Dixon Diversion Conceptual Study

Conceptual Alternatives Analysis Summary Report

Prepared For:

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1.0 EXECUTIVE SUMMARY

Alaska Energy Authority (AEA) is evaluating the potential expansion of hydroelectric power generation at the Bradley Lake Hydroelectric Project (BLHP). The Dixon Diversion Project would expand BLHP by capturing outflow from the Dixon Glacier, a tributary of Martin River adjacent to BLHP. The Conceptual Study is a high-level comparison of two Dixon Diversion alternatives – one would divert Dixon outflow to storage in Bradley Lake with power generation using the existing BLHP powerplant. The other alternative would divert water to a new powerplant (Martin River Powerplant), retaining flow in the Martin River basin. All components of both alternatives would be on lands owned by the State of Alaska. The Conceptual Study is based on the limited data available and has a large range of uncertainty. Data collection and investigations are needed to verify and refine the preliminary results of the Conceptual Study.

The Dixon Diversion to Bradley (D-B) alternative might capture 120,000 to 200,000 acre-feet of water annually for Bradley Lake. The BLHP powerplant generates approximately 1 Megawatt hour (MWh) of electricity from each acre-foot. Therefore, **the D-B alternative may generate 120,000 to 200,000 (MWh)** of additional electricity annually. The D-B alternative reduces flows in the Martin River and studies are needed to determine the amount of flow that must remain for the Martin River fisheries. The **estimated cost of the D-B alternative with Bradley Lake reservoir raise is $400 to $500 million** (see Table 1). The cost estimates are 2022 costs and include a 10% allowance for unlisted items and 25% contingency.

The Dixon Diversion to Martin River (D-M) alternative might capture 125,000 to 200,000 acre-feet of water annually to the new Martin River Powerplant. The Martin River Powerplant would have about 20% less head than the BLHP powerplant and generate about 0.8 MWh per acre-foot. Thus, **the D-M alternative may produce 100,000 to 160,000 MWh** annually. The D-M alternative returns all the diverted water to Martin River at the head of the active fishery reach of Martin River, reducing or eliminating the potential fisheries impact. The **estimated cost of the D-M alternative with Bradley Lake reservoir raise is $500 to $600 million**.

No flow measurement records are available for discharge from Dixon Glacier, or any other location within the Martin River basin. The Nuka Glacier streamgage (USGS Stream Site 15238990) is located about three miles east of the proposed Dixon Glacier diversion, and is the headwaters of Bradley Lake. The USGS streamgage was established below Nuka Glacier in 1984 to measure inflow to Bradley Lake, providing a 40-year record for discharge from a nearby, similar glacier. Because of the proximity and similar meteorological setting, the Nuka streamgage record was used to estimate Dixon Glacier outflow. The Dixon Glacier basin area above the proposed diversion is 19.1 square miles and the Nuka Glacier basin area above the USGS streamgage is 10.7 square miles. Based on area and meteorological ratios, it is estimated that discharges from the Dixon Glacier basin are about 1.6 to 2.1 times greater than the Nuka discharge. The average annual discharge at Dixon Glacier is estimated to be 156,000 to 201,000 acre-feet. In 2021, a new USGS streamgage (USGS Stream Site 15238950) was established at the proposed Dixon Diversion location. Flow measurements from the new gage will begin in 2022 and provide improved correlation for projecting Nuka's long-term records to Dixon.

The Nuka Glacier basin receives about 98 inches of average annual precipitation and the Nuka average annual gage flow is equivalent to 169 inches of runoff. If glacial melt accounts for the excess runoff, the average glacier melt over the Nuka basin is about 71 inches of water per year. The Dixon Basin receives about 104 inches of average annual precipitation and the projected annual glacier melt is 50 to 93 inches of glacier melt. The estimated Dixon runoff due to glacier melt is 30 to 45% of the total runoff.

The D-B alternative would consist of a diversion dam at Dixon glacier that would divert flows into a tunnel, 4.7 miles long, to Bradley Lake. The Martin River minimum instream flow would bypass the diversion and the remaining flows would be diverted to Bradley Lake. A minimum bypass of 100 cfs was assumed for the Conceptual Study, but the actual requirement will be based on fishery studies that will take several years. This alternative would require six miles of access road to the Dixon Diversion and another mile of access to the tunnel outfall location.

The D-M alternative would include the same diversion dam at Dixon Glacier diverting flows to a pressurized tunnel, 2.8 miles long, to a new powerplant on Martin River. A 55-MW powerplant sized for a maximum flow of 800 cfs was selected for initial estimating purposes. Optimization of the powerplant sizing, when improved streamflow data is obtained, is needed to refine the powerplant sizing and estimated annual power production. This alternative would require the same six miles of access road to the Dixon Diversion and a 4-mile-long access road to the new powerplant. About seven miles of new electric transmission line would connect the new powerplant to the substation at the existing BLHP powerplant.

Increasing the storage at Bradley Lake is included for both alternatives. The D-M alternative would be a “run of the river” system where the power generation would fluctuate based on the flow from Dixon Glacier. Peak flow from the glacier will occur in July and August, which is a period of lower energy demand in Alaska. The fluctuation would be partially offset by reducing the power generation at BLHP powerplant, keeping more water in Bradley Lake to generate electricity in the fall and winter. The D-B alternative diverts Dixon flow directly to Bradley Lake, and it would be beneficial to store the added water for increased fall and winter power production.

Raising the Bradley Lake reservoir level by 7-, 14- or 28-feet was considered in the Conceptual Study. A 7-foot reservoir raise could be accomplished by installing operable spillway crest gates 7 feet high. The existing flood capacity of the spillway would be maintained by opening the gates. Minor modifications to the dam would be needed. A 14-foot reservoir raise could be attained by raising the dam and spillway by 7 feet and including spillway crest gates for another 7 feet of storage. Raising the dam 7 feet is about the practical maximum for maintaining the same embankment design as the existing dam. The 28-foot reservoir raise represents the maximum level that would not inundate upstream Kenai National Wildlife Refuge property. The dam and spillway would be raised by 21 feet and spillway crest gates would provide another 7 feet to attain the 28-foot reservoir raise. Raising the dam 21 feet would require an atypical composite dam configuration. It will be very challenging to attain a composite design that meets the high seismic loading criteria at this site.

Currently, Bradley Lake active storage is 284,000 acre-feet. The 7-foot raise would provide about 27,000 additional acre-feet of storage, the 14-foot raise would provide about 55,000 acre-feet of additional storage, and the 28-foot raise would provide about 112,000 acre-feet of additional storage. Each acre-foot of water from Bradley Lake produces about 1 MWh of power generation – 55,000 acre-feet of storage is equivalent to 55,000 MWh of “battery” storage. Development of the 14-foot reservoir raise is assumed in this Conceptual Study Overview.

Additional costs include improvements to the BLHP facilities and establishing and operating a man-camp for construction support. Non-construction costs for administration, environmental studies, site investigations, design, and construction administration services are also included. Key features and estimated costs are summarized in Table 1.

Table 1: Estimated Costs Summary

		Dixon-Martin Alt.	Dixon-Bradley Alt.
Dixon Diversion Dam & Tunnel Intake Geologic investigations needed	Rock fill concrete core wall diversion dam, similar to recent Battle Creek Diversion Spillway over dam with gated sluiceway to maintain in-stream bypass flow and sediment flushing. Diversion Pool 20-ft deep, 3.5 Ac, 20 Ac-Ft	$10M	$10M
Dixon-Martin Tunnel Detailed topographic mapping and geologic investigations are needed to refine analyses	TBM tunnel from Dixon Glacier to new Martin River Powerplant Lined pressurized tunnel, 10-ft diameter, 2.8 miles long.	$243M	---
Martin River Powerplant Detailed Dixon Glacier outflow, topographic mapping and geologic investigations are needed to refine analyses	New 55MW hydroelectric plant located at head of Martin River anadromous fish habitat Powerplant would operate as run-of-the-river generating station with no depletion of Martin River flows. New powerhouse with single Pelton wheel turbine. Tailrace discharge above confluence with Red Lake outflow	$93M	---
Electric Transmission & Switchyards from Martin Powerplant Detailed topographic mapping and geologic investigations are needed to refine analyses	New 115-kV overhead transmission from Martin River Powerplant to BLHP substation. 6.9 mile route along new access roads.	$12M	---

		Dixon-Martin Alt.	Dixon-Bradley Alt.
Dixon-Bradley Tunnel Detailed topographic mapping and geologic investigations are needed to refine analyses Detailed fisheries studies are needed to establish Martin River instream flow requirements.	TBM tunnel from Dixon Glacier to Bradley Lake Unlined non-pressurized tunnel, 12-ft diameter, 4.7 miles long. Diverts Dixon outflow to storage at Bradley Lake. Reduces flow in Martin River.	---	$240M
Bradley Dam Raise Raising Bradley Dam provides added ability to store more water in the summer/fall when demand is lower to produce more power in winter. 1 ac-ft storage in Bradley Lake is equal to 1 MW-hr of battery storage. Raised pool will require environmental studies of the added inundation area.	7-ft Raise Add 7-ft crest gates to existing spillway and minor modifications to Bradley Dam. Appx 25,000 Ac-ft added storage	$4M	$4M
	14-ft Raise Raise existing spillway and dam by 7 ft and install 7-ft crest gates in spillway. Appx. 55,000 Ac-ft added storage Estimated Cost $29M **14-ft raise is assumed for the development of total project cost.**	$29M	$29M
	28-ft Raise Raise existing spillway and dam by 21 ft and install 7-ft crest gates in spillway Appx. 120,000 Ac-ft added storage 28-ft raise corresponds with maximum flood pool at Wildlife Refuge property boundary. Raises beyond 14-ft involve technical complications at the dam, that may increase cost significantly.	$95M	$95M
Access Roads Detailed topographic mapping and geologic investigations are needed to refine analyses.	Dixon Intake Access BLHP staging area to Dixon Glacier 6.3 Miles, appx 20' top, equivalent to recent Battle Creek Diversion Access Roads	$39M	$39M
	Martin Powerplant Access Dixon Access to new powerplant 3.8 miles along Martin River, appx 20' top, equivalent to recent Battle Creek Diversion Access Roads	$21M	---

		Dixon-Martin Alt.	Dixon-Bradley Alt.
Site Improvements	Development & operation of mancamp for construction as well as facilities improvements such as dock, airstrip, permanent office and housing, etc.	$42M	$42M
Total Construction Cost		**$465-560M**	**$340-430M**
Investigations, Environmental, Admin, & Engineering		$60-70M	$50-60M
Total Cost		**$530-630M**	**$390-490M**
Dixon Glacier Yield Avg Annual Flow Captured	Dixon Area ~ 19 sq.mi.; Nuka ~ 11 sq.mi. Dixon is 1.6 to 2.1 times Nuka outflow New USGS gage at Dixon will improve correlation	**125-200 kaf**	**120-200 kaf**
Anticipated Average Annual Power	800 cfs max Martin Powerplant 100 cfs Martin River bypass flow for D-B alt. Martin produces 0.8MWh/AF BLHP produces 1MWh/AF	**100,000 - 160,000 MWh**	**120,000 - 200,000 MWh**

2.0 INTRODUCTION

Alaska Energy Authority (AEA) is evaluating the potential expansion of hydroelectric power generation at the Bradley Lake Hydroelectric Project (BLHP). The Dixon Diversion Project would expand BLHP by capturing outflow from the Dixon Glacier, a tributary of Martin River adjacent to BLHP. This Conceptual Study is a high-level comparison of two Dixon Diversion alternatives – one would divert Dixon outflow to storage in Bradley Lake with power generation using the existing BLHP powerplant. The other alternative would divert water to a new powerplant (Martin River Powerplant) retaining flow in the Martin River basin. All components of both alternatives would be on lands owned by the State of Alaska. The Conceptual Study is based on limited available data with a large range of uncertainty. Data collection and investigations are needed to verify and refine the preliminary results of the Conceptual Study.

Following this report are appendices supporting the conceptual study. Included appendices are:

Appendix A: Concept Drawings

Appendix B: Dixon Glacier Basin Hydrologic Analysis

Appendix C: Concept Development - Tunnels

Appendix D: Concept Development – Bradley Dam Embankment Stability

Appendix E: Concept Development – Bradley Dam Spillway Stability

Appendix F: Cost Estimates

3.0 DIXON GLACIER OUTFLOW

No flow records are available for discharge of Dixon Glacier or any other location within the Martin River basin. Nuka Glacier is located about 3 miles east of Dixon Glacier and is the headwaters of Bradley Lake. A USGS streamgage was established below Nuka Glacier to measure inflow to Bradley Lake, providing a 40-year record for discharge from a nearby, similar glacier. The Nuka streamgage record was used to estimate Dixon Glacier outflow. The Dixon Glacier basin area above the proposed diversion is 19.1 square miles, and the Nuka Glacier basin area above the USGS streamgage is 10.7 square miles. It is estimated that discharges from the Dixon Glacier basin are about 1.6 to 2.1 times greater than the Nuka discharge. The average annual discharge at Dixon Glacier is estimated to be 156,000 to 201,000 acre-feet. A new USGS streamgage has been established at the proposed Dixon Diversion location. Flow measurements from the new gage will begin in 2022 and provide improved correlation to project Nuka's long-term records to Dixon.

The Nuka Glacier basin receives about 98 inches of average annual precipitation (PRISM 1981-2010), and the Nuka average annual gage flow is equivalent to 169 inches of runoff. If glacial melt accounts for the excess runoff, the average glacier melt over the Nuka basin is about 71 inches of water per year. The Dixon Basin receives about 104 inches of average annual precipitation (PRISM 1981-2010). Using the gage transformation of 156,000 acre-feet average annual runoff volume past the Nuka gage, the total basin runoff from the Dixon Glacier basin is 154 inches and the projected annual glacier melt is 50 inches. Using a precipitation water balance method, the Dixon Glacier runoff volume is 197 inches, with 93 inches of glacier melt; the estimated Dixon Glacier runoff due to glacier melt is 30 to 45% of the total runoff.

For further hydrologic information and supporting documentation of these runoff statistics, please refer to the hydrology memo in Appendix B.

4.0 PROJECT ALTERNATIVES

Two alternatives were evaluated, the Dixon to Bradley (D-B) and the Dixon to Martin River (D-M). Both alternatives include a diversion dam at Dixon Glacier, access roads, and increasing the storage of Bradley Lake. A compiled conceptual drawing set is included in Appendix A.

4.1 DIXON DIVERSION TO BRADLEY (D-B)

A tunnel would be constructed to route water from the proposed Dixon Diversion below the toe of Dixon Glacier to the southwestern portion of Bradley Lake. AEA anticipates that this flowline would comprise an approximately 4.7-mile-long tunnel with a finished diameter of approximately 12 feet. The invert of the tunnel entrance would be approximately 1,263 feet, and the invert at the outlet would be approximately 1,210 feet. The Martin River minimum instream flow would bypass the diversion, and the remaining flows would be diverted to Bradley Lake. A minimum bypass of 100 cfs was assumed for the Conceptual Study, but the actual requirement will be based on fishery studies that will take several years. Conceptual development of the D-B tunnel is described in Appendix C.

4.2 DIXON DIVERSION TO MARTIN RIVER (D-M)

A power tunnel would be constructed between the powerhouse on the Martin River and the intake below the toe of Dixon Glacier. The pressurized tunnel would be approximately 2.75-miles long and have a finished diameter of approximately 10 feet. The invert of the tunnel entrance would be at approximately 1,263 feet (Bradley Project Datum) and would convey water to the powerhouse on the Martin River at an elevation of approximately 300 feet. Conceptual development of the D-M tunnel is described in Appendix C.

4.2.1 Martin River Powerhouse

The Martin River powerhouse would be located approximately 5 miles upstream of the mouth of the Martin River, on the eastern shore near the confluence of East Fork Martin River and the Red Lake Fork. The reinforced concrete powerhouse footprint would be approximately 100 feet by 60 feet and include a 55 MW vertical Pelton turbine. The footprint and general arrangement of the powerhouse will be refined based on topography and geotechnical investigations.

4.2.2 Transmission Line

AEA would install a new, approximately 6.9 mile-long, 115-kV transmission line to connect the new Martin River powerhouse to the existing substation at the Bradley Lake Project powerhouse for the Dixon-Martin Alternative. Subject to further evaluation, AEA intends this transmission line to parallel the Dixon Diversion and Martin River powerhouse access road described below. From the existing Bradley powerhouse substation, the Project would connect to the Homer Electric Association line between Fritz Creek and Soldotna via the existing 115-kV transmission line. The transmission line was constructed in 1990 and is in excellent condition. AEA would evaluate the capacity of the existing line to handle any increased load.

4.3 DIXON GLACIER DIVERSION

The new diversion dam would be on state-owned land to impound water sufficient to feed a power tunnel to either Bradley Lake or a Martin River powerhouse. The design and configuration would be determined as part of the Project feasibility assessment and development. AEA anticipates that the diversion would be a concrete weir wall approximately 25-feet high by 75-feet long, with an overflow elevation of 1,275 feet. The approximate inlet elevation for either tunnel would be 1,263 feet, subject to additional topographic surveys and design layout. The diversion dam would create a forebay area for the intake, currently estimated to include approximately 1.0 surface acre with a storage capacity of approximately 5 acre-feet at elevation 1,275 feet (Bradley Project Datum).

4.4 ACCESS ROADS

A total of approximately 7.3 miles (for the D-M alternative) or 10.1 miles (for the D-B alternative) of new, 16-foot-wide, gravel-surfaced access roads would be constructed to support operations and maintenance of the new project facilities. An approximately 6.3-mile-long road segment would extend from the existing Bradley Lake Access Road to the new Dixon Diversion. For the Dixon-Martin alternative, a spur would extend about 3.8 miles to the Martin River powerhouse. For the Dixon-Bradley tunnel alternative, a spur road off the existing Upper Battle Creek Access Road would be extended one mile to the downstream exit of the tunnel from the Dixon Diversion.

4.5 BRADLEY LAKE DAM MODIFICATION

Bradley Lake Dam currently impounds Bradley Lake to a full pool elevation of 1,180 feet (Project Datum) with a surface area of 3,820 acres and a storage capacity of approximately 284,000 acre-feet. Regardless of which alternative is selected, AEA will request that FERC authorize an increase in the full pool elevation for Bradley Lake. If neither Dixon Diversion Alternative is viable, AEA may still pursue increasing storage of Bradley Lake.

The D-M alternative would be a “run of the river” system where the power generation would fluctuate based on the flow from Dixon Glacier. Peak flow from the glacier will occur in July and August, which is a period of lower energy demand in Alaska. The fluctuation would be partially offset by reducing the power generation at BLHP powerplant, keeping more water in Bradley Lake to generate electricity in the fall and winter. The D-B alternative diverts Dixon flow directly to Bradley Lake, and it would be beneficial to store the added water for increased fall and winter power production.

Raising the Bradley Lake reservoir level by 7-, 14- or 28-feet was evaluated in the Conceptual Study. Bradley Dam embankment considerations, including embankment stability, are described in Appendix D, and Bradley Dam spillway considerations, including the mass concrete spillway stability, are described in Appendix E. A summary of the dam modification alternatives is presented in Table 2 at the end of this section following a brief description of the three pool raise alternatives.

4.5.1 7-foot Raise

The 7-foot Alternative would involve increasing the normal maximum operating level of Bradley Lake to elevation 1,187 feet by adding a 7-foot-high spillway crest gate over the fixed (concrete) spillway crest. The crest of the embankment would not need to be raised as the design flood could be passed through the spillway with the spillway crest gates completely lowered. The raise would increase the normal surface area to 3,914 acres and increase storage capacity to approximately 312,000 acre-feet. This raise maintains the maximum reservoir level between the existing project boundary of elevation 1,200 feet.

4.5.2 14-foot Raise

The 14-foot Alternative would involve increasing the level of Bradley Lake to elevation 1,194 feet through a combination of raising the fixed crest of the concrete spillway and adding spillway crest gates. Under this alternative, the embankment crest would also be raised 7 feet through a combination of increased rockfill and a new parapet wall that would be extended to the left abutment. The raise would increase the total surface area to 4,021 surface acres and increase storage capacity to approximately 343,000 acre-feet. This will increase the maximum pool elevation to the existing project boundary elevation of 1,200 feet.

4.5.3 28-foot Raise

The 28-foot Alternative would involve increasing the normal full pool level of Bradley Lake to elevation 1,208 feet through a combination of raising the fixed crest of the concrete spillway and adding spillway crest gates. Under this alternative, the dam crest would also be raised 21 feet through a combination of increased rock fill and a new parapet wall that would be extended to the left abutment; the diversion tunnel gatehouse would also be raised. Constructing the ancillary features associated with the 28-ft raise, such as raising the gatehouse and extending the parapet wall, would be challenging. Additionally, the initial conceptual raise geometry of 1H:1V slopes creates stability challenges that will require mitigation through reinforcement of the rockfill raise section.

The 28-ft raise would increase the total surface area to 4,224 surface acres and increase storage capacity to approximately 386,000 acre-feet. AEA has planned this pool raise to ensure that Kenai National Wildlife Refuge lands will not be inundated at the proposed new maximum pool elevation. The maximum flood pool level would remain on lands owned by the State of Alaska.

Table 2: Bradley Lake Dam Modification Summary

Alternative	Description	Normal Pool Elevation (ft)	Surface Area (acre)	Storage (acre-feet)
Existing	Dam is currently in this state	1,180	3,820	284,000
7-foot Raise	Add 7-foot-high spillway crest gate	1,187	3,914	311,000
14-foot Raise	Embankment crest raise of 7-feet with addition of 7-foot-high spillway crest gate	1,194	4,021	339,000
28-foot Raise	Embankment crest raise of 21-feet with addition of 7-foot-high spillway crest gate	1,208	4,224	386,000

5.0 ESTIMATED PROJECT COSTS

Cost estimates for key elements of the Dixon Diversion Alternatives are summarized in Table 3. The bases for these costs are presented in Appendix F.

In general, the recent West Fork Upper Battle Creek Diversion (WFUBCD) bids were used to develop anticipated costs for the Dixon Diversion Project. The WFUBCD project was constructed in 2018-2020 and was an expansion of the water supply for Bradley Lake. The WFUBCD average bid prices, with high bid and low bid excluded, were used with a 25% cost escalation for inflation to 2022 prices. The tunnel costs are based on the recent Terror Lake Project and other typical tunnel costs with factors applied to represent the remote access to Bradley Lake Project. Costs include approximately 40% allowance for Unlisted Items; Mobilization, Bonds, Taxes & Insurance; and Contingencies within each Element.

Table 3: Estimated Costs Summary Matrix

Element	Element Cost	Dixon-Martin Alt: Bradley Dam 7-ft Raise	Dixon-Martin Alt: Bradley Dam 14-ft Raise	Dixon-Martin Alt: Bradley Dam 28-ft Raise	Dixon-Bradley Alt: Bradley Dam 7-ft Raise	Dixon-Bradley Alt: Bradley Dam 14-ft Raise	Dixon-Bradley Alt: Bradley Dam 28-ft Raise
General Site Improvements	$41,926,000	$41,926,000	$41,926,000	$41,926,000	$41,926,000	$41,926,000	$41,926,000
Dixon Intake Access Road	$39,249,000	$39,249,000	$39,249,000	$39,249,000	$39,249,000	$39,249,000	$39,249,000
Martin Powerplant Access Road	$20,500,000	$20,500,000	$20,500,000	$20,500,000			
DM Shaft Intake and Diversion Dam	$13,018,000	$13,018,000	$13,018,000	$13,018,000			
DB Tunnel Intake and Diversion Dam	$13,018,000				$13,018,000	$13,018,000	$13,018,000
Dixon-Martin Shaft & Tunnel	$242,568,000	$242,568,000	$242,568,000	$242,568,000			
Martin Powerplant	$92,779,000	$92,779,000	$92,779,000	$92,779,000			
Martin Transmission Line	$12,325,000	$12,325,000	$12,325,000	$12,325,000			
Dixon-Bradley Tunnel w/Outfall	$239,969,000				$239,969,000	$239,969,000	$239,969,000
Bradley Dam Raise (28-ft Pool Raise)	$94,703,000			$94,703,000			$94,703,000
Bradley Dam Raise (14-ft Pool Raise)	$29,081,000		$29,081,000			$29,081,000	
Bradley Spillway Gates (7-ft Pool Raise)	$4,109,000	$4,109,000			$4,109,000		
Construction Cost		**$466,474,000**	**$491,446,000**	**$557,068,000**	**$338,271,000**	**$363,243,000**	**$428,865,000**
FERC Licensing		$5,000,000	$5,000,000	$5,000,000	$7,500,000	$7,500,000	$7,500,000
Geologic & Hydrologic Studies	$5,000,000	$5,000,000	$5,000,000	$5,000,000	$5,000,000	$5,000,000	$5,000,000
Feasibility Design	3.00%	$13,994,000	$14,743,000	$16,712,000	$10,148,000	$10,897,000	$12,866,000
Final Design	4.00%	$18,659,000	$19,658,000	$22,283,000	$13,531,000	$14,530,000	$17,155,000
Construction Administration	4.00%	$18,659,000	$19,658,000	$22,283,000	$13,531,000	$14,530,000	$17,155,000
Subtotal Administration & Engineering		**$61,312,000**	**$64,059,000**	**$71,278,000**	**$49,710,000**	**$52,457,000**	**$59,676,000**
Total Cost		**$527,786,000**	**$555,505,000**	**$628,346,000**	**$387,981,000**	**$415,700,000**	**$488,541,000**

6.0 ESTIMATED POWER GENERATION

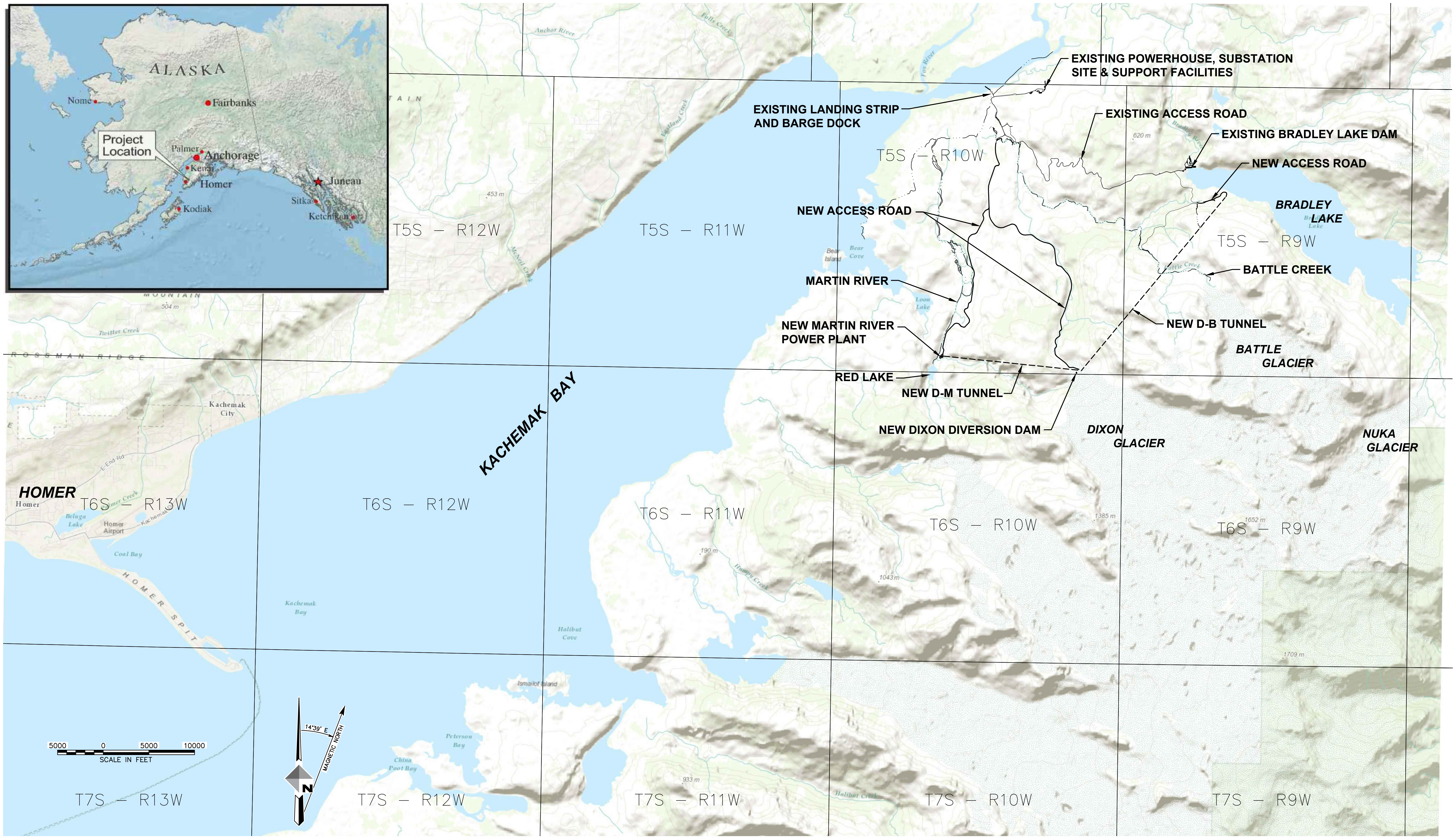
6.1 DIXON DIVERSION TO BRADLEY (D-B)

The Dixon Diversion to Bradley (D-B) alternative might capture 120,000 to 200,000 acre-feet of water annually to Bradley Lake. The BLHP powerplant generates approximately 1 Megawatt hour (MWh) of electricity from each acre-foot. Therefore, **the D-B alternative may generate 120,000 to 200,000 (MWh)** of additional electricity annually.

6.2 DIXON DIVERSION TO MARTIN RIVER (D-M)

The Dixon Diversion to Martin River (D-M) alternative might capture 125,000 to 200,000 acre-feet of water annually to the new Martin River Powerplant. The Martin River Powerplant would have about 20% less head than the BLHP powerplant and generate about 0.8 MWh per acre-foot. Thus, **the D-M alternative may produce 100,000 to 160,000 MWh** annually.

Appendix A: Concept Drawings



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HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

PROJECT 1136.90090.01
DATE 03/02/2022

GENERAL INFORMATION
PROJECT LOCATION PLAN

G-1

PAGE A-1

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BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

PROJECT 1136.90090.01
DATE

BRADLEY LAKE FAULT TRACES

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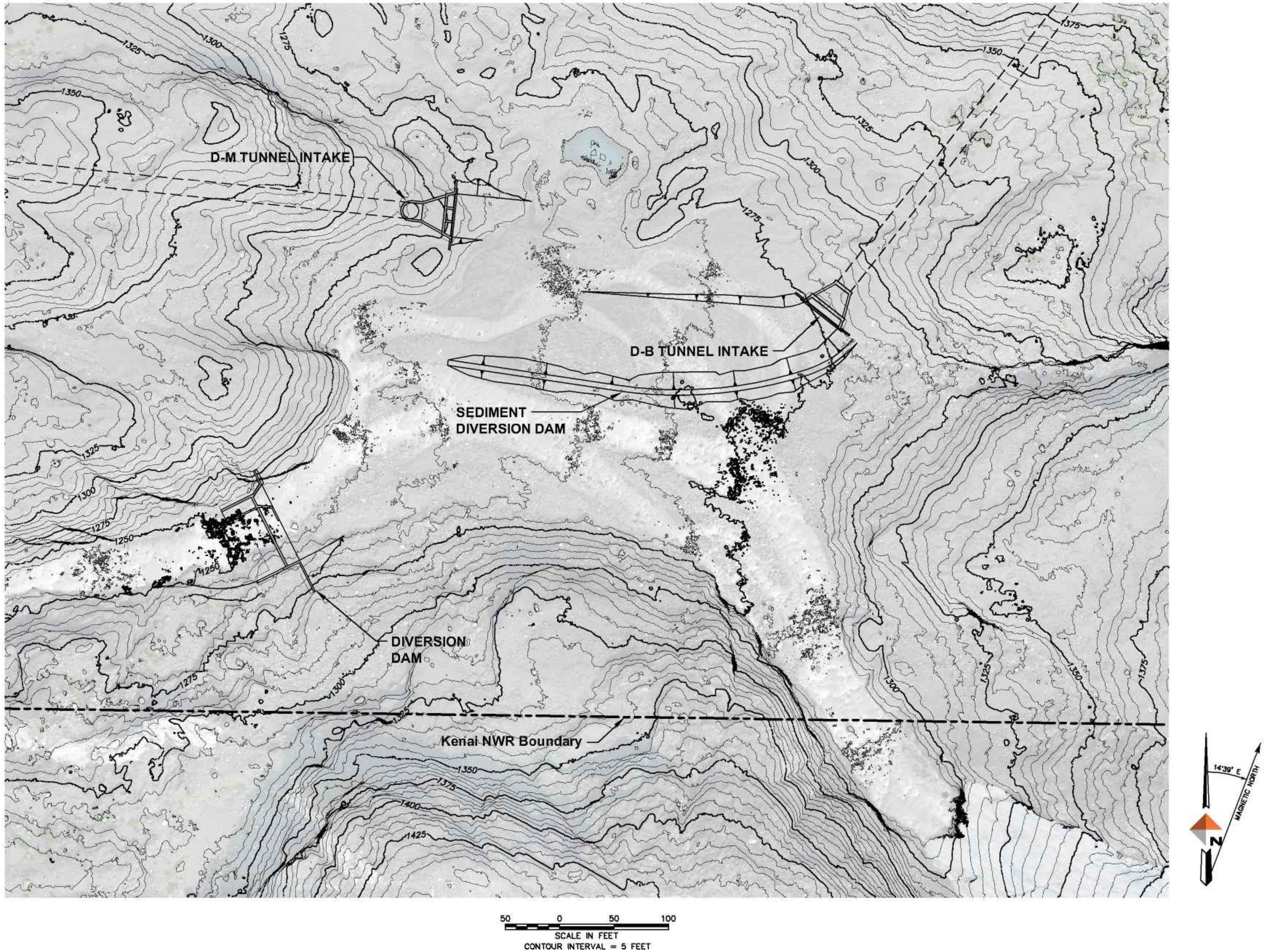

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BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

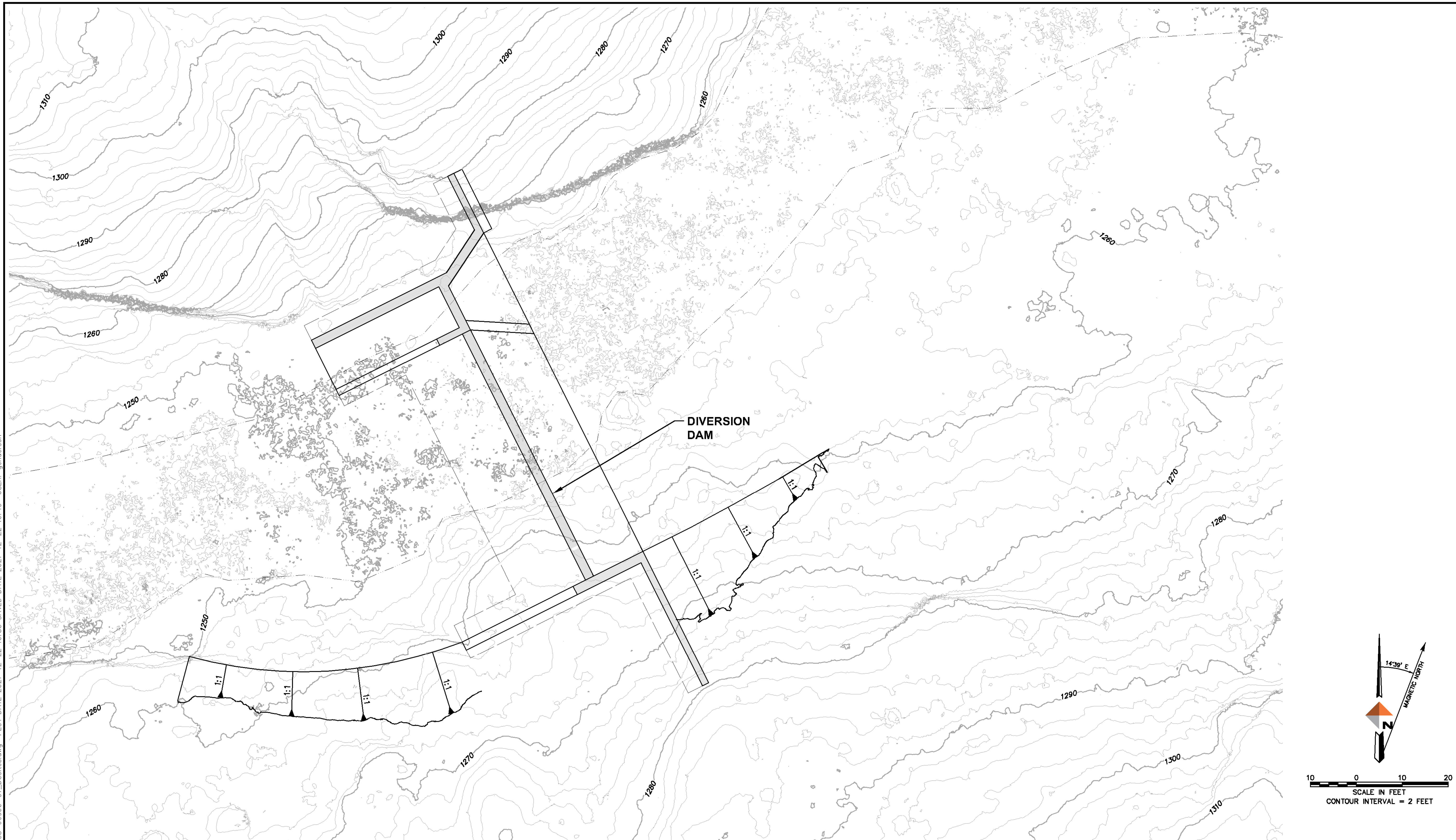
PROJECT	1136.90090.01
DATE	12/17/2021

DIXON DIVERSION
GENERAL SITE PLAN

DD-1

PAGE A-3

FERC P - 8221 - AK



HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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AECL848
Anchorage, Alaska

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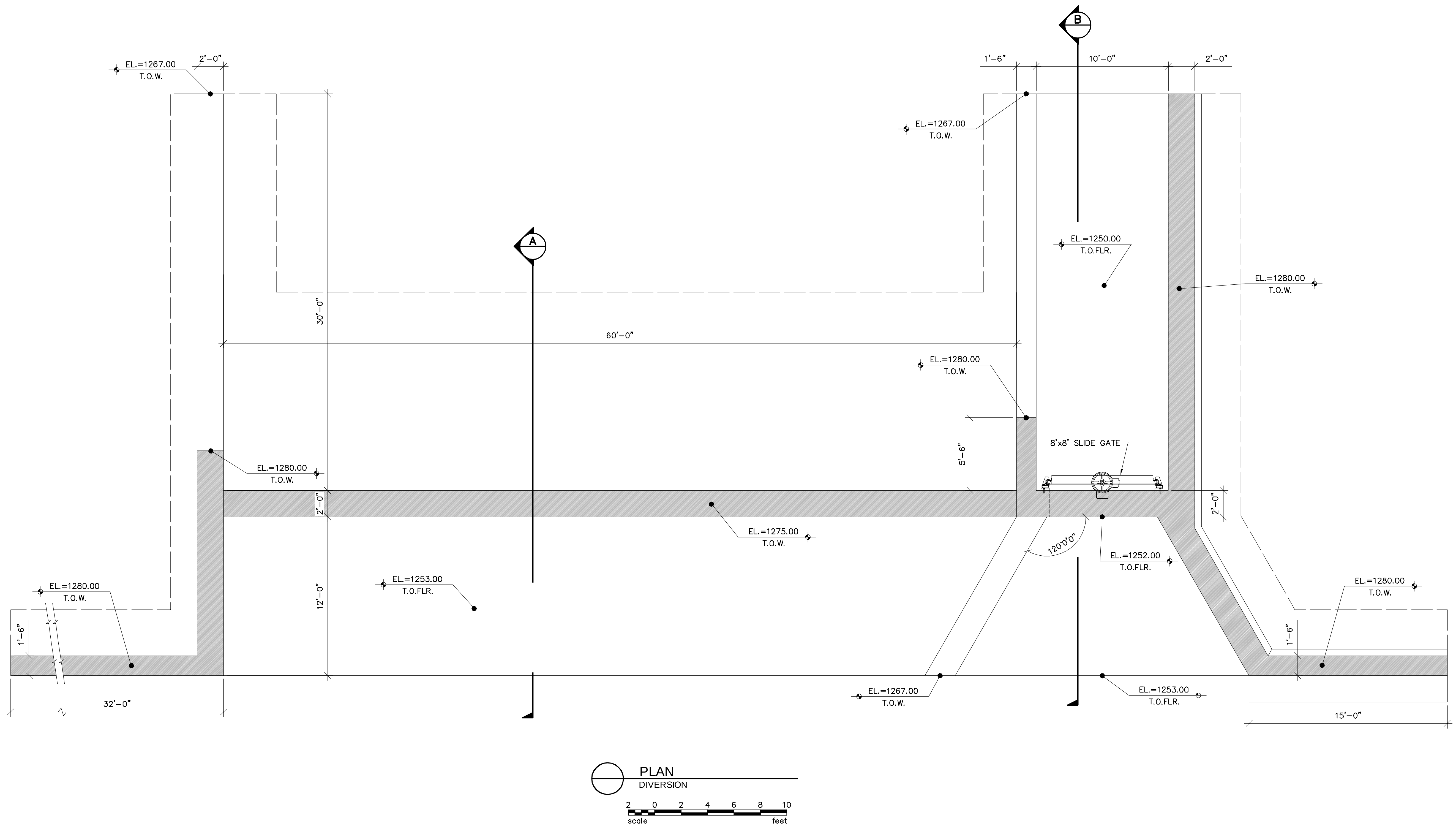
BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

