Clackamas River Hydroelectric Project

FERC No. 2195

Total Maximum Daily Load

Implementation Plan

October 2023

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Acronyms and Abbreviations

BML	Bureau of Land Management
BMP	Best Management Practice
cfs	Cubic feet per second
DMA	Designated Management Agency
DO	Dissolved Oxygen
DOC	Dissolved Organic Carbon
EPA	Environmental Protection Agency
EWEB	Eugene Water and Electric Board
FERC	Federal Energy Regulatory Commission
IP	TMDL Implementation Plan
MeHg	Methylmercury
OAR	State Administrative Rules
ODEQ	Oregon Department of Environmental Quality
Project	Clackamas River Hydroelectric Project
RM	River Mile
THg	Total Mercury
TSS	Total Suspended Solids
TMDL	Total Maximum Daily Load
USFS	United States Forest Service
VMP	Vegetation Management Plan

1 Purpose

The Oregon Department of Environmental Quality (DEQ) has set Total Maximum Daily Loads (TMDLs) for the Willamette Basin, which includes the Clackamas River. TMDLs limit the total amount of specific pollutants that may be discharged to a given waterway and include a Water Quality Management Plan (WQMP) that identifies how the TMDLs will be implemented.

1.1 Legal Background

A TMDL defines the amount of a pollutant that can be present in a water body without causing water quality criteria to be exceeded. On December 30, 2019, the Environmental Protection Agency (EPA) established the Willamette Basin Mercury TMDL, which replaced ODEQ's 2006 Willamette Basin Mercury TMDL, until EPA released the revised TMDL on February 4, 2021. EPA's 2019 TMDL, as revised in February 2021, is currently in effect, accompanied by ODEQ's 2019 WQMP.

The WQMP assigns PGE as a Designated Management Agency (DMA) responsible for evaluating and implementing mercury reduction strategies associated with lands draining into their reservoirs and impacts from reservoir operations, with particular consideration for factors affecting methylation rates. As a DMA, PGE is required under OAR 340-42-0080 to prepare a TMDL Implementation Plan (IP) for submission to ODEQ for review and approval by August 17, 2023. The IP describes the actions PGE will take to first assess and then address its impact on mercury methylation and transport through the Clackamas River Hydroelectric Project (Project). However, the Federal Energy Regulatory Commission (FERC) remains the primary regulatory authority for the Project, and any measures taken to implement mercury reduction strategies may be subject to review and approval by FERC.

1.2 WQMP Requirements

The WQMP identifies expectations for the IP, requiring PGE and other reservoir operators to assess factors affecting methylation rates in their reservoirs to establish baseline conditions for use in adaptive management and to inform evaluations of site-specific approaches to reduce methylmercury (MeHg) production. DMAs are also to identify measurable objectives and establish a timeline for implementing best management practices.

Methylation rates are of particular interest in reservoir management because while the reservoirs are not a primary source of mercury, they are thought to play a significant role in converting inorganic mercury to a more bioavailable form – MeHg. ODEQ identified five metrics to consider when assessing factors affecting methylation rates.

- Reservoir-specific mercury translator
- Nutrient status
- Dissolved oxygen profile
- Water level fluctuations
- Area of reservoir-adjacent lands affected by water fluctuations

1.3 Approach

This IP describes monitoring and analysis that PGE will perform to better understand baseline conditions within the Project and inform the process for identifying potential mercury reduction strategies and assessing progress towards TMDL goals. PGE will meet these objectives using a phased approach:

- **Phase 1** (Year 1 through Year 3) - Data Collection & Sampling
- **Phase 2** (Year 4) - Analysis & Evaluation
- **Phase 3** (Year 5) – Refine Implementation

This approach is described in Section 3.

Adaptive management is a process that acknowledges and incorporates improved technologies and practices over time in order to refine implementation. PGE will incorporate these principles in later years by evaluating performance and adjusting management practices and monitoring plans to suit.

2 Project Description

2.1 Project Setting

The Project is located within the Clackamas River Basin. The Clackamas River drains more than 940 square miles as it flows west from the Cascade Mountain Range for 83 miles to its confluence with the Willamette River at Oregon City, Oregon. Most of the headwaters are located within the Mt. Hood National Forest, and approximately 47 miles of the Clackamas River are designated as a federal Wild and Scenic River.

2.2 Project Overview

The Project influences approximately 75 miles of the Oak Grove Fork and the Clackamas River and is comprised of the Oak Grove Development and the Clackamas River Development (Figure 1). For the purposes of this report, river miles (RM) start at the mouth of the Clackamas River and are continuous through the Oak Grove Fork of the Clackamas River. The Oak Grove Development is located on the Oak Grove Fork between RM 57.7 and 68.7 and releases diverted water into the mainstem Clackamas River at RM 46.8. The Clackamas River Development is located on the mainstem Clackamas River between RM 22.3 and 29.2. Total land area within the FERC Project boundary is approximately 4,200 acres. Of that, about 28% is owned by PGE, with 69% owned by the United States Forest Service (USFS) and 3% by the Bureau of Land Management (BLM).

Note that approximately one mile downstream from Timothy Lake Dam, a portion of river flow is diverted to Eugene Water and Electric Board's (EWEB) Stone Creek Project (FERC Project No. 5264). The Stone Creek Powerhouse discharges back to the Oak Grove Fork approximately 3.5 miles upstream of Lake Harriet. Impacts from the Stone Creek Project will not be assessed as part of this IP.

