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March 2022
Dungeness Off-Channel Reservoir Project

ANCHOR QEA

Preliminary Basis of Design Report

Prepared for Clallam County

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Dungeness Off-Channel Reservoir Project

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ABBREVIATIONS

µg/L	microgram per liter
BPA	Bonneville Power Administration
cfs	cubic feet per second
cm/s	centimeter per second
CWA	Clean Water Act
cy	cubic yard
DAHP	Department of Archaeology and Historic Preservation
DID	Dungeness Irrigation District
DNS	Determination of Non-Significance
DO	dissolved oxygen
DSO	Dam Safety Office
Ecology	Washington State Department of Ecology
EO	Executive Order
ESA	Endangered Species Act
FAC	facultative
FACU	facultative upland
FEMA	Federal Emergency Management Agency
fps	feet per second
HDPE	high-density polyethylene
HID	Highland Irrigation District
HODR	hypolimnetic oxygen depletion rate
HPA	Hydraulic Project Approval
IDF	inflow design flood
IDP	inadvertent discovery plan
JARPA	Joint Aquatic Resources Permit Application
MTCA	Model Toxics Control Act
NAD83	North American Datum of 1983
NAVD88	North American Vertical Datum of 1988
NRCS	Natural Resources Conservation Service
NRHP	National Register of Historic Places
NWI	National Wetland Inventory
NWP	Nationwide Permit
O&M	operations and maintenance
OBL	obligate
OHWM	ordinary high-water mark
PHS	Priority Habitats and Species

psi	pounds per square inch
RM	river mile
SAR	shallow aquifer recharge
SEPA	State Environmental Policy Act
Services	National Marine Fisheries Service and U.S. Fish and Wildlife Service
SHPO	State Historic Preservation Officer
SMP	Shoreline Master Program
SPTIA	Sequim Prairie Tri-Irrigation Association
SSDP	Shoreline Substantial Development Permit
TP	total phosphorus
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USGS	U.S. Geological Survey
VWP	vibrating wire piezometer
WAC	Washington Administrative Code
WDFW	Washington Department of Fish and Wildlife
WDNR	Washington State Department of Natural Resources
WHR	Washington Heritage Register
Work Group	Dungeness Off-Channel Reservoir Work
WSEL	water surface elevation
WY	Water Year

1 Introduction

This Preliminary Basis of Design Report provides a summary of the development of preliminary designs for the Dungeness Off-Channel Reservoir Project. The project will construct a 1,600-acre-foot storage reservoir near River Road, south of the City of Sequim in Washington State. The reservoir will store water from the Dungeness River during the winter, spring, and early summer for irrigation use during the late summer. Reservoir water will also have potential to be used for managed shallow aquifer recharge (SAR) to further benefit flows in the Dungeness River and its tributaries. The project is being implemented by Clallam County Public Works Department with support from key teaming partners that compose the Dungeness Off-Channel Reservoir Work Group (referred to herein as the Work Group). Preliminary design work has been funded with major grants awarded to Clallam County by the Washington State Department of Ecology (Ecology) under Ecology's Streamflow Restoration Grant Program.

1.1 Project Background

The Dungeness River flows from the Olympic Mountains north to the Strait of Juan de Fuca on the Olympic Peninsula in Washington State. The Dungeness River Watershed supports wilderness and protected areas in Olympic National Park, working forests, a variety of fish and wildlife species, a productive agriculture industry, and a growing population. Due to their location in the rain shadow of the Olympic Mountains, agricultural lands in the lower Dungeness River Watershed require irrigation for crop production. The Sequim area receives approximately 16 inches of rain annually, similar to that of Los Angeles, California. For comparison, Seattle, Washington, receives approximately 36 inches annually, An extensive network of ditches and pipelines divert water from the Dungeness River for irrigation. Groundwater wells that provide domestic water supply for the growing population also are prevalent in the lower watershed. The Dungeness River and its tributaries also provide critical habitat for fish and wildlife, including salmonid species listed under the Endangered Species Act (ESA).

Resource managers have been working closely with water users and other stakeholders for more than three decades to implement a variety of water conservation, infiltration, water supply, and ecological restoration projects aimed at improving management of water in the Dungeness River Watershed. Several studies have recommended the creation of surface water storage to improve the reliability of water supply for out-of-stream water uses and to maintain flows in the Dungeness River during critical low-flow periods to sustain favorable fish passage and habitat conditions. Some of those prior studies are listed for reference in Section 1.1.3. Multiple storage concepts have been studied over the years. Other than two small re-regulating reservoirs used for irrigation, no surface water storage projects have been implemented.

The proposed Dungeness Off-Channel Reservoir Project offers a storage concept that has broad support among local resource managers, water users, and other key stakeholders. The proposed project is to construct a reservoir with up to 1,600 acre-feet of water storage capacity on a 319-acre parcel currently owned by Washington State Department of Natural Resources (WDNR). Clallam County and WDNR are negotiating a transaction that will transfer the 319-acre parcel and an adjacent 77-acre parcel to Clallam County for the reservoir and related facilities. The location of the project is shown in Figure 1-1. The reservoir parcel is located along River Road approximately 1 mile south of the City of Sequim and is currently managed for timber production. Most of the parcel has been harvested within the last 20 years and is now primarily used by the public for recreation. A network of trails provides opportunities for hiking and mountain biking.

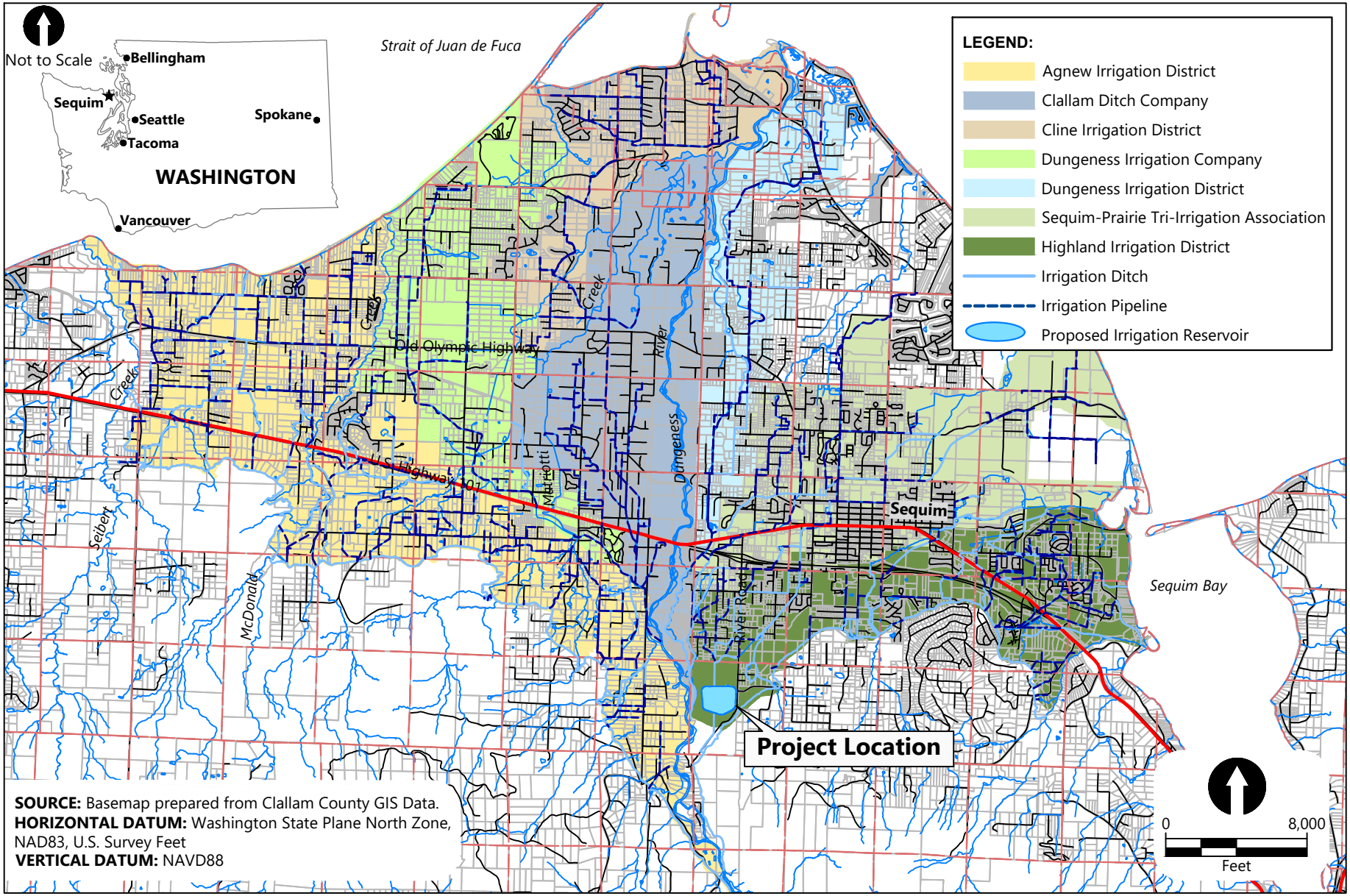
The reservoir will be filled with water diverted from the Dungeness River via the Highland Irrigation District (HID) canal system. An HID lateral, referred to herein as the H1 Lateral, bisects the site, flowing across the site from south to north. Water will be diverted from the Dungeness River, conveyed by gravity through the HID canal system, and stored in the proposed reservoir during the winter, spring, and early summer, when flows in the river are high and water is available[1]. The reservoir may also be designed to capture overland flow runoff conveyed by irrigation ditches from the east by Happy Valley Road. Stored water will be released by gravity to downstream irrigation ditches and pipelines to meet irrigation needs during the late-summer low-flow period and may potentially be used for SAR. Releases for irrigation will allow for a corresponding decrease in diversions from the Dungeness River during the late summer low-flow period, when flows in the river are critical to support ESA-listed fish and other wildlife.

1.1.1 Overview of Key Project Elements

Preliminary design drawings for the project are included in Appendix A. Key project elements are shown in Figure 1-2. The following key elements were developed as part of the preliminary design:

- **Reservoir:** A 1,600-acre-foot reservoir will be constructed by excavating native earth material and placing native and imported materials to form an earthen embankment around the reservoir.
- **Inlet Pipeline**: A 36-inch, high-density polyethylene (HDPE) inlet pipeline will be constructed to convey water from the HID Main Canal to the reservoir. The pipeline will replace the H1 Lateral from the HID Main Canal to the reservoir.

[1] The main source of water for filling the Dungeness Reservoir will be maximum allocation water diverted from the Dungeness River, which is defined in the Washington Administrative Code (WAC) 173-518-090 and includes the maximum amount of water available for withdrawal after meeting instream flow requirements.



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Filepath: K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\1439-BODR-001 (Location Map).dwg Figure 1-1

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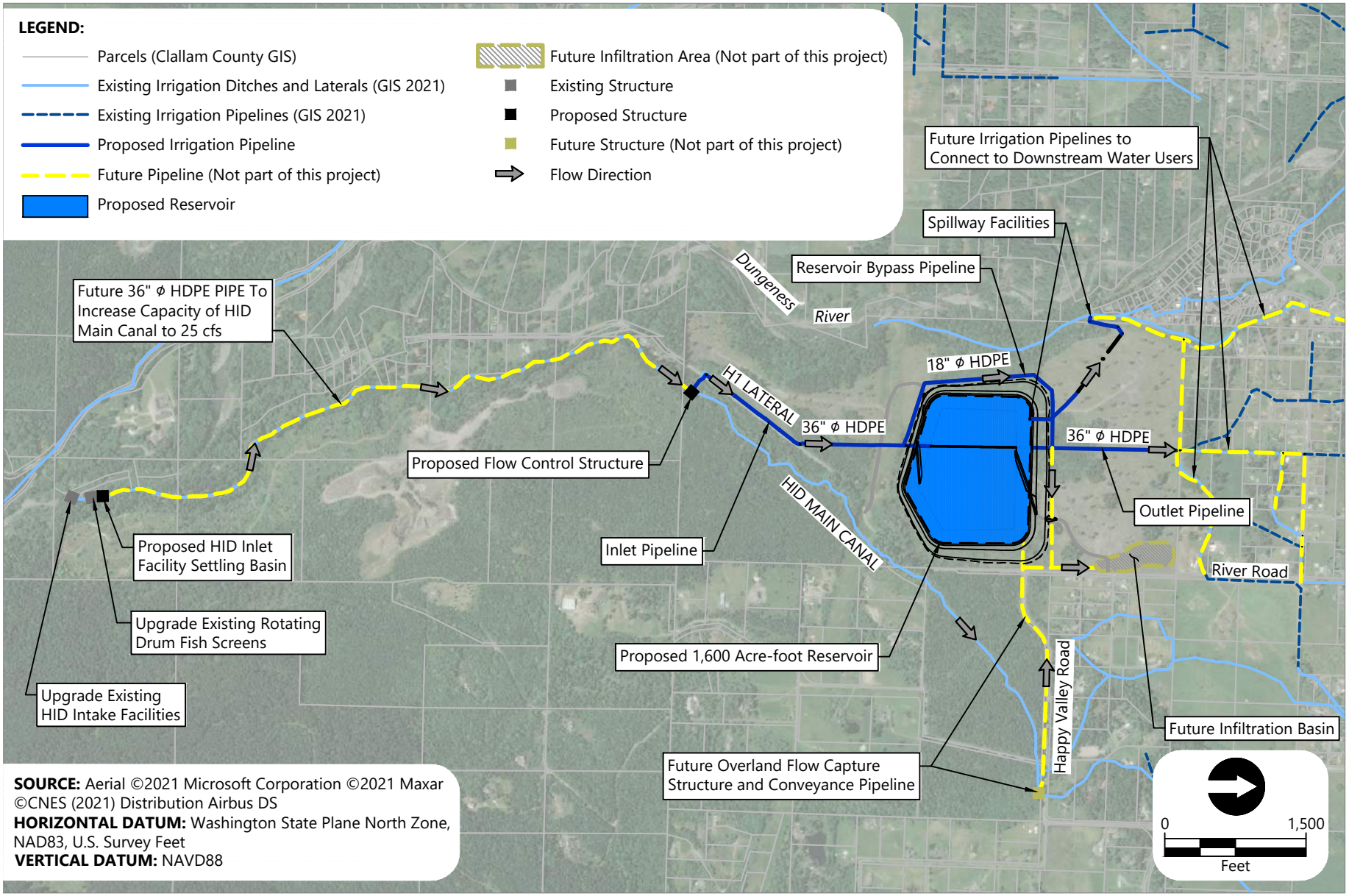
Figure 1-1
Location Map

Preliminary Basis of Design Report
Dungeness Off-Channel Reservoir Project



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Filepath: K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\1439-BODR-002 (Improvement Plan).dwg Figure 1-2

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Figure 1-2
Project Overview Map

Preliminary Basis of Design Report
Dungeness Off-Channel Reservoir Project

- **Flow Control Structure:** A flow control structure will be constructed on the HID Canal at the upstream end of the 36-inch inlet pipeline to control the flow of water from the HID Main Canal to the reservoir.
- **Inlet Structure:** An inlet structure will be constructed at the toe of the excavated slope within the reservoir to transition flow from the 36-inch inlet pipeline to the reservoir and dissipate energy at the end of the pipe.
- **Outlet Works:** The outlet works will consist of a pipe manifold buried in the face of the embankment with three gated inlets that will control the release of water from the bottom of the reservoir, midway up the embankment, and near the upper end of the reservoir.
- **Outlet Pipeline:** A 36-inch HDPE outlet pipeline will be constructed to convey water from the outlet works at the reservoir to the downstream irrigation system. The pipeline will replace the H1 Lateral from the reservoir to the north end of the reservoir parcel.
- **Bypass Pipeline:** An 18-inch HDPE bypass pipeline will be constructed around the west edge of the reservoir to connect the 36-inch inlet pipeline with the 36-inch outlet pipeline. It will provide a way for water to bypass the reservoir during construction and when the reservoir has to be drained for maintenance.
- **Spillway Facilities:** A drop inlet spillway will be constructed near the northwest corner of the reservoir to allow for the reservoir to overflow in the event that the reservoir experiences a large storm event when full. Spilled water will be conveyed through a combination of pipeline and ditch to a discharge point on the side channel of the Dungeness River just upstream of the Independent Canal intake facilities.
- **Intake Facility Improvements:** Several improvements will need to be made to the HID intake facilities at their point of diversion from the Dungeness River to allow for flows to be diverted through the HID system to fill the reservoir. These include upgrades to the channel that feeds the headgates, upgrade and automation of headgates, and upgrades to fish screens and measurement facilities.
- **Settling Basin:** To reduce the sediment load in the water diverted to the reservoir, the design proposes construction of a settling basin downstream of the fish screen facilities at the upstream end of the HID Main Canal.

1.1.2 Other Related Improvements

The Work Group has requested that several related improvements be considered for implementation in conjunction with the reservoir project. These improvements have been or will be evaluated and developed as separate projects or may be incorporated with the reservoir project during detailed design, but they are not currently included as part of the preliminary design prepared for the reservoir project. They are summarized as follows:

- **Overland Flow Capture and Conveyance System:** The City of Sequim recently secured grant funding from the Federal Emergency Management Agency (FEMA) to evaluate the potential

for capturing overland flows that reach the HID Main Canal and routing them to the reservoir site for infiltration or to be stored in the reservoir. This would involve construction of a structure on the HID Main Canal at Happy Valley Road, a pretreatment facility that would settle out solids, and a pipeline to capture overland flow collected by the HID Main Canal during storm events and convey it to the reservoir site.

- **Infiltration Facilities:** With the grant funding provided by FEMA, the City of Sequim will also be evaluating the potential for an infiltration facility at the reservoir site that would infiltrate overland flows captured in the HID Main Canal and routed to the reservoir site.
- **Irrigation Conveyance, HID Main Canal Upstream of the Reservoir:** The Work Group desires to divert up to 25 cubic feet per second (cfs) from the Dungeness River for storage in the reservoir. This will allow for more reliable refill of the reservoir because more flow can be captured during high-flow periods when more water is legally and physically available in the river. The HID Main Canal typically conveys 13 to 14 cfs in the summer. Flow records indicate that it has historically conveyed as much as 18 cfs. However, HID has indicated that they believe the capacity of the existing HID Main Canal may not be much more than 15 cfs. The capacity may need to be verified, but the HID Main Canal will need to be replaced with a pipeline or upgraded in size to convey up to 25 cfs from the Dungeness River to the reservoir outside the irrigation season and lesser flow rates during the irrigation season. No designs have yet been developed for this pipeline, although high-level sizing and costing calculations have been completed to better understand the order of magnitude costs for this project.
- **Irrigation Conveyance, Downstream of the Reservoir:** Clallam Conservation District contracted with Anchor QEA in late spring 2021 to develop preliminary designs for irrigation pipelines that will be needed to convey water from the proposed reservoir to downstream water users. The pipelines would replace some existing ditches to improve conveyance efficiency, and they would connect downstream irrigation systems to the reservoir that are not currently connected by pipe or ditches to the H1 Lateral at the reservoir site.
- **Slope Erosion Above the HID Canal at the Bonneville Power Administration (BPA) Easement:** Erosion has occurred upslope and downslope of the HID Main Canal where it crosses a cleared BPA transmission line easement, just east of the reservoir site. HID has requested that a solution be developed in conjunction with the reservoir project to limit or prevent further erosion. No designs or detailed evaluations have yet been developed for a potential solution to this problem.
- **Drought Pumping from Reservoir to HID Main Canal:** HID has also requested consideration of a facility that would pump water under drought conditions from the Dungeness Reservoir back to the HID Main Canal. The HID Main Canal is higher than the reservoir, and water users who are served by the canal would not be able to receive water released from the reservoir by gravity to downstream irrigators. The pumping would help address the situation that occurs sometimes during drought conditions when there is not

enough flow in the Dungeness River to support full HID diversions. The pump system would deliver water from the reservoir back to the HID Main Canal. No designs or detailed evaluations have yet been competed for this project.

- **Small Hydropower Generation**: The Work Group is interested in the potential for using the water conveyed from the HID Main Canal to the reservoir to generate hydropower. This would require a small hydropower system, installed somewhere along the inlet pipeline, that would take advantage of the flows in the pipeline and the drop in elevation from the HID Main Canal to the reservoir. No designs or detailed evaluations have yet been completed for this project.

1.1.3 Prior Studies

Table 1-1 provides a chronological summary of prior studies that have been completed leading up to the work summarized in this report. References for these studies and other documents and information referenced in this report are summarized in Section 9.

Table 1-1
Summary of Prior Studies

Prior Study	Author	Date
Technical Memorandum, Dungeness River Flow Enhancement Project: Designs and Supporting Analyses (PGG and Anchor QEA 2014) This memorandum summarizes projects that were identified as part of a flow enhancement study developed by Washington Water Trust. It was the first study to evaluate the potential storage reservoir at the River Road site. Conceptual designs were developed for the project as part of the study. A preliminary geotechnical evaluation was also completed.	Pacific Groundwater Group and Anchor QEA	May 2014
Technical Memorandum, Dungeness Flow Enhancement: River Road Storage Project, Preliminary Geotechnical Engineering Recommendations (Anchor QEA 2014) This memorandum summarizes Anchor QEA's initial investigation of geotechnical conditions at the site. It included completion of seven test pits distributed throughout the site, laboratory testing of soil samples collected from those test pits, and characterization of soils based on the test results and observations during test pit excavation.	Anchor QEA	May 2014
City of Sequim Water Quality Data Analysis Report (Herrera Environmental Consultants 2015) This report summarizes water quality and sediment data analysis associated with streams and stormwater in the City of Sequim.	Herrera Environmental Consultants	May 2015
Final City of Sequim Storm and Surface Water Master Plan (Herrera Environmental Consultants 2016) This report summarizes analysis and proposed improvements to the City of Sequim storm and surface water management system, including identification of issues associated with conveyance of stormwater via irrigation canals and pipelines through the City of Sequim.	Herrera Environmental Consultants	February 2016

Prior Study	Author	Date
Executive Summary and Proposal, Dungeness Off-Stream Reservoir Project (Anchor QEA 2016) This document was prepared at the request of Washington Water Trust, the Dungeness Water Users Association, Clallam Conservation District, and the City of Sequim to summarize the project for potential funders and other interested parties. The document summarizes the project, conceptual design analyses, and targeted benefits. Conceptual design drawings and opinions of probable project costs were also included.	Anchor QEA	January 2016
Stormwater Capture for the Dungeness Off-Channel Reservoir (Earth Economics 2019) This brief report represents the first high-level review and benefit-cost analysis of the proposed overland flow capture concept and was developed by Earth Economics under contract with the City of Sequim.	Earth Economics	March 2019
Geotechnical Engineering Feasibility Report Review, Dungeness Off-Line Storage Facility, River Road, Clallam County, Washington (PanGEO 2020) This letter report represents an independent review of the preliminary geotechnical report and conceptual designs provided by Anchor QEA in 2016. The review was completed for Clallam County to identify any fatal flaws or feasibility issues with the reservoir project concept.	PanGEO	December 2020
Cultural Resources Inventory for the Dungeness Streamflow Restoration Off-Channel Reservoir Project, Clallam County, Washington (Dudek 2021) This report was prepared following a field survey and review of potential cultural resources present within the parcel Clallam County is proposing to acquire from WDNR for the reservoir project. This report will serve as a basis for additional cultural resources review work to be completed for the project, and will provide a basis for compliance with Section 106 of the National Historic Preservation Act.	Dudek	February 2021
Memorandum: Task Assignment No. 4: Stormwater Capture and Infiltration RFI from FEMA (Wilson Engineering 2021) To support the request for funding from FEMA, the City of Sequim worked with Wilson Engineering to provide a more refined evaluation of and modeling for the overland flow capture and conveyance system and the potential for infiltrating stormwater at the site. Their evaluation is summarized in this memorandum.	Wilson Engineering	March 2021
Draft Dungeness Off-Channel Reservoir Fill Model Summary Report (Washington Water Trust 2021) This report summarizes modeling by Washington Water Trust using R Studio to simulate diversion of available Dungeness River flows and filling of the reservoir.	Washington Water Trust	September 2021

1.1.4 Other Studies Prepared by the Design Team

The design team has summarized work developed as part of the design of the project in separate documents that are incorporated into this report by reference or included as appendices. These documents are summarized in Table 1-2.

Table 1-2
Additional Studies Prepared by Design Team

Concurrent Study by the Design Team	Author	Date
Proposed Dungeness Reservoir Project, Phase 1 Environmental Assessment, DNR River Road Properties (Anchor QEA 2021a) This report was prepared at the request of Clallam County and summarizes the first phase of an environmental site assessment completed to characterize material that was dumped on the property through much of the 20th century. The material was observed and characterized and recommendations were provided for additional work.	Anchor QEA	January 2021
Data Summary, Data Gaps, and Additional Data Collection Plan for Dungeness Off-Channel Reservoir Project (Anchor QEA 2021b) This document summarizes background data collected to support this project, identifies additional data that may be needed, and summarizes work that was planned as part of the preliminary design effort to collect additional data to support the design of the project.	Anchor QEA	August 2021
Draft Cultural Resources Compliance for the Dungeness Off-Channel Reservoir Project (Anchor QEA 2021c) This memorandum summarizes information gathered about archaeological conditions at the site based on the prior Dudek survey and other research. It includes recommendations for compliance with cultural resources regulations as the project moves forward. The intent is that this memorandum will be reviewed by Ecology, the local tribes, and the State Historic Preservation Officer to minimize complications with future land-disturbing work.	Anchor QEA	October 2021
Proposed Dungeness Reservoir Project, Phase 2 Environmental Assessment, of the Old Sequim Dump Site (Anchor QEA 2022) This report followed the Phase 1 Environmental Assessment and included the results of site investigations for potential contamination, and recommendations and estimated costs for cleaning up the dumped material at the site. These recommendations will support property acquisition negotiations with WDNR.	Anchor QEA	January 2022
Draft Phase 1 Geotechnical Data Report, Dungeness Off-Channel Reservoir (Shannon & Wilson 2021a) This report summarizes the data collected as part of the geotechnical site investigations completed to support the preliminary design. The report also describes field observations and findings about subsurface soil characteristics at the site.	Shannon & Wilson	November 2021
Draft Phase 1 Conceptual Geotechnical Engineering Report, Dungeness Off-Channel Reservoir (Shannon & Wilson 2021b) This report summarizes the analyses and engineering recommendations for key geotechnical engineering design elements of the project, including the earthen embankment and reservoir, based on the data summarized in the Geotechnical Data Report. The recommendations in the report are preliminary and will be refined with additional geotechnical data that will be collected as part of the next phase of the project (Phase 2, Detailed Design).	Shannon & Wilson	November 2021

Concurrent Study by the Design Team	Author	Date
Conditional Assessment of Existing Intake on Highland Irrigation Canal (HDR 2021) This document provides a summary of a conditional assessment completed by HDR to evaluate the intake facilities, including the headgate structure, diversion channel, fish screen facilities, and bypass, to determine what upgrades will be needed to divert 25 cfs through these facilities to the reservoir for storage.	HDR	December 2021

1.1.5 Project Partners

The project is being developed under the direction of Clallam County Public Works Department and has the broad support of local and state government agencies, irrigators, conservation groups, and local municipalities. Project funding and development are being closely coordinated with the following project partners:

- **Washington Water Trust**, a nonprofit organization focused on working with water users to improve water use efficiency and restore instream flows. Washington Water Trust is working closely with Clallam County to secure funding and water rights, assist with public outreach, and aid in project management and implementing the project.
- **Dungeness Water Users Association**, an association representing the seven irrigation districts and companies that divert water from the Dungeness River and its tributaries. The irrigation districts on the east side of the Dungeness River will be supplied water from the reservoir and have been actively engaged in project planning and development.
- The **City of Sequim**, which is located approximately 1 mile north of the proposed project. The City has been heavily involved in planning for water resource improvements in the area. It has collaborated with Clallam County on funding for the project and evaluation of project-related elements, including the overland flow system and infiltration facilities.
- **Clallam Conservation District**, a nonregulatory subdivision of state government created to help the citizens of Clallam County conserve natural resources. They have been involved in development of this project from its inception and have played an instrumental role in the planning and implementation of irrigation efficiency projects, including the piping improvements that will be needed to deliver stored water to downstream irrigators.

State and local resource managers are also engaged in developing this project and supporting its development, as part of the Work Group. Key support has been provided by the following:

- The **Jamestown S'Klallam Tribe** is engaged in many efforts to restore habitat and passage conditions for ESA-listed fish species in the Dungeness River Watershed and is providing cultural resources support for the project.

- **Washington Department of Ecology (Ecology)** is funding the design of the project through grants provided under the Streamflow Restoration Grant Program. The work represented in this report has been completed to meet Ecology's funding requirements.
- The **Washington Department of Fish and Wildlife (WDFW)** works closely with the Jamestown S'Klallam Tribe to manage resources for fish and wildlife in the watershed. They also operate and maintain fish screens for several diversions on the Dungeness River, including the one near the HID point of diversion, and have provided key information on the condition and operation of existing intake facilities.
- **Washington Department of Natural Resources (WDNR)** currently owns the property on which the reservoir will be located. They have been actively engaged with Clallam County in negotiations to sell the property to the County for the reservoir and related facilities.

1.2 Project Need and Purpose

The proposed Dungeness Off-Channel Reservoir has been identified as critical infrastructure needed to improve the management of water resources in the Dungeness River Watershed. The hydrology of the Dungeness River is driven by rainfall in the fall and winter, and snowmelt from the Olympic Mountains which preserves flow into the summer. Naturally decreasing flows in the late summer are exacerbated by irrigation demand and other out-of-stream uses. The low flows also occur at a time that is critical to the migration and habitat conditions for ESA-listed fish species that migrate and spawn in the Dungeness River. Climate change is projected to further reduce late-summer flows.

To allow water to be managed to support both in-stream and out-of-stream needs into the future, water storage has been recommended. The proposed Dungeness Off-Channel Reservoir will divert and store water when it is available. During the critical late-summer low flow period, irrigation water supply needs will be met with water stored in the reservoir. This will allow for a reduction in diversions from the Dungeness River that will result in restored streamflows and improved agricultural water supply reliability during the late irrigation season. The project will also increase resiliency to climate change. The project also has potential to improve management of overland flows captured during storms to reduce flooding, increase infiltration to recharge the shallow aquifer and provide additional streamflow benefit, and provide opportunities for recreation,

The purpose of the project is to design, permit, and construct a reservoir with 1,600 acre-feet of storage capacity and related infrastructure on the property the County is working toward acquiring from DNR near River Road, just south of the City of Sequim. The goal of the project is to provide the following key community benefits identified by Clallam County and their key project partners.

1.2.1 Streamflow Restoration for Salmon

The proposed reservoir will store water diverted by gravity from the Dungeness River and could potentially also store overland flows captured by the HID Main Canal. Water will be released to meet

irrigation needs during the critical late-summer low-flow period (August to September). Water released from storage will allow for a corresponding reduction in diversions from the Dungeness River, which will increase flows in the river during the critical low-flow period. Increased streamflows will enhance fish passage and habitat conditions for ESA-listed salmon and steelhead. The project will contribute to a flow restoration goal of maintaining a minimum flow of 105 cfs in the river during average and wet years.

Dungeness River flows are measured at a gaging station upstream of irrigation diversions by the U.S. Geological Survey ([USGS] Gage No 12048000). Flows are also measured downstream of irrigation diversions, near the mouth of the river, by Ecology (Ecology Gage 18A050). Figure 1-3 illustrates the difference in the mean daily flow rates at the USGS Gage (green line) and the Ecology Gage (blue line) in the late summer. The difference is largely due to diversions for irrigation, which occur between April 15 and September 15. Irrigation efficiency projects have significantly reduced diversions from the Dungeness River during the last 25 years, but the potential to improve late-summer flows in the river remains substantial. The figure shows the potential increase that would occur in flows downstream of the irrigation diversions at the Ecology Gage with the reservoir in place (dashed red line) and indicates that the increase would allow water resource managers to meet the 105-cfs minimum flow targe on the river with storage in place during average flow conditions.

Figure 1-3 also illustrates the potential impact of storage on flow rates in the Dungeness River. The graph shows what the average Dungeness River flow rates are anticipated to be at the Ecology Gage (downstream of the irrigation diversions) under a scenario where water is diverted to storage in the spring and then released from storage in the late summer (dashed red line). The graph also illustrates how the proposed reservoir will enable water users to maintain a minimum 105-cfs low-flow target during an average year. Actual reservoir filling and release rates and durations will be adjusted to account for stormwater captured (if applicable), releases for SAR, precipitation, and evaporation, as discussed later in this report.

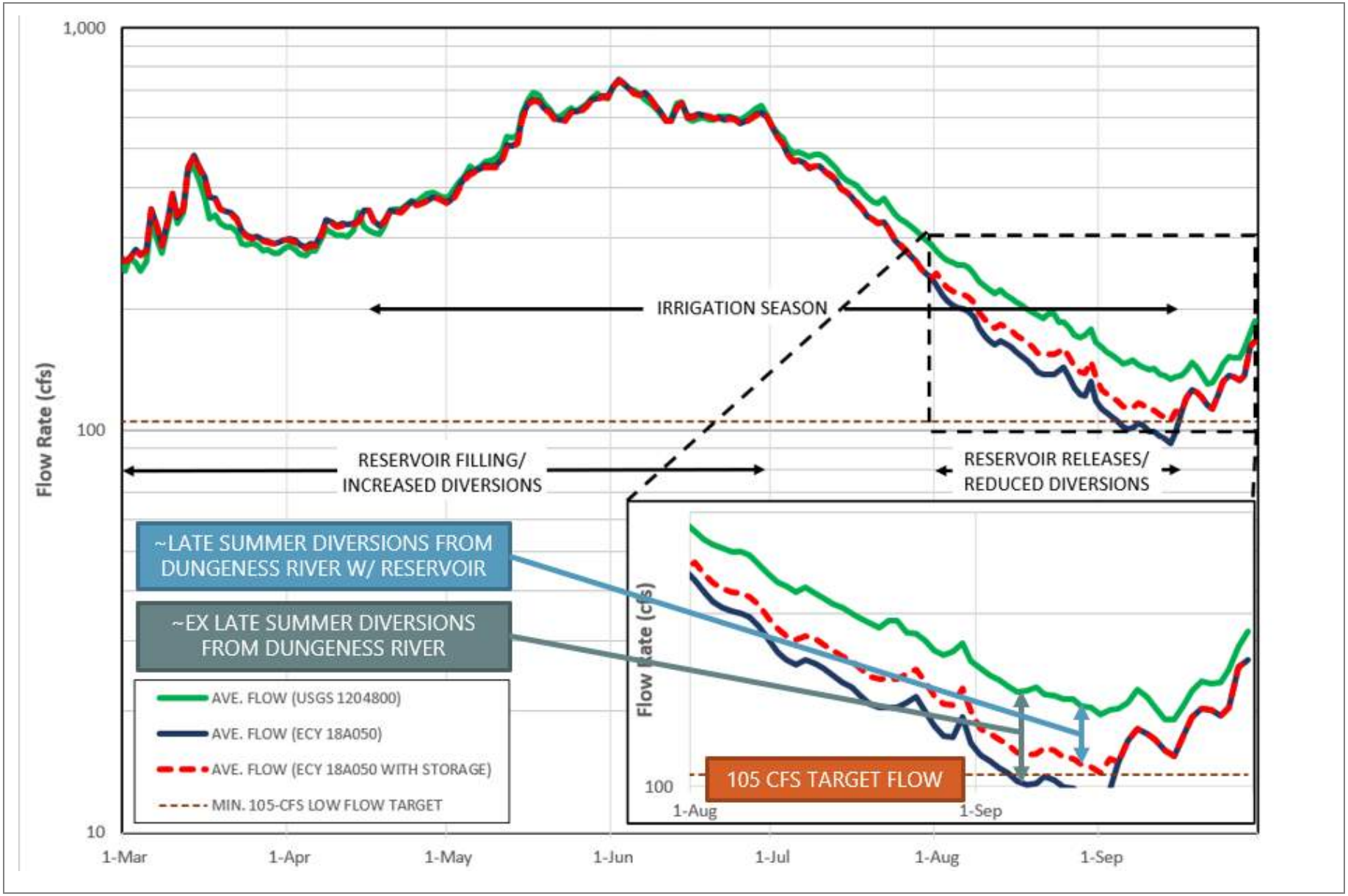

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Figure 1-3
Anticipated Impact of Storage on Dungeness River Flows
Preliminary Basis of Design Report
Dungeness Off-Channel Reservoir Project

1.2.2 Long-Term Agricultural Viability

Seven irrigation districts and ditch companies divert water from the Dungeness River, as illustrated in Figure 1-1. Three of those districts and companies divert water to irrigate properties to the east of the Dungeness River, where the proposed reservoir will be located. HID diverts water farthest upstream, at river mile (RM) 10.7, and delivers water for irrigation to land south and east of the City of Sequim. The Sequim Prairie Tri-Irrigation Association (SPTIA) serves lands in and near the City of Sequim and north of the City of Sequim. The Dungeness Irrigation District (DID) serves lands farther north and west of the City of Sequim.

With construction of irrigation pipelines downstream of the reservoir, the reservoir will be able to supply at least a portion of the water supply needed by the irrigation districts and ditch companies that divert water from the right bank (east side) of the Dungeness River. These irrigation districts and ditch companies typically divert a total of between 25 and 30 cfs from the Dungeness River in the early summer, with peak diversions in excess of 30 cfs. Not all of the properties irrigated by these diversions are downstream of the proposed reservoir location. A portion of the properties irrigated by HID are served from canals that are higher and not downstream of the reservoir. All of the properties irrigated by water conveyed through the HID H1 Lateral, the Independent Diversion, and the DID/Sequim-Prairie Diversion are downstream of the reservoir and can be supplied by gravity with reservoir water. Total diversions to these irrigation systems located downstream of the reservoir are typically between 15 and 20 cfs in the late summer, with peak diversions totaling approximately 25 cfs. Peak diversions typically occur in June and July and often have to be reduced through the late summer as less flow is available in the river. The proposed reservoir will have capacity to supply the late-summer irrigation demand on the east side of the river, except for irrigation demand at parcels served by HID that are not downstream of the reservoir. Stored water will add reliability to the irrigation supply system east of the Dungeness River because water can be diverted to storage over a longer period when water is available, then released when flows in the river are low.

1.2.3 Overland Flow Management

As noted previously, the City of Sequim has secured a grant from FEMA to investigate the potential for diverting overland flow from the HID Main Canal during peak storm events to reduce the impact of flooding in the City of Sequim. Existing irrigation ditches, including the HID Main Canal, capture and convey overland flow from hillsides in the Burnt Hill and Happy Valley areas of unincorporated Clallam County. The *City of Sequim Storm and Surface Water Master Plan* (Herrera Environmental Consultants 2015a) indicates that overland flow is incidentally captured by the HID Main Canal and conveyed through the network of irrigation ditches through the City of Sequim downtown. However, downstream culverts and connections to stormwater facilities are not sized to convey these flows, so flooding often occurs. With the funding acquired from FEMA, the City of Sequim will be investigating the potential for capturing overland flow from the HID Main Canal where the canal crosses under

Sporseen Road and Happy Valley Road. Flows would be conveyed to infiltration facilities at the reservoir site or directly to the reservoir for storage.

1.2.4 Infiltration

As part of the work to be completed with the grant funding provided by FEMA, the City of Sequim will investigate the potential for construction of infiltration facilities on the parcels being acquired from DNR for the project. The facilities would be designed to provide infiltration for overland flow intercepted from the HID Main Canal and could potentially also be used for SAR using excess stored reservoir water. Water resource managers have evaluated and implemented several SAR projects in the watershed. The SAR projects are mostly supplied through existing irrigation infrastructure and are often paired with irrigation efficiency projects. Several SAR facilities exist downstream of the reservoir and are connected to existing DID, SPTIA, and HID irrigation pipelines or laterals. Infiltration of stored water at the right time of year via one of these existing infiltration facilities or through new SAR facilities could be used to augment late-summer baseflow in the Dungeness River and small streams.

1.2.5 Climate Resiliency

Future climate change projections for the Dungeness River, provided by the University of Washington's Climate Impacts Group, show a trend toward higher late-fall and winter peak flows and lower flows in the spring and summer. The projections reflect the long-term forecast for warmer winters with more rain and less snow in the Olympic Mountains. Melting of the snowpack in the Olympic Mountains drives the peak flows in late spring and maintains flow rates through the summer. The projections indicate that climate change will result in lower peak flows in the late spring, an earlier drop in flow through the summer, and longer critical low-flow periods. This projected trend will only exacerbate water resource management challenges in the Dungeness River Watershed. The proposed Dungeness Off-Channel Reservoir will help address these challenges by allowing water users to capture and store water when there is excess for use when it is needed. In August through September of each year, east side Dungeness irrigators will use the stored water instead of diverting water from the river during its critical low flow period, increasing flows during this period by up to 50%.

1.2.6 Potential for Public Recreation Opportunities

The site is currently used by the public for a variety of recreational activities, including hiking, mountain biking, dog walking, and wildlife viewing. Old logging roads cross the existing parcel and are used to access the property by foot for these activities. Vehicular access to the site is currently blocked. The County is interested in future use of the site as a County park that would preserve some existing recreational uses and enhance recreational opportunities. The reservoir water surface will fluctuate several feet in elevation over the course of a year. In the spring and early summer, the

reservoir will be full. In the late summer, the reservoir will be nearly empty. The variation in water levels and public safety concerns will likely prevent access to and use of the reservoir itself for recreation, such as fishing, boating, or swimming. Recreational opportunities will be evaluated further by Clallam County Parks, Fair, and Facilities and the public. Design of recreational amenities will be completed as a separate project.

1.3 Report Organization

This preliminary basis of design report is organized as follows:

1. **Introduction:** Provides background on the project, including a summary of prior work, and summarizes the purpose of the project and key benefits offered.
2. **Site Assessment:** Summarizes the project locations, existing conditions observed at the site, existing irrigation infrastructure to be served by the project, and a summary of the site investigations completed to support the preliminary design.
3. **Description of Key Project Elements:** Includes a detailed description of the key elements that are included in the preliminary design of the project.
4. **Preliminary Design Analyses:** Outlines the key design criteria and summarizes the reservoir configuration evaluation, hydrologic analysis, hydraulic analysis, reservoir operations analysis, geotechnical engineering analysis, and assessment of HID intake facilities.
5. **Preliminary Cost Analysis:** Summarizes the analysis of project implementation costs, long-term operating costs, and life cycle replacement costs associated with the project.
6. **Environmental Impacts and Strategy:** Summarizes the likely environmental impacts that will result from the project, outlines anticipated permitting requirements, and provides a recommended strategy and approach to securing permits for the project.
7. **Operations, Monitoring, and Maintenance:** Outlines anticipated reservoir operations, inspection requirements, maintenance requirements, instrumentation and monitoring requirements, and reporting requirements.
8. **Conclusions and Recommendations:** Summarizes the preliminary design recommendations and outlines next steps toward completing the detailed design of the project.

2 Site Assessment

2.1 Project Location

The project site is located on Clallam County Parcels 043036210000 and 043036130000. The project falls primarily within Section 36, Township 30N, Range 04W. The location of the site is shown in Figure 1-1 and on the cover of the 30% design drawings included in Appendix A. Several sites have been evaluated for potential water storage projects in the past as part of studies summarized in Section 1. Most of the sites that were studied would have accommodated reservoirs with relatively small storage capacities, or would have required pumping to fill the reservoir or deliver water from the reservoir to existing irrigation facilities. The site identified for this project will allow for larger volumes of water to be stored and for filling the storage reservoir and releasing water from storage to downstream irrigators by gravity.

The proposed reservoir will be located on a portion of Parcel 043036210000 that slopes gently from south to north. The site is elevated above the adjacent Dungeness River, which flows from south to north along the west side of the site. Foothills of the Olympic Mountain Range rise to the south, east, and west of the site.

2.2 Existing Site Conditions

Parcel 043036210000 consists of approximately 319 acres currently owned by DNR. It is generally located west of River Road and east of the Dungeness River, approximately 1 mile south of the City of Sequim. The parcel is managed by DNR and a large portion of the timber on the site was harvested between 1994 and 2015. The site is now covered with large stumps left from logging activities, grasses, shrubs, and small trees (see photographs in Appendix B). Vehicular access to the site is blocked, but the old logging roads that cross the site are used by the public to access the site by foot, bicycle, or horseback for recreation. The HID H1 Lateral bisects the site, flowing from south to north. The HID H1 Lateral conveys water to other HID laterals, the Eureka Main Canal, and downstream connections with the Independent Canal system and other laterals north of the proposed reservoir location.

Parcel 043036130000 consists of approximately 77 acres that are also currently owned by DNR. This parcel is generally located south of Happy Valley Road and east of River Road. The HID Main Canal crosses this parcel along a relatively steep hillside from southwest to northeast, where it passes through culverts under Sporseen Road and under Happy Valley Road. The parcel is still mostly covered with trees and extends up the hillside east of River Road.

Notable site conditions and constraints within these parcels include the following:

- **Clallam County Roadways:** The parcels are bordered or bisected by Clallam County public right-of-way along River Road, which generally runs north and south; Happy Valley Road, which generally runs east and west; and Sporseen Road, which generally runs north-south perpendicular to Happy Valley Road.
- **BPA Transmission Lines and Easement:** BPA transmission lines cross both parcels in a cleared easement that extends generally east and west across both parcels. The cleared easement is clearly visible on aerial photographs and has been mapped on the 30% drawings based on a legal description of the easement provided by Clallam County.
- **Recreational Trails:** Parcel 043036210000 includes a network of trails, some of which were originally constructed for timber harvest, that are used by the public to access the site by foot, bicycle, or horseback for recreation. A local mountain biking group maintains the trail system on a volunteer basis.
- **Utilities:** In addition to the BPA transmission lines, there are utilities within and adjacent to River Road and Happy Valley Road. These include a 12-inch water transmission main that is owned by the City of Sequim. The main is buried under River Road along the south end of the site and then extends northeast from River Road across Happy Valley Road and private parcels east of the north end of the site. Utilities may also include communications and powerlines. The presence and locations of all existing utilities have not yet been verified.
- **Dumped Materials:** The site has been used in the past as an unauthorized location for dumping. These are documented in the *Proposed Dungeness Reservoir Project, Phase 1 Environmental Assessment, DNR River Road Properties* (Anchor QEA 2021a), the *Proposed Dungeness Reservoir Project, Phase 2 Environmental Assessment, of the Old Sequim Dump Site* (Anchor QEA 2022), and the *Cultural Resources Inventory for the Dungeness Streamflow Restoration Off-Channel Reservoir Project, Clallam County, Washington* (Dudek 2021). The following two general sites were identified in historical documents, through discussion with WDNR, and through site investigations:
  - **Happy Cat Debris Scatter:** This site is located just northwest of the intersection of River Road and Happy Valley Road. The material is not readily visible but is reported to be present in an area where trees were not harvested. The material is reported to consist of approximately four to five pickup truck loads of household debris that was dumped at the site dating back to the 1930s and 1940s. Evidence of this material was found during cultural resource site investigations (Dudek 2021).
  - **Old Sequim Dump:** This site is located at the south end of the site, south of the BPA easement and west of River Road. Dumping activity is reported to have occurred primarily between the 1930s and 1950s and ceased prior to the mid-1970s. The debris includes a mix of painted and rusted appliances, automobiles, and other materials, including some former automotive fuel tanks. This area was the focus of the site

investigations that were completed as part of the *Proposed Dungeness Reservoir Project, Phase 2 Environmental Assessment, of the Old Sequim Dump Site* (Anchor QEA 2022). Groundwater monitoring at this site is ongoing.

- **Dungeness River and Bluff:** The Dungeness River flows from south to north just west of the proposed reservoir site. The site drops off steeply along the west side down a bluff to the Dungeness River. The bluff is characterized in more detail in the *Draft Phase 1 Geotechnical Data Report, Dungeness Off-Channel Reservoir* (Shannon & Wilson 2021a). The bluff is steep and eroding in places. Other portions of the bluff are heavily vegetated.
- **Private Property:** The project parcels are bordered to the north, south, and east by private, rural residential properties. The Dungeness Meadows housing development is located northwest of the proposed reservoir site adjacent to the Dungeness River behind (east of) the Dungeness Meadows levee.

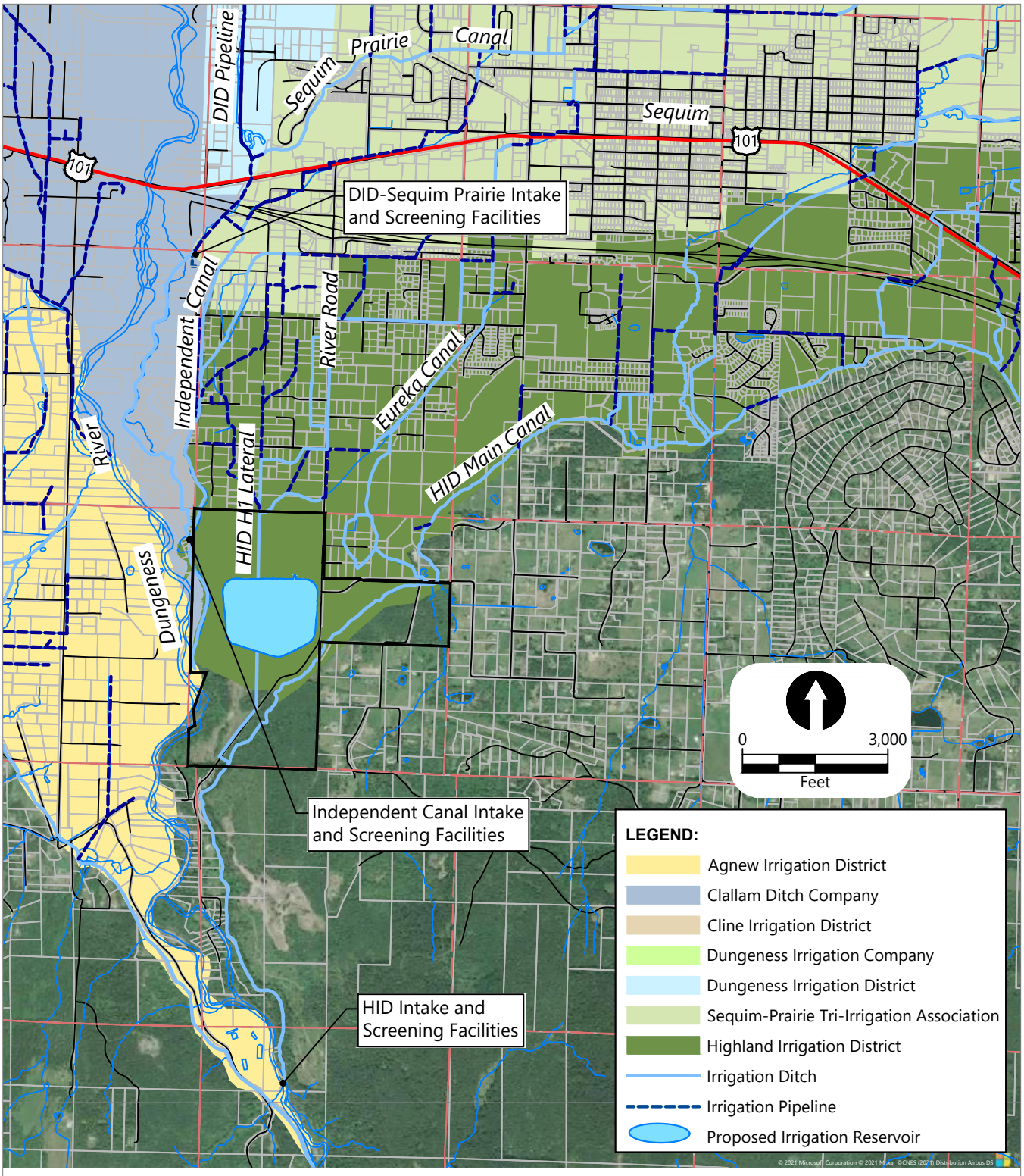
2.3 Existing Irrigation Infrastructure

Figure 2-1 shows the existing irrigation infrastructure located near the proposed reservoir. As noted previously, there are three irrigation entities (HID, SPTIA, and DID) that divert water from the right bank (east side) of the Dungeness River. Key infrastructure is summarized in the following paragraphs.

2.3.1 Highland Irrigation District

As noted previously, HID diverts water from the Dungeness River at RM 10.7 and is the highest of the three ditch or canal delivery systems that divert water from the right bank (east side of the Dungeness River). The HID Main Canal extends north and east from the point of diversion along the edge of the foothills south of Sequim. The canal is primarily an open, unlined canal. However, some segments of the canal have been piped. A series of laterals, consisting of open ditches and pipelines, extend north from the HID Main Canal to deliver water to irrigators. The H1 Lateral, which bisects the reservoir site from south to north, is one of these laterals. HID serves irrigation water to an area that is primarily south and east of the City of Sequim. Most of the areas served by HID are connected to ditches that are higher in elevation than the reservoir and will not be able to be served by gravity with water released from the reservoir.

From 2015 to 2020, the average diversions to the HID Main Canal from the Dungeness River were typically between 8 cfs and 10 cfs during June and July, decreasing to approximately 4 cfs by the end of the irrigation season in mid-September. HID's peak diversions were just under 14 cfs during this time period.



SOURCE: Basemap prepared from Clallam County GIS Data.
HORIZONTAL DATUM: Washington State Plane North Zone, NAD83, U.S. Survey Feet
VERTICAL DATUM: NAVD88

Publish Date: 2022/03/04 3:31 PM | User: drice
Filepath: K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\1439-BODR-003 (Ex Irr Infrastructure Map).dwg Figure 2-1

ANCHOR QEA

Figure 2-1
Existing Irrigation Infrastructure

Preliminary Basis of Design Report
Dungeness Off-Channel Reservoir Project

2.3.2 Sequim Prairie Tri-Irrigation Association

SPTIA was created with the merger of the Sequim Prairie Ditch Company, the Eureka Ditch Company, and the Independent Irrigation Company. SPTIA owns and operates the Independent Canal Diversion, which is located on the right bank of a side channel on the Dungeness River at RM 8.8. The Independent Canal runs north along Riverside Road and crosses U.S. Highway 101 in an inverted siphon that originates near Turnstone Lane and then continues to the north and east through the City of Sequim to irrigated parcels north, east, and within the City of Sequim. The portion of the Independent Canal south of U.S. Highway 101 is primarily open, unlined canal. Much of the canal system located north of U.S. Highway 101 is piped. A network of laterals, consisting of both open ditches and pipelines, supplies water to users both north and south of U.S. Highway 101.

From 2015 to 2020, the average diversions to the Independent Canal from the Dungeness River were typically between 4 cfs and 7 cfs from early May through mid-July and decreased to approximately 2 cfs by the end of the irrigation season in mid-September. Peak diversions to the Independent Canal were just over 8 cfs during this time period.

SPTIA shares the Sequim Prairie-Dungeness diversion with DID. The diversion is located on the right bank of the Dungeness River, just south of U.S. Highway 101 at RM 7.2. A shared SPTIA-Dungeness pipeline conveys water from the diversion to a bifurcation located north of West Washington Street in the City of Sequim. A new piping manifold at the bifurcation splits the flow in the pipeline between the SPTIA and DID systems. The Sequim Prairie Main Canal extends east from the bifurcation to deliver water to irrigated lands north, east, and within the City of Sequim. Laterals extend north from the Sequim Prairie Main Canal to parcels north of the canal. The Sequim Prairie Main Canal is a combination of open, unlined canal and a few segments of pipeline. Many of the laterals in the system have been piped.

From 2015 to 2020, the average diversions to the shared SPTIA-DID pipeline from the Dungeness River were typically between 12 cfs and 14 cfs from early May through late July and decreased to less than 1 cfs by the end of the irrigation season in mid-September. Peak diversions to the Independent Canal were just over 17 cfs during this time period.

2.3.3 Dungeness Irrigation District

As noted previously, DID shares a diversion with SPTIA on the right bank of the Dungeness River, just south of U.S. Highway 101 at RM 7.2. DID serves irrigation to parcels located north of the City of Sequim within a relatively narrow band east of the Dungeness River. The DID delivery system is now entirely enclosed in pipelines and is operated as a closed system from the diversion to the end of the system. The pipelines range in size from 12-inch diameter to 30-inch diameter. DID installed a pressure-reducing station at the downstream end of the system because the elevation difference between the diversion and the downstream end of the system resulted in excessive pressures at the

downstream end where DID's largest water users take water from the system. DID has expressed a desire that the pressures in the system not be increased by taking water from the reservoir, which will be substantially higher than the existing diversion. Delivery of reservoir water to the DID system will require some kind of pressure-reducing feature or pressure break that will allow DID to operate at pressures similar to those generated at the existing diversion.

2.4 Summary of Site Investigations

Several site investigations were completed, as outlined in the design team's approved scope of work, to support the development of preliminary designs for the project. Most of the site investigations were scoped as multi-phase efforts, where an initial set of data were collected to help define critical elements of the project. Another phase of more focused site investigations will be completed to supplement the preliminary site investigations as part of the detailed design phase of the project.

2.4.1 Cultural Resources Investigation

Ecology, the funding agency for the design effort, is responsible for complying with Governor's Executive Order (EO) 21-02, which requires state agencies and those receiving state funding to consider potential effects to cultural resources for state-funded projects. EO 21-02 does not apply to federally assisted projects that are reviewed under Section 106 of the National Historic Preservation Act. However, early in project development, a Section 106 nexus had not been identified, so Ecology reviewed the project under EO 21-02. Both EO 21-02 and Section 106 require inventory and evaluation of historic properties (prehistoric and historic sites, structures, districts, and objects) that are eligible for the National Register of Historic Places (NRHP). For EO-21-02, properties eligible for the Washington Heritage Register (WHR) are also included.

Under Ecology's direction, Clallam County hired Dudek to conduct a preliminary archaeological survey of the proposed reservoir area (Dudek 2021). Archaeological survey and research revealed no significant archaeological resources in the proposed reservoir area. Two archaeological sites were identified within the project area, both surface historic debris scatters (45CA524 and 45CA725) associated with dumping on the site during the 20th century, as previously noted. Both have been determined not eligible for listing in the NRHP or WHR, and they are not further considered under EO 21-02 or Section 106.

Based on the results of the survey, Ecology prepared a Preliminary Determination of low risk to cultural resources. Clallam County submitted the Dudek report to Ecology, and Ecology shared the report and Preliminary Determination with the Department of Archaeology and Historic Preservation (DAHP) and Native American Tribes in February 2021. Based on responses received from DAHP and

Tribes, Ecology made a Final Determination of low risk to cultural resources in March 2021. The Final Determination included conditions for future project activities, as follows:

- In order to avoid cultural resources impacts, Ecology required that an inadvertent discovery plan (IDP) be developed for the project. The recipient must follow the IDP protocol. In the event that archaeological deposits are inadvertently discovered during construction in any portion of the project's Area of Potential Effect, ground-disturbing activities should be halted immediately in an area large enough to maintain the integrity of the deposits. The DAHP, affected Tribes, and Ecology must be notified. Appropriate treatment of the archaeological resources and/or human remains would be determined among these parties.
- Once designed, if the proposed project includes potential ground-disturbing activities outside of the tested reservoir boundary and within any of the High Probability Areas identified in the survey, further archaeological investigations are recommended to test for buried cultural deposits prior to construction.

In fulfillment of the first condition listed above, an IDP has been developed for the project and approved by Ecology. Future activities in compliance with the second condition, and with Section 106, are described in Sections 6.1.6 and 6.2.1.

2.4.2 Environmental Site Assessment

Phase 1 and Phase 2 Environmental Site Assessments have been completed to evaluate areas at the site that have been used for dumping, as noted previously. The results are summarized in the *Proposed Dungeness Reservoir Project, Phase 1 Environmental Assessment, DNR River Road Properties* (Anchor QEA 2021a) and the *Proposed Dungeness Reservoir Project, Phase 2 Environmental Assessment, of the Old Sequim Dump Site* (Anchor QEA 2022).

2.4.2.1 Phase 1 Environmental Site Assessment

The Phase 1 Environmental Site Assessment consisted of a site visit to document dumped material that was visible from the surface, desktop research of historical documents characterizing the land uses and activities that led to dumping, and discussions with current and past DNR employees who have managed the property. As noted previously, the Phase 1 Environmental Site Assessment identified dumped material at two locations and characterized the findings as follows:

- **Old Sequim Dump Site:** This site is located at the south end of the property, south of the BPA easement and west of River Road at the bottom of a steep slope in an area that is mostly covered with trees and vegetation. The assessment found that the dumped material was placed on the property primarily between the 1930s and 1950s, with dumping activity ceasing prior to the mid-1970s. It contains car bodies, car parts, household appliances, and other debris and solid wastes. The debris includes a mix of painted and rusted (free of paint) materials, and some former automotive fuel tanks. The quantity of wastes and debris is

significant, estimated by DNR records to cover an area of 250 meters by 30 meters. The wastes appear superficial, lying on the top of the native soils rather than constituting a thick fill deposit. Some of the materials have decayed and are mixed with the surficial soil. Some of the car bodies remain on the steep hillside, and some have been raised into the air by the growth of trees through the materials. During prior timber sales, the dump site has been retained within a leave tree area. Given the presence of painted car bodies from the early to mid-1900s, there is a potential for paint-related metals to have become incorporated into soils in the dump site area. The presence of automotive debris, including former fuel tanks, indicates some potential for releases of oil or gasoline to soils, though no obvious signs of such contamination were observed. This area will not be impacted by reservoir construction.

- **Happy Cat Debris Scatter:** Smaller areas of apparent household debris are known to be present in the northeastern quarter of the reservoir site, just northwest of the intersection of River Road and Happy Valley Road. This is a much smaller quantity of materials, described by DNR records as four to five pickup truck loads. The materials are believed to be from the 1930s or 1940s, with one truck load from the 1960s. During recent timber sales, the debris scatter materials were left within an existing leave tree area on the property. The materials are present within the area that will be disturbed by reservoir construction and staging activities. They will need to be removed and appropriately disposed at that time. Given the history of household waste dumping at the property, other materials may also be encountered during reservoir construction. The quantity of such materials is not likely to be significant within the context of the proposed project.

The Phase 1 Environmental Site Assessment offered the following recommendations:

- Further work should be performed to quantify the nature and extent of the Old Sequim Dump materials and develop a cost estimate for appropriate removal and disposal of the materials and any associated contaminated soils.
- Removal and appropriate disposal of the materials from the Old Sequim Dump was recommended because the materials represent an uncontrolled solid waste deposit, they are likely to contain or to have previously contained hazardous substances, they may continue to release hazardous substances to soils (e.g., through corrosion of painted surfaces), and in some cases they represent physical hazards to current and future property users.
- Completion of a limited Phase 2 Environmental Site Assessment (i.e., limited soil and groundwater testing) was recommended prior to completion of property acquisition to define better the work and costs associated with removal and disposal of dumped materials.
- No further environmental testing was recommended for the Happy Cat Debris Scatter. The available information indicates that these scattered waste deposits are small and contain nonhazardous materials (e.g., bottles, cans, glass). It was recommended that provisions for

debris management be considered as part of future reservoir construction in the event that deposits of household debris are encountered during site grading activities.

2.4.2.2 Phase 2 Environmental Site Assessment

The Phase 2 Environmental Site Assessment included limited testing of soil and installation of a groundwater monitoring well at the Old Sequim Dump to allow for groundwater quality testing, as recommended in the Phase 1 Environmental Site Assessment. Additional field work was completed to define the dump area, sample and test soils from the area, and sample and test groundwater. As a follow-up to the initial testing, a shallow groundwater well was installed to allow for additional monitoring of groundwater quality. The monitoring well is located at the end of an access road adjacent to the dump site. The Phase 2 work resulted in the following findings:

- A limited amount of soil and groundwater contamination is associated with the dump, located in the southern portion of the property. Additional actions will be required to correct those conditions.
- The location and overall footprint of the dump are generally consistent with previous information provided by DNR. Mapping of the dump materials indicates that the waste debris covers an irregularly shaped area of approximately 1 acre.
- The extent of existing soil contamination at the property appears to be limited based on the work that was completed. Exceedances of Model Toxics Control Act (MTCA) soil cleanup levels were detected in only one of the seven soil samples analyzed.
- Detected soil contaminants included cadmium and lead, both of which are common in older paint formulations. These contaminants were likely released to the soil during decomposition (i.e., flaking and rusting) of painted metal debris present in the dump.
- Results of testing confirm that some hazardous substances are present in the waste materials and have the potential to release additional contamination to surface soils if the waste materials are not removed.
- Groundwater testing included analysis for a wide range of parameters. No impacts to groundwater were present for heavy metals, polycyclic aromatic hydrocarbon compounds, volatile organic compounds, gasoline, or diesel hydrocarbons. However, low levels of oil-range hydrocarbons were identified in one of three groundwater samples collected adjacent to the dump from temporary soil borings.
- Exceedance of groundwater cleanup levels at that location was confirmed in follow-up testing performed using a groundwater monitoring well installed adjacent to the original testing location. The concentrations exceeded the cleanup levels by less than 20% in that location.

Based on the findings of the Phase 2 Environmental Site Assessment, the following additional work was recommended:

- Waste materials should be removed. Given the type and quantity of waste materials present, a thin layer of soil and some trees and other vegetation will also need to be removed along with the wastes.
- Waste removal, with confirmation testing of soils to confirm that no contaminated soil remains, is recommended to restore compliance of the dump site soils with Washington's MTCA cleanup regulations. Some additional groundwater testing may also be required to verify that no additional actions (beyond waste removal) are required to resolve groundwater quality concerns associated with the dump.

2.4.3 Geotechnical Explorations

The subsurface conditions at the project site are being explored in a phased approach to provide relevant subsurface information as the design progresses. The first phase of geotechnical exploration (Phase 1) completed to support the preliminary design is summarized in the *Draft Phase 1 Geotechnical Data Report, Dungeness Off-Channel Reservoir* (Shannon & Wilson 2021a).

During the Phase 1 exploration program, Shannon & Wilson observed the drilling of seven borings and the excavation of eight test pits to characterize the subsurface conditions at the proposed reservoir site. The borings, including one drilled as a shallow groundwater monitoring well as part of the Phase 2 ESA work, ranged from 25 to 150 feet deep. The test pits reached depths of 12 to 15 feet. Soil samples retrieved from the explorations were reviewed by a geologist, and soil boring logs and test pit logs were prepared. Laboratory gradation and Atterberg limits tests were conducted on selected samples.

To further understand the subsurface conditions at the site, Shannon & Wilson completed a geologic reconnaissance of the site, the bluff above the Dungeness River along the west side of the site, and soil exposures east of River Road. Based on the geologic reconnaissance, subsurface explorations performed by Shannon & Wilson, subsurface explorations previously performed by Anchor QEA, and review of published data, the *Draft Phase 1 Geotechnical Data Report* concludes that the surficial soil at the site to depths of about 10 to 20 feet below the ground surface (bgs) is composed of older alluvium consisting of silt, sand, gravels, cobbles, and boulders. The cobbles and boulders make up about 15% to potentially greater than 50% of this deposit. The older alluvium is underlain by layered glacial recessional outwash, glaciolacustrine deposits, and glacial drift deposits to depths ranging from about 15 to 35 feet bgs. These materials are underlain by a 40- to 70-foot-thick, low-hydraulic-conductivity layer of glacially overridden till. Glacially overridden advance outwash and glaciolacustrine deposits, consisting primarily of silt and sand, were encountered below the glacial till in the deeper borings. Glacially overridden till and advance outwash are generally denser than

recessional deposits due to compaction by the overriding glacier. Bedrock was not encountered in the explorations.

Groundwater observation wells and vibrating wire piezometers (VWPs) were installed in the borings. Preliminary groundwater measurement data collected during September and October 2021, and interpretations made during the drilling program, suggest little free groundwater is present above the glacial till, and the groundwater that is present is locally perched in sand layers in the glacial recessional outwash, glaciolacustrine deposits, and glacial drift deposits or perched above the glacial till. VWPs installed in the glacial advance outwash and glaciolacustrine deposits below the glacial till indicate an unconfined groundwater surface is present 95 to 100 feet bgs at these exploration locations. This deep groundwater surface elevation is below the Dungeness River elevation west of the site. The groundwater conditions likely vary throughout the year and from year to year. The limited groundwater measurement data obtained during the short, late-fall, pre-wet season, groundwater monitoring period may not be representative of year-round conditions. Wet season data is not yet available but will be available early in the spring of 2022.

The *Draft Phase 1 Geotechnical Data Report* (Shannon & Wilson 2021a) presents details about the geologic reconnaissance, subsurface exploration program, groundwater monitoring, soil laboratory testing, and geologic interpretation of the site. At least one more phase (Phase 2) of geotechnical exploration will be required to collect additional data to support final design.

2.4.4 Topographic Survey

Limited topographic survey was completed to support the preliminary design, including the following work:

- Topographic survey of the thalweg of the HID H1 Lateral through the reservoir parcel. This included survey of key points along the thalweg of the H1 Lateral from the HID Main Canal through the reservoir parcel to the north parcel boundary to verify key existing ditch elevations at the reservoir and associated structures. Survey points were gathered at least once every 50 feet, including at changes in slope, at changes in direction, and at culverts.
- Topographic survey of the HID Main Canal at the location of the inlet flow control structure that will be designed to control flow from the HID Main Canal to the reservoir. This included survey of the area that covers the HID Main Canal from the existing structure that controls flow from the canal to the H1 Lateral downstream for nearly 100 feet. The trail access to the canal from River Road was also surveyed.

Contours generated from publicly available Light Detection and Ranging (LiDAR) data were used as a basis for the preliminary grading and design of the reservoir embankment and other features. Aerial photography and publicly available GIS data were also compiled and used as a basemap to support preliminary design.

Additional topographic survey data and mapping will be required to support the detailed design of the reservoir and appurtenances. The scope and the extent of the survey will be focused to support what is needed based on the completed preliminary design layout. The additional survey needed will likely include the following:

- High-resolution aerial survey of the entire area to be disturbed by the reservoir project, supplemented as needed with hand surveys to complete an accurate basemap of existing conditions at the site.
- Additional surveys of pipeline alignments extending beyond the area to be disturbed by reservoir construction.
- Topographic survey of intake facilities, including the Dungeness River channel at the headgate structure, the headgate structure, the diversion canal, the fish screening structure, related gates and channels, the Parshall flume, and other features adjacent to these facilities.
- Field location and survey of utilities in River Road and any other utilities adjacent to or on the site, so that those utilities can be added to the basemap of existing conditions.
- Topographic survey to support design of any additional or related project elements that are added to the detailed design scope of work for the project.

2.4.5 Wetland and Ordinary High-Water Mark Delineation

Anchor QEA staff performed a wetland reconnaissance and delineation and ordinary high-water mark (OHWM) delineation on October 27, 2021. The delineation included the proposed reservoir site, the HID intake facilities, and the portions of the H1 Lateral that will be converted to pipeline.

Prior to conducting the site visit, background materials such as the Natural Resources Conservation Service (NRCS) *Web Soil Survey* (NRCS 2021), *National Wetland Inventory* (NWI; USFWS 2021), and *Priority Habitats and Species on the Web* (PHS; WDFW 2021a) were reviewed. NRCS (2021) identifies Carlsborg gravelly sandy loam (0% to 5% slopes and 15% to 30% slopes) as present on the proposed reservoir site, lateral ditch area, and intake. These soils are moderately to excessively well drained and not listed as hydric soils (SCS 1987). NWI does not identify any wetlands present in the study area but shows the irrigation ditches in both correct and incorrect locations. PHS identifies the potential for fisher (*Martes pennanti*) and northern spotted owl (*Strix occidentalis*) within the study area township, and pink and coho salmon (*Oncorhynchus gorbuscha* and *O. kisutch*) and winter steelhead (*O. mykiss*) in the Dungeness River and irrigation canals.

In general, the study area is an upland Douglas fir (*Pseudotsuga menziesii*) forested area that has undergone timber harvest in different years on different parts of the site. Approximately half of the site was harvested approximately 6 years ago, and the other half of the site was harvested between 1994 and the early 2000s. The bluff slope and riparian zone along the Dungeness River are dominated by big-leaf maple (*Acer macrophyllum*), black cottonwood (*Populus balsamifera*), red

alder (*Alnus rubra*), and western red cedar (*Thuja plicata*), with willow (*Salix* sp.) vegetated bars and islands.

2.4.5.1 Wetland Delineation and Classification Methods

Wetlands were delineated using the methods in the U.S. Army Corps of Engineers (USACE) *Wetland Delineation Manual* (USACE 1987) and the *Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Western Mountains, Valleys, and Coast Region* (Version 2.0; USACE 2010). Wetland ratings were performed using the Clallam County Code definitions for watershed functions, landscape functions, and wetland hydrologic functions. Buffers were identified using the Clallam County Code Chapter 27.12, Critical Areas. Supporting resources used included the Munsell Soil Color Charts (2009 Edition; Munsell 2009) and *Flora of the Pacific Northwest* (Second Edition; Hitchcock and Cronquist 2018). Wetland plant indicator status was obtained from the USACE National Wetland Plant List website (USACE 2021).

The delineation was conducted by sampling representative plots within the study area. This methodology was designed to identify the range of vegetation communities and topographies present on the site. At each sample plot, indicators of vegetation, hydrology, and soils were documented.

Wetland ratings were determined using the most current version of Ecology guidance in the *Washington State Wetlands Rating System for Western Washington: 2014 Update* (Hruby 2014). The Clallam County Code, Section 27.12, classifies wetlands into four categories. The classification is different from the Ecology rating system (Hruby 2014) and is based on size, type, and presence of native vs. non-native species.

2.4.5.2 Ordinary High Water Delineation Methods

According to the USACE (2005; 33 CFR Sections 328.3[e] and 329.11[a][1]), an OHWM is a "…line on the shore established by the fluctuations of water and indicated by physical characteristics such as a clear, natural line impressed on the bank, shelving, changes in the character of soil, destruction of terrestrial vegetation, the presence of litter and debris, or other appropriate means that consider the characteristics of the surrounding areas."

The USACE determines, on a case-by case basis, the extent of geographic jurisdiction for the purpose of administering its regulatory program. For purposes of Section 404 of the Clean Water Act (CWA), the lateral limits of jurisdiction over nontidal waterbodies extend to the OHWM, in the absence of adjacent wetlands. When adjacent wetlands are present, CWA jurisdiction extends beyond the OHWM to the limits of the adjacent wetlands.

The methodology for determining the OHWM as described in *Determining the Ordinary High Water Mark for Shoreline Management Act Compliance in Washington State* (Anderson et al. 2016) was

followed to identify the OHWM at representative locations along the Independent Canal (directly connected to the river and flowing all year) and the Dungeness River.

Field data points were collected with a Trimble GeoExplorer 6000 Series GeoXH hand-held GPS, including OHWM points, sample data plot locations, and wetland boundary points. Where the river could not be accessed, the OHWM was estimated using aerial photographs and visual observation from the study area (e.g., top of the vertical bluff). The wetland sample plots were collected in GPS and the boundaries were determined based on an elevation where hydrophytic vegetation disappeared.

2.4.5.3 Results

Anchor QEA staff walked general transects across the reservoir study area to identify vegetation communities across the site and look for wetlands. Anchor QEA staff also walked along the hill upslope of the HID diversion canal and along the upstream end of the HID Main Canal from the intake structure to the downstream side of the fish screens to look for wetlands. A total of 10 sample plots were completed within the proposed reservoir study area, representing the vegetation community types and topographic areas. Additional soil pits were dug on the slope above the intake to determine that hydric soil indicators were not present. As a result of this sampling, one palustrine emergent wetland, designated as Wetland 1, was identified and delineated in October 2021. The results of the delineation are shown in Figure 2-2.

2.4.5.3.1 Wetland

Wetland 1 is located within an excavated borrow pit underneath the BPA powerlines. The wetland is occasionally inundated by precipitation, local runoff, and possibly by groundwater. The wetland boundary was determined where hydrophytic vegetation was no longer dominant or there was bare ground. Wetland 1 was classified as a palustrine emergent wetland and rated as a Category III wetland using the Ecology rating methodology (Hruby 2014), and as a Category IV wetland using the Clallam County Code (CCC 27.12.210).

Plot 2: This sample plot was located in the lowest part of the borrow pit. The dominant vegetation was creeping bentgrass (*Agrostis stolonifera*; facultative [FAC]) and young saplings of black cottonwood (FAC). Patches of narrow-leaved cattail (*Typha angustifolia*; obligate [OBL]) and spikerush (*Eleocharis palustris*; OBL) were also present, but not dominant over the whole wetland. The soil was entirely large cobbles and boulders and a soil pit could not be dug. No water was present at the time of the delineation, but based on geomorphic position and a subsequent site visit on December 1, 2021, it was determined that water inundates this wetland seasonally following heavy rains. This sample plot was determined to be wetland, as shown in Photographs 2-1 and 2-2.

Boundary Determination: The wetland boundary was determined to be located where hydrophytic vegetation was no longer dominant and upland species and bare ground were dominant. Vegetation

included sword fern (*Polystichum munitum*, facultative upland [FACU]), tall fescue (*Schenodorus arundinaceus*; FAC), pearly everlasting (*Anaphalis margaritacea*, FACU), and trailing blackberry (*Rubus ursinus*; FACU). Neither soil nor hydrology indicators were present at the time of delineation.

Photograph 2-1
Sample Plot 2 Looking Southwest (October 2021)

Photograph 2-2
Wetland 1 Looking West (December 1, 2021)

2.4.5.3.2 Irrigation Ditches

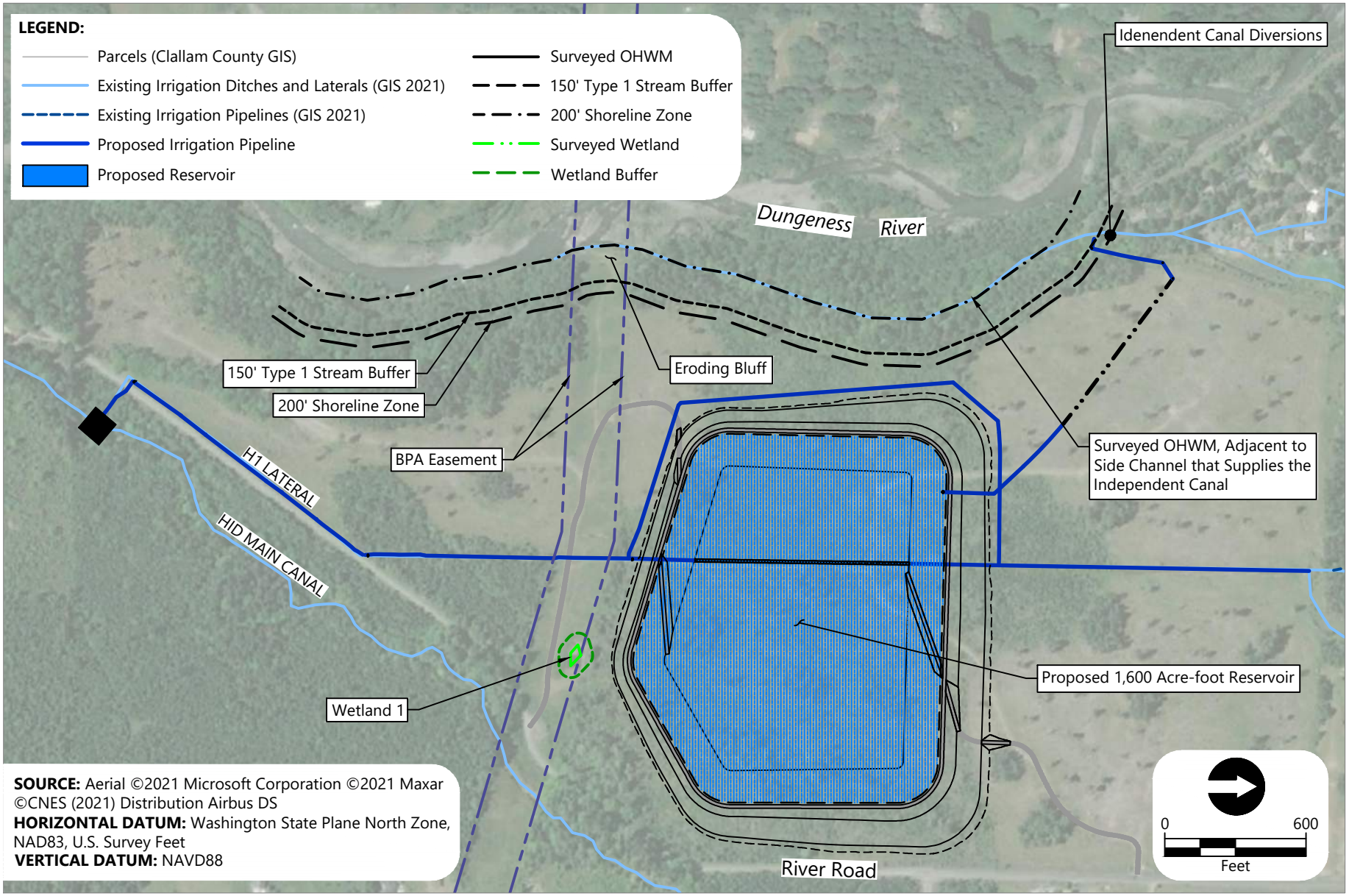
The HID Main Canal and the H1 Lateral that flow through the proposed reservoir site are excavated in uplands. At the time of the site visit, water was flowing in the HID Main Canal (for year-round stock watering) but the H1 Lateral was dry (only flows during the irrigation season from April 15 to September 15), as shown in Photograph 2-3. At a subsequent site visit on December 1, 2021, the H1 Lateral was flowing with about 1 inch of water from heavy rain the prior day. At a representative sample plot along the lateral irrigation canal, the vegetation was dominated by upland species including salal (*Gaultheria shallon*; FACU), trailing blackberry (*Rubus ursinus*; FACU), thimbleberry (*Rubus parviflorus*; FACU), and Douglas fir saplings (FACU) in the shrub layer and bracken fern (*Pteridium aquilinum*; FACU) and small willow herb (*Epilobium munitum*; FACU). The canal bed is gravelly, with ordinary high water approximately 12 inches above the bed. The open irrigation canals convey water from the Dungeness River to the proposed reservoir site and then via canals and pipes to downstream water users. Any water that remains in the system eventually returns to Geirin Creek,

which flows into Sequim Bay approximately 2 miles east of the Dungeness River. The HID Main Canal is presumed to be a jurisdictional waterbody (stream) at this time. The USACE has recommended that a request for a Preliminary Jurisdictional Determination be submitted in order to determine whether the USACE is likely to exert jurisdiction on this canal (P. Sanguinetti, USACE, pers. comm. 2021).

Photograph 2-3
HID H1 Lateral Looking Southwest (October 2021)

2.4.5.3.3 Ordinary High-Water Mark Results

The Dungeness River OHWM was delineated along the base of the bluff slope at the woody vegetation line and where there were scour or deposition lines. This generally followed the Independent Canal's diversion channel, which flows year-round as a side channel of the river, with some flow entering through the headgate structure year-round for stock watering, and the remainder of the side channel flow continuing into a secondary side channel and the river. Provisional streamflow during the OHWM delineation was 650 cfs (USGS 2021). The OHWM is mapped as shown in Figure 2-2.



Publish Date: 2022/01/03 6:50 AM | User: drice
Filepath: K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\1439-BODR-004 (Wetland and OHWM Map).dwg Figure 2-5

ANCHOR QEA

Figure 2-2
Wetland and OHWM Delineation Map

Preliminary Basis of Design Report
Dungeness Off-Channel Reservoir Project

2.4.6 Infiltration Potential and Hydrogeology

As summarized in the *Draft Phase 1 Geotechnical Data Report, Dungeness Off-Channel Reservoir* (Shannon & Wilson 2021a), seven borings and eight test pits were completed at the site to evaluate subsurface soil conditions in support of the preliminary design. Standpipe groundwater monitoring wells were installed in five borings. VWPs were installed in six of the borings to monitor groundwater conditions near the proposed reservoir site. A monitoring well was also installed in the boring south of the proposed reservoir site to allow for groundwater sampling and monitoring associated with the Phase 2 Environmental Site Assessment.

Observations made from the data collected, engineering analyses, and geotechnical engineering recommendations are summarized in the *Draft Phase 1 Conceptual Geotechnical Engineering Report, Dungeness Off-Channel Reservoir* (Shannon & Wilson 2021b). The explorations generally encountered approximately 15 to 30 feet of surficial alluvium, recessional glacial outwash, and glaciolacustrine deposits, underlain by 40 to 70 feet of glacial till, underlain by advance glacial outwash and glaciolacustrine deposits. The following is an overview of key findings related to groundwater conditions and hydrogeology at the site:

- The surface alluvium, recessional outwash, and deposits above the till layer are expected to be relatively free draining with higher hydraulic conductivities, while the till layer is expected to have much lower hydraulic conductivity. Within these sediments, zones of low vertical hydraulic conductivity may cause preferential horizontal flow, but these zones may not be continuous. In contrast, the till layer would have much lower hydraulic conductivity both in the horizontal and vertical flow directions.
- Based on the depositional environment of these materials, and the historic braided channel deposits visible in the LiDAR data, groundwater that may accumulate within the alluvium deposits above the till layer is expected to have preferential flow toward the north to northeast. However, because local heterogeneities may exist, additional explorations are recommended to better understand the slope and contour of the top of the till surface.
- Groundwater at the site was typically found at depths of approximately 95 to 100 feet below the ground surface in the sand and silt beneath the till layer. To date, no groundwater has been observed on top of the till surface; however, the first wet season of monitoring is currently underway.
- The preliminary design recommends using excavated till material to provide a low-permeability core and cutoff in the embankment and to provide a low-permeability layer across the bottom of the reservoir to control seepage from the reservoir. If the reworked till material does not provide sufficiently low hydraulic conductivity, it can be augmented with imported bentonite to decrease permeability.

- The hydraulic conductivity of the till material is not yet well known. A range of possible hydraulic conductivities was considered to estimate likely seepage rates from the reservoir through the low-permeability core and bottom liner, as follows:
  - If the hydraulic conductivity of the processed native till used in the core and bottom liner were 1E-07 centimeter per second (cm/s), water losses would be in the range of 10 to 20 acre-feet per year from the reservoir, or up to approximately 1.25% of the reservoir's storage capacity.
  - If the hydraulic conductivity of the processed native till used in the core and bottom liner were 1E-06 cm/s, water losses would be in the range of 100 to 200 acre-feet per year from the reservoir, or up to approximately 12.5% of the reservoir's storage capacity.

The hydraulic conductivity of the till material will be reviewed with more in-depth geotechnical analyses in the next phase of design, as discussed in Section 8.2. Field observations and established known ranges of hydraulic conductivity in typical till materials can be used to approximate potential seepage rates from the reservoir bottom, as was done for this analysis. However, additional field and laboratory testing is proposed to further define the hydraulic conductivity of the till material and potential water losses to seepage.

3 Description of Key Project Elements

A brief overview of key project elements is provided in Section 1.1.1, and an overview map showing the key project elements is included as Figure 1-2. Additional detail is provided in the preliminary design drawings, which are included in Appendix A. This section provides a more detailed description of the key project elements and the key design characteristics selected for each, as shown in the preliminary design drawings.

3.1 Reservoir

The project will construct a reservoir with a full capacity of 1,591 acre-feet. The reservoir will be created by excavating, sorting, and processing native earth materials from the site. Processed materials from the site and imported materials will be placed to form an embankment around the reservoir. Because the site slopes slightly from south to north, the reservoir embankment will be taller at the north end of the reservoir than the south end of the reservoir. The following are key design parameters currently recommended for the reservoir:

- Storage Capacity: 1,591 acre-feet
- Full Water Surface Elevation (WSEL): 435.00 feet
- Top of Embankment Elevation: 438.00 feet
- Full Water Surface Area: 41.6 acres
- Reservoir Bottom Elevation: Varies (385.50 feet to 389.00 feet)
- Bottom Slope: 1.5% from south to north (inlet to outlet)
- Reservoir Embankment Top Width: 15 feet
- Reservoir Embankment Interior Slope: 3H:1V
- Reservoir Embankment Exterior Slope: 3H:1V

The overall reservoir plan is shown in Drawing C01 in Appendix A. The reservoir is generally located adjacent to the BPA easement on the south and River Road on the east, with a limited buffer provided between those facilities and the reservoir. The northeast corner of the site is being considered by the City of Sequim for an infiltration facility related to the overland flow capture system that they are evaluating. The north half of the site is also designated as an area for staging and stockpile and processing of materials for the reservoir. These uses will need to be coordinated and phasing of the use of this portion of the site will need to be discussed as the design progresses.