PROJECT	1136.90090.01
DATE	12/17/2021

DIXON DIVERSION
SITE PLAN

DD-2

PAGE A-4



HORIZONTAL CONTROL

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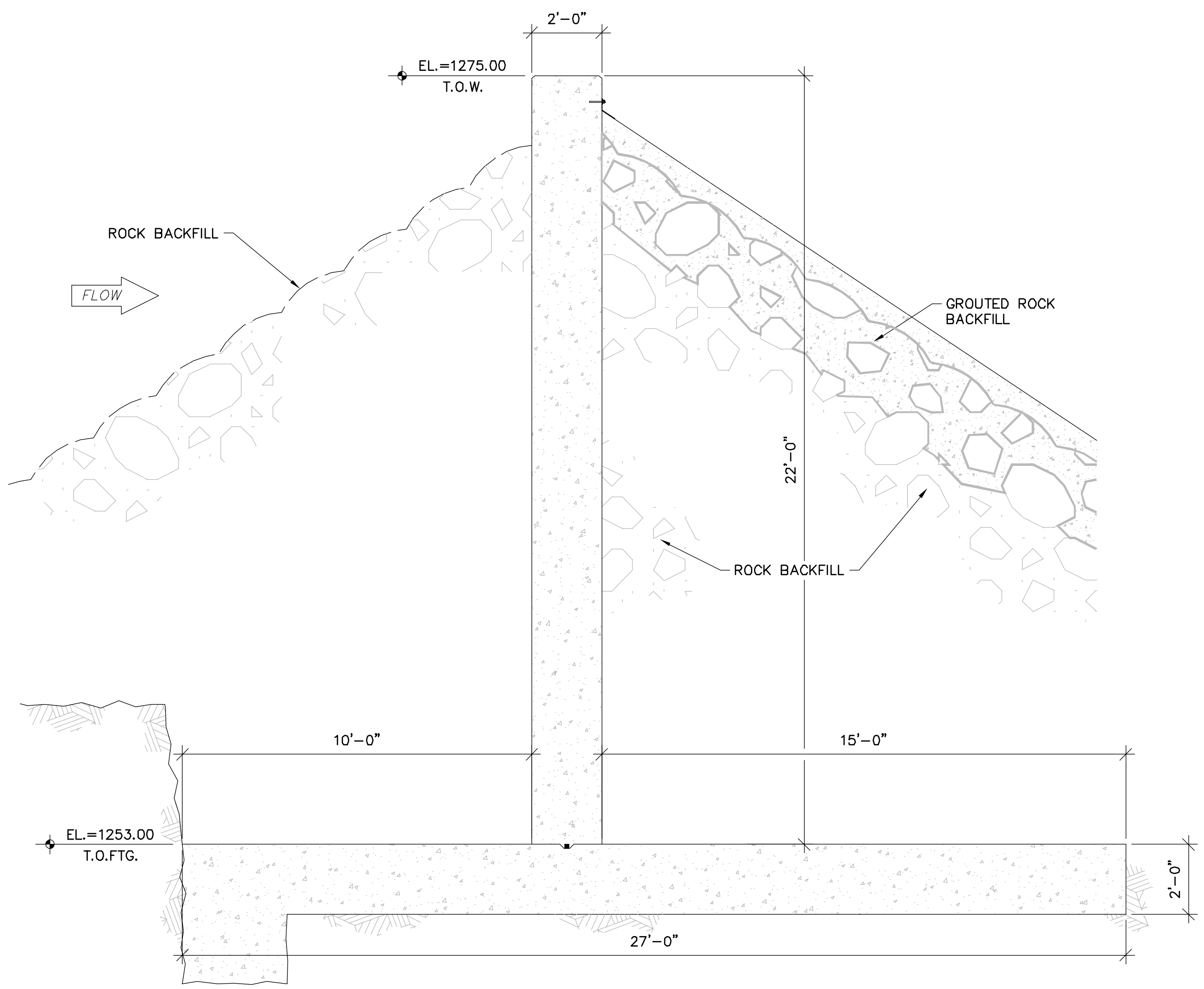
BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

PROJECT 1136.90090.01
DATE 12/17/2021

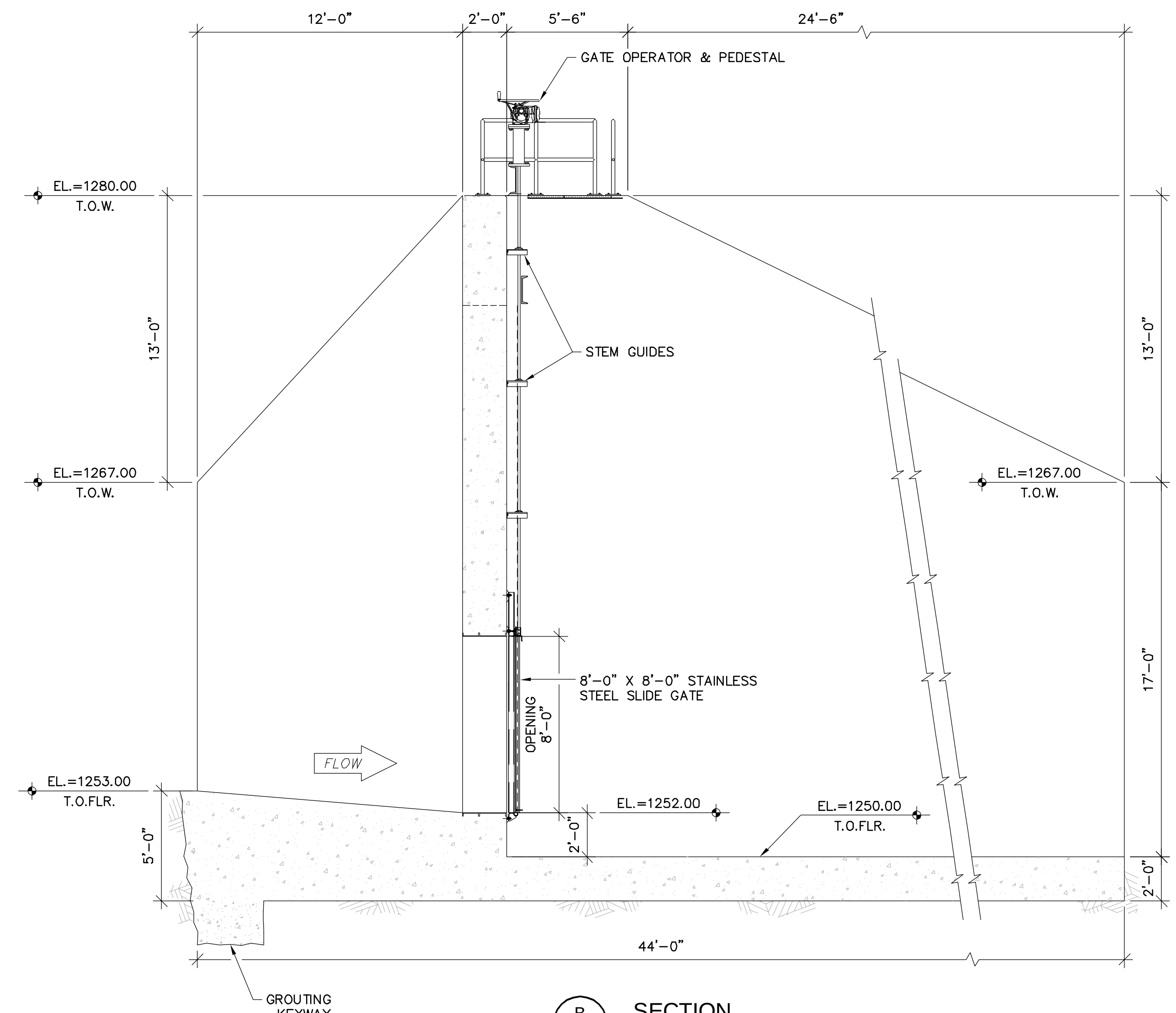
DIXON DIVERSION STRUCTURE
PLAN

DD-3
PAGE A-5



A SECTION
SPILLWAY WALL

1 0 1 2 3 4 5 6 7
scale feet



B SECTION
SLUICEWAY HEADWALL

2 0 2 4 6 8 10
scale feet

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HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

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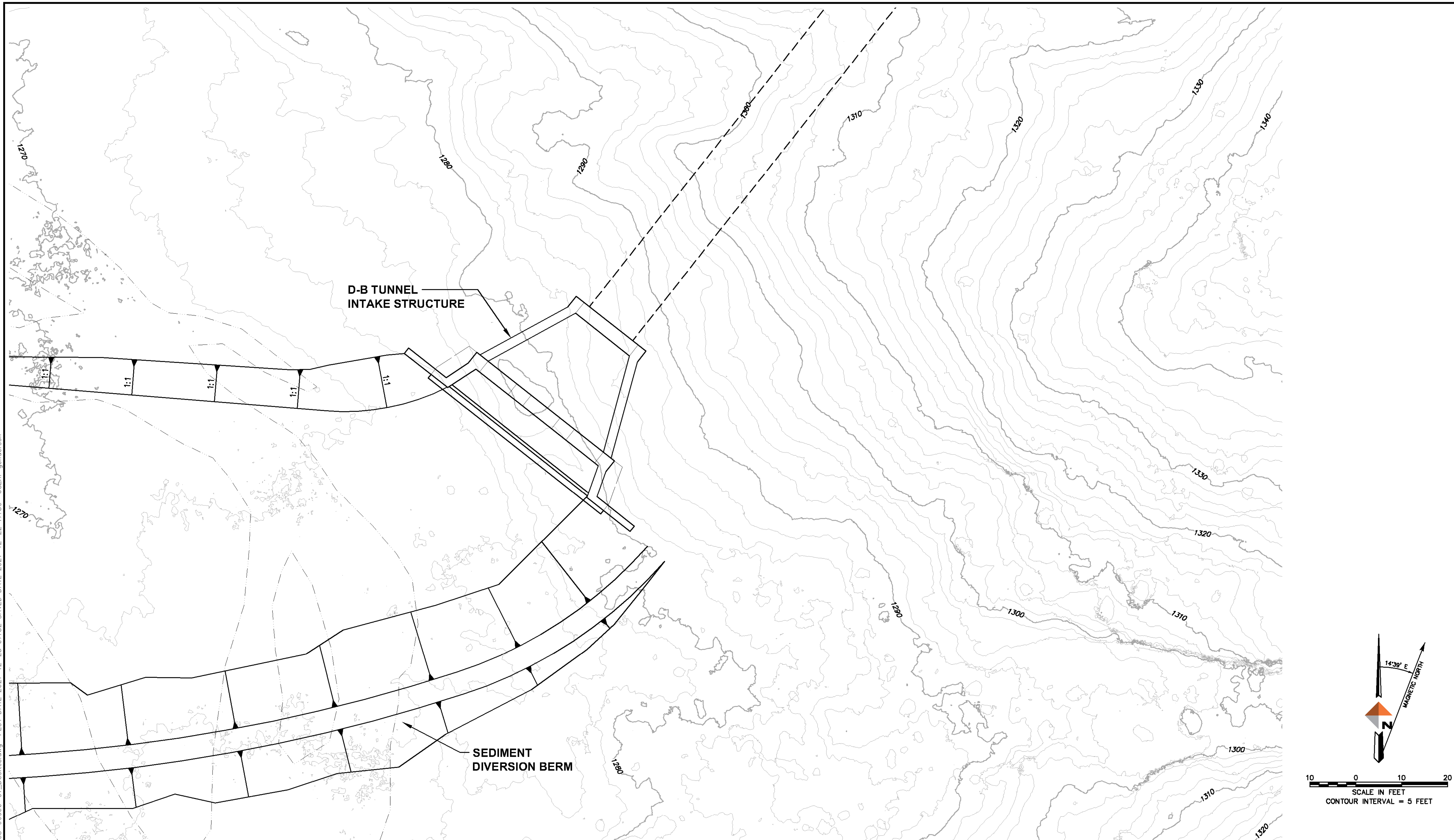
BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

PROJECT	1136.90090.01
DATE	12/17/2021

DIXON DIVERSION STRUCTURE
SECTIONS

DD-4
PAGE A-6



HORIZONTAL CONTROL

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VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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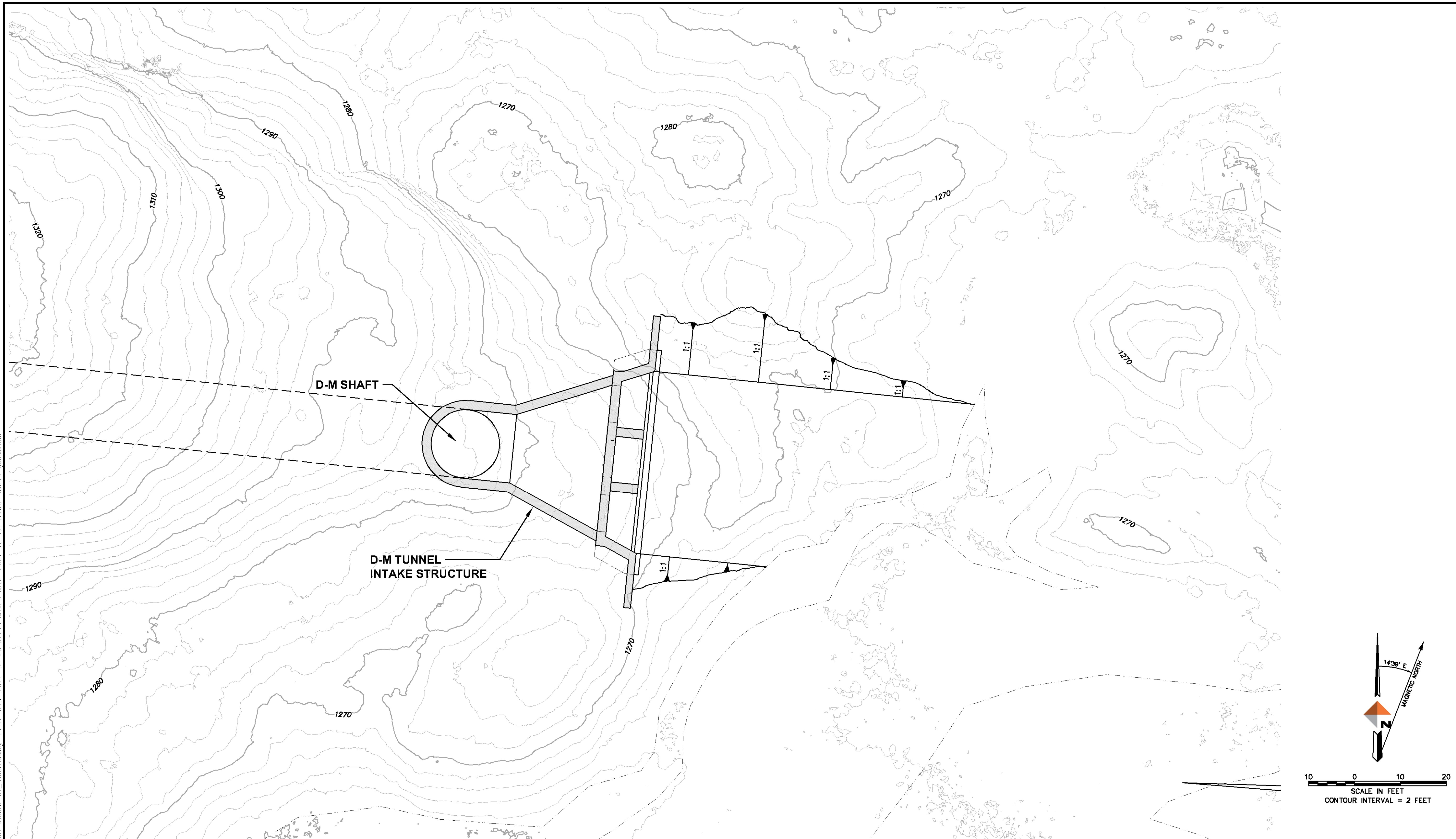
BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

PROJECT 1136.90090.01
DATE xx/xx/xx

D-B TUNNEL INTAKE
SITE PLAN

DD-5

PAGE A-7



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HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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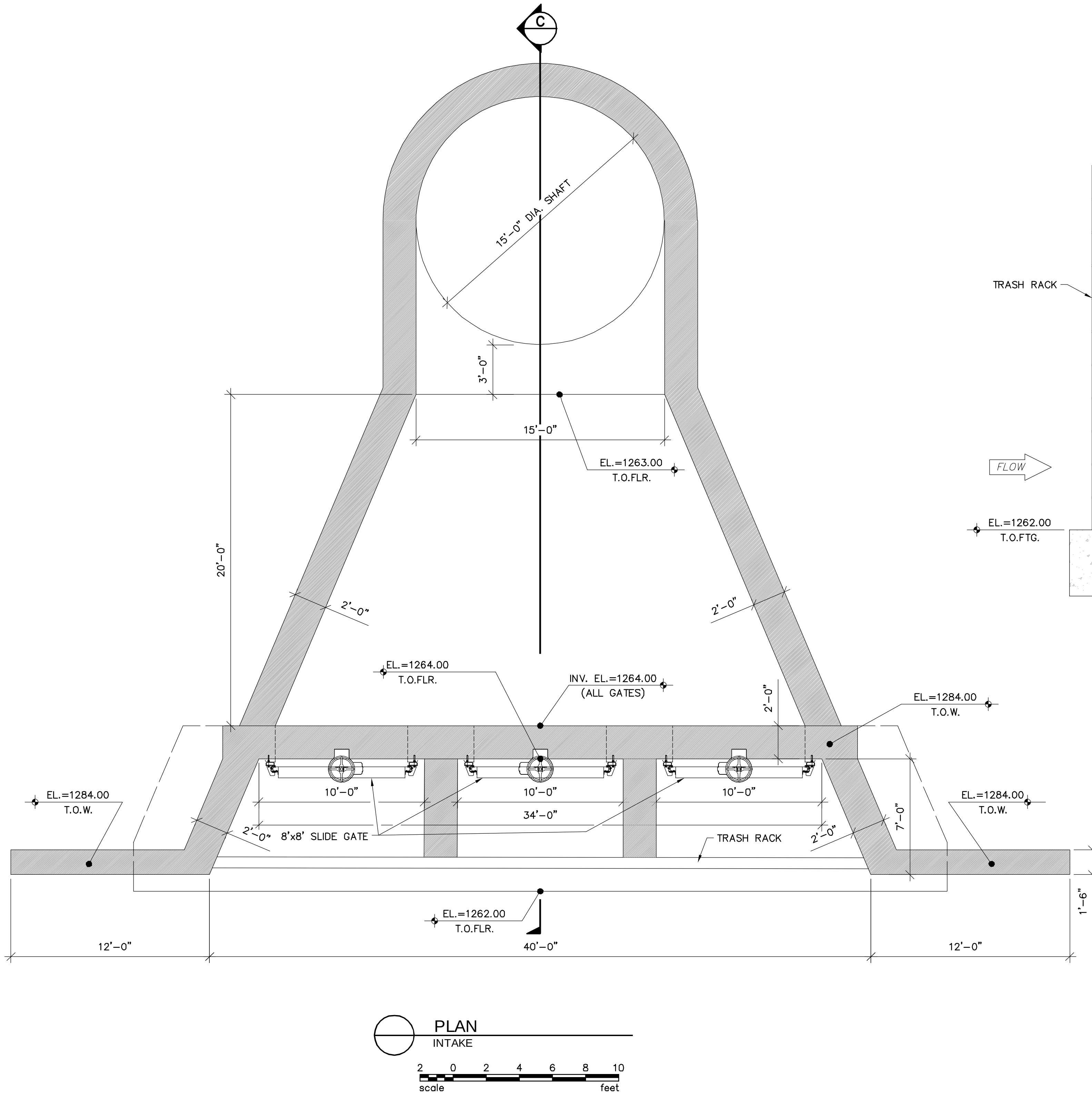
BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

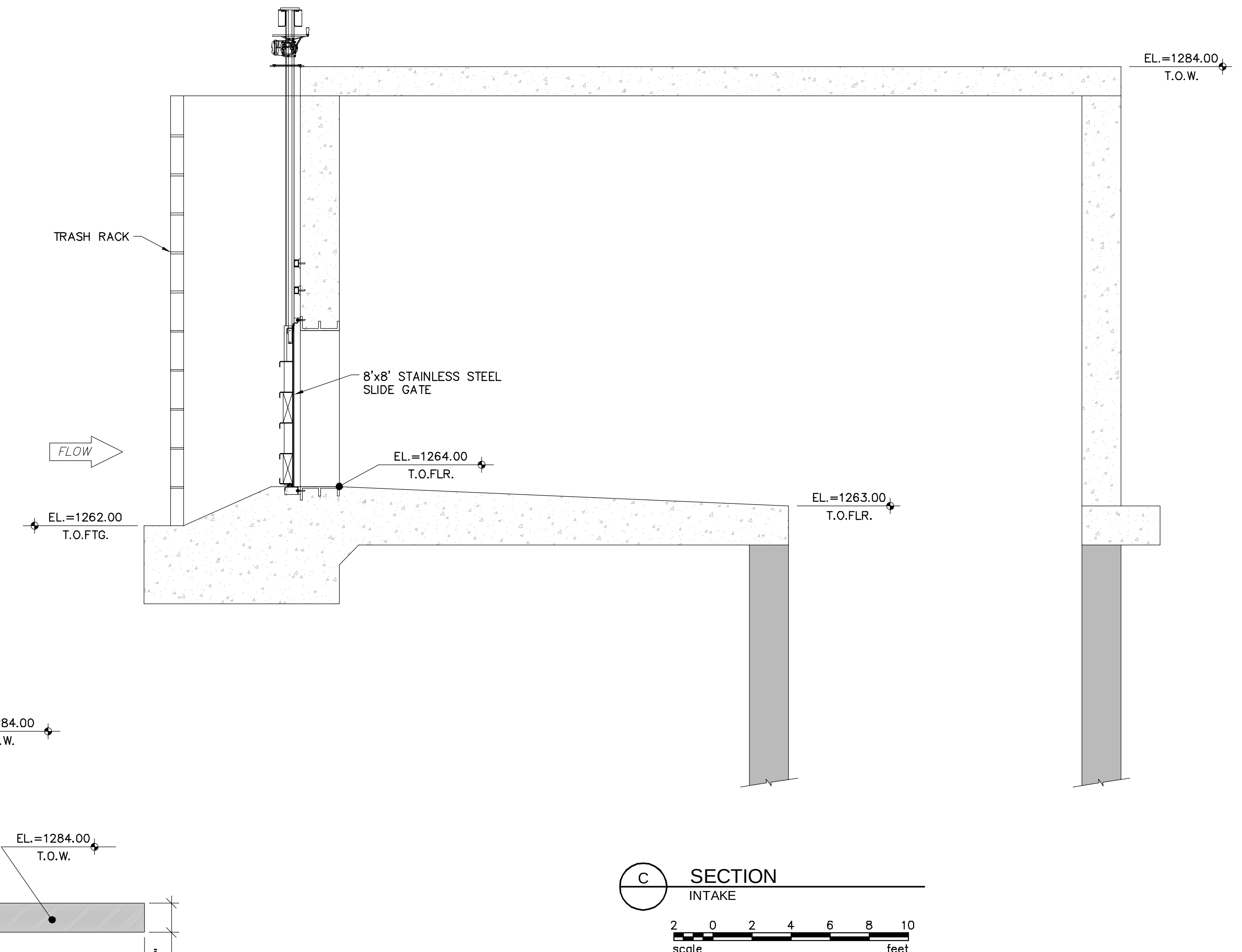
PROJECT 1136.90090.01
DATE 12/17/2021

D-M TUNNEL INTAKE
SITE PLAN

DD-6

PAGE A-8





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HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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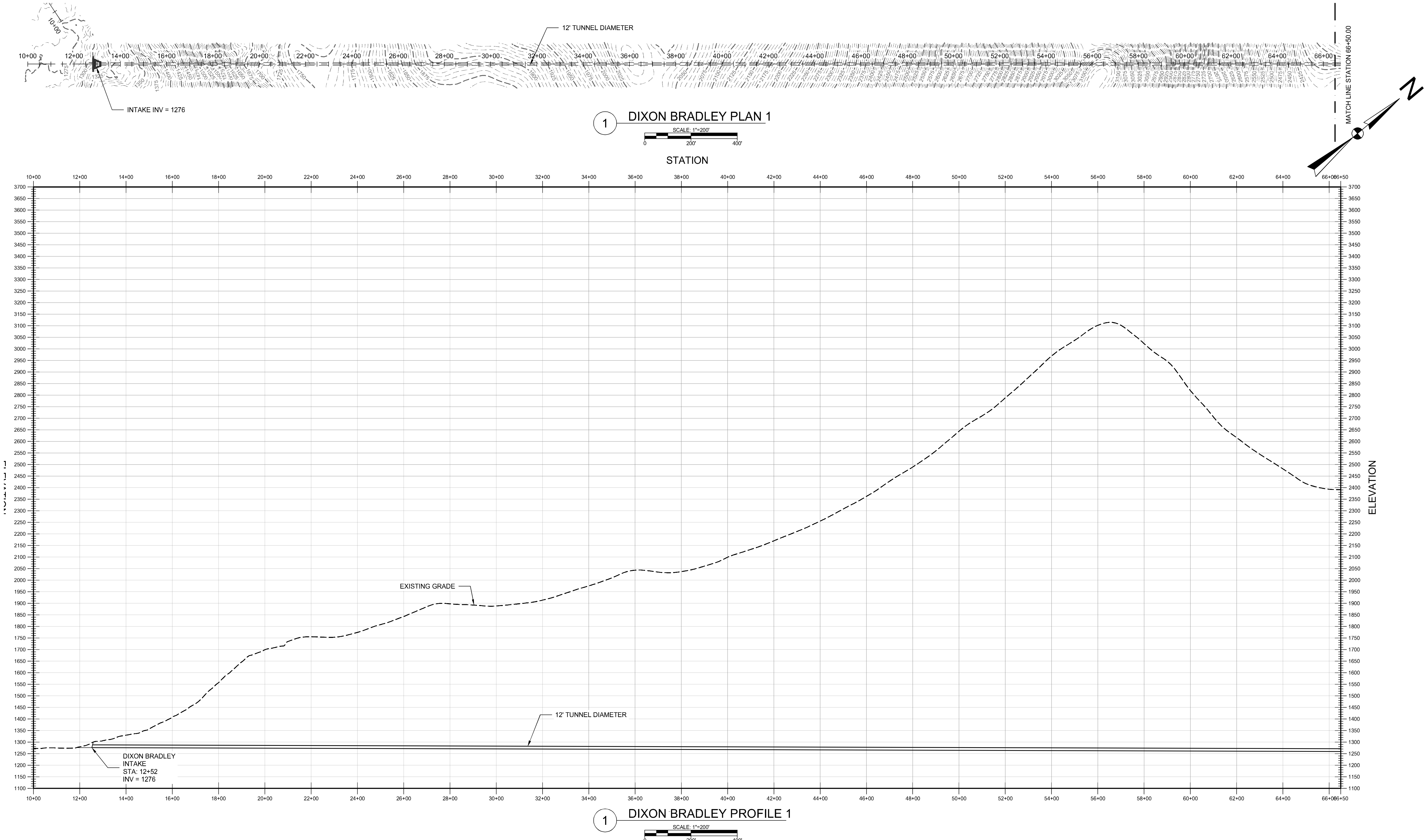
BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

PROJECT	1136.90090.01
DATE	12/17/2021

D-M INTAKE TUNNEL STRUCTURE
PLAN AND SECTION

DD-7
PAGE A-9



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HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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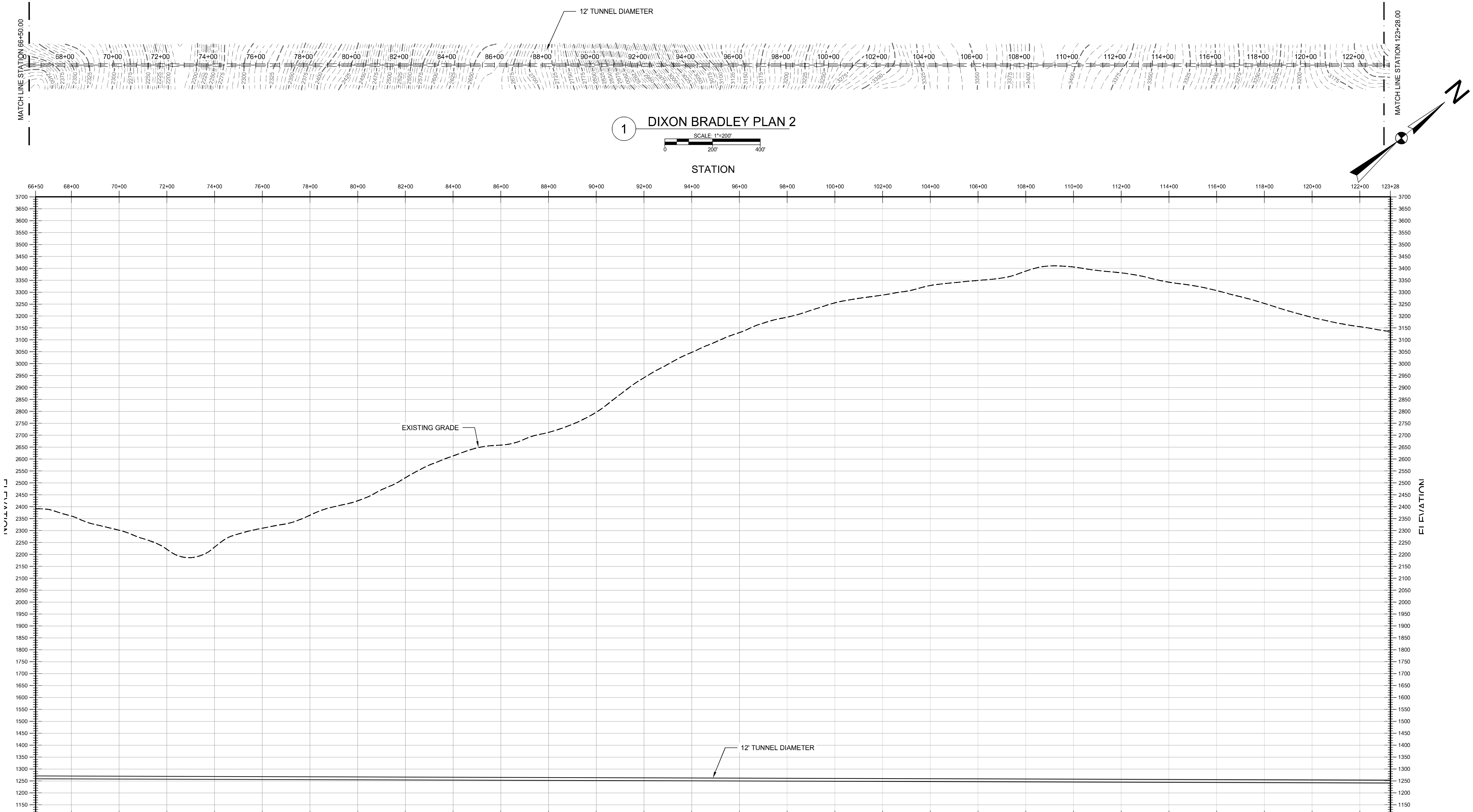
BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

DIXON BRADLEY TUNNEL
PLAN AND PROFILE - 1

PROJECT 1136.90090.01
DATE

PROJECT SHEET SET NUMBER: T-1
PROJECT PAGE NUMBER: PAGE A-10
A.E.A. DRAWING NUMBER:



1 DIXON BRADLEY PLAN 2
SCALE: 1"=200'

1 DIXON BRADLEY PROFILE 2
SCALE: 1"=200'

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HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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DOWL ALASKA

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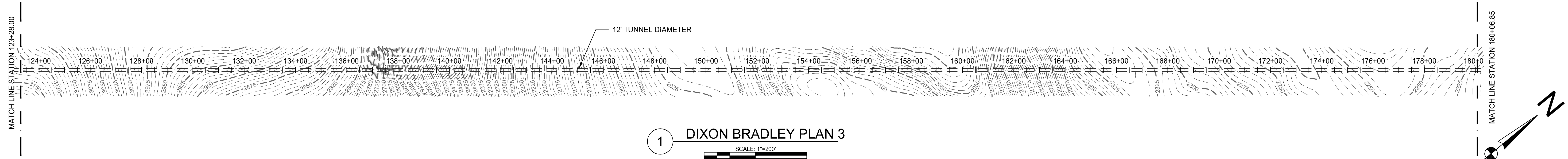
BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

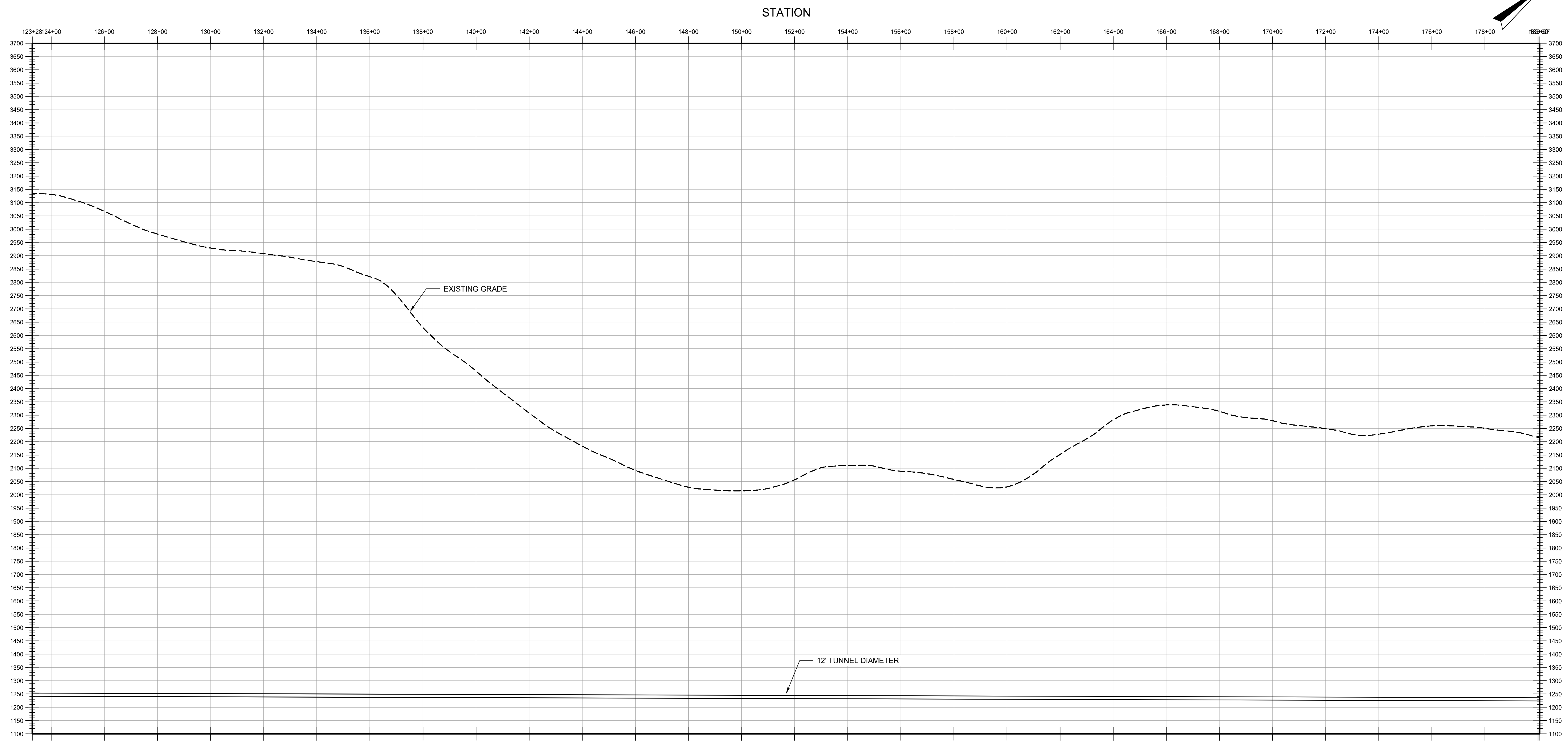
DIXON BRADLEY TUNNEL
PLAN AND PROFILE - 2

PROJECT	1136.90090.01
DATE	
PROJECT SHEET SET NUMBER:	T-2
PROJECT PAGE NUMBER:	PAGE A-11
A.E.A. DRAWING NUMBER:	



1 DIXON BRADLEY PLAN 3

SCALE: 1"=200'



1 DIXON BRADLEY PROFILE 3

SCALE: 1"=200'

HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

PROJECT 1136.90090.01
DATE

DIXON BRADLEY TUNNEL
PLAN AND PROFILE - 3

PROJECT SHEET SET NUMBER: T-3
PROJECT PAGE NUMBER: PAGE A-12
A.E.A. DRAWING NUMBER:

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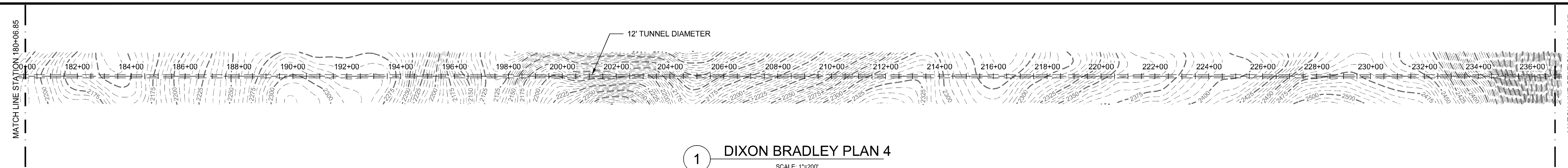
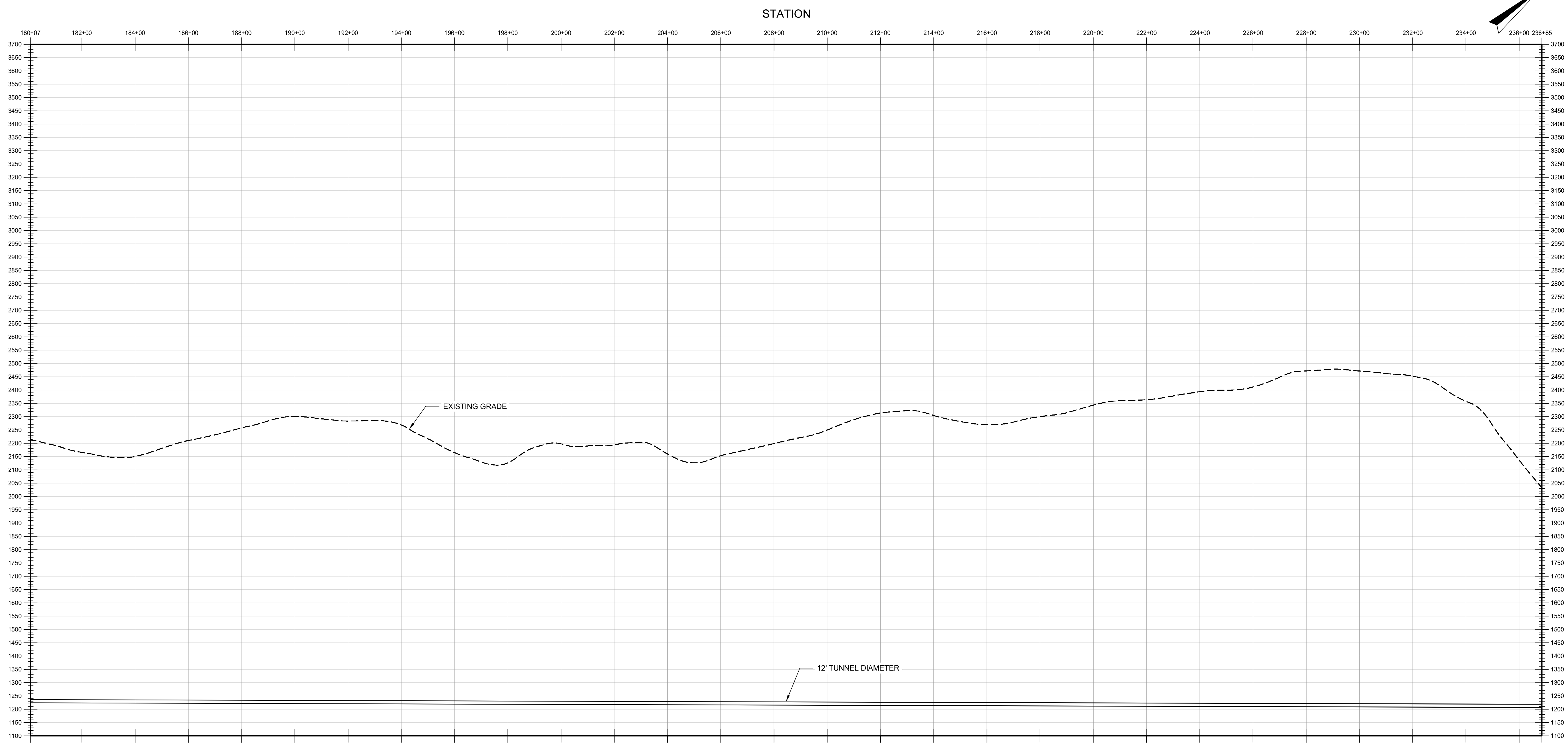


1 DIXON BRADLEY PLAN 4

SCALE: 1"=200'



1 DIXON BRADLEY PROFILE 4

SCALE: 1"=200'

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HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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DOWL ALASKA

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BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

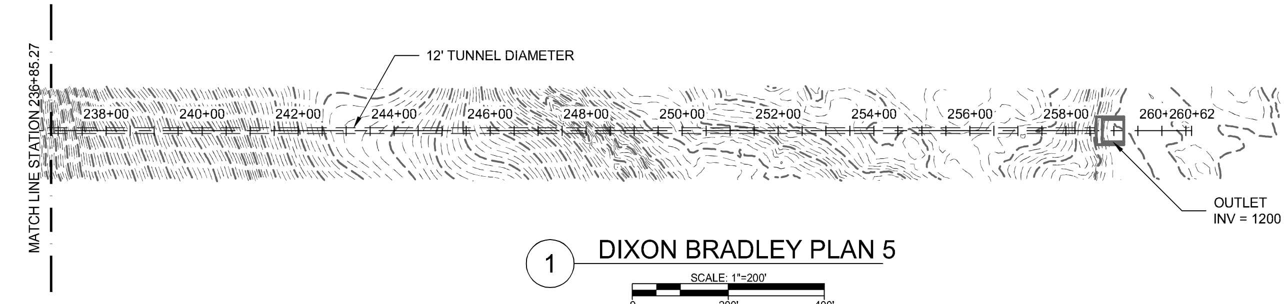
DIXON BRADLEY TUNNEL
PLAN AND PROFILE - 4

PROJECT 1136.90090.01
DATE

PROJECT SHEET SET NUMBER: T-4

PROJECT PAGE NUMBER: PAGE A-13

A.E.A. DRAWING NUMBER:



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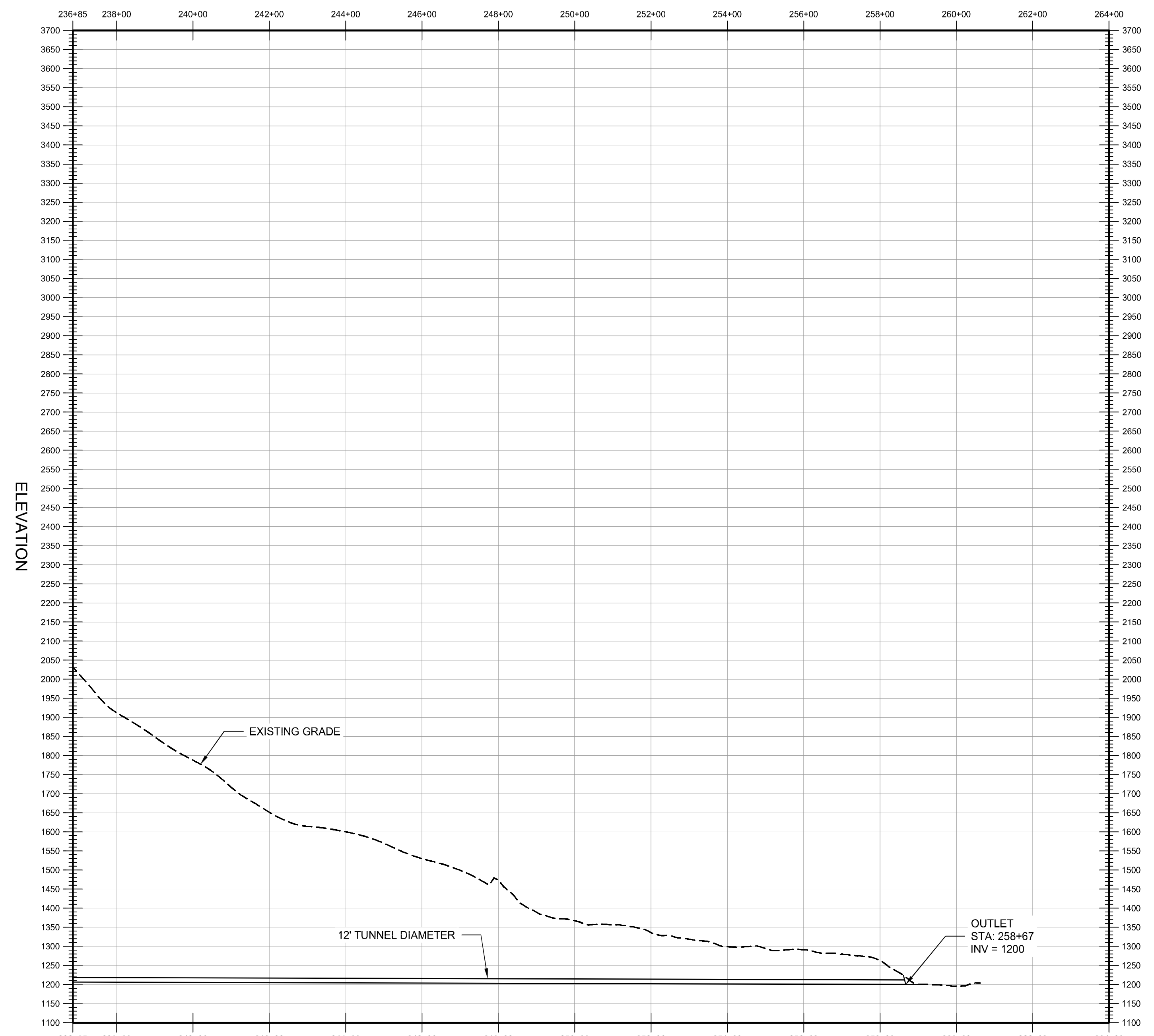
SCALE: 1"=200'



1 DIXON BRADLEY PROFILE 5

SCALE: 1"=200'

HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

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BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

DIXON BRADLEY TUNNEL
PLAN AND PROFILE - 5

PROJECT 1136.90090.01

DATE

PROJECT SHEET SET NUMBER: T-5

PROJECT PAGE NUMBER: PAGE A-14

A.E.A. DRAWING NUMBER:

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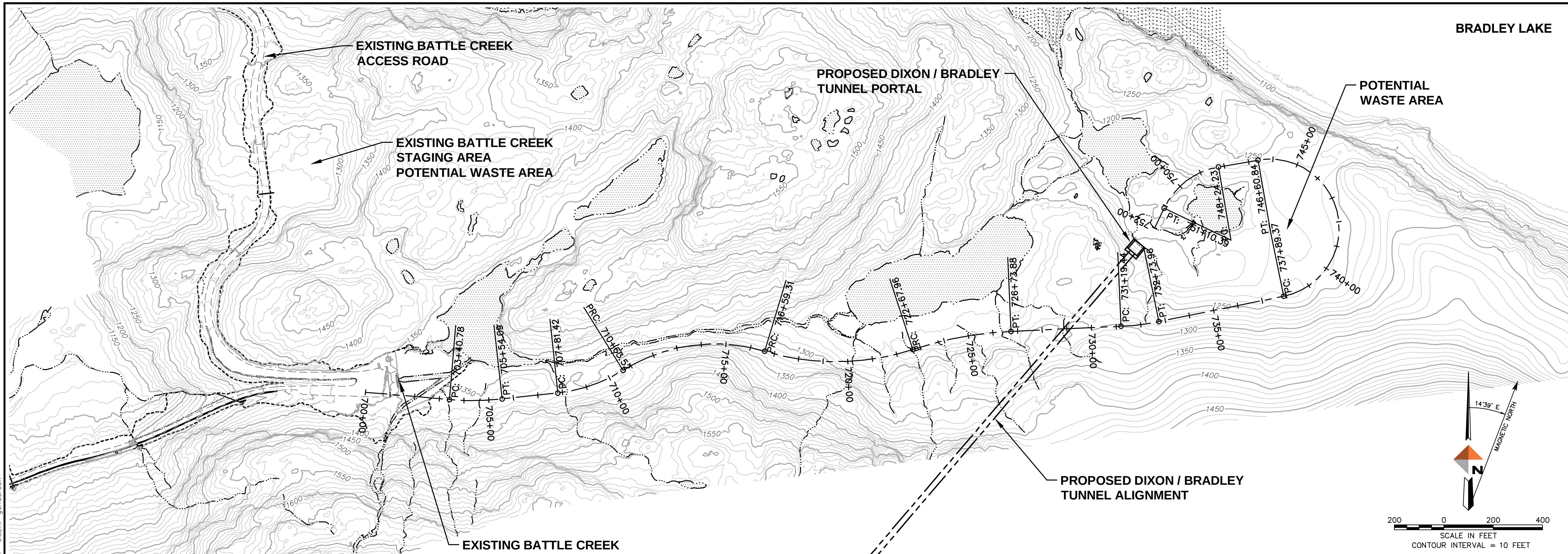

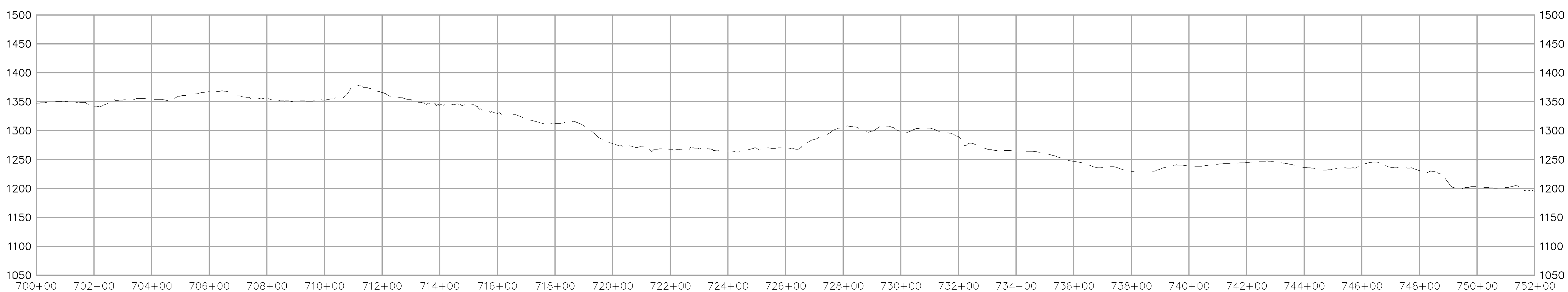

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VERTICAL CONTROL

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BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

PROJECT 1136.90090.01
DATE 01/10/22

DIXON / BRADLEY TUNNEL ACCESS ROAD PLAN AND PROFILE
STA. 700+00 TO STA. 752+00

T-6

PAGE A-15

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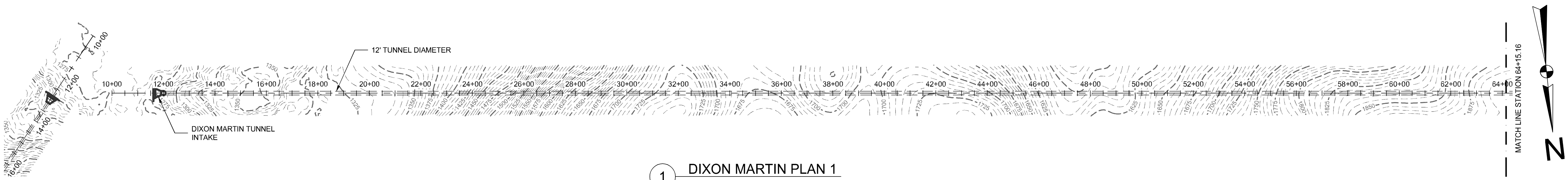
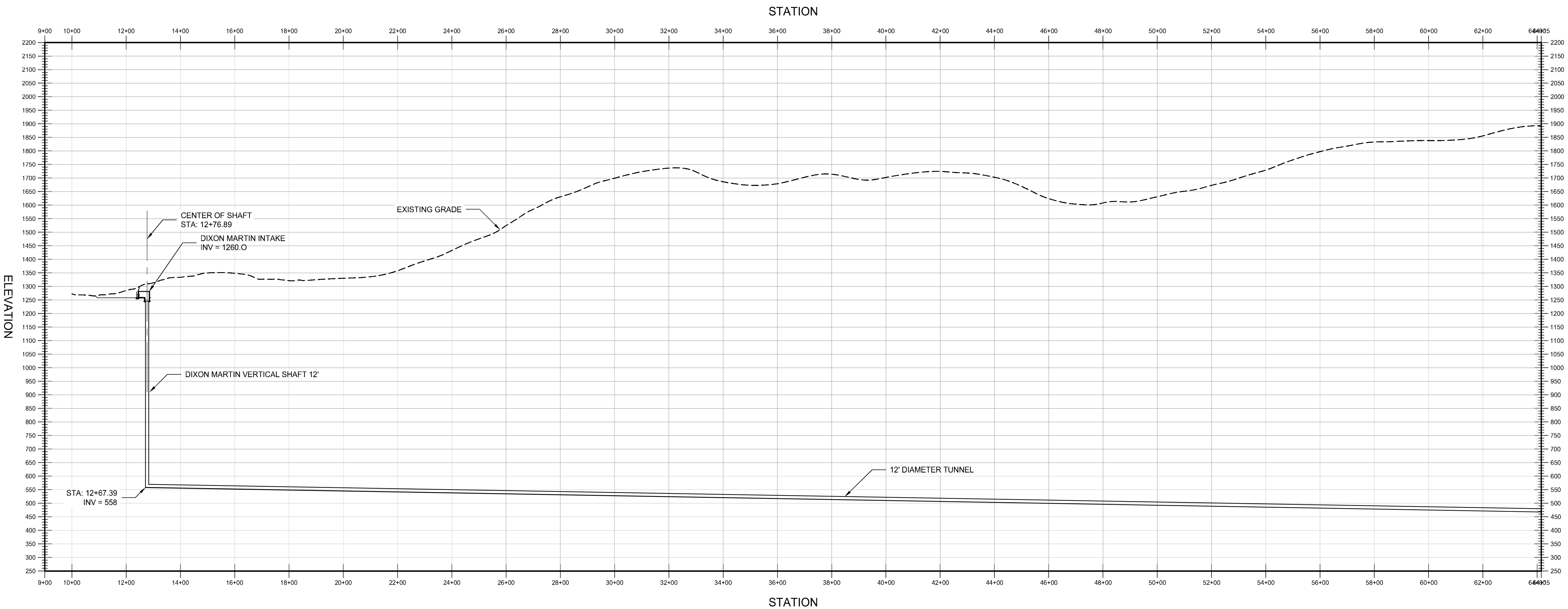


1 DIXON MARTIN PLAN 1

SCALE: 1"=200'



1 DIXON MARTIN PROFILE 1

SCALE: 1"=200'

HORIZONTAL CONTROL

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VERTICAL CONTROL

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Anchorage, Alaska

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BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

DIXON MARTIN TUNNEL
PLAN AND PROFILE - 1

PROJECT 1136.90090.01
DATE

PROJECT SHEET SET NUMBER: T-7
PROJECT PAGE NUMBER: PAGE A-16
A.E.A. DRAWING NUMBER:

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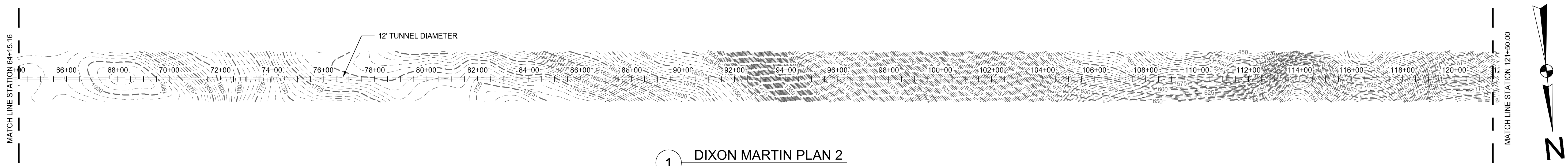
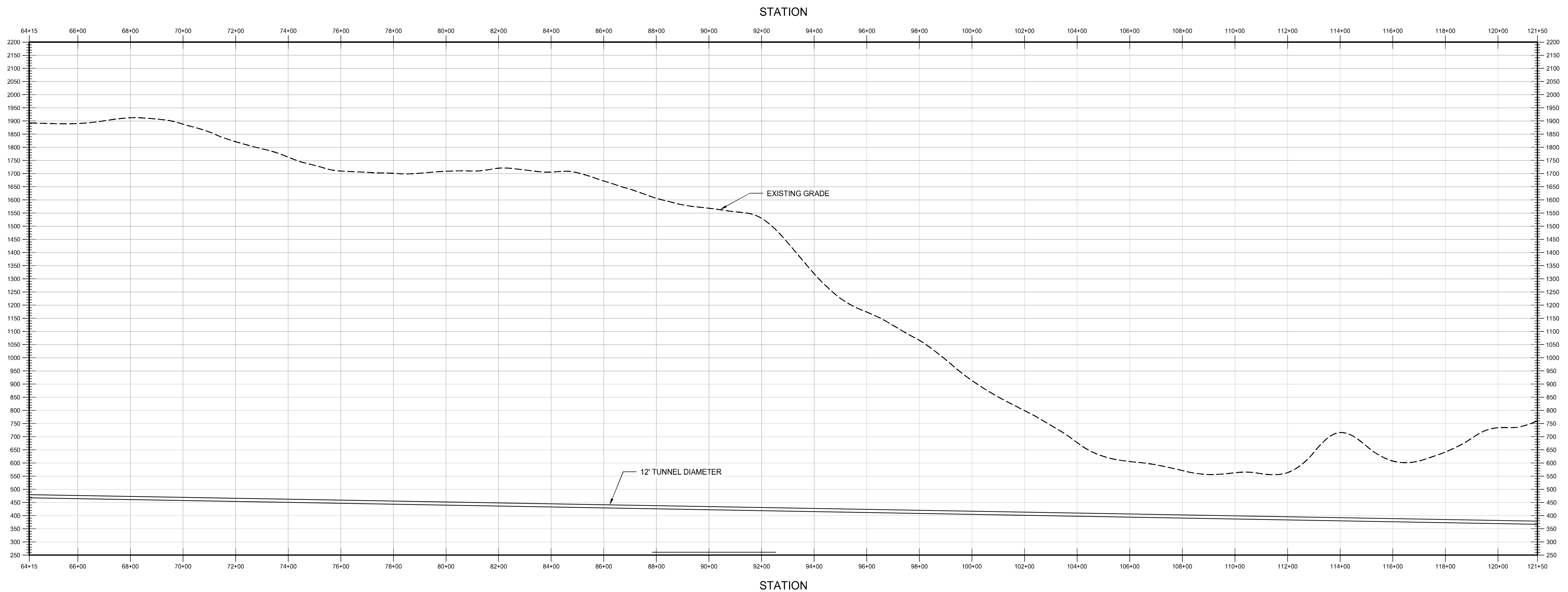


1 DIXON MARTIN PLAN 2

SCALE: 1"=200'



1 DIXON MARTIN PROFILE 2

HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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PREPARED BY: WWW.DOWL.COM DOWL ALASKA AECL848 Anchorage, Alaska

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BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

DIXON MARTIN TUNNEL
PLAN AND PROFILE - 2

PROJECT	1136.90090.01
DATE	
PROJECT SHEET SET NUMBER:	T-8
PROJECT PAGE NUMBER:	PAGE A-17
A.E.A. DRAWING NUMBER:	

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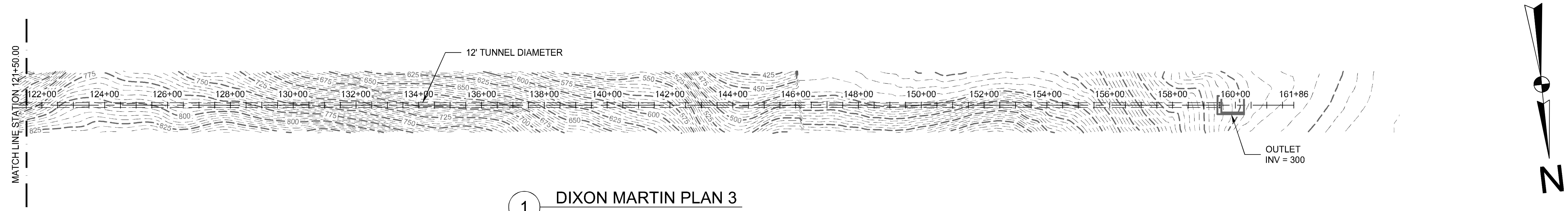
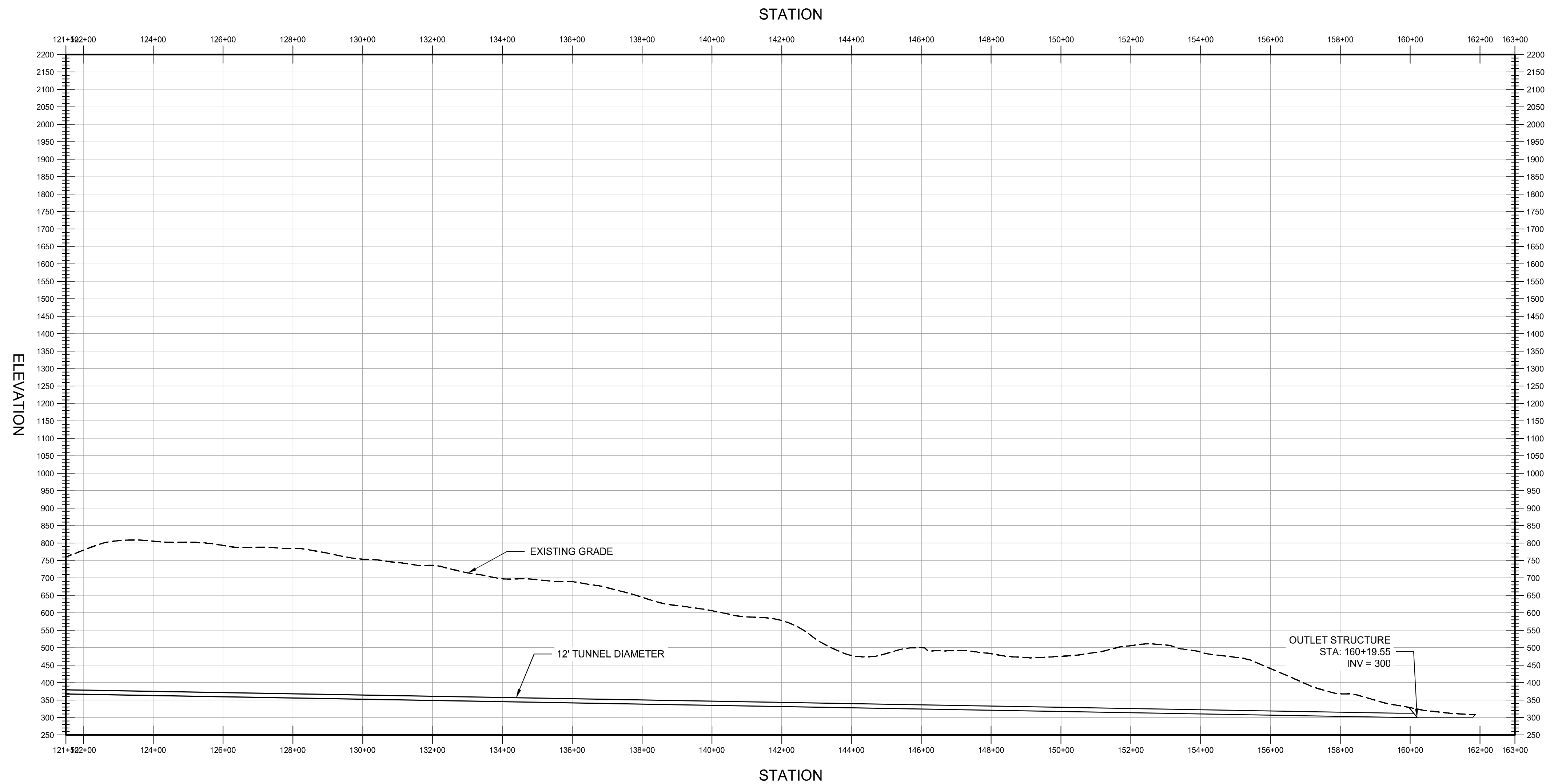


1 DIXON MARTIN PLAN 3

SCALE: 1"=200'

0 200' 400'



1 DIXON MARTIN PROFILE 3

SCALE: 1"=200'

0 200' 400'

HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

PREPARED BY: Schnabel ENGINEERING

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NOT FOR CONSTRUCTION

PREPARED BY: AECL848
WWW.DOWL.COM Anchorage, Alaska
DOWL ALASKA

PREPARED FOR:
ALASKA ENERGY AUTHORITY
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Anchorage, Alaska 99503
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BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

DIXON MARTIN TUNNEL
PLAN AND PROFILE - 3

PROJECT 1136.90090.01
DATE

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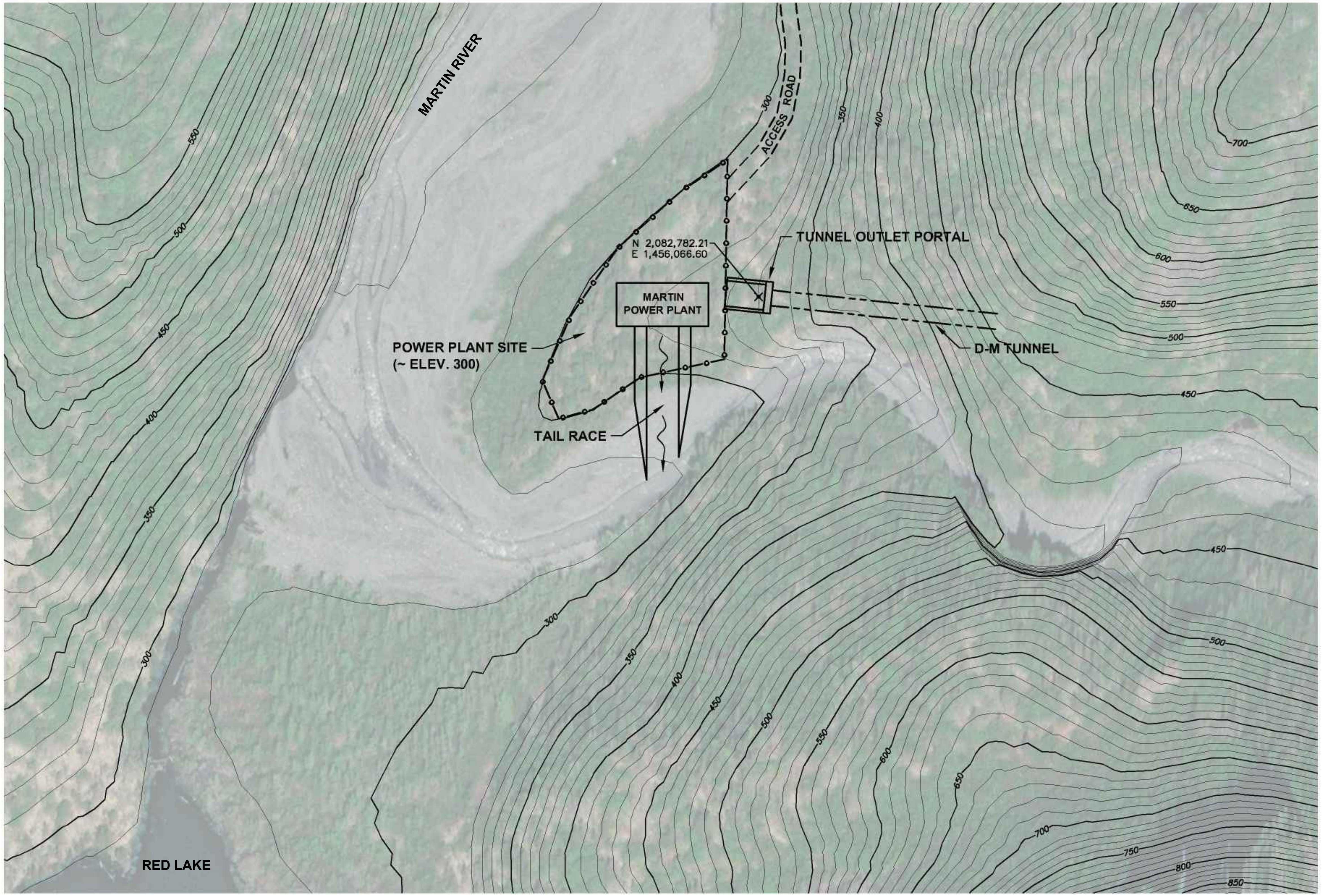
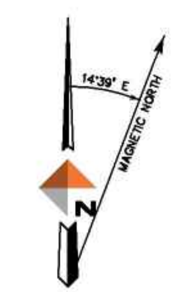
PROJECT PAGE NUMBER: PAGE A-18
A.E.A. DRAWING NUMBER:





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SCALE IN FEET
CONTOUR INTERVAL = 10 FEET

C:\dowl_pw\d0394697\SC-CS-90090-01_MRPP.dwg PLOT DATE 2021-11-16 15:15 SAVED DATE 2021-11-16 14:30 USER: genderson

HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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DOWL ALASKA
AECL848
Anchorage, Alaska

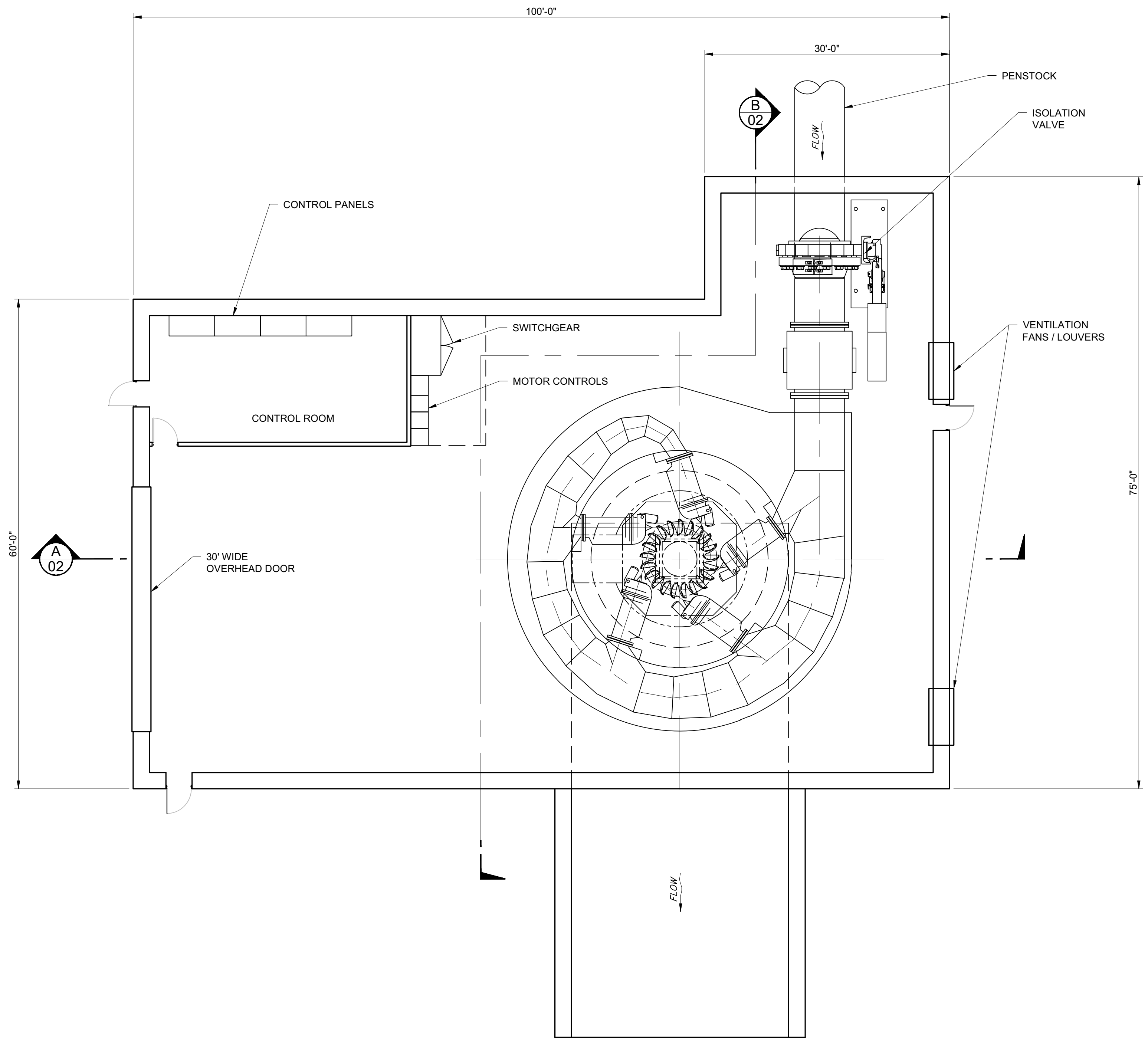
PREPARED FOR:
ALASKA ENERGY AUTHORITY
813 W. Northern Lights Blvd.
Anchorage, Alaska 99503
907-771-3000

BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

PROJECT 1136.90090.01
DATE xx/xx/xx

MARTIN RIVER POWER PLANT SITE PLAN

T-9



PLAN
1/8"= 1'-0"

8 0 8 16
SCALE IN FEET

24x36 = FULL SCALE

PRINTED Jan. 28, 2022 - 12:58 PM C:\Users\Chris Shea\AppData\Local\Temp\AcPublish_23148\2451008-01, 02.dwg

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DOWL ALASKA, LLC
ANCHORAGE, AK

BRADLEY LAKE EXPANSION PROJECT

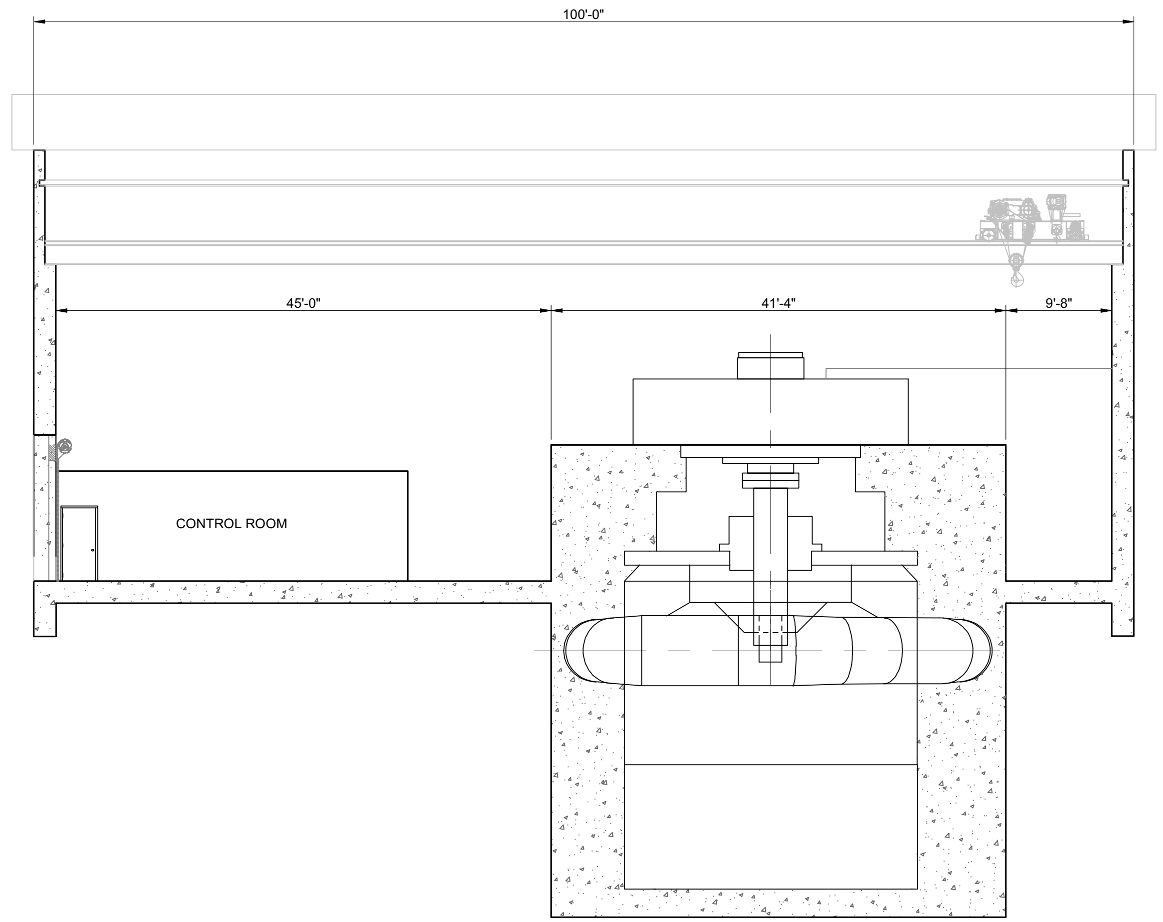
POWERHOUSE
PLAN VIEW

Kleinschmidt
888-224-5942
KleinschmidtGroup.com

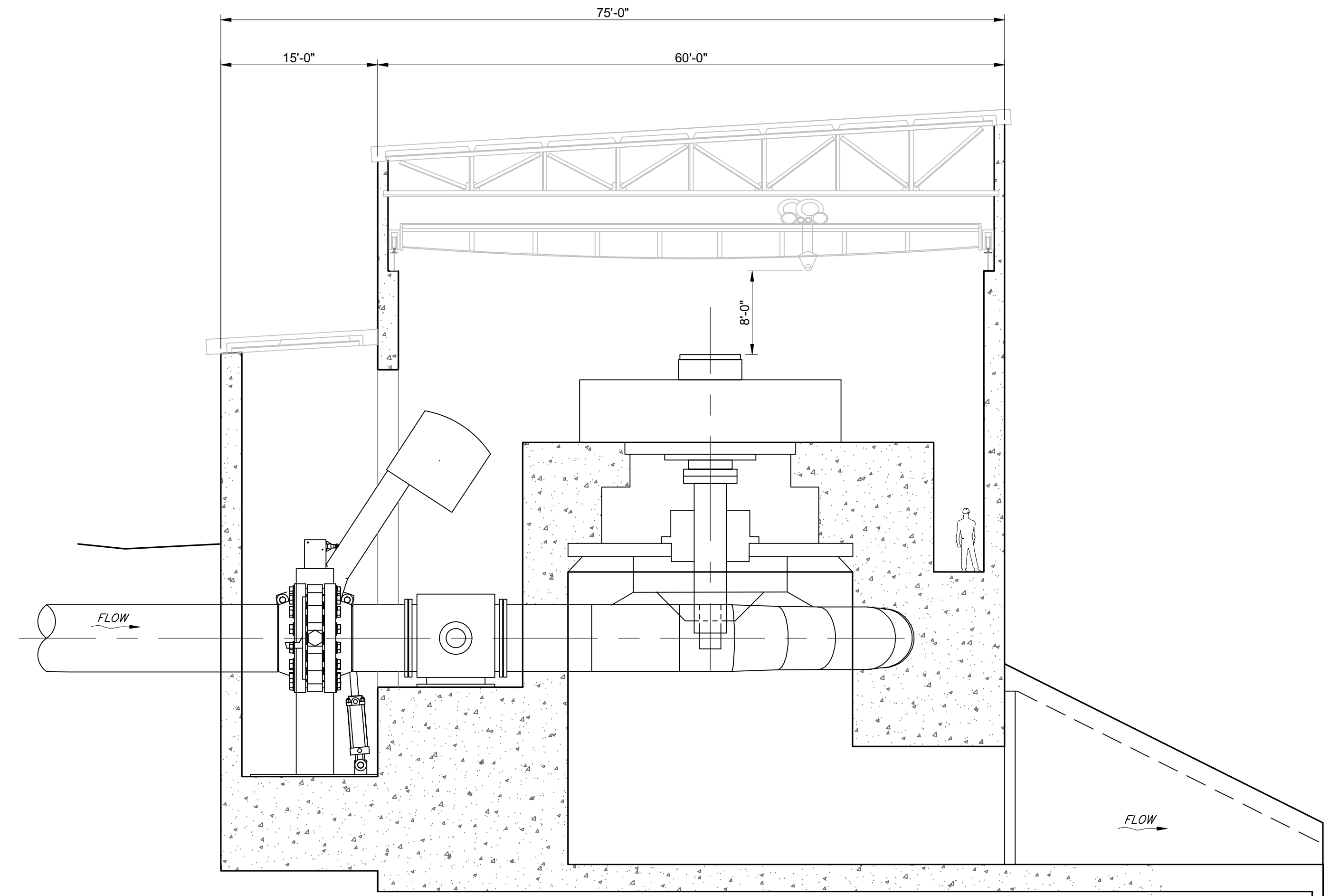
No.	Revision	Date	Drawn	Checked
-	-	-	-	-

Designed	Drawn	Checked	Project No.	Date Revised	Drawing No.
MSP	CRS	MSP	2451008	01-27-22	01

24x36 = FULL SCALE



SECTION A / 01
1/8"= 1'-0"



SECTION B / 01
1/8"= 1'-0"

8 0 8 16
SCALE IN FEET

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DOWL ALASKA, LLC
ANCHORAGE, AK

BRADLEY LAKE EXPANSION PROJECT

POWERHOUSE
SECTION VIEWS

Kleinschmidt
888-224-5942
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No.	Revision	Date	Drawn	Checked
-	-	-	-	-

Designed	Drawn	Checked	Project No.	Date Revised	Drawing No.
MSP	CRS	MSP	2451008	01-27-22	02

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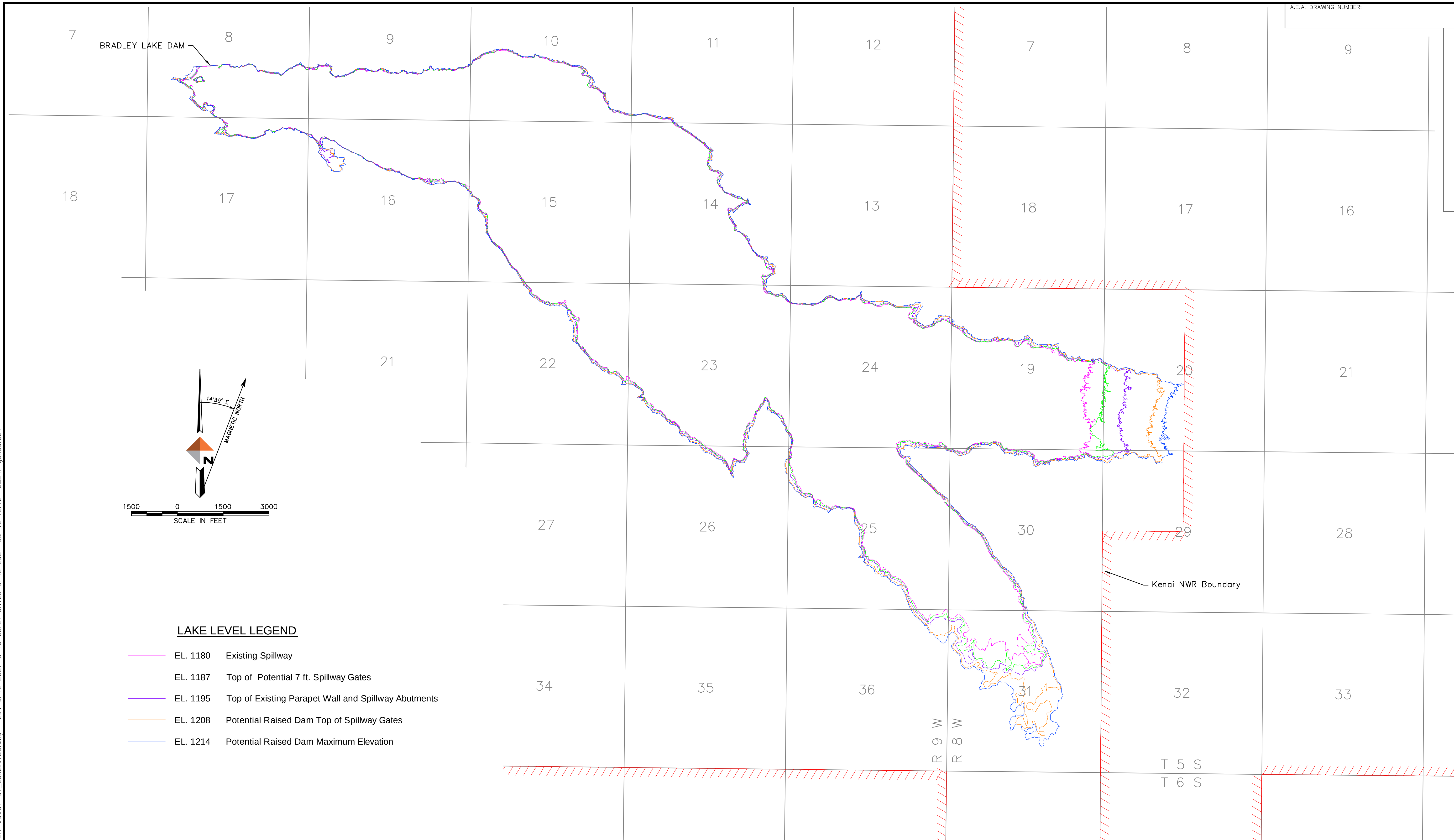

REVISIONS			
REV	DATE	DESCRIPTION	BY

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Anchorage, Alaska

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BRADLEY LAKE HYDROELECTRIC PROJECT
-

BRADLEY LAKE
KEY LAKE LEVELS

PROJECT 1136.90087.01
DATE

BD-1
PAGE A-22
A.E.A. DRAWING NUMBER:

C:\dowl_pw\d0392863\SC-EH-90087-01_LakeLevels.dwg PLOT DATE 2021-8-13 08:21 SAVED DATE 2021-08-12 12:12 USER: genderson

FERC P - 8221 - AK

REVISIONS			
REV	DATE	DESCRIPTION	BY

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BRADLEY LAKE HYDROELECTRIC PROJECT
-

