Yakima River Basin Integrated Water Resource Management Plan

Feasibility-Level Design Report

Kachess Drought Relief Pumping Plant

South and East Shore Pumping Plant Alternatives

U.S. Bureau of Reclamation

Contract No. R13PC10006 ID/IQ

Prepared by

HDR Engineering, Inc.

U.S. Department of the Interior
Bureau of Reclamation
Pacific Northwest Region
Columbia-Cascades Area Office

State of Washington
Department of Ecology
Office of Columbia River

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Feasibility-Level Design Report

Yakima Basin Integrated Water Resources Management Plan
Kachess Drought Relief Pumping Plant (South and East Shore Alternatives), Washington
Pacific Northwest Region

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Glossary and List of Acronyms and Terms

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
Alternative 1	East Shore Pumping Plant
Alternative 2	South Pumping Plant
ASCE	American Society of Civil Engineers
ASTM	American Society of Testing and Materials
AWWA	American Water Works Association
BIM	Building Information Model
cfs	cubic feet per second
DEIS	Draft Environmental Impact Statement
Ecology	Washington State Department of Ecology
EFH	Essential Fish Habitat
El.	Elevation
F	Fahrenheit
FLH	Federal Lands Highway
flip-flop	The annual late-summer river operation that shifts reservoir releases from the upper Yakima River basin reservoirs to the Naches system reservoirs to avoid disruption of salmonid habitat and impacts on aquatic insect populations.
Ft	foot or feet
HP	horsepower
ICC	International Code Council
ID	interior diameter
in.	inch or inches
Integrated Plan	Yakima River Basin Integrated Water Resource Management Plan
KDRPP	Kachess Drought Relief Pumping Plant
KC	Kittitas County Department of Public Works
KKC	Keechelus-to-Kachess Conveyance
ksf	thousand square-feet
kV	kilovolt
kVA	kilovolt-ampere
mini flip-flop	Similar to flip-flop, but river-reservoir operations performed to limit late summer and early fall releases from Keechelus Reservoir, by increasing releases from Kachess Reservoir.
Mm	millimeters

MCC	Motor Control Center
MW	megawatts
NEPA	National Environmental Policy Act
NMFS	National Marine Fisheries Service
pcf	pounds per cubic foot
pci	pounds per cubic inch
PDDM	Project Development and Design Manual
PCV	pump control valves
P&ID	process and instrumentation diagram
PSE	Puget Sound Energy
psf	per square foot
psi	per square inch
RQD	Recovery and Rock Quality Designation
SEPA	State Environmental Policy Act
Service	United States Fish and Wildlife Service
sf	square foot or square feet
TBM	tunnel boring machine
TDH	total dynamic head
TESC	temporary erosion and sedimentation
USC	United States Code
USFS	United States Forest Service
VFD	variable frequency drive
VTP	vertical turbine pump
WB	wheelbase
WDFW	Washington State Department of Fish and Wildlife

1.0 Executive Summary

This Feasibility-Level Design Report describes project alternatives and technical considerations for accessing additional water from the U.S. Department of the Interior Bureau of Reclamation's Kachess Reservoir as part of the Yakima River Basin Integrated Water Resource Management Plan (Integrated Plan) (Reclamation and Ecology, 2011c). The proposed Kachess Drought Relief Pumping Plant (KDRPP) would be located at the southern end of the Kachess Reservoir about 15 miles northwest of the City of Cle Elum, Washington (Figure 1).

The purpose of the KDRPP is to access stored water in Kachess Reservoir that is currently unavailable in order to improve water supply during periods of drought, with a goal of approaching not less than 70 percent of proratable water rights whenever feasible. The KDRPP would deliver up to an additional 200,000 acre-feet of water from Kachess Reservoir during drought years and in years following droughts when the reservoir is refilling to its normal operating levels, by installing a new deeper outlet works and pumping system to access existing stored water that cannot currently be accessed. The additional storage could supply a group of irrigation districts and other users entitled to federal project water that currently experience substantial reductions in supply during severe droughts (i.e., "proratable users"). The project would make maximum use of the existing reservoir for this purpose without increasing either the height of the existing Kachess Dam or the footprint of Kachess Reservoir.

The project would create a new outlet from Kachess Reservoir by constructing a new intake, tunnel, pumping plant, and release structure. The project would allow the reservoir to be drawn down approximately 80 feet lower than the existing gravity outlet, thereby allowing access to an additional 200,000 acre-feet of water that is stored in the reservoir at an elevation immediately below the existing gravity outlet. This additional water is "inactive" reservoir storage as it is located at an elevation below the existing outlet (2,192.75 feet). All elevations shown in this report and on profile views drawings are in North American Vertical Datum 88 vertical datum.

1.1 Background

The Integrated Plan is a comprehensive approach to manage water resources and ecosystem restoration improvements in the Yakima River basin of central Washington State. Reclamation and the Washington State Department of Ecology developed the Integrated Plan in collaboration with the Yakama Nation, irrigation districts, environmental groups, other Federal agencies, and state and county governments. The goals of the Integrated Plan are to protect, mitigate, and enhance fish and wildlife habitat; provide increased operational flexibility to manage instream flows to meet ecological objectives, and improve the reliability of the water supply for irrigation, municipal supply and domestic uses.

In 2012, Reclamation issued a Framework for Implementation (Reclamation and Ecology, 2012d), Four Account Analysis (Reclamation and Ecology, 2012a), Preliminary Cost Allocation (Reclamation and Ecology, 2012b), and a Final Programmatic Environmental Impact Statement (Reclamation and Ecology, 2012c) to analyze the broad economic and environmental effects of the Integrated Plan. The Final Programmatic Environmental Impact Statement Record of Decision (ROD) identified the Integrated Plan as the preferred alternative to improve water resources and restore ecological functions in the Yakima River basin. The ROD identified the KDRPP as a necessary component of the Integrated Plan that contributes to achieving the Plan's overall goals (Reclamation, 2013).

Reclamation and Ecology intend that components associated with the elements of the Integrated Plan be implemented with a balanced approach, so that the full and synergistic benefits of the Integrated Plan for ecosystem improvement and water supply can be achieved. A balanced approach means advancing projects associated with each element of the plan (appraisal analysis, feasibility-level study to implementation) during the same development phase. Reclamation and Ecology are advancing an Initial Development Phase, covering the first ten-year period (2013-2023), which advances all seven plan elements and represents approximately one-third of the estimated plan cost (about $900 million).

The KDRPP is a component within the broader Integrated Plan and is part of the Initial Development Phase. Other key projects include implementation of Cle Elum Fish Passage, Cle Elum Pool Raise, and Keechelus-to-Kachess Conveyance (KKC); and various projects associated with each element of the Integrated Plan such as habitat and tributary restoration, agricultural conservation, and groundwater recharge projects. As a whole, Integrated Plan activities benefit fish and irrigation and offer a synergy that would otherwise be unattainable without the plan.

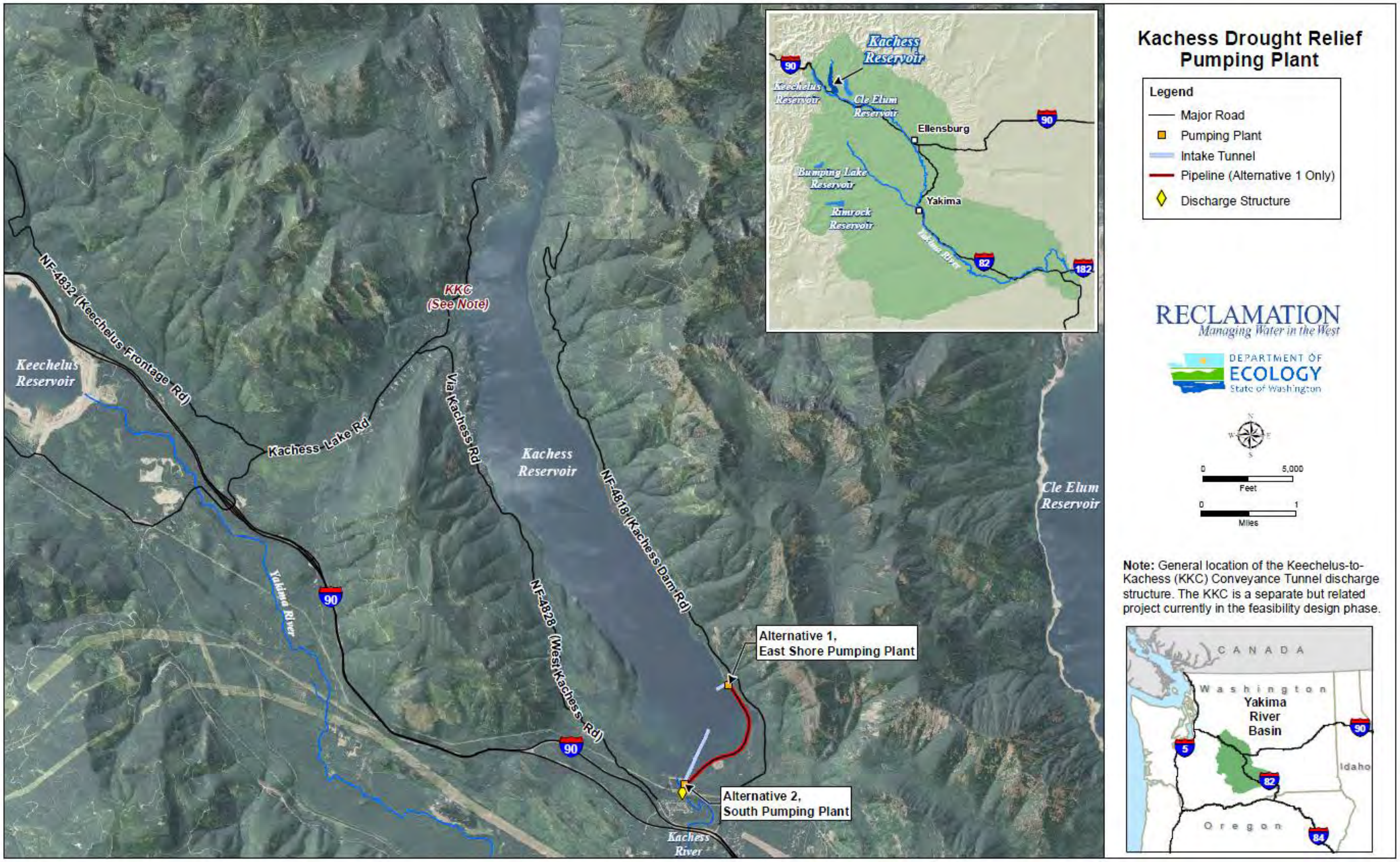

Figure 1. **Vicinity Map**

Reclamation is considering the following two proposed alternatives for the KDRPP in the current feasibility-level study. Both alternatives would include construction of a new intake in the reservoir and a pumping plant to convey water to a release point located immediately below Kachess Dam, where released water would be returned to the Kachess River.

- Alternative 1 – East Shore Pumping Plant[1]: Alternative 1 would withdraw water through a short intake tunnel constructed in rock to a new pumping plant located on the east shore of Kachess Reservoir. From the pumping plant, water would flow via a pipeline approximately 1.8 miles across the reservoir bed to the existing discharge pool. Section 12.1, Alternative 1 – East Shore Pumping Plant, provides further details on the Alternative 2 features.
- Alternative 2 – South Pumping Plant[1]: Alternative 2 would use a 3,275-foot-long tunnel to convey water from the intake to a pumping plant located just south of the Kachess Dam, and release it into the existing discharge pool. Section 12.2, Alternative 2 – South Pumping Plant, provides further details on the Alternative 2 features.

Figure 2 is a Building Information Model (BIM) depiction of the Alternative 1 intake tunnel, pumping plant shaft, primary pumps, building, and pipeline. Figure 3 is a BIM depiction of the Alternative 2 intake tunnel, pumping plant shaft, primary pumps, building, and discharge pipes. Section 12.0, Description of Proposed Facilities, describes project components pertinent to these alternatives.

[1] For purposes of this document, Alternative 1 refers to the East Shore Pumping Plant, and Alternative 2 refers to the South Pumping Plant. Environmental review documents related to KDRPP use a different numbering system.

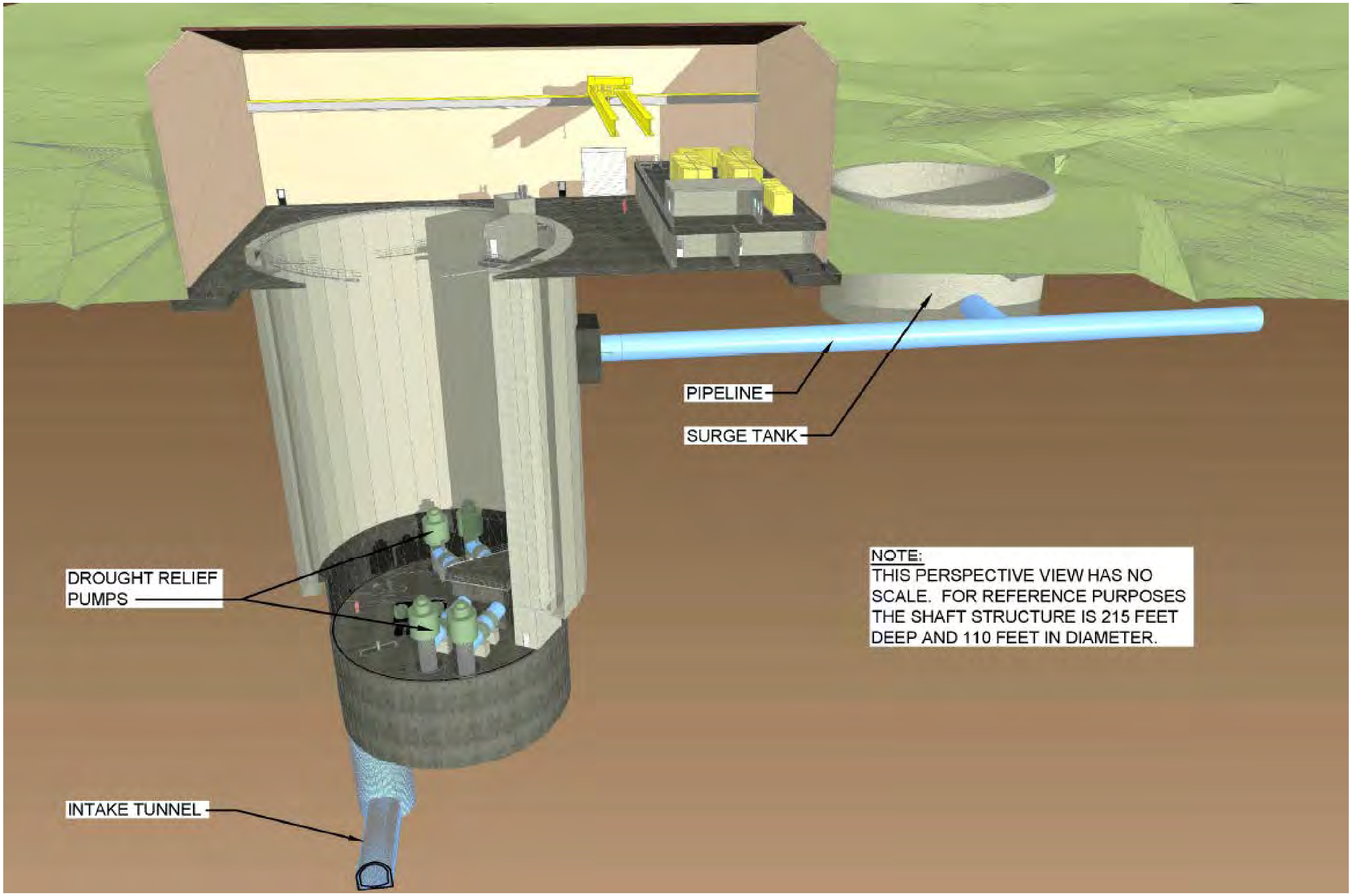

Figure 2. **Three-Dimensional Cross Section View of East Shore Pumping Plant (looking East)**

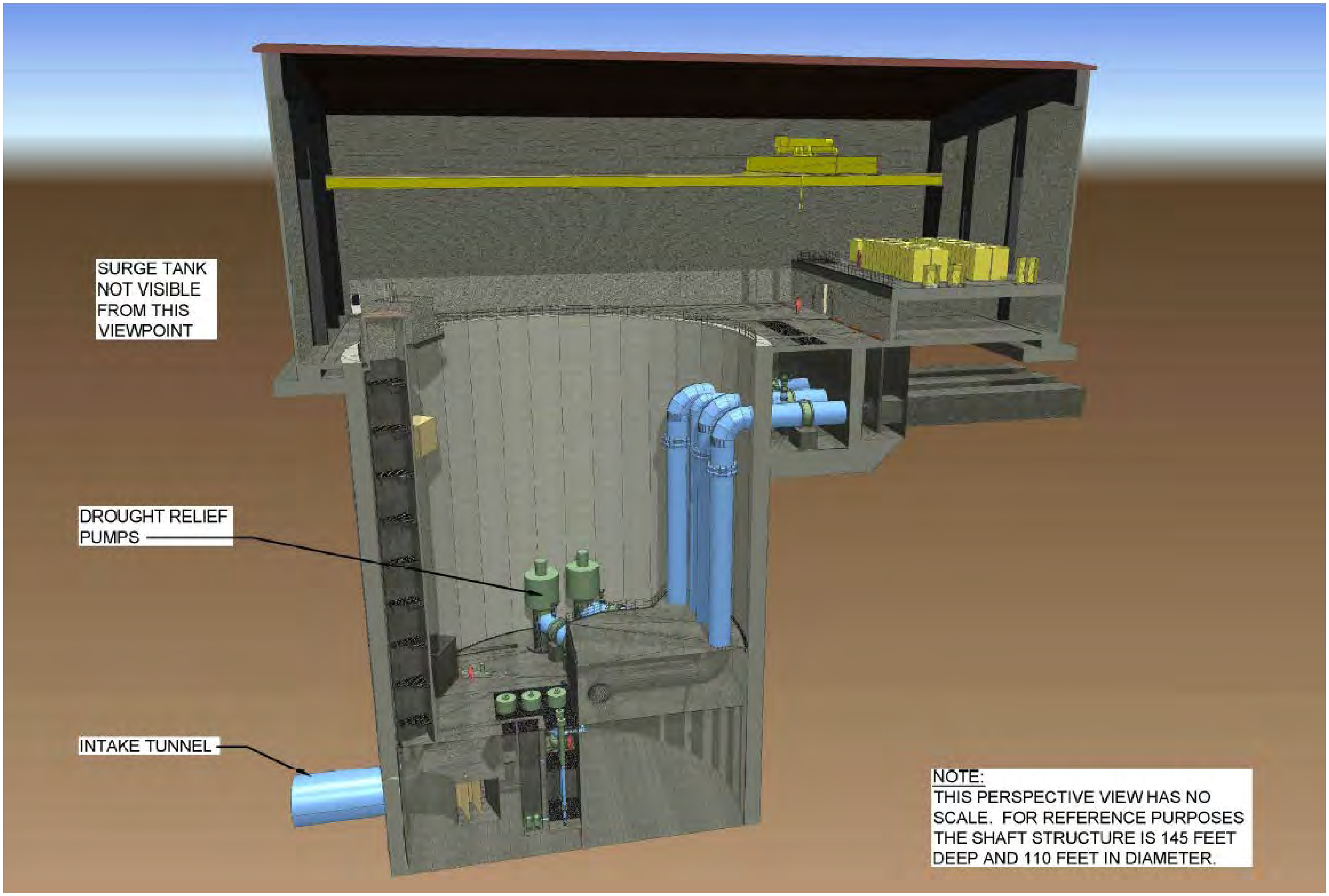

Figure 3. **Three-Dimensional Cross Section View of South Pumping Plant (looking East)**

1.2 Feasibility-level Study Limitations

During 2013, Reclamation completed three borings for Alternative 1, but only one boring for Alternative 2. The drilling contractor drilled the single Alternative 2 boring to Elevation (El.) 1989 and did not encounter bedrock (Shannon & Wilson, 2014). Based on this finding, Reclamation and HDR made a collective decision not to drill proposed onshore boreholes for Alternative 2 since the design team considered Alternative 2 not feasible. Subsequent to this decision, during the January 2014 Value Planning Study for KDRPP, the study team recommended and Reclamation approved further study of Alternative 2. Since Reclamation had not planned additional geotechnical work for KDRPP in 2014, it was not possible to secure additional geotechnical data for use as a part of this feasibility-level study. Therefore, geotechnical information for Alternative 2 is limited to a single borehole (located at the fish screen structure location). Reclamation conducted a second round of geotechnical exploration in fall 2014 and expects to do additional testing in the spring of 2015. Reclamation would use these findings to determine what types of geologic materials the tunnel would encounter, to provide information for the selection of the final alternative, and to potentially refine the design and cost of the selected alternative, as appropriate.

1.3 Summary of Field Cost Estimates

Table 1 summarizes the Field Cost Estimate developed for each of the two KDRPP alternatives. Section 17.0, Field Cost Estimate, provides a summary of the methodology used to develop the KDRPP Field Cost Estimate. The *Field Cost Estimate* technical memorandum contains details of the Field Cost Estimate. Costs were estimated in 2014 dollars (second quarter) (Reclamation and Ecology, 2015b).

The Field Cost Estimates were based on 2014 assumptions regarding the power supply to KDRPP. In 2017 a new power supply configuration was developed in connection with a floating pumping plant alternative for KDRPP. The new power supply configuration would be generally applicable to this study, but field costs have not been updated to reflect this change. Similarly, a concept for volitional fish passage from Big Kachess to Little Kachess was developed after this Feasibility-Level Design Report was prepared. The Field Costs shown below do not include costs of the volitional fish passage.

Table 1. Field Cost Estimate for KDRPP Alternatives

Project Components		Alternative 1 (in millions $$)		Alternative 2 (in millions $$)	
01	Site Work	$	1.74	$	1.44
02	Fish Screens	$	2.89	$	3.59
03	Surge Tank (Alt 1)	$	6.55	$	-
03	Surge Tank Shaft (Alt 2)	$	-	$	12.43
04	Tunnel Access Shaft, Tunnel & Intake Shaft (Alt 1)	$	8.88	$	-
04	Tunnel & Docking Station (Alt 2)	$	-	$	41.09
05	Pumping Plant Shaft	$	31.47	$	22.08
06	Drought Relief Pumping Units	$	40.69	$	35.68
07	Ancillary Systems	$	22.70	$	21.32
08	Building	$	11.31	$	11.83
09	Pipeline (Alt 1 only)	$	20.91	$	-
10	Outlet Works	$	0.90	$	0.89
11	Electrical	$	13.30	$	10.57
12	Instrumentation & Controls	$	0.68	$	0.94
13	Power Supply	$	8.16	$	7.05
	Materials & Labor Cost Subtotal	**$**	**170.19**	**$**	**168.91**
Contractors Field Overhead (12%) / Mobilization - Demobilization (3%)		$	25.53	$	25.34
Estimated State Sales Tax (8.2%)		$	11.59	$	12.02
	Subtotal	**$**	**207.31**	**$**	**206.26**
Unlisted Items (4%), Scope Changes (4%), Cost Refinement (2%)		$	20.73	$	20.63
	Subtotal	**$**	**228.05**	**$**	**226.89**
Contractor Fee (12%)		$	27.37	$	27.23
	Contract Cost Subtotal	**$**	**255.41**	**$**	**254.12**
Undefined Scope of Work (SOW) Contingency (25%)[1]		$	57.01	$	56.72
Escalation to the Midpoint of Construction (6.05%)[1]		$	13.80	$	13.73
	Subtotal	**$**	**326.22**	**$**	**324.57**
Bond & Insurance (1.5%)		$	4.89	$	4.87
Estimated Gross Receipts Tax (0.484%)		$	1.60	$	1.59
	Subtotal	**$**	**332.72**	**$**	**331.03**
	Field Cost Total	**$**	**332.72**	**$**	**331.03**
	Forecast Field Cost Low (-15%)	**$**	**282.81**	**$**	**281.37**
	Forecast Field Cost High (+30%)	**$**	**432.53**	**$**	**430.34**

(1) Contingency and Escalation costs are calculated from the Unlisted Items, Scope Changes, Cost Refinement Subtotal.

1.4 Comparison of Alternatives

Table 2 provides a comparison of differences between significant Alternative 1 and Alternative 2 features. Section 12.0, Description of Proposed Facilities, provides a detailed description of the proposed KDRPP features.

Table 2. Comparison of East Shore Pumping Plant and South Pumping Plant

Project Feature	Alternative 1- East Shore Pumping Plant	Alternative 2- South Pumping Plant	Advantages and Disadvantages
Fish Screens	Vertical Orientation	Horizontal Orientation	The lake bed power supply cable to the motor operated screen cleaners would be approximately 2,475 feet longer for Alternative 2.
Inlet Shaft	25-foot diameter, 52-foot tall	None	Alternative 1 would require a inlet shaft to connect the pumping plant shaft to the tunnel.
Docking Sleeve	None	38-foot by 40-foot by 42-foot concrete	Alternative 1 would not require a docking sleeve. For Alternative 2, the docking sleeve provides a location for the tunnel boring machine (TBM) to drive into and park. The docking sleeve would become the termination point for the tunnel and the attachment point for the fish screen structure.
Tunnel	Mined in rock, 711-foot long	Bored in soil, 3,275-foot long	There is limited geotechnical information available for Alternative 2. More information would be required to determine any specific advantages or disadvantages for that alignment.
Surge Tank	110-foot diameter, 43-foot deep	50-foot diameter, 200-foot deep	Alternative 2 would be more complex and take twice as long to construct.
Pumping Plant Shaft	110-foot diameter, 215-foot deep, 7-foot wall thickness	110-foot diameter, 145-foot deep, 5-foot wall thickness	The Alternative 1 pumping plant shaft would be approximately 70 feet deeper. Due to the location of the pumping plant, Alternative 1 would have greater visual impacts and may require additional property easements or acquisitions.
Power Transmission Line	~ 3.2 Miles	~ 1.7 Miles	Alternative 1 and 2 could potentially use the same power supply configuration as developed for the floating pumping plant alternative in 2017. However, the power transmission line for Alternative 1 would be approximately 1.5 miles longer than for Alternative 2 or the floating pumping plant alternative.
Drought Relief Pumps	10,000 HP each, (4 pumps) at 333 cfs, Vertical Turbine Pumps	6,000 HP each, (4 pumps) at 333 cfs, Vertical Turbine Pumps	Alternative 2 would have a smaller sized transformer since the pumping units require less power to operate. This alternative would have lower power costs.
Variable Frequency Drives	Yes	Yes	This feature is the same for both alternatives.
Throttling Valves	No	Yes	The design of Alternative 2 is more complex due to the wider range of total dynamic heads and requires throttling valves to operate at the lowest total dynamic head.
Pump Control Valves	Yes	Yes	This feature is the same for both alternatives.

Project Feature	Alternative 1- East Shore Pumping Plant	Alternative 2- South Pumping Plant	Advantages and Disadvantages
Pump Discharge Pipes	Manifold into one 136-inch diameter pipe	Four separate 84-inch diameter pipes	The design of Alternative 2 is more complex due to the wider range of total dynamic heads and therefore requires four separate discharge pipes to operate at the lowest total dynamic head.
Pipeline	7,755 feet, 136-inch diameter steel pipe	None	The Alternative 1 would include additional pipeline maintenance requirements.
Spillway & Stilling Basin	Yes	None	The Alternative 1 would have some minor additional maintenance requirements associated with the spillway and stilling basin.
Discharge Structure	Yes	Yes	This feature is the same for both alternatives.
Local Impacts during Construction	Potential traffic and cultural resources impacts		Alternative 2 would have less noise disturbance during construction.
Field Cost Estimate	$333 million	$331 million	Alternatives 1 and 2 are approximately equal in cost. (See notes in text regarding updated information not reflected in field costs)

2.0 Project Purpose

This Feasibility-Level Design Report describes project alternatives and technical considerations for accessing additional water from Reclamation's Kachess Reservoir as part of the Integrated Plan.

Reclamation and Ecology developed the KDRPP as part of a portfolio of projects intended to meet the goals of the Integrated Plan. The goals of the Integrated Plan are as follows: to protect, mitigate, and enhance fish and wildlife habitat; to provide increased operational flexibility to manage instream flows to meet ecological objectives; and to improve the reliability of the water supply for irrigation, municipal supply, and domestic uses.

The purpose of the KDRPP project is to access stored water in Kachess Reservoir that is currently unavailable in order to improve water supply during periods of drought. The additional water would supply proratable users, who currently experience substantial reductions in supply during severe droughts. The project would make maximum use of the existing reservoir for this purpose without increasing the reservoir footprint. Note that the project would not increase the maximum reservoir pool elevation.

The project would add a second outlet at Kachess Reservoir by means of a new intake, tunnel, pumping plant, and release structure. The project would allow the reservoir to be drawn down approximately 80 feet lower than the current elevation of the existing outlet works, thereby accessing an additional 200,000 acre-feet of currently inactive water stored in the reservoir below the existing outlet elevation (2,192.75 feet). Reclamation and Ecology completed the Draft Environmental Impact Statement (DEIS) for the KDRPP project in January 2015, which evaluates, among other impacts, the impacts associated with drawing the reservoir down below the historical minimum pool elevation, discussed further in Section 8.0, Environmental Considerations.

3.0 Project Description

A project team led by HDR Engineering developed the KDRPP feasibility design, as summarized in this report and the associated technical memoranda (discussed in Section 3.3, Study Process), by working in close collaboration with Reclamation staff located at the Columbia-Cascades Area Office in Yakima, WA and at the Reclamation Technical Services Center located in Denver, CO.

The project team has developed the following two alternatives to withdraw additional water from Kachess Reservoir:

- Alternative 1 - East Shore Pumping Plant
- Alternative 2 - South Pumping Plant

Both alternatives include a new intake constructed in the reservoir at an elevation approximately 80 feet lower than the existing outlet. Pumps would move water from the intake to the Kachess River just downstream from the dam.

This Feasibility-Level Design Report was prepared originally in 2015. In 2017 Reclamation completed an Appraisal Design Report on a new, floating pumping plant alternative. Information on the floating pumping plant alternative is not discussed in this report, but can be found in Reclamation 2017. The power supply configuration in this report has been updated to reflect the power supply configuration developed in 2017. In addition, a volitional fish passage concept was developed in 2017 for the floating pumping plant alternative. Details of that concept are also presented in Reclamation 2017.

3.1 Alternative 1- East Shore Pumping Plant

The proposed KDRPP Alternative 1, shown in Figure 4**,** consists of an underground pumping plant located on the eastern shore of the reservoir, an intake tunnel that connects the new intake and fish screen in the reservoir with the pumping plant, and a discharge pipeline that would convey water from the pumping plant to a discharge structure located just downstream of the existing Kachess Dam outlet channel, where the water would be released into the Kachess River. Major Alternative 1 facilities include the following:

- Intake and fish screen

- Intake tunnel
- Pumping plant
- Surge tank
- Pipeline
- Outlet works and Kachess River discharge
- Access roads
- Power supply substation and transmission line

Section 12.1, Alternative 1 – East Shore Pumping Plant, provides further details on the proposed Alternative 1 facilities.

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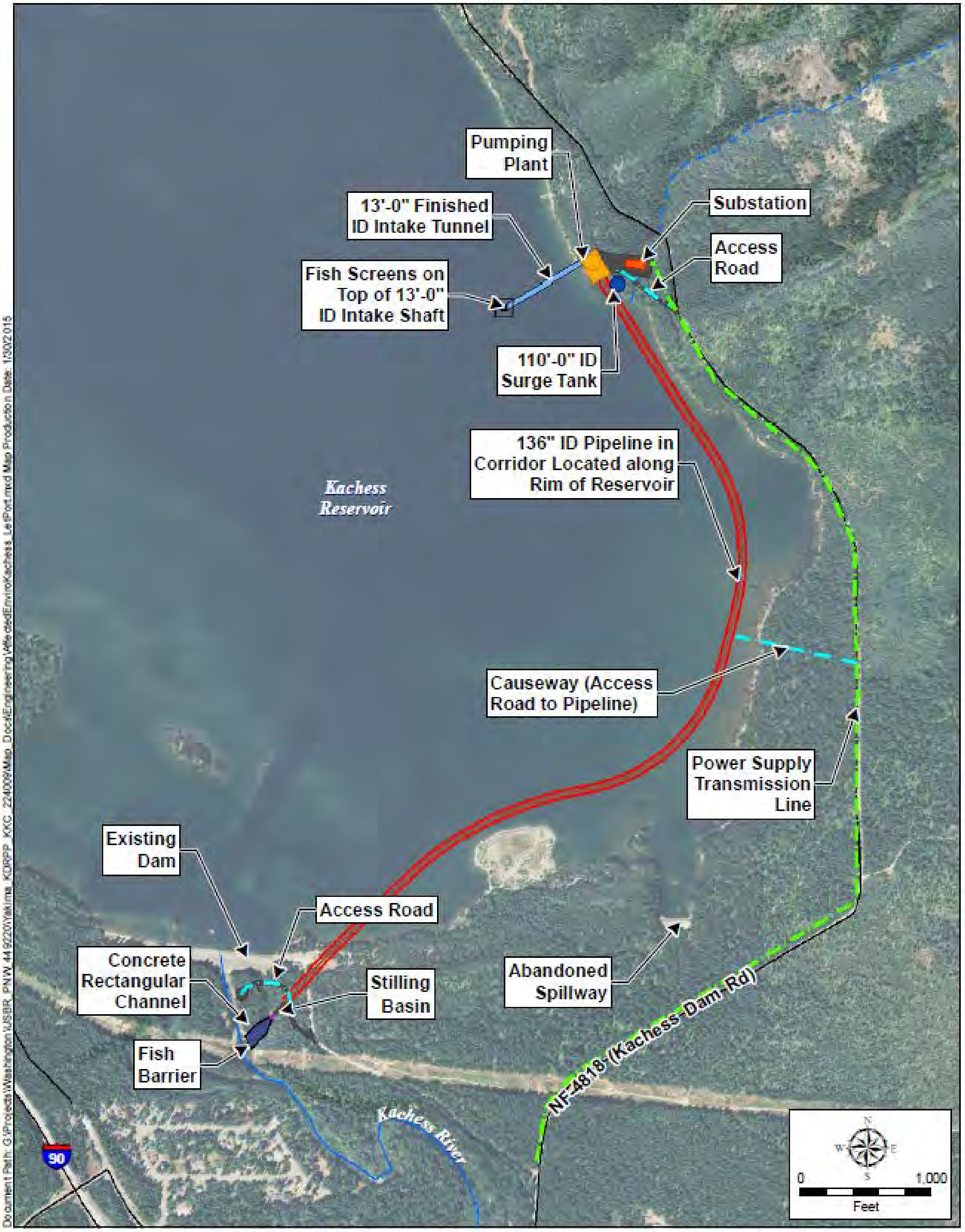


Figure 4. Plan View of Alternative 1, East Shore Pumping Plant

3.2 Alternative 2- South Pumping Plant

The proposed KDRPP Alternative 2, shown in Figure 5, consists of an underground pumping plant located at the south end of the reservoir immediately downstream of the existing dam and an intake tunnel that connects the new intake, docking sleeve, and fish screen in the reservoir with the pumping plant. The pumping plant lifts the water and releases it into the adjacent, existing outlet works discharge pool located at the downstream end of the existing Kachess Dam outlet channel into the Kachess River. Major Alternative 2 facilities include the following:

- Reservoir intake, docking sleeve, and fish screens
- Intake tunnel
- Pumping plant
- Surge tank
- Kachess River discharge
- Access roads
- Power supply substation and transmission line

Section 12.2, Alternative 2 – South Pumping Plant, provides further details on the proposed Alternative 2 facilities.

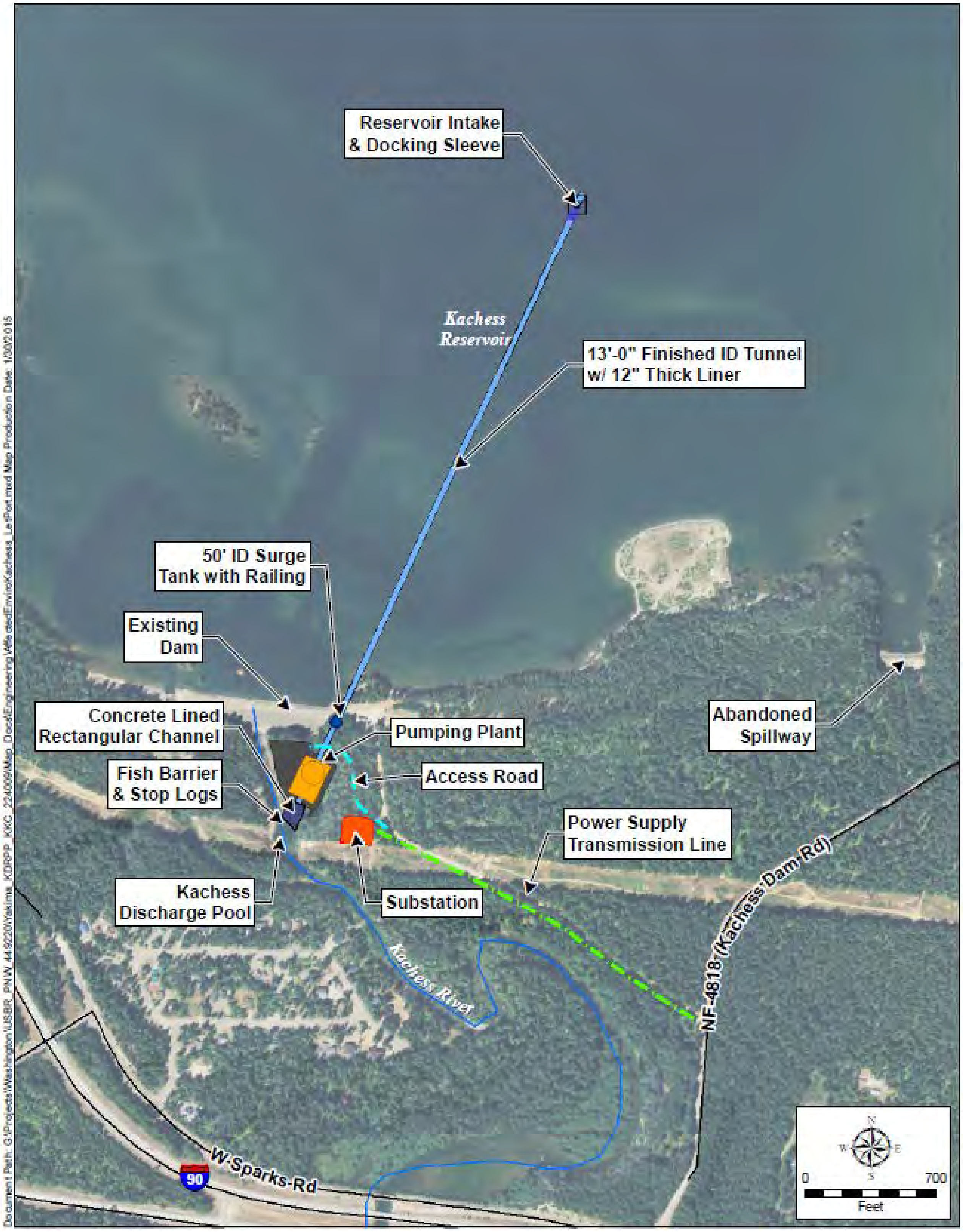


Figure 5. **Plan View of Alternative 2, South Pumping Plant**

3.3 Study Process

The design team evaluated the feasibility design features for both alternatives. The following technical memoranda details and results of these analyses:

- Pipeline Analysis (Alternative 1 only) (Reclamation and Ecology, 2014d)
- Summary of Prior Geotechnical Data for Alternative 2 – South Pumping Plant (Reclamation and Ecology, 2014j)
- Geotechnical Analysis (Reclamation and Ecology, 2014f)
- Hydraulic Analyses (Reclamation and Ecology, 2014g)
- Pumping Plant Shaft Structural Analysis (Reclamation and Ecology, 2014k)
- Civil and Site Elements (Reclamation and Ecology, 2014c)
- Intake and Fish Screen Analysis (Reclamation and Ecology, 2014h)
- Pumping Unit Analysis (Reclamation and Ecology, 2014l)
- Ancillary Systems Analysis (Reclamation and Ecology, 2014b)
- Electrical System Analysis (Reclamation and Ecology, 2014e)
- Power Supply Analysis (Reclamation and Ecology, 2014i and Reclamation 2017)
- Construction Scheme and Schedule (Reclamation and Ecology, 2015a)
- Field Cost Estimate (Reclamation and Ecology, 2015b)

The analyses described in these technical memoranda support the feasibility design described in this Report.

4.0 Existing Facilities

Existing facilities at the project location include the following Reclamation owned facilities:

- Kachess Dam
- Intake tower and outlet works
- Gravity outlet channel
- Spillway
- Discharge pool
- Abandoned original overflow spillway (3,000 feet south of the dam)

The KDRPP would not make modifications to these existing facilities. Note that the project would cross the left abutment of the dam, but would not penetrate or pass beneath the dam. Reclamation may, however, choose to make improvements to the existing Kachess Dam Road to accommodate large vehicles during construction.

5.0 Prior Studies

Reclamation and Ecology developed the KDRPP the (Reclamation and Ecology, 2011c) Reclamation and Ecology developed the Integrated Plan to address existing and forecasted water needs of the Yakima River basin. Based on over 30 years of studies in the basin, Reclamation and Ecology determined that current water supply in the basin does not meet instream or out-of-stream demand, including the instream aquatic demands for fish and wildlife and the out-of-stream needs for irrigation and municipal water supply. In addition, future climate change might decrease the basin's winter snowpack, leading to reduced spring and summer runoff. The implementation of the KDRPP would contribute to the following Integrated Plan goals:

- Improve water supply reliability during drought years
- Improve the ability of water managers to respond and adapt to potential effects of climate change
- Contribute to the vitality of the regional economy and riverine environment

The KDRPP project is currently at the Reclamation feasibility-level planning phase of development. Previous studies have contributed to the development of the current feasibility-level design. These previous studies include initial project criteria (Reclamation and Ecology, 2011b), cost estimation (Reclamation and Ecology, 2011a), and value analysis of KDRPP alternatives (Reclamation and Ecology, 2014o). In addition, there have been geotechnical investigations for the Alternative 1 alignment, the results of which are summarized in the Shannon & Wilson *Geology Report Kachess Drought Relief Pumping Plant* and the Golder Associates *Lake Kachess Offshore Geophysical Reconnaissance* (Shannon & Wilson, 2014; Golder, 2013). The geophysical reconnaissance also covered part of the Alternative 2 study area. The *Hydrologic Modeling of System Improvements, Phase 1 Report* analyzed alternative flow capacities for KDRPP using the Riverware® modeling software; this report established 1,000 cubic feet per second (cfs) as the approximate optimal capacity for the KDRPP (Reclamation and Ecology, 2014a). Building on these prior studies, HDR evaluated the feasibility design features for both alternatives (see Section 3.3, Study Process).

Reclamation has completed additional geotechnical exploration and testing, started with two new borings during the fall of 2014. The exploration program was then resumed with additional borings and testing beginning in the spring of 2015. The findings of those additional explorations, testing, and reporting will be used to refine the design and cost estimate of Alternative 2.

6.0 Climate

The project area is located in the Cascade Mountains at elevations between 1,880 and 2,400 feet above sea level. Table 3 shows the typical weather in the Kachess Reservoir area, based upon the available summarized period of record from Reclamation Hydromet and NOAA for temperature and rainfall, and the Western Regional Climate Center for snow.

Although the snowfall data is a bit dated, the general trends are still consistent with the current pattern of typical monthly snowfall in the project area. Snowfall typically occurs during the months of November through April. Peak precipitation months typically occur between October and March.

Table 3. Typical Weather at Kachess Reservoir

	Monthly Average for the Period of Record												Annual
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	
Avg Max. Temp (F)	33.2	38.4	44.9	52.3	60.9	67.6	76.5	76.6	69.1	56.6	41.8	34.5	54.6
Avg Min. Temp (F)	21.1	23.8	27.5	32.1	38.3	45.4	50.5	49.9	42.8	35.6	29.1	24.0	35.2
Avg Total Precipitation (in.)	8.6	6.0	4.9	2.9	2.1	1.5	0.7	0.8	1.9	4.4	7.9	8.7	50.5
Avg Total Snow (in.)	47.1	31.1	22.9	4.4	0.1	0.0	0.0	0.0	0.0	1.0	16.6	36.4	159.6
Avg Snow Depth (in.)	27.0	33.0	27.0	9.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	12.0	9.0

The period of record for temperature and precipitation data is from 1908 to 2014 and snow data is from 1931 to 1977.

7.0 Agency Coordination

Reclamation planning and National Environmental Policy Act (NEPA) compliance activities for the KDRPP project have included extensive coordination with State, Federal, and Tribal agencies. This coordination would continue during the final design and construction phases of the project. Agencies involved would include those listed below:

- United States Forest Service (USFS) – Reclamation would construct project facilities on federal land within the Okanogan-Wenatchee National Forest administered by USFS. Reclamation would coordinate with the USFS to finalize site selection and configurations; minimize and mitigate impacts on forest resources and recreational users; and coordinate construction and permanent access and traffic considerations. Following construction, restoration of vegetation on disturbed areas outside the permanent project footprint would require coordination and compliance with USFS requirements.
- United States Fish and Wildlife Service (Service) – Reclamation would coordinate with the Service, including achieving consistency with the Fish and Wildlife Coordination Act report developed for the Integrated Plan. Reclamation would also consult with the Service under the Endangered Species Act to determine effects on threatened and endangered species.

- National Marine Fisheries Service (NMFS) – Reclamation would consult with NMFS under the Endangered Species Act to determine effects on threatened and endangered species.
- United States Army Corps of Engineers – Reclamation would obtain permits for construction.
- Yakama Nation – Reclamation would coordinate with the Yakama Nation on water supply, fish, and cultural considerations.
- Washington State Department of Fish and Wildlife (WDFW) – Reclamation would coordinate with the WDFW, including obtaining permits for construction and operations of the KDRPP.
- Washington State Department of Ecology – Ecology is a partner with Reclamation in funding and leading development of the Integrated Plan and its various projects, including the KDRPP project. Reclamation would coordinate with Ecology's Office of Columbia River, which manages the agency's activities in this regard. Reclamation would also coordinate with Ecology's Water Quality Program related to protection of water quality during project construction.
- Kittitas County and local cities – Reclamation would inform Kittitas County, and the Cities of Easton, Cle Elum, and Ellensburg of construction planning and construction progress, to enable these cities to anticipate and respond to impacts or needs affected by the project.
- Irrigation districts served by water from the Yakima Irrigation Project – Reclamation would inform irrigation districts that have federal contracts of construction planning and construction progress. In general, Reclamation does not anticipate that construction would affect irrigation districts.

In addition to overall coordination activities, Reclamation would obtain a number of permits to construct the KDRPP project. Section 8.0, Environmental Considerations, describes the required construction permits as identified at this time.

8.0 Environmental Considerations

Reclamation and Ecology prepared the DEIS for the KDRPP project in January 2015. Reclamation and Ecology are preparing the Supplemental Draft Environmental Impact Statement (SDEIS) to include a floating pumping plant alternative, as well as changes to the proposed action and alternatives described in the DEIS. Reclamation and Ecology are jointly leading and preparing the SDEIS as a combined NEPA and State Environmental Policy Act (SEPA) document.

The NEPA of 1969 (40 U.S.C. Section 4321 et seq.) requires that the action agency determine whether there are significant adverse environmental impacts associated with proposed Federal actions. This evaluation will be documented and presented to the public in the SDEIS being prepared for this project. Reclamation will issue a ROD following completion of a Final EIS (FEIS). The ROD documents the decision on which alternative, if any, the action agency will implement and the reasons for its selection. The ROD completes the NEPA compliance process.

The KDRPP and KKC SDEIS will evaluate environmental considerations and potential impacts of the project on elements of the environment, including but not limited to air, soil, water resources, aesthetic values, cultural resources, wildlife, and vegetation. Reclamation and Ecology will circulate the SDEIS for review and comment to engage interested public, agencies, stakeholders, and Tribes. Reclamation and Ecology will consider comments received on the SDEIS during the public review period. Responses to comments on both the 2015 DEIS and the SDEIS will be included in the FEIS. The results of the EIS analysis will inform the final design of the project to mitigate environmental concerns.

To construct the KDRPP, Reclamation and Ecology would obtain all required permits and meet other requirements set forth by law, regulation, ordinance, and policy. Table 4 summarizes the potential permit requirements identified to date.

Table 4. Summary of Potential Permit Requirements and Other Approvals

Agency	Permits and Other Requirements	Jurisdiction or Purpose
Federal Agencies		
Service and NMFS	Endangered Species Act (16 United States Code (USC) § 1531)	Consultation to determine effects on threatened and endangered species.
NMFS	Magnuson-Stevens Fishery Conservation and Management Act (16 USC §§ 1801-1802)	Consultation with NMFS on activities that may adversely affect essential fish habitat to determine whether the Proposed Action “may adversely affect” designated essential fish habitat for relevant commercially, federally managed fisheries species within the area of the Proposed Action.
Service	Fish and Wildlife Coordination Act (16 USC 661066c)	Coordination with the Service on the effects of the proposed project on fish and wildlife.
United States Army Corps of Engineers	Clean Water Act Section 404 (§ 404, 33 USC §1251 et seq.)	Permitting and minimization of impacts associated with the discharge of dredged or fill material into waters of the United States, including wetlands.
State Agencies		
Ecology	Clean Water Act Section 401 (33 USC § 1251 et seq.)	Issuance of a Section 401 Water Quality Certification to indicate reasonable assurance that a project will comply with Federal and State water quality standards and other aquatic resources protection requirements under Ecology’s authority. Federal regulation delegated to the State. Triggered as part of Clean Water Act Section 404 authorization.
Ecology	Construction National Pollutant Discharge Elimination System (NPDES) (90.48 RCW); Clean Water Act Section 402 (§ 402, 33 USC § 1251 et seq.)	Issuance of a permit for construction projects engaged in clearing, grading, and excavating activities that disturb an area of at least 1 acre. Federal regulation delegated to the State.
Ecology	Chapter 90.03 RCW	Issue water rights, as necessary.

Agency	Permits and Other Requirements	Jurisdiction or Purpose
WDFW	Hydraulic Project Approval (77.55 RCW)	Granting of approval for construction projects that use, divert, obstruct, or change the natural bed or flow of State waters.
WDFW	Fish and Wildlife Coordination Act (16 USC 661066c)	Coordination with WDFW on effects of the project on fish and wildlife species.
Washington State Department of Archaeology and Historic Preservation	National Historic Preservation Act (NHPA) (16 USC § 470 et seq.)	Section 106 Consultation to determine whether the project would impact historic or cultural resources; to be completed by Reclamation and Ecology. The Washington State Department of Archaeology and Historic Preservation advises and assists Federal agencies in carrying out their Section 106 responsibilities.
Local Agencies		
Kittitas County	Critical Areas Ordinance, Shoreline Master Program	Granting of approval for actions on private land within the County shoreline jurisdiction.

Source: *Kachess Drought Relief Pumping Plant and Keechelus Reservoir-to-Kachess Reservoir Conveyance Draft Environmental Impact Statement* (Reclamation and Ecology, 2014m)

9.0 Design Criteria

This section summarizes the design criteria that the design team established for the following project features:

- Fish screens
- Intake
- Intake tunnel
- Pumping plant shaft
- Pumping units
- Ancillary systems
- Pipeline (applies to Alternative 1 only)
- Access roads
- Substations and electrical systems

The feasibility-level study technical memoranda (listed in Section 3.3, Study Process) provide further details on design criteria for specific project features. Unless otherwise specified, design criteria apply to both alternatives.

9.1 Fish Screen Design Criteria

The design team developed fish screening criteria using the NMFS Northwest Region *Anadromous Salmonid Passage Facility Design* (NMFS, 2011) and professional judgment. There are five species of concern related to this drainage: steelhead, bull trout, Chinook, coho, and sockeye salmon. The following are the NMFS criteria used.

9.1.1 Depth and Location

The NMFS fish screening criteria state that intakes in reservoirs should be as deep as practical, to reduce the number of juvenile salmon that encounter the intake. No natural sweeping velocity would be possible during intake facility operation because of its location near the bottom of the reservoir.

9.1.2 Wedge Wire

The NMFS fish screening criteria require that the design of wedge and profile wire screens meet the following criteria:

- Do not exceed 1.75 millimeters (mm) slotted screen face openings in the narrowest direction; have minimum percent open area for the screen material of at least 27 percent.
- Design metal materials below the water surface elevation with non-corrosive material.
- Calculate the minimum effective screen area by dividing the maximum-screened flow by the allowable approach velocity. For this application:
  - Effective Screen Area = 1,000 cfs / 0.4 ft/sec = 2,500 square feet (sf), with an added 10 percent screen area to account for structural blinding behind the screens.
  - Required Screen Area = 2,500 sf x 1.10% = 2,750 ft.

Based upon the above NMFS criteria, it is recommended that the fish screen be wedge wire with 1.75 mm slot openings and a minimum of 50 percent open area; this is to provide the least amount of head loss through the screens and minimize the screen size. Stainless steel 304L screen material is the most suitable screen material for freshwater lake application, and meets NMFS criteria. This intake would use 7-foot-diameter cylindrical tee screens. There are larger screen diameters manufactured, but they are not common and would be far more expensive due to the special fabrication. Listed below is the estimated required screen length:

- Required total tee screen length = 2,750 sf / (7 ft * 3.1416) = 125 linear feet.

9.2 Intake

Reclamation defined the maximum water diversion flow rate as not to exceed 1,000 cfs. Three main factors determined the location of the intake:

- Achieving the desired depth in the reservoir to capture the water supply below the inactive pool elevation for drought relief, and
- Minimizing the tunneling length of the conveyance pipe from the screen to the pumping plant by the intake proximity to the pumping plant location.
- Maintaining sufficient distance and open area from lake bottom sediments at the intake to avoid sucking in sediments.

9.3 Intake Tunnel

The design team developed the criteria and assumptions, discussed below, to address the following design and construction considerations:

- Tunnel size
- Construction dewatering requirements
- Initial support requirements
- Final lining requirements
- Internal pressures
- Leakage considerations
- External pressures

The design team estimates that the finished diameter of the tunnel, after final lining, would be 13 feet. The minimum excavated diameter of the tunnel would likely be in the range of 14 to 16 feet, depending on the equipment used to construct the tunnel and initial support approach utilized by the construction contractor.

The final tunnel lining would withstand the maximum expected external pressure, which would be the highest of the pressure due to earth loads and groundwater, or the estimated grouting pressures, but in any case, would not be less than 50 pounds per square inch (psi). The design team proposes to develop a tunnel unwatering protocol, which would prevent subjecting the tunnel lining to external pressures greater than the buckling strength of the lining. The tunnel would experience external pressures caused by earth loads and the head of groundwater above the tunnel. These external pressures apply mainly when the tunnel is unwatered for inspection or maintenance. The expected maximum groundwater head is at a pool elevation of 2,262 feet where it would have a maximum hydraulic pressure of about 262 feet above the tunnel invert.

Possible high permeability zones that are a source of groundwater inflows during construction would also be a leakage path in and out of concrete lined sections of the tunnel. The design must minimize leakage into the tunnel during construction and when the tunnel is unwatered for inspection and maintenance.

The design team would develop guidelines for identifying sections of concrete lined tunnel that would require treatment, based on observed groundwater inflows into the tunnel after the lining is constructed. Based on previous tunnel projects, inflows should be limited to about 20 gpm per 1,000 feet of tunnel and less than 1 to 2 gpm for a single feature.

9.4 Pumping Plant Shaft

The design team developed the following design criteria for the pumping plant shaft. The team would design the shaft as reinforced concrete structure. Applied loads would be combined according to applicable International Building Code 2012, American Concrete Institute (ACI) 350, American Society of Civil Engineers (ASCE) 7 2010 codes and Bureau of Reclamation design guidelines.

9.4.1 Materials

Steel reinforced cast-in-place concrete would be the primary construction material used for the pumping plant shaft. Structural concrete for this project would have a compressive strength design value of 4,500 psi minimum, and satisfy the appropriate codes and the following specifications unless specified otherwise in future design documents:

- Cement – American Society of Testing and Materials (ASTM) C150, Type I or II
- Pozzolan (Fly Ash) – ASTM C618 Class F
- Sand and Coarse Aggregate – American National Standards Institute and ASTM C33
- Reinforcing Steel – Deformed Bars ASTM A615, Grade 60 or ASTM A706, Grade 60

9.4.2 Structural Design & Loading Scenarios

Design team engineers would determine design loads based on geographic settings and surroundings, material weight, code compliance, geotechnical data, and other operational requirements of the shaft.

The engineers would consider several loads, load combinations, load scenarios (listed herein) in the structural design of the shaft. There are three main loading categories: construction loading, operation loading, and extreme loading:

- Construction loading: As the design of the shaft progresses, the engineers would evaluate the structure for construction equipment loading, such as backhoes, dump trucks, and cranes. The design team geotechnical engineer recommends a 300-psf uniform load applied over the top 10 feet of the shaft to compensate for typical construction equipment loading.
- Operation loading: Engineers envision the shaft subjected to groundwater while the interior of the shaft remains dry. They would consider the surcharge loads of future adjacent foundations.
- Extreme loading: This category includes seismic and hydrologic (flood) loadings. The earthquake loads would be included in the proper ACI 350-06 load combinations.

Table 5 summarizes the loading applied under each scenario:

Table 5. Summary of Applied Loading

Operational Loading
Full Height Groundwater, Hydrostatic and Hydrodynamic Loading
Equivalent Fluid Pressure Soil Loading and Seismic Soil Loading
Construction Loading
f Horizontal Surcharge Load for first 10 vertical feet

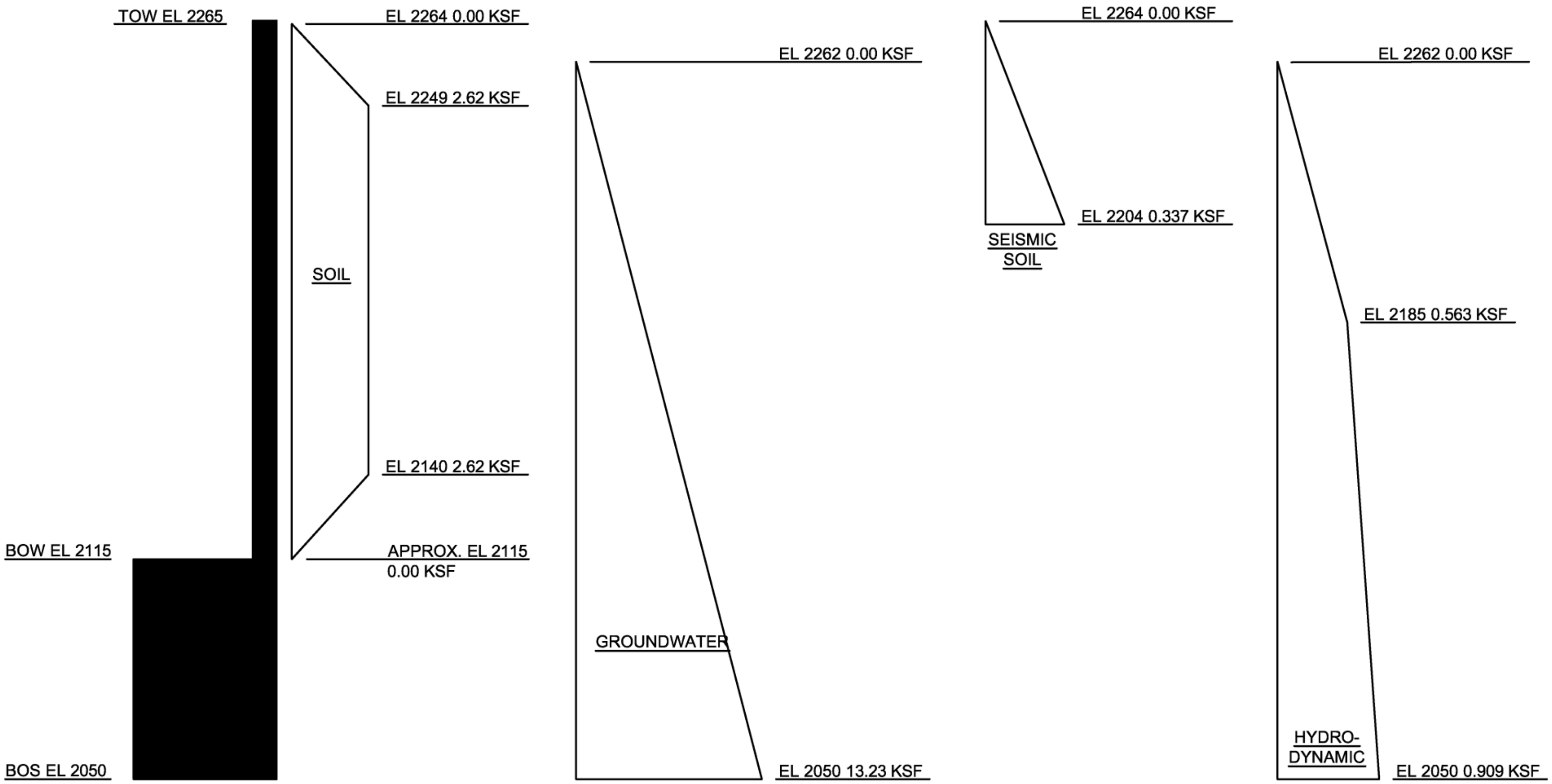
Note: The above loads would be combined per ASCE 7-10 and International Building Code 2012 requirements.

The engineers would calculate individual loads per the following parameters:

- Dead loads are the actual weights of the materials of construction and fixed service equipment. Concrete = 150 pounds per cubic foot (pcf).
- Live loads include vertical loads that are projected onto the structure by transient causes, such as surcharge loads caused by construction vehicles and soil compaction operations. Construction = 300 pounds per square foot (psf) applied horizontally to top 10 feet.
- Earthquake (seismic) loads include parameters set forth by the building codes and geotechnical (criteria) for the geological site conditions. The following summarize the parameters for each alternative:
- Alternative 1:
  - Soil Site Class: D
  - Mapped, spectral response acceleration parameter at short periods: Ss 0.2 sec = 0.799g
  - Mapped, spectral response acceleration parameter at a period of one second: S1 1.0 sec = 0.306g
  - Design, spectral response acceleration parameter at short periods: SDS = 0.629g
  - Design, spectral response acceleration parameter at a period of one second: SD1 = 0.365g
- Alternative 2:
  - Soil Site Class: C
  - Mapped, spectral response acceleration parameter at short periods: Ss 0.2 sec = 0.804g
  - Mapped, spectral response acceleration parameter at a period of one second: S1 1.0 sec = 0.307g
  - Design, spectral response acceleration parameter at short periods: SDS = 0.578g

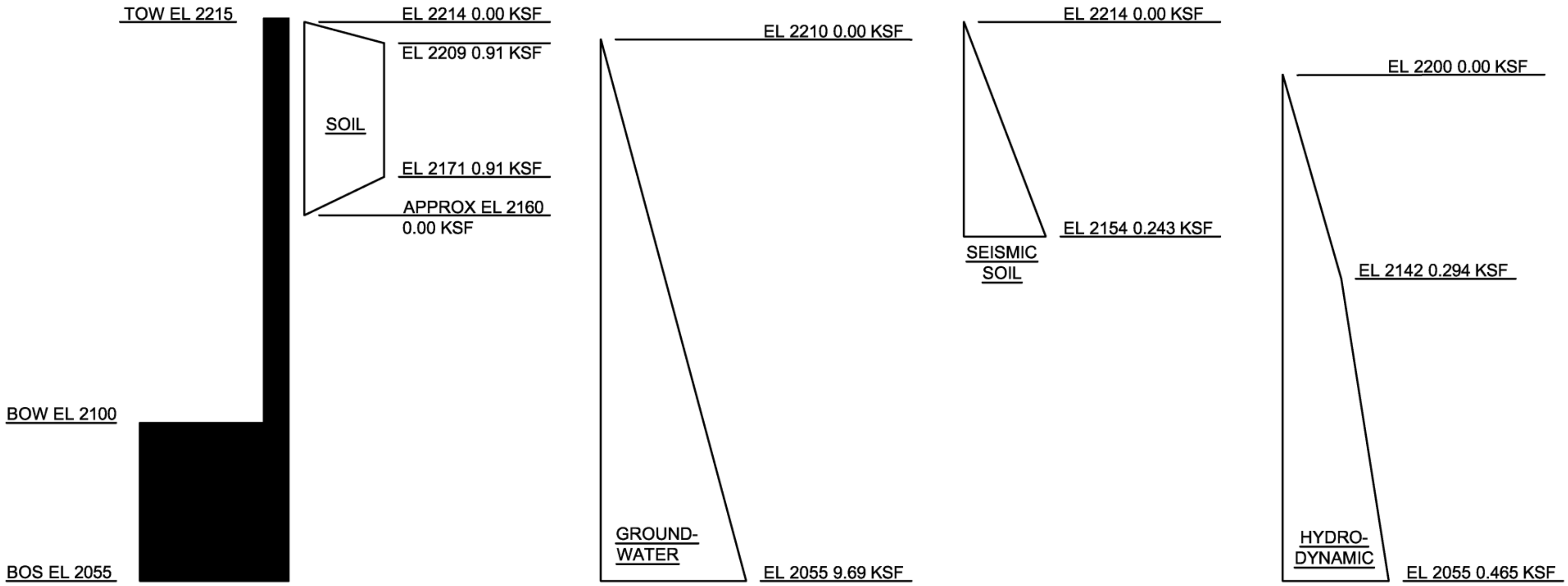
- Design, spectral response acceleration parameter at a period of one second: SD1 = 0.306g

- Seismic earth pressure: Triangular seismic earth pressure from top of excavation to a depth of 60 feet. The resultant is located at one-third point above depth Z. This load would be added to the static lateral earth pressures presented below. See Figure 6 and Figure 7.
- Groundwater: The design team geotechnical engineer recommends a high water table elevation of 2,262 feet (equivalent to the reservoir full pool) at Alternative 1 and 2,210 feet at Alternative 2. See Figure 6 and Figure 7.
- Hydrodynamic fluid forces: Forces generated during a seismic event due to groundwater lateral acceleration. See Figure 6 and Figure 7.
- Earth pressure or other bulk materials cause lateral loads. Earth pressure loads are per Figure 6 and Figure 7. The geotechnical engineer recommends that the structural design of the shaft be based on the following soil parameters:
  - Assumed soil's saturated unit weight: γ=130 pcf. Assumed internal friction angle is 30 degrees, no cohesion.



Note: Figure depicts the elevation and calculated soil, groundwater, seismic soil, and hydrodynamic loads on the pumping plant shaft. KSF= Thousand square-feet.

Figure 6. Alternative 1 Loading



Note: Figure depicts the elevation and calculated soil, groundwater, seismic soil, and hydrodynamic loads on the pumping plant shaft. KSF= Thousand square-feet.

Figure 7. Alternative 2 Loading

9.4.3 Load Combinations

Engineers would use ACI 350-06 and ASCE 7-10 load combinations as applicable:

Table 6. Applied Loads to Shafts

Basic Loads	Cat
Self Weight	DL
Lateral At-rest Earth Pressure	EPL
Construction Horizontal Surcharge (300psf)	LL
Seismic Soil	EQS
Groundwater	GW
Hydrodynamic Groundwater	EQW
Seismic Inertial Forces	EQI

Table 7. Load Combinations

Strength Design Load Combinations														
ACI 350-06 (9-1)	DL	1.4												
ACI 350-06 (9-2)	DL	1.2	LL	1.6	EPL	1.6	GW	1.6						
ACI 350-06 (9-5)	DL	1.2	LL	1.0	EPL	1.6	GW	1.6	EQS	1.4	EQW	1.4	EQI	1.0
ACI 350-06 (9-6)	DL	0.9			EPL	1.6	GW	1.6						

9.4.4 Structural Analysis

All design and analysis, regardless of material or structural element, would utilize the strength design method, or load and resistance factor design method, unless otherwise noted. Engineers would complete the structural calculations by hand or with the aid of STAAD.Pro® finite element analysis software.

9.4.5 Structural Configuration Evaluation

The design team selected a circular shaft design to provide the area required to house the selected pumping unit type at the requisite depth. The design team also determined the circular configuration is the most economical structural shape at the depths required to provide submergence for surge protection for the pumping units.

For Alternative 1, the design team used a wall thickness of 7 feet for modeling and design purposes. Based on results of computer analysis, initial reinforcing steel sizes were #10 @ 8 inches on center for the vertical bars and #6 @ 12 inches on center for the horizontal bars, on each face.

For Alternative 2, the design team used a wall thickness of 5 feet for modeling and design purposes. Preliminary analysis results indicate that #9 @ 8 inches on center for the vertical bars and #6 @ 12 inches on center for the horizontal bars would be required on each face.

Both models utilized a 45-foot-thick foundation slab that required #7 @ 8 inches on center bars on each face in each direction.

ACI 350-06 Equation 9-2, in conjunction with serviceability requirements, controlled wall reinforcing steel design. ACI 350-06 Equation 9-6 and minimum reinforcing steel requirements controlled mat foundation reinforcing steel design.

9.4.6 Foundation and Buoyancy

A 45-foot-thick mat foundation located at the base of the shaft walls would be suitable for the foundation design according to the design team's geotechnical engineer. The high groundwater level present at each alternative site would influence foundation design. As provided by the geotechnical engineer, the groundwater elevation is 212 feet above the bottom of excavation for Alternative 1 and 155 feet for Alternative 2. There is no expected permanent dewatering system required on the exterior of the shaft at either alternative site.

The depth of each shaft relative to the groundwater table present at each site would require the use of rock anchors or tendons to resist buoyant uplift forces. The stiffness of the mat would make the buoyant uplift forces evenly distributed across the bottom of the slab via rigid body action. Based on the required factor of safety of 1.25 (as provided by the geotechnical engineer), rock anchors would need to resist 70 tons of uplift for Alternative 1 and similarly, tendons would need to resist 40 tons of uplift for Alternative 2. The basis for these values is an estimated 5-foot orthogonal spacing for rock anchors and tendons.

9.5 Pumping Units

The plant's total rated capacity is set at 1,000 cfs. Table 8 shows the computed total dynamic head (TDH) at the reservoir drawdown elevations for the two alternatives:

Table 8. Required Total Dynamic Head at Plant Rated Discharge

	TDH at Reservoir Drawdown of 2,110 feet	TDH at Reservoir Drawdown of 2,203 feet
Alternative 1 – East Shore Pumping Plant	147 feet	54 feet
Alternative 2 – South Pumping Plant	107 feet	14 feet

As requested by Reclamation, the design includes an installed spare pumping unit. Thus, one pumping unit could be out of service and the pumping plant would still be able to pump the plant's total rated capacity of 1,000 cfs.