Detailed grading and sections for the reservoir and embankment that show the height, configuration, side slopes, and zoning of materials within the embankment are shown in Drawings C02 through C07 in Appendix A. As noted in Drawings C06 and C07, the key design parameters, dimensions, configuration, and layering or zoning of materials within the embankment shown are preliminary and will need to be refined through detailed design as additional geotechnical information and analysis are developed.

The *Draft Phase 1 Conceptual Geotechnical Engineering Report, Dungeness Off-Channel Reservoir* (Shannon & Wilson 2021b) evaluated several potential embankment and reservoir configurations consisting of different materials and liner types. The reservoir shown in the preliminary design drawings would consist of a low-permeability core material and liner along the bottom of the reservoir that would be processed from native glacial till material. The preliminary geotechnical explorations indicate that till material is likely to be encountered in excavations within the south portion of the reservoir. The presence, depth, and extent of the till material will need to be verified through additional geotechnical explorations to be completed during detailed design. The low-permeability core and liner material would tie into the native till material in the south portion of the reservoir. Core and liner material would be placed over a bedding of imported sand material. The embankment would also include gravel drain materials to control seepage and backfill material processed from native alluvium.

Another potential option for the reservoir and embankment configuration would consist of a fabricated geotextile liner over native materials. The selection of the optimal embankment configuration and any refinements to what is shown in the preliminary design will be made during detailed design, after additional data are collected and the design options have been reviewed with Ecology's Dam Safety Office (DSO).

Other features of the preliminary design include access roads to the top of the reservoir embankment and into the reservoir from the top of the embankment, a swale in the bottom of the reservoir to connect the reservoir inlet and outlet structures, and a toe berm to provide seismic stability based on the preliminary geotechnical stability analyses.

3.2 Inlet Pipeline

An inlet pipeline will be constructed to replace the portion of the H1 Lateral upstream of the reservoir; it will convey water from the HID Main Canal to the reservoir for storage. The pipeline will extend from the new flow control structure on the HID Main Canal down a relatively steep slope to River Road, running parallel to the existing H1 Lateral in the alignment of the trail that accesses the HID Main Canal from River Road. After crossing under River Road, the pipeline will follow the alignment of the H1 Lateral to the reservoir. The following are the key design parameters currently recommended for the pipeline:

- Design Flow Rate: 25 cfs
- Pipe Material: Butt-fused, solid-wall HDPE
- Pipe Size: 36-inch diameter
- Wall Thickness: DR 26 (minimum pressure rating of 80 pounds per square inch [psi])
- Pipe Length: 2,872 feet

The pipeline has been designed to operate for most of its length by gravity, running partially full. The downstream end of the pipeline will fill as the reservoir fills. The wall thickness was recommended to ensure adequate strength for placement and compaction of material over the pipe. Key pipeline appurtenances will include combination air release valves, to allow air to exit and enter the pipe in a controlled way as the downstream end of the pipeline fills with water, and molded HDPE fittings. The pipeline plan and profile are shown in Drawings C08 through C10 in Appendix A.

3.3 Flow Control Structure

Flow from the HID Main Canal to the inlet pipeline will be controlled through a new structure to be constructed in the HID Main Canal just downstream of the existing reinforced concrete side wall structure that controls flow from the canal to the H1 Lateral. The following are the key design parameters currently recommended for the flow control structure:

- Design Flow Rate: 25 cfs
- Structure Material: Reinforced concrete with steel grating and steel debris rack
- Overall Length: 24.00 feet
- Typical Width: 10.00 feet
- Typical Depth: 4.00 feet

An overtopping gate with automatic controls will be included in the downstream end of the structure to control the water level at the entrance to the inlet pipeline. When the reservoir is not filling, the gate will rotate into the down position, and water in the canal will flow directly over the gate and on down the canal. A slide gate with automatic controls will raise and lower to control the flow of water from the structure to the inlet pipeline and on to the reservoir. The gate controls in the structure will be automated and will control the flow of water to the reservoir based on the WSEL in the reservoir. When the reservoir is full, the gate at the inlet pipeline will automatically close, discontinuing flow to the reservoir. The gate controls will be linked to the intake gate controls to prevent continued diversion of flows exceeding the HID Main Canal capacity downstream of the flow control structure. Water in the HID Main Canal will continue to flow down the canal.

Other key appurtenances will include a welded-steel debris rack at the upstream end of the structure to keep debris out of the inlet pipeline, welded-steel bar grating to provide access over the structure, and rails to ensure safe operation. A preliminary plan and sections for the structure are included in Drawing C17 in Appendix A.

3.4 Inlet Structure

A U.S. Bureau of Reclamation (USBR) Type VI stilling basin is recommended to transition flow from the inlet pipeline to the reservoir. The structure will be located at the interior toe of the excavated slope on the south side of the reservoir and will be designed to dissipate the energy of water flowing

into the reservoir. Water will flow into the reservoir at high velocities when the reservoir is empty. The following are the key design parameters currently recommended for the inlet structure:

- Design Flow Rate: 25 cfs
- Structure Material: Reinforced concrete
- Overall Length: 8.00 feet
- Typical Width: 6.00 feet
- Typical Depth: 5.00 feet

The structure will include a baffle headwall downstream of the pipe outlet that will help dissipate the energy of water flowing from the pipe. Water will spill over a sill at the downstream end of the inlet structure to a shallow swale that will run along the bottom of the reservoir from the inlet to the reservoir outlet. The swale will be lined with 12 inches of quarry spalls to prevent scour of liner material. As the reservoir fills, the outlet of the inlet pipeline will become submerged, and the pipe will flow full under the embankment at the inlet to the reservoir. A preliminary plan and section for the inlet structure is included in Drawing C18 in Appendix A.

3.5 Outlet Works

Releases from the reservoir will be controlled by gates and inlets to an outlet piping manifold that will be buried in the interior slope of the embankment at the upstream end of the outlet pipeline. Three outlet ports are recommended: one at the bottom of the reservoir, one about halfway up the embankment, and one a few feet below the full WSEL. Each outlet port will consist of a gate over a 36-inch-diameter pipe opening. A reinforced concrete pad will be poured around the pipe opening to support the gate. The gates will be inclined to match the slope of the embankment and will include stems extending to gate operators at the top of the embankment. Gate stems will be supported along the slope of the embankment. The following are the key design parameters currently recommended for the inlet structure:

- Design Flow Rate: 25 cfs
- Structure Material: Reinforced concrete mounting pads
- Pipe Material: Welded steel, epoxy-coated and cement-mortar lined
- Outlet Gates: 36-inch stainless-steel slide gates, face-mounted
- Outlet Port Size: 36-inch diameter
- Outlet Pipe Manifold Size: 48-inch diameter

The outlet manifold gates will each be equipped with an electronic actuator that will allow for remote opening and closing. The gates will be opened and closed to deliver water from the reservoir to a buried 48-inch-diameter steel pipe manifold. The outlet manifold will connect to a 36-inch welded steel outlet pipeline that will be buried at the elevation of the bottom of the reservoir under the

embankment. A preliminary plan and section for the outlet manifold is included in Drawing C19 in Appendix A.

3.6 Outlet Pipeline

An outlet pipeline will be constructed to replace the portion of the H1 Lateral downstream of the reservoir. The pipeline will convey water from the reservoir to an outlet to the existing H1 Lateral near the north property boundary, or to a downstream network of irrigation pipelines that will be constructed in conjunction with the reservoir project. The pipeline will convey water released from the reservoir through the outlet works, as described previously. The following are the key design parameters currently recommended for the pipeline:

- Design Flow Rate: 25 cfs
- Pipe Material: Butt-fused, solid-wall HDPE
- Pipe Size: 36-inch diameter
- Wall Thickness: DR 26 for HDPE pipe (minimum pressure rating of 80 psi)
- Pipe Length: 1,710 feet

The pipeline has been designed to operate full, under the pressure created by the reservoir. The wall thickness was also recommended to ensure adequate strength for placement and compaction of material over the pipe. The pipe will be buried deep below the embankment and will be nearly 20 feet below the existing ground elevation on the downstream side of the embankment. The profile of the pipeline will meet the existing grade of the H1 Lateral near the north property boundary. Key pipeline appurtenances will include a filter diaphragm and drain layer to ensure that seepage through the embankment along the pipe alignment is controlled. The pipeline plan and profile are shown in Drawings C11 and C12 in Appendix A.

3.7 Bypass Pipeline

A bypass pipeline will be constructed to convey water from the H1 Lateral around the reservoir during construction and when the reservoir has to be drained for maintenance. The pipeline will extend west from a tee on the inlet pipeline around the west side of the proposed reservoir embankment to a tee connection with the outlet pipeline north of the reservoir. The following are the key design parameters currently recommended for the pipeline:

- Design Flow Rate: 6 cfs (sized to convey flows delivered by the H1 Lateral)
- Pipe Material: Butt-fused, solid-wall HDPE
- Pipe Size: 18-inch diameter
- Wall Thickness: DR 26 for HDPE pipe (minimum pressure rating of 80 psi)
- Pipe Length: 2,725 feet

The wall thickness was recommended to ensure adequate strength for placement and compaction of material over the pipe. At the upstream end and for most of its length, the bypass pipeline will be buried with only 3 to 5 feet of cover. However, the pipeline will be buried nearly 20 feet below the existing ground elevation where it ties into the outlet pipeline. The bypass pipeline plan and profile are shown in Drawings C13 through C15 in Appendix A.

3.8 Spillway Facilities

Ecology's DSO guidance requires consideration of spillways for operational spills and for emergency spilling of inflows that are in excess of what the reservoir can hold while maintaining minimum recommended freeboard heights between the water level and the top of the impounding structure. In this case, the spillway will need to be able to overflow any water conveyed to the reservoir through the inlet pipeline in the event that the automatic gates did not close to prevent inflow from the HID Main Canal when the reservoir reached its full WSEL (435 feet). The spillway will also need to be able to convey precipitation falling on the reservoir when the reservoir is full. Because the reservoir will be surrounded by an embankment, the reservoir will not capture runoff from a drainage area tributary to the reservoir. It will only capture flows conveyed to the reservoir and precipitation falling on the reservoir. Consequently, separate operating and emergency spillways were not determined to be necessary.

Based on these inputs, recommended spillway facilities include a drop inlet spillway, which will be located in the northwest corner of the reservoir; a pipeline designed to convey spilled water through the reservoir embankment to an outlet beyond the toe of the embankment; a ditch that will convey water to the northwest across the reservoir parcel; and a pipeline that will pick up the water and convey it down a relatively steep hill to a discharge point on a side channel of the Dungeness River just upstream of the Independent Canal intake facilities. The following are the key design parameters currently recommended for the pipeline:

- Design Flow Rate: 50 cfs
- Spillway Type: Drop inlet
- Spillway Structure Materials: Pre-cast, reinforced concrete
- Drop Inlet Size: 96-inch (8-foot) diameter
- Spillway Pipe Material: Butt-fused, solid-wall HDPE
- Pipe Size: 36-inch diameter (through embankment)
  24-inch diameter (downstream end)
- Wall Thickness: DR 26 for HDPE pipe (minimum pressure rating of 80 psi)
- Pipe Length: 635 linear feet of 36-inch (through embankment)
  425 linear feet of 24-inch (downstream end at bluff)

Additional detail on the design analysis completed for the spillway facilities is included in Section 4.4. The drop inlet spillway will consist of a pre-cast concrete manhole with a debris rack on top of it. The spillway and outlet pipeline have been designed to ensure that the weir flow over the top edge of the drop inlet controls the flow rate. The spillway facilities are designed to be completely passive, meaning that the spill path cannot be shut off or blocked by a gate or other control. Water will spill from the reservoir and be conveyed away from the embankment to a discharge point on the side channel of the Dungeness River.

3.9 Intake Facility Improvements

Anchor QEA's subconsultant, HDR, assessed the condition and capacity of intake facilities that divert water to the HID Main Canal from the Dungeness River (HDR 2021). The findings of that assessment are summarized in Section 4.7. The assessment recommended a series of improvements to ensure that the intake facilities are updated, automated, and sized to divert up to 25 cfs to the reservoir. The improvements recommended by HDR are illustrated schematically in Drawing C16 in Appendix A. The recommended improvements include the following:

- Upgrades to the HID intake structure and headgates, as follows:
  - Stabilize the side channel on the Dungeness River that currently conveys water to the intake structure to discourage migration of the side channel away from HID's headgate structure.
  - Refurbish the headgate structure.
  - Install automated headgates, including replacing the existing headgate, opening a better existing gate bay that is currently sealed, and installing an additional headgate.
  - Install a trash rack on the intake structure upstream of the headgates.
  - Install a flume in the diversion channel downstream of the headgates that will work in tandem with the headgates to automatically adjust the gates based on flows measured in the flume. This could be done by relocating the Parshall flume that currently measures flows downstream of the fish screens.
- Upgrades to the HID fish screens and fish bypass, as follows:
  - Coordinate with WDFW to remove the existing wire mesh rotary drum screens, transport them WDFW's Yakima Screen Shop, replace the wire mesh on each with stainless-steel perforated plate screen, and reinstall the screens.
  - Install a water jet spray system with pumps in front of the screen to keep sediment mobilized in the water upstream of the screen so that sediment does not settle and build up in front of the screens.
  - Paint the gantry crane above the screens.
  - Automate the control gate on the fish bypass.
  - Upgrade and automate the controls (stop logs and gate) downstream of the fish screen that help maintain the appropriate depth on the fish screen.

3.10 Settling Basin

In addition to the improvements recommended to the HID intake facilities, it is recommended that a settling basin be constructed at the upstream end of the HID Main Canal, just beyond the gate and stop logs downstream of the fish screens. The settling basin will be designed to settle out a portion of the suspended solids in the water so that those solids are not conveyed downstream to the reservoir. The settling basin will consist of the following:

- Reshape (widen) and line approximately 150 feet of the most upstream portion of the HID Main Canal with concrete over a geomembrane liner. Optionally, an unlined settling basin could be used to reduce cost and eliminate concerns about damaging the concrete and liner.
- Install a reinforced concrete control structure at the downstream end of the settling basin with stop logs or a weir to control the water level and velocity of water flow through the settling basin and provide transition to a pipeline.
- Install a flow measurement meter downstream of the settling basin.
- The existing Parshall flume operated by Ecology to monitor flows diverted to the HID Main Canal will need to be removed to accommodate the settling basin. It will be replaced with the flow meter installed in the pipe downstream of the settling basin.
- Install an 18-inch bypass pipe with a gate inlet parallel with the settling basin to allow for bypass of flows around the settling basin during maintenance.

The proposed settling basin is shown schematically in Drawing C16 in Appendix A.

4 Preliminary Design Analyses

This section summarizes the engineering analyses that have been completed to support the preliminary design. These analyses included evaluations of different reservoir configurations to select a preferred configuration; hydrologic analysis to better understand the flows available for diversion to the reservoir, design storm conditions, and inflow conditions at the reservoir; hydraulic analysis needed to size structures, pipelines, controls, the spillway, and related facilities; an operational analysis to better understand how filling of the reservoir and release of reservoir water will work; geotechnical engineering analyses to inform the design of the reservoir embankment and lining system to ensure that the design meets DSO guidelines and requirements; the assessment of HID intake facilities; and an evaluation of water quality impacts that will result from storing irrigation water in the proposed reservoir.

4.1 Project Design Criteria

The following summarizes the key design criteria that were used for preliminary design of the reservoir and appurtenant facilities.

4.1.1 Design Reservoir Storage Capacity

Clallam County and the Work Group have requested that the reservoir be designed to provide approximately 1,600 acre-feet of storage. That volume of storage, if released over a 4-week low-flow period during the late summer, would supply an average of 28.8 cfs for downstream irrigation. If released over a 6-week period, the 1,600 acre-feet of storage would supply an average of 19.2 cfs for downstream irrigation. Downstream irrigation demands are anticipated to range from 15 to 25 cfs during the period of peak irrigation in the late summer. Therefore, a 1,600-acre-foot reservoir would be able to meet those demands over a 4- to 6-week period during the late summer.

4.1.2 Design Flow Rates

The following design flow rates were used for pipelines and other conveyance facilities:

- Maximum Inflow, from the HID Intake Facility to the Reservoir: 25 cfs
- Maximum Release Rate, from the Reservoir to the Irrigation System: 25 cfs
- Maximum Bypass Rate, to Meet Demand on the H1 Lateral: 6 cfs
- Maximum Spillway Flow Rate: 50 cfs

A 25-cfs inflow would fill the reservoir in just over 32 days. However, as outlined in Section 4.3, the 25 cfs will not always be available for diversion from the Dungeness River. In addition, the existing diversion facilities and HID Main Canal are not currently sized to convey 25 cfs. New inlet pipelines and other facilities have been sized to convey 25 cfs to provide flexibility for diverting more flows

when they are available and when upgrades are made to HID infrastructure. This will allow for greater flexibility in managing the storage and higher reliability of reservoir refill.

4.1.3 Overview of Dam Safety Criteria and Guidelines

Ecology's DSO regulates over 1,100 dams in the State of Washington. They are required to regulate all dams that store at least 10 acre-feet of water, in accordance with the Washington Administrative Code (WAC) 173-175. The proposed reservoir will include an earthen embankment that will impound nearly 1,600 acre-feet of water for irrigation. The embankment will be regulated and will require a Dam Construction Permit from DSO.

The embankment will need to be designed to meet DSO's requirements, as outlined in *Dam Safety Guidelines Part IV, Dam Design and Construction* (Ecology 1993). That manual provides guidelines for design of dams and appurtenant facilities. Key criteria and guidelines outlined in the manual that apply to the project include the following:

- The reservoir embankment will likely be considered an "intermediate size dam" with a hydraulic height of greater than 15 feet but less than 50 feet. The maximum hydraulic height at the north end of the impoundment is approximately 50 feet. Depending on how the hydraulic height is interpreted, the dam size classification could be increased to a "large dam."
- The reservoir operation classification as "seasonal pool operation."
- The dam hazard classification will need to be determined, as outlined in Section 1 of *Dam Safety Guidelines Part IV, Dam Design and Construction* (Ecology 1993) to verify the appropriate design step to be applied to the design, which informs selection of a design storm and other key criteria.
- The behavior of the embankment during seismic events should be evaluated to ensure that it can meet the design requirements outlined in Section 2 of *Dam Safety Guidelines Part IV, Dam Design and Construction* (Ecology 1993).
- The embankment design should include zoning of materials to include the key embankment design elements outlined in Section 3.2 of *Dam Safety Guidelines Part IV, Dam Design and Construction* (Ecology 1993). These include proper foundation preparation, a foundation cutoff trench, a low-permeability core, drains, filters, and erosion protection.
- The embankment design shall provide for seepage control, such that the design prevents the development or mitigates the impact of cracks in the low-permeability core of the embankment; cracks at the embankment contact with appurtenances, abutments, and the foundation; and excessive seepage beneath or around the dam.
- Conduits that pass through or under the embankment shall be designed to control seepage by providing filter diaphragms or other features to prevent piping and uncontrolled seepage along conduits.

- Appropriate erosion protection shall be provided to prevent erosion of the embankment from storm runoff, wave action, or vehicular traffic and discourage the growth of undesirable vegetation on the embankment, such as trees, dense brush, or other deep-rooted plants.
- Debris protection should be provided at hydraulic structures to protect against floating debris in the reservoir.
- The dam spillway should be designed to pass the inflow design flood (IDF), calculated based on inflow from the design storm, while maintaining the minimum freeboard required between the peak WSEL and the top of the embankment.
- Wave height should be considered when estimating freeboard.
- For an intermediate dam, the embankment and spillway should be designed to maintain at least 0.75 foot (9 inches) of freeboard during the IDF with the maximum calculated wave height to prevent the embankment from overtopping.

Additional criteria and guidance provided in the *Dam Safety Guidelines Part IV, Dam Design and Construction* (Ecology 1993) will be incorporated into the design of the reservoir and appurtenances.

4.1.4 Conveyance Criteria

The following criteria were applied to the sizing and design of conveyance facilities:

- For pipelines designed to flow full, pipelines were generally sized to convey the design flow rate at velocities equal or less than 5 feet per second (fps).
- For pipelines designed to flow partially full, pipelines were sized to convey the design flow rate at a depth that is less than or equal to 66% of the pipe diameter.
- Air release vents or valves were incorporated at high points and other key locations to allow air to leave and enter pipelines designed to flow partially full.
- Energy-dissipating features will be included at the ends of pipes that have potential to flow at high velocities.
- Spillway pipes will be designed to continuously flow partially full at all flow rates up to the design flow rate. The spillway will also be designed to maintain hydraulic control at the rim of the drop inlet structure at all flow rates up to the design flow rate.

4.2 Reservoir Configuration Evaluation

As an initial step toward completing the design of the reservoir, Anchor QEA reviewed the conceptual design configuration for the reservoir developed in 2016. Anchor QEA then developed and evaluated several alternative configurations to optimize the size and shape of the reservoir with the excavation and placement of fill required. The conceptual design of the reservoir was focused on maximizing the volume while balancing cut and fill volumes. However, through discussions with key design team members, minimizing the footprint and potential liner area was prioritized over balancing cut and fill volumes due to the cost impact of the liner or other low-permeability layer.

Other key parameters considered as part of this evaluation included the ability to excavate down to the glacial till layer, depth, and embankment height. Reservoir configurations were evaluated using AutoCAD Civil 3D for discussion and review during a design charette. The recommendations were then used to develop a preferred reservoir configuration that is generally reflected in the preliminary design drawings.

4.2.1 Overview of Alternative Configurations

Several variations on the conceptual design configuration and multiple other alternative reservoir configurations were evaluated using grading tools in AutoCAD Civil 3D. Ultimately, these were narrowed down to a total of five alternative configurations for review and discussion with the design team and Clallam County. Table 4-1 outlines the key design parameters that were estimated in 2016 for the original conceptual design and for the five alternative configurations that were considered.

Table 4-1
Summary of Alternative Reservoir Configurations

Design Value	Original Concept	Alt. 1	Alt. 2	Alt. 3	Alt. 4	Alt. 5
Overflow Elevation (max. WSEL; feet)	425	420	430	420	430	430
Top Elevation (feet)	428	423	433	423	433	433
Bottom Elevation (average; feet)	406	388	388	388	388	388
Maximum Pond Area (acres)	88.3	57.4	44.5	44.5	42.9	43.4
Minimum Pond Area (acres)	78.7	44.7	30.7	30.7	27.8	28.9
Liner Area (acres)	89.9	58.1	46.4	46.2	43.7	45.4
Estimated Storage Capacity (acre-feet)	1,586	1,634	1,579	1,203	1,485	1,518
Estimated 4-week Flow Benefit (cfs)	28.5	29.4	28.4	21.7	26.7	27.3
Embankment Exterior Cut/Fill Slope	2.5H:1V	2.5H:1V	2.5H:1V	2.5H:1V	2.5H:1V	2.5H:1V
Embankment Interior Cut/Fill Slope	3H:1V	3H:1V	3H:1V	3H:1V	3H:1V	3H:1V
Exposed Till Area (acres)	N/A	28.0	23.3	25.2	20.4	24.6
Estimated Cut (cy)	710,867	2,165,151	1,460,908	1,598,442	1,419,011	1,428,845
Estimated Cut (till; cy)	N/A	321,626	281,482	304,888	259,399	285,737
Estimated Fill (cy)	768,082	133,360	297,395	115,521	255,740	302,630

4.2.2 Reservoir Design Charette

Anchor QEA held a design charette with key members of the design team, Clallam County, and Washington Water Trust late in October 2021 to look at these alternative reservoir configurations, discuss factors that are most likely to influence cost and constructability, and discuss ideas for a preferred design configuration. Rough reservoir grading plans and sections were developed for each

alternative configuration for the design charette discussion. Preliminary geotechnical findings, embankment design considerations, and early opinions of cost were also incorporated into that discussion. The following are some of the key conclusions that came out of the design charette:

- If a phased approach is needed due to cost, it would be less costly to increase the size of the reservoir in the future by increasing the height of the embankment rather than adding an additional reservoir cell.
- The cost of a liner will be a major component of the overall cost. The design should focus on reducing the size of the liner. The design should increase the depth of excavation and height of the embankment and decrease the footprint as much as possible.
- Increasing the depth will allow for more of the excavation to reach the glacial till layer. Accessing and using till material as a low-permeability core in the embankment and to line the bottom of the reservoir will likely be more cost effective than placing a fabricated liner.
- If a fabricated geomembrane liner is used, the more rectangular the reservoir can be, the better. Placement of liner would be more challenging and costly over an irregularly shaped reservoir bottom.
- Till material could be supplemented with bentonite to reduce permeability if the till material permeability is too high.
- If use of a fabricated liner is proposed, it cannot be the only low-permeability layer in the embankment. DSO will require a demonstration that the embankment will be stable with the assumption that a fabricated liner has failed or is not present.
- Construction will likely require at least 2 to 3 years. Bidding early in the year will be key, because bid prices are likely to be more favorable if the project is bid early in the year before prospective contractors have their work scheduled out for the summer.
- Pipe, valves, and other manufactured materials are difficult to procure right now, and costs have increased substantially in the last 18 months.

Ultimately, the discussion and recommendations provided during the design charette led to development of a preferred reservoir configuration similar to Alternative Configuration 3, but with a higher embankment, slightly different footprint, and increased storage volume to match the 1,600 acre-feet targeted for the project. Table 4-2 outlines the key design parameters that were selected for the preferred reservoir configuration, which is reflected in the preliminary design drawings included in Appendix A.

Table 4-2
Summary of Preferred Reservoir Configuration

Design Value	Preferred Configuration
Overflow Elevation (max. WSEL; feet)	435
Top Elevation (feet)	438
Bottom Elevation (average; feet)	388
Maximum Pond Area (acres)	41.6
Minimum Pond Area (acres)	25.5
Liner Area (acres)	42.4
Estimated Storage Capacity (acre-feet)	1,591
Estimated 4-week Flow Benefit (cfs)	28.6
Embankment Exterior Cut/Fill Slope	2.5H:1V[1]
Embankment Interior Cut/Fill Slope	3H:1V[1]
Exposed Till Area (acres)	14.3
Estimated Cut (cy)	1,243,501
Estimated Cut (till; cy)	149,295
Estimated Fill (cy)	642,529

Note:
The interior and exterior embankment slopes are likely to decrease based on the recommendations of the geotechnical engineering report. The configuration, geometry, and other design parameters are likely to be adjusted and refined as additional geotechnical information is collected during the detailed design phase of the project.

4.3 Hydrologic Analysis

The purpose of the hydrologic analysis is to provide an estimate of flow available for refill of the proposed reservoir, and to provide a basis for selection of the design storm, IDF, and other key hydrologic inputs needed to design the spillway and other reservoir elements to meet dam safety guidelines provided by Ecology DSO. This analysis will eventually be incorporated into a separate hydrology and hydraulics report to meet the requirements for obtaining a Dam Construction Permit from DSO as part of the detailed design phase of the project.

4.3.1 Dungeness River Flow Availability Analysis

A flow availability analysis was developed by Washington Water Trust (Washington Water Trust 2021) to provide estimates of flow available for diverting from the Dungeness River to the proposed reservoir for storage over a 22-year period of record (Water Years [WY] 2000 to 2021). Washington Water Trust estimated monthly flow volumes available based on Dungeness River historic flows from USGS Gage No. 12048000 (Dungeness River near the City of Sequim) and maximum allocation[2] of

[2] The main source of water for filling the Dungeness Reservoir will be maximum allocation water diverted from the Dungeness River, which is defined in WAC 173-518-090 and includes the maximum amount of water available for withdrawal after meeting instream flow requirements.

water available for new uses. Table 4-3 summarizes the instream flow rule and maximum allocation water available.

Table 4-3
Dungeness River Instream Flow and Maximum Allocation

Month	Instream Flow (cfs)	Maximum Allocation (cfs)
January – March	575	25
April	475	25
May – July 14	475	35
July 15 – July 31	475	0
August – October	180	0
November 1 – November 15	575	0
November 16 – December	575	25

Note:
Table from Washington Water Trust, 2021

The instream flow rule establishes a minimum flow level below which no new diversions are allowed. The limits were set by season based on the flow required to protect fish, wildlife, scenic, and other values. Maximum allocation water is interruptible water that is allocated for new uses, but is only available when the Dungeness River flows exceed the instream flow limits.

Washington Water Trust developed a model that estimates monthly reservoir fill volumes based on maximum diversion rates of 15 cfs and 25 cfs. Development of the reservoir fill model was initiated in response to a question from irrigators and other members of the Work Group regarding how the reservoir would be filled and with what certainty. The model considered Dungeness River flows at USGS Gage No. 12048000 from 2000 to 2021. The model compares those flows against instream flow limits and maximum allocation water, determines the flow available for diversion, then estimates the monthly volume of flow that can be diverted to and stored in the reservoir based on the flow available from the river. The model also estimates evaporation and considers the potential for capture of overland flow to help fill the reservoir.

Table 4-4 summarizes the estimated reservoir fill volumes accumulated using the reservoir fill model and Dungeness River flows from 2000 through 2021. The shaded cells indicate years when the reservoir could not be filled. The model assumed a reservoir capacity of 1,580 acre-feet. Based on the results of the model, the refill probability was estimated to be as follows:

- With a 15-cfs maximum diversion capacity:
  - The reservoir refills during 13 years out of the 22 years evaluated.
  - The refill volume is between 1,000 and 1,580 acre-feet during 7 years out of the 22 years evaluated.

  - The refill volume is less than 1,000 acre-feet during 2 years out of the 22 years evaluated.
- With a 25-cfs maximum diversion capacity:
  - The reservoir refills during 19 years out of the 22 years evaluated.
  - The refill volume is between 1,000 and 1,580 acre-feet during 2 years out of the 22 years evaluated.
  - The refill volume is less than 1,000 acre-feet during 1 year out of the 22 years evaluated.

Based on these results, increasing the diversion capacity to 25 cfs would increase the probability of refilling the reservoir during dry years. Washington Water Trust will continue to refine the reservoir fill model with the most up-to-date data available. There is also interest from project partners in incorporating Dungeness River flow projections to determine water availability and security into the future. These data are still being pursued.

Data from this model were used to develop a reservoir water balance (discussed in Section 4.5). Volumes of available flow for representative dry, average, and wet years are illustrated in Figure 4-1. Note that available flow volumes in Figure 4-1 are actual water years, so there are cases when a dry year may have months with more volume than the average or wet year. Overall, the data indicate that during wet years, flows may be available from the late fall through the early summer for diversion to the reservoir. During average years, flows are mostly likely to be available in the late fall and during the spring runoff period. During dry years, flow availability may be restricted to short periods during the winter and the spring runoff period.

Table 4-4
Summary of Reservoir Fill Model Results

Water Year	Based on 15-cfs Maximum Diversion		Based on 25-cfs Maximum Diversion	
	Refill Volume[1]	Refill Volume with Overland Flow[2]	Refill Volume[1]	Refill Volume with Overland Flow[2]
2000	1,763.2	1,843.2	2,951.4	3,031.5
2001	470.5	550.5	615.0	695.0
2002	1,981.1	2,061.2	3,301.0	3,381.0
2003	1,665.1	1,745.1	2,745.4	2,825.4
2004	1,259.3	1,339.3	1,989.2	2,069.3
2005	942.0	1,022.1	1,436.0	1,516.1
2006	2,195.9	2,276.0	3,782.7	3,862.7
2007	2,031.8	2,111.8	3,515.5	3,595.5
2008	1,437.5	1,517.5	2,470.2	2,550.3
2009	802.5	882.5	1,234.1	1,314.2
2010	2,178.0	2,258.0	3,722.7	3,802.7
2011	2,098.1	2,178.2	3,556.3	3,636.8
2012	1,852.5	1,932.5	3,208.7	3,288.8
2013	1,740.8	1,820.8	2,982.0	3,062.1
2014	1,267.4	1,347.4	2,100.0	2,180.1
2015	1,408.4	1,488.4	2,193.0	2,273.0
2016	2,889.3	2,969.4	4,840.3	4,920.4
2017	2,146.2	2,226.2	3,675.0	3,755.0
2018	1,845.5	1,925.5	3,092.8	3,172.8
2019	1,340.1	1,420.2	2,210.1	2,290.1
2020	1,585.6	1,665.7	2,677.8	2,757.8
2021	1,405.8	1,485.8	2,500.6	2,580.6

Notes:
The shaded cells indicate years when the reservoir could not be filled.

1. Results indicate the total volume of reservoir refill accumulated based on maximum allocation water plus water right water diverted from the Dungeness River.
2. Results indicate the total volume of reservoir refill accumulated based on maximum allocation water, plus water right water diverted from the Dungeness River, plus overland flow annually that is assumed to be captured in the HID Main Canal and routed to the reservoir for storage, as outlined in the *Memorandum: Task Assignment No. 4: Stormwater Capture and Infiltration RFI from FEMA* (Wilson Engineering 2021).

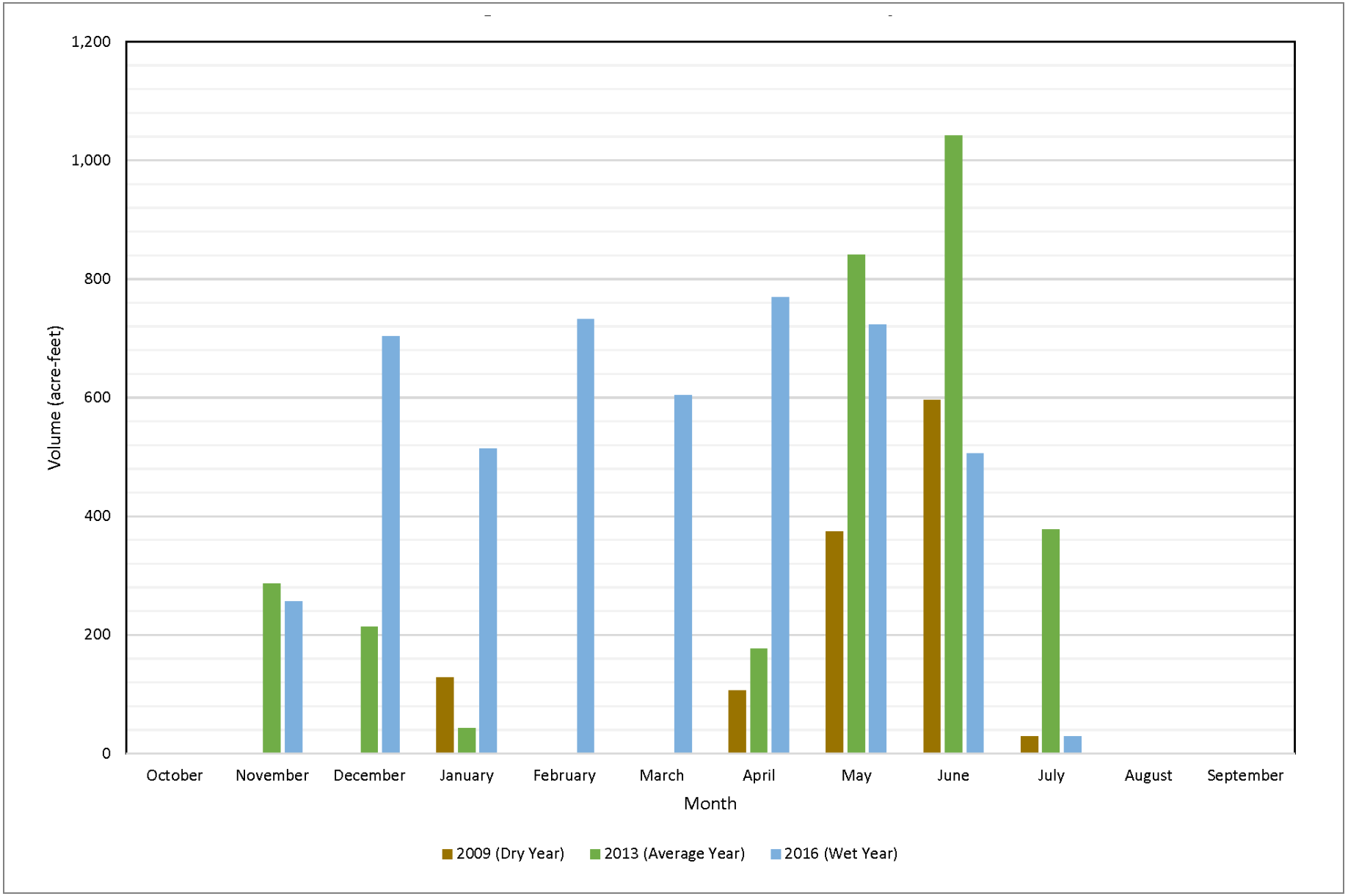


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Figure 4-1
Dungeness River Flow Volume Availability
Preliminary Basis of Design Report
Dungeness Off-Channel Reservoir Project

4.3.2 Design Step Selection

The first step in determining the hydrologic conditions that need to be used for design of a dam to meet DSO guidelines is to determine the hazard rating and select the appropriate design step, which indicates the magnitude of the storm that the facilities need to be designed to accommodate.

A downstream hazard analysis was completed to determine the specific design storm step to select. This analysis was based on guidance from DSO's Technical Note 2, which provides a decision-making framework to aid in the selection of appropriate design goals (Ecology 1993). Based on the Design Step Analysis Calculation (Appendix C), it was determined that a Step 8 design storm should be selected.

4.3.3 Precipitation and Reservoir Inflow from Design Storm

Ecology's *Dam Safety Guidelines Technical Note 3: Design Storm Construction* (MGS Engineering Consultants 2009) provides steps for developing a design storm for use in calculating the IDF hydrograph. Chapter 1.2.2 of Technical Note 3 indicates that the long-duration storm is commonly the controlling design event in western Washington, and it is always the design event for off-channel storage reservoirs that have minimal tributary watershed area. For this analysis, three design storm types were evaluated: short duration, intermediate duration, and long duration.

The first step in developing a design storm is to estimate precipitation at the site. Preliminary estimates of precipitation at the site were developed using worksheets provided by DSO and checked against data and figures in Technical Note 3 (MGS Engineering Consultants 2009). Table 4-5 lists data provided to the precipitation worksheets' automatic calculating tool.

Table 4-5
Dungeness Reservoir Precipitation Calculator Input

Parameter	Units	Input
Latitude	Degrees north	48.0533
Longitude	Degrees west	123.1404
Watershed Elevation	Feet	400
Design Step	No units	8
Drainage Area	Square miles	0.06658

These inputs were used to find the climatic region number and mean annual precipitation, as well as at-site mean precipitation, L-moment statistics, and event precipitation values for the short-duration, intermediate-duration, and long-duration storms. A summary of the results is included in Table 4-6; detailed worksheets and calculations are included in Appendix D.

Table 4-6
Results of Precipitation Frequency Analysis

Analysis Result	Short-Duration (2-hour) Storm	Intermediate-Duration (6-hour) Storm	Long-Duration (24-hour) Storm
Climatic Region Number	32		
Mean Annual Precipitation (inches)	21.9		
L-Cv	0.1489	0.1468	0.1875
L-Skew	0.2742	0.1859	0.2026
At-site Mean Precipitation (inches)	0.493	0.846	1.524
10-year Precipitation (inches)	0.66	1.14	2.21
25-year Precipitation (inches)	0.79	1.32	2.64
100-year Precipitation (inches)	1.04	1.61	3.32
500-year (Step 1) Precipitation (inches)	1.40	1.97	4.18
Step 2 Precipitation (inches)	1.60	2.14	4.58
Step 3 Precipitation (inches)	1.98	2.44	5.28
Step 4 Precipitation (inches)	2.45	2.75	6.04
Step 5 Precipitation (inches)	3.03	3.09	6.85
Step 6 Precipitation (inches)	3.75	3.46	7.72
Step 7 Precipitation (inches)	4.64	3.85	8.66
Step 8 Precipitation (inches)	5.75	4.27	9.66

The storm precipitation data calculated were scaled with design factors and storm factors to develop total storm precipitations for the short-duration, intermediate-duration, and long-duration storms using the DSO worksheets. These were compared against the probable maximum precipitation for storms at the site. Peak rainfall intensities were also calculated for the design storms. A summary of the results is included in Table 4-7; detailed worksheets and calculations are included in Appendix D.

Table 4-7
Total Precipitation and Peak Storm Intensities

Design Value	100-year Storms			500-year Storms			Step 8 (10^6-year) Storms		
	2-hour	6-hour	24-hour	2-hour	6-hour	24-hour	2-hour	6-hour	24-hour
P_{gds} (inches)	1.04	1.61	3.32	1.40	1.97	4.18	5.75	4.27	9.66
DF	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15	1.15
P_{sd} (inches)	1.19	1.85	3.82	1.61	2.27	4.81	4.32	4.49	10.00
Multiplier	1.205	1.667	1.415	1.205	1.667	1.415	1.205	1.667	1.415
Total Precipitation (inches)	1.44	3.08	5.41	1.94	3.79	6.81	5.20	7.48	14.15
Peak Intensity Factor	2.2307	0.3335	0.1328	2.2307	0.3335	0.1328	2.2307	0.3335	0.1328
Peak Storm Intensity (inches/hour)	3.21	1.03	0.72	4.33	1.26	0.90	11.60	2.49	1.88

Design storm hyetographs were calculated based on a dimensionless unit-hyetograph. Technical Note 3 presents unit hyetographs for each storm duration and climatic region. The hyetographs are normalized so that the incremental ordinates add up to 1.0. The ordinates are then simply multiplied by the total design storm depth to obtain preliminary design storm precipitation values. Hyetographs showing the precipitation distribution estimated for the short-, intermediate-, and long-duration Step 8 design storms are plotted in Figure 4-2.

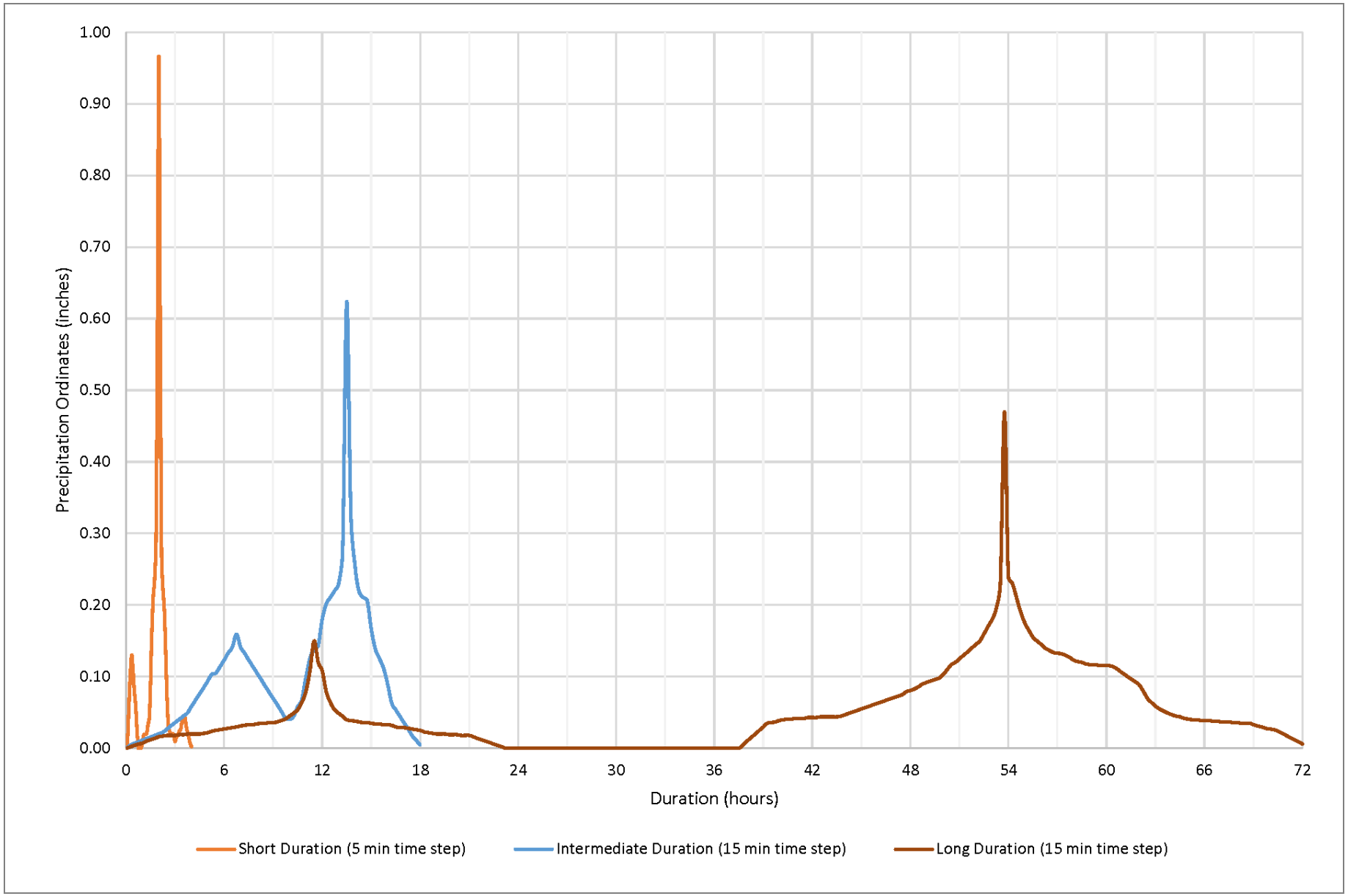

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Figure 4-2
Design Storm (Step 8) Hyetograph
Preliminary Basis of Design Report
Dungeness Off-Channel Reservoir Project

Because the project is an off-channel reservoir that will be surrounded entirely by the reservoir embankment, and inflows from the HID Main Canal will be controlled by automated gates, the reservoir will not capture flows from a tributary drainage basin or watershed. The reservoir will only capture precipitation that falls on the reservoir itself. Consequently, the peak flow and volume of water contributed to the reservoir from the design storm will be limited to precipitation that falls on the reservoir. A preliminary estimate of peak inflows and volumes resulting from the design storm events is summarized in Table 4-8.

Table 4-8
Design Storm (Step 8) Peak Inflow and Total Storm Volume

	Design Storm (Step 8)		
	Short	**Intermediate**	**Long**
Peak Inflow (cfs)	498.4	321.6	80.7
Inflow Volume (cubic feet)	804,342	1,157,015	2,188,739
Inflow Volume (acre-feet)	18.47	26.56	50.25

4.4 Hydraulic Analysis

The design criteria outlined in Section 4.1 and the results of the hydrologic analysis summarized in Section 4.3 were used to complete hydraulic analyses needed to size and complete preliminary designs for the reservoir and key reservoir components. The following outlines the hydraulic analyses completed to support the preliminary design.

4.4.1 Reservoir Stage-Storage Relationship

The relationship between reservoir stage (WSEL), water surface area, and volume of reservoir storage was developed based on data from the AutoCAD drawings of the reservoir and spreadsheet analysis of that data. Figure 4-3 illustrates the stage-storage-area relationship for the proposed reservoir reflected in the preliminary design drawings. The proposed reservoir will fill to a normal full WSEL of 435.00 feet. The full storage volume is estimated at 1,591 acre-feet. A table of the stage-storage-area data is included in Appendix E.

4.4.2 Reservoir Freeboard Analysis

Failure of earthen dams typically results from overtopping of the embankment or from uncontrolled seepage through or around the embankment. Reservoir freeboard was evaluated to ensure that adequate freeboard, or the distance between the water surface and the top of the embankment, is provided to prevent overtopping of the embankment under both normal operating and design storm conditions.

4.4.2.1 Normal Operating Conditions

The proposed reservoir has a normal operating pool elevation of 435.0 feet and a dam crest elevation of 438.0 feet, which allows for 3.0 feet of freeboard under normal operating conditions. This is less than the normal operating freeboard of 3.5 feet recommended as standard for intermediate dams by *Dam Safety Guidelines Part IV* (Ecology 1993). However, preliminary freeboard analysis was completed to demonstrate that the adequate freeboard is available during design storm conditions with wave runup, so it is anticipated that the freeboard provided will be adequate to meet the intent of the DSO guidelines.

Preliminary wave runup calculations were completed based on guidance and lookup tables in the *Dam Safety Guidelines Part IV* (Ecology, 1993). Table 4-9 summarizes inputs and results of the wave runup analysis. Based on the results, the required normal operating freeboard due to wind/wave runup is 2.26 feet. This value is less than the 3.0 feet of freeboard provided and the 3.5 feet of normal operating freeboard recommended for an intermediate dam.

Table 4-9
Wave Runup Analysis Summary – Normal Operating Conditions

Parameter	Value
Design Wind Speed	60 miles per hour
Fetch	1,400 feet
Wave Height	1.40 feet
Wave Runup Coefficient	1.6
Wind Setup	0.02 foot
Wave Runup	2.24 feet
Wind/Wave Freeboard	2.26 feet

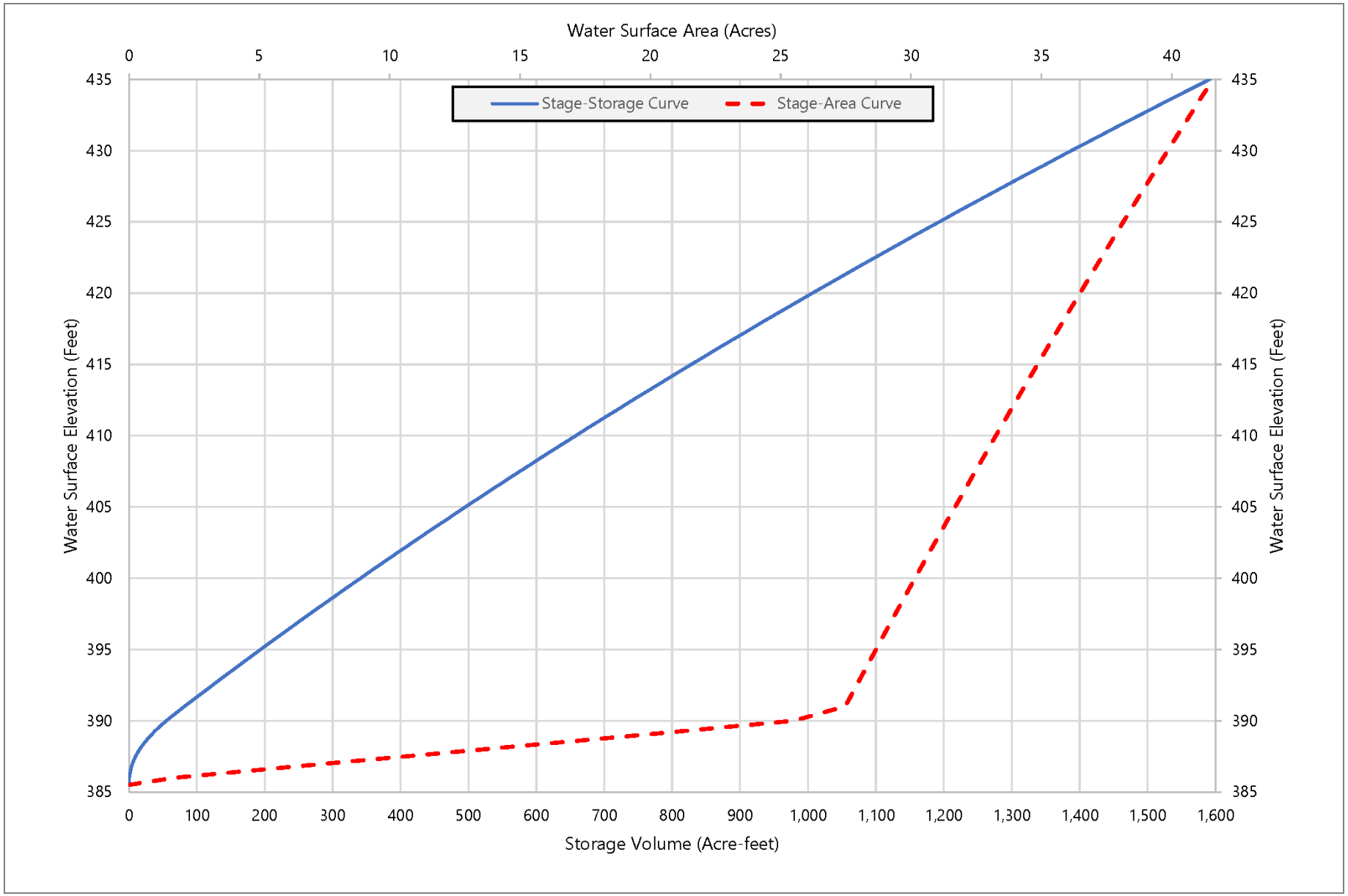

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Figure 4-3
Dungeness Off-Channel Reservoir Stage-Storage-Area Curve
Preliminary Basis of Design Report
Dungeness Off-Channel Reservoir Project

4.4.2.2 Design Storm Conditions

A preliminary freeboard analysis was completed for design storm conditions based on guidance in the *Dam Safety Guidelines Part IV* (Ecology 1993) and using the freeboard analysis worksheet tool provided by DSO. As noted previously, the selected design storm is the Step 8 design storm. The results of the analysis are summarized in Tables 4-10 and 4-11. To simplify the analysis for preliminary design, the assumption was made that none of the inflow from the design storm would be discharged through the spillway, so that the resulting peak water surface would essentially be the full reservoir water surface plus the depth of precipitation from the design storm. The peak WSELs listed in Table 4-10 reflect this assumption. As will be discussed later, a spillway will be provided that will accommodate the design storm and discharge flows back to the Dungeness River when the design storm occurs and the reservoir is full, so the assumption that none of the inflow from the storm would leave the reservoir is very conservative.

The analysis demonstrates that, even if no spillway were provided to discharge the inflow from the design storm, the freeboard provided during design storm conditions with wave runup would exceed the minimum 0.75 foot (9 inches) of freeboard required by DSO to prevent overtopping of the embankment. This analysis will be refined as the detailed design of the facilities progresses.

Table 4-10
Reservoir Freeboard Analysis – Design Storm (Step 8) Conditions

Parameter	Short Duration	Intermediate Duration	Long Duration
Peak Inflow	498.4 cfs	107.2 cfs	80.7 cfs
Inflow Volume	18.47 acre-feet	26.56 acre-feet	50.25 acre-feet
Peak Discharge	0 cfs	0 cfs	0 cfs
Discharge Volume	0 acre-feet	0 acre-feet	0 acre-feet
Peak WSEL	435.44 feet	435.63 feet	436.20 feet
Top of Embankment	438.00 feet	438.00 feet	438.00 feet
Freeboard	2.56 feet	2.37 feet	1.80 feet
Wave Runup	1.04 feet	1.04 feet	1.04 feet
Freeboard with Wave Runup	1.52 feet	1.33 feet	0.76 feet

Table 4-11
Wave Runup Analysis Summary – Design Storm (Step 8) Conditions

Parameter	Value
Design Wind Speed	30 miles per hour
Fetch	1,400 feet
Wave Height	0.65 feet
Wave Runup Coefficient	1.6
Wind Setup	0.00 feet
Wave Runup	1.04 feet
Wind/Wave Freeboard	1.04 feet

4.4.3 Spillway Sizing and Hydraulics

Analyses were completed to determine appropriate sizing for the reservoir spillway. A drop inlet spillway was selected for this reservoir based on the configuration, location, and lack of natural inflow to the reservoir. Preliminary spillway sizing calculations were based on the following criteria:

- The spillway should be able to overflow any water conveyed to the reservoir through the inlet pipeline in the event that the automatic gates do not close to prevent inflow from the HID Main Canal when the reservoir reaches its full WSEL (435 feet). The inflow design rate is 25 cfs.
- The spillway should also be sized to convey precipitation falling on the reservoir when the reservoir is full. As noted in Section 4.4, the reservoir will be surrounded by an embankment and will not capture runoff from a drainage area tributary to the reservoir, but it will need to pass the IDF resulting from precipitation that falls on the reservoir during the design storm. The peak design storm flow rate is approximately 25 cfs.
- The spillway should be sized to pass these flows while maintaining the minimum required freeboard noted in Section 4.4.
- The flows should be routed through the spillway to a discharge point beyond the reservoir embankment without causing any transitional hydraulic issues in the spillway pipe; that is, weir flow from the top edge of the drop inlet should control the flow rate through all conditions, and the spillway pipe should never transition to full pipe flow.
- The flow through the spillway pipe should be less than 70% of the flow area in the pipe (66% full by depth).

DSO's drop inlet calculation spreadsheet was used to size the drop inlet. A hydraulic backwater analysis spreadsheet was used to size the spillway pipe. The two calculations were performed iteratively to ensure that the pipe has capacity to run within the depth criteria outlined earlier, and that weir flow over the crest of the drop inlet riser controls the spillway flow rate at the peak design inflow rate. Detailed spillway sizing calculations are provided in Appendix F. Table 4-12 summarizes the analysis completed.

Table 4-12
Spillway Sizing Analysis Summary

Parameter	Design Value
Drop Inlet Diameter	96 inches
Pipe Diameter	36 inches
Pipe Roughness (n)	0.012[1]
Design Inflow	25 cfs
Peak Long-Duration Design Storm Inflow	80.7 cfs
Peak WSEL During Design Storm	435.75 feet
Peak Spillway Flow	49.6 cfs

Note:

1. True Manning's n values for HDPE pipe are closer to 0.010; however, pipe manufacturers generally advise to use 0.012 as a design value.

4.4.4 Settling Basin Sizing and Hydraulics

The settling basin was sized to settle out solids near the intake facilities. Limited water quality data are available for water that flows into the HID Main Canal at the intake. However, based on the available data and observations made during high-flow events, it appears that much of the suspended sediment in the water at the diversion under high-flow conditions is fine material. The settling basin will not be able to settle out all of the suspended solids in the water, but it is designed to settle out the bedload and larger particles and reduce the volume of suspended sediment conveyed through the HID Main Canal to the reservoir.

The settling basin represented in the preliminary design drawings will be accessed from the HID Main Canal access road, and will be able to be cleaned with an excavator. Fine suspended sediment that does not settle out in the settling basin near the intake facilities may settle out in the reservoir, but it is anticipated that the accrual rate in the reservoir will be very low (a small fraction of an inch annually) and will help seal the bottom of the reservoir to reduce seepage over time.

The settling basin shown schematically in the preliminary design drawings will be located at the upstream end of the HID Main Canal. It will be created by reshaping and widening the existing canal and installing a weir or stop logs at the downstream end of the basin. The resulting settling basin will be approximately 150 feet long and trapezoidal in shape with a base width of 10 to 12 feet. The weir or stop logs will be adjustable. It is recommended that they be set to maintain a depth of at least 2 feet in the basin. Under these conditions, the water will slow to an average velocity of less than 1 fps for approximately 150 feet before flowing over the weir. This should allow for settling of the larger half of the suspended solids in the water. Settling basin calculations are included in Appendix G.

4.4.5 Flow Control Structure Sizing and Hydraulics

The preliminary design includes a flow control structure at the upstream end of the inlet pipeline that will control flow from the HID Main Canal to the reservoir. The flow control structure will be approximately 10 feet wide at the base and 4 feet deep. This should accommodate the full range of flows up to the 25 cfs design flow recommended for filling the reservoir.

Hydraulic control will be provided with an overtopping gate at the downstream end of the structure and a slide gate at the pipe inlet. The overtopping gate will rotate up or down to maintain a relatively constant upstream WSEL in the canal upstream of the structure and at the upstream end of the inlet pipeline. The slide gate will work in tandem with a water level sensor in the reservoir to automatically open or close based on the water level in the reservoir. When the reservoir is filling, the slide gate will be fully open. When the reservoir is full, the slide gate will close, preventing additional flow to the reservoir. The gate controls will be linked to the intake gate controls to prevent continued diversion of flows exceeding the HID Main Canal capacity downstream of the flow control structure.

The overtopping gate will be set to maintain the water surface in the canal at the upstream end of the flow control structure at an elevation of approximately 486.7 to 486.8 feet, based on a water level transducer that will be installed in a stilling well adjacent to the structure. Based on preliminary hydraulic calculations for the inlet pipeline, this depth should maintain 25 cfs of gravity flow to the 36-inch-diameter inlet pipeline, with a depth at the pipe inlet of 2.6 to 2.7 feet above the invert. The depth at the upstream end of the structure will be 1.1 to 1.2 feet above the floor of the structure. Some adjustment and adaptive management of the gate controls will be required to achieve the desired flow rate and minimize the flow of water over the top of the overtopping gate when the reservoir is filling.

4.4.6 Inlet Hydraulics

A backwater spreadsheet calculation was used to evaluate the hydraulic conditions in the inlet pipeline. Hydraulic calculations were completed for both low and full reservoir conditions. Under low reservoir conditions, it is assumed that the pipeline would flow partially full from the flow control structure at the HID Main Canal all the way to the outlet of the pipeline at the reservoir. As the reservoir fills, the pipe outlet at the reservoir would become submerged and fill with water. The inlet pipeline calculations are included in Appendix H.

The analysis assumes that the inlet pipeline will be operated to flow partially full by gravity. However, additional discussion may be needed during detailed design to determine whether Clallam County and the Work Group would prefer to control the flow at the downstream end of the pipeline so that the pipeline runs full, pressurized from the HID Main Canal down to the reservoir. For example, if it is decided that micro-hydropower facilities should be incorporated into the project, then it would make

more sense to operate the pipeline flowing full. The pipeline material and appurtenances are designed so that it could operate either way.

A USBR Type VI stilling basin has been included to dissipate the energy in the inlet pipeline resulting from the elevation difference from the HID Main Canal and the reservoir. The structure will be located at the end of the inlet pipe at the toe of the excavated interior slope on the south side of the reservoir. Calculations have been developed to address energy dissipation for a condition when the reservoir is empty and just starting to fill and the inlet pipe is flowing by gravity. It is under these conditions that the velocities and energy at the downstream end of the inlet pipeline will be highest. The stilling basin is designed to fully dissipate the energy of the incoming flow without the aid of any tailwater in the reservoir. However, any tailwater (>2 feet depth) will help further reduce energy at the inlet to the reservoir. Water from the energy-dissipation structure would be discharged into a 10-foot-wide, 1-foot-deep, rock-lined bottom swale that will convey water toward the reservoir outlet.

A 6-foot-wide and 8-foot-long Type VI stilling basin is recommended at the inlet to the reservoir per the USBR *Hydraulic Design of Stilling Basins and Energy Dissipators* manual (USBR 1984). The structure is sized based the Froude number of the inflow, which was estimated to be approximately 3.5 at the basin under gravity flow conditions with partially full pipe outlet conditions. The calculations for the stilling basin are included in Appendix I.

4.4.7 Outlet Hydraulics

The outlet works shown in the preliminary design drawings in Appendix A includes a pipe manifold with three gated ports designed to release water from the reservoir at three different elevations: at the bottom of the reservoir, approximately halfway up the embankment, and approximately 10 feet below the full WSEL. Three different outlet levels will allow flexibility in operating the reservoir to achieve desired hydraulic, temperature, and water quality results for water released from the reservoir for irrigation. An outlet pipeline will convey water to a discharge point near the north property boundary. Water will either be discharged to the open H1 Lateral or to a network of pipelines constructed to connect the reservoir to the downstream irrigation delivery systems.

Hydraulic calculations were compiled to calculate hydraulic conditions of water released through the outlet works and pipeline. It is anticipated that the pipeline will eventually connect to a network of closed pipelines with valves that will all be designed to flow full under pressure generated by the water level in the reservoir. Consequently, the calculations assume that a valve at the downstream end of the outlet pipeline will be operated to keep the pipeline flowing full under pressure. Depending on the timing of downstream improvements, it may make more sense to operate the outlet system as a gravity release with the pipeline flowing only partially full. Additional discussion

may be warranted during detailed design to ensure the pipeline is designed to accommodate the full range of potential operating conditions.

Based on the hydraulic calculations provided, a 36-inch HDPE pipeline will release 25 cfs from the reservoir at a velocity of 4.2 fps. Approximately 2 to 3 feet of energy head will be lost in the pipeline between the outlet works at the discharge point at the north property boundary. The outlet pipeline calculations are included in Appendix J.

4.5 Reservoir Operations

This section provides an overview of proposed reservoir operations based on the hydrologic and hydraulic analyses provided in Sections 4.3 and 4.4. The primary goals of reservoir operation will be to meet the water supply needs of downstream irrigators, and to maximize the benefit to Dungeness River flows that would result from offsetting reservoir use by a corresponding decrease in diversions from the river. Secondary goals of reservoir operation may include management of overland flows and use of reservoir water for SAR.

4.5.1 Overview of Anticipated Reservoir Operations

Table 4-13 summarizes the proposed timeline for reservoir operation during a typical year. Annual operation of the reservoir will include operation of the HID intake and screening facilities, HID Main Canal, the flow control structure on the HID Main Canal, and the inlet pipeline and structure to fill the reservoir from the late fall through early summer. Once the reservoir is full, the water level will be maintained through June and July. At least one outlet gate will need to be partially opened at the beginning of the irrigation season to deliver irrigation water to those who are currently served through the H1 Lateral. The outlet gates would be opened further sometime in August to increase releases to meet the full downstream irrigation demand. The reservoir would be drawn down as reservoir water is delivered to downstream water users for irrigation. Releases for irrigators would be discontinued at the end of the irrigation season in September. If additional water is available at the end of the irrigation season, additional releases could be made after September to SAR facilities for managed recharge.

Maintenance would likely occur in late September and early October when the reservoir is drawn down and irrigation water is not being conveyed through the HID Main Canal. The cycle would then repeat when fall rainstorms increase flows in the Dungeness River enough to make water available for diversion to the reservoir for storage.

Table 4-13
Overview of Anticipated Annual Reservoir Operations

<table>
<tr><th>Month</th><th>Diversions to HID Main Canal</th><th>Reservoir Filling</th><th>Releases for Irrigation</th></tr>
<tr><td>October</td><td>• Stock water diversions.
• Perform maintenance.</td><td>• No filling, reservoir is low.
• Perform maintenance.</td><td rowspan="6">• No releases (releases may continue for SAR, if determined beneficial).
• Perform maintenance.
• Keep outlet gates closed during reservoir filling.</td></tr>
<tr><td>November</td><td rowspan="5">• Open headgates to divert water to reservoir when water is available.
• Maintain stock water diversions.
• Close headgates when water is not available and during high-flow events and freezing weather.</td><td rowspan="4">• Open gate at flow control structure to begin filling.
• Fill reservoir when water is available.
• Pause filling when water is not available and during high-flow events and freezing weather.</td></tr>
<tr><td>December</td></tr>
<tr><td>January</td></tr>
<tr><td>February</td></tr>
<tr><td>March</td></tr>
<tr><td>April</td><td rowspan="4">• Continue filling when water is available until reservoir is full.
• Gate will close automatically when reservoir is full.
• Filling may overlap with irrigation season.</td></tr>
<tr><td>May</td><td rowspan="4">• Adjust overtopping gate in flow control structure to pass flows to meet HID irrigation demand.
• Reduce diversions to reservoir as needed to maintain HID irrigation deliveries.</td><td rowspan="4">• Open outlet gate(s) as needed to meet irrigation demand currently served by H1 Lateral.
• Adjust outlet gates remotely or at site as needed to meet demand and optimize quality and quantity of releases.</td></tr>
<tr><td>June</td></tr>
<tr><td>July</td></tr>
<tr><td>August</td><td rowspan="2">• Continue HID irrigation diversions.</td><td rowspan="2">• No filling, reservoir is being drawn down.</td></tr>
<tr><td>September</td><td>• Stock water diversions.</td><td>• Close outlet gates.</td></tr>
</table>

As indicated in the reservoir refill analysis by Washington Water Trust, the timing and availability of water that can be diverted to fill the reservoir will vary from year to year. During wet years, water may be available to fill the reservoir from November to July. During dry years, filling may need to primarily occur from April through early July. Reservoir filling will likely overlap with delivery of irrigation water to HID water users. If there is overlap, flows to the reservoir may need to be reduced in favor of conveying flows to HID water users. Irrigation deliveries will likely require 8 to 10 cfs of the capacity of the HID intake facilities and the HID Main Canal from late May through early July. If the facilities are fully upgraded to convey up to 25 cfs, that would leave a capacity of 15 to 17 cfs for filling of the reservoir during that time period.

4.5.2 Water Balance Analysis

A water balance analysis was developed for the reservoir that considers inflows from reservoir filling from the Washington Water Trust analysis, historical precipitation from nearby precipitation gages, seepage through the reservoir bottom and embankment, irrigation releases, and reservoir sizing. This analysis was completed on a monthly time step to provide reservoir usage information for the period of record consistent with the Washington Water Trust analysis of WY 2000 to WY 2021. A summary of the water balance is included in Appendix K. The results of the water balance are shown in Figures 4-4, 4-5, and 4-6 for years analyzed that represent relatively dry conditions (WY 2001), average conditions (WY 2012), and wet conditions (WY 2016).

The water balance model is based on the following inputs and assumptions:

- **Diversions from the Dungeness River:** The water balance model assumes that the volumes of water available for diversion from the river modeled by Washington Water Trust, based on a 25-cfs maximum diversion rate, would be available for filling the reservoir. There will be some overlap between reservoir diversions and the need to convey water downstream to users who are supplied from the HID Main Canal system for stock water use (in the fall, winter, and spring) and for irrigation (from April 15 through September 15). Additional refinement may be required to fully account for the flows needed to serve downstream HID water users.
- **Other Reservoir Inflows:** The water balance estimated precipitation inflow based on rainfall records from nearby precipitation gages at Sequim 2E and Port Angeles Fairchild Airport.
- **Reservoir Losses:** Water would be lost via seepage and evaporation. Seepage losses were estimated at 1E-06 cm/s, which is the high end of the values evaluated in the geotechnical engineering report (Shannon & Wilson 2021b). No evaporation was included because it was already accounted for in the reservoir refill estimates generated by Washington Water Trust.
- **Irrigation Demands and Releases:** Irrigation demands were incorporated based on the average 2-week irrigation diversions recorded at each diversion from WY 2015 through WY2020. Irrigation demands from the exact period of record used for the water balance (WY2000 to 2021) were not used because irrigation demands have been reduced over the last 20 years through implementation of water conservation projects.

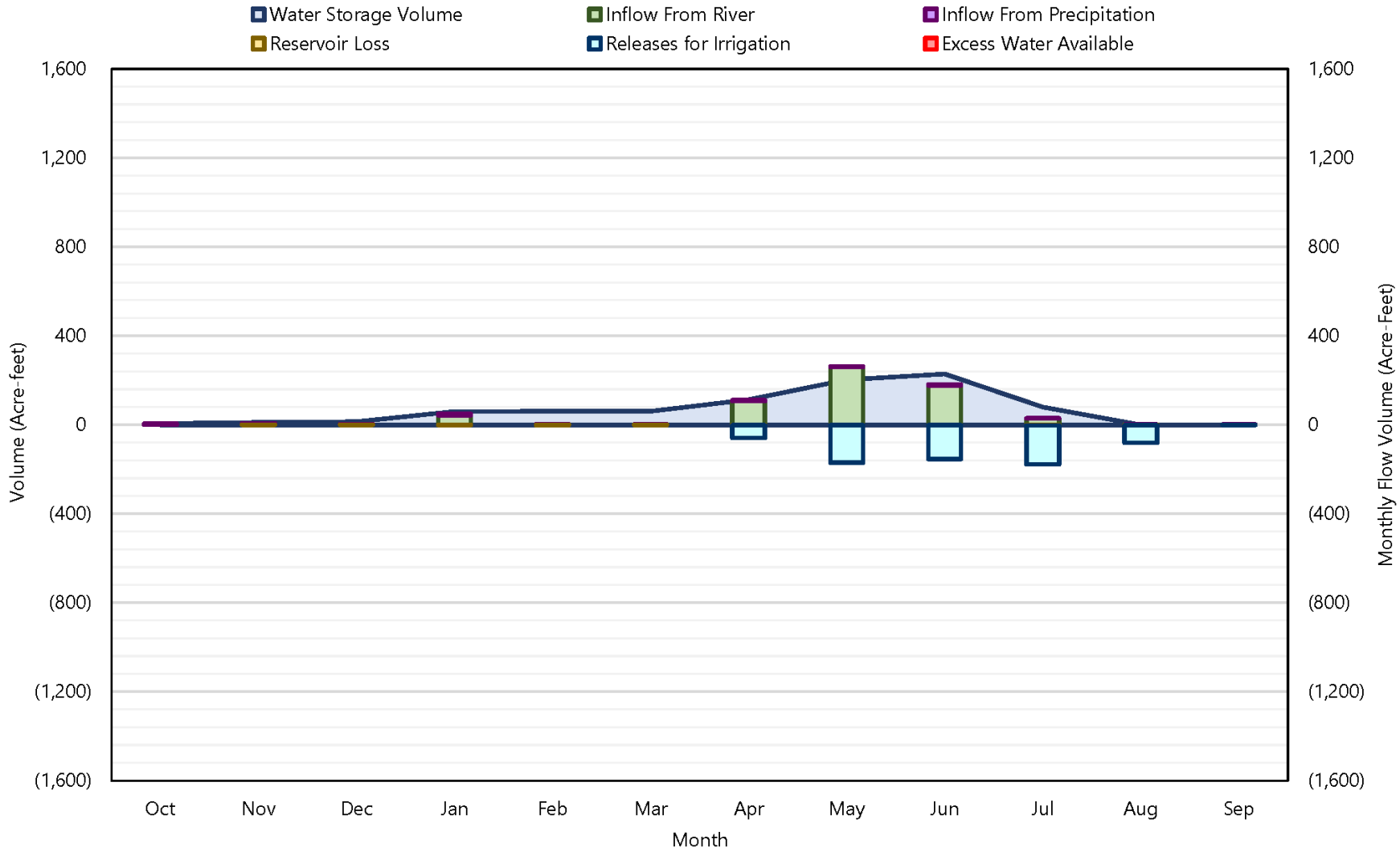

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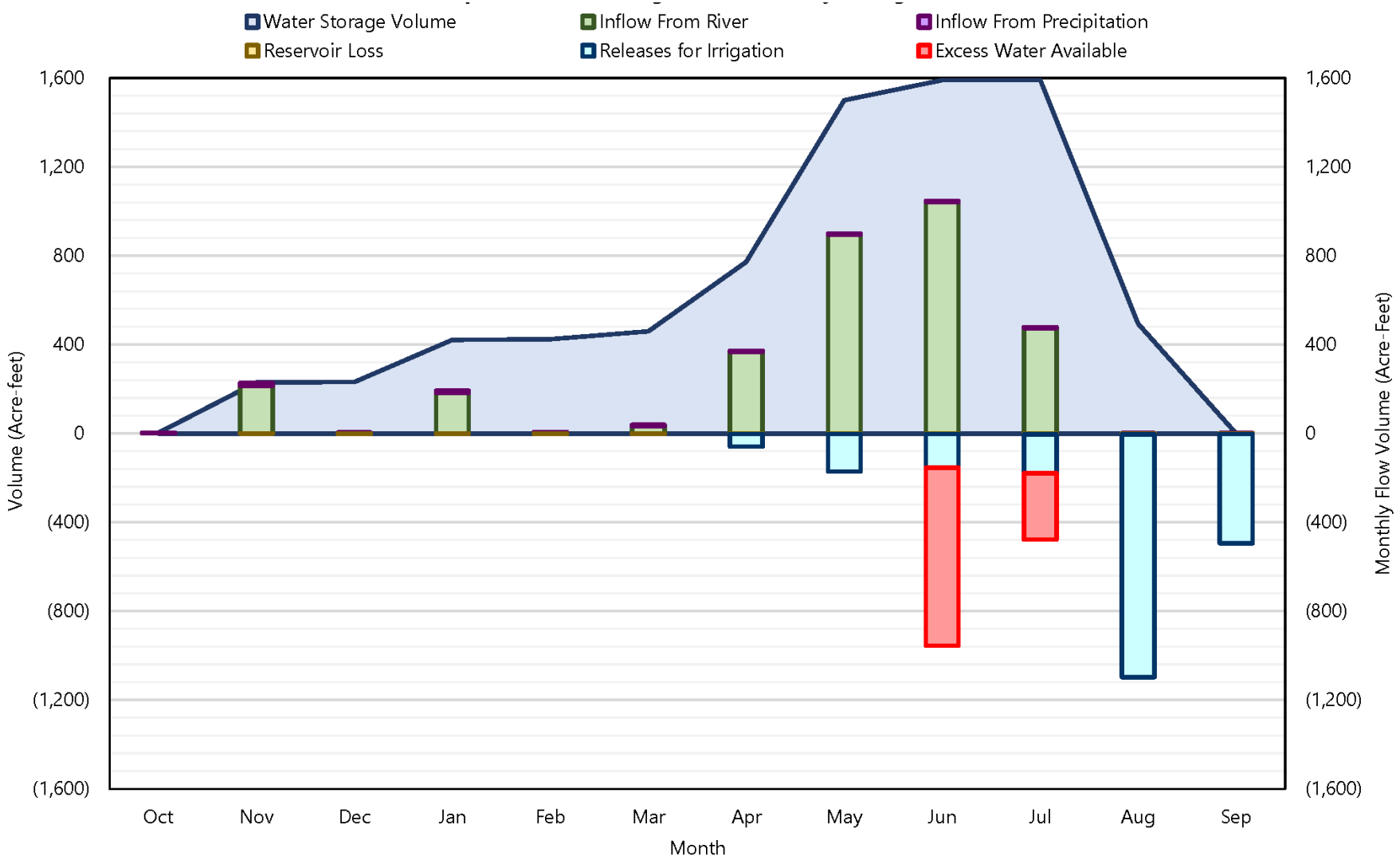
Figure 4-4
Reservoir Operations - Dry Year (2001 Hydrologic Conditions)
Preliminary Basis of Design Report
Dungeness Off-Channel Reservoir Project



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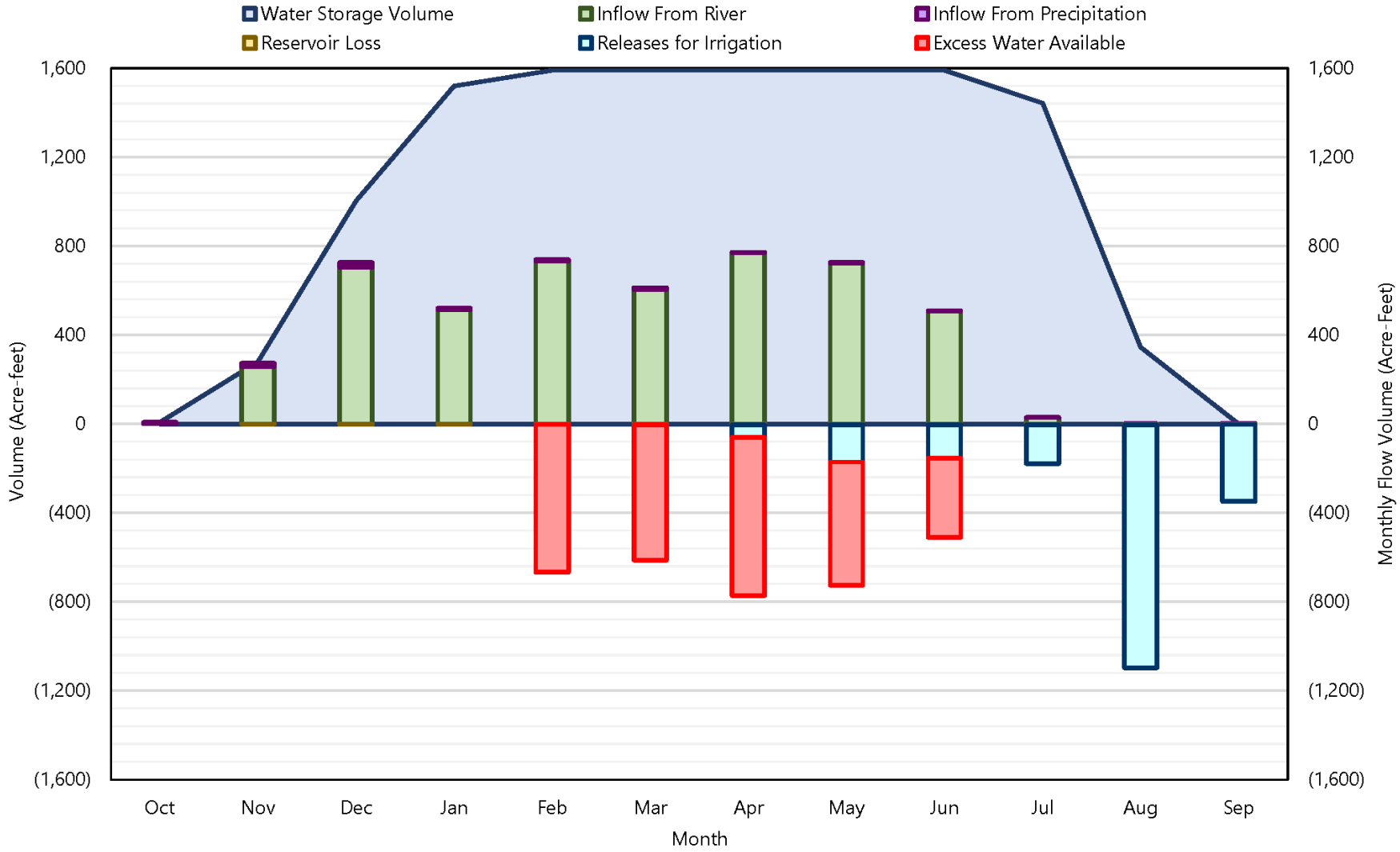
ANCHOR QEA

Figure 4-5
Reservoir Operations - Average Year (2012 Hydrologic Conditions)
Preliminary Basis of Design Report
Dungeness Off-Channel Reservoir Project



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ANCHOR QEA

Figure 4-6
Reservoir Operations - Wet Year (2016 Hydrologic Conditions)
Preliminary Basis of Design Report
Dungeness Off-Channel Reservoir Project

The average from the recent 5 years was used to more accurately evaluate the ability of the reservoir to meet current irrigation demands. Releases from the reservoir to meet irrigation demands were incorporated into the water balance model as follows:

- **H1 Lateral Demands:** The water balance model assumes that all demands on the H1 Lateral and the downstream irrigation ditches that it serves would be supplied by flow through the reservoir. The reservoir would release water throughout the irrigation season to meet those demands. The demands were assumed to be approximately 30% of the overall average diversions to the HID system from the Dungeness River.
- **Independent Canal Demands:** The water balance model assumes that water would be released from the reservoir to meet demands on the Independent Canal diversion and the downstream irrigation ditches that it serves from the beginning of August until water storage has been depleted.
- **Sequim-Prairie-DID Demands:** The water balance model assumes that water would be released from the reservoir to meet demands on the shared SPTIA-DID diversion and downstream pipelines and ditches that it serves until August, from the beginning of August until water storage has been depleted or until September 15, whichever is earlier.

The preliminary water balance indicates the following:

- The reservoir could not be completely filled during 3 years of the 22-year period evaluated, consistent with the results of the water refill analysis completed by Washington Water Trust. Those years included WY 2001, WY 2005, and WY 2009. This represents an annual refill probability of approximately 86% if up to 25 cfs can be conveyed to the reservoir through the HID Main Canal.
- The reservoir would store enough water to meet most, but not all, of the irrigation demand downstream of the reservoir, based on the water balance assumption that those currently served by the H1 Lateral would be served by reservoir water throughout the irrigation season, and those served by the Independent Canal and Sequim Prairie-DID diversions would only be served by the reservoir from the beginning of August until the reservoir is depleted. Additional water supplies (via existing points of diversion) would be required during at least some of the time from the beginning of August through the end of the irrigation season in September to supply average irrigation demands.
- For 2016 conditions (a representative wet year), the water balance indicates the following:
  - Approximately 4,840 acre-feet would be available for diversion to the reservoir.
  - The reservoir would be filled completely in February and stay full through June.
  - The reservoir would be drawn down by the end of the irrigation season in September.
  - Much of the water availability and precipitation would occur when the reservoir is full, so nearly 2,900 acre-feet of water that is available or captured via precipitation would

not be able to be stored in the reservoir, unless releases were made for managed SAR at or near the rate of precipitation.
  - Over 1,990 acre-feet of water would be released from the reservoir for irrigation, but approximately 349 acre-feet would be needed from other sources during August and September to meet all downstream irrigation demands if those demands are similar to the average demands experienced from WY 2015 through WY 2020.
- For 2012 conditions (a representative average year), the water balance indicates the following:
  - Approximately 3,209 acre-feet would be available for diversion to the reservoir.
  - The reservoir would be filled completely in June and stay full through July.
  - The reservoir would be drawn down by the end of the irrigation season in September.
  - Less water availability and precipitation would occur when the reservoir is full, so nearly 1,100 acre-feet of water that is available or captured via precipitation would not be able to be stored in the reservoir.
  - Almost 2,140 acre-feet of water would be released from the reservoir for irrigation, and approximately 202 acre-feet would be needed from other sources during August and September to meet all downstream irrigation demands if those demands are similar to the average demands experienced from WY 2015 through WY 2020.
- For 2001 conditions (a representative dry year), the water balance indicates the following:
  - Approximately 615 acre-feet would be available for diversion to the reservoir.
  - The reservoir would never fill completely. The maximum storage volume would only be 229 acre-feet and the maximum water surface would only rise to 396.2 feet.
  - The reservoir would be drawn down sometime in early August.
  - The reservoir would capture all of the available water diverted and precipitation. No water would spill and there would be no excess water available.
  - Only 632 acre-feet of water would be released from the reservoir for irrigation, and approximately 1,709 acre-feet would be needed from other sources during August and September to meet all downstream irrigation demands if those demands are similar to the average demands experienced from WY 2015 through WY 2020.

4.5.3 Controls and Automation

To ensure that the reservoir is operated efficiently to maximize the key benefits, it is recommended that the reservoir improvements include electronic actuators on key flow control gates, water level transducers, and other instrumentation, and that this equipment is tied to a telemetry system that will allow for remote operation and automation. Key facilities that will require control and automation are summarized in Table 4-14.

Table 4-14
Summary of Recommended Controls and Automation

Facility	Recommended Control Equipment	Recommended Automation
Headgates	• Electronic gate actuators. • Parshall flume relocated to diversion canal just downstream of intake structure. • Transducer at Parshall flume tied to gate actuator.	• Use programmable controller to open and close gates automatically to control the flow rate. • Tie to telemetry system for remote gate adjustment. • Override when flow in Dungeness River is insufficient for diversion.
Flow Control Structure – Overtopping Gate	• Electronic gate actuators. • Transducer in stilling well adjacent to upstream end of structure.	• Use manufacturer-provided controller to raise and lower gate automatically to maintain a constant upstream water level in the canal. • Tie to telemetry system for remote gate adjustment.
Flow Control Structure – Inlet Pipeline Slide Gate	• Electronic actuator. • Transducer in reservoir tied to gate actuator.	• Use programmable controller to close gate automatically when reservoir is full and open when reservoir is not full. • Tie to telemetry system for remote gate adjustment.
Outlet Works – Outlet Slide Gates	• Electronic actuator. • Flow meter in pipeline downstream of reservoir.	• No automation. Require operator to open and close based on downstream irrigation demand. • Tie to telemetry system for remote gate adjustment.

4.6 Geotechnical Engineering Analyses

An evaluation of subsurface conditions and geotechnical analyses, based on data from the Phase 1 geotechnical exploration, are summarized in the *Draft Phase 1 Conceptual Geotechnical Engineering Report, Dungeness Off-Channel Reservoir* (Shannon & Wilson 2021b). Recommendations for the preliminary design of the reservoir are also included.

Like most of Western Washington, the project site is situated in a seismically active region that is characterized by large earthquakes associated with subduction interface, subduction intraplate, and shallow crustal sources. Several large earthquakes have occurred regionally over the past 300 years. About a dozen faults are located within 40 miles of the project site, and most are considered Quaternary-active. The *Geotechnical Engineering Feasibility Report Review, Dungeness Off-Line Storage Facility, River Road, Clallam County, Washington* (PanGEO 2020) reviewed information about faulting in the area from the USGS and others. A potential fault, referred to as the Sequim Fault, has been mapped near the site. However, the existence of the Sequim Fault is based on one study and

additional field work (completed by PanGeo and the USGS in 2020) that attempted to find evidence of faulting near the site did not find evidence of a fault. Additional work will be completed during detailed design to ensure that the reservoir is designed to address the appropriate seismic risk.