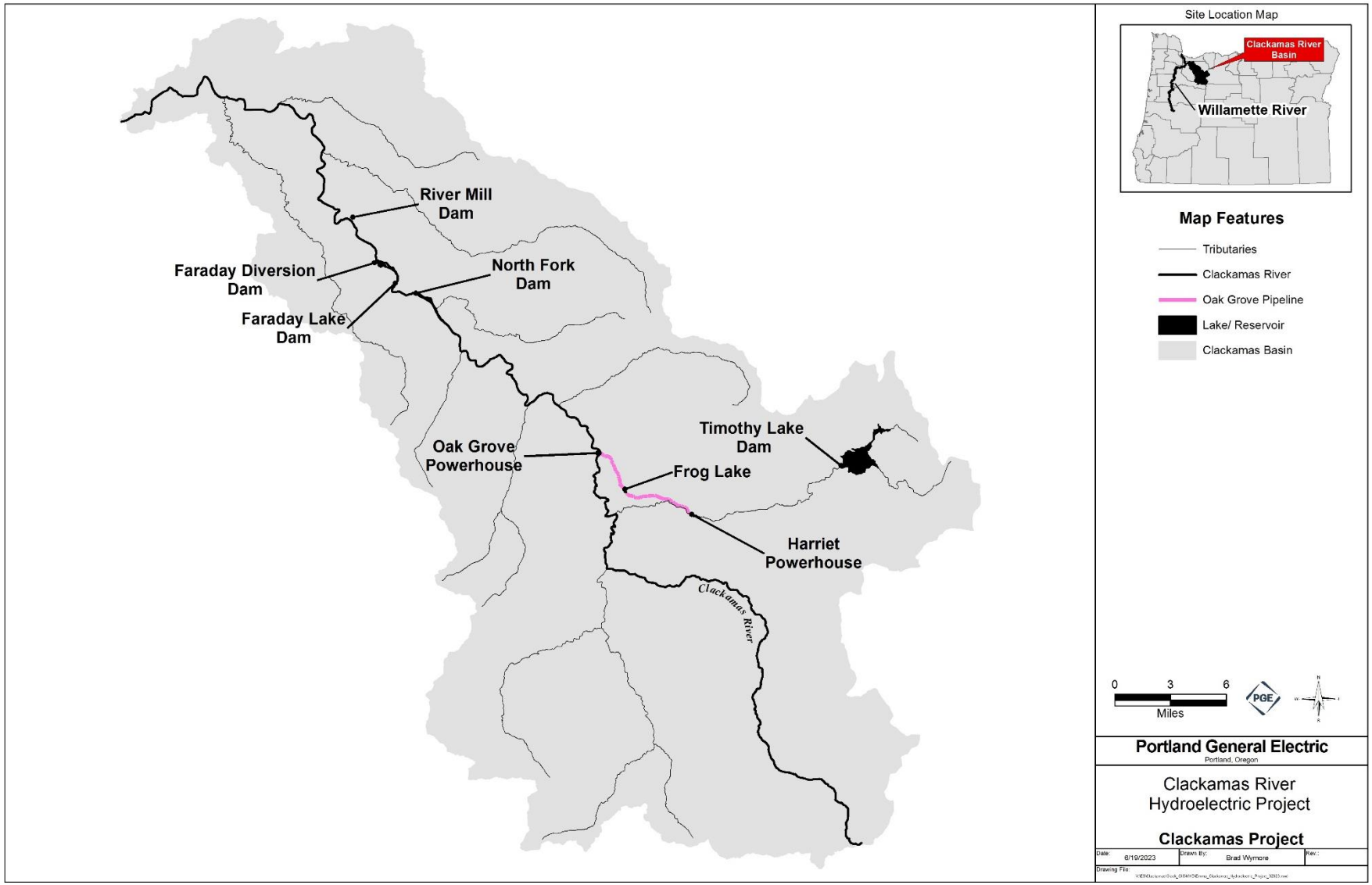

Figure 1. Clackamas River Hydroelectric Project area.

2.2.1 Oak Grove Development

The Oak Grove Development involves a system of three storage reservoirs, three powerhouses, and pipelines (Table 1). Timothy Lake is the most upstream component with a gross storage capacity of 69,000 ac-ft. Pool elevation and flows released from Timothy Lake are managed on a seasonal basis to enhance a variety of aquatic, terrestrial, recreational, and cultural resources. At Timothy Dam, water is taken from the bottom of the reservoir and passed through a plunger valve or through the Timothy powerhouse. Water discharged from Timothy Dam combines with inflow from the intervening catchment area of 72.5 mi^2 and flows approximately 10 miles down the Oak Grove Fork to Lake Harriet.

A diversion dam impounds Lake Harriet (gross storage capacity of approximately 300 ac-ft), where up to (740) cfs of river flow is diverted into the Oak Grove Pipeline through a bottom withdrawal intake. Generally, the lake is maintained at full pool while minimum and seasonal/pulsed flows, provided to support stream restoration strategies below the dam, are supplied either through spill or through a valve from the Oak Grove Pipeline. Approximately 0.25 miles downstream of Lake Harriet Dam, up to 85 cfs is diverted from the Oak Grove Pipeline back to the Oak Grove Fork through the Harriet Powerhouse. The Oak Grove Pipeline conveys the remaining water 4.1 miles downstream to Frog Lake, an off-stream forebay reservoir with a gross storage capacity of approximately 252 ac-ft.

From Frog Lake, water reenters the Oak Grove Pipeline and travels an additional 2.3 miles to a surge tank located just above the Oak Grove Powerhouse. Water flows down penstocks into the powerhouse, through turbines and discharges into the Clackamas River, approximately 17 miles upstream from the Clackamas River Development.

Table 1. Oak Grove Fork Development impoundment data (elevations based on USGS datum).

Parameter	Impoundment		
	Timothy Lake	**Lake Harriet**	**Frog Lake**
Construction Year	1956	1924	1924, 1965*, 1997*, 2020-2022*
Reservoir Dimensions	Width 1.5 mi (avg) Length 3.55 mi Depth 80 ft (max)	Width 0.1 mi (avg) Length 0.88 mi Depth 46 ft (max)	Width 0.1 mi (avg) Length 0.2 mi Depth 40 ft (max)
Normal Maximum Water Surface Area	1,430 ac	20 ac	9.25 ac
Normal Maximum Water Surface Elevation	3,191.9 ft	2,038 ft	1,988 ft
Gross Storage Capacity	69,000 ac-ft	300 ac-ft	252 ac-ft
Usable Storage Capacity	60,000 ac-ft	250 ac-ft	211 ac-ft
Drawdown	Seasonal (Sept - May)	NA	NA
Stratification	Yes	No	No
Intake	Bottom	Bottom	Bottom
Adjacent Wetlands	Yes	No	No

*Indicates years where construction associated with the dam resulted in the prolonged drawdown of the reservoir.

2.2.2 Clackamas River Development

The Clackamas River Development encompasses four reservoirs/dams and three powerhouses that are managed collectively as a run-of-river project with limited water level fluctuations (Table 2). North Fork Dam, the uppermost dam, impounds North Fork Reservoir with an approximate gross storage capacity of 18,630 ac-ft. The catchment area for North Fork Reservoir is 671 mi^2. While some flow is used to supplement fish passage facilities, the majority is passed downstream through the two bottom withdrawal intakes of the North Fork Powerhouse.