Reclamation envisions the KDRPP would experience relatively infrequent operation. The estimated duration of pumping is approximately six months every five years. Reclamation could schedule operation of the pumping plant several weeks in advance and schedule long-term maintenance activities to occur during nonirrigation months. Pumping units would normally be watered-up and pressurized, and would be dewatered only for maintenance activities. Reclamation expects to exercise pumping units on a regular basis to ensure that all systems are functioning correctly and to identify any deficiencies in advance of a severe drought requiring pumping plant service.

Drawing 1C-102 Hydraulic Profile illustrates the Alternative 1 hydraulic profile. Hydraulically, this alternative requires the pumping units to lift pumped water 143 feet, from El. 2,107 to El. 2,250. Drawings 1I-602 Process & Instrumentation Diagram (P&ID) – Fisheries and Dewatering Pumps, and 1I-603 P&ID – Drought Relief Pumps provide the P&IDs for the Alternative 1 pumping systems.

Drawing 2C-102 Hydraulic Profile illustrates the Alternative 2 hydraulic profile. Hydraulically, this alternative requires the pumping units to lift pumped water 100 feet, from El. 2,107 to El. 2,207. Alternative 2 minimizes the amount of pumping energy required to move water from Kachess Reservoir to the existing discharge pool on the Kachess River. Drawings 2I-602 P&ID – Fisheries and Dewatering Pumps and 2I-603 P&ID – Drought Relief Pumps provide the P&IDs for Alternative 2 pumping systems.

9.6 Ancillary Systems

For all ancillary systems, the following design criteria apply:

- The design, dimensions, and materials of permanent ancillary system equipment would be such that they would not suffer damage under the operating and service conditions specified in the Reclamation standards, guidelines, and relevant codes. They also would not result in deflections, vibrations, or any other condition that might adversely affect the operation of the equipment or result in a shorter design life.
- Equipment design would minimize the risk of fire and consequential damage, prevent ingress of dust and dirt, and preclude accidental contact with electrically energized or moving parts. The design would create an environment with the proper temperature and humidity to maximize the performance, reliability and life of the equipment.
- Anchorage and restraints designs for equipment would withstand operational and seismically induced loads.
- The design of parts subject to hydraulic oil, water, or air pressure would be in accordance with American Society of Mechanical Engineers Pressure Vessel Code Section VIII Division 1 and constructed and tested in accordance with the relevant sections of the American Society of Mechanical Engineers Pressure Vessel Code, unless noted otherwise.

9.7 Pipeline (Alternative 1)

Table 9 lists key design criteria for the pipeline associated with Alternative 1 only. HDR engineers used the following criteria as the basis for determining pipe size, evaluating pipe material options, and establishing construction and operations requirements. The velocity criteria are per Reclamation Design Standards (Reclamation, 1994; Reclamation, 2007). Based on the design flow rate and maximum velocity criteria, the required pipeline inside diameter is 136 inches.

Table 9. Design Criteria

Variable	Criteria
Design Flow Rate	1000 ft3/s
Maximum Velocity Criteria	10 ft/s
Working Pressure	100 psi (approximate)
Design Life	100 years
Pipeline Inside Diameter	136 inches

9.8 Access Roads

Table 10 summarizes the anticipated design criteria for the Alternative 1 and Alternative 2 access roads. Section 12.1.7, Access Roads, of the *Civil and Site Elements* technical memorandum (Reclamation and Ecology, 2014c) provide further information on access road design.

Table 10. Design Criteria for Access Roads

Access Road	Road Width (ft)	Shoulder Width (ft)	Road Maximum Slope (%)	Turnaround Minimum Radius (ft)	Minimum Centerline Radius (ft)	Entering Sight Distance (ft)	Access Spacing (ft)
Pumping Plant Building Access Road	26a	2	9b	50c	60	150d	250e
Fish Facilities Haul Road	16f	0	15f	NAf	NAf	NA	NA
Stormwater Access Road	12 in straight sections, 15 on curvesg	0	20g	NAg	40g	NA	NA

a. The county and International Fire Code require a wider road than the American Association of State Highway and Transportation Officials (AASHTO) manual (AASHTO 2011 manual, under Table 5-5). In this instance, the design team assumes that Reclamation would consent to compliance with the county and International Fire Code standards (International Code Council (ICC) 2012, under Section D103.4).

b. The PDDM recommends areas with winter snow-pack conditions or gravel roadways have a maximum grade of 9 percent with a 4 percent cross-slope (FLH, 2014, under Section 9.3.6.2 and 9.3.8.4). This is less steep than the county and International Fire Code (ICC 2012, under Section D103.4).

c. Reference ICC 2012, under Section D103.2; and WSDOT 2010, under Exhibit 1310-13c for wheelbase (WB)-67 vehicle.

d. The county road standard requires a longer entering sight distance than the AASHTO manual (AASHTO 2011 manual, under Table 9-3). In this instance, the team assumes that Reclamation would consent to compliance with the county standards (KC, 2012a, under Table 5-1).

e. The AASHTO manual does not contain specific distances for access spacing. In this instance, the team assumes that Reclamation would consent to compliance with the county standards (KC, 2012a, under Table 5-2).

f. The AASHTO manual does not contain specific widths or slopes for this type of roadway. In this instance, the team assumes that Reclamation would consent to compliance with the county standards (KC, 2012a, under driveway criteria in Table 4-4).

g. The AASHTO manual does not contain specific widths, slopes, or turning radii for this type of roadway. In this instance, the team assumes that Reclamation would consent to compliance with the county standards which adopted the Ecology Stormwater Management Manual for Eastern Washington (Ecology, 2004, under Section 6.2.1)

9.9 Substation and Electrical Systems

- Subsequent to the feasibility-level design activity documented in this report, Reclamation and Ecology contracted with HDR to perform an appraisal design study of a floating pumping plant alternative for KDRPP. This process enabled more extensive communication with Bonneville Power Administration (BPA) and Puget Sound Energy (PSE) regarding the potential configuration of a power supply for KDRPP. This subsection includes information available as of December 2017 on configuration of facilities to deliver power to the pump station site.There is an available 115-kilovolt (kV) power source from Puget Sound Energy's (PSE) existing Intermountain transmission line.
- Reclamation would need to locate a new power substation with step-down transformers between the Intermountain transmission line and the new pumping plant.
- Reclamation would not require a backup power supply for the primary pumping units, as Reclamation would discontinue drought relief pumping for the relatively short duration of time (a few minutes to a day or two maximum) that primary power might be lost.
- A standby power generator set GEN-01 (3000 kilowatts) for the two 4.16 kV 100-cfs fish flow pumps and for essential station service loads as fed from the Essential Motor Control Center (MCC-01) would be required.
- Reclamation would require a standby power generator set GEN-02 (500 kilowatts) to provide a second back up for Essential MCC-01 in the event that GEN-01 is down for maintenance or there are other problems with GEN-01. Reclamation would permit only GEN-01 or GEN-02 to run at one time.
- Reclamation would require power to non-essential loads from the non-essential Motor Control Center (MCC-02). In the event of a power outage, Reclamation would not supply backup power to nonessential loads.
- Water-cooled variable frequency drives (VFDs) would start the drought relief pumps. One of the four drought relief pumps is a spare.
- Synchronous motors for the drought relief pumps would avoid the need for power factor correction.
- High efficient, high efficacy light-emitting diode (LED) interior and exterior lighting would be needed.
- Interconnection of the ground grid at the substation to the ground mat for the pump station would be required.

9.10 Fish Passage

There currently are no fish passage facilities at Kachess Dam. As part of Reclamation's Storage Dam Fish Passage Study and the Integrated Plan fish passage element, Reclamation has reviewed fish passage at Kachess Dam at a conceptual level. In order to assess whether the location of proposed KDRPP facilities would be compatible with adult and juvenile fish passage facilities, HDR provided a preliminary layout of fish passage facilities at Kachess Dams as a component of the KDRPP feasibility-level study (Appendix C).

For Kachess Dam, future upstream fish passage facilities would include an adult trap-and-haul facility with a fish ladder to attract fish to its entrance. The ladder would allow fish to ascend to holding and collection pools for sorting and staging for transfer. Future downstream fish passage concepts include a fish collection barge and new outlet works in a helix configuration.

The *Keechelus and Kachess Dams Fish Passage Concepts Review* technical memorandum provides further detail on the adult (upstream) and juvenile (downstream) fish passage criteria and alternatives (Reclamation and Ecology, 2014n).

Reclamation 2017 presents information on proposed fish passage improvements in the area known as “The Narrows” between Big Kachess Lakeand Little Kachess Lake. The fish passage improvements at that location would be used during periods when the Kachess Reservoir pool level is drawn down due to drought relief operations.

10.0 Operating Criteria

The *Hydrologic Modeling of System Improvements, Phase 1 Report* analyzed alternative flow capacities for KDRPP using the Riverware® modeling software; this analysis established 1,000 cfs as the optimal capacity for the KDRPP based on hydrologic modeling of minimum year prorationing and total irrigation deliveries (Reclamation and Ecology, 2014a).

The KDRPP would contribute to the Integrated Plan goal to raise prorationing to 70 percent of full supply during drought years. Reclamation would not access the additional water made available by the KDRPP unless prorationing would cause proratable water supplies to be reduced to less than 70 percent of entitlements. If Reclamation determined that it was likely that prorationing requirements in a drought year would cause proratable water supplies to be less than 70 percent of full supply, then Reclamation would operate KDRPP to increase the water supply (up to 70 percent) for proratable water users. (HDR, 2014).

During early spring through late August, Reclamation meets Yakima River mainstem demands primarily through storage releases from the upper Yakima River reservoirs, Keechelus and Cle Elum Reservoirs. Reclamation uses an operational protocol referred to as “flip-flop” operations. Flip-flop is the annual late-summer (late August and early September) river operation that shifts reservoir releases from the Cle Elum Reservoir to Rimrock Reservoir to meet the September and October irrigation demands downstream from the confluence of the Naches and Yakima Rivers. Reclamation implemented flip-flop operations to mitigate the impacts to spawning fish in the upper Yakima River (Reclamation and Ecology, 2014a).

Reclamation performs a similar operation, referred to as “mini flip-flop”, between Keechelus and Kachess Reservoirs. Reclamation’s releases for irrigation supply from Keechelus Reservoir are substantially greater than from Kachess Reservoir during the June to mid-August period. Beginning in late August, Reclamation gradually switches the flow levels between the two reservoirs. By September and October, reservoir releases from Keechelus Reservoir are reduced to 100 cfs (or 80 cfs in dry years), and flows from Kachess Reservoir are raised to 1,000 to 1,400 cfs. Mini flip-flop operations help to protect spawning redds in the uppermost reach of the Yakima River, the Keechelus Reach, from winter dewatering. Consequently, during September and October releases from Kachess Reservoir are substantially higher. With the implementation of KDRPP, Reclamation would revise reservoir-balancing operations during critical drought years by utilizing Kachess Reservoir storage sooner in the irrigation season and more predominantly all season for irrigation supply.

Reclamation would operate the KDRPP during a severe drought period and, if needed, in refill years to meet stream flow and water supply requirements. Reclamation would draw down Kachess Reservoir by as much as 80 feet below existing low pool conditions and take 2 to 5 years following a drought to refill. The duration of the refill period would depend on the Kachess Reservoir pool elevation at the end of the irrigation season and the subsequent natural water supply in the seasons and years following the drought.

If the separate but related KKC is constructed, that project would move water from Keechelus Reservoir to Kachess Reservoir, accelerating the refill of Kachess Reservoir in years following pumping by KDRPP.

Outside of the irrigation season, at times when the Kachess Reservoir pool level is below the gravity outlet, Reclamation would operate the fish flow pumps to meet the minimum instream flow requirement in the Kachess Reach, which is the one-mile long reach of the Kachess River from immediately below Kachess Dam to the Yakima River and Lake Easton.

11.0 Reclamation Design Standards

The design team referenced the following Reclamation design standards during the feasibility design:

- Reclamation General Guidelines for Preparation of Feasibility Design Reports (Reclamation, 2008)
- Reclamation Design Standards No 3, Water Conveyance Systems
  - Chapter 4, Tunnels, Shafts, and Caverns
  - Chapter 11, General Hydraulic Considerations
  - Chapter 12, General Structural Considerations
- Reclamation Design Standards No 4, Electrical Apparatus and Systems:
  - Chapter 1, General Considerations for Power, Pumping, and Pumped-Storage Plants
  - Chapter 2, Electrical Rotating Machinery
  - Chapter 3, Associated Electrical Equipment
  - Chapter 9, Grounding Methods

- Reclamation Design Standards No 9, Buildings, Chapter 13:
  - Paragraph 135, General Design Requirements for New Structures
  - Paragraph 137, Seismic Design of Nonstructural Building Components
  - Paragraph 13515, Design Considerations for Plant Electrical Equipment
- Reclamation Design of Small Dams
- Reclamation Engineering Monograph No. 25, Hydraulic Design of Stilling Basins and Energy Dissipators
- Feasibility-Level Guidelines, Section 6.0, Pipelines
- Reclamation Engineering Monograph No 40, Selecting Large Pumping Units
- Design Standards No. 9, Buildings
- Design Standards No. 10, Transmission Structures

Reclamation is in the process of updating certain other Reclamation design standards and, therefore, these were not available for the design team to use. Rather, the design team followed applicable industry standards, as was recommended by Reclamation staff.

- Design Standards No. 6, Turbine and Pumps
- Design Standards No. 7, Valves, Gates and Steel Conduits
- Design Standards No. 8, Miscellaneous Mechanical Equipment

Note that the design team followed additional industry standards while developing the feasibility design of the KDRPP. The individual feasibility-level study technical memoranda references these standards (Reclamation and Ecology, 2014b-l; 2015a).

12.0 Description of Proposed Facilities

This section provides a description of the following proposed KDRPP project features:

- Alternative 1:
  - Intake and fish screens
  - Intake tunnel
  - Pumping plant (shaft, pumping units, and ancillary systems)
  - Surge tank
  - Pipeline
  - Outlet works and spillway
  - Access roads

- Interconnection to power source, substations and transmission Line

- Alternative 2:
  - Intake and fish screens
  - Intake tunnel
  - Pumping plant (shaft, pumping units, and ancillary systems)
  - Surge tank
  - Outlet works and release structure
  - Access roads
  - Interconnection to power source, substations and transmission Line

(Note that when an Alternative 2 facility is similar to a facility already described for Alternative 1, the reader is referred to the prior text description, rather than repeating the text.)

12.1 Alternative 1- East Shore Pumping Plant

12.1.1 Intake and Fish Screens

The top of the fish screens and intake would be located at El. 2,100, corresponding to the maximum KDRPP drawdown (El. 2,110). The design team selected the configuration of the intake to minimize installation requirements for the fish screen assembly. The fish screen design consists of six large tee screens, illustrated in Drawing 1C-203 – Headworks Fish Screens Plan and Sections. Each tee screen would be 7 feet in diameter and have two 10.5-foot-long screen cylinders. The vertical intake pipe would have a 15-foot outside diameter. A fabricated 15-foot-diameter intake manifold fitted with three 7-foot-diameter fittings would connect the six tee screens to the vertical intake pipe. Two tee screens would be flanged to one of the large fabricated fittings. This configuration would allow Reclamation to maintain a flow approach velocity below 0.4 feet per second when operating the pumps and remove or install each tee screen on as-needed basis.

12.1.2 Intake Tunnel

The intake tunnel would be an approximately 711-foot-long, 15-foot-diameter, horseshoe-shaped tunnel. Construction workers would mine the tunnel in Swauk Formation rock from the pumping plant shaft to the vertical intake shaft located at the base of the vertical intake pipe. The invert of the intake tunnel would slope gently downhill from the intake end to the pumping plant shaft end. The inside of the tunnel would be lined with steel from the steel-lined intake pipe to the location where steel lining was no longer required, assumed at this time, to be a 100-foot-long distance. The design of the tunnel final lining would provide a durable and smooth interior surface that minimizes hydraulic head losses, controls leakage from the tunnel, maintains a high level of serviceability, and minimizes maintenance during its design life. In addition, the team would design the final lining to withstand the internal water pressures, ground loads, external water pressures, and seismic strains due to earthquake ground motions.

The tunnel would then transition to a liner, consisting of reinforced and unreinforced concrete as indicated on Drawing 1C-204, Headworks-Tunnel-Sections and Details.

12.1.3 Pumping Plant

Pumping Plant Shaft

The pumping plant shaft would be a 215-foot-deep, 110-foot-diameter shaft constructed on the east shore of the reservoir and would house the pumping units. At the bottom of the 110-foot-diameter shaft, a 52-foot-deep, 25-foot-diameter inlet shaft would connect the pumping plant shaft to the intake tunnel. The pumping plant shaft would not only house the pumping plant, but would also provide access to and serve as the portal for intake tunnel construction.

As indicated on Drawing 1C-204 Headworks – Tunnel Sections and Details, the pumping plant shaft would be constructed through glacial overburden soils down to bedrock and then continue down into bedrock to the required depth of the wet well into which the pumping units would be located. The 110-foot-diameter shaft with permanent liner would rest on and connect to the underlying bedrock with rock anchors drilled into and secured to the underlying bedrock. The rock anchors would withstand net buoyant uplift forces once construction was completed and the temporary interior pumping plant dewatering wells were deactivated. Section 16.3.1, Permanent Project Feature Construction, describes the construction methods employed to construct the pumping plant shaft.

An abovegrade building enclosure would include a rectangular structure, with external dimensions of approximately 150 feet by 220 feet and a height of approximately 65 feet. The design would not structurally integrate the shaft and building enclosures and they would function independently from one another because of differential settlement considerations. Half of the building would overlay the 110-foot-diameter intake shaft. The other half of the building would include various pump control, administrative, and building specific rooms.

Pumping Units

The design team recommends four close-coupled vertical shaft turbine-pumping units for Alternative 1. Each pumping unit has a 333 cfs capacity. With four units installed, one unit would serve as a standby unit in the event a unit is unable to operate. The four-unit symmetrical pumping plant arrangement is recommended to provide a good balance among equipment supply cost, civil works layout, and achievable discharge capacities for either vertical turbine or vertical volute pumping units. Drawing 1C-206 Headworks – Pumping Plant – Plan B at El. 2,130 illustrates the four-unit, close-coupled, vertical shaft turbine units pumping plant layout. The four-unit pumping plant provides a more operationally flexible plant that is able to deliver flows from about 200 cfs to 1,000 cfs on a continuous basis. As indicated on Drawing 1C-206, the four units for Alternative 1 discharge into a common manifold. The *Pumping Unit Analysis Technical Memorandum* describes the KDRPP pumping units in detail (Reclamation and Ecology, 2014l).

Ancillary Systems

The *Ancillary Systems Analysis* Technical Memorandum describes the KDRPP ancillary systems in detail (Reclamation and Ecology, 2014b). Ancillary systems identified for the KDRPP include the following:

- Steel piping: The design team selected steel since it has good weldability, and is resistant to brittle facture. To ensure proper quality, Reclamation would hydrostatically test the piping to 1.5 times the design pressure or use other nondestructive methods to test the pipeline.
- Bonneted isolation gates for intake: The design team selected bonneted isolation gates to permit dewatering of the pumping unit wet wells for both alternatives. The gates serve as the single isolation device located between the reservoir and the pumping units.
- Check valves: The design uses "quick acting" pump check valves to prevent extended reverse flow from occurring after a power outage. The check valves assist in surge control by using a controlled closure time.
- Butterfly isolation valves for discharge: The isolation valves permit maintenance on the pumps and check valves. HDR recommends that Reclamation consider high quality, triple offset, butterfly valves for this application.
- Flowmeter: Reclamation typically requires a flowmeter on each plant discharge line. The design incorporates a single multi-path ultrasonic flowmeter on the vertical discharge pipe for Alternative 1, and four multi-path ultrasonic flowmeters (in each vertical discharge pipeline) for Alternative 2. The flowmeters connect to the plant's control system and measure the flow of water. The plant control system would adjust the pump speed to achieve the required discharge.
- Bridge crane and miscellaneous hoists and cranes: Reclamation would require an overhead travelling bridge crane for use during initial construction and ongoing project maintenance activities. The estimated required crane capacity is approximately 50 tons. Electricity would power the hoist, trolley, and bridge, and radio controls would execute operations. Workers would be able to operate the crane from the operating deck and from the pump floor.
- Elevator: Due to the depth of the pumping plant, an elevator would service the floors in the shaft. The elevator would stop at the pump floor, flowmeter access level, and operating level. It would not service the electrical floor level. Total travel distance is 170 feet for Alternative 1 and 115 feet for Alternative 2.
- Fish flow pumping system: A fish flow pumping system would continue to supply water to the Kachess River when the reservoir level is below the gravity outlet works channel and the pumping units are not in operation. The design uses vertical turbine pumps connected to the inlet tunnel, similar in design and construction to the main drought relief pumps. The design would provide for two pumps and each pump would be capable of providing the minimum required fish flow of 20 cfs. In addition to meeting the minimum flow requirements for the Kachess River, the team designed the intakes, hydraulic passages, and piping of this system to be able to accommodate an anticipated future

upstream fish passage flow requirements of 100 cfs. If and when required, the three 50-cfs pump units could replace the two 20-cfs pump units. The team designed the intakes to the fish flow pumps to the standards of the Hydraulic Institute (2012). Variable frequency drives would power the pump motors. The fish flow pumping system would operate after the main drought relief pumping units stop and until the Kachess Reservoir sufficiently refills to allow for water supply through the gravity outlet works for the existing dam.

- Gravity drainage system: The gravity drainage system consists of floor drains on the operating floor level, the small oil-water separator on the operating floor level, the drainage connection to the pump floor level, the floor drains around the perimeter of the pump floor level, the oil-water separator on the pump floor level, and the drainage pumping system. The drainage pumping system lifts the water collected by gravity from the pump floor level to the Kachess Reservoir in Alternative 1 or to the Kachess River in Alternative 2.
- Unwatering system: The design provides an unwatering system to unwater and refill the total volume of water contained in the wet well downstream of the bonneted isolation gates, vertical discharge piping, and pipeline. The system consists of unwatering pumps, associated drains in the wet well, piping, and controls.
- Fire suppression system: The fire suppression system would consist of the following elements: a wet pipe sprinkler system, clean agent suppression systems, wall-mounted dry chemical fire extinguishers, and a wheeled dry chemical fire extinguisher.
- Compressed Air System: The design would include a compressed air system for the pump floor and operating floor levels. Pumping plant personnel would use the system for operation of pneumatic tools during maintenance activities. The system would consist of the vertical receiver tank, a minimum of two rotary screw air compressors, an air dryer, and stainless steel distribution piping.
- Cooling Water: A cooling water system would supply cooling water to the following systems if required by design: drought relief motor air and water coolers; drought relief pump, motor guide, and thrust bearing coolers; variable frequency drive air and water coolers; pump shaft seals; heating, ventilating, and air conditioning (HVAC) system usage; and air compressor cooler. Two separate strained inlets taking water from the inlet tunnel or the wet wells would provide uninterrupted supply of water for the cooling system.
- Nonpotable Service Water System: The design would provide a nonpotable service water system for plant maintenance activities. The system would supply service water to the following plant elements: backup water supply to pump shaft seals, backflush water to self-cleaning strainers, and service water outlets.

- Domestic Water and Sanitary Waste System:
  - There is no existing source of potable water at the headworks location. Workers would install a new well at the site to supply potable water for the bathroom and washdown water for the pumping plant building. A preliminary estimate of the well capacity is 10 gpm, based on a peak 7 minute water usage for a toilet, sink, and washdown hose connection (WSDOH, 2009).
  - There are no sewer facilities at the headworks location. The design team selected a septic holding tank as the most cost effective option for collection of bathroom and washdown water discharge from the pumping plant building. A pumper truck would pump sewage from the holding tank and deliver it to a location for proper treatment and discharge. A preliminary estimate for the liquid volume capacity of a septic holding tank is 1,500 gallons.
- <u>Heating, Ventilating, and Air Conditioning System:</u> The HVAC system for the KDRPP would provide both equipment protection (for the operating deck, service bay, electrical room, pump floor area, office and control room) and occupancy requirements (office and control room). The pumping plant would be infrequently used by service or maintenance personnel and qualifies for an exemption from classification as an Underground Building per International Building Code. Based on this exception, the design team did not incorporate requirements such as a smoke control system and fire compartmentalization in the design.

12.1.4 Surge Tank

The large pumping units can experience significant dangerous or damaging pressure transients with the loss of power to the motors that drive the pumps. Adverse pressure transients can also occur during normal unit start-up and shut-down. To address this aspect of design, HDR engaged Northwest Hydraulic Consultants (NHC) to assist in developing surge protection features. Appendix F of the *Kachess Drought Relief Pumping Plant Project – Hydraulics Analysis* technical memorandum (Reclamation and Ecology, 2014g) contains NHC's transient analysis.

A surge tank would be required to control surge caused by sudden changes in pressure in the pipeline on loss of power to the pumping plant when the drought relief pumping units are operating. The surge tank for Alternative 1 would be a 110-foot interior diameter, approximately 43-foot- deep uncovered concrete tank. The surge tank would be located close to the pumping plant, as illustrated in Drawing 1C-202, Headworks Profile. A 120-inch pipe would connect the pipeline to the surge tank.

12.1.5 Pipeline

This subsection summarizes the design features of the Alternative 1 pipeline. Note that the pipeline is unique to the Alternative 1 design. The *Kachess Drought Relief Pumping Plant Project–East Shore Pumping Plant- Pipeline Analysis* technical memorandum provides further details on the Alternative 1 pipeline (Reclamation and Ecology, 2014d).

The proposed pipeline alignment is located across the floor of Kachess Reservoir and follows the eastern and southern banks of the reservoir on relatively level ground. Drawing 1C-301, Pipeline Plan, illustrates the horizontal alignment of the pipeline. The alignment becomes inundated when the water surface elevation of the reservoir exceeds approximately 2,240 feet. The water surface elevation at normal, full pool is 2,262 feet. However, the maximum water surface elevation at which the pumping plant starts operation is 2,203 feet. The length of the discharge pipeline is approximately 7,755 feet, measured from its origin at the pumping plant shaft at the north end, to the downstream end of the pipeline located near the crest of the discharge spillway at the south end.

The proposed discharge pipeline alignment has a constant upward slope of approximately 0.001 feet/feet moving in the downstream direction, as represented in Drawing 1C-102, Hydraulic Profile. The pipeline leaves the pumping plant shaft at invert El. 2,212 and discharges into the discharge spillway outlet works at invert El. 2,220. HDR designed the vertical alignment with the following objectives in mind:

- The crest of the outlet works structure is set at El. 2,231 at the downstream end to ensure full submergence of the pipe when the reservoir water level is higher than 2,231 feet. The pipeline vertical alignment is lower than El. 2,231 and, with the expected 12.5 feet of headloss (see Appendix B of the *Kachess Drought Relief Pumping Plant Project–East Shore Pumping Plant- Pipeline Analysis* technical memorandum for details), the pipeline would remain fully submerged when the water level in the reservoir is higher than approximately El. 2,244 feet. This is true even when the pumps are not operating, and thus it maintains the integrity of the lining of the pipeline in a fully wetted condition at all times unless Reclamation dewaters the pipeline for inspection or maintenance reasons.
- Lowering the vertical alignment from the shoreline allows the pumping system to overcome lower static head, which results in a lower operating energy cost.
- The upward uniform slope minimizes the need for air and drainage valves.
- When operators lower the water level in the reservoir, the upward slope allows water to drain back into the pumping plant if and when the pipeline is dewatered.

Table 11 provides a design summary for the pipeline.

Table 11. Pipe Design Summary- Welded Steel Pipe

Parameters	Values
Design Flow Rate	1000 ft3/s
Design Maximum Velocity	100 ft/s
Internal Pressure Requirements	100 psi (approximate)
Pipeline Inside Diameter	136 inches
Actual Velocity at 1000 cfs	9.91 ft/s
Pipe Material	Steel, 36,000 psi minimum yield strength
Pipe Lining (conform to AWWA C222)	Polyurethane lined , 20 mil
Pipe Coating (conform to AWWA C222)	Polyurethane coated, 40 mil
Pipe Joint	Double-fillet welded lap joint
Minimum Pipeline Wall Thickness *	0.6 inches
Pipeline Length	7,755 feet

* Refer to Appendix C of the *Kachess Drought Relief Pumping Plant Project–East Shore Pumping Plant-Pipeline Analysis* technical memorandum (Reclamation and Ecology, 2014d) for calculation of pipe size and minimum wall thickness. The governing load case for wall thickness is shipping and handling requirements for shallow depth of cover. Pipe sections that have deep soil cover would require a thicker pipe wall. Section 6.3.4 of the *Kachess Drought Relief Pumping Plant Project–East Shore Pumping Plant- Pipeline Analysis* technical memorandum discusses pipe wall thickness for deeper excavation (Reclamation and Ecology, 2014d).

AWWA = American Water Works Association

12.1.6 Outlet Works and Spillway

The pipeline would discharge flow to the upper end of a concrete spillway having an uncontrolled crest. The design team would select the type of crest in final design (e.g., traditional ogee crest, mitered ogee crest, broad crested weir). The spillway crest would be slightly higher than the top of the pipe to keep the interior of the pipeline filled at all times. This would ensure that the pipeline lining remains wet, to prolong its life span.

As illustrated in Drawing 1C-402, Outlet Works Profile, a concrete rectangular chute spillway would convey water down a steep hillside. The chute would have a 2H-to-1V longitudinal slope and a 25-foot width and keep spillway velocities below 60 ft/sec.

Discharge water would enter a concrete stilling basin located at the bottom of the chute spillway to dissipate energy in a controlled manner. The stilling basin would also have a 25-foot width. The system would convey a flow rate of 1,000 cfs, which equates to 40 cfs per foot of basin width. The design team used this rate in conjunction with the entering velocity from the chute to select the type of stilling basin best suited to accommodate these conditions. Based on Reclamation guidance, a Reclamation Type III rectangular stilling basin with chute blocks, impact baffle blocks, and end sill was selected (Reclamation, 1984, under Recommendations in Chapter 3).

Release Structure

The existing discharge pool currently receives flow from the outlet works of the dam at rates of up to about 2,000 cfs. A stage discharge rating curve (in development at the time this report was written) would aid in establishing the final design elevations and dimensions of the release structure. The release structure would be a concrete-lined rectangular channel and would convey discharge from the stilling basin to the existing discharge pool. The design team would use tailwater from this pool to provide the full conjugate depth for the new stilling basin.

To minimize fish attraction, designers would slow discharge from the pumping plant to a velocity of approximately 2 to 3 ft/sec where the release structure ends at the edge of the existing discharge pool by increasing the width of the concrete-lined rectangular channel to about 100 feet.

To avoid crosswaves and excessive turbulence, designers would use a gradual transition rate as the concrete-lined rectangular channel expands to the 100-foot width. This rate would conform to Reclamation guidelines (Reclamation, 1987, under equation 21 in Chapter 9). During normal operating conditions, ponding water from the existing discharge pool would back up through the concrete-lined rectangular channel, which may negate the need for a gradual transition rate. However, the team designed this pumping plant to supply water during drought conditions. During these conditions, water in the existing discharge pool likely would decrease and may not back up into the concrete-lined rectangular channel when operators first activate the pumps.

An upstream fish passage trap and haul facility may be constructed on the opposite side of the existing discharge pool sometime in the future. A future trap and haul facility would likely be located on the opposite side of the discharge pool from where the concrete-lined rectangular channel would enter. Integral to the release structure design is a physical fish barrier made of galvanized welded steel. The barrier would preclude adult fish from entering into the release structure.

12.1.7 Access Roads

Kachess Dam Road, also known as USFS Road NF-4818 and FS 4818-000RD, would provide vehicular access to the KDRPP. The classification for this road is a USFS major collector on the Kittitas County Road Atlas (KC, 2012b). It is unknown if an Inter-Governmental Agreement would be necessary with the USFS and other agencies for issuance of access and utility permits. Reclamation would need to evaluate this further as the design advances beyond the feasibility level.

Workers would install a gate on any access road off of Kachess Dam Road to prevent unauthorized vehicular access to the KDRPP. Reclamation would approve all gates on permanent access roads prior to installation to ensure compliance with Reclamation security standards. Once construction of the proposed facility is complete, use of the existing access road would be less frequent.

Access Road to the East Shore Pumping Plant

Drawing 1C-201, Headworks – Site Plan, illustrates the access road for the pumping plant facility. This access road extends from Kachess Dam Road to the 26-foot-wide double swing gates.

The pumping plant building would include a fire suppression system. Therefore, access roads to the pumping plant would adhere with fire apparatus access requirements (KCC Title 20; ICC 2012, under Appendix D).

Kachess Dam Road is gravel at the facility access location, and the design team recommends gravel surfacing also for this interior access road. Semi-trucks would need access to the pumping plant building to supply construction material and possibly replace equipment during maintenance or repair operations. The team would design this surfacing to support a vehicle weight of at least 75,000 pounds (ICC 2012, under Section D102.1). Greater weights may be necessary to accommodate transport of large equipment, such as pumps and cranes. Reclamation would evaluate this further as the design advances beyond the feasibility level.

The road design would also accommodate a WB-67 vehicle. The design team selected this vehicle as it is the largest legal vehicle in many states (FLH, 2014, under Section 9.3.1.9.2). Due to the limited use of this access road, the design of the horizontal curves would allow a semi-truck to navigate corners by using the entire width of the road where necessary. For gravel roadways or in areas with winter snow-pack conditions, the roadway slope would be a 9 percent maximum grade with a 4 percent cross-slope (FLH, 2014, under Section 9.3.6.2 and 9.3.8.4).

Pavement along Kachess Dam Road currently terminates approximately 300 feet north of West Sparks Road. This is also the current limit of the maintained roadway system. To provide perspective on the roadway conditions, on April 7, 2014 beyond this point the road was passible only by snow mobile or a 4-wheel-drive vehicle.

Access to the pumping plant building would need to remain clear of snow accumulations to accommodate fire vehicle access (KCC Title 20, under Title 20.02.040). Plowing a gravel road is more difficult than plowing a paved surface, but this is a common process in rural areas. For long term access during winter months, Reclamation could use a rotary snow thrower mounted on an acceptable service truck with a vehicle weight of at least 28,000 pounds. Reclamation would need to investigate maintenance responsibilities as the project advances beyond the feasibility level.

The design includes a large gravel yard approximately 0.75 acres in size within the 7-foot-high chain link perimeter fence, located between the pumping plant building and the proposed substation. Similar to the access road, the design of the gravel yard would accommodate a WB-67 vehicle. The size of the gravel yard would accommodate the turning movements of large trucks, as well as the anticipated parking activities.

Access Road to other Project Features

Drawings 1C-401, Outlet Works – Site Plan and 1C-405, Outlet Works – Access Road Profile/Sections, indicates the layout and profile for roads that provide access to the outlet works features. An existing gravel side road located off Kachess Dam Road would supply access to this area. Fire apparatus access requirements do not apply, as these roads do not supply access to a building with fire suppression systems.

The large semi-trucks discussed in Section 12.1.7, Access Road to the East Shore Pumping Plant, would not be using this roadway; therefore, the design of these auxiliary roads would accommodate SU-30 vehicles and have a graveled surface. An exception to this may include paving the steeper roads that supply access to the fish trap and haul facility. Reclamation would evaluate this further as the design advances beyond the feasibility level.

12.1.8 Interconnection to Power Source, Substations and Transmission Lines

The substation for Alternative 1, the East Shore Pumping Plant, would be located approximately 150 feet to the east of the pumping plant building. The substation for both alternatives would have approximate dimensions of 125 feet by 150 feet. Orientation of transformers, switches, disconnects, and overhead lines vary slightly for the two alternatives, but both alternatives include identical infrastructure within the substation footprint.

The power source for Alternative 1 has changed from the original design reported in 2015. As of December 2017 Reclamation and Ecology anticipate that the power source would be the same as developed in the Appraisal Level Design Report for the Floating Pumping Plant Alternative (2017, Draft). The remainder of this section presents information on the updated power source. (However, note that Drawing 1C-501 Alternative 1 Site Plan has not been updated and shows the old, 2015 power source.) Further consideration may be needed to fully integrate the new power supply configuration with Alternative 1 site and equipment requirements.

Interconnection to Existing Transmission Line

Reclamation or Roza would obtain a power supply to the pumping plant by interconnecting to PSE's existing Intermountain transmission line. The proposed point of interconnection is located on the south side of the Yakima River at the outlet of Lake Easton. The transmission line in this area is currently operated at 115 kV. PSE has been upgrading segments of the line to be able to operate at 230 kV. The transmission tap required for this substation would be constructed to 230kV standards and clearances to allow for operation at either voltage.

The transmission line would require a new, guyed single-pole 3-way tap structure less than 100 feet in height, in the Intermountain transmission line. The line would then span the Yakima River and Lake Easton just upstream of the Kittitas Reclamation District diversion dam. The line would run to a second guyed single-pole structure less than 100 feet in height located on the north side of the Yakima River and Lake Easton. The line would feed the substation on the north side of the dam. There would be one single-circuit, radial transmission line providing power to the substation.

Also within PSE's transmission line, two line disconnect switches would be required to isolate the tap from the transmission system. The line switches would be installed on existing PSE transmission structures adjacent to the new tap structure.

The transmission line would require a centerline easement 100 feet wide, with 50 feet on either side of the centerline. The alignment would be approximately 800–feet-long, from the existing PSE transmission line to the new substation. The transmission line would also require a guying easement of 80 feet x 10 feet, to the southwest of the PSE transmission line from the tap structure. PSE standards would be used for conductor sizing and structure requirements.

Lake Easton Substation

The Lake Easton Substation is anticipated to be constructed on the north side of Lake Easton dam. The substation would be a single bus design with the sole purpose to feed the pumping plant. The substation would require an approximate 115 feet x 110 feet plot of land. The substation transformer would be installed for dual high side voltage of 115 and 230 kV. The substation would be built to PSE standards and house the required equipment, including:

- Isolation switches with Motor Operated Disconnects on the transmission line. These switches would likely be installed on the first structure outside of the substation.
- A 115/230 kV power transformer.
- An air break disconnect switch.
- A circuit switcher (without integrated switch).
- An open-air 34.5 kV feeder structure/tree feeder breakers.
- A mobile substation hookup.
- Drive access within the station.
- Station service transformers.
- A control house.
- SCADA equipment.
- Associated protection equipment.
- Snow melting equipment to critical substation components.

The substation site is currently designed with no redundant 115/230 kV source feed or redundant transformer because this would increase the cost. The reliability of similar installations is very good without increased redundancy. In the case of the Kachess reservoir, maintenance can be performed on the substation during the times when the irrigation pumps are not operating. If additional redundancy is deemed necessary, Reclamation and Roza would consider additional costs and modifications during final design. The substation layout would have room for PSE to bring in a mobile substation, if it is ever needed.

Cable Loading Analysis

The estimated total loading for the pumping plant is 16 Megavolt Amperes (MVA) (Note, this value was developed for the floating pumping plant alternative; and may need revision for Alternative 1). An additional 4 MVA load is planned to accommodate potential growth and allow for system losses. The construction contractor would install two conduits from the Lake Easton Substation to the Kachess Reservoir Substation, and each would be loaded with approximately half the required capacity. In the event that one of the circuits is damaged or taken out of service, the entire load can be served by the remaining single circuit. With a total of 20 MVA, at 34.5 kV, a single, three-phase feeder must be able to adequately carry 335 amps under a contingency if one feeder needs to be taken out of service for maintenance. Heat trapped within conduit and cable often requires the cable ampacity to be de-rated from the manufacturer's published specifications. HDR conducted a thermal de-rating analysis on this installation to determine proper cable selection.

The 34.5 kV feeders are designed with two feeders for multiple reasons. First, it was determined early in this investigation that there would be two conduits installed along the route; therefore, it made sense to install energized cable in each conduit run. A redundant circuit allows both feeders to operate partially loaded, which extends the cable life. It is recommended to utilize both circuits for normal operation. In the event of a fault, cable dig in, or need to take equipment out of service at the pad yard, the entire load can be easily transferred and fed through a single transformer or vacuum fault interrupter (VFI) and still serve the entire pump station load.

Cable Routing and Construction

Two buried conduits, each having a 34.5 kV transmission cable installed in it, would run from the Lake Easton Substation to the Kachess Reservoir Substation a total distance of approximately 16,655 feet (3.15 miles). [*8,750 feet to the Kachess Dam site; plus 7,755 feet to the East Shore Pumping Plant site; plus 150 feet to the substation.]* Further refinement of this distance may be required to match the local road network. The conduits would cross beneath Interstate 90 by means of twin horizontal directional drilling (HDD) borings. The conductor cables would be placed in approximate 16-inch diameter high density polyethylene (HDPE) conduits (oversized to ease the cable pulling loads over these longer distances). The construction contractor would place the buried conduits in a shallow trench constructed to PSE specifications. The contractor would minimize conduit bends to ease cable pulling. Vault spacing is dictated by the physical capabilities of the cable to withstand the pulling tensions.

The power cables would be located within existing road right of way for as much of the distance as possible. From the Lake Easton Substation to the HDD crossing of I-90, it is possible that portions of the route would require clearing within or along the roadway, either in the existing road right of way or adjacent to it. From the HDD crossing of I-90 to the Kachess Reservoir Substation, the route is located entirely within existing road right of way. The vast majority of the distribution line route is located on property owned by Reclamation. A short reach located between Interstate 90 and Lake Easton is located on Washington State Agricultural Trust Land, and Reclamation has a crossing agreement for that land.

Alternative 1 consists of three large synchronous motor pumps rated 13,000 horsepower (HP), or approximately 10.1 megawatts (MW) each.

12.2 Alternative 2 – South Pumping Plant

12.2.1 Intake and Fish Screens

The top of the fish screens and intake would be located at El. 2,100, corresponding to the maximum KDRPP drawdown (El. 2,110). The design team selected the horizontal configuration of the intake screens to connect to the horizontal TBM (discussed further in Section 16.3.2, Fish Screens) constructed tunnel and while keeping the screens as deep as possible. The 15-foot-diameter screen manifold would connect to the docking sleeve, either by a flanged or welded connection. This 15-foot-diameter manifold would have 12 large cylinder screens, shown in Drawing 2C-301 – Intake and Fish Screens Site Plan and Sections. Each cylinder screen would be 7 feet in diameter by 10.5 feet long and was designed to provide flow approach velocity below 0.4 ft/sec for fish.

12.2.2 Docking Sleeve

The intake would include a docking sleeve section and intake structure. The intake tunnel would dock into the downstream end of the docking sleeve. The fish screens would dock onto the upstream end of the docking sleeve once the tunnel is completed and filled with water. Section 16.3.2, Docking Sleeve, provides further detail on the docking sleeve construction.

12.2.3 Intake Tunnel

The intake tunnel would be approximately 3,275 feet long with a finished inside diameter of 13 feet. The invert of the intake tunnel would start at El. 2,080 at the pumping station shaft and proceed upward at a slope of 0.20 percent to the intake at approximate El. 2,087.6. Drawing 2C-205, Tunnel Sections and Details, illustrates the inside of the tunnel lined with segmental concrete. An Earth Pressure Balance TBM would excavate the tunnel (see Section 16.3.2, Intake Tunnel).

12.2.4 Surge Tank Shaft

The large pumping units can experience significant dangerous or damaging pressure transients with the loss of power to the motors that drive the pumps. Adverse pressure transients can also occur during normal unit start-up and shut-down. To address this aspect of design, HDR engaged NHC to assist in developing surge protection features. Appendix F of the *Kachess Drought Relief Pumping Plan - Hydraulic Analysis* technical memorandum (Reclamation and Ecology, 2014g) contains NHC's transient analysis.

A surge tank would be required to control surge caused by sudden changes in pressure that would occur on loss of power to the pumping plant when the drought relief pumping units are operating. The surge tank shaft would be a 50-foot interior diameter concrete lined shaft approximately 200 feet deep. The surge tank would be located at the downstream end of the intake tunnel slightly upstream of the pumping plant, as illustrated in Drawing 2C-402, Pumping Plant Profile. The surge tank shaft would be integral to the intake tunnel.

12.2.5 Pumping Plant

Pumping Plant Shaft

The pumping shaft would be 145 feet deep and 110 feet in diameter. The contractor would build a vertical shaft and tunnel entrance portal on the bench located immediately downstream of the existing Kachess Dam. The contractor would construct the pumping plant shaft through glacial overburden soils down to a more stiff soil layer anticipated to be overconsolidated glacial till, and continue down into stiff soil to the required depth of the wet well, which would house the pumping units. Reclamation would need to gather further information about the soil as the design advances beyond the feasibility level.

The contractor would further advance the shaft from the overburden soil and into the overconsolidated glacial till interface at El. 2,160 down to approximate El. 2,055 (see Section 16.3.2, Pumping Plant Shaft, for construction method details). This section of the shaft would create the space required for construction of the pumping plant. The 110-foot-diameter shaft would rest on and connect to the underlying glacial till with tendons drilled into and secured to the underlying soil. The tendons would withstand the buoyant uplift forces once construction was complete and the temporary internal dewatering system deactivated.

The building enclosure described in Section 12.1.3, Pumping Plant Shaft, also applies to Alternative 2.

Pumping Units

Alternative 2 would also use the pumping units described in Section 12.1.3, Pumping Units. However, instead of discharging into a common manifold, the pumping units for Alternative 2 would discharge into individual pipelines as indicated on Drawings 2C-403 Pumping Plant – Plan A at EL. 2,115 and 2C-404 Pumping Plant– Plan B at EL. 2,200.

Both Alternative 1 – East Shore Pumping Plant, and Alternative 2 – South Pumping Plant, are feasible with respect to the pumping unit hydraulic and mechanical design. The design of the pumping units for Alternative 2 is more complex due to the wider range of total dynamic heads, but is readily achievable by several manufacturers with the potential addition of the pump control valves.

Ancillary Systems

Section 12.1.3, Ancillary Systems, describes the ancillary systems for both alternatives. Ancillary system features unique to Alternative 2 are as follows:

- Pump Control Valves for Alternative 2: Pump manufacturers have expressed concerns about potential cavitation when the pumping units operate at very low TDH. The design team incorporated pump control valves (PCV) on the discharge lines to provide additional hydraulic losses into the design of the Alternative 2 pumping plant.
- Domestic Water and Sanitary Waste System:
  - The pumping plant facility would require a potable water supply for the bathroom and washdown water for the pumping plant building. There is an existing well located on the site, but the design team needs more information to determine if it could provide a sufficient source of supply. Alternatively, Reclamation could install a new well on the site to supply the potable water for the building. A preliminary estimate of the well capacity is 10 gpm, based on a peak 7 minute water usage for a toilet, sink, and washdown hose connection (WSDOH, 2009).
  - Sanitary sewer design for Alternative 2 is the same as Alternative 1 (see Section 12.1.3, Ancillary Systems).

12.2.6 Release Structure

Drawings 2C-401, Pumping Plant – Site Plan and 2C-411, Discharge Structure depict the release structure. Four 7-foot-diameter discharge pipes would release flow from the pumping plant. The outlet of these pipes would be submerged to ensure that the pipe liner remains wet, which is anticipated to prolong its life span.

Discharge from these pipes would enter a concrete-lined rectangular channel that would convey flow to the existing discharge pool located at the downstream end of the gravity outlet works. To minimize fish attraction, designers would slow the discharge from the pumping plant to a velocity of approximately 2 to 3 ft/sec at the existing discharge pool, by gradually increasing the width of the concrete-lined rectangular channel to 100 feet.

See Section 12.1.6, Release Structure subsection, for discussion on avoiding crosswaves and excessive turbulence, and future trap and haul facilities.

The design would provide a location for stop logs in the pumping facility discharge system, just upstream of the fish barrier. During inspection and maintenance activities, workers could insert stop logs to prevent flow in the existing discharge pool from backing up into the discharge system. This would allow draining of the concrete-lined rectangular channel and discharge piping at the pumping plant for inspection and maintenance activities.

12.2.7 Access Roads

The information provided in Section 12.1.7, Access Roads, applies to access roads for Alternative 2, with the following modifications regarding the access road to the pumping plant building.

Access Road to the South Pumping Plant

Drawing 2C-401, Pumping Plant – Site Plan and Drawing 2C-412, Pumping Plant – Access Road Profile/Sections illustrate the access road layout and profile for the pumping plant facility. An existing gravel side road located off Kachess Dam Road supplies access to this area. The proposed access road extends down the steep hillside to the 26-foot-wide double swing gates at the proposed gravel yard.

Kachess Dam Road is gravel at the facility access location, and the design team proposes gravel surfacing also for this interior access road. An exception to this includes possible paving of the steeper portions of the road as it traverses down the hillside, which Reclamation could decide later as the project progresses beyond the feasibility level.

12.2.8 Interconnection to Power Source, Substations and Transmission Lines

The substation for Alternative 2 would be located approximately 300 feet southeast of the pumping plant building. The transmission interconnection, power outage, and overload information presented in Section 12.1.8, Substation and Transmission Lines, applies to Alternative 2.

The power source for both alternatives has changed from the original design reported in 2015. As of December 2017 Reclamation and Ecology anticipate that the power source would be the same as developed in the Appraisal Level Design Report for the Floating Pumping Plant Alternative (2017, Draft). (However, note that Drawing 2C-501 – Alternative 2 Site Plan has not been updated and shows the old, 2015 power source.) The transmission line would be shorter, at approximately 8,750 feet (1.67 miles). Further consideration may be needed to fully integrate the new power supply configuration with Alternative 1 site and equipment requirements.

Alternative 2 involves three smaller synchronous motor pumps rated 7,100 HP, or approximately 5.5 MW each. System simulations showed that impacts to the bulk electric system are within normal ratings under normal operating conditions for either alternative.

13.0 Geotechnical Engineering

This section summarizes the regional geology, the geotechnical characteristics of each alternative, and geotechnical design parameters. The *Kachess Drought Relief Pumping Plant, Geotechnical Analysis* technical memorandum provides more detailed geotechnical engineering information for the KDRPP (Reclamation and Ecology, 2014f).

13.1 Regional Geology

The project area is located on the eastern side of the Cascade Range between the northern and southern Cascades. The Straight Creek Fault is the major north-south trending fault of the northern Cascade Range. The Straight Creek Fault passes through Kachess Reservoir and the Yakima River valleys in the central Cascades to the south. Mesozoic crystalline rocks and Eocene volcanic and sedimentary rocks of Teanaway River Block dominate the middle Cascades. Records from original dam construction suggest that geology is of early Tertiary units, primarily volcanic tuff and breccias, with some interbedded sedimentary rocks.

The basement rock in the area, and to the northeast of the north end of Kachess Reservoir, is the pre-Tertiary Easton Schist, primarily comprised of metamorphosed greenschist and blueschist with local interbedded phyllite. The Eocene Naches Formation overlies it, consisting primarily of rhyolite, dacite, andesite and basaltic flows, tuff, and breccia with interbedded sandstone, siltstone, shale, conglomerate, and coal.

Pleistocene glaciation significantly affected the valleys. A late Pleistocene lodgment till consisting of glacial recessional deposits, such as lacustrine, outwash, and ice-contact sediment. Holocene beach deposits and colluviums mantle the ground surface and reservoir bottom. The dam rests on a moraine, and there are glacially derived, unconsolidated sediments upstream of the dam.

13.2 Alternative 1 – East Shore Pumping Plant

Drawing 1C-201 – Headworks Site Plan and Drawing 1C-202 – Headworks Profile illustrate three borings drilled along the Alternative 1 tunnel alignment: the intake, mid-tunnel, and pumping plant borings. The soil generally consists of the following:

- Zero to 5 feet of colluvium, consisting of silty sand with gravel, cobbles, and boulders.
- Overlying 0 to 10 feet of beach deposits, consisting of clayey gravel with sand and cobbles to silty gravel with sand and cobbles.
- Overlying 0 to 58 feet of recessional outwash, consisting of dense to very dense, brown to gray, silty sand with gravel, silty gravel with sand, and poorly graded gravel with silt and sand.
- Overlying 0 to 66 feet of glaciolacustrine deposits, consisting of hard, gray, silt, lean clay, and sandy silt.
- Overlying 0 to 16 feet of recessional ice contact deposits, consisting of silt with sand, silty sand with gravel and cobbles, silt, and sandy silt.
- Overlying 0 to 6 feet of recessional lacustrine deposits, consisting of silt, lean clay, and fat clay with lenses of fine sand.
- Overlying 0 to 4 feet of advance glacial outwash and till like deposits, consisting of silty sand and silty sand with gravel and cobbles.
- Overlying 9.5 to 25 feet of glacial till, consisting of very dense, gray, silty sand to silty sand with gravel and cobbles.

The bedrock is of the Swauk Formation and generally consists of interbedded sedimentary and volcanic rocks. Sandstone and siltstone are the dominant sedimentary rocks, with thinner coal seams and interbeds. The sandstone and siltstone typically are moderately hard to hard and fresh to slightly weathered. The coal interbeds are very soft to moderately soft, moderately to intensely weathered, with very closely spaced polished discontinuities. Sedimentary breccias are also present within this formation and are typically adjacent to zones of intensely weathered to decomposed bedrock layers of very soft, highly weathered graphite or coal that were generally interbedded with siltstone layers. The volcanic rocks are andesite and dacite, consisting of fine grained, gray, very soft to hard, slightly to intensely weathered with moderately to widely spaced, polished to rough discontinuities. The pumping shaft boring and mid-tunnel boring encountered deformation, shearing, and highly fractured rock.

The design team geologist did not perform a detailed analysis of Recovery and Rock Quality Designation (RQD). However, based on the RQD plots on the boring logs, the majority of the samples in the tunnel excavation horizon had values generally exceeding 75 percent. The mid tunnel boring had much lower values, with RQD ranging from zero to 30 percent and recovery values as low as 45 percent but generally exceeding 95 percent.

Groundwater was not encountered during drilling but it is assumed that the top of water in the subsurface would mirror top of reservoir water level and that saturated conditions would prevail below that point. The driller performed Packer tests during drilling; the results of the tests are contained in the *Geology Report* prepared by Shannon & Wilson, Inc. (Shannon & Wilson, 2014).

13.2.1 Summary of General Surface Conditions at Intake

The subsurface conditions would consist of 40.5 feet of soil overlying bedrock. The soil would consist of recessional ice contact deposits, recessional lacustrine deposits, and glacial till. The bedrock would be of the Swauk Formation (Shannon & Wilson, 2014).

13.2.2 Summary of General Surface Conditions at Mid-Tunnel

The anticipated tunnel excavation is entirely in the bedrock of the Swauk Formation (Shannon & Wilson, 2014).

13.2.3 Summary of General Surface Conditions at Pumping Shaft

The subsurface conditions would consist of 155 feet of soil overlying bedrock. The soil would consist of glaciolacustrine deposits, recessional ice contact deposits, advance glacial outwash, till-like deposits, and glacial till. The bedrock would be of the Swauk Formation (Shannon & Wilson, 2014).

13.3 Alternative 2 –South Pumping Plant

The only boring completed for Alternative 2 was at the extreme upstream end of the tunnel, in the reservoir near the proposed fish screens. The boring data, however, is limited to a soil description of silt (Reclamation and Ecology, 2014f).

The geotechnical data available to the design team for Alternative 2 reside no deeper than approximately El. 2,150, whereas the bottom of the pumping plant shaft and the invert of the entire tunnel fall beneath approximate El. 2,100 to El. 2,075, or about 50 to 75 feet below the deepest geotechnical data available. Thus, there is no site-specific data available to the design team on which to premise feasibility-level designs (Reclamation and Ecology, 2014j).

Based on prior geotechnical data, the assumed condition in the tunnel excavation zone would be soil, consisting of over-consolidated glacial till from the pump station shaft below the dam for approximately 2,000 to 3,000 feet; followed by a lacustrine soil for approximately 0 to 1,000 feet. The assumed conditions at the pumping station shaft consist of overburden overlying an over-consolidated glacial till, similar to that described for Alternative 1 above (Reclamation and Ecology, 2014j).

13.4 Geotechnical Design Parameters

13.4.1 General

This section includes geotechnical design parameters for the following project specific structures common to Alternatives 1 and 2 based on the limited amount of existing geotechnical data available and on professional experience on similar projects with similar ground conditions:

- Pumping plant and inlet shafts
- Substation foundations
- Hydraulic structure foundations
- Access roads
- Permanent and temporary cut slopes

Due to the limited available geotechnical data in the immediate vicinity of most of the proposed structure locations for both alternatives, the following geotechnical design recommendations are preliminary. To address geotechnical data gaps, Reclamation conducted a second round of geotechnical exploration in fall 2014 and expects to do additional testing in the spring of 2015. Reclamation would use these findings to determine what types of geologic materials the Alternative 2 tunnel would encounter, to provide information for the selection of the final alternative, and to potentially refine the design and cost of the selected alternative, as appropriate.

13.4.2 Geotechnical Design Recommendations

General Geotechnical Parameters

As discussed previously, the specific subsurface geologic layer orientation below proposed site features of interest is not currently well understood based on the limited geotechnical data available. The design team should consider the following general parameters when designing site infrastructure for head works, shaft, and outlet works locations for both alternatives:

Table 12. General Geotechnical Parameters

General Geotechnical Parameters				
	Soil Description			
Parameter	Colluvium	Beach Deposits	Glaciolacustrine Deposits	Bedrock
Total Unit Weight (pcf)	130	130	130	165
Internal Friction Angle (degree)	30	32	0	--
Cohesion (ksf)	1.5	0	2.5	--
Unconfined Compressive Strength (ksf)	NA	NA	5	750
Modulus of Subgrade Reaction (pci)*	230+5Z	90+1.3Z	90+1.3Z	2700
Earth Pressure Coefficients				
Active	0.33	0.31	--	N/A
At-Rest	0.50	0.47	--	N/A
Passive	3.00	3.25	--	N/A
Coefficient of Friction with Concrete	0.4	0.5	0.35	N/A

* Z indicates the depth from the top of excavation
kaf = thousand square feet
pci = pounds per cubic inch

Seismic Design Parameters

The designs of the proposed onsite infrastructure would resist the effects of seismic motions in accordance with ASCE 7 and the International Building Code. Based on the available geotechnical data, the following table includes site classes for significant major locations of interest:

Table 13. Seismic Site Class Information

Seismic Site Class Information		
Parameter	Alternative 1	Alternative 2
Site Class		
Head Works	D	D
Shaft	D	C
Outlet Works	D	D

Site Class D: Vs = 1040 ft/sec
Site Class C: Vs = 2270 ft/sec

The design team selected site classes in accordance with the 2012 International Building Code. Due to the lack of geotechnical data in the immediate vicinity of the headworks for Alternative 1 and the outlets works for both alternatives, the design team assigned a site class D as recommended by the International Building Code. The team can select specific seismic design coefficients based on the site class provided and the locations of the site relative to historic earthquake data.

Pumping Plant and Inlet Shafts

A deep 110-foot-diameter circular shaft with an abovegrade building enclosure at ground surface would enclose the proposed pumping plant equipment for both Alternatives 1 and 2 (described in Section 12.1.3 and12.2.5, respectively). The *Pumping Plant Shaft Structural Analysis* technical memorandum conceptually evaluated the buoyancy of the shaft and the design team would further evaluate it during final design (Reclamation and Ecology, 2014k).

Geotechnical parameters for the pumping plant shaft and pumping plant design are as follows, based on the previously discussed subsurface conditions:

- Use an allowable bearing pressure of 2,500 psf for foundations located near the ground surface for both alternatives. An allowable bearing pressure of 5,000 psf could be used for footings founded on dense, coarse-grained, glacial soils, at a minimum depth of 4 feet below the final grade.
- Extend shallow foundations to a minimum depth of frost as required by local building codes.
- Use 17,000 psf on the rock surface for allowable bearing pressures at the shaft bottom for both alternatives.
- The design team has not determined settlement or differential settlement, or both, for building and shafts. The design team would evaluate them in detail during final design.
- Anchor the shaft for both alternatives to the underlying ground to counteract buoyancy and minimize the volume of mass concrete to a 45-foot thickness.
- Use the following Factor of Safety for Buoyancy: FS = 1.25.
- Use the shear strength of concrete to resist uplift forces with a factor of safety of 1.5 for both alternatives to resisting buoyant uplift forces.

Table 14 summarizes the allowable bond strength values for designing anchors:

Table 14. Bond Strength Parameters

Bond Strength Parameters				
	Soil Description			
	Colluvium	Beach Deposits	Glaciolacustrine Deposits	Bedrock
Allowable Bond Strength, (ksf)	2.5	2	3	7.5

The design team recommends a maximum spacing for vertical tie down anchors of 10 feet on center.

Section13.4.2, General Geotechnical Parameters, presents lateral earth pressure values for various subsurface layers. For shaft design, parameters are included in Appendix A of the Geotechnical Analysis technical memorandum.

Lateral earth pressures should include appropriate surcharge loadings both during and post construction and should be based on anticipated construction and operating conditions. Use 300 pcf to 10 feet below ground surface.

- Seismic Design Parameters for Shafts Ss, S1, Sds, Sd1:
  - Alt 1: Ss= 0.799g; S1= 0.306g; Sds= 0.629g; Sd1= 0.365g
  - Alt 2: Ss= 0.804g; S1= 0.307g; Sds= 0.578g; Sd1= 0.306g
- Seismic soil loading profile or load and location of application (see Figure 6 and Figure 7).
- Shaft Location Coordinates:
  - Alt 1: 47.279N/121.194W
  - Alt 2: 47.263N/121.204W

Substation Foundations

The design team assumes that substation components would utilize shallow foundations placed upon soil. Transmission poles may utilize deeper foundations. The switchyard area could utilize a standard crushed rock or paved finished surface, including the criterion presented in Section13.4.2, Access Roads.

The design team recommends the following geotechnical parameters for the substation foundations, based on the previously discussed subsurface conditions:

- Use an allowable bearing pressure of 2,500 psf for foundations near the ground surface.
- Extend shallow foundations to a minimum depth of frost as required by local building codes.
- Use the following skin friction values for various subsurface layers to determine appropriate deep foundation requirements:

Table 15. Skin Friction Parameters

Skin Friction Parameters			
	Soil Description		
Shaft Description	Colluvium	Beach Deposits	Glaciolacustrine Deposits
Drilled (psf)	1,600	2,000	900
Driven (psf)	3,200	3,600	900

- Use the following tip resistance values for various subsurface layers to determine appropriate deep foundations:

Table 16. Tip Resistance Parameters

Tip Resistance Parameters				
	Soil Description			
Shaft Description	Colluvium	Beach Deposits	Glaciolacustrine Deposits	Bedrock
Drilled and Driven (ksf)	5	15	7.5	150

Hydraulic Structure Foundations

Hydraulic structures for Alternative 1 include the pipeline, concrete spillway, concrete stilling basin, concrete rectangular release structure with fish barrier, seepage monitoring and measurement weir, and stormwater conveyance system. Hydraulic structures for Alternative 2 include the concrete lined rectangular channel, seepage monitoring and measurement weir, and stormwater conveyance system. The design team assumes these structures would be lightly loaded and would not require deep foundations. The team recommends the following geotechnical design parameters for hydraulic structures:

- Use an allowable bearing pressure of 2,500 psf for structures situated near the ground surface for both alternatives.
- Vary foundation widths based on dead loads to balance pressure applied to the subsurface.
- Extend shallow foundations to a minimum depth of frost as required by local building codes.

Access Roads

Both alternatives would require new access roads. For Alternative 1, there would be a need for access roads to the pumping station, the pipeline (via a causeway), and the release or outlet facility. The maximum proposed grade for the three access roads for Alternative 1 is approximately 9 percent, and the access road would extend approximately 900 feet. Alternative 2 would need single access roads for the pumping station and outlet facility located at the southern end of the site. The maximum proposed grade for the Alternative 2 access road would be approximately 7 percent and the access road would extend approximately 580 feet. The design team recommends the following geotechnical design parameters for access roads:

- Loose material should not immediately underlay road base material. Over excavation may be required to remove unsuitable material. If roads were constructed at existing grades, the design team estimates the removal and replacement of approximately 2 feet of material would be needed to construct all access roads.
- The design should utilize a minimum 12 inches of base course underneath the selected road surface.
- The design could use a minimum 8 inches of hot mix asphalt, crushed stone, or other approved material as a finished surface for access roads.

- Materials used for base course and road surfacing shall conform to Washington State Department of Transportation Standard Specifications for Road, Bridge, and Municipal Construction.
- Access roads should be graded and raised as necessary to promote adequate drainage and prevent ponding.

Temporary and Permanent Cut Slopes

Temporary cut slopes would be required to construct specific site features. The design must adhere to Occupational Safety and Health Administration regulations for maximum slopes and layback angles. For this site, subsurface conditions encountered would include silty and sandy gravel and siltstone or sandstone bedrock. The Occupational Safety and Health Administration recommends the following classifications and slopes for temporary excavations indicated soil types:

- Clayey soils are Type B soils and should be temporarily sloped at a maximum 1H-to-1V (horizontal to vertical).
- Sandy, gravelly, and silty soils are type C soils and should be temporarily sloped at a maximum 1.5H-to-1V.
- Competent bedrock could be temporarily sloped at 0.5H-to-1V.

If these temporary layback slopes were exceeded, an engineer should determine whether structural excavation support would be required. In addition, a professional engineer, as required by the Occupational Safety and Health Administration, should design all excavations exceeding 20 feet in depth.

The design team recommends the following permanent slopes:

- Silty or clayey fine-grained soils should be permanently sloped at a maximum 3H-to-1V.
- Sandy and gravelly soils should be permanently sloped at a maximum 2.5H-to-1V.
- Competent bedrock should be permanently sloped at a maximum 1H-to-1V.

14.0 Right-of-way and Easements

14.1 Alternative 1- East Shore Pumping Plant

Project facilities would be located on private and federal land. The acquisition of one or two private properties located near the East Shore Pumping Plant may be required. Right-of-way easements along the power supply facilities and transmission lines may also be required. A portion of the facilities will be located on land that Reclamation currently owns and manages.

14.2 Alternative 2- South Shore Pumping Plant

Project facilities would be located on federal land that Reclamation currently owns and manages. Right-of-way easements along the power supply facilities and transmission lines may be required.

15.0 Operation and Maintenance Considerations

This section summarizes general operation and maintenance considerations for the KDRPP. The feasibility-level study technical memoranda (listed in Section 3.3, Study Process) summarize operation and maintenance details for individual project components.

15.1 Fish Screens

There are two common types of fish screen cleaning systems most applicable to this site and screen system: brush cleaning systems and air burst cleaning systems. A brush cleaning system physically cleans the screen using the brush to lift debris off the screen surface. An air burst cleaning system uses high pressure air to blow debris off the screen. Because the intake for each alternative is located far from shore (over 800 feet and 3,275 feet for Alternative 1 and 2, respectively) and would be submerged by 90 feet of water (when water levels are at the elevation of the existing outlet works), an air burst is not considered to be an appropriate cleaning system due to the size of the air receivers and compressors that would be required. Therefore, the most applicable screen cleaning system identified for these fish screens is a brush cleaning system. The tee screen brush cleaning systems would be electrically powered, and a marine-rated power cord would run from the intake manifold back to the pumping station. The design team does not consider anchor ice or frazil an issue for this intake due to its depth in the reservoir.

The screen cleaning system would automatically turn on based on a maximum allowable time period between cleanings, and whenever the differential head sensing system triggers the system. In the event of a loss of primary power supply to the site, it is acceptable for the fish screen cleaners to sit idle for the few hours or days during the time the primary power supply to the project is unavailable. A diver and support crew would perform regular inspections and maintenance on the fish screens as needed.

15.2 Pumping Units

15.2.1 Drought Relief Pumps

Reclamation would operate the drought relief pumps during a severe drought period and, if needed, in refill years to meet water supply demands under the guidelines that govern the prorationing of water to proratable water users. When called upon during a drought, these pumps would operate at up to 1,000 cfs as needed between May and October. If primary power supply to the site is lost, the drought relief pumps could sit idle until primary power supply to the project were restored.

In general, larger pumping units are easier to maintain since individual components, such as seals, bearings, and impeller, are physically larger. Additionally, infrequent pump operation means there would be sufficient time for maintenance between irrigation seasons.

Because the fish screens would be upstream of the pumping units, floating debris and sediment could not enter the inlet tunnel as long as the fish screens are in a physically "tight" condition, which is required for the screens to perform their duty of precluding fish from leaving the reservoir and entering into the pumping system. The intake would draw fine suspended sediment that may be present in the water when the reservoir is at low levels through the fish screens. The design team does not anticipate this to be a problem as the expected impact of the potential presence of fine, suspended sediments would not adversely affect pump impellers. The design may include self-cleaning strainers with a back flush system for shaft seal water supply.

For maintenance access, workers could remove each vertical turbine-pumping unit as individual one-piece assemblies. Note that individual components are not easily accessible and require dismantling the entire pump column.

15.2.2 Fish Flow Pumps

The fish flow pumps provide water to meet minimum instream flow requirements in the Kachess River, immediately downstream of Kachess Dam, whenever the water level in the reservoir is below the elevation of the gravity outlet works invert (El. 2,192.75) and the drought relief pumps are not operating. In the event of a loss of primary power supply to the site, the on-site emergency back-up power supply would continue to power the fish flow pumps until restoration of the primary power supply.

15.2.3 Seepage Sump Pumps

The seepage sump pumps would continuously operate to remove seepage water that enters the pumping plant shaft from within the pumping plant. In the event of a loss of primary power supply to the site, the onsite emergency backup power supply would continue to power the seepage sump pumps until the primary power supply were restored.

15.3 Health and Safety

The various health and safety systems for the project must be fully operable at all times. In the event of a loss of primary power supply to the site, the onsite emergency backup power supply would power the health and safety systems.

15.4 Operation and Maintenance

The Reclamation's Yakima Operations Center would operate KDRPP remotely. There would be provision for a local operating mode also. Each winter and spring Reclamation forecasts possible drought conditions affecting Yakima Project operations. Reclamation updates predictions frequently based upon the amount of precipitation that has fallen and the water content contained in the existing snowpack. Reclamation would need to maintain the KDRPP, and in particular the drought relief pumps, in a ready condition at all times for use in any year. This need requires that Reclamation maintain the project in a ready condition by spinning the pumps and testing the ancillary systems periodically (currently anticipated to be every other month). During final design, it is recommended that a detailed maintenance schedule be developed for the equipment and systems needed to operate the project.

15.5 Replacement

The design team anticipates that Reclamation would perform a detailed inspection of project facilities on a four-year cycle. Detailed inspections would look at the condition of the fish screens, intake tunnel, pipeline (if Reclamation selects Alternative 1), pumping plant shaft, building enclosure, discharge structure, surge tank, transmission line, and substations.

The design team anticipates a 50-year cycle of replacement for the equipment. This includes the fish screens and their cleaning system, large pumping units, ancillary systems, building enclosure, electrical system, instrumentation and controls, and power supply components.

16.0 Construction Considerations and Scheduling

Section 16.0, Construction Considerations and Scheduling, describes the following construction considerations:

- Weather conditions and reservoir levels
- Temporary construction features
- Permanent project feature construction
- Construction sequence and duration
- Construction schedule

16.1 Reservoir Pool Elevations

Section 6.0, Climate, presents historical weather conditions for the project site. The design team anticipates that the reservoir pool elevation would follow normal historical operation of Kachess Reservoir throughout the KDRPP construction period. Figure 8 and Figure 9, respectively, illustrate the average annual pool elevations by week and the average percentage of time the reservoir is at or below specific elevations for normal reservoir operations.