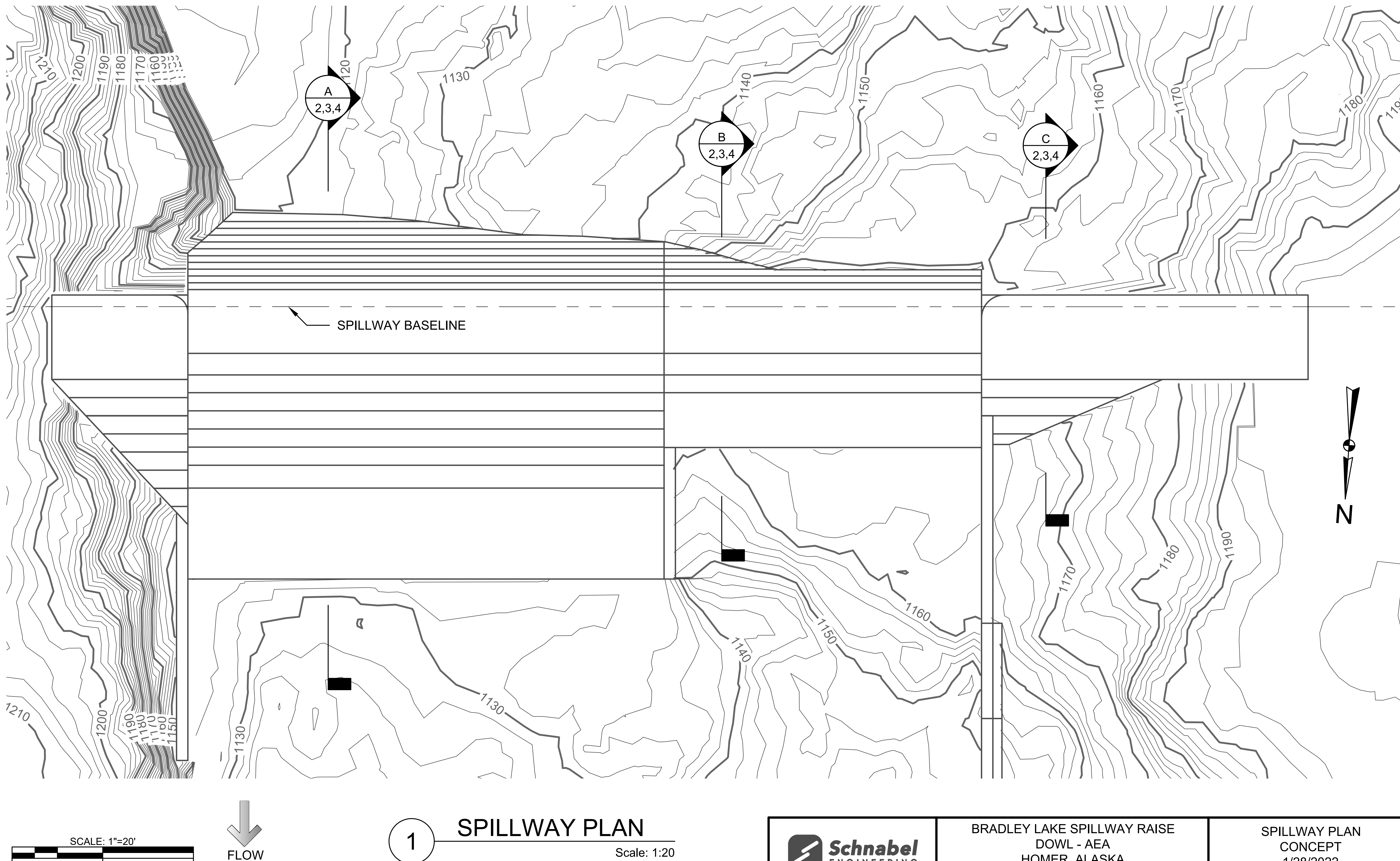
PROJECT 1136.90075.01
DATE

GENERAL ARRANGEMENT
DAM, SPILLWAY, AND FLOW STRUCTURES

BD-2
PAGE A-23
A.E.A. DRAWING NUMBER:

Q:\36\90075-01\65CAD\MC-SC-GR-90075-01.dwg PLOT DATE 2021-3-10 21:44 SAVED DATE 2021-03-10 21:43 USER: genderson

FERC P - 8221 - AK



1 SPILLWAY PLAN

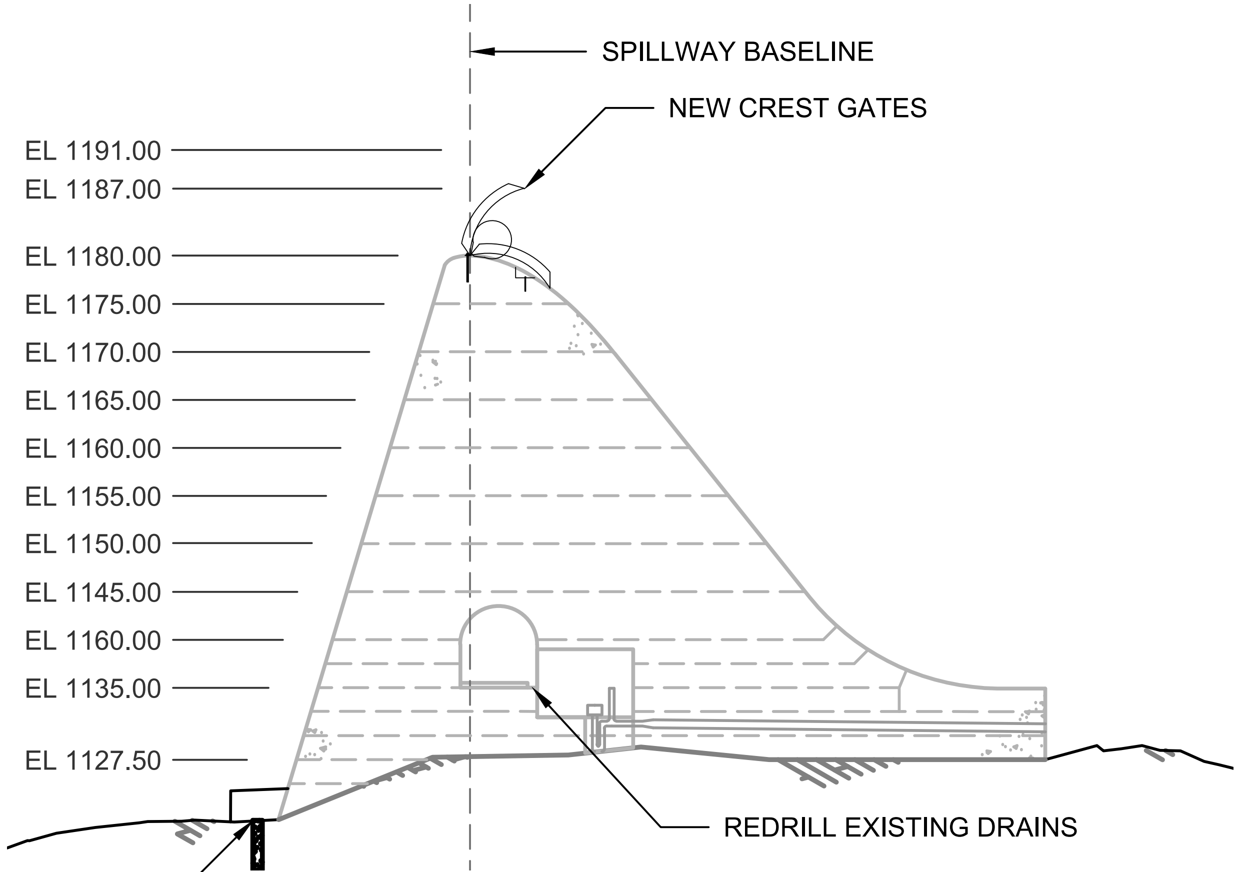
Scale: 1:20

Schnabel ENGINEERING

BRADLEY LAKE SPILLWAY RAISE
DOWL - AEA
HOMER, ALASKA
PROJECT NO. 21C310023.00

SPILLWAY PLAN
CONCEPT
1/28/2022

SHEET 1



A
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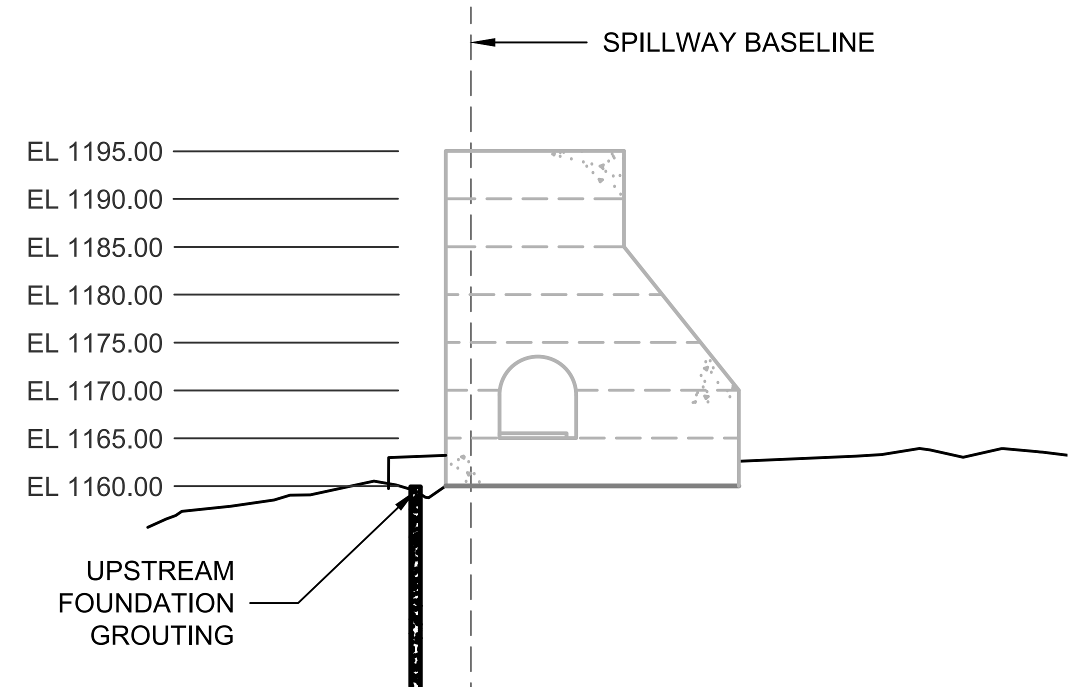
OVERFLOW SECTION
Scale: 1:20



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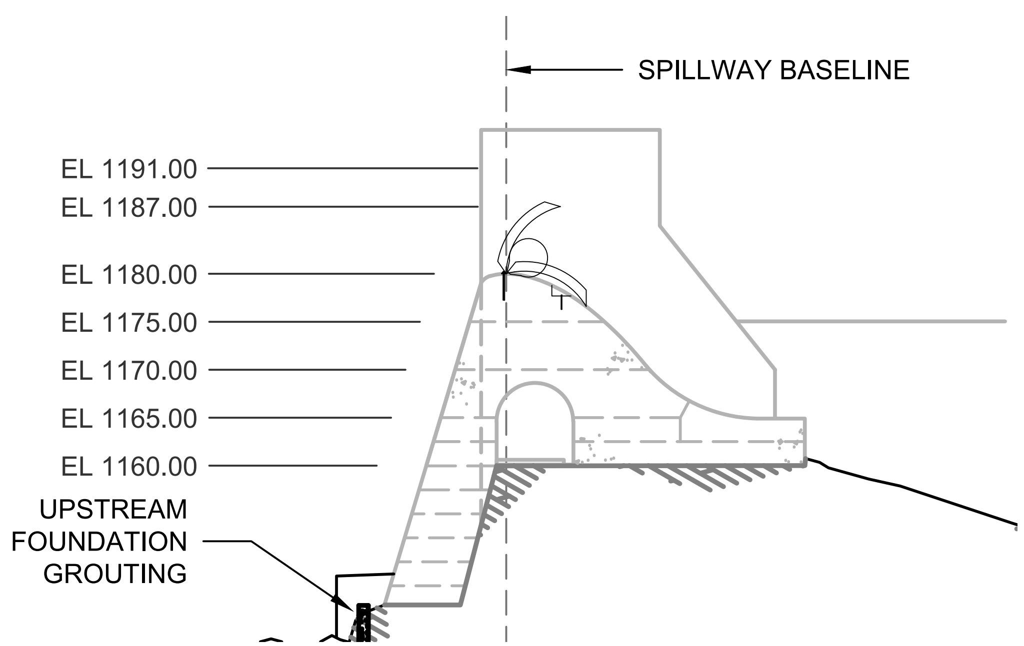
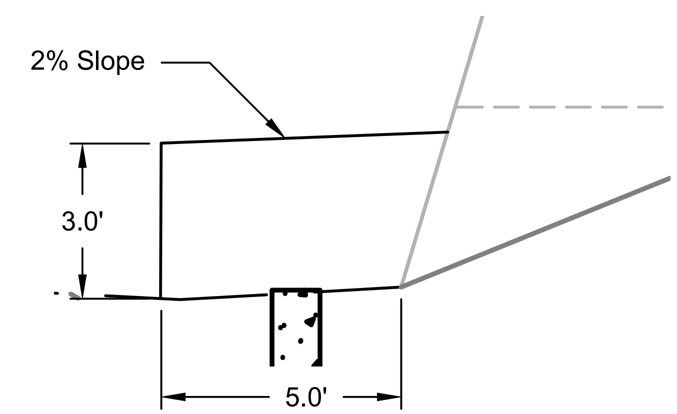
NON-OVERFLOW SECTION
Scale: 1:20



FLOW

SCALE: 1"=20'
0 20' 40'



D
UPSTREAM GROUT CAP
Scale: 1:4

B
1
UPPER OVERFLOW SECTION WITH NON-OVERFLOW
Scale: 1:20

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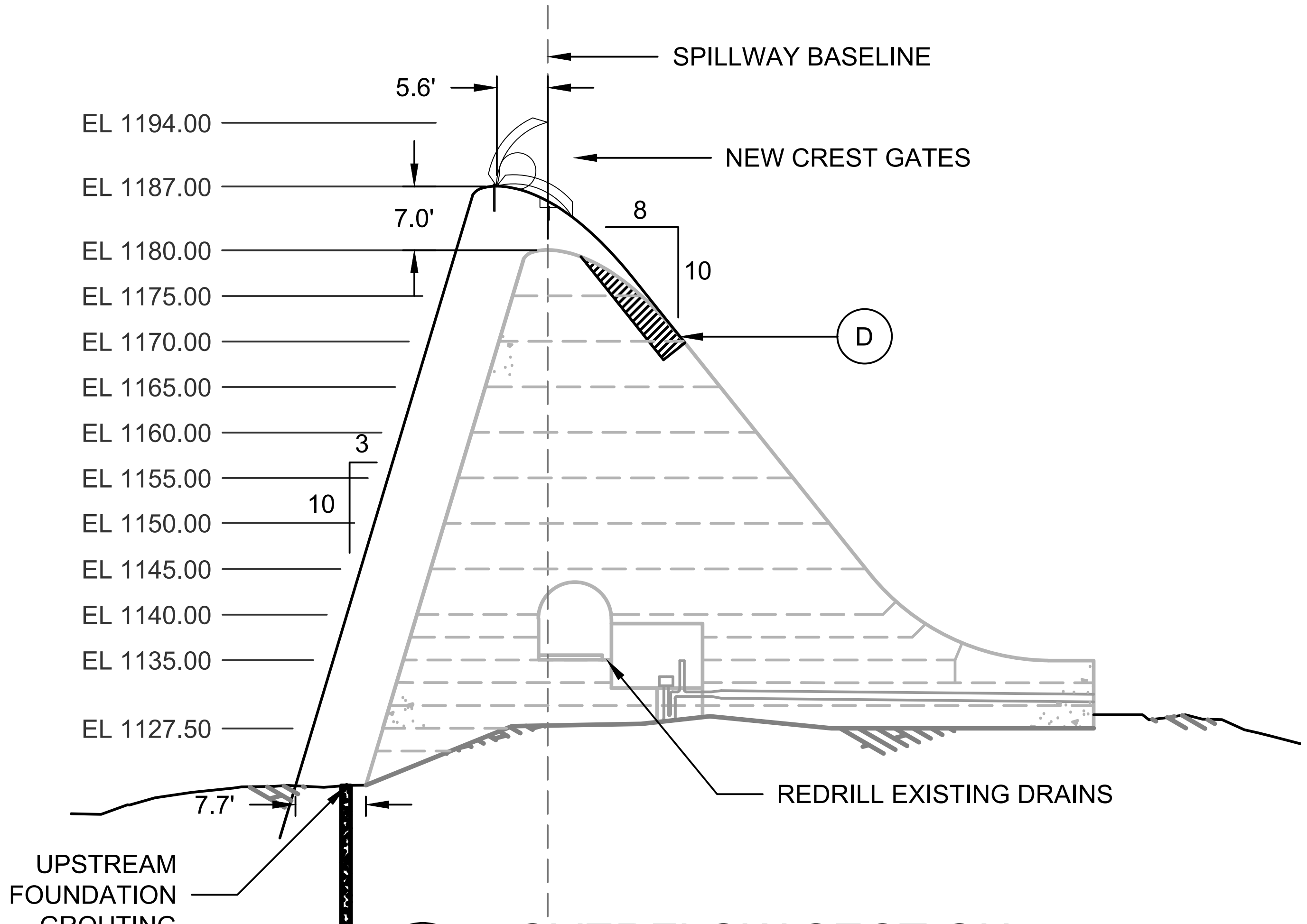
Schnabel ENGINEERING

BRADLEY LAKE SPILLWAY RAISE
DOWL - AEA
HOMER, ALASKA
PROJECT NO. 21C310023.00

7 FT POOL RAISE
CONCEPT
1/28/2022



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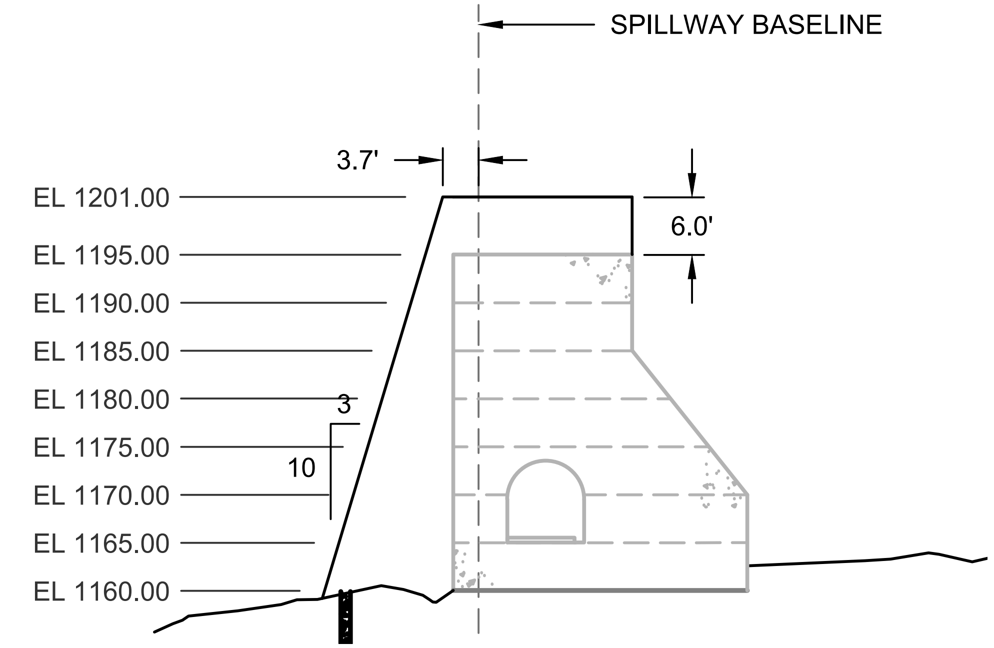
OVERFLOW SECTION
Scale: 1:20



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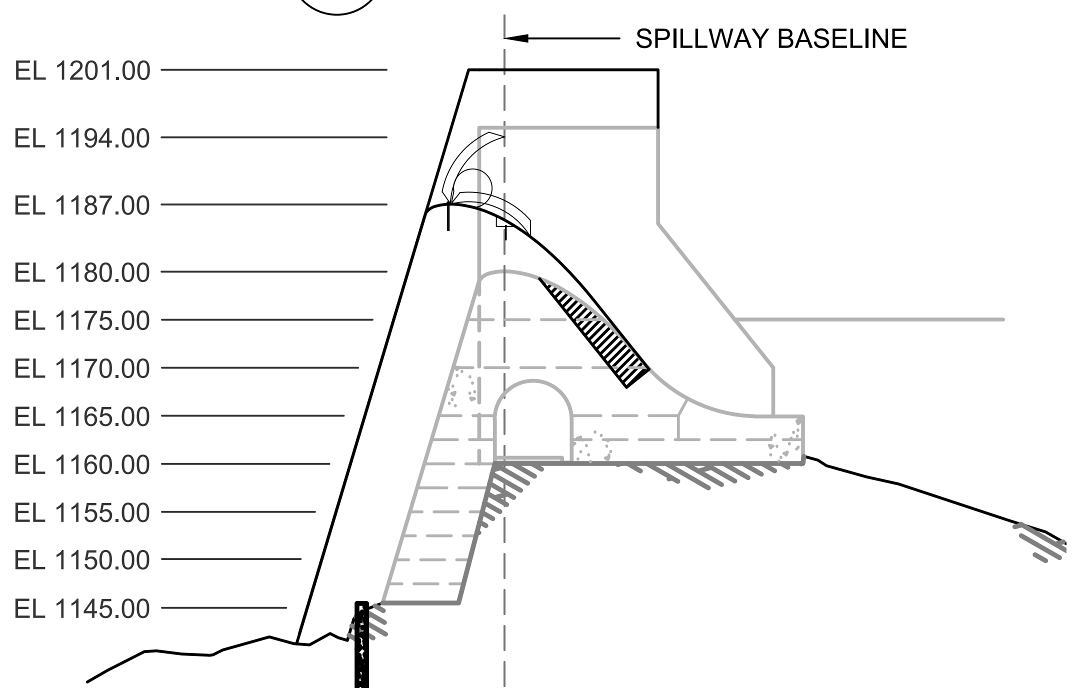
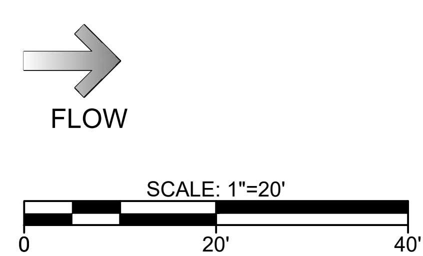
NON-OVERFLOW
Scale: 1:20





B
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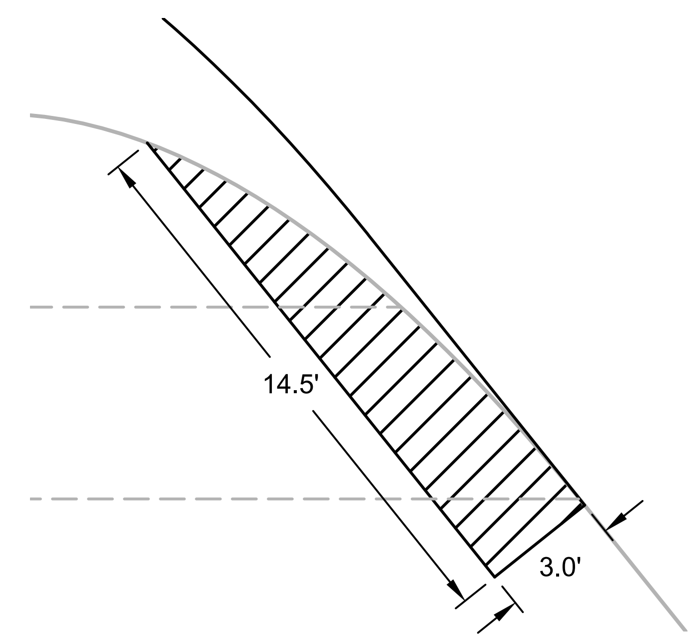
UPPER OVERFLOW WITH NON-OVERFLOW
Scale: 1:20



D
DEMO AT CREST
Scale: 1:5

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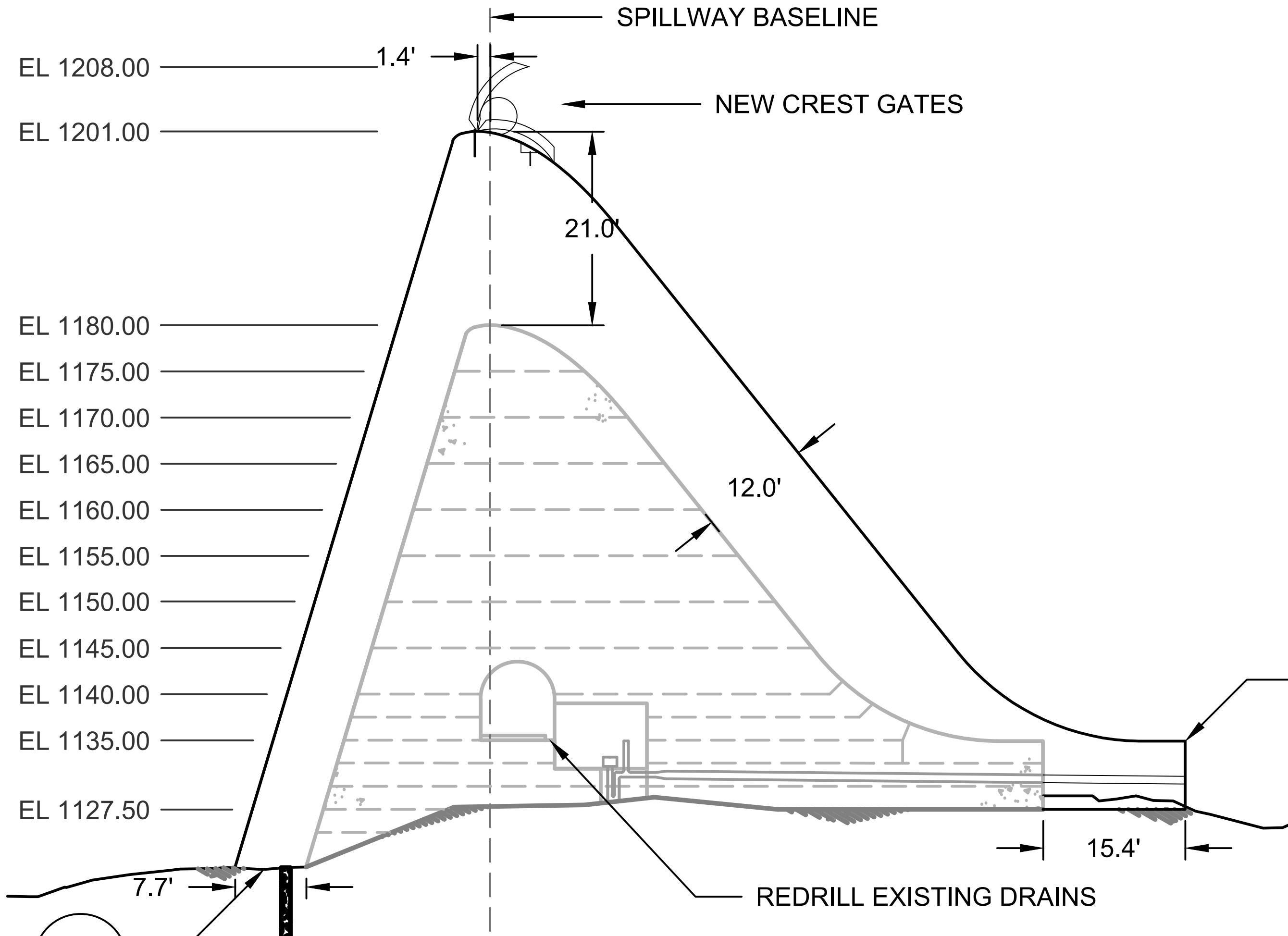
Schnabel ENGINEERING	BRADLEY LAKE SPILLWAY RAISE DOWL - AEA HOMER, ALASKA PROJECT NO. 21C310023.00	14FT POOL RAISE CONCEPT 1/28/2022 SHEET 3



A
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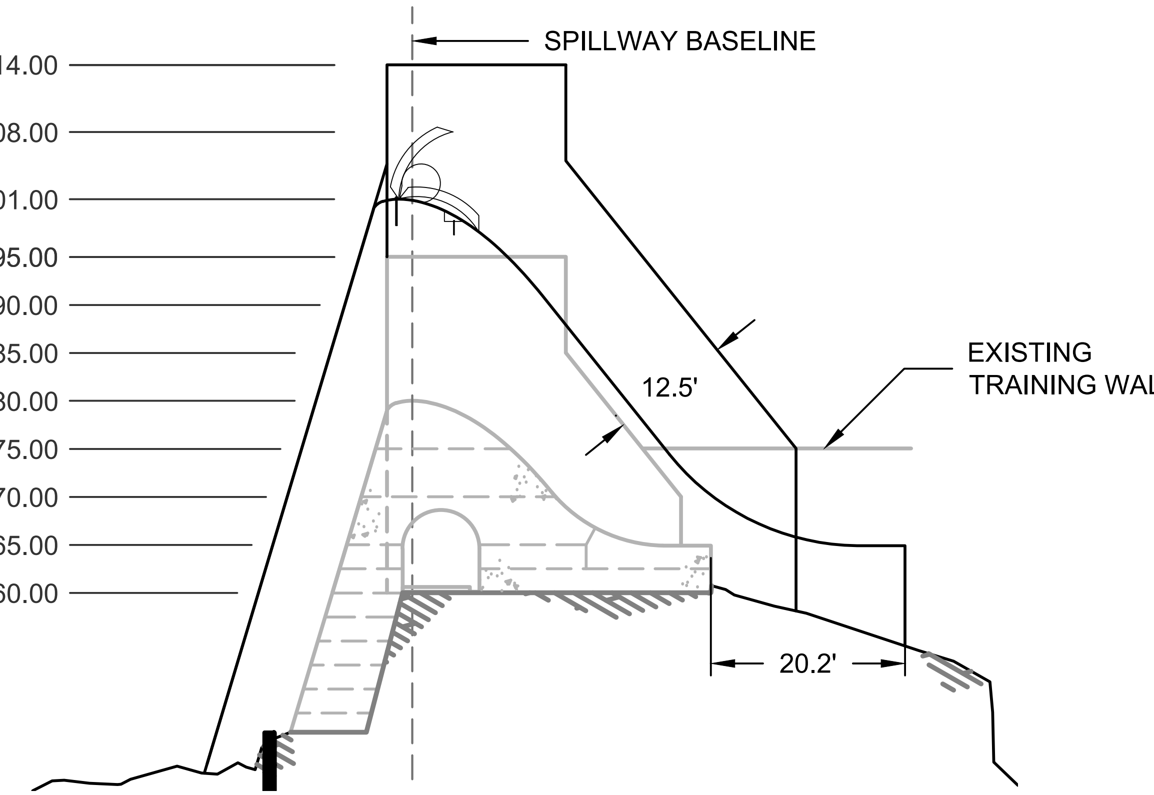
OVERFLOW SECTION
Scale: 1:20



B
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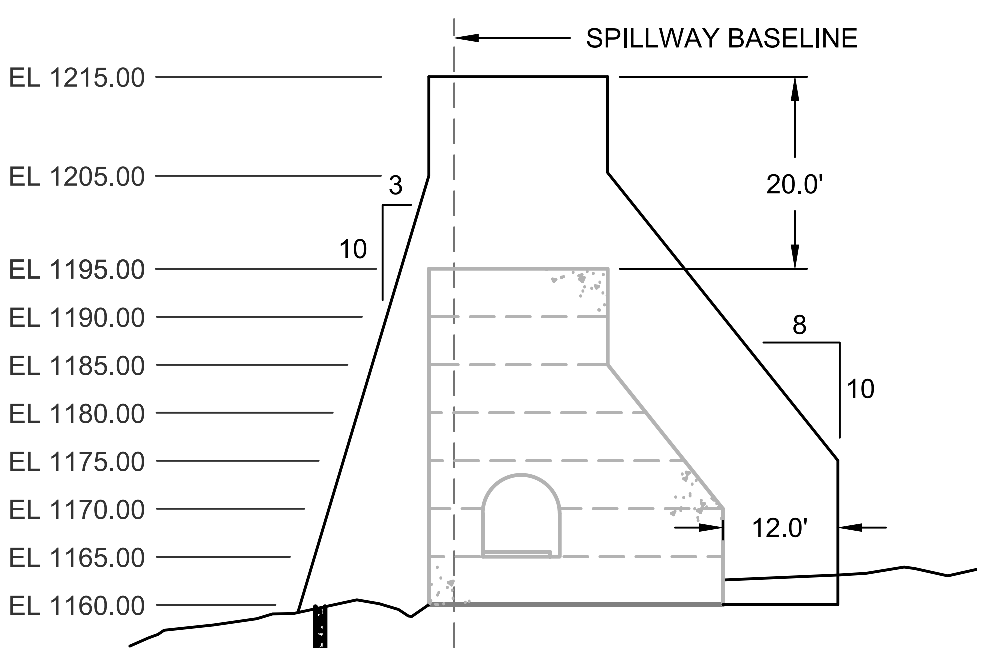
OVERFLOW WITH NON-OVERFLOW
Scale: 1:20



C
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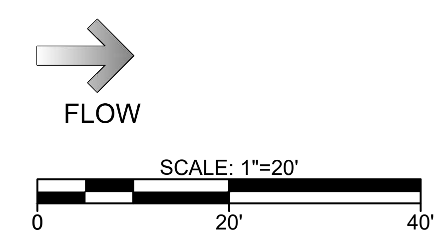
NON-OVERFLOW SECTION
Scale: 1:20



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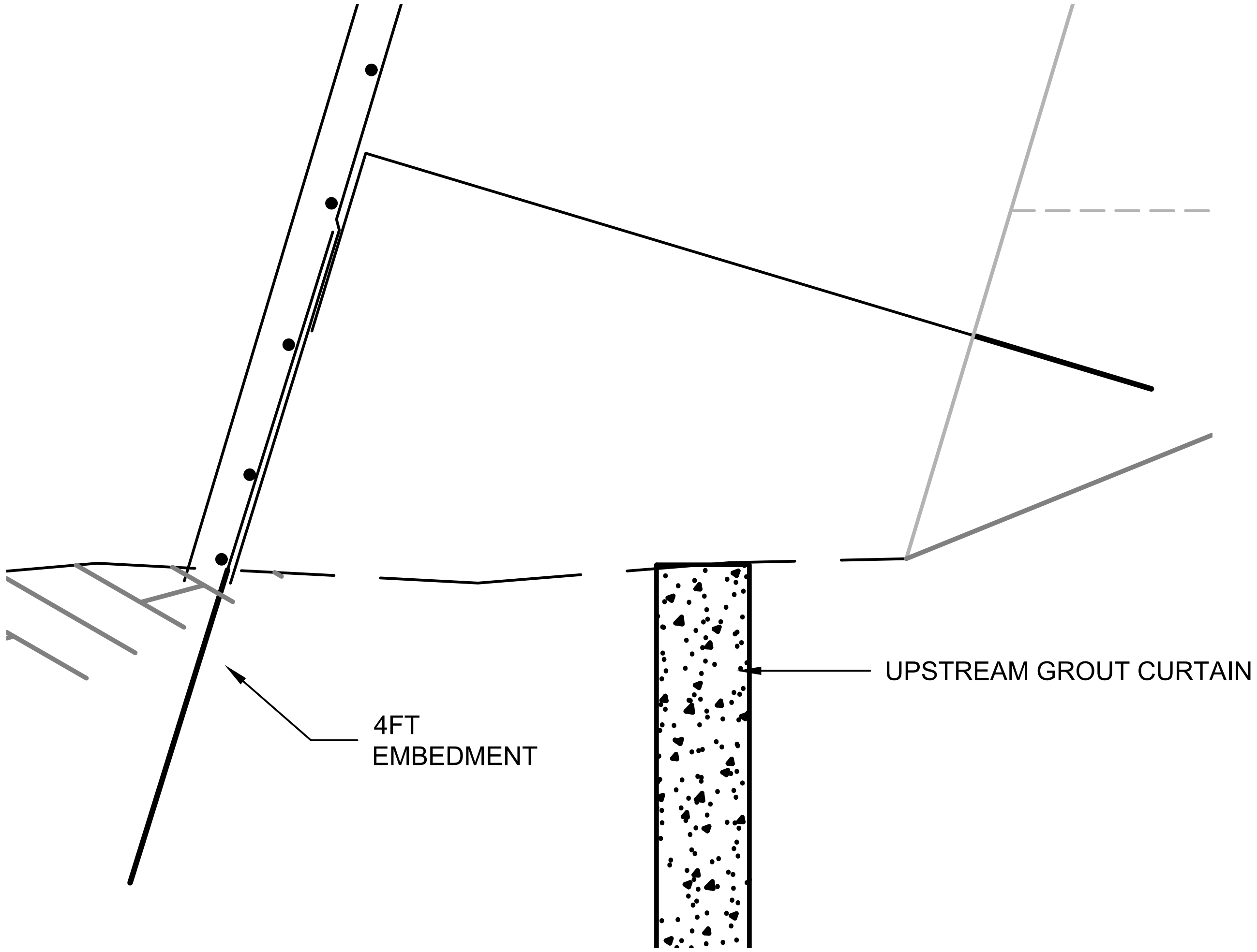
Schnabel ENGINEERING