Water released from North Fork Dam travels a short distance before entering the 1.6-mile-long reservoir behind the Faraday Diversion Dam. A minimum flow of 250 cfs is supplied to the Clackamas River below the diversion dam through the spillway or through an auxiliary pipeline used to provide attraction flow to the North Fork fish ladder. The majority of the water at the diversion dam is diverted into a 23-ft diameter tunnel, which carries the water 0.5 miles into Faraday Lake, a 0.65-mile-long canal that serves as the forebay for the Faraday Powerhouse. Seasonally this lake is drawn down 3 feet to mitigate surface water warming. Five bottom withdrawal intakes supply water to the Faraday Powerhouse. Discharge from the Faraday Powerhouse re-enters the Clackamas River approximately 2 miles downstream of the Faraday

Diversion Dam and immediately enters Estacada Lake. Estacada Lake is 2.85 miles long and has a gross storage capacity of 2,300 ac-ft. Five Intake gates are located 28 ft below the water surface and supply water to the River Mill Powerhouse.

Table 2. Clackamas River Development impoundment data (elevations based on USGS datum).

Parameter	Impoundment			
	North Fork Reservoir	**Diversion Dam Pool**	**Faraday Lake**	**Estacada Lake**
Construction Year	1958	1907, 1935*, 1965*	1907, 2012*, 2019-2023*	1911
Reservoir Dimensions	Width: 0.25 mi (avg) Length 4.6 mi Depth 130 ft (max)	Width: 0.75 mi (avg) Length 1.6 mi Depth 66 ft (max)	Width: 0.22 mi (avg) Length 0.65 mi Depth 39 ft (max)	Width: 0.11 mi (avg) Length 2.85 mi Depth 80 ft (max)
Normal Maximum Water Surface Area	350 ac	55 ac	51 ac	150 ac
Normal Maximum Water Surface Elevation	665 ft	526 ft	520 ft	389 ft
Gross Storage Capacity	18,630 ac-ft	1,200 ac-ft	484 ac-ft	2,300 ac-ft
Usable Storage Capacity	7,700 ac-ft	550 ac-ft	360 ac-ft	500 ac-ft
Drawn down	No	No	Seasonal (July to Oct)	No
Stratification	Weak	No	No	No
Intake	Bottom	Surface	Bottom	28 ft bws
Adjacent Wetlands	No	No	No	No

Note: bws = below water surface.

*Indicates years where construction associated with the dam resulted in the prolonged drawdown of the reservoir.

2.3 FERC License No. 2195

On December 21, 2010, the FERC issued PGE a 45-year term license (FERC No. 2195) that covers the Oak Grove Fork and Clackamas River developments. PGE is now operating the Project pursuant to the terms of the license. The following sections summarize the relevant sections of the license.

2.3.1 Project Operating Plan

This Project Operating Plan describes in detail the operating rules and constraints for the Oak Grove Fork and Clackamas River developments. Specific requirements for water levels, flow

rates, changes in flow, and non-power resources that may trigger unique constraints are described in this plan. As part of various license commitments, PGE has or will conduct various studies or analyses during the term of the license, the conclusions of which may result in changes to the Operating Plan. The plan has been revised several times since the license was issued. Commission approvals to the amended plan have been issued in January 2012, November 2015, September 2018, February 2019 and March 2023. Summary of Reservoir Operations is in Section Project Overview2.2 of this document.

2.3.2 Section 401 Water Quality Certification

On June 11, 2009, the ODEQ issued a water quality certification for the Project pursuant to Section 401 of the federal Clean Water Act (33 U.S. Code § 1341). The certification includes nine conditions that are set forth in Appendix A (ODEQ's 401 Certification Conditions) to the certification and incorporated into the license by Ordering Paragraph (E). These conditions include specific requirements for monitoring water quality parameters (i.e., dissolved oxygen, hydrogen ion concentrations, total dissolved gas, blue-green algae blooms, water temperature, total dissolved gas, and turbidity). The certification also includes stipulations for ensuring beneficial uses (i.e., fish passage and enhancing aquatic, riparian and wetland habitat) and compliance with other appropriate requirements of state law.

Concurrently, ODEQ issued a TMDL Implementation Order that approved PGE's Clackamas River Project Total Maximum Daily Load Implementation Plan. This plan and the § 401 Certification require PGE to implement the following measure to achieve its temperature load allocation below River Mill Dam: (i) seasonal drawdown following channelization of Faraday Lake to reduce heating during the summer months; (ii) shading along a total of 30 miles of tributaries to the lower Clackamas River; (iii) gravel augmentation in the Clackamas River downstream of River Mill Dam; and (iv) creation of two additional side-channel habitat enhancement projects in the Clackamas River downstream of River Mill Dam.

2.3.3 Vegetation Management Plan

The Vegetation Management Plan (VMP) establishes and describes the programs needed to effectively guide PGE's management of vegetation within the FERC Project boundary. The VMP is intended to cover all Project-related activities within the Project boundary, including the transmission line and pipeline corridors as well as all facilities associated with the Oak Grove Development and the Clackamas River Development. The Plan establishes goals for managing vegetation within the Project boundary; defines specific activities, processes, or measures to meet these goals; and describes how these activities will be implemented by PGE.

2.4 Mercury Sources and Reservoir Processes

Section 9 of the 2019 Mercury TMDL itemizes the existing mercury loads for source categories estimated using ODEQ's mass balance model. Sources of mercury to streams include point and nonpoint sources. ODEQ's existing load estimates from source categories are summarized in Table 3. Impoundments are classified as non-point sources and their current existing loads are combined with other nonpoint sources, including atmospheric deposition. As indicated in the 2019 Mercury TMDL, one of the largest sources of mercury in the Willamette Basin is

atmospheric deposition defined in the TMDL Technical Support Document as "sediment erosion," "surface runoff" and "atmospheric deposition direct to streams."

Table 3. TMDL mercury source allocations based on estimates of existing mercury loading to the outlet of the Willamette Basin (Oregon Department of Environmental Quality, 2019).

