slope areas and sinks identified during the GIS analyses were added to the map (Figure 4.3-3), and each quadrat was characterized based on whether it contained a low slope feature or a sink. Using this method, each quadrat was assigned to one of four categories: (1) Low Slope; (2) Sink; (3) Both; or (4) None. The quadrats within each sampling area were subsequently stratified using these categories, as described in step four, below.

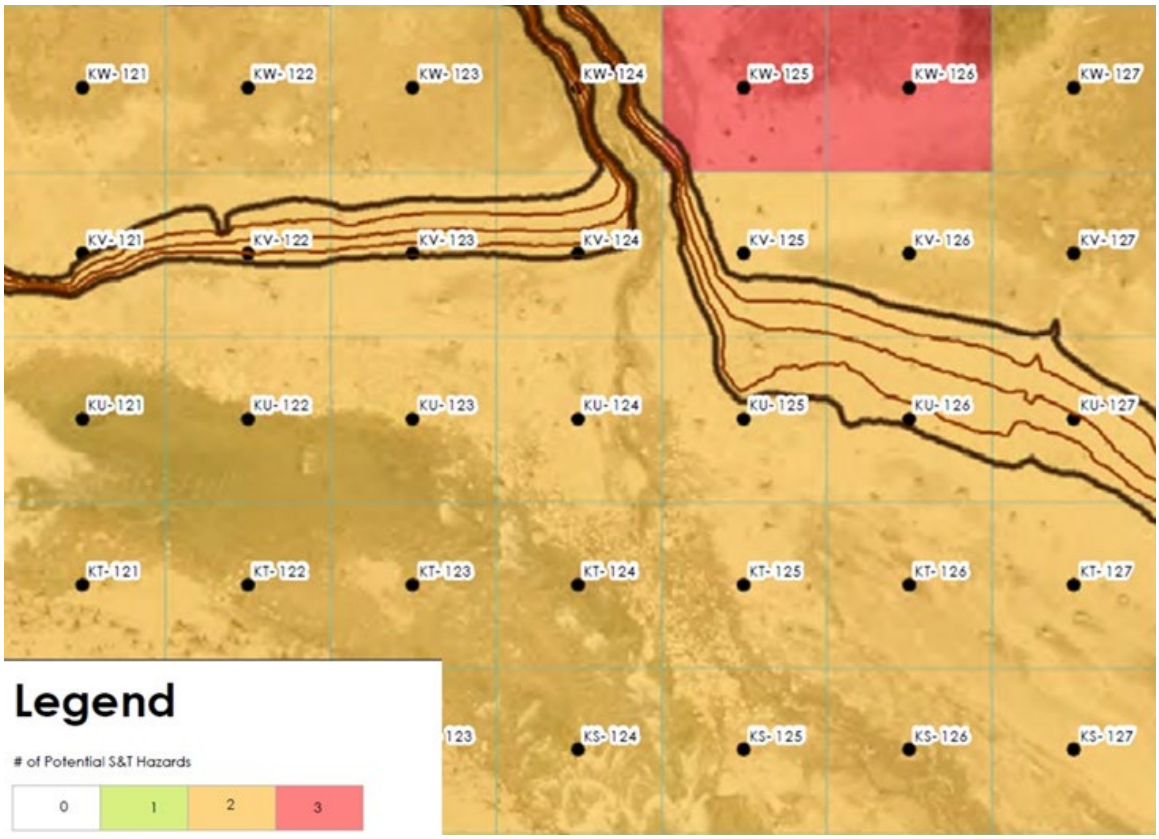

Figure 4.3-3. **Area around mouth of Big Beaver Creek, showing overlaid quadrats, color coded by potential stranding and trapping group as determined from GIS-analyses. Contour lines indicate projected WSE for a potential field survey. Cells are colored based on the count of different types of features they contain.**

Fourth, two to four days before a field survey, predicted Ross Lake WSE were calculated and the varial zone quadrats within each sampling area were stratified by elevation to focus on the anticipated band of recently dewatered varial zone at the time of the survey. This was done by first checking the USGS Ross Lake gage, plotting the previous two weeks of WSE, and estimating daily rate of WSE change during this period (Figure 4.3-4). Information about planned operational events (such as spill), obtained from City Light, was then incorporated to develop a prediction of the approximate WSE during the upcoming survey period. The predicted range of WSE was then buffered by four feet (i.e., two feet above and below the predicted WSE), to account for uncertainty. This range of WSE was used to stratify quadrats by querying the list of all available quadrats in the varial zone, and then retaining only those quadrats that intersected with contours corresponding to the minimum and maximum elevation within the predicted WSE range (Figure 4.3-5).

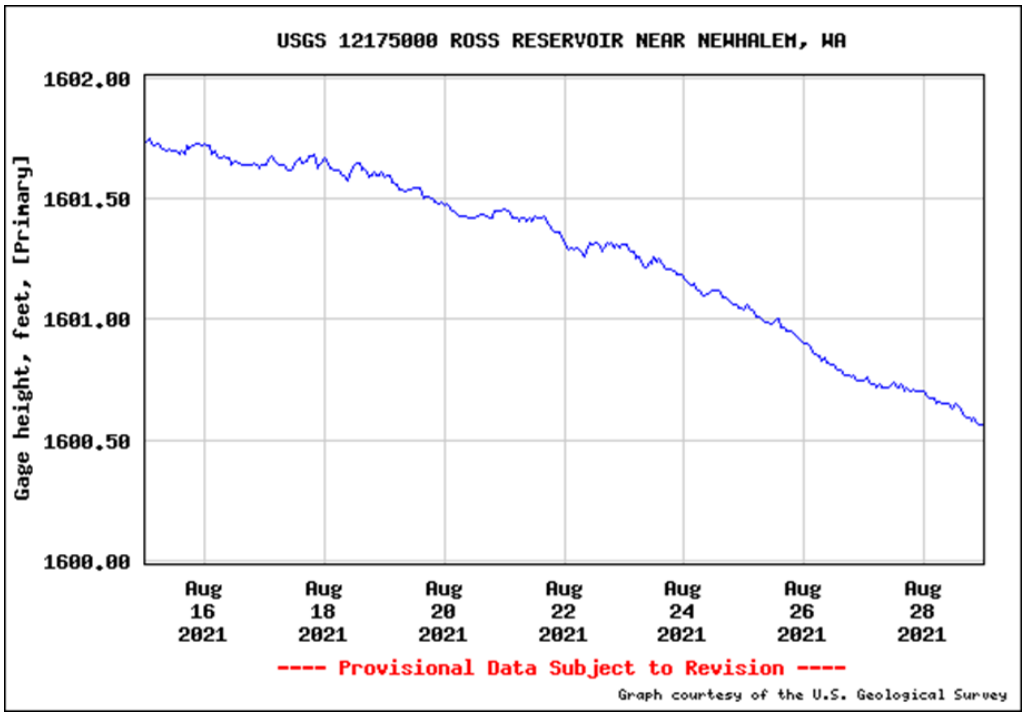

Figure 4.3-4. **Example WSE (feet above CoSD) plot at Ross Dam evaluated to estimate the rate of WSE change.**