The Kachess Reservoir pool elevation would affect project construction related to dewatering project components. In particular, the reservoir pool elevation would affect the construction schedule for the 7,755-foot-long pipeline (associated with Alternative 1 only). During final design, Reclamation would develop a Kachess Reservoir operation and management plan for the construction period. This plan would consider the operational constraints that may affect the construction schedule.

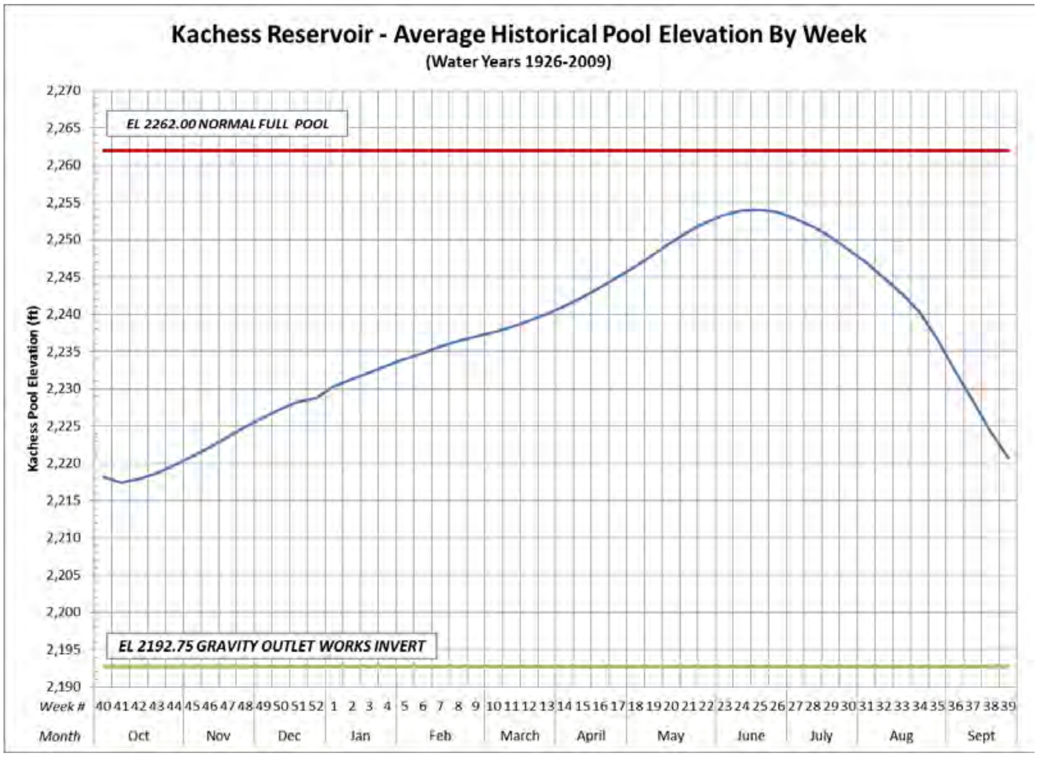


Figure 8. Kachess Reservoir – Average Historical Pool Elevation By Week

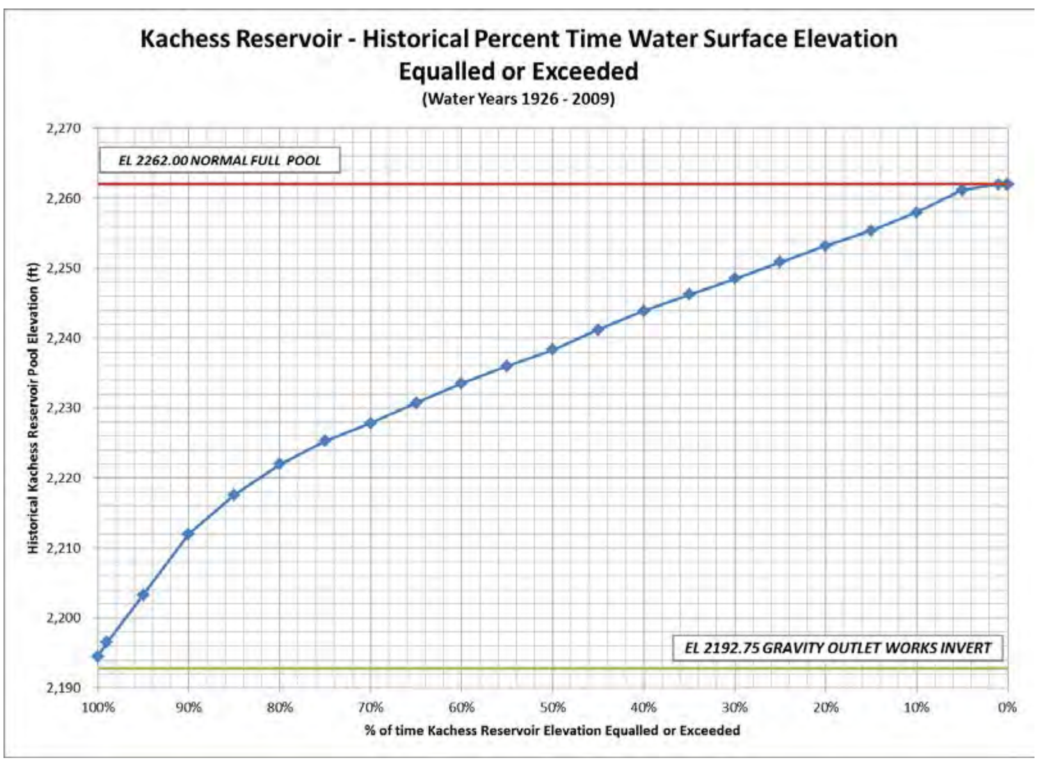


Figure 9. Kachess Reservoir – Historical Percent Time Water Surface Elevation Equaled or Exceeded

16.2 Temporary Construction Features

This section describes the temporary construction features needed to accomplish construction of the permanent project features comprising each of the two alternatives. Figure 10 and Figure 11 illustrates the primary temporary construction features for Alternative 1 and Alternative 2, respectively. The contractor would abandon, remove, restore, or convert these temporary features into permanent project features following the completion of construction of the permanent project features. (When a temporary construction feature of Alternative 2 is similar to that which has already been described in Alternative 1, the reader is referred to the prior text description, rather than repeating the text.)

16.2.1 Alternative 1 – East Shore Pumping Plant

Site Access

Access to Alternative 1 is from Exit 70 of Interstate 90 via Sparks Road, a paved road (Drawings 1G-001 and 1C-101). Going north about 4,000 feet on Sparks Road, drivers turn right onto Kachess Dam Road, which begins as a paved road. Kachess Dam Road becomes a gravel road after about one-quarter mile. Approximately 2,000 feet farther along Kachess Dam Road is a turn off road secured by a locked gate that is Reclamation's direct access road (closed to public vehicle traffic) to Kachess Dam. Kachess Dam Road continues east along the downstream end of Kachess Reservoir and then up the east shore of the Reservoir to where the East Shore Pumping Plant would be located.

Clearing and Grading

Following the installation of temporary erosion and sedimentation (TESC) measures, clearing and grading would be required for access roads, construction parking and administrative offices, staging areas, batch plant and material stockpiles, the transmission line corridor, the pumping plant, the substation and the outlet works structures (Drawings 1C-406 and 1C-407). The design team anticipates a total of approximately 52 acres of clearing for Alternative 1. The pipeline extends across the bottom of the existing reservoir and does not require any clearing.

Construction Access Roads

In addition to the existing dam access road, there would be three new vehicle access roads needed for Alternative 1 (Drawings 1C-406 and 1C-407). The new access roads would begin off the existing gravel Kachess Dam Road and extend from Kachess Dam Road to the edge of the Reservoir (Figure 10). The three new roads would provide access to the spoil disposal area, the pipeline causeway, and the pumping plant area. The current design includes approximately 0.4 miles of new construction access roads, which would be gravel-surfaced. The new access roads would be constructed using conventional construction equipment.

Construction Site Security

There is already a gate at the existing dam access road. However, each of the three new access roads would require a new security gate at the location where the new road first leaves Kachess Dam Road. Security fencing would encompass the entire pumping plant site (Drawings 1C-406 and 1C-407). Within the pumping plant site, security fencing would fully secure the substation perimeter and the perimeter of the open channel outlet structures.

Construction Parking and Administrative Offices

The primary temporary construction parking and temporary construction administration offices would be located along the existing graveled Kachess Dam Access Road near the dam end of the road (Drawings 1C-406 and 1C-407). The design team envisions construction offices at the pumping plant site, as a tremendous amount of the overall project work would occur at the upstream end of the project. These areas would be constructed using conventional construction equipment. The design team allocated an area of approximately 1.8 acres for this purpose.

Construction Staging Areas

Similar to the construction parking and administrative office, the primary construction staging area would be located along the existing graveled Kachess Dam access road near the dam end of the road. There is a domestic water well located in this area that would need to be protected. The Washington Department of Health requires a 100-foot radius well protection zone, centered on the well head, wherein hazardous materials cannot be stored or used. The well head requires a sanitary seal to preclude surface water from entering the well head. However, the protection zone can be driven on and have materials (non-hazardous) stored within its' radius. An additional construction staging area would be located at the pumping plant site (Figure 10) (Drawings 1C-406 and 1C-407). These two staging areas would be constructed using conventional construction equipment. The design team allocated an area of approximately 1.5 acres for this purpose.

Construction Batch Plant and Material Stockpiles

A single temporary construction batch plant and material stockpile area would be located along the existing graveled Kachess Dam access road near the dam end of the road (Drawings 1C-406 and 1C-407). This location would be conveniently located close to Interstate 90, facilitating the delivery and stockpiling of concrete batching materials (cement, sand, and aggregate). Redi-mix concrete trucks would transport batched concrete to the construction site, including the marina locations. The contractor would use conventional construction equipment for construction of the batch plant and material stockpile areas. The design team allocated an area of approximately 3 acres for this purpose.

Construction Dewatering

The design team does not anticipate any special measures for lowering the groundwater table before construction of the various permanent project features comprising Alternative 1, with the possible exception of the following:

- Construction of the pipeline across the floor of the reservoir
- Construction of the discharge structure that is located on the edge of the existing gravity outlet works discharge pool

Depending on the elevation of the reservoir at the time of pipeline construction, there might be need for point wells in the area where active excavation, installation, welding, backfilling, and compaction would occur. The dewatered area would move along slightly in advance of the area being constructed and would terminate soon after completion of compaction.

For construction of the discharge structure, it is likely that a simple, low cofferdam structure, such as a "Portadam™" or the use of "Supersacks" would be required. The contractor would collect the water seeping into the open excavation in sumps, pump it to a treatment area, and then dispose of the collected and treated water.

Within the underground excavations, the design team anticipates that seepage water entering into the construction excavation (both underground and surface excavations) would be collected in sumps, pumped to the surface, and treated appropriately for water quality purposes, prior to its discharge back into either Kachess Reservoir or the Kachess River, if located downstream of Kachess Dam. If the release of sump water back into either Kachess Reservoir or Kachess River is problematic, then dispersal of the discharge water into the adjacent wooded areas located at the project site is likely permissible. The contractor could not return water to either Kachess Reservoir or the Kachess River without it first meeting acceptable water quality standards.

Construction Basin & Boat Launch

The design team has planned both a shallow-water and a deep-water construction basin and boat launch (Drawings 1C-406 and 1C-407). It is likely that there would be need for only one of these two facilities. For planning purposes, the design team is considering both a shallow-water and a deep-water construction basin and boat launch (Figure 10). The contractor would construct the boat ramps and launches as permanent features that Reclamation could utilize following construction. The shallow water facilities would be located at the south end of the reservoir and accessed via the existing graveled Kachess Dam access road from the left abutment of the dam. The deep-water facilities would be located on the east shore of the reservoir and accessed from a location about two miles further down Kachess Dam Road past the existing road into Kachess Dam. The contractor would build the construction basin and boat launch using conventional construction equipment.

Spoils Disposal

Excess soil, rock, and blasting muck from project construction would be disposed of at a single location at the southeast end of the reservoir (Figure 10) (Drawings 1C-406 and 1C-407). The contractor would first construct a confining berm in the reservoir to contain the spoils prior to placing spoils into the disposal area. The spoils disposal area is approximately 148,000 square feet in area at mid-height (3.4 acres), has an approximate average base elevation of 2,255 feet, and a firm top elevation of 2,267 feet that cannot be exceeded (1-foot lower than the crest elevation of the adjacent former retired spillway that has a crest elevation of 2,268 feet). The spoils area is able to accommodate approximately 66,000 cubic yards of spoils plus the volume of spoils used to create the confining berm. The vast majority of spoils requiring disposal would originate from shaft and tunnel excavations. The design team estimates the volume of spoils originating from the pumping plant shaft, tunnel access shaft, tunnel, and surge tank features to be about 117,000 cubic yards. Therefore, the volume of soil used for construction of the confining berm is likely to be approximately 51,000 cubic yards.

The excavation method for underwater dredging would allow the contractor to spread spoils on the floor of the reservoir without bringing those spoils to the surface. Similarly, the contractor would spread excess pipeline trench excavation spoils on the reservoir floor. Therefore, the contractor would not dispose of dredge spoils and excess pipeline trench excavation spoils in the designated spoils disposal area.

Site Restoration

Following completion of construction, the contractor would restore all areas not needed for permanent project features with native vegetation.

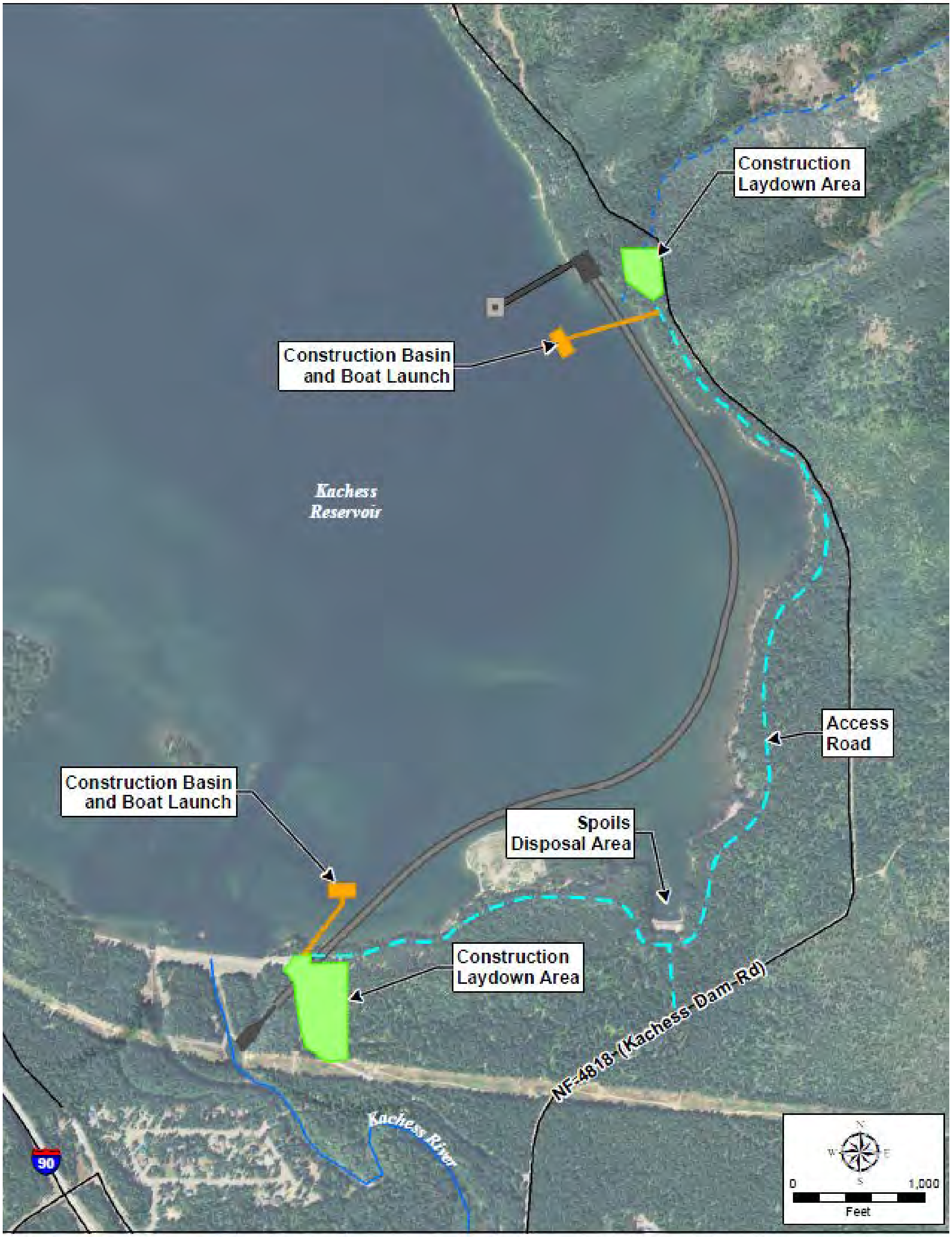


Figure 10. South Pumping Plant Temporary Construction Features

16.2.2 Alternative 2 – South Pumping Plant

Site Access

See Section16.2.1, Site Access. Alternative 2 is accessed the same as Alternative 1, with the exception that no access up the east shore of Kachess Reservoir is needed for Alternative 2, as the pumping plant is located immediately below the existing Kachess Dam (Drawings 2G-001 and 2C-101). If the contractor determines that a deep-water construction basin and boat launch is desirable, Alternative 2 would need to use the existing access road up the east shore of Kachess Reservoir for this purpose.

Clearing and Grading

Following the installation of TESC measures, clearing and grading would be required for access roads, construction parking and administrative offices, staging area, batch plant and material stockpiles, the transmission line corridor, the pumping plant, and the substation (Drawings 2C-413 and 2C-414). The design team anticipates a total of approximately 34 acres of clearing for Alternative 2.

Construction Access Roads

In addition to the existing dam access road, there would be two new vehicle access roads for Alternative 2 (Drawings 2C-413 and 2C-414). The other two access roads would begin at the existing gravel Kachess Dam Road and extend to the edge of the Reservoir. The two new roads would provide access to the spoil disposal area, the construction basin, and the deep-water boat launch (Figure 11). The design team planned the approximately 0.2 miles of new construction access roads to be gravel-surfaced. The new access roads would be constructed using conventional construction equipment.

Construction Site Security

There is already a gate at the existing dam access road. However, each of the two new access roads would require a new security gate installed at the location where the new road first leaves Kachess Dam Road (Drawings 2C-413 and 2C-414). Separate security fencing would encompass the entire pumping plant site and the substation perimeter. The design team allocated an area of approximately 19 acres for this purpose.

Construction Parking and Administrative Offices

Temporary construction parking and temporary construction administration offices would be located at a single location along the existing graveled Kachess Dam access road near the dam end of the road (Drawings 2C-413 and 2C-414). This area would be constructed using conventional construction equipment. The design team allocated an area of approximately 1 acre for this purpose.

Construction Staging Area

The single construction staging area would be located along the existing graveled Kachess Dam access road near the dam end of the road (Figure 11) (Drawings 2C-413 and 2C-414). The staging area would be constructed using conventional construction equipment. The design team allocated an area of approximately 1 acre for this purpose.

Construction Batch Plant and Material Stockpiles

See Section16.2.1, Construction Batch Plant and Material Stockpiles (Drawings 2C-413 and 2C-414).

Construction Basin & Boat Launch

The design team planned both a shallow-water and a deep-water construction basin and boat launch (Figure 11). It is likely there would be need for only one of these two facilities. For planning purposes, Reclamation is considering both a shallow-water and a deep-water construction basin and boat launch at this time (Drawings 2C-413 and 2C-414). The shallow water facilities are located on the south end of the reservoir, accessed on the existing graveled Kachess Dam access road from the left abutment of the dam. The deep-water facilities are located on the east shore of the reservoir, accessed from a location about two miles farther down Kachess Dam Road. The basin and boat launch would be constructed using conventional construction equipment.

Spoils Disposal

Excess soil, rock, and tunnel muck from project construction would be disposed of at a single location at the southeast end of the reservoir (Drawings 2C-413 and 2C-414). The volume of spoils originating from the pumping plant shaft, surge tank shaft, and tunnel features are estimated to total 102,000 cubic yards. Therefore, the volume of soil used for construction of the confining berm is likely to be approximately 36,000 cubic yards. The contractor would place materials in this area below elevation 2262.

The excavation method planned for underwater dredging would allow the contractor to spread spoils on the floor of the reservoir without bringing those spoils to the surface. Therefore, the contractor would not dispose of dredge spoils in the designated spoils disposal area.

Site Restoration

Following completion of construction, the contractor would restore all areas not needed for permanent project features with native vegetation.

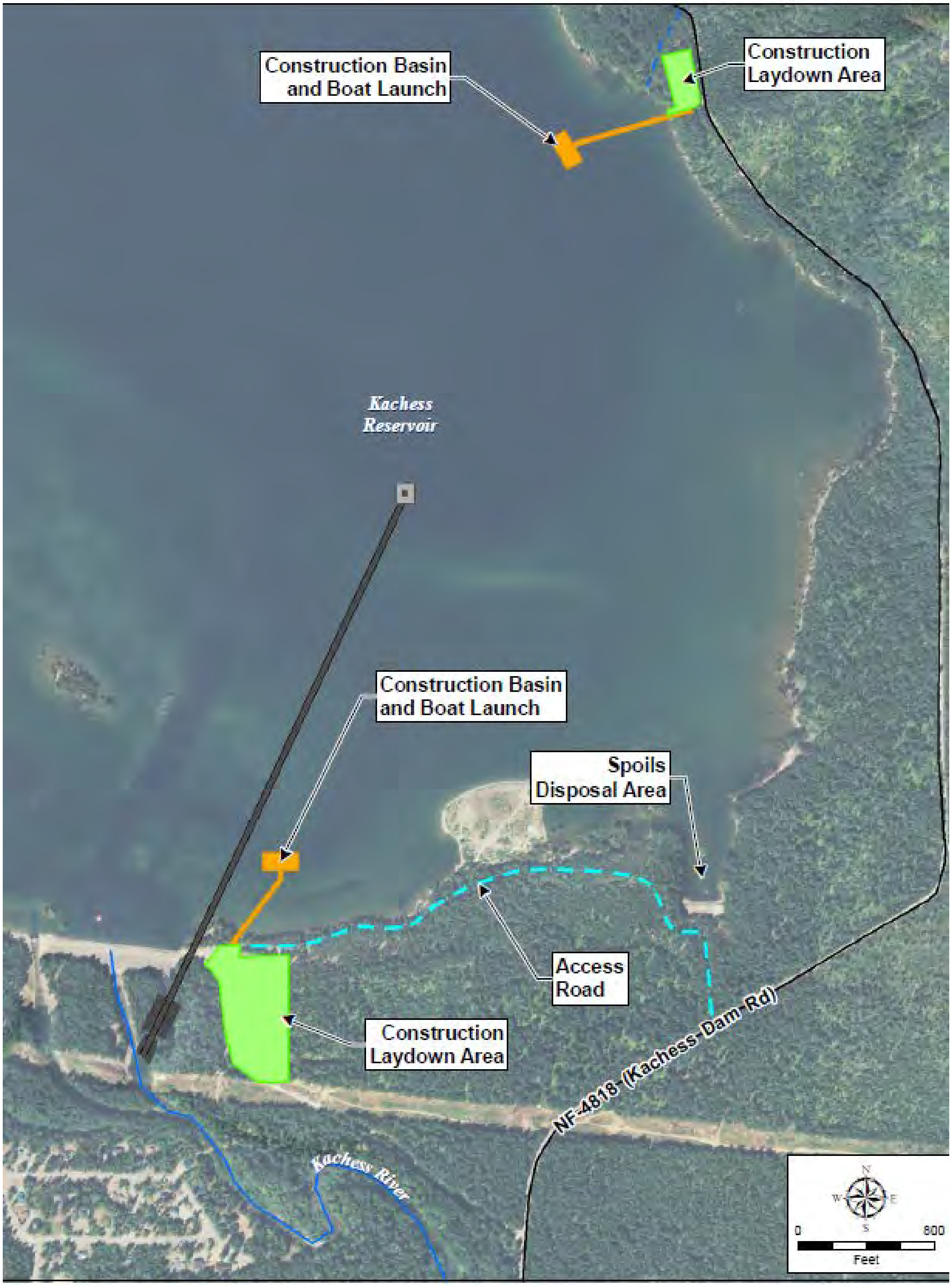


Figure 11. South Pumping Plant Temporary Construction Features

16.3 Permanent Project Feature Construction

This section provides a brief description of the likely construction techniques the team envisions to construct the various permanent project features that comprise each of the two alternatives. (Similar to the section above on Temporary Construction Features, if a permanent project feature has already been described in Alternative 1, the reader is referred to the prior text description, rather than repeating the text under Alternative 2. Refer to the *Geotechnical Analysis* Technical Memorandum (Reclamation and Ecology, 2014f) for more detailed descriptions and discussions of the specialized construction techniques and approaches associated with the project marine work, shafts, and tunnels for both alternatives.)

16.3.1 Alternative 1 – East Shore Pumping Plant

Intake Shaft and Dredging

The contractor would perform intake shaft construction as marine work. The contractor would dredge a conical shaped area, centered roughly on the intake shaft, prior to construction of the intake shaft and installation of the intake pipeline in the intake shaft. The contractor would hang a turbidity curtain from moored buoys prior to the initiation of dredging. The design team plans a hydraulic jetting dredge, sometimes called an "air-lift" dredge, for this purpose, with the dredged spoils being sidecast back onto the floor of the reservoir. Once dredging is complete, a barge mounted drill rig would drill an enlarged central hole and multiple smaller holes in the rock within the footprint and alignment of the intake shaft. The contractor would blast or split the rock and the material would be clam shelled out of the excavation, progressively enlarging the hole until it reached its full, clear 15-foot-wide diameter. The contractor would float the prefabricated steel intake pipeline, lower it into place in the drilled hole, and fill the annular space on the outside of the intake pipeline with tremie placed concrete.

Fish Screens

The contractor would install the fish screens as marine work. After delivery to the site from a fabrication shop, individual sections of the prefabricated fish screens would be barged to a position above the intake shaft, lowered into position, and bolted into place by divers. Power supply to the motor operated screen cleaners would originate at the pumping plant. The contractor would bury the power supply lines at a shallow depth from its origin to about El. 2,190, where the lines would run on the floor of the reservoir to the fish screens.

Pumping Units

The contractor would order pumping units as early as 18 to 24 months prior to installation to allow time for design, testing, manufacturing, and delivery. Installation could begin as soon as the contractor completes the pumping plant shaft and erects the prefabricating building to create a weather tight space.

Pumping Plant Shaft

The contractor would construct the panel walls of the upper portion of the 110-foot-diameter pumping plant shaft that are located in soil using a hydro-mill and the slurry wall construction technique. All of the odd numbered walls panels would be constructed and socketed into bedrock first, followed by construction of each individual even numbered panel that would also be socketed into bedrock. At this point, the diaphragm wall would be complete and the shaft interior would be ready for excavation. The design team does not plan on lowering the groundwater table around the exterior of the pumping plant shaft. The contractor would then excavate the interior of the shaft from the top down with seepage water collected in internal sumps, pumped to the surface, treated, and released back into the reservoir. Any areas of excessive seepage through the 7-foot-thick concrete panel walls would be cut off either by hand packing or by the use of grout injection to provide a relatively water tight permanent shaft structure.

The contractor would then construct walls of the lower portion of the pumping plant shaft that are located within rock using the conventional drill and blast technique, essentially lining the bedrock portion of the shaft with a concrete lining. A crane would move blasting muck up and out through the upper portion of the shaft and trucks would haul it to the spoil disposal area. The contractor would install temporary support for rock faces until the permanent walls were constructed. The contractor would then form and cast interior reinforced concrete walls.

The contractor would form the hydraulic passageways from the tunnel access shaft to the vertical turbine pumps and place mass reinforced concrete. The contractor would position embedded piping and form second stage concrete block outs prior to placing the concrete in the lower portion of the pumping plant shaft. The contractor would position the embedded equipment and place second stage concrete. Following assembly of the prefabricated building on its foundation, the contractor would install or construct in the dry all internal features and systems, such as pumps, valves, piping, stairs, and the elevator shaft.

Tunnel Access Shaft

Prior to installation of the prefabricated building, the contractor would construct the 25-foot-diameter tunnel access shaft through the floor of the pumping plant shaft using conventional drill and blast construction techniques. The contractor would install temporary support for rock faces until the permanent walls were constructed. The contractor would then form and cast interior reinforced concrete walls. Muck from this excavation would be disposed of the same as the muck from the lower pumping plant shaft.

Intake Tunnel

The contractor would then excavate the intake tunnel using conventional drill and blast techniques, also prior to installation of the prefabricated building. Tunnel muck from this excavation would be disposed of the same as the muck from the lower pumping plant shaft. The contractor would install temporary support for rock faces until the permanent walls were constructed. The contractor would form and cast interior reinforced concrete walls or, if conditions were suitable, use shotcrete for permanent interior walls.

After the contractor installs the steel intake shaft and grouts the annular space, the contractor would complete mining of the tunnel toward the shaft and excavate to connect the shaft to the tunnel. Once the contractor reached the steel intake shaft the contractor would slowly drain the intake shaft into the tunnel. The contractor would then cut the shaft liner and install the welded steel tee and first section of the steel tunnel liner. Once the tunnel liner is complete, the contractor would attach the screened intake manifold, and remove the upper bulkhead.

The tunnel lining system would include welded steel pipe and cast-in-place concrete lining to ensure high reliability and low maintenance requirements for the intake tunnel. The final lining would consist of 100 feet of welded steel pipe, and the remainder would be cast-in-place concrete lining as illustrated on Drawing 1C-204. The cast-in-place concrete lining would be primarily unreinforced. However, the contractor would construct a 20-foot reinforced transition zone between the welded steel pipe and the unreinforced cast-in-place concrete lining to provide for a smooth transition of stresses between the two lining types.

Prefabricated Steel Building

The contractor would construct an independent foundation comprised of a spread footing and stem wall with integral column support pillars in an open excavation. The contractor would attach pre-engineered steel columns to the concrete support pillars and attach the building's steel framework to the steel columns. Steel trusses would span the columns and the metal roof attached to the trusses. The contractor would secure metal walls to the steel framework, yielding a fully enclosed, dry space in which to complete the balance of the pumping plant and its numerous ancillary systems. The contractor would install a 50 to 60 ton overhead travelling bridge crane that would be used to install the pumping plant equipment.

Building Electrical and Ancillary Systems

The contractor would install the electrical systems and building mechanical systems (including the HVAC, elevator, fire suppression, drainage, wastewater, and potable water systems) after the construction of the prefabricated steel building is complete. After completing the installation of major equipment and electrical systems, the contractor would then install the supervisory control and data acquisition (SCADA) system and instrument and control (I&C) features.

Surge Tank

The design team envisions the 110-foot-diameter surge tank to be an uncovered concrete tank constructed in an open excavation. The contractor would place a reinforced concrete ground slab first, and then form and cast the reinforced concrete sidewalls.

Pipeline

The buried, welded, bell and spigot, steel pipeline would be constructed using the open trench, cut and cover technique. Where the steel pipeline first leaves the pumping plant shaft and where the pipeline crosses through the left abutment of the dam, the required excavation depth is up to approximately 40 feet deep. Special trench excavation or shoring measures, or both, would be required in these deeper areas of excavation. This feature would be constructed using conventional construction equipment.

Concrete Outlet Works Structures

The contractor would construct concrete outlet structures in areas of excavation. The design team envisions these structures to have a reinforced concrete ground slab with reinforced concrete sidewalls. These features would be constructed using conventional construction equipment.

Substation

The substation is located adjacent to the pumping plant shaft and is an at-grade structure constructed on a flat bench. The contractor would place substation components, such as transformers and switchgear, on shallow, reinforced concrete foundations. The contractor would place other related equipment on steel structures, supported on reinforced concrete pads and stem-type foundations. These features would be constructed using conventional construction equipment.

Transmission Line

The proposed new transmission line would originate at PSE Intermountain transmission line at the downstream end of Lake Easton and extend approximately 3.15 miles to the pumping plant substation. This feature would be constructed using conventional construction equipment. A horizontal directional drill bore would be needed beneath the I-90 freeway and coordination with Washington State Department of Transportation would be undertaken.

During final design, Reclamation would determine the route for a new transmission line and evaluate easement needs. Note that the estimated construction time presented in this report does not include the easement acquisition period.

16.3.2 Alternative 2 – South Pumping Plant

Jet Grouted Block

The contractor would perform jet-grout block construction as marine work at the intake to receive the tunnel. The contractor would construct a jet-grouted block at the location where the Alternative 2 TBM driven tunnel would leave soil having a blow count equal to or greater than 10. A barge mounted drill rig that would drill into the soil while simultaneously injecting cementatious grout into the ground creating a jet grouted block. Following construction of the jet-grouted block, the contractor would dredge an irregularly shaped area centered about the centerline of the tunnel alignment for the full length of the intake channel. Prior to dredging, the contractor would hang a turbidity curtain from moored buoys. Deeper dredging immediately in front of the jet-grouted block would create an excavated area for tremie placement of a foundation slab that would support the docking sleeve and the fish screens. The design team plans a hydraulic jetting dredge, sometimes called an “air-lift” dredge, for use with the dredged spoils being side cast onto the floor of the reservoir. Divers would be required to inspect the finished jet grouted block.

Docking Sleeve

The contractor would perform docking sleeve installation as marine work. An offsite shop would fabricate the docking sleeve and truck it in pieces to the construction basin and boat launch for assembly. Following assembly, the contractor would float the docking sleeve out to position it above its final installation location immediately in front of the jet-grouted block. Once positioned on the floor on its foundation slab, the contractor would completely fill the docking sleeve with tremie placed concrete. The docking sleeve would become the termination point for the tunnel and the attachment point for the fish screen structure. Divers would be required to inspect the finished docking sleeve.

Fish Screens

The contractor would perform fish screen installation as marine work. After delivery to the site from a fabrication shop, individual sections of the prefabricated fish screens would be barged to a position immediately in front of the docking sleeve, lowered into position, and bolted into place by divers. Power supply to the motor operated screen cleaners would originate at the pumping plant. The contractor would bury it at a shallow depth from its origin out to about El. 2,190, where it would lay on the floor of the reservoir for its final run to the fish screens.

Surge Tank Shaft

The walls of the 50-foot-diameter uncovered surge tank shaft are located in soil and the contractor would construct them using a hydro mill and the slurry wall construction technique. The contractor would construct all of the odd numbered walls panels first, followed by construction of each individual even numbered panel. At this point, the diaphragm wall is complete and the shaft interior would be ready for excavation. The design team plans no lowering of the groundwater table on the exterior of the surge tank shaft. The contractor would excavate the interior of the shaft from the top down, with seepage water collected in internal sumps pumped to the surface, treated, and released back into the reservoir. Any areas of excessive seepage through the 5-foot-thick concrete walls would be cut off either by hand packing or by the use of grout injection to provide a relatively water tight permanent structure. The surge tank shaft would serve as the launching point for the TBM constructed tunnel out to the intake.

Pumping Plant Shaft

The contractor would construct the walls of the 110-foot-diameter pumping plant shaft located in soil using a hydro-mill and the slurry wall construction technique. The contractor would construct the odd numbered walls panels first, followed by construction of each individual even numbered panel. At this point, the diaphragm wall is complete and the shaft interior is ready for excavation. The contractor would excavate the interior of the shaft from the top down with seepage water collected in internal sumps, pumped to the surface, treated, and released back into the reservoir. Any areas of excessive seepage through the 5-foot-thick concrete walls would be cut off either by hand packing or by the use of grout injection to provide a relatively water tight permanent structure. The contractor would form the hydraulic passageways from the tunnel to the vertical turbine pumps and place mass reinforced concrete. The contractor would position the embedded piping and form second stage concrete block outs prior to placing the concrete in the lower portion of the pumping plant shaft. The contractor would position the embedded equipment and place second stage concrete. Following assembly of the prefabricated building on its foundation, the contractor would install or construct in the dry internal features and systems, such as pumps, valves, piping, stairs, and the elevator.

Intake Tunnel

The contractor would drive the intake tunnel for Alternative 2 from the surge tank shaft to the docking sleeve. The design team envisions use of an Earth Pressure Balance TBM to construct the tunnel. The contractor would move tunnel muck from the face of the tunnel to the surge tank shaft, bring it to the surface, and haul it to the spoils disposal area. The TBM would excavate the tunnel and install the permanent precast concrete tunnel lining as it advances. Following completion of construction of the pumping plant shaft, the contractor would construct the short section of the intake tunnel from the surge tank shaft to the pumping plant shaft using a currently undefined, but conventional tunneling methods.

Prefabricated Steel Building

See Section 16.3.1, Prefabricated Steel Building.

Building Electrical and Ancillary Systems

See Section 16.3.1, Building Electrical and Ancillary Systems.

Substation

The substation is located adjacent to and slightly above the pumping plant shaft and is an at-grade structure constructed on a flat bench. The contractor would place substation components, such as transformers and switchgear, on shallow reinforced concrete foundations. The contractor would place other related equipment on steel structures, supported on reinforced concrete pads and stem-type foundations. These features would be constructed using conventional construction equipment. Due to the elevation difference and relatively steep slope that would exist between the substation and the pumping plant location, utilization of a directional drill installation of casing to carry transmission and communication lines may be required.

Transmission Line

The proposed new transmission line would originate at PSE Intermountain transmission line at the downstream end of Lake Easton and extend approximately 1.5 miles to the pumping plant substation. This feature would be constructed using conventional construction equipment. A horizontal directional drill bore would be needed beneath the I-90 freeway and coordination with Washington State Department of Transportation would be undertaken.

During final design, Reclamation would determine the route for a new transmission line and evaluate easement needs. Note that the estimated construction time presented in this report does not include the easement acquisition period.

16.4 Construction Sequence and Duration

Table 17 provides a possible sequence of construction activities and their individual likely durations for Alternative 1, the East Shore Pumping Plant. This information should be reviewed prior to final design, for changes related to the updated 2017 configuration of power supply and fish passage improvements at the Narrows.

Table 17. Construction Activities for Alternative 1 – East Shore Pumping Plant

Alternative 1 – East Shore Pumping Plant Temporary Construction Features and Permanent Project Features	Approximate Construction Duration (Months)
TESC, Clearing & Grading	2
Construction Access Roads and Site Security	2
Construction Parking, Administration Offices and Staging Areas	2
Concrete Batch Plant and Material Stockpile Area	2
Construction Basin and Boat Launch Area	2
Temporary Construction Power Supply/Generators	1
Construction Spoils Disposal Area	2
Intake Shaft and Dredging	6
Fish Screens	2
Pumping Plant Shaft	12
Tunnel Access Shaft	3
Intake Tunnel	4
Prefabricated Steel Building	4
Building Electrical and Ancillary Systems	3
Install Pumps and Other Equipment	3
SCADA and I&C	3
Testing and Start-up	6
Surge Tank	6
Pipeline	10
Concrete Outlet Works Structures	6
Substation	3
Transmission Line	6
Restoration	3

Table 18 provides a possible sequence of construction activities and their individual likely durations for Alternative 2, the South Pumping Plant. This information should be reviewed prior to final design, for changes related to the updated 2017 configuration of power supply and fish passage improvements at the Narrows.

Table 18. Construction Activities for Alternative 2 – South Pumping Plant

Alternative 2 – South Pumping Plant Temporary Construction Features and Permanent Project Features	Approximate Construction Duration (Months)
TESC, Clearing & Grading	2
Construction Access Roads and Site Security	2
Construction Parking, Administration Offices and Staging Areas	2
Concrete Batch Plant and Material Stockpile Area	2
Construction Basin and Boat Launch Area	2
Temporary Construction Power Supply/Generators	1
Construction Spoils Disposal Area	2
Jet Grouted Block	2
Docking Sleeve and Dredging	6
Fish Screens	2
Surge Tank Shaft	12
Pumping Plant Shaft	12
Intake Tunnel and Tunnel between Shafts	12
Prefabricated Steel Building	4
Building Electrical and Ancillary Systems	3
Install Pumps and Other Equipment	3
SCADA and I&C	3
Testing and Start-up	6
Substation	3
Transmission Line	6
Restoration	3

16.5 Construction Schedule

Using the construction sequence and durations developed in Section 16.4, Construction Sequence and Duration, the design team prepared a Microsoft Project® construction schedule for Alternative 1 (Figure 12) and Alternative 2 (Figure 13). The construction schedule presents a possible construction sequence and duration, while allowing for concurrent construction activities to occur where possible. It is possible that durations would be longer if site access were restricted due to winter conditions or congestion during peak construction periods. Reclamation would develop a more detailed construction schedule and sequence during final design. This should include any changes related to the updated 2017 configuration of power supply and fish passage improvements at the Narrows.

Kachess Drought Relief Pumping Plant (KDRPP) Project

Preliminary Construction Schedule - September 22, 2014 DRAFT

Alternative 1: East Shore Pumping Plant

ID	Task Name	Duration	Start	Finish
1	Award/NTP	0 days	Thu 1/1/15	Thu 1/1/15
2	Submittals	18 mons	Thu 2/26/15	Wed 7/13/16
3	Permitting	3 mons	Thu 1/1/15	Wed 3/25/15
4	Mobilization	1 mon	Thu 3/26/15	Wed 4/22/15
5	TESC, Clearing & Grading	2 mons	Thu 4/23/15	Wed 6/17/15
6	Construction Access Roads, Site Security	2 mons	Thu 6/18/15	Wed 8/12/15
7	Construction Parking, Admin. Office, Staging Area	2 mons	Thu 8/13/15	Wed 10/7/15
8	Construction Basin and Boat Launch Area	2 mons	Thu 8/13/15	Wed 10/7/15
9	Temp. Construction Power Supply/Generators	1 mon	Thu 8/13/15	Wed 9/9/15
10	Concrete Batch Plant and Stockpile Area	2 mons	Thu 8/13/15	Wed 10/7/15
11	Spoil Disposal Area	2 mons	Thu 8/13/15	Wed 10/7/15
12	Pumping Plant Shaft	12 mons	Thu 10/8/15	Wed 9/7/16
13	Tunnel Access Shaft	2 mons	Thu 9/8/16	Wed 11/2/16
14	Intake Tunnel	4 mons	Thu 11/3/16	Wed 2/22/17
15	Intake Shaft & Dredging	6 mons	Fri 1/1/16	Thu 6/16/16
16	Fish Screens	3 mons	Fri 6/17/16	Thu 9/8/16
17	Prefabricated Steel Building	4 mons	Thu 2/23/17	Wed 6/14/17
18	Building Electrical, HVAC, Ancillary Systems	3 mons	Thu 2/23/17	Wed 5/17/17
19	Install Pumps & Other Equipment	3 mons	Thu 5/18/17	Wed 8/9/17
20	SCADA and I&C	3 mons	Thu 5/18/17	Wed 8/9/17
21	Testing and Start-up	6 mons	Thu 8/10/17	Wed 1/24/18
22	Pipeline (Construction Season 1)	5 mons	Tue 9/1/15	Mon 1/18/16
23	Pipeline (Construction Season 2)	5 mons	Tue 8/30/16	Mon 1/16/17
24	Surge Tank	6 mons	Fri 4/1/16	Thu 9/15/16
25	Concrete Outlet Works Structures	8 mons	Tue 3/1/16	Mon 10/10/16
26	Transmission Line	12 mons	Fri 1/1/16	Thu 12/1/16
27	Electrical Substation	3 mons	Wed 6/1/16	Tue 8/23/16
28	Restoration	3 mons	Thu 11/2/17	Wed 1/24/18

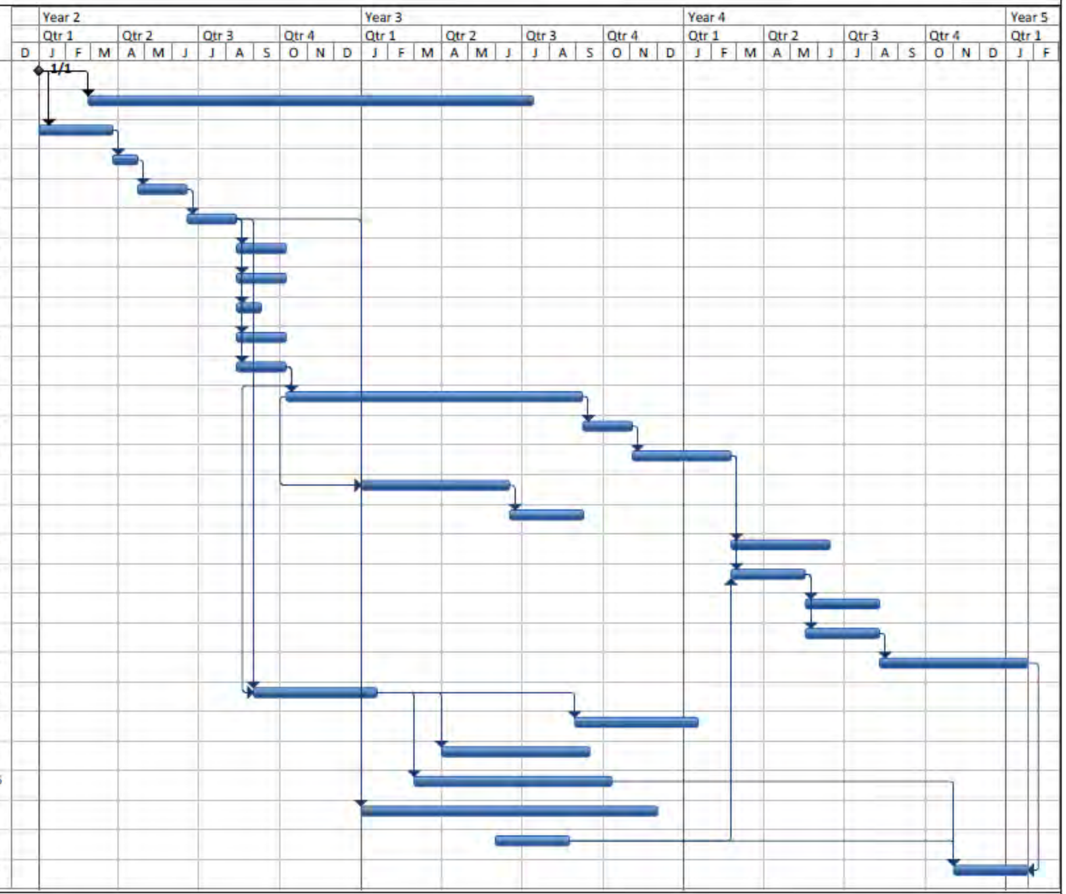


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Figure 12. Preliminary Construction Schedule- Alternative 1 East Shore Pumping Plant

Kachess Drought Relief Pumping Plant (KDRPP) Project
Preliminary Construction Schedule - September 22, 2014 DRAFT
Alternative 2: South Pumping Plant

ID	Task Name	Duration	Start	Finish
1	Award/NTP	0 days	Thu 1/1/15	Thu 1/1/15
2	Submittals	18 mons	Thu 2/26/15	Wed 7/13/16
3	Permitting	3 mons	Thu 1/1/15	Wed 3/25/15
4	Mobilization	1 mon	Thu 3/26/15	Wed 4/22/15
5	TESC, Clearing & Grading	2 mons	Thu 4/23/15	Wed 6/17/15
6	Construction Access Roads, Site Security	2 mons	Thu 6/18/15	Wed 8/12/15
7	Construction Parking, Admin. Office, Staging Area	2 mons	Thu 8/13/15	Wed 10/7/15
8	Construction Basin and Boat Launch Area	2 mons	Thu 8/13/15	Wed 10/7/15
9	Temp. Construction Power Supply/Generators	1 mon	Thu 8/13/15	Wed 9/9/15
10	Concrete Batch Plant and Stockpile Area	2 mons	Thu 8/13/15	Wed 10/7/15
11	Spoil Disposal Area	2 mons	Thu 8/13/15	Wed 10/7/15
12	Jet Grout Block	2 mons	Thu 10/8/15	Wed 12/2/15
13	Docking Sleeve and Dredging	6 mons	Thu 12/3/15	Wed 5/18/16
14	Fish Screens	3 mons	Thu 5/19/16	Wed 8/10/16
15	Surge Tank Shaft	8 mons	Thu 10/8/15	Wed 5/18/16
16	Intake Tunnel (from Surge Tank to Docking Sleeve)	10 mons	Thu 5/19/16	Wed 2/22/17
17	Pumping Plant Shaft	12 mons	Mon 3/21/16	Fri 2/17/17
18	Intake Tunnel (from Surge Tank to Pumping Plant Shaft)	2 mons	Thu 2/23/17	Wed 4/19/17
19	Prefabricated Steel Building	4 mons	Thu 4/20/17	Wed 8/9/17
20	Building Electrical, HVAC, Ancillary Systems	3 mons	Thu 8/10/17	Wed 11/1/17
21	Install Pumps & Other Equipment	3 mons	Thu 11/2/17	Wed 1/24/18
22	SCADA and I&C	3 mons	Thu 11/2/17	Wed 1/24/18
23	Testing and Start-up	6 mons	Thu 1/25/18	Wed 7/11/18
24	Transmission Line	12 mons	Fri 1/1/16	Thu 12/1/16
25	Electrical Substation	3 mons	Fri 12/2/16	Thu 2/23/17
26	Concrete Outlet Works Structures	6 mons	Mon 4/24/17	Fri 10/6/17
27	Restoration	3 mons	Thu 4/19/18	Wed 7/11/18

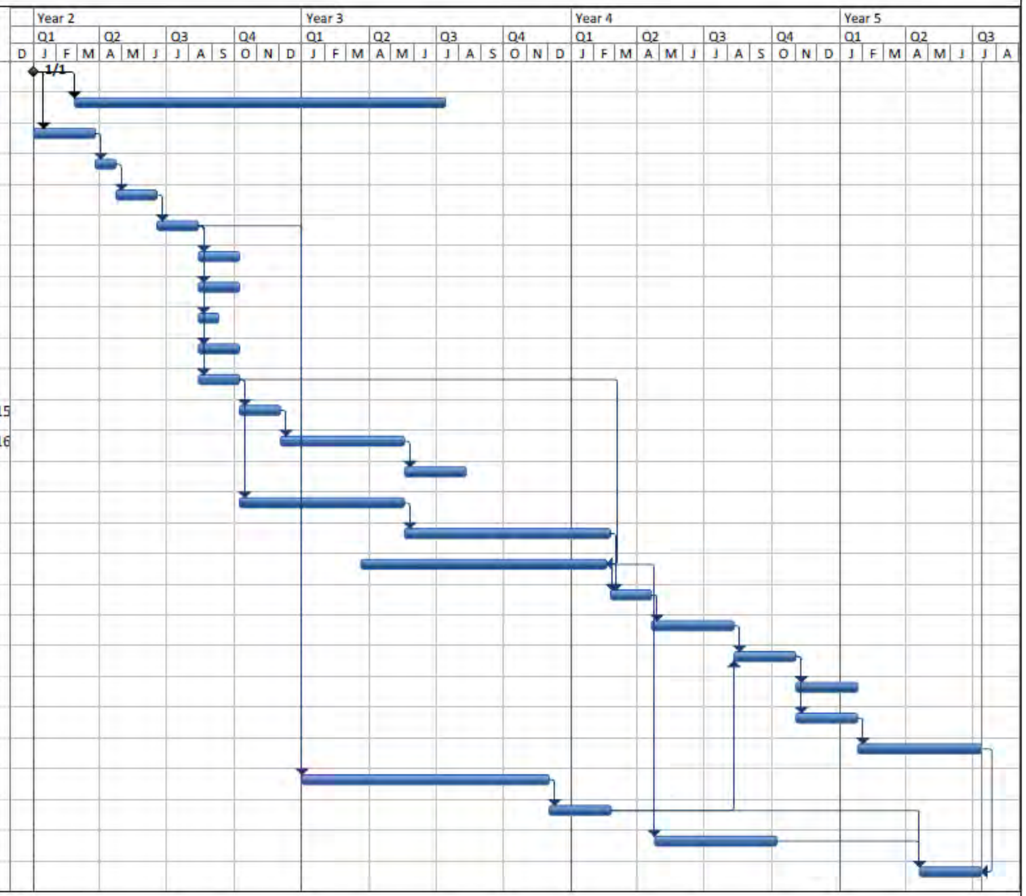

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Figure 13. Preliminary Construction Schedule- Alternative 2 South Pumping Plant

17.0 Field Cost Estimate

The design team developed a field cost estimate of the KDRPP. The following subsections summarize the field cost estimate approach and results. The *Field Cost Estimate* technical memorandum provides further detail on the field cost estimate methodology, inputs, and assumptions (Reclamation and Ecology, 2015b). Information in this section does not reflect the change in power supply configuration developed in 2017, nor the addition of proposed fish passage improvements at the Narrows.

17.1 Field Cost Estimating Approach

Development of feasibility-level field cost estimates for the KDRPP complied with the following sections of the Reclamation Manual:

- FAC P09, Policy
- FAC 09-01, Cost Estimating
- FAC 09-02, Construction Cost Estimates and Project Cost Estimates

(The Reclamation Manual provides policies, directives, and standards for Reclamation activities. The "FAC" series is for project planning activities.)

The design team developed the field cost estimates using a combination of stochastic and deterministic methodologies, whichever was the most appropriate for each aspect of the project. "Stochastic methodology" involves estimation-based variables, such as total cost per unit of storage or flow, based on similar projects constructed elsewhere with appropriate adjustments for location and time. "Deterministic methodology" involves calculations from definable project information that is typically available when a project feature has been described to at least an appraisal level of design and to the point where specific quantities may be estimated (e.g., reinforced concrete walls) and costs determined by using database or forecast unit prices (e.g., price per cubic yard) for the quantities estimated. A few of the project features lacked sufficient information for either method of estimating. In these cases, an allowance was included based on the best available data.

The cost estimating team's approach was to quantify the work to the greatest extent possible from either existing design documents, standard designs for similar work, or supplemental drawings provided by the HDR design team to provide a mix of deterministic and stochastic methodologies.

The cost estimating team used the following procedures, tools, and database to develop these field cost estimates:

1. The estimating team reviewed the existing design documents, drawings, photos, and design reports in sufficient depth to have an understanding of the feature characteristics of the proposed alternatives and developed questions for the design team.

2. The design team and estimating team discussed the project features. The pay items for each project comply with the Reclamation Uniform Classification Accounts Pay Items.
3. The estimating team then quantified and estimated the work in Sage Estimating Extended software using the latest RS Means Construction Cost database, supplemented by work items developed by HDR for items not included in the RS Means database. The RS Means Database contains over 75,000 individual unit prices updated quarterly. The basis of the labor costs are wages for 46 building trades in 314 major cities in North America. The bases of the cost for the estimate are indices for 989 zip code locations.
4. Upon completion of the estimating process, the estimating team distributed draft reports for quality control to design staff reviewers and an independent HDR peer reviewer. The estimating team then revised the draft field cost estimates based on the quality control comments received from these reviewers.

Table 19 is a summary of the markup percentages used in each field cost estimate. The estimating team examined Reclamation documents and previous estimates for project-by-project features and combined them with the estimating team's experience for this type of work to select appropriate markup percentages for each of the following components:

Table 19. Summary of Markup Percentages

Indirect Cost Element	Percentage
Contractors Field Overhead	12.00
Prime Contractor Mobilization/Demobilization Cost	3.00
Unlisted Minor Items	4.00
Design and Scope Changes Minor	4.00
Cost Refinements Minor	2.00
Contractor's Bonds and Insurance Cost	1.50
Contractor's Fee	12.00
Construction contingencies (includes overruns on quantities, quantity gap, FTE minimal work hours adjustments, etc.)	25.00
Escalation to the Midpoint of Construction (anticipate 2nd Qtr 2017	6.05
Sales Tax Estimate	8.20
Gross Receipts Tax	0.484

Based on the nature and size of the work, the estimating team did not include any markup percentage for procurement strategy, but rather elected to base each estimate on an open competition, sealed bid procurement strategy. The estimating team added Washington State Sales tax of 8.2 percent and Gross Receipts Tax (GRT) of 0.484 percent for the project area. Estimated costs are in 2014 dollars (second quarter). Construction cost indexing to the midpoint of construction was not included since the design team had not established a construction timeframe at the time these field cost estimates were prepared.

17.2 Tunnel and Shaft Cost Estimates by Jacobs Associates

HDR retained Jacobs Associates to prepare an independent cost estimate for tunnel and shaft construction for both alternatives for the following reasons:

- To secure cost estimates from a firm that specializes in the design of these types of underground construction features
- To secure an independent cost estimate as a check of the numbers generated by HDR internal cost estimates
- To secure review comments on HDR design of these specialized underground construction features

The independent cost estimates prepared by Jacobs Associates are contained in Appendix C of the *Field Cost Estimate Technical Memorandum* (Reclamation and Ecology, 2015b). The independent cost estimates prepared by Jacobs Associates compare quite well on a bottom line basis with the estimates prepared by HDR's internal cost estimators. Jacobs Associates did not have any specific comments on HDR's design of these features.

17.3 Specialty Item Quotes

Manufacturers and suppliers provided quotes for the following specialty items to inform the field cost estimates:

- Drought Relief Pumps
- Large variable frequency drive (VFD)
- Ball and Large Butterfly Valves
- Plug and Check Valve
- Pumping Plant Steel Pipe (within Building)
- Pipeline Steel Pipe (Alternative 1- East Shore Pumping Plant)
- Gate & Check Valves
- Flowmeters
- Fish Screens
- Fish Flow-Unwatering-Drainage Pumps
- Elevator
- Bridge Crane
- Bonneted Gates

The estimating team used an Opinion of Probable Construction Cost from a similar sized project to verify projected costs and production rates. The estimating team drew upon Gregg Sherry, Brierley Associates, to review and comment on tunneling, shaft, and marine work costs. The estimating team drew upon Dan Hertel, P.E., Engineering Solutions, LLC, to review and comment on the heavy civil construction and for overall completeness and quality of the cost estimates.

Appendix E of the *Field Cost Estimate* technical memorandum includes cost details for select specialty project features. Appendix F of the *Field Cost Estimate* technical memorandum includes quotes from equipment supplier (Reclamation and Ecology, 2015b).

17.4 Summary of Results

Table 20. Field Cost Estimate for KDRPP Alternatives

	Project Components[1]	Alternative 1 (in millions $$)	Alternative 2 (in millions $$)
01	Site Work	$ 1.74	$ 1.44
02	Fish Screens	$ 2.89	$ 3.59
03	Surge Tank (Alt 1)	$ 6.55	$ -
03	Surge Tank Shaft (Alt 2)	$ -	$ 12.43
04	Tunnel Access Shaft, Tunnel & Intake Shaft (Alt 1)	$ 8.88	$ -
04	Tunnel & Docking Station (Alt 2)	$ -	$ 41.09
05	Pumping Plant Shaft	$ 31.47	$ 22.08
06	Drought Relief Pumping Units	$ 40.69	$ 35.68
07	Ancillary Systems	$ 22.70	$ 21.32
08	Building	$ 11.31	$ 11.83
09	Pipeline (Alt 1 only)	$ 20.91	$ -
10	Outlet Works	$ 0.90	$ 0.89
11	Electrical	$ 13.30	$ 10.57
12	Instrumentation & Controls	$ 0.68	$ 0.94
13	Power Supply[1]	$ 8.16	$ 7.05
	Materials & Labor Cost Subtotal	$ 170.19	$ 168.91
	Contractors Field Overhead (12%) / Mobilization - Demobilization (3%)	$ 25.53	$ 25.34
	Estimated State Sales Tax (8.2%)	$ 11.59	$ 12.02
	Subtotal	$ 207.31	$ 206.26
	Unlisted Items (4%), Scope Changes (4%), Cost Refinement (2%)	$ 20.73	$ 20.63
	Subtotal	$ 228.05	$ 226.89
	Contractor Fee (12%)	$ 27.37	$ 27.23
	Contract Cost Subtotal	$ 255.41	$ 254.12
	Undefined Scope of Work (SOW) Contingency (25%)[2]	$ 57.01	$ 56.72
	Escalation to the Midpoint of Construction (6.05%)[2]	$ 13.80	$ 13.73

Project Components[1]	Alternative 1 (in millions $$)		Alternative 2 (in millions $$)	
Subtotal	$	326.22	$	324.57
Bond & Insurance (1.5%)	$	4.89	$	4.87
Estimated Gross Receipts Tax (0.484%)	$	1.60	$	1.59
Subtotal	$	332.72	$	331.03
Field Cost Total	$	332.72	$	331.03
Forecast Field Cost Low (-15%)	$	282.81	$	281.37
Forecast Field Cost High (+30%)	$	432.53	$	430.34

1 Costs do not reflect updated power supply design or fish passage at the Narrows, developed in 2017
2 Contingency and Escalation costs are calculated from the Unlisted Items, Scope Changes, Cost Refinement Subtotal.

18.0 Information Required for Final Design

This section summarizes information required for final design. The design team identified these items during the feasibility-level study and the design, estimating, and construction review process to document potential risks and uncertainties associated with the KDRPP. (Reclamation and Ecology, 2014 b-l; Reclamation and Ecology, 2015 a-b; Reclamation, 2014). Note this section does not provide a comprehensive listing of information required prior to final design. Reclamation would identify any additional information requirements after selecting the preferred alternative and prior to initiating the final design phase.

18.1 Surveying and Base Map Preparation

- Conduct a surface survey of the KDRPP site and prepare base maps to inform final design, contract documents, and permit and real estate acquisition.
- Conduct a bathymetric survey in areas of the KDRPP site where the contractor would perform underwater work including, but not limited to, the marina and dock, intake and fish screen, tunnel, and stilling basin construction.

18.2 Geotechnical Exploration, Testing and Analysis

- Perform comprehensive geotechnical exploration, testing, and analysis for the selected alternative. Identify all geotechnical data needs for final design and determine the means of construction.

18.3 Civil and Site Elements

- Verify shoreline setback requirements.
- Determine if an internal governmental agreement would be necessary for access and utility permits.
- Verify fire apparatus access requirements.
- Determine the maximum weight of trucks accessing the facility.

- Determine if paving of steeper roads would be necessary.
- Verify flow control requirements.
- Investigate the impacts of Ecology's decisions regarding permit-exempt well groundwater use.
- Verify water amenities and septic tank capacity.
- Determine if protection or relocation of existing dam safety, seepage, monitoring, and measuring facilities would be necessary.
- Determine the temporary construction access road route.

18.4 Hydraulic Data and Analyses

- Complete the discharge pool tailwater rating curve for the existing discharge pool.
- Analyze (HEC-RAS Backwater Analysis) the water surface elevation in the existing discharge pool relative to the maximum total releases from Kachess Reservoir to determine the maximum high water elevation that can occur in this pool. Based on results, determine if flooding could occur in the vicinity of the KDRPP features.
- Expand on and update the transient analysis to provide appropriate hydraulic transient protection for the entire pumping system from intake to discharge.
- Assign a laboratory to conduct a detailed physical model for the pumping unit selected for final design. Confirm the desired performance characteristics of the pumping unit and its associated piping, metering, and valve configuration. Using a hydraulic model study, evaluate if surface and submerged vortices, pre-swirl, non-uniform distribution of velocity, or entrained air bubbles could become an issue during operation.

18.5 Corrosion and High Voltage Study

- Perform an analysis of soil corrosion potential for areas where the KDRPP would have buried metal features and design appropriate cathodic protection to protect these buried features.
- Evaluate the potential for the existing Bonneville Power Administration high voltage lines located near the discharge pool to adversely affect project features or to be a danger to construction and operator personnel. If necessary, develop appropriate mitigation measures.

18.6 Power Supply Analysis

- Further consideration may be needed to fully integrate the new 2017 power supply configuration with the 2015 Alternative 1 design and equipment requirements, and to advance the design of these features.

18.7 Pumping Unit Analyses

- Determine wear factor requirements for pumping units. Wear factor requirements would allow for expected equipment wear by requiring that the pumping units be oversized or allowing over speeding of the pumping units with the VFD.
- Determine if a spare pumping unit would be required. Significant costs are associated with the provision of the spare pumping unit.
- Establish if extended operations at plant flows other than 1,000 cfs are required.
- Evaluate the use of variable frequency drives versus pump control valves, including comparison of capital, operation, and maintenance costs.
- Evaluate the back pressure on butterfly valves to ensure they would not cavitate.
- Consider using a throttling valve near the pipe discharge to control the pump operational point. Ensure that throttling valves would operate in a cavitation free zone.
- Investigate details of VFD and pump control valve settings and operating restrictions for the control system.
- Identify the procurement strategy for the pumping units early on in the development of the project, and align this strategy with the schedule for the civil and structural design elements.

18.8 Ancillary Systems Analysis

- Coordinate the minimum required fish flow pumping capacity with environmental requirements.
- Determine operational requirements for fish flow pumps with respect to required heads and discharges.
- Determine the requirement for fish flow capability when the reservoir pool level is above the elevation of the gravity outlet works.
- Investigate Kachess Reservoir drawdown during fish flow pumping to ensure sufficient water volume is available and that the net positive suction head on the pump is available.

18.9 Electrical Control System Analysis

- Determine if reduced voltage soft starters in lieu of VFDs could operate two of the four drought relief pumps.
- Perform a value engineering analysis to determine if use of fans or other means could limit moisture build up and condensation inside the substation transformers during non-use periods.

18.10 Fish Passage Analysis

- Further information (i.e. geotechnical investigations) are needed to complete the design of fish passage improvements at the Narrows.

18.11 Construction Schedule

Develop a reservoir operation and management plan for use during construction.

18.12 Environmental Compliance

Reclamation and Ecology prepared the DEIS for the KDRPP project in January 2015 Reclamation and Ecology are preparing the Supplemental Draft Environmental Impact Statement (SDEIS) to examine changes to the proposed action and alternatives described in the DEIS. Reclamation and Ecology are jointly leading and preparing the SDEIS as a combined NEPA and State Environmental Policy Act (SEPA) document.

The KDRPP and KKC SDEIS will evaluate environmental considerations and potential impacts of the project on elements of the environment, including but not limited to air, soil, water resources, aesthetic values, cultural resources, wildlife, and vegetation. The SDEIS provides further details on the environmental considerations, analyses, and information needed as the design advances beyond the feasibility-level

19.0 Comparison of Alternatives

Reclamation will postpone selection of a preferred alternative for the KDRPP pending completion of the NEPA process.

Reclamation does not envision the KDRPP as a stand-alone project, but rather as one component of the overall Integrated Plan. Therefore, Reclamation will continue to consider KDRPP for advancement as a component of the larger Integrated Plan.

Table 21 provides a summary of the differences between the Alternative 1 and Alternative 2 significant project features.

Table 21. Comparison of East Shore Pumping Plant and South Pumping Plant

Project Feature	Alternative 1- East Shore Pumping Plant	Alternative 2- South Pumping Plant	Advantages and Disadvantages
Fish Screens	Vertical Orientation	Horizontal Orientation	The lake bed power supply cable to the motor operated screen cleaners would be approximately 2,475 feet longer for Alternative 2.
Inlet Shaft	25-foot diameter, 52-foot tall	None	Alternative 1 would require a inlet shaft to connect the pumping plant shaft to the tunnel.
Docking Sleeve	None	38-foot by 40-foot by 42-foot concrete	Alternative 1 would not require a docking sleeve. For Alternative 2, the docking sleeve provides a location for the tunnel boring machine (TBM) to drive into and park. The docking sleeve would become the termination point for the tunnel and the attachment point for the fish screen structure.
Tunnel	Mined in rock, 711-foot long	Bored in soil, 3,275-foot long	There is limited geotechnical information available for Alternative 2. More information would be required to determine any specific advantages or disadvantages for that alignment.
Surge Tank	110-foot diameter, 43-foot deep	50-foot diameter, 200-foot deep	Alternative 2 would be more complex and take twice as long to construct.
Pumping Plant Shaft	110-foot diameter, 215-foot deep, 7-foot wall thickness	110-foot diameter, 145-foot deep, 5-foot wall thickness	The Alternative 1 pumping plant shaft would be approximately 70 feet deeper. Due to the location of the pumping plant, Alternative 1 would have greater visual impacts and may require additional property easements or acquisitions.
Power Transmission Line	~ 3.2 Miles	~ 1.7 Miles	Alternative 1 and 2 could potentially use the same power supply configuration as developed for the floating pumping plant alternative in 2017. However, the power transmission line for Alternative 1 would be approximately 1.5 miles longer than for Alternative 2 or the floating pumping plant alternative.
Drought Relief Pumps	10,000 HP each, (4 pumps) at 333 cfs, Vertical Turbine Pumps	6,000 HP each, (4 pumps) at 333 cfs, Vertical Turbine Pumps	Alternative 2 would have a smaller sized transformer since the pumping units require less power to operate. This alternative would have lower power costs.
Variable Frequency Drives	Yes	Yes	This feature is the same for both alternatives.
Throttling Valves	No	Yes	The design of Alternative 2 is more complex due to the wider range of total dynamic heads and requires throttling valves to operate at the lowest total dynamic head.
Pump Control Valves	Yes	Yes	This feature is the same for both alternatives.
Pump Discharge Pipes	Manifold into one 136-inch diameter pipe	Four separate 84-inch diameter pipes	The design of Alternative 2 is more complex due to the wider range of total dynamic heads and therefore requires four separate discharge pipes to operate at the lowest total dynamic head.
Pipeline	7,755 feet, 136-inch diameter steel pipe	None	The Alternative 1 would include additional pipeline maintenance requirements.

Project Feature	Alternative 1- East Shore Pumping Plant	Alternative 2- South Pumping Plant	Advantages and Disadvantages
Spillway & Stilling Basin	Yes	None	The Alternative 1 would have some minor additional maintenance requirements associated with the spillway and stilling basin.
Discharge Structure	Yes	Yes	This feature is the same for both alternatives.
Local Impacts during Construction	Potential traffic and cultural resources impacts		Alternative 2 would have less noise disturbance during construction.
Field Cost Estimate	$333 million	$331 million	Alternatives 1 and 2 are approximately equal in cost.

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Reclamation and Ecology, 2012d	Bureau of Reclamation and Washington State Department of Ecology. 2014. *Yakima River Basin Integrated Water Resource Management Plan, Framework for Implementation Report.* Prepared by HDR Engineering, Inc., Anchor QEA, ECONorthwest, Natural Resource Economics, and ESA, for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. 08CA10677A ID/IQ. October 2012.
Reclamation and Ecology, 2014a	Bureau of Reclamation and Washington State Department of Ecology. 2014. *Hydrologic Modeling of System Improvements, Phase 1 Report*. Technical Memorandum. Prepared by HDR Engineering, Inc., for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. R13PC10006 ID/IQ. November.
Reclamation and Ecology, 2014b	Bureau of Reclamation and Washington State Department of Ecology. 2014. *Kachess Drought Relief Pumping Plant Project–Ancillary Systems Analysis*. Technical Memorandum. Prepared by HDR Engineering, Inc., for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. R13PC10006 ID/IQ, September.