SOURCE SECTORS		EXISTING LOADS		
		g/day	kg/year	Relative Contribution to Total Load
NONPOINT SOURCES	**General Nonpoint Source and Background**[1] ***Captures*:** Forestry, Agriculture, Water Impoundments, Water Conveyance Entities	341.74[2]	124.82[2]	94.5%[2]
	Non-Permitted Urban Stormwater			
	Atmospheric Deposition			
	Legacy Metals Mines	4.00	1.46	1.1%
POINT SOURCES	**NPDES Wastewater Point Source Discharges**	4.44	1.62	1.2%
	NPDES Permitted Stormwater Point Source Discharges	11.31	4.13	3.2%
TOTALS		**361.49**	**132.03**	**100%**

[1]Combines the following source categories from the TMDL Technical Support Document: Sediment Erosion, Surface Runoff, Groundwater, Atmospheric Deposition to Direct to Streams, Urban DMAs

[2] Existing loads for General Nonpoint Source, Non-Permitted Urban Stormwater and Atmospheric Deposition were calculated in combination, though allocations for these three source categories are assigned separately.

Reservoirs can play an important role in the fate and transport of mercury downstream. While reservoirs are expected to reduce the overall mercury load to the outlet of the Willamette basin (Oregon Department of Environmental Quality, 2019), the mercury load released from the dam is dependent on the influent mercury load, current level of mercury bound to reservoir sediments, the biotic and abiotic characteristics of the reservoir and reservoir operations. Particularly, reservoirs act as a mercury sink by accumulating mercury-bound organic matter and particles and reducing the amount of mercury that would have otherwise been transported downstream. Reservoirs in which thermal stratification and water level fluctuations occur may experience conditions that promote mercury methylation. Mercury bond to sediment of reservoirs can be released under hypoxic conditions where mercury can be solubilized chemically or be released as a byproduct of bacterial reduction of sulfate. Further, dam operations that result in within-year fluctuations or prolonged exposure of reservoir sediments allow for the replenishment of sulfate and organic carbon, increasing the potential for methylation following rewatering of exposed sediment (Oregon Department of Environmental Quality, 2019).

3 Implementation Strategies & Plan Framework

Implementing measures to address reservoir methylation requires reservoir specific mercury management strategies based on the factors affecting mercury cycling within each reservoir. Since FERC relicensing, significant progress has been made to minimize water quality impacts related to each hydroelectric development operated by PGE. While mercury load reduction was not the intended purpose, implementation of these existing measures (see Section 5) has been shown to reduce reservoir methylation and transport downstream (Tetra Tech, 2019). However, little is known about mercury processes within PGE reservoirs and as such, it is premature to propose additional approaches to address methylation.

Consequently, PGE will deploy an adaptive management framework using a phased approach. During Phase 1, we will collect three years' worth of water quality data related to mercury methylation in two Project reservoirs. These data will be analyzed during Phase 2 and the findings of the analysis will be used to evaluate best management practices (BMPs) that could be effective in reducing methylation rates in the Project reservoirs. During Phase 3, using the findings from Phase 2, PGE will implement identified BMPs. Also, if we determine during our analysis of the water quality data in Phase 2 that additional data is needed, we will begin another phase of water quality monitoring. This phased approach is detailed in Table 4.

Annual reports will be submitted to ODEQ and posted on PGE's website by April 1 summarizing activities associated with the IP completed in the previous calendar year (defined as January 1 through December 31). Additionally, an evaluation report documenting Phase 2 will be submitted to ODEQ by December 31, 2027.

Table 4. Phased approach to TMDL implementation.

Phase	Objective	Timeline	Deliverables
Pre-phase:	Implementation Plan Development	2019-2023	Mercury TMDL Implementation Plan (Oct 2023)
Phase 1: Data Collection & Sampling	Collect water quality data from strategic locations within the subbasin	2024	Annual Report (April 1) • Calendar year 2023 activities
		2025	Annual Report (April 1) • Calendar year 2024 monitoring results
		2026	Annual Report (April 1) • Calendar year 2025 monitoring results
Phase 2: Analysis & Evaluation	• Analyze monitoring results in conjunction with relevant data from other sources • Identify locations where methylation is occurring • Identify BMPs that could be employed to reduce methylation • Identify data gaps and adjust future monitoring to suit	2027	Annual Report (April 1) • Calendar year 2026 monitoring results Evaluation Report (Dec 31) • Data summary (2024 – 2026 monitoring results) ○ Compiled monitoring data ○ Other relevant data • Data analysis • Basin-wide mercury translator • Recommendations ○ BMPs ○ Future monitoring plan
Phase 3: Refine Implementation	• Implement plan and timeline for recommended BMPs • Implement additional water quality monitoring if data were gaps identified	2028+	Annual Report (April 1) • Implementation status • Calendar year monitoring results

4 Water Quality Evaluation

Processes within a reservoir, such as sedimentation, stratification and anoxia, and water level fluctuations, influence the transformation and transport of mercury when it enters a reservoir. These processes can create conditions that are favorable for the methylation of inorganic mercury. These processes occur within some of the Project's reservoirs. Consequently, to better understand methylation within those reservoirs, our water quality monitoring objectives are to

- Collect total mercury (THg) and MeHg samples in Years 1–3 (2024–2026) to establish baseline conditions.
- Provide data for a mercury translator for the basin using the results from sampling in Years 1–3.
- Collect sufficient data to assess potential BMPs for reducing methylation in the Project.

4.1 Monitoring Locations

Water quality samples will be taken in the Project's two major reservoirs – Timothy Lake and North Fork Reservoir (Figure 1). These sites were chosen because conditions in the reservoirs may enhance mercury methylation. Conditions in the other five Project reservoirs are not favorable for methylation for a combination of reasons: they either do not stratify, are not drawn down seasonally, have little to no sedimentation, or there are no adjacent wetlands (EES Consulting, 2003).

Timothy Lake is the most upstream reservoir in the Project. It strongly stratifies in late spring through the fall, and during stratification, dissolved oxygen (DO) concentrations in the hypolimnion are hypoxic. As part of Project operations, the water level is lowered up to 21 ft starting on September 1 and then refilled by May 31. Additionally, wetlands along the shoreline of the northern arm of the reservoir are dewatered during drawdown.

North Fork Reservoir is located in the mainstem of the Clackamas River and it accumulates the most sediment of all the Project reservoirs. McBain and Trush (2002) estimated approximately 269,000 tons of sediment each year is blocked from traveling down the Clackamas River by North Fork Dam. Unlike Timothy Lake, the reservoir is weakly stratified with minimal water level fluctuation.