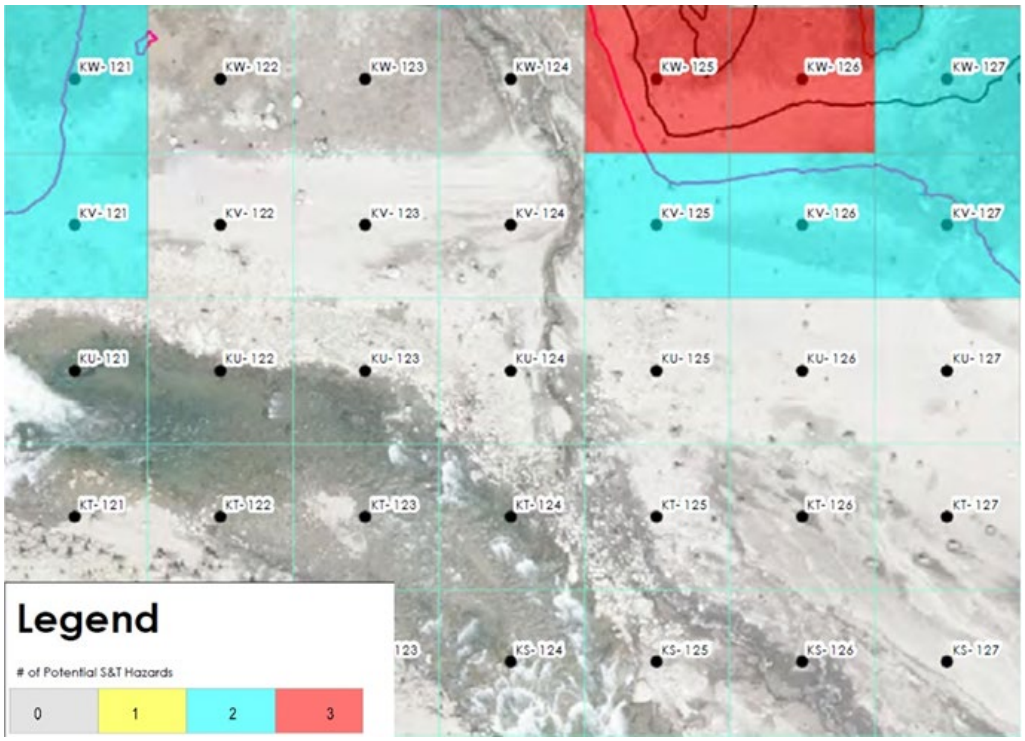

Figure 4.3-5. **Area around mouth of Big Beaver Creek, showing overlaid quadrats, color coded by potential stranding and trapping group as determined from GIS-analyses. Contour lines indicate projected WSE for a potential field survey.**

Fifth, the elevation stratified quadrats within each sampling area were secondarily stratified into the four groups described above (Low Slope, Sink, Both, None), and quadrats within each group were randomly subsampled to develop a list of starting locations for the ACS field sampling approach.

Using these stratified random starting points that were identified in the lab, an ACS approach was then employed in the field to survey for potential stranding and trapping features, generally following the methods outlined by Thompson (1990):

> *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. Methods for computing estimates of the density of features are outlined in Thompson.

4.3.1.2 Ross Lake 2021-2022 Field Survey Methodology

Ross Lake was to be sampled at least three times 2021-2022, under differing WSEs, to encompass as much of the drawdown range as feasible while also targeting periods when fish activity is expected to be greatest (e.g., during fall lake turnover and during late winter spring juvenile fish emergence). Two surveys were conducted in 2021; a third will occur in 2022. At the time of each field survey, efforts were focused on sampling areas with many exposed potential stranding and trapping features, and these areas were surveyed by foot. Areas with minimal exposed features were evaluated rapidly, in some cases from the boat. If these areas appear to contain dewatered features that could strand or trap fish, they were surveyed by foot.

For each sampled quadrat, a field data form, developed using ArcGIS Survey123 (ESRI), was completed using a mobile device or field tablet (Figure 4.3-6). Data collected at each site included date and time of observations, environmental conditions, observers, quadrat ID, location coordinates, and photo documentation. If live or dead fish are observed, then they were counted (as possible) by species and life stage, and a photograph was taken. If evidence of fish predators or scavengers (e.g., bird tracks or identifiable fish remains) was observed, then a photograph was taken, and a description of the evidence recorded. If either fish or evidence of fish predation was observed, then the stranding or trapping feature was surveyed for length, width, and maximum depth. To ensure an appropriate level of precision for geolocating field observations, field crews were equipped with Bluetooth-ready, surveyor grade, external antennas, capable of real-time 1-meter accuracy, using both Global Positioning System (GPS) and Global Navigation Satellite System (GNSS) antennas.