BRADLEY LAKE SPILLWAY RAISE
DOWL - AEA
HOMER, ALASKA
PROJECT NO. 21C310023.00

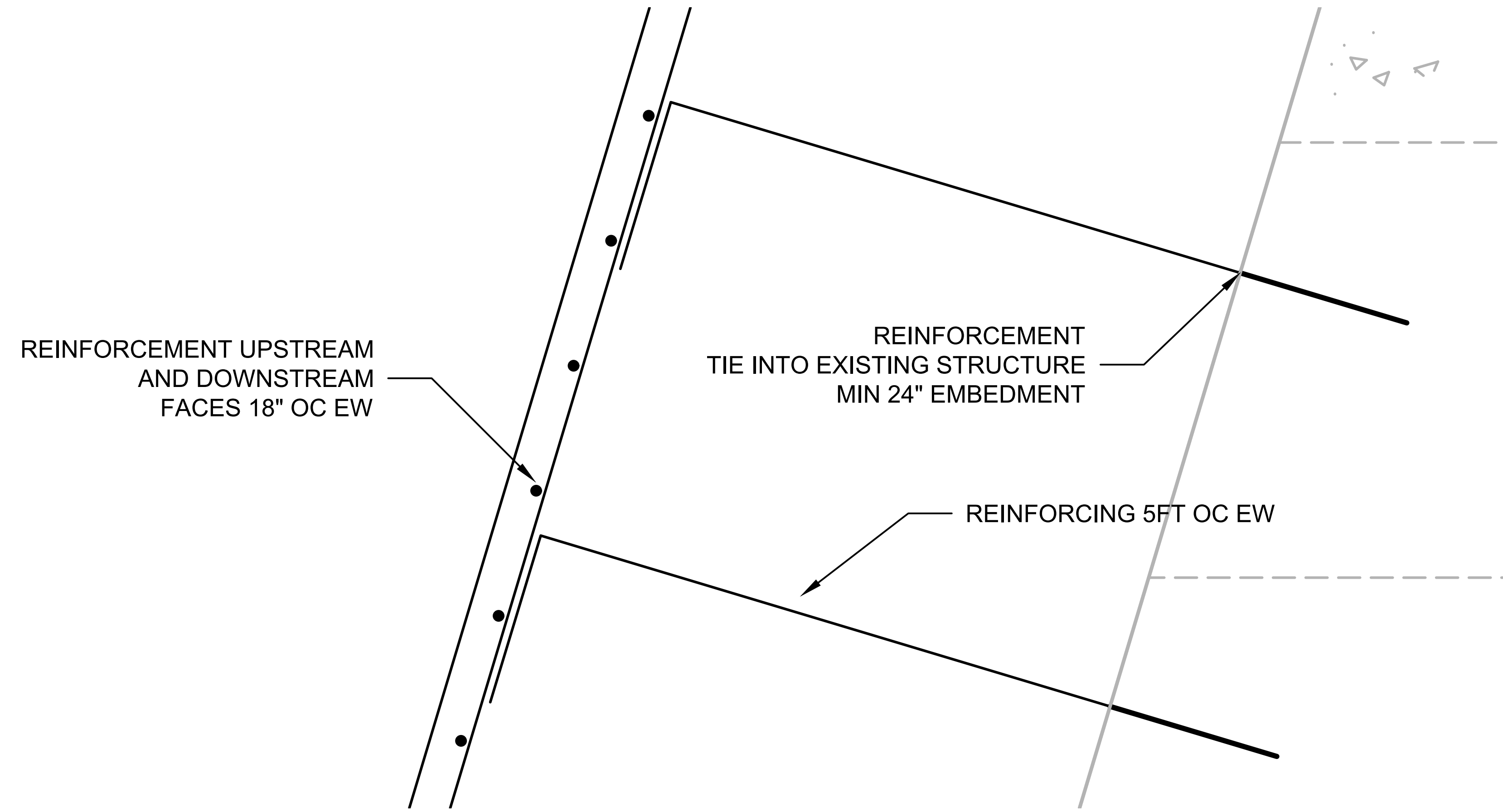
28FT POOL RAISE
CONCEPT
1/28/2022

SHEET 4



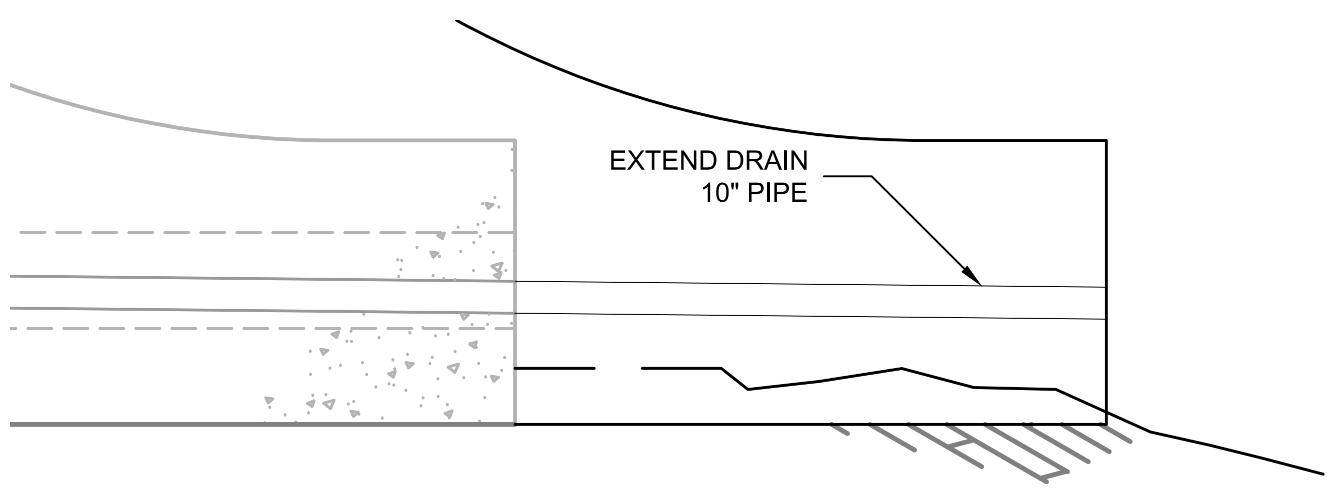
1/4 HEEL DETAILS 14FT & 28FT RAISE

Scale: 1:2



2/4 UPSTREAM FACE 14FT & 28FT RAISE

Scale: 1:2



3/5 DRAIN EXTENSION

Scale: 1:1

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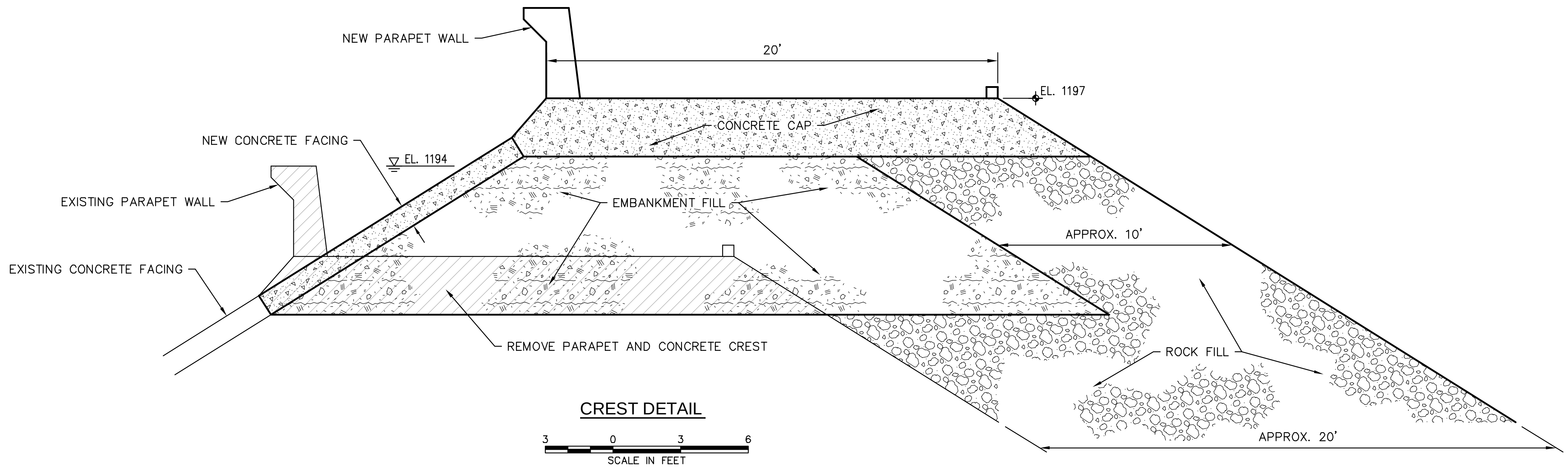
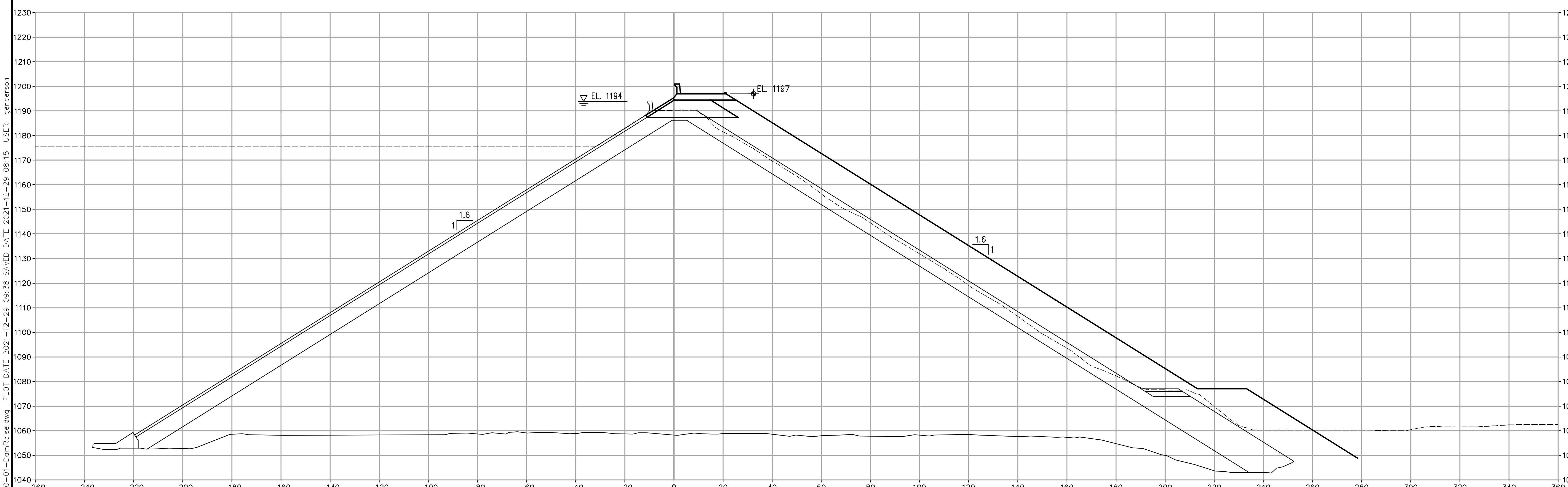
Schnabel ENGINEERING	BRADLEY LAKE SPILLWAY RAISE DOWL - AEA HOMER, ALASKA PROJECT NO. 21C310023.00	DETAILS CONCEPT 1/28/2022 SHEET 5



CREST DETAIL



SECTION A-A

HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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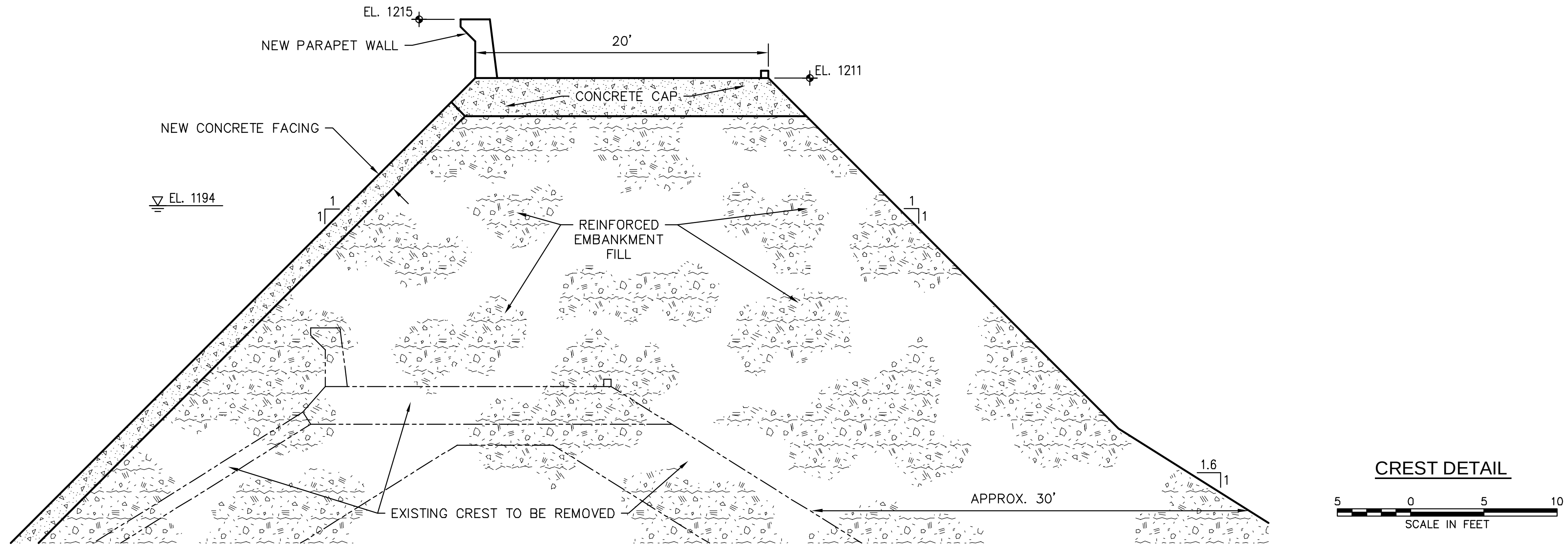
BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

PROJECT 1136.90090.01
DATE 12/29/21

TYPICAL EMBANKMENT SECTION
14 FT. POOL RAISE

BD-8

PAGE A-29



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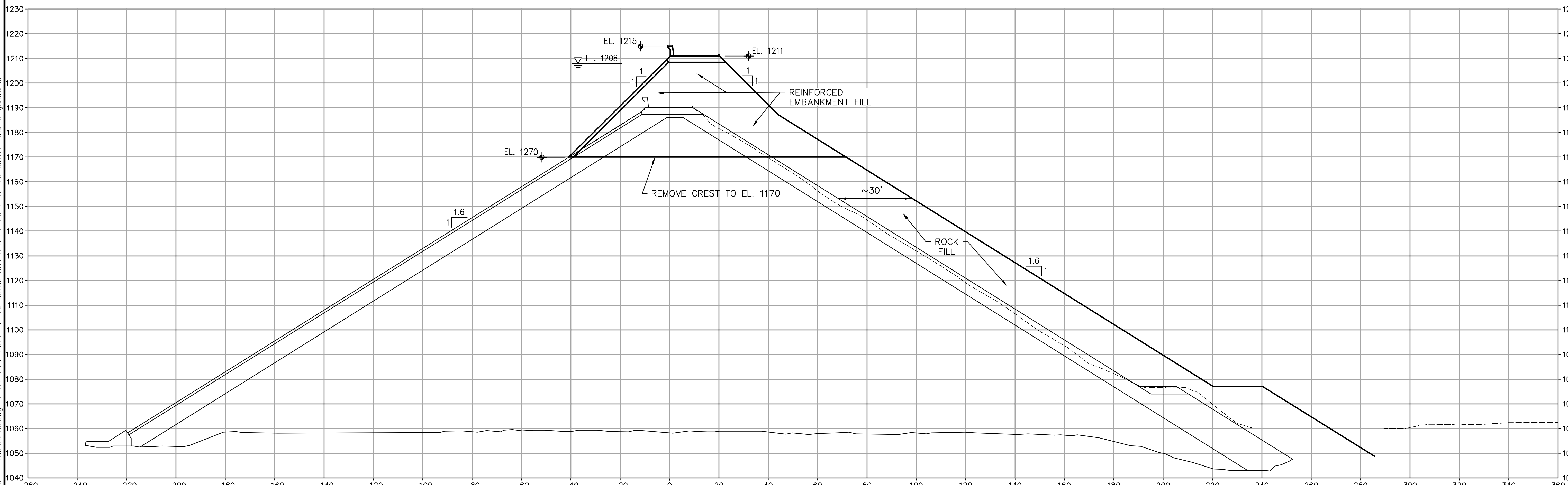

SECTION A-A

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HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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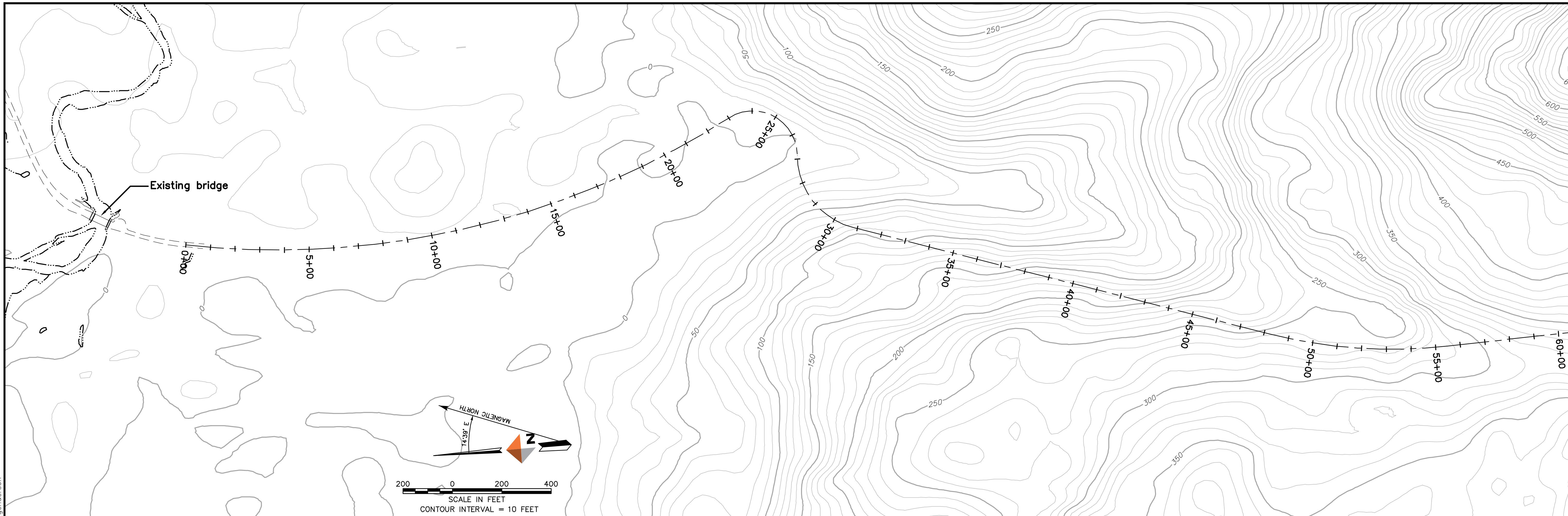
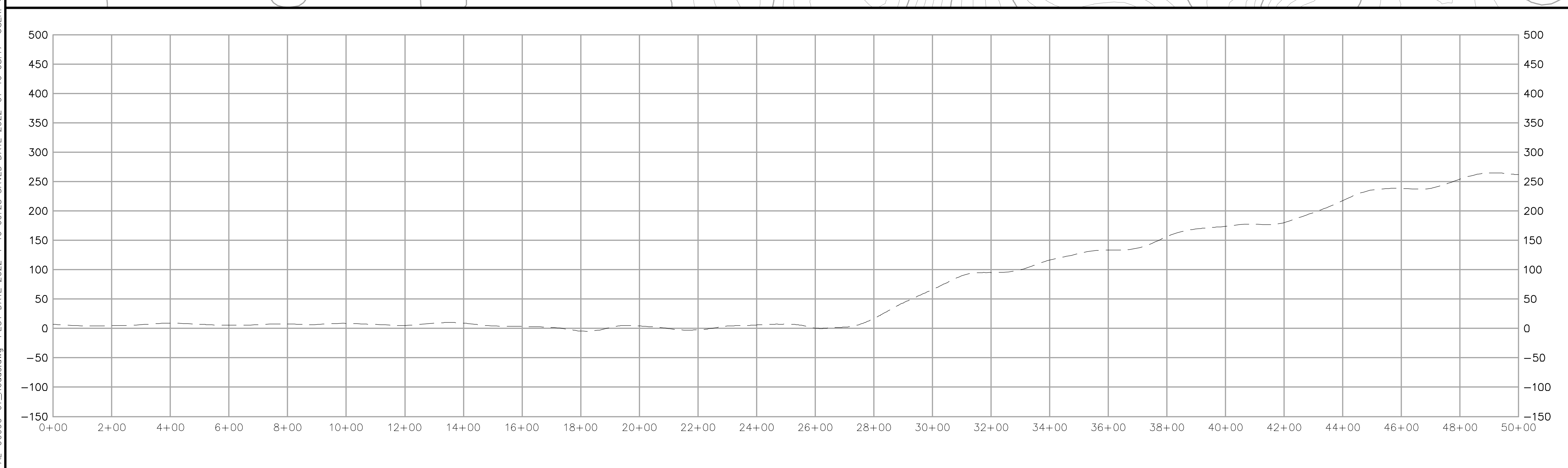
BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

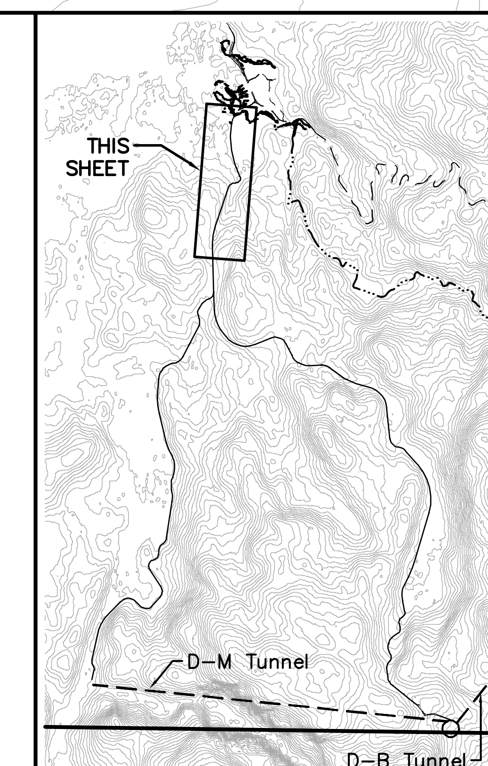
PROJECT	1136.90090.01
DATE	12/29/21

TYPICAL EMBANKMENT SECTION
28 FT. POOL RAISE

BD-9







HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

PROJECT 1136.90090.01
DATE 01/07/22

LOWER DIXON ACCESS ROAD PLAN AND PROFILE
STA. 0+00 TO STA. 50+00

AR-D1

PAGE A-31

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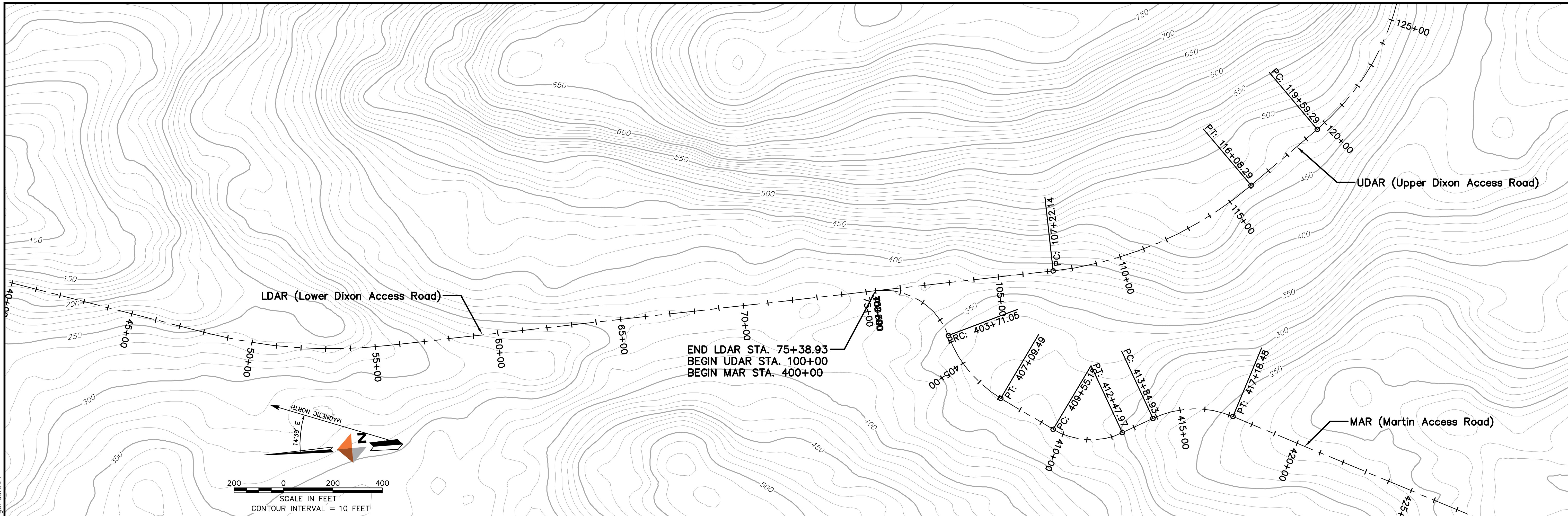

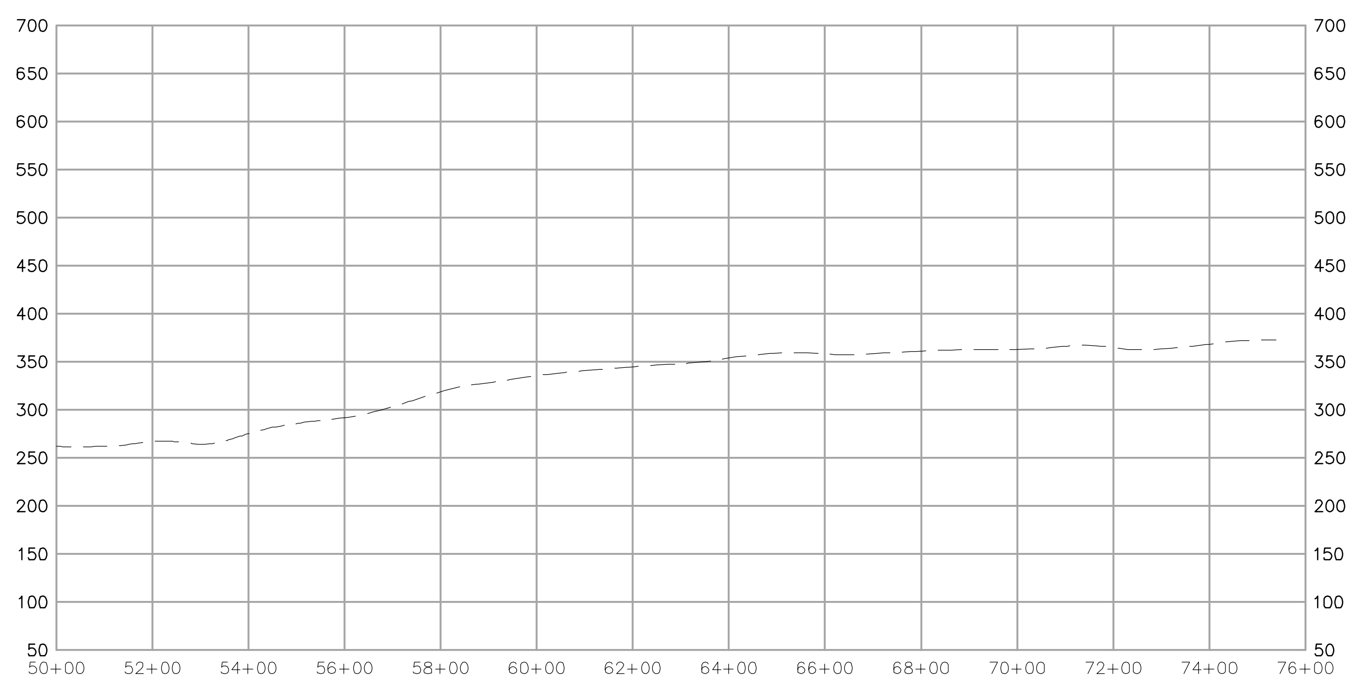

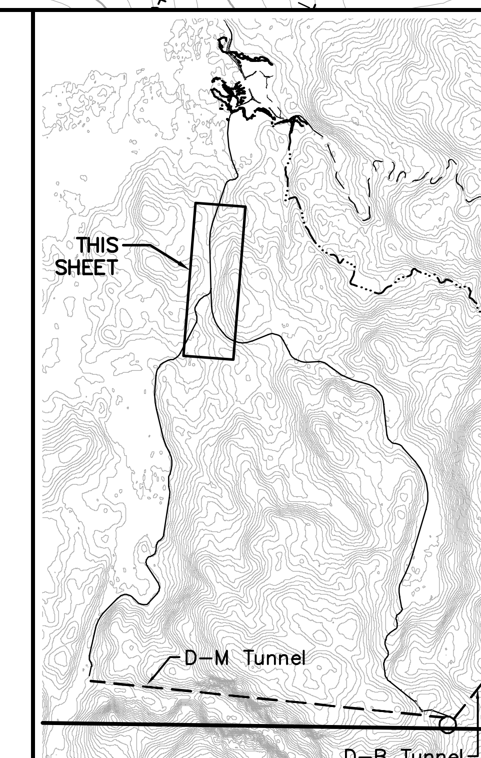

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HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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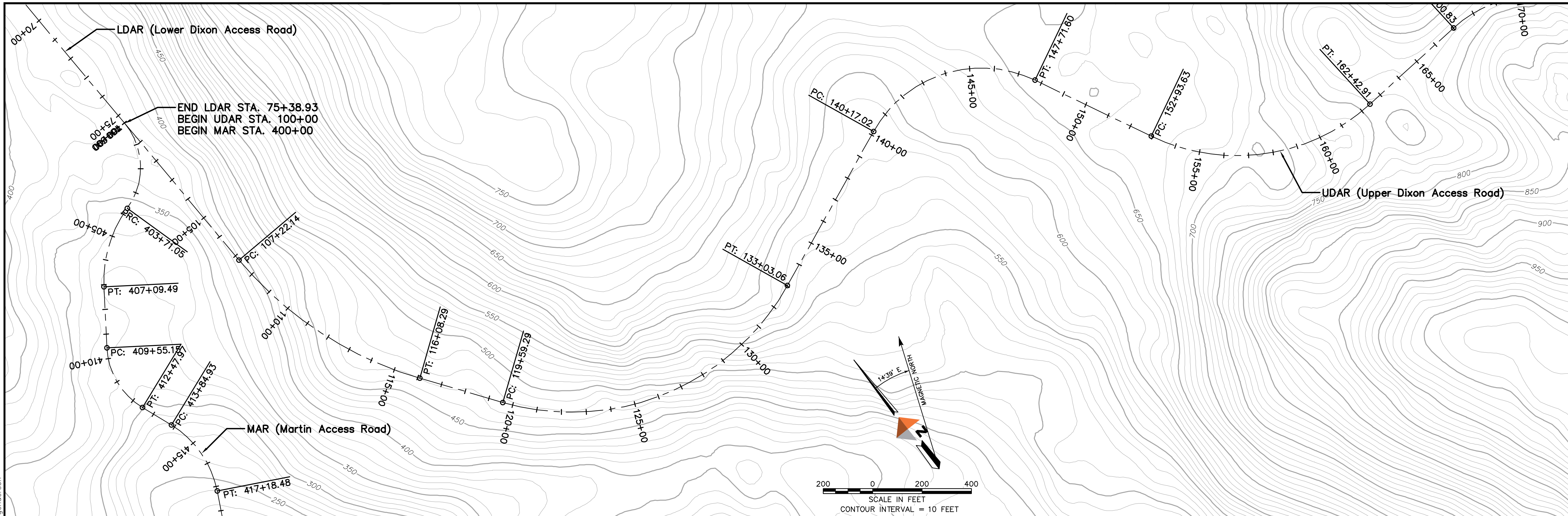
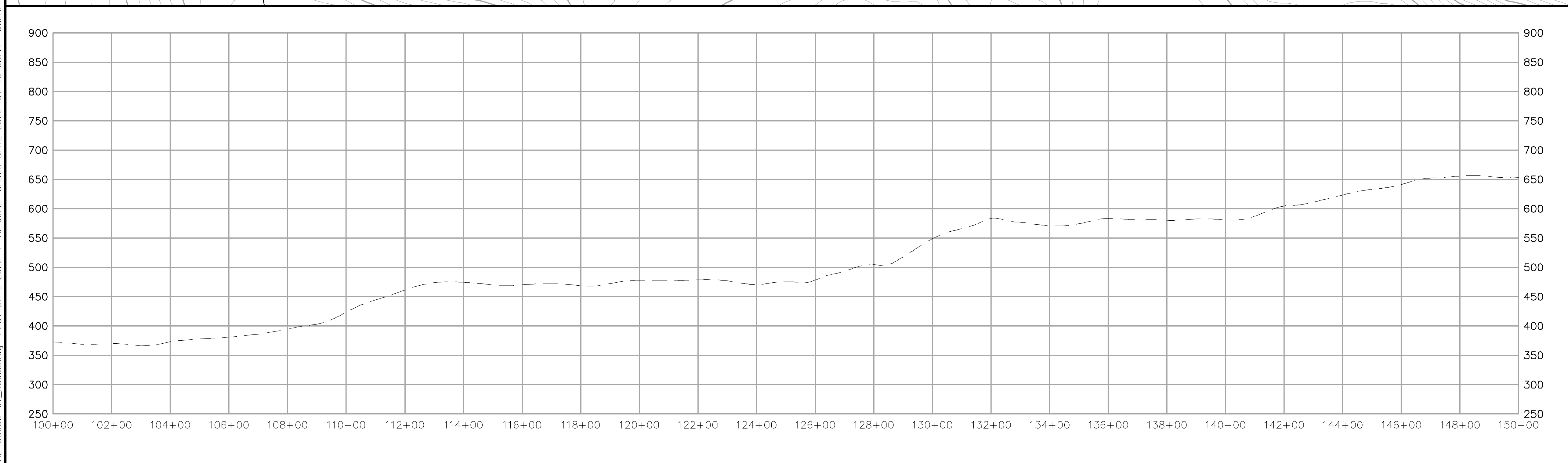
BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

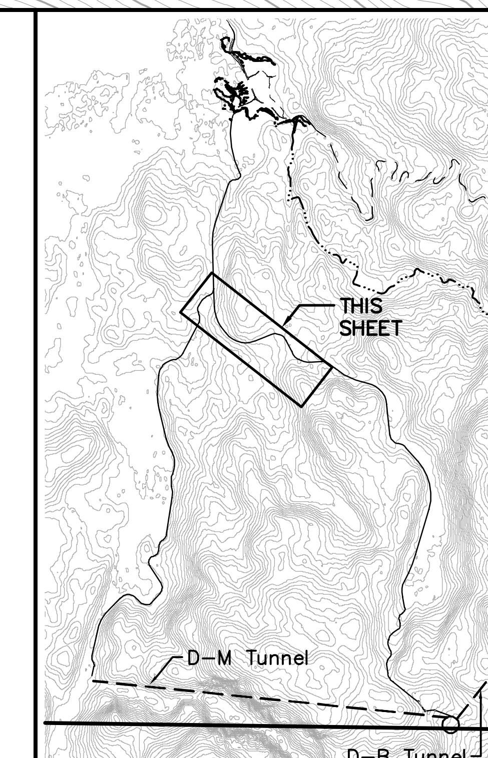
PROJECT	1136.90090.01
DATE	01/07/22

LOWER DIXON ACCESS ROAD PLAN AND PROFILE
STA. 50+00 TO STA. 75+38.93

AR-D2
PAGE A-32







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HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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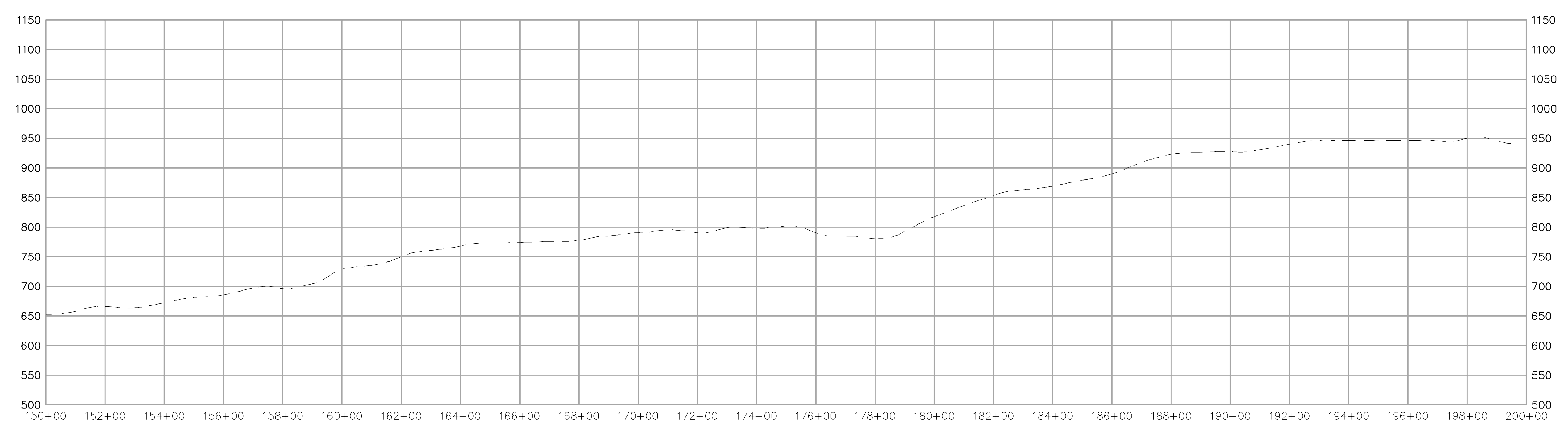
907-771-3000

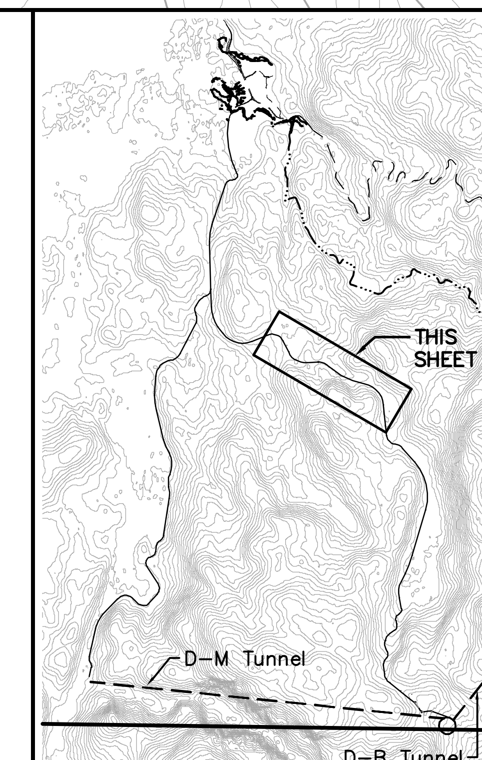
BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

PROJECT 1136.90090.01
DATE 01/07/22

UPPER DIXON ACCESS ROAD PLAN AND PROFILE
STA. 100+00 TO STA. 150+00

AR-D3





HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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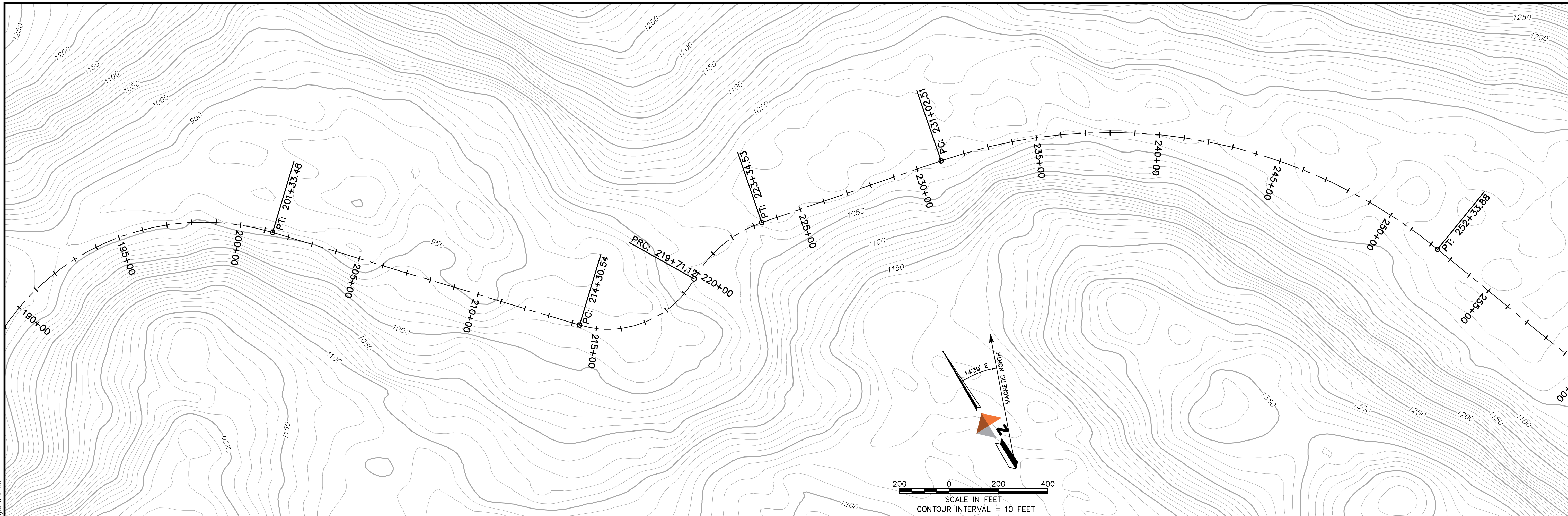
BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

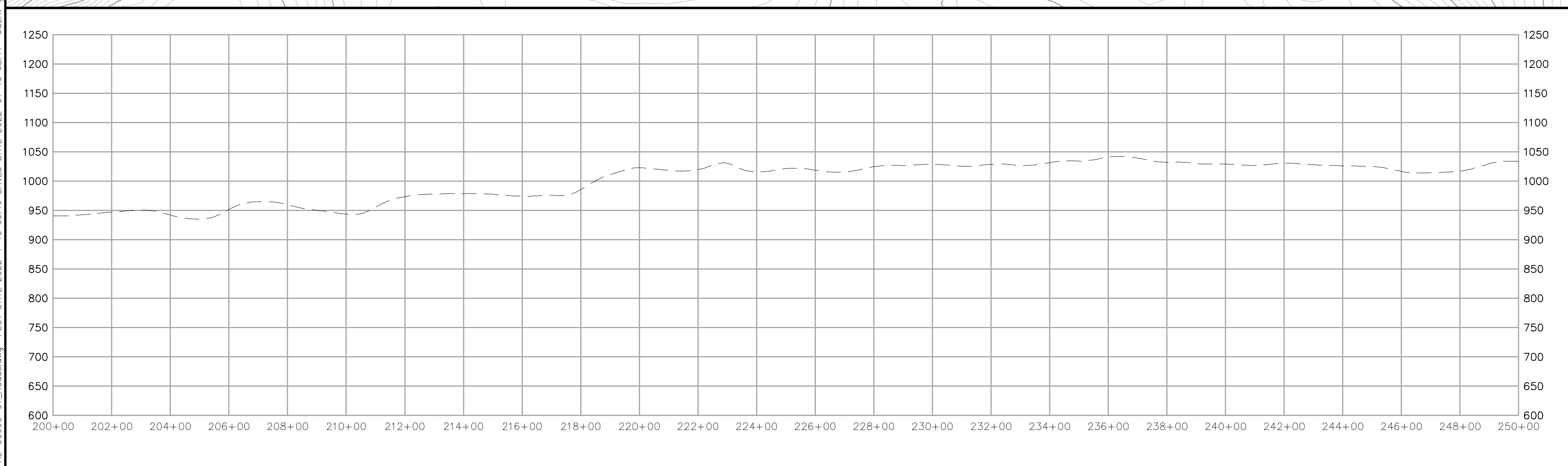
PROJECT 1136.90090.01
DATE 01/07/22

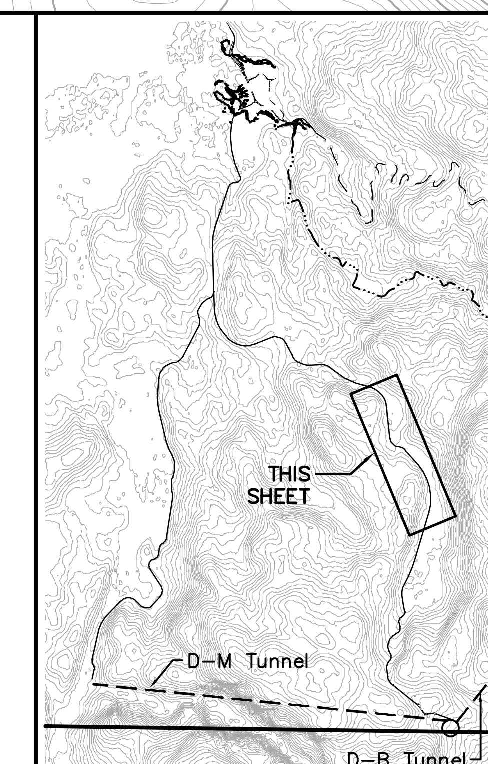
UPPER DIXON ACCESS ROAD PLAN AND PROFILE
STA. 150+00 TO STA. 200+00

AR-D4
PAGE A-34

C:\dowl_pw\d0395978\MC–AL–90090–01_Roads.dwg PLOT DATE 2022–1–10 09:22 SAVED DATE 2022–01–10 08:17 USER: genderson







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HORIZONTAL CONTROL

Project Coordinates are NAD83 CORS96 Epoch 2002, Alaska State Plane Zone 4 coordinates, expressed in U.S. Survey Feet.

VERTICAL CONTROL

The Vertical Datum is the "Bradley Lake Project Datum". To convert to NAVD88 elevations, add 9.76 feet.