Methylation is most likely to occur at the sediment-water interface because of low oxygen concentrations and microbial metabolism. To analyze hypolimnetic water, samples will be collected at the outlets of each reservoir. The outlet intakes in Timothy Lake and North Fork Reservoir are within one meter of the reservoirs' bottoms and discharge hypolimnetic water downstream. A study in the Guadalupe River Watershed in California, as part of a mercury TMDL, found no significant difference between MeHg concentrations taken within one meter of the sediment-water interface and a reservoir's outlet when the outlet intake in the reservoir is within one meter of the reservoir bottom (Seelos, 2017).

4.2 Analytes

Water quality samples will be collected in late summer/early fall in both reservoirs. Samples will be analyzed for five analytes: THg, MeHg, sulfate, dissolved organic carbon, and total suspended solids (Table 5). THg and MeHg will be collected following the trace metal sampling protocols in US EPA Method 1669. The other analytes will be collected following standard methods. Samples will be analyzed by certified laboratories. Table 6 lists the laboratory methods used for chemical analysis, the method detection limits, and the current reporting limits.

To characterize thermal stratification and chemical gradients, temperature, DO, pH, and conductivity will be measured in vertical water-column profiles in both reservoirs. Measurements will be made using a water quality Sonde. Readings will be taken at 1-m intervals in Timothy Lake to capture the lake's stratification profile and 2-m intervals in North Fork Reservoir since it weakly stratifies. Additional readings at North Fork Reservoir may be necessary to ensure water quality samples are taken during maximum anerobic conditions.

Table 5. Analytes collected during Phase 1 monitoring.

Analyte	Rationale
Total Mercury (THg)	Water column target pollutant of the TMDL
Methylmercury, dissolved (MeHg)	TMDL pollutant; the form of mercury that bioaccumulates in fish and is a potent neurotoxin. Reservoir conditions may enhance fish MeHg concentrations.
Sulfate	Sulfate is the oxygen source for anaerobic sulfate-reducing bacteria, which are the primary organisms responsible for MeHg production (Seelos, 2017).
Dissolved Organic Carbon	Organic matter in water affects the mobilization, transport, and bioavailability of mercury, and DOC is a source of carbon for microbial metabolism and associated Hg methylation in anoxic environments (Gu et al., 2011; Emmerton et al., 2018).
Total Suspended Solids	THg has the capacity to bind to particulate matter. TSS may be a surrogate measure for THg (DEQ, 2019).

Table 6. The method, detection and reporting limits for the monitored analytes.

Analytical Parameter/Field Measurement	Project Target	Minimum Detection Limit	Reporting Limit	Method
Total Mercury	0.14 ng/L	0.06 ng/L	0.5 ng/L	US EPA Method 1631
Methylmercury	No project target for water column	0.03 ng/L	0.1 ng/L	US EPA Method 1630
Sulfate	No project target	0.500 mg/L	1.00 mg/L	IC 300.0/9056A
Dissolved Organic Carbon	No project target	1.00 mg/L	1.00 mg/L	SM5310C (Diss)
Total Suspended Solids	No project target	0.500 mg/L	0.500 mg/L	SM 2540 D-LL

4.3 Sampling Methodology

Samples will be collected following the procedures detailed in PGE's Mercury TMDL Water Quality Monitoring Field & Sampling Procedures (*in development*). These procedures also

detail sample preservation and preparing the samples for shipping. Any change to the procedures will be documented in the Field & Sampling Procedures. Table 7 summarizes the field collection effort.

PGE's Mercury Total Maximum Daily Load QAPP (*in development)* documents the quality assurance and control measures that will be applied to the data collected to ensure the data meet the goals of the TMDL Implementation Plan.

Table 7. Summary of the Phase 1 water quality monitoring proposed for the mercury TMDL.

Sampling Location	Frequency	Parameters
Timothy Lake – Outlet	1 sample in late summer/early fall Taken in years 2024, 2025, 2026	• THg • MeHg, dissolved • Sulfate • DOC • TSS
Timothy Lake – Forebay	1 sample in late summer/early fall Taken in years 2024, 2025, 2026	• Temp/DO/pH/conductivity – profiles, 1-m interval
North Fork Reservoir – Outlet	1 sample in late summer/early fall Taken in years 2024, 2025, 2026	• THg • MeHg, dissolved • Sulfate • DOC • TSS
North Fork Reservoir – Forebay	1 sample in late summer/early fall* Taken in years 2024, 2025, 2026	• Temp/DO/pH/conductivity – profiles, 2-m interval

Note: THg = Total Mercury, MeHg = Methylmercury, DOC = Dissolved Organic Carbon, TSS = Total Suspended Solids

* Additional readings at North Fork Reservoir may be necessary to ensure water quality samples are taken during maximum anerobic conditions.

4.4 Reporting

The WQMP identified ODEQ expectations for annual reports as well as a more comprehensive 5-year progress review. PGE will meet those reporting goals by providing the information described in Table 4. Annual reports, summarizing activities and monitoring results of the previous calendar year, will be provided to ODEQ and posted on PGE's website by April 1. Additionally, an evaluation report documenting Phase 2 will be submitted to ODEQ by December 31, 2027. Reports will be provided to PGE's ODEQ program contact and posted on the PGE website.

5 Compliance with Land Use Requirements

On August 10, 2023, PGE filed a Land Use Compatibility Statement (LUCS) with Clackamas County. On August 22, 2023 Clackamas County determined that the actions proposed in this plan complied with all applicable local land use requirements.

6 Existing Management Strategies

Significant progress has been made to minimize water quality impacts related to each hydroelectric development operated by PGE. While mercury load reduction was not the intended purpose, it is likely implementation of these existing measures has led to a reduction in transport of mercury downstream. The measures include in-stream and riparian habitat improvements on the Clackamas River and Oak Grove Fork and their tributaries, erosion control measures during construction and operations, and minimization of water level fluctuations. These measures have been either implemented, are ongoing, or planned for future implementation. A table of PGE's BMPs in Attachment 1 details the different measures, actions, mercury benefit, and reporting requirements.

7 Budget

Table 8 lists the estimated analytical costs of Year 1 sampling. Table 9 lists estimated costs for purchasing and upgrading equipment. Other costs include any additional equipment, labor and overnight shipping.

Table 8. Water quality monitoring program Year 1 lab costs.