Preliminary analyses indicate peak ground motions for a 2,500-year event in excess of 0.8 g (g = gravitational constant) may be possible and need to be considered for reservoir embankment design. Since publication of the latest USGS ground motion hazards, new Next Generation Attenuation for Subduction Zone Ground Motion Models have been published; these may have an impact on the computed design ground motion values and could be considered in further seismic evaluations, such as Deterministic Seismic Hazard Assessment or Probabilistic Seismic Hazard Assessment. The absence of groundwater in the soil above the glacial till and the dense soil conditions below the top of the glacial till indicate the soil at the site has very low potential for liquefaction if the construction of the reservoir does not significantly change the groundwater conditions.

Preliminary seepage analyses were completed to evaluate groundwater flow and infiltration losses for soil-lined and geomembrane-lined reservoir alternatives. Extending a seepage cutoff into the till or fully lining the reservoir with a low-hydraulic conductivity material is recommended. Preliminary slope stability analyses were completed for various embankment slopes. Static slope stability analyses were completed for rapid drawdown conditions. Seismic slope stability analyses were completed using a pseudo-static approach and a horizontal seismic coefficient of 0.42g. Potential failures of the exterior and interior reservoir slopes under seismic loading conditions were evaluated.

The seepage and slope stability analyses results were used to inform selection of embankment interior and exterior slope inclinations and embankment zoning. The results indicate interior and exterior embankment slopes of 3H:1V (3 horizontal to 1 vertical) or flatter are required. If a non-geomembrane (i.e., soil) liner alternative is selected, interior embankment slopes of 3.5H:1V or flatter are required to meet rapid drawdown criteria. To meet seismic stability criteria, a stability berm should be constructed around the embankment exterior. The preliminary results indicate this stability berm should have with a height of about one-third the exterior embankment height.

Protection against seepage-induced piping of soil from the embankment or foundation should be provided. Filter and drain zones should be included in the zoned embankment and installed below the reservoir liner where geologic conditions warrant. The configuration, thickness, and aerial extent of these filter and drainage zones will be determined during final design. Seepage along conduits that pass through the embankment, such as the low-level outlet pipe and spillway pipe, could lead to erosion of the soils around the pipes. Therefore, low-hydraulic-conductivity backfill should be placed around the reach of pipe passing through the low-hydraulic-conductivity zone of the embankment. Downstream of the low-hydraulic-conductivity backfill, filtered drainage features including a filter diaphragm should be constructed.

The geologic reconnaissance and subsurface explorations conducted for the 30% design phase indicate the soil to be excavated for reservoir construction could be mostly reused in the embankment and embankment core. Older alluvium material could be used in embankment shells (outer zones) and the stability berm. Glacial till could be used for the low-hydraulic-conductivity embankment core and reservoir liner. Post-30% design-phase hydraulic conductivity testing should be conducted to assess whether the glacial till material is acceptable for use in low-hydraulic-conductivity embankment zones and for the reservoir liner, if bentonite should be mixed with the glacial till to reduce the hydraulic conductivity, or if a geomembrane liner is necessary. Post-30% design-phase borings and geophysics should be conducted to map depth to top of glacial till across the project site.

Processing of older alluvium and glacial till will be necessary to remove oversize cobbles and boulders from on-site derived material used for embankment fill. This processing might be accomplished during material excavation and placement operations or a separate screening operation. On-site gravel screening and washing might be considered to process older alluvium to produce filter and/or drainage material. Evaluation of the feasibility of on-site production of filter and drainage material should be performed during the next project phase.

The *Draft Phase 1 Geotechnical Engineering Report* (Shannon & Wilson 2021b) presents details on the preliminary engineering analyses performed, analysis results, geotechnical engineering considerations, conceptual design alternatives, and on-site material reuse potential.

4.7 HID Intake Facility and Screening System Assessment

HDR performed a preliminary assessment of HID's intake and screening facilities to determine whether the existing facilities have the capacity to divert up to 25 cfs while meeting regulatory fish screening criteria and, if not, what measures are necessary to bring the fish screening facility into regulatory compliance. A memorandum summarizing HDR's findings is included as Appendix L. The following is an overview of the key findings of the assessment related to key components of HID's intake and screening system:

- **Diversion Headgates:** To deliver the desired 25-cfs irrigation diversion, HDR estimated that a total of up to 31 cfs must be diverted from the river. Additional information, including survey of the headgate structure and bathymetric survey of the river channel at the intake structure, will be needed to determine that the intake gates can consistently pass the additional flow. The headgate structure should have a trash rack installed on the upstream side of the structure to protect the slide gates from damage due to river debris. New automated slide gates are recommended to control flow to the intake. The structure currently has two slide gate channels, but one is abandoned and sealed off. It is recommended that the abandoned slide gate opening be refurbished to increase capacity and add redundancy.

- **Upgrades to Diversion Channel:** HDR noted that minor losses and seepage in the diversion channel between the intake structure and the fish screening structure may limit the capacity of the diversion channel. Topographic survey of these features will be needed to verify the capacity of the diversion channel. Addition of a flow measuring device or relocation of the Parshall flume to the diversion channel downstream of the headgate is recommended to provide instrumentation to allow the headgates to operate automatically to control the flow rate through the intake structure.
- **Rotary Drum Fish Screens:** Based on the preliminary analysis, HDR concluded that the existing rotary drum fish screens are large enough to pass more than 25 cfs. WDFW was contacted to discuss their ideas and concerns regarding increasing the diversion flows up to 25 cfs. WDFW recommends that the wire mesh on the drum screens be replaced with new screening material. It is recommended that the project be coordinated with WDFW so that they can replace the wire mesh with stainless steel perforated plate or another type of screening material that meets their recommendations.
- **Fish Bypass:** An automatic gate is recommended for the fish bypass so that it can be adjusted to increase sweeping velocities across the fish screens. WDFW also indicated that excluding upstream migrating adult fish in the fish bypass channel is desired. To exclude these fish, it is recommended that a velocity barrier, or similar upstream barrier, be placed at the downstream extent of the bypass channel near the confluence with the river. Topographic survey data will be needed to measure the differential and determine if this is a potential solution.
- **Flow Control Downstream of Fish Screens:** Two sets of stop logs downstream of the fish screens control the water level and flow through the screens. HDR recommends removing the stop logs immediately downstream of the drum screens and automating the downstream overshot gate by installing an electronic actuator and controlling the gate with a new water measurement device.
- **Settling Basin:** Incorporation of a settling basis is recommended to settle out the bedload and suspended sediment that can be mobilized during high flows.

Some of these recommended improvements are shown schematically in Drawing C16 over a base that consists of the drawings WDFW generated when the fish screens were installed in 1994. This drawing will be refined with more detailed designs once topographic survey information is available for the intake and fish screen site.

4.8 Water Quality Evaluation

This section evaluates projected water quality characteristics of the proposed reservoir and identifies appropriate reservoir management options to ensure that water quality in the reservoir is suitable to support its intended beneficial use for irrigation.

Some natural lakes in Clallam and Jefferson counties have degraded water quality, including noxious algal blooms and depleted bottom water dissolved oxygen (DO) concentrations (Herrera Environmental Consultants 2020). Degraded lake water quality conditions in this region are often the result of relatively high concentrations of the nutrient phosphorus, the typical limiting nutrient controlling algae growth in freshwater lakes. As algae sink to the bottom of the lake and decay, they decrease bottom water oxygen concentrations.

4.8.1 Inflow Total Phosphorus Concentrations

From 1993 to 2001, total phosphorus (TP) concentrations in the Dungeness River near the HID intake structure were monitored by Ecology (monitoring station 18A070) using current analytical protocols (in-line ultraviolet/persulfate digestion and flow injection analysis with validated results). Measured TP concentrations during this period averaged 15 ± 2 micrograms per liter (µg/L; 47 samples), with no discernable annual or seasonal variability. Because of the largely undeveloped watershed within the protected Olympic National Park and National Forest upstream of this monitoring station, present-day and future TP concentrations in the Dungeness River are unlikely to deviate substantively from the 1993 to 2001 conditions.

Washington State Surface Water Quality Standards (WAC 173-201A) establish an action level of 20 µg/L for TP in Puget Sound lowland lakes to prevent undesirable algae growth that may interfere with recreational uses. Since the average measured TP concentration (15 ± 2 µg/L) near the proposed intake is below the 20 µg/L action level, projected water quality characteristics of the proposed reservoir are likely to be suitable to support its intended beneficial use for irrigation.

A site-specific evaluation of projected water quality conditions in the proposed reservoir was performed using the following assumptions, more fully described in the sections that follow:

- Reservoir filling projections from May 1 to June 1; full pool without discharge from June 1 to August 1; steady irrigation discharge from August 1 to September 15; empty reservoir from September 15 to May 1 (see Sections 4.4 and 4.5)
- Seasonal stratification projections
- Waterbird TP input projections
- Bottom water DO depletion projections

4.8.2 Seasonal Stratification

Nearby Anderson Lake (Jefferson County) is similar in size (65 acres), depth (29 feet maximum), and regional climate setting to the proposed reservoir; seasonal stratification characteristics in both waterbodies are also projected to be similar. Temperature profiles in Anderson Lake were monitored from March 2019 through February 2020 (Herrera Environmental Consultants 2020) to characterize thermal stratification between the epilimnion (warmer surface layer) and hypolimnion (cooler bottom

layer). These layers are separated by a thermocline, defined as the depth corresponding to the maximum vertical change in temperature. The thermocline depth in Anderson Lake was approximately 6 feet below lake surface from mid-May through July, lowered to 10 feet in in August, and lowered further to 15 feet by mid-September.

Using the anticipated reservoir filling schedule and stage-storage relationship (Section 4.4), along with seasonal stratification conditions (above), a spreadsheet model was developed to project seasonal changes in the epilimnion and hypolimnion volumes to support site-specific water quality evaluations. A reduced filling schedule with only half the inflow and outflow rate, and half the total storage volume, during a drought year was also evaluated as a sensitivity analysis. Results from this scenario were combined with other model runs to provide a range of projected outcomes.

4.8.3 Waterbird Loading

Many regional lakes and reservoirs support large numbers of waterbirds. Because these birds consume and excrete relatively large amounts of food containing nutrients, they can impact water quality. Scherer et al. (1995) characterized TP loading by bird droppings in Green Lake (Seattle), a 260-acre urban park with abundant mowed lawns supporting a greater density of waterbirds than that projected for the relatively undeveloped Dungeness River reservoir. Waterbirds increased TP loading in Green Lake, but only a portion of the TP in droppings was derived from outside the lake itself. The authors concluded that waterbirds increased TP loading to the lake by approximately 0.156 ± 0.004 grams TP per square meter per year. As a conservative assumption, this waterbird loading rate was added to the Dungeness River intake concentration, also assuming no in-lake sedimentation. This site-specific analysis revealed that waterbirds could potentially increase epilimnetic TP concentrations by up to approximately 20%, but TP concentrations would still be projected to be below the 20 µg/L TP action level.

4.8.4 Hypolimnion Dissolved Oxygen Depletion

As discussed previously, as algae sink to the bottom of reservoirs and decay, they decrease hypolimnetic DO concentrations. Using data from multiple lakes and reservoirs, Reckhow and Chapra (1995) correlated the hypolimnetic oxygen depletion rate (HODR) with in-lake TP concentrations as follows:

$$\text{HODR (grams oxygen per square meter per day)} = 0.086 \times \text{TP (µg/L)}^{\wedge 0.478}$$

This empirical relationship was input into the spreadsheet model discussed previously to calculate seasonal changes in hypolimnetic DO concentrations within the proposed reservoir. Starting DO concentrations in the reservoir during the spring filling period were based on average measurements during May at Ecology's monitoring station 18A070.

Projected seasonal changes in average DO concentrations within the reservoir hypolimnion are depicted in Figure 4-7, including the results of model sensitivity analyses. While hypolimnetic DO concentrations are projected to decline seasonally, particularly during August as the depth of the hypolimnion is significantly reduced by withdrawals, minimum DO concentrations are nevertheless projected to remain above 5 milligrams per liter, suggesting that well oxygenated conditions will persist in the reservoir hypolimnion even through late August and early September.

While the water quality evaluations summarized here suggest that additional reservoir management options such as aeration are unlikely to be needed to ensure that water quality in the reservoir is suitable to support its intended beneficial use for irrigation, it may be prudent to install the infrastructure needed (power) in the unlikely situation that it may be needed in the future. At this level of design, no aeration equipment is called out in the preliminary drawings. Clallam County may want to add power supply for future aeration in the final design.

In addition, the final design will include features to discourage waterfowl use of the reservoir. The features will include vegetation to discourage nesting and low fencing to inhibit waterfowl access from the reservoir embankment to the reservoir.

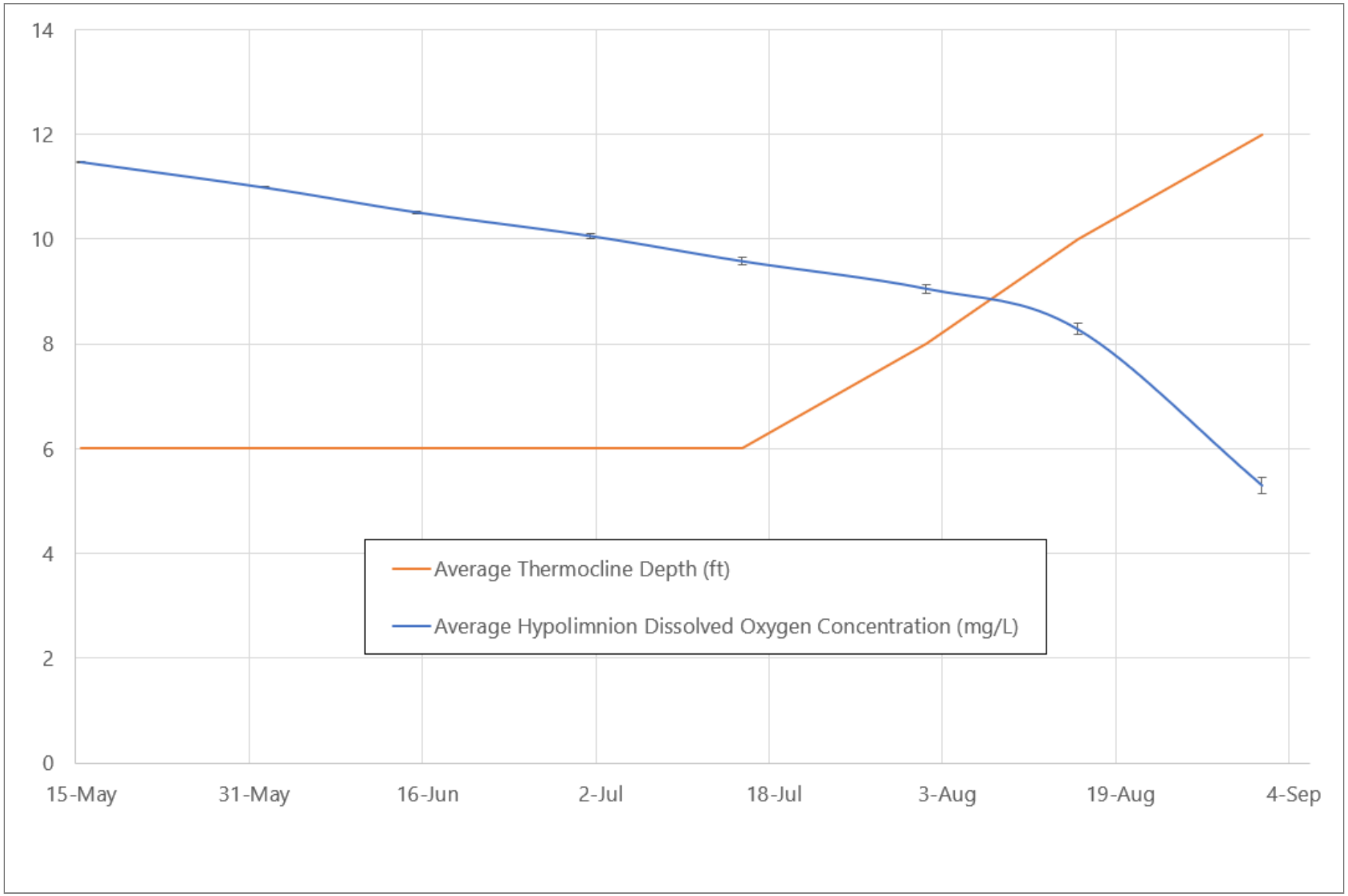

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Figure 4-7
Projected Seasonal Stratification and Hypolimnetic DO Levels, Dungeness River Reservoir

5 Preliminary Cost Analysis

5.1 Opinion of Probable Construction Costs

A preliminary opinion of probable construction costs was prepared for the reservoir and related appurtenances shown in the preliminary design drawings (Appendix A). A summary of the preliminary opinion of probable construction costs for key project elements is included in Table 5-1. Detailed opinion of cost tables with quantities for anticipated cost items are included in Appendix M. For comparison and to provide a basis for further decision-making regarding the configuration of the reservoir and embankment, two separate opinions of probable construction costs were prepared for the reservoir, as follows:

1. A preliminary opinion of probable cost was prepared for the embankment configuration shown in the drawings, which assumes an embankment core and liner consisting of processed glacial till material with embankment zoning and no fabricated geomembrane liner.
2. A preliminary opinion of probable cost was also prepared for an embankment configuration that would include a low-permeability geomembrane liner.

In addition, opinions of probable construction costs were prepared for some of the appurtenant projects that have been discussed but are not currently included as part of the preliminary design drawings (Table 5-2). These include piping of the HID Main Canal and a drought relief pump station. These related projects have only been evaluated to the concept level and the costs for these projects are likely to change as they are evaluated in more detail. Costs for pipeline improvements in the irrigation system downstream of the reservoir were evaluated under a separate contract with Clallam Conservation District. These costs were inflated to December 2021 dollars and are also included in the summary provided in Table 5-2.

No costs have yet been developed for other improvement projects that are being considered by the Work Group but that have not yet been evaluated and are not included in the preliminary design. These include the overland flow capture and conveyance system, infiltration facilities, slope erosion repairs on the HID Main Canal at the BPA easement, and small hydropower or solar generation.

Table 5-1
Opinion of Probable Costs – Dungeness Off-Channel Reservoir Key Elements

Cost Item	Opinion of Cost Till Core and Liner Option, No Geomembrane Liner	Opinion of Cost Geomembrane Liner Option
Reservoir and Appurtenances	$24,639,000	$25,738,000
Inlet Pipeline, HID Main Canal to Reservoir	$890,000	$890,000
Outlet Pipeline, Reservoir to North Parcel Boundary	$685,000	$685,000
Flow Control Structure on HID Main Canal	$90,000	$90,000
Settling Basin at Upstream End of HID Main Canal	$97,000	$97,000
HID Intake Screen Improvements	$269,000	$269,000
HID Headworks Improvements	$295,000	$295,000
Subtotal – Key Project Elements	**$26,965,000**	**$28,064,000**
Contingency (15%)	$4,044,750	$4,209,600
Construction Subtotal	**$31,010,000**	**$32,274,000**
Sales Tax (8.5%)	$2,635,850	$2,743,290
Construction Total	**$33,646,000**	**$35,017,000**
Other Construction-Related Costs		
Construction Management (8% of Construction Subtotal)	$2,480,800	$2,581,920
Total Project Cost	**$36,127,000**	**$37,599,000**

Notes:

1. Design, permitting, land acquisition, legal, and administrative costs are not included in this summary.
2. This opinion of cost was updated in December 2021. Actual construction costs will vary based on materials and labor costs at the time of construction.
3. The subtotals and construction total are rounded to the nearest $1,000.
4. The allowance for construction management cost is calculated as 8% of the pre-tax construction subtotal.

Table 5-2
Opinion of Probable Costs – Other Related Projects

Cost Item	Opinion of Cost
Piping of HID Main Canal (Expand to 25-cfs Capacity)[4]	$2,002,000
HID Drought Relief Pumping Station[5]	$636,000
Downstream Irrigation Pipelines to Convey Reservoir Water[6]	$3,280,000
Subtotal – Other Related Projects	**$5,918,000**
Contingency (15%)	$887,700
Construction Subtotal	**$6,806,000**
Sales Tax (8.5%)	$578,510
Construction Total	**$7,385,000**
Other Construction-Related Costs	
Construction Management (8% of Construction Subtotal)	$544,480
Total Cost – Other Related Projects	**$7,929,000**

Notes:

1. Design, permitting, land acquisition, legal, and administrative costs are not included in this summary.
2. This opinion of cost was updated in December 2021. Actual construction costs will vary based on materials and labor costs at the time of construction.
3. The subtotals and construction total are rounded to the nearest $1,000.
4. Costs represent conceptual-level sizing of a 36-inch HDPE pipeline that would replace the HID Main Canal to safely deliver up to 25 cfs from the HID intake facilities to the flow control structure on the HID Main Canal, where water would be diverted from the canal to the inlet pipeline that would fill the Dungeness Off-Channel Reservoir.
5. Costs represent conceptual-level sizing of a pumping plant that would deliver up to 10 cfs from the reservoir to the HID Main Canal. The costs assume that the conveyance or discharge pipeline would either be the inlet pipeline or the overland flow conveyance pipe, and the costs for that pipeline are not included in the cost for this item.
6. Costs for pipelines needed to deliver reservoir water to downstream irrigation systems and replace downstream irrigation canals and ditches were estimated as part of the preliminary design of those facilities in June 2021. The cost included in this summary has been inflated to reflect changes in labor and materials costs since June 2021.
7. The allowance for construction management cost is calculated as 8% of the pre-tax construction subtotal.

The opinions of probable construction costs provided in Tables 5-1 and 5-2 include the following allowances and reflect the following assumptions:

- A lump sum unit cost item was included for mobilization/demobilization. An allowance of 7.5% was included for this item based on the subtotal of all the individual cost items.
- A lump sum unit cost item was included for each major element to reflect items not yet identified. An allowance of 10% of the subtotal of all cost items was allocated as the lump sum price for this item.
- A 15% contingency was added to the subtotal of all the individual cost items to reflect the preliminary level of design.
- Sales tax of 8.5% was applied to the construction subtotal.
- An allowance of 8% of the construction subtotal was included for construction management.

The summary of costs does not include other nonconstruction-related costs such as design, permitting, land acquisition, legal, and administrative. These other costs will be incurred through project implementation but are being evaluated separately by Clallam County for various funding applications and as part of scoping for future design. Additional input will be provided on these costs as needed to ensure that adequate funding is secured for project implementation.

In addition, construction labor and materials prices have been extremely volatile since early 2020. Prices for many materials have increased dramatically and are currently very difficult to project. The costs provided are in December 2021 dollars. Actual construction costs will vary based on materials and labor costs at the time of construction. The project should be budgeted with adequate contingency to cover potential increases in labor and materials costs, as well as changes to the design that will occur between now and construction. The contingency has been provided primarily to reflect potential changes to the design and estimated material quantities that will occur as the design is refined. The contingency will be reduced as these variables are evaluated in more detail.

5.2 Long-Term Operating and Replacement Costs

Long-term operating costs will include operation and maintenance costs and the cost of funding replacement of the facilities when they have reached the end of their design life cycle. These costs are summarized in Table 5-3. Operations and maintenance costs were estimated based on the cost of operating storage facilities of similar size, and they include salary and benefits for a government employee at a rate of 1/4 full-time equivalency, administrative costs, transportation costs, supplies, maintenance, repairs, and contracted labor costs.

Replacement costs were evaluated to determine the annual deposit that would need to be made to an account to fund replacement of critical facilities at the end of an assumed 50-year design life cycle for the project. Key components that would need to be partially or fully replaced sometime during the 50-year design life of the project include the reservoir liner, pipelines, structures, control equipment, and monitoring equipment. It is unlikely that all of these facilities would need to be completely replaced within that assumed life cycle, so the analysis was done for three levels of replacement funding: 25%, 50%, and 100%. The analysis assumes that the annual interest rate on the replacement fund is 3% and an annual inflation rate is 3%. The analysis also assumes that the annual deposit would escalate at the assumed annual inflation rate.

Table 5-3
Opinion of Probable Annual Long-Term Operating and Replacement Costs

Cost Item	Opinion of Cost
Annual Operation and Maintenance Cost	$41,200
Annual Replacement Fund Cost (25% of Critical Facilities Replaced)	$37,090
Annual Replacement Fund Cost (50% of Critical Facilities Replaced)	$74,180
Annual Replacement Fund Cost (100% of Critical Facilities Replaced)	$148,360

Notes:
1. This opinion of cost was updated in December 2021. Actual costs will vary based the cost of labor and materials needed to operate and maintain the reservoir, long-term interest rates, inflation, and other factors.
2. Annual replacement fund cost represents the deposit required during the first year of operation to fund replacement of equipment over a 50-year design life cycle. Assumes an annual interest rate on the replacement fund of 3% and an average annual inflation rate on equipment to be replaced of 3%.

6 Preliminary Environmental Impacts and Permitting Strategy

As noted in the prior sections of this report, Clallam County is proposing to excavate and place earthen materials to construct an off-channel reservoir, convert portions of existing irrigation ditches to pipelines, modify the HID headgates and intake facilities to increase capacity for diversion during the winter season, modify the fish screen facilities, and create a spillway connection to the Dungeness River. Actions associated with the existing irrigation system may fit within activities allowed for repair or maintenance of existing facilities and qualify for related exemptions or programmatic permits and approvals. New upland and in-water work may not qualify for the same exemptions or programmatic permits, requiring individual permits and approvals. The final permit strategy for the proposed improvements will ultimately be determined through continued agency and stakeholder coordination and design refinements.

The following sections provide an overview of anticipated regulatory and permitting requirements for the project that consider both repair and maintenance and individual permitting scenarios. Due to the location of the proposed improvements in and adjacent to the Dungeness River, it is expected that federal, state, and local permits and approvals will apply.

6.1 Affected Environment and Preliminary Anticipated Impacts

The following section describes existing elements of the environment and a preliminary analysis of possible impacts. Further analysis of impacts will occur during the next phase of design and permitting.

6.1.1 Geology and Soils

The geology of the proposed reservoir site is mapped by the Washington Department of Natural Resources (WDNR 2021) as quaternary unconsolidated or semi-consolidated alluvial deposits that may consist of clay, silt, sand, gravel, or cobble. The hillslope to the east of the proposed reservoir site is mapped as Pleistocene glacial till and outwash deposits. A small landslide has been mapped just to the south of Happy Valley Road, and faults have been mapped in the general vicinity. The geology and soils at the site are described in more detail in the *Draft Phase 1 Conceptual Geotechnical Engineering Report, Dungeness Off-Channel Reservoir* (Shannon & Wilson 2021b).

The soils mapped on the proposed reservoir site are Carlsborg gravelly sandy loam with Dungeness silt loam and riverwash at the base of the bluff slope (NRCS 2021). Carlsborg soils are formed on terraces and alluvial fans from coarse-textured alluvium. The permeability is rapid and the hazard of erosion is slight (SCS 1987). Dungeness soils are formed on floodplains from finer grained alluvium. The permeability is moderate and the hazard of erosion is slight (SCS 1987).

The proposed reservoir and associated piping are unlikely to cause erosion hazards based on a design that will provide a controlled overflow route. The site does provide a good potential for groundwater infiltration and thus lining the reservoir is likely to be necessary. The design will need to account for the presence of the seismic fault trace to minimize the risk of damage from a seismic event.

6.1.2 Water Resources and Water Use

The proposed reservoir site is within Water Resource Inventory Area 18, Dungeness-Elwha Basin. One of the primary purposes of the project is to reduce the rate of irrigation water withdrawals from the Dungeness River during low flows in the late summer, thus improving streamflow conditions and water temperatures in the river for native species, including ESA-listed salmonid species.

6.1.3 Aquatic Habitat and Species

The Dungeness River provides habitat for up to eight species of salmonids, including spring-run and fall-run Chinook, coho, pink, chum, and sockeye salmon; winter-run and summer-run steelhead; cutthroat trout; and bull trout (WDFW 2021b). Dolly Varden trout may also be present (Wydoski and Whitney 2003). The Dungeness River is also critical habitat for the ESA-listed Puget Sound Chinook salmon and winter steelhead and Hood Canal chum salmon.

Major limiting factors causing the decline of native salmonids in the Dungeness River include low flows during the late summer, removal of riparian habitat, development in the floodplain, dikes and armoring along the river, and degradation of water quality from contaminants and nutrients (SSDC 2007). Water conservation is a key element in restoring habitat for listed salmonid species (SSDC 2007).

Other fish species likely to be present in the Dungeness River include Pacific lamprey, three-spine stickleback, and many types of sculpins (Wydoski and Whitney 2003).

Aquatic habitat in the Dungeness River within the study area includes mainstem and side-channel habitats and a diversity of in-channel habitats such as riffles and pools. Large wood presence is moderate, with some large accumulations of wood but also stretches with limited wood. The riparian zone is a mix of deciduous and coniferous vegetation. In residential areas, riparian vegetation has been removed for lawns and ornamental plantings.

The HID Main Canal has a fish screen that prevents fish from entering the system, although there may be flood conditions when fish can enter the canals. The HID Main Canal and H1 Lateral through the project site generally are excavated and uniform and are not intended for fish habitat. Leaf litter and wood debris are removed rapidly to prevent blockage of flows. The main ditch has year-round flow, including conveyance of stock water when not being used to convey irrigation flows, whereas

the lateral ditch has seasonal flow for irrigation (April 15 to September 15) and then periodically conveys stormwater runoff during the rainy season.

The project would result in primarily beneficial impacts on aquatic species and habitats by conserving water that can remain in the Dungeness River during low-flow periods. During construction, there is the potential for the runoff of contaminants and turbidity into the river, particularly from activities conducted within or near the river. Construction below the OHWM should only occur during the designated in-water work window (to be determined on a site-specific basis). The removal of riparian vegetation should be minimized and then revegetation with native species should occur at all disturbed areas. Cofferdams and other methods to isolate the work zone should also be implemented to minimize the potential for pollutants to enter the river.

6.1.4 Vegetation

The project area includes forestlands, rural residential, and riparian habitats. The proposed reservoir site is primarily a Douglas fir forest in various seral stages, from young seedlings to dense 20-year forest, to remaining older patches (60 to more than 80 years). The northern half of the proposed reservoir site was logged within the past 7 years, and the southern half was logged approximately 20 years ago.

Native tree species include western red cedar, big-leaf maple, black cottonwood, and red alder; native shrubs include Oregon grape, snowberry, beaked hazelnut, salal, rhododendron, oceanspray, Nootka rose, trailing blackberry, and willows. Non-native shrubs include Scotch broom and Himalayan blackberry. The herbaceous layer includes both native and non-native species such as strawberry, sword fern, bracken fern, creeping bentgrass, tall fescue, velvet grass, ox-eye daisy, Canada thistle, and various types of mosses.

The one wetland identified on the site is dominated by herbaceous species such as narrow-leaved cattail, creeping bentgrass, and spikerush. Saplings of willows and black cottonwood are frequently mowed because the wetland is underneath a BPA powerline.

The Dungeness River riparian zone within the study area is dominated by western red cedar, red alder, black cottonwood, and big-leaf maple with an understory of salmonberry, thimbleberry, trailing blackberry, salal, sword fern, and reed canarygrass (in some locations). The steep bluff along the project site generally has mature trees with a native understory, whereas the riparian zone at the irrigation intake is dominated by deciduous species with more non-native species present.

Project construction will involve clearing up to 120 acres for reservoir and related pipeline construction, including areas to stage and process excavated materials. This includes primarily areas that were harvested in the last 25 years. The project will remove young forest (approximately 20 years old) on the project site and convert it to an open-water reservoir. It would be desirable to

retain the older trees as possible outside of the reservoir footprint to provide wildlife habitat. Revegetating disturbed areas and the remainder of the project site with native tree and shrub species, and managing invasive species, would provide shade and wildlife habitat over the long term. The project will also convert land currently used for forestry to a County-owned park. Land that will not be used for the reservoir will likely be revegetated and will convert to mature vegetation and forest over time, providing more mature forest habitat than what currently exists at the site.

6.1.5 Wildlife

The PHS list identifies that fisher, northern spotted owl, marbled murrelet, harlequin duck, little brown bat, and Yuma myotis may occur in the study area (WDFW 2021a). Other species identified as needing conservation, such as the silver-haired bat, Townsend's big-eared bat, hoary bat, western bluebird, purple martin, and western toad, may occur in the study area (WDFW 2015). In addition, more common species such as mule deer, Roosevelt elk, coyote, long-tailed weasel, mink, raccoon, Douglas squirrel, voles, mice, and rats are likely to be present. Bald eagle, northern harrier, red-tailed hawk, common raven, northwestern crow, dark-eyed junco, spotted towhee, and song sparrow were observed on site in October 2021.

The removal of up to 120 acres of vegetation, including young forest (approximately 20 years old) on the project site and conversion to an open-water reservoir will tend to change the assemblage of wildlife that may use the site. Large mammals, songbirds, and cavity-nesting birds would be less likely to use the project area, whereas waterfowl would be more likely to use the open-water reservoir. The site will be subject to future recreation and maintenance activities that may discourage more sensitive wildlife from using the site, but revegetation with native species and managing invasive vegetation will benefit many wildlife species. As noted previously, the project will convert land currently used for forestry to a County-owned park. Land that will not be used for the reservoir will likely be revegetated and will convert to mature vegetation and forest over time, providing more mature forest habitat than what currently exists at the site.

6.1.6 Cultural Resources

As noted in Section 2.4.1, no NRHP or WHR-eligible historic properties have been identified in the reservoir area. However, there will be additional ground-disturbing work outside the surveyed reservoir area. Additional pre-design investigations are planned to support the final design of the reservoir and appurtenances, and will include excavation of additional geotechnical borings and test pits. A memorandum outlining recommendations for cultural resources compliance during future pre-design and pre-construction investigations is included in Appendix N. The eventual construction of the project will also include ground disturbance, including for utilities and other infrastructure outside the reservoir area.

According to Ecology's conditions in the Final Determination under EO 21-02, the following archaeological work will occur within high-probability areas:

a. Pre-design investigations in high-probability areas will be monitored by an archaeologist. Native American Tribes and DAHP will be notified of these investigations as early as possible.
b. During project construction, ground-disturbing work in high-probability areas will be treated as follows:
    i. Superficial activities such as vegetation clearing, placement of fill, and vehicle traversing, where ground disturbance will be less than 20 centimeters (8 inches) below the surface, can proceed with no monitoring or excavation, because this work is within the footprint of previous recent and historic logging activity, and surface deposits have been fully investigated by the 2021 pedestrian survey.
    ii. Any areas where ground disturbance is expected to be deeper than 8 inches below the surface should be surveyed by an archaeologist prior to construction, including appropriate subsurface testing.

If monitoring and survey result in the identification of significant historic properties, impacts will be avoided as feasible and practical. If impacts cannot be avoided, they will be mitigated through the Section 106 process.

6.2 Anticipated Permitting Requirements

6.2.1 Federal Permits and Approvals

If federal funding is received for the project, such as FEMA grant funding, the agency providing funding would be the lead agency for the project. If there is no federal funding, USACE would be the federal lead agency for the project, due to proposed in-water work occurring in Waters of the United States. If the project does not qualify as a repair and maintenance activity, an individual permit would be required (Clean Water Act Section 404 permit). As the federal lead agency, USACE will initiate consultation with other agencies requiring permits and approvals for the project. Agencies may include the following:

- National Marine Fisheries Service and U.S. Fish and Wildlife Service (known as "the Services"), for ESA Section 7 compliance
- DAHP, for National Historic Preservation Act Section 106 compliance
- Ecology, for Clean Water Act Section 401 water quality certification

The USACE Section 404 permit is required for any discharge of dredge or fill material into Waters of the United States. This permit may not be required if in-water excavation or filling activities are not required as part of the project. Should the project activities meet the definition of repair and

maintenance, USACE has a Nationwide Permit (NWP) 40, a programmatic permit that allows several types of agricultural activities and modifications to ditches. If there is less than ¼ acre of impact to Waters of the United States, Section 401 compliance is also covered under the NWP. Coverage of the Section 401 permit is determined in consultation with Ecology during the permit review process. The review timeframe for individual permits is typically 9 to 12 months or more from a complete application determination and includes a public notice process. If a Clean Water Act Section 401 Water Quality Certification is required, a joint public notice process may occur in coordination with Ecology. For NWPs, the review timeframe is reduced (generally 4 to 9 months from complete application determination). The NWP process does not include a public notice. These timeframes are contingent on the consultation process with other agencies.

ESA-listed aquatic species are present in the Dungeness River. To demonstrate ESA Section 7 compliance, a Biological Assessment is typically prepared for projects that require individual permits or are determined to have an effect on listed species. The consultation process is initiated by USACE and a concurrence letter or Biological Opinion is issued by the Services. For repair and maintenance projects, or a project with limited potential effects, a short-form Biological Evaluation may be applicable to initiate consultation with the Services. The timeframe for ESA review is incorporated within the USACE permit timeframe because USACE permits are not issued until consultation is complete.

USACE also consults with Ecology for Clean Water Act Section 401 compliance as part of the federal permitting review process. Clean Water Act Section 401 compliance is required for projects that propose discharge of dredge or fill material in Waters of the United States and for projects requiring compliance with Washington State Water Quality Surface Water Standards (WAC 173-201A). Projects proposing discharge of dredge or fill material are typically issued a Water Quality Certification. If the project qualifies as repair and maintenance, Section 401 compliance can be incorporated with the NWP, and a separate Water Quality Certification is not issued. The timeframe for Clean Water Act Section 401 review is incorporated within the USACE permit timeframe because USACE permits are not issued until consultation is complete.

USACE will review the project under Section 106, which requires federal agencies to evaluate the effects of their undertakings on historic properties in consultation with the State Historic Preservation Officer (SHPO) and Native American Tribes. This process will use supporting documentation developed for the project, including the cultural resources survey described in Section 2.4.1, and documents to be developed in the future as described in Section 6.1.6. USACE will make determinations of NRHP eligibility for any potential historic properties, and a determination of project effects. SHPO and Tribes have the opportunity to comment on determinations. If adverse effects to historic properties are identified, USACE will consult to avoid, minimize, and mitigate the effects.

6.2.2 State Permits and Approvals

WDFW regulates work that uses, diverts, obstructs, or changes the natural flow or bed of any of the salt or fresh waters of the state, including projects landward of the OHWM (e.g., activities outside the OHWM that will directly impact fish life and habitat). Because project activities include work in and adjacent to waters of the state, a WDFW Hydraulic Project Approval (HPA) would be required. HPA review begins once a State Environmental Policy Act (SEPA) determination is issued and takes up to 45 days. No public notice is required.

It does not appear that WDNR owns the aquatic bed of the Dungeness River, so it is unlikely that approval from WDNR would be required for activities below the river OHWM.

6.2.3 Local Permits and Approvals

Clallam County is the lead agency for SEPA compliance and could issue a Determination of Non-Significance or Mitigated Determination of Non-Significance for the project. The SEPA review will require a minimum 14-day public notice period. If a threshold determination is made that the project would have significant impacts that cannot be avoided or mitigated to non-significance, a SEPA EIS would be required and compensatory mitigation for significant impacts may be required.

Clallam County is also the lead agency for other local permits and approvals, providing review for Shoreline Management Act consistency, critical areas regulations compliance, floodplain permit consistency, and building code compliance. A pre-application meeting with the Department of Community Development will be required to review the concept design and determine which permits and associated deliverables are required for the project.

The project includes work within the 200-foot shoreline environment of the Dungeness River, which defines the jurisdiction of the Clallam County Shoreline Master Program (SMP), which was just updated in 2021. The shoreline designation for the Dungeness River in the project area is Residential Conservancy. The project does not specifically fit into the categories of activities described in the SMP but may be considered as an agricultural activity, utility, irrigation structure, flood control structure, or impoundment (off-line). These types of activities are allowed or may be permitted as a conditional use within the Residential Conservancy shoreline designation. A Shoreline Substantial Development Permit (SSDP) and Conditional Use Permit (CUP) are likely to be required.

Project elements may occur within Clallam County designated critical areas, including fish and wildlife habitat conservation areas, channel migration hazard areas, erosion hazard areas, critical recharge SAR areas, and frequently flooded areas (floodplain); therefore, the project must comply with critical areas regulations per Clallam County Code 27.12, Critical Areas. Expanded or new project elements within designated critical areas would be subject to review and compliance. It is expected that critical areas regulations consistency would be reviewed as part of the shoreline permit package.

According to the FEMA Flood Insurance Rate Maps, some project elements would occur within a Zone A floodplain where base flood elevations have not been determined (FEMA 1989). Due to its location within a floodplain, the project must comply with Clallam County floodplain requirements. This will include complying with the FEMA development regulations.

For building and construction code compliance, the project must obtain a building or grading permit from Clallam County. These permits are typically applied for at 90% or 100% design. Final plan sets are submitted to Clallam County for approval. A building permit cannot be issued until a SEPA determination is issued for the project.

6.2.4 Permit Summary

Table 6-1 summarizes the anticipated environmental permits and approvals needed for the project.

Table 6-1
Anticipated Environmental Permits and Approvals

Permit/Approval	Agency	Trigger	Approx. Agency Review Timeframe	Notes
Clean Water Act Section 404 Permit	USACE	Placement of dredged or fill material in Waters of the U.S.	9 to 12 months (individual permit) 4 to 6 months (Nationwide Permit)	A Joint Aquatic Resources Permit Application (JARPA) form will be submitted.
Endangered Species Act Compliance	National Marine Fisheries Service and U.S. Fish and Wildlife Service	Section 7 review required for actions that may affect any ESA-listed species or their critical habitat	9 to 12 months (concurrent with Section 404 permit)	A Biological Evaluation will be prepared and submitted with the JARPA to USACE.
National Historic Preservation Act Section 106 compliance	DAHP and Native American Tribes	Activities that may affect archaeological, cultural, or historic resources or sites	6 to 9 months (concurrent with Section 404 permit)	A Cultural Resources Assessment will be prepared and submitted with the JARPA to USACE.
Clean Water Act Section 401 Water Quality Certification	Ecology	Necessary for in-water work.	6 to 9 months (concurrent with Section 404 permit)	A JARPA form will be submitted.
Hydraulic Project Approval	WDFW	Work that uses, diverts, obstructs, or changes the natural flow or bed of state waters.	45 days from SEPA Determination Issuance	The HPA will be applied for via WDFW's online Aquatic Protection Permitting System (APPS)

Permit/Approval	Agency	Trigger	Approx. Agency Review Timeframe	Notes
SEPA Determination of Non-Significance (DNS) or Mitigated DNS	Clallam County	Work that has effects on elements of the environment within Clallam County jurisdiction.	2 to 3 months (DNS or MDNS) 6 to 12 months (EIS)	A SEPA Checklist will be prepared to make a threshold determination of effects. If the effects are significant, an EIS would be prepared.
Shoreline Substantial Development Permit (SSDP)	Clallam County	Activities occurring within the 200-foot shoreline environment.	3 to 6 months (SSDP)	A JARPA form and memorandum addressing shoreline compliance requirements will be submitted (if not exempt).
Critical Areas Approval	Clallam County	Activities occurring within critical areas.	Incorporated within SSDP timeline	The critical areas report will be included in the SSDP application.
Floodplain Consistency	Clallam County	Activities occurring within a designated floodplain.	2 months	A memorandum will be prepared by a qualified engineer demonstrating compliance with floodplain regulations.
Building and/or Clearing and Grading Permit	Clallam County	Activities requiring a building or clearing and grading permit within Clallam County.	2 to 4 months	A building and/or clearing and grading permit application will be submitted to Clallam County with 90% or 100% design package.

6.3 Recommended Permitting Approach

A proactive approach to permitting that involves early and frequent coordination with key regulatory agencies is recommended to ensure that permits can be secured within the timeframe desired by Clallam County for design and construction of the reservoir. We recommend the following general approach:

- **Early Agency Coordination:** It is recommended that Anchor QEA and Clallam County schedule a pre-planning meeting and site visit with key regulatory agency personnel early in 2022 after the preliminary designs are complete to present the project and discuss anticipated

permitting requirements. Anchor QEA has already reached out to the local USACE representative, WDFW personnel, and Clallam County to discuss various aspects of the project. A formal pre-planning meeting with the key regulatory personnel will help facilitate the following:

  - Formal kick-off of coordination with regulatory agencies to ensure that key regulatory personnel understand the project
  - Confirmation of key permitting assumptions
  - Collection of additional information needed for successful permitting
  - Confirmation of roles and responsibilities, such as who will lead permit reviews for each agency, who will lead SEPA review of the project, and what the anticipated level of SEPA review will be for the project

- **Design and Pre-Application Coordination**: Frequent coordination with the regulatory agencies is recommended throughout the detailed design process. A formal pre-application meeting is recommended as a follow-up to the pre-planning meeting with key regulatory agency personnel prior to submitting permit applications.
- **SEPA Determination:** It is recommended that SEPA documentation be completed early in 2022 so that the Clallam County Department of Community Development, which will likely serve as the SEPA lead for this project, can make a threshold determination. It will be important for the SEPA threshold determination to be made as early as possible to ensure that if an EIS is determined to be required, the overall SEPA compliance process does not delay the overall project schedule.
- **Complete Permit Applications and Supporting Documentation:** Completing permit applications and providing complete permit application packets with all supporting documentation is key to facilitating the permit review process. It is recommended that permit packages be reviewed to ensure that they are complete prior to submitting materials for review by the regulatory agencies. Supporting reports, drawings, and calculations will need to be complete, easy to read, and clearly labeled.
- **Key Permitting Strategies:** Strategies recommended for successful permitting of this project include early and frequent coordination with key regulatory personnel, early preparation of SEPA documentation to support a SEPA threshold determination, and identification of key issues with the regulatory agencies early in the design process, so that the design and environmental compliance documentation are developed in a way that addresses those key issues and allows for a streamlined permit review process.

6.4 Dam Safety Consultation, Dam Construction Permit

Early and frequent coordination is also recommended with Ecology DSO, the agency responsible for review of the project to issue a Dam Construction Permit. Anchor QEA and our subconsultants have initiated consultation with Ecology DSO through a virtual meeting during preliminary design. The

purpose of this meeting was to introduce key DSO personnel to the project and discuss design strategies for meeting DSO requirements. The design team will continue to coordinate with DSO as the design progresses.

Another coordination meeting will be scheduled early in 2022 to review the preliminary design drawings with DSO and obtain initial feedback. Consultation will continue through detailed design to ensure that the design is developed to meet DSO guidelines and requirements. Ultimately, a Dam Construction Permit application will be completed and submitted with the supporting design documentation to secure a Dam Construction Permit. The final Dam Construction Permit application and supporting documents will include final versions of all the documents required by DSO approval, including the following:

- A cover letter summarizing the project and introducing the deliverables
- A Dam Construction Permit application
- Engineering reports, including:
  - Geotechnical engineering reports
  - Hydraulics and hydrology report
- Detailed design drawings
- Technical specifications
- Construction Inspection Plan
- Operations and Maintenance (O&M) Plan
- Emergency Action Plan

The final engineering reports, design drawings, O&M Plan, and other documentation will build from the information included in this report and other reports prepared as part of this preliminary design effort. Stand-alone reports and documents will be prepared for final submittal to DSO.

7 Operations, Monitoring, and Maintenance

An O&M Plan will be prepared and submitted to DSO for review with the Dam Construction Permit application in accordance with DSO requirements. The information that is required in the O&M Plan by DSO will include, at a minimum, the following:

- **General Information:** This will include the dam name, owner's name, dam type, and Washington State dam identification number. It will also include a list and description of hydraulic elements controlling inflow to or outflow from the reservoir with an overview map highlighting key hydraulic elements.
- **Operational Information:** A summary of rules and procedures for operating the reservoir will be provided, as well as a list and description of record-keeping requirements. This section will also include a description of the elements included to keep key reservoir infrastructure secure, guidelines for annual dam inspections by the owner, and recommendations for circumstances that may trigger other routine or special inspections by the owner beyond the annual inspection.
- **Instruments and Monitoring:** The O&M Plan will list the instrumentation included to control flows to and from the reservoir and monitor conditions at the reservoir. The summary will specify the locations of key instrumentation and control equipment, specify the frequency with which those instruments will be monitored, and provide guidelines for record-keeping related to data recorded by these instruments and equipment.
- **Maintenance:** The O&M Plan will provide a summary of the maintenance activities that need to be performed for key project elements. The summary will note the required frequency for performing maintenance and a detailed description of the maintenance to be performed.

This section is not intended to provide all of the information that will be included in the O&M Plan but is intended to provide a basis for preparing the O&M Plan.

7.1 Reservoir Operations

A summary of anticipated reservoir operations was provided in Section 4.5. The reservoir will be operated to provide the key benefits outlined previously, including water supply for downstream irrigation and a reduction in late-summer diversions from the Dungeness River that will improve habitat and passage conditions for ESA-listed fish species and other wildlife. Reservoir operations will generally include two operating conditions: reservoir filling, which is expected to occur annually between the late fall and early summer; and irrigation releases, which are expected to occur during the irrigation season, from April 15 through September 15. Filling the reservoir and releasing water for irrigation will likely overlap each year between the beginning of the irrigation season (April 15) and when the reservoir has been completely filled (typically late spring or early summer).

The following summarizes key operational steps that will need to be taken to fill the reservoir:

- Verify that key diversion and conveyance facilities that will be used to fill the reservoir have been inspected and maintenance has been performed prior to filling the reservoir.
- Verify that valves are closed at both ends of the reservoir bypass pipeline.
- Close the low-, mid-, and high-level slide gates on the reservoir outlet works.
- Open valves and gates on the inlet pipeline.
- Open the slide gate at the entrance to the inlet pipeline at the flow control structure on the HID Main Canal.
- Close the gate on the downstream end of the settling basin bypass pipe to route flow through the settling basin.
- Open gates and set stop logs to the appropriate position in the settling basin to capture sediment in the flows diverted through the fish screen.
- Coordinate with WDFW to ensure that the fish screen facility is set to operate as recommended by WDFW. Begin operation of fish screen cleaning system and open gates.
- Open the headgates at the Dungeness River to divert available flows from the Dungeness River to the HID Main Canal to begin filling the reservoir. Gates should be set to adjust automatically to match flow rates needed to fill the reservoir and supply water to the HID Main Canal downstream of the flow control structure.
- Adjust the overtopping gate at the flow control structure on the HID Main Canal to maintain a relatively constant water level in the canal and pass sufficient water downstream for stock water delivered by the HID Main Canal outside the irrigation season.
- Adjust the headgates as needed via automatic controls and remote monitoring so that they do not divert water when it is not available and during high-flow events and freezing weather.
- Once the reservoir is full, close the slide gate at the entrance to the inlet pipeline in the flow control structure on the HID Main Canal to discontinue filling of the reservoir.
- Adjust the headgates and overtopping gate in the flow control structure on the HID Main Canal to modify diversions to meet irrigation demands on the HID canal system.

The following summarizes key operational steps that will need to be taken to release water for irrigation:

- Verify that key outlet and conveyance facilities that will be used to release water from the reservoir have been inspected and maintenance has been performed prior to releasing water.
- Verify that valves are closed at both ends of the reservoir bypass pipeline.
- Open the slide gate (or gates) on the reservoir outlet works until the desired flow is reached.
- Adjust the slide gates on the reservoir outlet works, as desired, to meet downstream irrigation demands and optimize the quality and quantity of releases.
- Once the reservoir is fully drawn down, close all the slide gates on the reservoir outlet works.

As noted previously, the reservoir will be designed with instrumentation and controls that will allow for remote operation and, in some cases, the activities above will be automated.

7.2 Observation and Inspection Requirements

The O&M Plan will outline requirements for annual inspections that are to be performed by the owner. This will include a detailed inspection and maintenance of all key components of the reservoir and hydraulic controls that manage flows to and from the reservoir. During filling and releasing operations, continual observation and regular monitoring of the reservoir embankment, control equipment, and key equipment will be necessary to ensure that the dam is safe and is operating efficiently to provide the key benefits outlined previously in this report.

7.3 Maintenance Requirements

Detailed maintenance and inspection of the reservoir and related facilities are generally expected to occur annually, once the irrigation season has ended and the reservoir has been drawn down, but before reservoir filling operations have begun. Table 7-1 provides an initial summary of anticipated maintenance activities for key components of the reservoir and related facilities.

Table 7-1
Summary of Recommended Maintenance for Reservoir and Related Facilities

Component	Maintenance Items to Look For	Occurrence
Reservoir/Earthen Embankment		
Vegetation Control	• Remove weeds and mow native grasses as needed to allow visual surveillance of the embankment surface and abutments. • Remove and/or control woody or deep-rooted vegetation. • Vegetation planted to discourage waterfowl may be managed differently.	Annually
Burrowing Animals	• Control burrowing animal population to alleviate the problem long term. • Repair animal burrows by compacting fill into the excavated areas. If burrowing is extensive, seek the advice of a professional engineer, as fill must be replaced to original grades and densities.	Annually
Embankment Crest	• Fill any ruts or minor depressions with similar fill material to reestablish the designed grade. • Repair erosion. If extensive, seek the advice of a professional engineer and contact DSO.	Annually
Erosion Control	• Repair rills and gully erosion. Reseed with native grasses or install appropriate erosion control measures such as wattles, net wire diversions, gravel fill, etc. • Fill large rills and gullies with compacted fill. If erosion is extensive, seek the advice of a professional engineer and contact DSO.	Annually and After Large Storm Events

Component	Maintenance Items to Look For	Occurrence
Drain Outfalls	• Keep free of obstructions and open to allow free drainage. • Control vegetation at outfalls so outfalls can be located and accessed for observation and inspection. • Monitor seepage through drains. Include photographic documentation.	Annually and After Large Storm Events
Reservoir Inlet and Outlet Structures		
Inlet Structure	• Remove blockages, debris, and sediment settled in structure. • Keep concrete joints and surfaces free of vegetation. • Monitor for cracks, spalling, exposed reinforcement, or other deterioration of the concrete. • Repair concrete surfaces and joints. Include photographic documentation.	Annually
Outlet Works	• Remove blockages, debris, and sediment settled in structure. • Keep concrete joints and surfaces free of vegetation. • Monitor for cracks, spalling, exposed reinforcement, or other deterioration of the concrete. • Repair concrete surfaces and joints. Include photographic documentation.	Annually
Gates	• Inspect gates for blockages and corrosion. • Cycle gates full open to full closed to ensure they are in good working order. • Grease or lubricate gates and replace gate seals as needed.	Annually
Inlet, Outlet, and Bypass Pipeline Facilities		
Pipelines	• Inspect pipelines for settlement, corrosion, leakage, or other significant problems. • Repair any corrosion, leakage, or other significant problems. • Remove blockages.	Annually
Gates and Valves	• Inspect gates and valves for blockages and corrosion. • Cycle gates and valves full open to full closed to ensure they are in good working order. • Grease or lubricate gates and valves and replace gate seals as needed.	Annually
Spillway Facilities		
Trash Rack, Pipe or Spillway Entrance	• Remove debris and vegetation from trash racks and spillway openings. • Keep free of obstructions and open to the reservoir.	Annually and After Large Storm Events
Drop Inlet Riser	• Keep entrances to spillway pipe(s) free of obstructions. • Remove debris that could interfere with flow capacity. • Assess sediment level at riser. If sediment is nearing intake, the sediment must be removed to prevent sediment from entering or clogging the riser.	Annually and After Large Storm Events
Concrete Surfaces, Joints, and Structures	• Keep concrete joints and surfaces free of vegetation. • Monitor for cracks, spalling, exposed reinforcement, or other deterioration of the concrete. • Repair concrete surfaces and joints. Include photographic documentation.	Annually
Pipelines	• Inspect pipelines for settlement, corrosion, leakage, or other significant problems. • Repair any corrosion, leakage, or other significant problems. • Remove blockages.	Annually

Component	Maintenance Items to Look For	Occurrence
Open Spillway Channels	• Keep free of obstructions and vegetation to maintain channel hydraulics. • Repair erosion damage and gullies by removing loose material and replacing it with compacted fill. • Add gravel and properly sized riprap should be added to the damaged area as appropriate to prevent future erosion. • Replace or repair riprap and other armoring materials to prevent movement or removal by flow events.	Annually
Pipe Outfalls and Energy Dissipation	• Keep free of obstructions and open to allow free drainage. • Control vegetation at outfalls so outfalls can be located and accessed for observation and inspection. • Control vegetation at outfalls so that energy dissipation features can be located and accessed for observation and inspection. • Keep energy dissipation free of obstructions and open to allow free overflow to downstream channel. • Replace or repair riprap or other armoring materials to prevent movement by flow events.	Annually
Intake, Settling Basin, Flow Control, and Inlet Pipeline Facilities		
Gates and Valves	• Inspect gates and valves for blockages and corrosion. • Cycle gates and valves full open to full closed to ensure they are in good working order. • Grease or lubricate gates and valves and replace gate seals as needed.	Annually
Structures	• Remove blockages, debris, and sediment settled in structure. • Keep concrete joints and surfaces free of vegetation. • Monitor for cracks, spalling, exposed reinforcement, or other deterioration of the concrete. • Repair concrete surfaces and joints. Include photographic documentation.	Annually
Pipelines	• Inspect pipeline for settlement, corrosion, leakage, or other significant problems. • Repair any corrosion, leakage, or other significant problems. • Remove blockages.	Annually
Sedimentation	• Remove accumulated sediment that exceeds 10% of the designed pond depth unless otherwise specified or affects flow through the facility.	Annually
Other Elements		
Fences	• Inspect and make repairs to fences and gates as needed.	Annually
Signs and Barriers	• Repair and replace safety signs and barriers as needed.	Annually
Instrumentation	• Monitor level transducers and make sure that data are downloading. • Monitor flow measurement devices to ensure that data are downloading. • Remove and charge equipment, as needed. • Verify that automatic controls are working and that remote telemetry is relaying information properly from instrumentation to remote computing and control devices.	Weekly

7.4 Instrumentation and Monitoring

The dam and related conveyance facilities will be equipped with instrumentation that can be connected to telemetry for continuous monitoring. It is anticipated that maintenance personnel will also visit key facilities at least weekly to visually inspect and monitor instrumentation and control equipment to ensure they are operating correctly. This weekly check should include, but will not be limited to, a visual inspection and monitoring of the following:

- **Headgates and Intake Structure:** To ensure that they are responding to flow measurements in the downstream diversion channel to control diversions from the river.
- **Flow Monitoring Devices:** To ensure they are operating correctly. This will a visual confirmation that static staff gage readings and electronic readings match.
- **Fish Screen and Downstream Gates:** To ensure that they are properly adjusting to maintain appropriate water levels at the fish screen.
- **Settling Basin:** To ensure that water is moving into and from the settling basin without any problems or blockages.
- **Flow Control Structure:** To ensure that the overtopping gate is responding to upstream water levels and that the slide gate is controlling flow to the inlet pipeline based on the water level in the reservoir.
- **Reservoir Water Level:** To verify water level and compare static staff gage readings and electronic readings from the water transducer in the reservoir to ensure they match.
- **Reservoir Outlet Works:** To ensure the reservoir outlet gates are adjusted appropriately to deliver the desired flow rate for irrigation and that the gates can be adjusted remotely.

7.5 Reporting

The owner will be required to submit a Dam Owner Annual Inspection Form for Earthen Dams to DSO following each annual inspection. It is also recommended that the owner record observations during weekly inspections or other special inspections. Documentation should include photographs, notes about adjustments to controls and equipment, and notes regarding any noted deficiencies or operational issues. These notes should be maintained by the owner electronically and could be collected via an electronic data collection program with a tablet or laptop, or by transferring hardcopy notes and photographs to an electronic format for storage on the owner's computing system.

8 Conclusions and Recommendations

The preliminary design phase for the Dungeness Off-Channel Reservoir project is nearing completion. The data collected and the analyses completed to support the preliminary design of the project indicate that the site is well suited for construction of a 1,600-acre-foot off-channel reservoir that will store water diverted from the Dungeness River during the late fall, winter, spring, and early summer. The water will be released during the late summer to support irrigation of properties downstream (north) of the reservoir on the east side of the Dungeness River. The water released from the reservoir will allow for a corresponding reduction in diversions from the Dungeness River that will provide up to 25 cfs of additional flow in the river during the critical late-summer low-flow period. The project will improve streamflows in the Dungeness River for ESA-listed salmonids and other key species, increase the reliability of water supply for irrigation on east side of the Dungeness River, and improve the resiliency of the irrigation water supply system in the face of changing climate conditions. The project will also have potential to provide other key benefits, including management of overland flows captured by the HID Main Canal, infiltration for overland flow management or ASR, water for SAR or restoration, and improved public recreation opportunities.

8.1 Key Findings and Design Recommendations

The following are key findings and recommendations resulting from the preliminary design effort:

- The site is well suited for an off-channel reservoir because of the potential to divert and capture flows by gravity and release flows by gravity to the downstream irrigation system.
- A preliminary cultural resources survey has been completed at the site. No resources have been discovered that are eligible for listing as historical in the NRHP or WHR. Ecology has prepared a Preliminary Determination of low risk to cultural resources. Future work will require compliance with the IDP prepared for the site and may require that ground-disturbing activities outside the area of detailed survey be monitored by an archaeologist.
- Phase 1 and 2 Environmental Site Assessments have been completed to assess material that has been dumped at the site in support of the County's ongoing property acquisition discussions with WDNR. Work has been done to characterize the material that was historically dumped at the site and evaluate the potential for contamination. Waste material should be removed from the site and groundwater monitoring should continue to ensure that additional actions (beyond waste removal) are not required to resolve groundwater quality concerns.
- Based on the results of the Phase 1 geotechnical exploration, the soil profile consists of alluvium to depths of 10 to 20 feet bgs over a layer of glacial drift deposits from about 15 to 35 feet bgs. The alluvium and glacial drift deposits are underlain by a 40- to 70-foot-thick layer of glacial till. A glacially overridden advance outwash layer of sands and silts was encountered below the glacial till.

- The Phase 1 geotechnical exploration indicates that groundwater levels are 95 to 100 feet bgs, below the till layer.
- The presence of a relatively shallow layer of low-permeability glacial till material may allow construction of the reservoir without a fabricated liner. Excavation down to glacial till at the south end of the proposed reservoir, and use of glacial till to construct a low-permeability core and bottom liner for the reservoir, are currently shown as the recommended preliminary design configuration. Additional geotechnical data collection will be needed to confirm the depth and location of the till layer at more locations within the footprint of the proposed reservoir. The data will be used to refine the recommendations for the embankment and reservoir configuration to ensure that adequate seepage control is provided, and that the most cost-effective reservoir configuration is proposed.
- Additional investigation will be required to verify the existence of faulting in the area and complete seismic analysis to ensure that the project is designed to address all seismic hazards, in accordance with DSO requirements.
- A wetland survey identified one wetland within the reservoir site. The wetland consists of a small depression that was likely an excavated borrow pit used to construct logging roads when the site was harvested for timber. The wetland was classified as a palustrine emergent Category III wetland.
- The Dungeness River OHWM was also surveyed and the shoreline buffer was mapped along the west edge of the site.
- The recommended reservoir configuration, as shown in the preliminary design drawings, will have a storage capacity of 1,591 acre-feet and a full water surface area of 41.6 acres. The full WSEL will be 435 feet. The reservoir will be constructed by excavating native earth materials, sorting and processing those materials, and placing and compacting both imported and native, processed earth materials into an embankment.
- The following key facilities will be constructed to support the reservoir and convey water to and from the reservoir:
  - A 36-inch inlet pipeline, extending from the HID Main Canal to the reservoir
  - A flow control structure on the HID Main Canal with gates that will control flow from the HID Main Canal to the reservoir
  - A reinforced concrete inlet structure that will dissipate energy at the end of the inlet pipeline and deliver flow to the reservoir
  - An outlet works consisting of a pipe manifold with low-, mid-, and high-level gated outlet ports that will allow for release of reservoir water from different lake levels to a low-level outlet pipeline
  - A 36-inch outlet pipeline that will convey flows released from the reservoir to a connection with the downstream irrigation system at the north property boundary

  - An 18-inch bypass pipeline that will allow flows to bypass the reservoir during construction and when the reservoir is down for maintenance
  - A 96-inch-diameter drop inlet spillway with a trash rack and a 36-inch spillway pipe that will convey water to an excavated spillway channel beyond the toe of the embankment
  - An open spillway channel and downstream 24-inch spillway pipeline that will convey spilled water from the reservoir site to the Dungeness River
  - Improvements to HID intake facilities needed to ensure that 25 cfs can be conveyed consistently and safely to the reservoir, including upgrades and automation of the headgates, improvements to the headgate structure and diversion channel, and upgrades to fish screens and flow measurement facilities
  - Incorporation of a settling basin near the HID fish screen to settle out suspended solids
- The preliminary design of the project was developed based on the following criteria:
  - A targeted storage capacity of approximately 1,600 acre-feet
  - A maximum inflow rate of 25 cfs
  - A maximum release rate of 25 cfs
  - A maximum bypass rate of 6 cfs
  - A maximum spill of 50 cfs during a Step 8 (10^{-6} recurrence probability) design storm
  - Compliance with DSO guidelines and requirements
- The analysis indicates that the reservoir and appurtenances, as configured in the preliminary design drawings (Appendix A), will have adequate capacity to meet DSO requirements for minimum freeboard under Step 8 design storm conditions and will be able to store and release up to 1,591 acre-feet for irrigation.
- A preliminary water quality analysis indicates that DO levels and nutrient levels in the reservoir are not expected to exceed action levels suggested for surface waterbodies in the area, and it is unlikely that reservoir management options, such as aeration, will be needed to ensure that reservoir water quality is suitable to support its intended use. However, these management options should continue to be considered as the design and analysis of the reservoir moves forward.
- An evaluation of the water available from the Dungeness River to fill the reservoir by Washington Water Trust indicates that the 1,591-acre-foot reservoir would be refilled during all but 3 years out of the 22 years that were evaluated (hydrologic conditions from 2000 to 2021) if HID intake facilities and the HID Main Canal are upgraded to convey up to 25 cfs to the reservoir.
- Additional analysis of reservoir operations, inflows, and outflows using a water balance spreadsheet indicates that during average and wet years, the reservoir would refill completely and would have capacity to supply most, but not all, of the irrigation demands downstream of the reservoir from the beginning of August through the end of the irrigation season.

- During very dry years, the reservoir would not refill and there would not be enough water stored to meet downstream irrigation demands in August and September.
- Installation of instrumentation and controls, including gates with actuators, electronic flow and water level monitoring devices, and a telemetry system, are recommended to allow the reservoir to be operated remotely and to allow for automation via programmable controllers that will allow for more precise control of flows to and from the reservoir.
- The opinion of probable construction costs for the key project elements shown in the preliminary design drawings is approximately $33.6 million. The opinion of probable construction costs for a configuration that would include a fabricated geomembrane liner is approximately $35.0 million. These are construction totals and do not include allowance for construction management.

8.2 Next Steps and Phase 2 Design Work Plan

Clallam County has expressed a desire to move forward with detailed design and permitting of the project, with the goal of completing design work in 2022 and initiating construction of key project elements late in 2022 or in 2023. The schedule for project implementation will depend not only on the schedule for completing the design, but also on timelines for securing funding and permitting the project.

Based on our recent experience, permitting timelines can be very long (more than a year for projects this size), so initiation of the permitting process early in 2022 will be critical to implementing the project on the time frame desired by Clallam County. One of the keys to permitting the project will be arriving at a SEPA threshold determination. If it is determined that some level of detailed environmental review is required to comply with SEPA, the timeline for implementation could be much longer than has been targeted.

Anchor QEA and our subconsultants recommend scheduling a meeting (or meetings) with Clallam County and the Work Group to accomplish the following:

- Present and review the preliminary design.
- Discuss which key elements will move forward through the detailed design process.
- Identify changes that many need to be incorporated during the next phase of design.
- Clarify how other related projects, such as irrigation conveyance pipelines, overland flow capture system, infiltration system, HID drought relief pumping station, erosion repairs on the HID Main Canal within the BPA easement, and micro-hydropower/solar will be evaluated and progress toward implementation.
- Discuss the scope and schedule for detailed design and permitting.

Anchor QEA's scope of work for preliminary design also included public outreach meetings to discuss the preliminary design with neighbors and other key members of the public. We recommend

that these meetings be scheduled early in 2022 so that the concerns of the public are well understood as the detailed design phase moves forward.

It is anticipated that the detailed (Phase 2) design effort will include the following tasks:

- Revisions to the final 30% design drawings to reflect input from Clallam County and key stakeholders, and preparation of permit-ready drawings that can be used to initiate the environmental permitting process.
- Additional support for funding applications.
- Supplemental data collection, including:
  - Detailed topographic and boundary surveys of the proposed reservoir site, key pipeline alignments, and HID intake and fish screening facilities.
  - Phase 2 geotechnical explorations that will include supplemental borings and test pit excavations at key locations, including excavation of a large test pit into the till material to better understand the hydraulic conductivity of the in situ till. The Phase 2 geotechnical explorations may also include geophysics, to confirm the presence and extent of the till layer, and laboratory tests and further characterization of on-site soils needed to support the final design.
  - On-site infiltration testing needed to confirm the hydraulic conductivity of underlying soils for design of the reservoir. This would include digging one or more test pits down to the till layer large enough to test the hydraulic conductivity of that layer.
  - It is anticipated that infiltration testing needed to evaluate the potential of infiltration facilities at the reservoir site would be completed as a separate task under the FEMA grant awarded to the City of Sequim for investigating the overland flow capture system and infiltration facility.
- Permitting support, including coordination with the permitting agencies, preparation of permit applications and supporting documentation, coordination during detailed design development, and response to permitting review comments and questions.
- Consultation with DSO and coordination for Dam Construction Permit approval. This will include completion of a Dam Construction Permit and preparation of supporting documentation needed to secure DSO approval, as well as regular coordination with DSO through the detailed design phase of the project.
- Development of detailed design documents, including drawings, specifications, opinions of probable cost, and a final basis of design report. It is anticipated that design documents will be submitted for review at the 60%, 90%, and final design stages.
- Final cost analyses and review of long-term operating and life cycle replacement costs.
- Constructability review and review of opinions of probable cost by Anchor QEA's principal construction manager and peer review by key subconsultants, including HDR and Ott Sakai.

- Preparation of a final bid package that will include final design drawings, technical specifications, permits, and other supporting documents.
- An evaluation of operations and maintenance needs and development of a final O&M Plan.
- Management of the design team effort and ongoing coordination with Clallam County and the Work Group.

9 References

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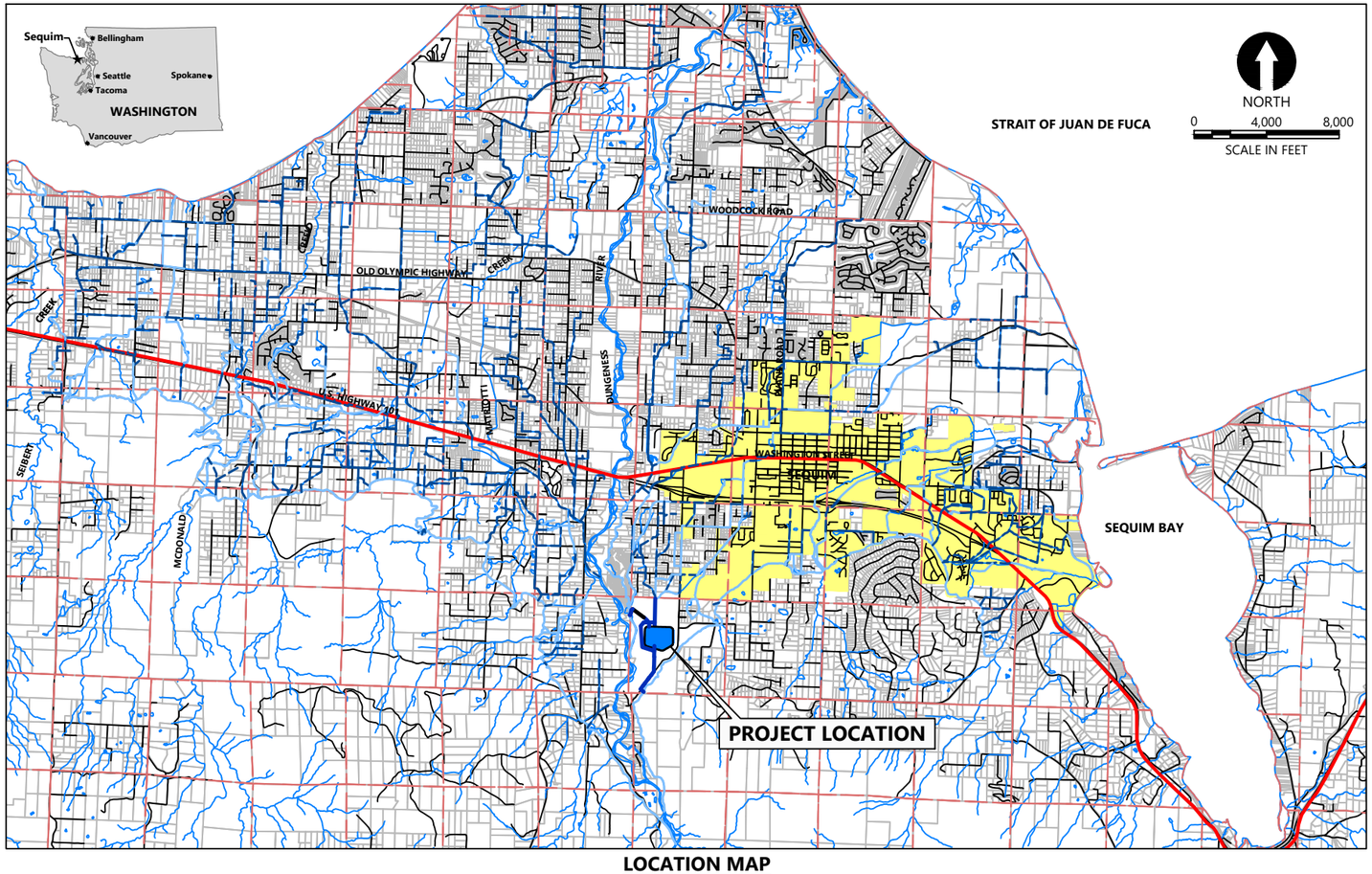
Appendix A
Preliminary Design Drawings

30% DESIGN

DUNGENESS OFF-CHANNEL RESERVOIR

CLALLAM COUNTY



LOCATION MAP

DRAWING INDEX		
SHT #	DWG #	TITLE
1	G01	COVER SHEET
2	G02	GENERAL NOTES, ABBREVIATIONS, AND LEGENDS
3	G03	OVERALL SITE PLAN AND DRAWING INDEX
4	T01	TEMPORARY ACCESS AND STAGING PLAN
5	C01	RESERVOIR SITE PLAN
6	C02	RESERVOIR GRADING PLAN (NORTHWEST)
7	C03	RESERVOIR GRADING PLAN (NORTHEAST)
8	C04	RESERVOIR GRADING PLAN (SOUTHEAST)
9	C05	RESERVOIR GRADING PLAN (SOUTHWEST)
10	C06	RESERVOIR SECTIONS
11	C07	RESERVOIR SECTIONS
12	C08	RESERVOIR INLET PIPELINE PLAN AND PROFILE
13	C09	RESERVOIR INLET PIPELINE PLAN AND PROFILE
14	C10	RESERVOIR INLET PIPELINE PLAN AND PROFILE
15	C11	RESERVOIR OUTLET PIPELINE PLAN AND PROFILE
16	C12	RESERVOIR OUTLET PIPELINE PLAN AND PROFILE
17	C13	RESERVOIR BYPASS PIPELINE PLAN AND PROFILE
18	C14	RESERVOIR BYPASS PIPELINE PLAN AND PROFILE
19	C15	RESERVOIR BYPASS PIPELINE PLAN AND PROFILE
20	C16	RESERVOIR INTAKE FACILITY UPGRADES
21	C17	RESERVOIR INLET FLOW CONTROL STRUCTURE PLAN AND SECTIONS
22	C18	RESERVOIR INLET STRUCTURE PLAN AND SECTIONS
23	C19	RESERVOIR OUTLET STRUCTURE PLAN AND SECTIONS
24	C20	RESERVOIR SPILLWAY PLAN AND PROFILE
25	C21	RESERVOIR SPILLWAY PLAN AND PROFILE
26	C22	RESERVOIR SPILLWAY STRUCTURE PLAN AND SECTIONS

PROJECT DATA

LOCATION:	CLALLAM COUNTY PARCEL 04036210000 SECTION 36, TOWNSHIP 30N, RANGE 04W
PROJECT ENGINEER:	DAVID RICE, P.E. ANCHOR QEA, LLC 1201 3RD AVENUE, SUITE 2600 SEATTLE, WA 98101 (206) 219-5902
GEOTECHNICAL ENGINEER:	STAN BOYLE, PHD, PE, D.GE, M.ASCE SHANNON & WILSON PO BOX 300303 400 N 34TH STREET, SUITE 100 SEATTLE, WA 98103 PHONE: (206) 632-8020
PROJECT ADMINISTRATOR/ CONTRACTING AGENCY:	CAROL L. CREASEY, RESERVOIR PROJECT MANAGER/HYDROGEOLOGIST CLALLAM COUNTY 223 E. 4TH STREET, SUITE 6 PORT ANGELES, WA 98362 (360) 417-2424

EARTHWORK	
TOTAL CUT VOLUME	1,243,501 CY
TOTAL FILL VOLUME	642,529 CY
TOTAL AREA OF DISTURBANCE	118 AC

SURVEY INFORMATION

HORIZONTAL DATUM FOR THIS SURVEY IS NAD 1983(11), WASHINGTON STATE PLANE NORTH ZONE COORDINATE SYSTEM, U.S. SURVEY FEET. THE HORIZONTAL DATUM IS BASED ON PUBLISHED INFORMATION FROM WSDOT, POINT DESIGNATIONS PETE AND FS0506.

POINT DESIGNATION PETE
NORTHING: 387953.181
EASTING: 1073114.596

POINT DESIGNATION FS0506
NORTHING: 399609.345
EASTING: 1077813.458

VERTICAL DATUM IS NAVD88 BASED ON PUBLISHED INFORMATION FROM WSDOT, POINT DESIGNATION PETE

POINT DESIGNATION
ELEVATION: 457.443

THE GEOTECHNICAL ENGINEER CONSENTS THAT THESE PLANS ARE IN ACCORDANCE TO THE *DRAFT PHASE 1 GEOTECHNICAL DATA REPORT, DUNGENESS OFF-CHANNEL RESERVOIR* AND *DRAFT PHASE 1 CONCEPTUAL GEOTECHNICAL ENGINEERING REPORT* AND *DUNGENESS OFF-CHANNEL RESERVOIR* BY SHANNON & WILSON DATED NOVEMBER 2021.

SIGNATURE _____ DATE _____

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

30% DESIGN: NOT FOR CONSTRUCTION

ANCHOR QEA

REVISIONS				
REV	DATE	BY	APP'D	DESCRIPTION

DESIGNED BY: G. HART
DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

COVER SHEET

G01

SHEET # 1 OF 26

K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\Construction Plans\1439-PL-Cover.dwg G01
Mar 14, 2022 12:39pm tgriga

GENERAL CONSTRUCTION NOTES:

1. CONTRACT DOCUMENTS REFER TO THESE DRAWINGS, THE PROJECT SPECIFICATIONS, AND THE BIDDING DOCUMENTS, AND THE CONSTRUCTION CONTRACT.
2. EXCEPT AS OTHERWISE NOTED HEREIN, ALL MATERIAL AND WORK SHALL BE ACCOMPLISHED IN ACCORDANCE WITH THE CONTRACT DOCUMENTS, THE WSDOT/APWA "STANDARD SPECIFICATIONS FOR ROAD, BRIDGE AND MUNICIPAL CONSTRUCTION" (2021 EDITION), OTHER APPLICABLE STANDARDS, AND ACCORDING TO MANUFACTURER'S RECOMMENDATIONS.
3. THE CONTRACTOR SHALL HAVE COPIES OF THE APPROVED CONTRACT DOCUMENTS AND THE WSDOT/APWA "STANDARD SPECIFICATIONS FOR ROAD, BRIDGE AND MUNICIPAL CONSTRUCTION" (2021 EDITION) ON THE JOBSITE AT ALL TIMES.
4. THE CONTRACTOR SHALL VISIT THE JOB SITE PRIOR TO CONSTRUCTION AND SHALL BE RESPONSIBLE FOR VERIFYING FIELD CONDITIONS AND DIMENSIONS, AND CONFIRMING THAT THE WORK CAN BE ACCOMPLISHED AS SHOWN ON THESE CONTRACT DOCUMENTS. ANY DISCREPANCIES BETWEEN THE EXISTING FIELD CONDITIONS AND DIMENSIONS SHOWN ON THE CONTRACT DOCUMENTS AND THOSE OBSERVED BY THE CONTRACTOR SHALL BE BROUGHT TO THE ATTENTION OF THE OWNER AND THE PROJECT ADMINISTRATOR PRIOR TO PROCEEDING WITH CONSTRUCTION.
5. A PRE-CONSTRUCTION MEETING BETWEEN THE OWNER, THE PROJECT ADMINISTRATOR AND THE ENGINEER SHALL BE REQUIRED PRIOR TO ANY ON-SITE WORK.
6. THE CONTRACTOR SHALL BE RESPONSIBLE FOR OBTAINING RIGHT-OF-WAY PERMITS FROM CLALLAM COUNTY PRIOR TO PROCEEDING WITH THE WORK. THE CONTRACTOR SHALL SUBMIT RIGHT-OF-WAY USE PERMIT APPLICATIONS AND PAY ALL APPLICABLE FEES.
7. THE CONTRACTOR SHALL RECEIVE, IN WRITING, AUTHORIZATION TO PROCEED BEFORE STARTING WITH ANY WORK ON ANY ITEM NOT CLEARLY DEFINED OR IDENTIFIED BY THE CONTRACT DOCUMENTS.
8. ALL WORK SHALL BE IN CONFORMANCE WITH EXISTING LABOR LAWS, SAFETY REQUIREMENTS, AND OTHER REGULATIONS, AS REQUIRED BY CLALLAM COUNTY, THE STATE OF WASHINGTON, AND THE FEDERAL GOVERNMENT. THE CONTRACTOR SHALL ASSUME SOLE AND COMPLETE RESPONSIBILITY FOR JOB SITE CONDITIONS DURING THE COURSE OF CONSTRUCTION, INCLUDING THE SAFETY OF ALL PERSONS AND PROPERTY. THIS REQUIREMENT SHALL APPLY CONTINUOUSLY AND IS NOT LIMITED TO NORMAL WORKING HOURS.
9. THE CONTRACTOR SHALL BE RESPONSIBLE FOR ALL CONSTRUCTION MEANS, METHODS, TECHNIQUES, SEQUENCES, AND PROCEDURES AND FOR COORDINATING ALL PORTIONS OF THE WORK UNDER THIS CONTRACT.
10. ALL MATERIALS SHALL BE NEW AND UNDAMAGED UNLESS OTHERWISE APPROVED BY THE CONTRACTING OFFICER AND HIS ENGINEER. THE SAME MANUFACTURER OF EACH ITEM SHALL BE USED THROUGHOUT THE WORK UNLESS OTHERWISE APPROVED BY THE OWNER'S REPRESENTATIVE.
11. ALL SITE WORK SHALL BE AS INDICATED ON THE DRAWINGS. THE CONTRACTOR SHALL NOT EXCAVATE OR DISTURB BEYOND THE CLEARING LIMITS SHOWN ON THE DRAWINGS UNLESS OTHERWISE APPROVED BY THE OWNER'S REPRESENTATIVE.
12. THE CONTRACTOR SHALL MAKE ALL NECESSARY PROVISIONS TO PROTECT EXISTING IMPROVEMENTS, ROADWAYS, DRAINAGE WAYS, CULVERTS, AND VEGETATION UNTIL SUCH ITEMS ARE TO BE DISTURBED OR REMOVED AS INDICATED ON THE CONTRACT DOCUMENTS.
13. THE CONTRACTOR SHALL BE RESPONSIBLE FOR REPAIR OF PROPERTY IN AND AROUND THE PROJECT AREA. UNLESS OTHERWISE NOTED ON THESE DRAWINGS, ITEMS SUCH AS MAILBOXES, CULVERTS, LAWN ORNAMENTS, FENCING, DRIVEWAYS, IRRIGATION BOXES, ETC., THAT ARE AFFECTED BY CONSTRUCTION ACTIVITIES SHALL BE REPAIRED OR REPLACED FOLLOWING CONSTRUCTION.
14. RUBBISH, DEBRIS, AND GARBAGE SHALL BE REMOVED FROM THE JOB SITE PRIOR TO ACCEPTANCE AND DISPOSED OF LEGALLY. SEE THE SPECIFICATIONS FOR ADDITIONAL REQUIREMENTS.
15. DISTURBED AREAS SHALL BE GRADED SMOOTH AND PROTECTED AND/OR REVEGETATED AS INDICATED IN THE SPECIFICATIONS.
17. THE NOTES, DETAILS AND SPECIFICATIONS ON THE CONTRACT DOCUMENTS SHALL TAKE PRECEDENCE OVER THESE GENERAL NOTES.
18. DIMENSION CALL-OUTS SHALL TAKE PRECEDENCE OVER SCALES SHOWN ON THE DRAWINGS.
19. THE CONTRACTOR SHALL MAINTAIN HAND DRAWN REDLINES, FIELD NOTES AND PHOTOGRAPHS ("FIELD DOCUMENTATION") OF ALL IMPROVEMENTS AS THE WORK PROGRESSES. THE CONTRACTOR'S FIELD DOCUMENTATION SHALL BE MAINTAINED ON-SITE AND SHALL BE AVAILABLE FOR REVIEW BY THE OWNER AND THE ENGINEER AT ALL TIMES. THE CONTRACTOR SHALL PROVIDE FIELD DOCUMENTATION TO THE ENGINEER FOR PREPARATION OF CERTIFIED RECORD DRAWINGS PRIOR TO PROJECT ACCEPTANCE.

PIPELINE CONSTRUCTION NOTES:

1. PIPE SHALL BE BUTT-FUSED HDPE, UNLESS OTHERWISE INDICATED ON THE DRAWINGS. IF NO PRESSURE RATING IS SHOWN ON THE DRAWINGS, PIPE SHALL HAVE A MINIMUM PRESSURE RATING OF 80 PSI. SEE THE SPECIFICATIONS FOR ADDITIONAL DETAILS.
2. FITTINGS SHALL BE HDPE SDR 26, BUTT-FUSED JOINT TYPE, AND SHALL HAVE A PRESSURE RATING EQUAL TO OR GREATER THAN THAT OF THE ADJACENT PIPE. SEE THE SPECIFICATIONS FOR ADDITIONAL DETAILS.
3. THE CONTRACTOR SHALL INSTALL PIPE TO MATCH THE ALIGNMENT AND GRADES SHOWN ON THE PLAN AND PROFILE DRAWINGS. THE CONTRACTOR SHALL FURNISH FITTINGS OR DEFLECT THE PIPE AS ALLOWED BY THE MANUFACTURER TO MATCH THE ALIGNMENT AND GRADES SHOWN.
4. MINIMUM COVER FOR ALL PIPE SHALL BE THIRTY-SIX INCHES (36") FROM TOP OF PIPE TO FINISH GRADE UNLESS OTHERWISE SHOWN ON THE DRAWINGS OR APPROVED BY THE ENGINEER. THE MAXIMUM COVER OVER THE PIPE SHALL BE AS ALLOWED BY THE PIPE MANUFACTURER FOR THE INTENDED USE.
5. PIPELINES ARE DESIGNED TO OPERATE UNDER PRESSURE. THE CONTRACTOR SHALL BE RESPONSIBLE FOR RESTRAINING PIPE AND FITTINGS AGAINST ALL UNRESOLVED HYDROSTATIC FORCES. PROVIDE THRUST BLOCKING, AS SHOWN ON THE DRAWINGS. WHERE ADEQUATE BEARING AREA AGAINST UNDISTURBED SOIL IS NOT AVAILABLE FOR THRUST BLOCKING, THE CONTRACTOR SHALL PROVIDE RESTRAINED JOINT FITTINGS. RESTRAINED JOINT FITTINGS SHALL BE APPROVED BY THE ENGINEER PRIOR TO INSTALLATION. NEW IRRIGATION PIPE SHALL BE PRESSURE TESTED IN ACCORDANCE WITH SECTION 7-09.3(23) OF THE WSDOT "STANDARD SPECIFICATIONS FOR ROAD, BRIDGE AND MUNICIPAL CONSTRUCTION" (2021 EDITION).
6. PRIOR TO BEGINNING THE WORK SHOWN ON THESE DRAWINGS, THE CONTRACTOR SHALL BE RESPONSIBLE FOR VERIFYING THE CONDITION AND INVERT ELEVATIONS OF EACH EXISTING CULVERT SHOWN ON THE DRAWINGS TO REMAIN WHERE THE PROPOSED PIPELINE WILL BE INSTALLED THROUGH THE CULVERT. THE CONTRACTOR SHALL CONFIRM THAT PIPE CAN BE INSTALLED IN EACH EXISTING CULVERT AS INDICATED ON THE DRAWINGS. IF THE CONTRACTOR IDENTIFIES A CONDITION OR CONFLICT THAT WILL PREVENT THE PROPOSED PIPE FROM BEING INSTALLED IN THE EXISTING CULVERT, THE CONTRACTOR SHALL NOTIFY THE OWNER'S REPRESENTATIVE PRIOR TO PROCEEDING WITH CONSTRUCTION.