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NOT FOR CONSTRUCTION

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AECL848
Anchorage, Alaska

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BRADLEY LAKE HYDROELECTRIC PROJECT
DIXON DIVERSION CONCEPTUAL STUDY

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STA. 200+00 TO STA. 250+00

PROJECT 1136.90090.01
DATE 01/07/22

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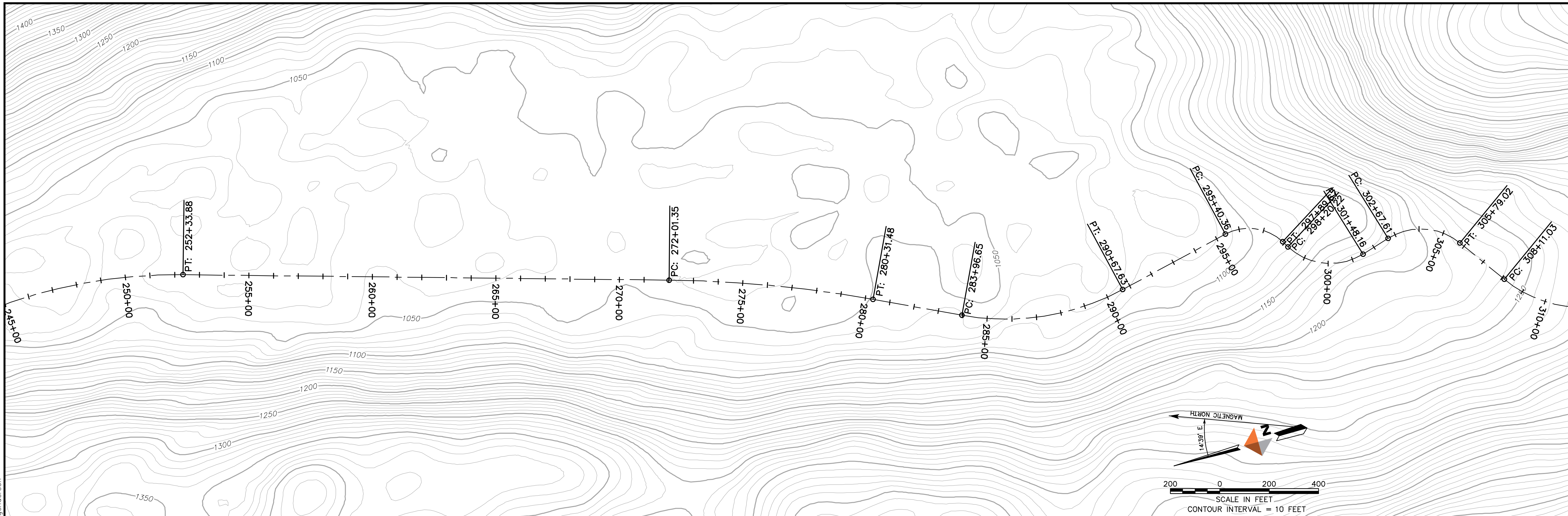

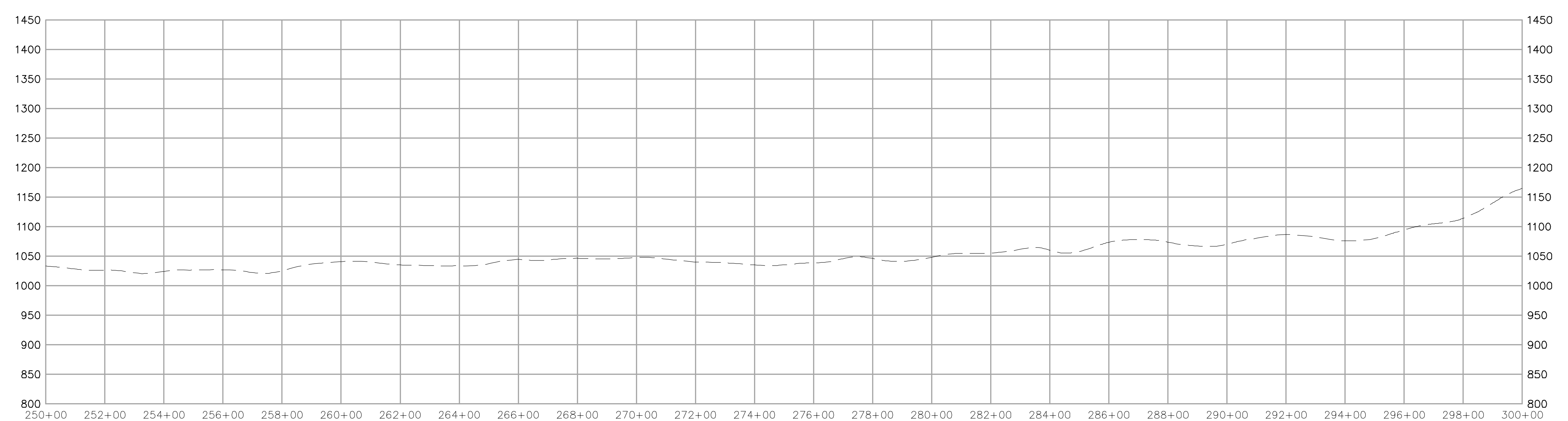

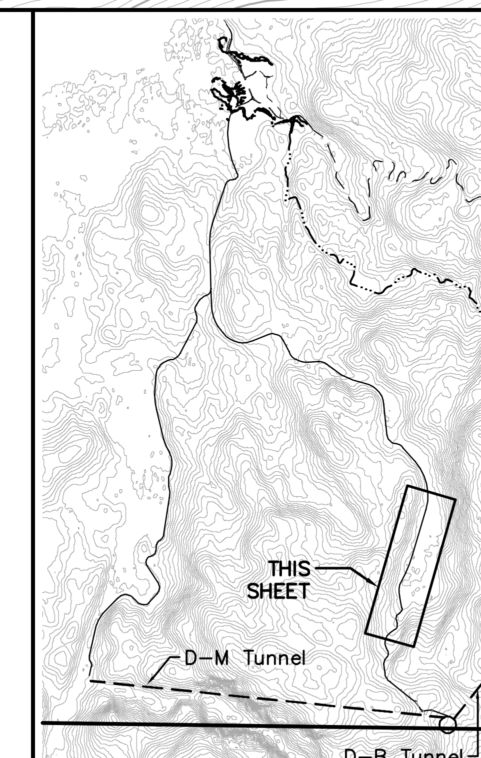

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DIXON DIVERSION CONCEPTUAL STUDY

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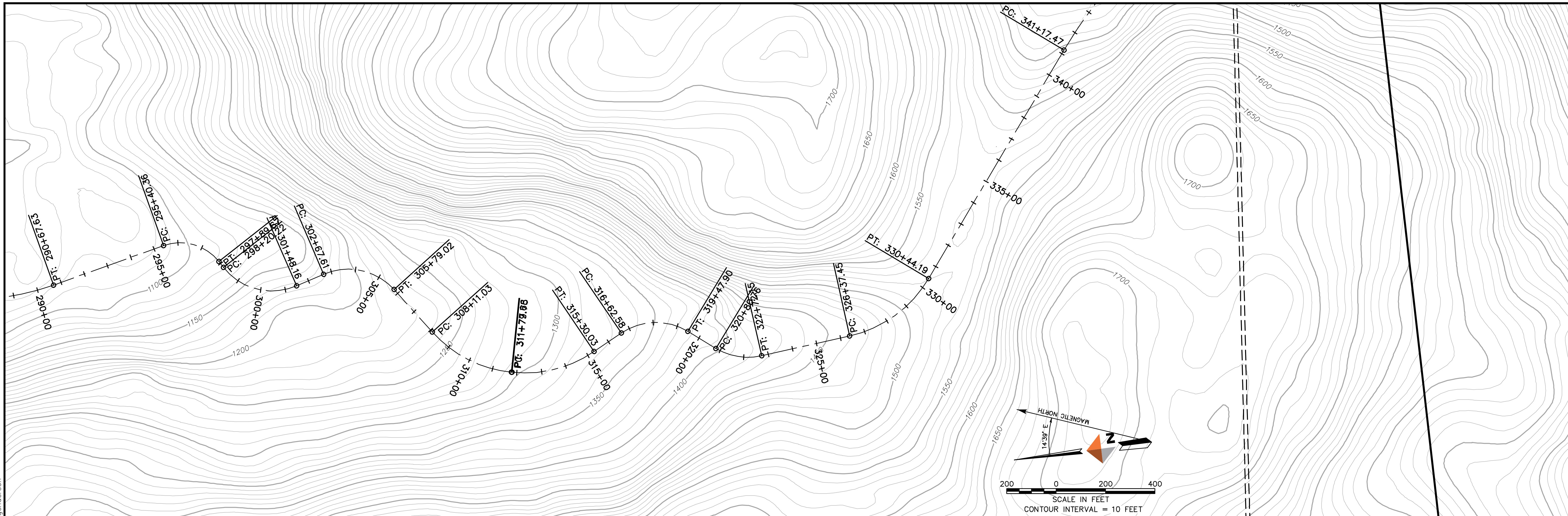

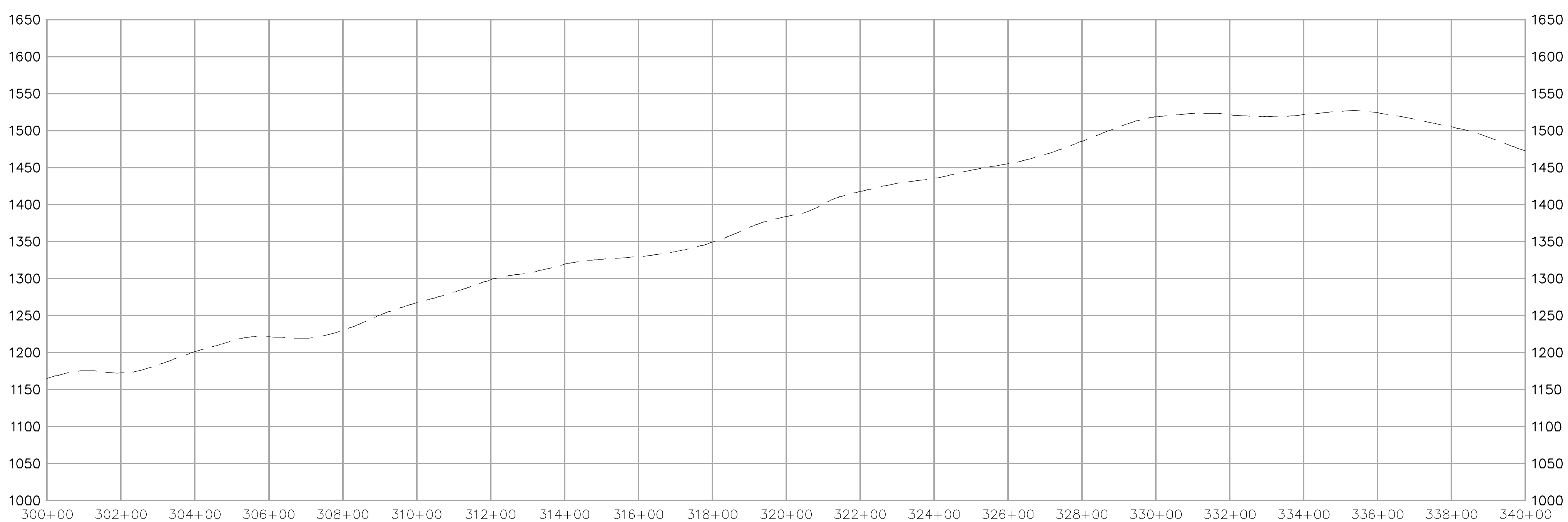

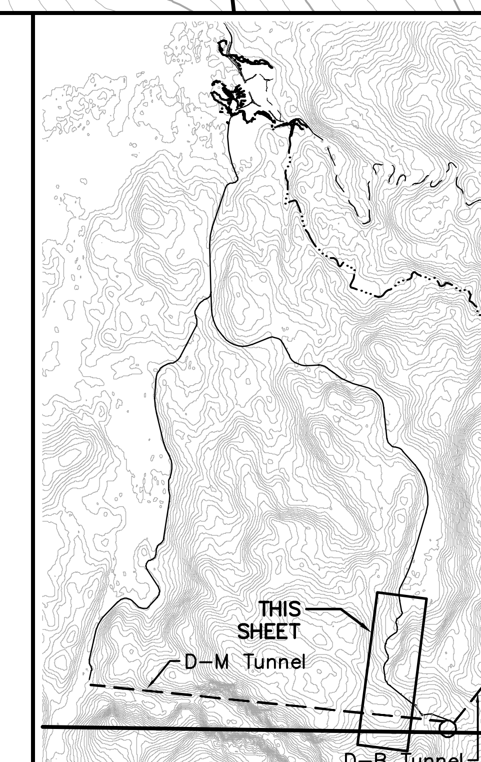

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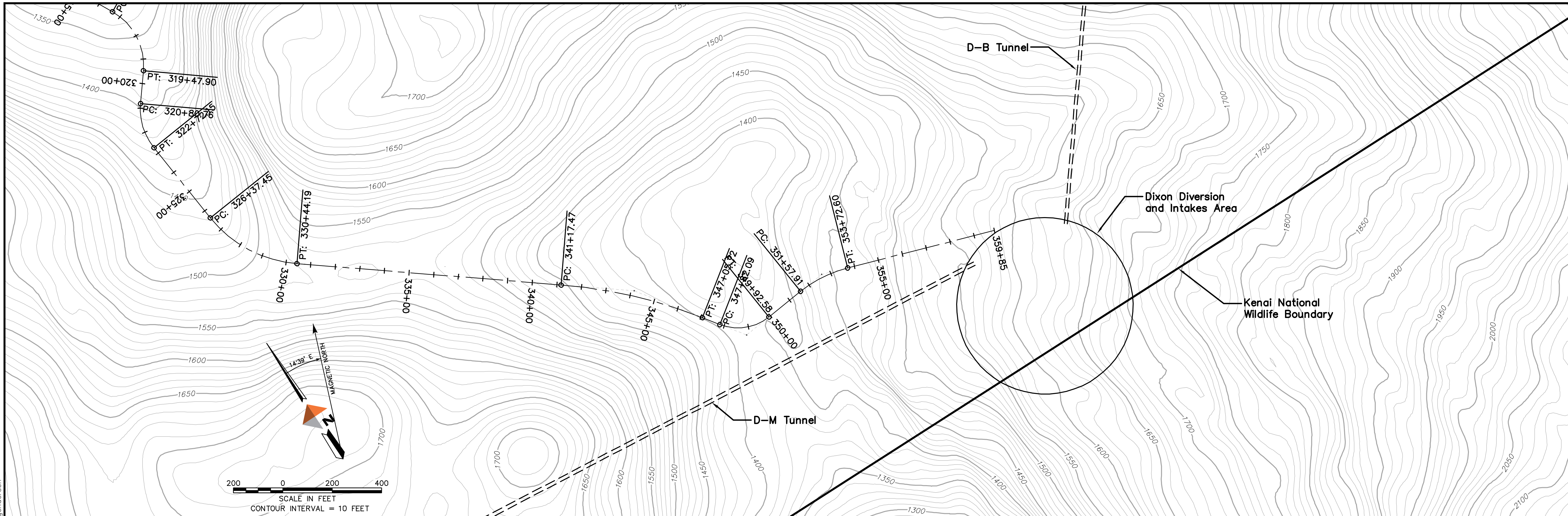

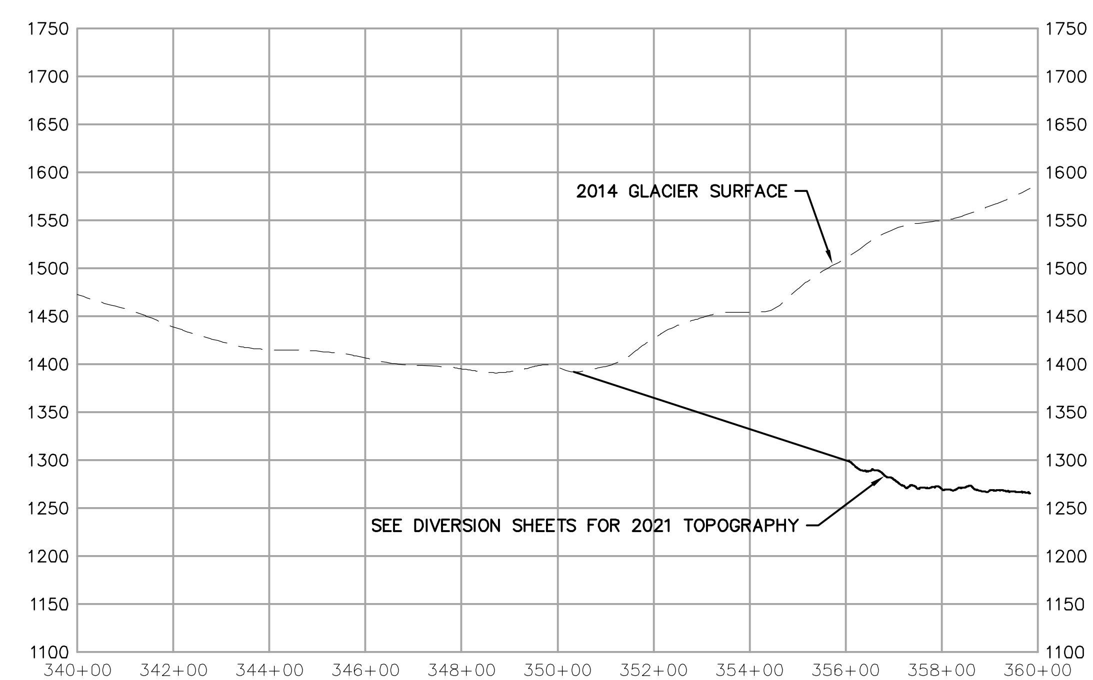

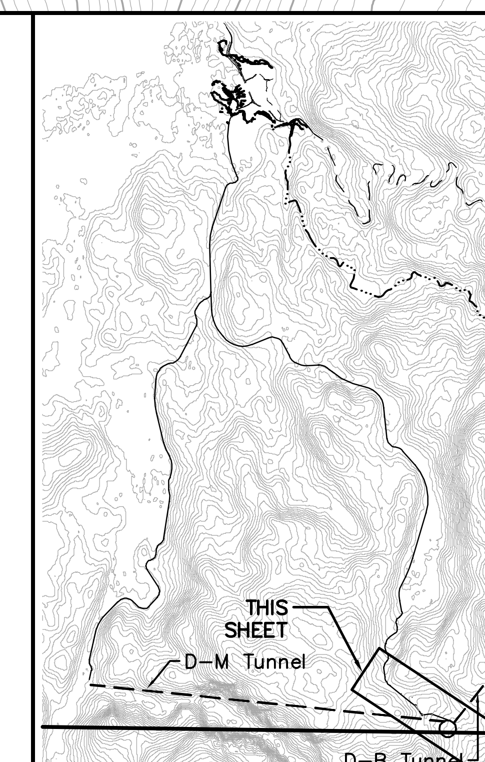

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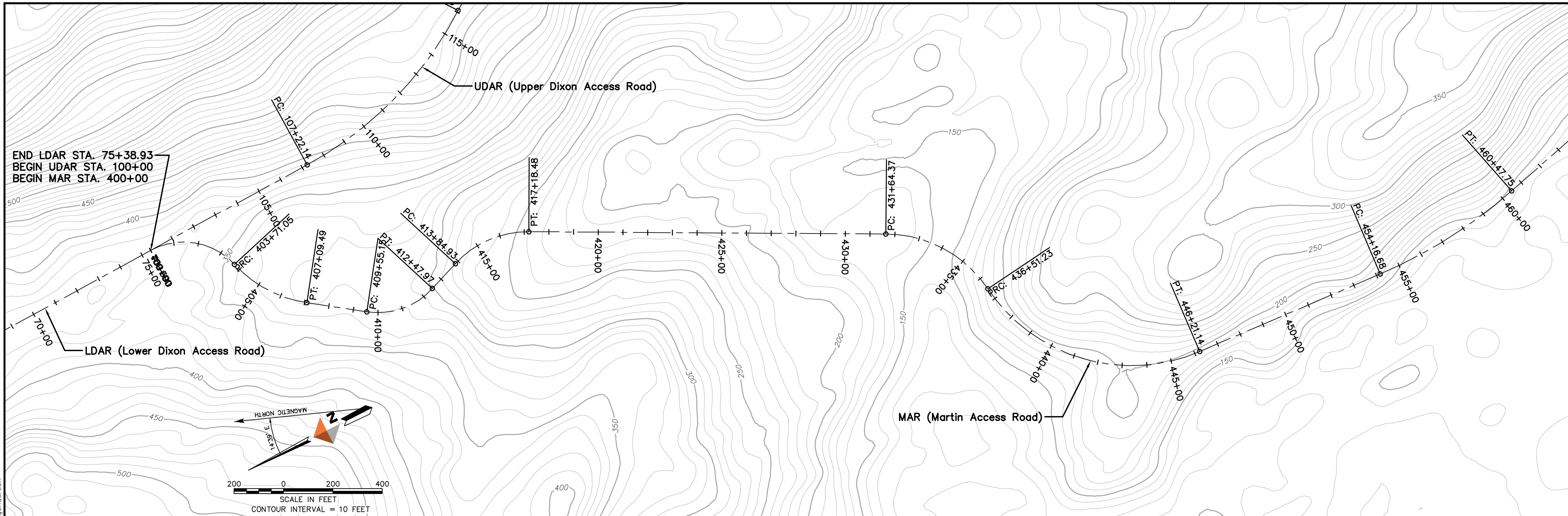

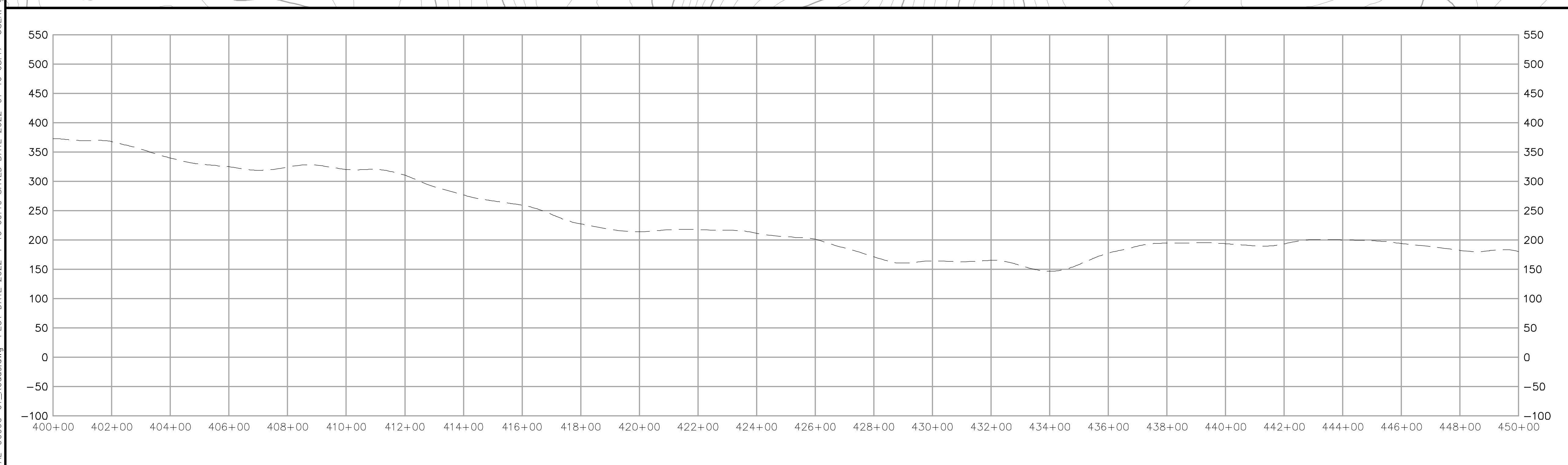

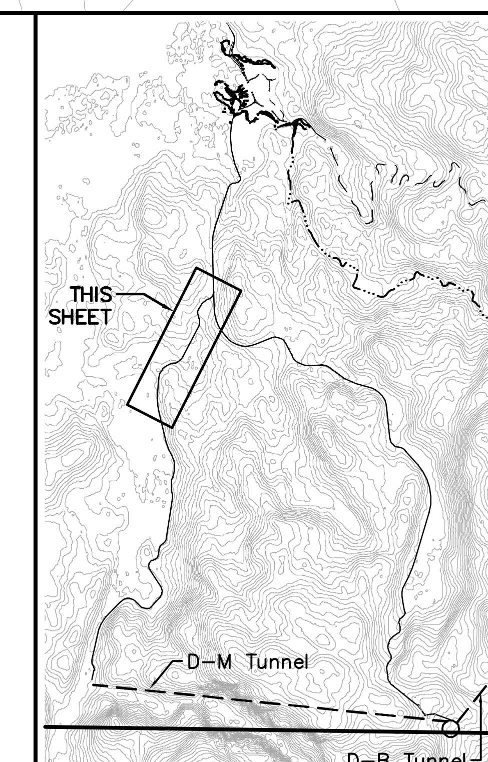

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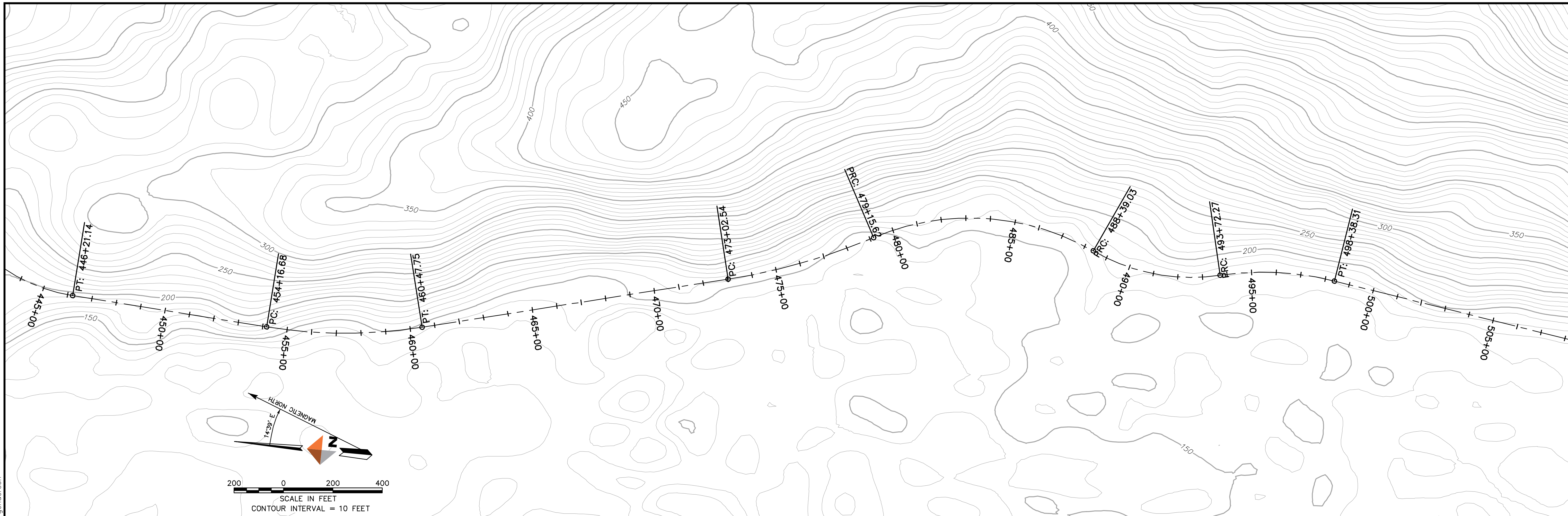

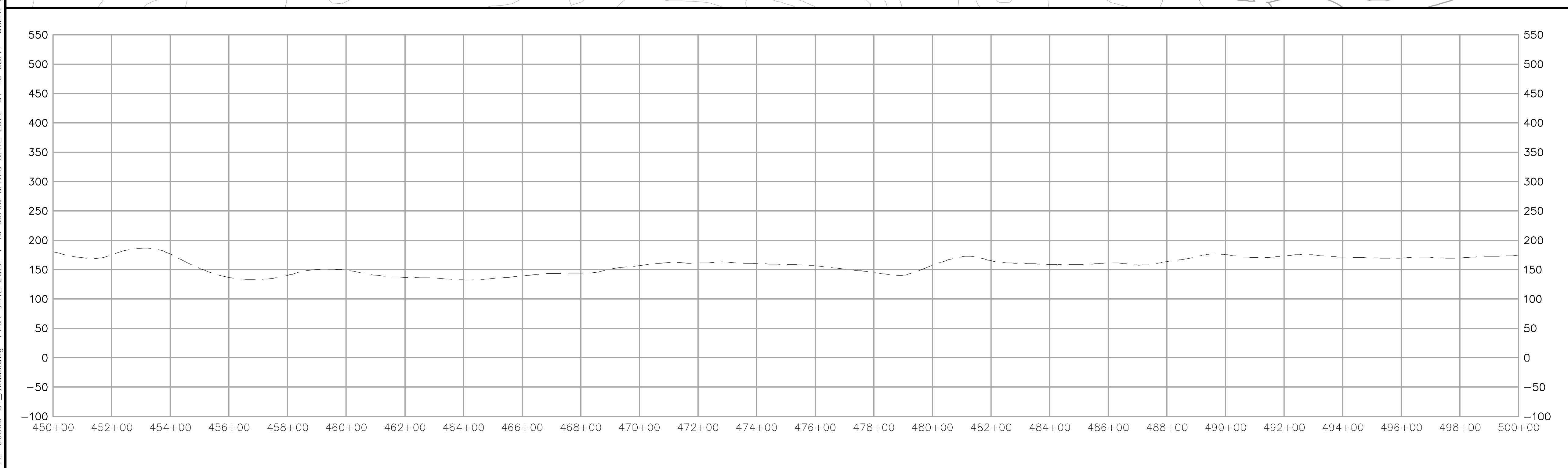

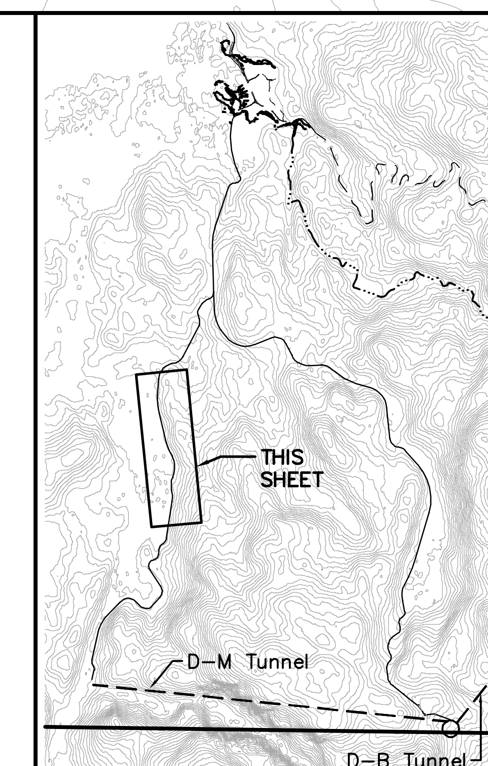

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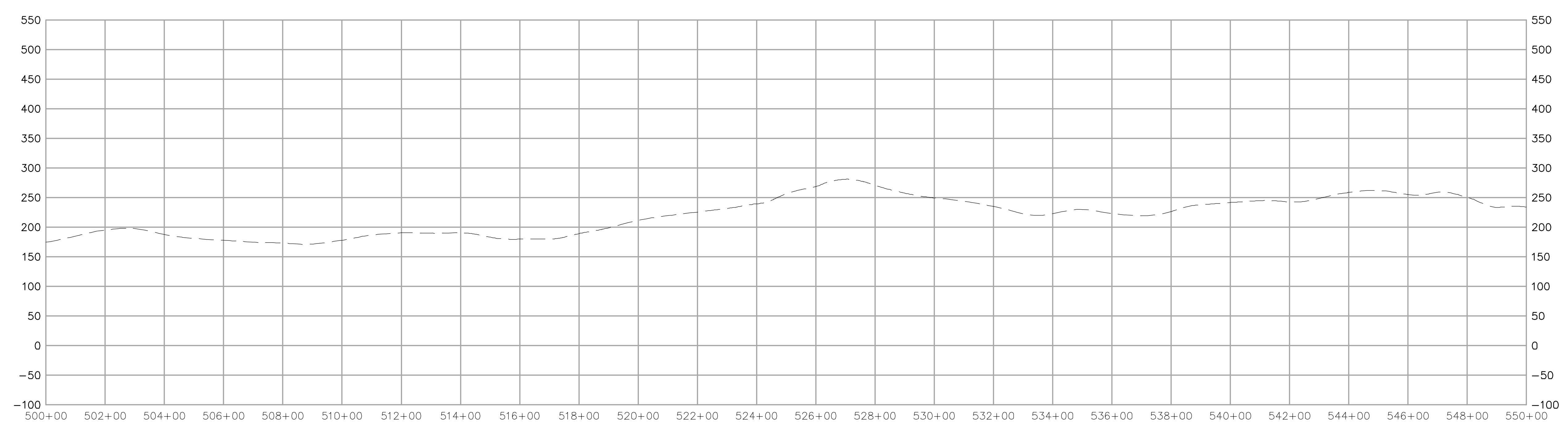

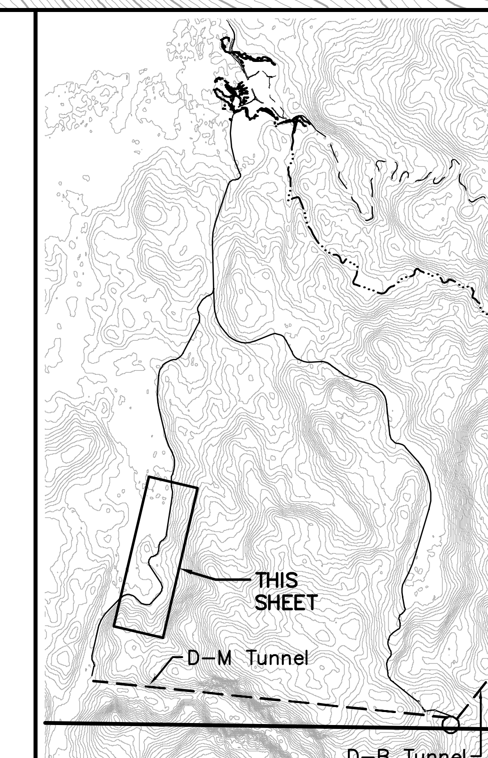

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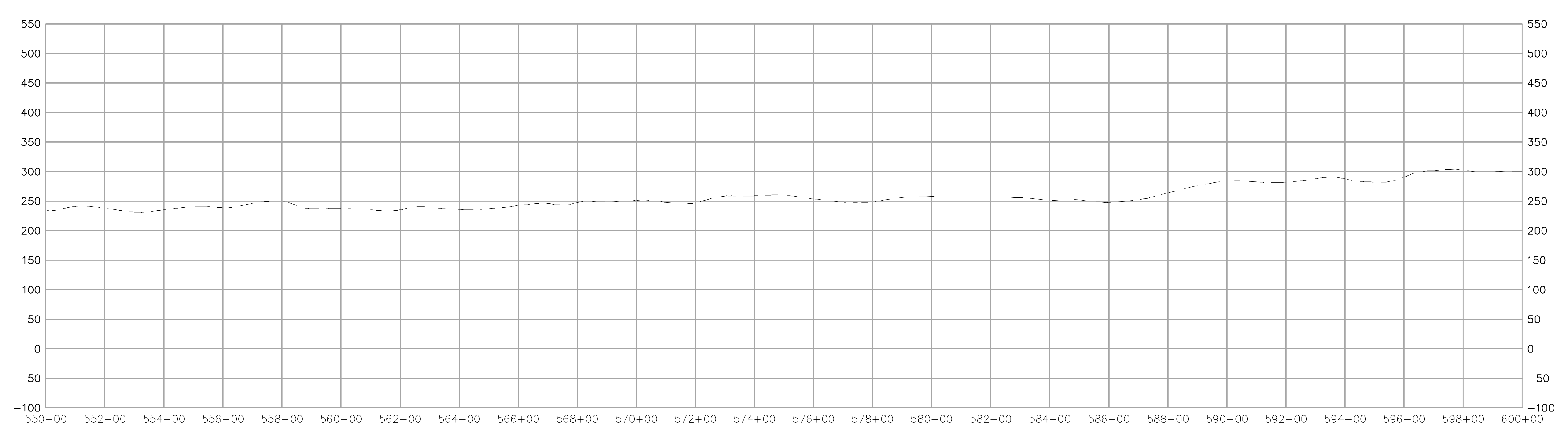

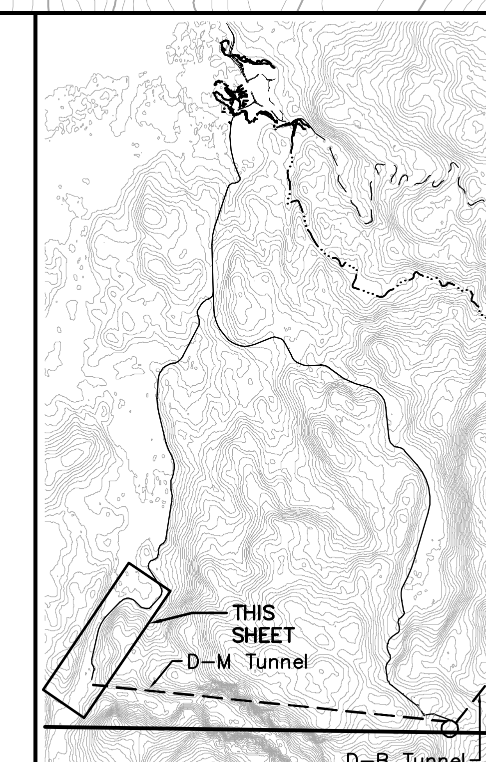

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Appendix B: Dixon Glacier Basin Hydrologic Analysis

TO: Bryan Carey, P.E.

FROM: Andrew Johnson, E.I.; Russ Reed, D.WRE;

DATE: March 23, 2022

SUBJECT: Dixon Glacier Basin Hydrologic Analysis
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Background

In 1991, Bradley Lake, the largest hydroelectric plant in Alaska, started producing power for Alaskans in the Homer-Anchorage region. Bradley Lake Dam is a 125-foot tall concrete-faced rock-filled gravity dam. The lake is fed primarily by the Kachemak and Nuka Glaciers. Many glaciers close to Bradley Lake hold the potential for additional renewable power production.

West Fork of Upper Battle Creek was the first project tapping into the opportunity these nearby glaciers present. In 2020, the project was completed, and Battle Creek glacial runoff is diverted to Bradley Lake in a 5-foot diameter pipe. The additional water increased the energy production of the Bradley Lake power plant by approximately 10-percent.

Dixon Glacier

Similar to Battle Glacier, the Dixon Glacier basin (Attachment 1) presents an opportunity to capture runoff for hydropower. The toe of the glacier is approximately 5-miles southwest of Bradley Lake. The Dixon Glacier basin is 19.1-mi^2 on the west side of the Kenai Mountains and drains to the northwest into Kachemak Bay via the Martin River. The Dixon basin has an average elevation of approximately 3,510 ft and receives an average of 104-in. of precipitation per year (Daly, Smith and Halbeib 2018).

Several alternatives are being analyzed to assess the viability of harnessing the runoff from Dixon Glacier to generate hydropower. In late 2021, the United States Geological Survey (USGS) installed a streamgage to measure water flowing from the Dixon basin (site 15238950 Dixon C nr Homer AK). Because this gage is new, there is no measured data describing discharge rates and volumes of water leaving the Dixon basin. Hence, historical discharge from Dixon Glacier must be estimated using data available from basins of similar hydrologic characteristics. Notably, the adjacent Nuka Glacier basin is hydrologically similar (e.g., average basin elevation and annual precipitation) to the Dixon Glacier basin and has over 40 years of measured stream data (USGS site 15238950 Upper Bradley R nr Nuka Glacier nr Homer AK).

Nuka Glacier

The Nuka Glacier basin is adjacent to the Dixon Glacier basin but is on the east side of the Kenai Mountains and drains into Bradley Lake via the Nuka Diversion. Before the construction of Bradley Lake, the USGS installed a streamgage below Nuka Glacier to measure the discharge into Bradley Lake. This gage provides over 40-years of daily record.

The USGS published value for the area tributary to the Nuka streamgage (titled "USGS Report" in Table 1) (Curran, et al. 2016) was delineated by an automated process (e.g., USGS StreamStats) using a historical terrain model (i.e., elevations) that does not accurately reflect the current topography. Based on review and comparison of current aerial imagery to USGS topographical maps, DOWL delineated a new Nuka Glacier basin area (titled "Nuka Basin" in Table 1) The USGS report also identifies characteristics for the Nuka Glacier basin area, including annual average precipitation based on the PRISM 1971-2000 precipitation Normals (Gibson 2009).

Table 1: Dixon and Nuka Basin Characteristics

	Dixon Basin	Nuka Basin	Nuka (USGS Report)	Nuka (DOWL Replication)
Area (mi^2)	19.1	10.7	6.4	6.4
Basin Average Annual Precipitation (in.) – PRISM 2010 Normals (1981 – 2010)	104	98	-	-
Basin Average Annual Precipitation (in.) – PRISM 2000 Normals (1971 – 2000)	123	128	121	122
Average Basin Elevation (ft)	3,510	3,180	3,030	3,010

Nuka Data Analysis

In addition to the USGS streamgage, there is an NRCS snow telemetry (SNOTEL) site (SNOTEL 1037 – Nuka Glacier) in the Nuka basin. The SNOTEL site has a 30-year record of precipitation and temperature data. Between the USGS streamgage and the NRCS SNOTEL site, there is an approximately 30-year record of rainfall, temperature, and runoff measurements for the Nuka Glacier basin.

Runoff volume and timing are the most important hydrologic considerations when evaluating hydropower generation potential. Figure 1 presents the annual total runoff volume over the period of record from USGS streamgage with tabular values in Table 2. Figure 2 shows the average annual precipitation and temperature over the period of record from the NRCS SNOTEL site.

