Knik Arm Tunnel Feasibility Study
Conceptual Alternatives Report

Prepared for:
Alaska Department of Transportation and Public Facilities

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Stantec
Emprise Concepts

November 2025

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Executive summary

This report presents the findings of the Knik Arm Tunnel Feasibility Study, commissioned by the Alaska Department of Transportation and Public Facilities (DOT&PF), to evaluate conceptual alternatives for a highway tunnel connecting Anchorage to Point MacKenzie. The report documents four tunnel alignment options, with Alignments 1 and 4 selected for further development based on constructability, cost, and environmental considerations.

Alignment 1 proposes a 3.9-mile twin bore tunnel beneath Government Hill and the Port of Alaska, emerging near the southern edge of Port MacKenzie. It offers a direct route with favorable geometry and manageable construction impacts.

Alignment 4, at 4.2 miles, is similar to Alignment1 but shifts west of the Port of Alaska to avoid utility and property conflicts. It serves as a technically feasible backup should Alignment 1 face legal or engineering constraints.

Alignment 2 and 3 were excluded from further development due to extended tunnel length, higher costs, and significant environmental and logistical challenges, including potential impacts to sensitive habitats and tidal zone construction complexity.

The proposed tunnel configuration for the alignments includes twin bores with cross passages every 650 feet for emergency egress and housing of tunnel systems. Portal designs accommodate TBM launch and retrieval, ventilation, drainage, and fire life safety systems. The report outlines construction methodologies, segmental lining design, fire protection standards (NFPA 502), and tunnel system requirements including SCADA, ITS, and emergency communications.

A preliminary construction schedule estimates a duration of approximately seven years for Alignment 1 and seven years four months for Alignment 4, without contingency. Future refinements and contingency allowances are to be determined through detailed design, risk assessment, and project planning. Preliminary estimates of the **direct cost only** place Alignment 1 at approximately $3.19 billion and Alignment 4 at $3.32 billion, with a Class 5 estimate accuracy range of -30% to +50%. The stated estimates are based on assumptions and exclusions outlined in Section 8 of the report. For example, costs are limited to anticipated construction direct costs and do not account for other potential costs such as engineering, right-of-way and/or land acquisition, legal, construction management, other indirect costs, profit, markups, and maintenance and operations. The cost also excludes all the surface works to the portals such as new bridge infrastructure over the railway at Government Hill.

The report concludes with recommendations for further geotechnical investigations, environmental studies, and comparative evaluation with bridge alternatives to inform final concept selection and project delivery strategy.

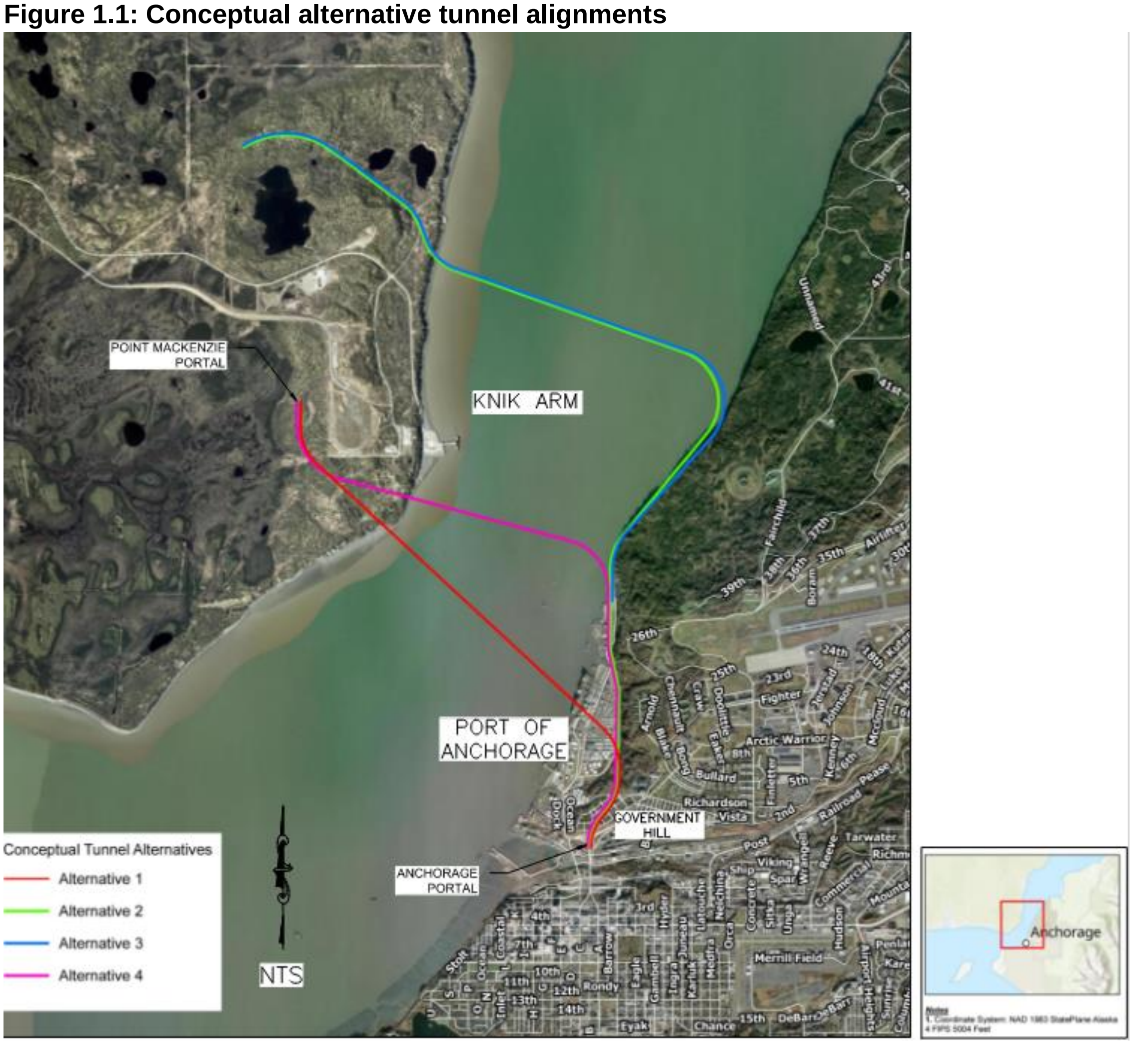
1 Introduction

The Alaska Department of Transportation and Public Facilities has appointed Stantec and their sub-consultant Mott MacDonald to perform a feasibility study for constructing a tunnel underneath Knik Arm, creating a new transportation corridor between Anchorage and the Matanuska-Susitna Valley, and destinations to the north and east (Figure 1.1).

Stantec is responsible for overall delivery of the feasibility study including project management, development of highway alignment options, conceptual design coordination, cost estimation and environmental documentation.

Mott MacDonald is responsible for developing portal and tunnel concepts and assisting in cost estimation of the tunnel section of the project. Emprise Concepts is responsible for geological and geotechnical data analysis, geostatistical modeling and development of geological and geotechnical models.

Figure 1.1: Conceptual alternative tunnel alignments



Source: Provided by Stantec (2025)

1.1 Scope of report

This report has been prepared in accordance with the scope defined by DOT&PF for the “Draft Conceptual Alternatives Report.” Table 1.1 summarizes the key components of the scope, with references to the corresponding sections of the report that address each item.

Table 1.1: Scope of report

Scope element	Section of report
Identification and presentation of up to 4 potential tunneling alignments	2 and 2.4
Comparison of the suitability of these alignments with an opinion of feasibility	9
Identification of tunnel launch and retrieval sites and laydown areas	7.5
Comparison of alternative costs	8.5
Discuss TBM technology as it pertains to currently understood geotechnical conditions for the site	7.1
Address constructability considerations including segment storage delivery, tunnel muck disposal, TBM power requirements, potential need for cross passages, ability to construct cross passages and cold weather considerations	7
Develop tunnel cross sections that cover the various cross-section options (i.e. tunnel with/without cross passages). Sketches will be provided for the most efficiently sized cross-section(s)	3.1
High level discussion on noise and vibration during construction	7.9
Provide options for selection criteria to evaluate the suitability of alternatives	9.1

1.2 Background and previous studies

This report is informed by previous studies undertaken to explore transportation solutions within the project corridor. These earlier investigations have provided foundational insights into the geological, environmental, and engineering constraints that inform the current phase of the analysis.

Prior studies have examined surface and subsurface conditions, preliminary alignment options, and corridor-wide feasibility considerations. These findings have been instrumental in shaping the development of potential tunnel alignments, identifying suitable portal locations for launch and retrieval of the TBMs, and assessing constructability challenges.

By referencing and integrating these earlier efforts, this report aims to advance the understanding of viable tunneling solutions and support informed decision-making for future project phases.

1.3 Acronyms and abbreviations

Table 1.2: Acronyms and abbreviations used in the report

Acronym/abbreviation	Definition
AASHTO	American Association of State Highway and Transportation Officials
ADEC	Alaska Department of Environmental Conservation
AFD	Anchorage Fire Department
AFFF	Aqueous Film Forming Fluid
AHJ	Authority Having Jurisdiction
AK	Alaska
ASTM	American Society for Testing and Materials
BTS	British Tunneling Society
CAF	Compressed Air Foam
CCTV	Closed-Circuit Television
CO	Carbon Monoxide
CSMP	Contaminated Soils Management Plan
DMS	Dynamic Message Signs
DOT&PF	Department of Transportation & Public Facilities
FFFS	Fixed Fire Fighting Systems
EFNARC	European Federation of Specialist Concrete Additives and Systems
ECS	Emergency Communication Systems
EOPCC	Engineers' Opinion of Probable Construction Cost
EPA	Environment Protection Agency
EPBM	Earth Pressure Balance Machine
EPDM	Ethylene Propylene Diene Monomer
EVS	Emergency Ventilation System
FHWA	Federal Highway Administration
FLS	Fire Life Safety
GB	Green Book (AASHTO – A Policy on Geometric Design of Highways and Streets)
HRMP	Hazardous Materials Response Plan
ITE	Institute of Transportation Engineers
ITS	Intelligent Transportation Systems
ITT	Immersed Tube Tunnel
JBER	Joint Base Elmendorf/Richardson
KAC	Knik Arm Crossing
LED	Light Emitting Diode
LUS	Lane Use Signals
MUTCD	Manual on Uniform Traffic Control Devices
NFPA	National Fire Protection Association
OCC	Operations and Control Center
OHVD	Over height Vehicle Detection System
NO_x	Nitrogen Oxides
OSHA	Occupational Safety and Health Administration
PA	Public Address

Acronym/abbreviation	Definition
PFHRR	Peak Fire Heat Release Rate
PIARC	Permanent International Association of Road Congresses
PPM	Parts Per Million
PTZ	Pan-Tilt-Zoom
SCADA	Supervisory Control and Data Acquisition
SO_2	Sulfur Dioxide
SOE	Support of Excavation
SPCCP	Spoil Prevention, Control, and Countermeasures Plan
TBM	Tunnel Boring Machine
TMS	Transportation Management Systems
TSCS	Traffic Surveillance and Control Systems
UPS	Uninterruptible Power Supply
VAID	Video Automatic Incident Detection
VD	Variable Density
VMS	Variable Messaging Signs

2 Tunnel alignment alternatives

During this phase of the project, alternative alignments have been developed and evaluated for the Knik Arm Crossing. The objective of the study is to identify alignments that best support transportation improvements and serve as basis for developing tunnel concepts, informing construction methodologies and preliminary cost estimates.

Four alignment options have been explored, with Alternatives 1 and 4 selected for further development to assess construction requirements and establish a probable cost range. The assessment does not include the bridge crossing alternative over the Knik Arm developed during previous studies nor the new bridge infrastructure over the railway at Government Hill.

2.1 Alignment 1

Alignment 1 starts on the south side of Government Hill on a bearing that is an extension of the existing A Street bridge over Ship Creek and the Alaska Railroad. A new bridge in this location will transition to a tunnel entry portal before entering the south side of Government Hill and passing under a residential area. Government Hill is a topographic high that provides the minimum cover necessary to advance TBMs. The alignment curves northeast to maintain tunnel cover before curving back to the northwest and passing beneath the Port of Alaska (POA). The alignment continues northwest beneath Knik Arm toward Point MacKenzie, emerging on the south side of the planned z development area, before advancing north at grade.

The conceptual horizontal alignment and vertical profile satisfies key highway design criteria that include a 55 mph design speed, a minimum allowable radius of curvature of 3,000 ft, maximum profile grade of 5%, superelevation rate e_{max} = 6%, and a stopping sight distance of 495 feet. The assumed lane configuration includes two 12-foot lanes and a 4-foot and 8-foot shoulder. Minimum overhead tunnel clearance to be maintained is 18’-6”. Roadway design criteria are provided in Table 3.1.

The conceptual tunnel profile descends at 5% beneath Government Hill continuing downward to avoid conflicting with 200-foot steel piles supporting the POA waterfront docks. The profile drops to a maximum depth of 300 feet below the Anchorage portal entry elevation on the south side of Government Hill. After traversing the Knik Arm channel bottom for about a mile, the profile turns upward at a 4.66% grade for the final 1.4 miles. The tunnel alignment will daylight on the west side of Knik Arm, near the south end of the planned Port MacKenzie development and future rail line. The overall length of tunnel for Alignment 1 is 3.9 miles.

Alignment 1 will require the replacement of A Street bridge and an expansion and reconfiguration of ramps serving Government Hill and POA. Additional study is necessary to optimize the conceptual geometric layout that preserves minimum vertical clearance over the railroad and mitigates other impacts. Major shoring designs are necessary to support excavation for entrance portal construction and to protect Government Hill residential properties and associated infrastructure.

Point MacKenzie roadway infrastructure beyond the tunnel portal structure will consist of northbound and southbound traffic lanes that will pass through an approximate 50-foot-high embankment constructed for a future rail line. Large diameter highway tunnel structures will pass through the base of the embankment fill and transition to Point MacKenzie Road.

Routing the tunnel under the POA infrastructure will require detailed soil and groundwater studies to identify soft or unstable zones that may need ground conditioning to improve soil properties and reduce settlement potential.

2.1.1 Geological overview

The most relevant geological information is summarized in two key reports prepared by Emprise Concepts:

- Knik Arm Tunnel Feasibility Study: DRAFT Geotechnical Data Summary (April 15, 2025)
- DRAFT Geotechnical Data Report and Statistical Summary (August 29, 2025).

A summary of the information presented in the reports is provided below.

2.1.1.1 Regional and site setting

The Knik Arm Tunnel project area lies within the Cook Inlet basin, a glaciated basin about 200 miles long and 60 miles wide. The area's geology reflects several glaciation periods, with the latest major advance around 20,000 to 25,000 years ago. The surficial geology of the Cook Inlet basin is dominated by glacial, alluvial, and estuarian soils. The glacial soils are composed of glacial moraine, glacial outwash, marine and lake deposits. The region is tectonically active, containing several faults and the Aleutian Megathrust, site of significant earthquakes in 1964 and 2018 (Emprise, 2025).

2.1.1.2 Project geology

A review of available data indicates that site-specific geological and geotechnical information is limited along Tunnel Alignment 1. Notably, there is a lack of bathymetric and subsurface geotechnical data for the section beneath Knik Arm, as well as for the on-land portions at Point Mackenzie and Anchorage at the proposed tunnel depth.

Both reports (Emprise, 2025) acknowledge that, although there is historical geotechnical data for the broader Knik Arm area, significant gaps remain along the proposed tunnel alignment. These gaps present challenges for characterizing subsurface conditions to inform the current phase of tunnel design and planning.

The geology of the project area comprises glacial, alluvial, and estuarine soils. Bedrock is estimated to be at least 600 feet deep within the Knik Arm channel and is not anticipated to be encountered during tunnel construction. Emprise Concepts (2025) note, the most commonly encountered geologic units, include:

- Recent channel marine deposits: These are loose, fine-grained sands deposited in the active channel environment. They are typically saturated and can present potential challenges for tunneling due to their low strength and susceptibility to liquefaction.
- Glacial till or moraine deposits: Dense, heterogeneous mixtures of gravel, sand, silt, and clay, deposited directly by glacial action. These units can be highly variable in thickness and composition.
- Glacial lake clays or marine/alluvial sands: This group includes both low-plasticity clays (glaciolacustrine) and interbedded sands deposited in ancient lake or marine environments. The clays are generally stiff to hard, while the sands are typically dense.
- Possible Knik Tills: Older glacial deposits, often found at greater depths, consisting of dense, gravelly soils with varying fines content.

These units were identified and characterized through historical bridge-focused investigations, with geologic cross sections presented in the 2004 and 2007 Shannon & Wilson reports (as summarized by Emprise Concepts, 2025).

The Emprise reports also note that the east and west shoreline soils are predominantly composed of glacial lake clays and glacial till. However, due to the lack of site-specific data along Tunnel Alignment 1, especially under the waterway and Point Mackenzie on-land sections, these interpretations are based on extrapolation from nearby investigations.

2.1.1.3 Hydrological conditions

Limited information is available regarding groundwater conditions along the tunnel alignment and at the Point MacKenzie portal. The existing geotechnical investigations summarized by Emprise Concepts (2025) primarily focused on bridge alternatives and did not include groundwater monitoring or piezometric data within the proposed tunnel corridor. As such, the depth of groundwater and its seasonal or tidal variability remains uncertain for much of the alignment.

It should be noted that groundwater levels in the vicinity of the Knik Arm are likely to be influenced by tidal fluctuations, particularly in the in-water and near-shore sections. The lack of site-specific groundwater data represents a key gap for tunnel design and risk assessment, and further hydrogeological investigation is recommended to inform future design stages.

2.1.1.4 Implications and geological risk

The tunnel alignment is expected to cross unconsolidated glacial, alluvial, and estuarine soils, with no competent bedrock anticipated above 600 ft depth. The absence of site-specific data at on the alignment and at the tunnel depth introduces significant uncertainty regarding soil stratigraphy, strength, permeability, and groundwater conditions.

Ground risk: Tunnel sections and cross passages

- Face stability: Mixed-face conditions (gravels, sands, silts, clays) and unknown permeability may compromise TBM face support in particular at TBM launch and reception and for cross passage excavations.
- Groundwater control: No groundwater monitoring or permeability data exists; tidal influence of hydrogeological conditions is possible. The risk of uncontrolled inflow and pore pressure variations is high.
- Ground movement/settlement: Limited deep borehole data; compressibility and strength of soils at tunnel depth are unknown, increasing risk to overlying on-land infrastructure.
- Cutterhead clogging/tool wear: Clogging potential from clays and elevated abrasion risk from gravels/sands; soil conditioning and wear rates are unquantified.
- Obstructions/geological variability: Potential for boulders/cobbles and abrupt stratigraphic changes; spatial distribution is undocumented.
- Seismic hazards: Liquefaction and seismic-induced deformation risks require further site-specific assessment.

Portal-specific risks

- Slope instability: Weak silty clays and loose sands may destabilize portal excavations, particularly at Government Hill/Anchorage portal location where historic slope failure activity has been recorded.
- Settlement/structural impacts: Compressible soils and uncertain dewatering requirements may affect portal support structures.

- Low Ground Cover at Anchorage Portal: The tunnel approaches beneath Government Hill have relatively shallow ground cover, which with potential settlement, noise, and vibration impacts on the overlying properties.

It is recommended that a comprehensive geotechnical investigation to be undertaken to develop a well defined geological and hydrogeological understanding along the alignment to inform mitigation measures for risks identified above.

2.2 Alignment 2

Tunnel Alignment 2 begins in the same location as Alignment 1 and advances northeast, on the backside of POA, to Cairn Point. The alignment traces the east bluff, adjacent to Joint Base Elmendorf/Richardson (JBER), before turning west and passing beneath Knik Arm. The alignment daylights on the west side of Knik Arm, on the north side of Port MacKenzie.

The tunnel profile grade descends at 4% under Government Hill then - below the A Street bridge entrance elevation. The final 1.5 miles ascends at a 5% grade before daylighting on the north side of the Port MacKenzie site within the right-of-way previously proposed for a Knik Arm Crossing bridge route.

The water crossing length is longer than other options and maintains a flatter profile grade because it passes under the east bluff prior to crossing beneath the waterbody. Accessing Point MacKenzie on the north side of Port MacKenzie is desirable as it reduces future port infrastructure conflicts and provides more upland tunnel laydown areas adjacent to the alignment. The flat profile grade for this option is desirable from a vehicle rideability standpoint, but the overall length of tunnel of 6.6 miles is much longer than the more direct crossing depicted for Alignment 1.

Alignment 2 was excluded from further study due to its extended length, which would result in significantly higher construction costs and longer project duration, making it an impractical option for the Knik Arm Crossing tunnel.

2.3 Alignment 3

Alignment 3 begins at the north end of the POA property. The Anchorage portal access at this location will require construction of access roads and/or interchanges to move traffic from the north end of the A Street bridge, around the POA, in a manner similar to routes studied for a Knik Arm Crossing bridge.

A large construction pad will be built near Cairn Point to support the tunnel portal. Due to security concerns and proximity to critical infrastructure, Joint Base Elmendorf-Richardson (JBER) has stated that a portal cannot be located on base property. The pad must be at least 2,500 feet long to accommodate a 5% grade and ensure minimum tunnel cover. Because the portal is in a tidal zone, it must be designed to protect against tidal influences. One proposed method involves placing fill behind 200-foot-long driven piles, similar to POA waterfront construction. The pad must also allow for a tunnel grade drop that avoids interference with piles extending approximately 150 feet below the existing ground surface.

The tunnel alignment proceeds north and west at a 1% grade along the east bluff, before descending for 2.2 miles to its lowest point. It then rises over the final 1.9 miles, maintaining minimum cover, before emerging at Point MacKenzie. The total tunnel length is 4.2 miles.

Alignment 3 offers advantages due to its shorter length and reduced disruption to Anchorage's transportation infrastructure compared to Alternative 2. However, it presents significant environmental and construction challenges. Locating the tunnel portal pad within the tidal zone introduces complex issues, including restricted site access, extreme tidal conditions, pile driving requirements, and a limited construction season. These factors not only complicate construction logistics but also trigger substantial environmental permitting hurdles. Of particular concern are the adverse impacts to wildlife, especially the endangered beluga whale population, which continues to decline.

Construction activities such as pile driving and fill placement in sensitive wetland areas risk disturbing critical beluga habitat, potentially exacerbating the threats to this vulnerable species. Furthermore, the long-term maintenance of infrastructure in this harsh northern marine environment—subject to ice flows, corrosion, and tidal forces will impose considerable ongoing costs and operational challenges.

Based on the identified limitations, Alternative 3 has not been selected for further consideration.

2.4 Alignment 4

Alignment 4 begins at the A Street bridge and follows a path under Government Hill, similar to Alignment 1. The alignment continues north in a straight line behind POA, then turns west under Knik Arm to daylight on the south side of Port MacKenzie. This alignment is intended to reduce potential challenges - both technical and non-technical - that could arise from passing beneath POA. The Point MacKenzie portal location skirts the planned Port MacKenzie development area to mitigate conflicts with future rail and utility infrastructure. The alignment bears north to avoid a large wetland complex located to the west. Conceptual horizontal and vertical design criteria outlined in Table 4.1 are met with Alignment 4.

The tunnel profile descends at an approximate 5% grade to a depth of 325 feet below the A Street entrance elevation, making this the deepest water crossing among the alternatives. The final 1.9 miles of the tunnel ascend at a 5.66% grade, resulting in a total tunnel length of 4.2 miles.

This alignment is technically feasible and slightly longer than Alignment 1. If technical or legal issues - such as utility conflicts, underground easement restrictions, or eminent domain concerns - make Alignment 1 unfeasible, Alignment 4 offers a potential solution by routing behind the POA and avoiding those constraints. Alternative 4 also presents greater potential for improving ground cover under the subaqueous crossing, pending the results of detailed bathymetric and geotechnical investigations. In contrast, Alternative 1 includes a segment with reduced ground cover, which may pose a design risk as the project progresses, and more information becomes available.

2.4.1 Geological overview

There is no varying information for Alignment 4 beyond what is provided in Section 2.1.1 for Alignment 1. Alignment specific geological and geotechnical details should be updated following location specific field investigation.

3 Tunnels and cross passage configuration

Section 5 of the Tunnel Technology Update Report (Mott MacDonald, 2025) presents a range of tunnel configurations based on single bore and twin bore arrangements, referencing relevant codes, standards, and DOT&PF design criteria. To minimize tunnel diameter, options with reduced shoulder arrangements are also included. The two primary configurations presented are:

- Twin bore tunnels: Two separate tunnels, each serving one direction of traffic. Emergency cross passages connect the tunnels, though these could potentially be replaced by a pressurized corridor, subject to fire authority acceptance.
- Single bore tunnel: Single, larger tunnel with stacked lanes for both directions. This configuration is more space efficient in constrained environments; however, it requires careful consideration of shoulder width, emergency egress, ventilation, lane configuration at the portals and traffic management.

3.1 Tunnel configuration and space proofing

The tunnel configuration proposed for the Draft Conceptual Alternative is based on a twin bore arrangement, with cross passages for emergency egress. This configuration enhances fire life safety by enabling same-level evacuation and allowing safe access for fire response teams through the non-incident tunnel. Additionally, the twin bore setup simplifies highway geometry at the portals, as traffic lanes are not vertically stacked.

Initial space proofing for the twin bore tunnels has been developed in accordance with the updated highway design criteria provided by DOT&PF, as outlined in Table 3.1. Key changes to the design criteria, compared to those presented in the Tunneling Technology Update Report, are highlighted in *italics*.

Requirement for flaring of the crash barrier at the cross passage openings are highlighted in the Tunneling Technology Update Report.

Tunnel space proofing also accommodates the spatial requirements for Fire Life Safety systems and tunnel systems. Table 3.2 summarizes the key space proofing elements considered in determining the indicative tunnel diameter. Considerations to reduce the tunnel diameter are discussed in Section 5.2.2 of the Tunneling Technology Update Report. Optimizing tunnel diameter will require detailed design development of Fire Life Safety systems and evaluation of reduced shoulders and overhead tunnel clearance. A single bore tunnel configuration also remains an alternative configuration at this stage.

Table 3.1: Preliminary design criteria for highway

Element	Preliminary design criteria
Functional classification	Urban Principal Arterial Interstate
Design vehicle	WB-67 (GB – Section 2.8.1)
Terrain classification	Level
Design speed	*55 mph (GB-Chapter 2)*
Stopping sight distance	*495 ft (GB – Table 3-1)*
Passing sight distance	*900 ft (GB - Table 3-4)*
Maximum allowable grade	5% (GB - Table 7-4a)
Minimum allowable grade	0.5% (GB - Section 3.4.2.2.2)
Minimum allowable radius of curvature	*3,000 (GB Table 3-9, e=6% max, GB Section 8.2.6)*
Tunnel lane and shoulder width	*LT shoulder: 4 ft (Shared 4 ft Egress Path)* Lane 12 ft (GB – Section 7.3.3.2) Lane 12 ft (GB – Section 7.3.3.2) RT shoulder: 8 ft Provision for dynamic sway
Minimum overhead tunnel clearance (including luminaire and dynamic clearances)	18’-6” (HPCM Table 1130-1)
Surface treatment	Asphalt concrete pavement
Crash barrier	Rigid concrete (allowance for barrier flare)

Source: Provided by DOT&PF

Table 3.2: Spatial requirements for Fire Life Safety and tunnel systems

Element	Preliminary design criteria
Tunnel construction tolerance as per BTS	4”
Fire Life Safety system	Provision of fire hydrants and deluge system Emergency egress through cross passages Emergency equipment cabinets Emergency telephones, Fire detection systems Provision for other systems to be developed at detailed design stage
Ventilation system	Semi transverse ventilation system with provision of smoke duct and jet fans based on assumed smoke duct area and size of ventilation fans
Tunnel systems	High voltage cables and trays, lighting, signage Traffic cameras/communication systems Provision for other systems to be developed at detail design stage
Drainage	Curb side drainage pits with connection to low point sump in the cross passage Discharge pipe from low point sump pumps
Internal tunnel diameter	47’0”
Drawing sheet	B120, B121, and B122

3.2 Segmental tunnel lining

The segmental tunnel lining concept, summarized in Table 3.3 and illustrated in Figure 3.1, is based on the descriptions of various lining elements and components outlined in Section 2.4 of the Tunneling Technology Update Report.

This concept is intended for planning purposes and is subject to change during the detailed design phase, based on comprehensive geotechnical investigations, structural analysis and input from the TBM manufacturer and construction contractor.

Table 3.3: Segmental tunnel lining details

Element	Detail
Ring arrangement	Universal taper ring with 10 segments
Internal tunnel diameter	47 ft
Lining thickness	20 in
Segment length	6’ 8”
Number of circumferential connectors	30 shear dowels (3 per segment)
Number of radial bolts	20 (2 bolts per segment) 20 guide rods (2 per joint)
Gasket type	Anchored gasket
Grout sockets/recess for erector cone	10 grout sockets (1 per segment – located in recess for erector) 20 recess for erector cone (2 per segment)
Reinforcement	Bar reinforcement (Inclusion of steel fiber to be considered at detailed design stage).
Fire resistance	Inclusion of polypropylene (PP) in the concrete mix (to be considered at detailed design stage) Provision for fire board for exposed surfaces

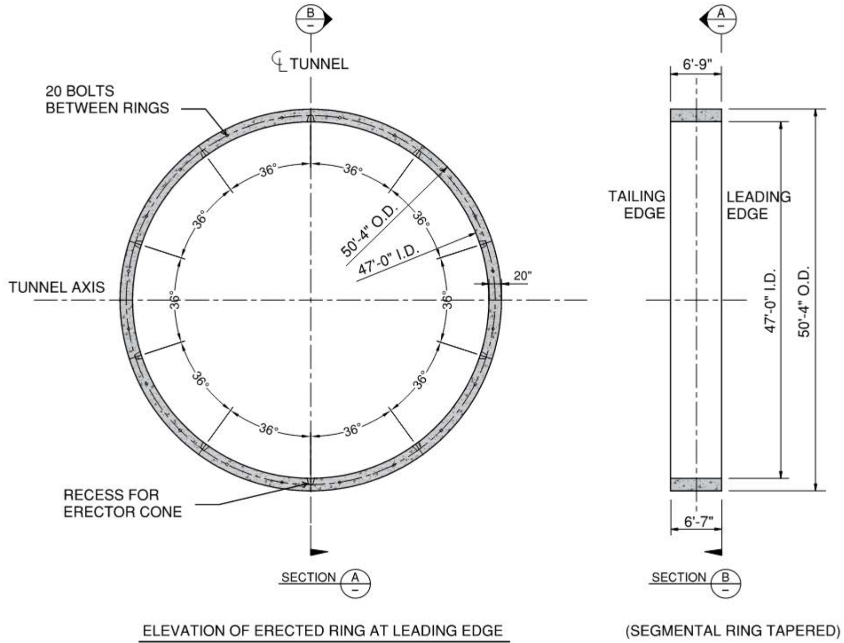
Tunnel linings are required to be designed to resist both structural and thermal loads during and after exposure to hydrocarbon or cellulose fires. Compliance with heat transmission and spalling requirements is based on the ASTM E3134 time-temperature curve, unless an alternative curve is justified through engineering analysis and accepted by the Authority Having Jurisdiction (NFPA 502 Section 7.3.2).

Fire resistance is improved by using appropriate aggregates, reducing water content, incorporating polypropylene (PP) fibers into the concrete mix and provision of fire boards for exposed surfaces. Fire protection measures to be considered at detailed design stage.

For further details on the fire resistance and fire testing of tunnel lining segments, refer to Section 2.4.3 of the Tunneling Technology Update Report.

The presence of liquefiable soils and regional seismic activity may present design challenges, particularly at tunnel-to-portal interfaces and cross passages and will require careful consideration during detailed design.

Figure 3.1: Tunnel segmental lining concept



Source: Prepared by Mott MacDonald, 2025

3.3 Cross passage configuration and space proofing

Cross passages are proposed at 650 ft intervals along the road tunnels to provide access between tunnels for emergency egress as outlined in 5.12 of this report. In addition to their life safety function, these passages accommodate tunnel system equipment, including electrical distribution boards, communication systems and lighting, as detailed on drawing 00028_B_121.

At the lowest point of the tunnel alignment, sump pumps are located within a cross passage, as shown in drawing 00028_B_122. The sizing requirements for the sump and associated pumps are outlined in Section 4.2.1 of the Tunneling Technology Update Report. For the current phase of the project, cross passages are also assumed to serve as an emergency egress route.

Fire-rated doors are provided at the entrances to cross passages in compliance with NFPA 502.

3.4 Cross passage opening

A permanent reinforced concrete frame is required to support the opening in the segmental tunnel lining. This frame provides vertical support to the edges of the opening in the tunnel lining. The frame is designed for the reactions from the segmental lining rings under the load combinations used for design of the segmental tunnel lining.

Prior to breaking out the tunnel lining for cross passage excavation, temporary structural steel supports, along with bicone connectors or shear dowels, will be required to support the opening in the lining.

3.5 Cross passage primary lining

Based on available geological information, ground improvement using the ground freezing method is proposed to ensure initial ground stability and watertightness during cross passage excavation. Details for ground freezing methodology is outlined in Section 2.6.1 of the Tunneling Technology Update Report.

An alternative method, such as pipe jacking described in Section 2.6.2 of the same report, is also considered feasible depending on the Contractor’s expertise. For the current stage of the project, ground freezing is selected for ground improvement.

The primary lining for cross passages will consist of lattice girders or steel sets and shotcrete, installed following a heading and invert excavation sequence. Shotcrete will be applied with an accelerator to achieve early strength gain, required before advancing to the next excavation round.

The selection of primary support will be based on geological mapping of the as-found conditions.

3.6 Cross passage secondary lining

A secondary lining is required in cross passages to provide long-term structural support against ground loads, hydrostatic pressure, and seismic forces. This lining ensures the structural integrity and durability of the cross passage by resisting earth pressures, maintaining watertightness under groundwater conditions, and accommodating dynamic loads during earthquake events.

To achieve watertightness, a composite waterproofing system will be installed between the primary and secondary linings. This system typically consists of a geotextile membrane placed directly against the primary lining to protect the waterproofing layer from mechanical damage, followed by a PVC sheet membrane that acts as the primary waterproof barrier. The PVC membrane is heat-welded at joints to form a continuous, impermeable layer, preventing water ingress into the tunnel structure. The interface between cross passages and the main tunnel presents a critical point in the waterproofing system and will require careful detailing to ensure long-term performance.

4 Portal configuration

The portals for tunnels constructed using TBMs require an access point that facilitates TBM launch, retrieval, and overall tunnel construction logistics. Excavation at the portal is supported by retaining structures and are required to be space proofed for construction operations including a launch chamber for TBM operations, and staging areas for equipment, segment storage, and muck handling.

The depth of the portal is determined based on required ground cover to the tunnel to ensure safe launch and retrieval of the TBMs. The portal also accommodates FLS, ventilation and tunnel system equipment such as power, water supply, ventilation and drainage systems.

4.1 Portal space proofing

The portal must provide adequate space to support TBM assembly and launch activities, along with all associated site infrastructure as detailed in Section 7.4.1 of this report. A decline will be excavated to access the tunnel alignment, ensuring approximately 50 feet of ground cover at the tunnel interface.

The space proofing of the portal is guided by highway design criteria and considers multiple elements listed in Table 4.1.