LOCATION OF EXISTING UTILITIES:

1. THE LOCATIONS OF EXISTING UTILITIES SHOWN ON THESE DRAWINGS ARE APPROXIMATE. AND HAVE NOT BEEN FIELD VERIFIED. THE CONTRACTOR SHALL BE RESPONSIBLE FOR LOCATING ALL EXISTING UTILITIES PRIOR TO CONSTRUCTION. THE CONTRACTOR SHALL CONTACT THE UTILITY LOCATION REQUEST CENTER (ONE-CALL CENTER) AT 811 OR 1-800-424-5555 FOR UTILITY LOCATIONS NOT LESS THAN TWO (2) BUSINESS DAYS BEFORE THE SCHEDULED DATE FOR EARTHWORK OR TRENCHING THAT MAY IMPACT EXISTING UTILITIES.
2. THE SIZE, LOCATION, AND TYPE OF UNDERGROUND UTILITIES EXPOSED OR MODIFIED BY THE CONTRACTOR SHALL BE ACCURATELY NOTED AND PLACED ON THE CONTRACTOR'S AS-BUILT DRAWINGS. SEE GENERAL CONSTRUCTION NOTE 19 FOR ADDITIONAL REQUIREMENTS RELATED TO THE CONTRACTOR'S AS-BUILT DRAWINGS AND FIELD DOCUMENTATION.

SURVEY AND BASEMAP INFORMATION:

TOPOGRAPHIC SURVEY OF EXISTING DITCH AND LATERAL ALIGNMENTS COMPLETED IN MAY AND JUNE 2021 BY PARAMETRICS, INCORPORATED. ADDITIONAL CONTOURS FROM SURVEY WITHIN EXTENTS SHOWN AND FROM PUGET SOUND LiDAR CONSORTIUM (PSLC) DATA OUTSIDE EXTENTS OF SURVEY. ADDITIONAL BASEMAP INFORMATION FROM CLALLAM COUNTY GIS DATA. AERIAL PHOTOGRAPHY: BING MAPS

HORIZONTAL DATUM FOR THIS SURVEY IS NAD 1983(11), WASHINGTON STATE PLANE NORTH ZONE COORDINATE SYSTEM, U.S. SURVEY FEET. THE HORIZONTAL DATUM IS BASED ON PUBLISHED INFORMATION FROM WSDOT, POINT DESIGNATIONS PETE AND FS0506.

POINT DESIGNATION PETE
NORTHING: 387953.181
EASTING: 1073114.596

POINT DESIGNATION FS0506
NORTHING: 399609.345
EASTING: 1077813.458

VERTICAL DATUM IS NAVD88 BASED ON
PUBLISHED INFORMATION
FROM WSDOT, POINT DESIGNATION PETE

POINT DESIGNATION
ELEVATION: 457.443

GRADING AND EARTHWORK GENERAL NOTES:

1. THE CONTRACTOR SHALL LIMIT DISTURBANCE OF THE EXISTING SURFACE TO THE LIMITS SHOWN ON THE DRAWINGS. THE CONTRACTOR SHALL FLAG OR MARK THE CLEARING AND DISTURBANCE LIMITS PRIOR TO CONSTRUCTION.
2. THE CONTRACTOR SHALL CLEAR AND GRUB WITHIN THE MARKED CLEARING LIMITS, AS NEEDED FOR RESERVOIR EXCAVATION, PIPELINE CONSTRUCTION, AND STAGING AND PROCESSING OF MATERIALS FOR THE PROJECT IN ACCORDANCE WITH SECTION 2-01 OF THE STANDARD SPECIFICATIONS. DISPOSAL OF CLEARED MATERIAL SHALL BE THE CONTRACTOR'S RESPONSIBILITY. THE CONTRACTING ORGANIZATION'S REPRESENTATIVE SHALL APPROVE THE DISPOSAL METHOD. DISPOSAL SHALL BE IN ACCORDANCE WITH APPLICABLE PERMITS AND STATE AND LOCAL REGULATIONS.
3. ALL EXPOSED OR EXCAVATED SLOPES STEEPER THAN 3:1 MUST BE STABILIZED WITH JUTE MAT OR OTHER APPROVED STABILIZATION WITHIN 24 HOURS OF EXPOSURE.
4. EXPOSED SOIL MUST BE COVERED WITHIN 5 DAYS OF EXPOSURE DURING THE DRY SEASON (APRIL 1 THROUGH SEPTEMBER 30), AND WITHIN 48 HOURS OF EXPOSURE DURING THE WET SEASON (OCTOBER 1 THROUGH MARCH 31).
5. FOR ADDITIONAL TESC REQUIREMENTS, SEE THE TESC PLANS, THE SPECIFICATIONS, AND THE APPROVED CONSTRUCTION SWPPP.
6. COMPACTION OF SOILS PLACED FOR THE PROJECT SHALL BE AS SHOWN ON THE DRAWINGS OR AS REQUIRED BY THE SPECIFICATIONS. WHERE NOT SHOWN OR SPECIFIED, EMBANKMENT SOILS AND SOILS SUPPORTING STRUCTURES OR TRAFFIC SHALL BE COMPACTED TO AT LEAST 95% MAXIMUM DRY DENSITY, AS DETERMINED BY A MODIFIED PROCTOR TEST. ALL OTHER SOILS SHALL BE COMPACTED TO AT LEAST 90% OF MAXIMUM DRY DENSITY.
7. WHERE REQUIRED BY THE CONTRACTING ORGANIZATION'S REPRESENTATIVE OR THE GEOTECHNICAL ENGINEER, UNSUITABLE SUBGRADE MATERIAL SHALL BE REMOVED AND REPLACED WITH SUITABLE ON-SITE EMBANKMENT FILL OR OTHER MATERIAL DESIGNATED BY THE CONTRACTING ORGANIZATION'S REPRESENTATIVE PRIOR TO COMPACTION AND FINAL GRADING.
8. THE CONTRACTOR SHALL DEWATER OR OTHERWISE DRAIN ALL EXCAVATIONS TO A MINIMUM OF 1 FOOT BELOW SUBGRADE ELEVATION PRIOR TO PLACING AND COMPACTING BACKFILL. DEWATERING AND DISPOSAL OF WATER SHALL COMPLY WITH STATE AND LOCAL REGULATIONS AND APPLICABLE PERMITS REQUIREMENTS. DWATERING WATER SHALL BE DISPERSED ON SITE.
9. A LICENSED GEOTECHNICAL ENGINEER SHALL SUPERVISE PLACEMENT OF ALL EMBANKMENT AND FILL MATERIAL AND SHALL WITNESS ALL ON-SITE GEOTECHNICAL TESTING.
10. CONSTRUCTION RECORDS OF SOIL ACTIVITIES AND COMPACTION TESTING SHALL BE TRANSMITTED TO THE CONTRACTING AGENCY ON A WEEKLY BASIS. ALL TEST RESULTS SHALL INCLUDE A MAP INDICATING THE TEST LOCATION.
11. FOR ADDITIONAL GRADING AND EARTHWORK REQUIREMENTS, SEE THE SPECIFICATIONS.
12. GRADING SHALL BE DONE UNDER THE SUPERVISION OF A LICENSED GEOTECHNICAL ENGINEER IN CONFORMANCE WITH THE RECOMMENDATIONS OF THE *DRAFT PHASE 1 GEOTECHNICAL DATA REPORT, DUNGENESS OFF-CHANNEL RESERVOIR* AND *DRAFT PHASE 1 CONCEPTUAL GEOTECHNICAL ENGINEERING REPORT* AND *DUNGENESS OFF-CHANNEL RESERVOIR* BY SHANNON & WILSON DATED NOVEMBER 2021. THIS REPORT IS PART OF THESE PLANS.

TOPOGRAPHIC SURVEY GENERAL NOTES:

1. THIS MAP CORRECTLY REPRESENTS CONDITIONS AND FEATURES EXISTING AT THE TIME OF THIS SURVEY IN OCTOBER, 2021.
2. CONVENTIONAL AND GPS SURVEY EQUIPMENT WAS USED IN THE PERFORMANCE OF THIS SURVEY. ALL EQUIPMENT IS MAINTAINED IN CONFORMANCE WITH CURRENT STATE STATUTE.
3. THIS SURVEY WAS PREPARED BY FIELD TRAVERSE AS PER WAC 332-130-090, PART C. RELATIVE ACCURACY EXCEEDS 1 FOOT IN TEN THOUSAND.
4. ALL SURFACE FEATURES AND INVERT STRUCTURE ELEVATION SHOWN HEREON WERE FIELD LOCATED AND MEASURED BY PARAMETRIX FOR THIS SURVEY. UNDERGROUND UTILITY LINES ARE BASED UPON A COMBINATION OF SURFACE FEATURE MEASUREMENTS AND ONSITE UNDERGROUND UTILITY MARKINGS PERFORMED BY OTHERS.
5. THE SURVEYOR MAKES NO GUARANTEE THAT THE UNDERGROUND UTILITIES SHOWN COMPRISE ALL SUCH UTILITIES IN THE AREA, EITHER IN SERVICE OR ABANDONED. THE SURVEYOR FURTHER DOES NOT WARRANT THAT THE UNDERGROUND UTILITIES SHOWN ARE IN THE EXACT LOCATION INDICATED ALTHOUGH HE DOES CERTIFY THAT THEY ARE LOCATED AS ACCURATELY AS POSSIBLE FROM INFORMATION AVAILABLE.

ABBREVIATIONS:

'	FEET, MINUTES
"	INCHES, SECONDS
°	DEGREES
APWA	AMERICAN PUBLIC WORKS ASSOCIATION
AWWA	AMERICAN WATER WORKS ASSOCIATION
ASSY	ASSEMBLY
ASTM	AMERICAN SOCIETY FOR TESTING AND MATERIALS
CFS	CUBIC FEET PER SECOND
CONC	CONCRETE
CY	CUBIC YARDS
D.I	DUCTILE IRON
DIA	DIAMETER
DWG	DRAWING
E	EAST, EASTING
ELEV	ELEVATION
EX	EXISTING
FG	FINISHED GRADE
FL	FLOW LINE, FLANGE, FLANGED
FPS	FEET PER SECOND
FT	FEET
GALV	GALVANIZED
GPM	GALLONS PER MINUTE
GV	GATE VALVE
HPDE	HIGH-DENSITY POLYETHYLENE
I.D.	INSIDE DIAMETER
IE	INVERT ELEVATION
IN	INCHES
L	LENGTH
LF	LINEAR FEET
MAX	MAXIMUM
MIN	MINIMUM
MJ	MECHANICAL JOINT
N	NORTH, NORTHING
NAD	NORTH AMERICAN DATUM
NGVD	NATIONAL GEODETIC VERTICAL DATUM
NO., #	NUMBER
NTS	NOT TO SCALE
O.C.	ON CENTERS
O.D.	OUTSIDE DIAMETER
P	POWER
PSI	POUNDS PER SQUARE INCH
PVC	POLYVINYL CHLORIDE
P.E.	PROFESSIONAL ENGINEER
R, RAD	RADIUS
REINF	REINFORCED, REINFORCEMENT
ROW	RIGHT OF WAY
S	SLOPE, SANITARY SEWER, SOUTH
SCH	SCHEDULE
STA	STATION
SY	SQUARE YARD
T	TELEPHONE
TYP	TYPICAL
W	WEST, WATER
W/	WITH
WSDOE	WASHINGTON STATE DEPARTMENT OF ECOLOGY
WSDOT	WASHINGTON STATE DEPARTMENT OF TRANSPORTATION
WSEL	WATER SURFACE ELEVATION
WWT	WASHINGTON WATER TRUST

PARAMETRIX CONTROL TABLE

POINT NO.	NORTHING	EASTING	ELEVATION	DESCRIPTION
3002	389371.36	1075574.86	459.42	SET MAG NAIL
3003	393414.30	1076311.40	399.63	SET HUB & TACK
3006	393014.30	1076293.87	407.50	SET HUB & TACK
3015	394275.38	1076395.40	382.28	SET HUB & MAG
3016	389296.14	1075516.70	459.55	SET HUB & TACK
3017	390127.03	1076140.96	444.54	SET HUB & TACK
3118	390269.15	1076248.33	442.22	SET HUB & TACK
3119	389212.86	1075589.65	464.08	SET HUB & TACK
3120	389148.27	1075682.01	488.84	SET NAIL
3121	389111.68	1075659.20	489.63	SET HUB & TACK
3122	389123.44	1075681.64	486.43	SET HUB & TACK

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE. IF NOT ONE INCH SCALE ACCORDINGLY

30% DESIGN: NOT FOR CONSTRUCTION

ANCHOR QEA

REVISIONS				
REV	DATE	BY	APP'D	DESCRIPTION

DESIGNED BY: G. HART
DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

GENERAL NOTES, ABBREVIATIONS, AND LEGENDS

G02

SHEET # 2 OF 26

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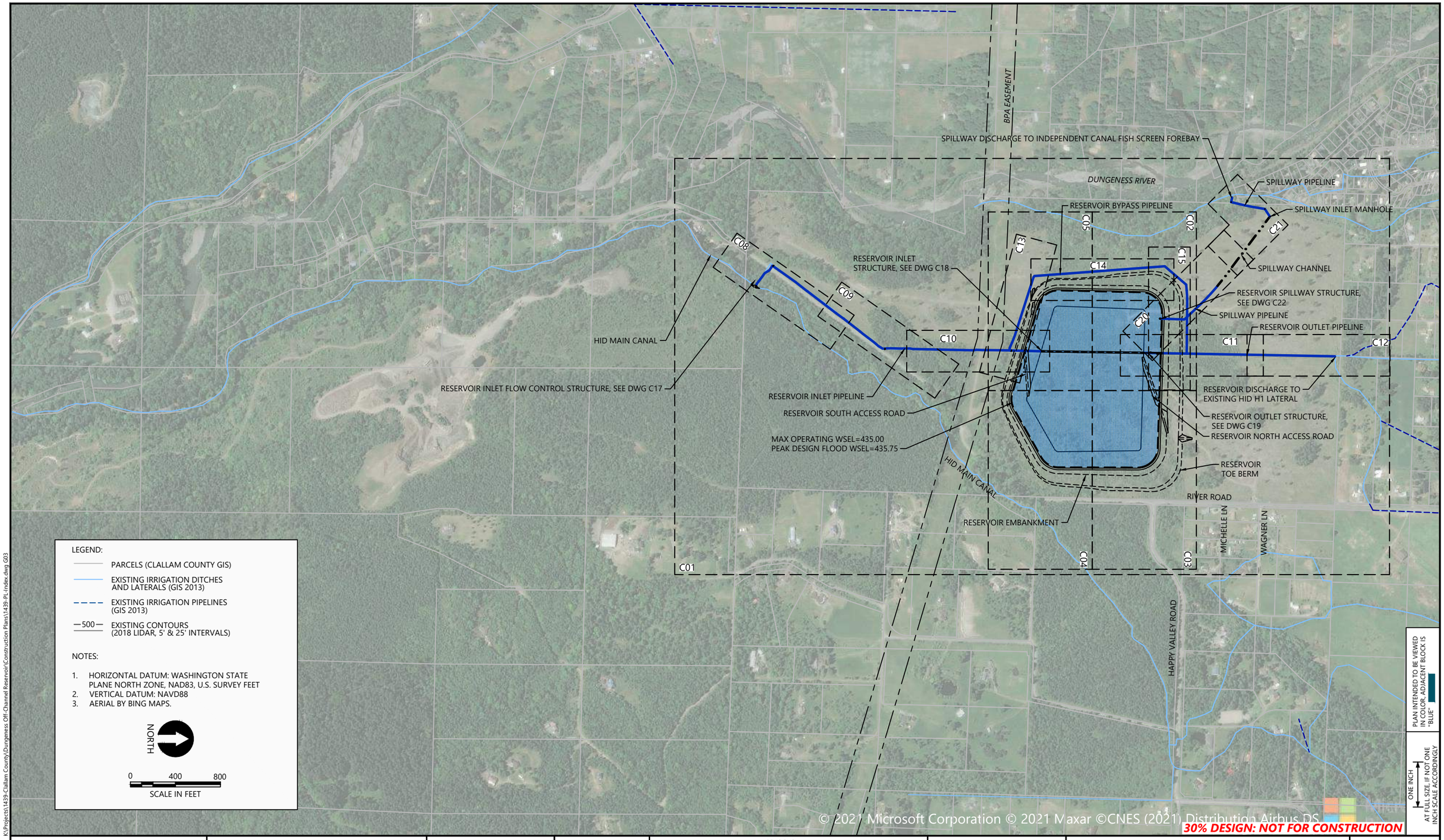

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CLALLAM COUNTY 1854

REVISIONS

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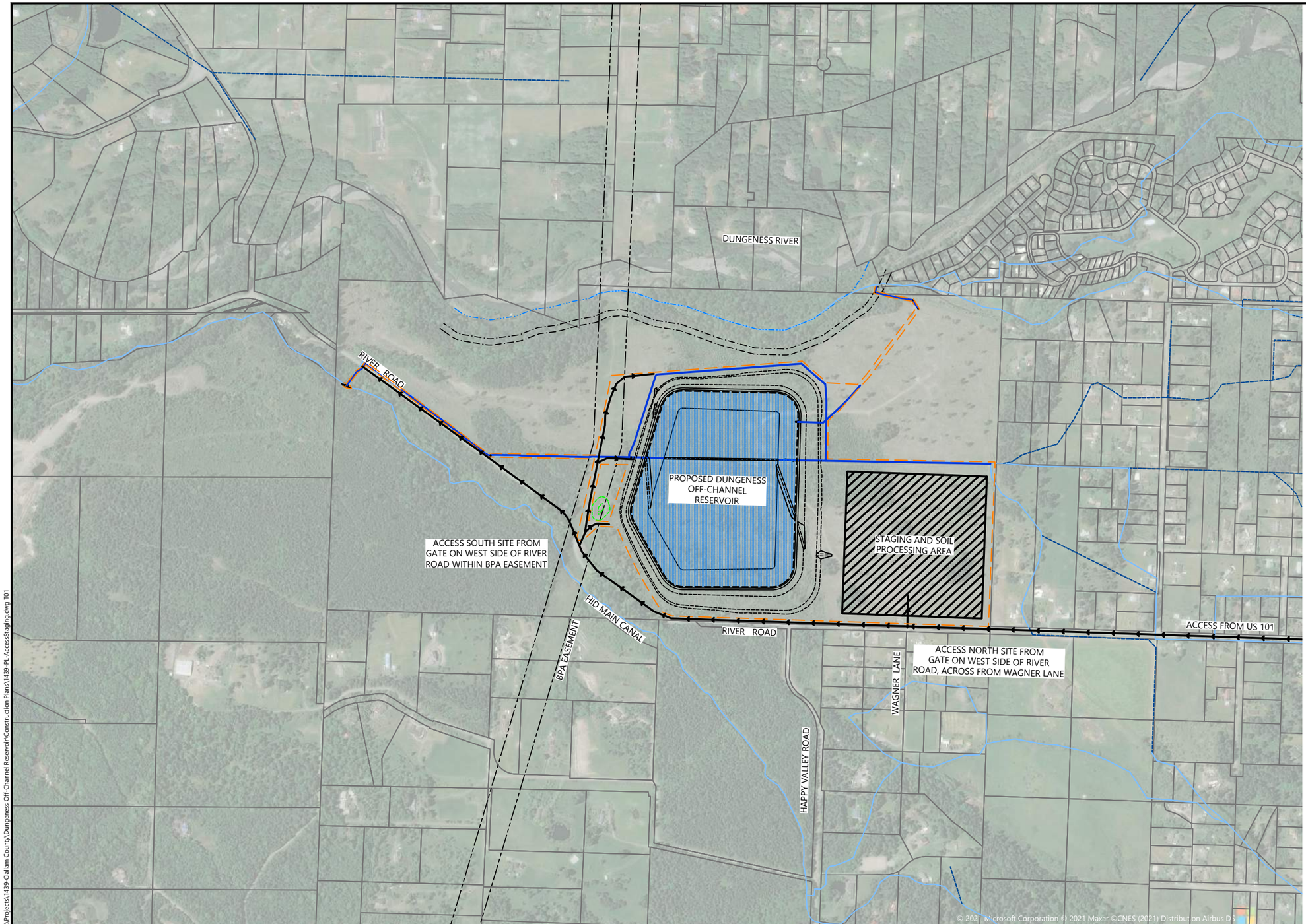
DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

OVERALL SITE PLAN AND DRAWING INDEX

G03

SHEET # 3 OF 26



LEGEND:

- PARCELS (CLALLAM COUNTY GIS)
- EXISTING IRRIGATION DITCHES AND LATERALS (GIS 2021)
- BPA EASEMENT
- CLASS IV WETLAND
- 50' WETLAND BUFFER
- DUNGENESS RIVER OHWM
- 150' TYPE 1 STREAM BUFFER
- 200' SHORELINE ZONE
- PROPOSED IRRIGATION PIPELINES
- TEMPORARY ACCESS ROUTE
- POTENTIAL STAGING AREAS
- CLEARING LIMITS
- PROPOSED CLALLAM COUNTY OWNED PARCELS

NOTES:

1. HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NORTH AMERICAN DATUM OF 1983 (NAD83), U.S. SURVEY FEET
2. AERIAL: BING MAPS
3. THE CONTRACTOR SHALL ARRANGE FOR STAGING MATERIALS AND EQUIPMENT NEAR THE SITE IN ACCORDANCE WITH THE SPECIFICATIONS.

NORTH

0 400 800

SCALE IN FEET

PLAN INTENDED TO BE VIEWED IN COLOR, ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

30% DESIGN: NOT FOR CONSTRUCTION

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APPROVED BY: R. MONTGOMERY
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DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

TEMPORARY ACCESS AND STAGING PLAN

T01

SHEET # 4 OF 26

SPILLWAY DISCHARGE TO DUNGENESS RIVER SIDE CHANNEL UPSTREAM OF INDEPENDENT CANAL INTAKE FACILITIES

SPILLWAY PIPELINE

SPILLWAY INLET MANHOLE

SPILLWAY CHANNEL

HID CANAL INLET FLOW CONTROL STRUCTURE, SEE DWG C17

RESERVOIR BYPASS PIPELINE

SOUTH ACCESS ROAD

RESERVOIR INLET STRUCTURE, SEE DWG C18

RESERVOIR INLET PIPELINE

RESERVOIR SOUTH ACCESS ROAD

MAX OPERATING WSEL=435.00
PEAK DESIGN FLOOD WSEL=435.75

RESERVOIR BOTTOM

RESERVOIR CREST

SPILLWAY PIPELINE

RESERVOIR SPILLWAY STRUCTURE, SEE DWG C22

RESERVOIR OUTLET PIPELINE

RESERVOIR DISCHARGE TO EXISTING HID H1 LATERAL

RESERVOIR OUTLET STRUCTURE, SEE DWG C19

RESERVOIR NORTH ACCESS ROAD

NORTH ACCESS ROAD

RESERVOIR TOE BERM

RESERVOIR EMBANKMENT

A C06 B C06 C C06 D C07 E C07 F C07

LEGEND:

- PARCELS (CLALLAM COUNTY GIS)
- EXISTING IRRIGATION DITCHES AND LATERALS (GIS 2021)
- EXISTING IRRIGATION PIPELINES (GIS 2021)
- 500 EXISTING CONTOURS (2018 LIDAR, 5' & 25' INTERVALS)
- BPA EASEMENT
- CLASS IV WETLAND
- 50' WETLAND BUFFER
- DUNGENESS RIVER OHWM
- 150' TYPE 1 STREAM BUFFER
- 200' SHORELINE ZONE
- PROPOSED IRRIGATION PIPELINES

NOTES:

1. HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD83, U.S. SURVEY FEET
2. VERTICAL DATUM: NAVD88
3. AERIAL BY BING MAPS.

NORTH

0 200 400

SCALE IN FEET

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE. IF NOT ONE INCH SCALE ACCORDINGLY

30% DESIGN: NOT FOR CONSTRUCTION

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DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

RESERVOIR SITE PLAN

C01

SHEET # 5 OF 26

LEGEND:

—300— EXISTING CONTOURS (2018 LIDAR, 2' & 10' INTERVALS)

—300— PROPOSED CONTOURS (1' & 5' INTERVALS)

PROPOSED BREAKLINE

PROPOSED IRRIGATION PIPELINES

NOTES:

1. HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD83, U.S. SURVEY FEET
2. VERTICAL DATUM: NAVD88
3. AERIAL BY BING MAPS.

NORTH

0 50 100

SCALE IN FEET

SPILLWAY PIPELINE

RESERVOIR OUTLET PIPELINE

RESERVOIR BYPASS PIPELINE

A C05

C C07

RESERVOIR TOE BERM

RESERVOIR EMBANKMENT

RESERVOIR NORTH ACCESS ROAD

RESERVOIR SPILLWAY STRUCTURE, SEE DWG C22

RESERVOIR OUTLET STRUCTURE, SEE DWG C19

RESERVOIR CREST ELEV=438.00

MAX OPERATING WSEL=435.00
PEAK DESIGN FLOOD WSEL=435.75

RESERVOIR BOTTOM

RESERVOIR BOTTOM SWALE

MATCHLINE DWG C03

MATCHLINE DWG C05

DUNGENESS RIVER OHWM

150' TYPE 1 STREAM BUFFER

200' SHORELINE ZONE

405 410 415 416 417 418 419 420 421 422 423 425 430 435 420 425 430 435 430 425 420 415 410 405 400 395 390 386 410 410 410 425 430 435 435 430 425 420 415 410 405 400 395 390 387 410 415 420

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE. IF NOT ONE INCH SCALE ACCORDINGLY

30% DESIGN: NOT FOR CONSTRUCTION

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CLALLAM COUNTY 1854

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CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

RESERVOIR GRADING PLAN (NORTHWEST)

C02

SHEET # 6 OF 26

RESERVOIR NORTH ACCESS ROAD

RESERVOIR TOE BERM

RESERVOIR EMBANKMENT

RESERVOIR NORTH ACCESS ROAD

RESERVOIR BOTTOM

RESERVOIR CREST ELEV=438.00

MAX OPERATING WSEL=435.00
PEAK DESIGN FLOOD WSEL=435.75

RESERVOIR BOTTOM SWALE

TO US 101

RIVER ROAD

HAPPY VALLEY ROAD

MATCHLINE DWG C02

MATCHLINE DWG C06

LEGEND:

- —300— EXISTING CONTOURS (2018 LIDAR, 2' & 10' INTERVALS)
- —300— PROPOSED CONTOURS (1' & 5' INTERVALS)
- PROPOSED BREAKLINE
- PROPOSED IRRIGATION PIPELINES

NOTES:

1. HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD83, U.S. SURVEY FEET
2. VERTICAL DATUM: NAVD88
3. AERIAL BY BING MAPS.

NORTH

0 50 100

SCALE IN FEET

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

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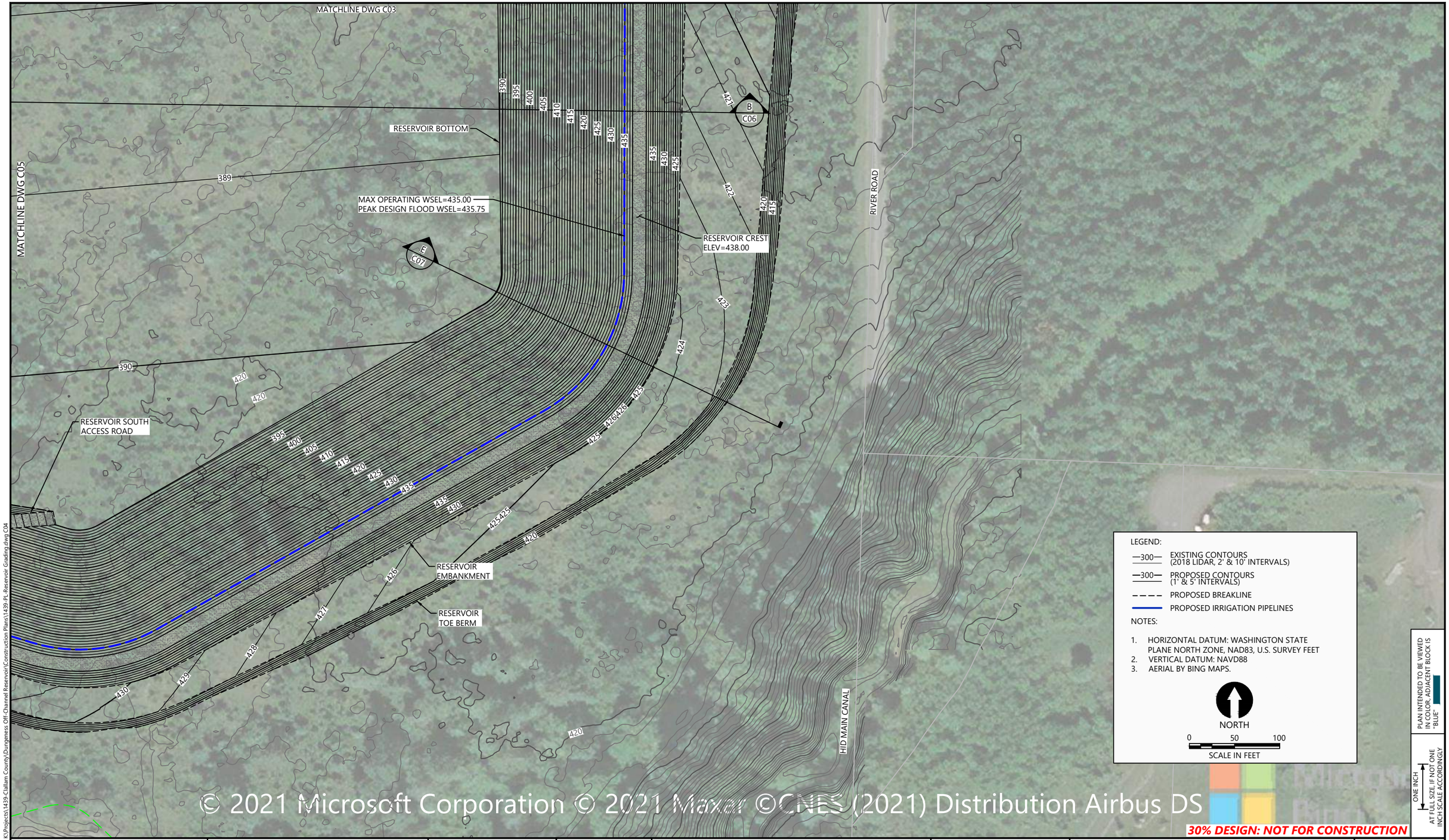
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

RESERVOIR GRADING PLAN (NORTHEAST)

C03

SHEET # 7 OF 26



PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

30% DESIGN: NOT FOR CONSTRUCTION

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DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

RESERVOIR GRADING PLAN (SOUTHEAST)

C04

SHEET # 8 OF 26

MATCHLINE DWG C02

MATCHLINE DWG C04

RESERVOIR CREST ELEV=438.00

RESERVOIR EMBANKMENT

RESERVOIR TOE BERM

MAX OPERATING WSEL=435.00
PEAK DESIGN FLOOD WSEL=435.75

RESERVOIR BOTTOM

RESERVOIR BOTTOM SWALE

RESERVOIR INLET STRUCTURE, SEE DWG C18

RESERVOIR SOUTH ACCESS ROAD

RESERVOIR BYPASS PIPELINE

BPA EASEMENT

RESERVOIR INLET PIPELINE

B C06

F C07

A C06

LEGEND:

- —300— EXISTING CONTOURS (2018 LIDAR, 2' & 10' INTERVALS)
- —300— PROPOSED CONTOURS (1' & 5' INTERVALS)
- PROPOSED BREAKLINE
- PROPOSED IRRIGATION PIPELINES

NOTES:

1. HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD83, U.S. SURVEY FEET
2. VERTICAL DATUM: NAVD88
3. AERIAL BY BING MAPS.

NORTH

0 50 100

SCALE IN FEET

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE. IF NOT ONE INCH SCALE ACCORDINGLY

30% DESIGN: NOT FOR CONSTRUCTION

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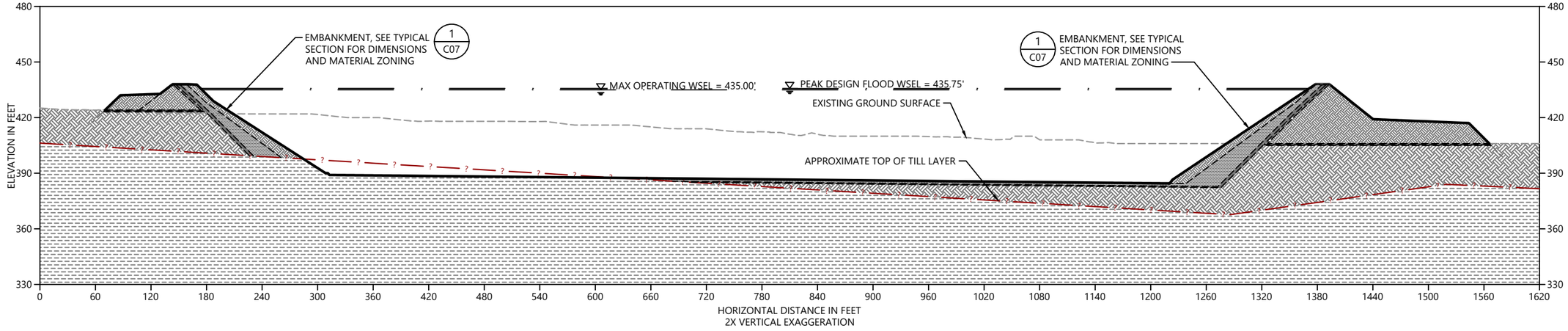
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

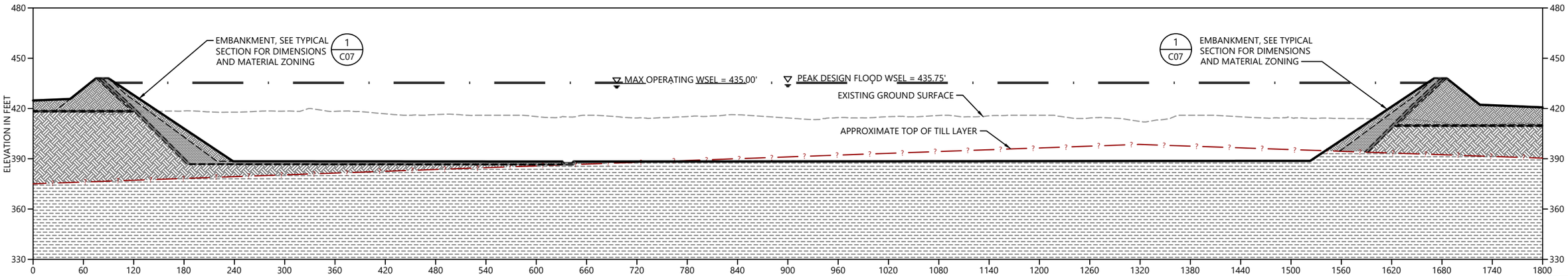
RESERVOIR GRADING PLAN (SOUTHWEST)

C05

SHEET # 9 OF 26



A
-
SECTION
HORIZONTAL SCALE: 1" = 60'
VERTICAL SCALE: 1" = 30'
(SECTION CUT N-S, LOOKING W)



B
-
SECTION
HORIZONTAL SCALE: 1" = 60'
VERTICAL SCALE: 1" = 30'
(SECTION CUT E-W, LOOKING N)

LEGEND:

- EXISTING ALLUVIUM
- EXISTING GLACIAL TILL
- FILTER SAND - IMPORTED OR PROCESSED FROM EXCAVATED MATERIALS
- CUTOFF/LINER MATERIAL - PROCESS FROM EXCAVATED NATIVE TILL
- DRAIN ROCK - PROCESSED FROM EXCAVATED ALLUVIUM
- CRUSHED ROCK - PROCESSED FROM EXCAVATED ALLUVIUM
- EMBANKMENT FILL - PROCESSED FROM EXCAVATED ALLUVIUM

NOTES:

1. THE EXTERIOR SLOPE OF THE EMBANKMENT IS SHOWN AS 2.5H:1V ON THE GRADING PLANS AND SECTIONS, BUT MAY BE INCREASED TO 3H:1V OR MORE TO MATCH THE RECOMMENDATIONS OF THE GEOTECHNICAL ENGINEERING REPORT.
2. THE INTERIOR SLOPE OF THE EMBANKMENT IS SHOWN AS 3H:1V ON THE GRADING PLANS AND SECTION, BUT MAY BE INCREASED TO MATCH THE RECOMMENDATIONS OF THE GEOTECHNICAL ENGINEERING REPORT.
3. THE WIDTH OF THE TILL CUTOFF IN THE EMBANKMENT SHALL BE 5 FEET MINIMUM PERPENDICULAR TO THE EDGES OF THE TILL LAYER FROM THE TOP OF THE EMBANKMENT DOWN TO A DISTANCE OF 20 FEET BELOW THE TO OF THE EMBANKMENT. THE WIDTH SHALL INCREASE BELOW A DISTANCE OF 20 FEET FROM THE TOP OF THE EMBANKMENT TO 25% OF THE DISTANCE BELOW THE TOP OF THE EMBANKMENT.
4. THE DIMENSIONS, CONFIGURATION, AND LAYERING OF THE EMBANKMENTS SHOWN IS PRELIMINARY AND MAY CHANGE AS ADDITIONAL GEOTECHNICAL INFORMATION AND ANALYSIS IS DEVELOPED DURING DETAILED DESIGN.

30% DESIGN: NOT FOR CONSTRUCTION

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

ANCHOR QEA

CLALLAM COUNTY 1854

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APPROVED BY: R. MONTGOMERY
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DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

RESERVOIR SECTIONS

C06

SHEET # **10** OF **26**

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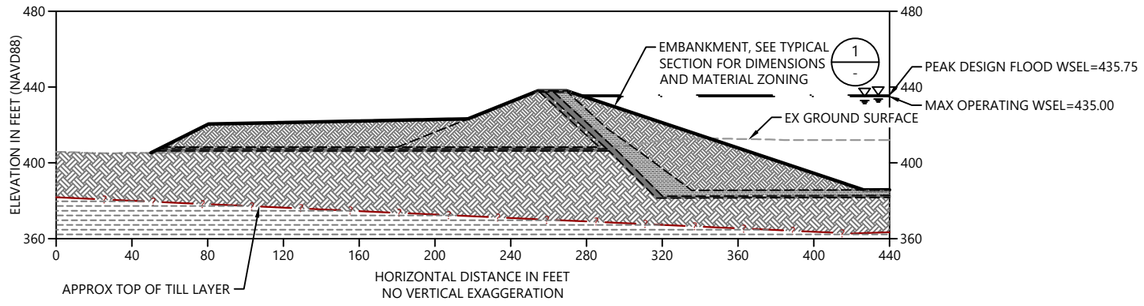
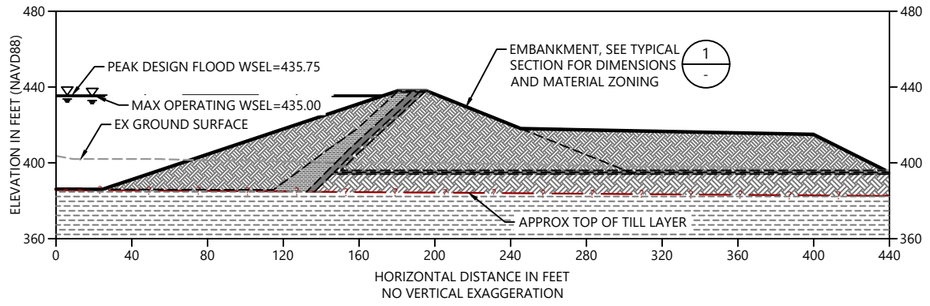
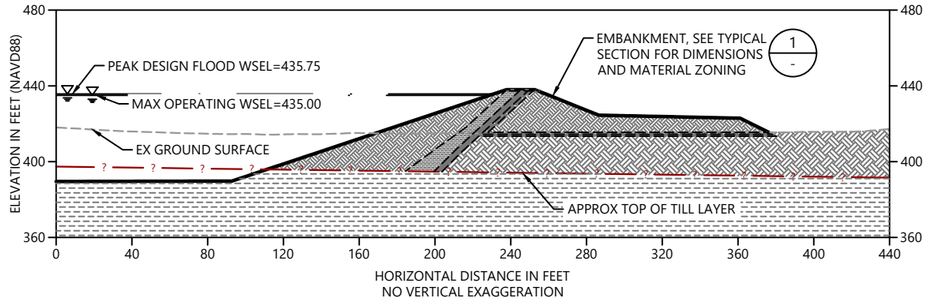


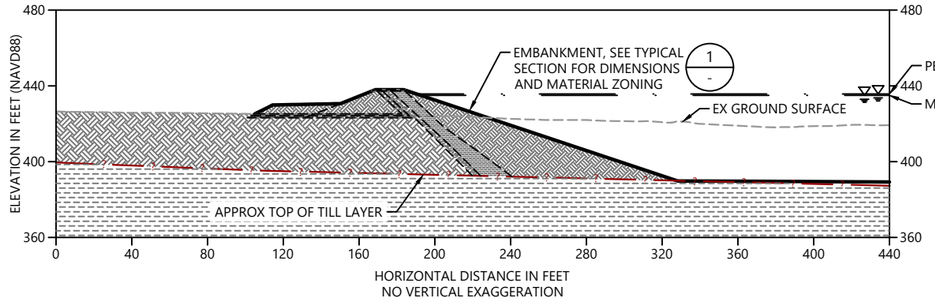
C SECTION
SCALE: 1" = 40'



D SECTION
SCALE: 1" = 40'



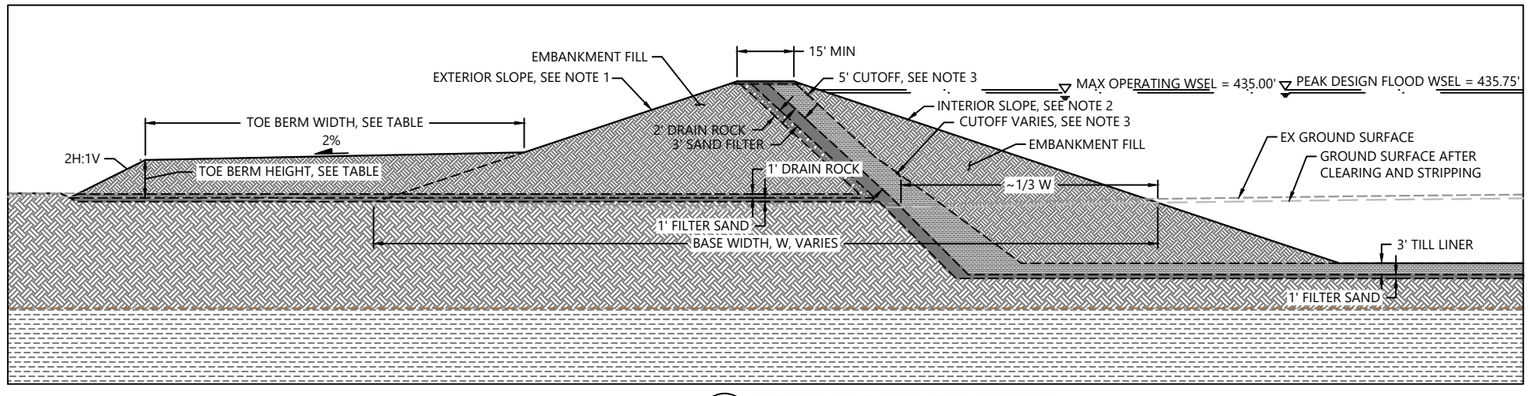
E SECTION
SCALE: 1" = 40'



F SECTION
SCALE: 1" = 40'

LEGEND:

- EXISTING ALLUVIUM
- EXISTING GLACIAL TILL
- FILTER SAND - IMPORTED OR PROCESSED FROM EXCAVATED MATERIALS
- CUTOFF/LINER MATERIAL - PROCESS FROM EXCAVATED NATIVE TILL
- DRAIN ROCK - PROCESSED FROM EXCAVATED ALLUVIUM
- CRUSHED ROCK - PROCESSED FROM EXCAVATED ALLUVIUM
- EMBANKMENT FILL - PROCESSED FROM EXCAVATED ALLUVIUM



1 TYPICAL EMBANKMENT SECTION
SCALE: NOT TO SCALE

TOE BERM DIMENSIONS		
EMBANKMENT HEIGHT (FT)	TOE BERM WIDTH (FT)	TO BERM HEIGHT (FT)
10	30	5
15	40	5
20	50	7
25	80	9
30	100	10
35	100	12

NOTES:

1. THE EXTERIOR SLOPE OF THE EMBANKMENT IS SHOWN AS 2.5H:1V ON THE GRADING PLANS AND SECTIONS, BUT MAY BE INCREASED TO 3H:1V OR MORE TO MATCH THE RECOMMENDATIONS OF THE GEOTECHNICAL ENGINEERING REPORT.
2. THE INTERIOR SLOPE OF THE EMBANKMENT IS SHOWN AS 3H:1V ON THE GRADING PLANS AND SECTION, BUT MAY BE INCREASED TO MATCH THE RECOMMENDATIONS OF THE GEOTECHNICAL ENGINEERING REPORT.
3. THE WIDTH OF THE TILL CUTOFF IN THE EMBANKMENT SHALL BE 5 FEET MINIMUM PERPENDICULAR TO THE EDGES OF THE TILL LAYER FROM THE TOP OF THE EMBANKMENT DOWN TO A DISTANCE OF 20 FEET BELOW THE TO OF THE EMBANKMENT. THE WIDTH SHALL INCREASE BELOW A DISTANCE OF 20 FEET FROM THE TOP OF THE EMBANKMENT TO 25% OF THE DISTANCE BELOW THE TOP OF THE EMBANKMENT.
4. THIS DIMENSIONS, CONFIGURATION, AND LAYERING OF THE EMBANKMENTS SHOWN IS PRELIMINARY AND MAY CHANGE AS ADDITIONAL GEOTECHNICAL INFORMATION AND ANALYSIS IS DEVELOPED DURING DETAILED DESIGN.

30% DESIGN: NOT FOR CONSTRUCTION

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\Construction Plans\1439-PL-Reservoir Grading.dwg C07

Mar 14, 2022 12:43pm tgriga

ANCHOR QEA

CLALLAM COUNTY 1854

REVISIONS				
REV	DATE	BY	APP'D	DESCRIPTION

DESIGNED BY: G. HART
DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

RESERVOIR SECTIONS

C07

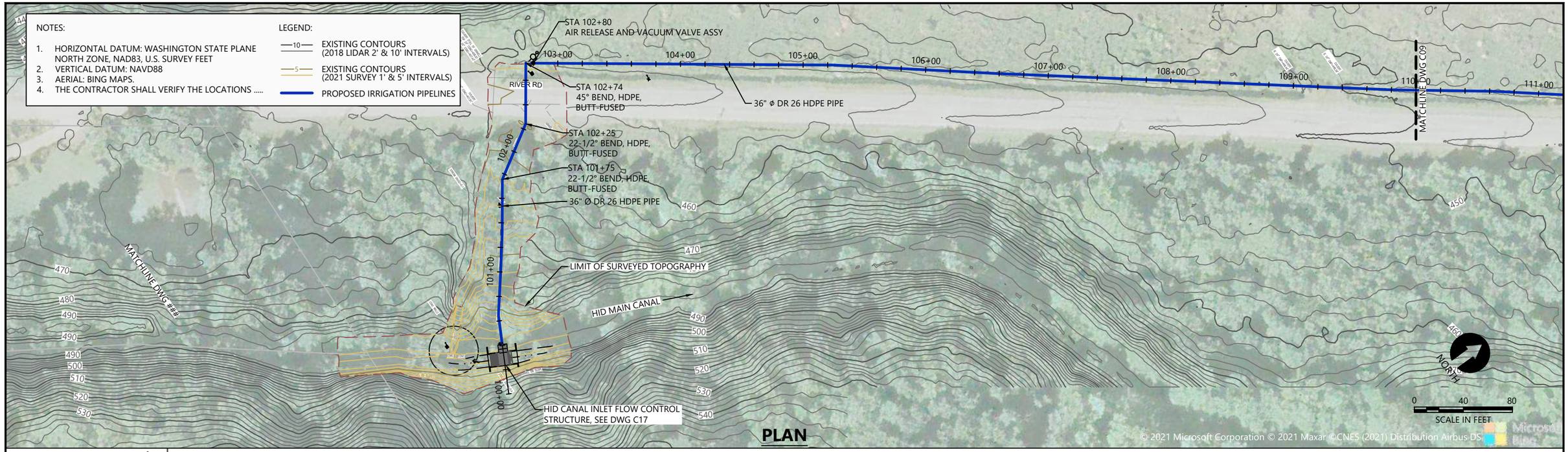
SHEET # **11** OF **26**

NOTES:

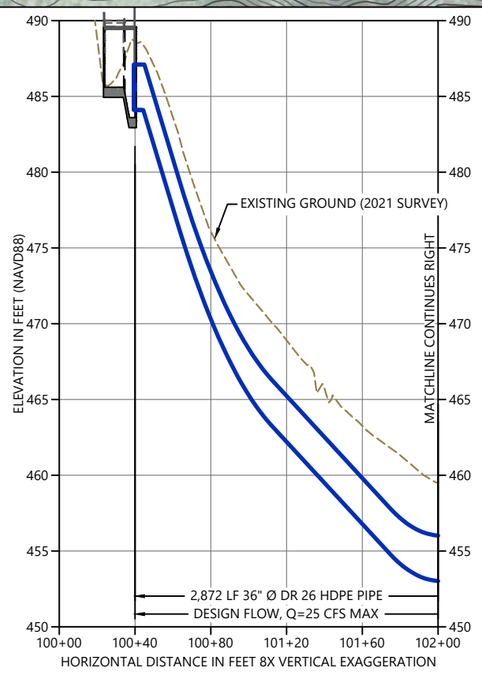
1. HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD83, U.S. SURVEY FEET
2. VERTICAL DATUM: NAVD88
3. AERIAL: BING MAPS.
4. THE CONTRACTOR SHALL VERIFY THE LOCATIONS .....

LEGEND:

- EXISTING CONTOURS (2018 LIDAR 2' & 10' INTERVALS)
- EXISTING CONTOURS (2021 SURVEY 1' & 5' INTERVALS)
- PROPOSED IRRIGATION PIPELINES



PLAN



PROFILE

30% DESIGN: NOT FOR CONSTRUCTION

PLAN INTENDED TO BE VIEWED IN COLOR; ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE. IF NOT ONE INCH SCALE ACCORDINGLY

ANCHOR QEA

CLALLAM COUNTY 1854

REVISIONS

REV	DATE	BY	APP'D	DESCRIPTION

DESIGNED BY: G. HART
DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

RESERVOIR INLET PIPELINE PLAN AND PROFILE

C08

SHEET # 12 OF 26

K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\Construction Plans\1439-PL-PlanProfile.dwg C08

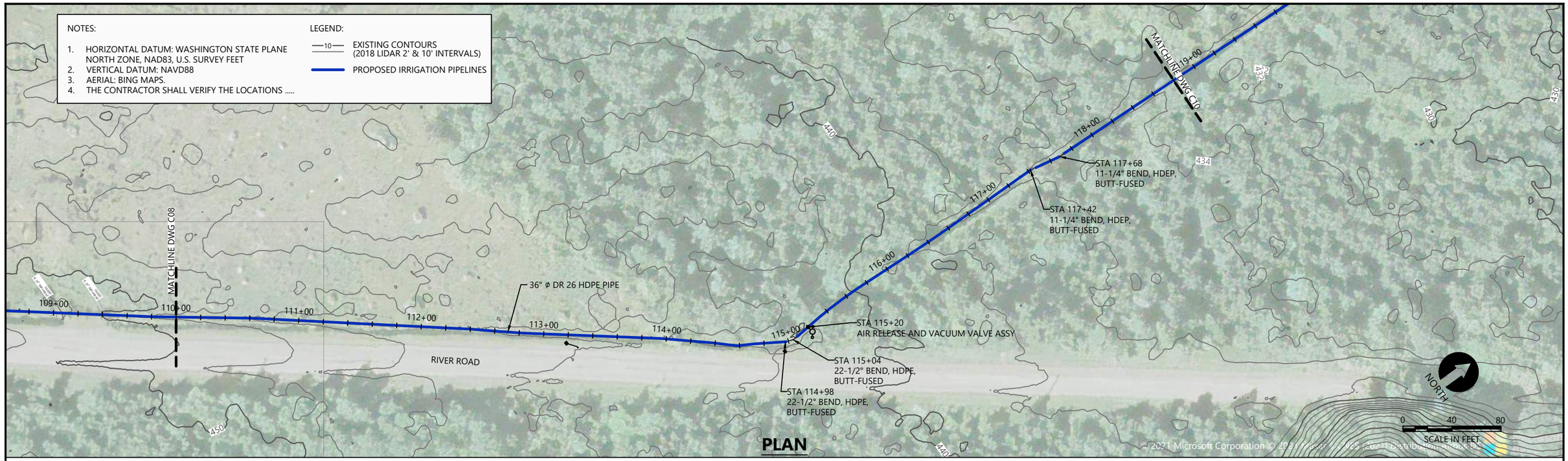
Mar 14, 2022 12:44pm tgriga

NOTES:

1. HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD83, U.S. SURVEY FEET
2. VERTICAL DATUM: NAVD88
3. AERIAL: BING MAPS.
4. THE CONTRACTOR SHALL VERIFY THE LOCATIONS .....

LEGEND:

- 10 — EXISTING CONTOURS (2018 LIDAR 2' & 10' INTERVALS)
- PROPOSED IRRIGATION PIPELINES



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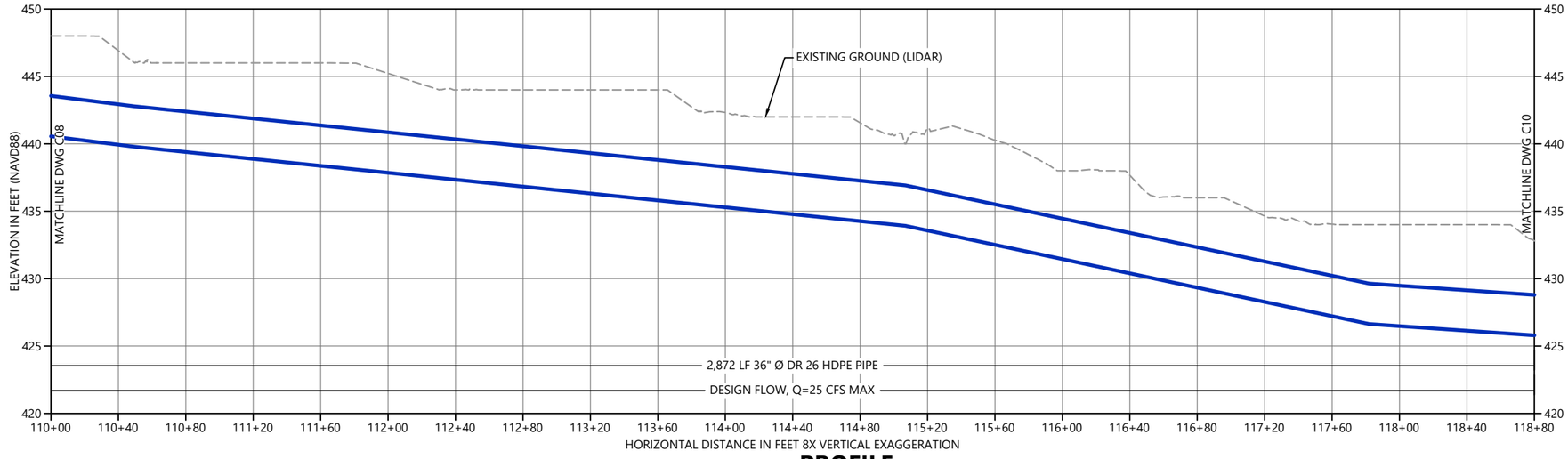


PROFILE

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE. IF NOT ONE INCH SCALE ACCORDINGLY

30% DESIGN: NOT FOR CONSTRUCTION

ANCHOR QEA

CLALLAM COUNTY 1854

REVISIONS				
REV	DATE	BY	APP'D	DESCRIPTION

DESIGNED BY: G. HART
DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

RESERVOIR INLET PIPELINE PLAN AND PROFILE

C09

SHEET # 13 OF 26

K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\Construction Plans\1439-PL-PlanProfile.dwg C09
Mar 14, 2022 12:45pm tgriga

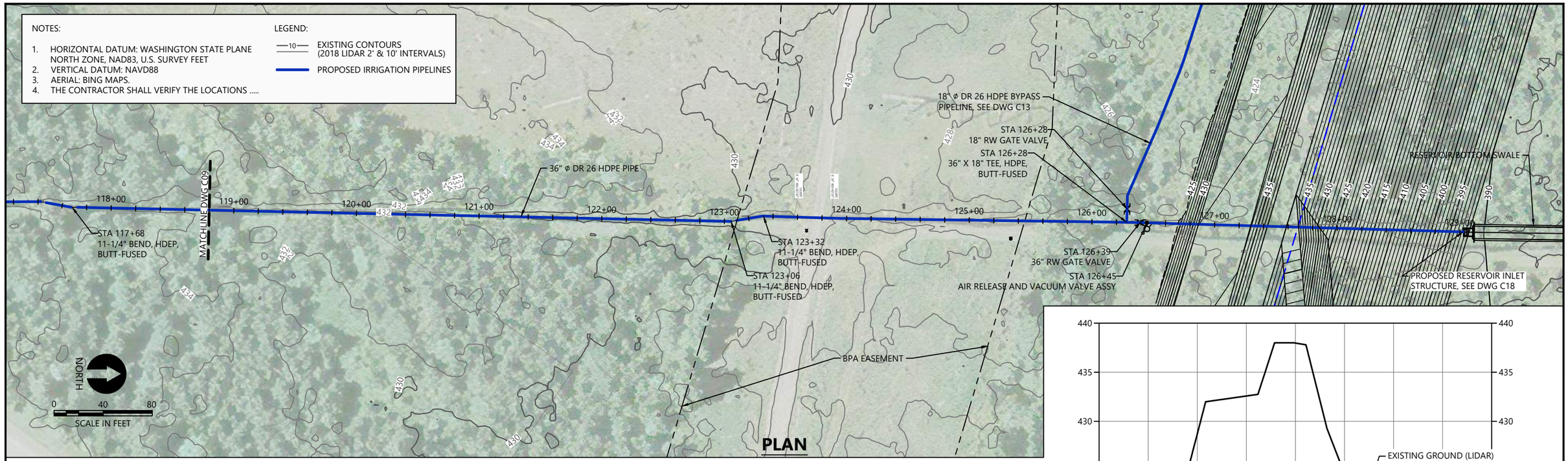
NOTES:

1. HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD83, U.S. SURVEY FEET
2. VERTICAL DATUM: NAVD88
3. AERIAL: BING MAPS.
4. THE CONTRACTOR SHALL VERIFY THE LOCATIONS .....

LEGEND:

10 EXISTING CONTOURS (2018 LIDAR 2' & 10' INTERVALS)

PROPOSED IRRIGATION PIPELINES



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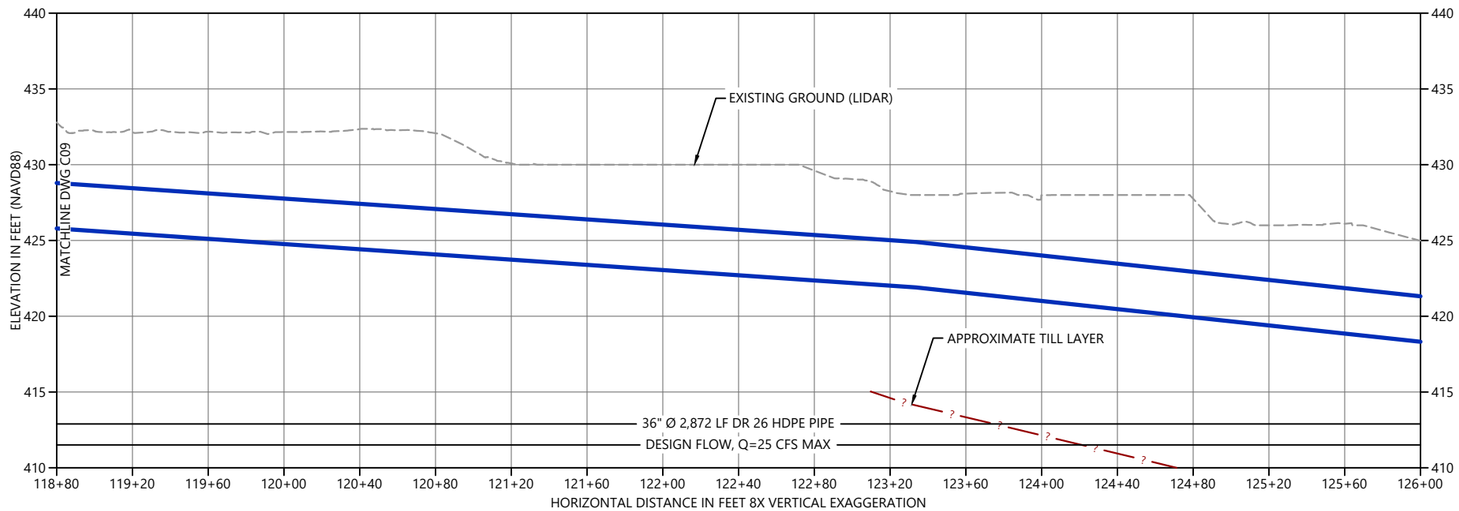
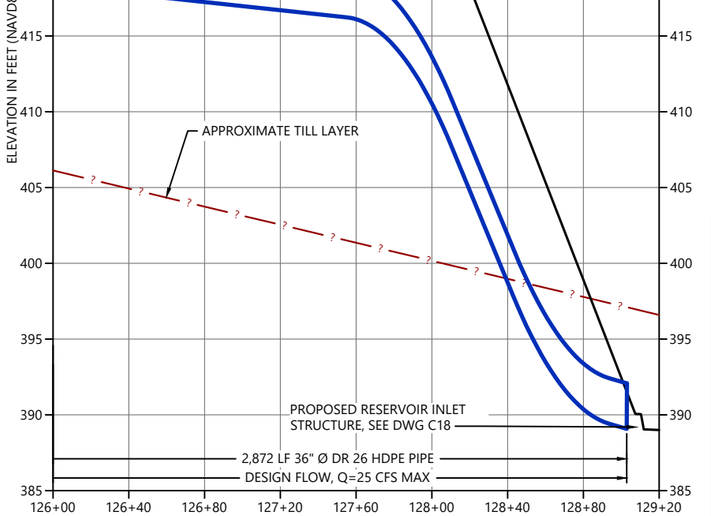




PROFILE

30% DESIGN: NOT FOR CONSTRUCTION

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

ANCHOR QEA

CLALLAM COUNTY 1854

REVISIONS				
REV	DATE	BY	APP'D	DESCRIPTION

DESIGNED BY: G. HART
DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

RESERVOIR INLET PIPELINE PLAN AND PROFILE

C10

SHEET # 14 OF 26

K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\Construction Plans\1439-PL-PlanProfile.dwg C10

Mar 14, 2022 12:46pm tgriga

NOTES:

1. HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD83, U.S. SURVEY FEET
2. VERTICAL DATUM: NAVD88
3. AERIAL: BING MAPS.
4. THE CONTRACTOR SHALL VERIFY THE LOCATIONS .....

LEGEND:

- 10 — EXISTING CONTOURS (2018 LIDAR 2' & 10' INTERVALS)
- PROPOSED IRRIGATION PIPELINES

RESERVOIR BOTTOM SWALE

PROPOSED RESERVOIR OUTLET STRUCTURE, SEE DWG C19

18" ø DR 26 HDPE BYPASS PIPELINE, SEE DWG C15

STA 204+82
18" RW GATE VALVE

STA 204+82
36" X 18" TEE, HDPE, BUTT-FUSED

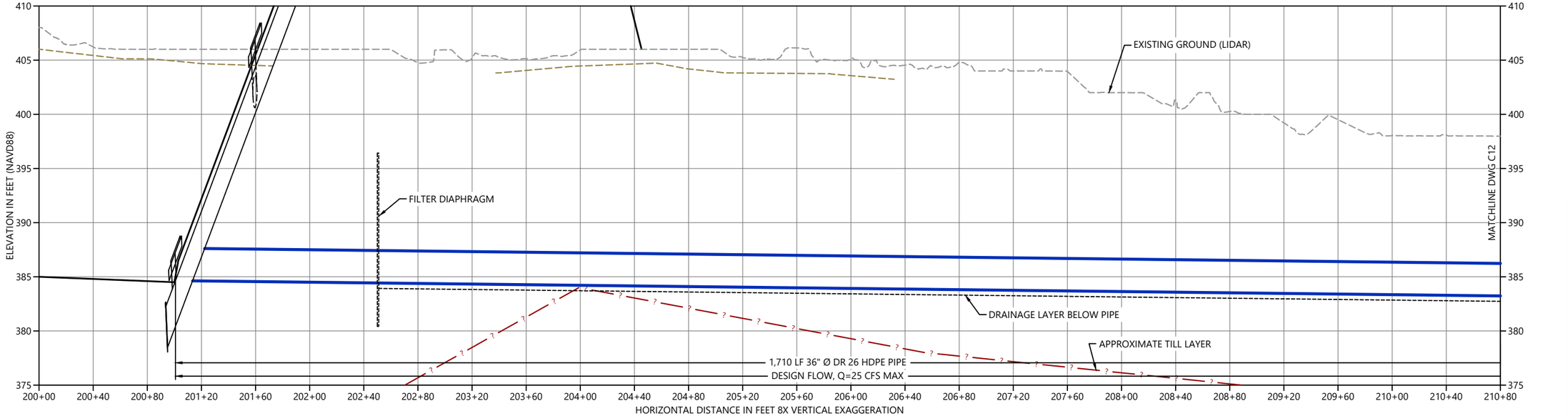
36" ø DR 26 HDPE PIPE

MATCHLINE DWG C12

NORTH

0 40 80
SCALE IN FEET

PLAN



PROFILE

30% DESIGN: NOT FOR CONSTRUCTION

PLAN INTENDED TO BE VIEWED IN COLOR, ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

ANCHOR QEA

CLALLAM COUNTY 1854

REVISIONS

REV	DATE	BY	APP'D	DESCRIPTION

DESIGNED BY: G. HART
DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

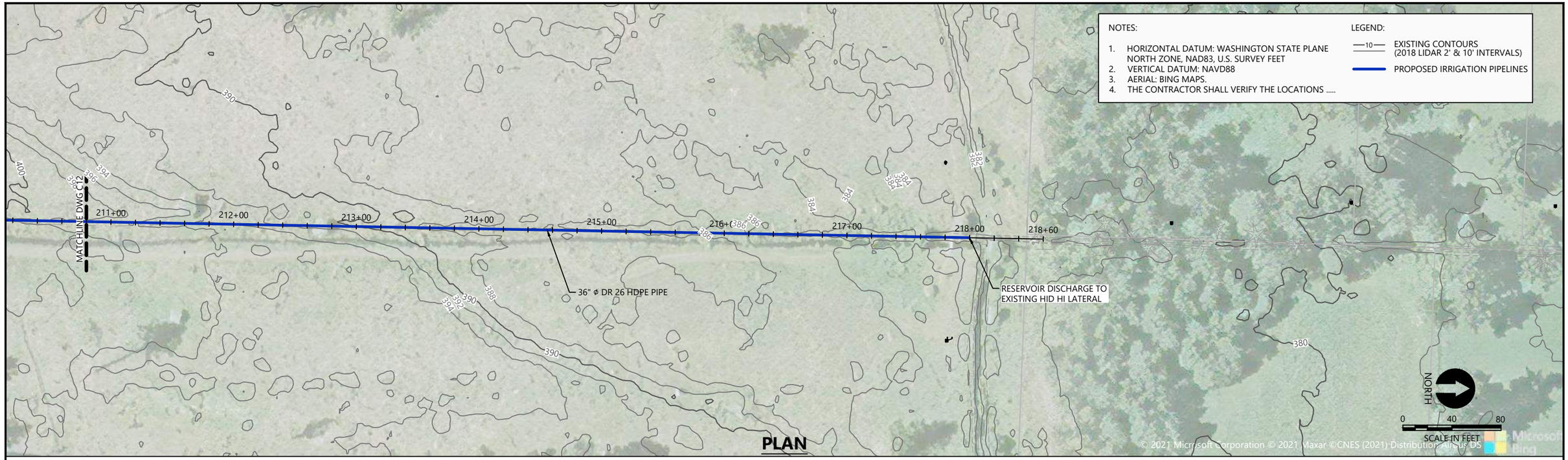
RESERVOIR OUTLET PIPELINE PLAN AND PROFILE

C11

SHEET # 15 OF 26

K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\Construction Plans\1439-PL-PlanProfile.dwg C11

Mar 14, 2022 12:46pm tgriga



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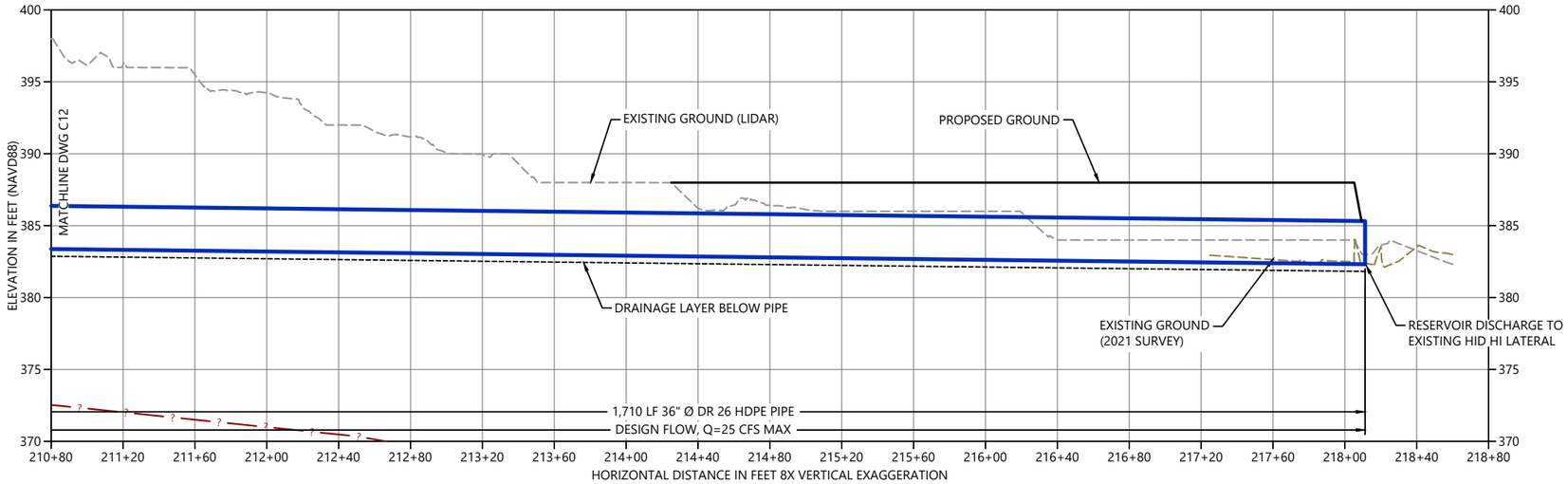

PROFILE

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

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30% DESIGN: NOT FOR CONSTRUCTION

K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\Construction Plans\1439-PL-PlanProfile.dwg C12

Mar 14, 2022 12:47pm tgriga

ANCHOR QEA

CLALLAM COUNTY 1854

REVISIONS				
REV	DATE	BY	APP'D	DESCRIPTION

DESIGNED BY: G. HART
DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

RESERVOIR OUTLET PIPELINE PLAN AND PROFILE

C12

SHEET # 16 OF 26

NOTES:

1. HORIZONTAL DATUM: WASHINGTON STATE PLANE NORTH ZONE, NAD83, U.S. SURVEY FEET
2. VERTICAL DATUM: NAVD88
3. AERIAL: BING MAPS.
4. THE CONTRACTOR SHALL VERIFY THE LOCATIONS .....

LEGEND:

- 10 — EXISTING CONTOURS (2018 LIDAR 2' & 10' INTERVALS)
- PROPOSED IRRIGATION PIPELINES

36" ø DR 26 HDPE INLET PIPELINE, SEE DWG C10

STA 300+40
36" X 18" TEE, HDPE, BUTT-FUSED

STA 300+51
18" RW GATE VALVE

STA 300+62
22-1/2° BEND, HDPE, BUTT-FUSED

18" ø DR 26 HDPE PIPE

STA 307+26
22-1/2° BEND, HDPE, BUTT-FUSED

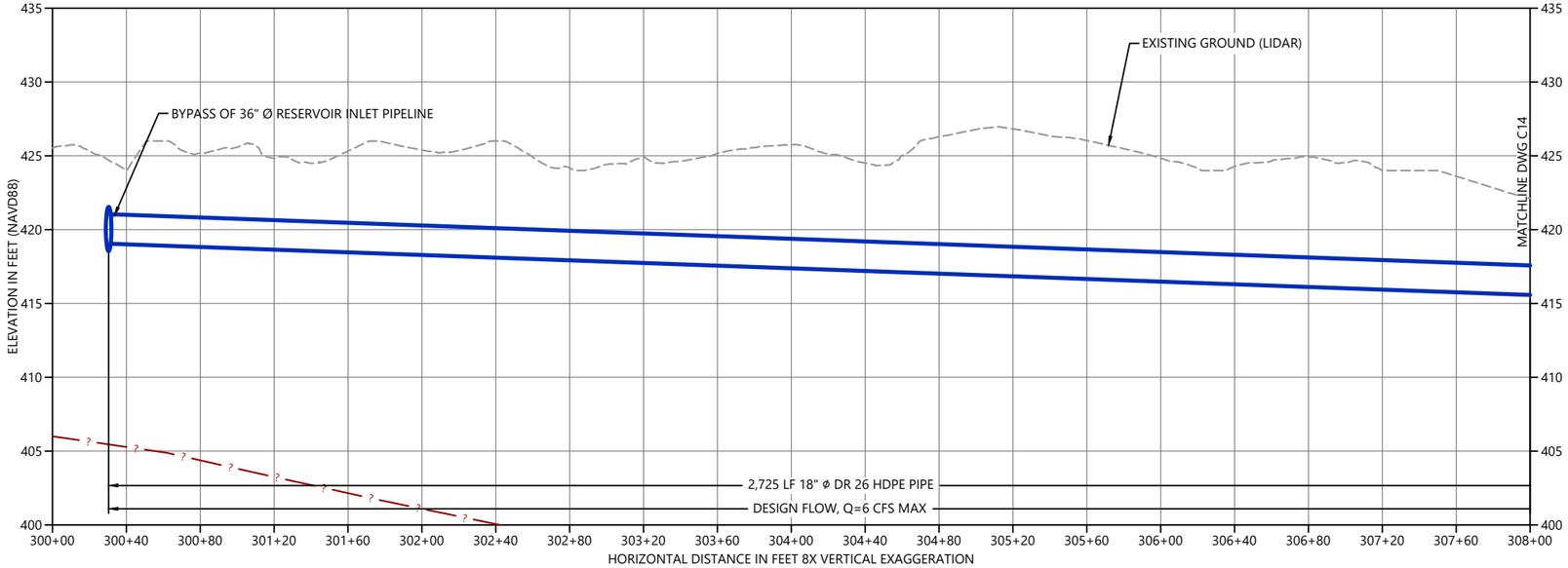
STA 307+40
22-1/2° BEND, HDPE, BUTT-FUSED

MATCHLINE DWG C14

NORTH

0 40 80
SCALE IN FEET

PLAN



PROFILE

30% DESIGN: NOT FOR CONSTRUCTION

PLAN INTENDED TO BE VIEWED IN COLOR; ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

ANCHOR QEA

REVISIONS

REV	DATE	BY	APP'D	DESCRIPTION

DESIGNED BY: G. HART
DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

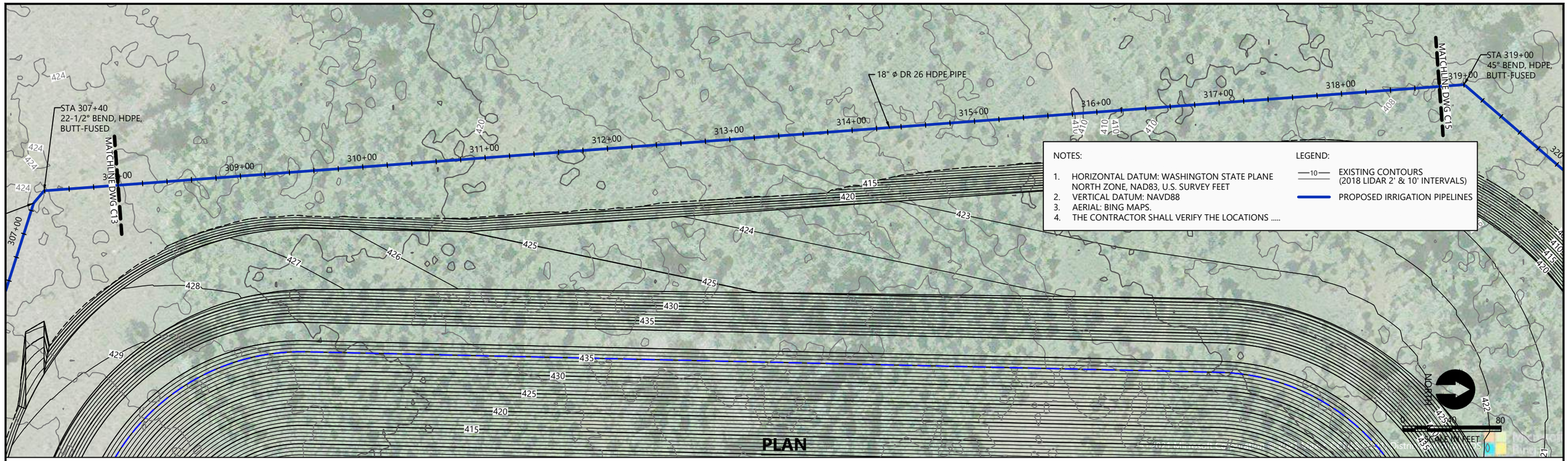
RESERVOIR BYPASS PIPELINE PLAN AND PROFILE

C13

SHEET # 17 OF 26

K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\Construction Plans\1439-PL-PlanProfile.dwg C13

Mar 14, 2022 12:48pm tgriga



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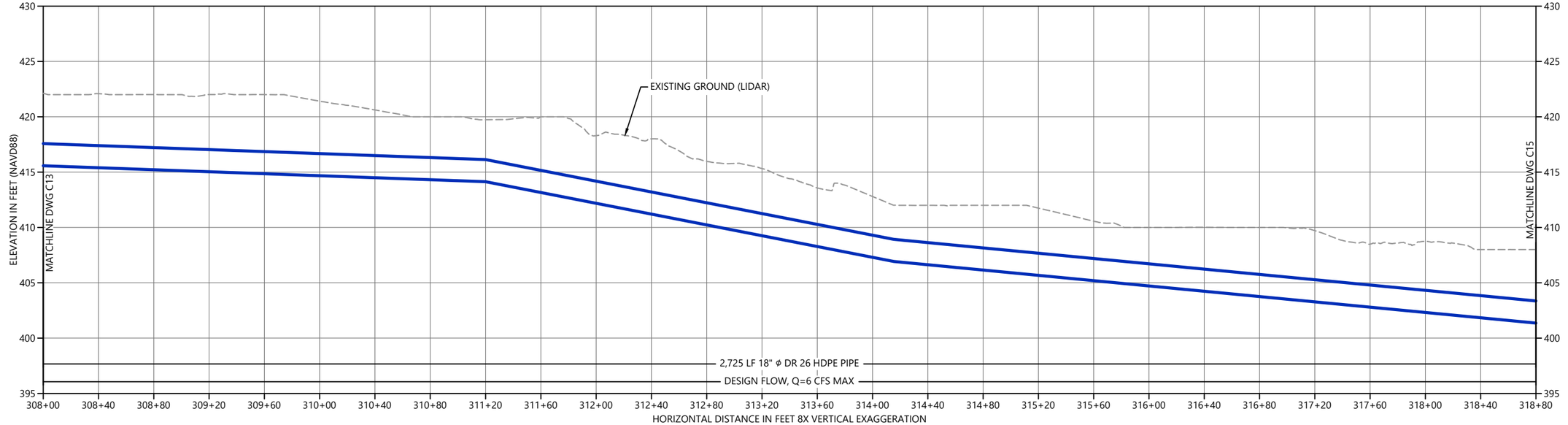


PROFILE

30% DESIGN: NOT FOR CONSTRUCTION

PLAN INTENDED TO BE VIEWED IN COLOR, ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

ANCHOR QEA

CLALLAM COUNTY 1854

REVISIONS				
REV	DATE	BY	APP'D	DESCRIPTION

DESIGNED BY: G. HART
DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

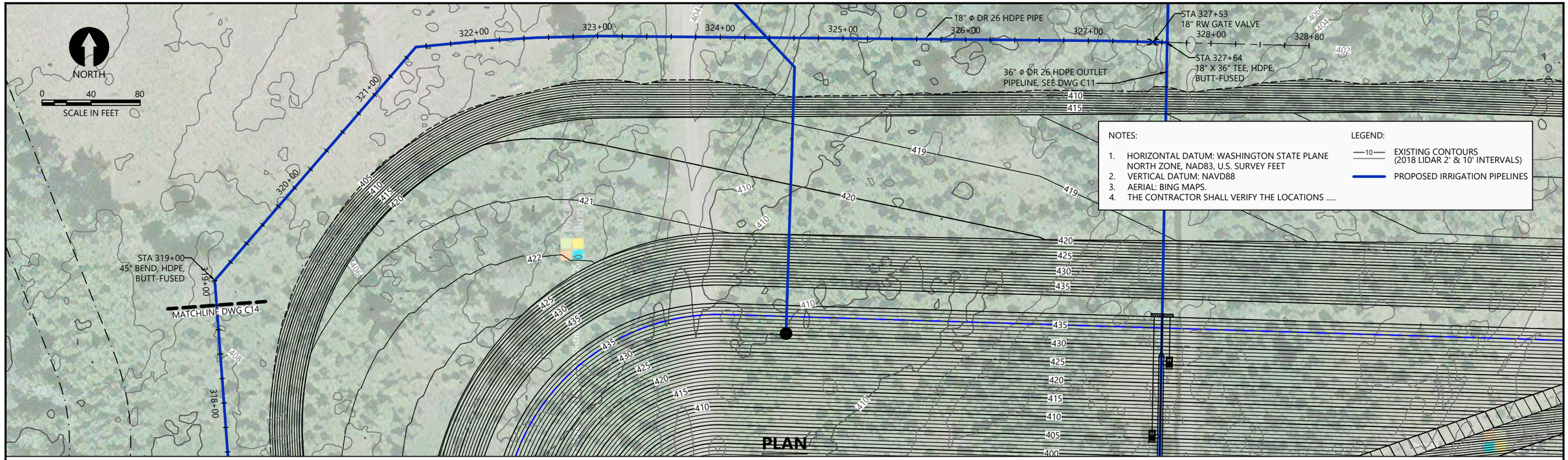
RESERVOIR BYPASS PIPELINE PLAN AND PROFILE

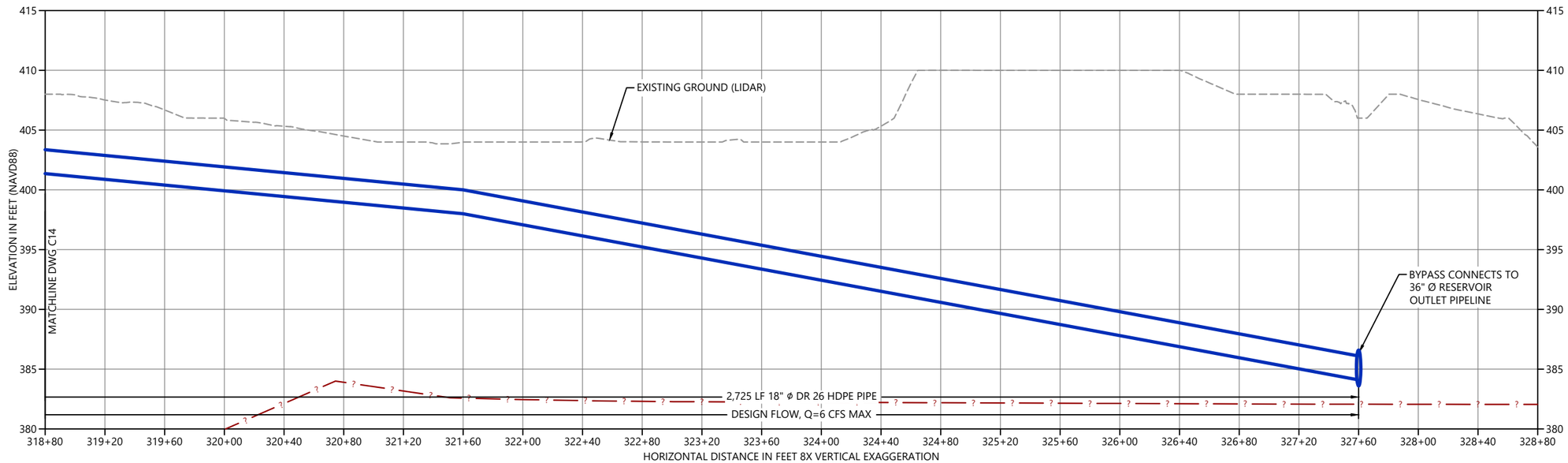
C14

SHEET # 18 OF 26

K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\Construction Plans\1439-PL-PlanProfile.dwg C14

Mar 14, 2022 12:48pm tgriga





PLAN INTENDED TO BE VIEWED IN COLOR, ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

30% DESIGN: NOT FOR CONSTRUCTION

K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\Construction Plans\1439-PL-PlanProfile.dwg C15
Mar 14, 2022 12:49pm tgriga

ANCHOR QEA

CLALLAM COUNTY 1854

REVISIONS				
REV	DATE	BY	APP'D	DESCRIPTION

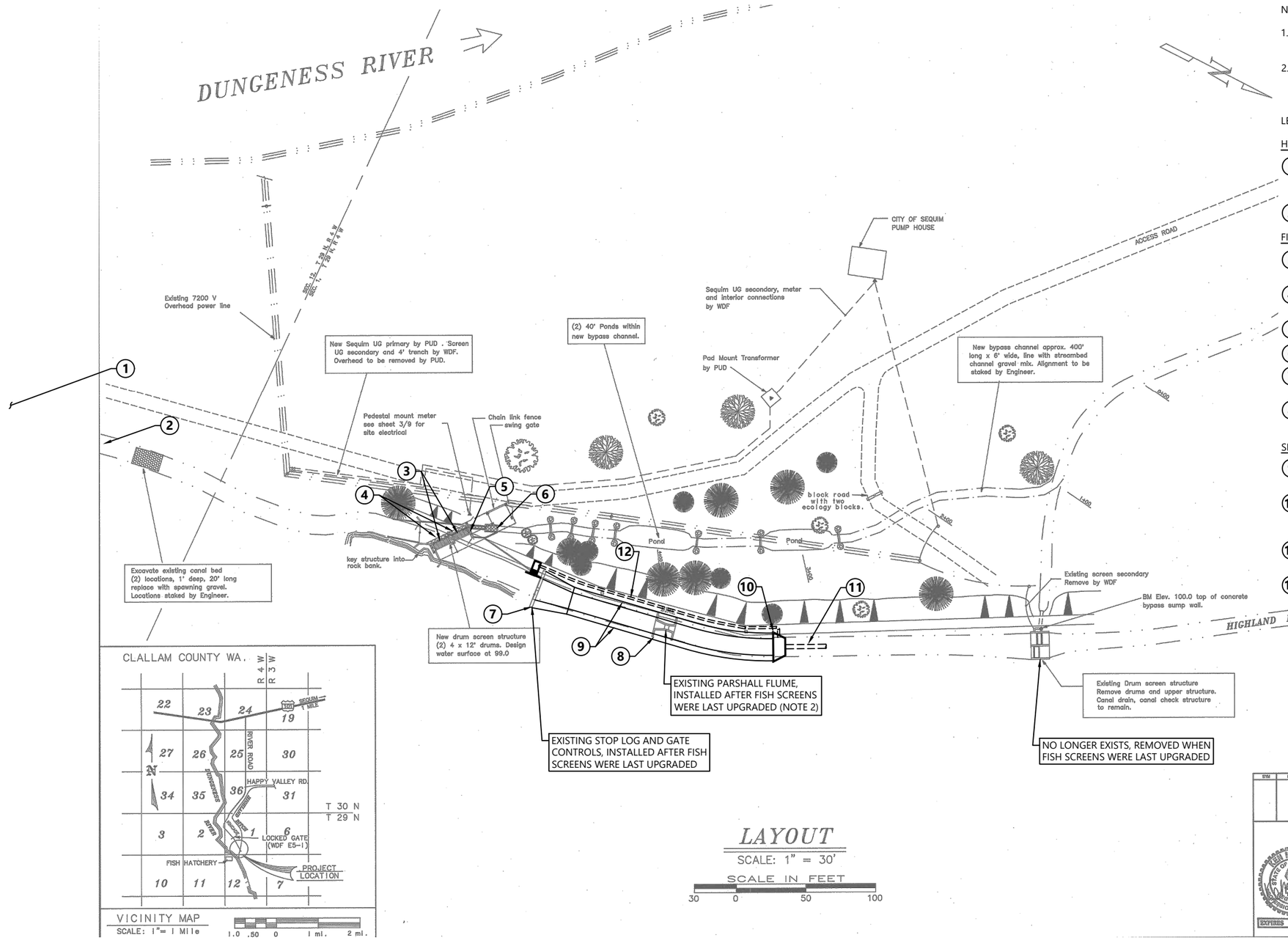
DESIGNED BY: G. HART
DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

RESERVOIR BYPASS PIPELINE PLAN AND PROFILE

C15

SHEET # 19 OF 26



LAYOUT

SCALE: 1" = 30'

SCALE IN FEET

30 0 50 100

NOTES:

1. SOURCE OF BACKGROUND - WASHINGTON DEPARTMENT OF FISH AND WILDLIFE (WDFW) DRAWINGS FOR SCREEN UPGRADES INSTALLED IN 1994.
2. A PARSHALL FLUME WAS INSTALLED AFTER THE WDFW SCREEN UPGRADES IN 1994 AND IS OPERATED AND MAINTAINED BY THE WASHINGTON DEPARTMENT OF ECOLOGY.