Reclamation and Ecology, 2014c	Bureau of Reclamation and Washington State Department of Ecology. 2014. *Kachess Drought Relief Pumping Plant Project – Civil and Site Elements*. Technical Memorandum. Prepared by HDR Engineering, Inc., for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. R13PC10006 ID/IQ, September.
Reclamation, 2017	Bureau of Reclamation. 2017. *Appraisal Design Report, Kachess Drought Relief Pumping Plant, Floating Pumping Plant Alternative*. Prepared by HDR Engineering et al. for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. R13PC10006 ID/IQ. December.
Reclamation and Ecology, 2014d	Bureau of Reclamation and Washington State Department of Ecology. 2014. *Kachess Drought Relief Pumping Plant Project– East Shore Pumping Plant- Pipeline Analysis*. Technical Memorandum. Prepared by HDR Engineering, Inc., for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. R13PC10006 ID/IQ, September.
Reclamation and Ecology, 2014e	Bureau of Reclamation and Washington State Department of Ecology. 2014. *Kachess Drought Relief Pumping Plant Project – Electrical System Analysis*. Technical Memorandum. Prepared by HDR Engineering, Inc., for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. R13PC10006 ID/IQ, September.
Reclamation and Ecology, 2014f	Bureau of Reclamation and Washington State Department of Ecology. 2014. *Kachess Drought Relief Pumping Plant Project – Geotechnical Analysis*. Technical Memorandum. Prepared by HDR Engineering, Inc., for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. R13PC10006 ID/IQ, September.
Reclamation and Ecology, 2014g	Bureau of Reclamation and Washington State Department of Ecology. 2014. *Kachess Drought Relief Pumping Plant Project – Hydraulics Analysis*. Technical Memorandum. Prepared by HDR Engineering, Inc., for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. R13PC10006 ID/IQ, September.
Reclamation and Ecology, 2014h	Bureau of Reclamation and Washington State Department of Ecology. 2014. *Kachess Drought Relief Pumping Plant Project– Intake and Fish Screen Analysis*. Technical Memorandum. Prepared by HDR Engineering, Inc., for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. R13PC10006 ID/IQ, September.

Reclamation and Ecology, 2014i	Bureau of Reclamation and Washington State Department of Ecology. 2014. *Kachess Drought Relief Pumping Plant– Power Supply Analysis*. Technical Memorandum. Prepared by HDR Engineering, Inc., for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. R13PC10006 ID/IQ. September.
Reclamation and Ecology, 2014j	Bureau of Reclamation and Washington State Department of Ecology. 2014. *Kachess Drought Relief Pumping Plant– Prior Geotechnical Data for Alternative 2*. Technical Memorandum. Prepared by HDR Engineering, Inc., for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. R13PC10006 ID/IQ. September.
Reclamation and Ecology, 2014k	Bureau of Reclamation and Washington State Department of Ecology. 2014. *Kachess Drought Relief Pumping Plant– Pumping Plant Shaft Structural Analysis*. Technical Memorandum. Prepared by HDR Engineering, Inc., for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. R13PC10006 ID/IQ. September.
Reclamation and Ecology, 2014l	Bureau of Reclamation and Washington State Department of Ecology. 2014. *Kachess Drought Relief Pumping Plant– Pumping Unit Analysis*. Technical Memorandum. Prepared by HDR Engineering, Inc., for the U.S. Department of the Interior, Bureau of Reclamation, Contract No. R13PC10006 ID/IQ. September.
Reclamation and Ecology, 2014m	Bureau of Reclamation and Washington State Department of Ecology. 2014. *Kachess Drought Relief Pumping Plant and Keechelus Reservoir-to-Kachess Reservoir Conveyance Environmental Impact Statement.* Prepared by ESA and HDR Engineering, Inc., for the U.S. Department of the Interior, Bureau of Reclamation. Contract No. R13PC10006 ID/IQ. (DRAFT). December 2014.
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21.0 List of Preparers

NAME	BACKGROUND	RESPONSIBILITY
HDR, Inc.		
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Ed Weber	Engineering	Power Supply
Ken McGowan	Engineering	Electrical Systems
Mark Hijazi	Engineering	Structural
Randy Maccaferri	Engineering	Structural
Jon Vanier	Engineering	Civil and Site
Val Kovalishyn	Engineering	Pumping Unit and Ancillary Systems
Sri Rajah	Engineering	Hydraulics
John Nelson	Engineering	Fish Screening and Passage
Scott Aronson	Cost Estimating	Cost Estimation Lead
George (Herb) Hickman	Cost Estimating	Cost Estimator
Richard Glassen	Cost Estimating	Cost Estimate Quality Control Review
Sarah Pistorese	Planning	Report Author
Mark Ohlstrom	Engineering	Quality Control Review
BRIERLEY ASSOCIATES		
Gregg Sherry	Engineering	Tunneling Quality Control Review
DR. MOLE, INC.		
Gary Brierley	Engineering	Geotechnical Quality Control Review
ENGINEERING SOLUTIONS, LLC		
Dan Hertel	Engineering	Civil Constructability Quality Control Review
JACOBS ASSOCIATES		
Troy Page	Cost Estimating	Cost Estimator- Tunnel and Shaft
RECLAMATION		
Ron Oaks	Engineering	Technical Lead

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Appendix A
Alternative 1- East Shore Pumping Plant Drawings

Alternative 1 – East Shore Pumping Plant

1G-001	Cover Sheet
1C-101	Overall Site Plan
1C-102	Hydraulic Profile
1C-201	Headworks – Site Plan
1C-202	Headworks – Profile
1C-203	Headworks – Fish Screens Plan and Sections
1C-204	Headworks – Tunnel Sections and Details
1C-205	Pumping Plant – Plan A at EL 2080
1C-206	Pumping Plant – Plan B at EL 2130
1C-207	Pumping Plant – Plan C at EL 2225
1C-208	Pumping Plant – Plan D at EL 2265
1C-209	Pumping Plant – Plan E at EL 2280
1C-210	Pumping Plant – Section A
1C-211	Pumping Plant – Section B
1C-212	Pumping Plant – Section C
1C-213	Pumping Plant – Section D
1C-301	Pipeline – Plan
1C-302	Pipeline – Sections and Details 1
1C-303	Pipeline – Sections and Details 2
1C-401	Outlet Works – Site Plan
1C-402	Outlet Works – Profile
1C-403	Outlet Works – Section 1
1C-404	Outlet Works – Section 2
1C-405	Outlet Works – Access Road Profile and Sections
1C-406	Temporary Construction Staging
1C-407	Temporary Construction Staging – Enlarged Plan
1C-501	Power Supply – Site Plan
1C-502	Power Supply – Substation Plan
1C-503	Power Supply – Section
1I-601	P&ID – Legend and Abbreviations
1I-602	P&ID – Fish Flow and Unwatering Pumps
1I-603	P&ID – Drought Relief Pumps
1E-701	Electrical – One-Line Diagram

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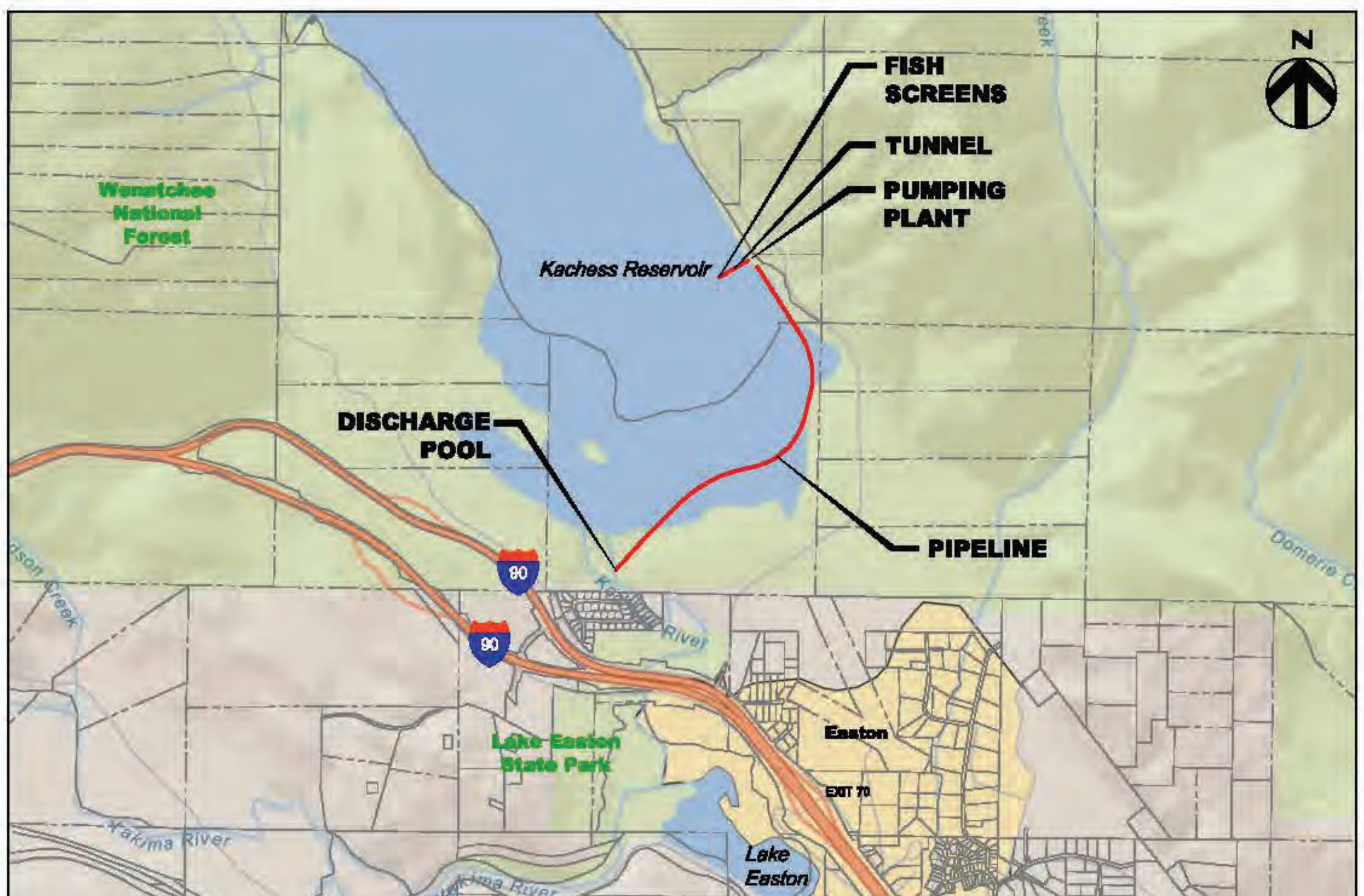
WASHINGTON STATE
SCALE: NO SCALE

VICINITY MAP
SCALE: NO SCALE

INDEX OF DRAWINGS



LOCATION MAP
SCALE: NO SCALE

Bureau of Reclamation

Yakima River Basin Integrated Water Resources Management Plan

Kachess Drought Relief Pumping Plant

Alternative 1- East Shore Pumping Plant

Contract No: R13PC10006 ID/IQ

HDR Project No: 224009

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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YAKIMA PROJECT – WA
KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

B. SHAHA
DESIGNED

V. KOVALISHYN
REVIEWED

YAKIMA, WA 2014-08-20

COVER SHEET

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1G-001
SHEET 1 OF 33

PLAN

0 250 500 1000
SCALE IN FEET

N

NOTE:

1. ABBREVIATIONS INCLUDE:
   - DOA – DEPARTMENT OF AGRICULTURE
   - DOT – DEPARTMENT OF TRANSPORTATION
   - BPA – BONNEVILLE POWER ADMINISTRATION
   - WNF – WASHINGTON NATIONAL FOREST

FEASIBILITY DRAWING
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BIROL SHAHA — STATE OF WASHINGTON — 43594 — REGISTERED PROFESSIONAL ENGINEER

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YAKIMA PROJECT – WA
KITTITAS DIVISION
KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED B. SHAHA
REVIEWED V. KOVALISHYN
YAKIMA, WA 2014-08-20

OVERALL SITE PLAN

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-101
SHEET 2 OF 33

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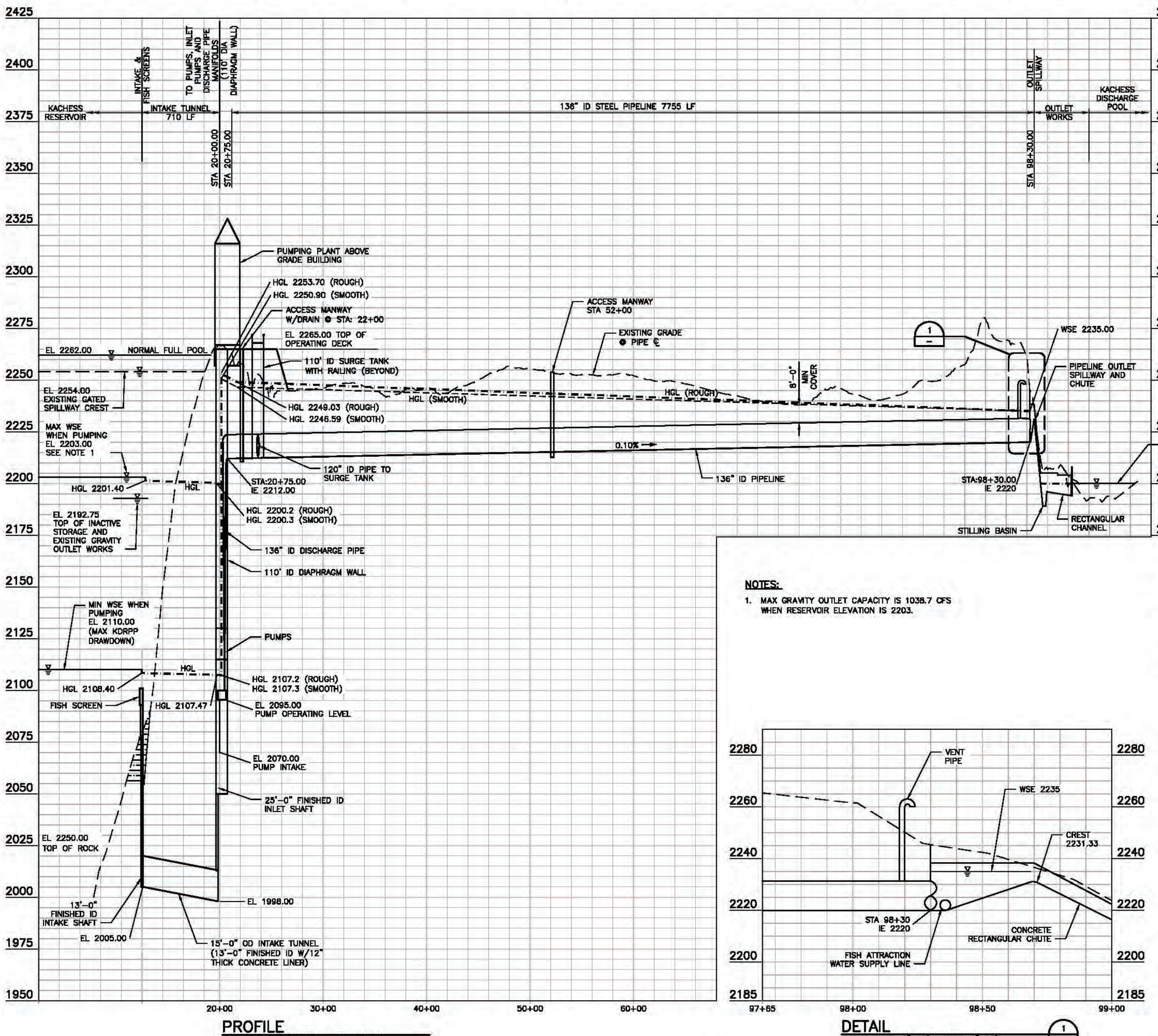

PROFILE
SCALE: HORIZ: 1"=500' VERT: 1"=25'

DETAIL 1
SCALE: HORIZ: 1"=20' VERT: 1"=20'

Station From	Station To	Length (feet)	Pipe Wall Thickness (Inch)
20+75	44+00	2,325	0.600 inch
44+00	60+00	1,600	0.650 inch
60+00	92+00	3,200	0.600 inch
92+00	93+00	100	0.750 inch
93+00	95+00	200	1.000 inch
95+00	98+30	330	0.750 inch
	Total =	7,755	

NOTE:

STATION VALUES AND LENGTHS IN THIS TABLE ARE APPROXIMATE. VALUES SHOWN ARE FOR COST ESTIMATING PURPOSES ONLY.

NOTES:

1. MAX GRAVITY OUTLET CAPACITY IS 1038.7 CFS WHEN RESERVOIR ELEVATION IS 2203.

HYDRAULIC DESIGN PARAMETERS

DESIGN FLOW RATE: 1000 CFS

HYDRAULIC REQUIREMENTS:

PIPELINE:

- MAX. DESIGN FLOW VELOCITY: 10 FPS
- INSIDE DIAMETER = 136-INCH
- WELDED STEEL PIPELINE, RUGOSITY OF LINING ON INTERIOR SURFACE = 0.0002 FT (SMOOTH), 0.001 ft (ROUGH)

INTAKE TUNNEL:

- MAX. DESIGN FLOW VELOCITY:
  - CONCRETE LINED TUNNEL = 10 FPS
  - UNLINED TUNNEL = 5 FPS
- INSIDE FINISHED DIAMETER = 13'-0"
  - 100 FT STEEL LINED CIRCULAR TUNNEL
  - 610 FT CONCRETE LINED HORSESHOE TUNNEL
- RUGOSITY OF LINING OR INTERIOR SURFACE
  - CONCRETED LINED TUNNEL = 0.002 FT (ROUGH), 0.0003 FT (SMOOTH)
  - SHOTCRETE LINED DRILL AND BLAST TUNNEL = 0.22 (ROUGH), 0.059 (SMOOTH)

UNITED STATES BUREAU OF RECLAMATION (USBR), 1994, "DESIGN STANDARDS NO. 3 – WATER CONVEYANCE SYSTEMS," DS-3, SEPTEMBER 30

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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YAKIMA PROJECT – WA
KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED B. SHAHA
REVIEWED V. KOVALISHYN
YAKIMA, WA 2014-08-20

HYDRAULIC PROFILE

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-102

SHEET 3 OF 33

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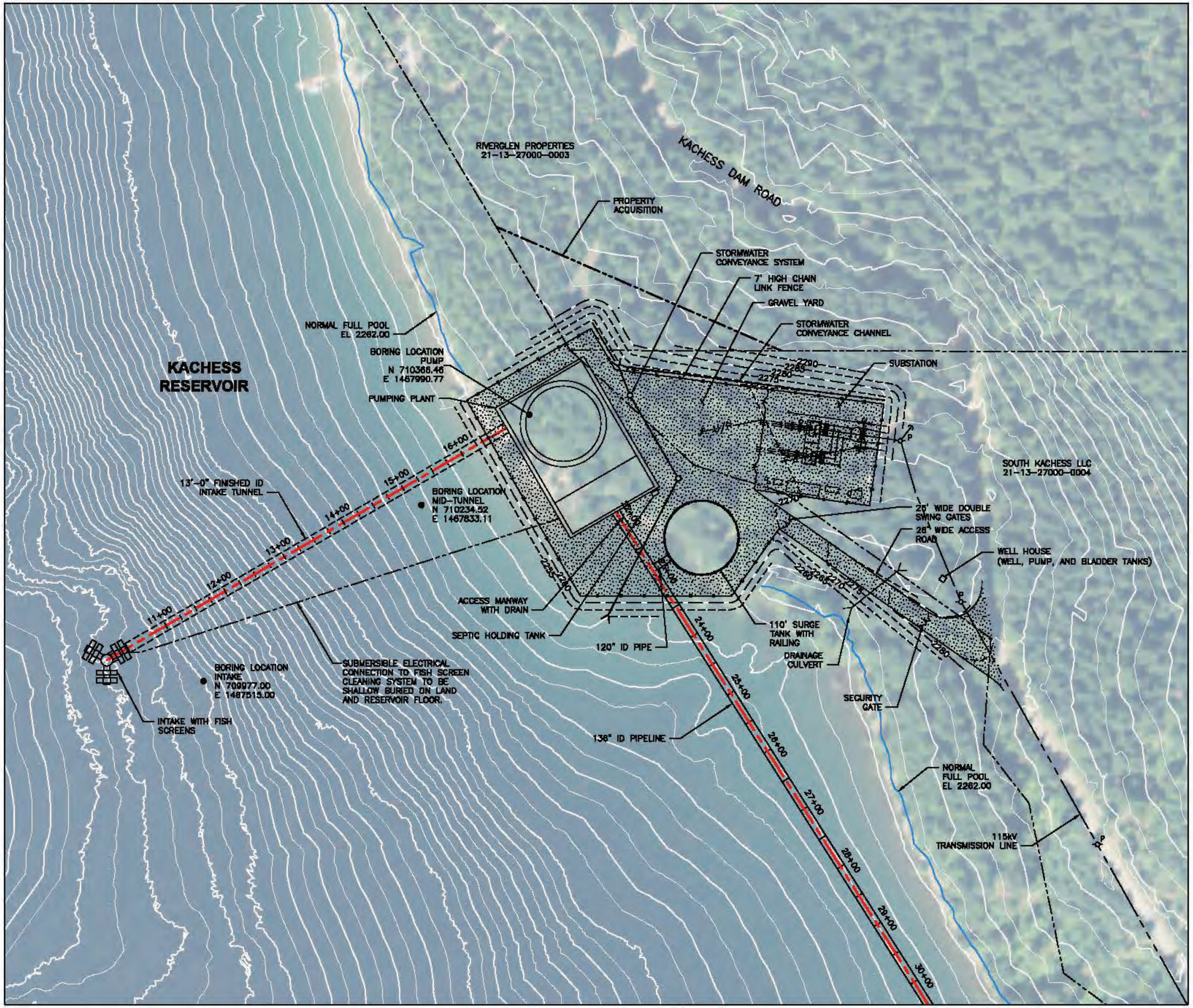

PLAN

0 40 80 160
SCALE IN FEET

N

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED J. VANIER
REVIEWED B. SHAHA
YAKIMA, WA 2014-08-20

HEADWORKS SITE PLAN

ALTERNATIVE 1
EAST SHORE PUMPING PLANT

1C-201
SHEET 4 OF 33

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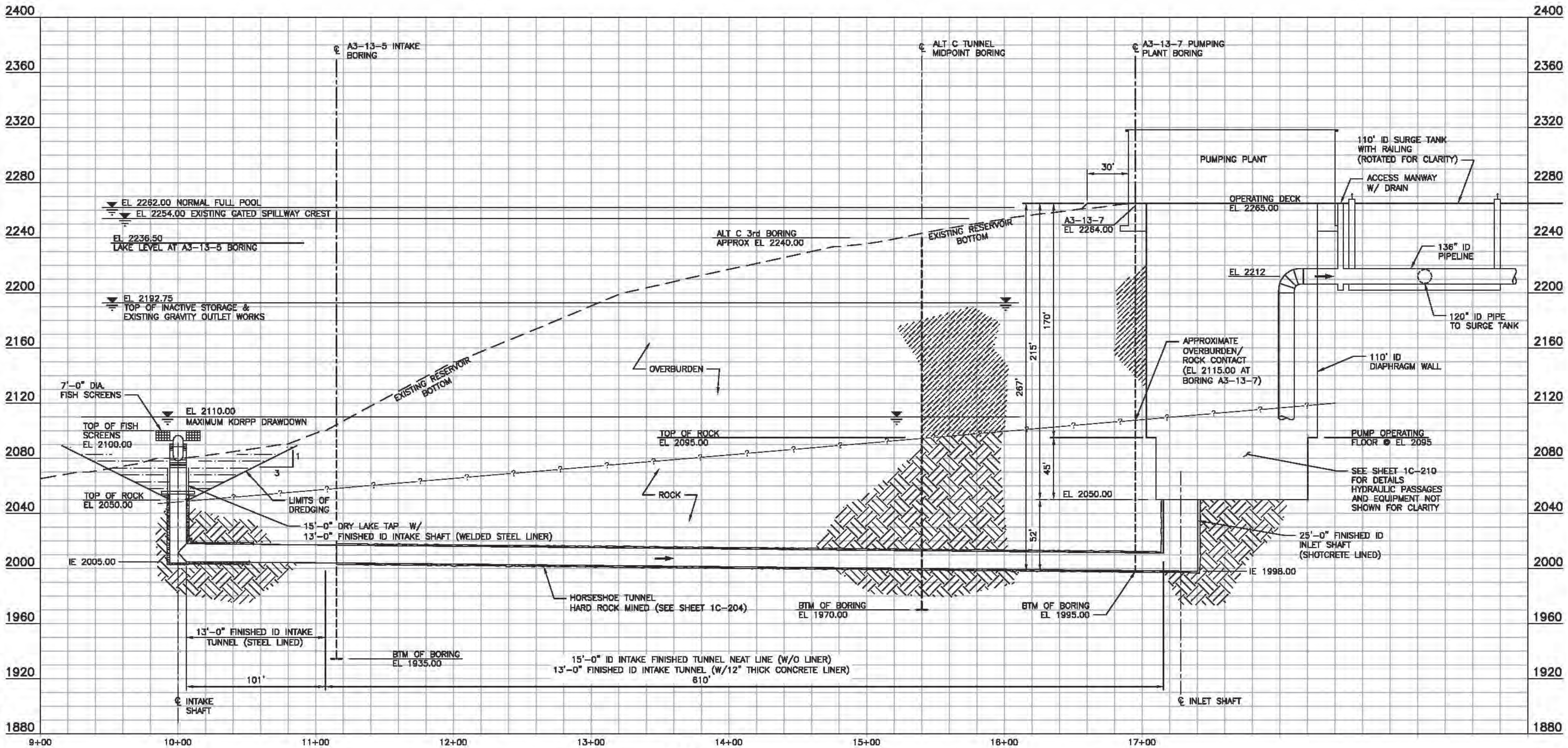

PROFILE

SCALE: 1" = 40'

FEASIBILITY DRAWING

ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED: B. SHAHA

REVIEWED: V. KOVALISHYN

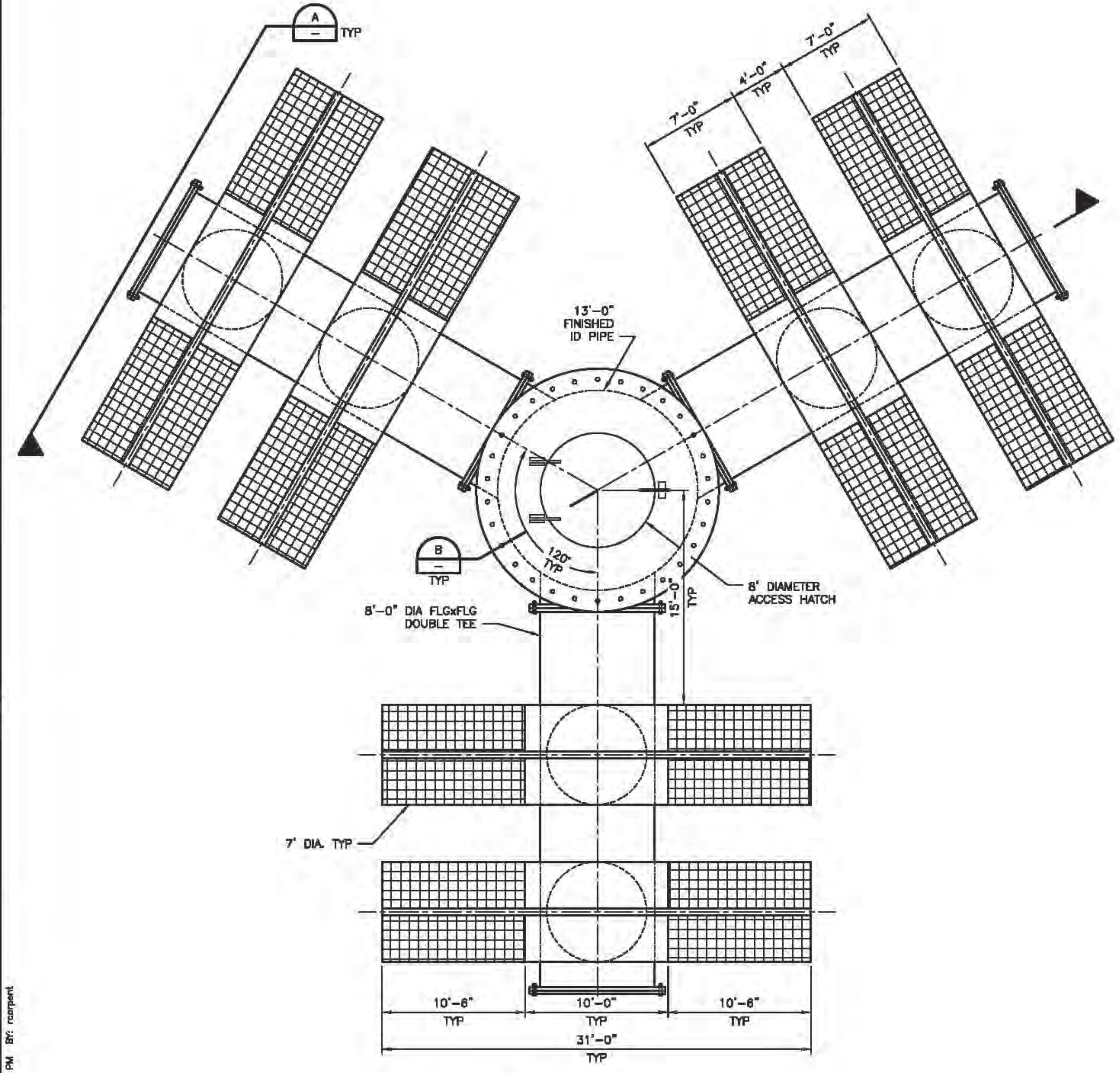
YAKIMA, WA 2014-06-20

HEADWORKS PROFILE

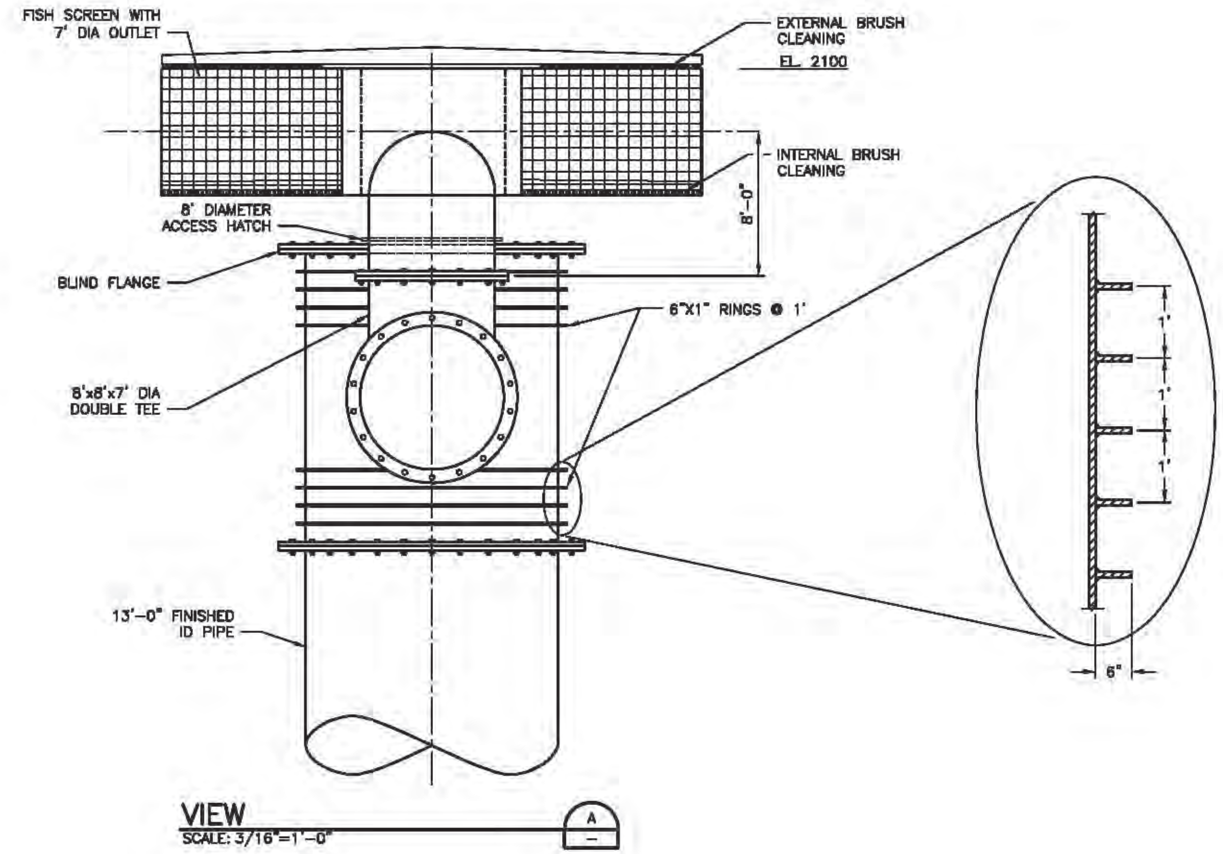
ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-202

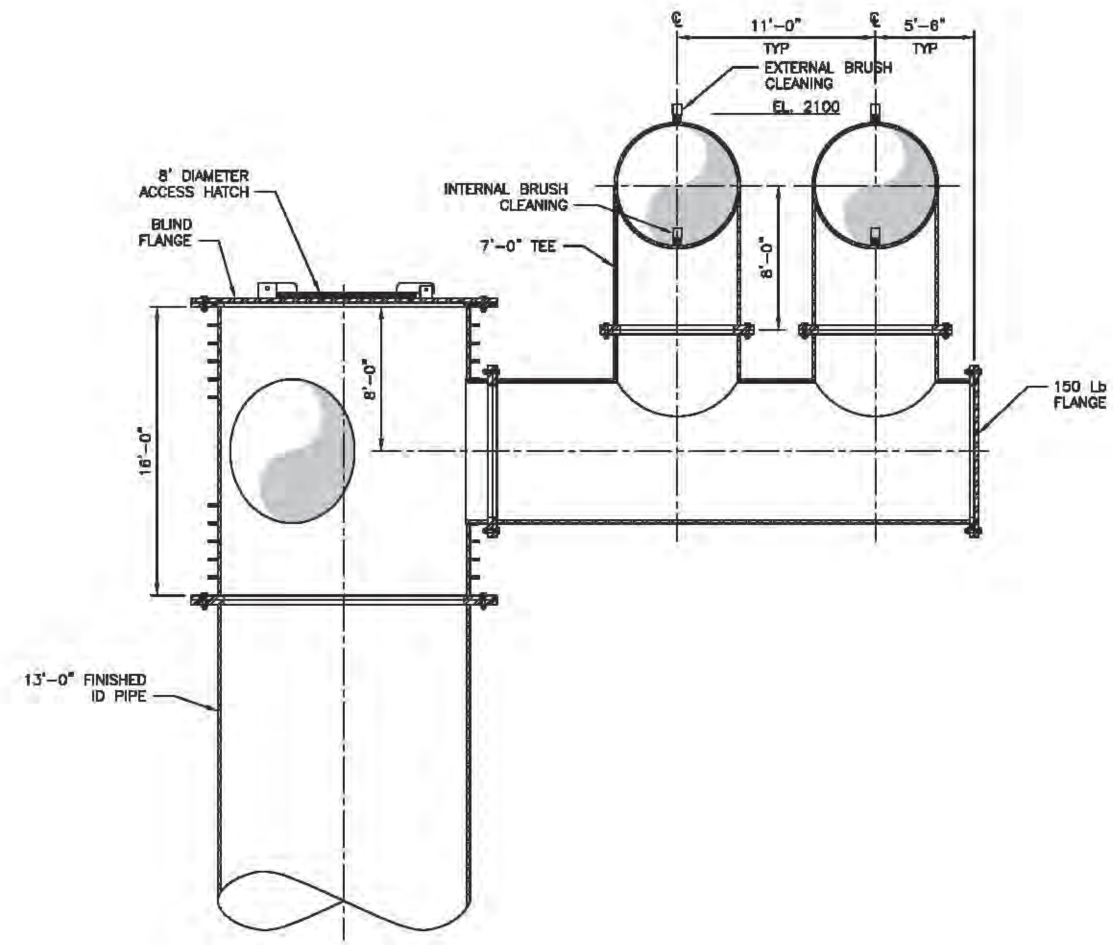
SHEET 5 OF 33



PLAN
SCALE: 3/16"=1'-0"



VIEW A
SCALE: 3/16"=1'-0"



SECTION B
SCALE: 3/16"=1'-0"

DESIGN CRITERIA:

- MAXIMUM DIVERSION: 1,000 CFS
- SCREEN AREA: 2,770 SF
- MAXIMUM APPROACH VELOCITY: 0.40 FPS
- BRUSH CLEANING SYSTEM

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF PUMPING PLANT

Draft
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J. NELSON
DESIGNED

B. SHAHA
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YAKIMA, WA 2014-08-20

HEADWORKS
FISH SCREENS
PLAN AND SECTIONS

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-203

SHEET 6 OF 33

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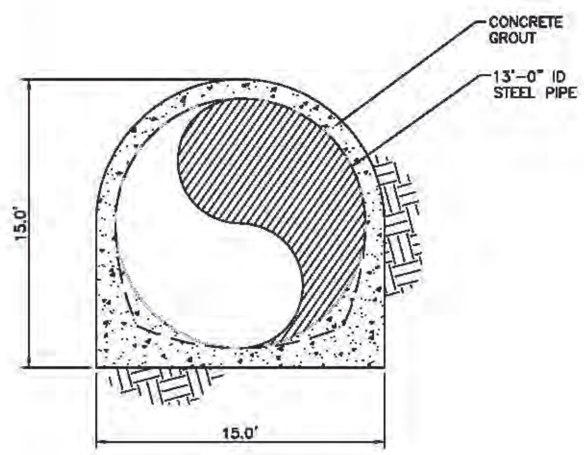

WELDED STEEL LINED TUNNEL SECTION 1

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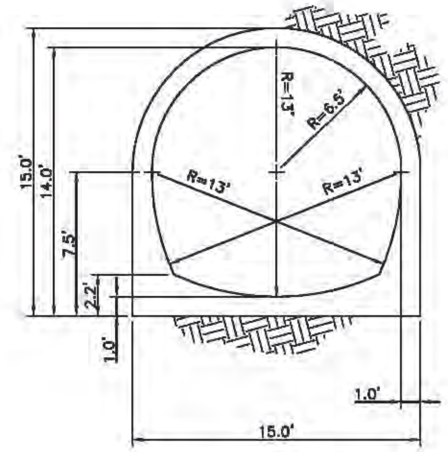

HORSESHOE SHAPED CONCRETE TUNNEL SECTION 2

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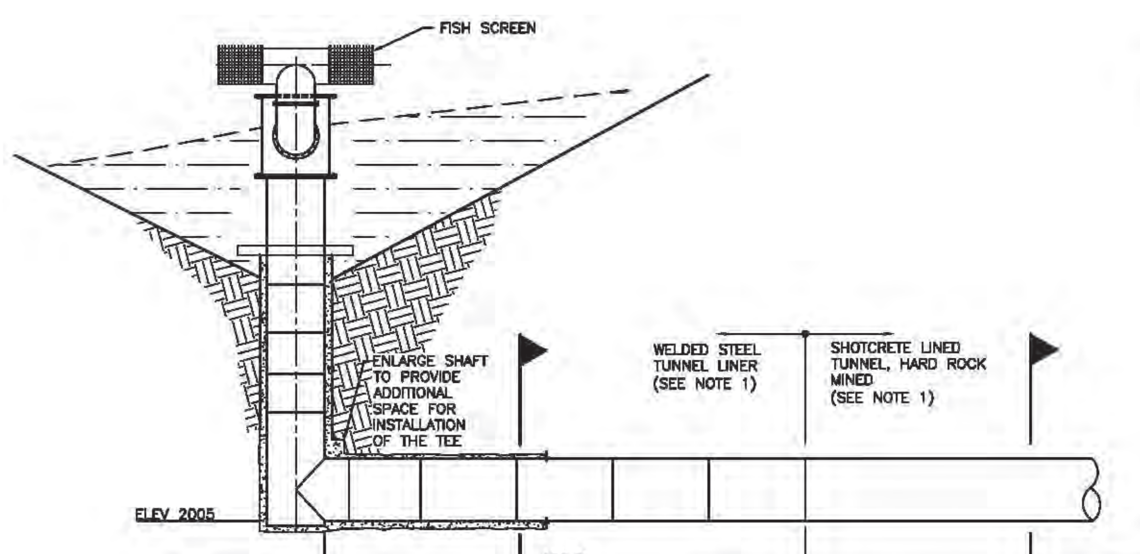
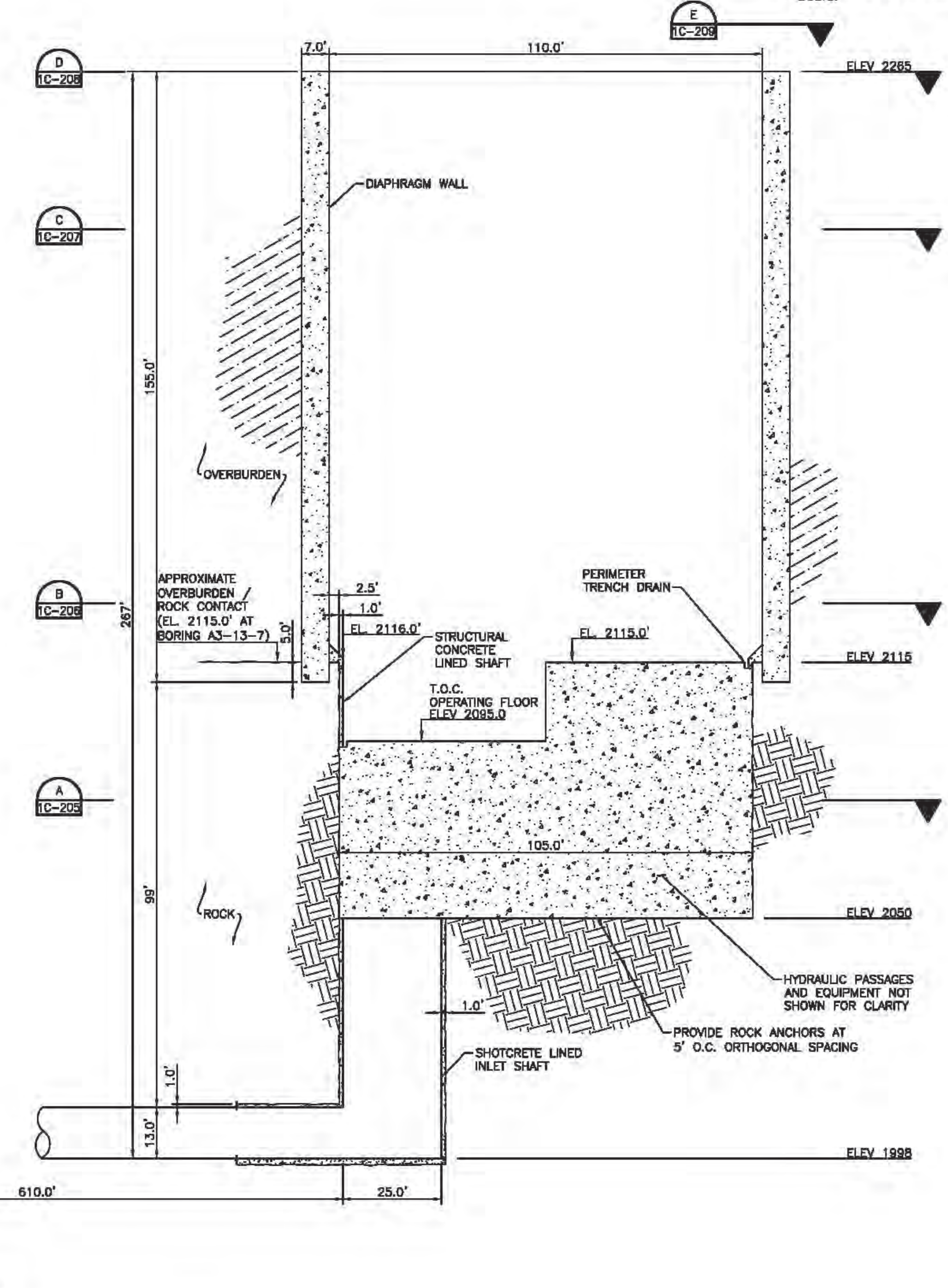
NOTES:

1. THE ANTICIPATED INITIAL TUNNEL SUPPORT WOULD CONSIST OF PATTERN ROCK BOLTS, 6.6 FEET LONG, INSTALLED RADIALLY ON A 5-FOOT-BY-5-FOOT PATTERN IN THE CROWN FROM APPROXIMATELY THE 10 O'CLOCK TO 2 O'CLOCK POSITIONS. ADDITIONALLY, THE PROJECT TEAM ASSUMED THAT 80 FEET OF THE TUNNEL LENGTH WOULD ALSO REQUIRE WIRE MESH AND STRAPS (STEEL, 3 INCHES WIDE BY 1/4 INCH THICK) TO SUPPLEMENT THE ROCK BOLTS.

PUMP STATION AND INTAKE SHAFT SECTION 1 / 1C-202

NOT TO SCALE

FEASIBILITY DRAWING

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KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED B. SHAHA

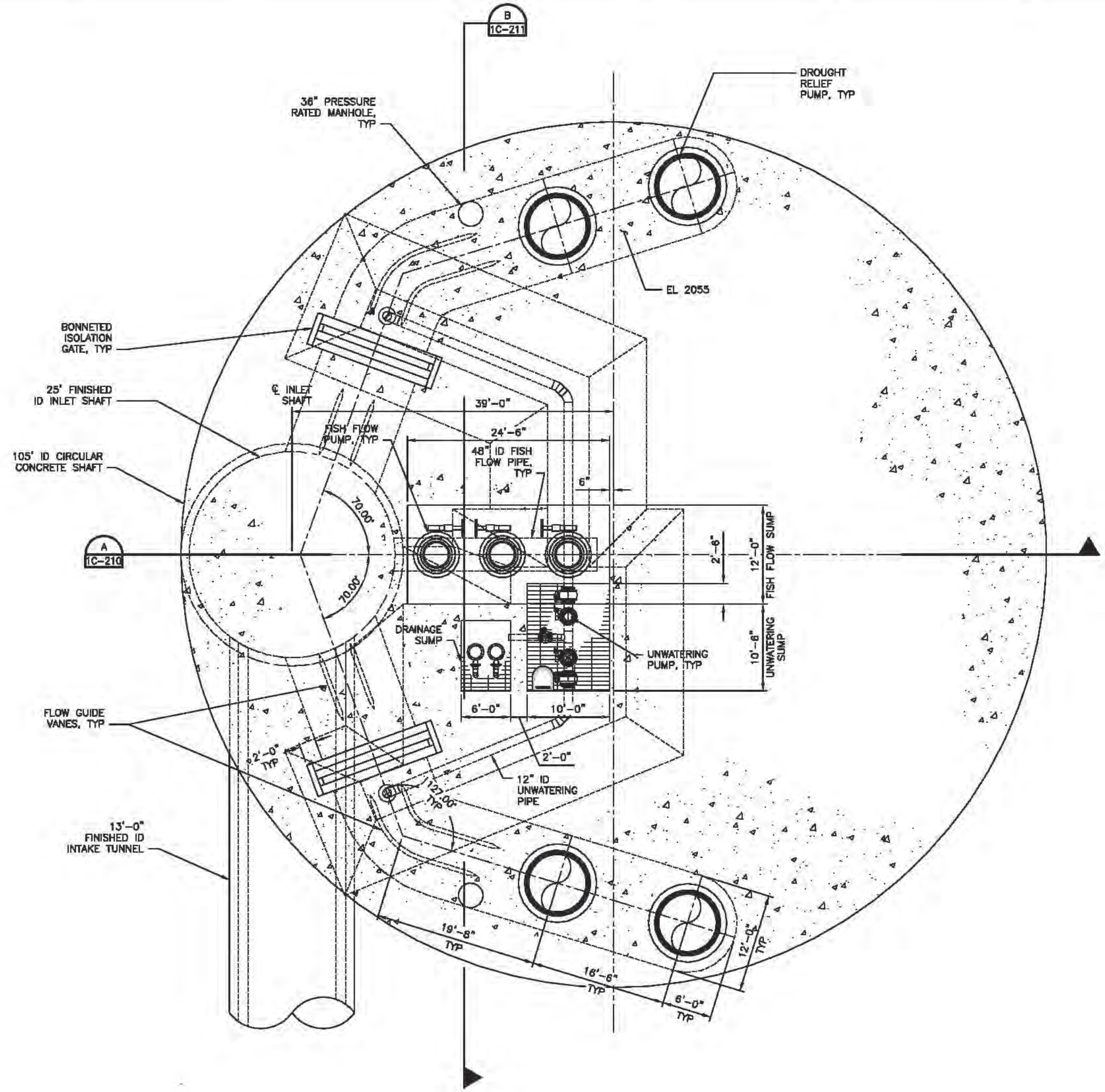
REVIEWED V. KOVALISHYN

YAKIMA, WA 2014-06-20

HEADWORKS TUNNEL SECTIONS AND DETAILS

ALTERNATIVE 1 EAST SHORE PUMPING PLANT

1C-204



PLAN AT EL 2080
SCALE: 1/8" = 1'-0"

A 1C-204

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VALERIY KOVALISHYN STATE OF WASHINGTON 51687 REGISTERED PROFESSIONAL ENGINEER

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KACHESS DROUGHT RELIEF PUMPING PLANT

V. KOVALISHYN
DESIGNED

J. STEWART
REVIEWED

YAKIMA, WA 2014-08-20

PUMPING PLANT
PLAN A @ EL 2080

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-205
SHEET 8 OF 33

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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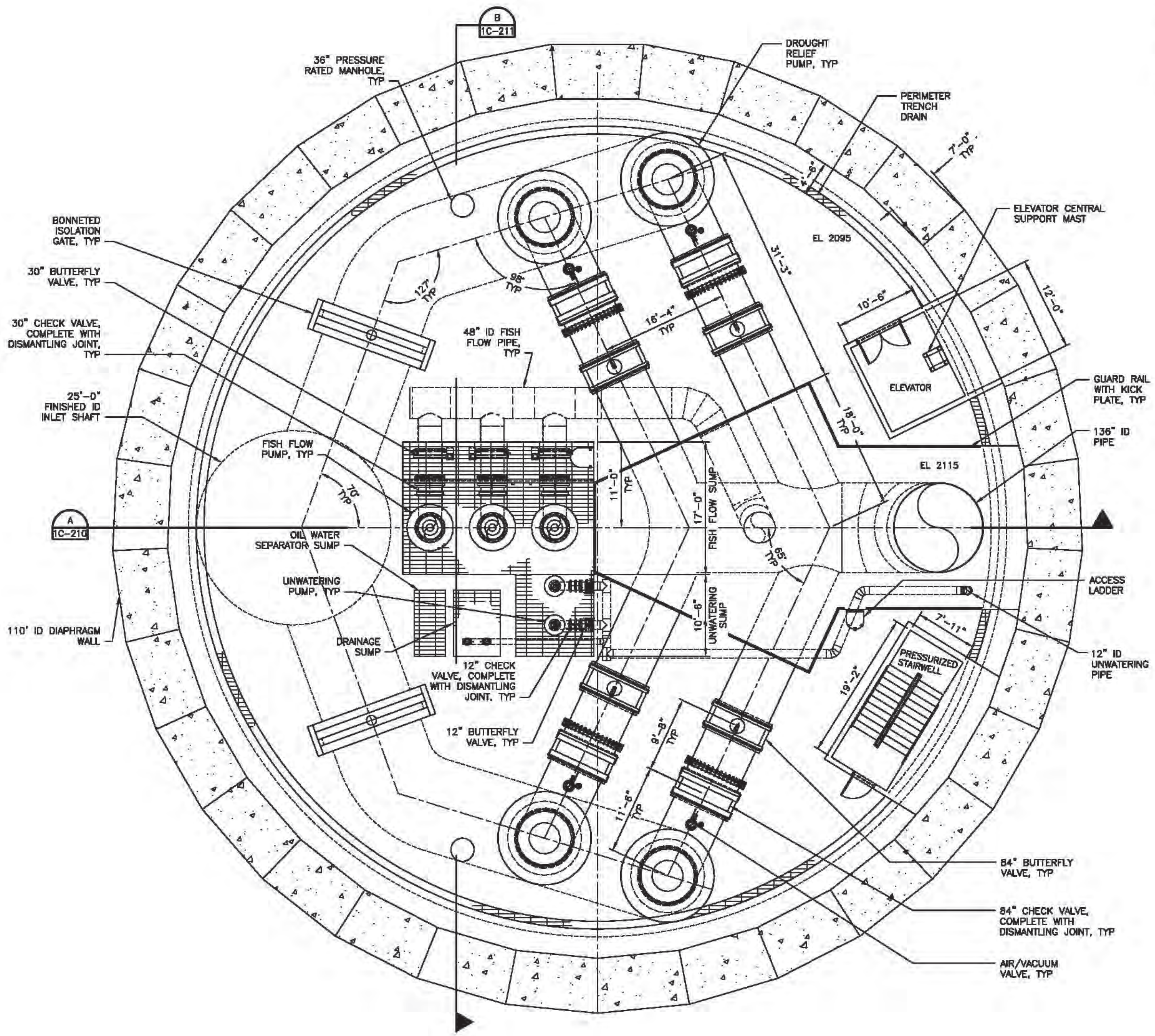

PLAN AT EL 2130 (B 1C-204)
SCALE: 1/8" = 1'-0"

N

PUMP DATA		
PUMP	RATED CAPACITY (CFS)	RATED HEAD (FT)
DROUGHT RELIEF	333.3	147.2
FISH FLOW	50 MAX	145

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED V. KOVALISHYN
REVIEWED J. STEWART
YAKIMA, WA 2014-08-20

PUMPING PLANT
PLAN B @ EL 2130

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-206
SHEET 8 OF 33

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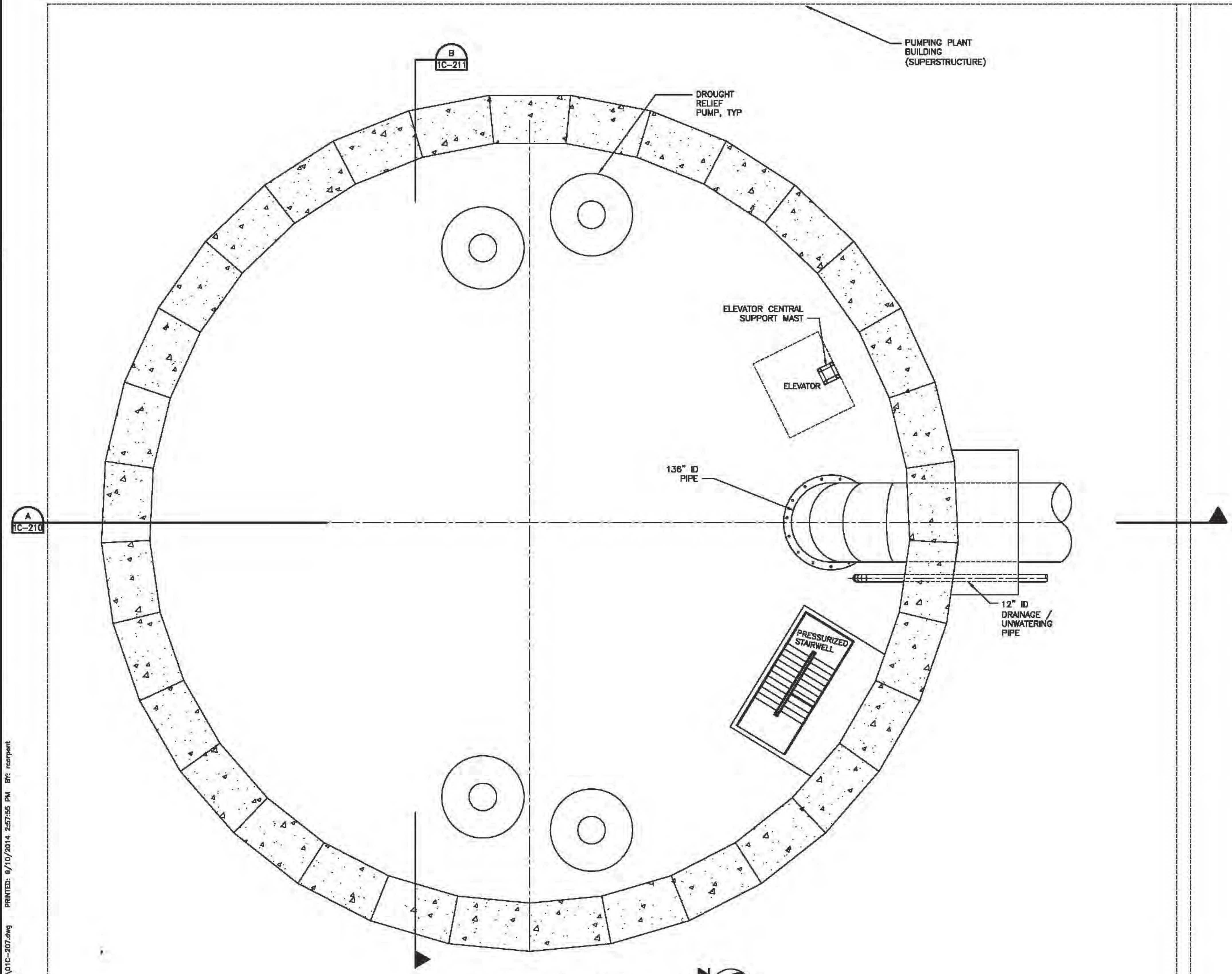

PLAN AT EL 2225
SCALE: 1/8" = 1'-0"
C
1C-204

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF PUMPING PLANT

V. KOVALISHYN
DESIGNED

J. STEWART
REVIEWED

YAKIMA, WA 2014-06-20

PUMPING PLANT
PLAN C @ EL 2225

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-207
SHEET 10 OF 33

DATE AND TIME PLOTTED Not Plotted
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CAD SYSTEM AUTOCAD
CAD FILENAME UNKNOWN
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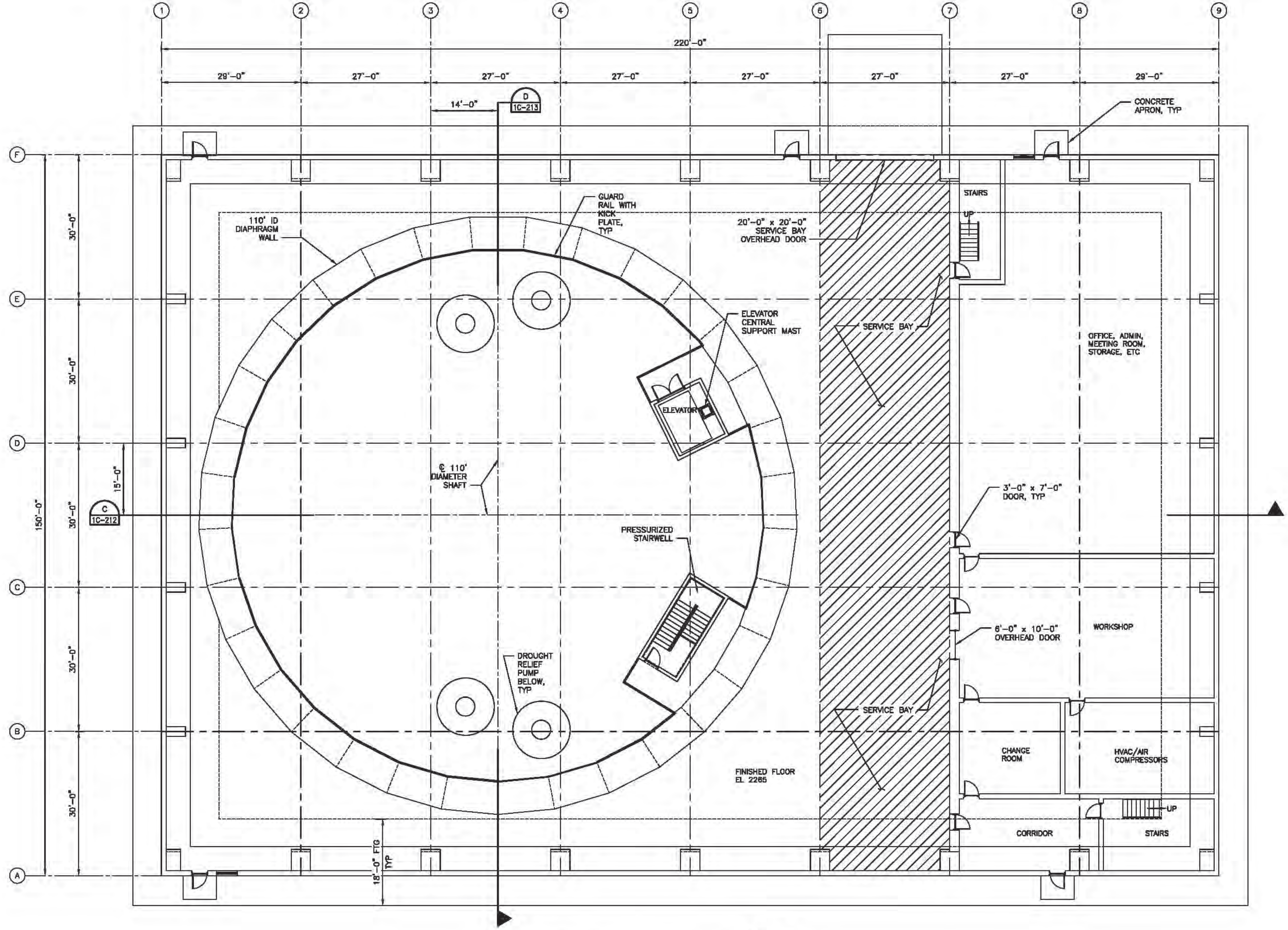

PLAN AT EL 2265
SCALE: 3/32" = 1'-0"
D 1C-204

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

RECLAMATION
Managing Water in the West

HDR

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YAKIMA PROJECT – WA
KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

For Reference Only
Draft
Not For Distribution

DESIGNED V. KOVALISHYN
REVIEWED J. STEWART
YAKIMA, WA 2014-06-20

PUMPING PLANT
PLAN D @ EL 2265

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-208
SHEET 11 OF 33

DATE AND TIME PLOTTED Not Plotted
PLOTTED BY Not Plotted
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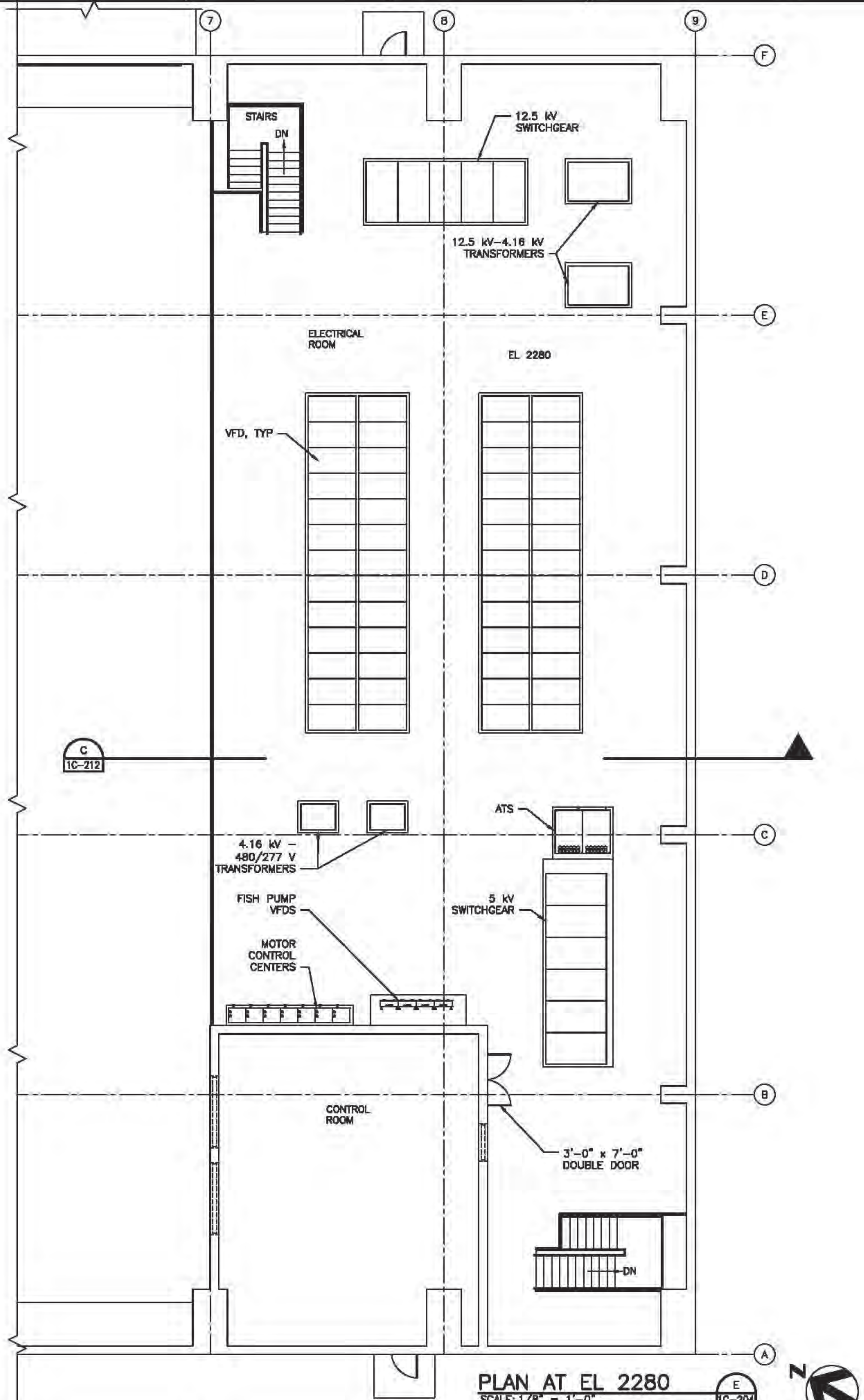

PLAN AT EL 2280
SCALE: 1/8" = 1'-0"
E
1C-204

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF PUMPING PLANT

V. KOVALISHYN
DESIGNED

J. STEWART
REVIEWED

YAKIMA, WA — 2014-08-20

PUMPING PLANT
PLAN E @ EL 2280

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-209

SHEET 12 OF 33

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CAD FILENAME UNKNOWN
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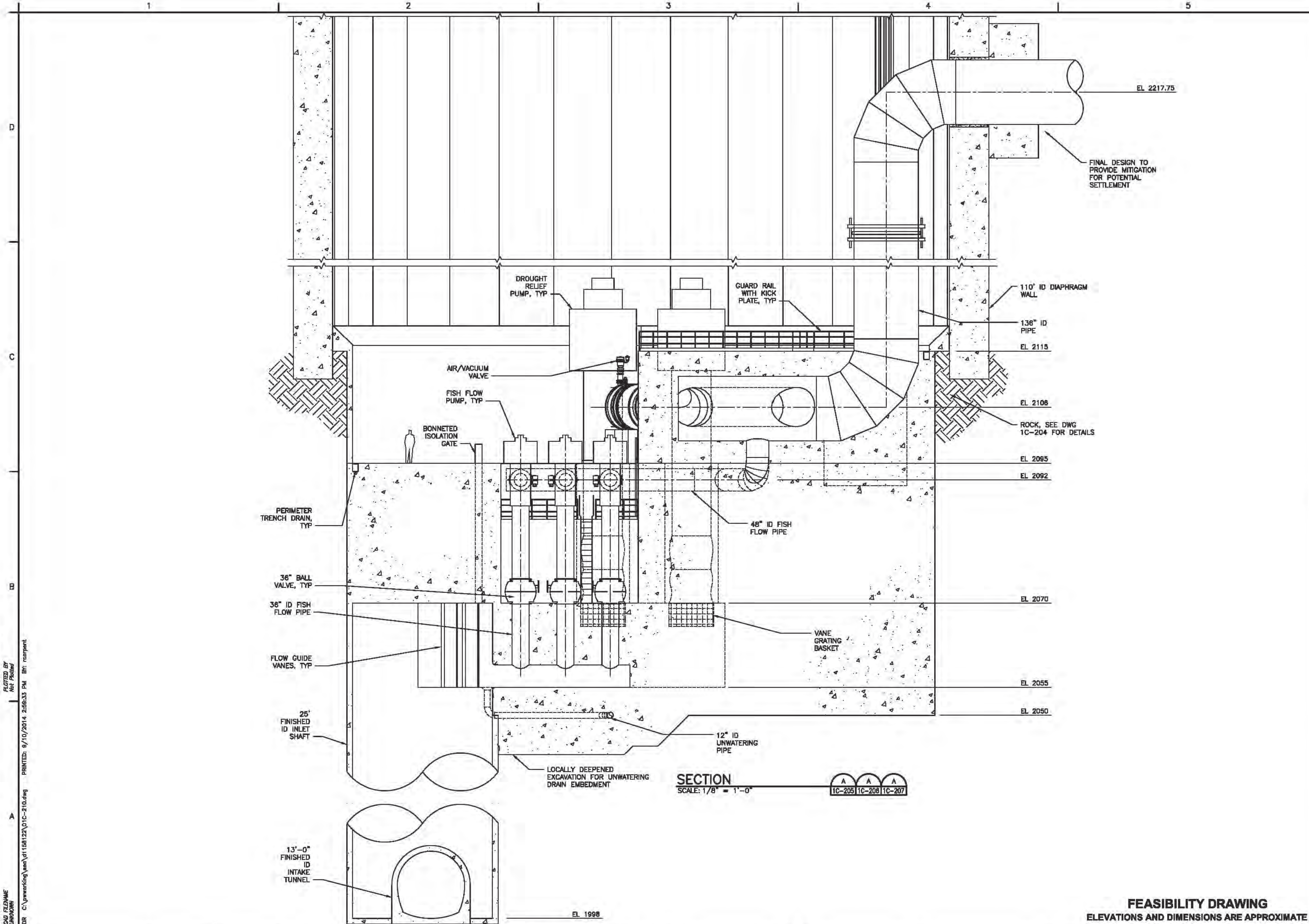

FEASIBILITY DRAWING

ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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V. KOVALISHYN
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YAKIMA, WA 2014-08-20