Table 4.1: Preliminary design criteria for portal space proofing

Elements	Preliminary design criteria
Highway	
Functional classification	Urban Principal Arterial/Interstate
Design vehicle	WB-67 (GB – Section 2.8.1)
Terrain classification	Level
Design speed	*55 mph (GB-Chapter 2)*
Stopping sight distance	*495 ft (GB – Table 3-1)*
Passing sight distance	*900 ft (GB - Table 3-4)*
Maximum allowable grade	5% (GB - Table 7-4a)
Minimum allowable grade	0.5% (GB - Section 3.4.2.2.2)
Minimum allowable radius of curvature	*3,000 ft (GB Table 3-9, e=6% max, GB Section 8.2.6)*
Tunnel lane and shoulder width	*LT shoulder: 4 ft (Shared 4 ft Egress Path)* Lane 12 ft (GB – Section 7.3.3.2) Lane 12 ft (GB – Section 7.3.3.2) RT shoulder: 8 ft Provision for dynamic sway
Minimum overhead tunnel clearance (including luminaire and dynamic clearances)	18'-6" (HPCM Table 1130-1)
Surface treatment	Asphalt concrete pavement
Crash barrier	Rigid concrete (allowance for barrier flare – refer to section xx)
Road features	Road signs, boom gate

Elements	Preliminary design criteria
Drainage system	
Road drainage	Curb side drainage pits with connection to portal sump Discharge pipe from the portal sump
Portal SOE Requirements	
Support of Excavation (SOE)	Temporary SOE in the form of Slurry wall or secant piles, waterproofing systems and permanent SOE in the form of reinforced concrete slab, walls and structural systems
Portal SOE construction tolerance	Vertical tolerance on SOE structures to be confirmed at detail design stage
Urban features	Architectural panels and urban design features
Portal and building accommodating FLS and tunnel systems equipment	
Ventilation system	Ventilation duct with motorized dampers and extraction fans with sound attenuators Jet fans Emissions sensors
FLS	Emergency equipment cabinets/Emergency communication systems Emergency egress Portable fire extinguishers Deluge and fire standpipe system elements and distribution mains Fire detection system
Portal building at portals	Fire Life Safety system and ventilation system
Lighting	Roadway lighting - above the carriageway Emergency lighting Maintenance lighting for maintenance corridor Emergency exit lighting with strobe above each cross passage
LV systems	Cable trays and service corridors Electrical cabinets, switch gears Emergency power/Uninterruptible Power Supply (UPS)
HV systems	Cable conduits and service corridors Electrical cabinets, switch gears Transformers
Intelligent Transportation Systems (ITS)	Variable Messaging Signs (VMS)/traffic and lane use signals Vehicle Detection Systems (VDS) Supervisory Control and Data Acquisition system Operations and Control Center (OCC)
Construction requirements	
TBM operation	TBM assembly and launch facilities at the tunnel interface Construction site facilities at surface.

Flood protection strategies are to be evaluated based on portal location and flood modeling. Where feasible, passive protection measures, such as locating portal entry above flood levels and installing flood walls, are preferred over flood gates.

4.2 Point MacKenzie portal

For the purposes of the construction concept, it is assumed that two TBMs will be assembled and launched from Point MacKenzie. This location has been selected due to its capacity to accommodate the necessary construction site facilities for TBM assembly and operation, and its relative isolation from nearby communities. Additional evaluation is needed to determine the feasibility of providing logistics required to launch the TBM from this location.

The current alignment concepts include a horizontal curve at the proposed TBM launch location. This configuration presents constructability challenges, as it is preferable for tunnel boring machines to have the shields fully advanced into the ground prior to entering a curve. To improve TBM launch, the alignment should be revised in the next phase of design to incorporate a straight section at the TBM launch point.

4.2.1 Temporary Support of Excavation (SOE)

Excavation method

The portal and approach structure will be constructed using a combination of open cut excavation and earth-retaining systems to reach the required depth for TBM launch.

Temporary support system

The temporary support of excavation will consist of slurry walls and steel walers and struts, designed to maintain stability during the staged excavation. The system will be designed to support the ground, groundwater pressure and adjacent loading from construction.

Monitoring and safety

A detailed Instrumentation and Monitoring (I&M) plan should be developed as part of subsequent design stages. As a minimum, the I&M system should include inclinometers to monitor lateral ground movement, piezometers for pore pressure measurement, and automated survey points for surface settlement.

The next design stages should consider the use of the observational method (OM) in design and construction. The use of OM has been demonstrated globally to reduce risk and provide program savings within deep excavations.

4.2.2 Permanent Support of Excavation (SOE)

A permanent retaining structure with integrated waterproofing will be constructed to support the portal excavation and form the portal building at the tunnel interface which will house essential tunnel systems such as ventilation fans, drainage infrastructure, communication systems, and electrical power equipment.

4.3 Anchorage portal

The Anchorage portal is located adjacent to Government Hill, at the interface with E Loop Road. The site presents spatial constraints due to proximity to railway infrastructure and local communities. As a result, the portal infrastructure will need to be constructed within a cutting along the hillside.

Tunnel Boring Machines (TBMs) launched from Point MacKenzie will break through at the Anchorage portal; TBM dismantling requirements are outlined in 7.4.2.

4.3.1 Temporary Support of Excavation (SOE)

Excavation method

The portal structure will be constructed using an open cut and staged excavation with depths ranging from ground surface to approximately 100 feet.

Temporary support system

The temporary support system will consist of an anchored contiguous piled wall, supported by temporary steel strand anchors outside the tunnel envelope and glass fiber reinforced polymer (GFRP) bars within it. This system will be designed to accommodate ground conditions, groundwater pressures, and adjacent construction loads. On either side of the portal structure, open-cut excavations will be supported using soil nails and reinforced shotcrete facing.

Monitoring and safety

A detailed Instrumentation and Monitoring (I&M) plan should be developed as part of the subsequent design stages. As a minimum, the I&M system should include inclinometers to monitor lateral ground movement, piezometers for pore pressure measurement, and automated survey points for surface settlement. Consideration should be given to the pre-construction surveys of adjacent properties and structures.

4.3.2 Permanent Support of Excavation (SOE)

A permanent retaining structure with integrated waterproofing will be constructed to support the portal excavation and form the portal building at the tunnel interface, which will house essential systems such as ventilation fans, drainage infrastructure, communication systems, and electrical power equipment. To facilitate safe TBM breakthrough and ensure a flush connection between the tunnel lining and portal wall, the interface between the portal building and the skewed contiguous piled wall will be backfilled with low-strength concrete.

5 Fire Life Safety requirements

The following requirements for the fire and life safety elements of the tunnel design have been considered in developing design concepts for the portals, tunnels and cross passages.

5.1 Relevant codes and applicable standards

Based on the location and scope of the project, the latest version of the codes and standards in Table 5.1 are applicable to the Knik Arm Tunnel Project. Additional references, where applicable, are provided.

Table 5.1: Applicable design standards

Design standard or reference document
AASHTO, LRFD Road Tunnel Design and Construction Guide Specifications, 1st edition
National Fire Protection Association 10 (NFPA 10), Standard for Portable Fire Extinguishers
National Fire Protection Association 13 (NFPA 13), Standard for the Installation of Sprinkler Systems
National Fire Protection Association 14 (NFPA 14), Standard for the Installation of Standpipe and Hose Systems
National Fire Protection Association 20 (NFPA 20), Standard for the Installation of Stationary Pumps for Fire Protection
National Fire Protection Association 22 (NFPA 22), Standard for Water Tanks for Private Fire Protection
National Fire Protection Association 24 (NFPA 24), Standard for the Installation of Private Fire Service Mains and Their Appliances
National Fire Protection Association 70 (NFPA 70), National Electrical Code
National Fire Protection Association 72 (NFPA 72), National Fire Alarm and Signaling Code
National Fire Protection Association 101 (NFPA 101), Life Safety Code
National Fire Protection 502 (NFPA 502), Standard for Road Tunnels, Bridges, and Other Limited Access Highways
Alaska Building Code (ABC), with local Anchorage Amendments

5.2 Authority Having Jurisdiction

The proposed tunnel will connect Anchorage and Point MacKenzie across the Knik Arm. The responding fire department to an incident in the proposed tunnel is assumed to be the Anchorage Fire Department. The DOT&PF is responsible for the management and regulation of road tunnels in Alaska.

Determining who will have final determination on AHJ issues is critical to the success of the project, and this determination should be made as early as possible. It is assumed that the DOT&PF will take on the role of AHJ. A fire and life safety committee consisting of all parties involved should be considered to discuss specific design considerations that arise. The governing standard is NFPA 502 with any local amendments.

5.3 Portal structure code requirements

To match the construction elements in the tunnel, the portal structures will be constructed as a Type I-B, noncombustible construction building (ABC Table 601). The portal structures are anticipated to be considered mixed-use occupancies containing Group A assembly spaces (if the OCC is provided in portals), Group S storage spaces, and Group S-2 electrical and mechanical spaces (ABC Section 508.1). Portal structures are required to comply with the suppression and detection requirements of the Alaska Building Code with local Anchorage amendments.

5.4 Tunnel category and application

The length of the proposed Alternative 1 alignment is approximately 20,725 feet. The length of the proposed Alternative 4 is approximately 21,915 feet. Both proposed alignments exceed 3,280 feet which is classified as a Category C Tunnel (NFPA 502 Section 7.2). The requirements for a Category C Tunnel are shown in the following table.

Table 5.2: Summary of NFPA 502 requirements for Category C tunnel

Fire protection systems	NFPA 502 sections	Category C [NFPA 502 Section 7.2(4)]
Engineering analysis		
Engineering analysis	4.3.1	MR
Fire protection of structural elements [a]		
Fire protection of structural elements	7.3	MR
Fire detection, identification, and location of fire in tunnel	7.4	MR
CCTV systems [b]	7.4.3	CMR
Automatic fire detection systems [b]	7.4.6.7	CMR
Fire alarm control panel	7.4.7	MR
Emergency communications systems [c]		
Emergency communications systems	4.5/7.5	CMR
Traffic control		
Stop traffic approaching tunnel portal	7.6.1	MR
Stop traffic from entering tunnel’s direct approaches	7.6.2	MR
Fire protection		
Fire apparatus [d]	7.7	-
Fire standpipe	7.8/10.1	MR
Water supply	7.8/10.2	MR
Fire department connections	10.3	MR
Hose connections	10.4	MR
Fire pumps [e]	10.5	CMR
Portable fire extinguishers	7.9	MR
Fixed water-based firefighting systems [f]	7.10/Chapter 9	CMR
Emergency ventilation system [g]	7.11/Chapter 11	MR
Tunnel drainage system [h]	7.12	MR
Hydrocarbon detection [h]	7.12.7	MR
Flammable and combustible environmental hazards [i]	7.15	CMR

Fire protection systems	NFPA 502 sections	Category C [NFPA 502 Section 7.2(4)]
Means of egress		
Emergency egress	7.16.1.1	MR
Exit identification	7.16.1.2	MR
Tenable environment	7.16.2	MR
Walking surface	7.16.4	MR
Emergency exit doors	7.16.5	MR
Emergency exits (includes cross passages) [j]	7.16.6	MR
Electrical systems [k]		
General	12.1	MR
Emergency power	12.4	MR
Emergency lighting	12.6	MR
Exit signs	12.6.8	MR
Security plan	12.7	MR
Emergency response plan		
Emergency response plan	13.3	MR

MR: Mandatory requirement (3.3.42). CMR: Conditionally mandatory requirement (3.3.42.1).
The purpose of Table A.7.2 is to provide guidance for locating minimum road tunnel fire protection requirements within this standard. If there is any conflict between the requirements defined in the standard text and this table, the standard text must always govern.
[a] Determination of requirements in accordance with Section 7.3
[b] Determination of requirements in accordance with Section 7.4
[c] Determination of requirements in accordance with Sections 4.5 and 7.5
[d] Not mandatory to be at tunnel; however, they should be near to minimize response time
[e] If required, must follow Section 10.5
[f] If installed, must follow Section 7.10 and Chapter 9
[g] Section 11.1 allows engineering analysis to determine requirements
[h] If required, must follow Section 7.12
[I] Determination of requirements in accordance with 7.15.2
[j] Emergency exit spacing must be supported by an egress analysis in accordance with 7.16.6
[k] If required, must follow Chapter 12.

5.5 Passive fire protection

The following considerations for the passive protection of the tunnel lining and fire rated construction in the tunnel are required to be considered in developing design concepts for the portals, tunnels and cross passages.

5.5.1 Tunnel passive fire protection requirements

Emergency exits are required to be separated from the tunnel by a minimum 2-hour fire-rated construction enclosure, rated based on the time-temperature curve presented in ASTM E3134, *Standard Specification for Transport Tunnel Structural Components and Passive Fire Protection Systems* (NFPA 502 Section 7.16.6.4). Doors leading into emergency exits are required to be a minimum 1 ½ hour fire-rated based on the time temperature curve presented in ASTM E3134, (NFPA 502 Section 7.16.5.5.1).

The design of the tunnel lining is required to be designed to prevent progressive collapse of the primary structural elements and present the failure of support for overhead equipment and systems. The intent of this protection is to support firefighter operations, minimize economic impact, and mitigate structural damage (NFPA 502 Section 7.3.1).

The structural lining of the tunnel is required to comply with the transmission of heat and spalling requirements from applying the time-temperature curve in ASTM E3134, unless an engineering analysis acceptable to the AHJ demonstrated that an alternative time-temperature curve is suitable (NFPA 502 Section 7.3.2).

Due to the high temperatures presented in the ASTM E3134 temperature curve, the use of protective lining in the form of a protective fire board or fibers in the concrete may be necessary. The details of this approach are described in Section 0 of this report.

5.6 Fire alarm and detection

Category C tunnels are required to have at least two independent means of identifying and locating a fire (NFPA 502 Section 7.4.1). Closed-circuit television (CCTV) systems with traffic-flow indication devices or surveillance cameras are permitted for use to identify and locate fires in tunnels with 24-hour supervision (NFPA 502 Section 7.4.3). Linear heat detection will be utilized in conjunction with CCTV to provide two independent means of locating a fire in the tunnel. This configuration was selected to provide a means of locating a fire, and a way to visually verify the event before activation of the deluge system.

5.6.1 Linear heat detection

A double looped, zoned linear heat detection system will be provided in the tunnel. A fiber optic linear heat detection system will be provided and zoned in coordination with the deluge system to provide an initial indication of fire location.

The system will require a detection cable that will provide an alarm once an initiating temperature is reached. The cable will detect temperature anywhere along the length of the tunnel.

5.6.2 Closed-circuit television (CCTV)

Closed-circuit television (CCTV) systems with surveillance cameras are permitted for use as a form of detection in tunnels with 24-hour supervision (NFPA 502 Section 7.4.3). The CCTV monitoring equipment will be located in the Operations and Control Center, the requirements of which are discussed in the following section of the report. Video Automatic Incident Detection (VAID) systems may be paired with CCTV supervision to aid in identifying incidents across multiple CCTV screens (PIARC Road Tunnels Manual Section 6.3). VAID can detect a range of incidents including stopped vehicles, smoke, vehicles moving in the wrong direction, speed reduction, slow vehicles, pedestrians, debris in the road tunnel, flames, entry into restricted zones, and lost goods in the tunnel. It is proposed that the CCTV system be provided with a VAID system such that the video monitoring equipment may serve as an additional notification device to the operators present in the OCC.

5.6.3 Operations Control Center (OCC)

The operations control center is required to be staffed by qualified, trained personnel and provided with the essential apparatus and equipment to communicate with, supervise and coordinate all personnel in accordance with Chapter 26 of NFPA 72.

The OCC will be provided with the ability to communicate rapidly with participating agencies. Equipment is required to be available for recording radio and telephone communications and CCTV transmissions during an emergency. OCC personnel are required to be thoroughly familiar with the emergency response plan and will be trained to implement the plan (NFPA 502 Sections 13.5.3-13.5.5).

Alternative locations are required to be provided in the event that the OCC is out of service for any reason and are required to be equipped with the essential apparatus or have readily available to function as required and have all necessary documents, records, and procedures available to duplicate the function of the primary OCC (NFPA 502 Section 13.5.6)

The OCC will be located in an area separate from other occupancies by construction of not less than 2-hour fire resistance rating doors (NFPA 502 Section 13.5.7). It is proposed that the primary OCC be located in the portal structure on the Anchorage side of the Knik Arm Tunnel with a secondary back up location remote from the tunnel.

The OCC is required to be protected by fire detection, fire protection, and fire-extinguishing equipment to provide early detection and suppression of fire in the OCC (NFPA 502 Section 13.5.8).

5.7 Emergency communications systems

The following emergency communications systems are proposed for the tunnel environment.

Mass notification

A mass notification system is proposed for use throughout the tunnel and cross-passages. The mass notification system is required to be designed following NFPA 72 Section 24.6. Recorded voice messages are required to comply with the intelligibility requirements of NFPA 72 Section 18.

The mass notification system will provide one-way voice communication messages broadcasted through a microphone located in the primary or secondary OCC. A prerecorded message selected by the operator may also be used to provide notification. Equipment associated with the mass notification system will be monitored by the fire alarm and SCADA systems.

Motorist call box

Two-way emergency service communication in the form of call boxes will be located within the tunnel and cross-passages. This system will be designed following the requirements NFPA 72 Section 24.8.

A notification signal at the primary and secondary OCC, distinctive from any other alarm, supervisory, or trouble signal is required to indicate the off-hook condition of a calling telephone circuit (NFPA 72 Section 24.8.7). The call box system will automatically record all call box calls with a time and date stamp. Equipment associated with the call box system will be monitored by the SCADA system.

An operator in the primary or secondary OCC location will be capable of initiating a call from or to a specific call box. The call box is required to be wired following the requirements of an emergency circuit (NFPA 502 Section 12.4.1).

Call boxes are required to be installed in the fire pump room(s), area(s) of refuge, or where required by the AHJ (NFPA 72 Section 24.8.12). It is proposed that call boxes be located at distances not to exceed 300 feet along the full length of the tunnel as well as in cross-passages.

Telephone

Courtesy telephones will be provided in portal structures as well as in the primary and secondary OCC.

5.8 Fire suppression

The following fire suppression requirements apply to the proposed tunnel.

5.8.1 Fixed water-based firefighting systems

As a category C tunnel, fixed water-based firefighting systems are conditionally mandatory (NFPA 502 Section 7.10.1).

A deluge type suppression system is proposed in the tunnel which will be installed, inspected, and maintained in accordance with NFPA 15 (NFPA 502 Section 9.1.2).

Values listed for typical deluge systems to provide extinguishment include a range of 0.15 gpm/ft^2 to 0.50 gpm/ft^2 (NFPA 15 Section 7.2.1.3). PIARC recommends a design density of 0.30 gpm/ft^2 to 0.40 gpm/ft^2.

A design density of 0.40 gpm/ft^2 will be conservatively assumed for purposes of sizing the fire suppression demand. The deluge system will be required to supply the required system demand for a duration of one hour (NFPA 502 Section 9.3.1).

The deluge zone will be coordinated with individual sections of the linear heat detection system to provide an indication of which area in the tunnel the fire occurs in. Once detected, the CCTV system will be used to verify the event before manual discharge of the deluge system is activated. For the purpose of sizing the fire tanks, a deluge zone length of 65 feet will be assumed (PIARC and fixed fire-fighting systems: A report on working group activity). The neighboring zones will not be activated. An estimation of the required water supply for both the FFFS and standpipe demand is included in the following section of the report.

5.8.2 Standpipes

A Class I standpipe system with 2.5-inch hose connections is required to be installed within road tunnels (NFPA 502 Section 10.1.1, NFPA 14 Section 3.3.30.1). Where a Class I standpipe system supplies three or more hose connections on any floor, the minimum flow rate for the hydraulically most demanding horizontal standpipe system will be 750 gpm (NFPA 14 Section 10.6.1.1.3).

A Class 1 wet standpipe is proposed for the Knik Arm Tunnel to address concerns with freezing conditions as well as the practical difficulty associated with supplying the line with pressure in 10 minutes or less as required for a dry standpipe system (NFPA 502 Section 10.1.1, NFPA 502 Section 10.1.5).

For areas subject to freezing, the water in the standpipe is required to be heated and circulated. All piping and fittings exposed to freezing conditions are required to be heat-traced and insulated. The material used for heat tracing is required to be listed for the intended purpose and monitored for power loss (NFPA 502 Section 10.1.4).

5.8.3 Water supply

The wet standpipe system is required to be connected to an approved water supply capable of supplying the system demand for a minimum of 1 hour (NFPA 502 Section 10.2.1).

Without flow data from the City of Anchorage and considering the large demand of the tunnel deluge and standpipe systems, space proofing for water storage tanks at each portal will conservatively be assumed at this stage in the design. This will be a gravity-type tank provided with a fire pump (NFPA 502 Sections 10.2.3).

5.8.4 Combined fire suppression demand

The fire system demand will include the demand from the standpipe system (750 gpm) for a minimum of one hour in combination with the demand for the operation of the deluge system within the tunnel which is required to operate at a design density of 0.40 gpm/ft^2 for a duration of one hour (NFPA 502 Section 9.3.1).

Based on an assumed deluge zone spacing of 65 feet and a tunnel width of approximately 36 feet, the design area of a deluge zone is approximately 2,340 ft^2. The total demand for the deluge system based on the design density is 936 gpm. For the required duration of one hour, this is approximately 56,160 gallons.

The standpipe demand of 750 gpm for the required duration of one hour is 45,000 gallons.

The total demand for the standpipe and deluge systems is approximately 101,160 gallons which is proposed to be located in two separate tanks located at each portal, each with a capacity of approximately 51,000 gallons. The proposed location of these tanks is the subterranean areas of the portal structure as indicated on the space proofing drawings with dimensions.

5.9 Portable fire extinguishers

Portable fire extinguishers, with a rating of 2-A:20B:C, are required to be located along the roadway in approved wall cabinets at intervals of not more than 300 feet (NFPA 502 Section 7.9.1). The maximum weight of each extinguisher may not exceed 20 lbs. (NFPA 502 Section 7.9.2). Portable fire extinguishers are required to be selected, installed, inspected and maintained in accordance with NFPA 10 (NFPA 502 Section 7.9.3).

5.10 Emergency Ventilation System (EVS)

The following assumptions have been made concerning the design of the EVS for the tunnels.

5.10.1 Design fire scenario

The assumed fire scenario adopted for the current tunnel configuration is a flammable liquid tanker vehicle fire within the tunnel. NFPA 502 notes that the peak fire heat release rate (PFHRR) for this type of vehicle may be up to 300 MW. It is assumed that vehicles carrying hazardous materials will be prohibited from entering the tunnel using traffic control systems. With the proposed installation of a deluge-type fire suppression system, it is predicted that the peak heat release rate may be reduced to approximately 100 MW. A peak heat release rate of 100 MW is assumed for use in the design of the EVS system.

5.10.2 EVS type

A semi-transverse ventilation system, with an overhead duct with motorized dampers and jet fans, is proposed in the current tunnel configuration. This type of ventilation system allows the smoke and heat to be extracted locally at the fire location. Makeup air is introduced at the portals.

5.11 Alternative fuels

The introduction of new technologies into enclosed spaces like road tunnels present new and complicated challenges concerning the accumulation of hazardous and flammable gases that may ignite. Hydrogen vehicles are one of the primary concerns with emerging technology due to the lighter density than air and rapid release mechanisms present on hydrogen storage tanks.

Any fail-safe release mechanism on this type of vehicle will vent the reservoir of hydrogen when exposed to elevated temperatures. The resulting hydrogen-air mixture will expand to fill the space and be pulled into the closest ventilation shaft where even small electrical charges may cause the flammable mixture to ignite.

NFPA 502 discusses the minimum fire protection and life safety requirements for road tunnels. Section 13.3.2 indicated that the emergency response plan is required to consider incidents involving alternative fuel sources, with recommendations for mitigation measures provided in NFPA 502 Annex G.

Examples of proposed mitigation in Annex G include the following:

- Establish a minimum level of ventilation to provide adequate airflow to dilute the explosive gases below the lower flammability limit (LFL)
- Provide alternative-fuel detection devices within the tunnel to detect the accumulation of gases (hydrogen gas detection, etc.)
- Specify emergency response procedures, precautions, and training requirements for each of the alternative-fuel vehicles.

Ultimately the standards in place do not adequately provide guidance on the mitigation of the emerging risks of alternative technology. It is recommended that the traffic monitoring systems prevent the entrance of alternative fuel vehicles unless specific consideration in the design of the ventilation and suppression system has addressed the hazard presented by the specific technology. Section 7.13 of NFPA 502 is a placeholder for further design requirements specific to alternative technologies and is still under development.

In the short term, further studies are required in discussion with AHJ as to the mitigation measures or restrictions for dealing with alternative fuels (CNG, cGH2, LP-Gas, LNG, Electric Vehicles (EV)) in road tunnels (NFPA 502 Annex G.1). The studies require to outline overview of alternative fuels in particular EVS, and extent of anticipated traffic volume using alternative fuel travelling through Knik Arm Tunnel to inform design measures.

5.12 Means of egress

5.12.1 Emergency exits

A traffic management system will be used in the tunnel design to allow the roadway surface to be considered part of the egress pathway (NFPA 502 Section 7.16.6.3.1). A minimum clear width of 3.7 feet will be maintained along the roadway and provided with protection from traffic (NFPA 502 Section 7.16.6.3.2).

The minimum width of a door into a means of egress is 32 inches (NFPA 101 Section 7.2.1.2.3.2). The minimum ceiling height required to be maintained in a means of egress is 7 feet 6 inches. Projections from the ceiling are required to be maintained at a clearance of 6 feet 8 inches (NFPA 101 Section 7.1.5.1).

Cross-passages will be used as emergency exits. Provisions to stop traffic in the non-incident tunnel will be required (NFPA 502 Section 7.16.6.7). The proposed configuration does not require an elevated walkway and allows occupants to use the egress path without ascending a dedicated ladder or set of additional stairs. Protection of mobility-impaired individuals and their impact on the egress will be addressed as part of the emergency response plan (NFPA 502 Section A.7.16.1.1).

The spacing between exits is required to be maintained below a maximum spacing of 1,000 feet (NFPA 502 Section 7.16.6.2). The actual spacing is required to be based on the results of an engineering analysis, with results for such an analysis typically ranging from 100 to 656 feet (NFPA 130 Sections 7.16.6.2 and A.7.16.6.2). PIARC also references a typical exit spacing of 328-1,640 feet.

Projects that adopt a spacing of approximately 650 feet for emergency exits include the following:

- Port of Miami Tunnel (Miami, FL), cross passages
- SR99 Tunnel (Alaskan Way Viaduct Replacement Tunnel), (Seattle, WA), exit corridors
- Parallel Thimble Shoal Tunnel (Chesapeake Bay, VA), exit corridors
- Hampton Roads Bridge-Tunnel (Virginia), exit corridors
- Midtown Tunnel West (Norfolk, VA), note that exit access doors for this tunnel are located at 300 feet increments based on the length of the immersed tube elements.

The selected cross-passage spacing will ultimately be based on the results of the required engineering analysis considering the following factors (NFPA 502 Section 7.16.6.2):

- Category, including types and classes of tunnels
- Design fire scenario
- Egress analysis
- Fire-life safety system analyses to provide tenable environment in tunnel (This includes type and operation of tunnel ventilation, detection, fire protection, and control systems.)
- Traffic management system
- Emergency response plan
- Consideration of uncertainties of people’s behavior during a fire event and of those who are unable to self-rescue.

Emergency exits (including cross-passages) are required to be pressurized in accordance with NFPA 92 (NFPA 502 Section 7.16.6.5). This will be accomplished using two pressurization fans located on either end of each cross-passage and sequenced to provide makeup air from the non-incident tunnel.

5.12.2 Doors

Doors into cross passages are required to comply with the following requirements:

- Doors are required to be self-closing and maintain a fire resistance rating of a minimum of 1 ½ hours when tested in accordance with ASTM E3134 (NFPA 130 Section 7.16.5.5)
- The maximum door opening force may not exceed 50 lb. (NFPA 502 Section 7.16.5.6).

5.13 Emergency response and planning

An emergency response plan will be required for the Knik Arm Tunnel to address responses from responding agencies including the fire department, police department, and ambulance operators. This response plan is required to be developed in collaboration with the authorities having jurisdiction including the City of Anchorage and the Alaska Department of Transportation and Public Facilities.

The following scenarios are required to be considered in the emergency response plan (NFPA 502 Section 13.2):

- Fire or a smoke condition in one or more vehicles or in the facility
- Fire or a smoke condition adjoining or adjacent to the facility
- Collision involving one or more vehicles
- Loss of electric power that results in loss of illumination, ventilation, or other life safety systems
- Rescue and evacuation of motorists under adverse conditions
- Disabled vehicles
- Flooding of a travel way or an evacuation route
- Seepage and spillage of flammable, toxic, or irritating vapors and gases
- Multiple casualty incidents
- Damage to structures from impact and heat exposure
- Serious vandalism or other criminal acts, such as bomb threats and terrorism
- First aid or medical attention for motorists
- Extreme weather conditions, such as heavy snow, rain, high winds, high heat, low temperatures, or sleet and ice, that cause disruption of operation
- Earthquake
- Hazardous materials accidentally or intentionally being released into the tunnel
- Fires exceeding design basis.

At a minimum the following information is required to be included in the emergency response plan (NFPA 502 Section 13.3):

- Name of plan and the specific facility(ies) the plan covers
- Name of responsible agency
- Names of responsible individuals
- Dates adopted, reviewed, and revised
- Policy, purpose, scope, and definitions
- Participating agencies, senior officials, and signatures of executives authorized to sign for each agency
- Safety during emergency operations
- Purpose and operation of operations control center (OCC) and alternative location(s) as applicable
- Procedure for staffing the backup location(s) shall be specified
- Procedure to control risk while the OCC does not have staff until the backup facility can take over shall be specified
- Purpose and operation of command post and auxiliary command post

- Communications (e.g. radio, telephone, messenger service) available at central supervising station and command post; efficient operation of these facilities
- Fire detection, fire protection, and fire-extinguishing equipment; access/egress and ventilation facilities available; details of the type, amount, location, and method of ventilation
- Procedures for single or multiple concurrent fire emergencies, including a list of the various types of fire emergencies, the agency in command, and the procedures to follow
- Maps and plans of the roadway system, including all local streets
- Any additional information that the participating agencies want to include
- Emergency response plan that recognizes the need to assist people who are unable to self-rescue with established, specific response procedures
- Emergency operational procedures developed based on the design
- Emergency response plan that includes traffic control procedures to regulate traffic during an emergency that can affect operation of the facility
- Emergency response plan that considers degraded modes of operation as identified in NFPA 3 and NFPA 4, as applicable
- Emergency response plan for tunnel facilities that anticipates elevated background noise levels within the facility resulting from the operation of emergency systems during various types of incidents, and provides specific guidance for emergency responders as to what noise levels to expect.

6 Tunnel systems

The following requirements for the ventilation system of the tunnels have been considered in developing design concepts for the portals, tunnels and cross passages.

6.1 Tunnel ventilation system

6.1.1 Emissions control

Sensors are to be installed at regular intervals in the tunnel. They will monitor the levels of carbon monoxide (CO), nitrogen oxide (NO_x), sulfur dioxide (SO_2), and haze. When the pollutant concentration reaches the preset thresholds, the ventilation system will automatically activate based on proposed pre-programmed mode(s). In response, the local damper(s) and jet fan(s) near the alarmed sensors will automatically operate to dilute pollutant concentration. Sensors will also be monitored in the OCC, where operators can choose to open additional dampers and operate more jet fans.

6.1.2 Maintenance operations

Ventilation airflow for maintenance operations will be based on the federal Occupational Safety and Health Administration (OSHA) requirements, as adopted by the Alaska Occupational Safety and Health Section (AKOSH) by reference. During maintenance servicing, the tunnel ventilation system will be operated to achieve a minimum of 30 feet per minute across the work area. Damper(s) will be opened, and jet fan(s) will be activated where maintenance activities occur. A minimum of 200 cubic feet of fresh air will be supplied for each maintenance person.

6.2 Plumbing and drainage system

6.2.1 Tunnel

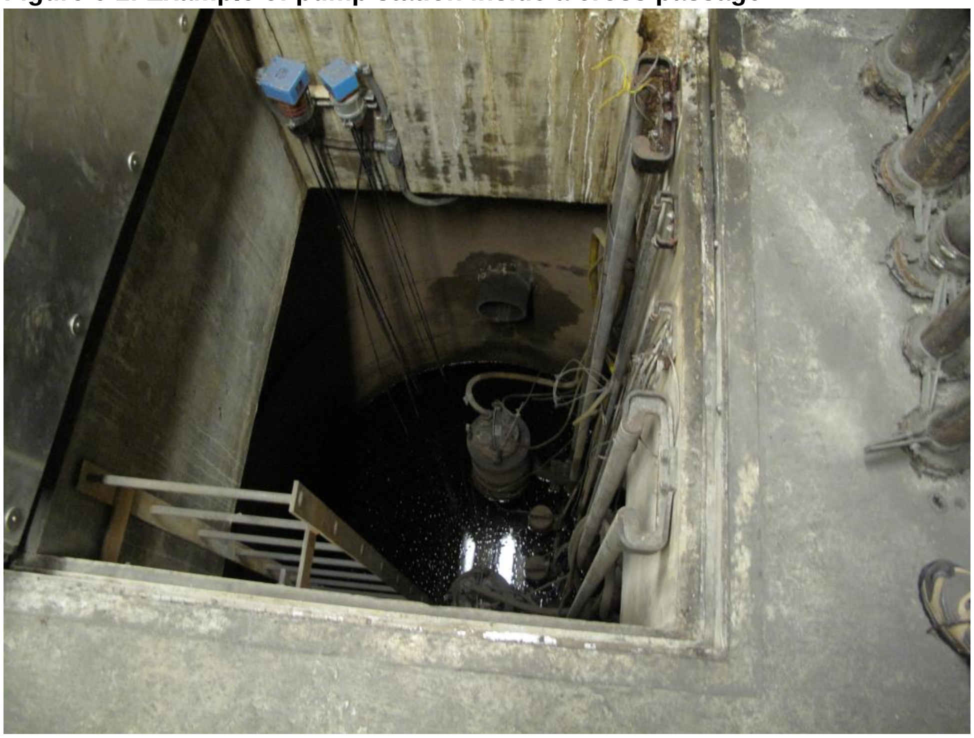
The tunnel drainage system will have drainage inlets on one side of the road at regular intervals. Each inlet contains a grating on top of a catch basin. The catch basins along the roadway will be connected via a subsurface pipe to allow the drainage to flow towards the tunnel low point. At the tunnel low point, drainage from both roadways will be directed to the wet well of the low point pump station located underneath the cross passage.

At each cross passage, the floor should be constructed such that it is sloping towards the roadway, and floor drains may be necessary to prevent liquid from pooling.

6.2.1.1 Low point pump station

A low point pump station will be located at the low point(s) of the tunnel and may consist of a wet well, a dry well, sump pumps (see Figure 6.1), oil-water separators and a debris filtration system. For this tunnel configuration, the low point pump station will be located within the cross passage at the low point of the tunnel. This allows for easier access to the pump station. The cross passage will also act as a path for equipment removal and access, with a monorail to help facilitate the pump maintenance and replacement operations. Pumps installed must be explosion-proof to account for the risk of oil ignitions from the roadway. Drainage should be filtered using oil-water separators and debris filtration systems before entering the wet well and then pumped out to the city sewer system. As noted in Drawing B122, the sump shown is indicative and detailed space proofing is needed to determine the size of the sump required to locate the identified infrastructure. Should space within the low point sump be insufficient, another alternative solution would be to pump from the low point to a portal pump station(s) where the effluent can be screened before discharge.