LEGEND:

HID INTAKE STRUCTURE/HEAD GATE (APPROXIMATELY 1/4-MILE UPSTREAM):

(1) IMPROVE SIDE CHANNEL ON DUNGENESS RIVER, REFURBISH HEADGATE STRUCTURE, INSTALL AUTOMATED HEADGATES, INSTALL TRASH RACK, INSTALL FLUME FOR FLOW MEASUREMENT

(2) IMPROVE DIVERSION CANAL TO MAINTAIN FLOWS

FISH SCREEN AND FISH BYPASS IMPROVEMENTS:

(3) COORDINATE WITH WDFW TO REPLACE WIRE MESH ON SCREENS WITH PERFORATED STAINLESS STEEL

(4) INSTALL WATER JET SPRAY SYSTEM IN FRONT OF SCREEN TO PREVENT SEDIMENT ACCUMULATION

(5) PAINT GANTRY CRANE ABOVE FISH SCREENS

(6) AUTOMATE FISH BYPASS GATE

(7) UPGRADE AND AUTOMATE EXISTING STOP LOG AND GATE CONTROLS DOWNSTREAM OF SCREEN

(8) RELOCATE EXISTING PARSHALL FLUME TO UPSTREAM DIVERSION CHANNEL (SEE ITEM 1) TO ACCOMMODATE SETTLING BASIN

SETTLING BASIN AND RELATED IMPROVEMENTS:

(9) SETTLING BASIN, RESHAPE AND LINE APPROXIMATELY 150 LF OF EXISTING CANAL WITH CONCRETE OVER GEOMEMBRANE LINER

(10) INSTALL A REINFORCED CONCRETE CONTROL STRUCTURE AT THE DOWNSTREAM END OF THE SETTLING BASIN WITH STOP LOGS OR AN ADJUSTABLE WEIR AT THE OUTLET OF THE SETTLING BASIN

(11) INSTALL A 36-INCH ϕ HDPE PIPE SEGMENT IN THE CANAL DOWNSTREAM OF THE SETTLING BASIN AND INSTALL A FLOW METER IN THE PIPE

(12) INSTALL AN 18-INCH ϕ HDPE BYPASS PIPE TO CONVEY FLOWS AROUND SETTLING BASIN, WHEN NEEDED FOR CLEANING AND MAINTENANCE

REVISIONS				
STM	DATE	REVISIONS	BY	APP'D

STATE OF WASHINGTON
DEPARTMENT OF FISHERIES
HABITAT MANAGEMENT DIVISION

DUNGENESS RIVER
HIGHLAND DITCH SCREEN
SITE PLAN

DESIGN BY K. BAYES DRAWN BY B. GOWEN
APPROVED DATE 1-19-94
APPROVED DATE
SCALE: NOTED 16HIL931 SHEET 1 OF 9

KEITH M. BAYES — STATE OF WASHINGTON — 19021 — REGISTERED PROFESSIONAL ENGINEER
EXPIRES 1-25-94

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE. IF NOT ONE INCH SCALE ACCORDINGLY

30% DESIGN: NOT FOR CONSTRUCTION

ANCHOR QEA

CLALLAM COUNTY 1854

REVISIONS				
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DESIGNED BY: G. HART
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APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

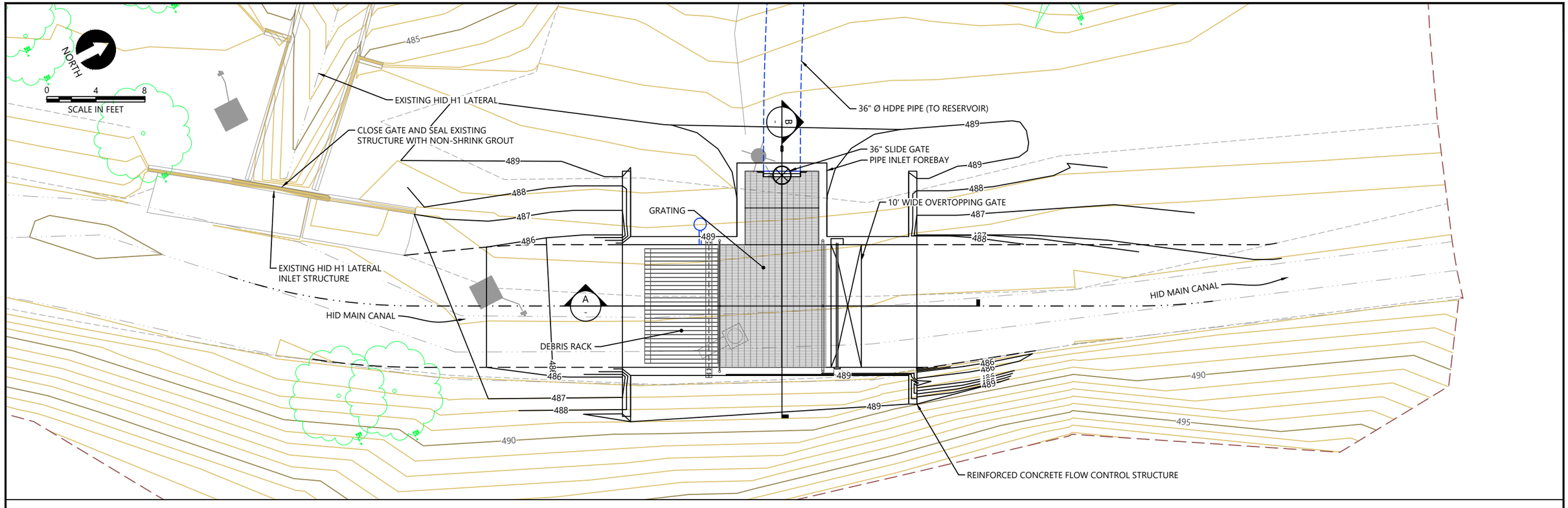
DUNGENESS OFF-CHANNEL RESERVOIR

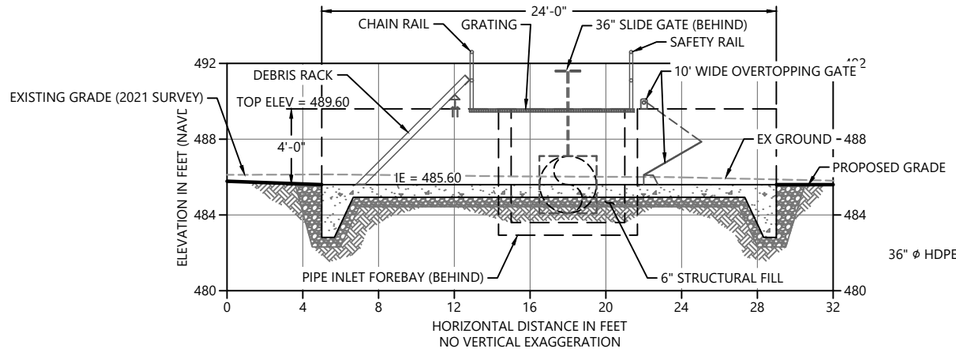
RESERVOIR INTAKE FACILITY UPGRADES

C16

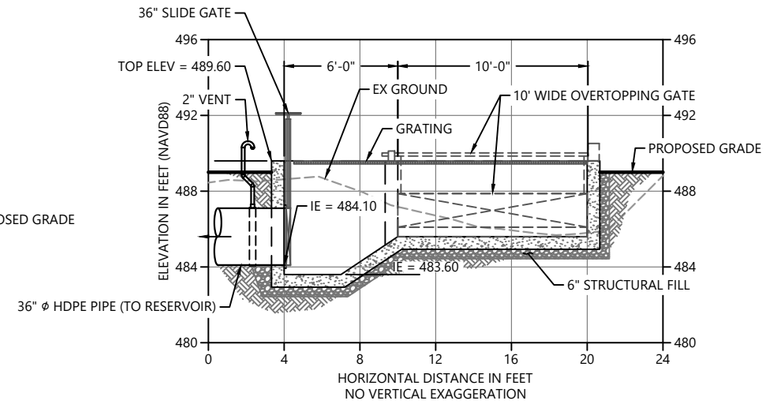
SHEET # **20** OF **26**

Mar 14, 2022 12:49pm tgriga K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\Construction Plans\1439-PL-Structures.dwg C16





A SECTION
SCALE: 1" = 4'



B SECTION
SCALE: 1" = 4'

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE. IF NOT ONE INCH SCALE ACCORDINGLY

30% DESIGN: NOT FOR CONSTRUCTION

ANCHOR QEA

CLALLAM COUNTY 1854

REVISIONS				
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APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

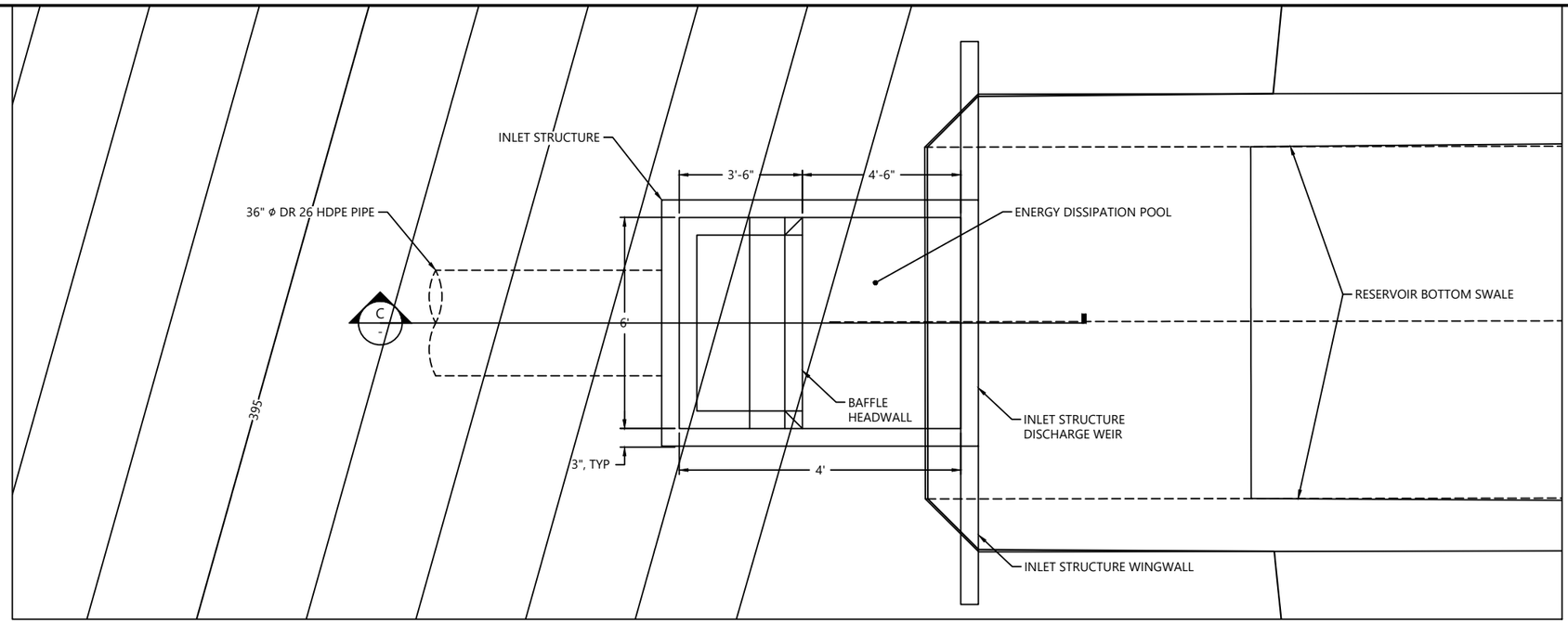
DUNGENESS OFF-CHANNEL RESERVOIR

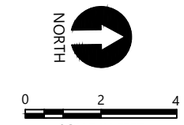
RESERVOIR INLET FLOW CONTROL STRUCTURE PLAN AND SECTIONS

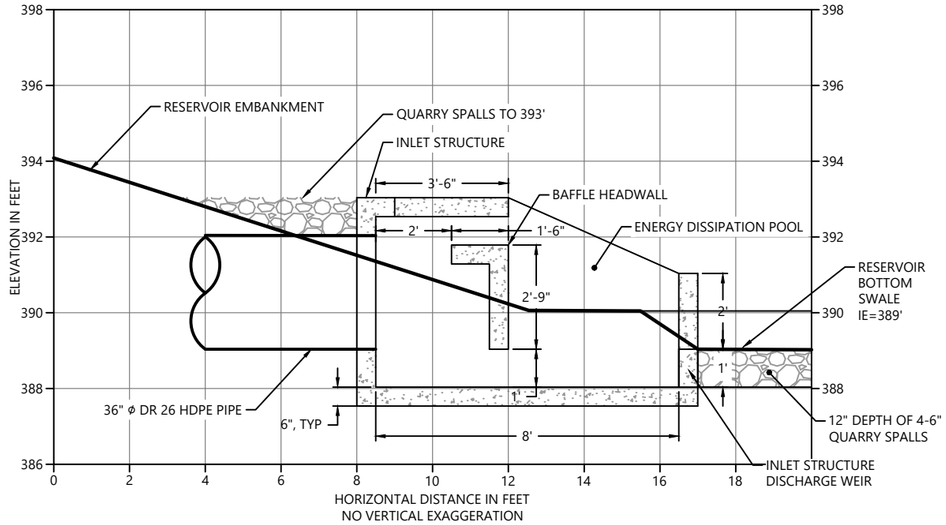
C17

SHEET # 21 OF 26

K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\Construction Plans\1439-PL-Structures.dwg C17
Mar 14, 2022 12:50pm tgriga







C
-
SECTION
SCALE: 1" = 2'

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE. IF NOT ONE INCH SCALE ACCORDINGLY

30% DESIGN: NOT FOR CONSTRUCTION

K:\Projects\1439-Clallam County\Dungeness Off-Channel Reservoir\Construction Plans\1439-PL-Structures.dwg C18
Mar 14, 2022 12:50pm tgriga

ANCHOR QEA

CLALLAM COUNTY 1854

REVISIONS				
REV	DATE	BY	APP'D	DESCRIPTION

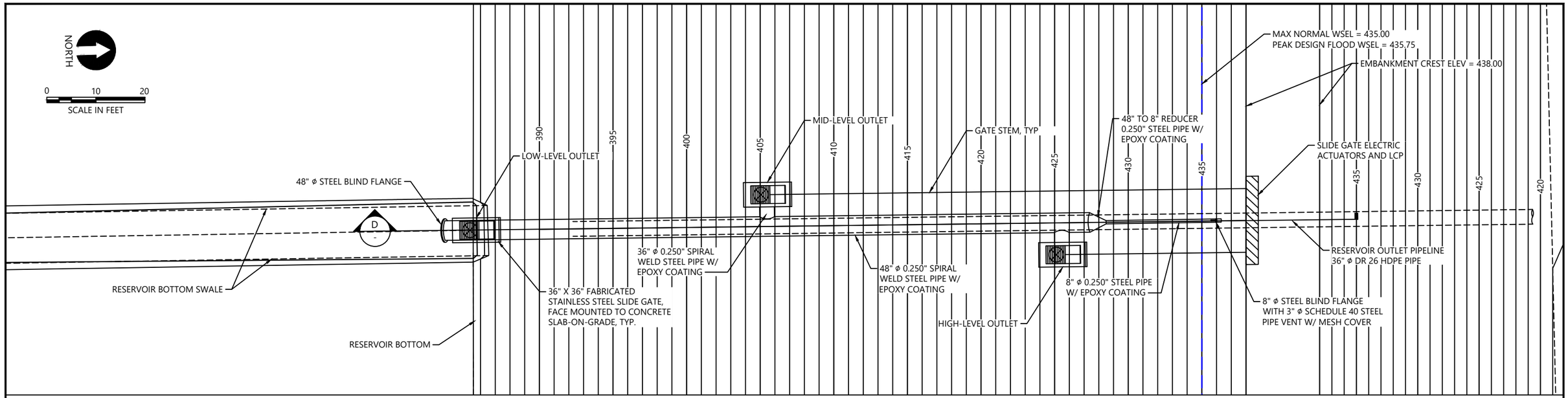
DESIGNED BY: G. HART
DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

RESERVIOIR INLET STRUCTURE PLAN AND SECTIONS

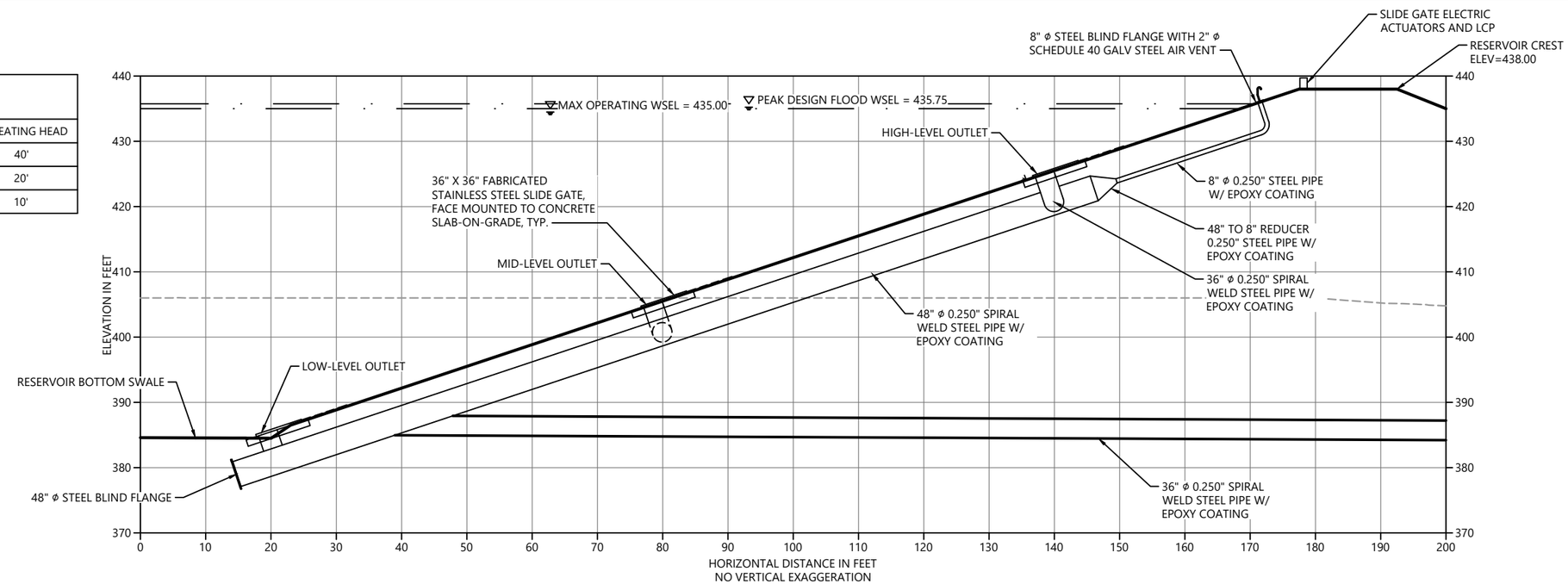
C18

SHEET # **22** OF **26**



GATE SCHEDULE

GATE	SIZE	MATL	SEATING HEAD	UNSEATING HEAD
LOW	36" X 36"	STAINLESS	54'	40'
MID	36" X 36"	STAINLESS	34'	20'
HIGH	36" X 36"	STAINLESS	14'	10'



D
-
SECTION
SCALE: 1" = 10'

PLAN INTENDED TO BE VIEWED IN COLOR, ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

30% DESIGN: NOT FOR CONSTRUCTION

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Mar 14, 2022 12:50pm tgriga

ANCHOR QEA

CLALLAM COUNTY 1854

REVISIONS

REV	DATE	BY	APP'D	DESCRIPTION

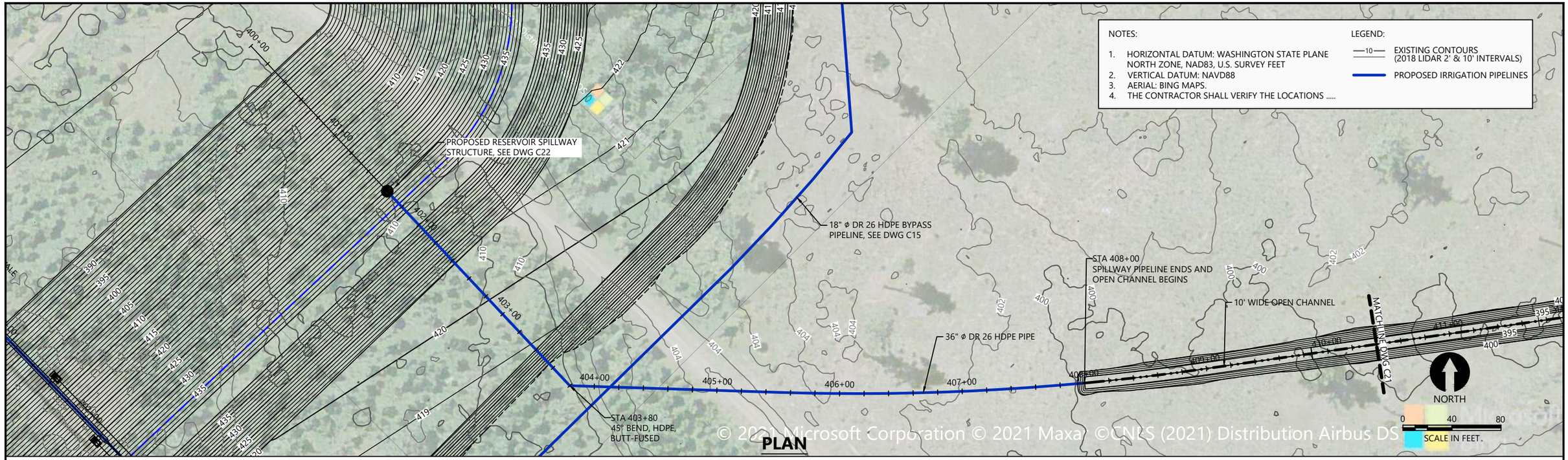
DESIGNED BY: G. HART
DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

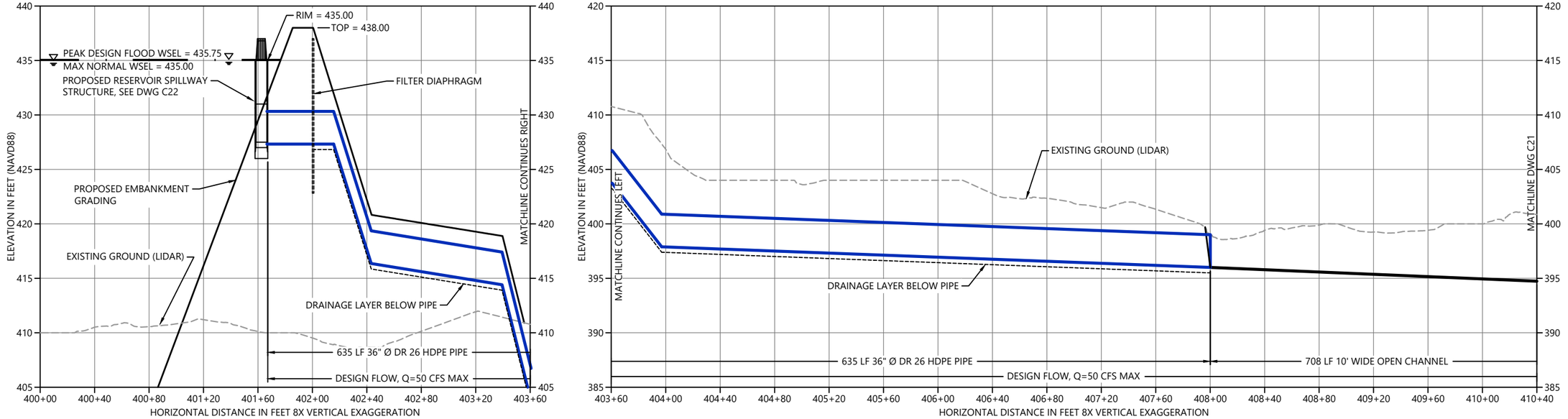
DUNGENESS OFF-CHANNEL RESERVOIR

RESERVOIR OUTLET STRUCTURE PLAN AND SECTIONS

C19

SHEET # **23** OF **26**





PROFILE

PLAN INTENDED TO BE VIEWED IN COLOR, ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

30% DESIGN: NOT FOR CONSTRUCTION

ANCHOR QEA

CLALLAM COUNTY 1854

REVISIONS				
REV	DATE	BY	APP'D	DESCRIPTION

DESIGNED BY: G. HART
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SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

RESERVOIR SPILLWAY PLAN AND PROFILE

C20

SHEET # 24 OF 26

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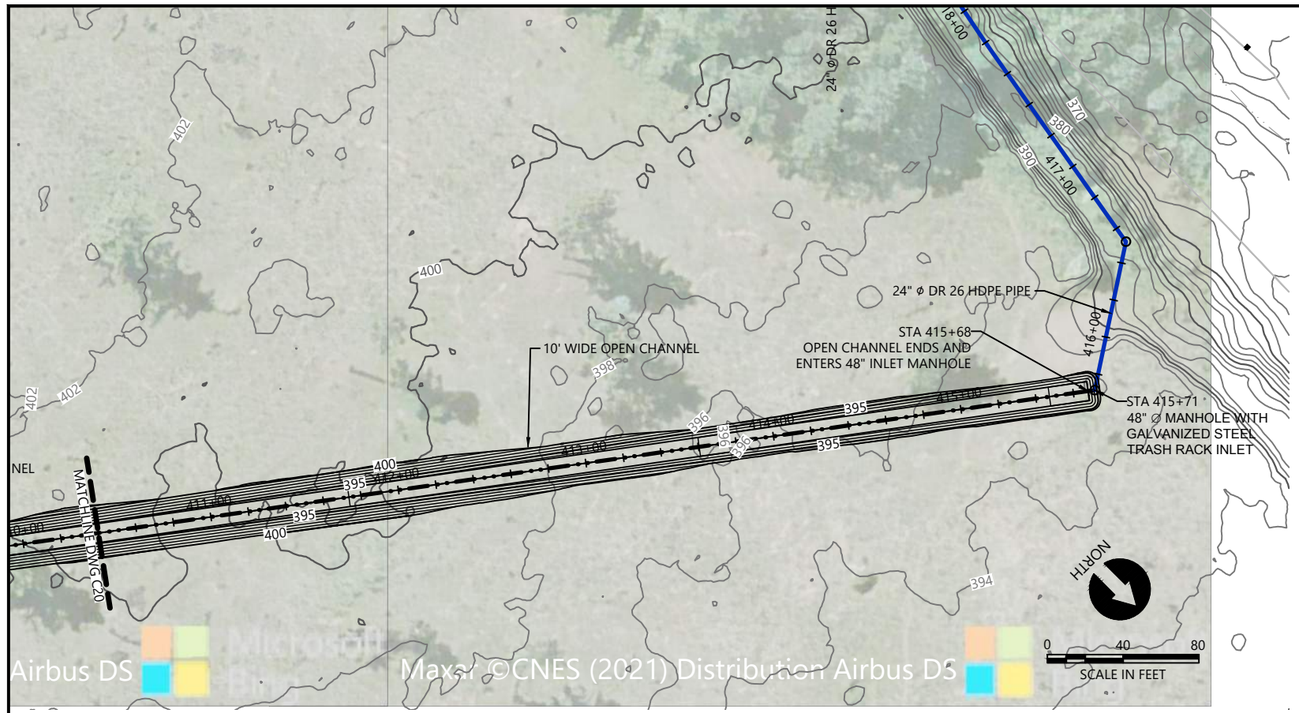
Mar 14, 2022 12:52pm tgriga



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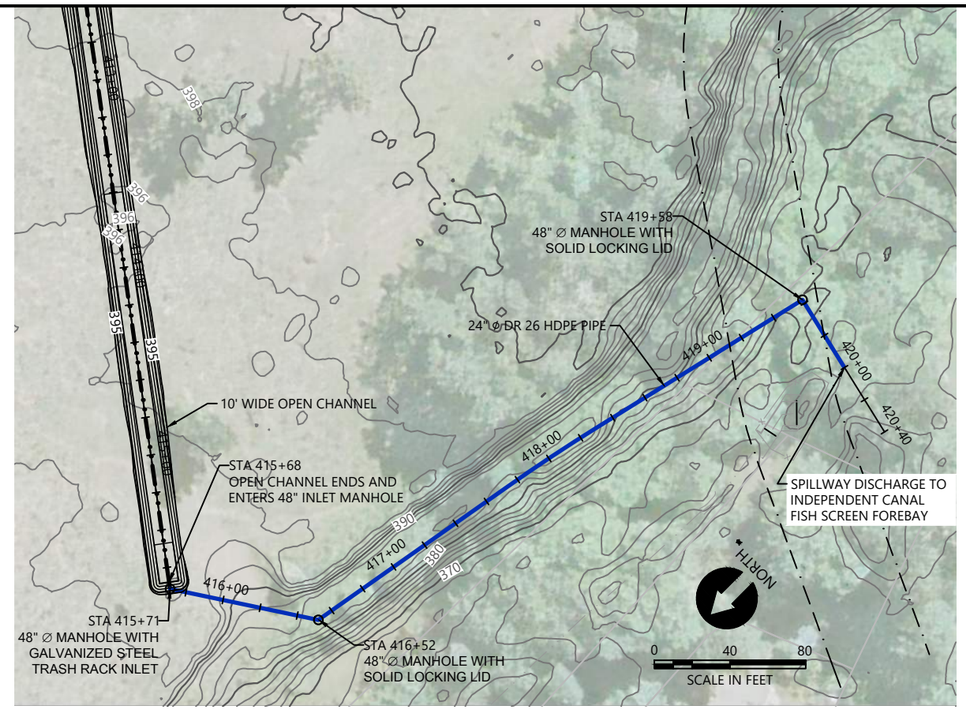

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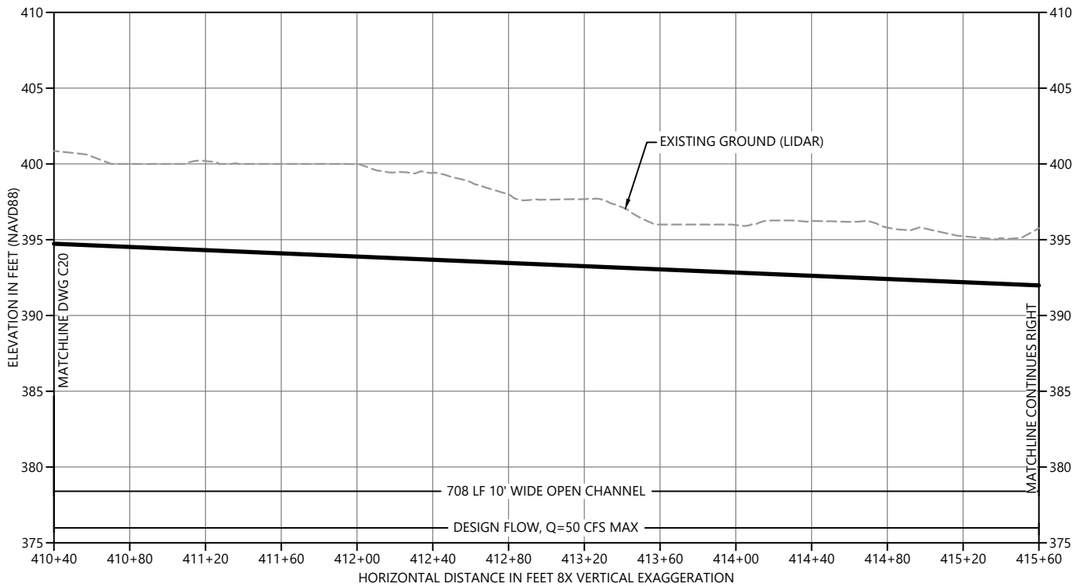

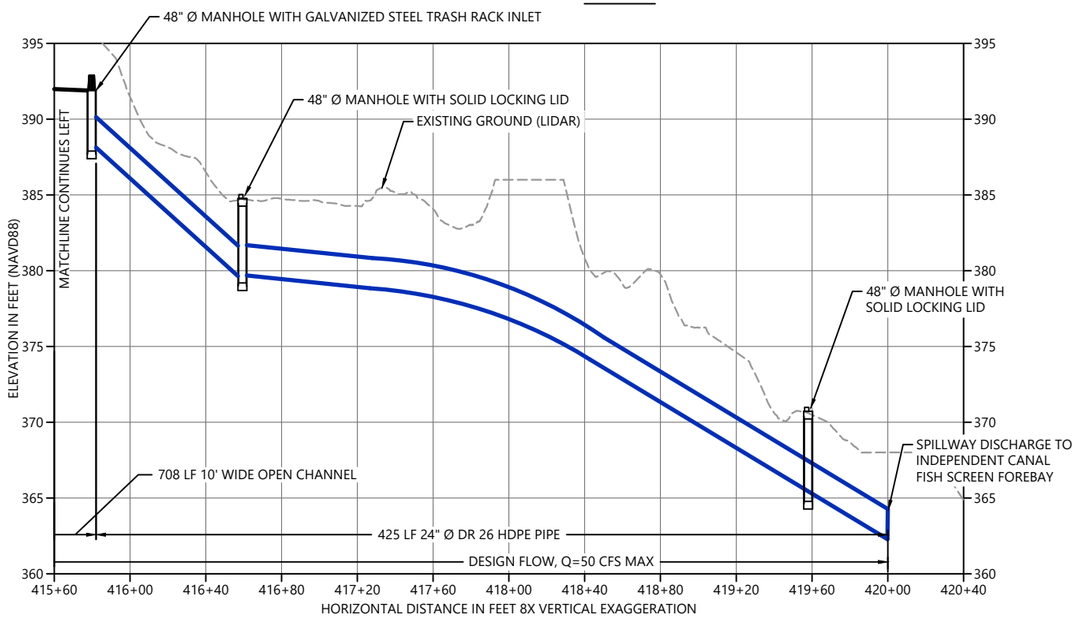

PROFILE

PLAN INTENDED TO BE VIEWED IN COLOR, ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE, IF NOT ONE INCH SCALE ACCORDINGLY

30% DESIGN: NOT FOR CONSTRUCTION

ANCHOR QEA

CLALLAM COUNTY 1854

REVISIONS				
REV	DATE	BY	APP'D	DESCRIPTION

DESIGNED BY: G. HART
DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

RESERVOIR SPILLWAY PLAN AND PROFILE

C21

SHEET # **25** OF **26**

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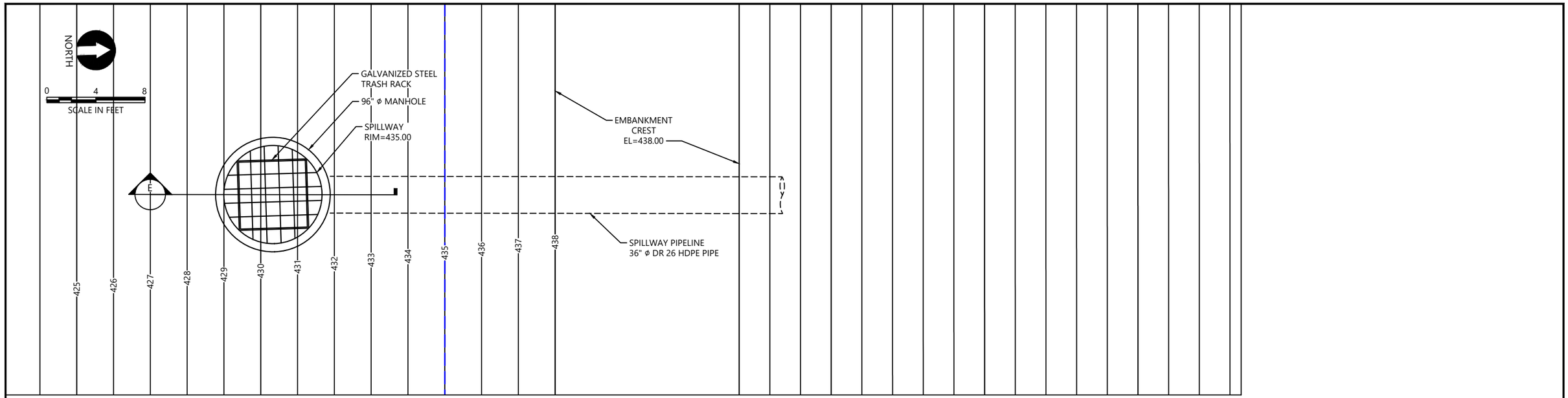

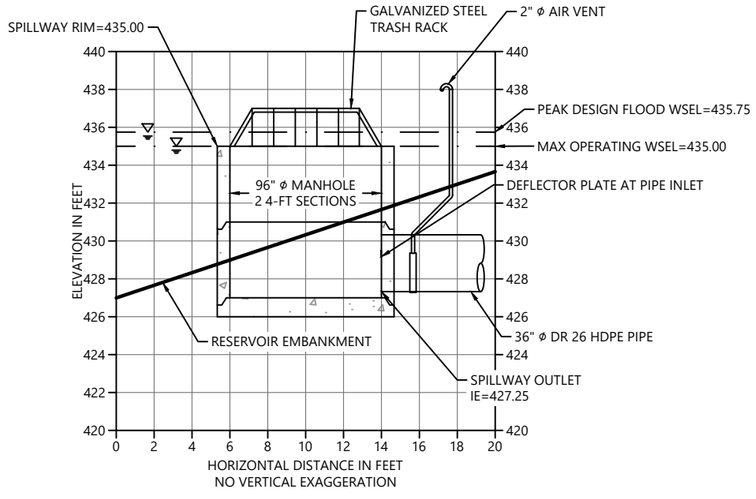

E
-
SECTION
SCALE: 1" = 4'

PLAN INTENDED TO BE VIEWED IN COLOR. ADJACENT BLOCK IS "BLUE"

ONE INCH AT FULL SIZE. IF NOT ONE INCH SCALE ACCORDINGLY

30% DESIGN: NOT FOR CONSTRUCTION

ANCHOR QEA

CLALLAM COUNTY 1854

REVISIONS				
REV	DATE	BY	APP'D	DESCRIPTION

DESIGNED BY: G. HART
DRAWN BY: T. GRIGA
CHECKED BY: D. RICE
APPROVED BY: R. MONTGOMERY
SCALE: AS NOTED
DATE: MARCH 2022

DUNGENESS OFF-CHANNEL RESERVOIR

RESERVOIR SPILLWAY STRUCTURE PLAN AND SECTIONS

C22

SHEET # **26** OF **26**

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Mar 14, 2022 12:53pm tgriga

Appendix B
Site Photographs

Photograph 1
H1 Lateral and Access – From BPA Easement Looking South

Photograph 2
H1 Lateral and Access – Looking North

Photograph 3
H1 Lateral and Access – Near North End of Site Looking North

Photograph 4
H1 Lateral – Looking Northeast Along River Road

Photograph 5
Site Access at BPA Easement

Photograph 6
Bluff, Dungeness River, and BPA Easement Looking West from Site

Photograph 7
Harvested Portion of Site – Looking West

Photograph 8
Harvested Portion of Site – Looking Northeast

Photograph 9
HID Headgates and Intake Structure on Dungeness River (From Downstream Side)

Photograph 10
HID Diversion Channel Downstream of Heagates

Photograph 11
HID Fish Screens

Photograph 12
Parshall Flume at Upstream End of HID Main Canal Downstream of Fish Screens

Photograph 13
HID Main Canal Downstream of Fish Screens

Photograph 14
H1 Lateral Inlet Structure on HID Main Canal

Photograph 15
HID Main Canal Downstream of H1 Lateral Structure

Photograph 16
Access to HID Canal at H1 Lateral from River Road

Appendix C
Downstream Hazard Analysis Worksheet

Design Step Analysis & Calculator - Design by Guy Hoyle-Dodson, 11-28-2017

Project: Dunguness Storage Reservoir

Date: December 28, 2021

Project lead: Adam Hill, P.E.

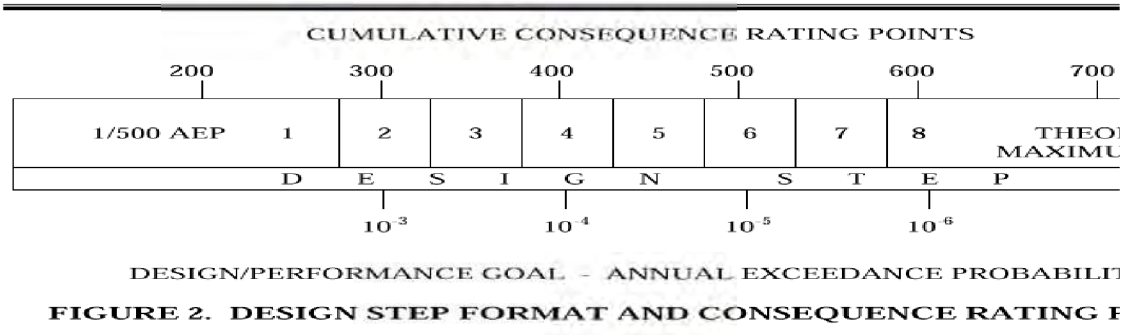


FIGURE 2. DESIGN STEP FORMAT AND CONSEQUENCE RATING F

Total Consequence Rating Points & Annual Exceedance Probability

Must Input Values
Override Results

Description	Parameter Symbol	Input (Enter Values Here)	Equation	Result (Do Not Input Here)
				Will Calculate
Annual Exceedance Probability	$P_{(Annual\ Exceed)}$:		AEP =	1.0002E-06
				Will Calculate
Design Step	DS :		Design Step =	8.00
				Will Calculate
Cumulative Consequence Rating Points	$Cp_{(cumulative)}$:		Cumulative Rating =	656.75
				Will Calculate
Base Consequence Rating Points	$CP_{(Base)}$:		Base Points =	150.00

Capital Value of Project

Description	Parameter Symbol	Input (Enter Values Here)	Equation	Result (Do Not Input Here)
Dam Height (ft)	H_{DAM} :	38	Input =	38.00
				Will Calculate
Cosequence Rating Points	$CP_{(Dam\ Height)}$:		Calculate Value =	62.41

Loss of Project Benefits

Description	Parameter Symbol	Input (Enter Values Here)	Equation	Result (Do Not Input Here)
Limited Resource (Losses Would Effect General Public)	$CP_{(Loss\text{-}public)}$:	0	**Mandatory** Rating Points (25 - 75) =	0.00
Private Enterprise (Losses Would Not Effect General Public)	$CP_{(Loss\text{-}private)}$:	10	**Total Discretionary** Rating Points = Irrigation/Industrial Water Supply (10 - 75) HydroPower generation (10 - 75) Mining/Manufacturing (10 - 75) Aesthetics/Recreation/Habitat (10 - 25) Other (10 - 25)	10.00

Potential for Loss of Life

Description	Parameter Symbol	Input (Enter Values Here)	Equation	Result (Do Not Input Here)
				Will Calculate
Dam Size Classification (Large, Intermediate, or Small)	Size :		Dam Size Classification =	Intermediate
Dam Breach Peak Discharge (cfs) (from Tech Note1 Breach Calculation)	$Q_{(Dam)}$:	19500	**Peak Discharge** from Dam Breach =	19500.00
100 Year Flood Peak Discharge (cfs) (From USGS Flood Calculation)	$Q_{(flood)}$:	195	**Peak Discharge** from 100 Year Flood =	195.00
				Will Calculate
Ratio of $Q_{(dam)}$ to $Q_{(flood)}$ =	Ratio :		Ratio Q(dam)/Q(flood) =	100.00
				Will Calculate
Loss of Life Consequence Rating Points	$CP_{(Loss\ of\ Life)}$:		Consequence Rating **Points** for **Loss of Life** =	50.15

Population at Risk

Description	Parameter Symbol	Input (Enter Values Here)	Equation	Result (Do Not Input Here)
Population At Risk	$Pop_{(At\ Risk)}$:	150	**Population At Risk =**	150
Increase Above Current due to Anticipated Population Increase (Typically 10%)	$Pop_{(Increse)}$:	15	**Increased Population At Risk =**	15
				Will Calculate
Total Population At Risk	$Pop_{(Total)}$:		Total Population At Risk =	165.00
				Will Calculate
Consequence Rating Points for Population at Risk	$CP_{(Pop\ Loss)}$:		Consequence Rating **Points** for **Population at Risk** =	195.97

Advance Warning Time

Description	Parameter Symbol	Input (Enter Values Here)	Equation	Result (Do Not Input Here)
Advanced Warning Time: A: Adequate = 0 M: Marginal = 25 I: Inadequate = 50	$Warn_{(Advanced)}$:	I	**Inadequate Warning Index Points =**	50
Likelihhood of Observation and Notification Adequate = 0 M: Marginal = 15 I: Inadequate = 30	$Warn_{(Notification)}$:	M	**Marginal Notification Index Points =**	15
Downstream High Ground and Ease of Evacuation Adequate = 0 M: Marginal = 10 I: Inadequate = 20	$Warn_{(Evacuation)}$:	M	**Marginal Evacuation Index Points =**	10
				Will Calculate
Consequence Index Points for Advanced Warning Factors	$CP_{(Warning)}$:		Consequence Index Points for Advanced Warning Factors =	75.00

Downstream Property at Risk

Description	Parameter Symbol	Input (Enter Values Here)	Equation or Parameter	Result (Do Not Input Here)
				Will Calculate
Number of Homes Downstream at Risk from Dam Breach	$Homes_{(Downstream)}$:		Number of Homes At Risk =	55.000
				Will Calculate
Consequence Rating Points for Homes at Risk	$CP_{(Home\ damage)}$:		Homes At Risk Rating Points =	58.212
				Will Calculate
Consequence Rating Points for Property Damage, Economic Disruption, & Environmental Damage (See Table 5)	$CP_{(total)}$:		Total Damage Rating Points =	55
Major Transportation Links (Enter Number of Items):	$CP_{(Interstate\ Highways/Railway\ Mainlines:\ 25\ pts.)}$:	1	Interstate Highways/Railway Mainlines = (*Summation of Items X 25*)	25
State Transportation Links: (Enter Number of Items):	$CP_{(State\ Highway:\ 10\ pts.)}$:	0	State or County Highways = (*Summation of Items X 10*)	0
Public Transportation Links: (Enter ∑[(Point Value) X (# Items)]:	$CP_{(Other\ Public\ Roads/Railway\ Lines:\ 2\ -\ 5pts.)}$:	5	Public Roads/Railway Lines =	5
Water Supply Systems: (Enter ∑[(Point Value) X (# Items)]:	$CP_{(Storage\ Reservoirs:\ 10\ -\ 75pts.)}$:	0	Water Storage Reservoirs =	0
Water Treatment Systems: (Enter ∑[(Point Value) X (# Items)]:	$CP_{(Treatment\ Facilities:\ 10-25pts.)}$:	0	Treatment Facilities =	0
Water Delivery Systems: (Enter ∑[(Point Value) X (# Items)]:	$CP_{(Water\ Delivery\ Systems:\ 5\ -\ 25pts.)}$:	5	Water Delivery Systems =	5
Wastewater Treatment Systems: (Enter ∑[(Point Value) X (# Items)]:	$CP_{(Wastewater\ Treatment\ Facilities:\ 5\ -\ 25pts.)}$:	0	Waste Water Treatment Systems =	0
Electrical Power Facilities: (Enter ∑[(Point Value) X (# Items)]:	$CP_{(Electrical\ Power\ Plants\ or\ Works:\ 5\ -\ 75pts.)}$:	0	Electrical Power Plants or Works =	0
Emergency Response Facilities: (Enter ∑[(Point Value) X (# Items)]:	$CP_{(Hospitals,\ Police,\ Fire,\ Emergency:\ 10\ -\ 75pts.)}$:	0	Hospitals, Police, Fire, Emergency =	0
Important Economic Facilities: (Enter ∑[(Point Value) X (# Items)]:	$CP_{(Industrial/Comercial/Agricultural:\ 5\ -\ 75\ pts.)}$:	0	Industrial/Comercial Developments =	0
Important Public Facilities: (Enter ∑[(Point Value) X (# Items)]:	$CP_{(Public\ Buildings,\ Schools,\ Libraries,\ etc.:\ 10\ -\ 75\ pts.)}$:	0	Public Buildings, Schools, Libraries, ect. =	0
Important Natural Resource Facilities: (Enter ∑[(Point Value) X (# Items)]:	$CP_{(Fish\ Hatcheries:\ 5\ -\ 25pts.)}$:	0	Fish Hatcheries =	0
Other Important Facilities: (Enter ∑[(Point Value) X (# Items)]:	$CP_{(Other\ Considerations\ ?\ pts.)}$:	0	Other Considerations =	0
Environmental Degradation Caused by Release of Deleterious Materials from Reservoir	$CP_{(Breach\ Causes\ Long\ Term\ Degradation:\ 10\ -\ 75pts.)}$:	0	Long Term Environmental Damage =	0
Environmental Degradation Caused by Release of Deleterious Materials from Reservoir	$CP_{(Breach\ Causes\ Temporary\ Minor\ Degradation:\ 5\ -\ 20pts.)}$:	5	Short Term Environmental Damage =	5
Environmental Degradation Caused by Deleterious Materials Released from Storage Downstream of Breach	$CP_{(Breach\ Causes\ Long\ Term\ Degradation:\ 10\ -\ 75pts.)}$:	10	Long Term Environmental Damage =	10
Environmental Degradation Caused by Deleterious Materials Released from Storage Downstream of Breach	$CP_{(Breach\ Causes\ Temporary\ Minor\ Degradation:\ 5\ -\ 20pts.)}$:	5	Short Term Environmental Damage =	5
				Will Calculate
Consequence Rating Points for Total Property Damage	$CP_{(Total\ Damage)}$:		Total Points for Property Damage =	113.212

END

Cut & Past Bottom Table from Previous Worksheed

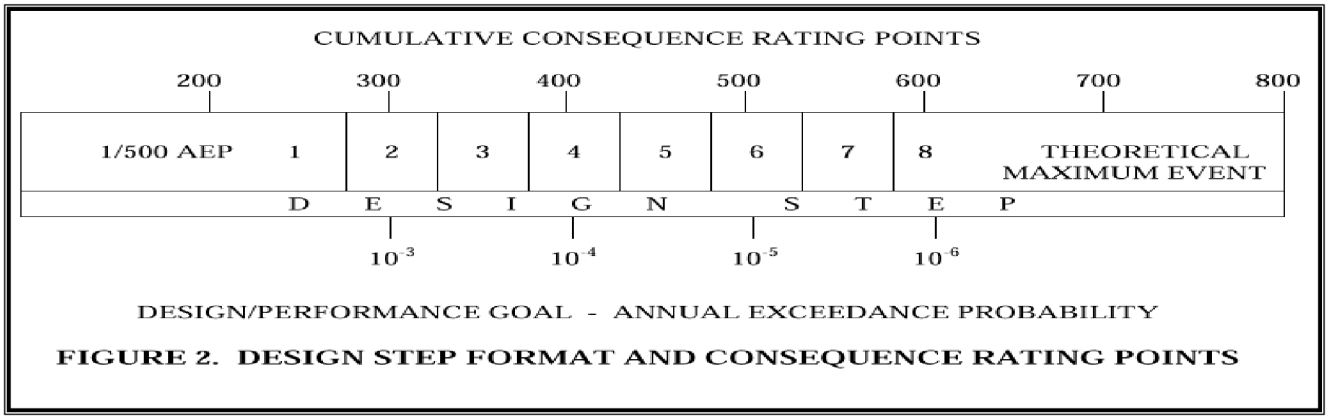


FIGURE 2. DESIGN STEP FORMAT AND CONSEQUENCE RATING POINTS

Total Consequence Rating Points & Design Step				
Description	**Parameter Symbol**	**Input (Enter Values)**	**Result**	
		(As Needed)		
Annual Exceedance Probability	**$AEP_{(Annual\ Exceedance)}$:**		**AEP =**	1.000E-06
Design Step	**DS :**		**Design Step =**	8.00
Cumulative Consequence Rating Points	**$Cp_{(cumulative)}$:**		**Cumulative Rating =**	656.75
Base Consequence Rating Points	**$CP_{(Base)}$:**		**Base Points =**	150.00

Appendix D
Design Storm Calculations

Dungeness Reservoir

Worksheet for Computation of **Short Duration** Precipitation Magnitude-Frequency Curve
Reference: Technical Note 3, Oct 2009 revision
Adam Hill, P.E., 11/18/2021

Project data:	*Input*		*Input*	
Dam location:	T 30 N, R 4 W, Section 36; 2 miles SW of Sequim			
Watershed Lat/Long:	48.0533	deg. N	123.1404	deg. W (> 3 decimal places)
Watershed elevation:	400	feet		(Lat/Long and elev for centroid of watershed)
Climatic Region:	32			(MGS Look-up Calculator)
Mean Annual Precip:	21.9	inches		(MGS Look-up Calculator)
Duration of interest:	2	hours		(Index for short duration storm)
Design Step:	8			(Worksheet from Tech Note 2)
Drainage area:	0.06658	sq.miles.		(Compare to small watershed < 1 sq.mile.)
	Input			

Key equations :

Precipitation estimates are calculated from gridded data set files by the MGS Look-up Calculator (the "Calculator" tab in this workbook) using the four-parameter Kappa probablility distribution. The specific equations are described in more detail in the following references :

Schaefer MG, Barker BL, Taylor GH and Wallis JR, Regional Precipitation-Frequency Analysis and Spatial Mapping of Precipitation for 24-Hour and 2-Hour Durations in Western Washington, prepared for Washington State Department of Transportation, Report WA-RD 544.1, MGS Engineering Consultants, March 2002.

Schaefer MG, Barker BL, Taylor GH and Wallis JR, Regional Precipitation-Frequency Analysis and Spatial Mapping of Precipitation for 24-Hour and 2-Hour Durations in Eastern Washington, prepared for Washington State Department of Transportation, MGS Engineering Consultants, January 2006.

The calculations were extended to the Dam Safety storms by the update to Technical Note 3.
The gridded data sets are provided by Ecology along with this spreadsheet and look-up calculator.

Scaling precipitation, P_{sd} = DF * P_{gds} Use design factor = 1.15 *Input*

where: P_{gds} = estimated 2-hr precip for selected frequency, inches
DF = design factor; DF = 1.15 for new dams
P_{sd} = scaling precip for 2-hr index period, inches

Total storm precip = (scaling precip for 2-hr index) x (multiplier from mass curve for 4-hr storm)
multiplier for 4-hr storm = 1.2050 for Climatic Region 32
*(from **Multipliers** worksheet)* Hyetograph no. 5

This project :

Frequency / design step :	10 yr	25 yr	100 yr	Step 1	Step 2	Step 3
Precip estimate, P_{gds} (in.) :	0.66	0.79	1.04	1.40	1.60	1.98
Scaling precipitation, P_{sd} (in.) :	0.76	0.91	1.19	1.61	1.84	2.27
Total precip for design storm :	0.92	1.10	1.44	1.94	2.21	2.74

Frequency / design step :	Step 4	Step 5	Step 6	Step 7	Step 8	PMP
Precip estimate, P_{gds} (in.) :	2.45	3.03	3.75	4.64	5.75	4.29
Scaling precipitation, P_{sd} (in.) :	2.82	3.49	4.32	4.32	4.32	4.32
Total precip for design storm :	3.40	4.20	5.20	5.20	5.20	5.20

Dungeness Reservoir

Worksheet for Computation of Short Duration Precipitation Magnitude-Frequency Curve
Reference: Technical Note 3, Oct 2009 revision
Adam Hill, P.E., 11/18/2021

Comparison to PMP for local storm (thunderstorm). Ref: HMR-57, Fig. 11.19 and 11.12, Table 11.4.

	Input	
Local storm, 1-hour PMP =	3.9	in.
2-hour PMP = 110% x 1-hr =	4.3	in.

Frequency / design step :	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8
Scaling precipitation, P_{sd} (in.) :	2.27	2.82	3.49	4.32	4.32	4.32
Percentage of 2-hr PMP (%) :	53.0	65.7	81.3	100.6	100.6	100.6

Note: Per Tech Note 3, page 10: For IDF = PMF, use PMP > Step 6.

Basin average precipitation for large watershed.

Drainage area = 0.06658 sq.miles. (Compare to small watershed < 1 sq.mile.)

Basin avg. precip = 100 % of total storm point precip.
*(from **Multipliers** worksheet)*

Frequency / design step :	10 yr	25 yr	100 yr	Step 1	Step 2	Step 3
Total storm point precip :	0.92	1.10	1.44	1.94	2.21	2.74
Basin avg total storm precip :	0.92	1.10	1.44	1.94	2.21	2.74

Frequency / design step :	Step 4	Step 5	Step 6	Step 7	Step 8	PMP
Total storm point precip :	3.40	4.20	5.20	5.20	5.20	5.20
Basin avg total storm precip :	3.40	4.20	5.20	5.20	5.20	5.20

Peak rainfall intensity for design storm.

Peak rainfall intensity (in/hr) = (total storm precip) x (peak intensity factor)
peak intensity factor = 2.23068 for Climatic Region 32
*(from **Multipliers** worksheet)* Hyetograph no. 5

Frequency / design step :	10 yr	25 yr	100 yr	Step 1	Step 2	Step 3
Basin avg total storm precip :	0.92	1.10	1.44	1.94	2.21	2.74
Peak storm intensity (in/hr) :	2.05	2.46	3.21	4.33	4.94	6.11

Frequency / design step :	Step 4	Step 5	Step 6	Step 7	Step 8	PMP
Basin avg total storm precip :	3.40	4.20	5.20	5.20	5.20	5.20
Peak storm intensity (in/hr) :	7.58	9.37	11.60	11.60	11.60	11.60

Dungeness Reservoir

Worksheet for Computation of **Intermediate** Precipitation Magnitude-Frequency Curve
Reference: Technical Note 3, Oct 2009 revision
Adam Hill, P.E., 11/18/2021

Project data:	*Input*		*Input*	
Dam location:	T 30 N, R 4 W, Section 36; 2 miles SW of Sequim			
Watershed Lat/Long:	48.0533	deg. N	123.1404	deg. W (> 3 decimal places)
Watershed elevation:	400	feet		(Lat/Long and elev for centroid of watershed)
Climatic Region:	32			(MGS Look-up Calculator)
Mean Annual Precip:	21.9	inches		(MGS Look-up Calculator)
Duration of interest:	6	hours		(Index for intermediate storm)
Design Step:	8			(Worksheet from Tech Note 2)
Drainage area:	0.06658	sq.miles.		(Compare to small watershed < 10 sq.miles)
	Input			

Key equations :

Precipitation estimates are calculated from gridded data set files by the MGS Look-up Calculator (the "Calculator" tab in this workbook) using the four-parameter Kappa probablility distribution. The specific equations are described in more detail in the following references :

Schaefer MG, Barker BL, Taylor GH and Wallis JR, Regional Precipitation-Frequency Analysis and Spatial Mapping of Precipitation for 24-Hour and 2-Hour Durations in Western Washington, prepared for Washington State Department of Transportation, Report WA-RD 544.1, MGS Engineering Consultants, March 2002.

Schaefer MG, Barker BL, Taylor GH and Wallis JR, Regional Precipitation-Frequency Analysis and Spatial Mapping of Precipitation for 24-Hour and 2-Hour Durations in Eastern Washington, prepared for Washington State Department of Transportation, MGS Engineering Consultants, January 2006.

The calculations were extended to the Dam Safety storms by the update to Technical Note 3.
The gridded data sets are provided by Ecology along with this spreadsheet and look-up calculator.

Scaling precipitation, P_{sd} = DF * P_{gds} Use design factor = 1.15 *Input*

where: P_{gds} = estimated 6-hr precip for selected frequency, inches
DF = design factor; DF = 1.15 for new dams
P_{sd} = scaling precip for 6-hr index period, inches

Total storm precip = (scaling precip for 6-hr index) x (multiplier from mass curve for 18-hr storm)
multiplier for 18-hr storm = 1.6670 for Climatic Region 32
*(from **Multipliers** worksheet)* Hyetograph no. 10

This project :

Frequency / design step :	10 yr	25 yr	100 yr	Step 1	Step 2	Step 3
Precip estimate, P_{gds} (in.) :	1.14	1.32	1.61	1.97	2.14	2.44
Scaling precipitation, P_{sd} (in.) :	1.31	1.52	1.85	2.27	2.46	2.80
Total precip for design storm :	2.19	2.54	3.08	3.79	4.10	4.67

Frequency / design step :	Step 4	Step 5	Step 6	Step 7	Step 8	PMP
Precip estimate, P_{gds} (in.) :	2.75	3.09	3.46	3.85	4.27	4.49
Scaling precipitation, P_{sd} (in.) :	3.16	3.55	3.98	4.43	4.49	4.49
Total precip for design storm :	5.27	5.93	6.63	7.38	7.48	7.48

Dungeness Reservoir

Worksheet for Computation of Intermediate Precipitation Magnitude-Frequency Curve
Reference: Technical Note 3, Oct 2009 revision

Adam Hill, P.E., 11/18/2021

Comparison to PMP for general storm. Ref: HMR-57, Map 1 - NW, Table 10.10.

PMP for a 6-hour period is estimated as a percentage of the 24-hour PMP. The percentage factor varies by climatic region as follows :

	Western Washington				Eastern Washington	
	Coast	Olympics	Cascades	Puget Sound	Mountains	Central Basin
Regions :	5	151-142	15-154	31-32	14-147-13	77-07
Factor :	0.43	0.40	0.40	0.44	0.52	0.59

This project :

Input

General storm, 24-hour PMP = 10.0 in.

For region: 32

6-hr PMP= 0.44 (*Input*) x 24-hr = 4.40 in.

Frequency / design step :	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8
Scaling precipitation, P_{sd} (in.) :	2.80	3.16	3.55	3.98	4.43	4.49
Percentage of 6-hr PMP (%) :	63.7	71.9	80.8	90.4	100.6	101.9

Note: Per Tech Note 3, page 10: For IDF = PMF, use PMP > Step 6.

Comparison to PMP for local storm (thunderstorm). Ref: HMR-57, Fig. 11.19 and 11.12, Table 11.4.

Input

Local storm, 1-hour PMP = 3.9 in.

6-hour PMP = 115% x 1-hr = 4.5 in.

Frequency / design step :	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8
Scaling precipitation, P_{sd} (in.) :	2.80	3.16	3.55	3.98	4.43	4.49
Percentage of 6-hr PMP (%) :	62.5	70.5	79.3	88.7	98.7	100.0

Note: Per Tech Note 3, page 10: For IDF = PMF, use PMP > Step 6.

Dungeness Reservoir

Worksheet for Computation of Intermediate Precipitation Magnitude-Frequency Curve
Reference: Technical Note 3, Oct 2009 revision

Peak rainfall intensity for design storm.

Peak rainfall intensity (in/hr) = (total storm precip) x (peak intensity factor)

peak intensity factor = 0.33352 for Climatic Region 32
*(from **Multipliers** worksheet)* Hyetograph no. 10

Frequency / design step :	10 yr	25 yr	100 yr	Step 1	Step 2	Step 3
Total precip for design storm :	2.19	2.54	3.08	3.79	4.10	4.67
Peak storm intensity (in/hr) :	0.73	0.85	1.03	1.26	1.37	1.56

Frequency / design step :	Step 4	Step 5	Step 6	Step 7	Step 8	PMP
Total precip for design storm :	5.27	5.93	6.63	7.38	7.48	7.48
Peak storm intensity (in/hr) :	1.76	1.98	2.21	2.46	2.49	2.49

Dungeness Reservoir

Worksheet for Computation of **Long Duration** Precipitation Magnitude-Frequency Curve
Reference: Technical Note 3, Oct 2009 revision
Adam Hill, P.E., 11/18/2021

Project data :	*Input*		*Input*	
Dam location:	T 30 N, R 4 W, Section 36; 2 miles SW of Sequim			
Watershed Lat/Long:	48.0533	deg. N	123.1404	deg. W (> 3 decimal places)
Watershed elevation:	400	feet		(Lat/Long and elev for centroid of watershed)
Climatic Region:	32			(MGS Look-up Calculator)
Mean Annual Precip:	21.9	inches		(MGS Look-up Calculator)
Duration of interest:	24	hours		(Index for long duration storm)
Design Step:	8			(Worksheet from Tech Note 2)
Drainage area:	0.06658	sq.miles.		(Compare to small watershed < 10 sq.miles)
	Input			

Key equations :

Precipitation estimates are calculated from gridded data set files by the MGS Look-up Calculator (the "Calculator" tab in this workbook) using the four-parameter Kappa probablility distribution. The specific equations are described in more detail in the following references :

Schaefer MG, Barker BL, Taylor GH and Wallis JR, Regional Precipitation-Frequency Analysis and Spatial Mapping of Precipitation for 24-Hour and 2-Hour Durations in Western Washington, prepared for Washington State Department of Transportation, Report WA-RD 544.1, MGS Engineering Consultants, March 2002.

Schaefer MG, Barker BL, Taylor GH and Wallis JR, Regional Precipitation-Frequency Analysis and Spatial Mapping of Precipitation for 24-Hour and 2-Hour Durations in Eastern Washington, prepared for Washington State Department of Transportation, MGS Engineering Consultants, January 2006.

The calculations were extended to the Dam Safety storms by the update to Technical Note 3. The gridded data sets are provided by Ecology along with this spreadsheet and look-up calculator.

Scaling precipitation, P_{sd} = DF * P_{gds} Use design factor = 1.15 *Input*

where: P_{gds} = estimated 24-hr precip for selected frequency, inches
DF = design factor; DF = 1.15 for new dams
P_{sd} = scaling precip for 24-hr index period, inches

Total storm precip = (scaling precip for 24-hr index) x (multiplier from mass curve for 72-hr storm)
multiplier for 72-hr storm = 1.4153 for Climatic Region 32
*(from **Multipliers** worksheet)* Hyetograph no. 16

This project :

Frequency / design step :	10 yr	25 yr	100 yr	Step 1	Step 2	Step 3
Precip estimate, P_{gds} (in.) :	2.21	2.64	3.32	4.18	4.58	5.28
Scaling precipitation, P_{sd} (in.) :	2.54	3.03	3.82	4.81	5.27	6.08
Total precip for design storm :	3.60	4.29	5.41	6.81	7.46	8.60

Frequency / design step :	Step 4	Step 5	Step 6	Step 7	Step 8	PMP
Precip estimate, P_{gds} (in.) :	6.04	6.85	7.72	8.66	9.66	10.00
Scaling precipitation, P_{sd} (in.) :	6.94	7.87	8.88	9.95	10.00	10.00
Total precip for design storm :	9.83	11.15	12.57	14.09	14.15	14.15

Dungeness Reservoir

Worksheet for Computation of Long Duration Precipitation Magnitude-Frequency Curve
Reference: Technical Note 3, Oct 2009 revision

Adam Hill, P.E., 11/18/2021

Comparison to PMP for general storm. Ref: HMR-57, Map 1 - NW.

Input

General storm, 24-hour PMP = 10.0 in.

Frequency / design step :	Step 3	Step 4	Step 5	Step 6	Step 7	Step 8
Scaling precipitation, P_{sd} (in.) :	6.08	6.94	7.87	8.88	9.95	10.00
Percentage of 24-hr PMP (%):	60.8	69.4	78.7	88.8	99.5	100.0

Note: Per Tech Note 3, page 8: For IDF = PMF, use PMP > Step 6.

Peak rainfall intensity for design storm.

Peak rainfall intensity (in/hr) = (total storm precip) x (peak intensity factor)

peak intensity factor = 0.13280 for Climatic Region 32

*(from **Multipliers** worksheet)* Hyetograph no. 16

Frequency / design step :	10 yr	25 yr	100 yr	Step 1	Step 2	Step 3
Total precip for design storm :	3.60	4.29	5.41	6.81	7.46	8.60
Peak storm intensity (in/hr) :	0.48	0.57	0.72	0.90	0.99	1.14

Frequency / design step :	Step 4	Step 5	Step 6	Step 7	Step 8	PMP
Total precip for design storm :	9.83	11.15	12.57	14.09	14.15	14.15
Peak storm intensity (in/hr) :	1.31	1.48	1.67	1.87	1.88	1.88

Western Washington - Regions 5-151-142-32-31-15-154
Short Duration Storm, 33% Curve
Unit Storm Scaled by Total Storm Depth

Time Step = **5** ***min.***

Area at 435' 1811569
Area at 438' 1856174

TIME (min)	TIME (hr)	Hyetograph Ordinates	Intensity Index	Mass Curve Ordinates	Water Volume (cf)	Cumulative Volume (cf)	Elevation (ft)
0	0.000	0.00000	0.00000	0.00000	0	0	435.00
5	0.083	0.01290	0.15475	0.01290	1995	1995	435.00
10	0.167	0.06037	0.72446	0.07327	9338	11333	435.00
15	0.250	0.10400	1.24800	0.17727	16087	27420	435.01
20	0.333	0.13000	1.56000	0.30727	20109	47529	435.02
25	0.417	0.11232	1.34784	0.41959	17374	64902	435.03
30	0.500	0.08195	0.98342	0.50154	12676	77579	435.04
35	0.583	0.06037	0.72446	0.56191	9338	86917	435.04
40	0.667	0.02584	0.31013	0.58776	3998	90915	435.05
45	0.750	0.00000	0.00000	0.58776	0	90915	435.05
50	0.833	0.00000	0.00000	0.58776	0	90915	435.05
55	0.917	0.00000	0.00000	0.58776	0	90915	435.05
60	1.000	0.00946	0.11357	0.59722	1464	92379	435.05
65	1.083	0.01940	0.23275	0.61662	3000	95379	435.05
70	1.167	0.01981	0.23774	0.63643	3065	98443	435.05
75	1.250	0.02028	0.24336	0.65671	3137	101580	435.05
80	1.333	0.03323	0.39874	0.68994	5140	106720	435.05
85	1.417	0.04399	0.52790	0.73393	6805	113525	435.06
90	1.500	0.10140	1.21680	0.83533	15685	129210	435.07
95	1.583	0.16567	1.98806	1.00100	25626	154836	435.08
100	1.667	0.21356	2.56277	1.21456	33034	187870	435.10
105	1.750	0.23733	2.84794	1.45189	36710	224580	435.12
110	1.833	0.29344	3.52123	1.74533	45389	269969	435.14
115	1.917	0.58256	6.99067	2.32788	90110	360080	435.19
120	**2.000**	0.96663	**11.59954**	3.29451	149519	509599	435.28
125	2.083	0.60414	7.24963	3.89865	93448	603047	435.33
130	2.167	0.27186	3.26227	4.17050	42051	645098	435.35
135	2.250	0.22266	2.67197	4.39317	34442	679540	435.37
140	2.333	0.19375	2.32502	4.58692	29970	709510	435.39
145	2.417	0.13416	1.60992	4.72108	20752	730262	435.40
150	2.500	0.06859	0.82306	4.78967	10609	740871	435.40
155	2.583	0.02974	0.35693	4.81941	4601	745472	435.41
160	2.667	0.02371	0.28454	4.84312	3668	749140	435.41
165	2.750	0.02111	0.25334	4.86424	3266	752406	435.41
170	2.833	0.02028	0.24336	4.88452	3137	755543	435.41
175	2.917	0.01810	0.21715	4.90261	2799	758342	435.41
180	3.000	0.00946	0.11357	4.91208	1464	759806	435.41
185	3.083	0.01638	0.19656	4.92846	2534	762339	435.42
190	3.167	0.01851	0.22214	4.94697	2863	765203	435.42
195	3.250	0.02371	0.28454	4.97068	3668	768871	435.42
200	3.333	0.02631	0.31574	4.99699	4070	772941	435.42
205	3.417	0.03749	0.44990	5.03448	5799	778740	435.42
210	3.500	0.04311	0.51730	5.07759	6668	785408	435.43
215	3.583	0.04399	0.52790	5.12158	6805	792213	435.43
220	3.667	0.03146	0.37752	5.15304	4866	797079	435.43
225	3.750	0.02200	0.26395	5.17504	3402	800481	435.44
230	3.833	0.01550	0.18595	5.19054	2397	802878	435.44
235	3.917	0.00733	0.08798	5.19787	1134	804012	435.44
240	4.000	0.00213	0.02558	5.20000	330	804342	435.44

Peak = 0.96663 11.59954

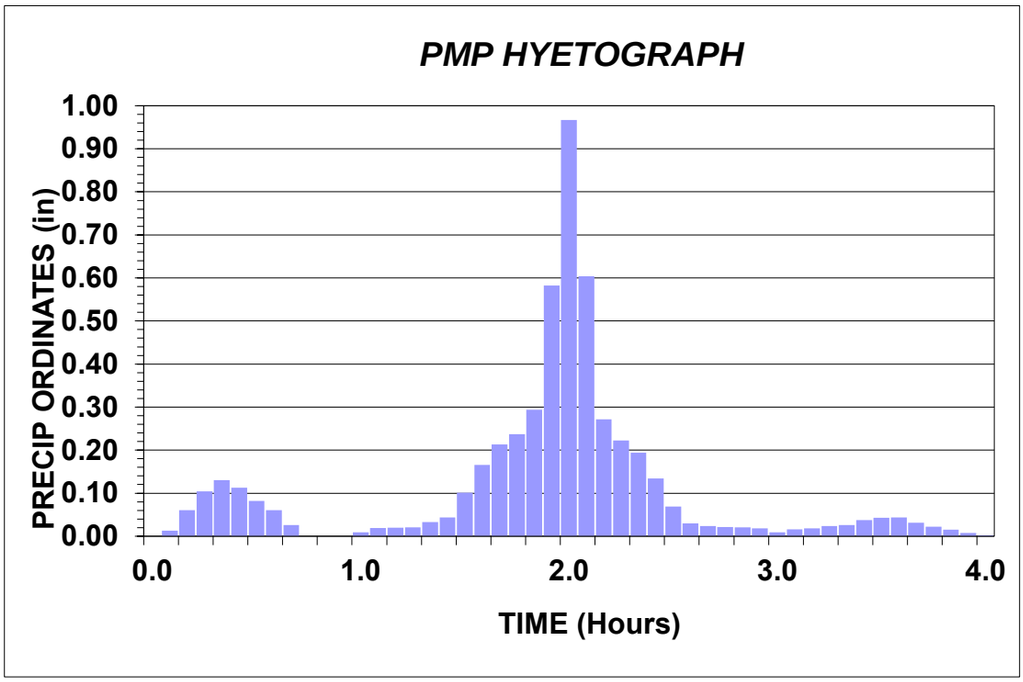
Total Storm Precip = 5.2 inches

Total storm multiplier = **1.2050**

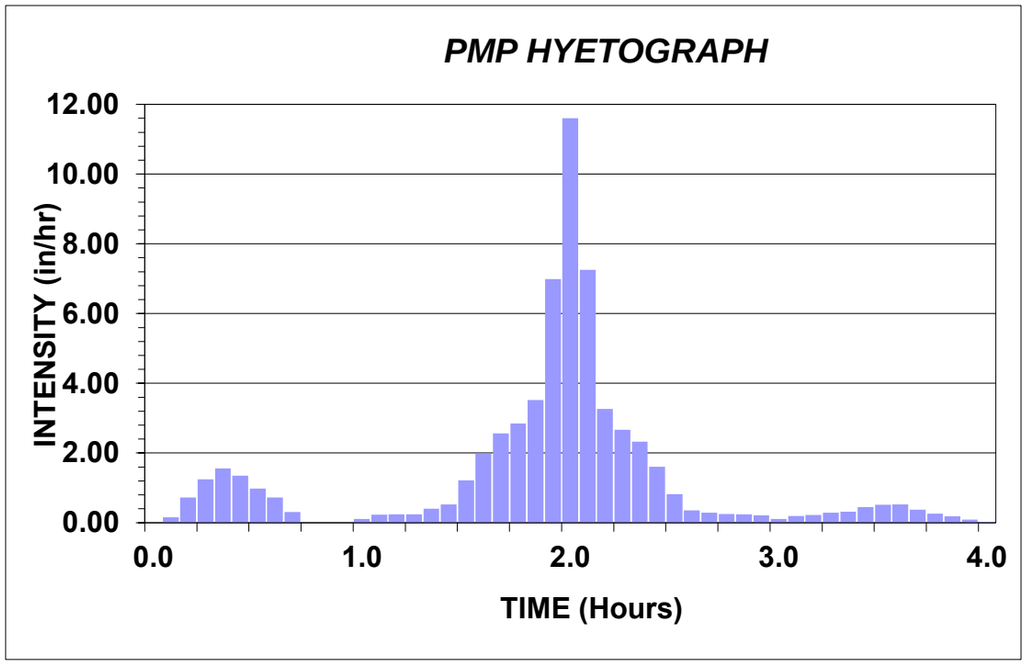
SF (For reference only; already factored into unit storm hyetograph.)

SF

Peak intensity factor = **11.59954**



Peak 5 min = 0.9666
Peak 15 min = 2.1533
Peak 30 min = 2.9559
Peak 60 min = 3.9872



Western Washington - Regions 31 - 32
Intermediate Storm, 20% Curve
Unit Storm Scaled by Total Storm Depth

Time Step = **15** ***min.***

Area at 435'
Area at 438'

TIME (min)	TIME (hr)	Hyetograph Ordinates	Intensity Index	Mass Curve Ordinates	Water Volume (cf)	Cumulative Volume (cf)	Elevation (ft)
0	0.00	0.00000	0.00000	0.00000	0	0	435.00
15	0.25	0.00441	0.01765	0.00441	683	683	435.00
30	0.50	0.00666	0.02663	0.01107	1030	1712	435.00
45	0.75	0.00890	0.03560	0.01997	1377	3089	435.00
60	1.00	0.01115	0.04458	0.03112	1724	4813	435.00
75	1.25	0.01339	0.05356	0.04451	2071	6884	435.00
90	1.50	0.01563	0.06253	0.06014	2418	9302	435.00
105	1.75	0.01788	0.07151	0.07802	2765	12068	435.00
120	2.00	0.02012	0.08048	0.09814	3112	15180	435.00
135	2.25	0.02237	0.08946	0.12050	3459	18640	435.01
150	2.50	0.02685	0.10741	0.14736	4154	22793	435.01
165	2.75	0.03134	0.12536	0.17870	4848	27641	435.01
180	3.00	0.03583	0.14332	0.21453	5542	33183	435.01
195	3.25	0.04032	0.16127	0.25484	6236	39420	435.02
210	3.50	0.04481	0.17922	0.29965	6931	46350	435.02
225	3.75	0.04929	0.19717	0.34894	7625	53975	435.02
240	4.00	0.05827	0.23308	0.40721	9013	62988	435.03
255	4.25	0.06725	0.26898	0.47446	10402	73389	435.04
270	4.50	0.07622	0.30488	0.55068	11790	85179	435.04
285	4.75	0.08520	0.34079	0.63587	13178	98358	435.05
300	5.00	0.09417	0.37669	0.73005	14567	112925	435.06
315	5.25	0.10330	0.41320	0.83335	15978	128903	435.07
330	5.50	0.10539	0.42157	0.93874	16302	145205	435.08
345	5.75	0.11437	0.45748	1.05311	17691	162896	435.08
360	6.00	0.12335	0.49338	1.17645	19079	181975	435.10
375	6.25	0.13314	0.53258	1.30960	20595	202570	435.11
390	6.50	0.14130	0.56519	1.45090	21856	224426	435.12
405	6.75	0.15917	0.63670	1.61007	24621	249048	435.13
420	7.00	0.14130	0.56519	1.75137	21856	270904	435.14
435	7.25	0.13314	0.53258	1.88451	20595	291498	435.16
450	7.50	0.12335	0.49338	2.00786	19079	310578	435.17
465	7.75	0.11437	0.45748	2.12223	17691	328268	435.18
480	8.00	0.10539	0.42157	2.22762	16302	344571	435.19
495	8.25	0.09642	0.38567	2.32404	14914	359485	435.19
510	8.50	0.08744	0.34976	2.41148	13526	373010	435.20
525	8.75	0.07847	0.31386	2.48994	12137	385147	435.21
540	9.00	0.06949	0.27796	2.55943	10749	395896	435.21
555	9.25	0.06051	0.24205	2.61994	9360	405256	435.22
570	9.50	0.05154	0.20615	2.67148	7972	413228	435.22
585	9.75	0.04256	0.17024	2.71404	6583	419811	435.23
600	10.00	0.04032	0.16127	2.75436	6236	426048	435.23
615	10.25	0.04481	0.17922	2.79917	6931	432978	435.23
630	10.50	0.05827	0.23308	2.85743	9013	441991	435.24
645	10.75	0.06725	0.26898	2.92468	10402	452393	435.24
660	11.00	0.09866	0.39464	3.02334	15261	467654	435.25
675	11.25	0.12559	0.50236	3.14893	19426	487080	435.26
690	11.50	0.13905	0.55621	3.28798	21509	508589	435.28
705	11.75	0.14354	0.57416	3.43152	22203	530792	435.29
720	12.00	0.17945	0.71778	3.61097	27757	558549	435.30

735	12.25	0.20189	0.80754	3.81286	31228	589777	435.32
750	12.50	0.21086	0.84344	4.02372	32616	622393	435.34
765	12.75	0.21984	0.87935	4.24355	34005	656398	435.36
780	13.00	0.22881	0.91525	4.47237	35393	691791	435.38
795	13.25	0.27369	1.09477	4.74606	42335	734126	435.40
810	**13.50**	0.62368	**2.49473**	5.36974	96472	830598	435.45
825	13.75	0.32755	1.31020	5.69729	50666	881264	435.48
840	14.00	0.25574	1.02296	5.95303	39558	920822	435.50
855	14.25	0.21984	0.87935	6.17287	34005	954827	435.52
870	14.50	0.21086	0.84344	6.38373	32616	987443	435.54
885	14.75	0.20637	0.82549	6.59010	31922	1019365	435.56
900	15.00	0.16598	0.66392	6.75609	25674	1045039	435.57
915	15.25	0.13905	0.55621	6.89514	21509	1066548	435.58
930	15.50	0.12559	0.50236	7.02073	19426	1085974	435.59
945	15.75	0.11213	0.44850	7.13285	17344	1103318	435.60
960	16.00	0.08969	0.35874	7.22254	13873	1117191	435.61
975	16.25	0.06276	0.25103	7.28530	9707	1126898	435.62
990	16.50	0.05378	0.21512	7.33908	8319	1135217	435.62
1005	16.75	0.04481	0.17922	7.38388	6931	1142147	435.62
1020	17.00	0.03583	0.14332	7.41971	5542	1147690	435.63
1035	17.25	0.02685	0.10741	7.44656	4154	1151843	435.63
1050	17.50	0.01788	0.07151	7.46444	2765	1154609	435.63
1065	17.75	0.01115	0.04458	7.47559	1724	1156332	435.63
1080	18.00	0.00441	0.01765	7.48000	683	1157015	435.63

Peak =	0.62368	2.49473

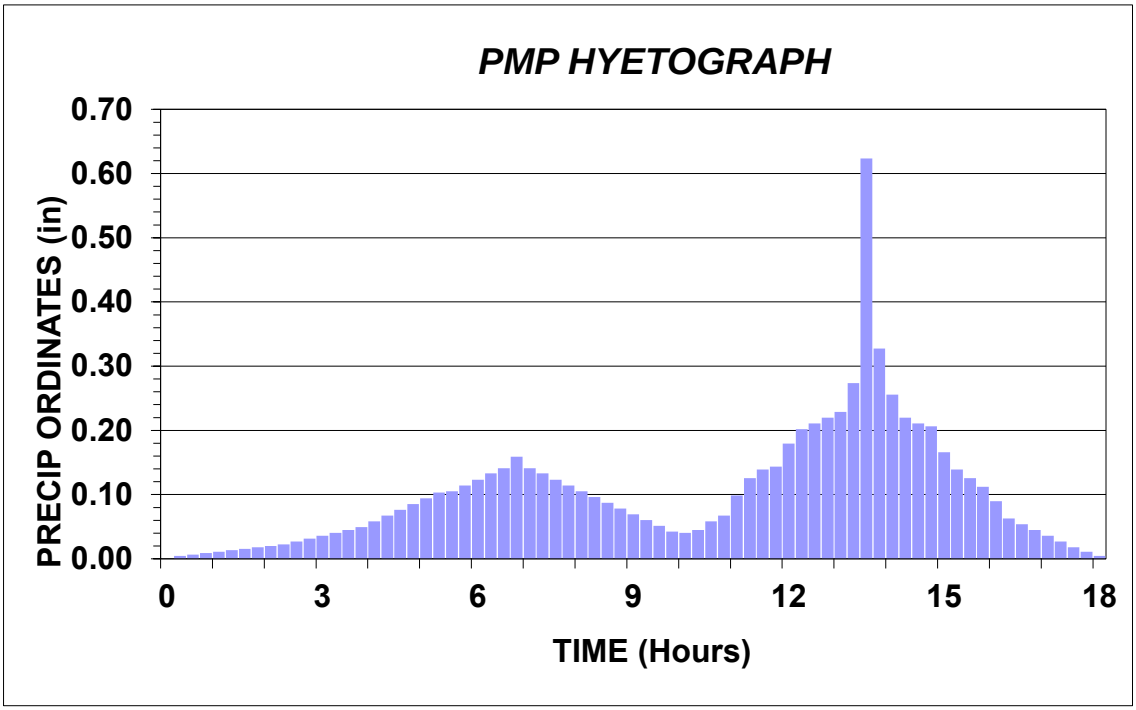
Total Storm Precip = 7.48 inches

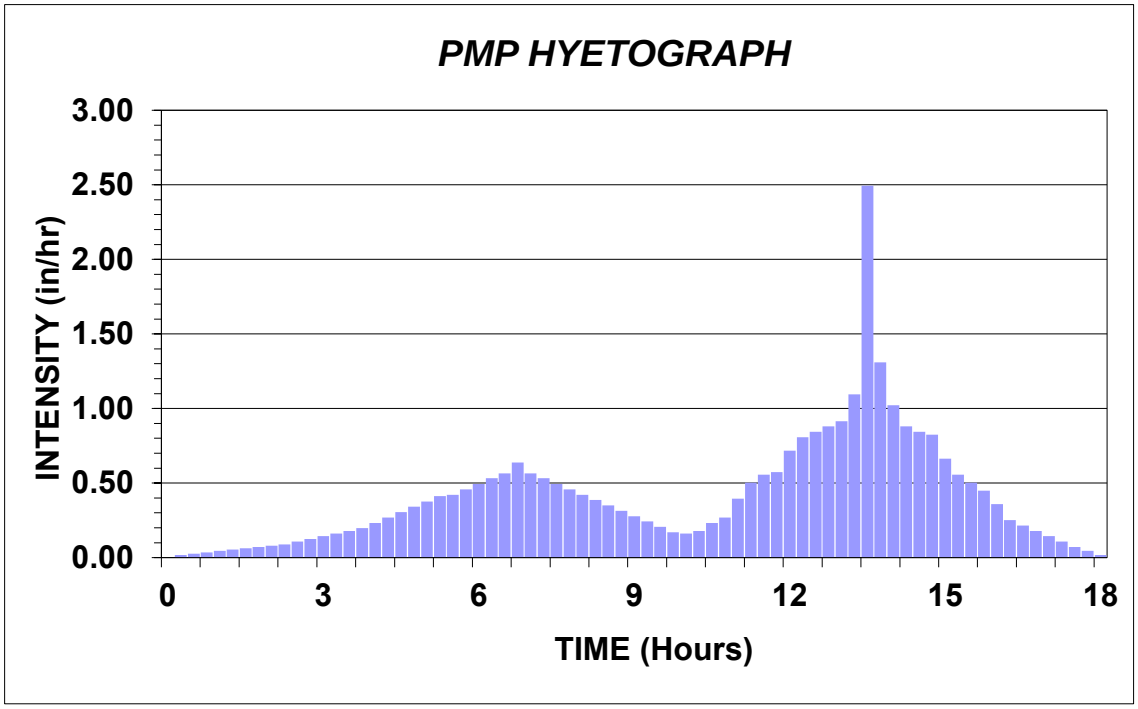
***Total storm multiplier* = 1.6670**

1811569 SF
1856174 SF

(For reference only; already factored into unit storm hyetograph.)