Parameter	Price per Parameter	No. of Sites	No. visits per site	No. routine samples	No. field blanks	No. field duplicates	Total number of samples	Cost
Total Mercury	$100	2	1	2	1	1	4	$400
Methylmercury	$350	2	1	2	1	1	4	$1,400
Sulfate	$30	2	1	2	1	1	4	$120
Total Organic Carbon	$50	2	1	2	1	1	4	$200
Total Suspended Solids	$25	2	1	2	1	1	4	$100
							Total Cost	$2,220

Table 9. Water quality monitoring program Year 1 equipment costs.

Item	Price per Unit	Quantity	Cost
Hydrolab HL4 Sonde	$4,400	1	$4,400
HL4 Internal Depth Sensor	--	1	--
HL4 Internal Temperature Sensor	--	1	--
HL4 Conductivity Sensor	$500	1	$500
HL4 LDO Dissolved Oxygen Sensor	$1,900	1	$1,900
HL4 pH Sensor	$650	1	$650
50 Meter HL4 Data Cable	$1,000	1	$1,000
pH Buffer Solution Kit	$300	1	$300
Conductivity Standard Solution	$50	1	$50
Timothy Lake Penstock Sample Port Installation	$500	1	$500
		Total Cost	$9,300

8 References

EES Consulting. 2003. Clackamas River WQ2 Water Quality Studies. Prepared for Portland General Electric.

Emmerton, Craig A., Colin A. Cooke, Gregory R. Wentworth, Jennifer A. Graydon, Andrei Ryjkov, and Ashu Dastoor. 2018. Total Mercury and Methylmercury in Lake Water of Canada's Oil Sands Region. Environ. Sci. Tecnol. Vol 52. Pg 10946-10955. Accessed from Total Mercury and Methylmercury in Lake Water of Canada's Oil Sands Region (acs.org).

Gu, Baohua, Yongrong Bian, Carrie L. Miller, Wenming Dong, Xin Jiang, and Liyuan Liang. 2011. Mercury reduction and complexation by natural organic matter in anoxic environments. PNAS. Vol 108, no. 4. Pg 1479-1483. Accessed from Mercury reduction and complexation by natural organic matter in anoxic environments | PNAS.

McBain and Trush, Inc. 2002. Sediment yield analysis for the Oak Grove Fork and upper mainstem Clackamas River above North Fork Reservoir. Technical report prepared for Clackamas River Hydroelectric Project Relicensing Fish and Aquatics Workgroup. McBain and Trush, Inc. Arcata, CA. (cited in Tetra Tech, 2019).

Oregon Department of Environmental Quality. 2019. Final Revised Willamette Basin Mercury Total Maximum Daily Loads. Accessed from https://www.oregon.gov/deq/wq/Documents/willHgtmdlwqmpF.pdf

Seelos, Mark. 2017. Guadalupe River Watershed Mercury TMDL : 2016-2017 Progress Report On Methylmercury Production and Control Measures. Santa Clara Valley Water District Library. Accessed from California Revealed https://californiarevealed.org/islandora/object/cavpp%3A172541

Tetra Tech. 2019. Mercury TMDL Development for the Willamette River Basin (Oregon) – Technical Support Document. Prepared for Oregon Department of Environmental Quality and U.S. Environmental Protection Agency, Region 10.

Attachment 1 PGE's Best Management Practices at the Clackamas River Hydroelectric Project

The table lists the measures PGE has implemented as part of its license to minimize the water quality impacts of the Clackamas River Hydroelectric Project. Each of these measures has some effect on reducing the mobilization of mercury. The specific mercury benefit for each measure is identified in the table and are defined as follows:

A: Reduce reservoir water level fluctuations

B: Reduce runoff and/or erosion through improved riparian vegetation

C: Reduce runoff and/or erosion through shoreline or in-stream modifications

D: Prevent sediment and mercury runoff into waters of the state during construction activities

E: Prevent sediment and mercury runoff into waters of the state during normal operation

F: Provides mixing of waters within the reservoir

License Obligation	Location	Primary Action	Primary Action Timeline	Secondary Action	Secondary Action Timeline	Mercury Specific Resource Benefit (see table*)	Reporting Requirement
Reservoir Elevation Fluctuation	Harriet Lake	No operating limits. Maintained with minimal reservoir elevation fluctuation	Ongoing	NA	NA	A	Annual Operations Report of Monitoring and Compliance
	North Fork Reservoir	Operated as "Run of River". Maintain an elevation between 660.0 ft and 666.0 ft with an extreme minimum of 640.0 ft. Normal elevation is maintained between 663.0 ft and 665.0 ft.	Ongoing	NA	NA	A	Annual Operations Report of Monitoring and Compliance
	Faraday Diversion	Maintain an elevation between 522.6 ft and	Ongoing	NA	NA	A	Annual Operations Report of Monitoring and Compliance

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	Dam Reservoir	544.4 ft with an extreme minimum of 517.6 ft.					
	Faraday Lake	From October 1 – June 30 maintain an elevation between 511.7 ft and 523.5 ft. From July 1- September 30 maintain an elevation between 511.7 ft and 520.5 ft.	Ongoing	The lake is operated with a 3 ft drawdown from July 1- Sept 30.	Ongoing	A	Annual Operations Report of Monitoring and Compliance
	Estacada Lake	Maintain an elevation below 389.25 ft year round. Jan 1- May 15: 387.0 ft minimum. May 16- July 31: 386.0 ft minimum. Aug 1- Dec 15: 384.5 ft minimum. Dec 16 – Dec 31: 386.0 ft minimum. July 31- Oct 31: 382.5 ft extreme minimum	Ongoing	NA	NA	A	Annual Operations Report of Monitoring and Compliance
Settlement Agreement Habitat Improvement	Dinger Creek	Pipe culvert replaced with bottomless arch culvert.	Completed 2012	NA	NA	C	Proposed Final Design Documentation Report - Dinger Creek Culvert Replacement. October 3, 2011
	Anvil Creek	Pipe culvert replaced with bottomless arch culvert.	Completed 2016	NA	NA	C	Anvil Creek Culvert Replacement- Notification of

