DORIS PROJECT
2018 CONSTRUCTION MONITORING REPORT

Nunavut Water Board

March 2019

Prepared by:

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Prepared for
Nunavut Water Board
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DORIS PROJECT
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1. Introduction

This Construction Monitoring Report summarizes the monitoring results, analysis and any mitigation measures employed as a result of the monitoring of the items required under Schedule D of the Nunavut Water Board licence 2AM-DOH1323.

In 2018 commercial operations continued at Doris with continued efforts to progressively ramp up production to increase ore throughput and optimize gold recovery. Infrastructure constructed included a fabric tent structure over the primary crusher of the mill and an enclosure for the detoxified tailings conveyor exiting the mill building. Two dorms were added to allow an additional 98 bed spaces at Doris Camp.

Earthworks continued to complete the Doris Airstrip south apron expansion and lined aircraft de-icing and refueling pad. Construction of the Tailings Impoundment Area South Dam and associated access road were completed in 2018. In addition to this, construction of the access road and outfall berm for the Roberts Bay ocean discharge line and fusing of the discharge pipeline began in 2018. To accommodate increased fuel storage required for future project activities, the Robert's Bay single tank farm berm was raised to allow full use of the 5ML tank and this tank was recommissioned in 2018. In order to support continued underground development, the Doris Connector Vent Raise access road was constructed. The final section of Pad T was completed in 2018 to allow additional ore and waste rock storage within the permitted footprint.

Underground waste development continued in 2018 with further advancement of the below the dyke (BTD) decline and necessary support infrastructure. TMAC completed ore development above the dyke for long hole drilling and blasting in the Doris Connector (DCO) and BTD in Doris North, and commenced ore sill development in the DCO. TMAC also continued waste development of the DCO for future mining horizons. Long hole blasting continued throughout 2018, with all ore production trucked to surface and processed through the mill or added to the stockpile. Development of the Doris Central (DCN) decline began in Q4 of 2018. TMAC continued underground exploration diamond drilling below the dyke at Doris, focused on the BTD East limb in 2018. The DCO Vent Raise was constructed and a conventional raise to surface was also developed from the BTD to support underground ventilation requirements.

Ore development also occurred from surface in Q4 of 2018 with the completion of surface blasting and hauling of ore and waste from the Doris Crown Pillar Trench (DCPT).

In the fall, TMAC concluded another successful sealift operation including the purchase and delivery of diesel fuel and Jet-A fuel as well as explosives and reagents to support mining and milling activities. The sealift also included additional heavy equipment and supplies to support mining and construction operations.

Waste disposal, fuel usage and chemical storage stayed consistent with previous years and 15 spills were reported to the Nunavut Spill Line, Water Licence Inspector and KIA Major Projects office. The remaining spills that occurred during 2018 were minor in nature, occurring on land, with quick response and clean up resulting in negligible impact to the receiving environment. Empty cargo aircraft were utilized in 2018 for waste backhaul from the Doris Camp to KBL Environmental in Yellowknife to arrange for final remediation/disposal.

2. Blast Vibration Monitoring for Quarrying Activity Carried Out in Close Proximity to Fish Bearing Waters

Construction blasting occurred in Quarry 2 from February to June and August to October to support construction activities however Quarry 2 is not in close proximity to fish bearing waters.

3. Monitoring of the Performance of Erosion Protection Measures Employed by the Construction Contractor

Erosion protection measures are generally installed by the construction contractor in consultation with TMAC Resources Inc. (TMAC) site Environment Department staff to ensure sensitive locations, or areas vulnerable to disturbance or impact, are adequately protected. During routine site inspections and via water quality monitoring associated with the SNP for water licence 2AM-DOH1323, the performance and efficacy of these erosion protection measures are verified and corrective measures implemented where needed. In 2018, no runoff was observed from construction areas, as such, no samples were collected for SNP monitoring station ST-10.

4. Monitoring for Sediment Release from Construction Areas

No uncontrolled sediment release with the potential of reaching water occurred in 2018. Sedimentation controls (flow energy dissipaters, silt fencing and turbidity curtains) were installed during the construction of the Roberts Bay Discharge Access Road and Culvert installation to contain any sediment that could become mobile if a rainfall event occurred during construction. A small coffer dam was constructed to temporarily hold and divert flow around the culvert installation area. Pooled water was pumped around the construction area and discharged into the stream approximately 10m downstream of the culvert installation. Flow energy dissipaters were installed at the point of discharge to prevent erosion and sedimentation. Silt fencing was also installed approximately 5m downstream of the culvert installation to contain sediment that may have been mobilized during construction.

A floating turbidity curtain was installed along the perimeter of the marine outfall berm in-water construction area to deflect and contain sediment. Routine inspections of the construction area were conducted to ensure integrity of the silt curtain was maintained and no sediment migration was occurring beyond the designated construction area. An aerial photo depicting the performance of the silt curtain can be observed in Figure 1.

Figure 1. Aerial Photo of Marine Outfall Berm Silt Curtain Installation

Sedimentation controls for the Doris Connector Vent Raise Access Road and Culvert were installed using a similar approach as the Robert's Bay Access Road and Culvert Installation. A small coffer dam was constructed to temporarily hold and divert flow around the culvert installation area. Pooled water was pumped around the construction area and discharged into the stream approximately 10m downstream of the culvert installation. Flow energy dissipaters were installed at the point of discharge to prevent erosion and sedimentation. Silt fencing was also installed approximately 5m downstream of the culvert installation to contain sediment that may have been mobilized during construction.

All sedimentation installations were routinely inspected during periods of construction and no signs of turbidity, sedimentation or erosion were observed downstream of the sedimentation controls.

All other construction took were located such that flow could not directly or indirectly enter a water body.

Water quality monitoring of sediment releases is conducted as part of the SNP for the Type A Water Licence 2AM-DOH1323. In 2018, no runoff was observed from construction areas, as such, no samples were collected for SNP monitoring station ST-10.

5. Waste Rock and Quarry Monitoring Report

The Waste Rock and Quarry Monitoring Report, will include the following:

I. **A summary of geochemical inspections;**

II. **Results of the seep surveys;**

III. **Results of geochemical sampling and analysis; and**

IV. A summary of all mitigation activities undertaken as a result of monitoring.

5.1 SUMMARY OF GEOCHEMICAL INSPECTIONS IN 2018

A summary of geochemical inspections in 2018 is as follows:

- Inspection of quarry rock construction material along as-built infrastructure by SRK including: the southern extent of the tailings impoundment area (TIA) access road, south dam, an expansion to the jetty road, the cyanide reagent pad, Pad T surface repairs, the Marine Outfall Berm (MOB) Access Road at Roberts Bay, airstrip south apron and the east airstrip access road.
- Operational waste rock inspections from the underground and crown pillar recovery trench (CPRT) by TMAC.
- Inspection of 2018 waste rock placed on the waste rock stockpile on Pad T by SRK. CPRT waste rock placed on Pad T was not inspected by SRK as its placement post-dated SRK's inspection date.
- Seepage monitoring by TMAC of infrastructure constructed from Quarry 2 rock (the southern extent of the TIA access road, the south dam, tailings catchment basin (east of Doris Creek), an expansion to the jetty road, the cyanide reagent pad, and airstrip) and the waste rock stockpile.

The inspection of the waste rock stockpile by SRK confirmed that TMAC was managing waste rock according to their approved waste rock management plan. Results of all other inspections are discussed in items (5.2) and (5.3) below.

5.2 RESULTS OF QUARRY ROCK SEEPAGE PROGRAM

See Section 5.6 below for results of the quarry rock seepage program.

The results of the 2018 seep survey indicated that there are no major issues with respect to metal leaching and acid rock drainage in seepage associated with infrastructure at Hope Bay.

Compared with seeps from infrastructure areas, and consistent with previous years, seepage from areas impacted by waste rock had elevated levels of chloride, nitrate, ammonia, arsenic, copper and selenium. Chloride concentrations are attributed to flushing of drilling brines and ammonia and nitrate to blasting residues from the waste rock. Increasing trends in sulphate, copper and selenium concentrations may be attributed to the placement of ore in the stockpile on top of Newmont's waste rock stockpile, which has higher sulphide content than waste rock. Increasing arsenic and iron concentrations are attributed to the presence of colloids.

5.3 RESULTS OF GEOCHEMICAL SAMPLING AND ANALYSIS

5.3.1 Quarry Rock

In 2018, blasting occurred in Quarry 2 from February to June and August to October. Geological inspections of the active quarry faces indicated that quarry rock was mafic metavolcanics (basalt) containing trace amounts of disseminated pyrite (<1%). The results of the run of quarry (ROQ) rock geochemistry investigation indicated that the monitoring samples were non-PAG. Total sulphur concentrations ranged between 0.13 and 0.28%. Modified NP and TIC content ranged between 19 and 151 kg CaCO3/t and 76 and 143 kg CaCO3/t, respectively. Elemental analyses indicate no appreciable enrichment compared to average crustal abundance for basaltic rocks. SFE test results indicated the risk of ML/ARD from ROQ rock is low.

The as-built construction rock geochemical characterization program included samples collected from the southern extent of the TIA access road, the south dam, an expansion to the jetty road, the cyanide reagent pad, Pad T surface repairs, the MOB Access Road, airstrip south apron and the east airstrip access road. All construction rock was sourced from Quarry 2. The results of the quarry rock geochemistry investigation indicated that all of the samples collected for testing are non-PAG with low sulphur content (0.04% to 0.22%), appreciable TIC (67 to 157 kg CaCO3/t) and NP (36 to 129 kg CaCO3/t). Arsenic and boron were enriched relative to the screening criteria in a sample from the East Airstrip Access Road and South Dam, respectively. All other parameters were below the screening criteria indicating no appreciable enrichment. SFE test results indicated that all test leachates were alkaline and that all parameters were below the screening criteria, except for pH. All results indicate the risk of ML/ARD from construction rock is low.

The geochemical monitoring of ROQ and in situ as-built construction rock indicated that the construction material was geochemically suitable for this purpose.

5.3.2 Waste Rock

In 2018, mine development at Doris included underground mining and development of the CPRT on surface. Waste rock brought to surface from all mining areas was placed on Pad T. All waste rock placed on Pad T was managed as mineralized rock.

In 2018, the Doris underground mine produced approximately 557,007 t of waste rock, of which almost half (260,452 t) was placed directly as backfill in the underground stopes with the balance (approximately 299,188 t) placed in a stockpile on the eastern side of Pad T. In 2018, 1,760 t of waste rock was moved from the waste rock stockpile on Pad T to the underground, where it was placed as backfill in underground stopes.

Mining of the CPRT between November and December 2018 resulted in the production of and placement of 263,500 t of waste rock on Pad T. Of this amount, 212,500 t was placed in the existing waste rock stockpile on the east side of Pad T, of which 190,000 t will be placed as backfill in the CPRT and 22,500 t will be placed as backfill in stopes of the underground mine. Another 51,000 t of material was placed in its own stockpile on the western expansion of Pad T - this material will be placed as capping material on the CPRT. None of the CPRT waste rock was placed as backfill in 2018.

The majority of waste rock types intersected in the Doris underground workings were: metavolcanic flow (1a); massive mafic metavolcanic flow (1i); vesicular mafic metavolcanics (1ay) and altered mafic metavolcanics (1as). Furthermore, 1 to 2% of waste rock was quartz veins (12q and 12qd) with minor amounts (<1%) of late felsic dykes (9); late gabbroic dykes (10a). All waste rock placed on Pad T was classified as mineralized.

A total of 36 underground waste rock samples were collected as part of the waste rock geochemical monitoring program in 2018, with one sample geologically identified as diabase (11c) and the others as mafic metavolcanics (1a). For the mafic metavolcanics samples (1a), total sulphur content was uniformly low (0.02% to 0.26%) and TIC content was typically (P25 to P75) high (130 to 230 kg CaCO3 eq/t). All underground waste rock samples were classified as non-PAG. Diabase (11c) contained low sulphur (0.07%) and low TIC (19 kg CaCO3 eq/t) and was classified as non-PAG. Trace element content was below the screening criteria (ten times the average crustal abundance for basalt) for all samples of 1a and 11c.

The CPRT waste rock from the western stockpile may potentially be used as construction material, pending regulatory approval of a revised WROMP. Accordingly, the sampling and test work program for CPRT waste rock was designed pursuant to the geochemical monitoring program for construction rock

outlined in the WROMP (TMAC 2019). Three CPRT samples were collected representing CPRT waste rock from the stockpile on west end of Pad T. At each sampling location, two sieved fractions (-2 mm and -1 cm) were collected, for a total of six samples for geochemical analysis.

Sulphur concentrations for CPRT samples ranged from 0.17 to 0.44% and TIC values ranged from 212 to 296 kg CaCO3 eq/t; all CPRT samples and size fractions were classified as non-PAG. Solid-phase arsenic, gold and sulphur were higher than the screening criteria in one or more samples. SFE test leachates were alkaline pH with ammonia concentrations higher than the screening criteria for the two samples. The source of ammonia is residues from explosives.

Mitigation activities as a result of monitoring were not required in 2018.

5.4 MONITORING OF CONTRACTOR'S ACTIVITY TO MINIMIZE GROUND IMPACTS TO THE TUNDRA (I.E KEEPING VEHICLES OFF THE TUNDRA AND ON CONSTUCTED ROADWAYS)

Routine travel is restricted to constructed roadways to keep vehicles off the tundra. Site inspections of work areas are conducted regularly to identify potential ground impacts to tundra. In 2018, there was no unauthorized overland tundra travel by contractors.

5.5 SUMMARY OF THE CONSTRUCTION OF THE NORTH AND SOUTH DAMS

Phase 1 of the South Dam was constructed between January and July of 2018, and the instrumentation system was set-up in November 2018 to February 2019. The South Dam is a frozen foundation dam providing containment at the southern end of the Doris Tailings Impoundment Area. A comprehensive as-built report containing the construction details, as-built drawings and all associated quality assurance and quality control (QC) documentation is provided in Appendix B. The summary components for the construction of the South Dam required under 2AM-DOH1323 Schedule D, item F are located in the as-built report as follows:

I. Laboratory results of subsurface investigation of the dam foundations from undisturbed samples

- A total of 72 QC laboratory tests and 23 QA laboratory tests were performed during construction of the Phase 1 South Dam. Appendix L of the as-built report contains the results of the performed testing, and all the corresponding laboratory test certificates.

II. Details of the geotechnical instrumentation and monitoring plan proposed to monitor the performance of the dams

- Monitoring of the structure's performance is critical to assess the extent of deformations and whether they are within the design limits of the dam. The long-term monitoring approach and geotechnical instrumentation is documented in Section 7 of the as-built report.

III. Results of subsurface investigations and laboratory analyses must be reviewed by MHBL and the dam design modified accordingly under the supervision of a Geotechnical Engineer

- TMAC would like to note that this condition relates to Miramar Hope Bay, Ltd. In regards to the results of the subsurface investigation and laboratory analyses, TMAC relies on the third party expertise of SRK and Maritz Rykaart, PhD, PEng, the Engineer-of-Record (EOR) for the North and South Dams, and Principal Consultant with SRK. Deviations from the original design of the Phase 1 South Dam are documented in Section 3 of the as-built report and approved under the EOR.

North Dam construction was completed in May, 2012. The as-built report was prepared and submitted to the NWB in November 2012. The report contains all the relevant information including results of geotechnical investigations undertaken during construction, and details of any instrumentation installed within the dam.

5.6 SUMMARY OF THE QUARRY ROCK SEEPAGE MONITORING PROGRAM REFERRED TO IN PART D, ITEM 20

TMAC conducted the quarry rock seepage survey between June 14 and 15, 2018. The construction seepage monitoring program included visual inspection and opportunistic sampling of seepage downstream of the areas constructed between summer 2017 and summer 2018 including the southern extent of the TIA access road, the south dam, tailings catchment basin (east of Doris Creek), an expansion to the jetty road, the cyanide reagent pad, and airstrip. Seepage was observed at eight locations along the TIA access road and airstrip. Seepage samples were collected at all locations. In addition, three references sites were sampled.

A summary of the field measurements is presented in Table 1. The median pH ranged from 8.1 to 8.6 with median levels of conductivity ranging from 96 to 230 µS/cm. The results of the 2018 sampling program indicate that there are no major issues with respect to metal leaching and acid rock drainage in seepage associated with infrastructure at Hope Bay.

Table 1. Mean Values for Field Conductivity and pH Measurements

		Median	
Site Area	**No. of Samples**	**Conductivity (µS/cm)**	**pH**
TLA Access Road	6	96	8.6
Airstrip	2	230	8.1

6. Status of the Construction Summary Report Referred to in Part D, Item 25

Construction activities occurring in 2018 for facilities under 2AM-DOH1323 were as follows:

1. South Dam of the Doris Tailings Impoundment Area,
2. Quarry 1 Fuel Tank Farm Liner Raise,
3. Roberts Bay Access Road,
4. Roberts Bay Marine Outfall Berm,
5. Doris Crown Pillar Recovery Trench Access Road, and
6. Doris Connector Vent Raise Access Road.

The Construction Summary Report for the aforementioned activities (with the exception of the South Dam) required under 2AM-DOH1323, Part D, Item 25 are attached as Appendix A. For the South Dam, a comprehensive as-built report containing the construction details, as-built drawings and all associated QA/QC documentation is provided in Appendix B.

Appendix A -
Construction Summary Report

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Memo

To:	Oliver Curran, Vice President Environmental Affairs	**Client:**	TMAC Resources Inc.
From:	Cameron Hore, PEng	**Project No:**	1CT022.036
Reviewed By:	Maritz Rykaart, PhD PEng	**Date:**	March 12, 2019
Subject:	Doris 2018 Construction Summary Report		

1 Introduction

This memo provides a summary of formal documentation related to the engineering and construction support of the following facilities at TMAC Resources Inc's Hope Bay site:

- Quarry 1 Fuel Tank Farm Liner Raise,
- Roberts Bay Access Road,
- Roberts Bay Marine Outfall Berm,
- Doris Crown Pillar Recovery Trench Access Road, and
- Doris Connector Vent Raise Access Road.

In addition to be above listed infrastructure items, the South Dam of the Doris Tailings Impoundment Area was constructed in 2018. The South Dam construction is documented in the South Dam As-Built Report (SRK 2019a) which is provided separately.

For all construction in 2018, SRK Consulting (Canada) Inc. provided Issue for Construction (IFC) drawings. High-density polyethylene (HDPE) liner installation was performed by Blomberg Building Group. Earthworks were completed by Nuna Logistics Ltd. and as-built surveys were conducted by Sub-Arctic Surveys Ltd. SRK has produced the as-built drawings based on the survey data provided by Sub-Arctic.

Construction rock for all the components described in this report was sourced from Quarry 2. Quarry 2 is a designated construction quarry and has been used since 2009. Geochemical characterization of this material has been completed (SRK 2019b) and the material has been confirmed to be non potentially acid generating and non neutral metal leaching.

2 Summary of Attachments

The attachments are organised into separate infrastructure items with sub-level attachments for different forms of documentation.

Of the infrastructure items constructed in 2018, only the Quarry 1 Fuel Tank Farm Liner Raise, and the South Dam involved the installation of liner materials; the South Dam construction is reported separately (2019a). The Blomberg Building Group Project Report for the Quarry 1 Fuel Tank Farm Liner Raise is provided in Attachment 1.3. Blomberg Building Group also collected HDPE seam samples which were sent to an independent laboratory, TRI/Environmental Inc. (TRI) to perform Peel and Shear Tests. The testing results conducted by TRI and the corresponding test request forms are found in Attachment 1.4

The contents of all attachments are summarized in Table 1.

Table 1: Contents of Attachments

Attachment		Infrastructure Item	Contents
1	1.1	Quarry 1 Fuel Tank Farm Liner Raise	Issued for Construction Drawings
	1.2		As-built Drawings
	1.3		BBG Project Report
	1.4		TRI Seam Test Report
2	2.1	Roberts Bay Access Road	Issued for Construction Drawings
	2.2		As-built Drawings
3	3.1	Roberts Bay Marine Outfall Berm	Issued for Construction Drawings
	3.2		As-built Drawings
4	4.1	Doris Crown Pillar Recovery Trench Access Road	Issued for Construction Drawings
	4.2		As-built Drawings
5	5.1	Doris Connector Vent Raise Access Road	Issued for Construction Drawings
	5.2		As-built Drawings

3 Field Decisions and Design Changes

3.1 Quarry 1 Fuel Tank Farm Liner Raise

As confirmed by the As-Built Drawings in Attachment 1.2, the Quarry 1 Fuel Tank Farm Liner Raise has been generally constructed in accordance with the design. There is a small area along the easternmost extent of the facility where survey data of the final over-liner fill was not completed, extending approximately 20 m long. The area was physically inspected and interpreted to have a slope of approximately 2H:1V as indicated on the As-Built Drawings.

This small gap in survey information is not material and does not affect the ability to be confidant that the required secondary containment volume has been satisfied. As indicated, the minimum liner containment elevation of 8.0 masl has been attained, and the As-Built secondary containment volume is 6,270 m^3 which is 170 m^3 over the required minimum design volume of 6,100 m^3.

3.2 Roberts Bay Access Road

The Roberts Bay Access Road was generally constructed in accordance with the design. The minor realignment of the road indicated on the As-Built Drawings (Attachment 2.2.) was required as the actual location of the culvert was different in the field as opposed the IFC Drawings (Attachment 2.1). The Site Surveyor sent SRK the actual stream alignment once the road reached the proposed stream crossing. The road was subsequently re-aligned to ensure that the culvert would be in the optimal location relative to the stream. All the culvert design criteria and construction requirements as stipulated in the IFC Drawings was adhered to. The re-aligned road maintains all the required road design criteria.

There is a small section of road around Station 0+250 of approximately 10 m where the road is underbuilt by about 200 mm. This is not material and will not impact the functionality of the road.

3.3 Roberts Bay Marine Outfall Berm

The Roberts Bay Marine Outfall Berm construction is not complete. The safety barriers and rip-rap armouring still needs to be constructed. Weather conditions however prohibited completion of these items in 2018 and installing them in 2019 is not a concern.

The structure is also slightly underbuilt, both in terms of width and length. This structure, by design is expected to undergo significant settlement, and therefore the fact that it is underbuilt is not a concern, as additional fill would be required in 2019 in any event, and the additional width and length can be added at that time.

The design included installation of a geogrid at the base of the structure. The purpose of the geogrid was to provide for improved safety during construction by allowing for less differential settlement. TMAC decided to not install the geogrid even though it was ordered and on site, since resources to install it was limited. Eliminating the geogrid required careful and slower construction to ensure safety of the personnel and equipment. This was all done without incident and not having the geogrid in place does not impact the long-term integrity of the structure.

3.4 Doris Crown Pillar Recovery Trench Access Road

The Doris Crown Pillar Recovery Trench Access Road was generally constructed in accordance with the design, although as indicated in the As-Built Drawings the alignment was shifted approximately 20 m to the west. This realignment is not material to the design or functionality of the road and was done to accommodate the actual crown pillar recovery trench excavation.

The vehicle turnout was smaller than designed, however the primary purpose of this turnout was to ensure safe road construction, and therefore the smaller size in not material. This is not a permanent road and therefore there is no need for a full-size turnout.

3.5 Doris Connector Vent Raise Access Road

The Doris Vent Raise Access Road was generally constructed in accordance with the design. Two significant changes however did occur. First, the alignment was changed at the start of the road to accommodate the presence of existing infrastructure. This change affects about 40 m of the road and is immaterial to the functionality or design of the road.

The second change is a shortening of the road. The vent raise location was changed to accommodate better rock conditions and as a result the required length of the road could be reduced. This change is not material to the design or the functionality of the road.

4 References

SRK Consulting (Canada) Inc., 2019a. South Dam As-Built Report. Prepared for TMAC Resources Inc. Project No. 1CT022.031. March 2019.

SRK Consulting (Canada) Inc., 2019b. 2018 Hope Bay Construction Rock Geochemical Monitoring – DRAFT. Memo prepared for TMAC Resources Inc. Project No. 1CT022.027. March 2019.

Disclaimer—SRK Consulting (Canada) Inc. has prepared this document for TMAC Resources Inc. Any use or decisions by which a third party makes of this document are the responsibility of such third parties. In no circumstance does SRK accept any consequential liability arising from commercial decisions or actions resulting from the use of this report by a third party.

The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

Attachment 1 – Quarry 1 Fuel Tank Farm Liner Raise

Attachment 1.1 Quarry 1 Fuel Tank Farm Liner Raise - IFC Drawings

TMAC Resources Inc.

Doris North Project

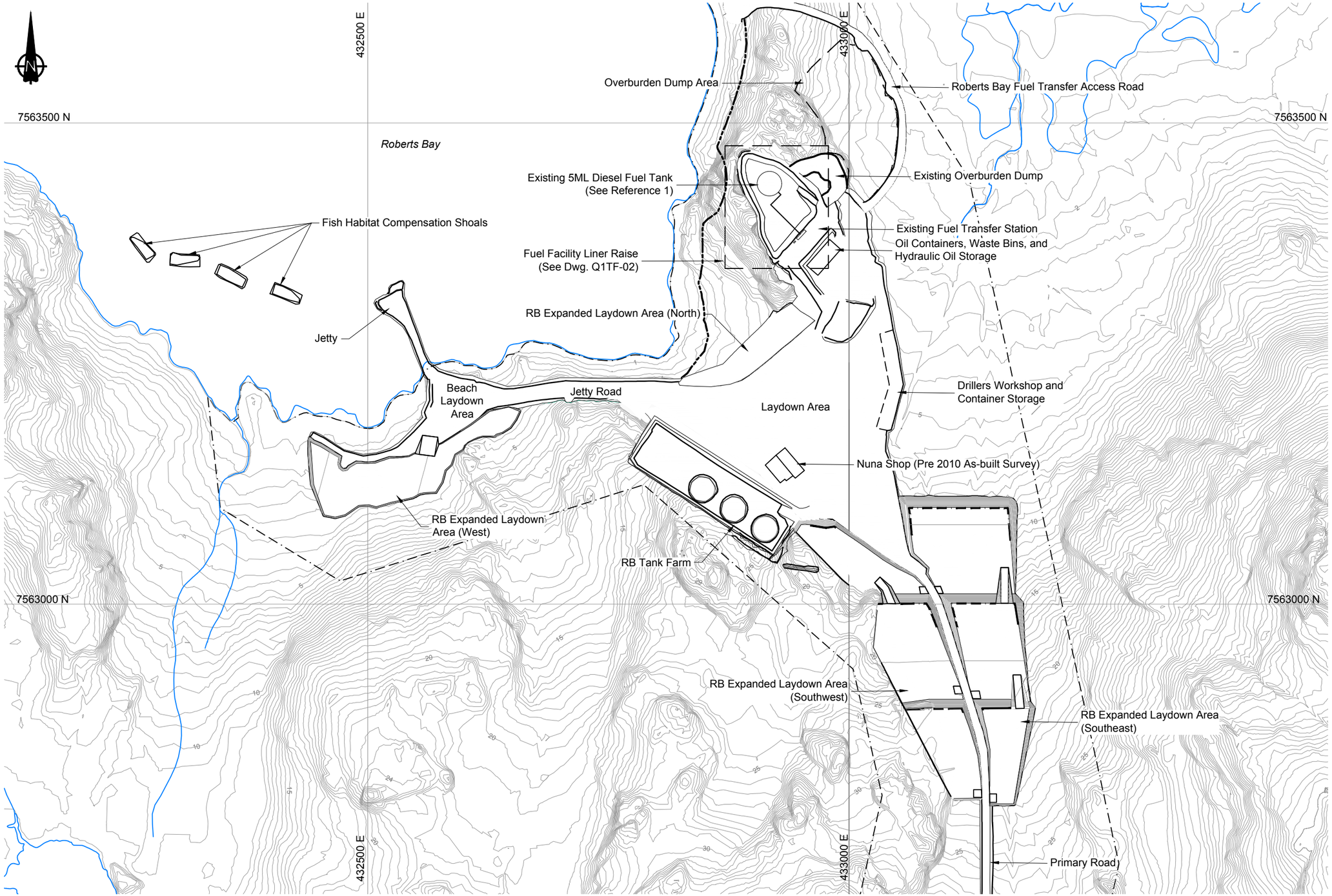
Quarry 1 Tank Farm Liner Raise

Drawing Number	Drawing Title	Issue	Date	Revision
Q1TF-01	General Arrangment	Issued for Construction	7/12/2018	0
Q1TF-02	Roberts Bay Quarry 1 Fuel Tank Farm - Plan View	Issued for Construction	7/12/2018	0
Q1TF-03	Cross Sections A-A', B-B', C-C', D-D', E-E' and F-F'	Issued for Construction	7/12/2018	0
Q1TF-04	Details	Issued for Construction	7/12/2018	0

srk consulting

SRK Job No. 1CM022.030

P:\01_SITES\Hope Bay\IACAD\IFC\RB Q1 Tank Farm Exp\Rev 0\1CT022.030 - Q1 Tank Farm Cover.dwg



LEGEND

- Commercial Lease Boundary
- Shoreline Setback

NOTES

1. The designs are based on the contour information shown on these drawings. It is the Contractor's responsibly to confirm that the contours are a fair reflection of the ground levels in the vicinity of the works, and to advice the Construction Manager and Engineer of any differences.
2. All dimensions are in meters unless otherwise specified.
3. The Engineer will provide the Construction Manager and Contractor with digital design files for setting out the works. The Engineer will instruct the Contractor to survey random spot checks to confirm whether the works have been set out correct.
4. Construction shall be in accordance with the following Technical Specifications: Technical Specifications Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut Canada, Revision H - Issued for Construction.

REFERENCES

1. SRK Consulting (Canada) Inc., 2011. Engineering Drawings for the Roberts Bay Quarry and Fuel Tank Farm, Doris North Project, Nunavut, Canada. Revision 2. Issued for Construction. Drawings prepared for Hope Bay Mining Limited. Project Number 1CH008.033. December 2, 2011.
2. NAD83 UTM Zone 13.

DRAWING NO.	DRAWING TITLE
--	--

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
--	--	--	--	--

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	CH	EMR	18/07/12
A	Issued for Review	CH	EMR	18/07/12

REVISIONS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	CH
CHECKED:	APPROVED:	DATE:
CH	EMR	July 12, 2018

FILE NAME: 1CT022.030 - Q1 Tank Farm GA.dwg

TMAC RESOURCES

Hope Bay Project

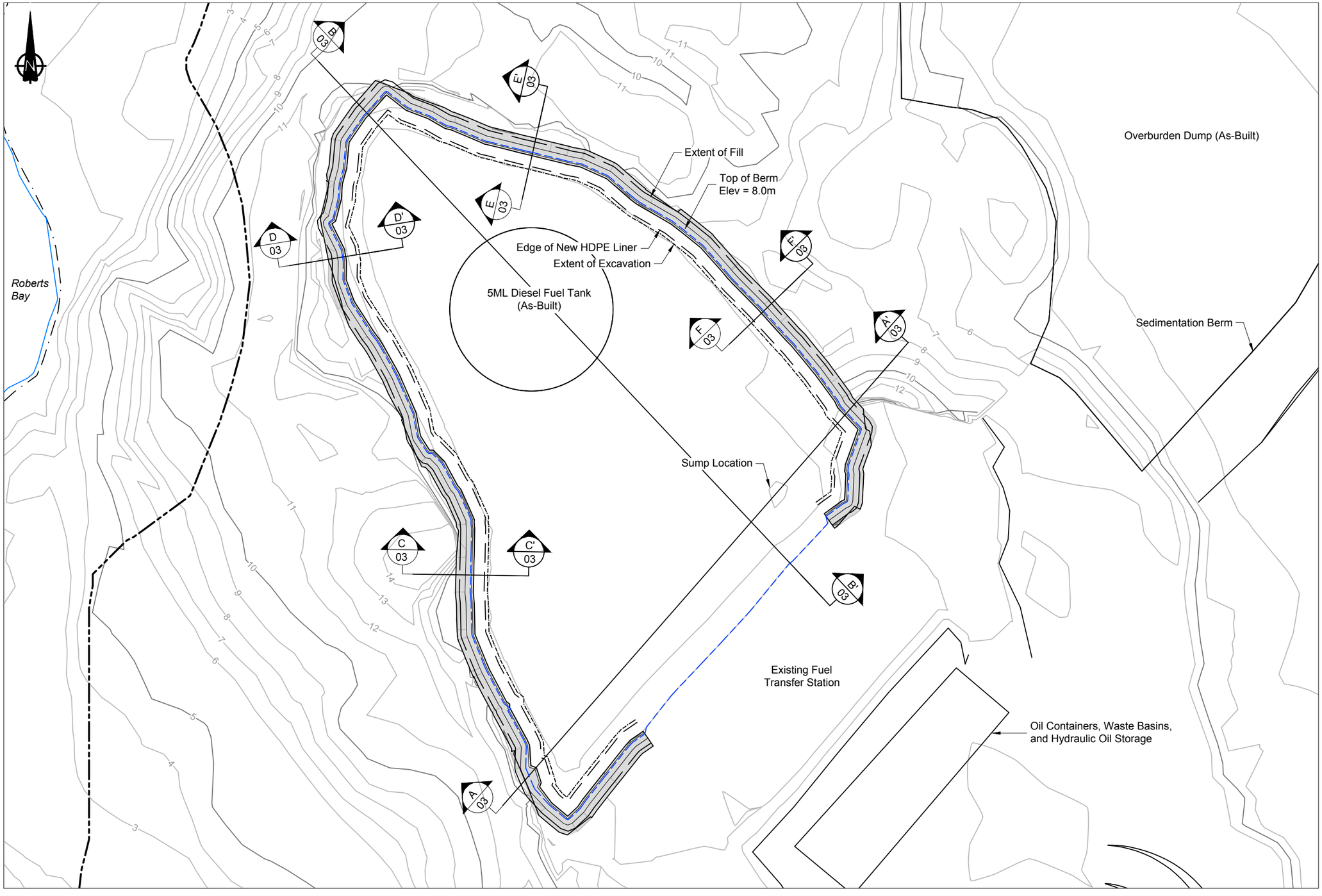
SRK JOB NO.: 1CT022.030

Q1 Fuel Facility Liner Raise

DRAWING TITLE: General Arrangement

DRAWING NO.	SHEET	REVISION NO.
Q1TF-01	1 OF 4	0

P:\01_SITES\Hope Bay\ACAD\VFC\RB Q1 Tank Farm Exp\Rev 0\1CT022.030 - Q1 Tank Farm GA.dwg



LEGEND

- 30m Shoreline Setback
- 8.0m Containment Elevation
- Commercial Lease Boundary
- Extent of Excavation
- Edge of new HDPE Liner
- Shoreline
- Liner Raise

NOTES

1. The designs are based on a combination of 2007 terrain model provided by Hope Bay Mining Limited as well as 2008 As-Built survey from SNC and 2010 As-Built survey from Nuna.
2. Contours shown at 1.0m interval.
3. All dimensions are in meters unless otherwise stated.
4. The Engineer will provide the Construction Manager and Contractor with digital design files for setting out the works. The Engineer will instruct the Contractor to survey random spot checks to confirm whether the works have been set out correct.
5. Construction shall be in accordance with the following Technical Specifications: Technical Specifications Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut Canada Revision H - Issued for Construction.
6. The original fuel tank farm facility was designed by others. SRK does not assume responsibility for any of the works other than those stipulated on these drawings.

REFERENCES

1. NAD83 UTM Zone 13.

MATERIALS AND QUANTITIES

Total Final Secondary Containment (Elev. 8.0m) = 6,230m³
HDPE Liner = 744m²
Non-woven Geotextile = 1,750m²
Protective Cover = 224m³
Fill under liner = 135m³
Excavation Volume = 249m³

*All volumes presented are to neat-lines and do not allow / account for bulking and compaction.

HDPE liner to be double sided textured 60mil HDPE.
Geotextile to be 12oz non-woven geotextile.

0m 6 12 18 24

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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							A	Issued for Review	CH	EMR	18/07/12

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srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	CH
CHECKED:	APPROVED:	DATE:
CH	EMR	July 12, 2018

FILE NAME: 1CT022030Q1TankFarmPS.dwg

TMAC RESOURCES

Hope Bay Project

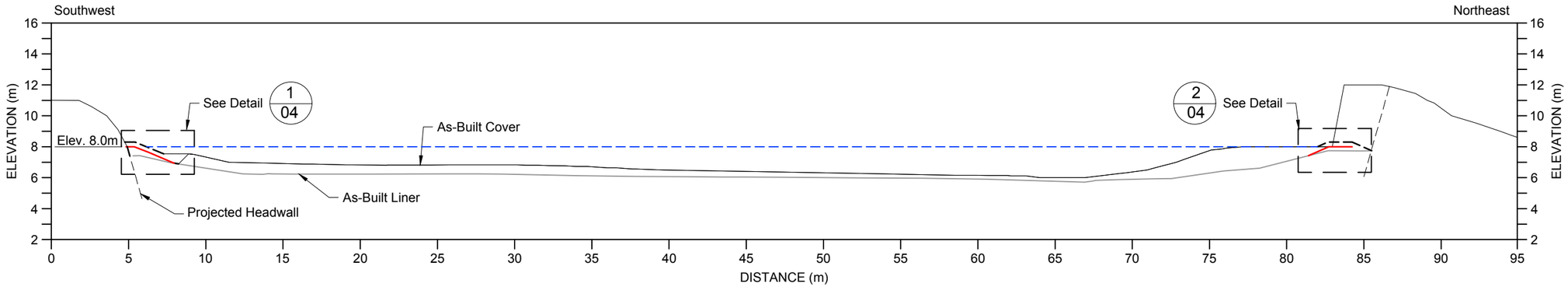
SRK JOB NO.: 1CT022.030

Q1 Fuel Facility Liner Raise

DRAWING TITLE:
Roberts Bay Quarry 1 Fuel Tank Farm Plan View

DRAWING NO.	SHEET	REVISION NO.
Q1FT-02	2 OF 4	0

P:\01_SITES\Hope Bay\MACAD\IFC\RB Q1 Tank Farm Exp\Rev 0\1CT022030Q1TankFarmPS.dwg



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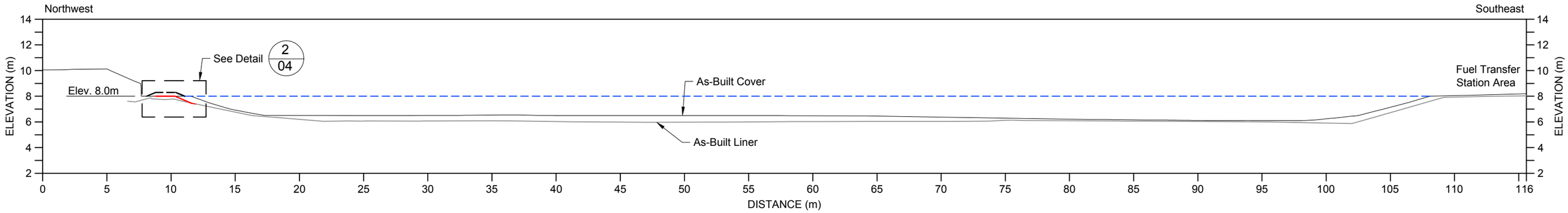

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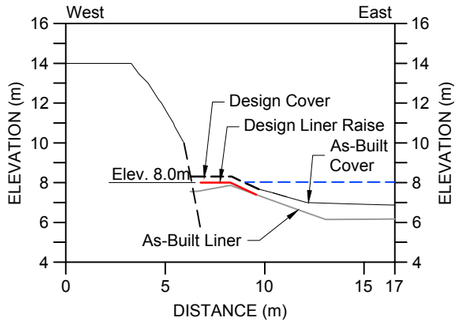
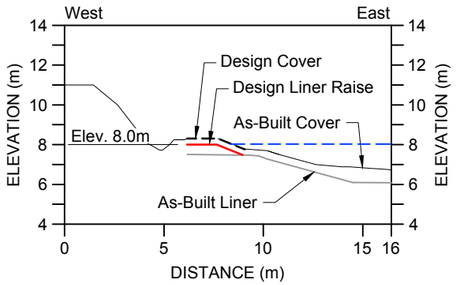


Cross Section C-C'



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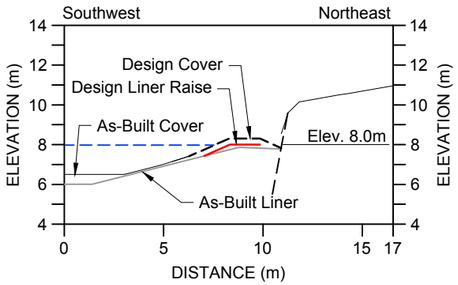
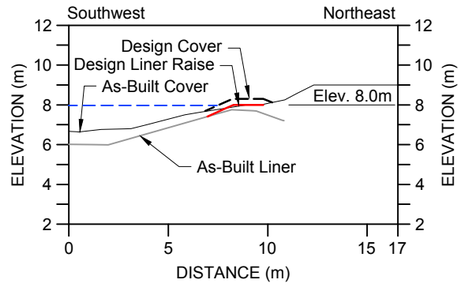


Cross Section E-E'



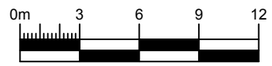
Cross Section F-F'

LEGEND

- 8.0m Containment Elevation
- Liner Raise
- Liner Cover
- As-Built Cover
- As-Built Liner

NOTES

1. All dimensions shown are in meters unless otherwise noted.
2. As-Built liner survey provided by TMAC, 2011.



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A	Issued for Review	CH	EMR	18/07/12

REFERENCE DRAWINGS — DRAWING NO. / DRAWING TITLE

REVISIONS

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DESIGN: CH	DRAWN: TAH	REVIEWED: CH
CHECKED: CH	APPROVED: EMR	DATE: July 12, 2018

FILE NAME: 1CT022030Q1TankFarmPS.dwg

TMAC RESOURCES

Hope Bay Project

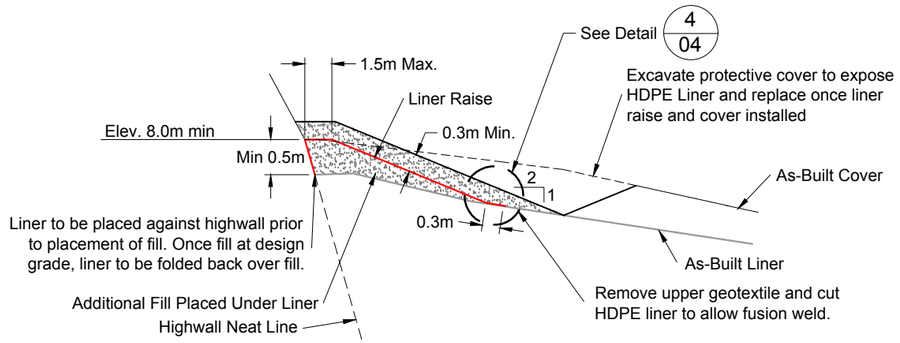
SRK JOB NO.: 1CT022.030

Q1 Fuel Facility Liner Raise

DRAWING TITLE: Cross Sections A-A', B-B', C-C', D-D', E-E', and F-F'

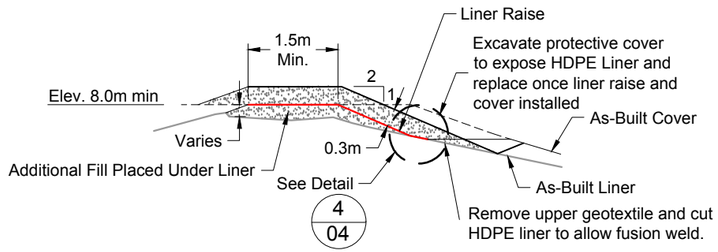
DRAWING NO.	SHEET	REVISION NO.
Q1TF-03	3 OF 4	0

P:\01 SITES\Hope Bay\ACAD\FICR\B Q1 Tank Farm Exp\Rev 0\1CT022030Q1TankFarmPS.dwg



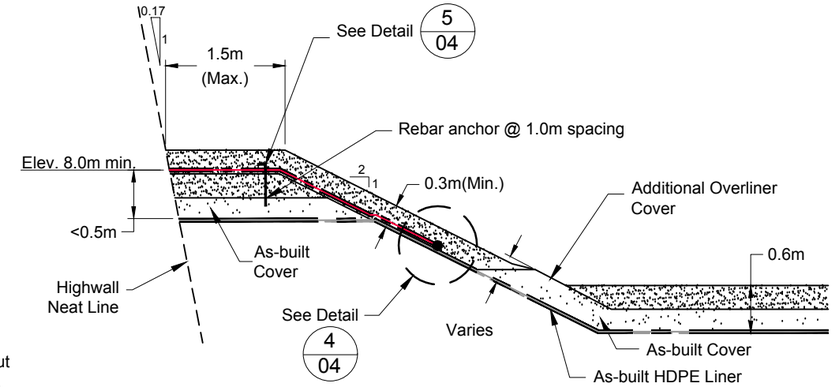
1/04 **Detail 1 - Liner Raise at Highwall (<1.5m anchor)**

0m 1 2 3 4



2/04 **Detail 2 - Liner Raise (≥1.5m anchor)**

0m 1 2 3 4



3/04 **TYPICAL DETAIL 3 - LINER RAISE (REBAR ANCHOR)**

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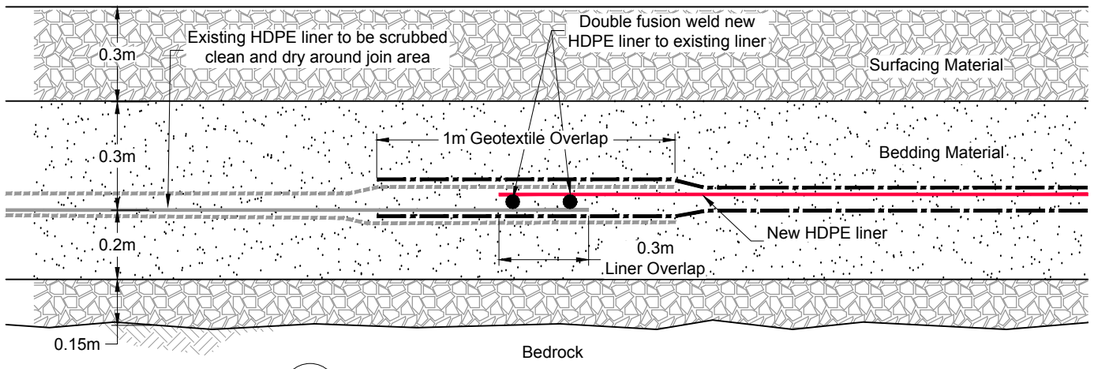
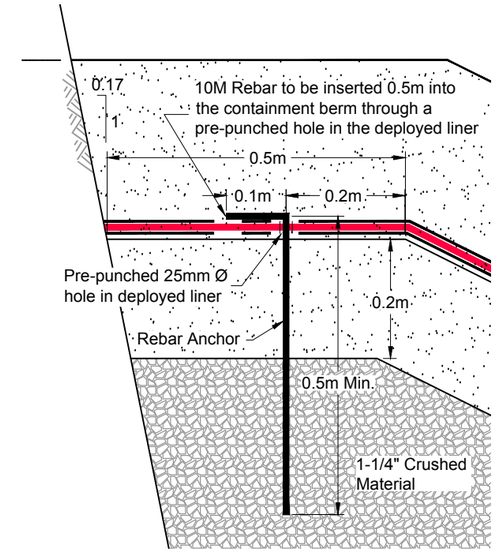


4/04 **TYPICAL DETAIL 4 - LINER OVERLAP CONNECTION**

0 0.2 0.4 0.6 0.8



5/04 **TYPICAL DETAIL 5 - REBAR ANCHOR**

0m 0.1 0.2 0.3 0.4

LEGEND

- Liner Raise
- Geotextile
- Existing Geotextile
- As-Built Cover
- As-Built Liner
- Bedding Material
- Surfacing Material
- ROQ

NOTES

1. All dimensions shown are in meters unless otherwise noted.
2. As-Built liner survey provided by TMAC, 2011.
3. Existing liner may retract once cut. Contractor should allow excess overlap for new liner and trim as required.
4. No below grade line elevation tolerance. Liner must be minimum level of 8.0m elevation in all cases.
5. Detail 2 liner raise anchor system should be implemented in all locations possible. Where insufficient horizontal distance to highwall to achieve 1.5m horizontal anchor; Detail 1 should be implemented where there is additional fill placed under the liner raise of 0.5m or more; and Detail 3 should be implemented where the additional fill placed under the liner raise is less than 0.5m.

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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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	CH
CHECKED:	APPROVED:	DATE:
CH	EMR	July 12, 2018

FILE NAME: 1CT022030Q1TankFarmPS.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.030

Q1 Fuel Facility Liner Raise

DRAWING TITLE: Details

DRAWING NO.	SHEET	REVISION NO.
Q1TF-04	4 OF 4	0

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Attachment 1.2 Quarry 1 Fuel Tank Farm Liner Raise – As-built Drawings

TMAC Resources Inc.

Doris North Project

Quarry 1 Tank Farm Liner Raise As-Built

Drawing Number	Drawing Title	Issue	Date	Revision
Q1TF-01	General Arrangment	As-Built	11/16/2018	AB
Q1TF-02	Roberts Bay Quarry 1 Fuel Tank Farm - Plan View	As-Built	11/21/2018	AB
Q1TF-03	Cross Sections A-A', B-B', C-C', D-D', E-E' and F-F'	As-Built	11/21/2018	AB
Q1TF-04	Details	As-Built	11/21/2018	AB

srk consulting

SRK Job No. 1CT022.030

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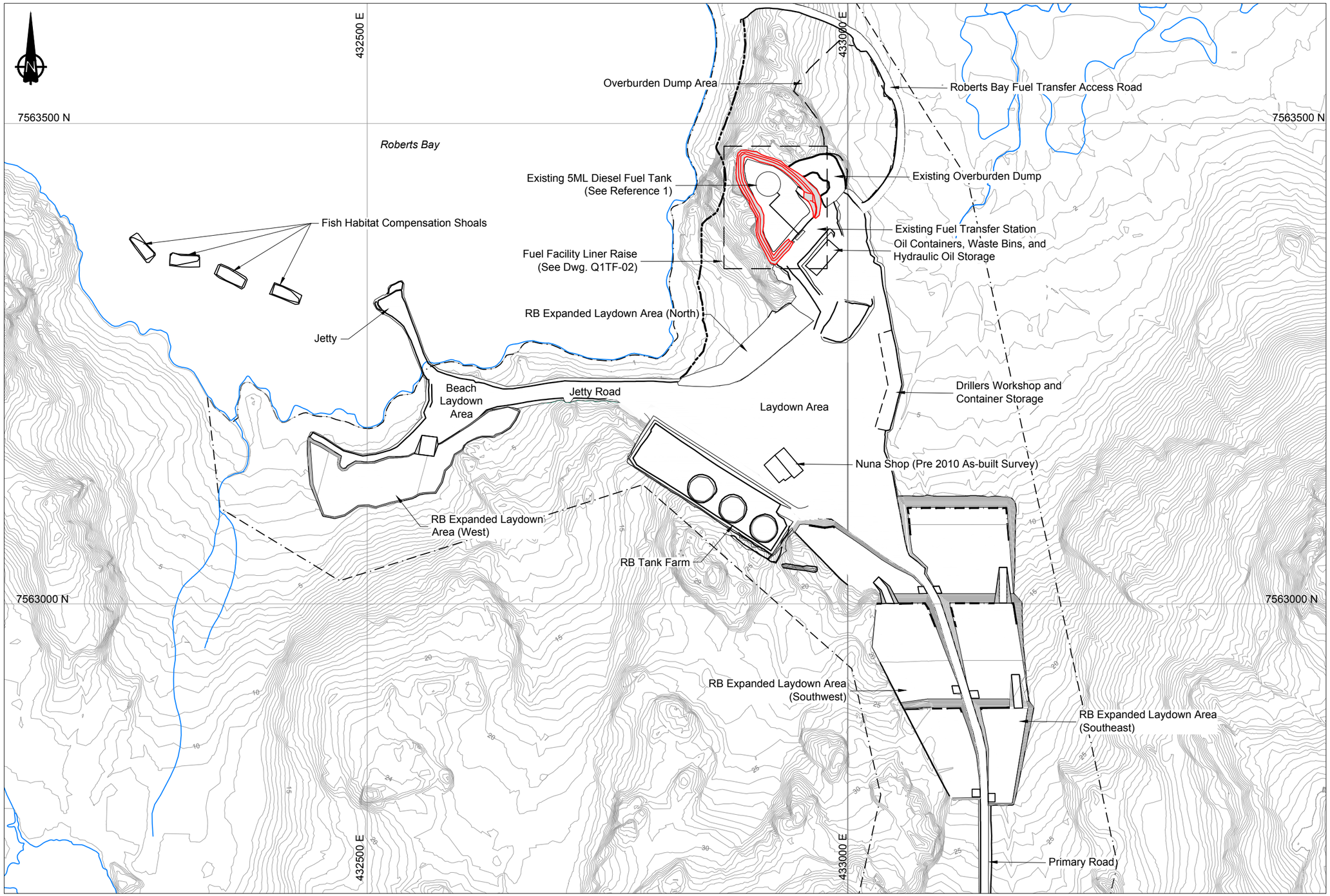

LEGEND

- Commercial Lease Boundary
- Shoreline Setback
- Liner Raise Extents

NOTES

1. The designs are based on the contour information shown on these drawings. It is the Contractor's responsibly to confirm that the contours are a fair reflection of the ground levels in the vicinity of the works, and to advice the Construction Manager and Engineer of any differences.
2. All dimensions are in meters unless otherwise specified.
3. The Engineer will provide the Construction Manager and Contractor with digital design files for setting out the works. The Engineer will instruct the Contractor to survey random spot checks to confirm whether the works have been set out correct.
4. Construction shall be in accordance with the following Technical Specifications: Technical Specifications Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut Canada, Revision H - Issued for Construction.

REFERENCES

1. SRK Consulting (Canada) Inc., 2011. Engineering Drawings for the Roberts Bay Quarry and Fuel Tank Farm, Doris North Project, Nunavut, Canada. Revision 2. Issued for Construction. Drawings prepared for Hope Bay Mining Limited. Project Number 1CH008.033. December 2, 2011.
2. NAD83 UTM Zone 13.

DRAWING NO.	DRAWING TITLE
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REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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NO.	DESCRIPTION	CHK'D	APP'D	DATE
AB	As-Built	CH	EMR	18/11/16
0	Issued for Construction	CH	EMR	18/07/12
A	Issued for Review	CH	EMR	18/07/12

REVISIONS

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	CH
CHECKED:	APPROVED:	DATE:
CH	EMR	2018/11/16

FILE NAME: 1CT022.030 - Q1 Tank Farm GA.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.030

Q1 Fuel Facility Liner Raise

DRAWING TITLE:

General Arrangement

DRAWING NO.	SHEET	REVISION NO.
Q1TF-01	1 OF 4	AB

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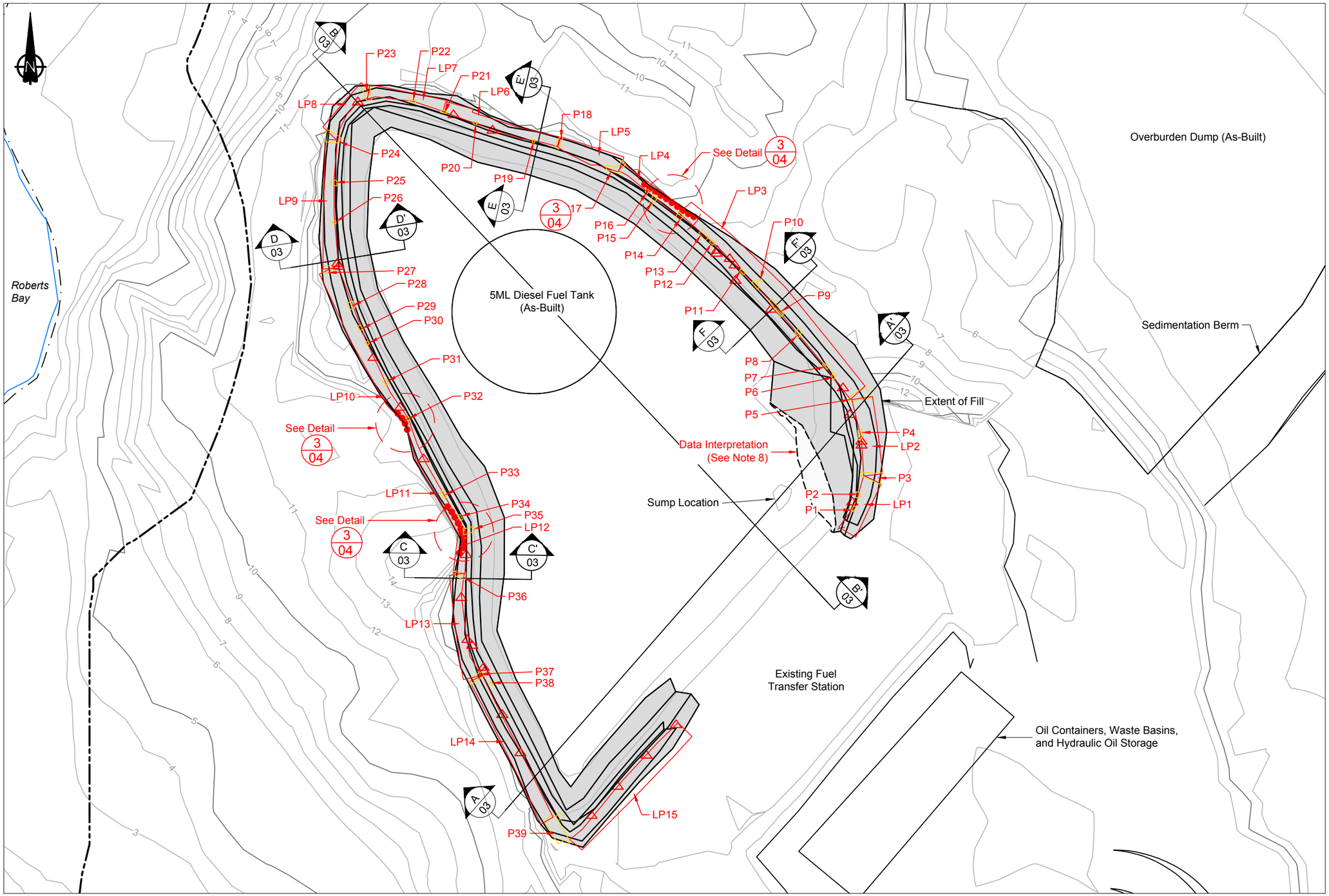

LEGEND

- Minor Patch Location
- Rebar Anchor Location
- 31m Shoreline Setback
- Commercial Lease Boundary
- Shoreline
- As-Built Cover
- As-Built Liner Panel Extents (LP#)
- As-Built Liner Patch Panel Extents (P#)

NOTES

1. The designs are based on a combination of 2007 terrain model provided by Hope Bay Mining Limited as well as 2008 As-Built survey from SNC and 2010 As-Built survey from Nuna.
2. Contours shown at 1.0m interval.
3. All dimensions are in meters unless otherwise stated.
4. As-built surveys provided by Sub-Arctic Geomatics Ltd. dated July 22, 2018, July 31, 2018, and August 4, 2018.
5. Construction shall be in accordance with the following Technical Specifications: Technical Specifications Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut Canada Revision H - Issued for Construction.
6. The original fuel tank farm facility was designed by others. SRK does not assume responsibility for any of the works other than those stipulated on these drawings.
7. SRK did not supervise the construction and has relied upon provided information in the preparation of these drawings.
8. Refer to Q1 Tank Farm Liner Raise Project Report, Blomberg Building Group, 2018 for liner installation and QAQC details.
9. Gap in as-built survey of final cover surface interpreted to have slope of 2H:1V.

REFERENCES

1. NAD83 UTM Zone 13.

0m 6 12 18 24

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
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REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
AB	As-Built	CH	EMR	18/11/21
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A	Issued for Review	CH	EMR	18/07/12

REVISIONS

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	CH
CHECKED:	APPROVED:	DATE:
CH	EMR	2018/11/21

FILE NAME: 1CT022030 - Q1TankFarmPS.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.030

Q1 Fuel Facility Liner Raise

DRAWING TITLE:
Roberts Bay Quarry 1 Fuel Tank Farm Plan View

DRAWING NO.	SHEET	REVISION NO.
Q1FT-02	2 OF 4	AB

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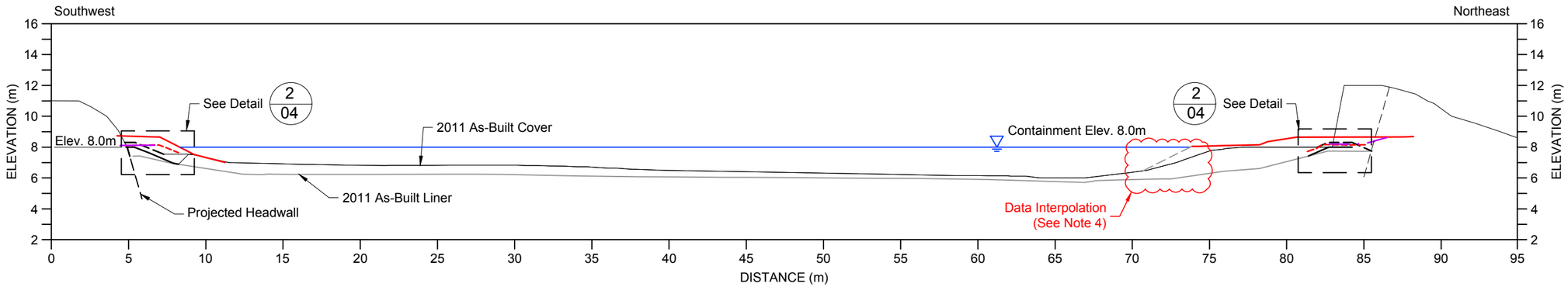


Cross Section A-A'

LEGEND

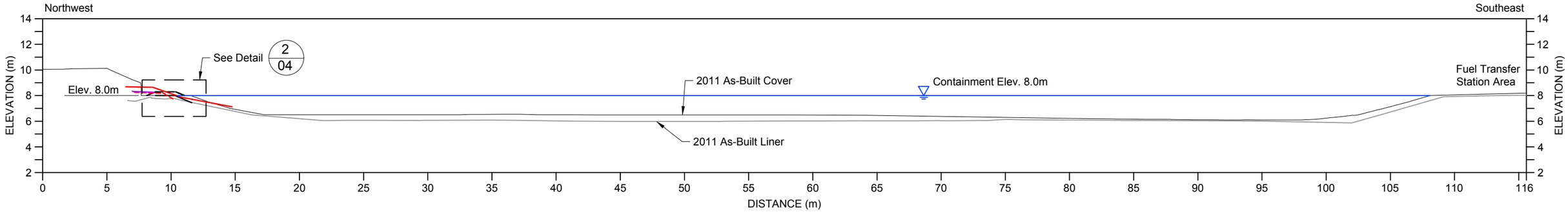
- As-Built Liner
- As-Built Cover
- As-built Underliner
- Design Liner Cover
- Design Liner
- Data Interpretation

NOTES

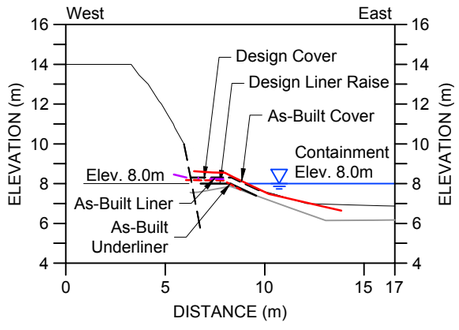
1. All dimensions shown are in meters unless otherwise noted.
2. As-built surveys provided by Sub-Arctic Geomatics Ltd. dated July 22, 2018, July 31, 2018, and August 4, 2018.
3. As-built 2018 liner seams joined and sealed as per detail 4 on drawing Q1TF-04.
4. Gap in as-built survey of final cover surface interpreted to have slope of 2H:1V.

ELEVATIONS AND VOLUMES

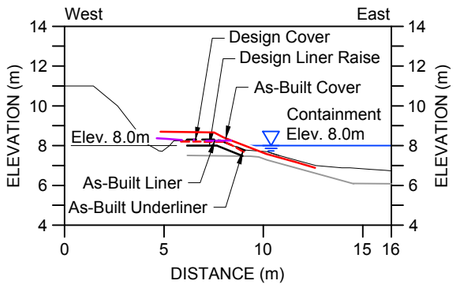
As-Built Containment Elevation: 8.0m
As-Built Containment Volume: 6,270m³
Design Containment Elevation: 8.0m
Design Containment Volume: 6,100m³



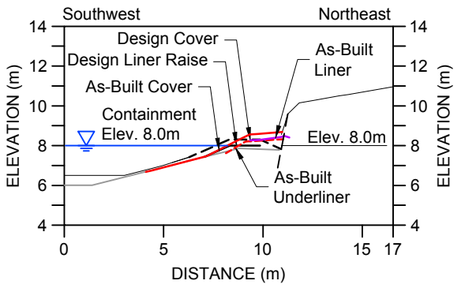
Cross Section B-B'



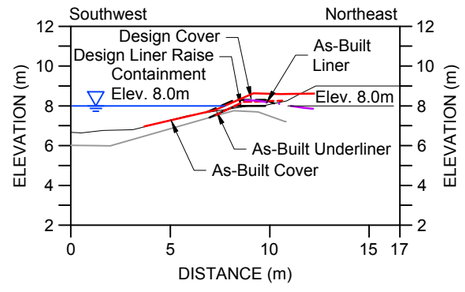
Cross Section C-C'



Cross Section D-D'



Cross Section E-E'



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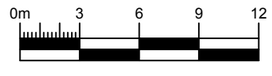

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	CH
CHECKED:	APPROVED:	DATE:
CH	EMR	2018/11/21

FILE NAME: 1CT022030 - Q1TankFarmPS.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.030

Q1 Fuel Facility Liner Raise

DRAWING TITLE: Cross Sections A-A', B-B', C-C', D-D', E-E', and F-F'

DRAWING NO.	SHEET	REVISION NO.
Q1TF-03	3 OF 4	AB

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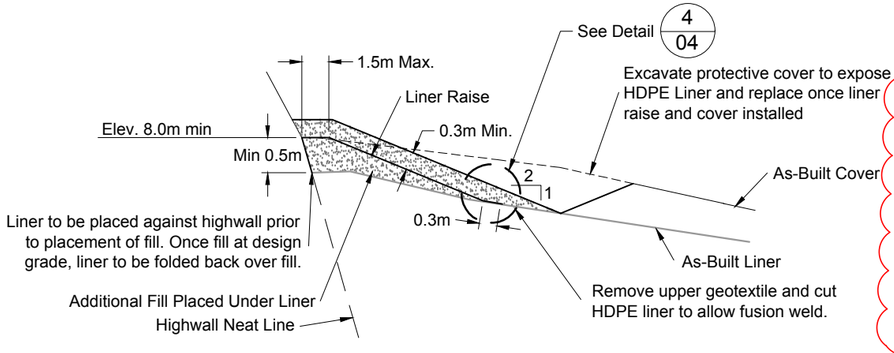
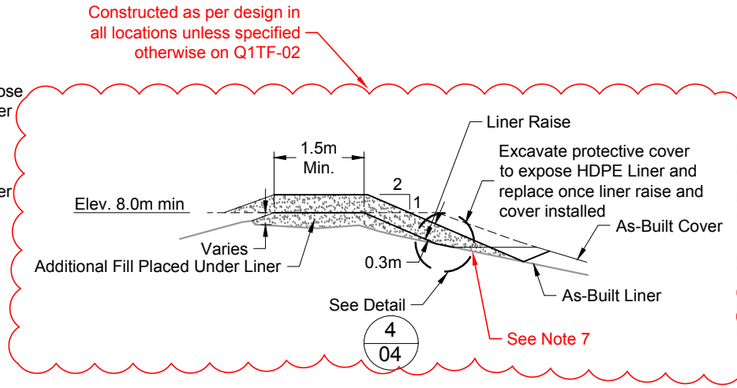


1/04 **Detail 1 - Liner Raise at Highwall (<1.5m anchor)**

0m 1 2 3 4



2/04 **Detail 2 - Liner Raise (≥1.5m anchor)**

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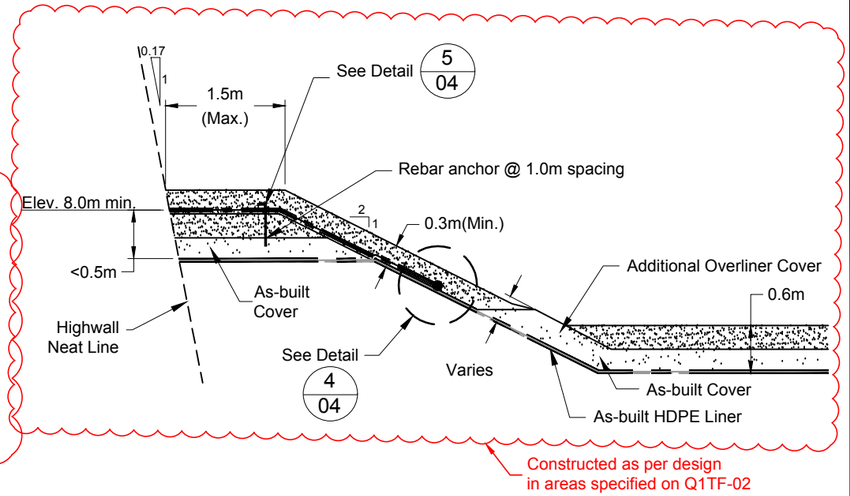

3/04 **TYPICAL DETAIL 3 - LINER RAISE (REBAR ANCHOR)**

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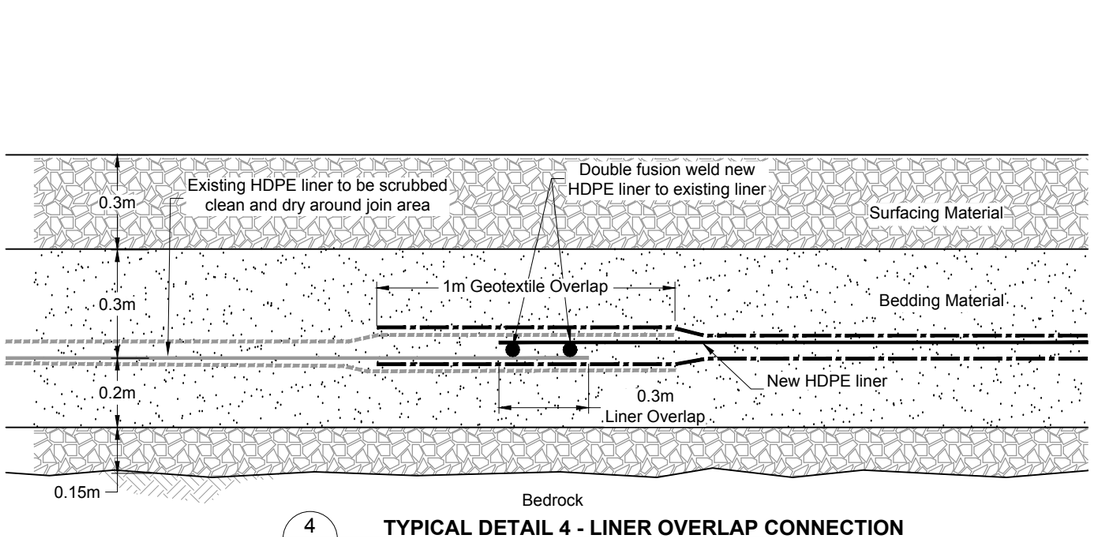

4/04 **TYPICAL DETAIL 4 - LINER OVERLAP CONNECTION**

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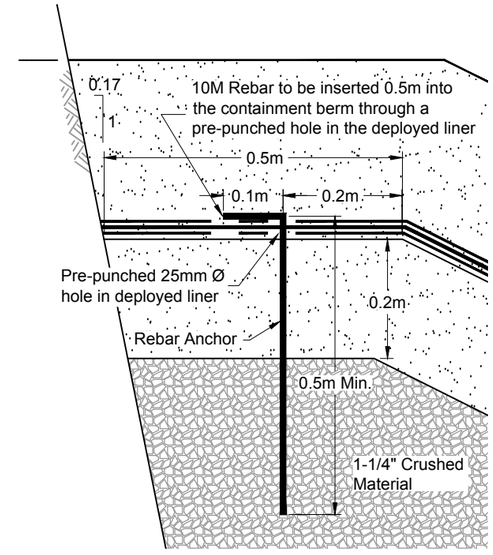

5/04 **TYPICAL DETAIL 5 - REBAR ANCHOR**

0m 0.1 0.2 0.3 0.4

LEGEND

- Liner Raise
- Geotextile
- Existing Geotextile
- As-Built Cover
- As-Built Liner
- Bedding Material
- Surfacing Material
- ROQ

NOTES

1. All dimensions shown are in meters unless otherwise noted.
2. As-Built liner survey provided by TMAC, 2011.
3. Existing liner may retract once cut. Contractor should allow excess overlap for new liner and trim as required.
4. No below grade line elevation tolerance. Liner must be minimum level of 8.0m elevation in all cases.
5. Detail 2 liner raise anchor system should be implemented in all locations possible. Where insufficient horizontal distance to highwall to achieve 1.5m horizontal anchor; Detail 1 should be implemented where there is additional fill placed under the liner raise of 0.5m or more; and Detail 3 should be implemented where the additional fill placed under the liner raise is less than 0.5m.
6. Refer to Q1 Tank Farm Liner Raise Project Report, Blomberg Building Group, 2018 for liner installation and QAQC details.
7. Existing liner was exposed, the under liner fill was placed, and the existing liner was folded back at the raised elevation to the extent possible to minimize new liner required.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
--	--	--	--	--	--	--	A	Issued for Review	CH	EMR	18/07/12
							0	Issued for Construction	CH	EMR	18/07/12
							AB	As-Built	CH	EMR	18/11/21

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	CH
CHECKED:	APPROVED:	DATE:
CH	EMR	2018/11/21

FILE NAME: 1CT022030 - Q1TankFarmPS.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.030

Q1 Fuel Facility Liner Raise

DRAWING TITLE: Details

DRAWING NO.	SHEET	REVISION NO.
Q1TF-04	4 OF 4	AB

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Attachment 1.3 Quarry 1 Fuel Tank Farm Liner Raise – BBG Project Report

Blomberg Building Group

Quarry 1 Fuel Berm Expansion

June 30th, 2018 – August 3rd, 2018

Hope Bay, Nunavut, Canada

Exposing liner

The liner was exposed using the 308 excavator and one employee, with the excavator doing the bulk of excavation. Once we were close to the liner the employee removed the material by hand. Upon uncovering the liner there were a few damaged areas encountered. The excavator had also ripped through the liner on the east side as the previous installers had left sandbags below the HDPE which created large humps that were torn out during excavation (picture below). Several pinholes were found upon initial inspection, likely caused by aggregate below the HDPE. As well, the excavator bucket nicked the liner in three locations. The ASB 0719 shows the base of excavation as well as the assumed crest and back of excavation. Many areas were higher in elevation than originally anticipated based on the 2011 survey data provided.

Cutting back liner

The liner was cut back enough to allow for us to seam the new HDPE on top of the berm.

Earthworks for liner:

See *0722- 8m Tank Berm ASB* for elevations.

First Lift before compaction

After Compaction

Second lift Prior to compaction

Second Lift After Compaction

The Earthworks for the berm raise were completed in two separate lifts as per *SRK's Technical Specifications Earthworks and Geotechnical Engineering Hope Bay Project, Nunavut Canada Revision H – Issue for Construction.* The first 300mm lift of bedding material was compacted using the BPR 70/70 D Bomag (575kg) walk behind compactor, and we observed 100-150mm of compaction from the ten passes done on the berm crest. The slopes on the first lift were bucket

packed and then four passes were completed with the Bomag. On the second lift an additional 100-200mm was placed to bring the berm to a rough elevation of 8.15m and after compaction the berm reduced 25-50mm in height. The slopes were too steep to use the walk behind compactor and the surface was bucket packed using the 329 excavator.

Base layer Geotextile

Serial No.	Width	Panel	Type	Manufacture date
26745Z002221	4.57m	1	12oz non-woven	05/16/17
26745Z001541	4.57m	2	12oz non-woven	11/21/17
26745Z003161	4.57m	3	12oz non-woven	05/17/17

The base layer geotextile was installed in full panels and the overlap was at least 1m in width. All geotextile was heat bonded and excess material from the backside was folded over onto the top of the berm and seamed flat.

Liner Install

The liner install was completed in 15 panel sections, the longest being 40 meters. By fusion welding the liner on the crest of the berm we were able to achieve the strongest and most stable weld possible. The existing panels were trimmed, and all sharp angle changes were rounded or removed. The new panel edge was traced and cut to the existing material. After it was cut we pulled the panel down to the maximum allowable overlap. Using the fusion welder (180mm), a test weld was completed to ensure the welding machine was in proper working condition. After testing was completed and the machine was calibrated, the new and existing liner were welded together. Rebar anchors were utilized at the highwall sections were the berm was narrower than 1.5m, the raise in these locations was less than 0.5m.

HDPE

Roll No.	Type	Resin Batch	Date manufactured	Manufacturer
5-16202	60 MIL Textured DS HDPE	15F1007	20-Jul-2015	Solmax

Extrusion Rod

ROD No.	Product Code	Manufactured Date	Resin Batch	Type	Manufacturer
5H60952C	ROD-HD-5-B	8-NOV-2017	HHG710470	HD-5-Black	Solmax
Illegible	ROD-HD-5-B	8-NOV-2017	HHG710470	HD-5-Black	Solmax

The manufacture tag on the second coil of extrusion rod had slight damage and ROD no was illegible.

QC Testing

Onsite destructive test results

Panel 3		**1**	**2**	**3**	**4**	**5**	**MEAN**
	Peel strength (ppi)	121	106	129	102	146	**120.8**
	Peel separation %	<5	<5	<5	<5	<5	
	Failure Code	FTB	FTB	FTB	FTB	FTB	
	Shear strength (ppi)	182	179	180	176	151	**173.6**
	Shear separation %	<5	<5	<5	<5	<5	
	Failure Code	FTB	FTB	FTB	FTB	FTB	

Panel 4		**1**	**2**	**3**	**4**	**5**	**MEAN**
	Peel strength (ppi)	126	129	99	97	104	**111**
	Peel separation %	<5	<5	<5	<5	<5	
	Failure Code	FTB	FTB	FTB	FTB	FTB	
	Shear strength (ppi)	191	187	200	194	195	**193.4**
	Shear separation %	<5	<5	<5	<5	<5	
	Failure Code	FTB	FTB	FTB	FTB	FTB	

Panel 5		**1**	**2**	**3**	**4**	**5**	**MEAN**
	Peel strength (ppi)	154	112	128	118	113	**125**
	Peel separation %	<5	<5	<5	<5	<5	
	Failure Code						
	Shear strength (ppi)	193	185	192	189	193	**190.4**
	Shear separation %	<5	<5	<5	<5	<5	
	Failure Code	FTB	FTB	FTB	FTB	FTB	

Panel 7		1	2	3	4	5	MEAN
	Peel strength (ppi)	128	123	100	108	114	**114.6**
	Peel separation %	<5	<5	<5	<5	<5	
	Failure Code	FTB	FTB	FTB	FTB	FTB	
	Shear strength (ppi)	176	175	178	182	166	**175.4**
	Shear separation %	<5	<5	<5	<5	<5	
	Failure Code	FTB	FTB	FTB	FTB	FTB	

Panel 9		1	2	3	4	5	MEAN
	Peel strength (ppi)	135	113	114	137	117	**123.2**
	Peel separation %	<5	<5	<5	<5	<5	
	Failure Code	FTB	FTB	FTB	FTB	FTB	
	Shear strength (ppi)	184	175	174	170	180	**176.6**
	Shear separation %	<5	<5	<5	<5	<5	
	Failure Code	FTB	FTB	FTB	FTB	FTB	

Panel 11		1	2	3	4	5	MEAN
	Peel strength (ppi)	104	98	118	105	108	**106.6**
	Peel separation %	<5	<5	<5	<5	<5	
	Failure Code	FTB	FTB	FTB	FTB	FTB	
	Shear strength (ppi)	166	170	169	157	170	**166.4**
	Shear separation %	<5	<5	<5	<5	<5	
	Failure Code	FTB	FTB	FTB	FTB	FTB	

Panel 13		1	2	3	4	5	MEAN
	Peel strength (ppi)	114	109	110	114	111	**111.6**
	Peel separation %	<5	<5	<5	<5	<5	
	Failure Code	FTB	FTB	FTB	FTB	FTB	
	Shear strength (ppi)	171	166	176	175	169	**171.4**
	Shear separation %	<5	<5	<5	<5	<5	
	Failure Code	FTB	FTB	FTB	FTB	FTB	

Air Channel Testing

(Hot wedge welds) 5 Min Test at 30 PSI, down 3 PSI max.

Air Channel Test

Seam ID:	Tester ID	Tester	Start Time	Finish Time	Start Pressure	Finish Pressure	Test Date
Panel 1 Destruct 1-2	CW617N 200-CWP PN 15	N.E.B	5:26	5:32	32	32	July 27th 2018
Panel 1 Destruct 2-3	CW617N 200-CWP PN 15	N.E.B	5:34	5:39	30	30	
Panel 2 Destruct 1-2	CW617N 200-CWP PN 15	N.E.B	5:41	5:46	32	32	
Panel 2 Destruct 2-3	CW617N 200-CWP PN 15	N.E.B	5:50	5:56	42	42	
Panel 3 Destruct 1-2	CW617N 200-CWP PN 15	N.E.B	6:00	6:05	36	36	
Panel 3 Destruct 2-3	CW617N 200-CWP PN 15	N.E.B	9:15	9:21	31	31	July 28th 2018
Panel 3 Destruct 3-4	CW617N 200-CWP PN 15	N.E.B	9:24	9:29	30	30	
Panel 3 Destruct 4-5	CW617N 200-CWP PN 15	N.E.B	10:53	11:01	32	20	
Panel 3 Destruct 5-6	CW617N 200-CWP PN 15	N.E.B	11:05	11:10	30	30	
Panel 3 Destruct 7-8	CW617N 200-CWP PN 15	N.E.B	11:14	11:19	30	30	
Panel 3 Destruct 8 - 9	CW617N 200-CWP PN 15	N.E.B	11:24	11:29	31	30	
Panel 4 Destruct 1-2	CW617N 200-CWP PN 15	N.E.B	11:30	11:35	28	28	
Panel 4 Destruct 2-End	CW617N 200-CWP PN 15	N.E.B	9:13	9:18	30	30	July 29th 2018
Panel 5	CW617N 200-CWP PN 15	N.E.B	9:21	9:26	30	30	

Panel 6 Start - Destruct 1	CW617N 200-CWP PN 15	N.E.B	9:30	9:35	30	30
Panel 6 Destruct 1-2	CW617N 200-CWP PN 15	N.E.B	9:38	9:43	30	30
Panel 6 Destruct 2-3	CW617N 200-CWP PN 15	N.E.B	9:45	9:50	30	30
Panel 6 Destruct 3-4	CW617N 200-CWP PN 15	N.E.B	9:54	9:59	30	30
Panel 7 Start - Destruct 1	CW617N 200-CWP PN 15	N.E.B	10:56	11:01	30	30
Panel 7 Destruct 1 - End	CW617N 200-CWP PN 15	N.E.B	11:06	11:11	30	30
Panel 8	CW617N 200-CWP PN 15	N.E.B	11:23	11:28	30	30
Panel 9 Start - Destruct 1	CW617N 200-CWP PN 15	N.E.B	11:30	11:35	30	30
Panel 9 Destruct 1-2	CW617N 200-CWP PN 15	N.E.B	11:36	11:41	30	30
Panel 9 Destruct 2-End	CW617N 200-CWP PN 15	N.E.B	11:44	11:50	30	30
Panel 10 start - Destruct 1	CW617N 200-CWP PN 15	N.E.B	11:54	11:59	30	30
Panel 10 Destruct 1 - 5	CW617N 200-CWP PN 15	N.E.B	12:06	12:11	30	30
Panel 11 Start - End	CW617N 200-CWP PN 15	N.E.B	12:12	12:17	30	28
Panel 12	CW617N 200-CWP PN 15	N.E.B	12:22	12:27	32	32

Panel 13	CW617N 200-CWP PN 15	N.E.B	1:22	1:27	30	30
Panel 14	CW617N 200-CWP PN 15	N.E.B	1:34	1:40	30	30
Panel 15	CW617N 200-CWP PN 15	N.E.B	1:47	1:52	30	30

Note: Panels 12-15 were tested in full panel section, the cross-seam tag ends were clipped and allowed for proper weld overtop of existing seam. Clamps were released from opposing end to ensure air was not trapped at cross-seam location.

Vacuum Box testing

*See Pictures for Visual Confirmation**

Test Summary

The conformance testing methods were conducted within all applicable ASTM standards and all tests were completed in full and surpassed ASTM standards for geosynthetics. The tables above reflect field documentation. Picture documentation was also taken as secondary confirmation for vacuum box and air channel testing. Third party verification samples were taken from four seams that weren't field tested and those samples are being sent to TRI Environmental for destructive testing.

Destructive testing was done every 30m of linear weld. Most of the destructive samples were taken from areas which were in proximity to weak spots and liner edges. Two field samples were taken from random locations in the middle of seams (panels 7 and 11), and two of the lab samples were taken from random locations along the seam (panels 10 and 6). The other two lab samples were taken from panels 1 and 14.

Air Channel tests were done using a small compressor on July 27th, the remainder of the tests were completed with a bike pump to ensure seams were not over pressurized and subject to unnecessary strain.

Vacuum Box (Negative pressure Testing) was done over all patches and suspect areas. When holes in the welds were located, extrusion beads were seamed over the area and they were tested again. Pictured yellow arrows were marked during visual inspection, the specified areas were tested for a longer duration (30+seconds) to ensure all welds were properly bonded.

Cross-seam areas were patched although all QC tests passed

Top Layer geotextile

Serial No.	Width	Panel	Type	Manufacture date
26745Z001301	4.57	1	4512 NON-WOVEN	05/16/17
26745Z002231	4.57	2	4512 NON-WOVEN	06/16/17
26745Z003531	4.57	3	4512 NON-WOVEN	05/17/17

All Non-woven geotextile was heat bonded to the existing geotextile with the largest overlap possible at minimum 1 meter.

Fill

The fill was completed using the skid steer, IT-28 loader, and the 308 excavator. The loader transported material to the skid steer which pushed material up the slope and over the top of the crest. Care was taken to ensure that none of the possibly contaminated material was pushed above the crest. The top of the berm and roadway have been filled using new bedding material while the slopes have received a mixed portion of existing and new material. The first lift of bedding placed on the roadway has since been covered in an additional lift of mixed

transition and bedding material. After our first lift (0802-RB TBRM LNR CVR), we placed an additional 300mm of bedding material on the crest to ensure that we had surpassed our minimum coverage.

Attachment 1.4 Quarry 1 Fuel Tank Farm Liner Raise – TRI Seam Test Report

Date: 2018-09-24

Mail To:
Eric Blomberg
Blomberg Building

, ,

e-mail:eric@blombergbuilding.com

Bill To:

Blomberg Building

Dear Mr. Blomberg,

Thank you for consulting with TRI/Environmental, Inc. (TRI) for your geosynthetics testing needs. TRI is pleased to submit this final report for laboratory testing.

Project:	**Quarry 1 Berm Raise**
TRI Job Reference Number:	**41344**
Material(s) Tested:	(4) Heat Fusion Weld Seam(s)
Test(s) Requested:	SAME DAY Peel and Shear (ASTM D 6392/GRI GM19/D 4437/NSF 54/882 mod.)

Codes:	
AD	Adhesion Failure (100% Peel)
BRK	Break in sheeting away from Seam edge.
SE	Break in sheeting at edge of seam.
AD-BRK	Break in sheeting after some adhesion failure - partial peel.
SIP	Separation in the plane of the sheet (leaving the bond intact).
FTB	Film tearing bond (all non "AD" failures).
NON-FTB	100% peel.

If you have any questions or require any additional information, please call us at 1-800-880-8378.
Sincerely,

Brian Anderson
Project Manager
Geosynthetic Services Division
http://www.geosyntheticstestinc.com

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.

DESTRUCTIVE SEAM QUALITY ASSURANCE TEST RESULTS
TRI Client: Blomberg Building
Project: Quarry 1 Berm Raise

Material: 60 mil. HDPE
SAME DAY Peel and Shear (ASTM D 6392/GRI GM19/D 4437/NSF 54/882 mod.)
TRI Log#: 41344

	TEST REPLICATE NUMBER					
PARAMETER	1	2	3	4	5	MEAN
Sample ID: D-1 | Weld: Heat Fusion						
Side: A						**Peel A**
Peel Strength (ppi)	108	114	114	110	126	**114**
Peel Incursion (%)	<5	<5	25	<5	<5	
Peel Locus Of Failure Code	SE	SE	AD-BRK	SE	SE	
Peel NSF Failure Code	FTB	FTB	FTB	FTB	FTB	
Side: B						**Peel B**
Peel Strength (ppi)	129	110	92	108	125	**113**
Peel Incursion (%)	25	<5	25	<5	<5	
Peel Locus Of Failure Code	AD-BRK	SE	AD-BRK	SE	SE	
Peel NSF Failure Code	FTB	FTB	FTB	FTB	FTB	
Shear						**Shear**
Shear Strength (ppi)	164	163	166	166	169	**166**
Shear Elongation @ Break (%)	>50	>50	>50	>50	>50	
Sample ID: D-2 | Weld: Heat Fusion						
Side: A						**Peel A**
Peel Strength (ppi)	118	118	113	112	119	**116**
Peel Incursion (%)	<5	<5	<5	<5	<5	
Peel Locus Of Failure Code	SE	SE	SE	SE	SE	
Peel NSF Failure Code	FTB	FTB	FTB	FTB	FTB	
Side: B						**Peel B**
Peel Strength (ppi)	93	72	105	90	122	**96**
Peel Incursion (%)	100	100	100	100	100	
Peel Locus Of Failure Code	AD	AD	AD	AD	AD	
Peel NSF Failure Code	NON-FTB	NON-FTB	NON-FTB	NON-FTB	NON-FTB	
Shear						**Shear**
Shear Strength (ppi)	165	163	167	167	163	**165**
Shear Elongation @ Break (%)	>50	>50	>50	>50	>50	

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.

DESTRUCTIVE SEAM QUALITY ASSURANCE TEST RESULTS

TRI Client: Blomberg Building
Project: Quarry 1 Berm Raise

Material: 60 mil. HDPE
SAME DAY Peel and Shear (ASTM D 6392/GRI GM19/D 4437/NSF 54/882 mod.)
TRI Log#: 41344

	TEST REPLICATE NUMBER					
PARAMETER	1	2	3	4	5	MEAN
Sample ID: D-3 | Weld: Heat Fusion						
Side: A						**Peel A**
Peel Strength (ppi)	126	127	144	138	133	**134**
Peel Incursion (%)	<5	<5	<5	<5	<5	
Peel Locus Of Failure Code	SE	SE	SE	SE	SE	
Peel NSF Failure Code	FTB	FTB	FTB	FTB	FTB	
Side: B						**Peel B**
Peel Strength (ppi)	117	117	117	123	122	**119**
Peel Incursion (%)	<5	<5	<5	<5	<5	
Peel Locus Of Failure Code	SE	SE	SE	SE	SE	
Peel NSF Failure Code	FTB	FTB	FTB	FTB	FTB	
Shear						**Shear**
Shear Strength (ppi)	163	163	169	163	166	**165**
Shear Elongation @ Break (%)	>50	>50	>50	>50	>50	
Sample ID: D-4 | Weld: Heat Fusion						
Side: A						**Peel A**
Peel Strength (ppi)	114	119	110	120	120	**117**
Peel Incursion (%)	<5	<5	<5	<5	<5	
Peel Locus Of Failure Code	SE	SE	SE	SE	SE	
Peel NSF Failure Code	FTB	FTB	FTB	FTB	FTB	
Side: B						**Peel B**
Peel Strength (ppi)	122	130	122	117	126	**123**
Peel Incursion (%)	<5	<5	<5	<5	<5	
Peel Locus Of Failure Code	SE	SE	SE	SE	SE	
Peel NSF Failure Code	FTB	FTB	FTB	FTB	FTB	
Shear						**Shear**
Shear Strength (ppi)	168	169	166	167	171	**168**
Shear Elongation @ Break (%)	>50	>50	>50	>50	>50	

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.

Attachment 2 – Roberts Bay Access Road

Attachment 2.1 Roberts Bay Access Road – IFC Drawings

TMAC Resources Inc.

Doris North Project

Engineering Drawings for

Roberts Bay Discharge System Access Road

Drawing Number	Drawing Title	Issue	Date	Revision	Old / Replaced Revisions
RBAR-01	Plan and Profile	Issued for Construction	January 30, 2018	0	
RBAR-02	Culvert Design	Issued for Construction	January 30, 2018	0	
RBAR-03	Roberts Bay Discharge Pipeline - Pipe Ramp at Culvert Crossing	Issued for Construction	January 30, 2018	0	
RBAR-04	Details and Quantities	Issued for Construction	January 30, 2018	0	

srk consulting

SRK Job No. 1CT022.030

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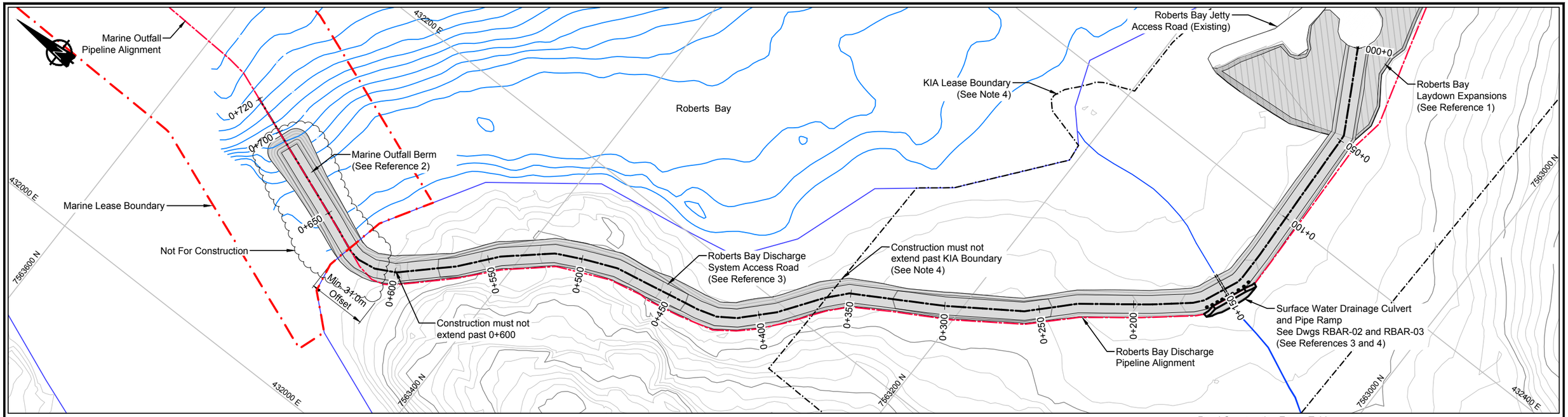
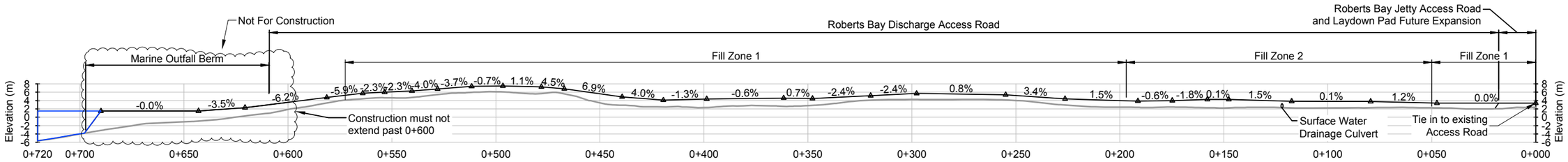


ROBERTS BAY DISCHARGE ACCESS ROAD AND MARINE OUTFALL BERM DESIGN

0 10 20 30 40 50
Scale in Metres

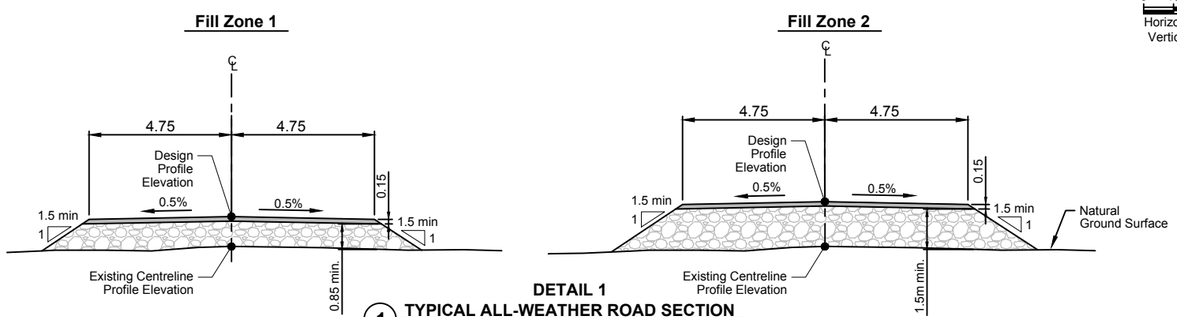
Road Construction Zones Table:

Fill Zone 1	1.5m min. Overall Road Thickness with 1.5H:1V Side Slopes
Fill Zone 2	2.0m min. Overall Road Thickness with 2.0H:1V Side Slopes
Bedrock Zone	0.3m min. Overall Road Thickness



ROBERTS BAY DISCHARGE ACCESS ROAD AND MARINE OUTFALLL BERM PROFILE

0 10 20 30 40 50
Horizontal Scale in Metres
Vertical Exaggeration X2



DETAIL 1 TYPICAL ALL-WEATHER ROAD SECTION

0 1 2 3 4 5
Scale in Metres

LEGEND

- Route Centerline
- Marine Outfall Pipeline Alignment
- KIA Lease Boundary
- 3.0 Major Contour
- Minor Contour
- Point of Vertical Intersection
- -6.0% Road Profile Grade
- Marine Lease Boundary
- Bathymetric Contour

NOTES

1. All dimensions are in meters unless noted otherwise.
2. Contours shown at 1m interval, and are based on aerial photography.
3. Marine Outfall Berm (chainage > 0+600) not to be constructed at this time.
4. Construction not to proceed out of approved KIA Lease boundary. KIA Lease boundary expansion application on-going at time of drawing. Once expansion of boundary has been approved Roberts Bay Discharge System Access Road may be fully constructed.
5. Additional notes located on drawing RBAR-04.

REFERENCE

1. SRK Consulting (Canada) Inc., 2011. Engineering Drawings for the Roberts Bay Laydown Expansions, Doris North Project, Nunavut, Canada. Water License Amendment. Revision A. Issued for Discussion. Drawings prepared for Hope Bay Mining Limited. Project Number 1CH008.049. June 13, 2011.
2. TMAC Resources Inc. Amendment Application No. 1 of Project Certificate No. 003 and Water License 2AM-DOH1323 (TMAC 2015).
3. Fisheries and Oceans Canada, Request for Review form, TMAC Resources Inc. Doris North Project - Roberts Bay Discharge Access Road Crossing Culvert, Project Certificate No. 003 Amendment. Document name: 05MN047_2AMDOH1323_TMAC_RforR_RobBayTribXing.
4. Fisheries and Oceans Canada. Letter to TMAC Resources Inc., ATTN: John Roberts. Subject: Implementation of mitigation measures to avoid and mitigate serious harm to fish - Roberts Bay Discharge Access Road Culvert - Project Certificate No. 003 Amendment (Doris North Gold Mine Project). File 02-HCAA-CA7-00117. August 30, 2016.

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

NO.	DESCRIPTION	CH'KD	APP'D	DATE
0	Issued for Construction	CH	EMR	23Jan18

REVISIONS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	EMR
CHECKED:	APPROVED:	DATE:
CH	EMR	January 2018

FILE NAME: 1CT022.002_RB Outfall.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.030

Roberts Bay Discharge System Access Road

DRAWING TITLE: Plan and Profile

DRAWING NO. RBAR-01 | SHEET 1 of 4 | REVISION NO. 0

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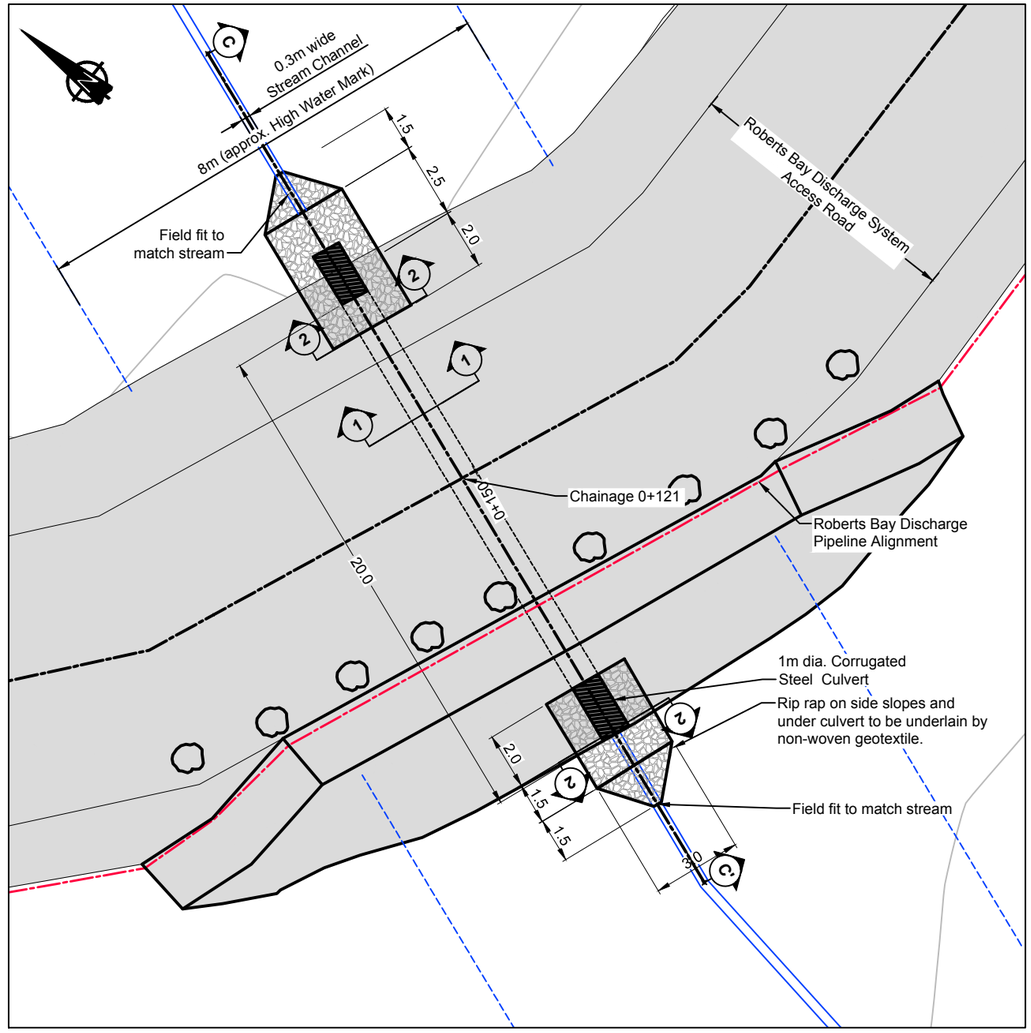
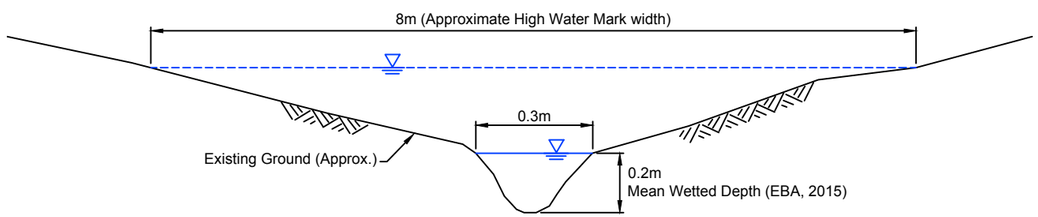


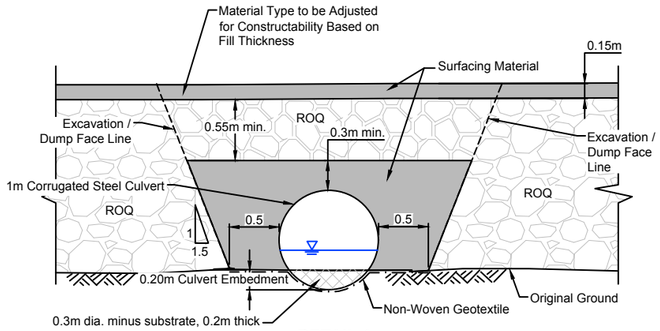
ROBERTS BAY DISCHARGE ACCESS ROAD CULVERT LOCATION

0 1 2 3 4 5
Scale in Metres



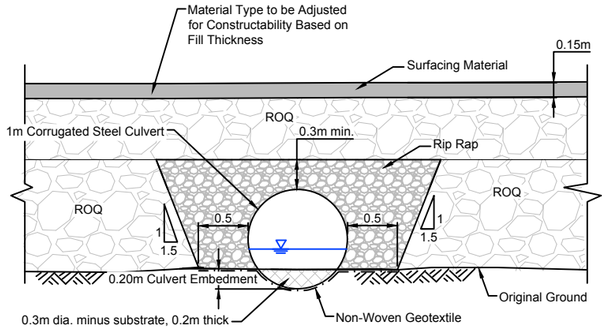
TYPICAL CREEK CROSS SECTION

NOT TO SCALE



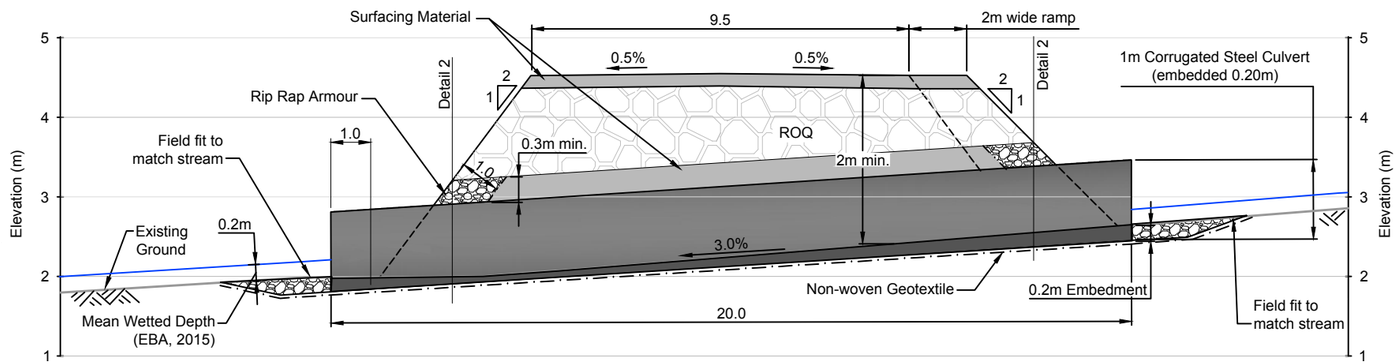
DETAIL 1
TYPICAL CROSS SECTION OF CULVERT CROSSING

1 NOT TO SCALE



DETAIL 2
TYPICAL CROSS SECTION OF CULVERT INLET/OUTLET

2 NOT TO SCALE



SECTION C - C'
CULVERT PROFILE

C 0 1 2 3 4 5
Horizontal Scale in Metres
Vertical Exaggeration X2

LEGEND

- Surfacing Material
- Run of Quarry Material
- Rip Rap, D_{50} = 0.15m
- 300mm Ø minus substrate material
- Original Ground
- Non-woven Geotextile
- Road and Stream Centerline
- 3.0 Major Contour
- Minor Contour
- Approx. High Water Mark
- Mean Wetted Depth (Section) / Stream Bank (Plan) (EBA, 2015)

NOTES

1. All dimensions are in metric units, unless otherwise noted.
2. Installation of the corrugated steel culvert will follow the manufacturers assembly and installation guide.
3. Total depth of cover above culvert, including surfacing material and ROQ, will be 1.0 m minimum.
4. Topographic contour data for the terrain model were provided by Hope Bay Mining, and is based on 2007 Aerial Photography. Contour intervals are 0.5 m.
5. Coordinate system is UTM Zone 13, datum NAD83.
6. Additional notes located on drawing RBAR-04.

REFERENCE

3. Fisheries and Oceans Canada, Request for Review form, TMAC Resources Inc. Doris North Project - Roberts Bay Discharge Access Road Crossing Culver, Project Certificate No. 003 Amendment. Document name: 05MN047_2AMDOH1323_TMAC_RforR_RobBayTribXing.
4. Fisheries and Oceans Canada. Letter to TMAC Resources Inc., ATTN: John Roberts. Subject: Implementation of mitigation measures to avoid and mitigate serious harm to fish - Roberts Bay Discharge Access Road Culvert - Project Certificate No. 003 Amendment (Doris North Gold Mine Project). File 02-HCAA-CA7-00117. August 30, 2016.

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHKD	APP'D	DATE
0	Issued for Construction	CH	EMR	23Jan18

REVISIONS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	EMR
CHECKED:	APPROVED:	DATE:
CH	EMR	January 2018

FILE NAME: 1CT022.002_RB Outfall.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.030

Roberts Bay Discharge System Access Road

DRAWING TITLE: Culvert Design

DRAWING NO.	SHEET	REVISION NO.
RBAR-02	2 of 4	0

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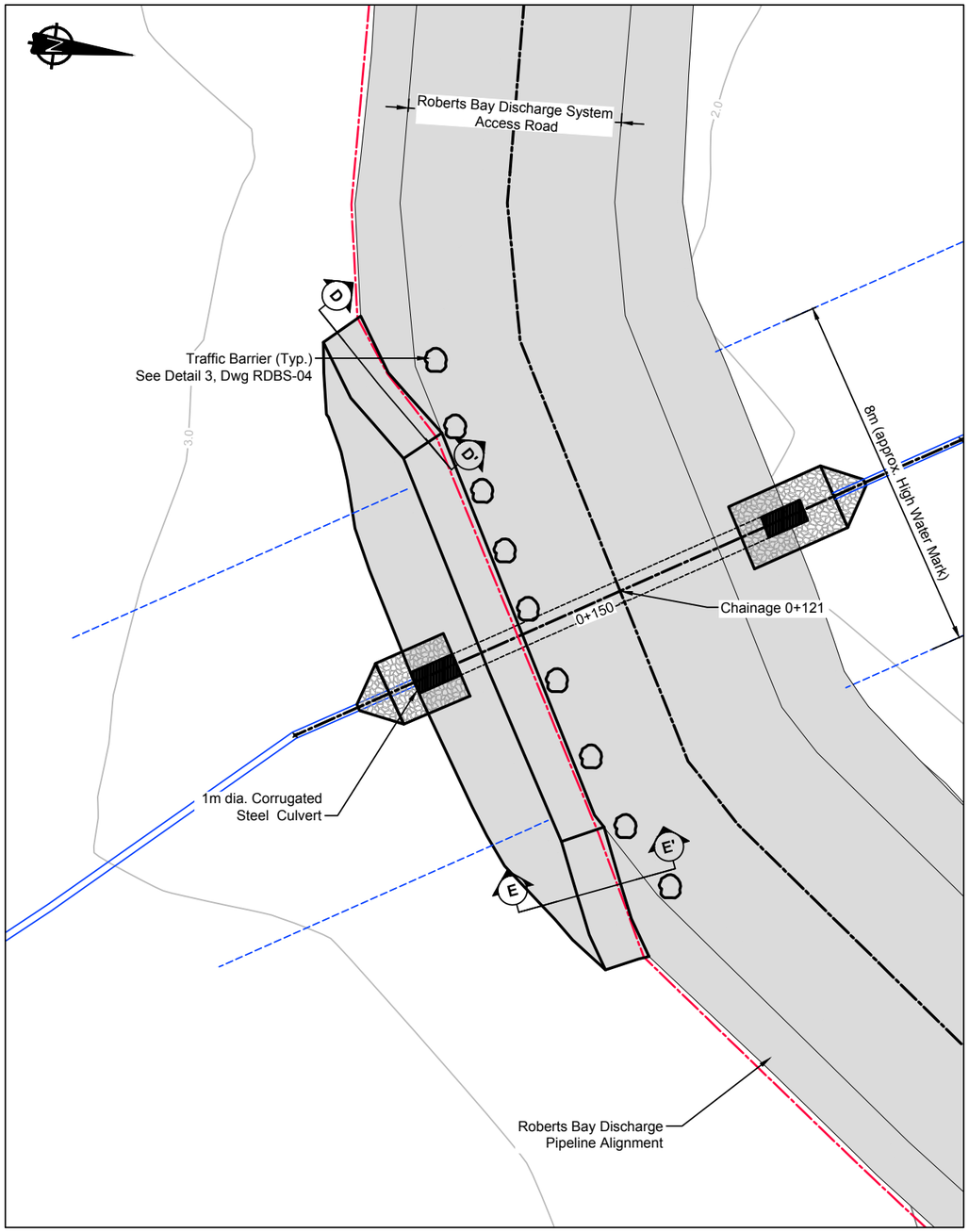


ROBERTS BAY DISCHARGE ACCESS ROAD CULVERT LOCATION

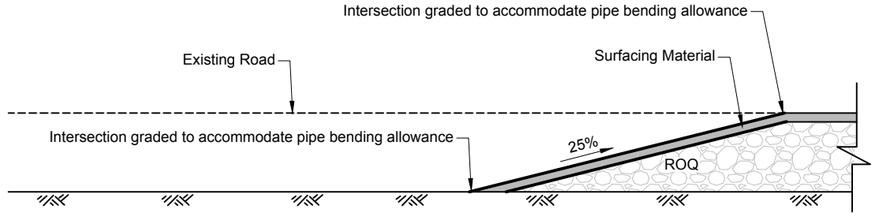
0 1.25 2.5 3.75 5
Scale in Metres

LEGEND

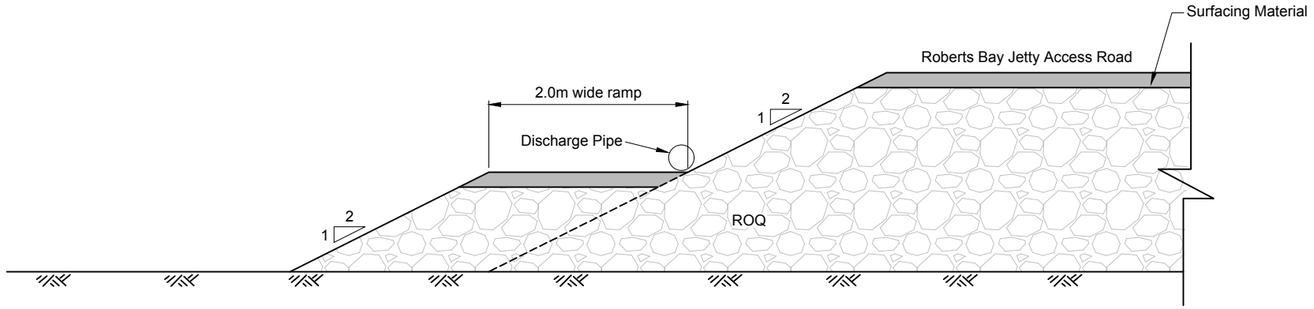
- Surfacing Material
- Run of Quarry Material
- Original Ground
- Road Centerline
- 3.0 — Major Contour
- Minor Contour
- Approx. High Water Mark
- Mean Wetted Depth (Section) / Stream Bank (Plan) (EBA, 2015)

NOTES

1. All dimensions are in metric units, unless otherwise noted.
2. Total depth of cover above culvert, including surfacing material and ROQ, will be 1.0 m minimum.
3. Topographic contour data for the terrain model were provided by Hope Bay Mining, and is based on 2007 Aerial Photography. Contour intervals are 1.0 m.
4. Coordinate system is UTM Zone 13, datum NAD83.



D SECTION D - PIPE RAMP PROFILE
NOT TO SCALE



E SECTION E - PIPE RAMP CROSS SECTION
NOT TO SCALE

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE
REFERENCE DRAWINGS			

NO.	DESCRIPTION	CH'K'D	APP'D	DATE
0	Issued for Construction	CH	EMR	23Jan18
REVISIONS				

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	EMR
CHECKED:	APPROVED:	DATE:
CH	EMR	January 2018

FILE NAME: 1CT022.002_RB Outfall.dwg

MAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.030

Roberts Bay Discharge System Access Road

DRAWING TITLE:
Roberts Bay Discharge Pipeline
Pipe Ramp at Culvert Crossing

DRAWING NO.	SHEET	REVISION NO.
RBAR-03	3 of 4	0

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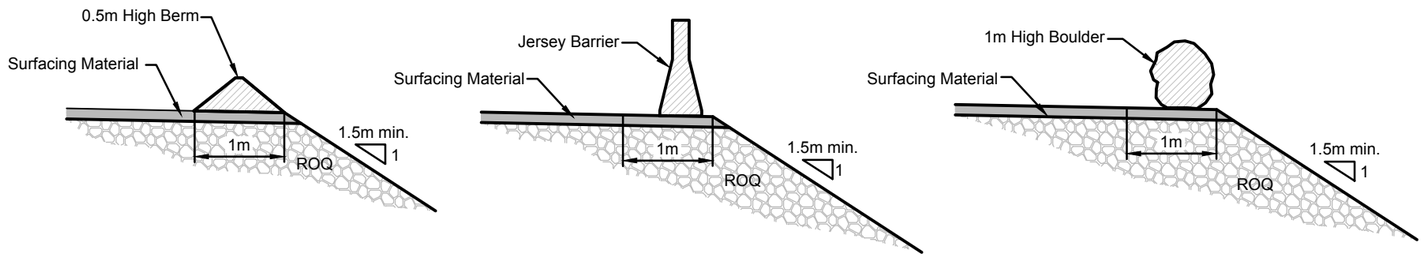
Materials List and Quantity Estimates

Item	Quantity / Area / Volume		Description
1. Run of Quarry Material		ROQ (cu.m.)	Approximate In-Place Neat-line Volume (3D volume based on Civil 3D surfaces - no allowance has been made for losses and/or tundra embedment)
	Roberts Bay Discharge Access Road	10,800	
	Pipe Ramp at Culvert Crossing	140	
	Total	10,940	
2. Surface Grade Material		Surfacing Material (cu.m.)	Approximate In-Place Neat-line Volume
	Roberts Bay Discharge Access Road	860	
	Pipe Ramp at Culvert Crossing	10	
	Total	870	
3. Rip Rap		Total 15 cu.m.	Based on Culvert Crossing
3. Geotextile		Total 55 sq.m.	Based on Culvert Crossing

Tolerances on Road Material Placement:

Location	Fill (mm)	Excavation (mm)
Vertical Tolerance on Roads	0 to +75	n/a
Horizontal Tolerance on Roads	-150 to +150	

Note: Grade shall not be uniformly high or low.



DETAIL 3
TYPICAL BERM BARRIER OPTIONS
3 N.T.S.

NOTES - GENERAL

1. The Engineer will provide the Construction Manager and Contractor with digital design files for setting out the works. The Engineer will instruct the Contractor to survey random spot checks to confirm whether the works have been set out correctly.
2. Construction shall be in accordance with the following;

   Technical Specifications: Earthworks and Geotechnical Engineering, Hope Bay project, Nunavut, Canada, Revision G - Issued for Construction.

3. Construction shall be in accordance with:

   Fisheries and Oceans Canada, Request for Review form, TMAC Resources Inc. Doris North Project - Roberts Bay Discharge Access Road Crossing Culver, Project Certificate No. 003 Amendment. Document name: 05MN047_2AMDOH1323_TMAC_RforR_RobBayTribXing. And,

   Fisheries and Oceans Canada. Letter to TMAC Resources Inc., ATTN: John Roberts. Subject: Implementation of mitigation measures to avoid and mitigate serious harm to fish - Roberts Bay Discharge Access Road Culvert - Project Certificate No. 003 Amendment (Doris North Gold Mine Project). File 02-HCAA-CA7-00117. August 30, 2016.

NOTES - ROBERTS BAY DISCHARGE ACCESS ROAD

1. Construction can be completed during the summer or winter in accordance with the normal construction procedures used on site for roads and rockfill pads.
2. If winter construction is used, road construction must cease at approximately 0+110, where the culvert is to be installed. A snow bridge should be constructed across the stream crossing, maintaining a minimum width of 2m, i.e. 1m on either side of the stream centerline. Any such snow bridge must be constructed in accordance with appropriate DFO guidelines for self-assessment. Once the snow bridge is in place construction of the road can proceed.
3. If summer construction is employed, construction of the road must cease at station 0+110. A temporary free-span crossing may be constructed to reach the opposite stream bank to allow construction to advance prior to installing the culvert.

NOTES - SEDIMENT AND EROSION CONTROL

1. If required, sandbags are to be placed by hand to create a small coffer dam approximately 5m upstream of the proposed culvert installation location.
2. Ponded water (maximum head of about 0.5m) which accumulates behind the sand bags must be pumped around the construction area and discharged back into the stream about 10m downstream of the culvert.
3. A flow energy dissipation blanket (likely old conveyor belt, or something equivalent) must be used to ensure erosion is minimized.
4. A silt fence must be installed approximately 5m downstream of the construction are to contain any sediment that may become mobiles should a rainfall event occur during construction.

NOTES - SUBSTRATE

1. The culvert must be embedded below existing ground by approximately 0.2m in order to place a layer of substrate material to promote fish habitat.
2. The substrate is to be a 300mm diameter minus cobble/gravel material (D_{100} of 0.3m), with several larger diameter boulders placed throughout the culvert length to increase roughness.
3. Quarry rock is to be used to mimic the natural stream bed as far as practical.

NOTES - CULVERT

1. Culvert installation must occur during the late summer season while the ground is thawed, and after fish spawning season (i.e., after August 1).
2. Culvert installation should be carried out from the edge of the road, with no need for temporary access to the tundra or streambed by equipment.
3. All fuels, lubricants and other potentially hazardous materials must be stored outside the riparian management area of the stream, in locations designated for such storage on site.
4. A non-woven geotextile must be placed along the surface of natural ground in the culverts footprint, to prevent loss of fines and gravels through seepage along the culvert.
5. The culvert must be placed from upstream to downstream. As each length of culvert is placed, the substrate material must be shoveled and raked into place using manual labour at the base of the culvert to a depth of 0.2m.
6. Once the culvert is in place, backfill lifts of 0.3m must be placed on either side using bedding material, and are compacted to 85% Standard Proctor Density.

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHKD	APP'D	DATE
0	Issued for Construction	CH	EMR	23Jan18

REVISIONS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	EMR
CHECKED:	APPROVED:	DATE:
CH	EMR	January 2018

FILE NAME: 1CT022.002_RB Outfall.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.030

Roberts Bay Discharge System Access Road

DRAWING TITLE: Details, Layout, and Quantities

DRAWING NO.	SHEET	REVISION NO.
RBAR-04	4 of 4	0

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Attachment 2.2 Roberts Bay Access Road – As-built Drawings

TMAC Resources Inc.

Doris Project
As-Built Drawings for
Roberts Bay Discharge System Access Road

Drawing Number	Drawing Title	Issue	Date	Revision	Old / Replaced Revisions
RBAR-01	Plan and Profile	As-Built	February 13, 2019	AB	Rev 0, Issued for Construction
RBAR-02	Culvert Design	As-Built	February 13, 2019	AB	Rev 0, Issued for Construction
RBAR-03	Roberts Bay Discharge Pipeline - Pipe Ramp at Culvert Crossing	As-Built	February 13, 2019	AB	Rev 0, Issued for Construction
RBAR-04	Details and Quantities	Issued for Construction	January 30, 2018	0	

srk consulting

SRK Job No. 1CT022.030

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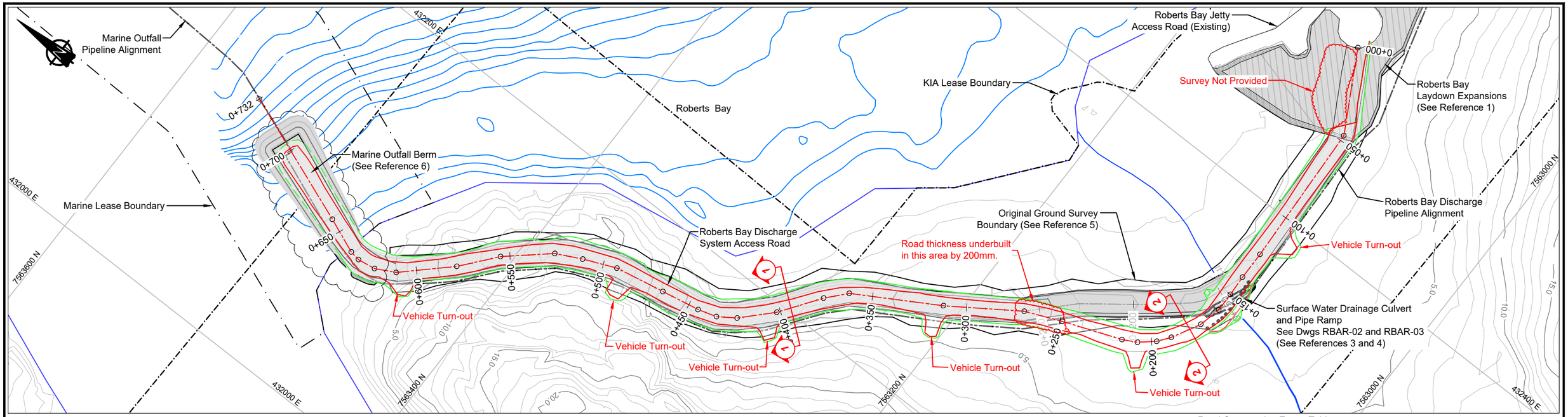
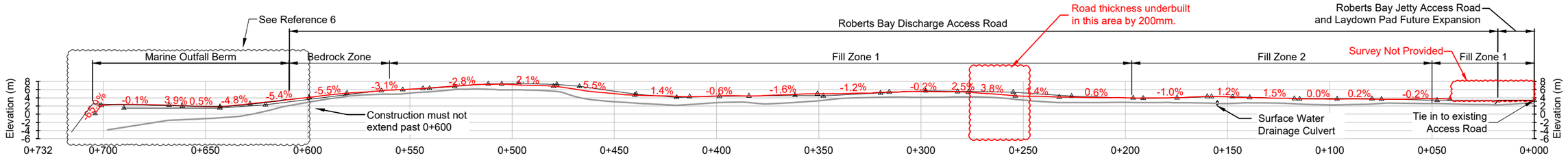


ROBERTS BAY DISCHARGE ACCESS ROAD AND MARINE OUTFALL BERM DESIGN

0 10 20 30 40 50
Scale in Metres

Road Construction Zones Table:

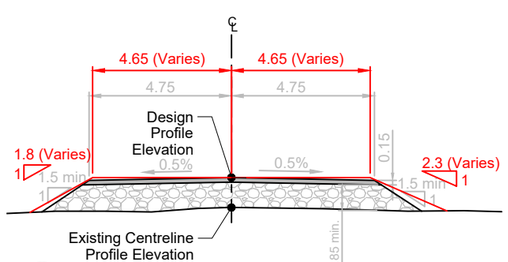
Fill Zone 1	1.0m min. Overall Road Thickness with 1.5H:1V Side Slopes
Fill Zone 2	1.5m min. Overall Road Thickness with 2.0H:1V Side Slopes
Bedrock Zone	0.3m min. Overall Road Thickness



ROBERTS BAY DISCHARGE ACCESS ROAD AND MARINE OUTFALLL BERM PROFILE

0 10 20 30 40 50
Horizontal Scale in Metres
Vertical Exaggeration X2

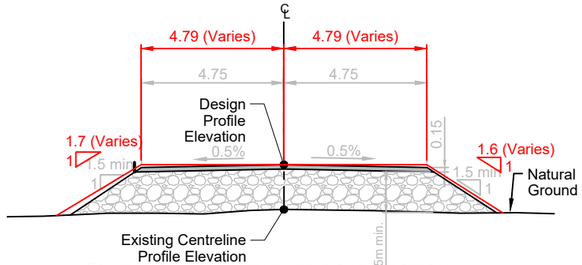
Fill Zone 1



1 TYPICAL ALL-WEATHER ROAD SECTION

0 1 2 3 4 5
Scale in Metres

Fill Zone 2



2 TYPICAL ALL-WEATHER ROAD SECTION

0 1 2 3 4 5
Scale in Metres

LEGEND

- Point of Vertical Intersection
- Marine Outfall Pipeline Alignment
- Design Centerline
- As-Built Centerline
- As-Built Crest
- As-Built Toe
- As-Built Toe at Water Surface
- 3.0 — Major Contour
- Minor Contour
- KIA Lease Boundary
- -6.0% — Road Profile Grade
- Marine Lease Boundary
- Bathymetric Contour
- OG Survey Boundary

NOTES

1. All dimensions are in meters unless noted otherwise.
2. Contours shown at 1m interval, and are based on aerial photography.
3. Additional notes located on drawing RBAR-04.
4. As-Built survey does not pick up toe below water surface.

REFERENCE

1. SRK Consulting (Canada) Inc., 2011. Roberts Bay Laydown Expansions, Doris Project. Issued for Construction. Drawings Prepared for TMAC resources Inc. Projects Number 1CT022.030. December 13, 2018.
2. TMAC Resources Inc. Amendment Application No. 1 of Project Certificate No. 003 and Water License 2AM-DOH1323 (TMAC 2015).
3. Fisheries and Oceans Canada, Request for Review form, TMAC Resources Inc. Doris North Project - Roberts Bay Discharge Access Road Crossing Culvert, Project Certificate No. 003 Amendment. Document name: 05MN047_2AMDOH1323_TMAC_RforR_RobBayTribXing.
4. Fisheries and Oceans Canada. Letter to TMAC Resources Inc., ATTN: John Roberts. Subject: Implementation of mitigation measures to avoid and mitigate serious harm to fish - Roberts Bay Discharge Access Road Culvert - Project Certificate No. 003 Amendment (Doris North Gold Mine Project). File 02-HCAA-CA7-00117. August 30, 2016.
5. Original ground survey provided by Sub-Arctic Geomatics Ltd., July 9, 2018.
6. As-Built Drawings for Roberts Bay Marine Outfall Berm, RMOB-01-05, RevAB, SRK Consulting, Project Number 1CT022.026, February 2019.
7. As-Built Survey provided by Sub-Arctic Geomatics Ltd. Survey Date: September 10, 2018.

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
AB	As-Built			
1	Issued for Construction	CH	EMR	11July18
0	Issued for Construction	CH	EMR	23Jan18

REVISIONS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN: CH	DRAWN: TAH	REVIEWED: EMR
CHECKED: CH	APPROVED: EMR	DATE: February 2019

FILE NAME: 1CT022.002_RB Outfall.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.030

Roberts Bay Discharge System Access Road

DRAWING TITLE: Plan and Profile

DRAWING NO.	SHEET	REVISION NO.
RBAR-01	1 of 4	AB

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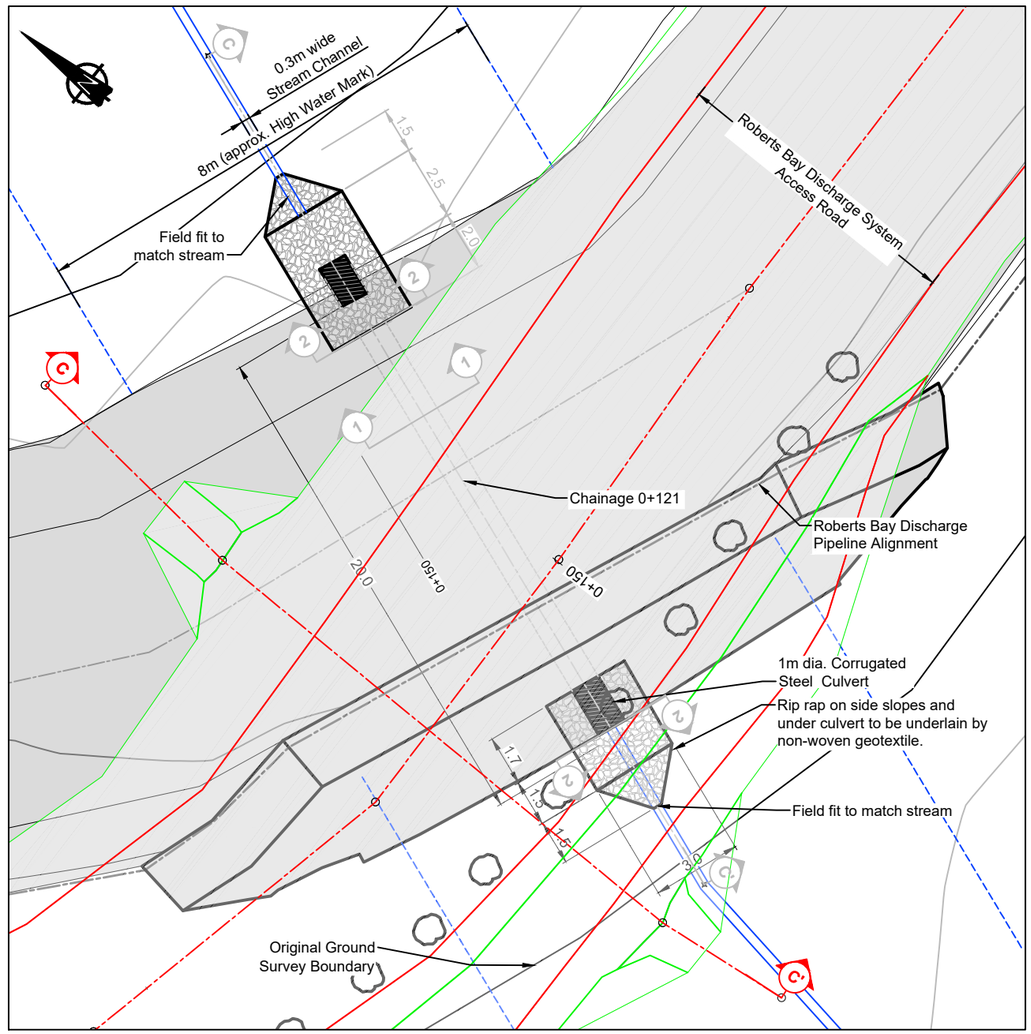
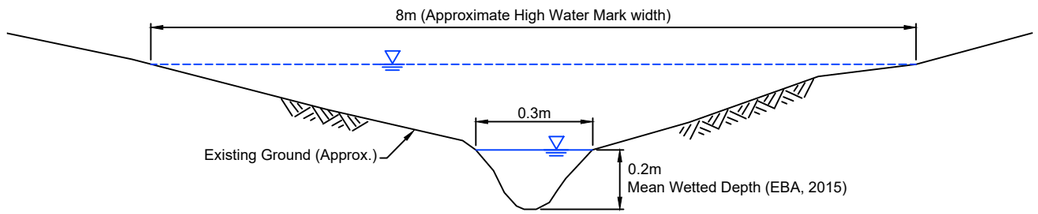
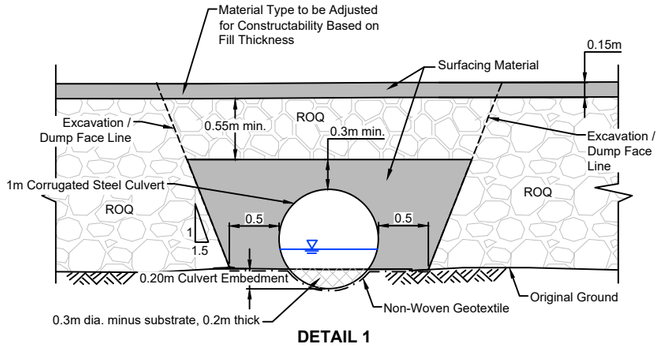


ROBERTS BAY DISCHARGE ACCESS ROAD CULVERT LOCATION

0 1 2 3 4 5
Scale in Metres

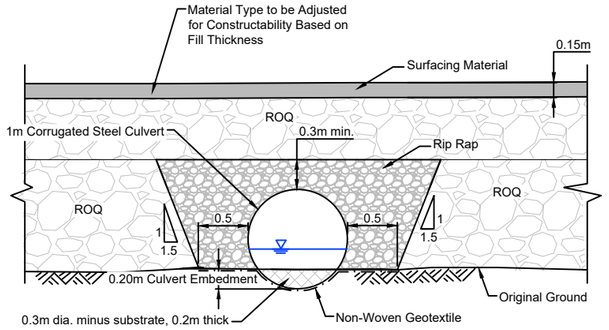


TYPICAL CREEK CROSS SECTION
NOT TO SCALE



DETAIL 1
TYPICAL CROSS SECTION
OF CULVERT CROSSING
1 NOT TO SCALE

Construction Details
Not Provided



DETAIL 2
TYPICAL CROSS SECTION
OF CULVERT INLET/OUTLET
2 NOT TO SCALE

LEGEND

- Original Ground
- Non-woven Geotextile
- 3.0 Major Contour
- Minor Contour
- Design Road and Stream Centerline
- As-Built Road and Stream Centerline
- As-Built Crest
- As-Built Toe
- Approx. High Water Mark
- Mean Wetted Depth (Section) / Stream Bank (Plan) (EBA, 2015)
- Surfacing Material
- Run of Quarry Material
- Rip Rap, D_{50} = 0.15m
- 300mm Ø minus substrate material

NOTES

1. All dimensions are in metric units, unless otherwise noted.
2. Installation of the corrugated steel culvert will follow the manufacturers assembly and installation guide.
3. Total depth of cover above culvert, including surfacing material and ROQ, will be 1.0 m minimum.
4. Topographic contour data for the terrain model were provided by Hope Bay Mining, and is based on 2007 Aerial Photography. Contour intervals are 0.5 m.
5. Coordinate system is UTM Zone 13, datum NAD83.
6. Additional notes located on drawing RBAR-04.

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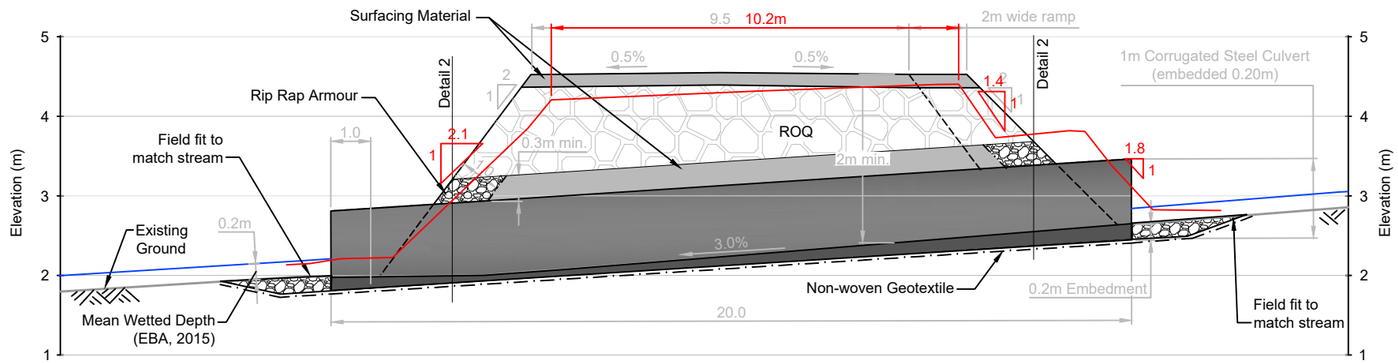
4. Fisheries and Oceans Canada. Letter to TMAC Resources Inc., ATTN: John Roberts. Subject: Implementation of mitigation measures to avoid and mitigate serious harm to fish - Roberts Bay Discharge Access Road Culvert - Project Certificate No. 003 Amendment (Doris North Gold Mine Project). File 02-HCAA-CA7-00117. August 30, 2016.



SECTION C - C'
CULVERT PROFILE
C 0 1 2 3 4 5
Horizontal Scale in Metres
Vertical Exaggeration X2

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

NO.	DESCRIPTION	CH'K'D	APP'D	DATE
AB	As-Built			
1	Issued for Construction	CH	EMR	11July18
0	Issued for Construction	CH	EMR	23Jan18

REVISIONS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	EMR
CHECKED:	APPROVED:	DATE:
CH	EMR	February 2019

FILE NAME: 1CT022.002_RB Outfall.dwg

TMAC RESOURCES

HOPE BAY PROJECT

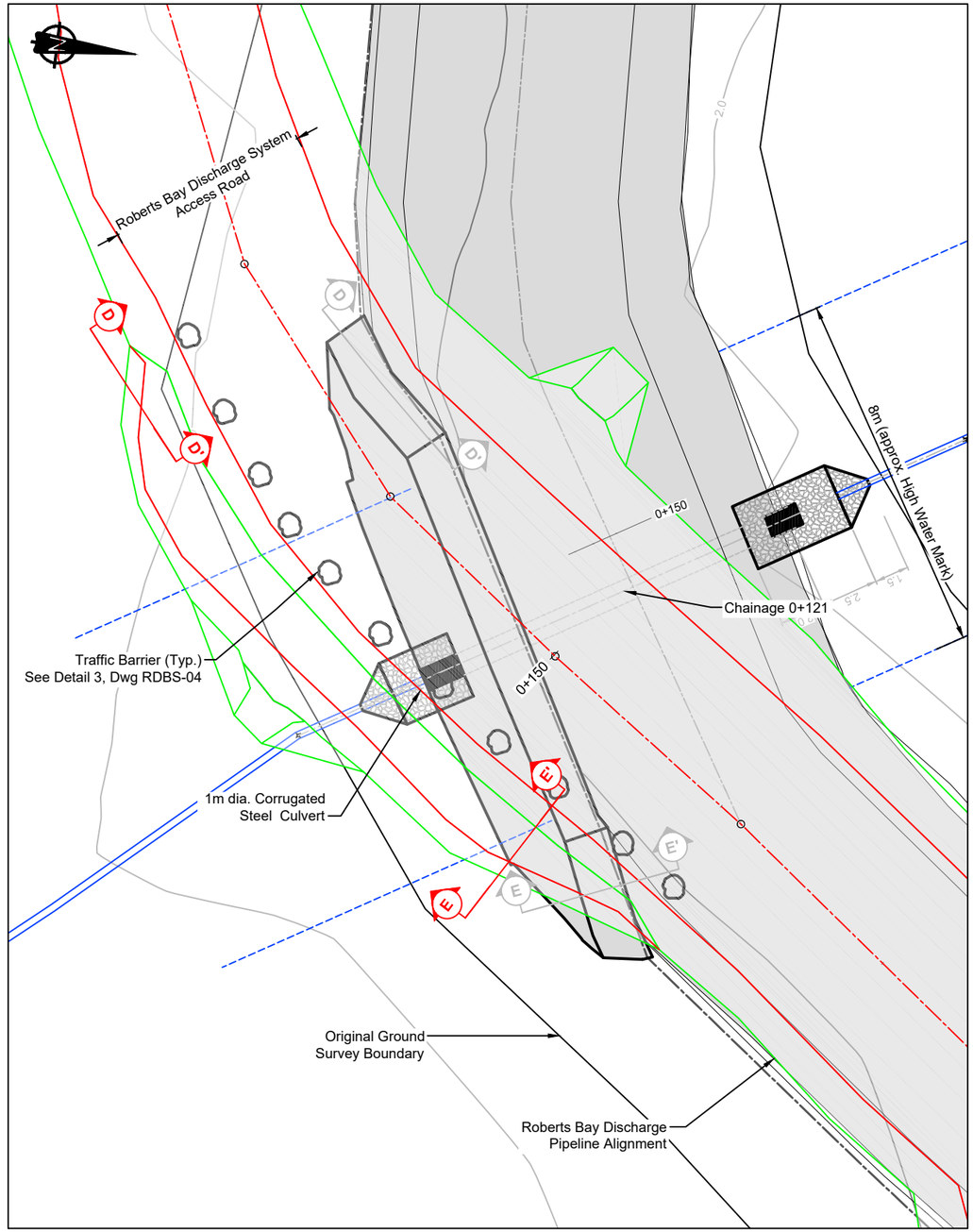
SRK JOB NO.: 1CT022.030

Roberts Bay Discharge System Access Road

DRAWING TITLE:
Culvert Design

DRAWING NO.	SHEET	REVISION NO.
RBAR-02	2 of 4	AB

P:\01_SITES\Hope Bay\ACAD\As-Builts\2018 Construction Summary Report\Roberts Bay Discharge System\1CT022.002_RB Outfall.dwg



ROBERTS BAY DISCHARGE ACCESS ROAD CULVERT LOCATION

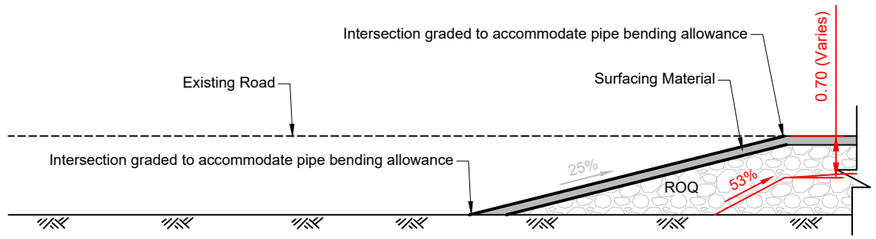
0 1.25 2.5 3.75 5
Scale in Metres

LEGEND

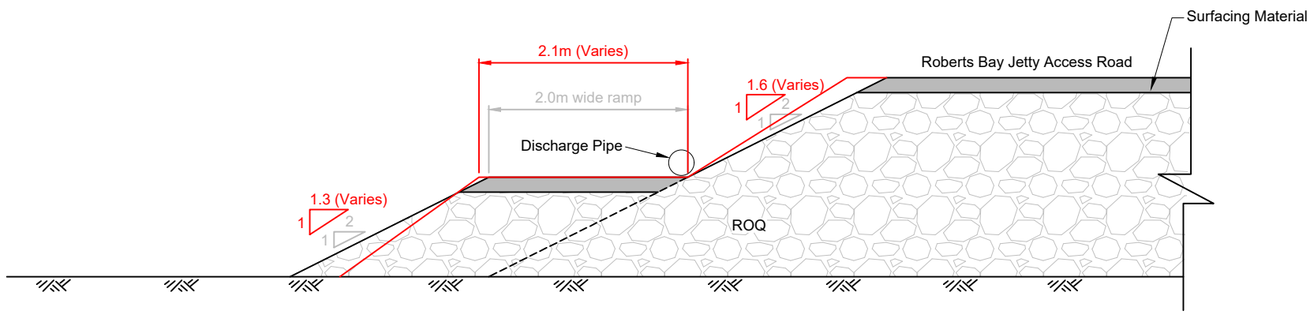
- Original Ground
- 3.0 Major Contour
- Minor Contour
- Design Centerline
- As- Built Centerline
- As-Built Crest
- As-Built Major Toe
- Approx. High Water Mark
- Mean Wetted Depth (Section) / Stream Bank (Plan) (EBA, 2015)
- Roberts Bay Discharge Pipe Alignment
- Surfacing Material
- Run of Quarry Material

NOTES

1. All dimensions are in metric units, unless otherwise noted.
2. Total depth of cover above culvert, including surfacing material and ROQ, will be 1.0 m minimum.
3. Topographic contour data for the terrain model were provided by Hope Bay Mining, and is based on 2007 Aerial Photography. Contour intervals are 1.0 m.
4. Coordinate system is UTM Zone 13, datum NAD83.



D SECTION D - PIPE RAMP PROFILE
NOT TO SCALE



E SECTION E - PIPE RAMP CROSS SECTION
NOT TO SCALE

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
AB	As-Built			
1	Issued for Construction	CH	EMR	11July18
0	Issued for Construction	CH	EMR	23Jan18

REVISIONS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	EMR
CHECKED:	APPROVED:	DATE:
CH	EMR	February 2019

FILE NAME: 1CT022.002_RB Outfall.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.030

Roberts Bay Discharge System Access Road

DRAWING TITLE:
Roberts Bay Discharge Pipeline
Pipe Ramp at Culvert Crossing

DRAWING NO.	SHEET	REVISION NO.
RBAR-03	3 of 4	AB

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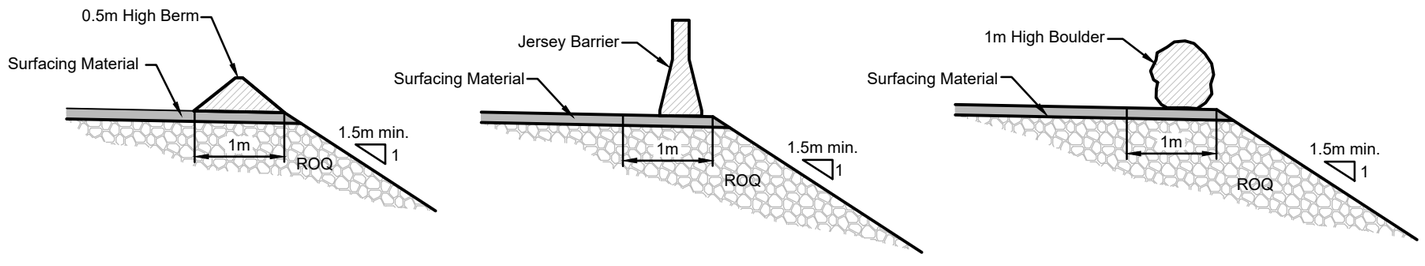
Materials List and Quantity Estimates

Item	Quantity / Area / Volume		Description
1. Run of Quarry Material		ROQ (cu.m.)	Approximate In-Place Neat-line Volume (3D volume based on Civil 3D surfaces - no allowance has been made for losses and/or tundra embedment)
	Roberts Bay Discharge Access Road	10,800	
	Pipe Ramp at Culvert Crossing	140	
	Total	10,940	
2. Surface Grade Material		Surfacing Material (cu.m.)	Approximate In-Place Neat-line Volume
	Roberts Bay Discharge Access Road	860	
	Pipe Ramp at Culvert Crossing	10	
	Total	870	
3. Rip Rap		Total 15 cu.m.	Based on Culvert Crossing
3. Geotextile		Total 55 sq.m.	Based on Culvert Crossing

Tolerances on Road Material Placement:

Location	Fill (mm)	Excavation (mm)
Vertical Tolerance on Roads	0 to +75	n/a
Horizontal Tolerance on Roads	-150 to +150	

Note: Grade shall not be uniformly high or low.



DETAIL 3
TYPICAL BERM BARRIER OPTIONS
NOT TO SCALE

3

NOTES - GENERAL

1. The Engineer will provide the Construction Manager and Contractor with digital design files for setting out the works. The Engineer will instruct the Contractor to survey random spot checks to confirm whether the works have been set out correctly.
2. Construction shall be in accordance with the following;

   Technical Specifications: Earthworks and Geotechnical Engineering, Hope Bay project, Nunavut, Canada, Revision G - Issued for Construction.

3. Construction shall be in accordance with:

   Fisheries and Oceans Canada, Request for Review form, TMAC Resources Inc. Doris North Project - Roberts Bay Discharge Access Road Crossing Culver, Project Certificate No. 003 Amendment. Document name: 05MN047_2AMDOH1323_TMAC_RforR_RobBayTribXing. And,

   Fisheries and Oceans Canada. Letter to TMAC Resources Inc., ATTN: John Roberts. Subject: Implementation of mitigation measures to avoid and mitigate serious harm to fish - Roberts Bay Discharge Access Road Culvert - Project Certificate No. 003 Amendment (Doris North Gold Mine Project). File 02-HCAA-CA7-00117. August 30, 2016.

NOTES - ROBERTS BAY DISCHARGE ACCESS ROAD

1. Construction can be completed during the summer or winter in accordance with the normal construction procedures used on site for roads and rockfill pads.
2. If winter construction is used, road construction must cease at approximately 0+110, where the culvert is to be installed. A snow bridge should be constructed across the stream crossing, maintaining a minimum width of 2m, i.e. 1m on either side of the stream centerline. Any such snow bridge must be constructed in accordance with appropriate DFO guidelines for self-assessment. Once the snow bridge is in place construction of the road can proceed.
3. If summer construction is employed, construction of the road must cease at station 0+110. A temporary free-span crossing may be constructed to reach the opposite stream bank to allow construction to advance prior to installing the culvert.

NOTES - SEDIMENT AND EROSION CONTROL

1. If required, sandbags are to be placed by hand to create a small coffer dam approximately 5m upstream of the proposed culvert installation location.
2. Ponded water (maximum head of about 0.5m) which accumulates behind the sand bags must be pumped around the construction area and discharged back into the stream about 10m downstream of the culvert.
3. A flow energy dissipation blanket (likely old conveyor belt, or something equivalent) must be used to ensure erosion is minimized.
4. A silt fence must be installed approximately 5m downstream of the construction are to contain any sediment that may become mobiles should a rainfall event occur during construction.

NOTES - SUBSTRATE

1. The culvert must be embedded below existing ground by approximately 0.2m in order to place a layer of substrate material to promote fish habitat.
2. The substrate is to be a 300mm diameter minus cobble/gravel material (D_{100} of 0.3m), with several larger diameter boulders placed throughout the culvert length to increase roughness.
3. Quarry rock is to be used to mimic the natural stream bed as far as practical.

NOTES - CULVERT

1. Culvert installation must occur during the late summer season while the ground is thawed, and after fish spawning season (i.e., after August 1).
2. Culvert installation should be carried out from the edge of the road, with no need for temporary access to the tundra or streambed by equipment.
3. All fuels, lubricants and other potentially hazardous materials must be stored outside the riparian management area of the stream, in locations designated for such storage on site.
4. A non-woven geotextile must be placed along the surface of natural ground in the culverts footprint, to prevent loss of fines and gravels through seepage along the culvert.
5. The culvert must be placed from upstream to downstream. As each length of culvert is placed, the substrate material must be shoveled and raked into place using manual labour at the base of the culvert to a depth of 0.2m.
6. Once the culvert is in place, backfill lifts of 0.3m must be placed on either side using bedding material, and are compacted to 85% Standard Proctor Density.

REFERENCE DRAWINGS				REVISIONS				
DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHKD	APP'D	DATE
				AB	As-Built			
				0	Issued for Construction	CH	EMR	23Jan18

PROFESSIONAL ENGINEERS STAMP

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	EMR
CHECKED:	APPROVED:	DATE:
CH	EMR	January 2018

FILE NAME: 1CT022.002_RB Outfall.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.030

Roberts Bay Discharge System Access Road

DRAWING TITLE: Details, Layout, and Quantities

DRAWING NO.	SHEET	REVISION NO.
RBAR-04	4 of 4	0

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Attachment 3 – Roberts Bay Marine Outfall Berm

Attachment 3.1 Roberts Bay Marine Outfall Berm – IFC Drawings

Doris North Project
Engineering Drawings for
Roberts Bay Marine Outfall Berm

Drawing Number	Drawing Title	Issue	Date	Revision	Old / Replaced Revisions
RMOB-01	General Arrangements	Issued for Construction	May 10, 2018	0	
RMOB-02	Plan and Profile	Issued for Construction	May 16, 2018	0	
RMOB-03	Pipe Ramp	Issued for Construction	May 10, 2018	0	
RMOB-04	Geogrid Layout Pattern	Issued for Construction	May 10, 2018	0	
RMOB-05	Schedule of Quantities	Issues for Construction	May 10, 2018	0	

SRK Job No. 1CT022.030

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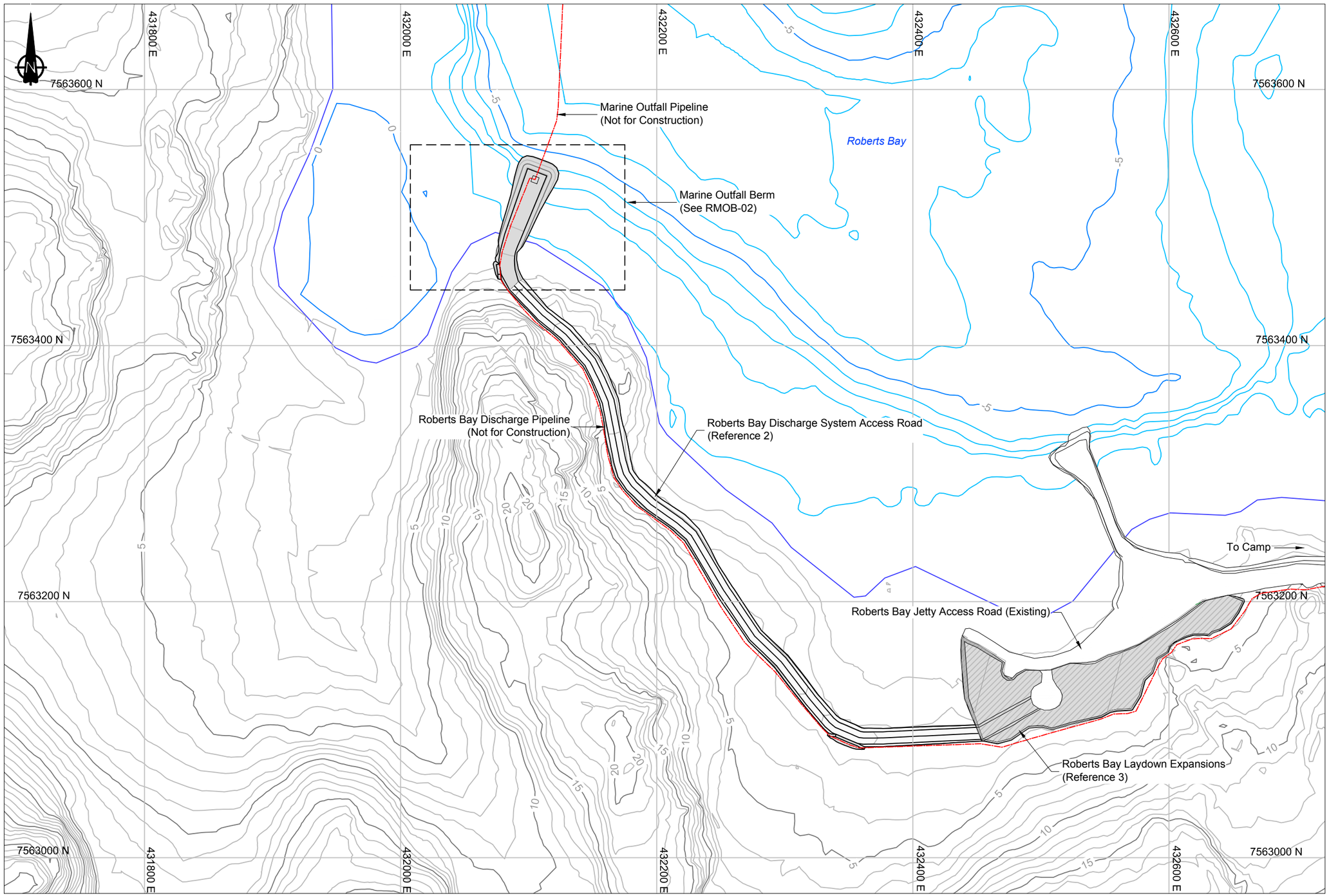

LEGEND

- Bathymetric Contour
- Topographic Contour
- Discharge Pipeline

NOTES

1. All dimensions are in meters unless otherwise stated.
2. Contours shown at 1.0m intervals.

REFERENCES

1. NAD83 UTM Zone 13.
2. SRK Consulting (Canada) Inc., 2018 Engineering Drawings for the Roberts Bay Discharge System Access Road. Doris North Project, Nunavut, Canada. Issued for Construction. Drawings prepared for Hope Bay Mining Limited. Project number 1CT022.030. January 30, 2018.
3. SRK Consulting (Canada) Inc., 2011. Engineering Drawings for the Roberts Bay Laydown Expansions, Doris North Project, Nunavut, Canada. Water License Amendment. Revision A. Issued for Discussion. Drawings prepared for Hope Bay Mining Limited. Project Number 1CH008.049. June 13, 2011.

0m 30 60 90 120

DRAWING NO.	DRAWING TITLE
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REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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0	Issued for Construction	CH	--	18/05/10

REVISIONS

Original Drawings
Stamped and
Signed by Engineer

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srk consulting

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CH	TAH	
CHECKED:	APPROVED:	DATE:
		2018/05/10

FILE NAME: 1CT022.002_MOB-GA.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.002

Roberts Bay Marine Outfall Berm

DRAWING TITLE:

General Arrangement

DRAWING NO.	SHEET	REVISION NO.
RMOB-01	1 OF 5	0

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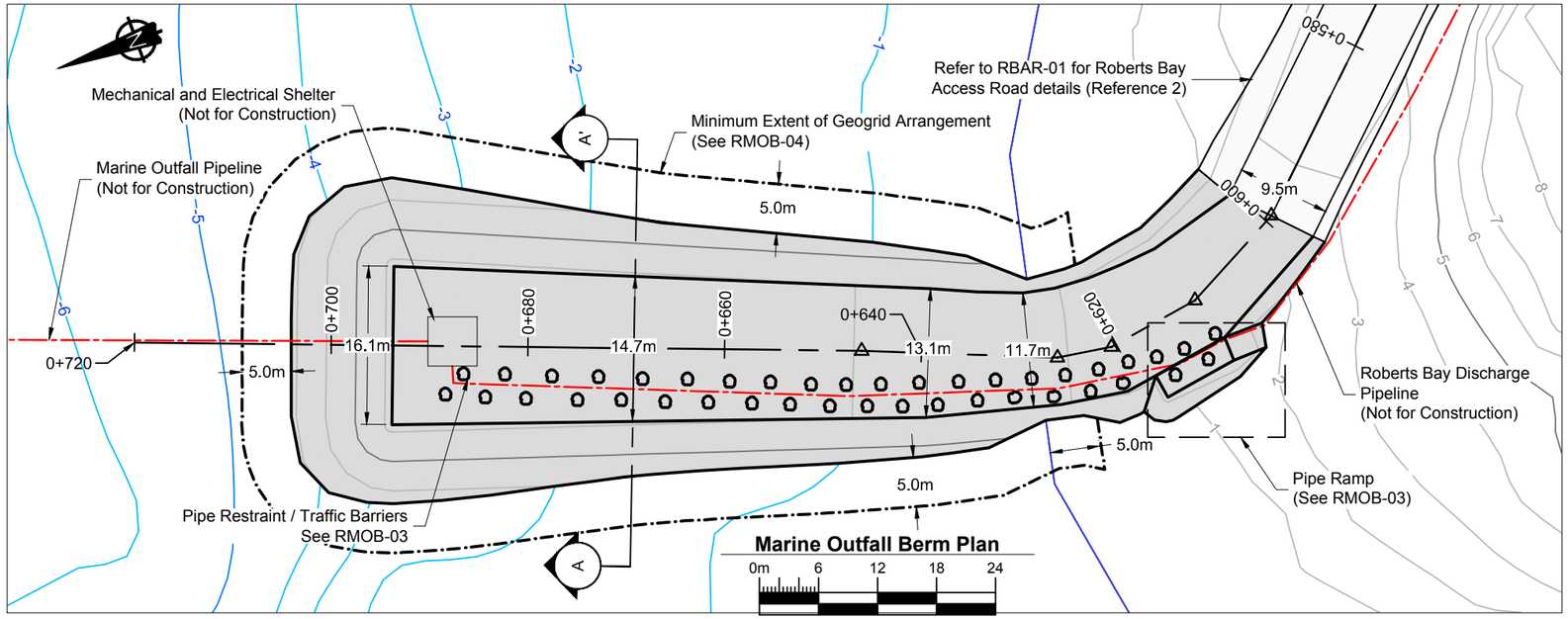
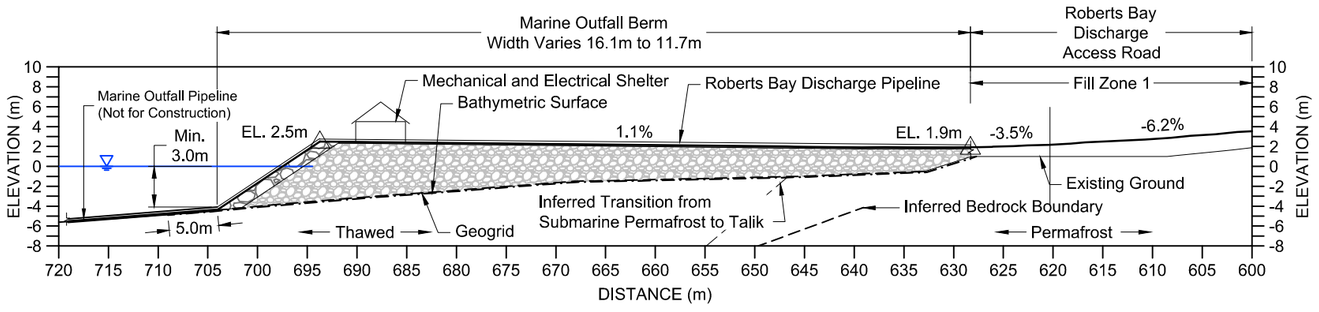
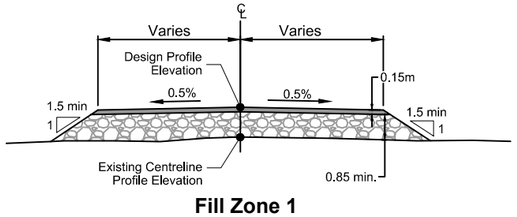




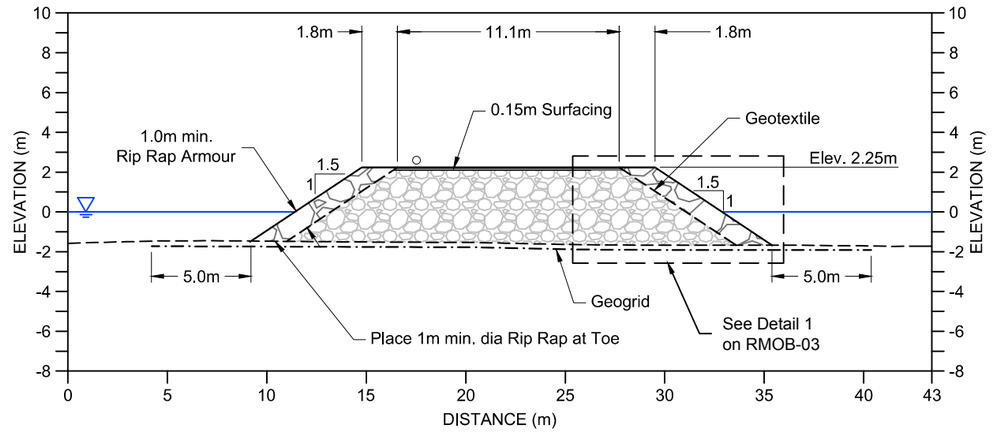
Marine Outfall Berm Profile

0m 6 12 18 24



Fill Zone 1

0m 2 4 6 8



Cross Section A-A'

0m 3 6 9 12

LEGEND

- Geotextile
- Geogrid
- Bathymetric Contour
- Topographic Contour
- Discharge Pipeline
- Rip Rap Armour
- ROQ Material
- Surfacing Material
- Traffic Barrier

NOTES

1. All dimensions are in meters unless noted otherwise.
2. Contours shown at 1m interval, and are based on aerial photography.
3. For details on Roberts Bay Discharge System Access road from 0+000 to 0+600, refer to drawings RBAR-01 to 04.
4. It is the Contractor's responsibility to ensure that the geogrid is installed in advance of the construction fill being placed. The Contractor must submit a construction procedure to the Engineer for approval before commencing this work.
5. Significant settlement of placed ROQ into the sea bed is expected during placement, even with geogrid installation.
6. The Contractor is responsible for silt and sediment control during construction. The construction methods by the Contractor must comply with TMAC environmental policies and permits and in line with requirements specified in References 1, 3, and 4.
7. The design provided considers the likely settlement of the marine outfall berm, and is deliberately raised and graded to account for this settlement. The final design is to have a horizontal crest at 1.5m elevation with 9.5m width (excluding armoring). Future 'repair' work designs should reflect this final design and not this initial construction design.

REFERENCES

1. TMAC Resources Inc. Amendment Application No. 1 of Project Certificate No. 003 and Water License 2AM-DOH1323 (TMAC 2015).
2. SRK Consulting (Canada) Inc., 2018. Engineering Drawings for the Roberts Bay Discharge System Access Road. Doris North Project, Nunavut, Canada. Issued for Construction. Drawings prepared for Hope Bay Mining Limited. Project number 1CT022.030. January 30, 2018
3. Fisheries and Oceans Canada. Letter to TMAC Resources, Inc., ATTN: Mr. Roberts. Subject: Implementation of mitigation measures to avoid and mitigate serious harm to fish - Marine Outfall Berm - Project Certification No. 003 Amendment (Doris North Gold Mine Project). File 02-HCAA-CA7-0017. August 30, 2016.
4. Fisheries and Oceans Canada, Request for Review form, TMAC Resources Inc. Doris North Project - Marine Outfall Berm, Project Certificate No. 003 Amendment. Document name: 2AM-DOH1323 (TMAC 2015)

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
- -	- -	0	Issued for Construction	CH	- -	18/05/16

REFERENCE DRAWINGS | REVISIONS

Original Drawings Stamped and Signed by Engineer

This drawing is uncontrolled when printed unless stamped and signed with original ink and recorded on a Distribution Register.

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN: CH | DRAWN: TAH | REVIEWED:
CHECKED: | APPROVED: | DATE: 2018/05/16
FILE NAME: 1CT022.002_MOB.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.002

Roberts Bay Marine Outfall Berm

DRAWING TITLE: Plan and Profile

DRAWING NO. RMOB-02 | SHEET 2 OF 5 | REVISION NO. 0

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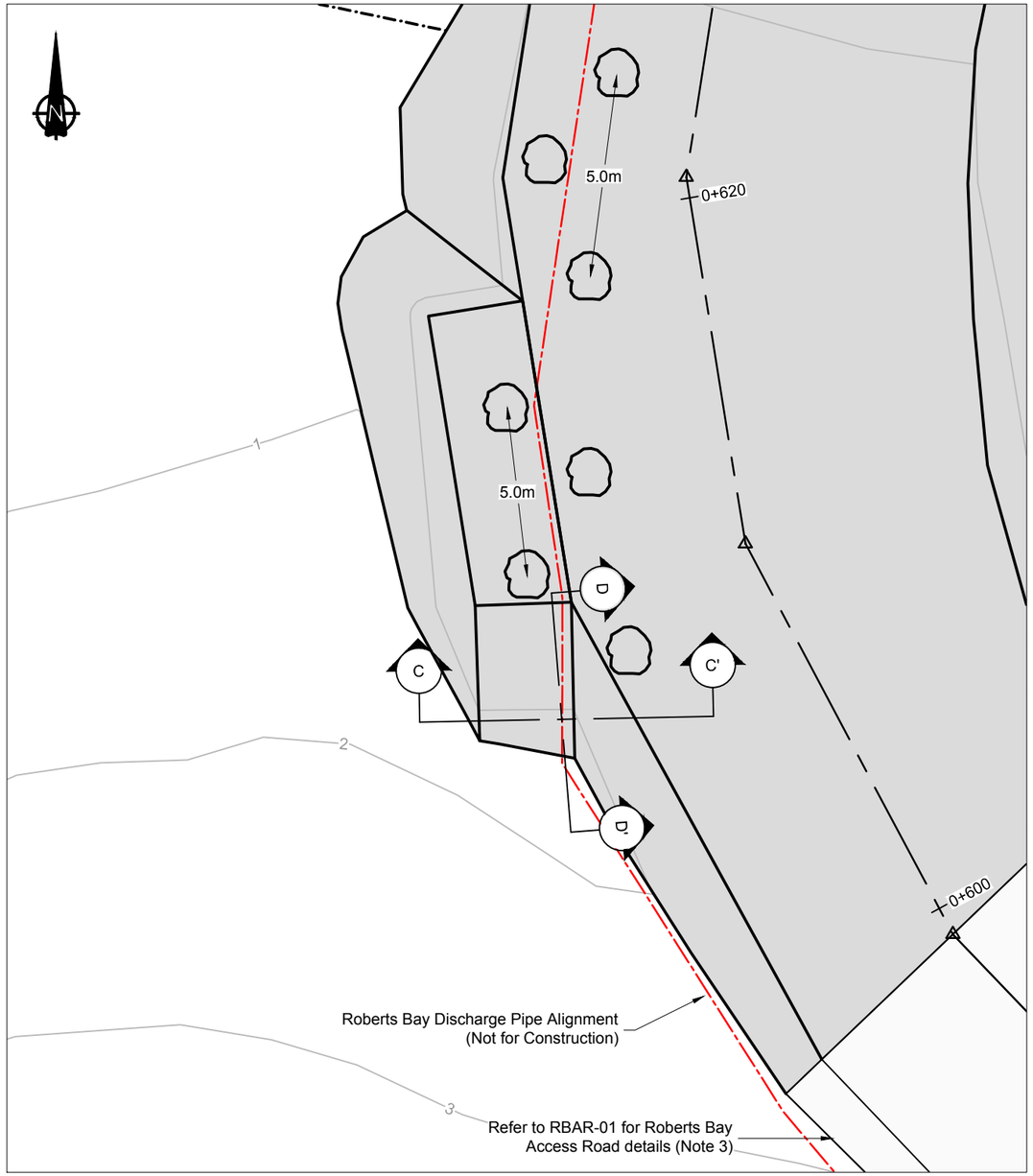
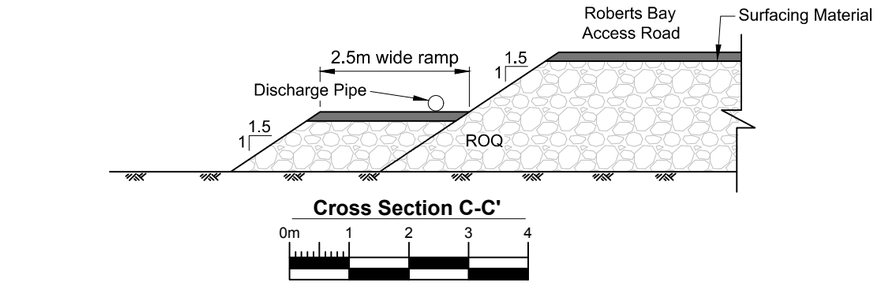


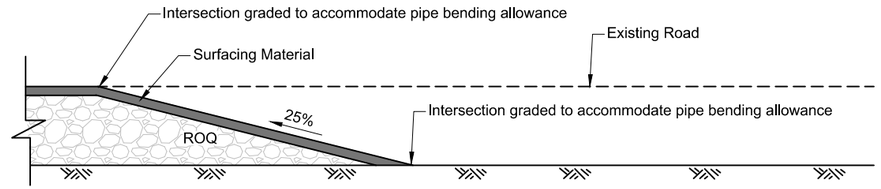
Marine Outfall Berm Pipe Ramp Location

0m 1 2 3 4 5 6



Cross Section C-C'

0m 1 2 3 4



Cross Section D-D'

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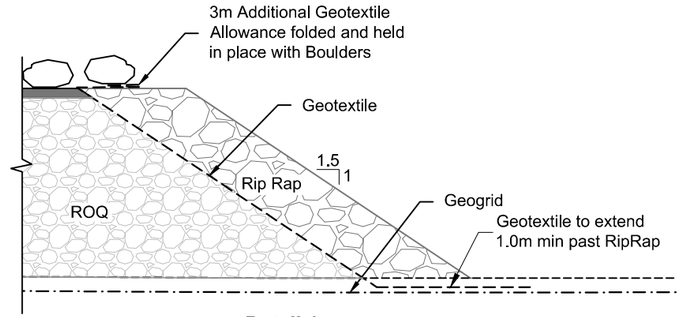

Detail 1

on Dwg. RMOB-02

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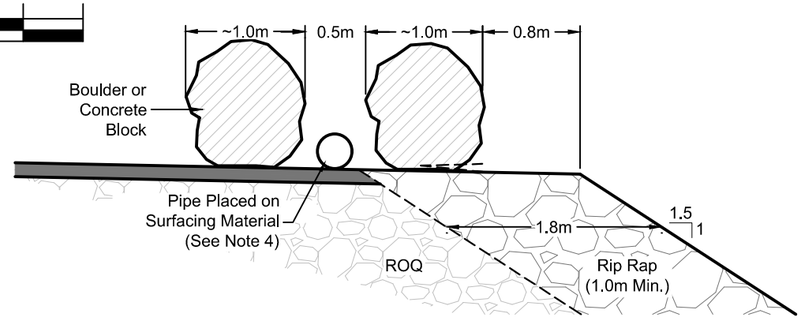

Pipe Restraint / Traffic Barriers

Not To Scale

LEGEND

- Discharge Pipeline
- Geotextile
- Geogrid.
- Road Centerline
- Topographic Contour
- Jetty Rip Rap Armour
- ROQ Material
- Surfacing Material
- Traffic Barrier

NOTES

1. All dimensions are in meters unless noted otherwise.
2. Contours shown at 1m interval, and are based on aerial photography.
3. For details on Roberts Bay Discharge System Access road from 0+000 to 0+600, refer to drawings RBAR-01 to 04.
4. Pipe restraints / traffic barriers to be located based on final pipe alignment.

DRAWING NO.	DRAWING TITLE
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REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	CH	--	18/05/02

REVISIONS

Original Drawings Stamped and Signed by Engineer

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DESIGN:	DRAWN:	REVIEWED:
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CHECKED:	APPROVED:	DATE:
		2018/05/10

FILE NAME: 1CT022.002_MOB.dwg

MAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.002

Roberts Bay Marine Outfall Berm

DRAWING TITLE: Pipe Ramp

DRAWING NO.	SHEET	REVISION NO.
RMOB-03	3 OF 5	0

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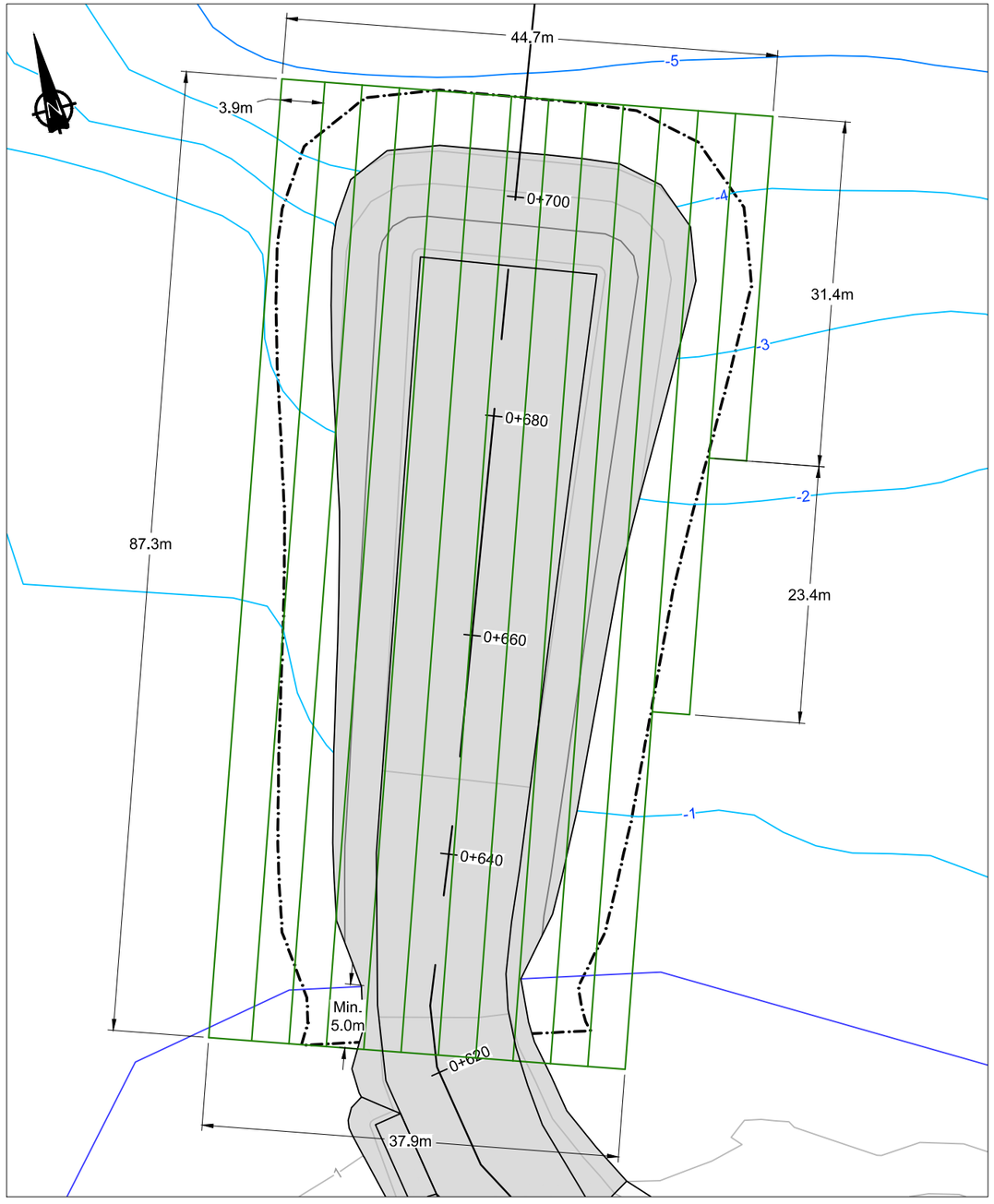

Geogrid Plan Layout

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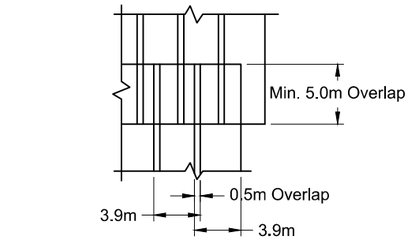
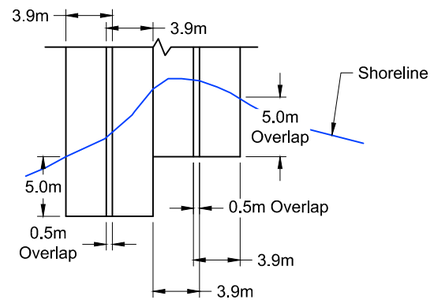


Typical Panel Tie-in

0m 5 10 15 20



Typical Panel End - Shoreline

0m 5 10 15 20

LEGEND

- Minimum Extent of Geogrid
- Geogrid Panel
- Bathymetric Contour
- Topographic Contour

NOTES

1. All dimensions are in meters unless noted otherwise.
2. Contours shown at 1m interval, and are based on aerial photography.
3. Geogrid panel placement will be Contractor's responsibility and must meet the Standards shown on this drawing. This drawing shows the panel layout proposed by SRK Consulting. Changes and layout deviation from this drawing must be approved by the Engineer prior to construction.
4. This layout assumes geogrid roll dimensions of 3.9m by 100.0m. Typical Panel Tie-in will be required if shorter geogrid rolls are ordered.
5. The setting out coordinates for the panel placements will be Contractor's responsibility and they must be approved by the Engineer prior to deployment.
6. The minimum longtitudinal overlap must be 0.5m and minimum transverse overlap must be 5m. More overlap may be required over the transverse joints toward deeper water to reinforce for strength as directed by the Engineer.
7. All joints will be permanently secured using heavy duty zip ties at a minimum spacing 1.0m. Heavy duty zip ties will have a minimum tensile strength of 175lbs, 641mm long, 8.6mm wide and 2.3mm thick.
8. Two layers of geogrids will be placed at all locations. The second layer of geogrid will be permanently secured to the first using heavy duty zip ties at a minimum 3.0m spacing in all directions.
9. The Contractor will provide methods for the Engineer to inspect and perform QA/QC on the work done in all parts of the Jetty.
10. The Contractor is responsible for silt and sediment control during the construction. The construction methods by the Contractor must comply with TMAC environmental policies and permits (refer to RMOB-2).

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
--	--						0	Issued for Construction	CH	--	18/05/10

Original Drawings Stamped and Signed by Engineer

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		2018/05/10

FILE NAME: 1CT022.002_MOB-Geogrid.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.002

Roberts Bay Marine Outfall Berm

DRAWING TITLE: Geogrid Layout Pattern

DRAWING NO.	SHEET	REVISION NO.
RMOB-04	4 OF 5	0

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Materials List and Quantity Estimates

Item	Quantity / Area / Volume		Description
1. Run of Quarry Material		ROQ (cu.m.)	Approximate In-Place Neat-line Volume (3D volume based on Civil 3D surfaces - no allowance has been made for losses and embedment) Access Road volume for 0+600 to 0+630 only.
	Roberts Bay Discharge Pipeline Access Road	470	
	Marine Outfall Berm	4,800	
	Pipe Ramp	35	
	Total	5,305	
2. Surface Grade Material		Surfacing Material (cu.m.)	Approximate In-Place Neat-line Volume Access Road volume for 0+600 to 0+630 only
	Roberts Bay Discharge Access Road	22	
	Marine Outfall Berm	150	
	Pipe Ramp	4	
	Total	176	
3. Rip Rap	Total	2,200 cu.m.	Based on Marine Outfall Berm Outer Surface 3D Area - no allowance has been made for losses and embedment.
4. Geogrid	Base of ROQ area	2,380sq.m.	Based on Marine Outfall Berm Footprint
	5m extension beyond ROQ toe	980 sq.m.	
	Total	3,360 sq.m.	
5. Geotextile	Total	1,215 sq.m.	Based on Marine Outfall Berm Outer Surface 3D Area

NOTES

1. All quantities are based on neat line Civil 3D surfaces and do not account for losses due to embedment and settlement. It is expected that there will significant settlement of the rockfill into the seabed and as such the required quantities will be significantly higher than those presented.

DRAWING NO.	DRAWING TITLE
- -	- -

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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REVISIONS

Original Drawings Stamped and Signed by Engineer

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CHECKED:	APPROVED:	DATE:
		2018/05/10

FILE NAME: 1CT022.002_MOB.dwg

MAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.002

Roberts Bay Marine Outfall Berm

DRAWING TITLE: Schedule of Quantities

DRAWING NO.	SHEET	REVISION NO.
RMOB-05	5 OF 5	0

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Attachment 3.2 Roberts Bay Marine Outfall Berm – As-built Drawings

Doris Project
As-Built Drawings for
Roberts Bay Marine Outfall Berm

Drawing Number	Drawing Title	Issue	Date	Revision	Old / Replaced Revisions
RMOB-01	General Arrangements	As-Built	February 13, 2019	AB	
RMOB-02	Plan and Profile	As-Built	February 13, 2019	AB	
RMOB-03	Pipe Ramp	As-Built	February 13, 2019	AB	
RMOB-04	Geogrid Layout Pattern	As-Built	February 13, 2019	AB	
RMOB-05	Schedule of Quantities	Issues for Construction	May 10, 2018	0	

SRK Job No. 1CT022.026

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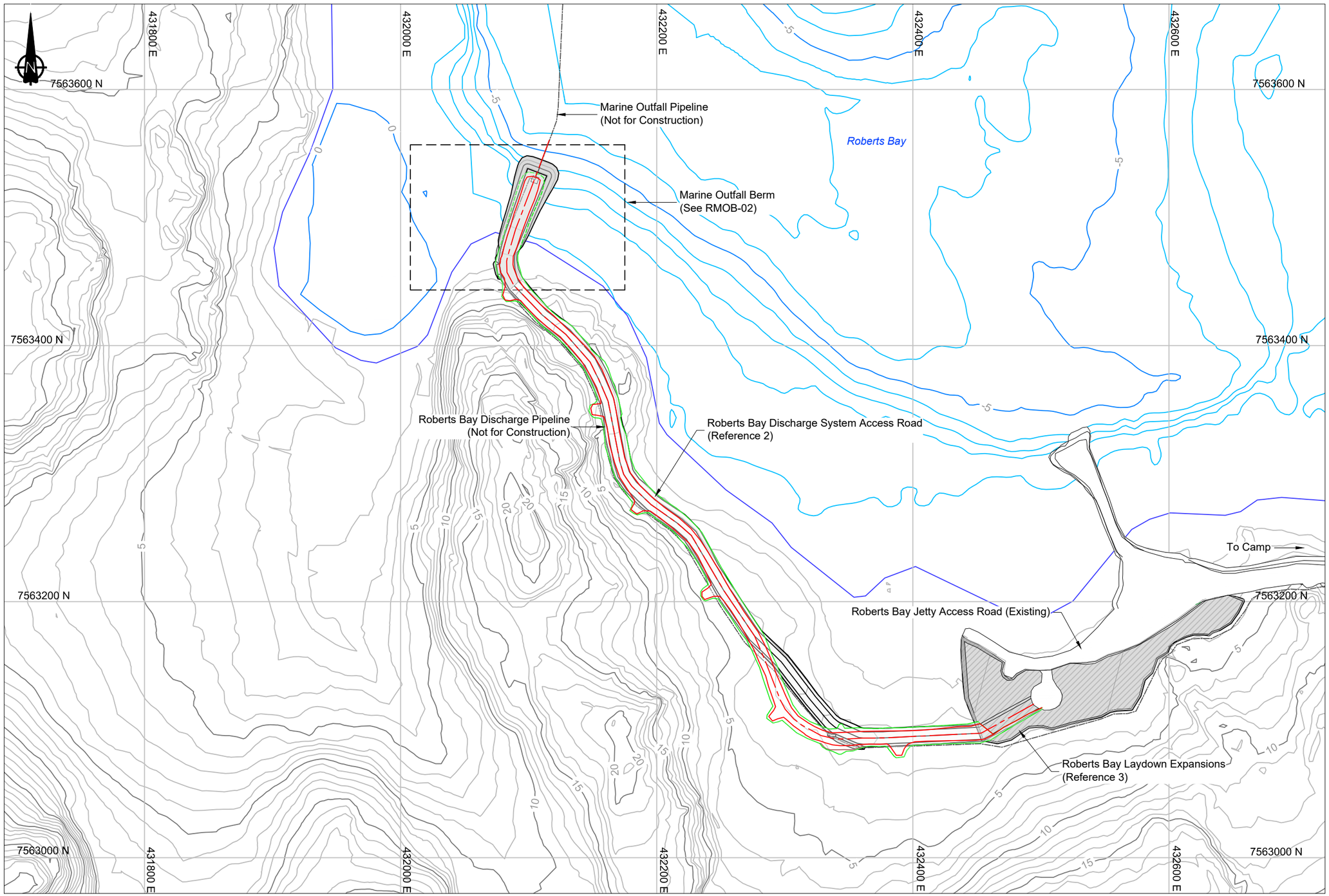

LEGEND

- As-Build Crest
- As-Build Toe
- As-Build Toe at Water Surface
- As-Built Center Line
- Bathymetric Contour
- Topographic Contour
- Discharge Pipeline

NOTES

1. All dimensions are in meters unless otherwise stated.
2. Contours shown at 1.0m intervals.
3. As-Built survey does not pick up toe below water surface.

REFERENCES

1. NAD83 UTM Zone 13.
2. SRK Consulting (Canada) Inc., 2018. As-Built Drawings for the Roberts Bay Discharge System Access Road. Doris Project, Nunavut, Canada. Drawings prepared for TMAC Resources. Project Number 1CT022.030 February, 2019.
3. SRK Consulting (Canada) Inc., 2011. Roberts Bay Laydown Expansions, Doris Project. Issued for Construction. Drawings Prepared for TMAC resources Inc. Projects Number 1CT022.030. December 13, 2018.
4. As-Built Survey provided by Sub-Arctic Geomatics Ltd. Survey Date: September 10, 2018.