Figure 6.1: Example of pump station inside a cross passage



Source: LA Metro Tunnel

6.2.2 Portal buildings

Each portal building will have a drainage system independent from the tunnel that connects to the city sewer system. Domestic water, preferably from a municipal water source, should be provided for the plumbing fixtures within the portal buildings. At locations where the domestic water lines are routed through unconditioned spaces, the pipework shall be heat traced and insulated to prevent freezing. Depending on location, if gravity drainage to the city sewer is not feasible, then a pump station should be provided.

6.2.3 Portal pump stations

Each portal building will include a pump station to remove storm water and drainage from the U-section of the tunnel approach. Water originating from the U-section will be collected through trench drains to prevent it entering the tunnel. Portal pump stations should have pump redundancy and other similar provisions as the low point pump station(s), which include wet and dry wells, oil-water separators, debris filtration systems, and monorails.

6.3 HVAC system

6.3.1 Facility rooms within the tunnel

A mechanical ventilation system, consisting of fans and dampers, will be provided at the low point pump station. There should be hydrocarbon sensors installed to monitor the hydrocarbon concentration and activate the ventilation system when a hydrocarbon concentration above the preset levels is detected. If the hydrocarbon concentration continues to rise, a high alarm warning will be triggered to alert the operators in the OCC.

The cross passage housing the pump station will also adopt a heating system, as the tunnel is expected to experience low temperatures. Depending on the type of equipment being installed in the cross passages without a pump station, a heating system may be required.

An exhaust fan and an opening should be installed at each cross passage to facilitate air circulation and remove heat generated from equipment. Air should be supplied into the cross passage from one roadway and exhausted into the other.

6.3.2 Portal buildings

Heat pumps should be utilized in facility spaces for environmental temperature control where necessary, and mechanical ventilation will be provided in all other rooms to meet the minimum outside air requirements.

A dedicated supply and exhaust fan will be installed for the portal pump station and the associated wet well to provide adequate air exchange and odor control. Mechanical ventilation system provisions provided at the low point pump station, such as the hydrocarbon concentration monitoring system, should also be adopted for the portal pump stations.

6.4 Lighting system

6.4.1 Roadway lighting

A symmetrical lighting layout, meeting ANSI/IES RP-8-22, is adopted as the roadway lighting system for this tunnel configuration concept for each of the three tunnel zones:

- Approach
- Threshold
- Interior.

The luminaries should be LED type and installed along the roadway walls. This configuration minimizes glare into the drivers’ eyes, increases visibility, and allows for easier access during maintenance. The lighting system should also adopt adjustable brightness features utilizing lighting controllers to accommodate different visibility requirements across multiple tunnel zones and environmental conditions.

6.4.2 Emergency lighting

An Uninterruptible Power Supply (UPS) is adopted, for both the tunnel and portal buildings, to provide backup power for the emergency lights, exit lights, and essential signs that are critical for evacuating motorists within the tunnel and any personnel inside the portal buildings.

6.5 Electrical system

6.5.1 Power supply

Primary electrical power supply for the tunnel and portal buildings should be provided from a nearby utility supplier substation. One option for this primary source could be the TBM substation used during tunneling. For redundancy and to minimize downtime, a secondary (backup) electrical power supply from a substation independent from the primary source should be adopted. In addition, an onsite generator will be provided as an additional backup power source. The onsite generator could be sized for the critical loads only, however, if an independent secondary power source is not available, the generator will need to be sized for all of the required loads.

6.5.2 Uninterruptible Power Supply (UPS)

As noted in the previous section, an Uninterruptible Power Supply (UPS) will be provided for emergency lighting systems and egress signages. In addition, the UPS will provide backup for control panels such as the fire alarm and ventilation control panels.

6.6 Intelligent Transportation Systems (ITS)

6.6.1 Transportation Management Systems (TMS)

Installation of dynamic messaging signs (DMS) at the tunnel approaches, portals, and at regular intervals throughout the tunnel should be included as part of the transportation management system (TMS). Operators can change the messages on the DMS when necessary, enabling real-time communication with motorists from the operation control center (OCC).

6.6.2 Vehicle detection

Radar-based type vehicle detector devices are adopted for this tunnel configuration and should be installed at regular intervals in the tunnel and at the portals, in addition to following the manufacturer’s spacing requirements. Radar devices are easy to install, require low maintenance, cover long detection ranges, and maintain reliable performance in low lighting conditions.

6.6.3 Overheight Vehicle Detection (OHVD) system

Overheight Vehicle Detection (OHVD) systems should be installed at the road tunnel approaches and ramp entrances leading to the tunnel. The detector should adopt an alert system that can notify the operators in the OCC when a vehicle exceeding the tunnel's clearance limit is attempting to pass through. The same alert system should also alert the driver through an automated message from the dynamic messaging signs that their vehicle exceeds the tunnel clearance limit.

6.6.4 Traffic control

Traffic control devices such as Lane Use Signals (LUS) and Dynamic Messaging Signs (DMS) should be installed to help traffic operators regulate traffic flow and communicate with incoming motorists as well as those already inside the tunnel. The traffic control units should be designed to operate in coordination with each other to prevent traffic congestion, provide guidance on lane usage during incidents or maintenance, and deliver real-time alerts about speed limit changes, closures, or emergencies.

6.6.5 Lane Use Signals (LUS)

Lane Use Signals (LUS) should be placed at the road tunnel approaches, portals entrance, and at regular intervals inside the tunnel for each lane to regulate incoming traffic and traffic within the tunnel. Traffic operators should be able to control each LUS independently to display the different traffic status of each lane. The display should follow the Manual on Uniform Traffic Control Devices (MUTCD) requirements.

6.6.6 Incident monitoring

Pan-Tilt-Zoom (PTZ) CCTV cameras should be installed at intervals suggested by the manufacturer to monitor vehicle incidents. The cameras can also be integrated with video fire detection system to detect and alarm operators of tunnel fires.

6.7 Supervisory Control and Data Acquisition (SCADA)

The SCADA system being adopted for the Knik Arm Tunnel should be from a reputable manufacturer and compatible with DOT&PF existing systems, and not a proprietary type. Further coordination with DOT&PF is required in future phases to determine the requirements in selecting a SCADA system.

6.8 Security

For the security system at the portal buildings, CCTV and access card systems should be adopted at restricted access areas such as the portal building entrances and exits. In the tunnel, CCTV cameras should be installed at each tunnel portal to monitor entrances and exits.

Vulnerability assessment will required to be done in future phase of the project.

6.9 Operations and Control Center

An Operations and Control Center (OCC) is proposed at the Anchorage Portal, where operators can monitor the roadway and various tunnel systems. A secondary OCC should be established at a location remote from the tunnel for backup (i.e. within the City of Anchorage). The OCC should be equipped with ultra-high definition quality computer monitors in a wall-type configuration and all the necessary equipment to allow the operators to monitor all tunnel assets.

7 Construction considerations

Construction considerations for the portal and tunnel elements along alternative Alignments 1 and 4 are summarized below.

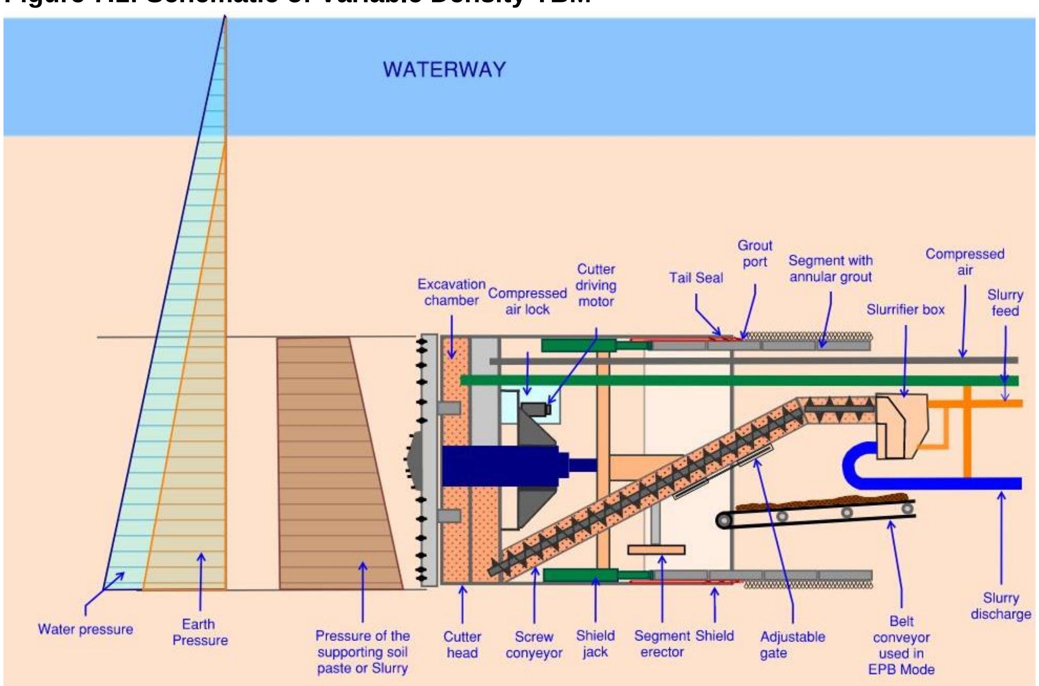
7.1 TBM technology

Section 2 of the Tunneling Technology Update Report (Mott MacDonald, 2025) outlines a range of TBM technologies, including the use of large-diameter TBMs in highway tunnel projects, cutterhead interventions using compressed air for disc cutter inspections, autonomous TBM operation systems, and segmental tunnel lining installation. Section 2.2 further highlights applications of these technologies in similar infrastructure projects.

Considering the depth of the tunnels—particularly beneath Knik Arm—the TBMs are expected to operate under high face pressure. This presents potential technical challenges, including the need for cutterhead interventions. Planning and mitigation strategies are required to be developed during design and construction phases to ensure safe and efficient tunneling operations.At this stage, geological data is limited along the tunnel alignment for Alignments 1 and 4 of the waterway crossing. For planning purposes, it is recommended to base the TBM selection on a Variable Density TBM, which is capable of operating across the range of anticipated geological conditions for the Knik Arm Tunnel.

Ultimately, the Contractor will determine the final TBM type based on updated geological information and their preferred construction methodology.

Figure 7.1: Schematic of Variable Density TBM



Source: Prepared by Mott MacDonald (2025)

7.2 TBM power requirements

Power coordination will be critical to delivering the project efficiently and within budget. Launching the tunnel boring machines (TBMs) from the Point MacKenzie side presents additional challenges for utility power delivery due to the lack of existing infrastructure. The project is expected to require approximately 30 MW of peak demand to support two TBMs operating simultaneously. Supplying this level of power to a remote site will be complex and potentially costly.

Potential solutions include extending utility power from the north, constructing a generator farm, or installing an undersea power cable. Given the long-term plans to develop infrastructure on the Point MacKenzie side, extending utility power now would be a prudent investment that supports both current project needs and future growth. Early coordination with the utility provider and design team will help identify the most cost-effective solution while ensuring scalability for future infrastructure.

Table 7.1: TBM Power Requirement

Connected load	Peak load	Utility delivery voltage
50MW	30MW	36kV

Refer to Appendix C for details on power demand and single line diagram.

7.3 Cross passage construction

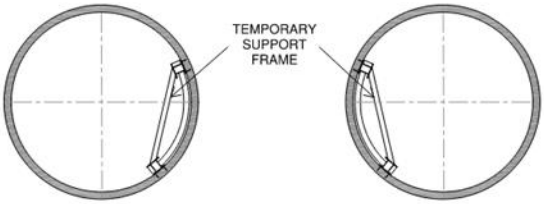
Ground improvement using the ground freezing method is proposed to ensure initial ground stability and watertightness during cross passage excavation. The methodology for ground freezing is detailed in Section 2.6.1 of the Tunneling Technology Update Report. Alternative method of constructing cross passages using pipe jacking techniques is detailed in section 2.6.2 of the technology report.

Cross passage construction sequence is as follows:

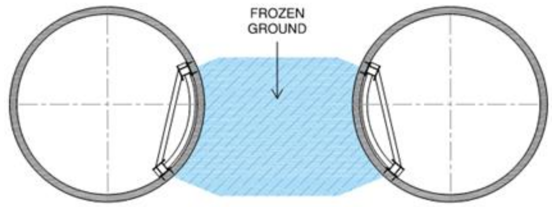
- Install temporary support frame for cross passage opening
- Install and commission the ground freezing plant, including refrigeration units and freeze pipes
- Commence coolant circulation through connected freeze pipes and continuously monitor ground conditions until the soil forms impermeable frozen block around the cross passage
- Break out tunnel segmental lining install temporary support (e.g. steel ribs or shotcrete) as excavation progresses
- Once excavation is complete, install waterproofing system and cast secondary concrete lining
- Decommission freezing plant and allow ground to thaw and remove temporary support frame
- Fit out cross passage (tunnel system equipment, fire doors).

Figure 7.2 Cross passage construction sequences

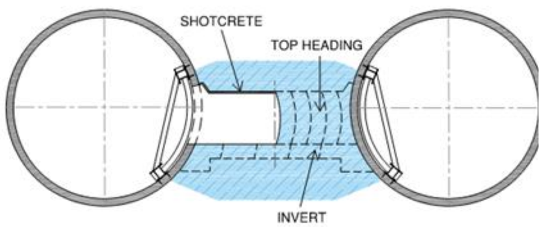
a) Install tunnel lining support frame



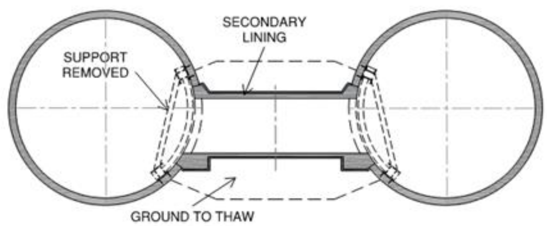
b) Freeze ground at cross passage location



c) Excavate and install primary lining



d) Complete waterproofing and secondary lining installation



Source: Sketch by Mott MacDonald (2025)

Figure 7.3 Cross passage construction methods

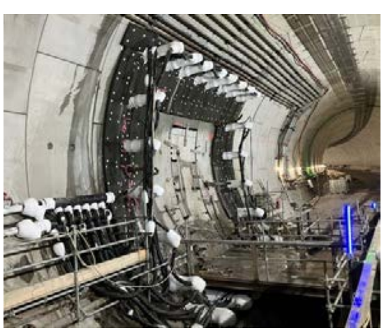
a) Steel frame support at opening

Source: Forrestfiel Airport Link, Perth

b) Heading excavation

Source: Forrestfiel Airport Link, Perth

c) Ground Freezing at cross passage



Source: High Speed 2, Silvertown Tunnel, UK

7.4 Portal construction

The tunnel portal locations for alternative Alignments 1 and 4 are situated in Point MacKenzie and Anchorage, with only minor differences in their vertical and horizontal geometry. Design drawings for both portals are based on Alignment 1 geometry.

7.4.1 Point MacKenzie portal

The portal at Point MacKenzie requires excavating a decline to the tunnel interface to enable assembly and launch of TBMs. Based on the design concept presented in drawing 00029_B_220, 221 and 222, construction sequence is as follow:

- Advance Works: Coordinate with the utility provider to establish a power supply at this location to support TBM operations.
- Clear the site and establish site facilities, including access road for construction, site offices, parking zones, maintenance shop, water supply and sewerage systems
- Mobilize and establish facilities for slurry wall construction such as slurry handling system, reinforcement cage fabrication and handling facilities, cranes and
- Construct slurry walls, starting with guide wall installation, followed by trench excavation using bentonite slurry, reinforcement placement, and concrete pouring via the tremie method. Recover and recycle slurry for reuse in subsequent panels
- Build slurry wall panels in a primary-secondary sequence
- Excavate the portal in stages, installing temporary steel walers and struts to support the slurry walls
- Construct the base slab and lower permanent walls, then remove lower struts to create space for TBM assembly
- Establish TBM slurry site facilities including segment storage and handling areas, spoil removal systems, and a fully operational slurry treatment plant to support tunneling operations (Figure 7.4 refers).
- Assemble and launch the TBMs to excavate the Northbound and Southbound tunnels
- Complete permanent portal structures in stages and remove temporary steel walers and struts
- Install portal systems including ventilation, mechanical, electrical, communication, and drainage infrastructure
- Test and commission tunnel systems and equipment to prepare for operational readiness.

7.4.2 Anchorage portal

The Anchorage portal is located adjacent to Government Hill, at the interface with E Loop Road. The site presents spatial constraints due to proximity to railway infrastructure and local communities. As a result, the portal infrastructure will need to be constructed within a cut along the hillside.

Based on the design concept presented in drawing 00029_B_200, 201 and 202, construction sequence is as follow:

- Install contiguous piles adjacent to W Harvard Avenue for support of portal excavation
- Excavate portal area in stages and install ground anchors progressively to support the soldier piles
- Construct permanent portal structures including base slab and retaining walls for TBM reception zone
- Place low strength concrete between the retaining soldier piles and portal structure to facilitate safe TBM breakthroughs.

Tunnel Boring Machines (TBMs) launched from Point MacKenzie will break through at the Anchorage portal, where facilities must be provided for TBM dismantling. Depending on the construction schedule, the Contractor may opt to partially complete portal infrastructure prior to TBM arrival to offer schedule benefits or ultimately remove this element from the critical path of the construction schedule. In this scenario, the TBMs would stop at the portal interface, and components would be dismantled and transported back to the Point MacKenzie portal, leaving the TBM skin in place. Tunnel lining would then be constructed within the TBM skin, either by installing precast tunnel segments using a specially developed segment erector or casting an in-situ concrete lining.

Given the significant site constraints - Including steep topography, existing road infrastructure, and nearby rail corridors - the proposed TBM dismantling methodology may mitigate the site logistic requirements at the Anchorage Portal, however it is recognized that significant craneage and logistical operations will still be required at this site. In addition, the time to remove the TBM backup and TBM itself through the tunnel will need to be evaluated from an overall schedule perspective since these operations may delay the commencement of interior fitout works.

For project planning purposes, this scenario has been adopted to guide the development of construction methodology and cost estimation. Further evaluation will be required during the detailed design and construction phases to determine the most effective and practical approach for dismantling the TBMs.

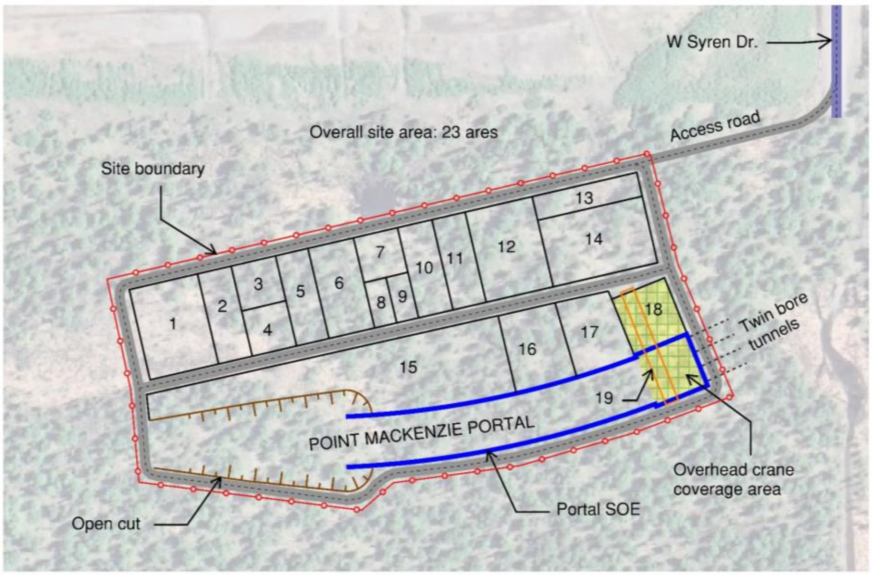
Construction sequencing for the portal must be closely coordinated with the staging and schedule of works of reconfiguration of existing A street, E loop, W loop and the new A Street bridge works, with particular attention to Maintenance of Traffic (MOT) requirements on surrounding local roads to ensure safe and continuous access throughout the construction period.

7.5 TBM launch and retrieval, and laydown areas

Conceptual construction laydown areas for the launching and reception of TBMs at the portals are illustrated in the Tunneling Technology Update Report.

Figure 7.4 below illustrates the construction facilities required at Point MacKenzie for portal construction, as well as the assembly and operation of the Variable Density Tunnel Boring Machines (TBMs).

Figure 7.4: Construction site layout at Point MacKenzie portal



PLAN VIEW OF CONSTRUCTION FACILITIES AT TBM LAUNCH SITE - INDICATIVE ARRANGEMENT

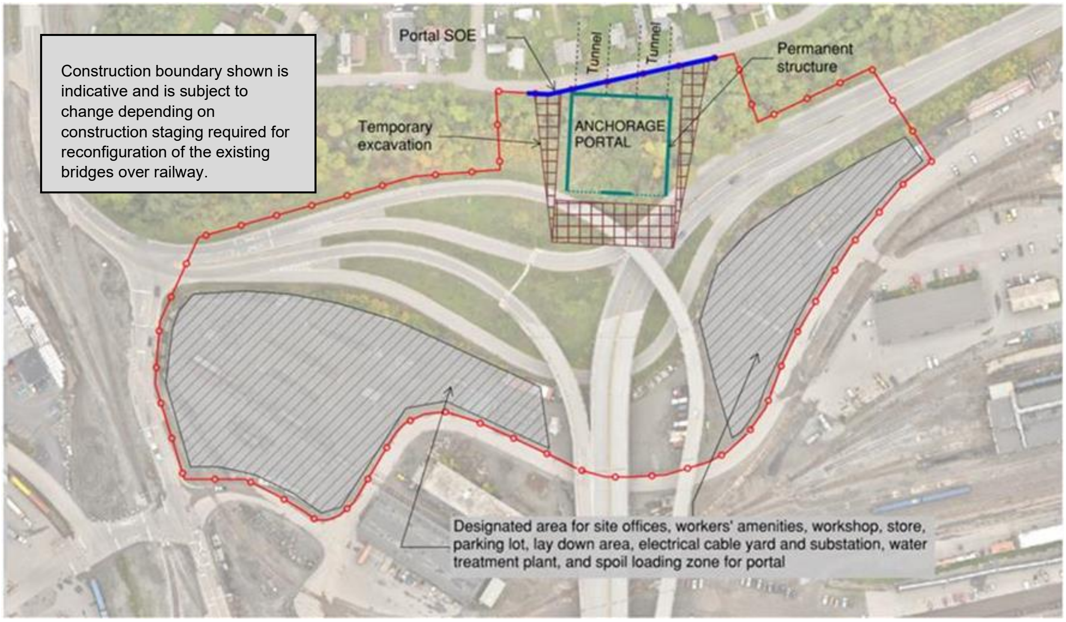
LEGEND

1. Parking Lot
2. Site Office & Workers' Amenities
3. Workshop
4. Store
5. Electrical Cable Yard & Substation
6. Chemical & Storage Area
7. Water Treatment Plant
8. Grout Batching Plant
9. Bentonite Plant
10. Fresh and Waste Bentonite Storage Tanks
11. Slurry Treatment Plant
12. Spoil Area
13. Filter Presses
14. Tunnel Spoil Loading Zone
15. Lay Down Area
16. Compressed Air Plant
17. Chiller Plant
18. Segment Storage
19. Overhead Cranes (Two No. 50T & 300T - Indicative Capacities)

Source: Prepared by Mott MacDonald (2025)

Figure 7.5 also illustrates the construction facilities at the Anchorage site, which are essential for developing the tunnel portal and the TBM reception area. Development of facilities and extent of construction site requires coordination with reconfiguration of existing A street as outline in section 7.4.2.

Figure 7.5: TBM retrieval site layout at Anchorage portal



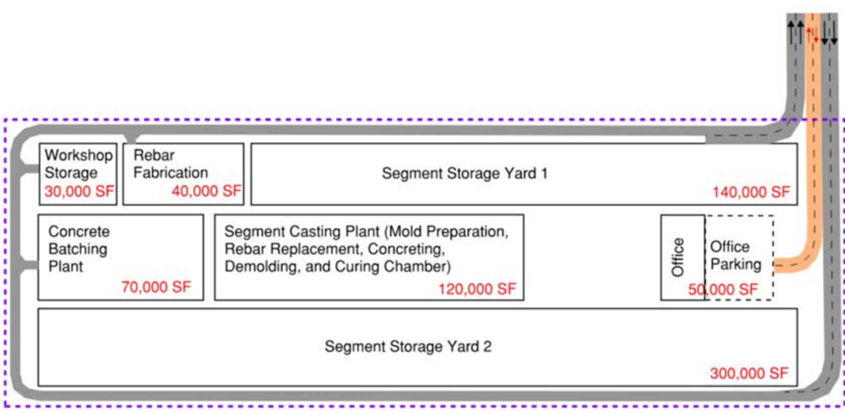
Source: Prepared by Mott MacDonald (2025)

7.6 Segment manufacturing facilities

A description of the precast manufacturing facility for segmental tunnel lining are detailed in the Tunneling Technology Report. A conceptual layout of the necessary manufacturing facilities is presented in Figure 7.6.

The location of segment manufacturing facilities and transport logistics, including the potential use of Port MacKenzie, should be further evaluated in the next phase of the project.

Figure 7.6: Schematic of segment manufacturing facility



Source: Prepared by Mott MacDonald (2025)

7.7 Spoil disposal

Requirements for spoil disposal, including key elements of the Spoil Management Plan, are outlined in the Tunnel Technology Report. Based on the developed portal and tunnel concepts for the Alignment 1 and 4 alternatives, the estimated excavation volumes for the portals, tunnels, and cross passages are summarized in Table 7.2 below.

Excavation volumes are presented in both in-situ and bulked quantities. The bulking factor accounts for the increase in volume when natural ground is excavated and becomes loose. While the bulking factor varies depending on geological conditions, a factor of 1.4 is assumed for planning purposes at this stage of the project to support spoil disposal estimates. This needs to be confirmed in future development stages of the project.

Table 7.2: Estimated excavation volumes

Element	Excavation volume for Alignment 1 (yd^3)	Excavation volume for Alignment 4 (yd^3)
Tunnels	3,197,900	3,381,500
Cross passages	16,600	17,100
Point MacKenzie portal	596,300	596,300
Anchorage portal	160,700	160,700
Total in situ excavation volume	**3,971,500**	**4,155,600**
Total bulked excavation volume using a bulking factor of 1.4	**5,560,100**	**5,817,840**

During construction of the proposed project, an ADEC-approved Contaminated Soils Management Plan (CSMP) would likely be required to address identification, testing, handling, and disposal of potentially contaminated materials discovered or excavated during construction activities. The construction Contractor would implement the CSMP to avoid and minimize the release or spread of contamination encountered during construction activities. Carefully selecting excavation and spoil disposal options will help minimize and mitigate the potential impacts.

Additionally, both a Hazardous Materials Response Plan (HRMP) and Spill Prevention, Control, and Countermeasures Plan (SPCCP) would likely need to be developed and implemented by the construction contractor to respectively identify appropriate storage, use and disposal protocols for project-related hazardous materials (fuels, lubricants, solvents, adhesives, etc.) present during construction, and to outline spill response procedures.

Solid waste generated during construction and not subsequently recycled would be required to be disposed of at an ADEC permitted landfill or, alternatively, as identified per the ADEC-approved CSMP for contaminated materials. A database of ADEC-approved and permitted solid waste facilities in Alaska is available at: https://dec.alaska.gov/Applications/EH/SWIMS.

Spoil disposal sites and transport routes should be assessed in the next project phase, including evaluating the feasibility of using Port MacKenzie for spoil removal.

7.8 Construction schedule

A preliminary construction schedule for Alignments 1 and 4, including portal works at Anchorage and Point MacKenzie, is provided in Appendix D. The schedules do not include highway connections to the portals, such as the reconfiguration of the A Street bridge and viaducts over the railway.

The estimated construction duration for Alignment 1 is approximately seven years, while Alignment 4 is estimated at seven years and four months. These schedules outline key activities and durations but do not currently include contingency allowances. To address schedule uncertainty, a P90 risk-based contingency period will need to be established in future planning phases.

This schedule is intended solely for comparative purposes between the two tunnel alternatives and the bridge alternative developed previously. It is based on current conceptual designs and assumptions. As the project progresses into the detailed design phase, the construction schedule including durations, sequencing, and contingency allowances will be subject to change based on detailed engineering, site investigations, contractual framework and risk assessments.

7.9 Noise and vibration

Methodologies for assessing noise and vibration effects from tunneling construction activities using TBMs and portal construction are outlined in the Tunneling Technology Report.

Using TBMs raises fewer regulatory concerns about noise than alternatives like pile driving for bridge construction. According to the National Marine Fisheries Service, noise from TBMs is not expected to cause harm to marine mammals. Studies have found that TBMs do not pose significant risks to these animals. Beluga whales, which are sensitive to high-frequency sounds and acoustic pressure waves, are less affected by vibrations. Since TBMs primarily produce low-frequency sounds (below 500 hertz), most of the noise they generate falls outside the range of beluga whales' peak hearing sensitivity.

It is noted that environmental assessments for tunnels constructed using TBMs for the Knik Arm Tunnel project are expected to indicate lower environmental impacts compared to immersed tube tunnels considering ground cover to the TBMs, and significantly less than those associated with foundation works required for the bridge alternative.

As the project advances into detailed design and site-specific environmental studies, detailed assessments will be required to demonstrate compliance with environmental requirements.

7.10 Cold weather considerations

As outlined in the Tunneling Technology Report, the design and construction of portals and tunnels in Anchorage must address cold weather challenges to ensure structural integrity and construction reliability. At construction phase of the project, a plan is required to outline strategies for concrete placement and curing in sub-freezing conditions, drawing on regional expertise and research from the Alaska University Transportation Center and DOT&PF.

Key considerations for developing cold weather concrete work plan and construction methodologies for the project are as follows:

- Planning phase: Apply protocols developed by the Alaska University Transportation Center and DOT&PF for specifying concrete materials and processes. These protocols cover the selection and preparation of cementitious materials, sand, aggregates, and admixtures; the development and testing of mix designs and trial batches; and the procedures for manufacturing, placing, and curing concrete under cold weather conditions.
- Manufacture and placement of concrete: Preheat mixing water and aggregates to achieve and maintain the desired concrete temperature during batching. Continuously monitor both ambient and concrete temperatures throughout the curing process to ensure compliance with cold weather specifications. Use insulated blankets, heated enclosures, or curing tents to protect the concrete and maintain appropriate curing conditions in sub-freezing environments.
- Precast structural elements including segmental tunnel lining: Incorporate precast concrete elements into the design of portal structures wherever feasible. Manufacture these elements and precast concrete segments in climate-controlled facilities.
- TBM operations: Use of heated bentonite slurry and insulated pipelines, equip TBMs with cold-resistant lubricants and heated work zones, and design grout mixes with anti-freezing additives to maintain proper flowability and compressive strength during annular grouting.

8 Direct cost estimation

8.1 Project overview and basis for direct cost estimation

The direct cost estimate has been prepared for Alternative 1 and Alternative 4 for the purpose of a direct cost comparison between the two alternative concepts consisting of:

- Alignment 1: Approximately 20,725 route feet of 47 ft inside diameter tunnel to be excavated with a Variable Density TBM with cross passages spaced at 650 feet
- Alignment 4: Approximately 21,915 route feet of 47 ft inside diameter tunnel to be excavated with a Variable Density TBM with cross passages spaced at 650 feet
- One large main launch portal (Point MacKenzie)
- One reception portal (Anchorage portal).

The Knik Arm twin bore tunnels also include various traffic safety control systems, ventilation, fire protection, electrical lighting, and roadway drainage as shown in the Draft Conceptual Alternative plans dated October 2025.

8.2 Methodology and assumptions

The purpose of this section of the report is to provide the basis of estimate for the Knik Arm Tunnel Feasibility Study and the assumptions made during the preparation of the Engineers Opinion of Probable Construction Cost (EOPCC) for the comparison of alternatives Alignment 1 and Alignment 4. As requested by the client, this EOPCC includes only direct costs for construction; all other components of a typical EOPCC are excluded as outlined herein.

The Stantec/Mott MacDonald team have developed an AACE Class 5 estimate based off the Tunnel Feasibility Study submission plans. The EOPCC has developed labor rates for the Knik Arm Tunnel project based on the Davis Bacon wage rates published in September 2025 as the basis for this estimate. Additionally, equipment rental and operating rates have been developed from RS Means published in 2025. Additionally, the costs provided in the following comparisons include all labor, equipment and materials required by a contractor to build the project. Currently, contractor overhead, and profit are not included in our analysis and these will have to be added by others. For a class 5 estimate for a mega tunnel project of this size, an appropriate Indirect multiplier would be in the range of 1.6x to 1.8x of the direct costs provided below in table 8.2.

For this EOPCC, the following list of assumptions were considered:

- Cost provided in the bid form for the tunnel items is Direct Cost only. As requested, contractor profit and all indirect costs are excluded.
- Cost provided for the tunnel mechanical, electrical, and systems item are Bid costs due to parametric cost model used
- Launch TBMs at Point MacKenzie portal, retrieval at Anchorage portal
- Two Variable Density TBMs will be procured by the selected tunnel contractor and operated in slurry mode
- Two slurry treatment plants will be procured by the selected tunnel contractor
- Advance rates for these machines including tool changes, slurry booster installation and mechanical downtime is 720 feet per month

- RSMeans cost data was used to estimate the aggregate backfill, concrete pavement, asphalt pavement, and concrete traffic barrier
- Mechanical, Electrical, and Systems cost was developed from past CALTRANS roadway tunnels and adjusted to 2025$.
- Cost of architectural panels in the tunnels are excluded from the estimates.

8.3 Cost estimate class and expected accuracy

Based on the current level of design, the cost estimate conforms to the requirements of a Class 5 estimate defined by the Association for the Advancement of Cost Engineering (AACE). An AACE Class 5 estimate is expected to be accurate within a range of -50% to +100%. Table 8.1 below provides a summary of the variability associated with estimate accuracy versus project maturity.

Table 8.1: Summary of AACE estimate classes

AACE estimate Class	Maturity level of project definition deliverables	End usage (typical purpose of estimate)	Methodology	Accuracy Range (approximate)
Class 5	**0% to 2%**	**Concept Screening**	**Cost / length factors, parametric models, judgment, or analogy**	**L: -20% to -50%** **H: +30% to +100%**
Class 4	1% to 15%	Study or feasibility	Cost/length, factored or parametric models	L: -15% to -30% H: +20% to +50%
Class 3	10% to 40%	Budget authorization or control	Semi-detailed unit costs with assembly level line items	L: -10% to -20% H: +10% to +30%
Class 2	30% to 75%	Control or bid/tender	Detailed unit costs with forced detailed take-off	L: -5% to -15% H: +5% to +20%
Class 1	65% to 100%	Check estimate or bid/tender	Detailed unit cost with detailed take-off	L: -3% to -10% H: +3% to +15%

For the Knik Arm EOPCC the expected accuracy utilized for the tunnel and portals scope of work has been determined to be -30% to +50%. This represents the typical percentage variation of the actual costs from the cost estimate after application of contingency (typically to achieve an 80% probability of project overrun versus underrun). Costs are limited to anticipated construction costs and do not include other potential costs such as, but not limited to:

- Engineering
- Right-of-way and/or land acquisition
- Legal
- Construction management
- Maintenance and operations of the highway after opening

The EOPCC costs have been developed using professional judgement based on the preliminary concepts and should be verified through typical due diligence associated with feasibility level engineering and technical analysis. Stantec/Mott MacDonald utilized the information available at the time of this document to estimate the potential construction costs. However, Stantec/Mott MacDonald have no ability to predict the future outcome of a competitive bidding environment or the outcome of such an event in the future.