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							Completion filed with FERC. Dec 19, 2016.
	Dinger Creek	Cutthroat trout habitat enhancement through construction of in-stream wood structures	Initial construction completed 2012	Continued inspection and maintenance of structures	Ongoing	C	Dinger Creek Habitat Enhancement Monitoring Report
	Oak Grove Fork: Timothy Lake Dam to Hammer Springs	Cutthroat trout in-stream habitat enhancement using logs, root wads, boulders, and pea gravel.	Initial construction completed 2011	Continued monitoring of enhancement modifications every eight years.	Ongoing	C	Habitat Enhancements between Timothy Lake Dam and Hammer Springs: Post-Enhancement Cutthroat Habitat Monitoring
	Oak Grove Fork: Barrier Falls to mouth	Side channel construction and enhancement to increase total juvenile coho side channel habitat.	Initial construction completed 2014	Annual side channel monitoring for total available 1+ coho side channel habitat	Ongoing	C	Annual Walk-Through Inspection of Juvenile Coho Habitat in the Lower Oak Grove Fork of the Clackamas River
	Oak Grove Fork: Ripplebrook Campground to mouth	Mainstem habitat enhancement through the addition of six structures designed to provide spawning habitat, holding habitat, and high flow refugia for winter steelhead, coho salmon, and spring Chinook salmon.	Initial construction completed 2014	Annual habitat structure monitoring to assess conditions and monitor change	Ongoing	C	Oak Grove Fork – Clackamas River Mainstem Fish Habitat Structure Post Project Monitoring Report

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	Clackamas River Basin downstream of River Mill Dam	Manage invasive species and plant 30 streamside miles of riparian forest in the Clackamas Basin through the "Shade Our Streams" program.	Planting completed 2018	Site maintenance completed for 2 years after planting	All post planting monitoring finished in 2020.	B	Clackamas River Basin Council Shade Our Stream Annual Report: 2020
Mitigation and Enhancement Fund	Clackamas Basin	Fund $8.0 M in resource projects to mitigate for Project-related impacts on native anadromous and non-anadromous fish populations. Funding distributed across five funding cycles (2012, 2015, 2019, 2023, and 2029)	Ongoing	NA	NA	B and C	Clackamas River Project (FERC 2195) Settlement Exhibit H; License Article 48.
2012 Fund Cycle	Clackamas River upstream of the Oak Grove Fork	*Bob's Pond Annex Side Channel :* Side channel restoration through large wood placement and improved pool habitat.	Completed 2015	NA	NA	C	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund 2015 Annual Report
	Winslow Creek	*Winslow Fish and Flow Culvert:* Culvert replacement at Winslow Creek to improve fish and aquatic organism passage and direct sediment runoff away from Winslow Creek.	Completed 2014	NA	NA	C	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund 2014 Annual Report

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	Clackamas River at Carli Creek	*Carli Creek Fish Habitat Restoration:* Removed fish passage barriers within Carli Creek, created new channels and 5-acres of habitat within adjacent Carli property, and improved water quality flowing into Carli Creek and the Clackamas River.	Completed 2015	Surrounding areas planted with native wetland and riparian species.	Completed 2015	B and C	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund 2015 Annual Report
2015 Fund Cycle	South Fork Clackamas River	*South Fork Culvert Replacement*: Replaced undersized culvert and enhanced 4 miles of fish passage.	Completed 2018	NA	NA	C	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund 2018 Annual Report
	North Fork of the Clackamas River	*Bakers Ferry Restoration Project:* Installed engineered log jams over 1 mile of the North Fork of the Clackamas River to restore structural and hydraulic complexity.	Completed 2016	Native tree and shrub plantings at restoration site.	Completed 2017	B and C	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund: 2016 Annual Report & 2017 Annual Report
	Clackamas Basin	*Riparian Road Decommissioning:* Decommissioned 1.3 miles of road via large berms, decompaction, enhance berm barriers with large boulders, logs,	Completed 2017	Decommissioned roads planted with native vegetation.	Completed 2017	B and C	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund 2016 Annual Report

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		root-wads, and installer water bars.					
	Clackamas River Confluence with Willamette River	*Clackamas River Confluence Restoration Project*: Improved floodplain and in-stream habitat by opening and restoring more than 1 acre of seasonal off-channel habitat and placement of large wood structures.	Completed 2016	Restored 9.3 acres of surrounding forest floodplain through invasive vegetation treatment and native plant revegetation.	Completed 2019	B and C	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund 2016 Annual Report
	Richardson Creek	*Richardson Creek:* Enhanced the Clackamas River floodplain by addressing diking, channelization, and culvert replacement to improve habitat diversity resulting from the loss of large wood in off-channel areas and tributaries, poor water quality due to sediment laden runoff, and high-water temperatures.	Completed 2018	Improved riparian habitat and stream conditions through invasive vegetation treatment and native plant revegetation	Completed 2018	B and C	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund 2018 Annual Report
	Clackamas Basin	*Clackamas River Invasive Species Partnership:* Identify and treat priority invasive weeds along the Clackamas River	Ongoing	NA	NA	B	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund Annual Report

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		mainstem and tributaries to protect high quality areas, promote degraded forest recovery, and contribute to recovery of fish populations.					
	Suter Creek	*Suter Creek Fish Passage and Habitat Restoration Project:* Two culverts replaced with a bridge to improve fish passage, riparian corridors, and water quality.	Completed 2016	Plant native trees and shrubs at disturbed areas.	Completed 2017	B and C	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund: 2016 Annual Report & 2017 Annual Report
	North Fork Reservoir	*Upper North Fork Reservoir Large Wood Fish Habitat:* Wood structures added to the upstream and downstream submerged point bars and the alcove at the upstream edge of North Fork Reservoir to improve material deposition and habitat complexity.	Completed 2017	Improve riparian habitat and stream conditions through invasive vegetation treatment and native plant revegetation	Completed 2017	B and C	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund 2017 Annual Report
2019 Fund Cycle	Suter Creek	*Suter Creek Fish Habitat Restoration:* Large wood placement utilized to enhance in-stream fish habitat.	Completed 2020	Replant riparian area adjacent to work with native vegetation.	Completed 2021	B and C	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund: 2020 Annual Report & 2021 Annual Report