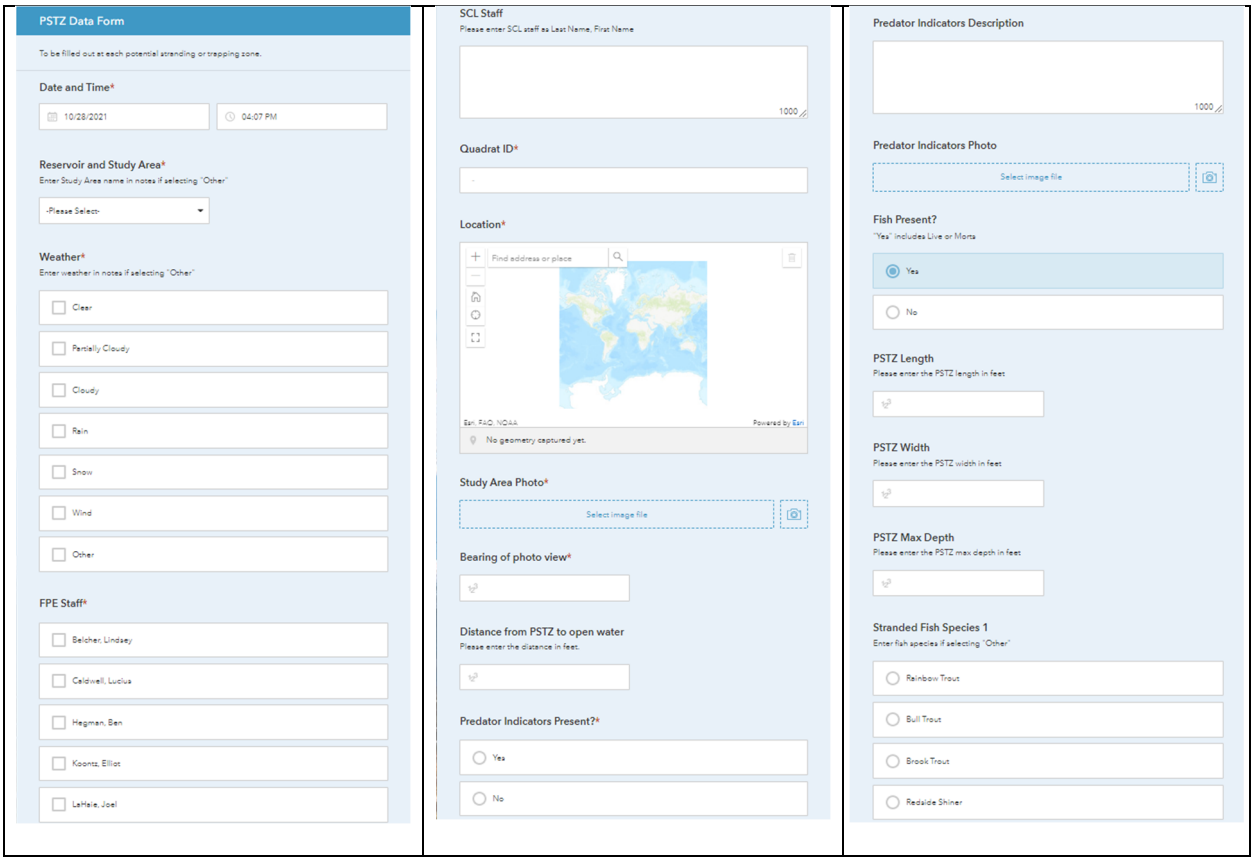

Figure 4.3-6. Survey data field form for use with tablet or mobile device.

4.3.2 Diablo and Gorge Sampling Design

Sampling in Diablo and Gorge lakes will generally follow the same protocol outlined above for Ross, pending complete DEMs for each lake. Until the DEMs are developed and to capitalize on planned and unplanned drawdowns, opportunistic surveys will adopt an alternative, transect-based approach to comprehensively survey areas previously identified as possible high-risk for stranding or trapping.

4.4 Analysis and Reporting

This study report will be followed by a study report for the USR at the conclusion of the program. Pursuant to the methods identified in the RSP (City Light 2021), 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 study report for the USR will also include the following:

- A description of the methodology employed within each reservoir;
- 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 of stranding and/or trapping features.

Data collected will be analyzed to test relevant hypotheses (e.g., H_o: normal operating ranges do not cause an increase in stranding). To the degree that multiple factors are recognized as influencing trapping or stranding risks, additional statistical tests may be used to evaluate the relative influence of each factor.

5.0 PRELIMINARY RESULTS

Results include data collected and analyses completed through September 1, 2021. Additional field data collected after this date are still being processed and analyzed. All results will be included in the USR.

5.1 Reconnaissance Surveys

As described in Section 4.1 of this study report, the purpose of the reconnaissance surveys was to identify and refine survey areas around Ross Lake, refine spatial sampling and survey methodology, identify access and logistics, and optimize order and seasonality of sampling. These surveys were not conducted to generate data that would be useable within an analytical framework for evaluating stranding and trapping risk. This section focuses on results pertaining to the intended purpose of these surveys, while also providing anecdotal information collected opportunistically, when illustrative or otherwise appropriate. Lessons learned during these surveys, summarized in Section 5.3 of this study report, were used to adaptively update the survey plan so that efforts could focus on surveying at times and in places when the likelihood of documenting stranding and trapping was greatest.

5.1.1 Ross Lake Reconnaissance

5.1.1.1 December 2020 Ross Lake Survey

No stranding events, dead fish, or evidence of predation were observed within any of the areas sampled along the eastern shore of the north end of Ross Lake. Crews noted that many of the sampled areas had been out of the water for an extended period, and that sampling less than 1 percent of the entire dewatered varial zone would be feasible. The extent of exposed survey area indicated a modification of the initial stratification of grid cells surveyed was n further stratified to examine cells most recently exposed, as described in Section 5.1.3.2.

5.1.1.2 March 2021 Ross Lake Survey

All sites surveyed around the mouth of Roland Creek were characterized by steep banks without appreciable depressions such as from tree wells. Sites around the mouth of Big Beaver Creek exhibited low potential for stranding or trapping. At the WSE when this area was sampled (Figures 4.1-1 and 4.1-2C), the banks exhibited a consistent downhill gradient towards the lake, with minimal depressions. Sites around the mouth of Lightning Creek exhibited low slope areas but not many tree wells or other depressions. The area around Lost Lake was characterized by low slope and many tree well depressions. In the area around Ruby Arm, crews observed no evidence of stranding or trapping. Of the areas surveyed during the March visit, the area around Lost Lake appeared to present the greatest potential for stranding or trapping—the area primarily represents a large stranding plane though several potential trapping sites were also observed. These trapping sites were found also to be identified through the preliminary DEM coverage developed to guide survey using the ACS approach stratified closer to the shoreline. Tree wells were relatively limited in comparison to the north end of the lake and, as identified in April, the confluence zones of Little Beaver and Arctic creeks.

5.1.1.3 April 2021 Ross Lake Survey

No evidence of stranding or trapping was observed in sites surveyed around the mouth of Lightning Creek or around Lost Lake. At sites around the mouth of Little Beaver, crews observed more potential stranding and trapping sites than during the March 2021 survey. These were characterized as undulating low-slope terrain with depressions that were holding water or appeared to have previously held water. Sites around the mouth of Arctic Creek contained a large number of potential trapping sites. At all sites surveyed during this visit, crews observed no evidence of stranding or trapping, including live fish, mortalities, or fish remains.

5.1.2 Opportunistic Diablo Lake Reconnaissance

On Wednesday, September 16, 2020, thirteen stranding pools were identified in the Thunder Arm area, ranging in size from 0.1 to 155 square meters (1 to 1,670 square feet). Ten of these pools contained no fish. The other three pools contained one or two live Rainbow Trout newly emergent fry that were approximately 2 centimeters (0.8 inches) long.