DRAWING NO.	DRAWING TITLE
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REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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NO.	DESCRIPTION	CHK'D	APP'D	DATE
AB	As-Built	-	--	-
0	Issued for Construction	CH	--	18/05/10

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FILE NAME: 1CT022.002_MOB-GA.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.026

Roberts Bay Marine Outfall Berm

DRAWING TITLE:

General Arrangement

DRAWING NO.	SHEET	REVISION NO.
RMOB-01	1 OF 5	AB

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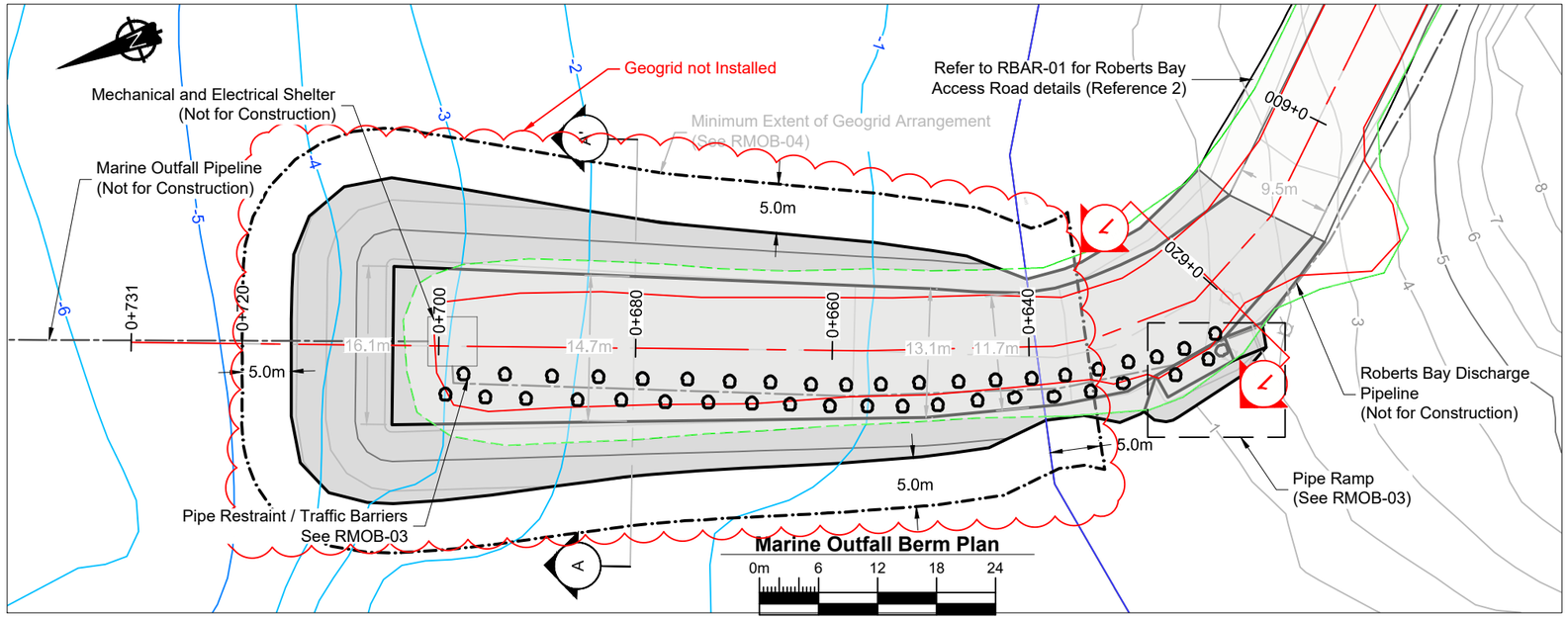
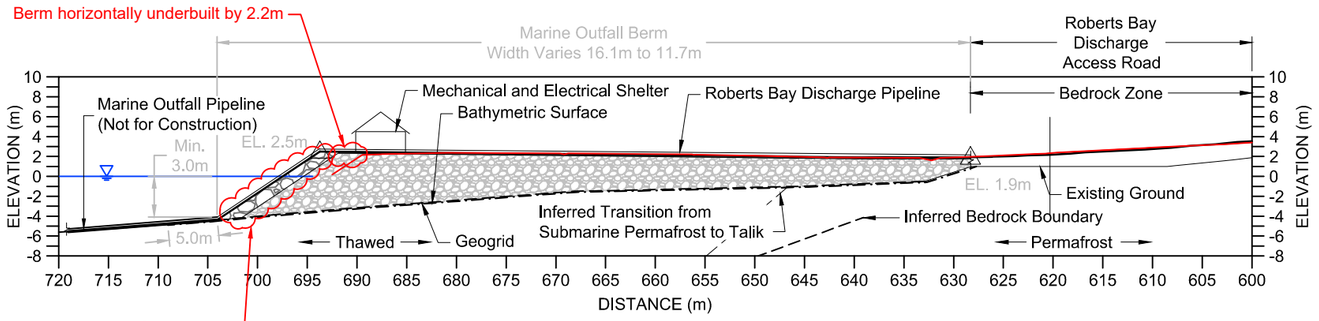
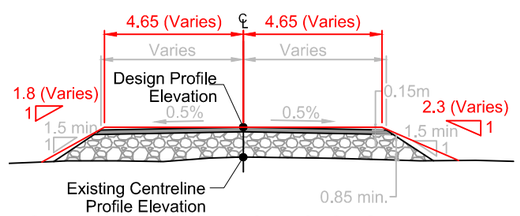




Marine Outfall Berm Profile

0m 6 12 18 24



1 TYPICAL ALL-WEATHER ROAD SECTION Fill Zone 1

0m 2 4 6 8

LEGEND

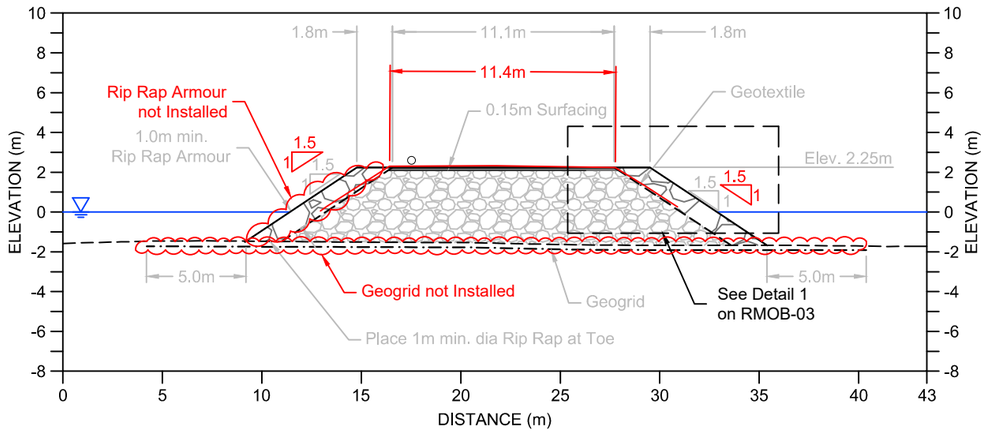
- Geotextile
- Design Centerline
- As-Built Centerline
- As-Built Crest
- As-Built Toe
- As-Built Toe at Water Surface
- Geogrid
- Bathymetric Contour
- Topographic Contour
- Discharge Pipeline
- Rip Rap Armour
- ROQ Material
- Surfacing Material
- Traffic Barrier

NOTES

1. All dimensions are in meters unless noted otherwise.
2. Contours shown at 1m interval, and are based on aerial photography.
3. For details on Roberts Bay Discharge System Access road from 0+000 to 0+600, refer to drawings RBAR-01 to 04.
4. It is the Contractor's responsibility to ensure that the geogrid is installed in advance of the construction fill being placed. The Contractor must submit a construction procedure to the Engineer for approval before commencing this work.
5. Significant settlement of placed ROQ into the sea bed is expected during placement, even with geogrid installation.
6. The Contractor is responsible for silt and sediment control during construction. The construction methods by the Contractor must comply with TMAC environmental policies and permits and in line with requirements specified in References 1, 3, and 4.
7. The design provided considers the likely settlement of the marine outfall berm, and is deliberately raised and graded to account for this settlement. The final design is to have a horizontal crest at 1.5m elevation with 9.5m width (excluding armoring). Future 'repair' work designs should reflect this final design and not this initial construction design.
8. As-Built survey does not pick up toe below water surface.

REFERENCES

1. TMAC Resources Inc. Amendment Application No. 1 of Project Certificate No. 003 and Water License 2AM-DOH1323 (TMAC 2015).
2. SRK Consulting (Canada) Inc., 2018. As-Built Drawings for the Roberts Bay Discharge System Access Road. Doris Project, Nunavut, Canada. Drawings prepared for TMAC Resources. Project number 1CT022.030. February, 2019.
3. Fisheries and Oceans Canada. Letter to TMAC Resources, Inc., ATTN: Mr. Roberts. Subject: Implementation of mitigation measures to avoid and mitigate serious harm to fish - Marine Outfall Berm - Project Certification No. 003 Amendment (Doris North Gold Mine Project). File 02-HCAA-CA7-0017. August 30, 2016.
4. Fisheries and Oceans Canada, Request for Review form, TMAC Resources Inc. Doris North Project - Marine Outfall Berm, Project Certificate No. 003 Amendment. Document name: 2AM-DOH1323 (TMAC 2015)



Cross Section A-A'

0m 3 6 9 12

NO.	DESCRIPTION	CHK'D	APP'D	DATE
AB	As-Built	-	-	-
0	Issued for Construction	CH	- -	18/05/16

REFERENCE DRAWINGS | REVISIONS

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TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.026

Roberts Bay Marine Outfall Berm

DRAWING TITLE: Plan and Profile

DRAWING NO. RMOB-02 | SHEET 2 OF 5 | REVISION NO. AB

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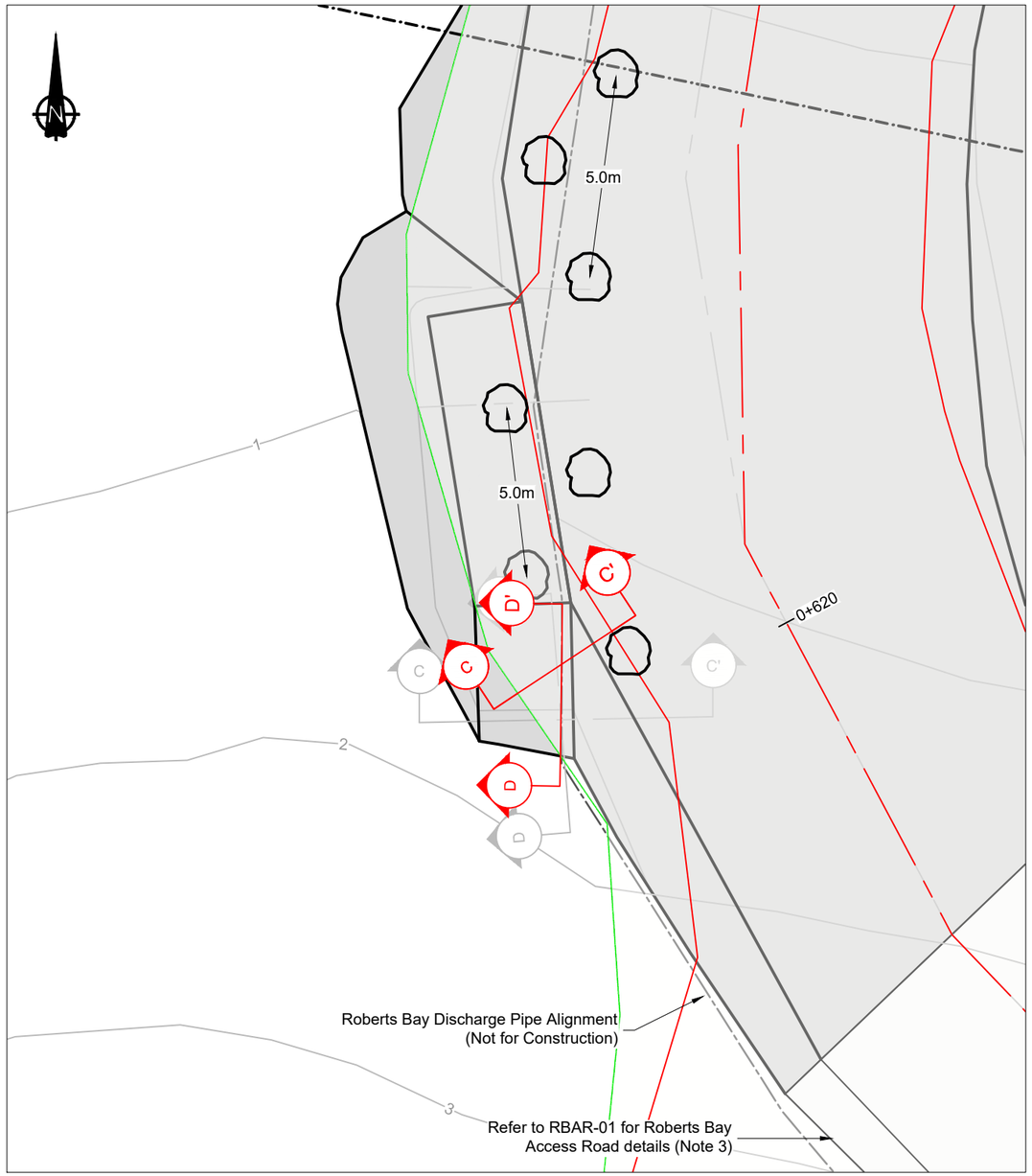
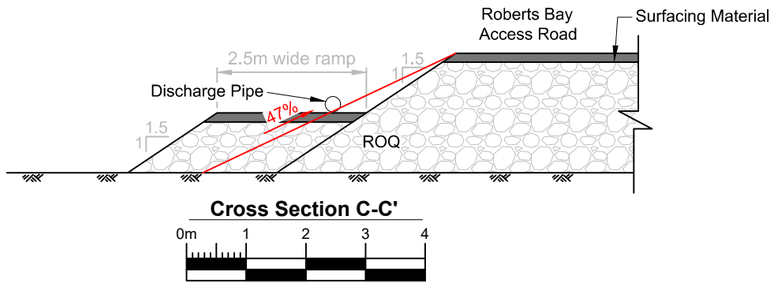


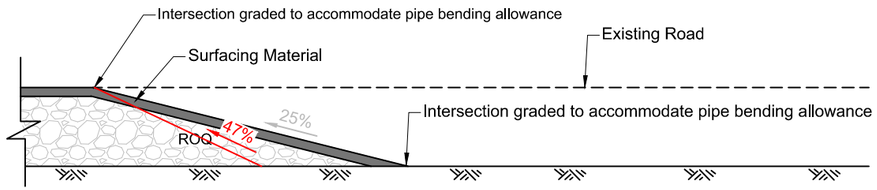
Marine Outfall Berm Pipe Ramp Location

0m 1 2 3 4 5 6



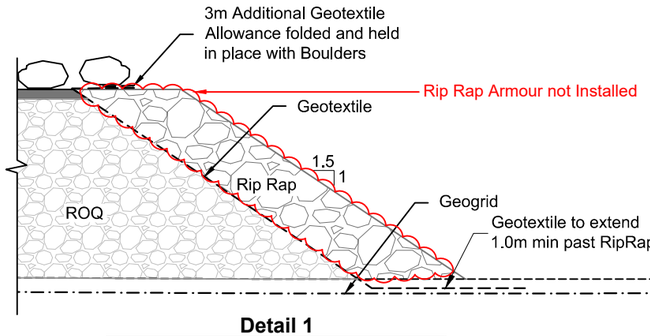
Cross Section C-C'

0m 1 2 3 4



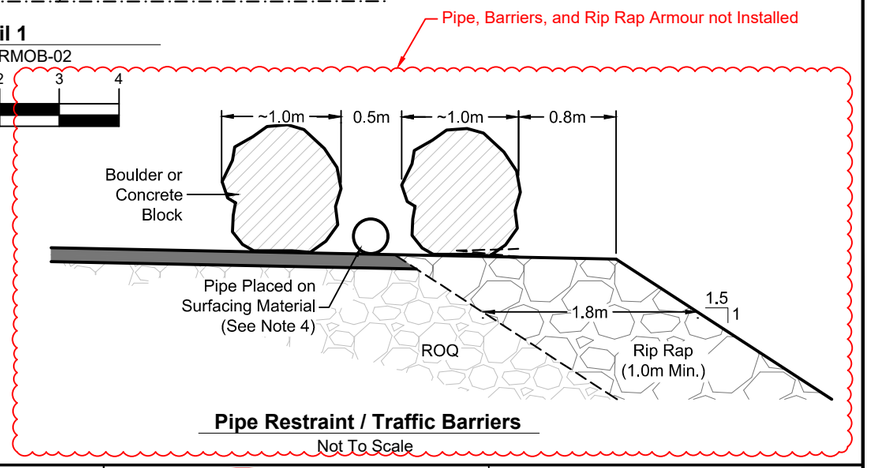
Cross Section D-D'

0m 1 2 3 4



Detail 1
on Dwg. RMOB-02

0m 1 2 3 4



Pipe Restraint / Traffic Barriers
Not To Scale

LEGEND

- As-Built Crest
- As-Built Toe
- As-Built Centerline
- Discharge Pipeline
- Geotextile
- Geogrid.
- Road Centerline
- Topographic Contour
- Jetty Rip Rap Armour
- ROQ Material
- Surfacing Material
- Traffic Barrier

NOTES

1. All dimensions are in meters unless noted otherwise.
2. Contours shown at 1m interval, and are based on aerial photography.
3. For details on Roberts Bay Discharge System Access road from 0+000 to 0+600, refer to drawings RBAR-01 to 04.
4. Pipe restraints / traffic barriers to be located based on final pipe alignment.

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
- -	- -	AB	As-Built	-	- -	-
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TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.026

Roberts Bay Marine Outfall Berm

DRAWING TITLE: Pipe Ramp

DRAWING NO.	SHEET	REVISION NO.
RMOB-03	3 OF 5	AB

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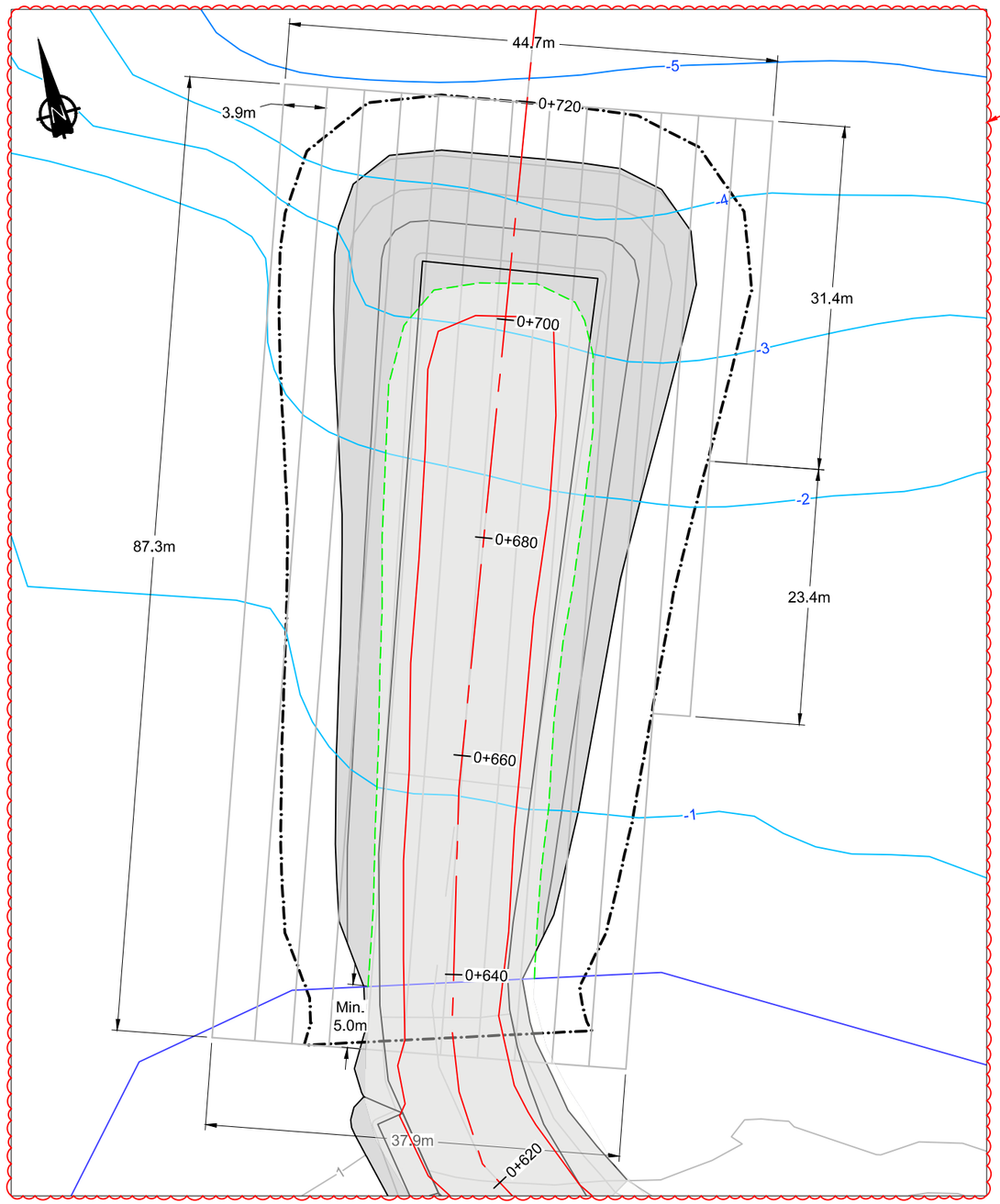
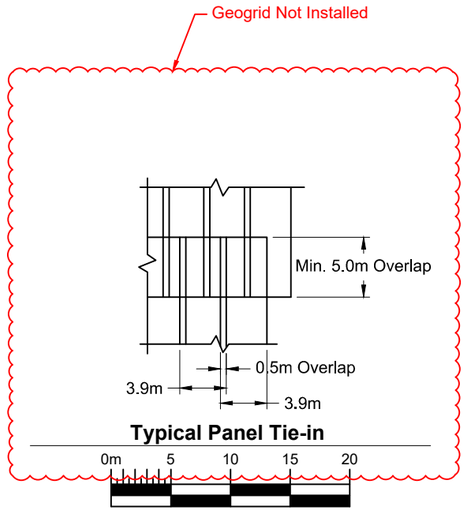


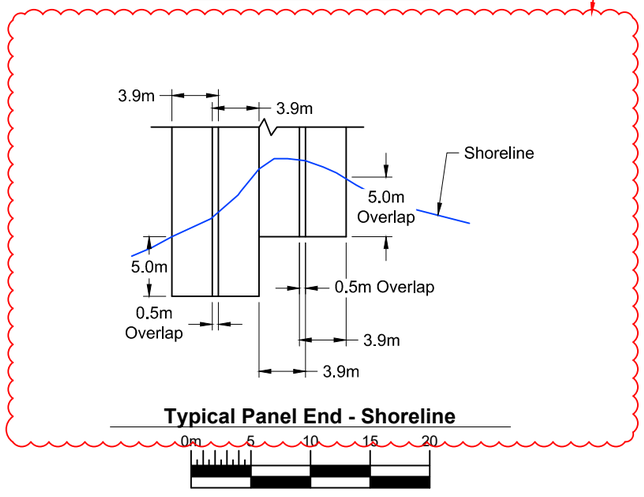
Geogrid Plan Layout

0m 5 10 15 20



Typical Panel Tie-in

0m 5 10 15 20



Typical Panel End - Shoreline

0m 5 10 15 20

LEGEND

- As-Built Crest
- As-Built Toe
- As-Built Toe at Water Surface
- As-Built Centerline
- Minimum Extent of Geogrid
- Geogrid Panel
- Bathymetric Contour
- Topographic Contour

NOTES

1. All dimensions are in meters unless noted otherwise.
2. Contours shown at 1m interval, and are based on aerial photography.
3. Geogrid panel placement will be Contractor's responsibility and must meet the Standards shown on this drawing. This drawing shows the panel layout proposed by SRK Consulting. Changes and layout deviation from this drawing must be approved by the Engineer prior to construction.
4. This layout assumes geogrid roll dimensions of 3.9m by 100.0m. Typical Panel Tie-in will be required if shorter geogrid rolls are ordered.
5. The setting out coordinates for the panel placements will be Contractor's responsibility and they must be approved by the Engineer prior to deployment.
6. The minimum longtitudinal overlap must be 0.5m and minimum transverse overlap must be 5m. More overlap may be required over the transverse joints toward deeper water to reinforce for strength as directed by the Engineer.
7. All joints will be permanently secured using heavy duty zip ties at a minimum spacing 1.0m. Heavy duty zip ties will have a minimum tensile strength of 175lbs, 641mm long, 8.6mm wide and 2.3mm thick.
8. Two layers of geogrids will be placed at all locations. The second layer of geogrid will be permanently secured to the first using heavy duty zip ties at a minimum 3.0m spacing in all directions.
9. The Contractor will provide methods for the Engineer to inspect and perform QA/QC on the work done in all parts of the Jetty.
10. The Contractor is responsible for silt and sediment control during the construction. The construction methods by the Contractor must comply with TMAC environmental policies and permits (refer to RMOB-2).
11. As-Built survey does not pick up toe below water surface.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
- -	- -						AB	As-Built	-	- -	-
							0	Issued for Construction	CH	- -	18/05/10

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		February 2019

FILE NAME: 1CT022.002_MOB-Geogrid.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.026

Roberts Bay Marine Outfall Berm

DRAWING TITLE: Geogrid Layout Pattern

DRAWING NO.	SHEET	REVISION NO.
RMOB-04	4 OF 5	AB

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Materials List and Quantity Estimates

Item	Quantity / Area / Volume		Description
1. Run of Quarry Material		ROQ (cu.m.)	Approximate In-Place Neat-line Volume (3D volume based on Civil 3D surfaces - no allowance has been made for losses and embedment) Access Road volume for 0+600 to 0+630 only.
	Roberts Bay Discharge Pipeline Access Road	470	
	Marine Outfall Berm	4,800	
	Pipe Ramp	35	
	Total	5,305	
2. Surface Grade Material		Surfacing Material (cu.m.)	Approximate In-Place Neat-line Volume Access Road volume for 0+600 to 0+630 only
	Roberts Bay Discharge Access Road	22	
	Marine Outfall Berm	150	
	Pipe Ramp	4	
	Total	176	
3. Rip Rap	Total	2,200 cu.m.	Based on Marine Outfall Berm Outer Surface 3D Area - no allowance has been made for losses and embedment.
4. Geogrid	Base of ROQ area	2,380sq.m.	Based on Marine Outfall Berm Footprint
	5m extension beyond ROQ toe	980 sq.m.	
	Total	3,360 sq.m.	
5. Geotextile	Total	1,215 sq.m.	Based on Marine Outfall Berm Outer Surface 3D Area

NOTES

1. All quantities are based on neat line Civil 3D surfaces and do not account for losses due to embedment and settlement. It is expected that there will significant settlement of the rockfill into the seabed and as such the required quantities will be significantly higher than those presented.

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MAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.026

Roberts Bay Marine Outfall Berm

DRAWING TITLE: Schedule of Quantities

DRAWING NO. RMOB-05 | SHEET 5 OF 5 | REVISION NO. 0

Attachment 4 – Doris Crown Pillar Recovery Trench Access Road

Attachment 4.1 Doris Crown Pillar Recovery Trench Access Road – IFC Drawings

Engineering Drawings for the
Doris Crown Pillar Trench Access Road
Hope Bay Project, Nunavut, Canada

Active Drawing Status

Drawing Number	Drawing Title	Issue	Date	Revision	Old Revision
TAR-01	General Arrangement	Issued for Construction	May 31, 2018	0	
TAR-02	Access Road Plan and Profile	Issued for Construction	May 31, 2018	0	
TAR-03	Access Road Typical Sections	Issued for Construction	May 31, 2018	0	

TMAC RESOURCES

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Project Number: 1CT022.030

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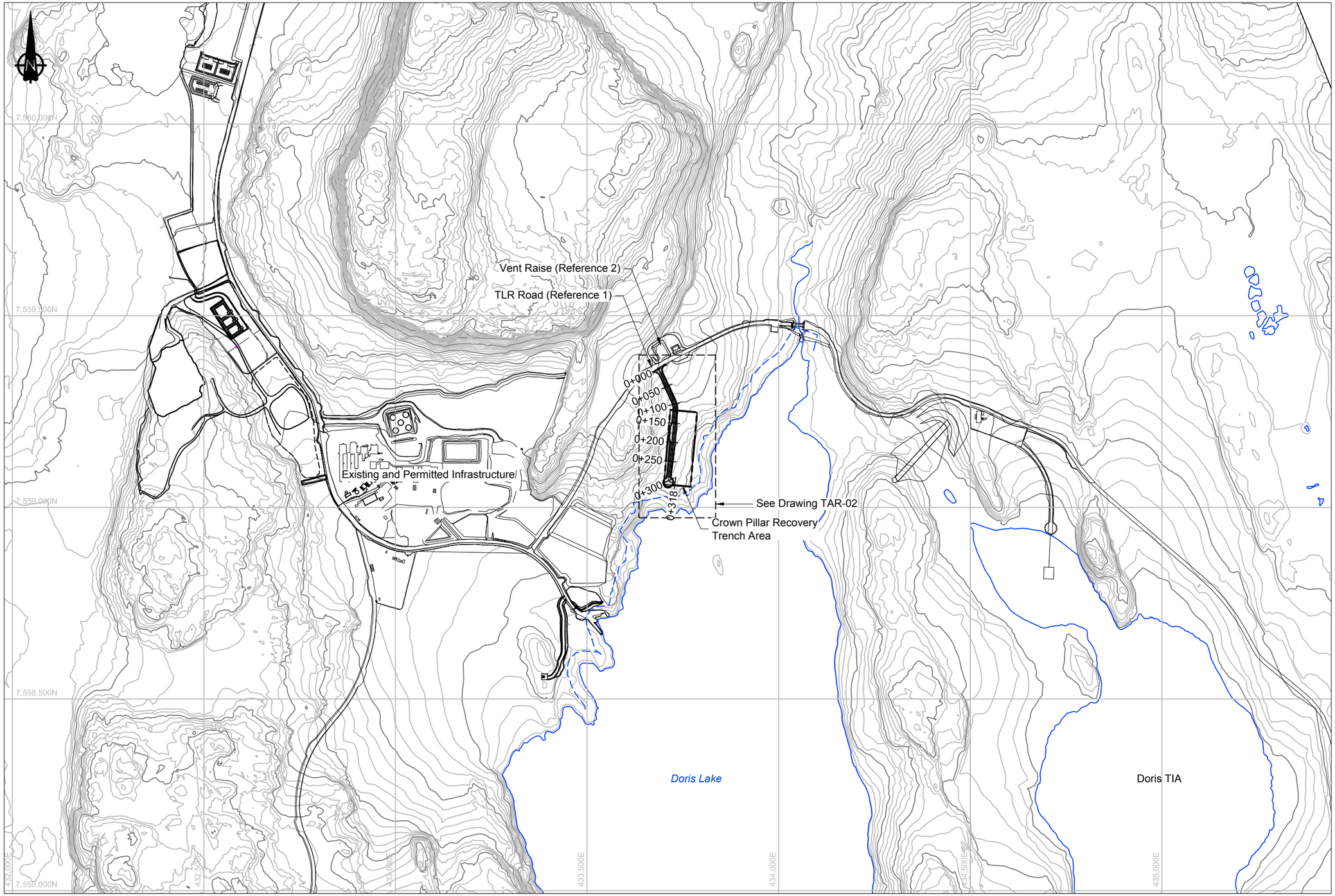

LEGEND

- Proposed Access Road
- 31m Water Body Offset

NOTES

1. Contours shown at 1.0m interval.
2. All dimensions shown are in meters unless noted otherwise.
3. Minimum fill thickness for Access Road and Turn Around is 1.0m.
4. Construction shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada.Revision H - Issued for Construction.
5. Profile based on available topography. Existing ground level to be surveyed prior to construction to confirm design thickness achieved.

REFERENCE

1. Engineering Drawings for the Doris North Secondary Road, Doris North Project, Nunavut, Canada. Project No.: 1CH008.033/058, 2011 As-built Revision AB, May 14, 2012. TL-RDS-00 / HB+T-CIV-CIV-OND-0001.
2. Engineering Drawings for the Doris North Primary Vent Raise Pad, Doris North Project, Nunavut, Canada. Project No.: 1CH008.033, ISSUED FOR CONSTRUCTION, 2011 AS-BUILT, May 4, 2012. ND-PVR-00 / HB+D-CIV-CIV-OND-0132.

DRAWING NO.	DRAWING TITLE
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REFERENCE DRAWINGS

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NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	CH	EMR	18/05/31
A	Issued for Discussion	CH	EMR	17/09/22

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TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.030

Doris Crown Pillar Trench Access Road

DRAWING TITLE:

General Arrangement

DRAWING NO.	SHEET	REVISION NO.
TAR-01	1 OF 3	0

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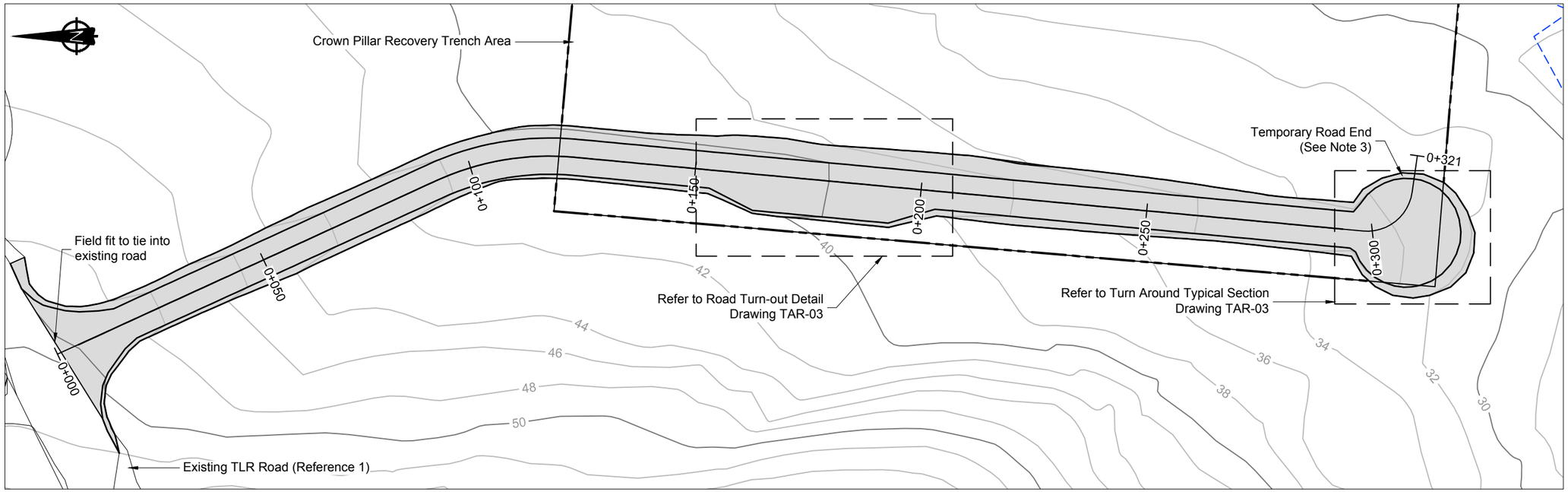
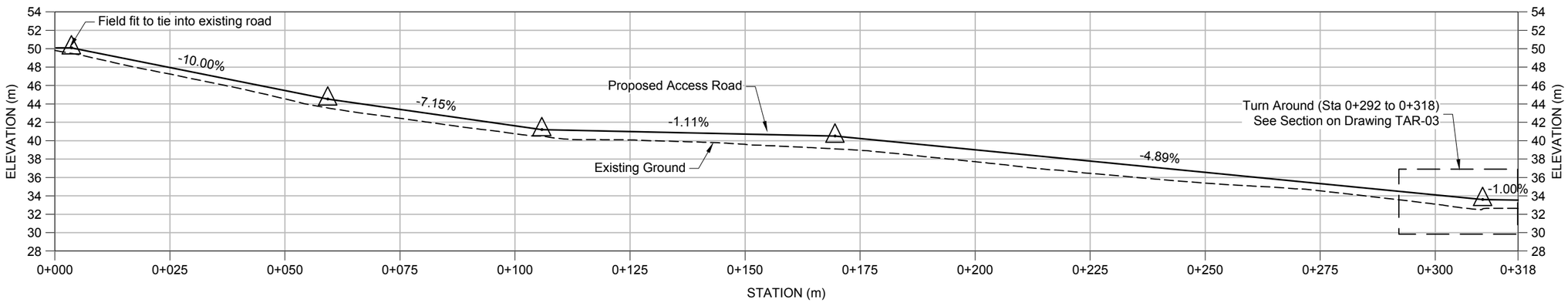


Access Road Plan

0m 10 20 30 40



Access Road Profile

Vertical 0m 5 10 15 20

Horizontal 0m 10 20 30 40

LEGEND

- Proposed Access Road
- Point of Inflection
- 31m Offset

NOTES

1. All dimensions shown are in meters unless noted otherwise.
2. Design assumes winter trench construction. Additional surface water and sediment management design is required for non-winter trench construction.
3. Temporary road end shown, ramp to be field fit to reach trench when trench designed / constructed.
4. An electronic design file will be provided to develop field set-out points.

REFERENCE

1. Engineering Drawings for the Doris North Secondary Road, Doris North Project, Nunavut, Canada. Project No.: 1CH008.033/058, 2011 As-built Revision AB, May 14, 2012. TL-RDS-00 / HB+T-CIV-CIV-OND-0001.

DRAWING NO.	DRAWING TITLE
-	-

REFERENCE DRAWINGS

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NO.	DESCRIPTION	CHK'D	APP'D	DATE
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A	Issued for Discussion	CH	EMR	17/09/22

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CH	EMR	2018/05/31

FILE NAME: 1CT022.030 - AR.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.030

Doris Crown Pillar Trench Access Road

DRAWING TITLE: Access Road Plan and Profile

DRAWING NO.	SHEET	REVISION NO.
TAR-02	2 OF 3	0

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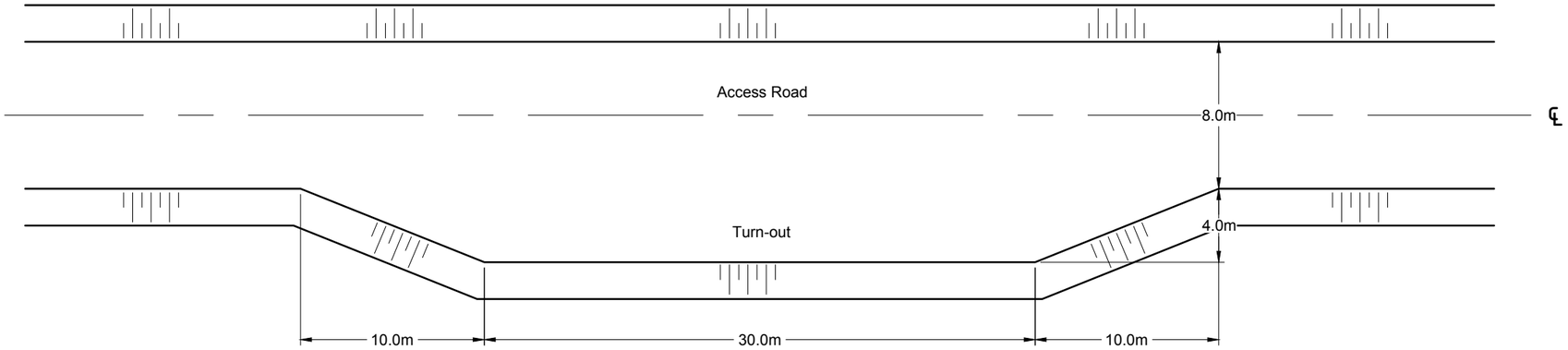


LEGEND

- Surfacing Material
- Run of Quarry Material

NOTES

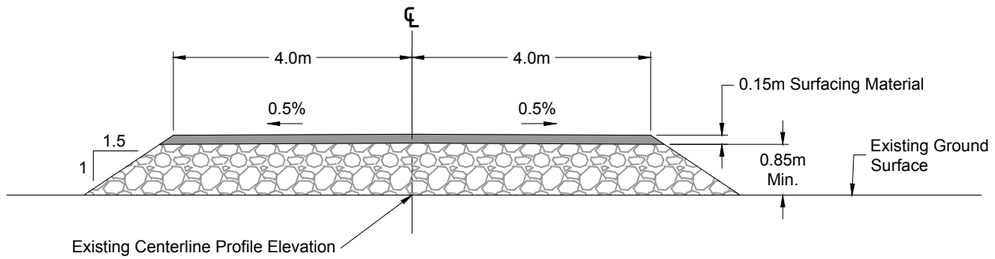
1. All dimensions shown are in meters unless noted otherwise.
2. Minimum design thickness must be maintained for all sections of the road, including turnouts.

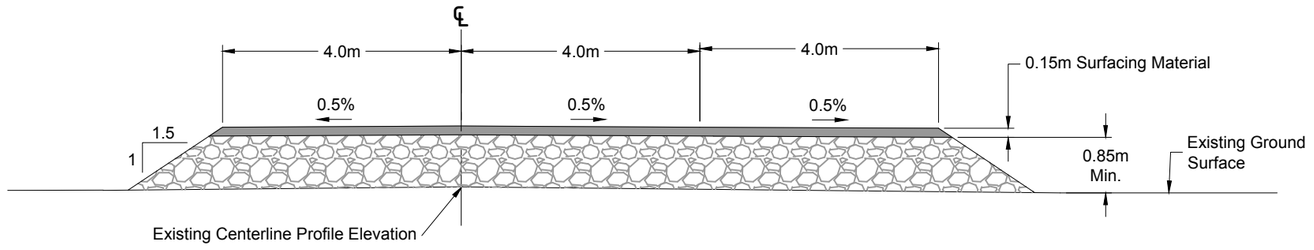
MATERIAL LIST AND QUANTITY ESTIMATES

Item	Volume	Description
Run of Quarry Material	3,500m³	Approximate In-Place Neat-Line Volume (3D volume based on Civil3D surfaces - no allowance has been made for losses and/or tundra embedment)
Surfacing Material	470m³	Approximate In-Place Neat-line Volume

Road Turn-out Detail

0m 3 6 9 12



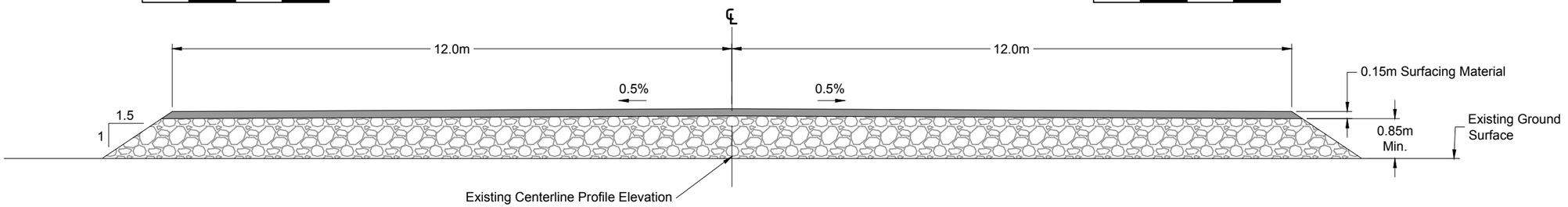


Typical Road Section

0m 1 2 3 4

Typical Road Turn-out Section

0m 1 2 3 4



Typical Turn Around Section

0m 1 2 3 4

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
REFERENCE DRAWINGS						

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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A	Issued for Discussion	CH	EMR	17/09/22
REVISIONS				

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TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.030

Doris Crown Pillar Trench Access Road

DRAWING TITLE:

Access Road
Typical Sections

DRAWING NO.	SHEET	REVISION NO.
TAR-03	3 OF 3	0

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Attachment 4.2 Doris Crown Pillar Recovery Trench Access Road – As-built Drawings

As-Built Drawings for the
Crown Pillar Trench Access Road
Hope Bay Project, Nunavut, Canada

Active Drawing Status

Drawing Number	Drawing Title	Issue	Date	Revision
TAR-01	General Arrangement	As-Built	February 19, 2019	AB
TAR-02	Access Road Plan and Profile	As-Built	February 19, 2019	AB
TAR-03	Access Road Typical Sections	As-Built	February 19, 2019	AB

TMAC RESOURCES

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Project Number: 1CT022.015

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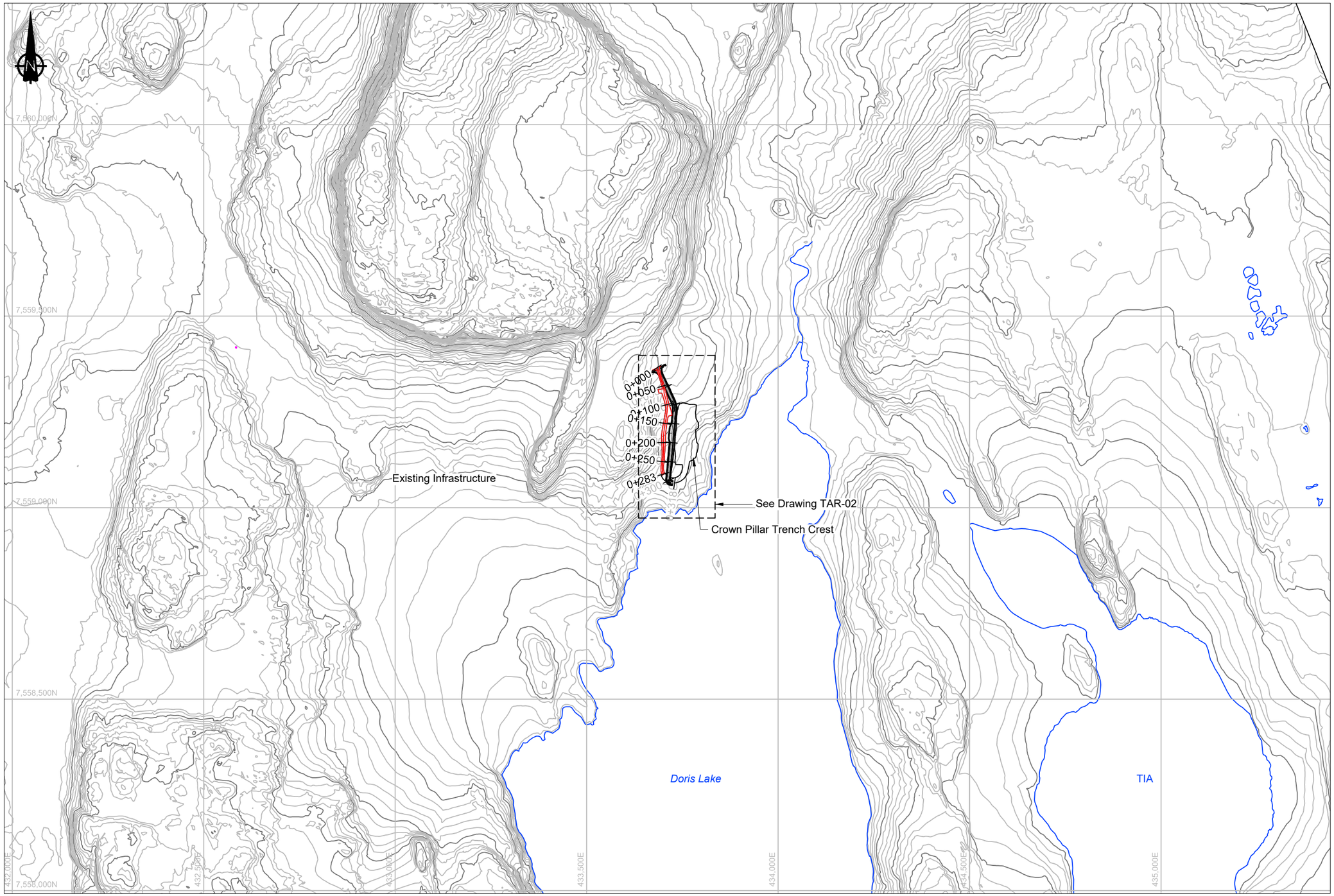

LEGEND

- As-Built Crest
- As-Built Centerline
- Design Centerline
- Major Contour
- Minor Contour
- Proposed Access Road

NOTES

1. All dimensions shown are in meters unless noted otherwise.

REFERENCE

1. As-Built Survey provided by Sub-Arctic Geomatics Ltd. Survey Date: January 18, 2018. Only crest survey points provided as toe was snow covered at time of survey.

P:\01_SITES\Hope Bay\ACAD\As-Builts\2018 Construction Summary Report\Crown Pillar Trench AR\1CT022.015 - AR.dwg

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							AB	As-Built			
		-	-				A	Issued for Discussion	CH		17/09/22

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

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CHECKED:	APPROVED:	DATE:
CH	EMR	February 2019

FILE NAME: 1CT022.015 - AR.dwg

TMAC RESOURCES

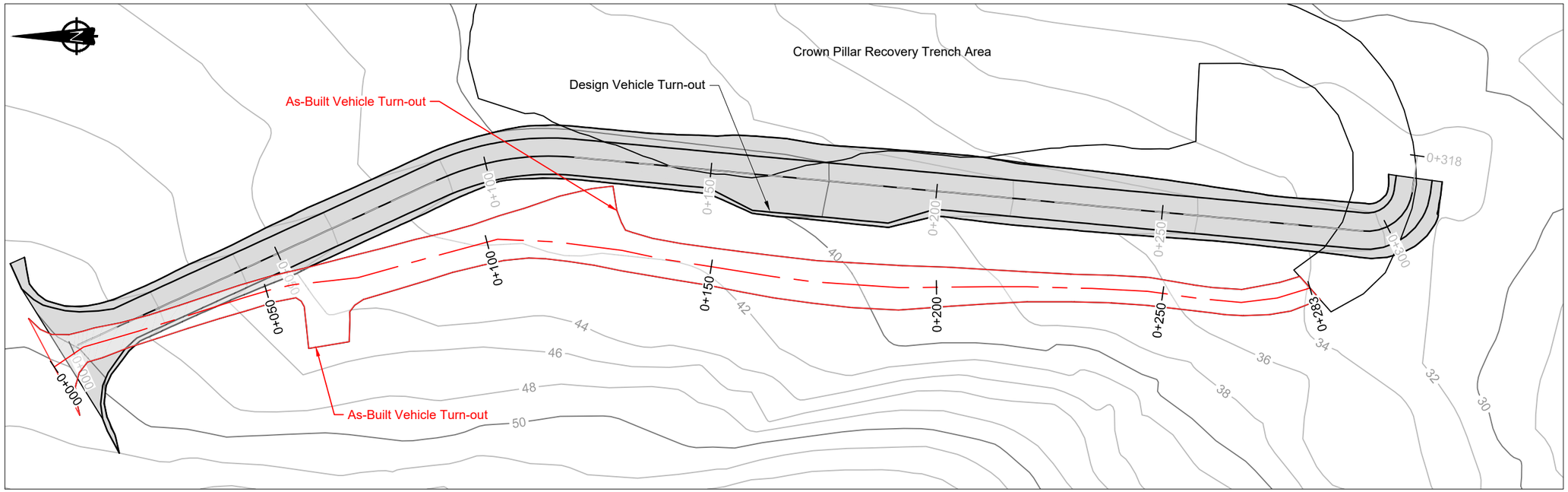
Hope Bay Project

SRK JOB NO.: 1CT022.015

Crown Pillar Trench Access Road

DRAWING TITLE: General Arrangement

DRAWING NO.	SHEET	REVISION NO.
TAR-01	1 OF 3	AB



LEGEND

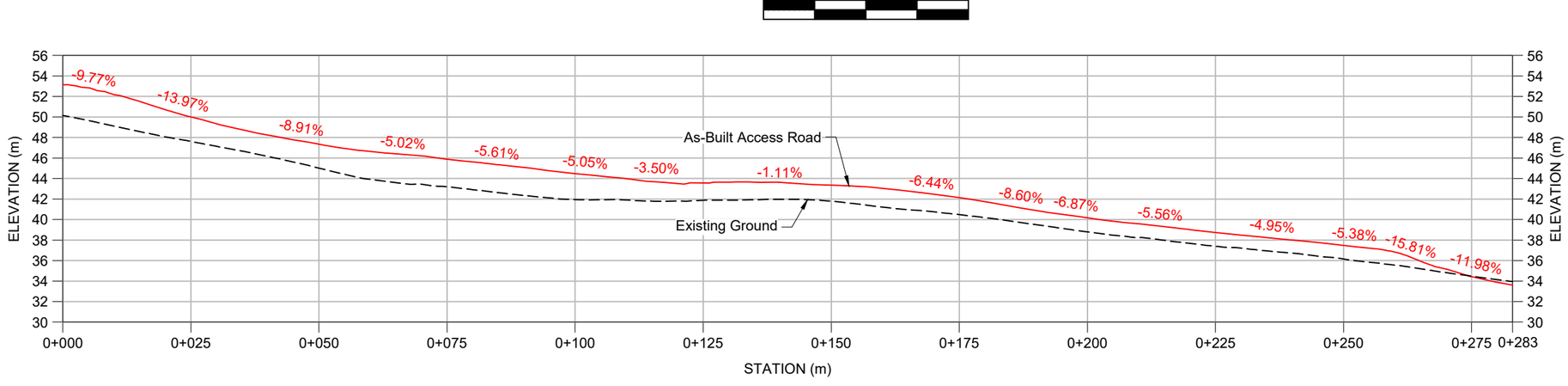
- As-Built Crest
- As Built Centerline
- Design Centerline
- Proposed Access Road
- Point of Inflection

NOTES

1. All dimensions shown are in meters unless noted otherwise.

Access Road Plan

0m 10 20 30 40



Access Road Profile

Vertical: 0m 5 10 15 20

Horizontal: 0m 10 20 30 40

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-	-	-			
		AB	As-Built			
		A	Issued for Discussion	CH		17/09/22

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CH	EMR	February 2019

FILE NAME: 1CT022.015 - AR.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.015

Crown Pillar Trench Access Road

DRAWING TITLE: Access Road Plan and Profile

DRAWING NO. TAR-02 | SHEET 2 OF 3 | REVISION NO. AB

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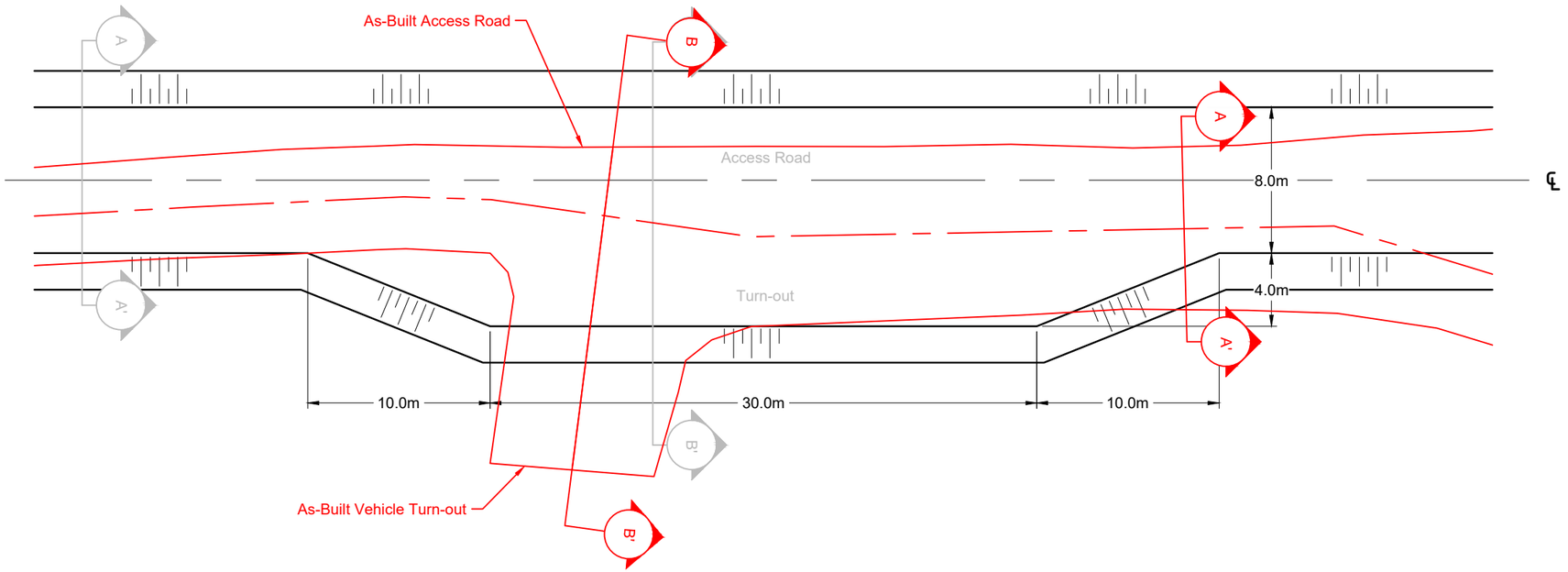


Typical Road Turn-out Section

0m 3 6 9 12

LEGEND

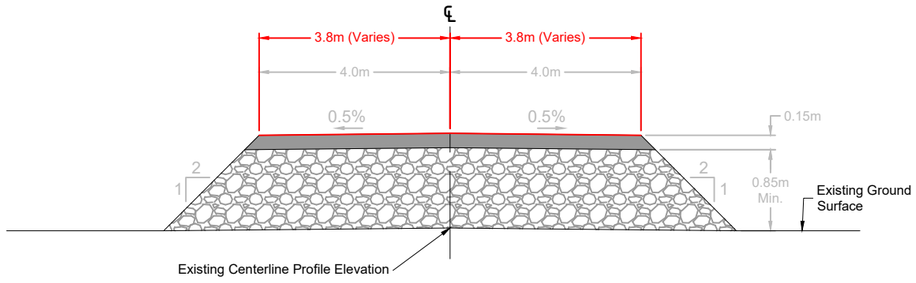
- As-Built Crest
- As Built Centerline
- Surfacing Material
- Run of Quarry Material

NOTES

1. All dimensions shown are in meters unless noted otherwise.
2. Minimum design thickness must be maintained for all sections of the road, including turnouts.

MATERIAL LIST AND QUANTITY ESTIMATES

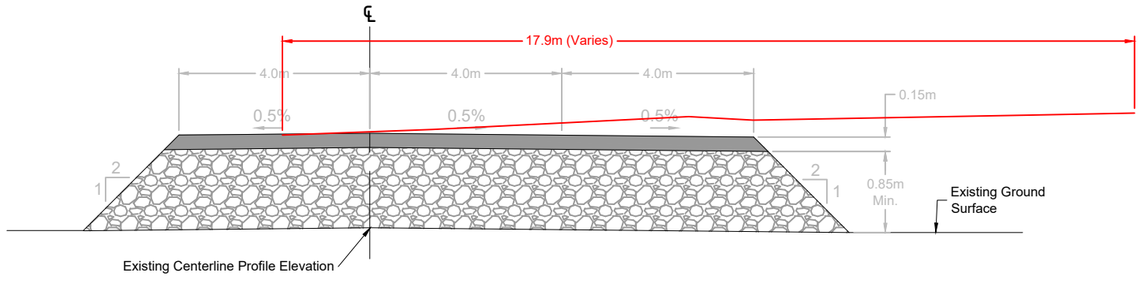
Item	Volume	Description
Run of Quarry Material	3050m³	Approximate In-Place Neat-Line Volume (3D volume based on Civil3D surfaces - no allowance has been made for losses and/or tundra embedment)
Surfacing Material	420m³	Approximate In-Place Neat-line Volume



A Typical Road Section

2X Vertical Exaggeration

0m 1 2 3 4 5



B Typical Road Turn-out Section

2X Vertical Exaggeration

0m 1 2 3 4 5

DRAWING NO.	DRAWING TITLE
-	-

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			

NO.	DESCRIPTION	CHK'D	APP'D	DATE
AB	As-Built			
A	Issued for Discussion	CH		17/09/22

REVISIONS

Original Drawings Stamped and Signed by Engineer

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CH	EMR	February 2019

FILE NAME: 1CT022.015 - AR.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.015

Crown Pillar Trench Access Road

DRAWING TITLE: Access Road Typical Sections

DRAWING NO.	SHEET	REVISION NO.
TAR-03	3 OF 3	AB

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Attachment 5 – Doris Connector Vent Raise Access Road

Attachment 5.1 Doris Connector Vent Raise Access Road – IFC Drawings

Engineering Drawings for the Doris Connector Vent Raise Access Road, Doris North Project, Nunavut, Canada

ACTIVE DRAWING STATUS

DWG NUMBER	DRAWING TITLE	REVISION	DATE	STATUS
DCVR-00	Engineering Drawings for the Doris Connector Vent Raise Access Road, Doris North Project, Nunavut, Canada	0	Aug 08, 2018	Issued For Construction
DCVR-01	General Arrangement	0	Aug 08, 2018	Issued For Construction
DCVR-02	Doris Connector Vent Raise Access Road Plan and Profile	0	Aug 08, 2018	Issued For Construction
DCVR-03	Culvert Design	0	Aug 08, 2018	Issued For Construction
DCVR-04	Typical Sections and Details	0	Aug 08, 2018	Issued For Construction
DCVR-05	Material List and Quantity Estimates	0	Aug 08, 2018	Issued For Construction

MAC RESOURCES

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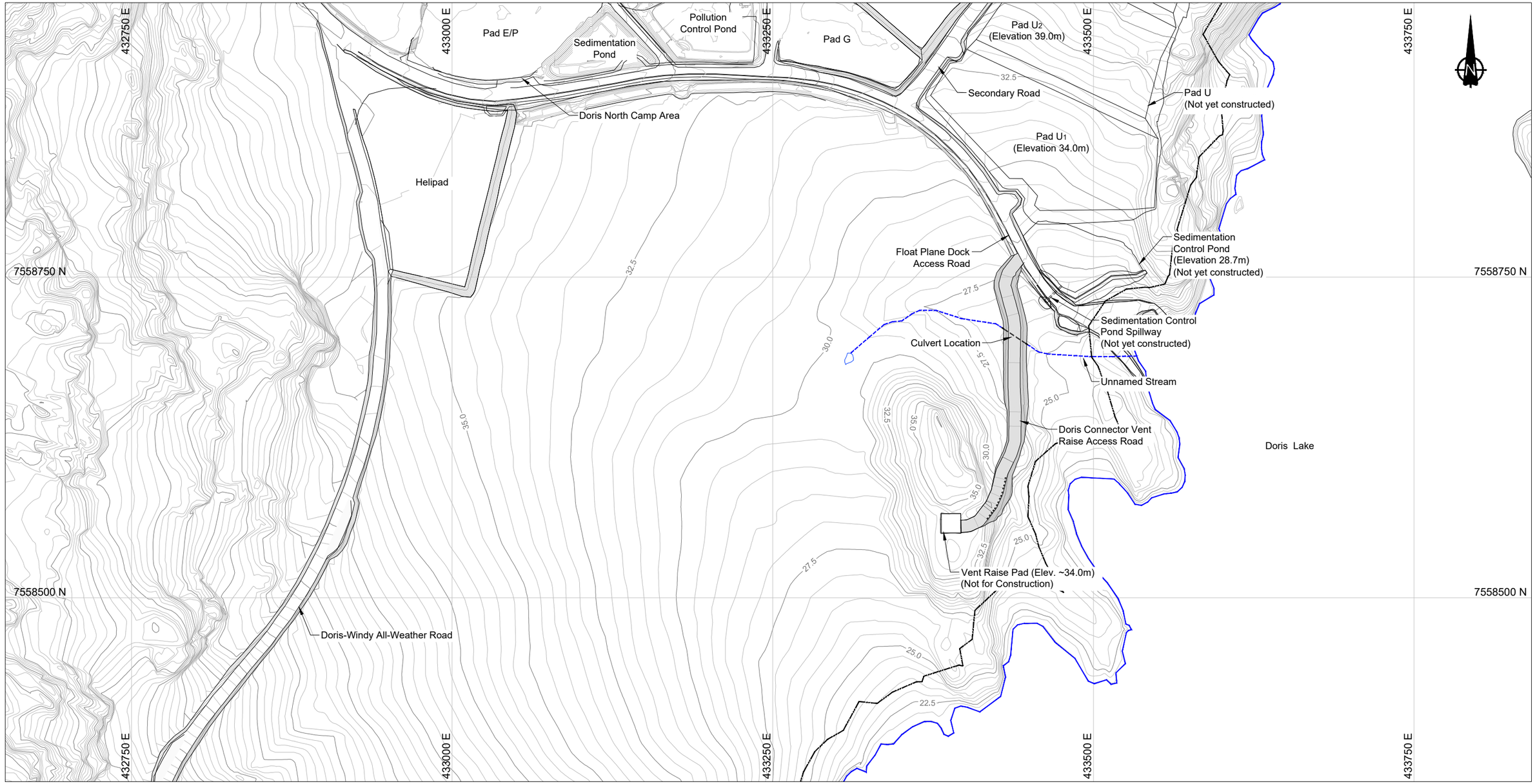
PROJECT NO: 1CT022.030
Revision 0
August 8, 2018
Drawing DCVR-00



NOTES

1. Topographic contour data for the terrain model were provided by Hope Bay Mining, and is based on 2007 Aerial Photography. Contour intervals are 0.5m.
2. The co-ordinate system is UTM NAD 83, Zone 13.
3. All dimensions are in metric units, unless specifically mentioned.
4. Notes in this drawing apply to all other active drawings.
5. See DCVR-04 and DCVR-05 for additional notes.

LEGEND

- Doris Connector Vent Raise Access Road
- 31m Lake Setback
- Approx. Unnamed Stream Alignment
- Lake Shoreline

0 10 20 30 40 50
Scale in Metres

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	CH	EMR	08Aug18

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CHECKED:	APPROVED:	DATE:
CH	EMR	August 8, 2018

FILE NAME: 1CT022.030_Doris Vent Raise_Rev0.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.030

Doris Connector Vent Raise Access Road

DRAWING TITLE:

General Arrangement

DRAWING NO.	SHEET	REVISION NO.
DCVR-01	2 OF 6	0

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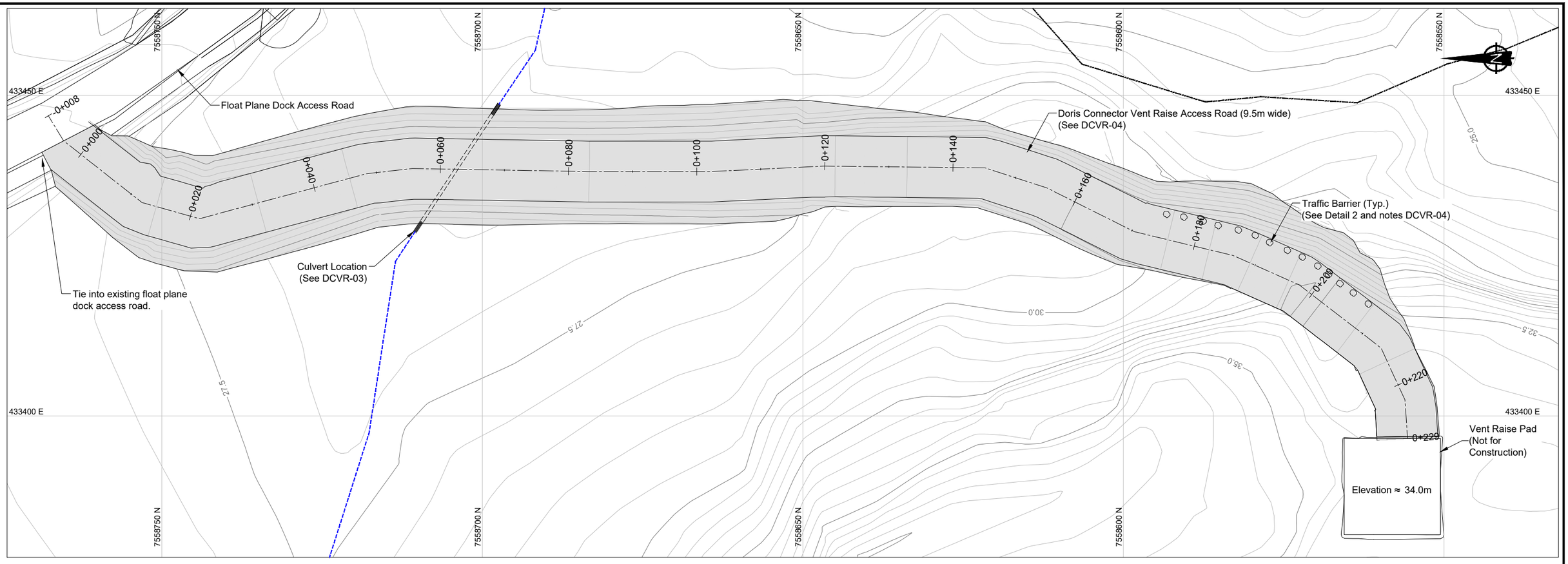
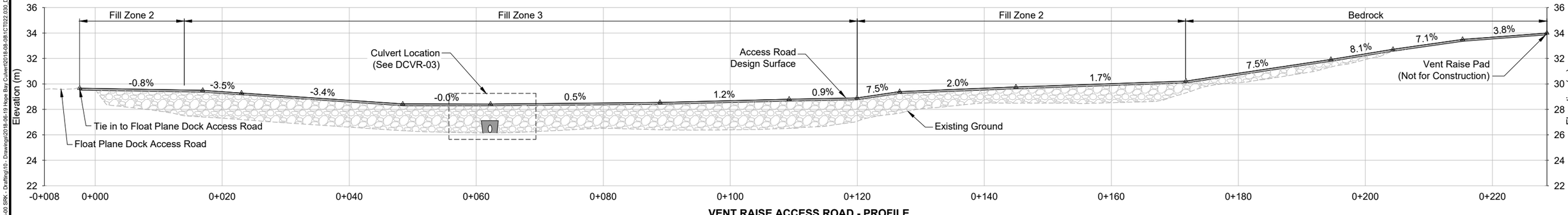


VENT RAISE ACCESS ROAD - PLAN VIEW

0 5 10 15
Scale in Metres



VENT RAISE ACCESS ROAD - PROFILE

0 5 10 15
Horizontal Scale in Metres
Vertical Exaggeration 3X

LEGEND

- Surfacing Material
- Run of Quarry Material
- Existing ground surface
- Approx. Unnamed Stream Alignment
- Bedding Material
- 31m Lake Setback

NOTES - GENERAL

1. Profile based on available topography. Existing ground level to be surveyed prior to construction to confirm design thickness achieved.
2. See DCVR-04 and DCVR-05 for additional notes.

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	CH	EMR	02Aug18

REVISIONS

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CH	EMR	August 2, 2018

FILE NAME: 1CT022.030_Doris Vent Raise_Rev0.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.030

Doris Connector Vent Raise Access Road

DRAWING TITLE:

Doris Connector Vent Raise Plan and Profile

DRAWING NO.	SHEET	REVISION NO.
DCVR-02	3 OF 6	0

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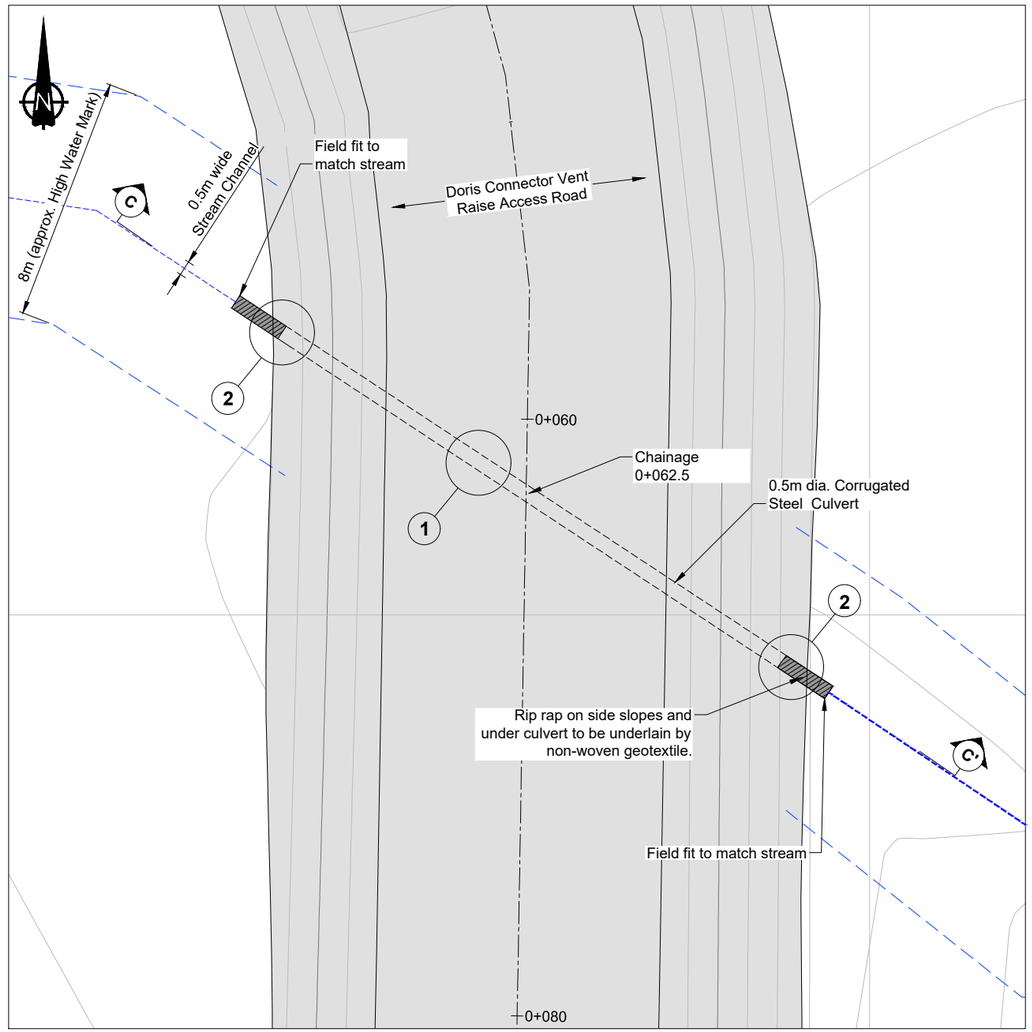
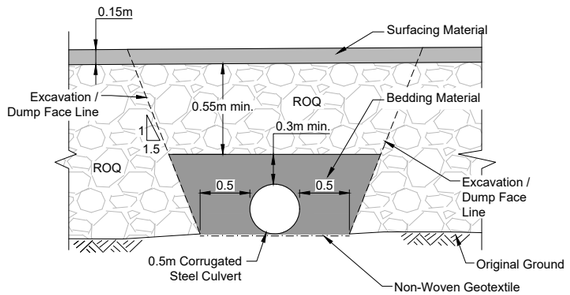
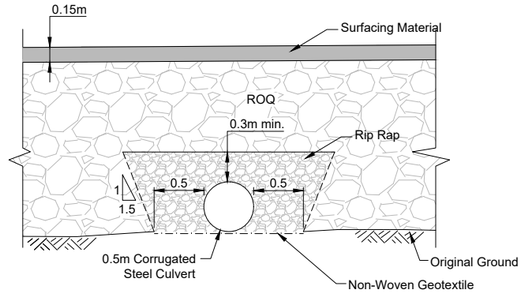


DORIS CONNECTOR VENT RAISE ACCESS ROAD CULVERT LOCATION

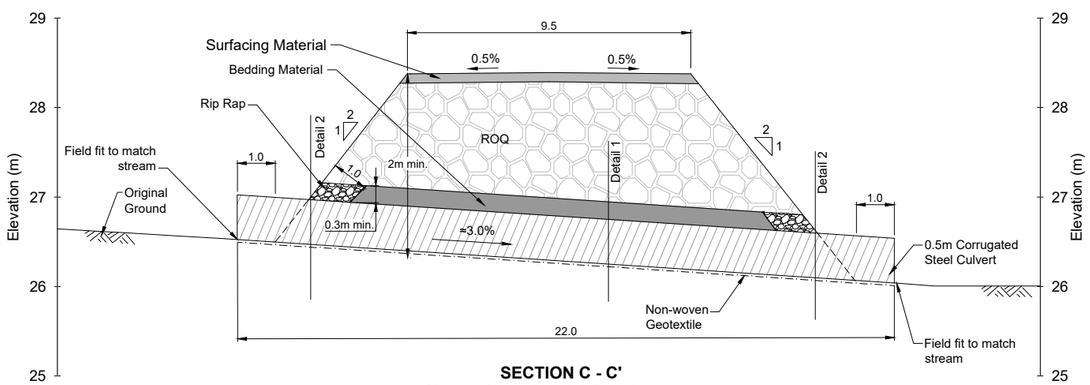
0 1 2 3 4 5
Scale in Metres



DETAIL 1
TYPICAL CROSS SECTION OF CULVERT CROSSING
1 NOT TO SCALE



DETAIL 2
TYPICAL CROSS SECTION OF CULVERT INLET/OUTLET
2 NOT TO SCALE



SECTION C - C'
CULVERT PROFILE
C
0 1 2 3 4 5
Horizontal Scale in Metres
Vertical Exaggeration X3

LEGEND

- Surfacing Material
- Bedding Material
- Run of Quarry Material
- Rip Rap, D_{50} = 0.15m
- Original Ground
- Non-woven Geotextile
- Road Centerline
- 3.0 Major Contour
- Minor Contour
- Approx. High Water Mark
- Approx. Unnamed Stream Alignment

NOTES

1. All dimensions are in metric units, unless otherwise noted.
2. Installation of the corrugated steel culvert will follow the manufacturers assembly and installation guide.
3. Total depth of cover above culvert, including bedding material, surfacing material and ROQ, will be 1.0 m minimum.
4. Topographic contour data for the terrain model were provided by Hope Bay Mining Ltd, and is based on 2007 Aerial Photography. Contour intervals are 0.5 m.
5. Coordinate system is UTM Zone 13, datum NAD83.
6. Culvert alignment will be field fit to match stream alignment.
7. Additional notes located on DCVR-05

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE
REFERENCE DRAWINGS			

NO.	DESCRIPTION	CH'K'D	APP'D	DATE
0	Issued for Construction	CH	EMR	08Aug18
REVISIONS				

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CH	EMR	August 8, 2018

FILE NAME: 1CT022.030_Doris Vent Raise_Rev0.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.030

Doris Connector Vent Raise Access Road

DRAWING TITLE:

Culvert Design

DRAWING NO.	SHEET	REVISION NO.
DCVR-03	4 OF 6	0

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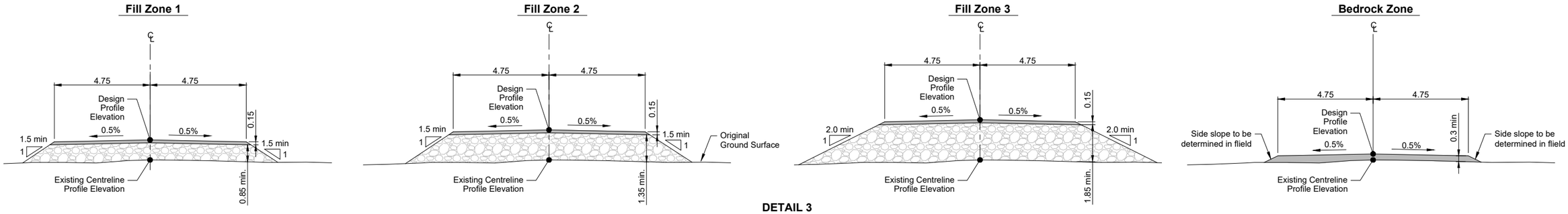
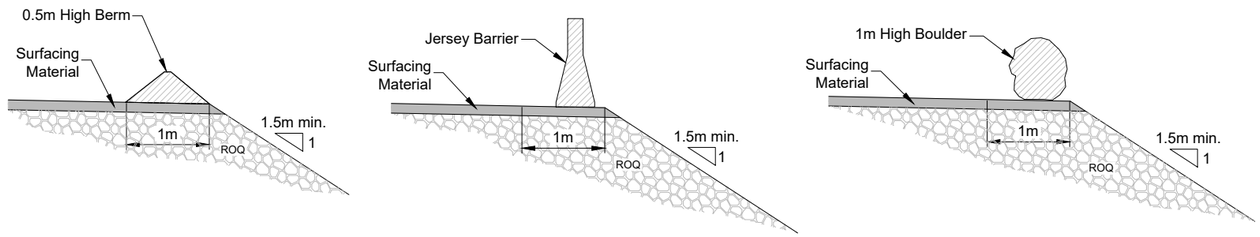


DETAIL 3
TYPICAL ROAD SECTION
3
0 1 2 3 4 5
Scale in Metres



DETAIL 4
TYPICAL BERM BARRIER OPTIONS
4
NTS

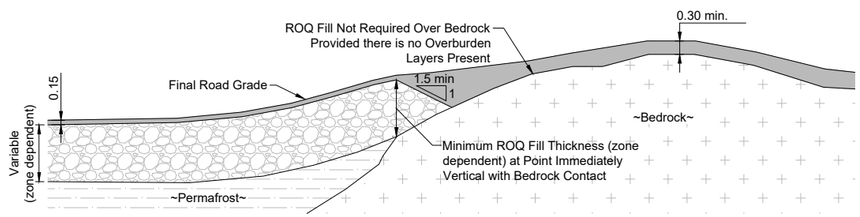
LEGEND

- Surfacing Material
- Run of Quarry Material

NOTES

1. All dimensions in metres unless noted otherwise.
2. Minimum design thickness must be maintained for all sections of the road including turnouts.
3. Where road side slope height is greater than or equal to 3 m safety berms or barriers will be placed along the road edge, and the road crest will be widened to accommodate the berms.
4. Notes in this drawing apply to all other active drawings.

ROAD CONSTRUCTION ZONES TABLE	
Fill Zone 1	1.0m min. Overall Road Thickness with 1.5H:1V Side Slopes
Fill Zone 2	1.5m min. Overall Road Thickness with 1.5H:1V Side Slopes
Fill Zone 3	2.0m min. Overall Road Thickness with 2.0H:1V Side Slopes
Bedrock Zone	0.3m min Road Thickness (ROQ not required) with Side Slopes to be determined in the field



DETAIL 5
ROAD PROFILE TRANSITION FROM PERMAFROST TO BEDROCK
5
0 1 2 3 4 5
Scale in Metres

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

NO.	DESCRIPTION	CH'K'D	APP'D	DATE
0	Issued for Construction	CH	EMR	08Aug18

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CH	EMR	August 8, 2018

FILE NAME: 1CT022.030_Doris Vent Raise-Berm3.dwg

MAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.030

Doris Connector Vent Raise Access Road

DRAWING TITLE:

Typical Sections and Details

DRAWING NO.	SHEET	REVISION NO.
DCVR-04	5 OF 6	0

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Materials List and Quantity Estimates

Item	Quantity / Area / Volume		Description
1. Run of Quarry Material		ROQ (cu.m.)	Approximate In-Place Neat-line Volume (3D volume based on Civil 3D surfaces - no allowance has been made for losses and/or tundra embedment)
	Doris Connector Vent Raise Access Road	4,420	
	Total	4,420	
2. Surface Material		Surfacing Material (cu.m.)	Approximate In-Place Neat-line Volume
	Doris Connector Vent Raise Access Road	330	
	Total	330	
3. Bedding Material		Bedding Material (cu.m.)	Approximate In-Place Neat-line Volume
	Culvert Crossing	34	
4. Rip Rap		Bedding Material (cu.m.)	Approximate In-Place Neat-line Volume
	Culvert Crossing	6	D_{50} = 0.15m
5. Culvert		Steal Pipe Culvert (each)	AIL Corrugated Steel Pipe
	Culvert Crossing	1	68x13 corrugated profile 500mm diameter Length = 22000mm

Tolerances on Road Material Placement:

Location	Fill (mm)	Excavation (mm)
Vertical Tolerance on Roads	0 to +75	n/a
Horizontal Tolerance on Roads	-150 to +150	

Note: Grade shall not be uniformly high or low.

NOTES - GENERAL

1. The Engineer will provide the Construction Manager and Contractor with digital design files for setting out the works. The Engineer will instruct the Contractor to survey random spot checks to confirm whether the works have been set out correctly.
2. Construction shall be in accordance with the following;

   Technical Specifications: Earthworks and Geotechnical Engineering, Hope Bay project, Nunavut, Canada, Revision H - Issued for Construction.
3. A temporary free-span crossing (design by others) may be constructed to reach the opposite stream bank to allow construction to advance prior to installing the culvert.
4. Construction can be completed during the summer or winter in accordance with the normal construction procedures used on site for roads and rockfill pads.
5. Construction must be in accordance with appropriate DFO guidelines for self-assessment.
6. Notes in this drawing apply to all other active drawings.

NOTES - CULVERT

1. Culvert installation should be carried out from the edge of the road, with no need for temporary access to the tundra or streambed by equipment.
2. All fuels, lubricants and other potentially hazardous materials must be stored outside the riparian management area of the stream, in locations designated for such storage on site.
3. A non-woven geotextile must be placed along the surface of natural ground in the culvert's footprint, to prevent loss of fines and gravels through seepage along the culvert.
4. Once the culvert is in place, backfill lifts of 0.3m must be placed on either side using bedding material, and are compacted to 85% Standard Proctor Density.

NOTES - SEDIMENT AND EROSION CONTROL

1. If required, sandbags are to be placed by hand to create a small coffer dam approximately 5m upstream of the proposed culvert installation location.
2. Ponded water (maximum head of about 0.5m) which accumulates behind the sand bags must be pumped around the construction area and discharged back into the stream about 10m downstream of the culvert.
3. A flow energy dissipation blanket (likely old conveyor belt, or something equivalent) must be used to ensure erosion is minimized from pump outlet.
4. A silt fence must be installed approximately 5m downstream of the construction area to contain any sediment that may become mobile should a rainfall event occur during construction.

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

NO.	DESCRIPTION	CH'K'D	APP'D	DATE
0	Issued for Construction	CH	EMR	08Aug18

REVISIONS

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DESIGN:	DRAWN:	REVIEWED:
LW	DP	MIS
CHECKED:	APPROVED:	DATE:
CH	EMR	August 8, 2018

FILE NAME: 1CT022.030_Doris Vent Raise_Material Specs.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.030

Doris Connector Vent Raise Access Road

DRAWING TITLE:

Material List and Quantity Estimates

DRAWING NO.	SHEET	REVISION NO.
DCVR-05	6 OF 6	0

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Attachment 5.2 Doris Connector Vent Raise Access Road – As-built Drawings

As-Built Drawings for the Doris Connector Vent Raise Access Road, Doris Project, Nunavut, Canada

ACTIVE DRAWING STATUS

DWG NUMBER	DRAWING TITLE	REVISION	DATE	STATUS
DCVR-00	Engineering Drawings for the Doris Connector Vent Raise Access Road, Doris North Project, Nunavut, Canada	AB	Feb 13, 2019	As-Built
DCVR-01	General Arrangement	AB	Feb 13, 2019	As-Built
DCVR-02	Doris Connector Vent Raise Access Road Plan and Profile	AB	Feb 13, 2019	As-Built
DCVR-03	Culvert Design	AB	Feb 13, 2019	As-Built
DCVR-04	Typical Sections and Details	0	Aug 2, 2018	Issued For Construction
DCVR-05	Material List and Quantity Estimates	0	Aug 2, 2018	Issued For Construction

MAC RESOURCES

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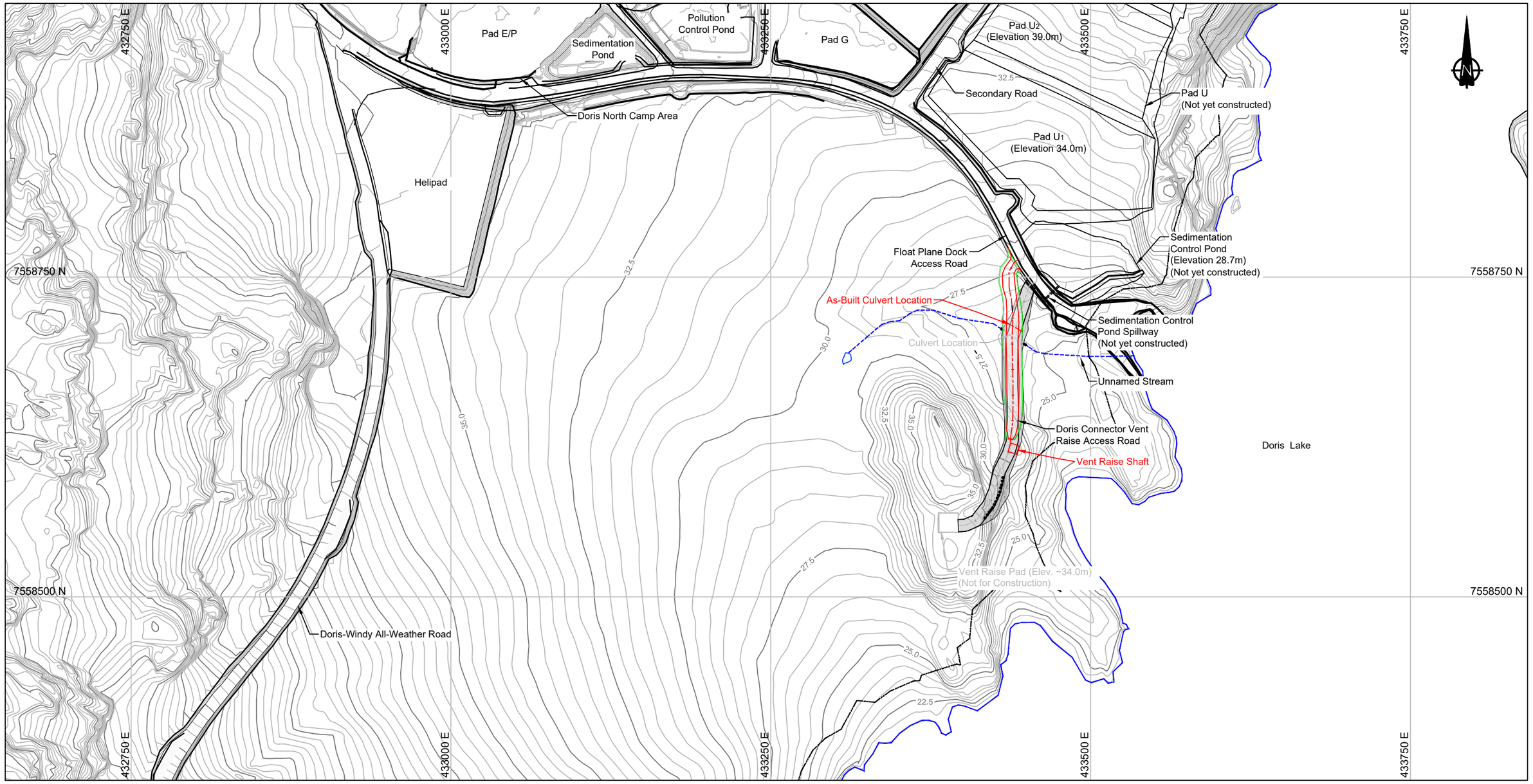
PROJECT NO: 1CT022.030
As-Built
February, 2019
Drawing DCVR-00



NOTES

1. Topographic contour data for the terrain model were provided by Hope Bay Mining, and is based on 2007 Aerial Photography. Contour intervals are 0.5m.
2. The co-ordinate system is UTM NAD 83, Zone 13.
3. All dimensions are in metric units, unless specifically mentioned.
4. Notes in this drawing apply to all other active drawings.
5. See DCVR-04 and DCVR-05 for additional notes.

REFERENCE

1. As-Built Road Survey provided by Sub-Arctic Geomatics Ltd. Survey Date: September 14, 2018.
2. As-Built Vent Raise Shaft Survey provided by Sub-Arctic Geomatics Ltd. Survey Date: February 12, 2018.

LEGEND

- Doris Connector Vent Raise Access Road
- 31m Lake Setback
- Approx. Unnamed Stream Alignment
- As-Built Crest
- As-Built Toe
- As-Built Centerline
- Design Center line
- Doris Connector Vent Raise Access Road

0 10 20 30 40 50
Scale in Metres

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
AB	As-Built			
1	Issued for Construction			28Aug18
0	Issued for Construction	CH	EMR	02Aug18

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CHECKED:	APPROVED:	DATE:
CH	EMR	February, 2019

FILE NAME: 1CT022.030_Doris Vent Raise_Rev0.dwg

MAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.030

Doris Connector Vent Raise Access Road

DRAWING TITLE:

General Arrangement

DRAWING NO.	SHEET	REVISION NO.
DCVR-01	2 OF 6	AB

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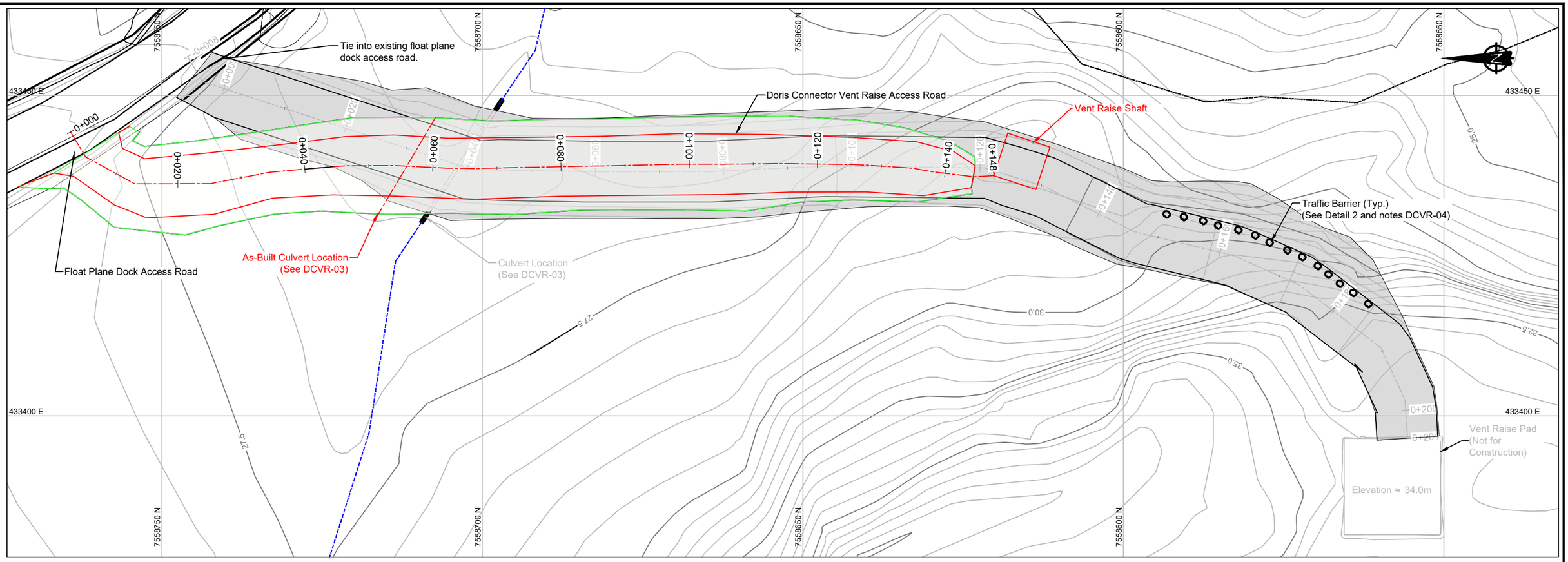
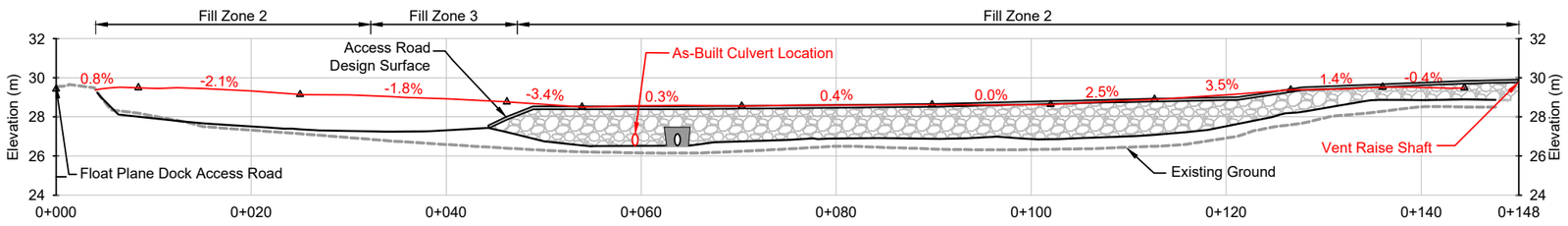


VENT RAISE ACCESS ROAD - PLAN VIEW

0 5 10 15
Scale in Metres



VENT RAISE ACCESS ROAD - PROFILE

0 5 10 15
Horizontal Scale in Metres
Vertical Exaggeration 2X

LEGEND

- Existing ground surface
- Approx. Unnamed Stream Alignment
- 31m Lake Setback
- Design Centerline
- As-Built Crest
- As-Built Toe
- As-Built Centerline
- Surfacing Material
- Run of Quarry Material
- Bedding Material

NOTES - GENERAL

1. Profile based on available topography. Existing ground level to be surveyed prior to construction to confirm design thickness achieved.
2. See DCVR-04 and DCVR-05 for additional notes.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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0	Issued for Construction	CH	EMR	02Aug18

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FILE NAME: 1CT022.030_Doris Vent Raise_Rev0.dwg

MAC RESOURCES
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SRK JOB NO.: 1CT022.030

Doris Connector Vent Raise Access Road

DRAWING TITLE:
Doris Connector Vent Raise Plan and Profile

DRAWING NO. DCVR-02 | SHEET 3 OF 6 | REVISION NO. AB

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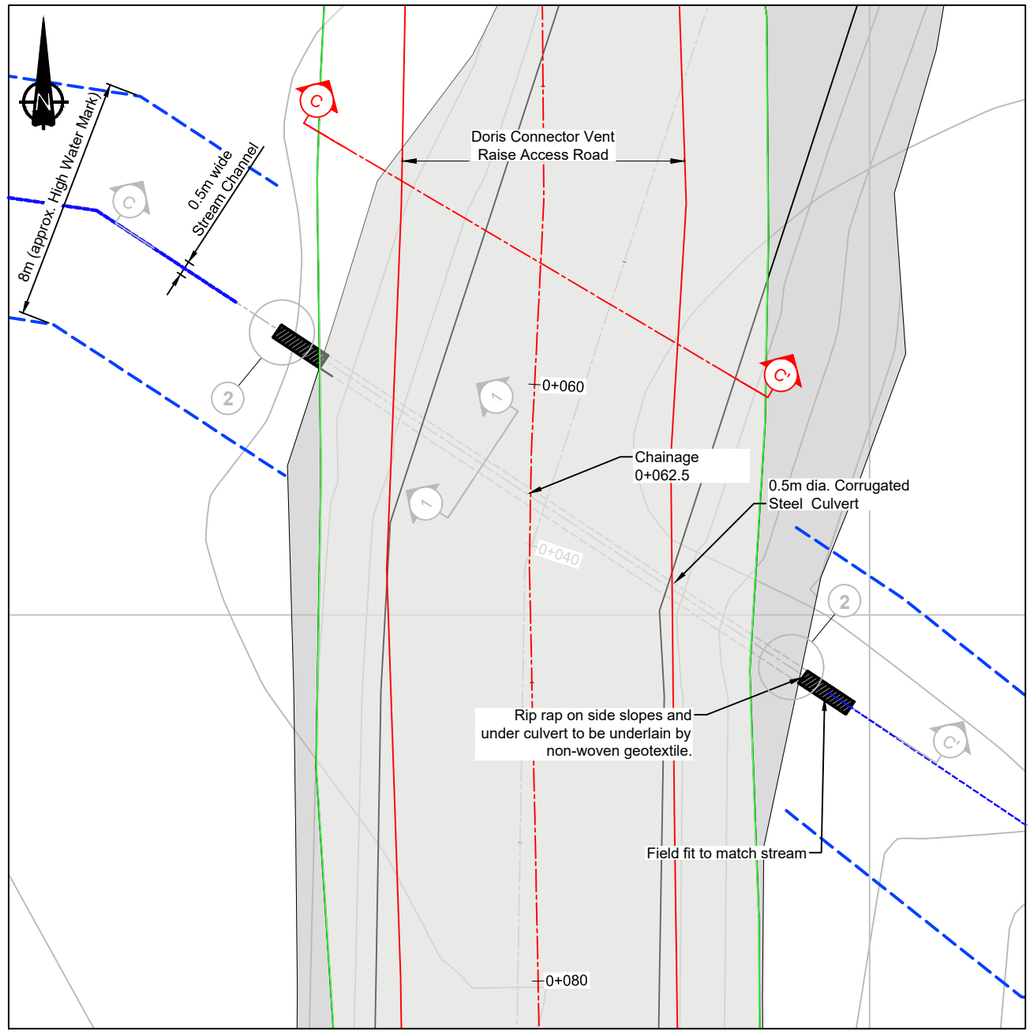
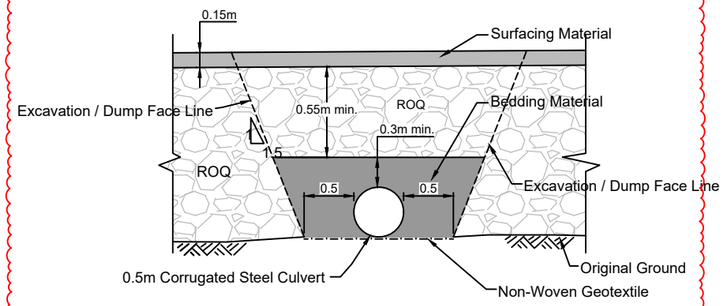
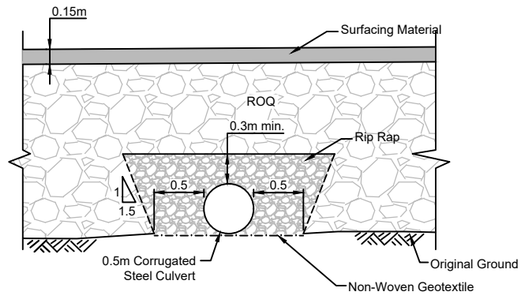


DORIS CONNECTOR VENT RAISE ACCESS ROAD CULVERT LOCATION

0 1 2 3 4 5
Scale in Metres



DETAIL 1
TYPICAL CROSS SECTION OF CULVERT CROSSING
1 NOT TO SCALE



DETAIL 2
TYPICAL CROSS SECTION OF CULVERT INLET/OUTLET
2 NOT TO SCALE

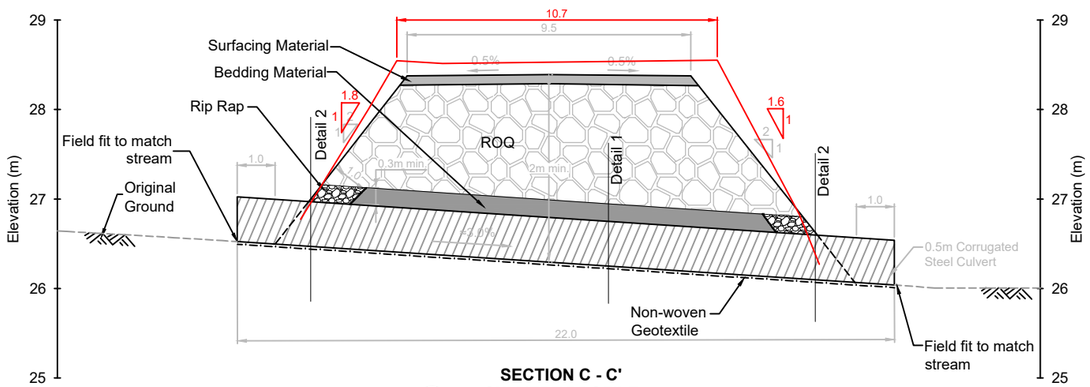
Construction Details Not Provided

LEGEND

- Original Ground
- Non-woven Geotextile
- Design Centerline
- 3.0 Major Contour
- Minor Contour
- Approx. High Water Mark
- Approx. Unnamed Stream Alignment
- As-Built Crest
- As-Built Toe
- As-Built Centerline
- Surfacing Material
- Bedding Material
- Run of Quarry Material
- Rip Rap, D_{50} = 0.15m

NOTES

1. All dimensions are in metric units, unless otherwise noted.
2. Installation of the corrugated steel culvert will follow the manufacturers assembly and installation guide.
3. Total depth of cover above culvert, including bedding material, surfacing material and ROQ, will be 1.0 m minimum.
4. Topographic contour data for the terrain model were provided by Hope Bay Mining Ltd, and is based on 2007 Aerial Photography. Contour intervals are 0.5 m.
5. Coordinate system is UTM Zone 13, datum NAD83.
6. Culvert alignment will be field fit to match stream alignment.
7. Additional notes located on DCVR-05



SECTION C - C'
CULVERT PROFILE
C
0 1 2 3 4 5
Horizontal Scale in Metres
Vertical Exaggeration X3

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE
REFERENCE DRAWINGS			

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TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.030

Doris Connector Vent Raise Access Road

DRAWING TITLE:
Culvert Design

DRAWING NO.	SHEET	REVISION NO.
DCVR-03	4 OF 6	AB

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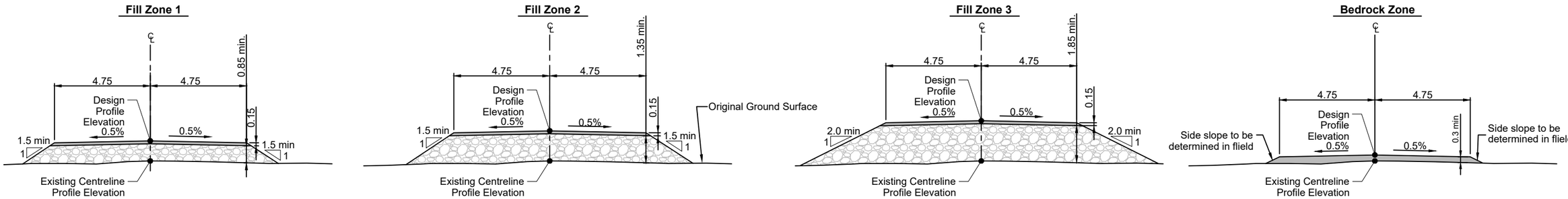
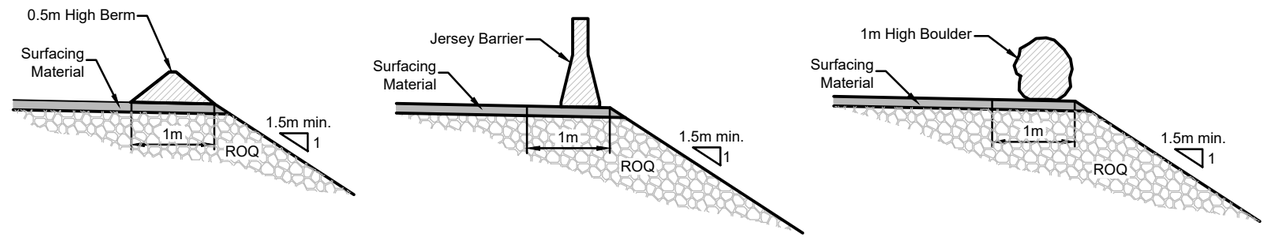


DETAIL 1
TYPICAL ROAD SECTION

0 1 2 3 4 5
Scale in Metres



DETAIL 2
TYPICAL BERM BARRIER OPTIONS
NTS

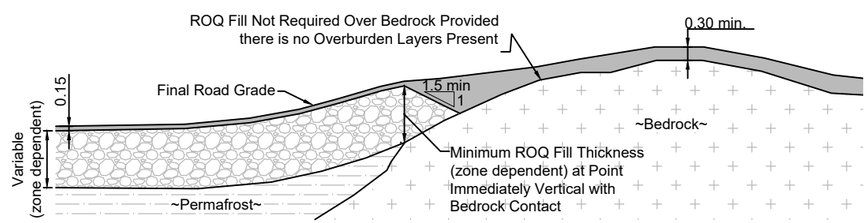
LEGEND

- Surfacing Material
- Run of Quarry Material

NOTES

1. All dimensions in metres unless noted otherwise.
2. Minimum design thickness must be maintained for all sections of the road including turnouts.
3. Where road side slope height is greater than or equal to 3 m safety berms or barriers will be placed along the road edge, and the road crest will be widened to accommodate the berms.
4. Notes in this drawing apply to all other active drawings.

ROAD CONSTRUCTION ZONES TABLE	
Fill Zone 1	1.0m min. Overall Road Thickness with 1.5H:1V Side Slopes
Fill Zone 2	1.5m min. Overall Road Thickness with 1.5H:1V Side Slopes
Fill Zone 3	2.0m min. Overall Road Thickness with 2.0H:1V Side Slopes
Bedrock Zone	0.3m min Road Thickness (ROQ not required) with Side Slopes to be determined in the field



DETAIL 3
ROAD PROFILE TRANSITION FROM PERMAFROST TO BEDROCK

0 1 2 3 4 5
Scale in Metres

DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE

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FILE NAME: 1CT022.030_Doris Vent Raise-Berm3.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.030

Doris Connector Vent Raise Access Road

DRAWING TITLE:

Typical Sections and Details

DRAWING NO.	SHEET	REVISION NO.
DCVR-04	5 OF 6	0

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Materials List and Quantity Estimates

Item	Quantity / Area / Volume		Description
1. Run of Quarry Material		ROQ (cu.m.)	Approximate In-Place Neat-line Volume (3D volume based on Civil 3D surfaces - no allowance has been made for losses and/or tundra embedment)
	Doris Connector Vent Raise Access Road	4,420	
	Total	4,420	
2. Surface Material		Surfacing Material (cu.m.)	Approximate In-Place Neat-line Volume
	Doris Connector Vent Raise Access Road	330	
	Total	330	
3. Bedding Material		Bedding Material (cu.m.)	Approximate In-Place Neat-line Volume
	Culvert Crossing	34	
4. Rip Rap		Bedding Material (cu.m.)	Approximate In-Place Neat-line Volume
	Culvert Crossing	6	D_{50} = 0.15m
5. Culvert		Steal Pipe Culvert (each)	AIL Corrugated Steel Pipe 68x13 corrugated profile 500mm diameter Length = 22000mm
	Culvert Crossing	1	

Tolerances on Road Material Placement:

Location	Fill (mm)	Excavation (mm)
Vertical Tolerance on Roads	0 to +75	n/a
Horizontal Tolerance on Roads	-150 to +150	

Note: Grade shall not be uniformly high or low.

NOTES - GENERAL

1. The Engineer will provide the Construction Manager and Contractor with digital design files for setting out the works. The Engineer will instruct the Contractor to survey random spot checks to confirm whether the works have been set out correctly.
2. Construction shall be in accordance with the following;

   Technical Specifications: Earthworks and Geotechnical Engineering, Hope Bay project, Nunavut, Canada, Revision H - Issued for Construction.
3. A temporary free-span crossing (design by others) may be constructed to reach the opposite stream bank to allow construction to advance prior to installing the culvert.
4. Construction can be completed during the summer or winter in accordance with the normal construction procedures used on site for roads and rockfill pads.
5. Construction must be in accordance with appropriate DFO guidelines for self-assessment.
6. Notes in this drawing apply to all other active drawings.

NOTES - CULVERT

1. Culvert installation should be carried out from the edge of the road, with no need for temporary access to the tundra or streambed by equipment.
2. All fuels, lubricants and other potentially hazardous materials must be stored outside the riparian management area of the stream, in locations designated for such storage on site.
3. A non-woven geotextile must be placed along the surface of natural ground in the culvert's footprint, to prevent loss of fines and gravels through seepage along the culvert.
4. Once the culvert is in place, backfill lifts of 0.3m must be placed on either side using bedding material, and are compacted to 85% Standard Proctor Density.

NOTES - SEDIMENT AND EROSION CONTROL

1. If required, sandbags are to be placed by hand to create a small coffer dam approximately 5m upstream of the proposed culvert installation location.
2. Ponded water (maximum head of about 0.5m) which accumulates behind the sand bags must be pumped around the construction area and discharged back into the stream about 10m downstream of the culvert.
3. A flow energy dissipation blanket (likely old conveyor belt, or something equivalent) must be used to ensure erosion is minimized from pump outlet.
4. A silt fence must be installed approximately 5m downstream of the construction area to contain any sediment that may become mobile should a rainfall event occur during construction.

REFERENCE DRAWINGS				REVISIONS				
DRAWING NO.	DRAWING TITLE	DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
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FILE NAME: 1CT022.030_Doris Vent Raise_Material Specs.dwg

TMAC RESOURCES

HOPE BAY PROJECT

SRK JOB NO.: 1CT022.030

Doris Connector Vent Raise Access Road

DRAWING TITLE:

Material List and Quantity Estimates

DRAWING NO.	SHEET	REVISION NO.
DCVR-05	6 OF 6	0

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Appendix B -
South Dam As-Built Report

Hope Bay Project,
Phase 1 South Dam As-Built Report - DRAFT

Prepared for

TMAC Resources Inc.

Prepared by

SRK Consulting (Canada) Inc.
1CT022.031
March 2019

Hope Bay Project,
Phase 1 South Dam As-Built Report

March 2019

Prepared for

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Project No: 1CT022.031

File Name: HopeBay_SouthDamAsBuilt_Report_1CT022.031_20190311.docx

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- Appendix L.4 – Moisture Content
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List of Abbreviations

AGI:	annual geotechnical inspection
BBG:	Blomberg Building Group
CDA:	Canadian Dam Association
DSR:	dam safety review
DTC:	digital temperature cable
EBA:	EBA, a Tetra Tech Company
EOR:	Engineer-of-Record
ID:	inner diameter
IFC:	issued for construction
GCL:	geosynthetic clay liner
GTC:	ground temperature cable
HDPE:	high density polyethylene
kts:	knots
masl:	meters above sea level
PSD:	particle size distribution
SRK:	SRK Consulting (Canada) Inc.
TMAC:	TMAC Resources Inc.
Nuna:	Nuna Logistics Limited
OD:	outer diameter
PPT:	parts per thousand
QA:	quality assurance
QC:	quality control
RFI:	request for information
ROQ:	run-of-quarry
SOP:	standard operating procedure
Sub-Arctic:	Sub-Arctic Geomatics Ltd.
TIA:	tailings impoundment area

1 Introduction

1.1 General

As part of the tailings management system for TMAC Resource Inc.'s (TMAC) Doris North Project, SRK Consulting (Canada) Inc.(SRK) was retained for the design and construction quality assurance of the frozen foundation South Dam (South Dam). The Doris North Project is located approximately 400 km east of Kugluktuk and 160 km southwest of Cambridge Bay in the Kitikmeot region of Nunavut.

Phase 1 of the South Dam was constructed between January and July of 2018, and the instrumentation system was set-up in November 2018 to February 2019. This as-built report contains the as-built drawings, all associated quality assurance (QA) and the available quality control (QC) documentation pertaining to Phase 1 of the South Dam.

1.2 Design Overview

The South Dam is one of three dams that will be constructed as part of the ultimate Tail Lake tailings impoundment area (TIA). Phase 1 tailings deposition requires the use of two out of the three structures; namely the North Dam and Phase 1 of the South Dam. Future Phase 2 tailings deposition will require the South Dam to be raised with downstream methods (Phase 2) to its ultimate crest elevation (46.0m). During Phase 2, as the tailings elevation continues above the containment provided by natural topography around Tail Lake, a third containment structure, the West Dam, will be required.

The North Dam was constructed during the winter months of 2011 and 2012 and is located over the Tail Lake outflow, between Tail Lake and Doris Lake. The North Dam is a water retaining structure that utilizes a central frozen core to maintain the reclaim pond against its upstream slope.

In contract the South Dam was designed to have tailings deposited off the upstream face to create a beach. Therefore, during Phase 1 of the TIA, the tailings will be deposited from the South Dam and all water will be ponded against the North Dam. The Phase 1 South Dam, approved under the existing Water License, has a crest elevation of 38.0 m. The main components of the South Dam include (see SRK 2019 and Appendix H):

- **Key Trench.** Due to the depth of overburden in the South Dam footprint, two central portions of the key trench were designed to terminate in the frozen overburden soil. The remainder of the key trench terminates in competent basalt bedrock. As it would be very difficult to tie-into the Phase 1 key-trench at a future date, the entire key trench (what is required for Phase 1 and required for the future Phase 2) was constructed. Over the two higher abutment (above elevation 38.0m) only a minimum cover section was placed. This minimum cover section was designed to ensure thermal protection of the foundation materials during Phase 1 tailings deposition.
- **Geosynthetic Clay Liner (GCL).** GCL was installed, in a chevron shape, along the upstream slope of the key trench and along the upstream slope of the above ground fill. This GCL

material was designed to limit seepage potential and provide water-retaining capability in the unlikely case that it is ever required. The GCL liner extends to an elevation of 37.0 m, 1 m below the Phase 1 crest.

- **Dam Shell.** The shell of the dam was constructed of run-of-quarry (ROQ) rock, transition material, and bedding material. The transition layer was placed between the bedding material and the ROQ dam shell, as a filter layer, to provide protection against the larger ROQ penetrating the bedding material and to prevent migration of bedding material towards the outer slopes. The slopes of the dam shell are 4H:1V and 2H:1V (horizontal:vertical) for the upstream and downstream slopes respectively.

1.3 Participants

The parties involved with the construction of the Phase 1 South Dam are listed in Table 1-1:. This list of companies is collectively referred to as the 'Project Team' throughout this report.

Table 1-1: Parties Involved in the Construction of Phase 1 South Dam

Element	Company
Client	TMAC Resources Inc.
Design	SRK Consulting (Canada) Inc.
Engineer of Record	SRK Consulting (Canada) Inc.
Site Construction QA	SRK Consulting (Canada) Inc.
Offsite Laboratory Testing	EBA, a Tetra Tech Company
Site Surveyor	Sub-Arctic Geomatics Ltd.
Construction Contractor	Nuna Logistics Limited
Site Construction QC	Nuna Logistics Limited
Liner Contractor	Blomberg Building Group
Drilling Contractor	McCaw North Drilling & Blasting Ltd.
Ground Temperature Cable and Data Logger Manufacturer	Beaded Stream

1.4 Main Tasks and Timeline

SRK oversaw construction of Phase 1 of the South Dam, and associated civil earthworks, at Doris North between January 19 and July 16, 2018. The main tasks involved with construction of the dam included:

- Percolation testing;
- Key trench excavation;
- Subgrade preparation of the upstream key trench slope and key trench base;
- GCL installation on the upstream key trench slope;
- Backfill of the key trench including:
  - Bedding material placement;

  - Transition material placement; and
  - ROQ material placement.
- Placement of above ground fill materials including:
  - Bedding material placement;
  - Transition material placement; and
  - ROQ material placement.
- GCL installation on the upstream slope of above ground fill materials;
- Ground temperature cable (GTC) installation including telemetry data acquisition system;
- Settlement instrumentation installation; and
- Construction of a temporary deposition berm and windrow for tailings containment.

A detailed breakdown and timeline of the Phase 1 South Dam construction activities are presented in Appendix A. A simplified timeline of the main construction tasks is presented below in Table 1-2.

Table 1-2: Phase 1 South Dam Construction Activities – Simplified Timeline

Activity	Period
Percolation Drilling and Testing	January 19 – February 2, 2018
Key Trench Excavation	February 25 – April 30, 2018
Sub-grade Preparation and GCL Installation in the Key Trench (Lower GCL)	April 2 – May 7, 2018
Backfill Key Trench with Below Ground Dam Fill:	April 2 – May 9, 2018
Bedding Material	April 2 – May 3, 2018
Transition Material	April 6 – May 8, 2018
ROQ Material	April 11 – May 9, 2018
Placement of Above Ground (Downstream) Dam Fill:	May 9 – June 26, 2018
Bedding Material	May 29 – June 26, 2018
Transition Material	May 9 – June 25, 2018
ROQ Material	May 9 – June 9, 2018
GCL Installation on Above Ground Dam Fill (Upper GCL)	June 3 – 25, 2018
Placement of Above Ground (Upstream) Dam Fill:	June 4 – July 10, 2018
Bedding Material	June 4 – 26, 2018
Transition Material	June 12 – July 1, 2018
ROQ Material	June 24 – July 10, 2018
Temporary Deposition Berm Raise and Construction of Tailings Containment Windrow	May 11 – 28, 2018
Construction of the East Access Road	May 22 – 30, 2018
Installation of GTCs	March 27 – July 15, 2018

Activity	Period
Installation of Settlement Instrumentation	July 11 – 16, 2018
Repair/Backfill of GTCs and Installation of Telemetry System	November 1 - 8, 2018
Replace/Swap out of two of the GTC Datalogger	February, 2019

As indicated in Table 1-2, sub-grade preparation and lower GCL installation (140 panels) in the key trench were done in conjunction with one another over a period of 36 days. In comparison, upper GCL installation on the above ground dam fill material (135 panels) was completed in 22 days. The time difference in these tasks was generally a product of the condition of the upstream key trench slope and key trench base following blasting in shallow bedrock. These sections required more extensive and detailed cleaning, sub-grade preparation, and placement of sacrificial GCL patches and panels prior to deployment of the 140 lower GCL panels.

1.5 Climatic Conditions

Figure 1 presents a summary of the mean daily temperatures recorded at Cambridge Bay, Nunavut. The start and finish dates of the main tasks associated with the Phase 1 South Dam construction are also shown for reference on this figure. Weather data was retrieved from the Canadian Government's Cambridge Bay, Nunavut, Weather Station (Government of Canada, 2018). Daily weather data from a station located on site at the Doris Airstrip was also recorded and incorporated in the construction daily reports (Appendix B). This data included maximum temperature (˚C), minimum temperature (˚C), wind speed (kts), minimum wind chill (˚C), and precipitation (mm). This data was not plotted on Figure 1 due to the ease of data acquisition and visualizations from the online weather database (Government of Canada, 2018). The onsite data was cross referenced with the Cambridge Bay data and the two data sets showed good correlation.

During the Phase 1 South Dam construction, the minimum recorded mean ambient air temperature was -42˚C on February 17, 2018 while the maximum was +13°C on July 11, 2018.

There were approximately five instances during the main six-month construction period when wind speeds were such that 'white out' conditions were present. During the white our conditions all construction at the South Dam work area was ceased until conditions improved and it was safe to resume work. White out conditions typically lasted for three to six hours.

1.6 Photo Record

Photographs were taken each day during quality assurance activities and incorporated in the construction daily reports (Appendix B).

A summarized photo record of the key construction activities is provided in Appendix C. Table 1-3: outlines the contents of the photo record.

Table 1-3: Contents of Photo Log (Appendix C)

Photo Log Figures:	Title
1	Overview (1 of 2)
2	Overview (2 of 2)
3	Dam Footprint Clearing
4	Key Trench Overburden Excavation
5	Key Trench Bedrock Blasting
6	Trench Surface Preparation
7	Key Trench Liner Installation
8	Bedding Material
9	Transition Material
10	Run of Quarry (ROQ) Material
11	Above Ground Liner Installation
12	Instrumentation (1 of 2)
13	Instrumentation (2 of 2)
14	Dam Access
15	Temporary Tailings Deposition Berm
16	Tailings Windrow
17	Aerial Overview of the South Dam

1.7 Report Layout

This report is broken down into eight sections, including this introduction. The second section of the report outlines the construction documents associated with the Phase 1 South Dam construction including drawings, specifications, daily reports, email correspondence, and memorandums. Deviations and required field fit modifications, from the original design lines, are documented in Section 3. Section 4 describes the construction materials utilized during construction and details of the actual construction are presented in Section 5. Section 6 presents the results of QA and QC testing performed during the construction. Section 7 outlines the long-term monitoring requirements associated with the dam. And Section 8 concludes the report with a brief closure. Figures and appendices can be found at the end of the report.

2 Construction Documentation

2.1 Construction Drawings

Table 2-1: lists details for the latest revision of each IFC drawing (Appendix D.1) and the complete set of construction drawings, including all revisions, is presented in Appendix D.2.

Table 2-1: Issued for Construction Drawings

Drawing Number	Title	Latest Revision	Date of Issue
DN-SD-00	Phase 1 General Arrangement (with Orthophoto)	2	April 30, 2018
DN-SD-02	Phase 1 General Arrangement	2	April 30, 2018
DN-SD-03	Typical Sections (General)	1	March 7, 2018
DN-SD-04	Key Trench Excavation Plan and Profile	1	March 7, 2018
DN-SD-05	Liner Placement Plan and Details – Key Trench and Phase 1	1	March 7, 2018
DN-SD-06	Liner and Bedding Placement Details	1	March 7, 2018
DN-SD-07	Bedding Material Placement Plan and Sections- Key Trench and Phase 1	1	March 7, 2018
DN-SD-08	Transition Material Placement Plan and Sections – Key Trench and Phase 1	1	March 7, 2018
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections – Key Trench and Phase 1	1	March 7, 2018
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections – Key Trench and Phase 1	1	March 7, 2018
DN-SD-11	Construction Access Road and Turn Around – Phase 1	2	April 30, 2018
DN-SD-12	Final Phase 1 Dam Plan, Profile and Sections	1	March 7, 2018
DN-SD-13	Sections Sta. 0+10 to 0+90 – Phase 1 Dam	1	March 7, 2018
DN-SD-14	Sections Sta. 1+00 to 1+80 – Phase 1 Dam	1	March 7, 2018
DN-SD-15	Sections Sta. 1+90 to 2+70 – Phase 1 Dam	1	March 7, 2018
DN-SD-16	Sections Sta. 2+80 to 3+60 – Phase 1 Dam	1	March 7, 2018
DN-SD-17	Sections Sta. 3+70 to 4+50 – Phase 1 Dam	1	March 7, 2018
DN-SD-18	Sections Sta. 4+60 to 5+30 – Phase 1 Dam	1	March 7, 2018
DN-SD-19	Infill Foundation Drilling – Phase 1	AB	March 7, 2018
DN-SD-20	Percolation Borehole / Test Locations	AB	March 7, 2018
DN-SD-21	Instrumentation Plan – Phase 1	2	May 24, 2018
DN-SD-22	GTC backfilled Cable Trench – Phase 1	2	April 26, 2018
DN-SD-23	Vertical GTC Layout – Phase 1	1	March 7, 2018
DN-SD-24	Horizontal GTC – Upstream Base / Toe of Key Trench	1	March 7, 2018
DN-SD-25	GTC Layout Along Upstream Above Ground Liner Slope	1	March 7, 2018
DN-SD-26	Sloped GTC – Above Ground Liner Slope	1	March 7, 2018
DN-SD-27	Instrumentation Details at Sta. 0+65 and 1+55	1	March 7, 2018
DN-SD-28	Instrumentation Details at Sta. 2+40 and 3+65	0	March 7, 2018
DN-SD-29	Instrumentation Details at Sta. 4+65 and 5+10	0	March 7, 2018
DN-SD-30	Typical Monitoring Point Details	1	May 24, 2018

2.2 Technical Specifications

A single revision of the Technical Specifications was issued during the construction of the Phase 1 South Dam. Revision H (the most recent revision), is included in Appendix E. This Technical Specifications document is intended to be all encompassing of earthworks construction projects at the Hope Bay Mine site and therefore contains sections that are not directly relevant to the Phase 1 South Dam construction.

2.3 Daily Reports

SRK had Site Engineer(s) present for the entire six-month construction duration, except for a one-week period between February 8 and 15, 2018. The Site Engineer(s) completed one construction daily report for every 24-hour construction period. The Daily Reports are generally considered an internal communication document between the SRK Site Engineers and the SRK Project Managers in the office. These daily reports summarized daily construction activities and have specific details on factual observations used to track progress and decisions. These reports were shared daily with the project team external to SRK; including Nuna Logistics Limited (Nuna), TMAC, Sub-Arctic Geomatics (Sub-Arctic), and Blomberg Building Group (BBG).

It should be noted that the construction quantities section of the SRK construction daily reports were populated based upon estimated volumes inferred from haul truck load counts. These estimates were conducted by Nuna and incorporated in their daily reporting. More accurate material quantities were since attained from the as-built survey data and are included in Section 4.7. Nuna's daily contractor reports are not included within this as-built document.

SRK's daily reports are included in Appendix B.

2.4 Email Correspondence

Correspondence between the Project Team was almost exclusively done through email. In many cases, these emails reflect the official means of communication between parties.

Important email correspondence relating to the construction of the Phase 1 South Dam is summarized chronologically in Table 2-2 and compiled in Appendix F. Additional correspondence relating to the day-to-day activities of the Phase 1 South Dam construction can be found in the construction daily reports (Appendix B).

Table 2-2 Summary of Important Email Correspondence

Date Sent	Subject and Attachments
Nov 17, 2017	• *South Dam Liner Selection* *Attachment: HopeBay_LinerComparison_1CT022.017_20171117_CH_KC_JBK.pdf*
Nov 29, 2017	• *South Dam Phase 1 IFC Drawings* • *Attachment: 1CT0022.017_HB_South Dam_IFC-1_Rev0_20171129.pdf*
Dec 22, 2017	• *South Dam IFCs -digital files* • *Attachment: South Dam IFCs - Digital File_20171222.zip*
Jan 9, 2018	• *South Dam Liner Quantities - HDPE + Geotextile + GCL*

Date Sent	Subject and Attachments
Jan 10, 2018	• *1CT022.017 - Potential South Dam Key Trench Overburden Storage Location* • *Attachment: 1CT022.017_South Dam_OVB_stockpile_NOTES_20180110.pdf*
Jan 19, 2018	• *South Dam draft construction plan* • *Attachment: WP-HB-001 - South Dam Construction Phase_Draft.docx*
Feb 3, 2018	• *South Dam – Potential Overburden Storage Location within TIA* • *Attachment: 1CT022.017_South Dam_OVB_stockpile_NOTES_20180110.pdf*
Feb 20, 2018	• *Hope Bay – South Dam – UPDATED KEY TRENCH DESIGN* • *Attachment: 1CT0022.017 - South Dam - Key TrenchDesignUpdate-NOTES_20180220.pdf; 180220 - South Dam - Key Trench.xml*
Feb 24, 2018	• *South Dam - ROQ and Transition Placement (outside of key trench) for Access* • *Attachments: 1CT0022.017 - South Dam - AccessRoadsUS&DS.DWG; 1CT0022.017 - South Dam - AccessRoadsUS&DS.DXF; 1CT0022.017 -South Dam-AccessRoadsDownstreamNOTES_20180221.pdf*
Feb 24, 2018	• *Hope Bay - South Dam - UPDATED KEY TRENCH DESIGN*
Mar 7, 2018	• *Ground disturbance clarification* • *Attachment: South Dam - ROQ and Transition Placement (outside of key trench) for Access*
Mar 13, 2018	• *Revised South Dam Key Trench Panel Layout* • *Attachment: South Dam Key Trench Panel Layout.pdf*
Mar 18, 2018	• *Offset Upstream KT Crest Points – Key Abutment* • *Attachment: OffsetUpstreamKTCrestPts_East Abutment.xlsx*
Mar 19, 2018	• *Updated Key Trench in East/West Abutments* • *Attachments: 80319 - South Dam - Key Trench.xml; KTUpdated180319.dxf; W-KTmod.pdf*
Mar 22, 2018	• *Standardized Asbuilt Process* • *Attachments: QC 170207 D1 Excavation 0+450 to 0+480 cut-fill design to excavation.pdf; QC 170210 D1 KT EXCAVATION 0+570-0+580.pdf; QC 170210 D1 KT EXCAVATION 0+550-0+560.pdf*
Mar 25, 2018	• *Updated QA/QC Documents* • *Attachments: GCL Documentation.xlsx; Daily Construction Summary Report Template.docx; Inspection and Testing Reports Template.docx; Problem Identification and Corrective Measures Reports Template.docx*
Mar 25, 2015	• *RK Review of Key Trench Excavation As-built from 0+90 to 2+00 - March 25, 2018* • *0223-SD KT ASB CS_SRK.PDF*
Mar 29, 2018	• *Dry Cement / Fly Ash Mix Design and Specification*
Apr 1, 2018	• *South Dam Key Trench* • *Attachments: Operational Work Plan GCL South dam.docx; GCL Documentation.xlsx*
Apr 6, 2018	• *Hope Bay Technical Specifications – IFC – Revision H* • *Attachment: HopeBay_TechSpecs_1CT022.031_20180406_KC_IM_JK_EMR.PDF*
Apr 6, 2018	• *South Dam - updated KT bedding and transition surfaces for guidance* • *Attachments: 80403 - updated KT Bedding.dxf; 180403 - updated KT Transition.dxf; 180403 - updated KT Bedding.xml; 180403 - updated KT Transition.xml*
Apr 15, 2018	• *Hope Bay South Dam – Installed GTCs at 2+40*

Date Sent	Subject and Attachments
Apr 18, 2018	• *Hope Bay South Dam – IFC Rev 1 Drawings* • *Attachment: 1CT022.031_HB_SDam_IFC_Rev1_20180413_compiled.pdf*
Apr 18, 2018	• *Hope Bay - South Dam - IFC Rev1 Drawings* • *Attachments: 180409 - US ROQ.XML; 180409 - DamLiner.xml; 180409 - DamTransition.xml; 180409 - DS Beddint.xml; 180409 - DS ROQ.XML; 180409 - KTBedding.xml; 180409 - KTtrans.xml; 180409 - US Beddint.xml; 180319 - South Dam - Key Trench.xml; P1 Dam Shell.xml; Phase 1 DamCL.XML*
Apr 20, 2018	• *Diagonal Lifts Above OG*
May 2, 2018	• *Hope Bay – South Dam – IFC Rev2 Drawings* • *Attachments: 1CT0022.017_HB_South Dam_IFC-1_Rev2_20180501.pdf; 1CT0022.017_HB_South Dam_IFC_Rev2_ 20180501_compiled.pdf; 180430 - East AR.XML*
May 3, 2018	• *Long Horizontal Thermistor Cable Install (SD-HST-B1-KT)*
May 10, 2018	• *South Dam Material Shortages*
May 14, 2018	• *Dam Surfaces Issues – CORRECTED* • *Attachments: 180514 - DS Bedding.dxf; 180514 - DS Bedding.xml; 180409 - DamTransition.xml; Chainage Check_SouthDam.dwg*
May 15, 2018	• *South Dam Foundation Contingency Plan* • *Attachments: 1CT022.031_South Dam Contingency Measures Memo_20180515.pdf*
May 17, 2018	• *Design Files for Temporary Deposition Berm Raise* • *Attachments: HBTIAroad.xml; HBTIAroad.dxf*
May 21, 2018	• *Drilling through Massive Ice* • *Attachments: SRK CableBuild_Approved.pdf; Invoice_1260_from_BeadedStream.pdf; DTC Order Sheet - SN 2839-2843 (14) - Hope Bay Phase 1 - SRK - 011518.pdf*
Jun 4, 2018	• *Hope Bay – South Dam – IFC Rev2 Instrumentation Drawings* • *Attachments: A1CT022.031_South Dam Inst_W.Points_20180604.pdf; 1CT0022.017_HB_South Dam_IFC_Rev2_ 20180604_compiled.pdf*

2.5 Memorandums

Select memorandums were issued during construction of the Phase 1 South Dam. Furthermore, SRK issued an additional memorandum following the completion of construction to document details of the foundation conditions in the key trench. These memos are summarized in Table 2-3 and compiled in Appendix G.

Table 2-3 Memorandums Issued for Phase 1 South Dam Construction

Date	Subject	Appendix
Nov 17, 2017	*2017 South Dam Design – Liner Comparison*	*G.1*
May 15, 2018	*South Dam Foundation Contingency Mitigation Measures*	*G.2*
Jan 21, 2019	*Hope Bay Project: South Dam Ground Ice*	*G.3*

3 Deviations from Original Design

3.1 General

In general, the Phase 1 South Dam was built to the lines, grades, and requirements outlined in the Issued for Construction (IFC) Drawings and Technical Specifications (Appendix D and E, respectively). Deviations from, and amendments to, the design documents are discussed in the following sections and are also detailed in the as-built drawings (Appendix H).

3.2 Key Trench Excavation

Based on results of the percolation testing and infill drilling, completed during foundation preparation, the 4 m (minimum) design depth of the key trench was reduced to 3 m in the two side abutments. The abutments were confirmed to be founded in shallow bedrock and therefore the same thermal design elements were not required, as were required in the thicker overburden sections. This change was aimed at reducing the amount of excavation required and the overall construction timeline. This change was implemented on approximately 185 m of the key trench between stations 0+00 and 0+75 and stations 4+20 and 5+30 in the east and west abutments, respectively. There was also shallow bedrock identified between stations 2+45 and 2+80 near the center of the dam. Due to the relatively limited extent of this bedrock feature, this section of key trench remained at a minimum depth of 4 m to tie into the sections of frozen overburden on either side. Additional details on the final extent of the key trench excavation are presented in the as-built drawings (Appendix H).

Based on difficulty experiences by the contractors to refine the upstream key trench slope to meet the design grades, following blasting in shallow bedrock, the upstream key trench slope was approved for GCL installation in select areas that had slope greater than 2H:1V. This change resulted from the highly erratic bedrock surface that was present following key trench excavation. In these areas notable additional effort would have been required to reduce this entire slope to 2H:1V or shallower. Achieving design grade in these areas would have required significant construction time including over excavation past the key trench design lines and additional dam fill materials. Furthermore, the downstream slope of the key trench was approved at grades greater than 1H:1V in some areas. This slope was inspected and scaled as necessary to remove any loose debris and ensure it was safe for workers in the key trench below. Also when required these areas were backfilled shortly after liner placement to ensure the GCL was kept anchored in place.

The Technical Specifications (Appendix E) detail the removal of any massive ice encountered during key trench excavation. Following excavation, the isolated presence of massive ice features

was noted in both the upstream and downstream slopes of the key trench. Typically, these features were logged, photographed, and surveyed for future reference. Ice rich ground features are further described in the technical memorandum found as Appendix G.3. Following internal discussion with SRK, and phone communication with TMAC, it was decided not to notably over excavate past design lines / to chase areas of massive ice.

SRK's understanding of the origin of the massive ground ice was supported by field data collected from the key trench and the surround dam footprint. The available information was considered in the context of the dam design, operation, and monitoring to inform the decision to not over-excavate ground ice in the key trench. It was determined that over-excavation would not guarantee intersection of lower ground ice soils and would result in a large, less thermally favorable key trench constructed with ROQ material. Contingency measures were implemented to control surface water during completion of the dam and allow for detect of thermal erosion that could potentially occur prior to tailings beaching along the upstream face. The required inspection and monitoring will allow for evaluation of dam performance and time to implement future mitigation measures, if required.

Further details on this decision is documented in the memo titled "Hope Bay Project: South Dam Ground Ice" found in Appendix G.3.

3.3 Key Trench Liner Sub-Grade Preparation

Due to the condition, following excavation, of the upstream key trench slope and base, a design amendment was approved by SRK to prepare these areas for lower GCL installation. Following key trench excavation, sections of the upstream key trench slope and base were irregular and incorporated protrusions, undulations, and imperfections larger than the 20 mm stated as acceptable in the Technical Specifications (Appendix E). To overcome this, a mix design and method specification was developed for a material that could be used to backfill imperfections prior to liner deployment. This material is further discussed in Section 4.4 but generally consisted of dry cement, fly-ash, and crushed aggregate. This fly-ask mix was designed to achieve a low permeability so that seepage pathways would not preferentially develop between the lower GCL and the frozen foundation. This material was placed in conjunction with sacrificial GCL patches/panels to fill in depressions and cover sharp protrusions in the upstream key trench slope and base that could hinder the effectiveness off the GCL system. The lower GCL material was then placed over this prepared subbase. Bedding material was then used above / on top of the lower GCL layer to bring the key trench base up to the design surface grades.

3.4 GCL Liner

The GCL overlap design, of the upper and lower GCL panels at the upstream crest of the key trench (or at the intersection with the original ground), was modified slightly to account for liner hydration. Following installation of the lower GCL panels in the key trench, a runout or extension of the GCL of approximately 1 to 2 m was left in place and covered with non-woven geotextile and/or sacrificial bedding material for protection. Upon excavation of these protective materials, it was discovered that accumulated snow had caused varying degrees of liner hydration in the runout of the lower GCL panel. To secure confidence in the seal of the upper and lower GCL panels, a sacrificial GCL panel and additional bentonite powder was placed over and upstream of

this overlap connection. In general, a 100 mm wide line of bentonite powder was placed directly in front of the design liner overlap. A sacrificial 1 m wide GCL panel was then placed approximately half on exposed overburden and half on the originally designed liner overlap of the upper and lower GCL panels. An additional 100 mm wide line of bentonite powder was also placed beneath the sacrificial panel and on top of the overlap flap. This design amendment was implemented in all areas except for the west abutment between approximate stations 4+10 and 5+30.

This detail is incorporated on as-built drawing DN-SD-06 (Appendix H). Additional details on this process can be found in the QC report of liner installation (Appendix I).

3.5 Above Ground Dam Fill

A discrepancy between the original ground survey used in detailed design and the actual original ground present during construction was noted during excavation of the key trench in March of 2018. Upon further investigation, it was concluded that the discrepancy was limited to the abutments of the dam. Detailed design surfaces in the abutments were based on an older and less accurate LiDAR data, while design in the center portion of the dam between approximate stations 0+80 and 4+50 was based on a detailed original ground survey completed by Sub-Arctic in June of 2017. This discrepancy generally related to the actual original ground being at a higher elevation than the original ground used in detailed design. This data discrepancy had little influence on construction of the Phase 1 South Dam as it was discovered and allowed for a detailed survey pickup of original ground in the abutments to be completed and incorporated during construction. This discrepancy did have minor influence on the above ground bedding material below and above the upper GCL panels in the east abutment. Placement of this material at the design grade of 3H:1V would have caused the runout of the lower GCL panel to be completely covered in downstream bedding material and eliminate the ability to seal the upper GCL panel to it. To account for this, the lower portion of this 3H:1V lifts of bedding material were over-steepened so that the upstream design toe of the bedding material was not altered, and ultimately, that the upstream toe of the dam was not shifted to the north. This design modification detail was generally incorporated between stations 0+00 and 1+00 in the east abutment and is displayed on as-built drawing DN-SD-07 (Appendix H).

Isolated locations of the as-built upstream and downstream dam toes were overbuilt past the design lines. The upstream toe is overbuilt near stations 4+55 and 5+10 and the downstream toe near 0+20, 4+45, and 4+90 as shown on as-built drawings DN-SD-10 and DN-SD-09 (Appendix H), respectively.

3.6 Instrumentation

3.6.1 Ground Temperature Cables

The boreholes drilled to house the vertical GTCs were backfilled with a mixture of dry bedding material and water rather than a slurry consisting of manufactured fines and water as detailed in Appendix E. This mixture was not pre-determined but rather field fit to ensure near saturation of the bedding material following its placement in the borehole. Furthermore, the typical water stop detail as shown on IFC drawing DN-SD-27 (Appendix D.1) was not incorporated.

All lead cables were ultimately run to the upstream toe of the Phase 1 South Dam through HDPE hard wall pipe with an outer diameter (OD) of 110 mm and an inner diameter (ID) of 80 mm. This pipe was buried within shallow trenches in the upstream ROQ shell near the original ground elevation and encapsulated in bedding material. This cable protection detail is not outlined on the IFC drawings (Appendix D.1) but was deemed necessary during construction for GTC protection in the final stage of upstream above ground material placement.

The position of GTC SD-HST-B1-KT was not installed as indicated on IFC drawing DN-SD-24 (Appendix D.1). Oversight during GCL placement in the key trench caused the installation of this cable to be missed. Once realized, the cable could not be installed in its original design position as backfill of the key trench had already progressed in that area. Instead, this cable was installed directly on top of the liner overlap of lower and upper GCL panels at the upstream crest of the key trench. The cable was installed between the originally planned dam stations of 2+45 and 4+25 as indicated on as-built drawing DN-SD-24 (Appendix H).

Two additional GTCs not indicated on IFC drawing DN-SD-23 were installed in conjunction with the contingency mitigation measures discussed in Section 3.7. These two cables were installed near the upstream toe at approximately station 3+35. These cables were deemed necessary to monitor ground temperature near the location of a suspected wedge of ground ice.

3.6.2 Settlement Instruments

Not all 26 Surficial Survey Points were installed at their pre-determined locations. Due to the 2H:1V downstream slope, equipment access on this slope was limited following construction and therefore instruments S7, S8, S11, S12, S15, S16, S19, and S22 were not able to be installed safely and in accordance with the Technical Specifications (Appendix E). Alternatively, the SRK field engineer selected appropriately sized particles of ROQ material already placed on the slope for use and replacement of these surficial instruments. The rocks did not always adhere to the maximum specified dimensions due to availability on the slope but were selected in locations as near to the originally planned location as possible. These rocks were marked so that site staff could locate them for installation of permanent survey markers.

Very minor adjustments were made to the manufacture details of the fixed survey monitoring instruments.

Position of the deep settlement point (D1 – D3) was shifted slightly to the to the west (to station 3+80, 3+40 and 2+90) to ensure that the borehole did not penetrate the lower GCL. As-built locations of all instruments are shown on as-built drawings in Appendix H.

3.7 Temporary Deposition Berm

Based on construction timing in comparison with the onset of increasing air temperature and the risk of ponded water against the upstream face of the Phase 1 South Dam, contingency mitigation measures were implemented in May 2018 to ensure that meltwater from the TIA could not impact the foundation of the dam. This contingency plan generally included a 1.5 m raise of the temporary deposition berm that was previously constructed to an elevation of 31.0 m in 2017. This berm is located approximately 35 m north of the ultimate upstream toe of the Phase 1 South

Dam. The spring contingency plan also incorporated the construction of a small windrow parallel to and offset approximately 105 m to the north from the temporary deposition berm and immediately south of the lake ice boundary on the frozen tailings beach. Both the temporary deposition berm raise and the windrow were constructed from ROQ material. Tailings were then deposited between the temporary deposition berm and the windrow to form the tailings beaching necessary to ensure ponded water remained offset from the dam.

Details of the contingency mitigation measures are incorporated within correspondence documented on May 15, 2018 in Appendix F and a memo titled “South Dam Foundation Contingency Mitigation Measures” incorporated in Appendix G. The as-built details of the temporary deposition berm raise and windrow are incorporated in the as-built drawing package associated with the Phase 1 South Dam (Appendix H).

3.8 Access Road

Alignment of the Phase 1 access road was modified slightly to connect to the existing access road almost directly north of the Phase 1 South Dam east abutment. Originally, the Phase 1 access road was to run sub-parallel to the existing access road and would therefore have been significantly longer. The construction of the alignment originally included will be done as part of Phase 2 construction.

Additionally, the 0.15 m of surfacing material which was to be placed along the crest of the dam and on the west turnaround to serve as road surfacing, was not placed. The purpose of these items was to improve access and turning for maintenance vehicles, and the removal does not change the design intent of the dam.

3.9 Quality Assurance and Quality Control Testing

Quality assurance in the Technical Specifications (Appendix E) outlines that two PSD tests (ASTM C136) were to be completed during production of transition material. Only one of these tests was completed. Due to the large particle sizes, the material was not shipped off-site for analysis but rather a visual PSD was completed on-site as discussed further in Section 6. The photographic records and site measurement checks for the Transition material(aside from visual inspections documented in the SRK Daily Reports) are presented in Appendix L.

The Technical Specifications (Appendix E) also state that compaction testing in accordance with ASTM D2922 was to be completed during placement of bedding material. Due to the larger allowable deformations for the South Dam compaction testing was alternatively completed as a method specification following the completion of a field compaction trial on April 5, 2018. Further details of this compaction trial and the findings are summarized in Section 6. In line with these same reasons, the maximum density testing in accordance with ASTM D698 during placement of bedding material was also not completed. In the key trench vibratory compaction was used. For the above ground fill either vibratory compaction or loaded haul traffic was completed to ensure some compaction of the Transition and ROQ material resulted on site.

Furthermore, the Technical Specifications state that QA and QC testing would be completed on-site. Rather, the testing was completed off-site by EBA Tetra Tech (EBA) in their Yellowknife, NWT and Edmonton, Alberta laboratories.

4 Construction Materials

A variety of materials were used in constructing the Phase 1 South Dam. The rock and granular materials were produced on-site by quarrying and crushing, while other materials were sourced from manufacturers off-site. Table 4-1 presents a summary of the materials used, as well as the location and the source of the material.

Table 4-1: Summary of Materials used in the Phase 1 South Dam

Material	Location/Use	Source
Run-of-quarry (ROQ)	Key trench backfill and above ground external dam shell	Quarry #2
Transition - 200 mm minus crush	Filter between the bedding material and ROQ material in key trench backfill and above ground materials	Quarry #2, on-site crusher
Bedding – 25 mm minus crush	Protection layers above the GCL in the key trench and above/below the GCL in above ground materials	Quarry #2, on-site crusher
Fly-Ash Mixture (dry cement, fly-ash, and aggregate)	Upstream slope and base of key trench to fill depressions and mitigate protrusions from surface	Dry cement/fly-ash sourced from off-site vendors (Unknown). Aggregate produced in Quarry #2, on-site crusher
Water	Percolation Testing	Windy Lake
Geosynthetic Clay Liner	Upstream slope and within above ground materials as a backup water retention system	Off-site vendor (Cetco)
Bentonite powder	GCL Installation	Off-site vendor (Nilex)
HDPE Pipe	GTC lead cable protection and casing for deep settlement instrument D2	Off-site vendor (Unknown)
Steel pipe	Casing for settlement instruments	Off-site vendor (Unknown)

4.1 Run-Of-Quarry Material

All ROQ material used as backfill and as an above ground dam shell material is non-acid generating basalt, quarried on-site from Quarry #2 by drilling and blasting methods. Quarry #2 was developed prior to the start of construction of the North Dam, i.e. pre 2011. Oversize was sorted during the loading of the haul trucks. Select ROQ was used as crusher feed in production of the transition and bedding materials. ROQ was only subject to visual QA/QC and was generally noted to be well graded with few oversize pieces as outlined in the Technical Specifications. This material was stockpiled and hauled from Quarry #2.

4.2 Transition Material

This material was produced by the on-site crusher using the primary jaw circuit only. The 200 mm minus material was used as a transition layer between the bedding material and the ROQ material and satisfies the filter criteria for particle migration. This material was generally subject to visual QA/QC only, however, a field level particle size distribution (PSD) test was conducted as mentioned in Section 3.9 and further described in Section 6.3. The Transition material was stockpiled near the crusher in Quarry #2 and hauled to a smaller stockpile located at the overburden dump within the TIA for a select period to facilitate a shorter haul distance once the material was required.

4.3 Bedding Material

The 25 mm minus crush was produced to meet the particle size envelope stated in the Technical Specifications (Appendix E). QA/QC testing of this material included maximum density, water content, and PSD testing as described below in Section 6. This material was stockpiled in Quarry #2 and hauled directly to the dam as necessary.

4.4 Fly-Ash Mix Material

As mentioned in Section 3.3, the fly-ash mixed material specification was developed as a design amendment to facilitate liner sub-grade preparation on the upstream slope and base of the key trench. The material incorporated 20 mm minus crushed aggregate, dry cement, and fly-ash at a ratio of 4:1:1, respectively. The material was mixed by BBG in the on-site batch plant. The material was subsequently mobilized to the construction area by either placing the material in mega bags and loading them on a trailer, or in a concrete mixing truck.

This material was subject to quality assurance (QA) and quality control (QC) testing which is detailed in Section 6 below. Further details of this mix-design are documented in email correspondence on March 29, 2018 in Appendix F.

4.4.1 Dry Cement

The dry cement was Type 10 General Use (GU) and was packaged in 1,500 kg double lined totes. The manufacturer of this material is unknown.

4.4.2 Fly-Ash

The fly-ash was onsite prior to construction of the Phase 1 South Dam. BBG estimates that the material was transported to site prior to 2013. The manufacturer of this material is unknown, but it was stored in 1,000 kg double lined totes.

4.4.3 Aggregate

The crushed aggregate was to conform to a D_{60} of 4.75 mm and a minimum D_{10} of 0.01 mm, ensuring a fines content greater than 15% and achieving a target permeability of 1e-07 m/s. This material was produced in Quarry #2 as a 20 mm minus crushed rock and then stored inside the on-site batch plant prior to mixing.

4.5 Geosynthetic Clay Liner

The GCL (Bentomat®CLT-SFT) was manufactured by Cetco, with a maximum hydraulic conductivity of $5x10^{-10}$ cm/s max. Detailed specifications are presented in Appendix G in the memo titled “2017 South Dam Design – Liner Comparison”.

The GCL liner was transported in multiple shipments to site by plane during the construction period in early 2018. The liner was generally stored in a combination of open-air conditions near the south apron of the airstrip and in enclosed conditions at the batch plant. The plastic wrapping of some of the rolls was torn. Signs of deterioration were noted in the form of hydration and tears on some rolls. This deterioration was generally relatively minor and was accounted for during installation by patching defects in accordance with the Technical Specifications (Appendix E).

Rolls were generally transported to the dam immediately prior to use and storage outside without an appropriate protective covering was not permitted.

4.6 Bentonite Powder

Bentonite powder was used to seal the joints between the overlapping panels of GCL, as well as sealing the patches where repairs were required. The bentonite used was bagged (50 lb) Granular Bentonite and was manufactured by Nilex.

4.7 Material Quantities

The as-built material quantities used for the Phase 1 South Dam construction are summarized in Table 4-2. In-place quantities are derived from survey data supplied by Sub-Arctic.

The ROQ material volume includes a minor amount of bedding material which was used to backfill the HDPE GTC lead cable protection pipes and the GTCs trenches on the upstream dam face and crest. As noted in Section 5.7 Transition material was also substituted for ROQ material in select areas. The as-built bedding material and GCL quantities increased above the estimated design quantities due to the condition of the upstream key trench slope, and the condition of the shallow blasted bedrock surface, as discussed in Section 3.3. In some of the over blasted areas of the key trench, additional bedding material was also placed over the GCL to smooth the surface and bring the fil closer to the design lines.

Table 4-2: As-Built and Design Material Quantities

Material	Quantity (neat-line)	
	As-Built	Design**
Key Trench Excavation	20,970 m^3	19,500 m^3
ROQ Material	39,700 m^3	36,800 m^3
Transition material	27,900 m^3	26,100 m^3
Bedding Material	8,800 m^3	5,600 m^3
Fly-ash Mix Material***	154 m^3	n/a
20 mm minus aggregate	168,000 kg	n/a
Dry cement	42 tonnes	n/a

Material	Quantity (neat-line)	
	As-Built	Design**
Fly-ash	42 tonnes	n/a
Surfacing Material (dam crest, access road, and turnaround)	100 m^3	1,000 m^3
West Turnaround (bulk)	2,400 m^3	2,000 m^3
East Access Road (bulk)	2,300 m^3	2,440 m^3
GCL*	20,370 m^2	14,300 m^2
ROQ Material for Temporary Deposition Berm Raise	2,700 m^3	2,520 m^3
ROQ Material for Tailings Deposition Windrow	1,400 m^3	1,050 m^3

Note(s):

*GCL design quantities do not account for patches, sacrificial panels, overlaps or wastage. Value based on estimated from BBG.
**All design quantities presented are to neat-lines and do not allow/account for bulking and compaction.
*** Total volume of fly-ash mixture material based off 11 m^3/truck and the use of 14 truck loads.
**** This is a estimate based on visual records. Only a small amount of surfacing material was placed on select areas of the top crest of the dam. See Section 8 for additional details

5 South Dam Construction

5.1 Equipment

5.1.1 Mobile Equipment

Conventional earth moving equipment was used in construction of the Phase 1 South Dam as listed in Table 5-1.

Table 5-1: Summary of Equipment used for Dam Construction

Equipment Type	Manufacturer	Model	Tool Attachments
Bulldozer	Caterpillar	D6	n/a
	Caterpillar	D8	Ripper tooth
Backhoe Excavator	Caterpillar	385	n/a
	Caterpillar	345	Rock hammer
	Caterpillar	325	n/a
	Caterpillar	308	n/a
Front End Loader	Caterpillar	IT38	Integrated tool carrier
	Caterpillar	980	n/a
	Caterpillar	988	Lifting forks
Articulating Haul Trucks	Caterpillar	740 (x 4)	n/a
	Caterpillar	725 (x 1)	n/a
Vibratory Drum Compactor	Caterpillar	CS-74B	n/a
Skid Steer Loader	Caterpillar	287C	Mechanical broom
Telehandler	Caterpillar	TL1255	Lifting forks
Crane	Link-Belt	80130	Spreader bar assembly

	Grove	RT-625	
Air Drill	Sandvik	DX-800	n/a
Concrete Mixer Transport Truck	Kenworth	Unknown	11 m^3 Mixing Barrel

A variety of other non-mobile equipment was also used to support the construction activities, including but not limited to:

- A Godwin Dri-Prime pump and two electric sump pumps to facilitate surface water management upstream of the dam;
- Numerous hand tools including shovels, rakes, and brooms used to support detailed cleaning of the key trench and spreading/placement of fly-ash mix material;
- A hand compactor to support installation of settlement instruments;
- An air compressor and attachments to support detailed cleaning of the key trench; and
- Light plants to facilitate work in dark conditions.

5.1.2 Crusher

The transition and bedding material were crushed using a Clemro crusher. The crushing circuit consisted of a primary jaw crusher, a classification screen, and a secondary cone crusher. A CAT 988 loader was used to feed the crusher with select ROQ, sourced exclusively from Quarry #2.

5.2 Survey

Survey control and reporting was performed by Sub-Arctic. Surveying was performed with Leica GPS equipment using the UTM zone 13 coordinate system and NAD83 datum. All survey data was processed on site by Sub-Arctic personnel. Interim as-built surveys were generally sent to SRK and Nuna at the end of each day for review. These interim as-built surveys were then attached to SRK's construction daily report (Appendix B). The survey data was used to check grades, minimum thicknesses, and extents for field decisions, as well as to prepare the as-built drawings (Appendix H).

5.3 Foundation Preparation

5.3.1 Percolation Testing

Prior to the key trench excavation, a percolation testing program was undertaken in accordance with the Technical Specifications to verify the foundation conditions assumed in the key trench design. This program was completed between January 19 and February 2, 2018. Thirty-four boreholes were drilled with a Sandvik DX-800 Air Track drill operated by McCaw North. Boreholes had a OD of approximately 115 mm and were advanced to depths between1.7 m and 10.1 m. A maximum 10 m total hole depth was targeted however boreholes in shallow bedrock were terminated approximately 1 to 2 m into competent rock. Thirty-nine boreholes were originally planned as part of the percolation testing program however five of the boreholes were deemed

unnecessary pending early program results and the presence of shallow bedrock. The location of the completed percolation test holes is presented in as-built drawing DN-SD-20 (Appendix H).

As boreholes were advanced, samples were collected at a 0.5 m frequency from surface to 4 m below ground and at a reduced frequency of every 1 m from a depth of 4 m to the end of hole. A total of three hundred and forty-seven samples were collected during the percolation testing program. Select samples were logged and tested by SRK on site for moisture content. Due to time constraints of testing all samples on site, the remainder of samples were shipped to EBA's Yellowknife, NWT laboratory for the same suite of testing and samples to receive salinity testing were further transported to EBA's Edmonton, AB laboratory. A discussion of the test results is included in Section 6.2.

Following the completion of drilling and sample collection, if the holes were not immediately subject to percolation testing, they were plugged/capped with insulation and marked with delineator cones. To initiate the percolation test, boreholes were filled individually with water at an approximate temperature of 15˚C. Measurements of the depth to the static water level were taken frequently until the static water level remained constant. Typically, this occurred within the first one hour following test initiation. The borehole was then re-insulated and capped, and a final reading was taken at the end of the day or on a subsequent day to confirm that the static water level previously recorded had turned to ice at or very near to that level. Due to the expansion of ice as it freezes, it was generally found that the final depth reading was slightly higher than the earlier recorded static level.

Upon completion of the analysis and review of the percolation field and laboratory testing data, the depth to competent ice saturated soil was inferred. As previously mentioned in Section 3.2, it was concluded that no change was justified to the IFC key trench design depth in sections of frozen overburden but that they key trench depth could be reduced by 1 m in sections of shallow bedrock. Results of the percolation testing are summarized in Table 5-2 below and presented in detail in Appendix J. Laboratory results associated with samples collected from the percolation testing boreholes are further discussed in Section 6.2.

Table 5-2 Summary of Field Percolation Testing

Station	Percolation Hole ID	Depth of Percolation Hole (m)*	Depth to Static Water Level (m)
5+ 20	SRK18-SD-DHP1	3.3	0.3
5+ 00	SRK18-SD-DHP2	5.0	0.8
4+ 80	SRK18-SD-DHP4	1.7	0.7
4+ 60	SRK18-SD-DHP5	2.7	0.3
4+ 40	SRK18-SD-DHP7	4.1	0.2
4+ 20	SRK18-SD-DHP8	2.2	0.1
4+ 00	SRK18-SD-DHP10	5.1	0.3
3+ 80	SRK18-SD-DHP11	8.7	0.6
3+ 80	SRK18-SD-DHP12	8.9	0.5
3+ 60	SRK18-SD-DHP13	9.0	0.5

Station	Percolation Hole ID	Depth of Percolation Hole (m)*	Depth to Static Water Level (m)
3+ 40	SRK18-SD-DHP14	6.6	0.6
3+ 40	SRK18-SD-DHP15	10.1	0.2
3+ 20	SRK18-SD-DHP16	9.2	0.3
3+ 00	SRK18-SD-DHP17	9.2	0.8
3+ 00	SRK18-SD-DHP18	9.7	0.9
2+ 80	SRK18-SD-DHP19	2.7	0.3
2+ 60	SRK18-SD-DHP20	6.3	0.4
2+ 60	SRK18-SD-DHP21	3.6	0.3
2+ 40	SRK18-SD-DHP22	8.3	0.6
2+ 20	SRK18-SD-DHP24	8.7	0.4
2+ 00	SRK18-SD-DHP25	9.3	0.3
1+ 80	SRK18-SD-DHP26	8.9	0.4
1+ 80	SRK18-SD-DHP27	9.0	0.5
1+ 60	SRK18-SD-DHP28	9.0	0.4
1+ 40	SRK18-SD-DHP30	9.1	0.4
1+ 20	SRK18-SD-DHP31	7.6	0.6
1+ 00	SRK18-SD-DHP32	9.3	0.4
1+ 00	SRK18-SD-DHP33	8.7	5.3
0+ 80	SRK18-SD-DHP34	4.8	0.3
0+ 60	SRK18-SD-DHP35	3.9	0.2
0+ 60	SRK18-SD-DHP36	3.3	0.2
0+ 40	SRK18-SD-DHP37	3.2	0.2
0+ 20	SRK18-SD-DHP38	3.8	0.2
0+ 20	SRK18-SD-DHP39	4.1	2.3

Note(s):
*Depth indicates the borehole depth at the time the falling head test was completed and not drilled depth.

5.3.2 Drilling, Blasting, and Excavation of Key Trench

The key trench was excavated between February 25 and April 30, 2018. Typically, drill and blast methods were utilized in sections of shallow overburden while the D8 dozer with ripper tooth was used in sections of thicker or finer frozen overburden. McCaw North drilled the blast holes to the required depth of each stake location (as set-out by Subarctic Surveyors) included in the blast grid.. McCaw North was advised by Nuna not to include a sub-drill in the west abutment to limit the final excavation depth of the key trench. The hole diameter was 3.5" (88.9 mm). Pattern drilled for the South Dam were typically done at1.5m by 1.5m spacing. McCaw North aimed for a powder factor of 0.8 kg/m^3. SRK is unable to comment on the final power factor realized on site for the South Dam (and if this was higher or lower than planed)

All overburden soils and bedrock excavated from the key trench were hauled to the overburden dump located on the eastern edge of the TIA, within the TIA footprint. The ultimate elevation of

the dump was graded below 33 m so that placed spoils did not impact future tailings deposition in this area. Details surrounding selection of this dump location is discussed in email correspondence on February 3, 2018 (Appendix F). The southern extent of the overburden dump is shown on as-built drawing DN-SD-01 (Appendix H).

5.3.3 Cleaning/Sub-Grade Preparation of Key Trench

Final cleaning of the exposed upstream slope and base of the key trench was typically performed with an air compressor on the 2H:1V slope and air compressor/skid steer with broom attachment in the base, as well as manually with brooms and shovels when necessary. The key trench was cleaned of all loose material, snow, and ice to the extent possible. Cleaned surfaces were then inspected by a field engineer prior to GCL deployment or further sub-grade preparation as discussed in Section 5.3.4 below.

5.3.4 Fly Ash Mix Material Placement

The fly-ash mix material was transported and placed in the key trench in either one of two ways:

- Transporting the material in mega bags on a flat bed trailer. The mega bags were subsequently suspended from an excavator boom such that the material could be released where needed on the upstream slope and/or base of the key trench by making appropriate cuts in the bottom; or
- Transporting the material in the barrel of the concrete mixing truck and then transferring the material into a smaller container at the dam site. This container was affixed with a controllable dispersal system at the base. The container was subsequently suspended from an excavator boom such that the material could be released where needed on the upstream slope and/or base of the key trench.

The fly-ash material was then spread and compacted using hand tools and/or the 287C skid steer or 308 excavator. The material was generally placed in accordance with the following guiding principle:

- The mix design must be placed in lifts no greater than 200 mm (loose density) and compacted using a method specification that will ensure a firm competent surface.

Dependent on the condition of the excavated surface, the fly-ash mix at times was placed in a single lift to fill depressions greater than 200 mm in depth. Based on the material composition and moisture content, compaction was difficult and achieving a firm competent surface was achieved as much as reasonably practical on the key trench base but was very difficult to achieve on the upstream slope which was at times steeper than 2H:1V which did not facilitate access for compaction equipment.

Use of this material was limited to the extent possible but the quantity required was highly variable and dependent upon the condition of the sub-grade following key trench excavation. Majority of the material used was in the sections of key trench founded in shallow bedrock.

5.4 GCL Placement

Following the placement of fly-ash mix material, sacrificial GCL patches and panels were placed at the discretion of the field engineer and the liner contractor. The sacrificial materials served as further protection of the below ground GCL system from protrusions and imperfections on the upstream slope and base of the key trench.

GCL panels were placed perpendicular to the dam axis, with a 0.5 m overlap between panels. The overlapping panel was always placed higher in elevation. A crane or excavator equipped with a spreader bar assembly was used to lift the rolls of GCL, while the GCL Contractor ensured the panels were properly aligned. The GCL Contractor placed a line of bentonite in the seams between panels at a minimum application rate of approximately 0.5 kg/m (approximately 5 mm thick and 100 mm wide). A manually operated device similar to a lawn fertilizer spreader was used to evenly apply the bentonite. Bentonite was placed at a higher application rate of approximately 5 kg/m (approximately 10 mm thick and 500 mm wide) on the overlap flap sealing the lower and upper GCL panels. As previously mentioned in Section 3.4, a design modification was incorporated in sealing the lower and upper GCL panels due to the presence of hydration. Patches were placed over holes, areas of visible damage, or hydration. The perimeter surrounding all defects was subject to application of an approximate 100 mm wide line of bentonite prior to installation of patches.

Liner deployment in the key trench was initiated near station 0+200 on April 2, 2018 and advanced eastward to station 0+105 by April 6. Liner deployment was then ceased in this area as the east abutment had not yet received detailed cleaning and final foundation preparation. At this time, liner deployment was shifted towards the center of the dam near station 0+335 on April 7, and advanced east to station 0+200 by April 15. Liner deployment was then re-initiated in the east abutment on April 16 at station 0+105 and advanced to station 0+30 by April 21. At this time, liner deployment was once again shifted back towards the center of the dam near station 0+335 and advanced westward to station 0+375 by April 22. On April 24 and 25, liner deployment was completed in the east abutment to station 0+00. Liner deployment re-commenced westward near station 0+375 on April 26 and was completed in the west abutment on May 7.

Above ground liner deployment commenced on June 3, 2018 near station 0+350, advancing westward to station 0+405 by June 4. Deployment was ceased at station 0+405 and commenced eastward from station 0+350 on June 4 and was completed on the east abutment June 22. Liner deployment then proceeded westward from station 0+405 on June 25 and was completed on the west abutment that same day.

Details on the GCL panel layout are presented on as-built drawing DN-SD-05 (Appendix H). Additional details of GCL deployment including panel IDs are incorporated in the Liner Construction Summary report (Appendix I) and in the construction daily reports between April 2 and June 25, 2018 (Appendix B).

5.5 Placement of Bedding Material

As outlined in Section 4.3, bedding material generally comprised a 25 mm (1 inch) minus crushed rock.

Bedding material was hauled to the dam with CAT 725/740 haul trucks. Bedding material placed in the key trench was generally off loaded directly from the back of the haul trucks using the 325 or 345 excavators. Material was then cast into place using this same machine and then firstly placed/spread using the 308 excavator and/or the 287C skid steer in the key trench base. These machines were only permitted to work on a minimum bedding material lift thickness of 300 mm. Compaction of bedding material along the base was achieved through tracking with either of these machines. Bedding material placed on the 2H:1V upstream key trench slope was generally completed using the 308 excavator working from the key trench base or the 345 excavator situated at the upstream crest. Material placed by the 345 excavator was cast into place and then pulled upward along the slope, beginning near the base of the slope and advancing up slope. Compaction of bedding material on the upstream slope was achieved through bucket tamping as no equipment access was possible on this slope. All bedding material was typically placed in a single 300 mm lift. Where bedding material thicknesses increased above 300 mm due to undulations/imperfections, material was generally placed in approximate 300 mm lifts.

Above ground downstream bedding material was generally placed on top of the above ground downstream Transition material by spreading (pushing upslope) with use of the dozers. Excavators were used as necessary to cast the material into place. Compaction of this material was achieved through equipment tracking during placement. Above ground upstream bedding material placed at 3H:1V and on top of the upper GCL was done so by casting material into place with the 325 or 345 excavators and then spread (pushing upslope) with use of the 287C skid steer working on a minimum lift thickness of 300 mm or by pulling material upslope with use of the 345 excavator as was done on the upstream key trench slope. Compaction of this material was achieved through bucket tamping and tracking with the 287C skid steer only as larger equipment access was not permitted.

5.6 Placement of Transition Material

Transition material was placed with CAT 325 and 345 excavators and CAT D6 and D8 bulldozers. Transition material was generally placed as a single 500 mm lift or maximum lifts of this same thickness when total material thickness was greater than 0.5 m. The first lift of Transition material placed within the key trench, and above bedding material, was done so by casting material into place with an excavator as no access with heavy equipment was permitted until an approximate minimum cover of 0.8 m was achieved on top of the GCL panels (i.e. following the first lift of transition material). Compaction of the horizontal Transition material placed in the key trench was achieved using a 10-tonne vibratory compactor however the vibration function was generally turned off to compact material in this area immediately above the lower GCL panels. Compaction of Transition material placed on the 2H:1V upstream slope of the key trench was achieved through bucket tamping and equipment tracking initially and was subject to further secondary compaction as successive horizontal lifts of ROQ material were placed and compacted with the vibratory drum compactor in the key trench.

Above ground Transition material on the 3H:1V upstream slope was placed in a single lift along the slope. Material was advanced by pushing upslope with the dozers such that the machine was always operating on a minimum total material thickness of approximately 0.8 m when working above the GCL panels. Compaction of this material was achieved by tracking with the dozers as

access on the 3H:1V slope was not possible for the vibratory compactor. Transition material placed horizontally above ROQ material and placed on the dam crest was subject to compaction by the 10-tonne vibratory compactor.

5.7 Placement of ROQ Material

The ROQ material produced in Quarry #2 was sorted in the quarry with the CAT 385 excavator and subsequently loaded into the CAT 725 and 740 haul trucks using this same machine or using the CAT 988 loader. Placement was generally done by end dumping and pushing with a CAT D6 or CAT D8 bulldozer. The lift thickness was maintained to a maximum of 1.85 m at all times, and each lift was compacted using the vibratory compactor and/or by loaded haul trucks using the area as a trafficking surface.

The first areas covered with ROQ were the outer footprint of the dam shell upstream of the key trench along the entire dam length, and a select portion downstream of the key trench between approximate stations 2+90 and 4+20, to create trafficable access for heavy equipment. Prior to any material placement directly on tundra, the surface was prepared for fill placement in accordance with the clearing and foundation preparation specifications detailed in Appendix E.

The final upstream 4H:1V slope of the dam shell was graded and shaped using CAT 325 and 345 excavators, and subsequently compacted using the vibratory compactor.

Transition material was used in place of ROQ material in select locations of the key trench backfill and above ground fill. This material substitution was generally a result of intermittent deficiencies of ROQ material dependent upon the blast schedule in Quarry #2. This substitution does not change the design intent of the dam.

5.8 Instrumentation

5.8.1 General

Instruments were installed to monitor the performance of the Phase 1 South Dam. Most of the instrumentation was installed during construction, or immediately following construction. The instrumentation comprises of the following:

- Ground temperature cables;
- Surficial, fixed (shallow), and deep settlement monitoring points; and
- A telemetry data acquisition system manufactured by Beaded Stream.

Details of each instrument type are presented in the following sections.

5.8.2 Ground Temperature Cables

A series of ground temperature cables (GTCs) were installed in the foundation of the dam and on top of the GCL system (above and below ground) to monitor the temperature of: the permafrost foundation, the upstream key trench slope, and within the above ground fill materials. All installed cables were digital temperature cables (DTCs) that were manufactured by Beaded Stream. The

cables location, bead distribution, and cable length are provided in the IFC drawings DN-SD-27 to DN-SD-29 (Appendix D) and Appendix K.

Following installation, cables were typically read approximately daily during construction to ensure they had not been subsequently damaged, and to monitor the associated temperature regimes.

One of the GTCs was damaged during construction (cable SD-HTS-155-KT). Multiple other GTCs were damaged by wildlife (chewed) following the completion of construction and before installation of the final cable protection and telemetry system in November 2018. Damaged GTCs were spliced by TMAC's onsite mill instrumentation personnel. Although all wildlife damaged cables were attempted to be fixes, some of the cables were still not fully operational at the time of writing this report. Table 5-3: provides a status summary of each GTC.

Table 5-3: Ground Temperature Cable Status Summary

String #	GTC Designation	Serial Number	Station	Status	Comments
2	SD-VTS-65-KTC	3259	0+65	Active	Functioning. Cable was damaged following completion of construction and was repaired.
3	SD-HTS-065-US	3263	0+65	Active	Functioning. Cable was damaged following completion of construction and was repaired.
4	SD-VTS-155-KTC	3251	1+55	Active	Functioning.
5	SD-VTS-155-UST	3272	1+55	Active	Only the top bead working (as of November 2018)
6	SD-VTS-155-DST	3264	1+55	Active	Functioning
7	SD-HTS-155-US	3266	1+55	Active	Functioning
8	SD-HTS-155-KT	3253	1+55	Inactive	Damaged. Permanently disabled after being damaged during construction.
11	SD-VTS-240-KTC	3255	2+40	Active	Functioning
12	SD-VTS-240-UST	3268	2+40	Inactive	Originally was functioning but stopped telemetry transmission on November 25 2018)
13	SD-VTS-240-DST	3265	2+40	Active	Functioning
14	SD-HTS-240-US	3269	2+40	Active	Functioning
15	SD-HTS-240-KT	3254	2+40	Active	Functioning. Cable ID 3254 was used in place of cable ID 3256.
16	SD-VTS-365-KTC	3258	3+65	Inactive	Cable was damaged following completion of construction. Repaired once but was not operating as of November 2018.

String #	GTC Designation	Serial Number	Station	Status	Comments
17	SD-VTS-365-UST	3270	3+65	Active	Functioning. Cable was damaged following completion of construction and was repaired. One damaged bead (second form top) was required to be removed during construction.
18	SD-VTS-365-DST	3275	3+65	Active	Functioning.
19	SD-HTS-365-US	3271	3+65	Active	Functioning.
20	SD-HTS-365-KT	3257	3+65	Active	Functioning. Cable was damaged following completion of construction and was repaired.
21	SD-VTS-460-KTC	3252	4+60	Active	Functioning.
22	SD-VTS-460-UST	3273	4+60	Active	Cable was damaged following completion of construction and was repaired.
23	SD-VTS-460-DST	3276	4+60	Active	Functioning.
24	SD-HTS-460-US	3267	4+60	Inactive	Cable was damaged following completion of construction and could not be repaired.
25	SD-HTS-460-KT	3256	4+60	Active	Functioning. Cable ID 3256 was used in place of cable ID 3254.
26	SD-VTS-510-KTC	3260	5+10	Active	Functioning.
27	SD-HTS-510-US	3274	5+10	Inactive	Cable was damaged following completion of construction and was repaired. Briefly active during November 2018 then damaged again by wildlife. Likely can be repaired in Spring 2019.
29	SD-VTS-US1	3197	3+35	Active	Installed within a suspected wedge of ground ice near the upstream toe. (SD-VTS-US1 (serial # 3197) corresponds to serial # 2841 on the build sheet – Appendix K).
30	SD-VTS-US2	3189	3+35	Active	Installed within a suspected wedge of ground ice near the upstream toe. (SD-VTS-US2 (serial # 3189) corresponds to serial number 2839 on the build sheet – Appendix K).
9	SD-HST-B1-KT	3261	n/a	Active	Installation location modified as discussed in Section 3.7.1

Note(s)
* GTC grouped by monitoring section perpendicular to the dam axis

5.8.2.1 Vertical GTC Installation

Installation of the vertical GTCs beneath the base of the key trench was performed following key trench excavation and prior to deployment of the below ground GCL panels. Vertical GTCs installed at the upstream and downstream dam toes was done following the completion of construction. Boreholes drilled to house the vertical GTCs were completed following the same

methods as the percolation testing holes. Samples were typically collected for soil logging and moisture content testing. This testing was performed by EBA in their Yellowknife, NWT laboratory, results are discussed in Section 6.2.

As mentioned in Section 3.6.1, backfilling the annulus around the cables was done using a combination of dry bedding material and water, as opposed to the wet slurry incorporating manufactured fines as specified in the Technical Specifications (Appendix E). The lead cables were bundled up and protected within wooden boxes constructed by the liner contractor. These boxes were painted with highly visible paint and constructed of appropriate dimensions to be obvious to operators working in the area. The wooden protection boxes were initially stationary near the upstream crest of the key trench, but their location was advanced towards the north as placement of above ground (upstream) dam fill material proceeded. As the boxes were shifted north, the lead cables were carefully backfilled and encapsulated within the dam fill. Following completion of above ground upstream transition material, a short portion of all cables near the upstream toe of the Transition material were encased in hard wall HDPE pipe and buried in shallow trenches within the ROQ material previously placed for heavy equipment access. The remainder of the cable leads which exited the pipe at the ultimate upstream toe were then embedded in shallow trenches on the upstream face and subsequently in shallow trenches on the crest parallel to the dam. These trenches were backfilled with approximately 0.5 m of bedding material for cable protection. Cables were then connected to the telemetry system at the fixed monitoring stations. In most cases, extension cables were spliced to the original cable lead so that the GTC was long enough to reach its associated fixed monitoring station.

As mentioned in Section 3.6.1, two additional GTCs were installed to monitor ground temperatures in an area inferred from the field reconnaissance to contain a massive ice wedge (see Appendix G.3 for additional details).

5.8.2.2 Inclined GTC Installation

The inclined GTCs were installed at the design stations and positioned by laying out the cables on top of the GTC panel beneath and covering them with bedding material as construction proceeded. The cables were typically backfilled with a small portion of bedding material by hand prior to final backfill with use of heavier equipment. The location of cables was well delineated, and operators were made aware of there existence prior to placing the remainder of bedding material. The lead cables of the inclined GTCs were protected and routed to the fixed monitoring stations on the dam crest in the same way as the vertical cable leads discussed in Section 5.8.2.1.

5.8.3 Settlement Monitoring Instrumentation

Three types of settlement monitoring points were planned to be installed within the Phase 1 South Dam as follows:

- Twenty-six surficial survey monitoring points installed in ROQ boulders placed in a grid pattern on the dam crest and the downstream face of the dam. These will monitor larger scale deformation of the dam shell. These monitoring points were not yet installed at the time

this as-built report was compiled. It is expected that these will be installed after snow melt in 2019.

- Six fixed (shallow) survey monitoring points installed at the upstream crest of the dam on top of the GCL system to monitor any movement of the GCL and dam fill materials below. Six additional fixed survey monitoring points installed at the downstream crest of the dam on top of the ROQ material to monitor any movement of the downstream ROQ material. These were installed in 2018.
- Three deep settlement points installed approximately 0.5 m into the original ground below the ROQ shell and near the base of the pre-construction active layer. These settlement points were installed in 2018 are located on the downstream side of the dam at stations 2+90, 3+40 and 3+80. These will be used to monitor movement of the foundation materials of the dam.

Complete details of these installations are described in the following sections.

5.8.3.1 Surficial Survey Monitoring Points

Upon completion of dam shell construction, surficial survey points were marked for installation in a grid pattern on the dam crest and 2H:1V downstream slope of the dam as shown on as-built drawing DN-SD-21 (Appendix H). The location of the surficial monuments on the downstream face were adjusted to accommodate existing boulder that presented a flat stable surface.

Surficial monuments at the crest were marked on specially placed 1m-size boulders. These were placed in an excavation and backfilled with ROQ materials in a way that a flat side of the boulder remains at the surface (see Photo 5 and 6 in construction daily report #168, Appendix B).

Expansion bolts were started to be installed in accordance with the IFC drawings (Appendix D.1) at the marked boulder to act as surficial survey monitoring points. At the time this report was completed, the expansion bolts had only been installed in a few locations along the crest and the points down the downstream slopes till remained / were not yet installed The surficial survey monitoring points should be revisited in the summer of 2019 (after the snow has melted) and a full survey pick-up of all points should be completed.

5.8.3.2 Fixed Survey Monitoring Points

Locations of the shallow survey monitoring points, located along the upstream and downstream crest of the Phase 1 South Dam, are shown on as-built drawing DN-SD-21 (Appendix H). The survey monuments were manufactured on-site, based to the specifications detailed on IFC drawing DN-SD-30 (Appendix D.1). The following adjustments were made regarding the original details:

- The steel rods were built to an effective length of 2.0m;
- The length of the outer pipe was adjusted to 2.2m; and
- The supporting 0.5m x 0.5m steel plates were installed at 1.7m bellow the crest elevation.

These adjustments are indicated on as-built drawing DN-SD-30 (Appendix H).

Installation of the monitoring points was performed after the dam was constructed to its final elevation (38.0 m). Previously placed ROQ and Transition material was excavated to the required depth and compacted bedding material was placed to provide a levelling course. The monitoring point base and rod were installed, and then compacted bedding material was placed around the rod prior to the installation of the 102 mm (4 inch) housing. The excavation was backfilled with ROQ material placed in lifts and compacted manually with a plate tamper (see Photos 3, 4, 5 and 6 in construction daily report #167, Appendix B).

5.8.3.3 Deep Survey Monitoring Points

The casings for the deep settlement points were also installed after construction of the dam was completed. These settlement points are located along the downstream crest of the dam, at stations 3+80 (D1), 3+40 (D2), and 2+90 (D3), as shown on as-built drawing DN-SD-21 (Appendix H).

The Sandvik DX-800 air drill operated by McCaw North was used to facilitate installation of the deep settlement instruments.

The deep settlement point casings were installed to a depth as to terminate approximately 0.5 m below the original ground surface. The characteristics of the casings are as follows:

- Monitoring Point D1: 102mm (4in) diameter and 7.5m length steel pipe. The bottom of pipe was placed at 6.2m below the dam crest, or an approximate elevation of 31.8 m.
- Monitoring Point D2: 51mm (2in) diameter and 8.5m length HDPE pipe. The bottom of the pipe is located approximately at 8.0m below the crest of the dam, or an approximate elevation of 30.0 m.
- Monitoring Point D3: 102mm (4in) diameter and 8.5m length steel pipe. The bottom is at 7.5m below the crest of the dam. The casing was partially backfilled with gravel, so that there is 6.4m of free length inside the pipe. In other words, the bottom of the outer steel casing is at an approximate elevation of 30.5 m and the inner pipe will terminate on top of the gravel at an approximate elevation of 32.6 m (estimated as approximately 1 m above the original ground surface).

At the time this report was completed, the inner pipes were not yet installed. When these inner monitoring pipes are installed, they are to adhere to the details outlined on IFC drawing DN-SD-30 (Appendix D.1).

5.8.4 Telemetry Data Acquisition System

Four dataloggers were installed at the South Dam. These data loggers were all manufactured by Beaded Stream and are powered by an internal battery that is charged from solar panels on each unit. Appendix K provides additional details on the D505 Beaded stream data loggers that were installed on site. These data loggers log the data internally and also have the ability to transmit readings (every 12hrs) remotely via worldwide telemetry. The telemetry is run through a two-way satellite transceiver and Iridium antenna. These dataloggers have an operating range of -40°C to +85°C.

6 Quality Assurance and Quality Control Testing

6.1 General

Quality Assurance (QA) and Quality Control (QC) testing for the Phase 1 South Dam was generally done in accordance with the Technical Specifications (Appendix E). Minor deviations from the Technical Specifications were incorporated during construction, as discussed in Section 3.9. SRK was responsible for the QA testing while Nuna and TMAC assumed responsibly for QC testing of dam fill materials and BBG assumed responsibility for QC testing of GCL and the fly-ash mix material.

A total of 72 QC laboratory tests and 23 QA laboratory tests were performed during construction of the Phase 1 South Dam. The majority of those were analyzed off-site. The exception to this was that approximately 163 QA samples from the percolation testing program were logged and tested for moisture contents on site by SRK.

Appendix L contains the results of the performed testing, and all the corresponding laboratory test certificates.

6.2 Foundation Testing

6.2.1 Salinity and Moisture Content

Salinity testing was performed on select samples collected from boreholes that were drilled during the percolation testing program. These samples were analyzed by EBA, in their Edmonton, AB laboratory, using the Refractometer method. A total of 36 tests were performed, with salinity values ranging between 0.3 and 11.7 parts per thousand (ppt). Test certificates are contained in Appendix L. These results did not suggest the presence of any highly saline foundation soils, when compared with the North Dam foundation for example.

Moisture content testing was also performed on all samples collected during the percolation testing program, as well as on samples collected during installation of the vertical GTCs. Results of the moisture content testing were used to infer the ice saturation of the foundation materials. Results specific to the percolation testing program were used in conjunction with results of the percolation testing to optimize the key trench excavation design, as discussed in Section 3.2.

6.2.1.1 Percolation Testing

The percolation test program comprised of 34 boreholes and was done in accordance with the methods detailed in the Technical Specifications (Appendix E). Complete details are provided in Section 5.3.1 and the results are presented in Appendix J. Results of this program confirmed that the extent of key trench excavation resides within competent ice saturated soil or bedrock.

6.2.1.2 Ground Temperature

Following installation of the GTCs, each cable was typically read daily to monitor ground temperatures as construction progressed. Readings were obtained between April 17, 2018 and July 16, 2018. This data is not presented herein as it was collected for construction purposes and

does not represent the temperature regime that will now be present following placement of all above ground dam fill. GTCs were not read following SRK's departure from site on July 16 until installation of the telemetry system installed the week of November 1, 2018 (discussed in Section 5.8.4). Additional details on the site QA instrumentation checks are provided in the SRK daily reports in Appendix B.

6.3 Particle Size Distribution Testing

Particle size distribution testing performed during construction of the Phase 1 South Dam is discussed in the sections below. The results of all tests carried out are summarized in Figures 2 and 3 for the bedding and fly-ash mix materials respectively. All laboratory test certificates are also incorporated in Appendix L.

6.3.1 Fly Ash Mixture Material

Prior to mixing each individual 4:1:1 (4 parts aggregate to part fly-ash to 1 part cement), at least two samples each of the aggregate and fly-ash were to be collected by BBG for QC PSD testing. Furthermore, BBG was to collect at least two completely mixed QC samples of the 4:1:1 blend for each batch mixed. Fourteen total batches were mixed. A total of 16 aggregate samples, 18 fly-ash samples, and 18 fully mixed QC samples were collected. Therefore roughly two thirds of the originally specified QC samples were collected.

SRK was also to collect at least one completely mixed QA sample of the 4:1:1 blend following its placement in the key trench at the Phase 1 South Dam. Overall SRK collected a total of thirteen completely mixed samples. This increased QA testing was used to help make up for the slight deficiency in the QC sampling and testing frequenting to confirm the material suitability.

The PSD results of all samples collected fly ash mixture samples meet specifications (See Figure 3).

6.3.2 Bedding Material

PSD tests were performed on samples of bedding material taken from the stockpile in Quarry #2 or from the in-place material from the Phase 1 South Dam footprint. This was done in accordance with the Technical Specifications (Appendix E).

The technical specifications state that one QC sample is to be collected by Nuna for every 1,000 m^3 produced and that one QA sample is to be collected by SRK for every 2,000 m^3 produced. A total of 12 QC samples and 4 QA samples were collected which meets the required sampling frequency for the total estimated bedding material production volume of 9,000 m^3. The tested sample PSD results indicate that the bedding material was consistently within the specified range except for one isolated sample which was slightly outside of the lower limit (See Figure 2).

6.3.3 Transition Material

As mentioned in Section 3.9, PSD testing was not completed in accordance with ASTM procedures outlined for on transition material. This was mainly due the very coarse gradation of this material that made completing this testing to the outlined ASTM standard difficult. An

improvised PSD field test was completed by SRK on March 14, 2018. This test was generally performed by having an excavator place a representative selection of Transition material from the stockpile onto clean sheet of plywood. SRK then separated the material by approximate particle size so that estimations of gradation could be achieved and compared with the material specification in the Technical Specifications (Appendix E). Details and photographs of this field level PSD test are contained in Appendix L.

Furthermore, frequent visual QA inspections of the Transition material stockpile in Quarry #2 were performed by SRK as crushing progressed as well as at the Phase 1 South Dam following placement.

6.3.4 ROQ Material

In accordance with the Technical Specifications (Appendix E), visual inspection of the ROQ material was performed by SRK, both at Quarry #2, and during placement on the dam. Any oversize or deleterious materials were identified and removed.

6.4 Compaction

6.4.1 Standard Proctor Density Tests

Six samples of bedding material were collected, and proctor tested in accordance with ASTM D698. Results of this testing generally indicated that the as received moisture content was consistently lower than the optimum moisture content. The average ‘as received’ moisture content for the six bedding material samples was 1.2% and the average optimum moisture content was 5.5%. Results of the proctor testing are not summarized here as in-situ density testing was not performed, and instead field compaction trials / testing (Section 6.4.2) was carried out, and therefore the proctor results were not relied upon. Test certificates of provided in Appendix L.

6.4.2 Field Compaction Testing

As mentioned in Section 3.9, compaction testing was not performed on bedding material as was outlined in the Technical Specifications (Appendix E). Rather, a compaction trial was performed on bedding material on April 5, 2018 to assess the materials compact ability in relation to construction specifics and to develop a method specification for its placement. This compaction trial was performed using the 308 excavator in the base of the key trench. Results are therefore specific to horizontal bedding material placed in the key trench and above ground downstream material; and not for the bedding material placed on slopes and on top of GCL panels that were subject to bucket tamping (see Section 5.5).