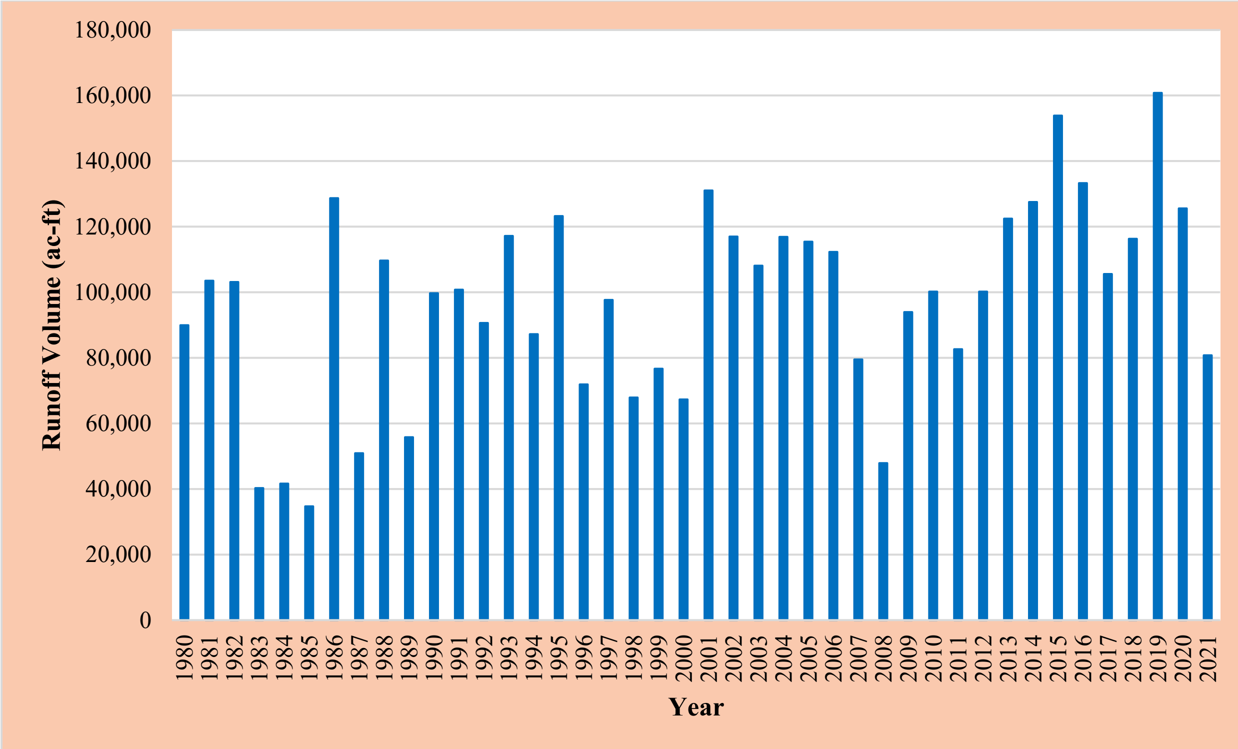


Figure 1: Nuka Basin Yearly Runoff Volume

Table 2: Nuka Basin Yearly Runoff Volume

Year	Runoff (ac-ft)	Year	Runoff (ac-ft)	Year	Runoff (ac-ft)	Year	Runoff (ac-ft)	Year	Runoff (ac-ft)
1980	89,975	1990	99,767	2000	67,270	2010	100,192	2020	125,548
1981	103,505	1991	100,750	2001	131,045	2011	82,594	2021	80,745
1982	103,148	1992	90,615	2002	116,973	2012	100,165		
1983	40,311	1993	117,151	2003	108,119	2013	122,496		
1984	41,684	1994	87,194	2004	116,916	2014	127,509		
1985	34,691	1995	123,263	2005	115,430	2015	153,905		
1986	128,739	1996	71,926	2006	112,279	2016	133,341		
1987	50,949	1997	97,645	2007	79,525	2017	105,564		
1988	109,654	1998	67,885	2008	47,862	2018	116,275		
1989	55,779	1999	76,641	2009	93,992	2019	160,857		

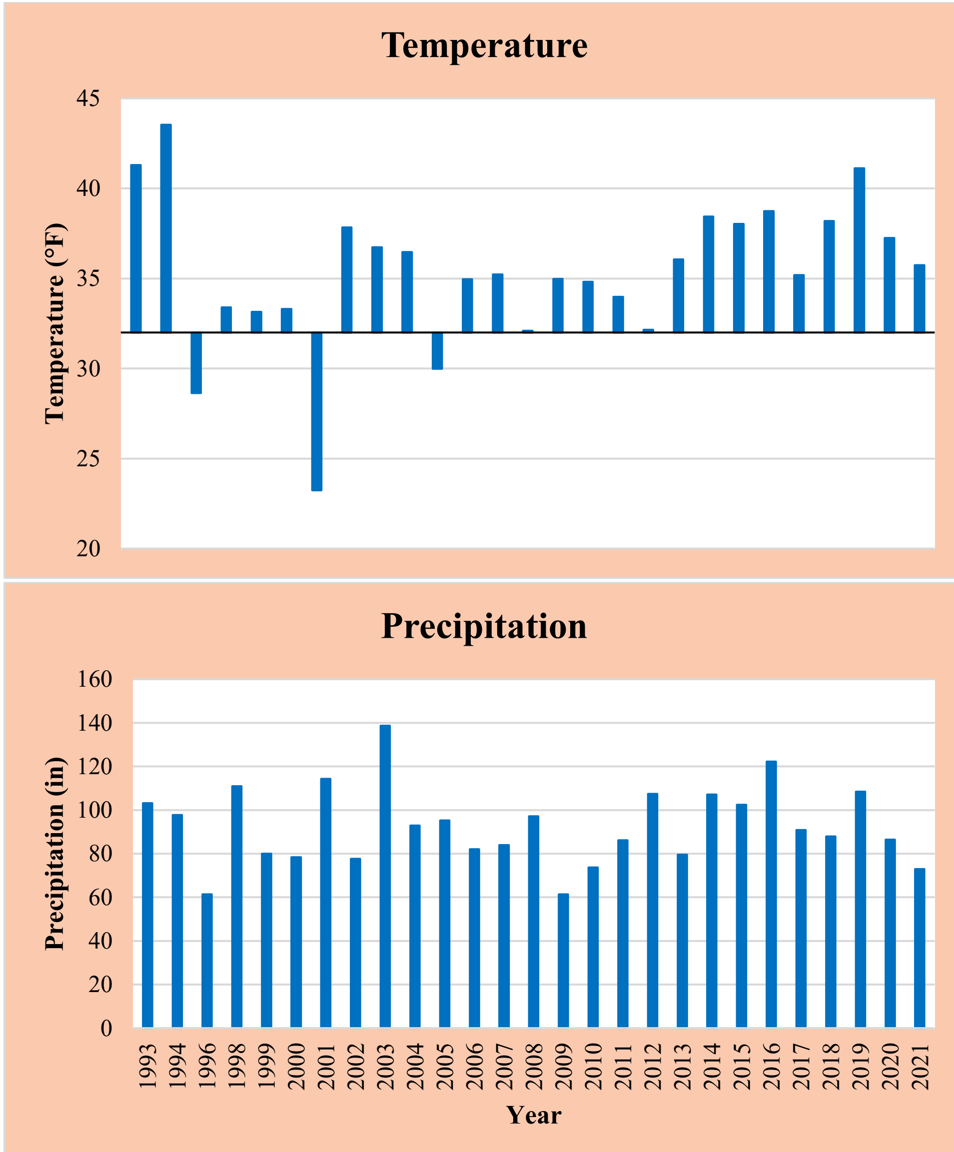


Figure 2: NRCS SNOTEL Site Average Yearly Temperature and Precipitation

To characterize the relationship between precipitation, temperature, and runoff, DOWL performed logarithmic regression of precipitation and temperature to runoff. The correlation coefficient was 0.72 (moderate) using the two variables, with a stronger correlation influence from temperature (0.69 alone) than precipitation (0.24 alone).

DOWL analyzed the Nuka SNOTEL precipitation and temperature data and compared it to the PRISM Normals; Table 3 and Table 4, respectively, present the comparison. To facilitate an accurate comparison, the SNOTEL record was divided into two periods: the years overlapping the PRISM 1981-2010 Normals, followed by the remaining period of record. The spread in PRISM precipitation and temperature across the basin is listed to demonstrate how the PRISM values vary over the elevation range of the Nuka Glacier basin. Review of Table 1 demonstrates that the PRISM Normals correlate well with the measured values at the SNOTE site; hence, the PRISM Normals may be a good indicator of temperature and precipitation for the Dixon Glacier basin.

Table 3: PRISM 1981-2010 Precipitation Normals Comparison to Gage Data at Nuka

Month	PRISM 1981-2010 Normals		SNOTEL Site 1037	
	Precipitation (Basin Avg.) (in.)	Precipitation Range (min-max) (in.)	Precipitation Average 1991-2010 (in.)	Precipitation Average 2011-2021 (in.)
January	8	7 – 10	6	10
February	8	7 – 9	7	6
March	6	5 – 9	6	5
April	8	6 – 10	7	5
May	5	5 – 6	5	5
June	4	4 – 5	4	4
July	5	4 – 7	5	5
August	7	6 – 8	6	8
September	12	11 – 16	11	15
October	13	10 – 18	13	15
November	10	7 – 13	11	9
December	12	9 - 15	11	10
Yearly	98	80 - 126	92	97

Table 4: PRISM 1981-2010 Temperature Normals Comparison to Gage Data at Nuka

Month	PRISM 1981-2010 Normals Over Basin		SNOTEL Site 1037	
	Temperature (°C)	Temperature Range (min – max) (°C)	Temperature Average 1993- 2010 (°C)	Temperature Average 2011- 2021 (°C)
January	-8	-10 – -5	-6	-4
February	-7	-9 – -5	-4	-4
March	-5	-8 – -3	-4	-4
April	-3	-5 – 0	0	0
May	3	0 – 5	3	4
June	6	3 – 9	8	9
July	9	6 – 11	12	12
August	8	6 – 11	12	11
September	4	1 – 7	9	8
October	-2	-5 – 2	2	4
November	-6	-8 – -3	-3	-2
December	-6	-9 – -4	-5	-3
Yearly	0	-3 – 2	2	3

Dixon Transformation

DOWL applied two methods to estimate the runoff rate and volume from the Dixon Glacier basin.

For the first method (area-discharge), a factor was applied to the Nuka streamgage daily record values to transform the Nuka gage measurements to the Dixon Glacier basin. The transformation factor is the ratio of basin areas raised to the area exponent identified in the Alaska Regional Regression Equations for ungagged streams (Curran, et al. 2016); the general form is shown below in Equation 1, and the equation variables are listed in Table 5.

$$\boldsymbol{Q = cArea^{x}Precip^{y}} \tag{1}$$

Table 5: Regression Parameters

Return Interval	c	x	y
2	0.944	0.836	1.023
5	2.47	0.795	0.916
10	4.01	0.775	0.865
50	8.79	0.743	0.787
100	11.4	0.732	0.764

The reduced equation to transform measured flow at the Nuka streamgage to the Dixon Glacier basin is shown as Equation 2. As seen in Table 5, the exponent (x) on the area term decreases with increasing return interval; however, an area exponent of 0.8 was selected to represent "normal" metrological conditions.

$$\boldsymbol{Q_{Dixon} = Q_{Nuka}\left(\frac{Area_{Dixon}}{Area_{Nuka}}\right)^{0.8} = Q_{Nuka}\left(\frac{19.1}{10.7}\right)^{0.8} = 1.6Q_{Nuka}} \tag{2}$$

The second method (water balance method) used to estimate the discharge of the Dixon basin also involves the streamgage data at Nuka, but it also accounts for precipitation.

Comparison of runoff volume (computed from streamflow measurements) from the Nuka Glacier Basin to the measured precipitation depths (depth over area equals volume) demonstrates the yearly average runoff volume is generally significantly greater (by a factor of two on average) than the volume of precipitation (Table 6). While most glacier melt occurs at lower elevations (Sass, et al. 2017) (toe recession), if the melt occurred uniformly over the Nuka glacier, it would account for nearly 71-inches of water per year on average.

Table 6: Nuka Precipitation Versus Runoff Volumes

Average Yearly Precipitation Volume PRISM 2010 Normals (ac-ft)	Average Yearly Runoff Volume (ac-ft)	Average Yearly Runoff in Excess of Precipitation Volume (ac-ft)
55,900	96,500	40,600

DOWL developed an equation (3) relating the computed runoff volume (in inches of runoff) from the Dixon Glacier basin to ratios of runoff volume volumes and average precipitation depths (as derived from PRISM Normals). Equation 3 shows the discharge relationship where P is the average annual precipitation. Table 7 presents the inputs and results of Equation 3.

$$\boldsymbol{Runoff_{Dixon}} = (\boldsymbol{Runoff\ Ratio}) * (\boldsymbol{P_{Nuka\ Gaged}}) * \left(\frac{\boldsymbol{P_{Dixon\ PRISM}}}{\boldsymbol{P_{Nuka\ PRISM}}}\right) \quad (3)$$

Table 7: Dixon Runoff Equation Inputs and Results

Input	Value
Runoff Ratio	2.0
Nuka Gage Average Annual Precipitation (in.)	93
Nuka Basin Average Annual Precipitation (in.) - 2010 Normals	98
Dixon Basin Average Annual Precipitation (in.) - 2010 Normals	104
Result	**Value**
Dixon Runoff Volume (in.)	197
Dixon Runoff Volume (ac-ft)	201,000

As shown in Table 8, the water balance method (method 2) results in estimates that are, on average, approximately 30% greater than estimating runoff based on area alone (method 1).

Table 8: Dixon Glacier Runoff Estimates

Method	Average Yearly Runoff Volume (in.)	Average Yearly Runoff Volume (ac-ft)
Area-Discharge	154	156,000
Water Balance	197	201,000

Dixon Hydrology

DOWL calculated several statistics on the Dixon "gage" data built from the two transform methods of the Nuka Glacier Basin gage data, a record of average daily streamflow for 30-years. Attachment 2 presents these analyses. Upon review of the data, the primary discharge months are from May through November (Figure 3), with the remainder of the year having little to no measurable flow.

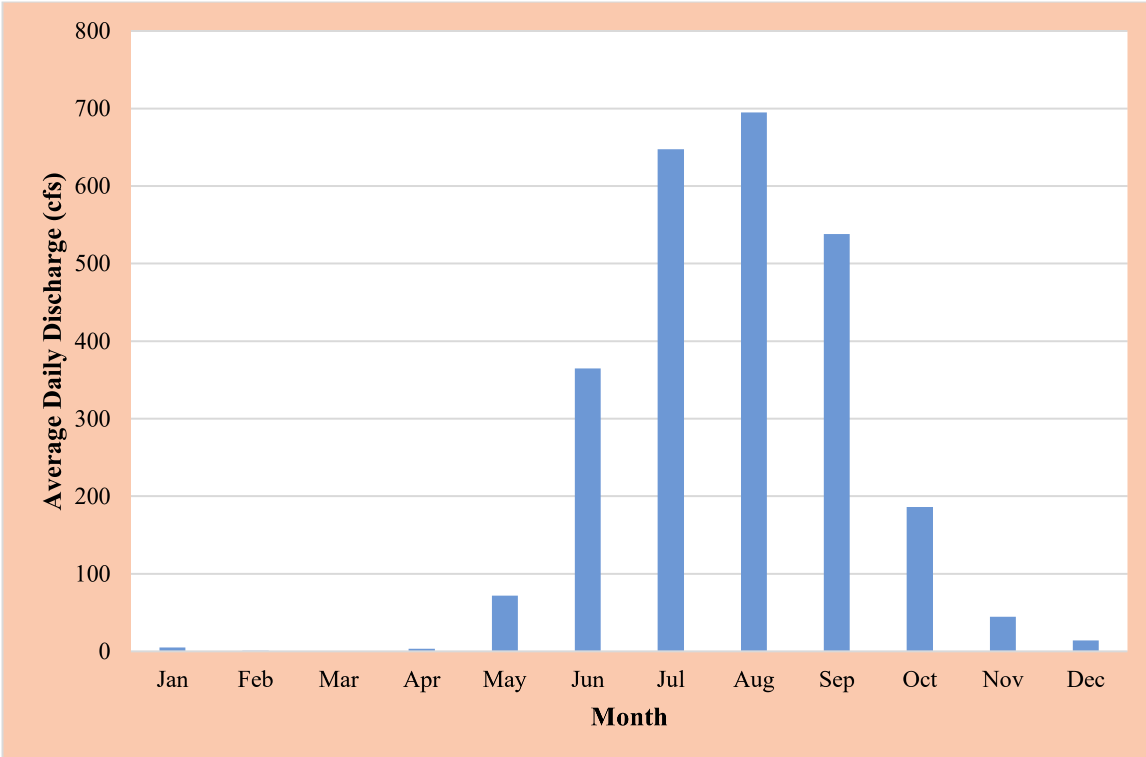


Figure 3: Dixon Glacier Basin – Estimated Average Flow Rate by Month

The probability that a flow rate occurs during the year helps determine the inflows expected by a hydraulic structure. Dixon glacier percent exceedance curves are shown in Figure 4 with tabulated values also in Attachment 2.

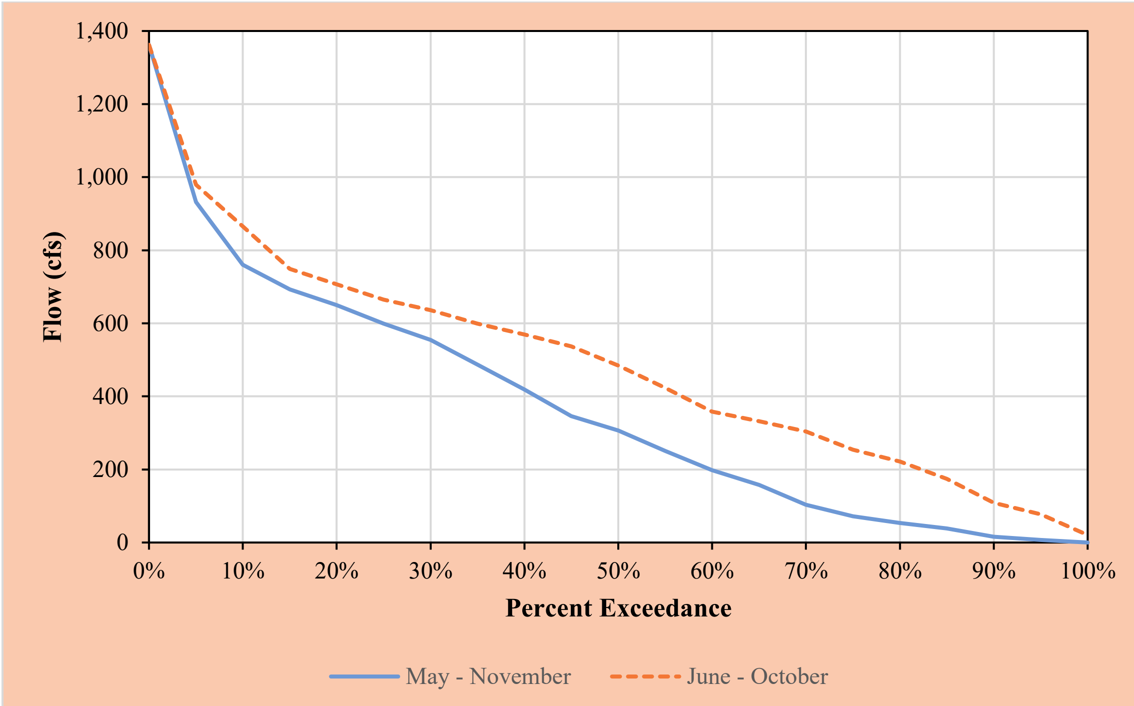


Figure 4: Dixon Glacier Basin – Estimated Flow Rate Exceedance Curves (Area Method)

Below, **Error! Reference source not found.** displays the variability in the Dixon Glacier Basin estimates using the two methods. The water balance method consistently estimates more discharge than the area method.

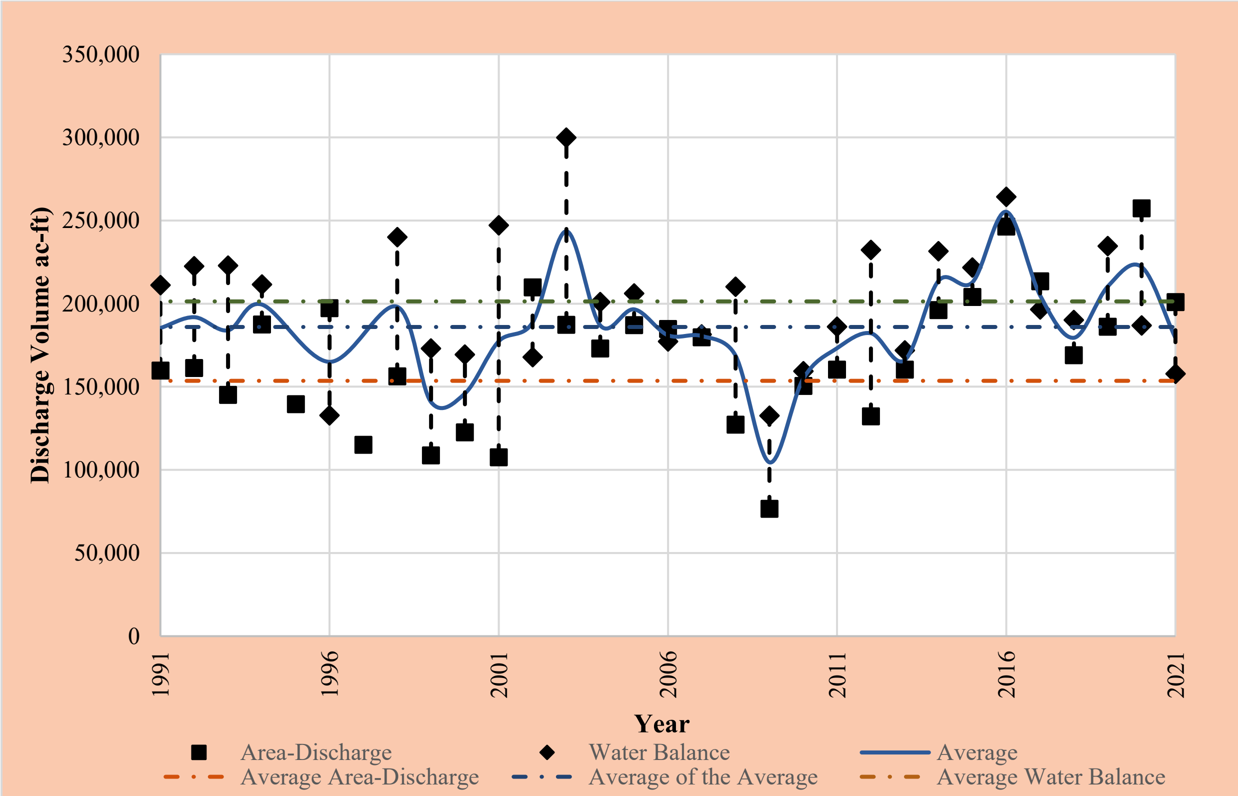


Figure 5: Dixon Discharge Method Comparison

The results of the Dixon Basin Hydrologic study are presented in Table 9. Table 9 begins with the distribution of the yearly discharge volume in percent. This is the same distribution as seen in Figure 3. The area method (method 1) for estimating the Dixon Glacier Basin discharge volumes serves as a lower (minimum) bound, while the water balance method (method 2) serves as a reasonable upper (maximum) bound of the estimated discharges. The average of the two methods is the expected discharge volume of the Dixon Glacier Basin.

Other statistics calculated include diverted volumes by month given different diversion flow rates and minimum instream flow requirements particular to specific design alternatives (Attachment 2). Also included are the statistics of the discharge distribution.

Table 9: Average Discharge – Monthly Runoff Volumes

Month	Yearly Distribution	Discharge Volume (ac-ft)		
		Minimum	Expected	Maximum
January	0.21%	290	360	430
February	0.06%	80	100	120
March	0.04%	40	60	80
April	0.11%	210	220	230
May	2.71%	4,300	4,900	5,400
June	13.98%	21,600	24,800	28,000
July	25.52%	39,900	45,600	51,000
August	27.58%	42,900	49,200	55,000
September	20.77%	32,400	37,100	42,000
October	6.91%	11,300	12,600	14,000
November	1.59%	2,600	2,900	3,200
December	0.50%	880	940	1,000
Average Annual	100.00%	156,000	179,000	201,000

References

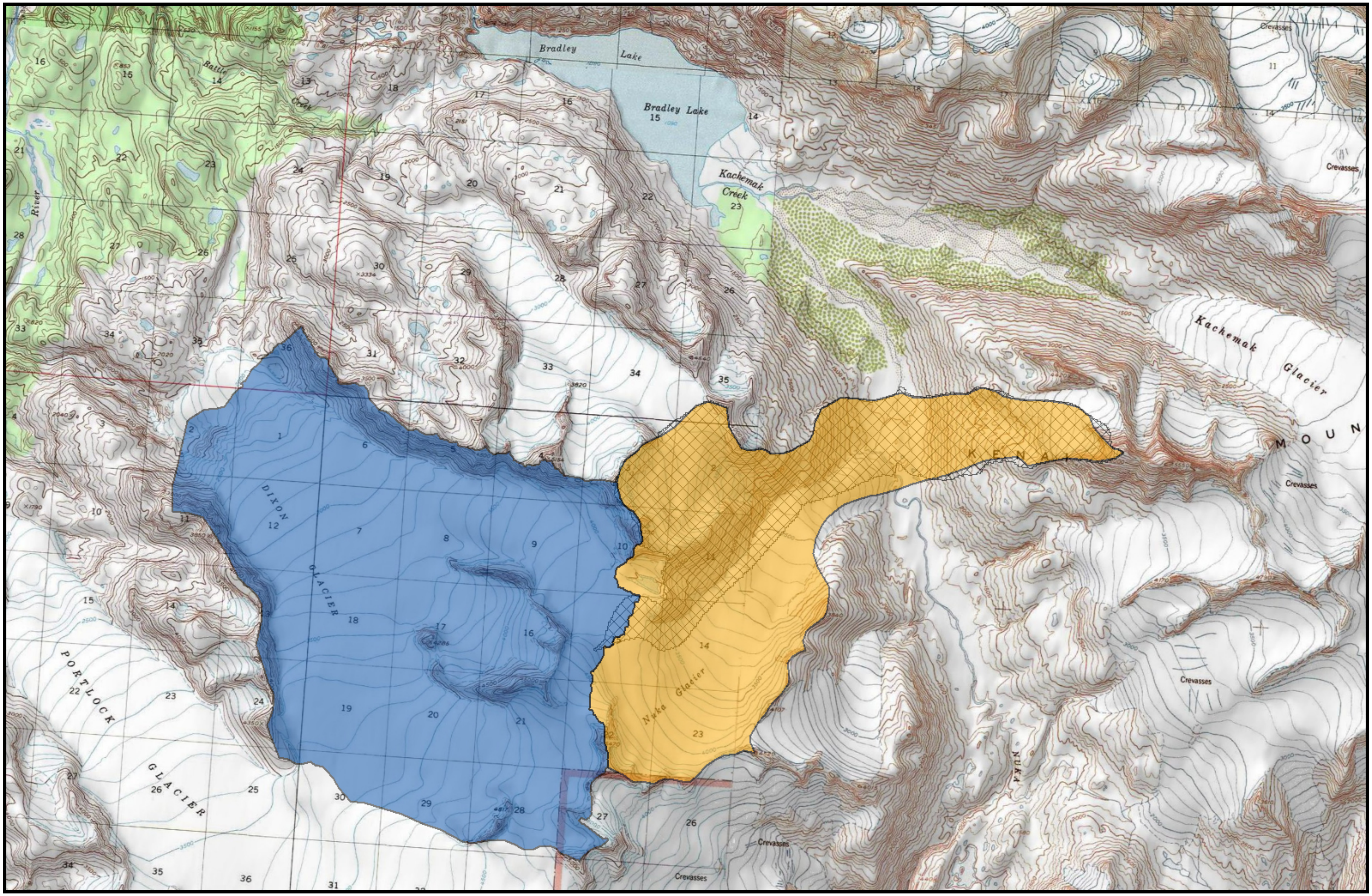
Curran, Janet H., Nancy A. Barth, Andrea G. Veilleux, and Robert T. Ourso. 2016. *Estimating flood magnitude and frequency at gaged and ungaged sites on streams in Alaska and conterminous basins in Canada, based on data through water year 2012.* Scientific Investigations Report 2016-5024, U.S. Geological Survey.

Daly, Christopher, Joseph Smith, and Michael Halbeib. 2018. *1981-2010 High Resolution Temperature and Precipitation Maps for Alaska.* Final Report, Corvallis, Oregon: PRISM Climate Group, Oregon State University.

Gibson, Wayne. 2009. *Mean Precipitation for Alaska 1971-2000.* National Park Service, Alaska Regional Office GIS Team.

Sass, Louis C., Michael G. Loso, Jason Geck, Evan E. Thoms, and Daniel Mcgrath. 2017. "Geometry, mass balance and thinning at Eklutna Glacier, Alaska: an altitude-mass-balance feedback with implications for water resources." *Journal of Glaciology.*

Attachment 1: Basin Delineations



Legend

- Dixon Glacier Basin
- Nuka Glacier Basin
- Nuka StreamStats Generated

0 1 2 Miles

N W E S

DIXON GLACIER
HYDROLOGIC ESTIMATES
NUKA GAGE FACTOR
WATERSHED DELINEATION

Page 1 of 1

January 2022

DOWL

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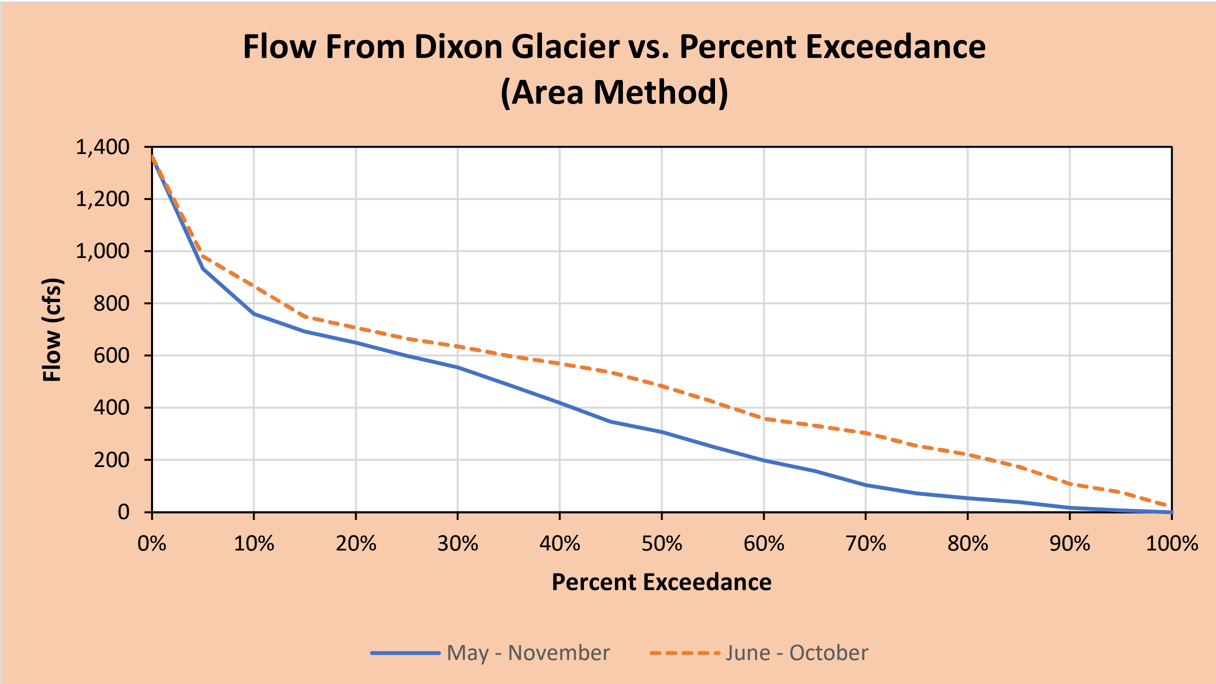
Attachment 2: Hydrologic Statistics



May - November					
Exceedance	**Flow (cfs)**	**Exceedance**	**Flow (cfs)**	**Exceedance**	**Flow (cfs)**
0%	1,362	35%	487	70%	103
5%	932	40%	418	75%	72
10%	760	45%	346	80%	53
15%	692	50%	307	85%	39
20%	649	55%	251	90%	16
25%	599	60%	198	95%	7
30%	555	65%	158	100%	0

June - October					
Exceedance	**Flow (cfs)**	**Exceedance**	**Flow (cfs)**	**Exceedance**	**Flow (cfs)**
0%	1,362	35%	599	70%	254
5%	980	40%	570	75%	205
10%	866	45%	526	80%	168
15%	749	50%	474	85%	100
20%	707	55%	416	90%	51
25%	665	60%	339	95%	12
30%	635	65%	307	100%	0

	Average Monthly Volume (ac-ft) - Area Method									
	400-cfs Diversion		600-cfs Diversion		800-cfs Diversion		1,000-cfs Diversion		1,200-cfs Diversion	
	Diverted	Bypassed	Diverted	Bypassed	Diverted	Bypassed	Diverted	Bypassed	Diverted	Bypassed
May	4,200	180	4,300	90	4,400	50	4,400	40	4,400	20
June	17,200	4,500	19,900	1,800	21,000	700	21,400	300	21,600	100
July	23,100	16,700	31,300	8,500	35,800	4,000	37,900	1,900	38,800	1,000
August	23,200	19,600	31,700	11,000	36,700	6,100	39,100	3,600	40,500	2,200
September	18,400	13,600	23,200	8,800	26,200	5,900	27,900	4,100	29,000	3,000
October	8,100	3,400	9,200	2,300	9,900	1,600	10,300	1,100	10,700	800
November	2,400	210	2,600	90	2,600	50	2,600	30	2,600	20
Total	96,600	58,190	122,200	32,580	136,600	18,400	143,600	11,070	147,600	7,140

	Average Monthly Volume (ac-ft) - Water Balance Method									
	400-cfs Diversion		600-cfs Diversion		800-cfs Diversion		1,000-cfs Diversion		1,200-cfs Diversion	
	Diverted	Bypassed	Diverted	Bypassed	Diverted	Bypassed	Diverted	Bypassed	Diverted	Bypassed
May	5,400	0	5,400	0	5,400	0	5,400	0	5,400	0
June	22,100	6,000	27,100	1,000	28,100	0	28,100	0	28,100	0
July	24,600	26,700	36,900	14,400	48,300	3,000	51,300	0	51,300	0
August	24,600	30,900	36,900	18,600	48,800	6,600	55,200	200	55,500	0
September	23,800	18,000	33,600	8,200	40,900	900	41,800	0	41,800	0
October	13,600	300	13,900	0	13,900	0	13,900	0	13,900	0
November	3,200	0	3,200	0	3,200	0	3,200	0	3,200	0
Total	117,400	81,900	157,000	42,200	188,700	10,500	199,000	200	199,200	0

	Annual Average Monthly Volume (ac-ft)					
	To Bradley Lake		To Martin Power Plant (800-cfs max. flow)		To Martin Power Plant (1,000-cfs max. flow)	
Martin River MIF	100-cfs		5-cfs		5-cfs	
	Area	Water Balance	Area	Water Balance	Area	Water Balance
May	1,800	1,100	4,100	5,137	4,200	5,100
June	16,000	22,200	20,700	27,800	21,100	27,800
July	33,700	45,200	35,600	48,200	37,600	51,000
August	36,600	49,300	36,500	48,800	38,800	55,000
September	26,300	35,800	25,900	40,700	27,700	41,500
October	6,900	7,800	9,200	13,600	9,700	13,600
November	900	0	2,200	2,900	2,200	2,900
Avg. Annual	**122,200**	**161,000**	**134,200**	**187,000**	**141,300**	**197,000**

	Dixon Glacier Basin Runoff Volume Statistics (ac-ft) (Area Method)			
	Minimum	Average	Maximum	Standard Deviation
January	0	300	2,030	450
February	0	80	430	130
March	0	40	640	110
April	0	210	2,440	470
May	0	4,410	20,490	4,570
June	8,990	21,720	43,560	8,390
July	10,440	39,810	80,950	15,210
August	13,050	42,740	73,530	13,760
September	6,010	32,030	81,060	16,000
October	1,270	11,460	33,240	8,760
November	130	2,650	18,580	3,580
December	0	870	6,740	1,540
Annual	35,400	153,000	257,400	50,700

Appendix C: Concept Development – Tunnels

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MEMORANDUM

TO:	Jason Thom, PE	**DATE:**	May 11, 2022
COMPANY:	DOWL	**SUBJECT:**	Tunnel Concept Development
ADDRESS:	222 N. 32nd Street, Suite 700 Billings, MT 59101	**PROJECT NAME/NO.:**	Bradley Dixon Diversion Study 21C31023.000
FROM:	Steve Brandon, PE	**CC:**	Tom Fitzgerald, PE

1.0 BACKGROUND

A review of existing data from the original Bradley Lake Hydroelectric Power Project (Project) was performed for this Conceptual Study (Study) with respect to the power tunnel options under consideration by the Alaska Energy Authority (AEA). Additionally, geologic and geotechnical information from the recent West Fork Upper Battle Creek Diversion Project were also reviewed. In this study there are two tunnel options to divert and convey runoff from the Dixon Glacier. One option includes conveying the runoff to the existing Bradley Lake Reservoir, and the second option is a tunnel leading to a new powerplant near tidewater on the Martin River. Both tunnel options include a common Diversion Dam, which would divert glacial runoff to an intake structure. The two options under consideration are referred to as the Dixon-Martin and Dixon-Bradley Alternatives.

2.0 GEOLOGIC CONDITIONS

The anticipated geologic conditions for the two tunnel alternatives are reasonably well known for this conceptual level design and cost estimate. The Project lies within the Kenai-Chugach Mountains physiographic province and is characterized by complex deformation and folding which has imparted an overall north to northeast trending foliation with a near vertical dip[1]. In general, the bedrock geology along both tunnel alignments is composed of graywacke, argillite, and cherty argillite; all of these rock types have been altered by varying degrees of metamorphism. As noted in historic reporting by Stone & Webster Engineering Corporation (SWEC)[2], individual lithologic units are typically discontinuous over short distances due to the complex folding of the region. Subsequently, projection of lithologic units and rockmass properties vertically into the subsurface from surface exposures are challenging at this project site.

SENT VIA:	☐	First Class Mail	☐	Overnight Service	☒	Email	☐	Other

A significant effort was made by SWEC and their geotechnical consultants toward geologic mapping and logging of boreholes in order to characterize the Project geology along the tunnel alignment. A review of SWEC reports, including consultant review board findings, indicated a strong emphasis on accurately characterizing the differences between the graywacke and argillite which may exhibit a similar visual appearance. The distinction between these rock types plays an important role in tunnel construction cost and productivity estimates as the hardness of these geologies is significantly different and will affect the penetration rate of a tunnel boring machine (TBM). The recommendations developed by SWEC and the consultant review boards from the original Project should be incorporated as part of the exploration and design phases of the future Bradley Lake expansion. A summary of some of these findings and recommendations include:

- Continuous field mapping along the power tunnel alignment was recommended to get an indication of the percentage of different lithologies which will be encountered by the tunnel. The rate of progress will be sensitive to the type of rock encountered by the TBM. The hardness values for the various rock types varies widely, therefore, any estimate of average tunneling progress is highly dependent on the percentage of each rock type encountered. It is imperative that the rock outcrops in the field be consistently described lithologically so that core samples collected during the field investigation can accurately be correlated to laboratory testing for hardness.
- Previous field mapping at the Bradley Lake site was not found to be ambiguous for rock types designated as graywacke, massive chert or foliated argillite. However, previous field descriptions of “massive” argillite, a very hard and siliceous rock, was recommended to be described as a very fine-grained graywacke. For these borderline materials described as fine-grained greywacke, the following guidelines were recommended:

Graywacke	Greater than 75% graywacke, less than 25% argillite
Argillite	Greater than 75% argillite, less than 25% graywacke
Chert	Massive chert
Argillite w/chert nodules	Describe % of chert
Dacite	100% dacite

- Run tests on representative samples of the various rock types. The tests should include Schmidt Hammer Hardness, Abrasion Hardness and Shore Hardness.

Information provided in two reports by SWEC[2,3] described the anticipated geologic conditions for the original Project power tunnel. The alignment of the approximately 18,000-foot long tunnel had it passing through two faults known as the Bull Moose Fault Zone and the Bradley River Fault Zone. Both of these features are high-angle (sub-vertical) strike-slip faults which trend N 5° E to N 20° E. The alignment for the Dixon-Martin Alternative trends nearly parallel to the original Project tunnel, and as a result, the Dixon-Martin Alternative is also expected to encounter both the Bull Moose and Bradley River Fault Zones. The Bradley River Fault Zone is designated as lineament ‘D’ and the Bull Moose Fault Zone is designated as lineament ‘E’ in Sheet G-4 of the conceptual study drawing set. The Dixon-Bradley Alternative is anticipated to cross at least one unnamed fault/shear zone based on fault mapping from R&M[1], see G-4.

3.0 DESIGN CONSIDERATIONS

The tunnel options in this Study include two alternatives:

Dixon-Martin Alternative

- The Dixon-Martin tunnel is a pressure tunnel which includes an approximately 12-foot (excavated) diameter x 700-foot deep vertical shaft (Figure 2). It is assumed that the vertical shaft will be concrete lined creating a 10-foot finished inside diameter. The intake structure is located in proximity to the foot of the Dixon Glacier, the shaft intake is planned at approximately EL. 1,263 and the base of the shaft is located at approximately EL 563. The conduit will make a 90-degree elbow and transition to the main power tunnel conduit. The outlet will be a penstock leading to a new powerhouse adjacent to the Martin River, the downstream tunnel outlet is planned at EL. 300. The tunnel is planned as a 10-foot ID pressure conduit constructed by a 12-foot diameter TBM. The total length of the tunnel is estimated at 14,750-feet long and would be driven on an approximate 1.67% grade.

Dixon-Bradley Alternative

- The Dixon-Bradley tunnel is an approximate 24,500-foot long, non-pressure conveyance tunnel. The intake and outlet portals will be constructed by conventional drill-blast methods. The intake structure is located in proximity to the Dixon Glacier, with an invert at EL. 1,276. The outlet structure is in proximity to the Bradley Reservoir and planned at EL. 1,200. The tunnel is planned as an unlined conduit with 12-foot diameter TBM on an approximate 0.3% grade.

Analyses made in the original Project conceptual design are relevant to the tunnel design for the current study. Of particular interest is the Dixon-Martin Alternative tunnel lining at the downstream end of the structure. Criteria were established for determining the location where a transition from a steel liner to concrete liner is located. The transition point is based on the depth of overhead rock cover in the tunnel to withstand the internal pressure in the pipe from causing hydrofracturing in the surrounding rock. The tie-in point from steel to concrete liner is located at a point where the overhead rock cover decreases to approximately 80% of the maximum normal static head. The same criterion was used in this assessment to estimate the length of steel-lined tunnel for the Dixon-Martin Alternative.

4.0 CONSTRUCTION CONSIDERATIONS

Tunnel

- We anticipate that for either tunnel Alternative the most competitive construction bids will come from contractors using a TBM to construct the tunnel. Although TBM’s have considerably more mobilization and set-up considerations over drill-blast tunnel construction, TBM’s typically provide much higher advance rates for long tunnels verses drill-blast. Additionally, the original Project power tunnel was successfully constructed by a TBM of similar size in the same geology.

- A geologic exploration should be performed to define the extent and nature of the known fault zones previously described. In particular, an assessment of the anticipated geologic conditions will be required for design of ground support from both a temporary/construction aspect as well as permanent reinforced concrete liners. Additionally, an assessment of the anticipated groundwater conditions in or near the faults will be a focus for determining potential inflow to the tunnels and shaft during construction.

- The hardness and abrasivity of the various rock types will be a key component of the laboratory testing during the geotechnical investigation and assessment. Some laboratory data exists from the original Project which will be helpful as a starting point for making penetration rate and cutter wear predictions for the TBM in the future expansion design effort.

Shaft

- The Dixon-Martin Alternative is planned to have a vertical shaft approximately 700-ft deep as part of the intake structure. The shaft collar will be in proximity to the Dixon Glacier and a new Diversion Dam for this project.

- Shaft construction can be accomplished by two primary methods: conventional top-down using drill-blast from the ground surface, or bottom-up construction using either a raise-bore drill or the Alimak method. A top-down approach for a 12-foot diameter (excavated) shaft is a straightforward approach which is achievable in this geology. However, given the logistics of establishing a hoist/crane system for personnel and equipment access, as well as muck removal, at the site would pose challenging constructability and cost issues. Given the seasonal nature of construction at Bradley Lake and all that would be required to establish a shaft sinking operation on top of the mountain, we think it is very unlikely this would be a preferred method by contractors bidding the project.

- More likely options for the shaft construction would be a mechanical raise-bore or drill-blast using the Alimak method.

  - A raise-bore is well suited for this project, it would require mobilizing the raise hydraulic unit and associated drill pipe string to the shaft collar. It is conceivable that a 12-foot diameter raise-bore could be constructed in a single pass, however a two-pass raise may be preferred by some contractors based on their equipment and experience. The same access road constructed to build the Diversion Dam and Diversion Structure would be utilized to mobilize the raise-bore equipment and mining personnel to construct the shaft.
  - The Alimak method is a bottom-up drill-blast method which utilizes a drilling platform that advances its way from the base of the shaft upwards. After each round of drilling and blasting a section of track is secured to the wall of the shaft, the drilling platform raises and lowers itself via a rack and pinion assembly attached to the track. This is a very common method of shaft construction in the mining industry and has been adopted for similar shaft construction for hydropower facilities.