On Thursday, September 17, 2020, twenty-six potential stranding pools were identified in the Thunder Arm area, ranging in size from less than 0.1 to 30 square meters (1 to 323 square feet). Nineteen of these pools contained no fish. Three pools contained one live 2-centimeter (0.8 inch) Rainbow Trout fry. One pool contained two live 2-centimeter (0.8-inch) Rainbow Trout fry. One pool contained a 5-centimeter (2-inch) live Rainbow Trout fry. One pool contained one live and one dead 2-centimeter (0.8-inch) Rainbow Trout fry. The remaining pool contained fourteen dead 2-centimeter (0.8-inch) Rainbow Trout fry.

5.1.3 Lessons Learned During Reconnaissance

Key takeaways from the field reconnaissance effort, which was used to inform future sampling, are summarized below.

5.1.3.1 Areas with High Potential for Stranding and Trapping

Eight areas around Ross Lake were identified as exhibiting topographic characteristics that may present high risk for stranding and trapping at certain WSE within normal operations (Figure 3.0-1). These areas were primarily shallow gradient alluvial fans located near the mouth of tributaries flowing into project reservoirs. Others were low gradient reaches characterized by a high density of relict stumps that have been eroded to form depressions within the surrounding sediment (tree wells). Input from LPs was taken into consideration during this process as well. For example, the Ruby Arm of Ross Lake does not contain a high concentration of low slope or depressional features, however the NPS suggested that this area may pose a high stranding or trapping risk, and therefore it was included in investigations.

The opportunistic survey in Diablo indicated that the Thunder Arm reach presents a stranding and trapping risk when reservoir elevations are rapidly drawn down from WSE of approximately 1,209.36 feet NAVD 88 (1,203 feet CoSD) to WSE below approximately 1,207.36 feet NAVD 88 (1,201 feet CoSD) (Figure 4.1-3).

5.1.3.2 Refinements to Survey Methodology Based on 2020 and 2021 Reconnaissance Surveys

As envisioned by the RSP, methods were refined for navigating to survey starting locations, establishing survey quadrats, measuring features, and collecting data. Crews developed systems and adopted technology such as handheld tablets equipped with georeferenced PDF maps and navigation software, which increased survey efficiency and enabled surveying more sites. In addition, refinements to the spatial stratification of the varial zone and the field survey methodology were made to focus efforts on sampling as much recently dewatered habitat as possible, to provide the greatest likelihood of observing stranding and trapping.

The initial approach to spatial sampling was based on sampling 10 percent of the exposed varial zone within each survey area. During the first reconnaissance surveys on Ross Lake, it became clear that this was not logistically feasible, and led to sampling large extents of the varial zone that had been dewatered for extended periods, where observing stranding and trapping was not likely. Stratifying the varial zone by elevation range would allow field crews to focus on the portion of the varial zone that was recently dewatered, and thus had a greater likelihood of containing actively stranded and trapped fish. Consequently, a process was developed for stratifying each survey area based on predicted WSE at the time of sampling and presence of potential stranding and trapping features, before randomly selecting starting locations from these nested strata (as described in Section 4.3.1.1 of this study report).

A method for rapidly establishing survey quadrats was developed, whereby crews established a 25-meter circle around the survey starting location. To address the small area near the corners of square quadrats that this approach would miss (i.e., by inscribing a 25-meter circle within a 25-meter square), crews extended the survey zone by approximately 5 meters beyond the circumference. The number of attributes of potential stranding and trapping surveys to be measured in the field was reduced to focus on topographic features and evidence of fish stranding and trapping. This ensured that field data focused on supporting the testing of GIS analyses, to develop a robust estimate of the total risk around each reservoir.

5.1.3.3 Logistics

Accessing the northern end of Ross Lake is challenging when the reservoir is near its annual minimum WSE. When Ross Lake WSE was approximately 1,510.76 feet NAVD 88 (1,504.5 CoSD), accessing the northern reaches near the U.S.-Canada border was not possible with the City Light boat due to shallow and fast-moving water and an abundance of exposed stumps. To address this challenge, a different boat that can accommodate these conditions is being sourced to sample this area at low water.

Surveying the Thunder Arm of Diablo Lake presents challenges associated with soft, deep sediment throughout the varial zone. Walking in this area was treacherous, and to address this logistical challenge, crews are planning to wear snowshoes to buoy themselves above the substrate composed of liquified silt and mud resembling quicksand. In addition to Thunder Arm, the dry-dock embayment south of Buster Brown campground and the area near the mouth of Sourdough Creek appear to contain low slope features with the potential for stranding and trapping. Preliminary bathymetry surveys have been conducted in these areas for which post-processing is underway, and these areas will be surveyed both for risk during normal operations and during

maintenance drawdown. A maintenance drawdown event is planned for Diablo during the winter of 2022, with estimated drawdown rate similar to what occurred in September 2020.

5.1.3.4 Survey Timing

Surveying Ross Lake throughout the range of normal operations is important to capture potential stranding and trapping features that emerge at different WSE. For example, the challenges in accessing the northern end of the lake under low WSE that were described above, plus the observation that potential stranding and trapping features in this area exist at elevations that are dewatered shortly after drawdown begins, means that these reaches need to be prioritized for sampling early during drawdown. Sampling these areas later in the drawdown is also important, however, and to do so safely, a different boat will be used. Additionally, the area around the mouth of Big Beaver is characterized by a steep shoreline with minimal stranding and trapping potential, that extends to a broad, low gradient shelf of littoral zone habitat containing many features that could strand or trap fish, below which the shoreline precipitously drops off towards the limnetic zone of lake. This means that within this area, a band of low-gradient varial zone habitat that could present stranding and trapping risk is exposed under a relatively narrow range of WSE, and efforts to sample this zone will target periods when WSE is within this range. Other reaches, like the exposed area around Lost Lake, are completely inundated until the reservoir is drawn down too much lower WSE. It was determined that crews could subsample a greater proportion of potentially high-risk areas by focusing on recently dewatered areas, at the scale of both the survey areas and the quadrats within each survey area.