License Obligation	Location	Primary Action	Primary Action Timeline	Secondary Action	Secondary Action Timeline	Mercury Specific Resource Benefit (see table*)	Reporting Requirement
	Clackamas Basin	*Clackamas River Invasive Species Partnership:* Manage invasive non-native weeds at high priority locations throughout the Clackamas Basin.	Ongoing	NA	NA	B	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund Annual Report
	Eagle Creek	*Eagle Creek Large Wood Enhancement:* Large wood structures placed in lower Eagle Creek to promote side channel activation, augment a developing floodplain, and provide in-stream complexity.	Completed 2020	Disturbed areas replanted with native vegetation.	Completed 2021	B and C	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund 2021 Annual Report
	Clackamas River (McIver Park)	*Kingfisher Side Channel:* Provide year-round, complex side channel habitat through channel excavation and large wood placement.	Completed 2021	Riparian habitat and stream conditions improved through invasive vegetation treatment and native plant revegetation	Completed 2022.	B and C	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund: 2021 Annual Report & 2022 Annual Report
	Clackamas Basin	*Shade Our Streams:* Manage invasive species and plant native vegetation in streamside habitat as a continuation of "Shade Our Streams."	Completed 2021	Two years of site maintenance following plantings.	Scheduled for completion in fall of 2023	B	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund 2022 Annual Report

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	Clackamas River (Upstream of North Fork Reservoir)	*Habitat Project Upstream of North Fork Reservoir:* Construction of a series of large wood habitat structures over 1,100 ft of Clackamas River to improve stream complexity and increase spawning habitat.	Completed 2020	NA	NA	C	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund 2020 Annual Report
Scheduled: 2023 Fund Cycle	Clackamas Basin	Fund resource projects to mitigate Project related impacts on native anadromous and non-anadromous fish populations.	Distribution of funds scheduled for 2023	NA	NA	B and C	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund 2019 Annual Report
Scheduled: 2029 Fund Cycle	Clackamas Basin	Fund resource projects to mitigate Project related impacts on native anadromous and non-anadromous fish populations.	Distribution of funds scheduled for 2029	NA	NA	B and C	Clackamas River Hydroelectric Project Mitigation and Enhancement Fund 2019 Annual Report
TMDL Habitat Improvement	Goose Creek	Habitat enhanced to create cool water rearing for salmonids. Initial construction included managing for native vegetation.	Construction Completed 2016	Annual inspection, periodic evaluation, and potential modifications	Ongoing	B and C	Annual Goose Creek Side Channel Habitat Monitoring Report
	Logan Side Channel	Habitat enhanced to create cool water rearing for salmonids. Initial construction included	Construction completed in 2010	Annual inspection, periodic evaluation, and	Ongoing	B and C	Annual Logan Side Channel Habitat Monitoring Report

License Obligation	Location	Primary Action	Primary Action Timeline	Secondary Action	Secondary Action Timeline	Mercury Specific Resource Benefit (see table*)	Reporting Requirement
		managing for native vegetation.		potential modifications			
	McIver Side Channel	Habitat enhanced to create cool water rearing for salmonids. Initial construction included managing for native vegetation.	Construction completed in 2014	Annual inspection, periodic evaluation, and potential modifications	Ongoing	B and C	Total Maximum Daily Load Implementation Plan
Faraday Lake Channelization	Faraday Lake Forebay	Faraday lakebed channelized to reduce summer reservoir temperature influence along with the addition of a rock blanket to the lake channel to improve slope stability.	Lake channelization completed 2012.	Summertime drawdown to expose berms and confine lake implemented annually from July 1- Sept 30.	Ongoing	C	Completed Construction Report: TMDL Implementation Plan: 2012 Annual Report. Appendix A-Faraday Lake Channelization Final Construction Report Ongoing Reporting: Annual Operations Report of Monitoring and Compliance
North Fork Floating Surface Collector	North Fork Reservoir	Provides 950 cfs of continuous pumped flow on the south side of the North Fork Forebay to provide downstream passage for juvenile salmonids.	Ongoing	Artificial circulation	Ongoing	F	Fish Passage and Protection Plan Annual Report

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North Fork Migrant Collector	North Fork Reservoir	Provides 180 cfs of continuous pumped flow on the south side of the North Fork Forebay to provide downstream passage for juvenile salmonids.	Ongoing	Artificial circulation	Ongoing	F	Fish Passage and Protection Plan Annual Report
Vegetation Management Plan	Project Wide	Promote native and prevent invasive non-native vegetation within the Project boundary	Ongoing	Revegetate disturbances from Project-related activities	Ongoing	B	Annual Planning Memorandum for the Vegetation Management Plan
Wetland Mitigation Plan	Davis Ranch Wetland	Restoration to original wetland through re-establish wetland hydrology, installation of large woody debris for flow dispersal and habitat features, noxious weed removal, planting and seeding native species, reinforcing an existing beaver dam, and closing vehicle access. 0.43 acres of Wetland Emergent Zone, 0.57 acres of Wetland Shrub, and 0.13 acres of Upland Forest were restored/supported.	Completed 2013	Periodic due diligence surveys and invasive, non-native plant surveys and control measures.	Ongoing	B and C	Completion Filing: Wetland Restoration As-Built Report, Davis Ranch Property. FERC Filing April 25, 2014. Annual reporting: Annual Report for the Terrestrial Resources Management Plan

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	North Fork Property Wetland	Habitat enhancement and restoration of 0.45 acres of wetland and 0.56 acres of upland through fill removal, grading, installation of habitat features, noxious weed removal, and native planting and seeding.	Completed 2013	Periodic due diligence surveys and invasive, non-native plant surveys and control measures.	Ongoing	B and C	Completion Filing: Wetland Enhancement As-Built Report, North Fork Wetland Site. FERC Filing April 24, 2014. Annual reporting: Annual Report for the Terrestrial Resources Management Plan
Turbidity Management	Project Wide	Implement Best Management Practices to protect surface water and beneficial uses from adverse Project related water quality impact	Ongoing	NA	NA	D	Activity specific requirements. Some activities will require notification to ODEQ.
NOAA Fisheries Service BMPs	Project wide	Follow construction practices to control sediment, disturbance, and other potential detrimental effects to listed salmonids during construction in or near waterways.	Ongoing	Prepare a Pollution and Erosion Control Plan, in consultation with NOAA fisheries, and carry out the plan to prevent pollution caused by construction activities.	Ongoing	D	Project specific consultation with NOAA Fisheries
County Specific Low Impact Design Criteria	Project Wide	Follow county standards for Low Impact Design Criteria during construction design and implementation	Ongoing	NA	NA	D and E	Project specific consultation with appropriate county design staff