Portals

- Portal construction for either of the tunnel Alternatives would be constructed by conventional drill-blast construction techniques using crawler-mounted drills.

5.0 SUMMARY OF PROPOSED CONSTRUCTION ALTERNATIVES

Dixon-Martin

- The Dixon-Martin Alterative will be a pressure tunnel with its entire length lined, including the shaft. It was assumed that the tunnel and shaft will have a 10-foot ID with a 1-foot thick concrete liner. The total length of the tunnel is estimated at 14,750-feet long and would be driven on an approximate 1.67% grade. The tunnel would be constructed using a 12-foot diameter hard rock TBM. A starter tunnel constructed by drill-blast will be constructed from the outlet portal adjacent to the future Martin powerplant. The length of the starter tunnel will be determined once geologic information is gathered from the geotechnical exploration, which will focus on rock quality and depth of weathering near the outlet portal. The starter tunnel is anticipated to be straightleg horseshoe with approximate dimensions of 14-feet high x 16-feet wide. The terrain at the outlet portal is relatively flat over the initial 150-feet to 200-feet of the proposed tunnel alignment, which may be an indication of either weathered and/or poorer quality rock. The length of the starter tunnel is a function of the rock quality and the ability of the TBM gripper pads to attain adequate bearing capacity to launch the machine. For purposes of this assessment the TBM starter tunnel is estimated to be 250-feet long.
- Lining of the tunnel will be a combination of unreinforced concrete, reinforced concrete and a steel liner. Observations during construction of both the tunnel and shaft will identify zones of poor rock quality. During the design phase, criteria will be developed to quantity differing categories of rock quality and corresponding structural (reinforcement) design for the liner in zones of poor-quality ground.

    - As described previously, the Dixon-Martin Alternative is anticipated to cross the Bull Moose Fault Zone and Bradley River Fault Zone as encountered by the power conduit in the original Project. We anticipate the tunnel liner through these fault zones will include reinforced concrete. For estimating purposes we assumed 1,200-feet of reinforced concrete lining in fault zones.
    - The 250-foot long TBM starter tunnel will be finished with a combination of steel liner, concrete backfill around the liner and possibly steel set or shotcrete support installed as ground support during the initial driving of the tunnel.
    - Due to the low rock cover for a significant portion of the downstream end of the tunnel, a steel liner will be installed to withstand the internal pressure in the pipe from causing hydrofracturing in the surrounding rock. Following on from the criteria established in the original Project, a steel liner was assumed when rock cover decreases to approximately 80% of the maximum normal static head, the steel liner for this Study is estimated to be approximately 6,100-feet long (includes the 250-feet of the starter tunnel).
    - The balance of 7,955-feet (tunnel and shaft) is estimated to be lined with a 1-foot thick unreinforced concrete liner.

- A short, undefined length, of drill-blast excavation will be required to construct the 90-degree elbow at the junction of the tunnel and shaft.
- Shaft construction considerations have been previously described. Regardless of which of the two shaft construction methods are used, the excavation and lining of the shaft can

only be completed after the full length of the tunnel is excavated and the TBM withdrawn from the tunnel. If the raise-bore option of shaft construction is selected, the pilot hole for the raise could be drilled concurrent with TBM construction, pulling the raise would still require waiting for the TBM to be removed.

Dixon-Bradley

- The Dixon-Bradley Alternative will be a non-pressure tunnel with a reinforced concrete liner installed in discrete zones of poor-quality ground to provide long-term support of the tunnel. The tunnel is planned as a 12-foot ID conduit to convey water from the Dixon Glacier to the Bradley Reservoir. The total length of the tunnel is estimated at 24,500-feet and would be driven on an approximate 0.3% grade. The tunnel would be constructed using a 12-foot diameter hard rock TBM. A starter tunnel constructed by drill-blast will be constructed from the outlet portal adjacent to the Bradley Reservoir. The length of the starter tunnel will be determined once geologic information is gathered from the geotechnical exploration, which will focus on rock quality and depth of weathering near the outlet portal. The starter tunnel is anticipated to be straightleg horseshoe with approximate dimensions of 14-feet high x 16-feet wide. The terrain at the outlet portal is relatively flat over the initial 150-feet of the proposed tunnel alignment which may be an indication of either weathered and/or poorer quality rock. The length of the starter tunnel is a function of the rock quality and the ability the TBM gripper pads to attain adequate bearing capacity to launch the machine. For purposes of this assessment the TBM starter tunnel is estimated to be 150-feet long. Due to low rock cover at the inlet portal we have assumed a 50-foot long reception tunnel (12-foot straightleg horseshoe) driven by drill-blast to provide a stable condition for the termination of the TBM bore.

- Lining of the tunnel will be a combination of reinforced concrete and shotcrete/rockbolts. Observations during construction of the tunnel will identify zones requiring permanent support. During the design phase, criteria will be developed to quantity differing categories of rock quality and corresponding structural (reinforcement) design for the liner in zones of poorer quality ground.
    - As previously described, based on previous geologic interpretation of fault traces for the Battle Creek Diversion project a fault zone is anticipated to be encountered near the downstream end of the tunnel. For estimating purposes, we have assumed 1,400-feet of full perimeter reinforced concrete lining for crossing fault zones.
    - The anticipated support in poor-quality rock zones for support of the tunnel arch is a combination of rockbolts and/or shotcrete, for estimating purposes we have estimated 1,080-feet of the tunnel will required this type of support.
    - To provide long-term support, we have assumed a total of 100-feet of reinforced concrete lining due to low rock cover at both portals in the TBM starter and reception sections of the tunnel.

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[1] R&M Consultants, Inc., "*Final Draft Submittal: Bradley Lake Hydroelectric Project, FERC P-8221-AK, Battle Creek Diversion Geotechnical Report",* September 2013.
[2] Stone & Webster Engineering Corporation, "*Feasibility Study Volume 1 Report, Bradley Lake Hydroelectric Project"*, October 1983.
[3] Stone & Webster Engineering Corporation, "*Final Supporting Design Report - General Civil Construction Contract, Bradley Lake Hydroelectric Project", March 1988.*

Appendix F: Cost Estimates

Alaska Energy Association - Dixon Diversion Project
Conceptual Cost Estimate
2022 Costs

		Dixon-Martin Alt			Dixon-Bradley Alt		
Element	**Element Cost**	**Bradley Dam 7-ft Raise**	**Bradley Dam 14-ft Raise**	**Bradley Dam 28-ft Raise**	**Bradley Dam 7-ft Raise**	**Bradley Dam 14-ft Raise**	**Bradley Dam 28-ft Raise**
General Site Improvements	$41,926,000	$41,926,000	$41,926,000	$41,926,000	$41,926,000	$41,926,000	$41,926,000
Dixon Intake Access Road	$39,249,000	$39,249,000	$39,249,000	$39,249,000	$39,249,000	$39,249,000	$39,249,000
Martin Powerplant Access Road	$20,500,000	$20,500,000	$20,500,000	$20,500,000			
DM Shaft Intake and Diversion Dam	$13,018,000	$13,018,000	$13,018,000	$13,018,000			
DB Tunnel Intake and Diversion Dam	$13,018,000				$13,018,000	$13,018,000	$13,018,000
Dixon-Martin Shaft & Tunnel	$242,568,000	$242,568,000	$242,568,000	$242,568,000			
Martin Powerplant	$92,779,000	$92,779,000	$92,779,000	$92,779,000			
Martin Transmission Line	$12,325,000	$12,325,000	$12,325,000	$12,325,000			
Dixon-Bradley Tunnel w/Outfall	$239,969,000				$239,969,000	$239,969,000	$239,969,000
Bradley Dam Raise (28-ft Pool Raise)	$94,703,000			$94,703,000			$94,703,000
Bradley Dam Raise (14-ft Pool Raise)	$29,081,000		$29,081,000			$29,081,000	
Bradley Spillway Gates (7-ft Pool Raise)	$4,109,000	$4,109,000			$4,109,000		
Construction Cost		**$466,474,000**	**$491,446,000**	**$557,068,000**	**$338,271,000**	**$363,243,000**	**$428,865,000**
FERC Licensing		$5,000,000	$5,000,000	$5,000,000	$7,500,000	$7,500,000	$7,500,000
Geologic & Hydrologic Studies	$5,000,000	$5,000,000	$5,000,000	$5,000,000	$5,000,000	$5,000,000	$5,000,000
Feasibility Design	3.00%	$13,994,000	$14,743,000	$16,712,000	$10,148,000	$10,897,000	$12,866,000
Final Design	4.00%	$18,659,000	$19,658,000	$22,283,000	$13,531,000	$14,530,000	$17,155,000
Construction Administration	4.00%	$18,659,000	$19,658,000	$22,283,000	$13,531,000	$14,530,000	$17,155,000
Subtotal Administration & Engineering		**$61,312,000**	**$64,059,000**	**$71,278,000**	**$49,710,000**	**$52,457,000**	**$59,676,000**
Total Cost		**$527,786,000**	**$555,505,000**	**$628,346,000**	**$387,981,000**	**$415,700,000**	**$488,541,000**
Costs include appx. 40% allowance for Unlisted Items; Mobilization, Bonds, Taxes & Insurance; and Contingencies within each Element.							

Dixon Intake Project

Cost Basis Notes – Hertel:

General Site Improvements

- *Mobilizations, Precon Activities, Housing* - Referenced total amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $13,259,508, plus 25% added for escalation from 2018 to 2022. WFUBCD bid was based on two construction seasons and included two seasonal mobilizations, two seasons of man camp facilities, and some initial staging improvements and environmental compliance measures. Depending on the final configuration of the Dixon project, the construction schedule could anticipate more than two seasons, resulting in higher costs in this category.
- *Port and Gen Access Improvements - Scope* is undefined, but the cost anticipates an allowance to include dock, airfield, and staging area upgrades.
- *Establish Offices and Permanent Facilities* - Scope is undefined, but the cost anticipates an allowance for establishing permanent offices and living quarters for use during construction and retained for future operations.

Dixon Intake Access Road

- *Clear and Grub* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $17,094 per Acre, plus 25% added for escalation from 2018 to 2022. Clearing quantity averages 80 feet of cleared corridor width.
- *Lower Dixon Road* - Referenced total amount of WFUBCD, Lower Access Road, Average Bid Prices, excluding the high and low bids. This cost is $440 per LF of constructed road, plus 25% added for escalation from 2018 to 2022. The Lower Dixon Road is assumed to be similar in construction approach and cost to the WFUBCD Lower Access Road.
- *Upper Dixon Road (Less Difficult Areas*) - Referenced total amount of WFUBCD, Lower Access Road , Average Bid Prices, excluding the high and low bids. This cost is $440 per LF of constructed road, plus 25% added for escalation from 2018 to 2022. Most of the Upper Dixon Road is assumed to be similar in construction approach and cost to the WFUBCD Lower Access Road.
- *Upper Dixon Road (More Difficult)* - Referenced total amount of WFUBCD, Upper Access Road , Average Bid Prices, excluding the high and low bids. This cost is $973 per LF of constructed road, plus 25% added for escalation from 2018 to 2022. About 25% of the Upper Dixon Road is assumed to be similar in construction approach and cost to the WFUBCD Upper Access Road.
- *Electrical & Communications* - Referenced total amount of WFUBCD, Power and Communications, Upper and Lower, Average Bid Prices, excluding the high and low bids. This cost is $118 per LF of communications, plus 25% added for escalation from 2018 to 2022. Construction of the buried conduit and cable is assumed to be similar to the WFUBCD project.

Martin Power Plant Access Road

- *Clear and Grub* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $17,094 per Acre, plus 25% added for escalation from 2018 to 2022. Clearing quantity averages 80 feet of cleared corridor width.
- *Martin Plant Access Road* - Referenced total amount of WFUBCD, Lower Access Road, Average Bid Prices, excluding the high and low bids. This cost is $440 per LF of constructed road, plus 25% added for escalation from 2018 to 2022. The Martin Plant Access Road is assumed to be similar in construction approach and cost to the WFUBCD Lower Access Road.
- *Electrical & Communications* - Referenced total amount of WFUBCD, Power and Communications, Upper and Lower, Average Bid Prices, excluding the high and low bids. This cost is $118 per LF of communications, plus 25% added for escalation from 2018 to 2022. Construction of the buried conduit and cable is assumed to be similar to that of the WFUBCD project.

Dixon Martin Shaft Intake and Diversion Dam

- *Site Improvements* – The cost represents an allowance for an adequate crew to develop localized access for the various features.
- *D-M Shaft Intake Foundation/Grout/Water Control* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 825,000, plus 25% added for escalation from 2018 to 2022. Costs include similar activities of water control and foundation improvements.
- *D-M Shaft Intake Structure Concrete* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost of concrete structures at the Dixon Diversion are envisioned as similar to the diversion structure at WFUBCD.
- *Diversion Dam Foundation/Grout/Water Control* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 825,000, plus 25% added for escalation from 2018 to 2022. Costs include similar activities of water control and foundation improvements.
- *Diversion Dam Structure Concrete* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost of concrete structures at the Dixon Diversion are envisioned as similar to the diversion structure at WFUBCD.
- *Sediment Diversion Dam* – The cost represents an allowance for an adequate crew to construct the sediment diversion dam, likely from localized excavated materials or from structure or shaft excavation. Some material sizing may be required.

- *Slide Gates with Trashracks* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 120,000 per installed gate, plus 25% added for escalation from 2018 to 2022.
- *Structure Excavation and Backfill* – The cost represents an allowance for an adequate crew to spend adequate time in excavating and backfilling concrete structures, likely from localized excavated materials or from structure or shaft excavation. Some material sizing will be required and is anticipated.
- *SCADA & Instrumentation* – Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost represents $126,000 for Diversion and Intake Electrical Power and Controls (WFUBCD) and $273,000 for SCADA Programming and Commissioning (WFUBCD), plus 25% added for escalation from 2018 to 2022. Costs for SCADA and Instrumentation at the Dixon-Martin Shaft Intake are thought to be similar to those at WFUBCD.

Dixon Martin Shaft Intake and Diversion Dam

- *Site Improvements* – The cost represents an allowance for an adequate crew to spend adequate time developing localized access for the various features.
- *D-B Tunnel Intake Foundation/Grout/Water Control* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 825,000, plus 25% added for escalation from 2018 to 2022. Costs include similar activities of water control and foundation improvements.
- *D-B Tunnel Intake Structure Concrete* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost of concrete structures at the Dixon Diversion are envisioned as similar to the diversion structure at WFUBCD.
- *Diversion Dam Foundation/Grout/Water Control* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 825,000, plus 25% added for escalation from 2018 to 2022. Costs include similar activities of water control and foundation improvements.
- *Diversion Dam Structure Concrete* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost of concrete structures at the Dixon Diversion are envisioned as similar to the diversion structure at WFUBCD.
- *Sediment Diversion Dam* – The cost represents an allowance for an adequate crew to spend adequate time constructing the sediment diversion dam, likely from localized excavated materials or from structure or shaft excavation. Some material sizing may be required.
- *Slide Gates with Trashracks* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 120,000 per installed gate, plus 25% added for escalation from 2018 to 2022.

- *Structure Excavation and Backfill* – The cost represents an allowance for an adequate crew to spend adequate time in excavating and backfilling concrete structures, likely from localized excavated materials or from structure or shaft excavation. Some material sizing will be required and is anticipated.
- *SCADA & Instrumentation* – Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost represents $126,000 for Diversion and Intake Electrical Power and Controls (WFUBCD) and $273,000 for SCADA Programming and Commissioning (WFUBCD), plus 25% added for escalation from 2018 to 2022. Costs for SCADA and Instrumentation at the Dixon-Bradley Tunnel Intake are thought to be similar to those at WFUBCD.

Dixon-Martin Shaft & Tunnel

- *TBM Mobilization & Setup* – Mobilization costs are based on average cost on a similar project (Terror Lake) cost (2017) from contract bids. Costs were escalated by 22% from 2017 to 2022 and adjusted for size and location of Bradley Lake project.
- *D-M Outlet Portal* – Outlet portal costs are based on average cost on a similar portal structure (Terror Lake) cost (2017) from contract bids. Costs were escalated by 22% from 2017 to 2022.
- *D-M Drill-Blast and Starter Tunnel* – Starter tunnel construction costs based on average cost on a similar tunnel (Terror Lake) cost (2017) from contract bids. Costs were escalated for increase in size of 2.1x from Terror Lake and for inflation by 22% from 2017 to 2022.
- *D-M TBM Tunnel Construction (12-ft Bore)* – TBM tunnel construction costs based on average cost on a similar tunnel (Terror Lake) cost (2017) from contract bids. Costs were escalated for increase in size of 2.1x from Terror Lake and for inflation by 22% from 2017 to 2022.
- *TBM Tunnel Lining (10-ft ID)* – Tunnel Lining costs are based on average costs on a similar tunnel (Glade Reservoir) cost (2022) developed by the CMGC contractor and Independent Cost Estimator teams, adjusted for location. Unit cost is based on a per CY cost, adjusted for quantity of lining per LF of tunnel.
- *TBM Tunnel Lining (10-ft ID) at Fault Zones* – Tunnel Lining at Fault Zones costs are based on average costs on a similar tunnel (Glade Reservoir) cost (2022) developed by the CMGC contractor and Independent Cost Estimator teams, adjusted for location. Unit cost has been adjusted for a reinforced and thickened lining at fault zones. This is anticipated to be about 10% of the total tunnel length.
- *Downstream Concrete Tunnel Lining* – Concrete tunnel lining costs are based on average costs on a similar tunnel (Terror Lake) cost (2017) from contract bids. Costs were escalated by 22% from 2017 to 2022.
- *Downstream Steel Tunnel Lining* – Steel tunnel lining costs are based on a similar project (Glade Reservoir) cost (2022) developed by the CMGC contractor and Independent Cost Estimator teams, adjusted for location.

- *D-M Intake Shaft* – Shaft construction cost based on independent estimates of similar shaft work (Quarry A Shaft) for pre-bid evaluation (2021), adjusted for diameter and location.
- *D-M Shaft Lining* – Shaft lining cost based on independent estimates of similar shaft work (Quarry A) for pre-bid evaluation (2021), adjusted for diameter and location.
- *D-M Shaft Drill-Blast and Concrete for Conduit Elbow* – Elbow drill-blast construction and concrete costs are based on average drill-blast tunnel and concrete tunnel lining (Terror Lake) cost (2017) from contract bids. Costs were escalated by 22% from 2017 to 2022 and adjusted for dimensions of D-M conceptual design.

Martin Power Plant

- *Initial Sitework* - The cost represents an allowance for an adequate crew to spend adequate time developing localized access for the various features.
- *Powerhouse Rock Excavation* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $36 per CY, plus 25% added for escalation from 2018 to 2022. Cost of Rock Excavation at the Martin Power Plant is considered to be similar to that at WFUBC.
- *Turbine and Generator Fdn Concrete* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost of concrete structures at the Martin Power Plant are envisioned as similar to the diversion structure at WFUBCD.
- *Valve Support and Tailrace Slab Concrete* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost of concrete structures at the Martin Power Plant are envisioned as similar to the diversion structure at WFUBCD.
- *Laydown and Control Room Slab Concrete* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost of concrete structures at the Martin Power Plant are envisioned as similar to the diversion structure at WFUBCD.
- *Powerhouse Concrete Walls* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost of concrete structures at the Martin Power Plant are envisioned as similar to the diversion structure at WFUBCD.
- *Powerhouse Roofing System w/ Structural* – This cost is anticipated based on experience in structural and roofing systems.
- *Control Room Enclosure* – This cost is anticipated based on experience in building construction.
- *Portal to Powerhouse Steel Section* – The steel section costs are based on average costs on a similar tunnel (Glade Reservoir) cost (2022) developed by the CMGC contractor and Independent Cost Estimator teams, adjusted for steel diameter and location.
- *Power House Excavation and Shoring* – The scope of this work is unclear. The cost is an allowance.

- *Power Plant and Generation* – The powerhouse layout concept was completed based on similar powerhouses to accommodate the Pelton unit that was preliminarily sized for this project.
- *Electro-Mechanical (BOP)* – The electro-mechanical cost was developed from a cost study of similar sized Pelton turbine plants and escalated using Handy-Whitman indices.

Martin Transmission Line

- *Transmission Line* – A preliminary PLS CAD design of the new transmission line was completed to inform the costing effort based on similar remote transmission line projects.
- *Martin Substation* – A line-item cost was given for the new substation based on its 55MW capacity and no preliminary design was completed for this item.
- *Bradley Substation Mods* – A line-item cost was given for the new substation based on the expansion of the exiting substation required to integrate the new line from Martin Powerhouse and no preliminary design was completed for this item.

Dixon-Bradley Tunnel with Outfall

- *Initial Sitework at Bradley* - The cost represents an allowance for an adequate crew to spend adequate time developing localized access for the various features.
- *Access Road to Portal* - Referenced total amount of WFUBCD, Lower Access Road, Average Bid Prices, excluding the high and low bids. This cost is $440 per LF of constructed road, plus 25% added for escalation from 2018 to 2022. The Bradly Portal and Outfall Access Road is thought to be similar in construction approach and cost to the WFUBCD Lower Access Road.
- *TBM Mobilization & Setup* – The cost is representative of mobilizing and setting up a TBM machine and associated facilities, based on past experiences.
- *D-B Intake Portal* – Intake portal costs are based on average cost on a similar portal structure (Terror Lake) cost (2017) from contract bids. Costs were escalated by 22% from 2017 to 2022.
- *D-B Outlet Portal* – Outlet portal costs are based on average cost on a similar portal structure (Terror Lake) cost (2017) from contract bids. Costs were escalated by 22% from 2017 to 2022.
- *TBM Tunnel Construction* – TBM tunnel construction costs based on average cost on a similar tunnel (Terror Lake) cost (2017) from contract bids. Costs were escalated for increase in size of 2.1x from Terror Lake and for inflation by 22% from 2017 to 2022.
- *Drill-Blast Starter Tunnel* – Starter tunnel construction costs based on average cost on a similar tunnel (Terror Lake) cost (2017) from contract bids. Costs were escalated for increase in size of 2.1x from Terror Lake and for inflation by 22% from 2017 to 2022.
- *Tunnel Lining at Portals* – Tunnel lining at portals construction costs based on average cost on a similar tunnel (Terror Lake) cost (2017) from contract bids. Costs were escalated for increase in size of 2.1x from Terror Lake and for inflation by 22% from 2017 to 2022.

- *Invert Tunnel Lining (Assume springline to springline)* – Invert Tunnel Lining costs are based on average costs on a similar tunnel (Glade Reservoir) cost (2022) developed by the CMGC contractor and Independent Cost Estimator teams, adjusted for location. Unit cost is based on a per CY cost, adjusted for quantity of lining per LF of tunnel.
- *Full Lining Through Fault Zones* – Tunnel Lining at Fault Zones costs are based on average costs on a similar tunnel (Glade Reservoir) cost (2022) developed by the CMGC contractor and Independent Cost Estimator teams, adjusted for location. Unit cost has been adjusted for a reinforced and thickened lining at fault zones. This is anticipated to be about 10% of the total tunnel length.

Bradley Dam 28-Ft Pool Raise

- *Initial Sitework and Access* - The cost represents an allowance for an adequate crew to spend adequate time developing localized access for the various features.
- *Concrete Cap and Parapet Demo* – Parametric cost for mechanical concrete demolition and disposal.
- *Embankment Excavation* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $12 per CY, plus 25% added for escalation from 2018 to 2022. Costs of excavating the embankment are anticipated to be similar to costs at WFUBC.
- *Embankment Reinforced Fill* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $38 per CY, plus 25% added for escalation from 2018 to 2022. Costs of reinforced fill are anticipated to be similar to retaining wall fill costs at WFUBC.
- *Embankment Rock Fill* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $14 per CY, plus 25% added for escalation from 2018 to 2022. Costs of embankment rock fill are anticipated to be similar to costs at WFUBC.
- *Embankment Concrete Facing* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost of concrete structures at the Bradley Dam Raise are envisioned as similar to the diversion structure at WFUBCD.
- *Embankment Concrete Cap* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost of concrete structures at the Bradley Dam Raise are envisioned as similar to the diversion structure at WFUBCD.
- *Left and Right Abutment Excavation* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $38 per CY, plus 25% added for escalation from 2018 to 2022. Costs of abutment excavation are anticipated to be similar to rock excavation costs at WFUBC upper access road.
- *Grout Curtain Below Right and Left Dikes* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $359 per LF (composite pricing) of drilled grout hole, plus 25% added for escalation from 2018 to 2022. This cost includes setups, drilling, water testing, and pressure grouting.

- *Foundation Prep at R&L Dikes* – Parametric cost for cleaning of rock surfaces in preparation for dike construction, based on past bid results.
- *Right Abutment Concrete Dike* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost was then reduced for effects of mass concrete and simplification of the structure.
- *Left Abutment Concrete Dike* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost was then reduced for effects of mass concrete and simplification of the structure.
- *Left Abutment Dike Fill* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $14 per CY, plus 25% added for escalation from 2018 to 2022. Costs of embankment rock fill are anticipated to be similar to costs at WFUBC.
- *Right Abutment Dike Fill* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $14 per CY, plus 25% added for escalation from 2018 to 2022. Costs of embankment rock fill are anticipated to be similar to costs at WFUBC.
- *Parapet Walls* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost of concrete structures at the Bradley Dam Raise are envisioned as similar to the diversion structure at WFUBCD.
- *Upstream Foundation Prep* – Parametric cost for cleaning of rock surfaces in preparation for spillway construction, based on past bid results.
- *Upstream Grout Cap* – Parametric cost for concrete grout cap construction, based on past bid results.
- *Spillway Prep and Concrete* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost was then reduced for effects of concrete overlay sections of the spillway.
- *Redrill Drains* – Allowance for drill crew to redrill and clean drains.
- *Grout Curtain* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $359 per LF (composite pricing) of drilled grout hole, plus 25% added for escalation from 2018 to 2022. This cost includes setups, drilling, water testing, and pressure grouting.
- *Obermeyer Gate Installed* – Based on Obermeyer budgetary quote, plus ROM allowances for freight, other materials, and installation.

Bradley Dam 14-Ft Pool Raise

- *Initial Sitework and Access* - The cost represents an allowance for an adequate crew to spend adequate time developing localized access for the various features.
- *Concrete Cap and Parapet Demo* – Parametric cost for mechanical concrete demolition and disposal.

- *Embankment Fill* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $14 per CY, plus 25% added for escalation from 2018 to 2022. Costs of embankment fill are anticipated to be similar to costs at WFUBC.
- *Embankment Rock Fill* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $14 per CY, plus 25% added for escalation from 2018 to 2022. Costs of embankment rock fill are anticipated to be similar to costs at WFUBC.
- *Embankment Concrete Facing* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost of concrete structures at the Bradley Dam Raise are envisioned as similar to the diversion structure at WFUBCD.
- *Embankment Concrete Cap* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost of concrete structures at the Bradley Dam Raise are envisioned as similar to the diversion structure at WFUBCD.
- *Parapet Walls* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost of concrete structures at the Bradley Dam Raise are envisioned as similar to the diversion structure at WFUBCD.
- *Upstream Foundation Prep* – Parametric cost for cleaning of rock surfaces in preparation for spillway construction, based on past bid results.
- *Upstream Grout Cap* – Parametric cost for concrete grout cap construction, based on past bid results.
- *Spillway Prep and Concrete* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost was then reduced for effects of concrete overlay sections of the spillway.
- *Redrill Drains* – Allowance for drill crew to redrill and clean drains.
- *Grout Curtain* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $359 per LF (composite pricing) of drilled grout hole, plus 25% added for escalation from 2018 to 2022. This cost includes setups, drilling, water testing, and pressure grouting.
- *Obermeyer Gate Installed* – Based on Obermeyer budgetary quote, plus ROM allowances for freight, other materials, and installation.

Bradley Dam 7-Ft Pool Raise

- *Initial Sitework and Access* - The cost represents an allowance for an adequate crew to spend adequate time developing localized access for the various features.
- *Upstream Foundation Prep* – Parametric cost for cleaning of rock surfaces in preparation for spillway construction, based on past bid results.
- *Upstream Grout Cap* – Parametric cost for concrete grout cap construction, based on past bid results.

- *Spillway Prep and Concrete* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $ 2,450 per CY, plus 25% added for escalation from 2018 to 2022. Cost was then reduced for effects of concrete overlay sections of the spillway.
- *Redrill Drains* – Allowance for drill crew to redrill and clean drains.
- *Grout Curtain* - Referenced amount of WFUBCD, Average Bid Prices, excluding the high and low bids. This cost is $359 per LF (composite pricing) of drilled grout hole, plus 25% added for escalation from 2018 to 2022. This cost includes setups, drilling, water testing, and pressure grouting.
- *Obermeyer Gate Installed* – Based on Obermeyer budgetary quote, plus ROM allowances for freight, other materials, and installation.

Alaska Energy Association - Dixon Diversion Project
Conceptual Cost Estimate - General Site Improvements
2022 Cost

Component	Unit	Quantity	Unit Cost		Total Cost
Mobilizations, Precon Activities, Housing	LS	1	$24,861,578		$24,862,000
Port and Gen Access Improvements	LS	1	$1,000,000		$1,000,000
Est. Offices and Perm. Facilities	SF	10,000	$400		$4,000,000
Major Field Items					**$29,862,000**
Unlisted Items				8%	$2,389,000
Subtotal					**$32,251,000**
Mobilization, Bonding, Taxes & Insurance				4%	$1,290,000
Subtotal					**$33,541,000**
Contingencies				25%	$8,385,000
Total Field Cost					**$41,926,000**

Alaska Energy Association - Dixon Diversion Project

Conceptual Cost Estimate - Dixon Intake Access Road

2022 Cost

Component	Unit	Quantity	Unit Cost		Total Cost
Clear and Grub	ACRE	65	$21,368		$1,389,000
Lower Dixon Road	LF	7,500	$550		$4,125,000
Upper Dixon Road (Less Diff.)	LF	20,000	$550		$11,000,000
Upper Dixon Road (More Diff.)	LF	6,000	$1,216		$7,298,000
Electrical & Communications	LF	33,500	$148		$4,941,000
Major Field Items					**$28,753,000**
Unlisted Items				5%	$1,438,000
Subtotal					**$30,191,000**
Mobilization, Bonding, Taxes & Insurance				4%	$1,208,000
Subtotal					**$31,399,000**
Contingencies				25%	$7,850,000
Total Field Cost					**$39,249,000**

Alaska Energy Association - Dixon Diversion Project

Conceptual Cost Estimate - Martin Power Plant Access Road

2022 Cost

Component	Unit	Quantity	Unit Cost		Total Cost
Clear and Grub	LF	50	$21,368		$1,068,000
Martin Plant Access Road	LF	20,000	$550		$11,000,000
Electrical & Communications	LF	20,000	$148		$2,950,000
Major Field Items					**$15,018,000**
Unlisted Items				5%	$751,000
Subtotal					**$15,769,000**
Mobilization, Bonding, Taxes & Insurance				4%	$631,000
Subtotal				3.8 miles,	**$16,400,000**
Contingencies				25%	$4,100,000
Total Field Cost					**$20,500,000**

Alaska Energy Association - Dixon Diversion Project

Conceptual Cost Estimate - Dixon Martin Shaft Intake and Diversion Dam

2022 Cost

Component	Unit	Quantity	Unit Cost		Total Cost
Site Improvements	LS	1	$90,000		$90,000
D-M Shaft Intake Fnd/Grt/Water Control	LS	1	$1,031,250		$1,031,000
D-M Shaft Intake Structure Concrete	CY	525	$3,060		$1,607,000
Diversion Dam Fnd/Grt/Water Control	LS	1	$1,031,250		$1,031,000
Diversion Dam Structure Concrete	CY	750	$3,060		$2,295,000
Sediment Diversion Dam	CY	1	$90,000		$90,000
Slide Gates with Trashracks	EA	4	$600,000		$2,400,000
Structure Excavation and Backfill	LS	1	$60,000		$60,000
SCADA & Instrumentation	LS	1	$498,750		$499,000
Major Field Items					**$9,103,000**
Unlisted Items				10%	$910,000
Subtotal					**$10,013,000**
Mobilization, Bonding, Taxes & Insurance				4%	$401,000
Subtotal					**$10,414,000**
Contingencies				25%	$2,604,000
Total Field Cost					**$13,018,000**

Alaska Energy Association - Dixon Diversion Project

Conceptual Cost Estimate - Dixon Bradley Tunnel Intake and Diversion Dam

2022 Cost

Component	Unit	Quantity	Unit Cost		Total Cost
Site Improvements	LS	1	$90,000		$90,000
D-B Tunnel Intake Fnd/Grt/Water Control	LS	1	$1,031,250		$1,031,000
D-B Tunnel Intake Structure Concrete	CY	525	$3,060		$1,607,000
Diversion Dam Fnd/Grt/Water Control	LS	1	$1,031,250		$1,031,000
Diversion Dam Structure Concrete	CY	750	$3,060		$2,295,000
Sediment Diversion Dam	CY	1	$90,000		$90,000
Slide Gates with Trashracks	EA	4	$600,000		$2,400,000
Structure Excavation and Backfill	LS	1	$60,000		$60,000
SCADA & Instrumentation	LS	1	$498,750		$499,000
Major Field Items					**$9,103,000**
Unlisted Items				10%	$910,000
Subtotal					**$10,013,000**
Mobilization, Bonding, Taxes & Insurance				4%	$401,000
Subtotal					**$10,414,000**
Contingencies				25%	$2,604,000
Total Field Cost					**$13,018,000**

Alaska Energy Association - Dixon Diversion Project

Conceptual Cost Estimate - Dixon-Martin Shaft & Tunnel

Component	Unit	Quantity	Unit Cost		Total Cost
		2022 Cost			Total Tunnel Length =
TBM Mobilization & Setup	LS	1	$5,000,000		$5,000,000
D-M Outlet Portal	LS	1	$1,400,000		$1,400,000
D-M Drill-Blast and Starter Tunnel	LF	250	$9,500		$2,375,000
D-M TBM Tunnel Construction (12-ft Bore)	LF	14,550	$2,500		$36,375,000
TBM Tunnel Lining (10-ft ID)	LF	7,250	$6,000		$43,500,000
TBM Tunnel Lining (10-ft ID) at Fault Zones	LF	1,200	$12,000		$14,400,000
Downstream Concrete Tunnel Lining	LF	250	$12,000		$3,000,000
Downstream Steel Tunnel Lining	LF	6,100	$6,000		$36,600,000
D-M Intake Shaft	VLF	700	$6,500		$4,550,000
D-M Shaft Lining	VLF	700	$20,000		$14,000,000
D-M Shaft Drill-Blast and Concrete for Conduit Elbow	LS	1	$2,145,000		$2,145,000
Major Field Items					**$163,345,000**
Unlisted Items				10%	$16,335,000
Subtotal					**$179,680,000**
Mobilization, Bonding, Taxes & Insurance				8%	$14,374,000
Subtotal					**$194,054,000**
Contingencies				25%	$48,514,000
Total Field Cost					**$242,568,000**

Alaska Energy Association - Dixon Diversion Project

Conceptual Cost Estimate - Martin Power Plant

2022 Cost

Component	Unit	Quantity	Unit Cost		Total Cost
Initial Sitework	LS	1	$135,000		$135,000
Powerhouse Rock Excavation	CY	3,100	$45		$140,000
Turbine and Generator Fdn Concrete	CY	1,100	$3,060		$3,366,000
Valve Support and Tailrace Slab Concrete	CY	800	$3,060		$2,448,000
Laydown and Control Room Slab Concrete	CY	225	$3,060		$689,000
Powerhouse Concrete Walls	CY	800	$3,060		$2,448,000
Powerhouse Roofing System w/ Structural	SF	6,000	$100		$600,000
Control Room Enclosure	SF	600	$60		$36,000
Portal to Powerhouse Steel Section	LF	100	$15,000		$1,500,000
Power House Excavation and Shoring	LS	1	$350,000		$350,000
Power Plant and Generation	MW	55	$900,000		$49,500,000
Electro-Mechanical (BOP)	MW	55	$23,000		$1,265,000
Major Field Items					**$62,477,000**
Unlisted Items				10%	$6,248,000
Subtotal					**$68,725,000**
Mobilization, Bonding, Taxes & Insurance				8%	$5,498,000
Subtotal					**$74,223,000**
Contingencies				25%	$18,556,000
Total Field Cost					**$92,779,000**

Alaska Energy Association - Dixon Diversion Project

Conceptual Cost Estimate - Martin Transmission Line

2022 Cost

Component	Unit	Quantity	Unit Cost		Total Cost
Transmission Line	Miles	7.6	$500,000		$3,800,000
Martin Substation	LS	1	$3,000,000		$3,000,000
Bradley Substation Mods	LS	1	$1,500,000		$1,500,000
Major Field Items					**$8,300,000**
Unlisted Items				10%	$830,000
Subtotal					**$9,130,000**
Mobilization, Bonding, Taxes & Insurance				8%	$730,000
Subtotal					**$9,860,000**
Contingencies				25%	$2,465,000
Total Field Cost					**$12,325,000**

Alaska Energy Association - Dixon Diversion Project

Conceptual Cost Estimate - Dixon-Bradley Tunnel with Outfall

2022 Cost

Component	Unit	Quantity	Unit Cost		Total Cost
Initial Sitework at Bradley	LS	1	$65,000		$65,000
Access Road to Portal	LF	5,200	$550		$2,860,000
TBM Mobilization & Setup	LS	1	$5,000,000		$5,000,000
D-B Intake Portal	LS	1	$1,000,000		$1,000,000
D-B Outlet Portal	LS	1	$1,400,000		$1,400,000
TBM Tunnel Construction	LF	24,800	$4,400		$109,120,000
Drill-Blast Starter Tunnel	LF	200	$16,500		$3,300,000
Tunnel Lining at Portals	LF	100	$11,500		$1,150,000
TBM Tunnnel Support though Low Quality Rock Zones	LF	1,080	$20,000		$21,600,000
Full Lining Through Fault Zones	LF	1,400	$11,500		$16,100,000
Major Field Items					**$161,595,000**
Unlisted Items				10%	$16,160,000
Subtotal					**$177,755,000**
Mobilization, Bonding, Taxes & Insurance				8%	$14,220,000
Subtotal					**$191,975,000**
Contingencies				25%	$47,994,000
Total Field Cost					**$239,969,000**

Alaska Energy Association - Dixon Diversion Project
Conceptual Cost Estimate - Bradley Dam 28-Ft Pool Raise
2022 Cost

Component	Unit	Quantity	Unit Cost		Total Cost
Initial Sitework and Access	LS	1	$200,000		$200,000
Concrete Cap and Parapet Demo	CY	1300	$250		$325,000
Embankment Excavation	CY	20,500	$15		$308,000
Embankment Reinforced Fill	CY	50,000	$48		$2,375,000
Embankment Rock Fill	CY	51,000	$18		$893,000
Embankment Concrete Facing	CY	1,600	$3,060		$4,896,000
Embankment Concrete Cap	CY	1,300	$3,060		$3,978,000
Left and Right Abut Excavation	CY	2,100	$48		$100,000
Grout Curtain Below Right and Left Dikes	LF	2,000	$449		$898,000
Foundation Prep at R&L Dikes	SY	1,500	$60		$90,000
Right Abutment Concrete Dike	CY	1,800	$2,500		$4,500,000
Left Abutment Concrete Dike	CY	5,300	$2,500		$13,250,000
Left Abutment Dike Fill	CY	11,200	$18		$196,000
Right Abutment Dike Fill	CY	3,600	$18		$63,000
Parapet Walls	CY	400	$3,060		$1,224,000
Spillway Raise					
Upstream Foundation Prep	SY	300	$60		$18,000
Upstream Grout Cap	CY	166	$2,000		$332,000
Spillway Prep and Concrete	CY	12,000	$2,500		$30,000,000
Redrill Drains	EA	40	$1,500	Verify Quantity	$60,000
Grout Curtain	LF	3,540	$449	Verify Quantity	$1,589,000
Obermeyer Gate Installed	LS	1	$930,000		$930,000
Major Field Items					**$66,225,000**
Unlisted Items				10%	$6,623,000
Subtotal					**$72,848,000**
Mobilization, Bonding, Taxes & Insurance				4%	$2,914,000
Subtotal					**$75,762,000**
Contingencies				25%	$18,941,000
Total Field Cost					**$94,703,000**

Alaska Energy Association - Dixon Diversion Project

Conceptual Cost Estimate - Bradley Dam 14-Ft Pool Raise

2022 Cost

Component	Unit	Quantity	Unit Cost		Total Cost
Initial Sitework and Access	LS	1	$200,000		$200,000
Concrete Cap and Parapet Demo	CY	1300	$250		$325,000
Embankment Fill	CY	4,700	$18		$82,000
Embankment Rock Fill	CY	50,000	$18		$875,000
Embankment Concrete Facing	CY	300	$3,060		$918,000
Embankment Concrete Cap	CY	1,300	$3,060		$3,978,000
Parapet Walls	CY	240	$3,060		$734,000
Spillway Raise					
Upstream Foundation Prep	SY	300	$60		$18,000
Upstream Grout Cap	CY	166	$2,000		$332,000
Demo Concrete at Crest	CY	200	$300		$60,000
Spillway Prep and Concrete	CY	4,200	$2,500		$10,500,000
Redrill Drains	EA	40	$1,500	Verify Quantity	$60,000
Grout Curtain	LF	2,950	$449	Verify Quantity	$1,324,000
Obermeyer Gate Installed	LS	1	$930,000		$930,000
Major Field Items					**$20,336,000**
Unlisted Items				10%	$2,034,000
Subtotal					**$22,370,000**
Mobilization, Bonding, Taxes & Insurance				4%	$895,000
Subtotal					**$23,265,000**
Contingencies				25%	$5,816,000
Total Field Cost					**$29,081,000**

Alaska Energy Association - Dixon Diversion Project

Conceptual Cost Estimate - Bradley Dam 7-Ft Pool Raise

2022 Cost

Component	Unit	Quantity	Unit Cost		Total Cost
Initial Sitework and Access	LS	1	$200,000		$200,000
Spillway Raise					
Upstream Foundation Prep	SY	300	$60		$18,000
Upstream Grout Cap	CY	170	$2,000		$340,000
Demo Concrete at Crest	CY	3	$600		$2,000
Redrill Drains	EA	40	$1,500		$60,000
Grout Curtain	LF	2,950	$449	Verify Quantity	$1,324,000
Obermeyer Gate Installed	LS	1	$930,000		$930,000
Major Field Items					**$2,874,000**
Unlisted Items				10%	$287,000
Subtotal					**$3,161,000**
Mobilization, Bonding, Taxes & Insurance				4%	$126,000
Subtotal					**$3,287,000**
Contingencies				25%	$822,000
Total Field Cost					**$4,109,000**