For this trial, firstly an approximate 300 mm loose lift of bedding material was spread with the 308 excavator into a pad within the base of the key trench. This pad was approximately 4 m x 7 m. Sub-Arctic then laid out a grid of 18 survey points over the pad and collecting base readings. Survey points were laid out on an approximate 1 m grid. The 308 excavator then tracked back and forth over the pad with six individual passes (tracking back and forth over the pad once was considered two individual passes). The excavator operator ensured that tracking was performed over the entire surface area of the pad. Sub-Arctic then re-surveyed the points following six, and

twelve individual passes. This data was then forwarded to SRK to evaluate the change in elevation for each survey point following each set of six individual passes. Interpretation of the data revealed that the average change (decrease) in elevation was approximately 18 mm and the greatest change in elevation (decrease) at a single point was approximately 49 mm. These results suggest that little compaction of the material is achieved following initial placement and spreading of a 300 mm lift which is subsequently run over with the 308 excavator. Figure 4 displays the data collected by Sub-Arctic during completion of the compaction trial. Note that only survey points 1 to 5, 11, and 12 displayed a notable decrease in elevation during the trial.

6.5 GCL Liner

QA incorporated visual inspection of the GCL prior to deployment, as well as during installation. The liner rolls were inspected visually by the SRK site engineer to determine suitability (i.e., general state, signs of hydration, and obvious defects) prior to placement. The sub-grade was also visually inspected by SRK following detailed cleaning, preparation and installation of sacrificial GCL patches and panels. During placement each panel was carefully inspected, and, where defects or damage was noted, patches were installed, or the liner was rejected. The longitudinal seams between the successive panels were also inspected to ensure a minimum of 0.5 kg/m of bentonite powder was applied. In addition, the liner overlap flap was inspected to ensure that it was completed as per the design amendment (discussed in Section 3.4), and that the required application rates of bentonite powder were adhered to.

Following construction, BBG completed a Liner Construction Summary report documenting the installation and QC of the lower and upper GCL. This report is included as Appendix I and generally outlines:

- A brief project description;
- Details on the general installation procedures;
- Details on the repair/patching process;
- Details on QC procedures; and
- Details on roll handling and storage prior to installation.

The report also includes as attachments as-built liner layout drawings supplied by Sub-Arctic, QC documentation and sign off sheets (Appendix I), QC material testing results of the fly-ash mixture (in Appendix L), and QC photographs (In the Appendix B daily reports).

7 Long Term Monitoring

7.1 Context

The Phase 1 South Dam has been designed as a tailings retaining structure and its successful performance is dependent on maintaining the integrity of the frozen foundation through preservation of permafrost in the dam foundation. Differential settlement longitudinally and transversely across the dam is expected over the life of the structure. Monitoring of the structure's performance is critical to assess the extent of deformations and whether they are within the design limits of the dam.

7.2 Approach

Responsibility for undertaking the monitoring program as presented herein resides with TMAC, and the data will be reviewed annually by the Engineer-of-Record (EOR) as part of the Annual Geotechnical Inspection (AGI). It is recommended that the monitoring be carried out under the guidance of either the Engineer-of-Record for the Phase 1 South Dam, or alternately an independent qualified licensed Geotechnical Engineer.

7.3 Monitoring Elements

7.3.1 Thermal Monitoring

The underlying foundation of the Phase 1 South Dam has been designed to remain frozen for the life of the structure. The upstream edge of the key trench base should always be at a temperature of at least -2°C, while the underlying foundation soils must be a temperature of at least -8°C (SRK 2019). Fifteen active vertical GTCs are installed to monitor the foundation temperature, to an approximate depth of 15 m below the base of the key trench or original ground dependent on the cables installed location. An additional three active GTCs are installed directly above the lower GCL liner to monitor foundation temperatures within the key trench and five active GTCs are installed directly above the upper GCL liner to monitor temperatures within the above ground dam fill. A single horizontal GTC is installed directly above the liner overlap flap between approx. stations 2+45 and 4+25 to monitor temperature at the base of the structure. As-built GTC locations can be seen on as-built drawings DN-SD-23,24,25, and 26 in Appendix H.

All GTCs are connected to a telemetry system designed and manufactured by Beaded Stream. This system was discussed in Section 5.8.4 (see Appendix K for further details) which allows data collection hourly to the internal data logger, with separate telemetry readings being send twice a day (approx. every 12 hours).

7.3.2 Deformation Monitoring

The Phase 1 South Dam is expected to undergo deformation because of creep over its design life, which includes differential longitudinal and transverse settlement. A total of 41 survey monitoring points were installed within the structure to track these deformations such that it can be confirmed that they are within the specified design limits.

The installed monitoring points are illustrated on as-built drawing DN-SD-21, in Appendix H, and include the following:

- Three deep settlement points, located near the downstream crest of the dam, intended to track deformation of the foundation soils directly below the dam;
- Twenty-six surficial survey points, located at select locations on the crests and downstream shell of the dam, intended to track deformation the dam shell and/or the foundation soils dependent on their installation location; and
- Twelve crest survey monitoring points (fixed survey points). These are located along the crests of the dam, six of which are intended to monitor deformation below the upstream crest near the upper GCL liner contact and six intended to monitor deformation below the downstream crest near in the upper approximately 2 m of transition material.

7.3.3 Water Balance Monitoring

The Phase 1 South Dam is not designed to retain water. Monitoring of the water level can be done by monthly survey measurements of the water level in conjunction with the survey monitoring points. This water level in the reclaim pond (by the north eastern shore – location TIA-2) is currently being monitored by a pressure transducer and a data logger. This should continue to be maintained / used or a similar system kept in place. See the SRK North Dam SOP for additional details (SRK 2018). As specified in the deposition plan (SRK, 2019) ponded water should never encroach closer than 200 m from the upstream Phase 1 South Dam ROQ toe.

Dam seepage is not expected. However, if seepage is noted it must be monitored, including making an estimate of the flow and collection of a water sample for testing to confirm its origin.

7.3.4 Tailings Deposition Monitoring

Performance of the Phase 1 South Dam is directly dependent on adherence to the tailings deposition plan (SRK 2019) and specifically establishment of adequate tailings beaches from the structure. Annual ground surface and bathymetric surveys should be completed to confirm that deposition is consistent with the current plan. The deposition plan can be modified as necessary based on the annual data.

7.3.5 Visual Monitoring

A daily visual inspection must be carried out of the Phase 1 South Dam and all its components looking for obvious signs of geotechnical concern. A comprehensive visual inspection must be carried out as part of the AGI while a Dam Safety Review (DSR) must be completed in accordance with the CDA guidelines, at a frequency dependent on the dam hazard classification and the Canadian Dam Association (CDA) guidelines. It would be suggested that the next South Dam DSR be completed in 2021 as this is when the next North Dam DSR is expected and this will help to look at the TIA more as a whole system. A DSR is intended to re-assess the containment facility to validate the safety margin established for day-to-day operation, engineering practices, and legal and/or regulatory requirements. DSRs are completed by an independent review engineer that is not influenced by his or her prior participation in the design, construction, operation, maintenance, or inspection of the dams under review.

7.4 Summary of Monitoring Requirements

A summary of the monitoring requirements and associated responsibility is listed in Table 7-1. These monitoring requirements can be revised at any time under the direction of the Phase 1 South Dam Engineer-of-Record, or the qualified Licensed Geotechnical Engineer carrying out the AGI or DSR.

Table 7-1: Summary of Monitoring Requirements

Element	Item	Method	Responsibility	Frequency
Thermal	Ground Temperature Cables	Data Loggers	TMAC	Daily
Deformation	Deep Settlement	Manual	TMAC	Monthly (from May to November)
	Shallow Settlement	Manual	TMAC	Monthly (from May to November)
	Surficial Settlement	Manual	TMAC	Monthly (from May to November)
Water Balance	Water Level	Data Logger	TMAC	Daily
	Seepage Rate	Manual	TMAC	As Required
Tailings Deposition	Ground and Bathymetric Surveys	Manual	TMAC	Annually
Visual	Walkover Survey	Manual	TMAC	Daily
	Annual Geotechnical Inspection	Manual	Independent Qualified Licensed Geotechnical Engineer	Annually
	Dam Safety Review	Manual	Independent Qualified Licensed Geotechnical Engineer	In accordance with CDA Guidelines

8 Closure

The Phase 1 South Dam is one of two dams that currently make up the existing Tail Lake tailings impoundment area (TIA). The South Dam has been designed and successfully constructed to be a tailings retaining structure. The primary construction activities for the Phase 1 South Dam, and associated civil earthworks, occurred at the at Doris North site between January and July 2018. Final installation and repair of the Ground Temperature Cables (GTC) and telemetry datalogger systems was completed in November 2018 and revisited in February 2019. This report provides the as-built records for the Phase 1 South Dam.

The successful performance of the South Dam is dependent on maintaining the integrity of the frozen foundation through preservation of permafrost in the dam foundation. Monitoring of the structure's performance is critical to assess the extent of deformation, and thermal performance, to ensure all aspects are within the design limits.

At the time this as-built report was written the following items were outstanding:

- **Surficial Survey Monitoring Points**. These locations were marked in the field on selected boulders however bolts were not yet installed to allow for more reproducible survey pick-ups to be completed on the dam shell. These survey monitoring points should still be installed.
- **Deep Survey Monitoring Points.** The inner pipes/ rods of the deep monitoring point still have to be built and put in place. The following is expected to be required for the internal monitoring pipes:
  - D1 (3+80). This location has a 4''-diam steel casing. Need a inner 7.4m-long and 2"-diam PVC pipe with caps.
  - D2 (3+40). This location has a 2"diam HDPE casing. Need to install an inner 8.7m-long rod/rebar with a diameter between 20mm to 40mm.
  - D3 (2+90). This location has a 4''-diam steel casing. Need a 6.3m-long and 2''-diam PVC pipe with caps for this location.
  - The current covers on the top of the Deep Survey Monitoring points need to be replaced with more robust metal or plastic covers
- **Ground Temperature Cables**. There is at least one ground temperature cable that has been re-damaged by wildlife (chewed through). See section 5.8.2 for additional details. It is expected that in the snow free months this cable, and maybe two others, can be inspected and the damaged areas of the cable removed and re-spliced together.
- **East Upstream Dam Toe**. As seen in the SRK daily report (Appendix B) there is a small area near the upstream toe of the eastern dam abutment where water flow is preferentially channeling as it flows towards the center of the dam. It is suggested that coarse rock fill be placed over this area to limit the potential for increased thermal degradation at this location (as it is above the maximum Phase 1 tailings deposition elevation).

- **Crest Surfacing Material.** A final lift of surfacing material, on the order of 200 m^3 is suggested to be placed on the top crest of the dam, and on the turnaround. This final surfacing material would assist to create vehicle access over the top of the dam and assist with ensure that the monitoring system can be readily accessed.

These remaining items, as outlined in the bullets above, are suggested to all be addressed immediately after the 2019 snowmelt on site (i.e. around June 2019).

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9 References

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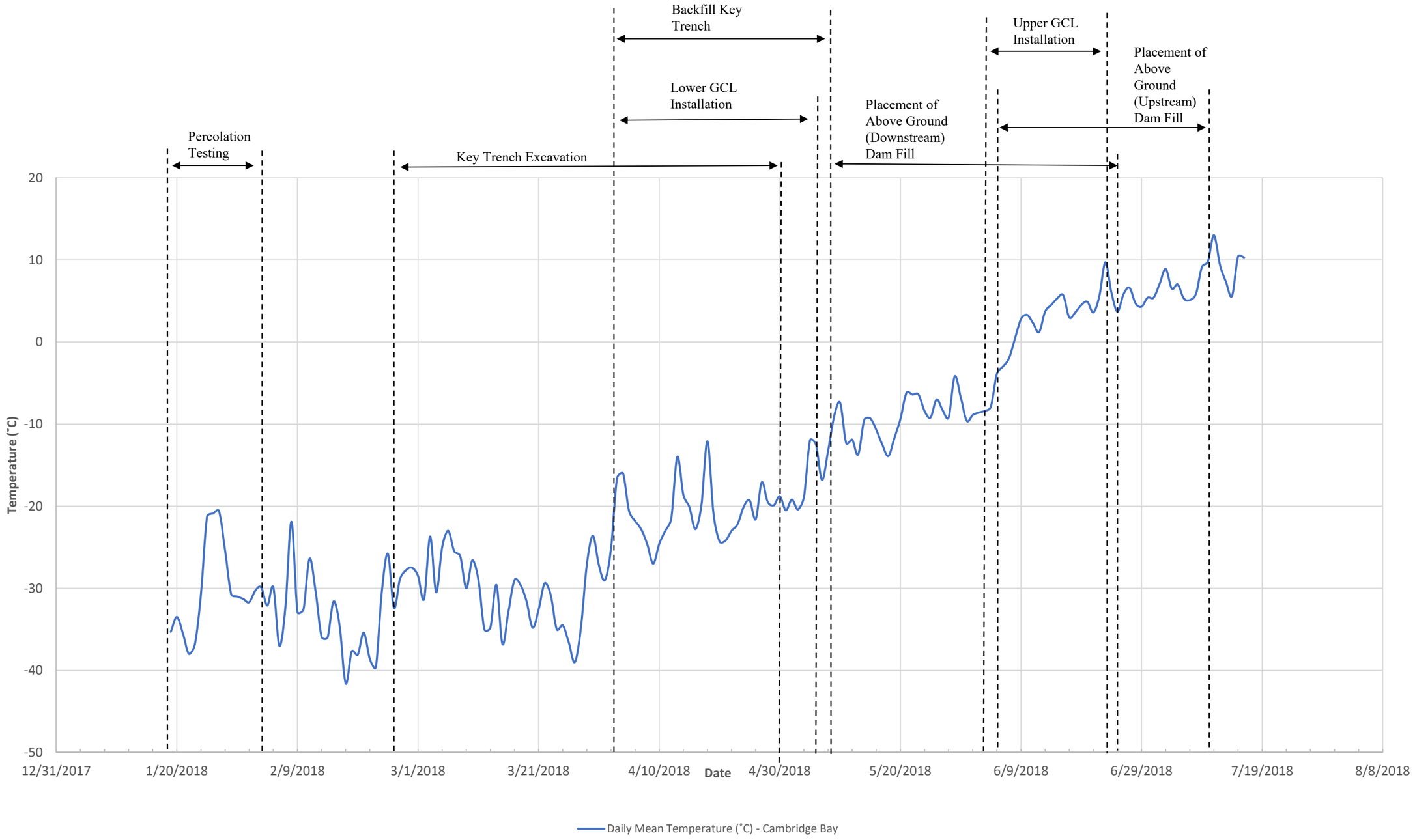
Figures



Note:

- Weather data obtained from the Canadian Government's Cambridge Bay, Nunavut, Canada Weather Station (Government of Canada, 2018)

srk consulting	TMAC RESOURCES	Phase 1 South Dam As-Built Report
		Construction Temperature Summary
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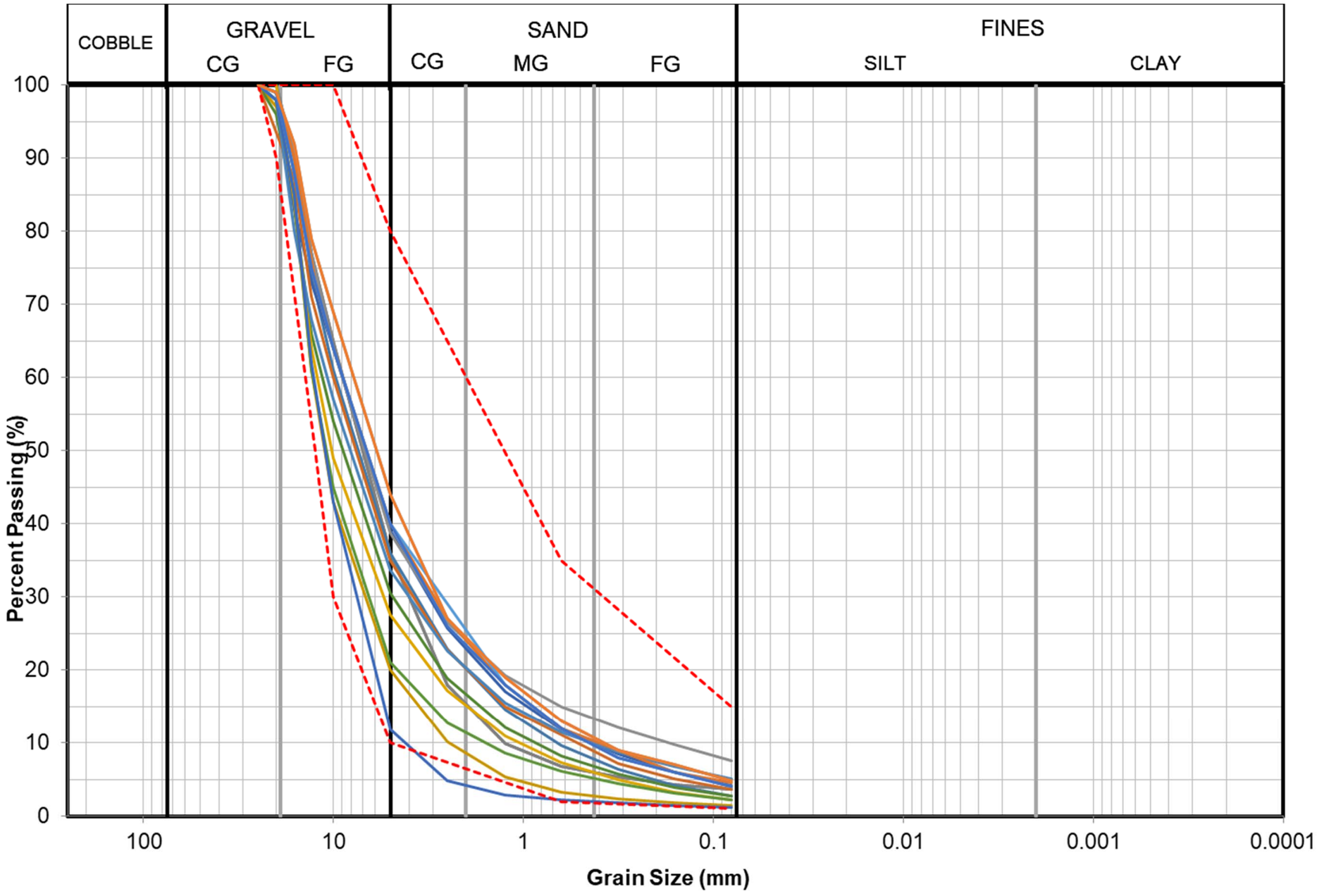
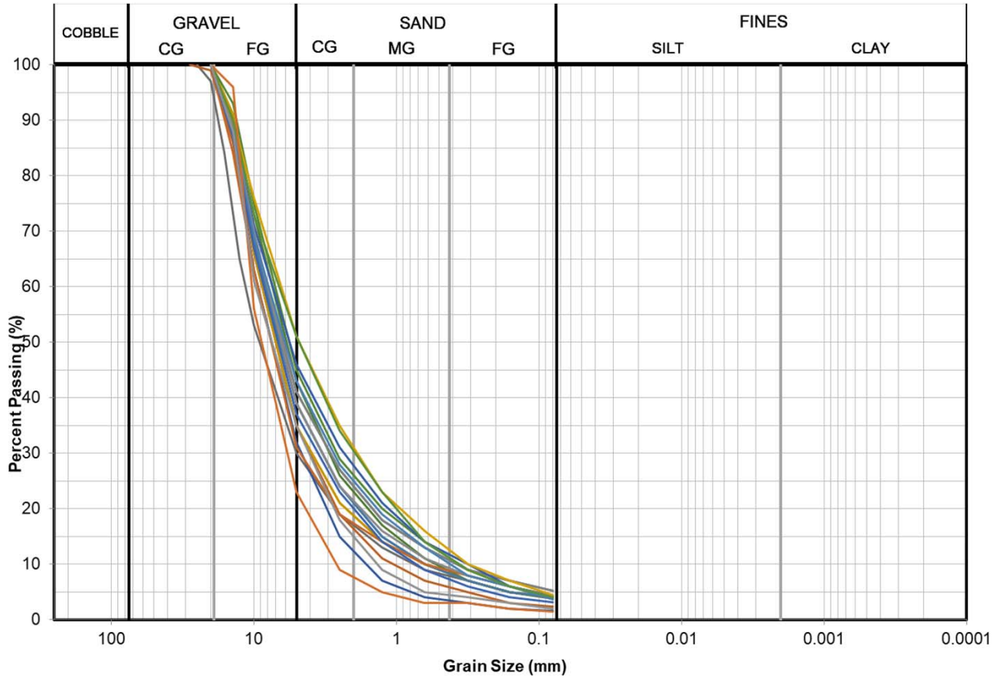
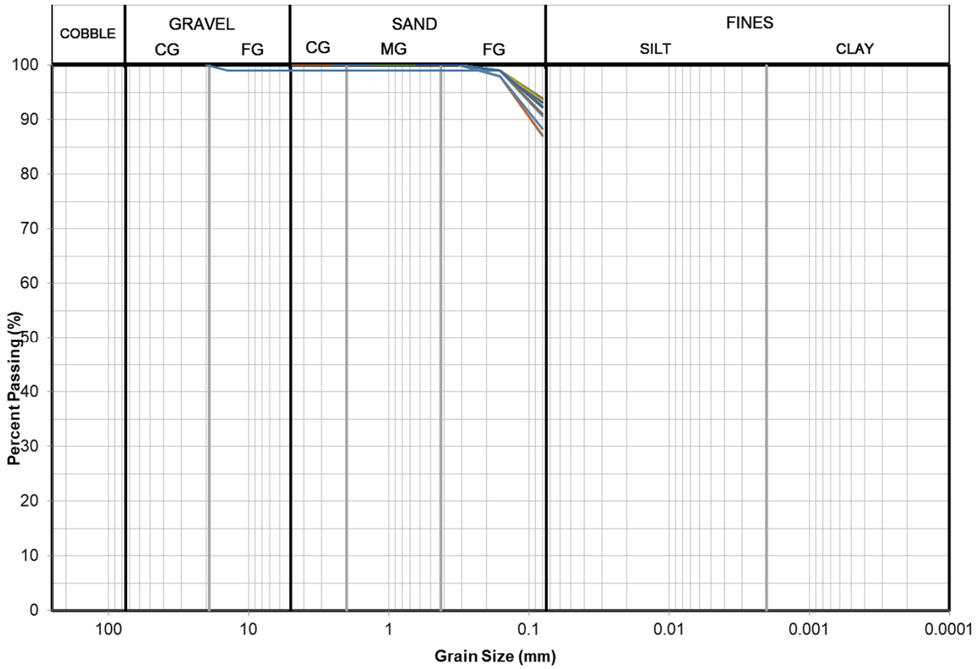


Note: Technical specification limits for bedding material are shown as red dashed lines

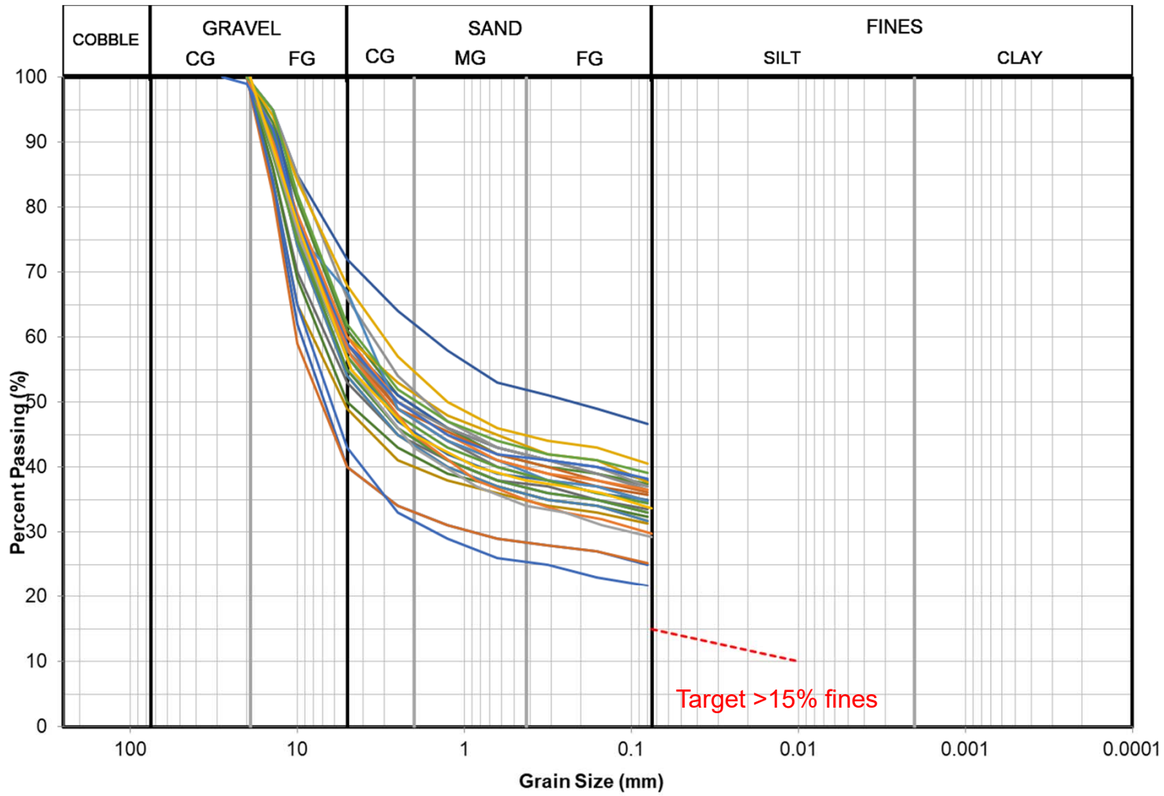
srk consulting	TMAC RESOURCES	Phase 1 South Dam As-Built Report
		Bedding Material Particle Size Distribution
Job No: 1CT022.031 Filename: Figures_REVA.pptx	TMAC Resources Inc.	Date: January 2019 / Approved: KK / Figure 2



Aggregate PSD

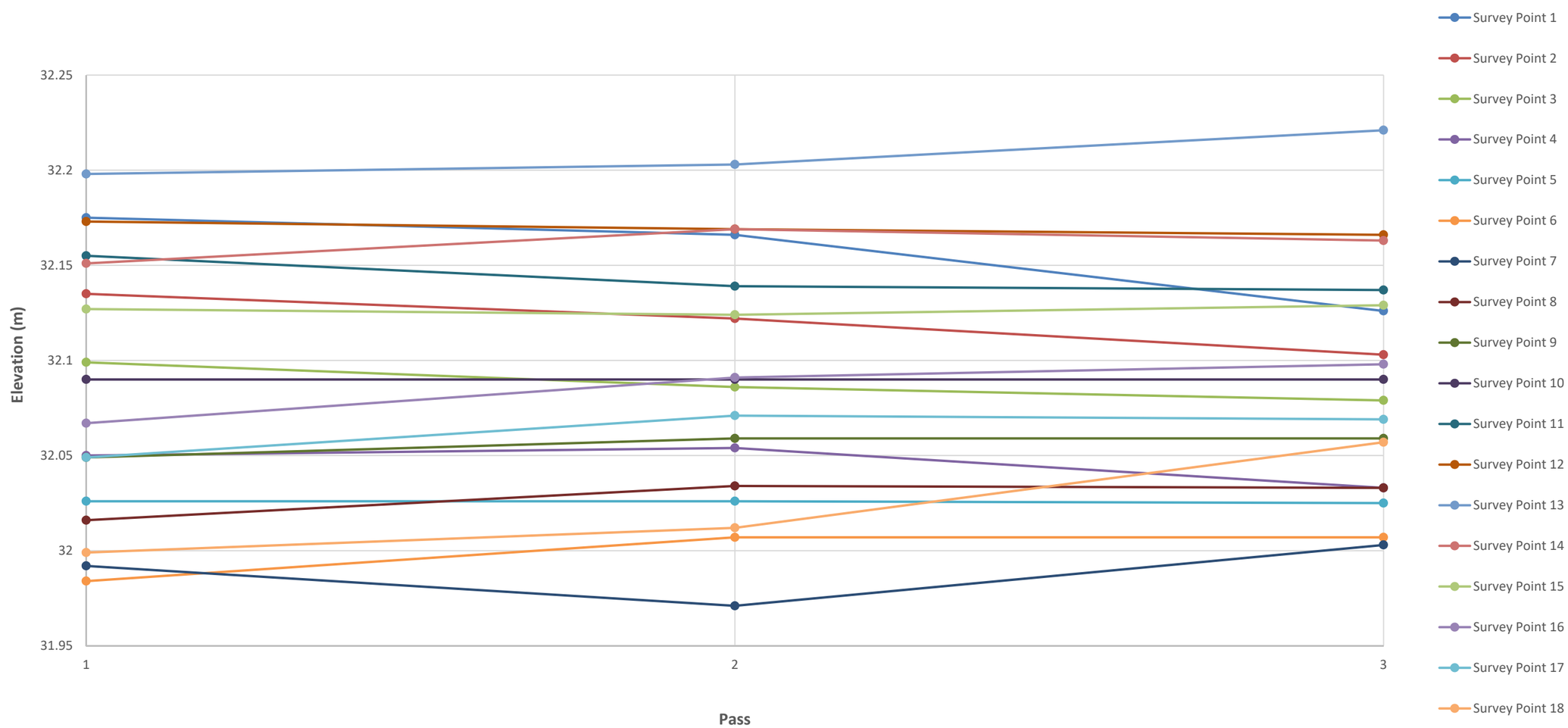


Fly-Ash PSD



Fly-Ash & Aggregate MIX PSD

srk consulting	TMAC RESOURCES	Phase 1 South Dam As-Built Report
		Fly-Ash Mix Material Particle Size Distributions
Job No: 1CT022.031 Filename: Figures_REVA.pptx	TMAC Resources Inc.	Date: January 2019 / Approved: KK / Figure 3



Note:

- Compaction trial completed on April 5, 2018

srk consulting	TMAC RESOURCES	Phase 1 South Dam As-Built Report
		Bedding Material Compaction Trial
Job No: 1CT022.031 Filename: Figures_REVA.pptx	TMAC Resources Inc.	Date: December 2018 / Approved: KRC / Figure 4

Appendix A – Detailed Timeline

Phase 1 South Dam Construction Timeline

Construction Activities	Start Date	End Date	Comments
SRK Mobilization and Demobilization from Site	January 19	July 16	Last construction daily report on July 16, 2018
Percolation Drilling and Testing Program within the Phase 1 Dam Footprint	January 19	February 2	34 percolation boreholes drilled and tested as part of the program.
On-Site Lab Testing	January 27	February 3	Approximately 163 samples from the Percolation Drilling and Testing Program logged and tested for moisture content on-site by SRK. Remaining 184 samples were tested off-site by EBA.
Geotechnical Infill Drilling	January 26	February 17	7 boreholes (SRK18-STH-05 to SRK18-STH-11) drilled beneath the Phase 1 South Dam footprint. 4 boreholes (SRK18-STH-DH-01 to SRK18-STH-DH04) drilled beneath the Phase 2 South Dam footprint. Samples collected and select boreholes in the Phase 2 footprint received GTCs.
Snow clearing Activities	February 5	June 7	Snow clearing for access roads, key trench excavation, snow drifted into the key trench or onto placed materials, and large masses of snow for construction of temporary deposition berm and windrow.
Crusher Operation	February 16	July 1	
Crushing Bedding	17 days		
Crushing Transition	59 days		
Crusher Out of Service	53 days		Crusher was out of service for maintenance, lack of personnel to operate, lack of available ROQ, and limited equipment to haul crusher feed.
Key trench excavation	February 25	April 30	Includes excavation of material from blasting, ripping, and bucket excavation.
McCaw North Drilling and Blasting	March 5	July 14	
Key trench	March 5	April 3	
Quarry #2	April 6	June 13	

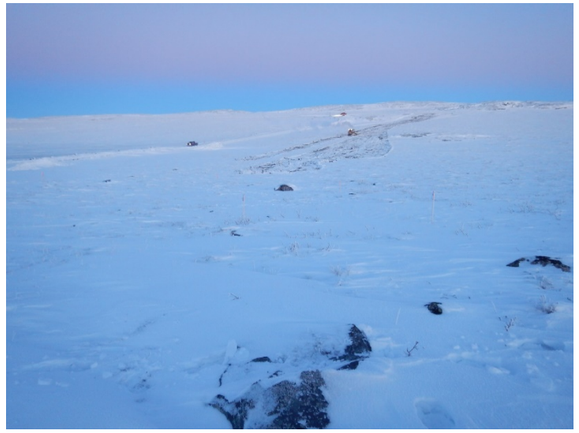
Construction Activities	Start Date	End Date	Comments
Vertical GTCs upstream of Phase 1 dam in suspected ground ice wedge	May 22	May 26	
Vertical GTCs	July 13	July 14	GTCs installed at the upstream and downstream toes. Vertical GTCs installed in the base of the key trench completed during key trench excavation (Feb 25 – Apr 30, 2018).
Delineation of Massive Ice and Ice Rich Material	March 9	April 16	Massive ice and ice rich deposits in key trench were documented, photographed, and surveyed.
Overburden Dump Placement and Grading	March 10	June 5	
Placement of Material in the Overburden Dump	March 10	May 6	Includes temporary usage of overburden dump to store materials used for construction of South Dam.
Grading Dump to Design Elevation (<33 masl)	May 13	June 5	
Installing Ground Temperature Cables	March 27	July 15	
SD-VTS-065-KTC	April 17	April 17	
SD-VTS-155-KTC	March 30	March 30	
SD-HTS-155-KT	April 6	April 6	Damaged on June 16 and subsequently abandoned
SD-VTS-240-KTC	April 14	April 14	
SD-HTC-240-KT	April 14	April 14	
SD-VTS-365-KTC	April 22	April 22	
SD-HST-365-KT	April 23	April 23	
SD-VTS-460-KTC	April 30	April 30	
SD-HST-460-KT	May 3	May 3	
SD-VTS-510-KTC	May 5	May 5	
SD-HST-B1-KT	June 3	June 3	
SD-VTS-US1	May 23	May 23	
SD-VTS-US2	May 23	May 23	
SD-HTS-365-UST	June 2	June 2	
SD-HTS-240-US	June 13	June 13	
SD-HTS-155-US	June 17	June 17	
SD-HTS-065-US	June 20	June 20	
SD-HTS-460-US	June 27	June 27	Installation date not clear

Construction Activities	Start Date	End Date	Comments
SD-HTS-510-US	June 27	June 27	Installation date not clear
SD-VTS-240-UST	July 13	July 13	
SD-VTS-155-DST	July 13	July 13	
SD-VTS-240-DST	July 13	July 13	
SD-VTS-460-UST	July 14	July 14	
SD-VTS-460-DST	July 14	July 14	
SD-VTS-365-UST	July 14	July 14	
SD-VTS-365-DST	July 14	July 14	
Construction and Deconstruction of Access Ramps into the Key Trench	March 18	June 11	Multiple temporary access ramps were constructed and de-constructed as needed.
Detailed Upstream Key Trench Slope and Key Trench Base Cleaning	March 25	May 7	Involved air lancing, brushing with broom, manual shoveling, and skid steer equipped with rotating brush.
Subgrade Preparation for Key Trench Liner Installation	April 1	May 7	
Key Trench Liner Installation (Lower GCL)	April 2	May 7	
Backfill Key Trench (Below Original Ground Surface Dam Fill)	April 2	May 9	
Bedding	April 2	May 3	
Transition	April 6	May 8	
ROQ	April 11	May 9	
Compaction Trials	April 5	April 29	First compaction trial on bedding material (April 5, 2018); Second and third compaction trials on transition material (April 25/29, 2018).
Reading Ground Temperature Cables	April 17	July 16	GTCs were read once daily to monitor cable function and ground temperatures.
Above Original Ground Surface Material Placement (Downstream)	May 9	June 26	
Bedding	May 29	June 26	
Transition	May 9	June 25	
ROQ	May 9	June 9	
Temporary Deposition Berm Construction Activities	May 11	May 28	Includes clearing of accumulated snow and placement of material.

Construction Activities	Start Date	End Date	Comments
Documentation and Management of Ponded Water Upstream of Dam Toe	May 18	July 16	Water management involved excavation of select shallow water diversion swales and continued pumping of ponded water into the TIA.
Windrow Construction Activities	May 19	May 23	Involves staking the windrow extents, excavation of snow/tailings, and placement of material.
East Access Road Construction Activities	May 22	May 30	
Construction of GCL Anchor Trench	June 1	June 25	
Above Original Ground Surface Liner Placement (Upper GCL)	June 3	June 25	
Above Original Ground Surface Material Placement (Upstream)	June 4	July 10	
Bedding	June 4	June 26	
Transition	June 12	July 1	
ROQ	June 24	July 10	
West Turnaround Construction Activities	July 5	July 6	Original staking of turnaround area on June 7 was incorrect.
Tailings Discharged into the TIA from Temporary Deposition Berm	June 10	July 16	First occurrence of tailings and water recirculating to the South of the temporary deposition berm on June 28.
Installation of Fixed Survey Monitoring Points	July 11	July 12	
Installation of Surficial Monitoring Points	July 12	July 12	
Installation of Deep Monitoring Points	July 14	July 16	

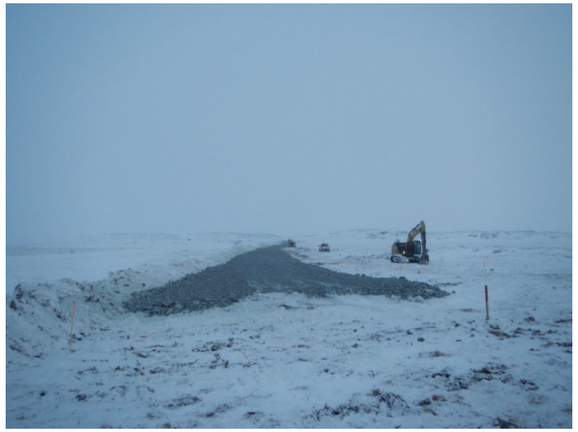
Appendix B – Daily Reports

Appendix C – Photographic Record

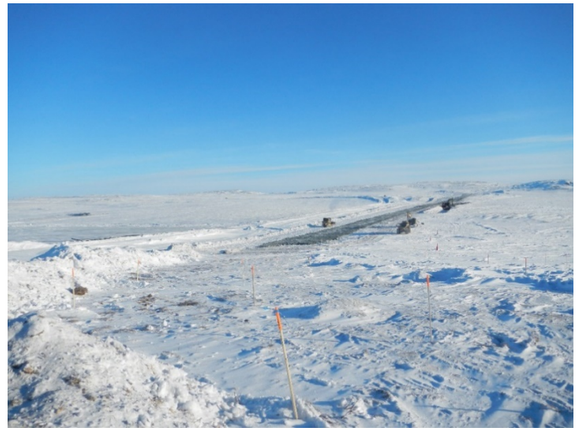


South Dam construction progress January 20, 2018

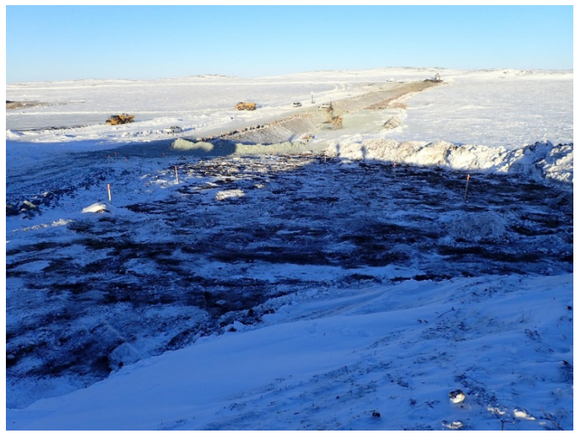
South Dam construction progress February 25, 2018



South Dam construction progress February 27, 2018



South Dam construction progress February 28, 2018



South Dam construction progress March 14, 2018

South Dam construction progress April 7, 2018

South Dam construction progress April 9, 2018

South Dam construction progress May 9, 2018

srk consulting

TMAC RESOURCES

South Dam As-Built Report

Overview (1 of 2)

Job No: 1CT022.31_2018

Filename: Figure 1_Overview_1CT022.31.pptx

Hope Bay Project

Date:	Approved:	Figure:
Dec 2018	KNK	**1**

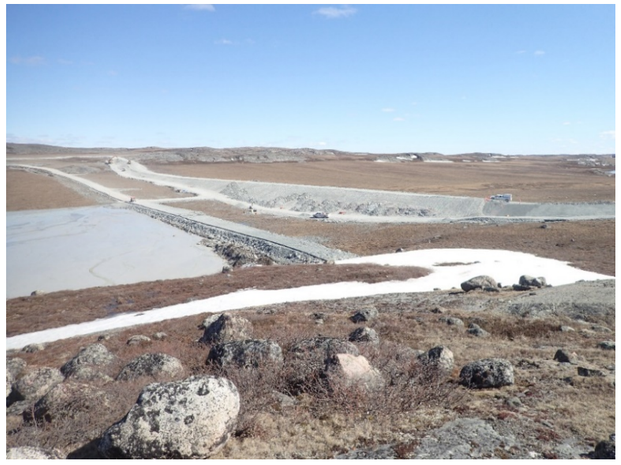
South Dam construction progress May 14, 2018

South Dam construction progress May 29, 2018

South Dam construction progress May 29, 2018

South Dam construction progress June 6, 2018

South Dam construction progress June 15, 2018



South Dam construction progress June 22, 2018

South Dam construction progress June 25, 2018

South Dam construction progress July 7, 2018

srk consulting	MAC RESOURCES	South Dam As-Built Report
		Overview (2 of 2)
Job No: 1CT022.31_2018 Filename: Figure 2_Overview_1CT022.31.pptx	Hope Bay Project	Date: Dec 2018 / Approved: KNK / Figure: **2**

Clearing snow from the dam footprint upstream of the key trench facing west February 25, 2018

Area cleared approx. 1m beyond the upstream toe of the dam February 26, 2018

Tundra beneath dam footprint cleared of snow February 25, 2018

Excavator used to clear smaller areas of snow February 27, 2018

Historical temperature monitoring monument within the dam footprint to be removed February 28, 2018

Large snow drifts to be removed on the west abutment March 1, 2018

Area cleared downstream of the key trench March 14, 2018

srk consulting

Job No: 1CT022.031_2018

Filename: Figure 3_FootPrintClearing_1CT022.031.pptx

TMAC RESOURCES

Hope Bay Project

South Dam As-Built Report

Dam Foot Print Clearing

Date:	Approved:	Figure:
Dec 2018	KNK	**3**

Ripper starting overburden key trench excavation February 19, 2018

Excavation of key trench facing south February 22, 2018

Key trench initial box cut facing northeast February 22, 2018

Key trench box cut facing east February 23, 2018

Ripped overburden facing west March 4, 2018

Ripping and excavating to key trench slopes facing west March 5, 2018

Key trench excavation to approx. half the design depth facing east March 6, 2018

Key trench excavation to design depth and access ramps facing east March 15, 2018

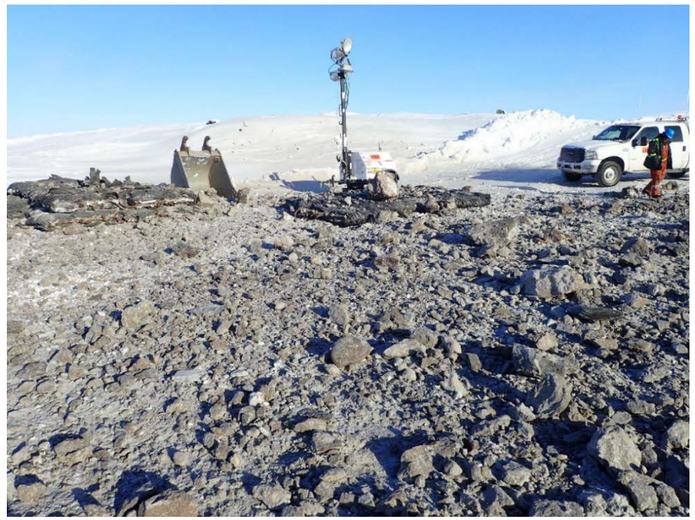
Boulders in permafrost above design depth April 29, 2018

srk consulting	TMAC RESOURCES	South Dam As-Built Report
		Key Trench Overburden Excavation
Job No: 1CT022.031_2018 Filename: Figure 4_TrenchExcavation_1CT022.031.pptx	Hope Bay Project	Date: Dec 2018 / Approved: KNK / Figure: **4**

Drilling blast holes March 5, 2018

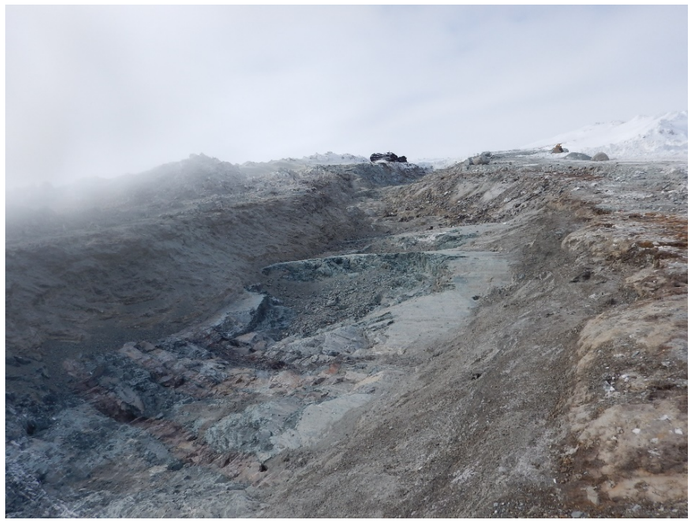
Blast mats March 6, 2018

Blast grid stakes on east abutment March 6, 2018



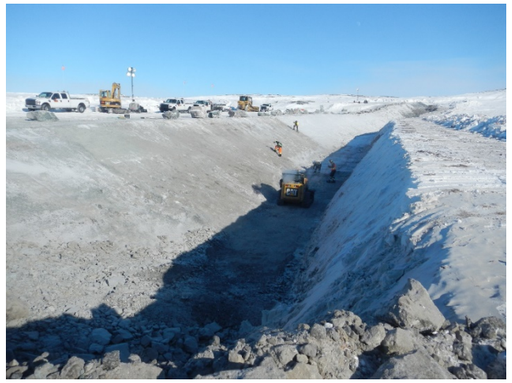
Test blast debris at the east abutment March 7, 2018

Excavator placing blast mats on loaded blast holes March 8, 2018



Blasted key trench at western abutment April 24, 2018

srk consulting	TMAC RESOURCES	South Dam As-Built Report
		Key Trench Bedrock Blasting
Job No: 1CT022.031_2018 Filename: Figure 5_BlastTrench_1CT022.031.pptx	Hope Bay Project	Date: Dec 2018 / Approved: KNK / Figure: **5**



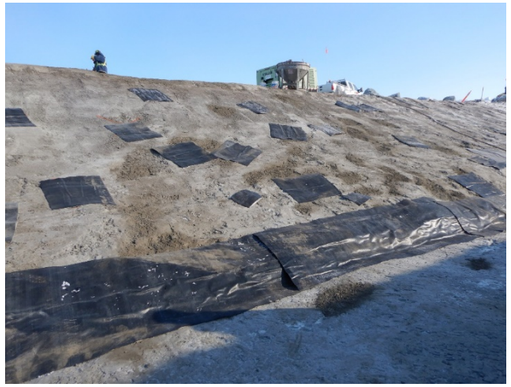
Using brooms and skid steer outfitted with a brush to clean snow and debris from the key trench surface March 26, 2018

Cleaned overburden surface March 28, 2018

Using compressed air to clean snow and debris from key trench surface March 30, 2018

Irregularities in the northern slope of the key trench caused by ripper March 31, 2018

Wind fence installed to the north of the key trench to reduce the amount of snow drifting in the fence March 31, 2018

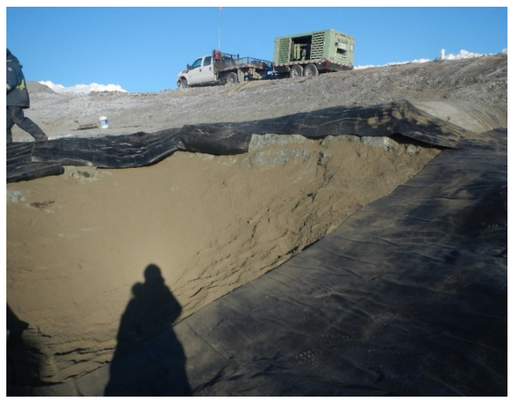


Using sacrificial GCL patches and a flash/aggregate mix to fill/cover irregularities in the key trench surface April 6, 2018

Using sacrificial GCL half panels, bedding material, and fly ash/aggregate mix to prepare rough and irregular blasted bedrock surface for GCL installation April 14, 2018

Cleaned key trench bedrock and overburden surface at the east abutment April 23, 2018

Permafrost in key trench thawing in the afternoons; GCL installation moved to the early morning April 25, 2018



Typical preparation of blasted bedrock with sacrificial GCL and fly ash/aggregate mix April 27, 2018

Cutting drill rod in blasted bedrock (rod previously broken while drilling blast holes) west abutment May 1, 2018

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TMAC RESOURCES

South Dam As-Built Report

Trench Surface Preparation

Job No: 1CT022.031_2018

Filename: Figure_6_TrenchSurfacePrep_1CT022.031.pptx

Hope Bay Project

Date: Dec 2018

Approved: KNK

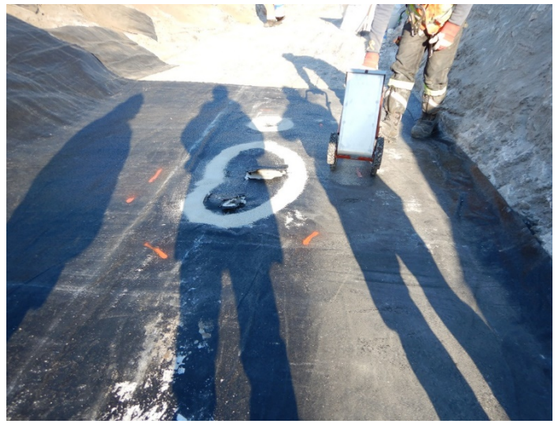
Figure: **6**

Wrapped rolls of GCL liner stored in warehouse February 19, 2018

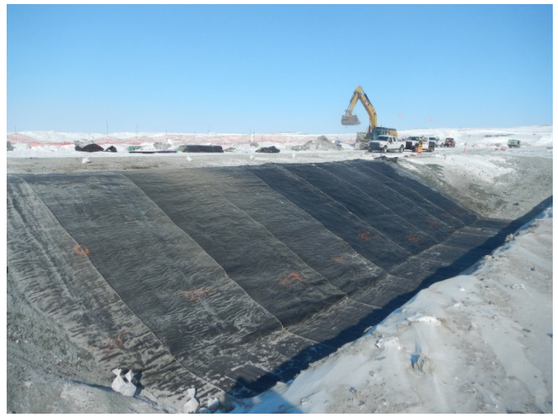
Applying bentonite seal between adjacent panels April 2, 2018

Bentonite seal beneath the GCL at the southern toe of the key trench April 2, 2018

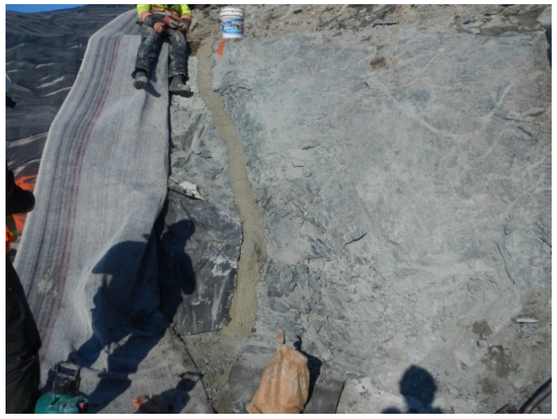
First panel installed in key trench April 2, 2018



Applying bentonite seal around GCL damage prior to placing GCL patch April 5, 2018



Several completed GCL panel installations near the center of the dam April 15, 2018



Using a bentonite paste to create seal between the easternmost GCL panel and the near-vertical bedrock face April 25, 2018

Example of partially hydrated GCL April 27, 2018

Several completed GCL panel installations in bedrock in the west abutment May 2, 2018

srk consulting	TMAC RESOURCES	South Dam As-Built Report
		Key Trench Liner Installation
Job No 1CT022.03_2018 Filename: Figure 7_LinerInstallation_1CT022.031.pptx	Hope Bay Project	Date: Dec 2018 / Approved: KNK / Figure: **7**

Bedding material stockpile at quarry February 17, 2018

Bedding material February 22, 2018

30cm tall guide for placing bedding material on GCL liner April 2, 2018

Placing bedding material on installed GCL April 2, 2018

Placing bedding material on the northern slope of the key trench April 7, 2018

srk consulting	TMAC RESOURCES	South Dam As-Built Report
		Bedding Material
Job No: 1CT022.031_2018 Filename: Figure8_BeddingMaterial_1CT022.031.pptx	Hope Bay Project	Date: Dec 2018 / Approved: KNK / Figure: **8**

Transition material March 3, 2018

Transition material stockpile March 3, 2018

Transition material placed in key trench April 6, 2018

Building access ramp into key trench April 6, 2018

Pushing transition material to specified thickness with dozer April 6, 2018

Pushing transition material up northern key trench slope April 7, 2018

Compacting transition material April 8, 2018

Transition material placed on upstream slope of May 14, 2018

srk consulting	TMAC RESOURCES	South Dam As-Built Report
		Transition Material
Job No: 1CT022.031_2018 Filename: Figure 9_TransitionMaterial_1CT022.031.pptx	Hope Bay Project	Date: Dec 2018 / Approved: KNK / Figure: **9**

ROQ February 25, 2018

Placing first lift of ROQ in the dam footprint to create a construction access road February 25, 2018

Filling key trench with ROQ April 27, 2018

Key trench at west abutment filled with ROQ to surface level May 9, 2018

Bulk placement of ROQ May 10, 2018

Boulder in ROQ to be removed June 25, 2018

Excavator shaping upstream slope of dam July 6, 2018

srk consulting	TMAC RESOURCES	South Dam As-Built Report
		Run of Quarry (ROQ) Material
Job No: 1CT022.031_2018 Filename: Figure 10_RunofQuarry_1CT022.031.pptx	Hope Bay Project	Date: Dec 2018 / Approved: KNK / **Figure: 10**

Exposing GCL at key trench crest in preparation for installation of above ground liner May 30, 2018

Bentonite powder seal between key trench and above ground GCL June 3, 2018

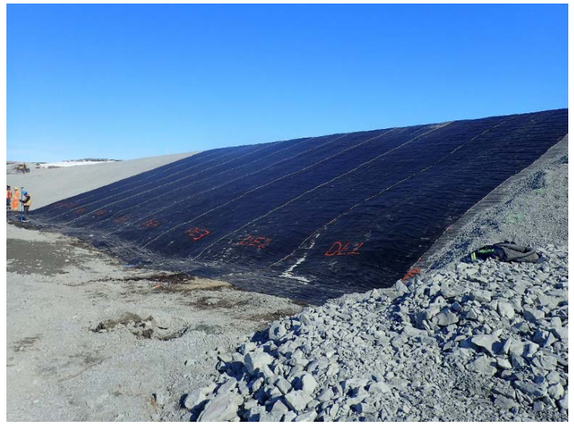
Installing first GCL panel above ground June 3, 2018

Top of GCL panel in anchor trench June 4, 2018

Bentonite seal between adjacent GCL panels and longitudinal thermistor cable June 5, 2018

Channel dug to drain ponded water near liner June 5, 2018

Installation of GCL panels June 8, 2018



Installation of GCL panels June 5, 2018

Removal of geofabric protecting "hinge point" in preparation for above ground GCL installation June 14, 2018

Addition of GCL panels in areas where the GCL became saturated along the "hinge point" June 21, 2018

srk consulting

Job No: 1CT022.031_2018
Filename: Figure 11_LinerInstallation-AboveGround_1CT022.031.pptx

TMAC RESOURCES

Hope Bay Project

South Dam As-Built Report

Above Ground Liner Installation

Date:	Approved:	**Figure:**
Dec 2018	KNK	**11**

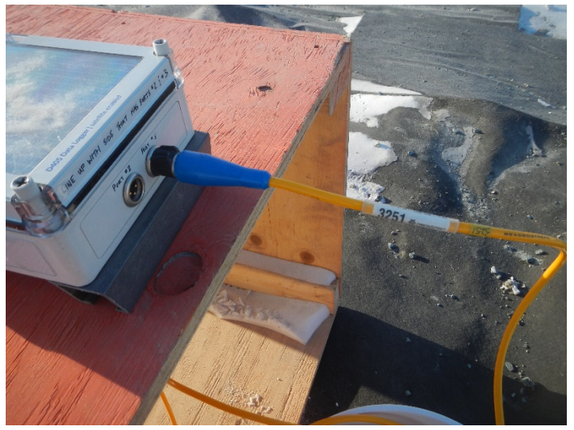
Historical temperature monitoring monument within the dam footprint to be removed February 28, 2018

Thermistor string installed in drill hole and backfilled with 3/4" minus and water March 30, 2018

Plywood protective housing for thermistor lead April 5, 2018

Running thermistor lead from base of key trench to surface April 5, 2018

Drilling hole for vertical thermistor at the toe of the key trench April 9, 2018



Taking temperature readings from thermistor installed in key trench during construction April 12, 2018

Longitudinal and above ground thermistor cables June 3, 2018

Installing thermistor string along the base and northern slope of the key trench April 6, 2018

Thermistor leads protected in HDPE pipe at the toe of the dam June 22, 2018

Typical HDPE pipe used to run thermistor lead through the ROQ construction traffic surface to the upstream toe of the dam June 25, 2018

srk consulting	TMAC RESOURCES	South Dam As-Built Report
		Instrumentation (1 of 2)
Job No: 1CT022.031_2018 Filename: Figure 12_Instumentation_1CT022.031.pptx	Hope Bay Project	Date: Dec 2018 / Approved: KNK / Figure: **12**

Excavation for installation of settlement plates July 11, 2018

Compacting bedding material around settlement survey plate July 11, 2018

Completed installation of settlement survey plate July 11, 2018

Drilling hole for installation of vertical thermistor cable at the downstream toe of the dam July 13, 2018

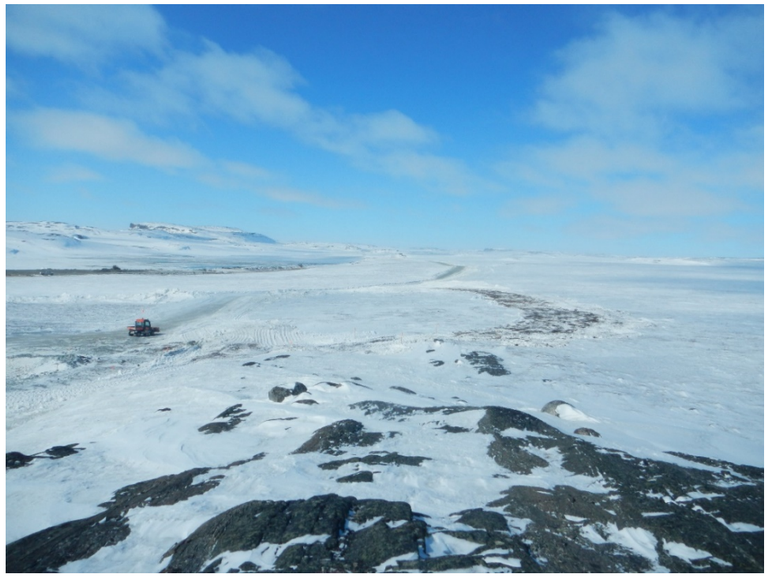
Completed installation of deep settlement monitoring July 14, 2018

Installation of deep settlement monitoring instrumentation July 15, 2018

Running vertical thermistor cable leads in bedding material to the crest of the dam July 15, 2018

Example of installed datalogger. View of datalogger SD-DL-03. November 8, 2018.

srk consulting	MAC RESOURCES	South Dam As-Built Report
		Instrumentation (2 of 2)
Job No: 1CT022.031_2018 Filename: Figure 13_Instumentation_1CT022.031.pptx	Hope Bay Project	Date: Dec 2018 / Approved: KNK / Figure: **13**

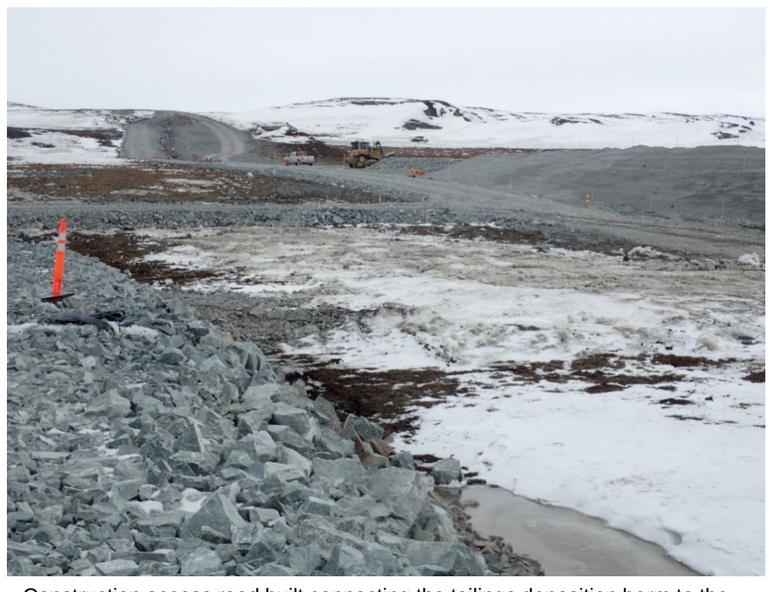


Snow cleared within footprint of dam road access May 13, 2018

ROQ placed during access road construction May 22, 2018

ROQ placed during access road construction May 24, 2018

Surfacing material placed on access road May 28, 2018



Construction access road built connecting the tailings deposition berm to the South Dam footprint May 31, 2018

srk consulting	TMAC RESOURCES	South Dam As-Built Report **Dam Access**
Job No: 1CT022.031_2018 Filename: Figure 15_DamAccess_1CT022.031.pptx	Hope Bay Project	Date: Dec 2018 / Approved: KNK / Figure: **14**

Clearing snow and ice from the footprint of the tailings deposition berm raise facing west May 21, 2018

Snow to be cleared on the south side of the existing berm May 25, 2018

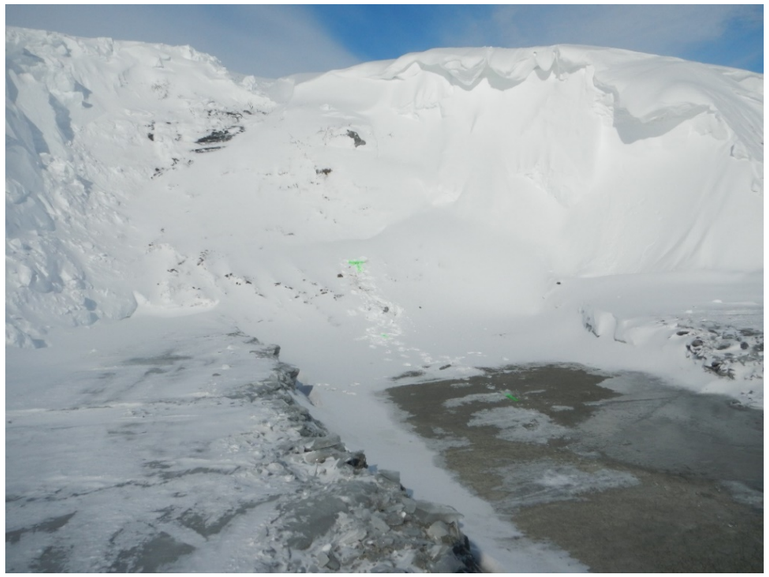
Bulk ROQ placement May 26, 2018

Bulk ROQ placement May 27, 2018

Water ponding on the south side of the berm May 27, 2018

Trash pump used to remove ponded water May 28, 2018

srk consulting	TMAC RESOURCES	South Dam As-Built Report
		Temporary Tailings Deposition Berm
Job No: 1CT022.031 Filename: Figure 16_Berm_1CH008.058.pptx	Hope Bay Project	Date: Dec 2018 / Approved: KNK / Figure: **15**

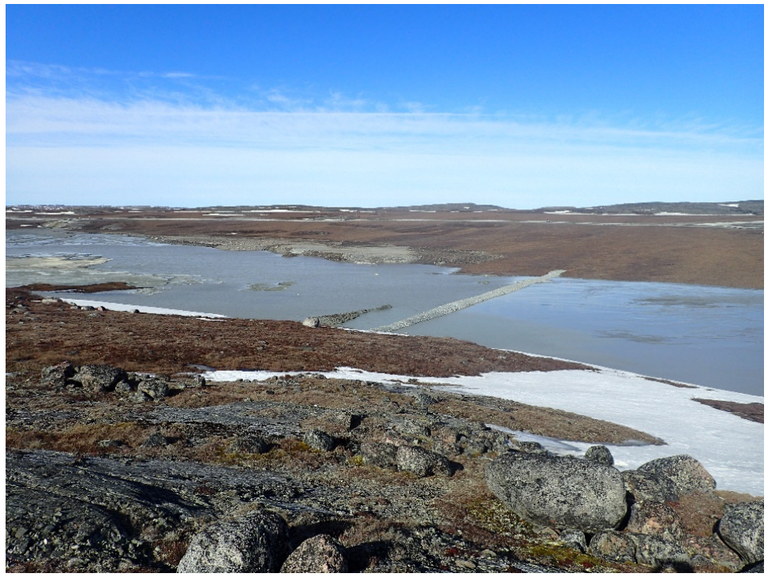


Cleared ice from the footprint of the tailings windrow May 22, 2018

Windrow progress May 23, 2018

ROQ placed at the start of the windrow construction May 22, 2018

Windrow nearly complete May 23, 2018



Windrow completed with tailings deposited to the south June 14, 2018

srk consulting	TMAC RESOURCES	South Dam As-Built Report
		Tailings Windrow
Job No: 1CT022.031_2018 Filename: Figure 17_Windrow_1CT022.031.pptx	Hope Bay Project	Date: Dec 2018 / Approved: KNK / Figure: **16**

Start of tailings deposition from upstream slope of dam, ~E view
August 2018

Aerial view of South Dam, ~NW view, August 2018

Aerial view of South Dam, ~N view, August 2018

Start of tailings deposition from upstream slope of dam, ~S view
August 2018

srk consulting	TMAC RESOURCES	South Dam As-Built Report
		Aerial Overview
Job No: 1CT022.031_2018 Filename: Figure 17_AerialOverview_1CT022.031.pptx	Hope Bay Project	Date: Feb 2019 / Approved: JBK / Figure: **17**

Appendix D – IFC Drawings

Appendix D.1 – Latest Revisions

Engineering Drawings for the South Dam - Phase 1
Doris North Project, Nunavut, Canada

Drawing Number	Drawing Title	Issue	Date	Revision	Old / Replaced Revisions	
DN-SD-01	Phase 1 General Arrangement (with Orthophoto)	Issued for Construction	April 30, 2018	2	Rev 0, 2017/11/29	Rev 1, March 7, 2018
DN-SD-02	Phase 1 General Arrangement	Issued for Construction	April 30, 2018	2	Rev 0, 2017/11/29	Rev 1, March 7, 2018
DN-SD-03	Typical Sections (General)	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-04	Key Trench Excavation Plan and Profile	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-05	Liner Placement Plan and Details - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-06	Liner and Bedding Placement Details	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-07	Bedding Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-08	Transition Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-11	Construction Access Road and Turn Around - Phase 1	Issued for Construction	April 30, 2018	2	Rev 0, 2017/11/29	Rev 1, March 7, 2018
DN-SD-12	Final Phase 1 Dam Plan, Profile and Sections	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-13	Sections Sta. 0+10 to 0+90 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-14	Sections Sta. 1+00 to 1+80 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-15	Sections Sta. 1+90 to 2+70 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-16	Sections Sta. 2+80 to 3+60 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-17	Sections Sta. 3+70 to 4+50 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-18	Sections Sta. 4+60 to 5+30 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-19	Infill Foundation Drilling - Phase 1	Issued for Construction	March 7, 2018	AB	Rev 0, 2018/02/16	
DN-SD-20	Percolation Borehole / Test Locations	Issued for Construction	March 7, 2018	AB	Rev 0, 2018/02/16	
DN-SD-21	Instrumentation Plan - Phase 1	Issued for Construction	May 24, 2018	2	Rev 0, 2018/03/07	Rev 1, March 7, 2018
DN-SD-22	GTC backfilled Cable Trench - Phase 1	Issued for Construction	April 26, 2018	2	Rev 0, 2018/03/07	Rev 1, March 7, 2018
DN-SD-23	Vertical GTC Layout - Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-24	Horizontal GTC - Upstream Base / Toe of Key Trench	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-25	GTC Layout Along Upstream Above Ground Liner Slope	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-26	Sloped GTC - Above Ground Liner Slope	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-27	Instrumentation Details at Sta. 0+65 and 1+55	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-28	Instrumentation Details at Sta. 2+40 and 3+65	Issued for Construction	March 7, 2018	0		
DN-SD-29	Instrumentation Details at Sta. 4+65 and 5+10	Issued for Construction	March 7, 2018	0		
DN-SD-30	Typical Monitoring Point Details	Issued for Construction	May 24, 2018	1	Rev 0, March 7, 2018	

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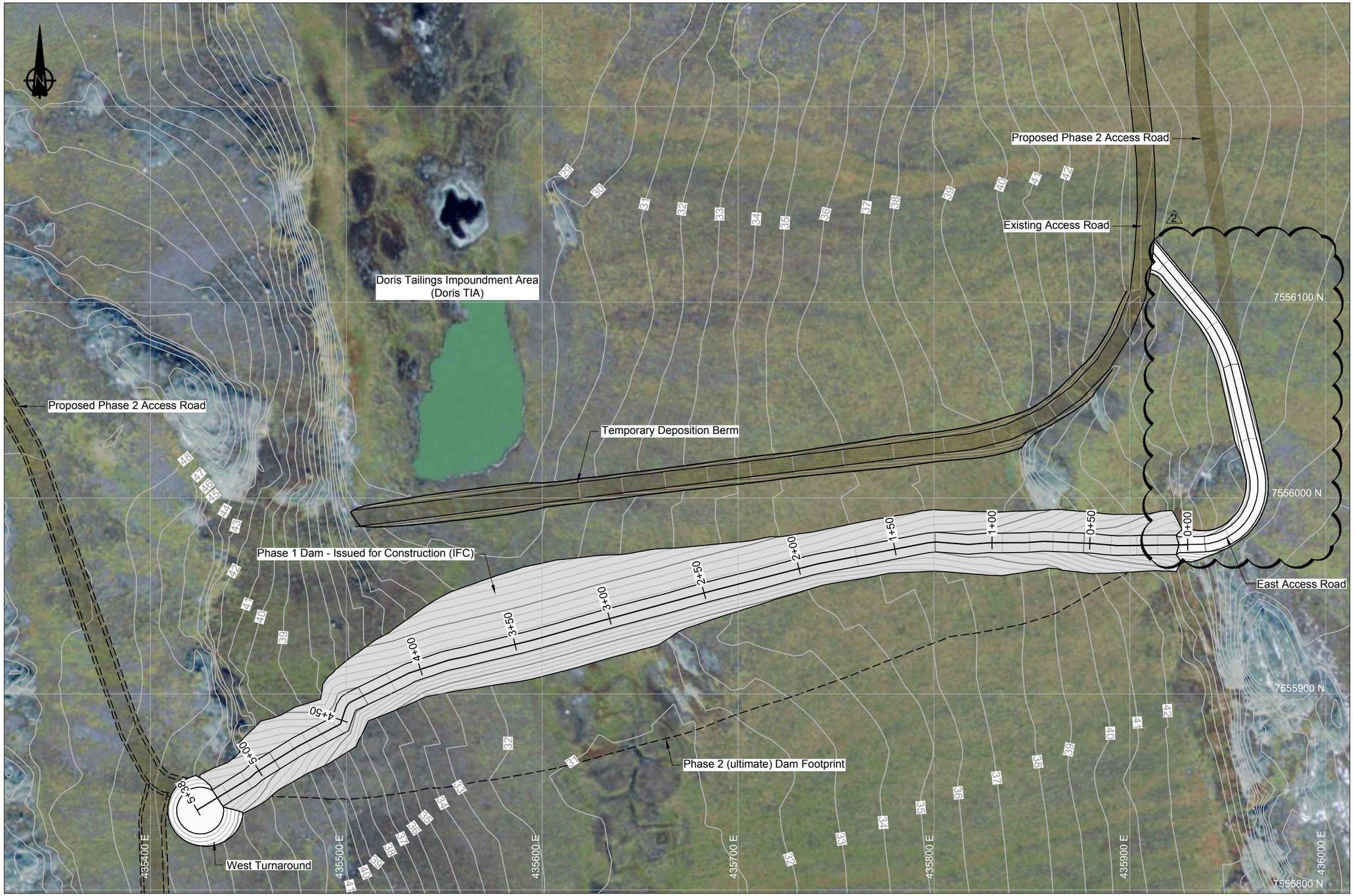

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Imagery (from 2010 PhotoSat compilation) provided by client.
5. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

0m 20 40 60 80

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/30
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

Original Drawings Stamped and Signed by Engineer

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srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/30

FILE NAME: 1CT0022.017 - South Dam GA - with ortho.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Phase 1 General Arrangement (with Orthophoto)

DRAWING NO.	SHEET	REVISION NO.
DN-SD-01	1 OF 30	2

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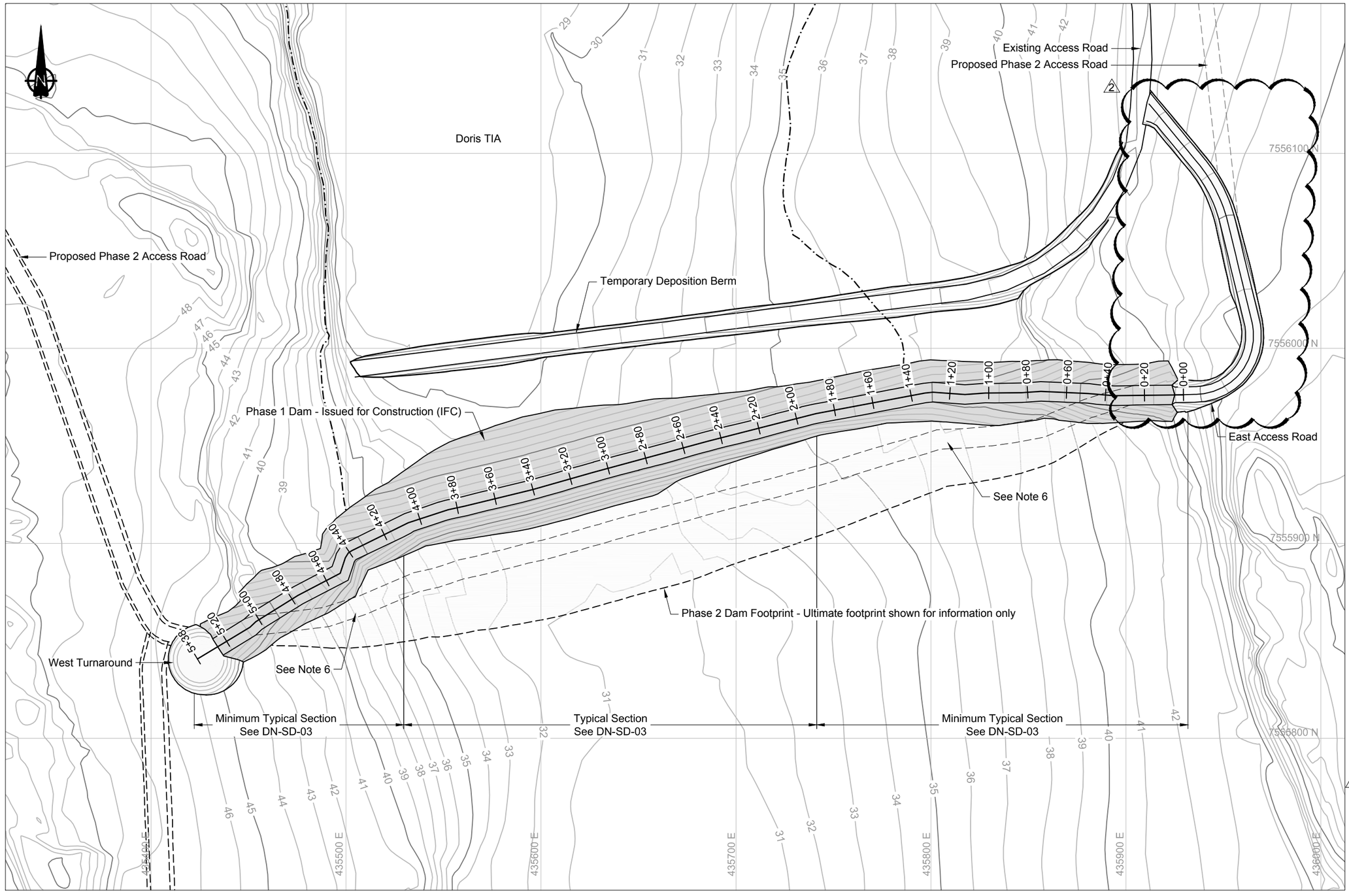

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Volumes presented based on neat-lines only and are approximate. These include no over-excavation or over-blasting allowance of the key trench.
5. All units shown are in meters unless otherwise stated.
6. Bend in the dam crest is to accommodate Phase 2 liner tie-in.
7. All snow roads placed on the upstream as a temporary construction measure, to help facilitate construction of the dam, must be completely removed before tailings deposition may commence.

REFERENCES

NAD83 UTM Zone 13.

TABLE OF QUANTITIES (NEAT-LINE)

Key Trench Bulk Excavation :	19,500m³
Total Phase 1 Fill:	68,500m³
ROQ:	36,800m³
Transition:	26,100m³
Bedding:	5,600m³
Total Liner:	14,300m²
West Turnaround (bulk):	2,000m³
East Access Road (bulk):	2,440m³

*all volumes presented are to neat-lines and do not allow / account for bulking and compaction.

0m 20 40 60 80

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
2	Issued for Construction	JBK	EMR	18/04/30
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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JBK	EMR	2018/04/30

FILE NAME: 1CT0022.017 - South Dam GA.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Phase 1 General Arrangement

DRAWING NO.	SHEET	REVISION NO.
DN-SD-02	2 OF 30	2

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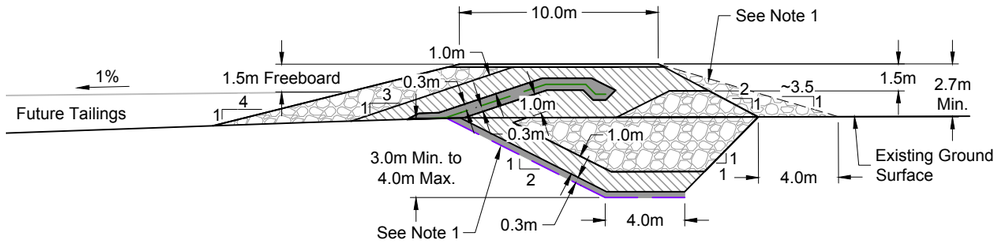
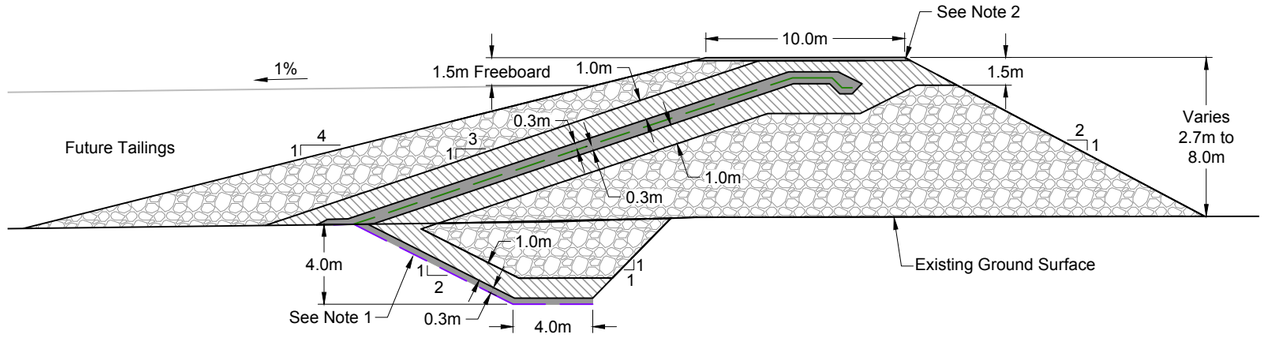


Minimum Typical Cover Section
STA.0+00 to 1+92 & 4+15 to 5+42

0m 3 6 9 12

ISSUED FOR CONSTRUCTION



Phase 1 Typical Dam Section
STA. 1+92 to 4+15

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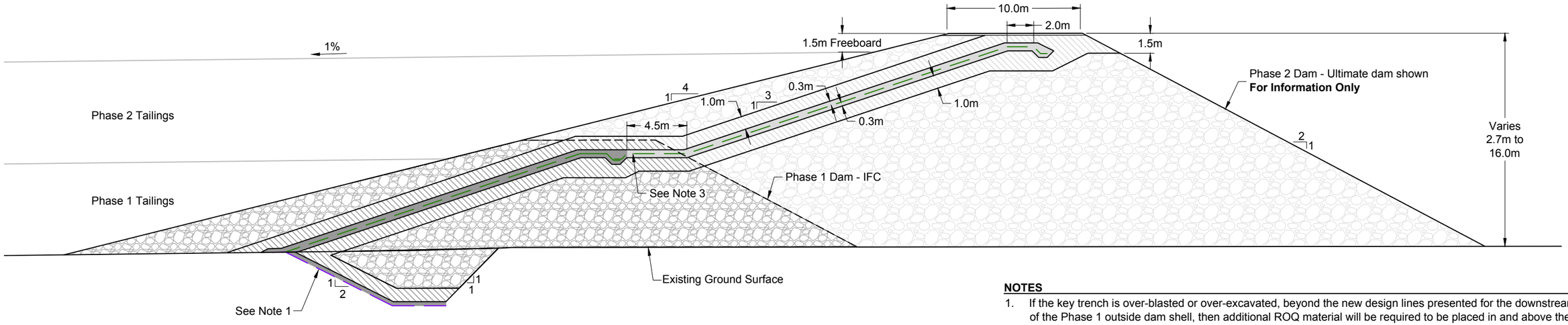
ISSUED FOR CONSTRUCTION



Phase 2 Typical Dam Section
STA. 0+25 to 5+25

0m 3 6 9 12

ISSUED FOR INFORMATION

LEGEND

- Key Trench Liner
- Phase 1 & 2 Dam Liner
- Bedding Material
- Transition Material
- Run of Quarry

NOTES

1. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench. This material would be placed to ensure that adequate thermal insulation of the key trench is maintained in all sections. See Detail 10 on drawing DN-SD-09 for additional details.
2. The top road surfacing (bedding material) for the Phase 1 dam is to be fully removed (upstream and downstream) before Phase 2 construction commences.
3. To allow for a proper tie-in the transition material around the top downstream portion of the Phase 1 dam will be required to be stripped back. Once the bedding material around the top liner anchor trench is reached hand excavation should be expected to result down to expose the liner. The on-site engineer will be required to inspect all exposed liner, to ensure that it is not damaged or in need of repairs before Phase 2 liner tie-ins result.
4. All units shown are in meters unless otherwise stated.

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-02	Phase 1 General Arrangement	-	-			

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS | REVISIONS

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Typ Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Typical Sections (General)

DRAWING NO.	SHEET	REVISION NO.
DN-SD-03	3 OF 30	1

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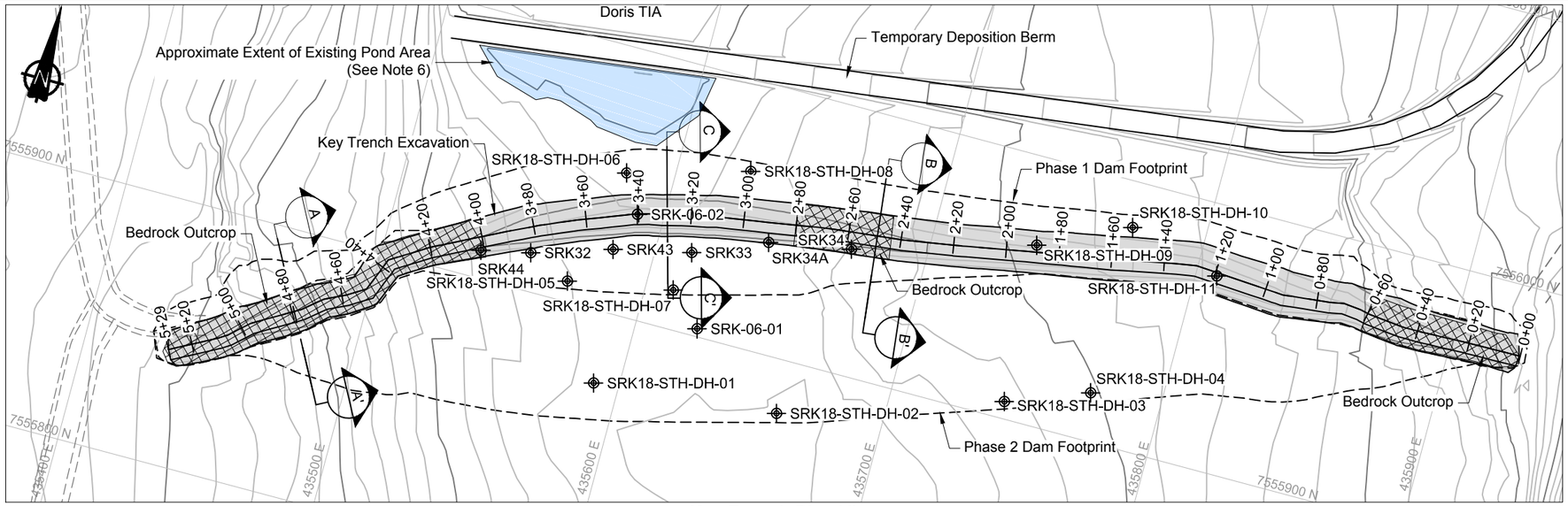
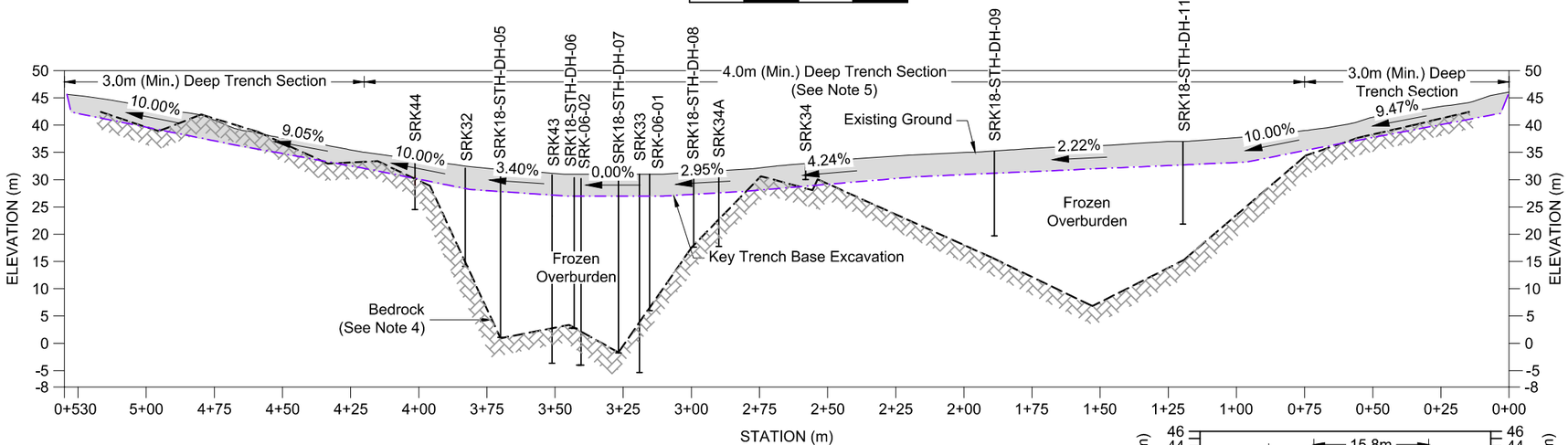


Key Trench Plan View

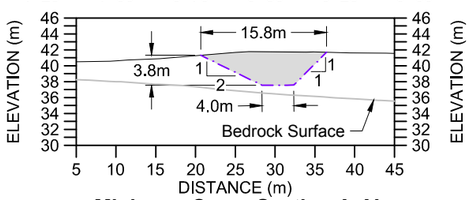
0m 20 40 60 80



Key Trench Profile View

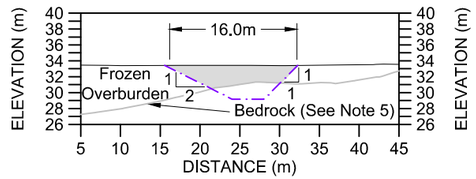
Vertical: 0m 10 20 30 40

Horizontal: 0m 20 40 60 80



Minimum Cross Section A-A'
Shallow Overburden over Bedrock

0m 5 10 15 20 25 30



Cross Section B-B'
Bedrock Outcropping in Key Trench

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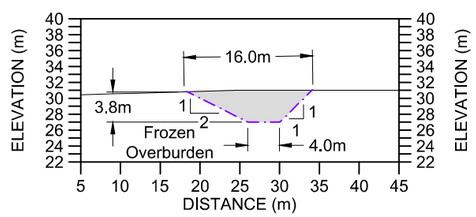

Cross Section C-C'
Deep Frozen Overburden

0m 5 10 15 20 25 30

LEGEND

- Drill Hole Location
- Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Trench Excavation Extent
- 1.00% Base Grades

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profile shown correspond to the upstream toe of the key trench.
4. The subsurface geology has been inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A , SRK43, SRK 44, SRK18-STH-DH01-11 and SRK18-WST-DH01-03), airphoto interpretations, and from limited available geophysical surveys around the Tails Lake area. This data was then used to create a bedrock surface with the Gemcom GEMS software. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.
5. The final key trench extent and depth will be determined in the field by the Engineer. Typical excavation depth is 4.0m, unless massive ice, hypersaline soil or bedrock encountered. The Engineer will inspect all excavations and approve the foundation conditions.
6. Ponded area to removed (frozen massive ice excavated or drained if possible). Up to approximately 4,700 m3 of (frozen) water may be expected to be removed from this area. Exact water levels are not known so the volume estimate above should be treated as a rough estimate based on topography.
7. If any area of the key trench is over-blasted or over-excavated then the extra excavation will need to be backfilled in thin lifts (*see 'Technical Specifications'*) until the key trench design lines and grades are reached.
8. Overblasting and/or overexcavation of the key trench beyond the design lines (as presented on this figure) should be avoided if at all possible. Extra care should be taken during the key trench excavation to ensure that the excavation can result as close to the design lines as possible. Excavation beyond the key trench design lines may require that the overall Phase 1 dam footprint be enlarged to provide the necessary thermal coverage and to uphold design requirements.

REFERENCES

NAD83 UTM Zone 13.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS | DRAWING NO. | DRAWING TITLE

REVISIONS

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Key Trench.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Key Trench Excavation Plan and Profile

DRAWING NO.: DN-SD-04 | SHEET: 4 OF 30 | REVISION NO.: 1

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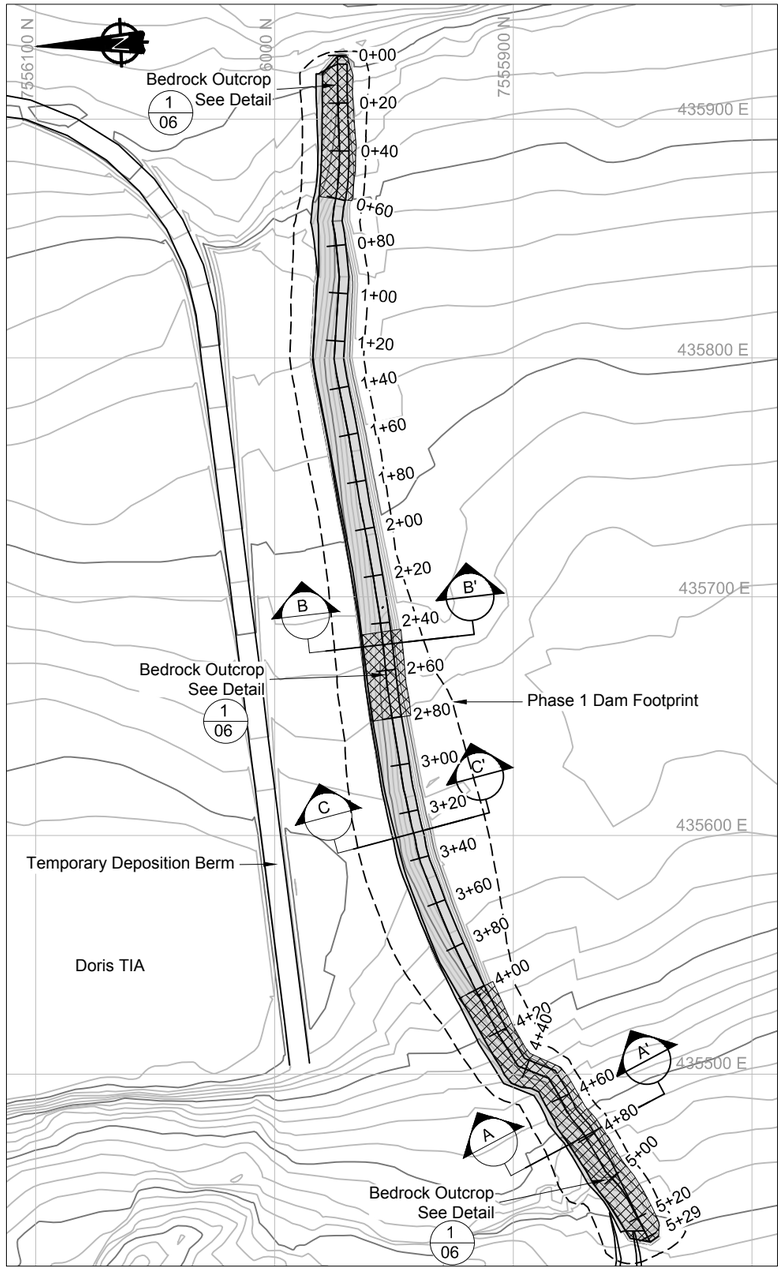
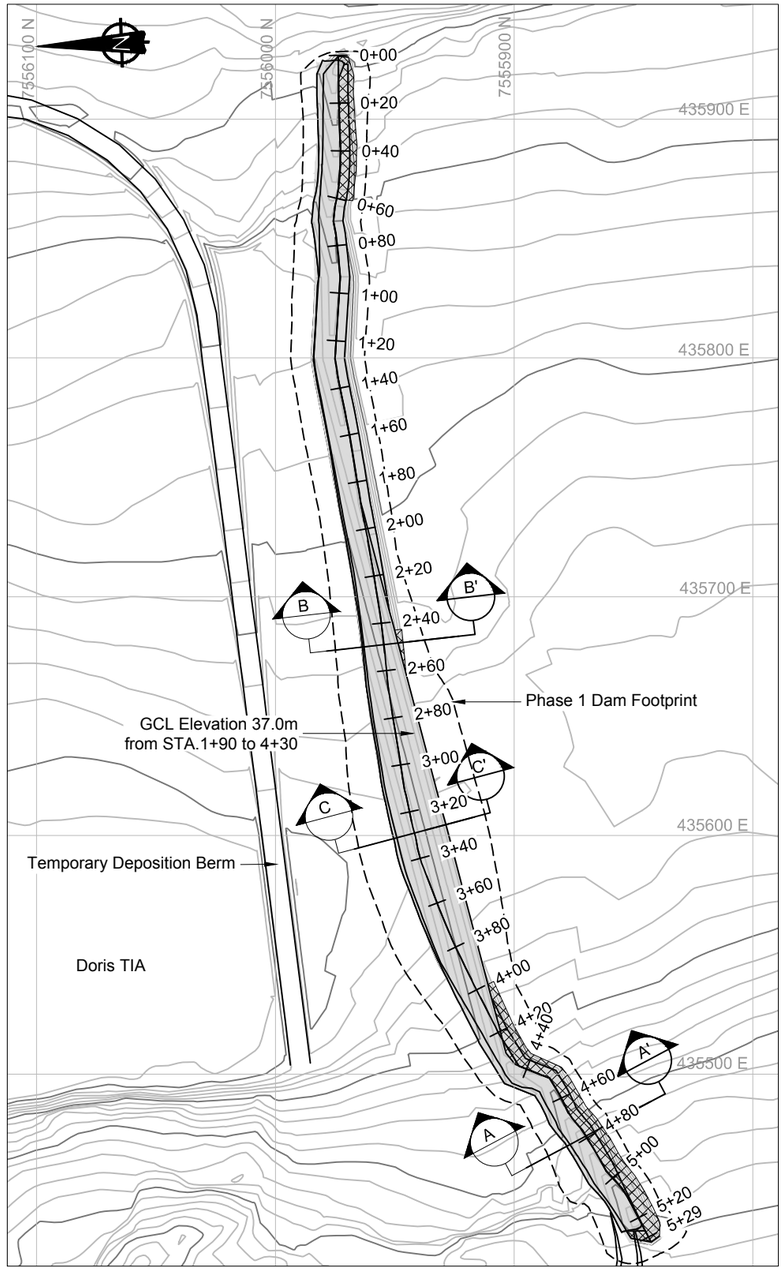


Lower Liner Plan - Placement in Key Trench

0m 20 40 60 80 100



Upper Phase 1 Liner Plan - Above Ground Upstream Slope Placement

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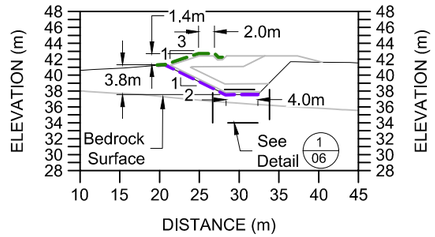

Minimum Cross Section A-A'

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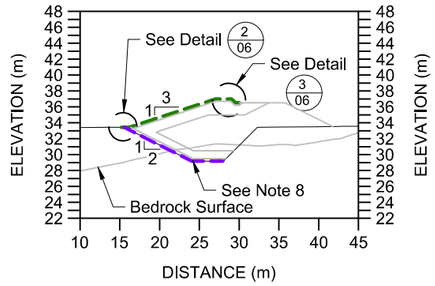

Cross Section B-B' - Bedrock Encountered in Trench

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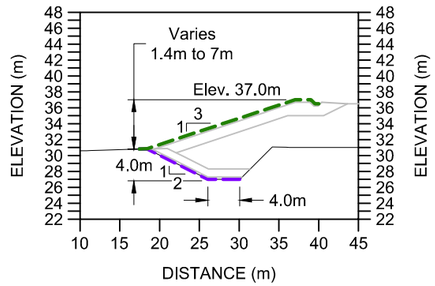

Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

- Key Trench Liner
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent
- GCL Liner Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The upstream slope of the key trench excavation need to be scraped and smoothed to prepare a suitable subbase for the GCL liner as determined by field Engineer. If any voids larger than 0.15m or undulation exist then they will need to be backfilled with compacted bedding material fill, placed in thin 0.15m lifts.
4. The subgrade surface must be free of vegetation, sharp-edged rocks, stones, sticks, construction debris, and other foreign material that could contact the GCL. Furthermore, all protrusions extending more than 12 mm from the subgrade surface shall either be removed, crushed, or pushed into the surface with a smooth-drum compactor.
5. GCL should not be placed over massive ice or standing water (both need to be removed prior to placement).
6. All Geosynthetic Clay Liner (GCL) liner sections / panels will be required to have a minimum 0.5m overlap on every edge. See Detail 2, 3, 5 and 6 on DN-SD-06 for additional information.
7. At the locations where bedrock is encountered in the key trench then these areas will be required to be ripped down to competent bedrock or scrapped smooth and then bentonite powder will be placed between the bedrock contact and the GCL liner (see Detail 1, DN-SD-06).
8. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m in depth), until competent bedrock is encountered, or as directed by Engineer.

REFERENCES

NAD83 UTM Zone 13.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-06	Liner and Bedding Placement Details	-	-				0	Issued for Construction	JBK	EMR	17/11/29

Original Drawings Stamped and Signed by Engineer

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Liner Placement Plan and Details Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-05	5 OF 30	1

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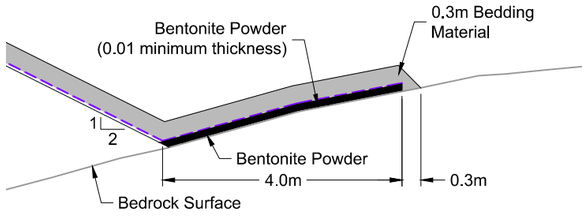
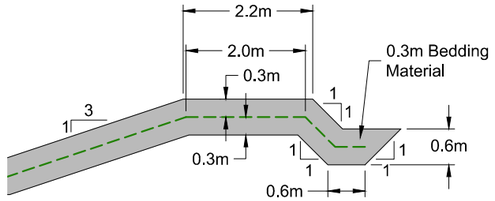
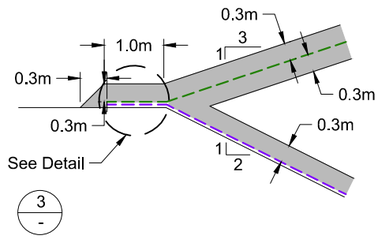
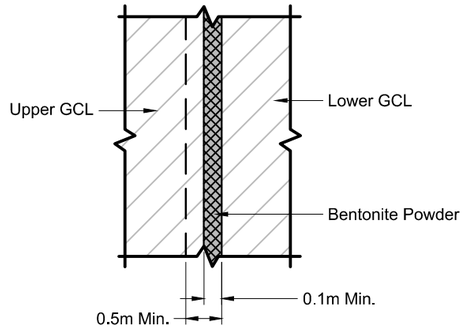


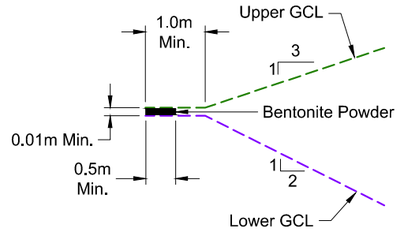
Detail 1 - Liner Attachment at Bedrock



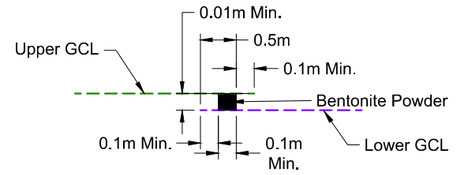


Detail 2 - Liner Overlap - Bedding



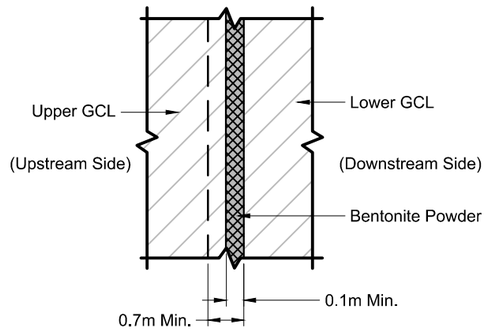


Detail 3 - Typical Upper and Lower GCL Joint



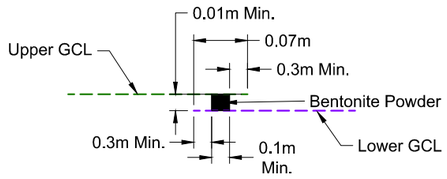
Detail 4 - Liner Anchor Trench Bedding

Detail 5 - Typical Longitudinal GCL Overlap - Plan



Detail 6 - Typical Longitudinal GCL Overlap - Section

Not To Scale



Detail 7 - Typical End of Panel GCL Overlap - Plan

Detail 8 - Typical End of Panel GCL Overlap - Section

Not To Scale

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material

NOTES

1. All units shown are in meters unless otherwise stated.
2. One end of the GCL roll should be anchored at the top of the slope. The front edge of the key trench (see Detail 4) shall be rounded so as to eliminate any sharp corners that could cause excessive stress on the GCL. Loose soil should be removed.
3. The GCL should be placed in the key trench such that it covers the entire key trench floor but does not extend up the rear trench wall (see Detail 4).
4. GCL seams are constructed by overlapping their adjacent edges (see Detail 5). Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris.
5. If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by placing a patch over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 500 mm is achieved around all parts of the damaged area. Bentonite mastic / powder should be applied around the damaged area prior to placement of the patch. It may be necessary to use an adhesive such as wood glue, or by hand placing material over the patch, to fix the patch in place so that it is not moved during overliner bedding material placement. Smaller patches also may be tucked under the damaged area to prevent patch movement.
6. Bedding shall be free of angular stones or other foreign matter which could damage the GCL. Cover soils should be approved by the Engineer, with respect to particle size and uniformity (as per the 'Technical Specifications').
7. Surface for the liner placement must be smooth competent 'virgin' ground with no loose or fractured material.

REFERENCES

NAD83 UTM Zone 13.

DRAWING NO.	DRAWING TITLE
-	-

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

MAC RESOURCES

Hope Bay Project

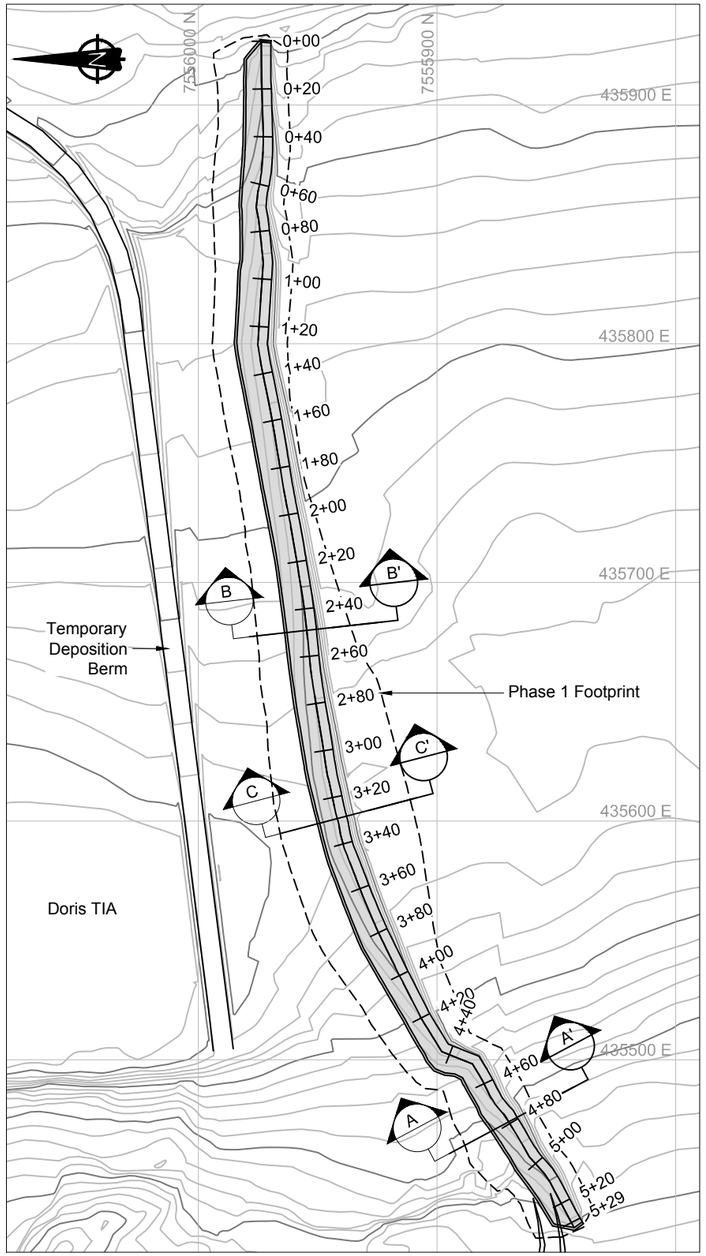
SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Liner and Bedding Placement Details

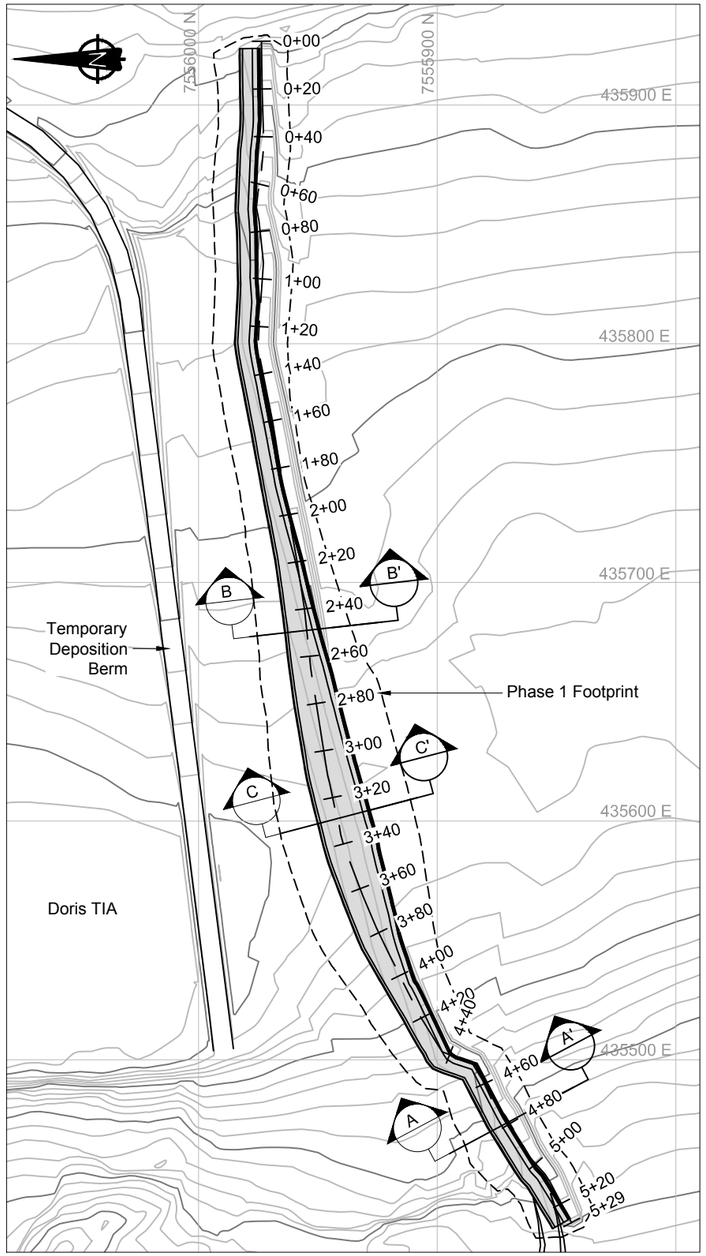
DRAWING NO.	SHEET	REVISION NO.
DN-SD-06	6 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1\1CT0022.017 - South Dam - Liner.dwg



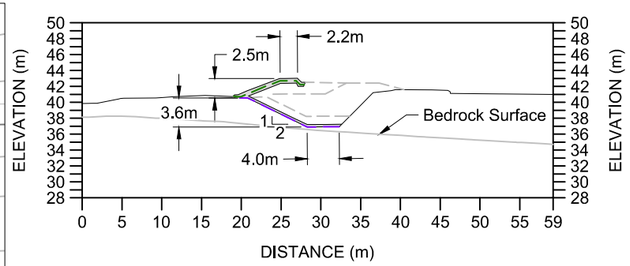
Key Trench Bedding Placement Plan View

0m 20 40 60 80 100



Phase 1 Dam Bedding Placement Plan View

0m 20 40 60 80 100



Minimum Cross Section A-A'

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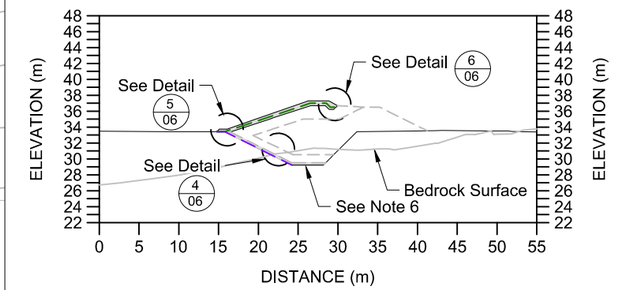

Cross Section B-B' - Bedrock Encountered in Trench

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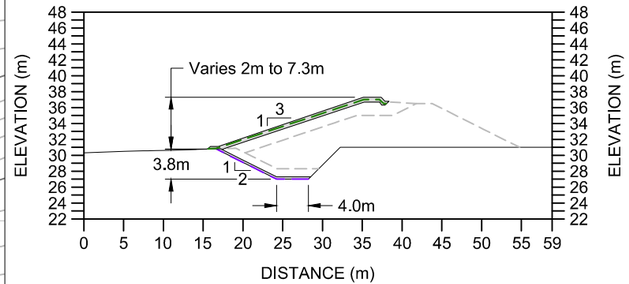

Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

- Phase 1 Dam Liner
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Bedding Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Bedding layer to be placed in 0.15m lifts and compacted before liner placement. The subsurface below the liner should be free of protrusions or any sharp / angular cobbles or larger size material. See the Technical Specifications document for more details (*'Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK).*
4. Bedding material cover shall be placed over the GCL using construction equipment that minimizes stresses on the GCL. Unless otherwise approved / directed by the Engineer a minimum thickness of 600mm or greater is required to be placed over any areas where heavy equipment will be trafficking over the liner. Thickness requirement are related to equipment type. For light equipment (which will have to be directly approved by the Engineer), as an absolute minimum a thickness of 300mm of cover must be maintained between light tracked equipment (e.g. skid-steer or 30 excavator) tracks/tires, and the GCL at all times during the covering process.
5. Soil cover should be placed in a manner that prevents the soil from entering/disturbing the GCL overlap zones.
6. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

REFERENCES

NAD83 UTM Zone 13.

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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							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-06	Liner and Bedding Placement Details	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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JKB	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Bedding.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Bedding Material Placement Plan and Sections - Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-07	7 OF 30	1

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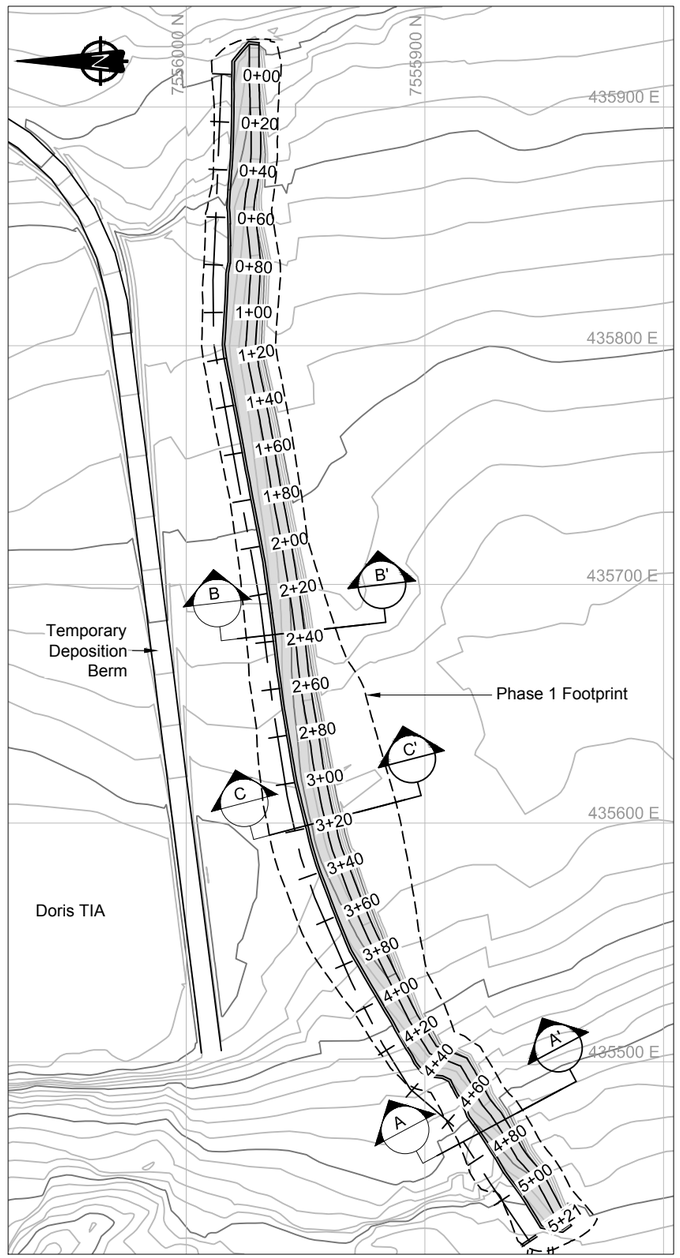

Key Trench Bedding Placement Plan View

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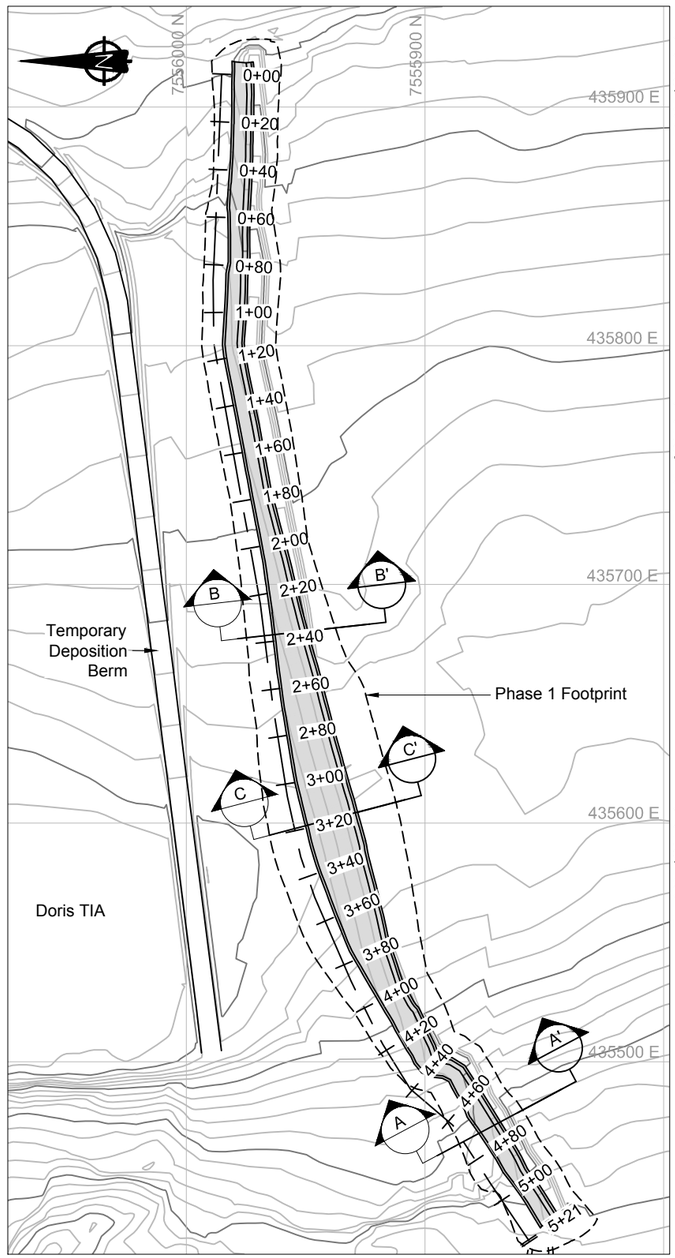

Phase 1 Dam Bedding Placement Plan View

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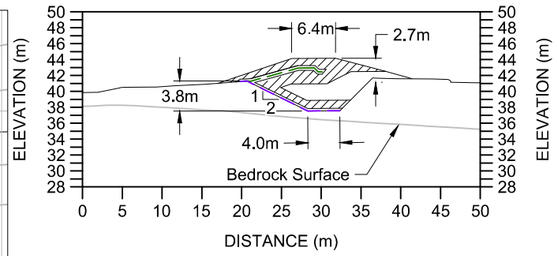

Minimum Cross Section A-A'

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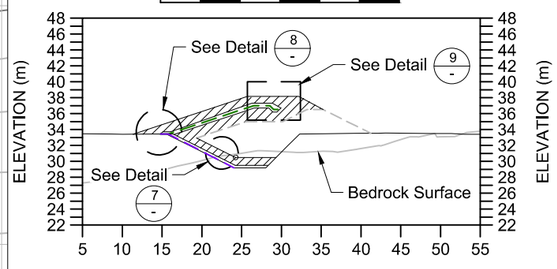

Cross Section B-B' - Bedrock Encountered in Trench

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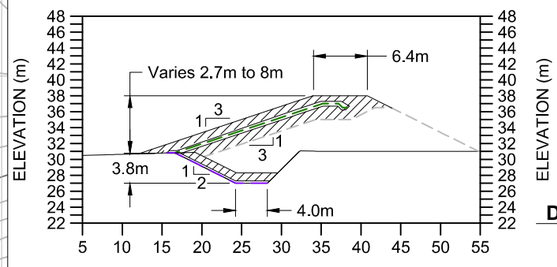


Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

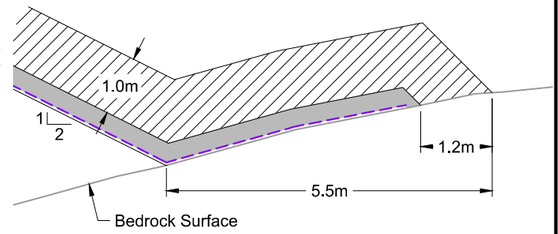
- Phase 1 Dam Liner
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Bedding Material
- Transition Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.

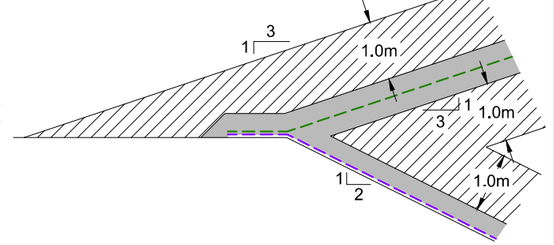
REFERENCES

NAD83 UTM Zone 13.



Detail 7 - Key Trench Bedrock Interface - Transition

0m 1 2 3 4



Detail 8 - Upper and Lower GCL Liner Overlap - Transition

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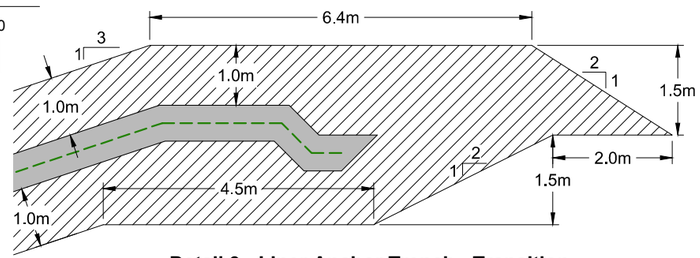

Detail 9 - Liner Anchor Trench - Transition

0m 1 2 3 4

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		-	-				0	Issued for Construction	JBK	EMR	17/11/29
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
REFERENCE DRAWINGS		REVISIONS									

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Transition.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Transition Material Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-08	7 OF 30	1

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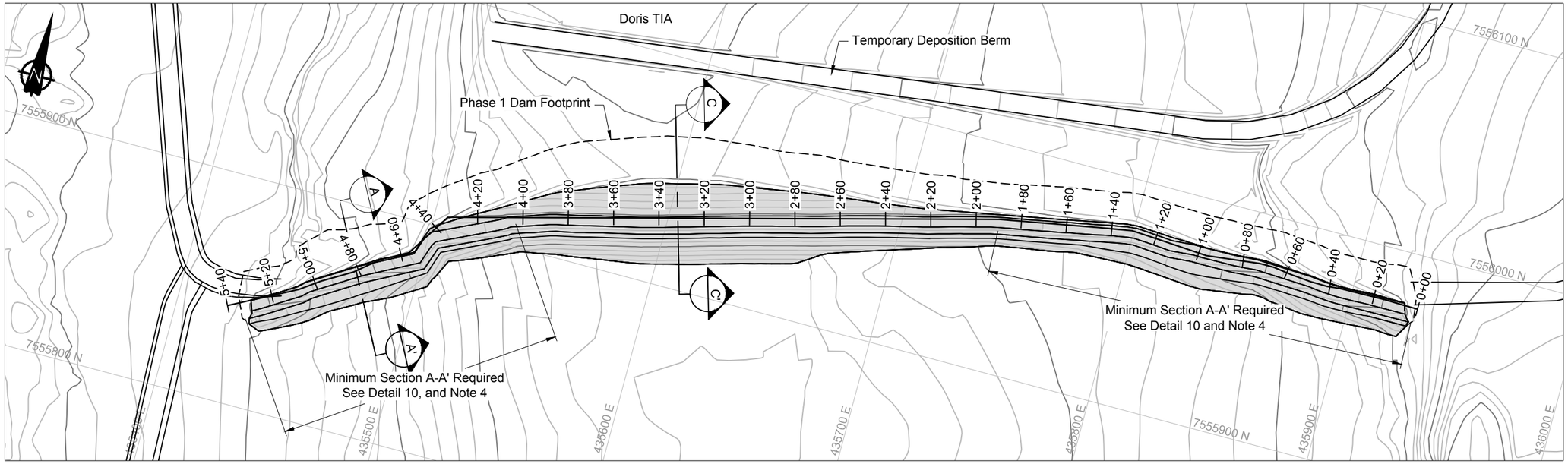


Run of Quarry Placement Plan View

0m 20 40 60 80

LEGEND

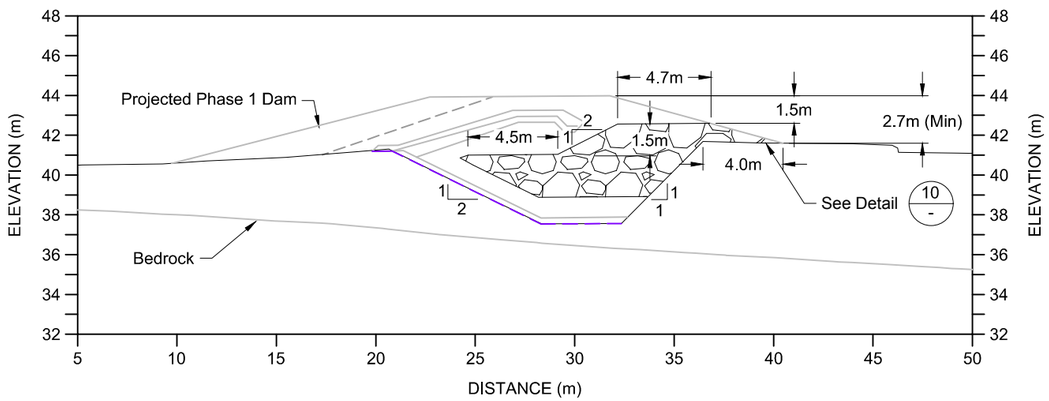
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Run of Quarry Backfill Extent
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profiles shown correspond to the upstream toe of the key trench.
4. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench. See Detail 10 on drawing DN-SD-09 for additional details.
5. The outside downstream ROQ should be sloped at 2H:1V or shallower.

REFERENCES

NAD83 UTM Zone 13.



Minimum Cross Section A-A'

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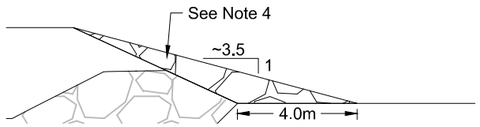
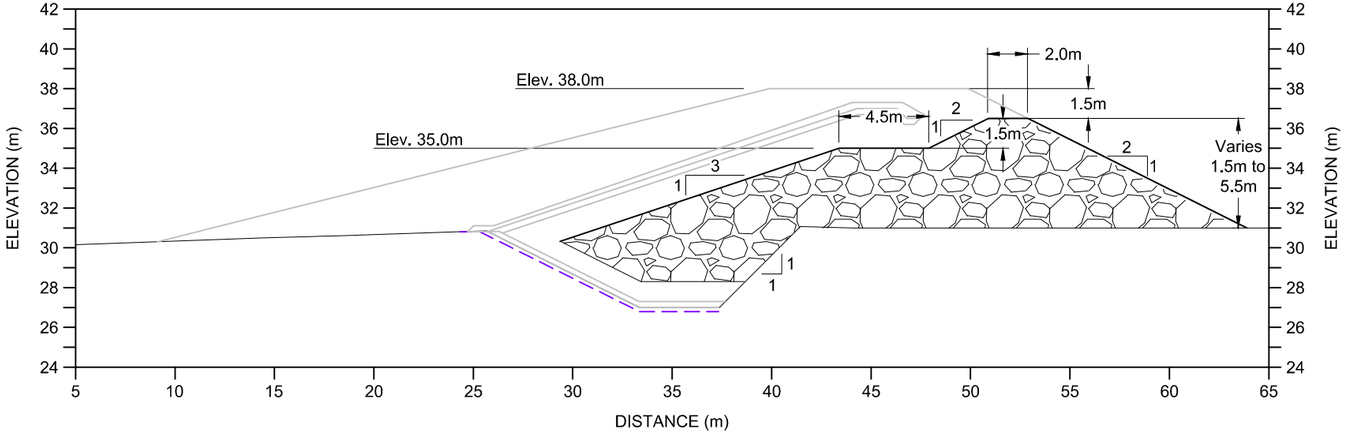


Detail 10 - Contingency ROQ Thermal Barrier Design

0m 2 4 6 8



Typical Cross Section C-C'

0m 3 6 9 12

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1					
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-09	9 OF 30	1

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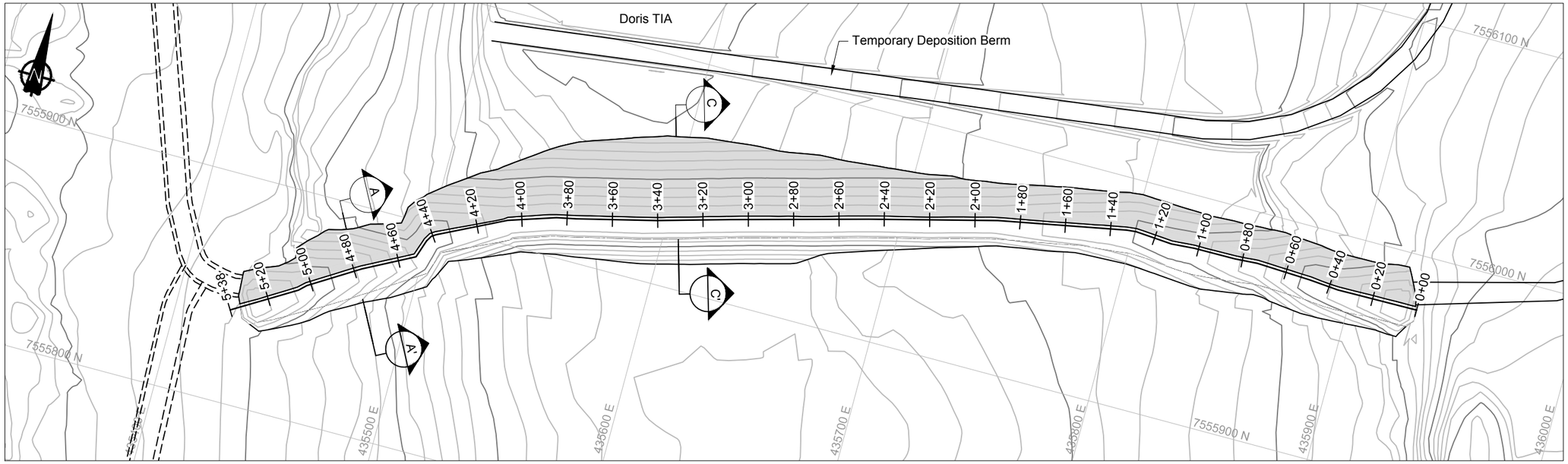

Run of Quarry Placement Plan View

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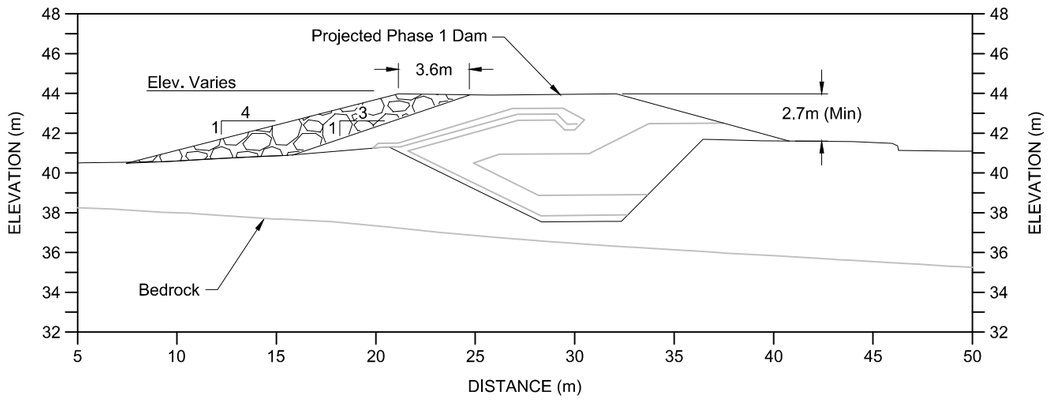

Minimum Cross Section A-A'

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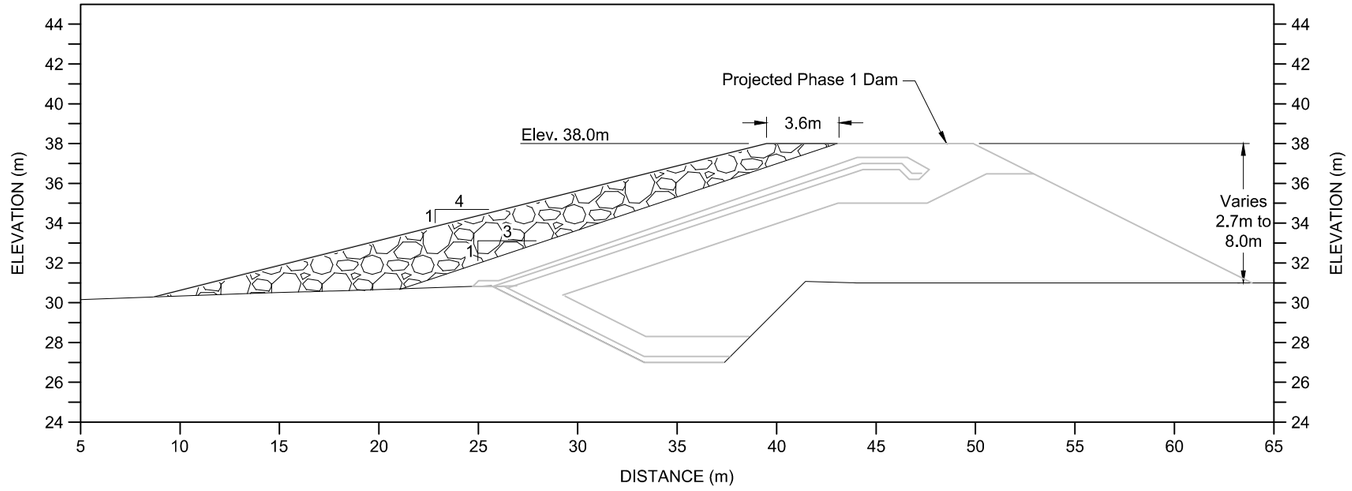

Typical Cross Section C-C'

0m 3 6 9 12

LEGEND

- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Run of Quarry Backfill Extent
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The outside upstream dam ROQ should be sloped at 4H:1V or shallower.

REFERENCES

NAD83 UTM Zone 13.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ-us.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-10	10 OF 30	1

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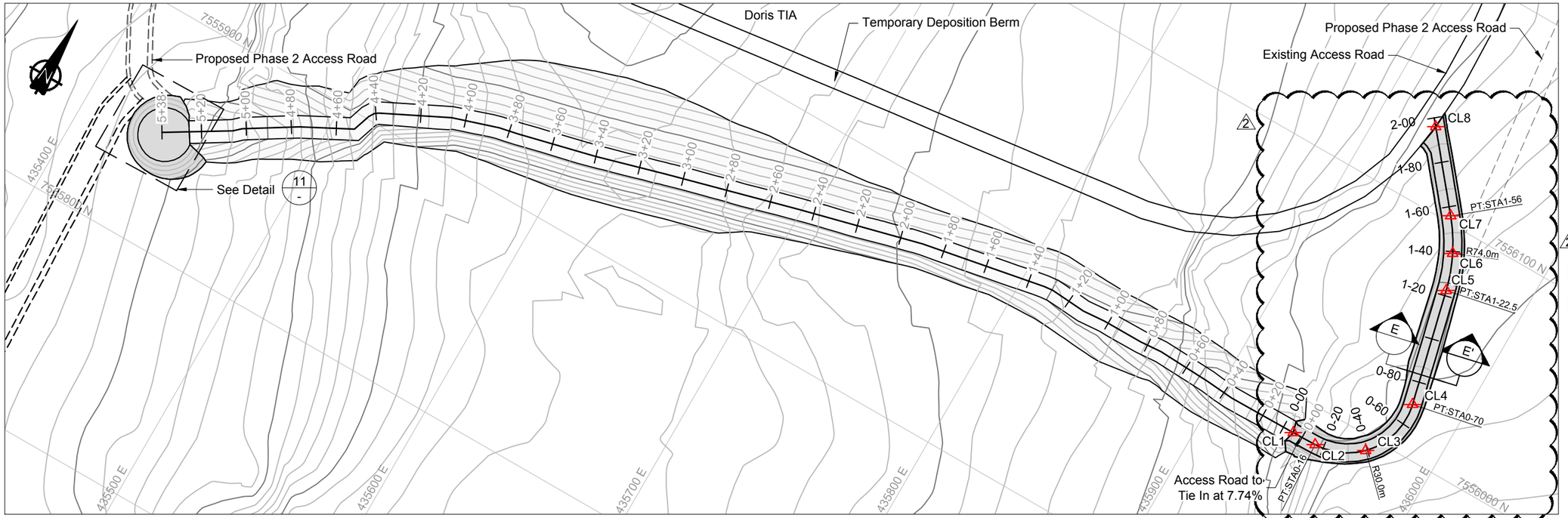
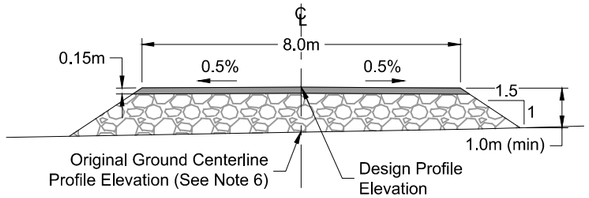
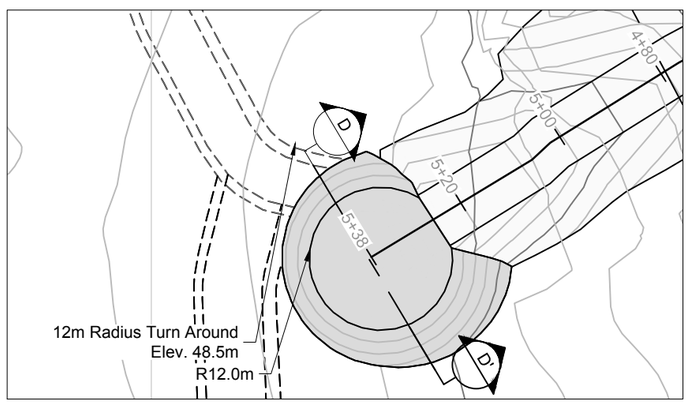


East Access Road and West Turn Around

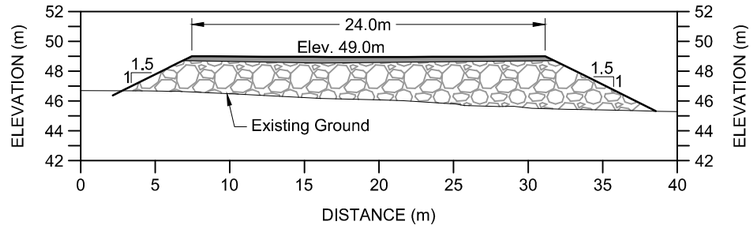
0m 20 40 60 80





Detail 11 - Turn Around

0m 10 20 30 40

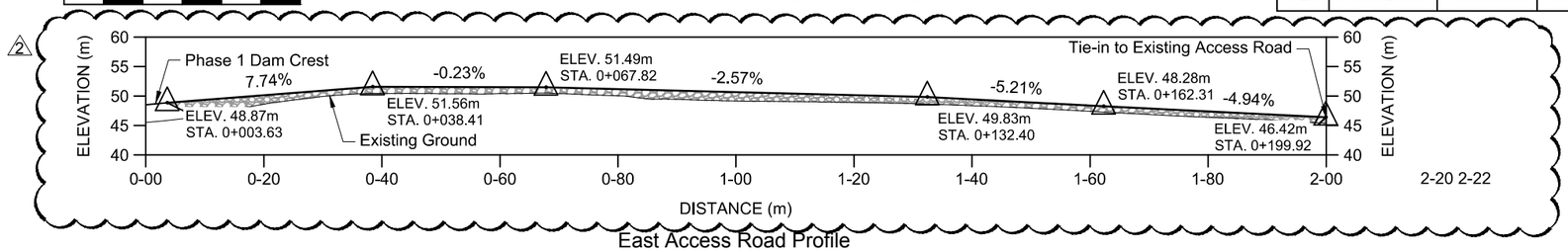


Section D-D' - Turn Around

0m 4 8 12 16

Section E-E' - Typical Road Section

0m 1 2 3 4 5 6



East Access Road Profile

0m 10 20 30 40

LEGEND

- Stakeout Point
- Vertical Inflection Point
- Proposed Road / Dam Infrastructure
- Phase 1 Access Road
- Run of Quarry
- Surfacing Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Approximately 2,440m³ of Fill material is estimated (to neat lines) to be needed for the Access Road and Turn Around.
4. Minimum fill thickness for Access Road and Turn Around is 1.0m
5. Construction shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction.
6. Profile based on available topography. Existing ground level to be surveyed prior to construction to confirm design thickness achieved.

REFERENCES

NAD83 UTM Zone 13.

STAKEOUT POINTS

ID	Northing	Easting	Elev. (m)
CL1	7555976.16	435925.08	48.97
CL2	7555976.39	435936.14	49.83
CL3	7555985.34	435956.86	51.56
CL4	7556013.44	435964.66	51.45
CL5	7556064.69	435952.27	51.09
CL6	7556080.41	435946.53	49.48
CL7	7556094.44	435937.41	48.61
CL8	7556125.37	435911.91	46.61

REFERENCE DRAWINGS		REVISIONS								
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29
DN-SD-03	Typical Sections (General)						1	Issued for Construction	JBK	EMR	18/04/13
							2	Issued for Construction	JBK	EMR	18/04/30

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/30

FILE NAME: 1CT0022.017 - South Dam AR.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Construction Access Road and Turnaround - Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-11	11 OF 26	2

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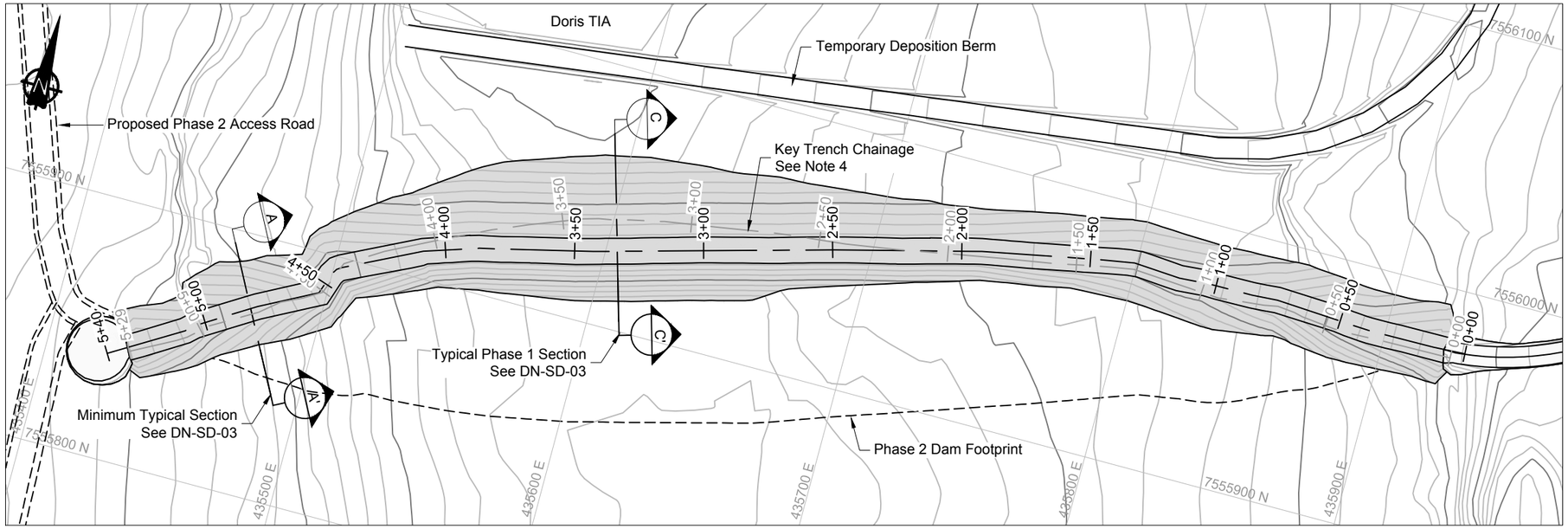
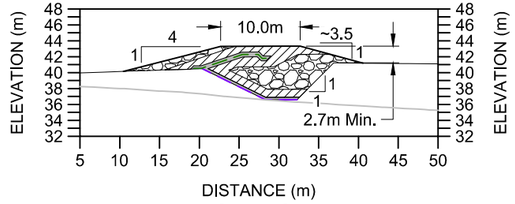


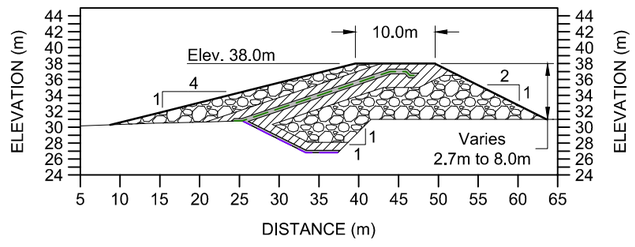
Phase 1 Dam Plan View

0m 20 40 60 80



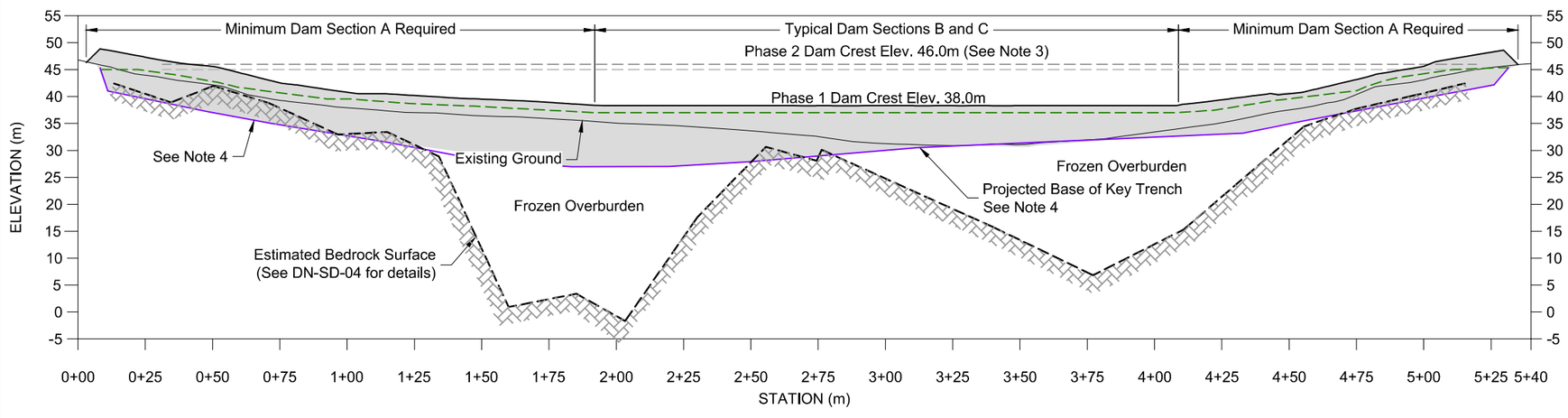
Minimum Cross Section A-A'

0m 5 10 15 20 25 30



Cross Section C-C'

0m 5 10 15 20 25 30



Phase 1 Dam Profile View - Through Crest Centerline

Horizontal: 0m 10 20 30 40

Vertical: 0m 20 40 60 80

LEGEND

- Key Trench Excavation
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The Phase 2 dam elevations are shown for information purposes only. Note that only Phase 1 dam designs and elevations are issued for construction use.
4. Base of key trench on this profile is based on a section down the centerline of the dam crest. Note that the key trench centerline and the dam crest centerline do not share the exact same alignment and overall the chainages vary in any given location (between the key trench and dam crest shown in these drawings) in the range of ±5m.

REFERENCES

NAD83 UTM Zone 13.

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
DN-SD-04	Key Trench Excavation Plan and Profile
DN-SD-03	Typical Sections (General)
DN-SD-02	Phase 1 General Arrangement

REVISIONS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Phase 1 Dam.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Final Phase 1 Dam Plan, Profile and Sections

DRAWING NO.	SHEET	REVISION NO.
DN-SD-12	12 OF 30	1

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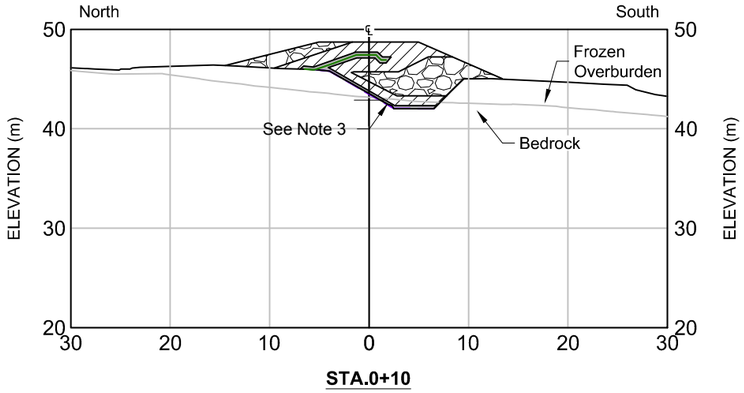

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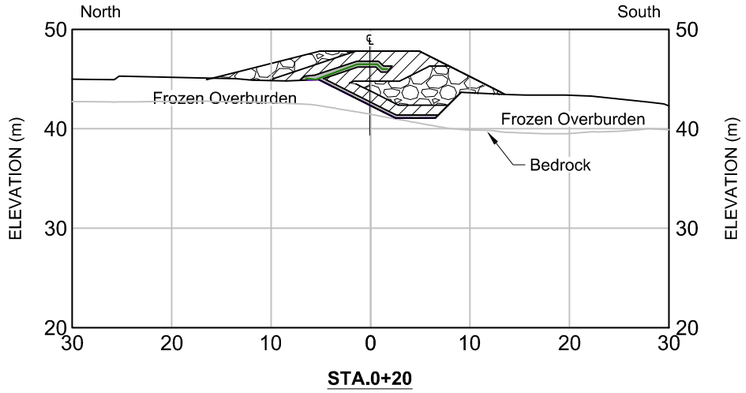

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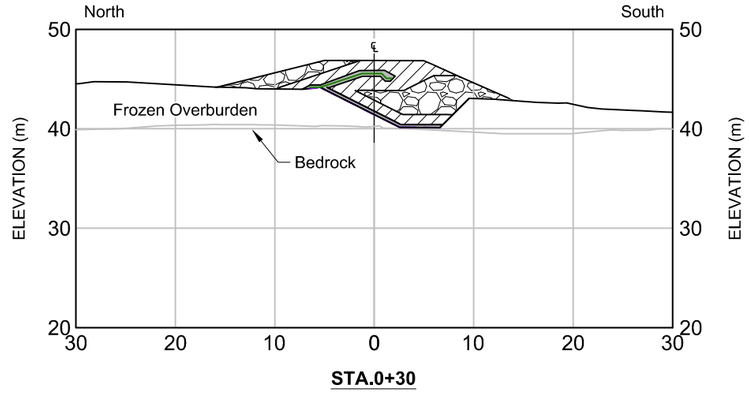

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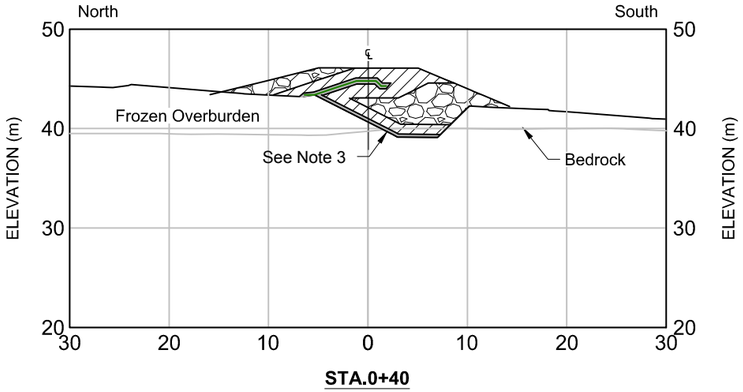

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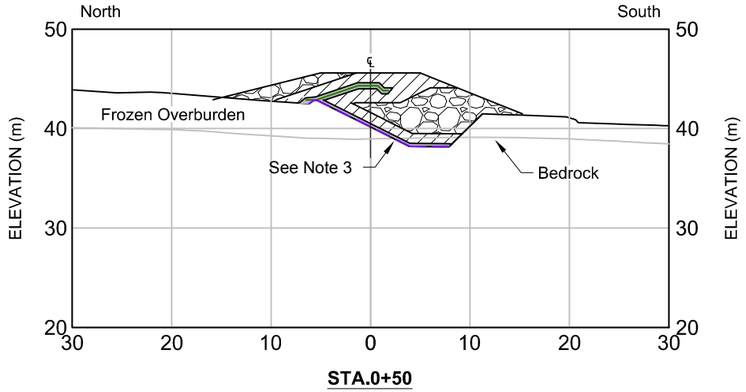

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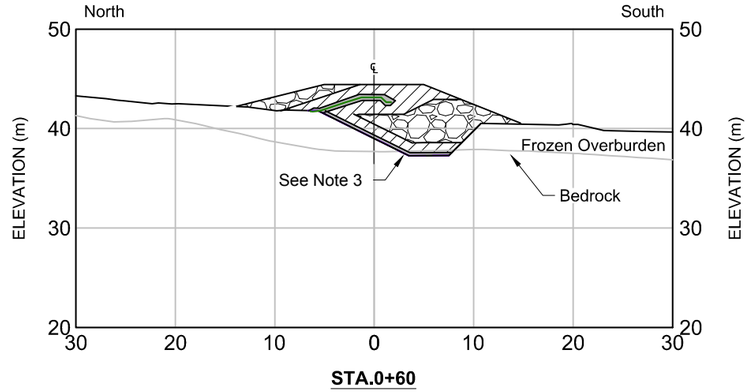

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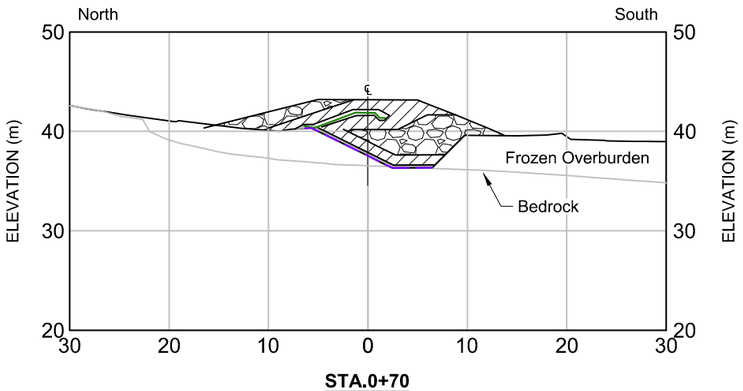

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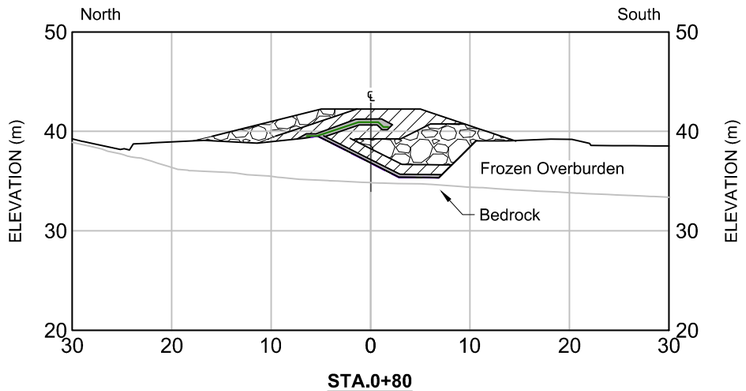

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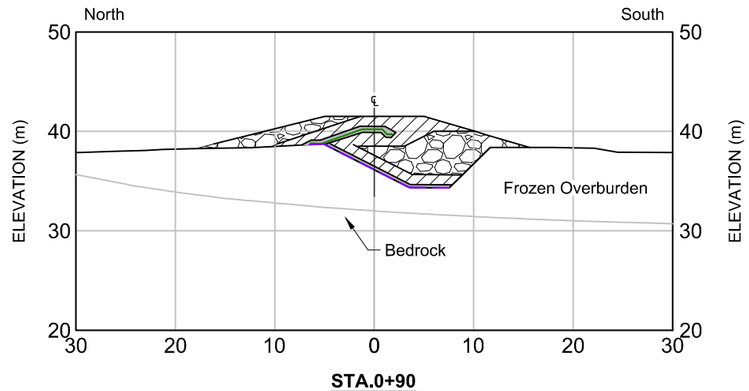


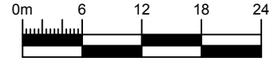
STA.0+90

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth of bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.



REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.0+10 to 0+90 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-13	13 OF 30	1

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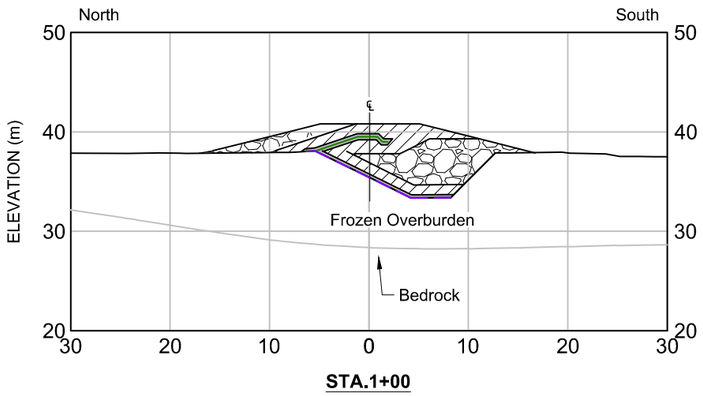

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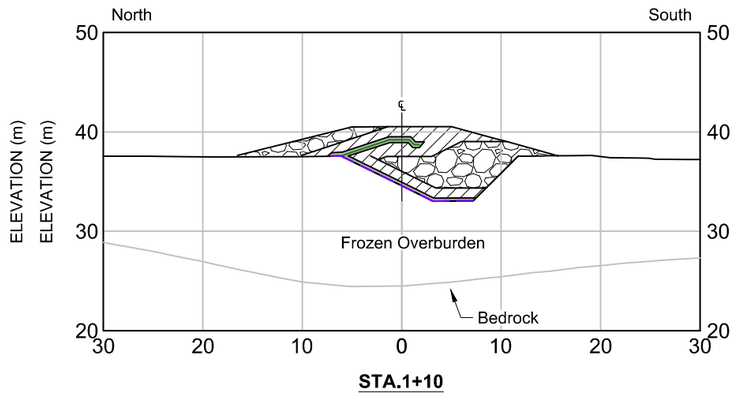

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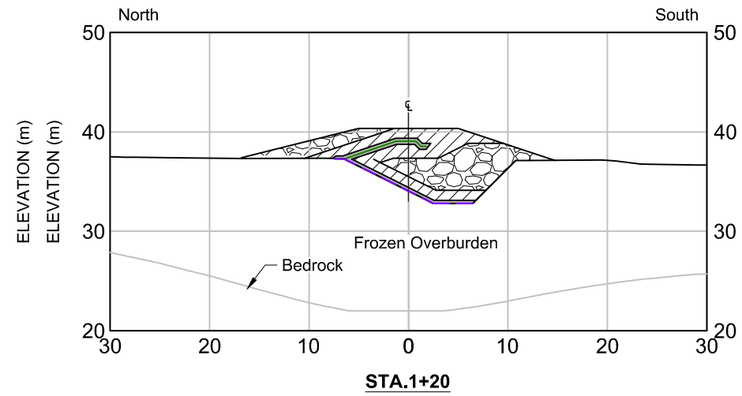

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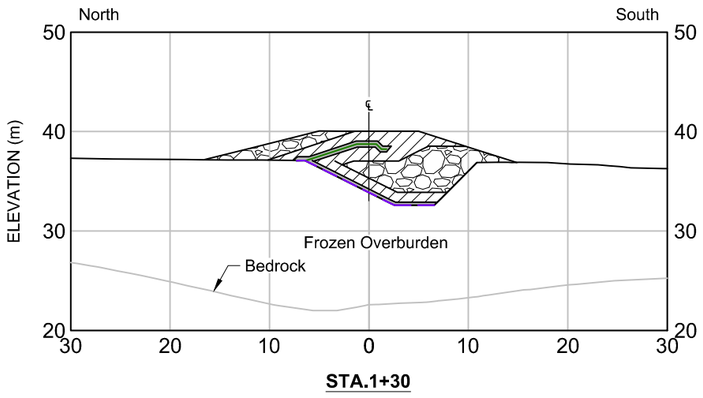

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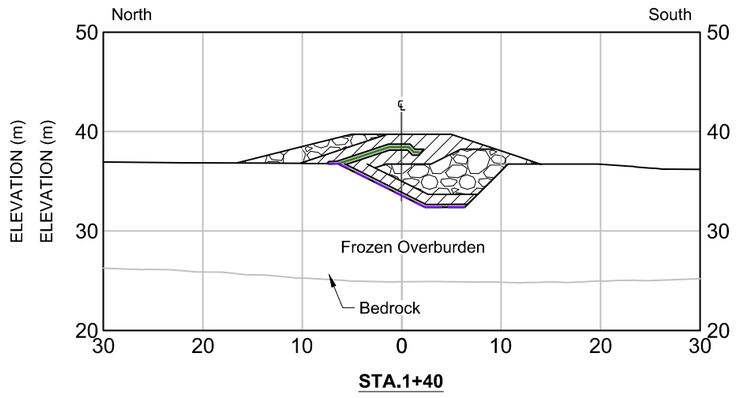

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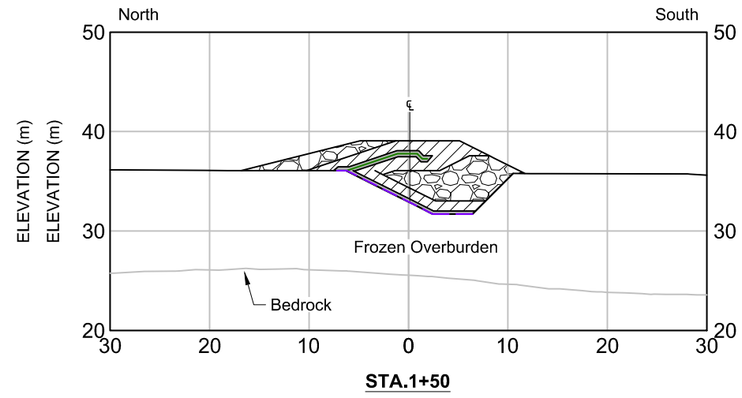

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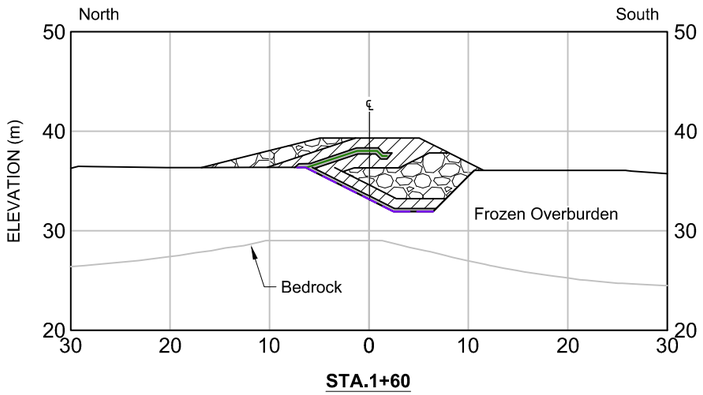

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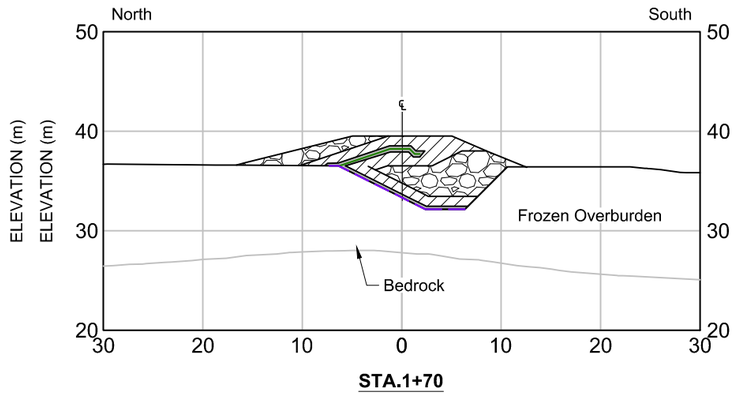

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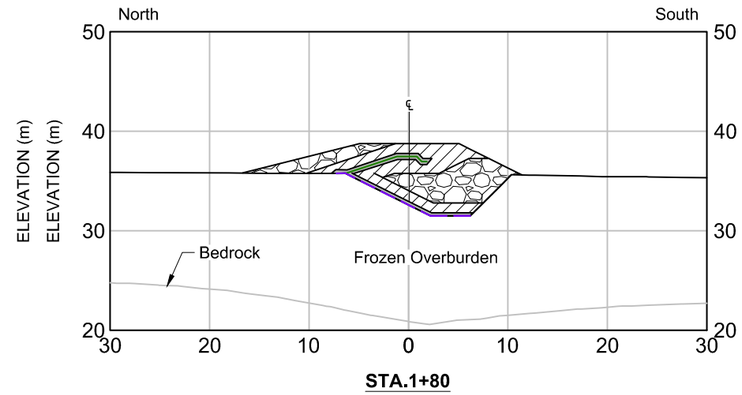

STA.1+80

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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0m 6 12 18 24

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-02	Phase 1 General Arrangement	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.1+00 to 1+80 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-14	14 OF 30	1

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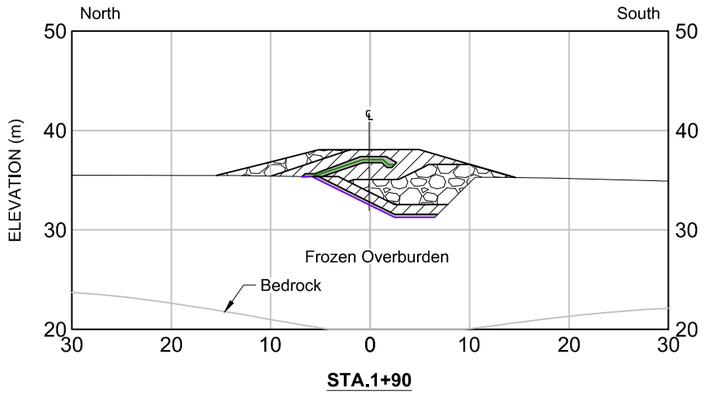

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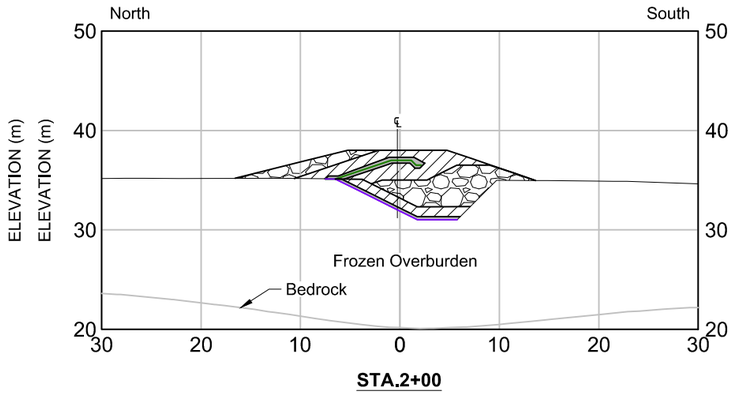

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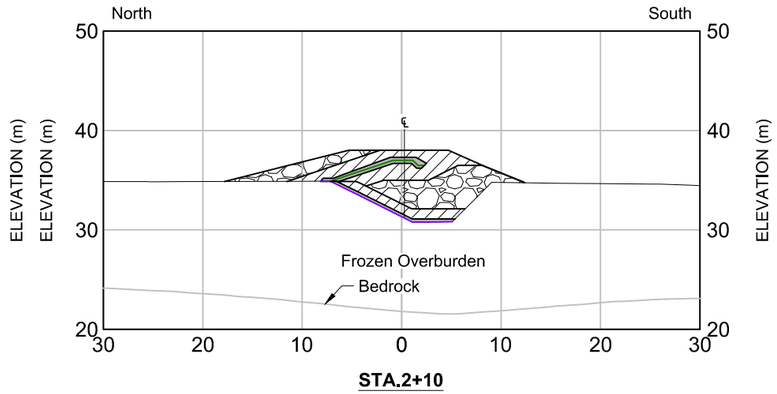

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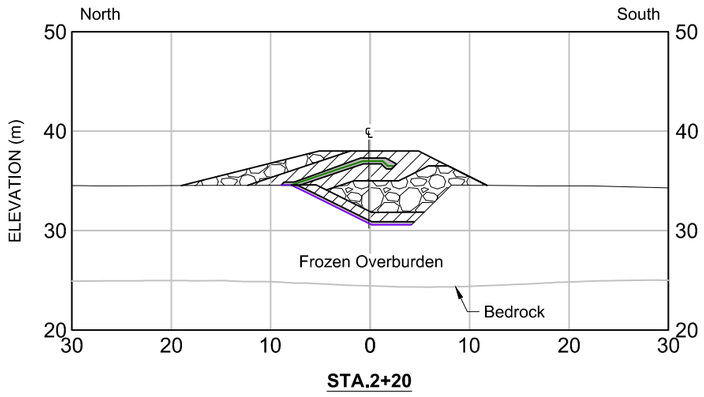

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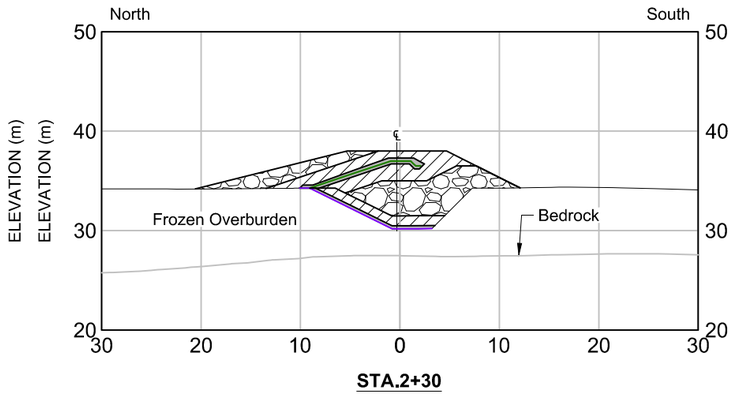

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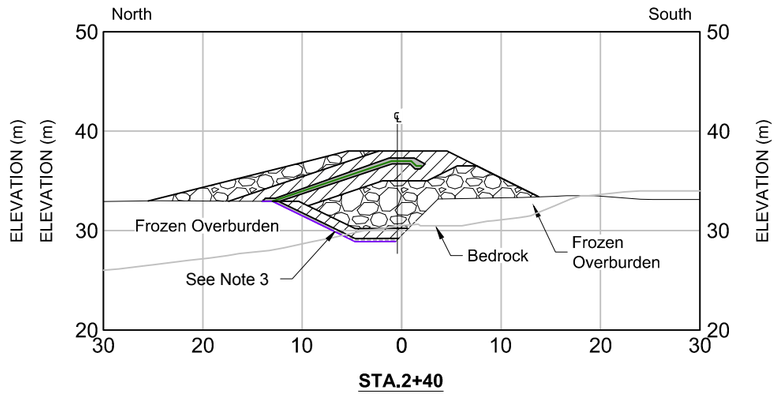

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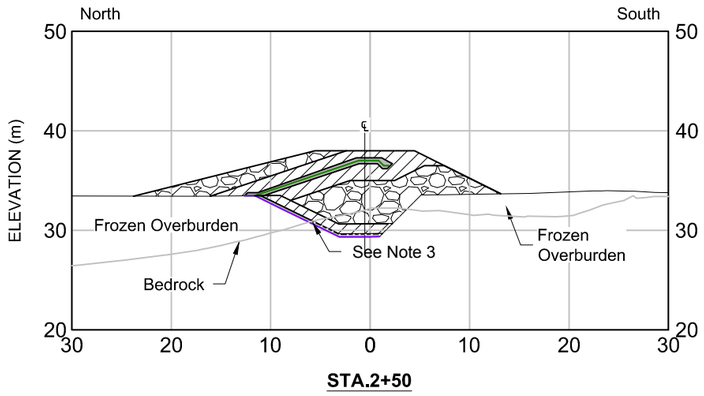

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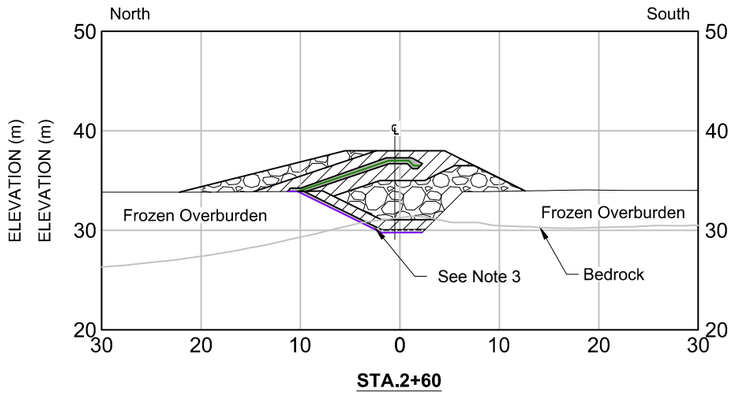

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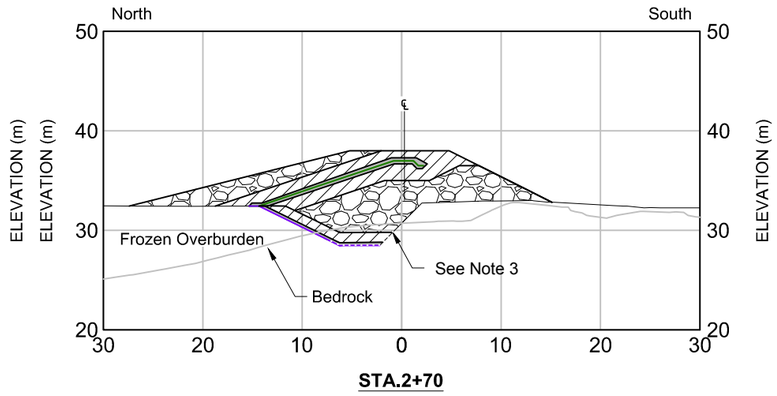

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LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

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0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.1+90 to 2+70 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-15	15 OF 30	1

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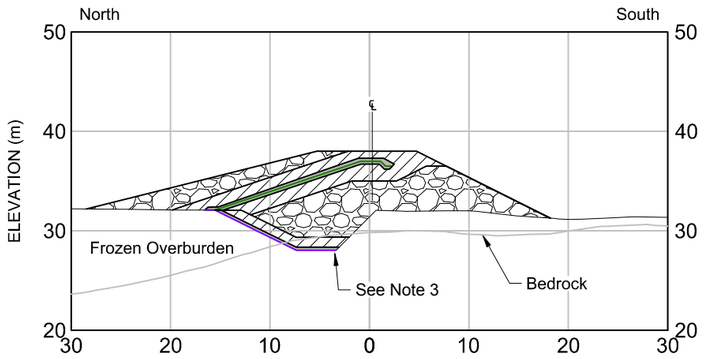

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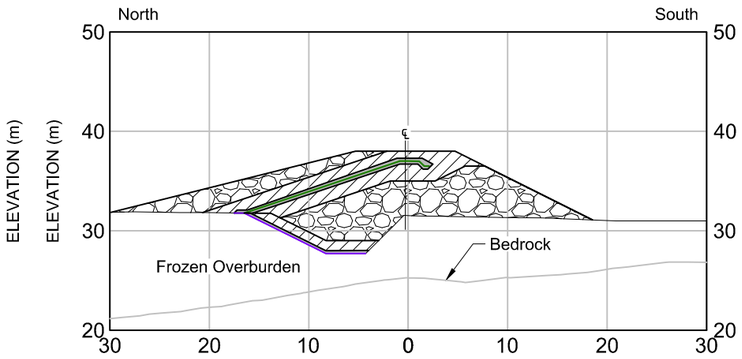

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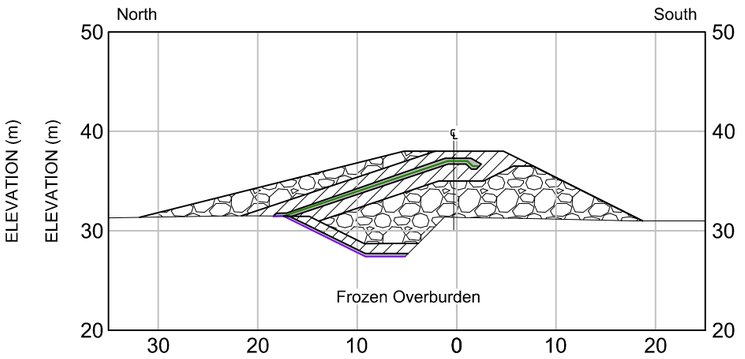

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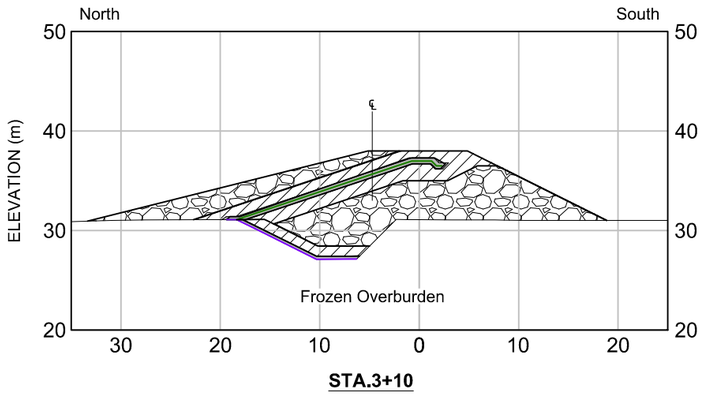

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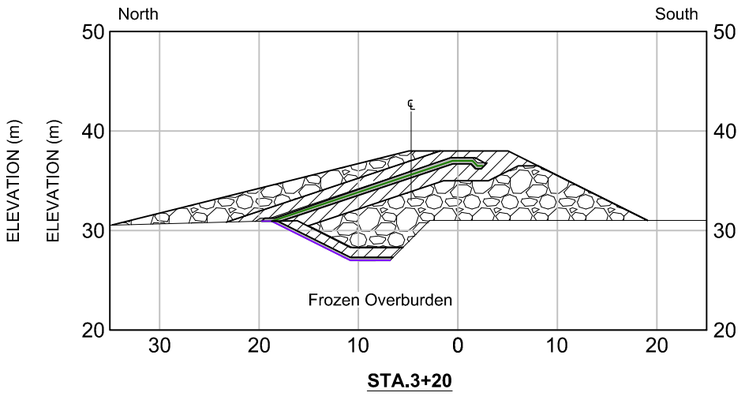

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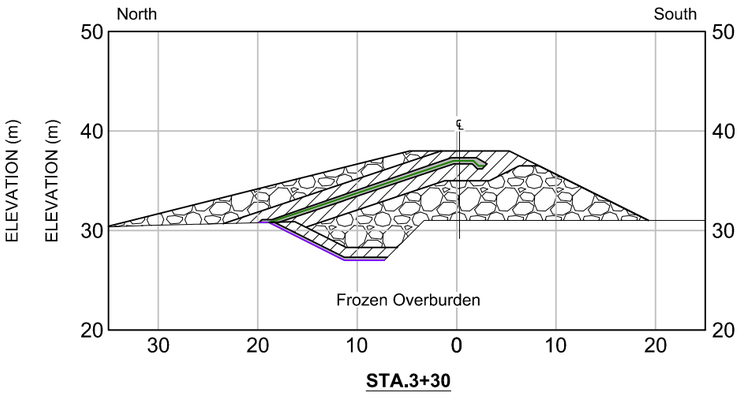

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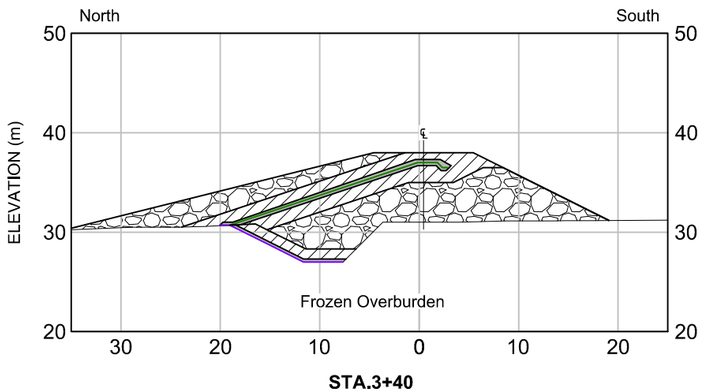

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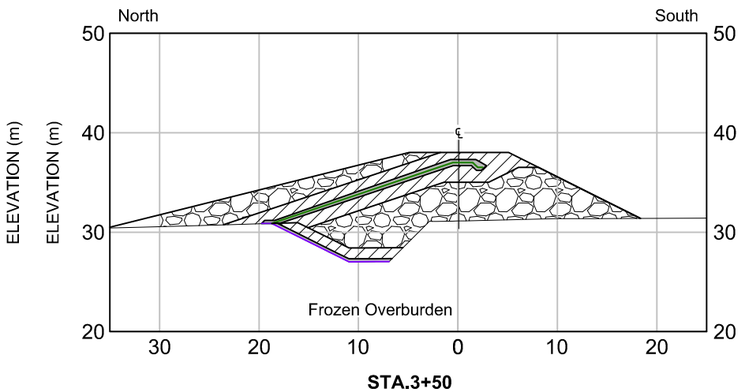

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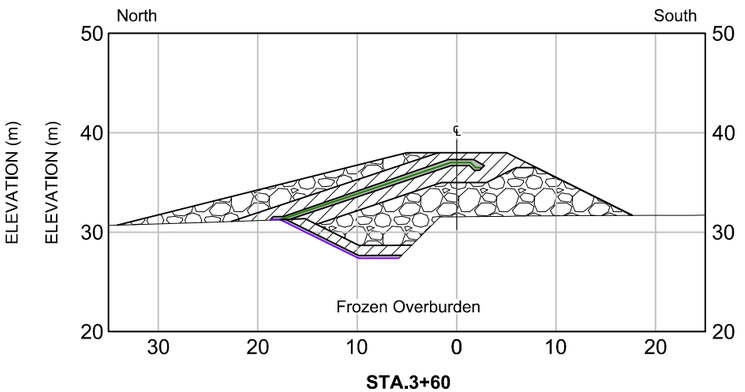


STA.3+60

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

Original Drawings Stamped and Signed by Engineer

This drawing is uncontrolled when printed unless stamped and signed with original ink and recorded on a Distribution Register.