PUMPING PLANT SECTION A

ALTERNATIVE 1
EAST SHORE PUMPING PLANT

1C-210

SHEET 13 OF 33

CAD SYSTEM AUTOCAD
CAD FILENAME UNKNOWN
DATE AND TIME PLOTTED Not Plotted
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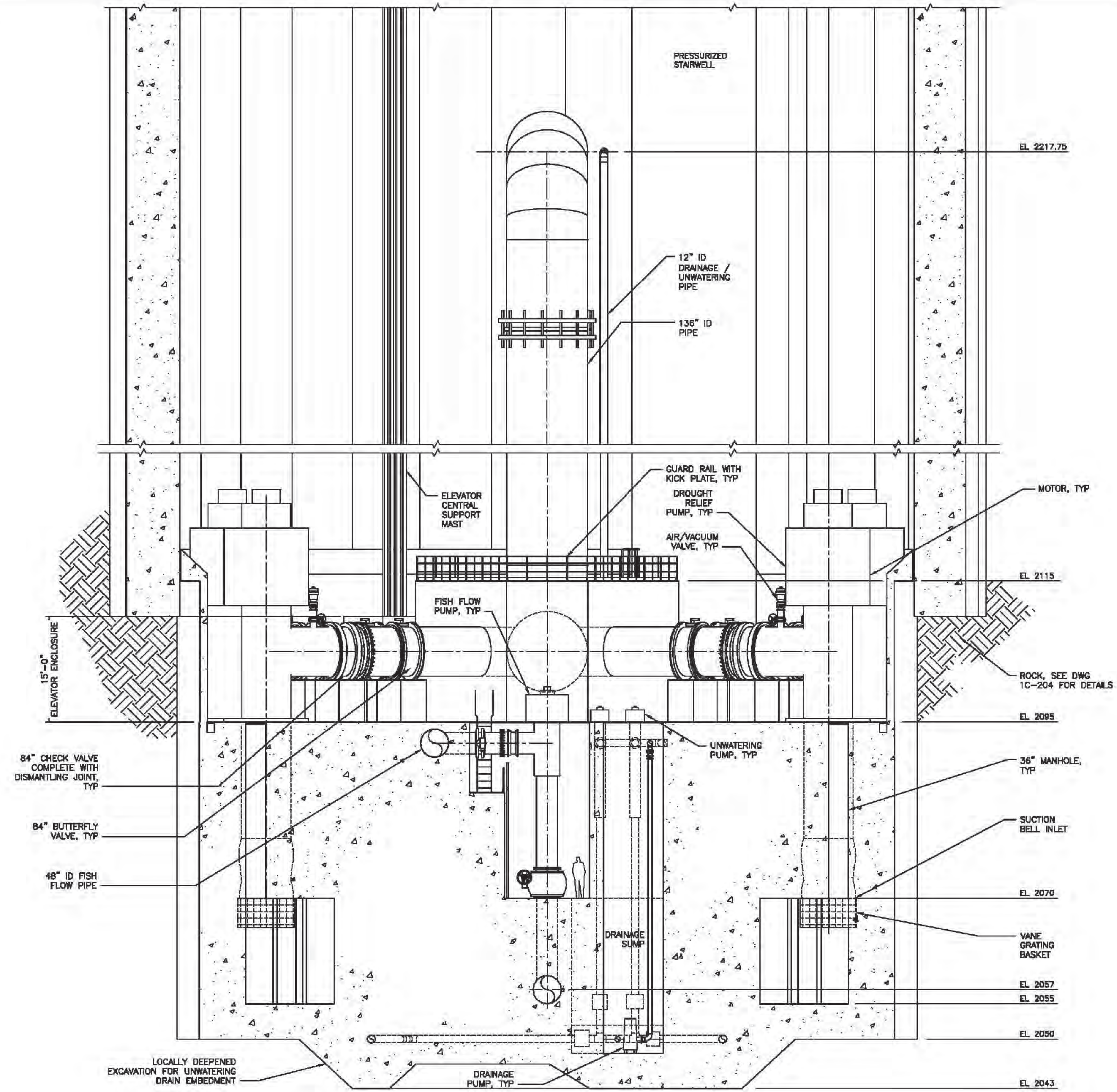

SECTION B

SCALE: 1/8" = 1'-0"

1C-205 | 1C-206 | 1C-207

FEASIBILITY DRAWING

ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED: V. KOVALISHYN

REVIEWED: J. STEWART

YAKIMA, WA 2014-08-20

PUMPING PLANT SECTION B

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-211

SHEET 14 OF 33

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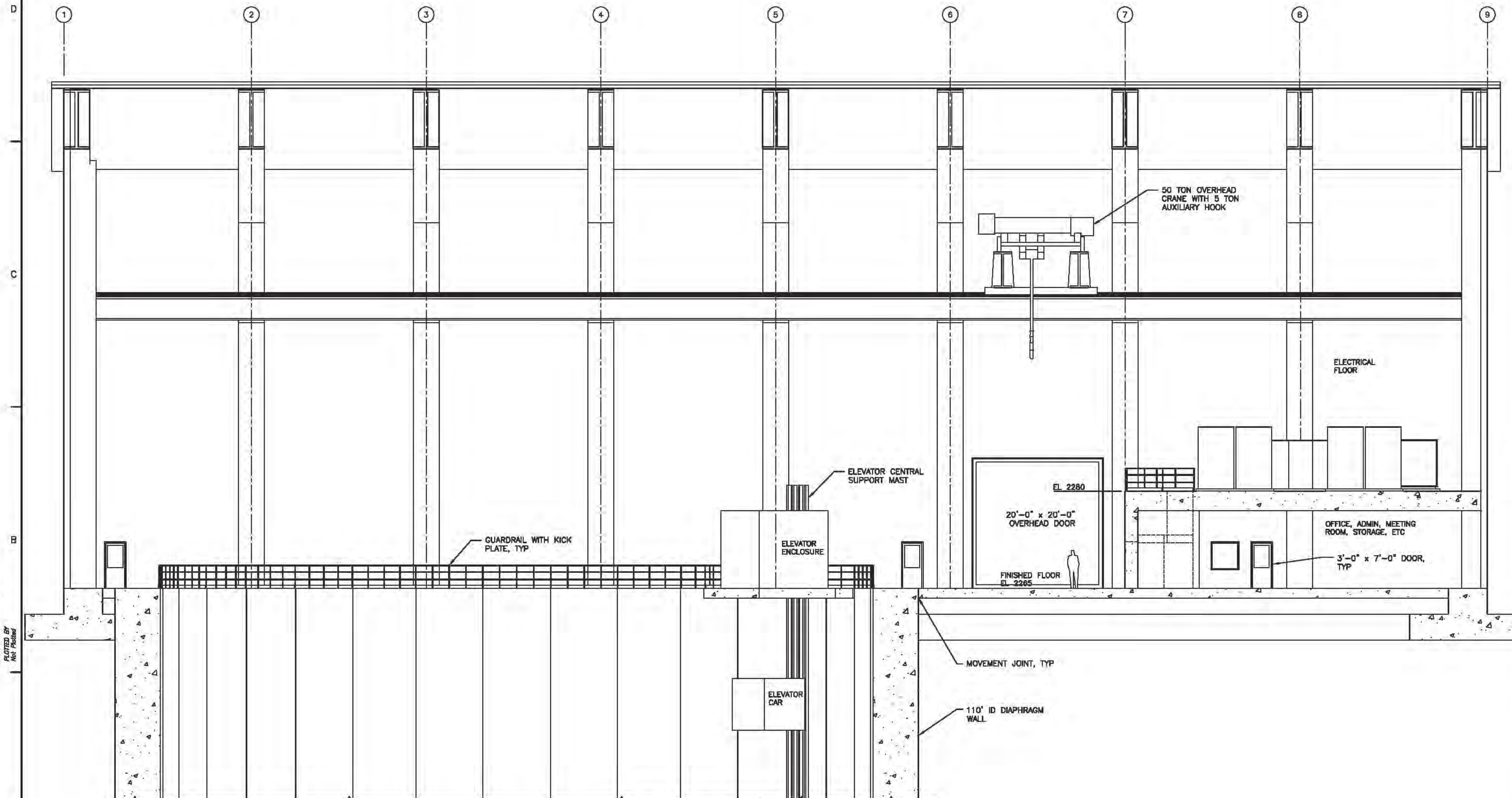

SECTION
SCALE: 1/8" = 1'-0"
C 1C-208 C 1C-209

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF PUMPING PLANT

V. KOVALISHYN
DESIGNED

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REVIEWED

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PUMPING PLANT SECTION C

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-212
SHEET 15 OF 33

DATE AND TIME PLOTTED Not Plotted
PLOTTED BY Not Plotted

CAD SYSTEM AUTOCAD
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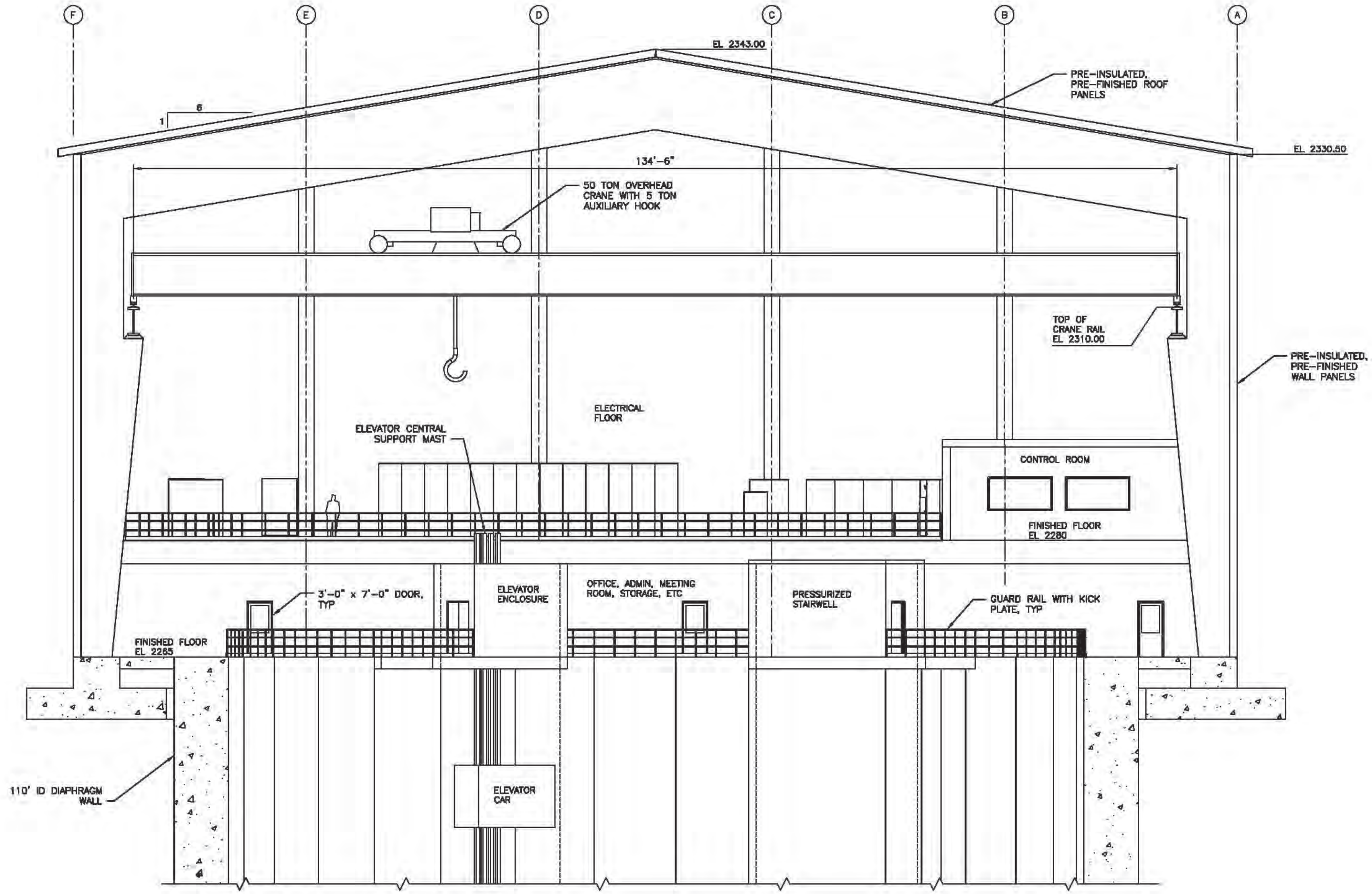

SECTION

SCALE: 1/8" = 1'-0"

D
1C-208

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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V. KOVALISHYN
DESIGNED

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PUMPING PLANT
SECTION D

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-213

SHEET 16 OF 33

DATE AND TIME PLOTTED Not Plotted
PLOTTED BY Not Plotted
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CAD FILENAME UNKNOWN
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BIROL SHAHA, STATE OF WASHINGTON, 43694, REGISTERED PROFESSIONAL ENGINEER

NOTES:

1. CAUSEWAY TO PROVIDE PERMANENT ACCESS TO PIPELINE AND MANWAY FOR OPERATION AND MAINTENANCE.
   - WIDTH OF GRAVEL ACCESS ROAD 25'–0"
   - FINISHED GRADE OF ACCESS ROAD AT PIPELINE = 2265'
   - MINIMUM RADIUS FOR TRUCK TURN–AROUND AT PIPELINE MANWAY = 50'–0"
   - 3:1 (H:V) SLOPE ASSUMED FOR CAUSEWAY CONSTRUCTION
2. CONSTRUCTION CORRIDOR WIDTH WILL VARY DEPENDING ON EXCAVATION DEPTH. SIDE SLOPES, AND SPACE REQUIRED FOR MATERIALS STOCKPILE. A 300' WIDE CONSTRUCTION CORRIDOR ALONG ENTIRE PIPELINE ASSUMED FOR ESTIMATION PURPOSES.

PLAN

0 200 400 800
SCALE IN FEET

N

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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YAKIMA PROJECT – WA
KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED	B. SHAHA
REVIEWED	V. KOVALISHYN
YAKIMA, WA	2014–08–20

PIPELINE PLAN

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C–301

SHEET 17 OF 33

DATE AND TIME PLOTTED Not Plotted
PLOTTED BY Not Plotted

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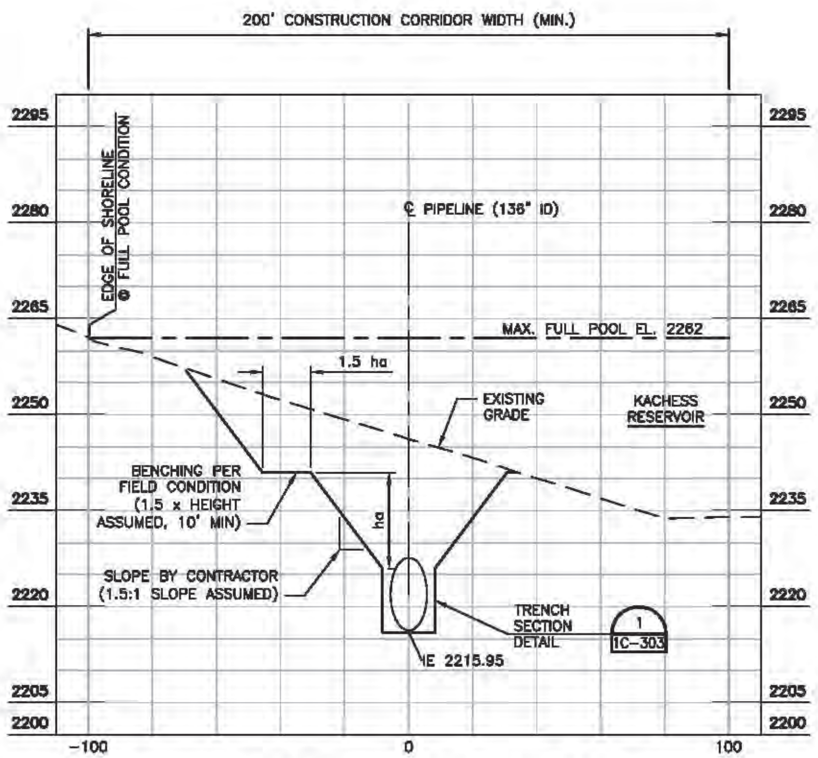
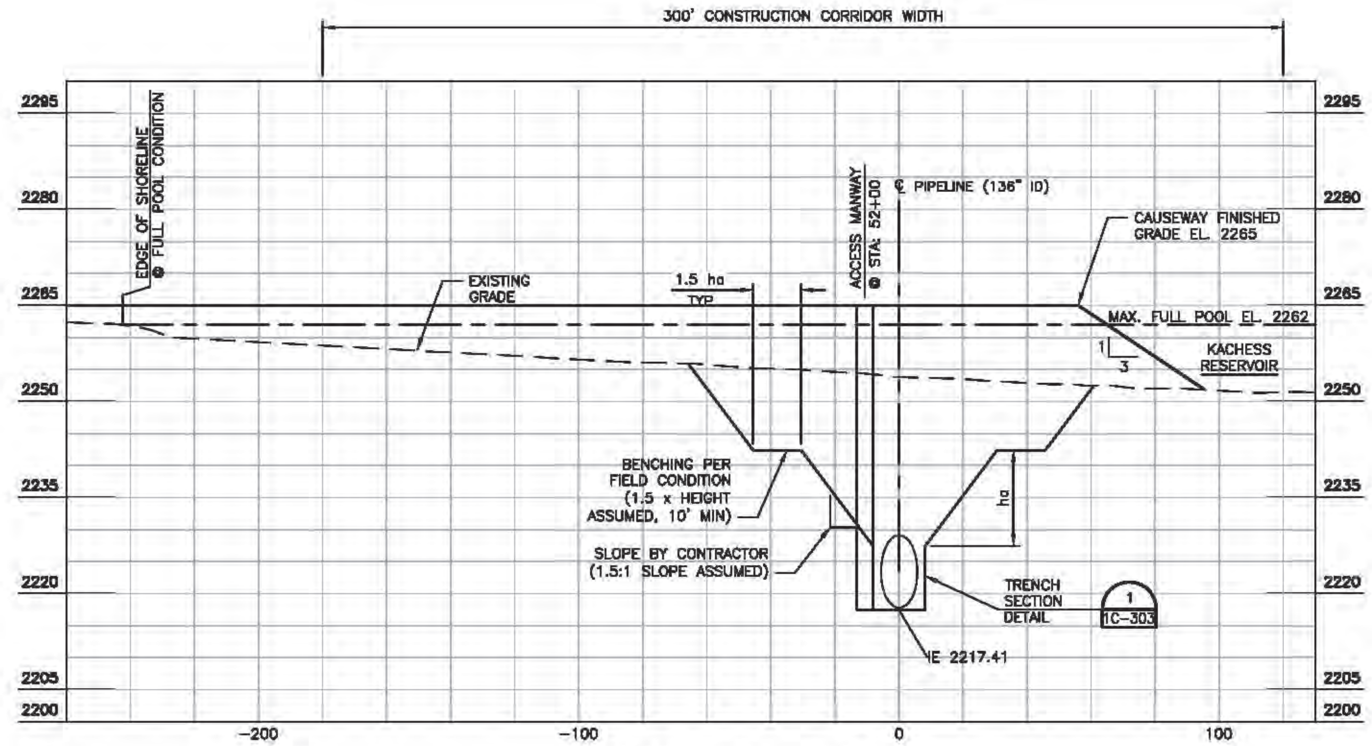
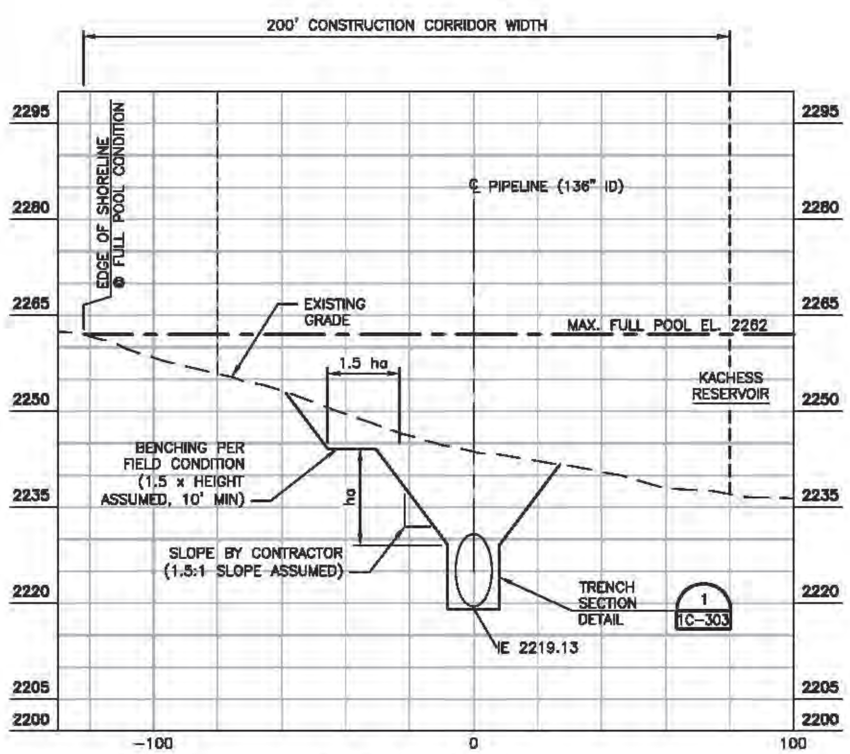


SECTION @ STA: 30+00
LOOKING SOUTH
SCALE: 1" = 30' H; 1" = 15' V
A
1C-301



SECTION @ STA: 52+00
LOOKING SOUTH
SCALE: 1" = 30' H; 1" = 15' V
B
1C-301



SECTION @ STA: 78+00
LOOKING SOUTH
SCALE: 1" = 30' H; 1" = 15' V
C
1C-301

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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BIROL SHAHA — STATE OF WASHINGTON — REGISTERED PROFESSIONAL ENGINEER

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KITTITAS DIVISION
KACHESS DROUGHT RELIEF
PUMPING PLANT

B. SHAHA
DESIGNED
V. KOVALISHYN
REVIEWED
YAKIMA, WA 2014-08-20

PIPELINE
SECTIONS AND DETAILS 1

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-302
SHEET 18 OF 33

DATE AND TIME PLOTTED Not Plotted
PLOTTED BY Not Plotted
CAD SYSTEM AUTOCAD
CAD FILENAME UNKNOWN
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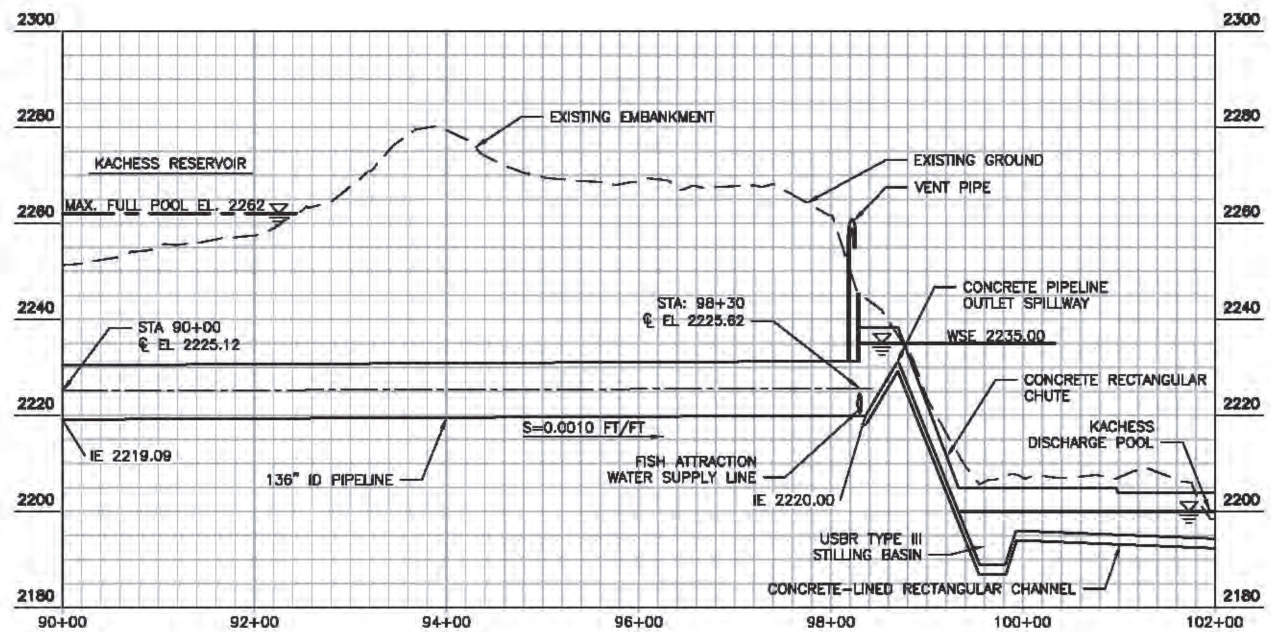
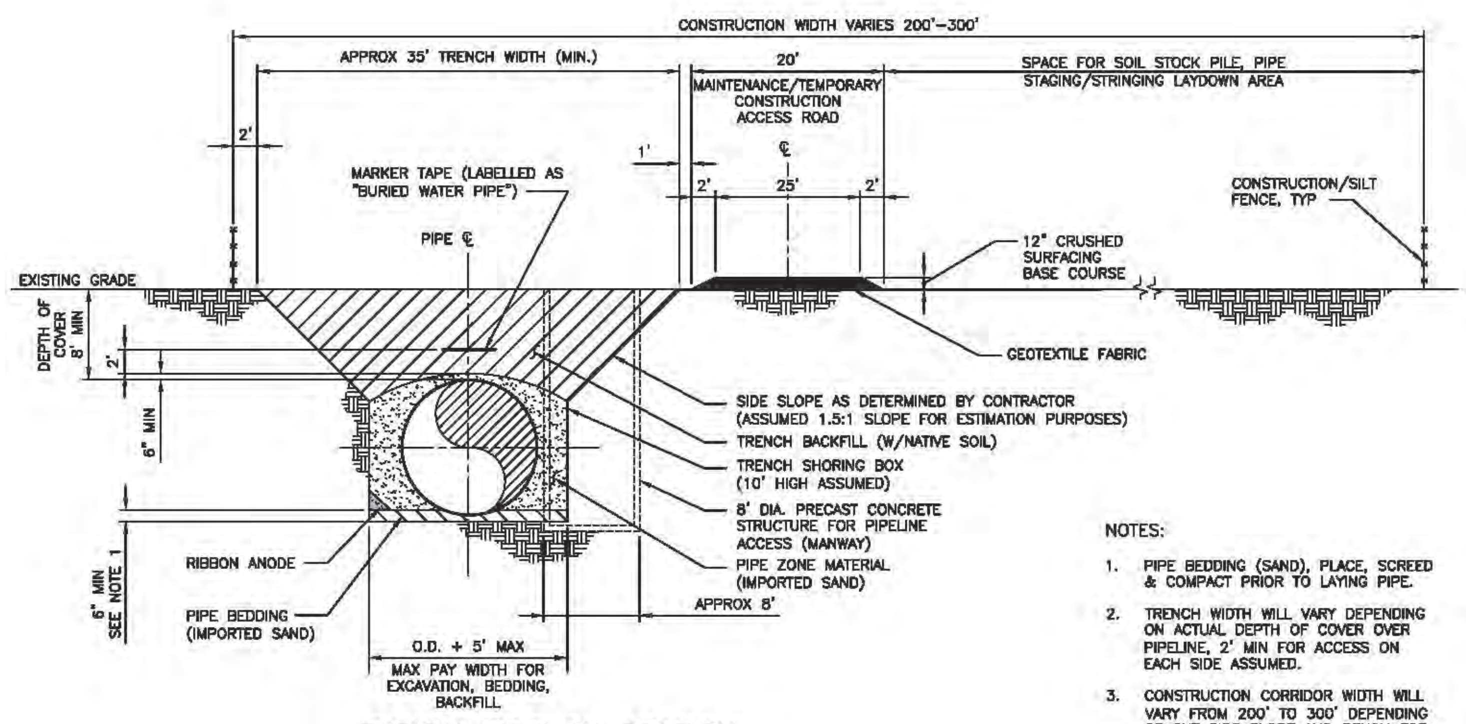


PIPELINE PROFILE
STA: 90+00 TO 102+00 (D / 1C-30)
SCALE: 1" = 100' H; 1" = 20' V



NOTES:

1. PIPE BEDDING (SAND), PLACE, SCREED & COMPACT PRIOR TO LAYING PIPE.
2. TRENCH WIDTH WILL VARY DEPENDING ON ACTUAL DEPTH OF COVER OVER PIPELINE, 2' MIN FOR ACCESS ON EACH SIDE ASSUMED.
3. CONSTRUCTION CORRIDOR WIDTH WILL VARY FROM 200' TO 300' DEPENDING OF CUT SIDE SLOPE AND BENCH FOR DEEPER EXCAVATION.

TYPICAL TRENCH SECTION
LOOKING SOUTH (1 / –)
SCALE: 1-1/2" = 1'-0"

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KITTITAS DIVISION
KACHESS DROUGHT RELIEF PUMPING PLANT

B. SHAHA
DESIGNED

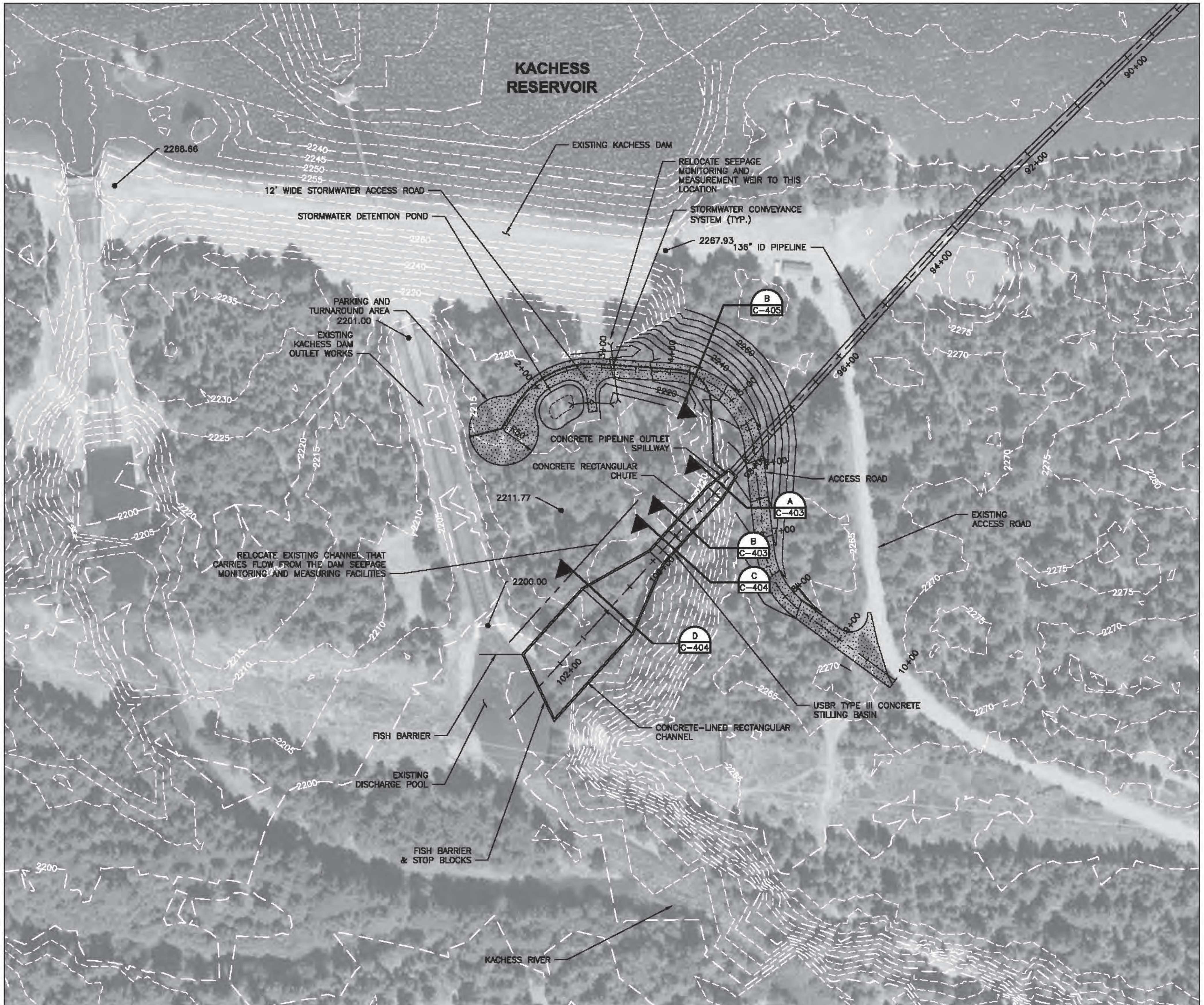
V. KOVALISHYN
REVIEWED

YAKIMA, WA 2014-08-20

PIPELINE SECTIONS AND DETAILS 2

ALTERNATIVE 1
EAST SHORE PUMPING PLANT

1C-303
SHEET 19 OF 33



PLAN

0 40 80 160
SCALE IN FEET

N

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KITTITAS DIVISION

KACHESS DROUGHT RELIEF
PUMPING PLANT

DESIGNED J. VANIER

REVIEWED B. SHAHA

YAKIMA, WA 2014-08-20

OUTLET WORKS
SITE PLAN

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-401

SHEET 20 OF 33

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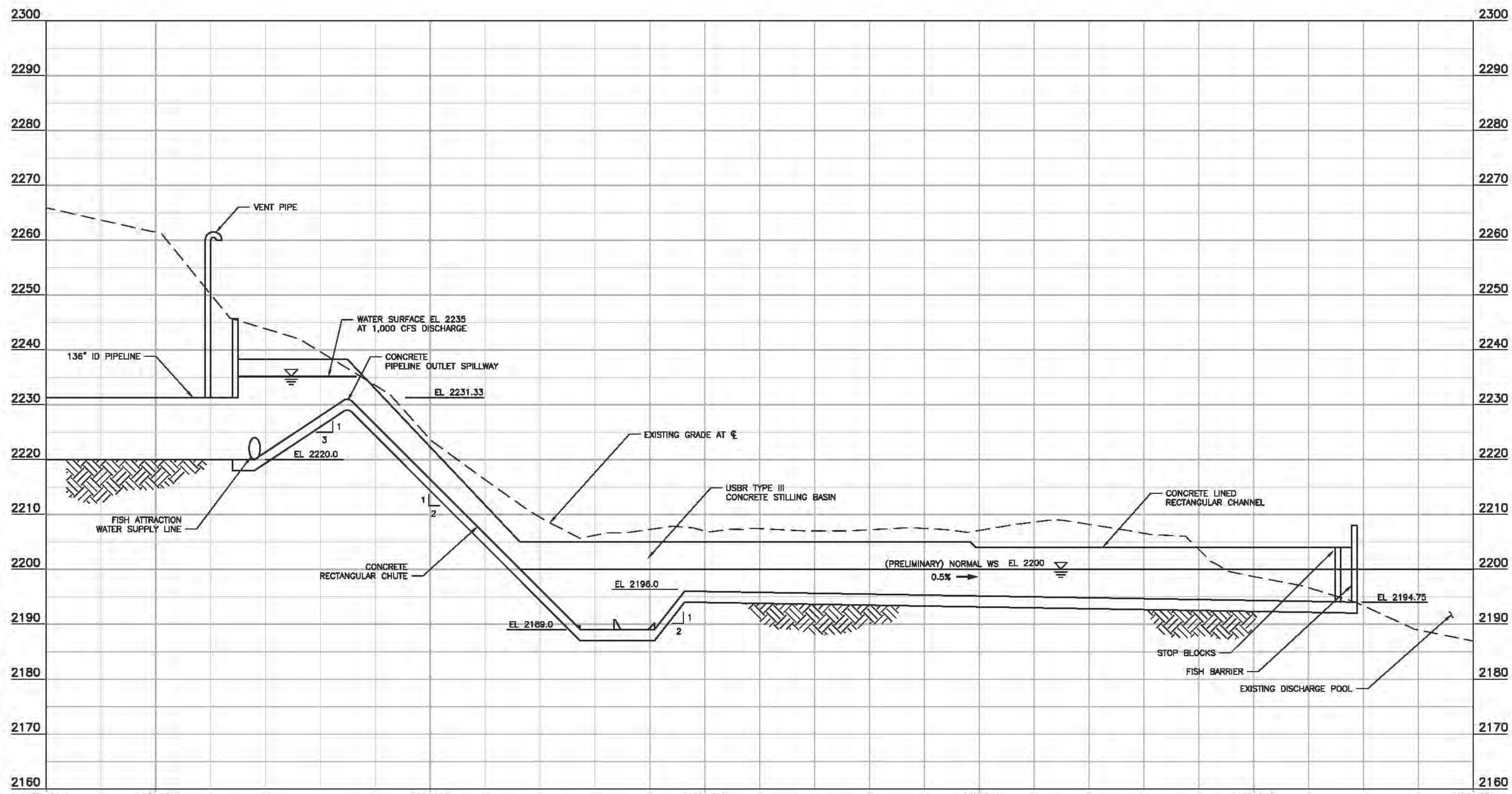

OUTLET WORKS PROFILE

SCALE: HORIZ 1" = 20'
VERT 1" = 10'

FEASIBILITY DRAWING
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KACHESS DROUGHT RELIEF PUMPING PLANT

J. VANIER
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OUTLET WORKS PROFILE

ALTERNATIVE 1 EAST SHORE PUMPING PLANT

1C-402

SHEET 21 OF 33

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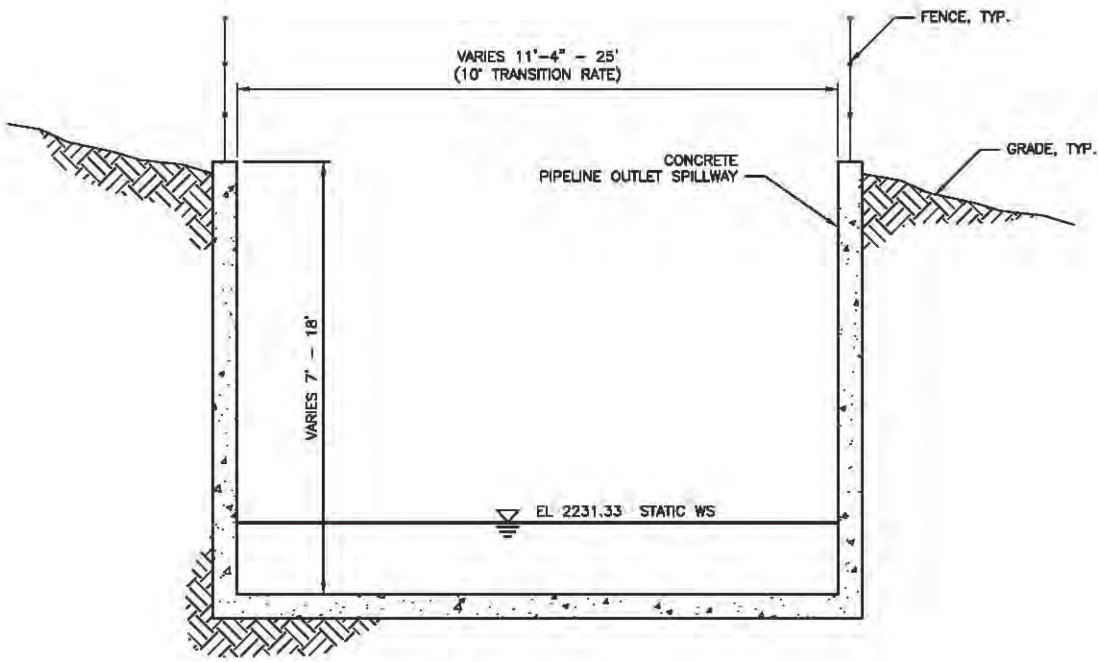
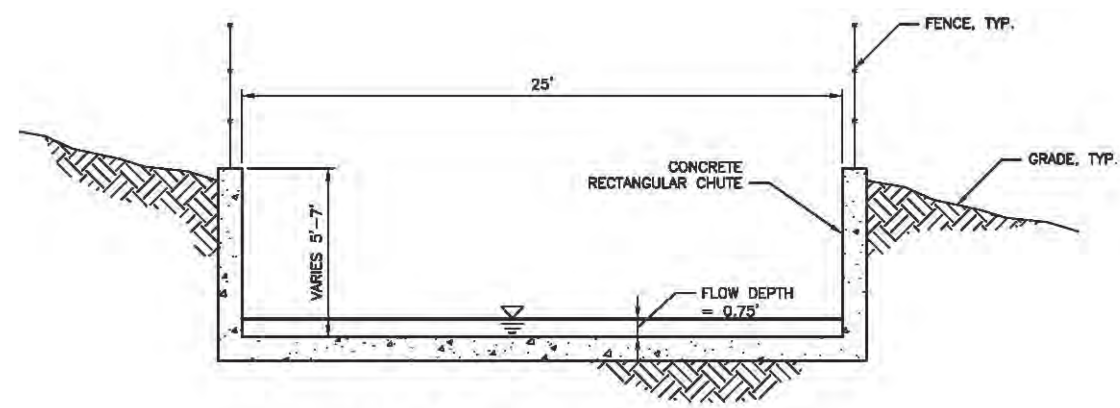


SECTION
STA 98+27 TO STA 98+67 (A / C-401)
SCALE: 1" = 4'



SECTION
STA 98+67 TO STA 99+52 (B / C-401)
SCALE: 1" = 4'

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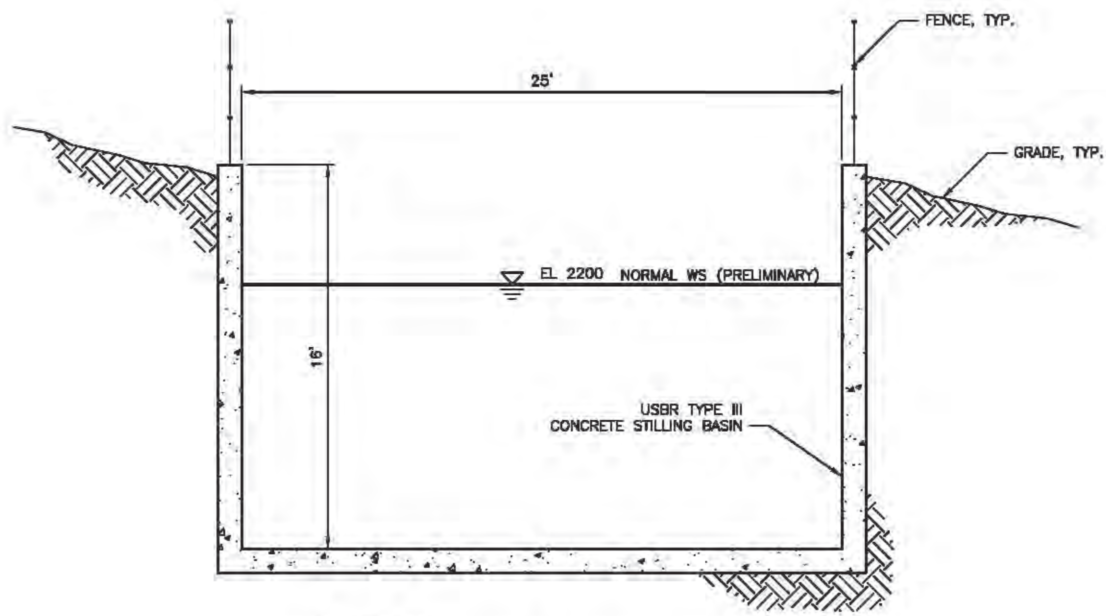
KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED J. VANIER
REVIEWED B. SHAHA
YAKIMA, WA 2014-08-20

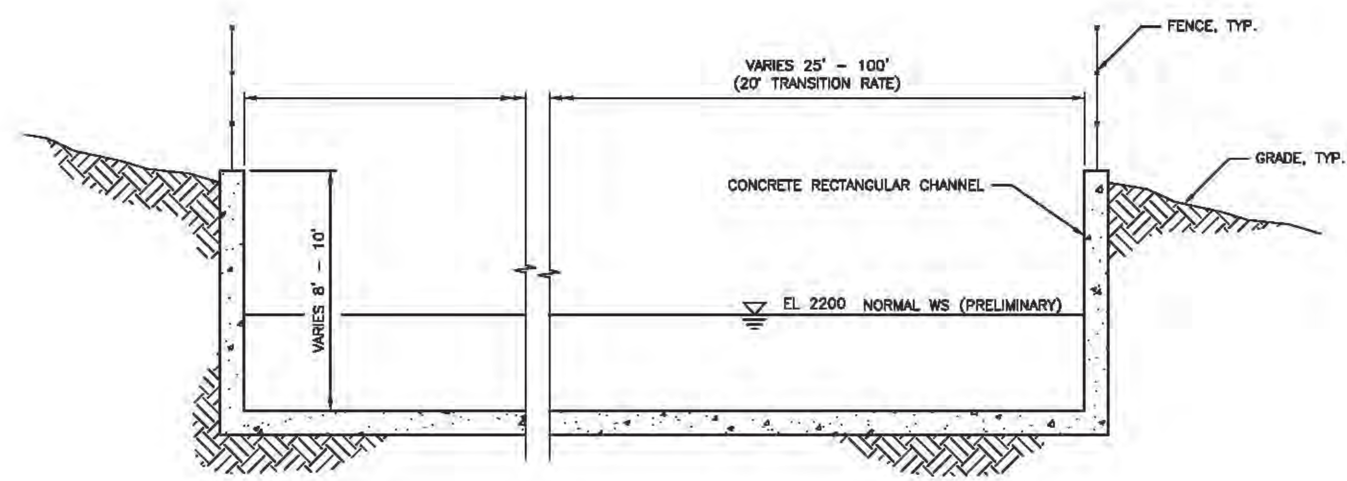
OUTLET WORKS
SECTIONS 1

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-403
SHEET 22 OF 33



SECTION
STA 99+52 TO STA 99+93 C C-401
SCALE: 1" = 4'



SECTION
STA 99+93 TO STA 102+44 D C-401
SCALE: 1" = 4'

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF PUMPING PLANT

J. VANIER
DESIGNED

B. SHAHA
REVIEWED

YAKIMA, WA 2014-06-20

OUTLET WORKS
SECTIONS 2

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-404
SHEET 23 OF 33

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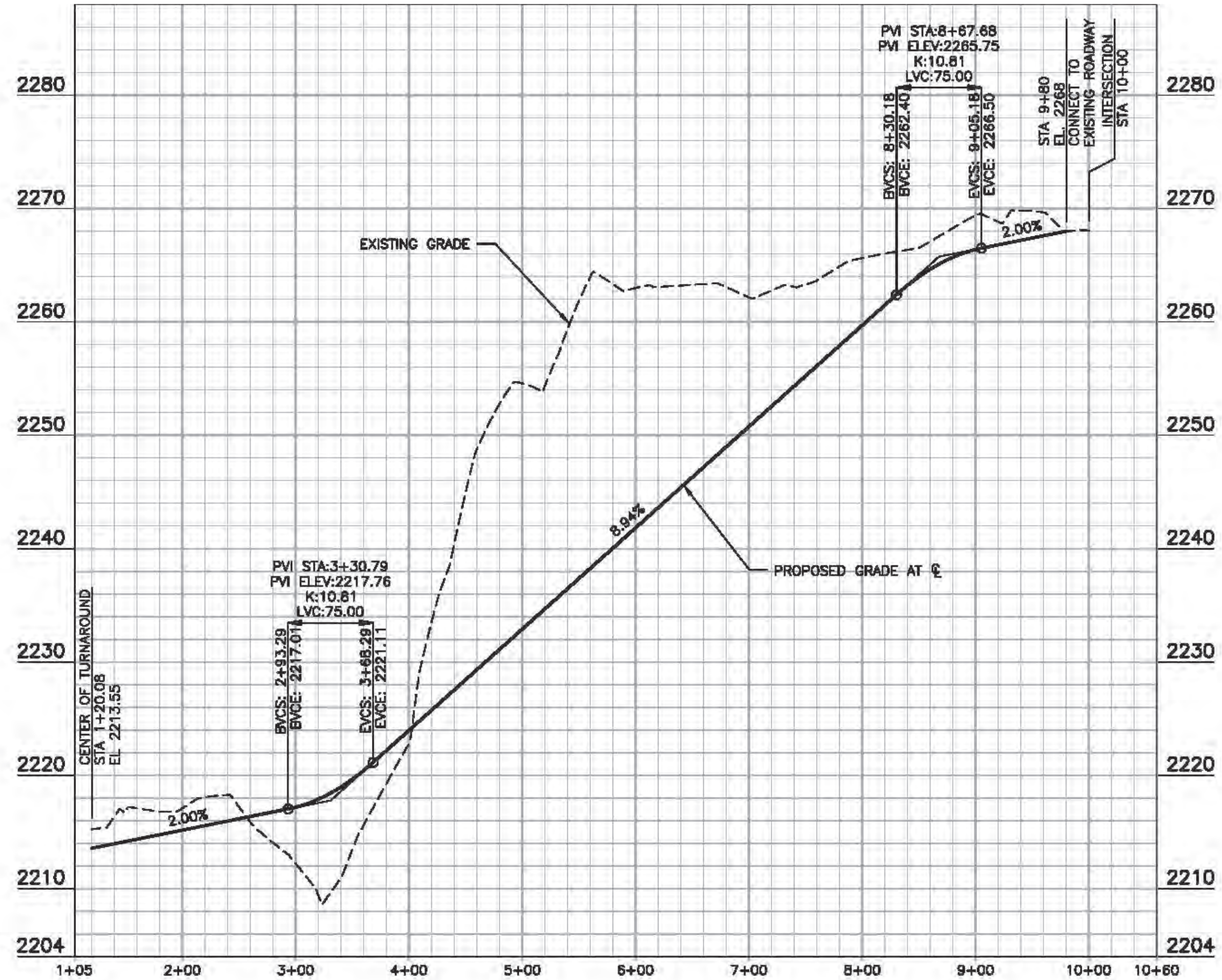
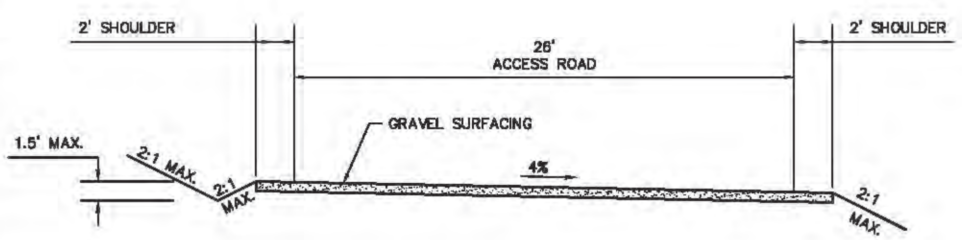


ACCESS ROAD PROFILE

SCALE: HORIZ 1"=80' VERT 1"=8'



SECTION

SCALE: NTS

B 1C-401

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KITTITAS DIVISION
KACHESS DROUGHT RELIEF
PUMPING PLANT

DESIGNED	J. VANIER
REVIEWED	B. SHAHA
YAKIMA, WA	2014-08-20

OUTLET WORKS
ACCESS ROAD
PROFILE AND SECTIONS

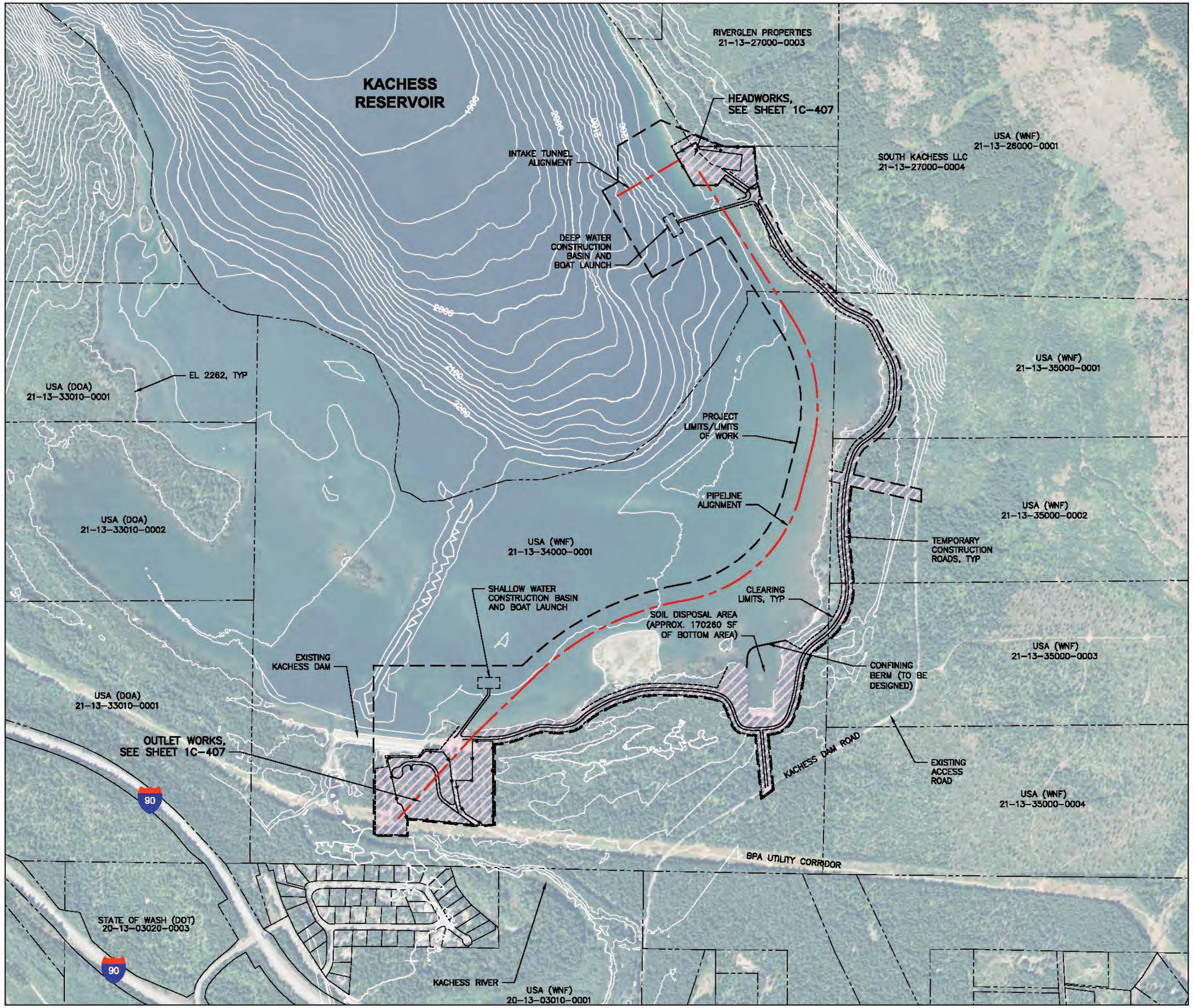
ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-405

SHEET 24 OF 33

NOTES:

1. THIS PLAN DEPICTS A CONCEPT FOR CONSTRUCTION STAGING TO FACILITATE INITIAL PLANNING AND COST ESTIMATION EFFORTS. IT WILL ULTIMATELY BE THE CONTRACTOR'S RESPONSIBILITY TO DESIGN THE BATCH PLANT, CONSTRUCTION BASIN AND BOAT LAUNCH, BLASTING MAGAZINE BUILDING, SECURITY FENCING AND ASSOCIATED CONSTRUCTION ROADS.
2. CLEARING ALONG THE POWER TRANSMISSION LINE CORRIDOR WILL BE NECESSARY, BUT HAS BEEN OMITTED FROM THIS PLAN AS THE ROUTE HAS NOT YET BEEN DETERMINED (SEE SHEET 1C-501)



PLAN

0 250 500 1000
SCALE IN FEET

N

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KITTITAS DIVISION
KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED: J. VANIER
REVIEWED: B. SHAHA
YAKIMA, WA 2014-08-20

TEMPORARY CONSTRUCTION STAGING

ALTERNATIVE 1
EAST SHORE PUMPING PLANT

1C-406

SHEET 25 OF 33

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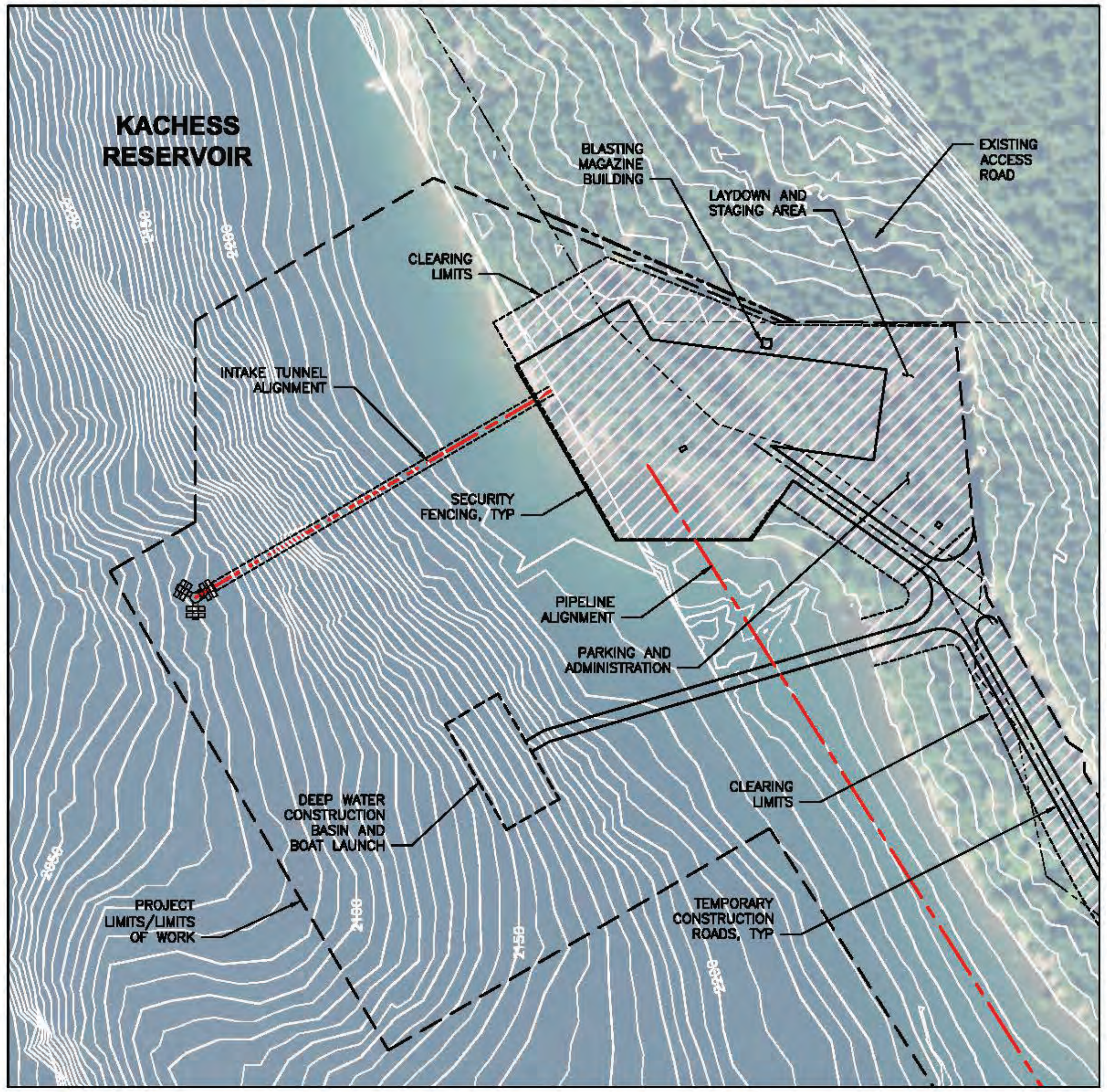

HEADWORKS PLAN

0 75 150 300
SCALE IN FEET

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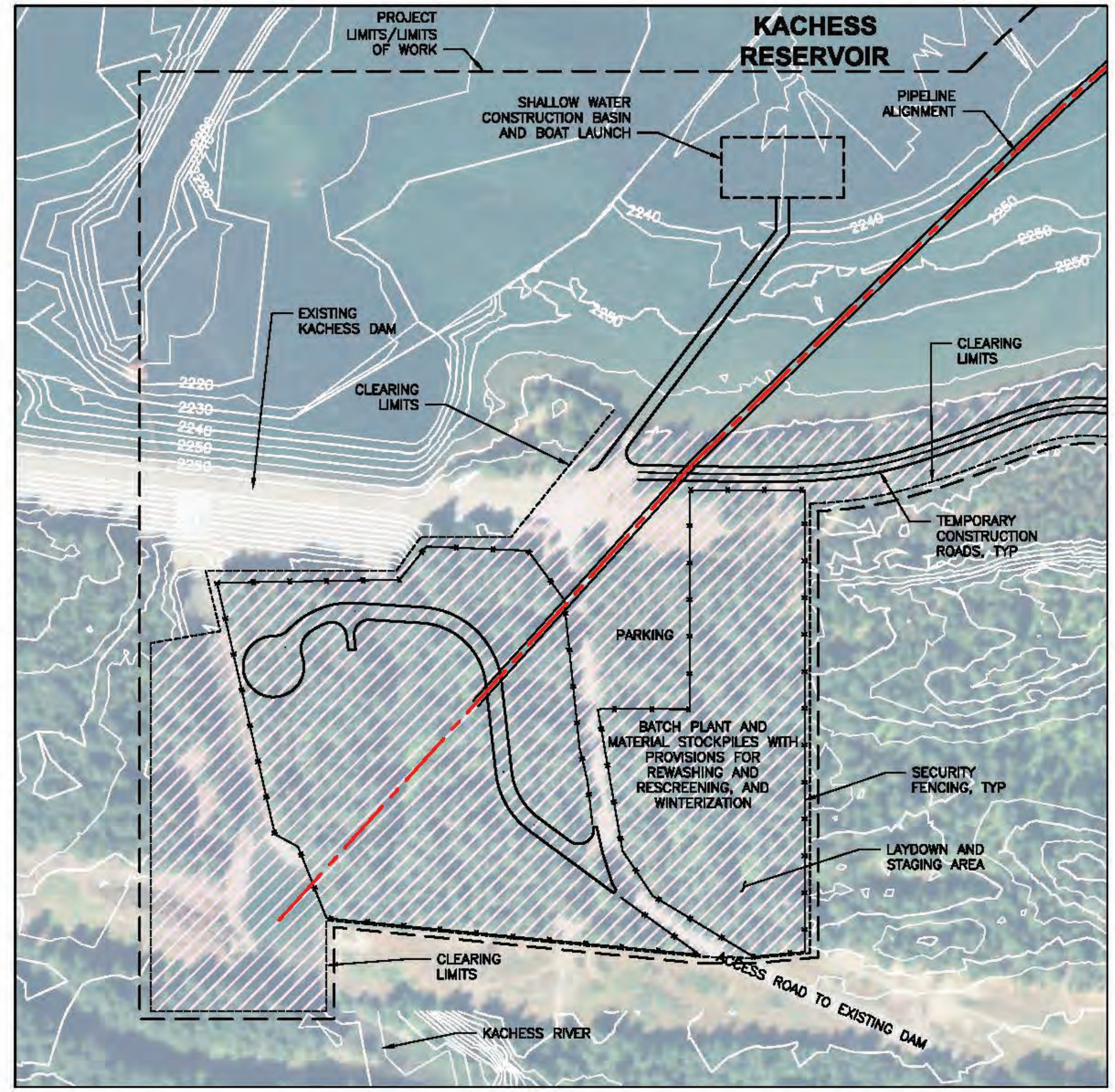

OUTLET WORKS PLAN

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NOTES:

1. THIS PLAN DEPICTS A CONCEPT FOR CONSTRUCTION STAGING TO FACILITATE INITIAL PLANNING AND COST ESTIMATION EFFORTS. IT WILL ULTIMATELY BE THE CONTRACTOR'S RESPONSIBILITY TO DESIGN THE BATCH PLANT, CONSTRUCTION BASIN AND BOAT LAUNCH, BLASTING MAGAZINE BUILDING, SECURITY FENCING AND ASSOCIATED CONSTRUCTION ROADS.
2. CLEARING ALONG THE POWER TRANSMISSION LINE CORRIDOR WILL BE NECESSARY, BUT HAS BEEN OMITTED FROM THIS PLAN AS THE ROUTE HAS NOT YET BEEN DETERMINED (SEE SHEET 1C-501)

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Managing Water in the West

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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA PROJECT – WA
KITTITAS DIVISION

KACHESS DROUGHT RELIEF
PUMPING PLANT

DESIGNED J. VANIER

REVIEWED B. SHAHA

YAKIMA, WA 2014-08-20

TEMPORARY CONSTRUCTION STAGING ENLARGED PLAN

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-407

SHEET 26 OF 33

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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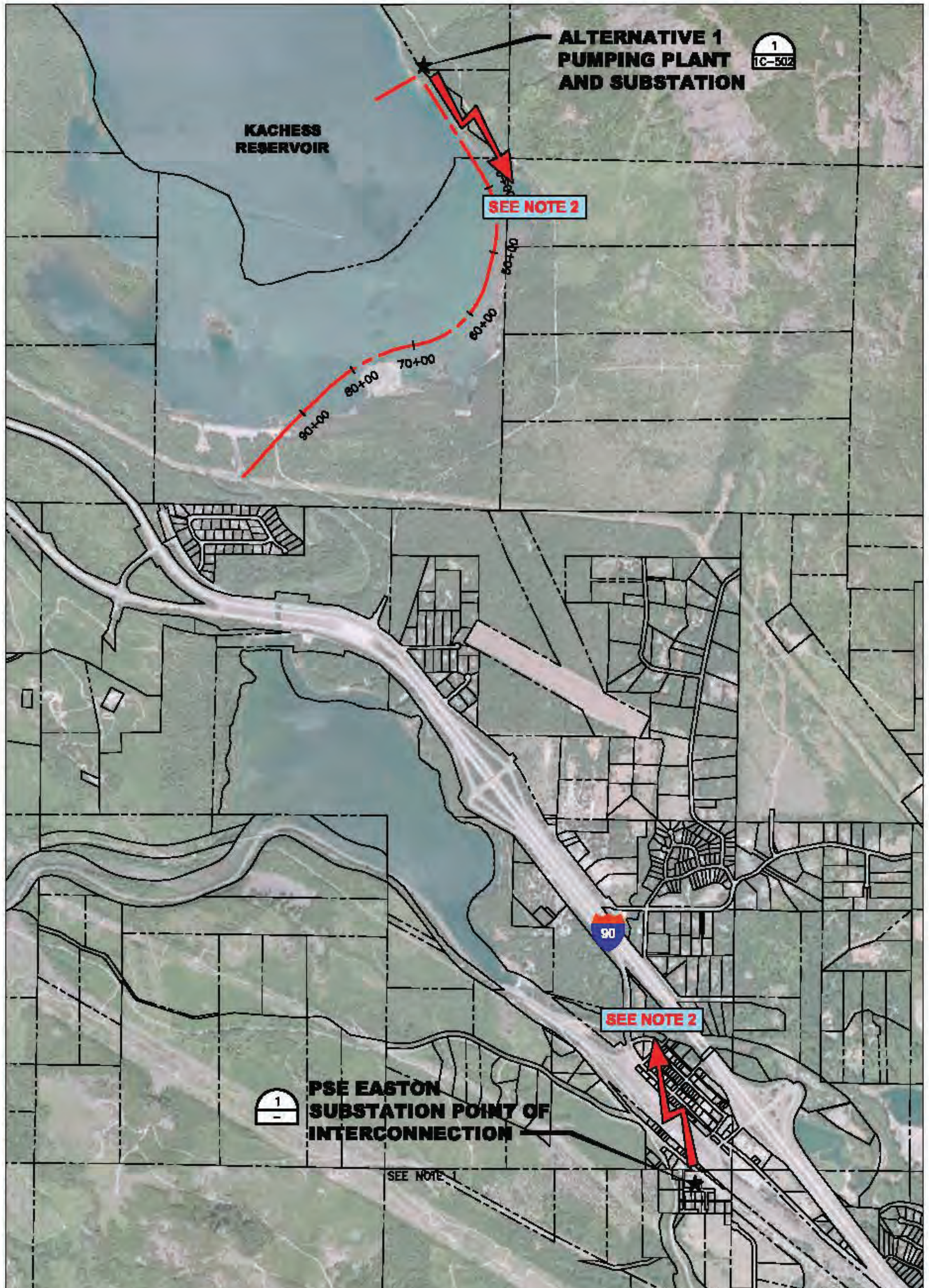

ALTERNATIVE 1 – POWER SUPPLY PLAN

SCALE: NO SCALE

EASTON INTERCONNECTION PLAN 1 –

SCALE: 1" = 60'

NOTES:

1. PUGET SOUND ENERGY (PSE) SUBSTATION LOCATED IN THE TOWN OF EASTON ON PELTON AVE AND 2ND STREET. CURRENTLY A DISTRIBUTION SUBSTATION, WHICH WILL REQUIRE MODIFICATIONS AND A 115 KV BAY ADDITION TO SUPPLY PUMPING LOADS. WILL ALSO REQUIRE CONTROL MODIFICATIONS.

2. DISTANCE FROM POINT OF INTERCONNECTION TO PUMPING PLANT SUBSTATION IS 3.3 MILES 'AS THE CROW FLIES'. ACTUAL ROUTE HAS NOT BEEN SELECTED. FOR ESTIMATING PURPOSES, USE 1.5 TIMES THE LINEAR DISTANCE.