8.4 Breakdown of cost components

The project cost estimate comprises of three core components outlined below.

The Base Estimate

The EOPCC for the tunnels and portals are broken down on the bid form into major cost components to allow for ease of comparison. Major tunneling bid items are provided to understand what is contributing to the total lump sum bid item. The base estimate is only the direct cost of construction and includes the following:

- Labor
- Equipment
- Supply and installation of permanent materials for the construction of tunnels, cross passages and portal structures.

The EOPCC only includes the direct costs of construction. All other Indirect Costs need to be added to the EOPCC Base Estimate to determine the overall Project Cost. These items generally consist of but are not limited to:

- General Contractors general conditions costs
- General Contractors staff cost
- General Contractors including sub-contractors overhead and admin costs
- General Contractors profit
- General Contractors insurance and bond costs.

Finally, the DOT&PF will need to consider additional expenses to complete the project related to:

- Property acquisition
- Design, engineering and management
- Construction management
- Permits, approvals and other agreements
- Quality control
- Utility expenses to provide necessary power to the Point Mackenzie portal.

Contingency Allowance

A contingency allowance of 30% is added to the respective alternatives to account for the level of design and is not intended to cover any excluded costs not included in the base estimate.

Escalation Allowance (excluded)

Escalation of the current EOPCC in 2025$ needs to be considered for planning purposes. The costs should be escalated at 3.5% per year to the mid-point of construction. Based on the preliminary construction schedule, the midpoint of construction is anticipated to be 2035.

8.5 Direct Cost comparison

Direct Cost comparison between Alignments 1 and 4 is presented in Table 8.2.

Table 8.2: Direct Cost comparison between Alignment 1 and Alignment 4

Item	Description	Alignment 1 Direct Cost (2025$)	Alignment 4 Direct Cost (2025$)	Comments
1	TBM bored tunnels	$1,596,132,000	$1,595,921,000	Direct cost of construction of the tunnel only.
1a	47 ft Inside diameter tunnel (twin bores)	$990,189,000	$1,045,205,000	Included in total of TBM bored tunnel
1b	Muck	$116,907,000	$123,604,000	Included in total of TBM bored tunnel
1c	Cross passages incl. Ground freezing	$152,965,000	$86,000 $157,769,000	Included in total of TBM bored tunnel
1d	Sump pit	$2,000,000	$2,000,000	Included in total of TBM bored tunnel
1e	Tunnel roadway & internal structural concrete	$154,071,000	$162,926,000	Included in total of TBM bored tunnel
1f	TBM & appurtenant equipment (Net cost after salvage)	$180,000,000	$180,000,000	Included in total of TBM bored tunnel
2	Tunnel mechanical/electrical/ systems	$432,100,000	$456,450,000	Cost includes contractor overhead and profit.
3	Point Mackenzie portal	$299,015,000	$299,015,000	
4	Anchorage portal	$104,820,000	$104,820,000	
5	Geotechnical instrumentation & monitoring	$19,804,000	$20,905,000	2% of the 47-ft ID tunnel cost
	Subtotal of All Bid Items above	$2,451,871,000	$2,552,694,000	Total of Direct Cost for tunnels and portals
6	30% estimate contingency	$735,561,000	$765,808,000	
	Subtotal	**$3,187,432,000**	**$3,318,502,000**	
AACE Class 5 Estimate – expected accuracy:				
	-30% of subtotal	$2,231,203,000	$2,322,952,000	
	+50% of subtotal	$4,781,148,000	$4,977,753,000	

Note: This table provides **Direct Costs** for tunnel alignments only. Costs associated with the approach network, highway, bridges etc. are reported separately. Indirect Costs must also be incorporated.

9 Alignment comparisons and feasibility

This section of the report presents a framework for comparing Alignments 1 and 4. It is recommended that the comparison also includes alternative alignments featuring the bridge crossing over the Knik Arm waterway.

9.1 Selection criteria to evaluate the suitability of alternatives

Table 9.1 presents the proposed evaluation criteria for reviewing and assessing alternative alignments to determine the most viable option for adoption.

A range of scoring methodologies, such as weighted matrices, multi-criteria decision analysis (MCDA) and qualitative ratings, can be used for this assessment. These criteria and the selected scoring approach will require further refinement in collaboration with DOT&PF prior to initiating the formal evaluation of alternative alignments.

Table 9.1: Proposed evaluation objectives and criteria

Category	Objectives	Evaluation criteria
Environmental and sustainability	Compliance with environmental regulations, minimizing ecological impacts and improving sustainability of resources	**Regulatory compliance:** Demonstrated adherence to all applicable local, state, and federal environmental regulations **Minimize ecological impacts:** reduction in noise and vibration levels during construction and operation; avoidance or minimization of disruption to sensitive habitats and species, including the Cook Inlet beluga whale **Sustainability:** minimize environmental impacts during development and operation, contribute to the reduction of greenhouse gas emissions, and enhance resilience to climate change
Land use	Minimize potential adverse effects on existing land use patterns, including residential, commercial, industrial properties, and associated infrastructure	**Residential:** Avoid displacement and reduce noise, visual, and access impacts **Commercial:** Minimize disruption to business operations and property access **Industrial:** Limit interference with industrial activities and utility services **Infrastructure:** Prevent conflicts with existing transport and utility networks **Opportunities:** Enhance land use integration, improve connectivity across residential, commercial, and industrial zones, and align with future development plans
Transport integration	Enhance the existing highway network by providing an alternative crossing of Knik Arm and improving connectivity to the surrounding road infrastructure	**Travel efficiency:** Reduction in travel time and congestion **Access improvement:** Enhanced access to key land uses **Network resilience:** Increased redundancy and reliability **Planning alignment:** Consistency with regional transportation goals

Category	Objectives	Evaluation criteria
Safety	Improve highway safety for drivers	**Crash reduction:** Improvements to reduce crash frequency and severity **Roadway design enhancements:** Incorporation of safety-focused design elements (e.g. sight distance) **Emergency response**: Efficiency of emergency access and response times within the tunnel **Emergency response access:** Enhanced access and response times for emergency services **Compliance with safety standards:** Alignment with federal, state, and local roadway safety guidelines and best practices
Reliability/ operations	Ensure reliability of highway operation	**Traffic flow:** Consistent traffic flow under normal and peak conditions **Disruption minimization:** Operational interruptions due to incidents, maintenance, or environment **System redundancy:** Availability of backup systems (e.g. ventilation, lighting, power) **Maintenance accessibility:** Ease of performing maintenance without major service disruptions
Achieving an economic and financially viable project	Achieve an economically and financially viable project by minimizing capital and operational costs, maximizing Benefit Cost Ratio, and ensuring alignment with available funding sources and long-term financial sustainability	**Capital cost:** Estimated construction and implementation costs relative to benefits **Operational cost:** Maintenance and operational expenses **Funding alignment:** Compatibility with available public and private funding sources **Cost-benefit performance:** Economic return on investment, including travel time savings and regional development support **Financial risk:** Exposure to cost overruns, schedule delays, or funding uncertainties
Construction schedule	Construction duration	Duration from the start of construction to the commencement of full tunnel operations, including the testing and commissioning of all tunnel systems.

10 Recommendations

This phase of the Knik Arm Crossing project focused on identifying and evaluating four tunnel alignment alternatives. Based on the initial assessment, Alignments 1 and 4 were selected for further tunnel concept development to inform construction methodologies and preliminary cost estimates presented in this report.

The following recommendations are intended to guide the next steps in advancing a technically viable, cost-effective, and environmentally compliant solution to support future transportation improvements across the Knik Arm:

1. Assess Alignments 1 and 4 using the evaluation criteria outlined in Section 9.1 of this report.
2. Compare the preferred tunnel alignment with the bridge alternative developed in earlier studies to inform preferred concept.
3. If the tunnel alternative is preferred and economically viable, proceed with the following steps:
    a. Conduct detailed land and marine surveys along the tunnel corridor and portal locations, including bathymetric surveys across the Knik Arm waterway
    b. Initiate comprehensive geotechnical site investigations to inform design concepts for tunnels and portal infrastructure
    c. Further validation of proposed tunnel systems and Fire Life Strategies will require design development, performance testing, code compliance reviews, and emergency planning, including fire safety systems, exit spacing, and considerations for alternative fuel vehicles.
    d. Investigate optimization of tunnel diameter by reduced shoulder widths. Also, elimination of cross passages by incorporating egress corridor based on methodologies outlined in Tunneling Technology Update Report.
    e. Investigate potential locations for segment manufacturing facilities, spoil disposal sites and transportation routes
    f. Explore feasibility of using Point MacKenzie port for delivery of TBMs, tunnel segments and removal of spoil.
    g. Evaluate the Point MacKenzie portal configuration, considering an open-cut trench if land availability permits, or a cut-and-cover structure instead of an open trench to eliminate the need for tension piles required to resist groundwater uplift.
    h. Advance design concept to the 30% level to support a more accurate cost estimates, detailed construction scheduling, and environmental studies.
    i. Undertake environmental studies in accordance with applicable legislation and permitting requirements
    j. Establish project funding strategies, labor agreements and identify appropriate contracting approaches to support implementation.
    k. Establishing an Authority Having Jurisdiction (AHJ) for project oversight, regulatory compliance, and coordinated decision-making across all phases of the tunnel project.

Appendices

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A. Conceptual drawings

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1	10/10/25	INTERNAL REVIEW
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STATE	PROJECT DESIGNATION	YEAR	SHEET NO.	TOTAL SHEETS
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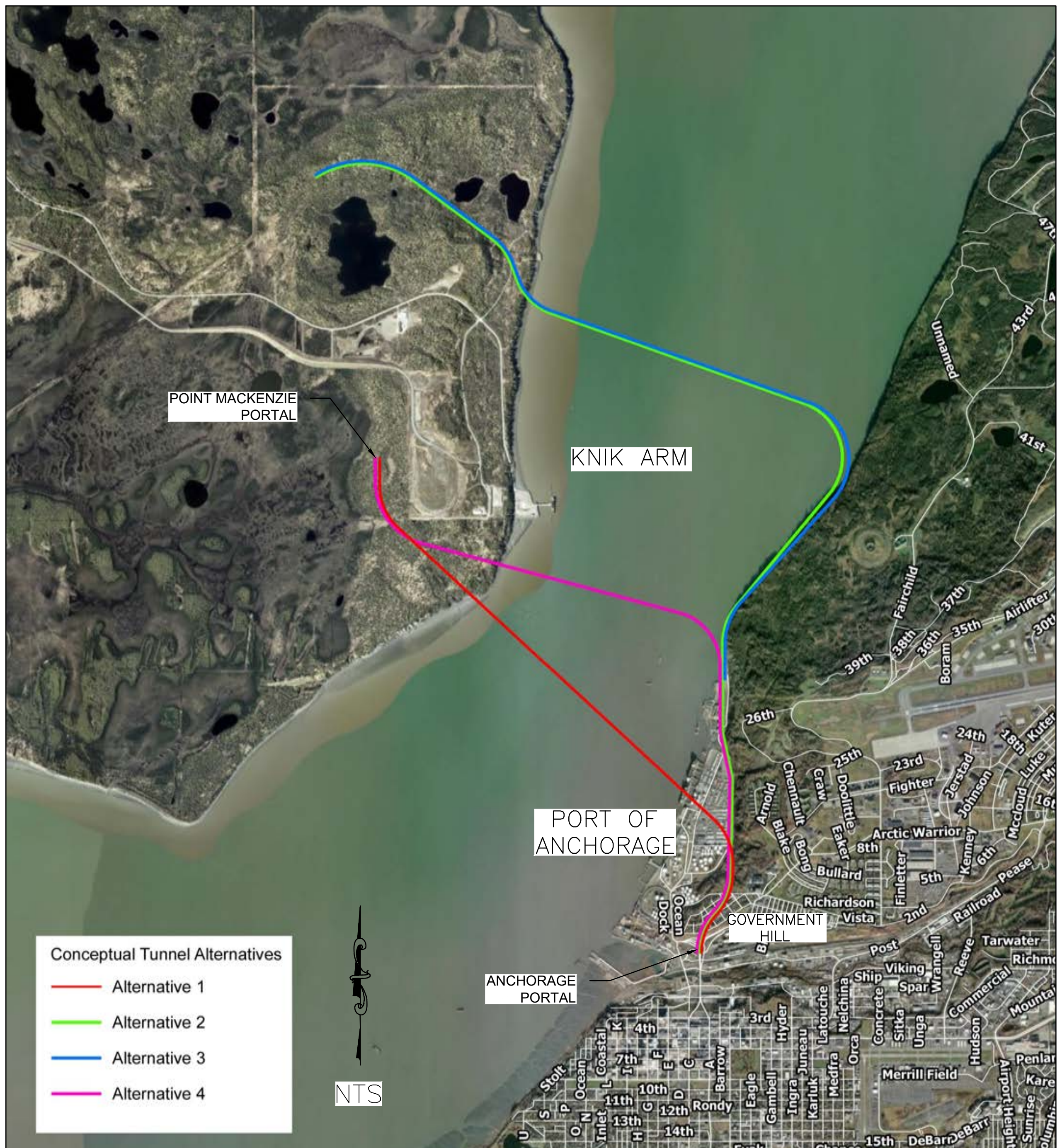

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F103	00029_F_103	ALTERNATIVE 1 HORIZONTAL AND VERTICAL ALIGNMENT SHEET 2 OF 3
F110	00029_F_110	ALTERNATIVE 4 HORIZONTAL AND VERTICAL ALIGNMENT SHEET 1 OF 3
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B122	00029_B_122	TWIN BORE TUNNELS CROSS PASSAGE WITH LOW POINT SUMP
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F201	00029_F_201	ANCHORAGE PORTAL – GENERAL ARRANGEMENT – TEMPORARY SUPPORT OF EXCAVATION
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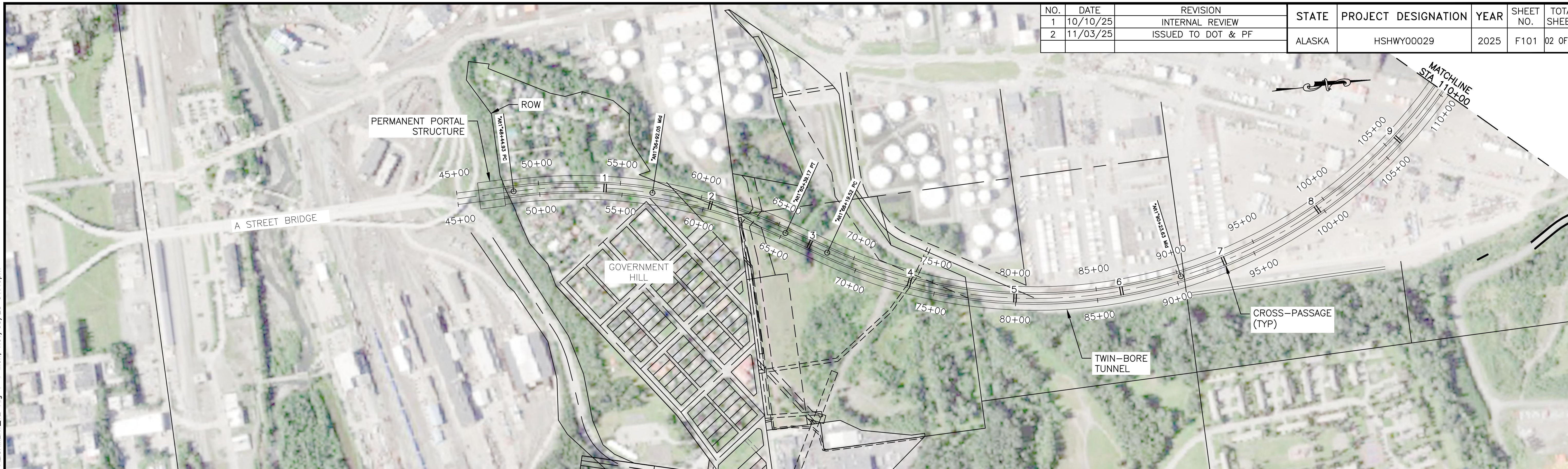

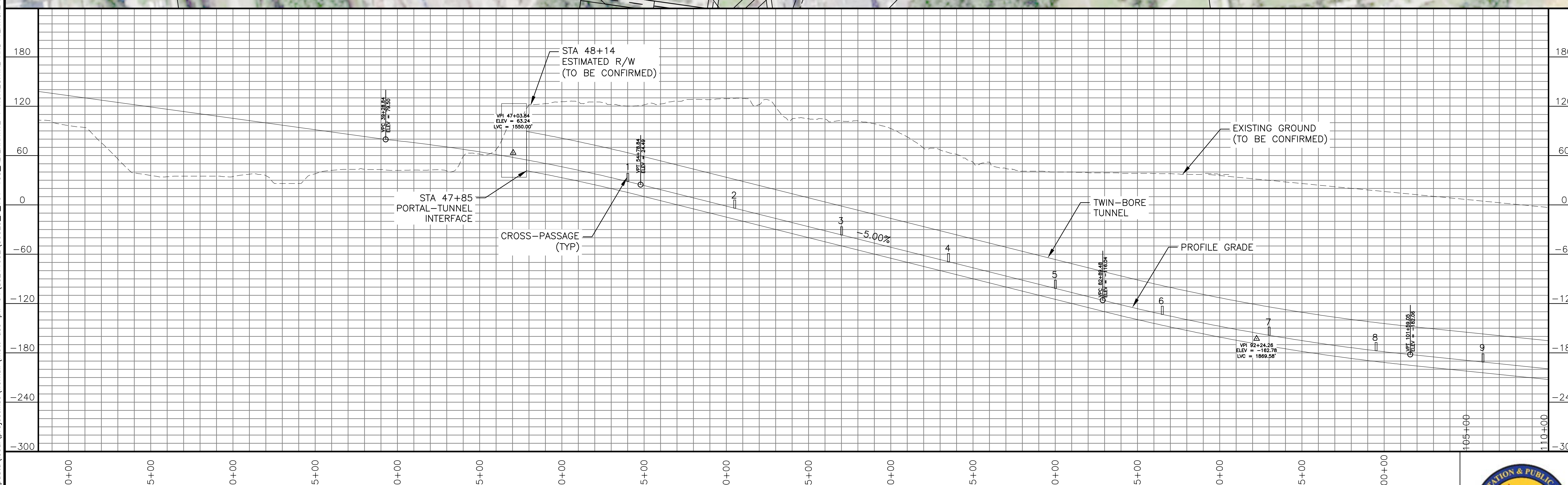

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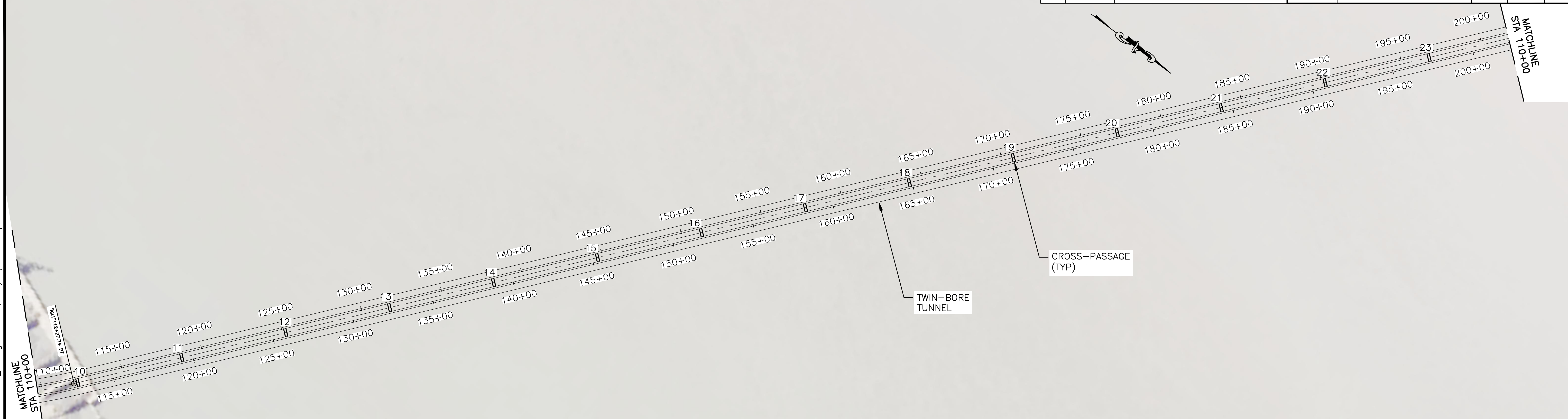

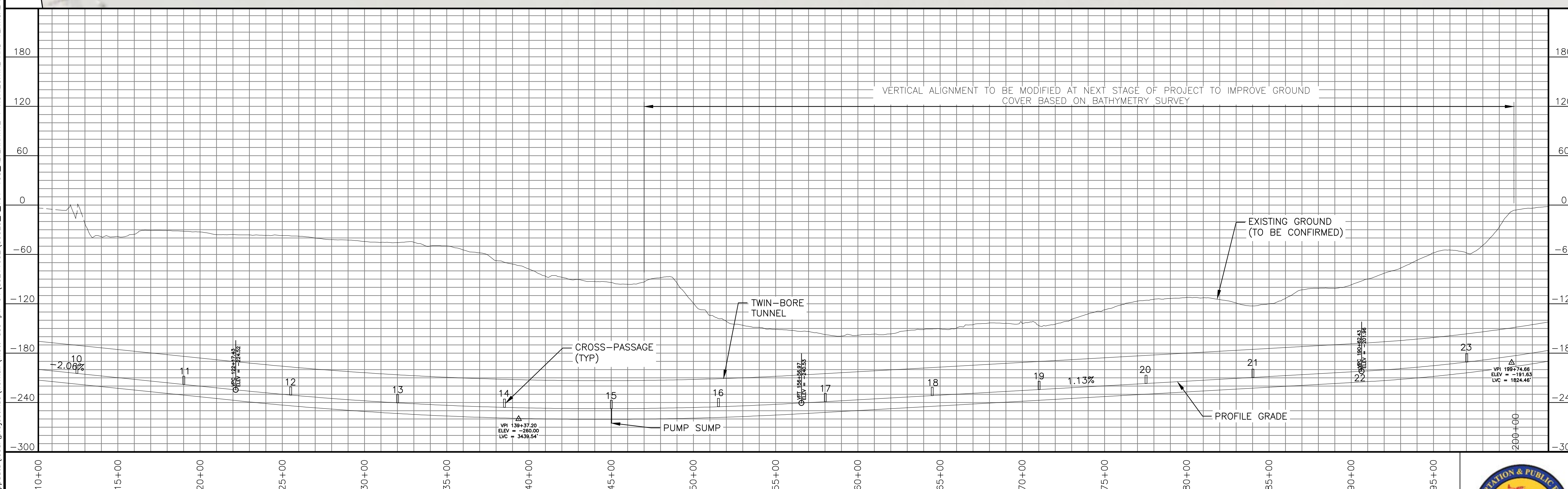

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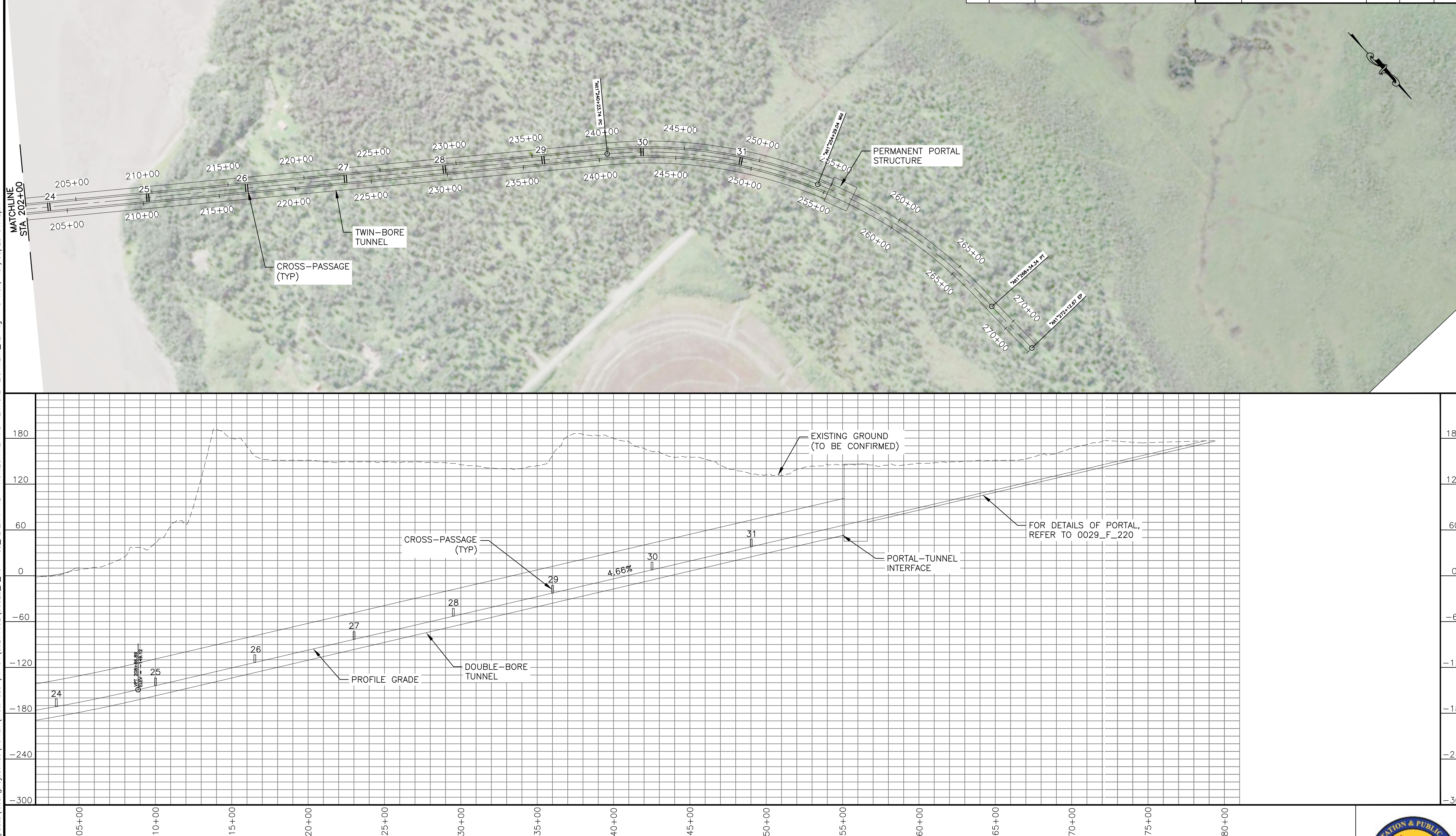

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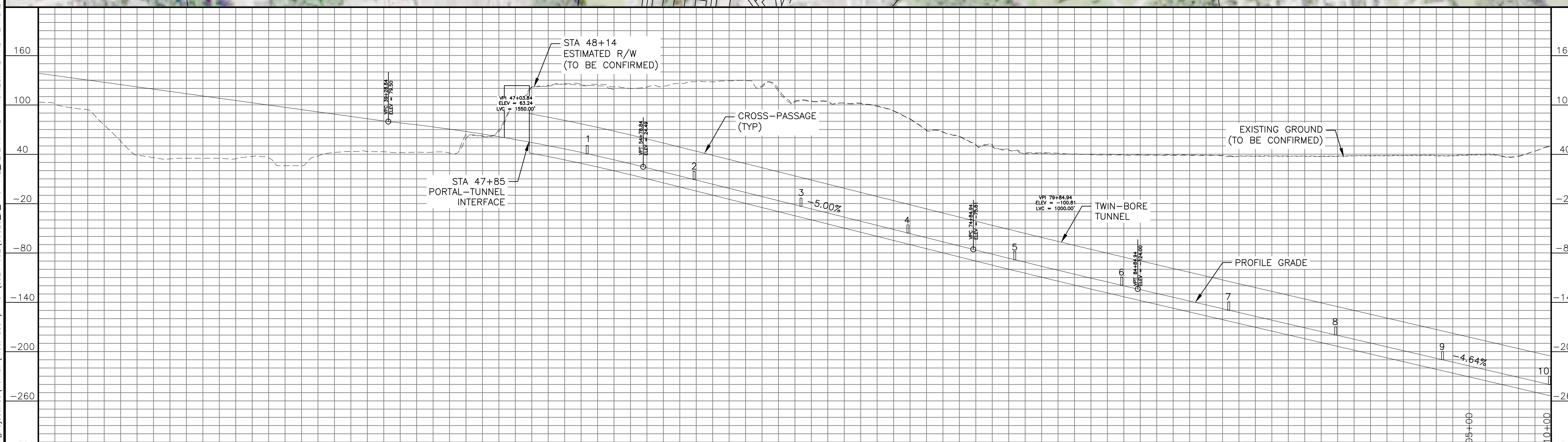

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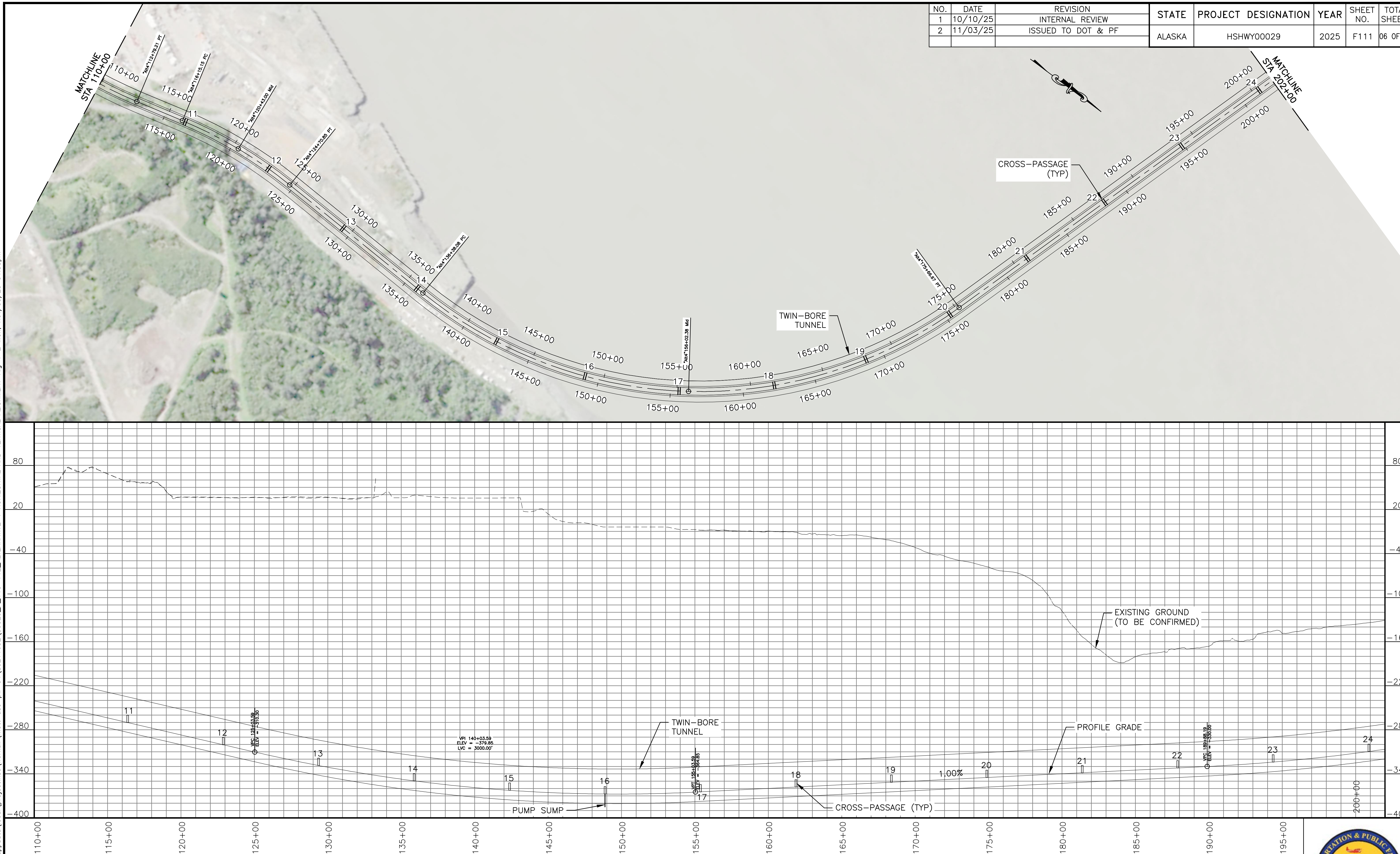

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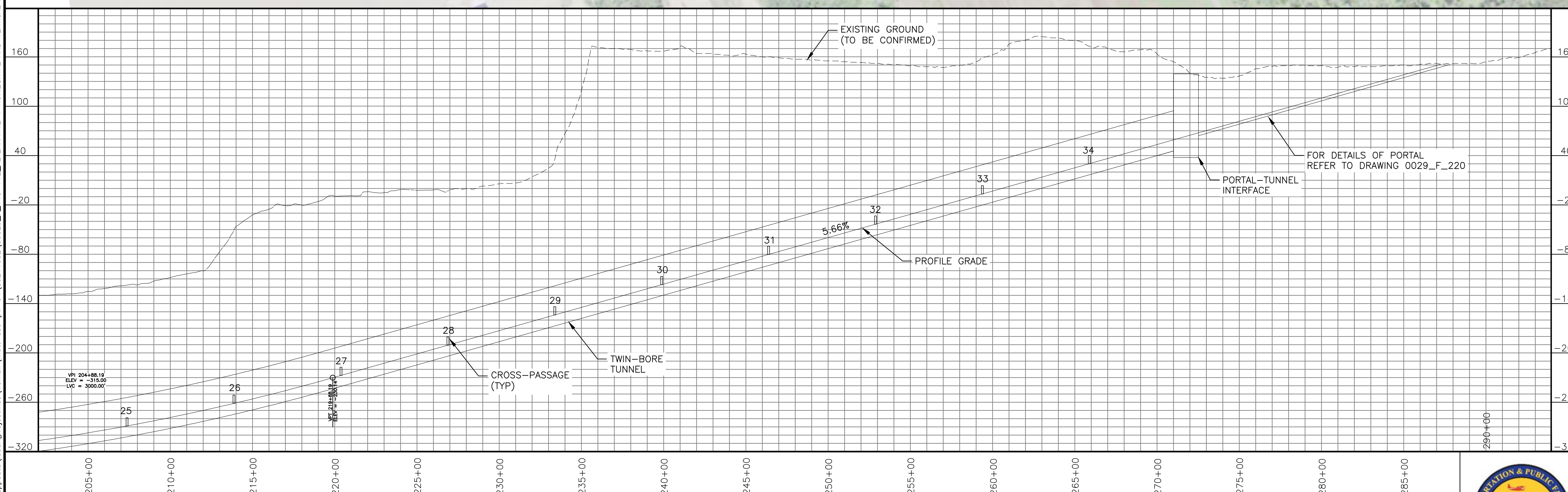

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PLANS DEVELOPED BY: MOTT MACDONALD

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES, NORTHERN REGION
KNIK ARM TUNNEL FEASIBILITY STUDY

00029_F_112_ALTERNATIVE 4 HORIZONTAL AND VERTICAL ALIGNMENT SHEET 3 OF 3

PLANS DEVELOPED BY: STATE OF ALASKA DEPARTMENT OF TRANSPORTATION & PUBLIC FACILITIES, NORTHERN REGION, 2301 PEGER ROAD, FAIRBANKS, AK 99709 (907)451-2200
C:\users\mal96066\appdata\local\projectwise\workdir\mott-use-pw-04\d0211692\00029_F_110-112_ALTERNATIVE 4 HORIZONTAL AND VERTICAL ALIGNMENT-Alg 4-3 Mon, Nov/03/25 01:54pm

NO.	DATE	REVISION
1	10/10/25	INTERNAL REVIEW
2	11/03/25	ISSUED TO DOT & PF

STATE	PROJECT DESIGNATION	YEAR	SHEET NO.	TOTAL SHEETS
ALASKA	HSHWY00029	2025	B120	08 OF 14

NOTES:

1) CULVERT BELOW THE ROADWAY IS FOR SERVICES, ACCESS TO THE CULVERT WILL BE REQUIRED AT CROSS PASSAGES, AND OPERATIONAL PROCEDURES WILL BE NECESSARY FOR ENTRY, INCLUDING TEMPORARY VENTILATION, LIGHTING, AND SAFETY MEASURES.

