AGNICO EAGLE
HOPE BAY

September 7th, 2022

Ali Shaikh
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Sent via Email: ali.shaikh@nwb-oen.ca

Re: Water License 2AM-DOH1335 – Conditions Applying to Construction and Operation – Construction of Interim Dike

Dear Mr. Shaikh,

This letter represents Agnico Eagle Mines (**Agnico**) written notification to the Nunavut Water Board (**NWB**) regarding the planned construction of an interim dike within the existing tailings impoundment area at the Hope Bay Project. This notification is being provided to the NWB prior to commencement of work, as required under the Type A Water License 2AM-DOH1335 Part D Item 1. The accompanying design report, along with construction drawings are provided in Attachment 1.

Should you have any questions please feel free to contact me at nancy.harvey@agnicoeagle.com

Sincerely,

Brennan Jay – on behalf of,
Nancy Duquet Harvey
Environmental Superintendent - Agnico Eagle Mines Limited - Hope Bay Mine

Cc:
Licencing (NWB)

Attachments
Doris Tailings Impoundment Area – 2022 Interim Dike

Doris Tailings Impoundment Area – 2022 Interim Dike

Hope Bay Mine, Nunavut, Canada
Agnico Eagle Mines Limited

SRK Consulting (Canada) Inc. ▪ CAPR001816 ▪ September 2022

srk consulting

Doris Tailings Impoundment Area – 2022 Interim Dike

Hope Bay Mine, Nunavut, Canada

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Cover Image(s):
Photo of the Doris TIA taken during the annual inspection.

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1 Introduction

1.1 Site Location and General Overview

Hope Bay is a gold mining and milling operation of Agnico Eagle Mines (Agnico Eagle). The Operation is located 705 km northeast of Yellowknife and 153 km southwest of Cambridge Bay in Nunavut Territory, and is situated east of Bathurst Inlet (Figure 1). The Operation comprises three distinct areas of known mineralization, Doris, Madrid (North and South), and Boston.

Phase 1 and 2 of the Tailings Impoundment Area (TIA) are now approved and the TIA is operated under the Amended Water Licences (2AM DOH1335, December 2018). Phase 1 included mining and infrastructure at Doris, while Phase 2 includes mining and infrastructure at Madrid and Boston located approximately 10 and 60 km south from Doris, respectively. The Doris Tailings Impoundment Area (TIA) (shown Figure 1 and 2) will ultimately contain both Phase 1 and 2 tailings.

Early design of the TIA started in the early 2000s (SRK 2002 and 2003), with the construction of Phase 1 infrastructure starting in 2007, and underground development commencing in 2010. The North Dam, which provides containment for the TIA at its northern perimeter, was constructed over two winter seasons, 2011 and 2012. In the fall of 2012, the Project was placed into Care and Maintenance prior to completing infrastructure development required to allow commercial production. Following an ownership change of the Project, Phase 1 was taken out of Care and Maintenance in 2015 and transitioned into commercial production in 2017. Construction of the South Dam, providing southern TIA containment, was carried out between January and June of 2018. Since the South Dam Phase 1 was completed, the Hope Bay site has undergone another ownership change. The Hope Bay site is currently being owned and operated, under the existing water license, by Agnico Eagle. Hope Bay site is currently in care and maintenance, and no tailings are actively being deposited at the TIA.

To best assist with water management, treatment, and discharge, and generally to help more effectively manage water on site, Agnico has identified the need to have additional contingency and operational flexibility at the TIA. To assist with this, a temporary AquaDam structure was erected at the south end of the TIA in 2022. This temporary structure was installed to help segregate different streams of contact water on site (such as water in the existing TIA, and underground water stream). To continue with the current operational water management strategies on site the AquaDam is planned to be updated to a more robust and engineered short term structure. This has led to the design and planned construction of the Interim Dike, which is the subject of this report.

1.2 Purpose of Document

In accordance with License 2AM DOH 1335, Part D, item 1, this report includes an overview of the design for the Doris TIA Interim Dike. The focus of this document is on the general earthworks, and geotechnical design for the Interim Dike. Detailed operation plans are not part of this report. General operations and performance would be overviewed in the annual Agnico regulatory submissions. The interim dike will be included in the 2022 update of the TIA Operation, Maintenance and Surveillance (OMS) Manual.

1.3 Reference Documents

This report is considered complimentary to reports that have been filed on the public registries as part of the Hope Bay project regulatory approval process, and subsequent compliance reporting. Since much of this information remains valid, the reader is referred to these reports for background information such as general site characterization data and the Tailings Management System details. Table 1 summarizes the key previous reports referred to in this context.

Table 1. Pertinent Previous Reports Relied upon for the South Dam Design

Reference	Report Function
SRK Consulting (Canada) Inc. (2005). *Preliminary Tailings Dam Design, Doris North Project, Hope Bay, Nunavut, Canada*. Report prepared for Miramar Mining Corporation, Project number 1CM014.006, October.	This report was submitted as part of the Final Environmental Impact Assessment for the Doris North Project (MHBL 2005), which ultimately led to issuance of the Project Certificate.
SRK Consulting (Canada) Inc. (2007). *Design of the Tailings Containment Area, Doris North Project, Hope Bay, Nunavut, Canada*. Report Prepared for Miramar Hope Bay Limited. Project number 1CM014.008.165, March.	This report was submitted as part of the Water Licence Application for the Doris North Project (MHBL 2007), which ultimately led to issuance of the Original Water Licence (2AM-DOH0713).
SRK Consulting (Canada) Inc. (2012). *Hope Bay Project, North Dam As-Built Report*. Report Prepared for Hope Bay Mining Limited. Project number 1CH008.058, October	This report was submitted to the NWB in fulfillment of a Licence Condition after completion of construction of the North Dam.
SRK Consulting (Canada) Inc. (2015). *Doris North Project Tailings Management System Design*. Report prepared for TMAC Resources Inc. Project Number 1CT022.002.200.560, May 2015.	This Report was submitted to the NWB as part of the application package for an amendment of the Water License (2AM-DOH1323).
SRK Consulting (Canada) Inc. (2017). *Doris Tailings Management System Phase 2 Design, Hope Bay Project.* Report prepared for TMAC Resources Inc. Project Number 1CT022.013, November 2017.	This Report was submitted to the NWB as part of the Phase 2 application package for a further amendment of the Water License (2AM-DOH1323).
SRK Consulting (Canada) Inc. (2019a). *Phase 1 South Dam Design Report, Hope Bay, Nunavut, Canada*. Report prepared for TMAC Resources Inc. Project Number 1CT022.031, last version updated August 2019	This report was prepared to document the South Dam Phase 1 designs.
SRK Consulting (Canada) Inc. (2019b). *Hope Bay Project, Phase 1 South Dam As-Built Report*. Report prepared for TMAC Resources Inc. Project Number 1CT022.031, March 2019	This report was submitted to the NWB in fulfillment of a Licence Condition after completion of construction of the Phase 1 South Dam construction.

Any of the reports outlined in Table 1 above can be re-provided upon request.

2 Description

2.1 Water Management Strategy

The Interim Dike would be constructed immediately downstream (north) of the current AquaDam location; constructed fully within the current TIA footprint. The Interim Dike will help to provide a location within the TIA to help segregate different contact water streams. The Interim Dike would be planned to be used primarily during the care and maintenance period on site. If / when the site goes back into operation and tailings deposition resumes in the TIA, then the need for the Interim Dike would be re-evaluated. Agnico is actively investigating and determining the required infrastructure for a more permanent long term water segregation strategy. The interim dike is planned to be a temporary water management structure and will eventually (over the mine life), be fully buried by the subaerial tailings beach when tailings deposition resumes At that time, it will no longer be exposed on the surface or present any notable geotechnical risk (effectively decommissioned once filled and eventually covered with tailings).

The purpose of this report is to describe the design of the Interim Dike which will act as part of the TIA water management system on site.

2.2 Site Access

The existing AquaDam and South Dam area (south end of the TIA) is accessed on site from the Secondary Road. The Secondary Road runs from the Doris Camp to the South Dam on the east side of the TIA. The South Dam Access Road, an extension of the Secondary Road and later called the Temporary Deposition Berm runs parallel to the South Dam alignment approximately 20 m upstream of the South Dam footprint and provides access to the upstream South Dam tailings. To support the summer 2022 AquaDam installation an additional access road was created within the TIA that goes from the tailings spigot location near the Secondary Road, as another extension down (west) towards the TIA shoreline and end of the existing subaerial tailings beach (most norther extents of). The existing access roads are planned to be utilized for this construction, therefore there is no notable change to this design aspect.

2.3 Regional Geology

The Doris Project is in the faulted Bathurst Block, forming the northeast portion of the Slave Structural Province, a geological sub-province of the Canadian Shield. The region is underlain by the late Archean Hope Bay Greenstone belt, which is 7 to 20 km wide and over 80 km long in a north-south direction. The belt is mainly comprised of mafic metavolcanic (mainly meta-basalts) and meta-sedimentary rocks that are bound by Archean granite intrusives and gneisses. The greenstone package has been deformed during multiple events and is transected by major north-south trending shear zones that appear to exert a significant control on the occurrence of mineralization, particularly where major flexures are apparent and coincident with antiforms.

2.4 Climate

The climate at the Project area is characterized by extremes. The Project area experiences relatively low amounts of precipitation, but due to sub-zero temperatures for the majority of the year, also experiences high snow accumulation. Summer is a season of nearly perpetual sunlight, while winter is dominated by night and extreme cold. Due to the relative absence of obstructions to impede the wind (e.g., trees, buildings, mountains), wind speeds are generally high.

The site specific mean annual temperature for Doris is around -11°C with temperatures ranging from about -43°C to +27°C. The mean annual precipitation is about 210 mm, with only 40% falling as rain (Golder 2009). Annual lake evaporation (typically occurring between June and September) is about 248 mm (NASA 2017).

2.5 Hydrology

The Project is located in the Doris Lake outflow drainage basin. The hydrologic regime of the Project is typical of high latitude regions of the continental Canadian Arctic and is strongly influenced by long cold winters, relatively low precipitation, and low relief topography generally with high watershed storage (i.e., lakes and wetlands). The physiography of the region is dominated by vegetated tundra hillslopes with lakes and scattered wetlands. The presence of permafrost is hydrologically significant, as it has very low hydraulic conductivity, and thus acts as a barrier to deep groundwater recharge. This physical restriction tends to increase surface water runoff and decrease sub-surface flows.

Extremely cold temperatures in the region, combined with permafrost, result in a short period of peak runoff that typically occurs around June during snowmelt. Compared to non-permafrost regions, permafrost watersheds tend to have higher peak flow and lower base flow (Kane et al 1997). A second smaller peak may occur from rainfall in late August or early September. The streams in the study area are usually frozen with negligible flow from November until May. The mean flow from June to October for Tail, Doris and Little Roberts Lake outflows are about 0.03, 0.85, and 1.73 m^3/s, respectively (AMEC 2003).

The latest details on the Doris meteorological evaluation and climate change predictions can be found in SRK (2022a).

2.6 Geochemical Considerations

2.6.1 Waste Rock

A portion of the TIA Interim Dike construction is expected to be completed using waste rock that was originally sourced from the Doris underground (currently in the waste rock pile at Pad T). Generally, for the Hope Bay waste rock, in terms of metal leaching and/or acid rock drainage (ML/ARD), the risk of ARD is low; potential flushing of blast residual or neutral pH leaching being the most significant factor for the waste rock.

No waste rock is planned to be placed outside the current TIA footprint. Any waste rock used to help with construction of the Interim Dike will be placed within the TIA, and eventually /mid-long term will be covered with tailings. Contact water, defined as water that has contacted waste rock, is prevented from release to the environment since it will be fully captured and managed within the TIA.

Past details on the waste rock at Doris can be found in SRK 2022b (2021 Waste Rock Monitoring Report). In August 2022 additional waste rock samples were collected from the AquaDam access road in the TIA. These waste rock samples have been shipped to the laboratory and will be reported on / included in the 2022 Waste Rock, Quarry and Tailings Monitoring Report, which will be included as part of the 2022 annual reporting submissions which occur annual at the end of quarter one (i.e. Q1 2023).

2.6.2 Tailings Geochemistry

Ore processing has included cyanidation and flotation methods, with two separate streams of tailings being produced, both captured under the Tailings Management System. The cyanidation tailings (about 6%) are typically detoxified (cyanide destruction) then filtered and blended with waste rock to be returned underground as backfill. Only the flotation tailings are then typically deposited in the Doris TIA. The geotechnical characteristics of the tailings are addressed and discussed in more detail in one of the appendices of the South Dam design report (see reference in Table 1).

2.6.3 Supernatant Water

The TIA is located in an isolated headwater catchment which exceeds the TIA footprint by a factor of 3. Diversion of non-contact water is not practical and as a result, although the climatic water balance at the site is near neutral, the TIA water balance is slightly positive which provides the opportunity for maximizing processing makeup water. This however requires the TIA to have the ability to store contact water, reducing the potential benefits of tailings technologies requiring substantive dewatering.

3 Interim Dike Design

3.1 Location

The TIA Interim Dike is located near the end of the existing subaerial tailings beach at the south end of the Doris TIA. The Interim Dike is located over 800 m away from the current upstream crest of the South Dam and is immediately south and downstream of the existing temporary AquaDam location (see Figure TL-ID-100).

Note that the following environmental setbacks have been applied, and will be followed, when defining any surface disturbances associated with this work

- Minimum 31 m setback from waterbodies (outside main impacted TIA catchment), 50 m setback where possible;
- Minimum 30 m buffer zone from known rare plants; and
- Minimum 30 m buffer zone from known archeological sites.

The footprint for the TIA Interim Dike is fully within the TIA and the design meets these environmental setback requirements.

3.2 Design Requirements and Criteria

Under the current license, environmental containment for the TIA is provided through the construction of two dams: a water retaining frozen core dam, the North Dam, and a frozen foundation dam, the South Dam, retaining tailings solids. These dams have both been taken into consideration of the design of the Interim Dike and water elevations behind the dike are set to avoid any notable impacts on these existing dams. The maximum water elevation upstream of the Interim Dike will be controlled by a water elevation control channel.

The design, construction, operation and monitoring of dams in Canada have to be completed in accordance with appropriate territorial, provincial, and federal regulations and industry best practices. The foremost guidance documents in this regard are the Canadian Dam Safety Guidelines (CDA 2013) and the Technical Bulletins on Application of Dam Safety Guidelines to Mining Dams (CDA 2014, 2019) published by the CDA.

3.3 Dam Design

The TIA Interim Dike design is presented in the attached drawings package (see drawings TL-ID-100 through to TL-ID-400, 15 drawings). Overall, the Interim Dike has been designed to be an upgrade to the existing temporary AquaDam system and has a very similar design capacity. Figure 1 below shows the stage storage curve for the Interim Dike.

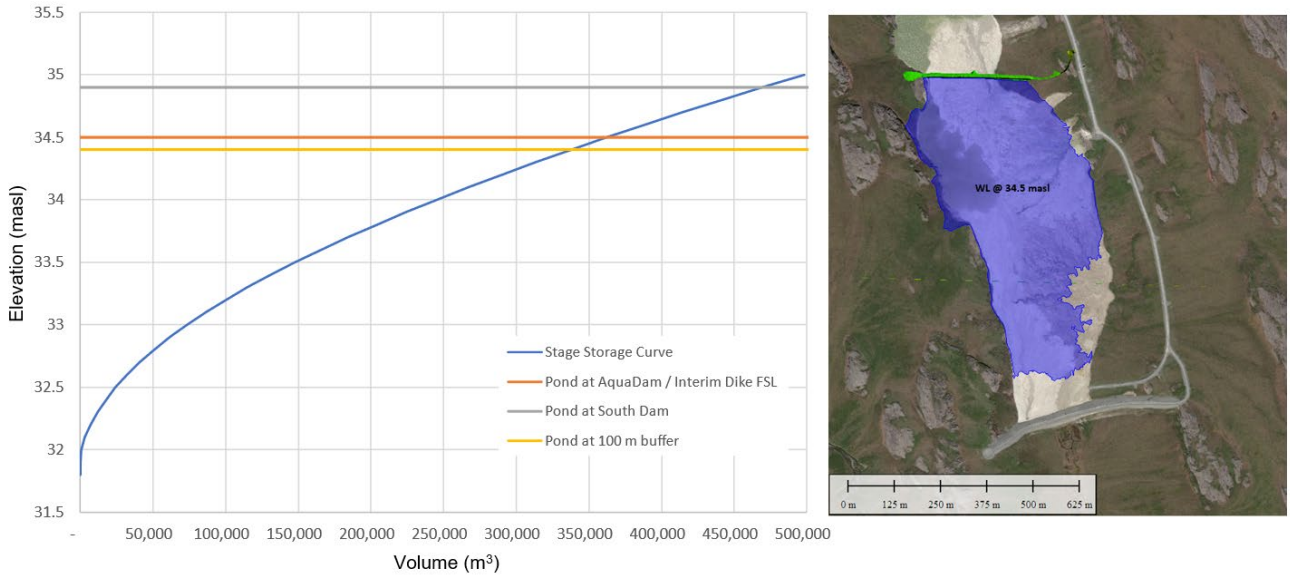

Figure 1: Design Capacity for the TIA Interim Dike

The TIA Interim Dike typical sections are presented on drawing TL-ID-300. The Interim Dike has been designed with a minimum crest width of 5 m and 3H:1V upstream and downstream slopes. The maximum crest elevation has been set at elevation 35.0 m and the maximum water level in the containment set at 34.5 m.

3.4 Dam Components

An overview of the Interim Dike design and primary components is provided in drawing TL-ID-101 and TL-ID-200. The subsections below give a brief description of the main dike elements / components.

All material specifications are to be as per the latest revision of the site-specific Construction Technical Specifications (Appendix B).

3.4.1 Run-of-Quarry (ROQ) or Waste Rock Shell

The main dike fill material is planned to be rockfill (either ROQ or waste rock). This material will be a maximum size of 900mm Drawing TL-ID-301 presents additional details on the main rockfill dam fill. Overall this rock is placed at an offset (typically at least 5 m downstream) from the existing AquaDam access road. The rock fill is planned to be placed with a minimum crest width of 5 m, crest elevation of 35.0 m, and side slopes at approximately 3H:1V. A portion of this rockfill being placed over the shoreline tundra (around chainages 0+000 to 0+070 and 0+370 to 0+430) with the rest of the rock being placed over the existing tailings beach (founded on tailings). If the tailings foundation is determined to non-frozen, then construction of the dike (over unfrozen tailings) will be required to be carried out in a slow manner that ensure that excess foundation pore water pressures do not build up. A small construction fleet (see Section 5.1) that is comprised of smaller equipment (which will impose lower loading onto the foundation) will be utilized to ensure the design intent and safety considerations

are upheld during construction. Routine daily inspections of the working area will also be completed for added diligence during the rock shell / fill material placement.

3.4.2 Filter / Bedding Material

Immediately upstream of the bulk rock fill shell, a filter zone comprised of manufactured crushed rock material, will be constructed. This material will act as a bedding layer to the Geosynthetic Clay Liner (GCL) as well as provide some filtering capacity from / for the upstream soils. Drawing TL-ID-302 shows an overview of the Filter layer. Agnico will be working over the coming months to ensure that a filter product can be manufactured on site (by the crusher) to meet the desired material gradations.

3.4.3 Key Trench

To better 'tie-in' the GCL liner, and to further extend potential seepage pathways in the foundation and reduce hydraulic gradients, a key trench will be excavated. Drawing TL-ID-303 presents and overview of this key trench excavation. Similar to the rock shell (see Section 3.4.1) a portion of this key trench will be constructed on tailings while a portion of this key trench will be into the tundra (on the two side abutments). Additional details and construction considerations for the key trench excavation are presented in the details on drawing TL-ID-400.

3.4.4 Geosynthetic Clay Liner (GCL)

A GCL liner has been procured and is in the process of being shipped to site. This GCL liner will be used to help reduce the hydraulic conductivity of the Interim Dike section to reduce the seepage rates through the Interim Dike (will be a secondary water retention system). This liner will also act as an additional layer (beyond the filter material) to mitigate any tailings migration through the dam. Drawing TL-ID-304 presents additional details on the GCL liner and additional details (including overlap and seaming considerations) are provided in the details on drawing TL-ID-400. The GCL will consist of a per-manufactured three-layer assembly of low permeability sodium bentonite enclosed between two geotextiles (with at least one of the geotextiles being non-woven).

3.4.5 Compacted Tailings

Upstream of the GCL liner, and between the downstream slope of the AquaDam access road and the upstream slope of the Interim Dike fill, a layer of compacted tailings is planned to be placed. This material will be placed in thin (approximately 0.3m lifts) and compacted. This material will assist to limit the upstream hydraulic conductivity, stretch out seepage pathways and to help with surface water management (i.e. help to avoid ponding between the AquaDam access road and the Interim Dike. Drawing TL-ID-300 and TL-ID-305 present additional details on the compacted tailings infill surface.

3.4.6 Abutment Cover

To avoid ponding and to limit potential erosion of tailings on each of the side abutment, two areas of fill, called the 'Abutment Cover' has been included in the designs. These Abutment Covers will help to

direct surface flow paths away from the upstream edges of the Interim Dike, where fill material is in contact with tundra, and can be constructed of coarser rockfill to assist with erosion protection. Drawing TL-ID-306 presents additional details on the areas where Abutment Covers have been proposed. The covers are expected to have some 'field-fitting' to ensure that they best tie into the topography in the area and meet the design intent.

3.4.7 Water Elevation Control Channel

The Water Elevation Control Channel has been set with an inlet elevation of 34.5 m (i.e. 0.5 m of freeboard). The Water Elevation Control Channel discharges to the North end of the TIA at a controlled rate (all contained within the TIA). Drawing TL-ID-present additional details on this control channel. To allow for access over the control channel, and to tie / blend the control channel excavation into the Interim Dike abutment a wider channel base width (approx. 5 m) and 10% side slopes have been utilized.

Overall the depth of the exaction has been minimized (typically aimed to be less than 1.5 to 2 m depth below the existing ground) to assist with construction excavation, while minimizing the extent of the permafrost disturbance. 0.2 m of compacted tailings will be placed at the base of the control channel excavation and then covered with nonwoven geotextile and 0.3 m of rip-rap material. The design grades of the channel (0 to 0.5%) as well as the side slopes (3H:1V) and base width approx. 5 m after rip-rap placement have been designed to convey peak flow associated with up to the Probable Maximum Flood (PMF). Table 2 presents additional details on the control channel hydraulics for varying storm events (note that all elevations presented assume a starting elevation at the spillway inlet, i.e., at 34.5 m elevation).

Table 2. TIA Interim Dike – Control Channel Hydrauilc Overview

Event	With 30-day Snow Melt	Maximum Water Level	Peak Outflow (m^3/s)
1000-year	No	34.70	0.85
	Yes	34.72	0.94
1/3rd	No	34.74	1.12
	Yes	34.74	1.13
2/3rds	No	34.77	1.33
	Yes	34.78	1.42
PMF	No	34.80	1.54
	Yes	34.82	1.74

3.4.8 ROQ or Waste Rock Contingency Buttress

Due to some of the uncertainty in the tailings foundation conditions (as further discussed in Section 3.5) Agnico has elected to take the conservative and prudent approach to also design a downstream

buttress to ensure that the minimum stability requirements are upheld. This buttress is only planned to be constructed if / as needed and therefore has been named the “Contingency Buttress”. Drawing TL-ID-308 show additional details on this contingency buttress. The need for the contingency buttress will be based on the drilling and installation of the planned instrumentation shown on drawing TL-1D-102, as well on-site QC and QA checks and construction monitoring (such as simple survey monitoring during construction).

3.5 Stability Considerations

The minimum factors of safety (FOS) that are required to be achieved, have been based on the Canadian Dam Safety Guidelines (CDA 2013, 2019), and are reproduced in Table 3.

Table 3. Minimum Required Factors of Safety for the South Dam in Accordance with CDA (2019)

Stability Condition	Minimum Factor of Safety	Slope
Static Assessment		
During, or at end of construction	Greater than 1.3 depending on risks assessed during construction	Typically downstream
Long-term (steady-state seepage, normal reservoir level)	1.5	Downstream
Full or partial rapid drawdown	1.2 to 1.3	Upstream slope where applicable
Seismic Assessment		
Pseudo-static	1.0	Downstream
Post-earthquake	1.2	Downstream

Appendix A provide additional notes, details, and shows some of the results from the various stability checks that have been performed to confirm the suitability of the proposed design arrangement.

The base case stability results present a scenario where the tailings angle of internal shearing resistance (friction angle) is 40^{o}. These results show long term conditions and requirements are met, i.e., Factor of Safety (FOS) = 1.5+.

As sensitivity checks, additional conservative scenarios (using very low undrained strength parameters for both tailings and lakebed sediments) have been included. These scenarios no not necessarily represent strength under the Interim Dike under normal loading conditions but have been included to help size a contingency buttress to make sure that a robust design is presented that can be adapted based on the encountered site conditions.

Note that Hope Bay is in a low seismic area (part of the Canadian Shield with low peak horizontal ground accelerations) and therefore, coupled with the short design life of a few years, the risk of liquefaction of the foundation is expected to be greatest for static loading during the construction period (as opposed to dynamic seismic triggered liquefaction). To further mitigate the potential for tailings static liquefaction, and the development of excess foundation pore pressures, during construction (will not be relevant if foundation is frozen) the construction timelines are planned to be extended, smaller

lift thickness and overall minimal rock loading (up to max elevation 35.0 m) are designed, and ongoing construction visual monitoring and surveys are planned.

Overall the in-situ strength properties of the tailings, and the presence (or absence) of any weaker lake bed sediments at depth is the greatest uncertainty in the stability assessments. Past tailings testing information has been reviewed (part of the Appendices that are outlined in the design documents in Table 1) and the available Cone Penetration Testing (CPT) done within the TIA downstream of the Interim Dike alignment (SRK 2016) have been considered as part of the stability assessment. Site observations have also indicated that in many areas portions of the tailings beach are frozen (and as observed as part of the AquaDam installation). To address this uncertainly two things have been incorporated into the Interim Dike design. Specifically, these are:

1. **Drilling and Instrumentation Installation** - Drilling and sampling at three locations, immediately before and during the construction of the initial construction of the Interim Dike, and subsequent installation of Ground Temperature Cables (GTCs) into the drillholes. The objective is to determine if the tailings foundation for the Interim Dam is frozen, and if so, to what extent.
2. **Contingency Buttress** - Incorporation of a 'Contingency Buttress' (see Section 3.4.8) into the design to further stabilize the design cross-sections and arrangement if foundation conditions are towards the lower range of expected strength values.

3.6 Instrumentation

Drilling and sampling at three locations, as shown on drawing TL-ID-102, is planned to be completed as part of the Interim Dike construction. Ground Temperature Cables (GTCs) are planned to be installed in each of these three locations to better monitor ground temperature profiles and to confirm if the current tailings foundation is frozen. All collected (expected to be disturbed) samples will be sent to a laboratory for, at a minimum, geotechnical index testing (e.g. moisture contents, Atterberg Limits, Particle Size Distributions, visual identification and logging).

3.7 Closure Considerations

The Interim Dike would be planned to be used during the care and maintenance period on site only. If / when the site goes back into operation and tailings deposition resumes in the TIA, then the need for the Interim Dike would be re-evaluated. Eventually (over the mine life) the Interim Dike will be buried by the subaerial tailings beach. After the Phase 2 South dam raise is completed then additional tailings material will be placed over the Interim Dike. The final tailings landform will still look the same as per the latest deposition plans, with a general tailings beach sloping multiple kilometers from the South Dam towards the North. Therefore, there're would not be any notable impacts on the final long term closure plans of the TIA from the construction and future burial of the interim dike. TIA closure plans remain as per past plans (see Table 1 references).

4 Construction Methods

4.1 Construction Method and Equipment

The equipment expected to be used in construction of the Interim Dike includes 40 T or 60 T haul trucks, dozers, excavator(s), and a vibrating smooth drum compactor. Generally, will be a small construction fleet that will be deployed to complete this work.

4.2 Quality Control / Assurance

When this construction is complete, a record of as-built drawings and report will be produced. Construction will proceed based on the site earthwork Technical Specifications (see Appendix B).

Site observations and survey data will be collected throughout the construction of the Interim Dike. At least one separate site visit (by the engineer-of-record for the TIA, and/or a field or design engineer) is also planned to be completed during construction of the Interim Dike (likely around the time of the GCL installation) as an additional quality assurance check. The site visit will be conducted by a Registered Professional Engineer in the Nunavut Territory.

The Interim Dike will be included in the Annual Geotechnical Inspection of the TIA. Ongoing dike maintenance (if / as required) will be determined each year after completion of this annual inspection

4.3 Water Management

Run off on material used for construction will be contained within the TIA watershed
The Interim Dike has no significant external upstream catchments (i.e. no new catchment areas will be impacted by this construction). Run off on material used for construction will be contained within the TIA watershed. Therefore, no major external surface water management activities are expected. Contact water is prevented from release to the environment since it will be contained within the Doris TIA.

4.4 Timeline and Seasonal Considerations

The expected date of construction start is to be the beginning of November 2022 (fall to winter 2022). Excavation activities will be aimed to be completed as early as possible in 2022, or in some cases (such as for the construction of the Interim Dike water control elevation channel) may result after the 2023 spring melt. The Interim Dike construction is planned to take place over multiple months and will be completed by summer 2023 (or sooner).

Closure

This design overview, Doris Tailings Impoundment Area – 2022 Interim Dike, was prepared by

John Kurylo, MSc, PEng
Principal Consultant (Geotechnical)

Report reviewed by:

Thomas Lepine *(PEng, Agnico Engineer of Record Nunavut; & Technical Specialist, Environmental Management)*

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

References

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SRK Consulting (Canada) Inc. 2019a. Phase 1 South Dam Design Report, Hope Bay, Nunavut, Canada. Report prepared for TMAC Resources Inc. Project Number 1CT022.031, last version updated August 2019

SRK Consulting (Canada) Inc. 2019b. Hope Bay Project, Phase 1 South Dam As-Built Report. Report prepared for TMAC Resources Inc. Project Number 1CT022.031, March 2019

SRK Consulting (Canada) Inc., 2022a. Hope Bay Climate Update. Nunavut, Canada. Memo prepared for Agnico Eagle Mines Ltd. Project No. 1CT022.066. April 2022.

SRK Consulting (Canada) Inc., 2022b. 2021 Waste Rock, Quarry and Tailings Monitoring Report, Doris and Madrid North Mines, Hope Bay Project. Nunavut, Canada. Report prepared for Agnico Eagle Mines Ltd. Project No. 1CT022.073. May 2022.

Drawings

Engineering Drawings for
TIA Interim Dike
Hope Bay Project, Nunavut, Canada

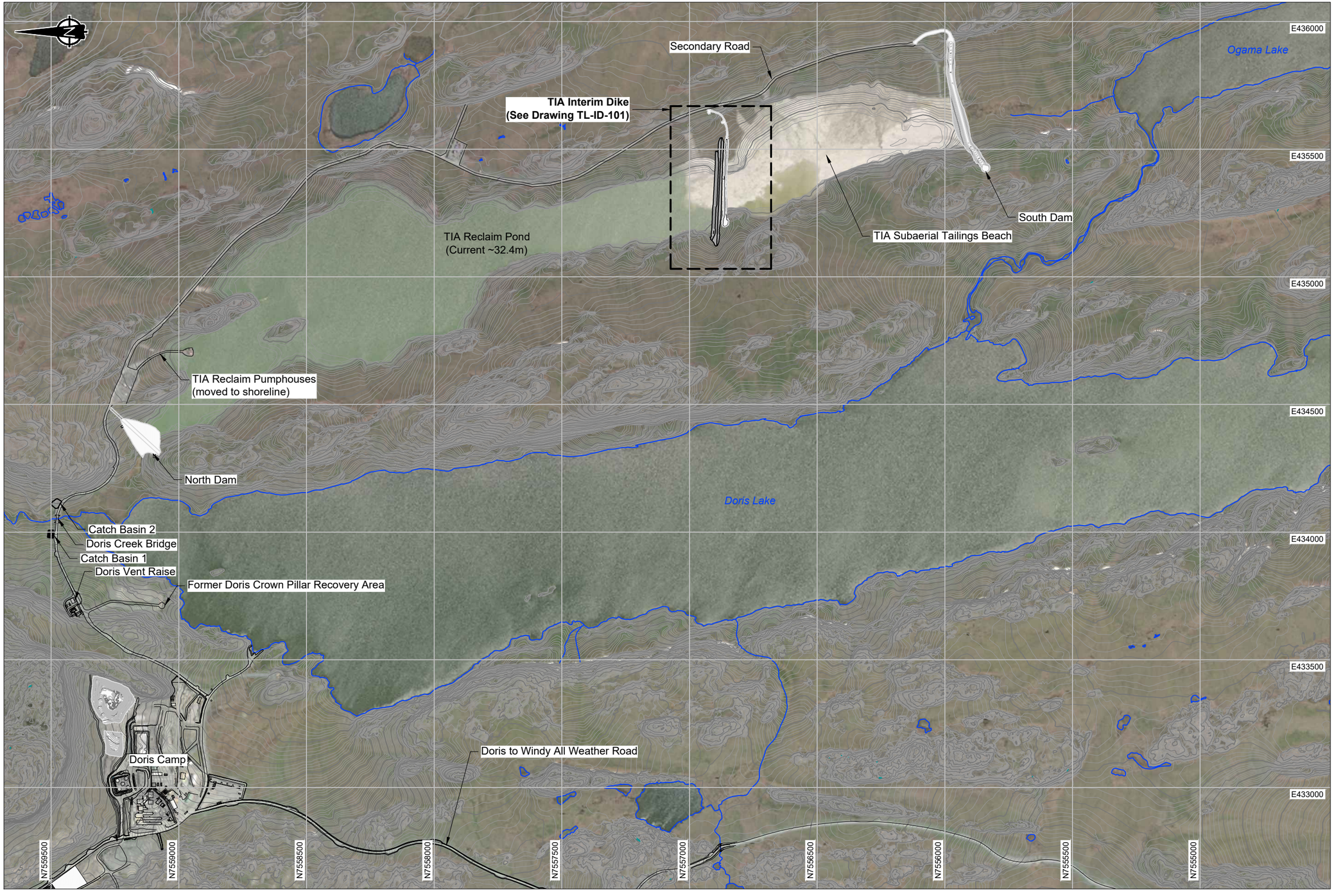
Active Drawing Status

Drawing Number	Drawing Title	Issue	Date	Revision
TL-ID-100	Site Plan	Issued for Permit	2022/08/26	A
TL-ID-101	Interim Dike General Arrangement	Issued for Permit	2022/08/26	A
TL-ID-102	Proposed Interim Dike Ground Temperature Cable Layout	Issued for Permit	2022/08/26	A
TL-ID-200	Interim Dike Plan and Profile	Issued for Permit	2022/08/26	A
TL-ID-201	Water Elevation Control Channel Plan, Profile and Cross Section	Issued for Permit	2022/08/26	A
TL-ID-300	Typical Cross Sections	Issued for Permit	2022/08/26	A
TL-ID-301	Interim Dike ROQ	Issued for Permit	2022/08/26	A
TL-ID-302	Interim Dike Filter / Bedding Material	Issued for Permit	2022/08/26	A
TL-ID-303	Interim Dike Key Trench Excavation	Issued for Permit	2022/08/26	A
TL-ID-304	Interim Dike GCL Liner	Issued for Permit	2022/08/26	A
TL-ID-305	Interim Dike Compacted Tailings	Issued for Permit	2022/08/26	A
TL-ID-306	Interim Dike Abutment Cover	Issued for Permit	2022/08/26	A
TL-ID-307	Interim Dike Water Elevation Control Channel	Issued for Permit	2022/08/26	A
TL-ID-308	Interim Dike ROQ Contingency Buttress	Issued for Permit	2022/08/26	A
TL-ID-400	Details	Issued for Permit	2022/08/26	A

AGNICO EAGLE

srk consulting

Project Number: CAPR001816



LEGEND

- Proposed Infrastructure
- Other Design Infrastructure

NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

REFERENCES

NAD83 UTM Zone 13.
World Imagery retrieved from Global Mapper on August 12, 2022.