5.2 Analysis of DEMs for Stranding and Trapping Risk

5.2.1 Ross Lake

The Ross Lake DEM has been partially analyzed for areas of low slope and sinks, following the methods described in Section 4.2.1 of this study report. Spatial analysis of the Canadian portion of the Ross Lake varial zone is slated for completion in January 2022, and results will be included in the USR. Additional quality control (QC) steps are required to account for WSE not being flat across the reservoir but reservoir stage being measured and reported at a single location (Ross Dam). To reiterate, this data gap means that the actual WSE at the north end of the lake during full drawdown is currently unknown. The implication of this data gap is that features near the north end of the lake that are at elevations approaching 1,494.26 feet NAVD 88 (1,488 feet CoSD) are likely never dewatered, but they currently appear so in the GIS analysis because of the reliance on stage measurements at Ross Dam, more than 20 river miles downstream. The QC steps applied to limit false-positive features of interest include the following:

- Remove stranding and trapping features identified using GIS analysis that are contiguous with the mainstem thalweg at full drawdown, and thus never dewatered; and
- Determine which features are truly dewatered at a given range of WSE, to accurately estimate stranding and trapping risk throughout drawdown.

Complete results will be available by March 2023 in the USR.

5.2.2 Diablo and Gorge Lakes

DEMs for Diablo and Gorge lakes are incomplete. City Light is currently collecting bathymetric data to address the missing coverage within each reservoir. These data are expected to become available sometime in early 2022. Results for this section will be presented in the study report for the USR.

5.3 Analysis of Reservoir Drawdown

As described in Section 4.2.2 of this study report, the purpose of the reservoir drawdown analysis is twofold. First, this analysis is used to inform survey planning. Understanding the pattern of WSE, refill, and drawdown throughout the year is important for determining when to sample areas around the reservoirs. Second, this analysis will be used in subsequent analyses to be included in the USR that contextualize findings of stranding and trapping by characterizing the timing, frequency, and duration of exposure of features that could present a risk to fish.

5.3.1 Ross Lake

Ross Lake WSE between 2011 and 2021 ranged between 1,487.46 and 1,608.76 feet NAVD 88 (1,481.2 and 1602.5 feet CoSD, Table 5.3-1 and Figure 5.3-1). On one occasion, around the time of the 2018 LiDAR flight, Ross Lake WSE dropped approximately 6.5 feet below the level of LiDAR coverage.

In general, Ross Lake does not exhibit substantial daily fluctuations within the normal operating range. However, daily changes in WSE of up to 5 feet can occur (Figure 5.3-1). Therefore, although daily (end of day) WSE were specified in the study plan, hourly gage heights were used in the analysis to better characterize WSE fluctuations on Ross Lake at a resolution sufficient to estimate the frequency at which trapping pools form and stranding areas become exposed.

Table 5.3-1. Ross Lake WSE statistics (2011 to 2021).

Statistic	WSE (feet NAVD 88)
Minimum	1,487.5
Maximum	1,608.8
Median	1,583.0
Mean	1,575.0
Range	121.3

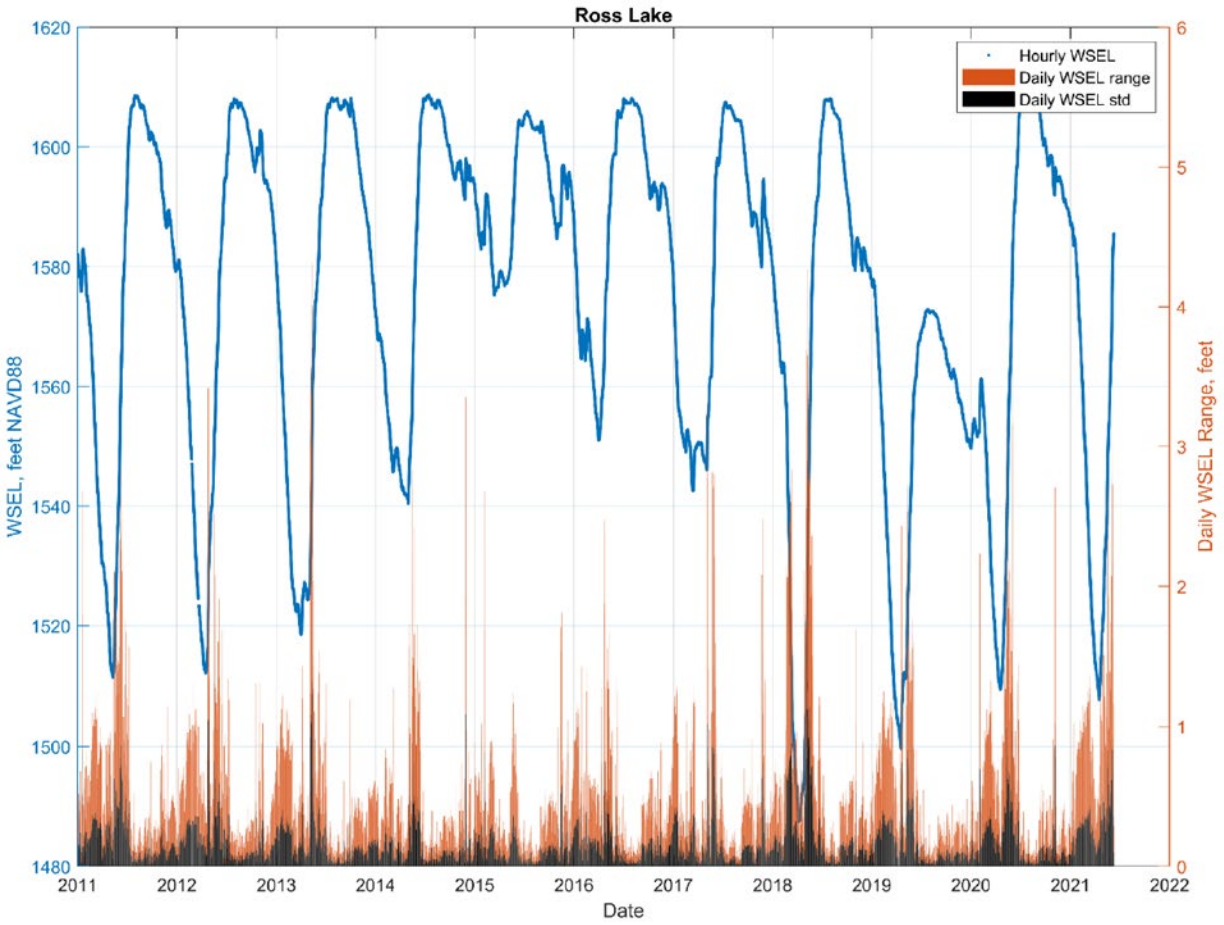

Figure 5.3-1. Ross Lake WSE time series (2011 to 2021).