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

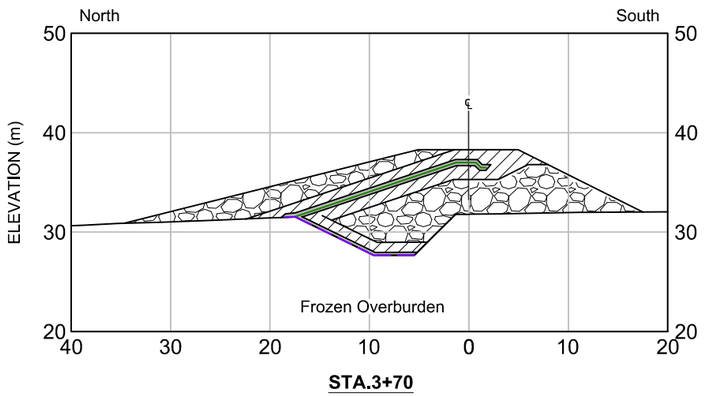
SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.2+80 to 3+60 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-16	16 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1-internal\1CT0022.017 - South Dam - Sections.dwg



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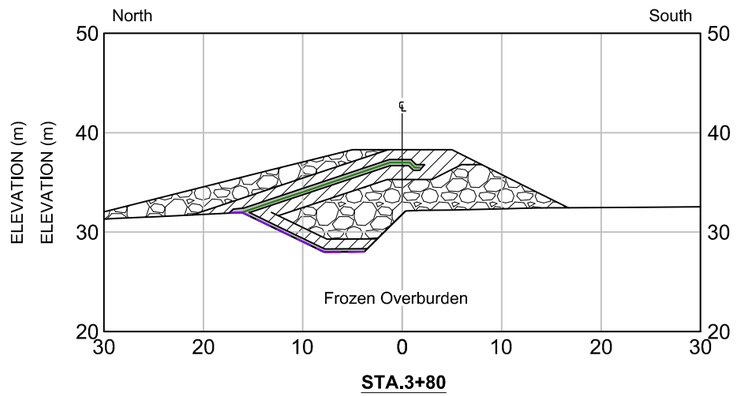

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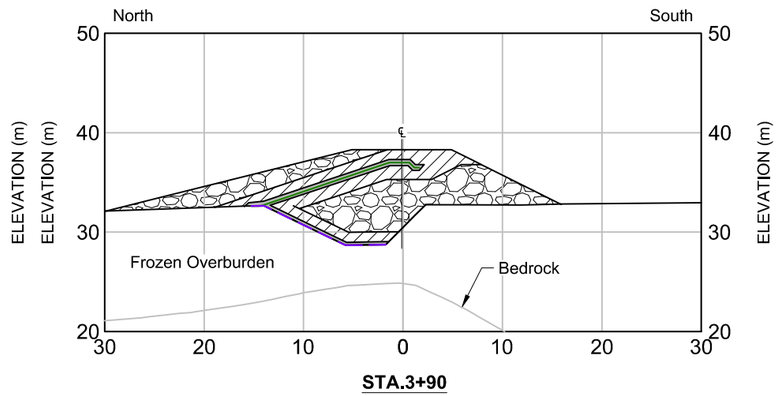

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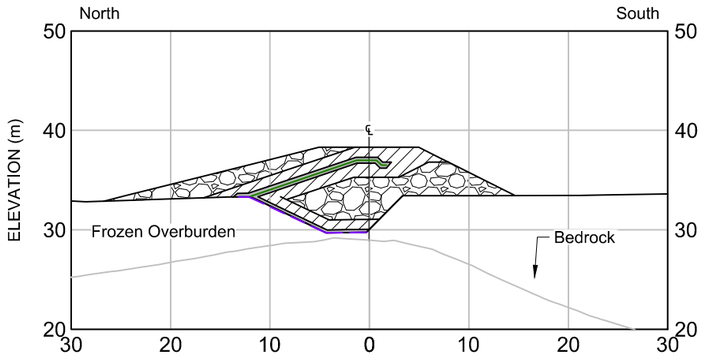

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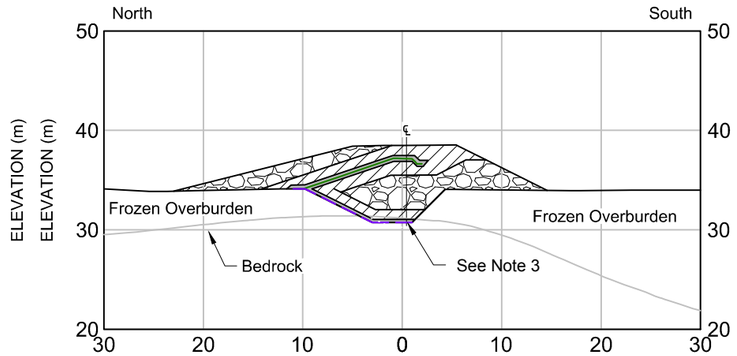

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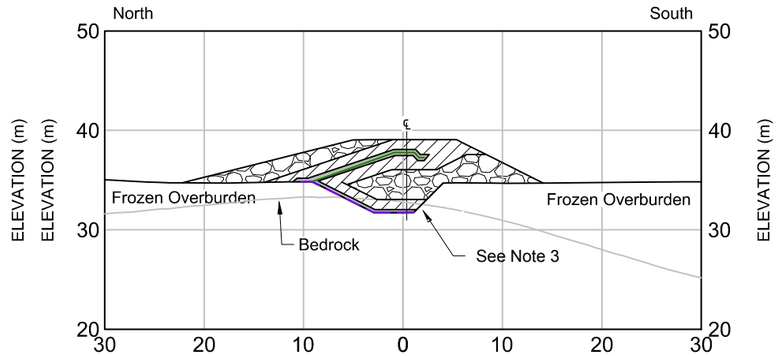

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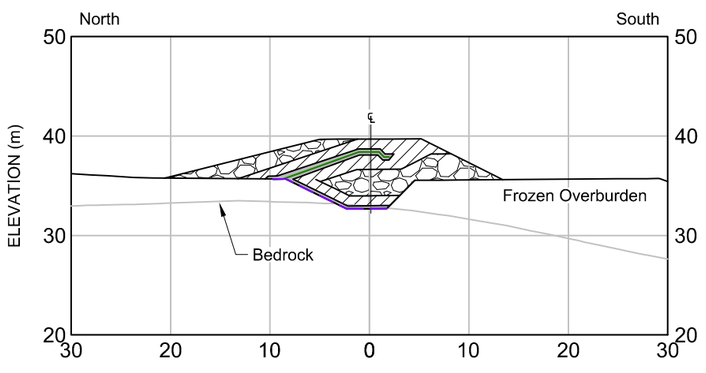

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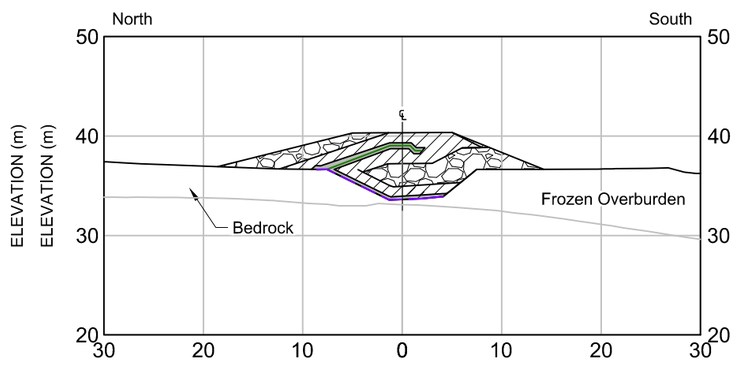

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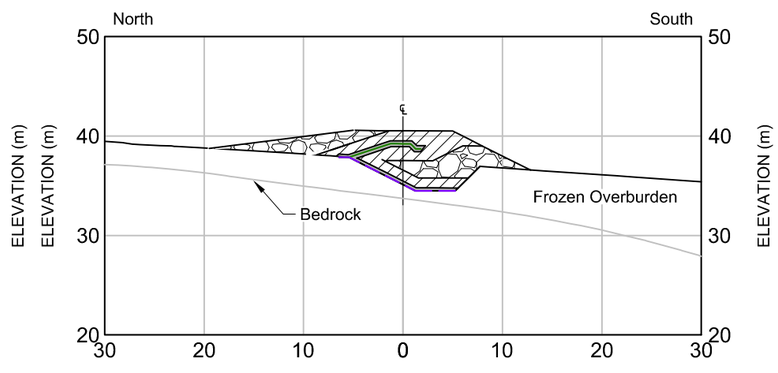

STA.4+50

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.3+70 to 4+50 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-17	17 OF 30	1

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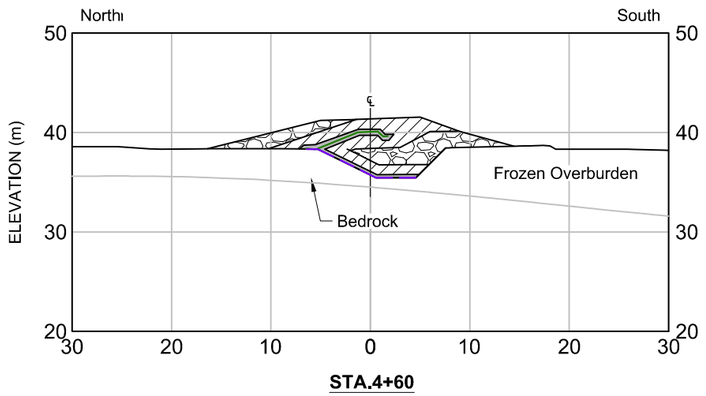

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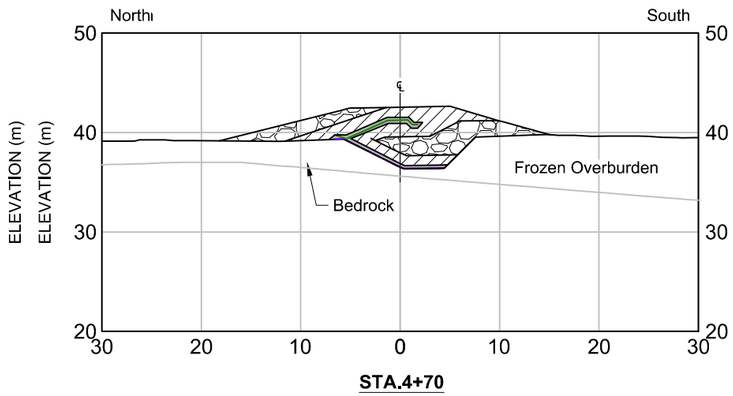

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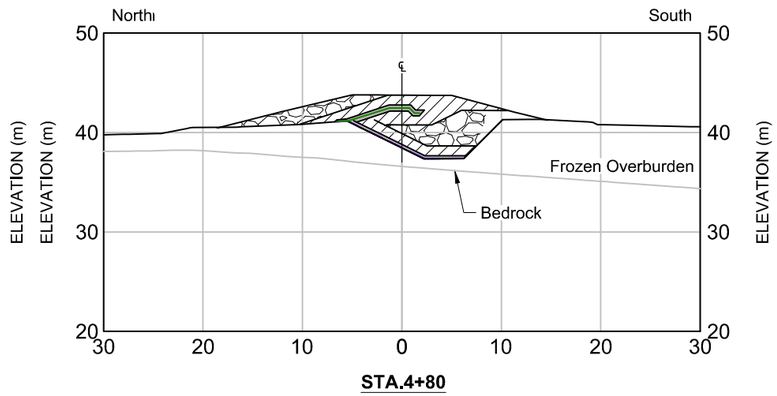

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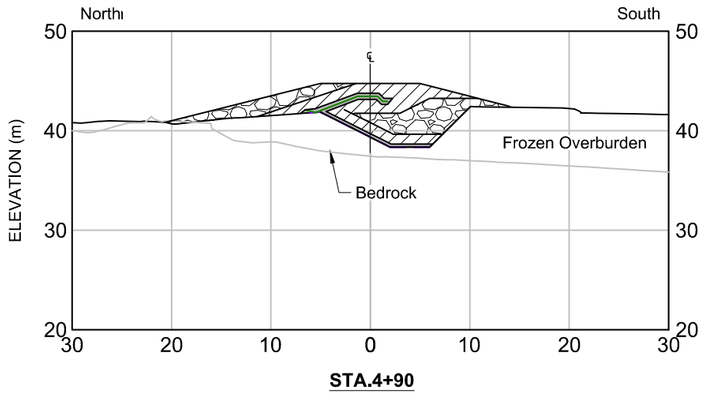

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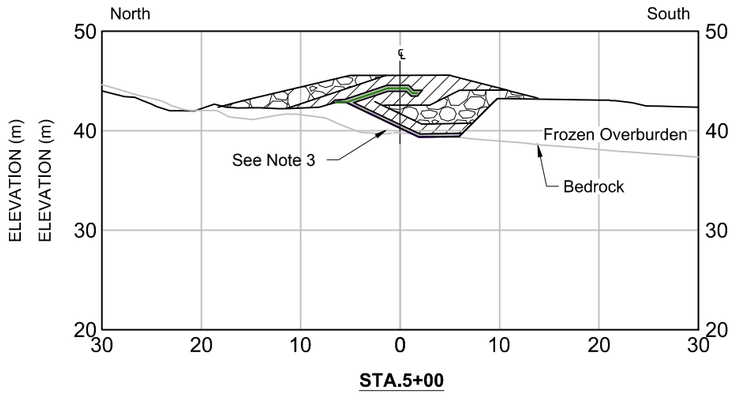

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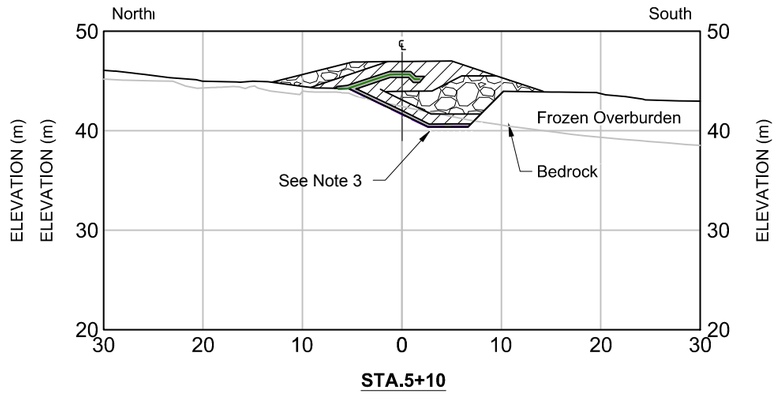

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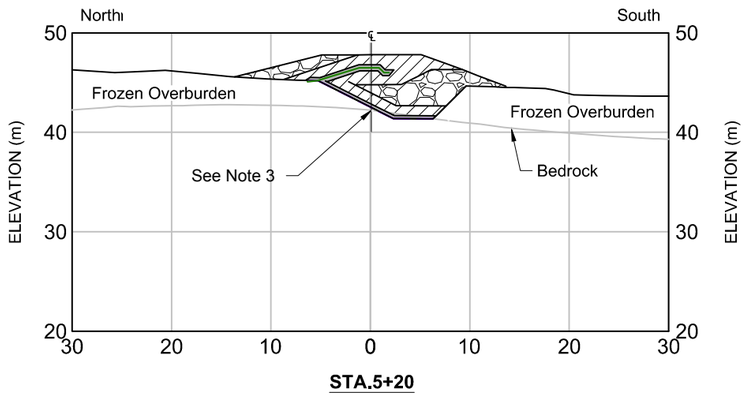

STA.5+20

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.
3. Depth of key trench intersection with bedrock estimated (see DN-SD-04 for additional details). Actual depth may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

REFERENCE DRAWINGS			REVISIONS								
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CH'K'D	APP'D	DATE	NO.	DESCRIPTION	CH'K'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.4+60 to 5+30 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-18	18 OF 30	1

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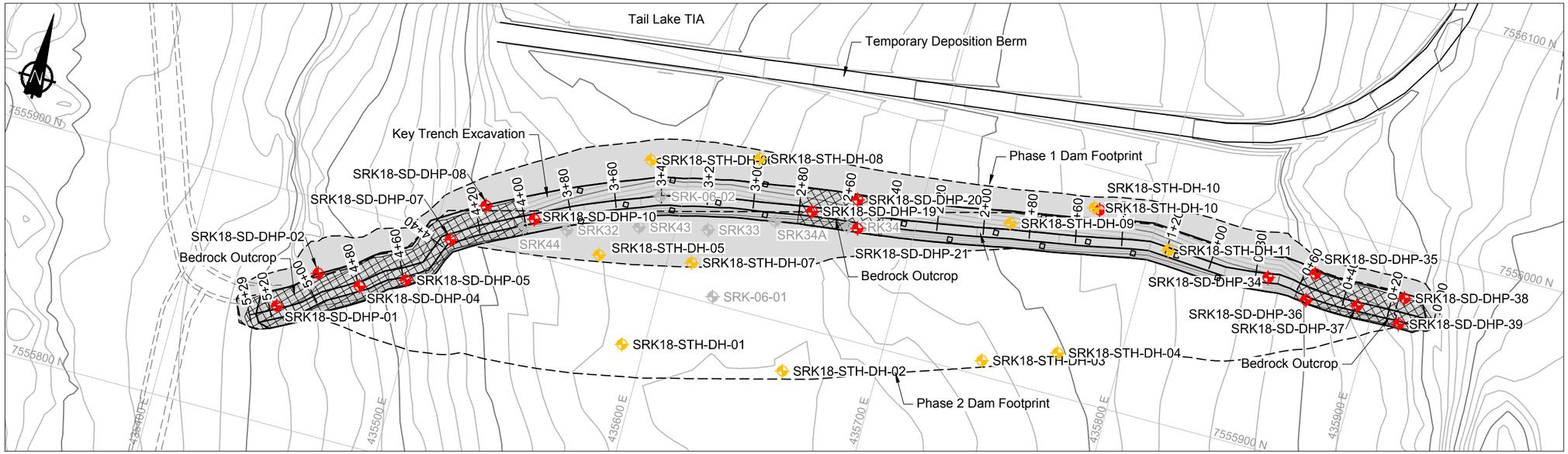
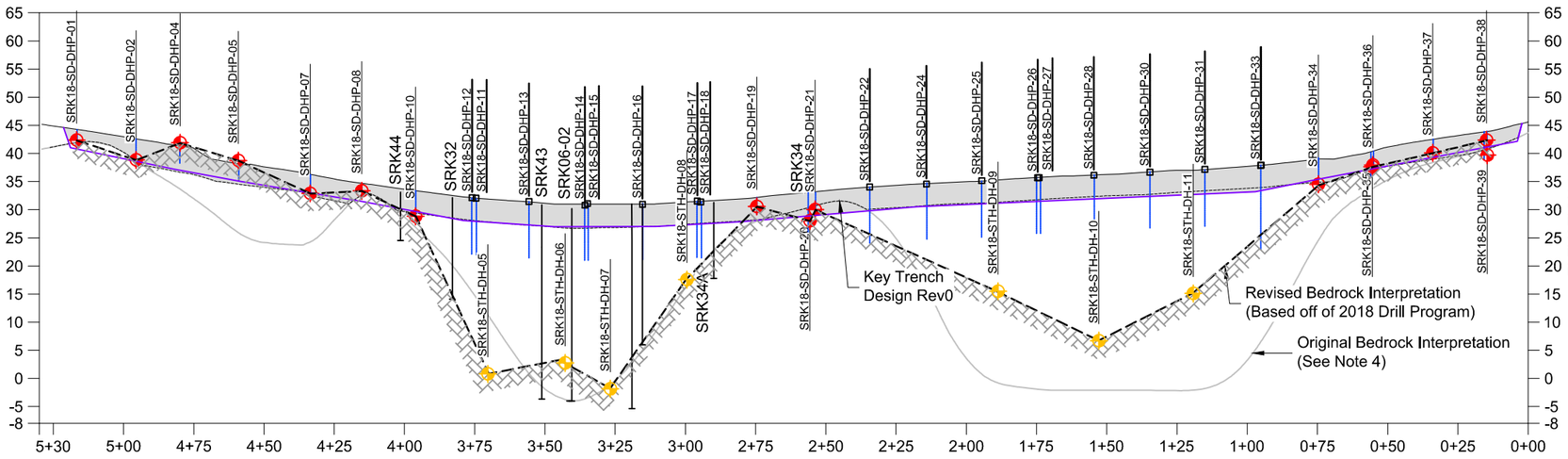


Key Trench Plan View

0m 20 40 60 80



Key Trench Profile View

Vertical 0m 10 20 30 40

Horizontal 0m 20 40 60 80

LEGEND

- Previous Investigation Hole Location
- 2018 Percolation Hole Location Intercepted Bedrock
- 2018 Percolation Hole Location Did Not Intercept Bedrock
- 2018 Borehole Location
- Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Trench Excavation Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profile shown correspond to the upstream toe of the key trench.
4. The subsurface geology has been inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A , SRK43, SRK 44, SRK18-STH-DH-01 to 11, and SRK18-WST-DH-01 to 03), airphoto interpretations, and from limited available geophysical surveys around the Tails Lake area. This data was then used to create a bedrock surface with the Gemcom GEMS software. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.
5. Infill drilling is planned to be completed to reduce the uncertainty and associated risks with the Phase 1 South Dam key trench excavation and overall dam performance (e.g. stability, seepage, settlement, and creep).
6. Depths of infill drill boreholes estimated based on available information (Note 4 and as noted on DN-SD-04). Boreholes should be drilled 3m into bedrock unless terminated earlier as directed by the onsite Engineer.
7. Inferred bedrock contact based off exploration and percolation testing holes drilled January / February 2018 by SRK Consulting.

REFERENCES

NAD83 UTM Zone 13.

AS-BUILT BOREHOLE LOCATIONS

Point ID	Northing	Easting	Collar Elevation	Depth to Bedrock
SRK18-STH-DH-01	7555,873	435,590	31.34	29.9
SRK18-STH-DH-02	7555,880	435,660	30.69	3.0
SRK18-STH-DH-03	7,555,907	435,742	33.59	13.5
SRK18-STH-DH-04	7,555,918	435,773	34.82	10.4
SRK18-STH-DH-05	7,555,908	435,571	31.81	31.0
SRK18-STH-DH-06	7,555,953	435,582	30.35	27.6
SRK18-STH-DH-07	7,555,915	435,610	30.86	32.7
SRK18-STH-DH-08	7,555,966	435,627	31.07	13.5
SRK18-STH-DH-09	7,555,967	435,739	35.03	15.5
SRK18-STH-DH-10	7,555,983	435,772	6.10	6.7
SRK18-STH-DH-11	7,555,973	435,808	36.82	15.1
SRK18-WST-DH-01	7,556,486	435,113	43.25	7.1
SRK18-WST-DH-02	7,556,296	435,200	41.42	1.1
SRK18-WST-DH-03	7,556,195	435,257	42.71	5.4

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
AB	As-Built	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/12/11

DN-SD-04 — Key Trench Excavation Plan and Profile (DRAWING NO. / DRAWING TITLE)

REFERENCE DRAWINGS | REVISIONS

Original Drawings Stamped and Signed by Engineer

This drawing is uncontrolled when printed unless stamped and signed with original ink and recorded on a Distribution Register.

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN: JBK | DRAWN: TAH | REVIEWED: EMR

CHECKED: JBK | APPROVED: EMR | DATE: 2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Infill Foundation Drilling.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Infill Foundation Drilling Phase 1

DRAWING NO.: DN-SD-19 | SHEET: 19 OF 30 | REVISION NO.: AB

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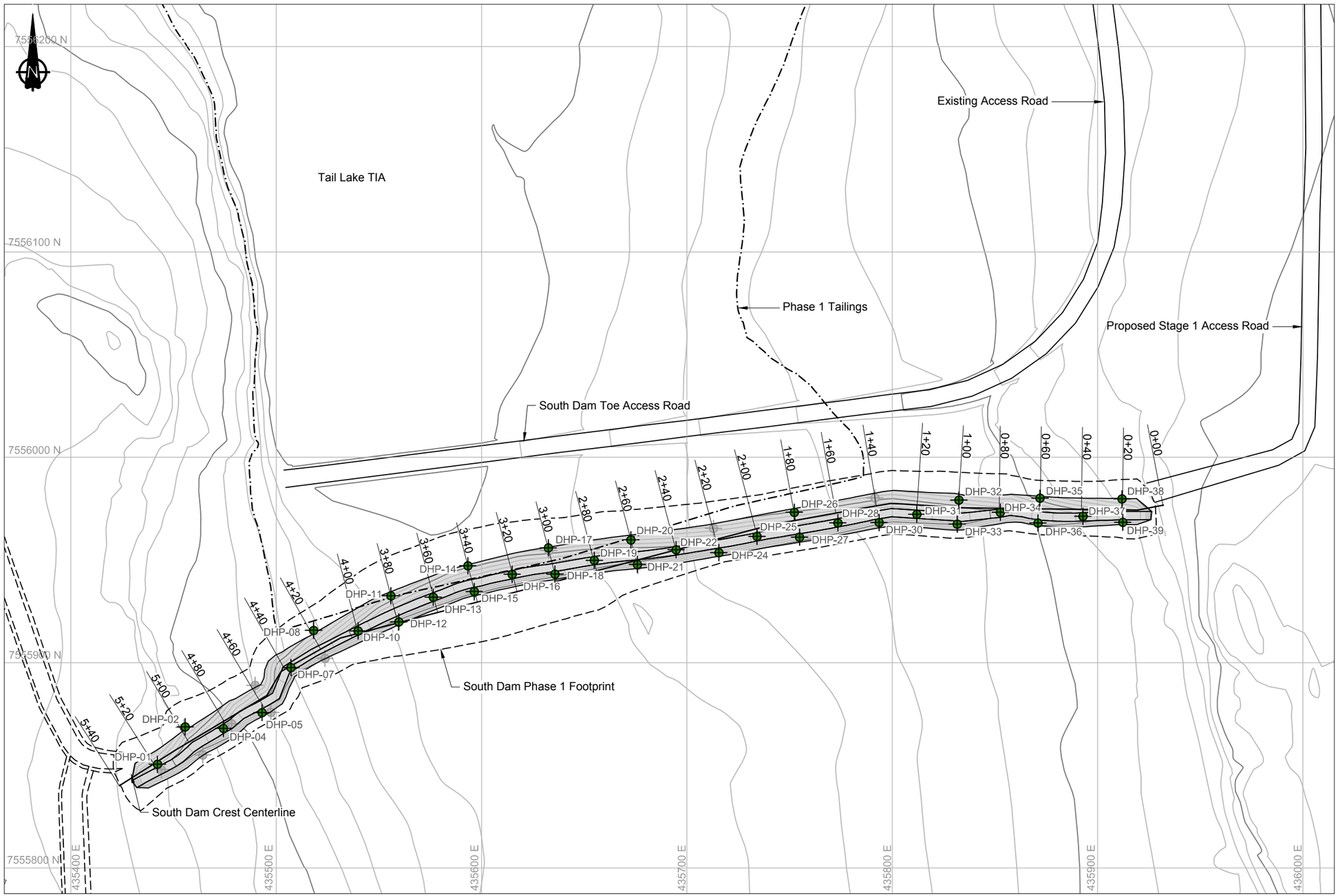

LEGEND

- Proposed Drill Hole Location
- As-Built Drill Hole Location
- Proposed Road Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Outline

NOTES

1. Contours shown at a 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. All percolation test boreholes should be a minimum 8.0m deep.
4. Percolation test boreholes should be a minimum of 4-6 inches (100-150mm) in diameter.
5. It is suggested that an air-track drill (quarry drill) be used to complete the percolation testing.
6. Once all percolation test locations are drilled the testing will be completed on site as directed by the Engineer.

REFERENCES

NAD83 UTM Zone 13.

AS-BUILT PERCOLATION BOREHOLE LOCATIONS

Point ID	Northing	Easting	Elevation
SRK18-SD-DHP1	7555850.42	435442.14	44.2
SRK18-SD-DHP2	7555868.68	435455.71	42.1
SRK18-SD-DHP4	7555867.85	435474.33	41.0
SRK18-SD-DHP5	7555875.60	435493.08	37.9
SRK18-SD-DHP7	7555897.52	435507.19	36.0
SRK18-SD-DHP8	7555915.67	435518.25	34.3
SRK18-SD-DHP10	7555915.40	435539.87	32.8
SRK18-SD-DHP11	7555932.47	435555.80	31.6
SRK18-SD-DHP12	7555919.75	435559.69	31.8
SRK18-SD-DHP13	7555931.76	435576.48	31.1
SRK18-SD-DHP14	7555947.08	435593.31	30.5
SRK18-SD-DHP15	7555934.56	435596.45	30.7
SRK18-SD-DHP16	7555942.92	435614.88	31.2
SRK18-SD-DHP17	7555955.86	435632.48	31.6
SRK18-SD-DHP18	7555943.01	435635.74	31.5
SRK18-SD-DHP19	7555949.72	435654.89	32.0
SRK18-SD-DHP20	7555959.68	435672.72	33.0
SRK18-SD-DHP21	7555947.75	435675.88	33.1
SRK18-SD-DHP22	7555954.90	435694.71	33.7
SRK18-SD-DHP24	7555953.48	435715.55	34.4
SRK18-SD-DHP25	7555961.44	435734.11	35.0
SRK18-SD-DHP26	7555973.14	435752.28	35.5
SRK18-SD-DHP27	7555961.00	435754.88	35.4
SRK18-SD-DHP28	7555967.97	435773.53	35.9
SRK18-SD-DHP30	7555968.15	435793.60	36.4
SRK18-SD-DHP31	7555972.15	435812.00	37.1
SRK18-SD-DHP32	7555979.10	435832.48	37.7
SRK18-SD-DHP33	7555967.38	435831.61	37.6
SRK18-SD-DHP34	7555973.14	435852.65	38.6
SRK18-SD-DHP35	7555980.03	435871.93	40.9
SRK18-SD-DHP36	7555967.95	435870.94	40.1
SRK18-SD-DHP37	7555971.21	435892.86	42.4
SRK18-SD-DHP38	7555979.68	435911.87	44.3
SRK18-SD-DHP39	7555968.28	435912.27	43.5

REFERENCE DRAWINGS		REVISIONS								
							AB	As-Built	JBK	EMR	18/04/13
DN-SD-04	Key Trench Excavation Plan and Profile	--	--	--	--	--	0	Issued for Construction	JBK	EMR	17/12/11
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
JBK	TAH	EMR
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT022.017 - Percolation Testing.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Percolation Borehole / Test Locations

DRAWING NO.	SHEET	REVISION NO.
DN-SD-20	20 OF 30	AB

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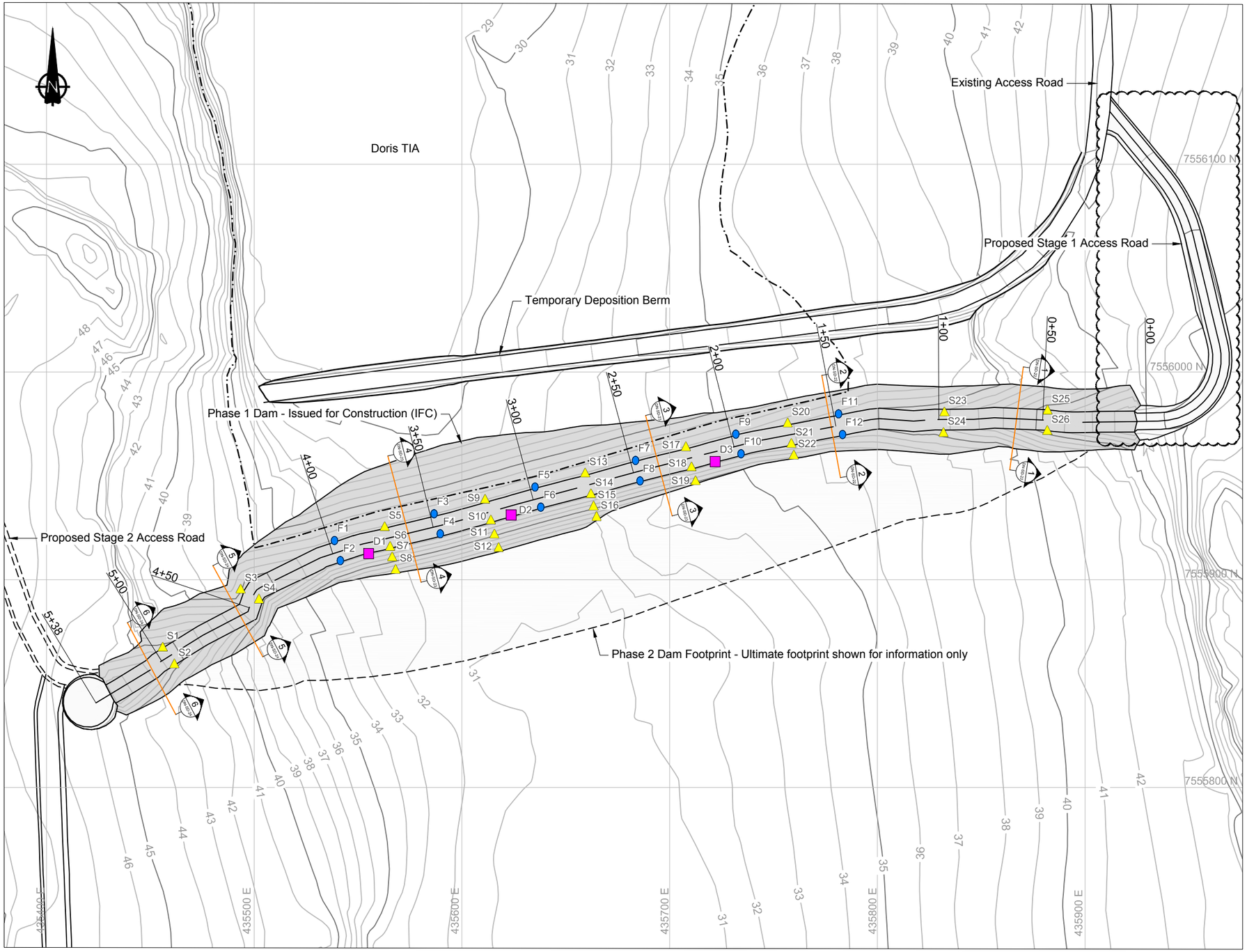

LEGEND

- Fixed Survey Monitoring Point
- Surficial Survey Monitoring Point
- Deep Monitoring Point
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

LAYOUT POINTS

FIXED MONITORING POINT LAYOUT

ID	Northing	Easting
F1	7555918.88	435538.64
F2	7555909.19	435541.45
F3	7555931.74	435586.59
F4	7555922.10	435589.57
F5	7555944.61	435635.18
F6	7555934.92	435637.95
F7	7555957.41	435683.57
F8	7555947.57	435685.75
F9	7555970.06	435731.86
F10	7555960.63	435734.37
F11	7555979.83	435781.32
F12	7555969.90	435783.25

DEEP MONITORING POINT LAYOUT

ID	Northing	Easting
D1	7555912.56	435555.09
D2	7555931.20	435623.72
D3	7555956.79	435721.92

SURFICIAL MONITORING POINT LAYOUT

ID	Northing	Easting
S1	7555867.13	435455.91
S2	7555859.09	435461.52
S3	7555895.08	435493.43
S4	7555890.27	435502.27
S5	7555925.14	435562.81
S6	7555915.59	435565.39
S7	7555910.58	435566.40
S8	7555904.53	435568.05
S9	7555938.29	435611.11
S10	7555928.31	435613.91
S11	7555921.52	435615.61
S12	7555915.02	435617.65
S13	7555950.93	435659.34
S14	7555940.95	435662.14
S15	7555935.05	435663.35
S16	7555929.97	435664.80
S17	7555963.60	435707.79
S18	7555953.90	435710.52
S19	7555947.23	435712.46
S20	7555975.02	435756.82
S21	7555965.18	435758.62
S22	7555959.58	435759.77
S23	7555980.34	435832.29
S24	7555970.43	435831.86
S25	7555981.21	435881.97
S26	7555971.37	435881.83

0m 20 40 60 80

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
2	Issued for Construction - Stakeouts Added	JBK	EMR	18/05/24
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	18/02/16

REVISIONS

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JBK	EMR	2018/05/24

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Plan Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-21	21 OF 30	2

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam Phase 1\21CT0022.017 - Instrumentation Plan.dwg

Doris TIA

Existing Access Road

Proposed Stage 1 Access Road

Proposed Stage 2 Access Road

Temporary Deposition Berm

Phase 1 Dam - Issued for Construction (IFC)

SD-DL01

SD-DL02

SD-DL03

SD-DL04

1+00

0+50

0+00

2+00

2+50

3+00

3+50

4+00

4+50

5+00

5+38

See Note 3

Cable Trench
~19.9m - 1.5m

7556100 N

7556000 N

7555900 N

7555800 N

435400 E

435500 E

435600 E

435700 E

435800 E

435900 E

436000 E

0m 20 40 60 80

LEGEND

- Data Logger Location
- Monitoring Section
- Cable Trench
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Ground Temperature Cable backfilled cable trenches to be excavated through final dam shell - See drawings DN-SD-27, 28 and 29.

REFERENCES

NAD83 UTM Zone 13.

DATA LOGGERS

SD-DL01Reporting Cables:
- SD-VTS-065-KTC
- SD-HTS-065-US
- SD-VTS-155-KTC
- SD-HTS-155-KT
- SD-HTS-155-US
- SD-VTS-155-UST
- SD-VTS-155-DST

SD-DL02 Reporting Cables
- SD-VTS-240-KTC
- SD-VTS-240-KT
- SD-HTS-240-US
- SD-VTS-240-UST
- SD-VTS-240-DST
- SD-HST-B1-KT

SD-DL03 Reporting Cables
- SD-HTS-365-KT
- SD-VTS-365-KTC
- SD-HTS-365-US
- SD-VTS-365-UST
- SD-VTS-365-DST

SD-DL04 Reporting Cables
- SD-HTS-460-KT
- SD-VTS-460-KTC
- SD-HTS-460-US
- SD-HTS-460-UST
- SD-VTS-460-DST
- SD-VTS-510-KTC
- SD-HTS-510-US

STAKE-OUT POINTS

ID	Northing	Easting
SD-DL01	7555978.14	435776.94
SD-DL02	7555959.13	435693.79
SD-DL03	7555927.20	435572.83
SD-DL04	7555887.49	435490.36

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-29	Instrumentation Details at Sta. 4+65 and 5+10					
DN-SD-28	Instrumentation Details at Sta. 2+40 and 3+65					
DN-SD-27	Instrumentation Details at Sta. 0+65 and 1+55					
DN-SD-03	Typical Sections	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
2	Issued for Construction	JBK	EMR	18/04/26
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	18/02/16

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JBK	EMR	2018/04/26

FILE NAME: 1CT0022.017 - GTC Trenches.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

GTC Backfilled Cable Trenches Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-22	22 OF 30	2

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam Phase 1\2\1CT0022.017 - GTC Trenches.dwg

Doris TIA

Existing Access Road

Proposed Stage 1 Access Road

Proposed Stage 2 Access Road

Temporary Deposition Berm

Phase 1 Dam - Issued for Construction (IFC)

7556100 N

7556000 N

7555900 N

7555800 N

435400 E

435500 E

435600 E

435700 E

435800 E

435900 E

436000 E

V-GTC-01 5+42

V-GTC-02 5+50

V-GTC-03

V-GTC-04 5+00

V-GTC-05

V-GTC-06 3+50

V-GTC-07 4+00

V-GTC-08

V-GTC-09 3+00

V-GTC-10 2+50

V-GTC-11 2+00

V-GTC-12 1+50

V-GTC-13 1+00

V-GTC-14 0+50 0+00

0m 20 40 60 80

LEGEND

- Vertical Ground Temperature Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

I.D.	Northing	Easting
V-GTC-01	7555854.81	435451.79
V-GTC-02	7555898.07	435484.95
V-GTC-03	7555882.32	435493.54
V-GTC-04	7555874.72	435497.69
V-GTC-05	7555955.78	435565.30
V-GTC-06	7555932.32	435571.39
V-GTC-07	7555906.23	435578.34
V-GTC-08	7555975.51	435689.29
V-GTC-09	7555956.36	435694.32
V-GTC-10	7555942.48	435698.15
V-GTC-11	7555988.45	435775.01
V-GTC-12	7555971.08	435778.29
V-GTC-13	7555963.40	435779.65
V-GTC-14	7555974.28	435866.64

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	17/12/15

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FILE NAME: 1CT0022.017 - Vertical GTC LO.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Vertical GTC Layout
Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-23	23 OF 30	1

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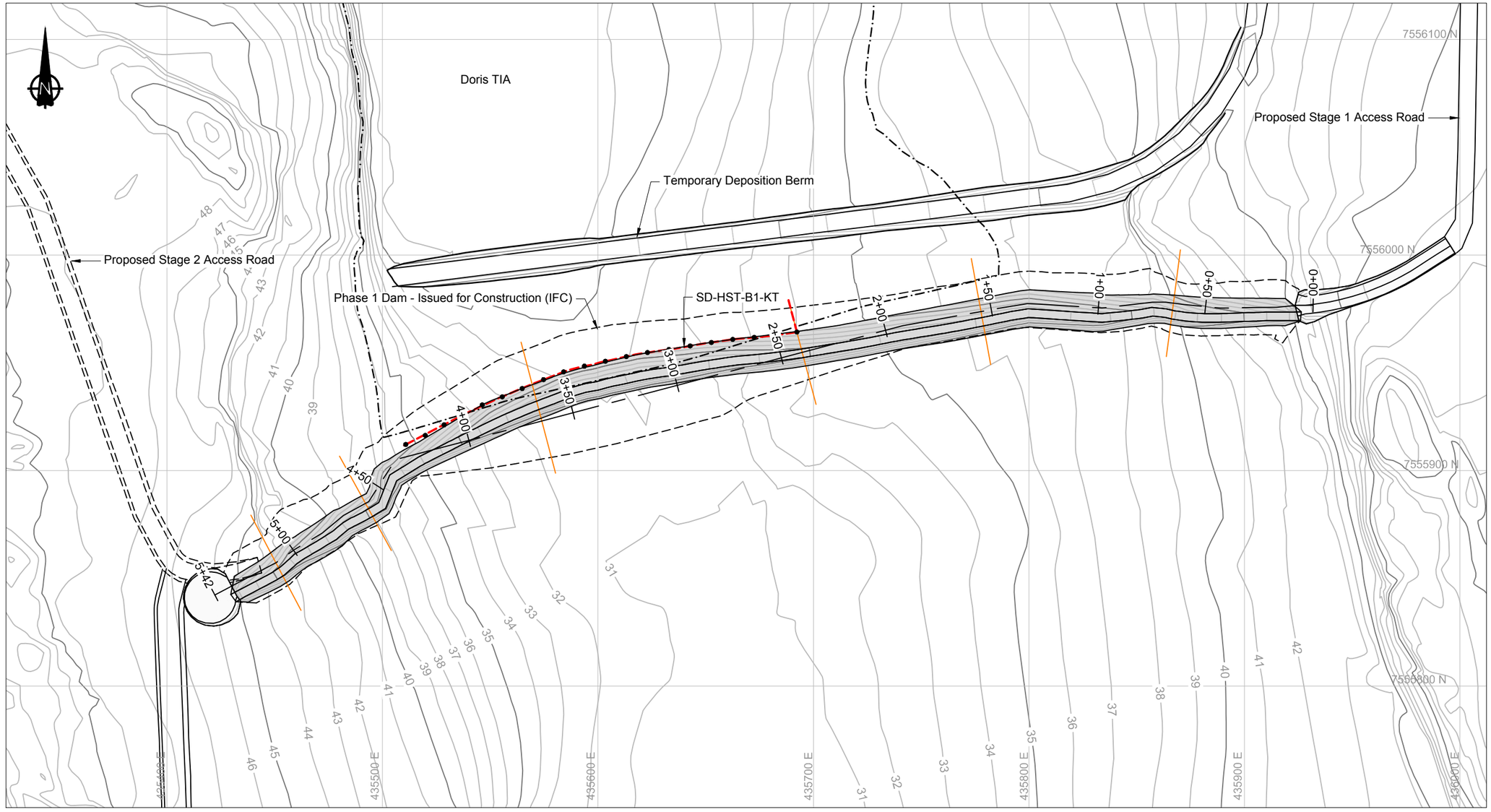

LEGEND

- Horizontal Ground Temperature Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Key Trench Footprint
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

ID	Northing	Easting
HST20098	7555964.28	435692.33
HST20099	7555962.86	435682.43
HST20100	7555961.78	435672.49
HST20101	7555960.86	435662.54
HST20102	7555959.44	435652.64
HST20103	7555957.83	435642.77
HST20104	7555956.14	435632.91
HST20105	7555954.75	435623.01
HST20106	7555952.88	435613.20
HST20107	7555950.71	435603.43
HST20108	7555948.45	435593.71
HST20109	7555945.81	435584.08
HST20110	7555942.19	435574.76
HST20111	7555938.05	435564.84
HST20112	7555934.18	435555.62
HST20113	7555930.47	435546.33
HST20114	7555925.96	435537.40
HST20115	7555921.21	435528.59
HST20116	7555916.34	435519.87
HST20117	7555912.10	435510.79

0m 20 40 60 80

Ground Temperature Cable Details - Center Base

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
1	SD-HST-B1-KT	A	Horizontal	Center	235	Top of Key Trench	20 beads spaced every 10m from the zero line on the cable, i.e. first bead at 0m										

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-	-	-				1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/02/15

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Lower H&II GTC LO.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Horizontal GTC
Upstream Base / Toe of Key Trench

DRAWING NO.	SHEET	REVISION NO.
DN-SD-24	24 OF 30	1

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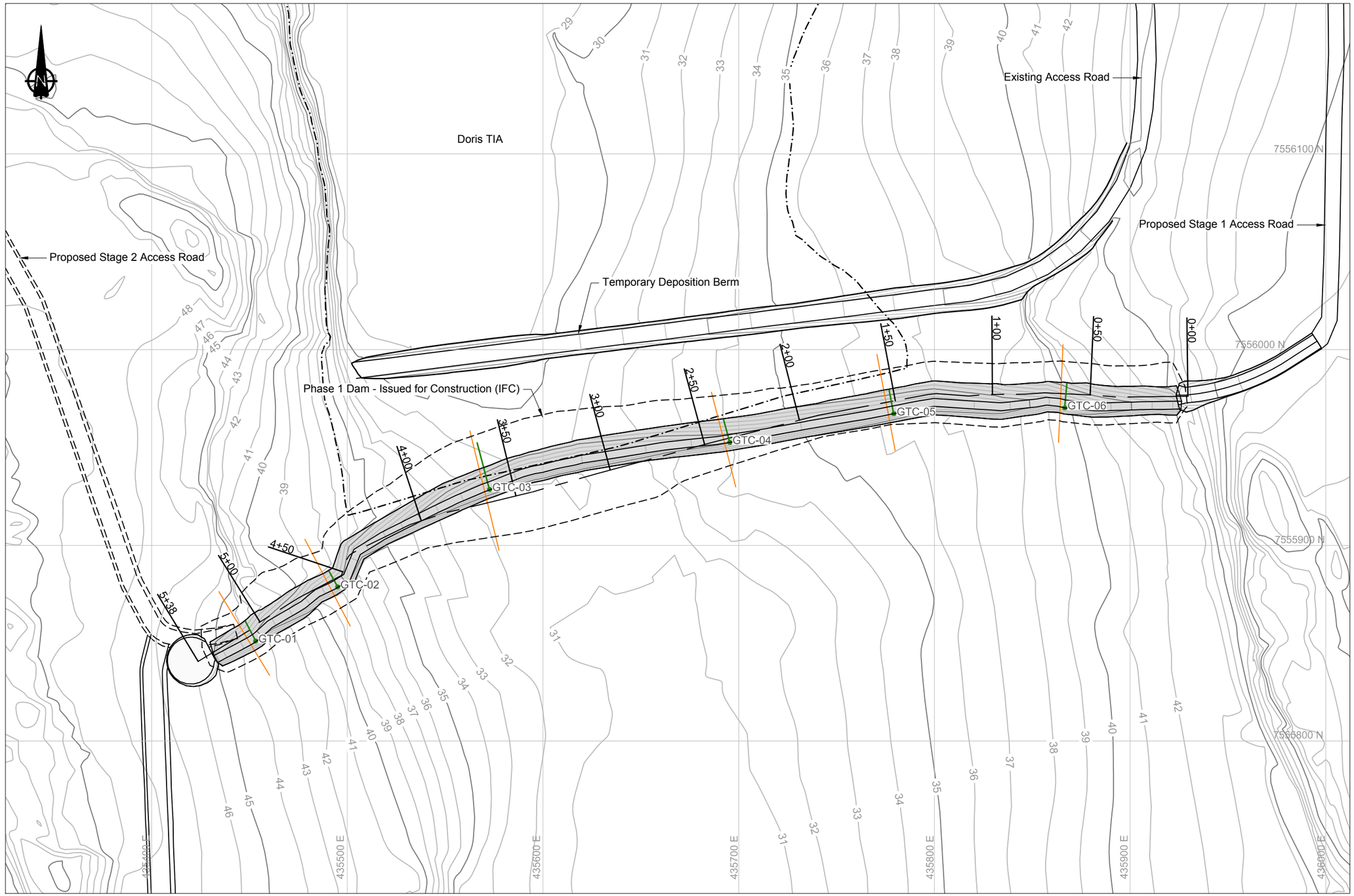

LEGEND

- Leak Detection Instrumentation
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

I.D.	Northing	Easting
GTC-01	7555851	435453
GTC-02	7555879	435495
GTC-03	7555929	435573
GTC-04	7555953	435695
GTC-05	7555937	435779
GTC-06	7555970	435867

0m 20 40 60 80

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-	JBK	EMR	17/12/11

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/12/11

REVISIONS

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FILE NAME: 1CT0022.017 - Leak Detection.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

GTC Layout Along Upstream Slope of Key Trench

DRAWING NO.	SHEET	REVISION NO.
DN-SD-25	25 OF 30	1

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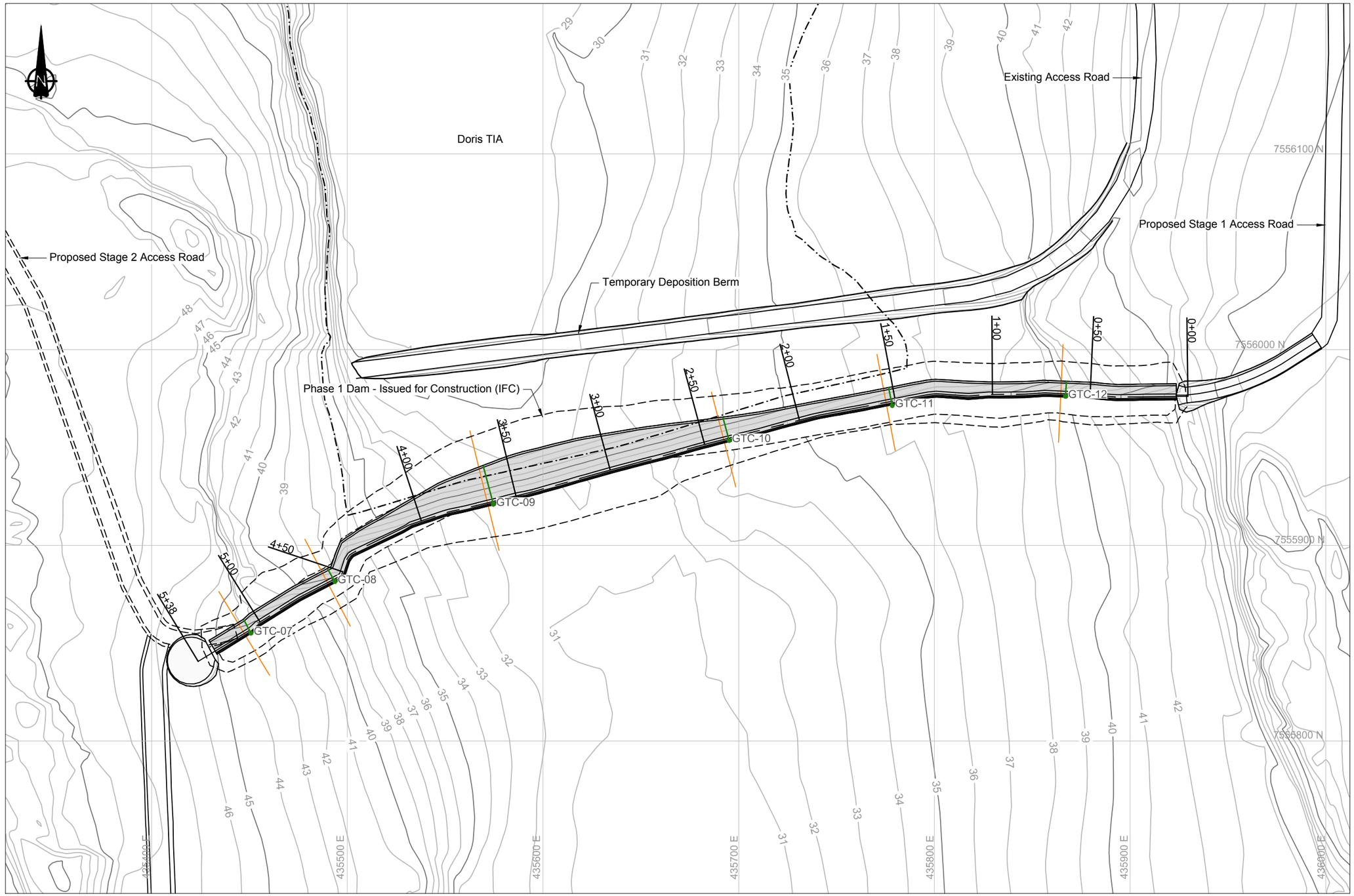

LEGEND

- Ground Temperature Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

I.D.	Northing	Easting
GTC-07	7555855	435451
GTC-08	7555882	435494
GTC-09	7555921	435575
GTC-10	7555954	435695
GTC-11	7555972	435778
GTC-12	7555976	435867

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/12/11

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Liner GTC.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

GTC Layout Along Upstream Above Ground Liner Slope

DRAWING NO.	SHEET	REVISION NO.
DN-SD-26	26 OF 30	1

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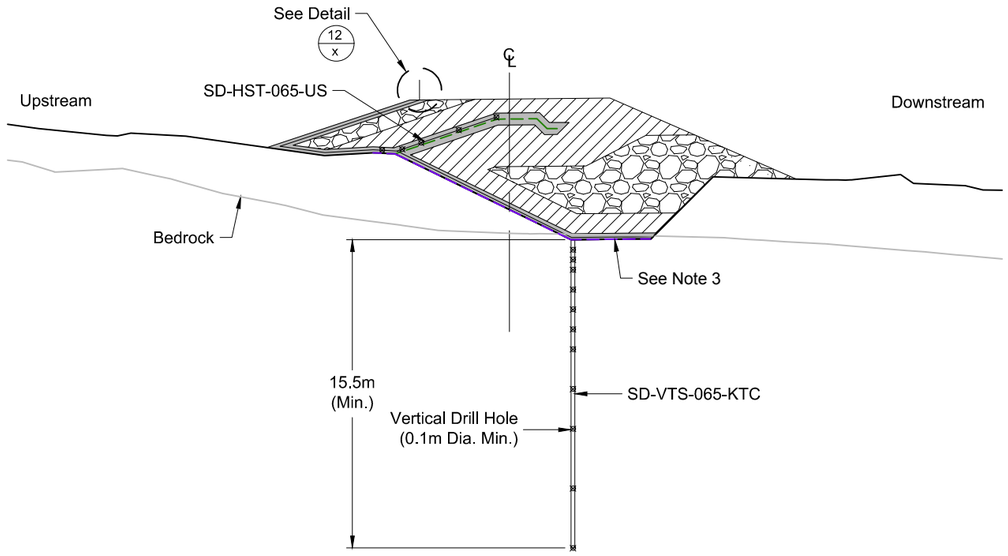
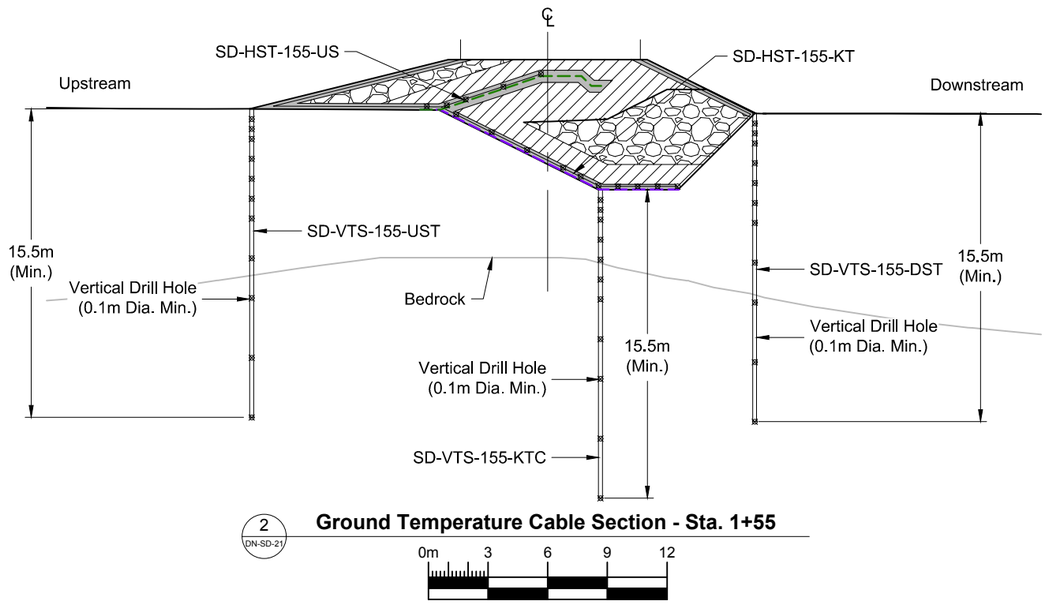


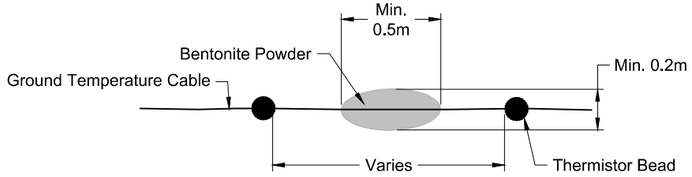
1 DN-SD-21 **Ground Temperature Cable Section - Sta. 0+65**

0m 3 6 9 12



2 DN-SD-21 **Ground Temperature Cable Section - Sta. 1+55**

0m 3 6 9 12



Detail 12 - Typical Water Stop Detail

0m 0.3 0.6 0.9 1.2

LEGEND

- Thermistor Bead Location
- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. Vertical cable boreholes to be filled with grout or backfilled with finer (sand size) material.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

Ground Temperature Cable Details - Monitoring Section 0+65 and 1+55

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
2	SD-VTS-65-KTC	A	Vertical	0+65	42	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
3	SD-HTS-065-US	B	Horizontal & Inclined	0+65	121	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
4	SD-VTS-155-KTC	A	Vertical	1+55	50	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
5	SD-VTS-155-UST	A	Vertical	1+55	41	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
6	SD-VTS-155-DST	A	Vertical	1+55	53	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
7	SD-HTS-155-US	B	Horizontal & Inclined	1+55	41	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
8	SD-HTS-155-KT	C	Horizontal & Inclined	1+55	39	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13
9	SD-HST-B1-KT	C	Horizontal	Center Base	235	Center Base	20 beads spaced every 10m from the zero line on the cable i.e. first bead at 0m										
10	Extension for SD-VTS-065-KTC	D	Vertical	0+65	90		Extension for existing cable. No beads needed.										

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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DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	JBK	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

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FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Details at Sta. 0+65 and 1+55

DRAWING NO. DN-SD-27 | SHEET 27 OF 30 | REVISION NO. 1

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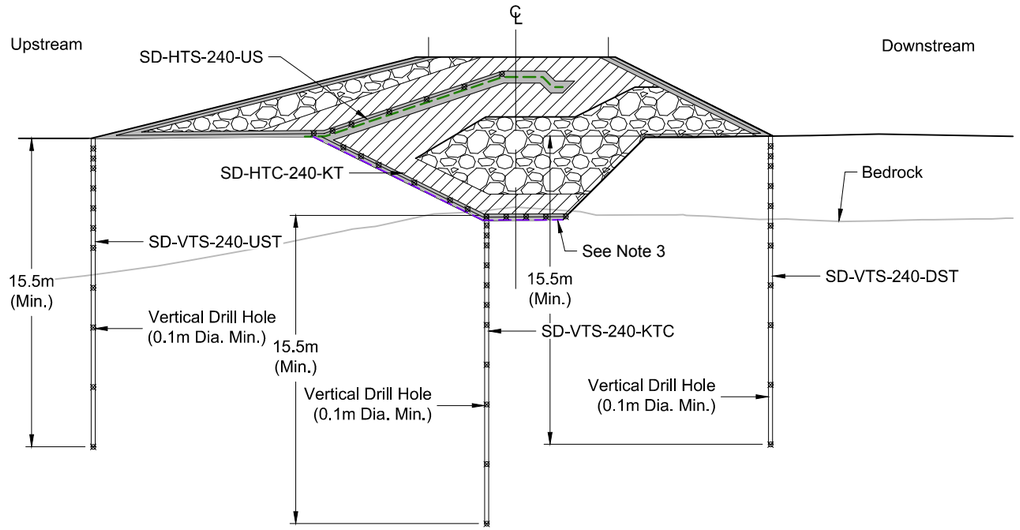
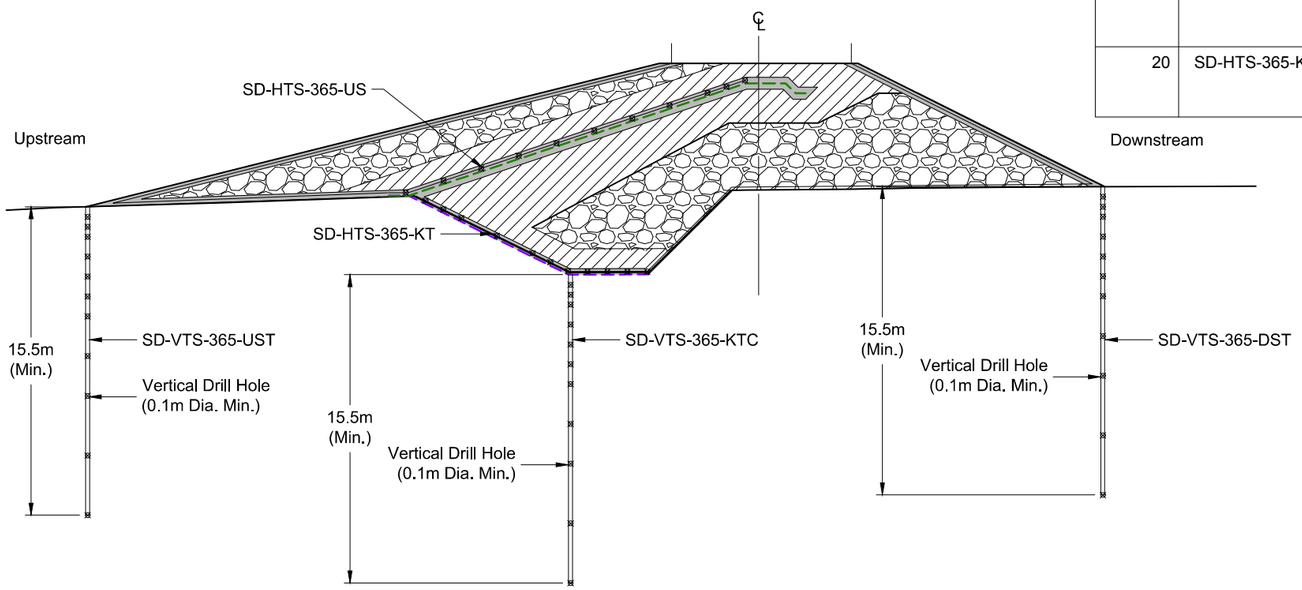


3 DN-SD-21

Ground Temperature Cable Section - Sta. 2+40

0m 3 6 9 12



4 DN-SD-21

Ground Temperature Cable Section - Sta. 3+65

0m 3 6 9 12

Ground Temperature Cable Details - Monitoring Section 2+40 and 3+65

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
11	SD-VTS-240-KTC	A	Vertical	2+40	58	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
12	SD-VTS-240-UST	A	Vertical	2+40	46	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
13	SD-VTS-240-DST	A	Vertical	2+40	53	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
14	SD-HTS-240-US	B	Horizontal & Inclined	2+40	50	Upstream Slope	0	2	4	6	8	9	10	-	-	-	-
15	SK-HTC-240-KT	B	Horizontal & Inclined	2+40	48	Upstream Slope	0	1	3	5	7	8	9	10	11	12	13
16	SD-VTS-365-KTC	A	Vertical	3+65	75	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
17	SD-VTS-365-UST	A	Vertical	3+65	57	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
18	SD-VTS-365-DST	A	Vertical	3+65	58	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
19	SD-HTS-365-US	B	Horizontal & Inclined	3+65	76	Upstream Slope	0	2	4	6	8	10	12	14	15	17	18
20	SD-HTS-365-KT	C	Horizontal & Inclined	3+65	65	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13

LEGEND

- Thermistor Bead Location
- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Instrumentation Details at Sta. 2+40 and 3+65

DRAWING NO.	SHEET	REVISION NO.
DN-SD-28	28 OF 30	1

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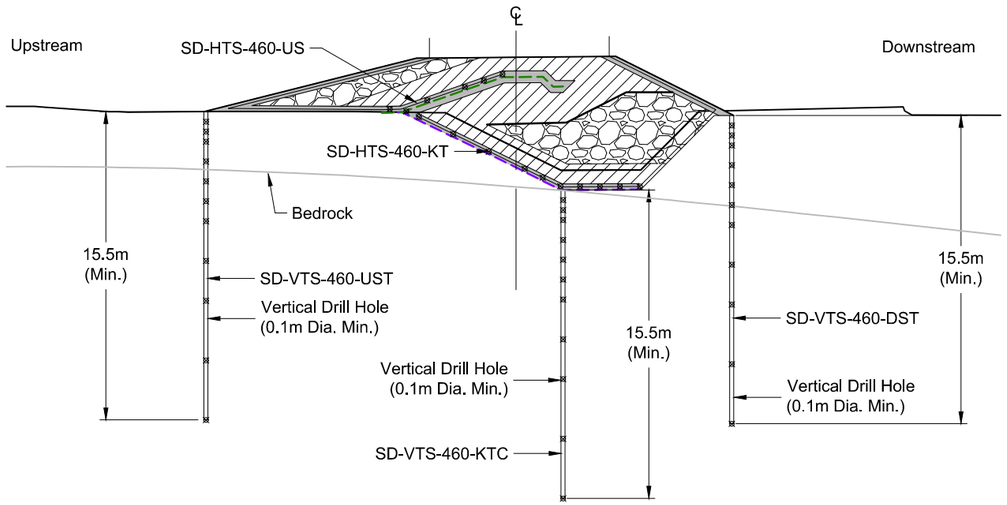
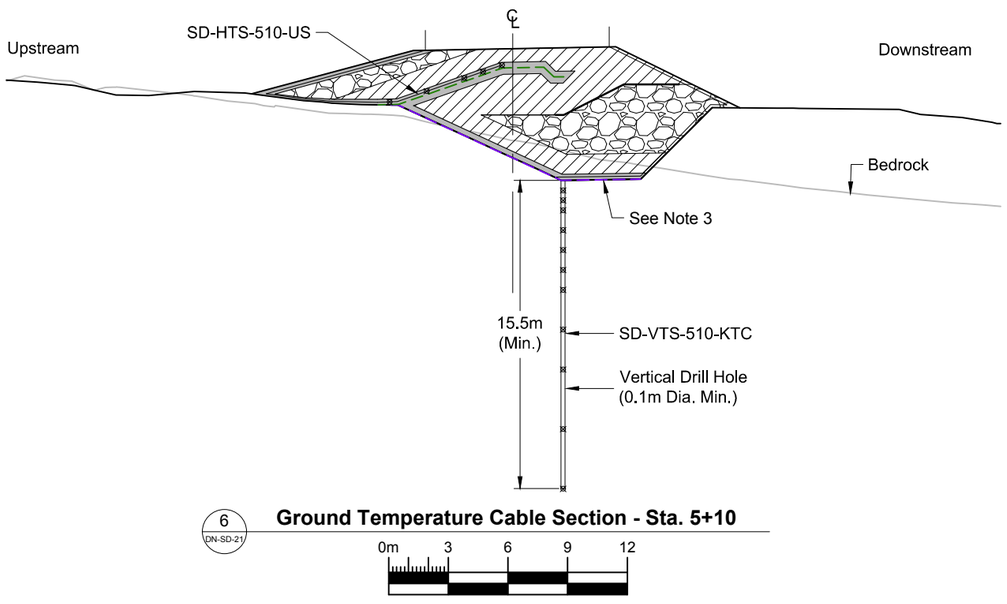


5 DN-SD-21 **Ground Temperature Cable Section - Sta. 4+60**

0m 3 6 9 12



6 DN-SD-21 **Ground Temperature Cable Section - Sta. 5+10**

0m 3 6 9 12

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

Ground Temperature Cable Details - Monitoring Section 4+60 and 5+10

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
21	SD-VTS-460-KTC	A	Vertical	4+60	50	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
22	SD-VTS-460-UST	A	Vertical	4+60	41	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
23	SD-VTS-460-DST	A	Vertical	4+60	58	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
24	SD-HTS-460-US	B	Horizontal & Inclined	4+60	41	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
25	SD-HTS-460-KT	C	Horizontal & Inclined	4+60	39	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13
26	SD-VTS-510-KTC	A	Vertical	5+10	48	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
27	SD-HTS-510-US	B	Horizontal & Inclined	5+10	86	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
28	Extension for SD-VTS-510-KTC	D	Vertical	5+10	90		Extension for existing cable. No beads needed.										

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Details at Sta. 4+65 and 5+10

DRAWING NO.	SHEET	REVISION NO.
DN-SD-29	29 OF 30	1

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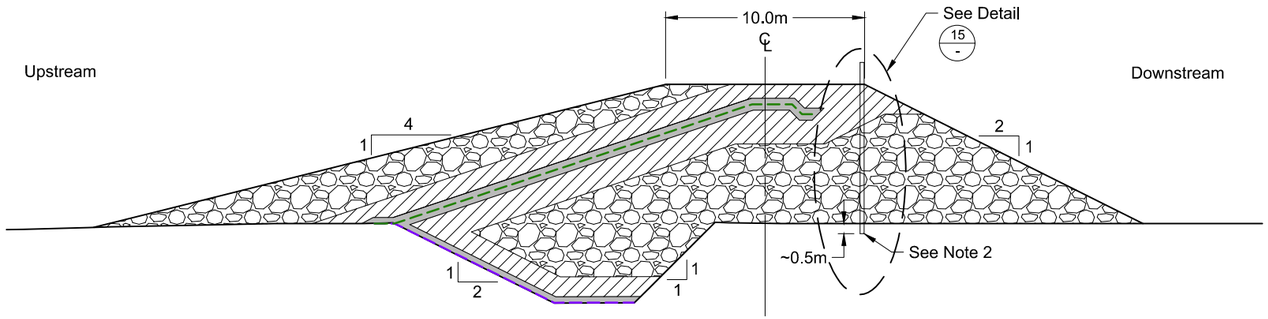
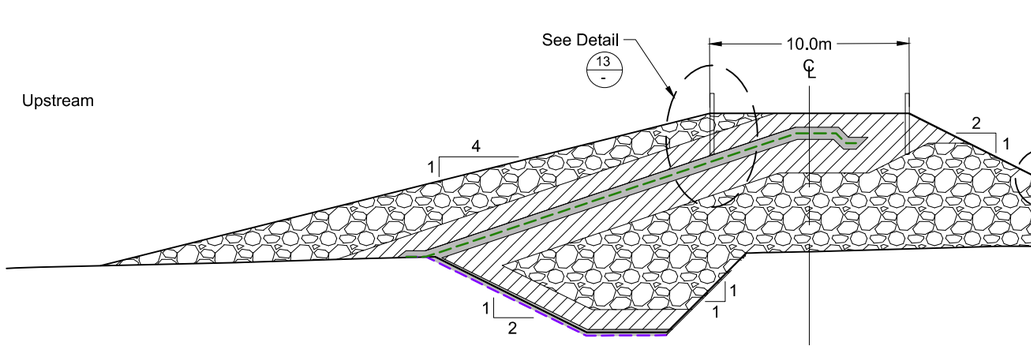


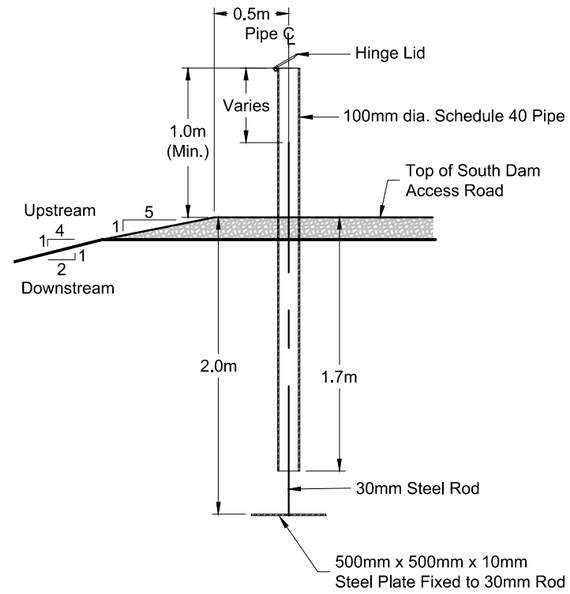
Deep Monitoring Point - Sta. 3+15

0m 3 6 9 12



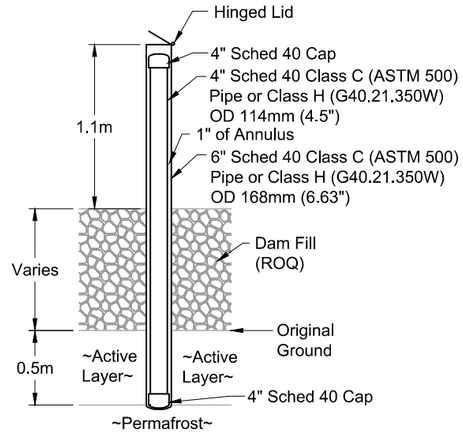
Fixed Survey Monitoring Point - Sta. 3+50

0m 3 6 9 12



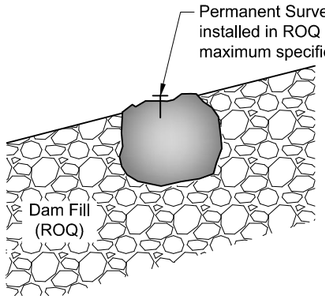
Detail 13 - Survey Monitoring Point Detail

0m 0.25 0.5 0.75 1.0



Detail 15 - Deep Settlement Point Detail

0m 0.25 0.5 0.75 1.0



Detail 14 - Surficial Survey Point Detail

0m 0.25 0.5 0.75 1.0

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. Deep settlement point installation depth to be directed by the field Engineer. Aim is to be near the active layer - permafrost contact.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction - Minor Text Edits	JBK	EMR	18/05/24
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/04/13

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JBK	EMR	2018/05/24

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Typical Monitoring Point Details

DRAWING NO.	SHEET	REVISION NO.
DN-SD-30	30 OF 30	1

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Appendix D.2 – All Revisions

Hope Bay Mining Ltd.

Doris North Project

Engineering Drawings for the South Dam - Phase 1

Drawing Number	Drawing Title	Issue	Date	Revision
DN-SD-01	General Arrangments	Issued for Construction	November 29, 2017	0
DN-SD-02	General Arrangements	Issued for Construction	November 29, 2017	0
DN-SD-03	Typical Sections (General)	Issued for Construction	November 29, 2017	0
DN-SD-04	Key Trench Excavation Plan and Profile	Issued for Construction	November 29, 2017	0
DN-SD-05	Liner Placement Plan and Details - Key Trench and Phase 1	Issued for Construction	November 29, 2017	0
DN-SD-06	Liner and Bedding Placement Details	Issued for Construction	November 29, 2017	0
DN-SD-07	Bedding Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	November 29, 2017	0
DN-SD-08	Transition Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	November 29, 2017	0
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	November 29, 2017	0
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	November 29, 2017	0
DN-SD-11	Construction Access Road and Turn Around - Phase 1	Issued for Construction	November 29, 2017	0
DN-SD-12	Final Phase 1 Dam Plan, Profile and Sections	Issued for Construction	November 29, 2017	0
DN-SD-13	Sections Sta. 0+10 to 0+90 - Phase 1 Dam	Issued for Construction	November 29, 2017	0
DN-SD-14	Sections Sta. 1+00 to 1+80 - Phase 1 Dam	Issued for Construction	November 29, 2017	0
DN-SD-15	Sections Sta. 1+90 to 2+70 - Phase 1 Dam	Issued for Construction	November 29, 2017	0
DN-SD-16	Sections Sta. 2+80 to 3+60 - Phase 1 Dam	Issued for Construction	November 29, 2017	0
DN-SD-17	Sections Sta. 3+70 to 4+50 - Phase 1 Dam	Issued for Construction	November 29, 2017	0
DN-SD-18	Sections Sta. 4+60 to 5+30 - Phase 1 Dam	Issued for Construction	November 29, 2017	0

November 29, 2017 - Compiled IFC Drawing Set

srk consulting

SRK Job No. 1CT0022.017

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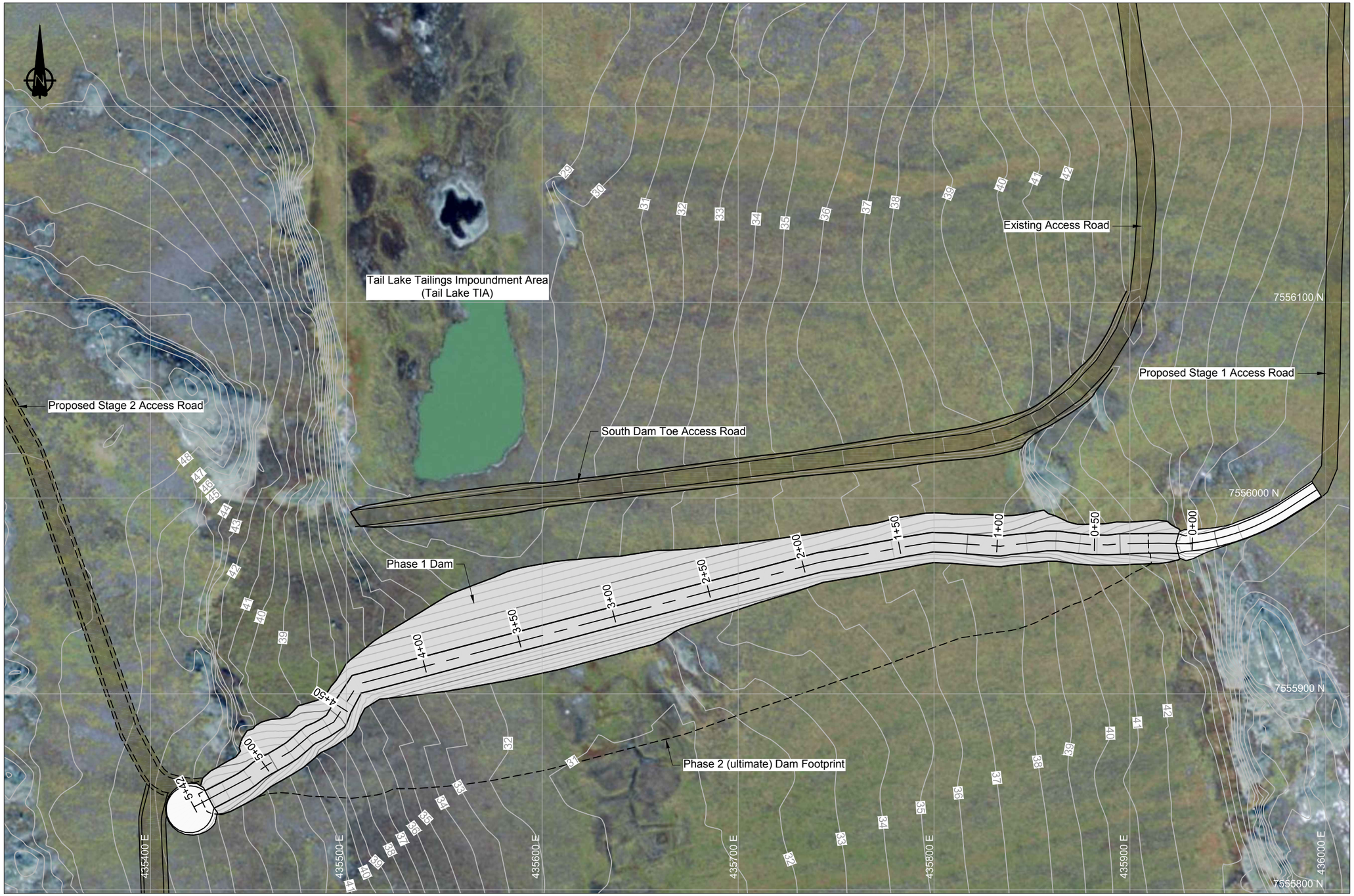

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Imagery (from 2010 PhotoSat compilation) provided by client.
5. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

0m 20 40 60 80

-	-										
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
REFERENCE DRAWINGS		REVISIONS									

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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam GA - with ortho.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:
Phase 1 General Arrangement (with Orthophoto)

DRAWING NO.	SHEET	REVISION NO.
DN-SD-01	1 OF 18	0

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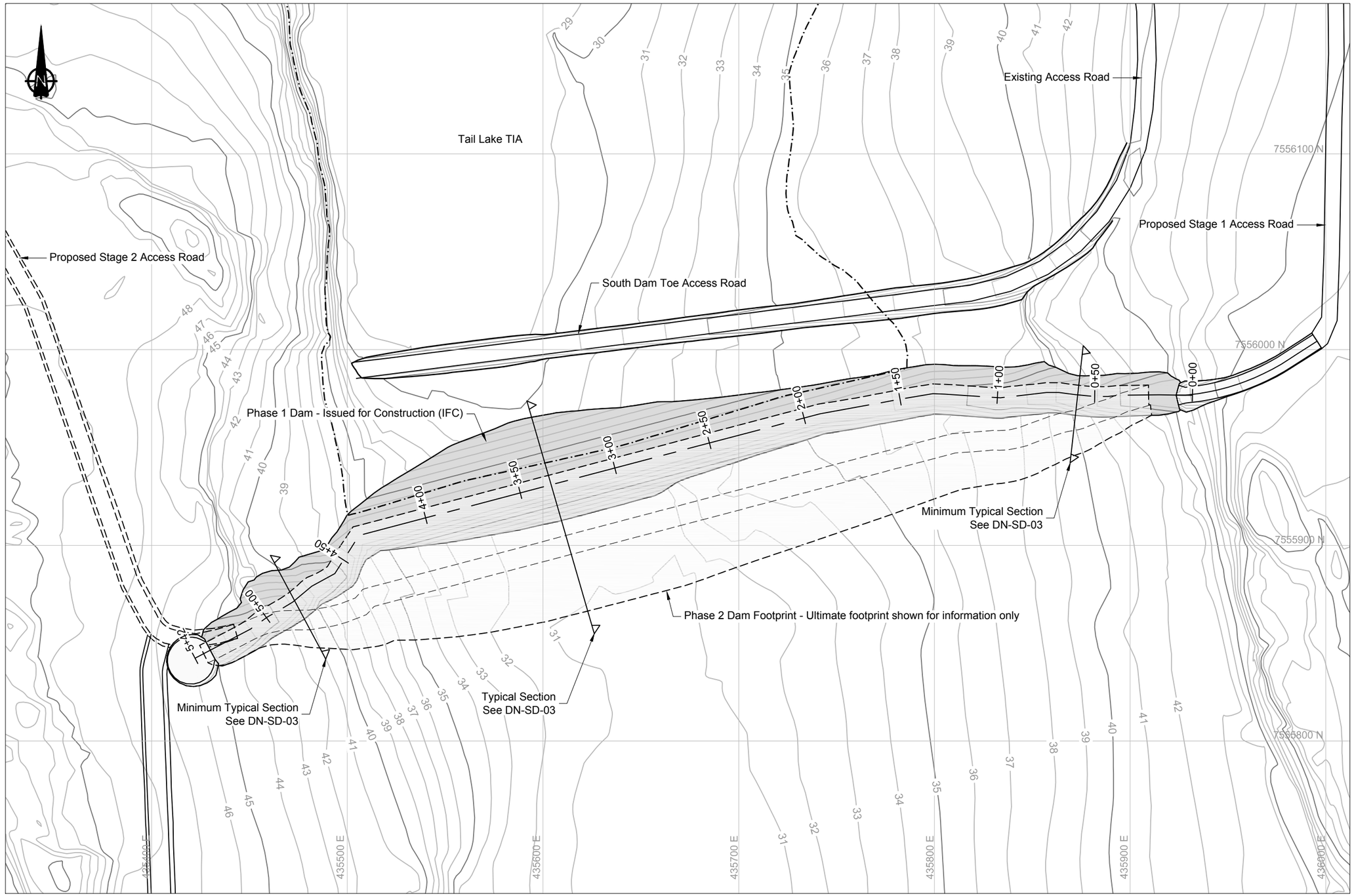

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Volumes presented based on neat-lines only and are approximate. These include no over-excavation or over-blasting allowance of the key trench.
5. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

TABLE OF QUANTITIES (NEAT-LINE)

Key Trench Bulk Excavation :	20,000m³
Total Phase 1 Fill:	66,000m³
ROQ:	33,500m³
Transition:	25,500m³
Bedding:	7,000m³
Total Liner:	15,000m²
West Turnaround (bulk):	375m³
East Turnaround (bulk):	605m³

0m 20 40 60 80

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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CHECKED: JBK	APPROVED: EMR	DATE: 17/11/29

FILE NAME: 1CT0022.017 - South Dam GA.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Phase 1 General Arrangement

DRAWING NO.	SHEET	REVISION NO.
DN-SD-02	2 OF 17	0

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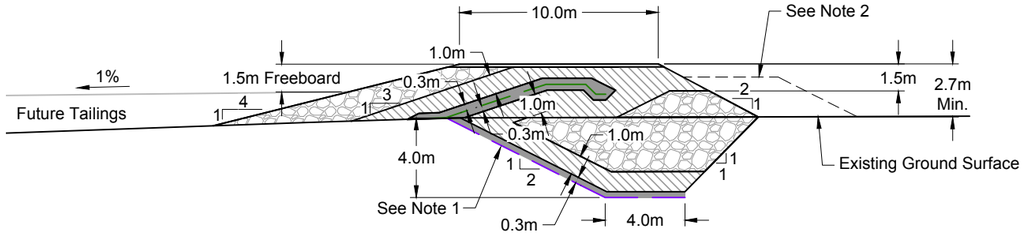
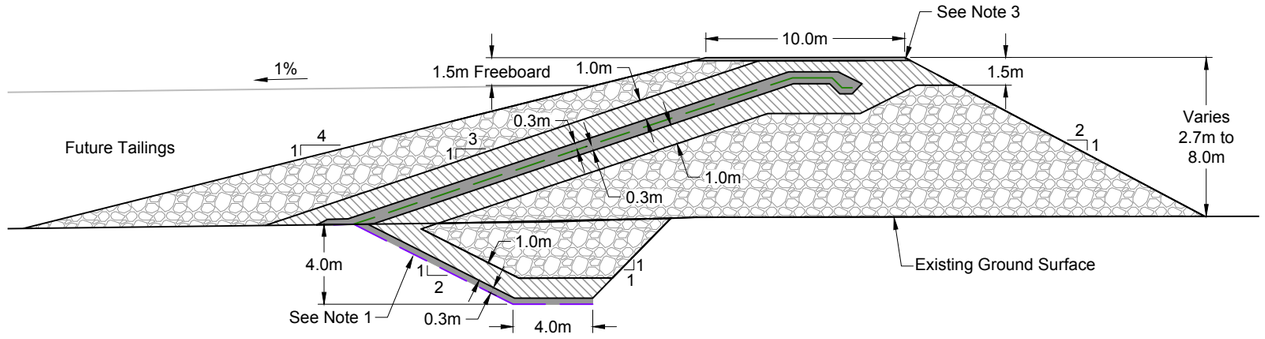


Minimum Typical Cover Section
STA.0+00 to 1+92 & 4+35 to 5+42

0m 3 6 9 12

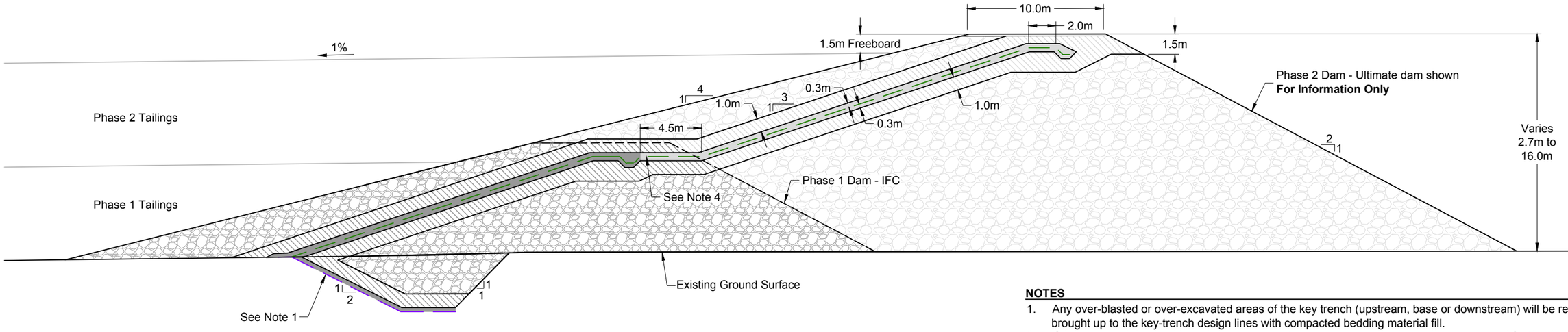
ISSUED FOR CONSTRUCTION



Phase 1 Typical Dam Section
STA. 1+92 to 4+35

0m 3 6 9 12

ISSUED FOR CONSTRUCTION



Phase 2 Typical Dam Section
STA. +06 to 3+50

0m 3 6 9 12

ISSUED FOR INFORMATION

LEGEND

- Key Trench Liner
- Phase 1 & 2 Dam Liner
- Bedding Material
- Transition Material
- Run of Quarry

NOTES

1. Any over-blasted or over-excavated areas of the key trench (upstream, base or downstream) will be required to be brought up to the key-trench design lines with compacted bedding material fill.
2. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench. This material would be placed to ensure that adequate thermal insulation of the key trench is maintained in all sections. See Detail 10 on drawing DN-SD-09 for additional details.
3. The top road surfacing (bedding material) for the Phase 1 dam is to be fully removed (upstream and downstream) before Phase 2 construction commences.
4. To allow for a proper tie-in the transition material around the top downstream portion of the Phase 1 dam will be required to be stripped back. Once the bedding material around the top liner anchor trench is reached hand excavation should be expected to result down to expose the liner. The on-site engineer will be required to inspect all exposed liner, to ensure that it is not damaged or in need of repairs before Phase 2 liner tie-ins result.
5. All units shown are in meters unless otherwise stated.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
0	Issued for Construction	JBK	EMR	17/11/29

DN-SD-02 — Phase 1 General Arrangement

DRAWING NO. — DRAWING TITLE

REFERENCE DRAWINGS — REVISIONS

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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Typ Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Typical Sections (General)

DRAWING NO. DN-SD-03 | SHEET 3 OF 18 | REVISION NO. 0

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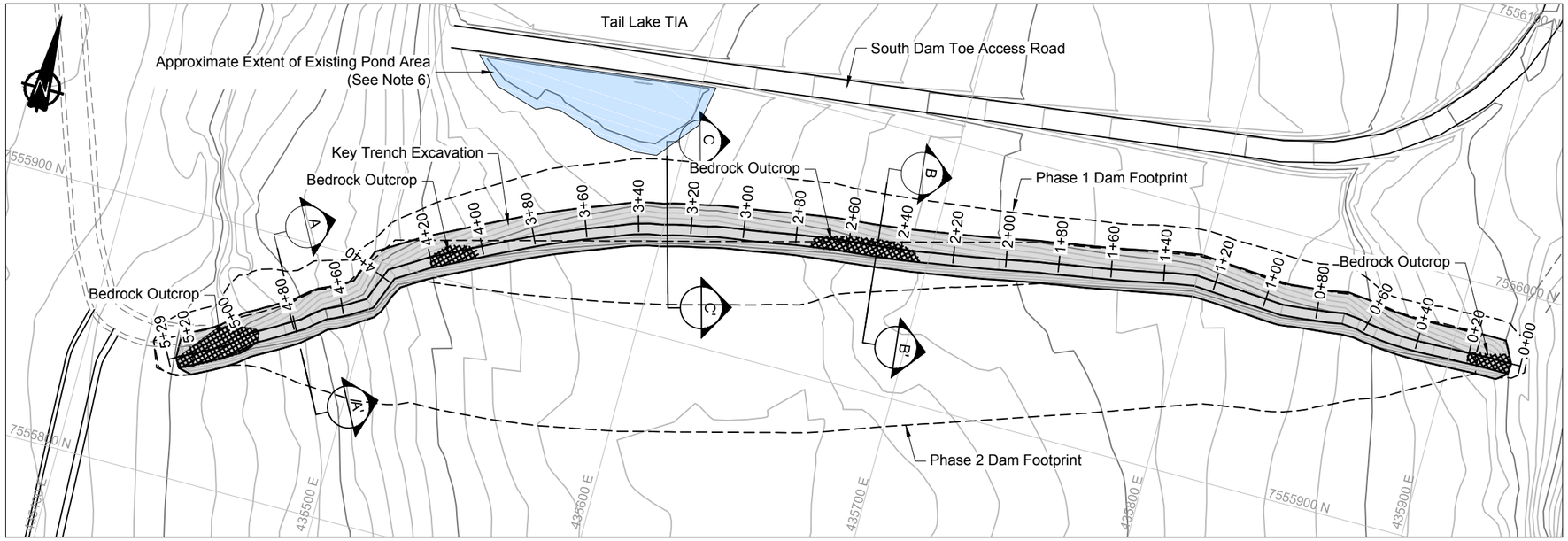
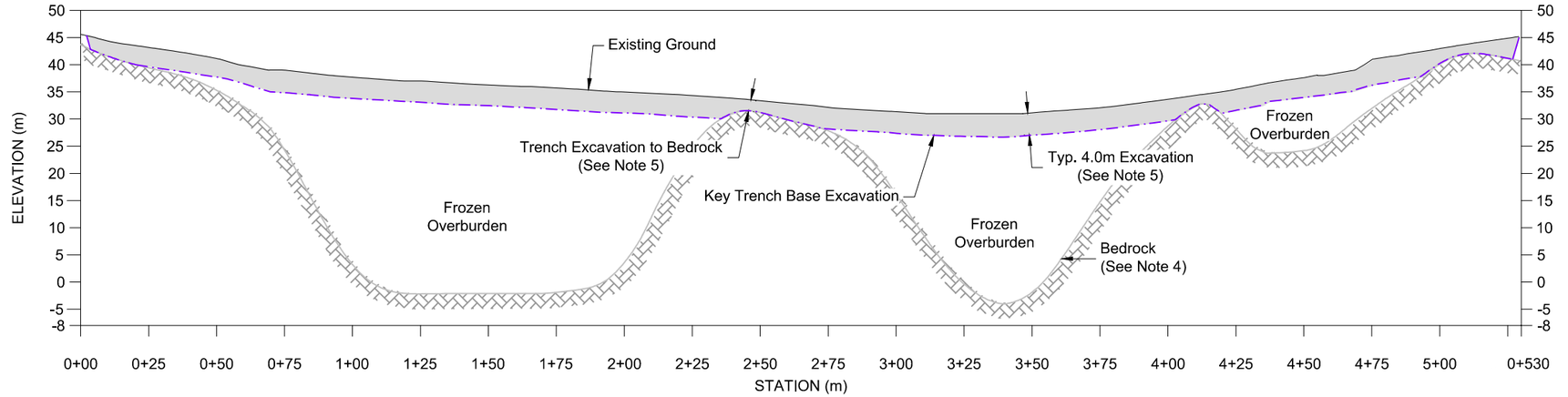


Key Trench Plan View

0m 20 40 60 80



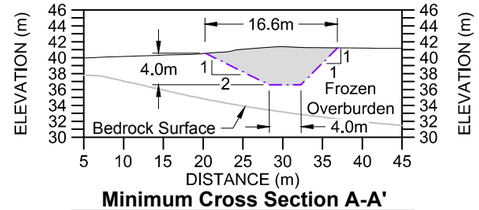
Key Trench Profile View

Vertical 0m 10 20 30 40

Horizontal 0m 20 40 60 80

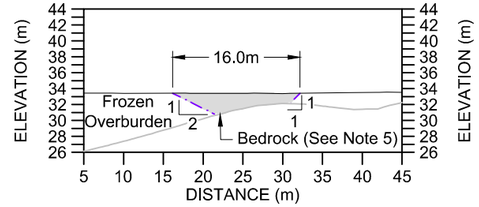
NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profile shown correspond to the upstream toe of the key trench.
4. The subsurface geology has been inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A , SRK43, SRK 44), airphoto interpretations, and from limited available geophysical surveys around the Tails Lake area. This data was then used to create a bedrock surface with the Gemcom GEMS software. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.
5. The final key trench extent and depth will be determined in the field by the Engineer. Typical excavation depth is 4.0m, unless massive ice, hypersaline soil or bedrock encountered. The Engineer will inspect all excavations and approve the foundation conditions.
6. Ponded area to removed (frozen massive ice excavated or drained if possible) prior to key trench excavation. Up to approximately 4,700 m3 of (frozen) water may be expected to be removed from this area. Exact water levels are not known so the volume estimate above should be treated as a rough estimate based on topography.
7. If any area of the key trench is over-blasted or over-excavated then the extra excavation will need to be backfilled in thin lifts (*see 'Technical Specifications'*) until the key trench design lines and grades are reached.



Minimum Cross Section A-A'
Shallow Overburden over Bedrock

0m 5 10 15 20 25 30



Cross Section B-B'
Bedrock Outcropping in Key Trench

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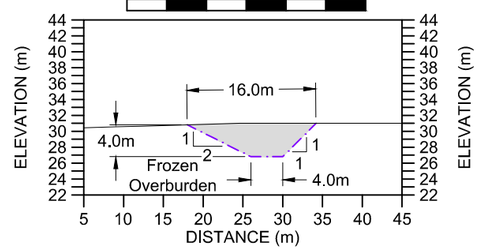

Cross Section C-C'
Deep Frozen Overburden

0m 5 10 15 20 25 30

LEGEND

- Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Trench Excavation Extent

REFERENCES

NAD83 UTM Zone 13.

DRAWING NO.	DRAWING TITLE
-	-

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Key Trench.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Key Trench Excavation
Plan and Profile

DRAWING NO.	SHEET	REVISION NO.
DN-SD-04	4 OF 18	0

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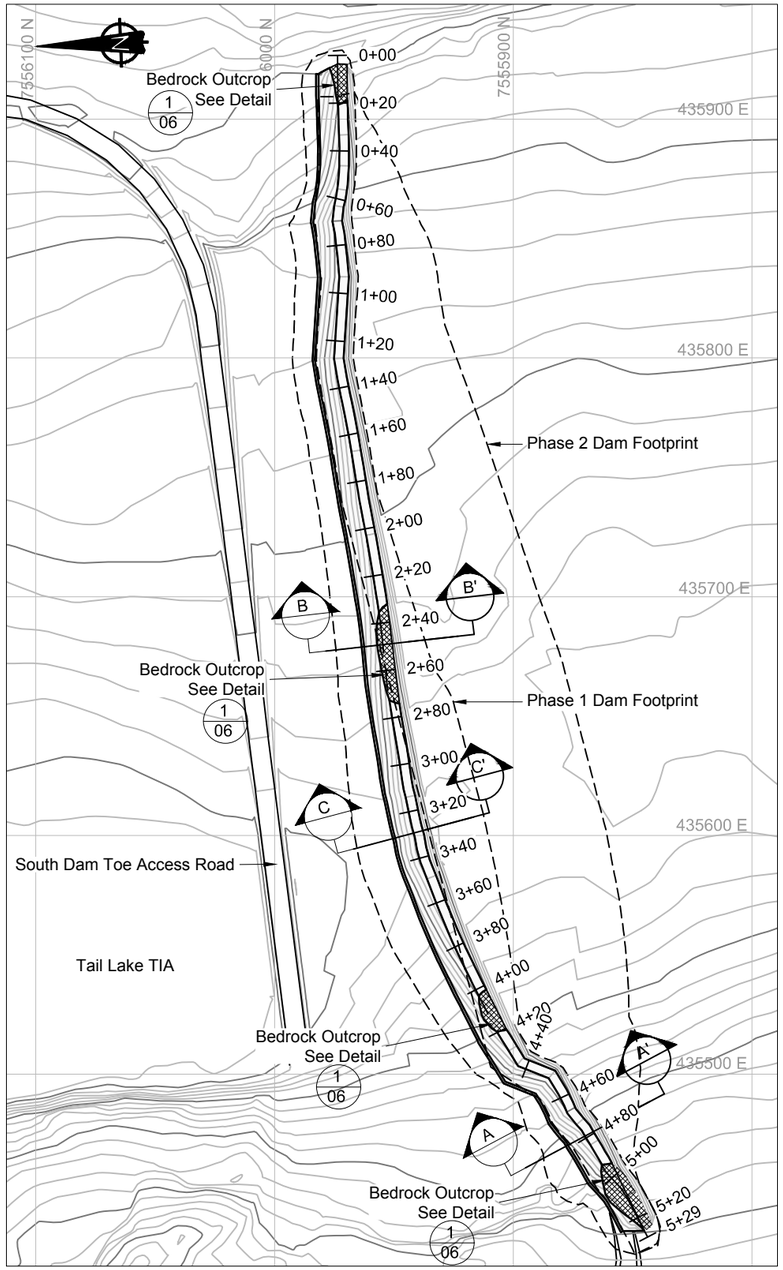

Lower Liner Plan - Placement in Key Trench

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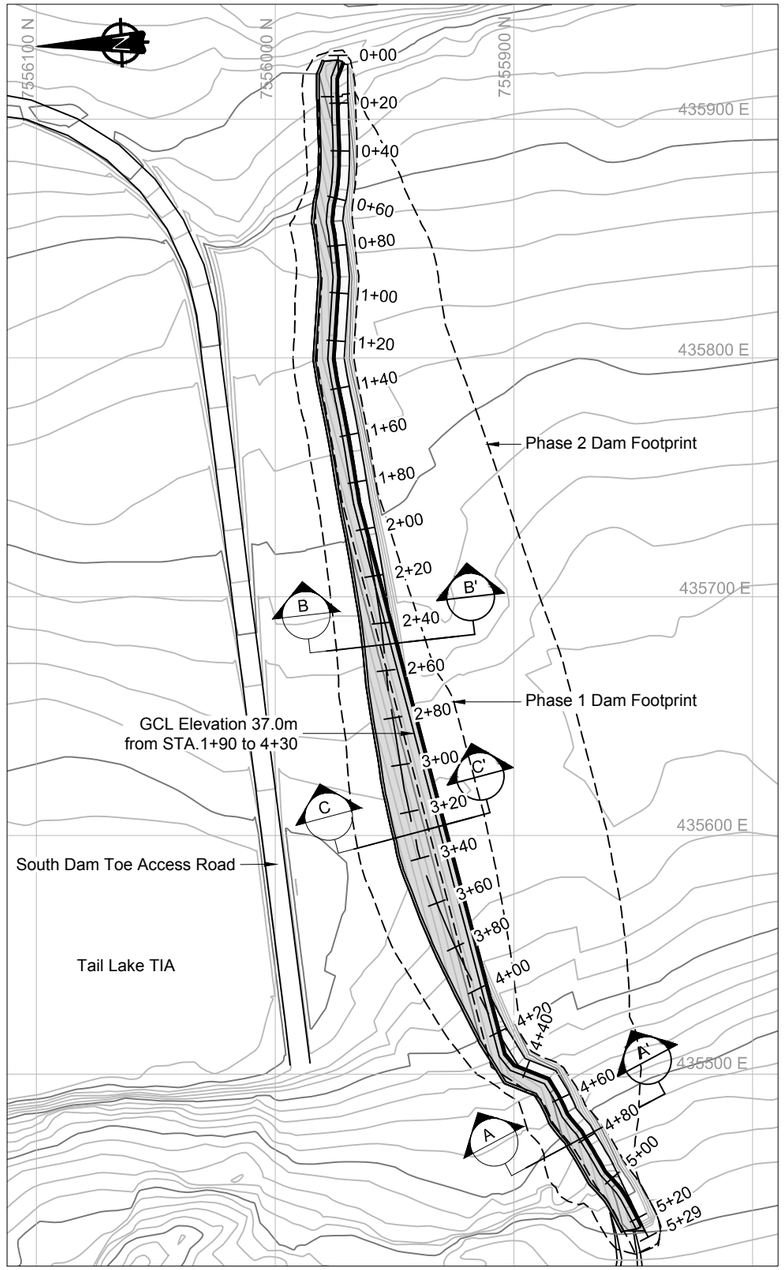

Upper Phase 1 Liner Plan - Above Ground Upstream Slope Placement

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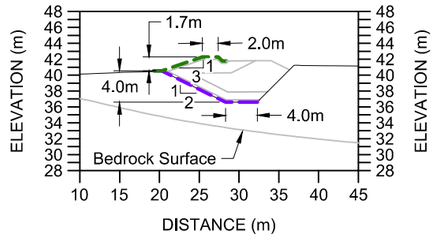

Minimum Cross Section A-A'

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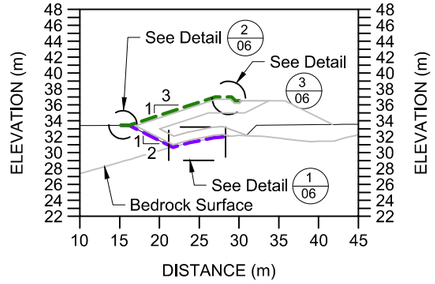

Cross Section B-B' - Bedrock Encountered in Trench

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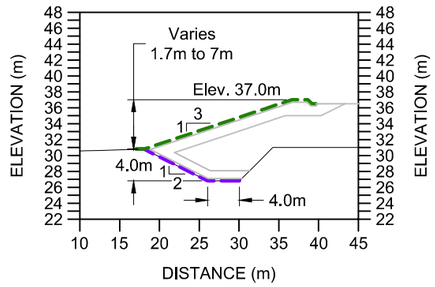

Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

- Key Trench Liner
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent
- GCL Liner Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The upstream slope of the key trench excavation need to be scraped and smoothed to prepare a suitable subbase for the GCL liner. If any larger voids or undulation exist then they will need to be backfilled with compacted bedding material fill, placed in thin lifts.
4. The subgrade surface must be free of vegetation, sharp-edged rocks, stones, sticks, construction debris, and other foreign material that could contact the GCL. Furthermore, all protrusions extending more than 12 mm from the subgrade surface shall either be removed, crushed, or pushed into the surface with a smooth-drum compactor.
5. GCL should not be placed over massive ice or standing water (both need to be removed prior to placement).
6. All Geosynthetic Clay Liner (GCL) liner sections / panels will be required to have a minimum 0.5m overlap on every edge. See Detail 2, 3, 5 and 6 for additional information.
7. At the locations where bedrock is encountered in the key trench then these areas will be required to be ripped down to competent bedrock or scrapped smooth and then bentonite powder will be placed between the bedrock contact and the GCL liner (see Detail 1).

REFERENCES

NAD83 UTM Zone 13.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS: DN-SD-06 — Liner and Bedding Placement Details

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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Liner Placement Plan and Details Key Trench and Phase 1

DRAWING NO.: DN-SD-05

SHEET: 5 OF 18

REVISION NO.: 0

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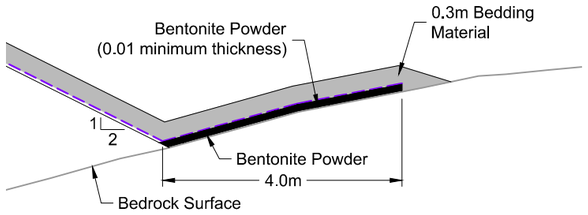
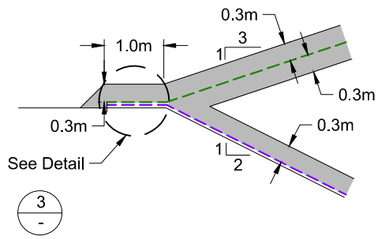
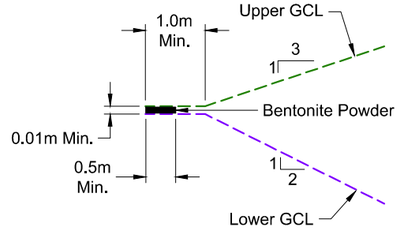


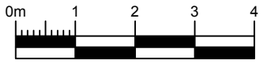
Detail 1 - Liner Attachment at Bedrock

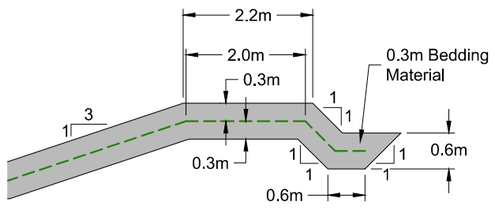


Detail 2 - Liner Overlap - Bedding

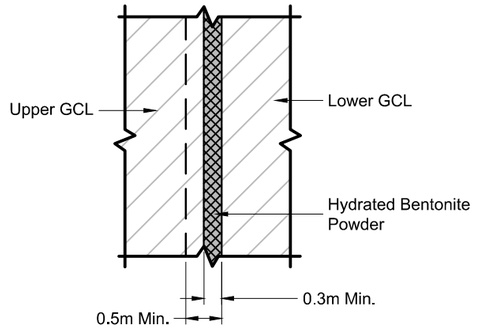


Detail 3 - Typical Upper and Lower GCL Joint

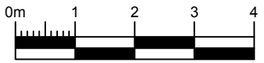


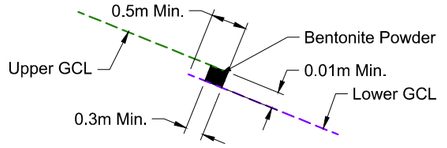


Detail 4 - Liner Key-In-Trench Bedding



Detail 5 - Typical GCL Overlap - Plan





Detail 6 - Typical GCL Overlap - Section

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material

NOTES

1. All units shown are in meters unless otherwise stated.
2. One end of the GCL roll should be placed in an anchor trench at the top of the slope. The front edge of the trench (see Detail 4) shall be rounded so as to eliminate any sharp corners that could cause excessive stress on the GCL. Loose soil should be removed or compacted into the floor of the trench.
3. The GCL should be placed in the anchor trench such that it covers the entire trench floor but does not extend up the rear trench wall (see Detail 4).
4. GCL seams are constructed by overlapping their adjacent edges (see Detail 5). Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris.
5. If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by placing a patch over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 500 mm is achieved around all parts of the damaged area. Bentonite mastic / powder should be applied around the damaged area prior to placement of the patch. It may be necessary to use an adhesive such as wood glue, or by hand placing material over the patch, to fix the patch in place so that it is not moved during overliner bedding material placement. Smaller patches also may be tucked under the damaged area to prevent patch movement.
6. Cover soils shall be free of angular stones or other foreign matter which could damage the GCL. Cover soils should be approved by the Engineer, with respect to particle size and uniformity (as per the 'Technical Specifications')

REFERENCES

NAD83 UTM Zone 13.

DRAWING NO.	DRAWING TITLE
-	-

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Liner and Bedding Placement Details

DRAWING NO.	SHEET	REVISION NO.
DN-SD-06	6 OF 18	0

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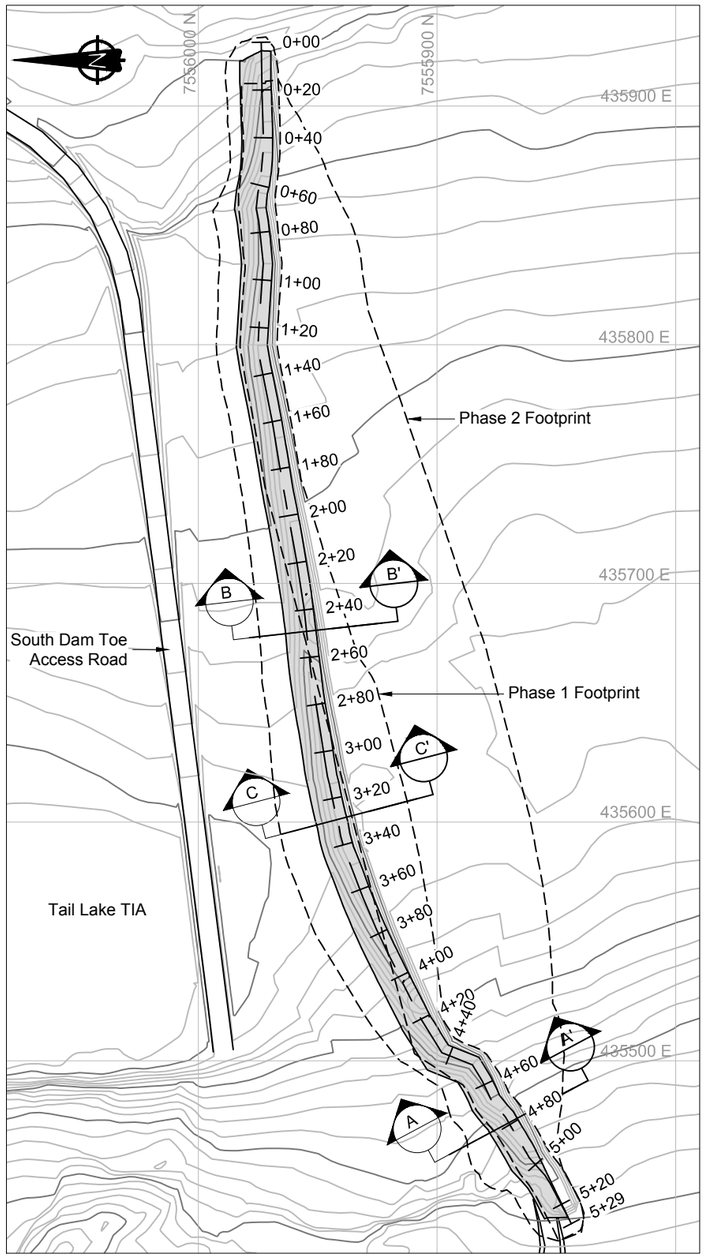

Key Trench Bedding Placement Plan View

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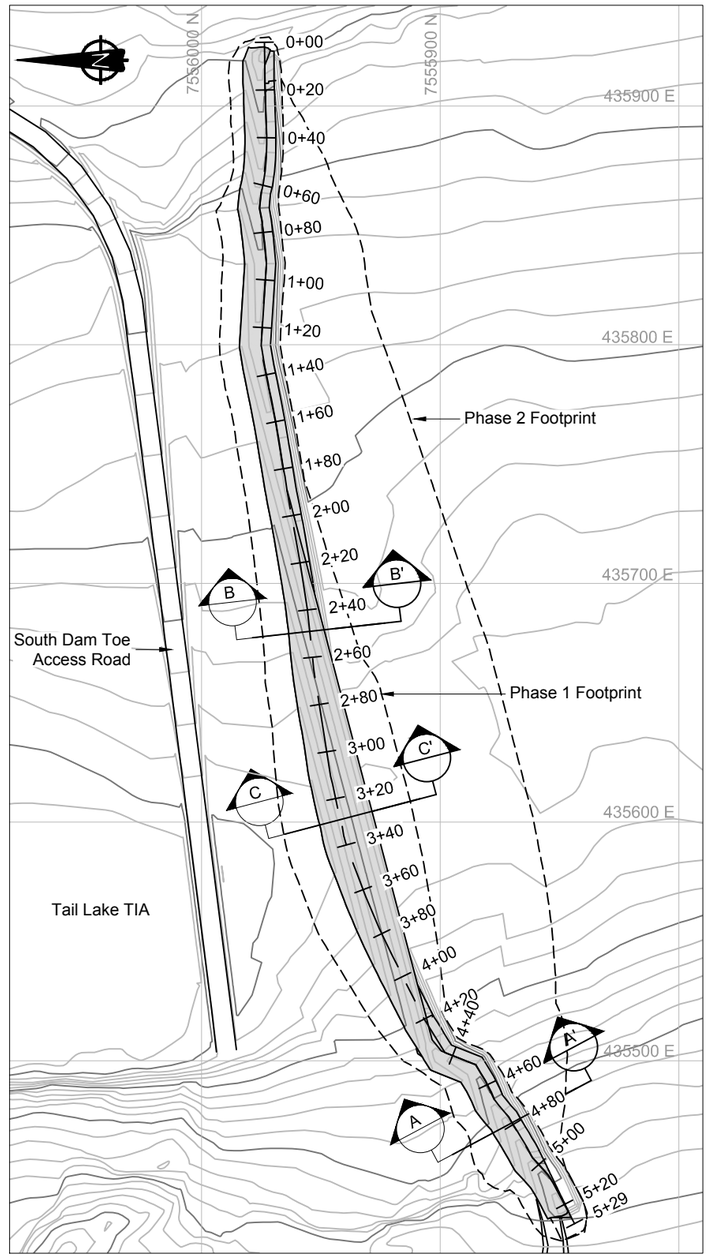
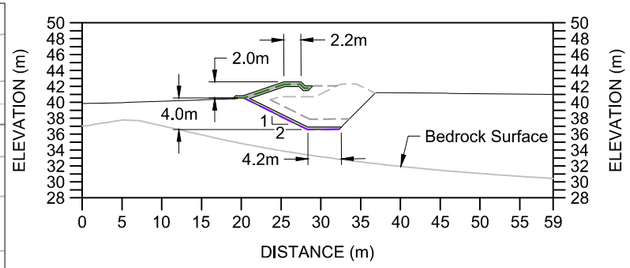


Phase 1 Dam Bedding Placement Plan View

0m 20 40 60 80 100



Minimum Cross Section A-A'

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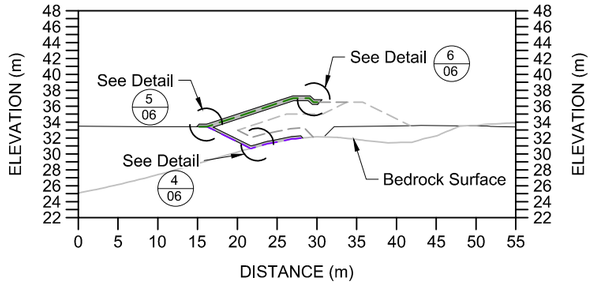

Cross Section B-B' - Bedrock Encountered in Trench

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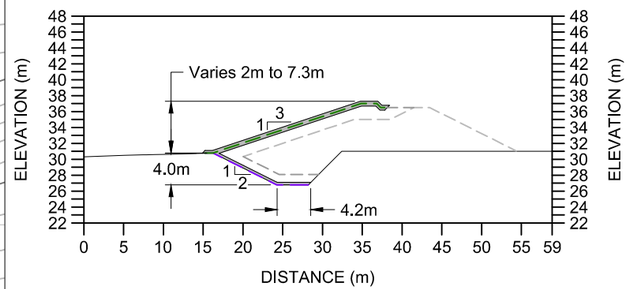

Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

- Phase 1 Dam Liner
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Bedding Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Bedding layer to be placed in thin lifts and compacted before liner placement. The subsurface below the liner should be free of protrusions or any sharp / angular gravel or larger size material. See the Technical Specifications document for more details (*'Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK).*
4. Bedding material cover shall be placed over the GCL using construction equipment that minimizes stresses on the GCL. A minimum thickness of 300 mm of cover should be maintained between the equipment tracks/tires and the GCL at all times during the covering process. This thickness recommendation does not apply to frequently trafficked areas or roadways, for which a minimum thickness of 600 mm is required.
5. Soil cover should be placed in a manner that prevents the soil from entering the GCL overlap zones.

REFERENCES

NAD83 UTM Zone 13.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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DN-SD-06 — Liner and Bedding Placement Details

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JKB	EMR	2017/11/29

FILE NAME: 1CT0022.017 - South Dam - Bedding.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Bedding Material Placement Plan and Sections - Key Trench and Phase 1

DRAWING NO.: DN-SD-07 | SHEET: 7 OF 18 | REVISION NO.: 0

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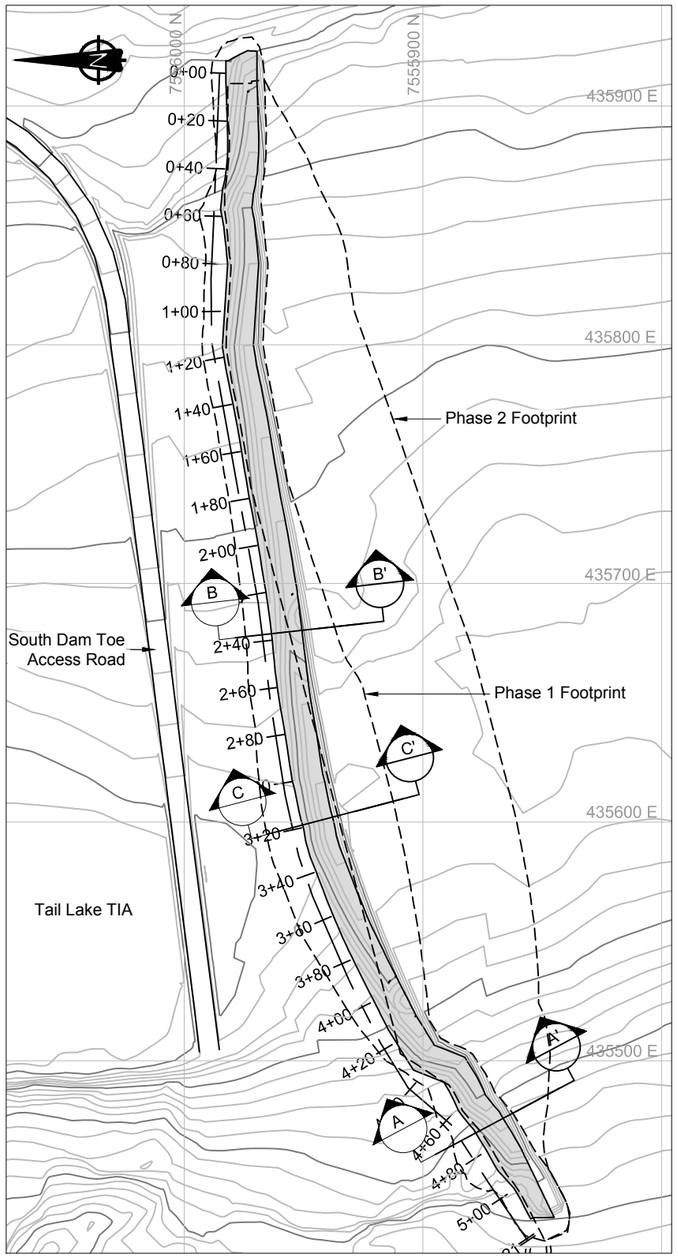

Key Trench Bedding Placement Plan View

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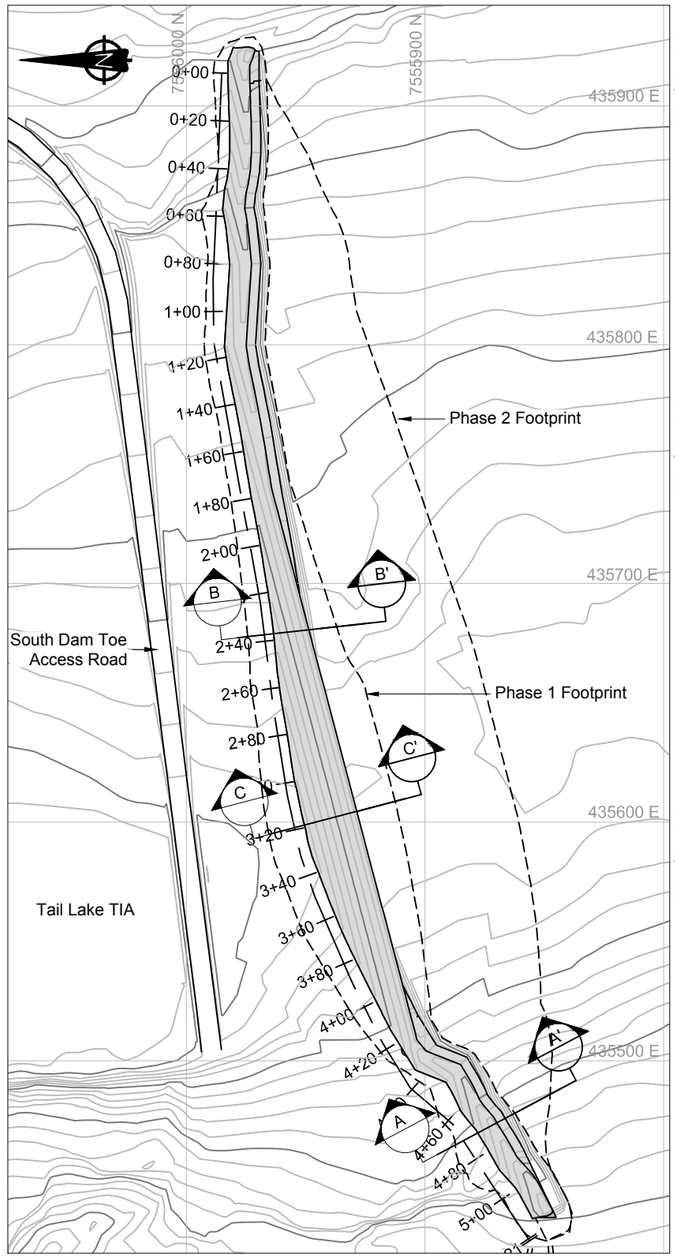

Phase 1 Dam Bedding Placement Plan View

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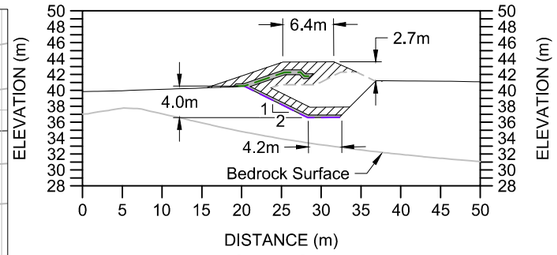

Minimum Cross Section A-A'

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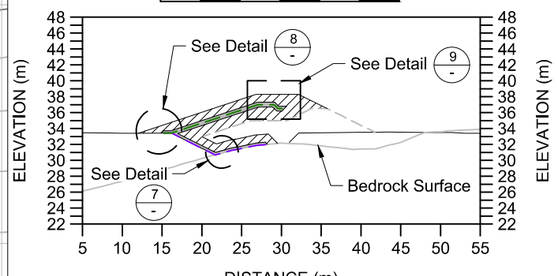

Cross Section B-B' - Bedrock Encountered in Trench

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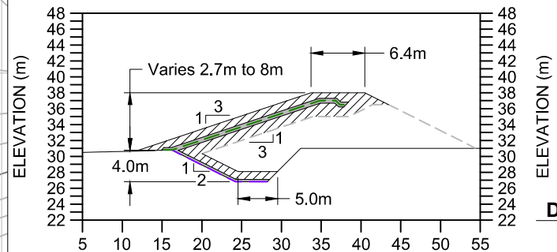


Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

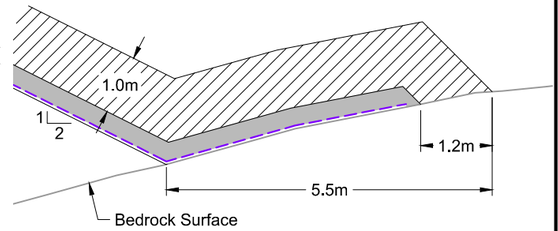
- Phase 1 Dam Liner
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Bedding Material
- Transition Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.



Detail 7 - Key Trench Bedrock Interface - Transition

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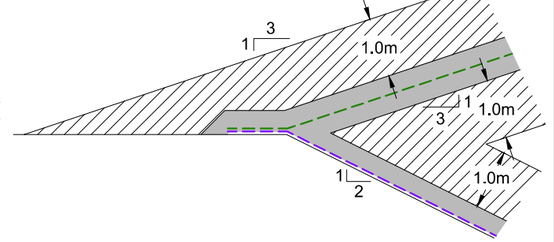
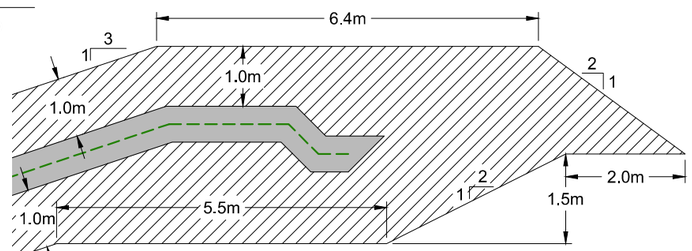


Detail 8 - Upper and Lower GCL Liner Overlap - Transition

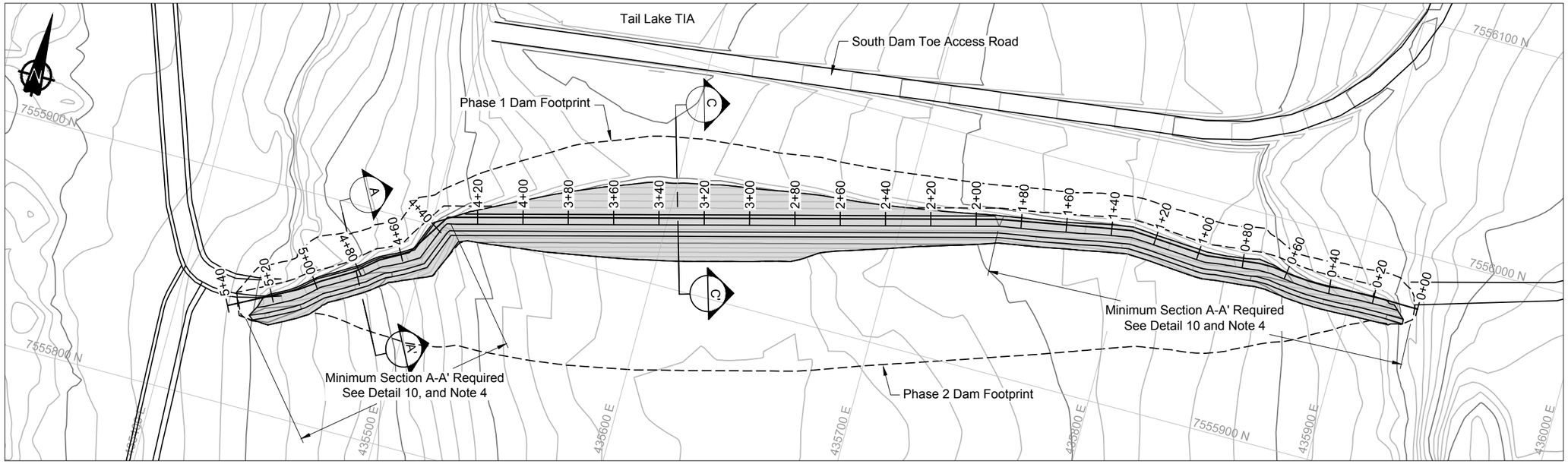
0m 1 2 3 4



Detail 9 - Liner Key-In-Trench - Transition

0m 1 2 3 4

-	-											



Run of Quarry Placement Plan View

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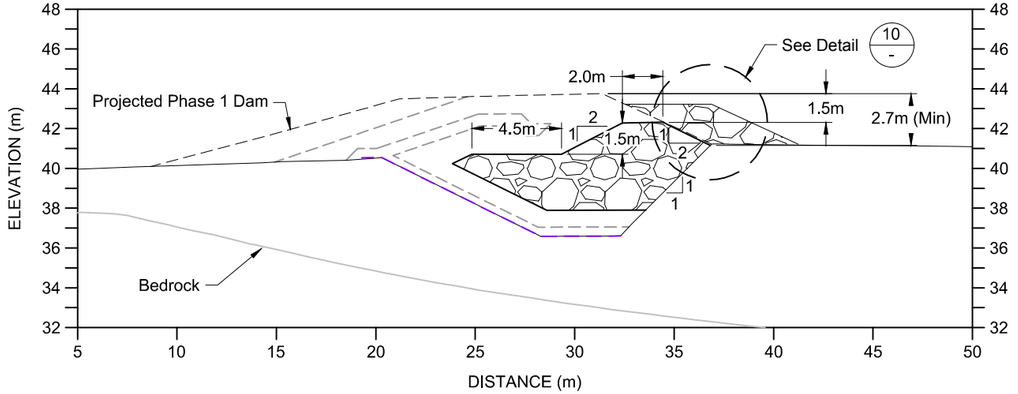

Minimum Cross Section A-A'

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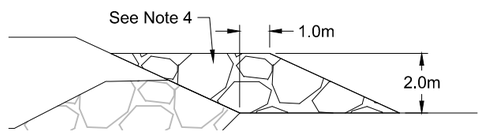

10 03,08 **Contingency ROQ Thermal Barrier Design**

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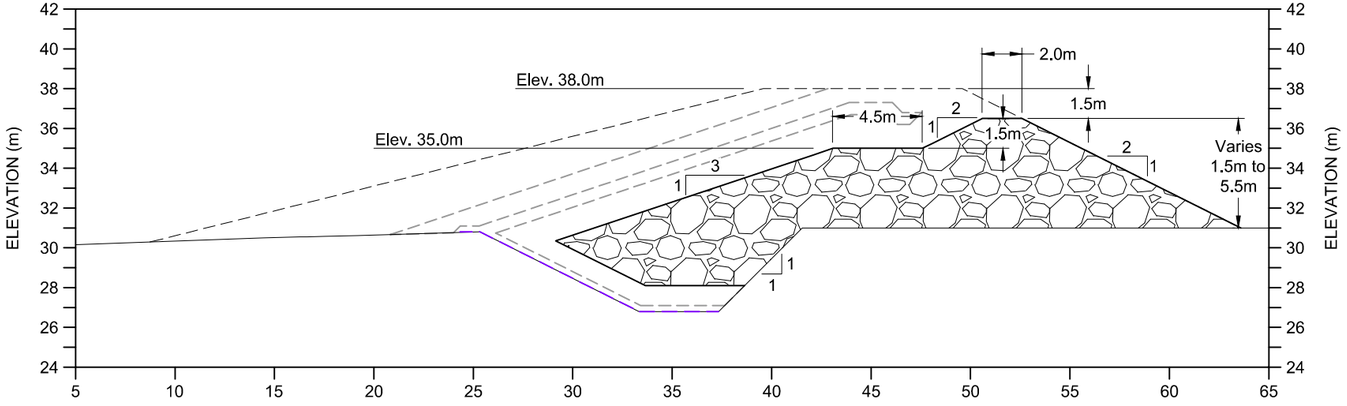

Typical Cross Section C-C'

0m 3 6 9 12

LEGEND

- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Run of Quarry Backfill Extent
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profiles shown correspond to the upstream toe of the key trench.
4. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench. See Detail 10 on drawing DN-SD-09 for additional details.
5. The outside downstream ROQ should be sloped at 2H:1V or shallower.

REFERENCES

NAD83 UTM Zone 13.

DRAWING NO.	DRAWING TITLE
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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NO.	DESCRIPTION	CHK'D	APP'D	DATE
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FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-09	9 OF 18	0

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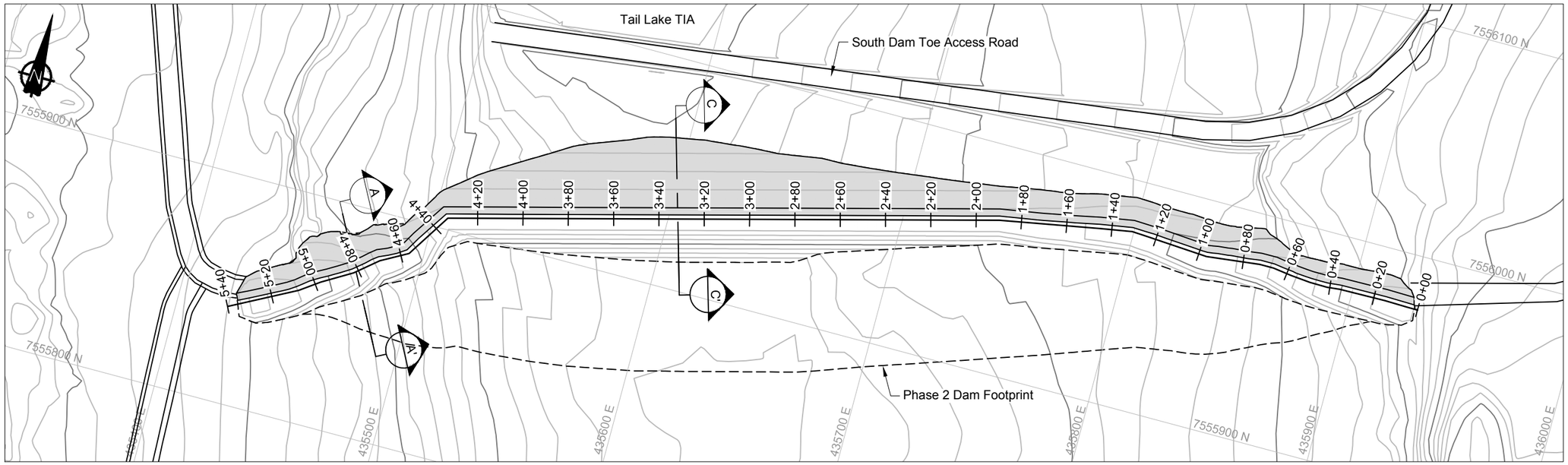
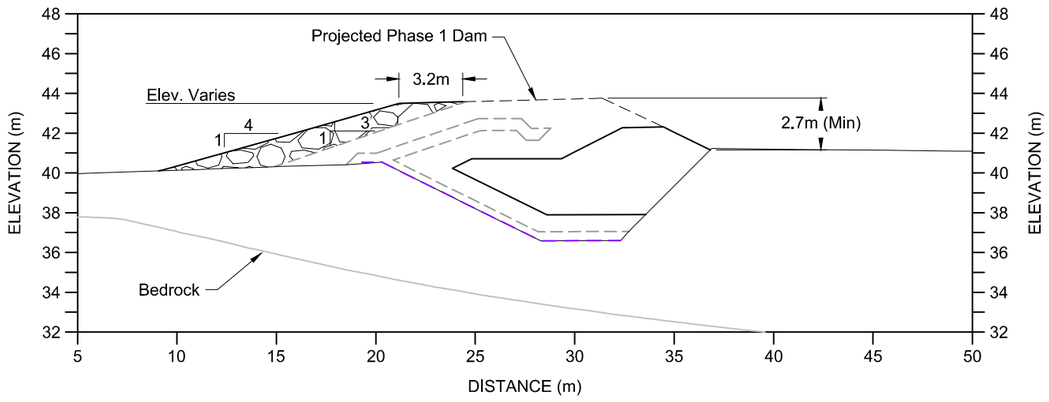


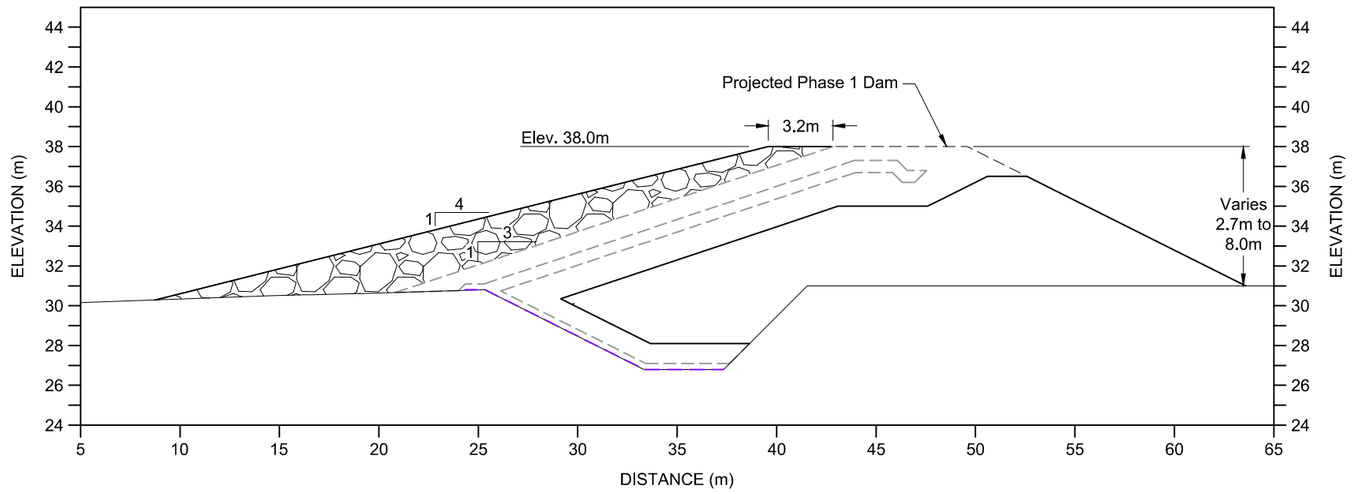
Run of Quarry Placement Plan View

0m 20 40 60 80



Minimum Cross Section A-A'

0m 3 6 9 12



Typical Cross Section C-C'

0m 3 6 9 12

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1			
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1	-	-	

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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DESIGN: CH | DRAWN: TAH | REVIEWED: JBK
CHECKED: JBK | APPROVED: EMR | DATE: 17/11/29
FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ-us.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO. DN-SD-10 | SHEET 10 OF 18 | REVISION NO. 0

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LEGEND

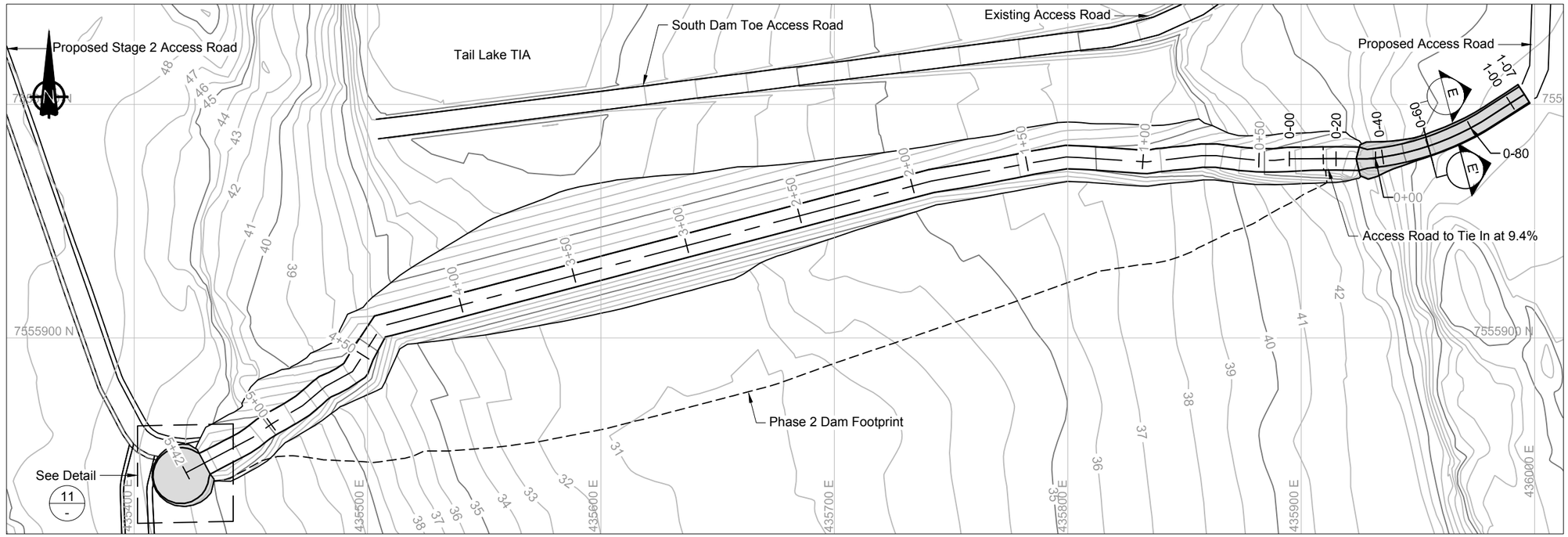
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Run of Quarry Backfill Extent
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The outside upstream dam ROQ should be sloped at 4H:1V or shallower.

REFERENCES

NAD83 UTM Zone 13.



LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Access Road
- Run of Quarry
- Surfacing Material

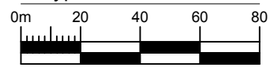
NOTES

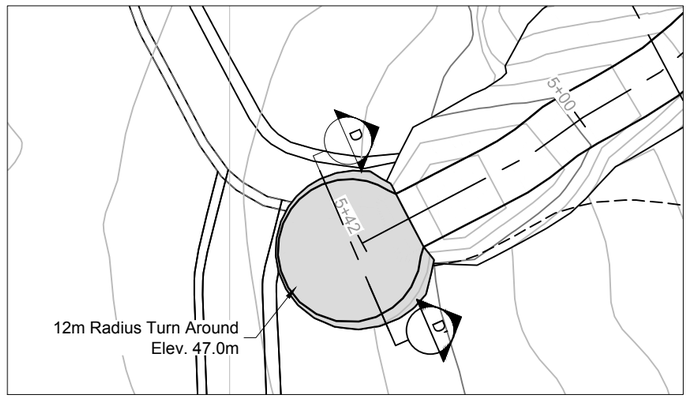
1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Approximately 325m³ of surfacing / bedding material is estimated (to neat lines) to be needed for the Access Road and Turn Around.

REFERENCES

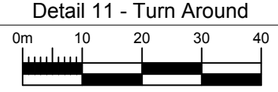
NAD83 UTM Zone 13.

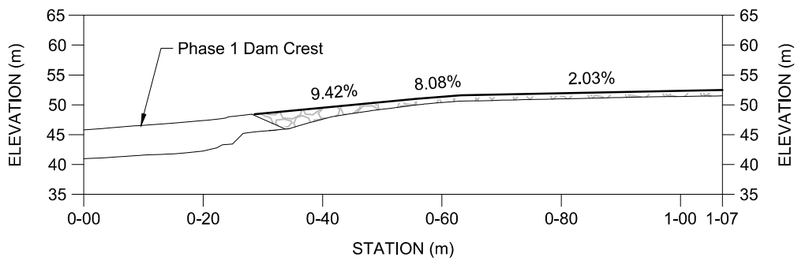
Typical Road Section



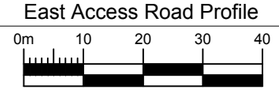


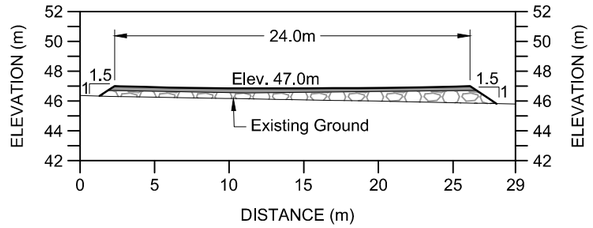
Detail 11 - Turn Around



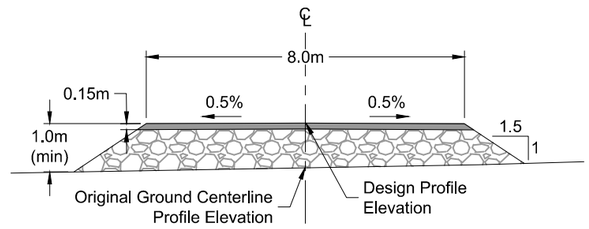


East Access Road Profile

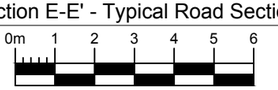




Section D-D' - Turn Around



Section E-E' - Typical Road Section



DRAWING NO.	DRAWING TITLE
DN-SD-03	Typical Sections (General)
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2017/11/29

FILE NAME: 1CT0022.017 - South Dam AR.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

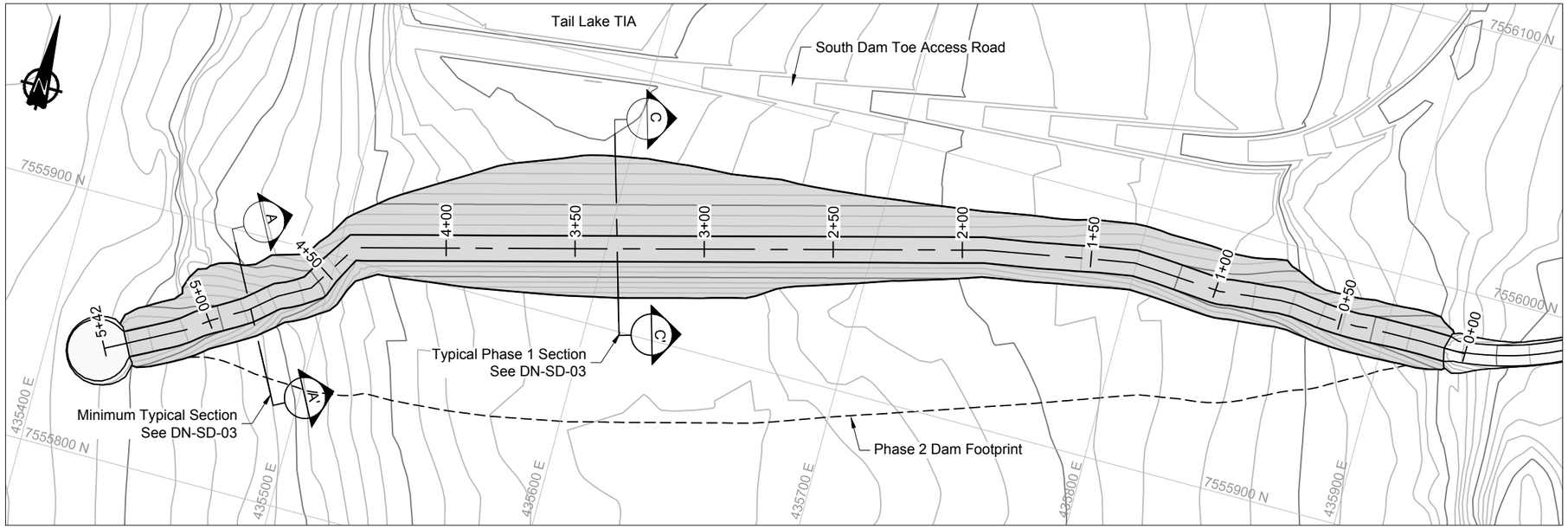
South Dam

DRAWING TITLE:

Construction Access Road and Turnaround - Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-11	11 OF 18	0

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1\1CT0022.017 - South Dam AR.dwg



Phase 1 Dam Plan View

0m 20 40 60 80

LEGEND

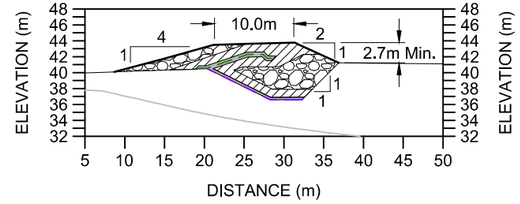
- Key Trench Excavation
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The Phase 2 dam elevations are showing for information purposes only. Note that only Phase 1 dam designs and elevations are issued for construction use.

REFERENCES

NAD83 UTM Zone 13.



Minimum Cross Section A-A'

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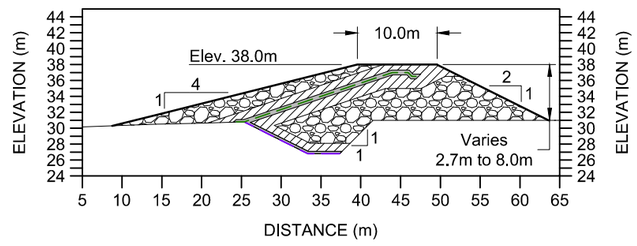

Cross Section C-C'

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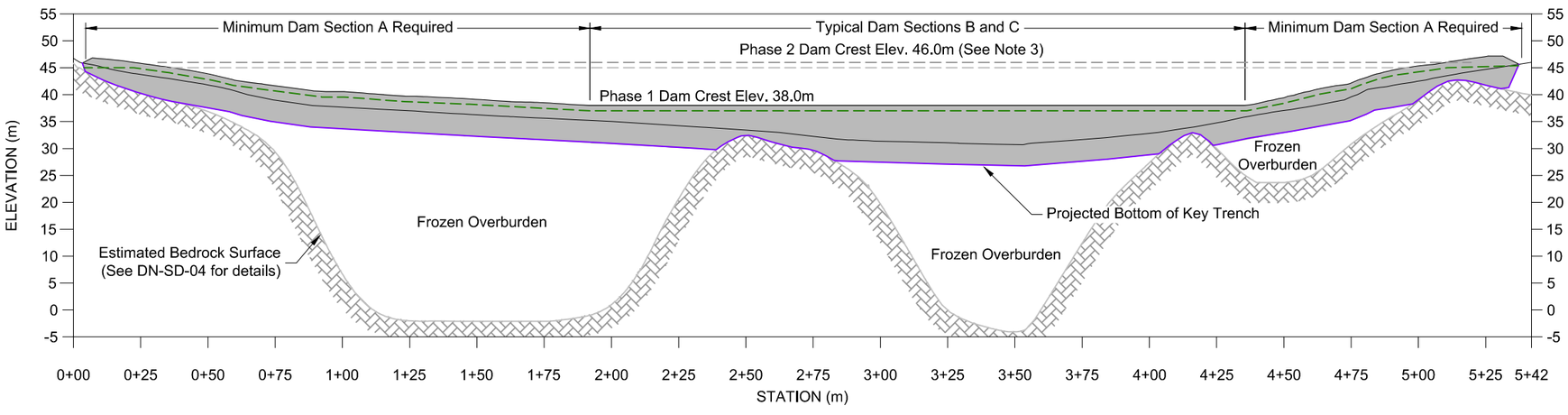

Phase 1 Dam Profile View

Horizontal: 0m 10 20 30 40

Vertical: 0m 20 40 60 80

DRAWING NO.	DRAWING TITLE
DN-SD-04	Key Trench Excavation Plan and Profile
DN-SD-03	Typical Sections (General)
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Phase 1 Dam.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Final Phase 1 Dam Plan, Profile and Sections

DRAWING NO.	SHEET	REVISION NO.
DN-SD-12	12 OF 18	0

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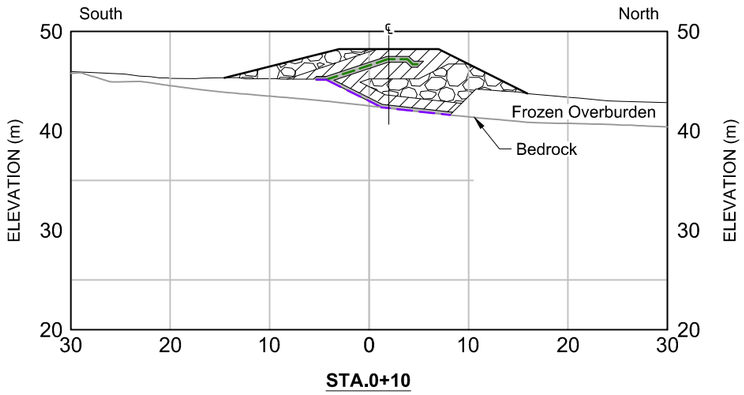

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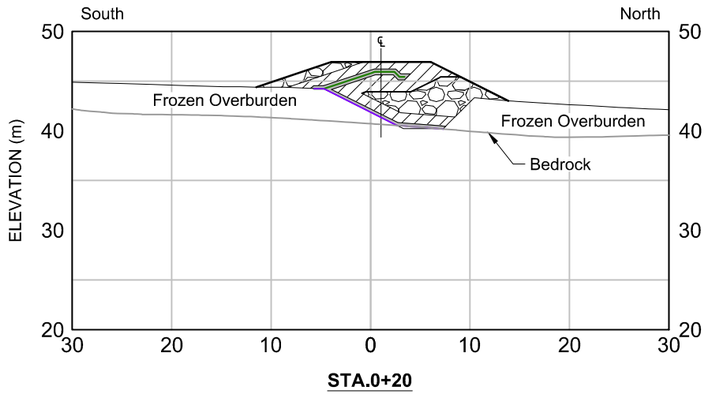

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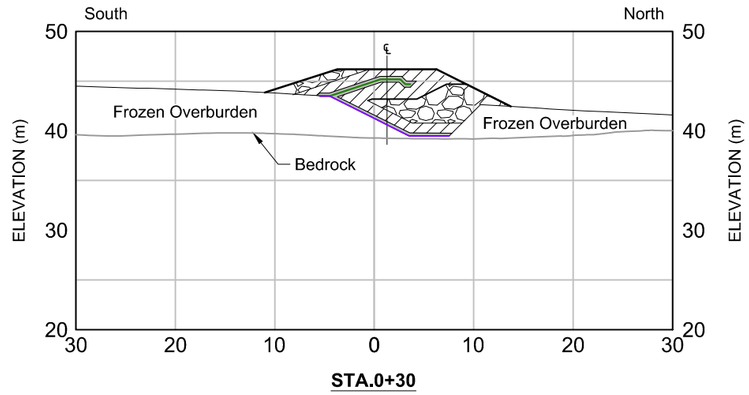

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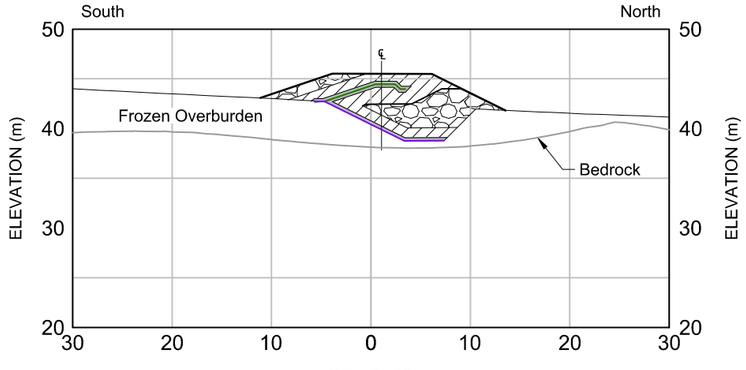

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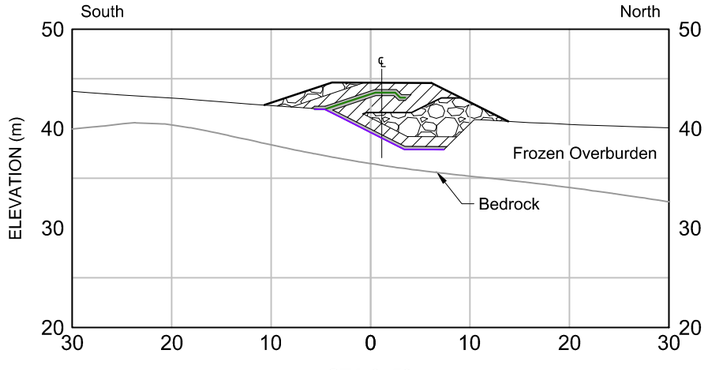

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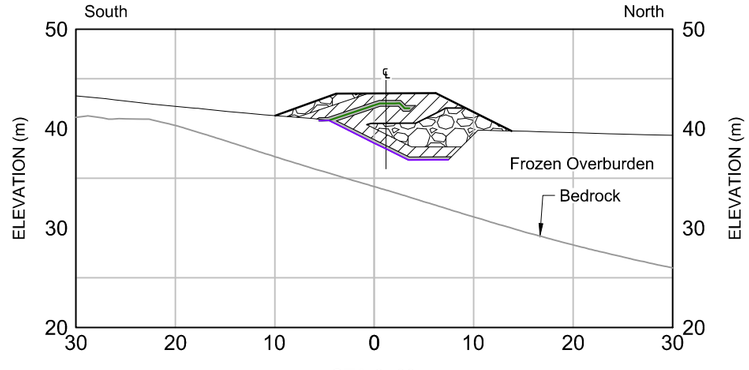

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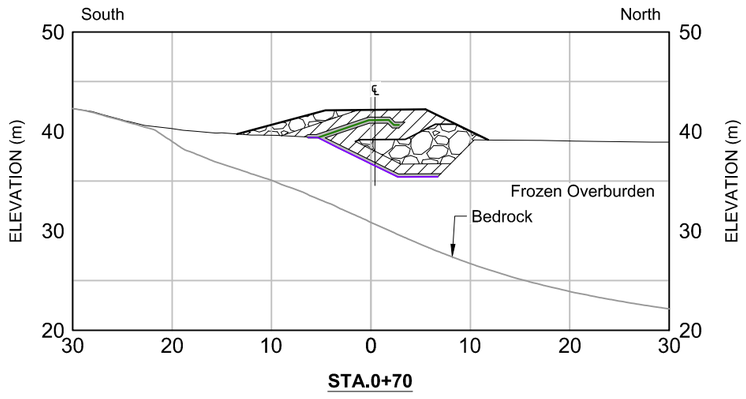

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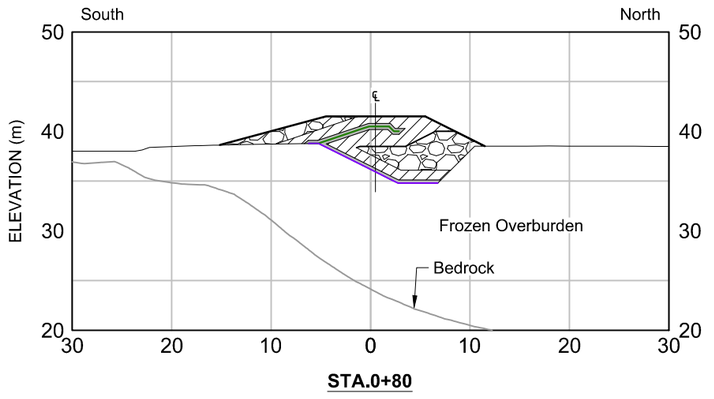

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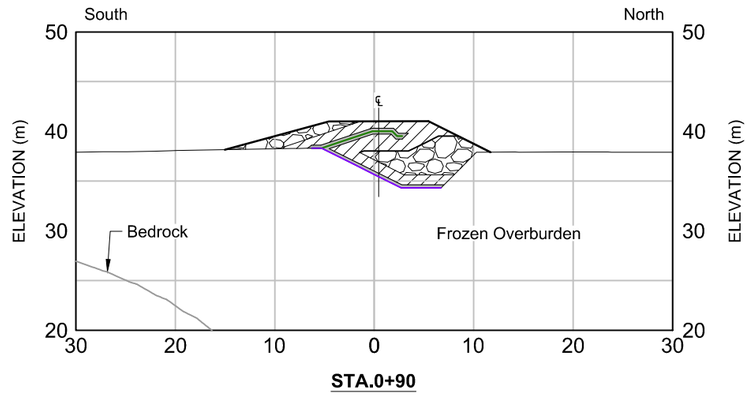

STA.0+90

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.

0m 6 12 18 24

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DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
REFERENCE DRAWINGS		REVISIONS									

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

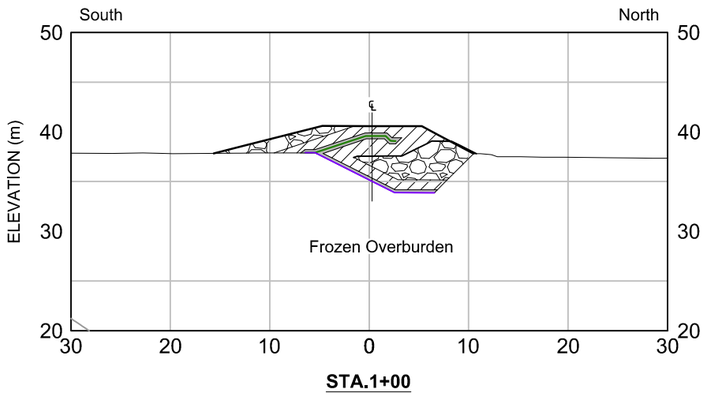
Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.0+10 to 0+90 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-13	13 OF 18	0



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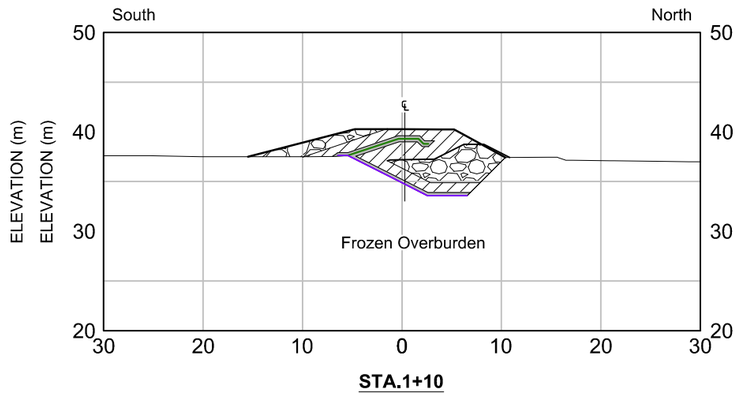

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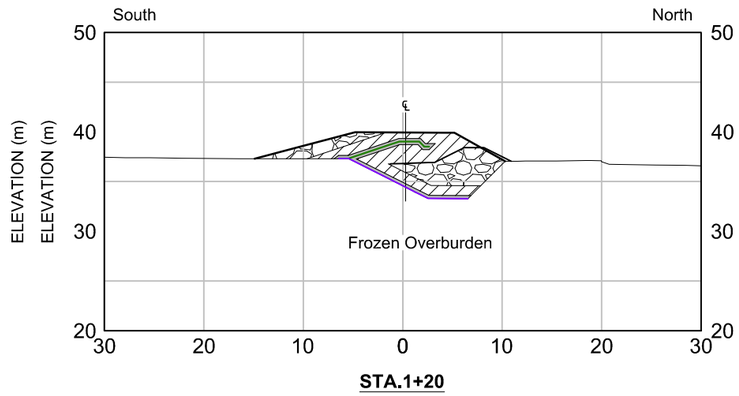

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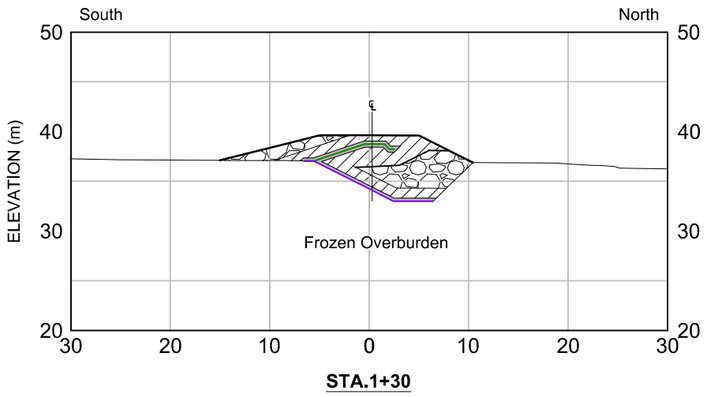

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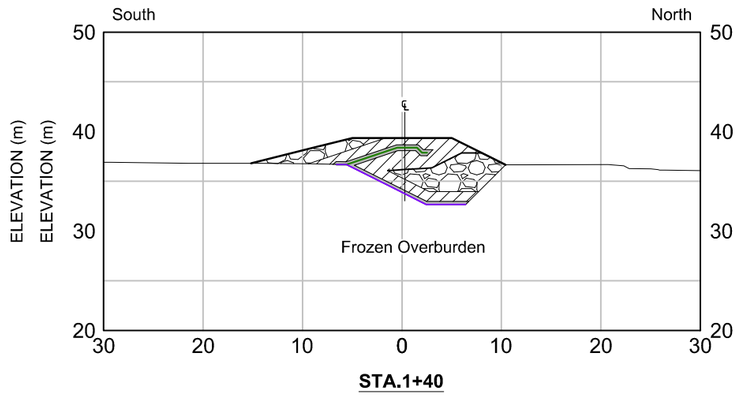

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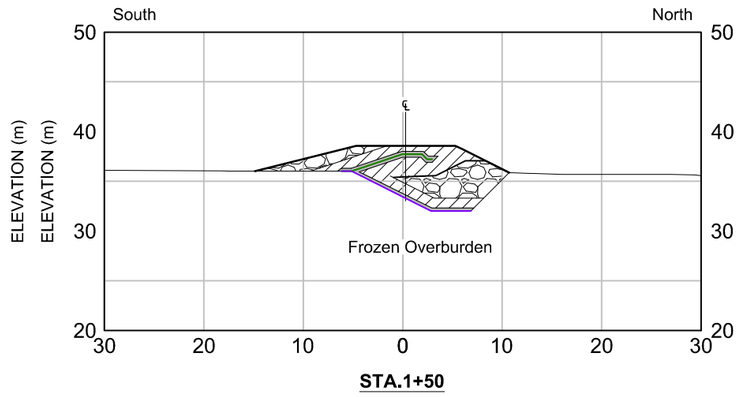

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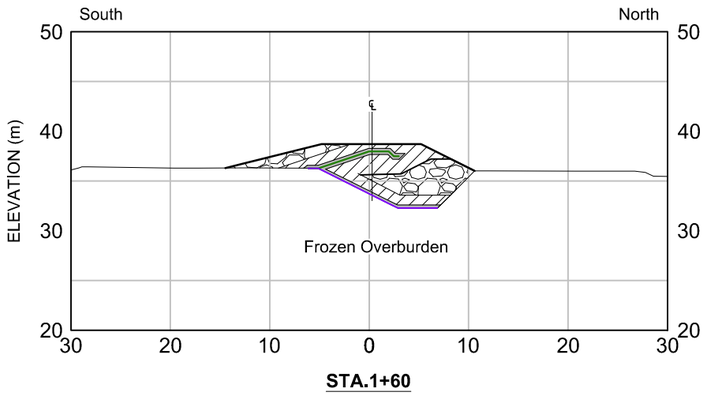

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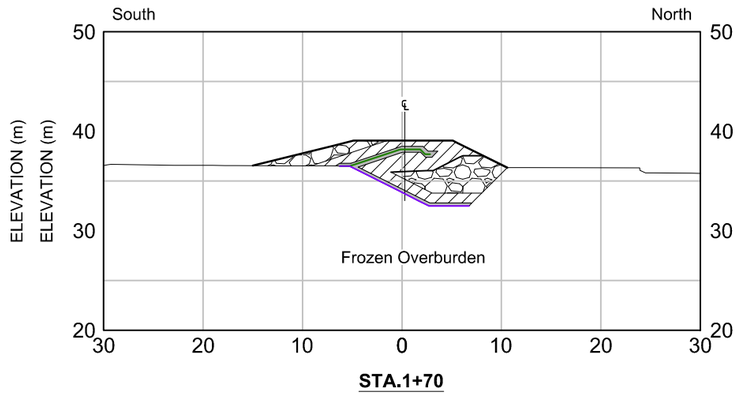

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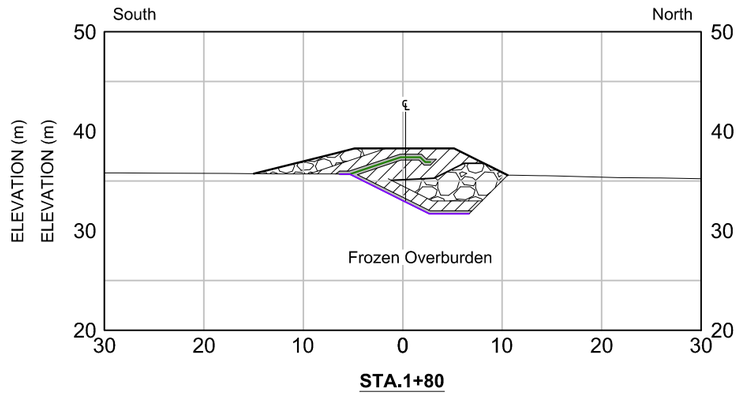

STA.1+80

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.

0m 6 12 18 24

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-02	Phase 1 General Arrangement	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.1+00 to 1+80 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-14	14 OF 18	0

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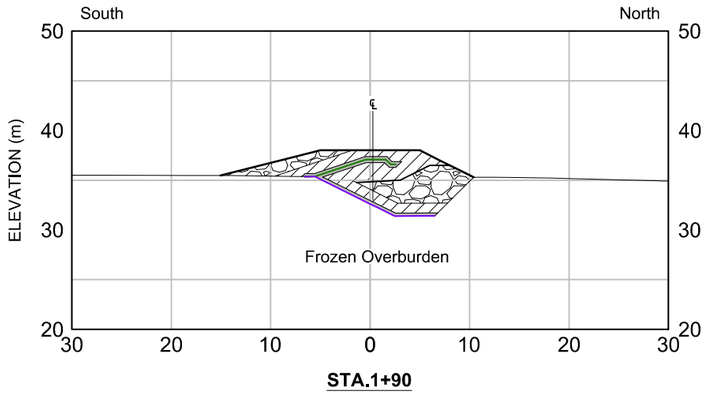

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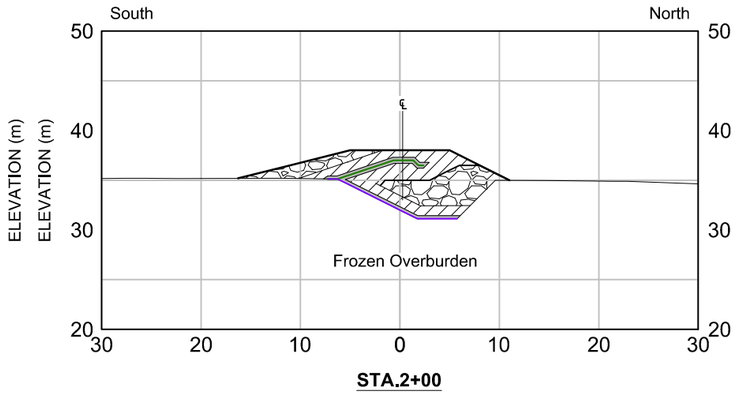

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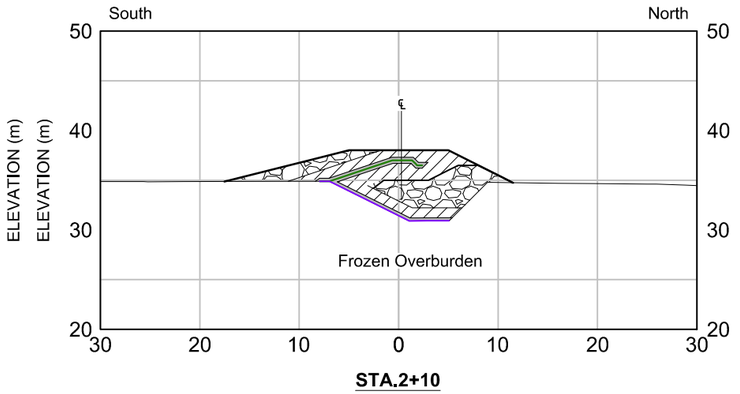

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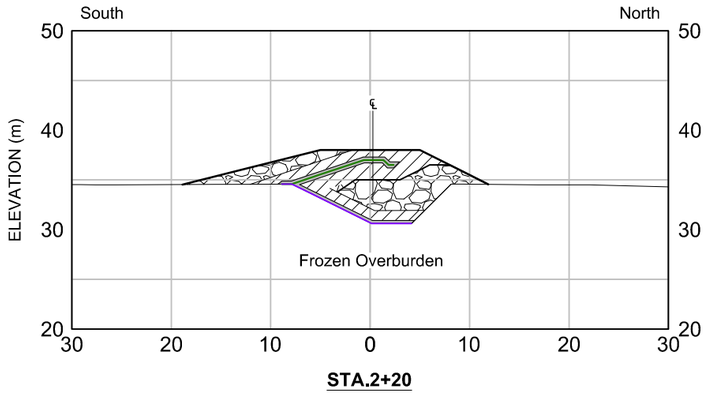

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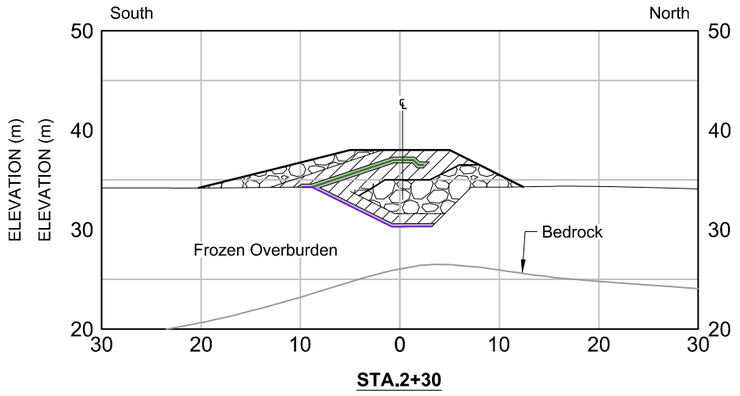

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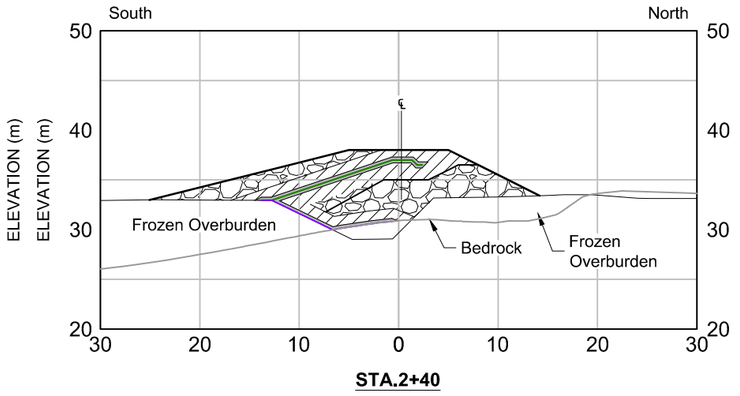

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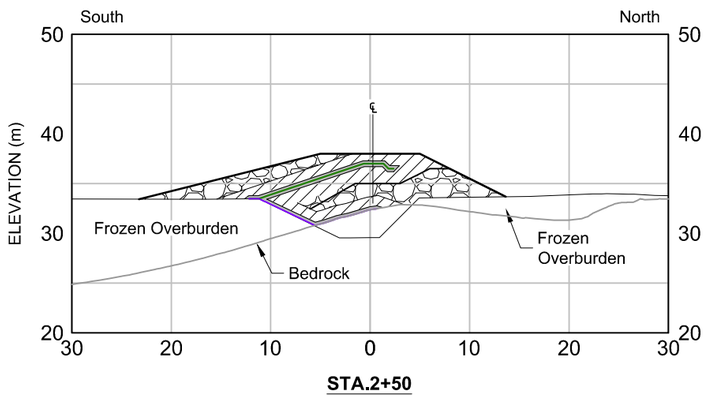
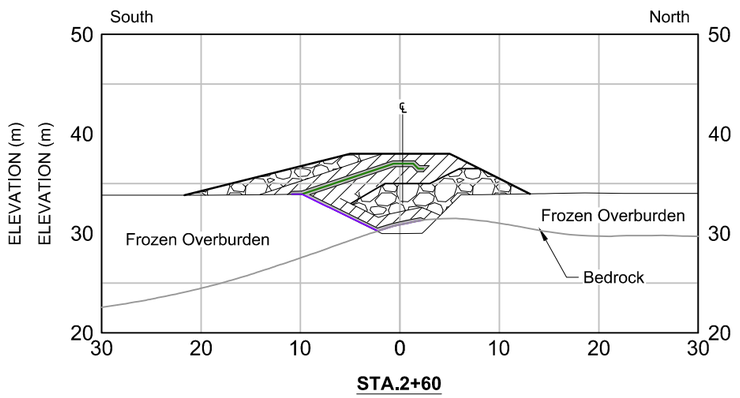
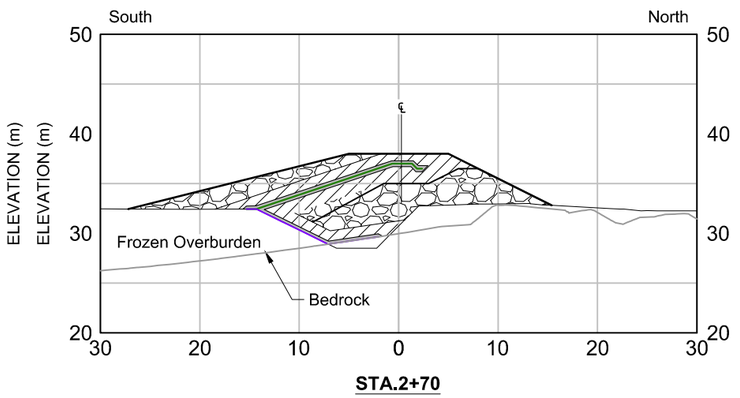


STA.2+50



STA.2+60



STA.2+70

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.

0m 6 12 18 24

P:\01_SITES\Hope Bay\AOA\DJFC\South Dam - Phase 1\1CT0022.017 - South Dam - Sections.dwg

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-02	Phase 1 General Arrangement	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

Original Drawings Stamped and Signed by Engineer

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

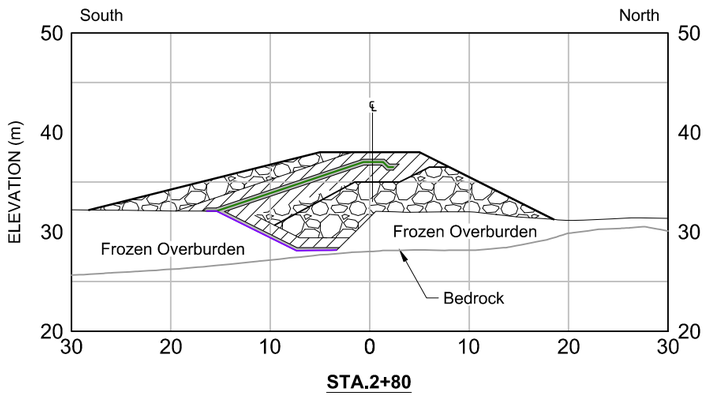
Hope Bay Project

SRK JOB NO.: 1CT022.017

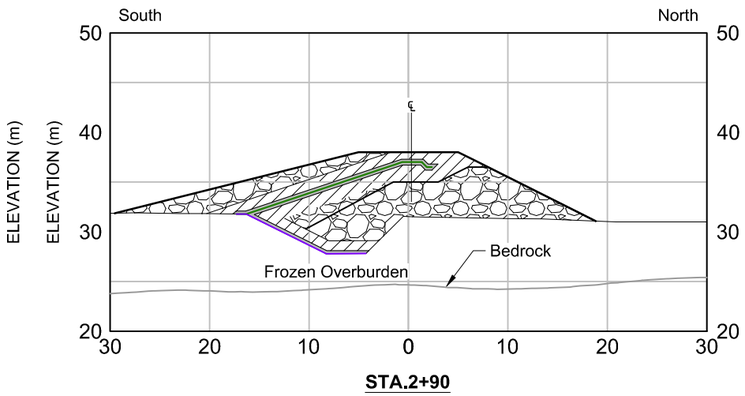
South Dam

DRAWING TITLE: Sections Sta.1+90 to 2+70 Phase 1 Dam

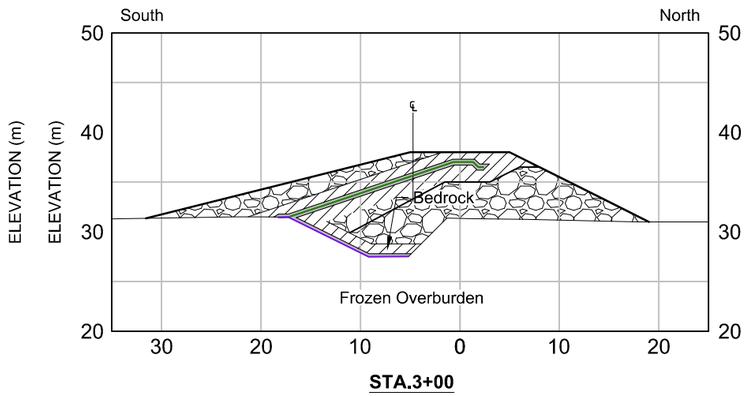
DRAWING NO.	SHEET	REVISION NO.
DN-SD-15	15 OF 18	0



STA.2+80



STA.2+90



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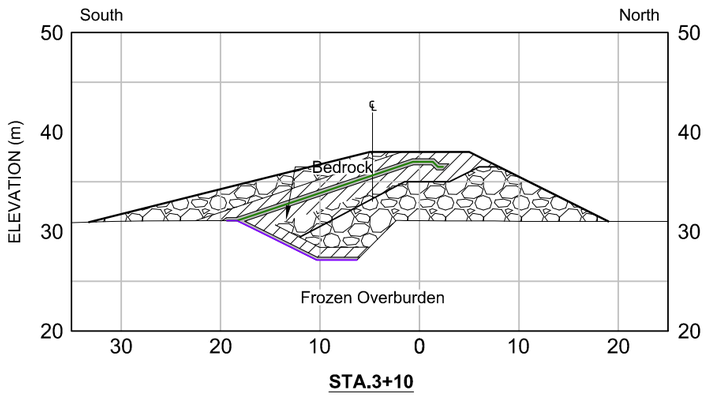
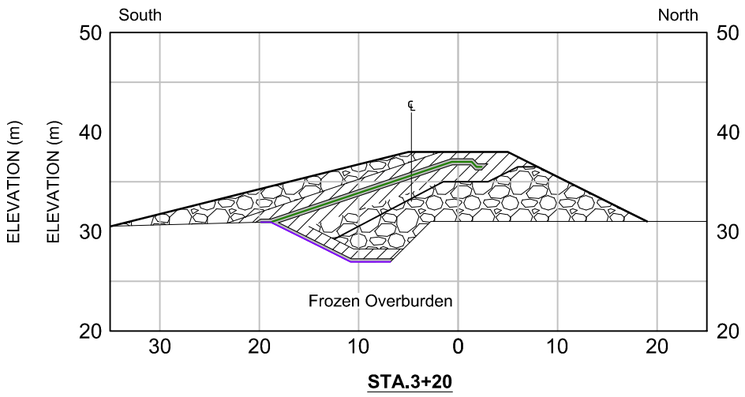
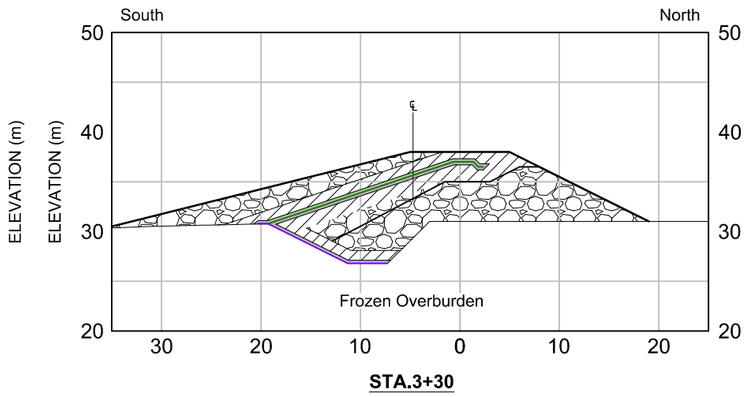


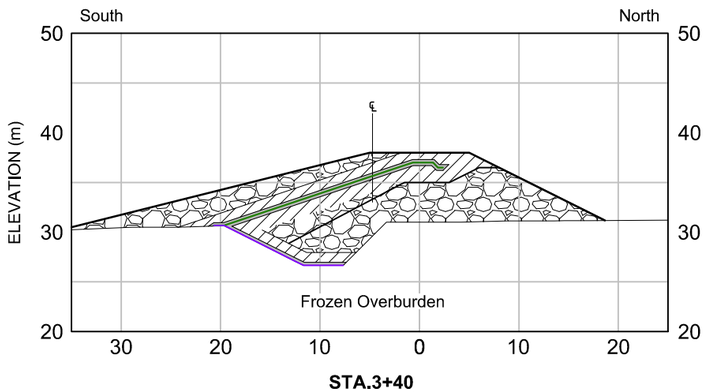
STA.3+10



STA.3+20



STA.3+30



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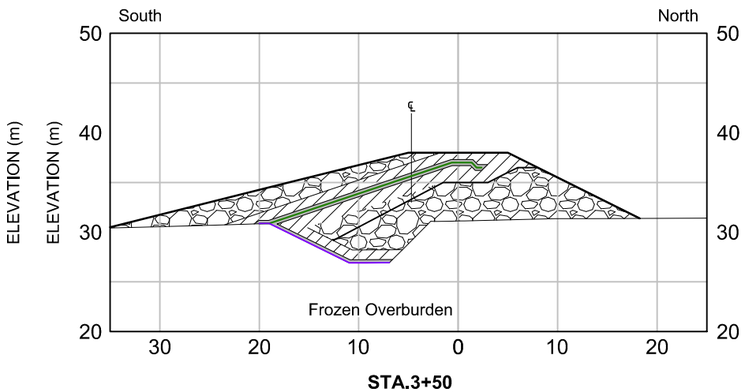

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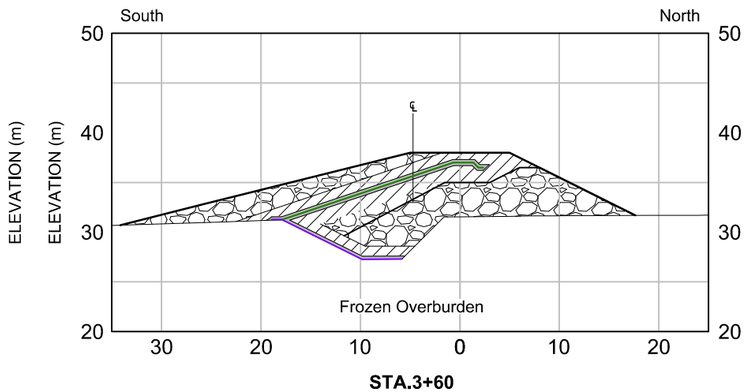

STA.3+60

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
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0m 6 12 18 24

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-02	Phase 1 General Arrangement	-	-			

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS

REVISIONS

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

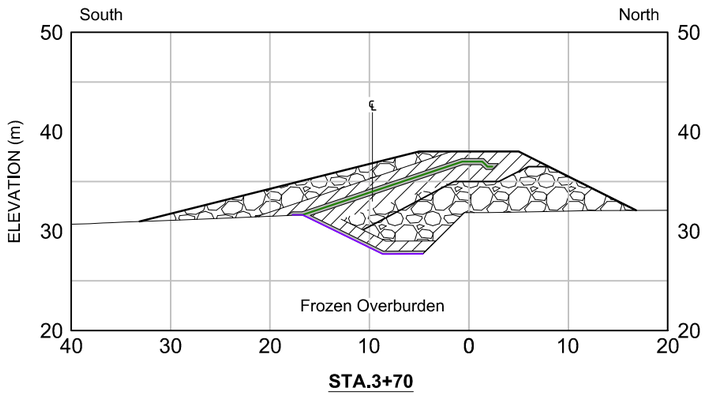
SRK JOB NO.: 1CT022.017

South Dam

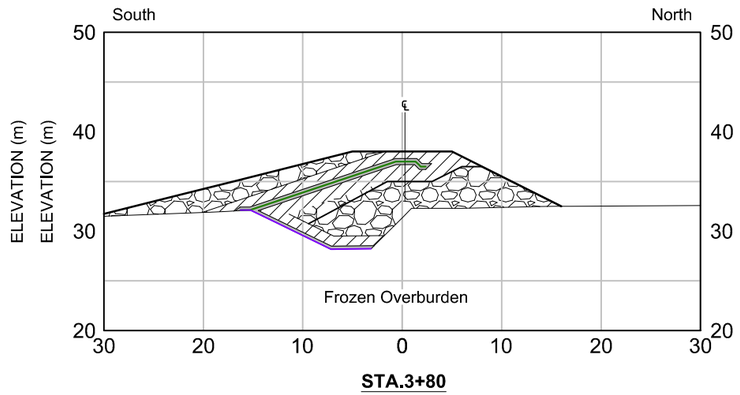
DRAWING TITLE: Sections Sta.2+80 to 3+60 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-16	16 OF 18	0

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1\1CT0022.017 - South Dam - Sections.dwg



STA.3+70



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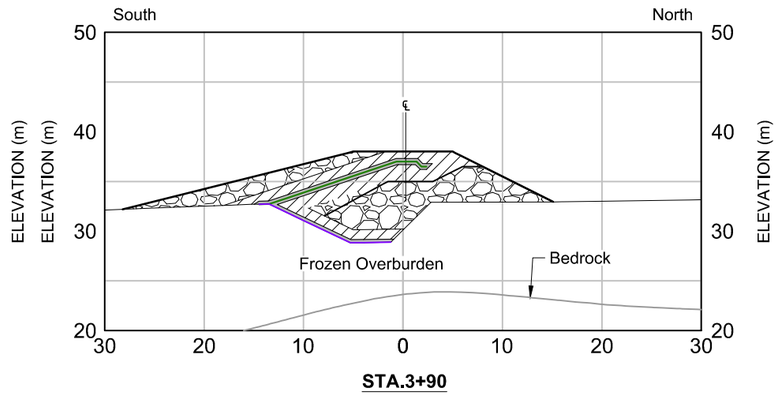

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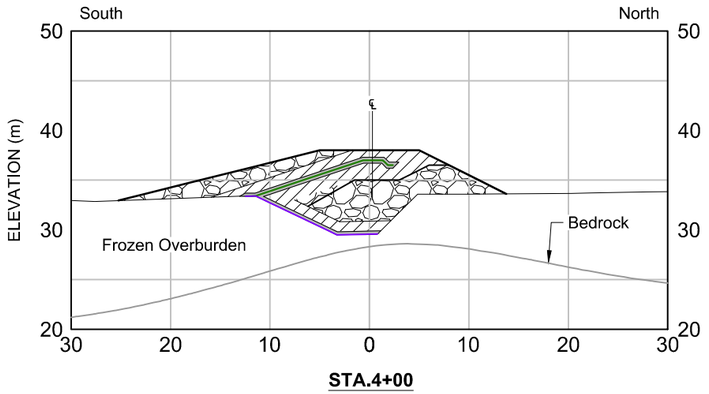

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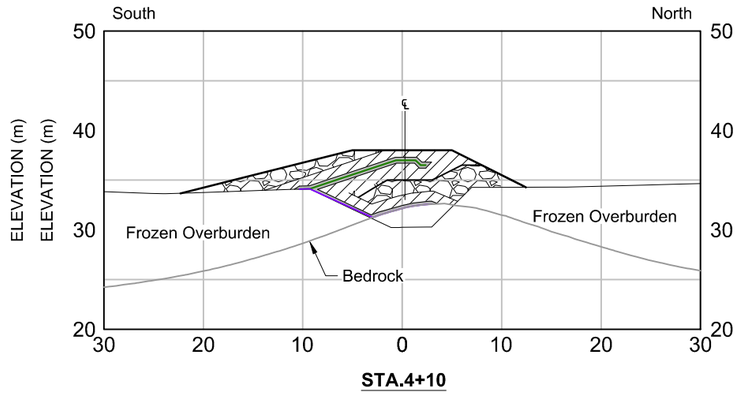
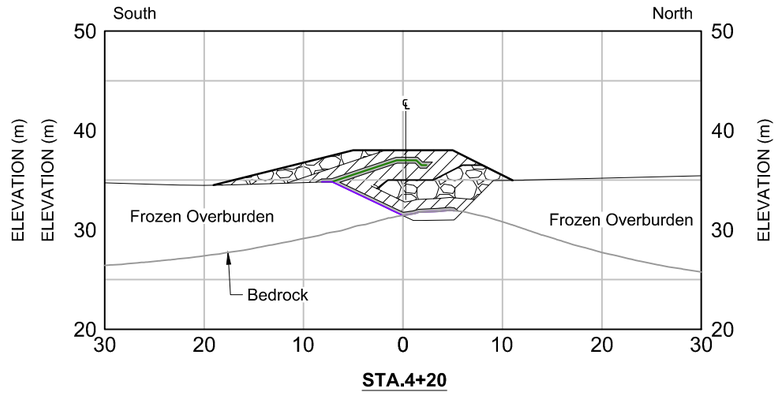
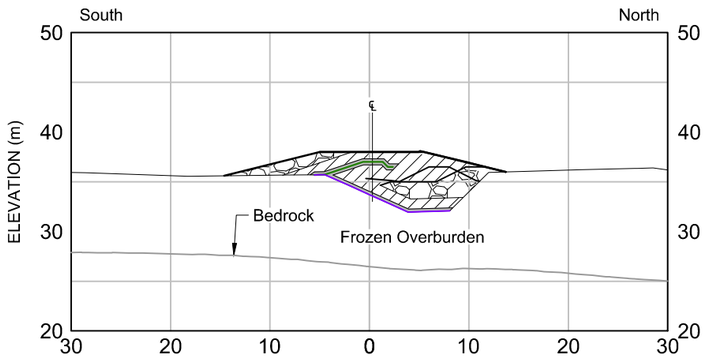


STA.4+10



STA.4+20



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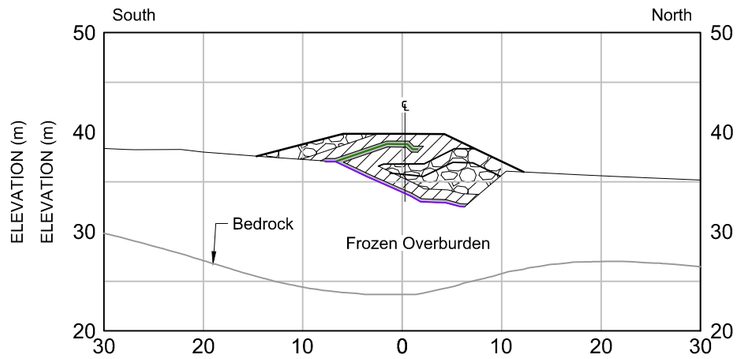
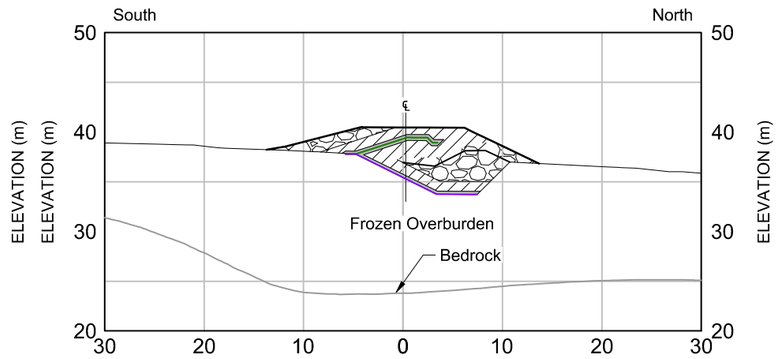


STA.4+40



STA.4+50

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
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0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
0	Issued for Construction	JBK	EMR	17/11/29

DN-SD-02 — Phase 1 General Arrangement

REFERENCE DRAWINGS — REVISIONS

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.3+70 to 4+50 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-17	17 OF 18	0

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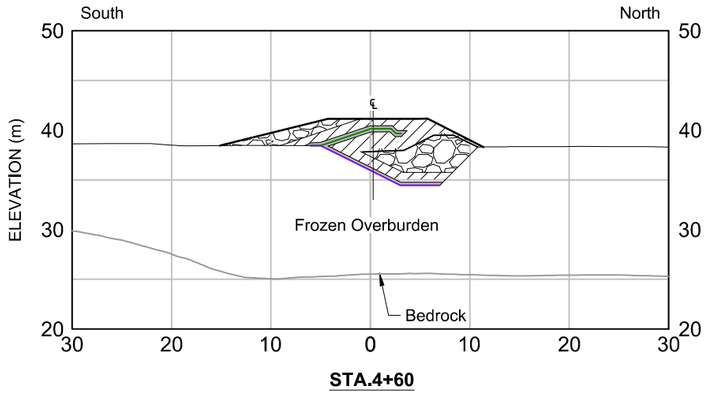

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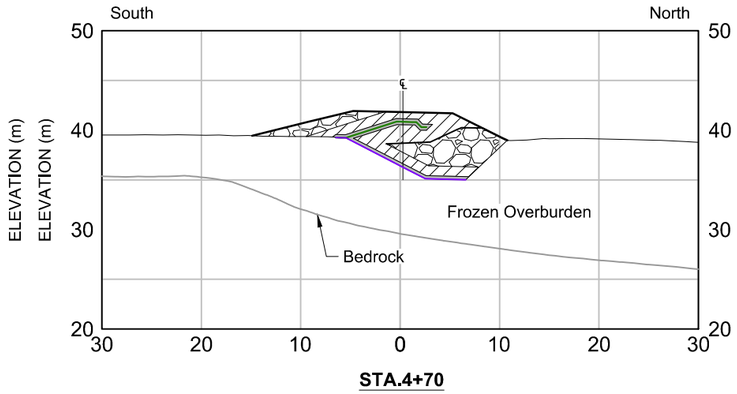

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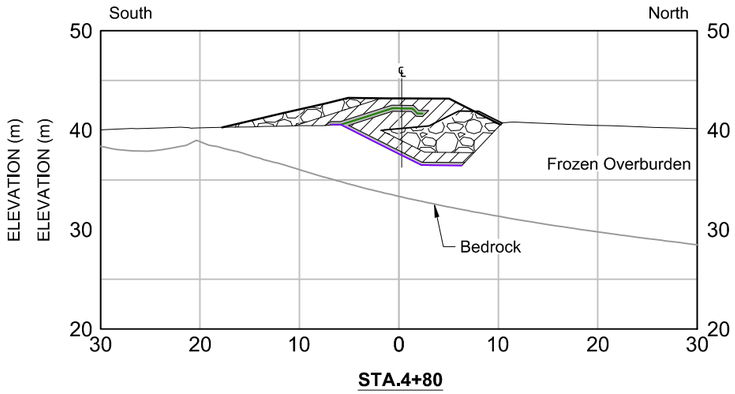

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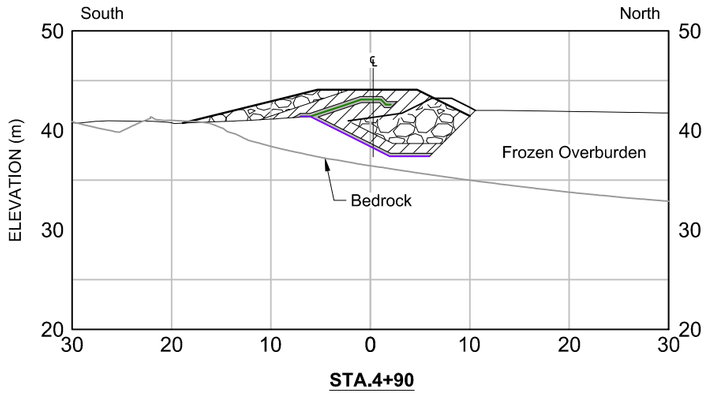
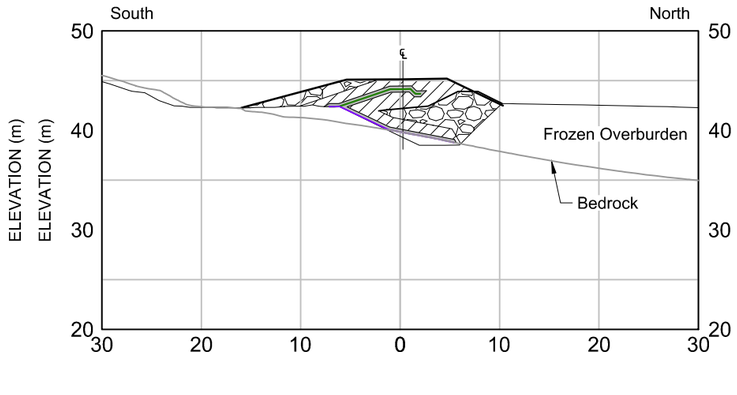
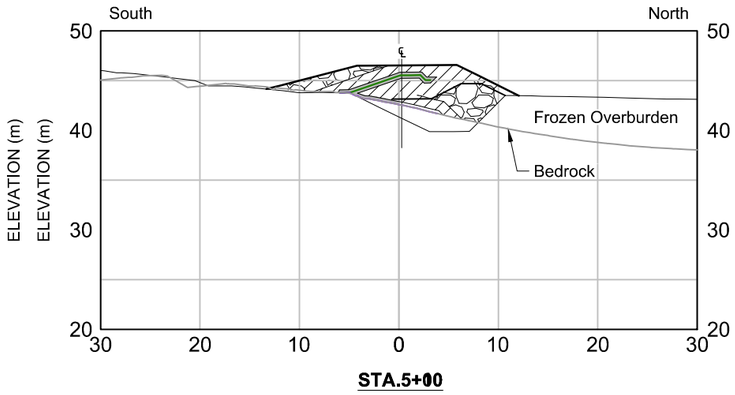


STA.4+90



STA.5+00



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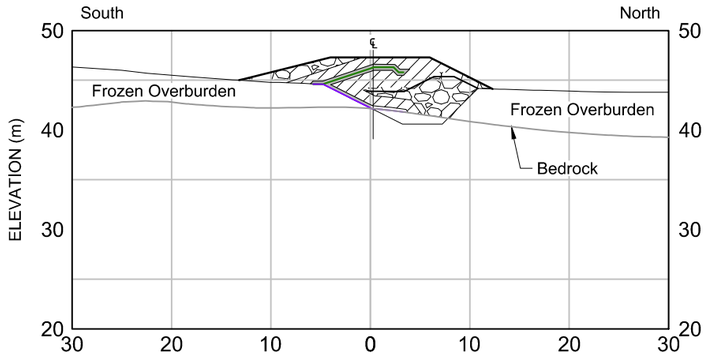
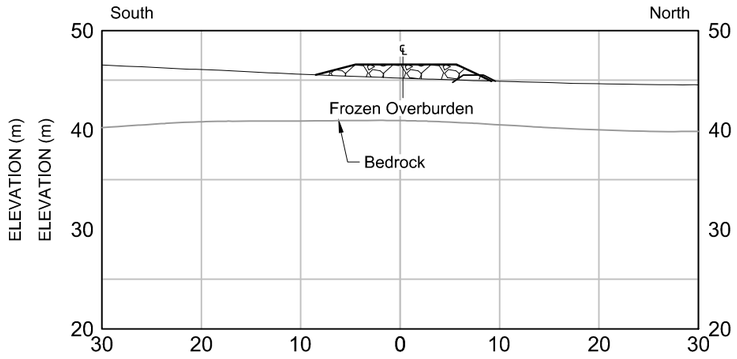


STA.5+20



STA.5+30

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
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0m 6 12 18 24

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1\1CT0022.017 - South Dam - Sections.dwg

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
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DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS | REVISIONS

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CH	TAH	JBK
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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.4+60 to 5+30 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-18	18 OF 18	0

Hope Bay Mining Ltd.