0m 100 200 300 400 500 600

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REFERENCE DRAWINGS

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CHECKED: TL/BJ/ML	APPROVED: JK	DATE: 2022/08/26
FILE NAME: CAPR001816 - GA.dwg		

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Hope Bay Project

SRK JOB NO.: CAPR001816 REG. NO.: EGBC 1003655

TIA Interim Dike

DRAWING TITLE:

Site Plan

DRAWING NO. TL-ID-100

REVISION NO. A

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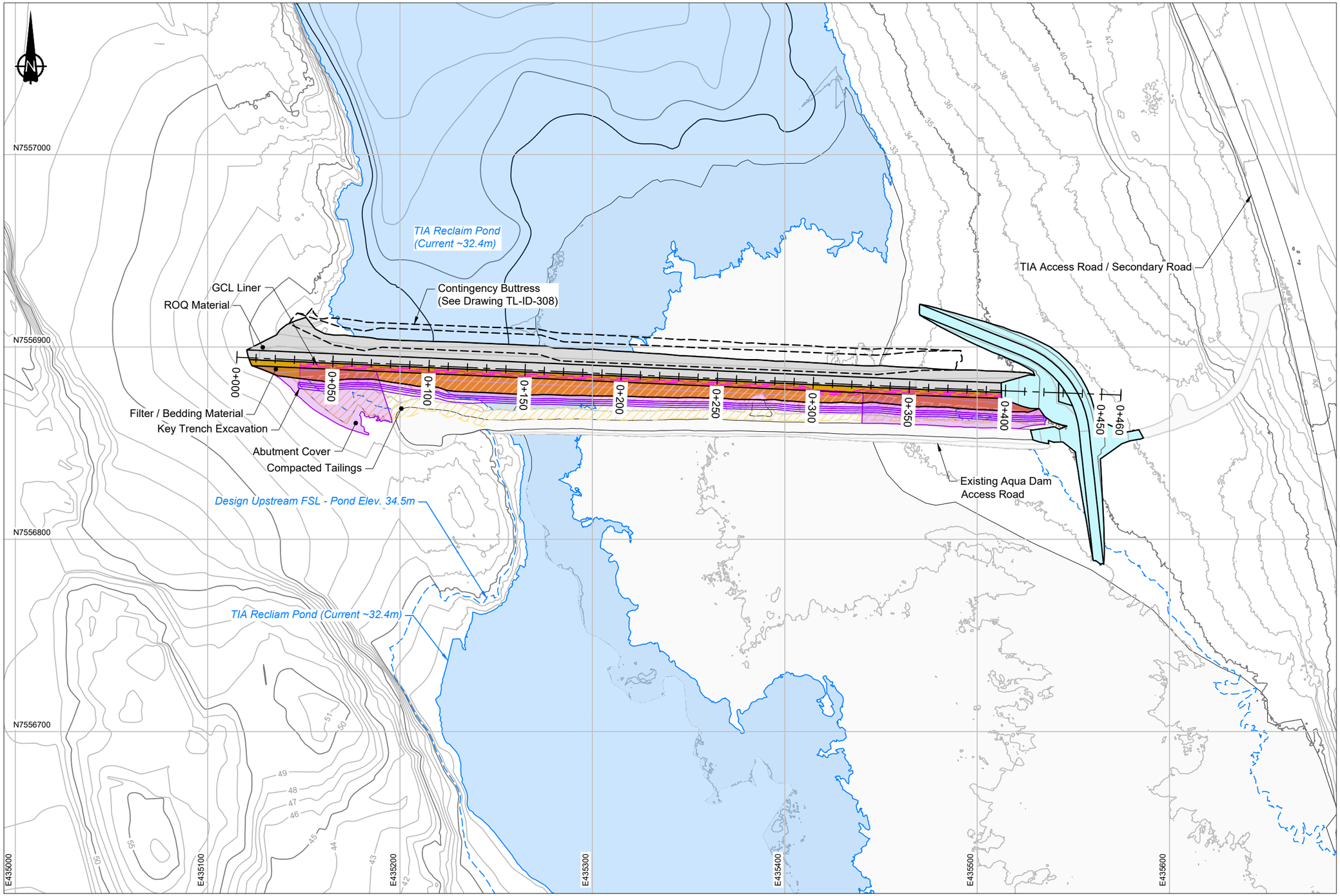

LEGEND

- ROQ Material
- Filter / Bedding Material
- Key Trench Excavation
- GCL Liner
- Compacted Tailings
- Abutment Cover
- Contingency Buttress
- Subaerial Tailings Beach
- Shallow Submerged Tailings Beach
- Current TIA Water Level (~32.4m)
- Design Upstream Full Supply Level (Elev. 34.5m)
- Water Elevation Control Channel

NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

REFERENCES

NAD83 UTM Zone 13.
Aqua Dam As-built provided by Client. File name: "Aqua Dam Asbuilt0713.dxf".

MATERIALS LIST AND QUANTITIES

Spillway
Excavation: 2,700m^3
Compacted Tailings: 400m^3
Riprap: 500m^3
Non-woven Geotextile: 2,100m^2

Interim Dike
Key Trench Excavation: 900m^3
ROQ: 12,900m^3
Bedding: 900m^3
Transition: 2,000m^3
Non-woven Geotextile: 4,500m^2
Compacted Tailings (Elev. 35m): 8,200m^3
Contingency Buttress: 5,000m^3

All volumes reported are calculated to neat lines. No bulking / shrinking factors have been applied. Losses into the tundra are not accounted for.

REFERENCE DRAWINGS		REVISIONS								
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
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Hope Bay Project

SRK JOB NO.: CAPR001816 REG. NO.: EGBC 1003655

TIA Interim Dike

DRAWING TITLE:
Interim Dike
General Arrangement

DRAWING NO. TL-ID-101

REVISION NO. A

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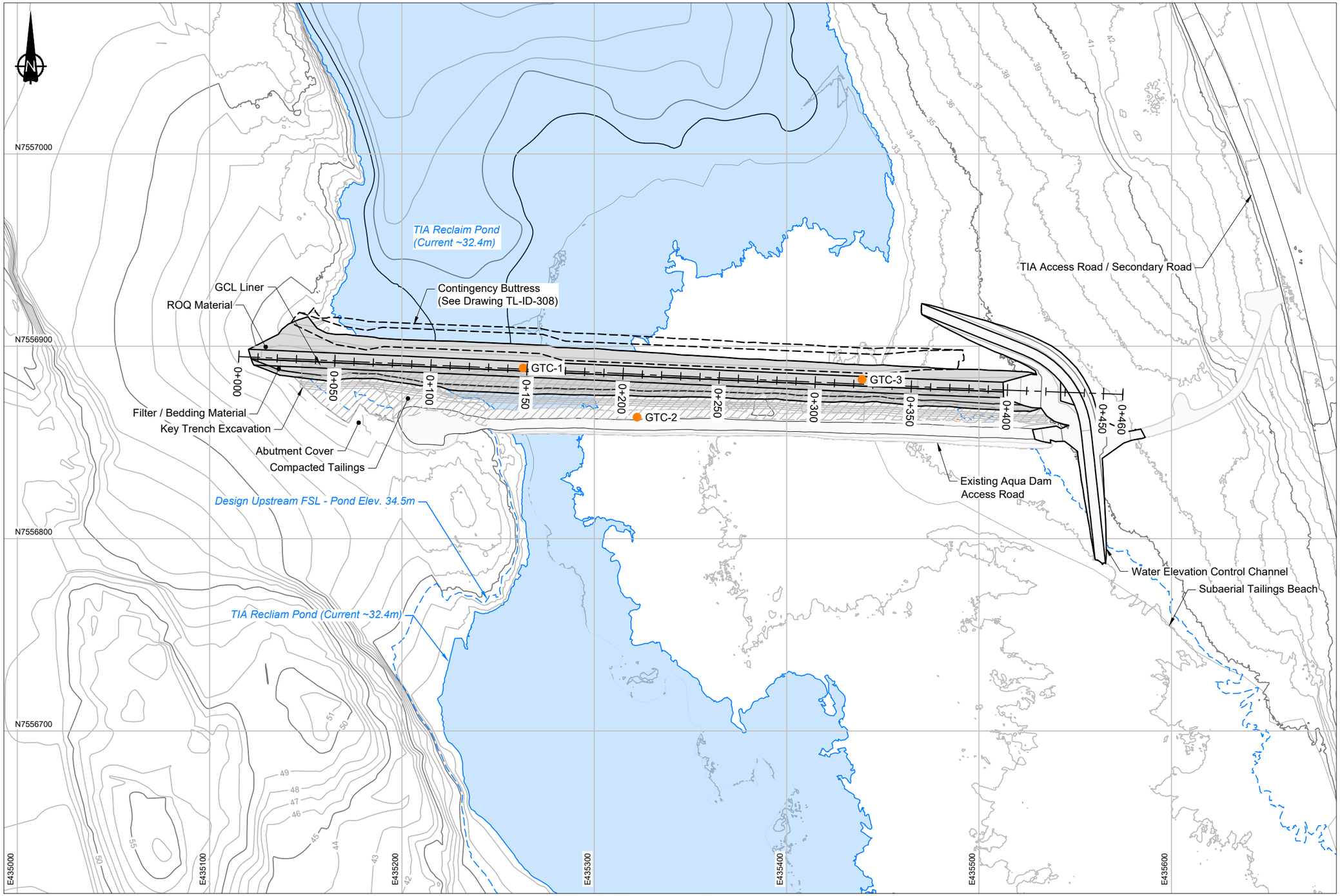

LEGEND

- Proposed Ground Temperature Cable
- Abutment Cover
- Contingency Buttress
- Compacted Tailings
- Current TIA Water Level (~32.4m)
- Design Upstream Full Supply Level (Elev. 34.5m)
- TIA Interim Dike

NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

REFERENCES

NAD83 UTM Zone 13.
Aqua Dam As-built provided by Client. File name: "Aqua Dam Asbuilt0713.dxf".

GTC INSTALLATION LOCATIONS

Description	Northing	Easting
GTC-1	7556888.70	435262.95
GTC-2	7556863.13	435322.19
GTC-3	7556882.73	435439.13

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Hope Bay Project

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TIA Interim Dike

DRAWING TITLE: Interim Dike Proposed Ground Temperature Cable Layout

DRAWING NO. TL-ID-102

REVISION NO. A

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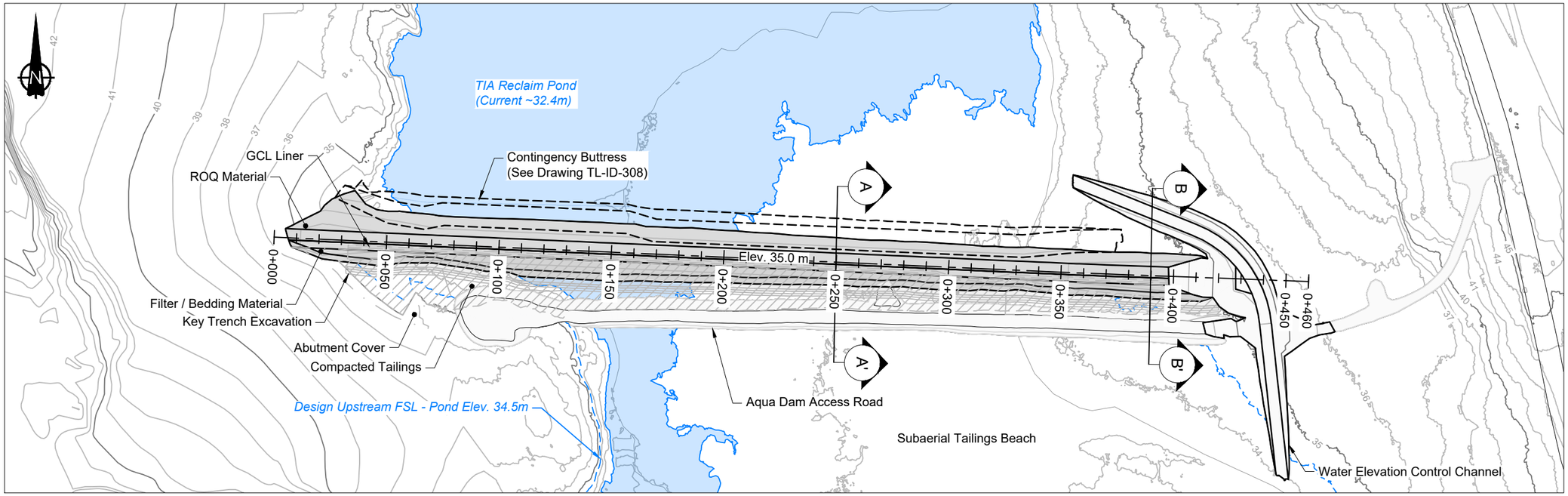
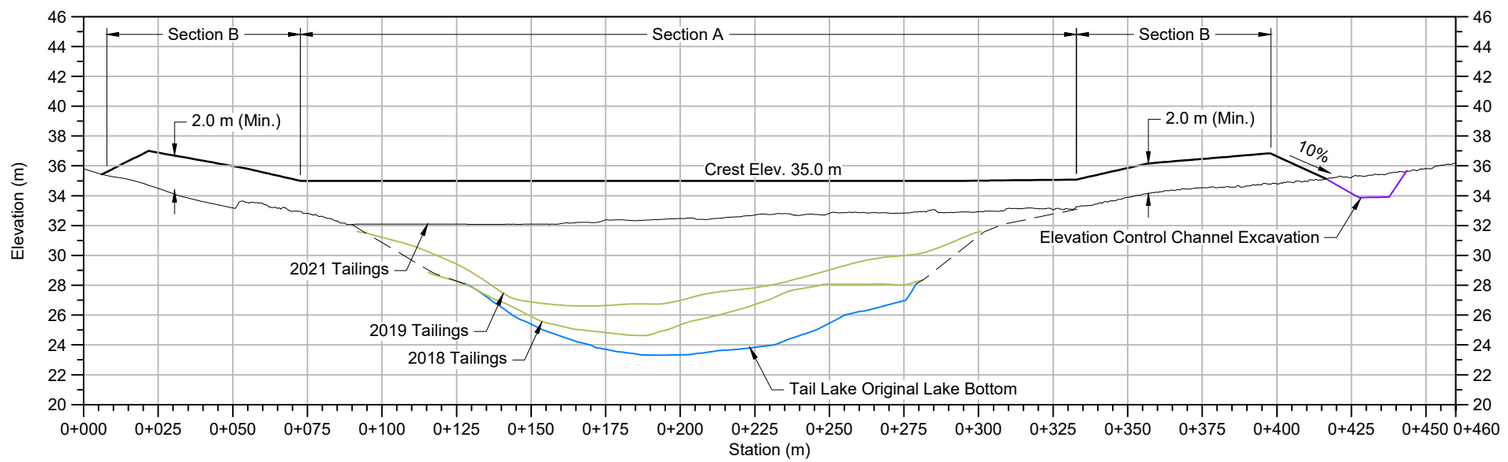


Interim Dike Plan View

0m 20 40 60 80



Interim Dike Profile

0m 4 8 12 16 Vertical

0m 20 40 60 80 Horizontal

LEGEND

- Abutment Cover
- Contingency Buttress
- Compacted Tailings
- Current TIA Water Level (~32.4m)
- Design Upstream Full Supply Level (Elev. 34.5m)
- TIA Interim Dike

NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

REFERENCES

NAD83 UTM Zone 13.
Aqua Dam As-built provided by Client. File name: "Aqua Dam Asbuilt0713.dxf".

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TIA Interim Dike

DRAWING TITLE: Interim Dike Plan and Profile

DRAWING NO. TL-ID-200

REVISION NO. A

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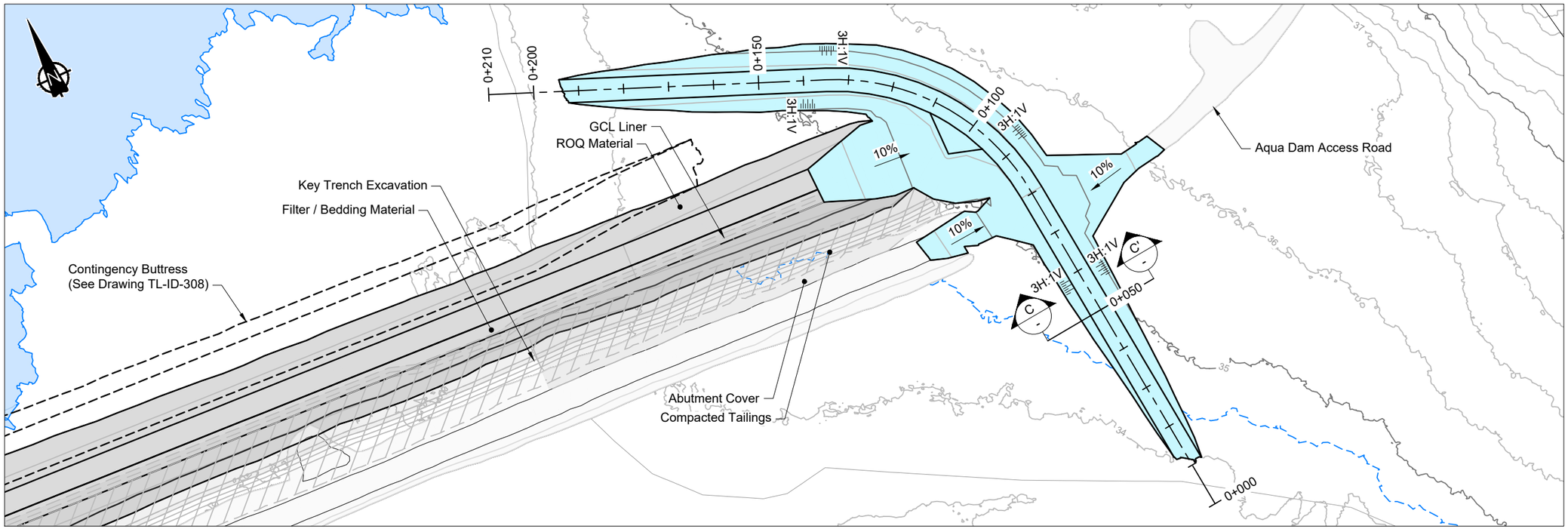


LEGEND

- Abutment Cover
- Contingency Buttress
- Compacted Tailings
- Current TIA Water Level (~32.4m)
- Design Upstream Full Supply Level (Elev. 34.5m)
- TIA Interim Dike
- Water Elevation Control Channel

NOTES

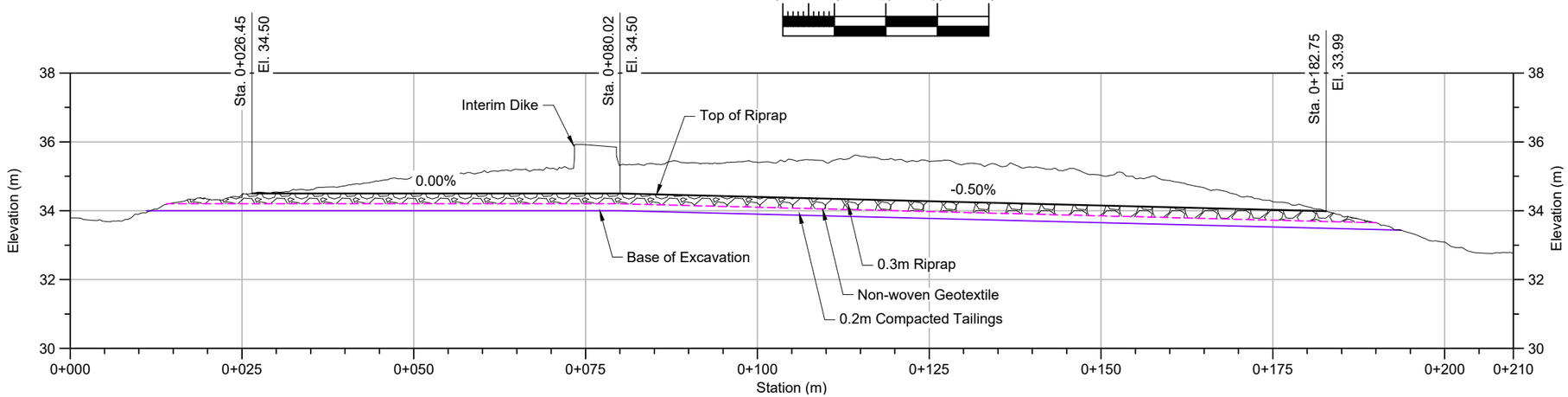
1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Water elevation control channel side slopes are 3H:1V along most of the spillway alignment and is 10H:1V when it crosses over the the aqua dam access road and 10H:1V to provide access to the crest of the Interim Dike.

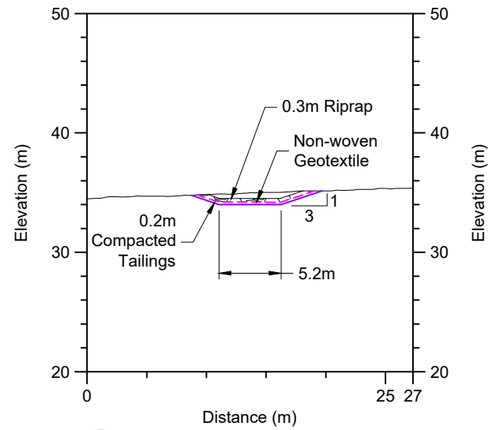
REFERENCES

NAD83 UTM Zone 13.
Aqua Dam As-built provided by Client. File name: "Aqua Dam Asbuilt0713.dxf".

Water Elevation Control Channel Plan View

0m 10 20 30 40





Cross Section C-C'

0m 5 10 15 20

Water Elevation Control Channel Profile

0m 1 2 3 4 5 6 Vertical

0m 5 10 15 20 25 30 Horizontal

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Hope Bay Project

SRK JOB NO.: CAPR001816 | REG. NO.: EGBC 1003655

TIA Interim Dike

DRAWING TITLE: Water Elevation Control Channel Plan, Profile and Cross Section

DRAWING NO.: TL-ID-201 | REVISION NO.: A

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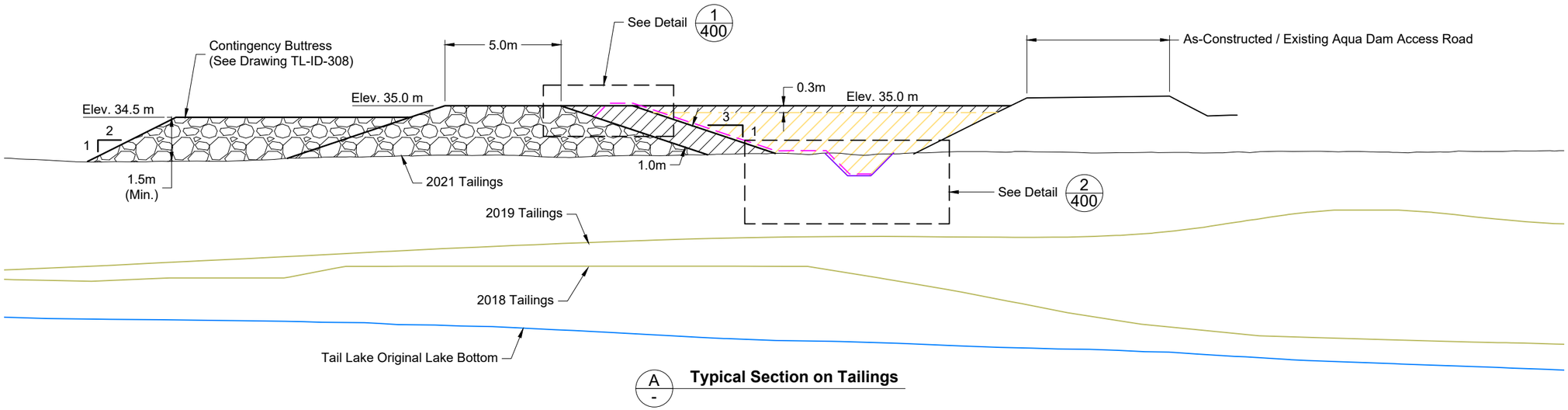
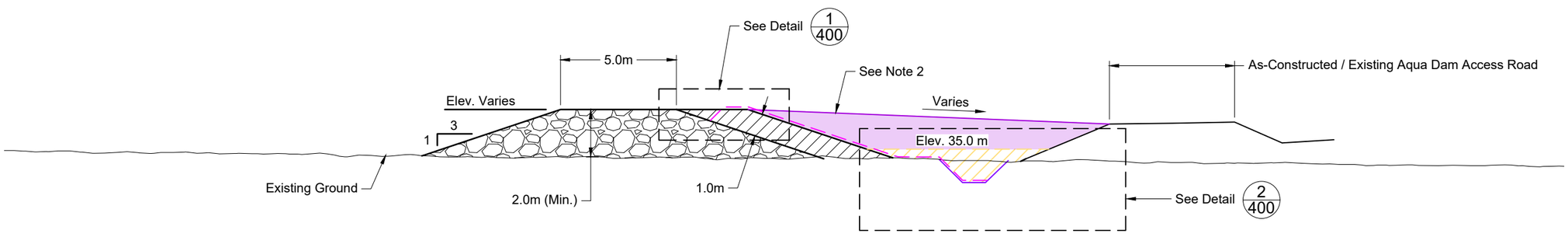


A - **Typical Section on Tailings**



B - **Typical Section on Tundra**

LEGEND

- GCL Liner
- ROQ Material
- Filter / Bedding Material
- Key Trench Excavation
- Compacted Tailings
- Abutment Cover

NOTES

1. All units are in meters unless otherwise specified.
2. The abutment cover could be constructed of coarser (more granular) fill material. Elevation on side abutment will be greater than elevation 35m and should be graded to help promote water flow away from Interim dike abutments, i.e. to help avoid pooling water at the abutments.

0m 2 4 6 8

REFERENCE DRAWINGS		REVISIONS									
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FILE NAME: CAPR001816 - ID Typ XS.dwg		

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Hope Bay Project

SRK JOB NO.: CAPR001816 REG. NO.: EGBC 1003655

TIA Interim Dike

DRAWING TITLE: Typical Cross Sections

DRAWING NO. TL-ID-300

REVISION NO. A

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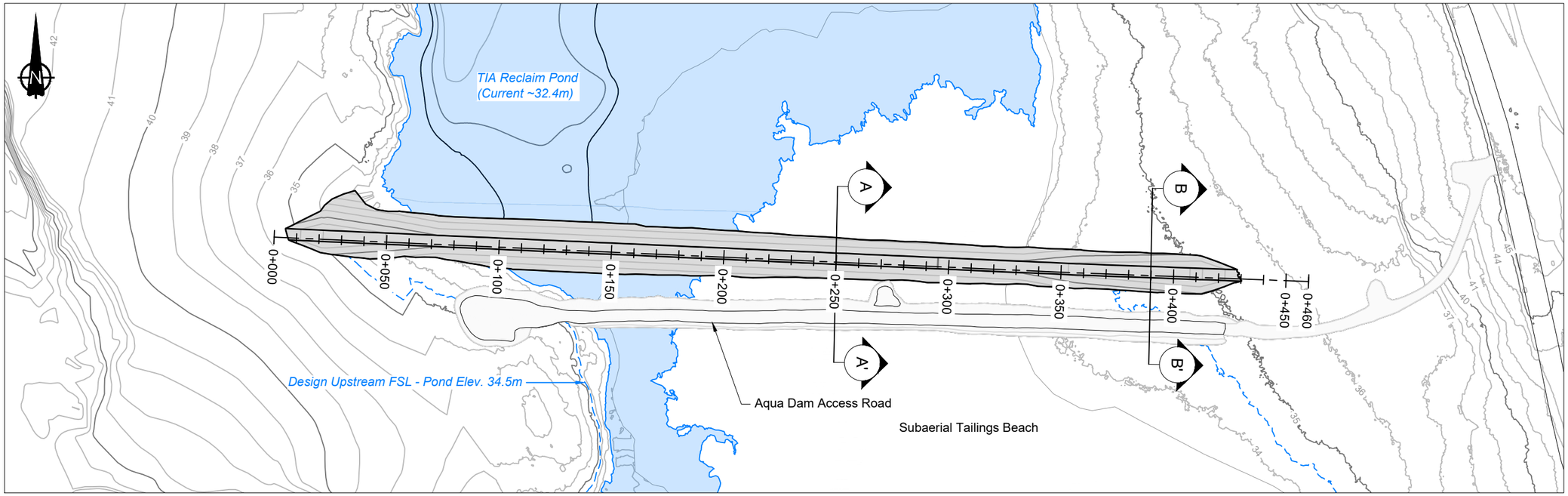


LEGEND

- ROQ Material
- Current TIA Water Level (~32.4m)
- Design Upstream Full Supply Level (Elev. 34.5m)

NOTES

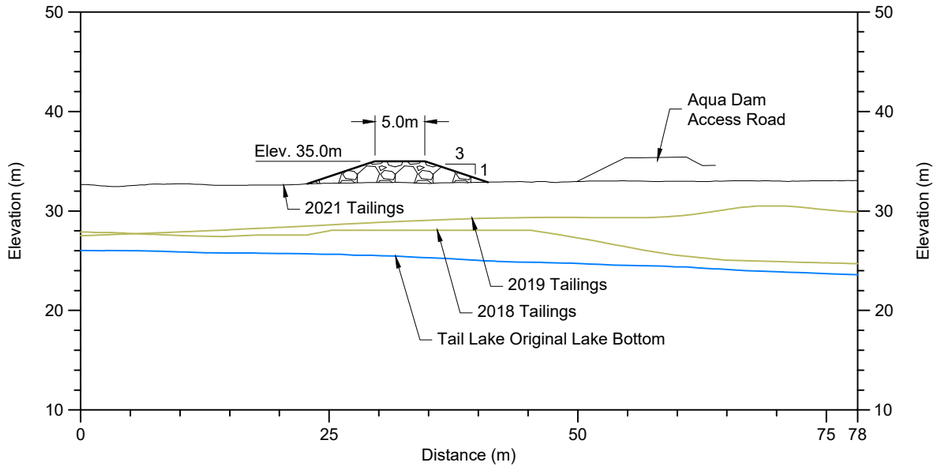
1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

REFERENCES

NAD83 UTM Zone 13.
Aqua Dam As-built provided by Client. File name: "Aqua Dam Asbuilt0713.dxf".

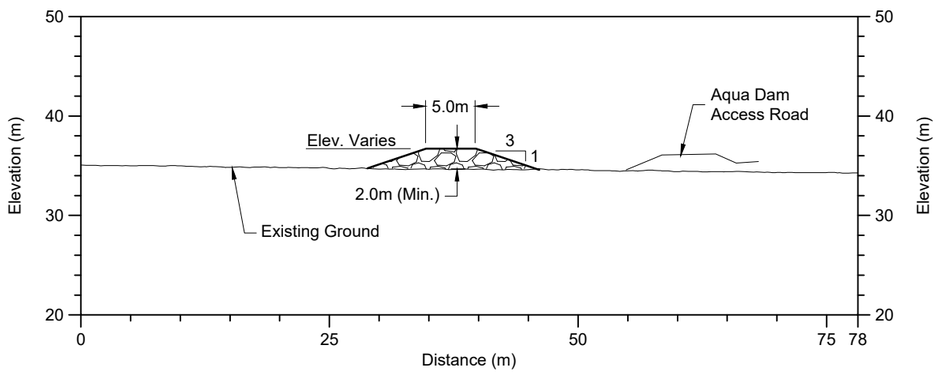
Interim Dike Plan View

0m 20 40 60 80



A - **Cross Section A-A'**

0m 6 12 18 24



B - **Cross Section B-B'**

0m 6 12 18 24

DRAWING NO.	DRAWING TITLE
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REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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FILE NAME: CAPR001816 - ID XS.dwg

AGNICO EAGLE

Hope Bay Project

SRK JOB NO.: CAPR001816 REG. NO.: EGBC 1003655

TIA Interim Dike

DRAWING TITLE: Interim Dike ROQ

DRAWING NO. TL-ID-301

REVISION NO. A

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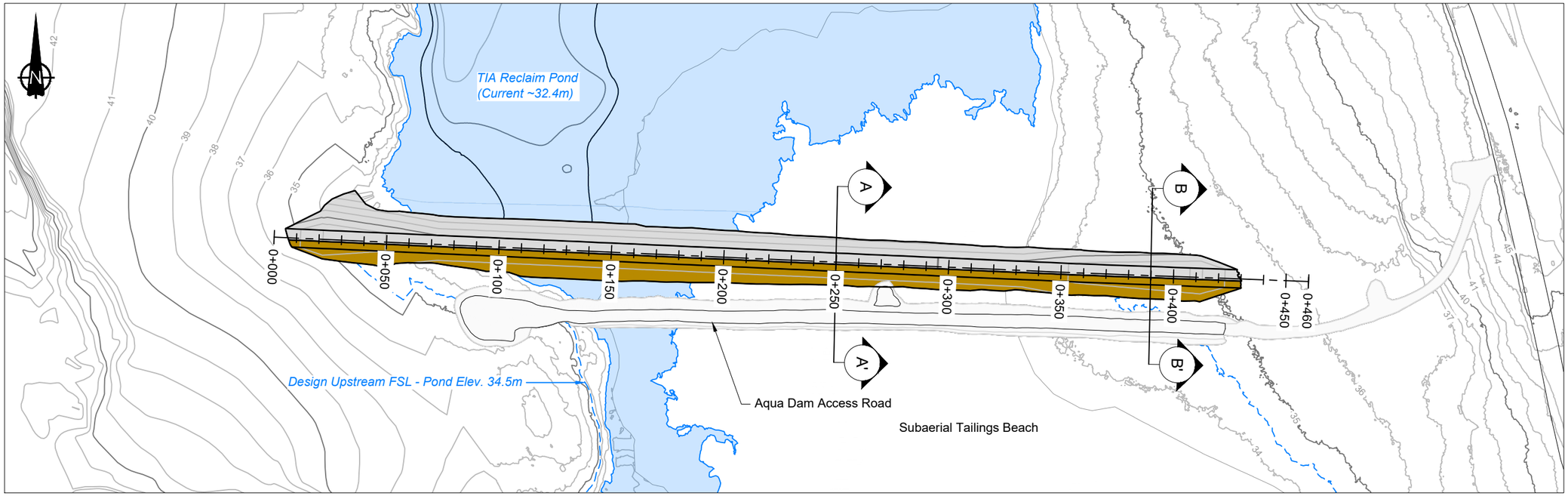


LEGEND

- ROQ Material
- Filter / Bedding Material
- Current TIA Water Level (~32.4m)
- Design Upstream Full Supply Level (Elev. 34.5m)

NOTES

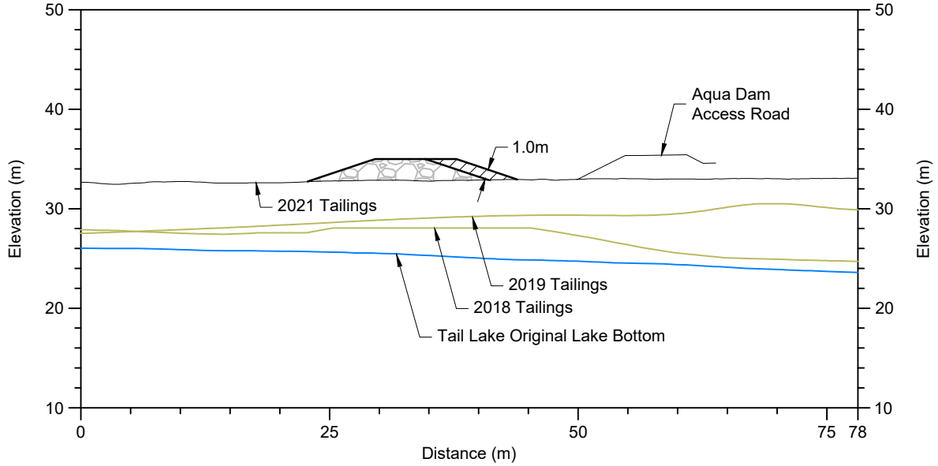
1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

REFERENCES

NAD83 UTM Zone 13.
Aqua Dam As-built provided by Client. File name: "Aqua Dam Asbuilt0713.dxf".