***Peak intensity factor* = 2.49473**





Western Washington - Regions 32 and 31
Long Duration Storm, 20% Curve
Unit Storm Scaled by Total Storm Depth

Time Step = **15** ***min.***

Area at 435'
Area at 438'

TIME (min)	TIME (hr)	Dimensionless Hyetograph Ordinates	Dimensionless Intensity Index	Dimensionless Mass Curve Ordinates	Water Volume (cf	mulative Volume	Elevation (ft)
0	0.00	0.00000	0.00000	0.00000	0	0	435.00
15	0.25	0.00198	0.00792	0.00198	306	306	435.00
30	0.50	0.00396	0.01585	0.00594	613	919	435.00
45	0.75	0.00594	0.02377	0.01189	919	1839	435.00
60	1.00	0.00722	0.02887	0.01910	1116	2955	435.00
75	1.25	0.00991	0.03962	0.02901	1532	4487	435.00
90	1.50	0.01189	0.04754	0.04089	1839	6325	435.00
105	1.75	0.01387	0.05547	0.05476	2145	8470	435.00
120	2.00	0.01599	0.06396	0.07075	2473	10944	435.00
135	2.25	0.01698	0.06792	0.08773	2626	13570	435.00
150	2.50	0.01797	0.07188	0.10570	2780	16350	435.00
165	2.75	0.01797	0.07188	0.12367	2780	19130	435.01
180	3.00	0.01797	0.07188	0.14164	2780	21909	435.01
195	3.25	0.01896	0.07584	0.16060	2933	24842	435.01
210	3.50	0.01896	0.07584	0.17956	2933	27775	435.01
225	3.75	0.01995	0.07981	0.19952	3086	30861	435.01
240	4.00	0.01995	0.07981	0.21947	3086	33947	435.01
255	4.25	0.01995	0.07981	0.23942	3086	37033	435.02
270	4.50	0.01995	0.07981	0.25937	3086	40120	435.02
285	4.75	0.02094	0.08377	0.28031	3239	43359	435.02
300	5.00	0.02193	0.08773	0.30224	3393	46751	435.02
315	5.25	0.02391	0.09565	0.32616	3699	50450	435.02
330	5.50	0.02490	0.09962	0.35106	3852	54303	435.02
345	5.75	0.02589	0.10358	0.37696	4005	58308	435.03
360	6.00	0.02689	0.10754	0.40384	4159	62467	435.03
375	6.25	0.02788	0.11150	0.43172	4312	66778	435.03
390	6.50	0.02887	0.11546	0.46058	4465	71243	435.03
405	6.75	0.02986	0.11943	0.49044	4618	75862	435.04
420	7.00	0.03099	0.12395	0.52143	4793	80655	435.04
435	7.25	0.03198	0.12792	0.55341	4947	85602	435.04
450	7.50	0.03297	0.13188	0.58638	5100	90701	435.05
465	7.75	0.03297	0.13188	0.61935	5100	95801	435.05
480	8.00	0.03396	0.13584	0.65331	5253	101054	435.05
495	8.25	0.03495	0.13980	0.68826	5406	106460	435.05
510	8.50	0.03495	0.13980	0.72321	5406	111866	435.06
525	8.75	0.03594	0.14376	0.75915	5559	117426	435.06
540	9.00	0.03594	0.14376	0.79509	5559	122985	435.06
555	9.25	0.03693	0.14773	0.83202	5713	128698	435.07
570	9.50	0.03891	0.15565	0.87093	6019	134717	435.07
585	9.75	0.04089	0.16357	0.91183	6325	141042	435.07
600	10.00	0.04486	0.17942	0.95668	6938	147981	435.08
615	10.25	0.04896	0.19584	1.00564	7573	155554	435.08
630	10.50	0.05391	0.21565	1.05955	8339	163893	435.09
645	10.75	0.06396	0.25583	1.12351	9893	173786	435.09
660	11.00	0.07896	0.31583	1.20247	12213	185999	435.10
675	11.25	0.10853	0.43412	1.31100	16788	202787	435.11
690	11.50	0.14985	0.59939	1.46085	23179	225965	435.12
705	11.75	0.11985	0.47940	1.58070	18539	244504	435.13
720	12.00	0.10853	0.43412	1.68923	16788	261292	435.14

735	12.25	0.07896	0.31583	1.76818	12213	273505	435.15
750	12.50	0.06396	0.25583	1.83214	9893	283398	435.15
765	12.75	0.05391	0.21565	1.88605	8339	291737	435.16
780	13.00	0.04896	0.19584	1.93501	7573	299310	435.16
795	13.25	0.04486	0.17942	1.97987	6938	306248	435.16
810	13.50	0.03990	0.15961	2.01977	6172	312421	435.17
825	13.75	0.03891	0.15565	2.05868	6019	318440	435.17
840	14.00	0.03792	0.15169	2.09661	5866	324305	435.17
855	14.25	0.03693	0.14773	2.13354	5713	330018	435.18
870	14.50	0.03594	0.14376	2.16948	5559	335577	435.18
885	14.75	0.03594	0.14376	2.20542	5559	341137	435.18
900	15.00	0.03495	0.13980	2.24037	5406	346543	435.19
915	15.25	0.03396	0.13584	2.27433	5253	351796	435.19
930	15.50	0.03396	0.13584	2.30829	5253	357049	435.19
945	15.75	0.03297	0.13188	2.34126	5100	362149	435.19
960	16.00	0.03297	0.13188	2.37423	5100	367248	435.20
975	16.25	0.03198	0.12792	2.40621	4947	372195	435.20
990	16.50	0.02986	0.11943	2.43606	4618	376813	435.20
1005	16.75	0.02887	0.11546	2.46493	4465	381278	435.21
1020	17.00	0.02887	0.11546	2.49380	4465	385743	435.21
1035	17.25	0.02788	0.11150	2.52167	4312	390055	435.21
1050	17.50	0.02689	0.10754	2.54856	4159	394214	435.21
1065	17.75	0.02589	0.10358	2.57445	4005	398219	435.21
1080	18.00	0.02490	0.09962	2.59936	3852	402071	435.22
1095	18.25	0.02292	0.09169	2.62228	3546	405617	435.22
1110	18.50	0.02193	0.08773	2.64421	3393	409010	435.22
1125	18.75	0.02094	0.08377	2.66515	3239	412249	435.22
1140	19.00	0.01995	0.07981	2.68510	3086	415335	435.22
1155	19.25	0.01995	0.07981	2.70506	3086	418421	435.23
1170	19.50	0.01995	0.07981	2.72501	3086	421507	435.23
1185	19.75	0.01896	0.07584	2.74397	2933	424440	435.23
1200	20.00	0.01896	0.07584	2.76293	2933	427373	435.23
1215	20.25	0.01896	0.07584	2.78189	2933	430306	435.23
1230	20.50	0.01797	0.07188	2.79986	2780	433086	435.23
1245	20.75	0.01797	0.07188	2.81783	2780	435865	435.24
1260	21.00	0.01797	0.07188	2.83580	2780	438645	435.24
1275	21.25	0.01599	0.06396	2.85179	2473	441118	435.24
1290	21.50	0.01387	0.05547	2.86566	2145	443263	435.24
1305	21.75	0.01189	0.04754	2.87754	1839	445102	435.24
1320	22.00	0.00991	0.03962	2.88745	1532	446634	435.24
1335	22.25	0.00792	0.03170	2.89537	1226	447860	435.24
1350	22.50	0.00594	0.02377	2.90132	919	448779	435.24
1365	22.75	0.00396	0.01585	2.90528	613	449392	435.24
1380	23.00	0.00198	0.00792	2.90726	306	449698	435.24
1395	23.25	0.00000	0.00000	2.90726	0	449698	435.24
1410	23.50	0.00000	0.00000	2.90726	0	449698	435.24
1425	23.75	0.00000	0.00000	2.90726	0	449698	435.24
1440	24.00	0.00000	0.00000	2.90726	0	449698	435.24
1455	24.25	0.00000	0.00000	2.90726	0	449698	435.24
1470	24.50	0.00000	0.00000	2.90726	0	449698	435.24
1485	24.75	0.00000	0.00000	2.90726	0	449698	435.24
1500	25.00	0.00000	0.00000	2.90726	0	449698	435.24
1515	25.25	0.00000	0.00000	2.90726	0	449698	435.24
1530	25.50	0.00000	0.00000	2.90726	0	449698	435.24
1545	25.75	0.00000	0.00000	2.90726	0	449698	435.24
1560	26.00	0.00000	0.00000	2.90726	0	449698	435.24
1575	26.25	0.00000	0.00000	2.90726	0	449698	435.24
1590	26.50	0.00000	0.00000	2.90726	0	449698	435.24
1605	26.75	0.00000	0.00000	2.90726	0	449698	435.24
1620	27.00	0.00000	0.00000	2.90726	0	449698	435.24
1635	27.25	0.00000	0.00000	2.90726	0	449698	435.24

1650	27.50	0.00000	0.00000	2.90726	0	449698	435.24
1665	27.75	0.00000	0.00000	2.90726	0	449698	435.24
1680	28.00	0.00000	0.00000	2.90726	0	449698	435.24
1695	28.25	0.00000	0.00000	2.90726	0	449698	435.24
1710	28.50	0.00000	0.00000	2.90726	0	449698	435.24
1725	28.75	0.00000	0.00000	2.90726	0	449698	435.24
1740	29.00	0.00000	0.00000	2.90726	0	449698	435.24
1755	29.25	0.00000	0.00000	2.90726	0	449698	435.24
1770	29.50	0.00000	0.00000	2.90726	0	449698	435.24
1785	29.75	0.00000	0.00000	2.90726	0	449698	435.24
1800	30.00	0.00000	0.00000	2.90726	0	449698	435.24
1815	30.25	0.00000	0.00000	2.90726	0	449698	435.24
1830	30.50	0.00000	0.00000	2.90726	0	449698	435.24
1845	30.75	0.00000	0.00000	2.90726	0	449698	435.24
1860	31.00	0.00000	0.00000	2.90726	0	449698	435.24
1875	31.25	0.00000	0.00000	2.90726	0	449698	435.24
1890	31.50	0.00000	0.00000	2.90726	0	449698	435.24
1905	31.75	0.00000	0.00000	2.90726	0	449698	435.24
1920	32.00	0.00000	0.00000	2.90726	0	449698	435.24
1935	32.25	0.00000	0.00000	2.90726	0	449698	435.24
1950	32.50	0.00000	0.00000	2.90726	0	449698	435.24
1965	32.75	0.00000	0.00000	2.90726	0	449698	435.24
1980	33.00	0.00000	0.00000	2.90726	0	449698	435.24
1995	33.25	0.00000	0.00000	2.90726	0	449698	435.24
2010	33.50	0.00000	0.00000	2.90726	0	449698	435.24
2025	33.75	0.00000	0.00000	2.90726	0	449698	435.24
2040	34.00	0.00000	0.00000	2.90726	0	449698	435.24
2055	34.25	0.00000	0.00000	2.90726	0	449698	435.24
2070	34.50	0.00000	0.00000	2.90726	0	449698	435.24
2085	34.75	0.00000	0.00000	2.90726	0	449698	435.24
2100	35.00	0.00000	0.00000	2.90726	0	449698	435.24
2115	35.25	0.00000	0.00000	2.90726	0	449698	435.24
2130	35.50	0.00000	0.00000	2.90726	0	449698	435.24
2145	35.75	0.00000	0.00000	2.90726	0	449698	435.24
2160	36.00	0.00000	0.00000	2.90726	0	449698	435.24
2175	36.25	0.00000	0.00000	2.90726	0	449698	435.24
2190	36.50	0.00000	0.00000	2.90726	0	449698	435.24
2205	36.75	0.00000	0.00000	2.90726	0	449698	435.24
2220	37.00	0.00000	0.00000	2.90726	0	449698	435.24
2235	37.25	0.00000	0.00000	2.90726	0	449698	435.24
2250	37.50	0.00000	0.00000	2.90726	0	449698	435.24
2265	37.75	0.00495	0.01981	2.91221	766	450464	435.24
2280	38.00	0.00991	0.03962	2.92212	1532	451996	435.24
2295	38.25	0.01486	0.05943	2.93697	2298	454295	435.25
2310	38.50	0.01995	0.07981	2.95693	3086	457381	435.25
2325	38.75	0.02490	0.09962	2.98183	3852	461233	435.25
2340	39.00	0.02986	0.11943	3.01169	4618	465851	435.25
2355	39.25	0.03495	0.13980	3.04664	5406	471257	435.25
2370	39.50	0.03594	0.14376	3.08258	5559	476817	435.26
2385	39.75	0.03693	0.14773	3.11951	5713	482529	435.26
2400	40.00	0.03891	0.15565	3.15842	6019	488548	435.26
2415	40.25	0.03990	0.15961	3.19832	6172	494721	435.27
2430	40.50	0.04089	0.16357	3.23922	6325	501046	435.27
2445	40.75	0.04089	0.16357	3.28011	6325	507371	435.27
2460	41.00	0.04188	0.16754	3.32200	6479	513850	435.28
2475	41.25	0.04188	0.16754	3.36388	6479	520329	435.28
2490	41.50	0.04188	0.16754	3.40576	6479	526807	435.29
2505	41.75	0.04287	0.17150	3.44864	6632	533439	435.29
2520	42.00	0.04287	0.17150	3.49151	6632	540071	435.29
2535	42.25	0.04287	0.17150	3.53439	6632	546703	435.30
2550	42.50	0.04387	0.17546	3.57825	6785	553488	435.30

2565	42.75	0.04387	0.17546	3.62212	6785	560273	435.30
2580	43.00	0.04387	0.17546	3.66598	6785	567058	435.31
2595	43.25	0.04387	0.17546	3.70985	6785	573843	435.31
2610	43.50	0.04387	0.17546	3.75371	6785	580629	435.32
2625	43.75	0.04486	0.17942	3.79857	6938	587567	435.32
2640	44.00	0.04698	0.18791	3.84555	7267	594833	435.32
2655	44.25	0.04896	0.19584	3.89450	7573	602406	435.33
2670	44.50	0.05094	0.20376	3.94544	7879	610286	435.33
2685	44.75	0.05292	0.21168	3.99837	8186	618472	435.34
2700	45.00	0.05490	0.21961	4.05327	8492	626964	435.34
2715	45.25	0.05688	0.22753	4.11015	8799	635763	435.35
2730	45.50	0.05886	0.23546	4.16901	9105	644868	435.35
2745	45.75	0.06099	0.24395	4.23000	9433	654301	435.36
2760	46.00	0.06297	0.25187	4.29297	9740	664041	435.36
2775	46.25	0.06495	0.25979	4.35792	10046	674088	435.37
2790	46.50	0.06693	0.26772	4.42485	10353	684440	435.37
2805	46.75	0.06891	0.27564	4.49376	10659	695100	435.38
2820	47.00	0.07089	0.28357	4.56465	10966	706065	435.38
2835	47.25	0.07287	0.29149	4.63752	11272	717337	435.39
2850	47.50	0.07485	0.29941	4.71237	11578	728916	435.40
2865	47.75	0.07896	0.31583	4.79133	12213	741129	435.40
2880	48.00	0.08094	0.32375	4.87227	12520	753648	435.41
2895	48.25	0.08292	0.33168	4.95519	12826	766474	435.42
2910	48.50	0.08589	0.34356	5.04108	13286	779760	435.42
2925	48.75	0.08985	0.35941	5.13093	13898	793658	435.43
2940	49.00	0.09198	0.36790	5.22291	14227	807885	435.44
2955	49.25	0.09396	0.37582	5.31686	14533	822418	435.45
2970	49.50	0.09594	0.38375	5.41280	14840	837258	435.46
2985	49.75	0.09792	0.39167	5.51072	15146	852404	435.46
3000	50.00	0.10287	0.41148	5.61359	15912	868316	435.47
3015	50.25	0.10995	0.43978	5.72353	17006	885323	435.48
3030	50.50	0.11688	0.46752	5.84041	18079	903402	435.49
3045	50.75	0.11985	0.47940	5.96026	18539	921940	435.50
3060	51.00	0.12494	0.49978	6.08521	19327	941267	435.51
3075	51.25	0.12990	0.51959	6.21510	20093	961360	435.52
3090	51.50	0.13485	0.53940	6.34995	20859	982218	435.54
3105	51.75	0.13994	0.55977	6.48990	21647	1003865	435.55
3120	52.00	0.14490	0.57958	6.63479	22413	1026278	435.56
3135	52.25	0.14985	0.59939	6.78464	23179	1049456	435.57
3150	52.50	0.15990	0.63958	6.94454	24733	1074189	435.59
3165	52.75	0.16994	0.67977	7.11448	26287	1100476	435.60
3180	53.00	0.17985	0.71939	7.29433	27819	1128295	435.62
3195	53.25	0.19485	0.77938	7.48917	30139	1158434	435.63
3210	53.50	0.22994	0.91975	7.71911	35567	1194001	435.65
3225	**53.75**	0.46978	**1.87912**	8.18889	72666	1266667	435.69
3240	54.00	0.23984	0.95937	8.42873	37099	1303766	435.71
3255	54.25	0.22994	0.91975	8.65867	35567	1339333	435.73
3270	54.50	0.20984	0.83938	8.86851	32459	1371792	435.75
3285	54.75	0.18989	0.75957	9.05841	29373	1401165	435.77
3300	55.00	0.17489	0.69958	9.23330	27053	1428218	435.78
3315	55.25	0.16485	0.65939	9.39815	25499	1453716	435.79
3330	55.50	0.15494	0.61977	9.55309	23967	1477683	435.81
3345	55.75	0.14985	0.59939	9.70294	23179	1500862	435.82
3360	56.00	0.14490	0.57958	9.84783	22413	1523274	435.83
3375	56.25	0.13994	0.55977	9.98778	21647	1544921	435.84
3390	56.50	0.13683	0.54732	10.12461	21165	1566086	435.86
3405	56.75	0.13386	0.53544	10.25847	20705	1586792	435.87
3420	57.00	0.13287	0.53147	10.39134	20552	1607344	435.88
3435	57.25	0.13188	0.52751	10.52321	20399	1627743	435.89
3450	57.50	0.12990	0.51959	10.65311	20093	1647836	435.90
3465	57.75	0.12693	0.50770	10.78004	19633	1667469	435.91

3480	58.00	0.12296	0.49185	10.90300	19020	1686489	435.92
3495	58.25	0.12084	0.48336	11.02384	18692	1705181	435.93
3510	58.50	0.11985	0.47940	11.14369	18539	1723719	435.94
3525	58.75	0.11787	0.47148	11.26156	18232	1741951	435.95
3540	59.00	0.11688	0.46752	11.37844	18079	1760030	435.96
3555	59.25	0.11688	0.46752	11.49532	18079	1778109	435.97
3570	59.50	0.11589	0.46355	11.61121	17926	1796035	435.98
3585	59.75	0.11589	0.46355	11.72710	17926	1813961	435.99
3600	60.00	0.11589	0.46355	11.84298	17926	1831887	436.00
3615	60.25	0.11490	0.45959	11.95788	17773	1849659	436.01
3630	60.50	0.11292	0.45167	12.07080	17466	1867125	436.02
3645	60.75	0.10896	0.43582	12.17975	16853	1883979	436.03
3660	61.00	0.10485	0.41941	12.28461	16219	1900197	436.04
3675	61.25	0.10089	0.40356	12.38550	15606	1915803	436.05
3690	61.50	0.09693	0.38771	12.48242	14993	1930796	436.06
3705	61.75	0.09297	0.37186	12.57539	14380	1945176	436.06
3720	62.00	0.08886	0.35545	12.66425	13745	1958921	436.07
3735	62.25	0.07995	0.31979	12.74420	12366	1971287	436.08
3750	62.50	0.06990	0.27960	12.81410	10812	1982100	436.08
3765	62.75	0.06396	0.25583	12.87806	9893	1991993	436.09
3780	63.00	0.05886	0.23546	12.93692	9105	2001098	436.09
3795	63.25	0.05490	0.21961	12.99182	8492	2009590	436.10
3810	63.50	0.05193	0.20772	13.04375	8033	2017623	436.10
3825	63.75	0.04896	0.19584	13.09271	7573	2025196	436.11
3840	64.00	0.04698	0.18791	13.13969	7267	2032463	436.11
3855	64.25	0.04486	0.17942	13.18455	6938	2039401	436.12
3870	64.50	0.04387	0.17546	13.22841	6785	2046186	436.12
3885	64.75	0.04188	0.16754	13.27029	6479	2052665	436.12
3900	65.00	0.04089	0.16357	13.31119	6325	2058990	436.13
3915	65.25	0.03990	0.15961	13.35109	6172	2065162	436.13
3930	65.50	0.03990	0.15961	13.39099	6172	2071335	436.13
3945	65.75	0.03891	0.15565	13.42991	6019	2077354	436.14
3960	66.00	0.03891	0.15565	13.46882	6019	2083373	436.14
3975	66.25	0.03891	0.15565	13.50773	6019	2089392	436.14
3990	66.50	0.03792	0.15169	13.54565	5866	2095257	436.15
4005	66.75	0.03792	0.15169	13.58358	5866	2101123	436.15
4020	67.00	0.03693	0.14773	13.62051	5713	2106836	436.15
4035	67.25	0.03693	0.14773	13.65744	5713	2112549	436.16
4050	67.50	0.03693	0.14773	13.69437	5713	2118261	436.16
4065	67.75	0.03594	0.14376	13.73031	5559	2123821	436.16
4080	68.00	0.03594	0.14376	13.76625	5559	2129380	436.16
4095	68.25	0.03495	0.13980	13.80120	5406	2134786	436.17
4110	68.50	0.03495	0.13980	13.83615	5406	2140192	436.17
4125	68.75	0.03495	0.13980	13.87110	5406	2145598	436.17
4140	69.00	0.03297	0.13188	13.90407	5100	2150698	436.18
4155	69.25	0.03099	0.12395	13.93506	4793	2155492	436.18
4170	69.50	0.02986	0.11943	13.96492	4618	2160110	436.18
4185	69.75	0.02788	0.11150	13.99279	4312	2164422	436.18
4200	70.00	0.02689	0.10754	14.01968	4159	2168580	436.19
4215	70.25	0.02589	0.10358	14.04557	4005	2172586	436.19
4230	70.50	0.02391	0.09565	14.06949	3699	2176285	436.19
4245	70.75	0.02094	0.08377	14.09043	3239	2179524	436.19
4260	71.00	0.01797	0.07188	14.10840	2780	2182304	436.19
4275	71.25	0.01486	0.05943	14.12326	2298	2184602	436.20
4290	71.50	0.01189	0.04754	14.13514	1839	2186440	436.20
4305	71.75	0.00891	0.03566	14.14406	1379	2187819	436.20
4320	72.00	0.00594	0.02377	14.15000	919	2188739	436.20

Peak =	0.46978	1.87912

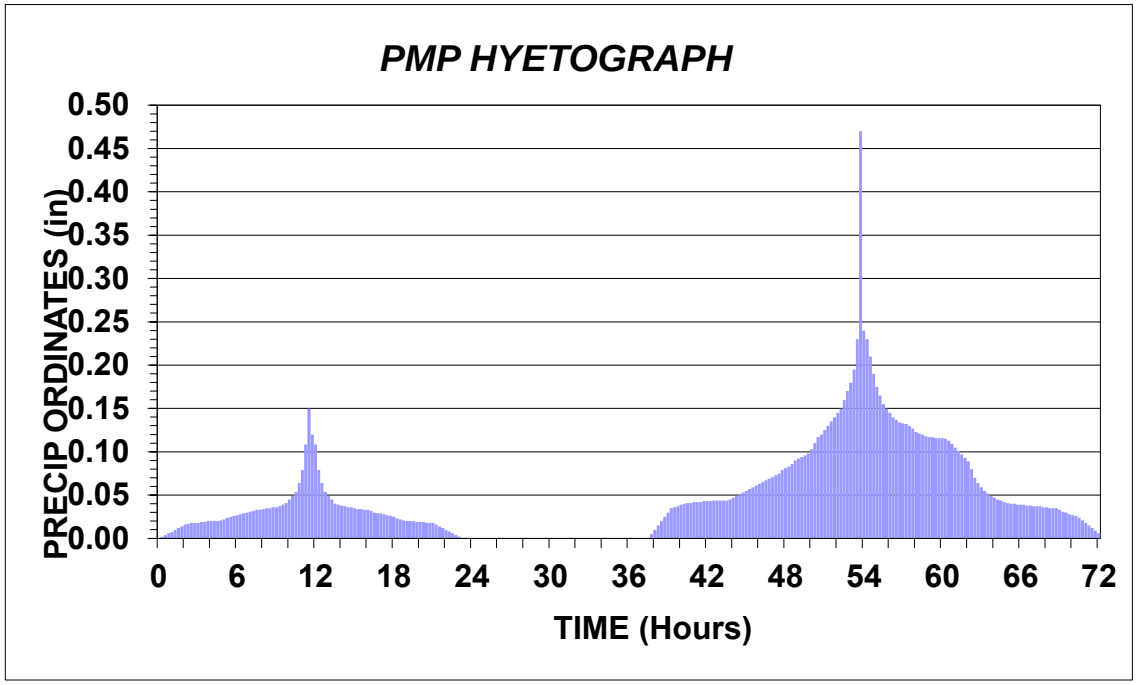
Total Storm Precip = 14.15 inches

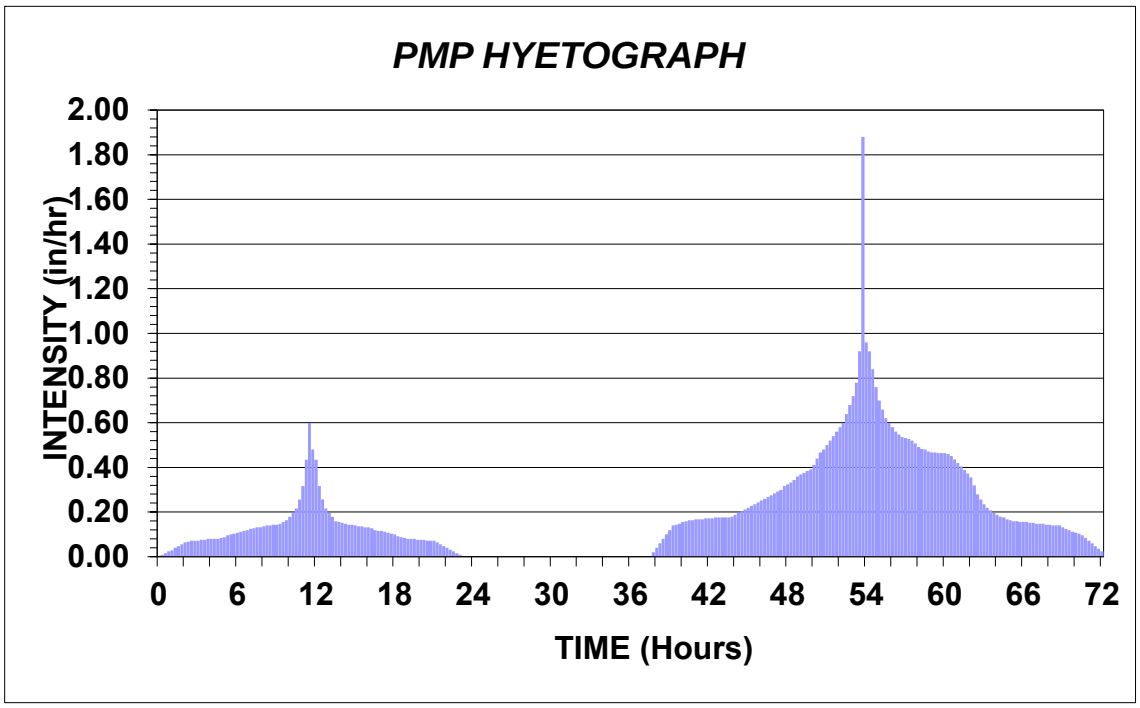
Total storm multiplier = **1.4153**

1811569 SF
1856174 SF

(For reference only; already factored into unit storm hyetograph.)

Peak intensity factor = **1.87912**



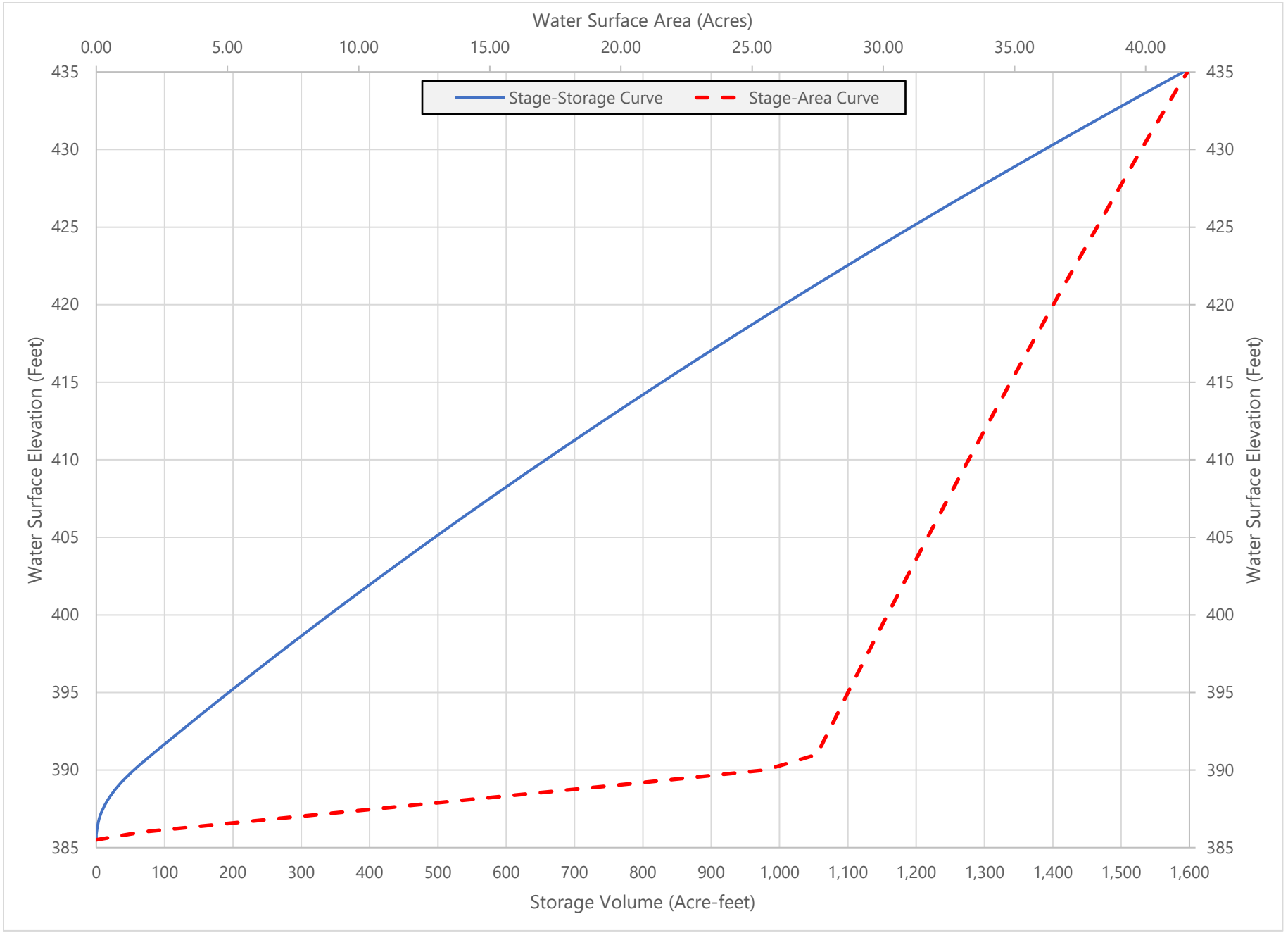


Appendix E
Stage-Storage-Area Table

Dungeness Off-Channel Reservoir
Stage-Storage-Area Relationship

Elevation (feet)	Depth (feet)	Area (SF)	Area (Acres)	Volume (Acre-feet)
385.50	0.00	100	0.00	0.00
386.00	0.50	76,352	1.75	0.44
387.00	1.50	333,332	7.65	5.14
388.00	2.50	593,680	13.63	15.78
389.00	3.50	857,253	19.68	32.44
390.00	4.50	1,110,591	25.50	55.02
391.00	5.50	1,196,894	27.48	81.51
392.00	6.50	1,209,627	27.77	109.13
393.00	7.50	1,222,417	28.06	137.05
394.00	8.50	1,235,264	28.36	165.26
395.00	9.50	1,248,167	28.65	193.77
396.00	10.50	1,261,126	28.95	222.57
397.00	11.50	1,274,142	29.25	251.67
398.00	12.50	1,287,215	29.55	281.07
399.00	13.50	1,300,344	29.85	310.77
400.00	14.50	1,313,530	30.15	340.77
401.00	15.50	1,326,772	30.46	371.08
402.00	16.50	1,340,070	30.76	401.69
403.00	17.50	1,353,426	31.07	432.61
404.00	18.50	1,366,837	31.38	463.83
405.00	19.50	1,380,306	31.69	495.37
406.00	20.50	1,393,830	32.00	527.21
407.00	21.50	1,407,412	32.31	559.36
408.00	22.50	1,421,050	32.62	591.83
409.00	23.50	1,434,744	32.94	624.61
410.00	24.50	1,448,495	33.25	657.70
411.00	25.50	1,462,302	33.57	691.11
412.00	26.50	1,476,166	33.89	724.84
413.00	27.50	1,490,087	34.21	758.89
414.00	28.50	1,504,064	34.53	793.26
415.00	29.50	1,518,097	34.85	827.95
416.00	30.50	1,532,187	35.17	862.96
417.00	31.50	1,546,334	35.50	898.30
418.00	32.50	1,560,537	35.82	933.96
419.00	33.50	1,574,797	36.15	969.95
420.00	34.50	1,589,113	36.48	1,006.27
421.00	35.50	1,603,485	36.81	1,042.91
422.00	36.50	1,617,915	37.14	1,079.89

423.00	37.50	1,632,400	37.47	1,117.20
424.00	38.50	1,646,943	37.81	1,154.84
425.00	39.50	1,661,542	38.14	1,192.81
426.00	40.50	1,676,197	38.48	1,231.13
427.00	41.50	1,690,913	38.82	1,269.78
428.00	42.50	1,705,698	39.16	1,308.76
429.00	43.50	1,720,553	39.50	1,348.09
430.00	44.50	1,735,475	39.84	1,387.76
431.00	45.50	1,750,466	40.19	1,427.77
432.00	46.50	1,765,527	40.53	1,468.13
433.00	47.50	1,780,657	40.88	1,508.84
434.00	48.50	1,795,856	41.23	1,549.89
435.00	49.50	1,812,035	41.60	1,591.30


Water Surface Area (Acres)
0.00
5.00
10.00
15.00
20.00
25.00
30.00
35.00
40.00
Stage-Storage Curve
Stage-Area Curve
Water Surface Elevation (Feet)
435
430
425
420
415
410
405
400
395
390
385
0
100
200
300
400
500
600
700
800
900
1,000
1,100
1,200
1,300
1,400
1,500
1,600
Storage Volume (Acre-feet)

Appendix F
Spillway Sizing Calculations

Spreadsheet Version 1.0 (08/1/02)

Pipe Drop Inlet Hydraulics
Circular Riser

Computed By:	*Adam Hill, P.E.*	*Landowner:*	*Dungeness Reservoir*	*12/29/21*
Checked By:		*Town:*	*Sequim*	

Design Discharge (cfs) *300*

Riser Information

Diameter (in)	*96*
Riser Crest Elevation (ft)	*435*

Barrel Information

Diameter (in)	*36*
Pipe Length (ft)	*50*
Barrel Inlet Elevation (ft)	*427.25*
Barrel Outlet Elevation (ft)	*426.75*
Pipe Type	*Smooth PE*
Barrel Orifice Coefficient (C)	*0.7*
Tailwater Elevation (ft)	
Elbow Elevation (ft)	
Length of Outlet (ft)	

Hydraulics Table Information

Beginning Elevation (ft)	*435*
Elevation Increment (ft)	*0.01*

Results

Weir Length (ft)	*24.63*	Manning's n	*0.010*
Riser Area (sq.ft.)	*50.27*	Ke	*1*
Riser Height (ft.)	*7.75*	Kp	*0.0043*
Barrel Area (sq. ft.)	*7.07*	Tailwater Elevation	*429.00*

Minimum HW Elevation for:	Weir Flow	*437.49*
	Inlet Orifice Flow	*436.54*
	Barrel Orifice Flow	*506.44*
	Full Pipe Flow	*490.92*
Barrel orifice controls with headwater elevation =		**506.44**

Press to Compute the Following Additional Information

Pipe Slope (ft/ft)	*0.010*
Friction Slope (ft/ft)	*0.120*
Elbow Angle (degrees)	*0.000*

For the size and type of riser and barrel entered

Max elev of barrel invert to prevent barrel orifice flow (ft):	*428.06*
Minimum riser height to prevent barrel orifice flow (ft):	*6.94*
Minimum riser diameter to prevent inlet orifice flow (in):	*59.47*

Hydraulics Table

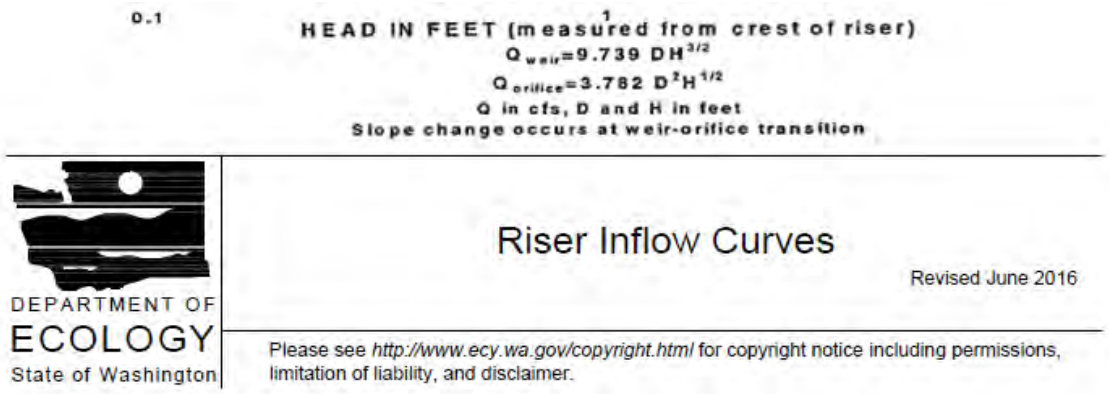
W.S. Elev. (ft)	Weir Flow (cfs)	Pipe Flow (cfs)	Barrel Orifice (cfs)	Inlet Orifice (cfs)	Controlling (cfs)	(type)
435.00	0.00	93.39	99.27	0.00	0.00	Weir Flow
435.01	0.08	93.46	99.35	24.20	0.08	Weir Flow
435.02	0.22	93.54	99.43	34.23	0.22	Weir Flow
435.03	0.40	93.62	99.51	41.92	0.40	Weir Flow
435.04	0.61	93.70	99.59	48.41	0.61	Weir Flow
435.05	0.85	93.77	99.67	54.12	0.85	Weir Flow
435.06	1.12	93.85	99.74	59.28	1.12	Weir Flow
435.07	1.41	93.93	99.82	64.03	1.41	Weir Flow
435.08	1.73	94.01	99.90	68.46	1.73	Weir Flow
435.09	2.06	94.08	99.98	72.61	2.06	Weir Flow
435.10	2.41	94.16	100.06	76.54	2.41	Weir Flow
435.11	2.79	94.24	100.14	80.27	2.79	Weir Flow
435.12	3.17	94.32	100.22	83.84	3.17	Weir Flow
435.13	3.58	94.39	100.30	87.26	3.58	Weir Flow
435.14	4.00	94.47	100.37	90.56	4.00	Weir Flow
435.15	4.44	94.55	100.45	93.74	4.44	Weir Flow
435.16	4.89	94.62	100.53	96.81	4.89	Weir Flow
435.17	5.35	94.70	100.61	99.79	5.35	Weir Flow
435.18	5.83	94.78	100.69	102.68	5.83	Weir Flow
435.19	6.32	94.85	100.77	105.50	6.32	Weir Flow
435.20	6.83	94.93	100.84	108.24	6.83	Weir Flow
435.21	7.35	95.01	100.92	110.91	7.35	Weir Flow
435.22	7.88	95.08	101.00	113.52	7.88	Weir Flow
435.23	8.42	95.16	101.08	116.07	8.42	Weir Flow
435.24	8.98	95.24	101.16	118.57	8.98	Weir Flow
435.25	9.55	95.31	101.23	121.01	9.55	Weir Flow
435.26	10.12	95.39	101.31	123.41	10.12	Weir Flow
435.27	10.71	95.46	101.39	125.76	10.71	Weir Flow
435.28	11.31	95.54	101.47	128.07	11.31	Weir Flow
435.29	11.93	95.62	101.55	130.34	11.93	Weir Flow
435.30	12.55	95.69	101.62	132.56	12.55	Weir Flow
435.31	13.18	95.77	101.70	134.75	13.18	Weir Flow
435.32	13.82	95.84	101.78	136.91	13.82	Weir Flow

Hydraulics Table						
W.S. Elev. (ft)	Weir Flow (cfs)	Pipe Flow (cfs)	Barrel Orifice (cfs)	Inlet Orifice (cfs)	Controlling (cfs)	(type)
435.33	14.48	95.92	101.86	139.03	14.48	Weir Flow
435.34	15.14	96.00	101.93	141.12	15.14	Weir Flow
435.35	15.81	96.07	102.01	143.19	15.81	Weir Flow
435.36	16.49	96.15	102.09	145.22	16.49	Weir Flow
435.37	17.19	96.22	102.17	147.22	17.19	Weir Flow
435.38	17.89	96.30	102.24	149.20	17.89	Weir Flow
435.39	18.60	96.37	102.32	151.15	18.60	Weir Flow
435.40	19.32	96.45	102.40	153.07	19.32	Weir Flow
435.41	20.05	96.52	102.47	154.97	20.05	Weir Flow
435.42	20.78	96.60	102.55	156.85	20.78	Weir Flow
435.43	21.53	96.67	102.63	158.71	21.53	Weir Flow
435.44	22.29	96.75	102.70	160.54	22.29	Weir Flow
435.45	23.05	96.82	102.78	162.36	23.05	Weir Flow
435.46	23.82	96.90	102.86	164.15	23.82	Weir Flow
435.47	24.60	96.97	102.93	165.93	24.60	Weir Flow
435.48	25.39	97.05	103.01	167.68	25.39	Weir Flow
435.49	26.19	97.12	103.09	169.42	26.19	Weir Flow
435.50	27.00	97.20	103.16	171.14	27.00	Weir Flow
435.51	27.81	97.27	103.24	172.84	27.81	Weir Flow
435.52	28.63	97.35	103.32	174.53	28.63	Weir Flow
435.53	29.46	97.42	103.39	176.20	29.46	Weir Flow
435.54	30.30	97.50	103.47	177.85	30.30	Weir Flow
435.55	31.15	97.57	103.54	179.49	31.15	Weir Flow
435.56	32.00	97.65	103.62	181.12	32.00	Weir Flow
435.57	32.86	97.72	103.70	182.73	32.86	Weir Flow
435.58	33.73	97.80	103.77	184.32	33.73	Weir Flow
435.59	34.61	97.87	103.85	185.90	34.61	Weir Flow
435.60	35.49	97.94	103.92	187.47	35.49	Weir Flow
435.61	36.38	98.02	104.00	189.03	36.38	Weir Flow
435.62	37.28	98.09	104.08	190.57	37.28	Weir Flow
435.63	38.18	98.17	104.15	192.10	38.18	Weir Flow
435.64	39.10	98.24	104.23	193.62	39.10	Weir Flow
435.65	40.02	98.31	104.30	195.13	40.02	Weir Flow
435.66	40.94	98.39	104.38	196.62	40.94	Weir Flow
435.67	41.88	98.46	104.45	198.11	41.88	Weir Flow
435.68	42.82	98.54	104.53	199.58	42.82	Weir Flow

Spillway Riser Inflow Sizing

Assumptions:

Q_{design}:	50 cfs
Design Head:	<1 ft



Spillway Riser Sizing Options

Riser Diameter D (in)	Design Head H (in)	Q Weir (cfs)	Check
72	6	20.7	FAIL
72	9	38.0	FAIL
84	6	24.1	FAIL
84	9	44.3	FAIL
96	6	27.5	FAIL
96	9	50.6	OKAY
108	6	31.0	FAIL
108	9	56.9	OKAY

Appendix G
Settling Basin Sizing Calculations

Dungeness River Fish Screen Settling Basin
Settling Velocity

Assumptions:

Q_{design}:	25 cfs	
Settling Particle Size:	0.0625 mm	U.S. 230 Sieve
Settling Velocity, v:	0.0115 fps	

Sediment Basin Sizing Options:

B (feet)	Sideslopes (feet H:1V)	D (feet)	A (sf)	V (fps)	L (feet)
10	3	1	13.0	1.923	167.2
10	3	2	32.0	0.781	135.9
11	3	1	14.0	1.786	155.3
11	3	2	34.0	0.735	127.9
12	3	1	15.0	1.667	144.9
12	3	2	36.0	0.694	120.8
13	3	1	16.0	1.563	135.9
13	3	2	38.0	0.658	114.4
14	3	1	17.0	1.471	127.9
14	3	2	40.0	0.625	108.7

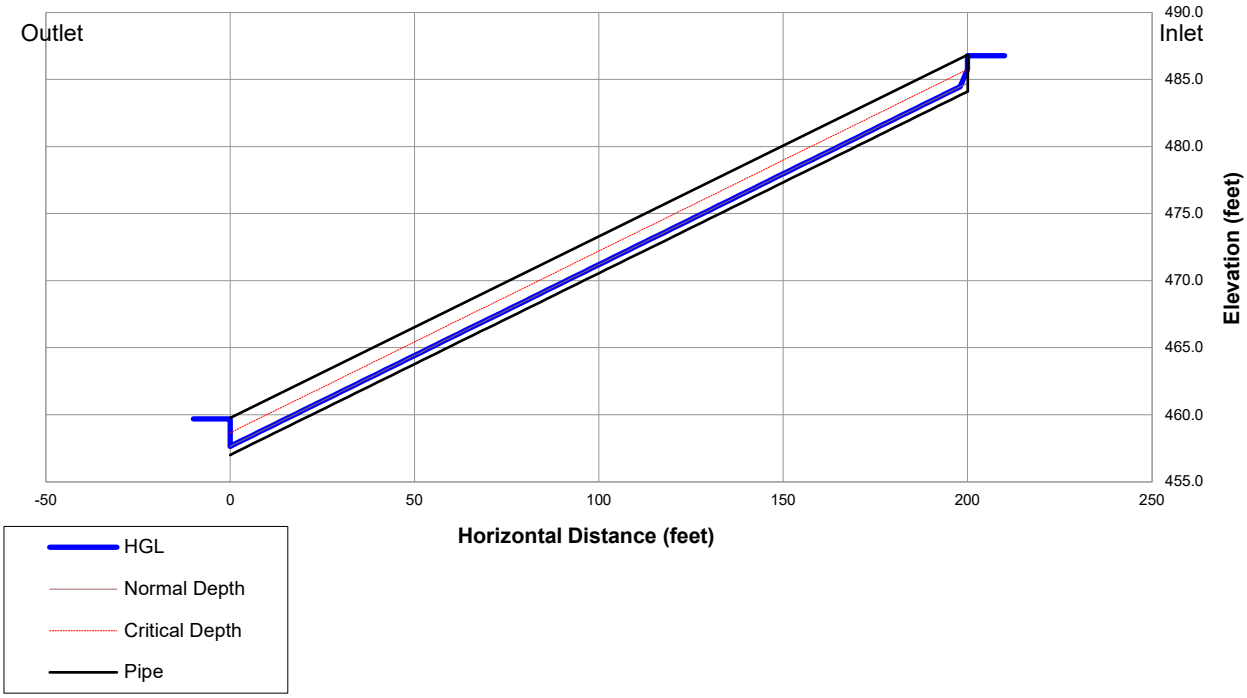
Appendix H
Inlet Pipeline Hydraulic Analysis

Standard Step Backwater Analysis

System: **HID Split to Reservoir**
Reach: **Diversion to River Road**
Design Event: **25 cfs - high diversion rate**

	Outlet	Inlet
Identification	**MH #2**	**SPLIT**
Station	**12+00**	**10+00**
Rim/Overflow Elev. (ft)	460.00	488.00
Invert Elevation (ft)	457.00	484.10
Water Surf. Elev. (ft)	459.69	**486.79**
Discharge (cfs)	25.00	
Diameter (inches)	33.12	
Ineffective Depth(ft)	0.00	
Length (feet)	200.0	
Manning n	0.012	
Entrance Vel. (fps)	0.00	
Entrance Loss (Ke)	0.50	
Slope	0.1355	

Normal Depth (ft)	0.64
Critical Depth (ft)	1.65
Froude No.	6.28
Avg. Velocity (fps)	23.72
Min. Velocity (fps)	6.68
Max. Velocity (fps)	23.89
Normal Velocity (fps)	23.89
Crit. Velocity (fps)	6.68
freeboard @ outlet	0.31
freeboard @ inlet	1.21
Normal EGL (ft)	9.50
Hyd.Jump d/s E	3.98

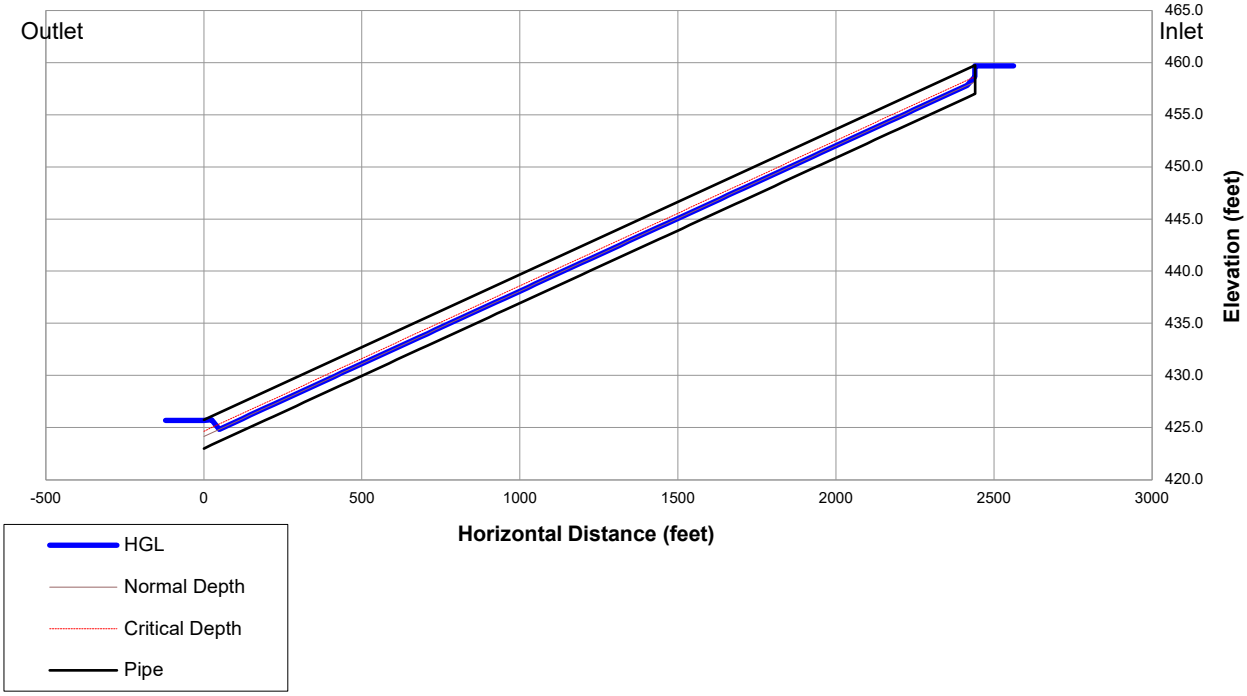


Standard Step Backwater Analysis

System: **HID Split to Reservoir**
Reach: **River Road to BPA Easement**
Design Event: **25 cfs - high diversion rate**

	Outlet	Inlet
Identification	**MH #3**	**MH #2**
Station	**36+40**	**12+00**
Rim/Overflow Elev. (ft)	425.00	460.00
Invert Elevation (ft)	423.00	457.00
Water Surf. Elev. (ft)	425.69	**459.69**
Discharge (cfs)	25.00	
Diameter (inches)	33.12	
Ineffective Depth(ft)	0.00	
Length (feet)	2440.0	
Manning n	0.012	
Entrance Vel. (fps)	0.00	
Entrance Loss (Ke)	0.50	
Slope	0.0139	

Normal Depth (ft)	1.15
Critical Depth (ft)	1.65
Froude No.	1.99
Avg. Velocity (fps)	10.39
Min. Velocity (fps)	4.21
Max. Velocity (fps)	10.55
Normal Velocity (fps)	10.55
Crit. Velocity (fps)	6.68
freeboard @ outlet	-0.69
freeboard @ inlet	0.31
Normal EGL (ft)	2.88
Hyd.Jump d/s E	2.62



Standard Step Backwater Analysis

System: **HID Split to Reservoir**
Reach: **BPA Easement to Reservoir**
Design Event: **25 cfs - high diversion rate**

	Outlet	Inlet
Identification	**RESERVOIR**	**MH #3**
Station	**39+40**	**36+40**
Rim/Overflow Elev. (ft)	393.00	425.00
Invert Elevation (ft)	390.00	423.00
Water Surf. Elev. (ft)	390.00	**425.69**
Discharge (cfs)	25.00	
Diameter (inches)	33.12	
Ineffective Depth(ft)	0.00	
Length (feet)	300.0	
Manning n	0.012	
Entrance Vel. (fps)	0.00	
Entrance Loss (Ke)	0.50	
Slope	0.1100	

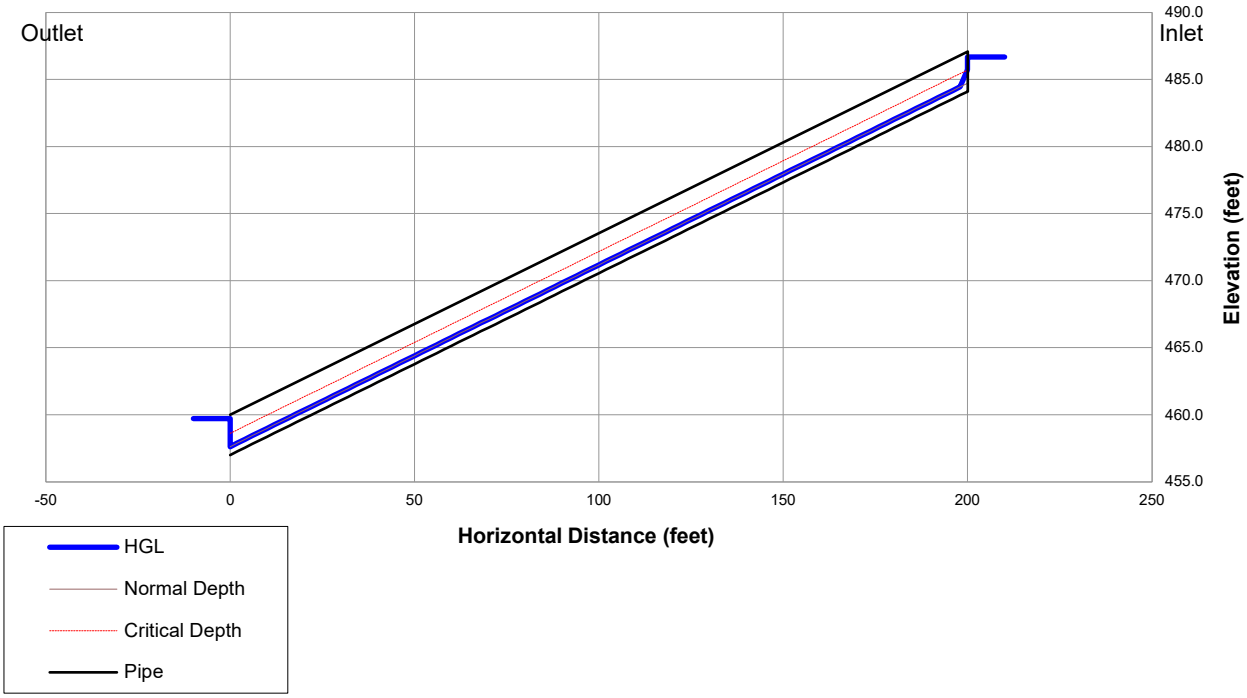
Normal Depth (ft)	0.67
Critical Depth (ft)	1.65
Froude No.	5.67
Avg. Velocity (fps)	22.04
Min. Velocity (fps)	6.68
Max. Velocity (fps)	22.19
Normal Velocity (fps)	22.19
Crit. Velocity (fps)	6.68
freeboard @ outlet	3.00
freeboard @ inlet	-0.69
Normal EGL (ft)	8.32
Hyd.Jump d/s E	3.81

Standard Step Backwater Analysis

System: **HID Split to Reservoir**
Reach: **Diversion to River Road**
Design Event: **25 cfs - high diversion rate**

	Outlet	Inlet
Identification	**MH #2**	**SPLIT**
Station	**12+00**	**10+00**
Rim/Overflow Elev. (ft)	460.00	488.00
Invert Elevation (ft)	457.00	484.10
Water Surf. Elev. (ft)	459.70	**486.68**
Discharge (cfs)	25.00	
Diameter (inches)	36	
Ineffective Depth(ft)	0.00	
Length (feet)	200.0	
Manning n	0.012	
Entrance Vel. (fps)	0.00	
Entrance Loss (Ke)	0.50	
Slope	0.1355	

Normal Depth (ft)	0.62
Critical Depth (ft)	1.61
Froude No.	6.33
Avg. Velocity (fps)	23.51
Min. Velocity (fps)	6.46
Max. Velocity (fps)	23.68
Normal Velocity (fps)	23.68
Crit. Velocity (fps)	6.46
freeboard @ outlet	0.30
freeboard @ inlet	1.32
Normal EGL (ft)	9.33
Hyd.Jump d/s E	3.88

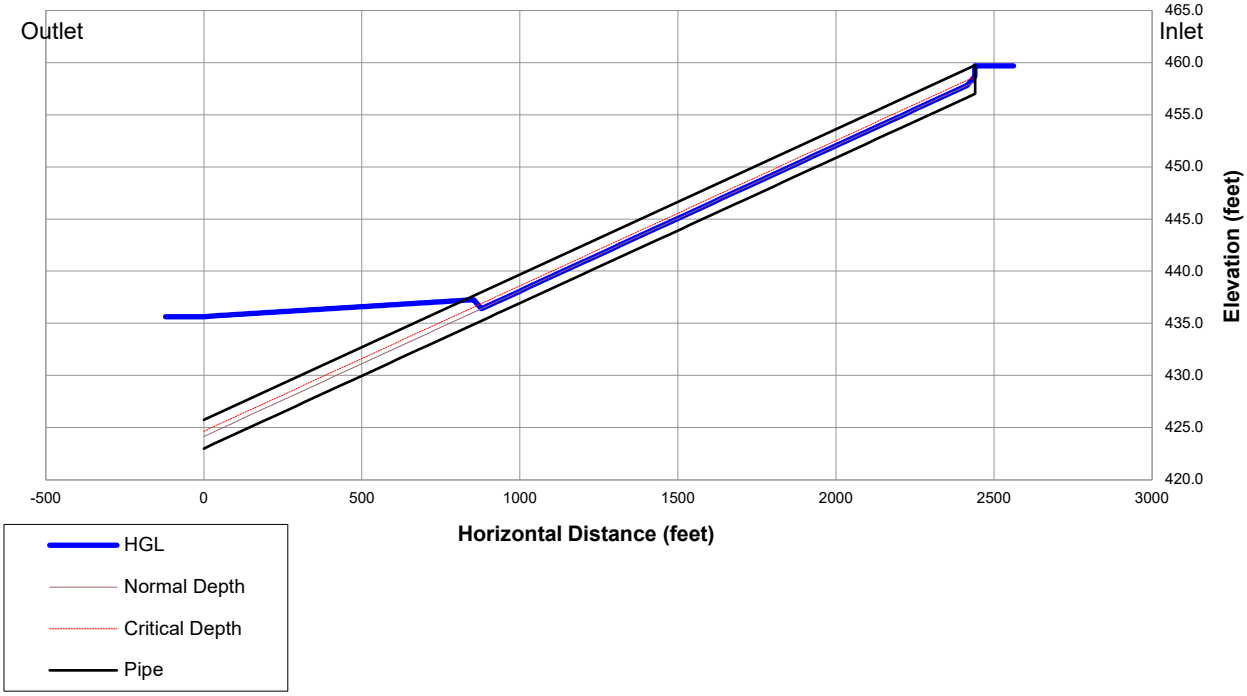


Standard Step Backwater Analysis

System: **HID Split to Reservoir**
Reach: **River Road to BPA Easement**
Design Event: **25 cfs - high diversion rate**

	Outlet	Inlet
Identification	**MH #3**	**MH #2**
Station	**36+40**	**12+00**
Rim/Overflow Elev. (ft)	425.00	460.00
Invert Elevation (ft)	423.00	457.00
Water Surf. Elev. (ft)	435.65	**459.70**
Discharge (cfs)	25.00	
Diameter (inches)	33	
Ineffective Depth(ft)	0.00	
Length (feet)	2440.0	
Manning n	0.012	
Entrance Vel. (fps)	0.00	
Entrance Loss (Ke)	0.50	
Slope	0.0139	

Normal Depth (ft)	1.16
Critical Depth (ft)	1.66
Froude No.	1.99
Avg. Velocity (fps)	8.26
Min. Velocity (fps)	4.21
Max. Velocity (fps)	10.55
Normal Velocity (fps)	10.55
Crit. Velocity (fps)	6.69
freeboard @ outlet	-10.65
freeboard @ inlet	0.30
Normal EGL (ft)	2.88
Hyd.Jump d/s E	2.63

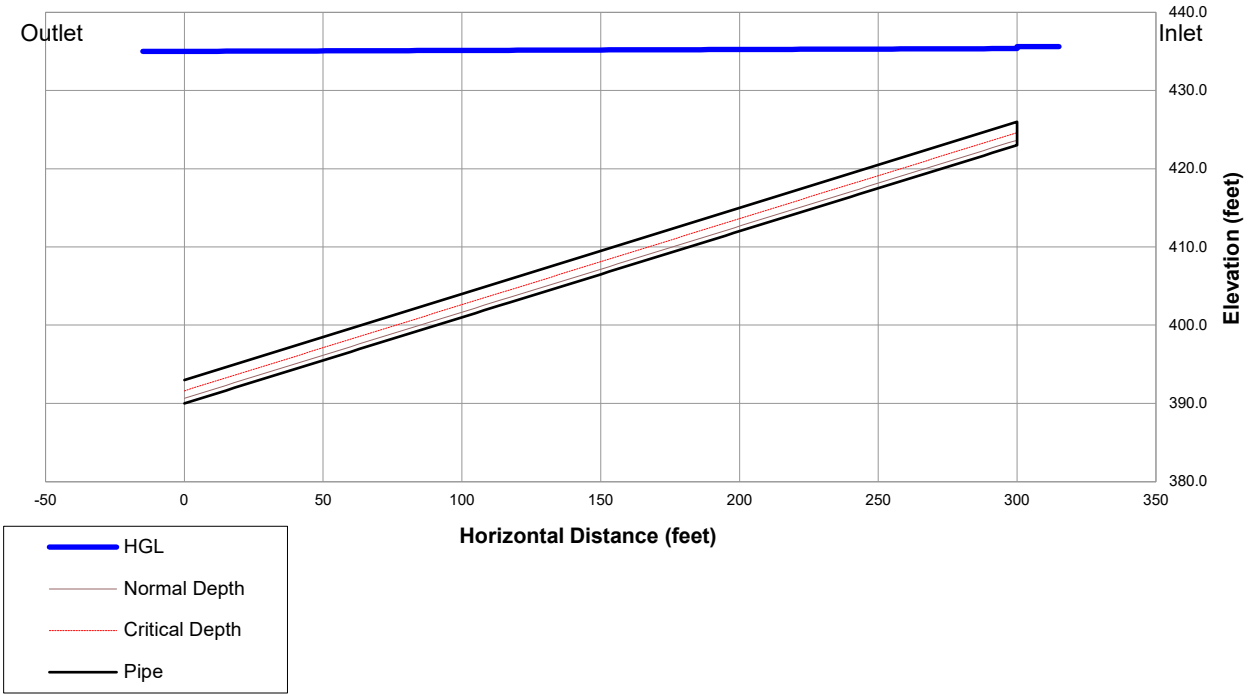


Standard Step Backwater Analysis

System: **HID Split to Reservoir**
Reach: **BPA Easement to Reservoir**
Design Event: **25 cfs - high diversion rate**

	Outlet	Inlet
Identification	**RESERVOIR**	**MH #3**
Station	**39+40**	**36+40**
Rim/Overflow Elev. (ft)	393.00	425.00
Invert Elevation (ft)	390.00	423.00
Water Surf. Elev. (ft)	435.00	**435.65**
Discharge (cfs)	25.00	
Diameter (inches)	36	
Ineffective Depth(ft)	0.00	
Length (feet)	300.0	
Manning n	0.012	
Entrance Vel. (fps)	0.00	
Entrance Loss (Ke)	0.50	
Slope	0.1100	

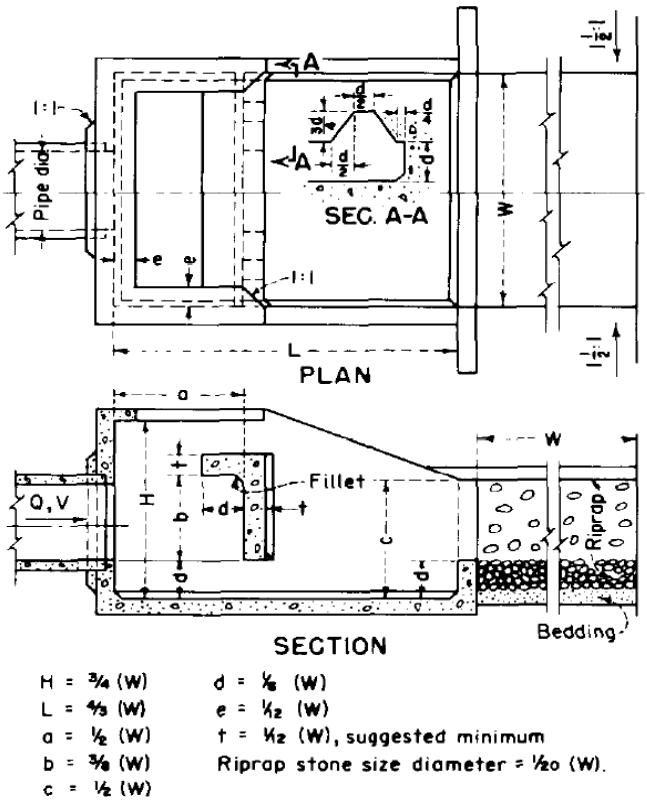
Normal Depth (ft)		0.65
Critical Depth (ft)		1.61
Froude No.		5.72
Avg. Velocity (fps)		3.54
Min. Velocity (fps)		3.54
Max. Velocity (fps)		3.54
Normal Velocity (fps)		21.99
Crit. Velocity (fps)		6.46
freeboard	@ outlet	-42.00
freeboard	@ inlet	-10.65
Normal EGL (ft)		8.16
Hyd.Jump d/s E		3.71

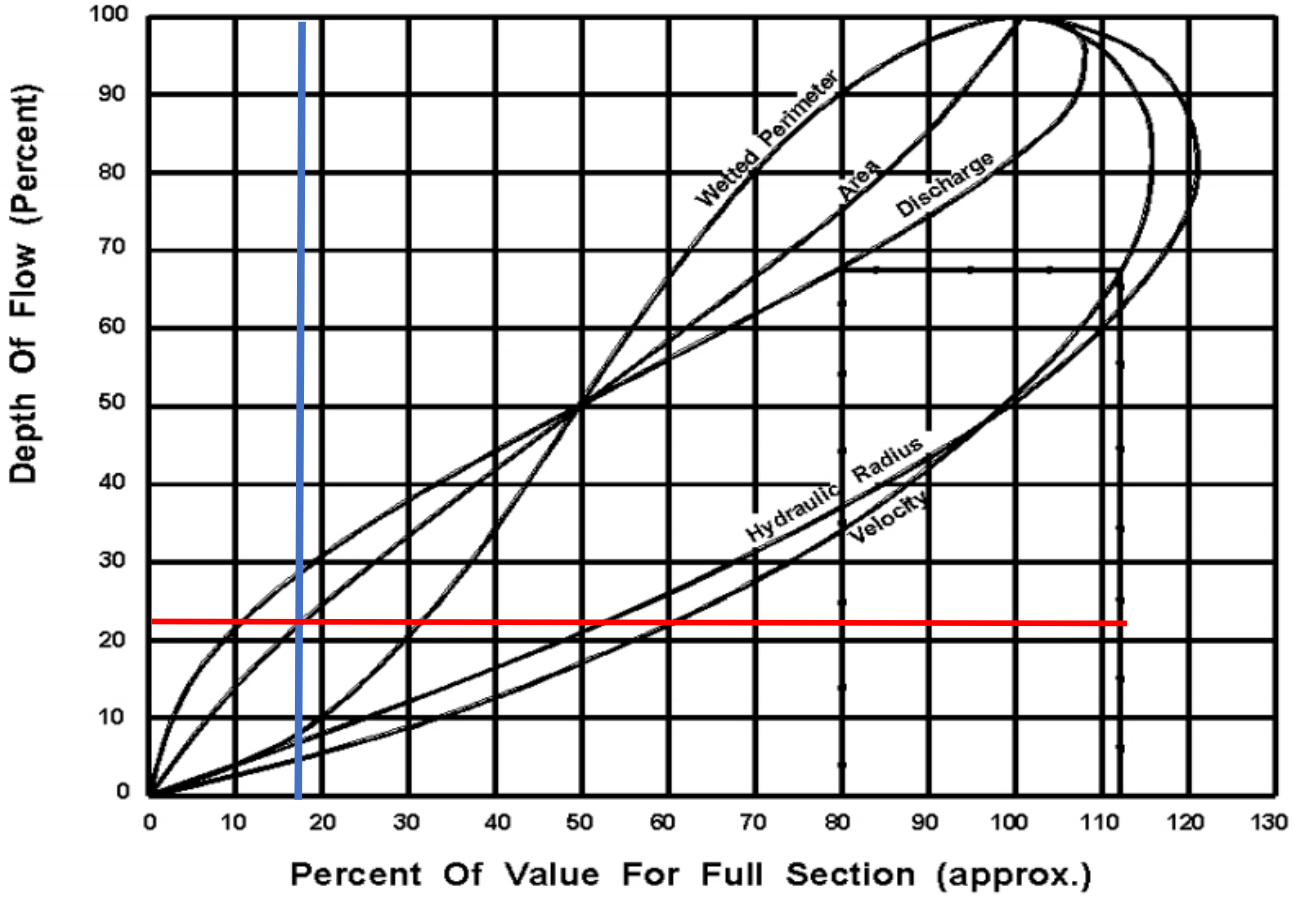


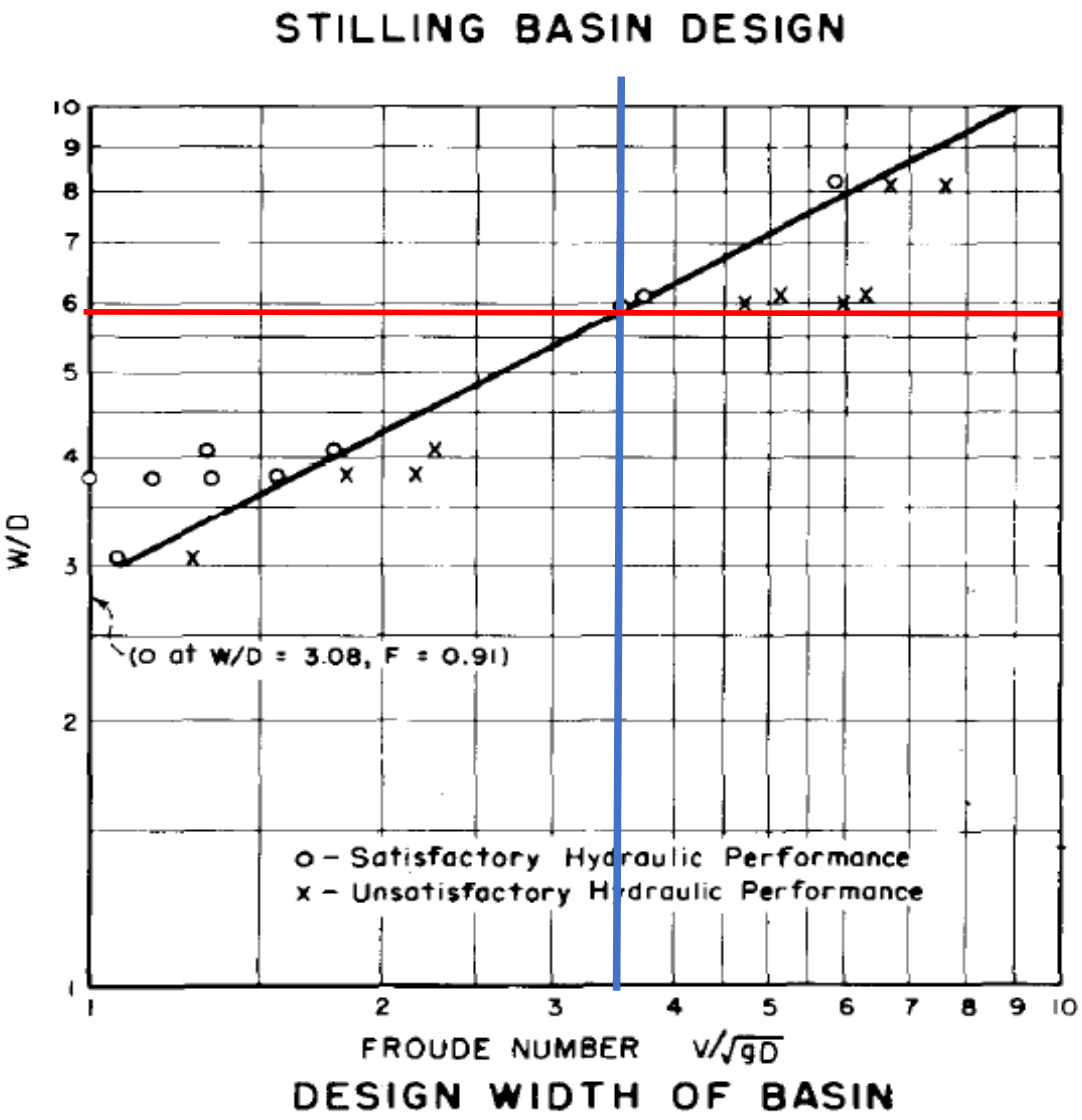
Appendix I
Inlet Structure Calculations

USBR Impact Basin
USBR Design of Small Dams

Fround#	3.501752381	Unitless	
V	20.80456772	ft/s	
g	32.2	ft/s^2	
D	1.096202167	ft	
Flow	25	cfs	
Depth of Fl	0.67	Ft	
Depth of Fl	17%	Value From Chart	
Diameter	3	ft	Pipe Diameter
W	6	ft	
W/D	5.8	See Figure	
H	4.5	ft	
L	8	ft	
a	3	ft	
b	2.25	ft	
c	3	ft	
d	1	ft	
e	0.5	ft	
t	0.5	ft	
Riprap	0.3	Size Dia.	Ft




Depth Of Flow (Percent)
100
90
80
70
60
50
40
30
20
10
0
0
10
20
30
40
50
60
70
80
90
100
110
120
130
Percent Of Value For Full Section (approx.)
Wetted Perimeter
Area
Discharge
Hydraulic Radius
Velocity



NOTES:

W is the inside width of the basin.
D represents the depth of flow entering the basin and is the square root of the flow area.
V is the velocity of the incoming flow.

Figure 10-14.—Dimensional criteria for impact-type stilling basin 288–D–2436.