The statistics by month for Ross Lake (Table 5.3-2) over the period of record considered indicate the lowest WSE occur during April, after drawdown and before the spring melt-off occurs. WSE peaks in the summer months during July and August, in the period immediately before drawdown begins. The most variability in WSE occurs during the spring months from March to May.

Table 5.3-2. Ross Lake WSE statistics by month of year based on data from January 1, 2011 thru June 9, 2021.

	Water Surface Elevation (feet NAVD 88)											
Statistic	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Minimum	1,549.8	1,527.0	1,491.0	1,487.5	1,503.0	1,541.0	1,568.9	1,571.3	1,565.6	1,561.3	1,555.5	1,549.7
Maximum	1,593.3	1,592.2	1,584.5	1,579.3	1,599.0	1,608.1	1,608.8	1,608.5	1,607.8	1,608.2	1,602.8	1,597.5
Median	1,573.2	1,557.9	1,536.3	1,524.6	1,554.3	1,594.2	1,606.9	1,606.8	1,602.1	1,594.6	1,591.7	1,586.8
Mean	1,572.1	1,559.0	1,537.3	1,529.4	1,554.2	1,590.2	1,602.9	1,603.0	1,598.9	1,591.7	1,588.0	1,583.6
Variance	112.0	187.1	418.1	629.4	614.5	219.1	115.6	107.7	115.8	123.5	120.3	139.5
Range	43.5	65.2	93.5	91.8	96.0	67.1	39.9	37.2	42.3	46.9	47.3	47.9

The frequency of occurrence and percent exceedance curves for the full dataset from 2011 to 2021 are plotted in Figure 5.3-2. The plot shows the range of WSE within the record to be 1,488.26 to 1,609.26 feet NAVD 88 (1,482 and 1,603 feet CoSD). The most frequently occurring WSE in the record are between 1,606.26 and 1,608.26 feet NAVD 88 (1,600 and 1,602 feet CoSD). A similar exceedance and frequency of occurrence curve (Figure 5.3-3) is provided for the month of January to show an example of the month-of-year analysis. The range in one month is reduced and the frequency/exceedance curves are "stepped" compared to the full dataset because of the narrower range of operating and hydrologic conditions that occurs in a single month and year to year variability.

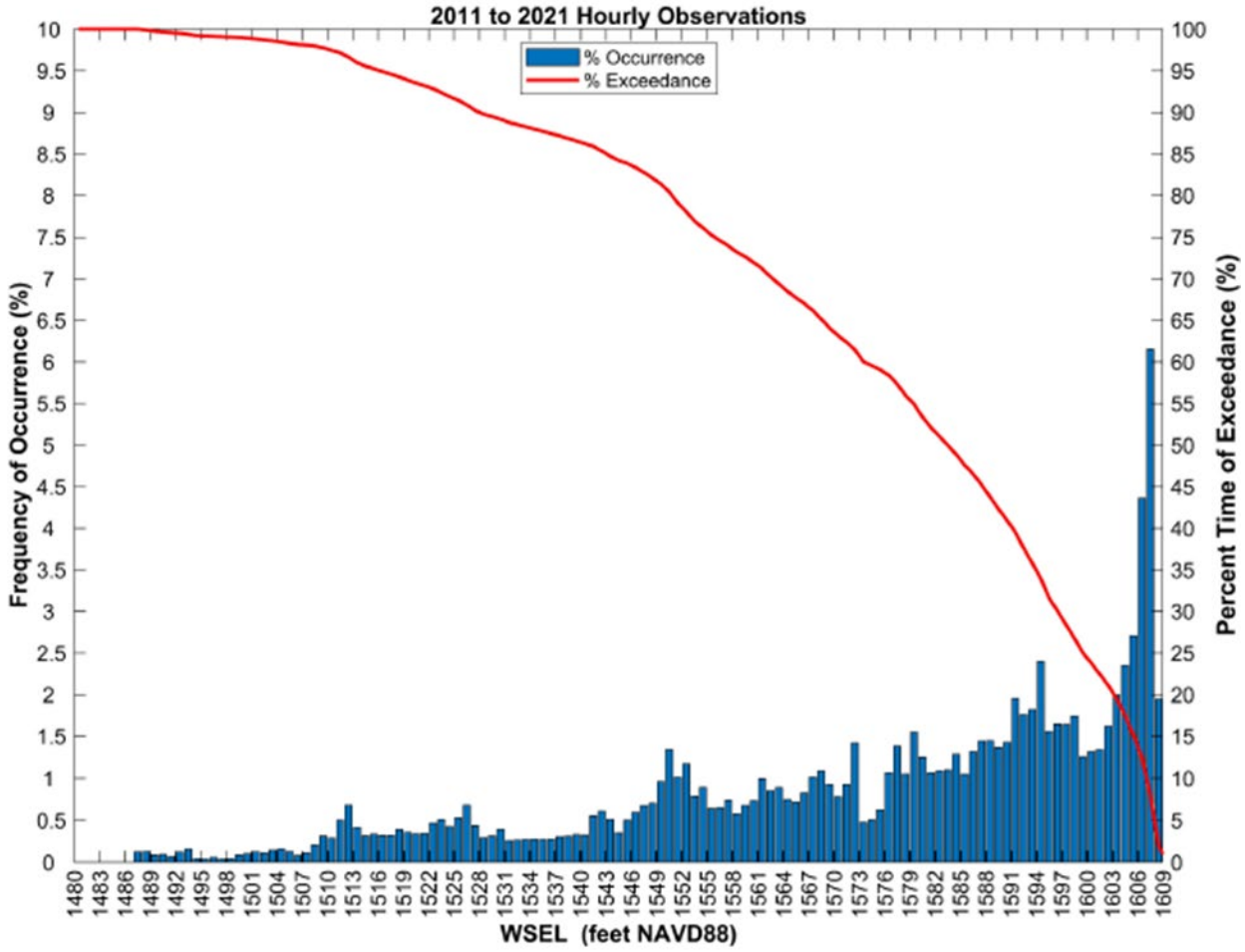

Figure 5.3-2. Frequency of occurrence and exceedance for hourly WSE records at Ross Lake (2011 to 2021).