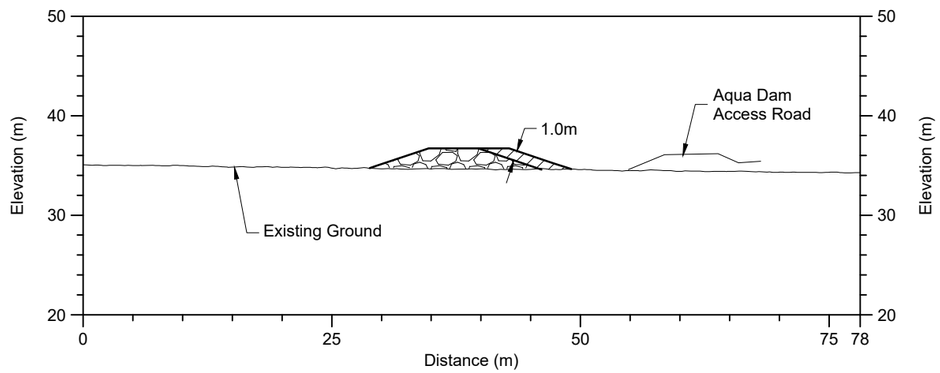
Interim Dike Plan View

0m 20 40 60 80



A - **Cross Section A-A'**

0m 6 12 18 24



B - **Cross Section B-B'**

0m 6 12 18 24

DRAWING NO.	DRAWING TITLE
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FILE NAME: CAPR001816 - ID XS.dwg

AGNICO EAGLE

Hope Bay Project

SRK JOB NO.: CAPR001816 REG. NO.: EGBC 1003655

TIA Interim Dike

DRAWING TITLE:
Interim Dike
Filter / Bedding Material

DRAWING NO. TL-ID-302

REVISION NO. A

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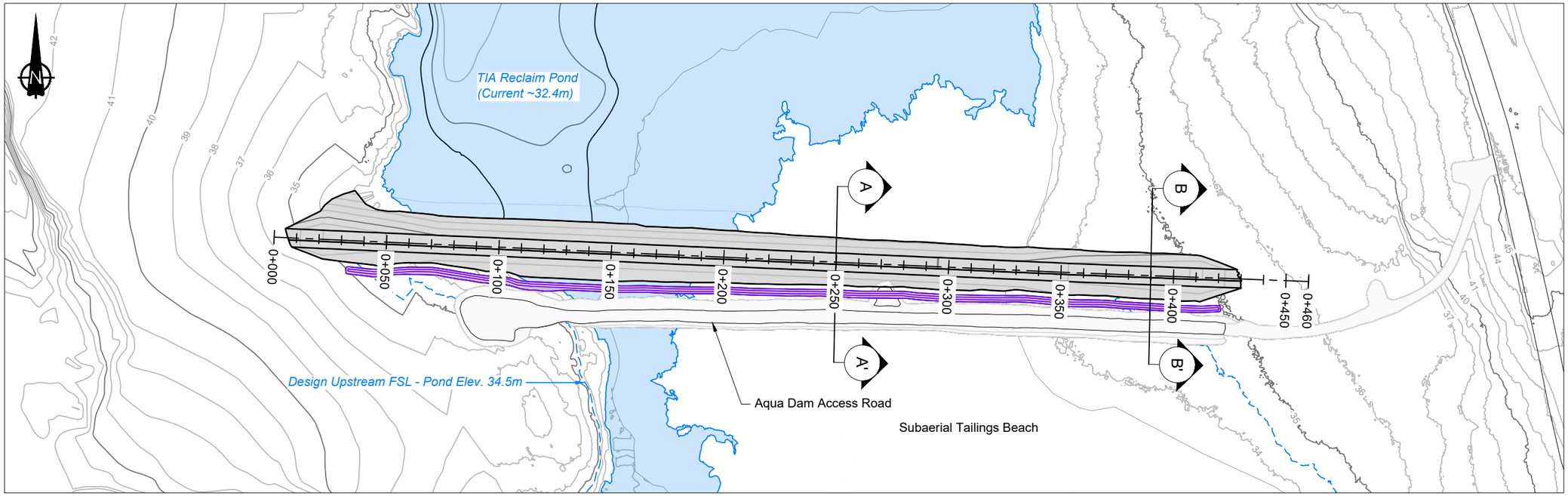
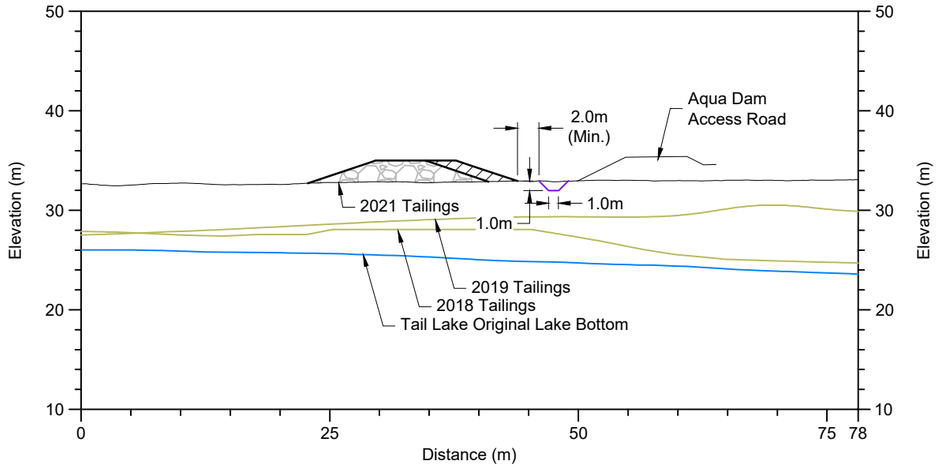


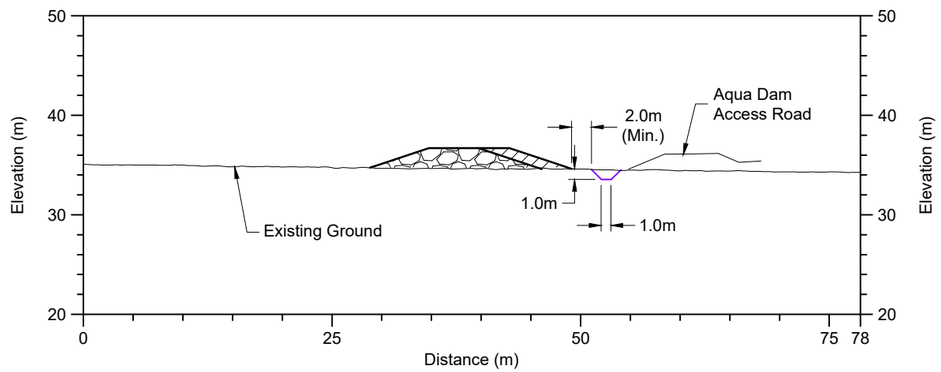
Interim Dike Plan View

0m 20 40 60 80



A - **Cross Section A-A'**

0m 6 12 18 24



B - **Cross Section B-B'**

0m 6 12 18 24

LEGEND

- ROQ Material
- Filter / Bedding Material
- Key Trench Excavation
- Current TIA Water Level (~32.4m)
- Design Upstream Full Supply Level (Elev. 34.5m)

NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

REFERENCES

NAD83 UTM Zone 13.
Aqua Dam As-built provided by Client. File name: "Aqua Dam Asbuilt0713.dxf".

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AGNICO EAGLE

Hope Bay Project

SRK JOB NO.: CAPR001816 REG. NO.: EGBC 1003655

TIA Interim Dike

DRAWING TITLE:
Interim Dike
Key Trench Excavation

DRAWING NO. TL-ID-303

REVISION NO. A

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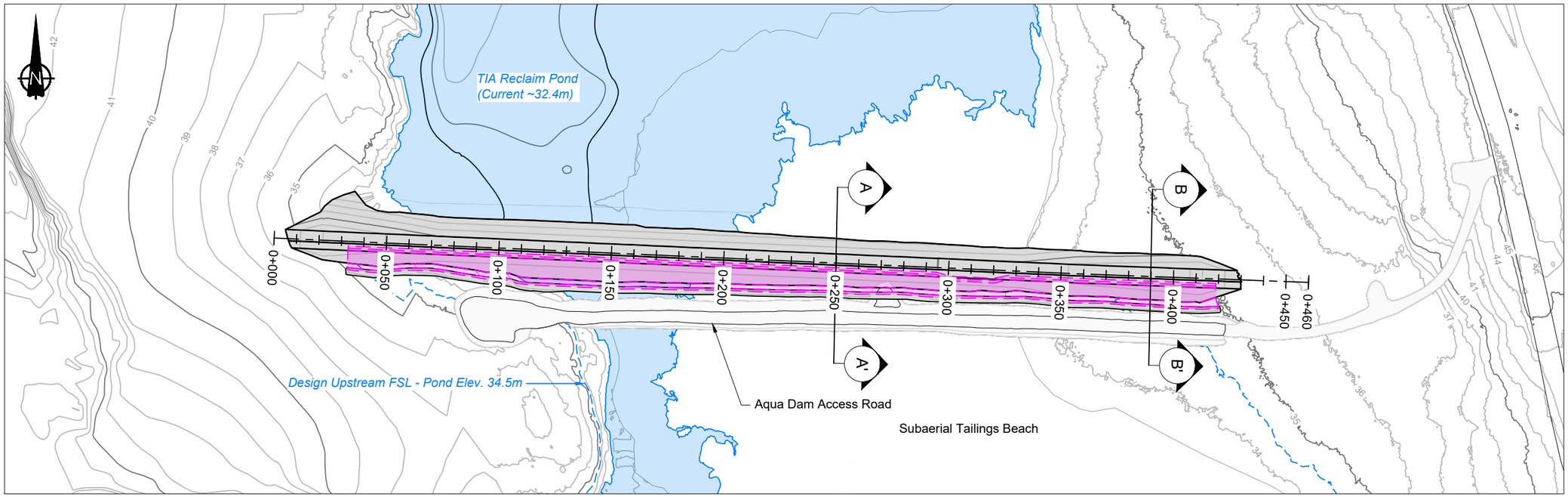


LEGEND

- GCL Liner
- ROQ Material
- Filter / Bedding Material
- GCL Liner
- Current TIA Water Level (~32.4m)
- Design Upstream Full Supply Level (Elev. 34.5m)

NOTES

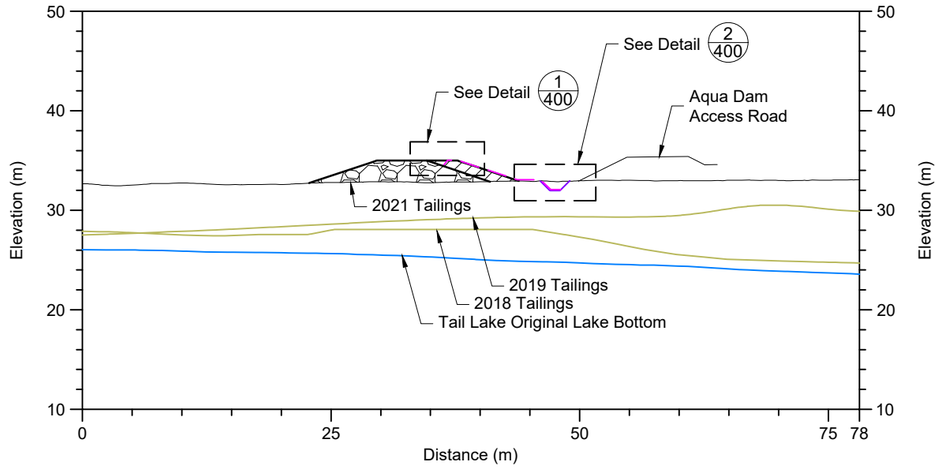
1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Filter and liner elevation may be adjusted to 35.0 m near abutments. Changes to be reflected in IFC drawings.

REFERENCES

NAD83 UTM Zone 13.
Aqua Dam As-built provided by Client. File name: "Aqua Dam Asbuilt0713.dxf".

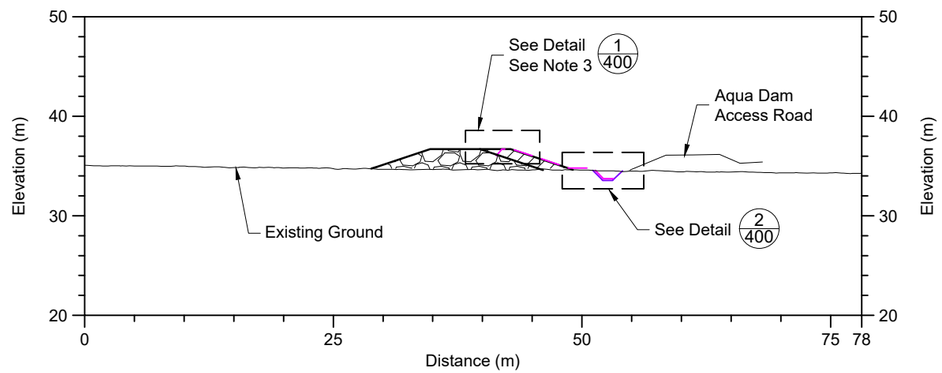
Interim Dike Plan View

0m 20 40 60 80



A - **Cross Section A-A'**

0m 6 12 18 24



B - **Cross Section B-B'**

0m 6 12 18 24

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FILE NAME: CAPR001816 - ID XS.dwg

AGNICO EAGLE

Hope Bay Project

SRK JOB NO.: CAPR001816 REG. NO.: EGBC 1003655

TIA Interim Dike

DRAWING TITLE: Interim Dike GCL Liner

DRAWING NO. TL-ID-304

REVISION NO. A

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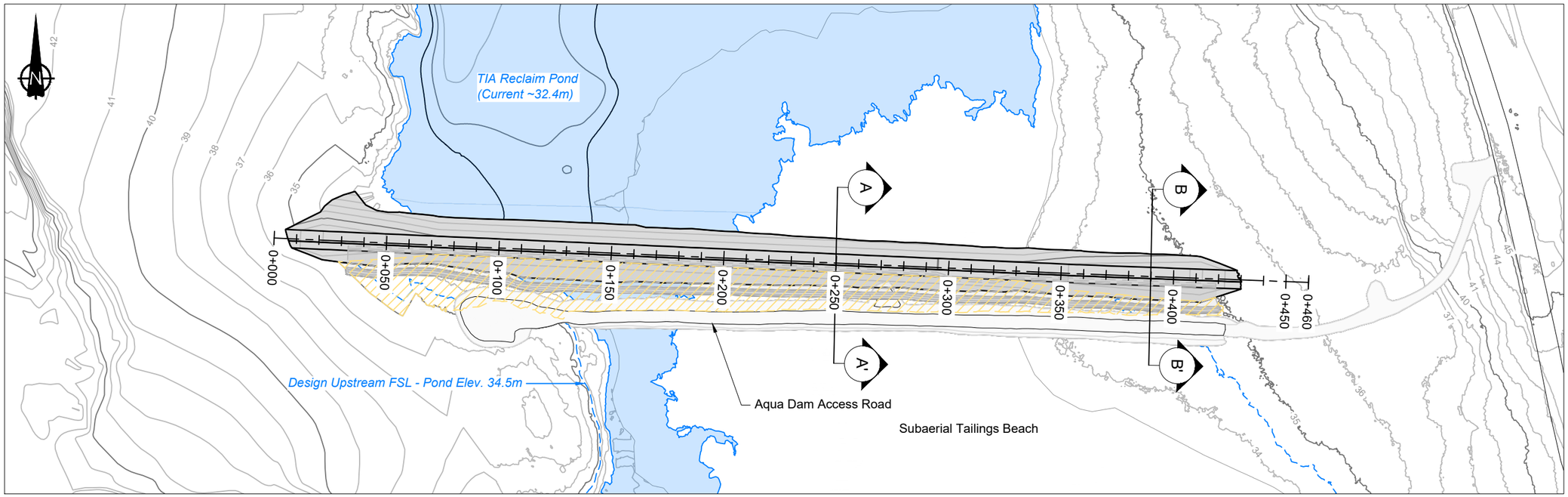


LEGEND

- GCL Liner
- ROQ Material
- Filter / Bedding Material
- Compacted Tailings
- Current TIA Water Level (~32.4m)
- Design Upstream Full Supply Level (Elev. 34.5m)

NOTES

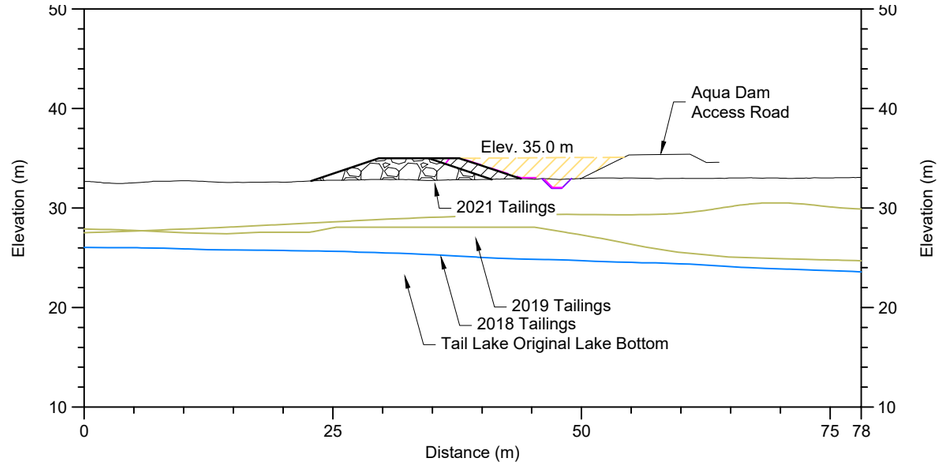
1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

REFERENCES

NAD83 UTM Zone 13.
Aqua Dam As-built provided by Client. File name: "Aqua Dam Asbuilt0713.dxf".

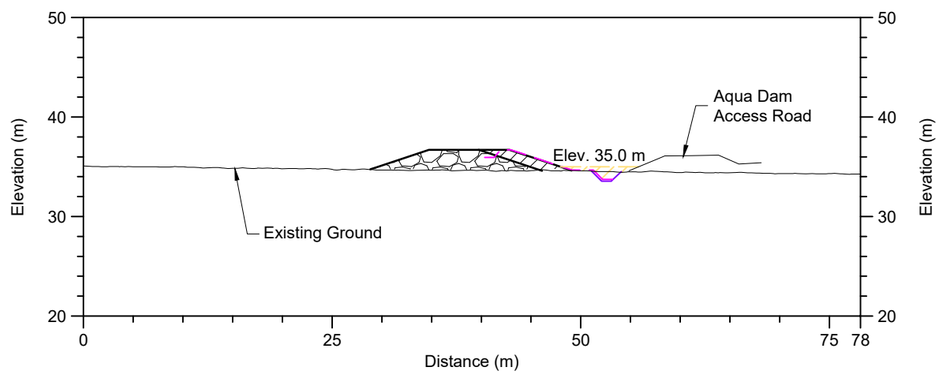
Interim Dike Plan View

0m 20 40 60 80



A
-
Cross Section A-A'

0m 6 12 18 24



B
-
Cross Section B-B'

0m 6 12 18 24

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
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AGNICO EAGLE

Hope Bay Project

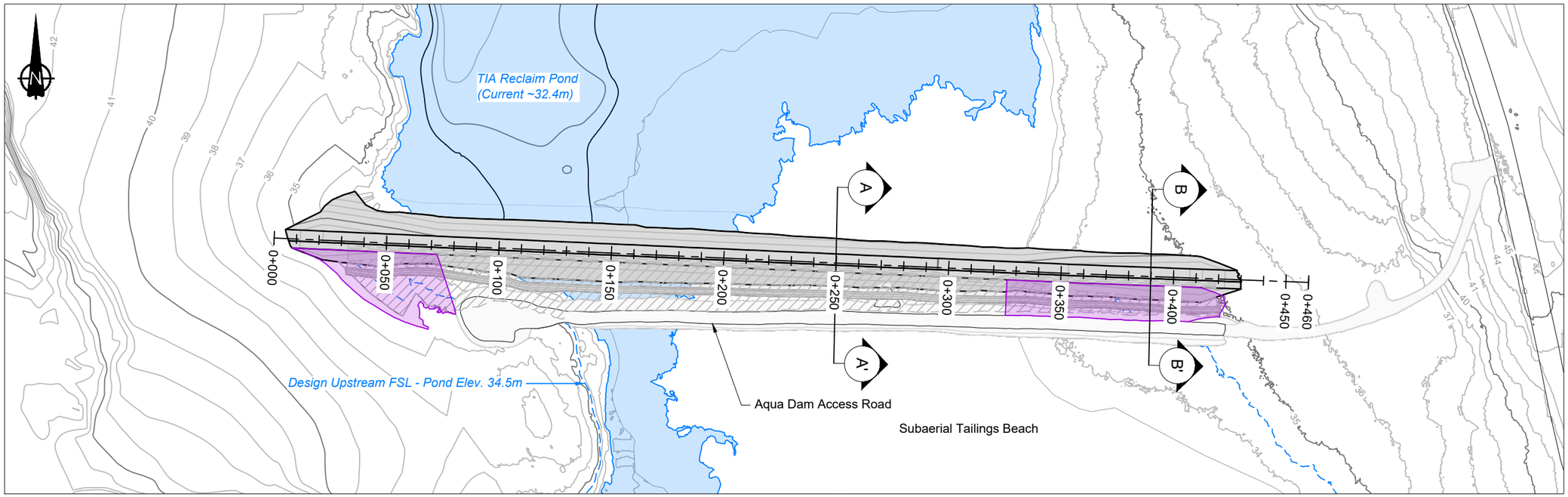
SRK JOB NO.: CAPR001816 | REG. NO.: EGBC 1003655

TIA Interim Dike

DRAWING TITLE: Interim Dike Compacted Tailings

DRAWING NO. TL-ID-305 | REVISION NO. A

C:\Users\dlee\SRK Consulting\FS208 Hope Bay (Doris North, Boston, Madrid) - Internal\ACAD\TIA Interim Dike\[FP]CAPR001816 - ID XS.dwg



LEGEND

- GCL Liner
- ROQ Material
- Filter / Bedding Material
- Abutment Cover (See Note 3)
- Compacted Tailings
- Current TIA Water Level (~32.4m)
- Design Upstream Full Supply Level (Elev. 34.5m)

NOTES

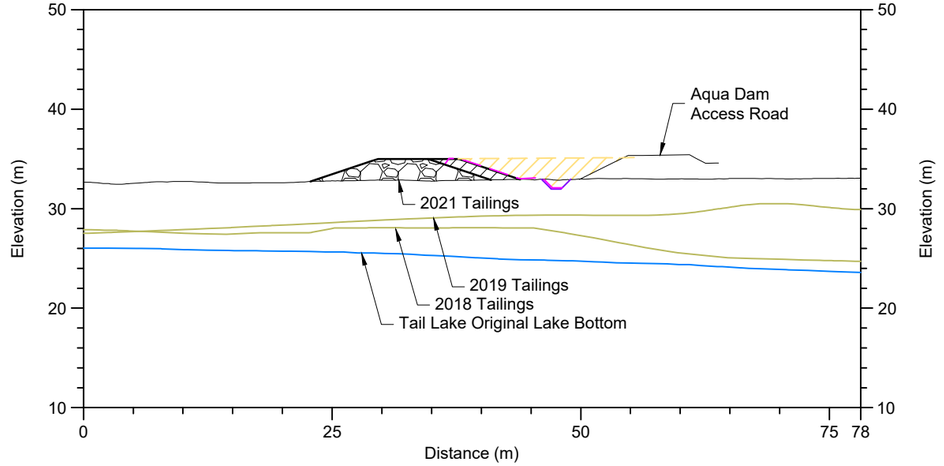
1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Material to be placed to prevent water ponding between the Interim Dike and Aqua Dam access road.

REFERENCES

NAD83 UTM Zone 13.
Aqua Dam As-built provided by Client. File name: "Aqua Dam Asbuilt0713.dxf".

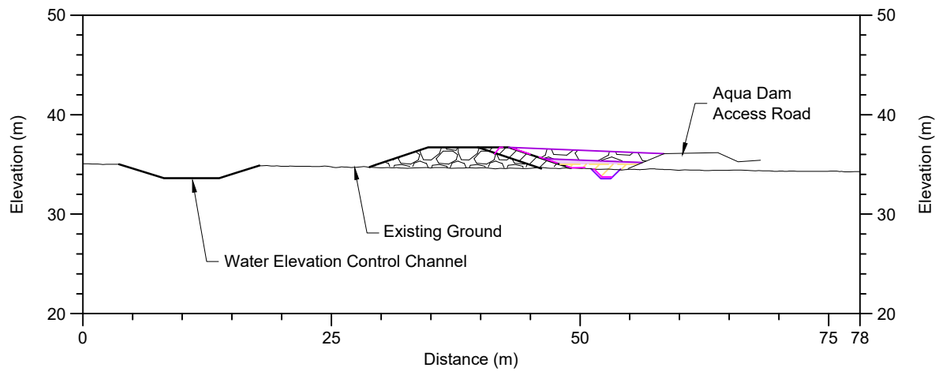
Interim Dike Plan View

0m 20 40 60 80



A - **Cross Section A-A'**

0m 6 12 18 24



B - **Cross Section B-B'**

0m 6 12 18 24

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FILE NAME: CAPR001816 - ID XS.dwg

AGNICO EAGLE

Hope Bay Project

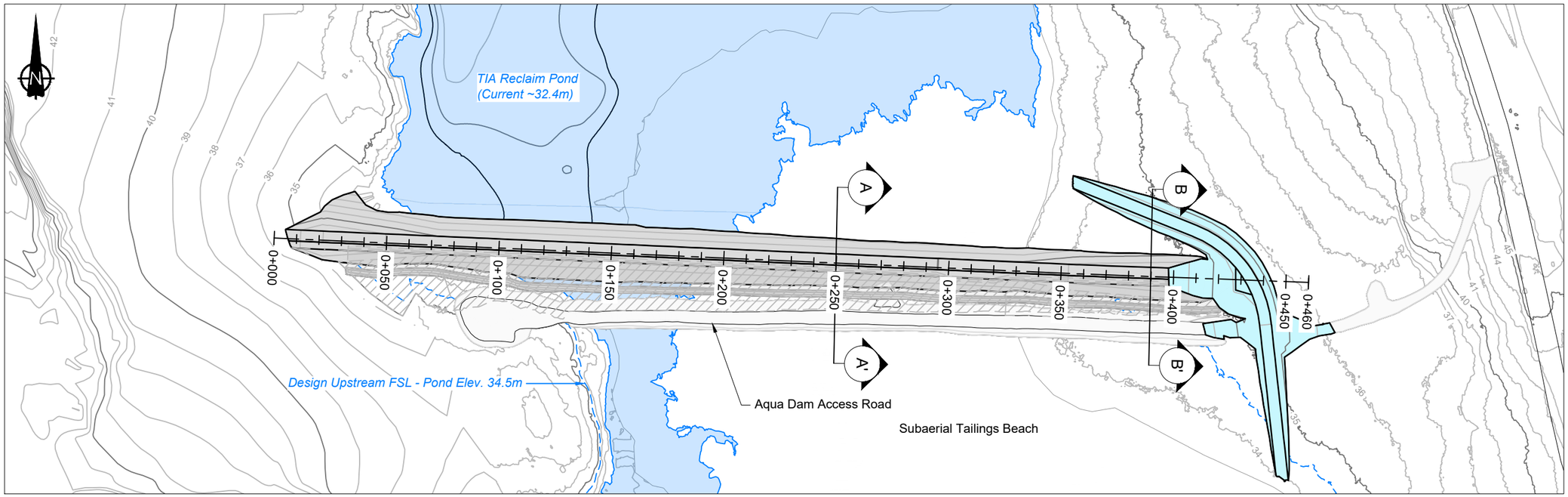
SRK JOB NO.: CAPR001816 | REG. NO.: EGBC 1003655

TIA Interim Dike

DRAWING TITLE: Interim Dike Abutment Cover

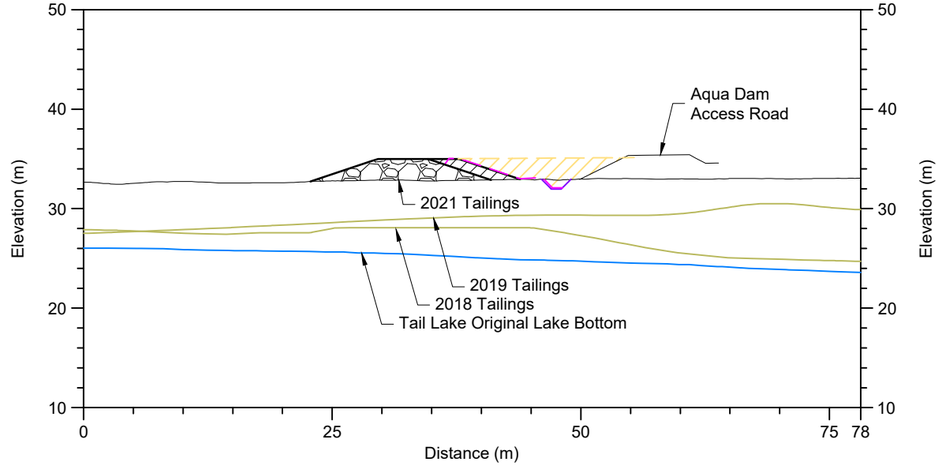
DRAWING NO.: TL-ID-306 | REVISION NO.: A

C:\Users\dlee\SRK Consulting\FS208 Hope Bay (Doris North, Boston, Madrid) - Internal\ACAD\TIA (Interim Dike)\[FP-CAPR001816 - ID XS.dwg



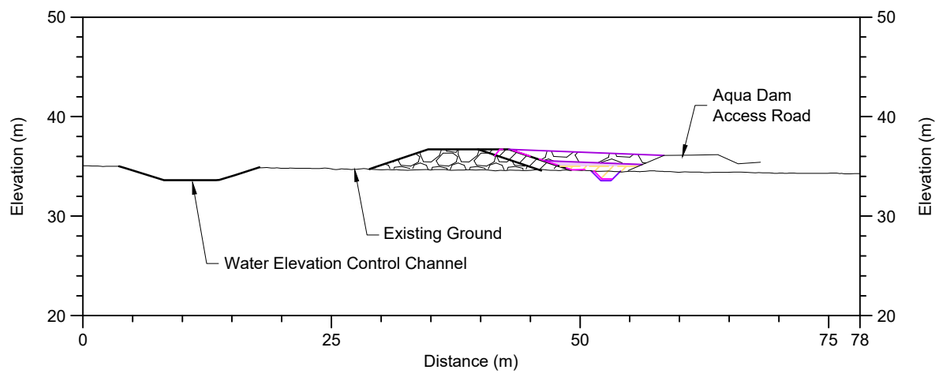
Interim Dike Plan View

0m 20 40 60 80



A - **Cross Section A-A'**

0m 6 12 18 24



B - **Cross Section B-B'**

0m 6 12 18 24

LEGEND

- GCL Liner
- ROQ Material
- Filter / Bedding Material
- Abutment Cover (See Note 3)
- Compacted Tailings
- Current TIA Water Level (~32.4m)
- Design Upstream Full Supply Level (Elev. 34.5m)
- Water Elevation Control Channel

NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Material to be placed to prevent water ponding between the Interim Dike and Aqua Dam access road.

REFERENCES

NAD83 UTM Zone 13.
Aqua Dam As-built provided by Client. File name: "Aqua Dam Asbuilt0713.dxf".

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FILE NAME: CAPR001816 - ID XS.dwg			

AGNICO EAGLE

Hope Bay Project

SRK JOB NO.: CAPR001816 | REG. NO.: EGBC 1003655

TIA Interim Dike

DRAWING TITLE: Interim Dike
Water Elevation Control Channel

DRAWING NO.: TL-ID-307 | REVISION NO.: A

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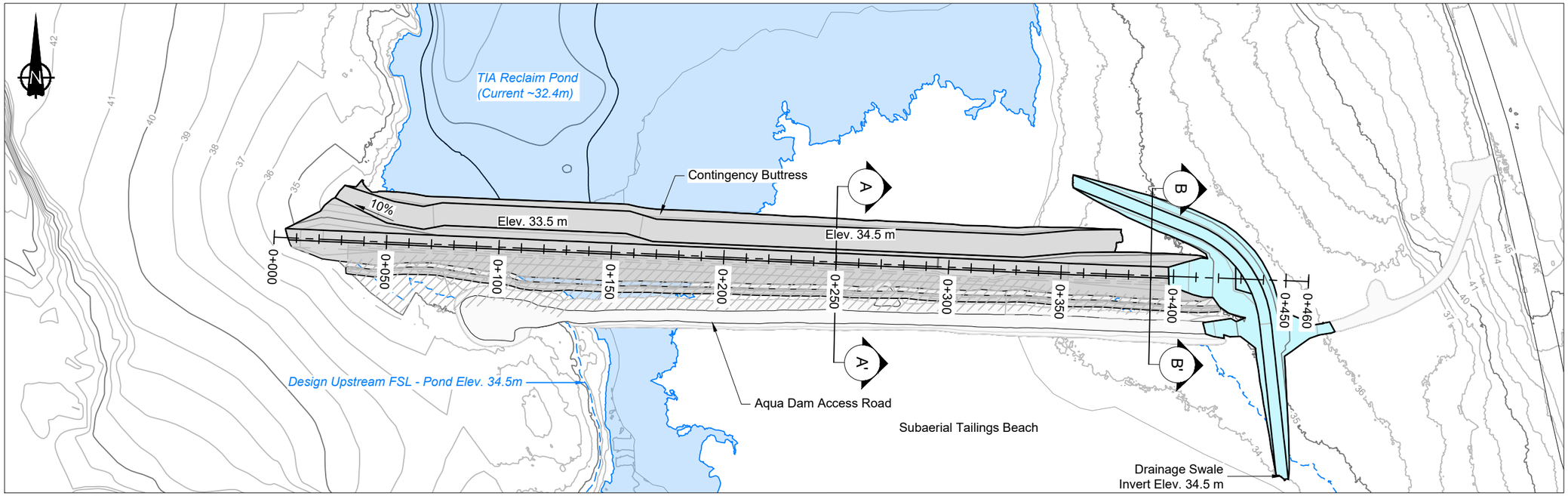
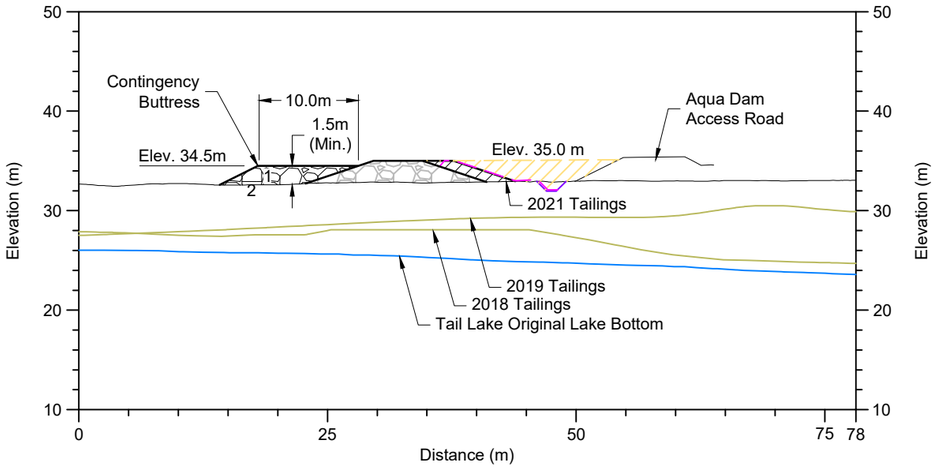


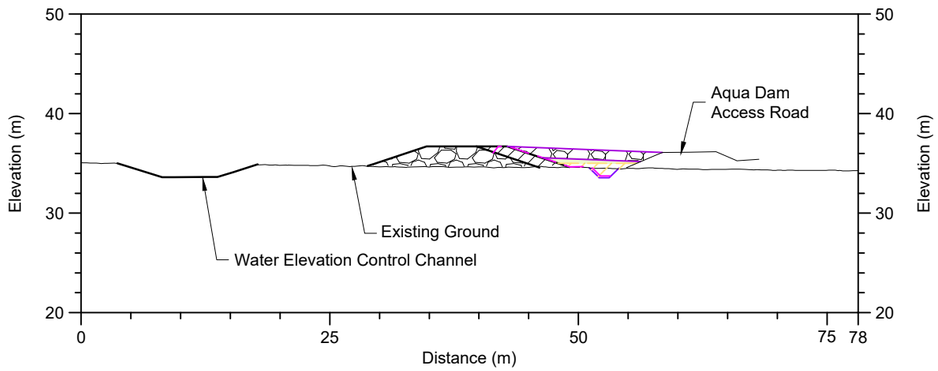
Interim Dike Plan View

0m 20 40 60 80



A
-
Cross Section A-A'

0m 6 12 18 24



B
-
Cross Section B-B'

0m 6 12 18 24

LEGEND

- GCL Liner
- ROQ Material
- Filter / Bedding Material
- Abutment Cover
- Compacted Tailings
- Current TIA Water Level (~32.4m)
- Design Upstream Full Supply Level (Elev. 34.5m)
- Water Elevation Control Channel

NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

REFERENCES

NAD83 UTM Zone 13.
Aqua Dam As-built provided by Client. File name: "Aqua Dam Asbuilt0713.dxf".