Doris North Project

Engineering Drawings for the South Dam - Phase 1

Drawing Number	Drawing Title	Issue	Date	Revision	Old / Replaced Revisions
DN-SD-01	Phase 1 General Arrangement (with Orthophoto)	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-02	Phase 1 General Arrangement	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-03	Typical Sections (General)	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-04	Key Trench Excavation Plan and Profile	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-05	Liner Placement Plan and Details - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-06	Liner and Bedding Placement Details	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-07	Bedding Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-08	Transition Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-11	Construction Access Road and Turn Around - Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-12	Final Phase 1 Dam Plan, Profile and Sections	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-13	Sections Sta. 0+10 to 0+90 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-14	Sections Sta. 1+00 to 1+80 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-15	Sections Sta. 1+90 to 2+70 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-16	Sections Sta. 2+80 to 3+60 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-17	Sections Sta. 3+70 to 4+50 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-18	Sections Sta. 4+60 to 5+30 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-19	Infill Foundation Drilling - Phase 1	Issued for Construction	March 7, 2018	AB	Rev 0, 2018/02/16
DN-SD-20	Percolation Borehole / Test Locations	Issued for Construction	March 7, 2018	AB	Rev 0, 2018/02/16
DN-SD-21	Instrumentation Plan - Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07
DN-SD-22	GTC backfilled Cable Trench - Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07
DN-SD-23	Vertical GTC Layout - Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07
DN-SD-24	Horizontal GTC - Upstream Base / Toe of Key Trench	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07
DN-SD-25	GTC Layout Along Upstream Above Ground Liner Slope	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07
DN-SD-26	Sloped GTC - Above Ground Liner Slope	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07
DN-SD-27	Instrumentation Details at Sta. 0+65 and 1+55	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07
DN-SD-28	Instrumentation Details at Sta. 2+40 and 3+65	Issued for Construction	March 7, 2018	0	
DN-SD-29	Instrumentation Details at Sta. 4+65 and 5+10	Issued for Construction	March 7, 2018	0	
DN-SD-30	Typical Monitoring Point Details	Issued for Construction	March 7, 2018	0	

March 7, 2018 -
Compiled IFC Drawing Set

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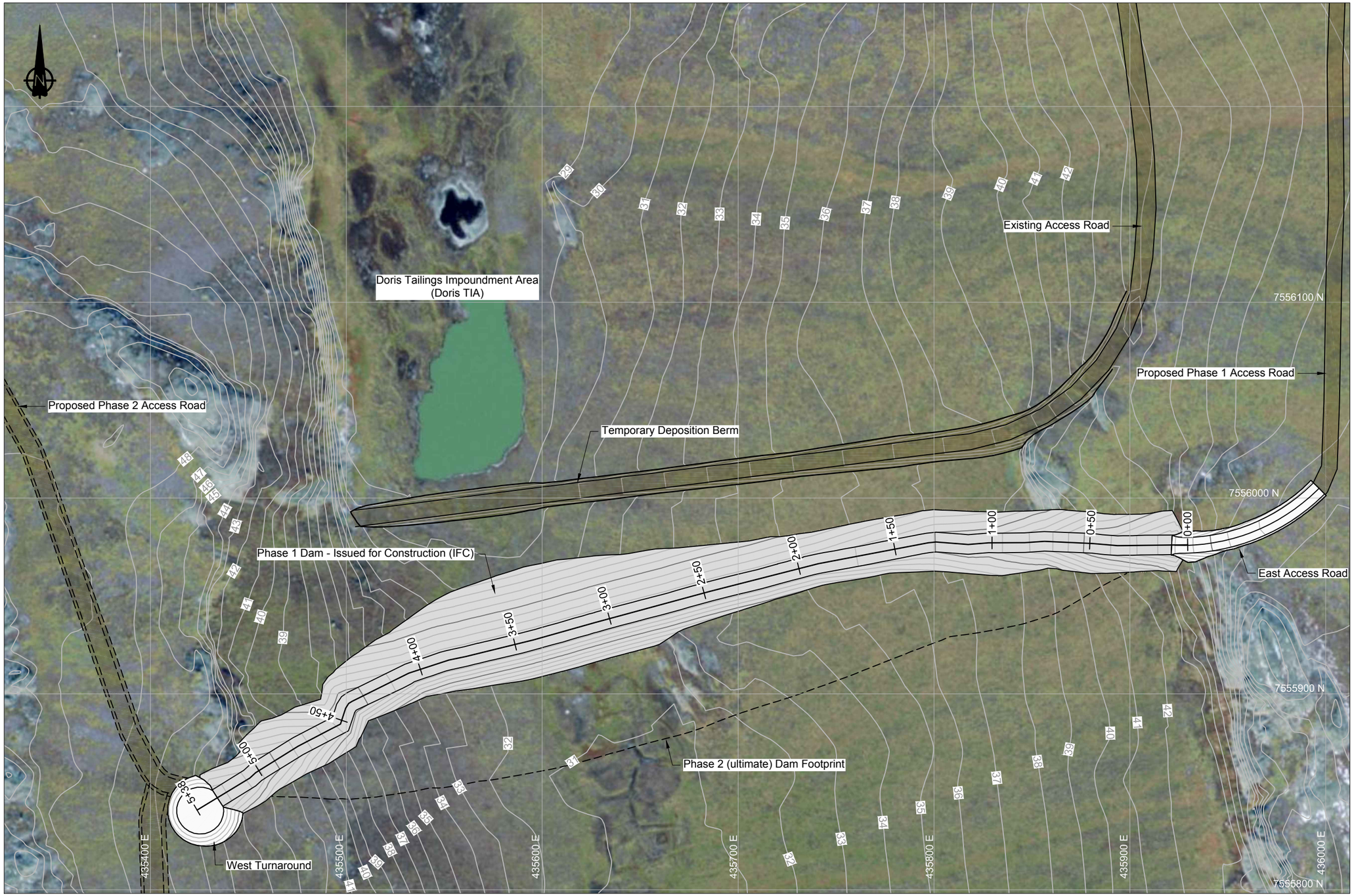

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Imagery (from 2010 PhotoSat compilation) provided by client.
5. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

0m 20 40 60 80

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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							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam GA - with ortho.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Phase 1 General Arrangement (with Orthophoto)

DRAWING NO.	SHEET	REVISION NO.
DN-SD-01	1 OF 30	1

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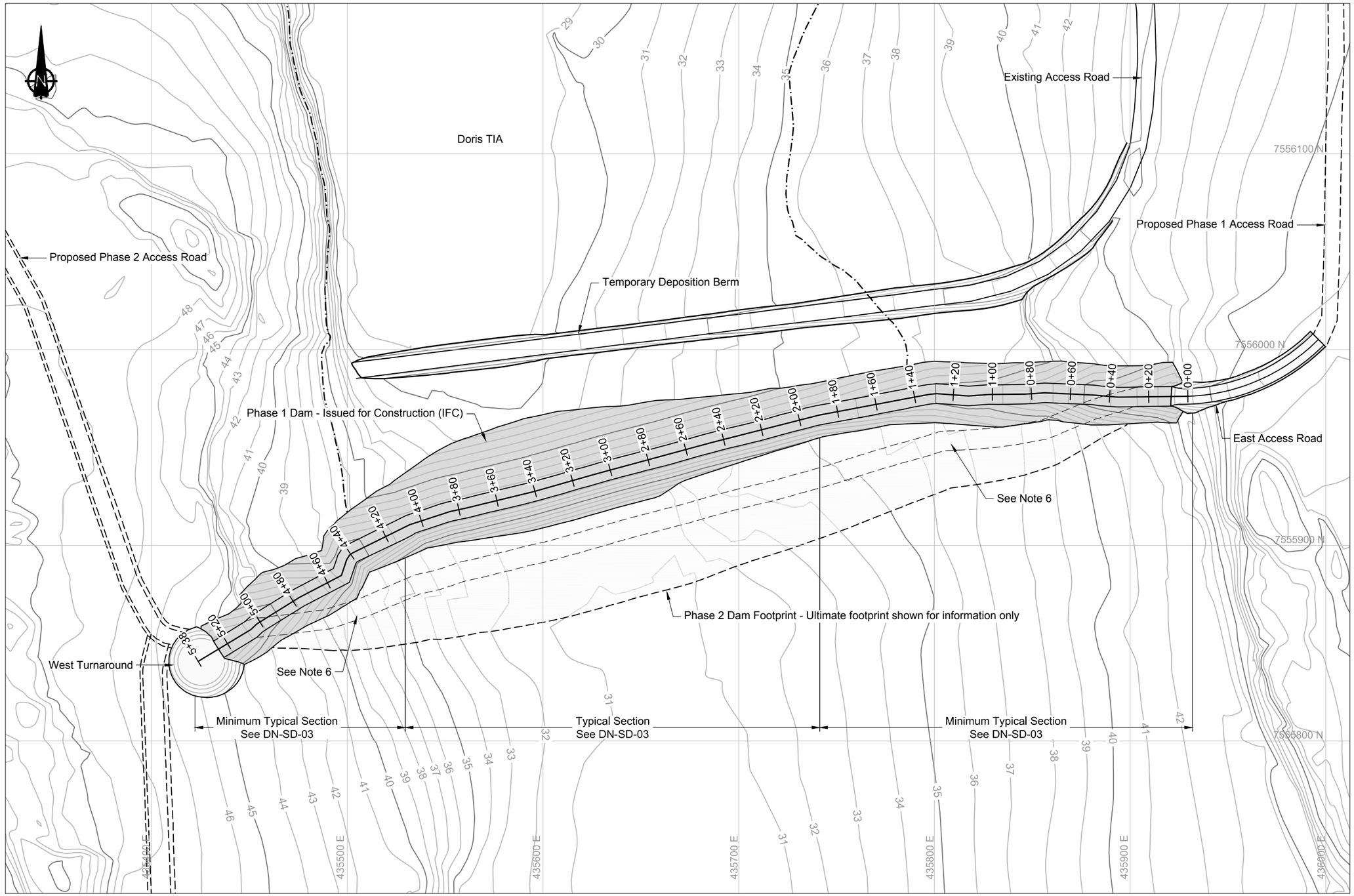

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Volumes presented based on neat-lines only and are approximate. These include no over-excavation or over-blasting allowance of the key trench.
5. All units shown are in meters unless otherwise stated.
6. Bend in the dam crest is to accommodate Phase 2 liner tie-in.
7. All snow roads placed on the upstream as a temporary construction measure, to help facilitate construction of the dam, must be completely removed before tailings deposition may commence.

REFERENCES

NAD83 UTM Zone 13.

TABLE OF QUANTITIES (NEAT-LINE)

Key Trench Bulk Excavation :	19,500m³
Total Phase 1 Fill:	68,500m³
ROQ:	36,800m³
Transition:	26,100m³
Bedding:	5,600m³
Total Liner:	14,300m²
West Turnaround (bulk):	2,000m³
East Access Road (bulk):	1,200m³

*all volumes presented are to neat-lines and do not allow / account for bulking and compaction.

0m 20 40 60 80

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam GA.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

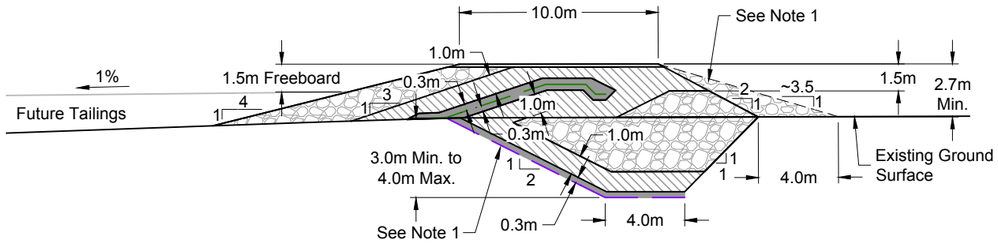
South Dam

DRAWING TITLE:

Phase 1 General Arrangement

DRAWING NO.	SHEET	REVISION NO.
DN-SD-02	2 OF 30	2

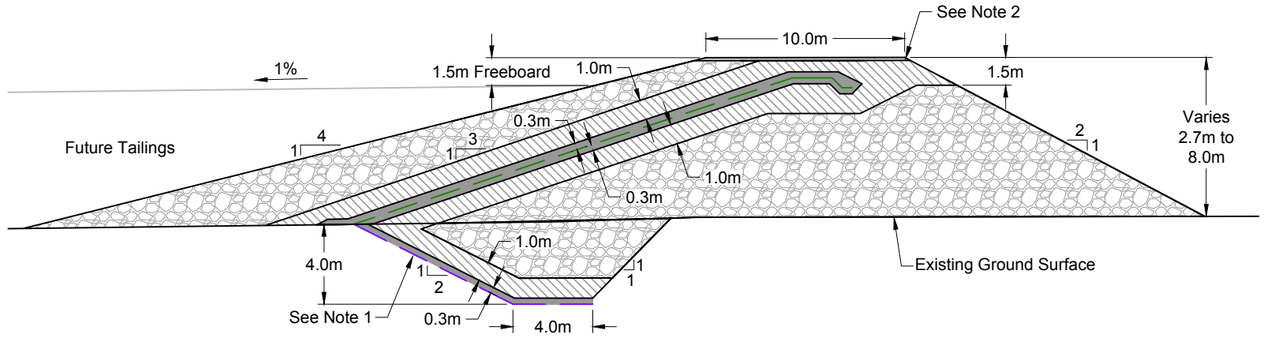
P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 rl\1CT0022.017 - South Dam GA.dwg



Minimum Typical Cover Section
STA.0+00 to 1+92 & 4+15 to 5+42

0m 3 6 9 12

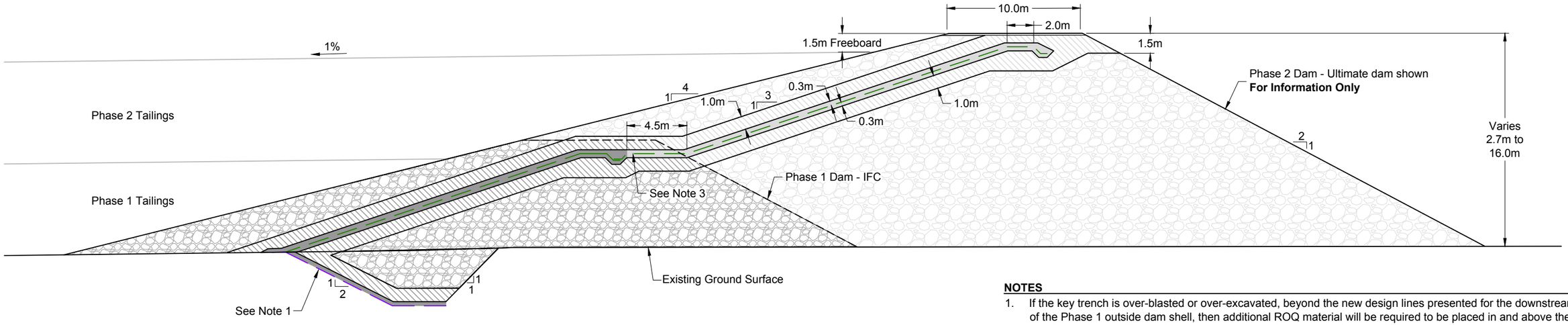
ISSUED FOR CONSTRUCTION



Phase 1 Typical Dam Section
STA. 1+92 to 4+15

0m 3 6 9 12

ISSUED FOR CONSTRUCTION



Phase 2 Typical Dam Section
STA. 0+25 to 5+25

0m 3 6 9 12

ISSUED FOR INFORMATION

LEGEND

- Key Trench Liner
- Phase 1 & 2 Dam Liner
- Bedding Material
- Transition Material
- Run of Quarry

NOTES

1. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench. This material would be placed to ensure that adequate thermal insulation of the key trench is maintained in all sections. See Detail 10 on drawing DN-SD-09 for additional details.
2. The top road surfacing (bedding material) for the Phase 1 dam is to be fully removed (upstream and downstream) before Phase 2 construction commences.
3. To allow for a proper tie-in the transition material around the top downstream portion of the Phase 1 dam will be required to be stripped back. Once the bedding material around the top liner anchor trench is reached hand excavation should be expected to result down to expose the liner. The on-site engineer will be required to inspect all exposed liner, to ensure that it is not damaged or in need of repairs before Phase 2 liner tie-ins result.
4. All units shown are in meters unless otherwise stated.

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-02	Phase 1 General Arrangement	-	-			

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Typ Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Typical Sections (General)

DRAWING NO.	SHEET	REVISION NO.
DN-SD-03	3 OF 30	1

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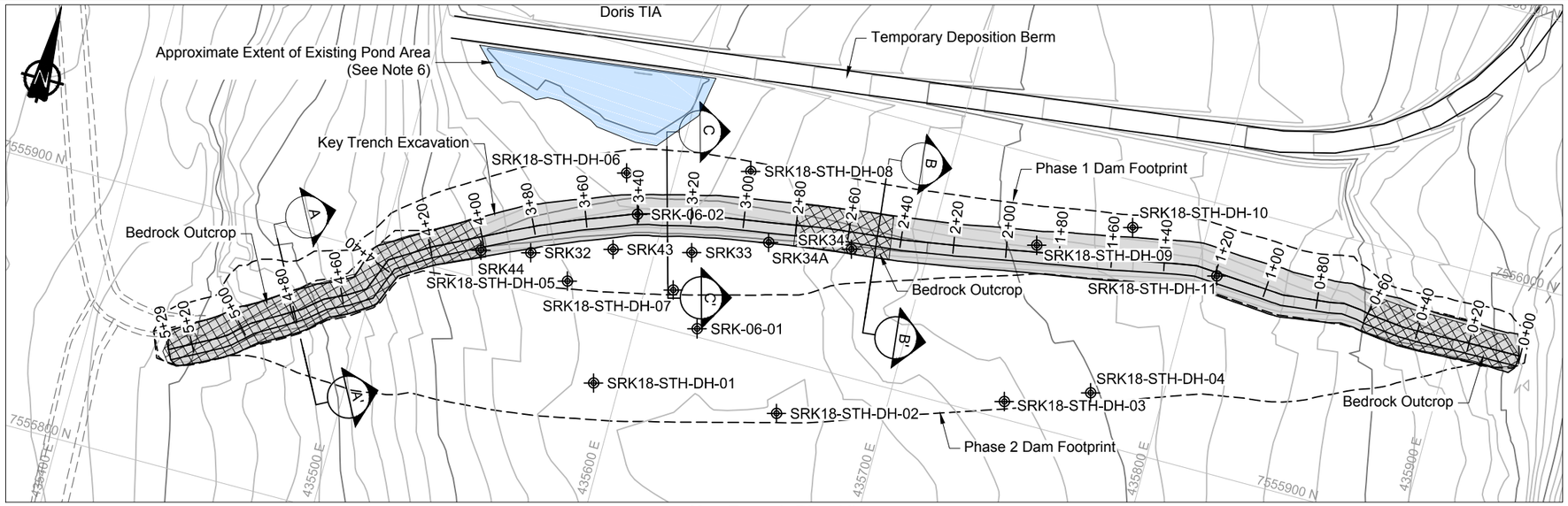
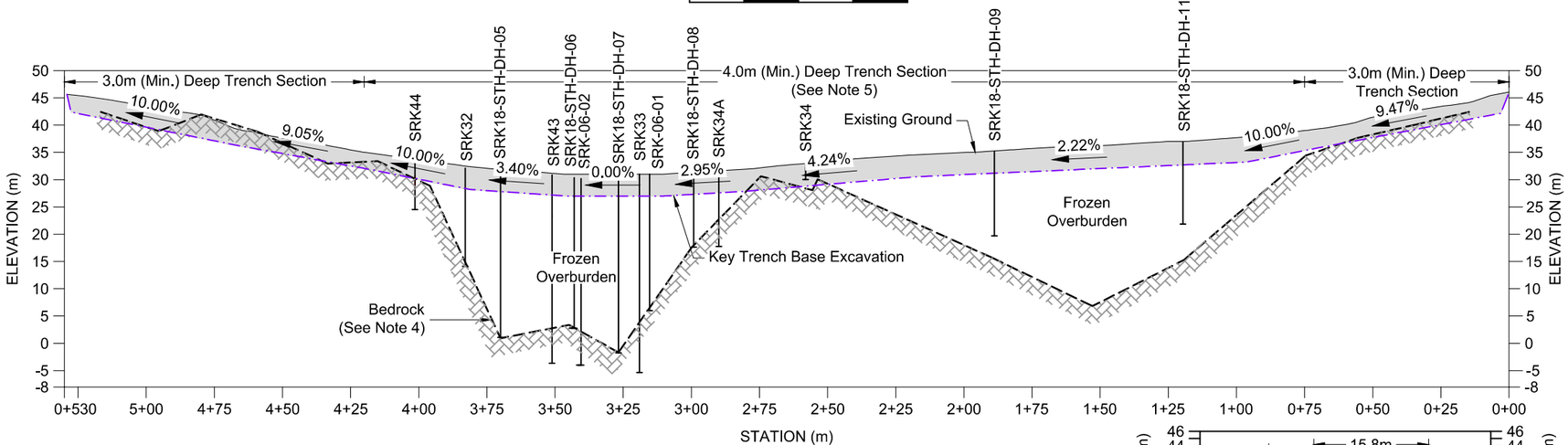


Key Trench Plan View

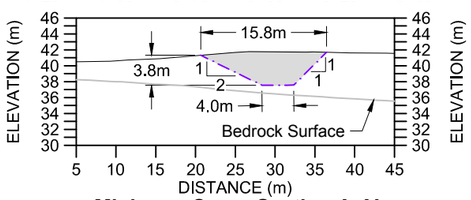
0m 20 40 60 80



Key Trench Profile View

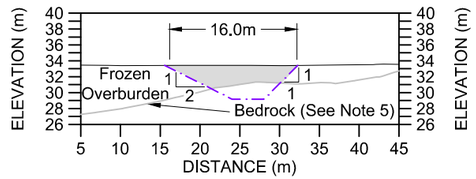
Vertical: 0m 10 20 30 40

Horizontal: 0m 20 40 60 80



Minimum Cross Section A-A'
Shallow Overburden over Bedrock

0m 5 10 15 20 25 30



Cross Section B-B'
Bedrock Outcropping in Key Trench

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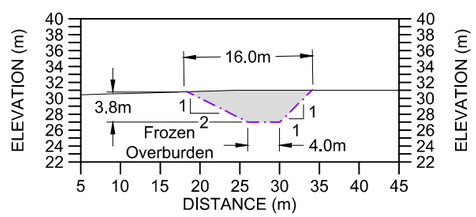

Cross Section C-C'
Deep Frozen Overburden

0m 5 10 15 20 25 30

LEGEND

- Drill Hole Location
- Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Trench Excavation Extent
- 1.00% Base Grades

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profile shown correspond to the upstream toe of the key trench.
4. The subsurface geology has been inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A , SRK43, SRK 44, SRK18-STH-DH01-11 and SRK18-WST-DH01-03), airphoto interpretations, and from limited available geophysical surveys around the Tails Lake area. This data was then used to create a bedrock surface with the Gemcom GEMS software. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.
5. The final key trench extent and depth will be determined in the field by the Engineer. Typical excavation depth is 4.0m, unless massive ice, hypersaline soil or bedrock encountered. The Engineer will inspect all excavations and approve the foundation conditions.
6. Ponded area to removed (frozen massive ice excavated or drained if possible). Up to approximately 4,700 m3 of (frozen) water may be expected to be removed from this area. Exact water levels are not known so the volume estimate above should be treated as a rough estimate based on topography.
7. If any area of the key trench is over-blasted or over-excavated then the extra excavation will need to be backfilled in thin lifts (*see 'Technical Specifications'*) until the key trench design lines and grades are reached.
8. Overblasting and/or overexcavation of the key trench beyond the design lines (as presented on this figure) should be avoided if at all possible. Extra care should be taken during the key trench excavation to ensure that the excavation can result as close to the design lines as possible. Excavation beyond the key trench design lines may require that the overall Phase 1 dam footprint be enlarged to provide the necessary thermal coverage and to uphold design requirements.

REFERENCES

NAD83 UTM Zone 13.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS | DRAWING NO. | DRAWING TITLE

REVISIONS

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Key Trench.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Key Trench Excavation Plan and Profile

DRAWING NO.: DN-SD-04 | SHEET: 4 OF 30 | REVISION NO.: 1

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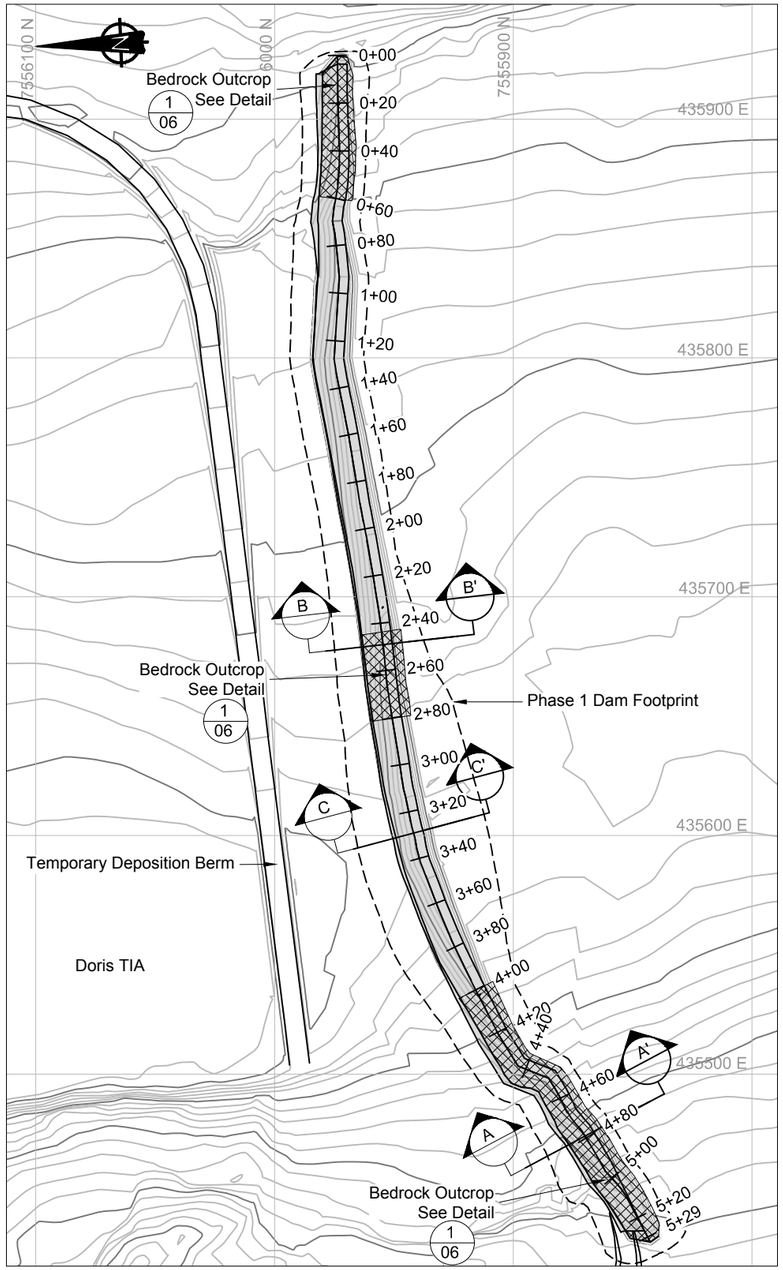
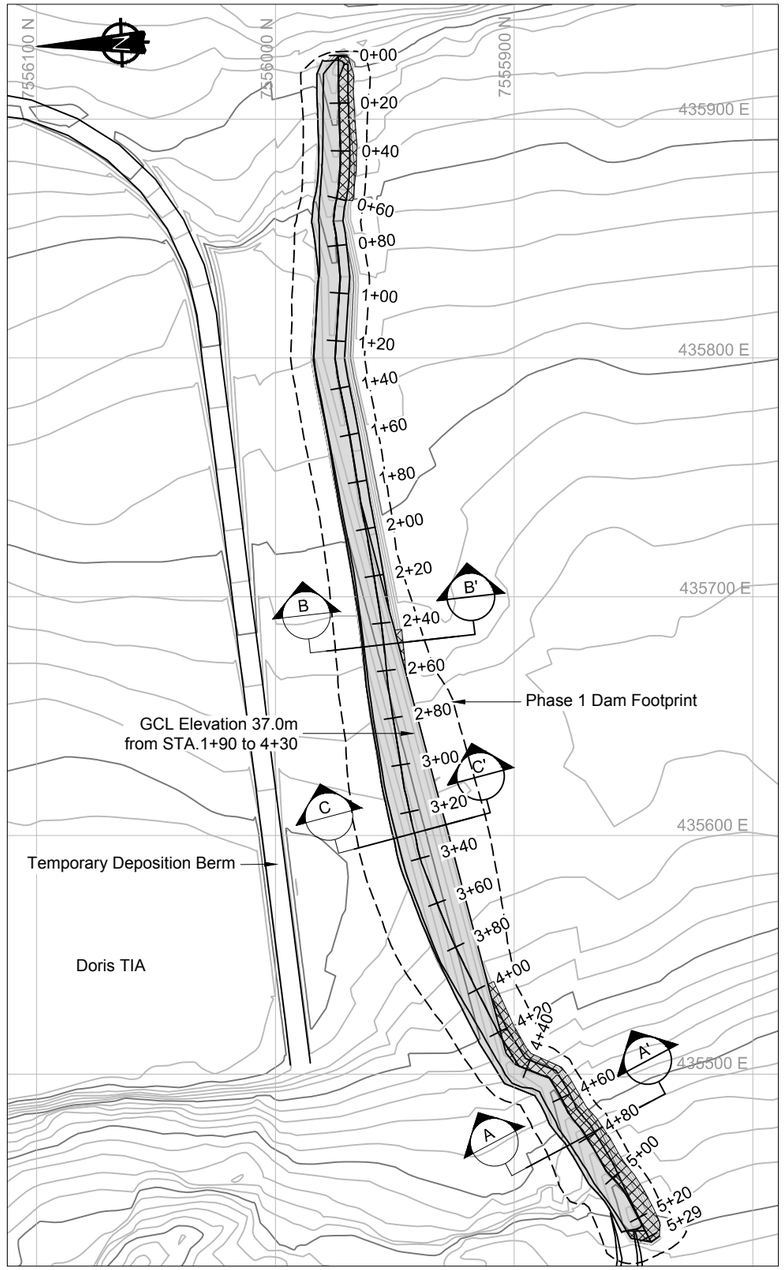


Lower Liner Plan - Placement in Key Trench

0m 20 40 60 80 100



Upper Phase 1 Liner Plan - Above Ground Upstream Slope Placement

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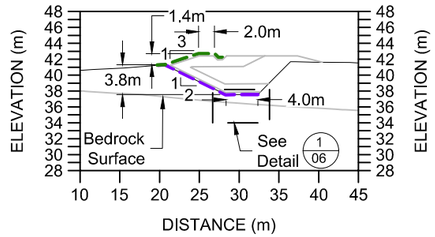

Minimum Cross Section A-A'

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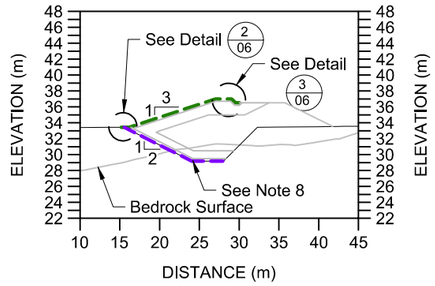

Cross Section B-B' - Bedrock Encountered in Trench

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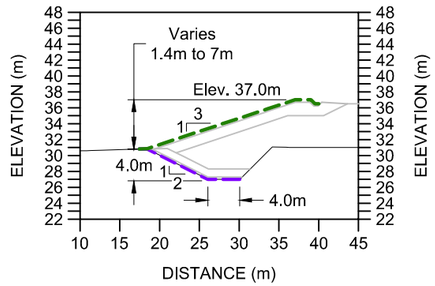

Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

- Key Trench Liner
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent
- GCL Liner Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The upstream slope of the key trench excavation need to be scraped and smoothed to prepare a suitable subbase for the GCL liner as determined by field Engineer. If any voids larger than 0.15m or undulation exist then they will need to be backfilled with compacted bedding material fill, placed in thin 0.15m lifts.
4. The subgrade surface must be free of vegetation, sharp-edged rocks, stones, sticks, construction debris, and other foreign material that could contact the GCL. Furthermore, all protrusions extending more than 12 mm from the subgrade surface shall either be removed, crushed, or pushed into the surface with a smooth-drum compactor.
5. GCL should not be placed over massive ice or standing water (both need to be removed prior to placement).
6. All Geosynthetic Clay Liner (GCL) liner sections / panels will be required to have a minimum 0.5m overlap on every edge. See Detail 2, 3, 5 and 6 on DN-SD-06 for additional information.
7. At the locations where bedrock is encountered in the key trench then these areas will be required to be ripped down to competent bedrock or scrapped smooth and then bentonite powder will be placed between the bedrock contact and the GCL liner (see Detail 1, DN-SD-06).
8. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m in depth), until competent bedrock is encountered, or as directed by Engineer.

REFERENCES

NAD83 UTM Zone 13.

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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							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-06	Liner and Bedding Placement Details	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Liner Placement Plan and Details Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-05	5 OF 30	1

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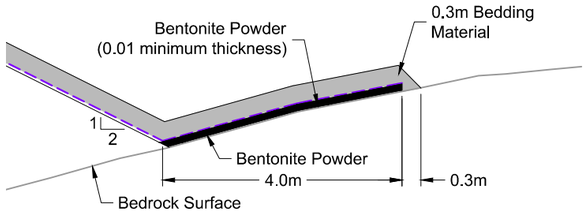
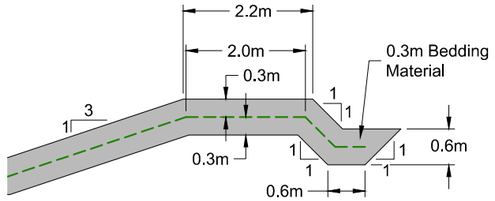
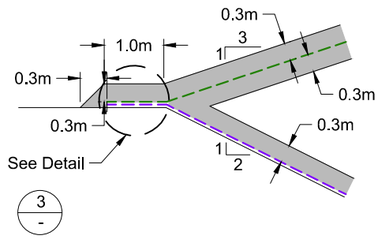
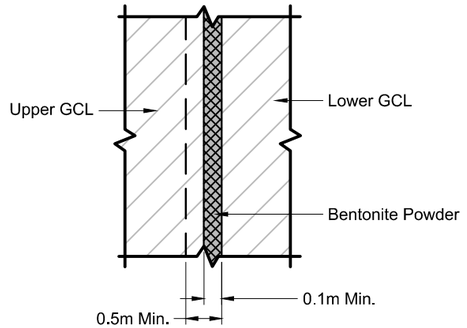


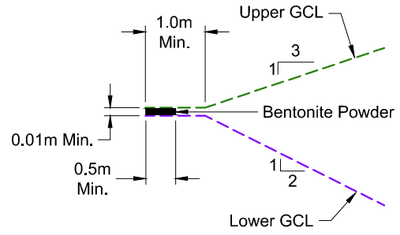
Detail 1 - Liner Attachment at Bedrock



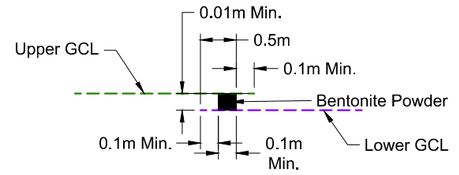


Detail 2 - Liner Overlap - Bedding



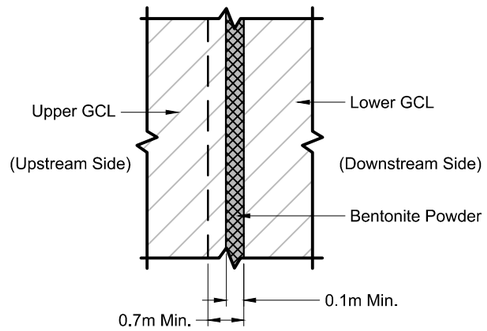


Detail 3 - Typical Upper and Lower GCL Joint



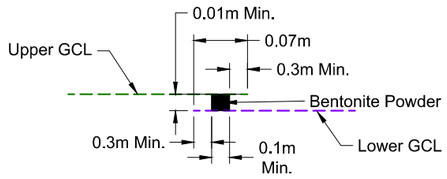
Detail 4 - Liner Anchor Trench Bedding

Detail 5 - Typical Longitudinal GCL Overlap - Plan



Detail 6 - Typical Longitudinal GCL Overlap - Section

Not To Scale



Detail 7 - Typical End of Panel GCL Overlap - Plan

Detail 8 - Typical End of Panel GCL Overlap - Section

Not To Scale

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material

NOTES

1. All units shown are in meters unless otherwise stated.
2. One end of the GCL roll should be anchored at the top of the slope. The front edge of the key trench (see Detail 4) shall be rounded so as to eliminate any sharp corners that could cause excessive stress on the GCL. Loose soil should be removed.
3. The GCL should be placed in the key trench such that it covers the entire key trench floor but does not extend up the rear trench wall (see Detail 4).
4. GCL seams are constructed by overlapping their adjacent edges (see Detail 5). Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris.
5. If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by placing a patch over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 500 mm is achieved around all parts of the damaged area. Bentonite mastic / powder should be applied around the damaged area prior to placement of the patch. It may be necessary to use an adhesive such as wood glue, or by hand placing material over the patch, to fix the patch in place so that it is not moved during overliner bedding material placement. Smaller patches also may be tucked under the damaged area to prevent patch movement.
6. Bedding shall be free of angular stones or other foreign matter which could damage the GCL. Cover soils should be approved by the Engineer, with respect to particle size and uniformity (as per the 'Technical Specifications').
7. Surface for the liner placement must be smooth competent 'virgin' ground with no loose or fractured material.

REFERENCES

NAD83 UTM Zone 13.

DRAWING NO.	DRAWING TITLE
-	-

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Liner and Bedding Placement Details

DRAWING NO.	SHEET	REVISION NO.
DN-SD-06	6 OF 30	1

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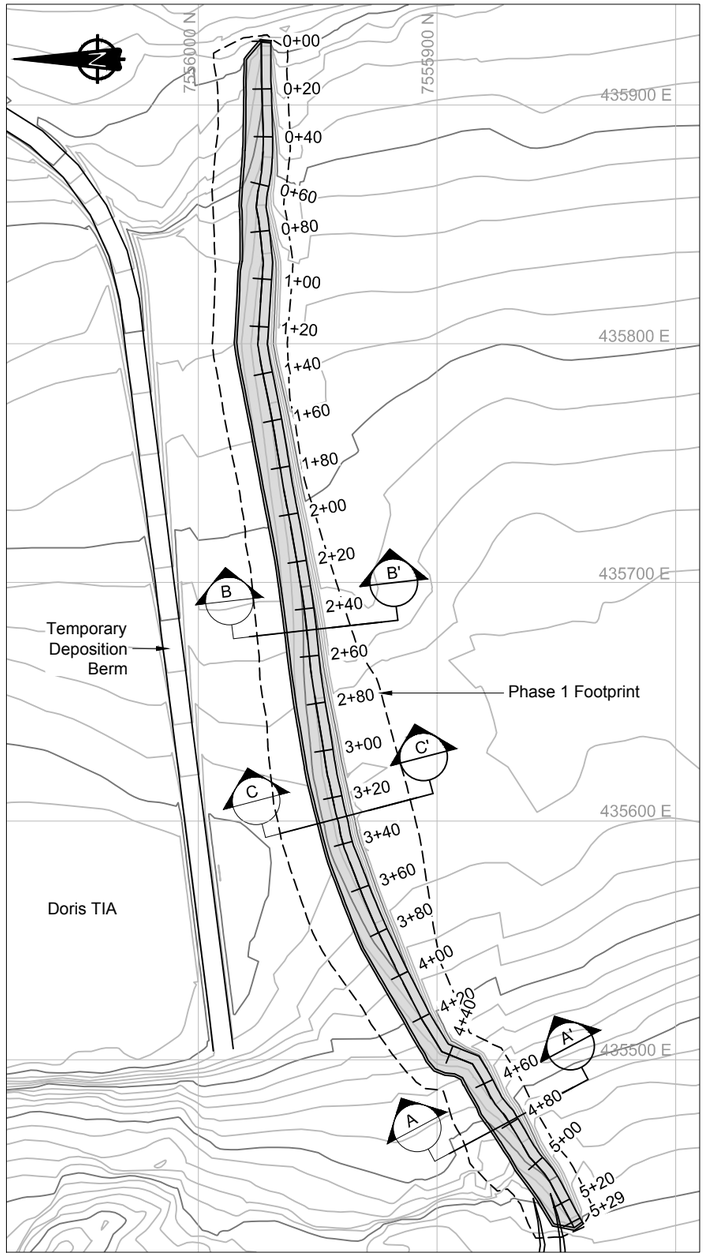

Key Trench Bedding Placement Plan View

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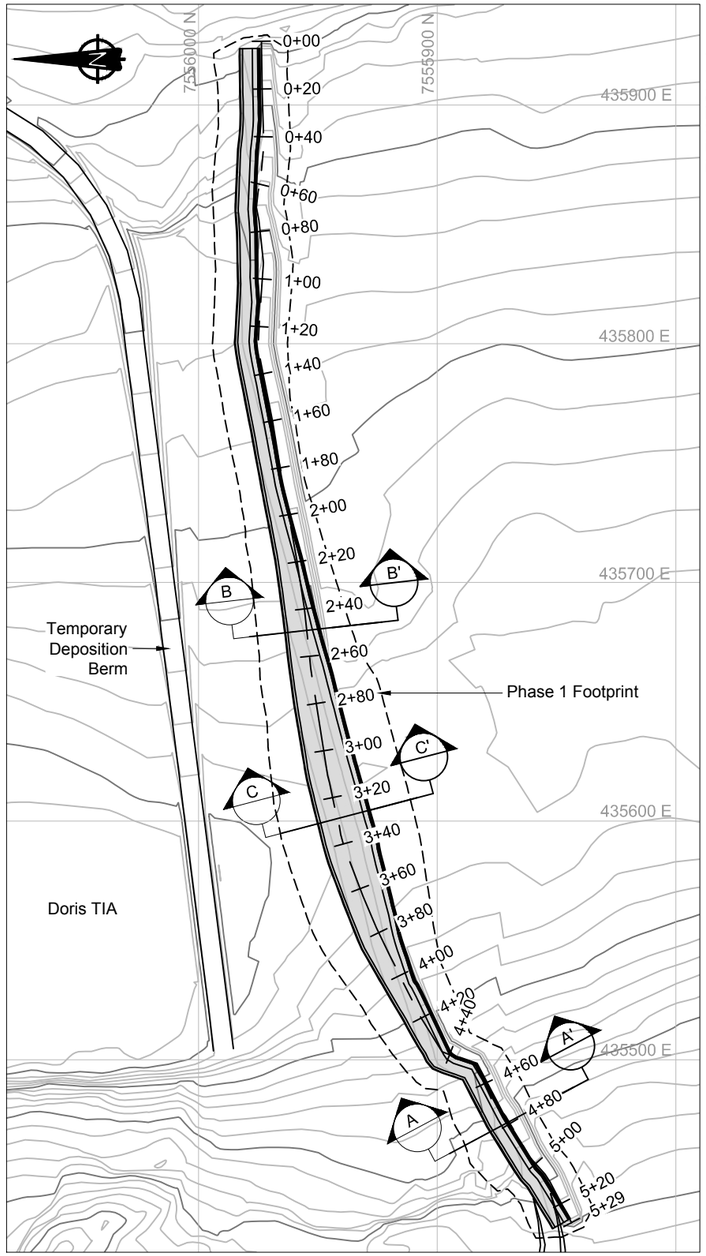

Phase 1 Dam Bedding Placement Plan View

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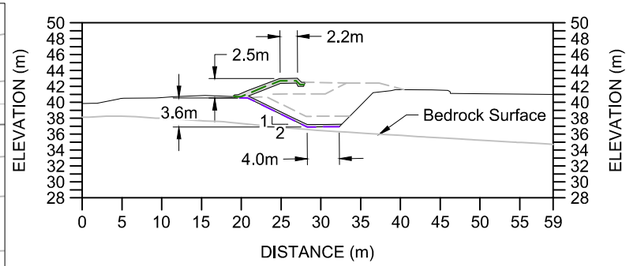

Minimum Cross Section A-A'

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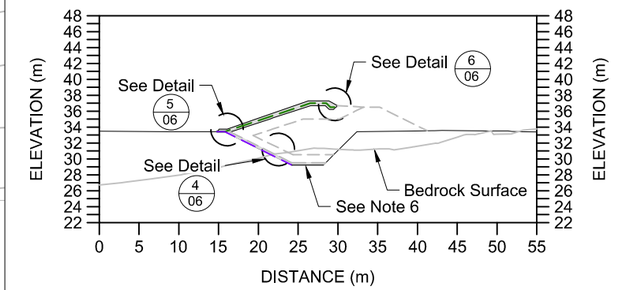

Cross Section B-B' - Bedrock Encountered in Trench

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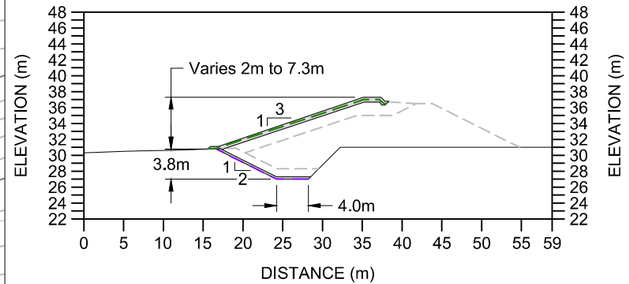

Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

- Phase 1 Dam Liner
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Bedding Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Bedding layer to be placed in 0.15m lifts and compacted before liner placement. The subsurface below the liner should be free of protrusions or any sharp / angular cobbles or larger size material. See the Technical Specifications document for more details (*'Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK).*
4. Bedding material cover shall be placed over the GCL using construction equipment that minimizes stresses on the GCL. Unless otherwise approved / directed by the Engineer a minimum thickness of 600mm or greater is required to be placed over any areas where heavy equipment will be trafficking over the liner. Thickness requirement are related to equipment type. For light equipment (which will have to be directly approved by the Engineer), as an absolute minimum a thickness of 300mm of cover must be maintained between light tracked equipment (e.g. skid-steer or 30 excavator) tracks/tires, and the GCL at all times during the covering process.
5. Soil cover should be placed in a manner that prevents the soil from entering/disturbing the GCL overlap zones.
6. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

REFERENCES

NAD83 UTM Zone 13.

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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							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-06	Liner and Bedding Placement Details	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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CHECKED:	APPROVED:	DATE:
JKB	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Bedding.dwg

TMAC RESOURCES

Hope Bay Project

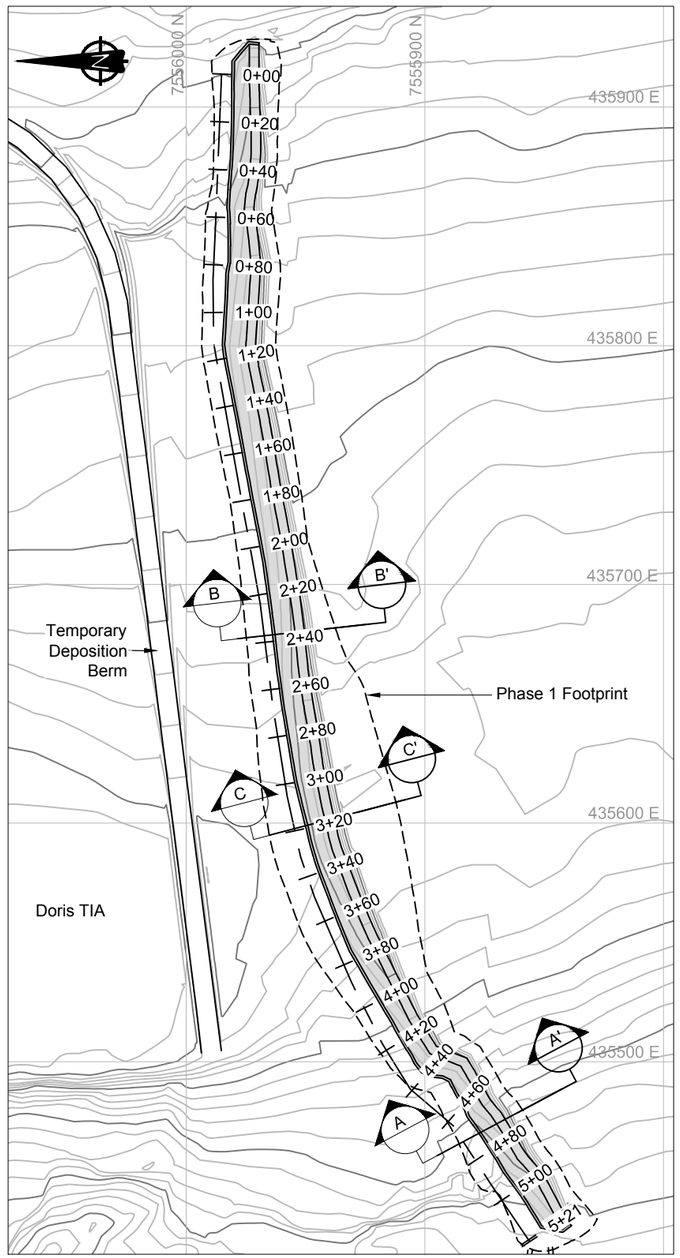
SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Bedding Material Placement Plan and Sections - Key Trench and Phase 1

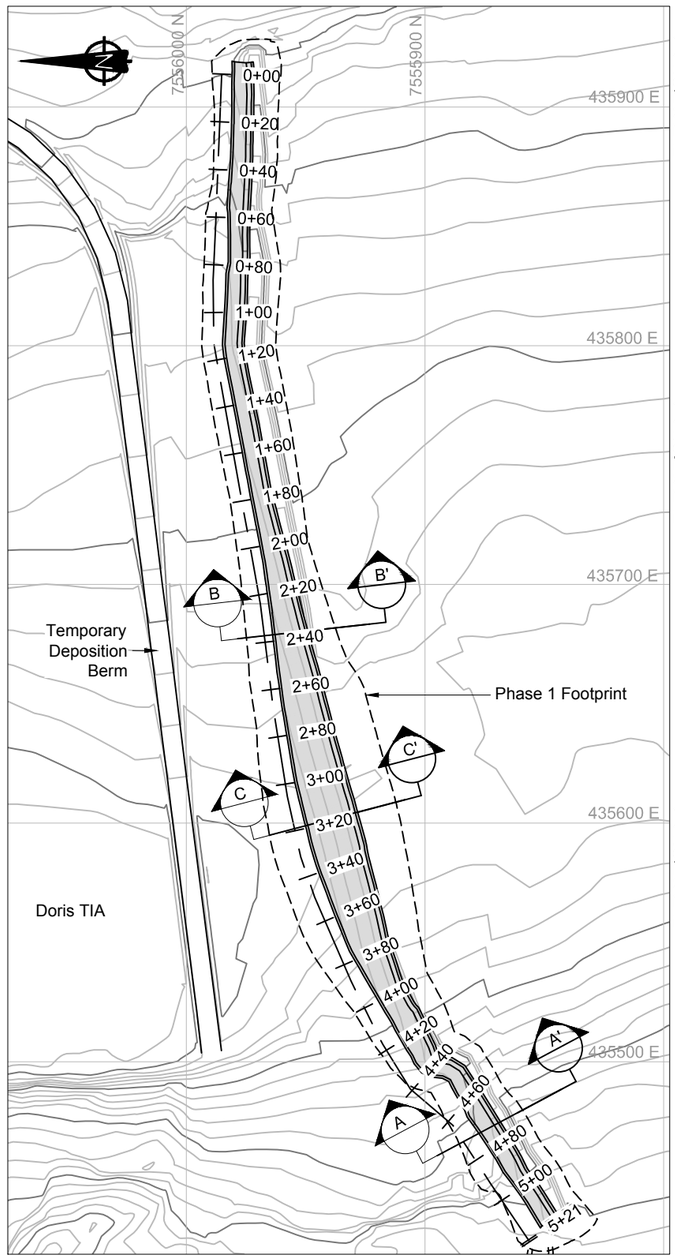
DRAWING NO.	SHEET	REVISION NO.
DN-SD-07	7 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1\1CT0022.017 - South Dam - Bedding.dwg



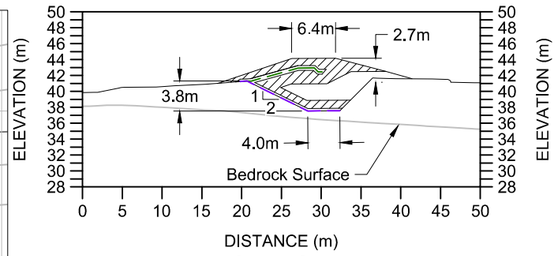
Key Trench Bedding Placement Plan View

0m 20 40 60 80 100



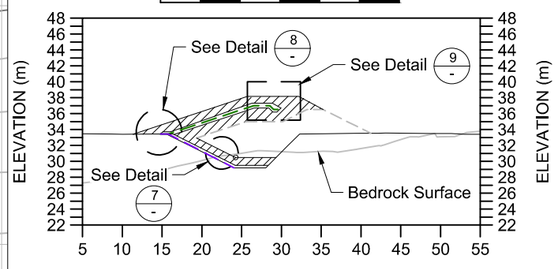
Phase 1 Dam Bedding Placement Plan View

0m 20 40 60 80 100



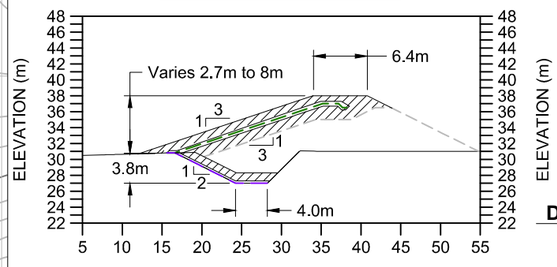
Minimum Cross Section A-A'

0m 5 10 15 20 25 30



Cross Section B-B' - Bedrock Encountered in Trench

0m 5 10 15 20 25 30



Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

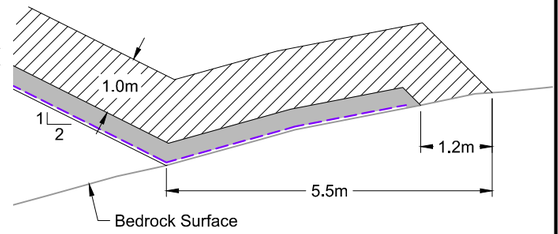
- Phase 1 Dam Liner
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Bedding Material
- Transition Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.

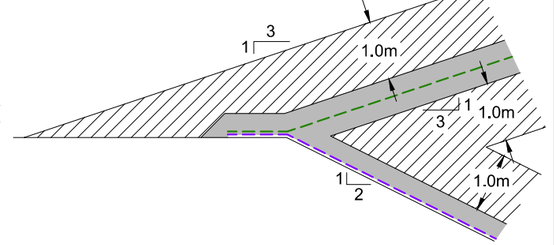
REFERENCES

NAD83 UTM Zone 13.



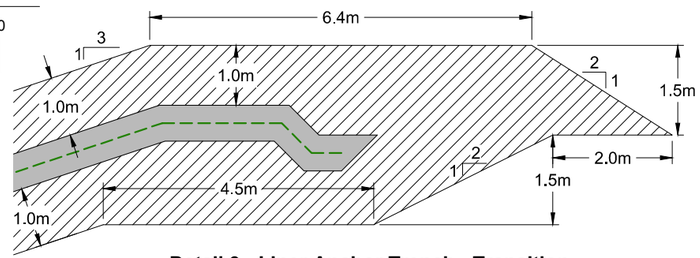
Detail 7 - Key Trench Bedrock Interface - Transition

0m 1 2 3 4



Detail 8 - Upper and Lower GCL Liner Overlap - Transition

0m 1 2 3 4



Detail 9 - Liner Anchor Trench - Transition

0m 1 2 3 4

-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
		-	-				0	Issued for Construction	JBK	EMR	17/11/29
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
REFERENCE DRAWINGS		REVISIONS									

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Transition.dwg

TMAC RESOURCES

Hope Bay Project

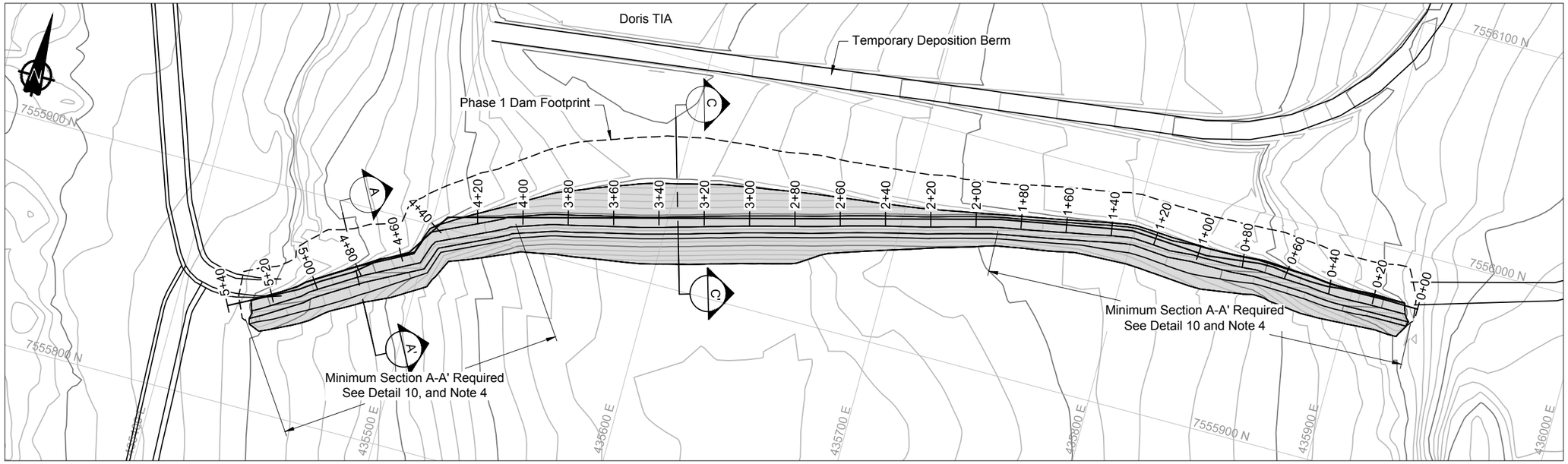
SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Transition Material Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-08	7 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1\1CT0022.017 - South Dam - Transition.dwg



Run of Quarry Placement Plan View

0m 20 40 60 80

LEGEND

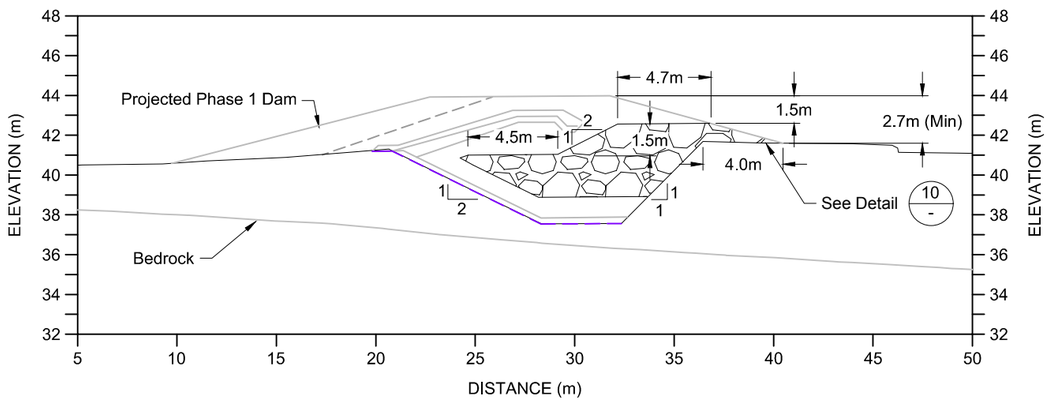
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Run of Quarry Backfill Extent
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profiles shown correspond to the upstream toe of the key trench.
4. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench. See Detail 10 on drawing DN-SD-09 for additional details.
5. The outside downstream ROQ should be sloped at 2H:1V or shallower.

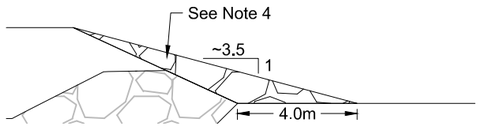
REFERENCES

NAD83 UTM Zone 13.



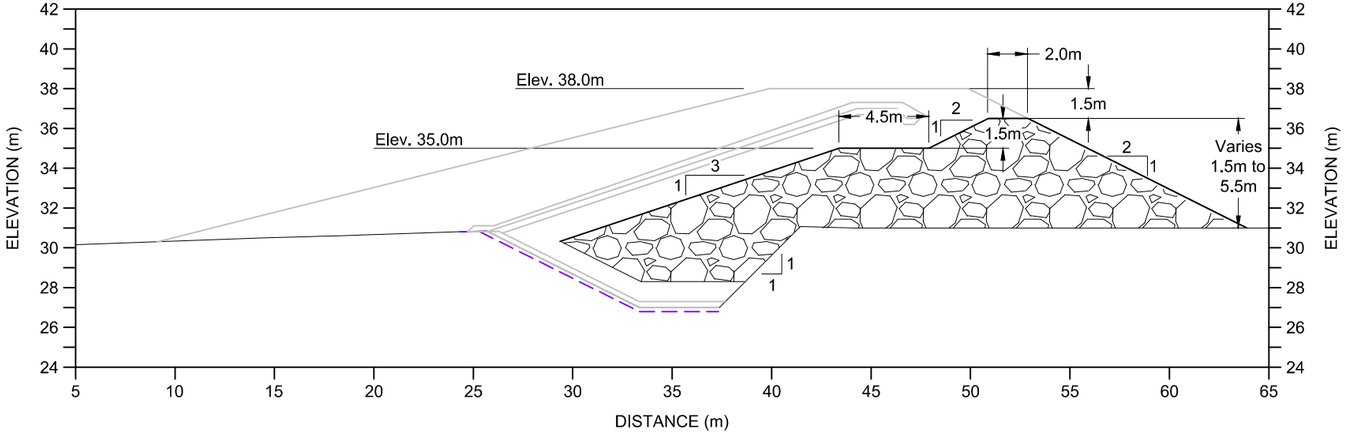
Minimum Cross Section A-A'

0m 3 6 9 12



Detail 10 - Contingency ROQ Thermal Barrier Design

0m 2 4 6 8



Typical Cross Section C-C'

0m 3 6 9 12

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1					
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ.dwg

MAC RESOURCES

Hope Bay Project

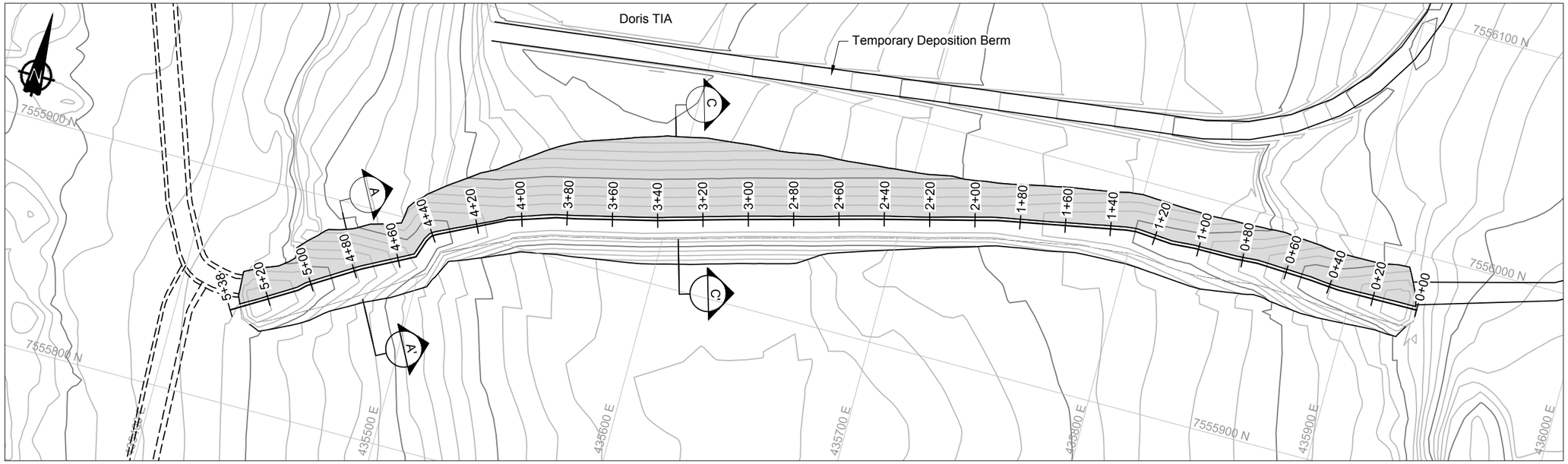
SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

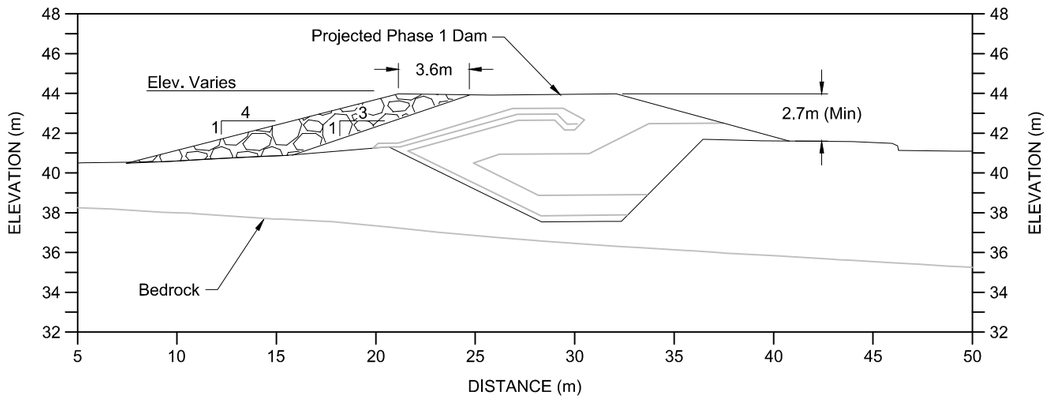
DRAWING NO.	SHEET	REVISION NO.
DN-SD-09	9 OF 30	1

P:\01_SITES\Hope Bay\ACAD\FC\South Dam - Phase 1 r1\1CT0022.017 - South Dam - Phase 1 ROQ.dwg



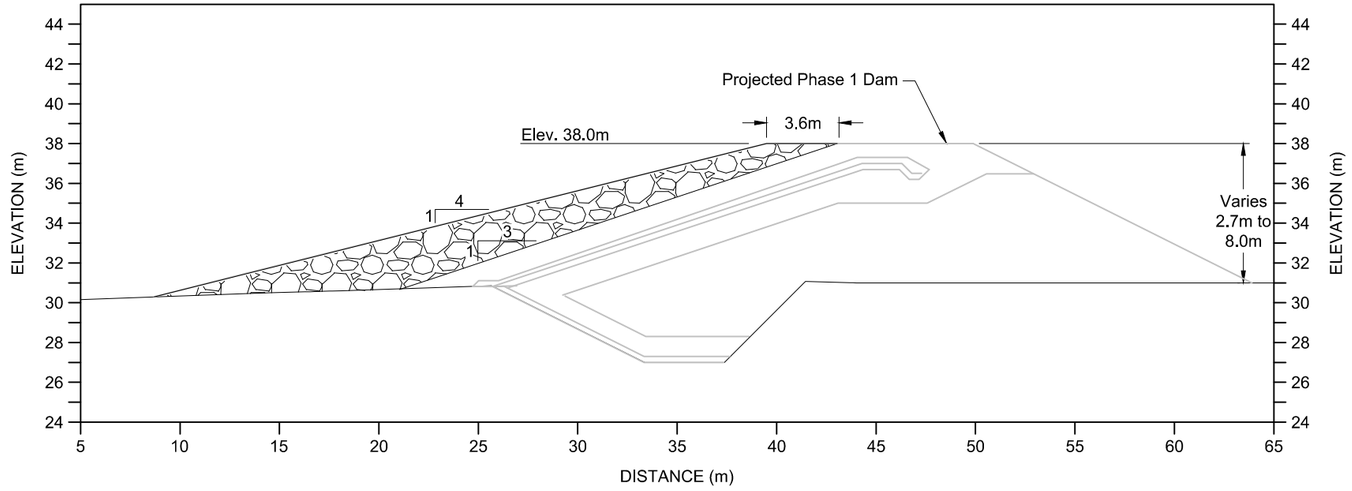
Run of Quarry Placement Plan View

0m 20 40 60 80



Minimum Cross Section A-A'

0m 3 6 9 12



Typical Cross Section C-C'

0m 3 6 9 12

LEGEND

- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Run of Quarry Backfill Extent
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The outside upstream dam ROQ should be sloped at 4H:1V or shallower.

REFERENCES

NAD83 UTM Zone 13.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ-us.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-10	10 OF 30	1

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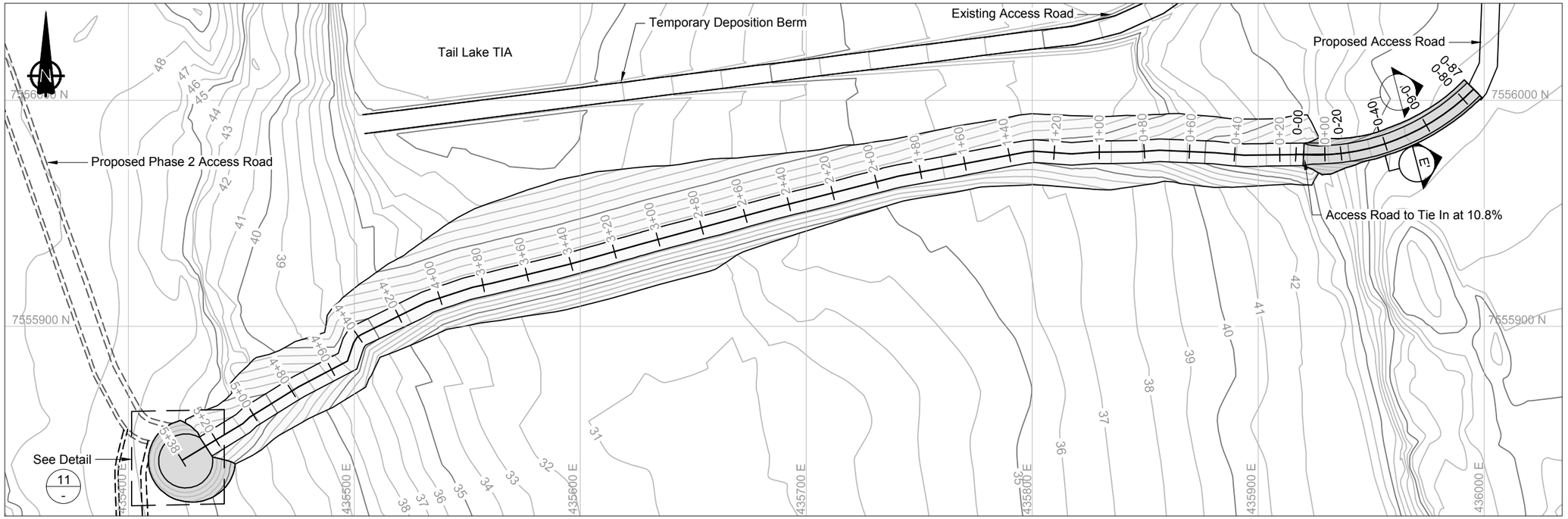


LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Access Road
- Run of Quarry
- Surfacing Material

NOTES

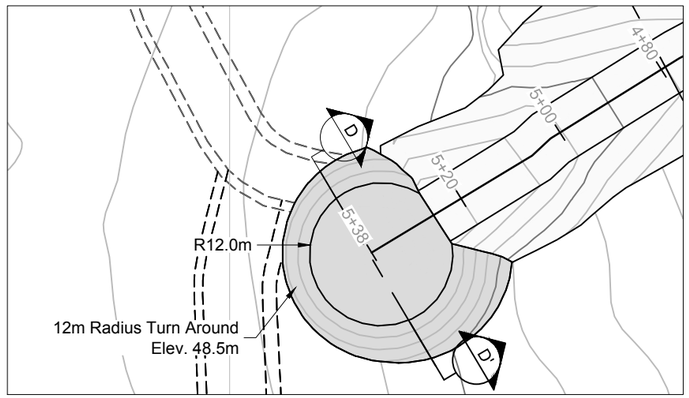
1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Approximately 3,300m³ of surfacing / bedding material is estimated (to neat lines) to be needed for the Access Road and Turn Around.
4. Minimum fill thickness for Access Road and Turn Around is 1.0m

REFERENCES

NAD83 UTM Zone 13.

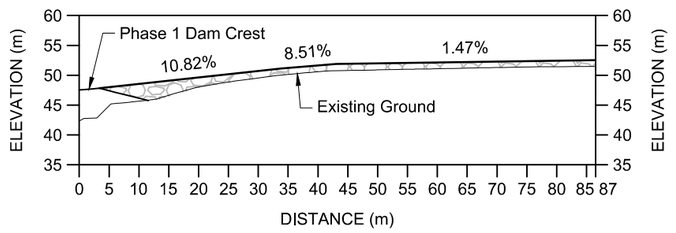
East Access Road and West Turn Around

0m 20 40 60 80



Detail 11 - Turn Around

0m 10 20 30 40

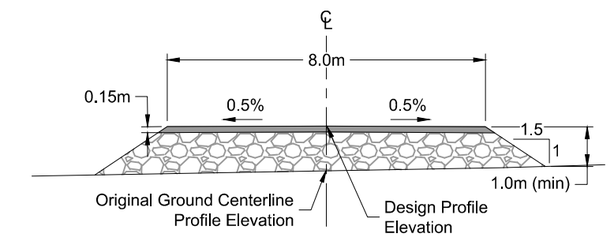


East Access Road Profile

0m 10 20 30 40

Section D-D' - Turn Around

0m 4 8 12 16



Section E-E' - Typical Road Section

0m 1 2 3 4 5 6

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-03	Typical Sections (General)					
DN-SD-02	Phase 1 General Arrangement	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam AR.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Construction Access Road and Turnaround - Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-11	11 OF 26	1

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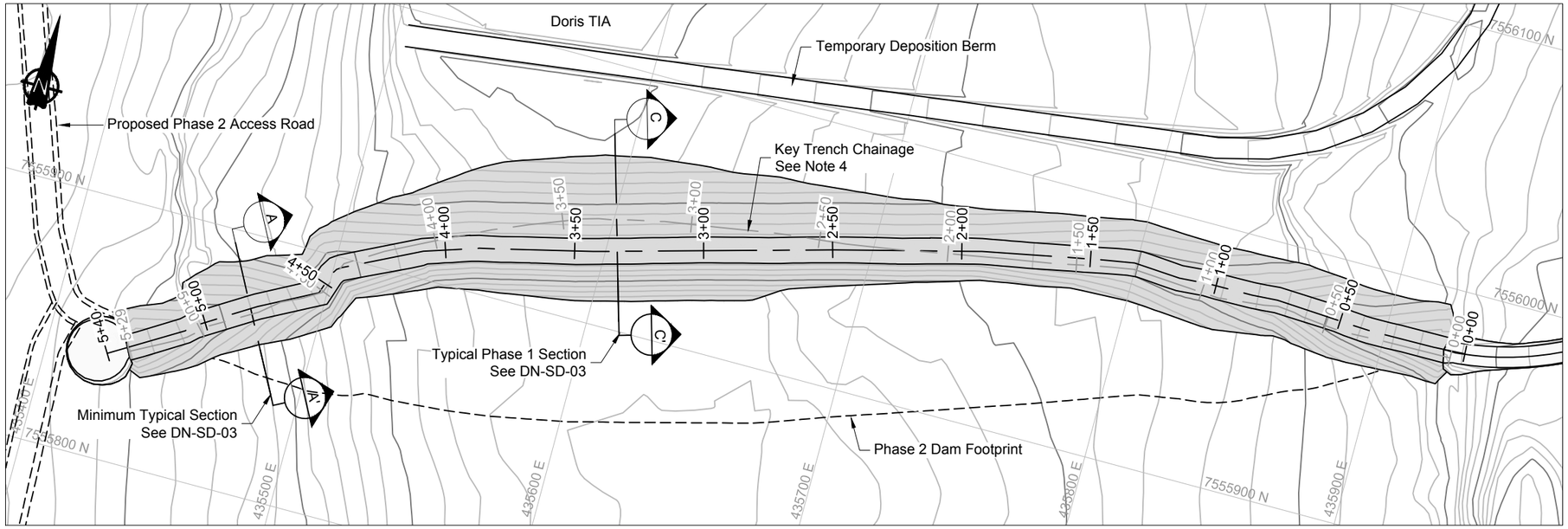
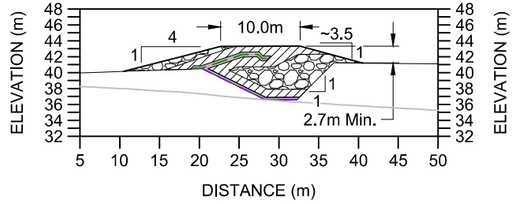


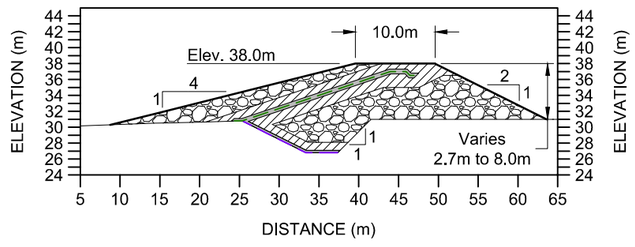
Phase 1 Dam Plan View

0m 20 40 60 80



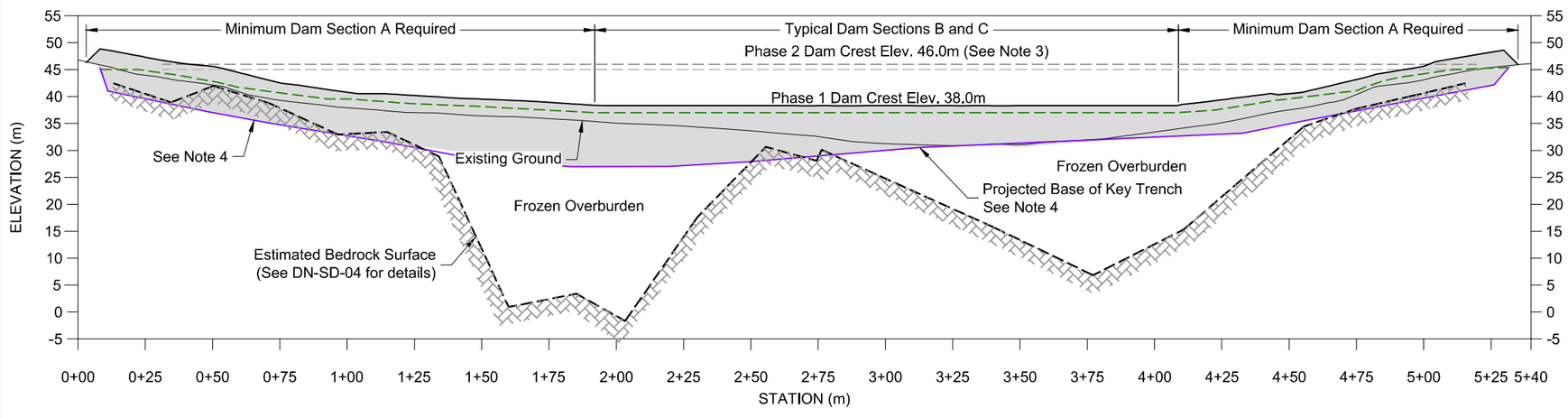
Minimum Cross Section A-A'

0m 5 10 15 20 25 30



Cross Section C-C'

0m 5 10 15 20 25 30



Phase 1 Dam Profile View - Through Crest Centerline

Horizontal: 0m 10 20 30 40

Vertical: 0m 20 40 60 80

LEGEND

- Key Trench Excavation
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The Phase 2 dam elevations are shown for information purposes only. Note that only Phase 1 dam designs and elevations are issued for construction use.
4. Base of key trench on this profile is based on a section down the centerline of the dam crest. Note that the key trench centerline and the dam crest centerline do not share the exact same alignment and overall the chainages vary in any given location (between the key trench and dam crest shown in these drawings) in the range of ±5m.

REFERENCES

NAD83 UTM Zone 13.

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
DN-SD-04	Key Trench Excavation Plan and Profile
DN-SD-03	Typical Sections (General)
DN-SD-02	Phase 1 General Arrangement

REVISIONS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Phase 1 Dam.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Final Phase 1 Dam Plan, Profile and Sections

DRAWING NO.	SHEET	REVISION NO.
DN-SD-12	12 OF 30	1

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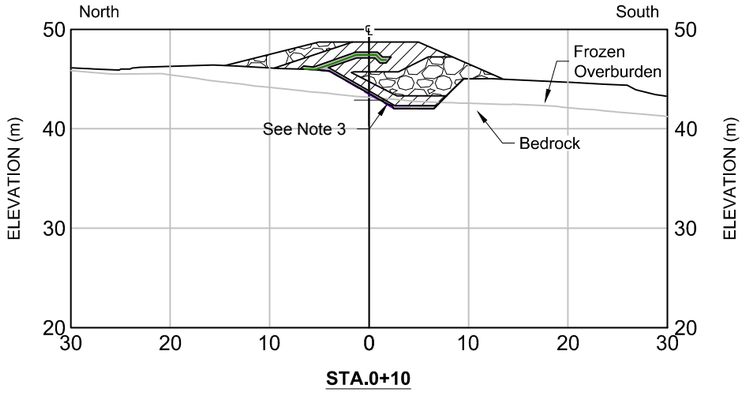

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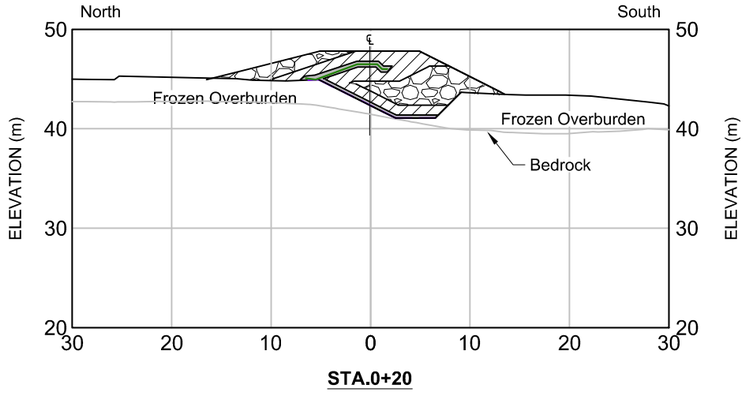

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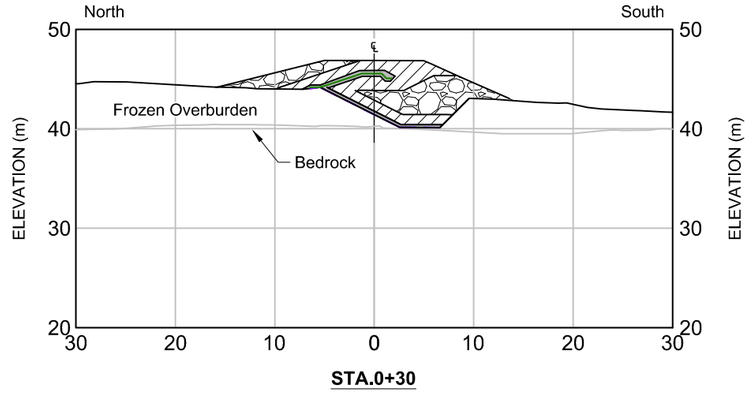

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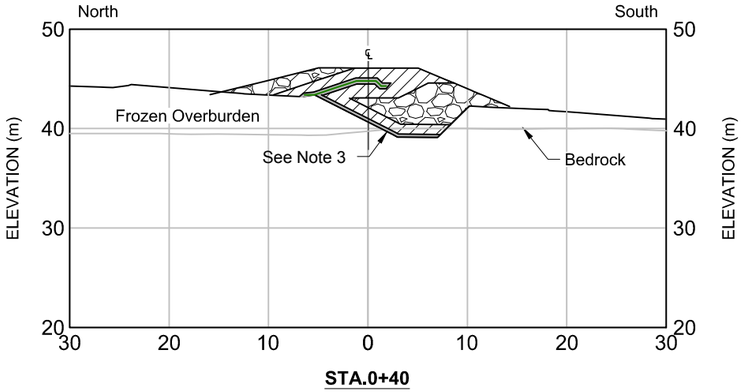

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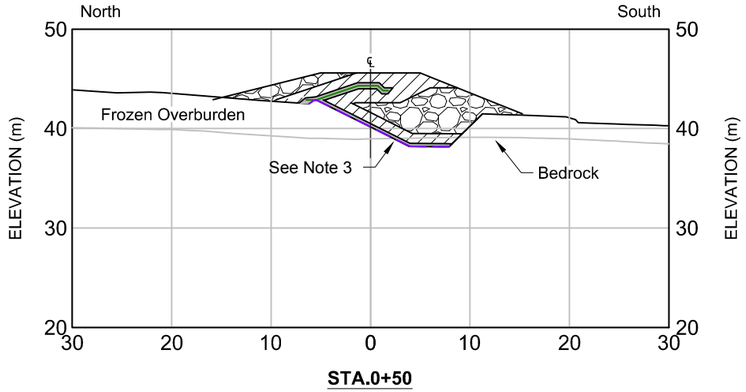

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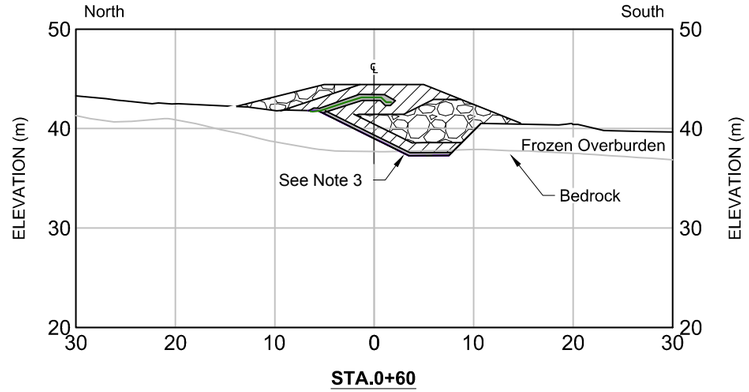

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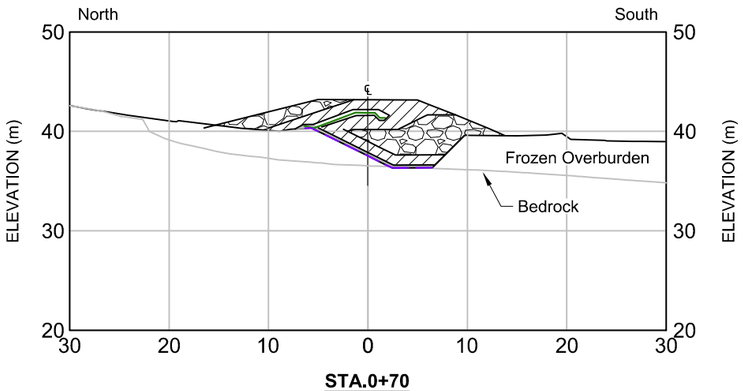

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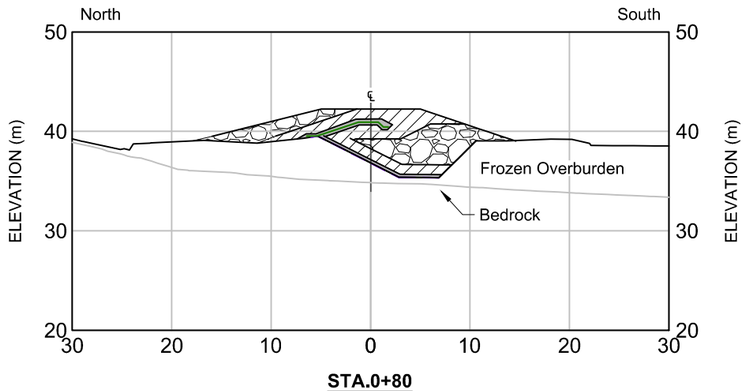

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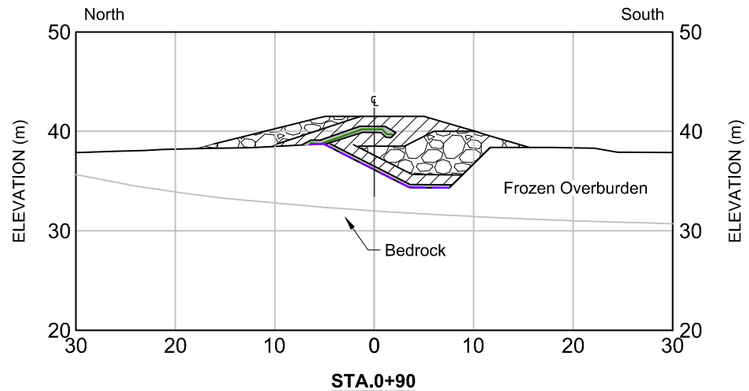

STA.0+90

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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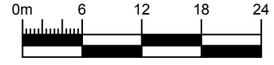

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

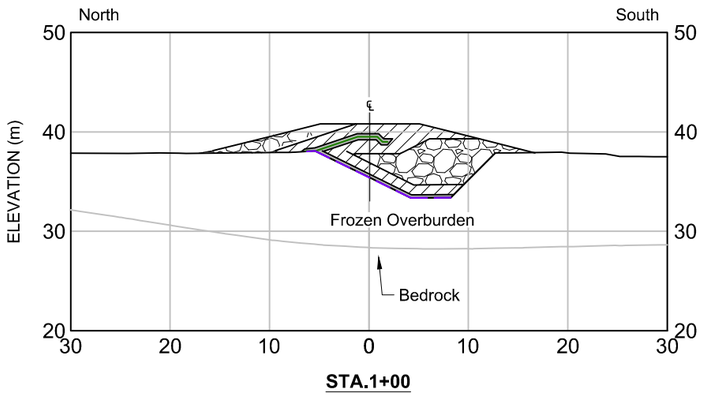
SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.0+10 to 0+90 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-13	13 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1\1CT0022.017 - South Dam - Sections.dwg



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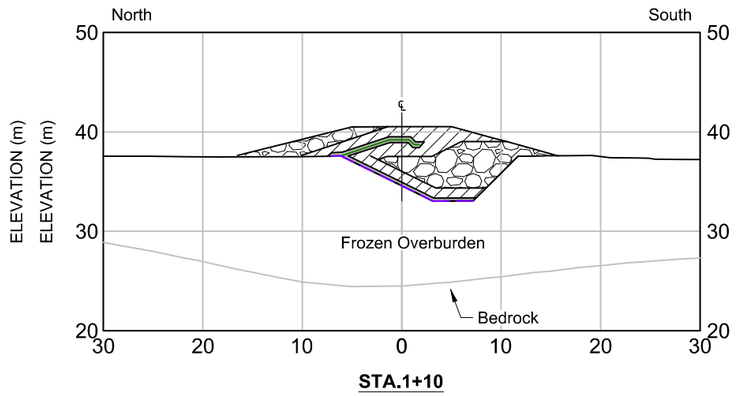
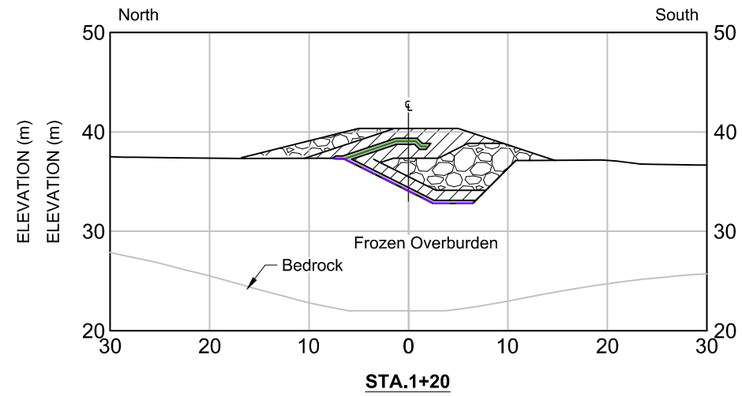
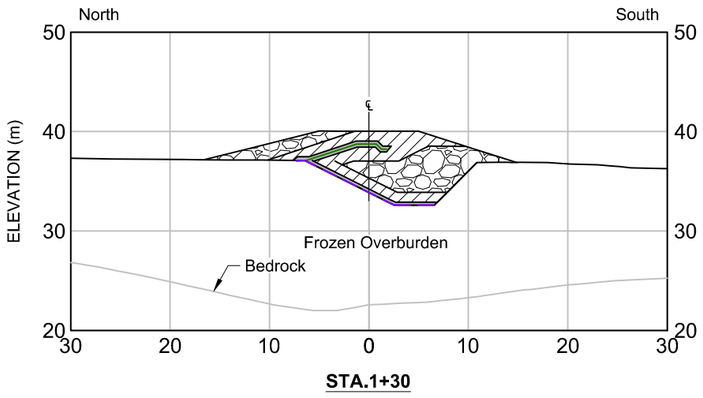


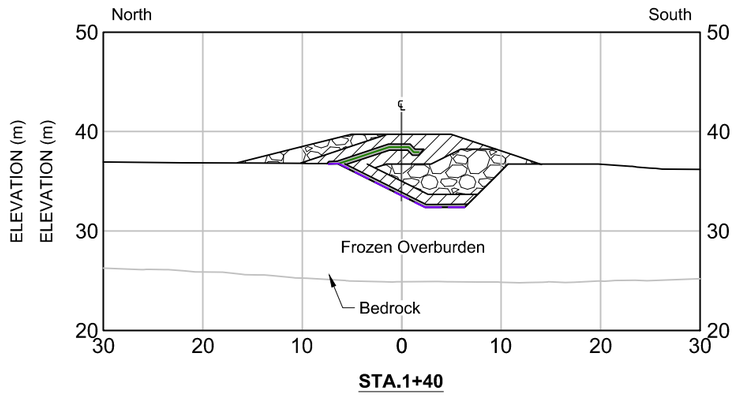
STA.1+10



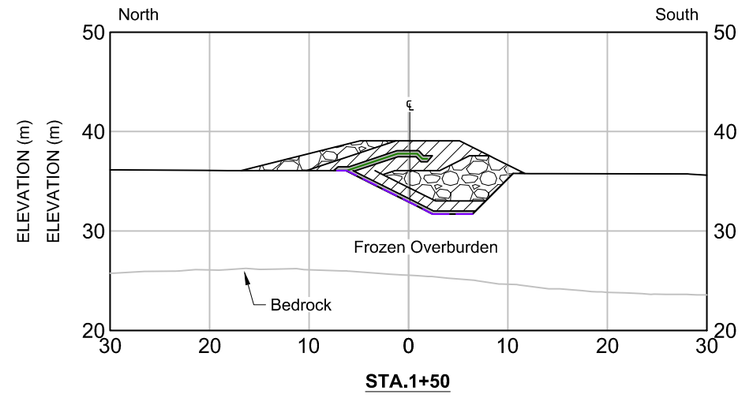
STA.1+20



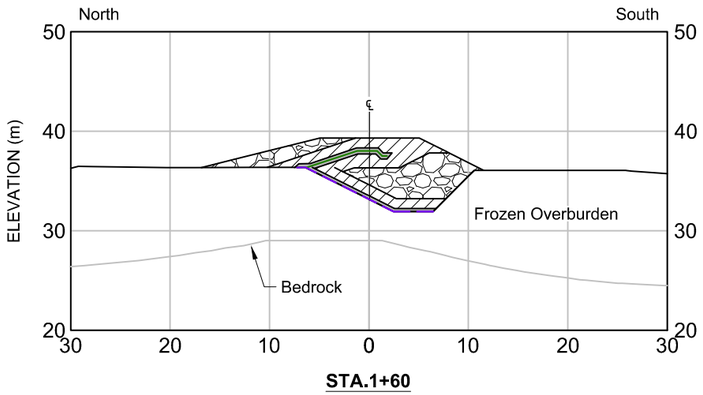
STA.1+30



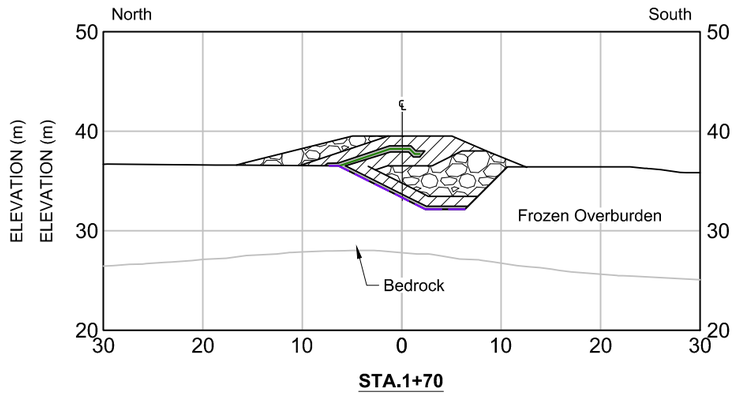
STA.1+40



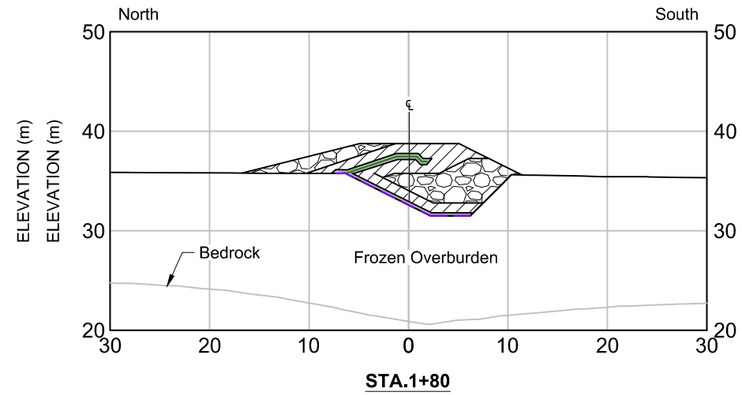
STA.1+50



STA.1+60



STA.1+70



STA.1+80

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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0m 6 12 18 24

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-02	Phase 1 General Arrangement	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

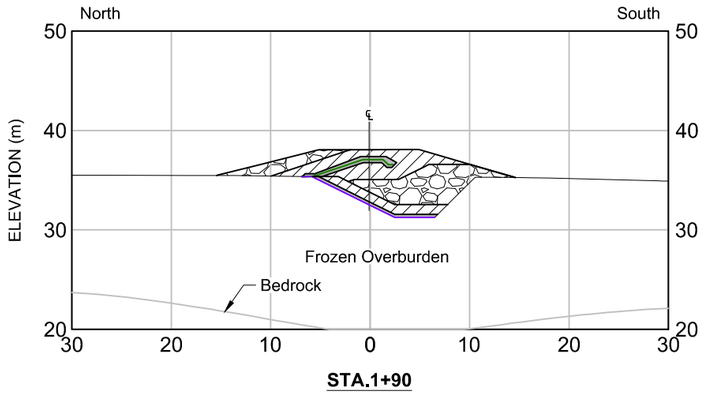
SRK JOB NO.: 1CT022.017

South Dam

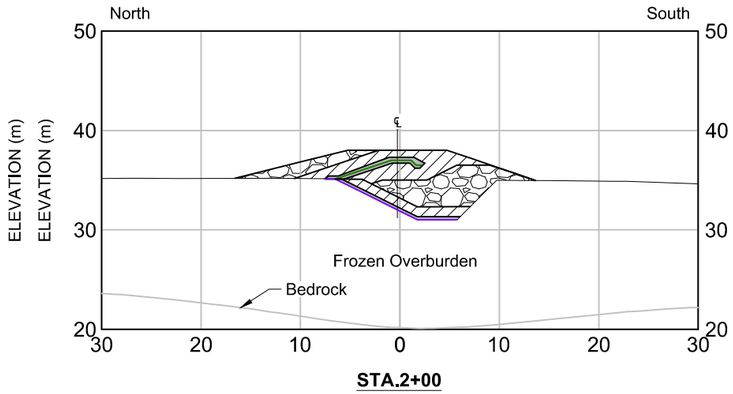
DRAWING TITLE: Sections Sta.1+00 to 1+80 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-14	14 OF 30	1

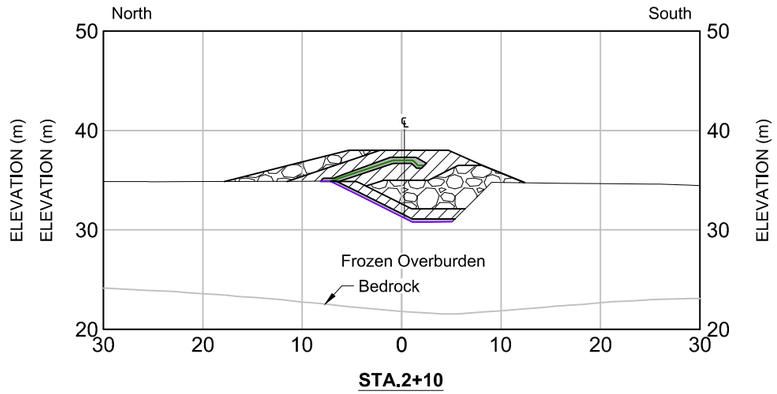
P:\01_SITES\Hope Bay\ACAD\DFC\South Dam - Phase 1 r1\1CT0022.017 - South Dam - Sections.dwg



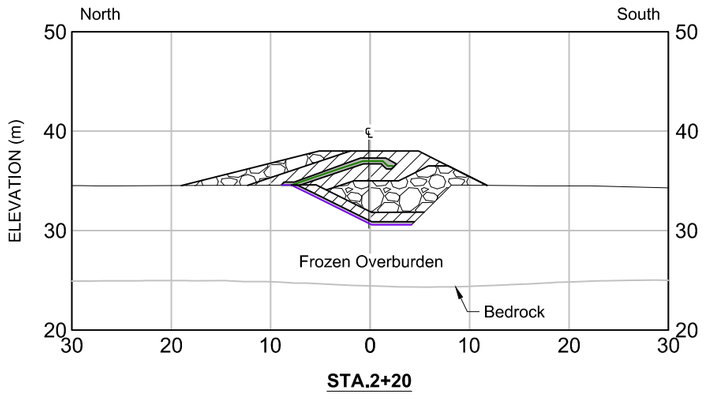
STA.1+90



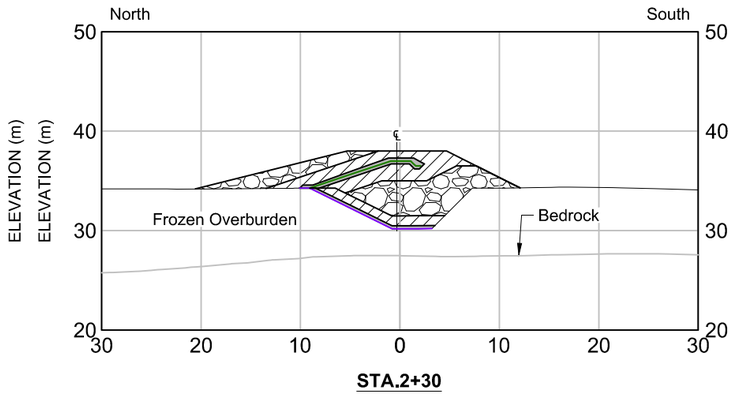
STA.2+00



STA.2+10



STA.2+20



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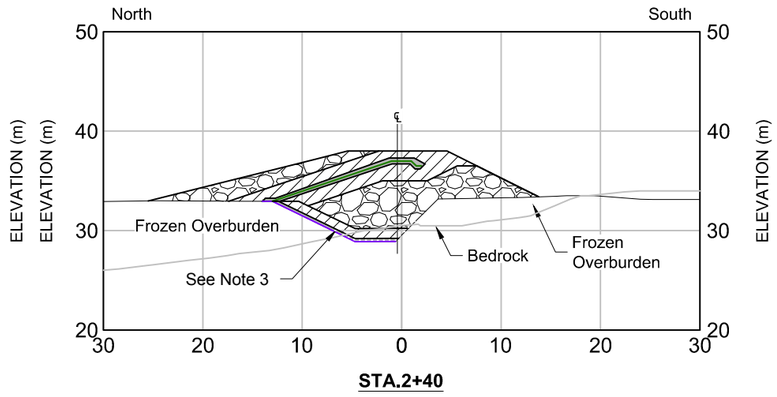

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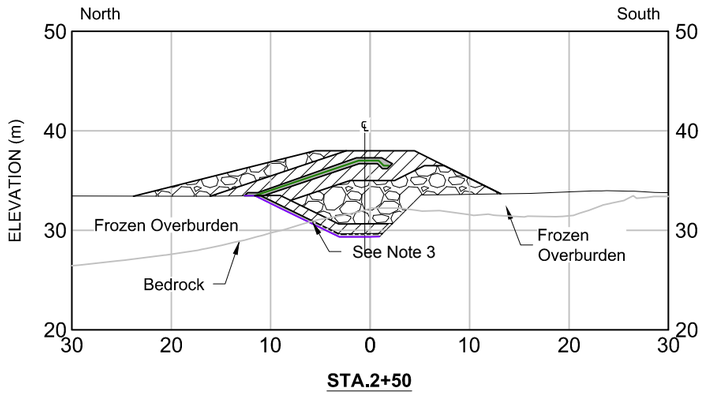
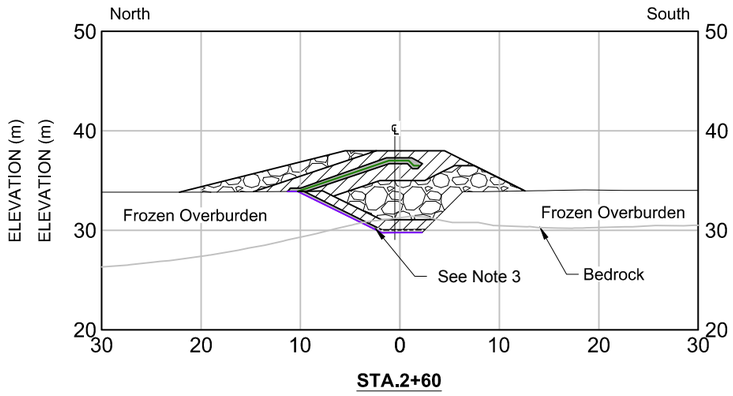
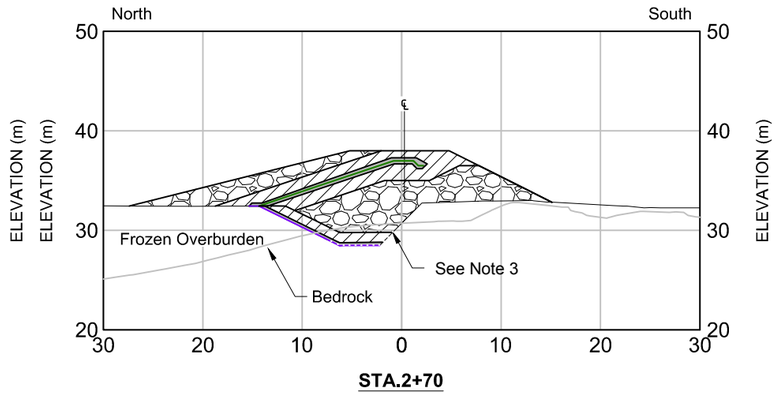


STA.2+50



STA.2+60



STA.2+70

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.1+90 to 2+70 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-15	15 OF 30	1

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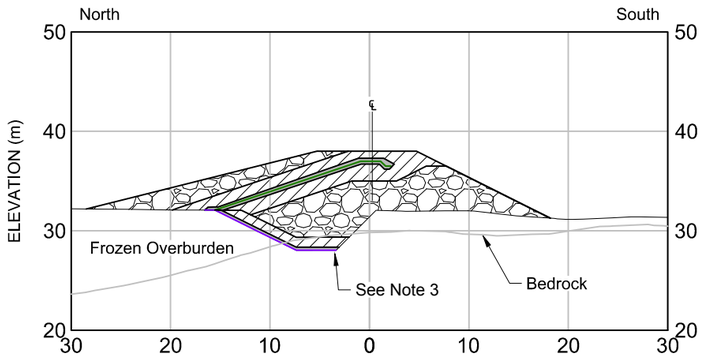
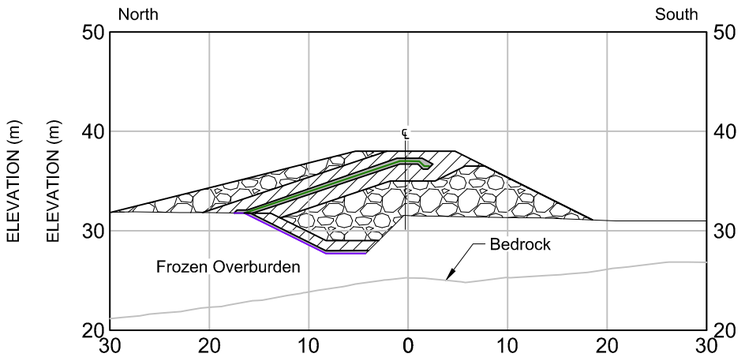
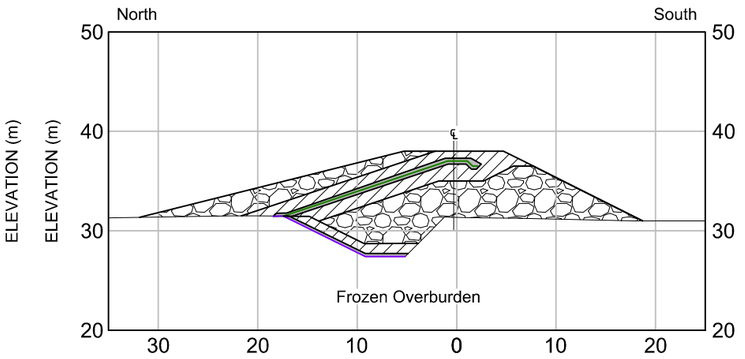


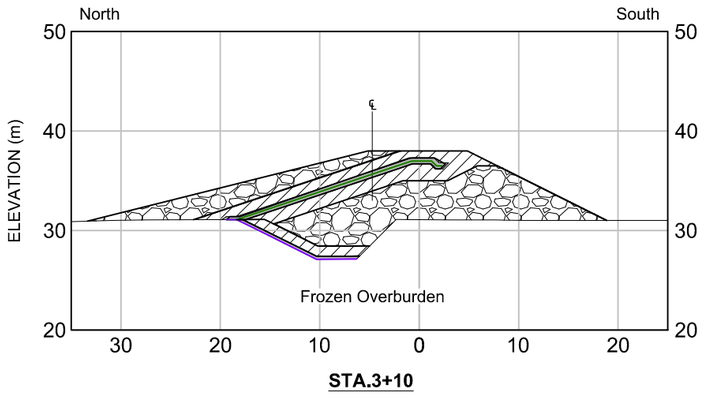
STA.2+80



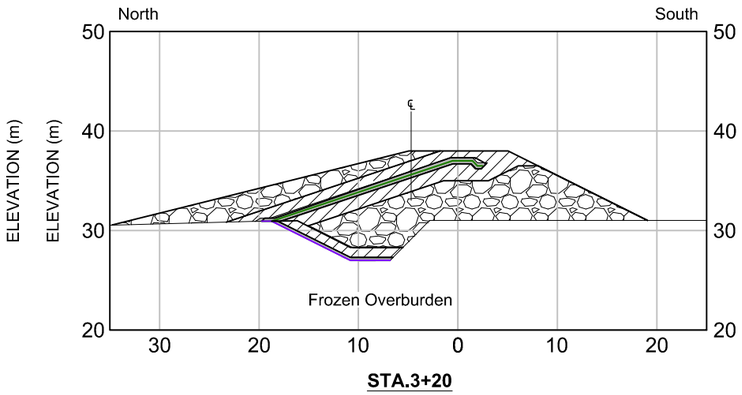
STA.2+90



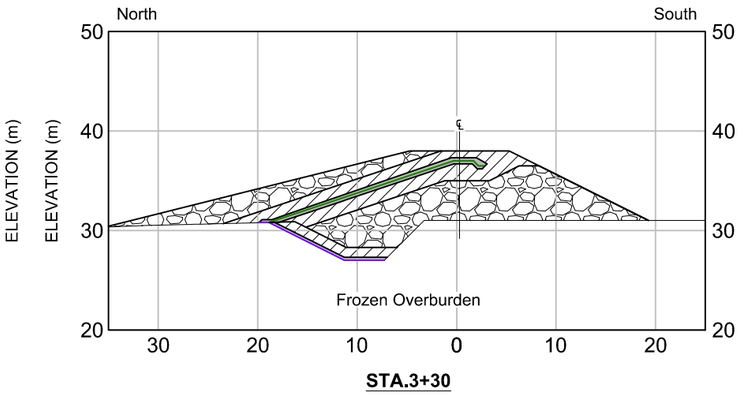
STA.3+00



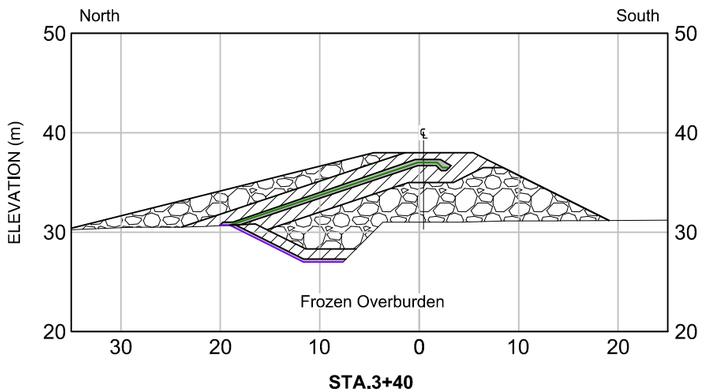
STA.3+10



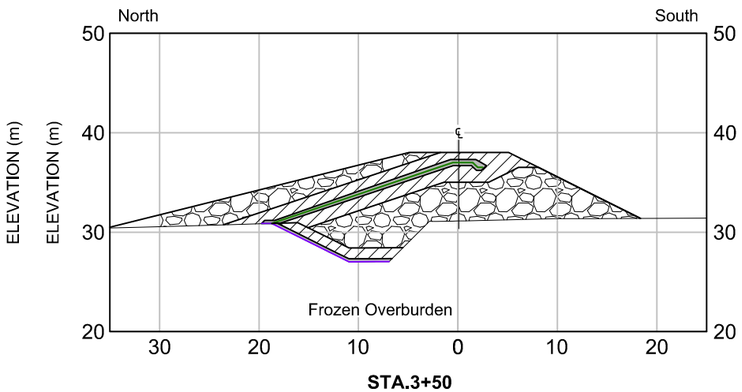
STA.3+20



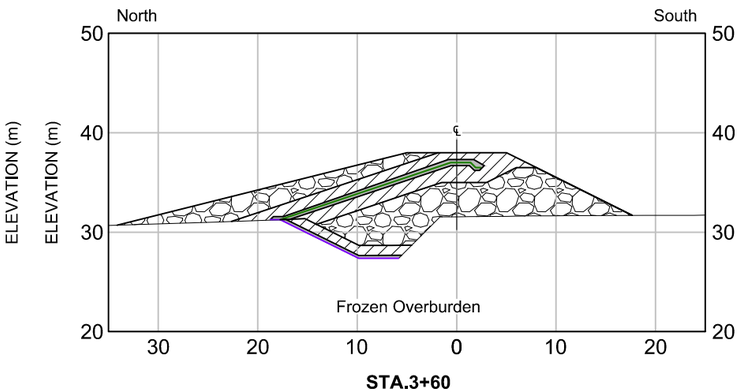
STA.3+30



STA.3+40



STA.3+50



STA.3+60

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

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DESIGN:	DRAWN:	REVIEWED:
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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

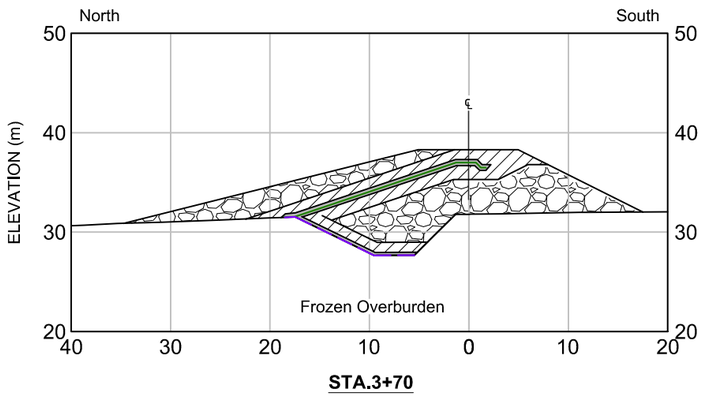
SRK JOB NO.: 1CT022.017

South Dam

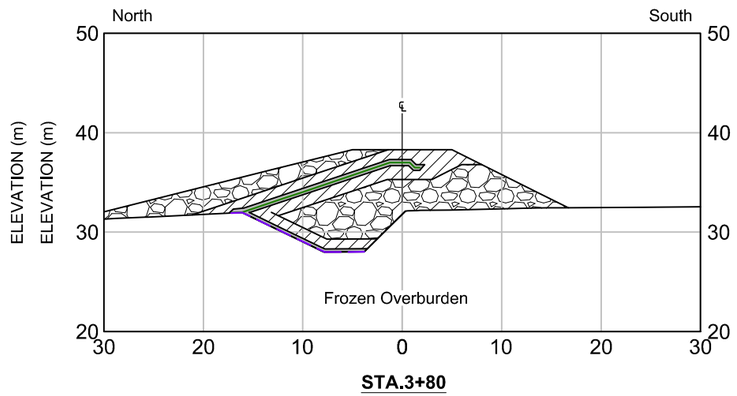
DRAWING TITLE: Sections Sta.2+80 to 3+60 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-16	16 OF 30	1

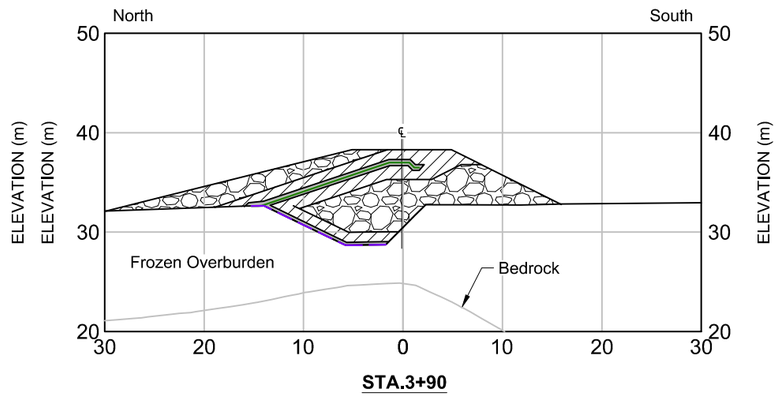
P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1-internal\1CT0022.017 - South Dam - Sections.dwg



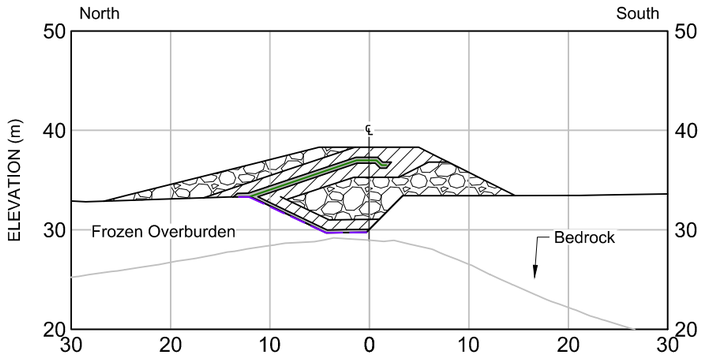
STA.3+70



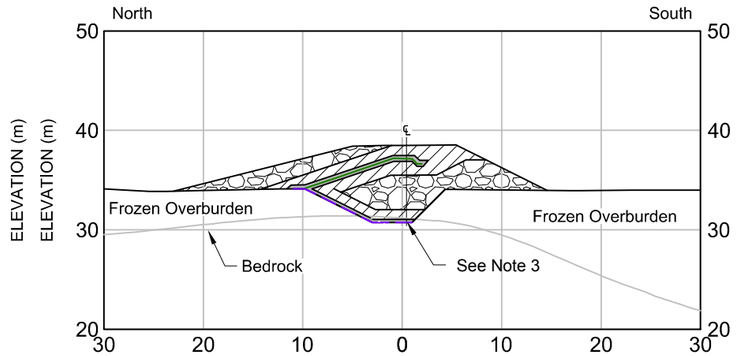
STA.3+80



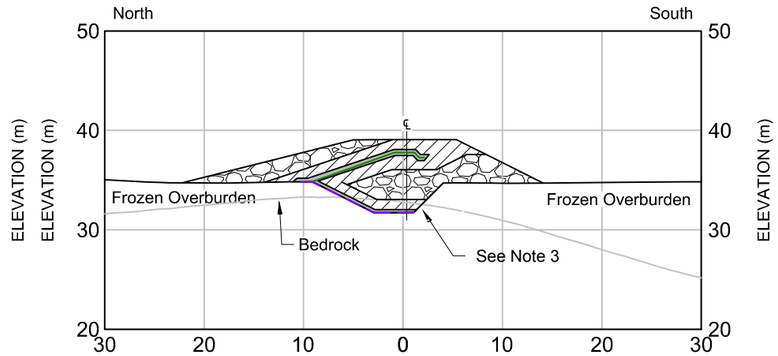
STA.3+90



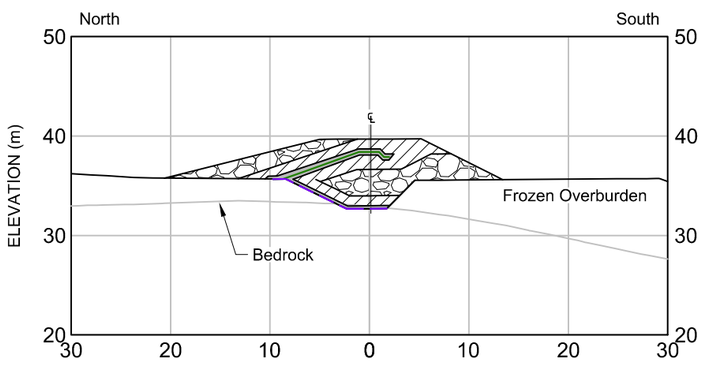
STA.4+00



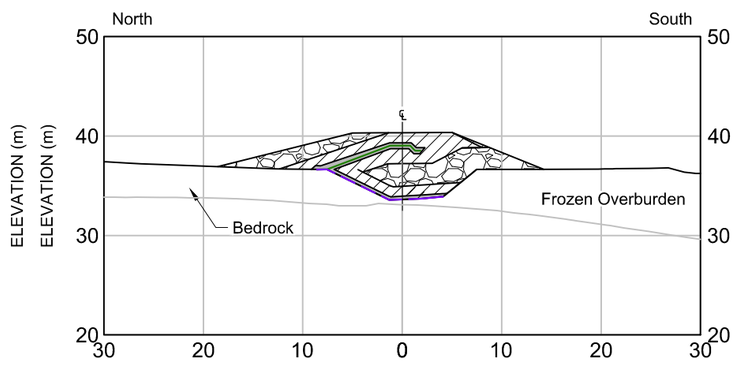
STA.4+10



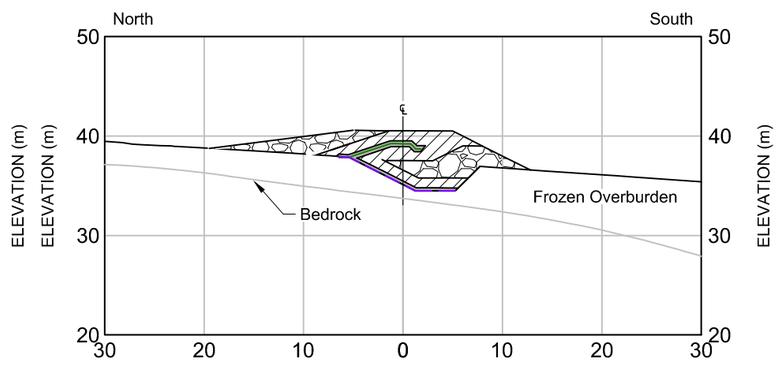
STA.4+20



STA.4+30



STA.4+40



STA.4+50

LEGEND

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- Upper GCL Liner
- Bedding Material
- Transition Material
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0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

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PROFESSIONAL ENGINEERS STAMP

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

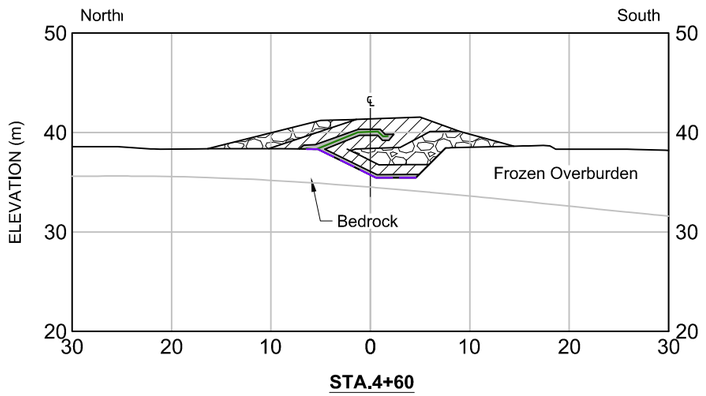
SRK JOB NO.: 1CT022.017

South Dam

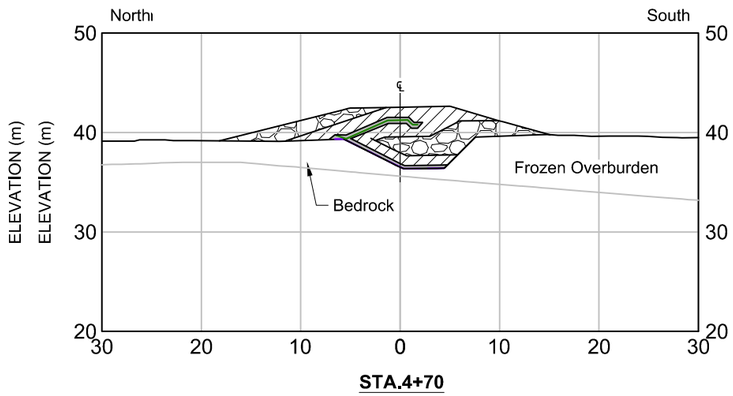
DRAWING TITLE: Sections Sta.3+70 to 4+50 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-17	17 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r\1\CT0022.017 - South Dam - Sections.dwg



STA.4+60



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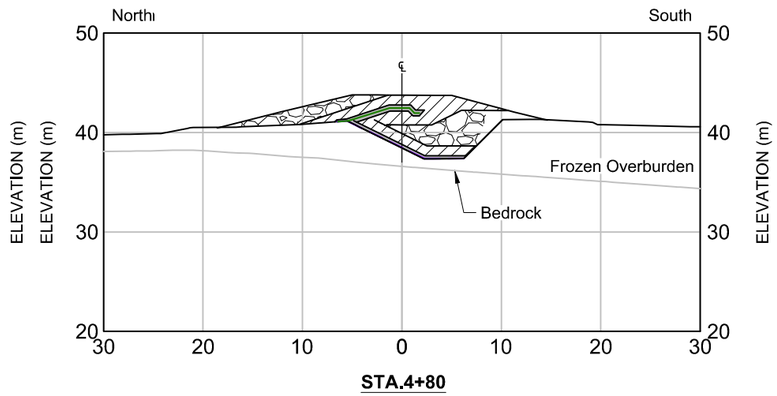
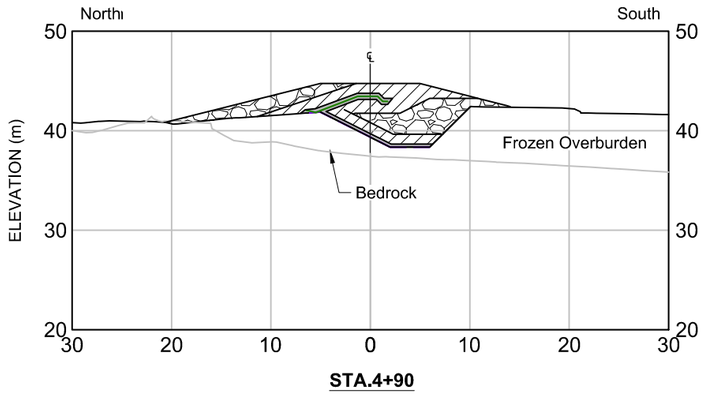
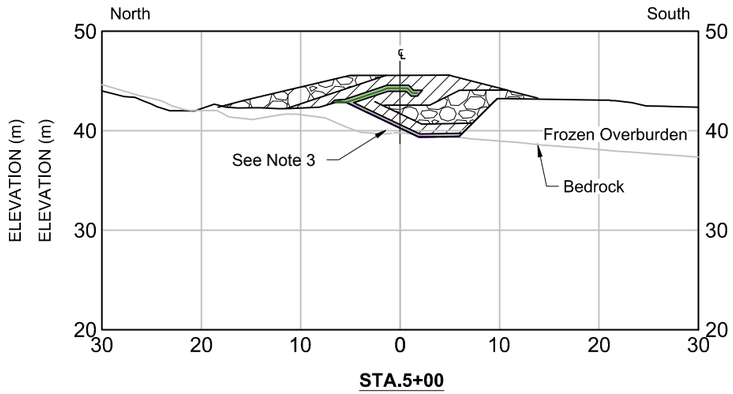


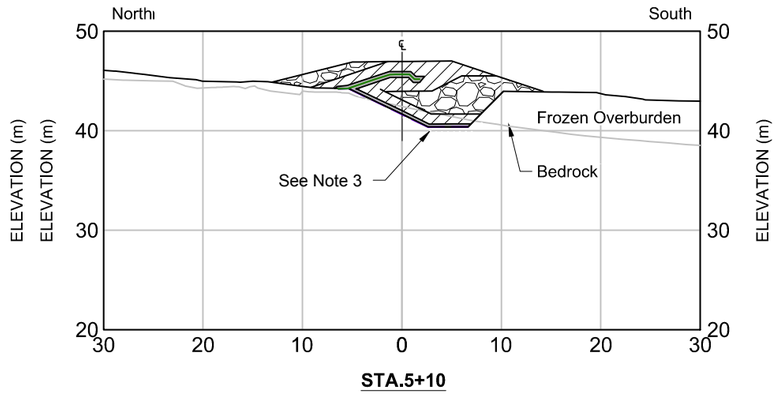
STA.4+80



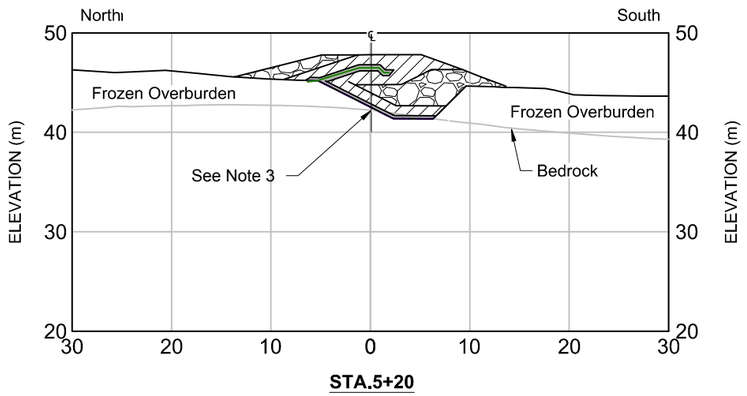
STA.4+90



STA.5+00



STA.5+10



STA.5+20

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.
3. Depth of key trench intersection with bedrock estimated (see DN-SD-04 for additional details). Actual depth may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

REFERENCE DRAWINGS			REVISIONS								
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CH'K'D	APP'D	DATE	NO.	DESCRIPTION	CH'K'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.4+60 to 5+30 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-18	18 OF 30	1

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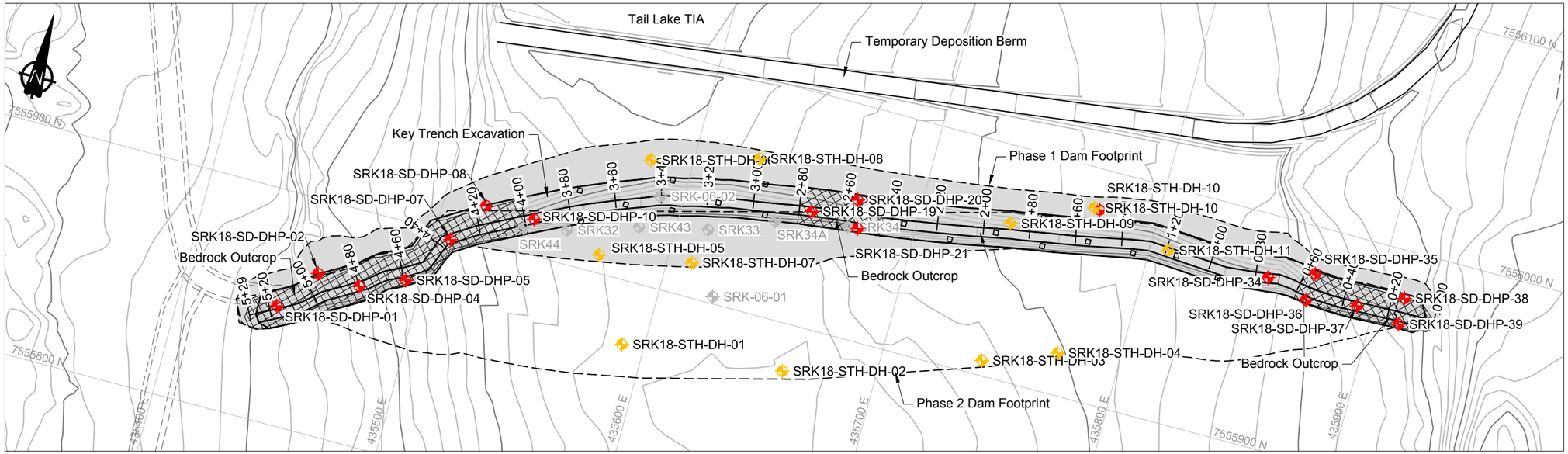
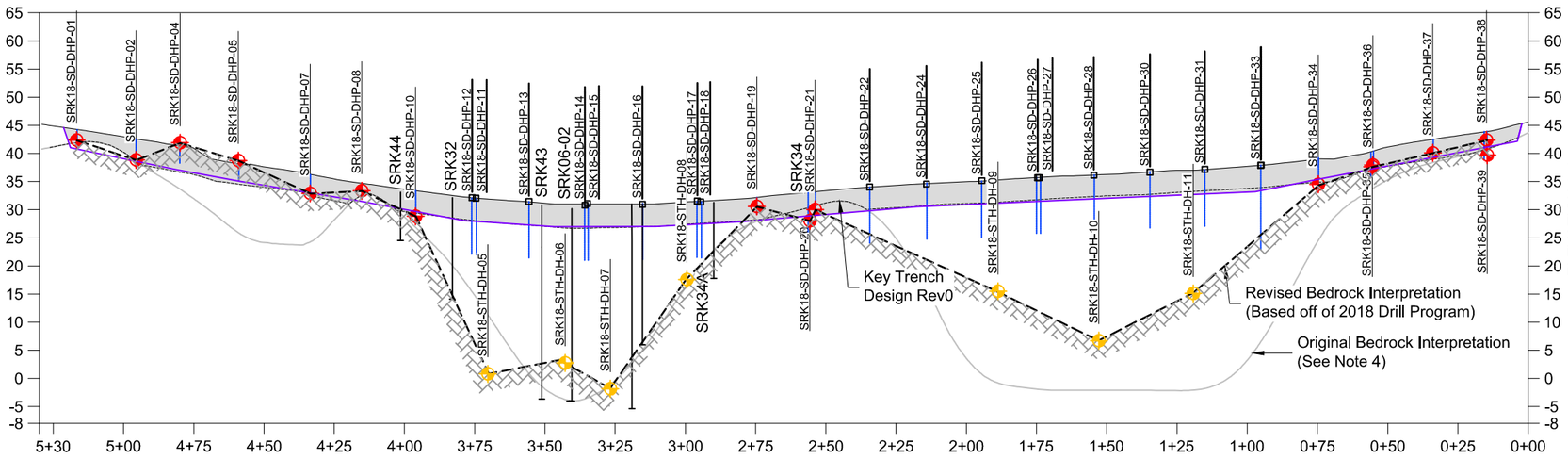


Key Trench Plan View

0m 20 40 60 80



Key Trench Profile View

Vertical 0m 10 20 30 40

Horizontal 0m 20 40 60 80

LEGEND

- Previous Investigation Hole Location
- 2018 Percolation Hole Location Intercepted Bedrock
- 2018 Percolation Hole Location Did Not Intercept Bedrock
- 2018 Borehole Location
- Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Trench Excavation Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profile shown correspond to the upstream toe of the key trench.
4. The subsurface geology has been inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A , SRK43, SRK 44, SRK18-STH-DH-01 to 11, and SRK18-WST-DH-01 to 03), airphoto interpretations, and from limited available geophysical surveys around the Tails Lake area. This data was then used to create a bedrock surface with the Gemcom GEMS software. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.
5. Infill drilling is planned to be completed to reduce the uncertainty and associated risks with the Phase 1 South Dam key trench excavation and overall dam performance (e.g. stability, seepage, settlement, and creep).
6. Depths of infill drill boreholes estimated based on available information (Note 4 and as noted on DN-SD-04). Boreholes should be drilled 3m into bedrock unless terminated earlier as directed by the onsite Engineer.
7. Inferred bedrock contact based off exploration and percolation testing holes drilled January / February 2018 by SRK Consulting.

REFERENCES

NAD83 UTM Zone 13.

AS-BUILT BOREHOLE LOCATIONS

Point ID	Northing	Easting	Collar Elevation	Depth to Bedrock
SRK18-STH-DH-01	7555,873	435,590	31.34	29.9
SRK18-STH-DH-02	7555,880	435,660	30.69	3.0
SRK18-STH-DH-03	7,555,907	435,742	33.59	13.5
SRK18-STH-DH-04	7,555,918	435,773	34.82	10.4
SRK18-STH-DH-05	7,555,908	435,571	31.81	31.0
SRK18-STH-DH-06	7,555,953	435,582	30.35	27.6
SRK18-STH-DH-07	7,555,915	435,610	30.86	32.7
SRK18-STH-DH-08	7,555,966	435,627	31.07	13.5
SRK18-STH-DH-09	7,555,967	435,739	35.03	15.5
SRK18-STH-DH-10	7,555,983	435,772	6.10	6.7
SRK18-STH-DH-11	7,555,973	435,808	36.82	15.1
SRK18-WST-DH-01	7,556,486	435,113	43.25	7.1
SRK18-WST-DH-02	7,556,296	435,200	41.42	1.1
SRK18-WST-DH-03	7,556,195	435,257	42.71	5.4

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
AB	As-Built	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/12/11

DN-SD-04 — Key Trench Excavation Plan and Profile (DRAWING NO. / DRAWING TITLE)

REFERENCE DRAWINGS | REVISIONS

Original Drawings Stamped and Signed by Engineer

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CHECKED: JBK | APPROVED: EMR | DATE: 2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Infill Foundation Drilling.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Infill Foundation Drilling Phase 1

DRAWING NO.: DN-SD-19 | SHEET: 19 OF 30 | REVISION NO.: AB

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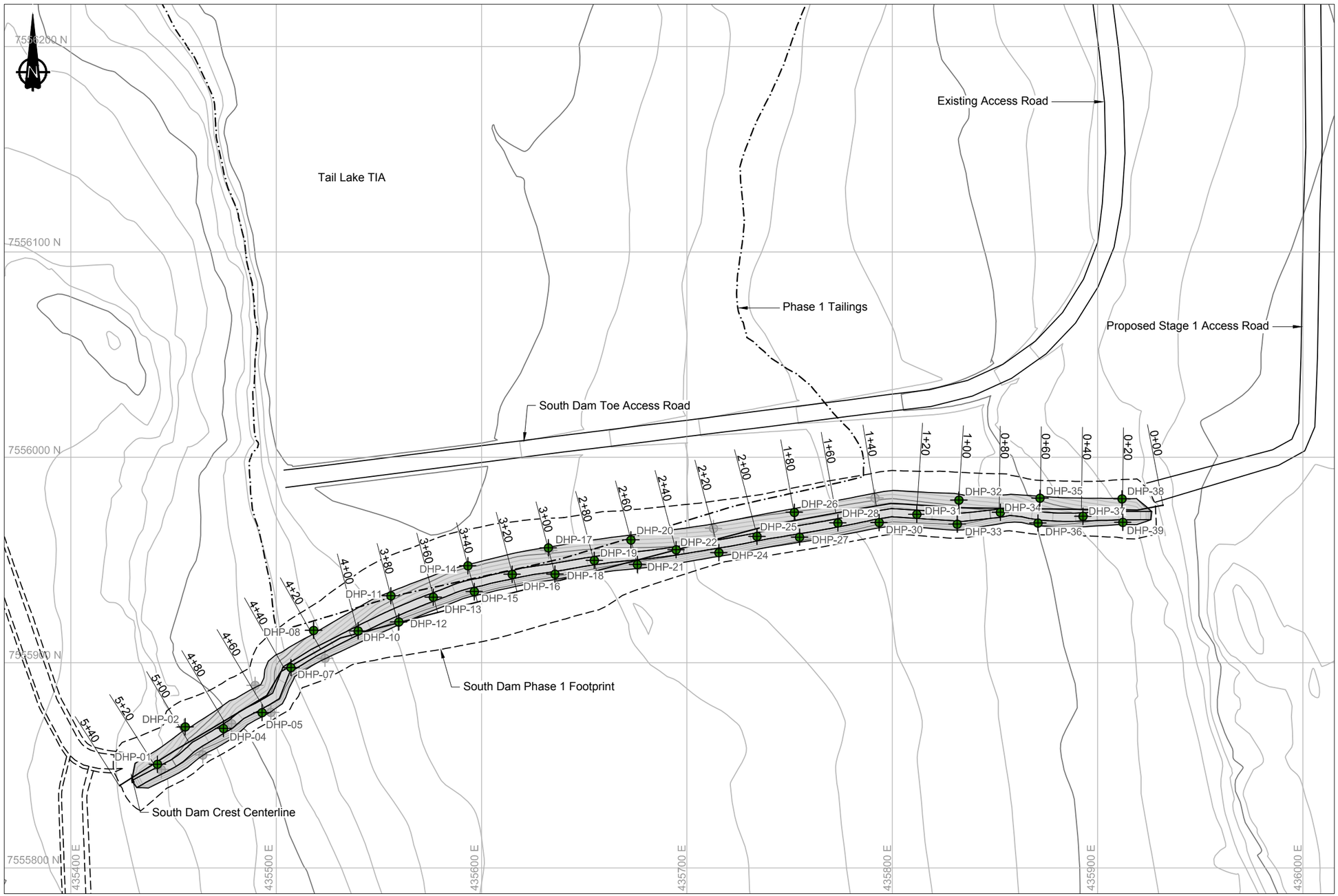

LEGEND

- Proposed Drill Hole Location
- As-Built Drill Hole Location
- Proposed Road Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Outline

NOTES

1. Contours shown at a 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. All percolation test boreholes should be a minimum 8.0m deep.
4. Percolation test boreholes should be a minimum of 4-6 inches (100-150mm) in diameter.
5. It is suggested that an air-track drill (quarry drill) be used to complete the percolation testing.
6. Once all percolation test locations are drilled the testing will be completed on site as directed by the Engineer.

REFERENCES

NAD83 UTM Zone 13.

AS-BUILT PERCOLATION BOREHOLE LOCATIONS

Point ID	Northing	Easting	Elevation
SRK18-SD-DHP1	7555850.42	435442.14	44.2
SRK18-SD-DHP2	7555868.68	435455.71	42.1
SRK18-SD-DHP4	7555867.85	435474.33	41.0
SRK18-SD-DHP5	7555875.60	435493.08	37.9
SRK18-SD-DHP7	7555897.52	435507.19	36.0
SRK18-SD-DHP8	7555915.67	435518.25	34.3
SRK18-SD-DHP10	7555915.40	435539.87	32.8
SRK18-SD-DHP11	7555932.47	435555.80	31.6
SRK18-SD-DHP12	7555919.75	435559.69	31.8
SRK18-SD-DHP13	7555931.76	435576.48	31.1
SRK18-SD-DHP14	7555947.08	435593.31	30.5
SRK18-SD-DHP15	7555934.56	435596.45	30.7
SRK18-SD-DHP16	7555942.92	435614.88	31.2
SRK18-SD-DHP17	7555955.86	435632.48	31.6
SRK18-SD-DHP18	7555943.01	435635.74	31.5
SRK18-SD-DHP19	7555949.72	435654.89	32.0
SRK18-SD-DHP20	7555959.68	435672.72	33.0
SRK18-SD-DHP21	7555947.75	435675.88	33.1
SRK18-SD-DHP22	7555954.90	435694.71	33.7
SRK18-SD-DHP24	7555953.48	435715.55	34.4
SRK18-SD-DHP25	7555961.44	435734.11	35.0
SRK18-SD-DHP26	7555973.14	435752.28	35.5
SRK18-SD-DHP27	7555961.00	435754.88	35.4
SRK18-SD-DHP28	7555967.97	435773.53	35.9
SRK18-SD-DHP30	7555968.15	435793.60	36.4
SRK18-SD-DHP31	7555972.15	435812.00	37.1
SRK18-SD-DHP32	7555979.10	435832.48	37.7
SRK18-SD-DHP33	7555967.38	435831.61	37.6
SRK18-SD-DHP34	7555973.14	435852.65	38.6
SRK18-SD-DHP35	7555980.03	435871.93	40.9
SRK18-SD-DHP36	7555967.95	435870.94	40.1
SRK18-SD-DHP37	7555971.21	435892.86	42.4
SRK18-SD-DHP38	7555979.68	435911.87	44.3
SRK18-SD-DHP39	7555968.28	435912.27	43.5

REFERENCE DRAWINGS		REVISIONS								
							AB	As-Built	JBK	EMR	18/04/13
DN-SD-04	Key Trench Excavation Plan and Profile	--	--	--	--	--	0	Issued for Construction	JBK	EMR	17/12/11
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE

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JBK	TAH	EMR
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JBK	EMR	2018/04/13

FILE NAME: 1CT022.017 - Percolation Testing.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Percolation Borehole / Test Locations

DRAWING NO.	SHEET	REVISION NO.
DN-SD-20	20 OF 30	AB

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Doris TIA

Existing Access Road

Proposed Stage 1 Access Road

Proposed Stage 2 Access Road

Temporary Deposition Berm

Phase 1 Dam - Issued for Construction (IFC)

Phase 2 Dam Footprint - Ultimate footprint shown for information only

7556100 N
7556000 N
7555900 N
7555800 N

435400 E
435500 E
435600 E
435700 E
435800 E
435900 E
436000 E

0+00
0+50
1+00
1+50
2+00
2+50
3+00
3+50
4+00
4+50
5+00
5+38

LEGEND

- Fixed Survey Monitoring Poind
- Surficial Survey Monitoring Point
- Deep Monitoring Point
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

0m 20 40 60 80

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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							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/02/16

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Plan Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-21	21 OF 30	1

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LEGEND

- Monitoring Section
- Cable Trench
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Ground Temperature Cable backfilled cable trenches to be excavated through final dam shell - See drawings DN-SD-27, 28 and 29.

REFERENCES

NAD83 UTM Zone 13.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-29	Instrumentation Details at Sta. 4+65 and 5+10										
DN-SD-28	Instrumentation Details at Sta. 2+40 and 3+65										
DN-SD-27	Instrumentation Details at Sta. 0+65 and 1+55						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/02/16

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - GTC Trenches.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

GTC Backfilled Cable Trenches Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-22	22 OF 30	1

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Doris TIA

Existing Access Road

Proposed Stage 1 Access Road

Proposed Stage 2 Access Road

Temporary Deposition Berm

Phase 1 Dam - Issued for Construction (IFC)

7556100 N

7556000 N

7555900 N

7555800 N

435400 E

435500 E

435600 E

435700 E

435800 E

435900 E

436000 E

V-GTC-01 5+42

V-GTC-02 5+50

V-GTC-03

V-GTC-04 5+00

V-GTC-05

V-GTC-06 3+50

V-GTC-07 4+00

V-GTC-08

V-GTC-09 3+00

V-GTC-10 2+50

V-GTC-11 2+00

V-GTC-12 1+50

V-GTC-13 1+00

V-GTC-14 0+50 0+00

0m 20 40 60 80

LEGEND

- Vertical Ground Temperature Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

I.D.	Northing	Easting
V-GTC-01	7555854.81	435451.79
V-GTC-02	7555898.07	435484.95
V-GTC-03	7555882.32	435493.54
V-GTC-04	7555874.72	435497.69
V-GTC-05	7555955.78	435565.30
V-GTC-06	7555932.32	435571.39
V-GTC-07	7555906.23	435578.34
V-GTC-08	7555975.51	435689.29
V-GTC-09	7555956.36	435694.32
V-GTC-10	7555942.48	435698.15
V-GTC-11	7555988.45	435775.01
V-GTC-12	7555971.08	435778.29
V-GTC-13	7555963.40	435779.65
V-GTC-14	7555974.28	435866.64

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	17/12/15

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Vertical GTC LO.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Vertical GTC Layout
Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-23	23 OF 30	1

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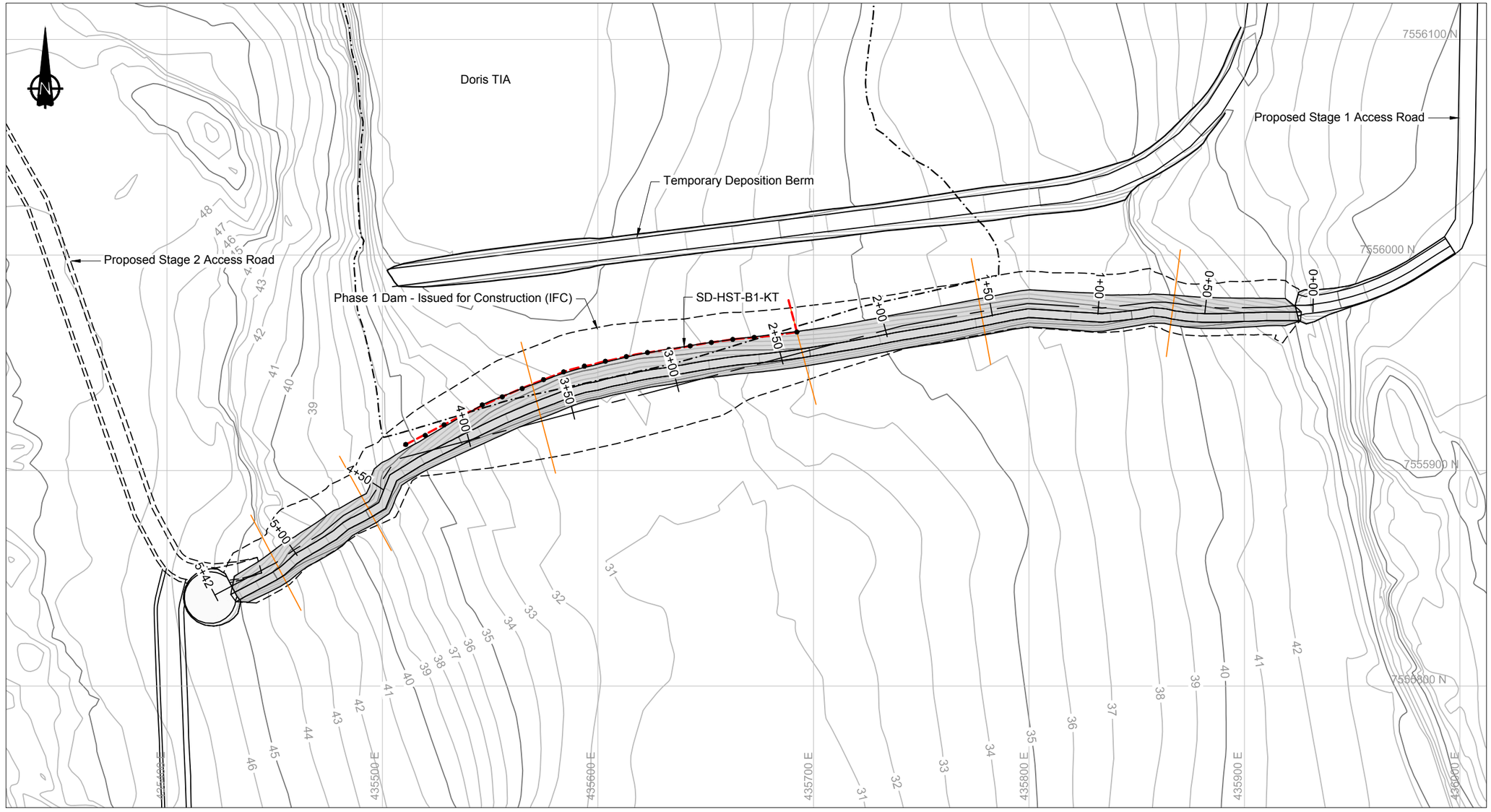

LEGEND

- Horizontal Ground Temperature Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Key Trench Footprint
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

ID	Northing	Easting
HST20098	7555964.28	435692.33
HST20099	7555962.86	435682.43
HST20100	7555961.78	435672.49
HST20101	7555960.86	435662.54
HST20102	7555959.44	435652.64
HST20103	7555957.83	435642.77
HST20104	7555956.14	435632.91
HST20105	7555954.75	435623.01
HST20106	7555952.88	435613.20
HST20107	7555950.71	435603.43
HST20108	7555948.45	435593.71
HST20109	7555945.81	435584.08
HST20110	7555942.19	435574.76
HST20111	7555938.05	435564.84
HST20112	7555934.18	435555.62
HST20113	7555930.47	435546.33
HST20114	7555925.96	435537.40
HST20115	7555921.21	435528.59
HST20116	7555916.34	435519.87
HST20117	7555912.10	435510.79

0m 20 40 60 80

Ground Temperature Cable Details - Center Base

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
1	SD-HST-B1-KT	A	Horizontal	Center	235	Top of Key Trench	20 beads spaced every 10m from the zero line on the cable, i.e. first bead at 0m										

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-	-	-				1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/02/15

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Lower H&II GTC LO.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Horizontal GTC
Upstream Base / Toe of Key Trench

DRAWING NO.	SHEET	REVISION NO.
DN-SD-24	24 OF 30	1

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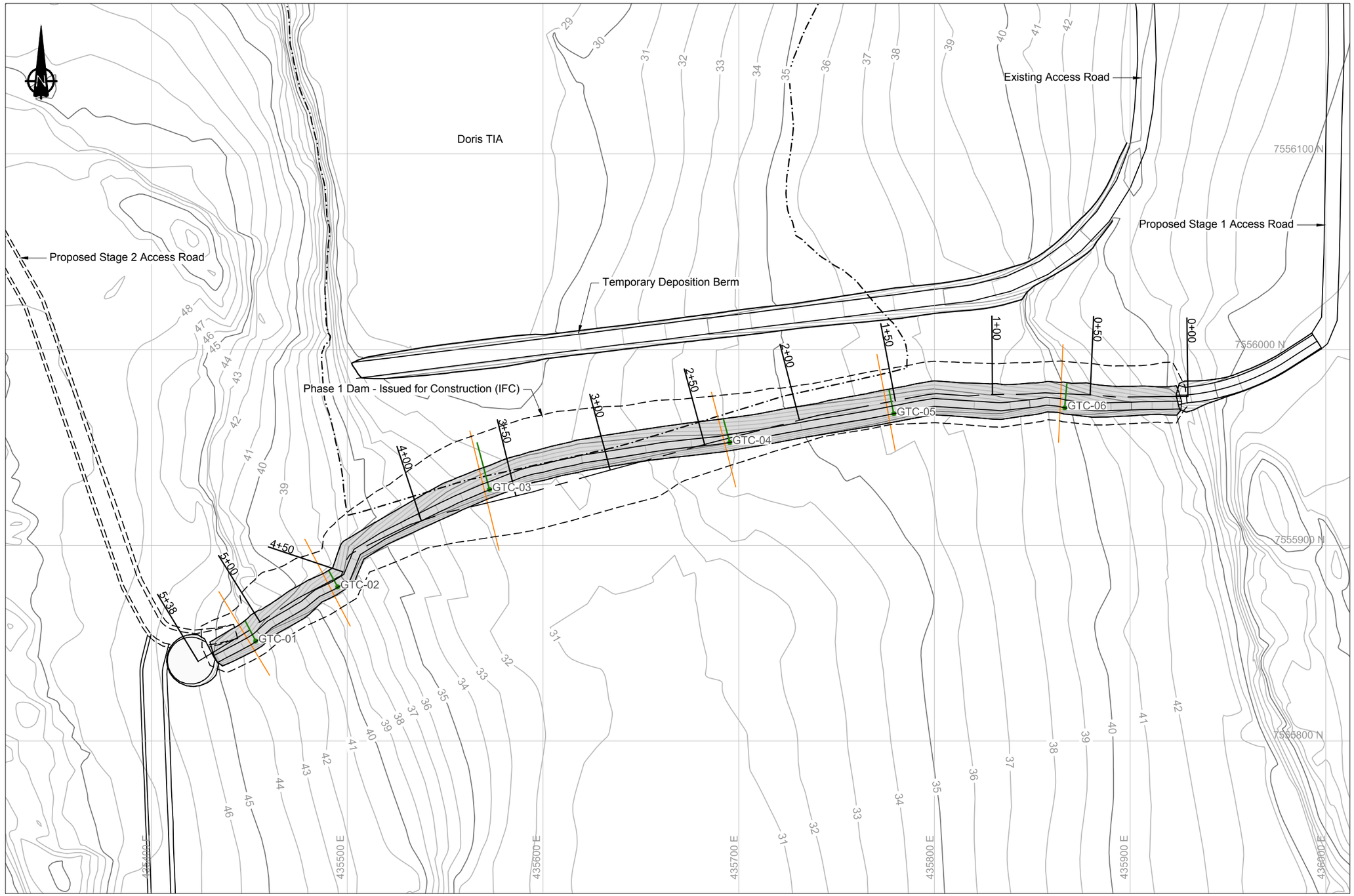

LEGEND

- Leak Detection Instrumentation
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

I.D.	Northing	Easting
GTC-01	7555851	435453
GTC-02	7555879	435495
GTC-03	7555929	435573
GTC-04	7555953	435695
GTC-05	7555937	435779
GTC-06	7555970	435867

0m 20 40 60 80

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-	JBK	EMR	17/12/11

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/12/11

REVISIONS

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Leak Detection.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

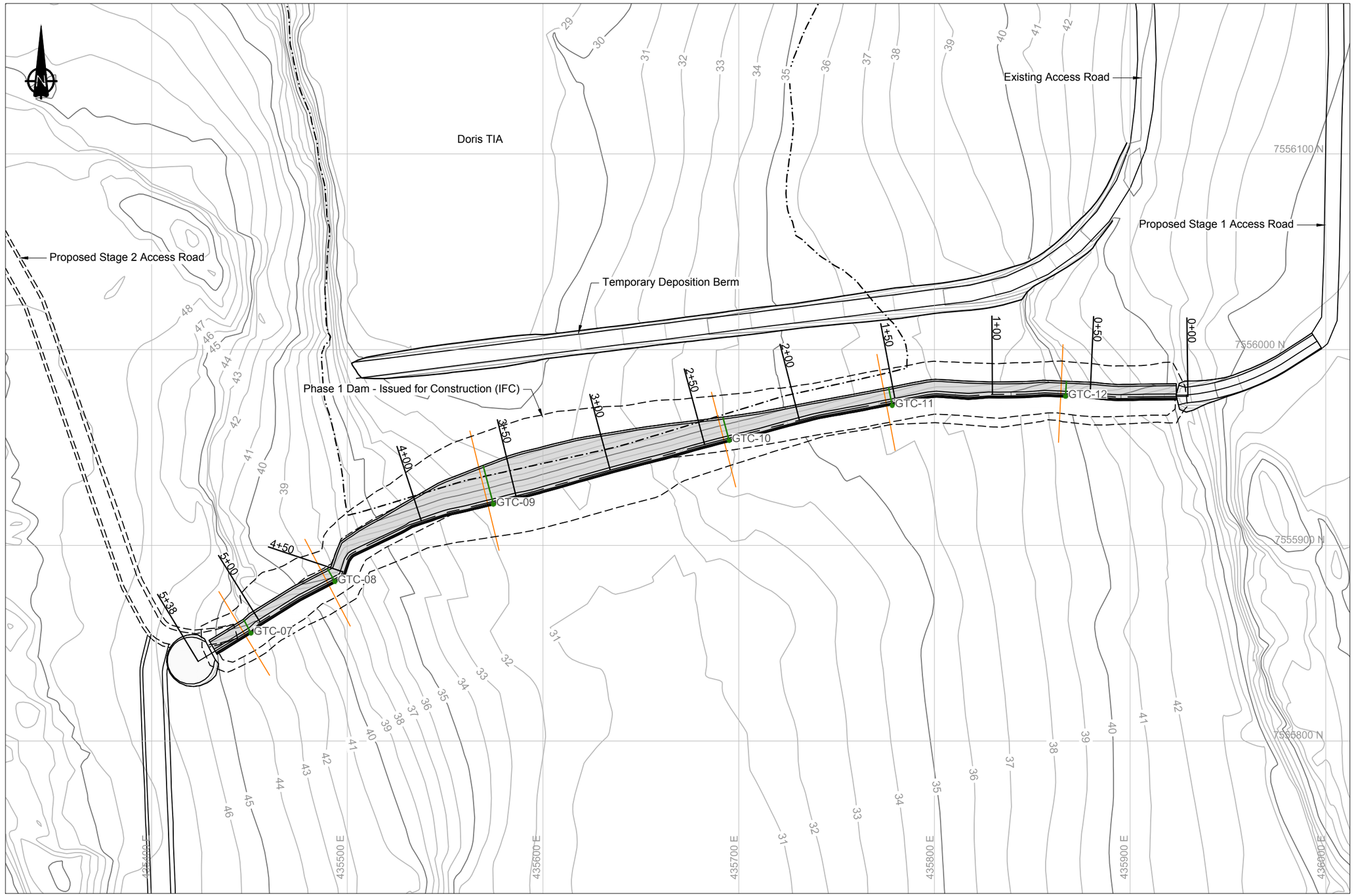
South Dam

DRAWING TITLE:

GTC Layout Along Upstream Slope of Key Trench

DRAWING NO.	SHEET	REVISION NO.
DN-SD-25	25 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 rl\1CT0022.017 - Leak Detection.dwg



LEGEND

- Ground Temperature Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

I.D.	Northing	Easting
GTC-07	7555855	435451
GTC-08	7555882	435494
GTC-09	7555921	435575
GTC-10	7555954	435695
GTC-11	7555972	435778
GTC-12	7555976	435867

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/12/11

REVISIONS

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Liner GTC.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

GTC Layout Along Upstream Above Ground Liner Slope

DRAWING NO.	SHEET	REVISION NO.
DN-SD-26	26 OF 30	1

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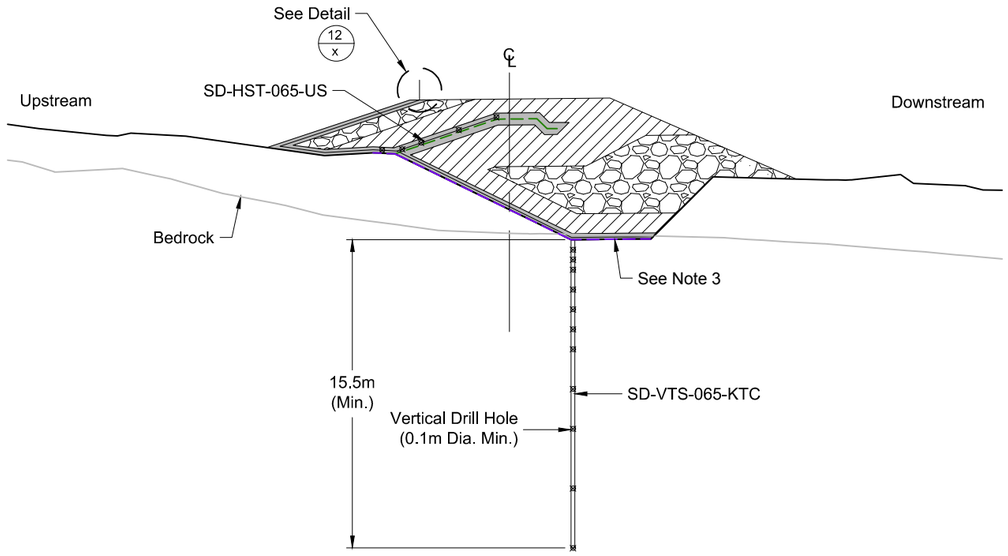
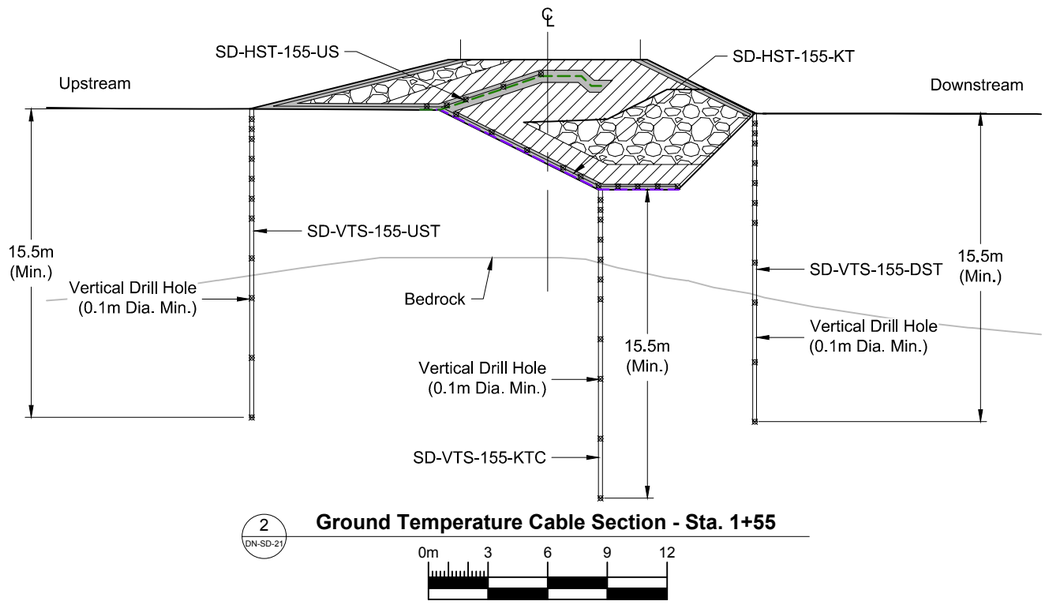


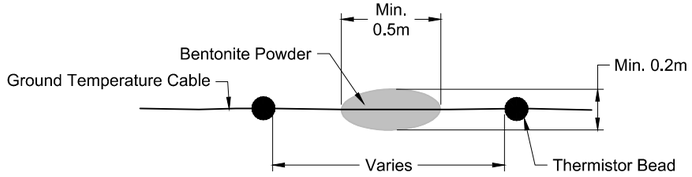
1 DN-SD-21 **Ground Temperature Cable Section - Sta. 0+65**

0m 3 6 9 12



2 DN-SD-21 **Ground Temperature Cable Section - Sta. 1+55**

0m 3 6 9 12



Detail 12 - Typical Water Stop Detail

0m 0.3 0.6 0.9 1.2

LEGEND

- Thermistor Bead Location
- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. Vertical cable boreholes to be filled with grout or backfilled with finer (sand size) material.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

Ground Temperature Cable Details - Monitoring Section 0+65 and 1+55

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
2	SD-VTS-65-KTC	A	Vertical	0+65	42	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
3	SD-HTS-065-US	B	Horizontal & Inclined	0+65	121	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
4	SD-VTS-155-KTC	A	Vertical	1+55	50	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
5	SD-VTS-155-UST	A	Vertical	1+55	41	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
6	SD-VTS-155-DST	A	Vertical	1+55	53	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
7	SD-HTS-155-US	B	Horizontal & Inclined	1+55	41	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
8	SD-HTS-155-KT	C	Horizontal & Inclined	1+55	39	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13
9	SD-HST-B1-KT	C	Horizontal	Center Base	235	Center Base	20 beads spaced every 10m from the zero line on the cable i.e. first bead at 0m										
10	Extension for SD-VTS-065-KTC	D	Vertical	0+65	90		Extension for existing cable. No beads needed.										

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	JBK	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Details at Sta. 0+65 and 1+55

DRAWING NO. DN-SD-27 | SHEET 27 OF 30 | REVISION NO. 1

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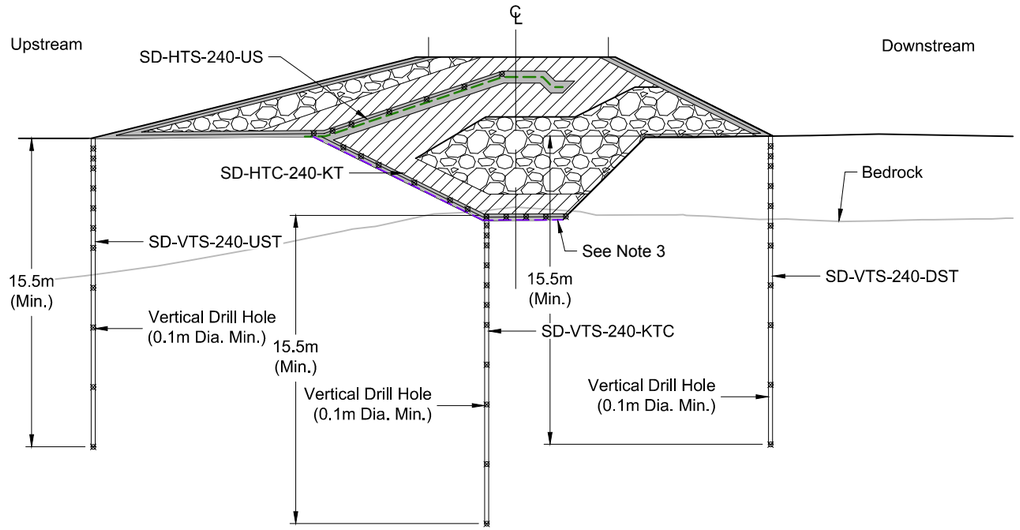
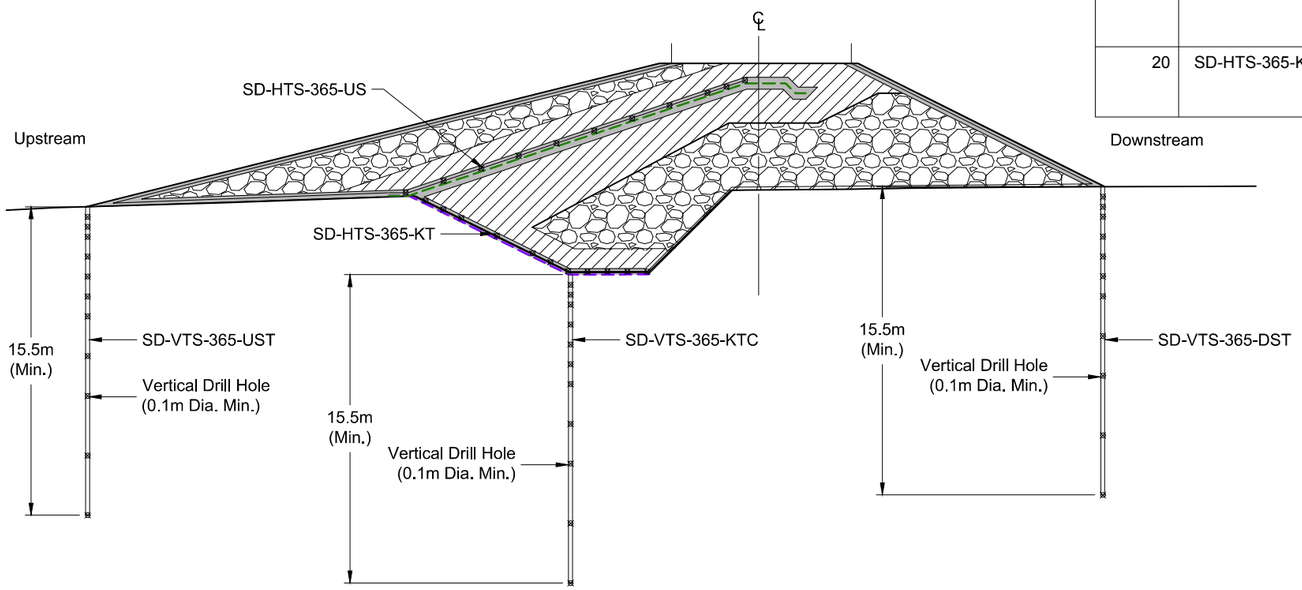


3 DN-SD-21

Ground Temperature Cable Section - Sta. 2+40

0m 3 6 9 12



4 DN-SD-21

Ground Temperature Cable Section - Sta. 3+65

0m 3 6 9 12

Ground Temperature Cable Details - Monitoring Section 2+40 and 3+65

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
11	SD-VTS-240-KTC	A	Vertical	2+40	58	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
12	SD-VTS-240-UST	A	Vertical	2+40	46	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
13	SD-VTS-240-DST	A	Vertical	2+40	53	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
14	SD-HTS-240-US	B	Horizontal & Inclined	2+40	50	Upstream Slope	0	2	4	6	8	9	10	-	-	-	-
15	SK-HTC-240-KT	B	Horizontal & Inclined	2+40	48	Upstream Slope	0	1	3	5	7	8	9	10	11	12	13
16	SD-VTS-365-KTC	A	Vertical	3+65	75	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
17	SD-VTS-365-UST	A	Vertical	3+65	57	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
18	SD-VTS-365-DST	A	Vertical	3+65	58	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
19	SD-HTS-365-US	B	Horizontal & Inclined	3+65	76	Upstream Slope	0	2	4	6	8	10	12	14	15	17	18
20	SD-HTS-365-KT	C	Horizontal & Inclined	3+65	65	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13

LEGEND

- Thermistor Bead Location
- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Instrumentation Details at Sta. 2+40 and 3+65

DRAWING NO.	SHEET	REVISION NO.
DN-SD-28	28 OF 30	1

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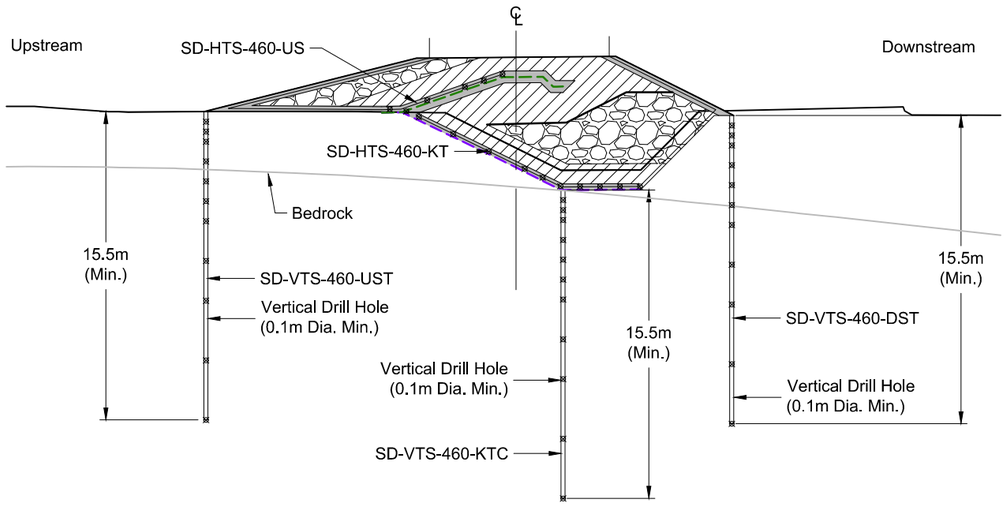
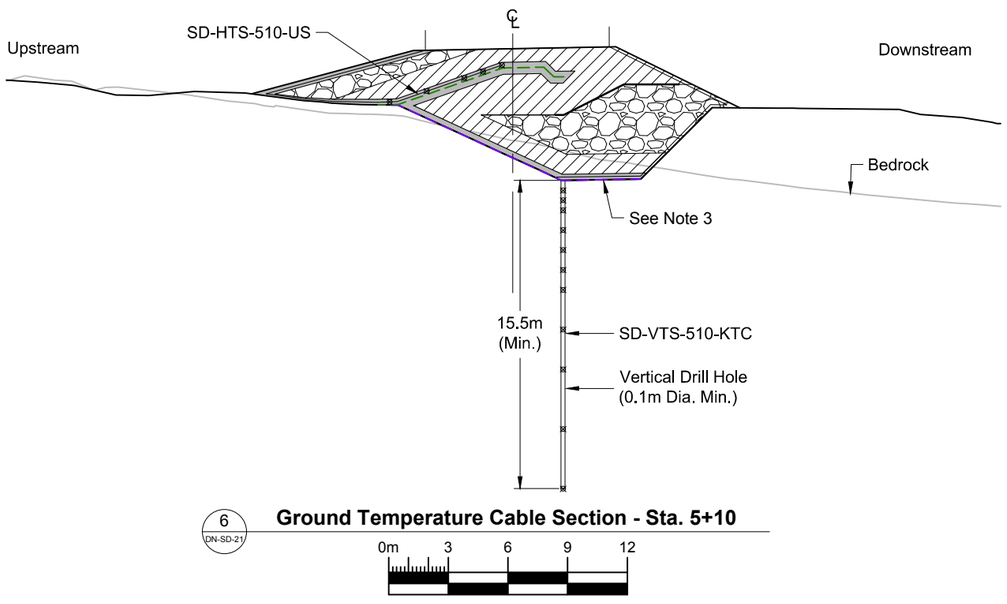


5 DN-SD-21 **Ground Temperature Cable Section - Sta. 4+60**

0m 3 6 9 12



6 DN-SD-21 **Ground Temperature Cable Section - Sta. 5+10**

0m 3 6 9 12

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

Ground Temperature Cable Details - Monitoring Section 4+60 and 5+10

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
21	SD-VTS-460-KTC	A	Vertical	4+60	50	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
22	SD-VTS-460-UST	A	Vertical	4+60	41	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
23	SD-VTS-460-DST	A	Vertical	4+60	58	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
24	SD-HTS-460-US	B	Horizontal & Inclined	4+60	41	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
25	SD-HTS-460-KT	C	Horizontal & Inclined	4+60	39	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13
26	SD-VTS-510-KTC	A	Vertical	5+10	48	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
27	SD-HTS-510-US	B	Horizontal & Inclined	5+10	86	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
28	Extension for SD-VTS-510-KTC	D	Vertical	5+10	90		Extension for existing cable. No beads needed.										

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Details at Sta. 4+65 and 5+10

DRAWING NO.	SHEET	REVISION NO.
DN-SD-29	29 OF 30	1

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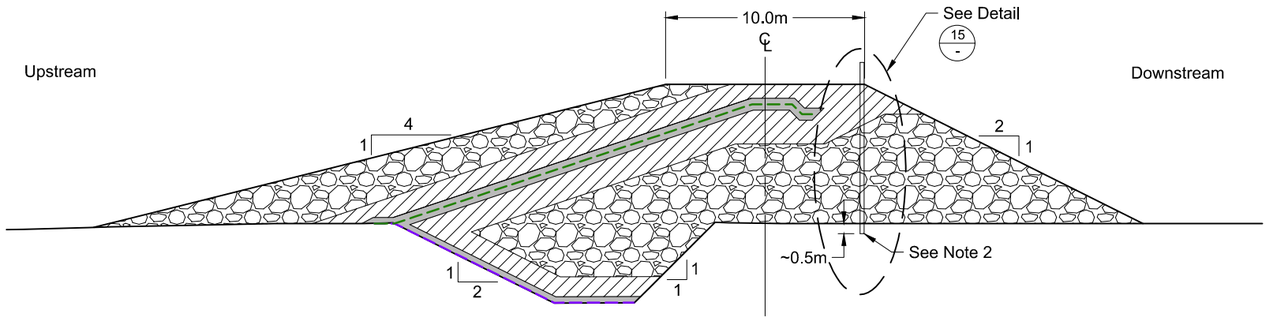
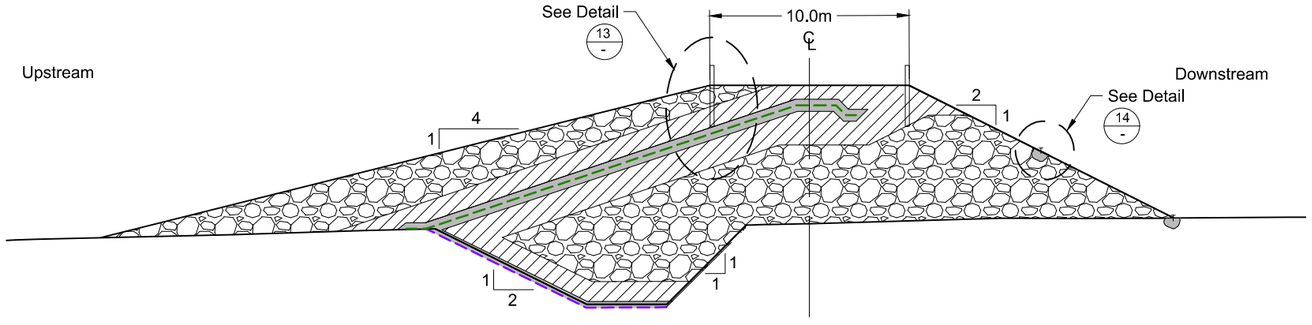


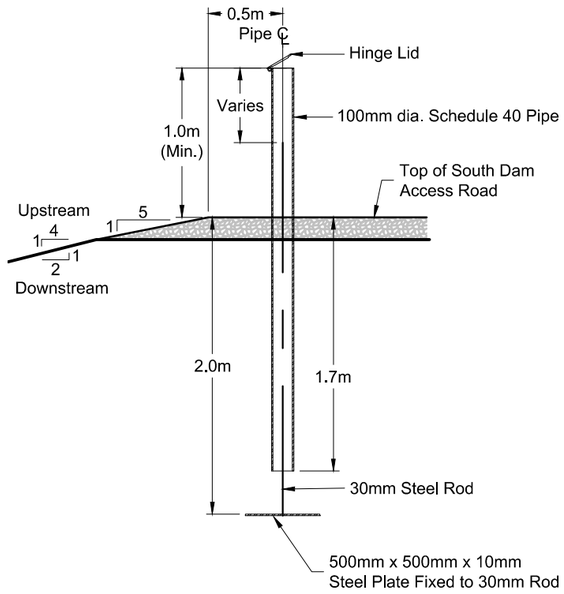
Surficial Survey Point - Sta. 3+15

0m 3 6 9 12



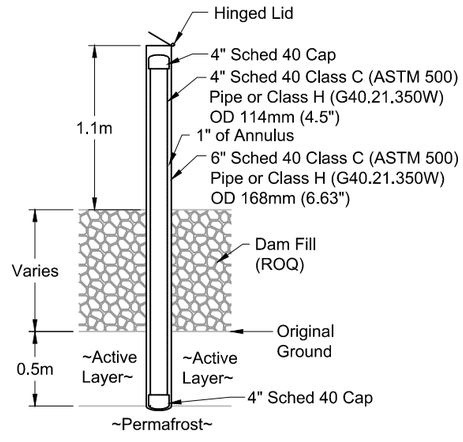
Deep Settlement Point - Sta. 3+50

0m 3 6 9 12



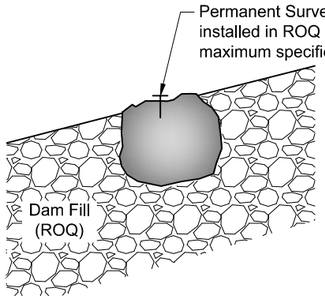
Detail 13 - Survey Monitoring Point Detail

0m 0.25 0.5 0.75 1.0



Detail 15 - Deep Settlement Point Installation

0m 0.25 0.5 0.75 1.0



Detail 14 - Surficial Survey Point Installation

0m 0.25 0.5 0.75 1.0

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. Deep settlement point installation depth to be directed by the field Engineer. Aim is to be near the active layer - permafrost contact.