FEASIBILITY DRAWING

ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

E. WEBBER
DESIGNED

V. KOVALISHYN
REVIEWED

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POWER SUPPLY
SITE PLAN

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C–501

SHEET 27 OF 33

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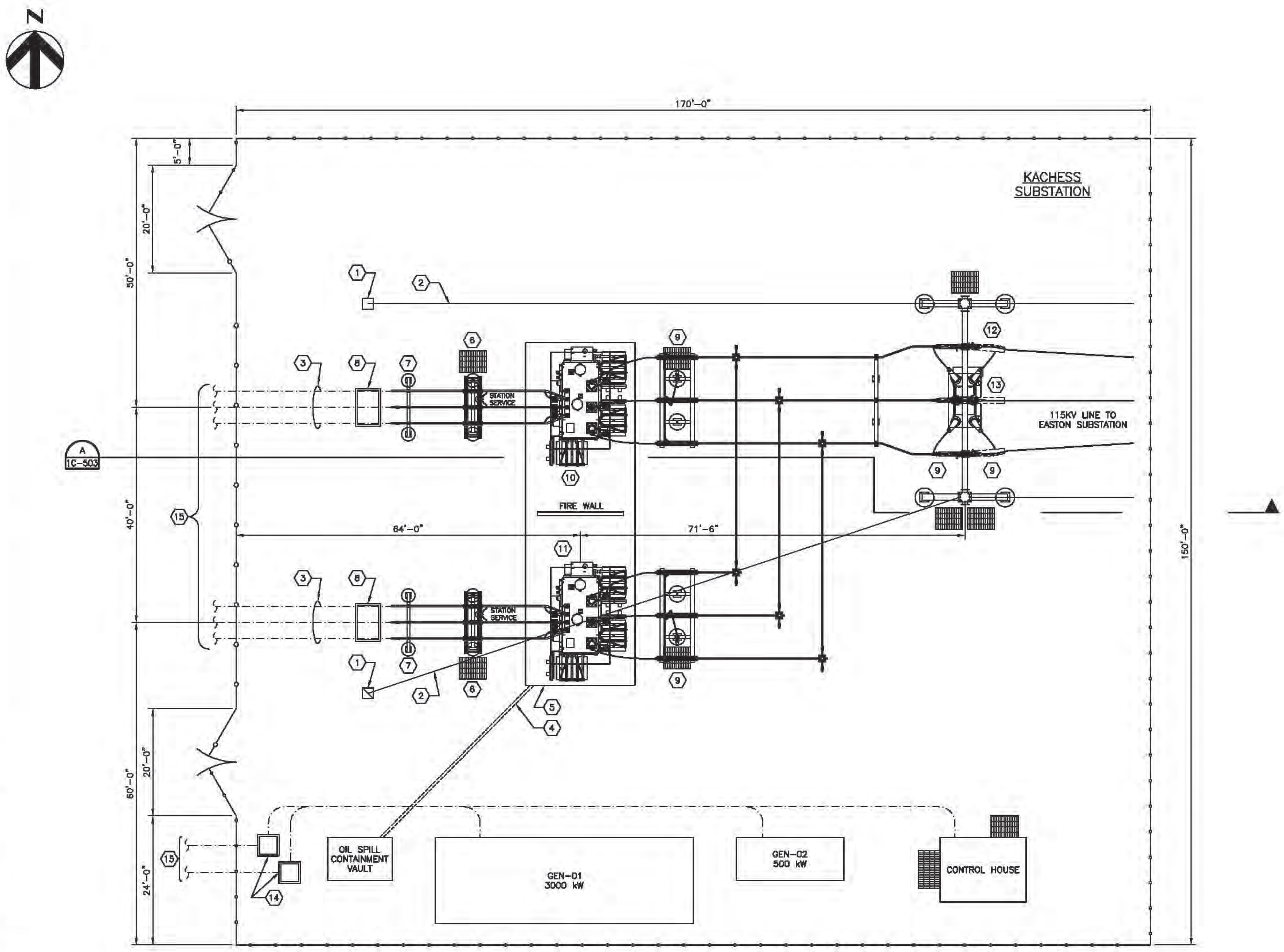

KEY NOTES:

1. GROUND WIRE MAST
2. OPTICAL GROUND WIRE (OPGW)
3. UNDERGROUND CABLE CONDUITS
4. OIL SPILL CONTAINMENT PIPE
5. OIL SPILL CONTAINMENT STRUCTURE
6. LOW SIDE DISCONNECT
7. TERMINATION STAND FOR UNDERGROUND TO PUMPING STATION
8. MANHOLE
9. 115kV DISCONNECT
10. 115-12.5kV, 16/25/35 MVA TRANSFORMER T1
11. 115-12.5kV, 16/25/35 MVA TRANSFORMER T2
12. 115kV LINE SWITCH
13. 115kV BREAKER
14. PULLBOX FOR CONTROL HOUSE AND GENSET
15. UNDERGROUND CABLE CONDUITS TO PUMPING PLANT

SUBSTATION PLAN

SCALE: 3/32"=1'-0"

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED E. WEBBER
REVIEWED V. KOVALISHYN
YAKIMA, WA 2014-08-20

POWER SUPPLY SUBSTATION PLAN

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1C-502

SHEET 28 OF 33

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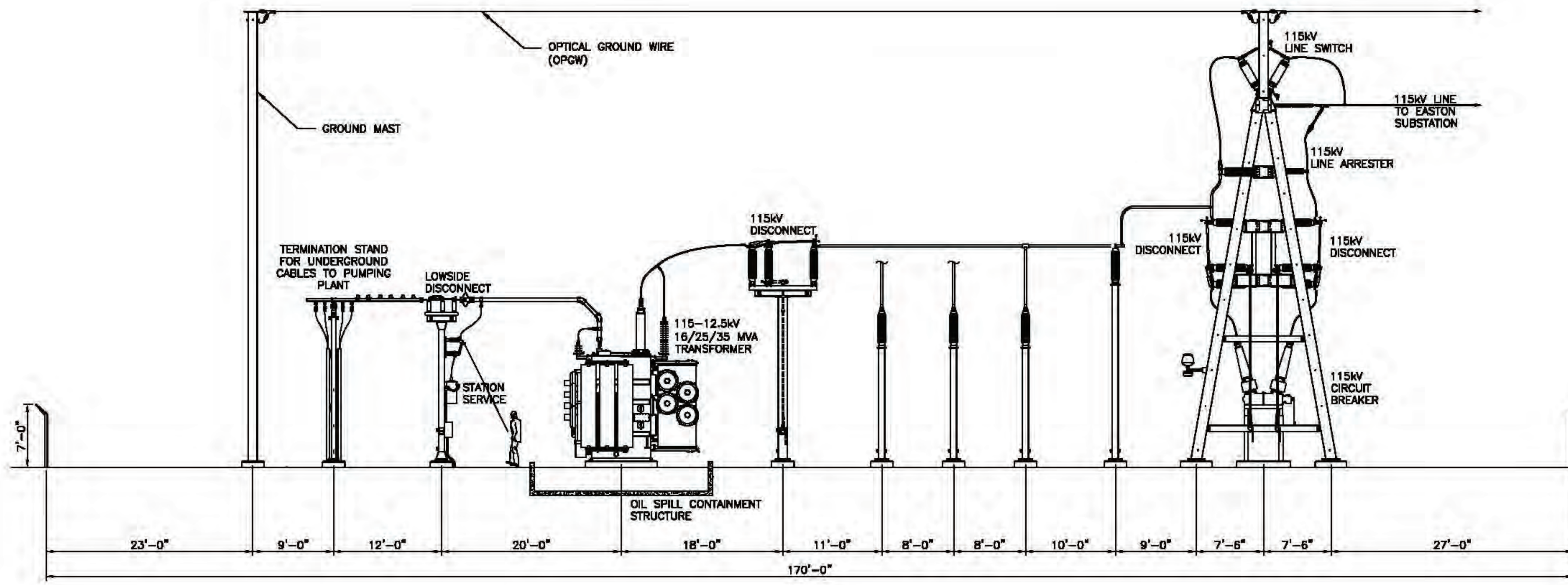
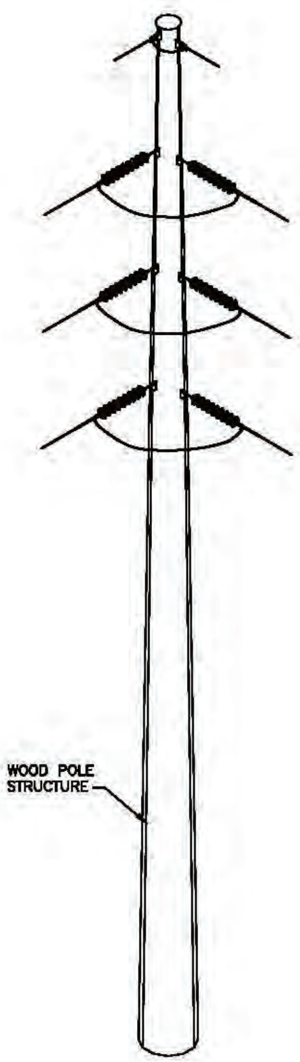
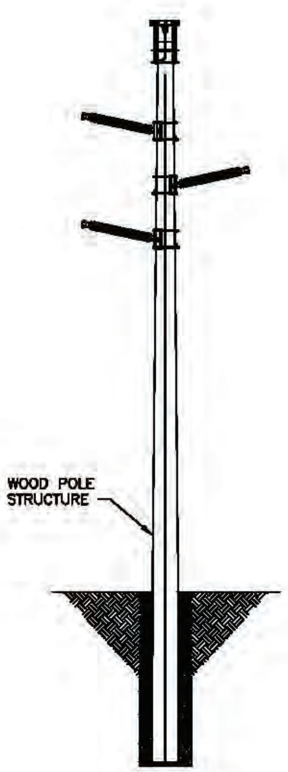


SUBSTATION SECTION
SCALE: 1/8"=1'-0"
A
1C-502



90° TURN TRANSMISSION POLE
SCALE: 3/32"=1'-0"



80' TANGENT TRANSMISSION POLE
SCALE: 3/32"=1'-0"

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

E. WEBBER
DESIGNED

V. KOVALISHYN
REVIEWED

YAKIMA, WA 2014-08-20

POWER SUPPLY SECTION

ALTERNATIVE 1
EAST SHORE PUMPING PLANT

1C-503

SHEET 29 OF 33

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PRIMARY ELEMENT SYMBOLOGY

- ORIFICE PLATE
- THERMAL DISPERSION FLOWMETER
- SONIC OR ULTRASONIC FLOWMETER
- MAGNETIC FLOWMETER
- PROPELLER OR TURBINE METER
- ROTAMETER
- FLUME
- WEIR
- VENTURI TUBE
- SUBMERSIBLE LEVEL SENSOR
- MOTOR
- DIAPHRAGM OPERATOR
- GAUGE
- THERMOWELL
- FLOAT SWITCHES

ACTUATOR SYMBOLS

OPERATOR ABBREVIATIONS:
M = MOTOR
P = PNEUMATIC (SINGLE OR DOUBLE)
S = SOLENOID
H = HYDRAULIC
XX: FO = FAIL TO OPEN
FC = FAIL TO CLOSE
FLP = FAIL TO LAST POSITION

FLOAT OPERATOR

LINE TYPES

- PRIMARY PROCESS LINE
- SECONDARY PROCESS LINE
- AUXILIARY PROCESS LINE
- FUTURE PROCESS LINE
- EXISTING PROCESS LINE
- PROCESS OPEN CHANNEL
- PNEUMATIC SIGNAL
- ELECTRIC SIGNAL, ANALOG
- ELECTRIC SIGNAL, DISCRETE
- ELECTRIC POWER
- HYDRAULIC SIGNAL
- SOFTWARE OR DATA LINK
- SIGNAL CONNECTION
- CROSSOVER – NO CONNECTION
- CAPILLARY TUBE
- TELEMETRY LINE
- ULTRASONIC SIGNAL (UNGUIDED)
- PACKAGED EQUIPMENT

INSTRUMENT SYMBOLOGY

- FIELD MOUNTED
- MOUNTED ON PANEL FACE
- MOUNTED BEHIND PANEL
- MOUNTED ON AUXILIARY PANEL
- MOUNTED BEHIND AUXILIARY PANEL
- INDICATOR LIGHT
- INTERLOCK. SEE CONTROL DIAGRAMS OR SPECIFICATIONS
- SHARED DISPLAY, SHARED PANEL, FIELD MOUNTED
- SHARED DISPLAY, SHARED CONTROL, PRIMARY LOCATION – NORMALLY ACCESSIBLE TO OPERATOR
- PROGRAMMABLE LOGIC CONTROL
- PLC ANALOG INPUT
- PLC DISCRETE INPUT
- PLC ANALOG OUTPUT
- PLC DISCRETE OUTPUT

PUMP AND COMPRESSOR SYMBOLS

- CENTRIFUGAL PUMP (DRY PIT)
- SUBMERSIBLE PUMP
- CHEMICAL FEED PUMP
- GEAR PUMP OR BLOWER
- PROGRESSING CAVITY PUMP
- METERING PUMP
- DIAPHRAGM PUMP
- VERTICAL TURBINE OR PROPELLER PUMP
- COMPRESSOR
- PERISTALTIC PUMP
- CENTRIFUGAL BLOWER OR FAN
- ROTARY PUMP
- ROTARY LOBE PUMP

MISCELLANEOUS SYMBOLS

- SPRAY NOZZLE
- CALIBRATION COLUMN
- FLEXIBLE HOSE
- DIAPHRAGM SEAL
- IN-LINE DIAPHRAGM SEAL
- ACCUMULATOR
- RUPTURE DISK
- HEAT EXCHANGER
- SPIRAL HEAT EXCHANGER
- BUBBLER LEVEL TUBE
- EJECTOR
- CHEMICAL INJECTOR
- MIXER
- STATIC MIXER
- FLOW STRAIGHTENER
- SLUDGE GRINDER
- MUD VALVE
- IN WALL PUMP
- IN SITU PROBE
- ULTRASONIC LEVEL SENSOR
- AIR DIAPHRAGM VALVE (HPA)
- DOUBLE AIR DIAPHRAGM VALVE (HPA)
- DRAIN (D)
- FLAME ARRESTER
- YARD HYDRANT (YH)
- QUICK DISCONNECT
- CIRCUIT SETTER

VALVES

- BALL VALVE
- BUTTERFLY VALVE
- CONE VALVE
- CHECK VALVE
- DOUBLE-DISK CHECK VALVE
- BALL CHECK VALVE
- DIAPHRAGM VALVE
- GATE VALVE
- GLOBE VALVE
- KNIFE GATE VALVE
- NEEDLE VALVE
- PINCH VALVE
- PLUG VALVE
- TELESCOPING VALVE
- THROTTLE VALVE
- THREE-WAY BALL VALVE
- THREE-WAY PLUG VALVE
- SAMPLE VALVE (SP)
- SOLENOID VALVE
- PRESSURE-REDUCING VALVE
- PRESSURE-REGULATING VALVE
- THREE-WAY CONTROL VALVE
- OR PRESSURE-RELIEF VALVE
- AIR-RELEASE VACUUM VALVE
  A = AIR RELEASE
  VAC = VACUUM

VALVE & EQUIPMENT TAG NUMBERS

XXX-AAA-NN

XXX:	INSTRUMENT TYPE OR EQUIPMENT TYPE (ACCORDING TO ISA 5.31–SEE TABLE)
AAA:	SITE AREA NUMBER
NN:	SUFFIX FOR DEVICE NUMBER

GATE SYMBOLS

- SLIDE
- BUTTERFLY
- FLAP
- STOP
- FABRICATED SLIDE
- SHEAR

CONTROL SWITCH NOTATION ABBREVIATIONS

XXXXX

ACK	ACKNOWLEDGE
ESTOP	EMERGENCY STOP
FAIL	FAILURE
FOR	FORWARD–OFF–REVERSE
FLT	FAULT
FR	FORWARD–REVERSE
FS	FAST–SLOW
HA	HAND–AUTO
HIM	HUMAN INTERFACE MODULE (DISPLAY AND KEYPAD)
HOA	HAND–OFF–AUTO
HOR	HAND–OFF–REMOTE
LL	LEAD–LAG
LLS	LEAD–LAG–STANDBY
LOR	LOCAL–OFF–REMOTE
LR	LOCAL–REMOTE
LS	LEAD–STANDBY
MA	MANUAL–AUTO
OAC	OPEN–AUTO–CLOSE
OC	OPEN–CLOSE
OO	ON–OFF
OSC	OPEN–STOP–CLOSE
RJ	RUN–JOG
RJR	RUN–JOG–REVERSE
RST	RESET
SIL	SILENCE
SP	SPEED
SS	START–STOP

TYPES OF POWER SUPPLY

A	PLANT COMPRESSED AIR
IA	INSTRUMENTATION AIR
ES	ELECTRIC SUPPLY
NG	NATURAL GAS
HYD	HYDRAULIC

CROSS REFERENCE SYMBOLOGY

- Y-3 CONTINUATION ON SHEET Y-3
- Y-3 CONTINUATION ON SHEET Y-3

GENERAL NOTES:

1. THIS IS A STANDARD INSTRUMENTATION SYMBOLOGY AND ABBREVIATIONS SHEET. LISTING OF SYMBOLS AND ABBREVIATIONS DOES NOT IMPLY ALL SYMBOLS AND ABBREVIATIONS HAVE BEEN USED ON THIS PROJECT.
2. SEE PROCESS, MECHANICAL AND PLUMBING LEGEND SHEET FOR MISCELLANEOUS PIPING SYMBOLS.
3. SCREENING OR SHADING OF WORK IS USED TO INDICATE EXISTING COMPONENTS OR TO DE-EMPHASIZE PROPOSED IMPROVEMENTS TO HIGHLIGHT SELECTED TRADE WORK. REFER TO CONTEXT OF EACH SHEET FOR USAGE.
4. VALVE SYMBOLS SHOWN HERE ARE APPLICABLE ONLY TO INSTRUMENTATION DIAGRAMS. SEE PROCESS, MECHANICAL AND PLUMBING LEGEND SHEET FOR VALVE SYMBOLS USED ELSEWHERE ON THE SHEETS.

MISCELLANEOUS INSTRUMENTATION ABBREVIATIONS

AC	AIR CONDITIONER
AI	ANALOG INPUT
AO	ANALOG OUTPUT
CB	CIRCUIT BREAKER
CMD	COMMAND
CO	CARBON MONOXIDE – ANALYZER MODIFIER
CO2	CARBON DIOXIDE – ANALYZER MODIFIER
COMB	COMBUSTIBLES – ANALYZER MODIFIER
CS	CARBON SENSOR
DEN	DENSITY – ANALYZER MODIFIER
DI	DISCRETE INPUT
DIFF	DIFFERENTIAL
DO	DISCRETE OUTPUT
DO	DISSOLVED OXYGEN – ANALYZER MODIFIER
DMP	DAMPER
EF	EXHAUST FAN
E/P	VOLTAGE TO PNEUMATIC
EUH	ELECTRIC UNIT HEATER
FCU	FAN COIL UNIT
FLT	FAULT
FPP	FIBER PATCH PANEL
HOA	HAND/OFF/AUTO
IRRIG	IRRIGATION
I/O	INPUT/OUTPUT
I/P	CURRENT TO PNEUMATIC
LEL	LOWER EXPLOSION LIMIT
LVL	LEVEL
MFR	MANUFACTURER
OI	OPERATOR INTERFACE
O2	OXYGEN – ANALYZER MODIFIER
OC	OPEN/CLOSE
OSC	OPEN/STOP/CLOSE
OVLD	OVERLOAD
P&ID	PROCESS AND INSTRUMENTATION DIAGRAM
PRS	PRESSURE
PS	POWER SUPPLY
RST	RESET
RUN'G	RUNNING
SC1	SUCTION CHAMBER 1
SC2	SUCTION CHAMBER 2
SF	SUPPLY FAN
SP	SETPOINT
SPD	SURGE PROTECTIVE DEVICE
TB	TERMINAL BLOCK
TEMP	TEMPERATURE
TQS	TORQUE SWITCH
TS	TEMPERATURE SENSOR
TURB	TURBIDITY – ANALYZER MODIFIER
TYP	TYPICAL
UPS	UNINTERRUPTIBLE POWER SUPPLY
VIB	VIBRATION
VCP	VENDOR CONTROL PANEL
VFD	VARIABLE FREQUENCY DRIVE
WAN	WIDE AREA NETWORK
WW	WIREWAY

INSTRUMENT IDENTIFICATION LETTER

	FIRST LETTER		SUCCEEDING LETTERS		
	MEASURED OR INITIATING VARIABLE	MODIFIER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	ANALYSIS		ALARM		
B	BURNER, COMBUSTION				
C				CONTROL	CLOSED
D		DIFFERENTIAL			
E	VOLTAGE		SENSOR (PRIMARY ELEMENT)		
F	FLOW RATE	RATIO (FRACTION)			
G			GLASS, VIEWING DEVICE		
H	HAND				HIGH
I	CURRENT (ELECTRICAL)		INDICATE		
J	POWER	SCAN			
K	TIME, TIME SCHEDULE	TIME; RATE OF CHANGE		CONTROL STATION	
L	LEVEL		LIGHT		LOW
M	USER'S CHOICE	MOMENTARY			MIDDLE, INTERMEDIATE
N	USER'S CHOICE				
O	USER'S CHOICE		ORIFICE, RESTRICTION		
P	PRESSURE, VACUUM		POINT (TEST) CONNECTION		
Q	QUANTITY	INTEGRATE, TOTALIZE			
R	RADIATION		RECORD		
S	SPEED, FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMIT	
U	MULTIVARIABLE		MULTIFUNCTION	MULTIFUNCTION	MULTIFUNCTION
V	VIBRATION, MECH. ANALYSIS			VALVE, DAMPER, LOUVER	
W	WEIGHT, FORCE		WELL		
X	UNCLASSIFIED	X AXIS	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED
Y	EVENT, STATE OR PRESENCE	Y AXIS		RELAY, COMPUTE, CONVERT	
Z	POSITION, DIMENSION	Z AXIS		DRIVER, ACTUATOR, UNCLASSIFIED FINAL CONTROL ELEMENT	

RECLAMATION
Managing Water in the West

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YAKIMA PROJECT – WA
KITTITAS DIVISION
KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED T. MORRIS
REVIEWED V. KOVALSHYN
YAKIMA, WA 2014-08-20

P&ID LEGEND AND ABBREVIATIONS

ALTERNATIVE 1 EAST SHORE PUMPING PLANT

1I-601

SHEET 30 OF 33

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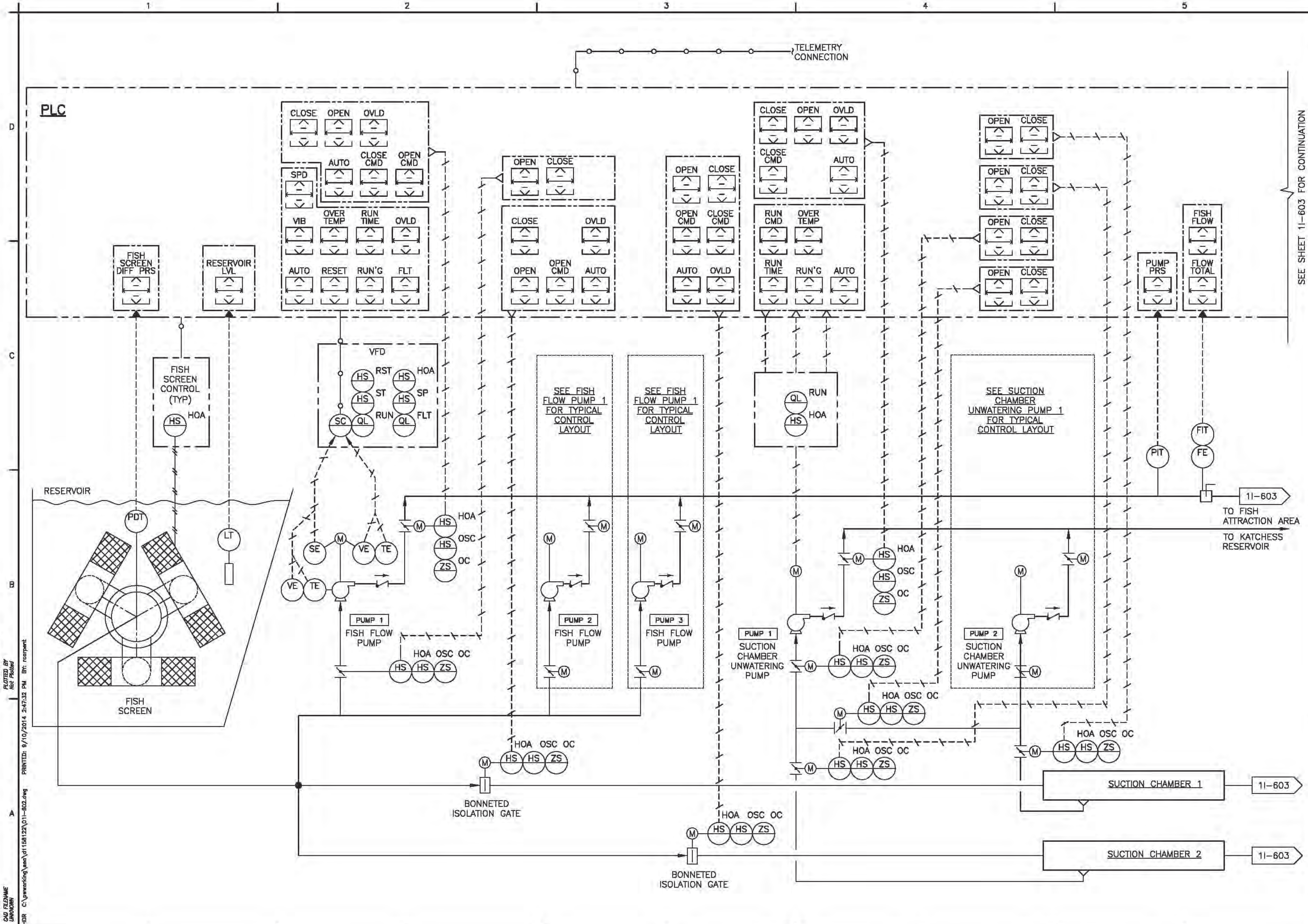

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KACHESS DROUGHT RELIEF PUMPING PLANT

For Discussion Purposes Only — Draft — Not For Distribution

DESIGNED T. MORRIS
REVIEWED V. KOVALISHYN
YAKIMA, WA 2014-08-20

P&ID
FISH FLOW AND UNWATERING PUMPS

ALTERNATIVE 1
EAST SHORE PUMPING PLANT

1I-602

SHEET 31 OF 33

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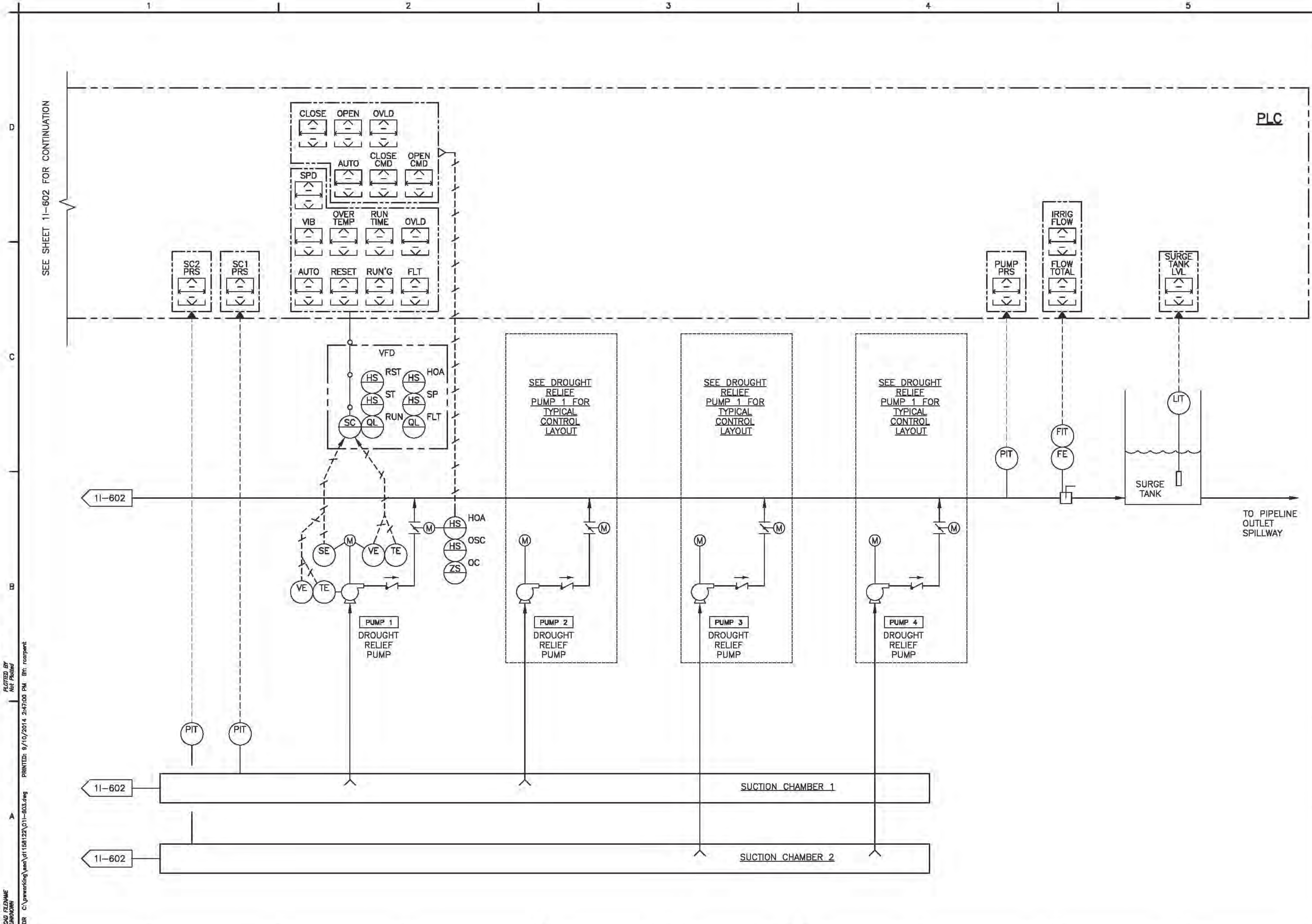

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DESIGNED T. MORRIS

REVIEWED V. KOVALISHYN

YAKIMA, WA 2014-08-20

P&ID
DROUGHT RELIEF PUMPS

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

1I-603

SHEET 32 OF 33

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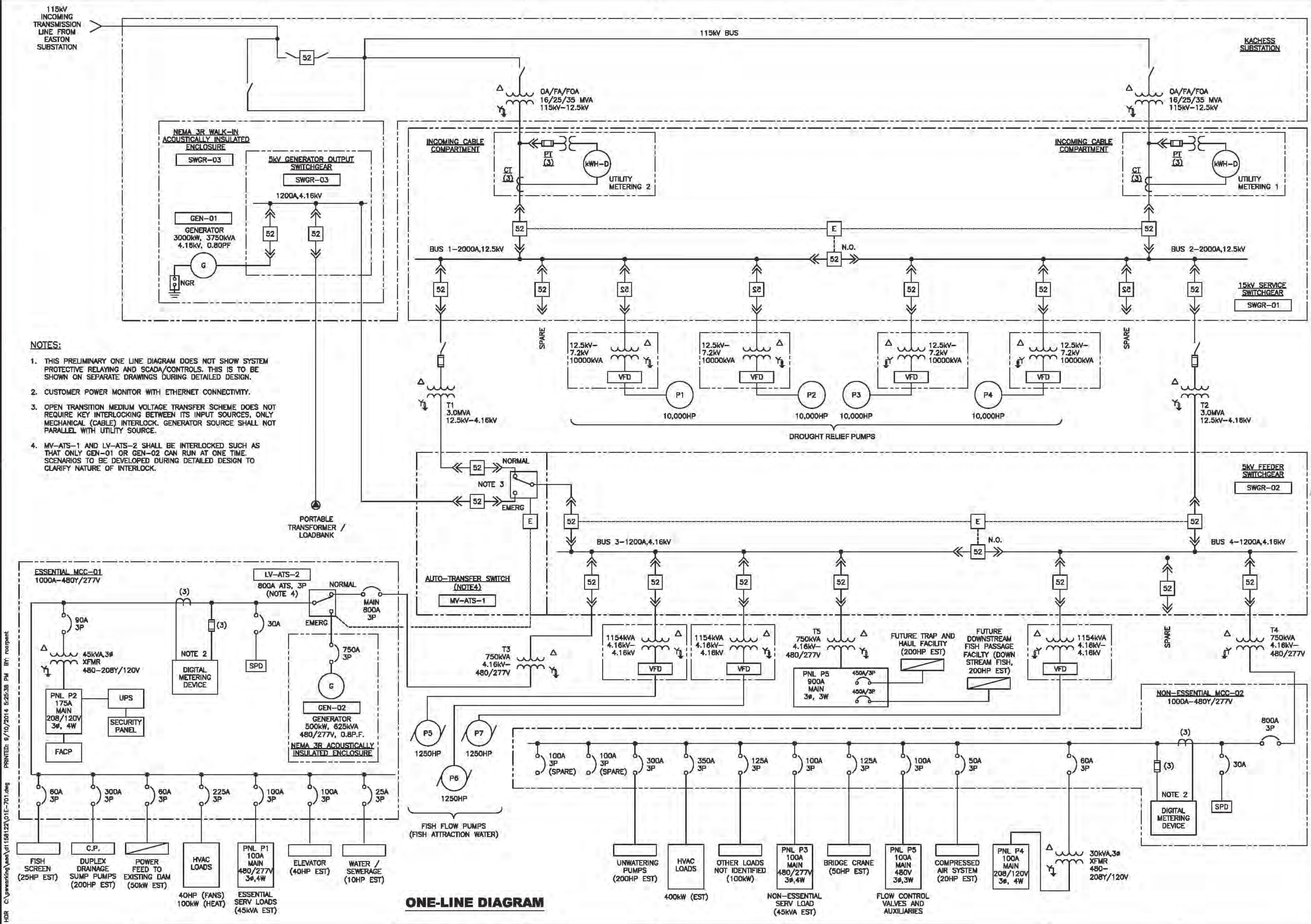

NOTES:

1. THIS PRELIMINARY ONE LINE DIAGRAM DOES NOT SHOW SYSTEM PROTECTIVE RELAYING AND SCADA/CONTROLS. THIS IS TO BE SHOWN ON SEPARATE DRAWINGS DURING DETAILED DESIGN.
2. CUSTOMER POWER MONITOR WITH ETHERNET CONNECTIVITY.
3. OPEN TRANSITION MEDIUM VOLTAGE TRANSFER SCHEME DOES NOT REQUIRE KEY INTERLOCKING BETWEEN ITS INPUT SOURCES, ONLY MECHANICAL (CABLE) INTERLOCK. GENERATOR SOURCE SHALL NOT PARALLEL WITH UTILITY SOURCE.
4. MV-ATS-1 AND LV-ATS-2 SHALL BE INTERLOCKED SUCH AS THAT ONLY GEN-01 OR GEN-02 CAN RUN AT ONE TIME. SCENARIOS TO BE DEVELOPED DURING DETAILED DESIGN TO CLARIFY NATURE OF INTERLOCK.

ONE-LINE DIAGRAM

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KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED K. McGOWAN
REVIEWED V. KOVALISHYN
YAKIMA, WA 2014-06-20

ELECTRICAL ONE-LINE DIAGRAM

ALTERNATIVE 1 EAST SHORE PUMPING PLANT

1E-701

SHEET 33 OF 33

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Appendix B
Alternative 2- South Pumping Plant Drawings

Alternative 2 – South Pumping Plant

2G-001	Cover Sheet
2C-101	Overall Site Plan
2C-102	Hydraulic Profile
2C-201	Tunnel – Plan and Profile
2C-202	Docking Sleeve – Plan
2C-203	Docking Sleeve – Section A
2C-204	Docking Sleeve – Section B
2C-205	Tunnel – Sections and Details
2C-301	Fish Screens – Plan and Details
2C-401	Pumping Plant t– Site Plan
2C-402	Pumping Plant t– Profile
2C-403	Pumping Plant– Plan A at EL. 2115
2C-404	Pumping Plant– Plan B at EL. 2200
2C-405	Pumping Plant– Plan C at EL. 2220
2C-406	Pumping Plant– Plan D at EL. 2250
2C-407	Pumping Plant– Section A
2C-408	Pumping Plant– Section B
2C-409	Pumping Plant– Section C
2C-410	Pumping Plant– Section D
2C-411	Pumping Plant – Discharge Structure
2C-412	Pumping Plant – Access Road Profile and Sections
2C-413	Temporary Construction Staging
2C-414	Temporary Construction Staging – Enlarged Plans
2C-501	Power Supply – Site Plan
2C-502	Power Supply – Substation Plan
2C-503	Power Supply – Section
2I-601	P&ID – Legend and Abbreviations
2I-602	P&ID – Fish Flow and Unwatering Pumps
2I-603	P&ID – Drought Relief Pumps
2E-701	Electrical – One-Line Diagram

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Managing Water in the West

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Bureau of Reclamation

Yakima River Basin Integrated Water Resources Management Plan

Kachess Drought Relief Pumping Plant

Alternative 2 - South Pumping Plant

Contract No: R13PC10006 ID/IQ

HDR Project No: 224009

WASHINGTON STATE
SCALE: NO SCALE

VICINITY MAP
SCALE: NO SCALE

INDEX OF DRAWINGS

LOCATION MAP
SCALE: NO SCALE

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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YAKIMA PROJECT – WA
KITTITAS DIVISION
KACHESS DROUGHT RELIEF PUMPING PLANT

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Draft
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B. SHAHA
DESIGNED

V. KOVALISHYN
REVIEWED

YAKIMA, WA 2014-08-20

COVER SHEET

ALTERNATIVE 2
SOUTH
PUMPING PLANT

2G-001
SHEET 1 OF 30

NOTE:

1. ABBREVIATIONS INCLUDE:
   - DOA – DEPARTMENT OF AGRICULTURE
   - DOT – DEPARTMENT OF TRANSPORTATION
   - BPA – BONNEVILLE POWER ADMINISTRATION
   - WNF – WASHINGTON NATIONAL FOREST

PLAN

0 200 400 800
SCALE IN FEET

N

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

RECLAMATION
Managing Water in the West

HDR

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STATE OF WASHINGTON
25753
REGISTERED
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BIROL SHAHA
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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA PROJECT – WA
KITTITAS DIVISION

KACHESS DROUGHT RELIEF
PUMPING PLANT

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B. SHAHA
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YAKIMA, WA 2014-08-20

OVERALL SITE PLAN

ALTERNATIVE 2
SOUTH
PUMPING PLANT

2C-101

SHEET 2 OF 30

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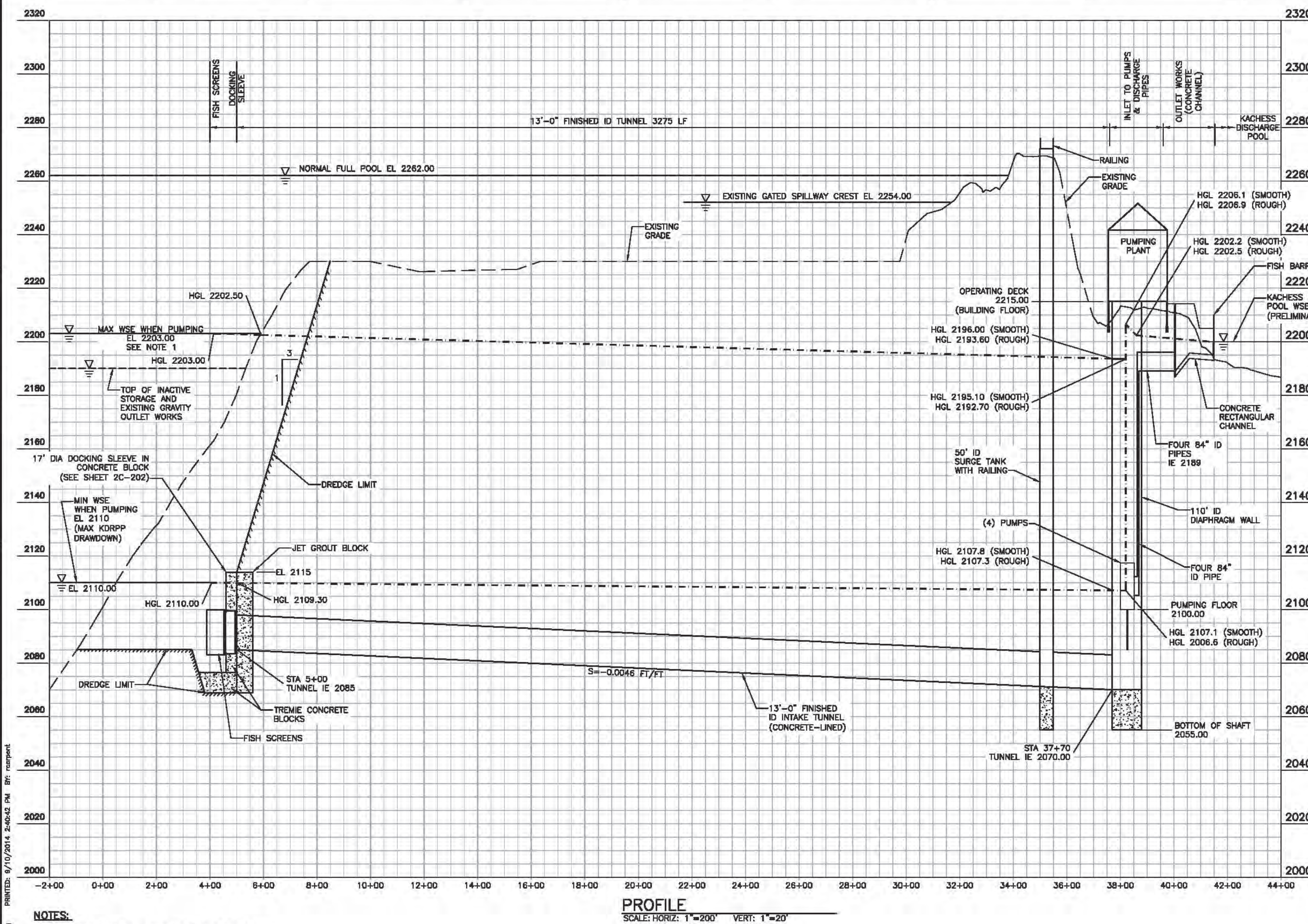

PROFILE
SCALE: HORIZ: 1"=200' VERT: 1"=20'

NOTES:

1. MAX GRAVITY OUTLET CAPACITY IS 1038.7 CFS WHEN RESERVOIR ELEVATION IS 2203.

HYDRAULIC PROFILE DESIGN PARAMETERS:

DESIGN FLOW RATE: 1000 CFS

HYDRAULIC REQUIREMENTS:

TUNNEL:

- MAX. DESIGN FLOW VELOCITY:
  CONCRETE LINED TUNNEL = 10 FPS
- INSIDE FINISHED DIAMETER = 13'-0"
  3250 FT CONCRETE SEGMENTALLY LINED TUNNEL
- RUGOSITY OF LINING OR INTERIOR SURFACE
  CONCRETED SEGMENTAL LINER = 0.002 FT (ROUGH), 0.0003 FT (SMOOTH)

DESIGN STANDARDS:

UNITED STATES BUREAU OF RECLAMATION (USBR),1994, "DESIGN STANDARDS NO. 3 – WATER CONVEYANCE SYSTEMS, " DS-3, SEPTEMBER 30

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED B. SHAHA
REVIEWED V. KOVALISHYN
YAKIMA, WA 2014-08-20

HYDRAULIC PROFILE

ALTERNATIVE 2
SOUTH
PUMPING PLANT

2C-102
SHEET 3 OF 30

DATE AND TIME PLOTTED Not Plotted PLOTTED BY Not Plotted
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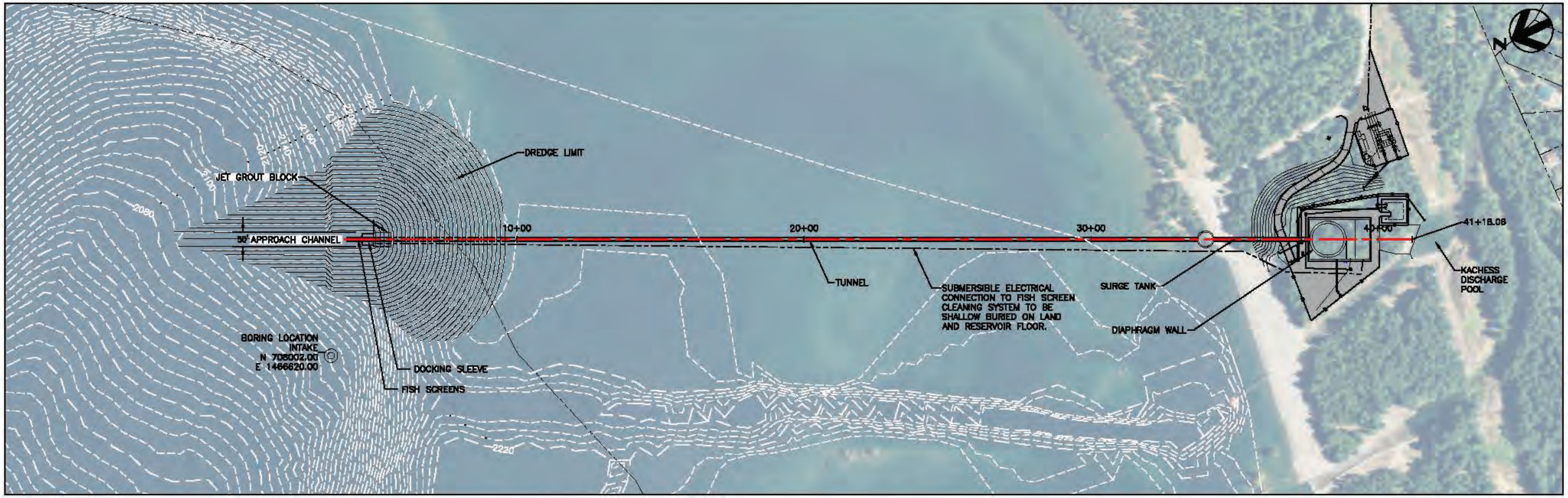
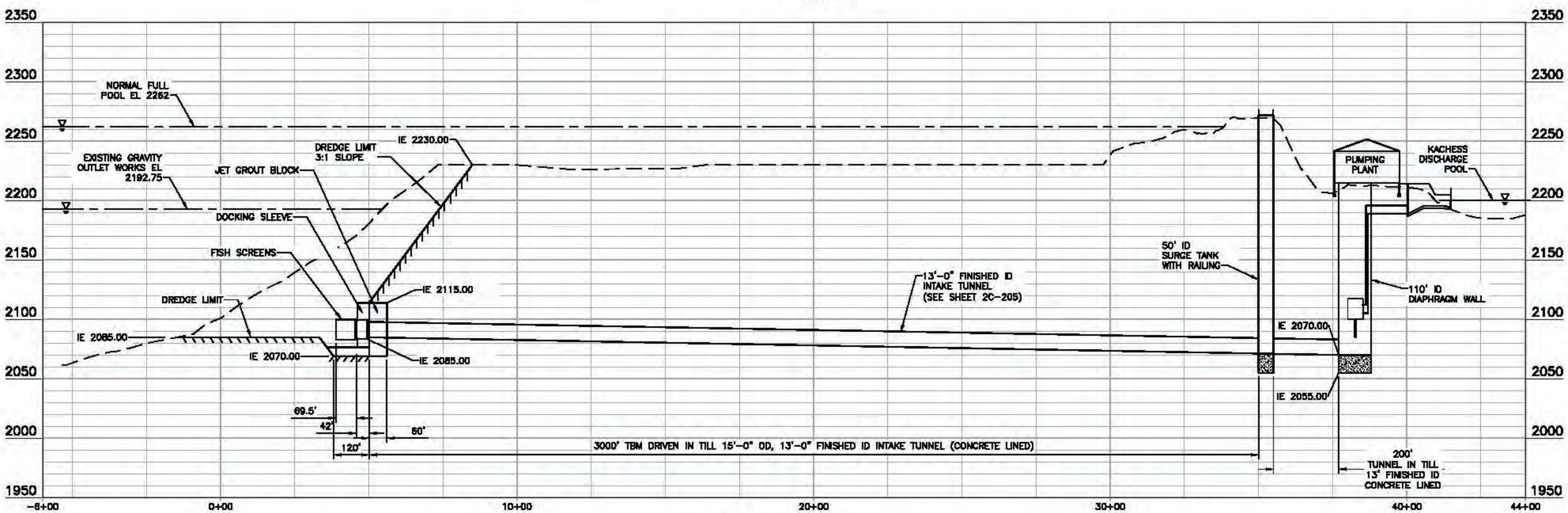


PLAN

0 100 200 400
SCALE IN FEET



PROFILE

SCALE: HORIZ: 1"=200' VERT: 1"=50'

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF PUMPING PLANT

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DESIGNED R. KING
REVIEWED B. SHAH
YAKIMA, WA 2014-08-20

TUNNEL PLAN AND PROFILE

ALTERNATIVE 2 SOUTH PUMPING PLANT

2C-201

SHEET 4 OF 30

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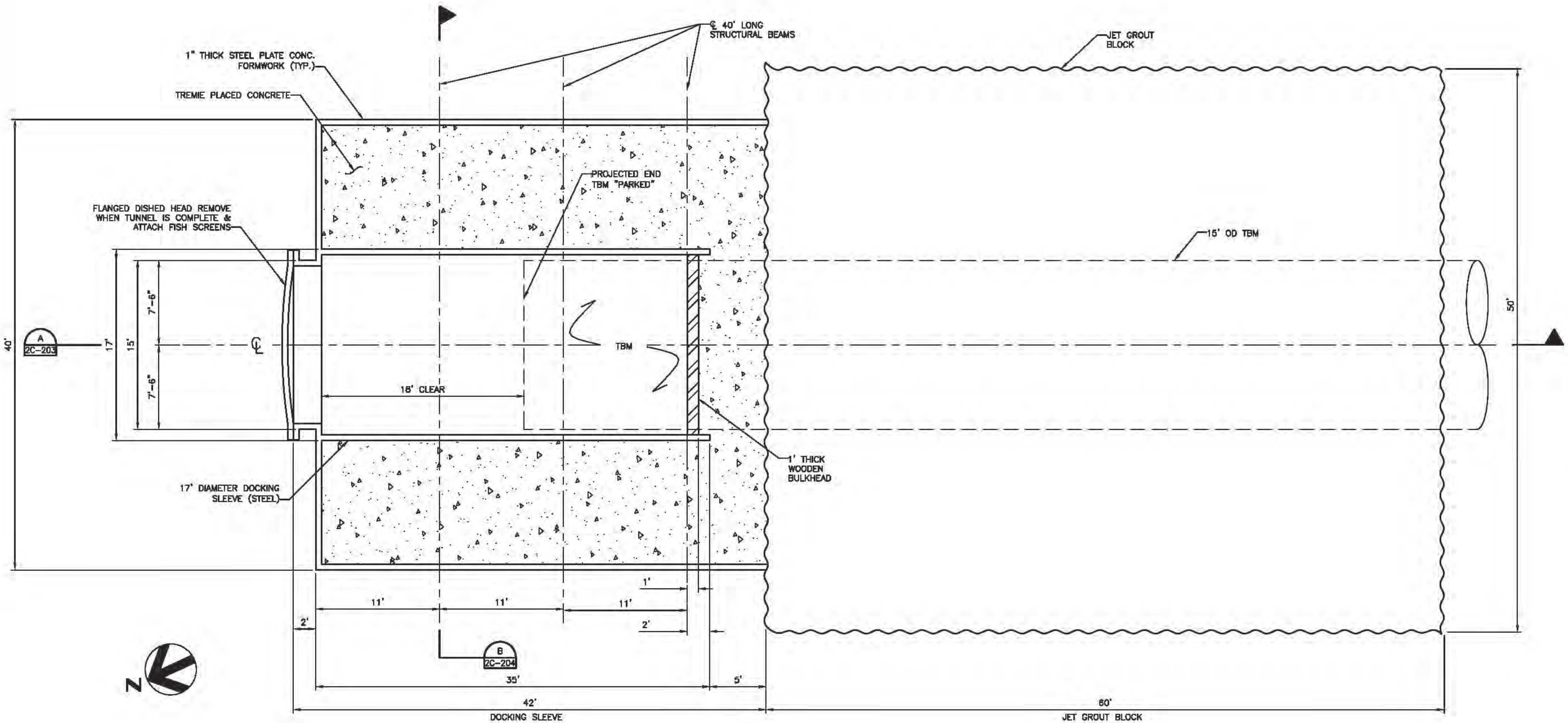

PLAN
SCALE: 1" = 5'

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YAKIMA PROJECT – WA
KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

B. KING
DESIGNED

B. SHAHA
REVIEWED

YAKIMA, WA 2014-08-20

DOCKING SLEEVE PLAN

ALTERNATIVE 2
SOUTH
PUMPING PLANT

2C-202

SHEET 5 OF 30

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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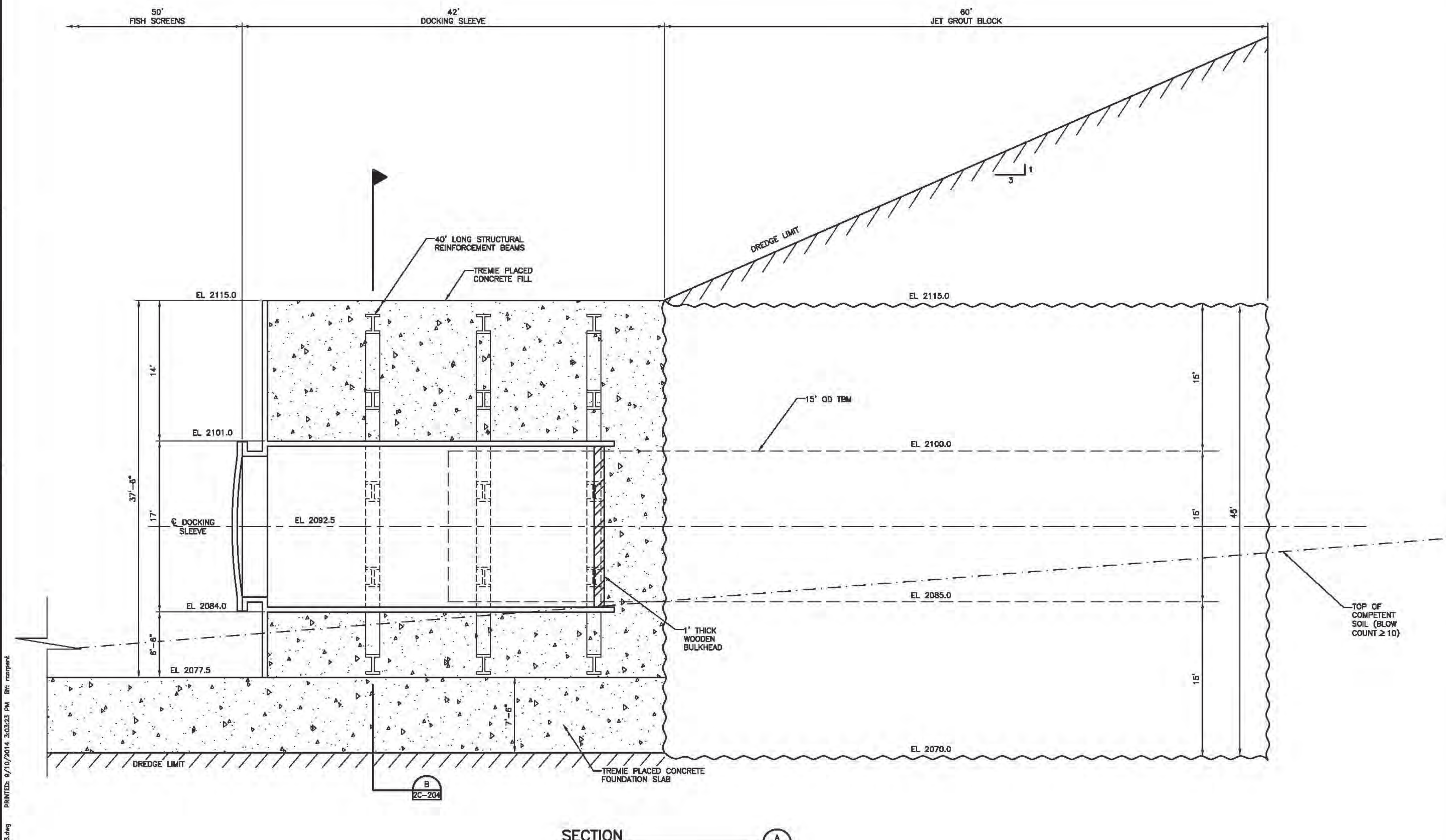

SECTION
SCALE: 1" = 5'

A
2C-202

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF PUMPING PLANT

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DESIGNED

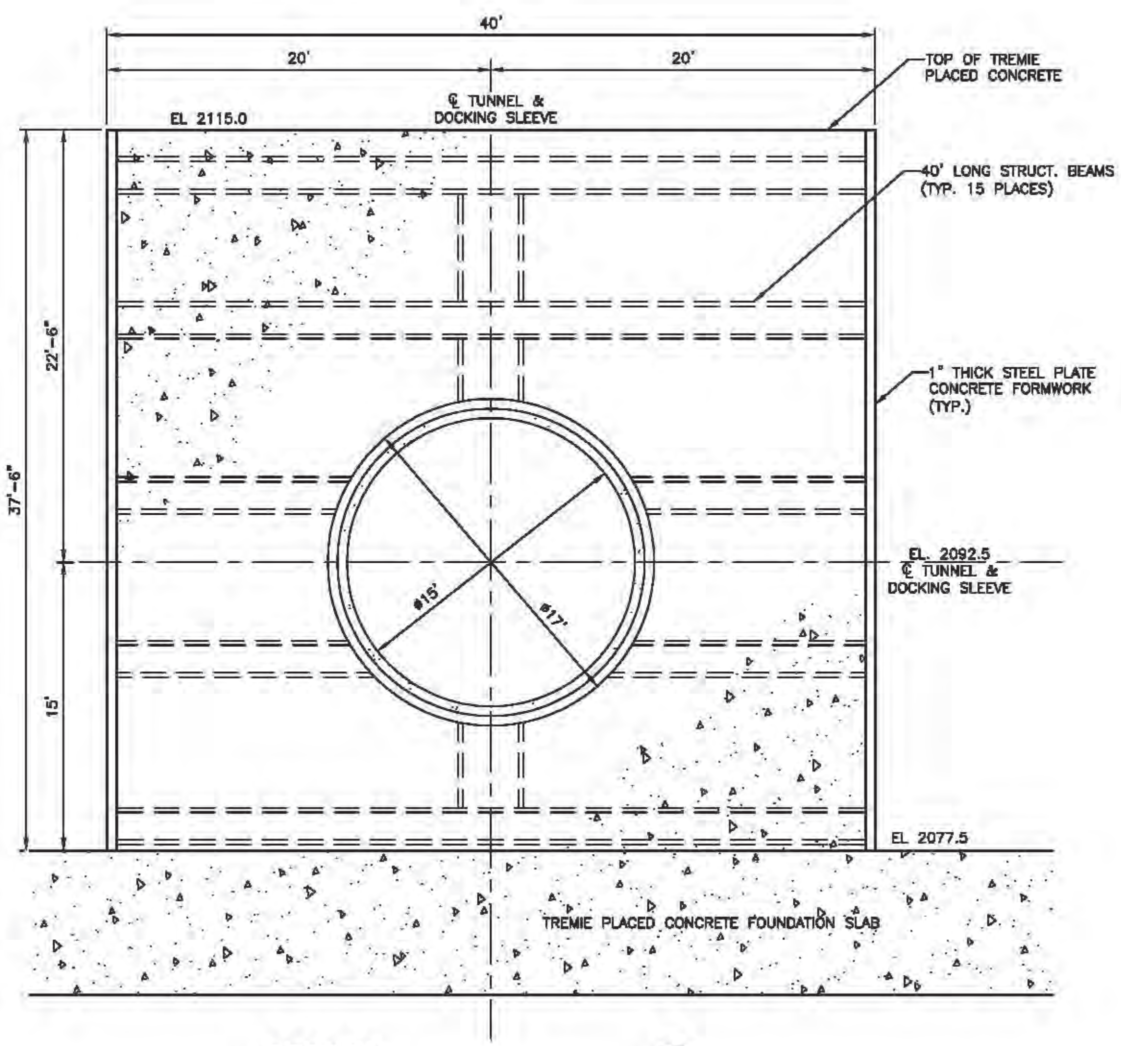
B. SHAHA
REVIEWED

YAKIMA, WA 2014-08-20

DOCKING SLEEVE SECTION A

ALTERNATIVE 2 SOUTH PUMPING PLANT

2C-203
SHEET 6 OF 30



SECTION
SCALE: 1" = 5'

B
2C-202
2C-203

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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REVIEWED B. SHAHA
YAKIMA, WA 2014-08-20

DOCKING SLEEVE SECTION B

ALTERNATIVE 2 SOUTH PUMPING PLANT

2C-204
SHEET 7 OF 30

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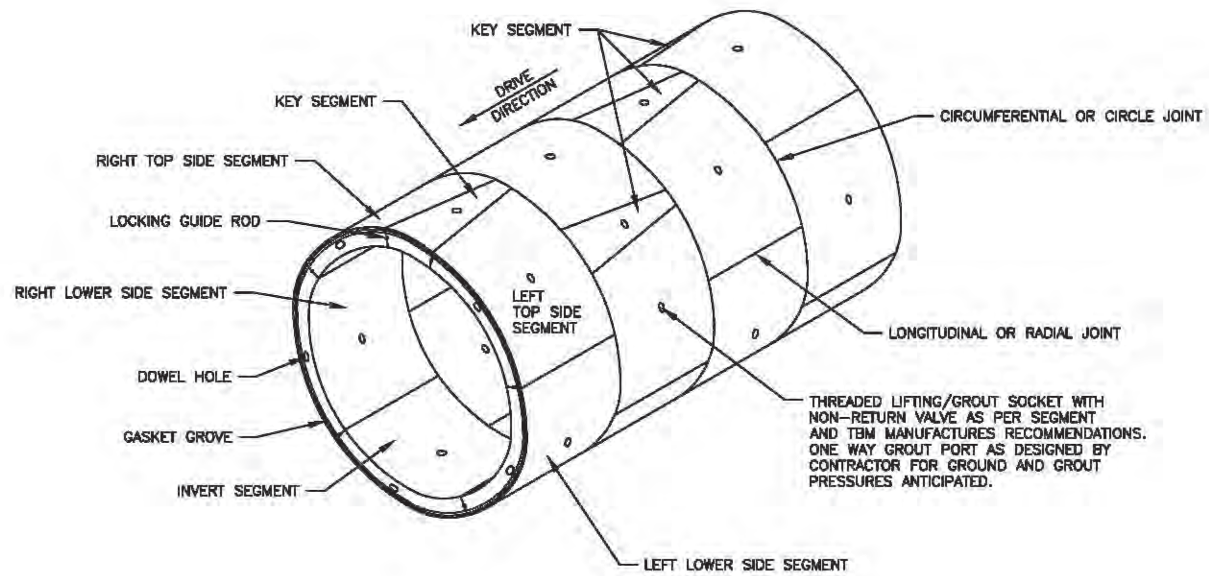
PLOTTED BY Not Plotted

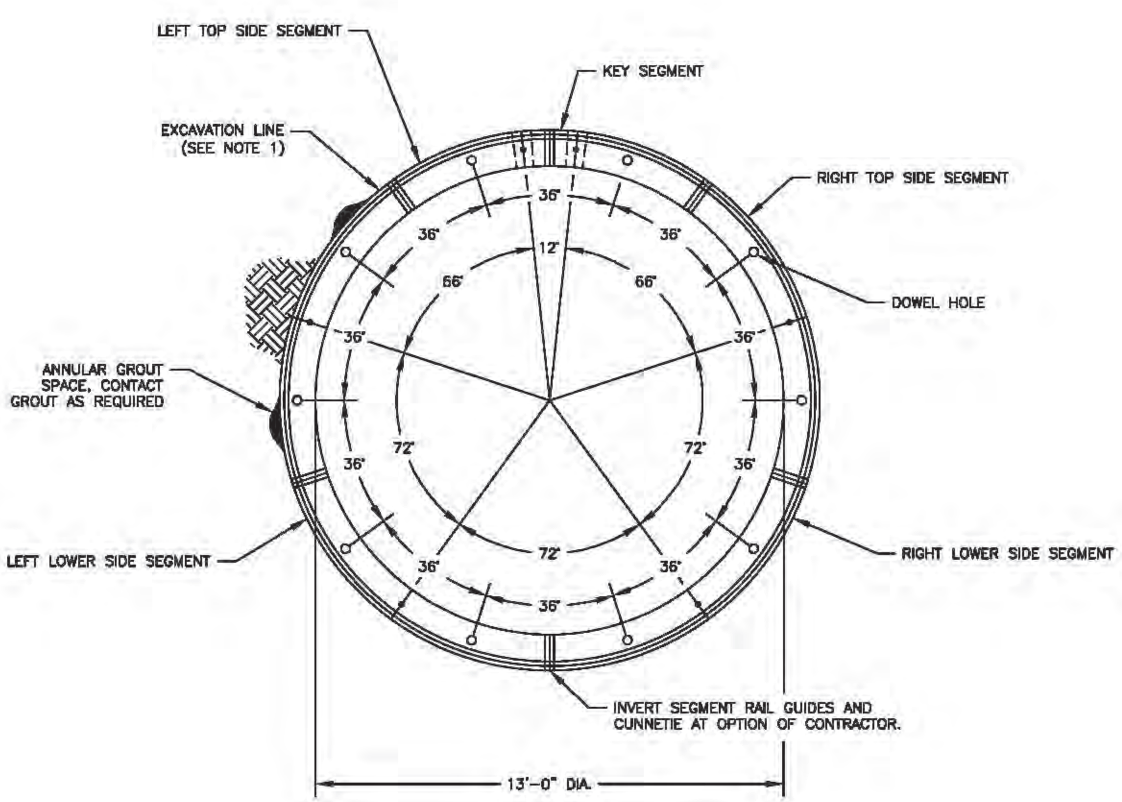
NOTES:

1. THE EARTH PRESSURE BALANCE (EPB) TBM WILL OVEREXTEND 1 TO 3 INCHES BEYOND THE OUTSIDE RADIUS OF THE MACHINE BODY TO ALLOW FOR EASIER JACKING OF MACHINE FORWARD.