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TL/BJ/ML	JK	2022/08/26

FILE NAME: CAPR001816 - ID XS.dwg

AGNICO EAGLE

Hope Bay Project

SRK JOB NO.: CAPR001816 REG. NO.: EGBC 1003655

TIA Interim Dike

DRAWING TITLE:
Interim Dike
ROQ Contingency Buttress

DRAWING NO.: TL-ID-308

REVISION NO.: A

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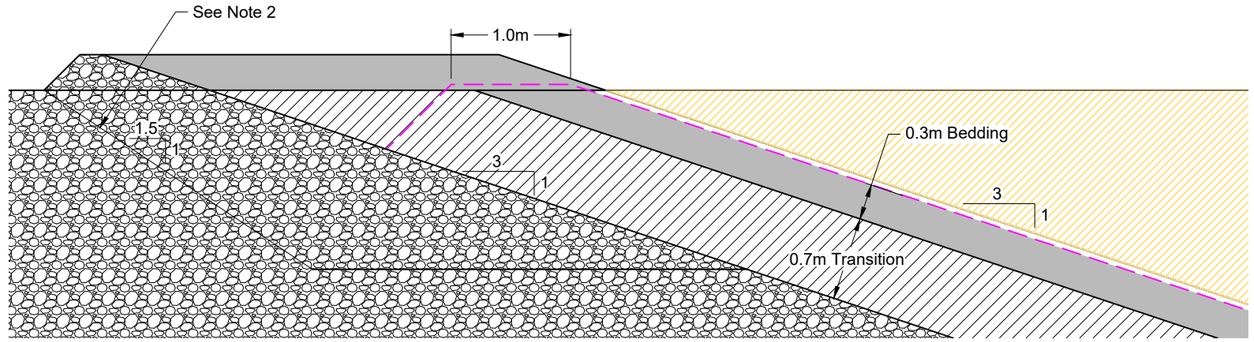
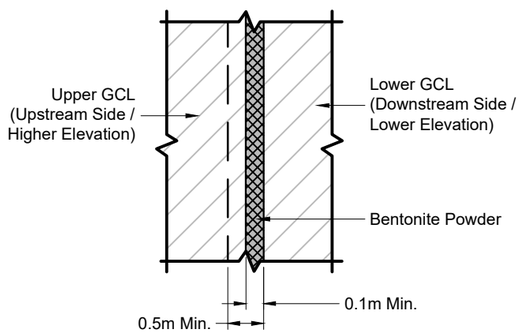


1/400 **Liner Key Trench at Dike Crest**

0m 0.5 1.0 1.5 2.0

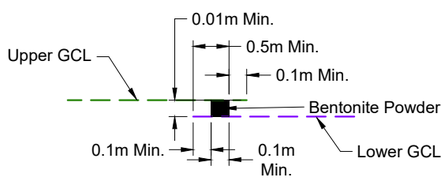
2/400 **Liner Key Trench at Dike Toe**

0m 0.5 1.0 1.5 2.0



3/- **Typical Longitudinal GCL Overlap - Plan**

0m 1 2 3 4



4/- **Typical Longitudinal GCL Overlap - Section**

0m 1 2 3 4

LEGEND

- GCL Liner
- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- ROQ Material
- Compacted Tailings

NOTES

1. All units are in meters unless otherwise specified.
2. Back slope for the tie in may be required to be cut at a shallower slope in the filed (up to 1.5H:1V) to help / allow for a better top liner key in.
3. A minimum 0.25m of compacted tailings should be placed and compacted to help have a level surface and smooth liner tie-in at the base of the liner key-trench.
4. Care should be taken to ensure that the key trench excavation doe not undermine / go below the upstream (non tailings) fill toe. The tailings or overburden, that will be excavated to form the toe key trench, may be unfrozen and / or saturated. If the field crews are unable to achieve a 1H:1V downstream cut slope in the key trench (1H:1V based on a more frozen condition) then this slope may be shallowed. The liner key trench excavation should not progress below the toe of the future liner to bedding material interface. A min 2m offset, from the upstream (non tailings) fill toe, has been left in the designs to allow some construction flexibility with this aspect. This offset would allow the downstream key trench excavation slope to be as shallow as ~3H:1V, if / as required.
5. All excavated slopes should be, at a minimum, compacted by tamping with the back of the excavator bucket.

DRAWING NO.	DRAWING TITLE
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REFERENCE DRAWINGS

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TL/BJ/ML	JK	2022/08/26

FILE NAME: CAPR001816 - ID Details.dwg

AGNICO EAGLE

Hope Bay Project

SRK JOB NO.: CAPR001816 REG. NO.: EGBC 1003655

TIA Interim Dike

DRAWING TITLE: Details

DRAWING NO. TL-ID-400

REVISION NO. A

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Appendix A Stability Results

Hope Bay – TIA Interim Dike

Overview of Stability Runs

(Revision 00) - 2022/09/02

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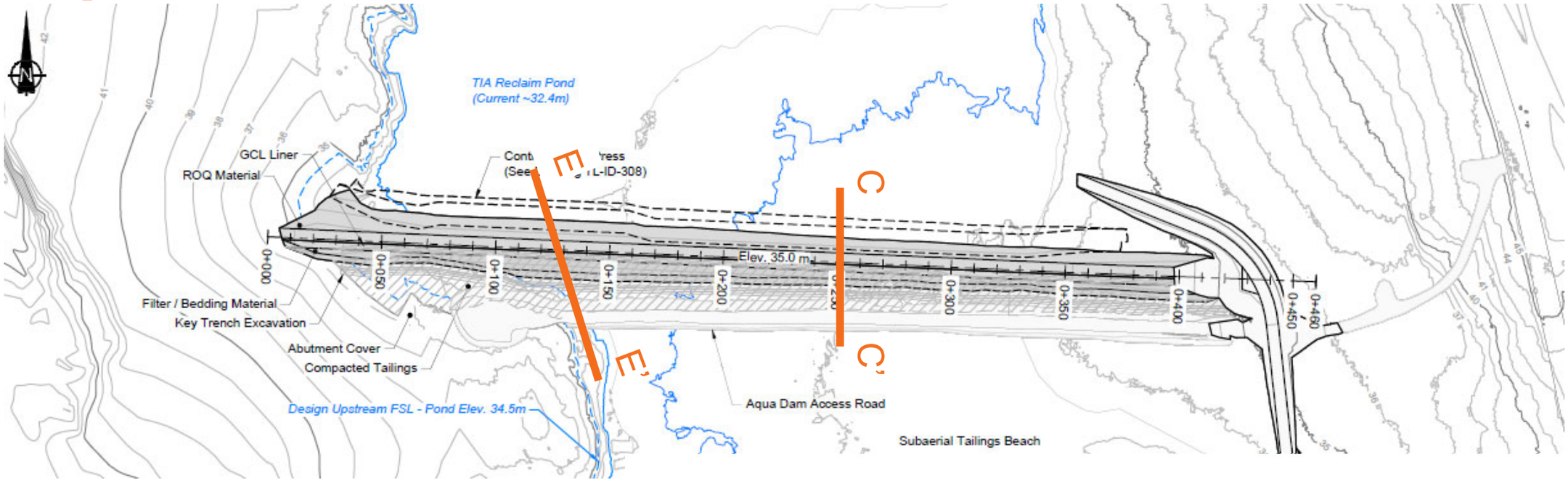
Plan View and Typical Cross-Section



LEGEND

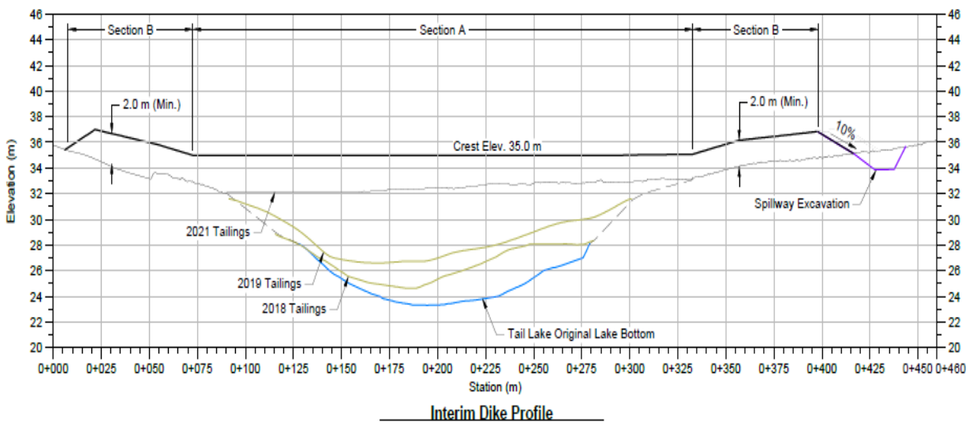
- Abutment Cover
- Contingency Buttress
- Compacted Tailings
- Current TIA Water Level (~32.4m)
- TIA Interim Dike

NOTES

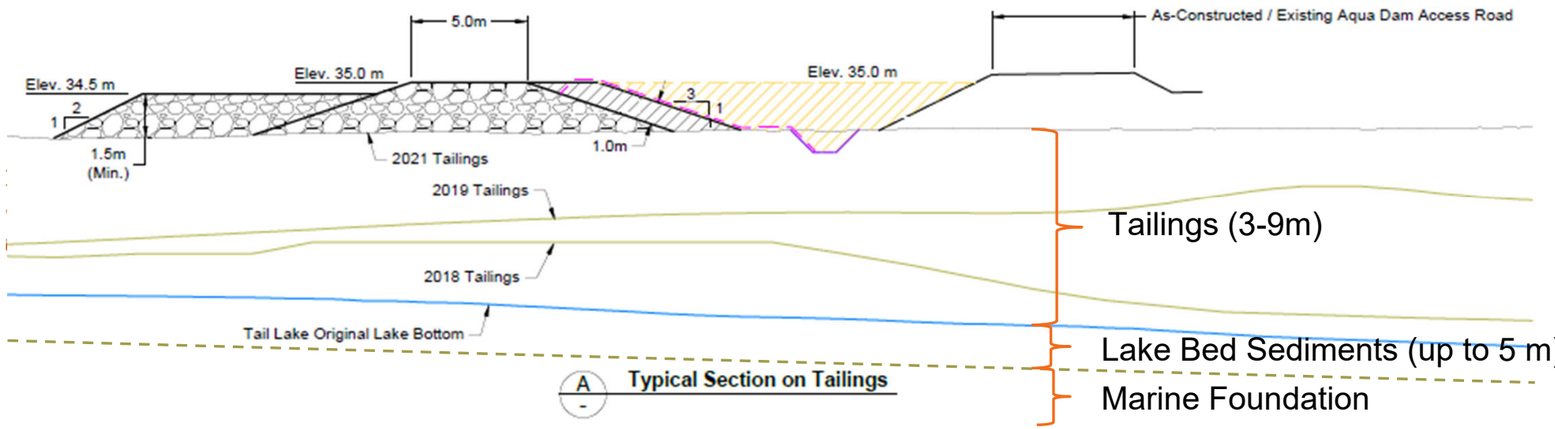
1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

REFERENCES

NAD83 UTM Zone 13.
Aqua Dam As-built provided by Client. File name: "Aqua Dam Asbuilt0713.dxf".

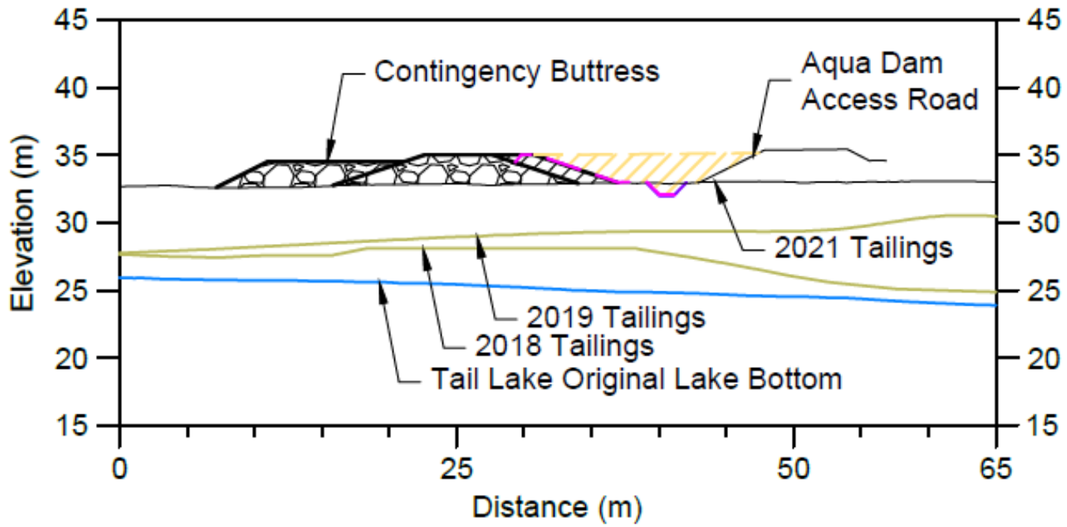


Interim Dike Profile

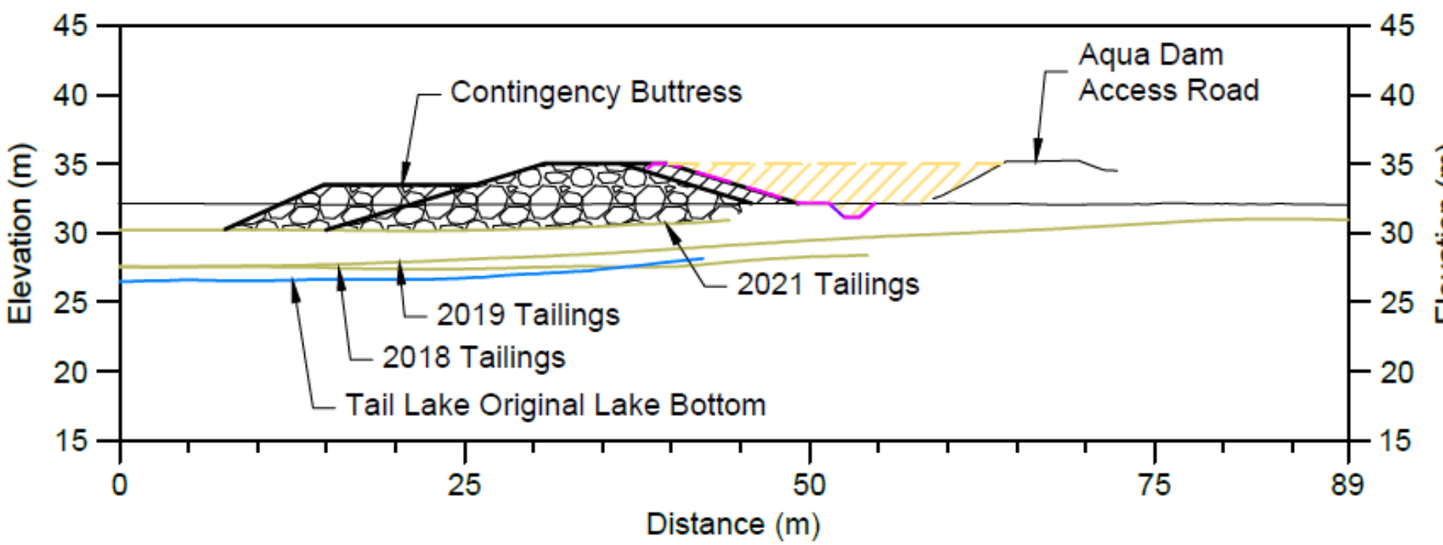


A – Typical Section on Tailings

Cross-Sections Used for Stability Checks



C
-
Cross Section C-C'



E
-
Cross Section E-E'

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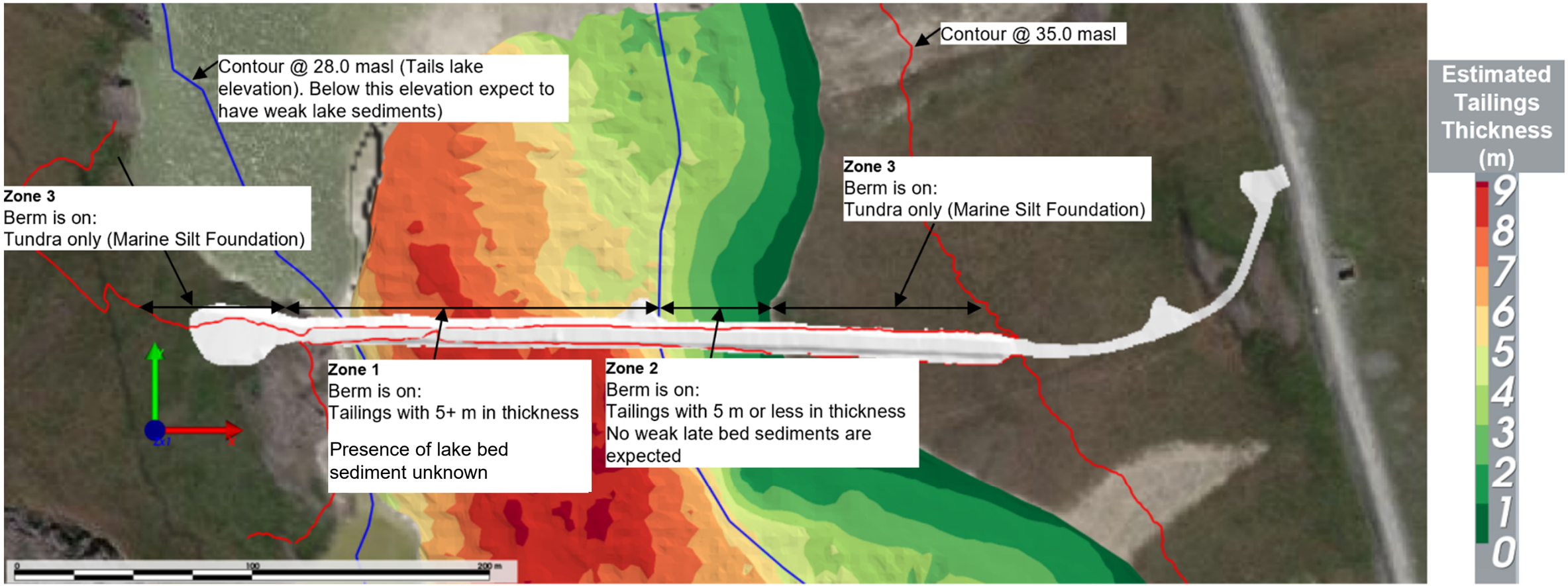
Foundation Tailings Thickness - Notes



Material Properties
Stability Analysis

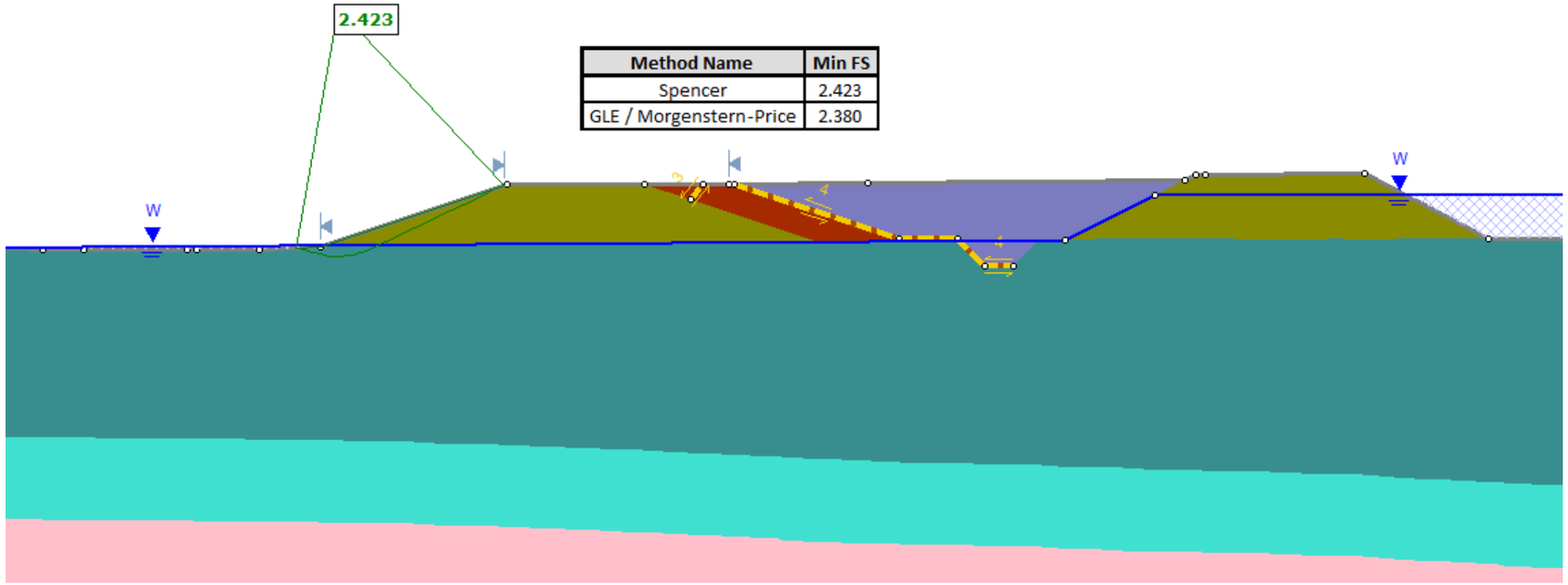
Material Name	Color	Unit Weight (kN/m3)	Strength Type	Cohesion (kPa)	Phi (deg)	Cohesion Type	Vertical Strength Ratio	Minimum Shear Strength (kPa)	Water Surface	Hu Type	Hu
GCL Liner		18	Mohr-Coulomb	0	15				Water Surface	Custom	1
Tailings Foundation - Undrained (Constant Cohesion)		17.5	Undrained	15		Constant	*Used in Sensitivity Checks*		Water Surface	Custom	1
Tailings Foundation C=0, phi=40		17.5	Mohr-Coulomb	0	40				Water Surface	Custom	1
Tailings Core		19	Mohr-Coulomb	0	35				Water Surface	Custom	1
Rockfill		20	Mohr-Coulomb	0	40				Water Surface	Custom	1
Filter/Bedding		20	Mohr-Coulomb	0	36				Water Surface	Custom	1
Marine Foundation (Silt and Clay)		17	Undrained	40		Constant			Water Surface	Custom	0
Lake bed sediments Su=16kP		16	Undrained	16		Constant			Water Surface	Custom	0

Primary Runs

Section	Case	Calculated FoS Assuming Foundation Tailings
		c=0 kPa, φ=40°
C-C’	“No Buttress” Case	2.42
	Base Case with “Buttress”	3.36
E-E’	“No Buttress” Case	1.78
	Base Case with “Buttress”	1.97

Cross-section C-C’ (Without Buttress)

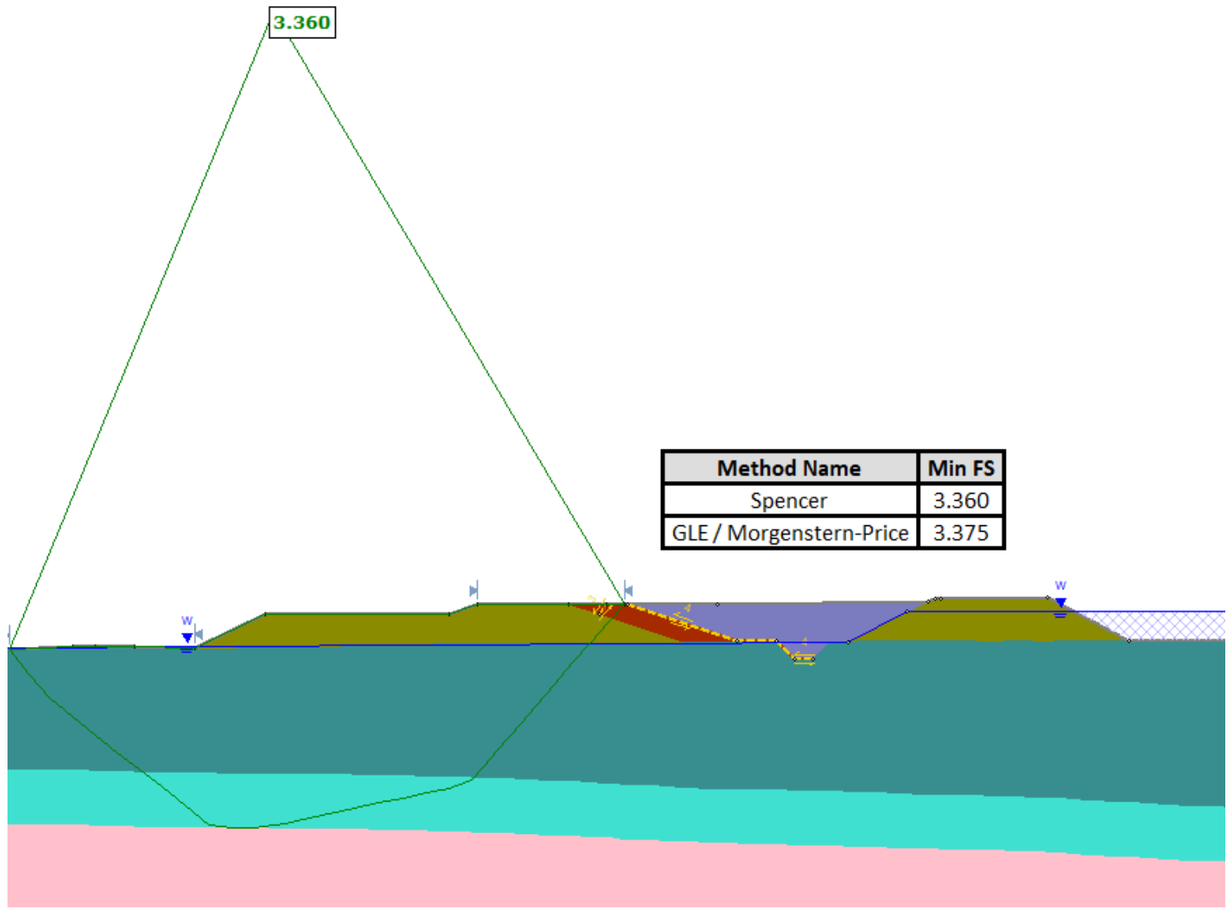
Tailings Foundation c=0 kPa, φ=40°,
Lakebed Sediments s_u=16 kPa



Method Name	Min FS
Spencer	2.423
GLE / Morgenstern-Price	2.380

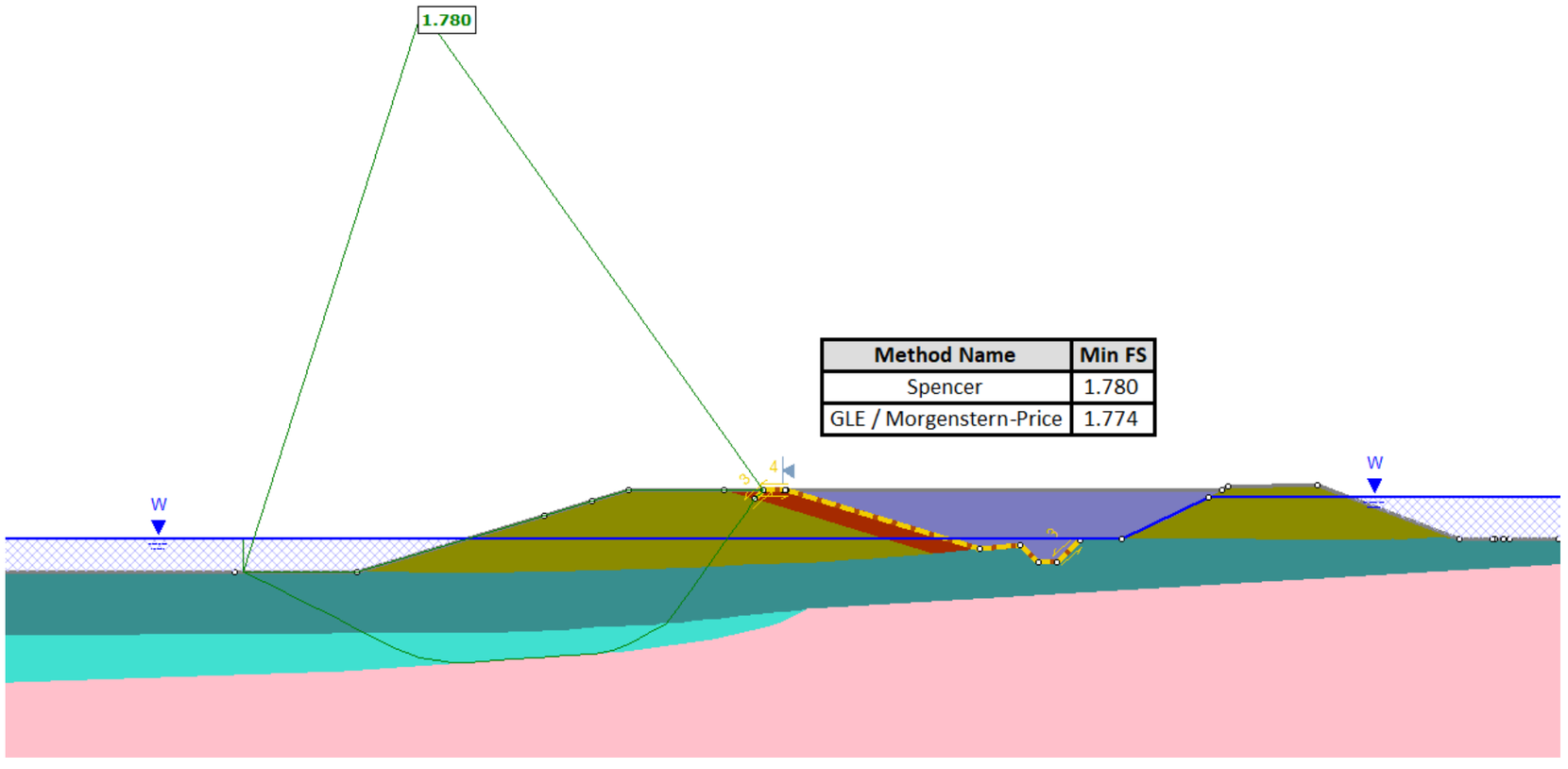
Cross-section C-C’ (Base Case w. Buttress)

Tailings Foundation c=0 kPa, φ=40°,
Lakebed Sediments s_u=16 kPa



Cross-section E-E’ (Without Buttress)

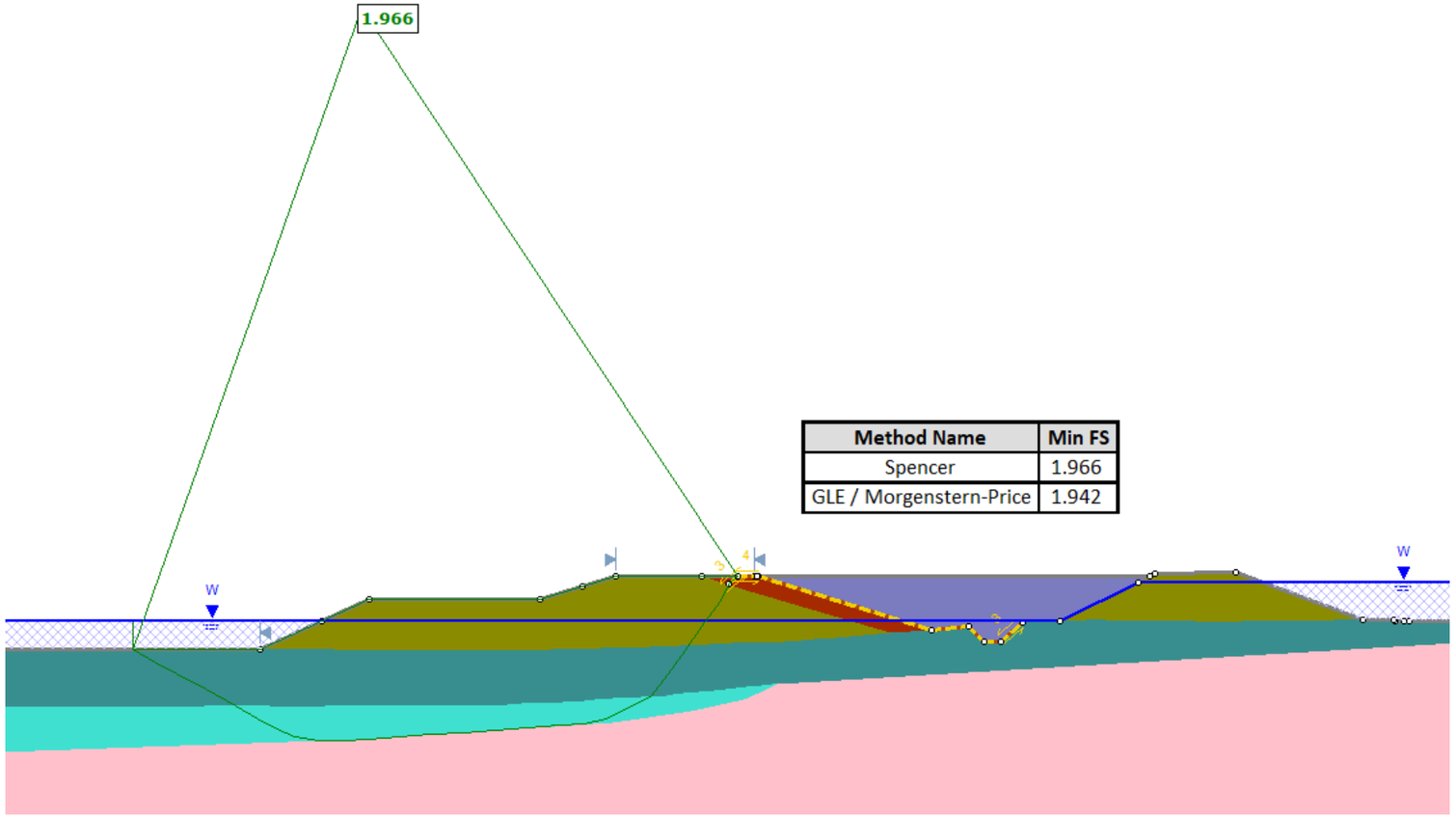
Tailings Foundation c=0 kPa, φ=40°,
Lakebed Sediments s_u=16 kPa