2) SUPERELEVATION ON ROADWAY AND LOCATION OF DRAINAGE PITS SHOWN IS INDICATIVE AND DEPENDENT ON HORIZONTAL CURVES IN THE ALIGNMENT.

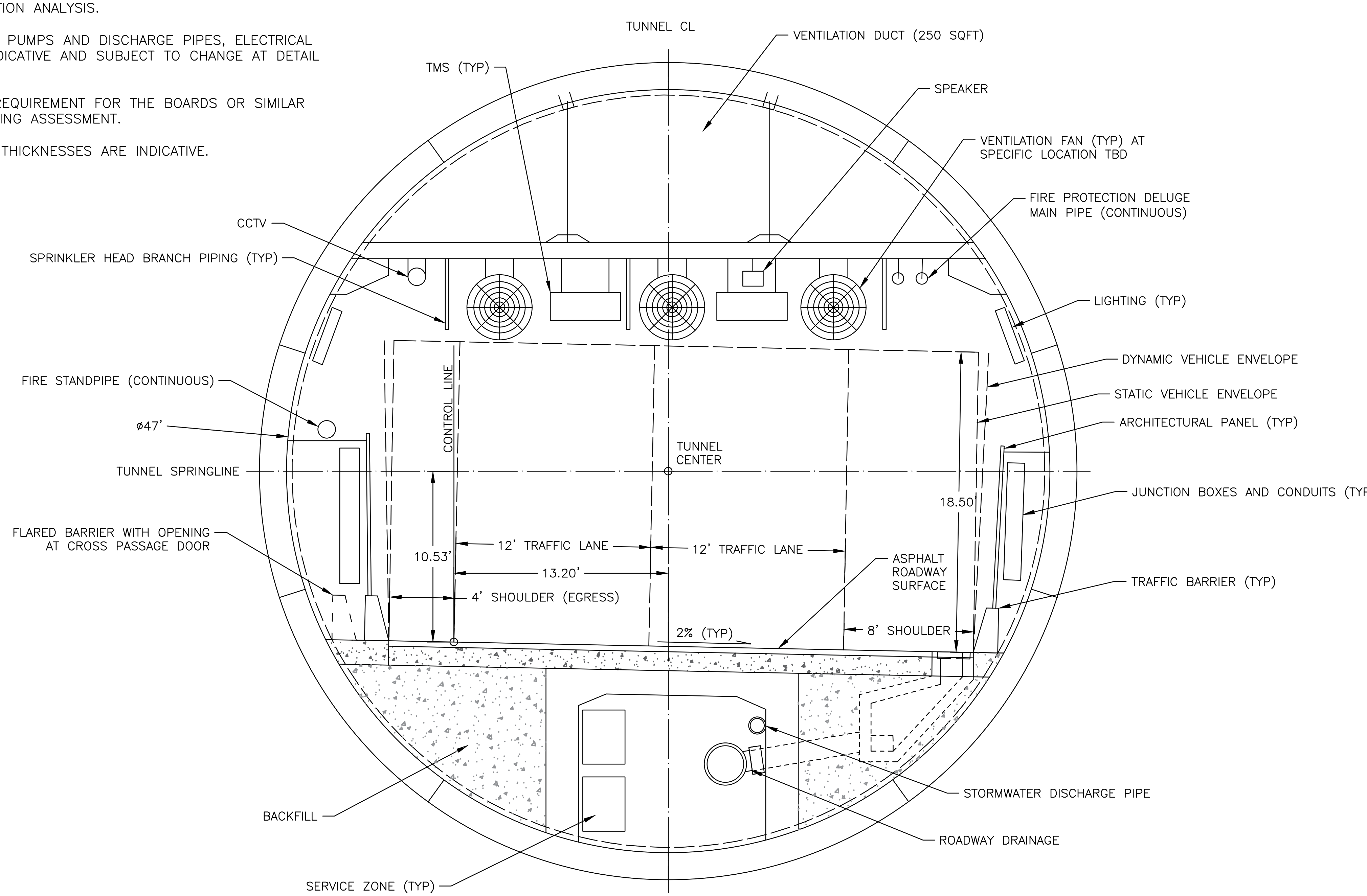
3) ARCHITECTURAL PANELS SHOWN ARE INDICATIVE AND SUBJECT TO MODIFICATIONS.

4) SIZE OF VENTILATION FAN AND CROSS-SECTIONAL AREA OF SMOKE DUCTS ARE INDICATIVE AND SUBJECT TO CHANGE BASED ON VENTILATION ANALYSIS.

5) LOCATIONS AND SIZES OF DRAINAGE SYSTEMS, PUMPS AND DISCHARGE PIPES, ELECTRICAL SYSTEMS, CABLES AND DELUGE PIPES ARE INDICATIVE AND SUBJECT TO CHANGE AT DETAIL DESIGN STAGE.

6) FIRE PROTECTION BOARDS ARE NOT SHOWN, REQUIREMENT FOR THE BOARDS OR SIMILAR TO BE DETERMINED BASED ON FIRE ENGINEERING ASSESSMENT.

7) TUNNEL DIAMETER, LINING ARRANGEMENT AND THICKNESSES ARE INDICATIVE.



TWIN BORE TUNNELS SPACE PROOFING

DRAFT CONCEPTUAL ALTERNATIVE

4 0 4 8

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

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES, NORTHERN REGION
KNIK ARM TUNNEL FEASIBILITY STUDY

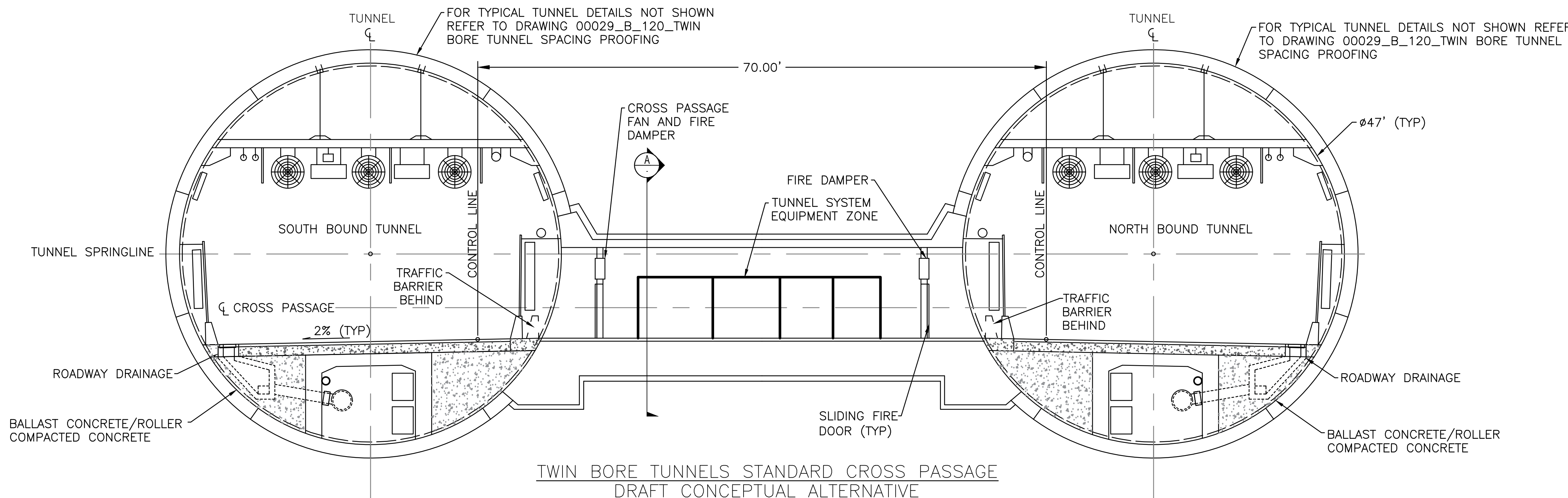
00029_B_120_TWIN BORE TUNNELS SPACE PROOFING

PLANS DEVELOPED BY: MOTT MACDONALD

PLANS DEVELOPED BY: STATE OF ALASKA DEPARTMENT OF TRANSPORTATION & PUBLIC FACILITIES, NORTHERN REGION, 2301 PEGER ROAD, FAIRBANKS, AK 99709 (907)451-2200
C:\users\mol96066\appdata\local\projectwise\workdir\mott-use-pw-04\d0211692\00029_B_120_TWIN BORE TUNNELS SPACE PROOFING-B-120 Mon, Nov/03/25 12:01pm

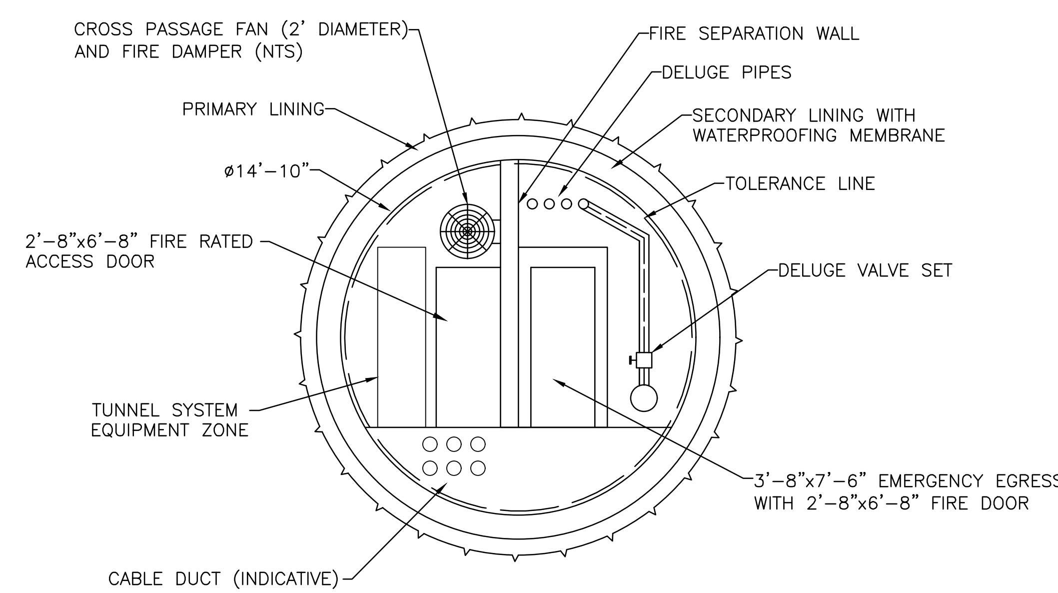
NO.	DATE	REVISION
1	10/10/25	INTERNAL REVIEW
2	11/03/25	ISSUED TO DOT & PF

STATE	PROJECT DESIGNATION	YEAR	SHEET NO.	TOTAL SHEETS
ALASKA	HSHWY00029	2025	B121	09 OF 14



TWIN BORE TUNNELS STANDARD CROSS PASSAGE
DRAFT CONCEPTUAL ALTERNATIVE
SCALE 1/8"= 1'-0"

8 0 8 16
SCALE: 1/8"=1'-0"



SECTION – A
SCALE 1/4"= 1'-0"

4 0 4 8
SCALE: 1/4"=1'-0"

PLANS DEVELOPED BY: MOTT MACDONALD

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES, NORTHERN REGION
KNIK ARM TUNNEL FEASIBILITY STUDY

00029_B_121_TWIN BORE TUNNELS STANDARD CROSS PASSAGE

PLANS DEVELOPED BY: STATE OF ALASKA DEPARTMENT OF TRANSPORTATION & PUBLIC FACILITIES, NORTHERN REGION, 2301 PEGER ROAD, FAIRBANKS, AK 99709 (907)451-2200
C:\users\mol96066\appdata\local\projectwise\workdir\mott-use-pw-04\d0211692\00029_B_121_TWIN BORE TUNNELS STANDARD CROSS PASSAGE-B-121 Mon, Nov/03/25 12:05pm

NO.	DATE	REVISION
1	10/10/25	INTERNAL REVIEW
2	11/03/25	ISSUED TO DOT & PF

STATE	PROJECT DESIGNATION	YEAR	SHEET NO.	TOTAL SHEETS
ALASKA	HSHWY00029	2025	B122	10 OF 14

NOTES:

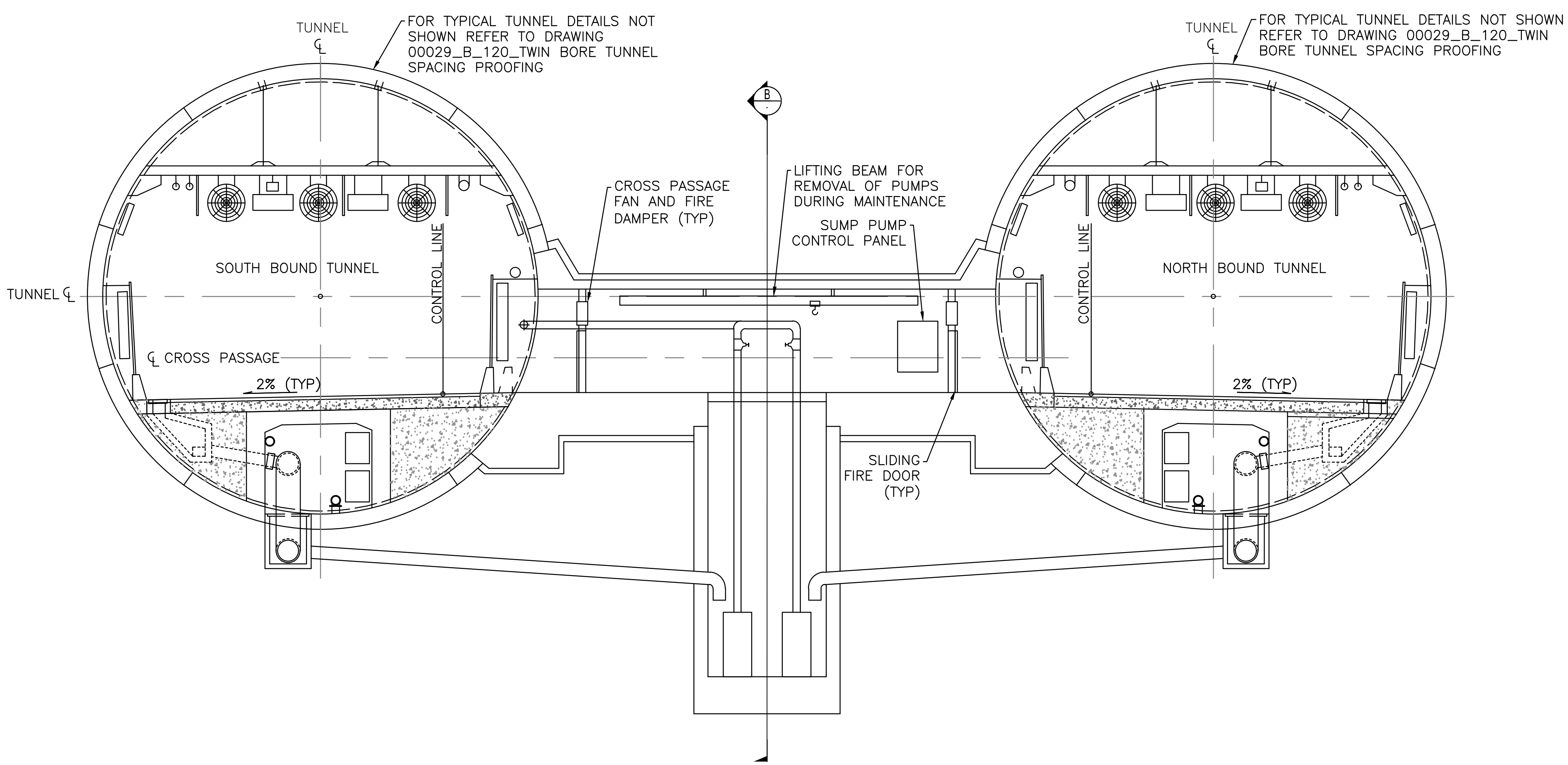
1) ALL EQUIPMENT LOCATED WITHIN THE CROSS PASSAGE MUST BE EXPLOSION-PROOF TO ENSURE SAFE OPERATION IN THE PRESENCE OF POTENTIAL HAZARDOUS CONDITIONS CAUSED BY THE WET WELL SUMP.

2) SUMP DIMENSIONS ARE INDICATIVE, AND THE REQUIRED VOLUME SHALL BE DETERMINED ONCE CONCEPT ALIGNMENTS ARE FINALIZED.

3) CROSS PASSAGE IS DESIGNATED FOR SUMP PUMP USE ONLY AND WILL NOT SERVE AS AN EMERGENCY EGRESS. HOWEVER, AN OPTION FOR A COMBINED CROSS PASSAGE FUNCTIONALITY WILL BE CONSIDERED DURING THE CONCEPT DESIGN STAGE.

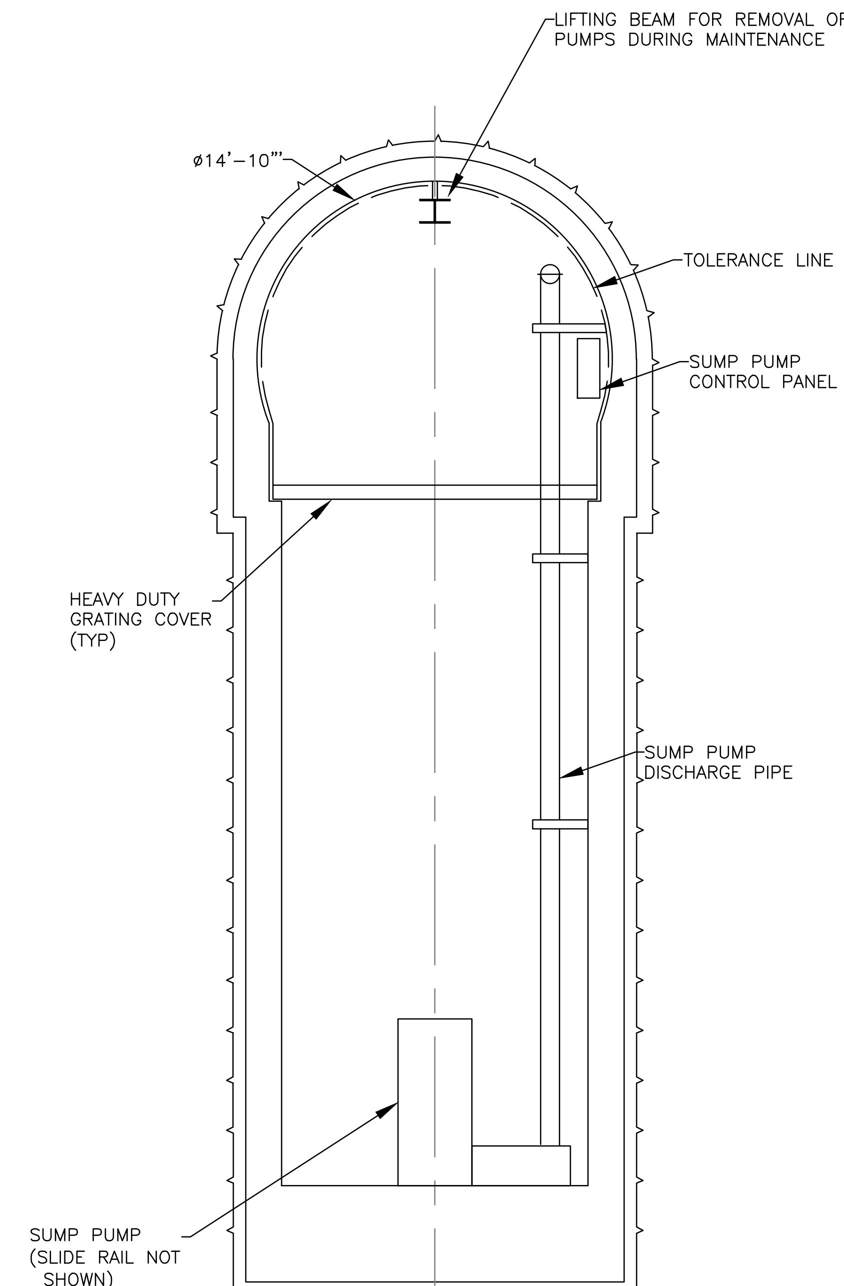
4) GAS EMISSION MONITORING TO BE PROVIDED IN THE SUMP AND CROSS PASSAGE.

5) CROSS PASSAGE DIMENSIONS ARE INDICATIVE AND TO BE CONFIRMED ONCE CONCEPT ALIGNMENTS ARE DEVELOPED.



TWIN BORE TUNNELS STANDARD CROSS PASSAGE WITH LOW POINT SUMP
DRAFT CONCEPTUAL ALTERNATIVE
SCALE 1/8"= 1'-0"

8 0 8 16
SCALE: 1/8"=1'-0"



SECTION - B
SCALE 1/4"= 1'-0"

4 0 4 8
SCALE: 1/4"=1'-0"

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES, NORTHERN REGION
KNIK ARM TUNNEL FEASIBILITY STUDY

00029_B_122_TWIN BORE TUNNELS CROSS PASSAGE WITH LOW POINT SUMP

PLANS DEVELOPED BY: MOTT MACDONALD

PLANS DEVELOPED BY: STATE OF ALASKA DEPARTMENT OF TRANSPORTATION & PUBLIC FACILITIES, NORTHERN REGION, 2301 PEGER ROAD, FAIRBANKS, AK 99709 (907)451-2200
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NO.	DATE	REVISION
1	10/10/25	INTERNAL REVIEW
2	11/03/25	ISSUED TO DOT & PF

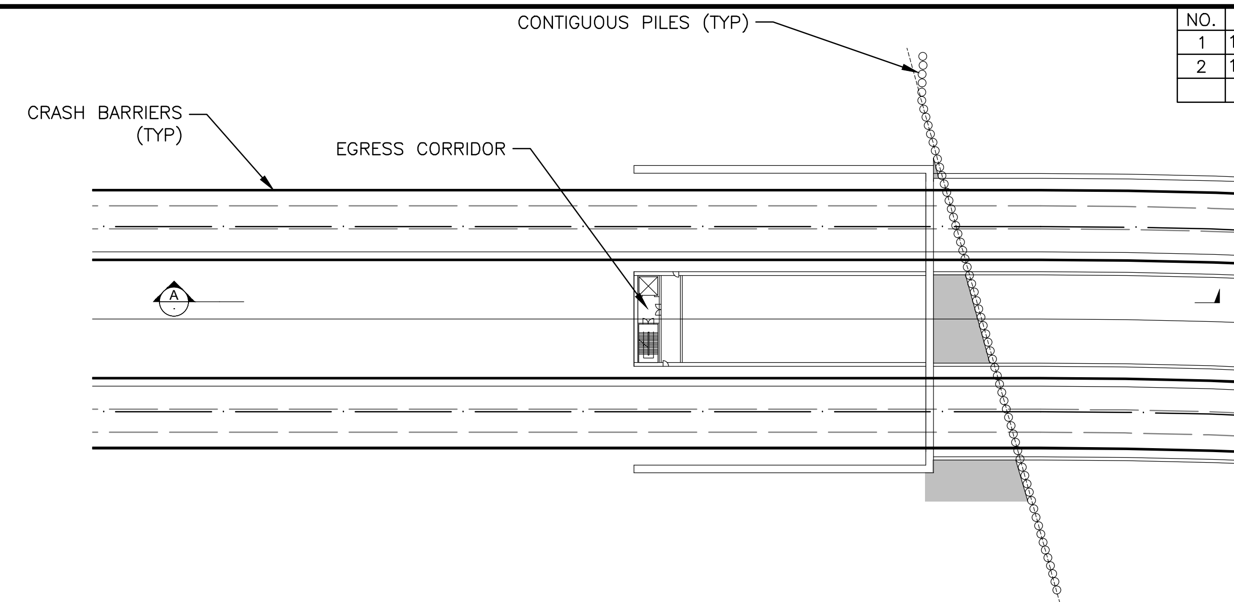
STATE	PROJECT DESIGNATION	YEAR	SHEET NO.	TOTAL SHEETS
ALASKA	HSHWY00029	2025	F200	11 OF 14

NOTES

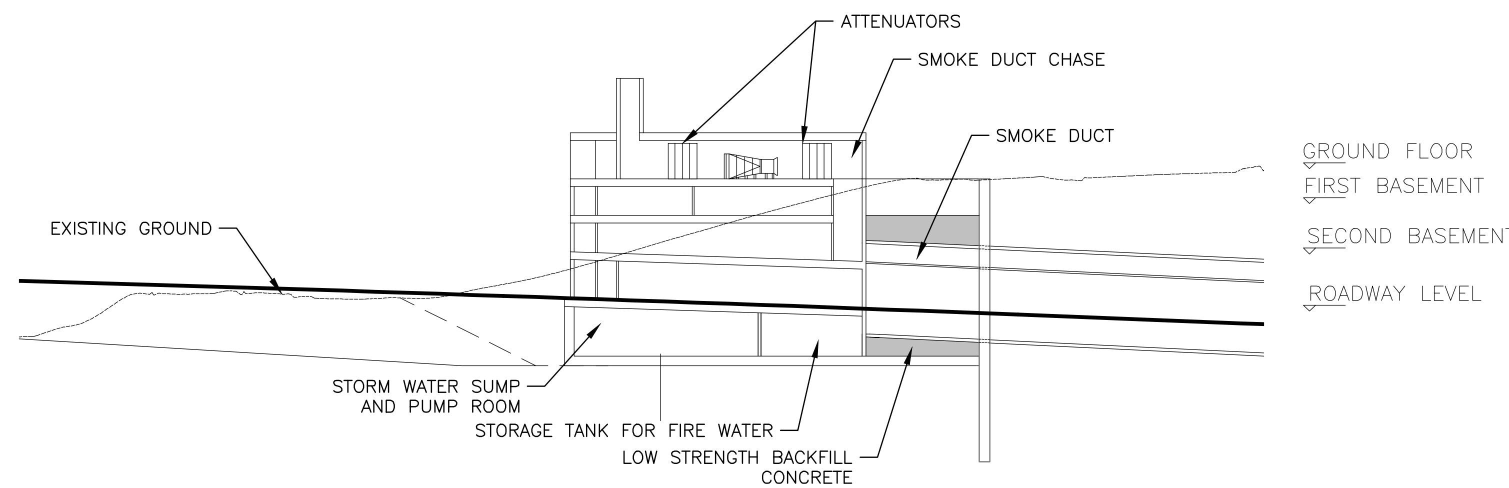
1) PORTAL ARRANGEMENT SHOWN IS BASED ON THE GEOMETRY OF ALTERNATIVE ALIGNMENT 1. ARRANGEMENT FOR ALTERNATIVE ALIGNMENT 4 IS SIMILAR; HOWEVER, GEOMETRY DIFFERS.

2) SUPPORT OF EXCAVATION, BUILDING ARRANGEMENT, AND TUNNEL SYSTEMS SHOWN ARE CONCEPTUAL ONLY. FINAL DESIGN TO BE DEVELOPED DURING DETAILED DESIGN PHASE.

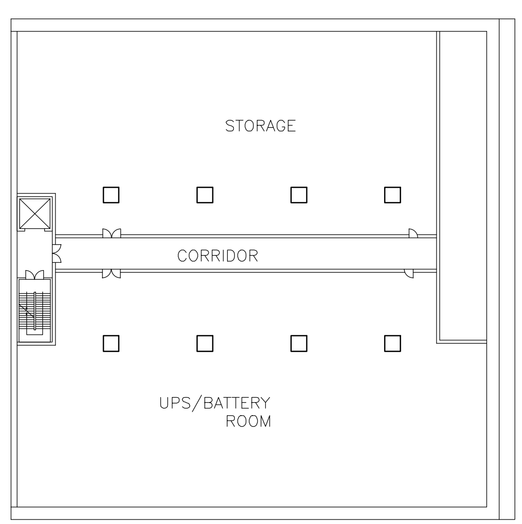
3) BUILDING ARRANGEMENT AND FACILITIES TO CONSIDER EQUIPMENT HANDLING DURING DETAILED DESIGN STAGE.



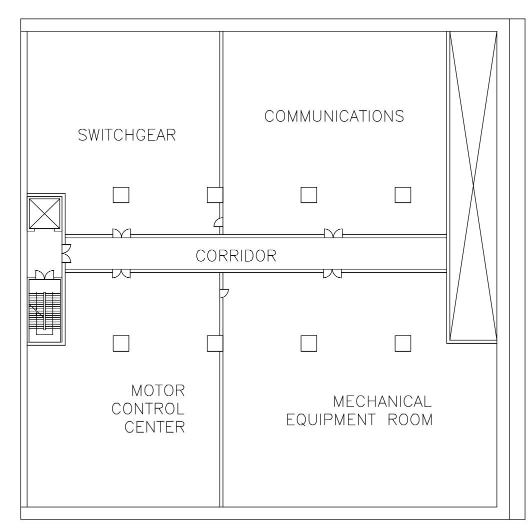
ROADWAY LEVEL PLAN VIEW
SCALE 1"=50'



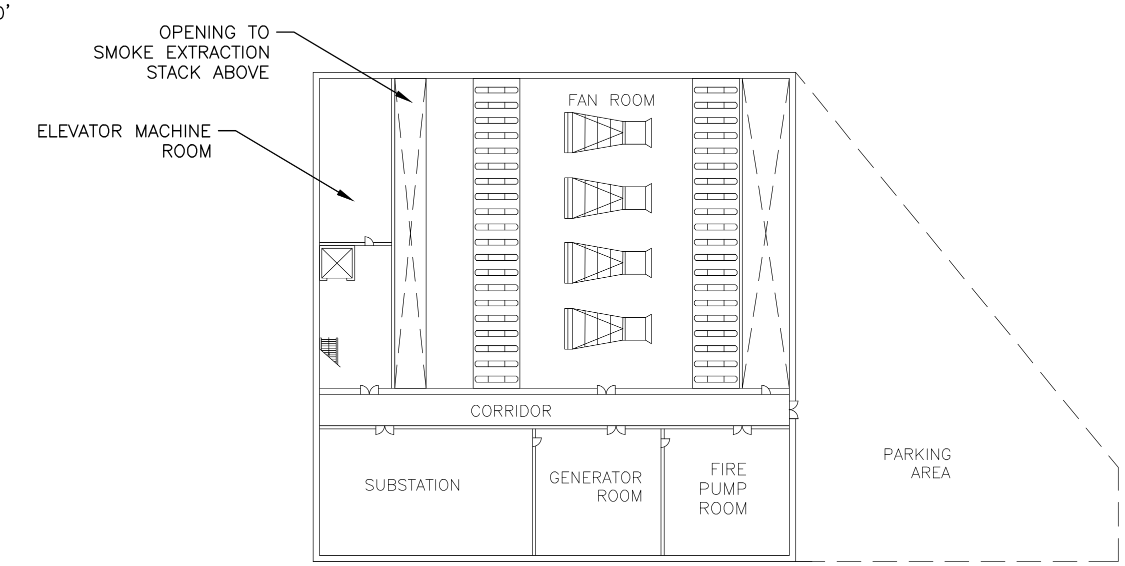
SECTION A–A
SCALE 1"=50'



SECOND BASEMENT PLAN
SCALE: 1"=30'



FIRST BASEMENT PLAN
SCALE: 1"=30'



GROUND FLOOR PLAN
SCALE: 1"=30'

PLANS DEVELOPED BY: MOTT MACDONALD

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES, NORTHERN REGION
KNIK ARM TUNNEL FEASIBILITY STUDY

00029_F_200_ANCHORAGE PORTAL – GENERAL ARRANGEMENT

PLANS DEVELOPED BY: STATE OF ALASKA DEPARTMENT OF TRANSPORTATION & PUBLIC FACILITIES, NORTHERN REGION, 2301 PEGER ROAD, FAIRBANKS, AK 99709 (907)451-2200
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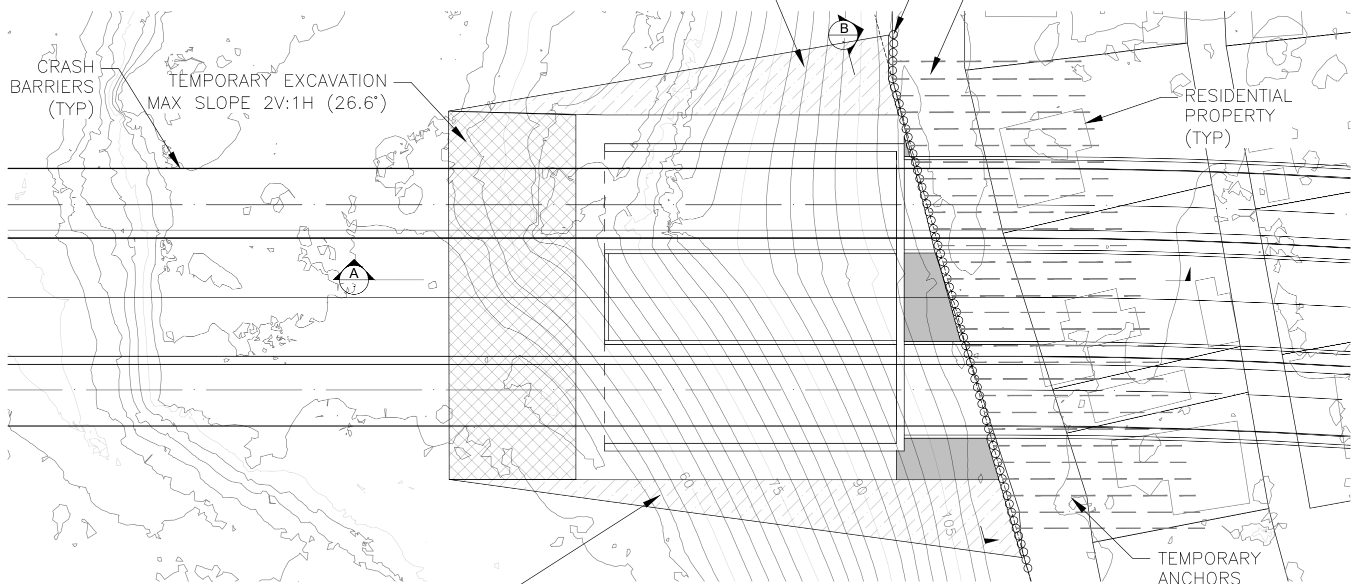
NO.	DATE	REVISION
1	10/10/25	INTERNAL REVIEW
2	11/03/25	ISSUED TO DOT & PF