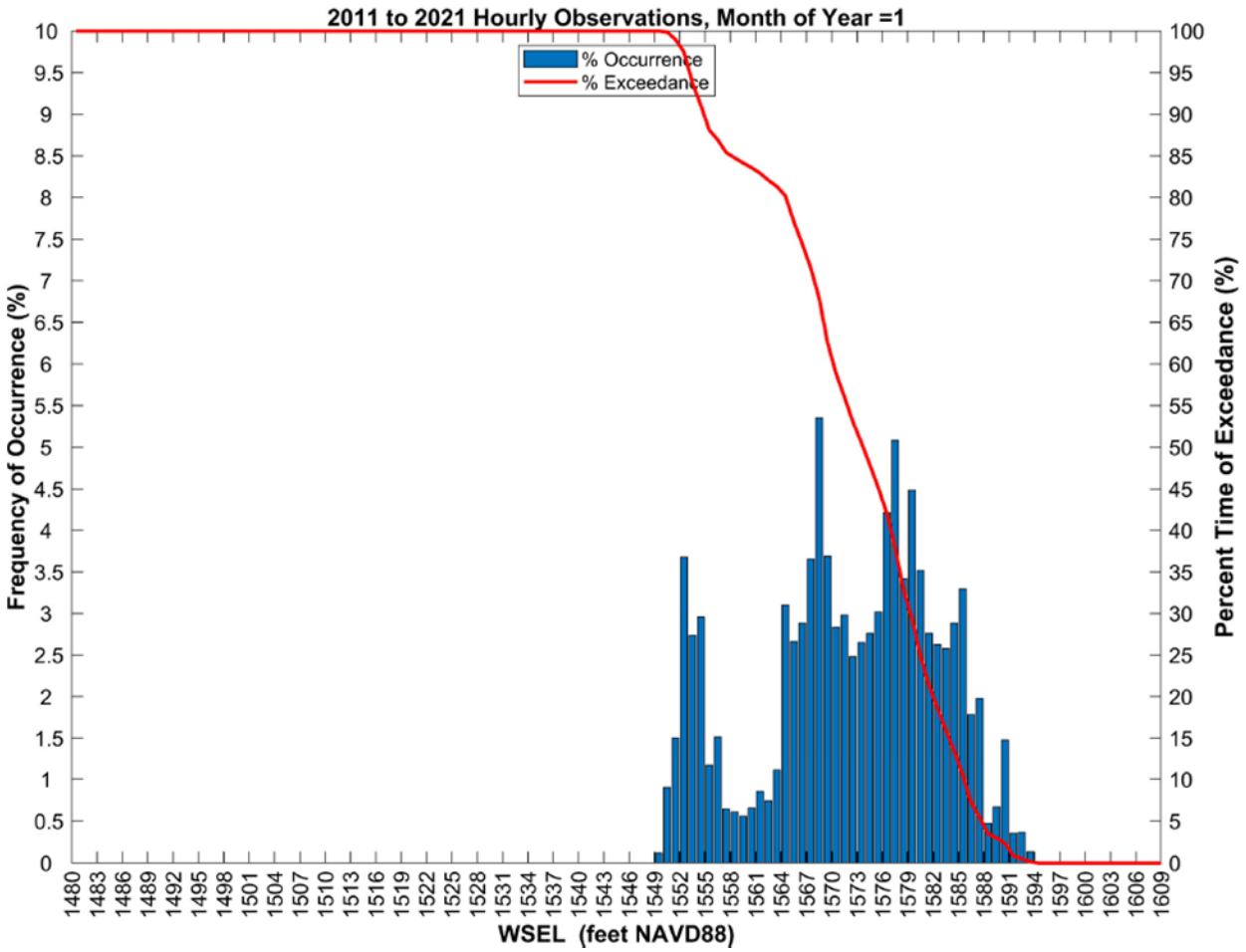

Figure 5.3-3. Frequency of occurrence and exceedance for hourly WSE records during the month of January at Ross Lake (2011 to 2021).

5.3.2 Diablo and Gorge Lakes

Reservoir drawdown analyses for Diablo and Gorge lakes have not yet been completed. These analyses will be completed by March 2022, and results for these reservoirs will be presented in the USR.

5.4 Native Species Life Stage and Periodicity Analysis

This section is still in progress. Results will be presented in the study report for the USR.

5.5 Field Surveys

This section is still in progress. Results will be presented in the study report for the USR.

6.0 SUMMARY

6.1 Study Implementation Status

As of September 1, 2021, the following components of this study have been completed:

- Three reconnaissance surveys in Ross Lake;
- One opportunistic reconnaissance survey in Diablo Lake during a drawdown beyond normal operations;
- Reservoir drawdown analysis for Ross Lake; and
- Preliminary GIS analysis of DEM for Ross Lake.

Since September 1, 2021, study implementation has continued for the following components, although data are not yet available for inclusion in this study report:

- GIS analysis of the Ross Lake DEM for U.S. portion completed, pending final QC and visualization;
- Two field surveys in Ross Lake have been completed; and
- October 20, 2021 LP work session.

The following next steps will be completed on the approximate schedule below:

- GIS analysis of the Ross Lake DEM will be finalized, including analyses of areas in Canada (February 2022);
- Remaining field survey of Ross Lake will be conducted (Spring 2022);
- Quarterly and opportunistic field surveys in Diablo and Gorge lakes will be initiated (beginning December 2021);
- Fish periodicity will be analyzed (Winter 2022); and
- GIS analyses of Diablo Lake and Gorge Lake DEMs (pending collection of bathymetric data for these areas, expected in early 2022).

6.2 Status of June 9, 2021 Notice

The June 9, 2021 Notice noted four items of discussion related to the implementation of this Stranding and Trapping Assessment. The status of each is summarized in Table 6.2-1.

Table 6.2-1. Status of Stranding and Trapping Assessment modifications identified in the June 9, 2021 Notice.

Study Modifications identified in the June 9, 2021 Notice: As Written	Status
City Light to hold technical meetings with the LPs to review initial information to assess adequacy of that information in informing stranding evaluation (including tree size).	City Light held a technical meeting with the LPs in October 2021 to review initial information to assess adequacy of that information related to the spatial scale of data in informing stranding evaluation (including tree size). The available Ross Lake DEM appears adequate to evaluate standing and trapping and methods for interpreting DEM are described in this interim report.
Review 2021 sampling in U.S. for risk assessment to refine and inform the expansion to Canadian drawdown zone in 2022.	The GIS risk assessment study area includes the drawdown area in Canada.
LPs requested that the study results inform the development of PMEs inclusive of a reservoir drawdown rate that avoids, limits, or greatly reduces stranding of fish and juvenile amphibians; and identifies reservoir elevations that prove problematic for trapping of fish and juvenile amphibians.	City Light and LPs recognize that the study report will not include proposed PME measures related to stranding and trapping. However, the information presented in the USR will provide data necessary to develop such PMEs, as necessary.
City Light to clarify the methods section of this report that if maintenance drawdowns or lowering of reservoirs beyond normal operations occurs, City Light will attempt to perform opportunistic surveys as safety procedures allow.	City Light has clarified in the methods section of this report that if maintenance drawdowns or lowering of reservoirs beyond normal operations occurs, crew will attempt to perform opportunistic surveys as safety procedures allow.