Method Name	Min FS
Spencer	1.780
GLE / Morgenstern-Price	1.774

Cross-section E-E’ (Base Case w. Buttress)

Tailings Foundation c=0 kPa, φ=40°,
Lakebed Sediments s_u=16 kPa



Method Name	Min FS
Spencer	1.966
GLE / Morgenstern-Price	1.942

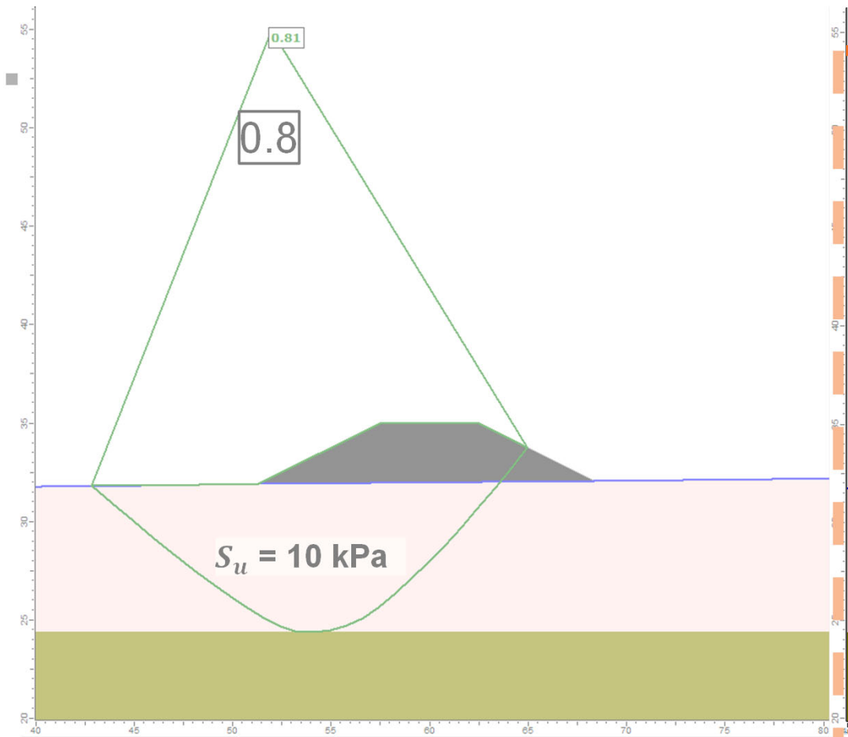
Sensitivity Runs

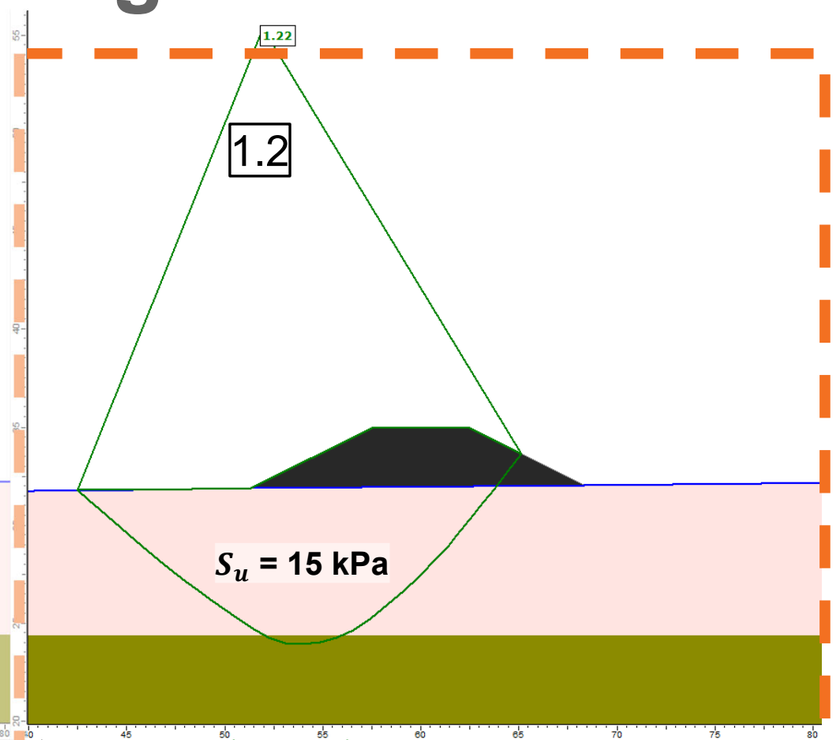
Section	Case	Calculated FoS Assuming Foundation Tailings Have Lower Undrained Shear Strength
		$S_u = 15$ kPa
C-C’	“No Buttress” Case	1.65
	Base Case with “Buttress”	1.85
E-E’	“No Buttress” Case	1.24
	Base Case with “Buttress”	1.48

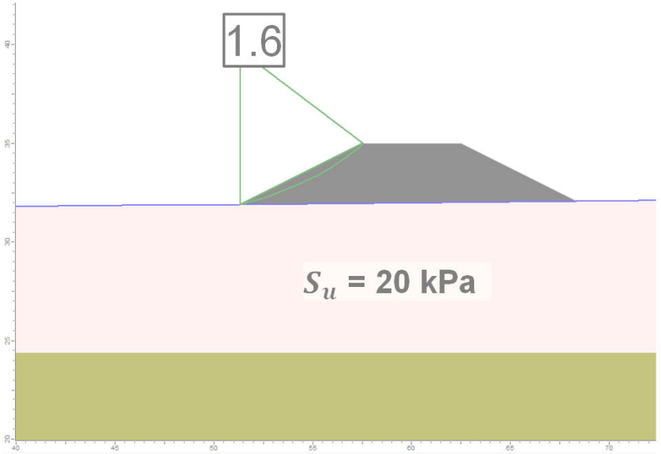
Assuming tailings foundation is not frozen and undrained (low strength) to assist in sizing the contingency buttress

Undrained Shear Strength Calibration

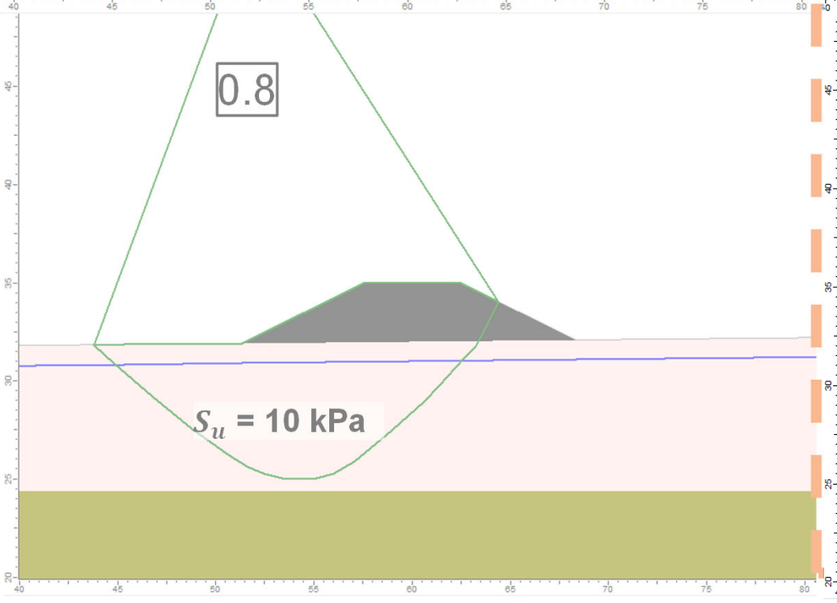
WT at tailings surface

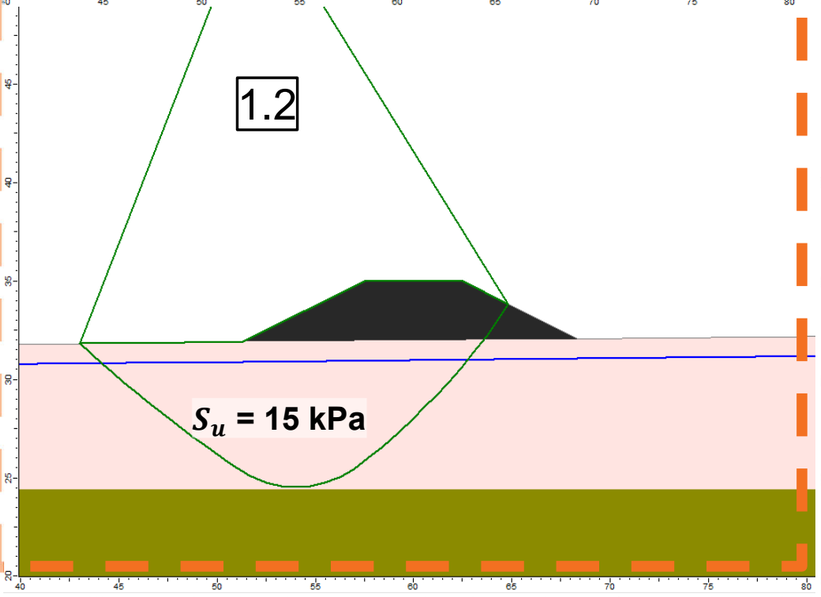


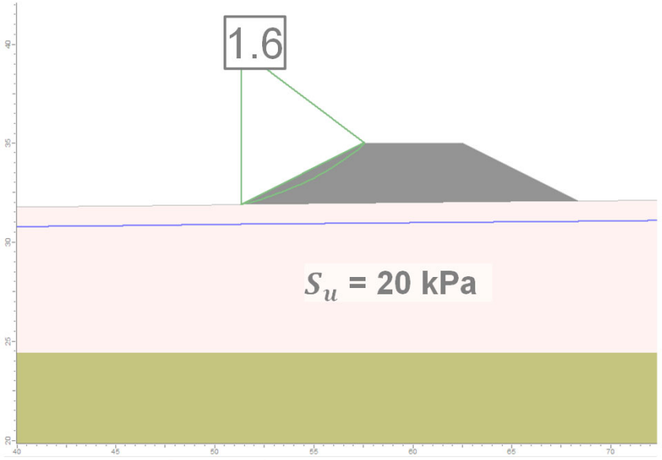




WT 1 m below tailings surface



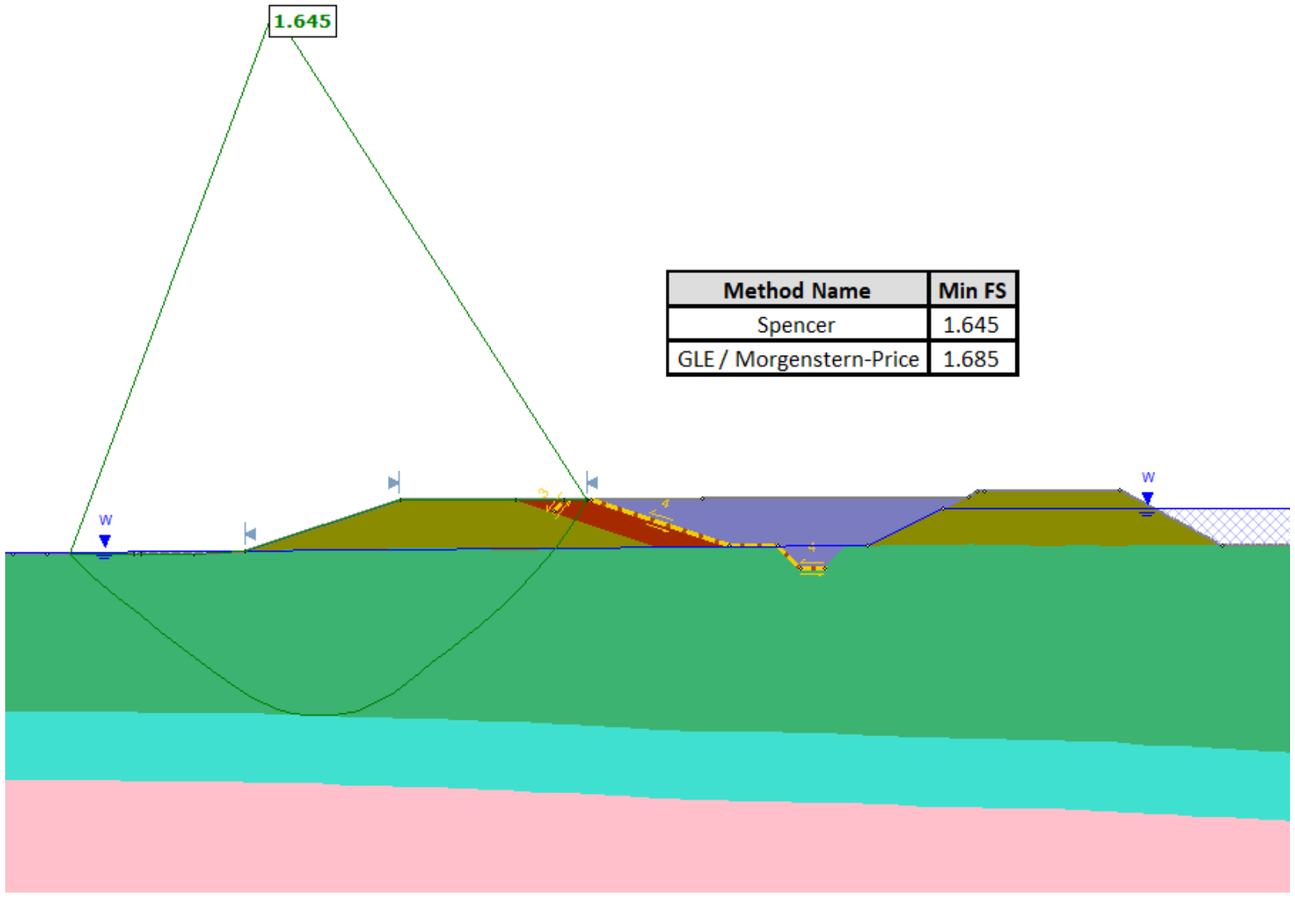




Given, the Aqua Dam access road is currently stable, foundation tailings cohesion is expected to be at least (approximately in the range of 15kPa).

Cross-section C-C’ (Without Buttress)

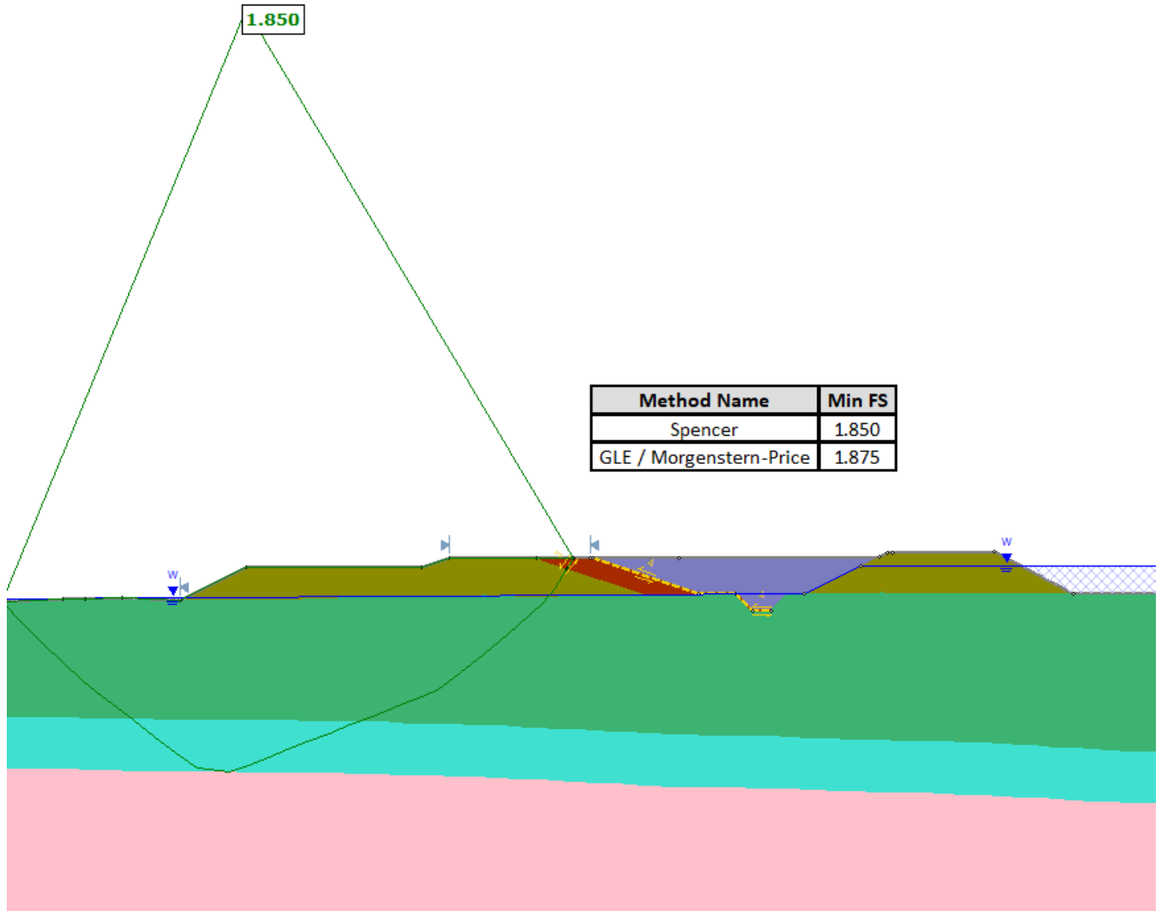
Tailings Foundation s_u=15kPa, Lakebed Sediments s_u=16 kPa



Method Name	Min FS
Spencer	1.645
GLE / Morgenstern-Price	1.685

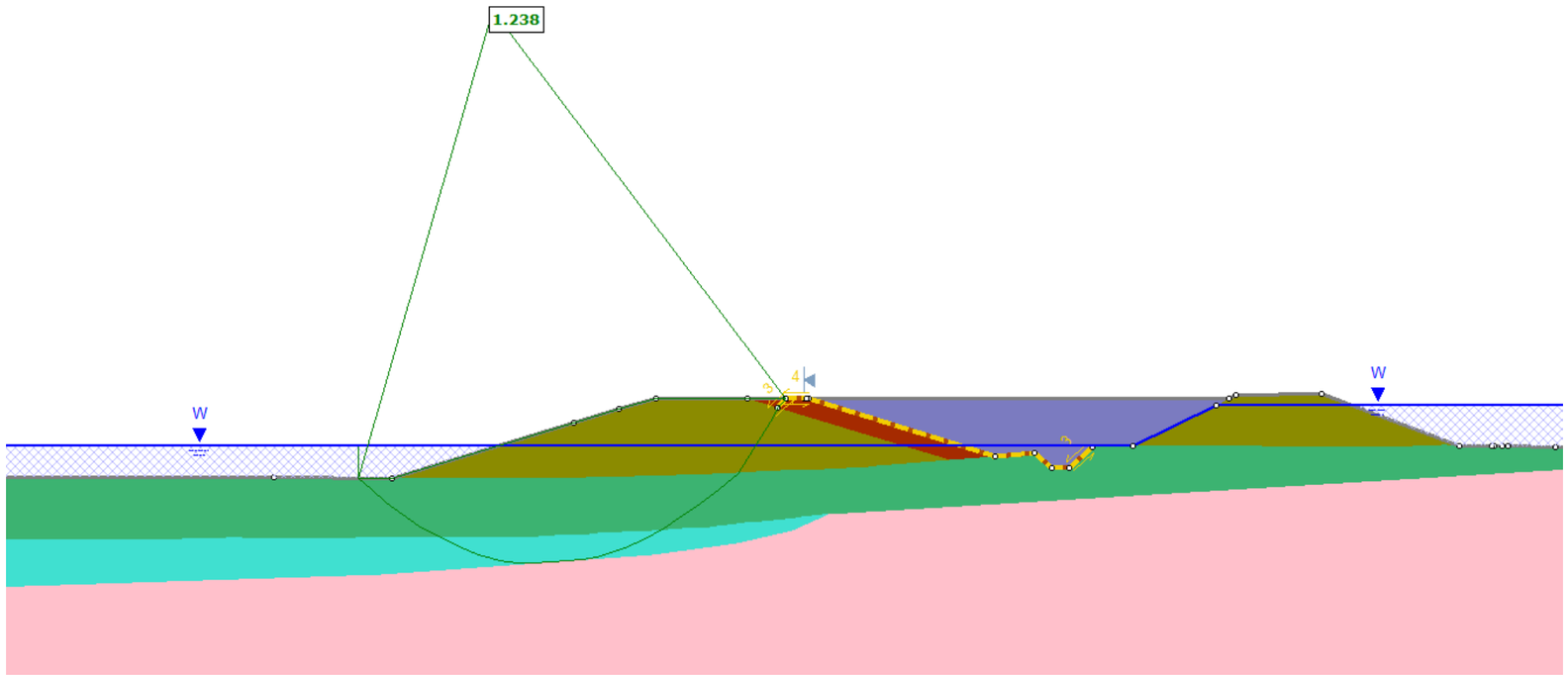
Cross-section C-C’ (Base Case, w. Buttress)

Tailings Foundation s_u=15kPa, Lakebed Sediments s_u=16 kPa



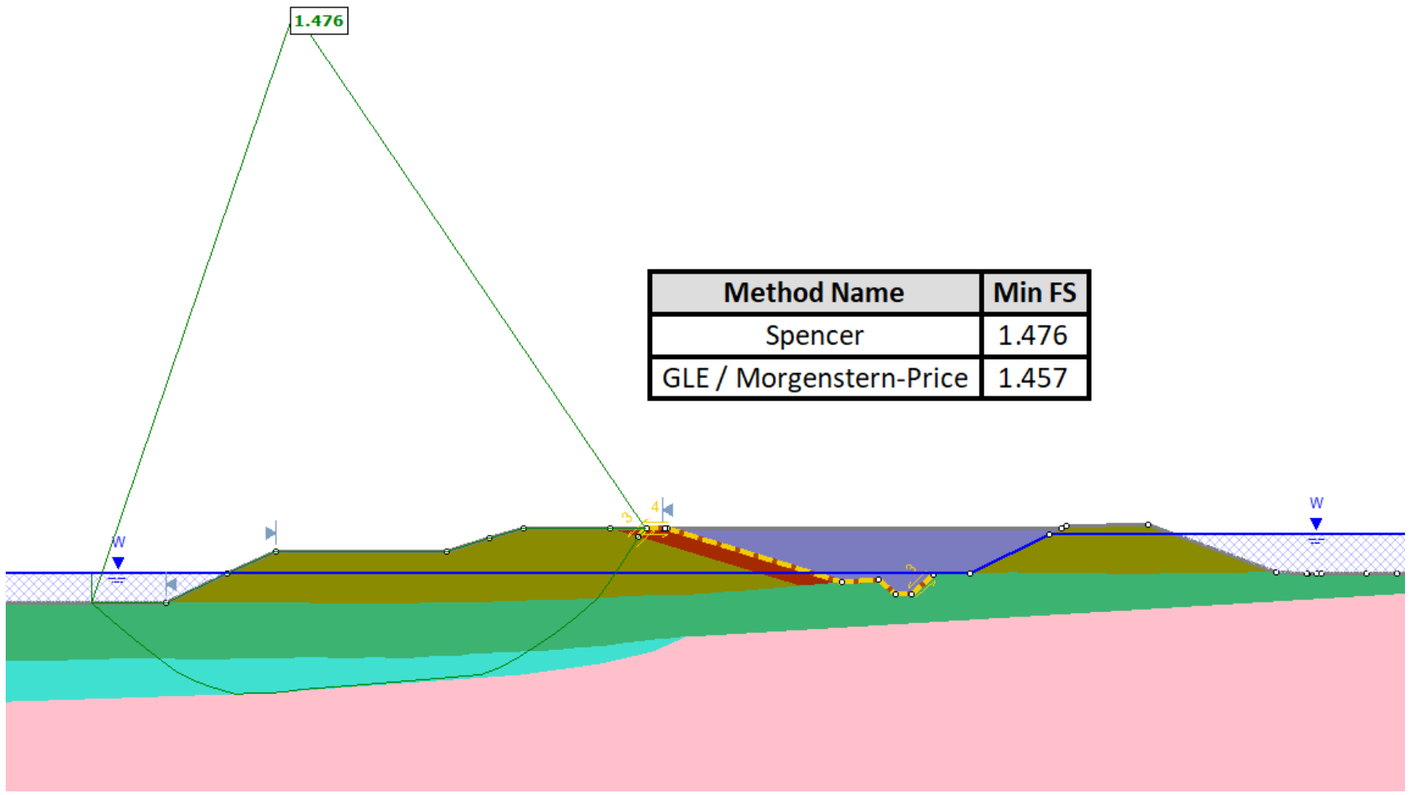
Cross-section E-E’ (Without Buttress)

Tailings Foundation s_u=15kPa, Lakebed Sediments s_u=16 kPa



Cross-section E-E’ (Base Case w. Buttress)

Tailings Foundation s_u=15kPa, Lakebed Sediments s_u=16 kPa



Method Name	Min FS
Spencer	1.476
GLE / Morgenstern-Price	1.457

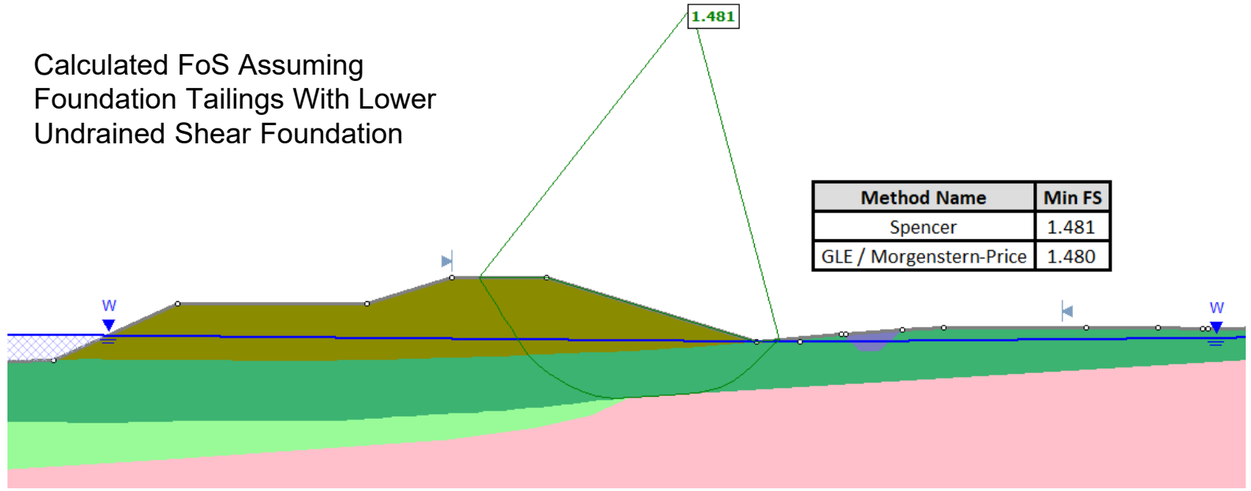
Additional Checks and Sensitivities

During Construction – Intermediate Condition

‘During Construction’ – Short Term Stability Checks (Upstream)

Bulk Rock Fill Placement

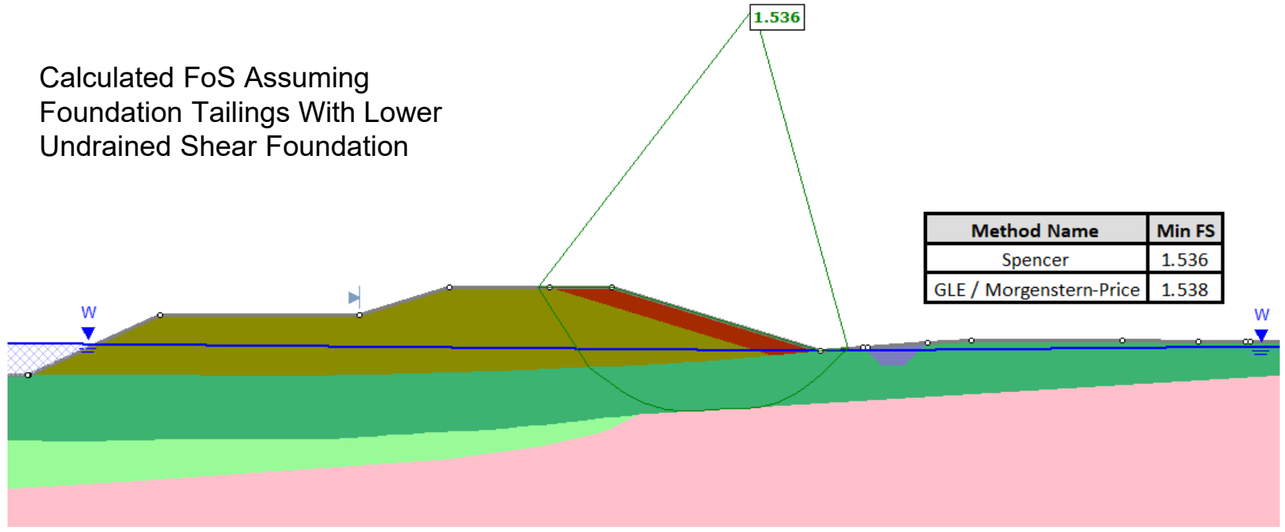
Calculated FoS Assuming Foundation Tailings With Lower Undrained Shear Foundation



Method Name	Min FS
Spencer	1.481
GLE / Morgenstern-Price	1.480

Upstream Filter and Backfilled Key Trench

Calculated FoS Assuming Foundation Tailings With Lower Undrained Shear Foundation



Method Name	Min FS
Spencer	1.536
GLE / Morgenstern-Price	1.538

Appendix B Technical Specifications

AGNICO EAGLE

Technical Specifications
Earthworks and Geotechnical Engineering
Hope Bay Project, Nunavut Canada
Revision I – Issue for Construction

Prepared for

Agnico Eagle Mines Limited

Prepared by

SRK Consulting (Canada) Inc.
CAPR00181
September 2022

Technical Specifications Earthworks and Geotechnical Engineering
Hope Bay Project, Nunavut Canada
Revision I – Issue for Construction

September 2022

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Project No: CAPR00181

File Name: HopeBay_TechSpecs_CAPR001959_IFC_RevI_20220901.docx

srk consulting

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1 General Requirements

1.1 Part 1 – General

1.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted and coordinated with all other parts.

1.1.2 Revision Summary

1. Table 1.1 provides a summary of the revision history of this Technical Specification.

Table 1.1: Revision history of this Technical Specification

Revision	Status	Date	Major Changes
A	Water Licence Application	Mar. 2007	-
A	Issued for Construction (IFC)	Mar. 2007	None
B	Issued for Construction (IFC)	Nov. 2007	Removal of payment clauses Revised scope of the Works Revised roles and responsibilities of parties Revised material specifications
C	Issued for Construction (IFC)	May 2010	Revised and added scope of the Works Revised responsible parties
D	Issued for Construction (IFC)	December 2010	Revised all elements related to the construction of the Frozen Core Dam
E	Issued for Construction (IFC)	February 2011	Added Engineers Responsibility Added clarity and detail pertaining to quality control and quality assurance requirements Corrected editorial mistakes
F	Issued for Construction (IFC)	February 2011	Updated Sections 5.3, 5.4, 7.3 and 7.4
G	Issued for Construction (IFC)	March 2011	Updated Section 7.2.10
H	Issued for Construction (IFC)	January 2018	Updated to reflect updated parties (specifically client) and considerations related to frozen foundation dam construction
I	Issued for Construction (IFC)	September 2022	Updated to reflect updated parties (specifically client) and revisited fill / material specifications.

1.1.3 Definitions

1. The following definitions and interpretations shall apply to these Technical Specifications:

   (1) PROJECT means the total Hope Bay Project Construction contemplated, of which the Works described in this Document may be the whole or part.

(2) WORKS is defined as the entire completed construction as defined by this Document, or the various separately identifiable parts thereof, required to be furnished under the Contract Documents. Works is the result of performing services, furnishing labour, and furnishing and incorporating materials and equipment into the construction, all as required by the Contract Documents.

(3) CONTRACT DOCUMENTS are defined as the agreement, addenda (which pertain to the Contract Documents), Contractor's bid (including documentation accompanying the bid and any post-bid addenda submitted) when attached as an exhibit to the agreement, the bonds, the general conditions, the supplementary conditions, these Specifications, the Drawings, together with all Modifications issued after the execution of the agreement.

(4) SPECIFICATIONS are defined as this Document of Specifications prepared by SRK Consulting (Canada) Inc. on behalf of the Owner. These Specifications are to be read, interpreted and coordinated with all Drawings and Modifications, or any other relevant documents produced by the Engineer.

(5) DRAWINGS are defined as all Engineering Drawings, plans, sketches and maps issued with these Specifications, or subsequently, as deemed necessary by the Engineer.

(6) MODIFICATIONS are defined as changes made to the Specifications and/or Drawings, which have been approved by the Engineer in writing. These modifications can be issued at any time, including after issuance of these Specifications and any accompanying Drawings and/or other Modifications.

(7) SUBMITTALS are defined as any documentation, as outlined in this Document, that are used as formal means of communication during execution of the Works, and originated by any of the Responsible Parties.

(8) Responsible Parties:

a) OWNER is defined as Agnico Eagle Mines Limited, or an authorized representative of the company. Agnico Eagle Mines Limited, Owner, Agnico, and Agnico Eagle shall have common meaning.

b) ENGINEER (also, ENGINEER-OF-RECORD) is defined as a representative appointed and authorized by the Owner for those Works described in this Document. The Engineer shall be a registered Professional Engineer in the Territory of Nunavut, or a designated site representative under direct supervision of the Engineer during construction. At the time of issuing this Document, the Engineer-of-Record is a designated employee of SRK Consulting (Canada) Inc. (SRK). The Engineer has a direct contract with the Owner, and reports to the Owner. The Engineer may not communicate directly with the Contractor and Environmental Monitor, unless approved by the Owner.

c) CONTRACTOR is defined as the party or appointed representative of the party that has an agreement with the Owner to execute the Works defined in this Document. At the time of issuing this Document, the Contractor is Nuna Logistics Limited (NUNA).