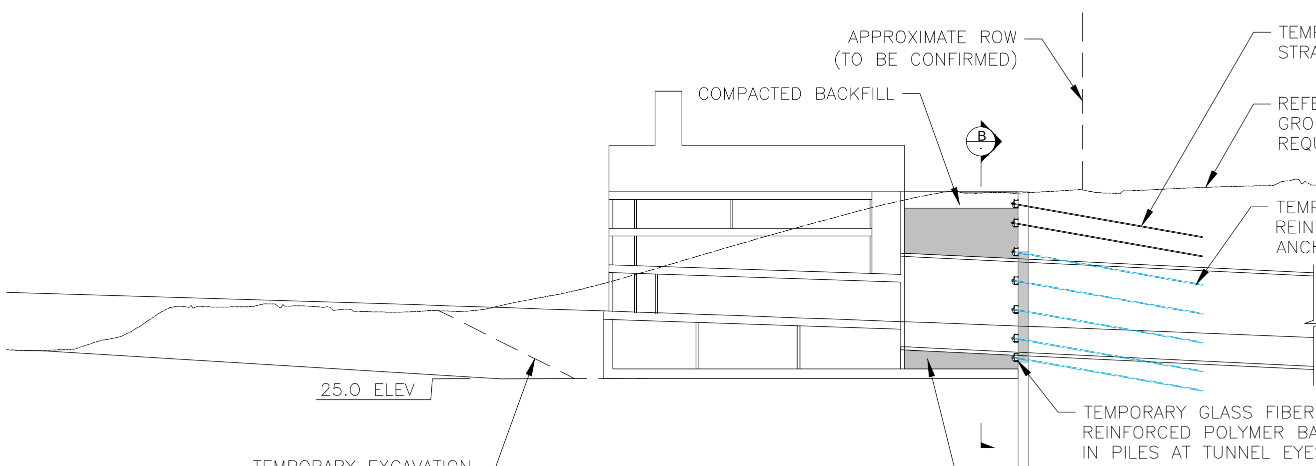
STATE	PROJECT DESIGNATION	YEAR	SHEET NO.	TOTAL SHEETS
ALASKA	HSHWY00029	2025	F201	12 OF 14



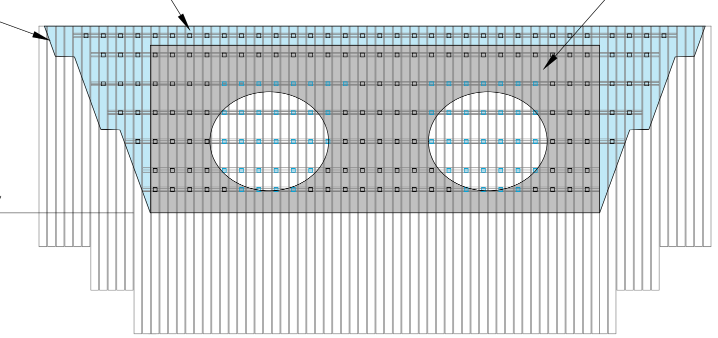
ROADWAY LEVEL PLAN VIEW
SCALE 1"=50'

CONCEPTUAL CONSTRUCTION SEQUENCE:

1. INSTALL INSTRUMENTATION AND MONITORING AND UNDERTAKE BASELINE MONITORING PERIOD.
2. INSTALL DE-WATERING SYSTEM.
3. INSTALL CONTIGUOUS PILE WALL.
4. SEQUENTIAL EXCAVATION AND INSTALLATION OF TEMPORARY GROUND ANCHORS
5. INSTALL TEMPORARY CANOPY STEEL PIPES
6. CONSTRUCT PORTAL STRUCTURE
7. BACKFILL INTERFACE WITH CONTIGUOUS PILE WALL USING LOW-STRENGTH CONCRETE IN STAGES DE-STRESS TEMPORARY GFRP ANCHORS AT TUNNEL EYE REMOVE TEMPORARY STEEL BRACKETS
8. TWO TBMS BREAKTHROUGH AND CONNECT TO PORTAL BUILDINGS
9. DISMANTLE TBM IN SITU AND REMOVE VIA POINT MACKENZIE PORTAL
10. CAST IN-SITU TUNNEL LINING INSIDE TBM TAILSHIELD TO COMPLETE TUNNEL LINING



SECTION A-A
SCALE 1"=50'



SECTION B-B
SCALE 1"=50'

NOTES:

1. TEMPORARY DE-WATERING WILL BE REQUIRED AND IS NOT SHOWN ON THE CONCEPTUAL DRAWINGS. DESIGN SHOULD BE CONFIRMED FOLLOWING GEOTECHNICAL INVESTIGATION, MONITORING, AND TBM OPERATION MODE.
2. PORTAL ARRANGEMENT SHOWN IS BASED ON THE GEOMETRY OF ALTERNATIVE ALIGNMENT 1. ARRANGEMENT FOR ALTERNATIVE ALIGNMENT 4 IS SIMILAR; HOWEVER, GEOMETRY DIFFERS.
3. SUPPORT OF EXCAVATION SHOWN ARE CONCEPTUAL ONLY. FINAL DESIGN TO BE DEVELOPED DURING DETAILED DESIGN.
4. GEOTECHNICAL SITE INVESTIGATION IS REQUIRED TO SUPPORT SUBSEQUENT DESIGN PHASES.
5. GROUND IMPROVEMENT AT THE TUNNEL INTERFACE WITH CONTIGUOUS PILES AND SHALLOW SECTION OF THE TUNNEL MAY BE REQUIRED DEPENDING ON THE GEOLOGICAL CONDITIONS.

PLANS DEVELOPED BY: MOTT MACDONALD

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES, NORTHERN REGION
KNIK ARM TUNNEL FEASIBILITY STUDY

00029_F_201_ANCHORAGE PORTAL - GENERAL ARRANGEMENT - TEMPORARY SUPPORT OF EXCAVATION

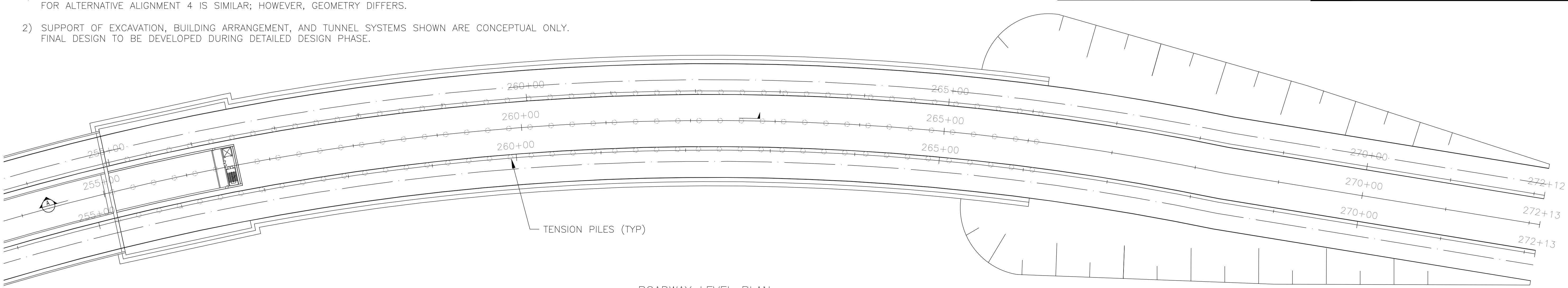
NO.	DATE	REVISION
1	10/10/25	INTERNAL REVIEW
2	11/03/25	ISSUED TO DOT & PF

STATE	PROJECT DESIGNATION	YEAR	SHEET NO.	TOTAL SHEETS
ALASKA	HSHWY00029	2025	F220	13 OF 14

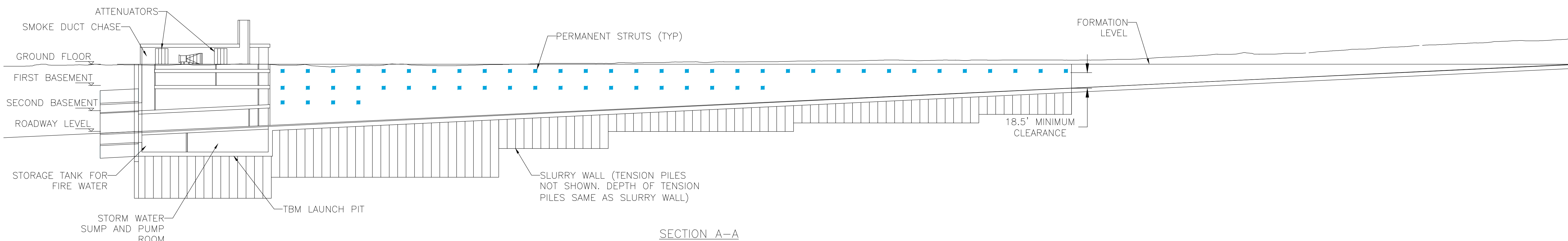
NOTES

1) PORTAL ARRANGEMENT SHOWN IS BASED ON THE GEOMETRY OF ALTERNATIVE ALIGNMENT 1. ARRANGEMENT FOR ALTERNATIVE ALIGNMENT 4 IS SIMILAR; HOWEVER, GEOMETRY DIFFERS.

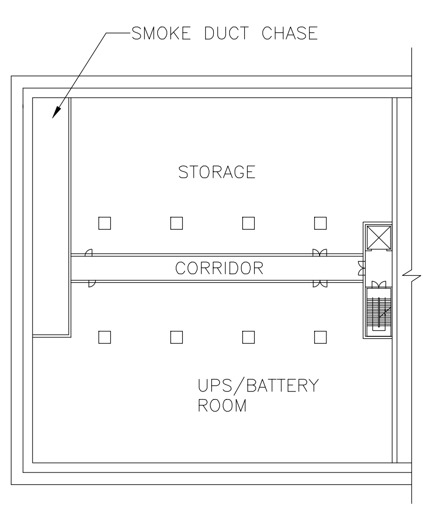
2) SUPPORT OF EXCAVATION, BUILDING ARRANGEMENT, AND TUNNEL SYSTEMS SHOWN ARE CONCEPTUAL ONLY. FINAL DESIGN TO BE DEVELOPED DURING DETAILED DESIGN PHASE.



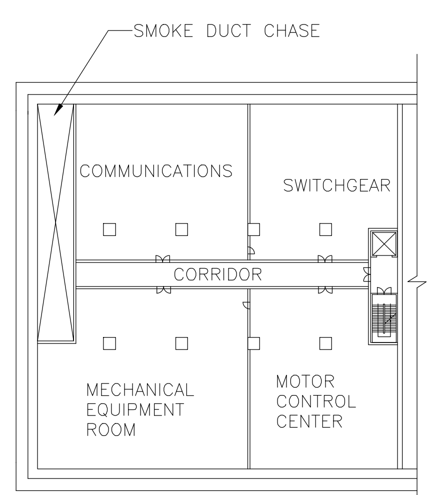
ROADWAY LEVEL PLAN
(REFER TO NOTE 1)
SCALE: 1"=60'



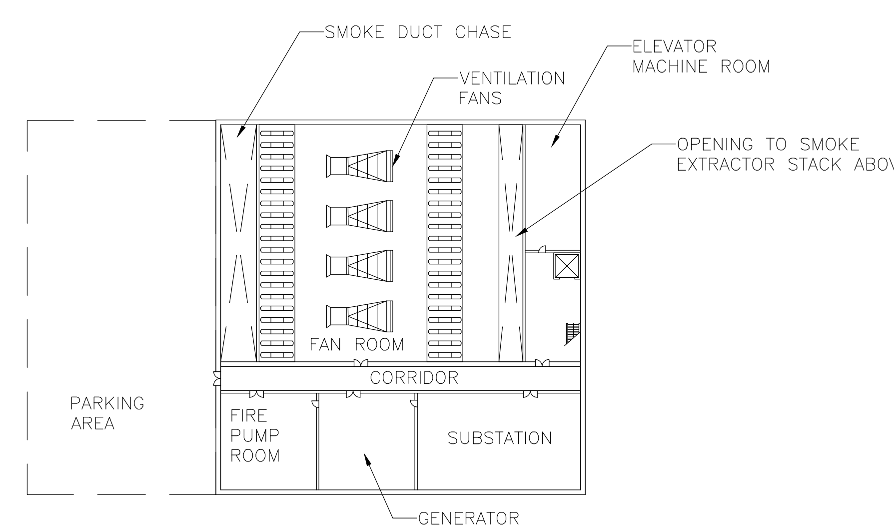
SECTION A–A
SCALE: 1"=60'



SECOND BASEMENT PLAN
SCALE: 1"=40'



FIRST BASEMENT PLAN
SCALE: 1"=40'



GROUND FLOOR PLAN
SCALE: 1"=40'

PLANS DEVELOPED BY: MOTT MACDONALD

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES, NORTHERN REGION
KNIK ARM TUNNEL FEASIBILITY STUDY

00029_F_220_POINT MACKENZIE PORTAL – GENERAL ARRANGEMENT

PLANS DEVELOPED BY: STATE OF ALASKA DEPARTMENT OF TRANSPORTATION & PUBLIC FACILITIES, NORTHERN REGION, 2301 PEGER ROAD, FAIRBANKS, AK 99709 (907)451-2200
C:\users\mal96066\appdata\local\projectwise\workdir\mott-use-pw-04\d0211692\00029_F_220_POINT MACKENZIE PORTAL – GENERAL ARRANGEMENT SHEET 1 OF 2-SHEET Mon, Nov/03/25 01:59pm

NO.	DATE	REVISION
1	10/10/25	INTERNAL REVIEW
2	11/03/25	ISSUED TO DOT & PF

STATE	PROJECT DESIGNATION	YEAR	SHEET NO.	TOTAL SHEETS
ALASKA	HSHWY00029	2025	F221	14 OF 14

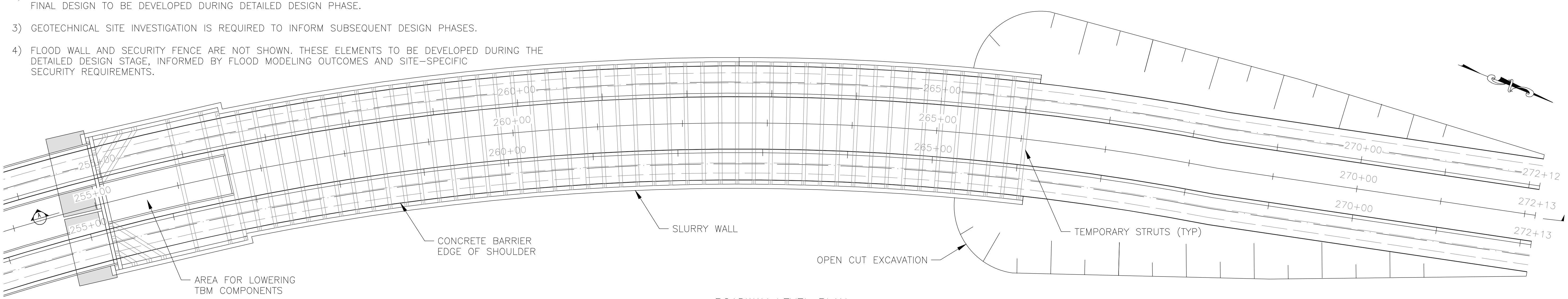
NOTES

1) PORTAL ARRANGEMENT SHOWN IS BASED ON THE GEOMETRY OF ALTERNATIVE ALIGNMENT 1. ARRANGEMENT FOR ALTERNATIVE ALIGNMENT 4 IS SIMILAR; HOWEVER, GEOMETRY DIFFERS.

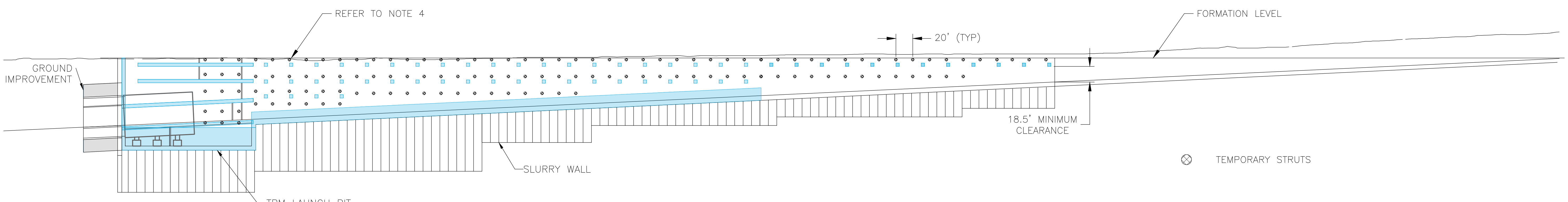
2) SUPPORT OF EXCAVATION, BUILDING ARRANGEMENT, AND TUNNEL SYSTEMS SHOWN ARE CONCEPTUAL ONLY. FINAL DESIGN TO BE DEVELOPED DURING DETAILED DESIGN PHASE.

3) GEOTECHNICAL SITE INVESTIGATION IS REQUIRED TO INFORM SUBSEQUENT DESIGN PHASES.

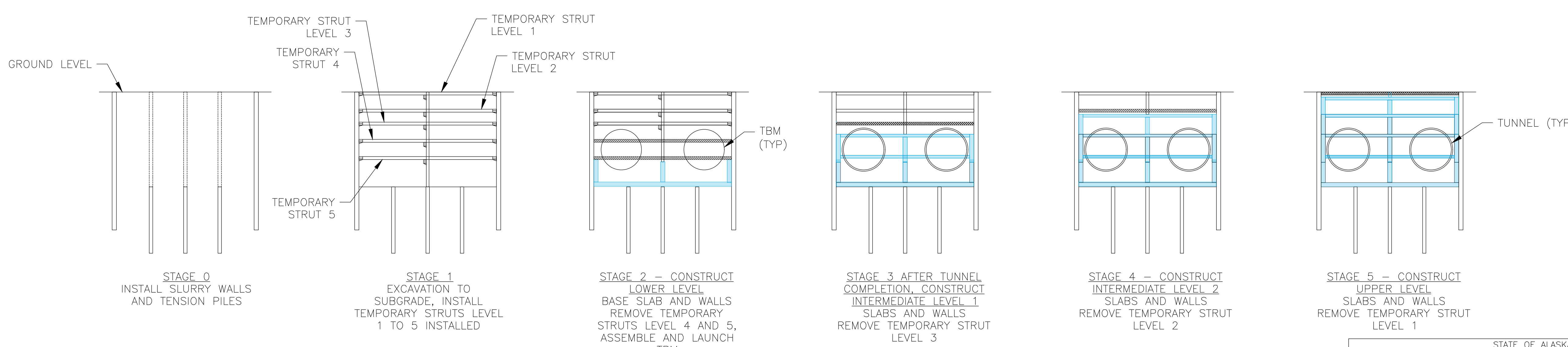
4) FLOOD WALL AND SECURITY FENCE ARE NOT SHOWN. THESE ELEMENTS TO BE DEVELOPED DURING THE DETAILED DESIGN STAGE, INFORMED BY FLOOD MODELING OUTCOMES AND SITE-SPECIFIC SECURITY REQUIREMENTS.



ROADWAY LEVEL PLAN
(REFER TO NOTE 1)
SCALE: 1"=60'



SECTION A–A
SCALE: 1"=60'



PLANS DEVELOPED BY: MOTT MACDONALD

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES, NORTHERN REGION
KNIK ARM TUNNEL FEASIBILITY STUDY

00029_F_221_POINT MACKENZIE PORTAL – GENERAL ARRANGEMENT – TEMPORARY SUPPORT OF EXCAVATION

PLANS DEVELOPED BY: STATE OF ALASKA DEPARTMENT OF TRANSPORTATION & PUBLIC FACILITIES, NORTHERN REGION, 2301 PEGER ROAD, FAIRBANKS, AK 99709 (907)451-2200
C:\users\mal96066\appdata\local\projectwise\workdir\mott-use-pw-04\d0211692\00029_B_221_POINT MACKENZIE PORTAL – GENERAL ARRANGEMENT – TEMPORARY SUPPORT OF EXCAVATION-SHEET Mon, Nov/03/25 01:42pm

NO.	DATE	REVISION

STATE	PROJECT DESIGNATION	YEAR	SHEET NO.	TOTAL SHEETS
ALASKA	HSHWY00029	2025	1	2

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES, NORTHERN REGION
KNIK ARM TUNNEL FEASIBILITY STUDY

ANCHORAGE PORTAL ENTRANCE

PLANS DEVELOPED BY: STANTEC

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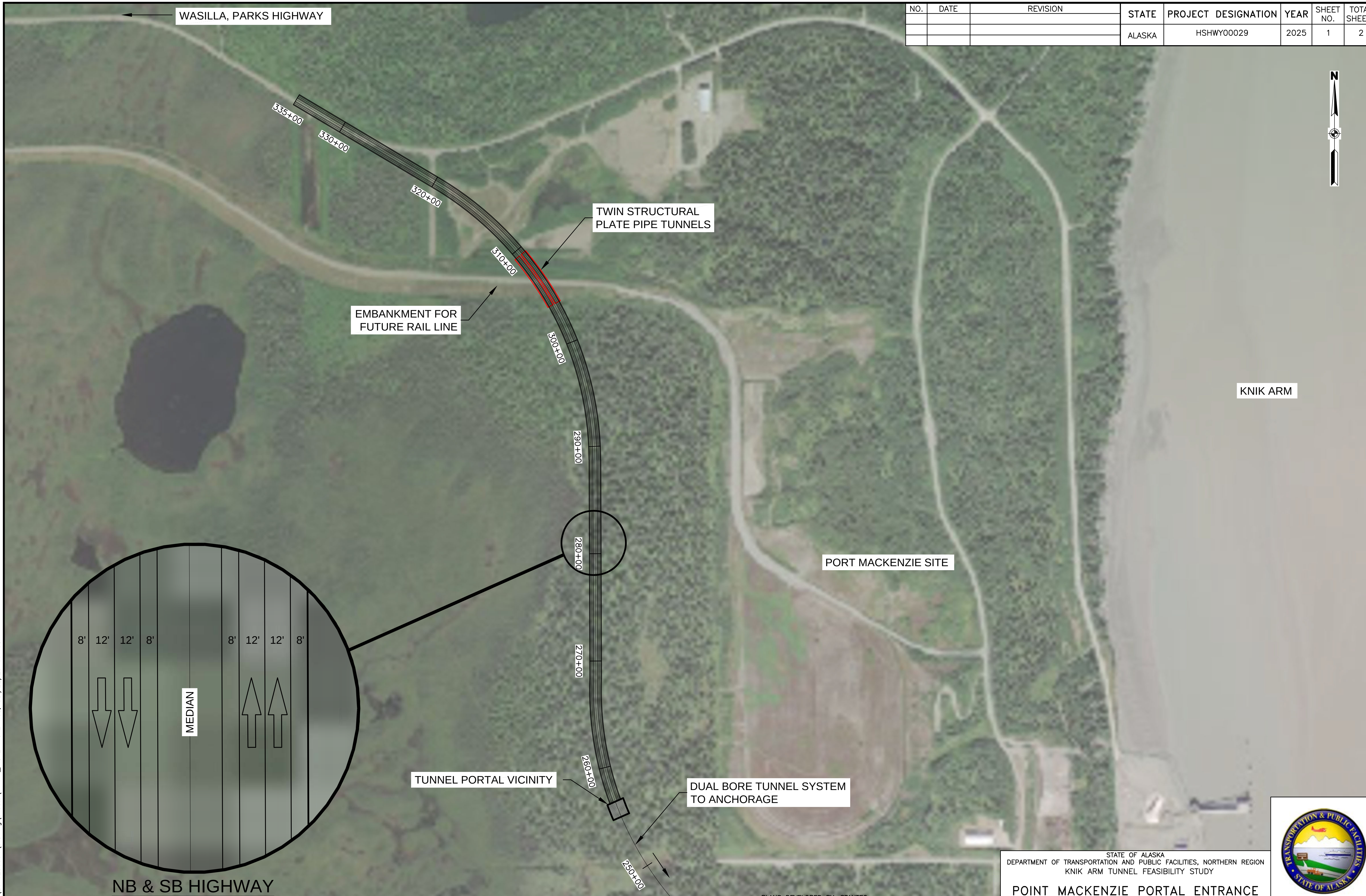
NO.	DATE	REVISION	STATE	PROJECT DESIGNATION	YEAR	SHEET NO.	TOTAL SHEETS
			ALASKA	HSHWY00029	2025	1	2



PLANS DEVELOPED BY: STANTEC

STATE OF ALASKA
DEPARTMENT OF TRANSPORTATION AND PUBLIC FACILITIES, NORTHERN REGION
KNIK ARM TUNNEL FEASIBILITY STUDY

POINT MACKENZIE PORTAL ENTRANCE

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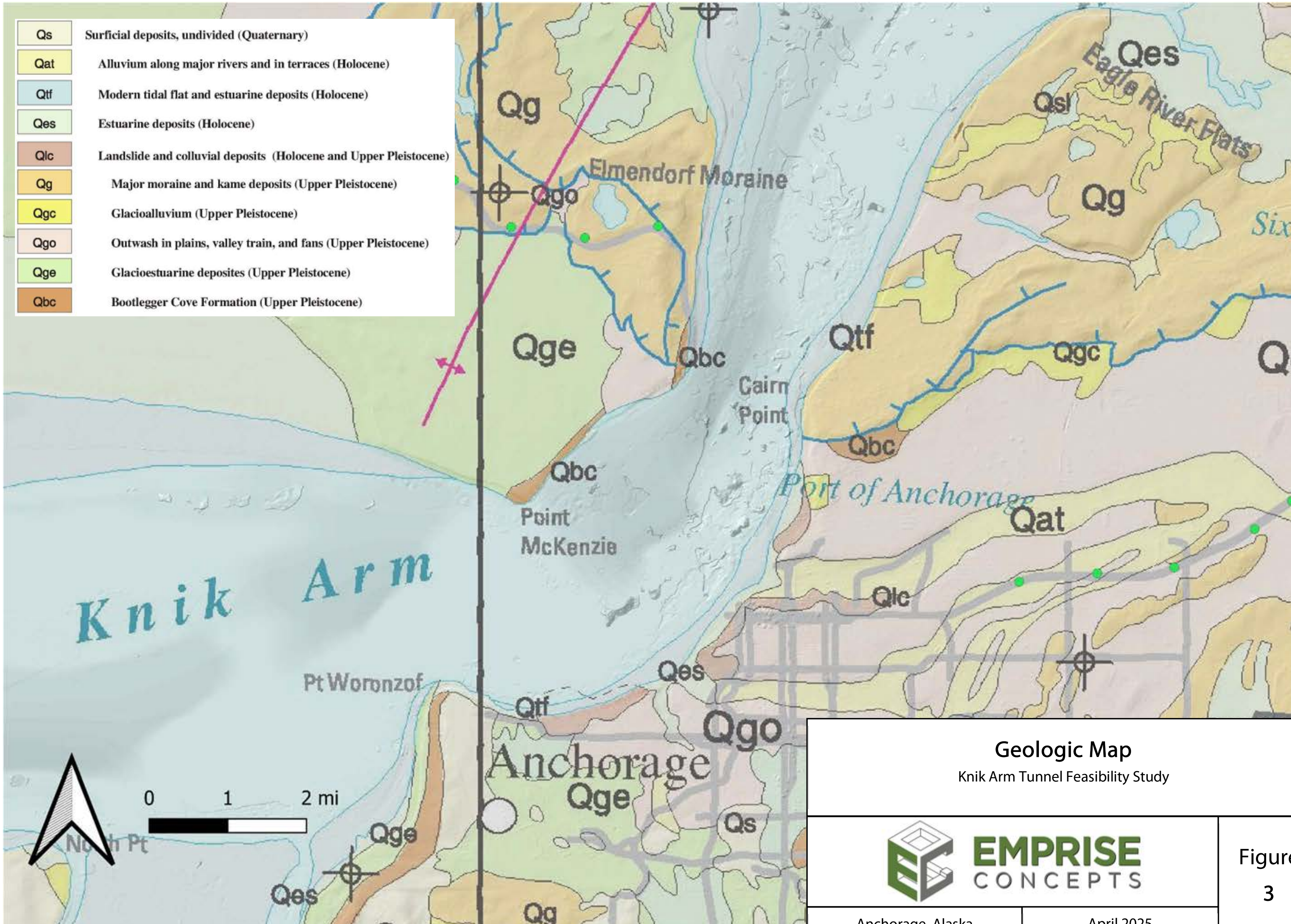
B. Geological sections



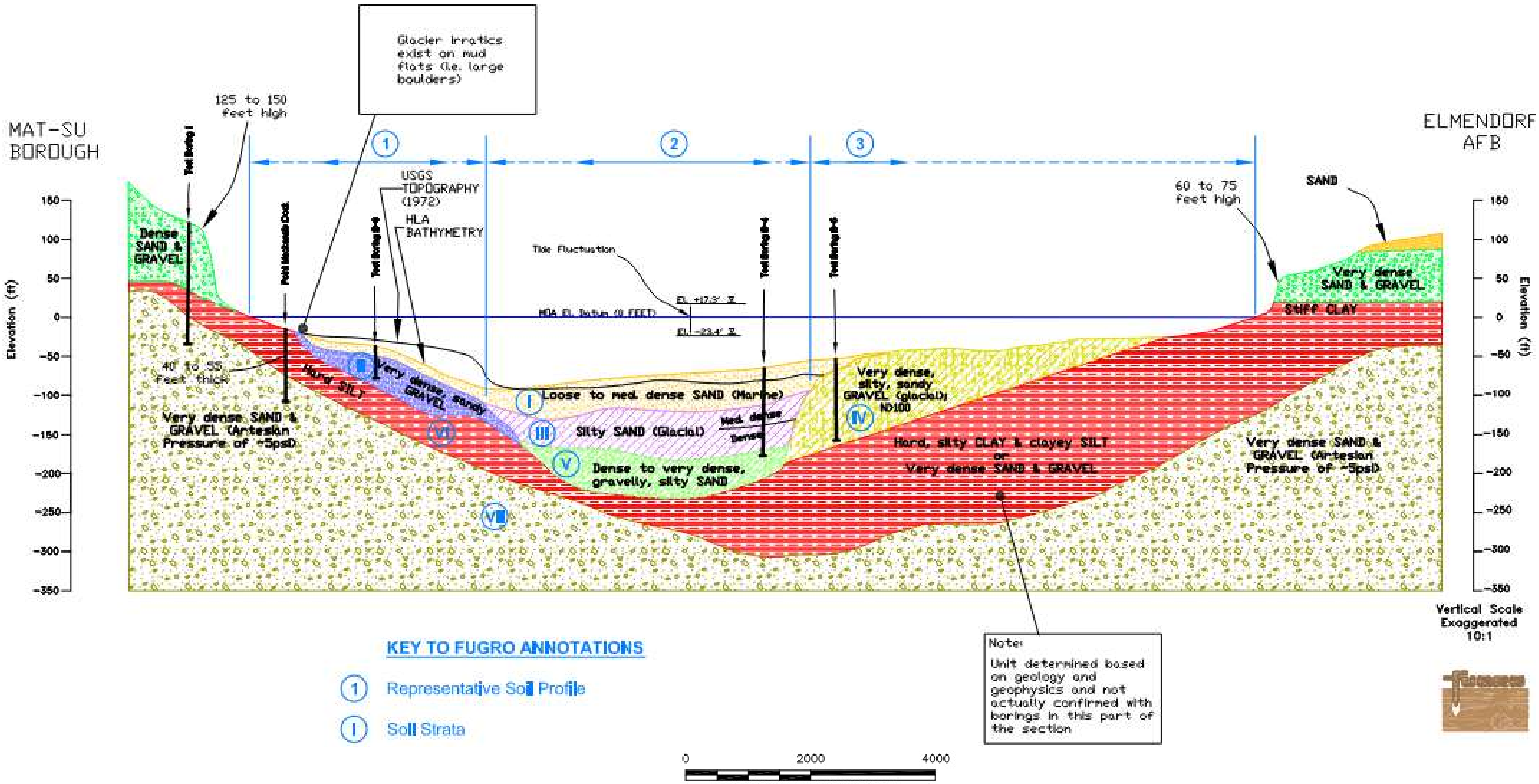
Geologic Map

Knik Arm Tunnel Feasibility Study

EMPRISE CONCEPTS

Figure 3

Anchorage, Alaska | April 2025



Modified cross section from HLA, 1984

Source: Knik Arm Crossing Engineering Feasibility and Cost Estimate Update, Volume 2 Technology Update, Parsons 2003

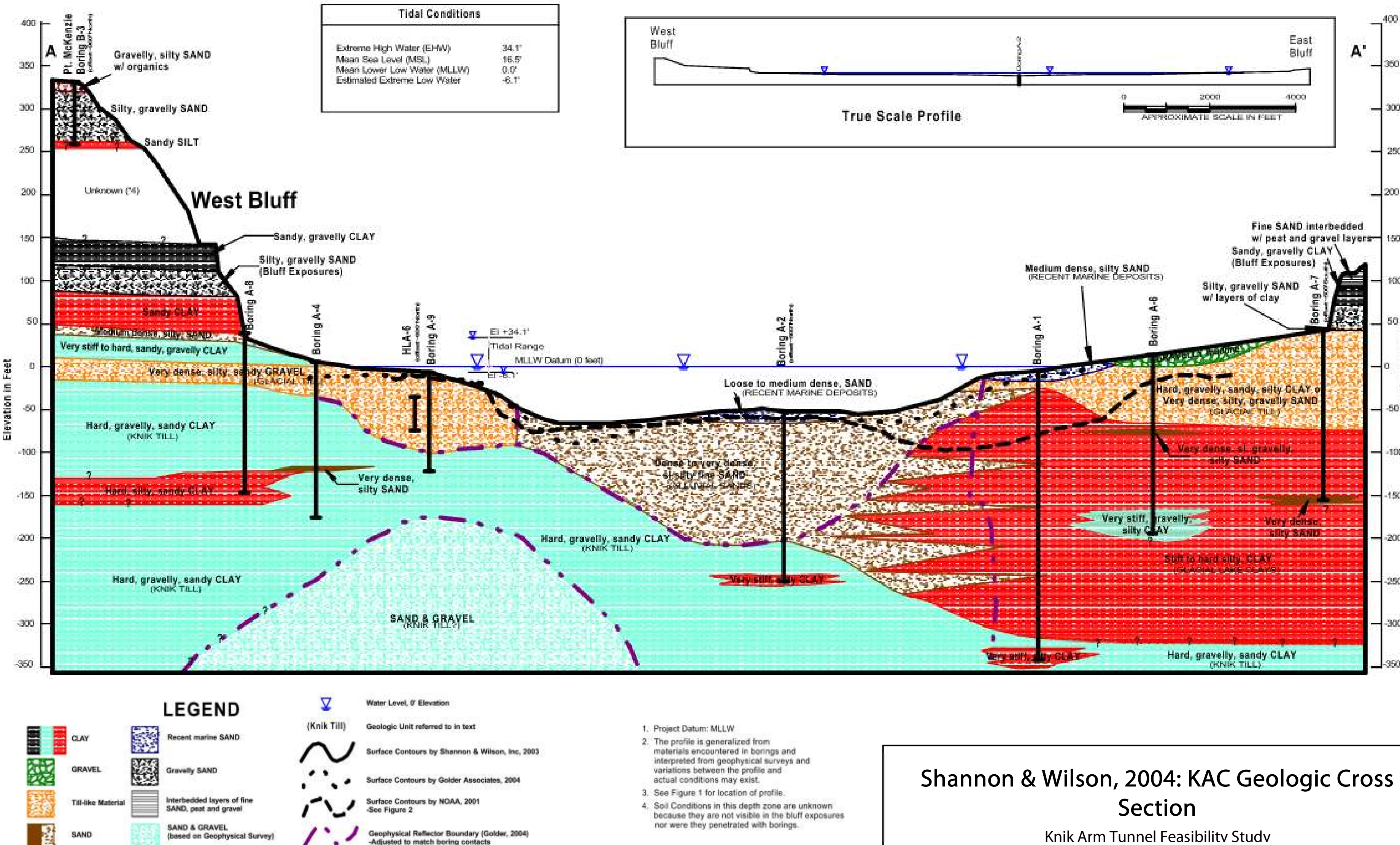
Parsons 2003: Geologic Cross Section

Knik Arm Tunnel Feasibility Study

EMPRISE CONCEPTS

Figure 4

Anchorage, Alaska | April 2025



1. Project Datum: MLLW
2. The profile is generalized from materials encountered in borings and interpreted from geophysical surveys and variations between the profile and actual conditions may exist.
3. See Figure 1 for location of profile.
4. Soil Conditions in this depth zone are unknown because they are not visible in the bluff exposures nor were they penetrated with borings.