7.0 VARIANCES FROM FERC-APPROVED STUDY PLAN AND PROPOSED MODIFICATIONS

The SRS and ACS approach to field sampling design was not used when Ross Lake was near normal maximum WSE and the area of varial zone to be surveyed was small. Instead, given the narrow band of varial zone that was exposed, a comprehensive census of the entire littoral zone was undertaken instead of random sampling.

The types of data collected from potential trapping pools and low gradient stranding areas were refined during field reconnaissance to enable staff to sample a greater proportion of the dewatered varial zone while minimizing collection of data that does not feed directly into subsequent analyses. Data collected when surveying features that presented a potential stranding or trapping risk were refined from the list in Section 2.6.3.2 of the RSP as detailed in Table 7.0-1.

Table 7.0-1. Refined data collected during field surveys under each scenario.

	Additional Data to be Collected per each Scenario		
Data to be Collected for Every Quadrat	**If Potential Stranding or Trapping Feature Observed**	**If Evidence of Predation Observed**	**If Stranded or Trapped Fish Present (All Parameters Collected for Each Species and Life Stage)**
1. Date and time of observations	9. Photograph of S&T feature and bearing of view	14. Description of predator or sign	16. Species
2. Reservoir and survey area	10. Distance to open water	15. Photograph or predator or sign	17. Status (Live/Dead)
3. Weather	11. Length of potential stranding/trapping feature		18. Photograph
4. Survey team members	12. Width of potential stranding/trapping feature		19. Life Stage
5. Quadrat ID	13. Maximum depth of potential stranding/trapping feature		20. Count
6. Latitude and longitude coordinates of observation			
7. Photograph of quadrat and bearing of view			
8. Additional Notes			

The following data, listed in Section 2.6.3.2 of the RSP were not collected, for reasons described in Table 7.0-2.

Table 7.0-2. Data mentioned in RSP that are not being collected, and rationale for omission.

Data Listed in RSP That Are Not Being Collected	Rationale for Omission
Water temperature	Drawdown occurs during cool periods when temperature is not likely a factor contributing to mortality. No methodology described to incorporate this information into risk assessment.
Dissolved oxygen concentration	Measuring DO at every potential trapping pool would slow crews down and prevent more extensive sampling of a broader area that could otherwise better document the full extent of potential stranding and trapping. No methodology described to incorporate this information into risk assessment.
Turbidity	Measuring turbidity at every potential trapping pool would slow crews down and prevent more extensive sampling of a broader area that could otherwise better document the full extent of potential stranding and trapping. No methodology described to incorporate this information into risk assessment.
Dominant and Subdominant sediment grain size	Unclear how this informs a risk assessment. More appropriate for a model of factors contributing to stranding and trapping. No methodology described to incorporate this information into risk assessment.
Distance from instream cover	Unclear how this informs a risk assessment. More appropriate for a model of factors contributing to stranding and trapping. No methodology described to incorporate this information into risk assessment.
Presence of canopy cover	Unclear how this informs a risk assessment. More appropriate for a model of factors contributing to stranding and trapping. No methodology described to incorporate this information into risk assessment.
Presence of macroinvertebrates	Unclear how this informs a risk assessment. More appropriate for a model of factors contributing to stranding and trapping. No methodology described to incorporate this information into risk assessment.
Field measured slope	Unclear how this informs a risk assessment. More appropriate for a model of factors contributing to stranding and trapping. No methodology described to incorporate this information into risk assessment.
Unusual hydraulic conditions	Unclear how this informs a risk assessment. More appropriate for a model of factors contributing to stranding and trapping. Vague as described. No methodology described to incorporate this information into risk assessment.
Presence of macrophytes	Unclear how this informs a risk assessment. More appropriate for a model of factors contributing to stranding and trapping. No methodology described to incorporate this information into risk assessment.
Reservoir drawdown rate at time of field survey	Information will be incorporated by reporting reservoir drawdown rate in written reports. Data reporting at gage is delayed, so field reporting would be inaccurate.

City Light is not proposing any additional modifications to this study.

8.0 REFERENCES

Bell, E., S. Kramer, D. Zajanc, and J. Aspittle. 2008. Salmonid fry stranding mortality associated with daily water level fluctuations in Trail Bridge Reservoir, Oregon. North American Journal of Fisheries Management 28:1515-1528.

Conrad, O., B. Bechtel, M. Bock, H. Dietrich, E. Fischer, L. Gerlitz, J. Wehberg, V. Wichmann, and J. Böhner. 2015. System for Automated Geoscientific Analyses (SAGA) v. 2.1.4. Geosci. Model Dev. 8:1991-2007.

Helsel, D. R., R. M. Hirsch, K. R. Ryberg, S. A. Archfield, and E. J. Gilroy. 2020. Statistical methods in water resources. United States Department of the Interior, Geological Survey, Reston, VA.

Quantum Spatial. 2018a. Ross Lake, Washington and British Columbia, Canada. LiDAR Technical Data Report. Prepared by: Quantum Spatial, Inc. (Corvallis, OR). Prepared for: Seattle City Light (Seattle, WA).

_____. 2018b. Upper Skagit, Gorge Lake & Diablo Lake, Washington. Topobathymetric LiDAR & orthoimagery technical data report. Prepared by: Quantum Spatial, Inc. (Corvallis, OR). Prepared for: Seattle City Light (Seattle, WA).

Seattle City Light (City Light). 2021. Revised Study Plan (RSP) for the Skagit River Hydroelectric Project, FERC Project No. 553. April 2021.

Thompson, S. K. 1990. Adaptive cluster sampling. Journal of the American Statistical Association 85:1050-1059.

U.S. Geological Survey (USGS). 2020. USGS Gage Number 12176500, Diablo Reservoir Near Newhalem, WA. U.S. Geological Survey. [Online] URL: https://waterdata.usgs.gov/wa/nwis/uv?site_no=12176500. Accessed October 14, 2021.

_____. 2021. USGS Gage Number 12175000, Ross Reservoir Near Newhalem, WA. U.S. Geological Survey. [Online] URL: https://waterdata.usgs.gov/wa/nwis/uv?station=12175000. Accessed October 14, 2021.

Wang, L., and H. Liu. 2006. An efficient method for identifying and filling surface depressions in digital elevation models for hydrologic analysis and modelling. International Journal of Geographical Information Science 20:193-213.

This page intentionally left blank.