The Contractor may not communicate directly with the Engineer or the Environmental Monitor, unless approved by the Owner.

d) SUB-CONTRACTOR is defined as the party or appointed representative of the party that has an agreement with the Contractor or Owner to execute specialized components of the Works defined in this Document that cannot be carried out by the Contractor.

e) ENVIRONMENTAL MONITOR is defined as the party or appointed representative of the party that has an agreement with the Owner to act as Environmental Monitor for the Project, including the Works defined in this Document. At the time of issuing this Document, the Environmental Monitor is the Owner.

f) SURVEYOR is defined as the party or appointed representative of the party that has an agreement with the Contractor and/or Owner to act as Site Surveyor for the execution of the Works defined in this Document. The Surveyor shall have equipment and means on site to carry out horizontal and vertical ground surveys with an accuracy of ±2 mm. The Surveyor shall also have the equipment and means to prepare Digital Terrain Models (DTM) and Drawings on site that is compatible with AutoCAD 2007 or later. The Surveyor reports to the Contractor, but will be available for use by the Engineer as required, provided the Engineer has requested such needs through the Owner.

g) QUALITY CONTROL TEAM is defined as the individual(s) working under the direction of the Owner and/or Contractor to perform on-site Quality Control (QC) for the Works defined in this Document.

h) QUALITY ASSURANCE TEAM is defined as the individual(s) working under the direction of the Engineer to perform on-site Quality Assurance (QA) for the Works defined in this Document.

(9) ON-SITE MATERIAL is defined as borrow materials obtained from within designated on-site facility excavations.

(10) OFF-SITE MATERIAL is defined as material obtained from sources other than on-site.

(11) RECORD DOCUMENTS are defined as the documents prepared and certified by a Land Surveyor, Material Testing Technician, Quality Control and/or Quality Assurance Personnel, Specialist Professionals, or any other parties documenting any aspect of the Works.

(12) PRODUCTS are defined as processed fill material, machines, components, equipment, fixtures, and systems forming the Works. This does not include machinery and equipment used for preparation, fabrication, conveying, and erection of the Works. Products may also include existing material or components required for reuse.

(13) SLOPES are defined in all instances in these Specifications and on Drawings in terms of horizontal distance to vertical distance (i.e., 2H:1V shall be read as 2 Horizontal to 1 Vertical).

(14) PLANT means all the fixed equipment and structures used in fill processing, concrete mixing and explosives production.

(15) EQUIPMENT means all mobile construction equipment that will be used in execution of the Works.

1.1.4 Summary of Works

1. The Contractor, with support from the Owner, will be responsible for ensuring that all the Works defined in this Document will be executed in accordance with all appropriate permits and approvals. Furthermore, the Contractor is responsible for ensuring that all the Works are carried out in accordance with the Owners Environmental Procedures.
2. The Works covered by this Specification includes, but is not limited to the following:

   (1) Implementation, operation, maintenance and removal of temporary construction runoff management and sediment control measures.

   (2) Construction of permanent surface water management controls, including contour berms, pollution control ponds and sumps.

   (3) Operation and management of permanent surface water management controls up to the time of complete demobilisation.

   (4) Clearing, stripping and excavation in required areas.

   (5) Development of borrow areas and borrow access roads. This includes quarry development, management and closure.

   (6) Production of construction material specified in the Specifications, and on the Drawings.

   (7) Construction of earthworks components of all-weather roads.

   (8) Construction of earthworks components of road turnouts and caribou crossings along all-weather roads.

   (9) Construction of earthworks components of bridge abutments.

   (10) Construction of earthworks components of arch culvert installations.

   (11) Construction of earthworks components of all-weather airstrip and aprons.

   (12) Construction of earthworks components of laydown areas.

   (13) Construction of earthworks components of camp/mill pads.

   (14) Construction of earthworks components of permanent explosives storage facility pads.

   (15) Construction of earthworks components of waste rock pile pad.

   (16) Construction of earthworks components (including liner) of pollution control pond(s).

   (17) Construction of earthworks components (including liner) of sedimentation pond(s).

   (18) Construction of earthworks components (including liner) of landfarm.

(19) Construction of North Dam (frozen core dam).

(20) Construction of South Dam (frozen foundation dam).

(21) Construction of an Emergency Overflow Channel

(22) Construction of earthworks components (including liner) of emergency dump catch basins.

(23) Construction on the TIA Interim Dike

(24) Installation of permanent monitoring instrumentation for the Works including, thermistors, settlement plates, slope inclinometers, and survey beacons.

(25) Installation of shoreline erosion protection measures around Doris Tailings Impoundment Area.

(26) Removal of temporary structures used during construction of the Works and clean-up of the construction areas, borrow areas, and stockpile areas.

3. Electrical, instrumentation (other than specified), mechanical, concrete and structural work are excluded from this scope of work.

1.1.5 Contradictions

1. Should any contradiction, either implied or real, exist between the Specifications and the Drawings, the Contractor shall:

   (1) Notify the Owner and the Engineer.

   (2) Stop all Works that concern the contradiction until the contradiction is remedied or clarified by the Engineer.

2. The decision of the Engineer is final.

1.1.6 Owner Responsibilities

1. The Owner, in the context of the Works defined in this Document, shall:

   (1) Be the formal liaison between all parties.

   (2) Be responsible for overseeing execution of the Works, in accordance with the Engineer's Specifications and Drawings.

   (3) Be responsible for procurement of all materials to execute the Works.

   (4) Become familiar with all relevant permits, approvals and any other administrative matters which may impact the Works. The Engineer will assume that all appropriate approvals have been obtained and that all conditions have been satisfied when giving technical approvals to proceed with the Works.

   (5) Before proceeding with the Works, examine all Drawings and Specifications and report to the Engineer any apparent discrepancies or interferences. The Engineer shall at all times retain the right to make revisions to the Drawings and the Specifications.

(6) Ensure an appropriate work space, necessary facilities and transportation equipment is available to the Engineer or the Engineer's representatives to perform their duties on site.

(7) Ensure that the Engineer and the Engineer's representatives receive appropriate site-specific health and safety training and/or orientation whilst on site.

1.1.7 Contractor's Responsibilities

1. The Contractor, in the context of the Works defined in this Document shall:

(1) Comply with Nunavut Worker Compensation Board, Northern Canada Mine Safety Act and any other relevant required health and safety regulations.

(2) Comply with Owner's Environmental Procedures.

(3) Provide the Owner with a copy of the Health and Safety Plan, which has been specifically prepared for this Project.

(4) Become familiar with the relevant regional and site-specific conditions that deviate from the Specification and Drawings, and inform the Engineer through the Owner when a problem or delay is anticipated.

(5) Be responsible for making independent measurements and installing the Works to fit the conditions encountered.

(6) Before proceeding with the Works, examine all Drawings and Specifications and report to the Engineer via the Owner any apparent discrepancies or interferences. The Engineer shall at all times retain the right to make revisions to the Drawings and the Specifications.

1.1.8 Engineer's Responsibilities

1. The Engineer, in the context of the Works defined in this Document, shall:

(1) Comply with Owner's Environmental Procedures.

(2) Provide the Owner and Contractor with Drawings and Specifications, including Revisions and Modifications, to be able to conduct the Works defined in this Document.

(3) Provide the Owner and Contractor with digital Drawing files to facilitate setting out the Works defined in this Document.

(4) Provide full-time site Engineer(s) during construction of the Works as defined in this Document. The Engineer will monitor construction activities to ensure that the Works are constructed in accordance with the Drawings and Specifications.

(5) Ensure timely response as defined in this Document, to Submittals pertaining to the Drawings or Specifications submitted by the Owner and Contractor.

1.1.9 Codes and Standards

1. The Quality Control and Assurance Program (QA/QC) as described in this Document, shall use testing procedures from, but not limited to the list of American Society of Testing and Materials Standards in Table 1.2.

Table 1.2: List of Codes and Standards

Test	Topic
ASTM D2487	Classification of Soils for Engineering Purposes
ASTM D2216	Water (Moisture) Content in Soil and Rock
ASTM C136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D854	Specific Gravity of Soils
ASTM D698	Laboratory Compaction Characteristics of Soil Using Standard Effort
ASTM D2922	Density of Soil in Place by Nuclear Methods

1.1.10 Quality Control

1. The Contractor will carry out Quality Control (QC) for the Works defined in this Document, and will undertake testing at a frequency and at the locations specified in the various sections of these Specifications and Drawings, or as defined in their approved Quality Control program.
2. The Contractor shall submit a copy of the QC program for review by the Engineer and Owner at least seven (7) days prior to commencement of the Works.
3. All QC or other test data, survey data or the like, collected by the Contractor, shall be made available to the Owner and Engineer on request.
4. The Owner and Contractor shall provide all the necessary equipment and technicians for materials and product testing required to execute the QC program.
5. QC shall be done continuously, as specified in this Document, to ensure the quality of products and Works.
6. The Contractor’s QC shall be done independently from the Engineer’s Quality Assurance (QA).
7. QA, or any other form of performance testing by the Engineer or Owner, shall in no way relieve the Contractor of its sole responsibility for completing the Works in accordance with the specified requirements.
8. Geochemical testing of any construction material will be the responsibility of the Owner, and will be controlled by the Owner. The Contractor is however responsible to ensure that any applicable testing has been carried out and that any construction material has been approved for use.

1.1.11 Quality Assurance

1. The Engineer will carry out Quality Assurance (QA) for the Works defined in this Document, and will undertake testing at a frequency and at the locations specified in the various sections of these Specifications and Drawings. The Engineer may undertake any additional testing which is deemed necessary on any part of the Works.
2. This Document, and the Drawings outline the Engineer's QA program, and is subject to review by the Owner and Contractor.
3. All QA or other test data, collected by the Engineer, shall be made available to the Owner and Contractor on request.
4. The Contractor and Owner shall render such assistance as is necessary to enable QA sampling and testing to be carried out expeditiously, and provide all the necessary equipment, including an adequately equipped on-site laboratory.
5. The Engineer's QA shall be done independently from the Contractors QC.
6. QA, or any other form of performance testing by the Engineer or Owner, shall in no way relieve the Contractor of its sole responsibility for completing the Works in accordance with the specified requirements.
7. Geochemical testing of any construction material will be the responsibility of the Owner, and will be controlled by the Owner. The Contractor is however responsible to ensure that any applicable testing has been carried out and that any construction material has been approved for use.

1.1.12 Submittals

1. The Contractor shall submit information as specified and requested from the Engineer through the Owner. All submittals required by the Engineer will be requested through the Owner.
2. The Engineer has the right to request as a Submittal any other information deemed necessary throughout execution of the Works. This includes information not currently defined as Submittal information on the Drawings and Specifications.

1.1.13 Construction Schedule

1. Construction scheduling is the responsibility of the Owner; however, the Contractor and Owner is reminded of the following very important facts:
   (1) Construction of the North Dam can ONLY be carried out in the winter, when the constant ambient outside air temperature is a maximum of -10°C. This ambient air temperature must be maintained from the time the foundation base is cleared and stripped, until the entire Run-of-Quarry shell has been placed in accordance with the Specifications and Drawings.

(2) The Core material placement must be conducted when air temperatures will freeze a lift of key trench material within 24 hours of placement. Experience has shown that a 250 mm thick lift freezes back within 24 hours when air temperatures are below -15ºC. The time to freeze back will depend on the moisture content, wind speed, air temperature and solar radiation.

(3) The excavation and backfill of the key trench for the South Dam can ONLY be completed in the winter, when ambient outside air temperature is a maximum of -5°C. The bulk rock fill of the South Dam can be constructed any time of the year.

(4) The Contractor and Owner must submit a detailed schedule of the dam construction to the Engineer at least 14 days prior to commencement of construction. The Engineer reserves the right to halt the start of construction of the dams, if in its opinion there is an unacceptable risk that the construction cannot be completed under the required ambient air temperatures.

1.1.14 Construction Drawings

1. Drawings will be issued by the Engineer specific to construction needs prior to commencement of the Work. Drawings shall be reviewed by the Owner and Contractor to ensure all aspects of the construction needs are covered, and report to the Engineer any discrepancies and interferences. The Owner shall notify and inform the Engineer of construction progress and Drawing requirements four (4) weeks prior to commencement of any Works.
2. Only Drawings explicitly marked with the following words are considered acceptable for Construction: ISSUED FOR CONSTRUCTION, or IFC.

1.1.15 Construction Specifications

1. Specifications will be issued by the Engineer specific to construction needs prior to commencement of the Work. Specifications shall be reviewed by the Owner and Contractor to ensure all aspects of the construction needs are covered, and report to the Engineer any discrepancies and interferences. The Owner shall notify and inform the Engineer of construction progress and Specification requirements four (4) weeks prior to commencement of any Works.
2. Only Specifications explicitly marked with the following words are considered acceptable for Construction: ISSUED FOR CONSTRUCTION, or IFC.

---------- END OF SECTION 1 ----------

2 Clearing and Stripping

2.1 Part 1 – General

2.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted and coordinated with all other parts.

2.1.2 Definitions

1. The following words and terms, unless the context otherwise requires, in this Specification, shall have the meanings set out below:

   (1) CLEARING means Works involved in the removal of snow and ice on natural ground or subgrade surface to the satisfaction of the Engineer.

   (2) STRIPPING means Works involving excavation and removal of unsuitable material including but not limited to organics and ice rich materials.

2.1.3 Description

1. The Works covered by this section consists of supplying all labour, materials, and equipment, and performing all Works necessary for clearing and stripping.
2. The Contractor shall clear and/or strip the Works areas as required including, but not limited to borrow areas, disposal areas, stockpile areas, laydown areas, water management areas, foundation zones and between individual lifts of fill placement, as shown on the Drawings, or inferred by these Specifications or as directed by the Owner with explicit approval from the Engineer.
3. Clearing and stripping in all areas shall require approval by the Engineer before such Works begins.
4. It is the Owner’s responsibility to identify and acquire all necessary permits and approvals for stockpiling and storage of materials removed through the process of clearing and/or stripping.

2.1.4 Submittals

1. At least seven (7) days prior to clearing, stripping, or clearing and stripping in any specific area, the Contractor shall submit to the Engineer and Owner, for approval, a Clearing and Stripping Work Plan describing the schedule, locations and extent of the clearing and stripping, and the proposed methods for disposal of clearing and stripping products.
2. Work shall not start until applicable approvals are obtained from the Owner in writing.
3. Approval of submittals shall not relieve the Contractor of its sole responsibility to construct the Works in accordance with specified requirements.

2.1.5 Permits and Regulations

1. The Owner shall conduct all work in accordance with the Owner's and all applicable Federal, Territorial, local or landowner regulations and licences regarding the disposal of materials from clearing and stripping.
2. It is the Owner's responsibility to be familiar with all said regulations, conditions and permits.

2.1.6 Protection

1. Unless otherwise instructed, the Contractor is to take all necessary precautions to prevent damage to natural and man-made features, including, but not limited to survey monuments, survey markers, archaeological sites, monitoring instrumentation and the sensitive tundra landscape.
2. The Contractor may not perform any Works outside of the permitted and approved construction area.

2.2 Part 2 – Execution

2.2.1 Preparation

1. The Contractor shall confirm the clearing or stripping limits by having the Surveyor lay out and flag the extents of all areas of work, prior to commencement of clearing or stripping. The Engineer will inspect these demarcated areas and confirm all clearing or stripping limits before giving approval to proceed to the Owner. The Owner will in turn authorize the Contractor to proceed with the Works.
2. The Contractor shall inspect the Works site and verify with the Engineer and the Owner any restrictions within or adjacent to the clearing limits.
3. Unless specifically instructed otherwise, the Contractor shall locate and protect natural and man-made features, including, but not limited to survey monuments, survey markers, archaeological sites, monitoring instrumentation and the sensitive tundra landscape.

2.2.2 Clearing

1. Snow and ice shall be removed from all construction footprint areas, prior to undertaking any work in that area, with a maximum tolerance of 10 cm of uncompacted snow material left above natural ground, or otherwise approved by the Engineer.
2. Should snow fall on previously cleared or stripped surfaces that have been prepared and approved for construction, including between individual lifts of fill placement, the Contractor will carry out any additional clearing as requested by the Engineer.
3. The Contractor shall take all necessary precautions to prevent damage to natural and frozen ground, unless specifically instructed otherwise by the Engineer.

2.2.3 Stripping

1. Where required, and as a minimum in areas to be excavated, areas subjected to clearing shall undergo stripping to the depth necessary to remove all soil, including permafrost and

other organic material necessary to expose bedrock, or other suitable foundation conditions as directed by the Engineer.

2. Should blasting be required of permafrost soils, the Contractor will comply to all Specifications associated with blasting, in addition to those listed in this Section.

2.2.4 Finished Surface

1. The Contractor shall leave the cleared and/or stripped surface clear, smooth, debris- and snow-free, in a condition suitable for inspection by the Engineer.

2.2.5 Disposal

1. Snow and ice cleared off the construction area shall be stockpiled downstream and outside of the construction area where it will not affect the construction or any constructed elements during thaw. The stockpile area shall be proposed by the Contractor and approved by the Owner. A water management plan, prepared by the Contractor, and approved by the Owner, must be in place prior to stockpiling snow and ice in the specified area.

2. Soil and organic material stripped off the construction areas shall be stockpiled in designated areas approved by the Owner with proper sediment control as instructed in permit requirements.

2.3 Part 3 – Quality Control

1. Submit a Clearing and Stripping Work Plan as defined in Section 2.1.4 of this Document.

2. Confirm with Owner that all permits and approvals are in place prior to commencing any work.

3. Physically demarcate, for review and approval by the Owner and Engineer, the Works area that will be cleared and/or stripped using appropriate survey control. Within this zone clearly identify natural and man-made features that require protection as defined in this Document.

4. Implement measures, including spotters as needed, to allow visual inspection of clearing and/or stripping activities during execution to ensure it is done in accordance with the Specifications as defined in this Document.

5. Conduct field surveys, and submit As-built Drawings, in electronic format of any cleared and/or stripped areas, as requested by the Engineer or Owner.

2.4 Part 4 – Quality Assurance

1. Review the Contractor's Clearing and Stripping Work Plan as defined in Section 2.1.4 of this Document and submit review comments back to the Contractor via the Owner.

2. Visually inspect the demarcated zone prepared by the Contractor for clearing and/or stripping and inform the Contractor via the Owner if changes are required.

3. Visually inspect the cleared and/or stripped areas and inform the Contractor via the Owner if changes are required.

4. Review As-built Drawings submitted by the Contractor of cleared and/or stripped areas and inform the Contractor via the Owner if any changes are required.

---------- END OF SECTION 2 ----------

3 Excavation and Water Control

3.1 Part 1 – General

3.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted and coordinated with all other parts.

3.1.2 Description

1. The excavation Works entails removal of soil and other materials below existing ground surface to neat lines and grades as indicated on the Drawings.
2. The Works to be done under this Section consists of furnishing all labour, material, plant and equipment, and the performance of all Works necessary to carry out rock, soil and permafrost excavation as shown on the Drawings, and as specified herein.
3. The Works shall also include the loading, transportation and permanent disposal of all excavated materials which are deemed by the Engineer to be surplus, or unsuitable for use as construction material, and the loading, transportation and possible temporary stockpiling and re-handling of acceptable materials to locations where they can either be used as part of the temporary or permanent structures, or stockpiled in readiness for future temporary or permanent use.
4. The Owner and Contractor will be responsible to locate suitable stockpile locations for any excavated material, whether temporary or permanent. The Engineer will however have the right to reject any identified sites, if in his opinion it may interfere with any of the Works.

3.1.3 Exclusions

1. The Contractor is responsible for quarry development. The Engineer does however reserve the right to request modifications to the quarry development plan if the materials being produced do not meet Specifications. Any such requests must be submitted through the Owner.

3.1.4 Definitions

1. The following words and terms, unless the context otherwise requires, in this Specification, shall have the meanings set out below:
   (1) SOIL and OVERBURDEN meaning is interchangeable and means general overburden material including glacial marine clays, silty clays, sand, gravel, till and any combination of these materials, which can be used in part as Bedding material for liners or concrete aggregate if they are free of contaminants, snow, ice and organic material, and if approved by the Engineer.
   (2) PERMAFROST means soil that is permanently frozen, in accordance with the appropriate normal geotechnical definitions.

(3) ROCK means quarried material from a designated quarry site, or from a designated foundation excavation.

(4) UNSUITABLE MATERIAL means any soil or rock that does not meet the Specifications for the use of this project.

(5) BLASTED MATERIAL means any material produced by production blasting at all quarry or excavation sites.

(6) NEAT LINE means the final line or grade to which excavation is to be performed.

(7) QUARRY and BORROW AREA meaning is interchangeable and means a designated location from where construction materials can be obtained.

(8) COMMON EXCAVATION means excavation of all materials, including rock, weathered bedrock, soil, permafrost and unsuitable material by mechanical means.

3.1.5 Procedures

1. The details of the surface excavations shown on Drawings represent an engineered design encompassing drainage under particular assumed conditions. Variations in site conditions may require adjustments to the excavation shape, slope reinforcement and drainage under the Engineer's direction.

2. If, in a specific area, a plan that has been previously adopted does not fit the site conditions in accordance with the requirements of these Specifications, the Engineer shall submit a revised plan to the Owner before continuing excavation in identified areas.

3. All earthworks that will potentially disturb original ground shall be constructed during the winter season to prevent damage to the tundra. All construction Works and traffic shall be within the constructed footprint during summer months.

4. Water management measures shall be constructed and implemented during the winter months as directed by the Owner, and only emergency adjustments can be made during the following spring and summer as approved by the Owner.

3.1.6 Submittals

1. The Contractor shall submit a detailed Excavation Plan to the Owner and the Engineer outlining the intended methods for excavation within a given area at least seven (7) days prior to the commencement of Works including, but not limited to the following details:

   (1) Typical equipment deployment.

   (2) Sediment and runoff control around the intended Works.

   (3) Water control and dewatering plan for Works where inflow of ground water or surface runoff could occur.

   (4) Typical blast method including hole size, depth, spacing, burden and loading details for production, buffer, pre-split holes, if required.

2. The Contractor's excavation plan must be approved by the Owner and the Engineer.
3. Work shall not start until applicable approvals are obtained from the Owner in writing.
4. Approval of submittals shall not relieve the Contractor of its sole responsibility to construct the Works in accordance with specified requirements.

3.2 Part 2 – Execution

3.2.1 Preparation

1. Prior to beginning a grading or excavation operation in any area, all necessary clearing and/or stripping in that area shall have been performed in accordance with the Specifications.
2. The Contractor shall confirm to its satisfaction the character, quantity, and distribution of all the material to be excavated.
3. The Contractor shall have in place a contingency plan for sudden unforeseeable change of weather conditions prior to excavation commencement. The Contractor shall have a daily Works plan in relation to the weather conditions, equipment, operator availability, area of Works, and schedule.
4. The Contractor shall be responsible for sediment and runoff control around the construction area to ensure there is minimal impact on the natural state of the surrounding environment in accordance to all issued regulations, licenses and permits.
5. The Contractor shall be responsible for all dewatering and water control to allow for fill placement in a dry, ice-free environment.

3.2.2 Common Excavation Methods

1. Common excavation of weathered bedrock and soil, including permafrost, shall be performed to the lines, grades, and elevations as indicated on the Drawings, or as directed by the Engineer, and shall be finished to a reasonable smooth and uniform surface.
2. Should the Contractor, through carelessness or other fault, excavate beyond the designated grades, it shall replace the excavation using an approved method, in accordance with the Specification, or any modification thereof as directed by the Engineer.
3. All excavated material determined unsuitable by the Engineer shall be disposed of as directed by the Owner.
4. At all times during construction, the Contractor shall adopt excavation procedures such that at no time shall the stability of any slope be impaired. The Engineer reserves the right to stop work if it deems the conditions to be unsafe.

3.2.3 Excavation in Quarry Areas

1. Borrow excavation shall be performed to the lines, grades, and elevation as indicated on the Drawings or as directed by the Engineer.

2. Borrow development will be the responsibility of the Contractor in accordance with staged plans submitted to the Owner and Engineer for approval prior to undertaking the Works.
3. Methods of access and excavation in the borrow areas will be determined by the Contractor, unless otherwise directed by the Owner or Engineer.
4. The Contractor shall use appropriate blasting methods to control the height of each bench and associated material gradation. The Contractor is responsible for fragmentation and throw of the material to ensure ease of excavation.
5. Excavation in the borrow area should be optimized by the Contractor for safety of equipment operation, water control, and bench stability.
6. Prior to excavation of the material, certified personnel must inspect the blast pattern to ensure all blasting agents were ignited and none were left behind.

3.2.4 Control of Water

1. Surface water flows during the melting seasons shall be directed away from the Works by means of diversion berms, ditches or other acceptable means and, in any case, all surface flows on the Works area shall be satisfactorily controlled, and to the environmental standards specified.
2. Any inflow of ground water or surface runoff water into an excavation must be controlled using suitably placed and sized sumps and pumps.
3. Any water collected in the sumps must be discharged in an approved manner to a designated area away from the construction activities. A pumping and discharge contingency plan should be discussed with and submitted to the Engineer and Owner for approval prior to construction.
4. The construction, operation, and maintenance of the sump(s) and pump(s) are the responsibility of the Contractor.

3.2.5 Scaling, Slope Stability and Safety

1. Immediately following excavation and at any time during the Works, all loose material on slopes, which appears to be unsafe or to endanger workmen, structures or equipment, shall be scaled and removed.
2. All slope stability measures will be considered incidental to the Works, and will be the responsibility of the Contractor with inspections done by the Owner and Engineer.

3.2.6 Key Trench Excavation

1. Key trench excavation for dam construction shall be performed to the lines, grades, and elevation as indicated on the Drawings or as directed by the Engineer. The key trench must be excavated into ice-saturated, permanently frozen soil or bedrock as determined by the Engineer.

2. The depth of excavation will be confirmed in the field by the Engineer. The depth of the key trench may be increased in some areas at the discretion of the Engineer to confirm the suitability of the foundation soils beneath the key trench.
3. Where bedrock is encountered, the base of the key trench must be ended on smooth and competent rock. Removal of fractured rock may be required, as directed by the Engineer.
4. The key trench can be excavated using mechanical, or drill and blast means.
5. Final cleaning of the key trench must be conducted with hand excavation, brooms and compressed air or other appropriate equipment such as rippers, jack hammers etc. to remove all loose, broken or altered material from the base of the key trench.
6. Areas underlying the liner system must be free of ice-rich soils or loose broken bedrock. Exposed ice-rich overburden and fractured bedrock must be removed. Additional excavation beyond the limits of the key trench excavation may be required at the Engineer's discretion.
7. Any inflow of water into the key trench excavation shall be controlled by sumps and pumps in a manner that minimizes thaw and erosion of the key trench base.

3.3 Part 3 – Quality Control

1. Submit an Excavation Plan (including a water management and dewatering plan, if required) as defined in Section 3.1.6 of this Document.
2. Confirm with Owner that all permits and approvals are in place prior to commencing any Works.
3. Physically demarcate, for review and approval by the Owner and Engineer, the Works area that will be excavated using appropriate survey control.
4. Implement measures, including spotters and frequent survey control as needed, to allow visual inspection of excavation activities during execution to ensure it is done in accordance with the Drawings and Specifications as defined in this Document.
5. Implement measures to ensure adequate water management and dewatering as necessary.
6. Advise the Engineer and Owner when an excavation has been completed and is ready for inspection and/or approval. Interim survey control may be requested by the Engineer via the Owner to confirm lines and grades have been met.
7. Conduct a field survey and submit As-built Drawings, in electronic format, of any excavated area to the Engineer and Owner.

3.4 Part 4 – Quality Assurance

1. Review the Excavation Plan (including a water management and dewatering plan, if required) as defined in Section 3.1.6 of this Document and submit review comments back to the Contractor via the Owner.
2. Visually inspect the demarcated zone, and any associated survey files prepared by the Contractor for excavation, and inform Contractor via the Owner if changes are required.

3. Visually inspect the excavated area, and any associated survey files, and inform the Contractor via the Owner if changes are required.
4. Visually inspect water management and dewatering if required, and inform the Contractor via the Owner if changes are required.
5. Review As-built Drawings submitted by the Contractor of excavated areas and inform the Contractor via the Owner if any changes are required.

---------- END OF SECTION 3 ----------

4 Drilling and Blasting

4.1 Part 1 – General

4.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted and coordinated with all other parts.

4.1.2 Description

1. All blasting operations must be performed in accordance with the Owners Environmental Procedures and all Federal and Territorial Regulations and Licences.
2. Blasting near water bodies frequented by fish, will require lower powder factors, as determined by Guidelines issued by the Department of Fisheries and Oceans.
3. The Contractor will be responsible to become familiar with all appropriate conditions and constraints that apply to blasting.
4. The Works to be done under this Section consists of supplying all labour, materials, plant and equipment, and performing all Works necessary to carry out drilling and blasting with certified personnel and chemical agents as shown on Drawings and specified herein.
5. The Works shall include; but are not limited to:
   (1) Provide a typical list of safety protocols, chemical blasting agents, blast patterns and powder factors suitable for carrying out the Works, and for producing the specified construction materials.
   (2) Drilling with appropriate equipment, to appropriate depth and grade to execute the Works, develop rock quarries and any other common excavation as shown on the Drawings, or as directed by the Engineer.
   (3) Provide suitably qualified personnel, with current blasting certificates, to carry out all safety protocols for blasting required by the regulations prior to ignition.

4.1.3 Definitions

1. The following words and terms, unless the context otherwise requires, in this Specification, shall have the meanings set out below:
   (1) CERTIFIED PERSONNEL mean a suitably qualified person holding current blasting certificates issued by the appropriate Territorial and Federal Regulatory agencies with jurisdiction over the Project.
   (2) CHEMICAL BLASTING AGENTS means any form of explosive materials, and components thereof, that are suitable for use in the Project.
   (3) DETONATOR and BLASTING CAP meaning is interchangeable and means any suitable form of explosive charge used to initiate the detonation of the chemical blasting agents.

(4) DETONATOR CORD, DETCORD, and PRIMER CORD meaning is interchangeable and means a waterproof, flexible tube containing a high explosive designed to transmit the detonation wave.

4.1.4 Submittals

1. The Contractor shall submit a Drilling and Blasting Plan to the Engineer and Owner describing the schedule, and proposed methods for borrow development and common excavation, at least seven (7) days prior to the commencement of Works.
2. Work shall not start until applicable approvals are obtained from the Owner in writing.
3. Approval of submittals shall not relieve the Contractor of its sole responsibility to complete the Works in accordance with specified requirements.

4.2 Part 2 – Products and Personnel

1. The Contractor is responsible to procure all necessary supplies and equipment for drilling and blasting operations, excluding the chemical blasting agents, detonators and detonator cords, which will be supplied by the Owner.
2. The Contractor is responsible to acquire all required licenses and notifications from Territorial and Federal Regulatory Agencies.
3. The Contractor is responsible to have appropriately qualified and certified persons to handle all aspects of the drilling and blasting Works, including, but not limited to management of inventory, mixing of explosives, storage of explosives, transportation of explosives, placing of detonators, initiation of blasts, and clearing of explosives after blast.
4. The Contractor is responsible for management, maintenance and security of the Explosives Facility, whether temporary or permanent.

4.3 Part 3 – Execution

4.3.1 Drilling

1. The Contractor will lay out the appropriate blast pattern for the specified material grade required, at appropriate locations.
2. The Contractor will drill the blast holes in accordance with the blast pattern requirements, taking due care to prevent over-breaking.
3. The Contractor will ensure that the appropriate surface water containment and management procedures are followed when drilling.

4.3.2 Blasting

1. The Contractor’s Health and Safety Plan, list of blasting agents, technician’s certificates, and proposed methods of blasting will be provided by the Contractor prior to blasting operation, for Owner’s approval.

2. The Contractor will provide appropriately qualified and certified personnel to manage all aspects of the blasting.
3. The Contractor will be responsible for notifying all air and land traffic of the time and location of any blast at least 24 hours in advance.
4. The Contractor will be responsible for putting in place all protocols and physical barriers to warn and prevent land and air traffic from entering the designated blast zone, according to all applicable Territorial and Federal Regulations and the Contractors Health and Safety Plan.
5. The Contractor should use controlled blasting methods to ensure production of specified materials, ease of excavation and to minimize processing requirements.
6. Certified Personnel must inspect the blast pattern post blasting to ensure there are no unexploded blasting agents and blasting caps left behind prior to excavation. If unexploded material is found in the pattern, Certified Personnel must remove the dangerous material according to normal practice and the Contractor's Health and Safety Plan.

4.3.3 Key Trench Drilling and Blasting

1. The Contractor must use excavation methods that minimize fracturing beyond excavation limits.
2. Care must be taken in locating the drill holes, orienting the drills, and monitoring drilling so that accurate positioning and alignment of the drill holes is achieved.
3. The method of excavation must produce a key trench base that is free of abrupt changes in elevation.
4. Controlled blasting techniques must be used to satisfy the excavation requirements stated herein. The blasting agent type and quantity, blasting sequence, and delay pattern must be flexible in order to meet these requirements.
5. The Contractor shall submit complete details of any proposed blast to the Owner and the Engineer. Submitted data shall include the following:
   (1) The location, depth and area of the blast;
   (2) The type, strength, quantity, column load, and distribution of explosives to be used per hole, per day, and per blast;
   (3) The sequence and pattern of the delay; and
   (4) The description and purpose of any special methods to be adopted.
6. If, in a specific area, a plan that was previously adopted does not produce conditions in accordance with the requirements stated herein, the Contractor must submit a revised blasting plan to the Owner and Engineer before continuing with drilling and blasting in adjacent areas.

4.4 Part 3 – Quality Control

1. Submit a Drilling and Blasting Plan as defined in Sections 4.1.4 and 4.3.3 of this Document.
2. Confirm with the Owner that all permits and approvals are in place prior to commencing any work.
3. Physically demarcate the Works area that will be drilled and blasted, using proper survey control, for review and approval by the Owner and the Engineer.
4. Implement and follow appropriate established protocols prior to and immediately following any Blast in compliance with all appropriate Rules and Regulations.

4.5 Part 4 – Quality Assurance

1. Review the Drilling and Blasting Plan as defined in Sections 4.1.4 and 4.3.3 of this Document and submit review comments back to the Contractor via the Owner.
2. Visually inspect the demarcated zone, and any associated survey files prepared by the Contractor for drilling and blasting, and inform the Contractor via the Owner if changes are required.

---------- END OF SECTION 4 ----------

5 Fill Material Specifications

5.1 Part 1 – General

5.1.1 Documents

1. This section of the Specification forms part of the Contract Documents and is to be read, interpreted and coordinated with all other parts.

5.1.2 Description

1. The sources and borrow areas of all fill are shown on the Drawings or as designated by the Engineer. For the types of material and related Specifications, refer to the Drawings. The material types required for completion of the Works are labelled as:
   (1) Riprap;
   (2) Run-of-Quarry;
   (3) Transition;
   (4) Surfacing;
   (5) Bedding;
   (6) Core; and
   (7) Tailings
2. All construction materials, potentially with the exception of the Tailings or waste rock materials that should only be used with in the impacted Tailings Impoundment Area (TIA) catchment, shall be non-acid generating, free of organic matter or similar impurities, as well as snow and ice.
3. Note that if Waste Rock is planned to be used for construction then it should be the same general criteria as the Run-of-Quarry (ROQ) material
4. The Contractor is responsible for supplying, installing, operating and maintaining all the necessary plant, equipment, materials, labour and supervision to produce and test the suitability of the specified construction material on site.
5. The Contractor must process all materials to meet the gradations specified herein.