REFERENCE DRAWINGS		REVISIONS										
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-21	Instrumentation Plan - Phase 1										
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/04/13

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Typical Monitoring Point Details

DRAWING NO.	SHEET	REVISION NO.
DN-SD-30	30 OF 30	1

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Engineering Drawings for the South Dam - Phase 1
Doris North Project, Nunavut, Canada

Drawing Number	Drawing Title	Issue	Date	Revision	Old / Replaced Revisions	
DN-SD-01	Phase 1 General Arrangement (with Orthophoto)	Issued for Construction	April 30, 2018	2	Rev 0, 2017/11/29	Rev 1, March 7, 2018
DN-SD-02	Phase 1 General Arrangement	Issued for Construction	April 30, 2018	2	Rev 0, 2017/11/29	Rev 1, March 7, 2018
DN-SD-03	Typical Sections (General)	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-04	Key Trench Excavation Plan and Profile	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-05	Liner Placement Plan and Details - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-06	Liner and Bedding Placement Details	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-07	Bedding Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-08	Transition Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-11	Construction Access Road and Turn Around - Phase 1	Issued for Construction	April 30, 2018	2	Rev 0, 2017/11/29	Rev 1, March 7, 2018
DN-SD-12	Final Phase 1 Dam Plan, Profile and Sections	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-13	Sections Sta. 0+10 to 0+90 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-14	Sections Sta. 1+00 to 1+80 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-15	Sections Sta. 1+90 to 2+70 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-16	Sections Sta. 2+80 to 3+60 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-17	Sections Sta. 3+70 to 4+50 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-18	Sections Sta. 4+60 to 5+30 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-19	Infill Foundation Drilling - Phase 1	Issued for Construction	March 7, 2018	AB	Rev 0, 2018/02/16	
DN-SD-20	Percolation Borehole / Test Locations	Issued for Construction	March 7, 2018	AB	Rev 0, 2018/02/16	
DN-SD-21	Instrumentation Plan - Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-22	GTC backfilled Cable Trench - Phase 1	Issued for Construction	April 26, 2018	2	Rev 0, 2018/03/07	Rev 1, March 7, 2018
DN-SD-23	Vertical GTC Layout - Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-24	Horizontal GTC - Upstream Base / Toe of Key Trench	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-25	GTC Layout Along Upstream Above Ground Liner Slope	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-26	Sloped GTC - Above Ground Liner Slope	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-27	Instrumentation Details at Sta. 0+65 and 1+55	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-28	Instrumentation Details at Sta. 2+40 and 3+65	Issued for Construction	March 7, 2018	0		
DN-SD-29	Instrumentation Details at Sta. 4+65 and 5+10	Issued for Construction	March 7, 2018	0		
DN-SD-30	Typical Monitoring Point Details	Issued for Construction	March 7, 2018	0		

April 30th, 2018 - Compiled IFC Drawing Set

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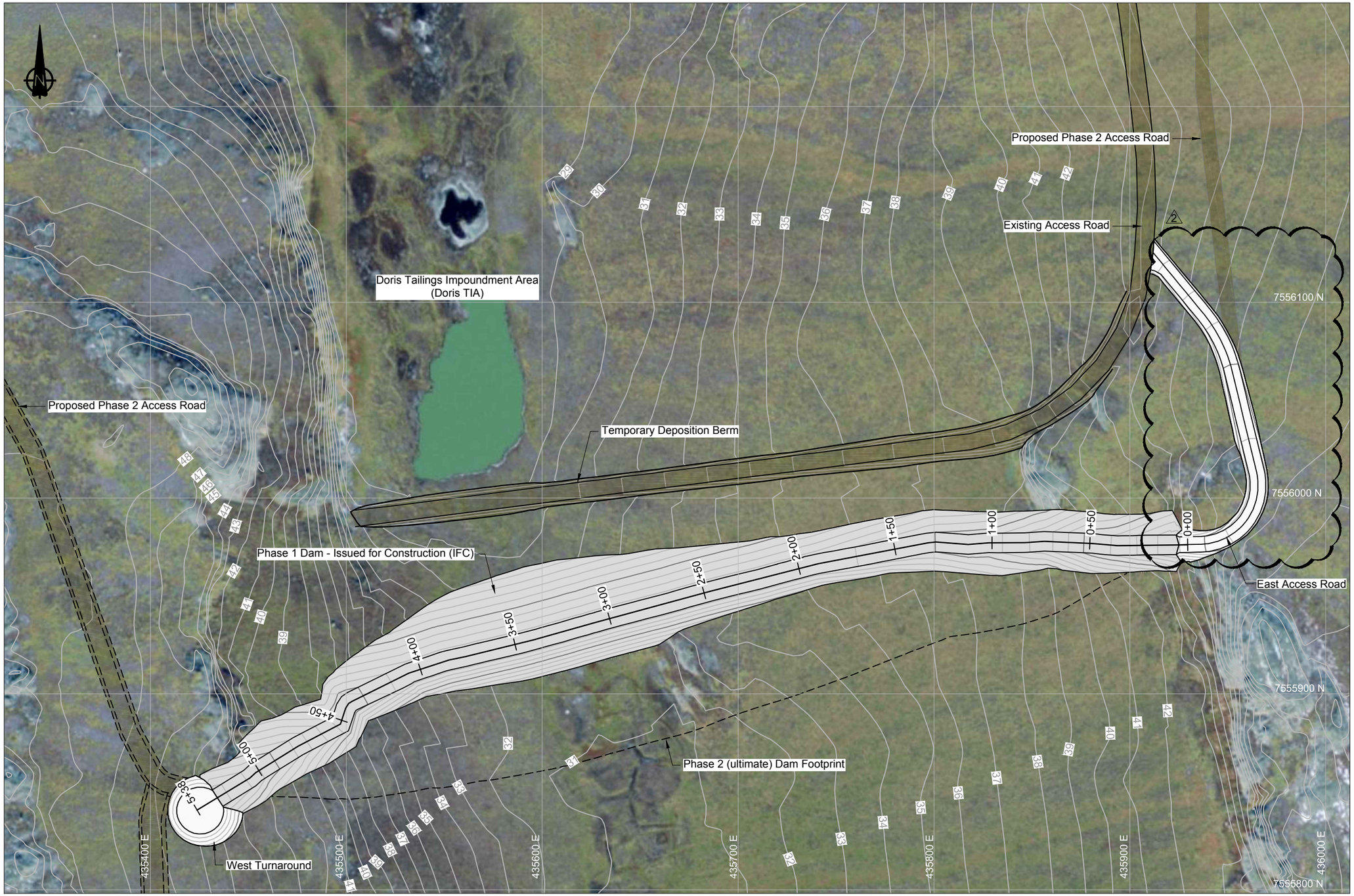

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Imagery (from 2010 PhotoSat compilation) provided by client.
5. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

0m 20 40 60 80

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/30
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/30

FILE NAME: 1CT0022.017 - South Dam GA - with ortho.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Phase 1 General Arrangement (with Orthophoto)

DRAWING NO.	SHEET	REVISION NO.
DN-SD-01	1 OF 30	2

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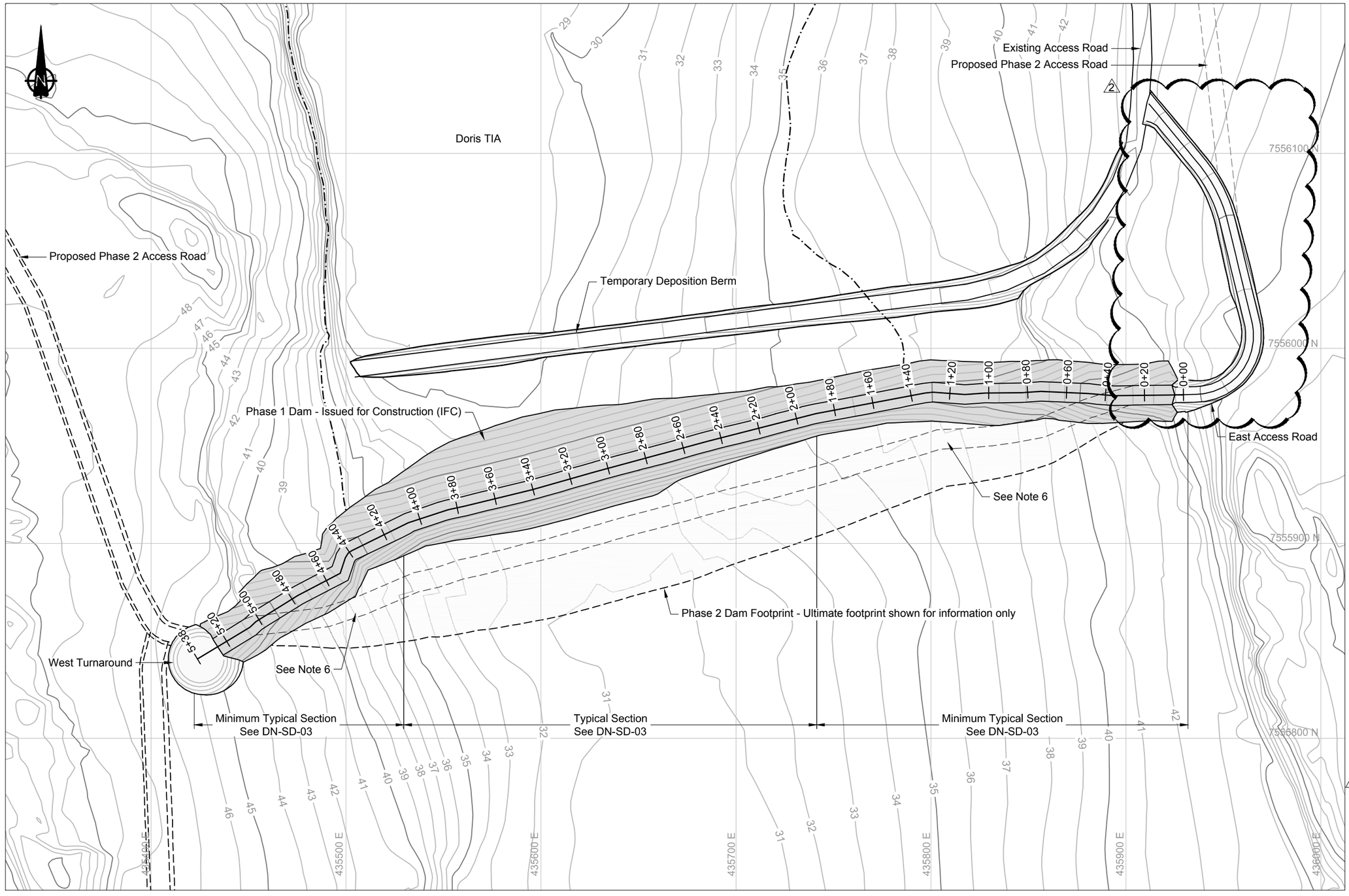

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Volumes presented based on neat-lines only and are approximate. These include no over-excavation or over-blasting allowance of the key trench.
5. All units shown are in meters unless otherwise stated.
6. Bend in the dam crest is to accommodate Phase 2 liner tie-in.
7. All snow roads placed on the upstream as a temporary construction measure, to help facilitate construction of the dam, must be completely removed before tailings deposition may commence.

REFERENCES

NAD83 UTM Zone 13.

TABLE OF QUANTITIES (NEAT-LINE)

Key Trench Bulk Excavation :	19,500m³
Total Phase 1 Fill:	68,500m³
ROQ:	36,800m³
Transition:	26,100m³
Bedding:	5,600m³
Total Liner:	14,300m²
West Turnaround (bulk):	2,000m³
East Access Road (bulk):	2,440m³

*all volumes presented are to neat-lines and do not allow / account for bulking and compaction.

0m 20 40 60 80

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
2	Issued for Construction	JBK	EMR	18/04/30
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/30

FILE NAME: 1CT0022.017 - South Dam GA.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Phase 1 General Arrangement

DRAWING NO.	SHEET	REVISION NO.
DN-SD-02	2 OF 30	2

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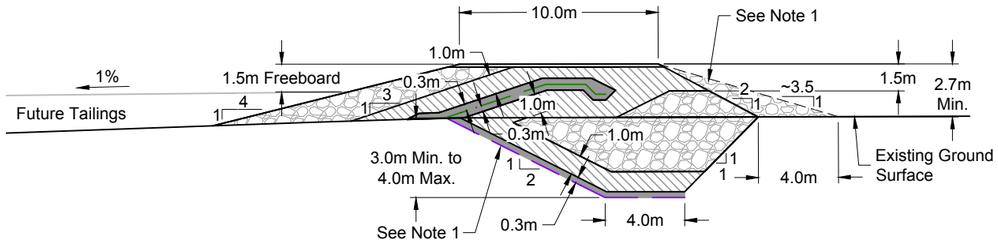
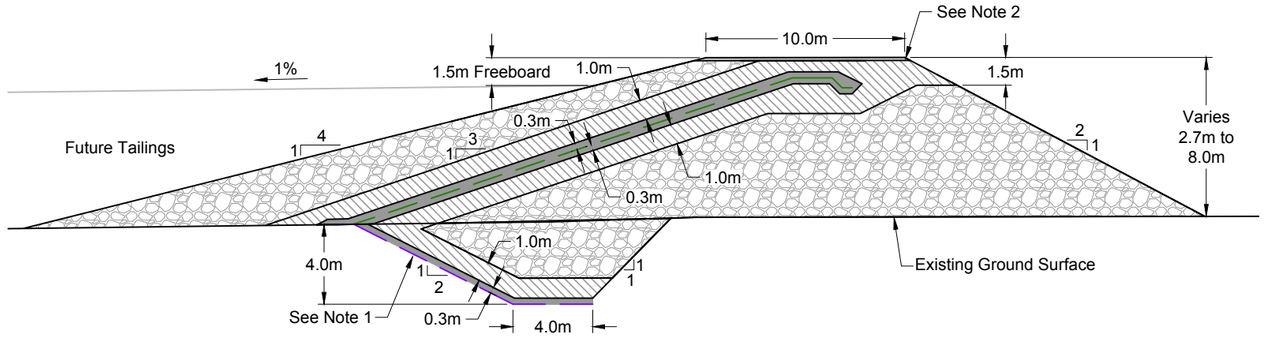


Minimum Typical Cover Section
STA.0+00 to 1+92 & 4+15 to 5+42

0m 3 6 9 12

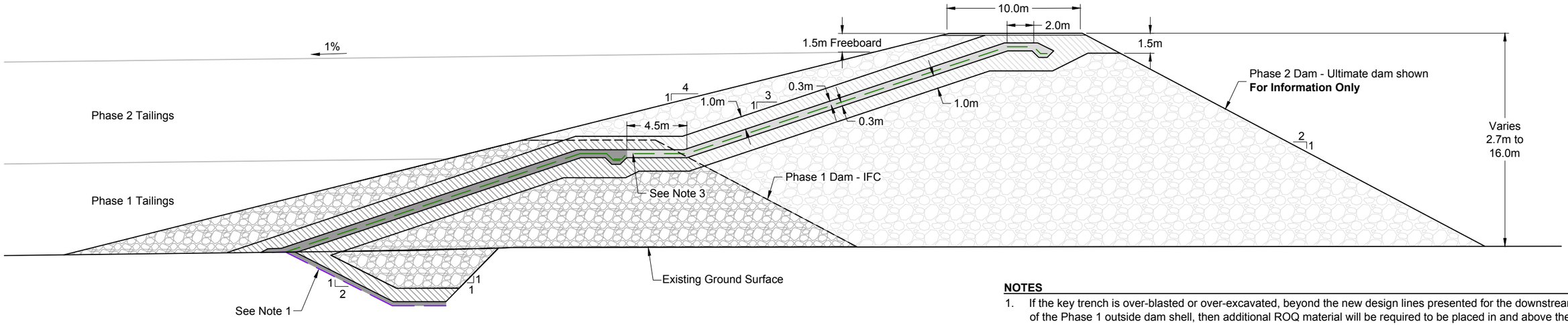
ISSUED FOR CONSTRUCTION



Phase 1 Typical Dam Section
STA. 1+92 to 4+15

0m 3 6 9 12

ISSUED FOR CONSTRUCTION



Phase 2 Typical Dam Section
STA. 0+25 to 5+25

0m 3 6 9 12

ISSUED FOR INFORMATION

LEGEND

- Key Trench Liner
- Phase 1 & 2 Dam Liner
- Bedding Material
- Transition Material
- Run of Quarry

NOTES

1. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench. This material would be placed to ensure that adequate thermal insulation of the key trench is maintained in all sections. See Detail 10 on drawing DN-SD-09 for additional details.
2. The top road surfacing (bedding material) for the Phase 1 dam is to be fully removed (upstream and downstream) before Phase 2 construction commences.
3. To allow for a proper tie-in the transition material around the top downstream portion of the Phase 1 dam will be required to be stripped back. Once the bedding material around the top liner anchor trench is reached hand excavation should be expected to result down to expose the liner. The on-site engineer will be required to inspect all exposed liner, to ensure that it is not damaged or in need of repairs before Phase 2 liner tie-ins result.
4. All units shown are in meters unless otherwise stated.

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-02	Phase 1 General Arrangement	-	-			

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS | REVISIONS

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Typ Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Typical Sections (General)

DRAWING NO.	SHEET	REVISION NO.
DN-SD-03	3 OF 30	1

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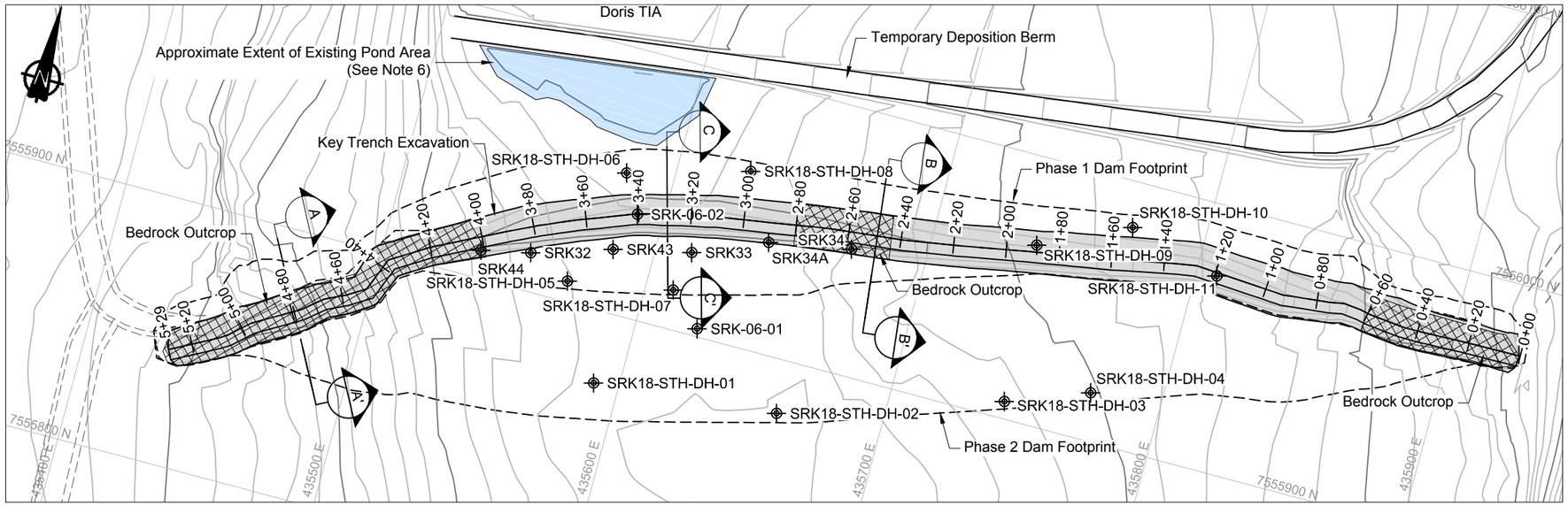
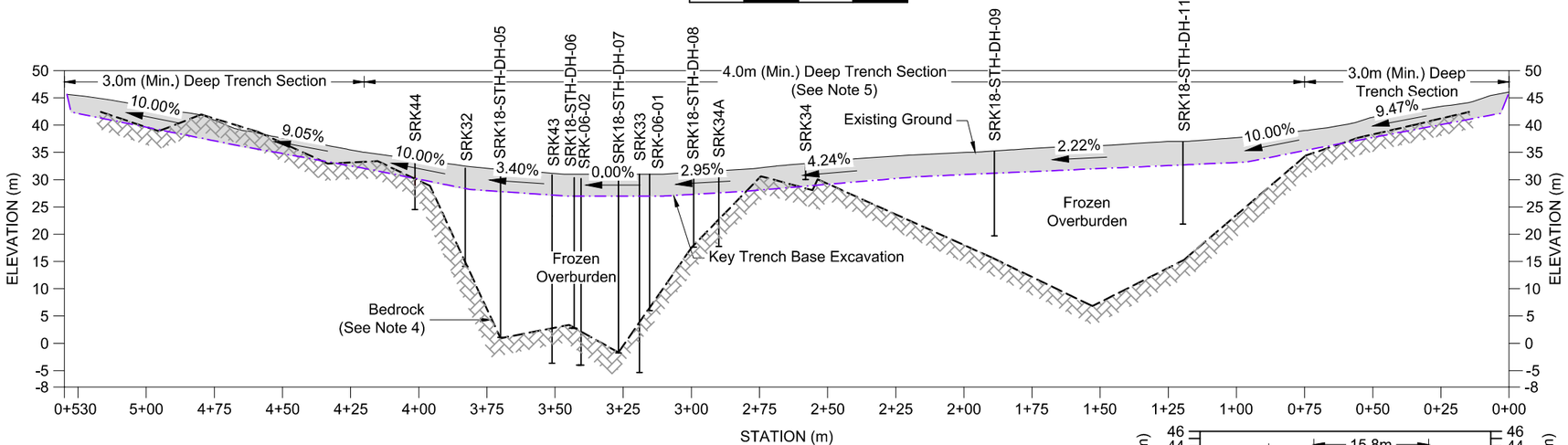


Key Trench Plan View

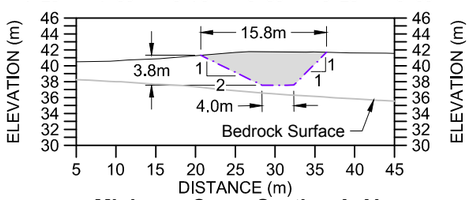
0m 20 40 60 80



Key Trench Profile View

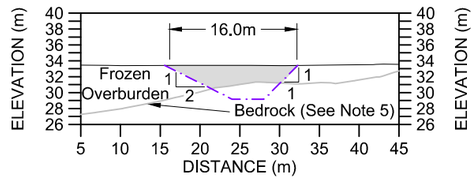
Vertical: 0m 10 20 30 40

Horizontal: 0m 20 40 60 80



Minimum Cross Section A-A'
Shallow Overburden over Bedrock

0m 5 10 15 20 25 30



Cross Section B-B'
Bedrock Outcropping in Key Trench

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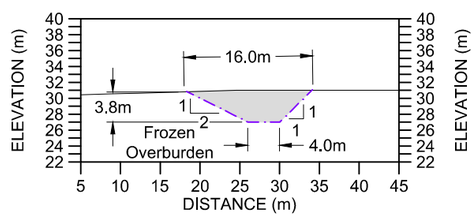

Cross Section C-C'
Deep Frozen Overburden

0m 5 10 15 20 25 30

LEGEND

- Drill Hole Location
- Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Trench Excavation Extent
- 1.00% Base Grades

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profile shown correspond to the upstream toe of the key trench.
4. The subsurface geology has been inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A , SRK43, SRK 44, SRK18-STH-DH01-11 and SRK18-WST-DH01-03), airphoto interpretations, and from limited available geophysical surveys around the Tails Lake area. This data was then used to create a bedrock surface with the Gemcom GEMS software. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.
5. The final key trench extent and depth will be determined in the field by the Engineer. Typical excavation depth is 4.0m, unless massive ice, hypersaline soil or bedrock encountered. The Engineer will inspect all excavations and approve the foundation conditions.
6. Ponded area to removed (frozen massive ice excavated or drained if possible). Up to approximately 4,700 m3 of (frozen) water may be expected to be removed from this area. Exact water levels are not known so the volume estimate above should be treated as a rough estimate based on topography.
7. If any area of the key trench is over-blasted or over-excavated then the extra excavation will need to be backfilled in thin lifts (*see 'Technical Specifications'*) until the key trench design lines and grades are reached.
8. Overblasting and/or overexcavation of the key trench beyond the design lines (as presented on this figure) should be avoided if at all possible. Extra care should be taken during the key trench excavation to ensure that the excavation can result as close to the design lines as possible. Excavation beyond the key trench design lines may require that the overall Phase 1 dam footprint be enlarged to provide the necessary thermal coverage and to uphold design requirements.

REFERENCES

NAD83 UTM Zone 13.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS | DRAWING NO. | DRAWING TITLE

REVISIONS

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Key Trench.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Key Trench Excavation Plan and Profile

DRAWING NO.: DN-SD-04 | SHEET: 4 OF 30 | REVISION NO.: 1

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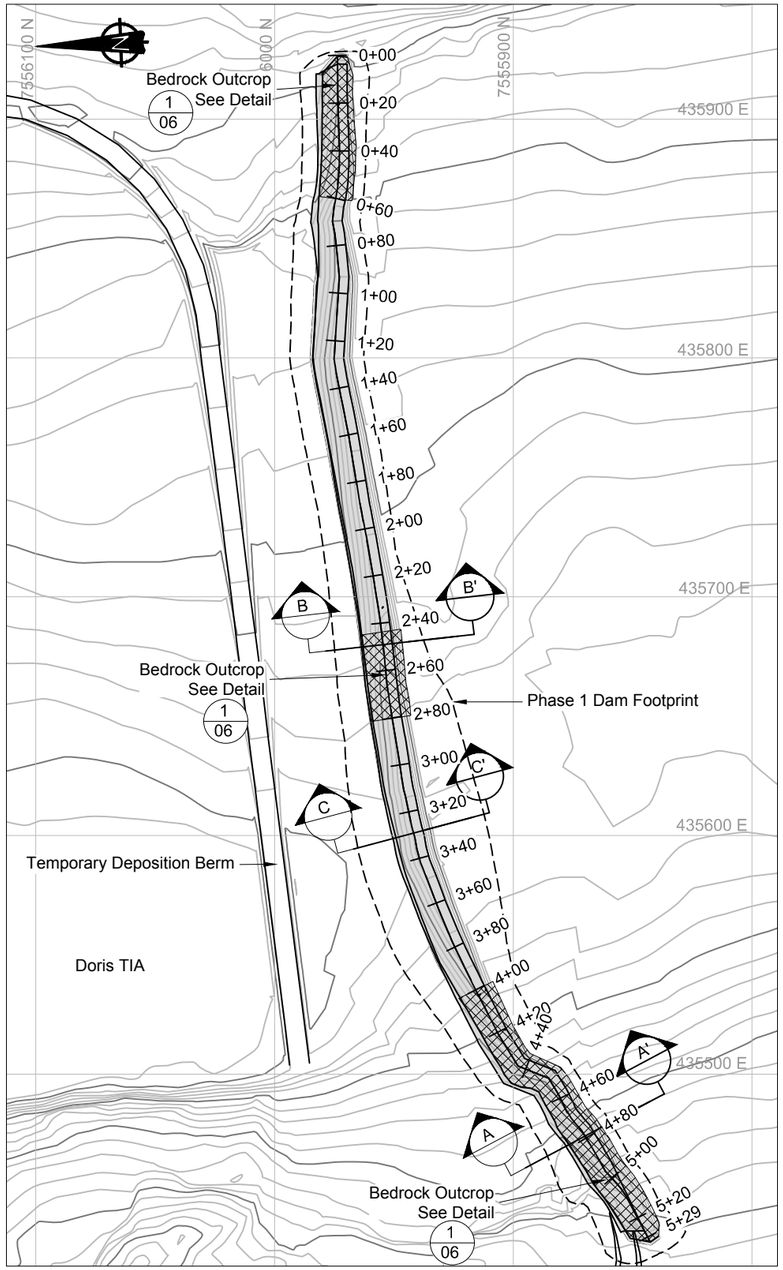
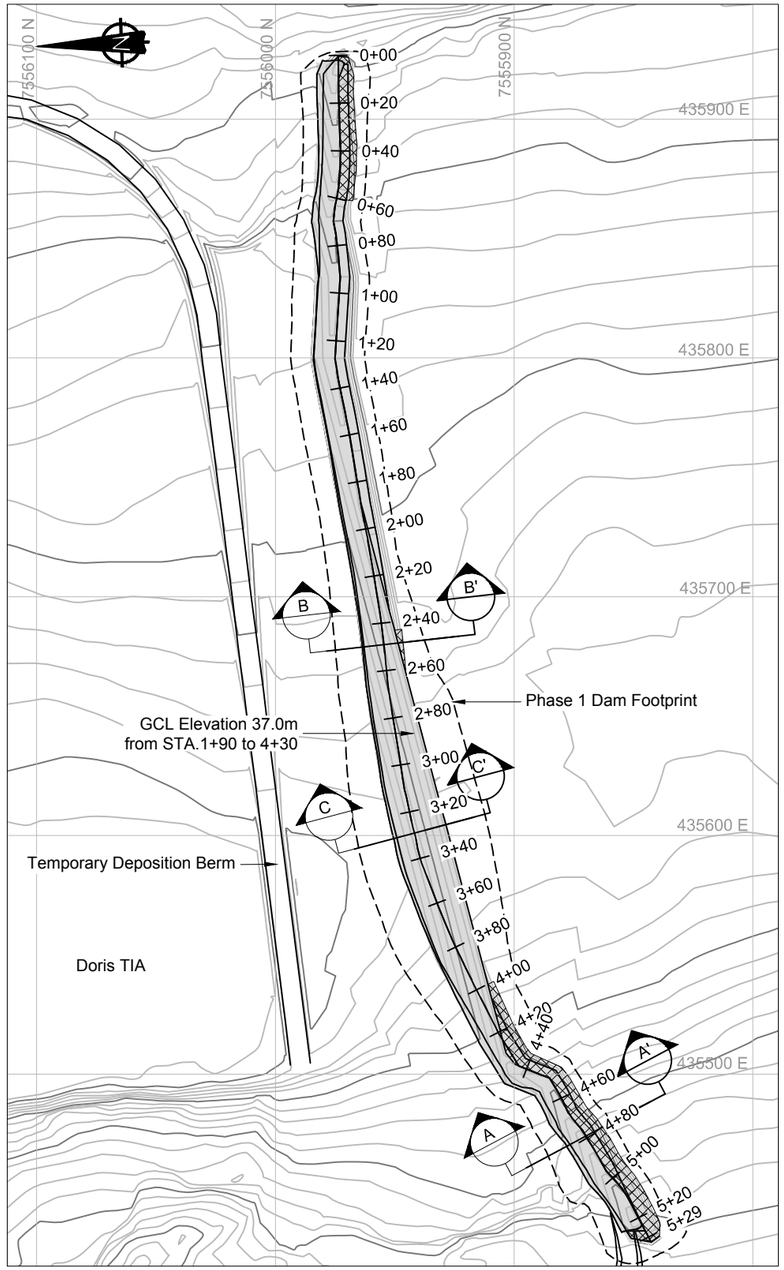


Lower Liner Plan - Placement in Key Trench

0m 20 40 60 80 100



Upper Phase 1 Liner Plan - Above Ground Upstream Slope Placement

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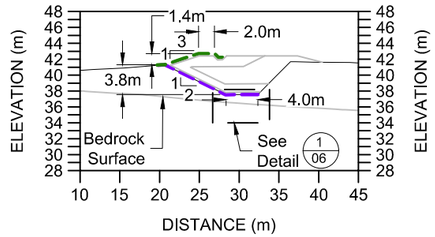

Minimum Cross Section A-A'

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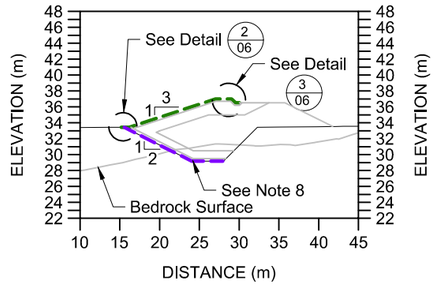

Cross Section B-B' - Bedrock Encountered in Trench

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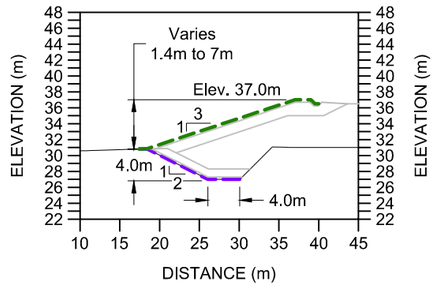

Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

- Key Trench Liner
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent
- GCL Liner Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The upstream slope of the key trench excavation need to be scraped and smoothed to prepare a suitable subbase for the GCL liner as determined by field Engineer. If any voids larger than 0.15m or undulation exist then they will need to be backfilled with compacted bedding material fill, placed in thin 0.15m lifts.
4. The subgrade surface must be free of vegetation, sharp-edged rocks, stones, sticks, construction debris, and other foreign material that could contact the GCL. Furthermore, all protrusions extending more than 12 mm from the subgrade surface shall either be removed, crushed, or pushed into the surface with a smooth-drum compactor.
5. GCL should not be placed over massive ice or standing water (both need to be removed prior to placement).
6. All Geosynthetic Clay Liner (GCL) liner sections / panels will be required to have a minimum 0.5m overlap on every edge. See Detail 2, 3, 5 and 6 on DN-SD-06 for additional information.
7. At the locations where bedrock is encountered in the key trench then these areas will be required to be ripped down to competent bedrock or scrapped smooth and then bentonite powder will be placed between the bedrock contact and the GCL liner (see Detail 1, DN-SD-06).
8. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m in depth), until competent bedrock is encountered, or as directed by Engineer.

REFERENCES

NAD83 UTM Zone 13.

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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							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-06	Liner and Bedding Placement Details	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Liner Placement Plan and Details Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-05	5 OF 30	1

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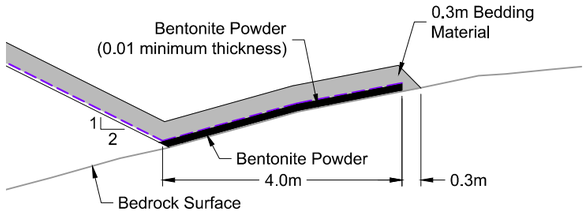
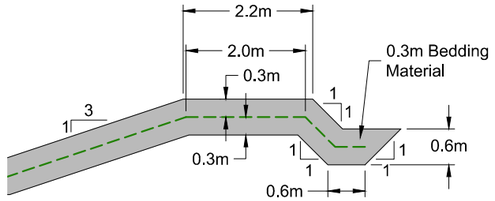
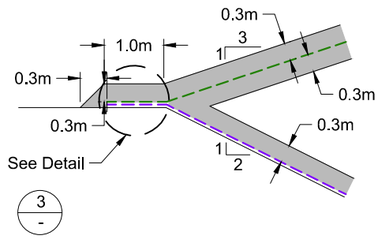
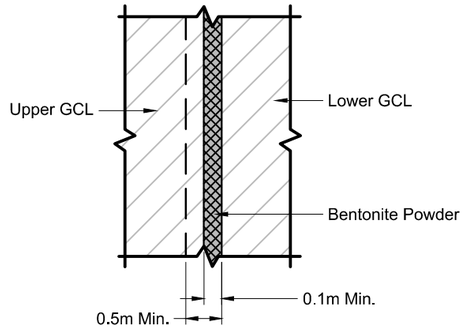


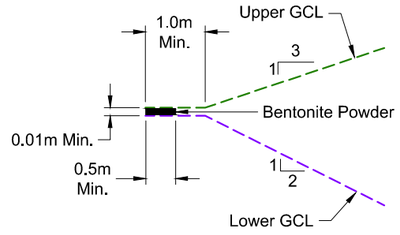
Detail 1 - Liner Attachment at Bedrock



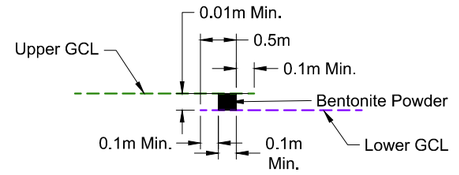


Detail 2 - Liner Overlap - Bedding



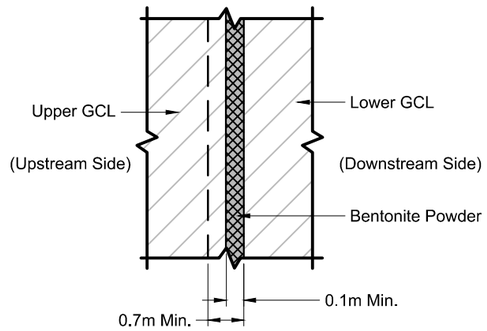


Detail 3 - Typical Upper and Lower GCL Joint



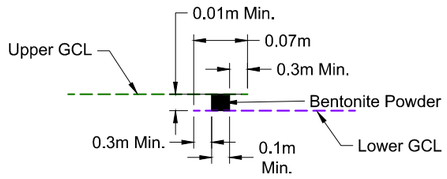
Detail 4 - Liner Anchor Trench Bedding

Detail 5 - Typical Longitudinal GCL Overlap - Plan



Detail 6 - Typical Longitudinal GCL Overlap - Section

Not To Scale



Detail 7 - Typical End of Panel GCL Overlap - Plan

Detail 8 - Typical End of Panel GCL Overlap - Section

Not To Scale

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material

NOTES

1. All units shown are in meters unless otherwise stated.
2. One end of the GCL roll should be anchored at the top of the slope. The front edge of the key trench (see Detail 4) shall be rounded so as to eliminate any sharp corners that could cause excessive stress on the GCL. Loose soil should be removed.
3. The GCL should be placed in the key trench such that it covers the entire key trench floor but does not extend up the rear trench wall (see Detail 4).
4. GCL seams are constructed by overlapping their adjacent edges (see Detail 5). Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris.
5. If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by placing a patch over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 500 mm is achieved around all parts of the damaged area. Bentonite mastic / powder should be applied around the damaged area prior to placement of the patch. It may be necessary to use an adhesive such as wood glue, or by hand placing material over the patch, to fix the patch in place so that it is not moved during overliner bedding material placement. Smaller patches also may be tucked under the damaged area to prevent patch movement.
6. Bedding shall be free of angular stones or other foreign matter which could damage the GCL. Cover soils should be approved by the Engineer, with respect to particle size and uniformity (as per the 'Technical Specifications').
7. Surface for the liner placement must be smooth competent 'virgin' ground with no loose or fractured material.

REFERENCES

NAD83 UTM Zone 13.

DRAWING NO.	DRAWING TITLE
-	-

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

MAC RESOURCES

Hope Bay Project

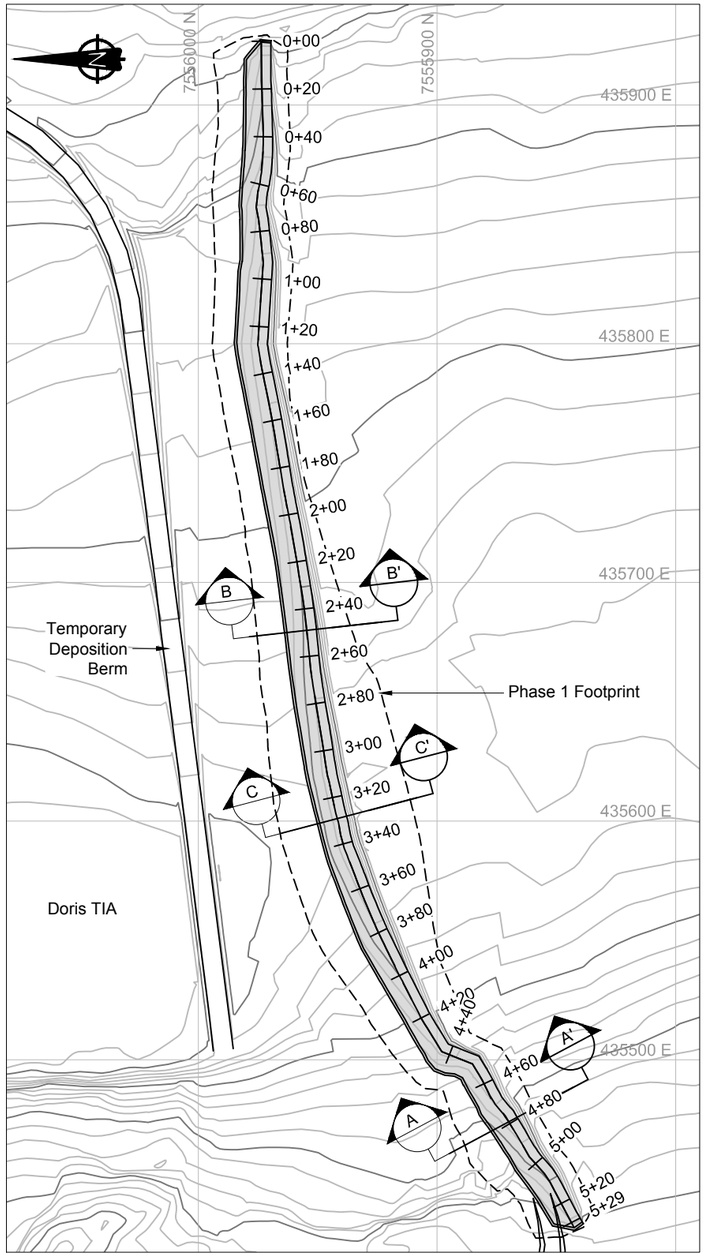
SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Liner and Bedding Placement Details

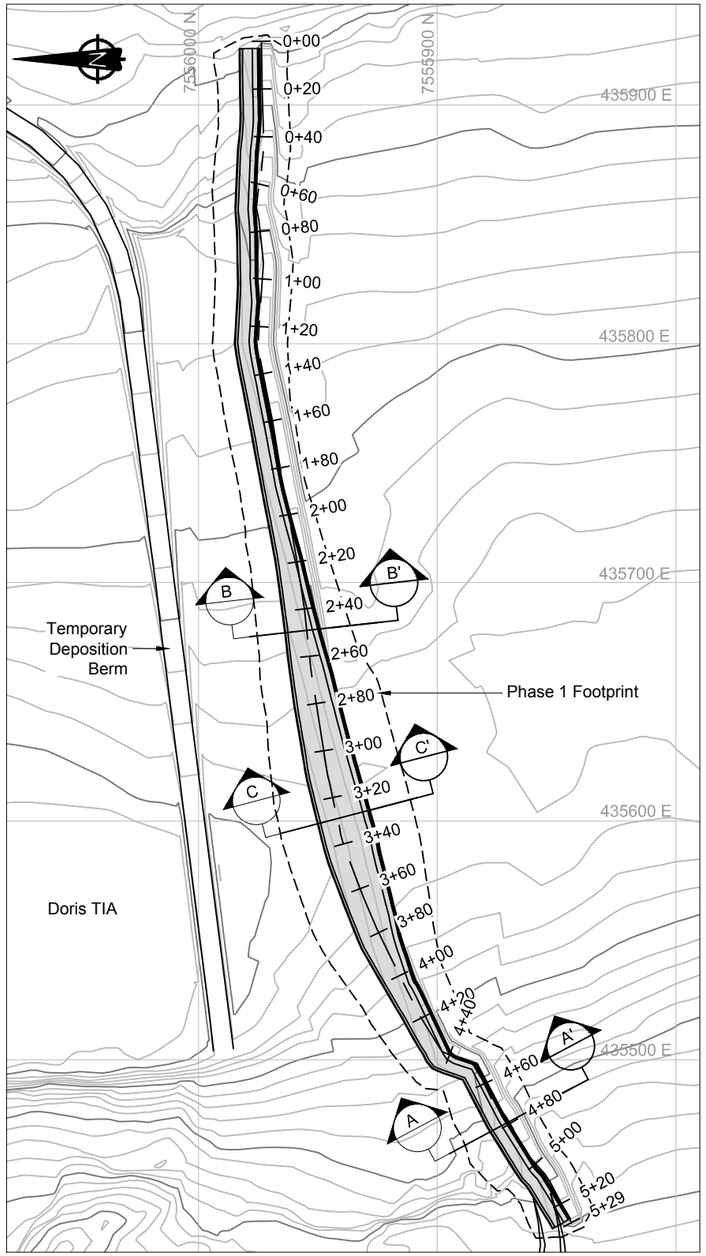
DRAWING NO.	SHEET	REVISION NO.
DN-SD-06	6 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1\1CT0022.017 - South Dam - Liner.dwg



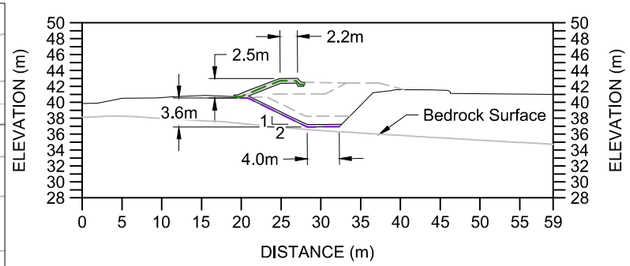
Key Trench Bedding Placement Plan View

0m 20 40 60 80 100



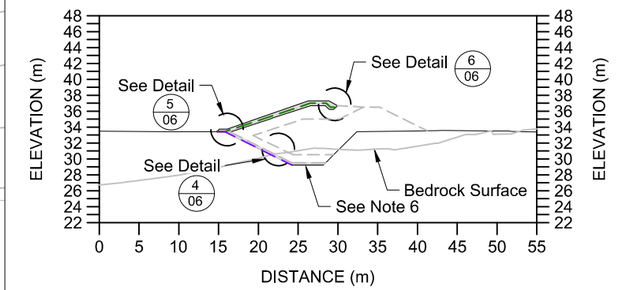
Phase 1 Dam Bedding Placement Plan View

0m 20 40 60 80 100



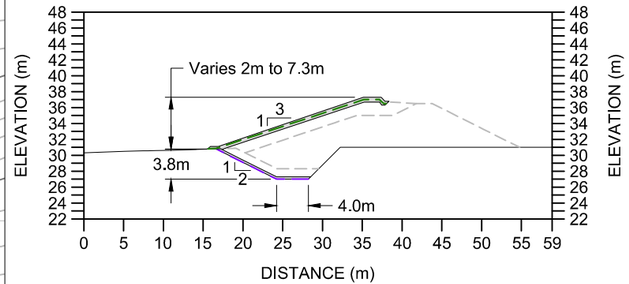
Minimum Cross Section A-A'

0m 5 10 15 20 25 30



Cross Section B-B' - Bedrock Encountered in Trench

0m 5 10 15 20 25 30



Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

- Phase 1 Dam Liner
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Bedding Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Bedding layer to be placed in 0.15m lifts and compacted before liner placement. The subsurface below the liner should be free of protrusions or any sharp / angular cobbles or larger size material. See the Technical Specifications document for more details (*'Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK).*
4. Bedding material cover shall be placed over the GCL using construction equipment that minimizes stresses on the GCL. Unless otherwise approved / directed by the Engineer a minimum thickness of 600mm or greater is required to be placed over any areas where heavy equipment will be trafficking over the liner. Thickness requirement are related to equipment type. For light equipment (which will have to be directly approved by the Engineer), as an absolute minimum a thickness of 300mm of cover must be maintained between light tracked equipment (e.g. skid-steer or 30 excavator) tracks/tires, and the GCL at all times during the covering process.
5. Soil cover should be placed in a manner that prevents the soil from entering/disturbing the GCL overlap zones.
6. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

REFERENCES

NAD83 UTM Zone 13.

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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							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-06	Liner and Bedding Placement Details	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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JKB	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Bedding.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Bedding Material Placement Plan and Sections - Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-07	7 OF 30	1

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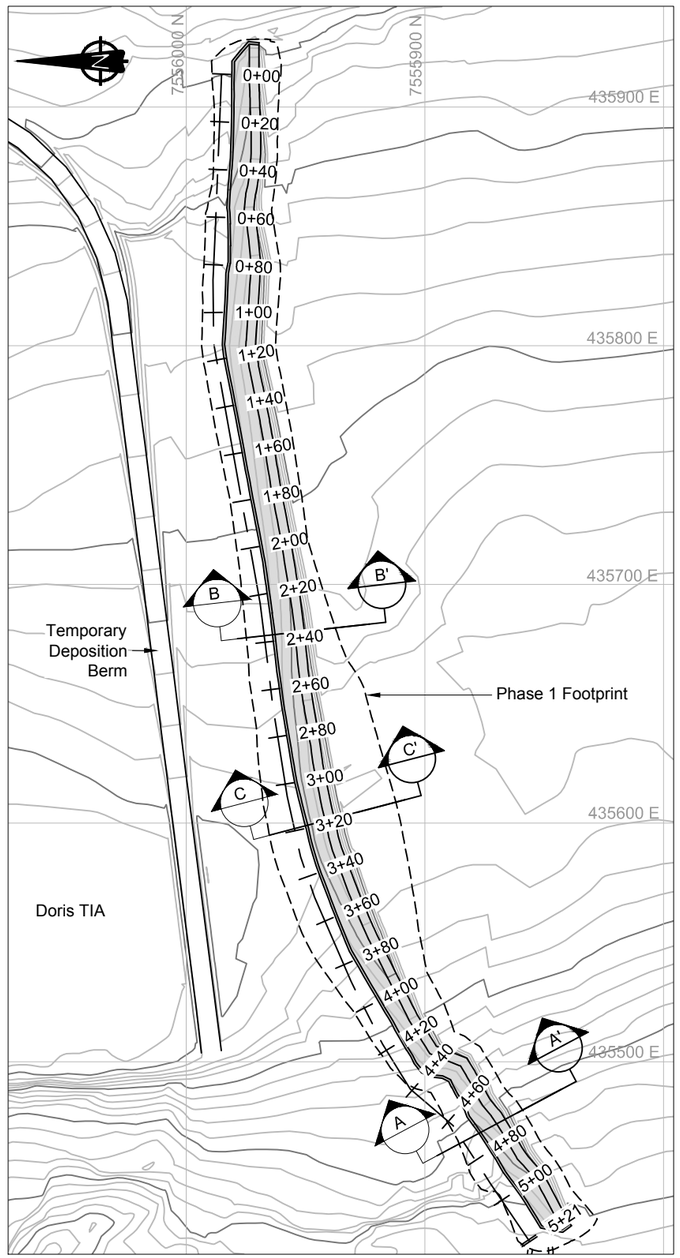
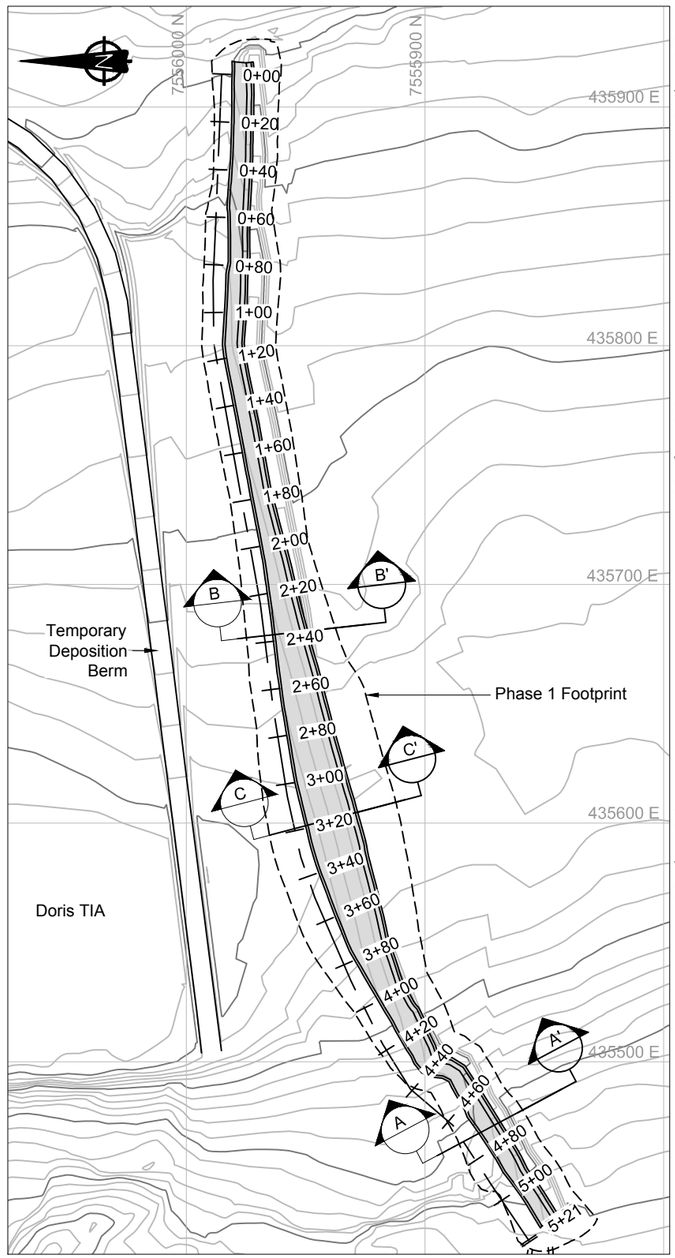


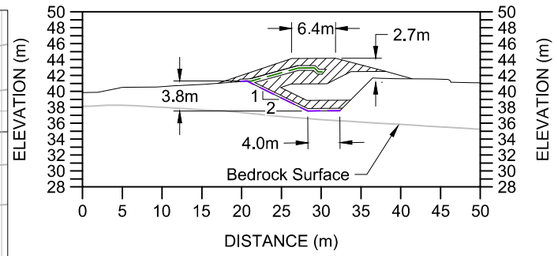
Key Trench Bedding Placement Plan View

0m 20 40 60 80 100



Phase 1 Dam Bedding Placement Plan View

0m 20 40 60 80 100



Minimum Cross Section A-A'

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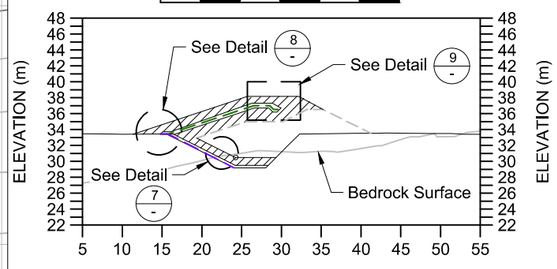

Cross Section B-B' - Bedrock Encountered in Trench

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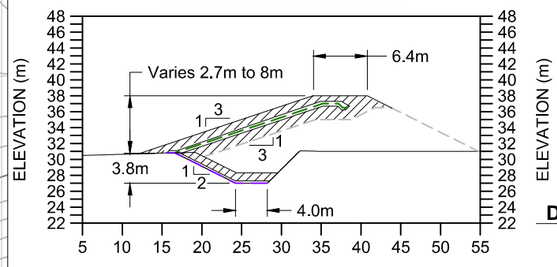


Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

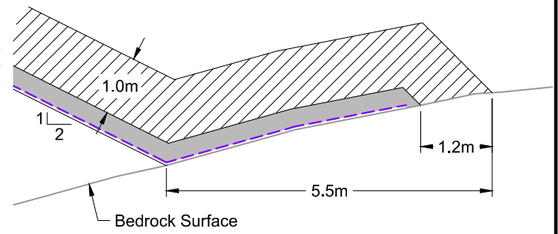
- Phase 1 Dam Liner
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Bedding Material
- Transition Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.

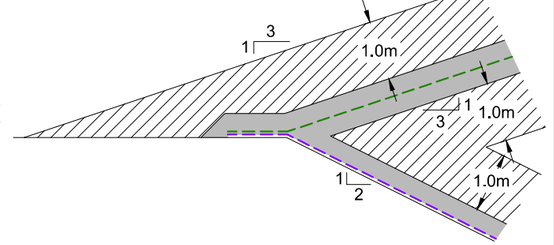
REFERENCES

NAD83 UTM Zone 13.



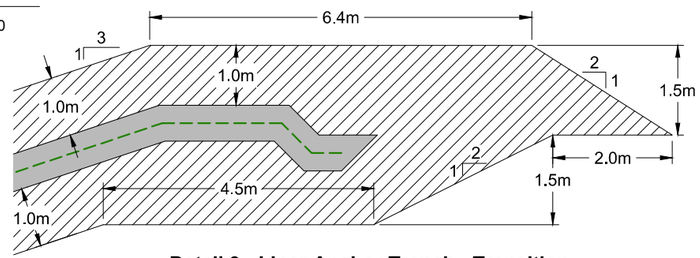
Detail 7 - Key Trench Bedrock Interface - Transition

0m 1 2 3 4



Detail 8 - Upper and Lower GCL Liner Overlap - Transition

0m 1 2 3 4



Detail 9 - Liner Anchor Trench - Transition

0m 1 2 3 4

-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
		-	-				0	Issued for Construction	JBK	EMR	17/11/29
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
REFERENCE DRAWINGS		REVISIONS									

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Transition.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Transition Material Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-08	7 OF 30	1

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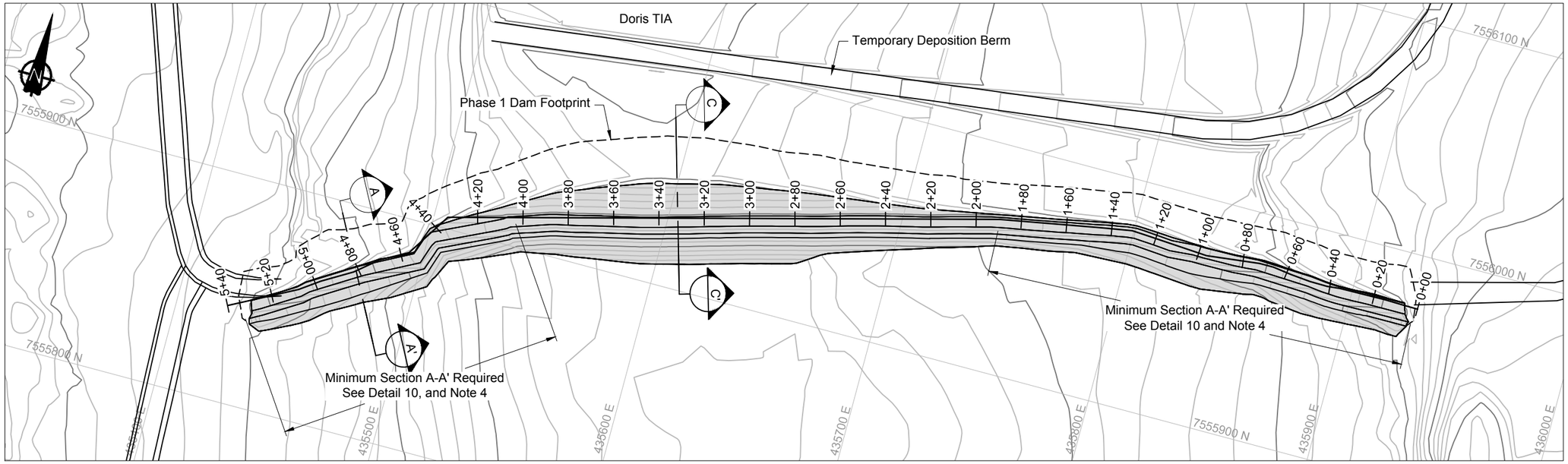


Run of Quarry Placement Plan View

0m 20 40 60 80

LEGEND

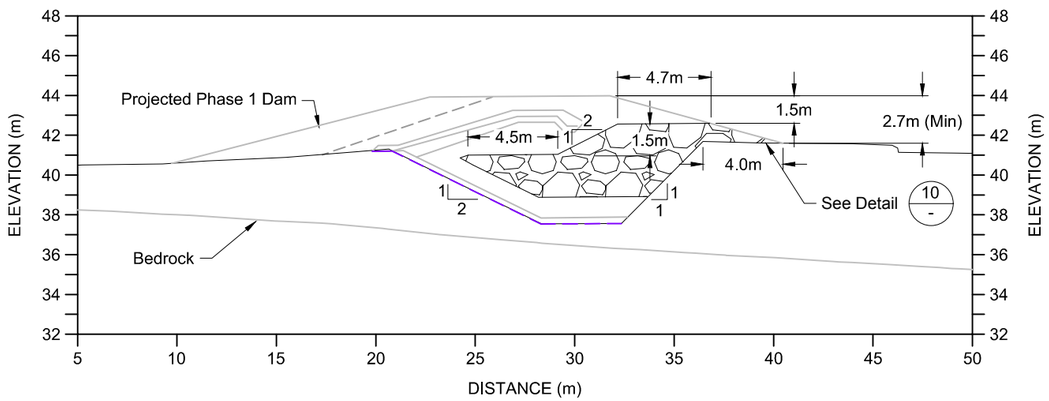
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Run of Quarry Backfill Extent
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profiles shown correspond to the upstream toe of the key trench.
4. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench. See Detail 10 on drawing DN-SD-09 for additional details.
5. The outside downstream ROQ should be sloped at 2H:1V or shallower.

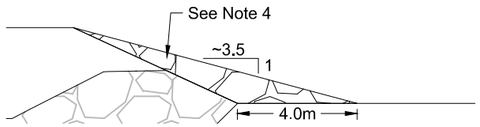
REFERENCES

NAD83 UTM Zone 13.



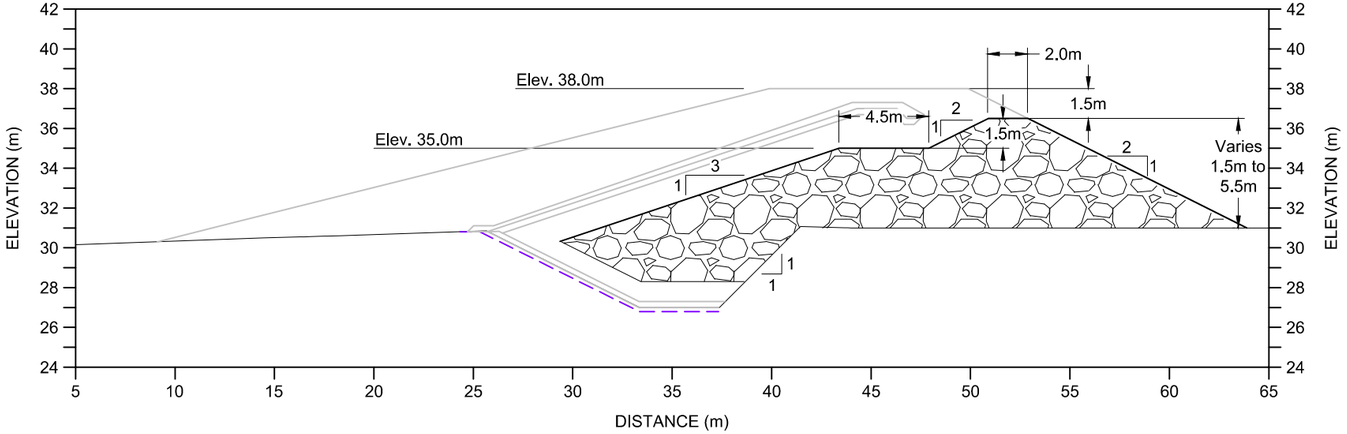
Minimum Cross Section A-A'

0m 3 6 9 12



Detail 10 - Contingency ROQ Thermal Barrier Design

0m 2 4 6 8



Typical Cross Section C-C'

0m 3 6 9 12

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1					
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-09	9 OF 30	1

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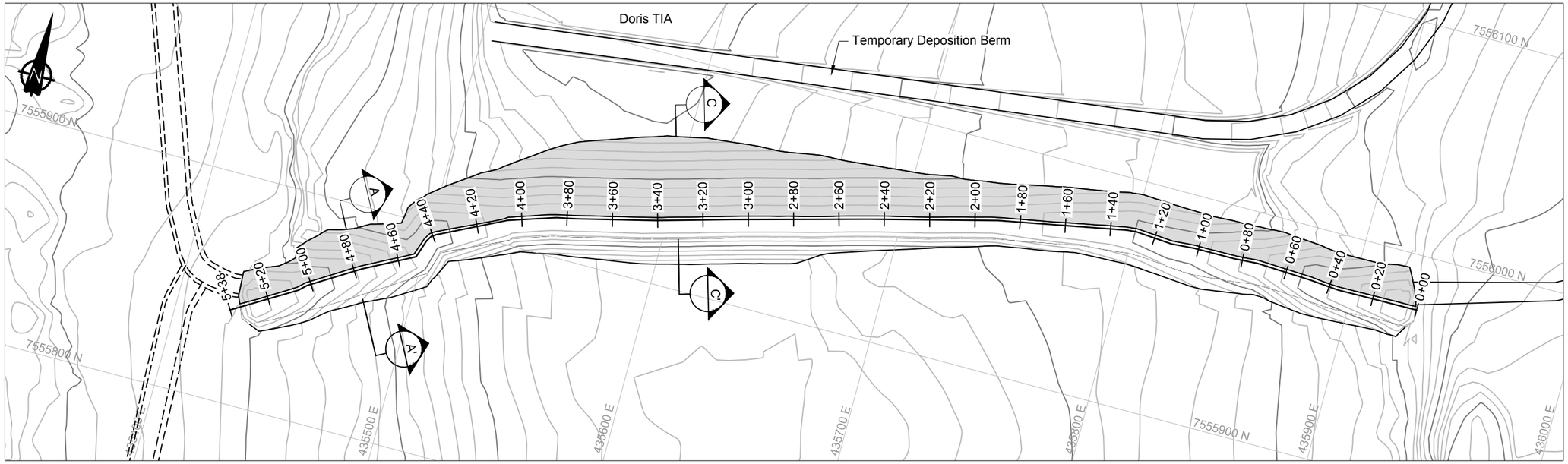
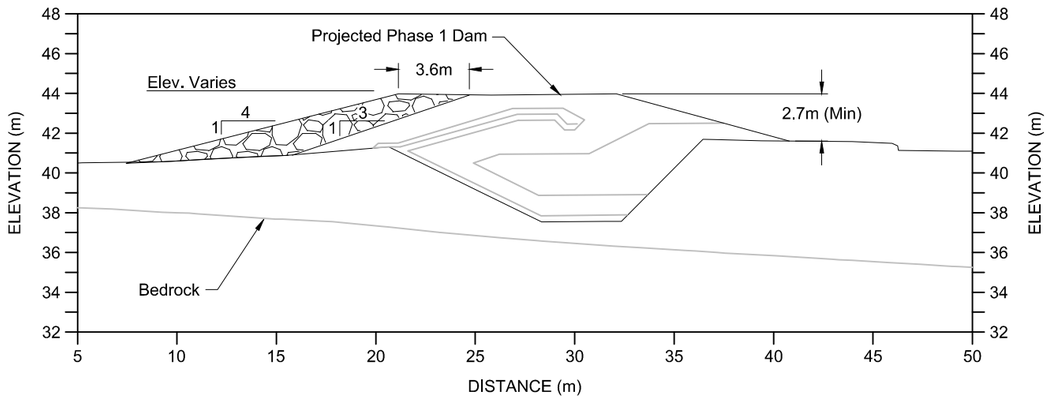


Run of Quarry Placement Plan View

0m 20 40 60 80



Minimum Cross Section A-A'

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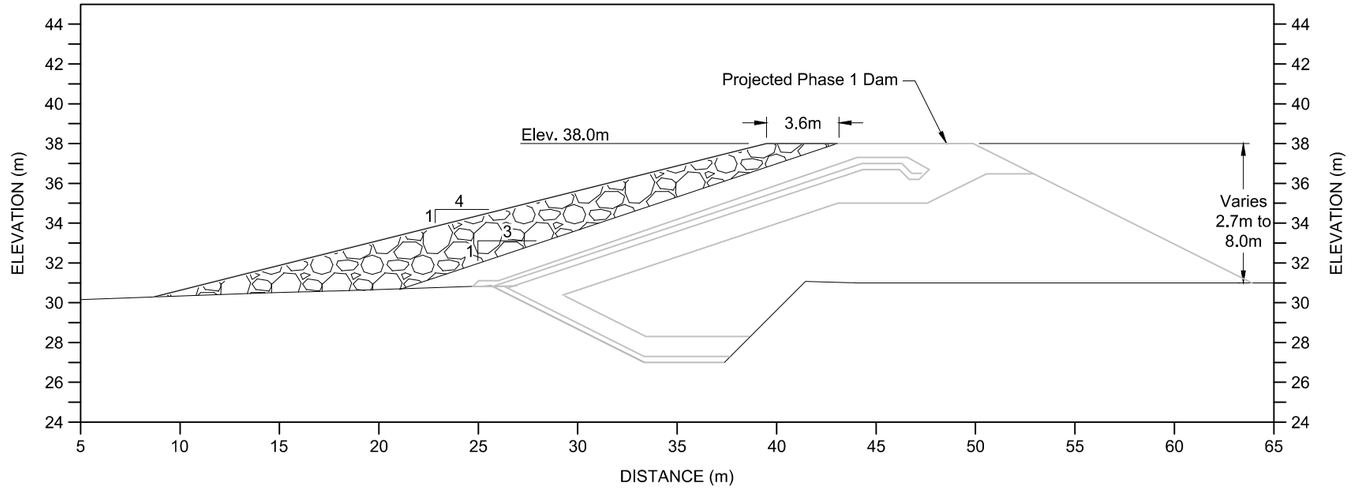

Typical Cross Section C-C'

0m 3 6 9 12

LEGEND

- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Run of Quarry Backfill Extent
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The outside upstream dam ROQ should be sloped at 4H:1V or shallower.

REFERENCES

NAD83 UTM Zone 13.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ-us.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-10	10 OF 30	1

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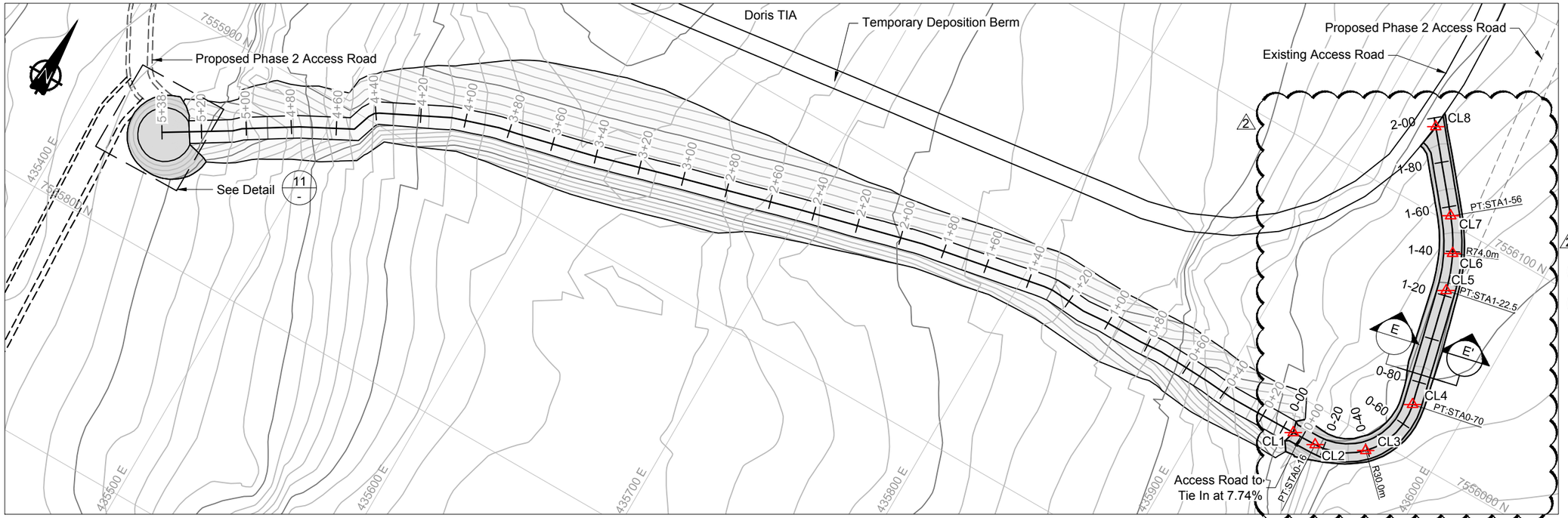
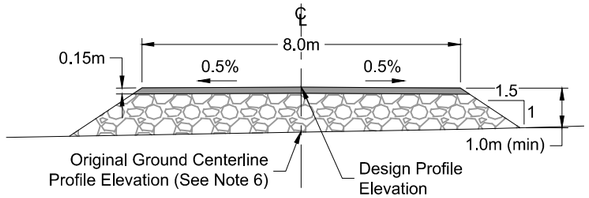
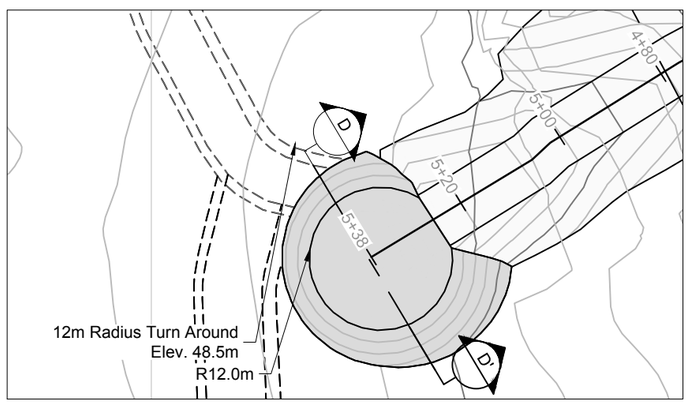


East Access Road and West Turn Around

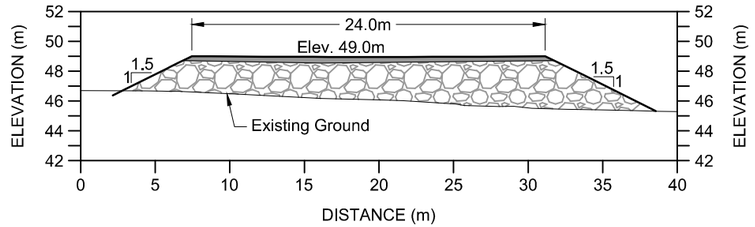
0m 20 40 60 80





Detail 11 - Turn Around

0m 10 20 30 40

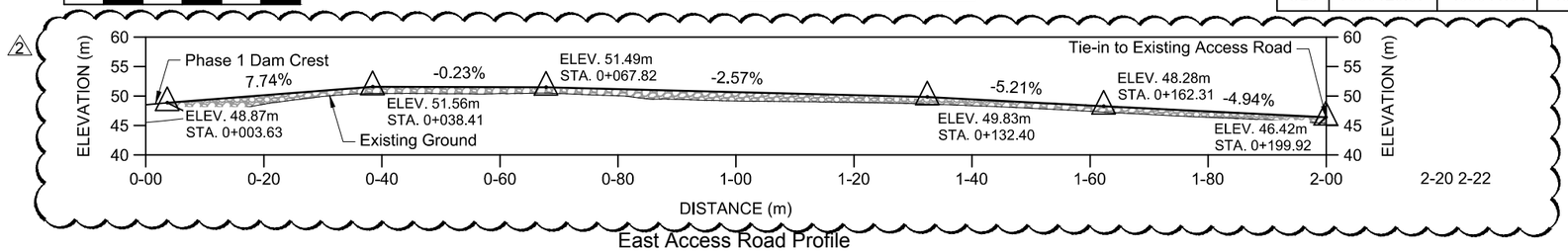


Section D-D' - Turn Around

0m 4 8 12 16

Section E-E' - Typical Road Section

0m 1 2 3 4 5 6



East Access Road Profile

0m 10 20 30 40

LEGEND

- Stakeout Point
- Vertical Inflection Point
- Proposed Road / Dam Infrastructure
- Phase 1 Access Road
- Run of Quarry
- Surfacing Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Approximately 2,440m³ of Fill material is estimated (to neat lines) to be needed for the Access Road and Turn Around.
4. Minimum fill thickness for Access Road and Turn Around is 1.0m
5. Construction shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction.
6. Profile based on available topography. Existing ground level to be surveyed prior to construction to confirm design thickness achieved.

REFERENCES

NAD83 UTM Zone 13.

STAKEOUT POINTS

ID	Northing	Easting	Elev. (m)
CL1	7555976.16	435925.08	48.97
CL2	7555976.39	435936.14	49.83
CL3	7555985.34	435956.86	51.56
CL4	7556013.44	435964.66	51.45
CL5	7556064.69	435952.27	51.09
CL6	7556080.41	435946.53	49.48
CL7	7556094.44	435937.41	48.61
CL8	7556125.37	435911.91	46.61

REFERENCE DRAWINGS		REVISIONS								
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29
DN-SD-03	Typical Sections (General)						1	Issued for Construction	JBK	EMR	18/04/13
							2	Issued for Construction	JBK	EMR	18/04/30

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JBK	EMR	2018/04/30

FILE NAME: 1CT0022.017 - South Dam AR.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Construction Access Road and Turnaround - Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-11	11 OF 26	2

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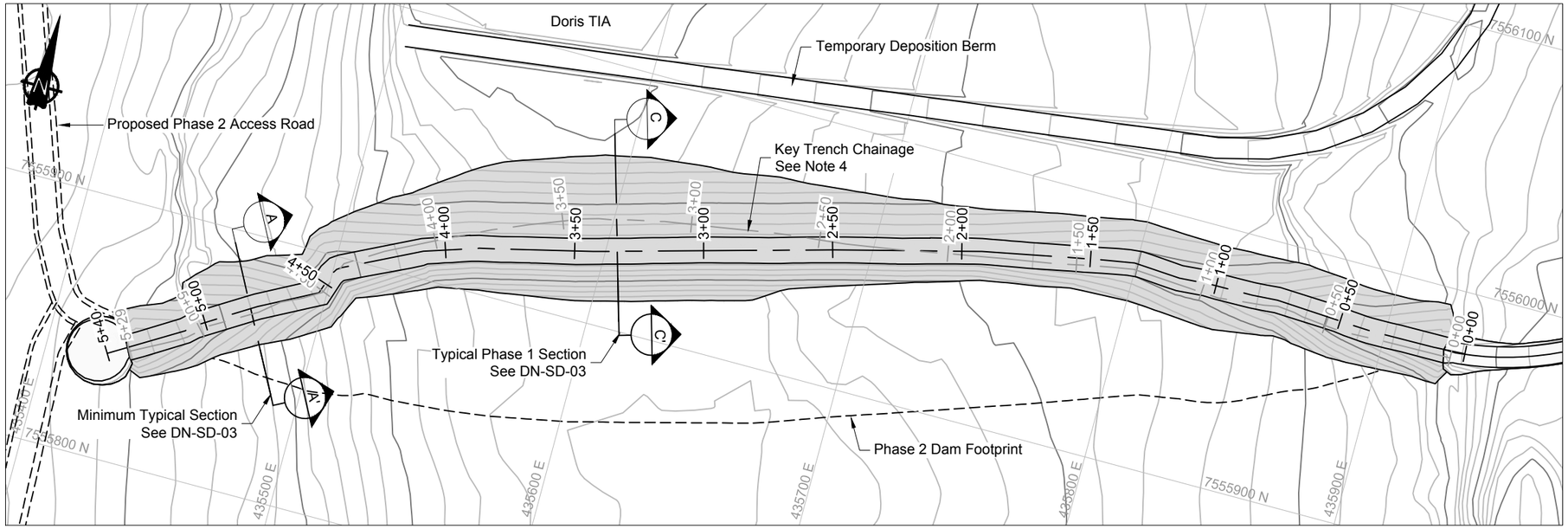

Phase 1 Dam Plan View

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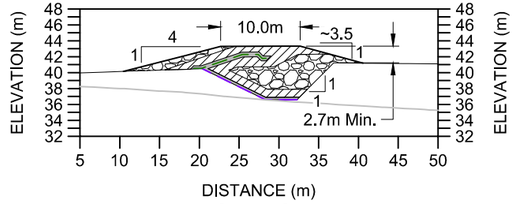
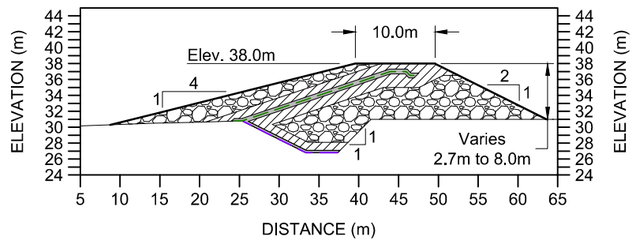


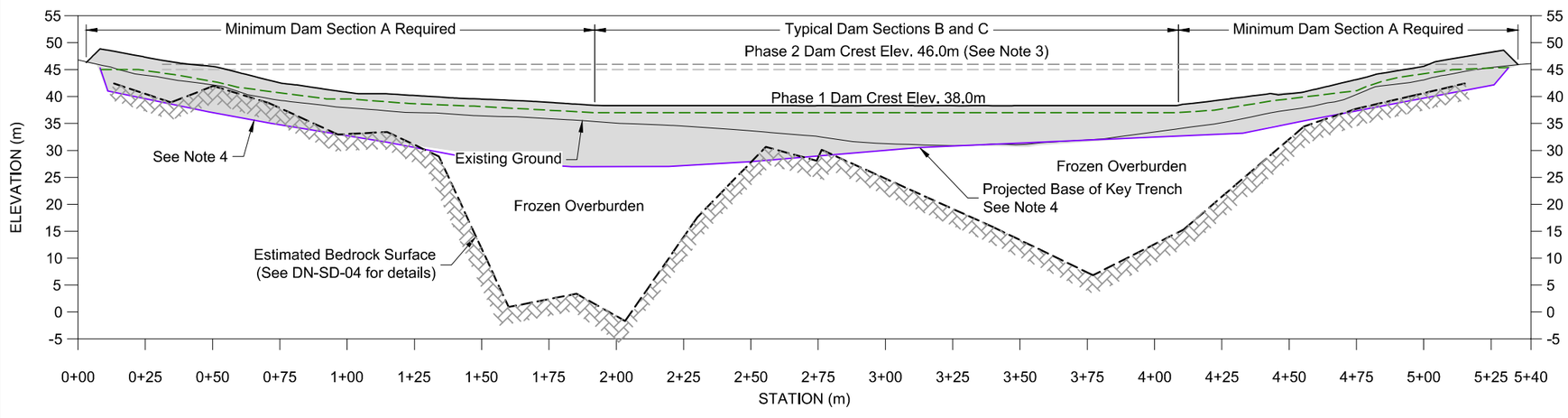
Minimum Cross Section A-A'

0m 5 10 15 20 25 30



Cross Section C-C'

0m 5 10 15 20 25 30



Phase 1 Dam Profile View - Through Crest Centerline

Horizontal: 0m 10 20 30 40

Vertical: 0m 20 40 60 80

LEGEND

- Key Trench Excavation
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The Phase 2 dam elevations are shown for information purposes only. Note that only Phase 1 dam designs and elevations are issued for construction use.
4. Base of key trench on this profile is based on a section down the centerline of the dam crest. Note that the key trench centerline and the dam crest centerline do not share the exact same alignment and overall the chainages vary in any given location (between the key trench and dam crest shown in these drawings) in the range of ±5m.

REFERENCES

NAD83 UTM Zone 13.

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
DN-SD-04	Key Trench Excavation Plan and Profile
DN-SD-03	Typical Sections (General)
DN-SD-02	Phase 1 General Arrangement

REVISIONS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Phase 1 Dam.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Final Phase 1 Dam Plan, Profile and Sections

DRAWING NO.	SHEET	REVISION NO.
DN-SD-12	12 OF 30	1

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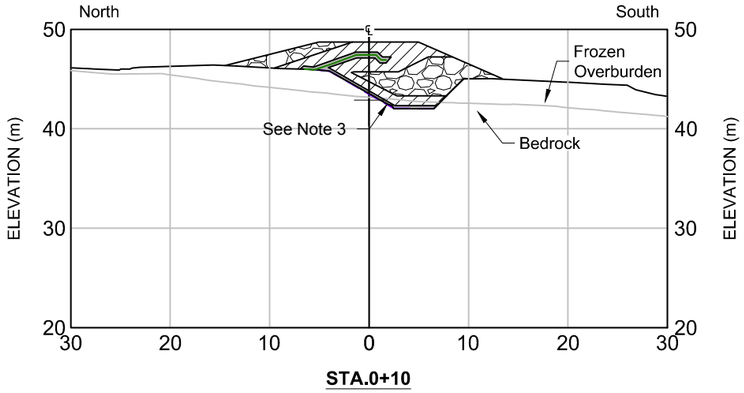

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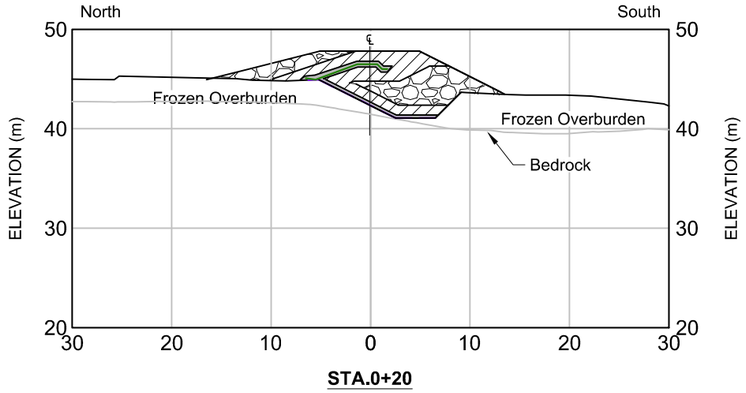

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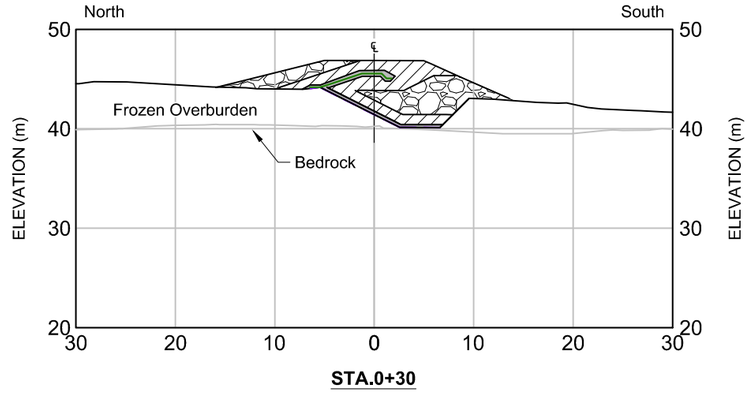

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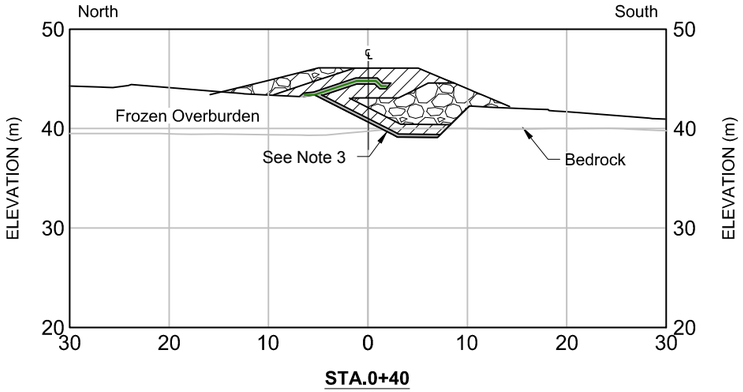

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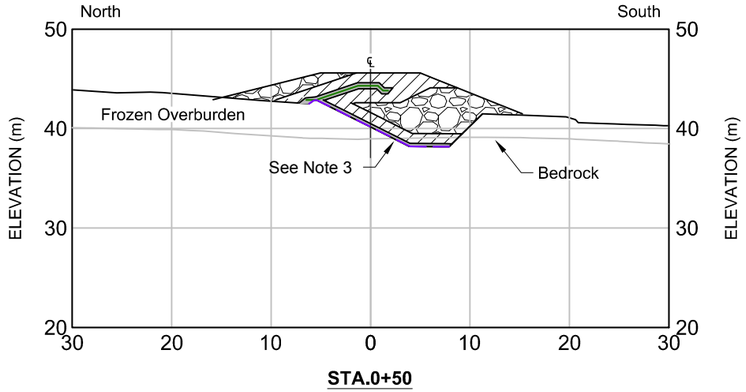

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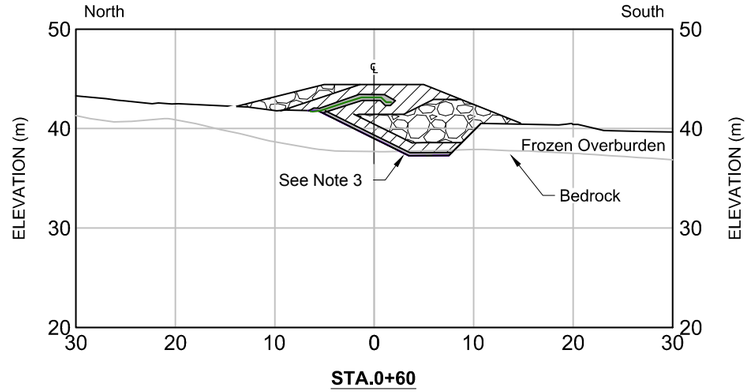

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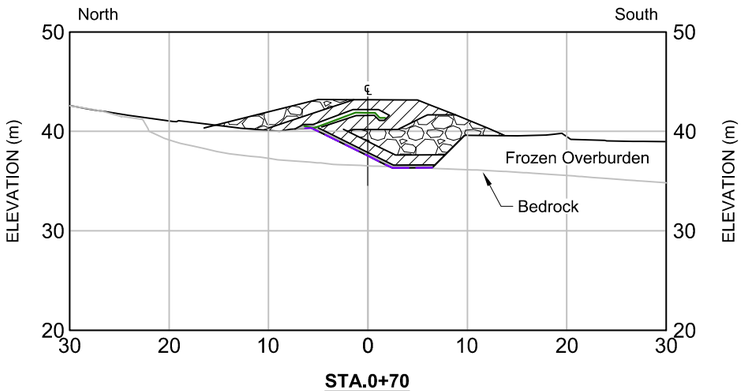

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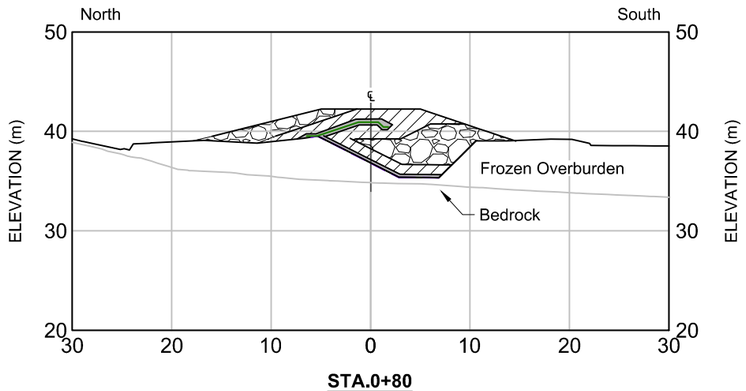

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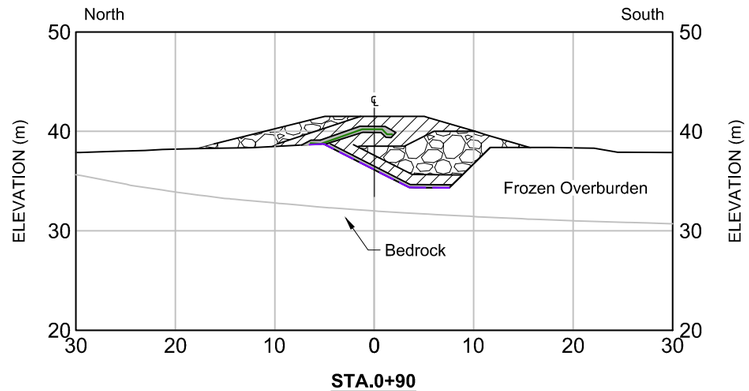

STA.0+90

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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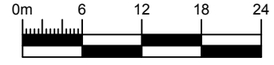

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.0+10 to 0+90 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-13	13 OF 30	1

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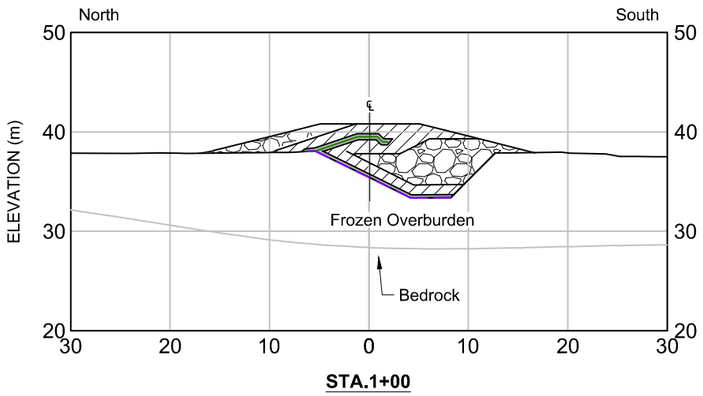

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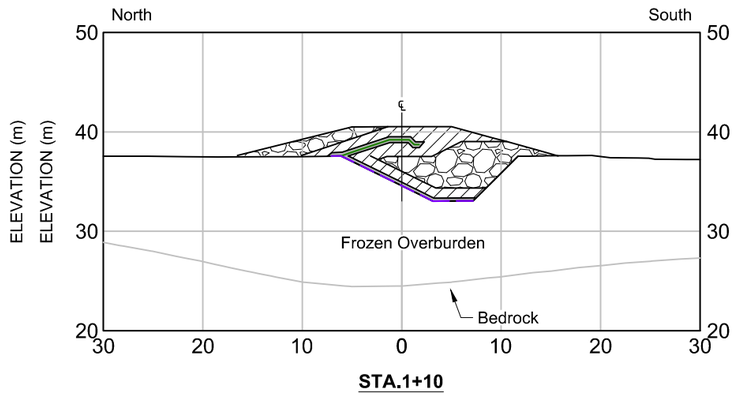

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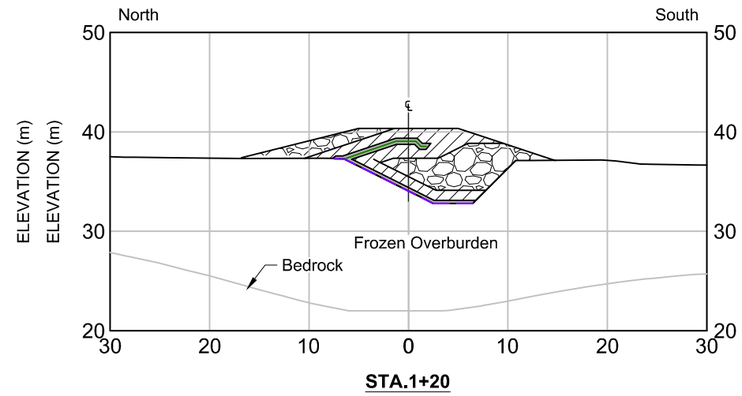

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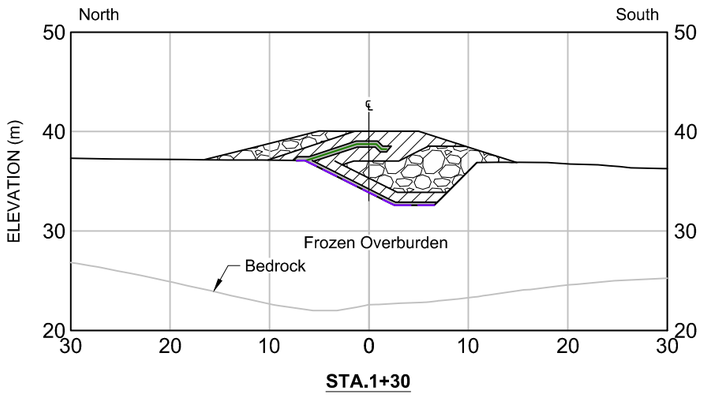

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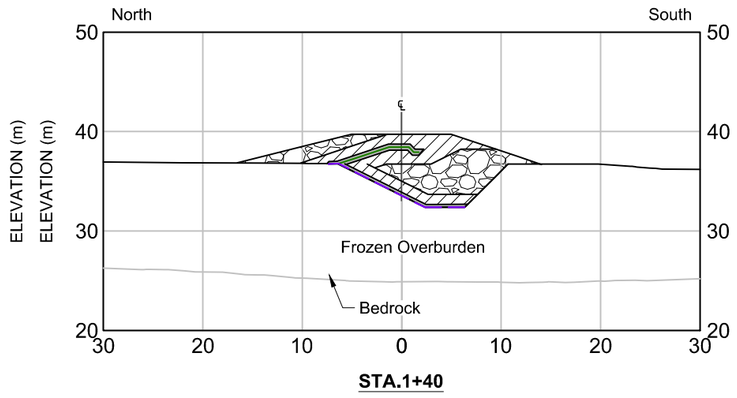

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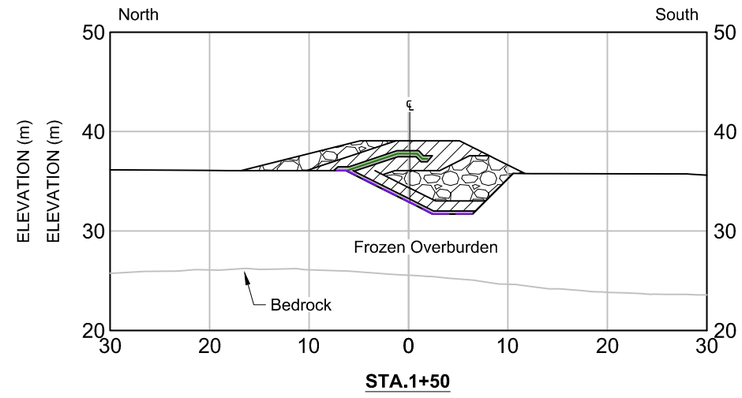

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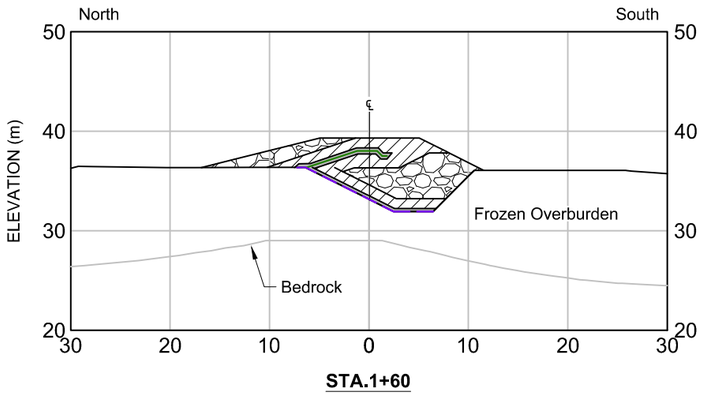

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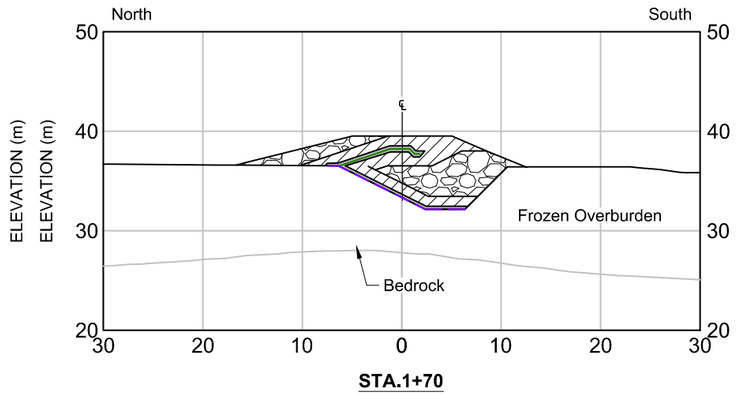

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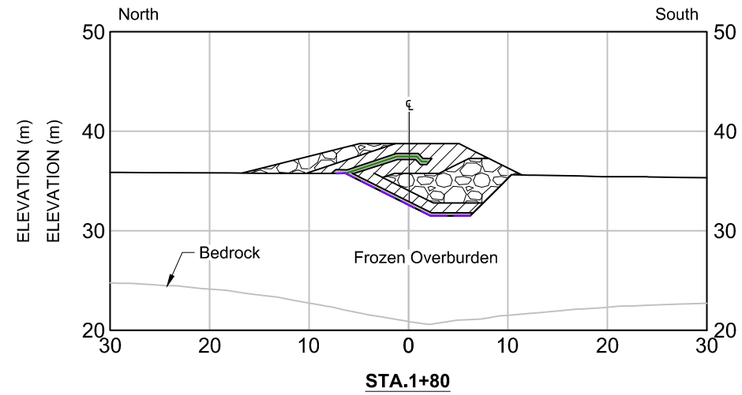

STA.1+80

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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0m 6 12 18 24

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-02	Phase 1 General Arrangement	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.1+00 to 1+80 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-14	14 OF 30	1

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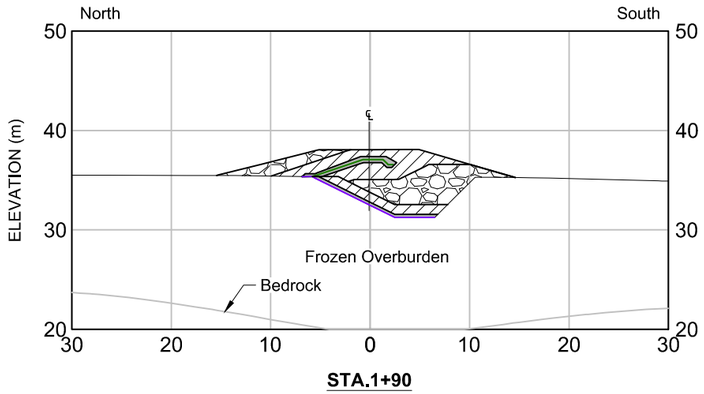

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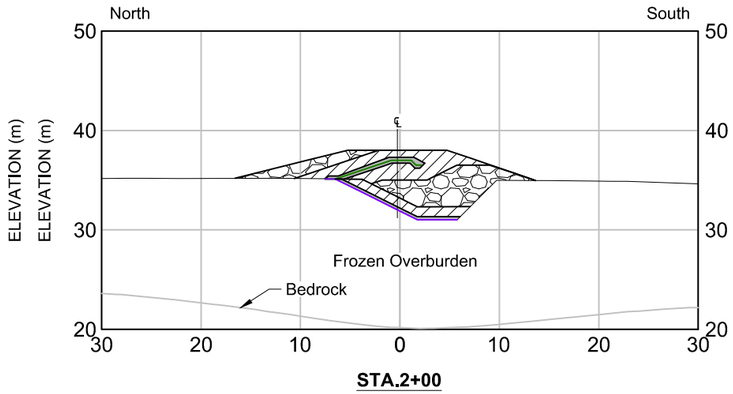

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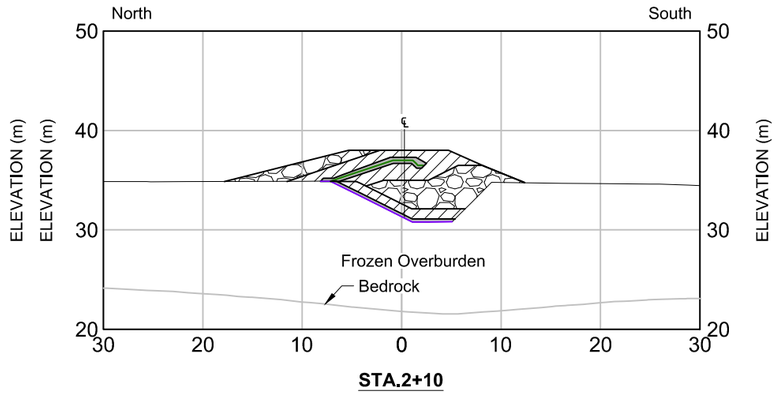

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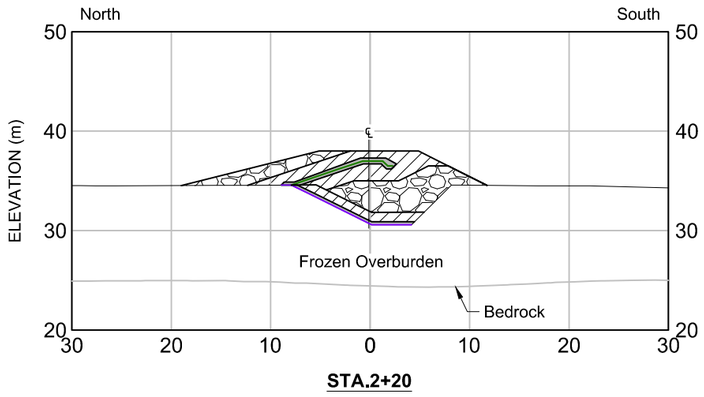

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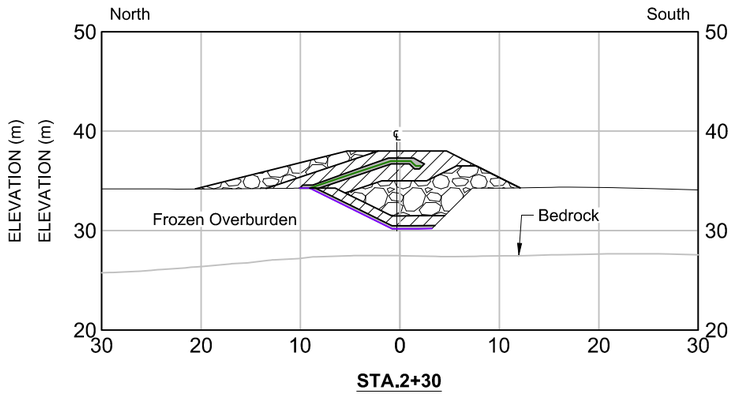

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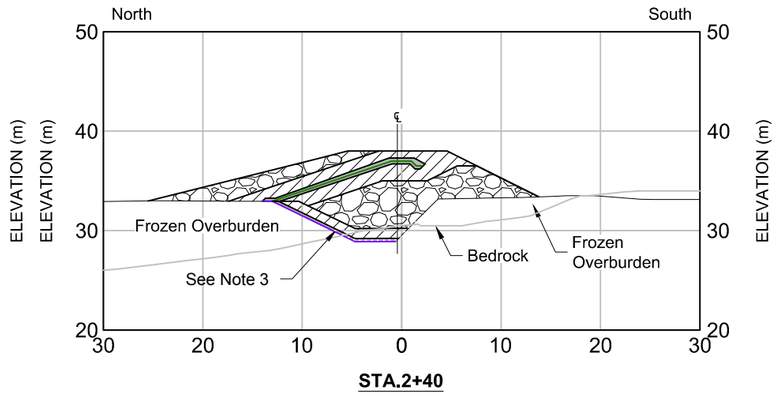

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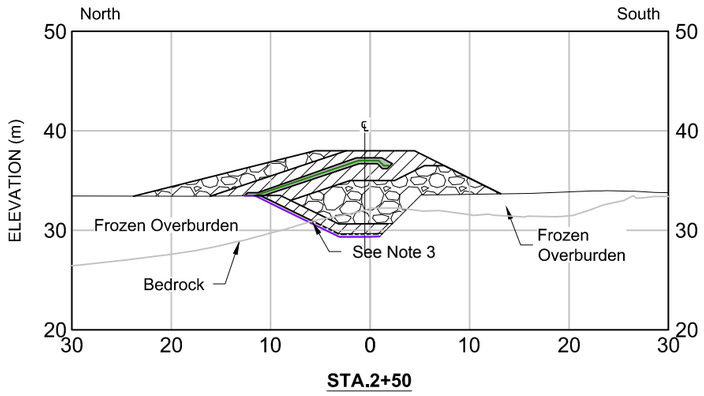

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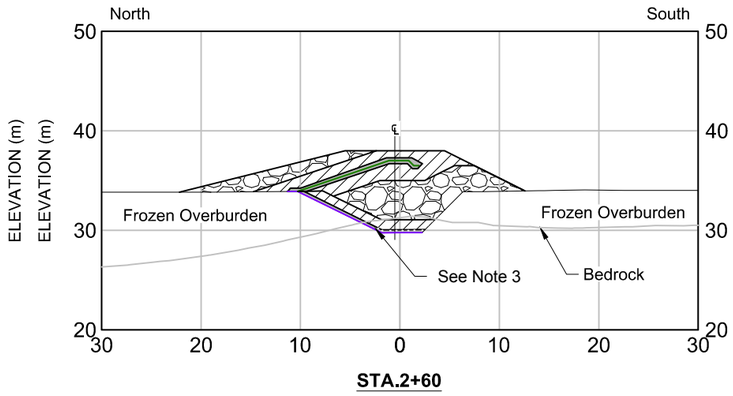

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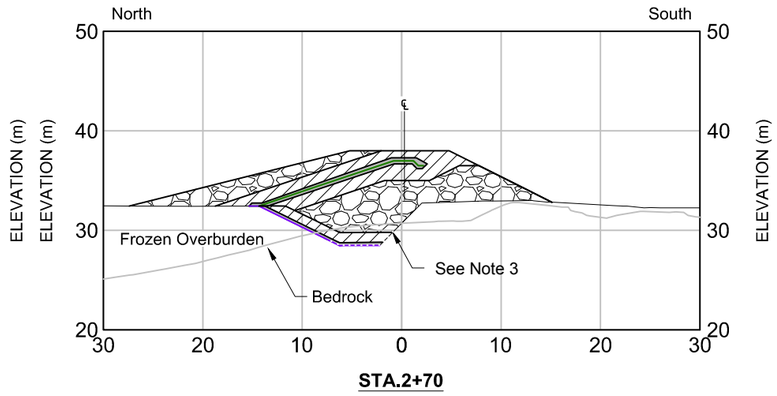

STA.2+70

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.1+90 to 2+70 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-15	15 OF 30	1

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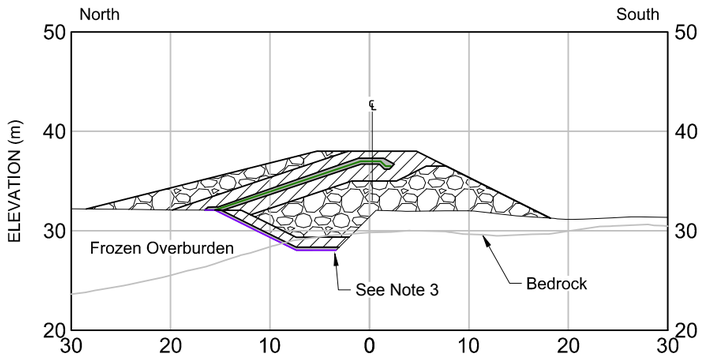

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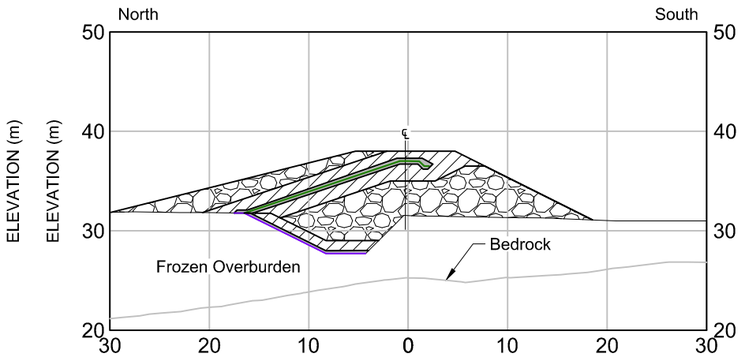

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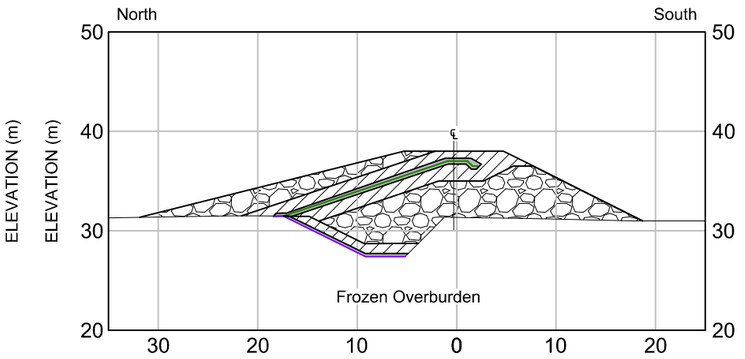

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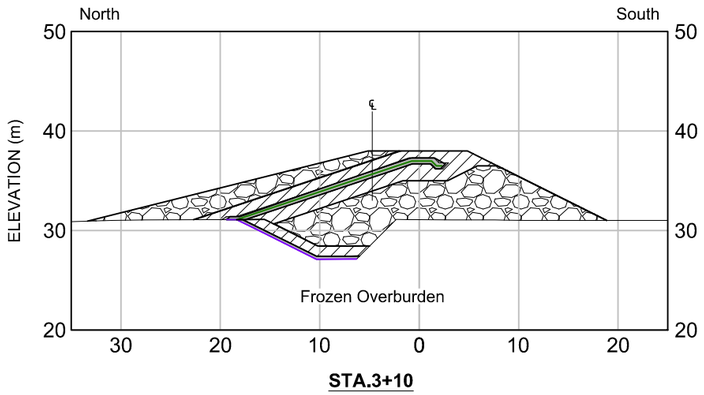

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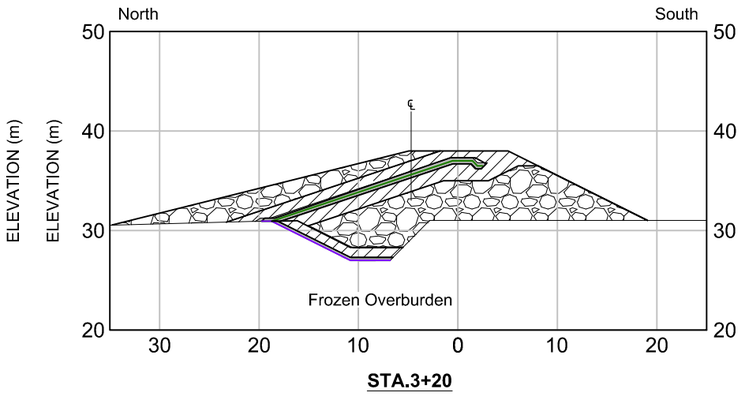

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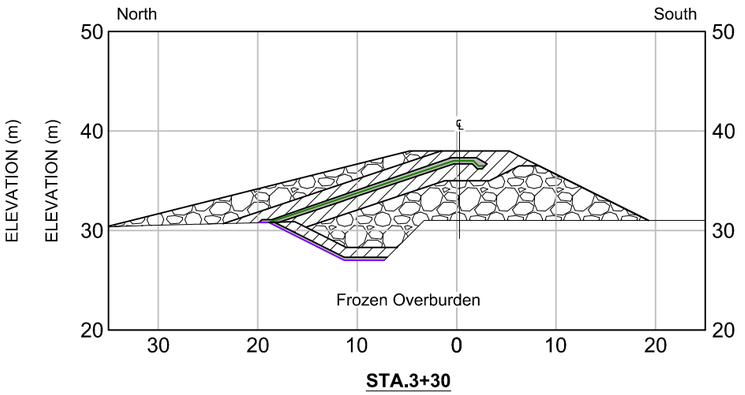

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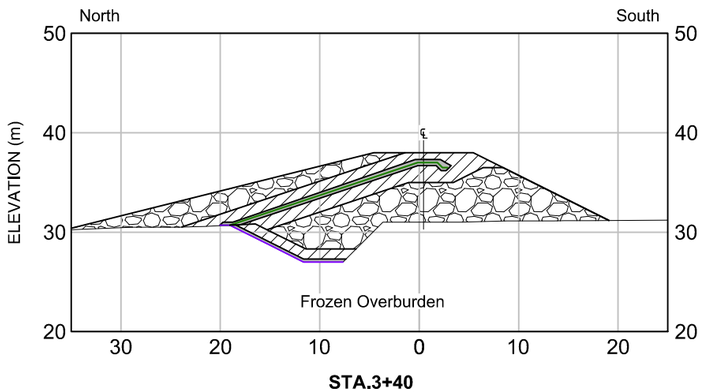

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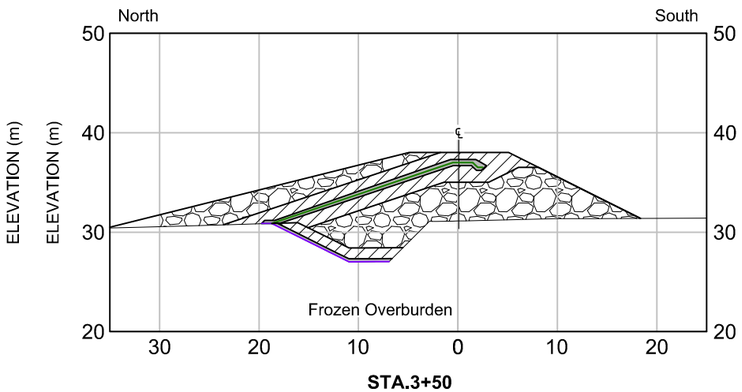

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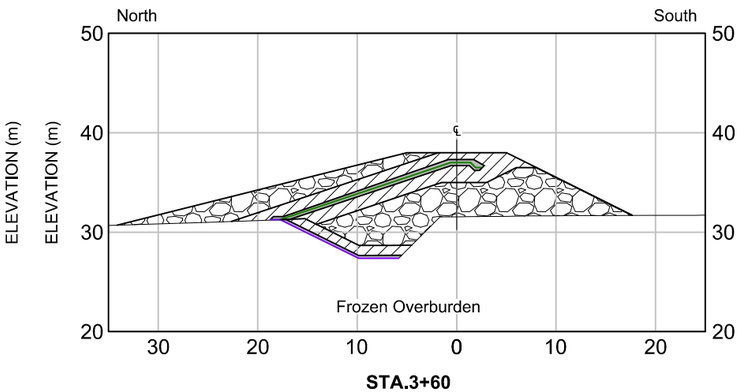

STA.3+60

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

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0m 6 12 18 24

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0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

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FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

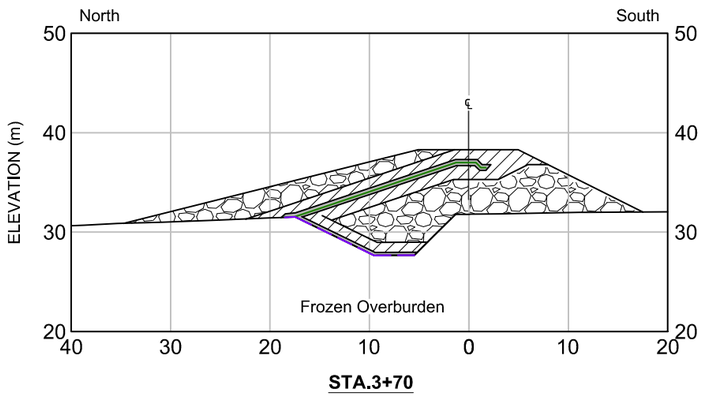
SRK JOB NO.: 1CT022.017

South Dam

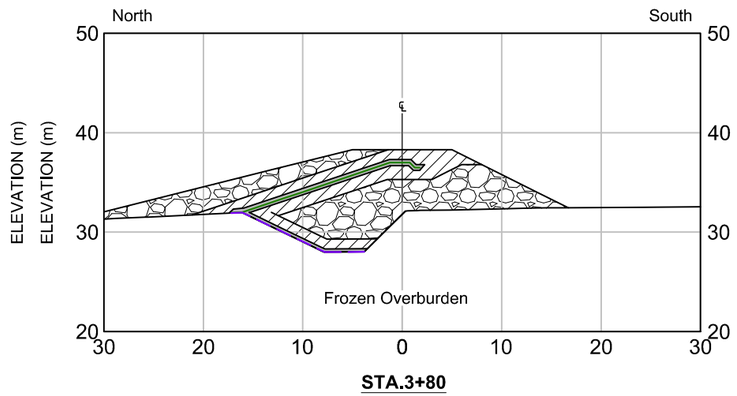
DRAWING TITLE: Sections Sta.2+80 to 3+60 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-16	16 OF 30	1

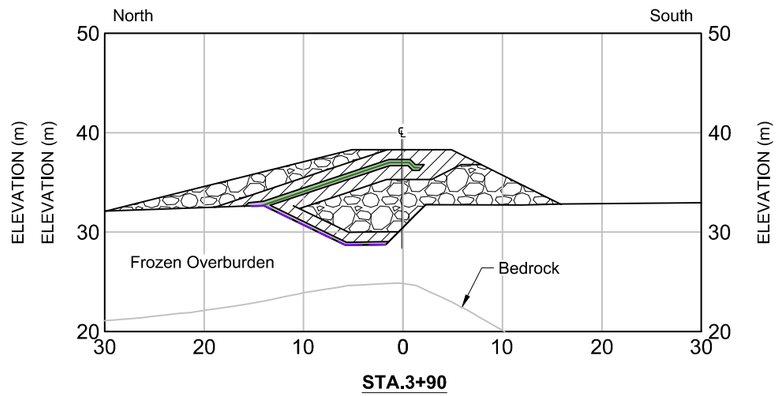
P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1-internal\1CT0022.017 - South Dam - Sections.dwg



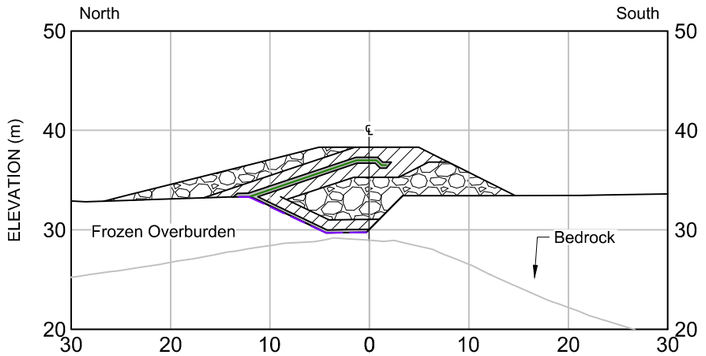
STA.3+70



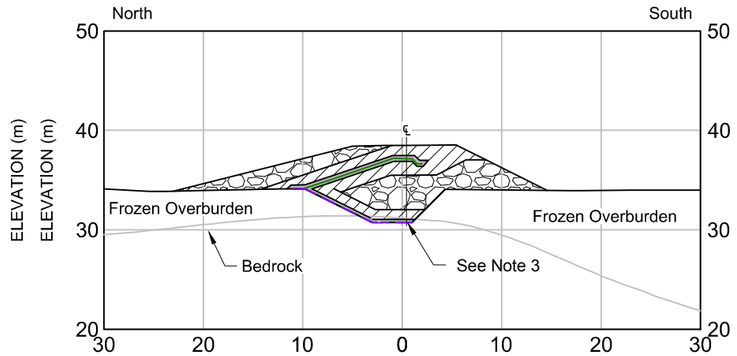
STA.3+80



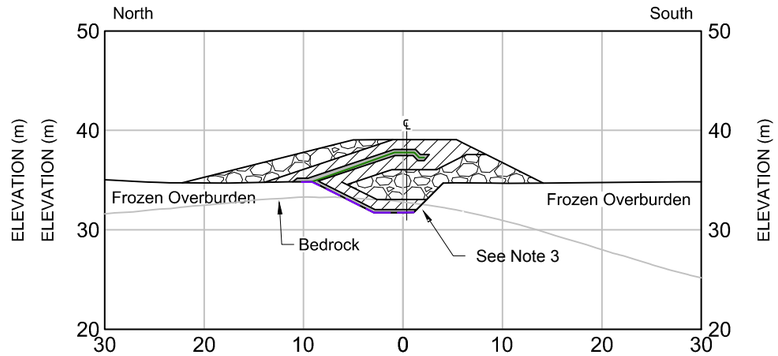
STA.3+90



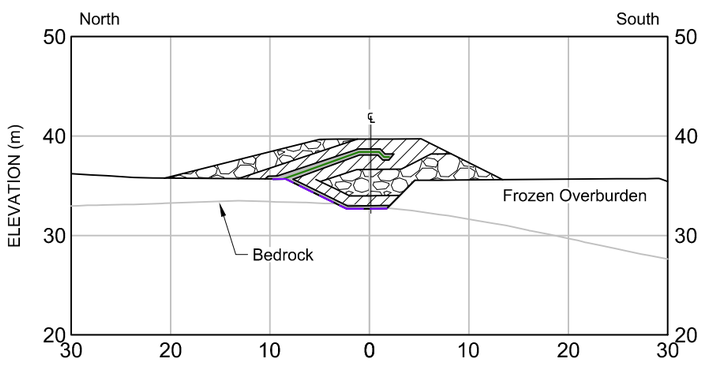
STA.4+00



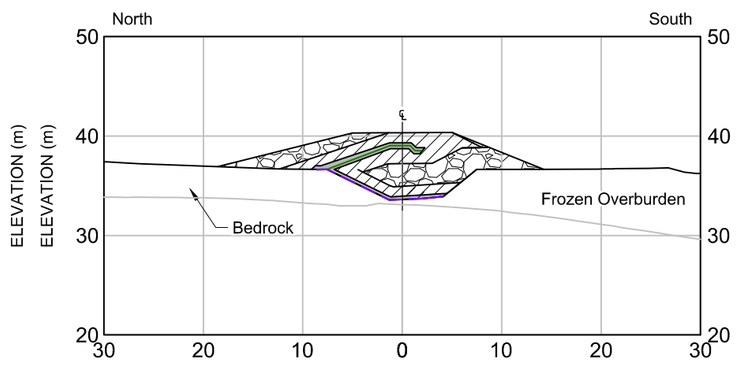
STA.4+10



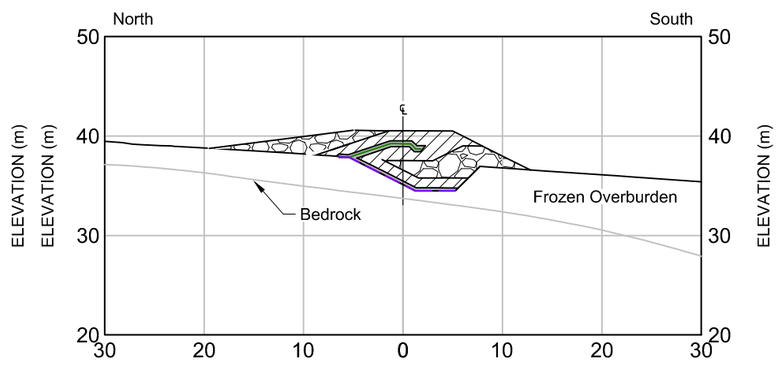
STA.4+20



STA.4+30



STA.4+40



STA.4+50

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

Original Drawings Stamped and Signed by Engineer

This drawing is uncontrolled when printed unless stamped and signed with original ink and recorded on a Distribution Register.

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

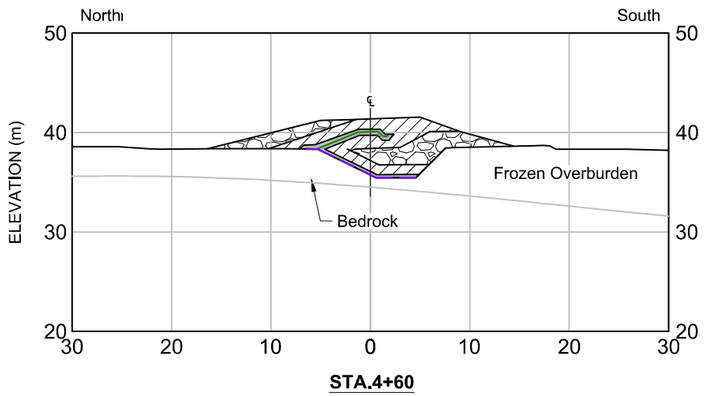
SRK JOB NO.: 1CT022.017

South Dam

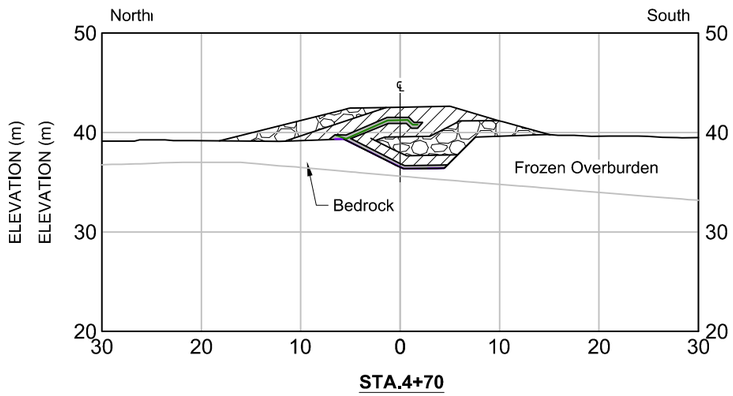
DRAWING TITLE: Sections Sta.3+70 to 4+50 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-17	17 OF 30	1

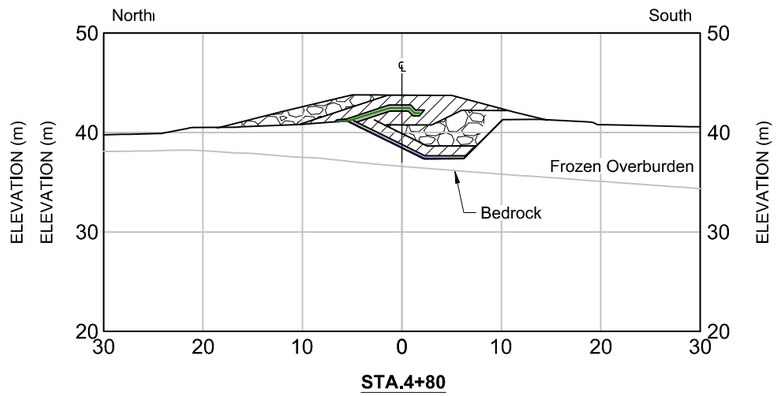
P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r\1\CT0022.017 - South Dam - Sections.dwg



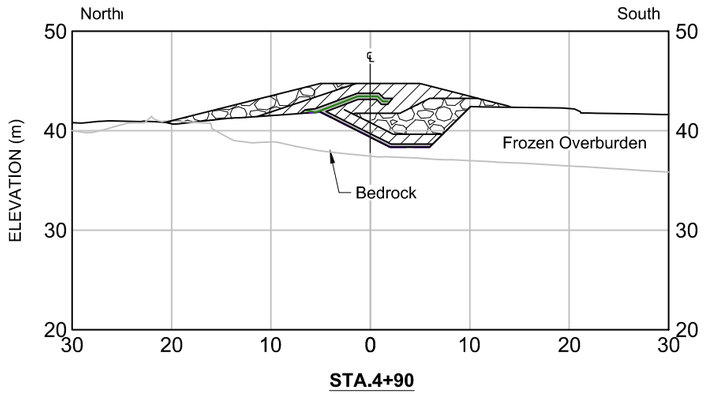
STA.4+60



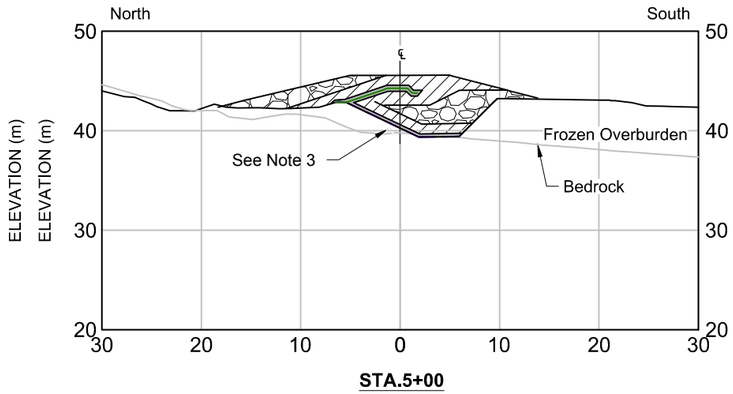
STA.4+70



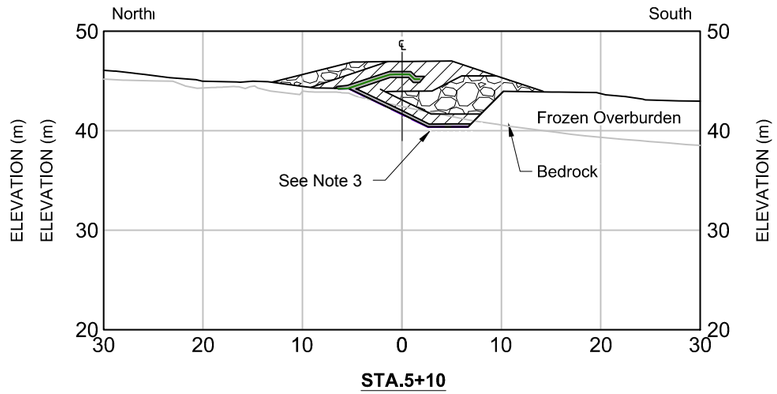
STA.4+80



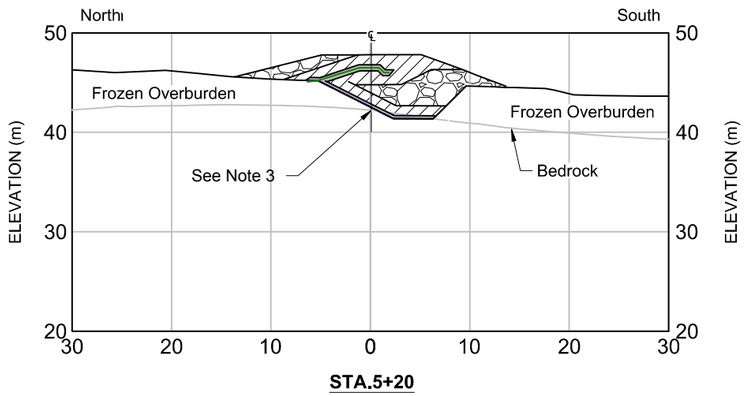
STA.4+90



STA.5+00



STA.5+10



STA.5+20

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.
3. Depth of key trench intersection with bedrock estimated (see DN-SD-04 for additional details). Actual depth may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

REFERENCE DRAWINGS			REVISIONS								
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CH'K'D	APP'D	DATE	NO.	DESCRIPTION	CH'K'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

Original Drawings Stamped and Signed by Engineer

This drawing is uncontrolled when printed unless stamped and signed with original ink and recorded on a Distribution Register.

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

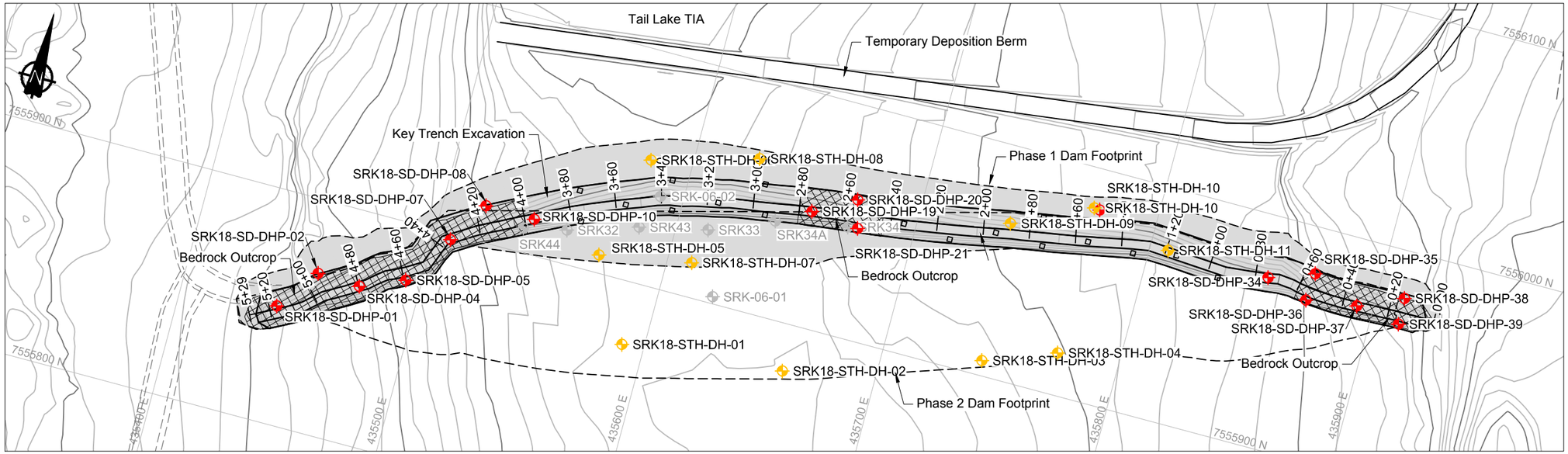
SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.4+60 to 5+30 Phase 1 Dam

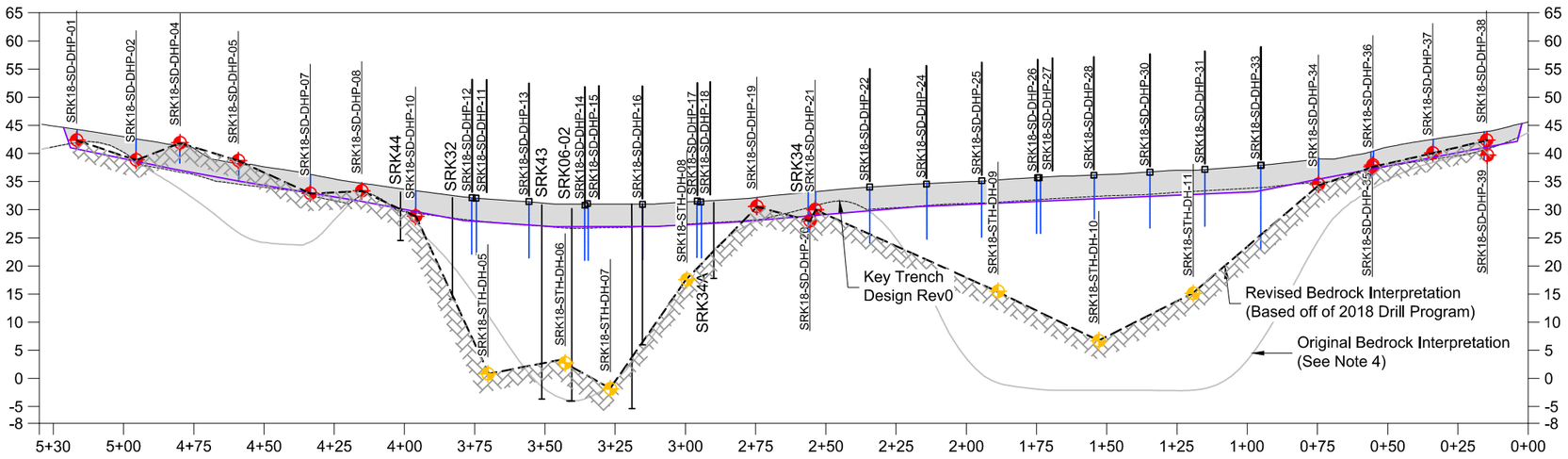
DRAWING NO.	SHEET	REVISION NO.
DN-SD-18	18 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1\1CT0022.017 - South Dam - Sections.dwg



Key Trench Plan View

0m 20 40 60 80



Key Trench Profile View

Vertical 0m 10 20 30 40

Horizontal 0m 20 40 60 80

LEGEND

- Previous Investigation Hole Location
- 2018 Percolation Hole Location Intercepted Bedrock
- 2018 Percolation Hole Location Did Not Intercept Bedrock
- 2018 Borehole Location
- Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Trench Excavation Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profile shown correspond to the upstream toe of the key trench.
4. The subsurface geology has been inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A , SRK43, SRK 44, SRK18-STH-DH-01 to 11, and SRK18-WST-DH-01 to 03), airphoto interpretations, and from limited available geophysical surveys around the Tails Lake area. This data was then used to create a bedrock surface with the Gemcom GEMS software. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.
5. Infill drilling is planned to be completed to reduce the uncertainty and associated risks with the Phase 1 South Dam key trench excavation and overall dam performance (e.g. stability, seepage, settlement, and creep).
6. Depths of infill drill boreholes estimated based on available information (Note 4 and as noted on DN-SD-04). Boreholes should be drilled 3m into bedrock unless terminated earlier as directed by the onsite Engineer.
7. Inferred bedrock contact based off exploration and percolation testing holes drilled January / February 2018 by SRK Consulting.

REFERENCES

NAD83 UTM Zone 13.

AS-BUILT BOREHOLE LOCATIONS

Point ID	Northing	Easting	Collar Elevation	Depth to Bedrock
SRK18-STH-DH-01	7555,873	435,590	31.34	29.9
SRK18-STH-DH-02	7555,880	435,660	30.69	3.0
SRK18-STH-DH-03	7,555,907	435,742	33.59	13.5
SRK18-STH-DH-04	7,555,918	435,773	34.82	10.4
SRK18-STH-DH-05	7,555,908	435,571	31.81	31.0
SRK18-STH-DH-06	7,555,953	435,582	30.35	27.6
SRK18-STH-DH-07	7,555,915	435,610	30.86	32.7
SRK18-STH-DH-08	7,555,966	435,627	31.07	13.5
SRK18-STH-DH-09	7,555,967	435,739	35.03	15.5
SRK18-STH-DH-10	7,555,983	435,772	6.10	6.7
SRK18-STH-DH-11	7,555,973	435,808	36.82	15.1
SRK18-WST-DH-01	7,556,486	435,113	43.25	7.1
SRK18-WST-DH-02	7,556,296	435,200	41.42	1.1
SRK18-WST-DH-03	7,556,195	435,257	42.71	5.4

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
AB	As-Built	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/12/11

DN-SD-04 — Key Trench Excavation Plan and Profile (DRAWING NO. / DRAWING TITLE)

REFERENCE DRAWINGS | REVISIONS

Original Drawings Stamped and Signed by Engineer

This drawing is uncontrolled when printed unless stamped and signed with original ink and recorded on a Distribution Register.

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN: JBK | DRAWN: TAH | REVIEWED: EMR

CHECKED: JBK | APPROVED: EMR | DATE: 2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Infill Foundation Drilling.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Infill Foundation Drilling Phase 1

DRAWING NO.: DN-SD-19 | SHEET: 19 OF 30 | REVISION NO.: AB

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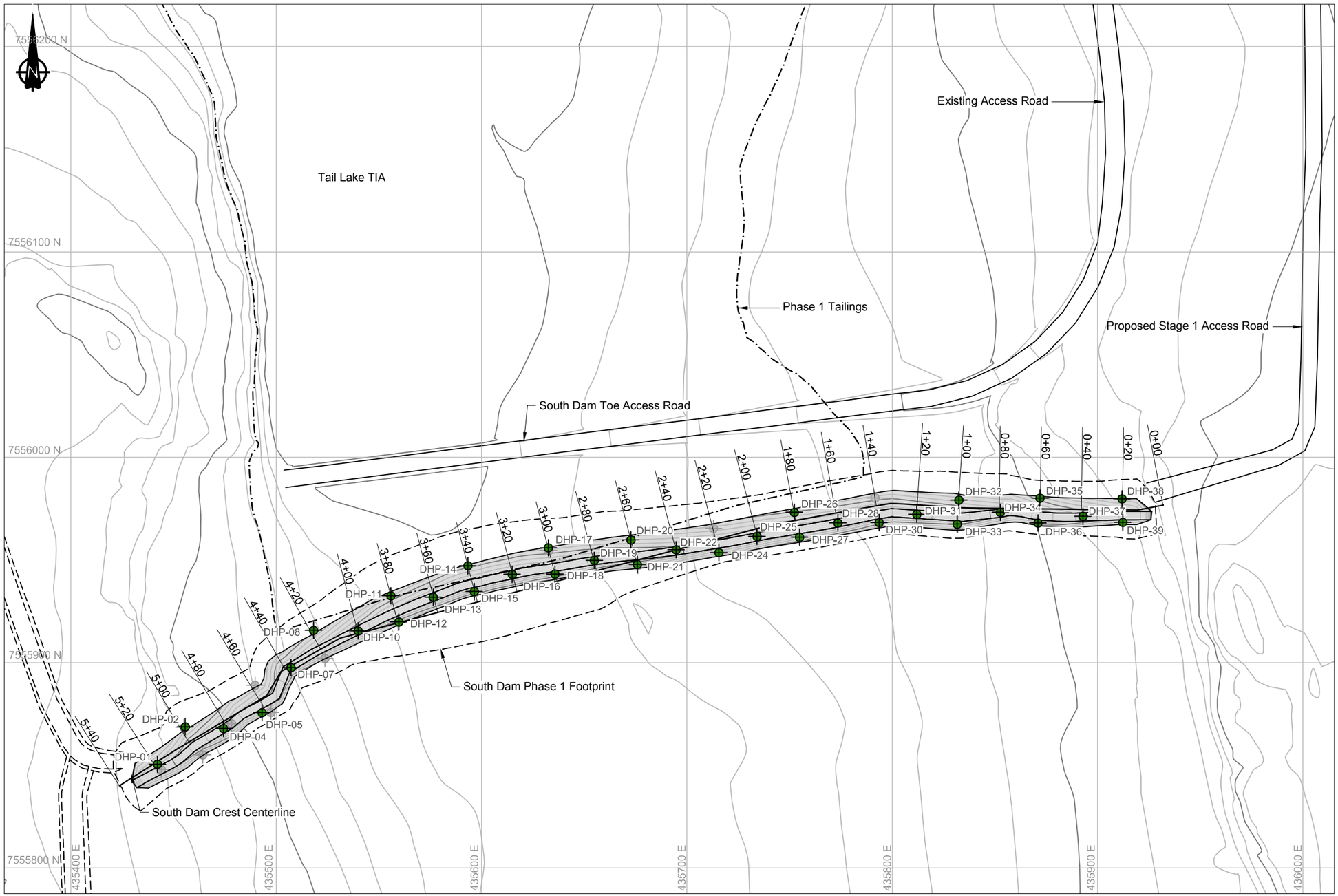

LEGEND

- Proposed Drill Hole Location
- As-Built Drill Hole Location
- Proposed Road Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Outline

NOTES

1. Contours shown at a 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. All percolation test boreholes should be a minimum 8.0m deep.
4. Percolation test boreholes should be a minimum of 4-6 inches (100-150mm) in diameter.
5. It is suggested that an air-track drill (quarry drill) be used to complete the percolation testing.
6. Once all percolation test locations are drilled the testing will be completed on site as directed by the Engineer.

REFERENCES

NAD83 UTM Zone 13.

AS-BUILT PERCOLATION BOREHOLE LOCATIONS

Point ID	Northing	Easting	Elevation
SRK18-SD-DHP1	7555850.42	435442.14	44.2
SRK18-SD-DHP2	7555868.68	435455.71	42.1
SRK18-SD-DHP4	7555867.85	435474.33	41.0
SRK18-SD-DHP5	7555875.60	435493.08	37.9
SRK18-SD-DHP7	7555897.52	435507.19	36.0
SRK18-SD-DHP8	7555915.67	435518.25	34.3
SRK18-SD-DHP10	7555915.40	435539.87	32.8
SRK18-SD-DHP11	7555932.47	435555.80	31.6
SRK18-SD-DHP12	7555919.75	435559.69	31.8
SRK18-SD-DHP13	7555931.76	435576.48	31.1
SRK18-SD-DHP14	7555947.08	435593.31	30.5
SRK18-SD-DHP15	7555934.56	435596.45	30.7
SRK18-SD-DHP16	7555942.92	435614.88	31.2
SRK18-SD-DHP17	7555955.86	435632.48	31.6
SRK18-SD-DHP18	7555943.01	435635.74	31.5
SRK18-SD-DHP19	7555949.72	435654.89	32.0
SRK18-SD-DHP20	7555959.68	435672.72	33.0
SRK18-SD-DHP21	7555947.75	435675.88	33.1
SRK18-SD-DHP22	7555954.90	435694.71	33.7
SRK18-SD-DHP24	7555953.48	435715.55	34.4
SRK18-SD-DHP25	7555961.44	435734.11	35.0
SRK18-SD-DHP26	7555973.14	435752.28	35.5
SRK18-SD-DHP27	7555961.00	435754.88	35.4
SRK18-SD-DHP28	7555967.97	435773.53	35.9
SRK18-SD-DHP30	7555968.15	435793.60	36.4
SRK18-SD-DHP31	7555972.15	435812.00	37.1
SRK18-SD-DHP32	7555979.10	435832.48	37.7
SRK18-SD-DHP33	7555967.38	435831.61	37.6
SRK18-SD-DHP34	7555973.14	435852.65	38.6
SRK18-SD-DHP35	7555980.03	435871.93	40.9
SRK18-SD-DHP36	7555967.95	435870.94	40.1
SRK18-SD-DHP37	7555971.21	435892.86	42.4
SRK18-SD-DHP38	7555979.68	435911.87	44.3
SRK18-SD-DHP39	7555968.28	435912.27	43.5

REFERENCE DRAWINGS		REVISIONS								
							AB	As-Built	JBK	EMR	18/04/13
DN-SD-04	Key Trench Excavation Plan and Profile	--	--	--	--	--	0	Issued for Construction	JBK	EMR	17/12/11
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
JBK	TAH	EMR
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT022.017 - Percolation Testing.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Percolation Borehole / Test Locations

DRAWING NO.	SHEET	REVISION NO.
DN-SD-20	20 OF 30	AB

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1-interna\1CT022.017 - Percolation Testing.dwg

Doris TIA

Existing Access Road

Proposed Stage 1 Access Road

Proposed Stage 2 Access Road

Temporary Deposition Berm

Phase 1 Dam - Issued for Construction (IFC)

Phase 2 Dam Footprint - Ultimate footprint shown for information only

7556100 N
7556000 N
7555900 N
7555800 N

435400 E
435500 E
435600 E
435700 E
435800 E
435900 E
436000 E

0+00
0+50
1+00
1+50
2+00
2+50
3+00
3+50
4+00
4+50
5+00
5+38

LEGEND

- Fixed Survey Monitoring Poind
- Surficial Survey Monitoring Point
- Deep Monitoring Point
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

0m 20 40 60 80

REFERENCE DRAWINGS			REVISIONS								
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/02/16

Original Drawings Stamped and Signed by Engineer

This drawing is uncontrolled when printed unless stamped and signed with original ink and recorded on a Distribution Register.

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Plan Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-21	21 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 rl\1CT0022.017 - Instrumentation Plan.dwg

Doris TIA

Existing Access Road

Proposed Stage 1 Access Road

Proposed Stage 2 Access Road

Temporary Deposition Berm

Phase 1 Dam - Issued for Construction (IFC)

SD-DL01

SD-DL02

SD-DL03

SD-DL04

1+00

0+50

0+00

2+00

2+50

3+00

3+50

4+00

4+50

5+00

5+38

See Note 3

Cable Trench
~19.9m - 1.5m

7556100 N

7556000 N

7555900 N

7555800 N

435400 E

435500 E

435600 E

435700 E

435800 E

435900 E

436000 E

0m 20 40 60 80

LEGEND

- Data Logger Location
- Monitoring Section
- Cable Trench
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Ground Temperature Cable backfilled cable trenches to be excavated through final dam shell - See drawings DN-SD-27, 28 and 29.

REFERENCES

NAD83 UTM Zone 13.

DATA LOGGERS

SD-DL01Reporting Cables:
- SD-VTS-065-KTC
- SD-HTS-065-US
- SD-VTS-155-KTC
- SD-HTS-155-KT
- SD-HTS-155-US
- SD-VTS-155-UST
- SD-VTS-155-DST

SD-DL02 Reporting Cables
- SD-VTS-240-KTC
- SD-VTS-240-KT
- SD-HTS-240-US
- SD-VTS-240-UST
- SD-VTS-240-DST
- SD-HST-B1-KT

SD-DL03 Reporting Cables
- SD-HTS-365-KT
- SD-VTS-365-KTC
- SD-HTS-365-US
- SD-VTS-365-UST
- SD-VTS-365-DST

SD-DL04 Reporting Cables
- SD-HTS-460-KT
- SD-VTS-460-KTC
- SD-HTS-460-US
- SD-HTS-460-UST
- SD-VTS-460-DST
- SD-VTS-510-KTC
- SD-HTS-510-US

STAKE-OUT POINTS

ID	Northing	Easting
SD-DL01	7555978.14	435776.94
SD-DL02	7555959.13	435693.79
SD-DL03	7555927.20	435572.83
SD-DL04	7555887.49	435490.36

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-29	Instrumentation Details at Sta. 4+65 and 5+10					
DN-SD-28	Instrumentation Details at Sta. 2+40 and 3+65					
DN-SD-27	Instrumentation Details at Sta. 0+65 and 1+55					
DN-SD-03	Typical Sections	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
2	Issued for Construction	JBK	EMR	18/04/26
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	18/02/16

REVISIONS

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/26

FILE NAME: 1CT0022.017 - GTC Trenches.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

GTC Backfilled Cable Trenches Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-22	22 OF 30	2

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam Phase 1\2\1CT0022.017 - GTC Trenches.dwg

Doris TIA

Existing Access Road

Proposed Stage 1 Access Road

Proposed Stage 2 Access Road

Temporary Deposition Berm

Phase 1 Dam - Issued for Construction (IFC)

7556100 N

7556000 N

7555900 N

7555800 N

435400 E

435500 E

435600 E

435700 E

435800 E

435900 E

436000 E

V-GTC-01 5+42

V-GTC-02 5+50

V-GTC-03

V-GTC-04 5+00

V-GTC-05

V-GTC-06 3+50

V-GTC-07 4+00

V-GTC-08

V-GTC-09 3+00

V-GTC-10 2+50

V-GTC-11 2+00

V-GTC-12 1+50

V-GTC-13 1+00

V-GTC-14 0+50 0+00

0m 20 40 60 80

LEGEND

- Vertical Ground Temperature Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

I.D.	Northing	Easting
V-GTC-01	7555854.81	435451.79
V-GTC-02	7555898.07	435484.95
V-GTC-03	7555882.32	435493.54
V-GTC-04	7555874.72	435497.69
V-GTC-05	7555955.78	435565.30
V-GTC-06	7555932.32	435571.39
V-GTC-07	7555906.23	435578.34
V-GTC-08	7555975.51	435689.29
V-GTC-09	7555956.36	435694.32
V-GTC-10	7555942.48	435698.15
V-GTC-11	7555988.45	435775.01
V-GTC-12	7555971.08	435778.29
V-GTC-13	7555963.40	435779.65
V-GTC-14	7555974.28	435866.64

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	17/12/15

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Vertical GTC LO.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

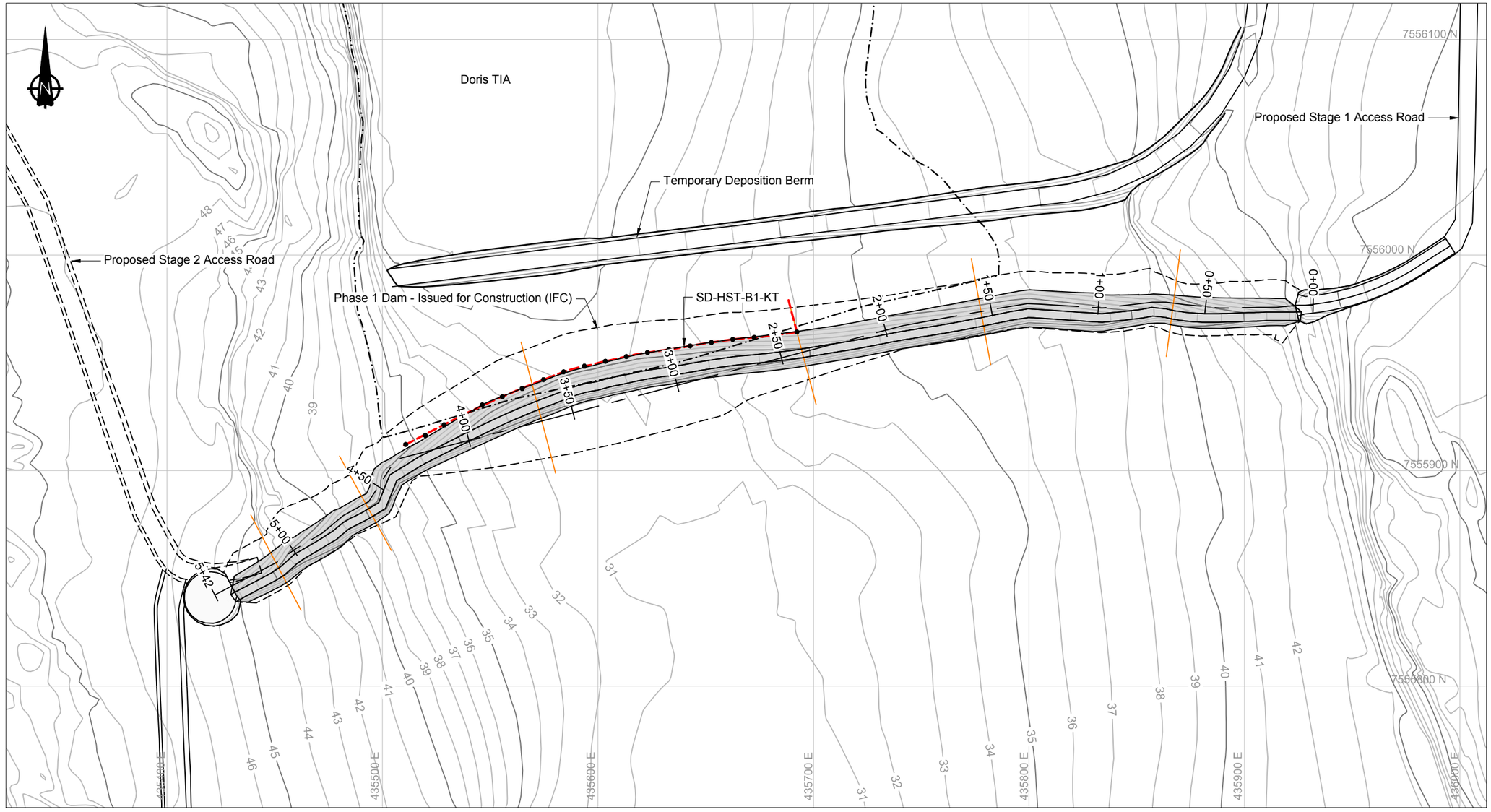
South Dam

DRAWING TITLE:

Vertical GTC Layout
Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-23	23 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 rl\1CT0022.017 - Vertical GTC LO.dwg



LEGEND

- Horizontal Ground Temperature Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Key Trench Footprint
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

ID	Northing	Easting
HST20098	7555964.28	435692.33
HST20099	7555962.86	435682.43
HST20100	7555961.78	435672.49
HST20101	7555960.86	435662.54
HST20102	7555959.44	435652.64
HST20103	7555957.83	435642.77
HST20104	7555956.14	435632.91
HST20105	7555954.75	435623.01
HST20106	7555952.88	435613.20
HST20107	7555950.71	435603.43
HST20108	7555948.45	435593.71
HST20109	7555945.81	435584.08
HST20110	7555942.19	435574.76
HST20111	7555938.05	435564.84
HST20112	7555934.18	435555.62
HST20113	7555930.47	435546.33
HST20114	7555925.96	435537.40
HST20115	7555921.21	435528.59
HST20116	7555916.34	435519.87
HST20117	7555912.10	435510.79

0m 20 40 60 80

Ground Temperature Cable Details - Center Base

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
1	SD-HST-B1-KT	A	Horizontal	Center	235	Top of Key Trench	20 beads spaced every 10m from the zero line on the cable, i.e. first bead at 0m										

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-	-	-				1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/02/15

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Lower H&II GTC LO.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Horizontal GTC
Upstream Base / Toe of Key Trench

DRAWING NO.	SHEET	REVISION NO.
DN-SD-24	24 OF 30	1

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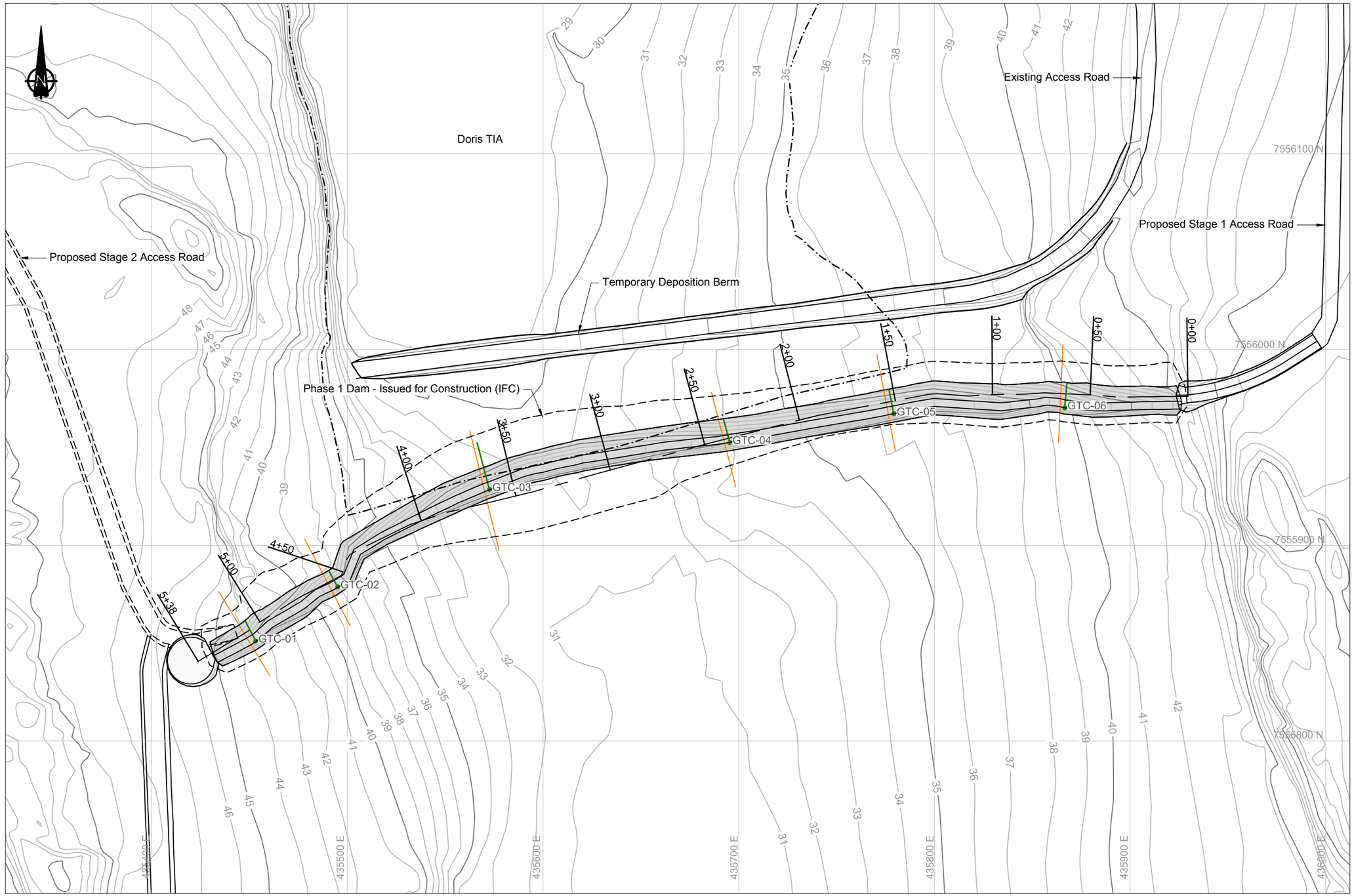

LEGEND

- Leak Detection Instrumentation
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

I.D.	Northing	Easting
GTC-01	7555851	435453
GTC-02	7555879	435495
GTC-03	7555929	435573
GTC-04	7555953	435695
GTC-05	7555937	435779
GTC-06	7555970	435867

0m 20 40 60 80

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-	JBK	EMR	17/12/11

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/12/11

REVISIONS

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Leak Detection.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

GTC Layout Along Upstream Slope of Key Trench

DRAWING NO.	SHEET	REVISION NO.
DN-SD-25	25 OF 30	1

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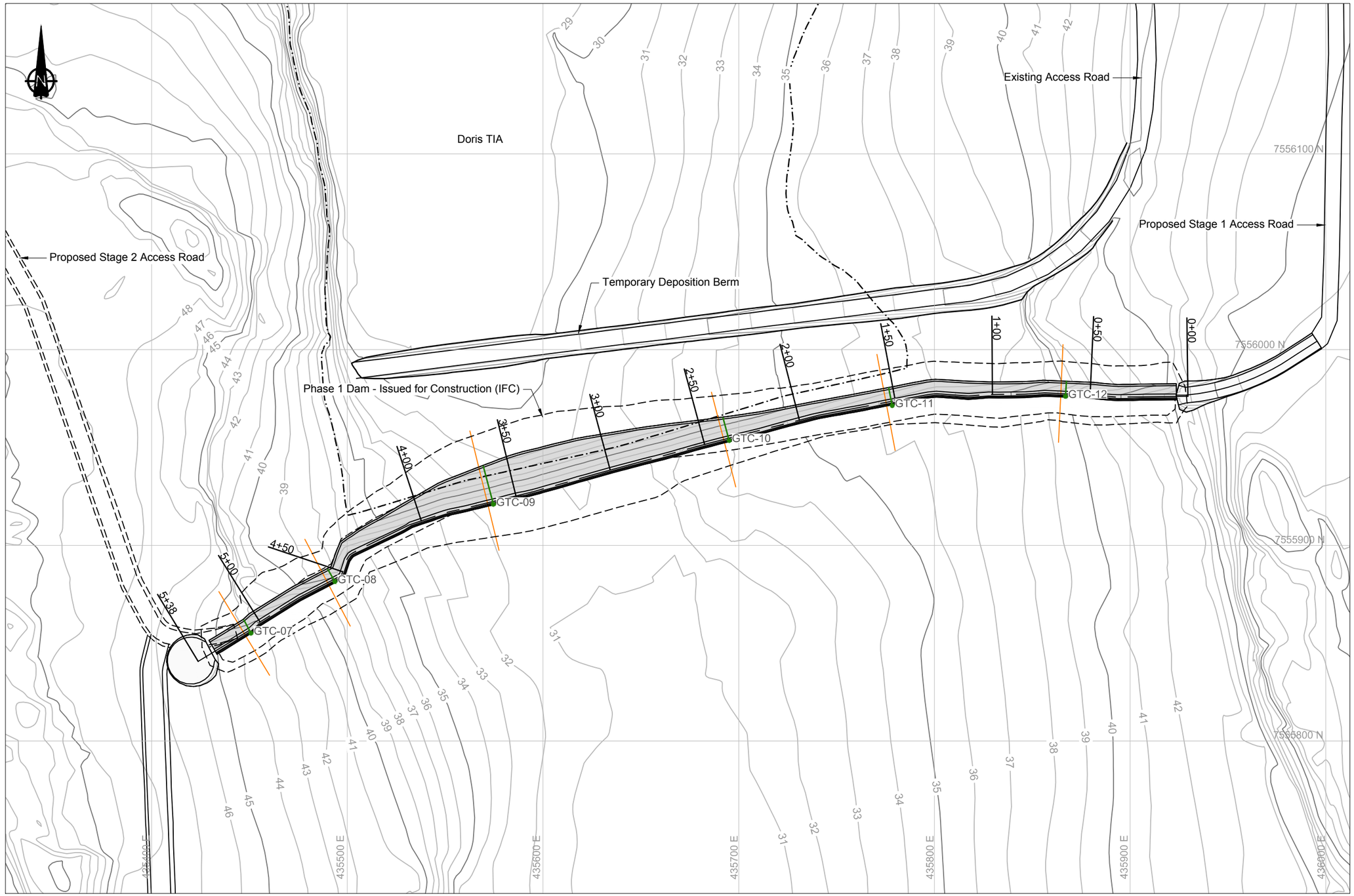

LEGEND

- Ground Temperature Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

I.D.	Northing	Easting
GTC-07	7555855	435451
GTC-08	7555882	435494
GTC-09	7555921	435575
GTC-10	7555954	435695
GTC-11	7555972	435778
GTC-12	7555976	435867

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/12/11

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Liner GTC.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

GTC Layout Along Upstream Above Ground Liner Slope

DRAWING NO.	SHEET	REVISION NO.
DN-SD-26	26 OF 30	1

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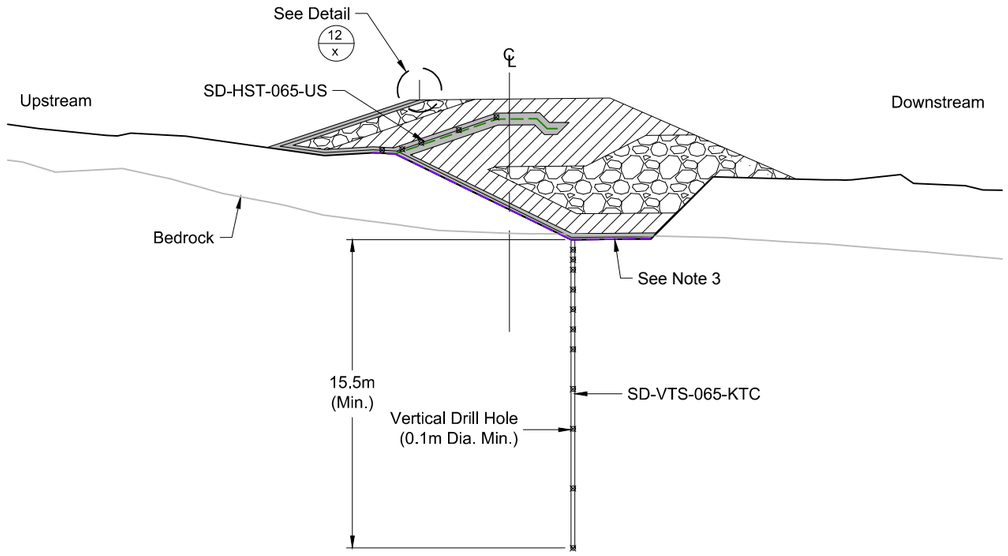
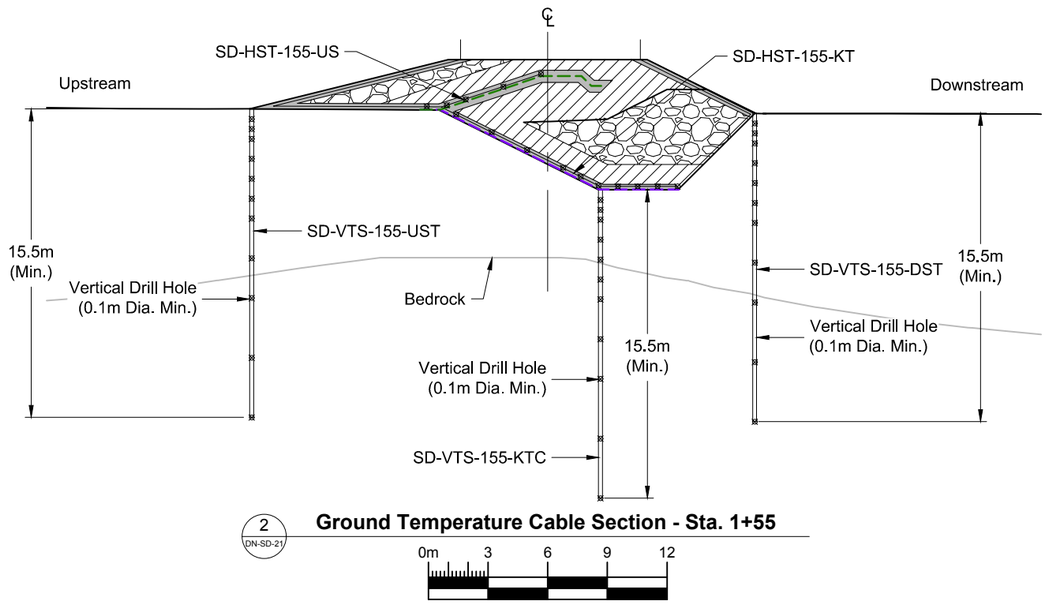


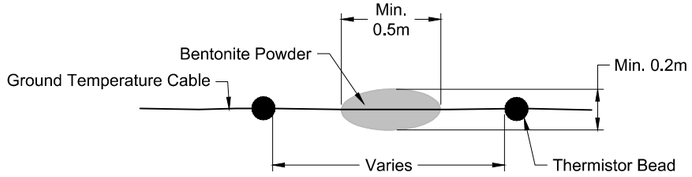
1 DN-SD-21 **Ground Temperature Cable Section - Sta. 0+65**

0m 3 6 9 12



2 DN-SD-21 **Ground Temperature Cable Section - Sta. 1+55**

0m 3 6 9 12



Detail 12 - Typical Water Stop Detail

0m 0.3 0.6 0.9 1.2

LEGEND

- Thermistor Bead Location
- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. Vertical cable boreholes to be filled with grout or backfilled with finer (sand size) material.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

Ground Temperature Cable Details - Monitoring Section 0+65 and 1+55

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
2	SD-VTS-65-KTC	A	Vertical	0+65	42	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
3	SD-HTS-065-US	B	Horizontal & Inclined	0+65	121	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
4	SD-VTS-155-KTC	A	Vertical	1+55	50	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
5	SD-VTS-155-UST	A	Vertical	1+55	41	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
6	SD-VTS-155-DST	A	Vertical	1+55	53	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
7	SD-HTS-155-US	B	Horizontal & Inclined	1+55	41	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
8	SD-HTS-155-KT	C	Horizontal & Inclined	1+55	39	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13
9	SD-HST-B1-KT	C	Horizontal	Center Base	235	Center Base	20 beads spaced every 10m from the zero line on the cable i.e. first bead at 0m										
10	Extension for SD-VTS-065-KTC	D	Vertical	0+65	90		Extension for existing cable. No beads needed.										

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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DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	JBK	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Details at Sta. 0+65 and 1+55

DRAWING NO. DN-SD-27 | SHEET 27 OF 30 | REVISION NO. 1

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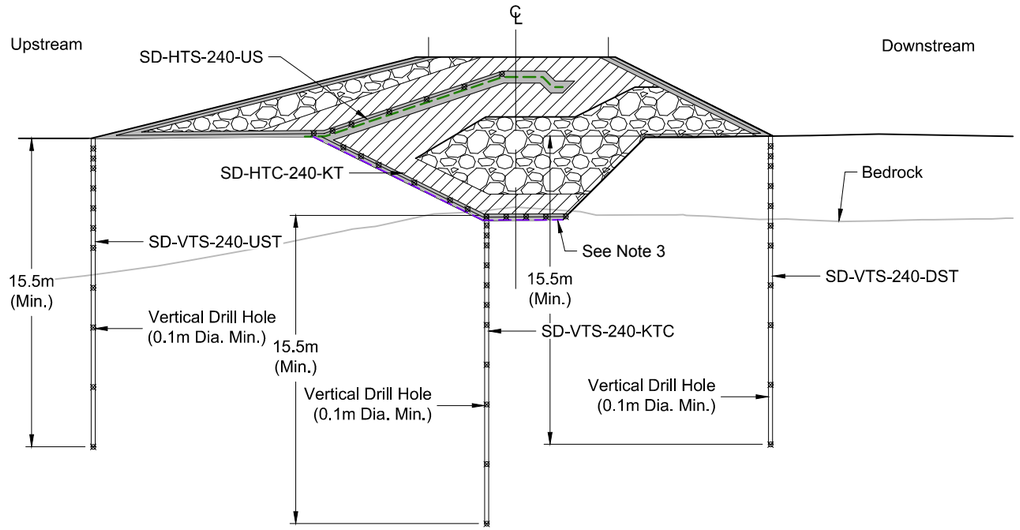
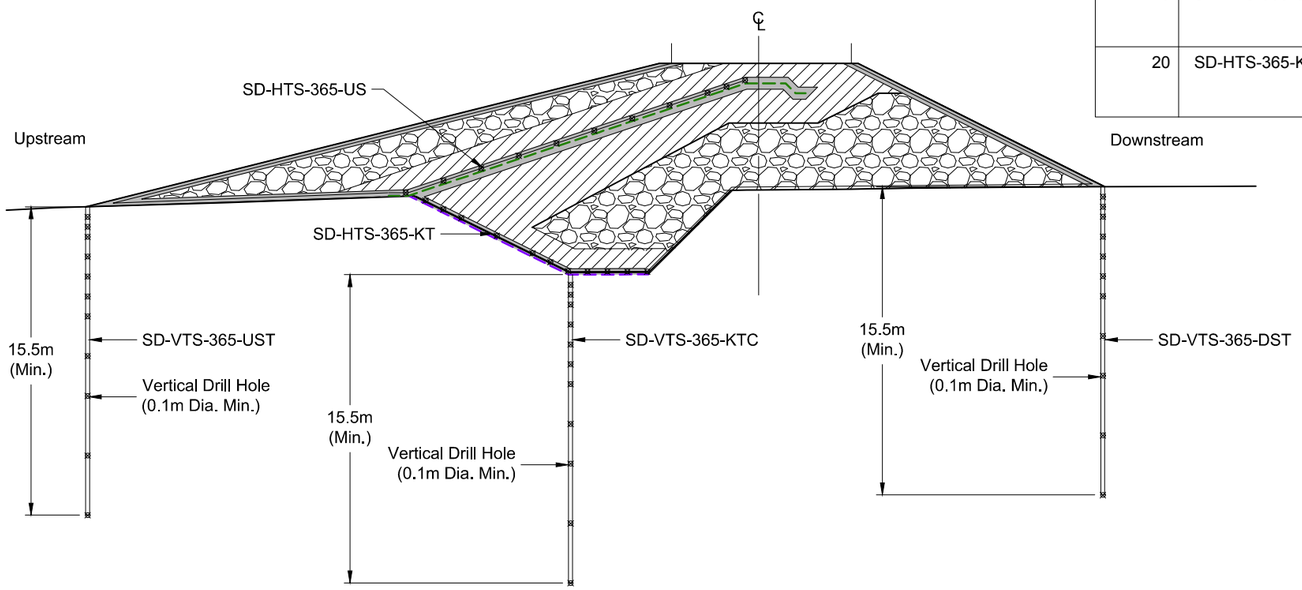


3 DN-SD-21

Ground Temperature Cable Section - Sta. 2+40

0m 3 6 9 12



4 DN-SD-21

Ground Temperature Cable Section - Sta. 3+65

0m 3 6 9 12

Ground Temperature Cable Details - Monitoring Section 2+40 and 3+65

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
11	SD-VTS-240-KTC	A	Vertical	2+40	58	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
12	SD-VTS-240-UST	A	Vertical	2+40	46	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
13	SD-VTS-240-DST	A	Vertical	2+40	53	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
14	SD-HTS-240-US	B	Horizontal & Inclined	2+40	50	Upstream Slope	0	2	4	6	8	9	10	-	-	-	-
15	SK-HTC-240-KT	B	Horizontal & Inclined	2+40	48	Upstream Slope	0	1	3	5	7	8	9	10	11	12	13
16	SD-VTS-365-KTC	A	Vertical	3+65	75	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
17	SD-VTS-365-UST	A	Vertical	3+65	57	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
18	SD-VTS-365-DST	A	Vertical	3+65	58	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
19	SD-HTS-365-US	B	Horizontal & Inclined	3+65	76	Upstream Slope	0	2	4	6	8	10	12	14	15	17	18
20	SD-HTS-365-KT	C	Horizontal & Inclined	3+65	65	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13

LEGEND

- Thermistor Bead Location
- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Instrumentation Details at Sta. 2+40 and 3+65

DRAWING NO.	SHEET	REVISION NO.
DN-SD-28	28 OF 30	1

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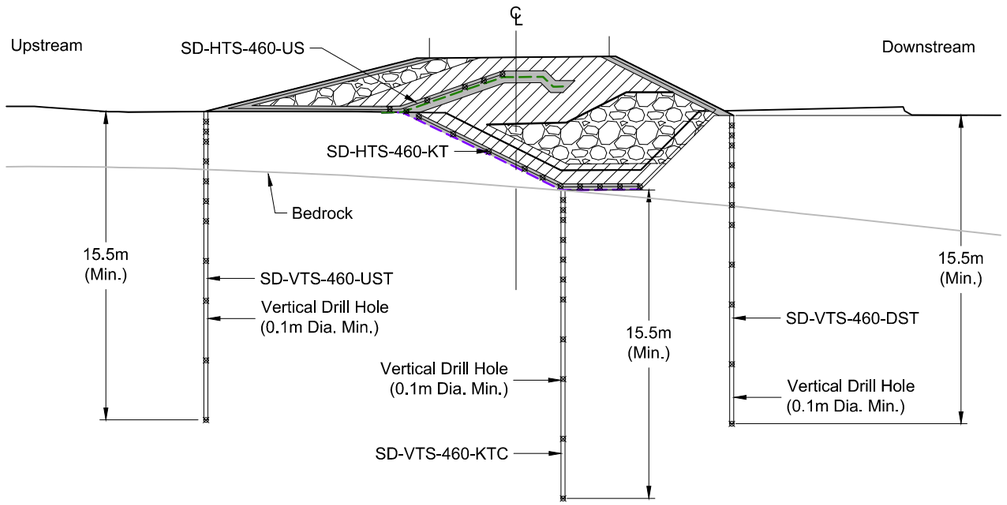
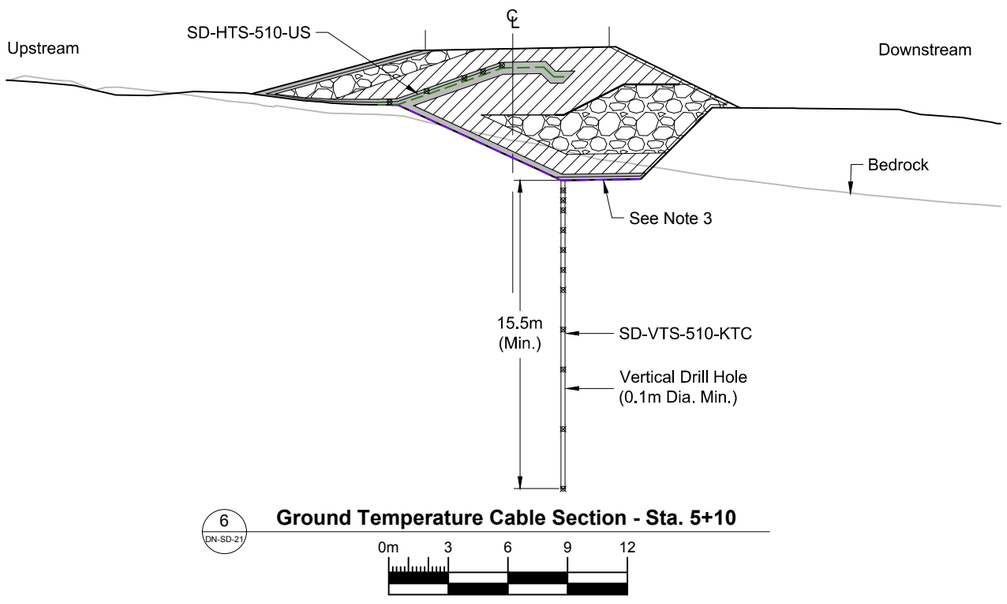


5 DN-SD-21 **Ground Temperature Cable Section - Sta. 4+60**

0m 3 6 9 12



6 DN-SD-21 **Ground Temperature Cable Section - Sta. 5+10**

0m 3 6 9 12

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

Ground Temperature Cable Details - Monitoring Section 4+60 and 5+10

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
21	SD-VTS-460-KTC	A	Vertical	4+60	50	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
22	SD-VTS-460-UST	A	Vertical	4+60	41	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
23	SD-VTS-460-DST	A	Vertical	4+60	58	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
24	SD-HTS-460-US	B	Horizontal & Inclined	4+60	41	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
25	SD-HTS-460-KT	C	Horizontal & Inclined	4+60	39	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13
26	SD-VTS-510-KTC	A	Vertical	5+10	48	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
27	SD-HTS-510-US	B	Horizontal & Inclined	5+10	86	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
28	Extension for SD-VTS-510-KTC	D	Vertical	5+10	90		Extension for existing cable. No beads needed.										

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

Original Drawings Stamped and Signed by Engineer

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Details at Sta. 4+65 and 5+10

DRAWING NO.	SHEET	REVISION NO.
DN-SD-29	29 OF 30	1

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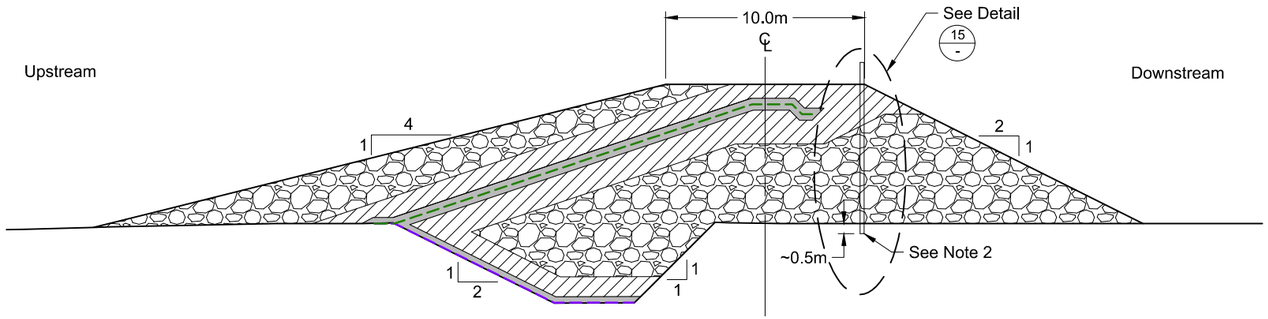
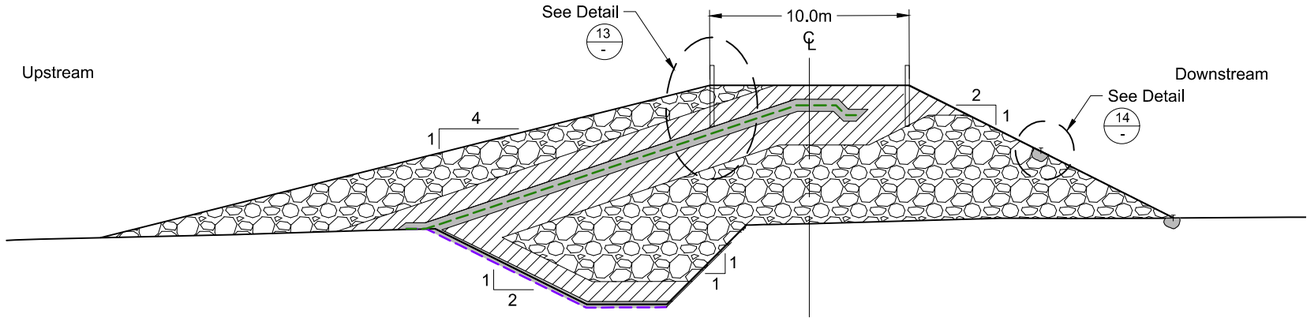


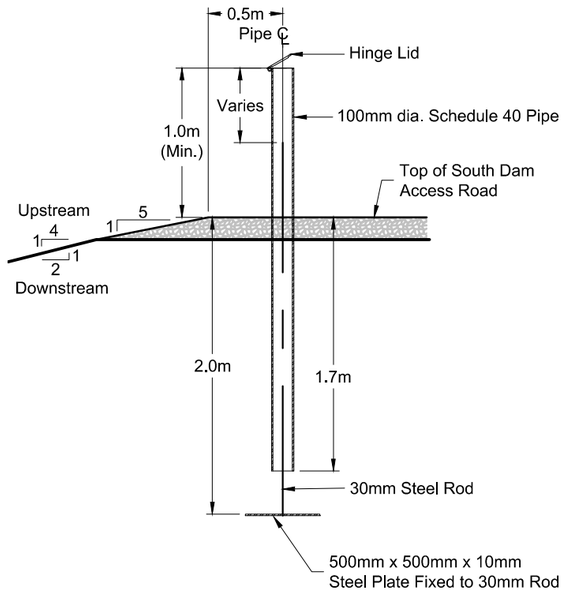
Surficial Survey Point - Sta. 3+15

0m 3 6 9 12



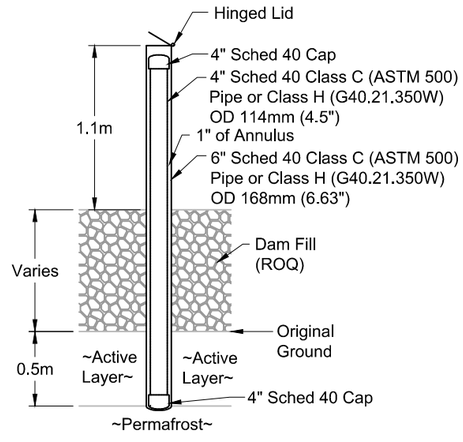
Deep Settlement Point - Sta. 3+50

0m 3 6 9 12



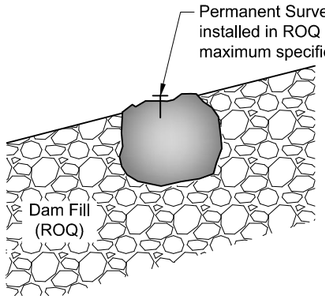
Detail 13 - Survey Monitoring Point Detail

0m 0.25 0.5 0.75 1.0



Detail 15 - Deep Settlement Point Installation

0m 0.25 0.5 0.75 1.0



Detail 14 - Surficial Survey Point Installation

0m 0.25 0.5 0.75 1.0

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. Deep settlement point installation depth to be directed by the field Engineer. Aim is to be near the active layer - permafrost contact.

REFERENCE DRAWINGS		REVISIONS										
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-21	Instrumentation Plan - Phase 1										
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/04/13

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Typical Monitoring Point Details

DRAWING NO.	SHEET	REVISION NO.
DN-SD-30	30 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1\1CT0022.017 - Instrumentation Plan.dwg

Appendix E – Technical Specifications

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

Prepared for

TMAC Resources

Prepared by

SRK Consulting (Canada) Inc.
1CT022.031
April 2018

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

April 2018

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Project No: 1CT022.031

File Name: HopeBay_TechSpecs_1CT022.031_20180406_KC_IM_JK_EMR.docx

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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

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 TMAC Resources Inc., or an authorized representative of the company. TMAC Resources Inc, Owner, TMAC 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 spillway.

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

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

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

(25) 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; and
   (6) Core.
2. All construction materials shall be non-acid generating, free of organic matter or similar impurities, as well as snow and ice.
3. 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.
4. 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

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.

5.2.4 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.

5.3 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

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QC Test Frequency	Submittal
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 Thermometer or Temperature Gun)	At Source	Immediate	Ongoing	None

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

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QA Test Frequency	Submittal
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
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 water tight 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 work day 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 work day.