Appendix J
Outlet Pipeline Hydraulic Analysis

Table A-1

Dungeness Off-Channel Reservoir Pipelines: Hydraulic Profile Calcs — High Water Level

CLALLAM COUNTY
DUNGENESS OFF-CHANNEL RESERVOIR PIPELINES - HYDRAULIC PROFILE CALCS - PRESSURE CONDITIONS

BY: **Graham Hart**
DATE: **12/28/2021**

HYDRAULIC PROFILE FOR PRESSURE FLOW CONDITIONS - PIPELINES FROM RESERVOIR TO DNR Property Line - HWL
ASSUMES: -Plastic Pipe, C = 150
-Plastic Pipe, HDPE SDR 26, OD 36 in
-Peak Flow Rate, Reservoir Full Condition **435 HWL**

Reach	Upstream End	Upstream Station	Upstream Elevation (Feet)	Downstream End	Downstream Station	Downstream Elevation (Feet)	Reach Length (Feet)	Pipe ID (Inches)	Flow (cfs)	Velocity (fps)	Headloss Gradient (feet/ 1,000 feet)	Headloss (feet)	Assumed Minor Loss (feet)	Upstream HGL (feet)	Upstream Pressure (psi)	Downstream HGL (feet)	Downstream Pressure (psi)
1	Reservoir	10+00.00	385.50	Reservoir Outlet Pipe	15+00.00	383.00	500	33.12	25.0	4.2	1.2	0.6	0.1	435.0	21.4	434.3	22.2
2	Reservoir Outlet Pipe	15+00.00	383.00	DNR Property Line	27+00.00	380.00	1200	33.12	25.0	4.2	1.2	1.5	0.1	434.3	22.2	432.7	22.8

HYDRAULIC PROFILE FOR PRESSURE FLOW CONDITIONS - PIPELINES FROM RESERVOIR TO DNR Property Line - LWL
ASSUMES: -Plastic Pipe, C = 150
-Plastic Pipe, HDPE SDR 26, OD 30 in
-Peak Flow Rate, Reservoir Full Condition **388 HWL**

Reach	Upstream End	Upstream Station	Upstream Elevation (Feet)	Downstream End	Downstream Station	Downstream Elevation (Feet)	Reach Length (Feet)	Pipe ID (Inches)	Flow (cfs)	Velocity (fps)	Headloss Gradient (feet/ 1,000 feet)	Headloss (feet)	Assumed Minor Loss (feet)	Upstream HGL (feet)	Upstream Pressure (psi)	Downstream HGL (feet)	Downstream Pressure (psi)
1	Reservoir	10+00.00	385.50	Reservoir Outlet Pipe	15+00.00	383.00	500	33.12	25.0	4.2	1.2	0.6	0.1	388.0	1.1	387.3	1.9
2	Reservoir Outlet Pipe	15+00.00	383.00	DNR Property Line	27+00.00	380.00	1200	33.12	25.0	4.2	1.2	1.5	0.1	387.3	1.9	385.7	2.5

Notes:
cfs: cubic feet per second
DNR: Department of Natural Resources
fps: feet per second
HGL: hydraulic grade line
ID: internal diameter
HWL: high water level
psi: pounds per square inch

Appendix K
Water Balance Analysis

Dungeness Off-Channel Reservoir
Reservoir Operations - Summary of Water Balance Analysis
DRAFT - 12-27-2021

Row Labels	Min Reservoir Volume (Acre-feet)	Min WSEL (Feet)	Max Reservoir Volume (Acre-feet)	Max WSEL (Feet)	Total River Diversion from WWT Model (Acre-feet)	Total Passed Downstream to HID Main Canal (Acre-feet)	Reservoir Inflow from Diversion (Acre-feet)	Total Precipitation (Inches)	Total Precipitation to Reservoir (Acre-feet)	Total Reservoir Seepage (Acre-feet)	Total Releases for Irrigation (Acre-feet)	Total Spill or Excess Water Available (Acre-feet)
2000	0	385.5	1,591	434.9	2,951.4	1,999.3	2,951.4	12.49	44.4	32.1	2,141.8	821.9
2001	0	385.5	229	396.2	615.0	2,069.0	615.0	10.07	35.8	18.9	631.8	0.0
2002	0	385.5	1,591	434.9	3,301.0	2,069.0	3,301.0	18.12	64.3	33.0	2,139.8	1,192.5
2003	0	385.5	1,591	434.9	2,745.4	2,069.0	2,745.4	11.54	41.0	29.2	2,140.1	617.0
2004	0	385.5	1,591	434.9	1,989.2	2,069.0	1,989.2	15.01	53.3	31.4	1,999.1	12.1
2005	0	385.5	1,085	422.1	1,436.0	2,069.0	1,436.0	13.91	49.4	26.6	1,458.9	0.0
2006	0	385.5	1,591	434.9	3,782.7	2,069.0	3,782.7	15.18	53.9	31.6	2,141.0	1,664.0
2007	0	385.5	1,591	434.9	3,515.5	2,069.0	3,515.5	18.36	65.2	32.9	2,141.2	1,406.5
2008	0	385.5	1,591	434.9	2,470.2	2,069.0	2,470.2	13.79	49.0	27.2	2,141.2	350.8
2009	0	385.5	868	416.1	1,234.1	2,069.0	1,234.1	16.99	60.3	21.4	1,273.1	0.0
2010	0	385.5	1,591	434.9	3,722.7	2,069.0	3,722.7	20.59	73.1	34.3	2,144.0	1,617.5
2011	0	385.5	1,591	434.9	3,556.3	2,069.0	3,556.3	19.69	69.9	30.5	2,138.2	1,457.5
2012	0	385.5	1,591	434.9	3,208.7	2,069.0	3,208.7	16.78	59.6	30.0	2,138.1	1,100.2
2013	0	385.5	1,591	434.9	2,982.0	2,069.0	2,982.0	17.29	61.4	30.6	2,150.0	862.8
2014	0	385.5	1,591	434.9	2,100.0	2,069.0	2,100.0	15.23	54.1	25.2	2,097.8	31.0
2015	0	385.5	1,591	434.9	2,193.0	2,069.0	2,193.0	17.74	63.0	33.4	1,848.8	373.7
2016	0	385.5	1,591	434.9	4,840.3	2,069.0	4,840.3	22.20	78.8	34.1	1,991.9	2,893.1
2017	0	385.5	1,591	434.9	3,675.0	2,069.0	3,675.0	15.44	54.8	32.0	2,139.2	1,558.6
2018	0	385.5	1,591	434.9	3,092.8	2,069.0	3,092.8	20.49	72.8	32.4	1,991.8	1,141.3
2019	0	385.5	1,591	434.9	2,210.1	2,069.0	2,210.1	19.17	68.1	31.3	2,001.8	245.0
2020	0	385.5	1,591	434.9	2,677.8	2,069.0	2,677.8	20.71	73.5	28.6	1,993.7	729.0
2021	0	385.5	1,591	434.9	2,500.6	2,069.0	2,500.6	18.24	64.8	29.8	2,144.7	390.8

Dungeness Off-Channel Reservoir
Reservoir Operations - Water Balance
DRAFT - 12-27-2021

					Starting Reservoir				Diversions From River						Reservoir Inflows				
					Volume		Elevation	Area	Total from WWT Model[1]		Diverted To HID[2]		Total Diversion[3]		From River Diversion		Precipitation		
Date	Month	No. of Days	Year	Water Year	CF	Acre-Feet	Feet	SF	Acre-feet	CF	Acre-feet	CF	cfs	CF	Acre-feet	CF	Inches	CF	Acre-feet
11/1/1999	11	30	1999	2000	0	0	385.50	100	458.1	19,953,046	68.1	2,966,266	8.8	22,919,312	458.1	19,953,046	2.77	428,467	9.8
12/1/1999	12	31	1999	2000	20,381,504	468	404.10	1,368,184	521.9	22,733,027	17.2	747,620	8.8	23,480,647	521.9	22,733,027	1.91	295,441	6.8
1/1/2000	1	31	2000	2000	43,289,745	994	419.60	1,583,386	0.0	0	25.3	1,101,354	0.4	1,101,354	0.0	0	1.52	235,115	5.4
2/1/2000	2	29	2000	2000	43,385,721	996	419.70	1,584,818	85.7	3,733,806	36.3	1,579,111	2.1	5,312,917	85.7	3,733,806	1.07	165,509	3.8
3/1/2000	3	31	2000	2000	47,154,757	1,083	422.00	1,617,915	0.0	0	38.8	1,688,774	0.6	1,688,774	0.0	0	0.93	143,853	3.3
4/1/2000	4	30	2000	2000	47,156,438	1,083	422.00	1,617,915	106.5	4,638,909	185.0	8,060,602	4.9	12,699,511	106.5	4,638,909	0.61	94,355	2.2
5/1/2000	5	31	2000	2000	49,268,462	1,131	423.30	1,636,763	473.8	20,637,029	393.0	17,117,050	14.1	37,754,079	473.8	20,637,029	1.66	256,771	5.9
6/1/2000	6	30	2000	2000	62,682,554	1,439	431.20	1,753,479	1,042.3	45,403,198	353.4	15,393,370	23.5	60,796,567	1,042.3	45,403,198	0.41	63,419	1.5
7/1/2000	7	31	2000	2000	69,317,141	1,591	434.90	1,810,417	263.2	11,465,624	409.0	17,815,586	10.9	29,281,210	263.2	11,465,624	0.29	44,858	1.0
8/1/2000	8	31	2000	2000	69,317,141	1,591	434.90	1,810,417	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.22	34,030	0.8
9/1/2000	9	30	2000	2000	21,532,204	494	404.90	1,378,959	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	1.1	170,149	3.9
10/1/2000	10	31	2000	2001	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	1.4	216,554	5.0
11/1/2000	11	30	2000	2001	216,545	5	386.90	307,634	0.0	0	68.1	2,966,266	1.1	2,966,266	0.0	0	1.73	267,598	6.1
12/1/2000	12	31	2000	2001	457,982	11	387.50	463,506	0.0	0	17.2	747,620	0.3	747,620	0.0	0	1.01	156,228	3.6
1/1/2001	1	31	2001	2001	573,480	13	387.70	515,576	42.9	1,866,903	25.3	1,101,354	1.1	2,968,257	42.9	1,866,903	1.4	216,554	5.0
2/1/2001	2	28	2001	2001	2,611,631	60	390.10	1,119,222	0.0	0	36.3	1,579,111	0.7	1,579,111	0.0	0	0.71	109,824	2.5
3/1/2001	3	31	2001	2001	2,632,622	60	390.20	1,127,852	0.0	0	38.8	1,688,774	0.6	1,688,774	0.0	0	0.7	108,277	2.5
4/1/2001	4	30	2001	2001	2,641,790	61	390.20	1,127,852	106.5	4,638,909	185.0	8,060,602	4.9	12,699,511	106.5	4,638,909	1.25	193,351	4.4
5/1/2001	5	31	2001	2001	4,894,484	112	392.10	1,210,906	260.2	11,336,394	393.0	17,117,050	10.6	28,453,444	260.2	11,336,394	0.2	30,936	0.7
6/1/2001	6	30	2001	2001	8,819,529	202	395.30	1,252,055	176.7	7,698,067	353.4	15,393,370	8.9	23,091,437	176.7	7,698,067	0.91	140,760	3.2
7/1/2001	7	31	2001	2001	9,954,724	229	396.20	1,263,729	28.7	1,248,552	409.0	17,815,586	7.1	19,064,138	28.7	1,248,552	0.06	9,281	0.2
8/1/2001	8	31	2001	2001	3,466,256	80	390.90	1,188,264	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.45	69,607	1.6
9/1/2001	9	30	2001	2001	0	0	385.50	100	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	0.25	38,670	0.9
10/1/2001	10	31	2001	2002	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	2.3	355,767	8.2
11/1/2001	11	30	2001	2002	355,758	8	387.30	411,436	300.0	13,068,322	68.1	2,966,266	6.2	16,034,589	300.0	13,068,322	2.04	315,550	7.2
12/1/2001	12	31	2001	2002	13,704,641	315	399.10	1,301,662	242.4	10,557,258	17.2	747,620	4.2	11,304,878	242.4	10,557,258	2.66	411,452	9.4
1/1/2002	1	31	2002	2002	24,558,969	564	407.10	1,408,776	492.5	21,453,814	25.3	1,101,354	8.4	22,555,168	492.5	21,453,814	4.41	682,144	15.7
2/1/2002	2	28	2002	2002	46,571,132	1,069	421.70	1,613,586	181.9	7,923,655	36.3	1,579,111	3.9	9,502,766	181.9	7,923,655	1.05	162,415	3.7
3/1/2002	3	31	2002	2002	54,529,133	1,252	426.50	1,683,555	0.0	0	38.8	1,688,774	0.6	1,688,774	0.0	0	2.09	323,284	7.4
4/1/2002	4	30	2002	2002	54,704,475	1,256	426.60	1,685,026	254.4	11,082,823	185.0	8,060,602	7.4	19,143,424	254.4	11,082,823	0.98	151,588	3.5
5/1/2002	5	31	2002	2002	63,311,938	1,453	431.60	1,759,503	377.3	16,435,571	393.0	17,117,050	12.5	33,552,621	377.3	16,435,571	1.14	176,337	4.0
6/1/2002	6	30	2002	2002	69,317,141	1,591	434.90	1,810,417	1,042.3	45,403,198	353.4	15,393,370	23.5	60,796,567	1,042.3	45,403,198	0.49	75,794	1.7
7/1/2002	7	31	2002	2002	69,317,141	1,591	434.90	1,810,417	410.2	17,866,221	409.0	17,815,586	13.3	35,681,807	410.2	17,866,221	0.2	30,936	0.7
8/1/2002	8	31	2002	2002	69,317,141	1,591	434.90	1,810,417	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.32	49,498	1.1
9/1/2002	9	30	2002	2002	21,547,672	495	404.90	1,378,959	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	0.44	68,060	1.6
10/1/2002	10	31	2002	2003	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	0.7	108,277	2.5
11/1/2002	11	30	2002	2003	108,268	2	386.50	204,842	0.0	0	68.1	2,966,266	1.1	2,966,266	0.0	0	0.83	128,385	2.9
12/1/2002	12	31	2002	2003	219,234	5	386.90	307,634	171.4	7,467,613	17.2	747,620	3.1	8,215,233	171.4	7,467,613	1.53	236,662	5.4
1/1/2003	1	31	2003	2003	7,896,476	181	394.50	1,241,715	606.6	26,423,779	25.3	1,101,354	10.3	27,525,133	606.6	26,423,779	2.56	395,984	9.1
2/1/2003	2	28	2003	2003	34,607,124	794	414.00	1,504,064	42.9	1,866,903	36.3	1,579,111	1.4	3,446,014	42.9	1,866,903	0.32	49,498	1.1
3/1/2003	3	31	2003	2003	36,404,147	836	415.20	1,520,915	300.0	13,068,322	38.8	1,688,774	5.5	14,757,097	300.0	13,068,322	2.04	315,550	7.2
4/1/2003	4	30	2003	2003	49,654,370	1,140	423.60	1,641,126	106.5	4,638,909	185.0	8,060,602	4.9	12,699,511	106.5	4,638,909	1.85	286,160	6.6
5/1/2003	5	31	2003	2003	51,956,225	1,193	424.90	1,660,082	315.4	13,738,680	393.0	17,117,050	11.5	30,855,730	315.4	13,738,680	0.57	88,168	2.0
6/1/2003	6	30	2003	2003	58,301,317	1,338	428.70	1,716,096	919.3	40,042,547	353.4	15,393,370	21.4	55,435,917	919.3	40,042,547	0.11	17,015	0.4
7/1/2003	7	31	2003	2003	69,317,141	1,591	434.90	1,810,417	283.4	12,342,883	409.0	17,815,586	11.3	30,158,469	283.4	12,342,883	0.18	27,843	0.6
8/1/2003	8	31	2003	2003	69,317,141	1,591	434.90	1,810,417	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.12	18,562	0.4
9/1/2003	9	30	2003	2003	21,516,736	494	404.90	1,378,959	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	0.73	112,917	2.6
10/1/2003	10	31	2003	2004	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	2.48	383,609	8.8
11/1/2003	11	30	2003	2004	383,600	9	387.40	437,471	342.9	14,935,226	68.1	2,966,266	6.9	17,901,492	342.9	14,935,226	2.72	420,733	9.7
12/1/2003	12	31	2003	2004	15,702,356	360	400.60	1,321,475	302.6	13,179,100	17.2	747,620	5.2	13,926,720	302.6	13,179,100	1.11	171,696	3.9
1/1/2004	1	31	2004	2004	28,937,029	664	410.10	1,449,876	153.7	6,695,943	25.3	1,101,354	2.9	7,797,297	153.7	6,695,943	1.56	241,303	5.5
2/1/2004	2	29	2004	2004	35,746,868	821	414.70	1,513,887	0.0	0	36.3	1,579,111	0.6	1,579,111	0.0	0	0.41	63,419	1.5

					Starting Reservoir				Diversions From River						Reservoir Inflows				
					Volume		Elevation	Area	Total from WWT Model[1]		Diverted To HID[2]		Total Diversion[3]		From River Diversion		Precipitation		
Date	Month	No. of Days	Year	Water Year	CF	Acre-Feet	Feet	SF	Acre-feet	CF	Acre-feet	CF	cfs	CF	Acre-feet	CF	Inches	CF	Acre-feet
3/1/2004	3	31	2004	2004	35,685,839	819	414.70	1,513,887	0.0	0	38.8	1,688,774	0.6	1,688,774	0.0	0	1.12	173,243	4.0
4/1/2004	4	30	2004	2004	35,726,050	820	414.70	1,513,887	106.5	4,638,909	185.0	8,060,602	4.9	12,699,511	106.5	4,638,909	0.29	44,858	1.0
5/1/2004	5	31	2004	2004	37,797,423	868	416.10	1,533,602	458.3	19,962,725	393.0	17,117,050	13.8	37,079,774	458.3	19,962,725	1.52	235,115	5.4
6/1/2004	6	30	2004	2004	50,524,620	1,160	424.10	1,648,403	596.7	25,990,283	353.4	15,393,370	16.0	41,383,653	596.7	25,990,283	0.42	64,966	1.5
7/1/2004	7	31	2004	2004	69,317,141	1,591	434.90	1,810,417	28.7	1,248,552	409.0	17,815,586	7.1	19,064,138	28.7	1,248,552	0.23	35,577	0.8
8/1/2004	8	31	2004	2004	62,806,929	1,442	431.30	1,754,985	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	1.98	306,269	7.0
9/1/2004	9	30	2004	2004	15,299,102	351	400.30	1,317,502	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	1.17	180,977	4.2
10/1/2004	10	31	2004	2005	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	1.2	185,617	4.3
11/1/2004	11	30	2004	2005	185,609	4	386.80	281,936	42.9	1,866,903	68.1	2,966,266	1.9	4,833,169	42.9	1,866,903	2.1	324,830	7.5
12/1/2004	12	31	2004	2005	2,353,367	54	389.90	1,085,257	257.1	11,201,419	17.2	747,620	4.5	11,949,039	257.1	11,201,419	1.87	289,254	6.6
1/1/2005	1	31	2005	2005	13,748,674	316	399.10	1,301,662	414.7	18,066,270	25.3	1,101,354	7.2	19,167,625	414.7	18,066,270	1.83	283,066	6.5
2/1/2005	2	28	2005	2005	31,983,628	734	412.20	1,478,950	0.0	0	36.3	1,579,111	0.7	1,579,111	0.0	0	0.61	94,355	2.2
3/1/2005	3	31	2005	2005	31,960,599	734	412.20	1,478,950	0.0	0	38.8	1,688,774	0.6	1,688,774	0.0	0	1.13	174,790	4.0
4/1/2005	4	30	2005	2005	32,005,428	735	412.20	1,478,950	194.8	8,485,880	185.0	8,060,602	6.4	16,546,482	194.8	8,485,880	1.36	210,366	4.8
5/1/2005	5	31	2005	2005	38,092,251	874	416.30	1,536,431	378.5	16,485,896	393.0	17,117,050	12.5	33,602,946	378.5	16,485,896	1.09	168,602	3.9
6/1/2005	6	30	2005	2005	47,275,858	1,085	422.10	1,619,363	119.3	5,198,328	353.4	15,393,370	7.9	20,591,698	119.3	5,198,328	1.3	201,085	4.6
7/1/2005	7	31	2005	2005	45,940,404	1,055	421.30	1,607,814	28.7	1,248,552	409.0	17,815,586	7.1	19,064,138	28.7	1,248,552	0.07	10,828	0.2
8/1/2005	8	31	2005	2005	39,423,247	905	417.10	1,547,754	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.76	117,558	2.7
9/1/2005	9	30	2005	2005	0	0	385.50	100	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	0.59	91,262	2.1
10/1/2005	10	31	2005	2006	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	0.96	148,494	3.4
11/1/2005	11	30	2005	2006	148,485	3	386.70	256,238	0.0	0	68.1	2,966,266	1.1	2,966,266	0.0	0	1.74	269,145	6.2
12/1/2005	12	31	2005	2006	395,840	9	387.40	437,471	471.4	20,535,935	17.2	747,620	7.9	21,283,555	471.4	20,535,935	2.89	447,029	10.3
1/1/2006	1	31	2006	2006	21,340,361	490	404.80	1,377,612	857.2	37,338,064	25.3	1,101,354	14.4	38,439,418	857.2	37,338,064	2.15	332,564	7.6
2/1/2006	2	28	2006	2006	58,889,933	1,352	429.00	1,720,553	214.3	9,334,516	36.3	1,579,111	4.5	10,913,627	214.3	9,334,516	0.81	125,292	2.9
3/1/2006	3	31	2006	2006	68,213,181	1,566	434.30	1,800,710	0.0	0	38.8	1,688,774	0.6	1,688,774	0.0	0	1.3	201,085	4.6
4/1/2006	4	30	2006	2006	68,256,030	1,567	434.40	1,802,328	165.4	7,203,556	185.0	8,060,602	5.9	15,264,158	165.4	7,203,556	1.26	194,898	4.5
5/1/2006	5	31	2006	2006	69,317,141	1,591	434.90	1,810,417	569.1	24,788,162	393.0	17,117,050	15.6	41,905,212	569.1	24,788,162	1.91	295,441	6.8
6/1/2006	6	30	2006	2006	69,317,141	1,591	434.90	1,810,417	1,042.3	45,403,198	353.4	15,393,370	23.5	60,796,567	1,042.3	45,403,198	0.78	120,651	2.8
7/1/2006	7	31	2006	2006	69,317,141	1,591	434.90	1,810,417	463.1	20,170,955	409.0	17,815,586	14.2	37,986,541	463.1	20,170,955	0.28	43,311	1.0
8/1/2006	8	31	2006	2006	69,317,141	1,591	434.90	1,810,417	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.06	9,281	0.2
9/1/2006	9	30	2006	2006	21,507,455	494	404.90	1,378,959	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	1.04	160,868	3.7
10/1/2006	10	31	2006	2007	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	0.62	95,902	2.2
11/1/2006	11	30	2006	2007	95,894	2	386.50	204,842	257.2	11,203,732	68.1	2,966,266	5.5	14,169,998	257.2	11,203,732	5.81	898,697	20.6
12/1/2006	12	31	2006	2007	12,180,904	280	397.90	1,285,908	557.2	24,269,741	17.2	747,620	9.3	25,017,361	557.2	24,269,741	3.23	499,620	11.5
1/1/2007	1	31	2007	2007	36,837,267	846	415.50	1,525,142	385.7	16,802,129	25.3	1,101,354	6.7	17,903,483	385.7	16,802,129	2.42	374,328	8.6
2/1/2007	2	28	2007	2007	53,879,704	1,237	426.10	1,677,668	0.0	0	36.3	1,579,111	0.7	1,579,111	0.0	0	0.86	133,026	3.1
3/1/2007	3	31	2007	2007	53,879,573	1,237	426.10	1,677,668	88.3	3,846,240	38.8	1,688,774	2.1	5,535,015	88.3	3,846,240	1.2	185,617	4.3
4/1/2007	4	30	2007	2007	57,764,007	1,326	428.40	1,711,640	192.2	8,372,717	185.0	8,060,602	6.3	16,433,318	192.2	8,372,717	0.93	143,853	3.3
5/1/2007	5	31	2007	2007	63,651,367	1,461	431.80	1,762,515	723.7	31,523,902	393.0	17,117,050	18.2	48,640,952	723.7	31,523,902	0.47	72,700	1.7
6/1/2007	6	30	2007	2007	69,317,141	1,591	434.90	1,810,417	907.8	39,543,425	353.4	15,393,370	21.2	54,936,794	907.8	39,543,425	0.87	134,573	3.1
7/1/2007	7	31	2007	2007	69,317,141	1,591	434.90	1,810,417	403.4	17,572,345	409.0	17,815,586	13.2	35,387,931	403.4	17,572,345	0.8	123,745	2.8
8/1/2007	8	31	2007	2007	69,317,141	1,591	434.90	1,810,417	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.34	52,592	1.2
9/1/2007	9	30	2007	2007	21,550,765	495	404.90	1,378,959	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	0.81	125,292	2.9
10/1/2007	10	31	2007	2008	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	1.35	208,820	4.8
11/1/2007	11	30	2007	2008	208,811	5	386.90	307,634	0.0	0	68.1	2,966,266	1.1	2,966,266	0.0	0	1.35	208,820	4.8
12/1/2007	12	31	2007	2008	391,469	9	387.40	437,471	214.3	9,334,516	17.2	747,620	3.8	10,082,136	214.3	9,334,516	2.39	369,688	8.5
1/1/2008	1	31	2008	2008	10,057,231	231	396.20	1,263,729	42.9	1,866,903	25.3	1,101,354	1.1	2,968,257	42.9	1,866,903	1.59	245,943	5.6
2/1/2008	2	29	2008	2008	12,059,028	277	397.80	1,284,600	0.0	0	36.3	1,579,111	0.6	1,579,111	0.0	0	0.85	131,479	3.0
3/1/2008	3	31	2008	2008	12,084,907	277	397.80	1,284,600	0.0	0	38.8	1,688,774	0.6	1,688,774	0.0	0	1.22	188,711	4.3
4/1/2008	4	30	2008	2008	12,160,735	279	397.90	1,285,908	106.5	4,638,909	185.0	8,060,602	4.9	12,699,511	106.5	4,638,909	1.5	232,022	5.3
5/1/2008	5	31	2008	2008	14,438,659	331	399.60	1,308,255	717.7	31,262,263	393.0	17,117,050	18.1	48,379,312	717.7	31,262,263	0.64	98,996	2.3
6/1/2008	6	30	2008	2008	38,349,077	880	416.40	1,537,846	1,042.3	45,403,198	353.4	15,393,370	23.5	60,796,567	1,042.3	45,403,198	1.31	202,632	4.7
7/1/2008	7	31	2008	2008	69,317,141	1,591	434.90	1,810,417	346.6	15,096,611	409.0	17,815,586	12.3	32,912,197	346.6	15,096,611	0.44	68,060	1.6
8/1/2008	8	31	2008	2008	69,317,141	1,591	434.90	1,810,417	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.81	125,292	2.9
9/1/2008	9	30	2008	2008	21,623,466	496	405.00	1,380,306	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	0.34	52,592	1.2
10/1/2008	10	31	2008	2009	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	0.85	131,479	3.0

					Starting Reservoir				Diversions From River						Reservoir Inflows				
					Volume		Elevation	Area	Total from WWT Model[1]		Diverted To HID[2]		Total Diversion[3]		From River Diversion		Precipitation		
Date	Month	No. of Days	Year	Water Year	CF	Acre-Feet	Feet	SF	Acre-feet	CF	Acre-feet	CF	cfs	CF	Acre-feet	CF	Inches	CF	Acre-feet
11/1/2008	11	30	2008	2009	131,470	3	386.60	230,540	0.0	0	68.1	2,966,266	1.1	2,966,266	0.0	0	3.46	535,197	12.3
12/1/2008	12	31	2008	2009	647,062	15	387.90	567,645	0.0	0	17.2	747,620	0.3	747,620	0.0	0	2.33	360,407	8.3
1/1/2009	1	31	2009	2009	957,588	22	388.40	699,109	128.6	5,600,710	25.3	1,101,354	2.5	6,702,064	128.6	5,600,710	2.52	389,796	8.9
2/1/2009	2	28	2009	2009	6,886,660	158	393.70	1,231,410	0.0	0	36.3	1,579,111	0.7	1,579,111	0.0	0	1.76	272,239	6.2
3/1/2009	3	31	2009	2009	7,061,162	162	393.80	1,232,694	0.0	0	38.8	1,688,774	0.6	1,688,774	0.0	0	2	309,362	7.1
4/1/2009	4	30	2009	2009	7,262,203	167	394.00	1,235,264	106.5	4,638,909	185.0	8,060,602	4.9	12,699,511	106.5	4,638,909	0.81	125,292	2.9
5/1/2009	5	31	2009	2009	9,437,703	217	395.70	1,257,238	374.1	16,293,653	393.0	17,117,050	12.5	33,410,702	374.1	16,293,653	1.63	252,130	5.8
6/1/2009	6	30	2009	2009	18,537,129	426	402.70	1,349,419	596.4	25,977,124	353.4	15,393,370	16.0	41,370,493	596.4	25,977,124	0.19	29,389	0.7
7/1/2009	7	31	2009	2009	37,831,730	868	416.10	1,533,602	28.7	1,248,552	409.0	17,815,586	7.1	19,064,138	28.7	1,248,552	0.3	46,404	1.1
8/1/2009	8	31	2009	2009	31,356,671	720	411.80	1,473,394	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.3	46,404	1.1
9/1/2009	9	30	2009	2009	0	0	385.50	100	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	0.84	129,932	3.0
10/1/2009	10	31	2009	2010	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	3.43	530,556	12.2
11/1/2009	11	30	2009	2010	530,548	12	387.70	515,576	642.9	28,003,548	68.1	2,966,266	11.9	30,969,814	642.9	28,003,548	3.85	595,522	13.7
12/1/2009	12	31	2009	2010	29,085,774	668	410.30	1,452,637	85.7	3,733,806	17.2	747,620	1.7	4,481,426	85.7	3,733,806	1.65	255,224	5.9
1/1/2010	1	31	2010	2010	32,947,155	756	412.90	1,488,695	669.2	29,150,944	25.3	1,101,354	11.3	30,252,299	669.2	29,150,944	1.54	238,209	5.5
2/1/2010	2	28	2010	2010	62,205,491	1,428	431.00	1,750,466	0.0	0	36.3	1,579,111	0.7	1,579,111	0.0	0	0.76	117,558	2.7
3/1/2010	3	31	2010	2010	62,184,114	1,428	430.90	1,748,967	0.0	0	38.8	1,688,774	0.6	1,688,774	0.0	0	1.82	281,520	6.5
4/1/2010	4	30	2010	2010	62,311,945	1,430	431.00	1,750,466	271.5	11,827,102	185.0	8,060,602	7.7	19,887,704	271.5	11,827,102	1.62	250,583	5.8
5/1/2010	5	31	2010	2010	69,317,141	1,591	434.90	1,810,417	537.3	23,404,453	393.0	17,117,050	15.1	40,521,502	537.3	23,404,453	2.97	459,403	10.5
6/1/2010	6	30	2010	2010	69,317,141	1,591	434.90	1,810,417	1,042.3	45,403,198	353.4	15,393,370	23.5	60,796,567	1,042.3	45,403,198	0.94	145,400	3.3
7/1/2010	7	31	2010	2010	69,317,141	1,591	434.90	1,810,417	473.7	20,635,836	409.0	17,815,586	14.4	38,451,422	473.7	20,635,836	0.06	9,281	0.2
8/1/2010	8	31	2010	2010	69,317,141	1,591	434.90	1,810,417	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.39	60,326	1.4
9/1/2010	9	30	2010	2010	21,558,500	495	404.90	1,378,959	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	1.56	241,303	5.5
10/1/2010	10	31	2010	2011	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	1.13	174,790	4.0
11/1/2010	11	30	2010	2011	174,781	4	386.80	281,936	0.0	0	68.1	2,966,266	1.1	2,966,266	0.0	0	2.02	312,456	7.2
12/1/2010	12	31	2010	2011	463,261	11	387.50	463,506	448.7	19,545,681	17.2	747,620	7.6	20,293,301	448.7	19,545,681	2.35	363,501	8.3
1/1/2011	1	31	2011	2011	20,331,713	467	404.00	1,366,837	466.3	20,313,043	25.3	1,101,354	8.0	21,414,397	466.3	20,313,043	3.15	487,246	11.2
2/1/2011	2	28	2011	2011	41,011,892	942	418.20	1,563,389	0.0	0	36.3	1,579,111	0.7	1,579,111	0.0	0	2.16	334,111	7.7
3/1/2011	3	31	2011	2011	41,221,917	946	418.30	1,564,815	233.3	10,161,489	38.8	1,688,774	4.4	11,850,264	233.3	10,161,489	2.49	385,156	8.8
4/1/2011	4	30	2011	2011	51,631,056	1,185	424.80	1,658,622	227.6	9,914,226	185.0	8,060,602	6.9	17,974,827	227.6	9,914,226	1.64	253,677	5.8
5/1/2011	5	31	2011	2011	59,174,256	1,358	429.20	1,723,537	664.4	28,939,295	393.0	17,117,050	17.2	46,056,345	664.4	28,939,295	3.18	491,886	11.3
6/1/2011	6	30	2011	2011	69,317,141	1,591	434.90	1,810,417	1,042.3	45,403,198	353.4	15,393,370	23.5	60,796,567	1,042.3	45,403,198	0.77	119,104	2.7
7/1/2011	7	31	2011	2011	69,317,141	1,591	434.90	1,810,417	473.7	20,635,836	409.0	17,815,586	14.4	38,451,422	473.7	20,635,836	0.49	75,794	1.7
8/1/2011	8	31	2011	2011	69,317,141	1,591	434.90	1,810,417	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.11	17,015	0.4
9/1/2011	9	30	2011	2011	21,515,189	494	404.90	1,378,959	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	0.2	30,936	0.7
10/1/2011	10	31	2011	2012	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	0.84	129,932	3.0
11/1/2011	11	30	2011	2012	129,923	3	386.60	230,540	214.3	9,334,516	68.1	2,966,266	4.7	12,300,782	214.3	9,334,516	3.52	544,478	12.5
12/1/2011	12	31	2011	2012	9,989,312	229	396.20	1,263,729	0.0	0	17.2	747,620	0.3	747,620	0.0	0	1.26	194,898	4.5
1/1/2012	1	31	2012	2012	10,073,161	231	396.20	1,263,729	183.5	7,994,860	25.3	1,101,354	3.4	9,096,214	183.5	7,994,860	2.31	357,313	8.2
2/1/2012	2	29	2012	2012	18,314,286	420	402.60	1,348,084	0.0	0	36.3	1,579,111	0.6	1,579,111	0.0	0	1.74	269,145	6.2
3/1/2012	3	31	2012	2012	18,472,612	424	402.70	1,349,419	32.1	1,396,616	38.8	1,688,774	1.2	3,085,390	32.1	1,396,616	1.81	279,973	6.4
4/1/2012	4	30	2012	2012	20,030,622	460	403.80	1,364,155	366.6	15,971,051	185.0	8,060,602	9.3	24,031,653	366.6	15,971,051	1.53	236,662	5.4
5/1/2012	5	31	2012	2012	33,638,674	772	413.30	1,494,280	896.1	39,035,458	393.0	17,117,050	21.0	56,152,507	896.1	39,035,458	0.83	128,385	2.9
6/1/2012	6	30	2012	2012	65,335,330	1,500	432.70	1,776,118	1,042.3	45,403,198	353.4	15,393,370	23.5	60,796,567	1,042.3	45,403,198	1.39	215,007	4.9
7/1/2012	7	31	2012	2012	69,317,141	1,591	434.90	1,810,417	473.7	20,635,835	409.0	17,815,586	14.4	38,451,421	473.7	20,635,835	1.27	196,445	4.5
8/1/2012	8	31	2012	2012	69,317,141	1,591	434.90	1,810,417	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.04	6,187	0.1
9/1/2012	9	30	2012	2012	21,504,361	494	404.90	1,378,959	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	0.24	37,123	0.9
10/1/2012	10	31	2012	2013	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	1.73	267,598	6.1
11/1/2012	11	30	2012	2013	267,590	6	387.10	359,367	286.6	12,483,775	68.1	2,966,266	6.0	15,450,042	286.6	12,483,775	2.49	385,156	8.8
12/1/2012	12	31	2012	2013	13,105,961	301	398.60	1,295,092	214.3	9,334,516	17.2	747,620	3.8	10,082,136	214.3	9,334,516	2.41	372,782	8.6
1/1/2013	1	31	2013	2013	22,699,453	521	405.80	1,391,125	42.9	1,866,903	25.3	1,101,354	1.1	2,968,257	42.9	1,866,903	1.61	249,037	5.7
2/1/2013	2	28	2013	2013	24,693,149	567	407.20	1,410,139	0.0	0	36.3	1,579,111	0.7	1,579,111	0.0	0	0.53	81,981	1.9
3/1/2013	3	31	2013	2013	24,663,208	566	407.20	1,410,139	0.0	0	38.8	1,688,774	0.6	1,688,774	0.0	0	0.96	148,494	3.4
4/1/2013	4	30	2013	2013	24,687,787	567	407.20	1,410,139	176.8	7,701,892	185.0	8,060,602	6.1	15,762,493	176.8	7,701,892	1.84	284,613	6.5
5/1/2013	5	31	2013	2013	30,070,720	690	410.90	1,460,922	841.1	36,638,813	393.0	17,117,050	20.1	53,755,862	841.1	36,638,813	1.57	242,849	5.6
6/1/2013	6	30	2013	2013	59,488,126	1,366	429.40	1,726,521	1,042.3	45,403,198	353.4	15,393,370	23.5	60,796,567	1,042.3	45,403,198	0.51	78,887	1.8

					Starting Reservoir				Diversions From River						Reservoir Inflows				
					Volume		Elevation	Area	Total from WWT Model[1]		Diverted To HID[2]		Total Diversion[3]		From River Diversion		Precipitation		
Date	Month	No. of Days	Year	Water Year	CF	Acre-Feet	Feet	SF	Acre-feet	CF	Acre-feet	CF	cfs	CF	Acre-feet	CF	Inches	CF	Acre-feet
7/1/2013	7	31	2013	2013	69,317,141	1,591	434.90	1,810,417	378.0	16,467,780	409.0	17,815,586	12.8	34,283,366	378.0	16,467,780	0	0	0.0
8/1/2013	8	31	2013	2013	69,317,141	1,591	434.90	1,810,417	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.67	103,636	2.4
9/1/2013	9	30	2013	2013	21,601,810	496	405.00	1,380,306	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	2.97	459,403	10.5
10/1/2013	10	31	2013	2014	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	1.14	176,337	4.0
11/1/2013	11	30	2013	2014	176,328	4	386.80	281,936	0.0	0	68.1	2,966,266	1.1	2,966,266	0.0	0	1.24	191,805	4.4
12/1/2013	12	31	2013	2014	344,157	8	387.30	411,436	0.0	0	17.2	747,620	0.3	747,620	0.0	0	1.29	199,539	4.6
1/1/2014	1	31	2014	2014	507,541	12	387.60	489,541	42.9	1,866,903	25.3	1,101,354	1.1	2,968,257	42.9	1,866,903	2.5	386,703	8.9
2/1/2014	2	28	2014	2014	2,718,129	62	390.20	1,127,852	0.0	0	36.3	1,579,111	0.7	1,579,111	0.0	0	2.76	426,920	9.8
3/1/2014	3	31	2014	2014	3,055,531	70	390.50	1,153,743	385.7	16,802,129	38.8	1,688,774	6.9	18,490,903	385.7	16,802,129	2.15	332,564	7.6
4/1/2014	4	30	2014	2014	20,088,840	461	403.90	1,365,496	106.5	4,638,909	185.0	8,060,602	4.9	12,699,511	106.5	4,638,909	0.66	102,090	2.3
5/1/2014	5	31	2014	2014	22,230,064	510	405.40	1,385,716	658.3	28,677,168	393.0	17,117,050	17.1	45,794,218	658.3	28,677,168	0.9	139,213	3.2
6/1/2014	6	30	2014	2014	43,588,798	1,001	419.80	1,586,249	774.6	33,741,842	353.4	15,393,370	19.0	49,135,211	774.6	33,741,842	0.45	69,607	1.6
7/1/2014	7	31	2014	2014	69,317,141	1,591	434.90	1,810,417	132.0	5,749,554	409.0	17,815,586	8.8	23,565,140	132.0	5,749,554	0.28	43,311	1.0
8/1/2014	8	31	2014	2014	67,315,666	1,545	433.80	1,792,816	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	1.1	170,149	3.9
9/1/2014	9	30	2014	2014	19,668,395	452	403.60	1,361,473	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	0.76	117,558	2.7
10/1/2014	10	31	2014	2015	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	3.02	467,137	10.7
11/1/2014	11	30	2014	2015	467,128	11	387.50	463,506	214.3	9,334,516	68.1	2,966,266	4.7	12,300,782	214.3	9,334,516	1.97	304,722	7.0
12/1/2014	12	31	2014	2015	10,066,950	231	396.20	1,263,729	669.4	29,159,055	17.2	747,620	11.2	29,906,675	669.4	29,159,055	2.39	369,688	8.5
1/1/2015	1	31	2015	2015	39,484,644	906	417.20	1,549,174	436.8	19,029,029	25.3	1,101,354	7.5	20,130,383	436.8	19,029,029	2.13	329,471	7.6
2/1/2015	2	28	2015	2015	58,707,012	1,348	428.90	1,719,067	471.4	20,535,935	36.3	1,579,111	9.1	22,115,046	471.4	20,535,935	2.74	423,826	9.7
3/1/2015	3	31	2015	2015	69,317,141	1,591	434.90	1,810,417	85.7	3,733,806	38.8	1,688,774	2.0	5,422,581	85.7	3,733,806	2.69	416,092	9.6
4/1/2015	4	30	2015	2015	69,317,141	1,591	434.90	1,810,417	106.5	4,638,909	185.0	8,060,602	4.9	12,699,511	106.5	4,638,909	0.48	74,247	1.7
5/1/2015	5	31	2015	2015	69,317,141	1,591	434.90	1,810,417	60.8	2,648,783	393.0	17,117,050	7.4	19,765,833	60.8	2,648,783	0.3	46,404	1.1
6/1/2015	6	30	2015	2015	64,517,362	1,481	432.30	1,770,066	119.3	5,198,328	353.4	15,393,370	7.9	20,591,698	119.3	5,198,328	0.24	37,123	0.9
7/1/2015	7	31	2015	2015	63,005,130	1,446	431.40	1,756,491	28.7	1,248,552	409.0	17,815,586	7.1	19,064,138	28.7	1,248,552	0.26	40,217	0.9
8/1/2015	8	31	2015	2015	56,504,298	1,297	427.70	1,701,263	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.65	100,543	2.3
9/1/2015	9	30	2015	2015	8,795,465	202	395.20	1,250,759	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	0.87	134,573	3.1
10/1/2015	10	31	2015	2016	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	2.22	343,392	7.9
11/1/2015	11	30	2015	2016	343,383	8	387.30	411,436	257.1	11,201,419	68.1	2,966,266	5.5	14,167,685	257.1	11,201,419	4.35	672,863	15.4
12/1/2015	12	31	2015	2016	12,182,677	280	397.90	1,285,908	704.0	30,668,274	17.2	747,620	11.7	31,415,894	704.0	30,668,274	6.14	949,742	21.8
1/1/2016	1	31	2016	2016	43,687,696	1,003	419.90	1,587,681	514.3	22,402,838	25.3	1,101,354	8.8	23,504,192	514.3	22,402,838	1.64	253,677	5.8
2/1/2016	2	29	2016	2016	66,204,695	1,520	433.20	1,783,697	732.1	31,890,359	36.3	1,579,111	13.4	33,469,469	732.1	31,890,359	1.83	283,066	6.5
3/1/2016	3	31	2016	2016	69,317,141	1,591	434.90	1,810,417	604.5	26,330,221	38.8	1,688,774	10.5	28,018,995	604.5	26,330,221	2.35	363,501	8.3
4/1/2016	4	30	2016	2016	69,317,141	1,591	434.90	1,810,417	769.9	33,534,971	185.0	8,060,602	16.0	41,595,573	769.9	33,534,971	0.66	102,090	2.3
5/1/2016	5	31	2016	2016	69,317,141	1,591	434.90	1,810,417	723.4	31,511,173	393.0	17,117,050	18.2	48,628,223	723.4	31,511,173	0.64	98,996	2.3
6/1/2016	6	30	2016	2016	69,317,141	1,591	434.90	1,810,417	506.4	22,056,732	353.4	15,393,370	14.4	37,450,102	506.4	22,056,732	1	154,681	3.6
7/1/2016	7	31	2016	2016	69,317,141	1,591	434.90	1,810,417	28.7	1,248,552	409.0	17,815,586	7.1	19,064,138	28.7	1,248,552	0.31	47,951	1.1
8/1/2016	8	31	2016	2016	62,819,304	1,442	431.30	1,754,985	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.14	21,655	0.5
9/1/2016	9	30	2016	2016	15,026,863	345	400.10	1,314,854	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	0.92	142,307	3.3
10/1/2016	10	31	2016	2017	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	3.1	479,512	11.0
11/1/2016	11	30	2016	2017	479,503	11	387.60	489,541	257.1	11,201,419	68.1	2,966,266	5.5	14,167,685	257.1	11,201,419	2.18	337,205	7.7
12/1/2016	12	31	2016	2017	11,976,497	275	397.70	1,283,293	0.0	0	17.2	747,620	0.3	747,620	0.0	0	1.57	242,849	5.6
1/1/2017	1	31	2017	2017	12,106,578	278	397.80	1,284,600	171.4	7,467,613	25.3	1,101,354	3.2	8,568,967	171.4	7,467,613	0.77	119,104	2.7
2/1/2017	2	28	2017	2017	19,580,412	450	403.50	1,360,132	404.1	17,600,949	36.3	1,579,111	7.9	19,180,060	404.1	17,600,949	1.19	184,071	4.2
3/1/2017	3	31	2017	2017	37,257,478	855	415.70	1,527,960	321.4	13,998,790	38.8	1,688,774	5.9	15,687,564	321.4	13,998,790	1.69	261,411	6.0
4/1/2017	4	30	2017	2017	51,383,412	1,180	424.60	1,655,702	265.5	11,566,517	185.0	8,060,602	7.6	19,627,119	265.5	11,566,517	1.97	304,722	7.0
5/1/2017	5	31	2017	2017	60,630,196	1,392	430.10	1,736,974	866.5	37,746,134	393.0	17,117,050	20.5	54,863,184	866.5	37,746,134	1.42	219,647	5.0
6/1/2017	6	30	2017	2017	69,317,141	1,591	434.90	1,810,417	1,042.3	45,403,198	353.4	15,393,370	23.5	60,796,567	1,042.3	45,403,198	0.96	148,494	3.4
7/1/2017	7	31	2017	2017	69,317,141	1,591	434.90	1,810,417	346.6	15,096,611	409.0	17,815,586	12.3	32,912,197	346.6	15,096,611	0	0	0.0
8/1/2017	8	31	2017	2017	69,317,141	1,591	434.90	1,810,417	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.1	15,468	0.4
9/1/2017	9	30	2017	2017	21,513,642	494	404.90	1,378,959	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	0.49	75,794	1.7
10/1/2017	10	31	2017	2018	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	1.93	298,535	6.9
11/1/2017	11	30	2017	2018	298,526	7	387.20	385,402	471.4	20,535,935	68.1	2,966,266	9.1	23,502,201	471.4	20,535,935	4.36	674,410	15.5
12/1/2017	12	31	2017	2018	21,476,096	493	404.90	1,378,959	0.0	0	17.2	747,620	0.3	747,620	0.0	0	2.81	434,654	10.0
1/1/2018	1	31	2018	2018	21,789,576	500	405.10	1,381,658	280.7	12,228,760	25.3	1,101,354	5.0	13,330,114	280.7	12,228,760	2.33	360,407	8.3
2/1/2018	2	28	2018	2018	34,257,331	786	413.80	1,501,268	385.7	16,802,129	36.3	1,579,111	7.6	18,381,239	385.7	16,802,129	2.32	358,860	8.2

					Starting Reservoir				Diversions From River						Reservoir Inflows				
					Volume		Elevation	Area	Total from WWT Model[1]		Diverted To HID[2]		Total Diversion[3]		From River Diversion		Precipitation		
Date	Month	No. of Days	Year	Water Year	CF	Acre-Feet	Feet	SF	Acre-feet	CF	Acre-feet	CF	cfs	CF	Acre-feet	CF	Inches	CF	Acre-feet
3/1/2018	3	31	2018	2018	51,299,164	1,178	424.60	1,655,702	0.0	0	38.8	1,688,774	0.6	1,688,774	0.0	0	1.62	250,583	5.8
4/1/2018	4	30	2018	2018	51,404,254	1,180	424.60	1,655,702	283.6	12,355,289	185.0	8,060,602	7.9	20,415,890	283.6	12,355,289	2.63	406,811	9.3
5/1/2018	5	31	2018	2018	61,541,900	1,413	430.60	1,744,470	991.5	43,187,754	393.0	17,117,050	22.5	60,304,803	991.5	43,187,754	0.09	13,921	0.3
6/1/2018	6	30	2018	2018	69,317,141	1,591	434.90	1,810,417	651.1	28,363,754	353.4	15,393,370	16.9	43,757,124	651.1	28,363,754	1.07	165,509	3.8
7/1/2018	7	31	2018	2018	69,317,141	1,591	434.90	1,810,417	28.7	1,248,552	409.0	17,815,586	7.1	19,064,138	28.7	1,248,552	0.09	13,921	0.3
8/1/2018	8	31	2018	2018	62,785,274	1,441	431.30	1,754,985	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.48	74,247	1.7
9/1/2018	9	30	2018	2018	15,045,425	345	400.10	1,314,854	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	0.76	117,558	2.7
10/1/2018	10	31	2018	2019	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	2.04	315,550	7.2
11/1/2018	11	30	2018	2019	315,541	7	387.20	385,402	128.6	5,600,710	68.1	2,966,266	3.3	8,566,976	128.6	5,600,710	2.19	338,752	7.8
12/1/2018	12	31	2018	2019	6,222,228	143	393.20	1,224,986	385.7	16,802,129	17.2	747,620	6.6	17,549,749	385.7	16,802,129	2.22	343,392	7.9
1/1/2019	1	31	2019	2019	23,260,104	534	406.20	1,396,547	300.0	13,068,322	25.3	1,101,354	5.3	14,169,676	300.0	13,068,322	1.57	242,849	5.6
2/1/2019	2	28	2019	2019	36,448,556	837	415.20	1,520,915	0.0	0	36.3	1,579,111	0.7	1,579,111	0.0	0	2.72	420,733	9.7
3/1/2019	3	31	2019	2019	36,748,573	844	415.40	1,523,733	0.0	0	38.8	1,688,774	0.6	1,688,774	0.0	0	0.27	41,764	1.0
4/1/2019	4	30	2019	2019	36,656,441	842	415.30	1,522,324	159.4	6,942,828	185.0	8,060,602	5.8	15,003,430	159.4	6,942,828	1.8	278,426	6.4
5/1/2019	5	31	2019	2019	41,264,583	947	418.30	1,564,815	823.2	35,857,851	393.0	17,117,050	19.8	52,974,901	823.2	35,857,851	1.14	176,337	4.0
6/1/2019	6	30	2019	2019	69,317,141	1,591	434.90	1,810,417	384.5	16,749,992	353.4	15,393,370	12.4	32,143,361	384.5	16,749,992	1.08	167,056	3.8
7/1/2019	7	31	2019	2019	69,317,141	1,591	434.90	1,810,417	28.7	1,248,552	409.0	17,815,586	7.1	19,064,138	28.7	1,248,552	0.73	112,917	2.6
8/1/2019	8	31	2019	2019	62,884,270	1,444	431.30	1,754,985	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.5	77,341	1.8
9/1/2019	9	30	2019	2019	15,147,515	348	400.20	1,316,178	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	2.91	450,122	10.3
10/1/2019	10	31	2019	2020	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	1.7	262,958	6.0
11/1/2019	11	30	2019	2020	262,949	6	387.10	359,367	0.0	0	68.1	2,966,266	1.1	2,966,266	0.0	0	0.83	128,385	2.9
12/1/2019	12	31	2019	2020	360,774	8	387.30	411,436	42.9	1,866,903	17.2	747,620	1.0	2,614,523	42.9	1,866,903	3.42	529,010	12.1
1/1/2020	1	31	2020	2020	2,720,532	62	390.20	1,127,852	300.0	13,068,322	25.3	1,101,354	5.3	14,169,676	300.0	13,068,322	3.22	498,073	11.4
2/1/2020	2	29	2020	2020	16,187,819	372	401.00	1,326,772	428.6	18,669,032	36.3	1,579,111	8.1	20,248,142	428.6	18,669,032	3.57	552,212	12.7
3/1/2020	3	31	2020	2020	35,299,996	810	414.40	1,509,677	0.0	0	38.8	1,688,774	0.6	1,688,774	0.0	0	1.78	275,332	6.3
4/1/2020	4	30	2020	2020	35,442,667	814	414.50	1,511,081	123.0	5,357,527	185.0	8,060,602	5.2	13,418,129	123.0	5,357,527	0.59	91,262	2.1
5/1/2020	5	31	2020	2020	38,279,300	879	416.40	1,537,846	778.3	33,903,345	393.0	17,117,050	19.0	51,020,394	778.3	33,903,345	1.69	261,411	6.0
6/1/2020	6	30	2020	2020	64,973,041	1,492	432.50	1,773,092	976.4	42,530,098	353.4	15,393,370	22.3	57,923,467	976.4	42,530,098	2.05	317,096	7.3
7/1/2020	7	31	2020	2020	69,317,141	1,591	434.90	1,810,417	28.7	1,248,552	409.0	17,815,586	7.1	19,064,138	28.7	1,248,552	0.18	27,843	0.6
8/1/2020	8	31	2020	2020	62,799,195	1,442	431.30	1,754,985	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.39	60,326	1.4
9/1/2020	9	30	2020	2020	15,045,425	345	400.10	1,314,854	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	1.29	199,539	4.6
10/1/2020	10	31	2020	2021	0	0	385.50	100	0.0	0	69.8	3,038,435	1.1	3,038,435	0.0	0	1.11	171,696	3.9
11/1/2020	11	30	2020	2021	171,687	4	386.80	281,936	99.2	4,323,151	68.1	2,966,266	2.8	7,289,418	99.2	4,323,151	2.98	460,950	10.6
12/1/2020	12	31	2020	2021	4,931,813	113	392.10	1,210,906	0.0	0	17.2	747,620	0.3	747,620	0.0	0	3.56	550,665	12.6
1/1/2021	1	31	2021	2021	5,376,071	123	392.50	1,216,022	471.4	20,535,935	25.3	1,101,354	8.1	21,637,289	471.4	20,535,935	2.82	436,201	10.0
2/1/2021	2	28	2021	2021	26,241,350	602	408.30	1,425,158	0.0	0	36.3	1,579,111	0.7	1,579,111	0.0	0	1.36	210,366	4.8
3/1/2021	3	31	2021	2021	26,338,601	605	408.30	1,425,158	0.0	0	38.8	1,688,774	0.6	1,688,774	0.0	0	0.84	129,932	3.0
4/1/2021	4	30	2021	2021	26,343,299	605	408.30	1,425,158	106.5	4,638,909	185.0	8,060,602	4.9	12,699,511	106.5	4,638,909	0.88	136,119	3.1
5/1/2021	5	31	2021	2021	28,513,479	655	409.90	1,447,120	600.4	26,152,792	393.0	17,117,050	16.2	43,269,842	600.4	26,152,792	0.86	133,026	3.1
6/1/2021	6	30	2021	2021	47,336,254	1,087	422.10	1,619,363	1,022.7	44,547,767	353.4	15,393,370	23.1	59,941,136	1,022.7	44,547,767	1.69	261,411	6.0
7/1/2021	7	31	2021	2021	69,317,141	1,591	434.90	1,810,417	200.3	8,725,430	409.0	17,815,586	9.9	26,541,015	200.3	8,725,430	0	0	0.0
8/1/2021	8	31	2021	2021	69,317,141	1,591	434.90	1,810,417	0.0	0	334.2	14,555,983	5.4	14,555,983	0.0	0	0.08	12,374	0.3
9/1/2021	9	30	2021	2021	21,510,548	494	404.90	1,378,959	0.0	0	139.2	6,061,824	2.3	6,061,824	0.0	0	2.06	318,643	7.3
10/1/2021	10		2021	2022	0	0	385.50	100											

Notes:

1) Represents the total estimated water available each month for diversion from the river based on WWT Reservoir Refill Model analysis with a maximum diverison capacity of 25 cfs.

2) Represents the water that would need to be diverted and continue to flow down the HID Main Canal beyond the H1 Lateral; see Tables worksheet, "To D/S HID Main Canal" under "Irrigation Deliveries - Based on Daily Average 2-week Delivery from "Hist Irrigation Diversions"".

3) Checks to see if the sum of the average flow "from WWT Model" and "Max Diverted to HID" is greater than 25 cfs. Assumes that the average diversion from the river is the sum or 25 cfs, whichever is less.

4) Represents seepage calculated based on a seepage rate of 10^{-6} cm/s; see Tables worksheet.

5) Evaporation was already incorporated in the WWT's Reservoir Refill Model, so no additional evaporation is factored in here.

6) Represents the total volume of water that could be available at the Reservoir to meet downstream needs; Starting Reservoir Volume + Reservoir Inflows - Reservoir Losses

7) Estimated irrigation demand based on 2-week average from 2015-2020; see Tables under "Irrigation Deliveries - Based on Daily Average 2-week Delivery from "Hist Irrigation Diversions".

8) Assumes reservoir water is released to meet H1 Lateral demands whenever it is available, meet Independent demands in August and September when enough storage is available, and meet SPTIA-DID demands in August and September when enough storage is available. Prioritizes H1 Later, th

9) Represents water available to divert to reservoir or inflow via precipitation when reservoir is full.

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	Reservoir Losses				Starting Reservoir Volume		Downstream Irrigation Demand[7]						Releases from Reservoir to Downstream Irrigation System[8]					
	Seepage[4]		Evaporation[5]		+ Inflows - Losses[6]		H1 Lateral	Independent	SPTIA-DID	Total	Total	Average	H1 Lateral	Independent	SPTIA-DID	Total	Total	Average
Date	In/Day	CF	Inches	CF	CF	Acre-feet	CF	CF	CF	CF	Acre-feet	cfs	CF	CF	CF	CF	Acre-feet	cfs
11/1/1999	1.020	9	0	0	20,381,504	468	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/1999	1.054	120,228	0	0	43,289,745	994	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2000	1.054	139,139	0	0	43,385,721	996	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2000	0.986	130,280	0	0	47,154,757	1,083	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2000	1.054	142,173	0	0	47,156,438	1,083	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2000	1.020	137,586	0	0	51,752,116	1,188	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2000	1.054	143,829	0	0	70,018,433	1,607	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2000	1.020	149,115	0	0	108,000,057	2,479	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2000	1.054	159,089	0	0	80,668,534	1,852	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2000	1.054	159,089	0	0	69,192,082	1,588	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2000	1.020	117,266	0	0	21,585,087	496	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	12,813,068	21,585,087	496	8.3
10/1/2000	1.054	9	0	0	216,545	5	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2000	1.020	26,161	0	0	457,982	11	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2000	1.054	40,730	0	0	573,480	13	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2001	1.054	45,306	0	0	2,611,631	60	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2001	0.952	88,833	0	0	2,632,622	60	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2001	1.054	99,109	0	0	2,641,790	61	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2001	1.020	95,912	0	0	7,378,139	169	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2001	1.054	106,407	0	0	16,155,408	371	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2001	1.020	106,474	0	0	16,551,882	380	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2001	1.054	111,049	0	0	11,101,507	255	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2001	1.054	104,417	0	0	3,431,445	79	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	3,431,445	0	0	3,431,445	79	1.3
9/1/2001	1.020	9	0	0	38,662	1	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	38,662	0	0	38,662	1	0.0
10/1/2001	1.054	9	0	0	355,758	8	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2001	1.020	34,988	0	0	13,704,641	315	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2001	1.054	114,382	0	0	24,558,969	564	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2002	1.054	123,795	0	0	46,571,132	1,069	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2002	0.952	128,070	0	0	54,529,133	1,252	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2002	1.054	147,941	0	0	54,704,475	1,256	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2002	1.020	143,294	0	0	65,795,592	1,510	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2002	1.054	154,615	0	0	79,769,231	1,831	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2002	1.020	153,957	0	0	114,642,176	2,632	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2002	1.054	159,089	0	0	87,055,210	1,999	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2002	1.054	159,089	0	0	69,207,550	1,589	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2002	1.020	117,266	0	0	21,498,466	494	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	12,726,447	21,498,466	494	8.3
10/1/2002	1.054	9	0	0	108,268	2	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2002	1.020	17,420	0	0	219,234	5	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2002	1.054	27,033	0	0	7,896,476	181	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2003	1.054	109,114	0	0	34,607,124	794	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2003	0.952	119,378	0	0	36,404,147	836	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2003	1.054	133,649	0	0	49,654,370	1,140	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2003	1.020	139,560	0	0	54,439,879	1,250	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2003	1.054	145,878	0	0	65,637,195	1,507	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2003	1.020	145,936	0	0	98,214,944	2,255	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2003	1.054	159,089	0	0	81,528,778	1,872	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2003	1.054	159,089	0	0	69,176,614	1,588	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2003	1.020	117,266	0	0	21,512,387	494	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	12,740,368	21,512,387	494	8.3
10/1/2003	1.054	9	0	0	383,600	9	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2003	1.020	37,202	0	0	15,702,356	360	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2003	1.054	116,123	0	0	28,937,029	664	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2004	1.054	127,406	0	0	35,746,868	821	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2004	0.986	124,449	0	0	35,685,839	819	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0

	Reservoir Losses				Starting Reservoir Volume		Downstream Irrigation Demand[7]						Releases from Reservoir to Downstream Irrigation System[8]					
	Seepage[4]		Evaporation[5]		+ Inflows - Losses[6]		H1 Lateral	Independent	SPTIA-DID	Total	Total	Average	H1 Lateral	Independent	SPTIA-DID	Total	Total	Average
Date	In/Day	CF	Inches	CF	CF	Acre-feet	CF	CF	CF	CF	Acre-feet	cfs	CF	CF	CF	CF	Acre-feet	cfs
3/1/2004	1.054	133,031	0	0	35,726,050	820	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2004	1.020	128,740	0	0	40,281,077	925	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2004	1.054	134,764	0	0	57,860,499	1,328	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2004	1.020	140,179	0	0	76,439,690	1,755	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2004	1.054	159,089	0	0	70,442,181	1,617	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2004	1.054	154,218	0	0	62,958,981	1,445	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2004	1.020	112,040	0	0	15,368,040	353	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	6,596,020	15,368,040	353	5.9
10/1/2004	1.054	9	0	0	185,609	4	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2004	1.020	23,976	0	0	2,353,367	54	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2004	1.054	95,366	0	0	13,748,673	316	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2005	1.054	114,382	0	0	31,983,628	734	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2005	0.952	117,384	0	0	31,960,599	734	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2005	1.054	129,961	0	0	32,005,428	735	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2005	1.020	125,769	0	0	40,575,905	931	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2005	1.054	135,012	0	0	54,611,737	1,254	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2005	1.020	137,710	0	0	52,537,563	1,206	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2005	1.054	141,285	0	0	47,058,498	1,080	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2005	1.054	136,007	0	0	39,404,798	905	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	20,612,599	39,404,798	905	14.7
9/1/2005	1.020	9	0	0	91,253	2	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	91,253	0	0	91,253	2	0.0
10/1/2005	1.054	9	0	0	148,485	3	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2005	1.020	21,790	0	0	395,840	9	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2005	1.054	38,442	0	0	21,340,361	490	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2006	1.054	121,056	0	0	58,889,933	1,352	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2006	0.952	136,560	0	0	68,213,181	1,566	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2006	1.054	158,236	0	0	68,256,030	1,567	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2006	1.020	153,269	0	0	75,501,216	1,733	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2006	1.054	159,089	0	0	94,241,655	2,163	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2006	1.020	153,957	0	0	114,687,033	2,633	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2006	1.054	159,089	0	0	89,372,318	2,052	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2006	1.054	159,089	0	0	69,167,333	1,588	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2006	1.020	117,266	0	0	21,551,057	495	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	12,779,038	21,551,057	495	8.3
10/1/2006	1.054	9	0	0	95,894	2	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2006	1.020	17,420	0	0	12,180,904	280	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2006	1.054	112,998	0	0	36,837,267	846	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2007	1.054	134,020	0	0	53,879,704	1,237	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2007	0.952	133,157	0	0	53,879,573	1,237	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2007	1.054	147,423	0	0	57,764,007	1,326	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2007	1.020	145,557	0	0	66,135,021	1,518	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2007	1.054	154,879	0	0	95,093,089	2,183	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2007	1.020	153,957	0	0	108,841,182	2,499	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2007	1.054	159,089	0	0	86,854,142	1,994	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2007	1.054	159,089	0	0	69,210,644	1,589	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2007	1.020	117,266	0	0	21,558,791	495	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	12,786,772	21,558,791	495	8.3
10/1/2007	1.054	9	0	0	208,811	5	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2007	1.020	26,161	0	0	391,469	9	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2007	1.054	38,442	0	0	10,057,231	231	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2008	1.054	111,049	0	0	12,059,028	277	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2008	0.986	105,600	0	0	12,084,907	277	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2008	1.054	112,883	0	0	12,160,735	279	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2008	1.020	109,353	0	0	16,922,313	388	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2008	1.054	114,962	0	0	45,684,956	1,049	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2008	1.020	130,777	0	0	83,824,130	1,924	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2008	1.054	159,089	0	0	84,322,723	1,936	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2008	1.054	159,089	0	0	69,283,344	1,591	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2008	1.020	117,380	0	0	21,558,677	495	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	12,786,658	21,558,677	495	8.3
10/1/2008	1.054	9	0	0	131,470	3	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0

	Reservoir Losses				Starting Reservoir Volume		Downstream Irrigation Demand[7]						Releases from Reservoir to Downstream Irrigation System[8]					
	Seepage[4]		Evaporation[5]		+ Inflows - Losses[6]		H1 Lateral	Independent	SPTIA-DID	Total	Total	Average	H1 Lateral	Independent	SPTIA-DID	Total	Total	Average
Date	In/Day	CF	Inches	CF	CF	Acre-feet	CF	CF	CF	CF	Acre-feet	cfs	CF	CF	CF	CF	Acre-feet	cfs
11/1/2008	1.020	19,605	0	0	647,062	15	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2008	1.054	49,881	0	0	957,588	22	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2009	1.054	61,434	0	0	6,886,660	158	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2009	0.952	97,737	0	0	7,061,162	162	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2009	1.054	108,322	0	0	7,262,203	167	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2009	1.020	105,046	0	0	11,921,357	274	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2009	1.054	110,479	0	0	25,873,008	594	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2009	1.020	114,754	0	0	44,428,888	1,020	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2009	1.054	134,764	0	0	38,991,922	895	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2009	1.054	129,473	0	0	31,273,602	718	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	12,481,404	31,273,602	718	11.7
9/1/2009	1.020	9	0	0	129,924	3	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	129,924	0	0	129,924	3	0.1
10/1/2009	1.054	9	0	0	530,548	12	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2009	1.020	43,844	0	0	29,085,774	668	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2009	1.054	127,649	0	0	32,947,155	756	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2010	1.054	130,818	0	0	62,205,491	1,428	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2010	0.952	138,935	0	0	62,184,114	1,428	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2010	1.054	153,689	0	0	62,311,945	1,430	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2010	1.020	148,859	0	0	74,240,771	1,704	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2010	1.054	159,089	0	0	93,021,908	2,135	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2010	1.020	153,957	0	0	114,711,782	2,633	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2010	1.054	159,089	0	0	89,803,169	2,062	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2010	1.054	159,089	0	0	69,218,378	1,589	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2010	1.020	117,266	0	0	21,682,536	498	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	12,910,517	21,682,536	498	8.4
10/1/2010	1.054	9	0	0	174,781	4	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2010	1.020	23,976	0	0	463,261	11	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2010	1.054	40,730	0	0	20,331,713	467	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2011	1.054	120,109	0	0	41,011,892	942	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2011	0.952	124,086	0	0	41,221,917	946	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2011	1.054	137,507	0	0	51,631,056	1,185	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2011	1.020	141,048	0	0	61,657,910	1,415	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2011	1.054	151,454	0	0	88,453,983	2,031	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2011	1.020	153,957	0	0	114,685,487	2,633	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2011	1.054	159,089	0	0	89,869,682	2,063	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2011	1.054	159,089	0	0	69,175,067	1,588	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2011	1.020	117,266	0	0	21,428,859	492	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	12,656,840	21,428,859	492	8.3
10/1/2011	1.054	9	0	0	129,923	3	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2011	1.020	19,605	0	0	9,989,312	229	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2011	1.054	111,049	0	0	10,073,161	231	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2012	1.054	111,049	0	0	18,314,286	420	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2012	0.986	110,819	0	0	18,472,612	424	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2012	1.054	118,579	0	0	20,030,622	460	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2012	1.020	116,007	0	0	36,122,328	829	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2012	1.054	131,308	0	0	72,671,208	1,668	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2012	1.020	151,040	0	0	110,802,495	2,544	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2012	1.054	159,089	0	0	89,990,332	2,066	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2012	1.054	159,089	0	0	69,164,240	1,588	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2012	1.020	117,266	0	0	21,424,219	492	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	12,652,200	21,424,219	492	8.3
10/1/2012	1.054	9	0	0	267,590	6	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2012	1.020	30,560	0	0	13,105,961	301	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2012	1.054	113,805	0	0	22,699,453	521	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2013	1.054	122,244	0	0	24,693,149	567	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2013	0.952	111,923	0	0	24,663,208	566	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2013	1.054	123,915	0	0	24,687,787	567	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2013	1.020	119,917	0	0	32,554,374	747	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2013	1.054	128,377	0	0	66,824,005	1,534	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2013	1.020	146,822	0	0	104,823,389	2,406	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5

	Reservoir Losses				Starting Reservoir Volume		Downstream Irrigation Demand[7]						Releases from Reservoir to Downstream Irrigation System[8]					
	Seepage[4]		Evaporation[5]		+ Inflows - Losses[6]		H1 Lateral	Independent	SPTIA-DID	Total	Total	Average	H1 Lateral	Independent	SPTIA-DID	Total	Total	Average
Date	In/Day	CF	Inches	CF	CF	Acre-feet	CF	CF	CF	CF	Acre-feet	cfs	CF	CF	CF	CF	Acre-feet	cfs
7/1/2013	1.054	159,089	0	0	85,625,832	1,966	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2013	1.054	159,089	0	0	69,261,689	1,590	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2013	1.020	117,380	0	0	21,943,833	504	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	13,171,814	21,943,833	504	8.5
10/1/2013	1.054	9	0	0	176,328	4	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2013	1.020	23,976	0	0	344,157	8	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2013	1.054	36,155	0	0	507,541	12	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2014	1.054	43,018	0	0	2,718,129	62	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2014	0.952	89,518	0	0	3,055,531	70	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2014	1.054	101,384	0	0	20,088,840	461	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2014	1.020	116,121	0	0	24,713,718	567	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2014	1.054	121,768	0	0	50,924,677	1,169	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2014	1.020	134,894	0	0	77,265,353	1,774	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2014	1.054	159,089	0	0	74,950,917	1,721	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2014	1.054	157,542	0	0	67,328,273	1,546	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2014	1.020	115,779	0	0	19,670,174	452	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	10,898,155	19,670,174	452	7.6
10/1/2014	1.054	9	0	0	467,128	11	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2014	1.020	39,416	0	0	10,066,950	231	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2014	1.054	111,049	0	0	39,484,644	906	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2015	1.054	136,132	0	0	58,707,012	1,348	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2015	0.952	136,443	0	0	79,530,331	1,826	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2015	1.054	159,089	0	0	73,307,951	1,683	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2015	1.020	153,957	0	0	73,876,340	1,696	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2015	1.054	159,089	0	0	71,853,240	1,650	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2015	1.020	150,525	0	0	69,602,288	1,598	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2015	1.054	154,350	0	0	64,139,549	1,472	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2015	1.054	149,497	0	0	56,455,343	1,296	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2015	1.020	106,364	0	0	8,823,674	203	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	51,655	8,823,674	203	3.4
10/1/2015	1.054	9	0	0	343,383	8	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2015	1.020	34,988	0	0	12,182,677	280	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2015	1.054	112,998	0	0	43,687,696	1,003	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2016	1.054	139,516	0	0	66,204,695	1,520	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2016	0.986	146,628	0	0	98,231,492	2,255	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2016	1.054	159,089	0	0	95,851,774	2,200	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2016	1.020	153,957	0	0	102,800,245	2,360	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2016	1.054	159,089	0	0	100,768,222	2,313	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2016	1.020	153,957	0	0	91,374,598	2,098	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2016	1.054	159,089	0	0	70,454,555	1,617	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2016	1.054	154,218	0	0	62,686,742	1,439	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2016	1.020	111,814	0	0	15,057,356	346	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	6,285,336	15,057,356	346	5.8
10/1/2016	1.054	9	0	0	479,503	11	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2016	1.020	41,630	0	0	11,976,497	275	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2016	1.054	112,768	0	0	12,106,578	278	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2017	1.054	112,883	0	0	19,580,412	450	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2017	0.952	107,954	0	0	37,257,478	855	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2017	1.054	134,268	0	0	51,383,412	1,180	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2017	1.020	140,800	0	0	63,113,851	1,449	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2017	1.054	152,635	0	0	98,443,343	2,260	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2017	1.020	153,957	0	0	114,714,876	2,633	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2017	1.054	159,089	0	0	84,254,663	1,934	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2017	1.054	159,089	0	0	69,173,520	1,588	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2017	1.020	117,266	0	0	21,472,170	493	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	12,700,151	21,472,170	493	8.3
10/1/2017	1.054	9	0	0	298,526	7	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2017	1.020	32,774	0	0	21,476,096	493	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2017	1.054	121,175	0	0	21,789,576	500	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2018	1.054	121,412	0	0	34,257,331	786	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2018	0.952	119,156	0	0	51,299,164	1,178	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0

	Reservoir Losses				Starting Reservoir Volume		Downstream Irrigation Demand[7]						Releases from Reservoir to Downstream Irrigation System[8]					
	Seepage[4]		Evaporation[5]		+ Inflows - Losses[6]		H1 Lateral	Independent	SPTIA-DID	Total	Total	Average	H1 Lateral	Independent	SPTIA-DID	Total	Total	Average
Date	In/Day	CF	Inches	CF	CF	Acre-feet	CF	CF	CF	CF	Acre-feet	cfs	CF	CF	CF	CF	Acre-feet	cfs
3/1/2018	1.054	145,493	0	0	51,404,254	1,180	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2018	1.020	140,800	0	0	64,025,555	1,470	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2018	1.054	153,294	0	0	104,590,282	2,401	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2018	1.020	153,957	0	0	97,692,447	2,243	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2018	1.054	159,089	0	0	70,420,525	1,617	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2018	1.054	154,218	0	0	62,705,304	1,440	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2018	1.020	111,814	0	0	15,051,168	346	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	6,279,149	15,051,168	346	5.8
10/1/2018	1.054	9	0	0	315,541	7	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2018	1.020	32,774	0	0	6,222,228	143	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2018	1.054	107,644	0	0	23,260,104	534	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2019	1.054	122,720	0	0	36,448,556	837	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2019	0.952	120,715	0	0	36,748,573	844	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2019	1.054	133,897	0	0	36,656,441	842	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2019	1.020	129,458	0	0	43,748,237	1,004	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2019	1.054	137,507	0	0	77,161,264	1,771	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2019	1.020	153,957	0	0	86,080,232	1,976	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2019	1.054	159,089	0	0	70,519,521	1,619	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2019	1.054	154,218	0	0	62,807,393	1,442	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2019	1.020	111,927	0	0	15,485,710	356	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	6,713,691	15,485,710	356	6.0
10/1/2019	1.054	9	0	0	262,949	6	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2019	1.020	30,560	0	0	360,774	8	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2019	1.054	36,155	0	0	2,720,532	62	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2020	1.054	99,109	0	0	16,187,819	372	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2020	0.986	109,067	0	0	35,299,996	810	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2020	1.054	132,661	0	0	35,442,667	814	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2020	1.020	128,501	0	0	40,762,955	936	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2020	1.054	135,137	0	0	72,308,919	1,660	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2020	1.020	150,783	0	0	107,669,452	2,472	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2020	1.054	159,089	0	0	70,434,447	1,617	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2020	1.054	154,218	0	0	62,705,304	1,440	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2020	1.020	111,814	0	0	15,133,149	347	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	6,361,130	15,133,149	347	5.8
10/1/2020	1.054	9	0	0	171,687	4	0	2,509,215	15,624,883	18,134,098	416	6.8	0	0	0	0	0	0.0
11/1/2020	1.020	23,976	0	0	4,931,813	113	0	1,615,392	17,386,063	19,001,455	436	7.3	0	0	0	0	0	0.0
12/1/2020	1.054	106,407	0	0	5,376,071	123	0	226,944	9,918,720	10,145,664	233	3.8	0	0	0	0	0	0.0
1/1/2021	1.054	106,857	0	0	26,241,350	602	0	7,776	4,587,989	4,595,765	106	1.7	0	0	0	0	0	0.0
2/1/2021	0.952	113,115	0	0	26,338,601	605	0	0	2,694,848	2,694,848	62	1.1	0	0	0	0	0	0.0
3/1/2021	1.054	125,234	0	0	26,343,299	605	0	43,200	3,322,080	3,365,280	77	1.3	0	0	0	0	0	0.0
4/1/2021	1.020	121,195	0	0	30,997,133	712	2,483,654	8,773,920	20,046,096	31,303,670	719	12.1	2,483,654	0	0	2,483,654	57	1.0
5/1/2021	1.054	127,164	0	0	54,672,133	1,255	7,335,878	17,608,320	36,002,880	60,947,078	1,399	22.8	7,335,878	0	0	7,335,878	168	2.7
6/1/2021	1.020	137,710	0	0	92,007,722	2,112	6,597,158	15,789,600	35,946,720	58,333,478	1,339	22.5	6,597,158	0	0	6,597,158	151	2.5
7/1/2021	1.054	159,089	0	0	77,883,482	1,788	7,635,251	14,525,834	35,877,600	58,038,685	1,332	21.7	7,635,251	0	0	7,635,251	175	2.9
8/1/2021	1.054	159,089	0	0	69,170,427	1,588	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8	6,238,278	12,553,920	28,867,680	47,659,878	1,094	17.8
9/1/2021	1.020	117,266	0	0	21,711,926	498	2,365,459	6,406,560	21,470,400	30,242,419	694	11.7	2,365,459	6,406,560	12,939,907	21,711,926	498	8.4
10/1/2021																		

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Reservoir O
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	Spill or Excess Flow Not Stored[9]			Ending Reservoir				Irrigation Demands Not Supplied from Reservoir							
				Volume		Elevation	Area	H1 Lateral		Independent		SPTIA-DID		Total	
Date	CF	Acre-feet	cfs	CF	Acre-Feet	Feet	SF	CF	Acre-feet	CF	Acre-feet	CF	Acre-feet	CF	Acre-feet
11/1/1999	0	0	0.0	20,381,504	468	404.1	1,368,184	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/1999	0	0	0.0	43,289,745	994	419.6	1,583,386	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2000	0	0	0.0	43,385,721	996	419.7	1,584,818	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2000	0	0	0.0	47,154,757	1,083	422.0	1,617,915	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2000	0	0	0.0	47,156,438	1,083	422.0	1,617,915	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2000	0	0	0.0	49,268,462	1,131	423.3	1,636,763	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2000	0	0	0.0	62,682,554	1,439	431.2	1,753,479	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2000	32,085,757	737	12.4	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2000	3,716,141	85	1.4	69,317,141	1,591	434.9	1,810,417	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2000	0	0	0.0	21,532,204	494	404.9	1,378,959	0	0	0	0	0	0	0	0
9/1/2000	0	0	0.0	0	0	385.5	100	0	0	0	0	8,657,332	199	8,657,332	199
10/1/2000	0	0	0.0	216,545	5	386.9	307,634	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2000	0	0	0.0	457,982	11	387.5	463,506	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2000	0	0	0.0	573,480	13	387.7	515,576	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2001	0	0	0.0	2,611,631	60	390.1	1,119,222	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2001	0	0	0.0	2,632,622	60	390.2	1,127,852	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2001	0	0	0.0	2,641,790	61	390.2	1,127,852	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2001	0	0	0.0	4,894,484	112	392.1	1,210,906	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2001	0	0	0.0	8,819,529	202	395.3	1,252,055	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2001	0	0	0.0	9,954,724	229	396.2	1,263,729	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2001	0	0	0.0	3,466,256	80	390.9	1,188,264	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2001	0	0	0.0	0	0	385.5	100	2,806,834	64	12,553,920	288	28,867,680	663	44,228,434	1,015
9/1/2001	0	0	0.0	0	0	385.5	100	2,326,797	53	6,406,560	147	21,470,400	493	30,203,757	693
10/1/2001	0	0	0.0	355,758	8	387.3	411,436	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2001	0	0	0.0	13,704,641	315	399.1	1,301,662	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2001	0	0	0.0	24,558,969	564	407.1	1,408,776	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2002	0	0	0.0	46,571,132	1,069	421.7	1,613,586	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2002	0	0	0.0	54,529,133	1,252	426.5	1,683,555	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2002	0	0	0.0	54,704,475	1,256	426.6	1,685,026	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2002	0	0	0.0	63,311,938	1,453	431.6	1,759,503	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2002	3,116,211	72	1.2	69,317,141	1,591	434.9	1,810,417	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2002	38,727,876	889	14.9	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2002	10,102,818	232	3.8	69,317,141	1,591	434.9	1,810,417	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2002	0	0	0.0	21,547,672	495	404.9	1,378,959	0	0	0	0	0	0	0	0
9/1/2002	0	0	0.0	0	0	385.5	100	0	0	0	0	8,743,953	201	8,743,953	201
10/1/2002	0	0	0.0	108,268	2	386.5	204,842	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2002	0	0	0.0	219,234	5	386.9	307,634	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2002	0	0	0.0	7,896,476	181	394.5	1,241,715	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2003	0	0	0.0	34,607,124	794	414.0	1,504,064	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2003	0	0	0.0	36,404,147	836	415.2	1,520,915	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2003	0	0	0.0	49,654,370	1,140	423.6	1,641,126	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2003	0	0	0.0	51,956,225	1,193	424.9	1,660,082	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2003	0	0	0.0	58,301,317	1,338	428.7	1,716,096	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2003	22,300,644	512	8.6	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2003	4,576,386	105	1.7	69,317,141	1,591	434.9	1,810,417	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2003	0	0	0.0	21,516,736	494	404.9	1,378,959	0	0	0	0	0	0	0	0
9/1/2003	0	0	0.0	0	0	385.5	100	0	0	0	0	8,730,032	200	8,730,032	200
10/1/2003	0	0	0.0	383,600	9	387.4	437,471	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2003	0	0	0.0	15,702,356	360	400.6	1,321,475	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2003	0	0	0.0	28,937,029	664	410.1	1,449,876	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2004	0	0	0.0	35,746,868	821	414.7	1,513,887	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2004	0	0	0.0	35,685,839	819	414.7	1,513,887	0	0	0	0	2,694,848	62	2,694,848	62

	Spill or Excess Flow Not Stored[9]			Ending Reservoir				Irrigation Demands Not Supplied from Reservoir							
				Volume		Elevation	Area	H1 Lateral		Independent		SPTIA-DID		Total	
Date	CF	Acre-feet	cfs	CF	Acre-Feet	Feet	SF	CF	Acre-feet	CF	Acre-feet	CF	Acre-feet	CF	Acre-feet
3/1/2004	0	0	0.0	35,726,050	820	414.7	1,513,887	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2004	0	0	0.0	37,797,423	868	416.1	1,533,602	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2004	0	0	0.0	50,524,620	1,160	424.1	1,648,403	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2004	525,391	12	0.2	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2004	0	0	0.0	62,806,929	1,442	431.3	1,754,985	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2004	0	0	0.0	15,299,102	351	400.3	1,317,502	0	0	0	0	0	0	0	0
9/1/2004	0	0	0.0	0	0	385.5	100	0	0	0	0	14,874,380	341	14,874,380	341
10/1/2004	0	0	0.0	185,609	4	386.8	281,936	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2004	0	0	0.0	2,353,367	54	389.9	1,085,257	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2004	0	0	0.0	13,748,674	316	399.1	1,301,662	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2005	0	0	0.0	31,983,628	734	412.2	1,478,950	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2005	0	0	0.0	31,960,599	734	412.2	1,478,950	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2005	0	0	0.0	32,005,428	735	412.2	1,478,950	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2005	0	0	0.0	38,092,251	874	416.3	1,536,431	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2005	0	0	0.0	47,275,858	1,085	422.1	1,619,363	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2005	0	0	0.0	45,940,404	1,055	421.3	1,607,814	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2005	0	0	0.0	39,423,247	905	417.1	1,547,754	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2005	0	0	0.0	0	0	385.5	100	0	0	0	0	8,255,081	190	8,255,081	190
9/1/2005	0	0	0.0	0	0	385.5	100	2,274,206	52	6,406,560	147	21,470,400	493	30,151,166	692
10/1/2005	0	0	0.0	148,485	3	386.7	256,238	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2005	0	0	0.0	395,840	9	387.4	437,471	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2005	0	0	0.0	21,340,361	490	404.8	1,377,612	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2006	0	0	0.0	58,889,933	1,352	429.0	1,720,553	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2006	0	0	0.0	68,213,181	1,566	434.3	1,800,710	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2006	0	0	0.0	68,256,030	1,567	434.4	1,802,328	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2006	3,700,421	85	1.4	69,317,141	1,591	434.9	1,810,417	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2006	17,588,636	404	6.6	69,317,141	1,591	434.9	1,810,417	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2006	38,772,734	890	15.0	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2006	12,419,926	285	4.6	69,317,141	1,591	434.9	1,810,417	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2006	0	0	0.0	21,507,455	494	404.9	1,378,959	0	0	0	0	0	0	0	0
9/1/2006	0	0	0.0	0	0	385.5	100	0	0	0	0	8,691,362	200	8,691,362	200
10/1/2006	0	0	0.0	95,894	2	386.5	204,842	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2006	0	0	0.0	12,180,904	280	397.9	1,285,908	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2006	0	0	0.0	36,837,267	846	415.5	1,525,142	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2007	0	0	0.0	53,879,704	1,237	426.1	1,677,668	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2007	0	0	0.0	53,879,573	1,237	426.1	1,677,668	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2007	0	0	0.0	57,764,007	1,326	428.4	1,711,640	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2007	0	0	0.0	63,651,367	1,461	431.8	1,762,515	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2007	18,440,070	423	6.9	69,317,141	1,591	434.9	1,810,417	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2007	32,926,882	756	12.7	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2007	9,901,750	227	3.7	69,317,141	1,591	434.9	1,810,417	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2007	0	0	0.0	21,550,765	495	404.9	1,378,959	0	0	0	0	0	0	0	0
9/1/2007	0	0	0.0	0	0	385.5	100	0	0	0	0	8,683,628	199	8,683,628	199
10/1/2007	0	0	0.0	208,811	5	386.9	307,634	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2007	0	0	0.0	391,469	9	387.4	437,471	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2007	0	0	0.0	10,057,231	231	396.2	1,263,729	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2008	0	0	0.0	12,059,028	277	397.8	1,284,600	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2008	0	0	0.0	12,084,907	277	397.8	1,284,600	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2008	0	0	0.0	12,160,735	279	397.9	1,285,908	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2008	0	0	0.0	14,438,659	331	399.6	1,308,255	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2008	0	0	0.0	38,349,077	880	416.4	1,537,846	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2008	7,909,830	182	3.1	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2008	7,370,331	169	2.8	69,317,141	1,591	434.9	1,810,417	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2008	0	0	0.0	21,623,466	496	405.0	1,380,306	0	0	0	0	0	0	0	0
9/1/2008	0	0	0.0	0	0	385.5	100	0	0	0	0	8,683,742	199	8,683,742	199
10/1/2008	0	0	0.0	131,470	3	386.6	230,540	0	0	2,509,215	58	15,624,883	359	18,134,098	416

	Spill or Excess Flow Not Stored[9]			Ending Reservoir				Irrigation Demands Not Supplied from Reservoir							
				Volume		Elevation	Area	H1 Lateral		Independent		SPTIA-DID		Total	
Date	CF	Acre-feet	cfs	CF	Acre-Feet	Feet	SF	CF	Acre-feet	CF	Acre-feet	CF	Acre-feet	CF	Acre-feet
11/1/2008	0	0	0.0	647,062	15	387.9	567,645	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2008	0	0	0.0	957,588	22	388.4	699,109	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2009	0	0	0.0	6,886,660	158	393.7	1,231,410	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2009	0	0	0.0	7,061,162	162	393.8	1,232,694	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2009	0	0	0.0	7,262,203	167	394.0	1,235,264	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2009	0	0	0.0	9,437,703	217	395.7	1,257,238	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2009	0	0	0.0	18,537,129	426	402.7	1,349,419	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2009	0	0	0.0	37,831,730	868	416.1	1,533,602	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2009	0	0	0.0	31,356,671	720	411.8	1,473,394	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2009	0	0	0.0	0	0	385.5	100	0	0	0	0	16,386,276	376	16,386,276	376
9/1/2009	0	0	0.0	0	0	385.5	100	2,235,536	51	6,406,560	147	21,470,400	493	30,112,496	691
10/1/2009	0	0	0.0	530,548	12	387.7	515,576	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2009	0	0	0.0	29,085,774	668	410.3	1,452,637	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2009	0	0	0.0	32,947,155	756	412.9	1,488,695	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2010	0	0	0.0	62,205,491	1,428	431.0	1,750,466	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2010	0	0	0.0	62,184,114	1,428	430.9	1,748,967	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2010	0	0	0.0	62,311,945	1,430	431.0	1,750,466	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2010	2,439,976	56	0.9	69,317,141	1,591	434.9	1,810,417	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2010	16,368,889	376	6.1	69,317,141	1,591	434.9	1,810,417	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2010	38,797,483	891	15.0	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2010	12,850,777	295	4.8	69,317,141	1,591	434.9	1,810,417	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2010	0	0	0.0	21,558,500	495	404.9	1,378,959	0	0	0	0	0	0	0	0
9/1/2010	0	0	0.0	0	0	385.5	100	0	0	0	0	8,559,883	197	8,559,883	197
10/1/2010	0	0	0.0	174,781	4	386.8	281,936	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2010	0	0	0.0	463,261	11	387.5	463,506	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2010	0	0	0.0	20,331,713	467	404.0	1,366,837	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2011	0	0	0.0	41,011,892	942	418.2	1,563,389	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2011	0	0	0.0	41,221,917	946	418.3	1,564,815	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2011	0	0	0.0	51,631,056	1,185	424.8	1,658,622	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2011	0	0	0.0	59,174,256	1,358	429.2	1,723,537	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2011	11,800,964	271	4.4	69,317,141	1,591	434.9	1,810,417	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2011	38,771,187	890	15.0	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2011	12,917,290	297	4.8	69,317,141	1,591	434.9	1,810,417	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2011	0	0	0.0	21,515,189	494	404.9	1,378,959	0	0	0	0	0	0	0	0
9/1/2011	0	0	0.0	0	0	385.5	100	0	0	0	0	8,813,560	202	8,813,560	202
10/1/2011	0	0	0.0	129,923	3	386.6	230,540	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2011	0	0	0.0	9,989,312	229	396.2	1,263,729	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2011	0	0	0.0	10,073,161	231	396.2	1,263,729	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2012	0	0	0.0	18,314,286	420	402.6	1,348,084	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2012	0	0	0.0	18,472,612	424	402.7	1,349,419	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2012	0	0	0.0	20,030,622	460	403.8	1,364,155	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2012	0	0	0.0	33,638,674	772	413.3	1,494,280	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2012	0	0	0.0	65,335,330	1,500	432.7	1,776,118	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2012	34,888,195	801	13.5	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2012	13,037,940	299	4.9	69,317,141	1,591	434.9	1,810,417	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2012	0	0	0.0	21,504,361	494	404.9	1,378,959	0	0	0	0	0	0	0	0
9/1/2012	0	0	0.0	0	0	385.5	100	0	0	0	0	8,818,200	202	8,818,200	202
10/1/2012	0	0	0.0	267,590	6	387.1	359,367	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2012	0	0	0.0	13,105,961	301	398.6	1,295,092	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2012	0	0	0.0	22,699,453	521	405.8	1,391,125	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2013	0	0	0.0	24,693,149	567	407.2	1,410,139	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2013	0	0	0.0	24,663,208	566	407.2	1,410,139	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2013	0	0	0.0	24,687,787	567	407.2	1,410,139	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2013	0	0	0.0	30,070,720	690	410.9	1,460,922	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2013	0	0	0.0	59,488,126	1,366	429.4	1,726,521	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2013	28,909,090	664	11.2	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188

	Spill or Excess Flow Not Stored[9]			Ending Reservoir				Irrigation Demands Not Supplied from Reservoir							
				Volume		Elevation	Area	H1 Lateral		Independent		SPTIA-DID		Total	
Date	CF	Acre-feet	cfs	CF	Acre-Feet	Feet	SF	CF	Acre-feet	CF	Acre-feet	CF	Acre-feet	CF	Acre-feet
7/1/2013	8,673,440	199	3.2	69,317,141	1,591	434.9	1,810,417	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2013	0	0	0.0	21,601,810	496	405.0	1,380,306	0	0	0	0	0	0	0	0
9/1/2013	0	0	0.0	0	0	385.5	100	0	0	0	0	8,298,586	191	8,298,586	191
10/1/2013	0	0	0.0	176,328	4	386.8	281,936	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2013	0	0	0.0	344,157	8	387.3	411,436	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2013	0	0	0.0	507,541	12	387.6	489,541	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2014	0	0	0.0	2,718,129	62	390.2	1,127,852	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2014	0	0	0.0	3,055,531	70	390.5	1,153,743	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2014	0	0	0.0	20,088,840	461	403.9	1,365,496	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2014	0	0	0.0	22,230,064	510	405.4	1,385,716	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2014	0	0	0.0	43,588,798	1,001	419.8	1,586,249	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2014	1,351,054	31	0.5	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2014	0	0	0.0	67,315,666	1,545	433.8	1,792,816	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2014	0	0	0.0	19,668,395	452	403.6	1,361,473	0	0	0	0	0	0	0	0
9/1/2014	0	0	0.0	0	0	385.5	100	0	0	0	0	10,572,245	243	10,572,245	243
10/1/2014	0	0	0.0	467,128	11	387.5	463,506	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2014	0	0	0.0	10,066,950	231	396.2	1,263,729	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2014	0	0	0.0	39,484,644	906	417.2	1,549,174	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2015	0	0	0.0	58,707,012	1,348	428.9	1,719,067	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2015	10,213,190	234	4.2	69,317,141	1,591	434.9	1,810,417	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2015	3,990,810	92	1.5	69,317,141	1,591	434.9	1,810,417	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2015	2,075,545	48	0.8	69,317,141	1,591	434.9	1,810,417	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2015	0	0	0.0	64,517,362	1,481	432.3	1,770,066	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2015	0	0	0.0	63,005,130	1,446	431.4	1,756,491	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2015	0	0	0.0	56,504,298	1,297	427.7	1,701,263	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2015	0	0	0.0	8,795,465	202	395.2	1,250,759	0	0	0	0	0	0	0	0
9/1/2015	0	0	0.0	0	0	385.5	100	0	0	0	0	21,418,745	492	21,418,745	492
10/1/2015	0	0	0.0	343,383	8	387.3	411,436	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2015	0	0	0.0	12,182,677	280	397.9	1,285,908	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2015	0	0	0.0	43,687,696	1,003	419.9	1,587,681	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2016	0	0	0.0	66,204,695	1,520	433.2	1,783,697	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2016	28,914,351	664	11.5	69,317,141	1,591	434.9	1,810,417	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2016	26,534,633	609	9.9	69,317,141	1,591	434.9	1,810,417	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2016	30,999,449	712	12.0	69,317,141	1,591	434.9	1,810,417	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2016	24,115,202	554	9.0	69,317,141	1,591	434.9	1,810,417	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2016	15,460,298	355	6.0	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2016	0	0	0.0	62,819,304	1,442	431.3	1,754,985	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2016	0	0	0.0	15,026,863	345	400.1	1,314,854	0	0	0	0	0	0	0	0
9/1/2016	0	0	0.0	0	0	385.5	100	0	0	0	0	15,185,064	349	15,185,064	349
10/1/2016	0	0	0.0	479,503	11	387.6	489,541	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2016	0	0	0.0	11,976,497	275	397.7	1,283,293	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2016	0	0	0.0	12,106,578	278	397.8	1,284,600	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2017	0	0	0.0	19,580,412	450	403.5	1,360,132	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2017	0	0	0.0	37,257,478	855	415.7	1,527,960	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2017	0	0	0.0	51,383,412	1,180	424.6	1,655,702	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2017	0	0	0.0	60,630,196	1,392	430.1	1,736,974	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2017	21,790,323	500	8.1	69,317,141	1,591	434.9	1,810,417	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2017	38,800,577	891	15.0	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2017	7,302,271	168	2.7	69,317,141	1,591	434.9	1,810,417	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2017	0	0	0.0	21,513,642	494	404.9	1,378,959	0	0	0	0	0	0	0	0
9/1/2017	0	0	0.0	0	0	385.5	100	0	0	0	0	8,770,249	201	8,770,249	201
10/1/2017	0	0	0.0	298,526	7	387.2	385,402	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2017	0	0	0.0	21,476,096	493	404.9	1,378,959	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2017	0	0	0.0	21,789,576	500	405.1	1,381,658	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2018	0	0	0.0	34,257,331	786	413.8	1,501,268	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2018	0	0	0.0	51,299,164	1,178	424.6	1,655,702	0	0	0	0	2,694,848	62	2,694,848	62

	Spill or Excess Flow Not Stored[9]			Ending Reservoir				Irrigation Demands Not Supplied from Reservoir							
				Volume		Elevation	Area	H1 Lateral		Independent		SPTIA-DID		Total	
Date	CF	Acre-feet	cfs	CF	Acre-Feet	Feet	SF	CF	Acre-feet	CF	Acre-feet	CF	Acre-feet	CF	Acre-feet
3/1/2018	0	0	0.0	51,404,254	1,180	424.6	1,655,702	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2018	0	0	0.0	61,541,900	1,413	430.6	1,744,470	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2018	27,937,262	641	10.4	69,317,141	1,591	434.9	1,810,417	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2018	21,778,148	500	8.4	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2018	0	0	0.0	62,785,274	1,441	431.3	1,754,985	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2018	0	0	0.0	15,045,425	345	400.1	1,314,854	0	0	0	0	0	0	0	0
9/1/2018	0	0	0.0	0	0	385.5	100	0	0	0	0	15,191,251	349	15,191,251	349
10/1/2018	0	0	0.0	315,541	7	387.2	385,402	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2018	0	0	0.0	6,222,228	143	393.2	1,224,986	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2018	0	0	0.0	23,260,104	534	406.2	1,396,547	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2019	0	0	0.0	36,448,556	837	415.2	1,520,915	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2019	0	0	0.0	36,748,573	844	415.4	1,523,733	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2019	0	0	0.0	36,656,441	842	415.3	1,522,324	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2019	0	0	0.0	41,264,583	947	418.3	1,564,815	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2019	508,245	12	0.2	69,317,141	1,591	434.9	1,810,417	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2019	10,165,932	233	3.9	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2019	0	0	0.0	62,884,270	1,444	431.3	1,754,985	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2019	0	0	0.0	15,147,515	348	400.2	1,316,178	0	0	0	0	0	0	0	0
9/1/2019	0	0	0.0	0	0	385.5	100	0	0	0	0	14,756,709	339	14,756,709	339
10/1/2019	0	0	0.0	262,949	6	387.1	359,367	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2019	0	0	0.0	360,774	8	387.3	411,436	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2019	0	0	0.0	2,720,532	62	390.2	1,127,852	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2020	0	0	0.0	16,187,819	372	401.0	1,326,772	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2020	0	0	0.0	35,299,996	810	414.4	1,509,677	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2020	0	0	0.0	35,442,667	814	414.5	1,511,081	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2020	0	0	0.0	38,279,300	879	416.4	1,537,846	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2020	0	0	0.0	64,973,041	1,492	432.5	1,773,092	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2020	31,755,153	729	12.3	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2020	0	0	0.0	62,799,195	1,442	431.3	1,754,985	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2020	0	0	0.0	15,045,425	345	400.1	1,314,854	0	0	0	0	0	0	0	0
9/1/2020	0	0	0.0	0	0	385.5	100	0	0	0	0	15,109,270	347	15,109,270	347
10/1/2020	0	0	0.0	171,687	4	386.8	281,936	0	0	2,509,215	58	15,624,883	359	18,134,098	416
11/1/2020	0	0	0.0	4,931,813	113	392.1	1,210,906	0	0	1,615,392	37	17,386,063	399	19,001,455	436
12/1/2020	0	0	0.0	5,376,071	123	392.5	1,216,022	0	0	226,944	5	9,918,720	228	10,145,664	233
1/1/2021	0	0	0.0	26,241,350	602	408.3	1,425,158	0	0	7,776	0	4,587,989	105	4,595,765	106
2/1/2021	0	0	0.0	26,338,601	605	408.3	1,425,158	0	0	0	0	2,694,848	62	2,694,848	62
3/1/2021	0	0	0.0	26,343,299	605	408.3	1,425,158	0	0	43,200	1	3,322,080	76	3,365,280	77
4/1/2021	0	0	0.0	28,513,479	655	409.9	1,447,120	0	0	8,773,920	201	20,046,096	460	28,820,016	662
5/1/2021	0	0	0.0	47,336,254	1,087	422.1	1,619,363	0	0	17,608,320	404	36,002,880	827	53,611,200	1,231
6/1/2021	16,093,423	369	6.2	69,317,141	1,591	434.9	1,810,417	0	0	15,789,600	362	35,946,720	825	51,736,320	1,188
7/1/2021	931,090	21	0.3	69,317,141	1,591	434.9	1,810,417	0	0	14,525,834	333	35,877,600	824	50,403,434	1,157
8/1/2021	0	0	0.0	21,510,548	494	404.9	1,378,959	0	0	0	0	0	0	0	0
9/1/2021	0	0	0.0	0	0	385.5	100	0	0	0	0	8,530,493	196	8,530,493	196
10/1/2021															

Appendix L
HID Intake and Screening Assessment

Technical Memo

Date:	Tuesday, December 07, 2021
Project:	Dungeness Off-Channel Reservoir Project
To:	Anchor QEA – David Rice
From:	John D. Nelson and Kristin LaForge
Subject:	Conditional Assessment of Existing Intake on Highland Irrigation District Canal

Introduction

Clallam County Department of Public Works is proposing to construct a new irrigation reservoir that would be supplied from the Highland Irrigation District (Highland) main canal. HDR, under subcontract to Anchor QEA, has conducted a Conditional Assessment of Highland's diversion structure located on their main canal intake that diverts from Dungeness River at River Mile 11.0, south of Sequim, WA. The intent of this assessment is to determine if the existing diversion has the capacity to divert up to 25 cfs for irrigation demands while meeting regulatory fish screening criteria. If it does not meet criteria or have the capacity to deliver flow, this assessment presents measures that could bring the fish screening facility into regulatory compliance. This memo presents our findings of the existing condition of the diversion structure as well as assesses the other water control structures located on their surface water diversion system that could impact diversion capacity.