5.1.3 Submittals

1. The Contractor shall submit the information requested in the Quality Control program listed in Section 5.3 to the Engineer and Owner in a timely manner, understanding that approvals to proceed with the Works may be contingent on review and approval of these submittals.
2. Work shall not start until applicable approvals are obtained from the Owner in writing.
3. Approval of submittals shall not relieve the Contractor of its sole responsibility to construct the Works in accordance with specified requirements.

5.2 Part 2 – Product

5.2.1 General

1. Quarry areas

   (1) Fill, required for the Works, shall be obtained and manufactured by the Contractor from designated borrow areas as shown on the Drawings, and from the excavation of select foundations.

   (2) The parent rock sources for all fill materials must be inspected by the Engineer throughout the material processing and construction activities to ensure the requirements stated herein are being met.

   (3) Excavated material that is unsuitable for the Works shall be disposed of in a designated onsite disposal area as directed by the Owner.

   (4) If the Contractor proposes to obtain fill from an area not within the excavations or designated areas shown on the Drawings, it shall communicate its intention to the Owner. The Owner then shall first obtain the necessary approvals and permits to carry out such sub-surface investigation and obtain and submit such samples, as are required, to enable the Engineer to assess the suitability of the fill for the Works.

   (5) The Contractor shall keep accurate exploration records of any test pit, trench or drill hole which it makes for the purpose of investigating borrow material, and a copy of such records shall be submitted to the Owner and to the Engineer within seven (7) days of the completion of such exploration Works.

   (6) The Contractor shall give the Owner no less than 14 days notice, of the intention to develop any potential borrow area not shown on the Drawings.

   (7) The Contractor shall make its own determination of the adequacy of any borrow source it intends to exploit.

2. Foundation excavation

   (1) Fill acquired from foundation excavation shall meet the Specifications; otherwise it will be considered as unsuitable material and disposed of accordingly.

   (2) Unsuitable material from the excavation for the Works shall be disposed of in a designated onsite disposal area as directed by the Owner.

   (3) Fill shall be used in place with minimum handling to minimize degradation and segregation.

3. Core material handling

   (1) The Contractor shall supply, operate and maintain all necessary plant to ensure that the appropriate moisture conditioning, placement and compaction of the Core material can be carried out as specified.

(2) Special care must be taken to minimize material handling to minimize segregation.

5.2.2 Riprap

1. Riprap material shall be competent non-acid generating rock sourced from the quarries or foundation excavations, and that is free from organic matter, snow and ice.
2. Riprap shall be clean with no fine-grained material and a minimum boulder size of 1,000 mm and maximum boulder size of 1,500 mm or as specified on the Drawings.
3. Basic screening or manual selection may be used to achieve the desired gradation.
4. The Riprap material shall be washed to remove blast residue and/or fines, unless otherwise directed by the Engineer.

5.2.3 Run-of-Quarry Material and / or Waste Rock

1. Run-of-Quarry (ROQ) material shall consist of competent non-acid generating rock sourced from the quarries or foundation excavations, and that is free of organic matter, frozen soil, snow and ice.
2. ROQ material shall be well-graded, containing sufficient quantities of unfrozen gravel, sand and silt sized material to allow the material to be compacted. In areas where the overall ROQ fill thickness is less than 0.85 m, the maximum boulder size shall not exceed 500 mm, as measured in any direction. In areas where the overall ROQ fill thickness is greater than 0.85 m, the maximum boulder size shall not exceed 900 mm as measured in any direction.
3. Basic screening, or crushing and screening may be used to achieve the desired gradation.
4. The ROQ material shall be washed to remove blast residue, unless otherwise directed by the Engineer.
5. Note that if Waste Rock is planned to be used for construction then it should be the same general criteria as the Run-of-Quarry (ROQ) material.

5.2.4 Transition Material

1. The Transition material shall consist of competent non-acid-generating material from the quarries or foundation excavations, and that is free of organic matter, frozen soil, snow and ice.
2. The Transition material shall have a particle size distribution falling within the limits presented in Table 5.1.

Table 5.1: Transition material particle size distribution limits

Particle Size (mm)	% Passing
200	100
100	60-100
50	40-70
20	20-50

10	0-30
5	0-10

3. Crushing and screening may be required to meet the Specification.
4. The Transition material shall be washed to remove blast residue, unless otherwise directed by the Engineer.

5.2.5 Surfacing Material

1. Surfacing material shall consist of competent non-acid-generating rock from the quarries or foundation excavations, and that is free of organic matter, frozen soil, snow and ice.
2. The Surfacing material shall have a particle size distribution falling within the limits presented in Table 5.2.

Table 5.2: Surfacing material particle size distribution limits

Particle Size (mm)	% Passing
38.0	100
25.0	60-100
12.5	25-100
5.0	10-50
0.63	2-20
0.08	1-15

3. Crushing and screening will be required to meet the Specifications.
4. The Surfacing material shall be washed to remove blast residue, unless otherwise directed by the Engineer.

5.2.6 Bedding Material

1. Bedding material shall consist of competent non-acid-generating material from the quarries or foundation excavations, including unfrozen soil, and that is free of organic matter, frozen soil, snow and ice.
2. The Bedding material shall have a particle size distribution falling within the limits presented in Table 5.3.

Table 5.3: Bedding material particle size distribution limits

Particle Size (mm)	% Passing
25.0	100
20.0	90-100
12.5	50-100
10.0	30-100
5.0	10-80

0.63	2-35
0.08	1-15

3. Crushing and screening may be required to meet the Specifications.
4. The Bedding material shall be washed to remove blast residue, unless otherwise directed by the Engineer.

5.2.7 Core Material

1. Core material shall consist of competent, non-saline, non-acid generating rock from the quarries or foundation excavations, and that is free of organic matter, frozen or unfrozen soil, snow and ice.
2. The Core material shall have a particle size distribution falling within the limits presented in Table 5.4.

Table 5.4: Core material particle size distribution limits

Particle Size (mm)	% Passing
20.0	100
12.5	65-100
5.0	45-70
0.63	15-35
0.08	4-10

3. Crushing and screening of the Core material will be required to meet the Specification.
4. The Core material shall be washed to remove blast residue, unless otherwise directed by the Engineer.

5.2.8 Tailings

1. There is not a set gradation for the tailings. Typical tailings gradation would be sand (medium to fine), with some silt size fraction.
2. The use of tailings in construction would only be allowed within the impacted Tailings Impoundment Area catchment. The use of any tailings should first be discussed with the Engineer and Owner and approved before use.
3. Tailings material would typically be used to either help as a base bedding and levelling layer or to be placed to create a longer seepage pathway (reduce hydraulic conductivity) over excavated surfaces or upstream of rockfill placement.
4. All tailings would be harvested (excavated) from the subaerial tailings beach located north of the TIA South Dam.

5. Generally, tailings should be placed and spread in thin lifts (in the range of 0.3 to 0.5m) and compacted using 'static roll' (i.e., no vibration) passes with the compactor. Static rolling would be done to avoid excess pore pressure build-up in the compacted tailings mass.

   (a) Coarser tailings will help to improve strength and more readily dissipate pore pressures but will have a higher hydraulic conductivity.

   (b) Finer tailings will have a lower hydraulic conductivity but will be more prone to excess pore pressure build-up. If finer tailings are used, then a slow rate of rise (thin lifts with time between placement of subsequent lifts to allow for pore pressure to dissipate) should be targeted.

5.3 Part 3 – Quality Control

1. The Contractor shall carry out Quality Control testing during the production of construction materials as outlined in Table 5.5.

Table 5.5: Required QC testing during production of construction materials

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QC Test Frequency	Submittal
Riprap	At Quarry	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Run-of-Quarry	At Quarry	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Transition (General)	At Crusher	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Transition (Dam Construction)	At Crusher	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Surfacing	At Crusher	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One per 3,000 m^3	Test Certificate
Bedding	At Crusher	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One per 1,000 m^3	Test Certificate
Bedding	At Crusher	Grab	Maximum Density (ASTM D698)	On Site	24-hrs	One per 2,000 m^3	Test Certificate
Bedding	At Crusher	Grab	Water Content (ASTM D2216)	On Site	24-hrs	One per 2,000 m^3	Test Certificate
Core	At Crusher	Grab	Particle Size Analysis (ASTM C136)	Site Lab	24-hrs	One per 500 m^3	Test Certificate
Core	At Crusher	Grab	Moisture Content (ASTM D2216)	Site Lab	24-hrs	One per 2,000 m^3	Test Certificate
Core	At Crusher	Grab	Maximum Density (ASTM D698 - Proctor)	Site Lab	24-hrs	One per 2,000 m^3	Test Certificate
Core	At FCP Outlet	n/a	Mix Consistency (Visual)	n/a	n/a	Ongoing	None
Core	At FCP Outlet	Grab	Aggregate Temperature (Concrete	At Source	Immediate	Ongoing	None

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QC Test Frequency	Submittal
			Thermometer or Temperature Gun)				

5.4 Part 4 – Quality Assurance

1. The Engineer shall carry out Quality Assurance testing during the production of materials as outlined in Table 5.6.

Table 5.6: Required QA testing during production of construction materials

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QA Test Frequency	Submittal
Riprap	At Quarry	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Run-of-Quarry	At Quarry	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Transition (General)	At Crusher	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Transition (Dam Construction)	At Crusher	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Transition (Dam Construction)	At Crusher	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One on upstream slope; One on downstream slope	Test Certificate
Surfacing	At Crusher	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One per 6,000 m3	Test Certificate
Bedding	At Crusher	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One per 2,000 m3	Test Certificate
Bedding	At Crusher	Grab	Maximum Density (ASTM D698)	On Site	24-hrs	One per 4,000 m3	Test Certificate
Bedding	At Crusher	Grab	Water Content (ASTM D2216)	On Site	24-hrs	One per 4,000 m3	Test Certificate
Core	At Crusher	Grab	Particle Size Analysis (ASTM C136)	Site Lab	24-hrs	One per 1,000 m3	Test Certificate
Core	At Crusher	Grab	Moisture Content (ASTM D2216)	Site Lab	24-hrs	One per 4,000 m3	Test Certificate
Core	At Crusher	Grab	Maximum Density (ASTM D698 - Proctor)	Site Lab	24-hrs	One per 4,000 m3	Test Certificate
Core	At Crusher	Grab	Specific Gravity (ASTM D854)	Off Site Lab	7-days	One per 8,000 m3	Test Certificate

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QA Test Frequency	Submittal
Core	At Crusher	Grab	Salinity	Off Site Lab	7-days	One per 8,000 m3	Test Certificate
Core	At FCP Outlet	n/a	Mix Consistency (Visual)	n/a	n/a	Ongoing	None
Core	At FCP Outlet	Grab	Particle Size Analysis (ASTM C136)	Site Lab	24-hrs	One per 500 m3	Test Certificate
Core	At FCP Outlet	Grab	Moisture Content (ASTM D2216)	Site Lab	Immediate	One per 50 m3	Test Certificate
Core	At FCP Outlet	Grab	Bulk Density and Air Content (EBA Method adapted from CSA A23.2-6C)	Site Lab	Immediate	One per 500 m3	Test Certificate
Core	At FCP Outlet	Grab	Aggregate Temperature (Concrete Thermometer or Temperature Gun)	At Source	Immediate	Ongoing	None

---------- END OF SECTION 5 ----------

6 Geosynthetics

6.1 Part 1 – General

6.1.1 Documents

1. This section of the Specification forms part of the Contract Documents and is to be read, interpreted, and coordinated with all other parts.
2. This section specifies requirements for the supply and installation of the following geosynthetic products:
   (1) Textured High Density Polyethylene (HDPE) Liner;
   (2) Non-Woven Geotextile Fabric;
   (3) Woven Geotextile Fabric;
   (4) Geosynthetic Clay Liner (GCL);
   (5) Extrusion rods; and
   (6) Bentonite powder.

6.1.2 Description

1. The Works to be done under this Section consists of furnishing all labour, materials and equipment and the performance of all Works necessary to carry out geosynthetic installations as shown on the Drawings and as specified herein.

6.2 Part 2 – Products

6.2.1 Submittals

1. The Owner will submit the following information at least 14 days prior to material arrival at the designated marshalling area:
   (1) Manufacturer's written certification that the geosynthetic products to be used meet the Specifications and have been continuously inspected.
   (2) The certification shall identify the origin and the manufacturer of any resin used in manufacturing of the geosynthetic product.
2. Work shall not start until applicable approvals are obtained from the Owner in writing.
3. Approval of submittals shall not relieve the Contractor of its sole responsibility to construct the Works in accordance with specified requirements.

6.2.2 Definitions

1. The following words and terms, unless the context otherwise requires, in this Specification, shall have the meanings set out below:

   (1) GEOSYNTHETICS includes textured HDPE liner, GCL, geotextile and other supplies used in liner, geotextile or GCL deployment.

   (2) HDPE Liner means textured High Density Polyethylene liner, as specified.

   (3) GCL means Geosynthetic Clay Liner, as specified.

   (4) GEOTEXTILE means woven or non-woven geotextile, as specified.

   (5) EXTRUSION RODS mean HDPE rods that are fed into an apparatus for extrusion welding.

   (6) BENTONITE POWDER means sodium montmorillonite clay used as a high swelling soil sealant, as specified.

6.2.3 Product Specifications

1. The High-Density Polyethylene (HDPE) liner shall be textured and have a nominal thickness of at least 1.4mm (57 mil). The basic liner requirements are listed in Table 6.1.

Table 6.1: HDPE liner specifications (typical product)

Parameter	Standard	HDPE 60 Textured
Nominal Thickness	ASTM D5199	1.42 mm (57 mil)
Density (Untextured)	ASTM D792	0.94
Tensile Strength Modified Type IV Die	ASTM D638 (Stress at Yield)	22.0 kN/m (126 ppi)
	ASTM D638 (Stress @ Break)	15.8 kN/m (90 ppi)
	ASTM D638 (Strain @ Yield 33mm Gauge)	12%
	ASTM D638 (Strain @ Break 50mm Gauge)	100%
Tear Resistance	ASTM D1004	187 N (42 lbs)
Dimensional Stability	ASTM D1204 (Max Cng).	± 2%
Notched Constant Load ESCR	ASTM D5397	200 Hours
Punctured Resistance	ASTM D4833	400N (90 lbs)
Carbon Black Content	ASTM D1603	2.0 – 3.0%
Carbon Black Dispersion	ASTM D5596	CAT 1 or 2
Bonded Seam Strength Test Temp 23°C, 73°F	ASTM D6392	21 N/mm (120 ppi)
Peel Adhesion Test (FTB) Test Temp 23°C, 73°F	ASTM D6392	14 N/mm (78 ppi)

2. The Geosynthetic Clay Liner (GCL) shall consist of sodium bentonite between two non-woven geotextiles which are bonded by needle punching and shall satisfy the Specifications as listed in Table 6.2.

Table 6.2: GCL specifications (typical product)

Parameter	Standard	GCL VN
Bentonite Mass per Unit Area[1]	ASTM D5993	3.67 kg/m^2 (0.75 lb/ft$^{2)}$
Grab Tensile Strength[2]	ASTM D4632	420 N (95 lbs)
Peel Strength	ASTM D4632	66 N (15 lbs)
Hydraulic Conductivity[3]	ASTM D5321	5x10^{-9}cm/sec max.
Internal Shear Strength (Typical) at 200 psf normal stress (10 kPa)	ASTM D5321	24 kPa (500 psf)
Geotextile Component Properties		
Mass per Unit Area	ASTM D5261	non-woven 200 g/m^2 (6.0 oz/yd^2)
Bentonite Component Properties		
Swell Index	ASTM D5890	24 ml/2 g min.
Moisture Content	ASTM D4643	12% max.
Fluid Loss	ASTM D5891	18 ml max.

Notes:

[1] Oven-dried measurements

[2] Measured in weakest principal direction

[3] De-aired tap water @ 5 psi effective stress and 2 psi head

3. The geotextile shall be a non-woven needle-punched fabric with a nominal weight of at least 385 g/m^2 (12 oz) and must satisfy the Specifications listed in Table 6.3.

Table 6.3: Geotextile specifications (typical product)

Parameter	Standard	LP12
Grab Tensile	ASTM D4632	1,330 N
Elongation	ASTM D4632	50%
Tear	ASTM D4533	510 N
Puncture	ASTM D4833	775 N
Mullen Burst	ASTM D3786	3,995 kPa
AOS	ASTM D4751	150 microns
Permittivity	ASTM D4491	0.9 sec-1
Water Flow	ASTM D4491	2,648 l/min/m^2
Weight	ASTM D5261	385 g/m^2 (Nominal)
Thickness[1]	ASTM D5199	3.0 mm (Nominal)
UV (500 hrs)	ASTM D4355	70%
Roll Size	n/a	4.57 X 91.4 m
Roll Weight[1]	n/a	181 kg

Notes:

[1] Typical values. All other values are minimum average roll values (MARV)

4. Extrusion rods and other welding supplies shall conform to the following Specifications:

   (1) Extruded material shall be made from same type resin as the HDPE liner.

   (2) The extrusion rod has compatible diameter for proposed apparatus.

   (3) Contractor shall submit product certificates for the Owner and the Engineer's approval prior to deployment.

   (4) Additives shall be thoroughly dispersed.

   (5) Material shall be free of contamination by moisture or foreign matter.

5. Bentonite powder specification:

   (1) The bentonite supplied as a soil sealant shall be high swelling sodium montmorillonite clay.

   (2) High swelling is defined as the ability of 2 grams of bentonite, when mechanically reduced to a minus 0.15 mm particle size, to swell in water to an apparent volume of 1.6 cm^3 when added to 100 cm^3 of water.

   (3) The dry fineness of the soil sealant shall be 98% minimum passing 4.75 mm mesh and 5% maximum passing 0.85 mm mesh.

   (4) The bentonite shall be stored in a dry area and shall not be used if hydrated.

   (5) Contractor shall submit the manufacturer's product specification for approval by the Owner and the Engineer, 14 days prior to procurement.

6.2.4 Equipment

1. The Owner shall ensure the Contractor supplies proper handling equipment, as recommended by the manufacturer, for the geosynthetic installation, which does not pose any danger to installation personnel or risk damage or deformation of the geosynthetics. Examples of suitable handling equipment include, but is not limited to:

   (1) Spreader bar assembly;

   (2) Stinger;

   (3) Roller cradles; and

   (4) Straps.

2. Equipment for welding HDPE:

   (1) A self-propelled fusion wedge welder and an extrusion welding apparatus from a recognized manufacturer.

   (2) The fusion wedge welder shall have certified working gauges showing working temperature and speed.

(3) An adequate number of extrusion welding apparatus shall be available to maximize production.

(4) The Contractor must supply an adequate power source, capable of providing constant voltage under combined line load.

(5) The Contractor must provide a suitable shelter and heater to ensure that a suitable environment can be created for completion of seams according to the Specifications.

6.2.5 Delivery Storage and Handling

1. Delivery, storage, and handling shall conform to the requirements of the manufacturer and shall be carried out in a manner which shall protect the geosynthetics from damage or water penetration during shipment.

2. Packing and shipping shall as a minimum conform to the following:

   (1) Supply geosynthetics in rolls with straps for unloading.

   (2) Supply geosynthetics marked or tagged with the following information:

      a) Manufacturer's name

      b) Product information

      c) Roll number

      d) Batch or lot number

      e) Roll dimensions

   (3) Ensure that geosynthetics are properly loaded and secured to prevent damage during transit.

   (4) Protect geosynthetics from excessive cold, heat, puncture, cutting, or other damaging or deleterious conditions.

   (5) Ensure personnel responsible for loading, transport and unloading of geosynthetics are familiar with the handling and transport constraints imposed by the manufacturer.

3. Acceptance at Works site shall as a minimum conform to the following:

   (1) Engineer may perform inventory and surface inspection for defects and damage of geosynthetic rolls upon delivery.

   (2) The Engineer will unroll and inspect any geosynthetic roll that may appear to be damaged below surface layers.

   (3) The Contractor will repair damage resulting from handling and transport of geosynthetics. If irreparable, in the opinion of the Engineer, the Owner will replace damaged materials.

4. Storage and protection shall as a minimum conform to the following:

   (1) Storage of geosynthetics shall be in a secure location that will minimize exposure. It is absolutely essential that GCL rolls are protected from exposure to water.

   (2) Contractor will provide on-site area for storage of geosynthetic rolls from time of delivery until installation with the approval from the Engineer.

   (3) Prepare storage area so that the geosynthetic products are stored off the ground and protected from the elements (e.g., ultraviolet light, water, moisture, etc.).

   (4) After removing material from storage area, protect geosynthetics from puncture, dirt, groundwater, moisture, mud, mechanical abrasion, excessive heat and cold, ultraviolet light exposure, and other sources of damage. Keep geotextile and GCL rolls in relatively opaque and watertight wrappings.

   (5) Preserve integrity and readability of the geosynthetics roll labels, and store such that Engineer shall have access to the package slips or roll labels for each roll to verify roll acceptance.

6.3 Part 3 – HDPE Liner Installation

6.3.1 Installation

1. Deployment

   (1) The Contractor must submit a proposed liner layout 14 days prior to deployment for Engineer's approval through the Owner.

   (2) An anchor trench shall be excavated, or weight ballast constructed by the Contractor to the lines and grades shown on the Drawings or as directed by the Engineer.

   (3) The liner should cover the depth and width plus minimum 200 mm slack beyond the width of the trench.

   (4) The liner shall not be excessively dragged across the subgrade.

   (5) Assign each panel a simple and logical identifying code. The coding system shall be subject to Engineer's approval.

   (6) Visually inspect the geomembrane during deployment for imperfections and mark faulty or suspect areas.

   (7) Deployment of geomembrane panels shall be performed in a manner that will comply with the following guidelines:

      a) Unroll the geomembrane using methods that will not damage geomembrane and will protect underlying surface from damage.

      b) Unroll the geomembrane with the textured surface on top. Its purpose for this Project is to provide some slip resistance for workers, as opposed to structural integrity.

c) Place ballast on geomembrane which will not damage or puncture the geomembrane to prevent wind uplift.

d) Personnel walking on geomembrane shall not engage in activities or wear shoes that could damage the liner. Smoking will not be permitted on the geomembrane.

e) Do not allow heavy vehicular traffic directly on geomembrane. Low bearing vehicles under 42 kPa might be permitted with Engineer's approval.

f) Protect geomembrane in areas of heavy traffic by placing protective cover over the liner. The protective cover should as a minimum consist of 300 mm of approved fill material. This thickness is subject to change by the Engineer depending on site conditions.

(8) The Contractor shall determine to his own satisfaction that sufficient extra material for anchor embedment, seams, slack, thermal expansion and contraction of the material and waste are included on top of the neat area given.

2. Field seaming

(1) Fusion weld seams shall meet the following requirements:

a) To the maximum extent possible, orient seams parallel to line of slope.

b) Minimize number of field seams in corners, odd-shape geometric locations and outside corners.

c) Slope seams shall extend a minimum of 1.5 m beyond the grade break into the flat area.

d) Use a sequential seam numbering system compatible with panel numbering system that is agreeable to the Engineer.

e) Align seam overlaps consistent with the requirements of the welding equipment being used. A minimum 150 mm overlap is recommended to ensure proper welding.

f) Use manufacturer's recommended temperature and speed for the wedge welders.

g) Clean seam area of dust, mud, moisture, and debris immediately ahead of wedge welder.

h) Protect against moisture build-up between sheets due to condensation.

(2) Extrusion welding

a) Hot-air tack adjacent pieces together using procedures that do not damage the geomembrane.

b) Clean and roughen geomembrane surfaces by disc grinder or equivalent.

c) Purge extrusion welding apparatus of heat-degraded extrudate before welding.

(3) Seaming shall not proceed when ambient air temperature or adverse weather conditions jeopardize the integrity of the liner installation. Contractor shall demonstrate that acceptable seaming can be performed by completing a weld and obtaining approval by the Engineer.

(4) Repair and non-destructively test each suspect location in both seam and non-seam areas. Do not cover geomembrane at locations that have been repaired until test results with passing values are available to the Engineer.

6.3.2 Seam Testing and Repair

1. Non-destructive testing may be carried out as the seaming progresses.

   (1) Vacuum testing shall be performed in accordance with ASTM D 5641, Standard Practice for Geomembrane Seam Evaluation by Vacuum Chamber.

   (2) Air pressure testing shall be performed in accordance with ASTM D 5820, Standard Practice for Pressurized Air Channel Evaluation of Dual Seamed Geomembrane.

2. Destructive Testing procedures

   (1) One sample per 450 m liner seam length or at Engineer's request.

   (2) Contractor shall cut samples at locations designated by the Engineer as the seaming progresses in order to obtain field laboratory test results.

   (3) Destructive testing shall be performed in accordance with ASTM D 6392, Standard Test Method for Determining the Integrity of Non-Reinforced Geomembrane Seams Produced Using Thermo-Fusion Methods.

3. Failed seam procedures

   (1) Reconstruct the seam between any two passed test locations, or,

   (2) Trace the weld to intermediate location at least 3 m minimum, or where the seam ends in both directions from the location of failed test.

   (3) Extrude weld or cap the failed section tying into passed seam.

4. Repair procedure

   (1) Contractor shall be responsible for repair of defective areas.

   (2) Remove damaged geomembrane and replace with acceptable geomembrane material if damage cannot be satisfactorily repaired.

5. All repairs shall be verified by the Engineer.

6.3.3 Liner Cover

1. All exposed HDPE liner will be covered with minimum 300 mm of Bedding material unless stated otherwise. The material shall be deployed with care to ensure that the liner will not be

damaged during the operation. The material is to be spread evenly without any compaction. Traffic shall not be permitted directly on the geomembrane.

2. Unless specifically indicated by the Engineer, HDPE liner shall at all times be placed between two geotextiles.

6.4 Part 4 – GCL Installation

6.4.1 GCL Deployment

1. The key trench shall be excavated as shown on the Drawings. The surface prepared for the GCL shall be smooth with all protrusions and angular particles larger than 20 mm removed.
2. In the areas where bedrock was encountered in the key trench a layer of bentonite powder shall be placed over the prepared rock surface prior to GCL deployment.
3. The installation of the GCL shall not begin until a proper subbase has been prepared and approved by the Engineer.
4. The GCL shall be placed in the key trench in a manner that will prevent damage to the liner. The method of deployment shall be discussed with and approved by the Engineer.
5. The Contractor shall submit a proposed panel lay out plan for Engineer's approval 14 days prior to deployment through the Owner.
6. The GCL panels should be placed perpendicular to the dam axis.
7. The Contractor shall have sufficient amount of ballast weights, such as sand bags, during the deployment to hold and keep panels in place as protection against wind.
8. The GCL shall be temporarily anchored to prevent movement while backfilling.
9. The GCL should not be deployed during any form of precipitation, or in periods of high wind.
10. GCL shall not be excessively dragged across the subgrade.
11. The GCL in the key trench shall be carefully covered with the saturated Core material or Bedding material. The Core material should be mixed and placed as described in Section 7.
12. The upstream of the core slope GCL subgrade (bedding material) should be uniformly compacted and graded and free of loose material.

6.4.2 GCL Lapping and Joining

1. Unless shown otherwise on the Drawings, the GCL shall have a minimum overlap of 500 mm.
2. Each overlap should be treated with powdered bentonite comprised of the same bentonite as used in the manufacture of the GCL. The bentonite shall be applied at the minimum rate of 0.4 kg/m of seam.
3. All joints shall be placed so the higher liner overlaps the lower liner.

6.4.3 GCL Cover

1. The cover material refers to the material placed directly on top of the GCL on the upstream slope and over the crest of the frozen Core material.
2. The cover material shall be placed in such a manner that it is pushed across the seams from the overlap roll to the underlap roll. Care must be taken to not push aggregate between the seam overlap. Equipment shall push the cover material ahead of the equipment, and never travel directly on the GCL.
3. The cover material shall comprise Core material or Bedding material as specified in Section 5.
4. Uncovered edges of GCL panels shall be protected with a waterproof sheet adequately secured with ballast, if the GCL installation sequence is delayed for a period in excess of 12 hours or the edges remain exposed for a period in excess of 12 hours.
5. The cover material shall be placed with the minimum thickness of 300 mm over the GCL.
6. The cover material shall be placed with low ground pressure equipment. Care should be taken to avoid damaging the GCL by not making sharp turns or pivots with equipment as well as sudden starts or stops.
7. A minimum thickness of 600 mm, as determined by the Engineer, shall be kept between heavy equipment and the GCL at all times, except during final-grading. Heavy vehicles should not be driven directly on the GCL until the proper thickness of cover has been placed.
8. The first fill of Cover material over the GCL shall be compacted to a maximum of 90% of the maximum dry density (ASTM D698) or as specified by the Engineer to prevent damage to the GCL. Subsequent lifts, if required, of the Cover material over the GCL shall be compacted to 95% of the maximum dry density (ASTM D698). Moisture conditioning may be required to achieve the specified level of compaction.
9. The cover material should be pushed up-slope to minimize tension on the GCL when covering GCL on sloped areas.
10. Precautions shall be taken to prevent damage to the GCL by restricting the use of heavy equipment over the GCL.

6.4.4 GCL Damage

1. The Engineer shall record all areas requiring repair due to damage during shipping, handling, or deployment, or manufacturing flaws. The Engineer shall prescribe the method of repair to be used.
2. The Contractor shall report to the Engineer all areas where the GCL is damaged or suspected to be damaged. The Engineer shall prescribe the method of repair to be used.
3. All repairs made by the placement of a patch of the same material over the damage shall extend at least 500 mm beyond the flaw or damage in every direction.

6.5 Part 5 – Geotextile Installation

6.5.1 Geotextile Deployment

1. The Contractor shall submit a proposed panel layout 14 days prior to deployment for Engineer's approval through the Owner.
2. The Contractor shall have sufficient amount of ballast weights, such as sand bags, during the deployment to hold and keep the deployed panels in place as protection against wind.
3. The geotextile shall be unrolled as smoothly as possible on the prepared subgrade in the direction of construction traffic.
4. Geotextile rolls shall be overlapped in the direction of sub-base placement.
5. The geotextile shall be 200 mm minimum overlapped and stitched or heat bonded together. The Engineer will inspect the stitching or heat bonding to ensure quality of Works.
6. On curves, the geotextile may be folded or cut and overlapped to conform to the curve.
7. The fold or overlap shall be in the direction of construction and shall be held in place as prescribed above.
8. The geotextile shall not be excessively dragged across the subgrade.
9. Damaged geotextile, as identified by the Engineer, shall be repaired immediately. The damaged area plus an additional 1 m around the damaged area shall be cleared of all fill material. A geotextile patch extending 1 m beyond the perimeter of the damage shall be installed as directed by the Engineer.
10. A method of attaching the geotextile patch may be required over soft subgrade as directed by the Engineer.

6.6 Part 6 – Quality Control

1. The Owner and Contractor must ensure that all geosynthetic manufacturers have an internal product QC program that meets contract requirements.
2. The Owner and Contractor are responsible to ensure that all geosynthetic material delivered to site meet the Specifications.
3. Geosynthetics that do not meet the Specifications will be rejected. The Owner and Contractor will replace any rejected material with new material that meets the Specifications.
4. The Owner and Contractor must ensure that the geosynthetic installations are carried out by a suitably qualified and experienced team or subcontractor.
5. The Contractor shall supply a QC program for installation of the geosynthetics for review and approved by the Owner and the Engineer.
6. The Contractor shall supply all testing technicians and equipment required in the QC program.

7. The Contractor, or his designated Subcontractor's testing technicians shall be responsible for panel labelling, destructive testing, repair labelling and inspections, overall QC of Works, as outlined in the QC program, and record keeping.

8. The Contractor shall generate, and submit for review to the Engineer and Owner, an As-built QC report that includes:

   (1) Record of material deployment.

   (2) As-built panel layout with panel number and associated roll number finalized in AutoCAD 2007 or later format.

   (3) All destructive test results with panel numbers and associated roll numbers.

6.7 Part 7 – Quality Assurance

1. The Engineer will confirm that all geosynthetic material delivered to site meet the Specifications. This will be done through visual inspection, and through review of product certificates.

2. Geosynthetics that do not meet the Specifications will be rejected. The Owner and Contractor will replace any rejected material with new material that meets the Specifications.

3. The Engineer will review the Contractor's QC program for installation of the geosynthetics and inform the Contractor via the Owner if changes are needed.

4. The Contractor shall supply all testing technicians and equipment required in the QC program and make the personnel and equipment available to the Engineer for QA testing, over and above continuous visual inspection.

5. The Engineer shall review the Contractor's an As-built QC report and inform the Contractor via the Owner if changes are needed.

---------- END OF SECTION 6 ----------

7 Fill Placement

7.1 Part 1 – General

7.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted, and coordinated with all other parts.

7.1.2 Description

1. The Works specified in this section includes furnishing all supervision, labour, materials, tools, and equipment for placement of fill material to the lines and grades shown on the Drawings and specified herein.
2. The Works shall include, but are not limited to the following:
   (1) Foundation preparation to receive fill.
   (2) The supply, hauling, placing, and compacting of the specified fill materials as shown on the Drawings.
   (3) All related surveys for layout and control of the Works.
   (4) The Contractor shall assist the Engineer when necessary while Engineer is performing QA testing. In addition, the Contractor shall submit a copy of Contractor's QC results.
   (5) Maintenance of haul roads (as applicable) including snow and ice removal.
   (6) The development, maintenance, and restoration of fill material borrow areas.
   (7) Any other related Works not covered elsewhere.
3. Fill materials required to be placed include, but are not limited to the following:
   (1) Haul, place, and compact Run-of-Quarry (ROQ) material as base layer, as a thermal protection layer, as an erosion protection layer, or as a dam shell material.
   (2) Haul, place, and compact Surfacing material as final trafficking surfaces.
   (3) Haul and place Riprap as an erosion protection or wave energy dissipation layer.
   (4) Haul, place and compact Bedding material as a liner bedding and cover material.
   (5) Haul, place compact moisture conditioned Core material as an impermeable permanently frozen water retaining barrier.
   (6) Haul, place, and compact Transition material as a filter layer between Core and/or Bedding and ROQ material.

7.1.3 Submittals

1. The Contractor shall submit the information requested in the Quality Control Plan listed in Section 7.3 to the Engineer and Owner in a timely manner, understanding that approvals to proceed with the Works may be contingent on review and approval of these submittals.
2. Work shall not start until applicable approvals are obtained from the Owner in writing.
3. Approval of submittals shall not relieve the Contractor of its sole responsibility to construct the Works in accordance with specified requirements.

7.2 Part 2 - Execution

7.2.1 Compaction Equipment

1. The compaction equipment shall be the appropriate size and type to achieve the specified densities of the respective fill materials.
2. Where compaction procedures (lift thickness, number of passes, compactor type) are specified the Contractor shall provide compactors that meet or exceed those described in the Specification.
3. A vibratory plate tamper, or other suitable equivalent hand operated compactor will be required for compaction around instrumentation, or in confined spaces. The hand compactor shall be rated to provide sufficient pressure to meet compaction requirements.
4. Notwithstanding the requirements stated above, the equipment and compaction procedures employed by the Contractor shall be subject to approval from the Engineer.

7.2.2 Snow Removal Equipment

1. Care shall be taken when clearing snow above or adjacent to previously placed compacted material to avoid ripping and subsequent damage. Any material, which, in the opinion of the Engineer, has been damaged, shall be removed and replaced.
2. Care shall be taken when clearing snow from original ground to prevent damage to the tundra.
3. If deemed necessary by the Engineer, the Contractor shall use manual labour to clear snow.