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 ----------

Appendix F – Correspondence

Seema Kang

From: Hore, Cameron
Sent: Friday, November 17, 2017 3:45 PM
To: Kelly Schwenning
Cc: Kurylo, John; Rykaart, Maritz
Subject: South Dam Liner Selection
Attachments: HopeBay_LinerComparison_1CT022.017_20171117_CH_KC_JBK.pdf

Hi Kelly,

I have attached a short memo which outlines the liner options and ultimately our recommendation to use GCL in the South Dam.

Please review and let us know if you have any questions.

Cheers

Cameron Hore *CPEng P.Eng*
Senior Consultant (Geotechnical Engineering)
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Please consider the environment before printing this e-mail.

Memo

To:	Kelly Schwenning, Manager, Surface Operations	**Client:**	TMAC Resources Inc.
From:	Cameron Hore, CPEng, PEng and Kendell Cator, EIT	**Project No:**	1CT022.017
Reviewed By:	John Kurylo, PEng, Maritz Rykaart, PhD PEng	**Date:**	November 17, 2017
Subject:	2017 South Dam Design – Liner Comparison		

1 Introduction

SRK Consulting (Canada) Inc. was requested by TMAC Resources Inc. to undertake the detailed design of the frozen foundation South Dam, as part of the Doris TIA at the Hope Bay Project. The intent of this memo is to present a comparison to assist in selecting a liner for use in construction of the South Dam. The liner will provide a low permeability element to minimise seepage through the dam.

This memo provides an overview of each liner type considered and includes a brief comparison in terms of constructability in cold climates and required quantities; taking into considering the liner supple currently on hand at the project. All liner material options presented below are considered technically suitable for purpose in the South Dam design. The decision on which liner to use therefore comes down primary to constructability, shipping requirements, and cost.

Recommendations for the preferred liner are presented at the end of the memorandum.

2 Liner Options

This section provides a brief overview of each of the liner options under consideration.

2.1 High Density Polyethylene (HDPE)

HDPE geomembrane liners are comprised of densely packed crystalline polymer chains. HDPE is the most commonly used geomembrane material world-wide, primarily due to price. The low cost of material not only results in common usage, but also allows designers and engineers to select thicker HDPE liners that have greater puncture resistance. A shortcoming of HDPE is that it lacks the flexibility and ability to maintain good contact with uneven surfaces in comparison to other liners. The use of HDPE liner in the South Dam would also require its pairing with a non-woven geotextile to protect the HDPE from over and underlying coarse aggregate.

A linear-low density polyethylene (LLDPE) which provides additional flexibility relative to HDPE could also be used, however this would not make use of the HDPE currently on site, as discussed

in Section 4.1. Due to the additional material requirements LLDPE is expected to end up being more expensive than the HDPE and, with only marginal benefits in terms of workability, has not been carried further forward in this comparison.

2.2 Geosynthetic Clay Liner (GCL)

GCLs consist of two layers of geotextiles, surrounding a layer of low permeability sodium bentonite, that are needle punched together to increase internal shear resistance (Nilex, 2010). GCL's can replace significantly thicker compacted clay liners, decreasing installation and construction efforts while achieving the same desired result.

2.3 Bituminous Geomembrane (BGM)

Bituminous geomembrane liners (BGM) consist of a polyester root barrier, a fiberglass structural reinforcing layer, a bitumen impregnated non-woven geotextile core, and an additional layer of oxidized bitumen. BGM's are heavy, thick and therefore fairly resistant to punctures, tearing, and stress cracking. Their weight and physical properties also allow them flexibility and the ability to maintain intimate contact with a properly prepared substrate. Since they are bitumen based, they are generally UV resistant and weather resistant (they may soften under high temperatures, but are slow to degrade), as well as chemically resistant. The coefficient of thermal expansion is essentially zero: BGMs are not susceptible to folding or wrinkling (leading to cracking) unlike most 'poly' liners and are able to a small extent self-heal (with limitations) due to the bituminous properties.

3 Construction Considerations

Several constructability factors should be considered when selecting a geomembrane including: the climate and weather (particularly extreme temperature ranges and high wind), chemical resistance, whether specialized equipment or crews are required, flexibility and workability of the material, and the method and ease in which the material is tied into the existing surface or bedrock.

3.1 HDPE

HDPE liners are moderately suited for deployment and installation in cold climates. These products become rigid and brittle when subject to sub-zero temperatures and they become harder to handle. It is typically required that HDPE liner is stored in a heated environment up to and immediately prior to use to remain flexible and free of moisture. The complexity and effort required to form the liner to irregular surfaces (exposed bedrock, etc.) can become increasingly difficult as temperatures progress further below 0°C. Due to HDPE liners light weight, it can be difficult to install them during windy conditions. This can become a major issue when installing a liner in an open and un-shielded setting. Welding (seaming) of individual product panels also becomes difficult in cold temperatures. HDPE (60 mil) normally has a practical welding restriction of -25˚C (Layfield, 2011). HDPE liner requires specialized equipment and crews to ensure successful joining of seams, and welding requires that no moisture is present on the seam in the form of frost or snow.

Backfilling against HDPE liners in cold temperatures requires significant care be taken in ensuring that backfill is free of frozen materials and that the backfill is cautiously placed on the liner to prevent localised destruction upon impact. In summary, installation of an HDPE liner may be more difficult than that of other liners due to its relative rigidity at low temperatures, its light weight, and the fact that it requires a considerable amount of intricate seam welding in the field.

HDPE liners can be installed in cold climates and in fact have already been installed previously (although on smaller areas) when SRK was on site during the construction of some of the ditches and ponds at the Doris North site. HDPE liners would be required to be 'textured' to ensure that they are easier to install (less slipping hazard), increase the frictional performance, and get better adhesion against underlying nonwoven geotextile.

3.2 GCL

Due to GCL weight, in comparison to HDPE, they can be installed in windier conditions with minimal additional effort (eliminates weighting the panels with sandbags, etc.). Welding seams of GCLs does not require specialized equipment or personnel, but requires the placement of bentonite powder between overlap seams and, if chosen, sewing seams shut.

A key consideration for GCLs is that they perform best when allowed to saturate under confinement following installation. A GCL does not function as a barrier until hydration takes place. The GCLs are ideally hydrated with clean water prior to use. As detailed in the Bentotext GCL Installation Guide (Geosynthetics, 2012) hydration is usually accomplished by natural rainfall if the GCL is covered by a permeable material. Care needs to be taken during installation to ensure that moisture is not introduced during installation (and snow removal is able to be carried out prior to installation). To limit the potential for the outside of the GCLs liner rolls to be come saturated before installation it is recommended that the GCL be kept under cover until deployed / installed. GCLs will not function as designed if the bentonite is allowed to free swell, i.e., if the bentonite swells after absorbing water during or before installation and before being confined in place

As detailed in the US EPA guidance (2001) free and thaw cycles do not affect GCLs when installed below the frost line (or $0^{o}C$ isotherm). As far as the authors are aware, only a small number of laboratory and field testing of freeze and thaw cycles for bentonite blankets have been completed to date. This being noted, the limited laboratory tests that have been performed on a bentonitic blanket do indicate that hydraulic conductivity before freezing of 2×10^{-11} cm/sec was unaltered after five freeze and thaw cycles (US EPA 2001).

Also, as the rigidity of the GCL liners are not notably affected by cold weather they are overall fairly easy to install in cold weather. The North Dam at Hope Bay was successfully constructed with a GCL liner during winter on the Doris North site (SRK, 2012). SRK also successfully installed a secondary GCL liner at the Dam 1B on the Colomac site in the Northwest Territories. Another case study that supports GCL liners installation in extreme cold conditions is a case history form one of the Suncor oil sands tailings ponds (Athanassopoulos et al, 2011).

3.3 BGM

Due to the chemical and strength properties of BGM liners, they are able to be installed in cold climates. BGM liners have been proven to be installed in cold climates with installation up to - 40˚C. BGM liners are only moderately flexible but can be heated once laid down to better conform to the underlying subgrade. Like HDPE, BGM liner must be stored in a heated facility up to and immediately prior to use to remain flexible and free of moisture to ensure that the rolls are not damaged and will be able to be unrolled on site when needed. For the same reasons as a GCL, BGM liners can be installed during windier conditions. Welding seams between panels of BGM liners is a relatively straight forward process simply requiring propane torches, or similar tools, to heat the material prior to its adhesion to the adjacent panel. This being noted overall the installation of BGM liners is typically more labour intensive than installing GCL liners. Note that a bedding layer and a cover layer (above and below the liner) would still be expected to be maintained for a BGM liner. This bedding layer, if constructed with ROQ material crushed to pea gravel size (1" minus), can potential eliminate the need for a non-woven geotextile to be paired with the BGM liner (as confirmed by talking with Nilex Saskatoon, November 2017). This being noted based on SRKs past experiences the BGM installers can be somewhat particular about the subgrade and therefore a geotextile product is often required to be placed to avoid meticulous liner subgrade preparation and to ensure that the supplier will guarantee their placed product. Due to the time delays that would result if the liner supplier did not approve the subgrade or overline material before BGM placement it would suggested that geotextile be planned to be installed with the BGM to minimize schedule risks / impacts.

SRK has monitored the successful installation of a BGM liner in temperatures as low as - 40˚C at the Giant Mine in the Northwest Territories (SRK, 2008). For an additional case history example, BGM liners were also used in the construction of one of the dams at Diavik (Cunning et al, 2008).

4 Material Quantities

4.1 Currently on Site

It is SRK's understanding that materials currently available on site can be summarized as presented in Table 1. The condition of these materials (geotextile and HDPE) is not known. If the HDPE and/or the non-woven geotextile on site are to be used for construction, they must be inspected to ensure they are acceptable for use prior to placing the remaining material order. If the liner materials on site are damaged in any way they should be expected to not be able to be used.

Table 1: Material Quantities on Site

Material	Quantity (rolls)	Roll Dimension (m x m)	Total Area (roll - m^2)	Total Area (on site - m^2)	Storage Location on Site
HDPE Liner - SOLMAX 460ST (60 mil)[3]	6	6.8 x 159.5	1,083	6,500	Flat rack in Roberts Bay
Geotextile – 1200N non-woven (12oz)[2]	18	4.6 x 91.5[1]	418	15,000	CAN 389066 - Lower Reagent Pad
	18				CAN 291172 - Lower Reagent Pad

Notes:

1. Roll dimension based off WINFAB 1200N non-woven product data sheet.
2. It is assumed that the non-woven present on site is a 12 oz material produced by WINFAB (should be confirmed by site).

4.2 Required

Preliminary estimate for the liner requirement equates to 15,000 m^2, not including overlap between panels or wastage. The preliminary estimate for the non-woven geotextile requirement equates to 26,000 m^2 when paired with an HDPE liner (required above the HDPE liner in the key trench and on both sides within the dam shell). SRK has assumed a preliminary overlap and wastage allowance of 15%. A detailed panel layout should be developed once a liner is selected based on the dimensions of the rolls that will be taken to site. Based on the preliminary overlap and wastage allowance of 15% the total liner requirement equals 17,250 m^2. Table 2 summarizes the material requirements for each type of material, considering the HDPE liner and non-woven geotextile already present on site (Table 1).

For the HDPE and BGL liner options (Option A and C respectively) it is assumed that a crushed (sand and gravel or finer 1” minus or smaller) material will be used as a bedding layer for the liner. Therefore, a 12 oz (385 g/m^2) geotextile is assumed to be appropriate. If a bedding layer is not used on site, or if the bedding layer is coarse (i.e. primarily coarser than 1” gravel size), then the geotextile listed above would need to be increased in thickness to 16 oz or greater.

Table 2: Materials Required in Addition to Those Present on Site

Scenario	Material	Roll Dimension (panel - m x m)	Total Area (roll - m^2)	Quantity Required		Roll Weight (kg)	Total Shipment Weight (kg)	Roll Volume (m^3)	Total Shipment Volume (m^3)
				Area (m^2)	Rolls				
A*	HDPE Liner - SOLMAX 460T-2000 (60 mil)	6.8 x 164.6	1119.3	10,750[7]	10	1578	15,780	3.7	37
	Geotextile - 1200N non-woven (12 oz)	4.6 x 91.5	418	11,000[7]	27	170	4,590	0.9	44
	Total			21,750[7]	37	-	20,370		81
	*Scenario A - HDPE liner and geotextile quantities presented above are in addition to what is available on site. This assumes that all materials currently on site are suitable for use. Note that HDPE available on site is SOLMAX 460ST which is a one-sided slingle textured HDPE. This material is seen as suitable for the key trench but a double sided textured HDPE has been specified above for the portions of the liner systems that is above ground level.								
B	GCL Liner - Cetco Bentomat CLT	4.6 x 45.7	210	17,250	83	1,338	111,054	1.7	141
C**	BGM Liner - Coletanche ES4	5.1 x 55	280.5	17,250	62	1,795	111,290	3.3	206
	SUGGESTED Geotextile - 1200N non-woven (12 oz)	4.6 x 91.5	418	11,000[7]	27	170	4,590	0.9	44
	Total			28,250[7]	37	-	115,880		250
	**Scenario C – The BGM liner has been assumed to also require the placement of geotextile. Additional comments on this assumption are presented in Section 3.3. Similar to Case A all geotextile quantities presented above are in addition to what is available on site. This assumes that all materials currently on site are suitable for use.								

Other Notes:

1. HDPE Liner and non-woven geotextile are required together; the combined shipment weight of Option A is therefore approximately 20,370 kg and combined shipment volume is 81 m^3.
2. For Option B no geotextile is currently planned to be used (based on the expected liner subgrade preparation). Therefore, the total shipment weight for this option is approximately 111,054 kg and total shipment volume of 141 m^3.
3. For Option C a non-woven geotextile in addition to the BGM has been assumed. Therefore, the combined shipment weight of Option C is therefore approximately 115,880 kg with a combined shipment volume of 250 m^3.
4. The total material requirement for non-woven geotextile is 26,000 m^2 (required above the HDPE liner in the key trench and on both sides within the dam shell, including 15% wastage and overlap).
5. Materials specified for GCL liner and BGM liner were chosen for comparison purposes only, actual product specified if use in construction may vary.
6. Shipment weight does not include the steel core pipe of each roll.
7. Represents an additional quantity to that already present on site.
8. Technical Data Sheets for materials incorporated in Table 2 can be found in Attachment 1.

5 Recommendation

Due to logistics of constructing a frozen foundation dam, it is required that construction takes place in the winter months. Installation of an appropriate liner system is an important and integral part of the project, and must be completed correctly. There are many considerations and modified installation procedures that must be followed when installing liner in cold temperatures. Doing so can decrease installation effort and increase project success. Selecting the correct liner for the job is the first consideration which must be addressed.

Based on the comparison presented in this memorandum it is recommended that a GCL liner is selected for use in South Dam construction due to:

- Proven success of these liners on past cold climate projects completed by SRK,
- Ease of installation in cold/windy weather; and as it
- Does not require specialized equipment/crew for installation

Once a final decision has been made on the liner, SRK should also be supplied with planned purchase and shipping information. Specifically, SRK is interested in receiving the roll dimensions (length and width) for any liner material that is planned to be ordered. Following the receipt of this information a preliminary liner panel layout can be completed by SRK to confirm that the assumed 15% contingency for panel overlap and wastage is correct, thereby ensuring that enough liner material is shipped to site.

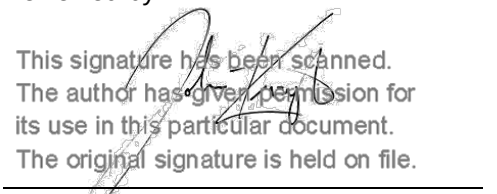
Finally, once the liner is shipped to site arrangements should be made to store the liner at a covered location on site.

Regards,

SRK Consulting (Canada) Inc.

Cameron Hore, CPEng.
Senior Consultant

Reviewed by



John Kurylo, MSc, PEng
Senior Consultant

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Attachment 1
Technical Data Sheets

SOLMAX

TECHNICAL DATA SHEET

Solmax HDPE Smooth - Imperial Values

Solmax International Inc., 2801 Boul. Marie-Victorin, Varennes, Qc, Canada, J3X 1P7
Tel.: (450) 929-1234 Fax: (450) 929-2550 www.solmax.com

PROPERTY	TEST METHOD	FREQUENCY(1)	UNIT Imperial	Solmax 430-1000	Solmax 440-1000	Solmax 460-1000	Solmax 480-1000	Solmax 500-1000
SPECIFICATIONS								
Thickness (min. avg.)	ASTM D-5199	Every roll	mils	30.0	40.0	60.0	80.0	100.0
Thickness (min.)	ASTM D-5199	Every roll	mils	27.0	36.0	54.0	72.0	90.0
Resin Density	ASTM D-1505	1/Batch	g/cc	> 0.932	> 0.932	> 0.932	> 0.932	> 0.932
Melt Index - 190/2.16 (max.)	ASTM D-1238	1/Batch	g/10 min	1.0	1.0	1.0	1.0	1.0
Sheet Density (8)	ASTM D-1505	Every 2 rolls	g/cc	≥ 0.940	≥ 0.940	≥ 0.940	≥ 0.940	≥ 0.940
Carbon Black Content (9)	ASTM D-4218	Every 2 rolls	%	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D-5596	Every 6 rolls	Category	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2
OIT - standard (avg.)	ASTM D-3895	1/Batch	min	100	100	100	100	100
Tensile Properties (min. avg) (2)	ASTM D-6693	Every 2 rolls						
Strength at Yield			ppi	66	84	130	177	210
Elongation at Yield			%	13	13	13	13	12
Strength at Break			ppi	122	162	243	326	380
Elongation at Break			%	700	700	700	700	700
Tear Resistance (min. avg.)	ASTM D-1004	Every 6 rolls	lbf	21	28	42	57	70
Puncture Resistance (min. avg.)	ASTM D-4833	Every 6 rolls	lbf	60	80	122	155	180
Dimensional Stability	ASTM D-1204	Certification	%	± 2	± 2	± 2	± 2	± 2
Stress Crack Resistance (SP-NCTL)	ASTM D-5397	1/Batch	hr	500	500	500	500	500
Oven Aging - % retained after 90 days	ASTM D-5721	Per formulation						
HP OIT (min. avg.)	ASTM D-5885		%	80	80	80	80	80
UV Resistance - % retained after 1600 hr	GRI-GM-11	Per formulation						
HP-OIT (min. avg.)	ASTM D-5885		%	50	50	50	50	50
SUPPLY SPECIFICATIONS	(Roll dimensions may vary ±1%)							
Roll Dimension - Width	-		ft	22.3	22.3	22.3	22.3	22.3
Roll Dimension - Length	-		ft	1,000	780	520	400	320
Area (Surface/Roll)	-		sf	20,494	17,394	11,596	8,920	7,136

NOTES

1. Testing frequency based on standard roll dimensions and one batch is approximately 180,000 lbs (or one railcar).
2. Machine Direction (MD) and Cross Machine Direction (XMD or TD) average values should be on the basis of 5 specimens each direction.
8. Correlation table is available for ASTM D792 vs ASTM D1505. Both methods give the same results.
9. Correlation table is available for ASTM D1603 vs ASTM D4218. Both methods give the same results.

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SOLMAX

TECHNICAL DATA SHEET

Solmax Single-Sided Textured - Imperial Values

Solmax International Inc., 2801 Boul. Marie-Victorin, Varennes, Qc, Canada, J3X 1P7
Tel.: (450) 929-1234 Fax: (450) 929-2550 www.solmax.com

PROPERTY	TEST METHOD	FREQUENCY(1)	UNIT Imperial	Solmax 430ST-1000	Solmax 440ST-1000	Solmax 460ST-1000	Solmax 480ST-1000	Solmax 500ST-1000
SPECIFICATIONS								
Nominal Thickness	-	-	mils	30.0	40.0	60.0	80.0	100.0
Thickness (min. avg.)	ASTM D-5994	Every roll	mils	28.5	38.0	57.0	76.0	95.0
Lowest individual for 8 out of 10 values			mils	27.0	36.0	54.0	72.0	90.0
Lowest individual for 10 out of 10 values			mils	26.0	34.0	51.0	68.0	85.0
Asperity Height (min. avg.) (3)	ASTM D-7466	Every roll	mils	16	16	16	16	16
Resin Density	ASTM D-1505	1/Batch	g/cc	> 0.932	> 0.932	> 0.932	> 0.932	> 0.932
Melt Index - 190/2.16 (max.)	ASTM D-1238	1/Batch	g/10 min	1.0	1.0	1.0	1.0	1.0
Sheet Density (8)	ASTM D-1505	Every 2 rolls	g/cc	≥ 0.940	≥ 0.940	≥ 0.940	≥ 0.940	≥ 0.940
Carbon Black Content (9)	ASTM D-4218	Every 2 rolls	%	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D-5596	Every 6 rolls	Category	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2
OIT - standard (avg.)	ASTM D-3895	1/Batch	min	100	100	100	100	100
Tensile Properties (min. avg) (2)	ASTM D-6693	Every 2 rolls						
Strength at Yield			ppi	63	88	132	176	210
Elongation at Yield			%	12	13	13	13	12
Strength at Break			ppi	46	88	132	167	150
Elongation at Break			%	100	150	150	150	100
Tear Resistance (min. avg.)	ASTM D-1004	Every 6 rolls	lbf	21	30	45	60	70
Puncture Resistance (min. avg.)	ASTM D-4833	Every 6 rolls	lbf	45	90	120	150	150
Dimensional Stability	ASTM D-1204	Certification	%	± 2	± 2	± 2	± 2	± 2
Stress Crack Resistance (SP-NCTL)	ASTM D-5397	1/Batch	hr	500	500	500	500	500
Oven Aging - % retained after 90 days	ASTM D-5721	Per formulation						
HP OIT (min. avg.)	ASTM D-5885		%	80	80	80	80	80
UV Resistance - % retained after 1600 hr	GRI-GM-11	Per formulation						
HP-OIT (min. avg.)	ASTM D-5885		%	50	50	50	50	50
SUPPLY SPECIFICATIONS	(Roll dimensions may vary ±1%)							
Roll Dimension - Width	-		ft	22.3	22.3	22.3	22.3	22.3
Roll Dimension - Length	-		ft	1,000	780	560	440	320
Area (Surface/Roll)	-		sf	22,300	17,394	12,488	9,812	7,136

SOLMAX

TECHNICAL DATA SHEET

Solmax Single-Sided Textured - Imperial Values

Solmax International Inc., 2801 Boul. Marie-Victorin, Varennes, Qc, Canada, J3X 1P7
Tel.: (450) 929-1234 Fax: (450) 929-2550 www.solmax.com

PROPERTY	TEST METHOD	FREQUENCY(1)	UNIT Imperial	Solmax 430ST-1000	Solmax 440ST-1000	Solmax 460ST-1000	Solmax 480ST-1000	Solmax 500ST-1000

NOTES

1. Testing frequency based on standard roll dimensions and one batch is approximately 180,000 lbs (or one railcar).
2. Machine Direction (MD) and Cross Machine Direction (XMD or TD) average values should be on the basis of 5 specimens each direction.
3. Lowest individual and 8 out of 10 readings as per GRI-GM13 / 17, latest version.
8. Correlation table is available for ASTM D792 vs ASTM D1505. Both methods give the same results.
9. Correlation table is available for ASTM D1603 vs ASTM D4218. Both methods give the same results.

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SOLMAX

TECHNICAL DATA SHEET

Solmax HDPE Textured - Imperial Values

Solmax International Inc., 2801 Boul. Marie-Victorin, Varennes, Qc, Canada, J3X 1P7
Tel.: (450) 929-1234 Fax: (450) 929-2550 www.solmax.com

PROPERTY	TEST METHOD	FREQUENCY(1)	UNIT Imperial	Solmax 430T-1000	Solmax 440T-1000	Solmax 460T-1000	Solmax 480T-1000	Solmax 500T-1000
SPECIFICATIONS								
Nominal Thickness	-	-	mils	30.0	40.0	60.0	80.0	100.0
Thickness (min. avg.)	ASTM D-5994	Every roll	mils	28.5	38.0	57.0	76.0	95.0
Lowest individual for 8 out of 10 values			mils	27.0	36.0	54.0	72.0	90.0
Lowest individual for 10 out of 10 values			mils	26.0	34.0	51.0	68.0	85.0
Asperity Height (min. avg.) (3)	ASTM D-7466	Every roll	mils	16	16	16	16	16
Resin Density	ASTM D-1505	1/Batch	g/cc	> 0.932	> 0.932	> 0.932	> 0.932	> 0.932
Melt Index - 190/2.16 (max.)	ASTM D-1238	1/Batch	g/10 min	1.0	1.0	1.0	1.0	1.0
Sheet Density (8)	ASTM D-1505	Every 2 rolls	g/cc	≥ 0.940	≥ 0.940	≥ 0.940	≥ 0.940	≥ 0.940
Carbon Black Content (9)	ASTM D-4218	Every 2 rolls	%	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D-5596	Every 6 rolls	Category	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2
OIT - standard (avg.)	ASTM D-3895	1/Batch	min	100	100	100	100	100
Tensile Properties (min. avg) (2)	ASTM D-6693	Every 2 rolls						
Strength at Yield			ppi	66	88	132	176	210
Elongation at Yield			%	12	12	13	13	12
Strength at Break			ppi	66	88	132	167	150
Elongation at Break			%	150	150	150	150	150
Tear Resistance (min. avg.)	ASTM D-1004	Every 6 rolls	lbf	23	30	45	60	70
Puncture Resistance (min. avg.)	ASTM D-4833	Every 6 rolls	lbf	60	90	120	150	150
Dimensional Stability	ASTM D-1204	Certification	%	± 2	± 2	± 2	± 2	± 2
Stress Crack Resistance (SP-NCTL)	ASTM D-5397	1/Batch	hr	500	500	500	500	500
Oven Aging - % retained after 90 days	ASTM D-5721	Per formulation						
HP OIT (min. avg.)	ASTM D-5885		%	80	80	80	80	80
UV Resistance - % retained after 1600 hr	GRI-GM-11	Per formulation						
HP-OIT (min. avg.)	ASTM D-5885		%	50	50	50	50	50
SUPPLY SPECIFICATIONS	(Roll dimensions may vary ±1%)							
Roll Dimension - Width	-		ft	22.3	22.3	22.3	22.3	22.3
Roll Dimension - Length	-		ft	1,000	780	540	420	320
Area (Surface/Roll)	-		sf	22,300	17,394	12,042	9,366	7,136

SOLMAX

TECHNICAL DATA SHEET

Solmax HDPE Textured - Imperial Values

Solmax International Inc., 2801 Boul. Marie-Victorin, Varennes, Qc, Canada, J3X 1P7
Tel.: (450) 929-1234 Fax: (450) 929-2550 www.solmax.com

PROPERTY	TEST METHOD	FREQUENCY(1)	UNIT Imperial	Solmax 430T-1000	Solmax 440T-1000	Solmax 460T-1000	Solmax 480T-1000	Solmax 500T-1000

NOTES

1. Testing frequency based on standard roll dimensions and one batch is approximately 180,000 lbs (or one railcar).
2. Machine Direction (MD) and Cross Machine Direction (XMD or TD) average values should be on the basis of 5 specimens each direction.
3. Lowest individual and 8 out of 10 readings as per GRI-GM13 / 17, latest version.
8. Correlation table is available for ASTM D792 vs ASTM D1505. Both methods give the same results.
9. Correlation table is available for ASTM D1603 vs ASTM D4218. Both methods give the same results.

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SOLMAX

TECHNICAL DATA SHEET

HDPE Series, 1.50 mm

Black, Textured

2801 Marie-Victorin Blvd. Varennes, Quebec Canada J3X 1P7
Tel: (450) 929-1234 Sales: (450) 929-2544 Toll free in North America:1-800-571-3904 www.Solmax.com www.solmax.com

PROPERTY	TEST METHOD	FREQUENCY(1)	UNIT Metric	1042792
SPECIFICATIONS				
Nominal Thickness	-	-	mm	1.50
Thickness (min. avg.)	ASTM D-5994	Every roll	mm	1.43
Lowest ind. for 8 out of 10 values			mm	1.35
Lowest ind. for 10 out of 10 values			mm	1.28
Asperity Height (min. avg.) (3)	ASTM D-7466	Every roll	mm	0.40
Resin Density	ASTM D-1505	1/Batch	g/cc	> 0.932
Sheet Density (8)	ASTM D-792	Every 10 rolls	g/cc	≥ 0.940
Carbon Black Content (9)	ASTM D-4218	Every 2 rolls	%	2.0 - 3.0
Carbon Black Dispersion	ASTM D-5596	Every 10 rolls	Category	Cat. 1 / Cat. 2
OIT - standard (avg.)	ASTM D-3895	Per formulation	min	100
Tensile Properties (min. avg) (2)	ASTM D-6693	Every 2 rolls		
Strength at Yield			kN/m	23
Elongation at Yield			%	13
Strength at Break			kN/m	23
Elongation at Break			%	150
Tear Resistance (min. avg.)	ASTM D-1004	Every 5 rolls	N	200
Puncture Resistance (min. avg.)	ASTM D-4833	Every 5 rolls	N	535
Dimensional Stability	ASTM D-1204	Certified	%	± 2
Stress Crack Resistance (SP-NCTL)	ASTM D-5397	1/Batch	hr	500
Oven Aging - % retained after 90 days	ASTM D-5721	Per formulation		
HP OIT (min. avg.)	ASTM D-5885		%	80
UV Res. - % retained after 1600 hr	GRI-GM-11	Per formulation		
HP-OIT (min. avg.)	ASTM D-5885		%	50
SUPPLY SPECIFICATIONS (Roll dimensions may vary ±1%)				
Roll Dimension - Width	-		m	6.80
Roll Dimension - Length	-		m	164.6
Area (Surface/Roll)	-		m^2	1119.3

NOTES

1. Testing frequency based on standard roll dimension and one batch is approximately 180,000 lbs (or one railcar).
2. Machine Direction (MD) and Cross Machine Direction (XMD or TD) average values should be on the basis of 5 specimens each direction.
3. Lowest individual and 8 out of 10 readings as per GRI-GM13 / 17, latest version.
8. Correlation table is available for ASTM D792 vs ASTM D1505. Both methods give the same results.
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Solmax is not a design professional and has not performed any design services to determine if Solmax's goods comply with any project plans or specifications, or with the application or use of Solmax's goods to any particular system, project, purpose, installation or specification.

WINFAB INDUSTRIAL FABRICS

PRODUCT DATA SHEET

WINFAB 1200N

FILTRATION | EROSION PROTECTION | DRAINAGE | SEPARATION

WINFAB 1200N is a needlepunched nonwoven geotextile manufactured using polypropylene fibers that are formed into a dimensionally stable network, which allows the fibers to maintain their relative position.
WINFAB 1200N resists ultraviolet deterioration, rotting, and biological degradation and is inert to commonly encountered soil chemicals.

PROPERTY	TEST METHOD	MARV English	MARV Metric
Tensile Strength (Grab)	ASTM D4632	300 x 300 lbs	1335 x 1335 N
Elongation	ASTM D4632	50%	50%
CBR Puncture	ASTM D6241	825 lbs	3670 N
Trapezoidal Tear	ASTM D4533	115 x 115 lbs	511 x 511 N
UV Resistance (500 hrs)	ASTM D4355	70%	70%
Apparent Opening Size (AOS)*	ASTM D4751	100 US Std. Sieve	0.150 mm
Permittivity	ASTM D4491	1.0 sec^{-1}	1.0 sec^{-1}
Water Flow Rate	ASTM D4491	75 gpm/ft^2	3055 lpm/m^2

***Maximum Average Roll Valve**

Notes:
- Mullen Burst ASTM D3786 has been removed. It is not recognized by ASTM D35 on Geosynthetics.
- Puncture ASTM D4833 has been removed. It is not recognized by AASHTO M288 and has been replaced with CBR Puncture ASTM D6241

PROPERTY	Typical English	Typical Metric
Roll Dimensions	15 x 300 ft	4.6 x 91.5 m
Roll Area	500 yd^2	418 m^2

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GMA Geosynthetic Materials Association

CETCO® LINING TECHNOLOGIES

BENTOMAT® & CLAYMAX® PANEL & ROLL SPECIFICATIONS

Panel Specifications

PRODUCTS	DIMENSIONS WIDTH x LENGTH	AREA	EFFECTIVE AREA
BENTOMAT® ST	15 ft x 150 ft (4.6 m x 45.7 m)	2,250 ft^2 (209 m^2)	2,145 ft^2 (200 m^2)
BENTOMAT SDN	14.5 ft x 150 ft (4.4 m x 45.7 m)	2,175 ft^2 (202 m^2)	2,071 ft^2 (193 m^2)
BENTOMAT DN	14.5 ft x 150 ft (4.4 m x 45.7 m)	2,175 ft^2 (202 m^2)	2,071 ft^2 (193 m^2)
BENTOMAT CL	15 ft x 150 ft (4.6 m x 45.7 m)	2,250 ft^2 (209 m^2)	2,070 ft^2 (193 m^2)
BENTOMAT CLT	15 ft x 150 ft (4.6 m x 45.7 m)	2,250 ft^2 (209 m^2)	2,070 ft^2 (193 m^2)
BENTOMAT 200R	15 ft x 150 ft (4.6 m x 45.7 m)	2,250 ft^2 (209 m^2)	2,145 ft^2 (200 m^2)
CLAYMAX 200R (Lovell)	15 ft x 150 ft (4.6 m x 45.7 m)	2,250 ft^2 (209 m^2)	2,040 ft^2 (190 m^2)

Roll Specifications

PRODUCTS	DIMENSIONS Length x Diameter (Avg.)	NOMINAL WEIGHT	ROLLS / TRUCKLOAD
BENTOMAT ST	16 ft x 24 in (4.9 m x 610 mm)	2,650 lbs (1204 kg)	17 rolls per truckload
BENTOMAT SDN	16 ft x 24 in (4.9 m x 610 mm)	2,650 lbs (1204 kg)	16 rolls per truckload
BENTOMAT DN	16 ft x 24 in (4.9 m x 610 mm)	2,700 lbs (1227 kg)	16 rolls per truckload
BENTOMAT CL	16 ft x 25 in (4.9 m x 635 mm)	2,750 lbs (1250 kg)	15 rolls per truckload
BENTOMAT CLT	16 ft x 26 in (4.9 m x 660 mm)	2,950 lbs (1340 kg)	15 rolls per truckload
BENTOMAT 200R	16 ft x 24 in (4.9 m x 610 mm)	2,650 lbs (1204 kg)	17 rolls per truckload
CLAYMAX 200R (Lovell)	16 ft x 20 in (4.9 m x 510 mm)	3,000 lbs (1363 kg)	15 rolls per truckload

Unloading and handling equipment for all GCL products:

- Spreader bar and core pipe: Spreader bar 17 ft (5.2 m) long; core pipe 20 ft (6.1 m) long, nominal pipe size, XXH.
- A solid 3.5 in. (90 mm) O.D. x 14.5 ft (4.4 m) solid steel pipe stinger attachment for a forklift.
- Slings: 2 Polyester slings are required, approximately 12 ft (3.7 m) long x 2 in (50 mm) wide each.
- Vehicle needed: Front end loader or forklift (are typical).

Standard Roll Specifications:

- Packaging: U.V. resistant polyethylene sleeve.

800.527.9948 Fax 847.577.5566

For the most up-to-date product information, please visit our website, www.cetco.com.
A wholly owned subsidiary of AMCOL International Corporation. The information and data contained herein are believed to be accurate and reliable, CETCO makes no warranty of any kind and accepts no responsibility for the results obtained through application of this information.

BENTOMAT® CLT

GEOSYNTHETIC CLAY LINER

BENTOMAT CLT CERTIFIED PROPERTIES			
MATERIAL PROPERTY	**TEST METHOD**	**TEST FREQUENCY ft²(m²)**	**REQUIRED VALUES**
Bentonite Swell Index[1]	ASTM D 5890	1 per 50 tonnes	24 mL/2g min.
Bentonite Fluid Loss[1]	ASTM D 5891	1 per 50 tonnes	18 mL max.
Bentonite Mass/Area[2]	ASTM D 5993	40,000 ft² (4,000 m²)	0.75 lb/ft² (3.6 kg/m²) min
GCL Grab Strength[3]	ASTM D 6768	200,000 ft² (20,000 m²)	45 lbs/in (70 N/cm) MARV
GCL Peel Strength[3]	ASTM D 6496	40,000 ft² (4,000 m²)	3.5 lbs/in (6.1 N/cm) min
GCL Hydraulic Conductivity[4]	ASTM D 5887	Periodic	5 x 10^{-10} cm/sec max
GCL Hydrated Internal Shear Strength[5]	ASTM D 5321 ASTM D 6243	Periodic	500 psf (24 kPa) typical

Bentomat CLT is a reinforced GCL consisting of a layer of sodium bentonite between two geotextiles, which are needlepunched together and laminated to a 20-mil (0.5mm) double-sided textured HDPE geomembrane. Bentomat CLT is also available with textured HDPE geomembrane thicknesses of 30-mils (0.75mm), 40-mils (1.0mm) and 60-mils (1.5mm). The geomembrane component of Bentomat CLT is compliant with the GRI-GM-13 specification for HDPE geomembranes.

Notes

[1] Bentonite property tests performed at a bentonite processing facility before shipment to CETCO's GCL production facilities.

[2] Bentonite mass/area reported at 0 percent moisture content.

[3] All tensile strength testing is performed in the machine direction using ASTM D 6768. All peel strength testing is performed using ASTM D 6496. Upon request, tensile and peel results can be reported per modified ASTM D 4632 using 4 inch grips.

[4] ASTM D5887 Index flux and hydraulic conductivity testing with deaired distilled/deionized water at 80 psi (551 kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tailwater pressure. ASTM D 5887 testing is performed only on a periodic basis because the geomembrane is essentially impermeable. The GCL component alone (without the geomembrane) has a hydraulic conductivity of 5 x 10^{-9} cm/s.

[5] Peak value measured at 200 psf (10 kPa) normal stress for a specimen hydrated for 48 hours. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

TR 401-BMCLT 09/13

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A Minerals Technologies Company

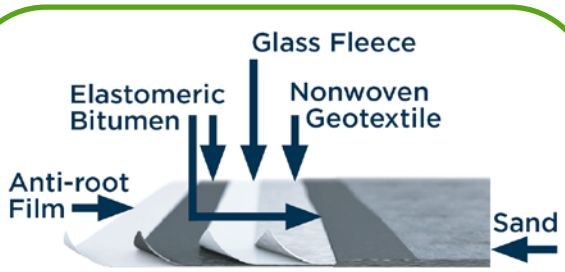
COLETANCHE BITUMINOUS GEOMEMBRANE (BGM) LINERS

Bituminous Geomembrane (BGM) liners are an extremely versatile flame-resistant containment solution. The U.S. Nuclear Safety Agency qualifies them for a 1,000 year life span, based on UV resistance and physical durability. Highly resistant to punctures and tearing, they're also highly flexible and can hold a friction angle of 34 degrees. They are compatible with most materials, which makes them safe for direct installation on most soil types.

Some other BGM features include:

- Meets ULC-S668-12 flammability requirements
- Capable of direct cover by vegetation, poured concrete and hot mix asphalt -- temperature is not a concern
- Flexibility and dimensional stability provide permanent contact with substrate and makes it ideal for differential settlement
- Resistance to chemicals (including VOCs), biological agents and oxidation
- UV resistance means it can be left exposed indefinitely
- Self-sealing bituminous internal mass can flow and seal penetrations
- Installation on 2" compacted subgrade significantly reduces site preparation costs
- High surface mass allows installation in strong wind or underwater and saves on ballasting costs and effort
- Easy to weld and bond and can be welded to other membranes (HDPE, LLDPE, Polypropylene or PVC), other types of BGM, concrete or steel
- Can be installed at conditions as low as -40°C

Product Specifications are included on the back of this sample card



- Sanded finish aids site safety by providing worker traction, and helps hold soil in place.
- The combination of glass fleece and nonwoven polyester gives BGM liners superior puncture resistance and tensile strength.

PRODUCT SPECIFICATIONS

Coletanche Bituminous Geomembrane (BGM) Liners

Properties for the five product layers:	**ES1**	**ES2**	**ES3**	**ES4**
Glass Mat Reinforcement:	• 50 g/m²	• 50 g/m²	• 50 g/m²	• 50 g/m²
Nonwoven Geotextile Reinforcement:	• 200 g/m²	• 250 g/m²	• 300 g/m²	• 400 g/m²
Binder:	• 3,800 g/m²	• 4,300 g/m²	• 4,800 g/m²	• 5,400 g/m²
Surface Finish:	• Sand, 200 g/m²	• Sand, 200 g/m²	• Sand, 200 g/m²	• Sand, 200 g/m²
Under Surface Finish, 15 g/m²:	• Polyester	• Polyester anti-root	• Polyester anti-root	• Polyester anti-root
Roll dimensions (W x L):	• 5.10 m x 90 m	• 5.10 m x 80 m	• 5.10 m x 65 m	• 5.10 m x 55 m
Uses	• Ditches • Landfill covers • Waste tip covers of moderate height	• Landfill covers • Hydraulic ponds • Industrial liquid waste containment • Canals • Contaminated Land	• Railways, directly under ballast • Dams	• Railways, directly under ballast • Dams
Thickness ASTM D5199 (mm, incl. Min/Max)	4.00 3.80 / 4.40	4.00 3.80 / 4.40	4.80 4.56 / 5.28	5.60 5.32 / 6.16
Surface Mass ASTM D3776 (kg/m² incl. Min/Max)	4.20 3.89 / 4.50	4.85 4.50 / 5.20	5.80 5.37 / 6.20	6.40 6.10 / 7.00
Max. Tensile Strength ASTM D7275 (kN/m)	Longitudinal: 22 Cross-Direction: 18	Longitudinal: 27 Cross-Direction: 24	Longitudinal: 33 Cross-Direction: 29	Longitudinal: 39 Cross-Direction: 31
Tensile Elongation ASTM D7275 (%)	Longitudinal: 60 Cross-Direction: 60	Longitudinal: 60 Cross-Direction: 60	Longitudinal: 60 Cross-Direction: 60	Longitudinal: 60 Cross-Direction: 60
Water Permeability ASTM E96 (m/s)	6.10^{-14}	4.10^{-14}	6.10^{-14}	6.10^{-14}
Gas Permeability ASTM D1434-82 [m³/(m².j.atm)]	< 2, 3.10^{-14}	< 2, 3.10^{-14}	< 2, 3.10^{-14}	< 2, 3.10^{-14}
Oxidation EN 14575 (Max. Tensile Strength / Elongation, %)	100 / 100	100 / 100	100 / 100	100 / 100

Rolls must not be stored directly on the ground. They must be supported on concrete blocks, trestles or timber beams of a minimum 35 cm height, placed under the mandrel ends.

Disclaimer: The information provided by Nilex is believed to be correct and is generally based on information supplied by the manufacturers of the product offered. Any recommendations made by Nilex concerning uses or applications of our products are also believed to be reliable; however, as Nilex has no control over design execution, and field conditions of the project which incorporate the product. Nilex disclaims all warranties, expressed or implied, including, without limitation, the warranties of merchantability and/or fitness for a particular purpose.

COLETANCHE®
www.coletanche.com

Axter Coletanche® Inc.
1030, rue Beaubien est, Suite 301
Montreal, QC, H2S 1T4
CANADA

Prepared: 05/07/2013
Cancels and replaces: 29/04/2013
Code : 1878001
Manufacture source Courchelettes (59-France)
Technical ref: FT AXTER ES4 ASTM

PRODUCT DATA SHEET

COLETANCHE ES 4

DESCRIPTION

COLETANCHE ES 4 is an SBS elastomeric modified bituminous geomembrane.

USE

Extreme level of mechanical resistance, for use as environmental protection and droungworks waterproofing (aggressive materials,reinforced precautions), in particular :
- Railways, directly under ballast,
- Dams,

Product use must be validated by Axter.

APPLICATION METHOD

Torched

STORAGE

Rolls must not be stored directly on the ground. They must be laid supported on concrete blocks, trestles or timber beams) min 35 cm height, placed under the mandrel ends.

COMPOSITION

(indicative)

Reinforcement (g/m²) :	Glass mat	50
Reinforcement (g/m²) :	Non-woven geotextile	400
Binder (g/m²) :	Elastomeric SBS	5400
Surface finish (g/m²) :	Sand	200
Under surface finish (g/m²) :	Polyester antiroot film	15

CHARACTERISTICS

		STANDARD	UNITS	VALUES	Tolerance Min	Tolerance Max
Dimensions	Length	-	*m*	54	≥	
	Width		*m*	5.01	≥	
Thickness (on finished product)		*ASTM D 5199*	mm	5.60	*5.32*	*6.16*
Surface mass		*ASTM D 3776*	kg/m²	6.40	*6.10*	*7.00*
Resistance to tearing	Longitudinal	*ASTM D 4073*	N	1225	*919*	
	Cross direction			1025	*769*	
Tensile properties : maximum tensile strength	Longitudinal	*ASTM D 7275*	kN/m	39	*29.2*	
	Cross direction			31	*23.2*	
Tensile properties : elongation	Longitudinal		%	60	*48*	
	Cross direction			60	*48*	
Tensile properties : maximum tensile strength	Longitudinal	*ASTM D 4595*	kN/m	32	*24*	
	Cross direction			28	*21*	
Tensile properties : elongation	Longitudinal		%	90	*60*	
	Cross direction			90	*60*	
Static Puncture		*ASTM D 4833*	N	650	*585*	
Flexibility at low temperature	Surface	*ASTM D 5147*	°C	-20		
	Under surface			-20		
Water permeability (liquid tightness)		*ASTM E 96*	*m/s*	6.10^{-14}		
Gas permeability (gas tightness)		*ASTM D 1434-82*	*m3/(m².j.atm)*	$< 2{,}3.10^{-14}$		

NOTE: AXTER COLETANCHE INC. may modify the composition and/or utilisation of its products without prior notice. Consequently orders will be filled according to the latest specification.
The manufacturer reserves the right to modify, at any time, the characteristics of its products.

Seema Kang

From: Rykaart, Maritz
Sent: Wednesday, November 29, 2017 6:34 PM
To: Kelly Schwenning; shelley.potter@tmacresources.com
Cc: John Roberts; Gil Lawson; Kurylo, John; Hore, Cameron
Subject: South Dam Phase 1 IFC Drawings
Attachments: 1CT0022.017_HB_South Dam_IFC-1_Rev0_20171129.pdf

Kelly and Shelley

Attached please find Issue for Construction (IFC) Drawings for the Phase 1 South Dam for submission to the Mines Inspector and NWB (if required). Please note the following:

1. Next week we will issue a few more IFC drawings that cover the "percolation" testing and the final instrumentation. These are however secondary to the attached set and therefore we believe that you can submit this to ensure the regulators are on board.
2. Next week we will also issue an updated set of IFC technical specifications.
3. In 2 weeks' time we will also release the final design report that accompanies these designs that can be submitted to the NWB for their records.

If there are any questions please don't hesitate to give me or John Kurylo a shout.

Cheers
Maritz

Maritz Rykaart *PhD, PEng*
Practice Leader/Principal Consultant (Geotechnical Engineering)
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Hope Bay Mining Ltd.

Doris North Project

Engineering Drawings for the South Dam - Phase 1

Drawing Number	Drawing Title	Issue	Date	Revision
DN-SD-01	General Arrangments	Issued for Construction	November 29, 2017	0
DN-SD-02	General Arrangements	Issued for Construction	November 29, 2017	0
DN-SD-03	Typical Sections (General)	Issued for Construction	November 29, 2017	0
DN-SD-04	Key Trench Excavation Plan and Profile	Issued for Construction	November 29, 2017	0
DN-SD-05	Liner Placement Plan and Details - Key Trench and Phase 1	Issued for Construction	November 29, 2017	0
DN-SD-06	Liner and Bedding Placement Details	Issued for Construction	November 29, 2017	0
DN-SD-07	Bedding Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	November 29, 2017	0
DN-SD-08	Transition Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	November 29, 2017	0
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	November 29, 2017	0
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	November 29, 2017	0
DN-SD-11	Construction Access Road and Turn Around - Phase 1	Issued for Construction	November 29, 2017	0
DN-SD-12	Final Phase 1 Dam Plan, Profile and Sections	Issued for Construction	November 29, 2017	0
DN-SD-13	Sections Sta. 0+10 to 0+90 - Phase 1 Dam	Issued for Construction	November 29, 2017	0
DN-SD-14	Sections Sta. 1+00 to 1+80 - Phase 1 Dam	Issued for Construction	November 29, 2017	0
DN-SD-15	Sections Sta. 1+90 to 2+70 - Phase 1 Dam	Issued for Construction	November 29, 2017	0
DN-SD-16	Sections Sta. 2+80 to 3+60 - Phase 1 Dam	Issued for Construction	November 29, 2017	0
DN-SD-17	Sections Sta. 3+70 to 4+50 - Phase 1 Dam	Issued for Construction	November 29, 2017	0
DN-SD-18	Sections Sta. 4+60 to 5+30 - Phase 1 Dam	Issued for Construction	November 29, 2017	0

SRK Job No. 1CT0022.017

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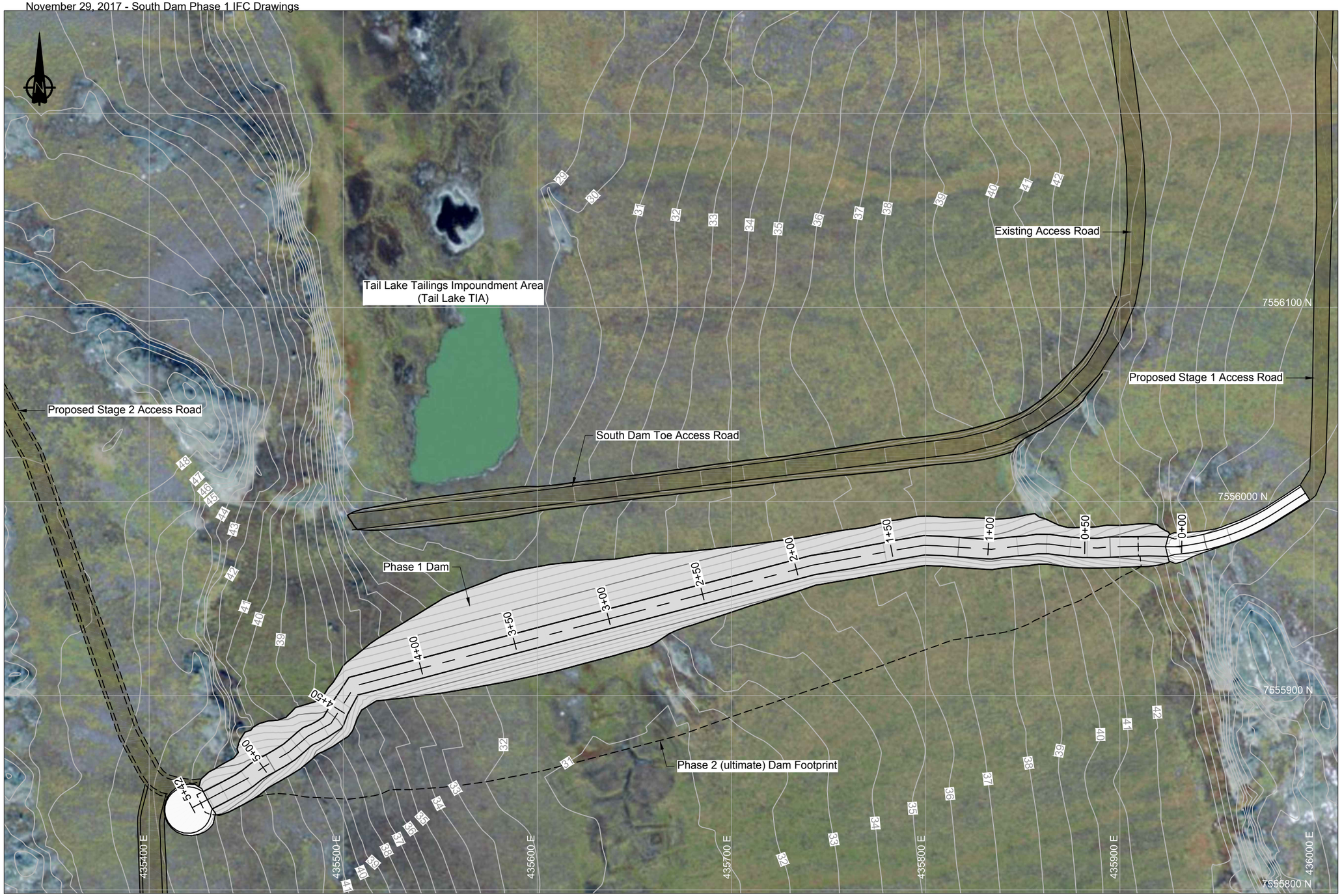

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Imagery (from 2010 PhotoSat compilation) provided by client.
5. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

0m 20 40 60 80

-	-										
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
REFERENCE DRAWINGS		REVISIONS									

Original Drawings
Stamped and
Signed by Engineer

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CHECKED: JBK	APPROVED: EMR	DATE: 17/11/29

FILE NAME: 1CT0022.017 - South Dam GA - with ortho.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:
Phase 1 General Arrangement
(with Orthophoto)

DRAWING NO.	SHEET	REVISION NO.
DN-SD-01	1 OF 18	0

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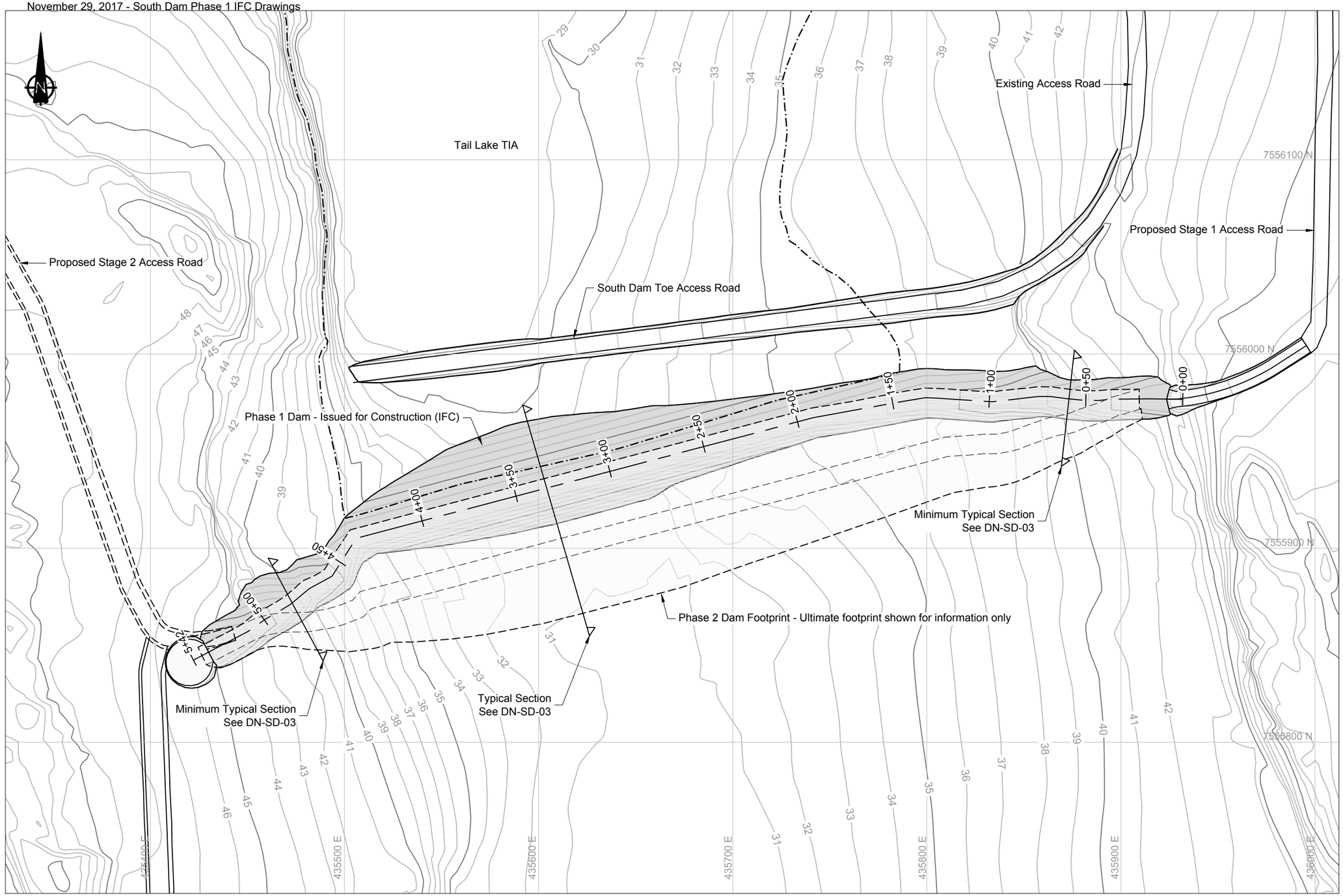

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Volumes presented based on neat-lines only and are approximate. These include no over-excavation or over-blasting allowance of the key trench.
5. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

TABLE OF QUANTITIES (NEAT-LINE)

Key Trench Bulk Excavation :	20,000m³
Total Phase 1 Fill:	66,000m³
ROQ:	33,500m³
Transition:	25,500m³
Bedding:	7,000m³
Total Liner:	15,000m²
West Turnaround (bulk):	375m³
East Turnaround (bulk):	605m³

0m 20 40 60 80

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-			

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	JBK	EMR	17/11/29

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FILE NAME: 1CT0022.017 - South Dam GA.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Phase 1 General Arrangement

DRAWING NO.	SHEET	REVISION NO.
DN-SD-02	2 OF 17	0

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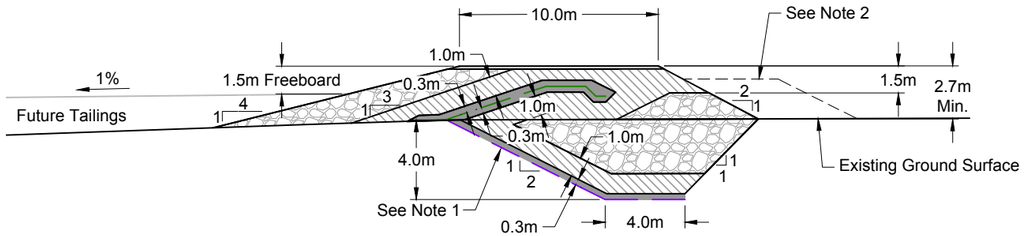
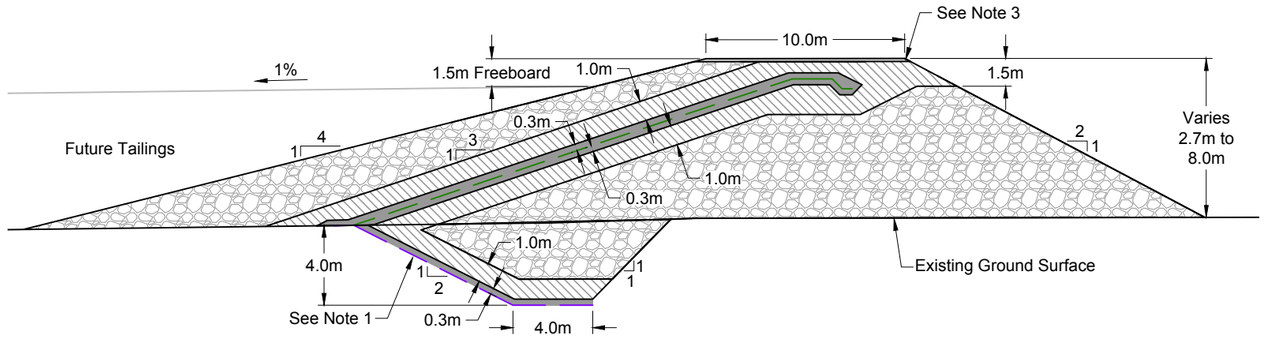


Minimum Typical Cover Section
STA.0+00 to 1+92 & 4+35 to 5+42

0m 3 6 9 12

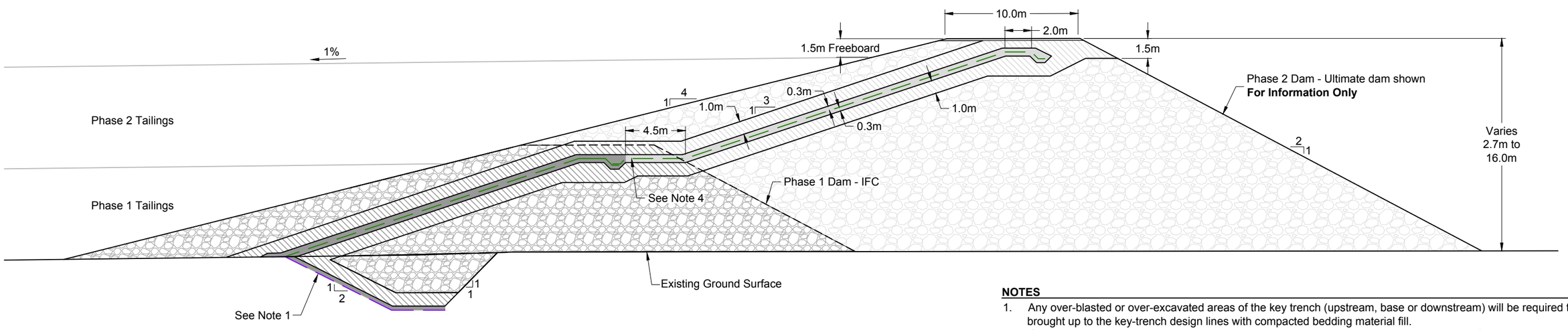
ISSUED FOR CONSTRUCTION



Phase 1 Typical Dam Section
STA. 1+92 to 4+35

0m 3 6 9 12

ISSUED FOR CONSTRUCTION



Phase 2 Typical Dam Section
STA. +06 to 3+50

0m 3 6 9 12

ISSUED FOR INFORMATION

LEGEND

- Key Trench Liner
- Phase 1 & 2 Dam Liner
- Bedding Material
- Transition Material
- Run of Quarry

NOTES

1. Any over-blasted or over-excavated areas of the key trench (upstream, base or downstream) will be required to be brought up to the key-trench design lines with compacted bedding material fill.
2. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench. This material would be placed to ensure that adequate thermal insulation of the key trench is maintained in all sections. See Detail 10 on drawing DN-SD-09 for additional details.
3. The top road surfacing (bedding material) for the Phase 1 dam is to be fully removed (upstream and downstream) before Phase 2 construction commences.
4. To allow for a proper tie-in the transition material around the top downstream portion of the Phase 1 dam will be required to be stripped back. Once the bedding material around the top liner anchor trench is reached hand excavation should be expected to result down to expose the liner. The on-site engineer will be required to inspect all exposed liner, to ensure that it is not damaged or in need of repairs before Phase 2 liner tie-ins result.
5. All units shown are in meters unless otherwise stated.

-	-										
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
REFERENCE DRAWINGS		REVISIONS									

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FILE NAME: 1CT0022.017 - South Dam - Typ Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Typical Sections (General)

DRAWING NO.	SHEET	REVISION NO.
DN-SD-03	3 OF 18	0

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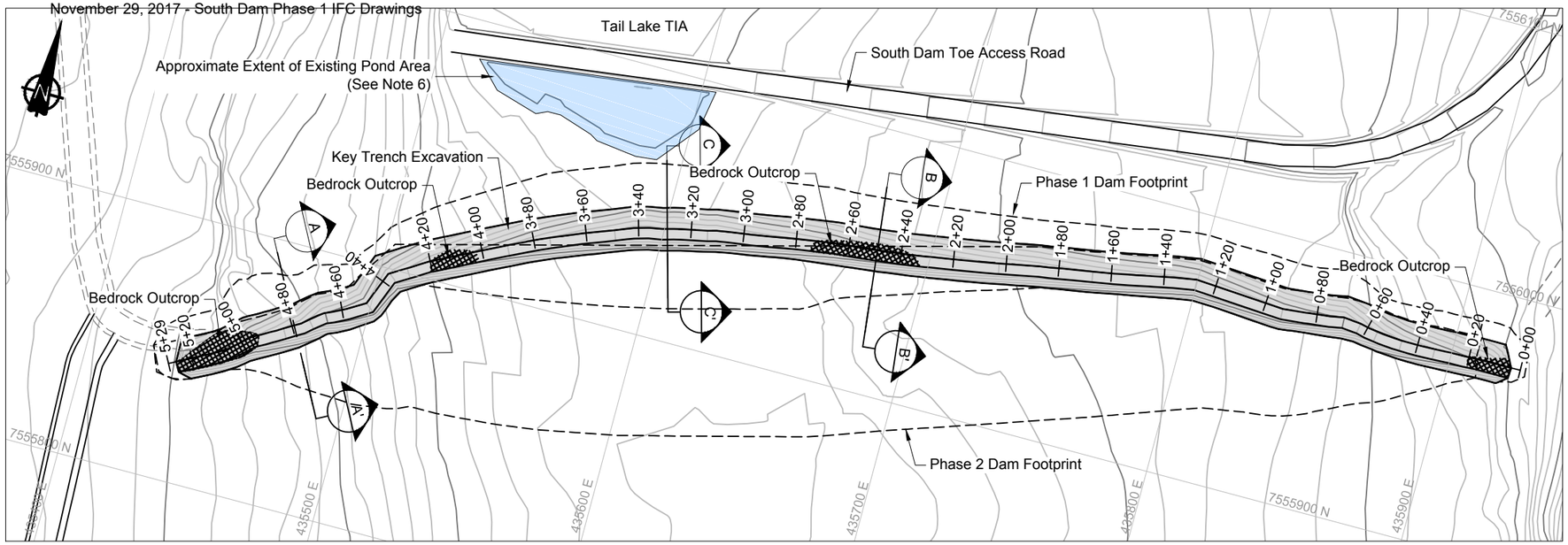
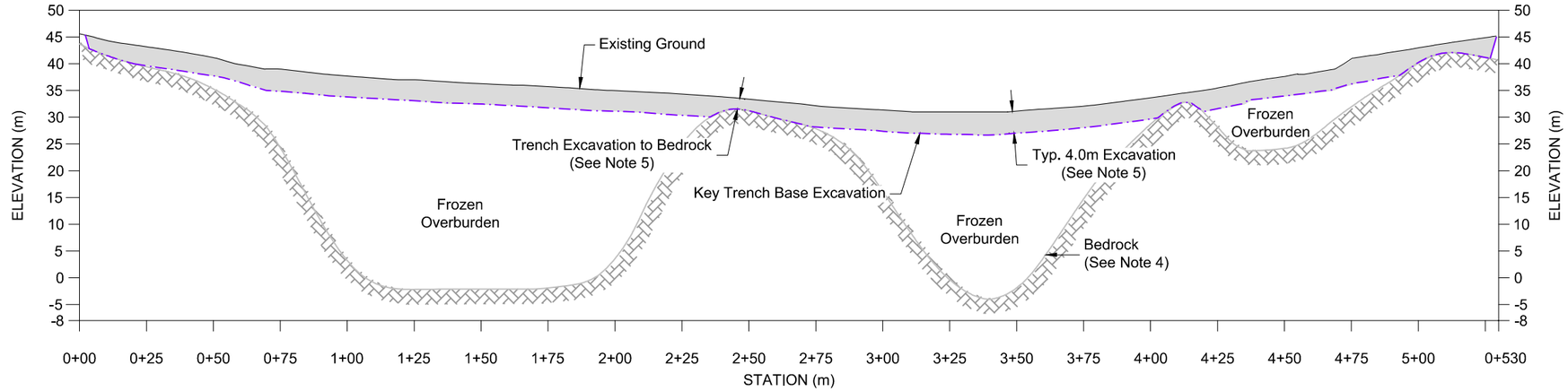


Key Trench Plan View

0m 20 40 60 80



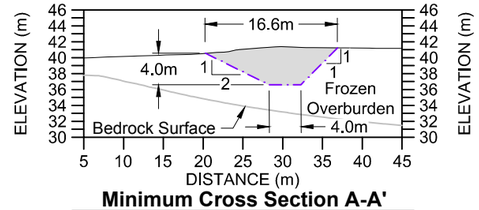
Key Trench Profile View

Vertical 0m 10 20 30 40

Horizontal 0m 20 40 60 80

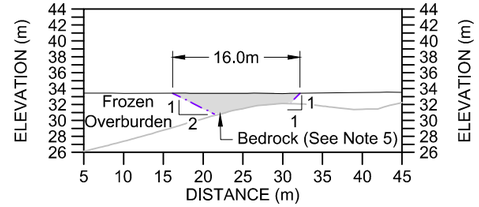
NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profile shown correspond to the upstream toe of the key trench.
4. The subsurface geology has been inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A , SRK43, SRK 44), airphoto interpretations, and from limited available geophysical surveys around the Tails Lake area. This data was then used to create a bedrock surface with the Gemcom GEMS software. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.
5. The final key trench extent and depth will be determined in the field by the Engineer. Typical excavation depth is 4.0m, unless massive ice, hypersaline soil or bedrock encountered. The Engineer will inspect all excavations and approve the foundation conditions.
6. Ponded area to removed (frozen massive ice excavated or drained if possible) prior to key trench excavation. Up to approximately 4,700 m3 of (frozen) water may be expected to be removed from this area. Exact water levels are not known so the volume estimate above should be treated as a rough estimate based on topography.
7. If any area of the key trench is over-blasted or over-excavated then the extra excavation will need to be backfilled in thin lifts (*see 'Technical Specifications'*) until the key trench design lines and grades are reached.



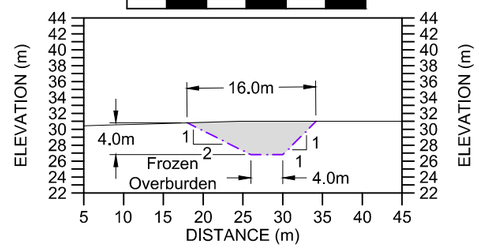
Minimum Cross Section A-A'
Shallow Overburden over Bedrock

0m 5 10 15 20 25 30



Cross Section B-B'
Bedrock Outcropping in Key Trench

0m 5 10 15 20 25 30



Cross Section C-C'
Deep Frozen Overburden

0m 5 10 15 20 25 30

LEGEND

- Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Trench Excavation Extent

REFERENCES

NAD83 UTM Zone 13.

DRAWING NO.	DRAWING TITLE
-	-

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

Original Drawings Stamped and Signed by Engineer

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Key Trench.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:
Key Trench Excavation
Plan and Profile

DRAWING NO.	SHEET	REVISION NO.
DN-SD-04	4 OF 18	0

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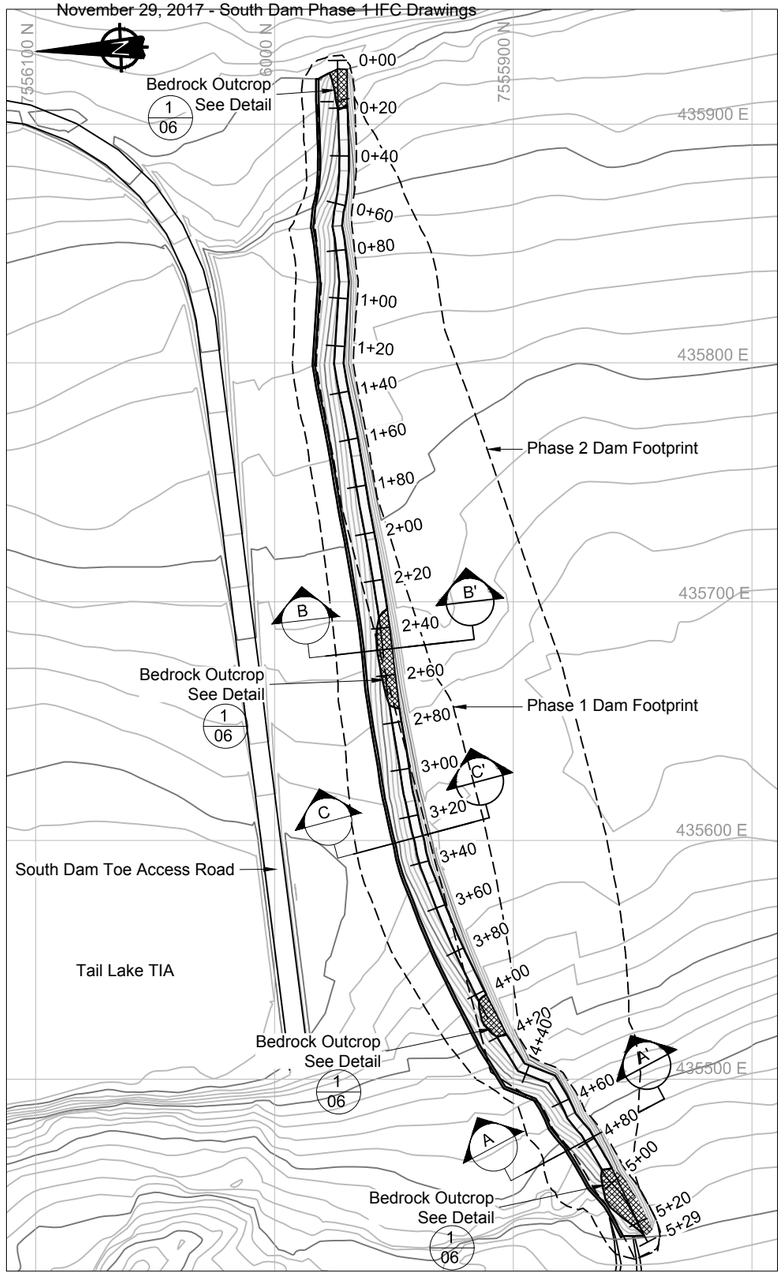
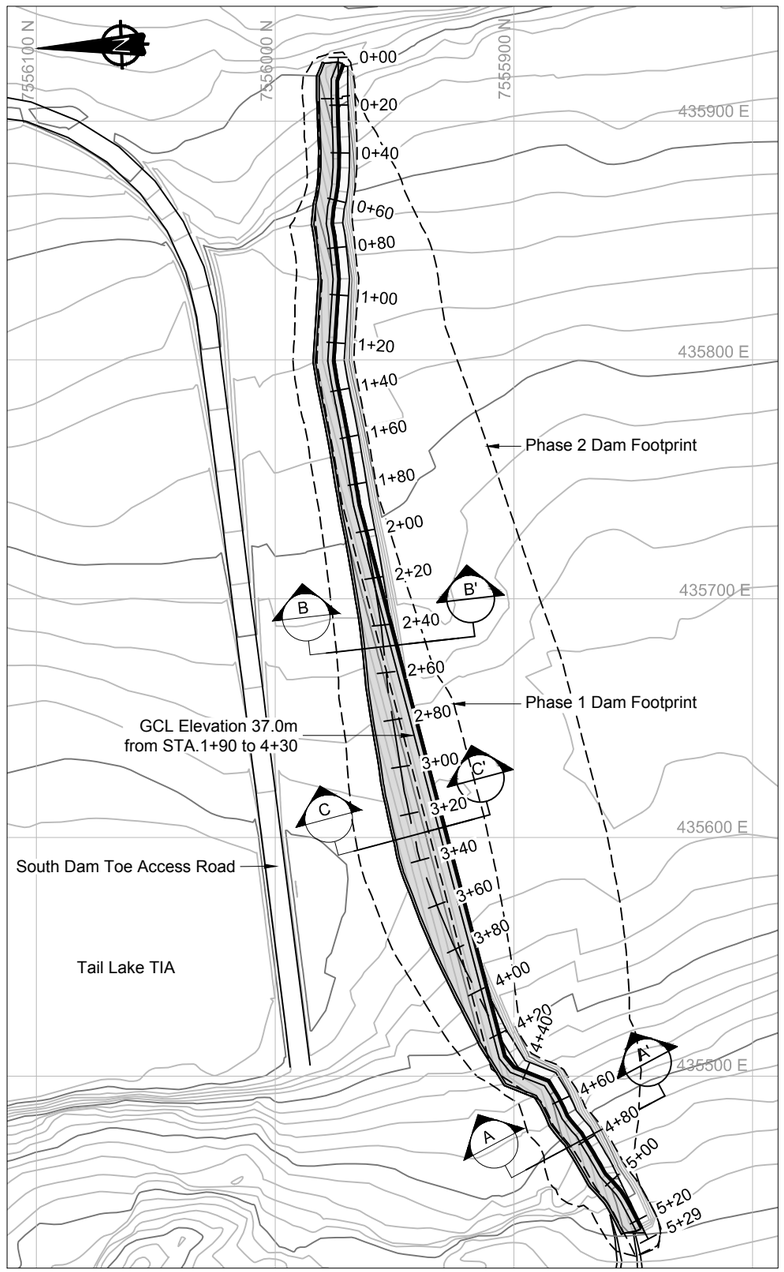


Lower Liner Plan - Placement in Key Trench

0m 20 40 60 80 100



Upper Phase 1 Liner Plan - Above Ground Upstream Slope Placement

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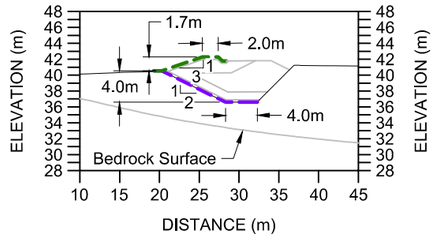

Minimum Cross Section A-A'

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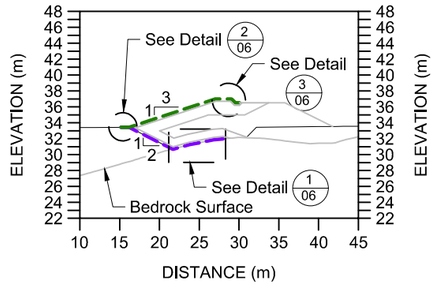

Cross Section B-B' - Bedrock Encountered in Trench

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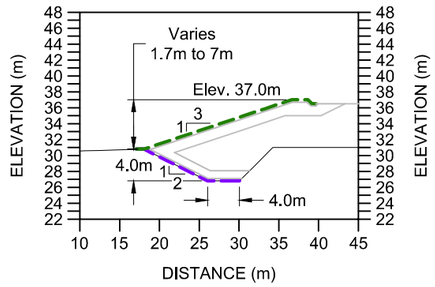

Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

- Key Trench Liner
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent
- GCL Liner Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The upstream slope of the key trench excavation need to be scraped and smoothed to prepare a suitable subbase for the GCL liner. If any larger voids or undulation exist then they will need to be backfilled with compacted bedding material fill, placed in thin lifts.
4. The subgrade surface must be free of vegetation, sharp-edged rocks, stones, sticks, construction debris, and other foreign material that could contact the GCL. Furthermore, all protrusions extending more than 12 mm from the subgrade surface shall either be removed, crushed, or pushed into the surface with a smooth-drum compactor.
5. GCL should not be placed over massive ice or standing water (both need to be removed prior to placement).
6. All Geosynthetic Clay Liner (GCL) liner sections / panels will be required to have a minimum 0.5m overlap on every edge. See Detail 2, 3, 5 and 6 for additional information.
7. At the locations where bedrock is encountered in the key trench then these areas will be required to be ripped down to competent bedrock or scrapped smooth and then bentonite powder will be placed between the bedrock contact and the GCL liner (see Detail 1).

REFERENCES

NAD83 UTM Zone 13.

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-06	Liner and Bedding Placement Details	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	JBK	EMR	17/11/29

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FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Liner Placement Plan and Details Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-05	5 OF 18	0

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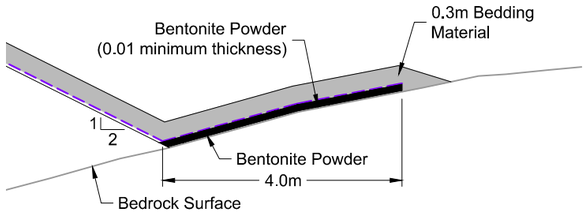
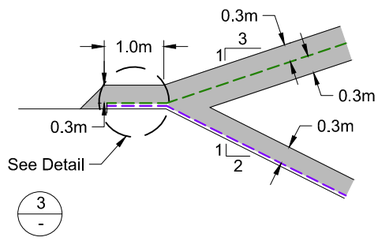
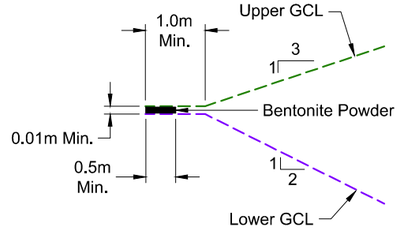


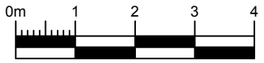
Detail 1 - Liner Attachment at Bedrock

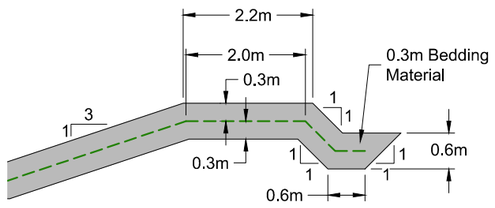


Detail 2 - Liner Overlap - Bedding

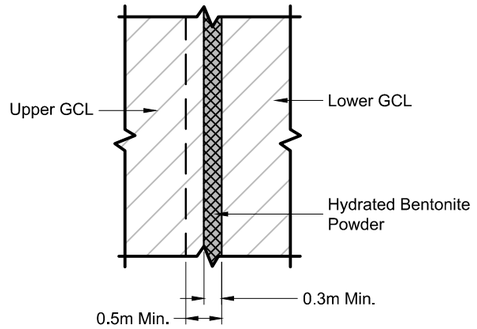


Detail 3 - Typical Upper and Lower GCL Joint

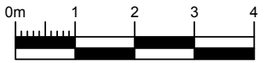


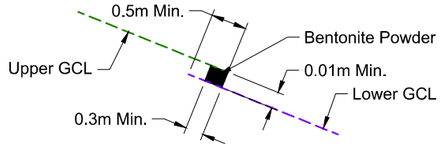


Detail 4 - Liner Key-In-Trench Bedding

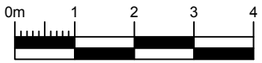


Detail 5 - Typical GCL Overlap - Plan





Detail 6 - Typical GCL Overlap - Section



LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material

NOTES

1. All units shown are in meters unless otherwise stated.
2. One end of the GCL roll should be placed in an anchor trench at the top of the slope. The front edge of the trench (see Detail 4) shall be rounded so as to eliminate any sharp corners that could cause excessive stress on the GCL. Loose soil should be removed or compacted into the floor of the trench.
3. The GCL should be placed in the anchor trench such that it covers the entire trench floor but does not extend up the rear trench wall (see Detail 4).
4. GCL seams are constructed by overlapping their adjacent edges (see Detail 5). Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris.
5. If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by placing a patch over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 500 mm is achieved around all parts of the damaged area. Bentonite mastic / powder should be applied around the damaged area prior to placement of the patch. It may be necessary to use an adhesive such as wood glue, or by hand placing material over the patch, to fix the patch in place so that it is not moved during overliner bedding material placement. Smaller patches also may be tucked under the damaged area to prevent patch movement.
6. Cover soils shall be free of angular stones or other foreign matter which could damage the GCL. Cover soils should be approved by the Engineer, with respect to particle size and uniformity (as per the 'Technical Specifications')

REFERENCES

NAD83 UTM Zone 13.

DRAWING NO.	DRAWING TITLE
-	-

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Liner and Bedding Placement Details

DRAWING NO.	SHEET	REVISION NO.
DN-SD-06	6 OF 18	0

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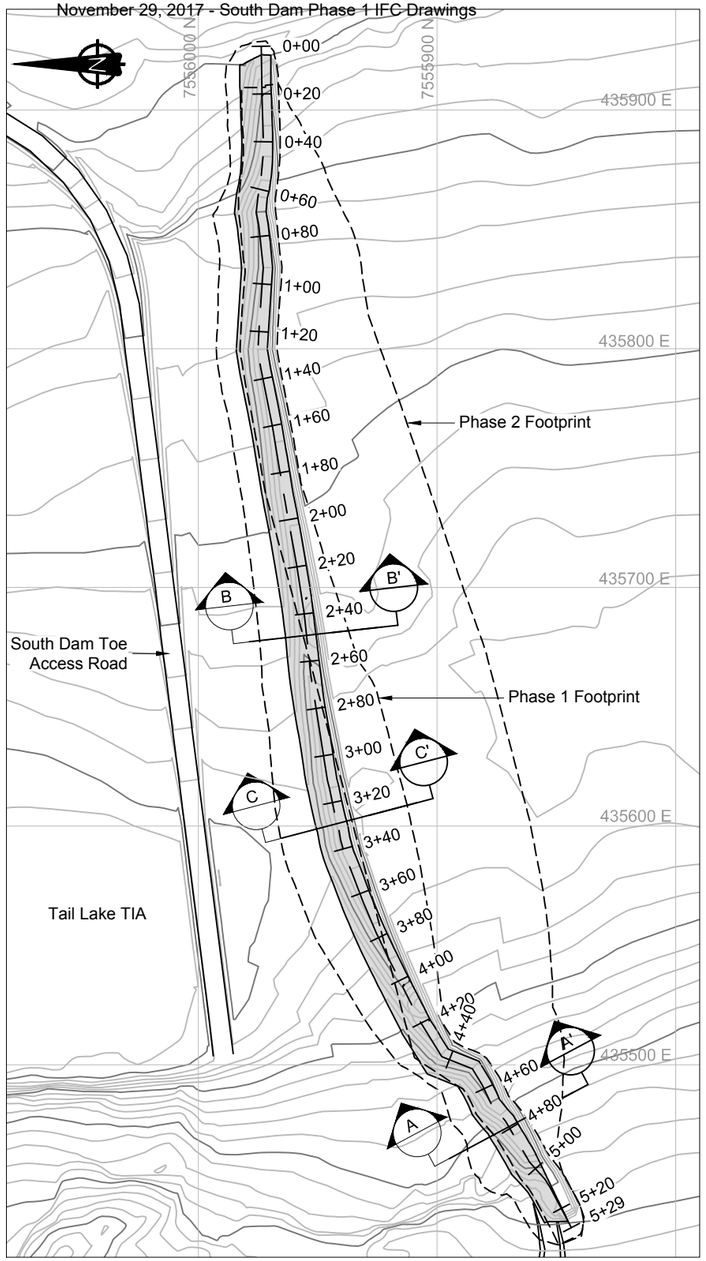
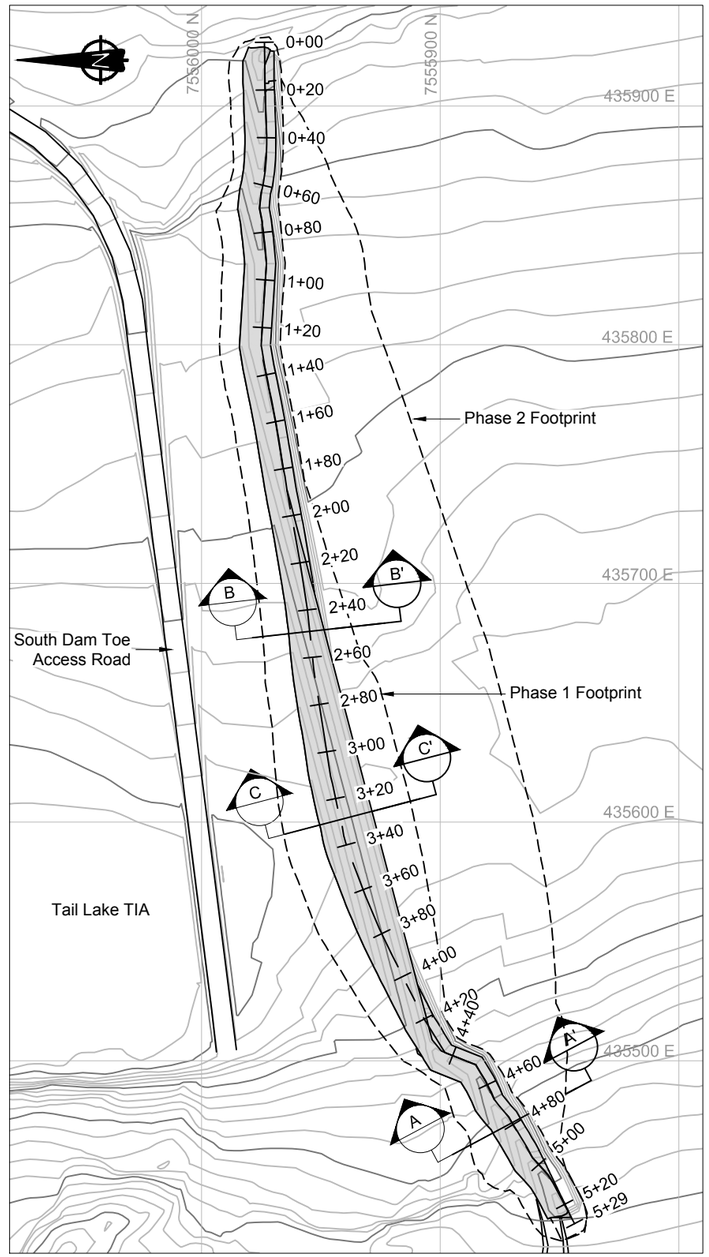


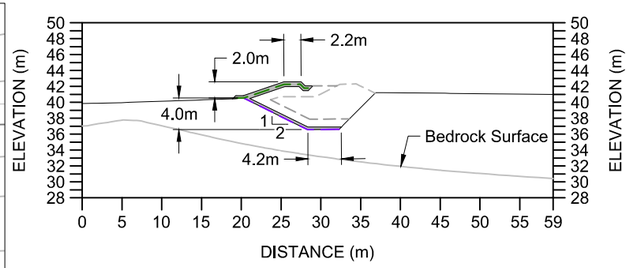
Key Trench Bedding Placement Plan View

0m 20 40 60 80 100



Phase 1 Dam Bedding Placement Plan View

0m 20 40 60 80 100



Minimum Cross Section A-A'

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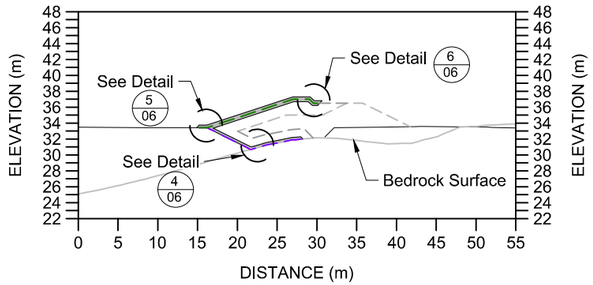

Cross Section B-B' - Bedrock Encountered in Trench

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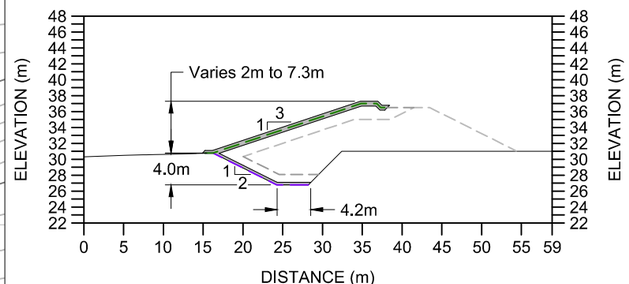

Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

- Phase 1 Dam Liner
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Bedding Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Bedding layer to be placed in thin lifts and compacted before liner placement. The subsurface below the liner should be free of protrusions or any sharp / angular gravel or larger size material. See the Technical Specifications document for more details (*'Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK).*
4. Bedding material cover shall be placed over the GCL using construction equipment that minimizes stresses on the GCL. A minimum thickness of 300 mm of cover should be maintained between the equipment tracks/tires and the GCL at all times during the covering process. This thickness recommendation does not apply to frequently trafficked areas or roadways, for which a minimum thickness of 600 mm is required.
5. Soil cover should be placed in a manner that prevents the soil from entering the GCL overlap zones.

REFERENCES

NAD83 UTM Zone 13.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
0	Issued for Construction	JBK	EMR	17/11/29

DN-SD-06 — Liner and Bedding Placement Details

REFERENCE DRAWINGS

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JKB	EMR	2017/11/29

FILE NAME: 1CT0022.017 - South Dam - Bedding.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Bedding Material Placement Plan and Sections - Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-07	7 OF 18	0

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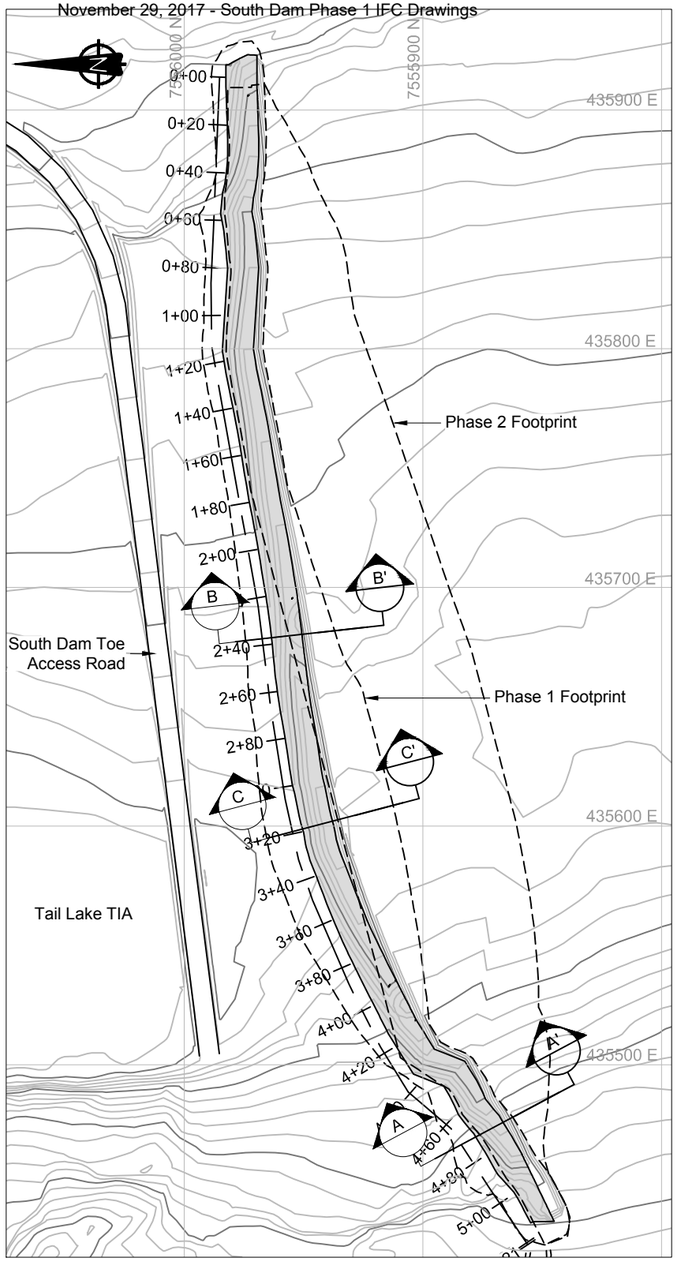

Key Trench Bedding Placement Plan View

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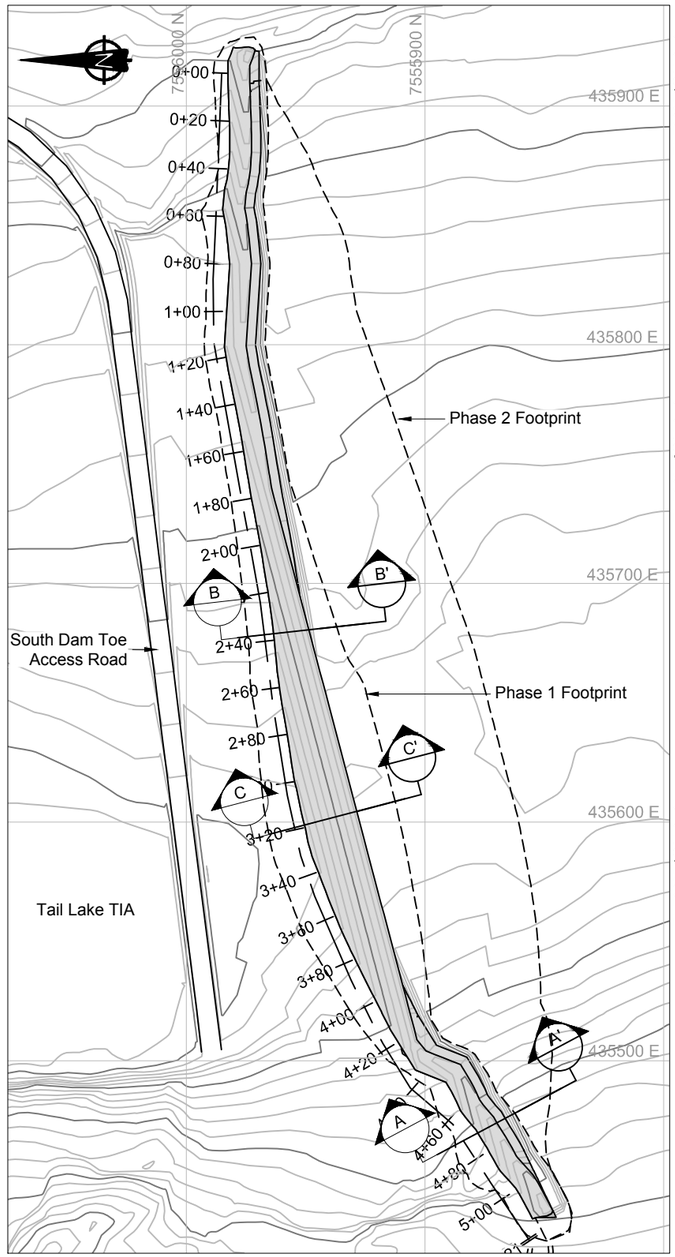

Phase 1 Dam Bedding Placement Plan View

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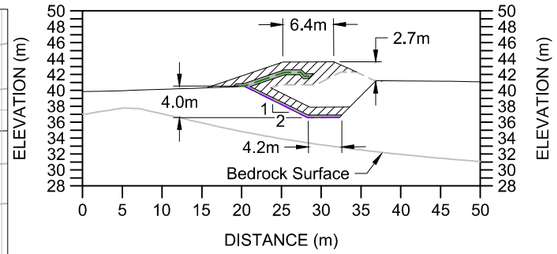

Minimum Cross Section A-A'

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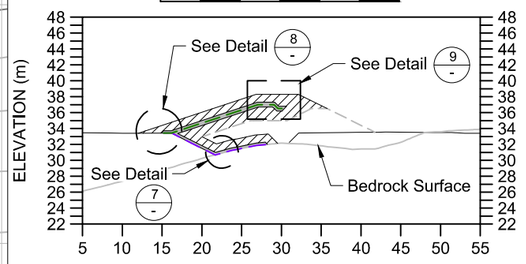

Cross Section B-B' - Bedrock Encountered in Trench

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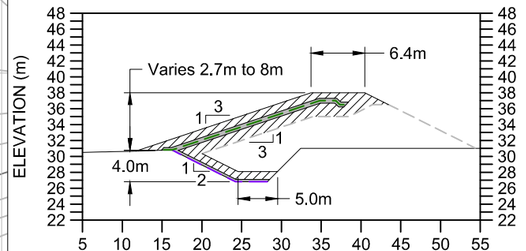


Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

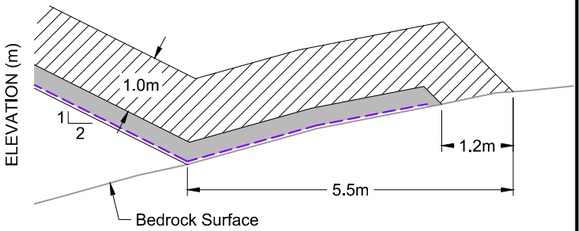
- Phase 1 Dam Liner
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Bedding Material
- Transition Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.

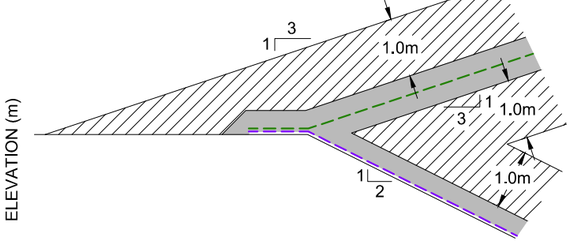
REFERENCES

NAD83 UTM Zone 13.



Detail 7 - Key Trench Bedrock Interface - Transition

0m 1 2 3 4



Detail 8 - Upper and Lower GCL Liner Overlap - Transition

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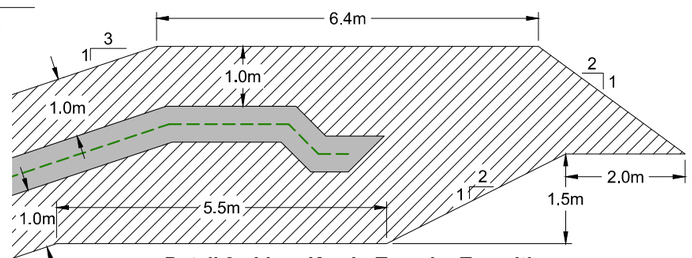

Detail 9 - Liner Key-In-Trench - Transition

0m 1 2 3 4

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REFERENCE DRAWINGS	

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FILE NAME: 1CT0022.017 - South Dam - Transition.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Transition Material Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-08	7 OF 18	0

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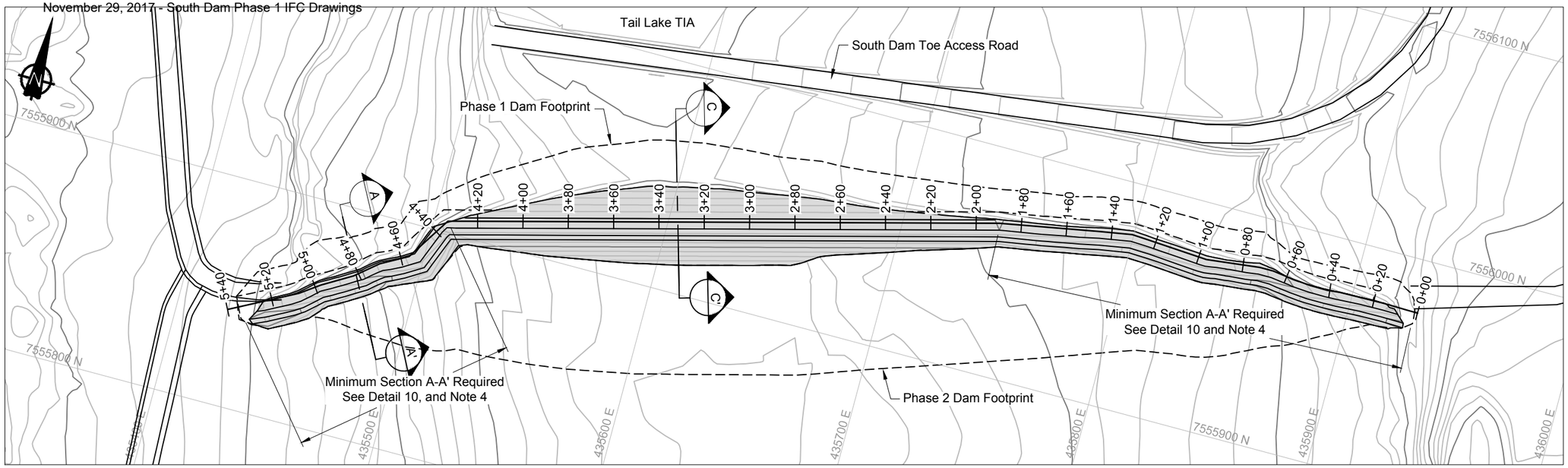

Run of Quarry Placement Plan View

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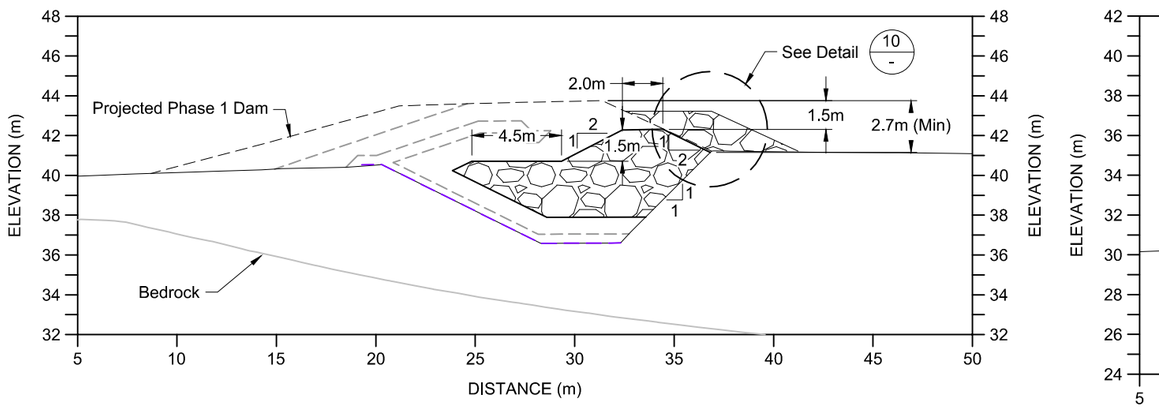

Minimum Cross Section A-A'

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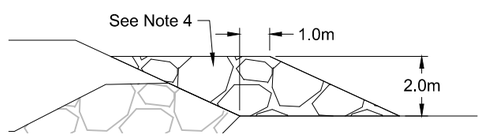

10 03,08 **Contingency ROQ Thermal Barrier Design**

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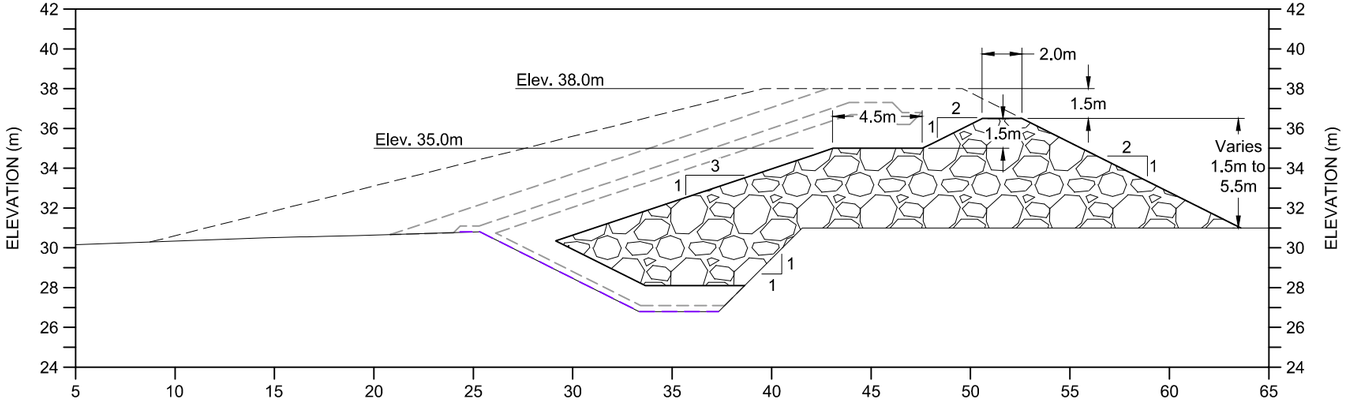

Typical Cross Section C-C'

0m 3 6 9 12

LEGEND

- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Run of Quarry Backfill Extent
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profiles shown correspond to the upstream toe of the key trench.
4. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench. See Detail 10 on drawing DN-SD-09 for additional details.
5. The outside downstream ROQ should be sloped at 2H:1V or shallower.

REFERENCES

NAD83 UTM Zone 13.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1										
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ.dwg

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SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-09	9 OF 18	0

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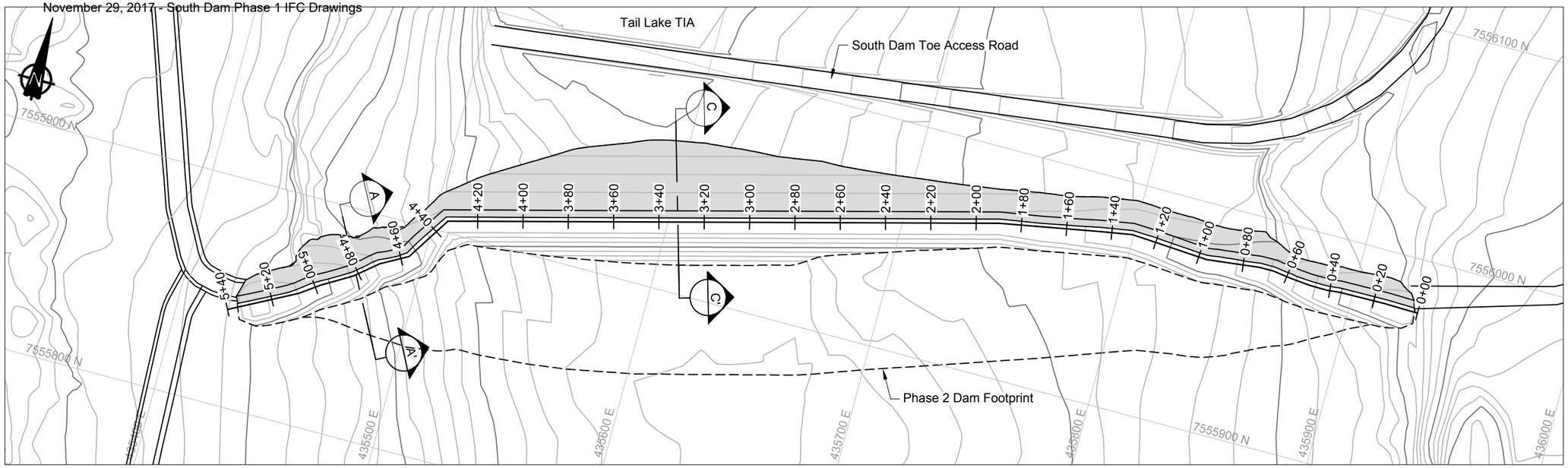

Run of Quarry Placement Plan View

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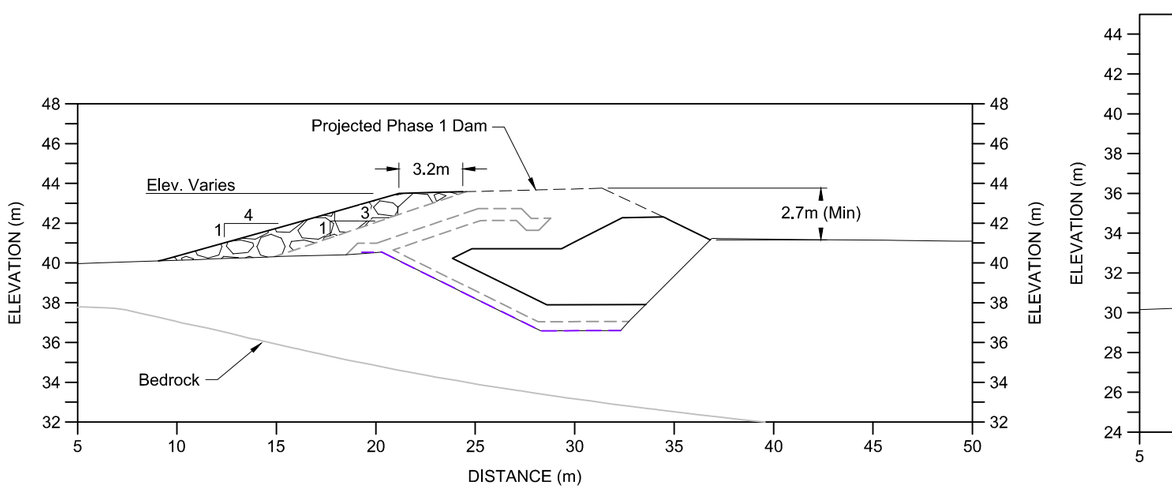

Minimum Cross Section A-A'

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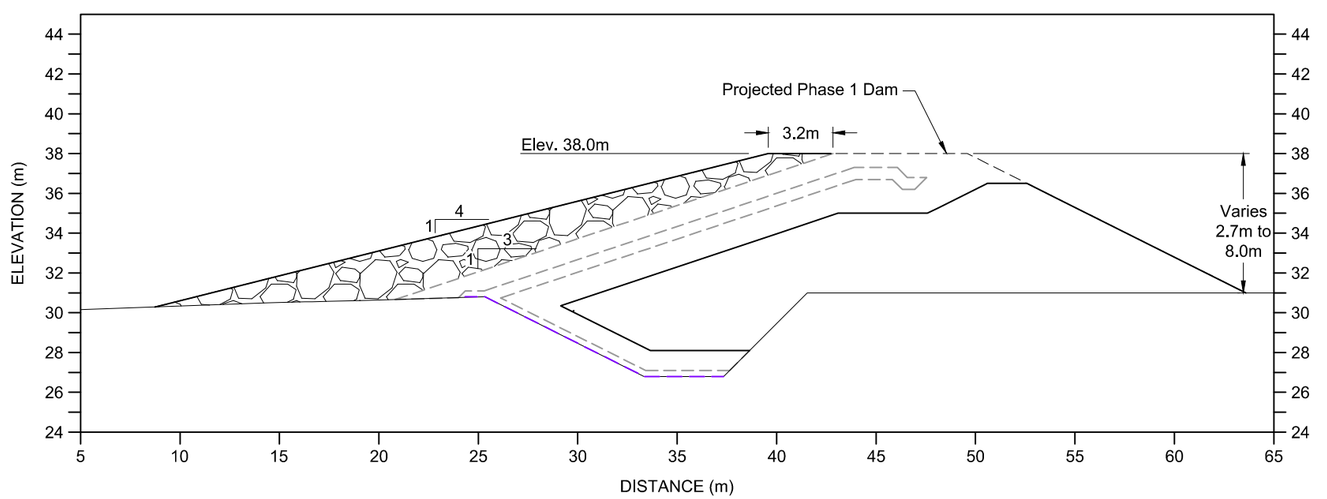

Typical Cross Section C-C'

0m 3 6 9 12

LEGEND

- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Run of Quarry Backfill Extent
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The outside upstream dam ROQ should be sloped at 4H:1V or shallower.

REFERENCES

NAD83 UTM Zone 13.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1										
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1	-	-				0	Issued for Construction	JBK	EMR	17/11/29
-	-										

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CHECKED:	APPROVED:	DATE:
JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ-us.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-10	10 OF 18	0

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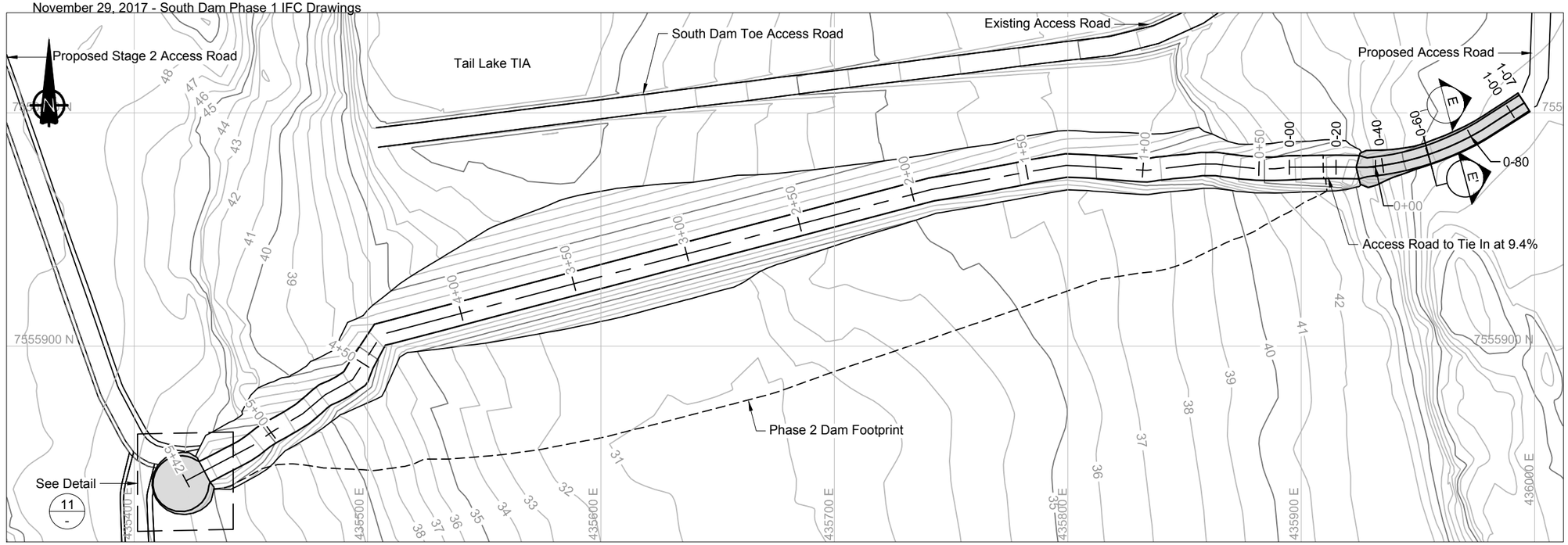


LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Access Road
- Run of Quarry
- Surfacing Material

NOTES

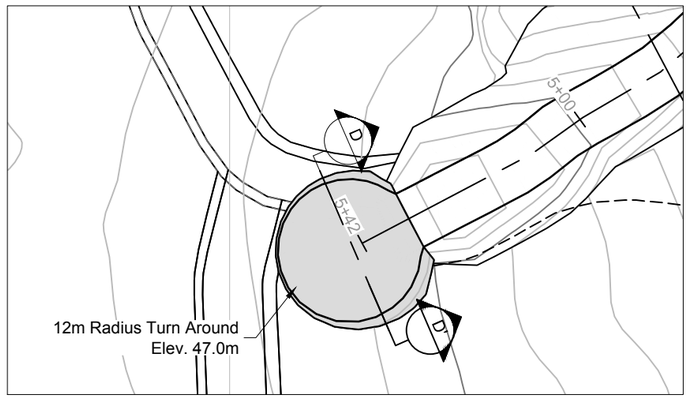
1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Approximately 325m³ of surfacing / bedding material is estimated (to neat lines) to be needed for the Access Road and Turn Around.

REFERENCES

NAD83 UTM Zone 13.

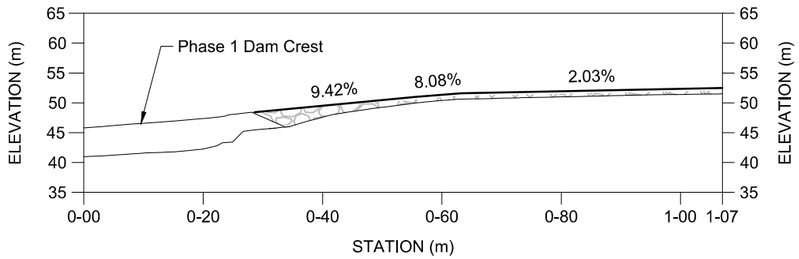
Typical Road Section

0m 20 40 60 80



Detail 11 - Turn Around

0m 10 20 30 40

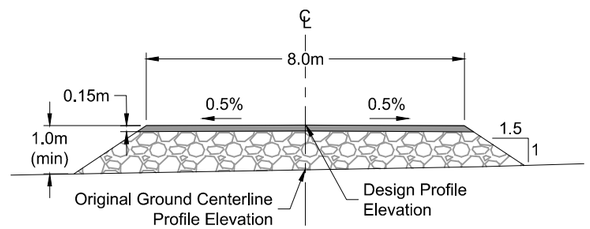


East Access Road Profile

0m 10 20 30 40

Section D-D' - Turn Around

0m 4 8 12 16



Section E-E' - Typical Road Section

0m 1 2 3 4 5 6

DRAWING NO.	DRAWING TITLE
DN-SD-03	Typical Sections (General)
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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JBK	EMR	2017/11/29

FILE NAME: 1CT0022.017 - South Dam AR.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

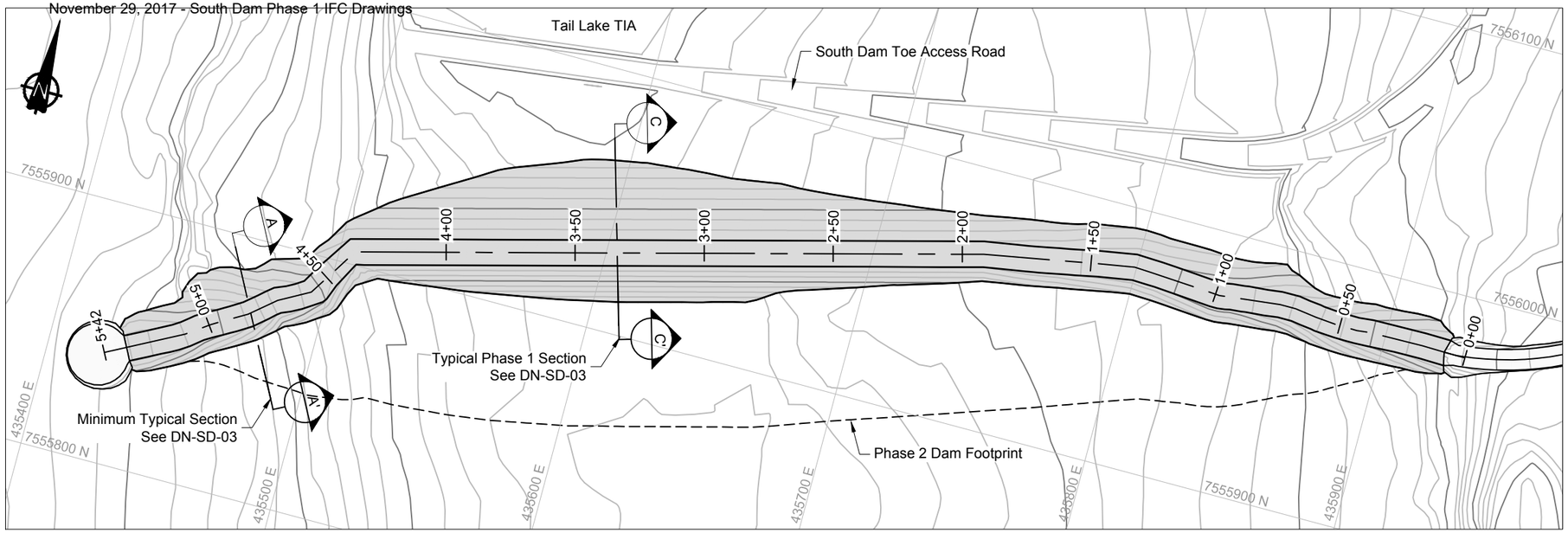
South Dam

DRAWING TITLE:

Construction Access Road and Turnaround - Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-11	11 OF 18	0

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1\1CT0022.017 - South Dam AR.dwg



Phase 1 Dam Plan View

0m 20 40 60 80

LEGEND

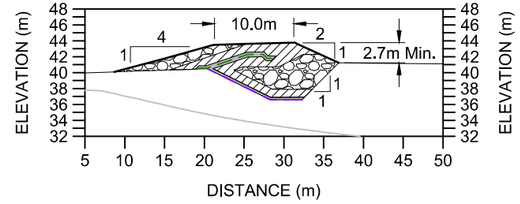
- Key Trench Excavation
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The Phase 2 dam elevations are showing for information purposes only. Note that only Phase 1 dam designs and elevations are issued for construction use.

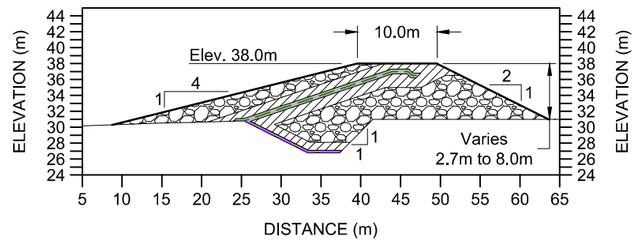
REFERENCES

NAD83 UTM Zone 13.



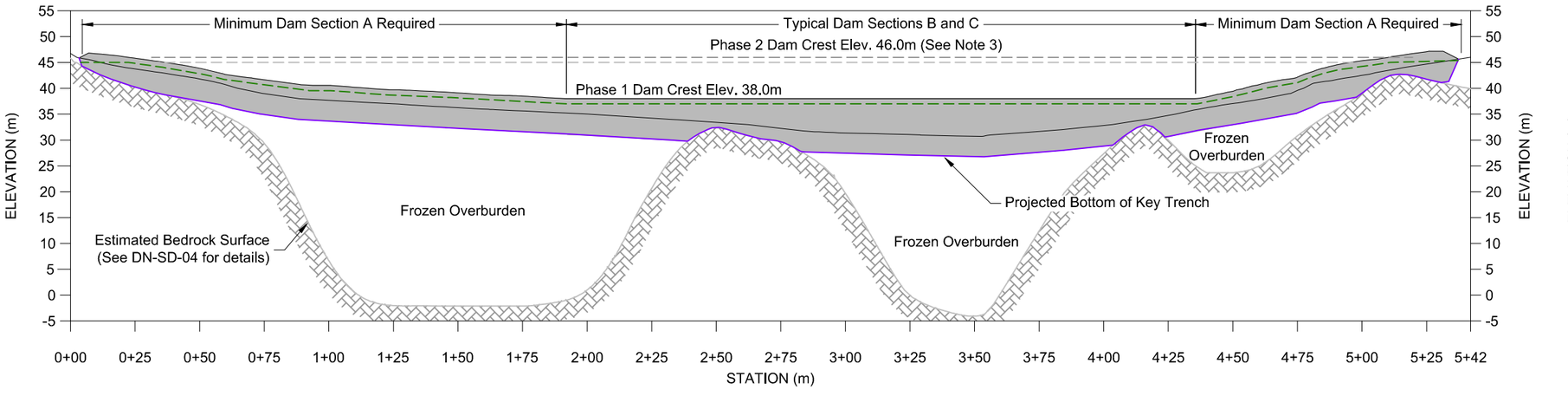
Minimum Cross Section A-A'

0m 5 10 15 20 25 30



Cross Section C-C'

0m 5 10 15 20 25 30



Phase 1 Dam Profile View

Horizontal: 0m 10 20 30 40

Vertical: 0m 20 40 60 80

DRAWING NO.	DRAWING TITLE
DN-SD-04	Key Trench Excavation Plan and Profile
DN-SD-03	Typical Sections (General)
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
0	Issued for Construction	JBK	EMR	17/11/29

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FILE NAME: 1CT0022.017 - South Dam - Phase 1 Dam.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Final Phase 1 Dam Plan, Profile and Sections

DRAWING NO.	SHEET	REVISION NO.
DN-SD-12	12 OF 18	0

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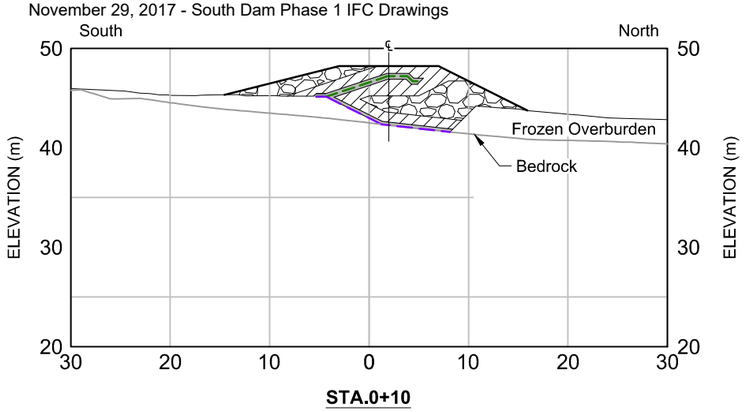

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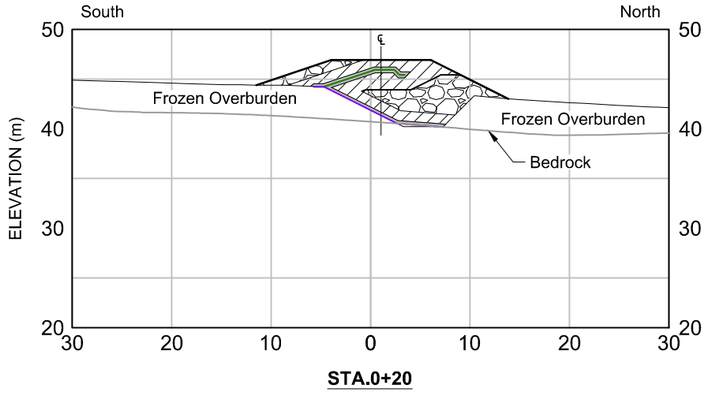

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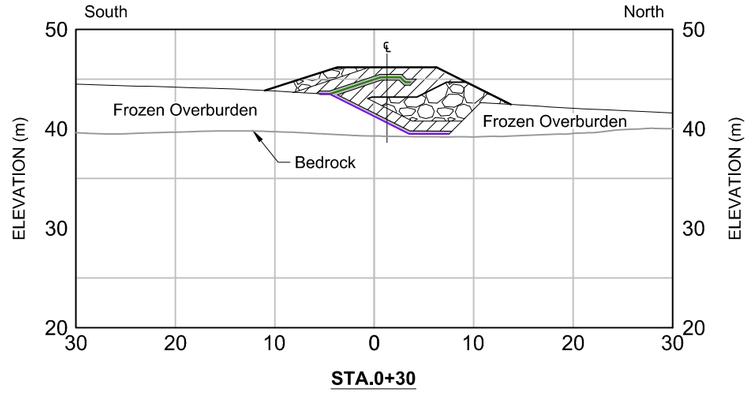

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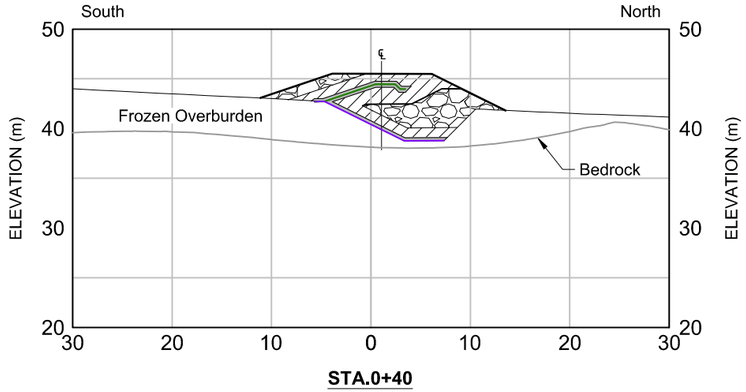

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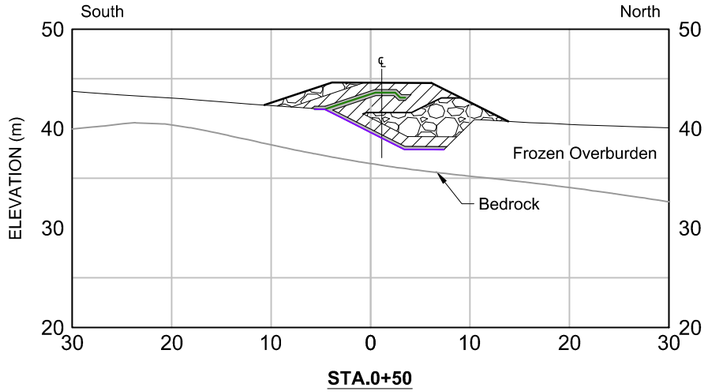

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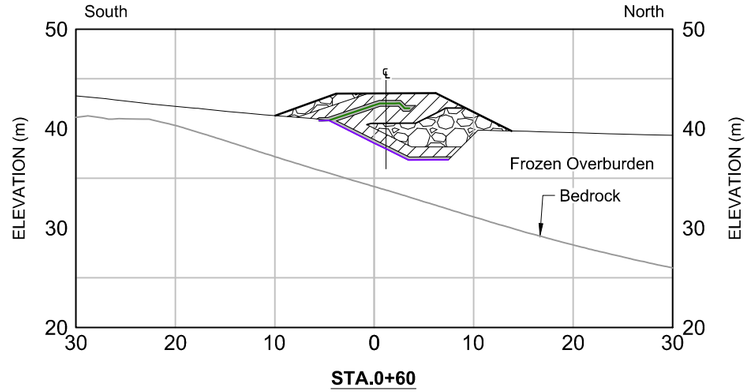

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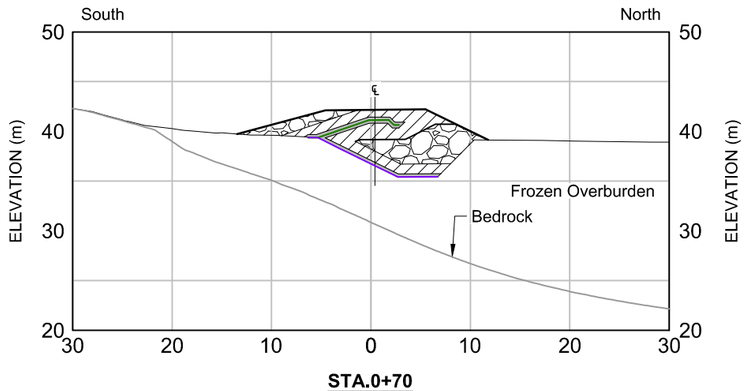

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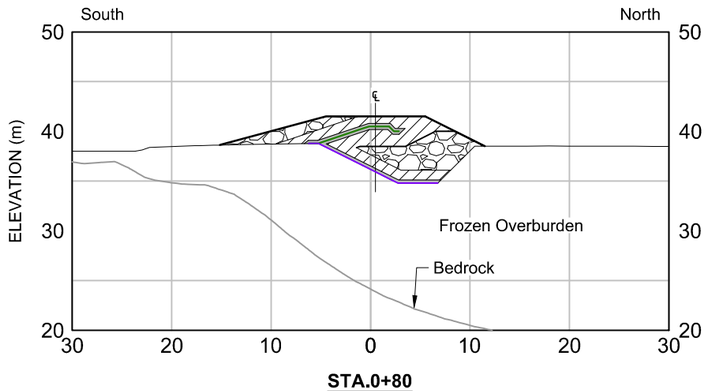

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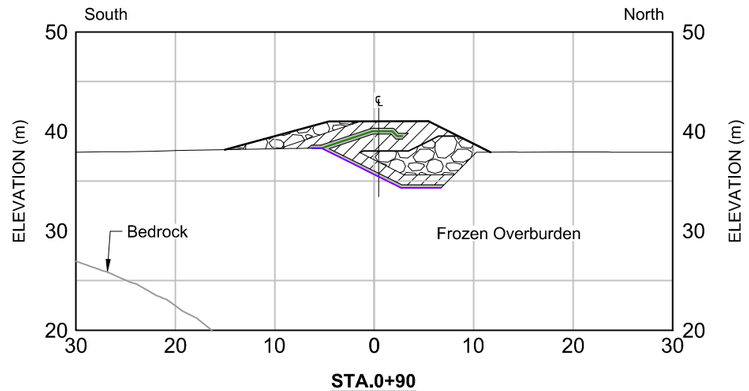

STA.0+90

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.

0m 6 12 18 24

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS | REVISIONS

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CHECKED:	APPROVED:	DATE:
JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.0+10 to 0+90 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-13	13 OF 18	0

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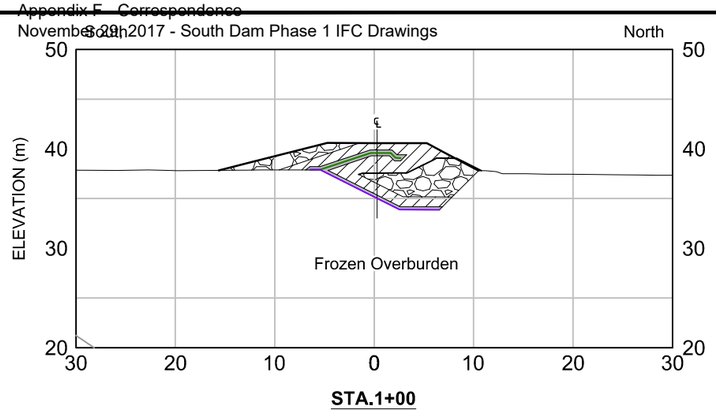

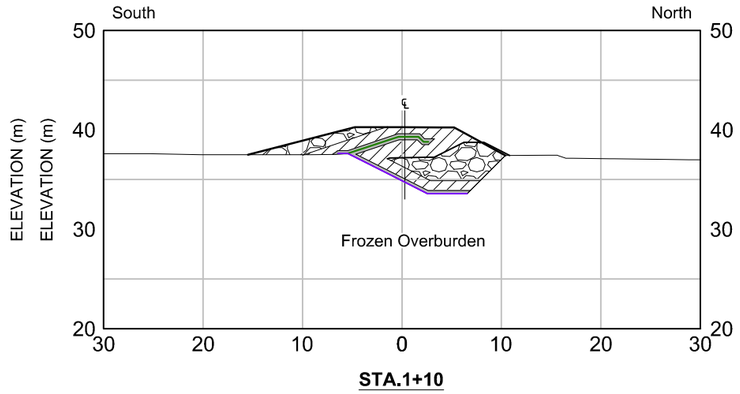

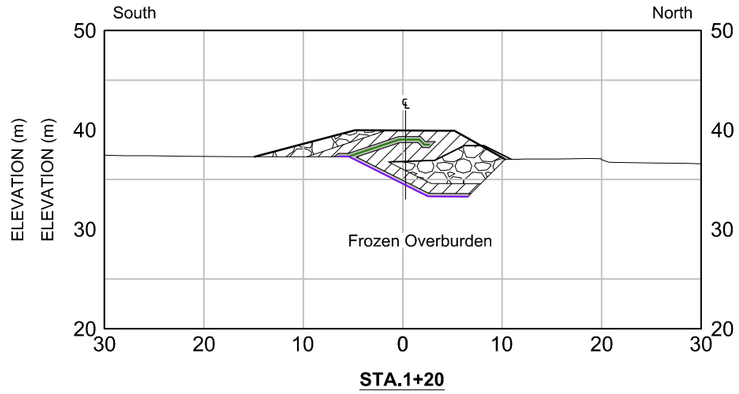

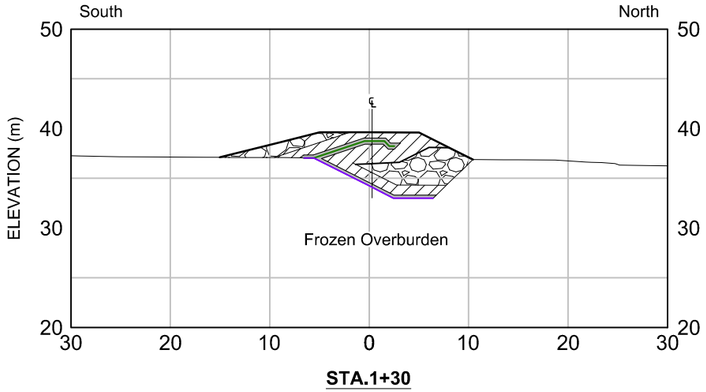

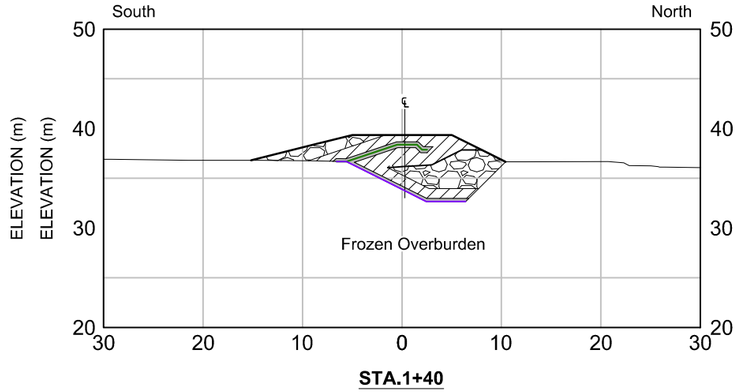

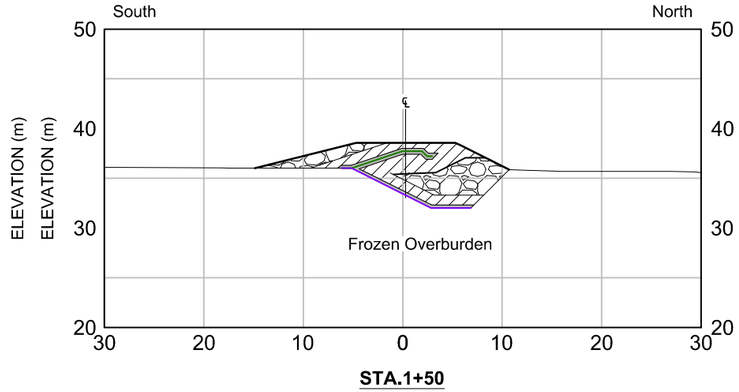

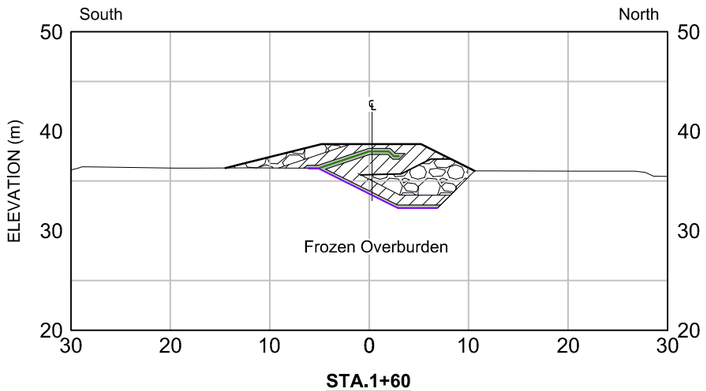

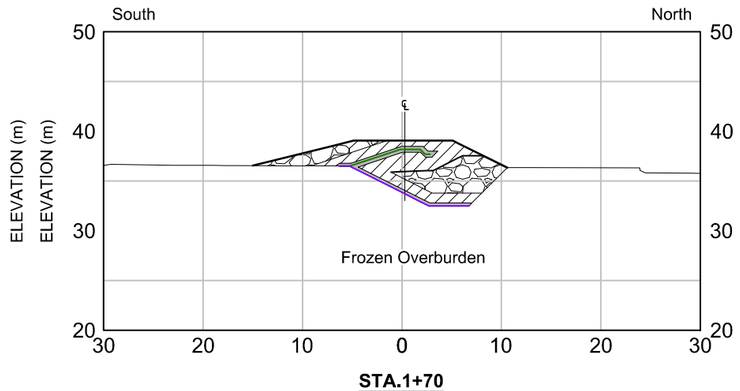

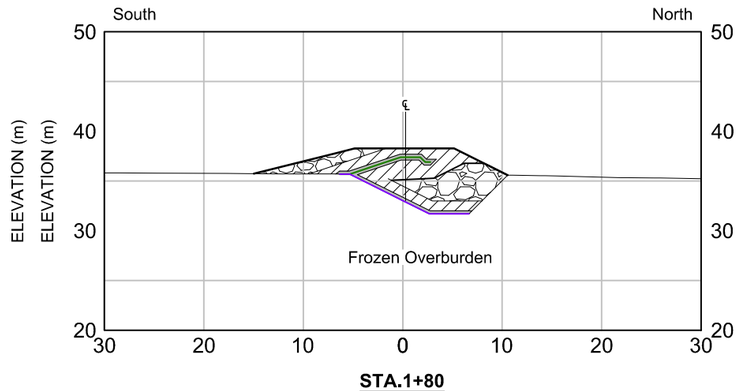

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.

0m 6 12 18 24

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-02	Phase 1 General Arrangement	-	-			
REFERENCE DRAWINGS		REVISIONS				

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.1+00 to 1+80 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-14	14 OF 18	0

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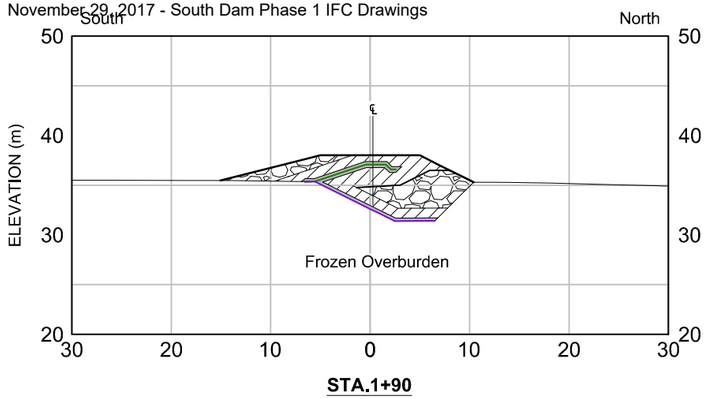

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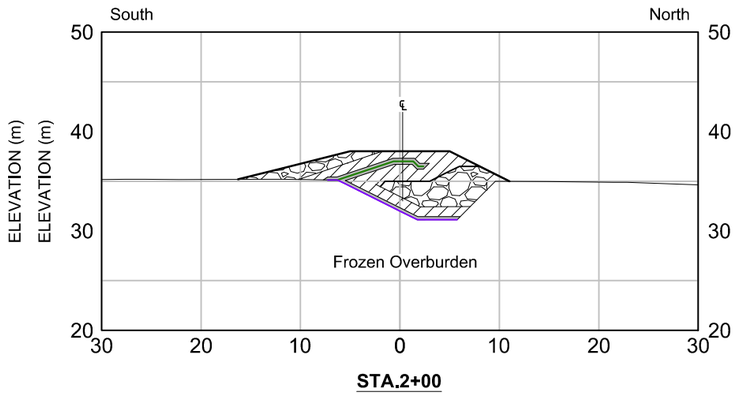

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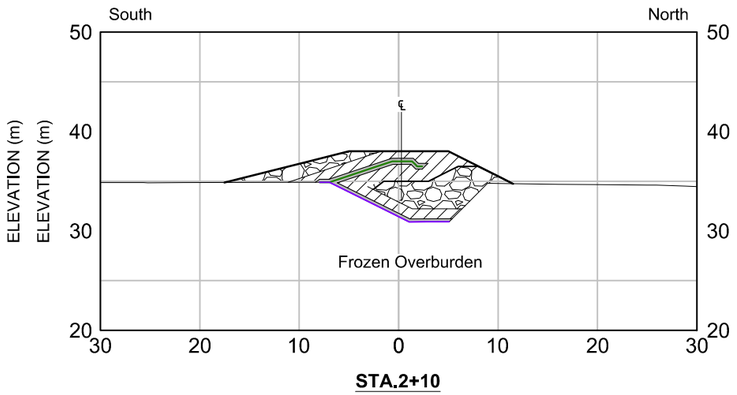

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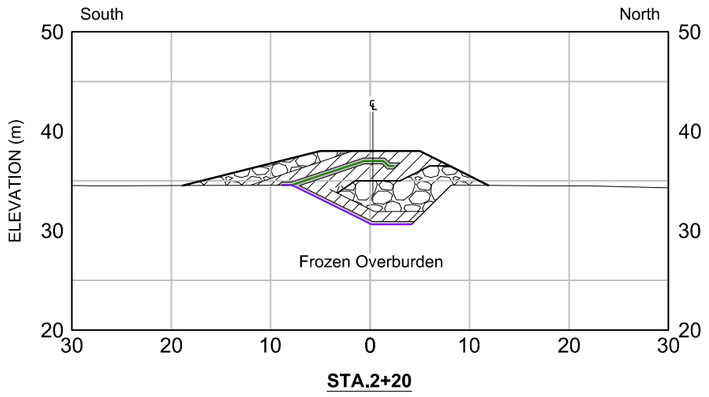

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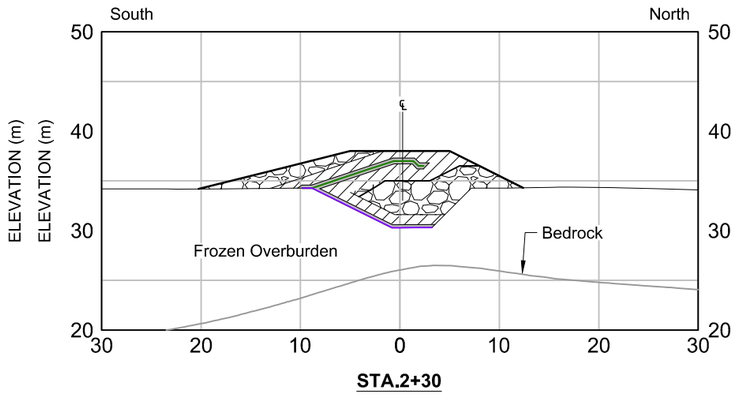

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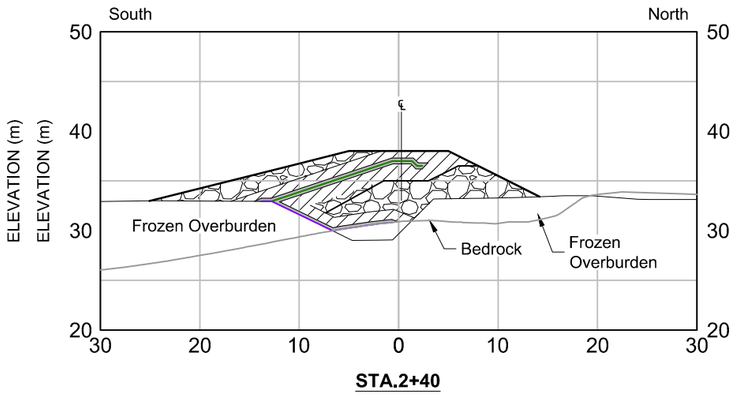

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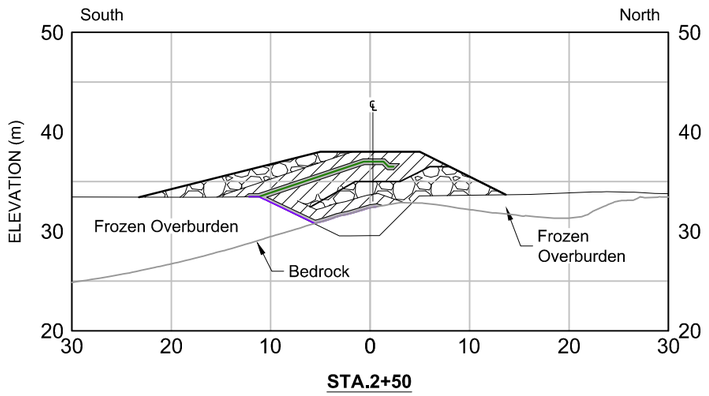

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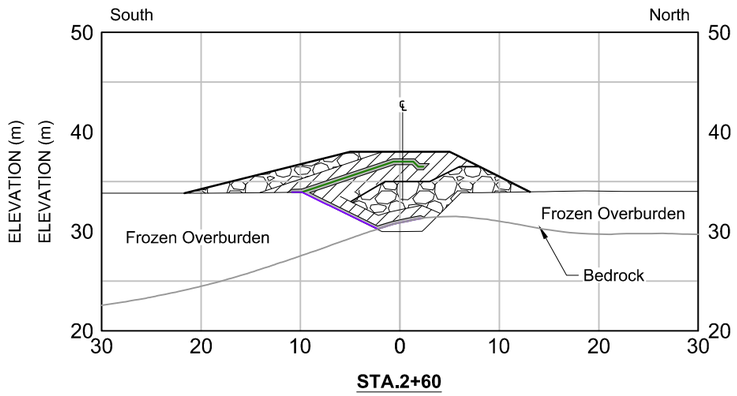

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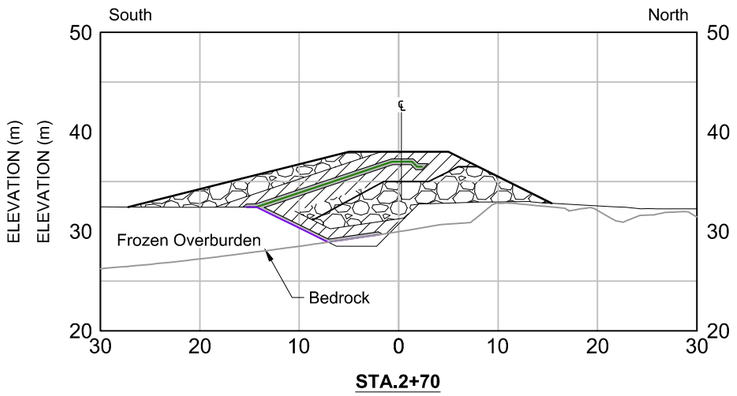

STA.2+70

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.

0m 6 12 18 24

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1\1CT0022.017 - South Dam - Sections.dwg

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-02	Phase 1 General Arrangement	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

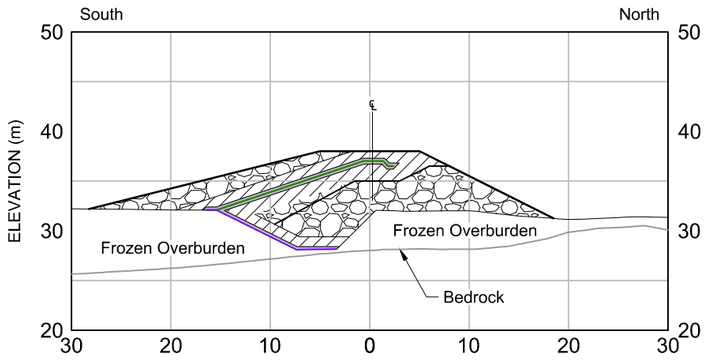
Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.1+90 to 2+70 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-15	15 OF 18	0



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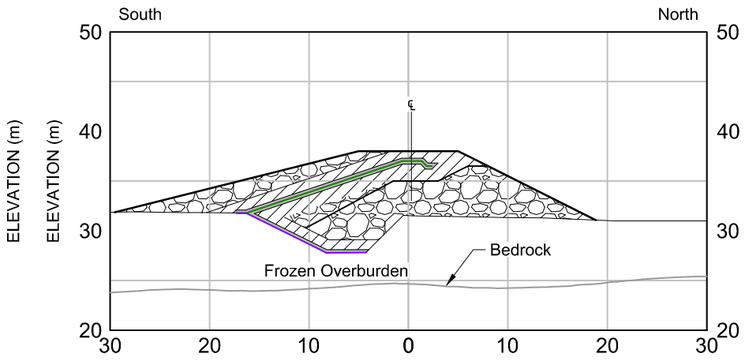

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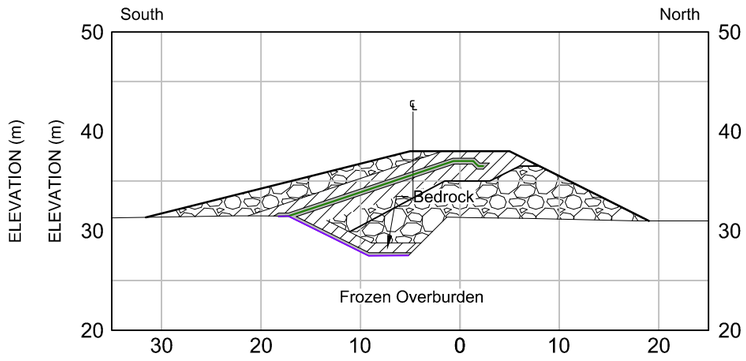

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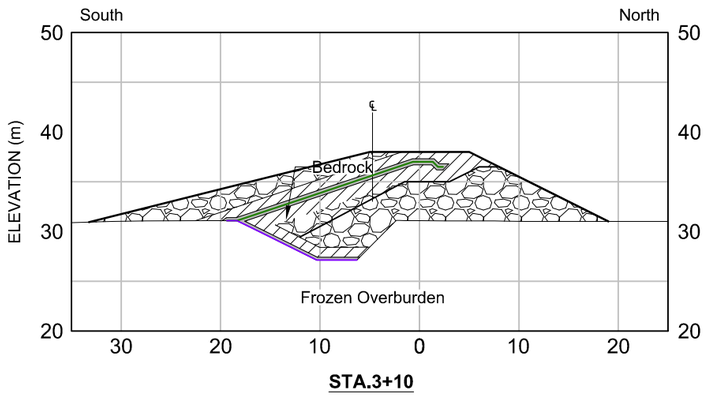

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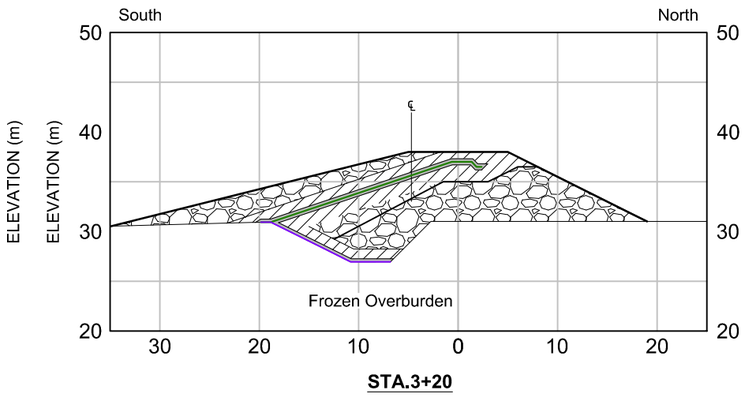

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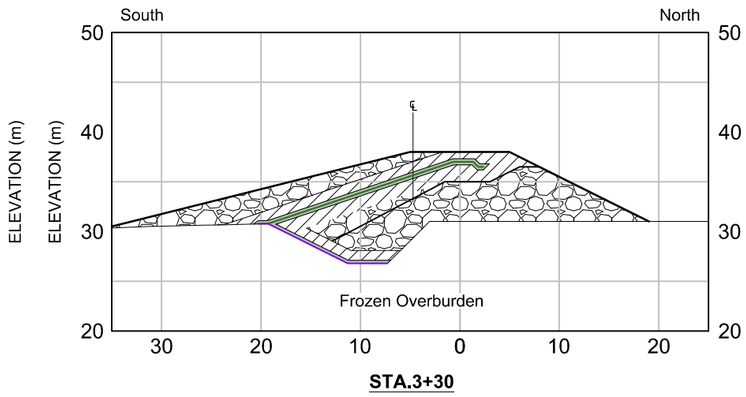

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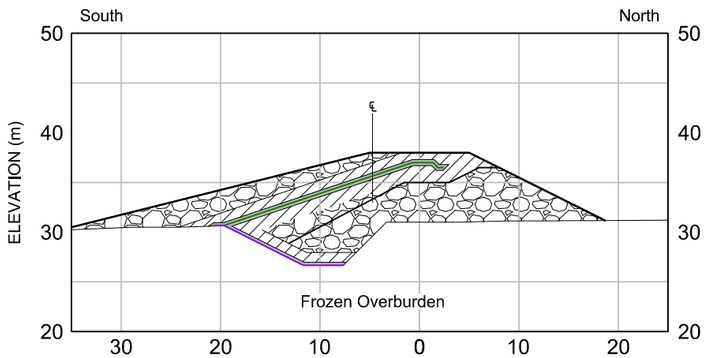

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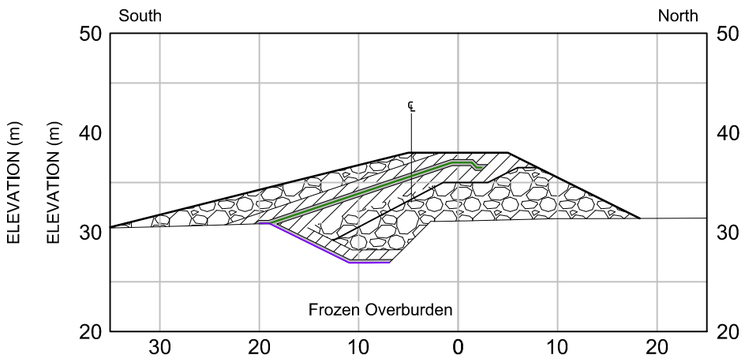

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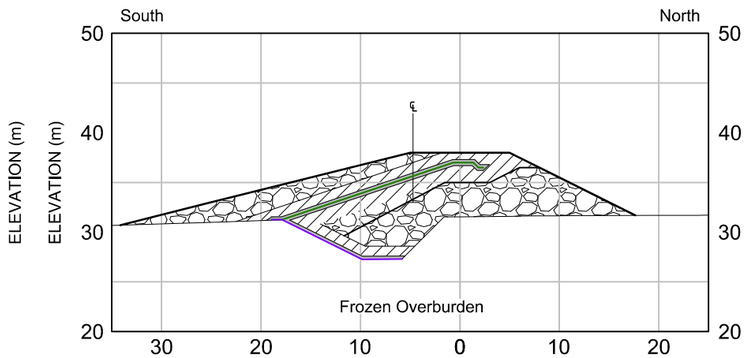

STA.3+60

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.

0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
0	Issued for Construction	JBK	EMR	17/11/29

DN-SD-02 — DRAWING NO. — Phase 1 General Arrangement — DRAWING TITLE

REFERENCE DRAWINGS — REVISIONS

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.2+80 to 3+60 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-16	16 OF 18	0

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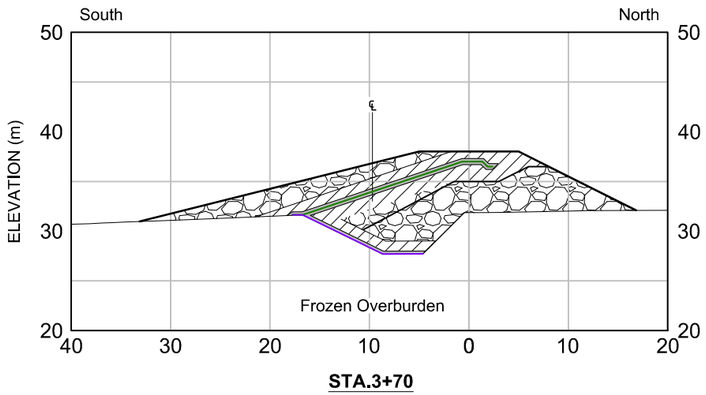

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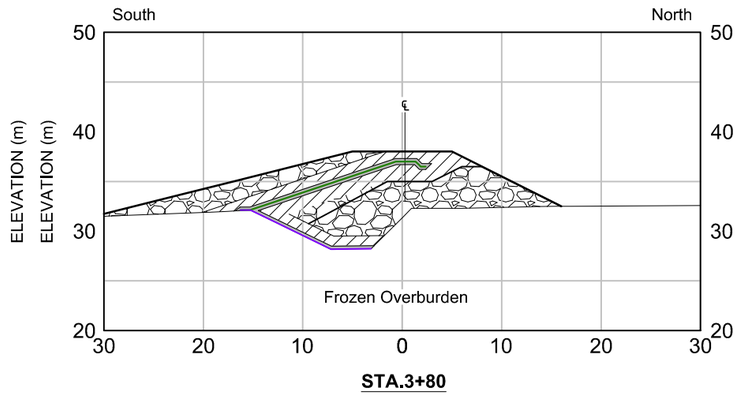

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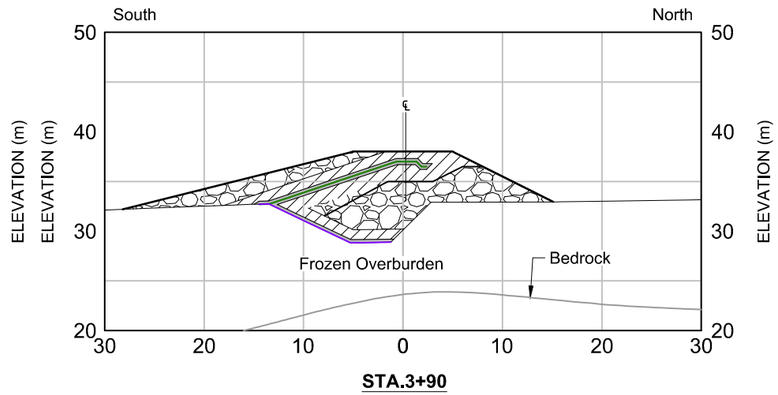

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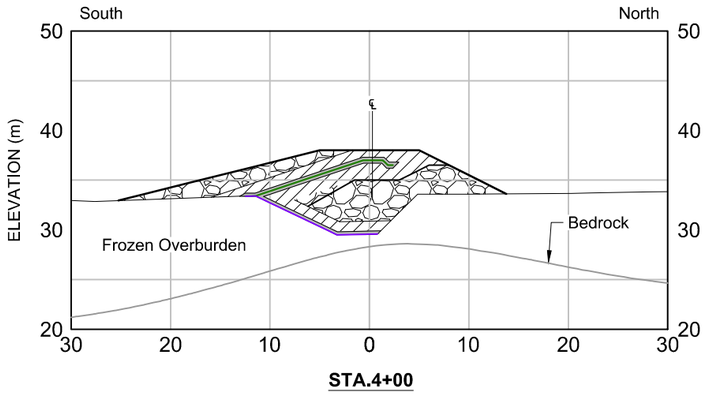

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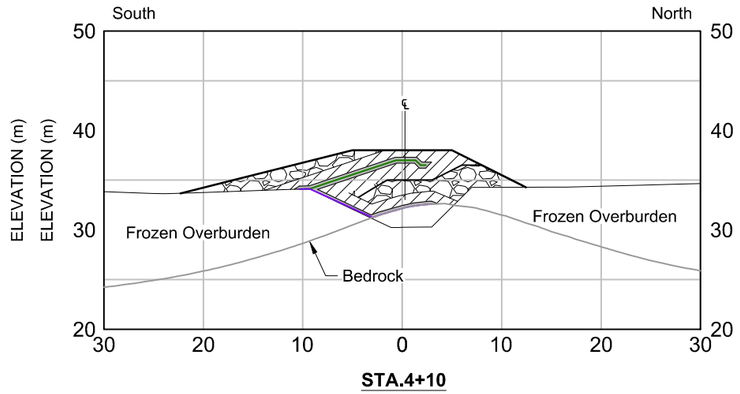

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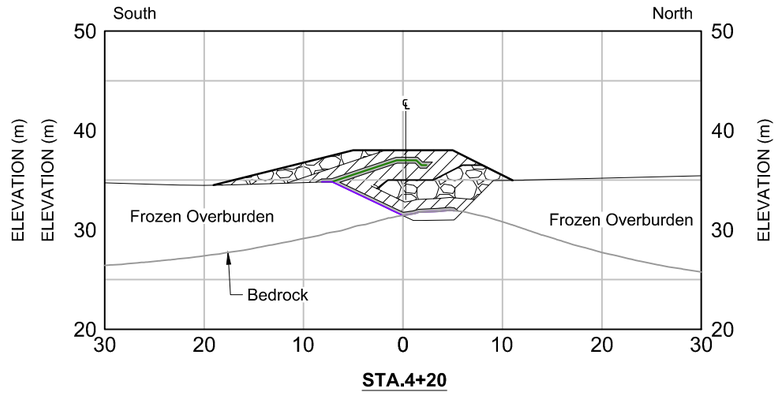

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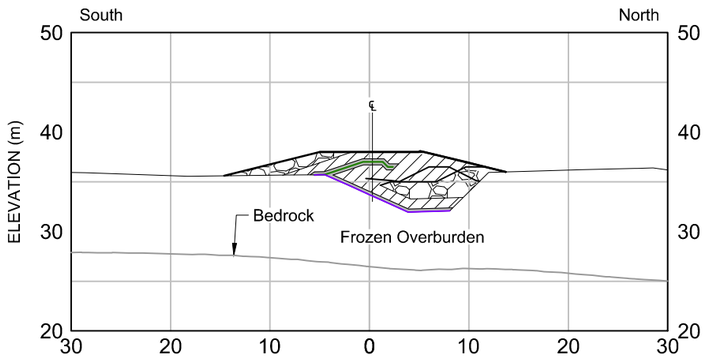

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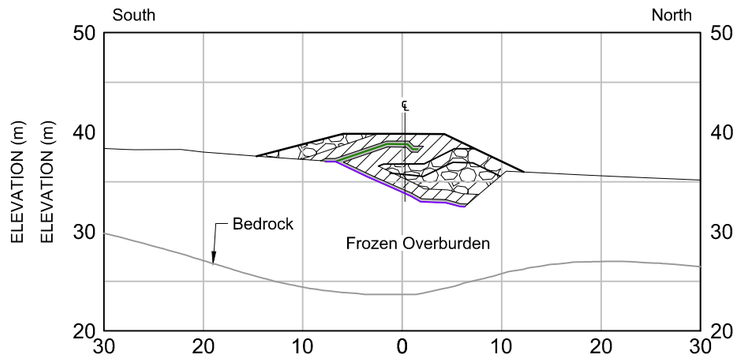

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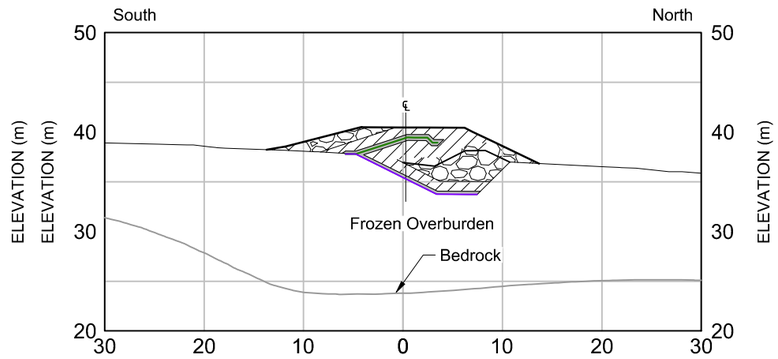

STA.4+50

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
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DN-SD-02 — Phase 1 General Arrangement

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.3+70 to 4+50 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-17	17 OF 18	0

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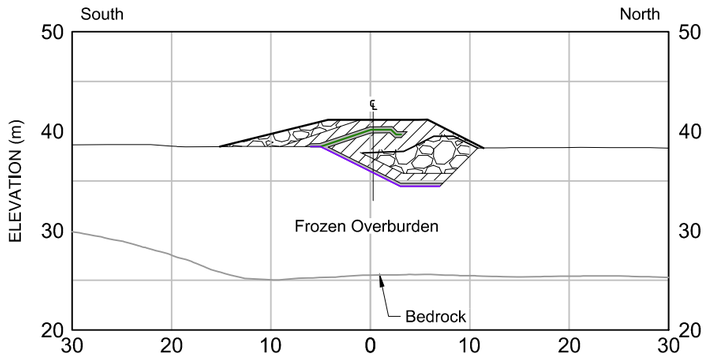

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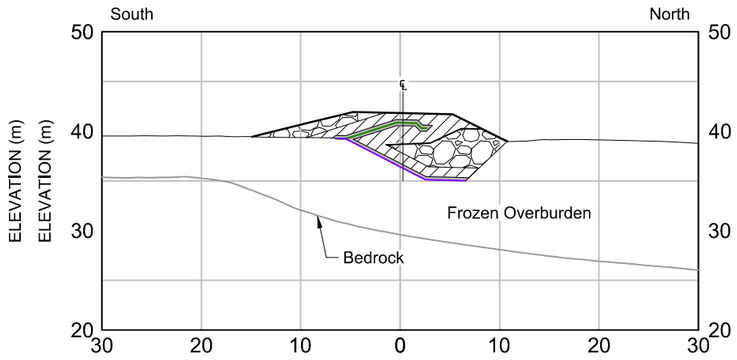

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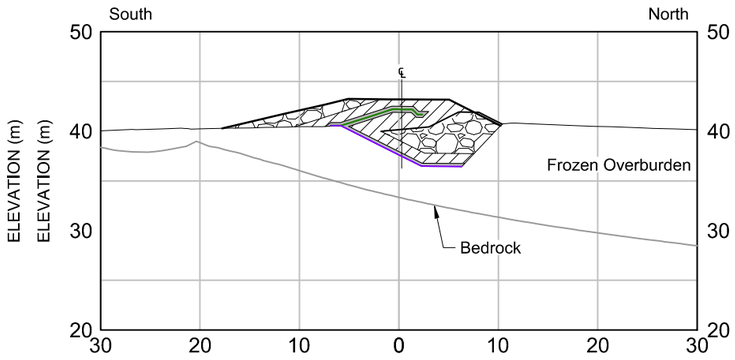

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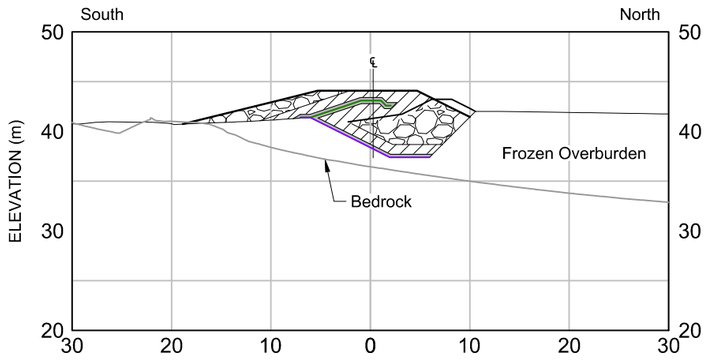

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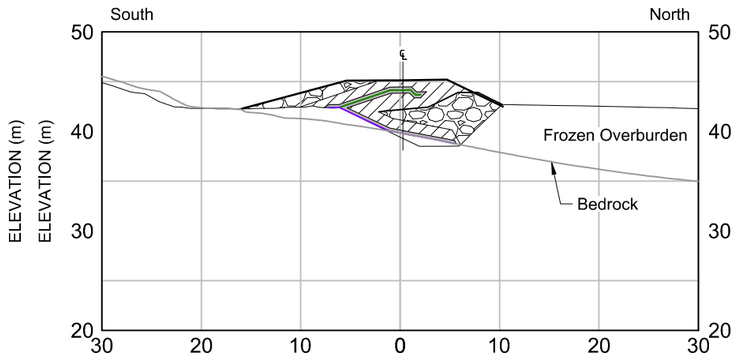

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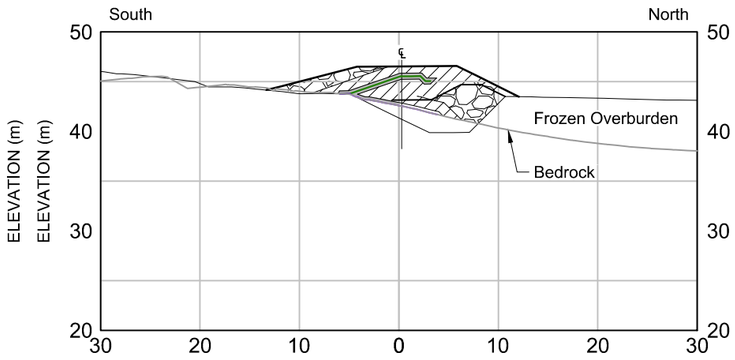

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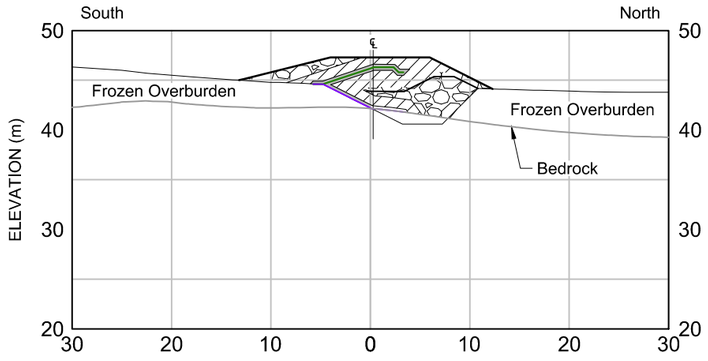

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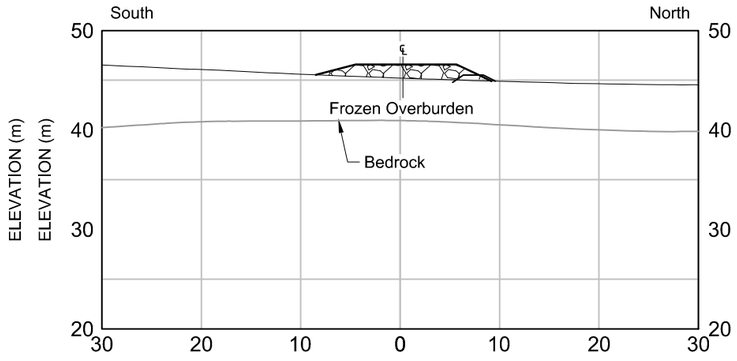

STA.5+30

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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2. All sections shown are for Phase 1 designs only.

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DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-02	Phase 1 General Arrangement	-	-			
		0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS | REVISIONS

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DESIGN: CH | DRAWN: TAH | REVIEWED: JBK
CHECKED: JBK | APPROVED: EMR | DATE: 17/11/29
FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.4+60 to 5+30 Phase 1 Dam

DRAWING NO. DN-SD-18 | SHEET 18 OF 18 | REVISION NO. 0

Seema Kang

From: John Kurylo
Sent: Tuesday, January 2, 2018 10:51 AM
To: John Kurylo
Subject: FW: South Dam IFCs -digital files
Attachments: South Dam IFCs - Digitial File_20171222.zip

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

From: John Kurylo
Sent: Friday, December 22, 2017 10:28
To: Mark Doucette <markd@sub-arctic.ca>
Cc: 'Kelly Schwenning' <kelly.schwenning@tmacresources.com>; Maritz Rykaart <mrykaart@srk.com>; Cameron Hore <chore@srk.com>
Subject: RE: South Dam IFCs -digital files

Hi again Mark,

To follow-up with our past discussions attached are additional digital files for all the LandXML (surfaces) for the South Dam Phase 1 design components. Specifically the following is attached:

1. Key Trench Excavation (LandXML)
2. Key Trench Liner (LandXML)
3. Key Trench Bedding (LandXML)
4. Key Trench Transition (LandXML)
5. Downstream ROQ (LandXML)
6. Downstream Bedding [top of Transition] (LandXML)
7. Above Ground Liner – Phase 1 Dam (LandXML)
8. Upstream Bedding (LandXML)
9. Upstream Transition (LandXML)
10. Upstream ROQ (LandXML)
11. Overall Phase 1 Dam Shell (LandXML)
12. Phase 2 Dam Shell [not IFC just for information purposes only] (LandXML)
13. Phase 1 Design Lines [dwg and text file] (LandXML)

If you have any issues opening these files, or if you have any questions at any point then please let me know. Happy Holidays.

Regards,
John

From: Mark Doucette [mailto:markd@sub-arctic.ca]
Sent: Monday, December 11, 2017 10:19
To: John Kurylo <jkurylo@srk.com>
Cc: 'Kelly Schwenning' <kelly.schwenning@tmacresources.com>; Cameron Hore <chore@srk.com>; Maritz Rykaart <mrykaart@srk.com>
Subject: RE: South Dam IFCs -digital files

Thanks John.
These lines will do the trick.
I'll be in touch if I have questions.

Mark Doucette
Geomatics Engineering Technologist
Sub-Arctic Surveys Ltd.
Canada Lands Surveyors
Yellowknife, NT

From: John Kurylo [mailto:jkurylo@srk.com]
Sent: December-11-17 10:28 AM
To: Mark Doucette
Cc: 'Kelly Schwenning'; Cameron Hore; Maritz Rykaart
Subject: RE: South Dam IFCs -digital files

Hi Mark,

To introduce myself name is John Kurylo and I am a Senior Engineering that has been working with Martiz and Cam on the South Dam designs.

To follow-up with your request, attached to this email please find a zip file that contains design lines and surfaces for the following Hope Bay – South Dam elements:

- Phase 1 dam shell; and
- Key Trench excavation

I thought it would be good to start with just these two dam elements so that you can look over the supplied files and let us know if these file formats work. Alternately if would like this information supplied in a different format then please let me know. Note that all of our designs were completed with ACAD Civil3D 2017 so we can export our designed in most digital formats.

I was wondering if you were able to upload / use LandXML formats? This format would likely be the easiest to send but we can also send you 3Dfaces or .dem options if that is easier for you. If you are able to let me know what software you are planning on using, then together we can make a plan on what the best data file format will be to send going forward. Let me know your thoughts.

Kind Regards,
John K

From: Maritz Rykaart [mailto:mrykaart@srk.com]
Sent: December-09-17 11:29 AM
To: Mark Doucette
Cc: Kelly Schwenning; John Kurylo
Subject: Re: South Dam IFCs

Mark

Yes absolutely we will do that. We intentionally did but our stake out tables because we know you will be using the CAD files.

Regards
Maritz

Maritz Rykaart, PhD, PEng,
Practice Leader/Principal Consultant
Geotechnical Engineering

On Dec 9, 2017, at 09:57, Mark Doucette <markd@sub-arctic.ca> wrote:

> Maritz,
>
> I've had a chance to review the IFC drawings for the south dam here at Hope Bay.
>
> I am hoping you can send me some CAD files of the design as there is no coordinate info in the drawings.
>
> Mark Doucette
> Geomatics Engineering Technologist
> ***Sub-Arctic Surveys Ltd.***
> ***Canada Lands Surveyors***
> Yellowknife, NT
>
> **From:** Maritz Rykaart [mailto:mrykaart@srk.com]
> **Sent:** December-06-17 6:47 AM
> **To:** Kelly Schwenning; mikemauvieux@mccaweast.com
> **Cc:** Mark Doucette; Jason Lanoue; Murray Weddell; TMAC Resources Hope Bay Schedule; Roland Jones; boydb@nunalogistics.com; John Kurylo
> **Subject:** RE: Quarry3 and South Dam development
>
> Kelly and Mike
>
> SRK will prepare a written procedure for the percolation testing at the South Dam and send that through to you all in the next few weeks. That way both Nuna and TMAC can be better prepared for exactly what is needed in that regard.
>
> In a nutshell, the testing is conducted by an SRK engineer with the help of the drilling crew.
>
> Please note that we also need to do some geotechnical characterization drilling at the same time (ideally), but that will likely have to be coordinated with TMAC geology. We will connect with Dave and Scott in this regard.
>
> Maritz
>
> **Maritz Rykaart** *PhD, PEng*
> Practice Leader/Principal Consultant (Geotechnical Engineering)
>
> <image001.png>
>
> SRK Consulting (Canada) Inc.
> 22nd Floor, 1066 West Hastings Street, Vancouver, BC, V6E 3X2, Canada
>
> **Tel:** +1-604-681-4196; **Fax**: +1-604-687-5532
>
> **Mobile**:+ 1-604-928-1552; **Direct**: +1-604-601-8426
> **Email**: mrykaart@srk.com
>
> www.srk.com

From: Kelly Schwenning [mailto:kelly.schwenning@tmacresources.com]
Sent: Wednesday, December 06, 2017 5:44 AM
To: mikemauvieux@mccaweast.com
Cc: Maritz Rykaart <mrykaart@srk.com>; Mark Doucette <markd@sub-arctic.ca>; Jason Lanoue <jason.lanoue@tmacresources.com>; Murray Weddell <murray.weddell@tmacresources.com>; TMAC Resources Hope Bay Schedule <hb.schedule@tmacresources.com>; Roland Jones <RolandJ@nunalogistics.com>; boydb@nunalogistics.com
Subject: Quarry3 and South Dam development
Importance: High

Mike, I've tentatively have placeholders for your people scheduled to start coming in for advance prep Jan 9.
When we get the drill up we'll need to start percolation testing at the South Dam location in conjunction with SRK, once complete we'll get set up with survey support etc. at quarry 3
Throwing this out there now so we can morph this together going forward

Kelly Schwenning
Manager, Surface Operations
Hope Bay Project,Nunavut
TMAC Resources Inc.
867-988-6882 Ext.106
604-290-1726 C
www.tmacresources.com

"Building Canada's next Gold Mining District"

<image002.png><image003.png>

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Seema Kang

From: John Kurylo
Sent: Wednesday, January 17, 2018 7:03 PM
To: Kendell Cator
Cc: Cameron Hore
Subject: FW: South Dam Liner Quantities - HDPE + Geotextile + GCL

From: Maritz Rykaart
Sent: Tuesday, January 9, 2018 10:32
To: Kelly Schwenning <kelly.schwenning@tmacresources.com>
Cc: John Kurylo <jkurylo@srk.com>
Subject: FW: South Dam Liner Quantities - HDPE + Geotextile + GCL

Hi Kelly,

Below please find some information on the quantities of liner that would be required if we went for the option where we used all of the site HDPE material in the key trench (surrounded by geotextile) and then used GCL in the above ground portions of the dam. **Overall we estimate the following additional materials will need to be shipped to site for this option**:

- 3 rolls of HDPE – SOLMAX 460T 2000 (60 mill) – textured on each side
- 8 rolls of Geotextile – 1200N non woven (12 oz) – note that this assumes that the current geotextile on site is a 12oz material – site to confirm
- 50 rolls of GCL Liner – Ceto Bentomat CLT or equivalent

Additional notes are provided below this message however overall some of the main considerations for the HDPE liner installation would be that:

- The HDPE materials needs to be stored in a covered and heated location until it can be deployed
- Will have to keep the seams dry and likely Heated. Expect will need to horded and heated where the seams will be welded.
- Will not be able to deploy the HDPE liner in any periods of higher winds.
- A specialist subcontractor will need to come in to fusion weld and test the HDPE liner seams
- The condition of the existing liner on site needs to be checked to see that it is not damaged / is in suitable condition

If you have any questions on any of this then please let myself and John know.

ADDITIONAL DETAILS:

HDPE liners are moderately suited for deployment and installation in cold climates. These products become rigid and brittle when subject to sub-zero temperatures and they become harder to handle. It is typically required that HDPE liner is stored in a heated environment up to and immediately prior to use to remain flexible and free of moisture. The complexity and effort required to form the liner to irregular surfaces (exposed bedrock, etc.) can become increasingly difficult as temperatures progress further below 0°C. Due to HDPE liners light weight, it can be difficult to install them during windy conditions. This can become a major issue when installing a liner in an open and un-shielded setting. Welding (seaming) of individual product panels also becomes difficult in cold temperatures. HDPE (60 mil) normally has a practical welding restriction of -25˚C (Layfield, 2011). HDPE liner requires specialized equipment and crews to ensure successful joining of seams, and welding requires that no moisture is present on the seam in the form of frost or snow.

The following materials are expected to be presently on site:

Table 1: Material Quantities on Site

Material	Quantity (rolls)	Roll Dimension (m x m)	Total Area (roll - m^2)	Total Area (on site - m^2)	Storage Location on Site
HDPE Liner - SOLMAX 460ST (60 mil)[3]	6	6.8 x 159.5	1,083	6,500	Flat rack in Roberts Bay
Geotextile – 1200N non-woven (12oz)[2]	18	4.6 x 91.5[1]	418	15,000	CAN 389066 - Lower Reagent Pad
	18				CAN 291172 - Lower Reagent Pad

Notes:

1. Roll dimension based off WINFAB 1200N non-woven product data sheet.
2. It is assumed that the non-woven present on site is a 12 oz material produced by WINFAB (should be confirmed by site).

Site will need to confirm the condition of the HDPE liner (in case more need to be ordered) and also site will need to confirm that the non-woven geotextile is at least 12oz thickness (or thicker).

Preliminary estimate for the liner requirement equates to 15,000 m^2, not including overlap between panels or wastage. In additional to this non-woven geotextile will be required on both sides of the HDPE liner. SRK has assumed a preliminary overlap and wastage allowance of 15%. A detailed panel layout should be developed once a liner is selected based on the dimensions of the rolls that will be taken to site. Based on the preliminary overlap and wastage allowance of 15% the total liner requirement equals 17,250 m^2. Table 2 and 3 below show the liner design areas and the breakdown for the additional liner that is suggested to be shipped to site for this option (i.e. HDPE in the key trench and GCL above the key trench).

Table 2: Liner Design Requirements

Liner Element	3D Area (neat line) [m^2]	Areas + 15% overlap [m^2]
Liner in Key Trench (includes 1m apron) - **HDPE**	7,300	8,395
Liner for Phase 1 Dam (includes 1m apron, and crest key in) - **GCL**	7,700	8,855
Total	*15,000*	*17250*

Table 3: Assumed Available and Required Liner Quantities

Materials on Site	Roll Area Available	Additional Roll Area Required	Additional Rolls Re Min
HDPE - SOLMAX 460T (60 mil)	6,500	1,900	
Geotextile - 1200N non woven (12 oz)	15,000	1,790	
GCL Liner - Cetco Bentomat CLT	0	8,855	

Regards,

Maritz Rykaart *PhD, PEng*
Practice Leader/Principal Consultant (Geotechnical Engineering)

Seema Kang

From: John Kurylo
Sent: Wednesday, January 17, 2018 6:59 PM
To: Kendell Cator
Subject: FW: 1CT022.017 - Potential South Dam Key Trench Overburden Storage Location
Attachments: 1CT022.017_South Dam_OVB_stockpile_NOTES_20180110.pdf

See email below FYI / for some background in regards to a place for overburden removed from the key trench excavation

John

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

From: John Kurylo
Sent: Wednesday, January 10, 2018 12:31
To: 'Kelly Schwenning' <kelly.schwenning@tmacresources.com>
Cc: Cameron Hore <chore@srk.com>; Oliver Curran <oliver.curran@tmacresources.com>; Mark Doucette <markd@sub-arctic.ca>; Boyd Barstad (boydb@nunalogistics.com) <boydb@nunalogistics.com>; Rob Cook <robc@nunalogistics.com>; Maritz Rykaart <mrykaart@srk.com>
Subject: 1CT022.017 - Potential South Dam Key Trench Overburden Storage Location

Hi Kelly,

To follow-up with our discussions on Monday, attached to this email please find a figure with some mark-ups / notes showing a potential location (within the TSF footprint) where we could consider placing overburden from the key trench excavation.

Overall this location is:

- A minimum of 200m away from the upstream face of the South Dam
- Along the East shoreline; and
- At elevation of 33m or lower (want overburden below the ultimate Phase 1 tailings deposition surface)

One important construction consideration is that snow and ice (for example frozen pond ice) should be removed / excavated before overburden is placed within the TSF Phase 1 footprint. This would be done to ensure that we do not trap / entrain a massive ice lenses below the overburden material.

If you have any additional questions when you review the attached figure then please let me know.

Kind Regards,
John

John Kurylo *MSc (DIC), PEng*
Senior Consultant (Geotechnical)
srk consulting

North Dam (Elev. 37.0m FSL 33.5m)

N 7559000

N 7558000

DORIS LAKE

N 7557000

N 755 000

Reclaim Pond
(Elev. 28.3m)

Interim Dike (Elev. 31m)

uarry 3

South Dam (Elev. 38m)

E 435000

E 43 000

0m 100 200 300 400

Other Notes:

1) Note tailings sloping at ~1% slope i.e.. down 1m every 100m away from South Dam. Want overburden level below ultimate Phase 1 tailings deposition surface; and ~2m below areas where potential tailings spigots may be placed.

2) Overburden to be placed within the Phase 1 TSF tailings footprint. Note that any lake or massive ice that exists at the location the overburden will be placed need to be removed / excavated. Do not want to trap / entrain a large ice lens below the overburden.

Preferred Locations For Key Trench Overburden Storage
(along the East shoreline further than 200m away from the upstream face of the dam)

Overburden should be below ~33m elevation (or lower).

Want a minimum 200m offset from the upstream slope of the South Dam where no overburden is placed

Absolutely no overburden to be placed downstream of the South Dam

NOTES

1. Phase 1 TIA Configuration accommodates Doris North Tailings (2.5Mt).
2. Phase 1 complete at the end of August 2020. Production rates vary from 1,092 tpd up to 3 000 tpd.

LEGEND

- Spigot Location
- Deposited Tailings
- Dam/Dike
- Proposed Road
- Proposed Tailings Line
- Proposed Tailings Topography

srk consulting

SRK JOB NO.: 1CT022.004. 00.010

FILE NAME: HB PH2 DEPOSITION FIGURE 2.dwg

TMAC RESOURCES

HOPE BAY PROJECT

PHASE 2 TAILINGS DEPSOSITION PLAN

TIA CONFIGURATION
END OF PHASE 1 (2.5 Mt)

DATE:	APPROVED:	FIGURE:
201 /10/2	TPP	02

P:\01_SITES\Hope Bay\ACAD\2015 Deposition Planning\Phase 2 Options\HB PH2 DEPOSITION FIGURE 2.dwg

NOTES ON KEY TRENCH OVERBURDEN PLACEMENT

Seema Kang

From: John Kurylo
Sent: Friday, January 19, 2018 6:46 PM
To: Kendell Cator; Maritz Rykaart
Cc: Cameron Hore
Subject: FW: South Dam draft construction plan
Attachments: WP-HB-001 - South Dam Construction Phase_Draft.docx

FYI see Nuna's plan below and in the attached word document for the South Dam.