Background

The watershed that feeds the Dungeness River upstream of the Highland diversion structure is approximately 170 square miles. The drainage is characterized by steep mountainous terrain with deep forested canyons. Roughly 75 percent of the annual precipitation (60 in.) occurs October to March with the remaining months dependent upon annual snowpack. The existing drum screen diversion was designed and built by WDFW in 1994. It is assumed that all vertical as-built elevation data is in reference to NGVD 29 (North America Datum of 1927).

Site Observations

HDR visited the site on September 7, 2021 to visually inspect irrigation infrastructure for the Highland Irrigation District which includes a river diversion headgate, irrigation channel, a drum fish screen with a fish bypass system, and a Parshall Flume. The following observations were made during the site visit. Based on USGS gage 12048000 that is less than a mile upstream of the intake, the flow in the Dungeness River during the site visit was approximately 93 cfs.

Diversion Headgate

Water is diverted from the Dungeness River at approximately river mile 11.0, just downstream of the confluence of Canyon Creek and the Dungeness River. Flow enters the headgate between a point bar and the right bank of the Dungeness River as depicted in Figure 1. The concrete diversion structure appears to be the original diversion structure and is in functional condition (Figure 2). One of the two openings in the headgate structure has been permanently closed.

The other opening is 3-foot wide and controls flow to the irrigation ditch (Figure 3). The permanently closed opening was abandoned by filling the downstream channel, installing a wood bulkhead downstream of the slide gate and closing the upstream opening with wood planking on the river side of the opening.

The remaining slide gate is manually operated and has been field repaired several times due to debris damage and general wear and tear. The slide gate is mounted on the downstream side of the concrete headgate wall resulting in an unseated head condition. There is an additional concrete wall that does not extend the full height of the structure that also helps support the slide gate. During the site visit, the water depth was measured to be 3.25 feet immediately downstream of the slide gate.

Upstream channel
Once the diverted surface water passes the headgate structure, it flows through a circular ABS pipe (Figure 4) and discharges into a narrow densely vegetated open canal. Downstream of the canal, the water enters a wide pool (Figure 5) immediately upstream of the intake structure.

Drum Screen
After traveling through the canal, the diverted surface flow splits between a fish bypass system and fish screen. The fish screen is comprised of two 4 ft diameter by 12 ft long drum screens depicted in Figure 6. Immediately downstream of each drum screen are stoplogs set to a specific elevation to control flow. The water depth in front of the screens was measured at 44 inches, or 3.7 feet. The screen sits on a sill raised a half foot above the measured bottom in front of the screen, giving it a water depth of 3.2 feet at the screen. With a 4-foot diameter, this 3.2 foot depth submerges the screen by approximately 80 percent. Per communication on site, the target is 80 percent screen submergence. NMFS criteria for Anadromous Salmonid Passage Facility Design states that for “rotating drum screens, the design submergence must not exceed 85%, nor be less than 65% of the drum diameter” (NFMS 2011).

To divert 25 cfs through the drum screen, the water depth in the drum screen forebay would need to operate at 3.1 feet. With the half foot sill, the minimum submergence depth at the screen would be 2.6 feet. The drum screens can divert up to 32.6 cfs while still in compliance with regulatory criteria and would require a water depth of 3.9 ft on the upstream side of the drum screens, and 3.4-foot depth at the screens.

Fish Bypass System
During the site visit, diversion flow through the drum screen was 4.1 cfs based upon the Parshall Flume. The bypass flow was approximately 1 cfs per communication with the District, which is approximately 24 percent of the total diversion flow. The fish bypass channel was covered with grating that was bolted down so details of the water control gate are unknown. It is assumed that WDFW is using their standard over/under weir gate to control fish bypass flows. Spawning adult Chum Salmon were observed downstream of the fish bypass in a small canal that runs back to the river. Upstream passage is not currently available.

Downstream channel
Downstream of the drum screens, the channel flow rate is controlled with a water control structure consisting of two openings. One opening is comprised of stoplogs and the other

opening uses a manual overshot slide gate. The flow then passes through a Parshall Flume as depicted in Figure 7. The water depth over the stop log was 1.75 inches. The water depth measured through the Parshall Flume during the site visit was 0.5 feet (Figure 8). Using a Parshall Flume Discharge table for a 36" wide Parshall Flume, flow would be 4.1 cfs, and we assume this was the actual flow during the site visit. The Parshall Flume has a water depth level reader with a maximum of approximately 2.5 ft which would result in 41.3 cfs so the Parshall Flume has enough capacity to accommodate 25 cfs.

Regulatory Fish Screen and Fish Bypass Criteria

This section compares existing intake components with regulatory fish screening criteria. The following is a summary of the suggested intake criteria from the agencies for the design of fish screens in the state of Washington:

- Approach Velocity – Uniform approach velocity shall be provided across the face of the screen. Approach velocity must be less than 0.4 feet/second (fps). **Based on calculations, the existing drum screens have a maximum withdrawal capacity of 32.6 cfs with an approach velocity of 0.4 fps and a submergence depth of 85%.**
- Screen Cleaning – For water diversions exceeding 3 cfs, automated screen cleaning is required and shall automatically clean the entire fish screen within a 5-minute cycle. **The existing intake facility has an automated screen cleaning system which meets criteria.**
- Sweeping Velocity – Sweeping velocity shall be at least two times the approach velocity (0.4 fps or higher) and should not decrease along the length of the screen. **Current sweeping velocities do not meet criteria. Sweeping flows decrease from upstream of the screens to the bypass channel. Changing the channel geometry in front of the drum screens and/or increasing bypass flow will bring the sweeping velocities into regulatory compliance. This can be accomplished by adding a training wall on the opposite side of the forebay from the drum screens as well as reducing the bypass channel depth.**
- Screen Openings – Screen opening size shall not exceed 1.75 millimeters (0.07''), with a minimum open area of 27 percent for wedge wire or profile bar screens. If the screen is made from wire mesh or perforated plate, the screen opening size shall not exceed 3/32" (2.4 mm) with a minimum open area of 27 percent. The existing structure has 3/32'' wire mesh. **The existing screen material meets criteria.**
- Screen – The screens shall be constructed of rigid, corrosion-resistant material with no sharp edges or projections (e.g., stainless steel, plastic). The existing screen material is stainless steel. **The existing screen material meets criteria.**
- Minimum Screen Submergence
    - For rotating drum screens the submergence depth must not exceed 85% nor be less than 65% of the drum diameter. **The current set submergence depth is approximately 80% of the drum diameter which falls within criteria.**
- Specific Criteria and Guidelines – Bypass Entrance
    - Flow Control: The bypass entrance shall be provided with independent flow-control capability. **The existing bypass system uses WDFW over/under gate to control flow which meets criteria.**

- Minimum Velocity: The minimum bypass entrance flow velocity shall be greater than 110% of the maximum canal velocity upstream of the bypass entrance. **Current entrance velocity does not meet criteria. Either increasing the bypass flows or making the bypass channel shallower will increase bypass flow velocities.**
- Dimensions: The bypass entrance shall extend from the floor to the canal water surface and shall be a minimum of 18 inches wide. **Current outlet configuration meets criteria.**

- Specific Criteria and Guidelines – Bypass Conduit and System Design
  - General: Bypass pipes and joints shall have smooth surfaces to provide conditions that minimize turbulence, the risk of catching debris, and the potential for fish injury. **Current bypass channel meets criteria.**
  - Flows and Pressure: Bypass flows in the bypass system shall be open channel flow and designed to allow trapped air to escape. **N/A**
  - Bypass flow is approximately 1 cfs for 4.1 cfs diversion which is 24% of the 4.1 diversion flow. Regulatory suggest bypass flow is 5% to 10% of the diversion flow. **Current bypass flow exceeds the minimum % flow bypass recommended criteria for a diversion flow of 4.1 cfs.**

Summary and Recommendations

Diversion Headgate
To meet 25 cfs irrigation diversion and maintain a bypass flow that matches the current percent of flow going to the bypass from the diversion flow (approximately 25 percent), a total of 31 cfs must be diverted from the river. To determine if this is possible at the headgate, the following data needs to be obtained:

- Approximate river water surface elevations when diverting 31 cfs,
- River bathymetric data at the headgate, and
- Headgate as-builts (dimensions and elevations).

The headgate structure should have a trashrack installed on the upstream side of the structure to protect the slide gates from damage due to river debris. New automated slide gates should be installed to control flow to the intake. Refurbishing the abandoned slide gate/channel so it is operational is recommended. This would provide not only increase in flow capacity, but also redundancy by having two slide gates if one was to be damaged.

Flow Control Upstream
Minor hydraulic head losses and seepage may occur through the ABS pipe and the irrigation ditch that decrease the amount of flow conveyed from the headgate to the fish bypass structure. Survey of the existing diversion, the ABS pipe and the canal between the ABS pipe and the fish screen is recommended to allow a hydraulic analysis for verification of capacities and to determine what improvements need to be made to accommodate a 31 cfs diversion.

HDR recommends adding a flow measuring device such as a Parshall Flume downstream of the headgate and the ABS pipe to measure flow coming through the headgate. A duplicate of the existing Parshall Flume downstream of the drum screens would have the required capacity to

measure 31 cfs through the headgate and ABS pipe. This flow measuring device would control the slide gates to achieve the desired diversion flow. Desired flow rates could be set remotely, with the headgates adjusting up or down to accommodate changing flows in Dungeness River.

Sedimentation
Because the Dungeness River transports substantial bed load during high flow events, allowing bed material to pass through the headgate will assist in providing self-cleaning in front of the headgate by allowing the material to pass through. Further analysis to determine expected sediment particle sizes during the diversion period is recommended. Installing a sedimentation pond downstream of the Parshall Flume is a potential design option to reduce the sediment entering the reservoir while also maintaining the hydraulics of the channel.

Ice Impacts on Diversion Structure
Ice should not impact the ability to deliver 31 cfs through the headgate because diversion from the river will only occur during 475-500 cfs or higher flows when ice buildup is not an issue. The bypass and drum screens should not be impacted by ice during high flows.

Drum Screens
WDFW was contacted to discuss their ideas and concerns regarding increasing the diversion through the drum screens at flows up to 25 cfs. WDFW recommends that the drum screens be replaced with new screening materials that meet regulatory criteria and provided a budgetary cost of $120K to replace both drum screen wire mesh screens with 3/23” diameter perforated plate screens. HDR contacted a third-party screen fabricator who builds and installs diversion screens. Their cost estimate is $365,000 which includes the full replacement of the drum screens, associated structural and mechanical components, control panel and installation/start-up.

Flow Control Downstream
Two sets of stoplogs downstream of the screens act as downstream controls: one immediately downstream of the fish screens and one between the Parshall Flume and screens working in tandem with an overshot gate. HDR recommends removing the stop logs immediately downstream of the drum screens because it is redundant with the other set of stoplogs. Furthermore, HDR recommends modulating the overshot gate so that downstream flow through the screens can be controlled. If the stop logs immediately downstream of the drum screens are not removed, changes from the modulated downstream control to adjust flow would be negated.

The gate operator would be controlled by measuring the water depth in the existing Parshall Flume. We suggest using a water surface measuring device such as a sonic or radar meter.

Fish Bypass
The fish bypass should be modulated to adjust flow through the bypass which would increase sweeping velocities to meet agency criteria for the varying flow diversion conditions. WDFW also indicated that excluding upstream migrating adult fish in the fish bypass channel is desired. To exclude these fish, it is recommended that a velocity barrier, or similar upstream barrier, be placed at the downstream extent of the bypass channel near the confluence to the river. Further surveys and measurements are needed to measure the differential in order to determine if this is a potential solution.

APPENDIX A – FIELD NOTES AND SITE PHOTOS

Figure 1 Right bank diversion channel off the Dungeness River at River Mile 11.0

Figure 2 Upstream concrete face of Highland Diversion Ditch Headgate

Figure 3 Highland Ditch Diversion Headgate (Two - 3 ft wide by 3 ft tall unseating head mounted slide gates)

Figure 4 Highland Ditch Canal flowing through a circular ABS Culvert Pipe

Figure 5 Highland Diversion Ditch Canal just upstream of Diversion Structure

Figure 6 Two fish screens looking upstream

Figure 7 Stop log structure, overshot gate and Parshall Flume downstream of fish screen

Figure 8 Parshall Flume with water depth measurement at 0.5 feet

Appendix M
Preliminary Cost Analysis

Dungeness Off-Channel Reservoir Project
Opinion of Probable Cost - SUMMARY - 30% Design

Dungeness Reservoir Key Elements:

Key Project Element	Opinion of Cost Till Core and Liner Option, No Geomembrane Liner	Opinion of Cost Geomembrane Liner Option
Reservoir and Appurtenances	$24,639,000	$25,738,000
Inlet Pipeline, HID Main Canal To Reservoir	$890,000	$890,000
Outlet Pipeline, Reservoir To North Parcel Boundary	$685,000	$685,000
Flow Control Structure On HID Main Canal	$90,000	$90,000
Settling Basin at Upstream End of HID Main Canal	$97,000	$97,000
HID Intake Screen Improvements	$269,000	$269,000
HID Headworks Improvements	$295,000	$295,000
Subtotal - Key Project Elements	**$26,965,000**	**$28,064,000**
Contingency (15%)	$4,044,750	$4,209,600
Construction Subtotal	**$31,010,000**	**$32,274,000**
Sales Tax (8.5%)	$2,635,850	$2,743,290
Construction Total	**$33,646,000**	**$35,017,000**
Other Construction-Related Costs		
Construction Management (8% of Construction Subtotal)	$2,480,800	$2,581,920
Total Project Cost	**$36,127,000**	**$37,599,000**

Other Related Projects:

Proejct	Related Project Costs
Piping Of Hid Main Canal (Expand Capacity To 25 Cfs)	$2,002,000
HID Drought Relief Pumping Station	$636,000
Downstream Irrigation Pipelines to Convey Reservoir Water to Water Users	$3,280,000
Subtotal - Other Related Projects	**$5,918,000**
Contingency (15%)	$887,700
Construction Subtotal	**$6,806,000**
Sales Tax (8.5%)	$578,510
Construction Total	**$7,385,000**
Other Construction-Related Costs	
Construction Management (8% of Subtotal)	$544,480
Total Project Cost	**$7,929,000**

Dungeness Off-Channel Reservoir Project
Opinion of Probable Cost - PRELIMINARY - 30% Design
Preliminary Design Configuration; Till Core and Bottom Liner/No Geomembrane Liner - 1,600 Acre-foot Reservoir

RESERVOIR AND APPURTENANCES

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	1-09.7	$1,847,925	$1,847,925
2	1	LS	Construction Surveying	1-05.5(4)	$100,000	$100,000
3	1	LS	Right-of-Way Use, Construction Permit Compliance	1-07.6(4)	$20,000	$20,000
4	1	LS	Temporary Water Pollution/Erosion Control	1-07.15(4)	$252,000	$252,000
5	1	LS	Utilities Locate and Protection	1-07.17(1)	$10,000	$10,000
6	1	FA	Force Account	1-09.6	$100,000	$100,000
7	1	LS	Temporary Traffic Control	1-10.5	$9,000	$9,000
8	118	AC	Clearing and Grubbing	2-01.5	$5,000	$590,000
9	1	LS	Removal of Structures and Obstructions	2-02.5	$7,500	$7,500
10	190,374	CY	Stripping, Haul, and Stockpile of Topsoil Layer	2-03.5	$4.00	$761,496
11	114,000	CY	Reservoir Excavation, Haul, Place, and Compact for Embankment	2-03.5	$6.50	$741,000
12	1,025,300	CY	Reservoir Excavation, Haul, and Compact in Stockpile	2-03.5	$6.50	$6,664,450
13	28,700	CY	Overexcavation for Crushed Rock Maintenance Course	2-03.5	$4.00	$114,800
14	79,900	CY	Overexcavation for Bottom Liner and Filter Material Layers	2-03.5	$4.00	$319,600
15	279,400	CY	Screening and Placement of On-site Embankment Fill Material	2-03.5	$6.50	$1,816,100
16	102,900	CY	Import and Placement of Sand Filter	2-03.5	$40.00	$4,116,000
17	50,600	CY	Screening and Placement of On-site Embankment Drain Material	2-03.5	$6.50	$328,900
18	175,600	CY	Screening and Placement of Till Core and Bottom Liner Material	2-03.5	$7.50	$1,317,000
19	13,200	TN	Bentonite Amendment for Till Cutoff	2-03.5	$90.00	$1,188,000
20	28,700	CY	Processing and Placement of Crushed Rock Maintenance Course	2-03.5	$6.50	$186,550
21	190,374	CY	Placement of Onsite Topsoil Material	2-03.5	$4.00	$761,496
22	4,390	CY	Trenching for Spillway Pipe Installation, including Shoring	2-03.5	$6.00	$26,340
23	2,192	CY	Spillway Ditch Excavation, Haul, and Stockpile	7-10.5	$4.00	$8,768
24	310	CY	Placement of On-site Processed Spillway Pipe Bedding	2-03.5	$7.50	$2,325
25	3,870	CY	Placement of On-site Spillway Trench Backfill	2-03.5	$6.50	$25,155
26	1	LS	Final Cleanup	2-11.5	$22,000	$22,000
27	15,510	SY	Geotextile	2-12.5	$3.60	$55,836
28	2,600	CY	Processing and Placement of Crushed Surfacing for Access Roads	4-04.5	$6.50	$16,900
29	1	LS	Reservoir Inlet Structure	6-02.5	$5,250	$5,250
30	1	LS	Reservoir Outlet Works	6-02.5	$252,400	$252,400
31	1	LS	Drop Inlet Spillway Structure	6-02.5	$13,500	$13,500
32	3	EA	48-inch Manhole on Downstream Spillway Pipeline	6-02.5	$6,000	$18,000
33	1	EA	36-inch Automated Control Gate at Inlet	7-10.5	$37,500	$37,500
34	2	EA	18-Inch Automated Control Gate at Bypass	7-10.5	$9,400	$18,800
35	635	LF	36-inch HDPE DR 26 Spillway Pipeline	7-10.5	$230.00	$146,050
36	425	LF	24-inch HDPE DR 26 Spillway Pipeline	7-10.5	$45.00	$19,125
37	51	AC	Revegetation (Planting Seeding, Fertilizing, and Mulching)	8-02.5	$5,000	$255,000
38	1	LS	Items not Yet Identified	TBD	$2,463,900	$2,463,900
				Subtotal		**$24,639,000**
				Contingency	15.00%	$3,696,000
				Construction Subtotal		**$28,335,000**
				Sales Tax	8.50%	$2,408,000
				Construction Total		**$30,743,000**

NOTES:

(1) Design, permitting, construction administration, legal and administrative costs are not included with this estimate.

(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.

(3) The Subtotals and Construction Total are rounded to the nearest $1,000.

Dungeness Off-Channel Reservoir Project
Opinion of Probable Cost - PRELIMINARY - 30% Design

INLET PIPELINE - FROM HID MAIN CANAL TO RESERVOIR

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	1-09.7	$66,750	$66,750
2	1	LS	Construction Surveying	1-05.5(4)	$7,000	$7,000
3	1	LS	Right-of-Way Use, Construction Permit Compliance	1-07.6(4)	$5,000	$5,000
4	1	LS	Temporary Water Pollution/Erosion Control	1-07.15(4)	$15,000	$15,000
5	1	LS	Utilities Locate and Protection	1-07.17(1)	$3,000	$3,000
6	1	FA	Force Account	1-09.6	$10,000	$10,000
7	1	LS	Temporary Traffic Control	1-10.5	$4,000	$4,000
8	1.4	AC	Clearing and Grubbing	2-01.5	$5,000	$7,000
9	1	LS	Removal of Structures and Obstructions	2-02.5	$1,800	$1,800
10	10,340	CY	Trenching for Pipe Installation, including Shoring	2-03.5	$6.00	$62,040
11	950	CY	Placement of Imported Pipe Bedding	2-03.5	$7.50	$7,125
12	8,650	CY	Placement of On-site Trench Backfill	2-03.5	$6.50	$56,225
13	1	LS	Final Cleanup	2-11.5	$3,600	$3,600
14	1	LS	Hot Mix Asphalt - Repair of County Roadway	5-04.5	$1,000	$1,000
15	2,863	LF	36-inch HDPE DR 26 Inlet Pipeline, Control Structure to Reservoir	7-10.5	$190	$543,970
16	1.4	AC	Hydroseed (Seeding, Fertilizing, and Mulching)	8-02.5	$5,000	$7,000
17	1	LS	Items not Yet Identified	TBD	$89,000	$89,000
				Subtotal		**$890,000**
				Contingency	15.00%	$134,000
				Construction Subtotal		**$1,024,000**
				Sales Tax	8.50%	$87,000
				Construction Total		**$1,111,000**

NOTES:

(1) Design, permitting, construction administration, legal and administrative costs are not included with this estimate.

(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.

(3) The Subtotals and Construction Total are rounded to the nearest $1,000.

OUTLET PIPELINE - HID RESERVOIR TO NORTH BOUNDARY OF RESERVOIR PARCEL

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	1-09.7	$51,375	$51,375
2	1	LS	Construction Surveying	1-05.5(4)	$4,000	$4,000
3	1	LS	Temporary Water Pollution/Erosion Control	1-07.15(4)	$10,000	$10,000
4	1	LS	Utilities Locate and Protection	1-07.17(1)	$1,000	$1,000
5	1	FA	Force Account	1-09.6	$10,000	$10,000
6	0.80	AC	Clearing and Grubbing	2-01.5	$5,000	$4,000
7	1	LS	Removal of Structures and Obstructions	2-02.5	$1,800	$1,800
8	13,760	CY	Trenching for Pipe Installation	2-03.5	$4.00	$55,040
9	570	CY	Placement of Imported Pipe Bedding	2-03.5	$7.50	$4,275
10	12,750	CY	Placement of On-site Trench Backfill	2-03.5	$6.50	$82,875
11	1	LS	Final Cleanup	2-11.5	$2,700	$2,700
12	381	LF	36-inch Steel Outlet Pipeline, Through Embankment	7-10.5	$360	$137,160
13	1,318	LF	36-inch HDPE DR 26 Outlet Pipeline, Reservoir to Parcel Boundary	7-10.5	$190	$250,420
14	0.80	AC	Hydroseed (Seeding, Fertilizing, and Mulching)	8-02.5	$2,500	$2,000
15	1	LS	Items not Yet Identified	TBD	$68,500	$68,500
				Subtotal		**$685,000**
				Contingency	15.00%	$102,750
				Construction Subtotal		**$788,000**
				Sales Tax	8.50%	$66,980
				Construction Total		**$855,000**

NOTES:

(1) Design, permitting, construction administration, legal and administrative costs are not included with this estimate.

(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.

(3) The Subtotals and Construction Total are rounded to the nearest $1,000.

Dungeness Off-Channel Reservoir Project
Opinion of Probable Cost - PRELIMINARY - 30% Design

FLOW CONTROL STRUCTURE ON HID CANAL

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	1-09.7	$6,750	$6,750
2	1	LS	Construction Surveying	1-05.5(4)	$2,500	$2,500
3	1	LS	Temporary Water Pollution/Erosion Control	1-07.15(4)	$2,000	$2,000
4	1	FA	Force Account	1-09.6	$10,000	$10,000
5	0.05	AC	Clearing and Grubbing	2-01.5	$5,000	$250
6	1	LS	Final Cleanup	2-11.5	$2,700	$2,700
7	1	LS	Reinforced Concrete Flow Control Structure	6-02.5	$57,000	$57,000
8	0.05	AC	Hydroseed (Seeding, Fertilizing, and Mulching)	8-02.5	$2,500	$125
9	1	LS	Items not Yet Identified	TBD	$9,000	$9,000
				Subtotal		**$90,000**
				Contingency	15.00%	$13,500
				Construction Subtotal		**$104,000**
				Sales Tax	8.50%	$8,840
				Construction Total		**$113,000**

NOTES:

(1) Design, permitting, construction administration, legal and administrative costs are not included with this estimate.

(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.

(3) The Subtotals and Construction Total are rounded to the nearest $1,000.

SETTLING BASIN AT UPSTREAM END OF HID CANAL

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	1-09.7	$7,275	$7,275
2	1	LS	Construction Surveying	1-05.5(4)	$2,500	$2,500
3	1	LS	Temporary Water Pollution/Erosion Control	1-07.15(4)	$5,000	$5,000
4	1	LS	Utilities Locate and Protection	1-07.17(1)	$1,000	$1,000
5	1	FA	Force Account	1-09.6	$10,000	$10,000
6	0.23	AC	Clearing and Grubbing	2-01.5	$5,000	$1,150
7	120	CY	Excavate to Widen Existing Canal by 4 Feet, Shape Canal	2-03.5	$8.00	$960
8	190	CY	Trenching for Bypass Pipe Installation	2-03.5	$4.00	$760
9	40	CY	Placement of Imported Pipe Bedding	2-03.5	$40.00	$1,600
10	150	CY	Placement of On-site Trench Backfill	2-03.5	$7.00	$1,050
11	1	LS	Final Cleanup	2-11.5	$2,700	$2,700
12	3,880	SF	Concrete Over Geomembrane Canal Lining	6-02.5	$6.00	$23,280
13	1	LS	Weir, Pipe Inlet , and Bypass Pipeline Headwall Structures	6-02.5	$17,300	$17,300
14	185	LF	18-inch HDPE DR 26 Bypass Pipeline	7-10.5	$50	$9,250
15	1	EA	18-inch Canal Gate	7-13.5	$3,000	$3,000
16	0.23	AC	Hydroseed (Seeding, Fertilizing, and Mulching)	8-02.5	$2,500	$575
17	1	LS	Items not Yet Identified	TBD	$9,700	$9,700
				Subtotal		**$97,000**
				Contingency	15.00%	$14,550
				Construction Subtotal		**$112,000**
				Sales Tax	8.50%	$9,520
				Construction Total		**$122,000**

NOTES:

(1) Design, permitting, construction administration, legal and administrative costs are not included with this estimate.

(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.

(3) The Subtotals and Construction Total are rounded to the nearest $1,000.

Dungeness Off-Channel Reservoir Project
Opinion of Probable Cost - PRELIMINARY - 30% Design

HID INTAKE SCREEN IMPROVEMENTS

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	TBD	$20,175	$20,175
2	1	LS	General Contractor Overhead	TBD	$40,350	$40,350
3	1	LS	Facilities Start-up and Testing	TBD	$4,035	$4,035
4	1	LS	Repaint Gantry Structure	TBD	$5,000	$5,000
5	2	EA	WDFW Refurbished Drum Screens	TBD	$60,000	$120,000
6	1	EA	Motor actuator for bypass gate	TBD	$5,000	$5,000
7	1	EA	7.5 HP Waterjet Pump (300 gpm at 50 ft TDH)	TBD	$15,000	$15,000
8	1	LS	Waterjet Manifold	TBD	$27,500	$27,500
9	1	LS	Yard Hydrant with hose and 15' Stinger	TBD	$5,000	$5,000
10	1	LS	Items not Yet Identified	TBD	$26,900	$26,900
				Subtotal		**$269,000**
				Contingency	15.00%	$40,350
				Construction Subtotal		**$309,000**
				Sales Tax	8.50%	$26,265
				Construction Total		**$335,000**

NOTES:
(1) Design, permitting, construction administration, legal and administrative costs are not included with this estimate.
(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.
(3) The Subtotals and Construction Total are rounded to the nearest $1,000.

HID HEADWORKS IMPROVEMENTS

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	TBD	$22,125	$22,125
2	1	LS	General Contractor Overhead	TBD	$44,250	$44,250
3	1	LS	Facilities Start-up and Testing	TBD	$4,425	$4,425
4	1	LS	Site Prep	TBD	$5,000	$5,000
5	1	LS	Dewatering/Surface Water Management	TBD	$20,000	$20,000
6	1	LS	Temp sediment barrier system	TBD	$5,000	$5,000
7	89	CY	Headgate U/S Channel Improvements (assume 200 ft)	TBD	$100	$8,889
8	1	LS	Headworks Modification (open both openings)	TBD	$1,000	$1,000
9	400	LF	Highland Canal U/S of Intake Improvements (assume 400 ft)	TBD	$50	$20,000
10	200	LF	Highland Canal D/S of Intake Improvements (assume 200 ft)	TBD	$50	$10,000
11	1	LS	Site Clean-up	TBD	$2,000	$2,000
12	1	LS	Misc. concrete work on Headworks Structure	TBD	$25,000	$25,000
13	1,000	LBS	Trash Rack U/S of Headworks, A36 coated	TBD	$12	$12,000
14	3	EA	Flow Meter, Sonic	TBD	$12,000	$36,000
15	1	LS	Misc Instrumentation and Controls	TBD	$10,000	$10,000
16	2	EA	3' wide x 4' tall GH-40 slide gates with motor actuators	TBD	$20,000	$40,000
17	1	LS	Items not Yet Identified	TBD	$29,500	$29,500
				Subtotal		**$295,000**
				Contingency	15.00%	$44,250
				Construction Subtotal		**$339,000**
				Sales Tax	8.50%	$28,815
				Construction Total		**$368,000**

NOTES:
(1) Design, permitting, construction administration, legal and administrative costs are not included with this estimate.
(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.
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Dungeness Off-Channel Reservoir Project
Opinion of Probable Cost - PRELIMINARY - 30% Design

PIPING OF HID MAIN CANAL (EXPAND CAPACITY TO 25 CFS)

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	1-09.7	$150,150	$150,150
2	1	LS	Construction Surveying	1-05.5(4)	$4,400	$4,400
3	1	LS	Temporary Water Pollution/Erosion Control	1-07.15(4)	$10,000	$10,000
4	1	LS	Utilities Locate and Protection	1-07.17(1)	$1,000	$1,000
5	1	FA	Force Account	1-09.6	$25,000	$25,000
6	3.40	AC	Clearing and Grubbing	2-01.5	$5,000	$16,988
7	1	LS	Removal of Structures and Obstructions	2-02.5	$1,800	$1,800
8	6,783	CY	Trenching for Pipe Installation	2-03.5	$4.00	$27,133
9	2,971	CY	Placement of Imported Pipe Bedding	2-03.5	$40.00	$118,852
10	2,467	CY	Placement of On-site Trench Backfill	2-03.5	$7.00	$17,267
11	1	LS	Final Cleanup	2-11.5	$2,500	$2,500
12	1	LS	Pipeline Inlet Structure	6-02.5	$12,000	$12,000
13	7,400	LF	36-inch HDPE DR 26 Pipeline, HID Canal, Intake to H1 Lateral	7-10.5	$190	$1,406,000
14	3.40	AC	Hydroseed (Seeding, Fertilizing, and Mulching)	8-02.5	$2,500	$8,494
15	1	LS	Items not Yet Identified	TBD	$200,200	$200,200
				Subtotal		**$2,002,000**
				Contingency	15.00%	$300,300
				Construction Subtotal		**$2,302,000**
				Sales Tax	8.50%	$195,670
				Construction Total		**$2,498,000**

NOTES:

(1) Design, permitting, construction administration, legal and administrative costs are not included with this estimate.

(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.

(3) The Subtotals and Construction Total are rounded to the nearest $1,000.

HID DROUGHT RELIEF PUMP STATION

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	1-09.7	$70,200	$70,200
2	1	LS	Construction Surveying	1-05.5(4)	$4,600	$4,600
3	1	FA	Force Account	1-09.6	$15,000	$15,000
4	1	LS	Final Cleanup	2-11.5	$2,500	$2,500
5	150	HP	Drought Relief Pump Station, East Side of Reservoir	6-02.5	$3,000	$450,000
6	1	LS	Items not Yet Identified	TBD	$93,600	$93,600
				Subtotal		**$636,000**
				Contingency	15.00%	$95,400
				Construction Subtotal		**$731,000**
				Sales Tax	8.50%	$62,135
				Construction Total		**$793,000**

NOTES:

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(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.

(3) The Subtotals and Construction Total are rounded to the nearest $1,000.

Dungeness Off-stream Reservoir Project
Opinion of Probable Cost - PRELIMINARY - 30% Design
Alternative Configuration; With Geomembrane Liner - 1,600 Acre-foot Reservoir

RESERVOIR AND APPURTENANCES

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	1-09.7	$1,930,350	$1,930,350
2	1	LS	Construction Surveying	1-05.5(4)	$100,000	$100,000
3	1	LS	Right-of-Way Use, Construction Permit Compliance	1-07.6(4)	$20,000	$20,000
4	1	LS	Temporary Water Pollution/Erosion Control	1-07.15(4)	$252,000	$252,000
5	1	LS	Utilities Locate and Protection	1-07.17(1)	$10,000	$10,000
6	1	FA	Force Account	1-09.6	$100,000	$100,000
7	1	LS	Temporary Traffic Control	1-10.5	$9,000.00	$9,000
8	118	AC	Clearing and Grubbing	2-01.5	$5,000.00	$590,000
9	1	LS	Removal of Structures and Obstructions	2-02.5	$7,500.00	$7,500
10	190,374	CY	Stripping, Haul, and Stockpile of Topsoil Layer	2-03.5	$4.00	$761,496
11	114,000	CY	Reservoir Excavation, Haul, Place, and Compact for Embankment	2-03.5	$6.50	$741,000
12	1,025,300	CY	Reservoir Excavation, Haul, and Compact in Stockpile	2-03.5	$6.50	$6,664,450
13	28,700	CY	Overexcavation for Crushed Rock Maintenance Course	2-03.5	$6.50	$186,550
14	69,900	CY	Overexcavation, Haul, and Stockpile for Liner Layers	2-03.5	$6.50	$454,350
15	358,700	CY	Screening and Placement of On-site Embankment Fill Material	2-03.5	$6.50	$2,331,550
16	68,500	CY	Import and Placement of Sand Filter Material Below Liner	2-03.5	$40	$2,740,000
17	102,800	CY	Screening and Placement of Till Cap Below Liner	2-03.5	$7.50	$771,000
18	7,800	TN	Bentonite Amendment for Till Cap Layer	2-03.5	$90	$702,000
19	68,500	CY	Screening and Placement of Liner Cusion	2-03.5	$6.50	$445,250
20	28,700	CY	Processing and Placement of Crushed Rock Maintenance Coarse	2-03.5	$6.50	$186,550
21	205,410	SY	40-mil LLPDE Liner with Drainage and Leak Detection	2-03.5	$12	$2,464,920
22	190,374	CY	Placement of Onsite Topsoil Material	2-03.5	$4.00	$761,496
23	4,390	CY	Trenching for Spillway Pipe Installation, including Shoring	2-03.5	$6.00	$26,340
24	2,192	CY	Spillway Ditch Excavation, Haul, and Stockpile	7-10.5	$4.00	$8,768
25	310	CY	Placement of Imported Spillway Pipe Bedding	2-03.5	$40.00	$12,400
26	3,870	CY	Placement of On-site Spillway Trench Backfill	2-03.5	$7.00	$27,090
27	1	LS	Final Cleanup	2-11.5	$22,000.00	$22,000
28	15,510	SY	Geotextile	2-12.5	$3.60	$55,836
29	2,600	CY	Crushed Rock Surfacing	4-04.5	$6.50	$16,900
30	1	LS	Reservoir Inlet Structure	6-02.5	$5,250.00	$5,250
31	1	LS	Outlet Structure	6-02.5	$252,400.00	$252,400
32	1	LS	Drop Inlet Spillway Structure	6-02.5	$13,500.00	$13,500
33	3	EA	48" Manhole	6-02.5	$6,000.00	$18,000
34	1	EA	36-inch Automated Control Gate at Inlet	7-10.5	$37,500.00	$37,500
35	2	EA	18-Inch Automated Control Gate at Bypass	7-10.5	$9,400.00	$18,800
36	635	LF	36-inch HDPE DR 26 Spillway Pipeline	7-10.5	$230.00	$146,050
37	425	LF	24-inch HDPE DR 26 Spillway Pipeline	7-10.5	$45.00	$19,125
38	51	AC	Revegetation (Planting Seeding, Fertilizing, and Mulching)	8-02.5	$5,000.00	$255,000
39	1	LS	Items not Yet Identified	TBD	$2,573,800	$2,573,800
				Subtotal		**$25,738,000**
				Contingency	15.00%	$3,861,000
				Construction Subtotal		**$29,599,000**
				Sales Tax	8.50%	$2,516,000
				Construction Total		**$32,115,000**

NOTES:

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(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.

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Dungeness Off-stream Reservoir Project
Opinion of Probable Cost - PRELIMINARY - 30% Design

INLET PIPELINE - FROM HID MAIN CANAL TO RESERVOIR

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	1-09.7	$66,750	$66,750
2	1	LS	Construction Surveying	1-05.5(4)	$7,000	$7,000
3	1	LS	Right-of-Way Use, Construction Permit Compliance	1-07.6(4)	$5,000	$5,000
4	1	LS	Temporary Water Pollution/Erosion Control	1-07.15(4)	$15,000	$15,000
5	1	LS	Utilities Locate and Protection	1-07.17(1)	$3,000	$3,000
6	1	FA	Force Account	1-09.6	$10,000	$10,000
7	1	LS	Temporary Traffic Control	1-10.5	$4,000	$4,000
8	1.4	AC	Clearing and Grubbing	2-01.5	$5,000	$7,000
9	1	LS	Removal of Structures and Obstructions	2-02.5	$1,800	$1,800
10	10,340	CY	Trenching for Pipe Installation, including Shoring	2-03.5	$6.00	$62,040
11	950	CY	Placement of Imported Pipe Bedding	2-03.5	$7.50	$7,125
12	8,650	CY	Placement of On-site Trench Backfill	2-03.5	$6.50	$56,225
13	1	LS	Final Cleanup	2-11.5	$3,600	$3,600
14	1	LS	Hot Mix Asphalt - Repair of County Roadway	5-04.5	$1,000	$1,000
15	2,863	LF	36-inch HDPE DR 26 Inlet Pipeline, Control Structure to Reservoir	7-10.5	$190	$543,970
16	1.4	AC	Hydroseed (Seeding, Fertilizing, and Mulching)	8-02.5	$5,000	$7,000
17	1	LS	Items not Yet Identified	TBD	$89,000	$89,000
				Subtotal		**$890,000**
				Contingency	15.00%	$134,000
				Construction Subtotal		**$1,024,000**
				Sales Tax	8.50%	$87,000
				Construction Total		**$1,111,000**

NOTES:

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(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.

(3) The Subtotals and Construction Total are rounded to the nearest $1,000.

OUTLET PIPELINE - HID RESERVOIR TO NORTH BOUNDARY OF RESERVOIR PARCEL

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	1-09.7	$51,375	$51,375
2	1	LS	Construction Surveying	1-05.5(4)	$4,000	$4,000
3	1	LS	Temporary Water Pollution/Erosion Control	1-07.15(4)	$10,000	$10,000
4	1	LS	Utilities Locate and Protection	1-07.17(1)	$1,000	$1,000
5	1	FA	Force Account	1-09.6	$10,000	$10,000
6	0.80	AC	Clearing and Grubbing	2-01.5	$5,000	$4,000
7	1	LS	Removal of Structures and Obstructions	2-02.5	$1,800	$1,800
8	13,760	CY	Trenching for Pipe Installation	2-03.5	$4.00	$55,040
9	570	CY	Placement of Imported Pipe Bedding	2-03.5	$7.50	$4,275
10	12,750	CY	Placement of On-site Trench Backfill	2-03.5	$6.50	$82,875
11	1	LS	Final Cleanup	2-11.5	$2,700	$2,700
12	381	LF	36-inch Steel Outlet Pipeline, Through Embankment	7-10.5	$360	$137,160
13	1,318	LF	36-inch HDPE DR 26 Outlet Pipeline, Reservoir to Parcel Boundary	7-10.5	$190	$250,420
14	0.80	AC	Hydroseed (Seeding, Fertilizing, and Mulching)	8-02.5	$2,500	$2,000
15	1	LS	Items not Yet Identified	TBD	$68,500	$68,500
				Subtotal		**$685,000**
				Contingency	15.00%	$102,750
				Construction Subtotal		**$788,000**
				Sales Tax	8.50%	$66,980
				Construction Total		**$855,000**

NOTES:

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(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.

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Dungeness Off-stream Reservoir Project
Opinion of Probable Cost - PRELIMINARY - 30% Design

FLOW CONTROL STRUCTURE ON HID CANAL

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	1-09.7	$6,750	$6,750
2	1	LS	Construction Surveying	1-05.5(4)	$2,500	$2,500
3	1	LS	Temporary Water Pollution/Erosion Control	1-07.15(4)	$2,000	$2,000
4	1	FA	Force Account	1-09.6	$10,000	$10,000
5	0.05	AC	Clearing and Grubbing	2-01.5	$5,000	$250
6	1	LS	Final Cleanup	2-11.5	$2,700	$2,700
7	1	LS	Reinforced Concrete Flow Control Structure	6-02.5	$57,000	$57,000
8	0.05	AC	Hydroseed (Seeding, Fertilizing, and Mulching)	8-02.5	$2,500	$125
9	1	LS	Items not Yet Identified	TBD	$9,000	$9,000
				Subtotal		**$90,000**
				Contingency	15.00%	$13,500
				Construction Subtotal		**$104,000**
				Sales Tax	8.50%	$8,840
				Construction Total		**$113,000**

NOTES:

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(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.

(3) The Subtotals and Construction Total are rounded to the nearest $1,000.

SETTLING BASIN AT UPSTREAM END OF HID CANAL

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	1-09.7	$7,275	$7,275
2	1	LS	Construction Surveying	1-05.5(4)	$2,500	$2,500
3	1	LS	Temporary Water Pollution/Erosion Control	1-07.15(4)	$5,000	$5,000
4	1	LS	Utilities Locate and Protection	1-07.17(1)	$1,000	$1,000
5	1	FA	Force Account	1-09.6	$10,000	$10,000
6	0.23	AC	Clearing and Grubbing	2-01.5	$5,000	$1,150
7	120	CY	Excavate to Widen Existing Canal by 4 Feet, Shape Canal	2-03.5	$8.00	$960
8	190	CY	Trenching for Bypass Pipe Installation	2-03.5	$4.00	$760
9	40	CY	Placement of Imported Pipe Bedding	2-03.5	$40.00	$1,600
10	150	CY	Placement of On-site Trench Backfill	2-03.5	$7.00	$1,050
11	1	LS	Final Cleanup	2-11.5	$2,700	$2,700
12	3,880	SF	Concrete Over Geomembrane Canal Lining	6-02.5	$6.00	$23,280
13	1	LS	Weir, Pipe Inlet , and Bypass Pipeline Headwall Structures	6-02.5	$17,300	$17,300
14	185	LF	18-inch HDPE DR 26 Bypass Pipeline	7-10.5	$50	$9,250
15	1	EA	18-inch Canal Gate	7-13.5	$3,000	$3,000
16	0.23	AC	Hydroseed (Seeding, Fertilizing, and Mulching)	8-02.5	$2,500	$575
17	1	LS	Items not Yet Identified	TBD	$9,700	$9,700
				Subtotal		**$97,000**
				Contingency	15.00%	$14,550
				Construction Subtotal		**$112,000**
				Sales Tax	8.50%	$9,520
				Construction Total		**$122,000**

NOTES:

(1) Design, permitting, construction administration, legal and administrative costs are not included with this estimate.

(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.

(3) The Subtotals and Construction Total are rounded to the nearest $1,000.

Dungeness Off-stream Reservoir Project
Opinion of Probable Cost - PRELIMINARY - 30% Design

HID INTAKE SCREEN IMPROVEMENTS

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	TBD	$20,175	$20,175
2	1	LS	General Contractor Overhead	TBD	$40,350	$40,350
3	1	LS	Facilities Start-up and Testing	TBD	$4,035	$4,035
4	1	LS	Repaint Gantry Structure	TBD	$5,000	$5,000
5	2	EA	WDFW Refurbished Drum Screens	TBD	$60,000	$120,000
6	1	EA	Motor actuator for bypass gate	TBD	$5,000	$5,000
7	1	EA	7.5 HP Waterjet Pump (300 gpm at 50 ft TDH)	TBD	$15,000	$15,000
8	1	LS	Waterjet Manifold	TBD	$27,500	$27,500
9	1	LS	Yard Hydrant with hose and 15' Stinger	TBD	$5,000	$5,000
10	1	LS	Items not Yet Identified	TBD	$26,900	$26,900
				Subtotal		**$269,000**
				Contingency	15.00%	$40,350
				Construction Subtotal		**$309,000**
				Sales Tax	8.50%	$26,265
				Construction Total		**$335,000**

NOTES:
(1) Design, permitting, construction administration, legal and administrative costs are not included with this estimate.
(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.
(3) The Subtotals and Construction Total are rounded to the nearest $1,000.

HID HEADWORKS IMPROVEMENTS

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	TBD	$22,125	$22,125
2	1	LS	General Contractor Overhead	TBD	$44,250	$44,250
3	1	LS	Facilities Start-up and Testing	TBD	$4,425	$4,425
4	1	LS	Site Prep	TBD	$5,000	$5,000
5	1	LS	Dewatering/Surface Water Management	TBD	$20,000	$20,000
6	1	LS	Temp sediment barrier system	TBD	$5,000	$5,000
7	89	CY	Headgate U/S Channel Improvements (assume 200 ft)	TBD	$100	$8,889
8	1	LS	Headworks Modification (open both openings)	TBD	$1,000	$1,000
9	400	LF	Highland Canal U/S of Intake Improvements (assume 400 ft)	TBD	$50	$20,000
10	200	LF	Highland Canal D/S of Intake Improvements (assume 200 ft)	TBD	$50	$10,000
11	1	LS	Site Clean-up	TBD	$2,000	$2,000
12	1	LS	Misc. concrete work on Headworks Structure	TBD	$25,000	$25,000
13	1,000	LBS	Trash Rack U/S of Headworks, A36 coated	TBD	$12	$12,000
14	3	EA	Flow Meter, Sonic	TBD	$12,000	$36,000
15	1	LS	Misc Instrumentation and Controls	TBD	$10,000	$10,000
16	2	EA	3' wide x 4' tall GH-40 slide gates with motor actuators	TBD	$20,000	$40,000
17	1	LS	Items not Yet Identified	TBD	$29,500	$29,500
				Subtotal		**$295,000**
				Contingency	15.00%	$44,250
				Construction Subtotal		**$339,000**
				Sales Tax	8.50%	$28,815
				Construction Total		**$368,000**

NOTES:
(1) Design, permitting, construction administration, legal and administrative costs are not included with this estimate.
(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.
(3) The Subtotals and Construction Total are rounded to the nearest $1,000.

Dungeness Off-stream Reservoir Project
Opinion of Probable Cost - PRELIMINARY - 30% Design

PIPING OF HID MAIN CANAL (EXPAND CAPACITY TO 25 CFS)

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	1-09.7	$150,150	$150,150
2	1	LS	Construction Surveying	1-05.5(4)	$4,400	$4,400
3	1	LS	Temporary Water Pollution/Erosion Control	1-07.15(4)	$10,000	$10,000
4	1	LS	Utilities Locate and Protection	1-07.17(1)	$1,000	$1,000
5	1	FA	Force Account	1-09.6	$25,000	$25,000
6	3.40	AC	Clearing and Grubbing	2-01.5	$5,000	$16,988
7	1	LS	Removal of Structures and Obstructions	2-02.5	$1,800	$1,800
8	6,783	CY	Trenching for Pipe Installation	2-03.5	$4.00	$27,133
9	2,971	CY	Placement of Imported Pipe Bedding	2-03.5	$40.00	$118,852
10	2,467	CY	Placement of On-site Trench Backfill	2-03.5	$7.00	$17,267
11	1	LS	Final Cleanup	2-11.5	$2,500	$2,500
12	1	LS	Pipeline Inlet Structure	6-02.5	$12,000	$12,000
13	7,400	LF	36-inch HDPE DR 26 Pipeline, HID Canal, Intake to H1 Lateral	7-10.5	$190	$1,406,000
14	3.40	AC	Hydroseed (Seeding, Fertilizing, and Mulching)	8-02.5	$2,500	$8,494
15	1	LS	Items not Yet Identified	TBD	$200,200	$200,200
				Subtotal		**$2,002,000**
				Contingency	15.00%	$300,300
				Construction Subtotal		**$2,302,000**
				Sales Tax	8.50%	$195,670
				Construction Total		**$2,498,000**

NOTES:

(1) Design, permitting, construction administration, legal and administrative costs are not included with this estimate.

(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.

(3) The Subtotals and Construction Total are rounded to the nearest $1,000.

HID DROUGHT RELIEF PUMP STATION

Bid Item	Estimated Quantity	Unit	Item	Spec.	Unit	Total
1	1	LS	Moblization/Demobilization	1-09.7	$70,200	$70,200
2	1	LS	Construction Surveying	1-05.5(4)	$4,600	$4,600
3	1	FA	Force Account	1-09.6	$15,000	$15,000
4	1	LS	Final Cleanup	2-11.5	$2,500	$2,500
5	150	HP	Drought Relief Pump Station, East Side of Reservoir	6-02.5	$3,000	$450,000
6	1	LS	Items not Yet Identified	TBD	$93,600	$93,600
				Subtotal		**$636,000**
				Contingency	15.00%	$95,400
				Construction Subtotal		**$731,000**
				Sales Tax	8.50%	$62,135
				Construction Total		**$793,000**

NOTES:

(1) Design, permitting, construction administration, legal and administrative costs are not included with this estimate.

(2) Opinion of cost updated February 2022. Actual construction costs will vary based on materials and labor costs at time of construction.

(3) The Subtotals and Construction Total are rounded to the nearest $1,000.

Dungeness Off-stream Reservoir Project
Life Cycle Cost Analysis

Input Cells - Assumed or Given Values
Input Cells - Adjust Using Goal Seek Tool to Make Account Balance at end of

ASSUMPTIONS:	
Estimated Capital Cost[1]:	$7,129,941 Total Cost (Non-Earthwork, Critical Items)
Interest on Replacement Fund:	3.00%
Rate of Inflation:	3.00%
Project Design Life:	50 Years

SUMMARY REPLACEMENT COSTS:			CURRENT COST[2]	FUTURE COST[3]
Estimated Project Replacement Cost:				
To Replace	25%	After Life of Project		$7,814,248
To Replace	50%	After Life of Project		$15,628,495
To Replace	100%	After Life of Project	$7,129,941	$31,256,991
Disposal and Removal Cost:				
To Replace	25%	After Life of Project		$78,910
To Replace	50%	After Life of Project		$157,821
To Replace	100%	After Life of Project	$72,000 ~1%	$315,641
Total Replacement Cost:				
To Replace	**25%**	**After Life of Project**		**$7,893,158**
To Replace	**50%**	**After Life of Project**		**$15,786,316**
To Replace	**100%**	**After Life of Project**	**$7,201,941**	**$31,572,632**

REPLACEMENT FUND SUMMARY			
Annual Deposit Required (Assume Equal Deposit Made Each Year):			
To Replace	25%	After Life of Project	$69,977
To Replace	50%	After Life of Project	$139,953
To Replace	100%	After Life of Project	$279,907
Deposit Required at Year 1 (Assume Deposits Increase at the Rate of Inflation):			
To Replace	25%	After Life of Project	$37,090
To Replace	50%	After Life of Project	$74,180
To Replace	100%	After Life of Project	$148,360
Deposit Required at Year 25 (Assume Deposits Increase at the Rate of Inflation):			
To Replace	25%	After Life of Project	$75,396
To Replace	50%	After Life of Project	$150,793
To Replace	100%	After Life of Project	$301,585
Deposit Required at Year 50 (Assume Deposits Increase at the Rate of Inflation):			
To Replace	25%	After Life of Project	$157,863
To Replace	50%	After Life of Project	$315,726
To Replace	100%	After Life of Project	$631,453

LIFE CYCLE COSTS:

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**
Capital Expenses:	$7,129,941																							
Replacement Fund (For Funding Replacement of 25% of System):																								
Deposits		$37,090	$38,203	$39,349	$40,529	$41,745	$42,997	$44,287	$45,616	$46,984	$48,394	$49,846	$51,341	$52,881	$54,468	$56,102	$57,785	$59,519	$61,304	$63,143	$65,038	$66,989	$68,998	$71,068
Interest		$0	$1,113	$2,292	$3,541	$4,864	$6,262	$7,740	$9,300	$10,948	$12,686	$14,518	$16,449	$18,483	$20,624	$22,877	$25,246	$27,737	$30,354	$33,104	$35,992	$39,023	$42,203	$45,539
End of Year Balance		**$37,090**	**$76,405**	**$118,046**	**$162,117**	**$208,726**	**$257,985**	**$310,012**	**$364,928**	**$422,860**	**$483,940**	**$548,304**	**$616,095**	**$687,459**	**$762,551**	**$841,529**	**$924,560**	**$1,011,815**	**$1,103,474**	**$1,199,721**	**$1,300,751**	**$1,406,762**	**$1,517,963**	**$1,634,570**
Replacement Fund (For Funding Replacement of 50% of System):																								
Deposits		$74,180	$76,405	$78,698	$81,058	$83,490	$85,995	$88,575	$91,232	$93,969	$96,788	$99,692	$102,682	$105,763	$108,936	$112,204	$115,570	$119,037	$122,608	$126,286	$130,075	$133,977	$137,997	$142,137
Interest		$0	$2,225	$4,584	$7,083	$9,727	$12,524	$15,479	$18,601	$21,896	$25,372	$29,036	$32,898	$36,966	$41,248	$45,753	$50,492	$55,474	$60,709	$66,208	$71,983	$78,045	$84,406	$91,078
End of Year Balance		**$74,180**	**$152,811**	**$236,093**	**$324,234**	**$417,451**	**$515,970**	**$620,024**	**$729,856**	**$845,721**	**$967,881**	**$1,096,609**	**$1,232,189**	**$1,374,918**	**$1,525,101**	**$1,683,058**	**$1,849,120**	**$2,023,631**	**$2,206,948**	**$2,399,443**	**$2,601,501**	**$2,813,524**	**$3,035,926**	**$3,269,140**
Replacement Fund (For Funding Replacement of 100% of System):																								
Deposits		$148,360	$152,811	$157,395	$162,117	$166,980	$171,990	$177,150	$182,464	$187,938	$193,576	$199,383	$205,365	$211,526	$217,872	$224,408	$231,140	$238,074	$245,216	$252,573	$260,150	$267,955	$275,993	$284,273
Interest		$0	$4,451	$9,169	$14,166	$19,454	$25,047	$30,958	$37,201	$43,791	$50,743	$58,073	$65,797	$73,931	$82,495	$91,506	$100,984	$110,947	$121,418	$132,417	$143,967	$156,090	$168,811	$182,156
End of Year Balance		**$148,360**	**$305,622**	**$472,185**	**$648,468**	**$834,902**	**$1,031,939**	**$1,240,047**	**$1,459,713**	**$1,691,442**	**$1,935,761**	**$2,193,217**	**$2,464,379**	**$2,749,836**	**$3,050,203**	**$3,366,117**	**$3,698,240**	**$4,047,262**	**$4,413,896**	**$4,798,886**	**$5,203,003**	**$5,627,047**	**$6,071,852**	**$6,538,281**
Operations and Maintenance Expenses:	**$41,200**	**$42,436**	**$43,709**	**$45,020**	**$46,371**	**$47,762**	**$49,195**	**$50,671**	**$52,191**	**$53,757**	**$55,369**	**$57,030**	**$58,741**	**$60,504**	**$62,319**	**$64,188**	**$66,114**	**$68,097**	**$70,140**	**$72,244**	**$74,412**	**$76,644**	**$78,943**	
Salaries	$15,000																							
Benefits	$5,200																							
Administrative	$2,000																							
Transportation	$1,000																							
Supplies	$2,000																							
Maintenance and Repairs	$8,000																							
Contracted Labor	$8,000																							

Year	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**23**

NOTES:
1) The Estimated Capital Cost is the construction total from the Opinion of Probable Costs for all key project elements, but does not include embankment earthwork costs. It includes construction costs and contingency.
2) The Current Cost is equal to the Estimated Capital Cost at the beginning of project life (in December 2021 dollars) plus the current estimated cost of disposal and removal of items that would be replaced.
3) Future cost is the future value of the current project cost at end of life cycle of the project, or the current cost inflated at the rate shown through the life cycle of the project.
4) Salaries assumes salary for 1/4 full-time equivalent (FTE) to help manage/operate the reservoir, or one person for 10 hours per week.
5) Benefits assumes benefits = salaries X 40%.
6) Maintenance and repairs and contracted labor each assumed to be ~0.1% of the capital cost during the first year.

Dungeness Off-stream Reservoir Project
Life Cycle Cost Analysis (Cont.)

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50
$73,200	$75,396	$77,658	$79,988	$82,388	$84,859	$87,405	$90,027	$92,728	$95,510	$98,375	$101,326	$104,366	$107,497	$110,722	$114,044	$117,465	$120,989	$124,619	$128,357	$132,208	$136,174	$140,259	$144,467	$148,801	$153,265	$157,863
$49,037	$52,704	$56,547	$60,573	$64,790	$69,206	$73,828	$78,665	$83,725	$89,019	$94,555	$100,343	$106,393	$112,715	$119,322	$126,223	$133,431	$140,958	$148,816	$157,019	$165,581	$174,514	$183,835	$193,558	$203,699	$214,274	$225,300
$1,756,808	**$1,884,908**	**$2,019,114**	**$2,159,675**	**$2,306,853**	**$2,460,918**	**$2,622,150**	**$2,790,842**	**$2,967,295**	**$3,151,824**	**$3,344,753**	**$3,546,422**	**$3,757,181**	**$3,977,394**	**$4,207,438**	**$4,447,704**	**$4,698,601**	**$4,960,548**	**$5,233,983**	**$5,519,359**	**$5,817,148**	**$6,127,837**	**$6,451,931**	**$6,789,956**	**$7,142,456**	**$7,509,995**	**$7,893,158**
$146,401	$150,793	$155,316	$159,976	$164,775	$169,718	$174,810	$180,054	$185,456	$191,020	$196,750	$202,653	$208,732	$214,994	$221,444	$228,087	$234,930	$241,978	$249,237	$256,714	$264,416	$272,348	$280,519	$288,934	$297,602	$306,530	$315,726
$98,074	$105,408	$113,094	$121,147	$129,580	$138,411	$147,655	$157,329	$167,451	$178,038	$189,109	$200,685	$212,785	$225,431	$238,644	$252,446	$266,862	$281,916	$297,633	$314,039	$331,162	$349,029	$367,670	$387,116	$407,397	$428,547	$450,600
$3,513,615	**$3,769,816**	**$4,038,227**	**$4,319,350**	**$4,613,706**	**$4,921,835**	**$5,244,300**	**$5,581,684**	**$5,934,590**	**$6,303,647**	**$6,689,507**	**$7,092,845**	**$7,514,362**	**$7,954,788**	**$8,414,875**	**$8,895,409**	**$9,397,201**	**$9,921,095**	**$10,467,965**	**$11,038,719**	**$11,634,296**	**$12,255,673**	**$12,903,862**	**$13,579,912**	**$14,284,912**	**$15,019,990**	**$15,786,316**
$292,801	$301,585	$310,633	$319,952	$329,550	$339,437	$349,620	$360,109	$370,912	$382,039	$393,500	$405,305	$417,465	$429,989	$442,888	$456,175	$469,860	$483,956	$498,475	$513,429	$528,832	$544,697	$561,037	$577,869	$595,205	$613,061	$631,453
$196,148	$210,817	$226,189	$242,294	$259,161	$276,822	$295,310	$314,658	$334,901	$356,075	$378,219	$401,370	$425,571	$450,862	$477,287	$504,893	$533,725	$563,832	$595,266	$628,078	$662,323	$698,058	$735,340	$774,232	$814,795	$857,095	$901,199
$7,027,230	**$7,539,632**	**$8,076,454**	**$8,638,700**	**$9,227,411**	**$9,843,670**	**$10,488,600**	**$11,163,367**	**$11,869,180**	**$12,607,295**	**$13,379,014**	**$14,185,690**	**$15,028,725**	**$15,909,575**	**$16,829,751**	**$17,790,818**	**$18,794,403**	**$19,842,190**	**$20,935,931**	**$22,077,437**	**$23,268,592**	**$24,511,347**	**$25,807,724**	**$27,159,825**	**$28,569,824**	**$30,039,980**	**$31,572,632**
$81,312	**$83,751**	**$86,264**	**$88,852**	**$91,517**	**$94,263**	**$97,090**	**$100,003**	**$103,003**	**$106,093**	**$109,276**	**$112,554**	**$115,931**	**$119,409**	**$122,991**	**$126,681**	**$130,482**	**$134,396**	**$138,428**	**$142,581**	**$146,858**	**$151,264**	**$155,802**	**$160,476**	**$165,290**	**$170,249**	**$175,356**

24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50

Appendix N
Cultural Resources Compliance Memorandum

DRAFT

1201 3rd Avenue, Suite 2600
Seattle, Washington 98101
206.287.9130

ANCHOR QEA

Memorandum

October 8, 2021

To: Carol Creasey, Clallam County

From: Barbara Bundy, Anchor QEA, LLC

cc: David Rice, Anchor QEA, LLC

Re: Cultural Resources Compliance for the Dungeness Off-Channel Reservoir Project

Introduction

Water resource managers and water users in the Dungeness River Watershed have been working together for more than two decades to implement a variety of water conservation, infiltration, water supply, and ecological restoration projects aimed at increasing water use efficiency and improving management of the resources provided by the watershed. The proposed Dungeness Off-Channel Reservoir Project offers a storage concept that has broad support among local resource managers, water users, and other key stakeholders.

The proposed project is to construct a reservoir with up to 1,600 acre-feet of water storage capacity on a 319-acre parcel currently owned by the Washington State Department of Natural Resources (DNR). The parcel is located along River Road approximately 1 mile south of Sequim and is currently managed for timber production and public recreation. Clallam County is working with local irrigators and other key stakeholders to complete designs for the project with funding provided by the Washington State Department of Ecology (Ecology) under the Streamflow Restoration Grant Funding Program (Ecology Agreement Number WRSRP-2019-ClCoCD-00083).

Ecology is responsible for complying with Governor's Executive Order 21-02 (EO 21-02), which requires state agencies and those receiving state funding to consider potential effects to cultural resources for state-funded projects. Under Ecology's direction, Clallam County hired Dudek to review the project and conducted an archaeological survey (Windler et al. 2021). Based on the results of the survey, Ecology prepared a Preliminary Determination of low risk to cultural resources. Clallam County submitted the report to Ecology and Ecology shared the report and Preliminary Determination with the Department of Archaeology and Historic Preservation (DAHP) and Native American Tribes in February 2021. Based on responses received from DAHP and Tribes, Ecology made a Final Determination of low risk to cultural resources in March 2021. The Final Determination included conditions for future project activities. This memorandum offers a specific roadmap for complying with the conditions.

Cultural Resources Conditions

The 2021 Final Determination included the following requirements:

- In order to avoid cultural resources impacts, Ecology is requiring an inadvertent discovery plan (IDP). The recipient must follow the IDP protocol. In the event that archaeological deposits are inadvertently discovered during construction in any portion of the Project Area of Potential Effect, ground-disturbing activities should be halted immediately in an area large enough to maintain the integrity of the deposits. The DAHP, affected Tribes, and Ecology must be notified. Appropriate treatment of the archaeological resources and/or human remains would be determined among these parties.
- Once designed, if the proposed project includes potential ground-disturbing activities outside of the tested reservoir boundary and within any of the High Probability Areas (HPAs) identified in the survey, further archaeological investigations are recommended to test for buried cultural deposits prior to construction.

In fulfillment of the first condition listed above, an IDP has been developed for the project and approved by Ecology.

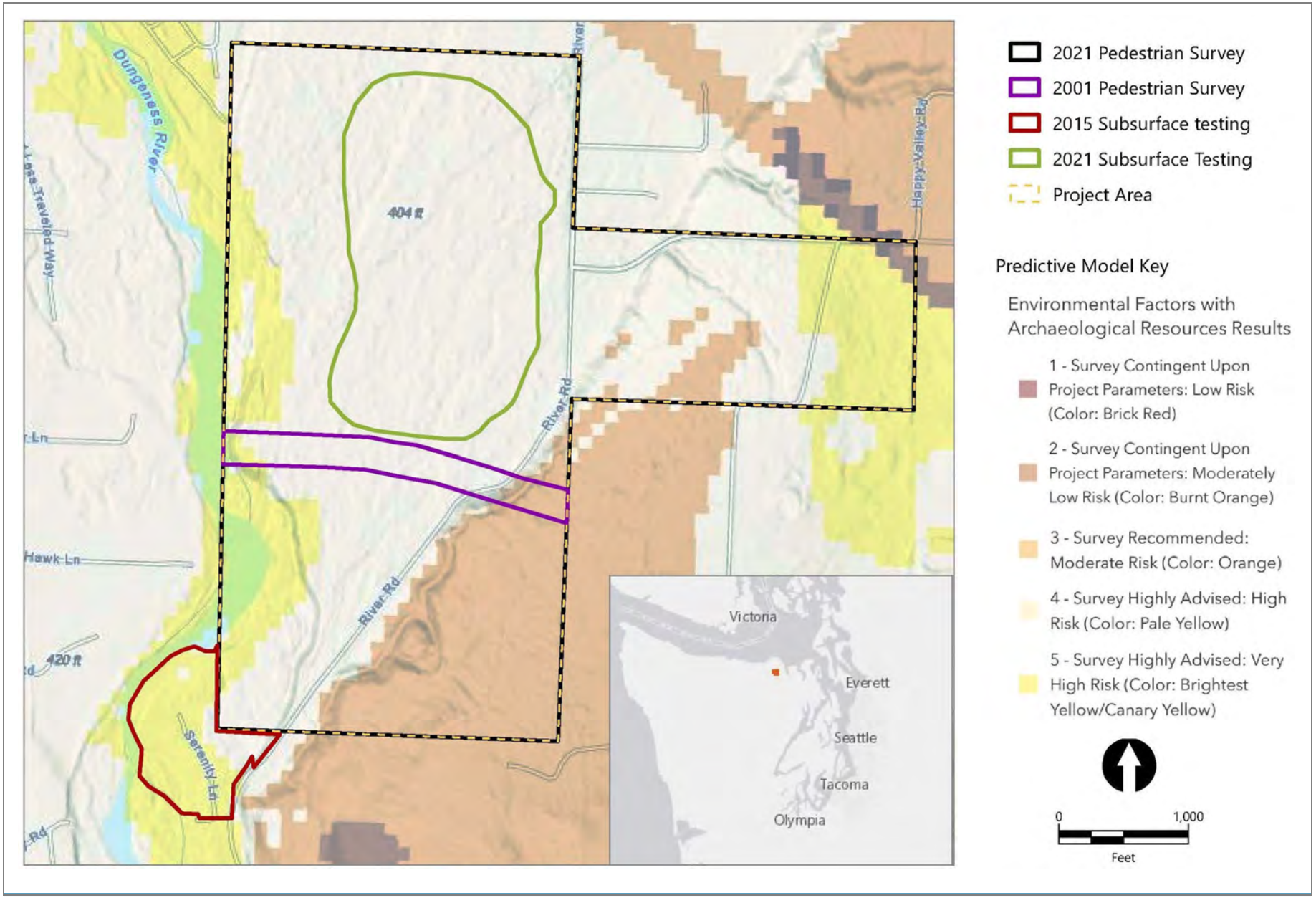
The second condition listed above discusses HPAs identified in the 2021 survey. However, no post-survey HPAs were specifically mapped in the 2021 survey report. Therefore, in order to meet the second condition, the horizontal and vertical extent of HPAs must be defined.

Assessing Archaeological Potential

HPAs are defined as areas where there is a very high or high probability of encountering archaeological materials. HPAs can be defined by modeling, analysis of the cultural history of a location or vicinity, results of previous research, and consultation with affected communities (particularly Native American Tribes. In the current project area, all four types of information are available.

Modeling

In the Washington Statewide Archaeology Predictive Model (Geoengineers 2009), very high and high potential areas are identified by seven environmental factors (elevation, slope percent, aspect, distance to water, geology, soils, and landform) organized and weighted by their importance to pre-contact communities. The model is not applicable to historic sites. According to the model, areas of higher elevation, generally to the south and east of River Road, are of moderate probability (Figure 1). The remainder of the project area is of high or very high probability. This model is a baseline, to be adjusted with data from the other three sources.



ANCHOR QEA

Figure 1
Archaeological Potential and Archaeological Surveys
Cultural Resources Compliance Memorandum
Dungeness Streamflow Restoration Off-Channel Reservoir Project

Environmental and Cultural Context

The environmental and cultural context is discussed at length in the cultural resources survey report (Windler et al. 2021); aspects most relevant to archaeological potential are summarized here.

The area was glaciated during the last Pleistocene glacial maximum, with glaciers retreating by the beginning of the Holocene approximately 10,000 years ago. Sea level stabilized near modern levels around 5,000 years ago. Surficial soils in the project vicinity reflect this history, generally formed in Holocene alluvium or Pleistocene outwash atop glacial till.

The earliest recorded archaeological sites in the Puget Sound area date to the late Pleistocene (Ames and Maschner 1999). These sites are typically sparse stone tool assemblages found in upland areas. The Manis Mastodon site (45CA218), one of the earliest dated sites in Washington, is approximately 0.8 mile northeast of the project area. The site, which includes a bone point embedded in a mastodon rib, has been radiocarbon dated to about 12,000 years before present. By the mid-Holocene, larger populations began to organize in complex ways to exploit a wide range of terrestrial and littoral resources. Cultures around Puget Sound and northward show adaptation to coastal resources. Over time, populations grew and began to reside in large semi-sedentary cedar plank house villages located at river mouths and confluences and on protected shorelines. The artifact tool kits became increasingly complex and specialized, allowing for large takes of resources, which were processed and stored for year-long consumption. These late-Holocene cultures correlate with ethnographically described Southern Coast Salish peoples.

The project area is in the traditional territory of the Clallam, a Central Coast Salish people who occupied the villages along the southern shore of the Strait of Juan de Fuca between Clallam Bay and Port Discovery Bay (although they had seasonal camps in a much larger area). Clallam descendants are members of several federally recognized Tribes, including the Jamestown S'Klallam Tribe, Lower Elwha Klallam Tribe, and Port Gamble S'Klallam Tribe (Ruby and Brown 1986).

The first Euroamerican exploration of the Puget Sound region was Captain George Vancouver's 1792 expedition, although earlier Spanish explorers passed through the region. Occasional trade occurred in the following decades, bringing introduced diseases but minimal Euroamerican settlement. The first homesteads in Clallam County were at Dungeness Spit, about 7 miles north of the project area and near the Clallam village. In 1853, Washington was separated from the Oregon Territory, and a year later, Clallam County was split from Jefferson County (Oldham 2005). The early economy revolved around logging, with settlers pushing farther inland in search of timber, and large mills at Port Angeles and elsewhere. By the late 1800s, agricultural production became a focus, with organization around irrigation. Through the efforts of a number of private companies, an irrigation system was constructed in the Sequim Valley that is still in use.

The project parcels were presumably logged, probably more than once, between the mid-1800s and mid-1900s. The Bonneville Power Administration (BPA) transmission line was constructed between 1942 and 1954. The project area is now managed by DNR for timber harvesting and recreation.

Previous Research

An archaeological survey (pedestrian survey only) crossed the current project area, in the BPA right-of-way, in 2001 (Wilt and Roulette 2001). No archaeological resources were identified. The survey identified the portion of the BPA right-of-way that is west of River Road as an HPA.

In addition to the 2001 and 2021 surveys within the project area, 11 other surveys have been conducted within a mile of the site (see Windler et al. 2021). Of particular note is a survey adjacent to the current project area to the southwest, along the east bank of the Dungeness River (Amell and Treichel 2015). The survey, in what is described as the "active floodplain" of the river, included 100 shovel probes. None contained archaeological resources. The probes revealed general stratigraphy of about 40 centimeters of sandy loam with 30% rounded gravels atop sandy loam with 50% or more gravels and cobbles. This was identified as the Carlsborg gravelly sandy loam that forms surficial soils in the area.

Two archaeological sites have been identified within the project area, both surface historic debris scatters (45CA524 and 45CA725). Both have been determined not eligible for listing in the National Register of Historic Places and Washington Heritage Register, and they are not further considered under EO 21-02.

In addition to the two sites in the project area, there is one site within a mile: the Manis Mastadon site described earlier.

Based on the environmental and cultural context and this previous research, the 2021 survey identified the following areas of elevated probability prior to fieldwork.

> The DAHP Predictive Model shows the western edge and the eastern edge of the project area as having a very high likelihood for archaeological resources. The western edge of the project area has a very high likelihood due to its proximity to the eastern bank of the Dungeness River—indeed, AAR considered this area to be part of an HPA during their 2001 survey (Wilt and Roulette 2001)—while the eastern edge is probably mapped as having a very high likelihood because it is a relatively flat landform located within 1 mile of the Manis Mastodon Site. Smaller portions of the project area are mapped as having a moderate or moderately low likelihood, probably because they are located on slopes (Windler et al. 2021:27).

The 2021 survey included pedestrian transects (a combination of 20-meter intervals and meandering) and excavation of 81 shovel probes (Windler et al. 2021). Pedestrian survey occurred across the entire project area, but shovel probes were only excavated within an 88-acre area identified as the proposed reservoir area. No cultural resources were identified below the surface in probes, which reached no more than 55 centimeters (just under 2 feet) below the surface. Soils were consistent with the Carlsborg gravelly sandy loam found in the 2015 survey about 0.6 mile southeast of the reservoir footprint.

Following field survey, the report had the following recommendations:

> Yet unidentified archaeological deposits could be situated at or near the ground surface (or deeper) on the terrace adjacent to the boundaries of the reservoir area, on the low Dungeness River-adjacent floodplain at the western edge of the project area, and on the relatively flat upland benches along the eastern margins of the project area. Archaeological deposits are not likely to be present on the very low, inundated, and active floodplain of the Dungeness River or along the steep slopes that make up much of the eastern half of the project area. Once designed, should the proposed project include potential ground disturbing activities outside of the tested reservoir boundary and within any of the HPAs defined above, further archaeological investigations are recommended to test for buried cultural deposits prior to construction (Windler et al. 2021:27).

Consultation

Tribal consultation has also occurred and is ongoing for the current project. The Jamestown S'Klallam Tribe, in a letter to Clallam County and Ecology dated September 22, 2021 regarding proposals for geotechnical exploration at the site, requested the following:

> It is our recommendation that test pits and borings outside the reservoir boundary include archeological monitoring. Once the reservoir is designed, if the proposed project includes potential ground disturbing activities outside of the tested reservoir boundary and within any of the High Probability Areas identified in the survey, further archaeological investigations are recommended.

High Probability Areas

The Statewide Predictive Model, environmental and cultural context, archaeological research, and Tribal consultation inform the following assessment of HPAs. The most recent field assessment recommended that HPAs are present in the project area as follows:

- The terrace adjacent to the boundaries of the reservoir area
- The low Dungeness River-adjacent floodplain at the western edge of the project area
- The relatively flat upland benches along the eastern margins of the project area

Portions of the project area that are not HPAs are as follows:

- The very low, inundated, and active floodplain of the Dungeness River
- Along the steep slopes that make up much of the eastern half of the project area

Consultation between DAHP and the Tribes has not resulted in any changes to this description. Figure 2 shows HPAs based on LiDAR imagery and topographic maps.

Recommendations

There are a number of different project-related activities that could result in ground disturbance, including the following:

- Pre-design investigations
  - Geotechnical borings and test pits
  - Excavation to confirm the location of utilities or other buried infrastructure
- Project construction activities
  - Clearing and grubbing
  - Construction of access roads
  - Excavation for the reservoir and associated utilities

Additional pre-design investigations are planned for the first quarter of 2022. Those activities will be planned to support the final design of the reservoir and appurtenances, as determined through preliminary design activities that are currently underway and will be completed late in 2021. The reservoir configuration and location of appurtenant facilities will differ from the reservoir area shown on Figure 1, that was used as a basis for the cultural resources investigation completed early in 2021. Additional pre-design investigations will include completion of additional geotechnical borings and test pits needed to develop a complete understanding of subsurface soil condition over the entire area where the reservoir and appurtenant facilities will be constructed. Borings and test pits will need to be completed inside and outside the area that was fully investigated for cultural resources earl in 2021, including within HPAs shown on Figure 2.

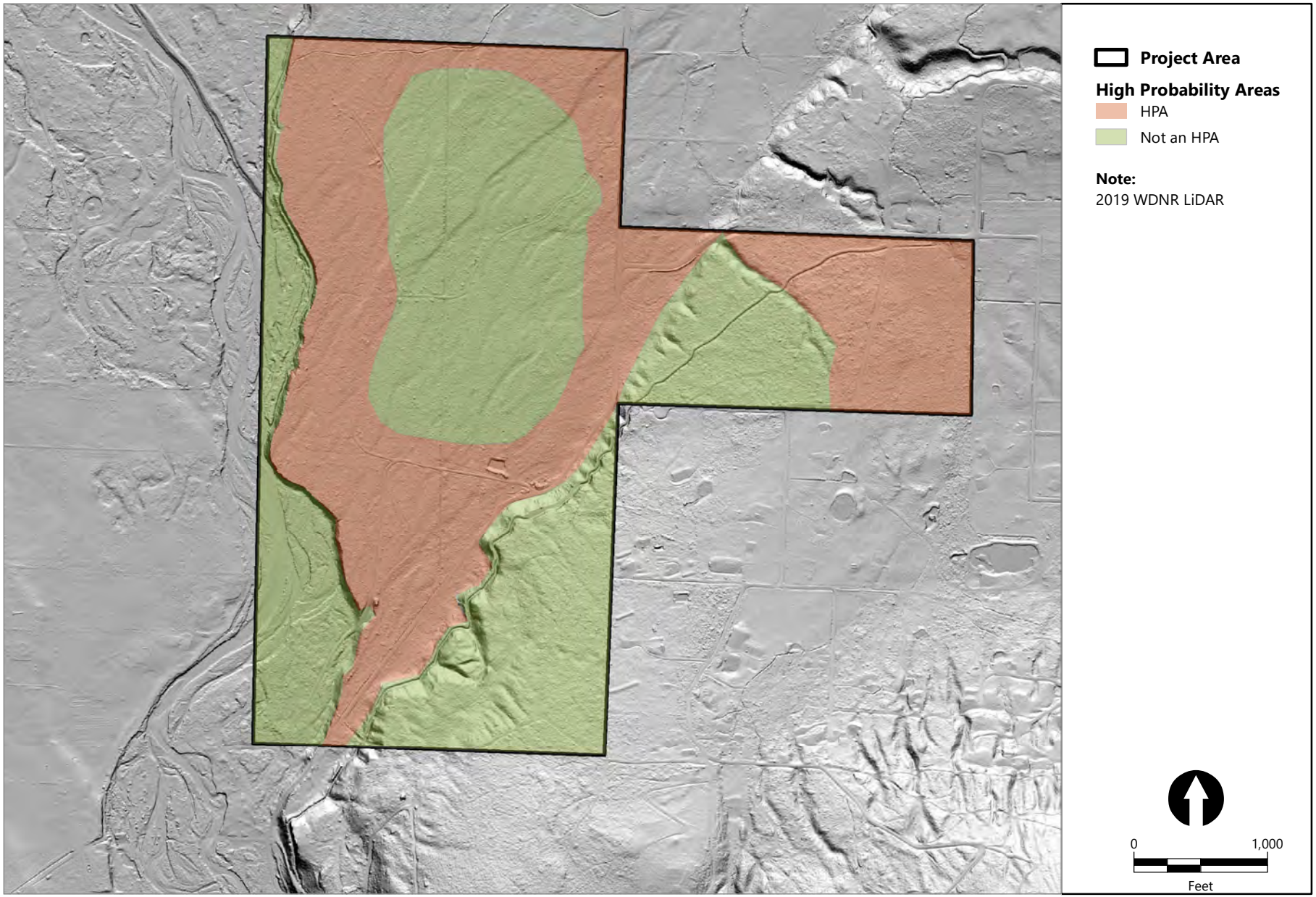


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Figure 2
High Probability Areas
Cultural Resources Compliance Memorandum
Dungeness Streamflow Restoration Off-Channel Reservoir Project

Neither the 2021 survey report nor the Final Determination drew distinctions amongst the various pre-design and project construction activities. However, the Jamestown S'Klallam Tribe letter recommends archaeological monitoring of pre-construction activities, and archaeological testing prior to construction in areas of ground disturbance that will occur in HPAs.

Pre-design investigations are limited in spatial extent and often provide a better mechanism for viewing stratigraphy. In particular, both surveys on the landform (in 2021 and 2015) were generally not able to hand-excavate below about 50 to 55 centimeters below the surface due to cobble obstructions. Borings, test pits, and utility "potholes" are mechanically excavated and can reach much deeper. These pre-design investigations, by definition, do not occur during construction and can be terminated to avoid impacting a potentially significant discovery. Archaeological monitoring of pre-design activities provides an opportunity to extend the horizontal and vertical area that can be examined by archaeologists.

Therefore, it is recommended that:

1. No further archaeological investigations or monitoring be required outside of HPAs, as stated in the Final Determination. The IDP should be kept on site for all ground-disturbing activities, and the on-site staff should be trained in its requirements.
2. Within the HPAs, the following additional archaeology work should be required:
    a. Pre-design investigations should be monitored by an archaeologist. Native American Tribes and the DAHP should be notified of these investigations as early as possible.
    b. Ground-disturbing construction work in HPAs should be treated as follows:
        i. Superficial activities such as vegetation clearing, placement of fill, and vehicle traversing, where ground disturbance will be less than 20 centimeters (8 inches) below the surface can proceed with no monitoring or excavation, because this work is within the footprint of previous recent and historic logging activity, and surface deposits have been fully investigated by the 2021 pedestrian survey.
        ii. Any areas where ground disturbance is expected to be deeper than 8 inches below the surface should be surveyed by an archaeologist prior to construction.

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