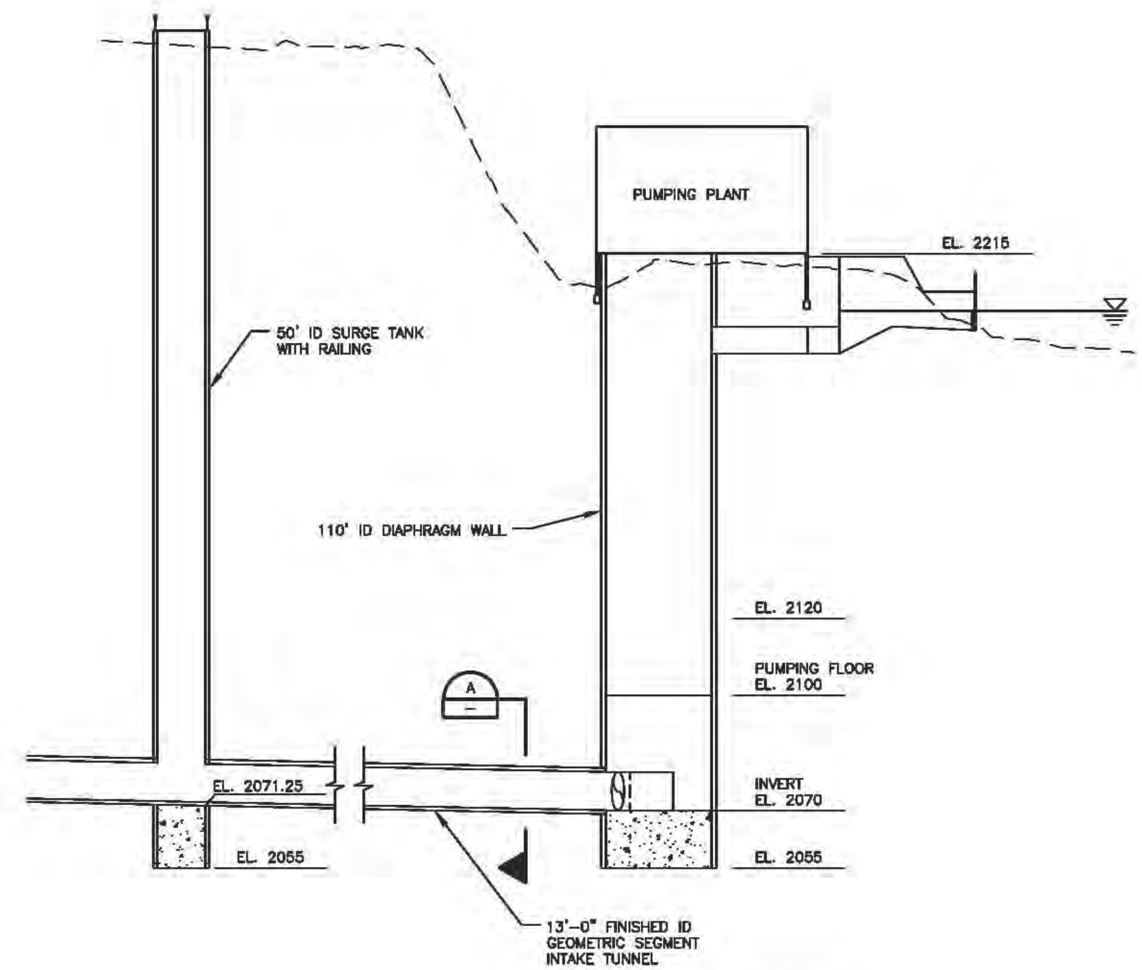
PRECAST SEGMENT ASSEMBLY

SCALE: SCALE: 3/16" = 1'-0"



SECTION A

SCALE: SCALE: 3/8" = 1'-0"



PUMPING PLANT SECTION

SCALE: HORIZ 1"=100' VERT 1"=25'

FEASIBILITY DRAWING

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KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

G. SHERRY
DESIGNED

B. SHAHA
REVIEWED

YAKIMA, WA 2014-06-20

TUNNEL SECTIONS AND DETAILS

ALTERNATIVE 2
SOUTH
PUMPING PLANT

2C-205

SHEET 8 OF 30

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CAD SYSTEM
AUTOCAD
CAD FILENAME
UNKNOWN

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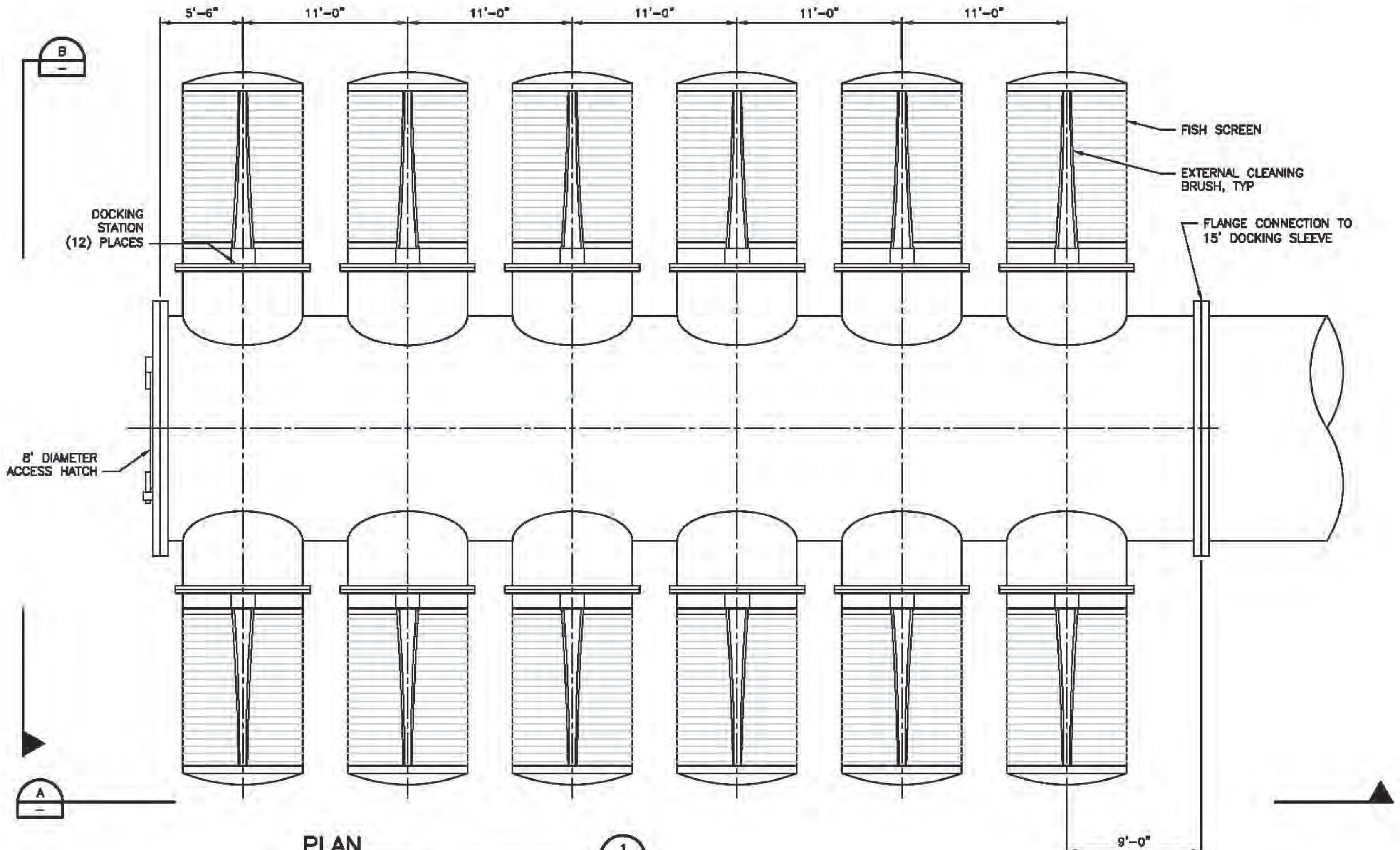
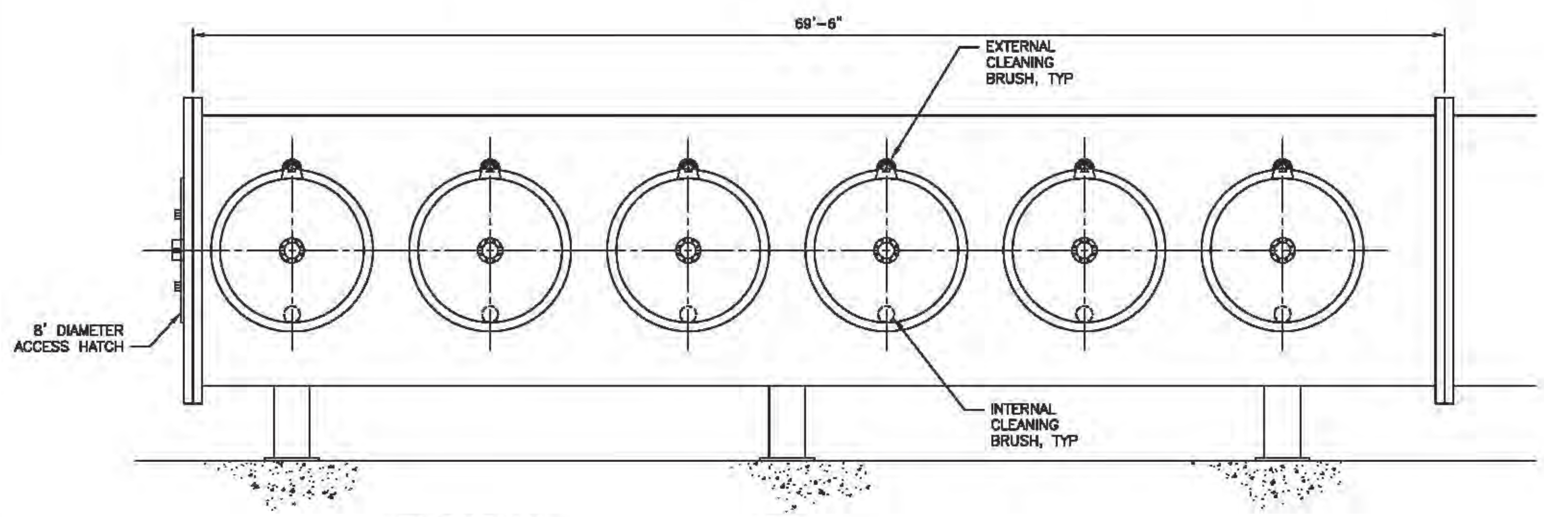
DESIGN CRITERIA

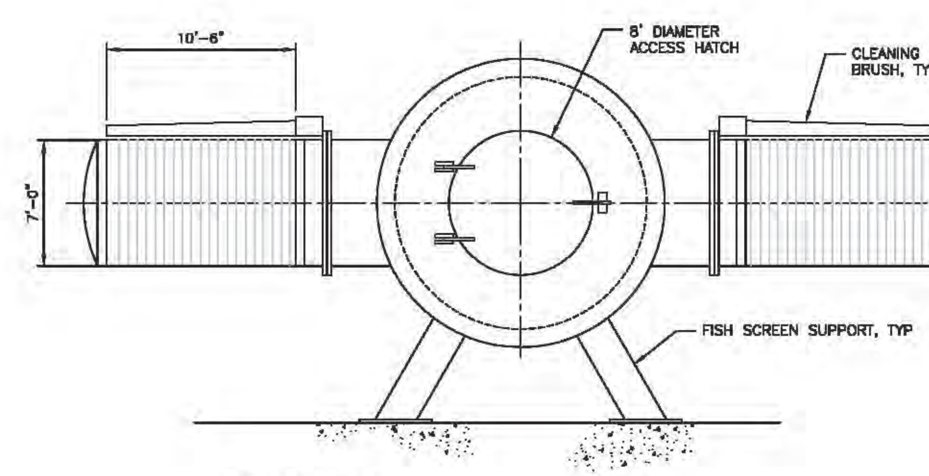
- MAXIMUM DIVERSION: 1000 CFS
- SCREEN AREA: 2,770 SQ FT
- MAXIMUM APPROACH VELOCITY: 0.40 FPS
- BRUSH CLEANING SYSTEM



PLAN
SCALE: 3/16" = 1'-0"



ELEVATION
SCALE: 3/16" = 1'-0"



ELEVATION
SCALE: 3/16" = 1'-0"

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED: J. NELSON
REVIEWED: B. SHAHA
YAKIMA, WA 2014-08-20

FISH SCREENS
PLAN AND SECTIONS

ALTERNATIVE 2
SOUTH
PUMPING PLANT

2C-301
SHEET 8 OF 30

DATE AND TIME PLOTTED: Not Plotted
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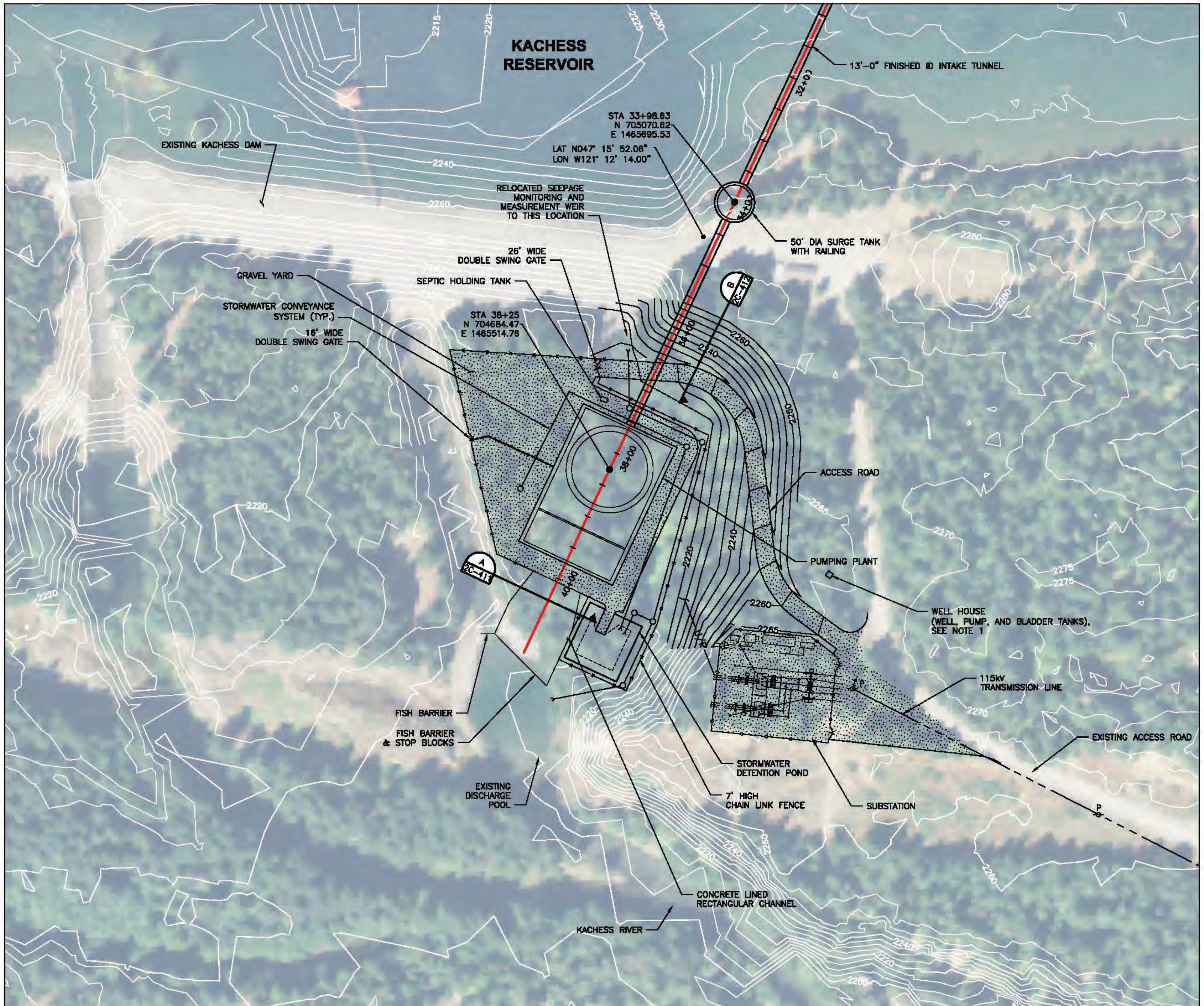
NOTE:

1. A WELL CURRENTLY EXISTS ON THE SITE, BUT THE LOCATION IS PRESENTLY UNKNOWN. TO COORDINATE WITH THE SITE PLAN, EXISTING WELL MAY NEED TO BE ABANDONED AND A NEW WELL INSTALLED IN THE LOCATION SHOWN ON THIS PLAN.



PLAN

0 40 80 160
SCALE IN FEET

N

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KITTITAS DIVISION
KACHESS DROUGHT RELIEF
PUMPING PLANT

DESIGNED J. VANIER
REVIEWED B. SHAHA
YAKIMA, WA 2014-08-20

PUMPING PLANT SITE PLAN

ALTERNATIVE 2
SOUTH
PUMPING PLANT

2C-401
SHEET 10 OF 30

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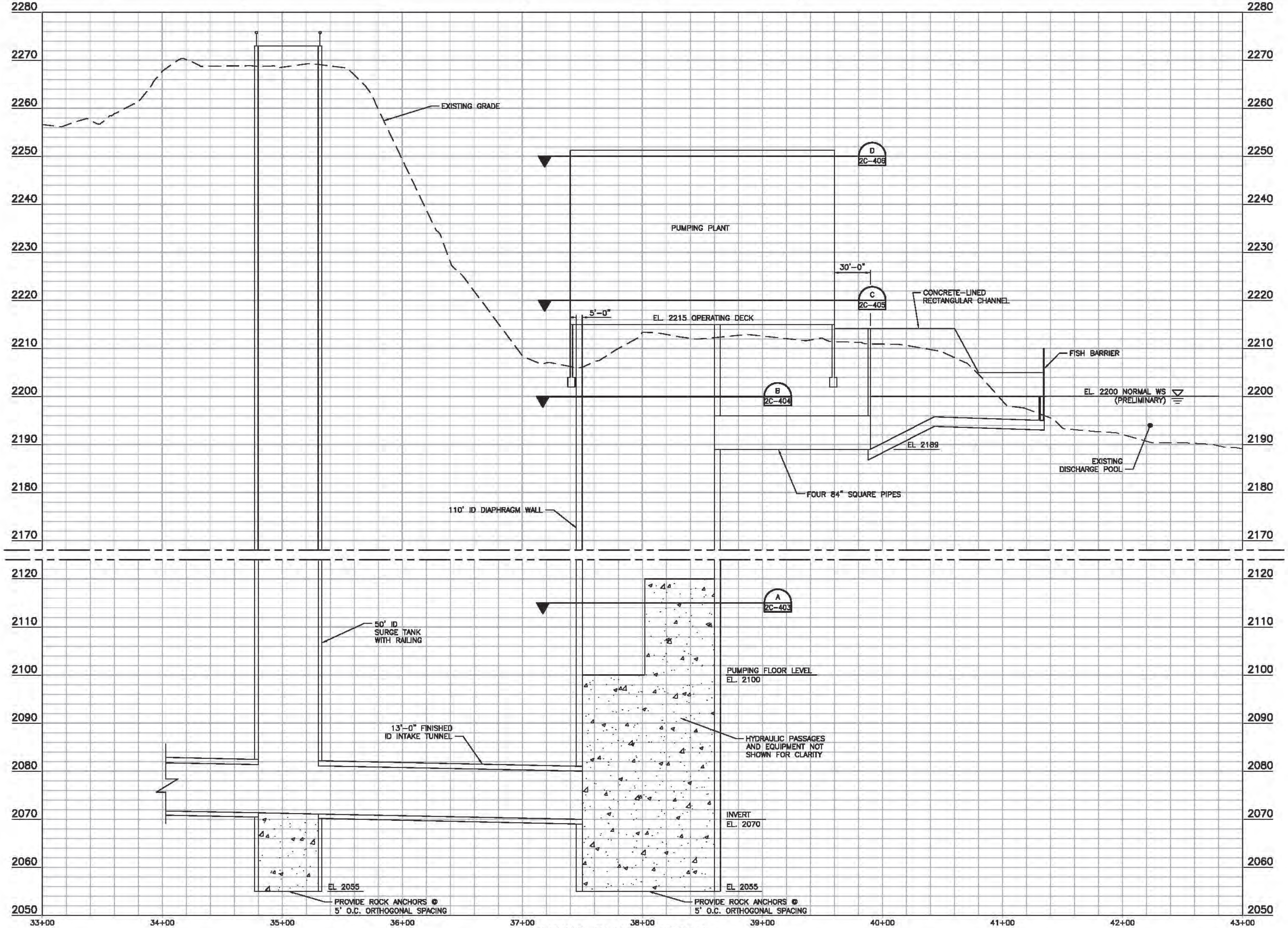

PUMPING PLANT PROFILE

SCALE: HORIZ 1"=40' VERT 1"=10'

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

RECLAMATION
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YAKIMA PROJECT – WA
KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED: J. VANIER
REVIEWED: B. SHAHA
YAKIMA, WA — 2014-06-20

PUMPING PLANT PROFILE

ALTERNATIVE 2 SOUTH PUMPING PLANT

2C-402

SHEET 11 OF 30

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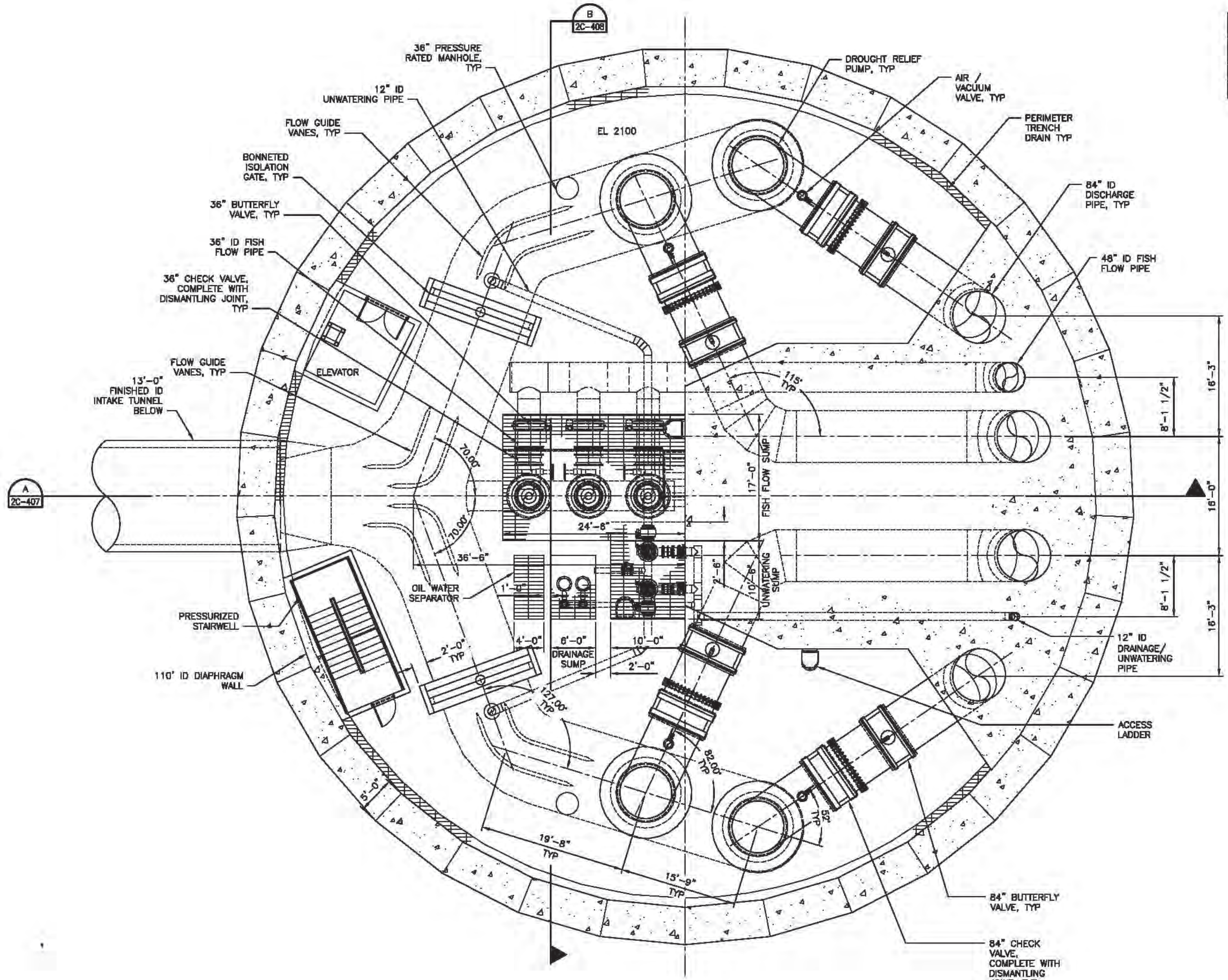
PUMP DATA		
PUMP	RATED CAPACITY (CFS)	RATED HEAD (FT)
DROUGHT RELIEF	333.3	106.6
FISH FLOW	50 MAX	107



PLAN AT EL 2115

SCALE: 1/8" = 1'-0"

A 2C-402

N

FEASIBILITY DRAWING

ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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Managing Water in the West

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KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

V. KOVALISHYN
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YAKIMA, WA 2014-08-20

PUMPING PLANT PLAN @ EL 2115

ALTERNATIVE 2 SOUTH PUMPING PLANT

2C-403

SHEET 12 OF 30

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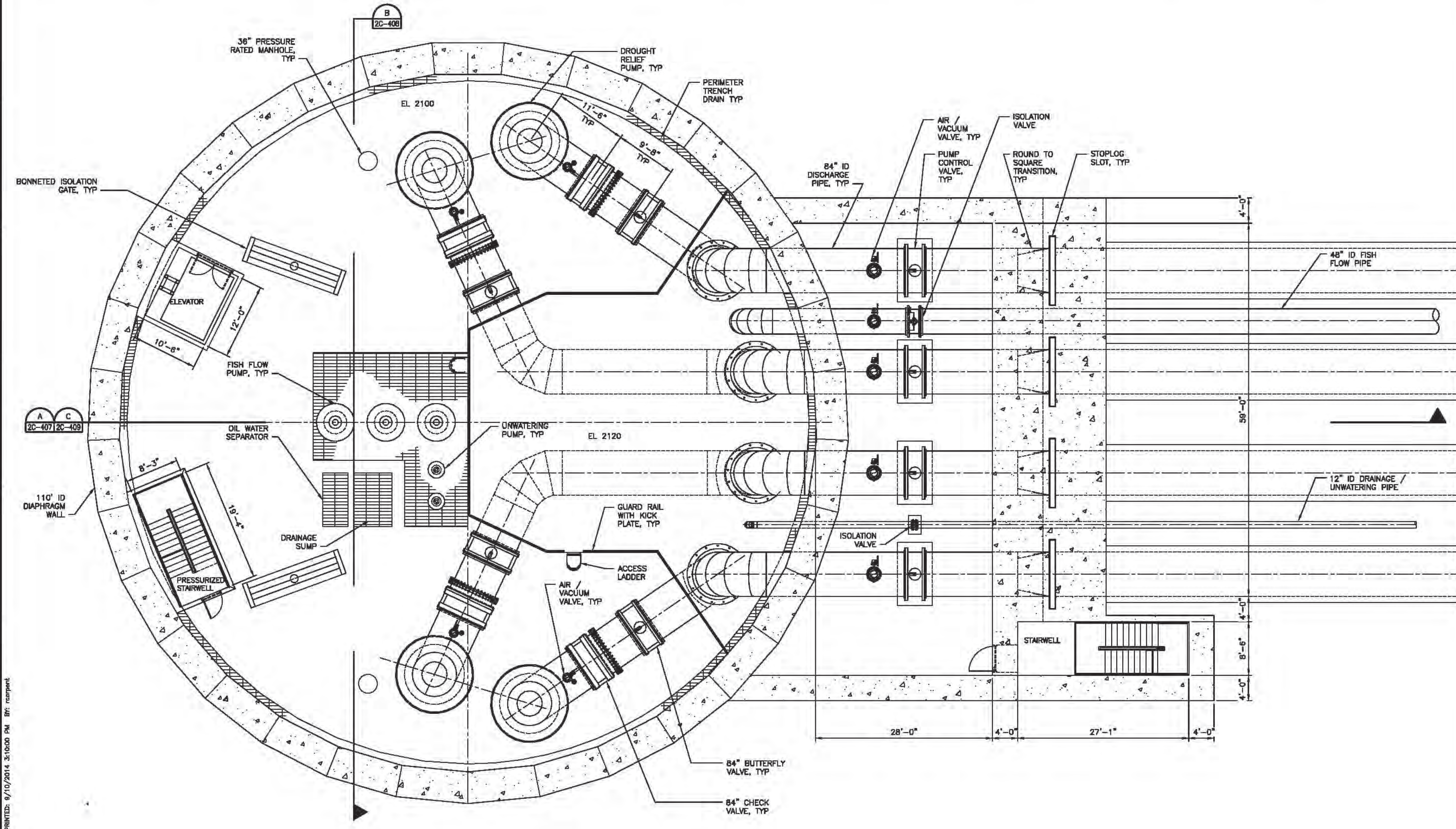

PLAN AT EL 2200
SCALE: 1/8" = 1'-0"
2C-402

FEASIBILITY DRAWING
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KACHESS DROUGHT RELIEF PUMPING PLANT

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PUMPING PLANT
PLAN @ EL 2200

ALTERNATIVE 2
SOUTH
PUMPING PLANT

2C-404
SHEET 13 OF 30

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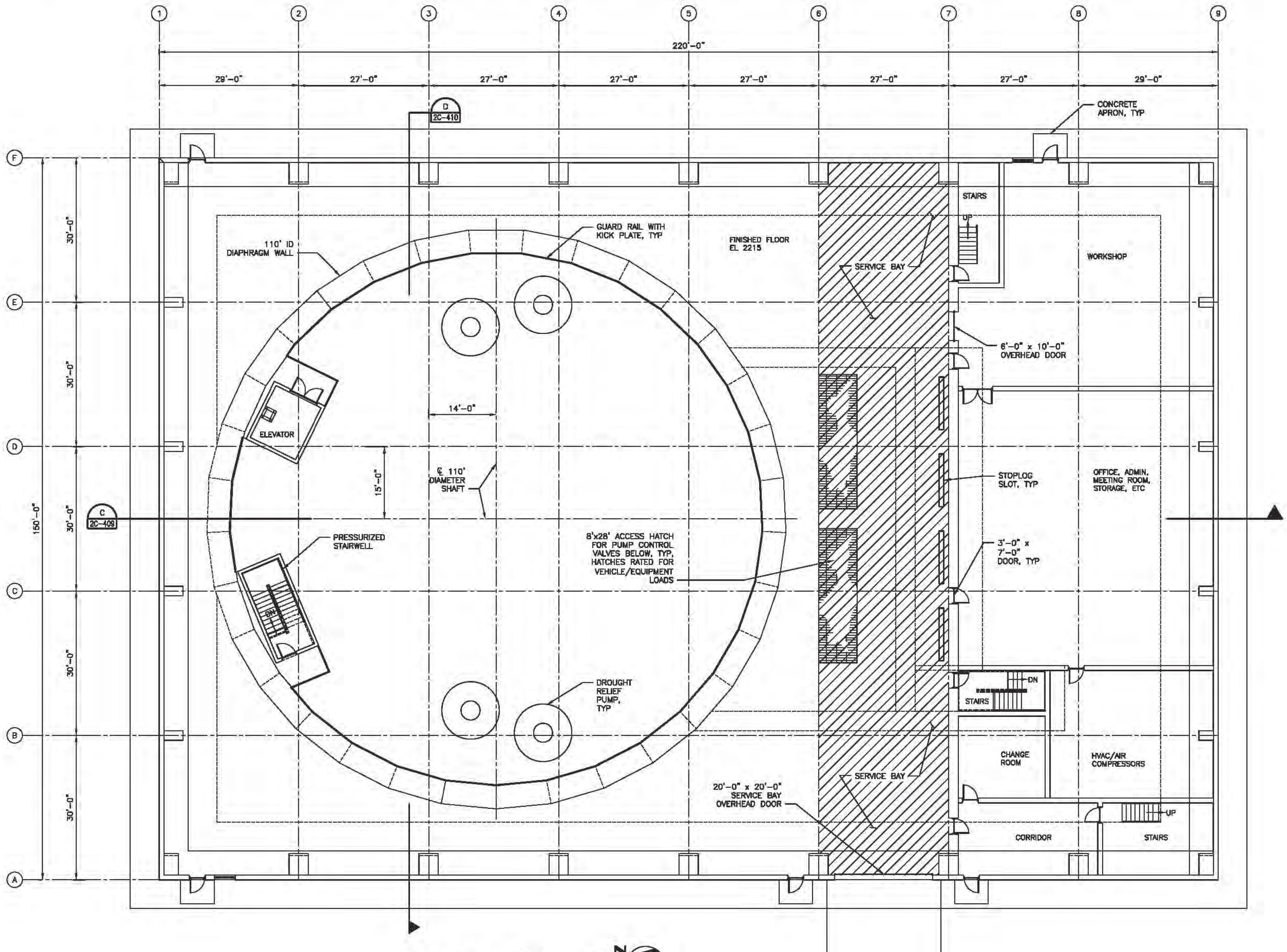

PLAN AT EL 2220
SCALE: 3/32" = 1'-0"

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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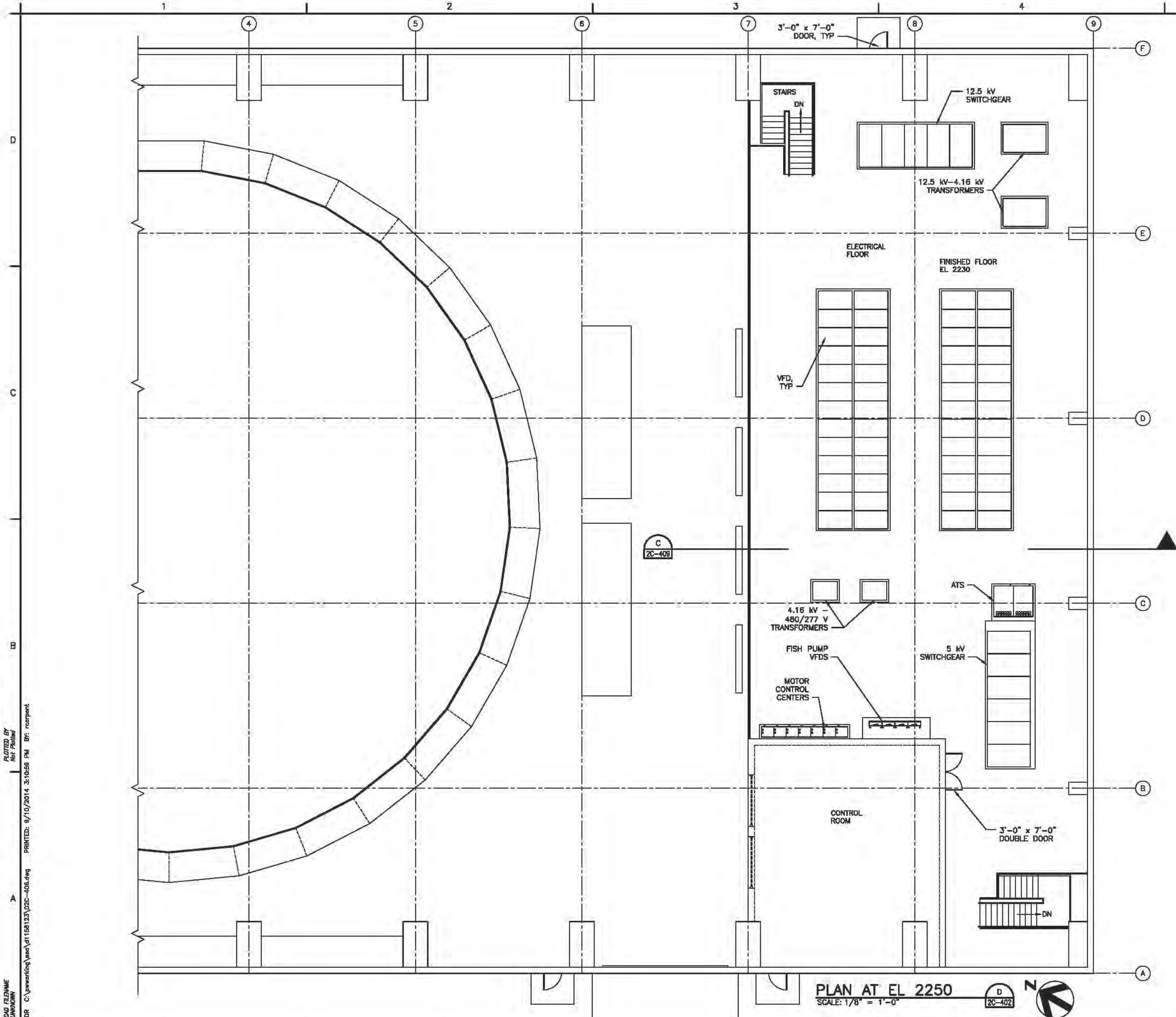
KITTITAS DIVISION
KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED: V. KOVALISHYN
REVIEWED: J. STEWART
YAKIMA, WA 2014-08-20

PUMPING PLANT PLAN @ EL 2220

ALTERNATIVE 2 SOUTH PUMPING PLANT

2C-405
SHEET 14 OF 30



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Managing Water in the West

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KACHESS DROUGHT RELIEF PUMPING PLANT

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PUMPING PLANT PLAN @ EL 2250

ALTERNATIVE 2 SOUTH PUMPING PLANT

2C-406
SHEET 15 OF 30

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CAD FILENAME UNKNOWN
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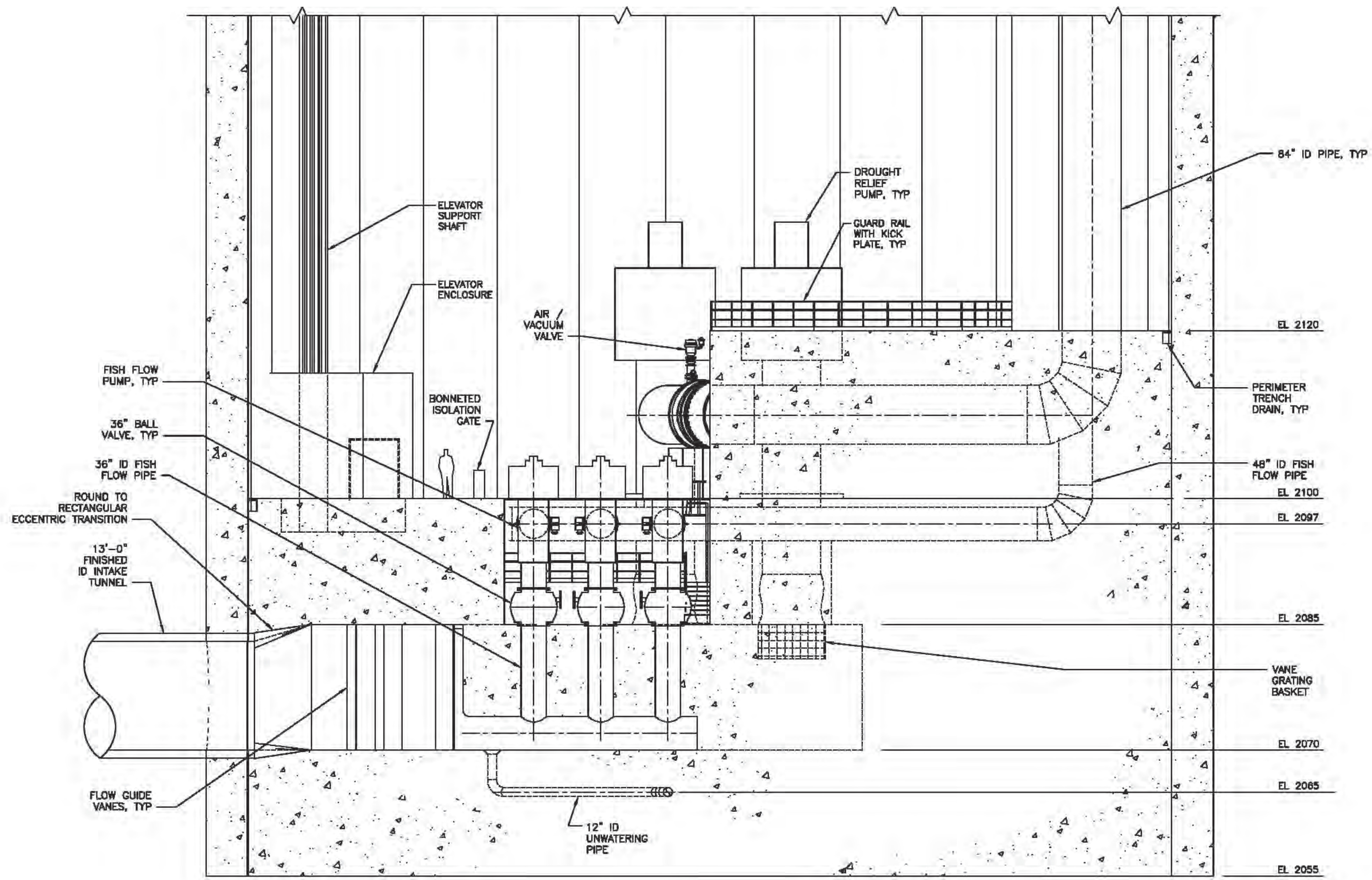

SECTION

SCALE: 1/8" = 1'-0"

A 2C-403 A 2C-404

FEASIBILITY DRAWING

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KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

V. KOVALISHYN
DESIGNED

J. STEWART
REVIEWED

YAKIMA, WA 2014-08-20

PUMPING PLANT SECTION A

ALTERNATIVE 2 SOUTH PUMPING PLANT

2C-407

SHEET 16 OF 30

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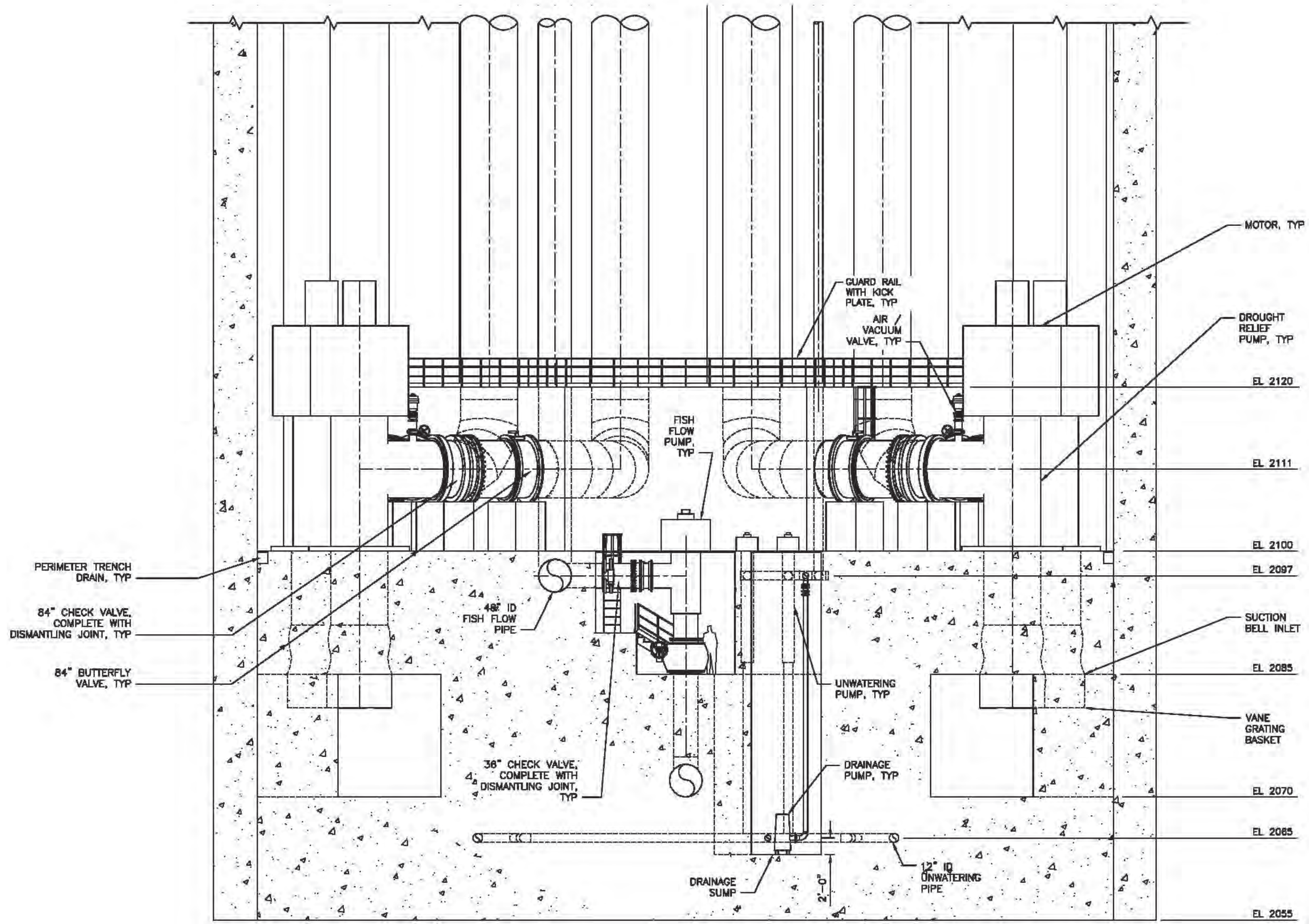

SECTION
SCALE: 1/8" = 1'-0"
B 2C-403 B 2C-404

FEASIBILITY DRAWING
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DESIGNED

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PUMPING PLANT SECTION B

ALTERNATIVE 2 SOUTH PUMPING PLANT

2C-408
SHEET 17 OF 30

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PLOTTED BY Not Plotted
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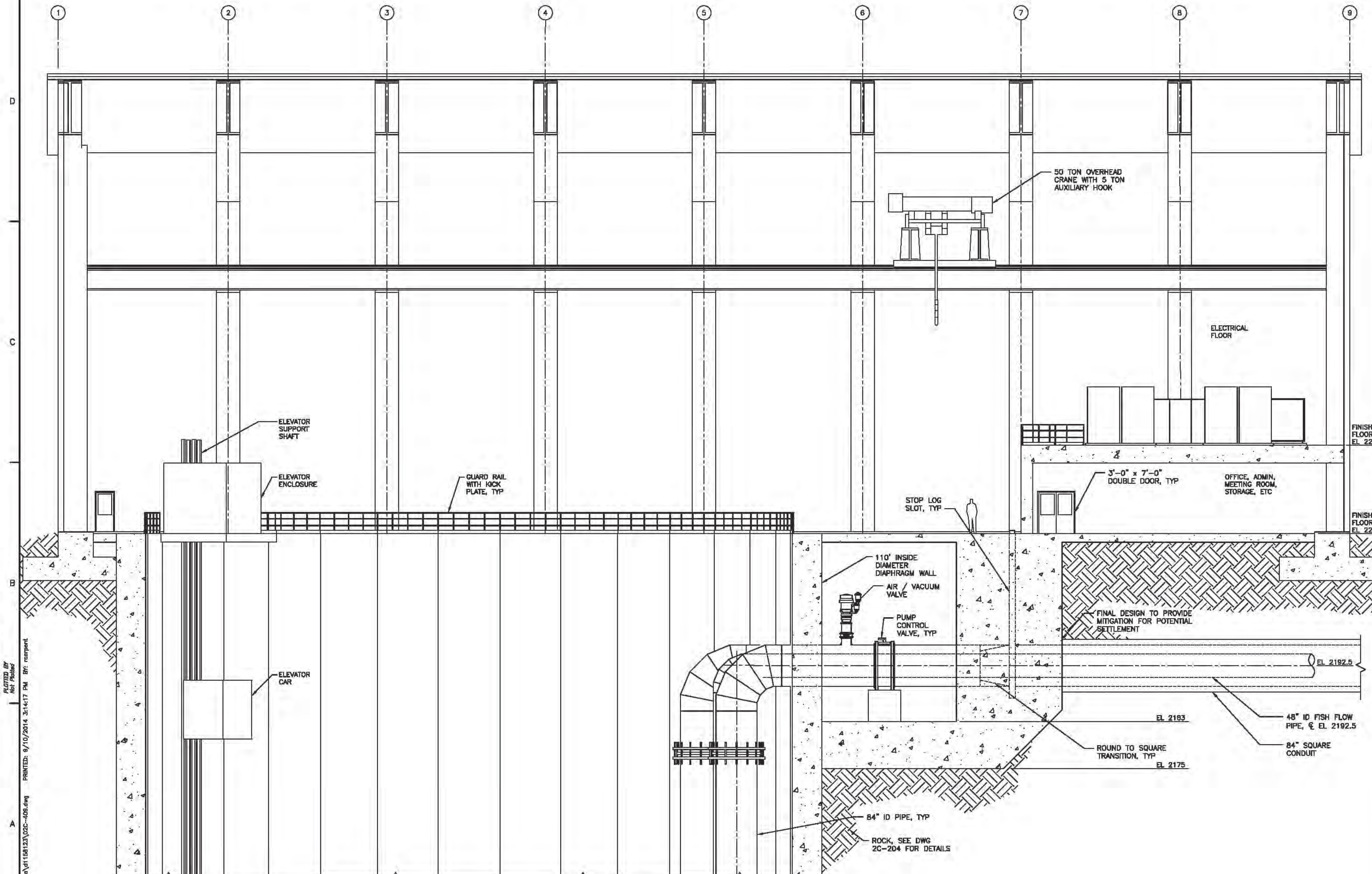

SECTION
SCALE: 1/8" = 1'-0"

C 2C-404 C 2C-405 C 2C-406

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA PROJECT – WA
KITTITAS DIVISION

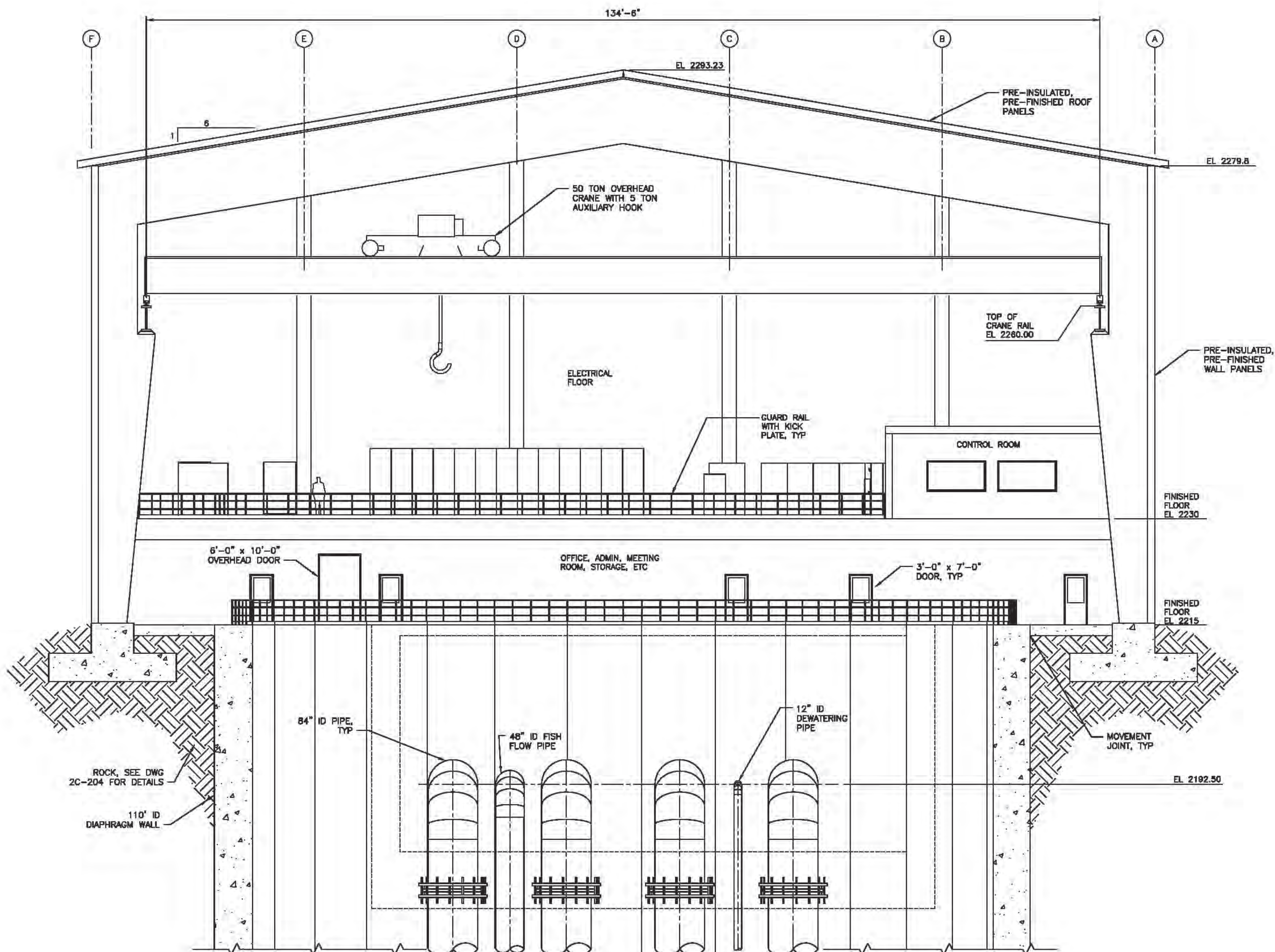
KACHESS DROUGHT RELIEF
PUMPING PLANT

DESIGNED V. KOVALISHYN
REVIEWED J. STEWART
YAKIMA, WA 2014-08-20

PUMPING PLANT
SECTION C

ALTERNATIVE 2
SOUTH
PUMPING PLANT

2C-409
SHEET 18 OF 30



SECTION

SCALE: 1/8" = 1'-0"

D / 2C-405

FEASIBILITY DRAWING

ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF PUMPING PLANT

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REVIEWED: J. STEWART

YAKIMA, WA 2014-08-20

PUMPING PLANT SECTION D

ALTERNATIVE 2 SOUTH PUMPING PLANT

2C-410

SHEET 19 OF 30

CAD SYSTEM AUTOCAD CAD FILENAME UNKNOWN

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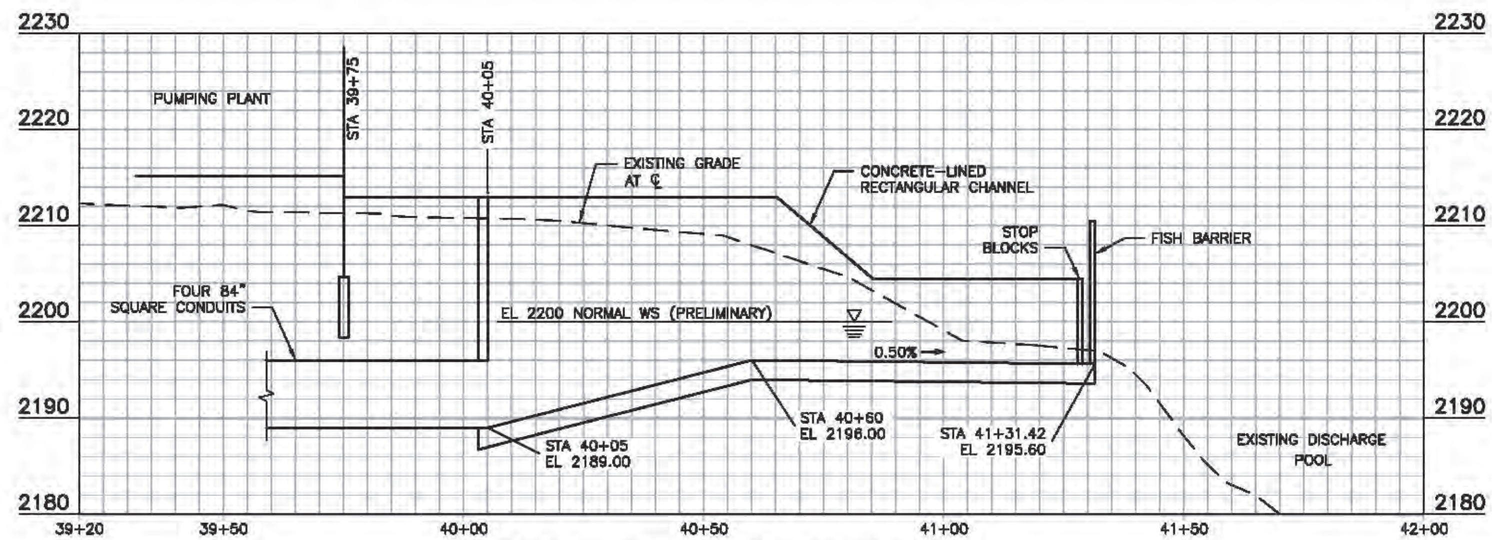
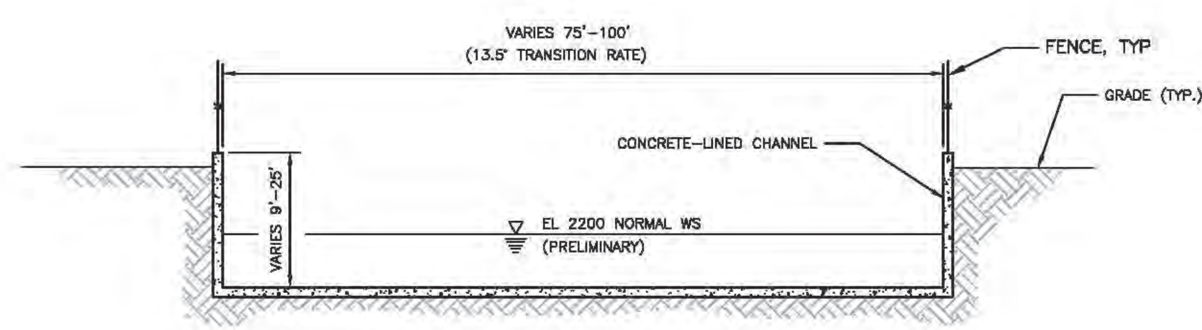


DISCHARGE STRUCTURE PROFILE

SCALE: HORIZ 1"=40' VERT 1"=5'



SECTION

SCALE: 1"=20'

A 2C-401

FEASIBILITY DRAWING
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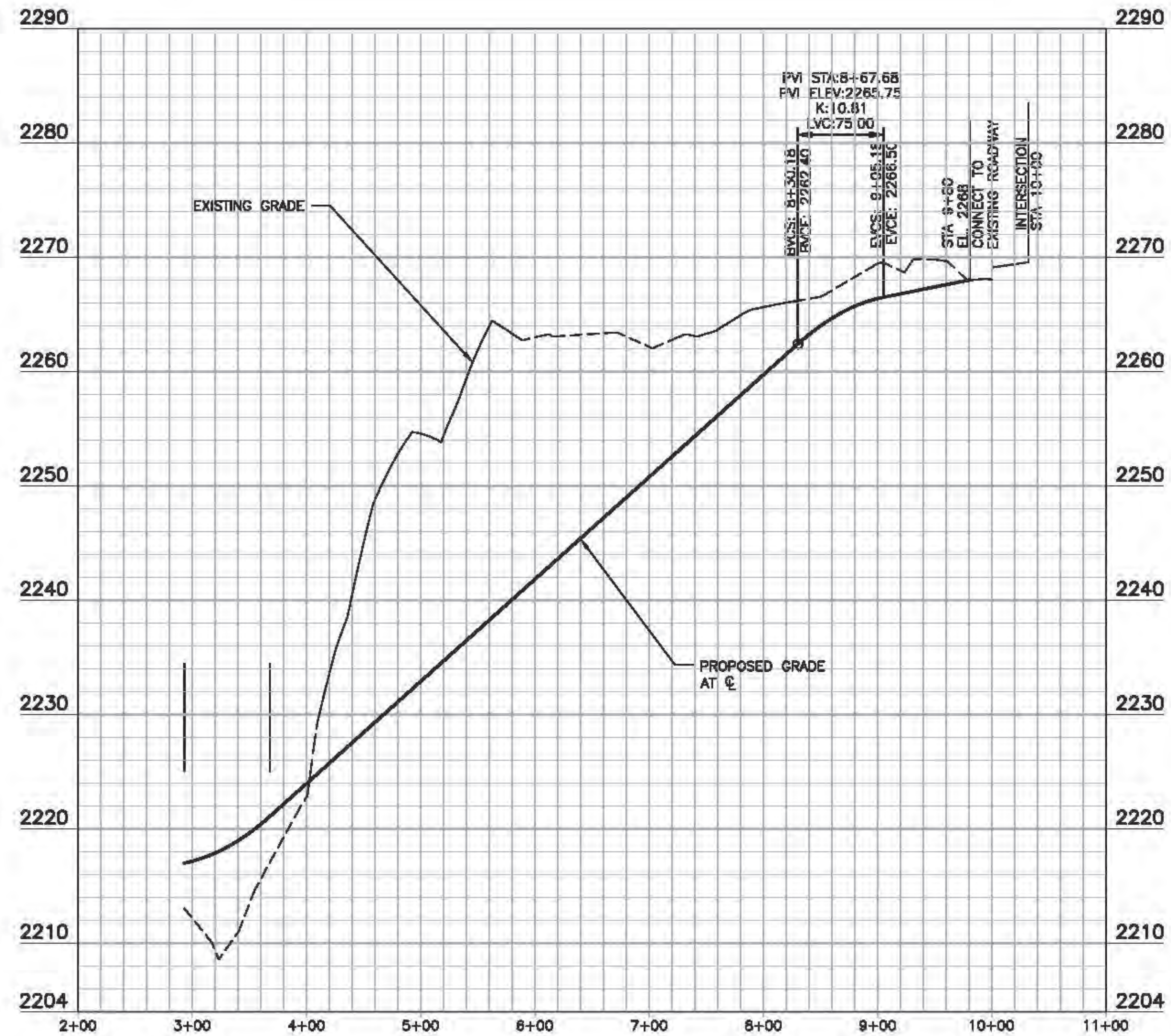
PUMPING PLANT DISCHARGE STRUCTURE

ALTERNATIVE 2 SOUTH PUMPING PLANT

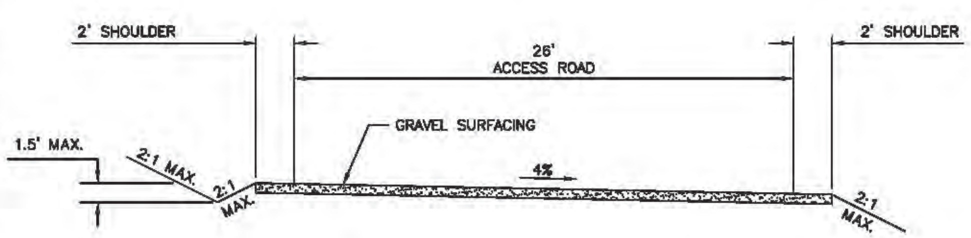
2C-411

SHEET 20 OF 30



PUMPING PLANT BUILDING ACCESS ROAD PROFILE

SCALE: HORIZ 1"=160' VERT 1"=16'



SECTION

SCALE: NTS

B
2C-401

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF
PUMPING PLANT

J. VANIER
DESIGNED

B. SHAHA
REVIEWED

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PUMPING PLANT
ACCESS ROAD
PROFILE AND SECTIONS

ALTERNATIVE 2
SOUTH
PUMPING PLANT

2C-412

SHEET 21 OF 30

DATE AND TIME PLOTTED Not Plotted
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PRINTED: 2/19/2015 7:51:50 AM BY: parborra
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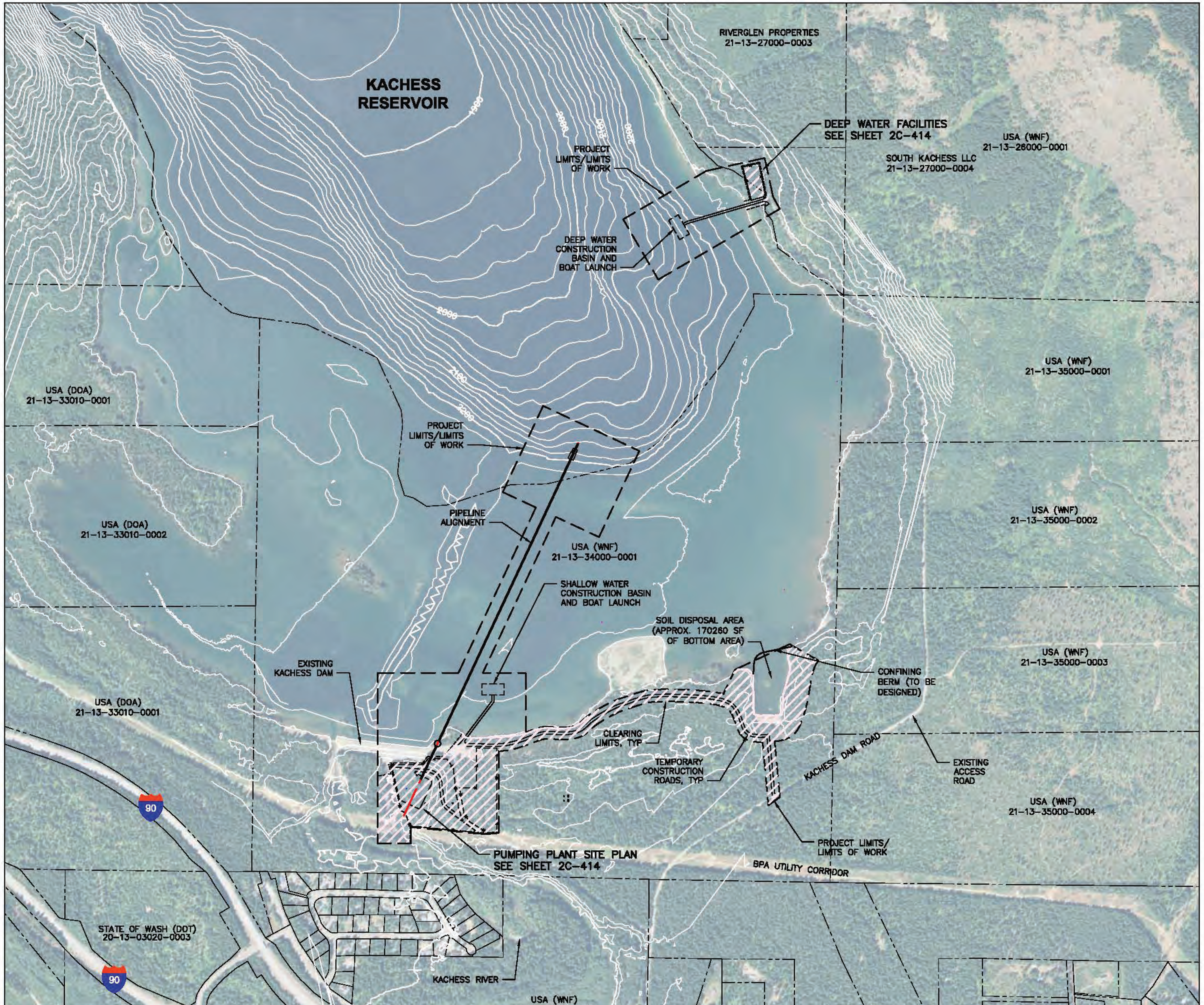

PLAN

0 250 500 1000
SCALE IN FEET

N

NOTES:

1. THIS PLAN DEPICTS A CONCEPT FOR CONSTRUCTION STAGING TO FACILITATE INITIAL PLANNING AND COST ESTIMATION EFFORTS. IT WILL ULTIMATELY BE THE CONTRACTOR'S RESPONSIBILITY TO DESIGN THE BATCH PLANT, CONSTRUCTION BASIN AND BOAT LAUNCH, BLASTING MAGAZINE BUILDING, SECURITY FENCING AND ASSOCIATED CONSTRUCTION ROADS.
2. CLEARING ALONG THE POWER TRANSMISSION LINE CORRIDOR WILL BE NECESSARY, BUT HAS BEEN OMITTED FROM THIS PLAN AS THE ROUTE HAS NOT YET BEEN DETERMINED (SEE SHEET 2C-501)

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF
PUMPING PLANT

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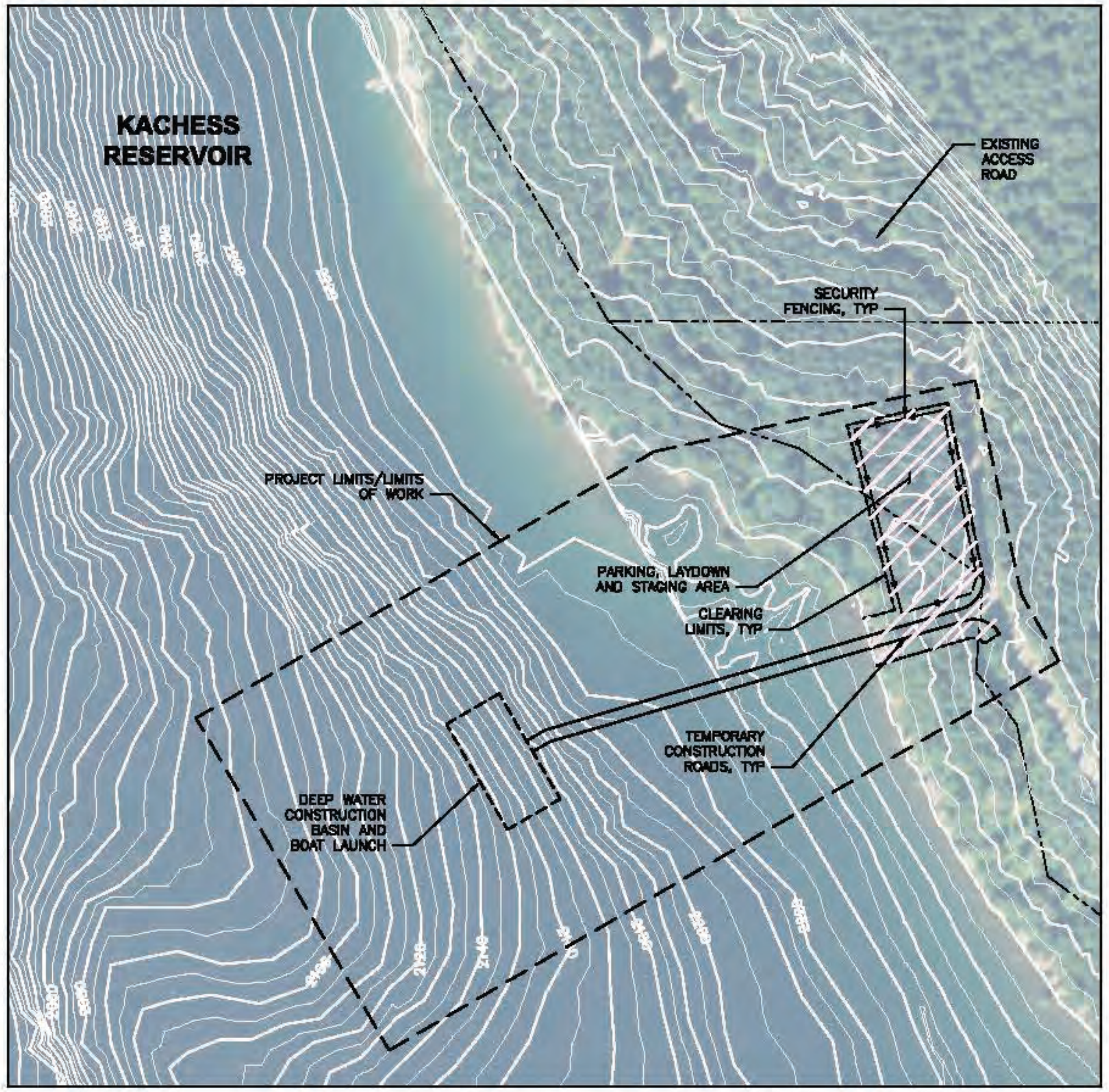
TEMPORARY CONSTRUCTION STAGING

ALTERNATIVE 2
SOUTH
PUMPING PLANT

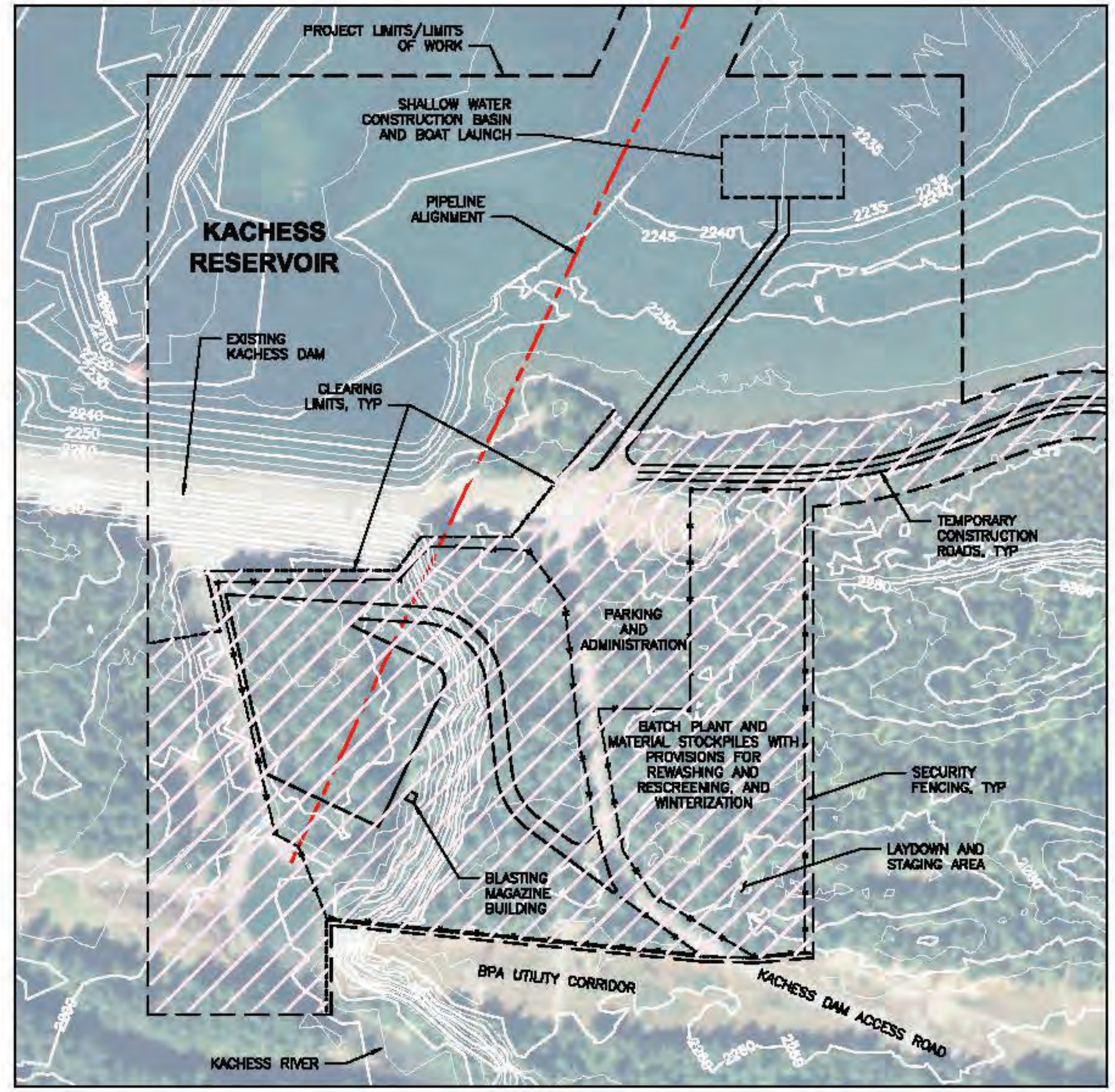
2C-413
SHEET 22 OF 30



DEEP WATER FACILITIES

0 75 150 300
SCALE IN FEET

N



PUMPING PLANT SITE PLAN

0 75 150 300
SCALE IN FEET

N

NOTES:

1. THIS PLAN DEPICTS A CONCEPT FOR CONSTRUCTION STAGING TO FACILITATE INITIAL PLANNING AND COST ESTIMATION EFFORTS. IT WILL ULTIMATELY BE THE CONTRACTOR'S RESPONSIBILITY TO DESIGN THE BATCH PLANT, CONSTRUCTION BASIN AND BOAT LAUNCH, BLASTING MAGAZINE BUILDING, SECURITY FENCING AND ASSOCIATED CONSTRUCTION ROADS.
2. CLEARING ALONG THE POWER TRANSMISSION LINE CORRIDOR WILL BE NECESSARY, BUT HAS BEEN OMITTED FROM THIS PLAN AS THE ROUTE HAS NOT YET BEEN DETERMINED (SEE SHEET 2C-501)

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

RECLAMATION
Managing Water in the West

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KACHESS DROUGHT RELIEF PUMPING PLANT

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REVIEWED B. SHAHA
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TEMPORARY CONSTRUCTION STAGING ENLARGED PLANS

ALTERNATIVE 2 SOUTH PUMPING PLANT

2C-414

SHEET 23 OF 30

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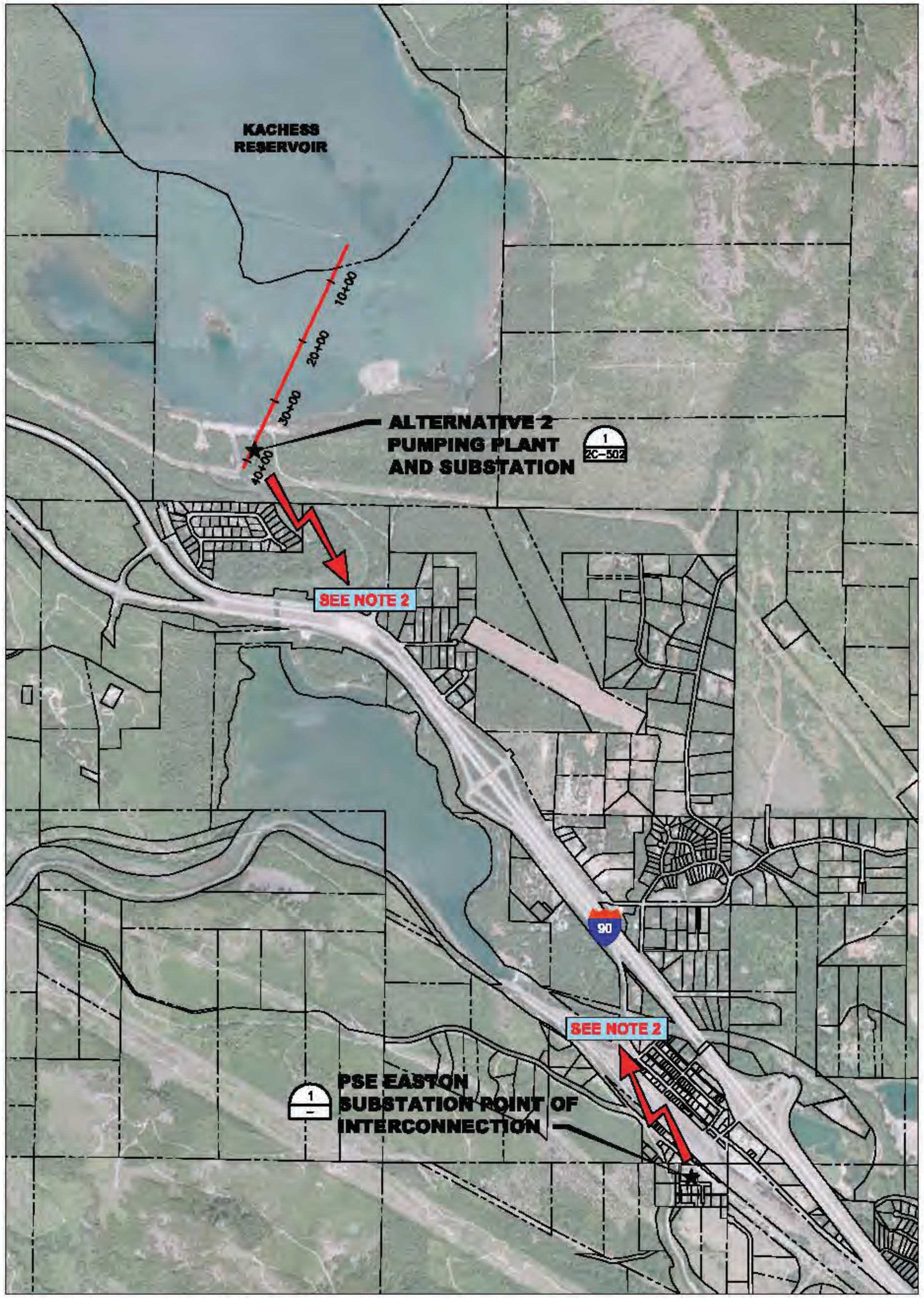

ALTERNATIVE 2 – POWER SUPPLY PLAN

SCALE: NO SCALE

EASTON INTERCONNECTION PLAN

SCALE: 1" = 60'

1

NOTES:

1. PUGET SOUND ENERGY (PSE) SUBSTATION LOCATED IN THE TOWN OF EASTON ON PELTON AVE AND 2ND STREET. CURRENTLY A DISTRIBUTION SUBSTATION, WHICH WILL REQUIRE MODIFICATIONS AND A 115 KV BAY ADDITION TO SUPPLY PUMPING LOADS. WILL ALSO REQUIRE CONTROL MODIFICATIONS.
2. DISTANCE FROM POINT OF INTERCONNECTION TO PUMPING PLANT SUBSTATION IS 2.4 MILES 'AS THE CROW FLIES'. ACTUAL ROUTE HAS NOT BEEN SELECTED. FOR ESTIMATING PURPOSES, USE 1.5 TIMES THE LINEAR DISTANCE.