Source: Preliminary Geotechnical Report, Knik Arm Bridge Project, Shannon & Wilson, Feb. 2004

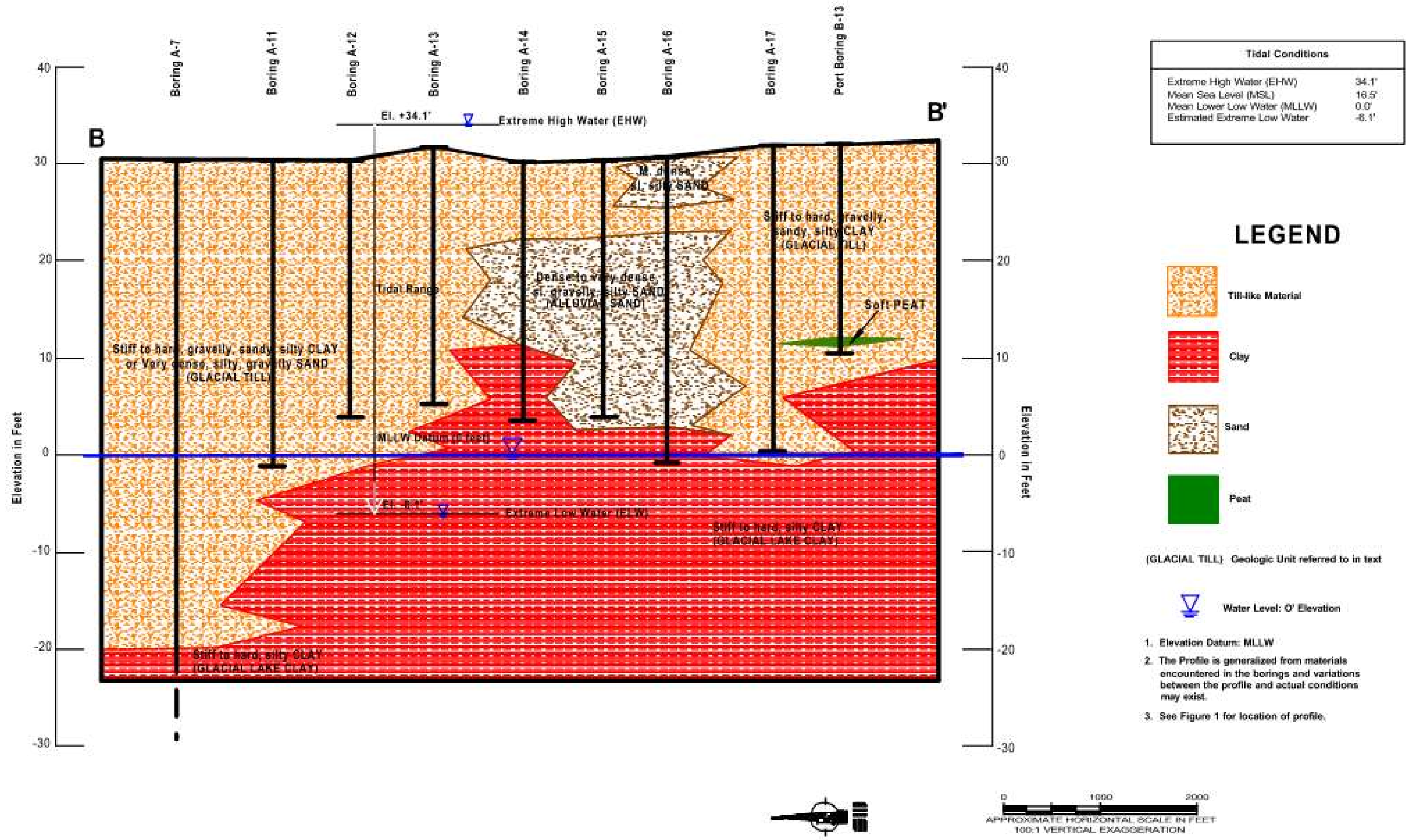
Shannon & Wilson, 2004: KAC Geologic Cross Section

Knik Arm Tunnel Feasibility Study

EMPRISE CONCEPTS

Figure 6

Anchorage, Alaska | April 2025



Shannon & Wilson, 2004: East Shoreline Geologic Cross Section

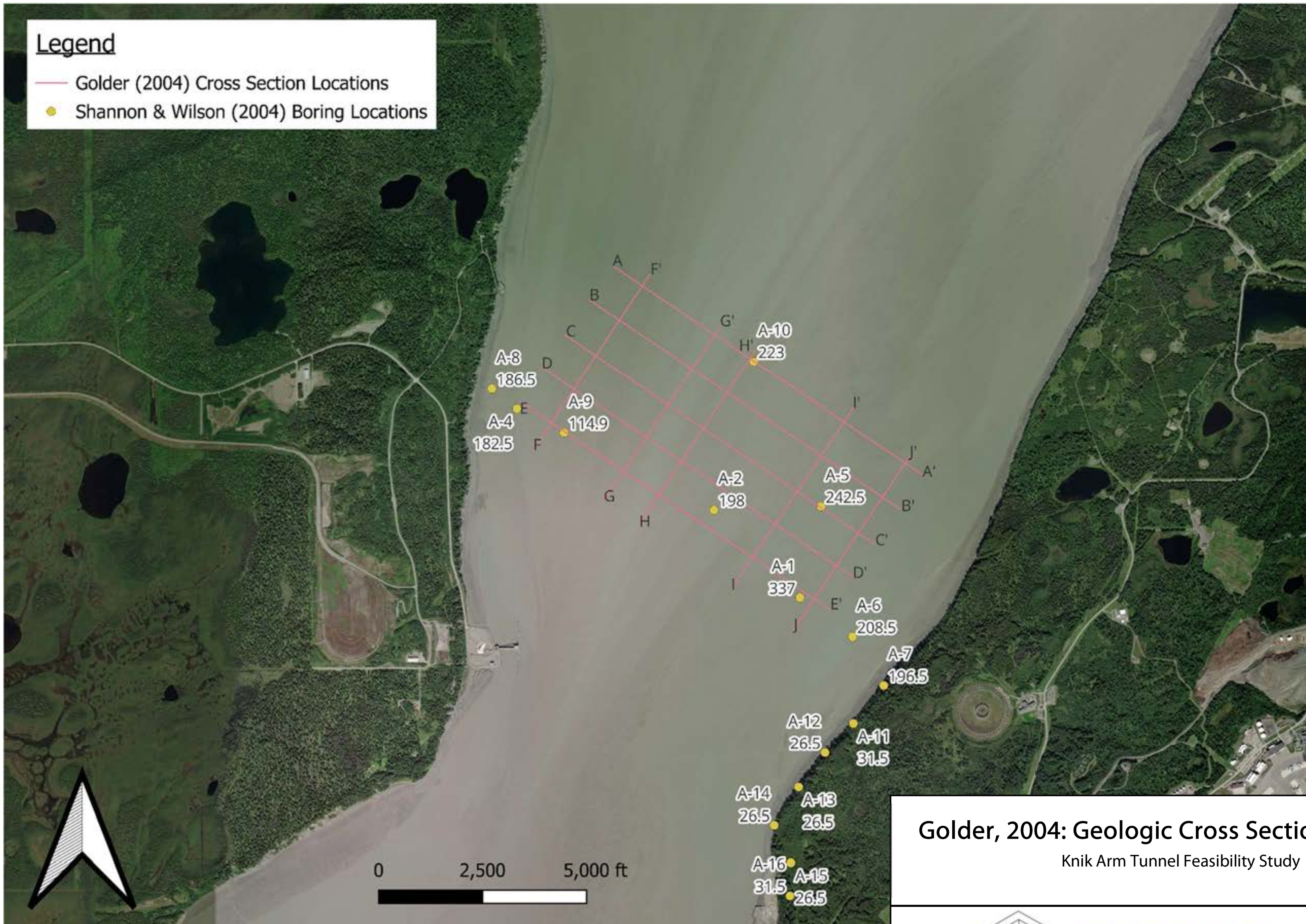
Knik Arm Tunnel Feasibility Study

EMPRISE CONCEPTS

Figure 7

Anchorage, Alaska | April 2025

Source: Preliminary Geotechnical Report, Knik Arm Bridge Project, Shannon & Wilson, Feb. 2004



Golder, 2004: Geologic Cross Section Locations

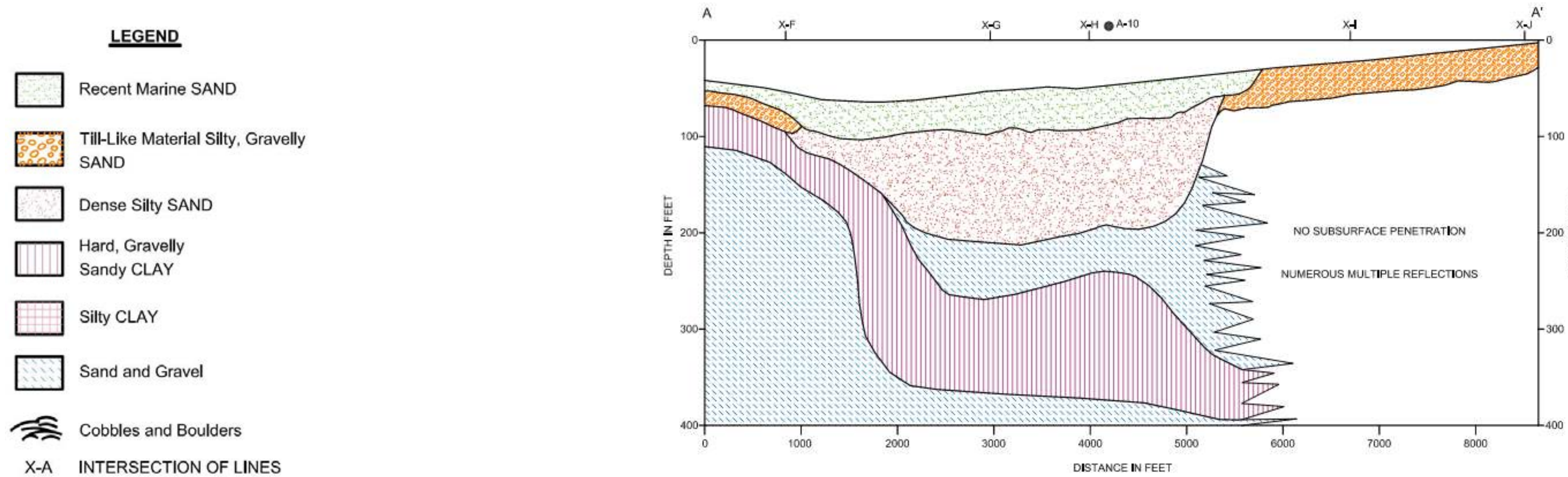
Knik Arm Tunnel Feasibility Study

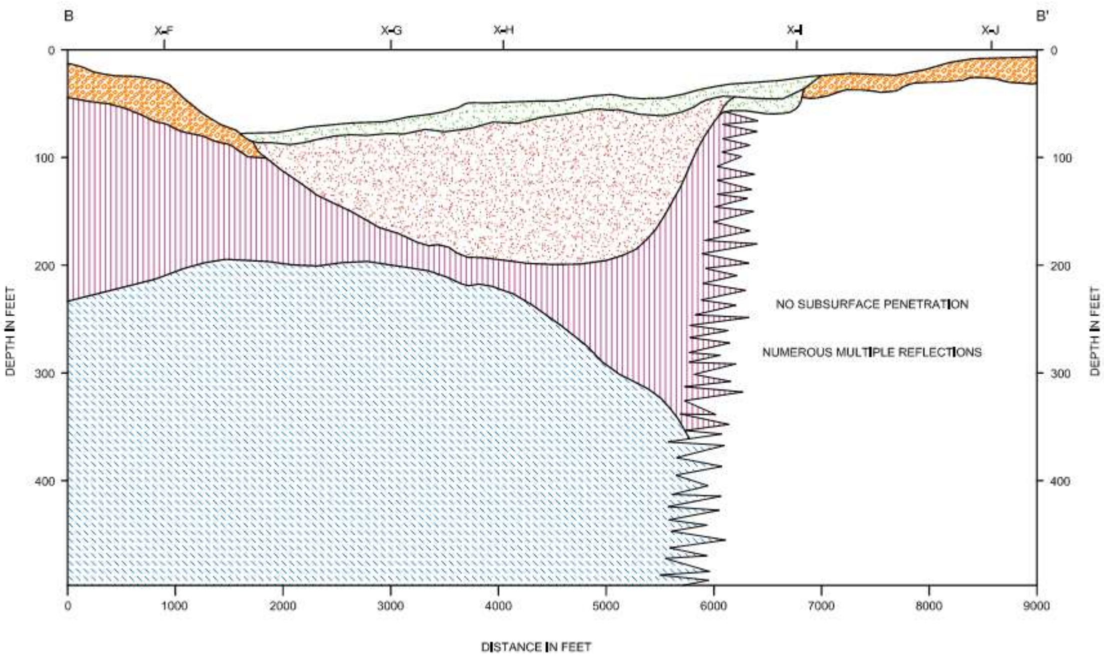
EMPRISE CONCEPTS

Figure 9

Anchorage, Alaska

April 2025





Source: Knik Arm Geophysical Investigation, Golder Associates, Feb. 2004

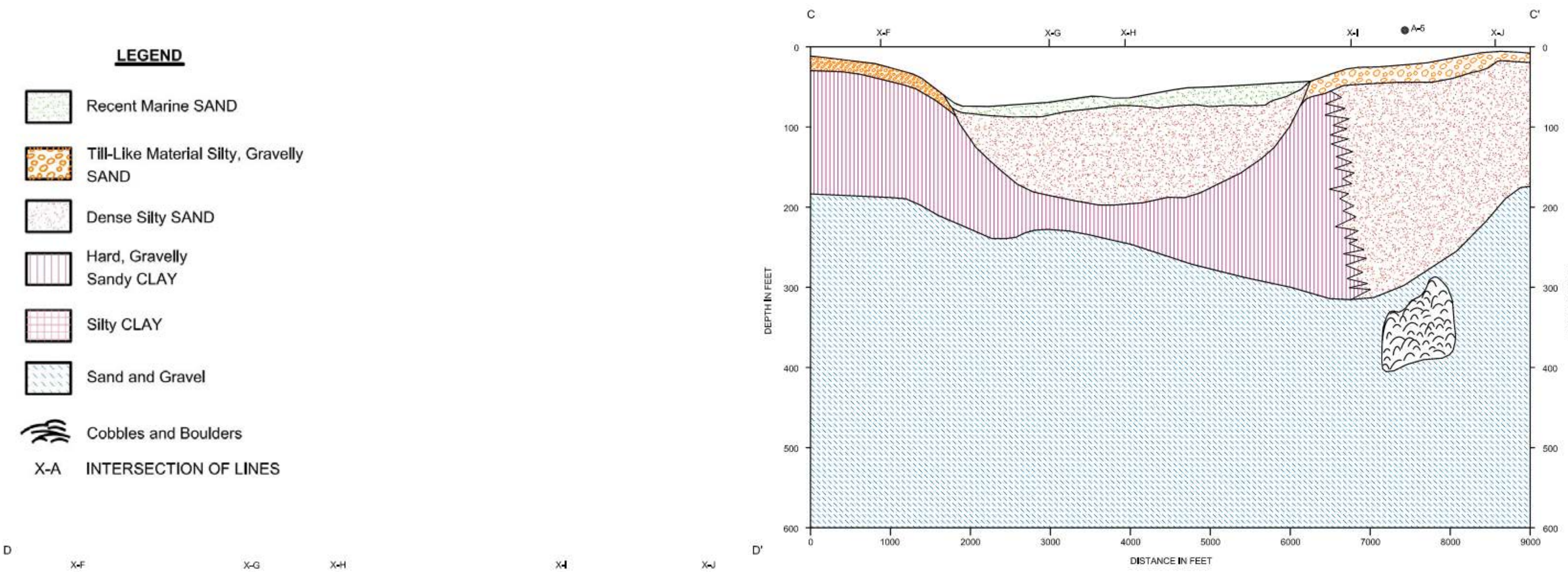
Golder, 2004: Geologic Cross Sections A-A' and B-B'

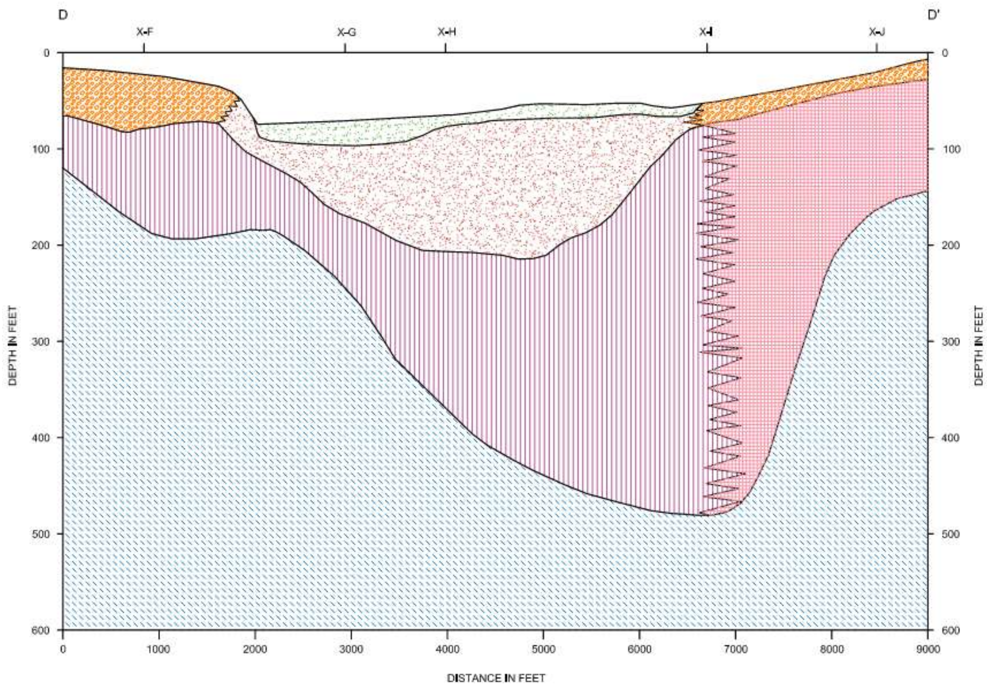
Knik Arm Tunnel Feasibility Study

EMPRISE CONCEPTS

Figure 10

Anchorage, Alaska | April 2025





Source: Knik Arm Geophysical Investigation, Golder Associates, Feb. 2004

Golder, 2004: Geologic Cross Sections C-C' and D-D'

Knik Arm Tunnel Feasibility Study

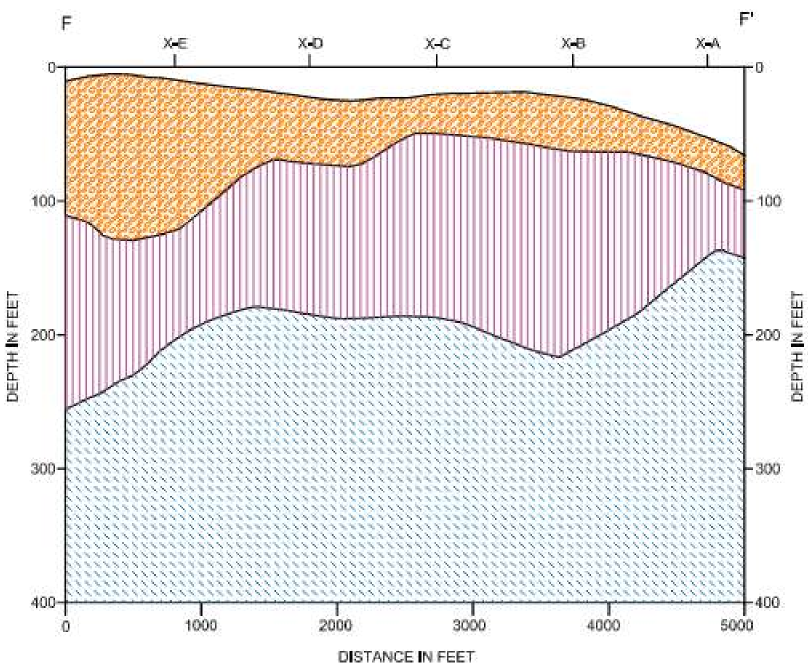
EMPRISE CONCEPTS

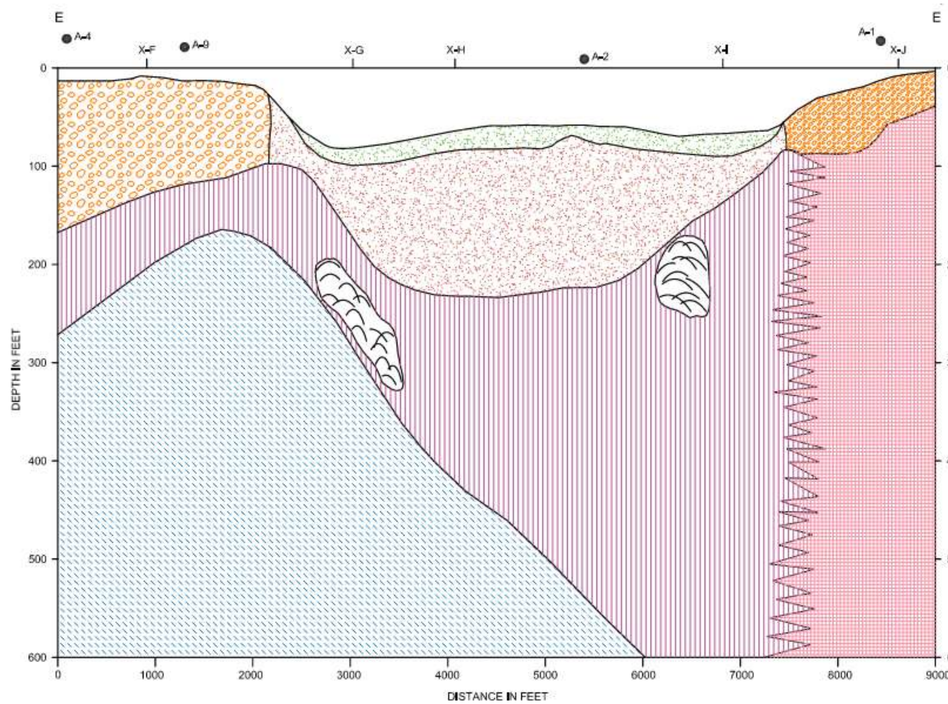
Anchorage, Alaska | April 2025

Figure 11

LEGEND

- Recent Marine SAND
- Till-Like Material Silty, Gravelly SAND
- Dense Silty SAND
- Hard, Gravelly Sandy CLAY
- Silty CLAY
- Sand and Gravel
- Cobbles and Boulders
- X-A INTERSECTION OF LINES





Source: Knik Arm Geophysical Investigation, Golder Associates, Feb. 2004

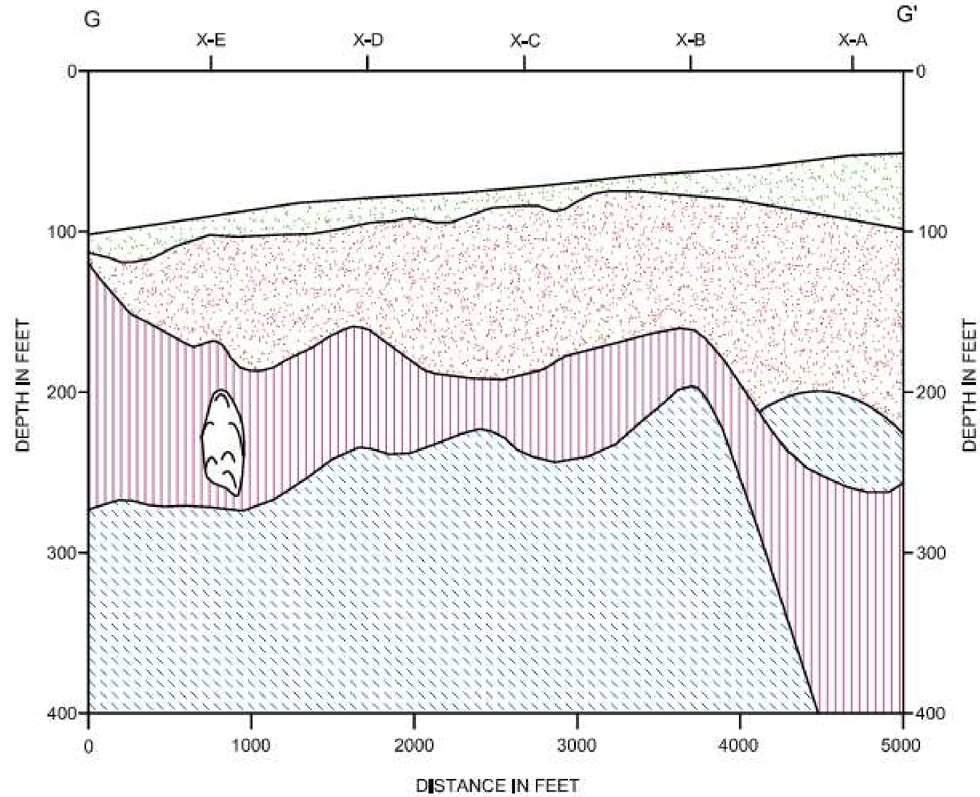
Golder, 2004: Geologic Cross Sections E-E' and F-F'

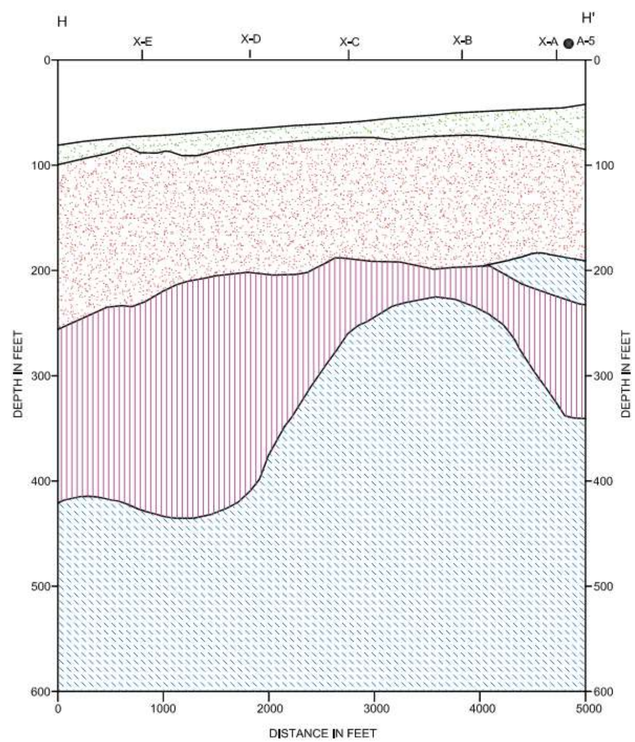
Knik Arm Tunnel Feasibility Study

EMPRISE CONCEPTS

Figure 12

Anchorage, Alaska | April 2025





Source: Knik Arm Geophysical Investigation, Golder Associates, Feb. 2004

Golder, 2004: Geologic Cross Sections G-G' and H-H'

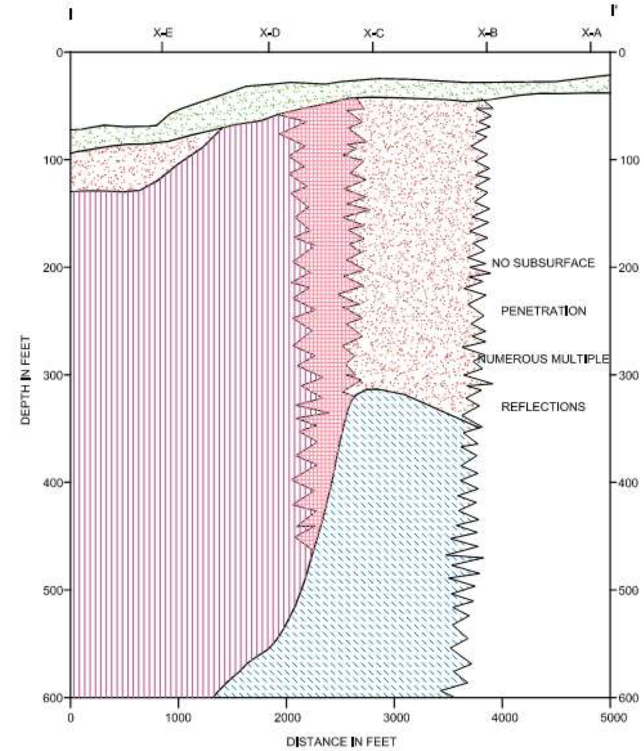
Knik Arm Tunnel Feasibility Study

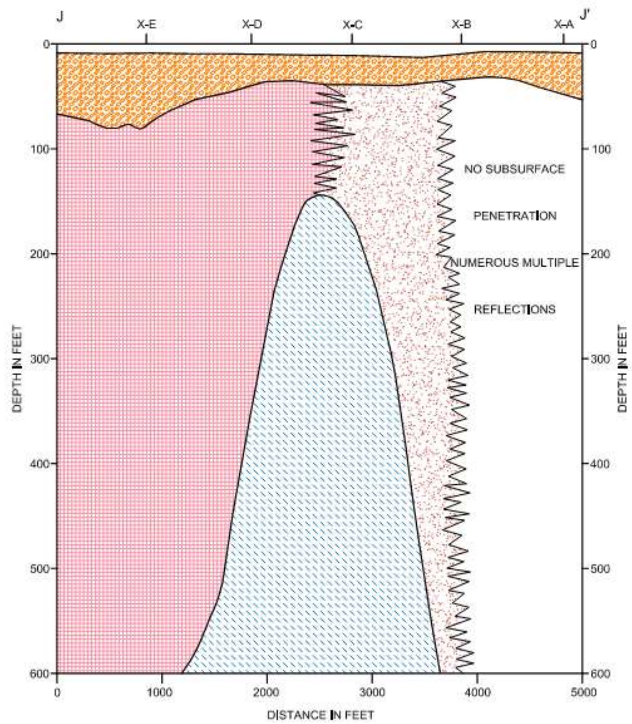
EMPRISE CONCEPTS

Anchorage, Alaska

April 2025

Figure 13





Source: Knik Arm Geophysical Investigation, Golder Associates, Feb. 2004

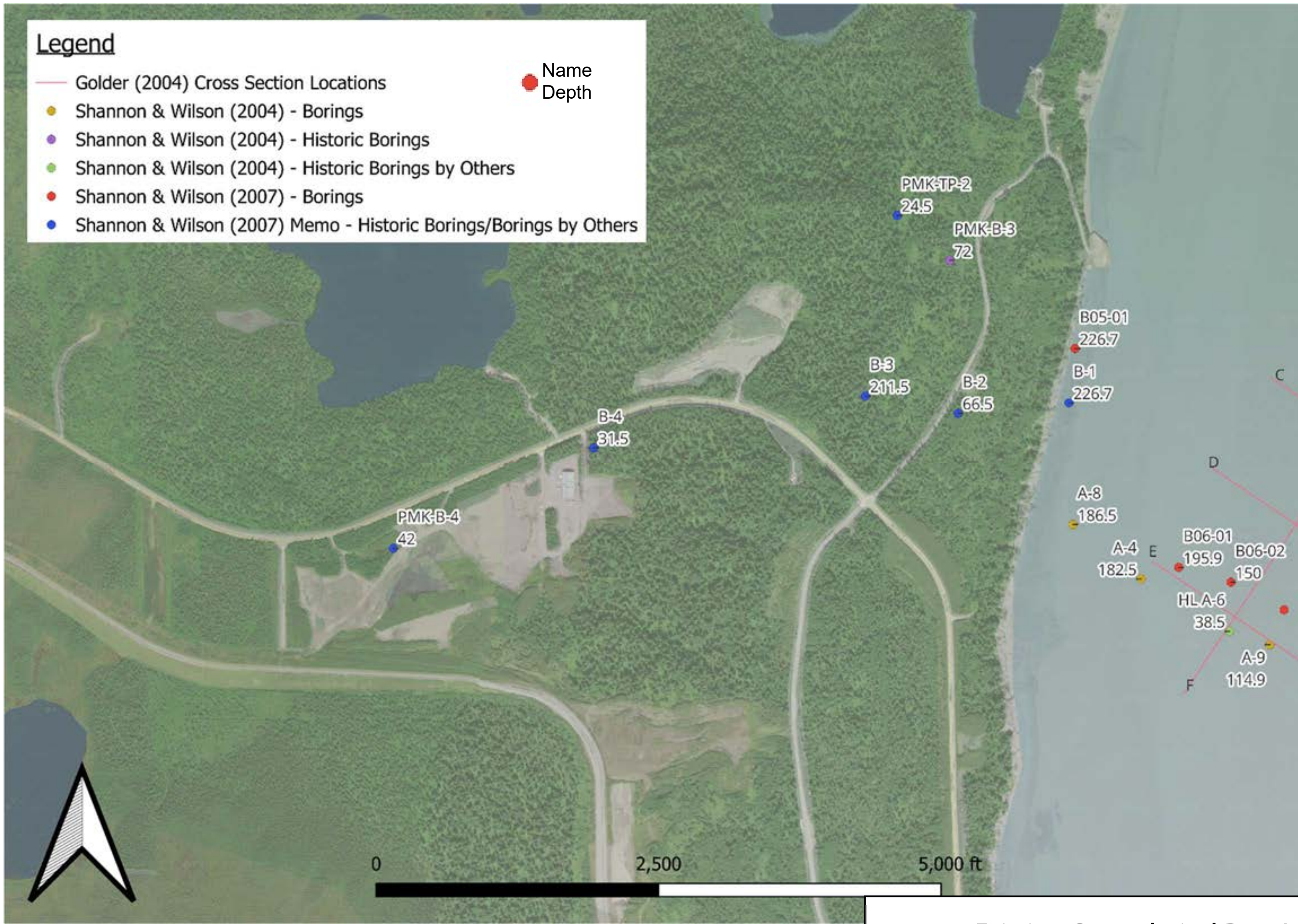
Golder, 2004: Geologic Cross Sections I-I' and H-H'