7.2.3 Foundation Preparation

1. The Contractor shall prepare an acceptable foundation surface to receive the specified fill material. An acceptable foundation surface is a surface which is clean, sound and firm, and which does not contain any loose, softened, or disturbed foundation material as determined by the Engineer.
2. Riprap, ROQ, Surfacing, Bedding, Core and Transition materials shall be graded in accordance with the Drawings, compacted in lifts and be free of snow, ice, and any other loose or deleterious material.

3. Dense foundation surfaces to receive fill shall be free from noncompacted fill, snow, ice, or other unsuitable materials. The surfaces shall be inspected by the Engineer, who may direct proof rolling with a loaded haul truck, and/or local over excavation and backfilling with approved material. Placement shall be completed as outlined in the applicable sections of these Specifications.

4. Exposed bedrock surfaces shall be reasonably smooth and free of loose or broken rock. Ripping and scraping the fractured bedrock may be required to remove unsuitable rock, as directed by the Engineer.

5. Where depressions or holes exist in the foundation material, acceptable fill shall be placed in depressions, as directed, and compacted as specified herein. Special techniques, handwork and the like shall be required as necessary.

6. Fill shall not be placed on the prepared foundations until they have been inspected and approved by the Engineer.

7.2.4 Fill Placement (General – All Products)

1. Construction must be performed in accordance with the best modern practice and with equipment best adapted to the work being performed. Materials must be placed so that each zone is homogenous, free of stratifications, ice chunks, lenses or pockets, ruts, and layers of material with different texture or grading not conforming to the requirements stated herein.

2. No fill material shall be placed on any part of the foundation until it has been prepared as specified herein and approved by the Engineer. The placement of fill material must conform to the lines, grades and elevations shown on the Drawings, as specified herein or as per the direction of the Engineer. Fill placement must be conducted in such a manner that mixing of fill materials with fill materials in the adjacent zones is avoided.

3. Embankment construction shall not proceed when the work cannot be performed in accordance with the requirements of the Specifications. Any part of the embankment that has been damaged by the action of rain, snow or any other cause must be removed and replaced with the appropriate material conforming to the requirements stated herein before succeeding layers are placed.

4. Stockpiling, loading, transporting, dumping, and spreading of all materials shall be carried out in such a manner to avoid segregation or any other condition that does not meet the requirements stated herein. Segregated materials must be removed and replaced with materials meeting the requirements stated herein and receiving the Engineer’s approval.

5. The Contractor must remove all debris, vegetation or any other material not conforming to the requirements stated herein. The Contractor must dispose of these materials in an area approved by the Owner.

6. The compaction operations for fill shall be conducted within the same workday to provide a smooth compact surface. Adjacent individual passes of the compactor shall overlap by approximately 1/3 of the width of the compactor’s drum. New fill shall be “keyed” into existing approved fill. Keying in is by placing new fill adjacent to exposed compacted fill. The

Contractor is responsible to repair all damages on unfinished work from the previous workday.

7. Unless otherwise specified by the Engineer construction material maximum lift thicknesses and compaction requirements shall be as indicated herein or otherwise specified on the Drawings.

7.2.5 Riprap Material Placement

1. The Riprap material must be placed in accordance with the Drawings, or otherwise as directed by the Engineer.

7.2.6 Run-of Quarry Material Placement

1. The Run of Quarry material must be placed in lifts not exceeding 0.85 m thickness if the total fill thickness is less than 0.85 m. The ROQ material must be placed in lifts not exceeding 1.85 m thickness if the total fill thickness is greater than 1.85 m. The placement method must ensure that segregation and nesting of coarse particles is avoided.
2. Compaction Trials (see Section 7.2.13) shall be used to develop a site-specific Method Specification for compaction of ROQ material.
3. Unless otherwise defined by a Method Specification, the ROQ material (each lift) shall be compacted in accordance with either of the following standards:
   (1) Compacted with a smooth drum vibratory compactor weighing no less than 10 tonnes, with at least eight passes of the compactor (back and forth being two passes). Rolling patterns must be used throughout construction to optimize the number of passes, and vibration frequency for compaction of the ROQ material.
   (2) Compacted by ensuring that loaded haul truck traffic is routed over the entire surface of each lift with a minimum of 4 passes (back and forth being two passes).

7.2.7 Transition Material Placement

1. The Transition material must be placed in lifts not exceeding 500 mm thickness. The placement method used must ensure that segregation and nesting of coarse particles is avoided.
2. Compaction Trials (see Section 7.2.13) shall be used to develop a site-specific Method Specification for compaction of Transition material.
3. Unless otherwise defined by a Method Specification, the Transition material (each lift) shall be compacted in accordance with either of the following standards:
   (1) Compacted with a smooth drum vibratory compactor weighing no less than 10 tonnes, with at least six passes of the compactor (back and forth being two passes). Rolling patterns must be used throughout construction to optimize the number of passes, and vibration frequency for compaction of the Transition material.
   (2) Compacted by ensuring that loaded haul truck traffic is routed over the entire surface of each lift with a minimum of 4 passes (back and forth being two passes).

7.2.8 Surfacing Material Placement

1. The Surfacing material must be placed in lifts not exceeding 200 mm thickness. The placement method used must ensure that segregation and nesting of coarse particles is avoided.

2. Compaction Trials (see Section 7.2.13) shall be used to develop a site-specific Method Specification for compaction of Surfacing material.

3. Unless otherwise defined by a Method Specification, the Surfacing material (each lift) shall be compacted in accordance with either of the following standards:

   (1) Compacted with a smooth drum vibratory compactor weighing no less than 10 tonnes, with at least four passes of the compactor (back and forth being two passes). Rolling patterns must be used throughout construction to optimize the number of passes, and vibration frequency for compaction of the Surfacing material.

   (2) Compacted by ensuring that loaded haul truck traffic is routed over the entire surface of each lift with a minimum of two (2) passes (back and forth being two passes).

7.2.9 Bedding Material Placement

1. Bedding material underlying geosynthetic products must be placed in lifts not exceeding 300 mm thickness. The placement method used must ensure that segregation and nesting of coarse particles is avoided.

2. Bedding material overlying geosynthetic products must be placed in lifts no less than 300 mm thickness if low ground pressure equipment is used. The Contractor must submit a work plan outlining the Bedding material placement strategy to the Engineer and Owner for review and approval prior to covering geosynthetics, to allow this specification to be modified to suit.

3. Bedding material underlying geosynthetic products must be compacted to 95% of the maximum dry density (ASTM D698). Moisture conditioning may be required to achieve the specified level of compaction.

4. The first lift of bedding material overlying geosynthetic products shall be compacted to a maximum of 90% of the maximum dry density (ASTM D698) or as specified by the Engineer to prevent damage to the geosynthetic products. Subsequent lifts, if required, of the Bedding material over the geosynthetic products shall be compacted to 95% of the maximum dry density (ASTM D698). Moisture conditioning may be required to achieve the specified level of compaction.

5. The Contractor must ensure that the integrity of the geosynthetic products is not compromised during construction.

6. Any damage to geosynthetic products must be immediately reported to the Engineer and Owner. Repair work must commence as soon as possible. Fill placement must cease immediately in an area where the integrity of the geosynthetic products has been compromised. Excavation of fill surrounding the damaged geosynthetic products, to allow

repairs to be made, must be done without further damaging the integrity of the products. Hand excavation may be required.

7.2.10 Core Material Placement

1. The Core material shall be placed in a near-saturated state to achieve an impermeable dam core after freeze back. The dam core comprises the bedding layer, key trench backfill, and core structure. A near-saturated condition is not required for the Core material that lies between the upstream face of the GCL and below the Transition material.
2. The key trench foundation must be cleared of all deleterious materials as described in Section 3. The foundation area must be inspected and approved by the Engineer before fill placement proceeds.
3. Snow and ice must be removed from the base of the key trench excavation before Core material can be placed in that area.
4. The Core material placement must be conducted when air temperatures will freeze a lift of core material within 24 hours of placement. Experience has shown that a 250 mm thick lift freezes back within 24 hours when air temperatures are below -15ºC. The time to freeze back will depend on the moisture content, wind speed, air temperature and solar radiation.
5. The lift thickness must be varied to achieve 100% freeze back prior to placement of the next lift. Freeze back is defined as maximum temperature of -2ºC. The lift thickness may be adjusted depending on the placed moisture content and climatic conditions and results of fill temperature monitoring. Individual lifts must have uniform thickness.
6. The Core material from the stockpile must be mixed with heated water using a method approved by the Engineer to create a homogeneous mix that is fully thawed and does not contain interstitial ice. The mix must not freeze until after it is placed and compacted. The temperature of the mix water required to meet the requirements stated herein may vary depending on the air temperature, wind speed and solar radiation.
7. The placed Core material must have a moisture content no less than 2% above the optimum moisture content (OMC) determined from density testing (ASTM D698).
8. The placed Core material shall have a minimum degree of saturation of 85% with no results falling below 80%. The moisture content shall be adjusted so that the material shall be saturated and flow easily but shall not produce free water when placed. The optimum moisture content shall be determined by undertaking a test fill pad prior to beginning the main fill placement. The established moisture content may be adjusted from time to time during construction based on results of the QC/QA tests.
9. The Core material must be spread and levelled immediately upon placement. The material must not be reworked, disturbed, or rutted after compaction. Extra care should be taken by the Contractor to ensure the surface of the first lift before liner placement is as smooth and even as possible. Additional work, described in Section 7, may be required if the lift surface is rough or uneven.

10. The Core material placed shall be compacted with a smooth drum vibratory compactor weighing not less than 10 tonnes. The material shall be compacted with at least six passes (back and forth being two passes) to achieve the maximum density possible at the placed moisture content, but not less than 90% of the maximum dry density. The number of passes may be adjusted at the Engineer's discretion to suit varying conditions.

11. A test fill pad shall be constructed when the air temperature is low enough as specified by the Engineer.

    (1) The following test fill characteristics shall be evaluated:

        a) Optimum moisture content;

        b) Optimum lift thickness;

        c) Bonding with the foundation and between lifts;

        d) Freeze back time for a lift given the ambient climatic conditions; and

        e) Contractor's placement methodology.

    (2) The test fill pad shall be a minimum 4 m wide and 4 m long. A minimum of two lifts of material shall be placed.

    (3) Test fill properties shall be evaluated from core samples and percolation tests.

    (4) Test fill should be removed if it is within the core footprint and has been judged unsuitable by the Engineer.

12. The fill area must be cleared of snow, ice and loose material before a new lift is placed. The surface area of each lift must be approved by the Engineer before it is covered by a subsequent lift.

13. Small batches of the Core material may be required to provide localised levelling and smoothing of the first lift surface to ensure the liner system has a level, even subgrade beneath it. Localised frozen high points on the surface of the first lift that the Engineer believes may cause puncture or stressing of the liner system must be removed without disturbing the surrounding surface. Equipment suitable for this task may include, but not be limited to, an excavator with a toothless bucket or jackhammer. Smoothing and patching with the Core material must be done if the lift surface is rough or pocketed after the high points are removed.

14. The Contractor must ensure that the integrity of the GCL and thermosyphon system is not compromised during construction. Precaution the Contractor may take to avoid damaging the GCL and thermosyphons may include but will not be limited to: avoiding turning tracked vehicles on the first two lifts after liner system installation, providing light plants in the work area to improve operator visibility, or using pylons to mark the lift/liner interface or any other sensitive areas.

15. Any damage to the must be immediately reported to the Engineer. Repair work must commence as soon as possible. Fill placement must cease immediately in an area where the integrity of the GCL has been compromised.

16. Any damage to GCL and thermosyphons must be immediately reported to the Engineer and Owner. Repair work must commence as soon as possible. Fill placement must cease immediately in an area where the integrity of the GCL or thermosyphons has been compromised. Excavation of fill surrounding the damaged GCL or thermosyphons, to allow repairs to be made, must be done without further damaging the integrity of the products. Excavation methods suitable for this task may vary depending on the degree of freezing that may have already taken place.

7.2.11 Core Material Placement (GCL Cover)

1. The Core material on the upstream GCL slope shall be placed as described in Section 6. The placement method used must ensure that segregation and nesting of coarse particles is avoided.

2. The first lift of cover material over the GCL shall be compacted to a maximum of 90% of the maximum dry density (ASTM D698) or as specified by the Engineer to prevent damage to the GCL. Subsequent lifts, if required, of the Cover material over the GCL shall be compacted to 95% of the maximum dry density (ASTM D698). Moisture conditioning may be required to achieve the specified level of compaction.

3. The Contractor must ensure that the integrity of the GCL is not compromised during construction. The precautions the Contractor may take to avoid damaging the GCL may include but will not be limited to: providing light plants in the work area to improve operator visibility or using pylons to mark the lift/GCL system interface.

4. Any damage to the GCL must be immediately reported to the Engineer and Owner. Repair work must commence as soon as possible. Fill placement must cease immediately in an area where the integrity of the GCL has been compromised. Excavation of fill surrounding the damaged GCL, to allow repairs to be made, must be done without further damaging the integrity of the products. Hand excavation may be required.

7.2.12 Tolerances

1. Fill shall be placed in horizontal lifts to the lines and levels shown on the drawings or as directed herein.

2. Unless specifically detailed on the drawings or from direct communication from the Engineer, then fill and cut surfaces should be completed to an accuracy of ±5 cm or less.

7.2.13 Compaction Trials

1. Compaction trials shall be performed upon production of fill material to determine site specific parameters such as density and compaction standards. The trials shall be carried out as part of the fill placing operation.

2. The Engineer may request through the Owner to periodically conduct field trials to optimize moisture conditioning, lift thickness and compaction effort.

3. The compaction trials on the material in question shall be done using a survey method according to the general procedure detailed below, or as specified by the Engineer:

   (1) A rectangular pad made with the approved material of approximately 7 m width by 20 m length with specified thickness associated with the specified material with placement method according to this Specification.

   (2) A set of survey points with accuracy of ±5 mm shall be laid out as specified by the Engineer in a grid pattern.

   (3) The elevations of each survey points shall be recorded immediately after placement and after each compaction effort.

   (4) The compaction be done upward of 10 passes in accordance with this Specification or otherwise specified by the Engineer and survey recorded after each pass.

   (5) This process shall be repeated to simulate construction as directed by the Engineer.

4. The Owner and or the Contractor shall obtain the Engineer's approval before implementing any change to the Specifications.

7.2.14 Restrictions Due to Weather and Suspension of Operations

1. The Contractor shall not place any fill when conditions for such operations are unsatisfactory due to heavy snowfall, extraordinarily freezing conditions, or any other reason determined by the Engineer.

2. Where operations have been discontinued by the Contractor or suspended by the Engineer, the effects of adverse conditions shall be assessed by the Engineer and the surficial layers of fill treated or replaced to the satisfaction of the Engineer before resumption of fill placement.

3. Before suspension of operations each day, or each construction shift, as described in this Section 2, and before suspension due to inclement weather, Core material fill in place shall be:

   (1) Surface shaped to drain excess water.

   (2) Rolled smooth to seal against ice lens development.

   (3) The Engineer will examine the quality of surficial fill to determine if rework is required to meet requirements.

4. In freezing conditions, the Contractor shall:

   (1) Provide satisfactory snow and ice removal from subgrade surface.

   (2) Provide heating capabilities to condition the Core material to the specified moisture content during placement and compaction.

5. In conditions that is warmer than -10°C during the Core material placement, the Contractor shall:

   (1) Prove to the Engineer that a satisfactory uniformly frozen core without free ice lenses can be constructed.

7.2.15 Sediment and Runoff Control

1. The Owner is responsible to provide the Contractor the locations and methods to construct facilities such as diversion berms, sediment ponds, and other measures as are required to prevent the discharge of fines from construction areas and from entering any natural water courses downstream of the Works during the spring melt season immediately following construction.
2. In general, when placing fill material, the Contractor shall slope the surfaces toward collection channels for surface water management.
3. The Contractor shall not excavate any ditches in the original ground, especially in permafrost overburden. Diversion berms will be the preferred method to re-route surface water.

7.3 Part 3 – Quality Control

1. The Contractor shall be responsible for the quality of fill as described in Section 5.
2. The Contractor shall conduct regular topographic surveys to demonstrate the placement of fill to the specified lines, levels, grades and tolerances. The Engineer may from time-to-time witness survey checks. Survey results shall be reported to the Engineer and Owner within 24 hours of the completion of each survey.
3. The Contractor shall carry out Quality Control testing during fill placement as outlined in Table 7.1.

Table 7.1: Required QC testing during placement of construction material

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QC Test Frequency	Submittal
Riprap	In-Place	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Riprap	In-Place	n/a	Visual and Survey Controlled	n/a	24-hrs	Ongoing	Survey Report
Run-of-Quarry	In-Place	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Run-of-Quarry	In-Place	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Run-of-Quarry	In-Place	n/a	Compaction (Visual)	n/a	n/a	Ongoing	None
Transition (General)	In-Place	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QC Test Frequency	Submittal
Transition (Dam Construction)	In-Place	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Transition	In-Place	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Transition	In-Place	n/a	Compaction (Visual)	n/a	n/a	Ongoing	None
Surfacing	In-Place	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One per 3,000 m^3	Test Certificate
Surfacing	In-Place	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Surfacing	In-Place	n/a	Compaction (Visual)	n/a	n/a	Ongoing	None
Bedding	In-Place	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One per 1,000 m^3	Test Certificate
Bedding	In-Place	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Bedding	In-Place	n/a	Compaction (ASTM D2922)	On Site	Immediate	One per 100 m^2/Lift	Test Certificate
Core	During placement, but before freeze-back	Grab	Mix Consistency (Visual)	n/a	n/a	Ongoing	None
Core	During placement, but before freeze-back	n/a	Compaction (Visual)	n/a	n/a	Ongoing	None
Core	During placement, but before freeze-back	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report

7.4 Part 4 – Quality Assurance

1. QA testing shall be carried out across the full length, width, and depth of the various fill zones so as to fully represent the overall quality of the structure.

2. The Contractor shall conduct regular topographic surveys to demonstrate the placement of fill to the specified lines, levels, grades and tolerances. The Engineer may from time-to-time conduct survey checks. Survey results shall be reported to the Engineer and Owner within 24 hours of the completion of each survey.

3. The compacted density of the Core material must be evaluated by coring samples for laboratory testing and in-situ compaction testing. Samples of the placed fill will be obtained using a concrete coring machine. The core sample will be used to determine if the lift of key trench backfill is completely frozen and to determine the soil properties.

4. Samples of placed Core material must be taken once freeze-back is completed by means of a concrete coring machine. The core must extend through the lower contact of the lift. All cored samples must be evenly distributed over the lift surface. All holes must be thoroughly washed with clean water to remove any remaining drilling fluid and backfilled with saturated Core material immediately after extraction of the core.

5. Each cored sample of core key trench fill shall be split in half longitudinally and transversely and then examined and photographed by the Engineer. The bonding between layers, ice-saturation, and ice bonding will be evaluated.

6. The method of determining bulk density of cored samples will depend on the quality of the sample. The sample volume can be determined from the dimensions if the core has uniform dimensions. The Engineer will rely on in-situ measurements of core and key trench fill density with a nuclear densometer if core recovery is poor or if the recovered cores are non-uniform.

7. The degree of saturation for cored samples will be determined, when possible, from the measured moisture content, bulk density, and measured specific gravity.

8. Final acceptance of earthworks will be made only after fill materials have been dumped, spread, moisture conditioned (if required based on the fill type and as per the directions of the Engineer), and compacted, and tests and surveys have demonstrated compliance with the Specifications.

9. If on the basis of the sampling and testing, or if in the opinion of the Engineer, an area of the fill does not meet the specified requirements; such fill shall be removed and replaced with conforming material. Rejection of fill material by the Engineer may be made at source, in transporting vehicles, or in place.

10. The Engineer can re-inspect previously approved areas for damages and instruct the Contractor to repair said damages in accordance with the Specifications.

11. The Engineer shall carry out Quality Assurance testing during fill placement as outlined in Table 7.2. Additional testing may be conducted at the discretion of the Engineer.

Table 7.2: Required QA testing during placement of construction materials

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QA Test Frequency	Submittal
Riprap	In-Place	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Riprap	In-Place	n/a	Visual and Survey Controlled	n/a	24-hrs	Ongoing	Survey Report
Run-of-Quarry	In-Place	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Run-of-Quarry	In-Place	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Run-of-Quarry	In-Place	n/a	Compaction (Visual)	n/a	n/a	Ongoing	None
Transition (General)	In-Place	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QA Test Frequency	Submittal
Transition (Dam Construction)	In-Place	n/a	Particle Size Analysis (Visual)	n/a	n/a	Ongoing	None
Transition	In-Place	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Transition	In-Place	n/a	Compaction (Visual)	n/a	n/a	Ongoing	None
Surfacing	In-Place	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One per 6,000 m^3	Test Certificate
Surfacing	In-Place	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Surfacing	In-Place	n/a	Compaction (Visual)	n/a	n/a	Ongoing	None
Bedding	In-Place	Grab	Particle Size Analysis (ASTM C136)	On Site	24-hrs	One per 2,000 m^3	Test Certificate
Bedding	In-Place	Grab	Maximum Density (ASTM D698)	On Site	24-hrs	One per 3,000 m^3	Test Certificate
Bedding	In-Place	Grab	Water Content (ASTM D2216)	On Site	24-hrs	One per 3,000 m^3	Test Certificate
Bedding	In-Place	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Bedding	In-Place	n/a	Compaction (ASTM D2922)	On Site	Immediate	One per 400 m^2/Lift	Test Certificate
Core	During placement, but before freeze-back	Grab	Mix Consistency (Visual)	n/a	n/a	Ongoing	None
Core	During placement, but before freeze-back	n/a	Compaction (Visual)	n/a	n/a	Ongoing	None
Core	During placement, but before freeze-back	n/a	Compaction (ASTM D2922 - Nuclear Densometer)	In-Situ	Immediate	One per 225 m^2/Lift	Test Certificate
Core	During placement, but before freeze-back	n/a	Lift Thickness (Survey Control)	n/a	Hold Point - Before Next Lift is Placed	Every Lift	Survey Report
Core	After freezeback (from "cored" sample)	Drilled Core	Ice Saturation and Bulk Density (EBA Method on "Cored" Sample)	Site Lab	Hold Point - Before Next Lift is Placed	4 "cores" per lift or 2 per day	Test Certificate
Core	After freezeback (from "cored" sample)	Drilled Core	Moisture Content (ASTM D2216)	Site Lab	24-hrs	75% of "cores" collected per lift/per day	Test Certificate

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QA Test Frequency	Submittal
Core	After freezeback (from "cored" sample)	Drilled Core	Particle Size Analysis (ASTM C136)	Site Lab	24-hrs	One per lift (use aggregate of "cores")	Test Certificate
Core	After freezeback (from "cored" sample)	Drilled Core	Specific Gravity (ASTM D854)	Off Site Lab	7-days	One from 2nd lift and one from last lift	Test Certificate
Core	After freezeback (from "cored" sample)	Drilled Core	Salinity	Off Site Lab	7-days	One per 8,000 m^3	Test Certificate
Core	During freezeback	n/a	Freeze back (Thermistor)	In-Situ	Hold Point - Before Next Lift is Placed	2 (beads) per lift, equally spaced	Data Report

---------- END OF SECTION 7 ----------

8 Horizontal Thermosyphons

8.1 Part 1 –General

8.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted, and coordinated with all other parts.

8.1.2 Definitions

1. The following words and terms, unless the context otherwise requires, in the Specification, shall have the meanings set out below:

   (1) THERMOSYPHON means a passive heat transfer system using a combination of evaporator pipes and radiators to ensure that the base of the key trench remain frozen for the design life of the frozen core dam.

   (2) RADIATOR means a manufactured product with fins to enhance heat transfer from the evaporator pipes to ensure efficient working of the thermosyphon.

   (3) EVAPORATOR PIPE means the steel pipe installed at the base of the dam key trench to transfer heat from the ground to the atmosphere via the radiator.

8.1.3 Materials

1. The horizontal thermosyphons shown on the drawings will be manufactured, supplied, and installed by a specialist contractor.
2. The thermosyphons shall be two-phase, liquid-vapour type thermosyphons charged with carbon dioxide refrigerant.
3. The thermosyphons shall be constructed with A53B Schedule 40 steel pipe.
4. The radiators shall be 75 mm O.D. pipe with 32 mm high x 0.012 mm nominal thickness carbon steel fins. Fin density shall be four (4) rows of fins per 25 mm of pipe.
5. Standard of Acceptance: Thermosyphons as manufactured by Arctic Foundations of Canada Inc., Winnipeg, Manitoba, or an approved equal.
6. The evaporator and radiator sizes shall be as shown on the Drawings.
7. All welds shall meet ASME boiler and pressure vessel Code B31.3.

8.2 Part 2 – Execution

8.2.1 Installation

1. The evaporator pipes shall be installed as specified on the Drawings.
2. The radiators shall be erected plumb.
3. All piping shall be tested by the installer prior to burial.

8.2.2 Monitoring

1. The operation of the thermosyphons shall be monitored with a contact thermometer or an infrared surface temperature measuring device to verify operation. Operation is generally indicated by a thermosyphon temperature being a few degrees warmer than the air temperature. Monitoring shall be carried out twice a month during the first three months in which the thermosyphons are expected to be operational. The thermosyphons will only be operational during the period when the air temperatures are colder than the ground temperatures.
2. Performance of the thermosyphons shall be evaluated with ground temperature cables as shown on the Drawings and as described in Section 9 of this document.

8.3 Part 3 – Quality Control

1. Physically demarcate, for review and approval by the Owner and Engineer, the Works area where the thermosyphons will be installed using proper survey control.
2. Conduct field surveys, and submit As-built Drawings, in electronic format of the installed thermosyphons.
3. Conduct a pressure test on each individual completed thermosyphon, and submit the results of the test to Owner and the Engineer for review.

8.4 Part 4 – Quality Assurance

1. Visually inspect the demarcated zone prepared by the Contractor for installing the thermosyphons and inform the Contractor via the Owner if changes are required.
2. Visually inspect the installed thermosyphons and inform the Contractor via the Owner if changes are required.
3. Review As-built Drawings submitted by the Contractor of installed thermosyphons and inform the Contractor via the Owner if any changes are required.
4. Review the results of the pressure tests conducted on the thermosyphons and inform the Contractor via the Owner if any changes are required.
5. Monitor the thermosyphon temperatures and inform the Contractor and Owner is trends emerge suggesting non-performance of the system.

---------- END OF SECTION 8 ----------

9 Instrumentation

9.1 Part 1 –General

9.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted, and coordinated with all other parts.

9.1.2 Definitions

1. The following words and terms, unless the context otherwise requires, in the Specification, shall have the meanings set out below:

   (1) GROUND TEMPERATURE CABLE means a manufactured cable with thermistor beads that allows in-situ ground temperature measurement.

   (2) THERMISTOR BEAD means an instrument capable of measuring in-situ ground temperature.

   (3) SETTLEMENT MONUMENT means an instrument capable of measuring in-situ ground deformations.

9.1.3 Materials

1. The ground temperature cables shown on the Drawings will be manufactured and supplied by a specialist contractor.
2. Ground temperature cables, casings, and datalogger housings will be supplied by the Contractor and Owner, with explicit direction provided by the Engineer.
3. The settlement monuments will be supplied and installed by the Contractor, with explicit direction provided by the Engineer.
4. The Contractor shall be responsible for providing protection for all instruments installed before construction of the dam is complete. The method of protection must be approved by the Engineer. The Contractor may be held responsible (at the Engineer's discretion) for replacement or repair of instruments damaged during construction.

9.1.4 Procedures

1. Ground temperature cables must be installed as shown on the Drawings to measure ground temperature during construction and operation of the dams.
2. Single bead ground temperature cables will be used to monitor the freeze back of individual lifts of the key trench backfill (when frozen core material used).
3. Settlement monuments must be installed as shown on the Drawings to allow any settlements of the dams to be measured.

9.1.5 Submittals

1. At least seven (7) days prior to installation of the ground temperature cables, the Contractor shall submit to the Engineer and Owner, for approval, the Manufacturers Calibration Certificates for each ground temperature cable.

9.2 Part 2 – Execution

9.2.1 Ground Temperature Cable Installation

1. Horizontal and vertical ground temperature cables must be installed during construction. The locations and orientation of the ground temperature cables are shown in the Drawings.
2. Drill holes for ground temperature cable installation must be 100 mm diameter or greater. Drill holes must be drilled in the presence of the Engineer to the depths shown on the Drawings.
3. The drill hole with the installed ground temperature cable must be backfilled with slurry as described in Section 11 to prevent air voids around the ground temperature cable.
4. The portion of the cable extending beyond the dam fill must be protected with a steel pipe extending 1 m above the final elevation of the dam. The steel pipe must be painted with fluorescent paint.
5. The location of the installed instruments must be surveyed.

9.2.2 Settlement Monuments Installation

1. Settlement monuments must be supplied and installed by the Contractor according to the Drawings and as directed by the Engineer.

9.3 Part 3 – Quality Control

1. Physically demarcate, for review and approval by the Owner and Engineer, the Works area where the instrumentation will be installed using proper survey control.
2. Conduct field surveys, and submit As-built Drawings, in electronic format of the installed instrumentation.

9.4 Part 4 – Quality Assurance

1. Visually inspect the demarcated zone prepared by the Contractor for installing the instrumentation and inform the Contractor via the Owner if changes are required.
2. Visually inspect the installed instrumentation and inform the Contractor via the Owner if changes are required.
3. Review As-built Drawings submitted by the Contractor of installed instrumentation and inform the Contractor via the Owner if any changes are required.
4. Review the manufacturers Calibration certificates for the ground temperature cables and inform the Contractor via the Owner if any changes are required.

5. Confirm that each ground temperature cable is functioning prior to installation, and throughout the construction stage.

---------- END OF SECTION 9 ----------

10 Percolation

10.1 Part 1 –General

10.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted, and coordinated with all other parts.

10.1.2 Definitions

1. The following words and terms, unless the context otherwise requires, in the Specification, shall have the meanings set out below:

   (1) PERCOLATION TEST means a test within the footprint of a dam key trench prior to excavation to confirm the base of the key trench is founded within saturated frozen soil.

10.2 Part 2 – Execution

10.2.1 Test Procedure

1. Survey and mark the layout of the percolation test holes within the footprint of the proposed key trench area.
2. Drill the percolation test holes using an air-track drill and air flush with a minimum hole diameter of 100 mm. The depth of the test holes will depend on the local geotechnical conditions as defined by the Engineer. For the Doris Dams the percolation holes should be a minimum of 10 metres deep, unless bedrock is encountered.
3. Drill cutting samples should be collected and bagged every 500 mm during drilling to a depth of 4 m, and every 1,000 mm between a depth of 4 m and 10 m. A box, board, or shovel placed near the test hole during drilling may be used to collect samples of the drill cuttings.
4. The samples collected during drilling of the percolation holes should be logged using geotechnical and permafrost logging procedures to develop a soil profile log.
5. Moisture content determinations should be completed on all the samples collected. Salinity testing should be carried out on approximately 30% of the samples collected or as directed by the Engineer. The samples for salinity testing should be determined based on varying depths and material type changes.
6. Upon completion of drilling, the top of the percolation hole should be insulated until ready for testing. Insulation can be fibreglass batting, or other equivalent material, which should penetrate about 600 mm down the percolation hole.
7. When ready for testing, remove the insulation and fill the percolation hole with water that has a temperature of approximately 15°C (holes are filled only once). Where possible, record the volume of water required to fill the hole. Volume estimation may be achieved through use of 20-liter pails.

8. Record the change of the water level in the percolation hole using a measuring tape. Readings should be undertaken at suitable time intervals to determine the rate of water level change and at which level there is no further change of the water level. For example, the reading schedule can be: 0 min, 1 min, 2 min, 5 min, 10 min, 15 min, 30 min, 45 min, 60 min, 2 hrs, 8 hrs, 16 hrs, 24 hrs, and 36 hrs.
9. Keep the percolation holes insulated between water level readings.
10. Following the completion of percolation testing, all percolation holes with a final depth to ice greater than 1 m should be backfilled with 20 mm crush and water and allowed to freeze back after percolation testing is completed.

10.3 Part 3 – Quality Control

1. The Contractor shall carry out Quality Control testing during percolation testing, including, but not limited to:
   (1) Survey control of the percolation test hole locations.
   (2) Survey control of the percolation test hole diameter and final depth.

10.4 Part 4 – Quality Assurance

1. The Engineer shall carry out Quality Assurance testing during percolation testing, including, but not limited to:
   (1) Recording of percolation test conditions as specified in this document.
   (2) Logging of percolation test holes, including completion of moisture content testing, and conducting two (2) to three (3) salinity tests per percolation test hole.

---------- END OF SECTION 10 ----------

11 Adfreeze Piles

11.1 Part 1 –General

11.1.1 Documents

1. This section of the Specifications forms part of the Contract Documents and are to be read, interpreted and coordinated with all other parts.

11.1.2 Definitions

1. The following words and terms, unless the context otherwise requires, in the Specification, shall have the meanings set out below:

   (1) ADFREEZE PILES means steel pipes required to support the thermosyphon radiators.

11.2 Part 2 – Execution

11.2.1 Installation

1. A minimum 4” (102 mm) nominal Schedule 80 pipe is recommended. The pile installation holes shall be drilled to a diameter at least 100 mm larger than the outside diameter of the pipe.
2. The pile shall penetrate a minimum of 6.0 m below grade.
3. Holes shall be cut on opposite sides of the pile to ensure the sand slurry fills the annulus between the steel pipe pile and the wall of the borehole. The holes also provide a mechanical interlock between the frozen sand backfill and the steel which contributes to the specified allowable bond strength. The holes shall be spaced at 500 mm and be approximately 50 mm wide by 100 mm long. Each pile shall have a minimum of sixteen holes within the frozen bond length. No holes shall be placed within the top 2 m of the pile embedment.
4. After drilling, the hole shall be free of water, mud, slough and any other delirious material. The procedure is very important for obtaining a suitable bond between the slurry and the pile, and between the slurry and the permafrost or rock. Loose material and oil and grease shall be completely cleaned off the pile immediately before installation. These operations shall be monitored by the Engineer.
5. It is recommended that the pile be placed in the hole first and slurry placed down the centre of the pile. The slurry shall consist of approximately 15% to 35% water by volume. The water content shall be moist enough to attain a workable and fully saturated mixture but shall be minimized to facilitate freeze back. A pencil vibrator or a pile vibrator shall be used to densify the slurry.
6. Aggregate used for slurry shall consist of mineral soils conforming to the following gradation limits listed in Table 11.1.

Table 11.1: Typical Gradation of Slurry Sand for Backfill

Sieve Size (mm)	Percent Passing by Weight
10	100
5	85-100
2	60-100
0.63	20-65
0.08	0-15

7. Water used for slurry production shall be fresh potable water. The temperature of the slurry when placed shall not exceed 10°C to minimize permafrost disturbance and freeze back time.

8. Accurate records of slurry volumes placed down the hole shall be kept. This is to identify that there are no voids between the pile and the side of the hole.

11.3 Part 3 – Quality Control

1. Physically demarcate, for review and approval by the Owner and Engineer, the Works area where the adfreeze piles will be installed using proper survey control.

2. Conduct field surveys, and submit As-built Drawings, in electronic format of the installed piles.

11.4 Part 4 – Quality Assurance

1. Visually inspect the demarcated zone prepared by the Contractor for installing the adfreeze piles and inform the Contractor via the Owner if changes are required.

2. Visually inspect the installed piles and inform the Contractor via the Owner if changes are required.

3. Review As-built Drawings submitted by the Contractor of installed piles and inform the Contractor via the Owner if any changes are required.

4. Record the slurry temperature and collect for testing one (1) sample per pile of the slurry mix. Conduct a particle size distribution (ASTM C136) and Moisture Content (ASTM D2216) test per sample.

---------- END OF SECTION 11 ----------