FEASIBILITY DRAWING

ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF PUMPING PLANT

E. WEBBER
DESIGNED

V. KOVALISHYN
REVIEWED

YAKIMA, WA 2014-08-20

POWER SUPPLY SITE PLAN

ALTERNATIVE 2 SOUTH PUMPING PLANT

2C-501

SHEET 24 OF 30

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CAD FILENAME UNKNOWN
DATE AND TIME PLOTTED Not Plotted
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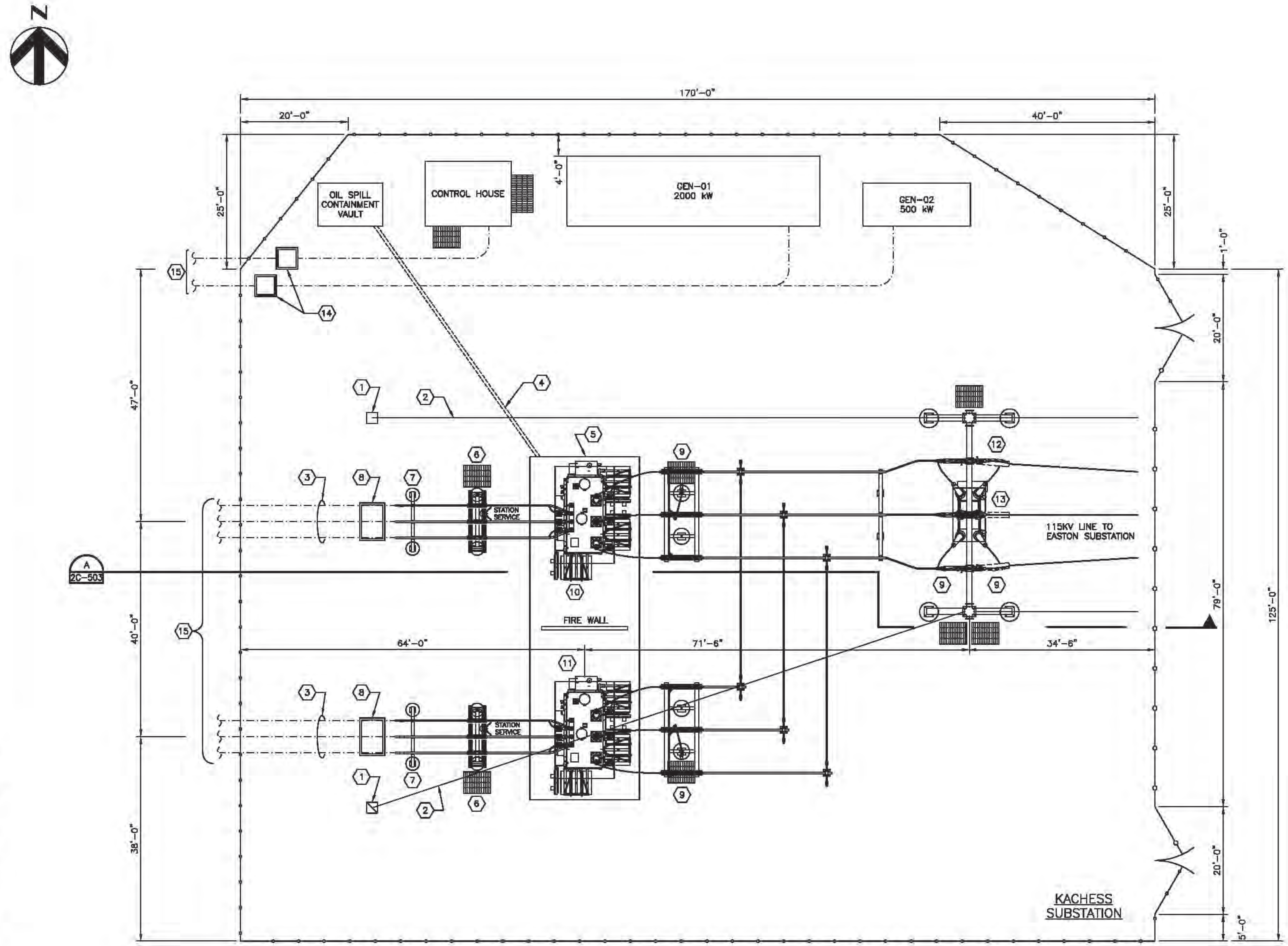

SUBSTATION PLAN

SCALE: 3/32"=1'-0"

KEY NOTES:

1. GROUND WIRE MAST
2. OPTICAL GROUND WIRE (OPGW)
3. UNDERGROUND CABLE CONDUITS
4. OIL SPILL CONTAINMENT PIPE
5. OIL SPILL CONTAINMENT STRUCTURE
6. LOW SIDE DISCONNECT
7. TERMINATION STAND FOR UNDERGROUND TO PUMPING STATION
8. MANHOLE
9. 115kV DISCONNECT
10. 115-12.5kV, 10/15/20 MVA TRANSFORMER T1
11. 115-12.5kV, 10/15/20 MVA TRANSFORMER T2
12. 115kV LINE SWITCH
13. 115kV BREAKER
14. PULLBOX FOR CONTROL HOUSE AND GENSET
15. UNDERGROUND CABLE CONDUITS TO PUMPING PLANT

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED E. WEBBER

REVIEWED V. KOVALISHYN

YAKIMA, WA 2014-08-20

POWER SUPPLY SUBSTATION PLAN

ALTERNATIVE 2 SOUTH PUMPING PLANT

2C-502

SHEET 28 OF 33

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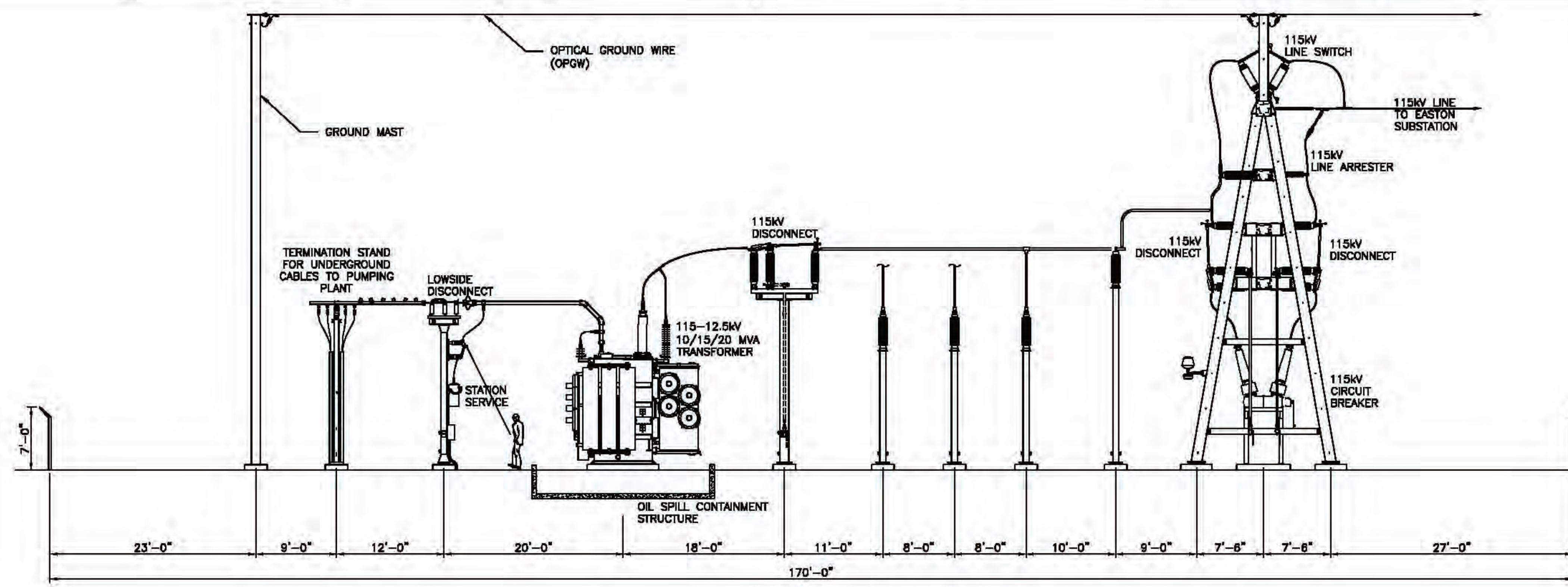
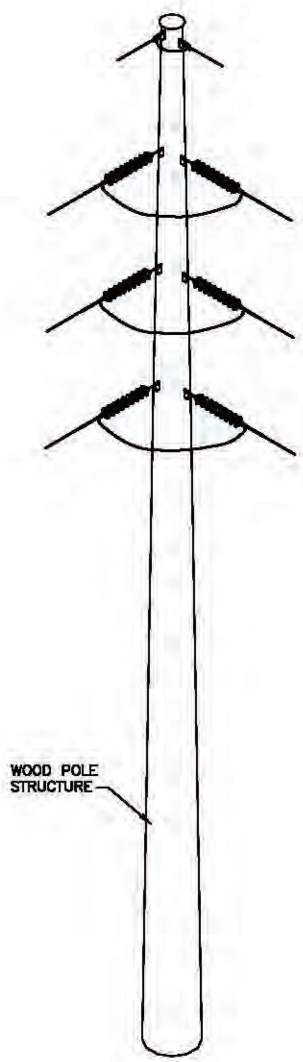
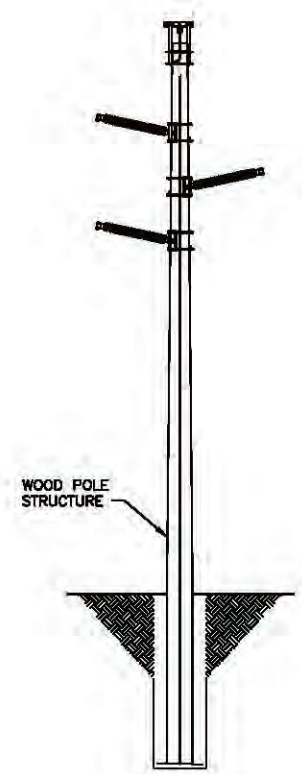


SUBSTATION SECTION A 2C502
SCALE: 1/8"=1'-0"



90' TURN TRANSMISSION POLE
SCALE: 3/32"=1'-0"



80' TANGENT TRANSMISSION POLE
SCALE: 3/32"=1'-0"

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF PUMPING PLANT

E. WEBBER
DESIGNED

V. KOVALISHYN
REVIEWED

YAKIMA, WA 2014-08-20

POWER SUPPLY SECTION

ALTERNATIVE 2 SOUTH PUMPING PLANT

2C-503
SHEET 26 OF 30

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PRIMARY ELEMENT SYMBOLOGY

- ORIFICE PLATE
- THERMAL DISPERSION FLOWMETER
- SONIC OR ULTRASONIC FLOWMETER
- MAGNETIC FLOWMETER
- PROPELLER OR TURBINE METER
- ROTAMETER
- FLUME
- WEIR
- VENTURI TUBE
- SUBMERSIBLE LEVEL SENSOR
- MOTOR
- DIAPHRAGM OPERATOR
- GAUGE
- THERMOWELL
- FLOAT SWITCHES

ACTUATOR SYMBOLS

OPERATOR ABBREVIATIONS:
M = MOTOR
P = PNEUMATIC (SINGLE OR DOUBLE)
S = SOLENOID
H = HYDRAULIC
XX: FO = FAIL TO OPEN
FC = FAIL TO CLOSE
FLP = FAIL TO LAST POSITION

FLOAT OPERATOR

LINE TYPES

- PRIMARY PROCESS LINE
- SECONDARY PROCESS LINE
- AUXILIARY PROCESS LINE
- FUTURE PROCESS LINE
- EXISTING PROCESS LINE
- PROCESS OPEN CHANNEL
- PNEUMATIC SIGNAL
- ELECTRIC SIGNAL, ANALOG
- ELECTRIC SIGNAL, DISCRETE
- ELECTRIC POWER
- HYDRAULIC SIGNAL
- SOFTWARE OR DATA LINK
- SIGNAL CONNECTION
- CROSSOVER – NO CONNECTION
- CAPILLARY TUBE
- TELEMETRY LINE
- ULTRASONIC SIGNAL (UNGUIDED)
- PACKAGED EQUIPMENT

INSTRUMENT SYMBOLOGY

- XXX XXXX — FIELD MOUNTED
- XXX XXXX — MOUNTED ON PANEL FACE
- XXX XXXX — MOUNTED BEHIND PANEL
- XXX XXXX — MOUNTED ON AUXILIARY PANEL
- XXX XXXX — MOUNTED BEHIND AUXILIARY PANEL
- XXX XXXX — INDICATOR LIGHT
- INTERLOCK, SEE CONTROL DIAGRAMS OR SPECIFICATIONS
- XXX XXXX — SHARED DISPLAY, SHARED PANEL, FIELD MOUNTED
- XXX XXXX — SHARED DISPLAY, SHARED CONTROL, PRIMARY LOCATION – NORMALLY ACCESSIBLE TO OPERATOR
- PROGRAMMABLE LOGIC CONTROL
- PLC ANALOG INPUT
- PLC DISCRETE INPUT
- PLC ANALOG OUTPUT
- PLC DISCRETE OUTPUT

PUMP AND COMPRESSOR SYMBOLS

- CENTRIFUGAL PUMP (DRY PIT)
- SUBMERSIBLE PUMP
- CHEMICAL FEED PUMP
- GEAR PUMP OR BLOWER
- PROGRESSING CAVITY PUMP
- METERING PUMP
- DIAPHRAGM PUMP
- VERTICAL TURBINE OR PROPELLER PUMP
- COMPRESSOR
- PERISTALTIC PUMP
- CENTRIFUGAL BLOWER OR FAN
- ROTARY PUMP
- ROTARY LOBE PUMP

MISCELLANEOUS SYMBOLS

- SPRAY NOZZLE
- CALIBRATION COLUMN
- FLEXIBLE HOSE
- DIAPHRAGM SEAL
- IN–LINE DIAPHRAGM SEAL
- ACCUMULATOR
- RUPTURE DISK
- HEAT EXCHANGER
- SPIRAL HEAT EXCHANGER
- BUBBLER LEVEL TUBE
- EJECTOR
- CHEMICAL INJECTOR
- MIXER
- STATIC MIXER
- FLOW STRAIGHTENER
- SLUDGE GRINDER
- MUD VALVE
- IN WALL PUMP
- IN SITU PROBE
- ULTRASONIC LEVEL SENSOR
- HPA — AIR DIAPHRAGM VALVE
- HPA — DOUBLE AIR DIAPHRAGM VALVE
- D — DRAIN
- FLAME ARRESTER
- YH — YARD HYDRANT
- QUICK DISCONNECT
- CIRCUIT SETTER

VALVES

- BALL VALVE
- BUTTERFLY VALVE
- CONE VALVE
- CHECK VALVE
- DOUBLE–DISK CHECK VALVE
- BALL CHECK VALVE
- DIAPHRAGM VALVE
- GATE VALVE
- GLOBE VALVE
- KNIFE GATE VALVE
- NEEDLE VALVE
- PINCH VALVE
- PLUG VALVE
- TELESCOPING VALVE
- THROTTLE VALVE
- THREE–WAY BALL VALVE
- THREE–WAY PLUG VALVE
- SP — SAMPLE VALVE
- SOLENOID VALVE
- PRESSURE–REDUCING VALVE
- PRESSURE–REGULATING VALVE
- THREE–WAY CONTROL VALVE
- OR — PRESSURE–RELIEF VALVE
- X — AIR–RELEASE VACUUM VALVE A = AIR RELEASE VAC = VACUUM

VALVE & EQUIPMENT TAG NUMBERS

XXX–AAA–NN

XXX:	INSTRUMENT TYPE OR EQUIPMENT TYPE (ACCORDING TO ISA 5.31–SEE TABLE)
AAA:	SITE AREA NUMBER
NN:	SUFFIX FOR DEVICE NUMBER

GATE SYMBOLS

- SLIDE
- BUTTERFLY
- FLAP
- STOP
- FABRICATED SLIDE
- SHEAR

CONTROL SWITCH NOTATION ABBREVIATIONS

XXX XXX XXXXX

ACK	ACKNOWLEDGE
ESTOP	EMERGENCY STOP
FAIL	FAILURE
FOR	FORWARD–OFF–REVERSE
FLT	FAULT
FR	FORWARD–REVERSE
FS	FAST–SLOW
HA	HAND–AUTO
HIM	HUMAN INTERFACE MODULE (DISPLAY AND KEYPAD)
HOA	HAND–OFF–AUTO
HOR	HAND–OFF–REMOTE
LL	LEAD–LAG
LLS	LEAD–LAG–STANDBY
LOR	LOCAL–OFF–REMOTE
LR	LOCAL–REMOTE
LS	LEAD–STANDBY
MA	MANUAL–AUTO
OAC	OPEN–AUTO–CLOSE
OC	OPEN–CLOSE
OO	ON–OFF
OSC	OPEN–STOP–CLOSE
RJ	RUN–JOG
RJR	RUN–JOG–REVERSE
RST	RESET
SIL	SILENCE
SP	SPEED
SS	START–STOP

TYPES OF POWER SUPPLY

A	PLANT COMPRESSED AIR
IA	INSTRUMENTATION AIR
ES	ELECTRIC SUPPLY
NG	NATURAL GAS
HYD	HYDRAULIC

CROSS REFERENCE SYMBOLOGY

- Y–3 — CONTINUATION ON SHEET Y–3
- Y–3 — CONTINUATION ON SHEET Y–3

GENERAL NOTES:

1. THIS IS A STANDARD INSTRUMENTATION SYMBOLOGY AND ABBREVIATIONS SHEET. LISTING OF SYMBOLS AND ABBREVIATIONS DOES NOT IMPLY ALL SYMBOLS AND ABBREVIATIONS HAVE BEEN USED ON THIS PROJECT.
2. SEE PROCESS, MECHANICAL AND PLUMBING LEGEND SHEET FOR MISCELLANEOUS PIPING SYMBOLS.
3. SCREENING OR SHADING OF WORK IS USED TO INDICATE EXISTING COMPONENTS OR TO DE–EMPHASIZE PROPOSED IMPROVEMENTS TO HIGHLIGHT SELECTED TRADE WORK. REFER TO CONTEXT OF EACH SHEET FOR USAGE.
4. VALVE SYMBOLS SHOWN HERE ARE APPLICABLE ONLY TO INSTRUMENTATION DIAGRAMS. SEE PROCESS, MECHANICAL AND PLUMBING LEGEND SHEET FOR VALVE SYMBOLS USED ELSEWHERE ON THE SHEETS.

MISCELLANEOUS INSTRUMENTATION ABBREVIATIONS

AC	AIR CONDITIONER
AI	ANALOG INPUT
AO	ANALOG OUTPUT
CB	CIRCUIT BREAKER
CMD	COMMAND
CO	CARBON MONOXIDE – ANALYZER MODIFIER
CO2	CARBON DIOXIDE – ANALYZER MODIFIER
COMB	COMBUSTIBLES – ANALYZER MODIFIER
CS	CARBON SENSOR
DEN	DENSITY – ANALYZER MODIFIER
DI	DISCRETE INPUT
DIFF	DIFFERENTIAL
DO	DISCRETE OUTPUT
DO	DISSOLVED OXYGEN – ANALYZER MODIFIER
DMP	DAMPER
EF	EXHAUST FAN
E/P	VOLTAGE TO PNEUMATIC
EUH	ELECTRIC UNIT HEATER
FCU	FAN COIL UNIT
FLT	FAULT
FPP	FIBER PATCH PANEL
HOA	HAND/OFF/AUTO
IRRIG	IRRIGATION
I/O	INPUT/OUTPUT
I/P	CURRENT TO PNEUMATIC
LEL	LOWER EXPLOSION LIMIT
LVL	LEVEL
MFR	MANUFACTURER
OI	OPERATOR INTERFACE
O2	OXYGEN – ANALYZER MODIFIER
OC	OPEN/CLOSE
OSC	OPEN/STOP/CLOSE
OVLD	OVERLOAD
P&ID	PROCESS AND INSTRUMENTATION DIAGRAM
PRS	PRESSURE
PS	POWER SUPPLY
RST	RESET
RUN'G	RUNNING
SC1	SUCTION CHAMBER 1
SC2	SUCTION CHAMBER 2
SF	SUPPLY FAN
SP	SETPOINT
SPD	SURGE PROTECTIVE DEVICE
TB	TERMINAL BLOCK
TEMP	TEMPERATURE
TQS	TORQUE SWITCH
TS	TEMPERATURE SENSOR
TURB	TURBIDITY – ANALYZER MODIFIER
TYP	TYPICAL
UPS	UNINTERRUPTIBLE POWER SUPPLY
VIB	VIBRATION
VCP	VENDOR CONTROL PANEL
VFD	VARIABLE FREQUENCY DRIVE
WAN	WIDE AREA NETWORK
WW	WIREWAY

INSTRUMENT IDENTIFICATION LETTER

	FIRST LETTER		SUCCEEDING LETTERS		
	MEASURED OR INITIATING VARIABLE	MODIFIER	READOUT OR PASSIVE FUNCTION	OUTPUT FUNCTION	MODIFIER
A	ANALYSIS		ALARM		
B	BURNER, COMBUSTION				
C				CONTROL	CLOSED
D		DIFFERENTIAL			
E	VOLTAGE		SENSOR (PRIMARY ELEMENT)		
F	FLOW RATE	RATIO (FRACTION)			
G			GLASS, VIEWING DEVICE		
H	HAND				HIGH
I	CURRENT (ELECTRICAL)		INDICATE		
J	POWER	SCAN			
K	TIME, TIME SCHEDULE	TIME; RATE OF CHANGE		CONTROL STATION	
L	LEVEL		LIGHT		LOW
M	USER'S CHOICE	MOMENTARY			MIDDLE, INTERMEDIATE
N	USER'S CHOICE				
O	USER'S CHOICE		ORIFICE, RESTRICTION		
P	PRESSURE, VACUUM		POINT (TEST) CONNECTION		
Q	QUANTITY	INTEGRATE, TOTALIZE			
R	RADIATION		RECORD		
S	SPEED, FREQUENCY	SAFETY		SWITCH	
T	TEMPERATURE			TRANSMIT	
U	MULTIVARIABLE		MULTIFUNCTION	MULTIFUNCTION	MULTIFUNCTION
V	VIBRATION, MECH. ANALYSIS			VALVE, DAMPER, LOUVER	
W	WEIGHT, FORCE		WELL		
X	UNCLASSIFIED	X AXIS	UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED
Y	EVENT, STATE OR PRESENCE	Y AXIS		RELAY, COMPUTE, CONVERT	
Z	POSITION, DIMENSION	Z AXIS		DRIVER, ACTUATOR, UNCLASSIFIED FINAL CONTROL ELEMENT	

RECLAMATION
Managing Water in the West

HDR

ROBERT D. KING · STATE OF WASHINGTON · 25753 · REGISTERED PROFESSIONAL ENGINEER

MELVAN E. MORRISH II · STATE OF WASHINGTON · 38559 · REGISTERED PROFESSIONAL ENGINEER

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U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
YAKIMA PROJECT – WA
KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED T. MORRIS
REVIEWED V. KOVALISHYN
YAKIMA, WA 2014–08–20

P&ID LEGEND AND ABBREVIATIONS

ALTERNATIVE 2 SOUTH PUMPING PLANT

21–601

SHEET 27 OF 30

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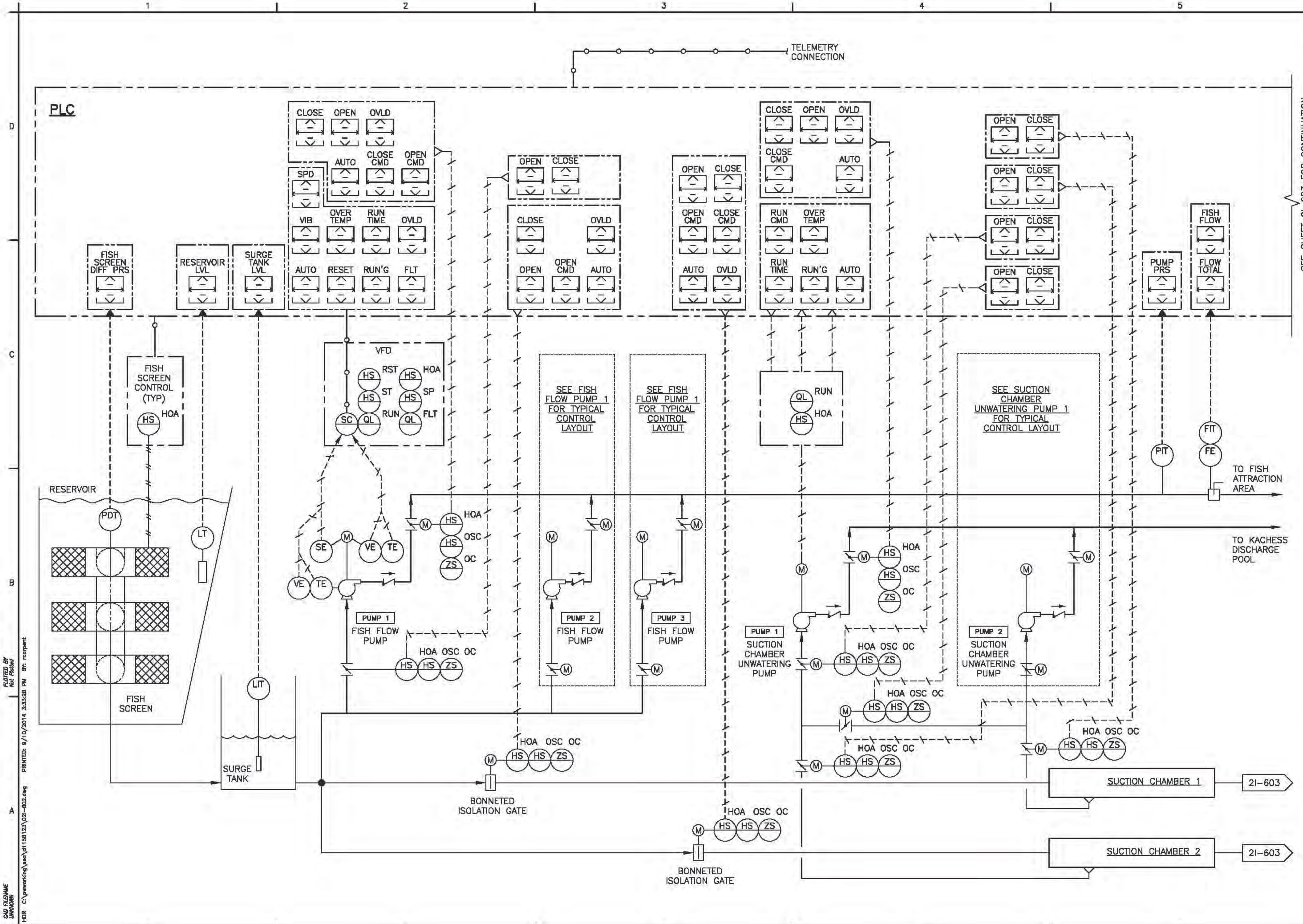

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YAKIMA PROJECT – WA
KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED T. MORRIS

REVIEWED V. KOVALISHYN

YAKIMA, WA 2014-08-20

P&ID
FISH FLOW AND UNWATERING PUMPS

ALTERNATIVE 2
SOUTH
PUMPING PLANT

2I-602

SHEET 28 OF 30

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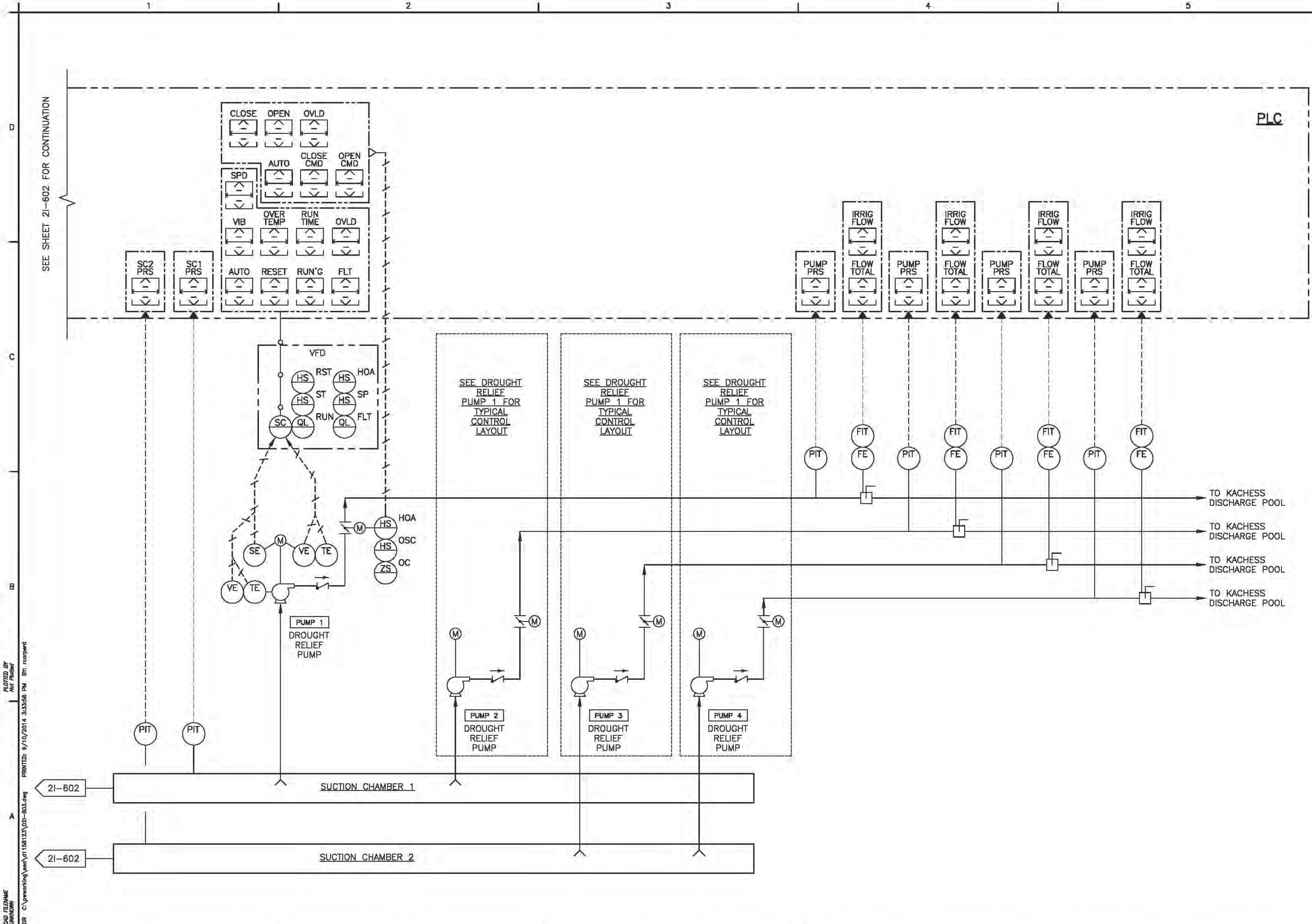

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KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED T. MORRIS

REVIEWED V. KOVALISHYN

YAKIMA, WA 2014-08-20

P&ID
DROUGHT RELIEF PUMPS

ALTERNATIVE 2
SOUTH
PUMPING PLANT

2I-603

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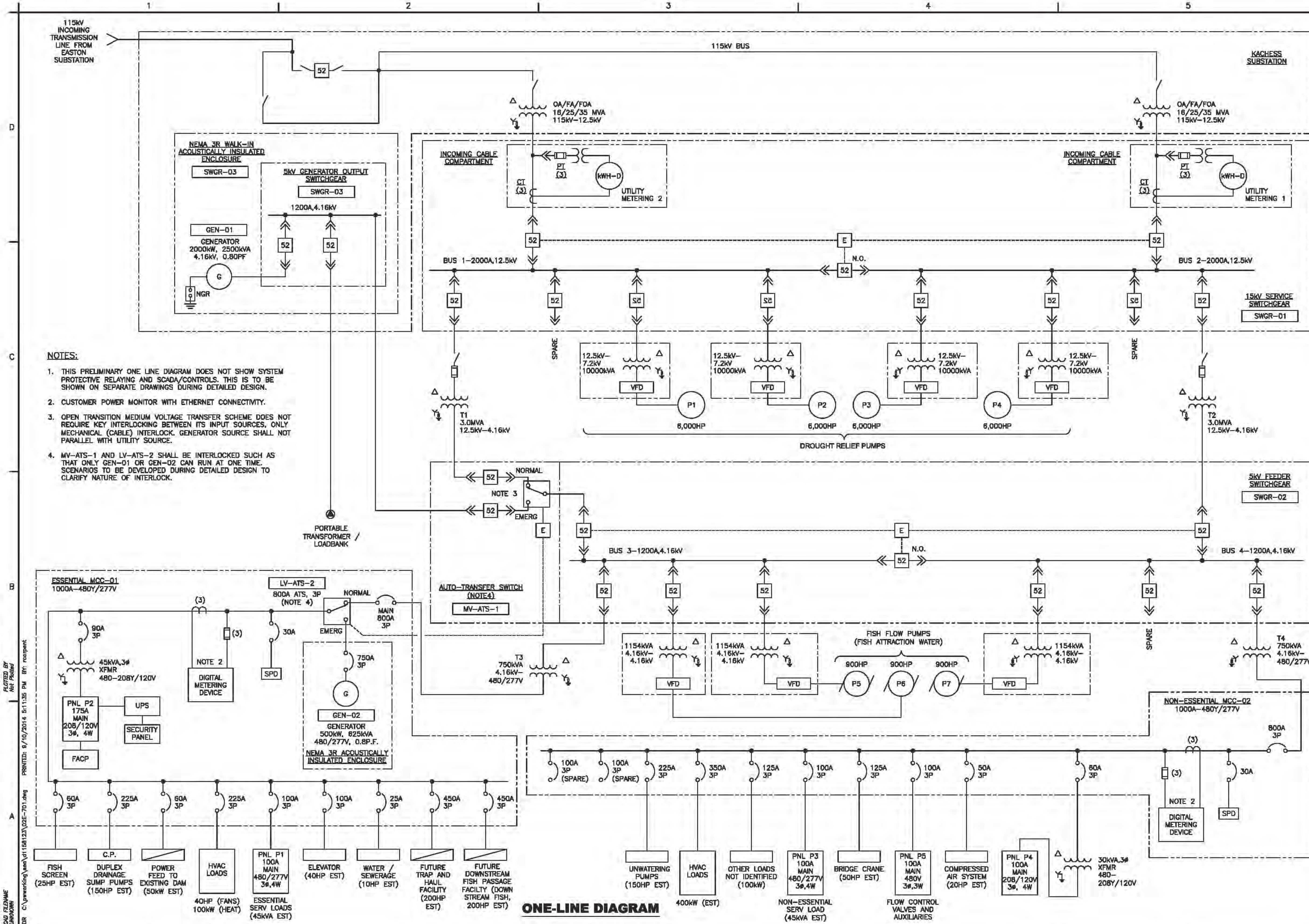

NOTES:

1. THIS PRELIMINARY ONE LINE DIAGRAM DOES NOT SHOW SYSTEM PROTECTIVE RELAYING AND SCADA/CONTROLS. THIS IS TO BE SHOWN ON SEPARATE DRAWINGS DURING DETAILED DESIGN.
2. CUSTOMER POWER MONITOR WITH ETHERNET CONNECTIVITY.
3. OPEN TRANSITION MEDIUM VOLTAGE TRANSFER SCHEME DOES NOT REQUIRE KEY INTERLOCKING BETWEEN ITS INPUT SOURCES, ONLY MECHANICAL (CABLE) INTERLOCK. GENERATOR SOURCE SHALL NOT PARALLEL WITH UTILITY SOURCE.
4. MV-ATS-1 AND LV-ATS-2 SHALL BE INTERLOCKED SUCH AS THAT ONLY GEN-01 OR GEN-02 CAN RUN AT ONE TIME. SCENARIOS TO BE DEVELOPED DURING DETAILED DESIGN TO CLARIFY NATURE OF INTERLOCK.

ONE-LINE DIAGRAM

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KITTITAS DIVISION

KACHESS DROUGHT RELIEF PUMPING PLANT

DESIGNED K. McGOWAN
REVIEWED V. KOVALISHYN
YAKIMA, WA 2014-06-20

ELECTRICAL ONE-LINE DIAGRAM

ALTERNATIVE 2 SOUTH PUMPING PLANT

2E-701

SHEET 30 OF 30

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Appendix C
Fish Passage Concept Drawings

FC-101	Kachess Dam Upstream Fish Passage Trap and Haul Facility Concept with KDRPP Alternative 1
FC-102	Kachess Dam Downstream Fish Passage Options with KDRPP Alternative 1
FC-201	Keechelus Dam Downstream Fish Passage Options
1C-202	Keechelus Dam KKC Yakima River Diversion & Intake Site Plan including future fish passage facilities
1C-203	Keechelus Dam KKC Yakima River Diversion Dam Plan and Sections including future fish passage facilities

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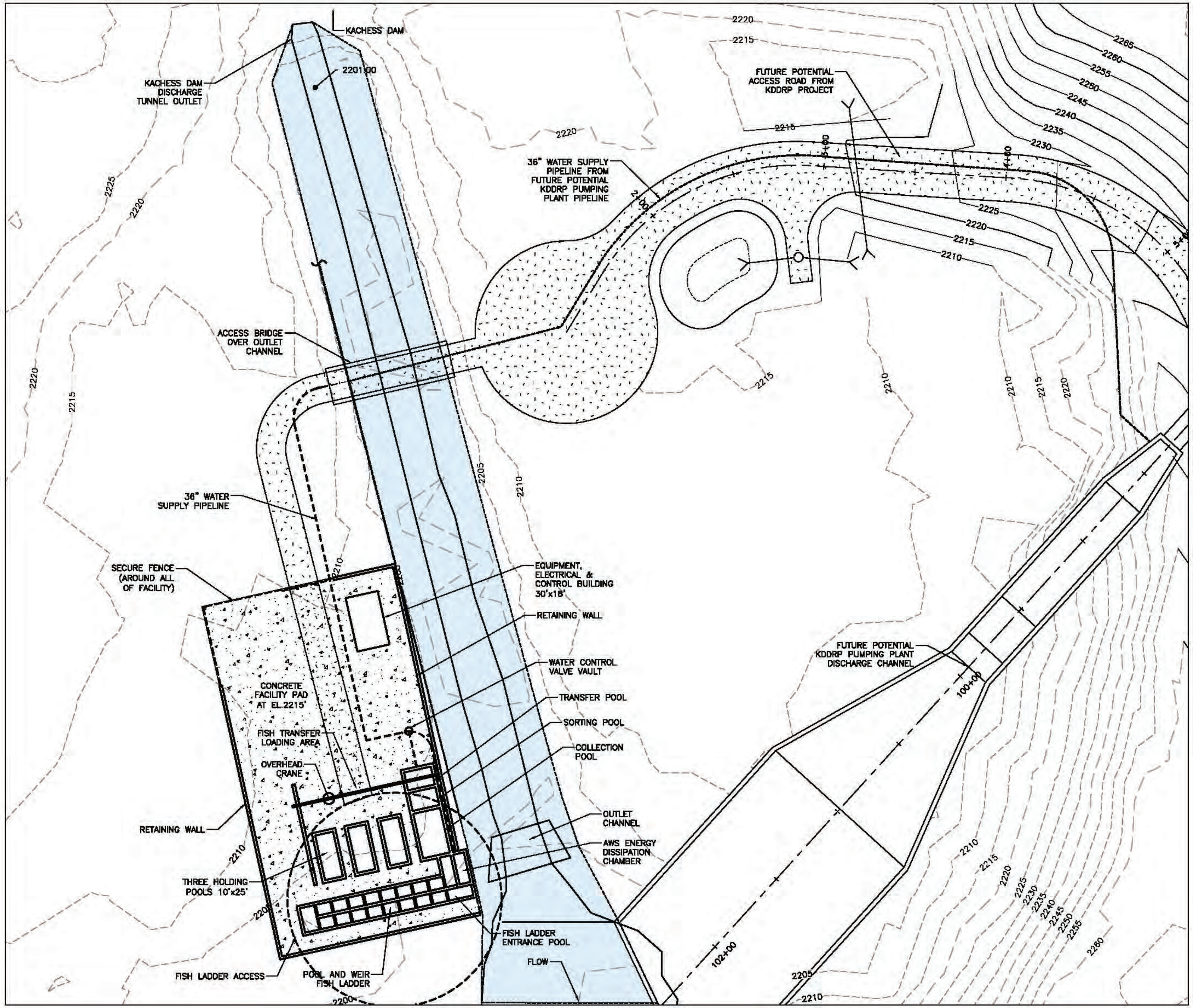

PLAN

0 15 30 60
SCALE IN FEET

N

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KACHESS DROUGHT RELIEF
PUMPING PLANT

J. VANIER
DESIGNED

B. SHAHA
REVIEWED

YAKIMA, WA 2014-08-20

US FISH PASSAGE
CONCEPT DESIGN
PLAN
TRAP AND HAUL FACILITY

ALTERNATE 1

FC-101
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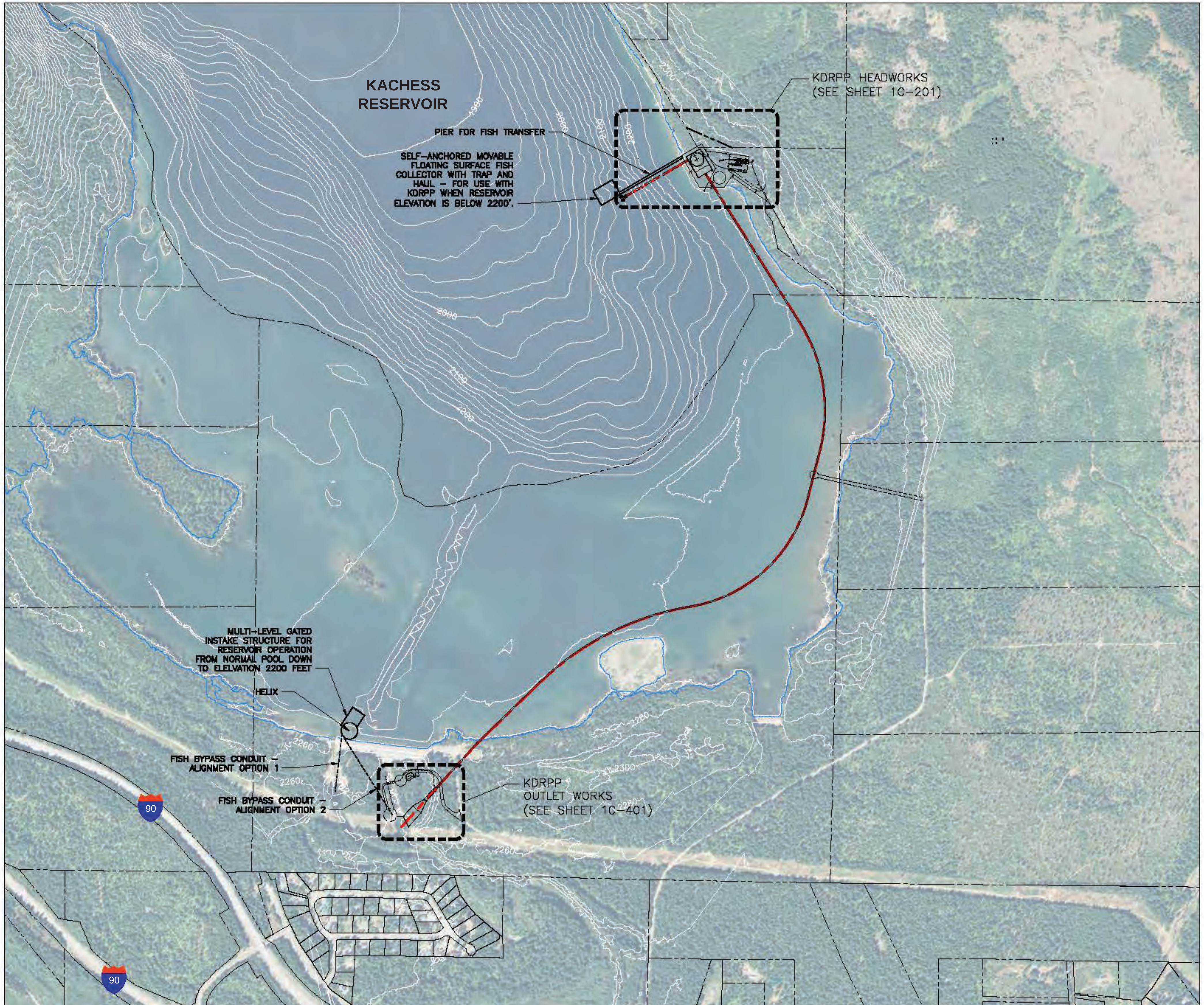
NOTE:

1. ABBREVIATIONS INCLUDE:
   - DOA – DEPARTMENT OF AGRICULTURE
   - DOT – DEPARTMENT OF TRANSPORTATION
   - BPA – BONNEVILLE POWER ADMINISTRATION
   - WNF – WASHINGTON NATIONAL FOREST



PLAN

0 250 500 1000
SCALE IN FEET

N

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KITTITAS DIVISION

KACHESS DROUGHT RELIEF
PUMPING PLANT
KDRPP

J. MANN
DESIGNED

M. BORELLO
REVIEWED

YAKIMA, WA 2014-08-20

DOWNSTREAM FISH PASSAGE OPTIONS

KDRPP

ALTERNATIVE 1
EAST SHORE
PUMPING PLANT

FC-102

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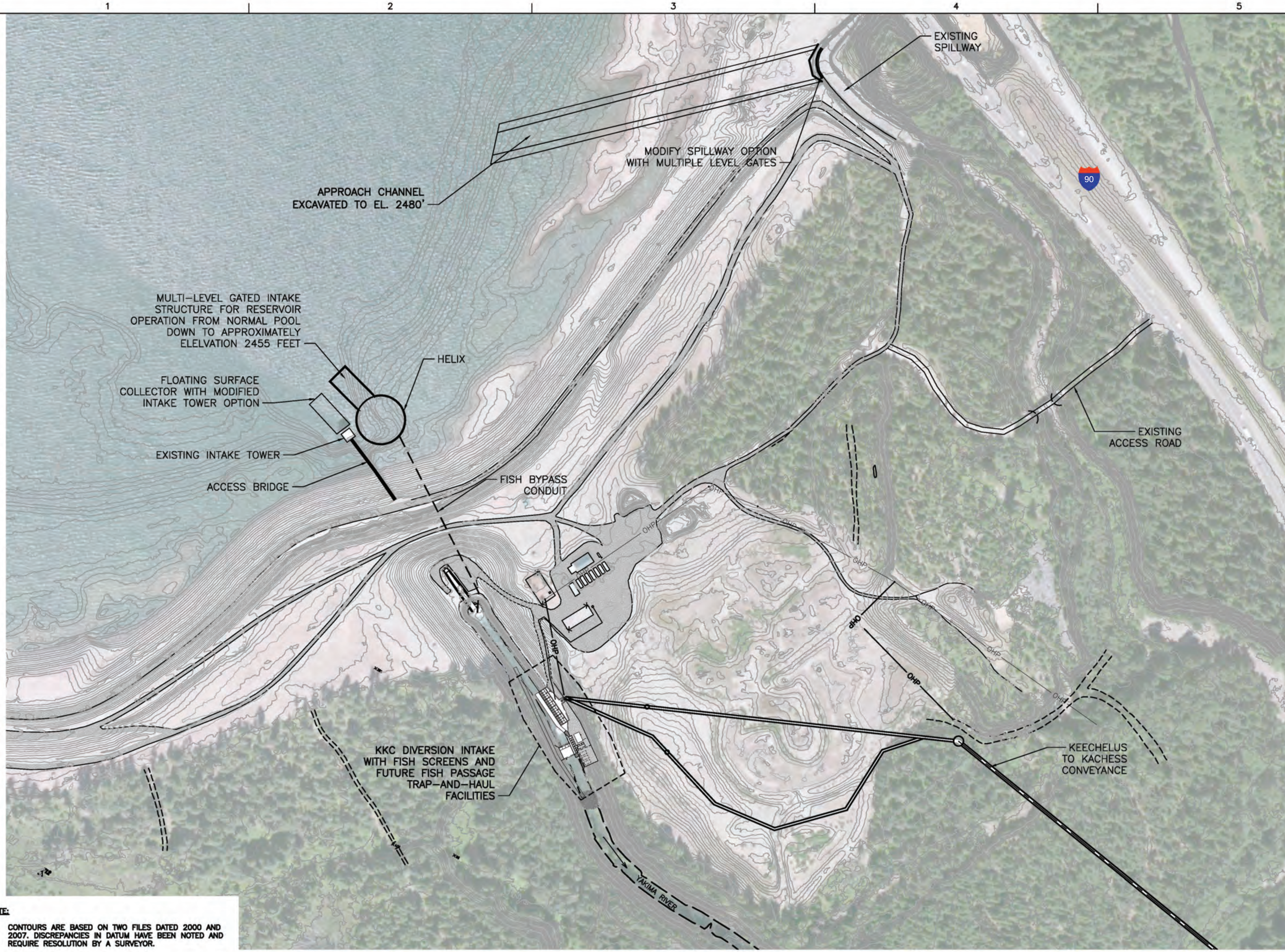

NOTE:

1. CONTOURS ARE BASED ON TWO FILES DATED 2000 AND 2007. DISCREPANCIES IN DATUM HAVE BEEN NOTED AND REQUIRE RESOLUTION BY A SURVEYOR.

SITE PLAN

0 75 150 300
SCALE IN FEET

N

0 1" 2"

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KEECHELUS RESERVOIR TO KACHESS RESERVOIR

J. MANN
DESIGNED

REVIEWED

YAKIMA, WA 2014-09-__

KEECHELUS DAM
DOWNSTREAM
FISH PASSAGE

FC-201

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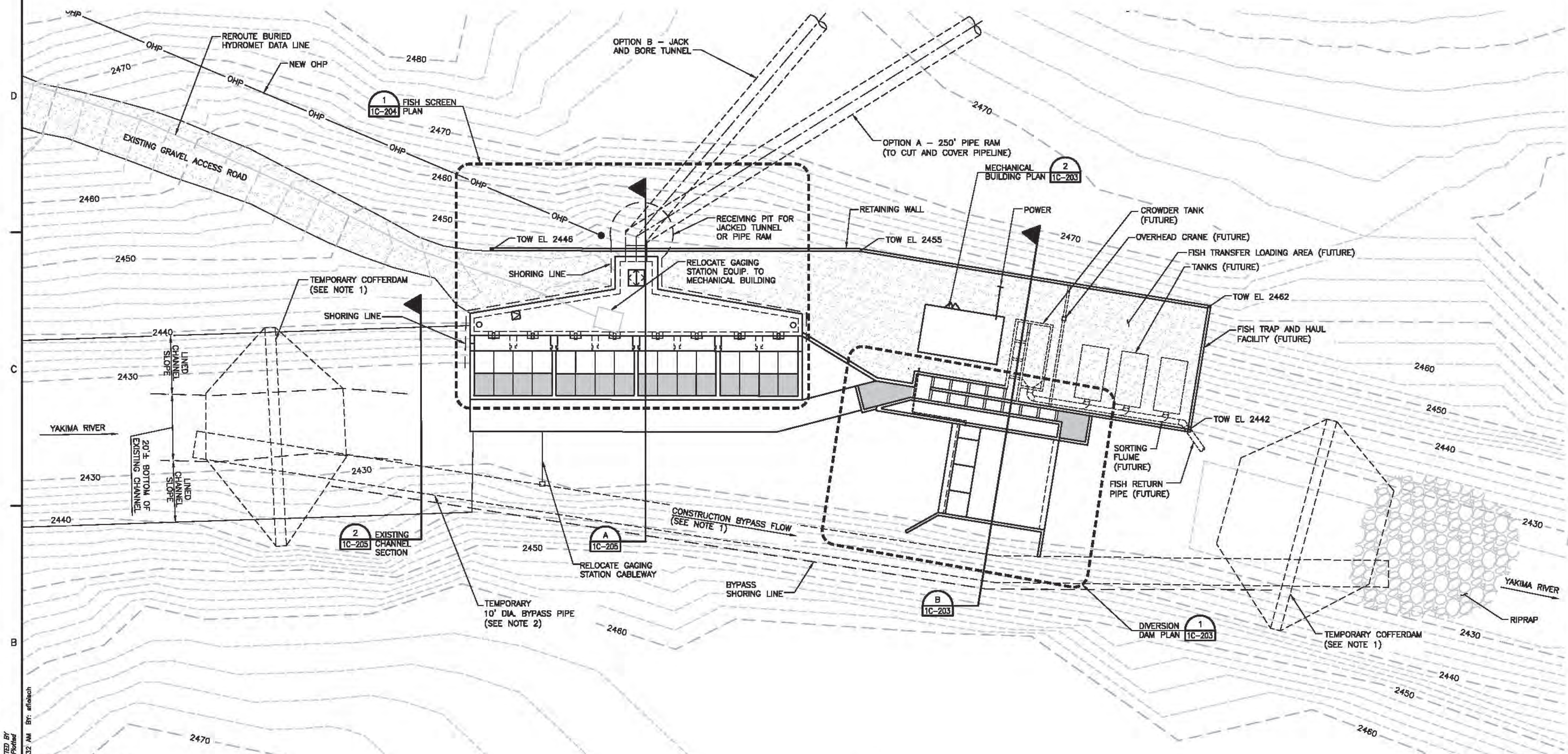

DESIGN CRITERIA

- MAXIMUM DIVERSION: 400 CFS
- MINIMUM POOL DEPTH: 7.0 FT
- SCREEN AREA: 1,150 SQ FT (4 BAYS, 29.25 FT LONG x 9.92 FT WIDE EACH)
- MAXIMUM APPROACH VELOCITY: 0.40 FPS
- MINIMUM 0.8 FPS SWEEPING FLOW
- ATTRACTION FLOW: 50 CFS
- TRAP AND HAUL WATER SUPPLY: 10 CFS (FUTURE)
- MINIMUM FISH LADDER FLOW: 20 CFS
- FISH LADDER MINIMUM POOL SIZE: 8 FT LONG x 6 FT WIDE x 5 FT DEEP
- AUTOMATED AIR BURST CLEANING

DIVERSION & INTAKE SITE PLAN 1

0 10 20 40
SCALE IN FEET

NOTES:

1. COFFERDAM AND RIVER BYPASS TO BE IMPLEMENTED BY CONTRACTOR. PIPE BYPASS IS ONE ALTERNATIVE. RELOCATION WILL BE REQUIRED DURING CONSTRUCTION TO ACCOMMODATE COMPLETION OF ADJUSTABLE CREST DIVERSION DAM AND SCREEN STRUCTURE.
2. BYPASS PIPE ALIGNMENT IS APPROXIMATE.

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KITTITAS DIVISION

KEECHELUS RESERVOIR TO KACHESS RESERVOIR

DESIGNED J. NELSON
REVIEWED J. PETERSON
YAKIMA, WA 2014-08-20

YAKIMA RIVER DIVERSION AND INTAKE SITE PLAN

NORTH TUNNEL ALIGNMENT

1C-202
SHEET 6 OF 17

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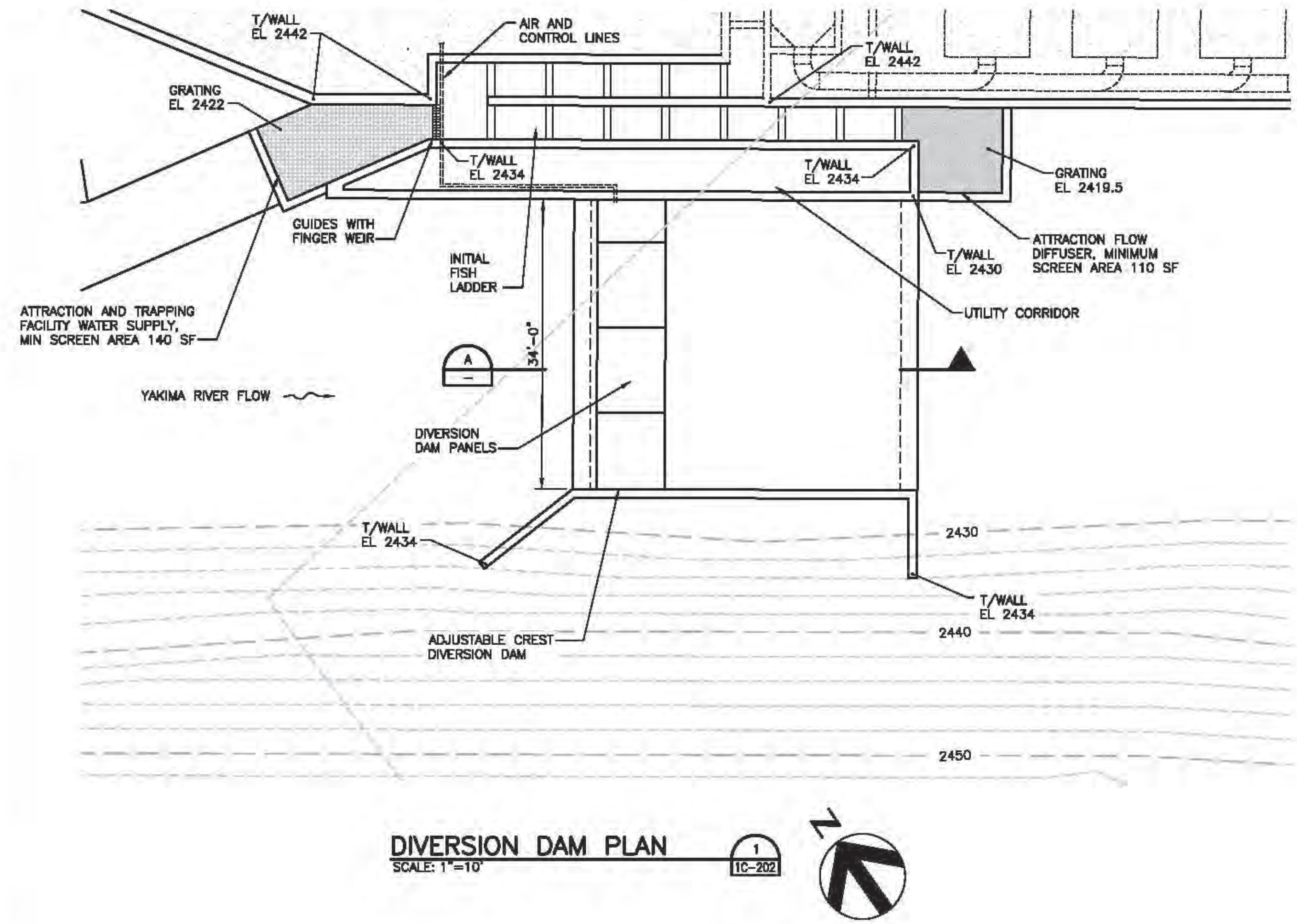
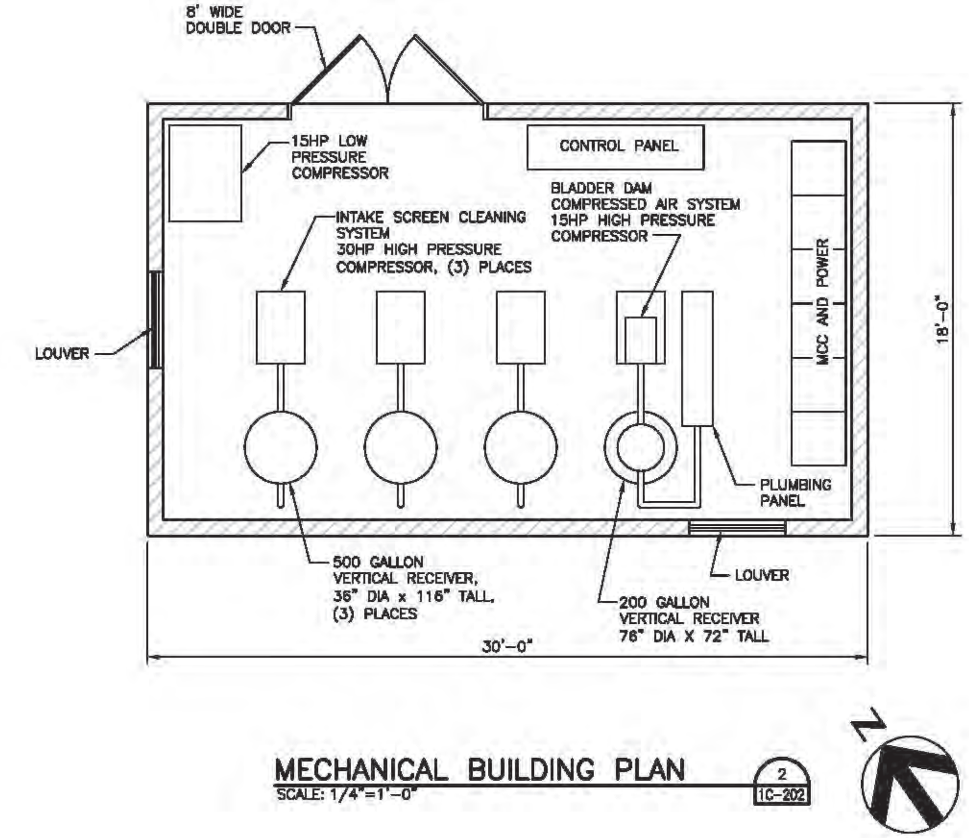


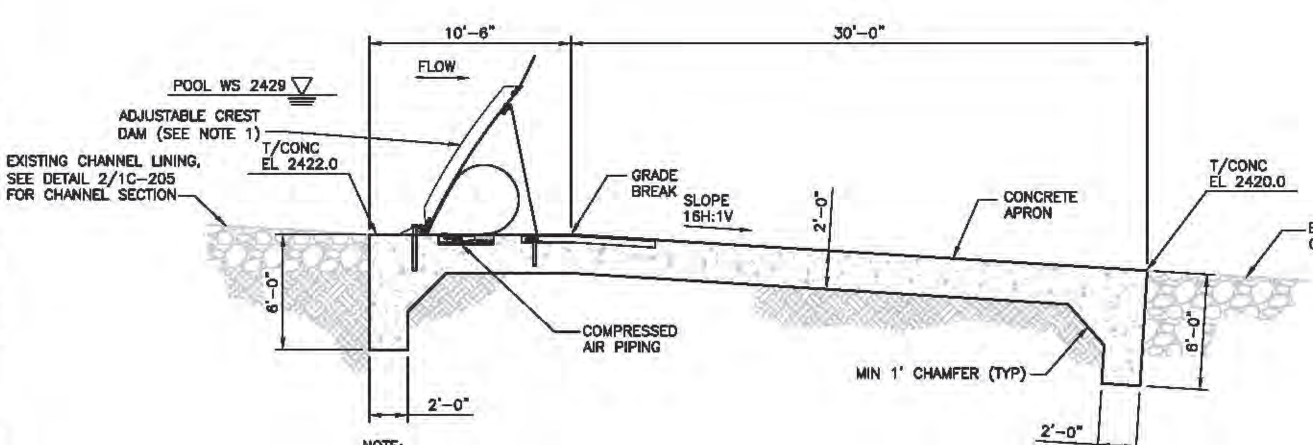
DIVERSION DAM PLAN

SCALE: 1"=10'



MECHANICAL BUILDING PLAN

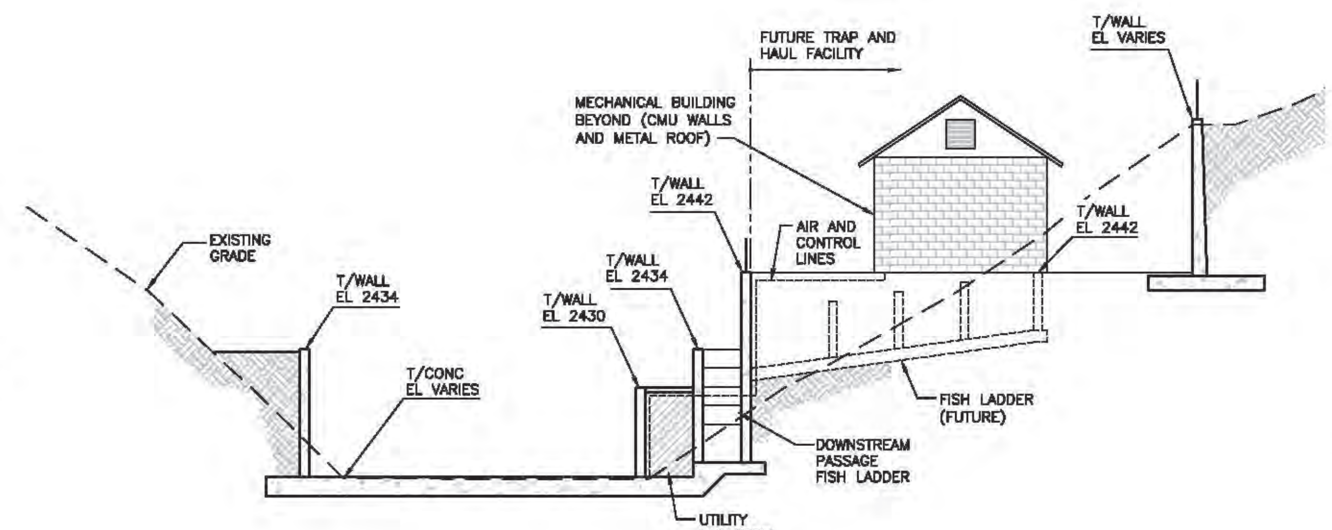
SCALE: 1/4"=1'-0"



NOTE:
1. INFLATABLE DAM SHOWN, BUT ANOTHER ADJUSTABLE DAM TYPE COULD BE USED.

DIVERSION DAM SECTION

SCALE: 1"=5'



DAM SECTION

SCALE: 1"=10'

FEASIBILITY DRAWING
ELEVATIONS AND DIMENSIONS ARE APPROXIMATE

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KEECHELUS RESERVOIR TO KACHESS RESERVOIR

DESIGNED J. NELSON
REVIEWED J. PETERSON
YAKIMA, WA 2014-08-20

YAKIMA RIVER DIVERSION DAM PLAN AND SECTION

NORTH TUNNEL ALIGNMENT

1C-203
SHEET 7 OF 17

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