Knik Arm Tunnel Feasibility Study

EMPRISE CONCEPTS

Figure 14

Anchorage, Alaska | April 2025



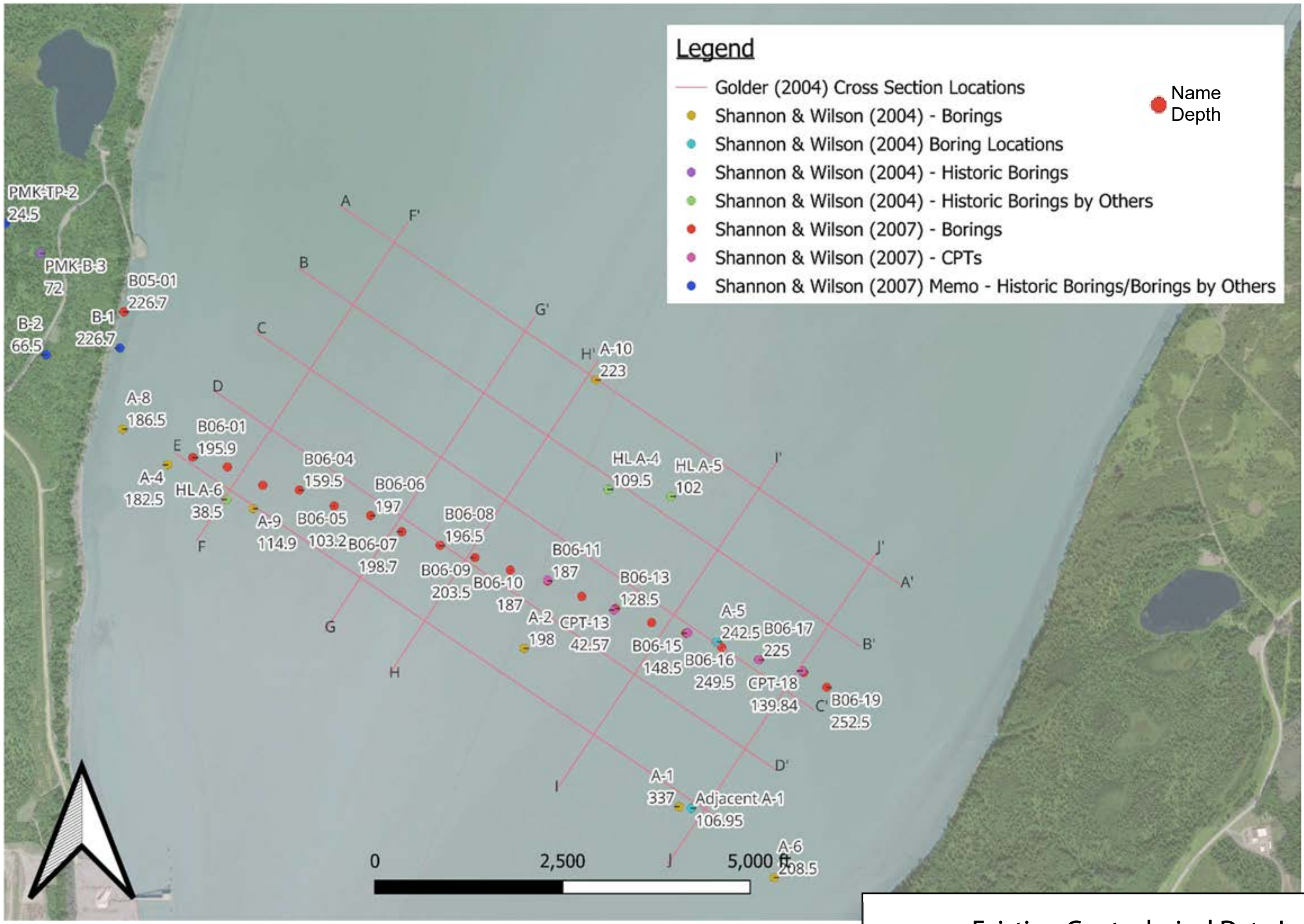
Existing Geotechnical Data Locations
Matanuska-Susitna Side

Knik Arm Tunnel Feasibility Study

EMPRISE CONCEPTS

Figure 15

Anchorage, Alaska | April 2025



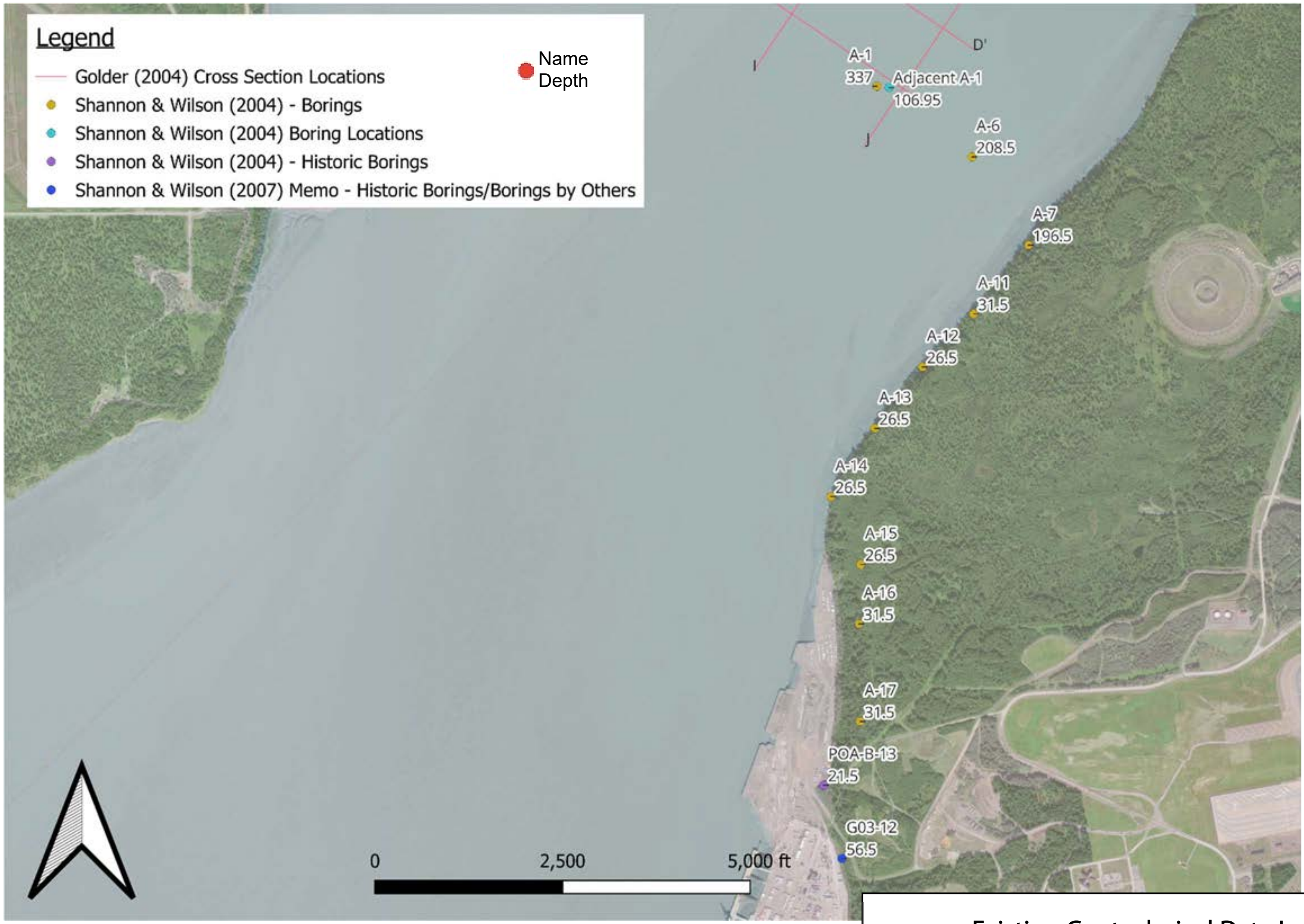
Existing Geotechnical Data Locations
Knik Arm Crossing

Knik Arm Tunnel Feasibility Study

EMPRISE CONCEPTS

Figure 16

Anchorage, Alaska | April 2025



Existing Geotechnical Data Locations
East Bluffs

Knik Arm Tunnel Feasibility Study

EMPRISE CONCEPTS

Figure 17

Anchorage, Alaska | April 2025

Existing Geotechnical Data Locations
Anchorage Side

Knik Arm Tunnel Feasibility Study

EMPRISE CONCEPTS

Figure 18

Anchorage, Alaska

April 2025

C. TBM power requirements

ELECTRICAL SERVICE POWER USAGE - THIS IS AN ESTIMATE ONLY

Device Name	Load Size in KW	Load Factor	kW	Utilization Factor	Actual KW Used	Kwh Cost	Hours/Day	kWh/day	Cost Per Day	Days Per Week	Cost Per Week	Total Duration (in Weeks)	Subtotal	Total Kwh
Kink Arm Tunnel														
Support														
Main Office	150	50%	75.00	25%	18.75	0.25	24	450	$112.50	7	$ 787.50	365	$287,550	1,150,200
Field Offices	150	50%	75.00	25%	18.75	0.25	24	450	$112.50	7	$ 787.50	365	$287,550	1,150,200
Dry House	150	50%	75.00	25%	18.75	0.25	24	450	$112.50	7	$ 787.50	365	$287,550	1,150,200
Residence / Lodging	750	50%	375.00	50%	187.50	0.25	24	4500	$1,125.00	7	$ 7,875.00	365	$2,875,500	11,502,000
Tunnel 1														
TBM1	10,000	70%	7000.00	33%	2310.00	0.25	24	55440	$13,860.00	7	$ 97,020.00	113	$10,963,260	43,853,040
Tunnel Ventilation Plant	500	75%	375.00	25%	93.75	0.25	24	2250	$562.50	7	$ 3,937.50	113	$444,938	1,779,750
Tunnel Slurry Feed Booster 1	350	70%	245.00	30%	73.50	0.25	24	1764	$441.00	7	$ 3,087.00	60	$185,220	740,880
Tunnel Slurry Feed Booster 2	350	70%	245.00	30%	73.50	0.25	24	1764	$441.00	7	$ 3,087.00	113	$348,831	1,395,324
Tunnel Slurry Feed Booster 3	350	70%	245.00	30%	73.50	0.25	24	1764	$441.00	7	$ 3,087.00	113	$348,831	1,395,324
Tunnel Slurry Return Booster 1	450	70%	315.00	30%	94.50	0.25	24	2268	$567.00	7	$ 3,969.00	113	$448,497	1,793,988
Tunnel Slurry Return Booster 2	450	70%	315.00	30%	94.50	0.25	24	2268	$567.00	7	$ 3,969.00	80	$317,520	1,270,080
Tunnel Slurry Return Booster 3	450	70%	315.00	30%	94.50	0.25	24	2268	$567.00	7	$ 3,969.00	60	$238,140	952,560
Tunnel Slurry Return Booster 4	450	70%	315.00	30%	94.50	0.25	24	2268	$567.00	7	$ 3,969.00	40	$158,760	635,040
Ventilation Booster 1	300	70%	210.00	80%	168.00	0.25	24	4032	$1,008.00	7	$ 7,056.00	60	$423,360	1,693,440
Low Point Dewatering Station	150	70%	105.00	80%	84.00	0.25	24	2016	$504.00	7	$ 3,528.00	113	$398,664	1,594,656
Tunnel 2														
TBM2	10,000	70%	7000.00	33%	2310.00	0.25	24	55440	$13,860.00	7	$ 97,020.00	113	$10,963,260	43,853,040
Tunnel Ventilation Plant	500	75%	375.00	25%	93.75	0.25	24	2250	$562.50	7	$ 3,937.50	113	$444,938	1,779,750
Tunnel Slurry Feed Booster 1	350	70%	245.00	30%	73.50	0.25	24	1764	$441.00	7	$ 3,087.00	60	$185,220	740,880
Tunnel Slurry Feed Booster 2	350	70%	245.00	30%	73.50	0.25	24	1764	$441.00	7	$ 3,087.00	113	$348,831	1,395,324
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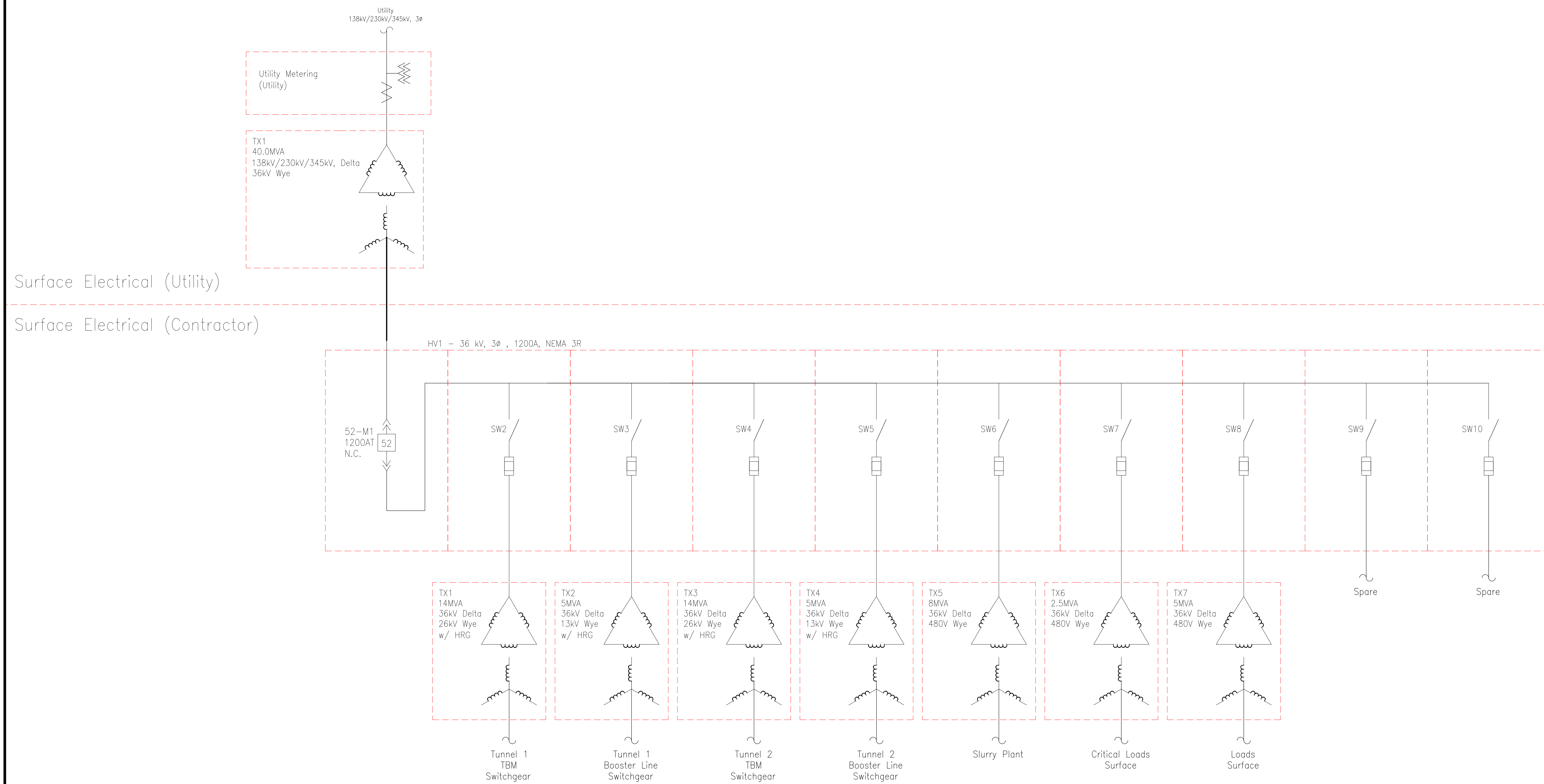
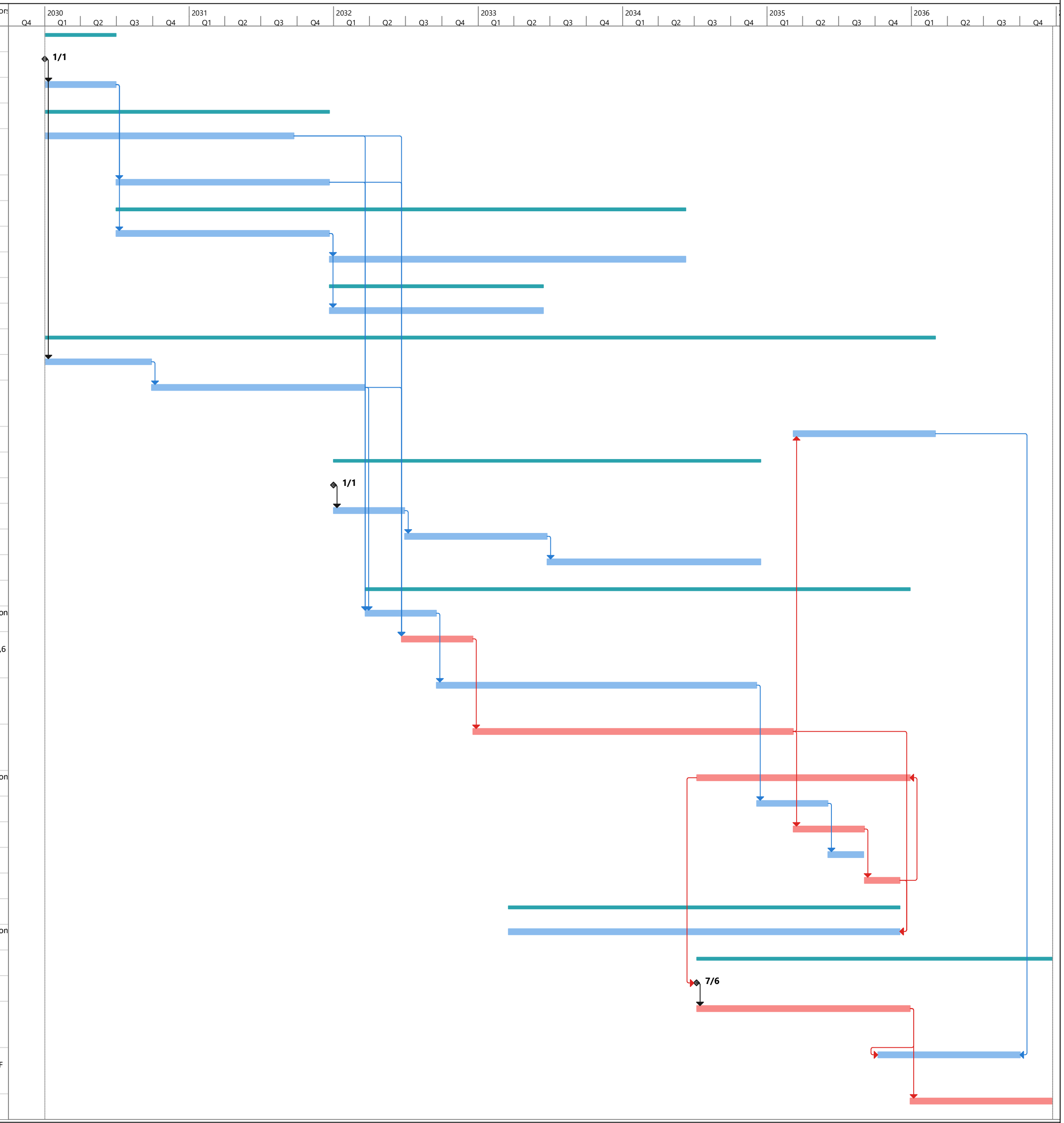
Tunnel Slurry Return Booster 1	450	70%	315.00	30%	94.50	0.25	24	2268	$567.00	7	$ 3,969.00	113	$448,497	1,793,988
Tunnel Slurry Return Booster 2	450	70%	315.00	30%	94.50	0.25	24	2268	$567.00	7	$ 3,969.00	80	$317,520	1,270,080
Tunnel Slurry Return Booster 3	450	70%	315.00	30%	94.50	0.25	24	2268	$567.00	7	$ 3,969.00	60	$238,140	952,560
Tunnel Slurry Return Booster 4	450	70%	315.00	30%	94.50	0.25	24	2268	$567.00	7	$ 3,969.00	40	$158,760	635,040
Ventilation Booster 1	300	70%	210.00	80%	168.00	0.25	24	4032	$1,008.00	7	$ 7,056.00	60	$423,360	1,693,440
Low Point Dewatering Station	150	70%	105.00	80%	84.00	0.25	24	2016	$504.00	7	$ 3,528.00	113	$398,664	1,594,656
Surface														
Slurry Treatment Plant	6,000	70%	4200.00	50%	2100.00	0.25	23	48300	$12,075.00	7	$ 84,525.00	113	$9,551,325	38,205,300
Air Plant	600	50%	300.00	15%	45.00	0.25	24	1080	$270.00	7	$ 1,890.00	113	$213,570	854,280
Water Treatment Plant	500	25%	125.00	15%	18.75	0.25	24	450	$112.50	7	$ 787.50	365	$287,550	1,150,200
Grout Plant	400	50%	200.00	25%	50.00	0.25	24	1200	$300.00	7	$ 2,100.00	113	$237,300	949,200
Tunnel Lighting	300	50%	150.00	15%	22.50	0.25	24	540	$135.00	7	$ 945.00	365	$345,060	1,380,240
Gantry Crane	400	50%	200.00	25%	50.00	0.25	24	1200	$300.00	7	$ 2,100.00	365	$766,800	3,067,200
Dewatering Pump 1	150	50%	75.00	25%	18.75	0.25	24	450	$112.50	7	$ 787.50	365	$287,550	1,150,200
Dewatering Pump 2	150	50%	75.00	25%	18.75	0.25	24	450	$112.50	7	$ 787.50	365	$287,550	1,150,200
Shop	250	50%	125.00	25%	31.25	0.25	24	750	$187.50	7	$ 1,312.50	365	$479,250	1,917,000
Heaters	500	25%	125.00	25%	31.25	0.25	24	750	$187.50	7	$ 1,312.50	365	$479,250	1,917,000
Alimack	30	25%	7.50	25%	1.88	0.25	24	45	$11.25	7	$ 78.75	365	$28,755	115,020
Cooling Tower	150	50%	75.00	30%	22.50	0.25	24	540	$135.00	7	$ 945.00	113	$106,785	427,140
Misc Loads	150	50%	75.00	30%	22.50	0.25	24	540	$135.00	7	$ 945.00	113	$106,785	427,140
Vent Fans (Post Mining)	300	75%	225.00	50%	112.50	0.25	24	2700	$675.00	7	$ 4,725.00	200	$945,000	3,780,000
Freeze Plant, Cross Passages	3,000	80%	2400.00	80%	1920.00	0.25	24	46080	$11,520.00	7	$ 80,640.00	100	$8,064,000	32,256,000
Connected Loads (kW)	**41,680**	**Peak Demand (kW)**	**28327.50**											
		Cost per KWHR				**0.25**						**Totals**	**$54,476,721**	**217,906,884**
		https://www.eia.gov/electricity/monthly/epm_table_grapher.php?t=epmt_5_6_a												



SAMPLE HIGH VOLTAGE LAYOUT FOR TBM AT LAUNCH SITE

D. Construction schedule

ID	Task Name	Duration	Start	Finish	Predecessors
1	**Project commencement**				
2	Contract award	0 mons	1/1/2030	1/1/2030	
3	Mobilization and site establishments	6 emons	1/1/2030	6/30/2030	2
4	**TBM Porcurement**				
5	Design, Fabrication, and Site Delivery of Two Tunnel Boring Machines (TBMs)	21 emons	1/1/2030	9/23/2031	
6	TBM power supply to Point MacKenzie	18 emons	6/30/2030	12/22/2031	3
7	**Segment precast Facilities**				
8	Establish precast facilities	18 emons	6/30/2030	12/22/2031	3
9	Segment production	30 emons	12/22/2031	6/9/2034	8
10	**Precast units**				
11	Manufacture of precast culvert and smoke duct slab	18 emons	12/22/2031	6/14/2033	8
12	**Point MacKenzie Portal**				
13	Ground clearing ,site setup for SOE construction	9 emons	1/1/2030	9/28/2030	2
14	Construction of temporary Support of Excavation and portal excavation / Excavation to base level	18 emons	9/28/2030	3/21/2032	13
15	Construct permanent portal structure after completion of tunnels	12 emons	3/8/2035	3/2/2036	25
16	**Anchorage portal**				
17	Site access at Anchorage	0 mons	1/1/2032	1/1/2032	
18	Ground clearing, site setup for SOE construction / Excavation to base level	6 emons	1/1/2032	6/29/2032	17
19	Construction of temporary Support of Excavation	12 emons	6/29/2032	6/24/2033	18
20	Construct permanent portal structure and TBM reception zone	18 emons	6/24/2033	12/16/2034	19
21	**Tunnels**				
22	Assembly first TBM at Point MacKenzie portal including support systems	6 emons	3/21/2032	9/17/2032	5FS+3 emon
23	Assembly of second TBM at Point MacKenzie portal including support systems	6 emons	6/21/2032	12/18/2032	5FS+6 emons,14,6
24	Launch first TBM and excavate Northbound tunnel (assume 720ft per month)	27 emons	9/17/2032	12/6/2034	22
25	Launch second TBM and excavate Southbound tunnel (assume 720ft per month)	27 emons	12/18/2032	3/8/2035	23
26	Install smoke duct slab and precast culvert in both tunnels	18 emons	7/6/2034	12/28/2035	30FF+1 mon
27	Dismantle first TBM after completion of Northbound tunnel	6 emons	12/6/2034	6/4/2035	24
28	Dismantle second TBM after completion of Southbound tunnel	6 emons	3/8/2035	9/4/2035	25
29	Construct insitu tunnel lining within TBM casing in first TBM	3 emons	6/4/2035	9/2/2035	27
30	Construct insitu tunnel lining within TBM casing in second TBM	3 emons	9/4/2035	12/3/2035	28
31	**Cross passages**				
32	Excavate and construct cross passages	33 emons	3/18/2033	12/3/2035	25FF+6 mon
33	**Tunnel and Portal Systems Installation**				
34	Commencemet of tunnel system installation phase	0 days	7/6/2034	7/6/2034	26SS
35	Instullation of tunnel systems (ventilation, drainage, electrical, lighting, ITS, SCADA, Communication, FLS systems)	18 emons	7/6/2034	12/28/2035	34
36	Fitout of portal facilities including ventilation systems and Tunnel Control Center, FLS systems	12 emons	10/8/2035	10/2/2036	35FS-3 mons,15FF
37	Comimissioning, Integration, & user testing	12 emons	12/28/2035	12/22/2036	35

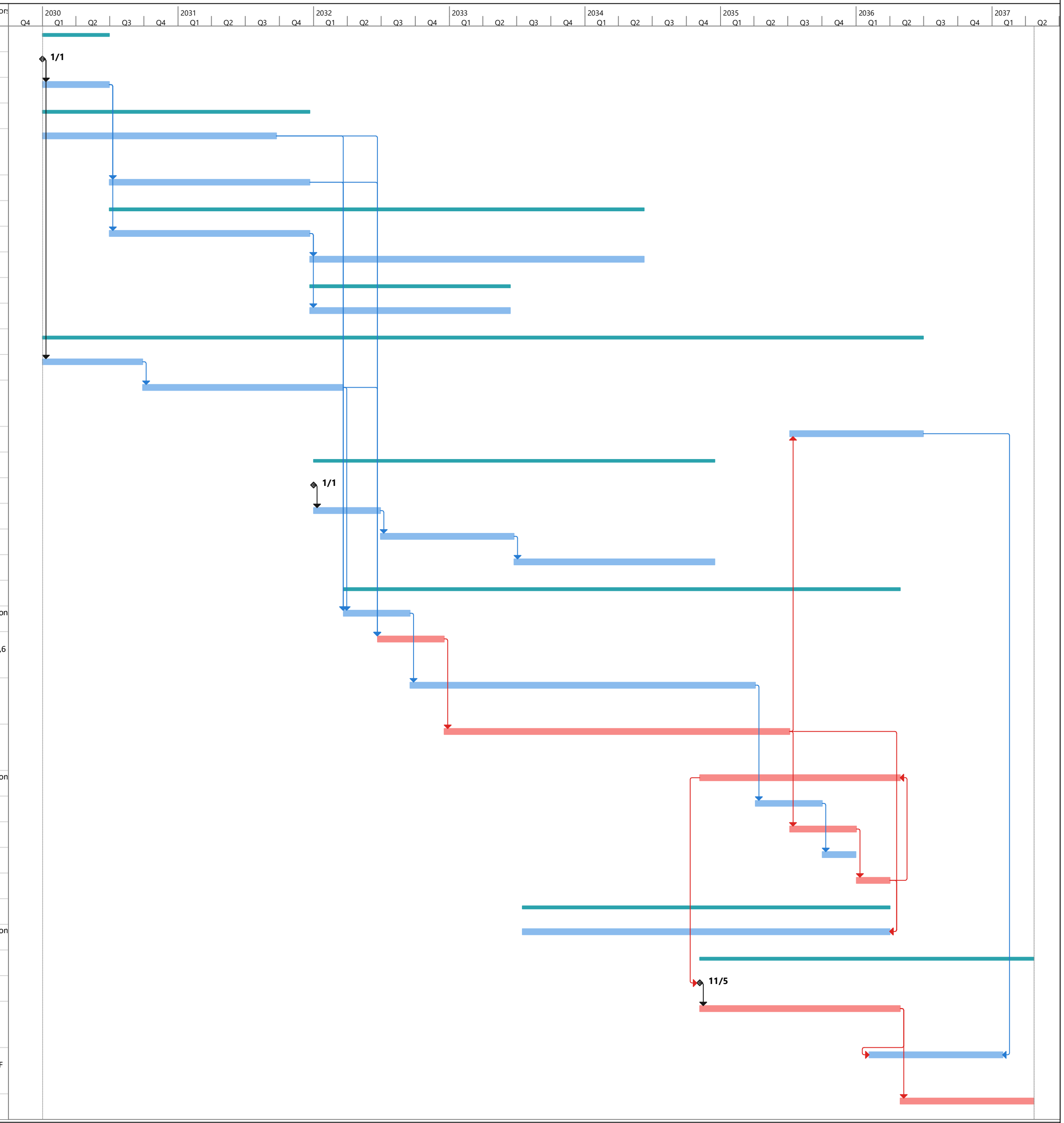


Project: Draft Conceptual Construction Schedule
Date: 10/28/2025

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Critical | Critical Split | Progress | Manual Progress

Project: Draft Conceptual Construction Schedule_Alt 4 Alignment

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1		**Project commencement**				
2		Contract award	0 mons	1/1/2030	1/1/2030	
3		Mobilization and site establishments	6 emons	1/1/2030	6/30/2030	2
4		**TBM Porcurement**				
5		Design, Fabrication, and Site Delivery of Two Tunnel Boring Machines (TBMs)	21 emons	1/1/2030	9/23/2031	
6		TBM power supply to Point MacKenzie	18 emons	6/30/2030	12/22/2031	3
7		**Segment precast Facilities**				
8		Establish precast facilities	18 emons	6/30/2030	12/22/2031	3
9		Segment production	30 emons	12/22/2031	6/9/2034	8
10		**Precast units**				
11		Manufacture of precast culvert and smoke duct slab	18 emons	12/22/2031	6/14/2033	8
12		**Point MacKenzie Portal**				
13		Ground clearing ,site setup for SOE construction	9 emons	1/1/2030	9/28/2030	2
14		Construction of temporary Support of Excavation and portal excavation / Excavation to base level	18 emons	9/28/2030	3/21/2032	13
15		Construct permanent portal structure after completion of tunnels	12 emons	7/6/2035	6/30/2036	25
16		**Anchorage portal**				
17		Site access at Anchorage	0 mons	1/1/2032	1/1/2032	
18		Ground clearing, site setup for SOE construction / Excavation to base level	6 emons	1/1/2032	6/29/2032	17
19		Construction of temporary Support of Excavation	12 emons	6/29/2032	6/24/2033	18
20		Construct permanent portal structure and TBM reception zone	18 emons	6/24/2033	12/16/2034	19
21		**Tunnels**				
22		Assembly first TBM at Point MacKenzie portal including support systems	6 emons	3/21/2032	9/17/2032	5FS+3 emon
23		Assembly of second TBM at Point MacKenzie portal including support systems	6 emons	6/21/2032	12/18/2032	5FS+6 emons,14,6
24		Launch first TBM and excavate Northbound tunnel (assume 720ft per month)	31 emons	9/17/2032	4/5/2035	22
25		Launch second TBM and excavate Southbound tunnel (assume 720ft per month)	31 emons	12/18/2032	7/6/2035	23
26		Install smoke duct slab and precast culvert in both tunnels	18 emons	11/5/2034	4/28/2036	30FF+1 mon
27		Dismantle first TBM after completion of Northbound tunnel	6 emons	4/5/2035	10/2/2035	24
28		Dismantle second TBM after completion of Southbound tunnel	6 emons	7/6/2035	1/2/2036	25
29		Construct insitu tunnel lining within TBM casing in first TBM	3 emons	10/2/2035	12/31/203	27
30		Construct insitu tunnel lining within TBM casing in second TBM	3 emons	1/2/2036	4/1/2036	28
31		**Cross passages**				
32		Excavate and construct cross passages	33 emons	7/16/2033	4/1/2036	25FF+6 mon
33		**Tunnel and Portal Systems Installation**				
34		Commencemet of tunnel system installation phase	0 days	11/5/2034	11/5/2034	26SS
35		Instullation of tunnel systems (ventilation, drainage, electrical, lighting, ITS, SCADA, Communication, FLS systems)	18 emons	11/5/2034	4/28/2036	34
36		Fitout of portal facilities including ventilation systems and Tunnel Control Center, FLS systems	12 emons	2/5/2036	1/30/2037	35FS-3 mons,15FF
37		Comimissioning, Integration, & user testing	12 emons	4/28/2036	4/23/2037	35



Project: Draft Conceptual Construction Schedule

Date: 10/28/2025

Task | Split | Milestone | Summary | Project Summary | Inactive Task | Inactive Milestone | Inactive Summary | Manual Task | Duration-only | Manual Summary Rollup | Manual Summary | Start-only | Finish-only | External Tasks | External Milestone | Deadline | Critical | Critical Split | Progress | Manual Progress

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