I will review over the weekend and let everyone know on Monday if I have any comments / major concerns.

Cheers,
John

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

From: Rob Cook [mailto:robc@nunalogistics.com]
Sent: Friday, January 19, 2018 08:01
To: John Kurylo <jkurylo@srk.com>
Subject: FW: South Dam draft construction plan

Hi John,

Sorry I missed you on the original distribution list a few minutes ago.

I hope you have some time to go through our draft construction plan and provide some feedback that we can incorporate prior to mobilizing.

Any other comments are welcome too.

Thanks,
Rob

From: Rob Cook
Sent: Friday, January 19, 2018 8:57 AM
To: Kelly Schwenning <kelly.schwenning@tmacresources.com>
Cc: Boyd Barstad <boydb@nunalogistics.com>; Roland Jones (RolandJ@nunalogistics.com) <RolandJ@nunalogistics.com>; Darko Filipic (DarkoF@nunalogistics.com) <DarkoF@nunalogistics.com>
Subject: South Dam draft construction plan

Good Morning Kelly,

As per the process outlined in my previous email, we have been working through the constructability and scheduling aspects of the south dam project. As you know, Mike Price was on site for a few days in early January and after some

consultation with SRK, our Supt, estimator and scheduling folks**;** he has prepared the attached draft execution plan. This plan will be modified further with input from all parties.

In parallel with this we have entered the project info into our estimating software to generate a budget and schedule based on the expected productivities of the drill and earthmoving fleet. The goal of this exercise was to determine the requirements for completion of the temperature sensitive areas of the dam prior to May 1, 2018. As per my discussions with John Kurylo at SRK this would require completion of the key trench liner and backfill as well as the first 2 m of fill above the key trench for thermal protection.

At a high level the general durations and manpower requirements have been used in our assessment:

Task	Activity	Duration	Manpower Required
1	Drilling		
	• Percolation testing	4-5 days	2 dayshift
	• Production Blast Q2	10-12 days	6 total (double shift)
	• Key trench drill and blast	21 days	6 total (double shift)
	• Mat blasting Q3	80 days	8 total (double shift)
2	Key Trench Construction	Feb 1 – April 13	10 – dayshift only
3	2 m Thermal layer above key trench	April 13 – May 1	10 – day shift only
4	Remainder of dam	May 1 – June 15	10 – day shift only
5	Safety, training, project coordinator support	Feb 1 – June 15	2-3 day shift only

The 10 man construction crew consists of a foreman with 3 multi ops (excavator, loader and dozer), 4 haul truck drivers, 1 labour and 1 packer op for a dayshift only operation. This crew requires full time support from a site engineer/coordinator and safety officer with a trainer at start-up for 3-4 wks. This is considered to be a minimum crew size for the scope of work and the May 1 deadline for cold weather work. We will also have a crusher crew on for about 45 days to produce materials for the dam. There will also be the liner installation crew, and quality control personnel assumed to be hired by TMAC at various times during construction.

We have generated a manpower curve based on this plan which shows total Nuna and Westarc only ranging from 16 – 22 people over and above the existing site crew.

This program is limited by drilling production and does not have any contingency time built in for equipment downtime, weather delays, design delays, unforeseen ground conditions, snow events, etc. The only opportunity we see at the present time to improve productivity and ultimately completion time would be to add a second drill. Night shift hauling will have no impact on the schedule as the single drill cannot produce material fast enough from Q3 (mat blasting) to support 2 shifts of hauling. Also, a second drill would provide essential backup to the current drill in the event of any significant downtime.

This analysis considers that approximately 1/3 of the required material would be produced from Q3. A shift to more production from Q2 would greatly assist the drilling and material production schedule, allowing benefit from a second hauling shift if necessary. I know that G wing is opening shortly and hoping that we will be provided with sufficient beds to complete this project within the timelines required.

We are actively recruiting and will be hiring immediately to fill these necessary positions for startup. I have outlined what I believe to be a minimum crew to meet schedule, however we will ramp up with due consideration for opportunities to be more efficient with the crew.

I can be available to discuss in more detail at your convenience.

Rob Cook, P.Eng., Senior Project Manager
T: 780.408.4532 C: 780.504.1256

NUNA LOGISTICS LIMITED 9839 - 31 Avenue, Edmonton, AB, T6N 1C5
Email: robc@nunalogistics.com Website: nunalogistics.com

Operational Work Plan

Work Package: South Dam Construction	**Revision:** Rev 0
Description: South Dam Phase 1 - WP-HB-001	**Date:** January 16, 2018

Safety			
Description	Potential Hazard	Precautions and Actions	Notes:
Hazard # 1	Weather (Whiteouts, wind chill etc.)	Monitor daily weather and dress appropriately for the conditions. Follow site procedures for whiteouts.	
Hazard # 2	Traffic	Signage will be placed for "Call For Access" and only authorized vehicle will be permitted to enter the work area. Traffic Management Plan.	
Hazard # 3	Wildlife Encounters	Report all sightings to the Environmental Department, stay in equipment if possible	
Hazard # 4	Heavy Equipment	THA, use radios and proper PPE, Horn Signals.	
Hazard # 5	Communication	Radio Checks must be performed at pre-discussed intervals.	CH – TBD for Dam Use
Hazard # 6	Walking on uneven surfaces	Watch your footing, surfaces can be icy, uneven and difficult to judge. Good footwear.	
Hazard # 7	Steep Side Slopes (1:1 / 2:1 in Key Trench)	Ensure the berms are constructed in progression with excavation and placement above 3m	

Quality Control			
Description	Critical Items	Actions to Build it right the first Time	Notes:
Item # 1	Subgrade inspection	Subgrade to be approved by onsite engineering rep prior to any material being placed. All loose material including cobbles and boulders must be removed prior to fill placement.	
Item # 2	OG pick-up and as builts	Hold points will be used to insure survey needs are met.	
Item # 3	ROM and Manufactured Materials	Meets required spec, clear of large particles of overburden material and free of snow and other deleterious materials.	
Item # 4	Slopes	Excavator / Dozer to construct slopes as per design. Survey to confirm.	
Item # 5	Maximum Lift thickness	ROM = 1.85 – 0.85m / Transition = 0.5m / Bedding = 0.3m or as approved by onsite engineering rep.	

Environment			
Description	Critical Items	Precautions and Actions	Notes:
Hazard # 1	Damage to tundra outside or work limits	Keep within working design lines or Dam and Access Road. Utilize snow road accesses if travel required outside of Phase 1 footprint.	
Hazard # 2	Spills	Report any spills (fuel, oil, etc.); Spill kits with equip and at Dam Site and Quarry	
Hazard # 3	Wildlife Encounters	Do not disturb or feed wildlife.	

Operational Work Plan

Water Mgmt.			
Description	Critical Items	Precautions and Actions	Notes:
Hazard # 1	Permafrost	All measures must be taken to be sure that the permafrost isn't affected.	
Hazard # 2	Sediment run-off (freshet)	Install sediment control fencing as required, pile waste material in designated areas, contaminated snow on the downstream side will be removed and hauled to snow dump	

Hold Points					
		Description			Description
1	☐	Survey to layout - Dam footprint	18	☐	Survey to as built - transition
2	☐	Survey to layout - Dam footprint	19	☐	Eng Rep to review and approve - transition
3	☐	Survey to pick up OG	20	☐	Survey to layout - bedding
4	☐	Blast Design to be confirmed with excavation	21	☐	Survey to as built - bedding
5	☐	Survey to as built - excavation	22	☐	Eng Rep to review and approve – bedding
6	☐	Eng Rep to review and approve - excavation	23	☐	Survey to as built liner
7	☐	Survey to as built - liner installation	24	☐	Eng Rep to review and approve – liner
8	☐	Eng Rep to review and approve - liner	25	☐	Survey to layout – liner cover
9	☐	Survey to layout – liner cover	26	☐	Survey to as built – liner cover
10	☐	Survey to as built - liner cover	27	☐	Eng Rep to review and approve – liner cover
11	☐	Eng Rep to review and approve – liner cover	28	☐	Survey to layout – transition
12	☐	Survey to layout – transition	29	☐	Survey to as built – transition
13	☐	Survey to as built – transition	30	☐	Eng Rep to review and approve – transition
14	☐	Eng Rep to review and approve - transition	31	☐	Survey to layout – ROQ
15	☐	Survey to as built – ROQ	32	☐	Survey to as built – ROQ
16	☐	Eng Rep to review and approve - ROQ	33	☐	Eng Rep to review and approve – ROQ
17	☐	Survey to layout - transition	34	☐	Survey to layout - surfacing

Work Procedure / Step-by-Step / Activity Sequence / Access	Hold Point
1.0 Site Access	
1.1 Survey to layout the toe limit stakes along the Dam footprint.	HP-1
1.2 Snow access road to be constructed from the existing access road to the South Dam site and around the perimeter of the dam to allow access around the entire site for light and heavy equipment travel.	
1.3 Snow required to construct the access will be sourced along the TLR and hauled to place.	
1.4 Care will be taken to ensure that the snow access does not encroach on the areas of design fill placement within the Dam footprint.	
1.5 In addition to the South Dam, snow road access will be installed from the existing TLR into the approved overburden dumpsite.	
2.0 Site Preparation	
2.1 Survey to refresh Dam footprint toe stake as required to ensure a clear limit is visible	HP-2
2.2 Snow within the footprint will be removed via a combination of excavator, dozer and snow cat support. Snow will be pushed to the upstream side of the Dam in an effort to keep any organics and sediment contained come freshet.	
2.3 Survey to complete an OG survey of the entire area to be use as the baseline starting point for the project.	HP-3
3.0 Drill and Blast Key Trench (by others)	
3.1 Blast design will be developed to reflect the final design excavation surface as determined following the percolation testing.	

Operational Work Plan

3.2 Blasting to commence at station 0+000 with a small sample blast (25m) to ensure proper parameters are being used for blasting. 3.3 Blast to be excavated and checked against design lines to identify if any adjustments are required prior to continuing with drilling. 3.4 Once the blast design is confirmed to provide the desired result, drill and blast will continue in sections progressing along the Dam.	HP-4
4.0 Key Trench Excavation and Detailed Cleaning 4.1 The blasted overburden material will be loaded from the key and hauled to the approved stockpile area along the east shoreline of Tail Lake. 4.2 For this activity the fleet will consist of a 349 excavator loading at the Key, 3 x 740 Haul trucks and a D8 tending to the dump site. 4.3 Due to the narrow design of the key trench, material will be top loaded following a tradition trench excavation style. Haul trucks will access the loading face along the downstream side limiting travel along the upstream hinge point. 4.4 The excavation will progress along the dam alignment bulking out the rough side slopes (US=2:1 / DS=1:1) and base along the way. 4.5 The final trimming of the key to final design lines will follow directly behind the excavation in an effort complete trimming before material can refreeze in place. 4.6 Once the excavation and detailed trimming in complete the Key will be inspected to ensure there are no sharp rocks protruding or sudden grade changes that could be detrimental to the liner. Bedding material will be used as required to ensure a smooth surface for the liner. 4.7 Survey to complete as built of the key and compare with the design line to ensure excavation is within tolerance. 4.8 Engineering rep to complete a field review of key excavation and approve surface for liner installation prior to proceeding.	HP-5 HP-6
5.0 Lower Liner Installation 5.1 Base to be free of snow and ice, cleaning with mechanical broom, shovel and air lance as required to meet engineering requirements. 5.2 Engineering Rep to approve section for placement 5.3 The liner will be deployed with the assistance of an excavator to hang the spreader bar and liner from. This will allow the roll to be held at the bottom by the ground crew and pulled up the slope into place limiting the time spent working / pulling on the slopes. 5.4 Liner installation to follow requirements set out in the technical specifications depending on type (GCL / HDPE) 5.5 Heat and hoarding will be required for HDPE installation. 5.6 All installation QC to be completed as required. 5.7 The 1m of exposed liner at the hinge point will be protected with a combination of geotextile and plywood. 5.8 Survey to complete as built pick up of liner panels and any patches that may be installed. 5.9 Engineering Rep to complete final review and release liner for backfill.	HP-7 HP-8
6.0 Bedding Cover – Lower Liner 6.1 Following approval from the engineer material placement will begin for the over liner cover material. 6.2 Survey to stake out bedding cover as required, in addition cones with 0.3m lifts will be used as an alternate check for ongoing placement. 6.3 Material will be loaded at the crusher stockpile at Quarry 2 and hauled with a fleet of 4 x 740 haul trucks to the Dam site. 6.4 Material will be placed to the upstream slope working from the bottom up with the 349 excavator (or alternate as required) in an even manor to prevent the liner from slipping on the slope. (note the hinge point liner will be protected and not be travelled on) 6.5 The material for the base of the key will be cast to place from the downstream side and touched up on the floor with a skid steer.	HP-9

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Operational Work Plan

TMAC RESOURCES

6.6 Compaction will be achieved through the use of the 10T roller as per the prescribed rolling pattern.	
6.7 Ongoing snow removal will be complete as required throughout the operation to ensure there is no buildup of snow / ice within the lifts.	
6.8 Survey to complete an as built pick up of the placed bedding and compare with design lines to ensure fill requirements are met (300mm)	HP-10
6.9 Engineering rep to review and approve material for transition placement.	HP-11
7.0 Transition Placement – Lower Liner	
7.1 Following approval from the engineer material placement will begin for the transition material.	
7.2 Survey to stake out lifts as required, in addition cones with 0.5m lifts will be used as an alternate check for ongoing placement.	HP-12
7.3 Material will be loaded at the crusher stockpile at Quarry 2 and hauled with a fleet of 4 x 740 haul trucks to the Dam site.	
7.4 Material will be placed to the upstream slope working from the bottom up with the 349 excavator (or alternate as required).	
7.5 The material for the base of the key will be cast to place from the downstream side and touched up on the floor dozer as required	
7.6 For the second lift of material a combination of excavator placement and ramps will be used to have the haul trucks dump to a placement dozer in the trench as at this point the line will have 800mm of compacted cover.	
7.7 Compaction will be achieved through the use of the 10T roller as per the prescribed rolling pattern.	
7.8 Ongoing snow removal will be complete as required throughout the operation to ensure there is no buildup of snow / ice within the lifts.	
7.9 Once material placement is complete Survey will complete an as built pick up of the placed transition and compare with design lines to ensure fill requirements are met (1.0m)	HP-13
7.10 Engineering rep to review and approve material for ROQ placement.	HP-14
8.0 ROQ Placement – Key	
8.1 Following approval from the engineer material placement will begin for ROQ.	
8.2 Material will be source from a combination of Quarry 2 to start with the remaining balance from Quarry 3 and hauled with a fleet of 4 and 3 x 740 haul trucks to the Dam site.	
8.3 Material will hauled to the downstream side of the Dam and placed with the Dozer (D8/D6), ramping into the key and placing as per the prescribed lift thicknesses (max 1.85m).	
8.4 Compaction will be achieved through the use of the 10T roller as per the prescribed rolling pattern on all lifts prior to continuing.	
8.5 Ongoing snow removal will be complete as required throughout the operation to ensure there is no buildup of snow / ice within the lifts.	
Note * the key liner and fill will be broken up into sections based on the weather conditions onsite and steps 4-8 will be complete as a grouping working along the Dam. This is in an effort to limit any snow removal and rework that may result of changing weather conditions.	
9.0 ROQ Placement - Above OG	
9.1 ROQ placement will continue as per item 8 with focus to the belly of the Dam where the greatest fill is required.	
9.2 In an effort to ensure that no material comes in contact with the lower liner hinge point the excavator will be used to place and trim material to the final location as required in this area. This same process will be used to complete the narrow / shallow fills located at the beginning and end of the Dam.	
9.3 Compaction will be achieved through the use of the 10T roller as per the prescribed rolling pattern on all lifts prior to continuing.	
9.4 Once material placement is complete Survey will complete an as built pick up of the placed ROQ and compare with design lines to ensure the final surface is within tolerances.	HP-15
9.5 Engineering rep to review and approve material for transition placement.	HP-16

Operational Work Plan

10.0 Transition Placement – Under Upper Liner	
10.1 Following approval from the engineer material placement will begin for the transition material.	
10.2 Survey to stake out lifts as required, in addition cones with 0.5m lifts will be used as an alternate check for ongoing placement.	HP-17
10.3 Material will be loaded at the crusher stockpile at Quarry 2 and hauled with a fleet of 4 x 740 haul trucks to the Dam site.	
10.4 Material will be placed to the 3:1 slopes in 2 x 0.5m lifts via the dozer (D8/D6), similar to the ROQ the final trimming in the shallow fills and next to the liner will be completed with the excavator as required.	
10.5 Compaction will be achieved through the use of the 10T roller as per the prescribed rolling pattern.	
10.6 Ongoing snow removal will be complete as required throughout the operation to ensure there is no buildup of snow / ice within the lifts.	
10.7 Once material placement is complete Survey will complete an as built pick up of the placed transition and compare with design lines to ensure fill requirements are met (1.0m)	HP-18
10.8 Engineering rep to review and approve material for bedding placement.	HP-19
11.0 Bedding Placement – Under Upper Liner	
11.1 Following approval from the engineer material placement will begin for the bedding material.	
11.2 Survey to stake out bedding cover as required, in addition cones with 0.3m lifts will be used as an alternate check for ongoing placement.	HP-20
11.3 Material will be loaded at the crusher stockpile at Quarry 2 and hauled with a fleet of 4 x 740 haul trucks to the Dam site.	
11.4 Material will be placed to the 3:1 slopes in 1 – 300mm lift via the dozer (D8/D6), similar to the transition the final trimming in the shallow fills and next to the liner will be completed with the excavator as required.	
11.5 Compaction will be achieved through the use of the 10T roller as per the prescribed rolling pattern.	
11.6 Ongoing snow removal will be complete as required throughout the operation to ensure there is no buildup of snow / ice within the lifts.	
11.7 Once material placement is complete Survey will complete an as built pick up of the placed bedding and compare with design lines to ensure fill requirements are met 300mm)	HP-21
11.8 Engineering rep to review and approve material for liner installation.	HP-22
12.0 Liner Installation – Upper	
12.1 Base to be free of snow and ice, cleaning with mechanical broom, shovel and air lance as required to meet engineering requirements.	
12.2 Engineering Rep to approve section for placement	
12.3 The liner will be deployed with the assistance of an excavator to hang the spreader bar and liner from. This will allow the roll to be held at the bottom by the ground crew and pulled up the slope into place limiting the time spent working / pulling on the slopes.	
12.4 Liner installation to follow requirements set out in the technical specifications depending for GCL	
12.5 All installation QC to be completed as required.	
12.6 Survey to complete as built pick up of liner panels and any patches that may be installed.	HP-23
12.7 Engineering Rep to complete final review and release liner for backfill.	HP-24
13.0 Bedding Placement – Over Upper Liner	
13.1 Following approval from the engineer material placement will begin for the bedding material.	
13.2 Survey to stake out bedding cover as required, in addition cones with 0.3m lifts will be used as an alternate check for ongoing placement.	HP-25
13.3 Material will be loaded at the crusher stockpile at Quarry 2 and hauled with a fleet of 4 x 740 haul trucks to the Dam site.	
13.4 Material will be placed to the 3:1 slopes in 1 – 300mm lift via the excavator as cover requirements will not be sufficient for the dozer to be used.	
13.5 Compaction will be achieved through the use of the 10T roller as per the prescribed rolling pattern.	
13.6 Ongoing snow removal will be complete as required throughout the operation to ensure there is no buildup of snow / ice within the lifts.	

Operational Work Plan

13.7 Once material placement is complete Survey will complete an as built pick up of the placed bedding and compare with design lines to ensure fill requirements are met 300mm)	HP-26
13.8 Engineering rep to review and approve material for transition placement.	HP-27
14.0 Transition Placement – Over Upper Liner	
14.1 Following approval from the engineer material placement will begin for the transition material.	
14.2 Survey to stake out lifts as required, in addition cones with 0.5m lifts will be used as an alternate check for ongoing placement.	HP-28
14.3 Material will be loaded at the crusher stockpile at Quarry 2 and hauled with a fleet of 4 x 740 haul trucks to the Dam site.	
14.4 Material will be placed to the 3:1 slopes in 2 x 0.5m lifts via the dozer (D8/D6).	
14.5 Compaction will be achieved through the use of the 10T roller as per the prescribed rolling pattern.	
14.6 Ongoing snow removal will be complete as required throughout the operation to ensure there is no buildup of snow / ice within the lifts.	
14.7 Once material placement is complete Survey will complete an as built pick up of the placed transition and compare with design lines to ensure fill requirements are met (1.0m)	HP-29
14.8 Engineering rep to review and approve material for ROQ placement.	HP-30
15.0 ROQ Thermal Cover	
15.1 Following approval from the engineer material placement will begin for the ROQ material.	
15.2 Survey to stake out lifts as required for ongoing material placement.	HP-31
15.3 Material will be loaded at Quarry 3 and hauled with a fleet of 3 x 740 haul trucks to the Dam site.	
15.4 Material will be placed to the 3:1 slopes in lifts (max 1.85m) via the dozer (D8/D6). In order to allow for access for the haul trucks the lifts will be overbuilt at a 1:1 slope vs 3:1 slope. The material will be trimmed at a later date and incorporated into the higher lifts.	
15.5 Compaction will be achieved through the use of the 10T roller as per the prescribed rolling pattern.	
15.6 Ongoing snow removal will be complete as required throughout the operation to ensure there is no buildup of snow / ice within the lifts.	
15.7 Once material placement is complete Survey will complete an as built pick up of the placed ROQ and compare with design lines to ensure fill requirements are met.	HP-32
15.8 Engineering rep to review and approve material.	HP-33
16.0 Surfacing Placement	
16.1 Following approval from the engineer material placement will begin for the surfacing material.	
16.2 Survey to stake out surfacing design and grades.	HP-34
16.3 Material will be loaded at Quarry 3 and hauled with a fleet of 3 x 740 haul trucks to the Dam site.	
16.4 Material will be placed via the dozer (D8/D6) to the dam surface.	
16.5 Compaction will be achieved through the use of the 10T roller as per the prescribed rolling pattern.	
16.6 Ongoing snow removal will be complete as required throughout the operation to ensure there is no buildup of snow / ice within the lifts.	
16.7 Once material placement is complete Survey will complete an as built pick up of the placed surfacing and compare with design lines to ensure fill requirements are met.	
16.8 Engineering rep to review and approve material.	

Operational Work Plan

Quantities – South Dam – Phase 1 Construction				
NCC	Task Description	Quantity	Unit	Notes
2171	Key Excavation	20,000	m^3	
2611	Load, Haul, Place ROM	33,500	m^3	
2625	Load, Haul, Place Transition	25,500	m^3	
2631	Load, Haul, Place Bedding	7,000	m^3	
2615	Liner Installation Support	15,000	m^2	
TBD	Load, Haul, Place Surfacing	980	m^3	

List of Required Equipment

	Description:
4	Cat 740 Haul Trucks
1	Cat 349 Excavator
1	Cat 345 Excavator
1	Cat 325 Excavator
1	Cat D8 Dozer
1	Cat D6 Dozer
1	Cat 988 Loader
1	Cat 980 Loader
1	Cat 10T Smooth Drum Roller
1	Skid Steer – Bucket and Broom Attachments
1	Break Room / Warm Up Shack
6	Light Plants
2	Pick up
1	Compressor and Lance

Clarifications / Information / General Notes

- Lift Thickness by Engineer
- Subgrade competency by Engineer

Engineering/Survey Support Required

- Survey Support for layout and as-built pickup

Reference of Contract Specifications, RFI's and Site Instructions

- HopeBay_TechnicalSpecifications_Report_1CH008 027_RevG_20110329
- Drawings: DN-SD-01 to DN-SD-18
- Overburden Dump Site - 1CT022.017_South Dam_OVB_stockpile_NOTES_20180110.pdf

This Work Plan is Approved for Construction.

Superintendent: _____
Name Signature Date

Client Representative: _____
Name Signature Date

Kendell Cator

From: John Kurylo
Sent: Saturday, February 03, 2018 11:50 AM
To: jakec@sub-arctic.ca; Boyd Barstad; Kendell Cator
Cc: Roland Jones; Mark Doucette; Kelly Schwenning; Maritz Rykaart
Subject: South Dam - Potential Overburden Storage Location within TIA
Attachments: 1CT022.017_South Dam_OVB_stockpile_NOTES_20180110.pdf

Hi Jake and Boyd,

To follow-up with our discussions on site, for the key trench overburden storage location, site should place the key trench overburden at a location that is overall:

- A minimum of 200m away from the upstream face of the South Dam
- Along the East shoreline;
- At elevation of 33m or lower (want overburden below the ultimate Phase 1 tailings deposition surface); and
- Within the Phase 1 tailings storage (TIA) footprint

Below please find a field reference point (found along the East shoreline, down from the existing road) that will mark the approximate maximum south extents that would be acceptable for overburden placement.

MAX ALLOWABLE SOUTH EXTENTS OF OVERBURDEN PLACEMENT:

- 435700 m East
- 7556190 m North
- Elevation below 33m

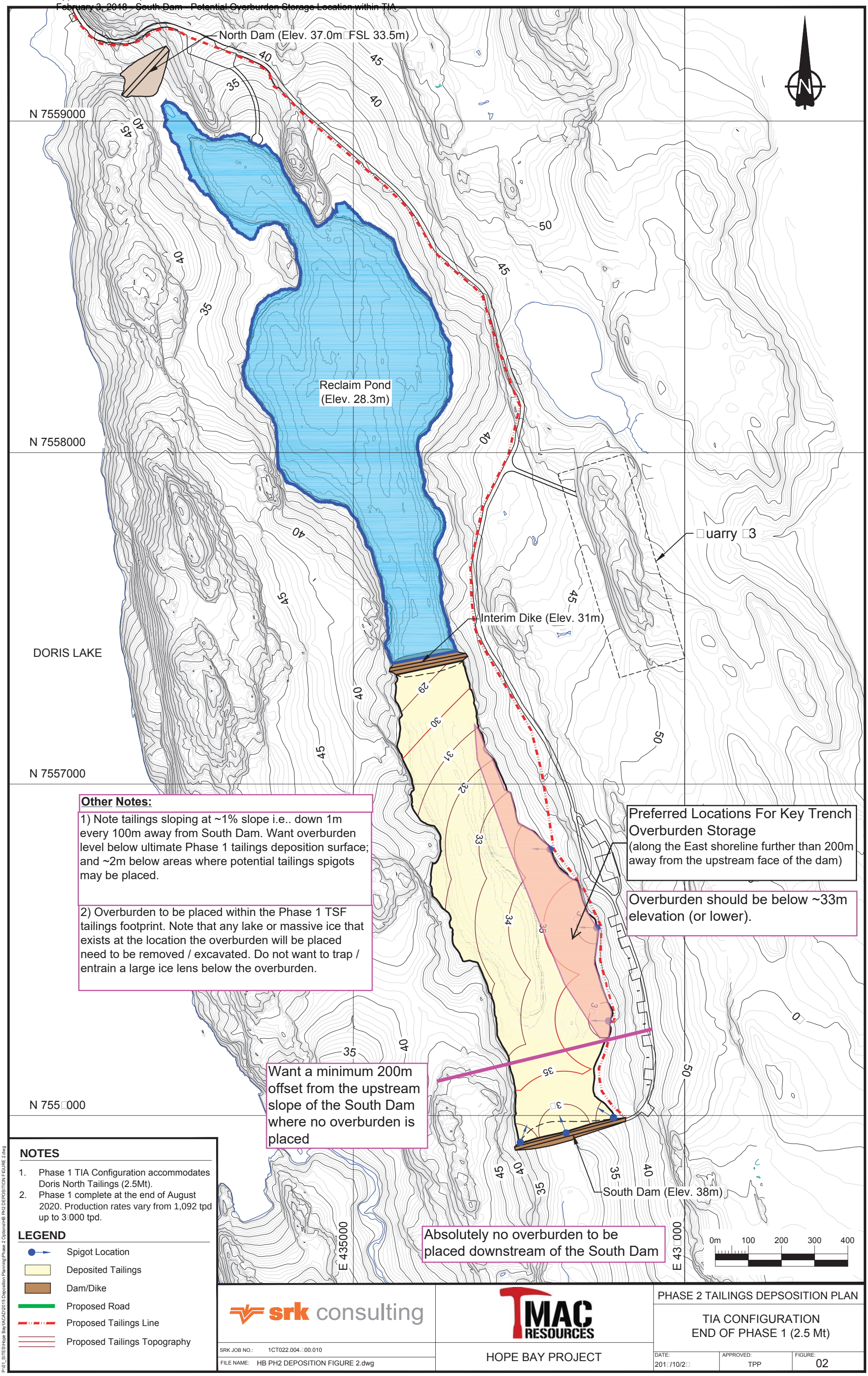
It is expected that this point will be marked in the field and then used to find the most appropriate location / best access you can find on the east shoreline, which is at this point or ideally north of this point (i.e. further away from the South Dam location).

Attached to this email I have also included a figure with some mark-ups / notes showing the potential location (within the TSF footprint) for this overburden placement. One important construction consideration is that snow and ice (for example frozen pond ice) should be removed / excavated before overburden is placed within the TSF Phase 1 footprint. This would be done to ensure that we do not trap / entrain a massive ice lenses below the overburden material.

If you have any additional questions when you review the attached figure then please let me know or chat with Kendell on site.

Regards,
John

John Kurylo *MSc (DIC), PEng*
Senior Consultant (Geotechnical)
srk consulting
SRK Consulting (Canada) Inc.
22nd Floor, 1066 West Hastings Street, Vancouver, BC, V6E 3X2, Canada
Tel: +1-604-681-4196; **Fax**: +1-604-687-5532
Mobile:+ 1-604-345-2211; **Direct**: +1-604-235-8541



NOTES ON KEY TRENCH OVERBURDEN PLACEMENT

Kendell Cator

From: John Kurylo
Sent: Tuesday, February 20, 2018 1:24 PM
To: Jake Chisholm; 'Mark Doucette'
Cc: Kendell Cator; Kaitlyn Kooy; Maritz Rykaart; kelly.schwenning@tmacresources.com; Roland Jones; 'Murray Weddell'; Cameron Hore; Boyd Barstad; Rob Cook
Subject: Hope Bay - South Dam - UPDATED KEY TRENCH DESIGN
Attachments: 1CT0022.017 - South Dam - Key TrenchDesignUpdate-NOTES_20180220.pdf; 180220 - South Dam - Key Trench.xml

Hi Jake,

To follow-up with our discussion on site, please find attached a draft figure (and digital surface / Land XML file) that shows the updated key trench design for the South Dam. This updated design is based on the recent sonic drilling, percolation testing (field and lab) carried out on site. Note that the main things that have changed / have been updated in the key trench designs are:

- The key trench depth on the two sides (east and west) has been raised to 3m depth - the rest of the key trench is still at 4m design depth
- The base of the key trench has been updated so that it has a maximum grade of around 10% to allow for truck access along then entire base length of the key trench

An official IFC drawing update will follow / be submitted later this week. This being noted the attached can be used to layout the key trench design in the interim (and give Nuna guidance on site where and how deep to excavate or drill and blast).

If you have any questions on the attached then please let me know.

Kind Regards,
John

John Kurylo *MSc (DIC), PEng*
Senior Consultant (Geotechnical)
srk consulting

SRK Consulting (Canada) Inc.
22nd Floor, 1066 West Hastings Street, Vancouver, BC, V6E 3X2, Canada
Tel: +1-604-681-4196; **Fax**: +1-604-687-5532
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Email: jkurylo@srk.com

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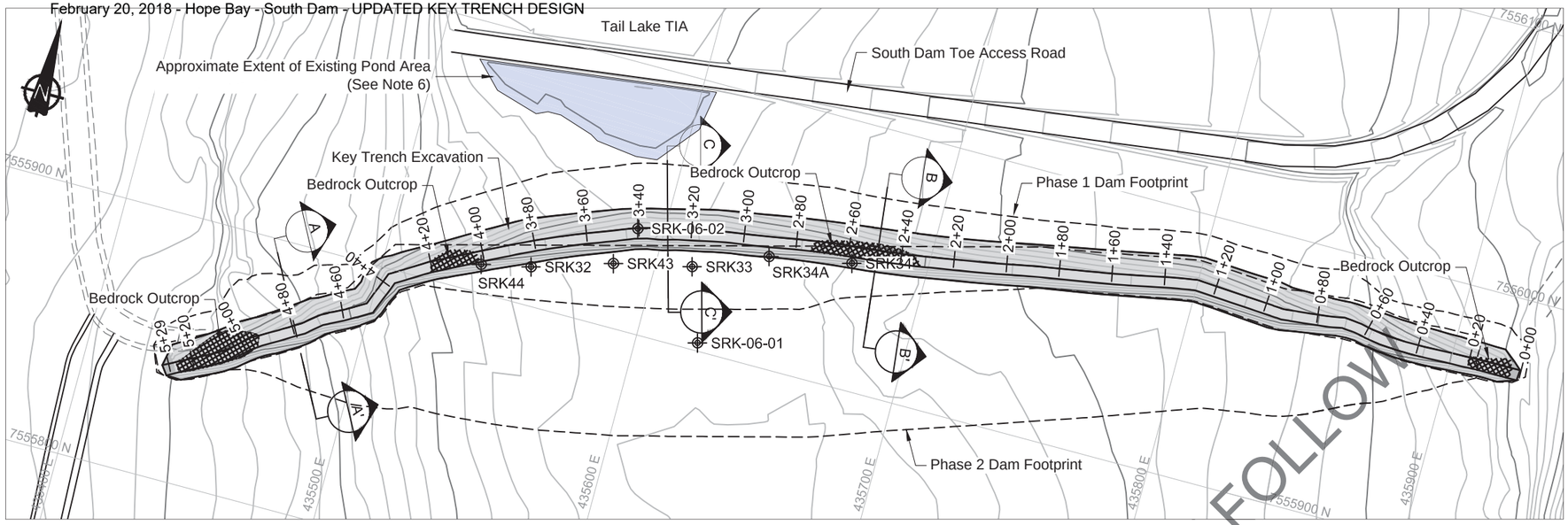
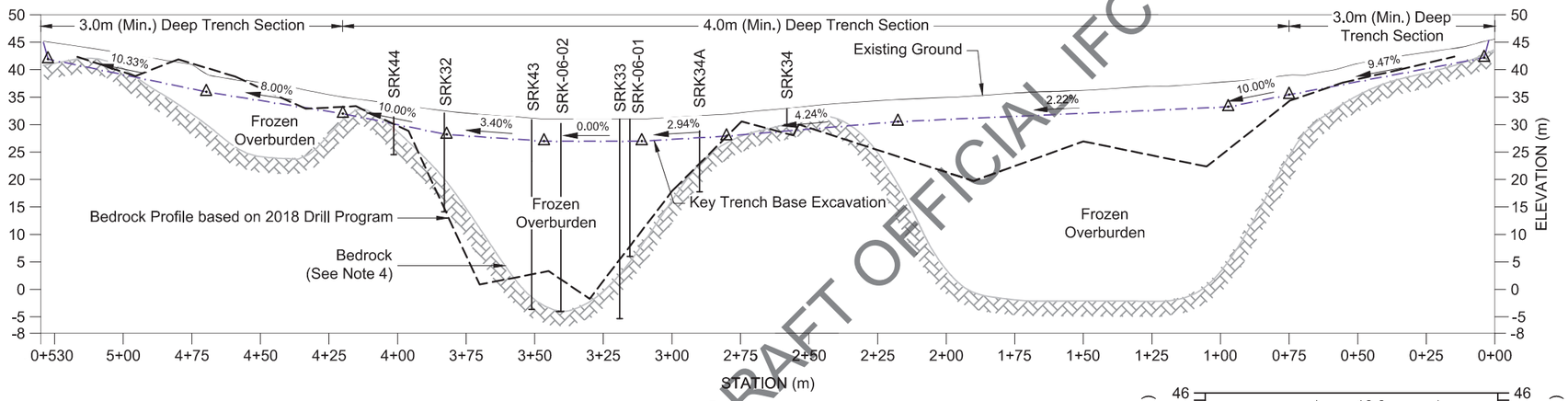


Key Trench Plan View

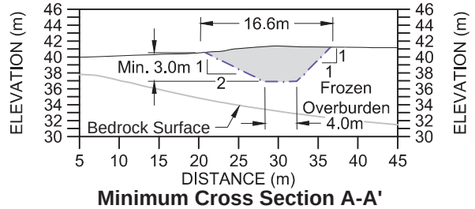
0m 20 40 60 80



Key Trench Profile View

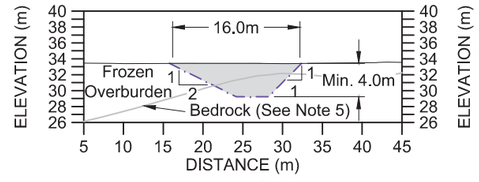
Vertical 0m 10 20 30 40

Horizontal 0m 20 40 60 80



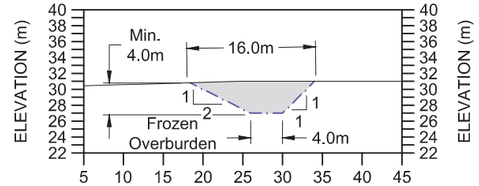
Minimum Cross Section A-A'
Shallow Overburden over Bedrock

0m 5 10 15 20 25 30



Cross Section B-B'
Bedrock Outcropping in Key Trench

0m 5 10 15 20 25 30



Cross Section C-C'
Deep Frozen Overburden

0m 5 10 15 20 25 30

LEGEND

- Drill Hole Location
- Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Trench Excavation Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profile shown correspond to the upstream toe of the key trench.
4. The subsurface geology has been inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A , SRK43, SRK 44), airphoto interpretations, and from limited available geophysical surveys around the Tails Lake area. This data was then used to create a bedrock surface with the Gemcom GEMS software. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.
5. The final key trench extent and depth will be determined in the field by the Engineer. Typical excavation depth is 4.0m, unless massive ice, hypersaline soil or bedrock encountered. The Engineer will inspect all excavations and approve the foundation conditions.
6. Ponded area to removed (frozen massive ice excavated or drained if possible) prior to key trench excavation. Up to approximately 4,700 m3 of (frozen) water may be expected to be removed from this area. Exact water levels are not known so the volume estimate above should be treated as a rough estimate based on topography.
7. If any area of the key trench is over-blasted or over-excavated then the extra excavation will need to be backfilled in thin lifts (*see 'Technical Specifications'*) until the key trench design lines and grades are reached.
8. Overblasting and/or overexcavation of the key trench beyond the design lines (as presented on this figure) should be avoided if at all possible. Extra care should be taken during the key trench excavation to ensure that the excavation can result as close to the design lines as possible. Excavation beyond the key trench design lines may require that the overall Phase 1 dam footprint be enlarged to provide the necessary thermal coverage and to uphold design requirements.

REFERENCES

NAD83 UTM Zone 13.

DRAFT OFFICIAL IFC TO FOLLOW

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
2	Issued for Construction			18/02/20
1	Issued for Construction	JBK	EMR	17/12/11
0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS (DRAWING NO. / DRAWING TITLE)

REVISIONS

DRAFT

Signature of Engineer

This drawing is uncontrolled when printed unless stamped and signed with original ink and recorded on a Distribution Register.

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2017/12/11

FILE NAME: 1CT0022.017 - South Dam - Key Trench.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:
Key Trench Excavation
Plan and Profile

DRAWING NO. DN-SD-04

SHEET 4 OF 26

REVISION NO.

DRAFT

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 (2)\1CT0022.017 - South Dam - Key Trench.dwg

Kendell Cator

From: John Kurylo
Sent: Saturday, February 24, 2018 8:21 PM
To: Gramoz Rexhepi; Boyd Barstad; Jake Chisholm
Cc: Kaitlyn Kooy; Murray Weddell; Maritz Rykaart; 'Mark Doucette'; Kelly Schwenning; Kendell Cator; Kyle Scale
Subject: South Dam - ROQ and Transition Placement (outside of key trench) for Access
Attachments: 1CT0022.017 - South Dam - AccessRoadsUS&DS.DWG; 1CT0022.017 - South Dam - AccessRoadsUS&DS.DXF; 1CT0022.017 -South Dam-AccessRoadsDownstreamNOTES_20180221.pdf

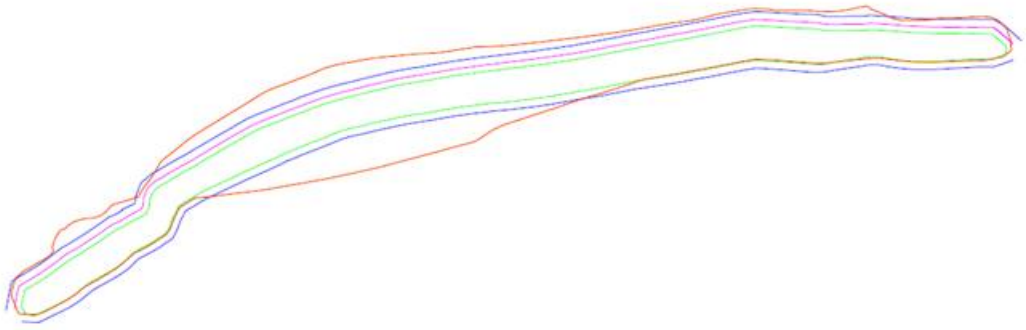
Hi All,

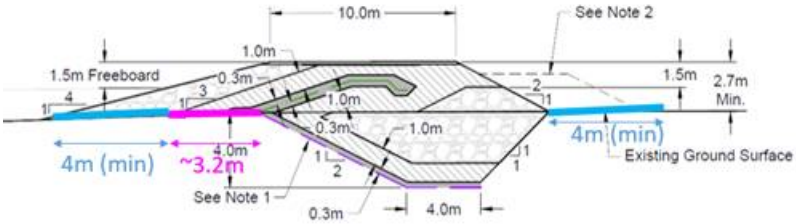
Attached please find a CAD file that provides some polylines to assist with giving site guidance with where ROQ can be placed on the downstream, and where ROQ and Transition can be placed on the upstream (outside of the key trench on the existing ground). You should be able to use the attached to give you some guidance and stakeouts about where you can place material outside of the key trench.

The attached pdf *'1CT0022.017 -South Dam-AccessRoadsDownstreamNOTES_20180221.pdf'* give some additional details about the considerations for the downstream ROQ placement, and shows how this one time allowance -to place material outside of the downstream Phase 1 footprint - will ultimately affect the final Phase 1 downstream slope design (it will shallow the slope on the downstream of the top two sides).

The screenshots below show what is in the attached CAD files. Note that lines show the following information:

- **RED** lines = outside of Phase 1 footprint (original IFC)
- **GREEN** lines = updated key trench design
- **MAGENTA** line = upstream transition material (top of key trench offset 3.2m see second screenshot below)
- **BLUE** line = upstream and downstream ROQ (min 4m width).
    - 4m away from the edge of the transition on the upstream
    - 4m away from the edge of the key trench on the downstream

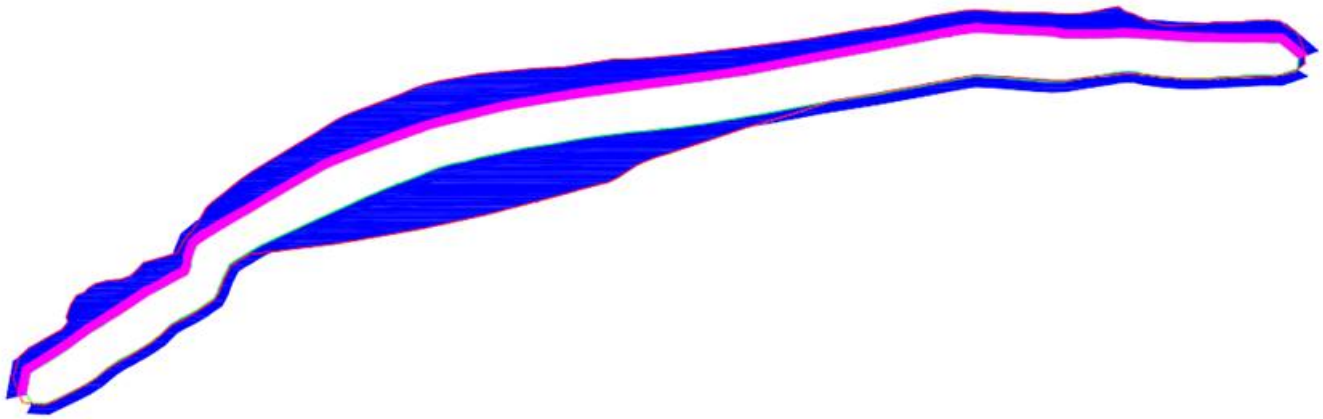




Minimum Typical Cover Section

The areas where rock can be placed, above the key trench on the natural ground, for access or while you are waiting for the key trench excavation, are shown in the screenshot below:

- **BLUE** hatch = areas where ROQ can be placed
- **MAGENTA** hatch = areas where Transition can be placed



If you have any questions when you review the attached then please let Kaitlyn or myself know.

Best,
John

John Kurylo *MSc (DIC), PEng*
Senior Consultant (Geotechnical)

SRK Consulting (Canada) Inc.

22nd Floor, 1066 West Hastings Street, Vancouver, BC, V6E 3X2, Canada

Tel: +1-604-681-4196; **Fax**: +1-604-687-5532
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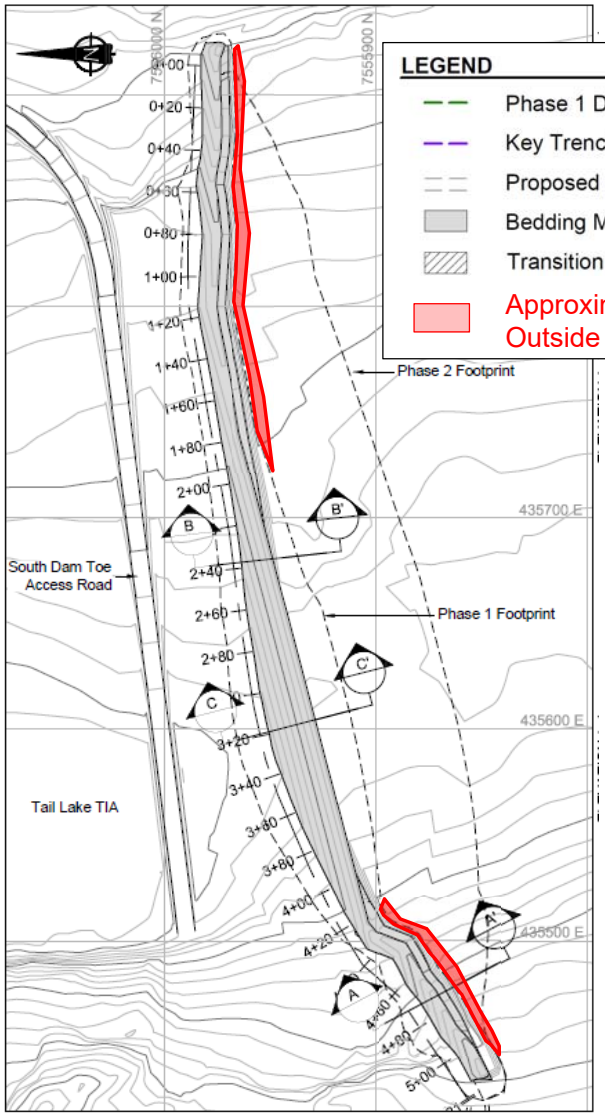
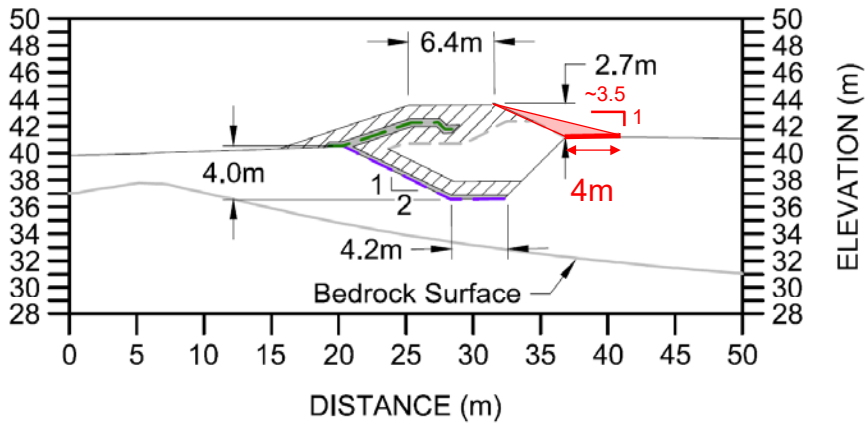
Potential Shallowing of Outside Slopes Between ~ Chainage 0+00 and 2+00, as well as Between 4+10 to 5+30

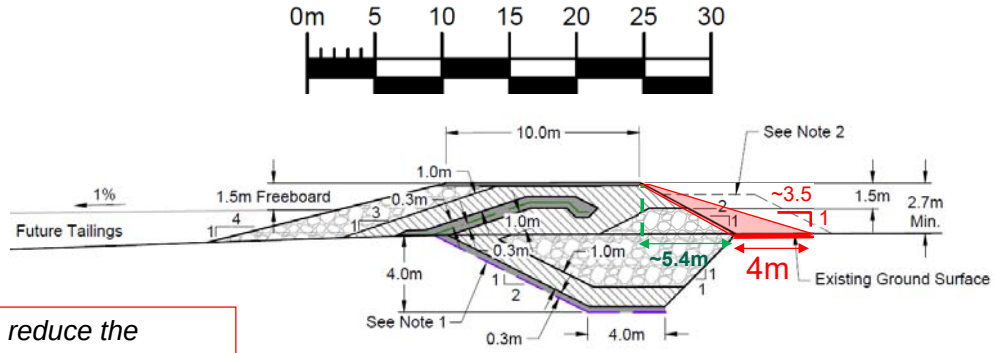


Phase 1 Dam Bedding Placement Plan View

0m 20 40 60 80 100



Minimum Cross Section A-A'



Note: *Looking to reduce the outside slope of the South Dam in the minimum sections to allow for a ROQ access road to be placed along the downstream and also to allow for more thermal protection of the downstream toe/ edge of the key trench.*

Minimum Typical Cover Section
STA.0+00 to 1+92 & 4+35 to 5+42

0m 3 6 9 12

srk consulting	TMAC RESOURCES	South Dam	
		Daily Report Field Notes and Photos	
Project No: 1CT022.031	Hope Bay	Date: February 21, 2018	Approved: JBK / Figure: 1

Seema Kang

From: John Kurylo
Sent: Saturday, February 24, 2018 5:16 PM
To: Gramoz Rexhepi; Boyd Barstad; Rob Cook; Kaitlyn Kooy
Cc: Murray Weddell; Maritz Rykaart; Jake Chisholm; Kelly Schwenning
Subject: RE: Hope Bay - South Dam - UPDATED KEY TRENCH DESIGN

Hi All,

It sounds like everything has been sorted out on site now but please see my comments below for the engineering record, to reinforce Kaitlyn's comments, and to close the loop on this email chain.

The latest key trench design that was provided (provided by email on 2018/02/20) is the latest design and this design should be followed.

The suggestions on other potential options / alternatives to modifying the key trench on the 3m min cut sides (on each end of the dam alignment) are noted, however, this proposed modification should NOT be completed. This proposed modification will not work as this will change the dam centerline, change the design of the other dam elements, and will create an unwanted 'kink' in the dam alignment (which will also make liner installation more difficult). Please see the notes / sketch below for a visual explanation of this.

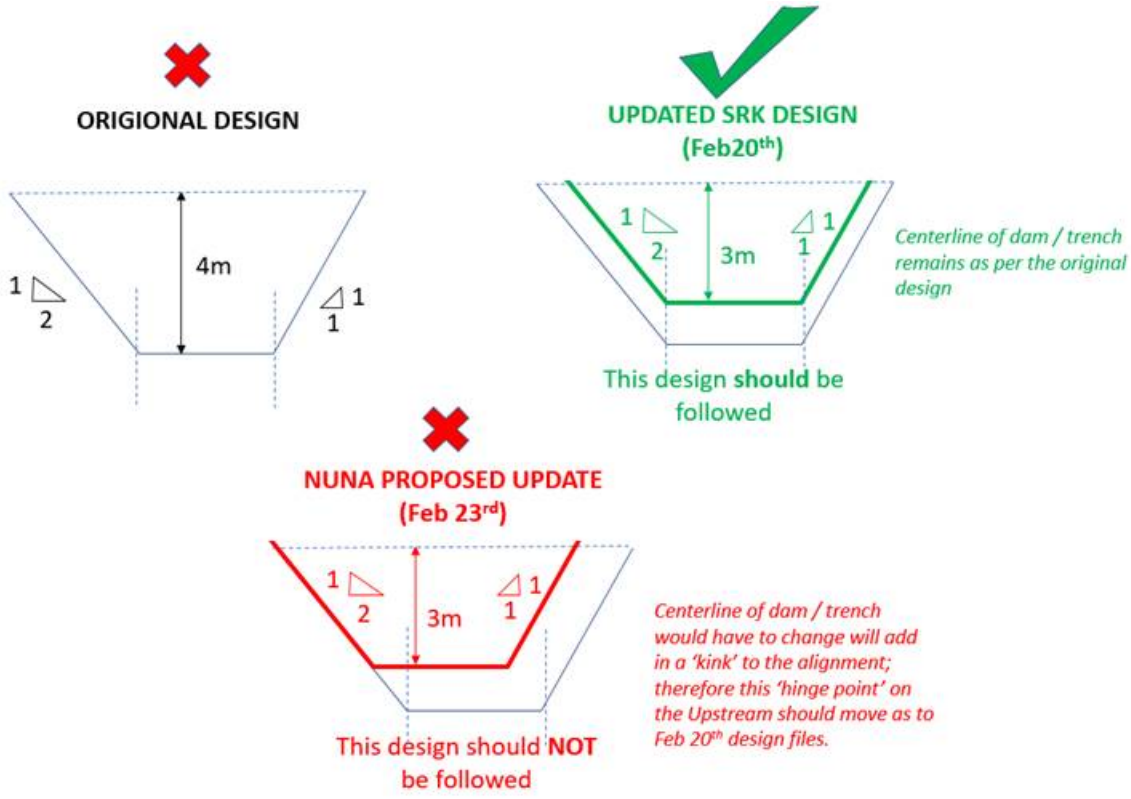


Figure 1: Key trench cross-sections highlighting updates made to the original design and limitations of recent suggestions

Secondly, raising the key trench from 4m to 3m on the two side would have saved notably more than 1,800 m^3 of excavation if we just raise the trench and did nothing else. This being noted the updated key trench design not only raises the cuts on the two sides but also optimized the base slopes of the key trench so that it is less undulating; and has slopes of ~10% or less to allow for equipment access across the base (as requested by Nuna). By smoothing the base slopes we inherently get more cut in some areas (in excess of 4m in the base in some areas and in excess of 3m in some areas on this two sides). This smoothing of the base results in more cuts but this volume increase is balanced by the raising of the two sides of the key trench up to a minimum 3m so overall so that we still have a small net volume savings with a more optimized design. If Nuna no longer wants to have this sloped base then they can have a smooth but undulating base (that more or less mimics the existing ground), as long as the key trench is at least 3m depth on the two sides (approx between station 0+00 and 0+75 an ~4+30 and 5+30) and at minimum 4m depth for the rest of the key trench. Sign-off can be granted in the field once the as-built survey files have been submitted for checks and then approved. Additional details on the differences between the original key trench design and the updated key trench design are presented in the screenshot below.

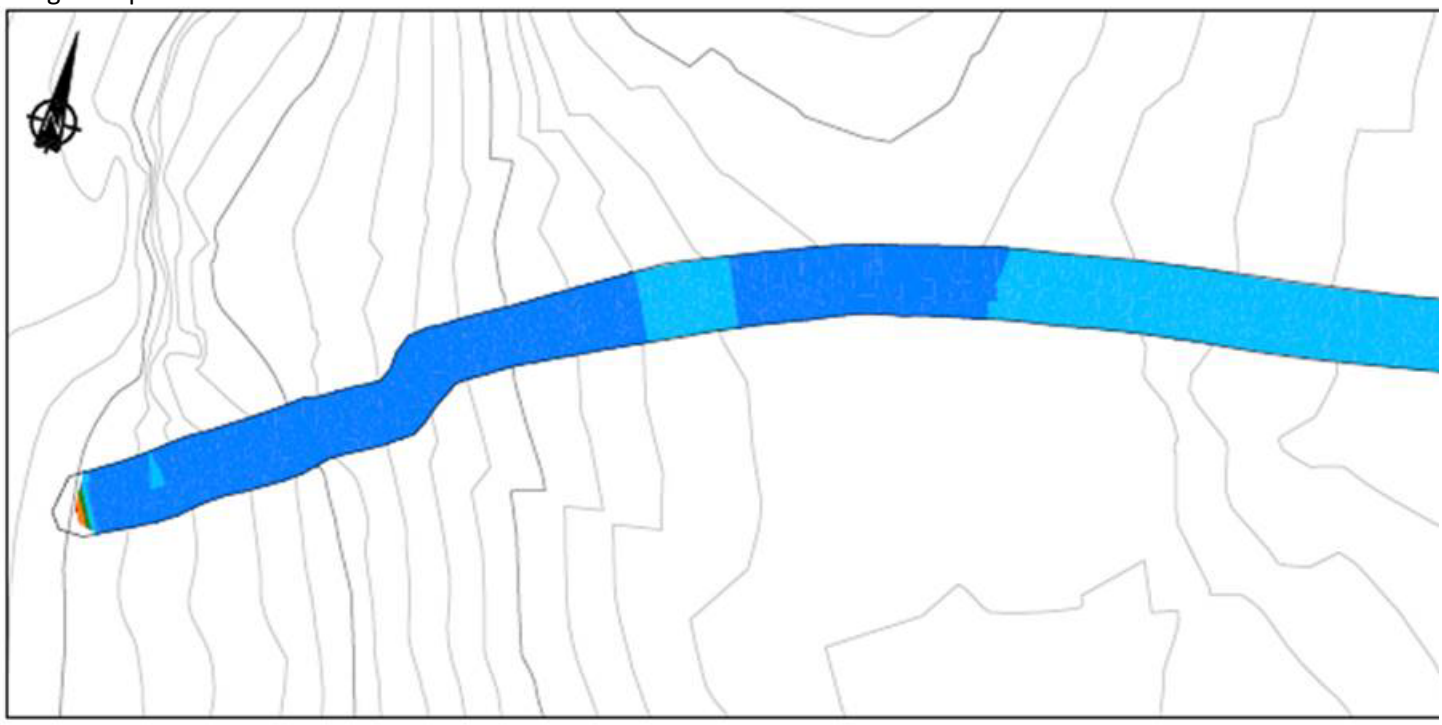


Figure 2: Original key trench design versus updated key trench design (note that they dark blue areas highlight the main areas that have changed)

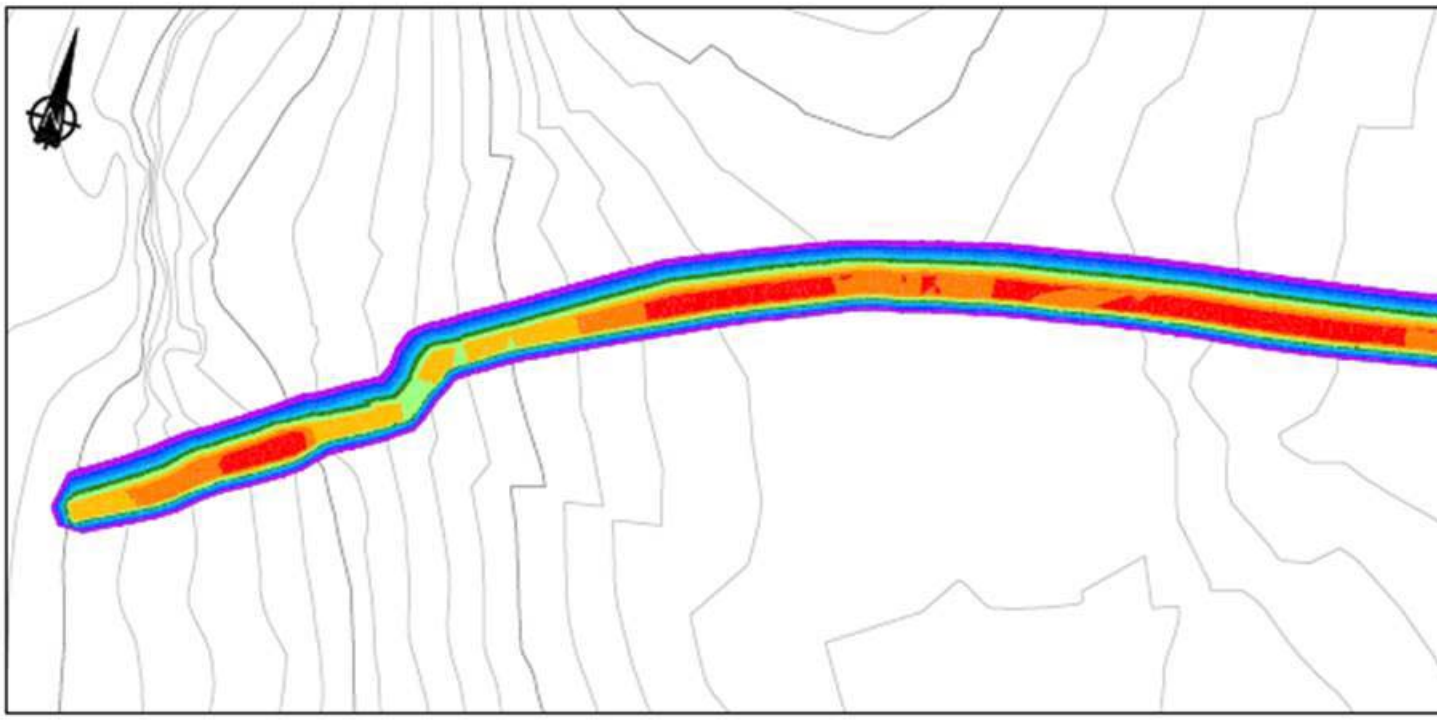


Figure 3: Existing ground versus new key trench design (note that lighter / hotter colours show deeper areas of the key trench excavation)

I fail to see how any hold ups to the current schedule have resulted since the updated key trench design was submitted on the 20th. Drilling could have started as early as last Saturday (February 17th) when I was on site, and ROQ and Transition material placement outside of the key trench (after snow clearing) could have resulted since the original IFC drawings were issued months ago.

Discussions and verbal guidance has been provided on fill road placements on the upstream and downstream toes of the dam. When in doubt no material should be placed outside of the Phase 1 dam footprint (as per the original IFCs). This being noted we had discussed making a small, ONE TIME, allowance to allow for an ~4m wide ROQ access road to constructed along the upstream and downstream dam toes that will extend slightly beyond the Phase 1 footprint (where the distance between the ROQ and transition or between the outside edge of the key trench and ROQ are small). These types of decisions are typically left to be made in the field and SRK will not be submitting new IFC for each of these slight 'field-fit' modifications that may result over the course of building the South Dam. Any field-fit modifications will instead be documented in the final as-built. In the spirit of moving forward, SRK will provide additional information to help you lay out a ROQ and Transition access road along the upstream and downstream toes (as recent discussions) here in the next couple hours.

Regards
John

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

From: Kaitlyn Kooy
Sent: Saturday, February 24, 2018 11:28
To: Kelly Schwenning <kelly.schwenning@tmacresources.com>; Gramoz Rexhepi <GramozR@nunalogistics.com>

Cc: Rob Cook <robc@nunalogistics.com>; John Kurylo <jkurylo@srk.com>; Murray Weddell <murray.weddell@tmacresources.com>
Subject: RE: Hope Bay - South Dam - UPDATED KEY TRENCH DESIGN

Hi All,

Please see my comments below highlighted in yellow.

Thanks,
Kaitlyn

Office: +1-604-235-8560
Mobile: +1-778-888-2070

From: Kelly Schwenning [mailto:kelly.schwenning@tmacresources.com]
Sent: Saturday, February 24, 2018 11:48 AM
To: Gramoz Rexhepi <GramozR@nunalogistics.com>
Cc: Rob Cook <robc@nunalogistics.com>; Kaitlyn Kooy <kkooy@srk.com>; John Kurylo <jkurylo@srk.com>; Murray Weddell <murray.weddell@tmacresources.com>
Subject: RE: Hope Bay - South Dam - UPDATED KEY TRENCH DESIGN

Kaitlyn, we were just discussing this, could you provide your comments to the below in yellow please

Kelly Schwenning
Projects Manager
Hope Bay Project,Nunavut
TMAC Resources Inc.
867-988-6882 Ext.106
604-290-1726 C
www.tmacresources.com

"Building Canada's next Gold Mining District"

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From: Gramoz Rexhepi [mailto:GramozR@nunalogistics.com]
Sent: February-24-18 11:40 AM
To: Kelly Schwenning <kelly.schwenning@tmacresources.com>
Cc: Rob Cook <robc@nunalogistics.com>
Subject: FW: Hope Bay - South Dam - UPDATED KEY TRENCH DESIGN

Kelly,

As discussed, below is what would need to be done if we raise part of the excavation from 4m depth to 3 m depth. I did a quick calculation and it's about 1800 m2 of excavation saved and the same quantity for backfill. This equated to about 4 days of hauling and maybe 2 day of drilling. However, you would lose most of that saved time(survey, as-builts, AUTOCAD modeling, grading, etc), by trying to transition the key trench from 3m to 4m. Not to mention the lost time

waiting for these revisions. The design is not to be changed from the optimized key trench design. The revisions that are needed to support the optimized key trench design have been expedited and will be provided today.

If they move the upstream instead of the downstream, the entire thermal cover (ROQ above ground) will need to be redesigned for phase one and phase two because the hinge point would need to be shifted. This vwould lower the top of dam elevation in order to maintain the existing slope(4/1 and 2/1). I don't think they will do this but if they do it may save some material and haul time, but again will add costs to survey, grading and etc. Not to mention the additional engineering costs.

This is holding up the current schedule which is already compromised from the drill testing. We are currently waiting for a decision to be made so we can come up with a blast pattern and start excavating the bedrock areas. It is also holding up on starting the ROQ above ground areas which we need to start sloping the already ripped areas. Sloping of the key trench can begin now (as discussed yesterday with Gromaz and Boyd) with the excavator working within the dam footprint and the haul truck restricted to the key trench footprint that has not yet been sloped (the same hauling route that has been used for the box cut).

My suggestion is to talk to SRK and leave the design the way it is. We already have areas that are staked and our survey has the models to proceed.

Let me know your thoughts.

Kind Regards,

Gramoz Rexhepi
Project Coordinator
Site: 867-988-6882 ext 123
Cell: 587-920-9486

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TMAC Resources – Hope Bay South Dam Project
GramozR@nunalogistics.com
www.nunalogistics.com

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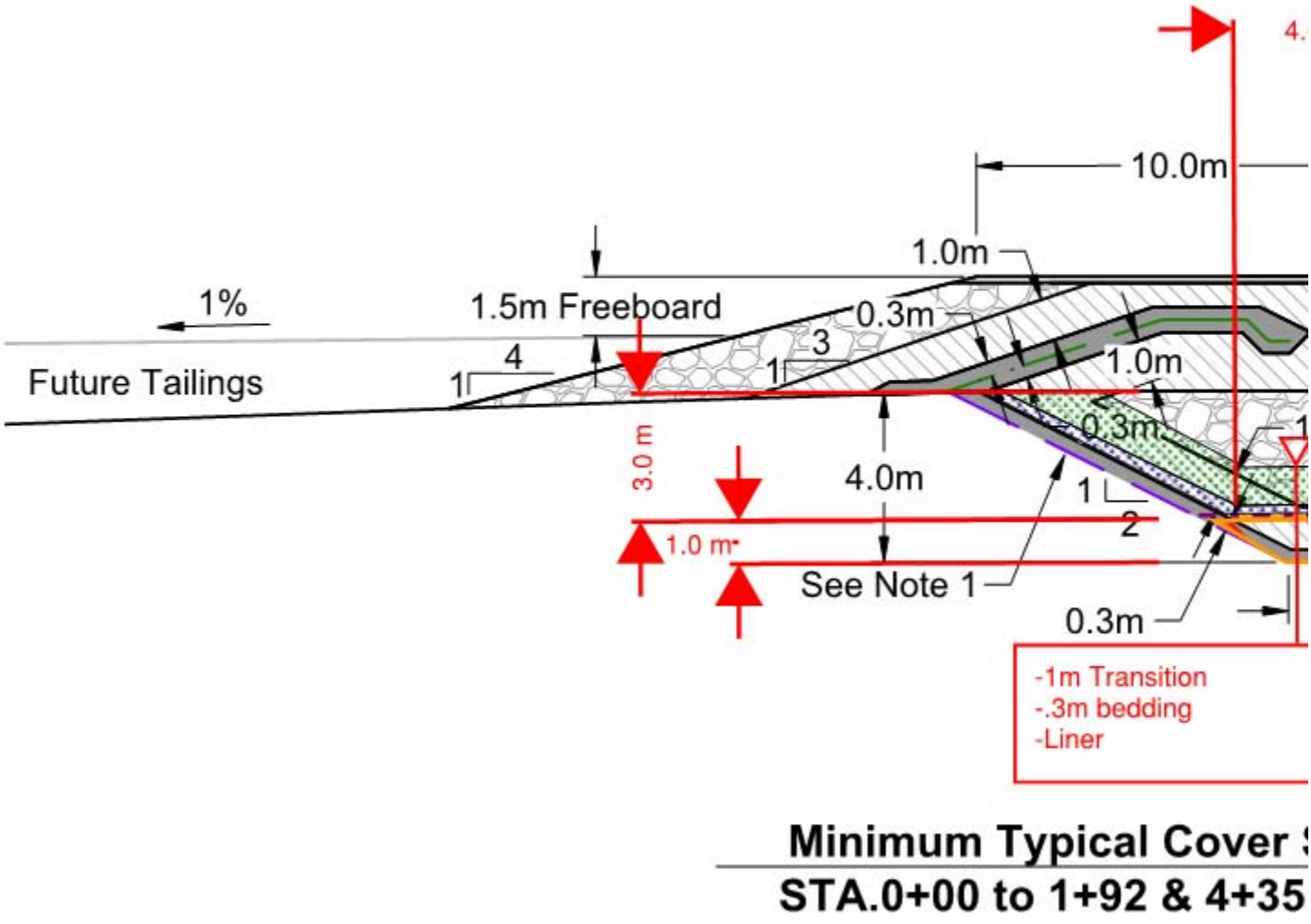
From: Gramoz Rexhepi
Sent: Friday, February 23, 2018 8:29 PM
To: 'John Kurylo' <jkurylo@srk.com>
Cc: Kaitlyn Kooy <kkooy@srk.com>; Boyd Barstad <boydb@nunalogistics.com>
Subject: RE: Hope Bay - South Dam - UPDATED KEY TRENCH DESIGN

Hi John,

Please see the sketch below. This is the solution we thought might be worth considering in the areas were the excavation is 3 meters deep. All we need to do is shift the downstream side of the key trench over 2 meters. If you do it this way you won't need to change any of the above ground design.It accomodates your 3 meter depth and all your layers are as per the original design in the trench (with the exception of ROQ). Moving the Hinge Point will cause more headaches then it's worth. In the area where we are transition from 3 meter depth to 4 meter depth, all we need to do is lower the key trench in .25 incoments every 2.5 meter and bring the wall out in .5 meter incroments every 2.5 meters.

A other option would be to just stick with the original design and not change the depth.



Let me know your thoughts.

Thanks,

Gramoz Rexhepi
Project Coordinator
Site: 867-988-6882 ext 123
Cell: 587-920-9486

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TMAC Resources – Hope Bay South Dam Project
GramozR@nunalogistics.com
www.nunalogistics.com

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From: John Kurylo [mailto:jkurylo@srk.com]
Sent: Friday, February 23, 2018 6:30 PM
To: Gramoz Rexhepi <GramozR@nunalogistics.com>
Cc: Kaitlyn Kooy <kkooy@srk.com>
Subject: RE: Hope Bay - South Dam - UPDATED KEY TRENCH DESIGN

Hmm. Ok I see what you mean. I will have to look into this and report back to see if this is a function of the base grade and topo or if this is an error.

Thanks for the note. I will get back to you on this but likely will not be until the morning.

John

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

From: John Kurylo
Sent: Friday, February 23, 2018 17:21
To: 'Gramoz Rexhepi' <GramozR@nunalogistics.com>
Cc: Kaitlyn Kooy <kkooy@srk.com>
Subject: RE: Hope Bay - South Dam - UPDATED KEY TRENCH DESIGN

Does the attached pdf work or do you need something specific?

John

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

From: Gramoz Rexhepi [mailto:GramozR@nunalogistics.com]
Sent: Friday, February 23, 2018 17:19
To: John Kurylo <jkurylo@srk.com>; Kaitlyn Kooy <kkooy@srk.com>
Subject: RE: Hope Bay - South Dam - UPDATED KEY TRENCH DESIGN

Can you send me a pdf of the line work? I don't have CAD.

From: John Kurylo [mailto:jkurylo@srk.com]
Sent: Friday, February 23, 2018 6:09 PM
To: Gramoz Rexhepi <GramozR@nunalogistics.com>; Kaitlyn Kooy <kkooy@srk.com>
Subject: FW: Hope Bay - South Dam - UPDATED KEY TRENCH DESIGN

FYI – in case you have not seen this attached is the updated key trench design. This is what was provided to survey before I left site.

Cheers,
John

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

From: John Kurylo
Sent: Tuesday, February 20, 2018 11:24
To: 'Jake Chisholm' <jakec@sub-arctic.ca>; 'Mark Doucette' <markd@sub-arctic.ca>
Cc: Kendell Cator <kcator@srk.com>; Kaitlyn Kooy <kkooy@srk.com>; Maritz Rykaart <mrykaart@srk.com>; 'kelly.schwenning@tmacresources.com' <kelly.schwenning@tmacresources.com>; Roland Jones <RolandJ@nunalogistics.com>; 'Murray Weddell' <murray.weddell@tmacresources.com>; Cameron Hore <chore@srk.com>; Boyd Barstad <boydb@nunalogistics.com>; 'Rob Cook' <robc@nunalogistics.com>
Subject: Hope Bay - South Dam - UPDATED KEY TRENCH DESIGN

Hi Jake,

To follow-up with our discussion on site, please find attached a draft figure (and digital surface / Land XML file) that shows the updated key trench design for the South Dam. This updated design is based on the recent sonic drilling, percolation testing (field and lab) carried out on site. Note that the main things that have changed / have been updated in the key trench designs are:

- The key trench depth on the two sides (east and west) has been raised to 3m depth - the rest of the key trench is still at 4m design depth
- The base of the key trench has been updated so that it has a maximum grade of around 10% to allow for truck access along then entire base length of the key trench

An official IFC drawing update will follow / be submitted later this week. This being noted the attached can be used to layout the key trench design in the interim (and give Nuna guidance on site where and how deep to excavate or drill and blast).

If you have any questions on the attached then please let me know.

Kind Regards,
John

John Kurylo *MSc (DIC), PEng* Senior Consultant (Geotechnical)
Tel: +1-604-681-4196; Fax: +1-604-687-5532
Mobile:+ 1-604-345-2211; Direct: +1-604-235-8541
Email: jkurylo@srk.com
www.srk.com

Kendell Cator

From: John Kurylo
Sent: Thursday, March 01, 2018 5:02 PM
To: kelly.schwenning@tmacresources.com
Cc: Kaitlyn Kooy; Kendell Cator; Maritz Rykaart; Cameron Hore; Kyle Scale
Subject: FW: Sieve Test Results Hope Bay (Y14103336-02.003)
Attachments: Y4103336-02.003 Sieve 18-02-17 6652A 25mm crush bedding.pdf; Y4103336-02.003 Sieve 18-02-17 6652B 25mm crush bedding.pdf

Hey Kelly,

The two initial 25mm minus crush results (QA tests for the bedding for the South Dam) show that the material being developed on site is near the lower (coarser) end of our specification - however this material is currently still within our specification. Therefore the 25mm minus crush material initially produced at Quarry #2 looks ok for use at the South Dam.

Nuna should have also submitted a bunch of QC crush samples for testing to Tetra Tech as well. As far as I know those results are not back / in yet. We will follow-up with Nuna on site about these QC tests to see what the status of those tests are. Also we will overlap with Nuna to see if we might be able to do a few optimizations at the crusher so any future 25mm minus crush material that is produced might be able to be crushed a bit finer – in hopes of moving a bit towards the middle of our bedding material specification (our specification is shown as the two dashed lines in the attached pdf results) to buy us a bit more lead room on site (incase we loose any of the finer end of our crush during loading, or in transport – from wind etc..).

When we get the results back from the latest QA crush samples we took we will let you know.

Cheers,
John

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

From: Archibald, Kati [mailto:Kati.Archibald@tetratech.com]
Sent: Thursday, March 1, 2018 13:08
To: Kelly Schwenning <kelly.schwenning@tmacresources.com>
Cc: John Kurylo <jkurylo@srk.com>; Fortin, Barb <Barb.Fortin@tetratech.com>; 704-y14103336-02@sites.tetratech.com
Subject: Sieve Test Results Hope Bay (Y14103336-02.003)

Hi Kelly,
Please see the attached test results.
Thank you,

Kati Archibald | Office Administrator
Direct **+1 (867) 766-3728 x259** | Business **+1 (867) 920-2287** | Kati.Archibald@tetratech.com

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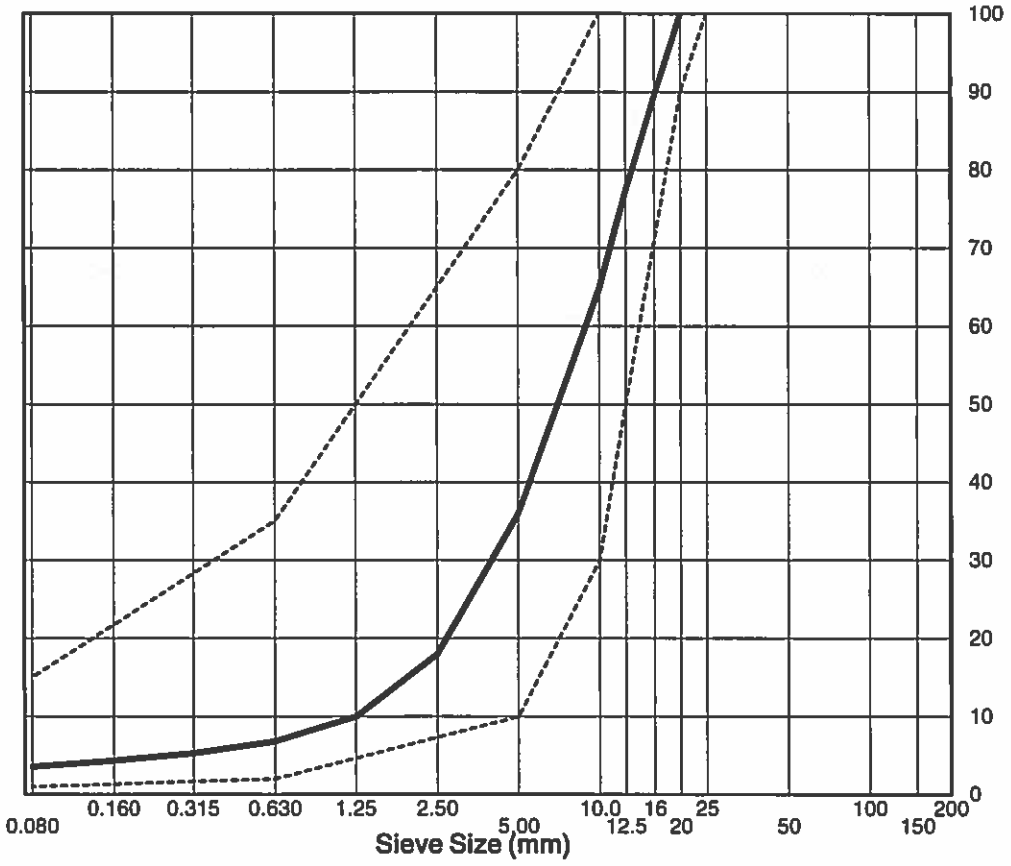
SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103336-02.003	Sample No.:	6652-A
Project:	Hope Bay South Dam Project	Date Sampled:	February 14, 2018
Client:	TMAC Resources	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	February 17, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	WM Office: Yellowknife
Description:	25mm(-) crush bedding	Moisture Content (as received):	2.5%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Quarry 2	By particle mass:	100% 100%
Supplier:	TMAC Resources	ASTM D5821	
Sample Location:			
Specification:	SRK 25(-) Crush Bedding		

Sieve Size	Percent Passing
20	100
16	90
13	77
10	65
5	36.0
2.5	17.9
1.25	9.9
0.630	6.8
0.315	5.3
0.160	4.3
0.080	3.6



Remarks:

Reviewed By: _____ P.Geol.

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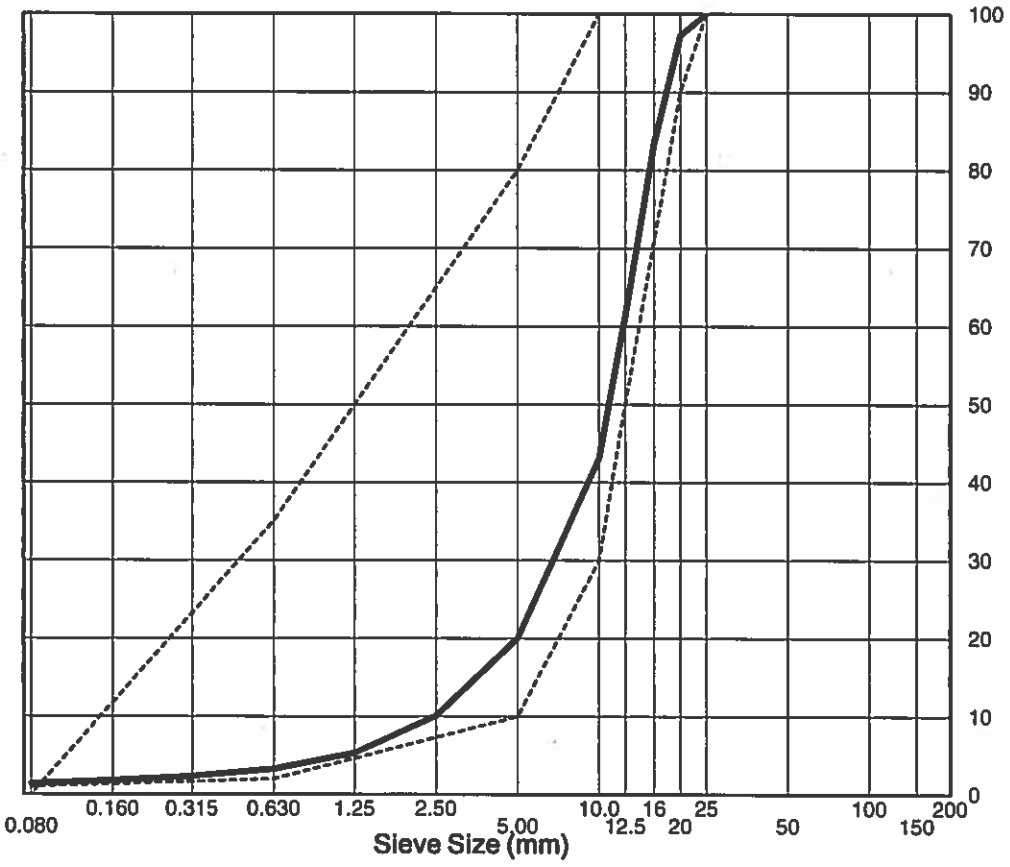
TETRA TECH

SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103336-02.003	Sample No.:	6652-B
Project:	Hope Bay South Dam Project	Date Sampled:	February 14, 2018
Client:	TMAC Resources	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	February 17, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	WM Office: Yellowknife
Description:	25mm(-) crush bedding	Moisture Content (as received):	1.0%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Quarry 2	By particle mass:	
Supplier:	TMAC Resources		
Sample Location:			
Specification:	SRK 25(-) Crush Bedding		

Sieve Size	Percent Passing
25	100.0
20	97
16	84
13	61
10	43
5	20.0
2.5	10.1
1.25	5.3
0.630	3.3
0.315	2.3
0.160	1.8
0.080	1.4



Remarks:

Reviewed By: BF P.Geol.

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TETRA TECH

Seema Kang

From: John Kurylo
Sent: Wednesday, March 7, 2018 9:35 AM
To: Kelly Schwenning; Darko Filipic
Cc: Boyd Barstad; Roland Jones; Gramoz Rexhepi; Cameron Hore; Enviro; Maritz Rykaart
Subject: RE: Ground disturbance clarification
Attachments: South Dam - ROQ and Transition Placement (outside of key trench) for Access

Hi Darko,

Just to follow-up with Kelly's comment he is correct that we are to remain within the Phase 1 dam footprint (including the access road and turn around in the IFC drawings) for all construction and access - to minimize any potential disturbance to the tundra.

Attached is an email that was sent out in regards to the ROQ and transition placement (outside the key trench) for access. The latter was a onetime allowance / modification that site has been constructing recently on site. If there is a specific plan that you think will really assist with construction activities then please provide a sketch of the location you would like to use for access (along with some notes) and we can evaluate this request in more detail and detail.

If you require any additional clarification then please let me know.

Kind Regards,
John

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

From: Kelly Schwenning [mailto:kelly.schwenning@tmacresources.com]
Sent: Tuesday, March 6, 2018 15:45
To: Darko Filipic <DarkoF@nunalogistics.com>
Cc: Boyd Barstad <boydb@nunalogistics.com>; Roland Jones <RolandJ@nunalogistics.com>; Gramoz Rexhepi <GramozR@nunalogistics.com>; Cameron Hore <chore@srk.com>; John Kurylo <jkurylo@srk.com>; Enviro <enviro@tmacresources.com>; Maritz Rykaart <mrykaart@srk.com>
Subject: RE: Ground disturbance clarification

I'm waiting some additional feedback from SRK , however, I think it was pretty clear that we were to remain within the footprint to minimize degradation to the Tundra, among other things…….

Kelly Schwenning
Projects Manager
Hope Bay Project,Nunavut
TMAC Resources Inc.
867-988-6882 Ext.106
604-290-1726 C
www.tmacresources.com

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From: Darko Filipic [mailto:DarkoF@nunalogistics.com]
Sent: March-06-18 4:13 PM
To: Kelly Schwenning <kelly.schwenning@tmacresources.com>
Cc: Boyd Barstad <boydb@nunalogistics.com>; Roland Jones <RolandJ@nunalogistics.com>; Gramoz Rexhepi <GramozR@nunalogistics.com>
Subject: Ground disturbance clarification

Kelly,

We are looking for some clarification regarding our ability to utilize areas beyond the dam footprint for construction access purposes.

We understand that there is a directive for us to keep our construction activities, including equipment tracks, construction materials and access roads within the dam footprint, due to ground disturbance permitting, however as construction progresses it may become necessary to stage items outside the construction area.

Basically, what I am wondering is whether it would possible to have some leeway to utilize areas outside of the Phase 1 dam footprint as needed - perhaps within the future tailings area, or within the Phase 2 footprint?

We are not looking to go wild on the tundra, and we will continue to plan our work so as to not disturb the tundra, but if there is some tolerance in this regard of if the environmental department can have a look at ground disturbance permitting with us, it would help us a lot.

Regards,

Darko Filipic
Project Coordinator
Site: 867-988-6882 ext 123
Cell: 403-929-5397

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TMAC Resources – Hope Bay South Dam Project
DarkoF@nunalogistics.com
www.nunalogistics.com

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Kendell Cator

From: Kyle Scale
Sent: Tuesday, March 13, 2018 3:56 PM
To: Kendell Cator
Subject: FW: GCL panel layout and deployment plan
Attachments: south dam drawings W panel layout.pdf; GCL Storage handling and Delivery QA.pdf; Operational Work Plan GCL South dam.pdf; South Dam GCL Documentation Sheet.xlsx; South Dam Phase 1 QAQC.pdf; Notes for GCL liner Panel layout.pdf

From: Eric Blomberg [mailto:eric@blombergbuilding.com]
Sent: Monday, March 12, 2018 9:22 AM
To: Cameron Hore <chore@srk.com>
Subject: GCL panel layout and deployment plan

Hi Cameron,

I've attached the documents Nikolas sent me last night. They include a proposed panel layout, as well as a deployment plan and some QAQC documents. If you have any questions, need me to revise anything, or feel that anything has been missed, please let me know. Also, if we will be using bentonite at a rate of 1.1kg/m I calculated that we would need over 2100kgs for the key trench longitudinal seams only. Does this seem right? If so, I can let Larry know that we will need to order more since we only have 2043kg currently on site.

Thanks,
Patrick

Eric Blomberg
Director
Blomberg Building Group
W:867-988-6882 ext. 134
C:604-841 9858
H:604-947 0110

BLOMBERG BUILDING

Blomberg Building Group

South Dam – Phase 1 key trench

Storage, Handling, and Delivery QA

GCL inspection:

Roll Inspection – Inspect all rolls upon site arrival, during storage and after transportation to south dam. If any of the GCL rolls have been mishandled, improperly stored, or encountered moisture they are to be tagged. Damage is to be documented and roll is to be placed aside for engineer inspection. If engineer deems damage to roll is negligible, obtain engineers initial before deploying GCL.

All rolls require

1. Manufacturer's name
2. Product Information
3. Roll number
4. Batch/lot number
5. Roll dimensions

Rolls that are missing above documentation are to be set aside.

Roll Delivery:

Upon delivery to site, recommended equipment set forth by the manufacturer must be used to unload and deliver Geosynthetics to storage area. Rigging and handling procedures found in the manufactures installation manual must be followed. Improper unloading can damage and deform Geosynthetics.

All Geosynthetics that arrive to site must be inspected prior to storage. Inspection must include, checks for damage, water penetration, all damage must be recorded. Damaged rolls shall be tagged, and all major damage shall be directly reported to CETCO and TMac Resources.

Roll Storage:

Once the Geosynthetics have been delivered to site, proper transportation to storage is required. All procedures and measures taken in safe handling can be found in the manufactures installation guidelines.

GCL rolls will be stored inside the Batch Plant. Any rolls that can not be fit inside will be stored outside and moved inside to warm up once there is space available. Rolls can be stacked no more than four high, on flat level ground. Rolls shall be chocked to prevent rolling or falling. Prepare the storage area so all Geosynthetics can be stored off the ground.

All rolls require further inspection once they have been delivered to the dam site.

Visual inspection will proceed with supervision/permission from the onsite engineer. As the GCL is deployed, all small defects will be circled and repaired before they are covered.

Documentation:
All Documentation is to be filled out to the best of the QA Supervisors ability. Documentation is pertinent for overall quality of project. Picture documentation, accurate inspections, and proper handling procedures will be maintained throughout the entire project. All documentation can be found in South Dam QAQC folder. Picture documentation is mandatory for all stages of the project.

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Notes for GCL liner Panel layout:

The first panel will be laid out starting from the lowest point in the trench. Subsequent panels will be laid out to each end of the key trench.

Regarding bedrock outcrops, the elevation change will alter processes, we will have to fold back 0.5m of GCL liner, this will ensure we have the correct panel overlapping. (Areas 2+25 - 2+50, 4+00 – 4+25, 5+00 – 5+30)

The order will be done as follows: the overlying panel must be upslope and higher in elevation. Starting at the lowest point in elevation will have a dramatic effect on the amount of time, energy, and the overall quality of the project. This will also limit the amount of pulling, folding, and maneuvering exerted on the GCL liner itself. *Refer to South Dam Phase 1 Operational work Plan for Specific Instruction.*

Panels will be identified through a numerical system. The lowest panel, also the first to be installed, will be labelled Panel "0." Panels located east of this will be identified by 1E, 2E, 3E, etc. Panels located west of this will be identified by 1W, 2W, 3W, etc.

Panel ID layout (example)

Panel Number	Roll Number	Roll Identification no.
0	**1**	**31783240**
1W	**1**	**31783240**
1E	**2**	**31783251**
2W	**1**	**31783240**
2E	**2**	**31783251**

It is estimated that we will require between 42-44 rolls of Bentomat CLT for the Key Trench

We have Approximately 90 bags of Bentonite on site. (2,041 kg, or 1855.45m of seam at a ratio of 1.1kg/m)

The seam will be 10mm x 100mm = 1.1 kg of bentonite per m, this works is in accordance with specification 2 in section *6.4.2 GCL lapping and joining. Of SRK consulting, technical specification – Revision G of Geosynthetics, Cameron Hore (SRK) has also said it is acceptable.* See Calculation below.

Bentonite = 2.2g/cm^3, bead size = 10cm (wide) x 100cm (long) x 0.5cm (thick) = 1000 cm^3, 1000 cm^3 x 2.2 = 1,100 g = 1.1 kg/m.

We will use a Dry line chalk spreading machine to disperse an even amount of bentonite for lapping and joining. It can hold 50 Lbs (one bag of Bentonite) and would provide even, uniform control of the product.

Only GCL

Table 1: Liner Design Requirements

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Liner Element	**3D Area (neat line) [m^2]**	**Areas + 15% overlap [m^2]**
Liner in Key Trench (includes 1m apron) – **HDPE or GCL**	7,300	**8,395**
Liner for Phase 1 Dam (includes 1m apron, and crest key in) **- GCL**	7,700	**8,855**

BLOMBERG BUILDING

Operational Work Plan

Project: South Dam Phase 1 GCL	Revision: 0
Description: South dam Phase 1 (DN-SD-00 – DN-SD-18)	Date: March 12, 2018

Safety

Description	Potential Hazards	Controls	Notes:
Environmental hazard	Slippery/unstable surfaces	Waddle, watch footing, three points of contact when exiting vehicles and on slopes.	
Environmental hazard	Limited access	Walk in operator's line of sight; don't walk through blind spots. Three points of contact on steep grades.	
Exposure hazards	Weather Conditions	Dress appropriately, wear proper winter gear, check weather daily, buddy system, and follow whiteout procedures.	SEE SWP 0008 Cold weather safety.
Exposure hazards	Bentonite dust inhalation	Wear proper respirator, have fit test complete. Only use approved cartridges, Use in well-ventilated area.	See Section 17 In BBG safety Manual.
Personal Work limits	Overexertion, complacency and Fatigue.	Don't over lift, proper lifting techniques, ask for assistance. Micro breaks, review safe work Practices, mind on task.	
Equipment hazards	Hand tools	Keep blades sharp to avoid skipping, do not walk with blade out, cut away from you.	
Equipment hazards	Mobile equipment	Use spotter; keep in eye contact with machine operator. Use proper horn signals, proper radio communication. Have clean hi visibility PPE.	SEE SWP 0015 for universal hand signals.
Equipment hazards	Rigging material	Use proper rigging techniques, don't walk under load, use taglines, and inspect slings before use.	
Physical energy hazards	Manual lifting, awkward lifting, bending/twisting,	Use proper lifting technique, don't lift more than 50lbs, Have stable footing, spine in line, lift with	

	repetitive motions, unstable positions, pushing/pulling, potential for falling objects.	your legs, stretch regularly, and stay clear of uphill material.	
Wildlife hazards	Wildlife encounters	Report all sightings, stay in equipment, DON'T FEED ANIMALS, and follow proper bear response protocol.	

Quality Control			
Control description	Critical Items	Actions taken	Notes
Earthworks	Surface inspection	Survey is to shoot locations and dimensions, grade to be uniformly compacted with no protrusions.	Take pictures of subgrade before laying GCL down.
GCL inspection	Inspect rolls that arrive to site	Go through rolls; check to see they have been properly handled in accordance with manufactured specifications.	Damaged rolls shall be marked, pictures shall be taken
GCL deployment	GCL	Panels are in accordance with GCL panel layout, overlaps meet spec, all materials are properly inspected, and pictures are taken for visual confirmation.	Photo documentation
Lapping and joining	Minimum overlap	Overlap is checked frequently, and remains 0.5m min.	Photo documentation
Lapping and joining	Bentonite seam	Bentonite is properly distributed, and is in accordance with the engineer's specs.	Photo documentation
Cover	Fill distribution	All fill is to be properly placed with no deviations from engineer spec.	

BLOMBERG BUILDING

Operational Work Plan

Procedure
1.0 <u>Material Storage and handling</u> 1.1 All lot and roll numbers should be recorded. Each roll of GCL should also be visually inspected to determine if any packaging has been damaged. Damage is to be recorded and the affected rolls marked. 1.2 To load and unload the rolls from the flatbed with a spreader bar. Place the core pipe inside the roll tube and then around the spreader bar. Watch to see that slings around the spreader bar do not pinch the GCL material. 1.3 Forks shall not be used to lift carry or place GCL liner. 1.4 If slings are attached to rolls when they arrive you may use slings to lift with Stinger and Hook. 1.5 To Unload rolls from planes an extendable boom forklift must be used (telehandler), rolls that are center or near the front of the cargo bay can be gently pulled toward the door of the aircraft. 1.6 Rolls shall never be stacked on end and shall be chocked to prevent rolling or sliding while in storage or transportation. Rolls can be stacked no more than four high.
2.0 <u>GCL deployment</u> 2.1 The surface, which the GCL shall be deployed on, will be cleared of all Debris, snow, and protruding material. Using a broom, shovel, and machine with the engineer's approval. 2.2 . Engineer's signoff is required. 2.3 The method of deployment requires further discussion. Our suggestion is as follows: the reach stacker will be used to hoist the spreader bar and GCL roll. Workers will use vice grips to pull the material down the hill to its desired location. Once the GCL is in place, the reach stacker operator will lower the roll so that it is resting on the ground. At this point, a worker will cut the roll to its desired length and it will be secured using sand bags.

BLOMBERG BUILDING

Operational Work Plan

2.4 The meter of exposed liner at the hinge point will be covered with geotextile and plywood.

2.5 Each successive piece would then be unrolled with a rough overlap of 500mm. rough maneuvering may be required, this would be done by ground crew. Measuring the overlap every 2 meters to ensure appropriate lapping is achieved.

3.0 Lapping and joining

Once the overlap is adequate the overlying panel will be folded back and the bentonite will be applied in a ratio of 100mm x 5mm bead or 1.1kg/m. (up to engineer's discretion)

3.1 Refer to panel layout to see Lapping and Joining locations.

3.2 Starting from the low point in the dam working to the east, Panels will be laid out from the lowest point in the trench (3+00 – 3+50). Subsequent panels will be laid out to the 5+29 mark. Once Completed we will work from 3+00 – 0+00. (May need to change working west before continuing east.)

3.3 All areas that require repair will be recorded by the engineer, the engineer shall proscribe the method of repair to be used. *Repairs will be done with a 300mm overlap from the damaged area. *

4.0 GCL cover

4.1 GCL cover will be done by Nuna West Contracting. BBG personnel will be available for monitoring/help where deemed necessary.

Task Description	Material	Quantity	Notes
Key Trench	GCL Liner - Cetco Bentomat CLT	8395m^2	Area + 15% Overlap (m^2)
Liner for Phase 1 Dam	GCL Liner - Cetco Bentomat CLT	8855m^2	Area + 15% Overlap (m^2)

Hope Bay Mining Ltd.

Doris North Project

Engineering Drawings for the South Dam - Phase 1

Dr□□ □□□□N umbe r	Dr□□ □□□□T□□□□	Issue	D□□□□	□evis □□n
DN-SD-01	General Arrangments	Issued for Construction	November 29□2017	0
DN-SD-02	General Arrangements	Issued for Construction	November 29□2017	0
DN-SD-03	Typical Sections (General)	Issued for Construction	November 29□2017	0
DN-SD-04	Key Trench E□cavation Plan and Profile	Issued for Construction	November 29□2017	0
DN-SD-05	Liner Placement Plan and Details - Key Trench and Phase 1	Issued for Construction	November 29□2017	0
DN-SD-06	Liner and Bedding Placement Details	Issued for Construction	November 29□2017	0
DN-SD-07	Bedding Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	November 29□2017	0
DN-SD-08	Transition Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	November 29□2017	0
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	November 29□2017	0
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	November 29□2017	0
DN-SD-11	Construction Access Road and Turn Around - Phase 1	Issued for Construction	November 29□2017	0
DN-SD-12	Final Phase 1 Dam Plan□Profile and Sections	Issued for Construction	November 29□2017	0
DN-SD-13	Sections Sta. 0+10 to 0+90 - Phase 1 Dam	Issued for Construction	November 29□2017	0
DN-SD-14	Sections Sta. 1+00 to 1+80 - Phase 1 Dam	Issued for Construction	November 29□2017	0
DN-SD-15	Sections Sta. 1+90 to 2+70 - Phase 1 Dam	Issued for Construction	November 29□2017	0
DN-SD-16	Sections Sta. 2+80 to 3+60 - Phase 1 Dam	Issued for Construction	November 29□2017	0
DN-SD-17	Sections Sta. 3+70 to 4+50 - Phase 1 Dam	Issued for Construction	November 29□2017	0
DN-SD-18	Sections Sta. 4+60 to 5+30 - Phase 1 Dam	Issued for Construction	November 29□2017	0

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SRK Job No. 1CT0022.017

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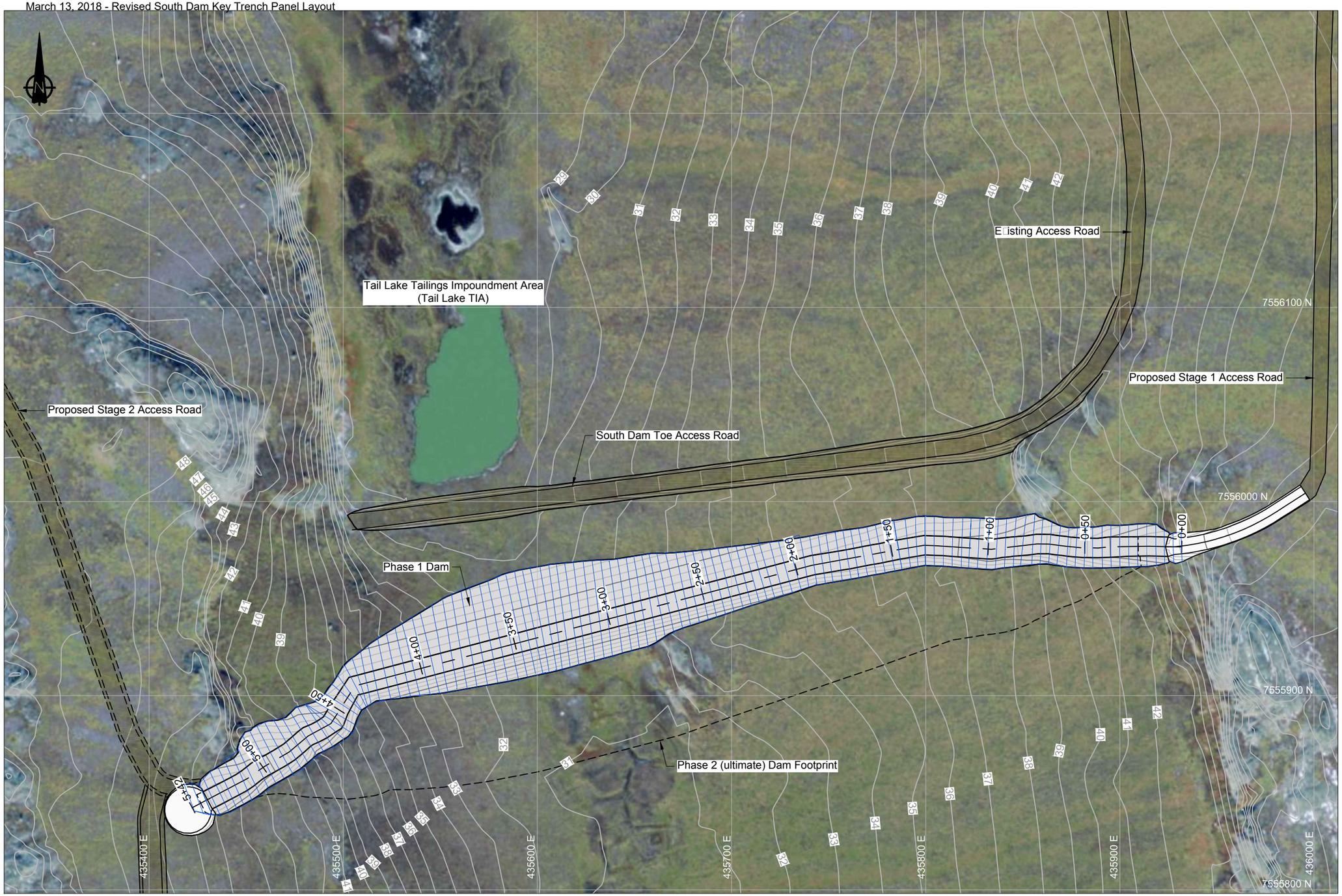

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Imagery (from 2010 PhotoSat compilation) provided by client.
5. All units shown are in meters unless otherwise stated.

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NAD83 UTM □one 13.

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DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29	
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	
REFERENCE DRAWINGS		REVISIONS										

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FILE NAME: 1CT0022.017 - South Dam GA - with ortho.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:
Phase 1 General Arrangement (with Orthophoto)

DRAWING NO.	SHEET	REVISION NO.
DN-SD-01	1 OF 18	0

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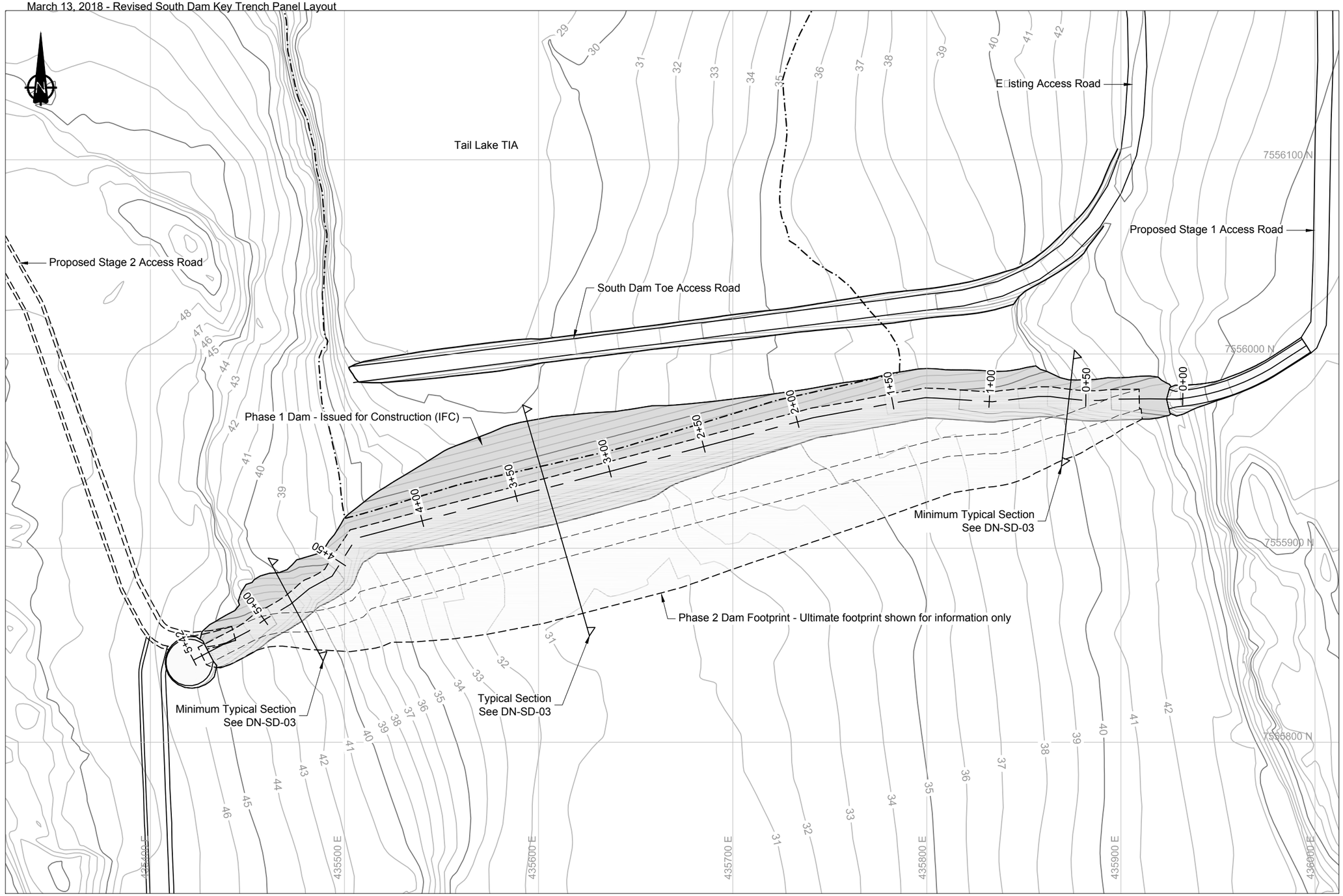

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Volumes presented based on neat-lines only and are approximate. These include no over-excavation or over-blasting allowance of the key trench.
5. All units shown are in meters unless otherwise stated.

DETAILS

NAD83 UTM Zone 13.

TABLE OF QUANTITIES - NEAT LINE

Key Trench Bulk Excavation :	20,000m³
Total Phase 1 Fill:	66,000m³
ROQ:	33,500m³
Transition:	25,500m³
Bedding:	7,000m³
Total Liner:	15,000m
West Turnaround (bulk):	375m³
East Turnaround (bulk):	605m³

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DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
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DN-SD-03	Typical Sections	-	-			

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FILE NAME: 1CT0022.017 - South Dam GA.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Phase 1 General Arrangement

DRAWING NO.	SHEET	REVISION NO.
DN-SD-02	2 OF 17	0

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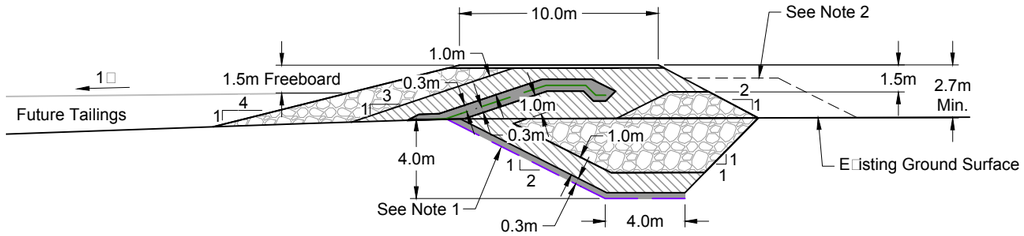

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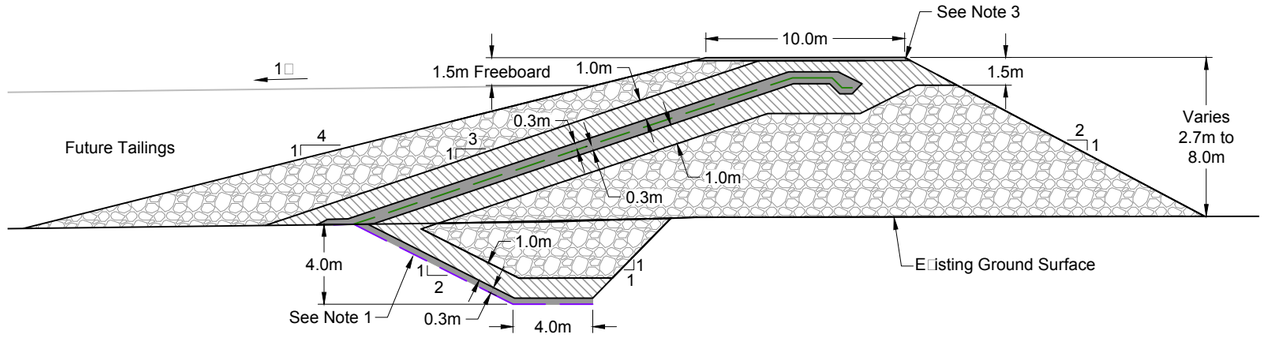

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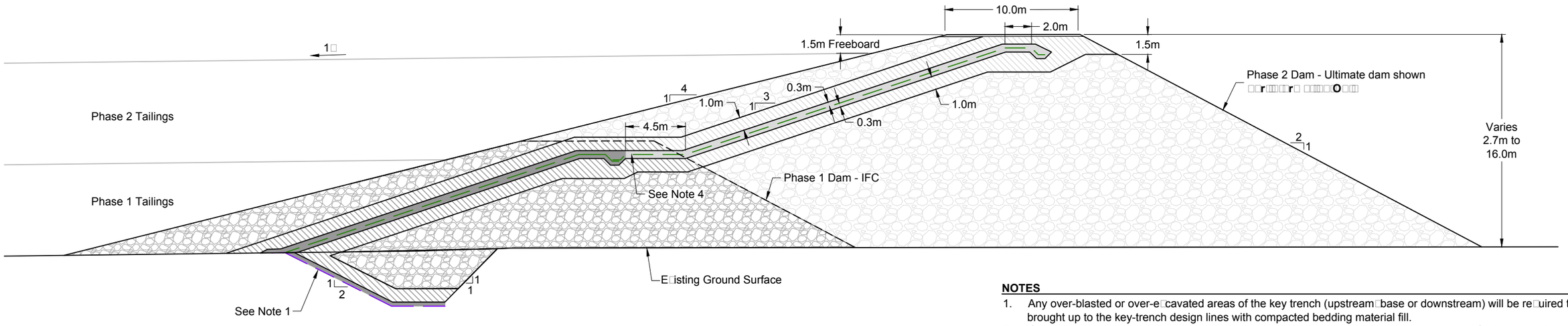

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STA. +06 [illegible] 3+50

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ISSUED FOR INFORMATION

LEGEND

- Key Trench Liner
- Phase 1 2 Dam Liner
- Bedding Material
- Transition Material
- Run of Quarry

NOTES

1. Any over-blasted or over-excavated areas of the key trench (upstream base or downstream) will be required to be brought up to the key-trench design lines with compacted bedding material fill.
2. If the key trench is over-blasted or over-excavated beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell then additional ROQ material will be required to be placed in and above the backfill key trench. This material would be placed to ensure that adequate thermal insulation of the key trench is maintained in all sections. See Detail 10 on drawing DN-SD-09 for additional details.
3. The top road surfacing (bedding material) for the Phase 1 dam is to be fully removed (upstream and downstream) before Phase 2 construction commences.
4. To allow for a proper tie-in the transition material around the top downstream portion of the Phase 1 dam will be required to be stripped back. Once the bedding material around the top liner anchor trench is reached hand excavation should be expected to result down to expose the liner. The on-site engineer will be required to inspect all exposed liner to ensure that it is not damaged or in need of repairs before Phase 2 liner tie-ins result.
5. All units shown are in meters unless otherwise stated.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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DN-SD-02 — Phase 1 General Arrangement

REFERENCE DRAWINGS

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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Typ Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Typical Sections (General)

DRAWING NO. DN-SD-03 | SHEET 3 OF 18 | REVISION NO. 0

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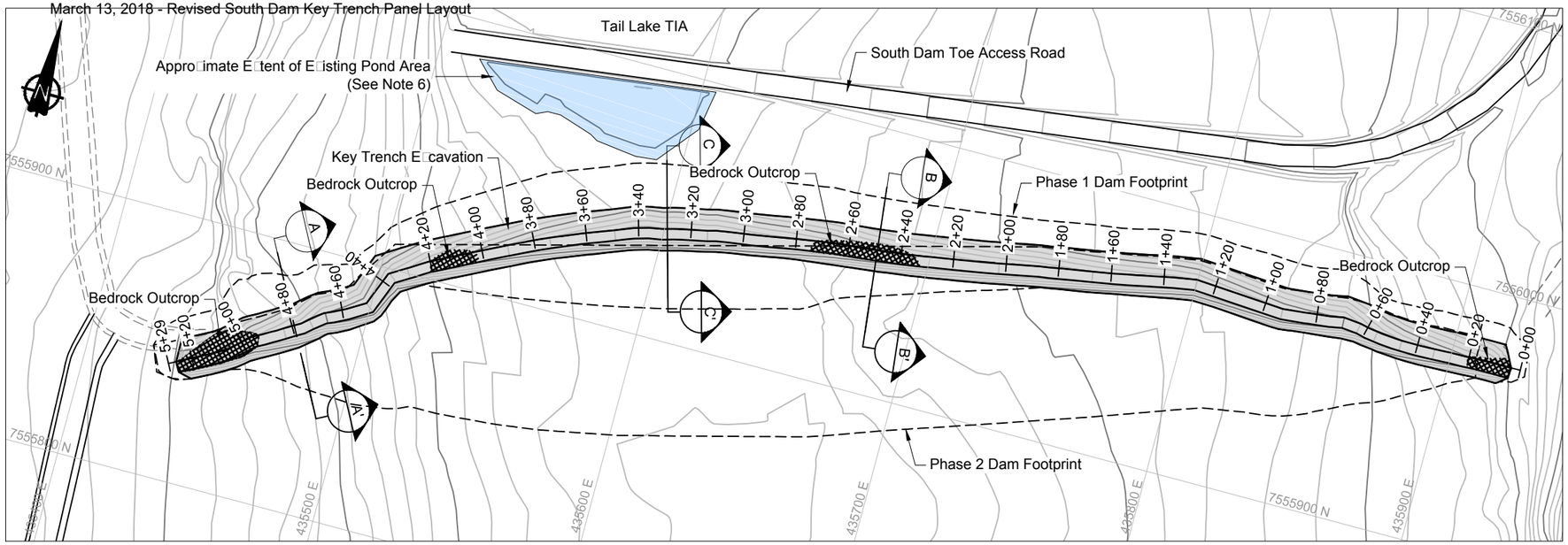
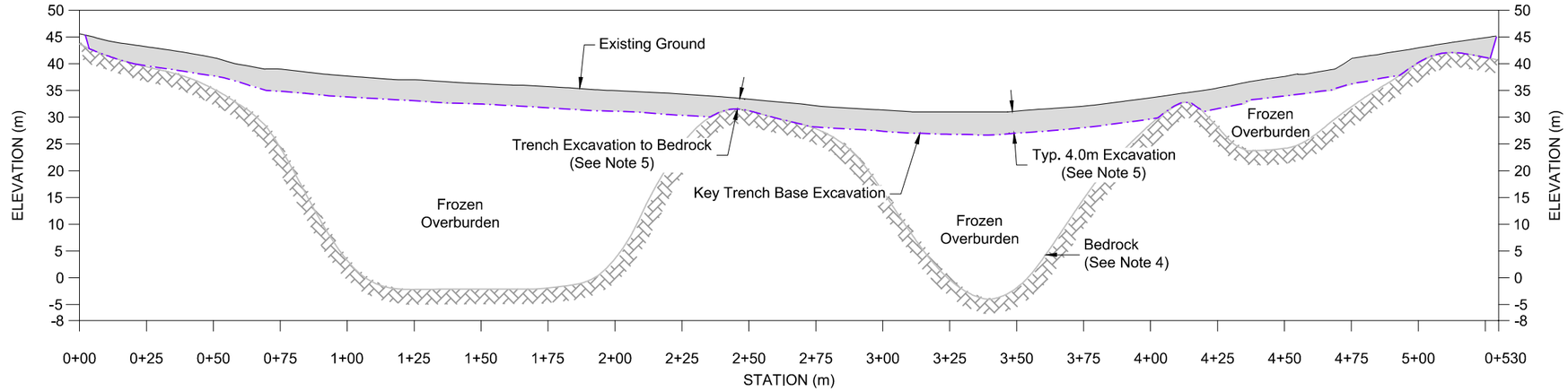


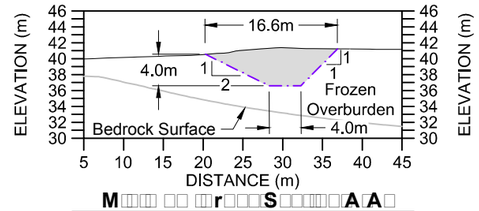


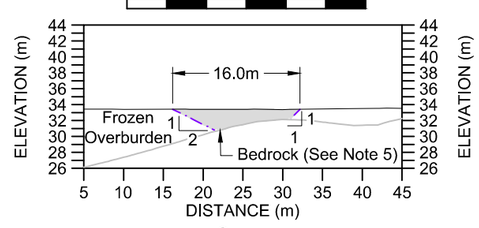
LEGEND

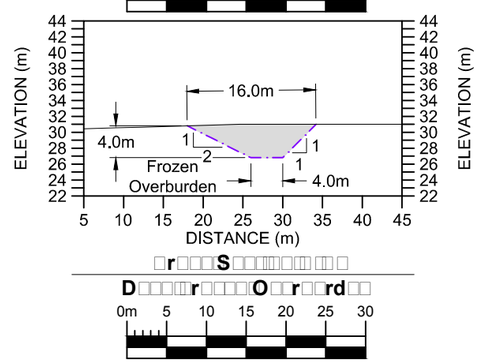
- Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Trench Excavation Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profile shown correspond to the upstream toe of the key trench.
4. The subsurface geology has been inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A, SRK43, SRK 44), airphoto interpretations, and from limited available geophysical surveys around the Tails Lake area. This data was then used to create a bedrock surface with the Gemcom GEMS software. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.
5. The final key trench extent and depth will be determined in the field by the Engineer. Typical excavation depth is 4.0m, unless massive ice, hypersaline soil or bedrock encountered. The Engineer will inspect all excavations and approve the foundation conditions.
6. Ponded area to removed (frozen massive ice excavated or drained if possible) prior to key trench excavation. Up to approximately 4,700 m3 of (frozen) water may be expected to be removed from this area. Exact water levels are not known so the volume estimate above should be treated as a rough estimate based on topography.
7. If any area of the key trench is over-blasted or over-excavated then the extra excavation will need to be backfilled in thin lifts (*see 'Technical Specifications'*) until the key trench design lines and grades are reached.







ENGINEERS

NAD83 UTM Zone 13.

Vertical 0m 10 20 30 40

Horizontal 0m 20 40 60 80

DRAWING NO.	DRAWING TITLE
REFERENCE DRAWINGS	

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Key Trench.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Key Trench Excavation
Plan and Profile

DRAWING NO.	SHEET	REVISION NO.
DN-SD-04	4 OF 18	0

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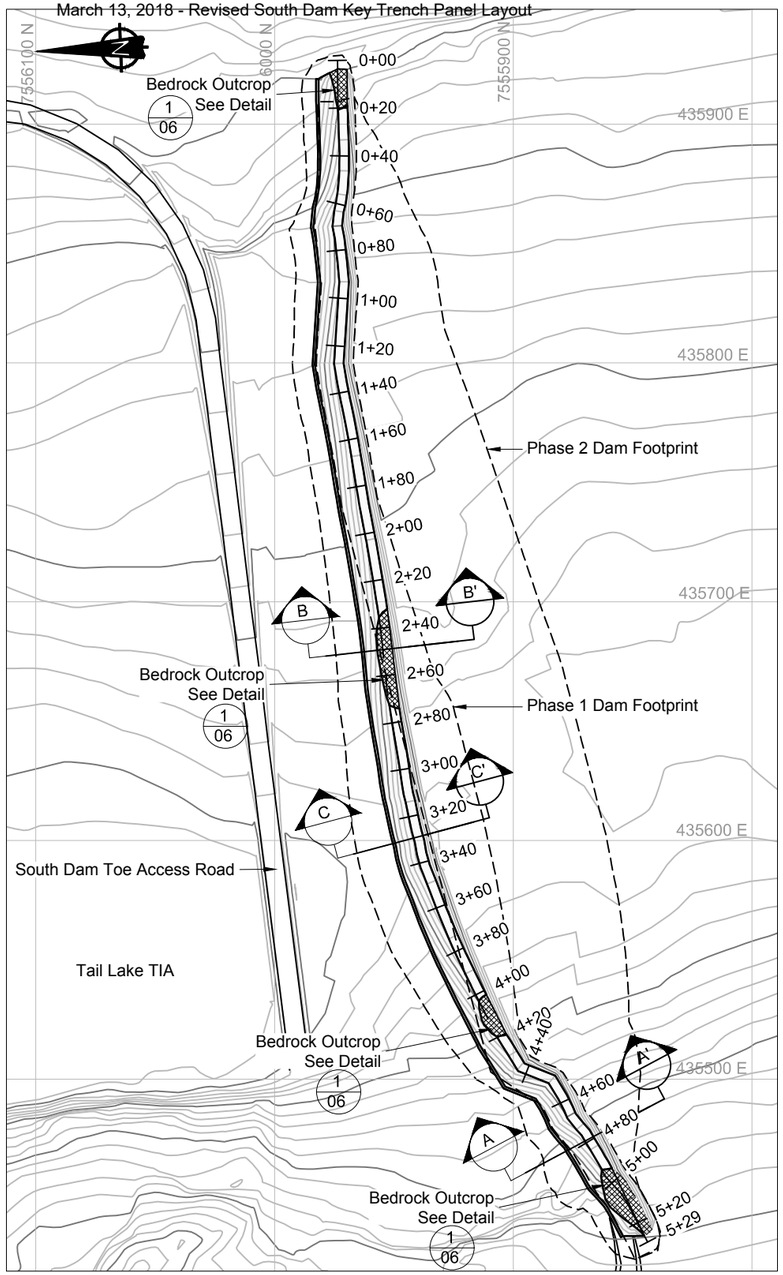

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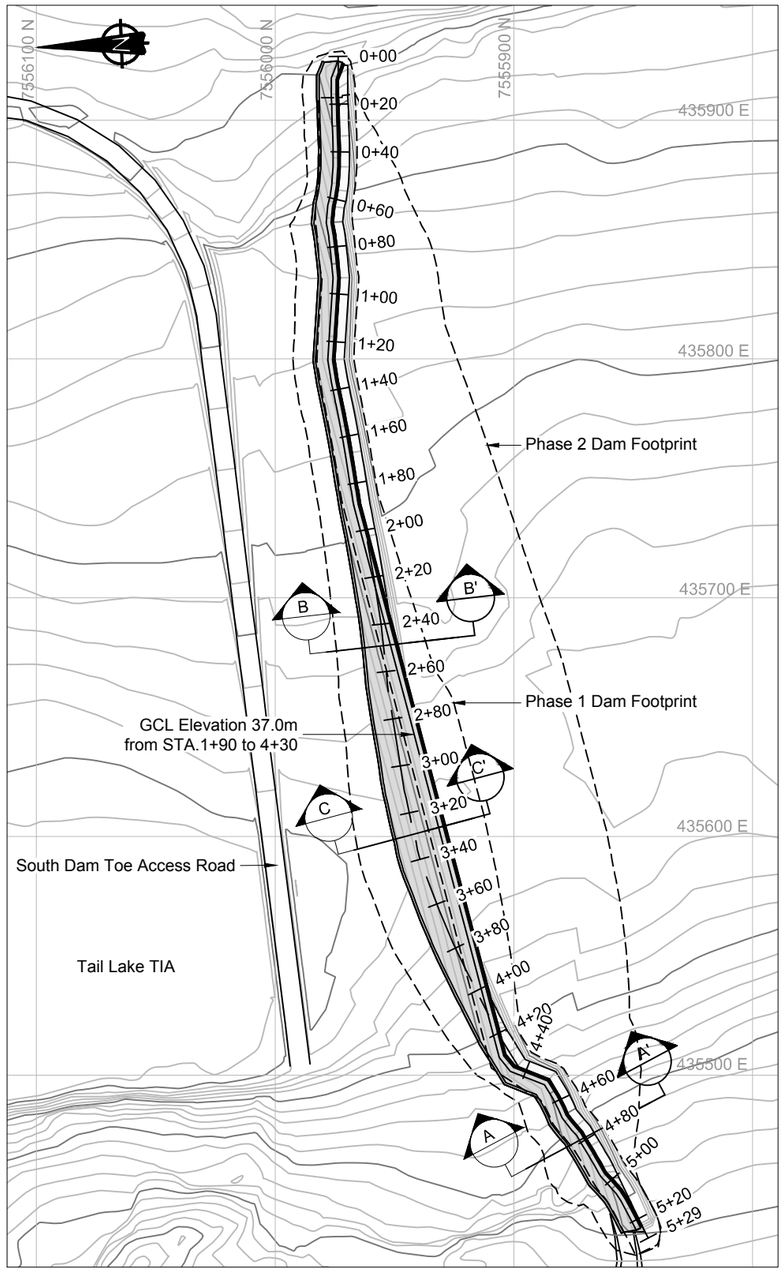

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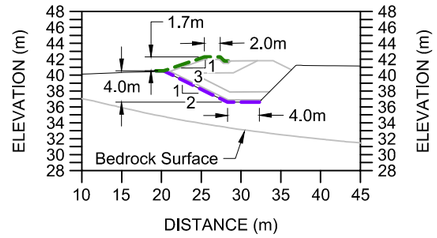

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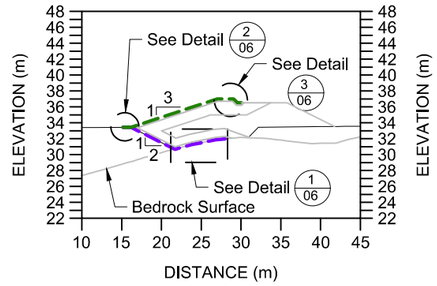

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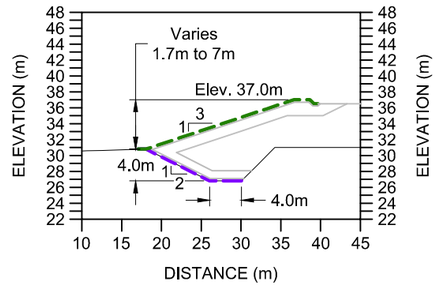

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LEGEND

- Key Trench Liner
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- Appro□imate Bedrock Outcrop E□tent
- GCL Liner E□tent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The upstream slope of the key trench e□cavation need to be scraped and smoothed to prepare a suitable subbase for the GCL liner. If any larger voids or undulation e□ist then they will need to be backfilled with compacted bedding material fill□placed in thin lifts.
4. The subgrade surface must be free of vegetation□sharp-edged rocks□stones□ sticks□construction debris□and other foreign material that could contact the GCL. Furthermore□all protrusions e□tending more than 12 mm from the subgrade surface shall either be removed□ crushed□or pushed into the surface with a smooth-drum compactor.
5. GCL should not be placed over massive ice or standing water (both need to be removed prior to placement).
6. All Geosynthetic Clay Liner (GCL) liner sections / panels will be re□uired to have a minimum 0.5m overlap on every edge. See Detail 2□3□5 and 6 for additional information.
7. At the locations where bedrock is encountered in the key trench then these areas will be re□uired to be ripped down to competent bedrock or scrapped smooth and then bentonite powder will be placed between the bedrock contact and the GCL liner (see Detail 1).

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NAD83 UTM □one 13.

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DN-SD-06 — Liner and Bedding Placement Details

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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Liner Placement Plan and Details Key Trench and Phase 1

DRAWING NO. DN-SD-05 | SHEET 5 OF 18 | REVISION NO. 0

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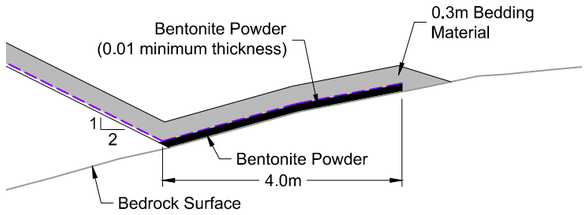

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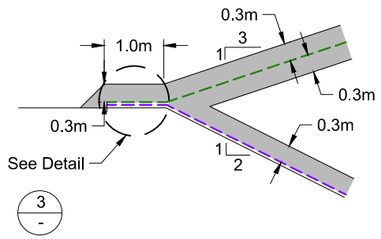

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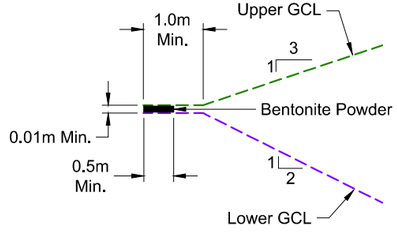

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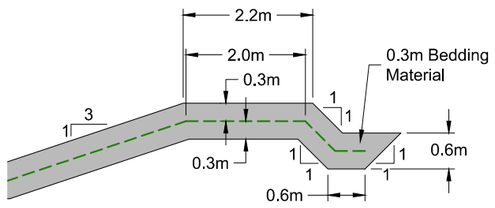

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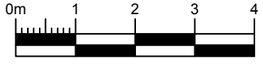

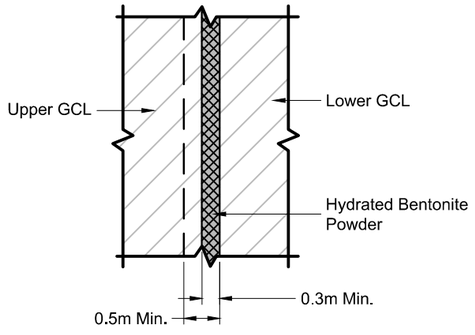

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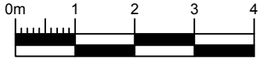

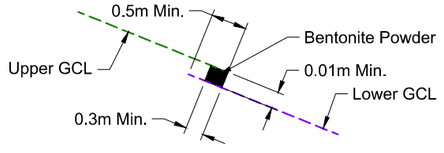

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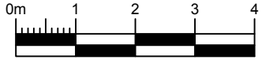

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material

NOTES

1. All units shown are in meters unless otherwise stated.
2. One end of the GCL roll should be placed in an anchor trench at the top of the slope. The front edge of the trench (see Detail 4) shall be rounded so as to eliminate any sharp corners that could cause e□cessive stress on the GCL. Loose soil should be removed or compacted into the floor of the trench.
3. The GCL should be placed in the anchor trench such that it covers the entire trench floor but does not e□tend up the rear trench wall (see Detail 4).
4. GCL seams are constructed by overlapping their adjacent edges (see Detail 5). Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris.
5. If the GCL is damaged (torn□punctured□ perforated□etc.) during installation□it may be possible to repair it by placing a patch over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 500 mm is achieved around all parts of the damaged area. Bentonite mastic / powder should be applied around the damaged area prior to placement of the patch. It may be necessary to use an adhesive such as wood glue□or by hand placing material over the patch□to fi□the patch in place so that it is not moved during overliner bedding material placement. Smaller patches also may be tucked under the damaged area to prevent patch movement.
6. Cover soils shall be free of angular stones or other foreign matter which could damage the GCL. Cover soils should be approved by the Engineer□with respect to particle size and uniformity (as per the 'Technical Specifications')

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NAD83 UTM □one 13.

DRAWING NO.	DRAWING TITLE
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NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	JBK	EMR	17/11/29

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CHECKED:	APPROVED:	DATE:
JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Liner and Bedding Placement Details

DRAWING NO.	SHEET	REVISION NO.
DN-SD-06	6 OF 18	0

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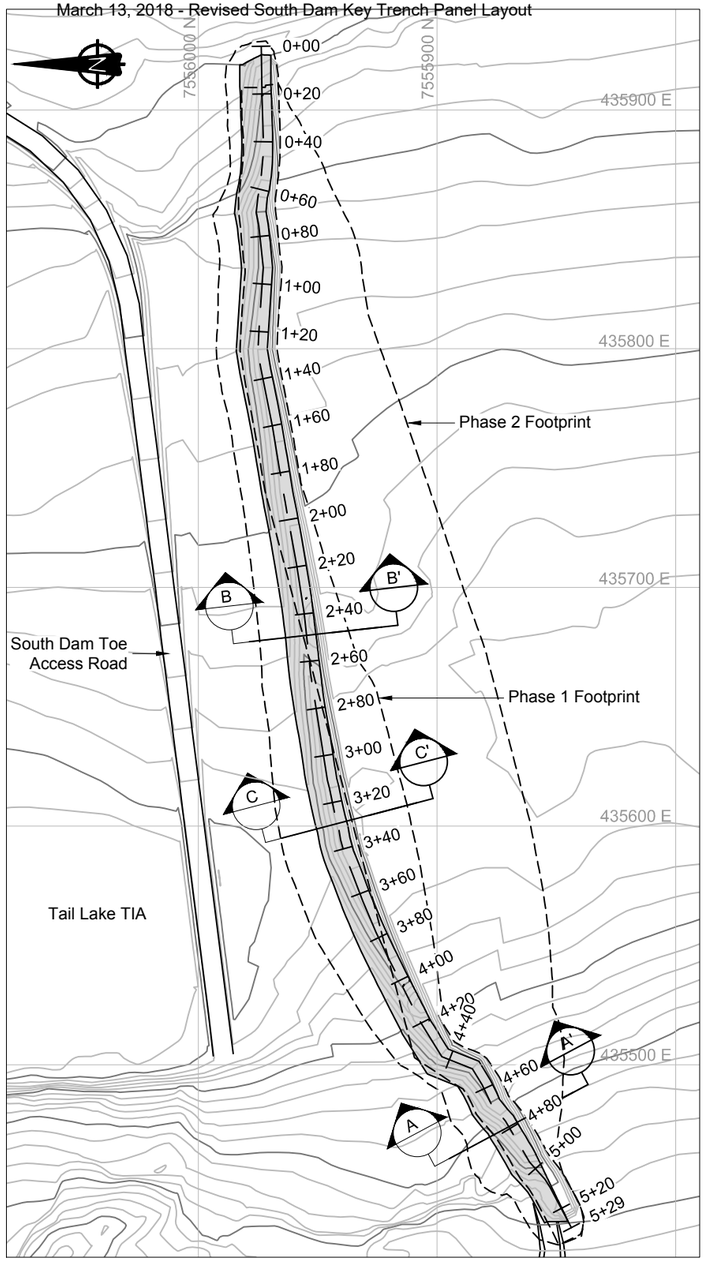

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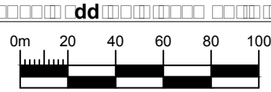

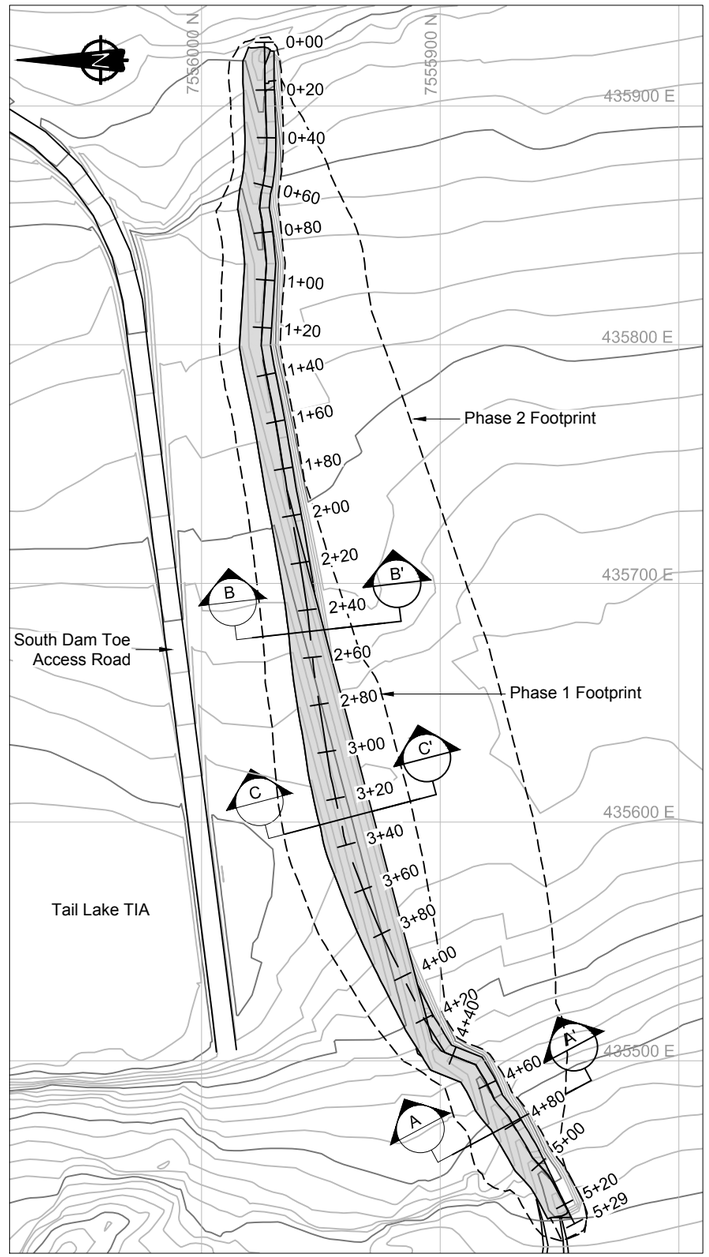

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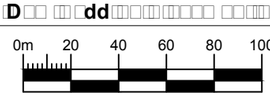

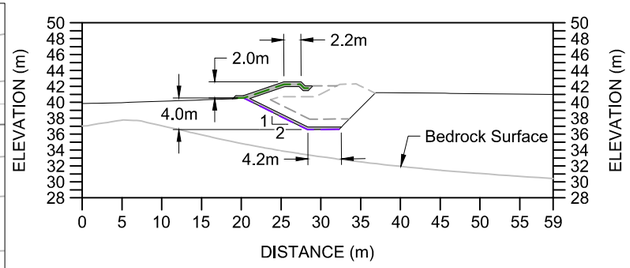

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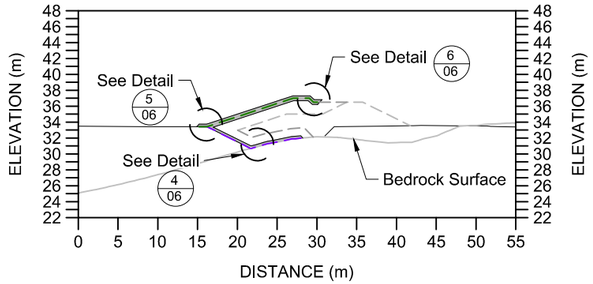

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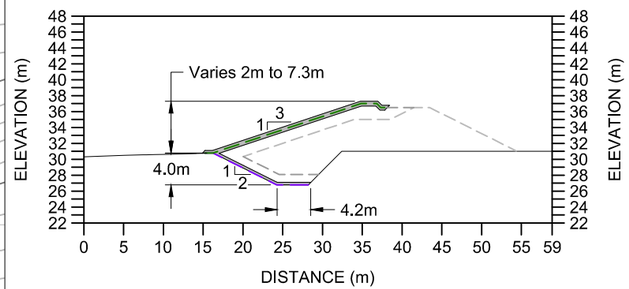

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LEGEND

- Phase 1 Dam Liner
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Bedding Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Bedding layer to be placed in thin lifts and compacted before liner placement. The subsurface below the liner should be free of protrusions or any sharp / angular gravel or larger size material. See the Technical Specifications document for more details (*'Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK).*
4. Bedding material cover shall be placed over the GCL using construction e□uipment that minimizes stresses on the GCL. A minimum thickness of 300 mm of cover should be maintained between the e□uipment tracks/tires and the GCL at all times during the covering process. This thickness recommendation does not apply to fre□uently trafficked areas or roadways□ for which a minimum thickness of 600 mm is re□uired.
5. Soil cover should be placed in a manner that prevents the soil from entering the GCL overlap zones.

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NO.	DESCRIPTION	CHK'D	APP'D	DATE
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DN-SD-06 — Liner and Bedding Placement Details

REFERENCE DRAWINGS

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JKB	EMR	2017/11/29

FILE NAME: 1CT0022.017 - South Dam - Bedding.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Bedding Material Placement Plan and Sections - Key Trench and Phase 1

DRAWING NO.: DN-SD-07

SHEET: 7 OF 18

REVISION NO.: 0

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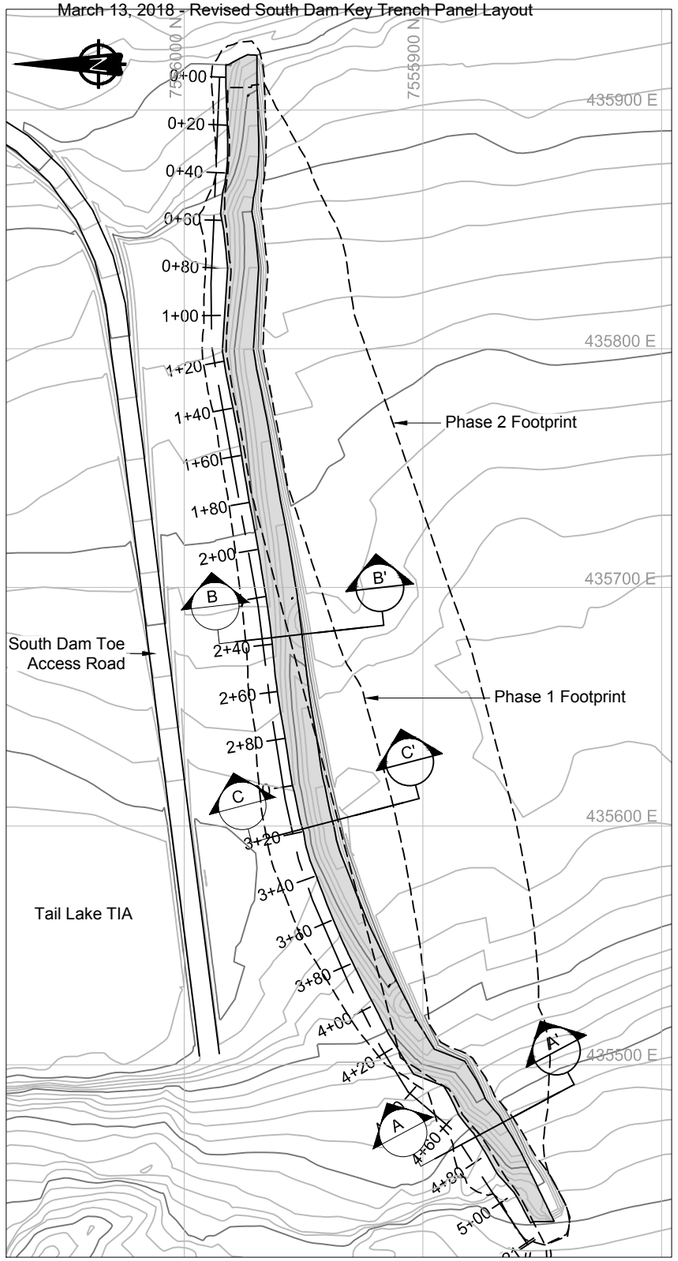

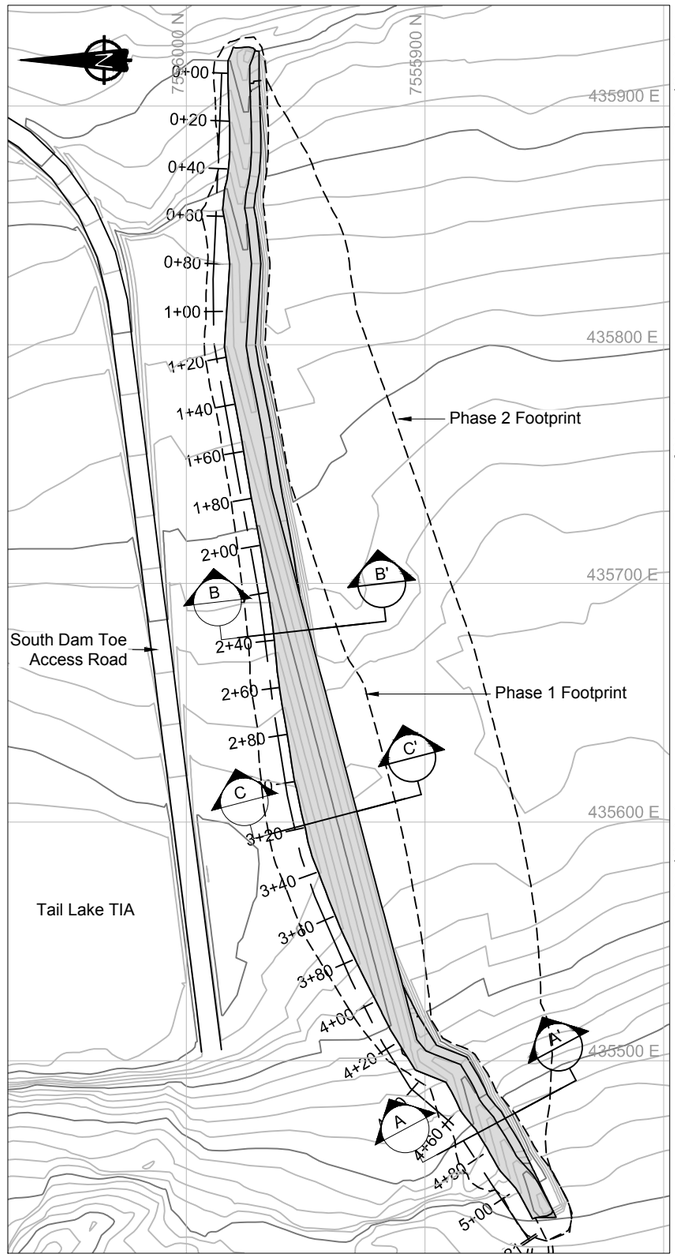

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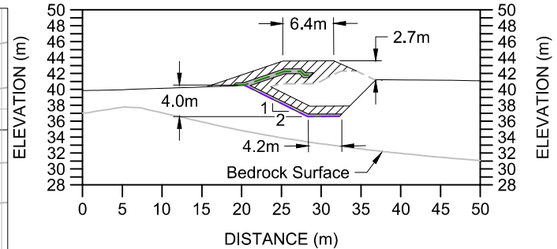

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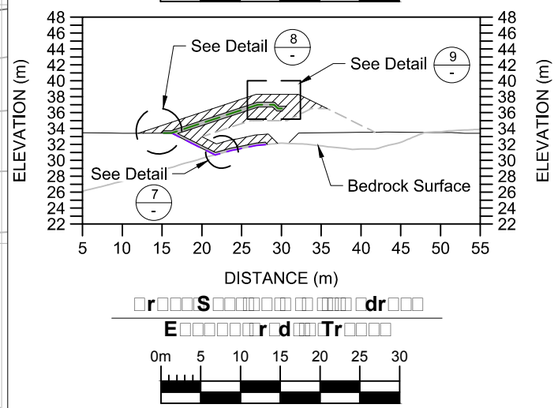

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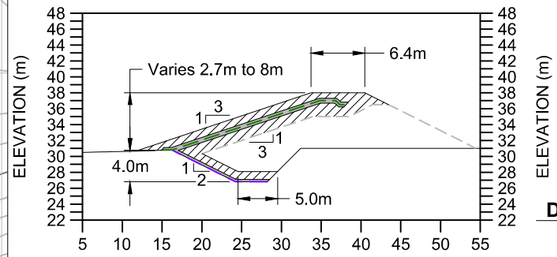

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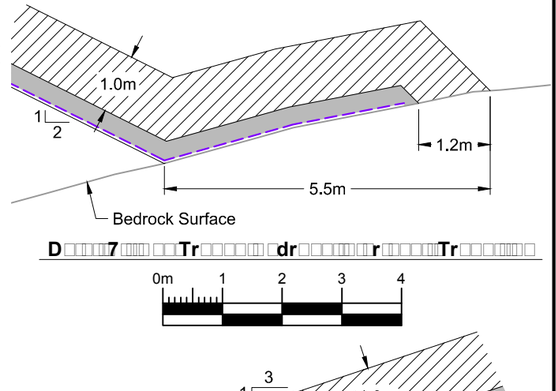

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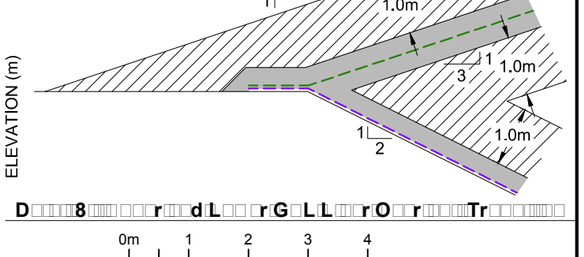

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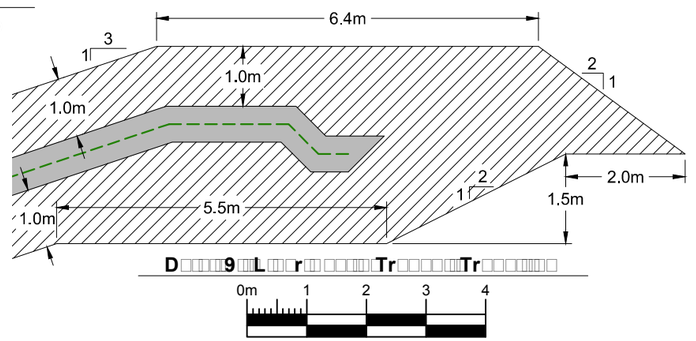

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DRAWING NO.	DRAWING TITLE
REFERENCE DRAWINGS	

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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Transition.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Transition Material Placement Plan and Sections Key Trench and Phase 1

DRAWING NO. DN-SD-08 | SHEET 7 OF 18 | REVISION NO. 0

LEGEND

- Phase 1 Dam Liner
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Bedding Material
- Transition Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.

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NAD83 UTM □one 13.

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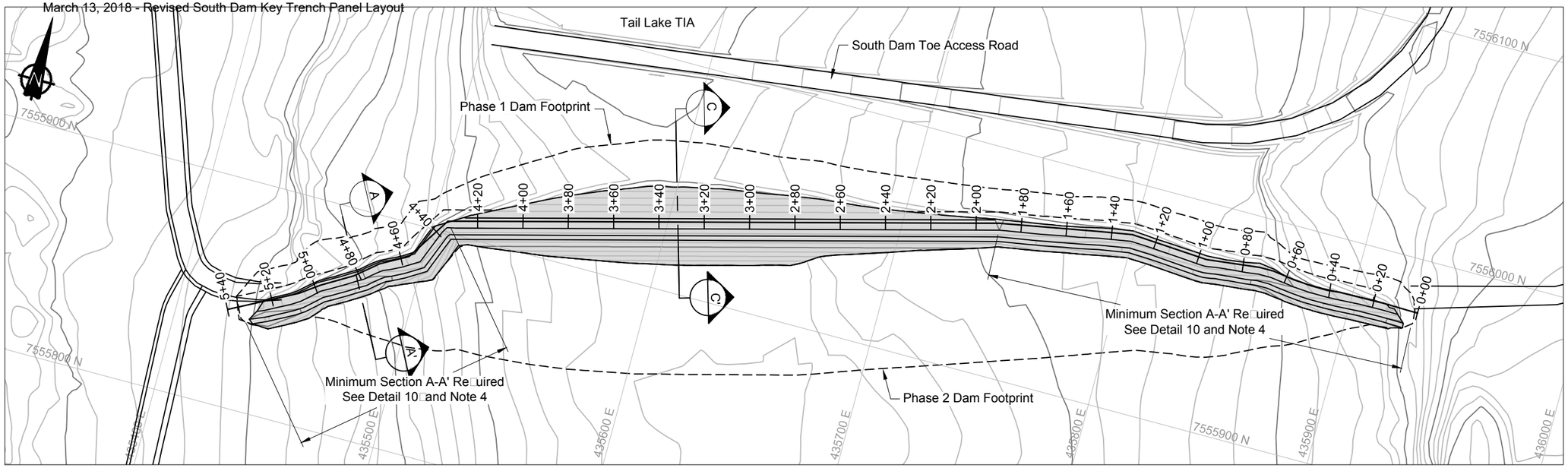

LEGEND

- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Run of Quarry Backfill Extent
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profiles shown correspond to the upstream toe of the key trench.
4. If the key trench is over-blasted or over-excavated beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell then additional ROQ material will be required to be placed in and above the backfill key trench. See Detail 10 on drawing DN-SD-09 for additional details.
5. The outside downstream ROQ should be sloped at 2H:1V or shallower.

DATUMS

NAD83 UTM Zone 13.

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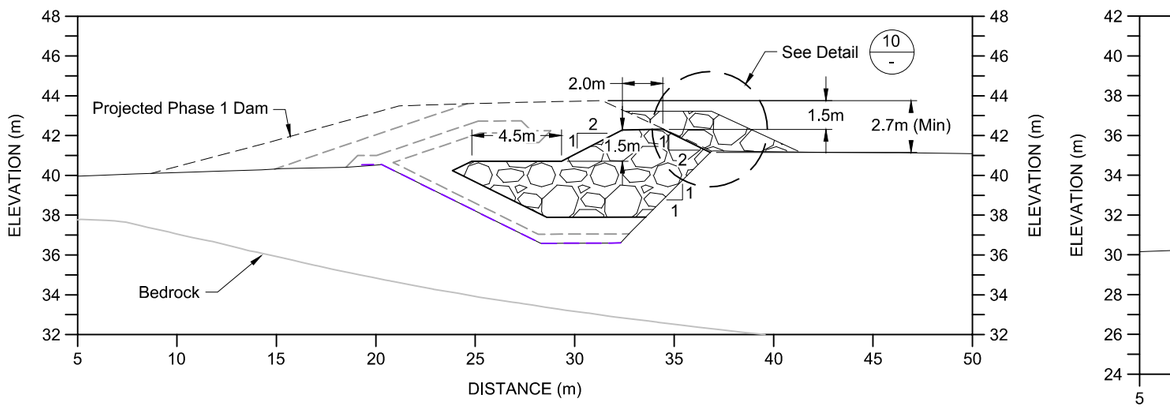

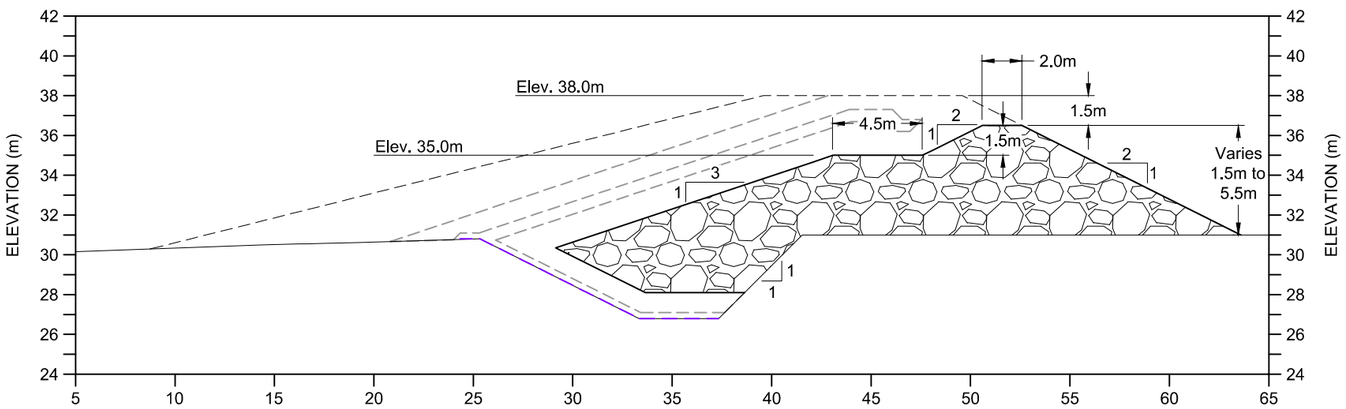

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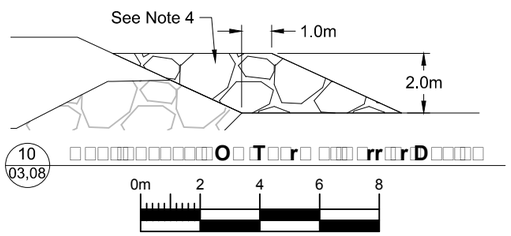

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DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1										
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1	-	-				0	Issued for Construction	JBK	EMR	17/11/29
REFERENCE DRAWINGS		REVISIONS									

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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO. DN-SD-09 | SHEET 9 OF 18 | REVISION NO. 0

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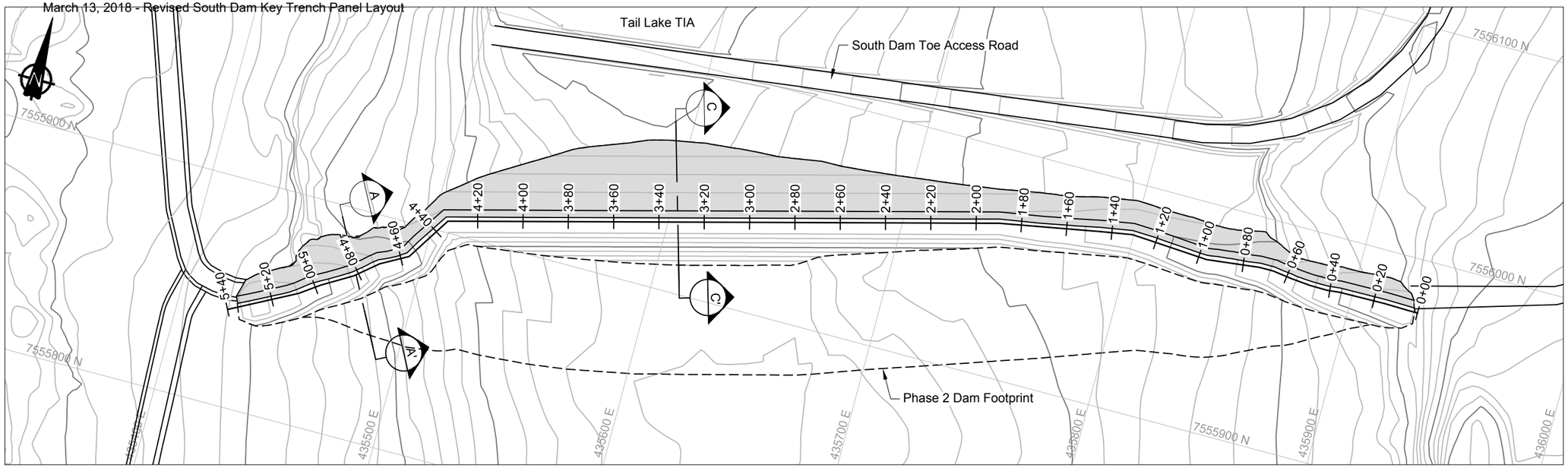


LEGEND

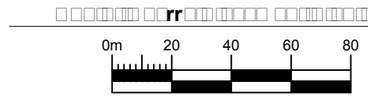
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Run of Quarry Backfill Extent
- Run of Quarry Backfill

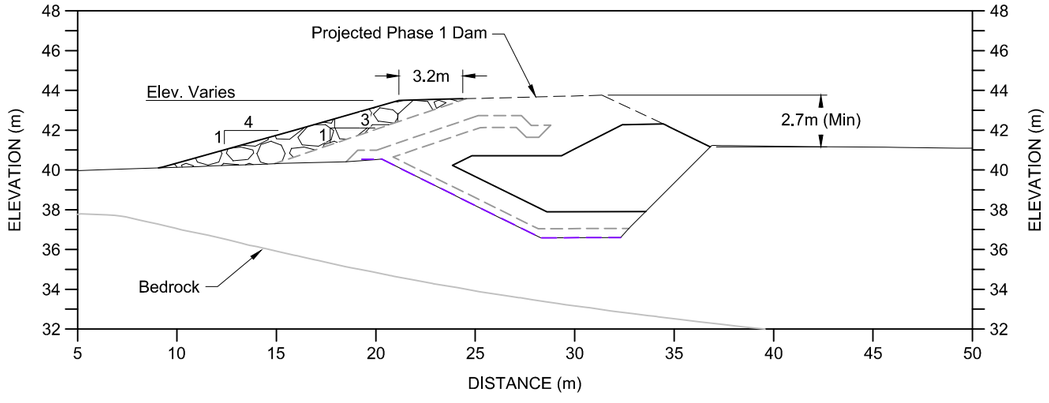
NOTES

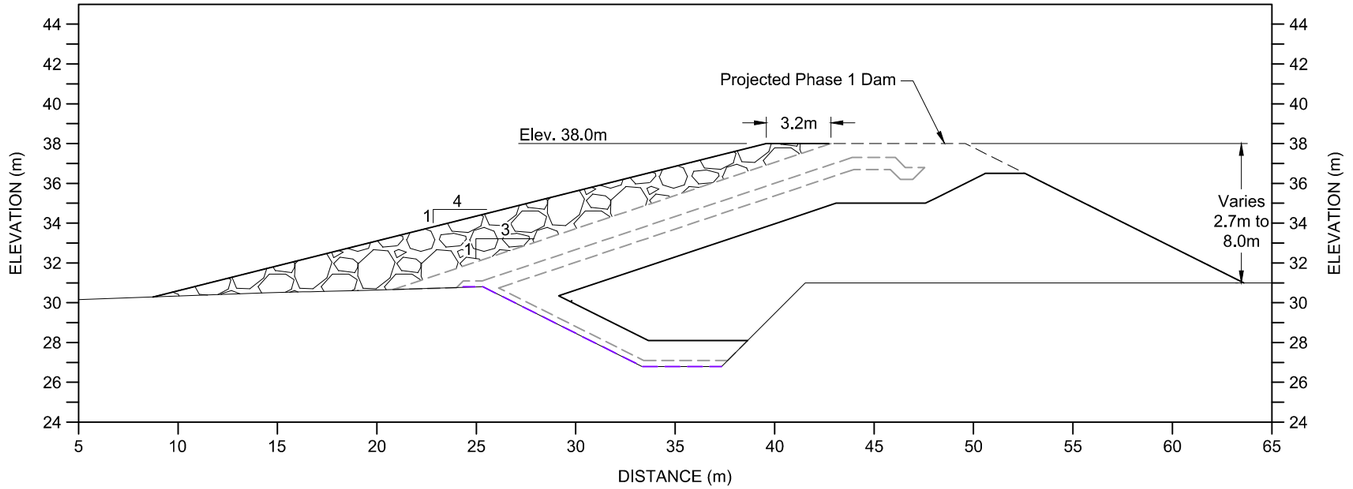
1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The outside upstream dam ROQ should be sloped at 4H:1V or shallower.

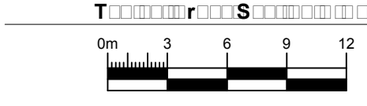
REFERENCES

NAD83 UTM Zone 13.









NO.	DESCRIPTION	CHK'D	APP'D	DATE
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DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1			
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1	-	-	

REFERENCE DRAWINGS

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FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ-us.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-10	10 OF 18	0

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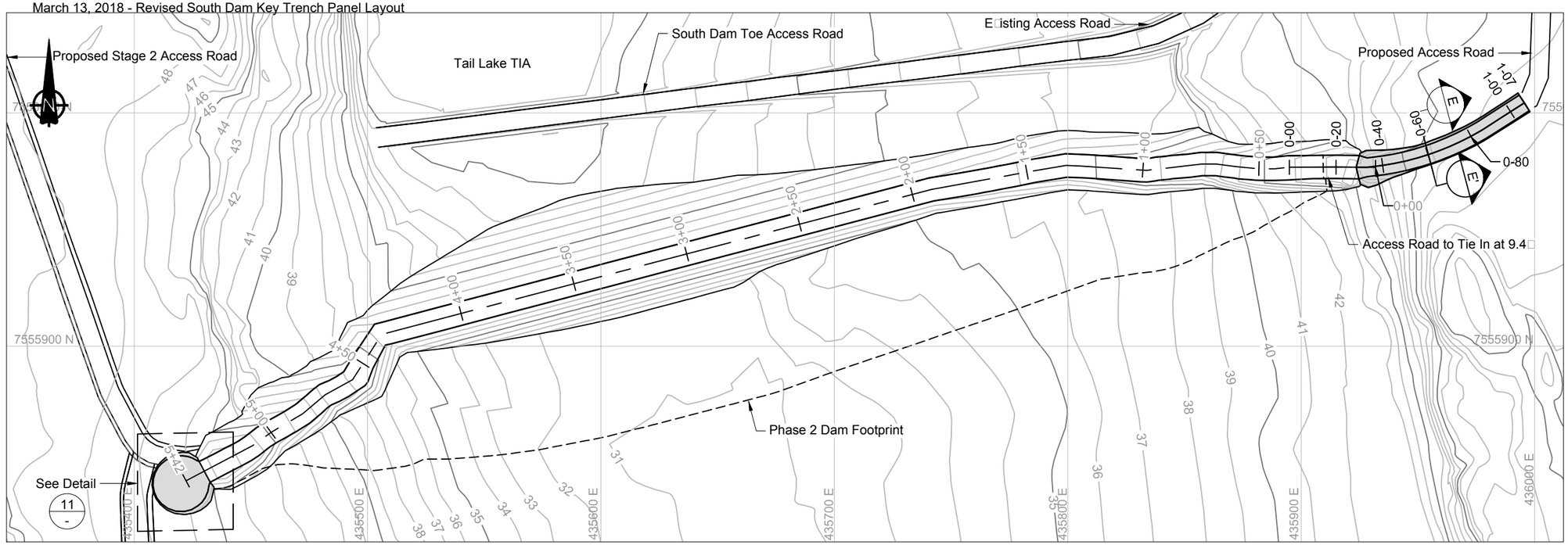

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Access Road
- Run of Quarry
- Surfacing Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Approximately 325m³ of surfacing / bedding material is estimated (to neat lines) to be needed for the Access Road and Turn Around.

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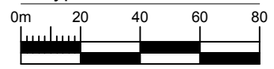
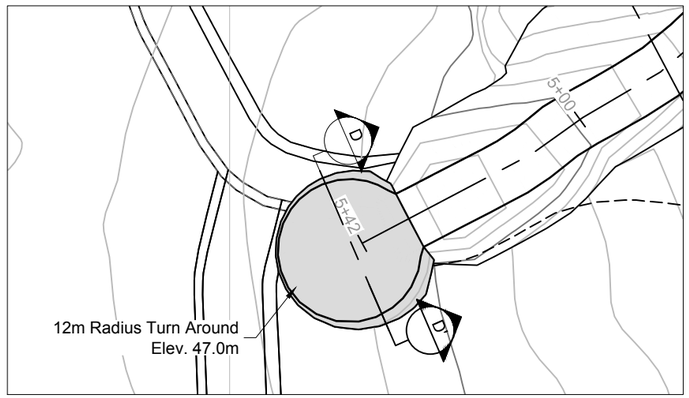
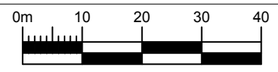
NAD83 UTM □one 13.

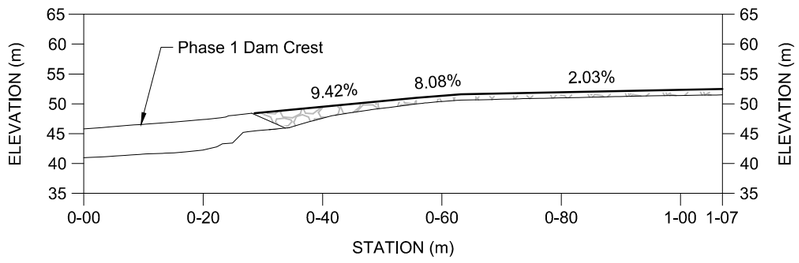
Typical Road Section



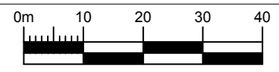


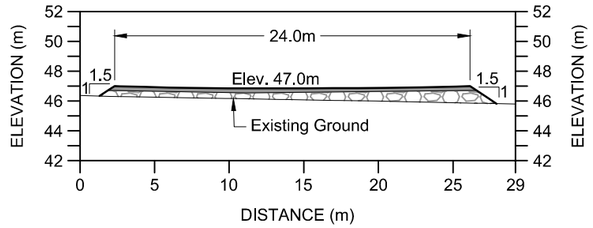
Detail 11 - Turn Around



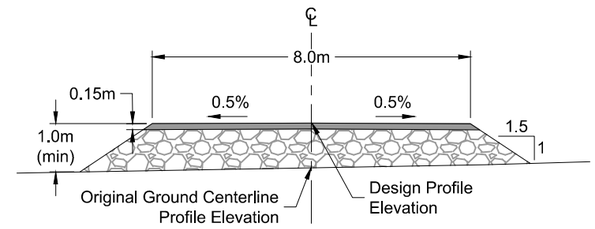


East Access Road Profile

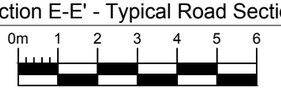




Section D-D' - Turn Around



Section E-E' - Typical Road Section



DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-03	Typical Sections (General)					
DN-SD-02	Phase 1 General Arrangement	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2017/11/29

FILE NAME: 1CT0022.017 - South Dam AR.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

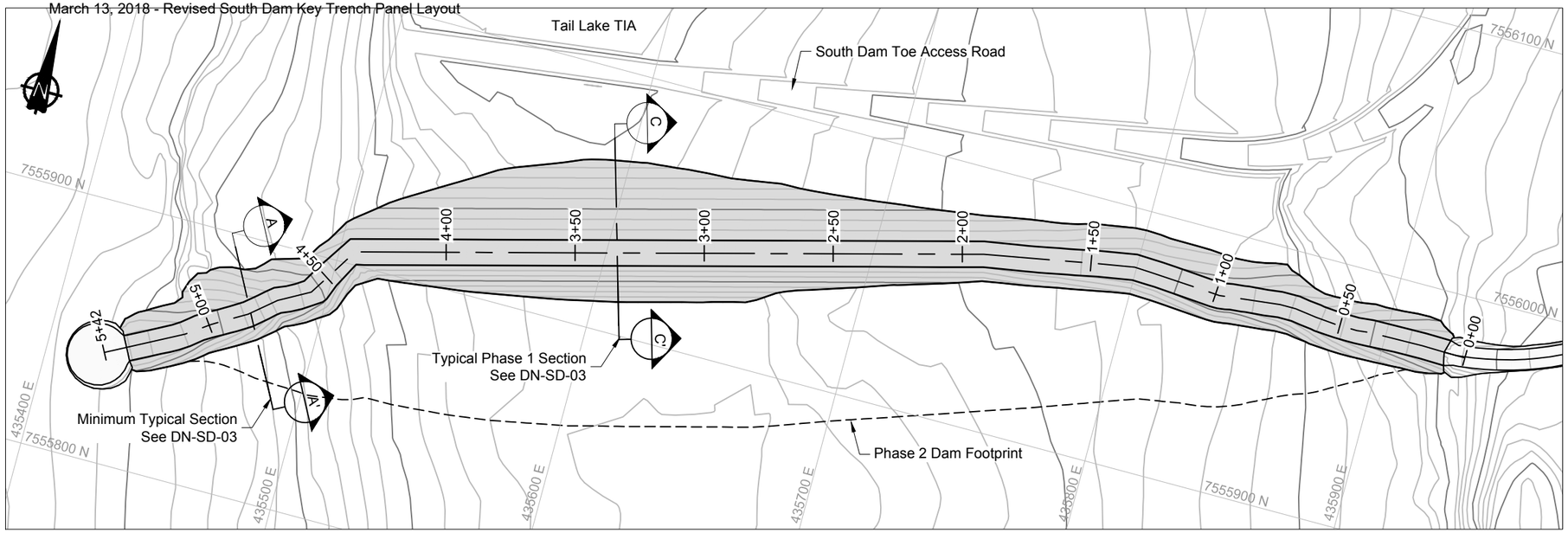
South Dam

DRAWING TITLE:

Construction Access Road and Turnaround - Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-11	11 OF 18	0

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1\1CT0022.017 - South Dam AR.dwg



LEGEND

- Key Trench E□cavation
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

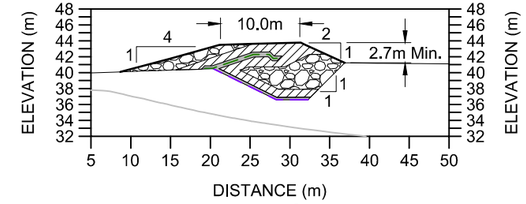
1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The Phase 2 dam elevations are showing for information purposes only. Note that only Phase 1 dam designs and elevations are issued for construction use.

□E□E□EN□ES

NAD83 UTM □one 13.

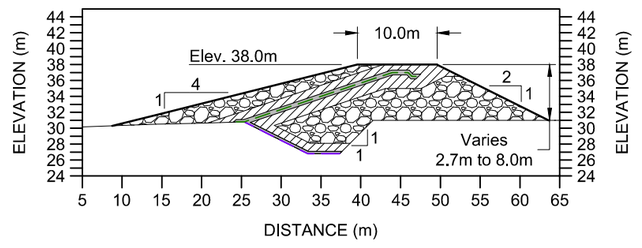
□□□□□1□D□□ □□□□□□□□

0m 20 40 60 80



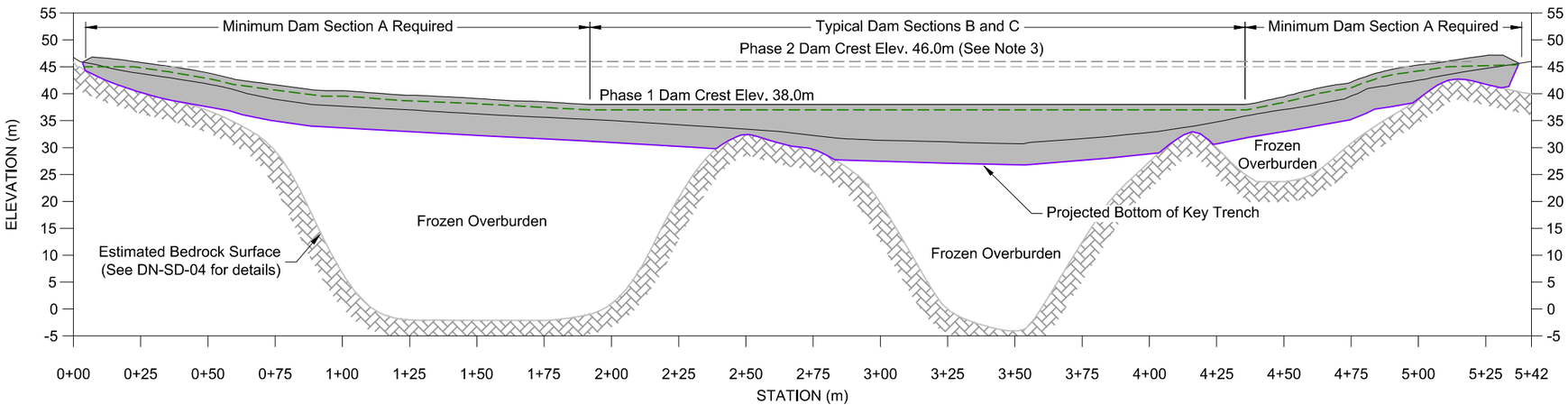
M□□□ □□ □r□□□S□□□□□□A□A□

0m 5 10 15 20 25 30



□r□□□S□□□□□□□□□

0m 5 10 15 20 25 30



□□□□□1□D□□ □□r□□□□□□□□

Horizontal: 0m 10 20 30 40

Vertical: 0m 20 40 60 80

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-04	Key Trench E□cavation Plan and Profile
DN-SD-03	Typical Sections (General)
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Phase 1 Dam.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Final Phase 1 Dam Plan□Profile and Sections

DRAWING NO. DN-SD-12

SHEET 12 OF 18

REVISION NO. 0

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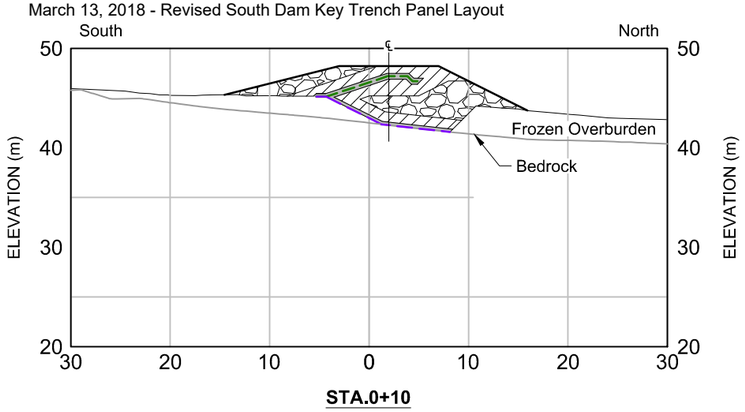

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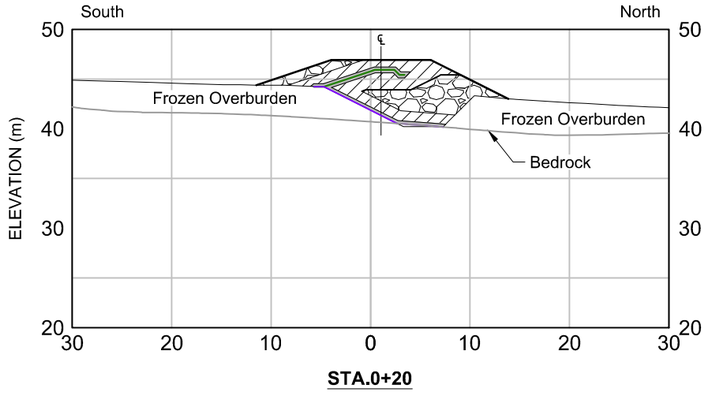

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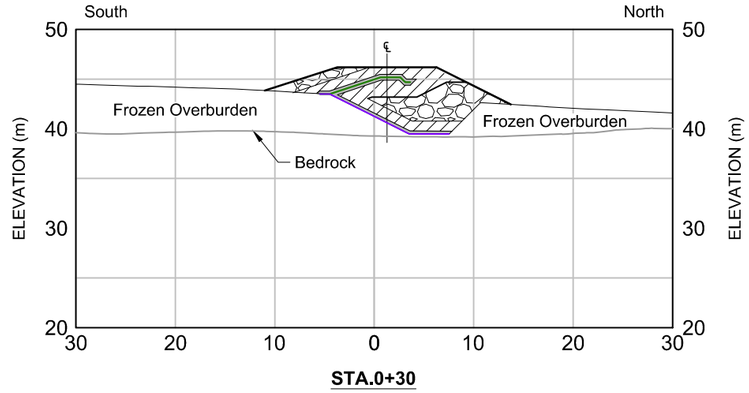

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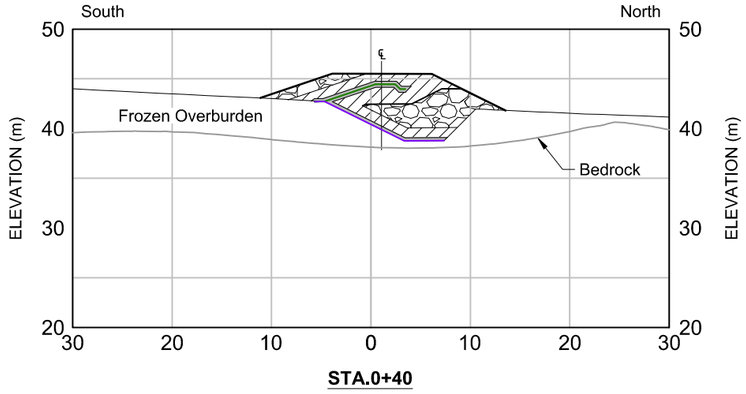

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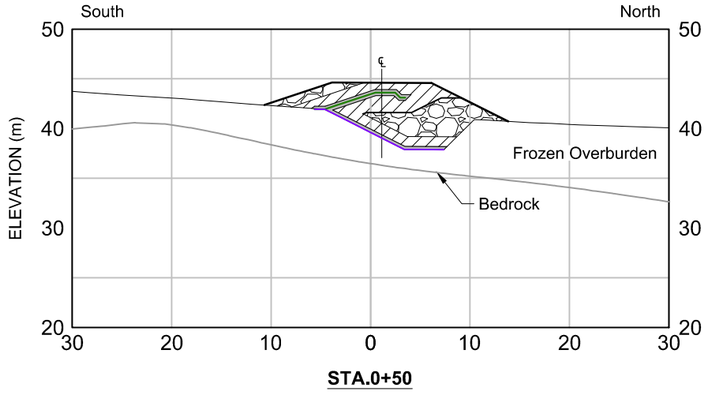

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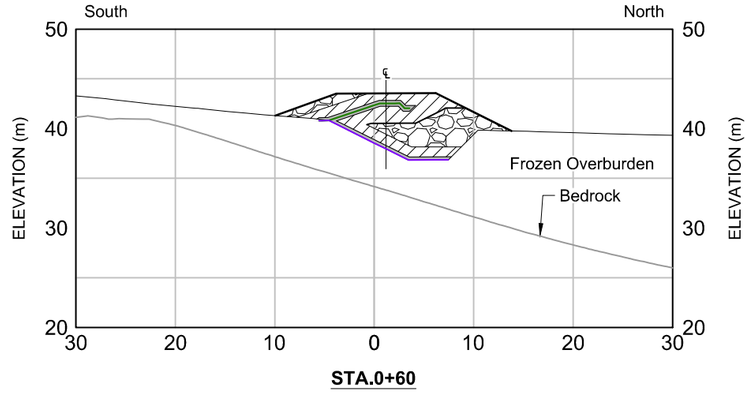

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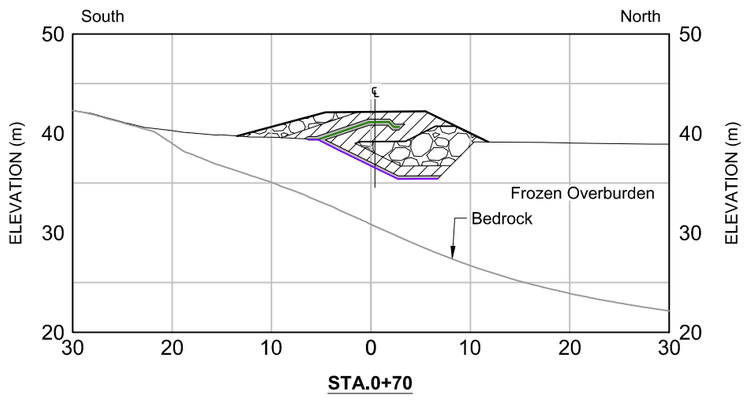

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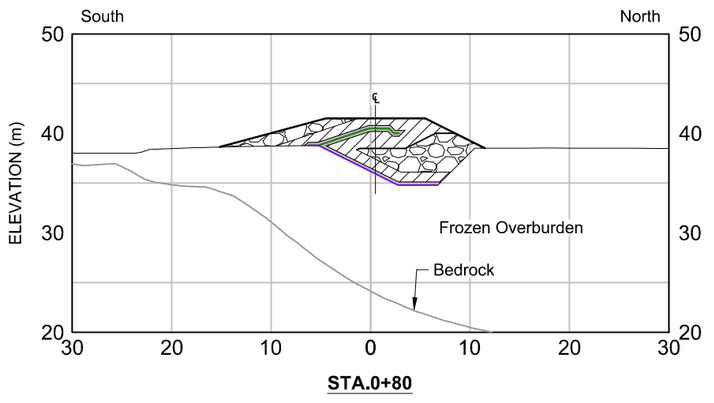

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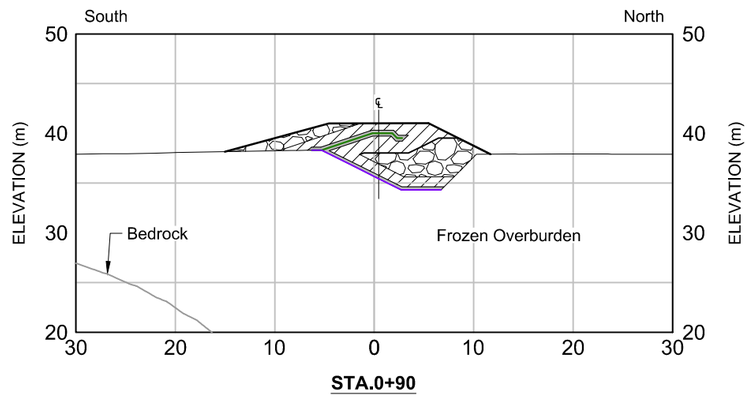

STA.0+90

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.

0m 6 12 18 24

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS | REVISIONS

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.0+10 to 0+90 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-13	13 OF 18	0

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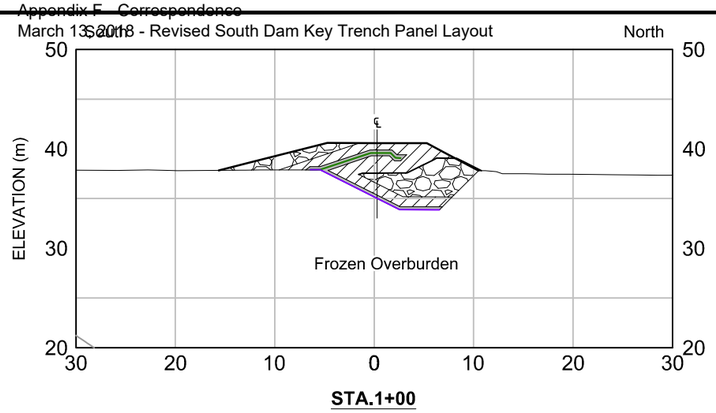

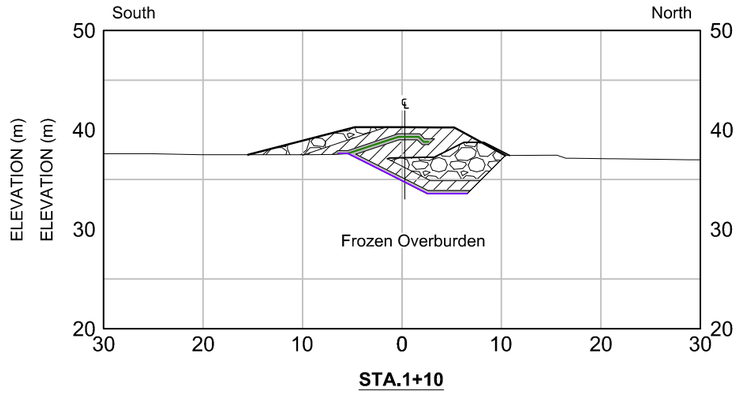

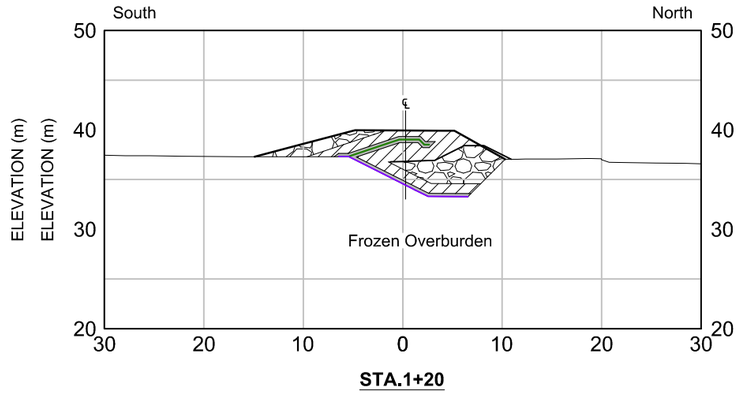

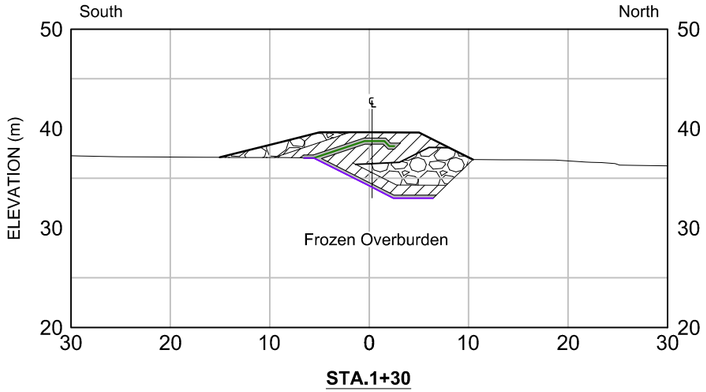

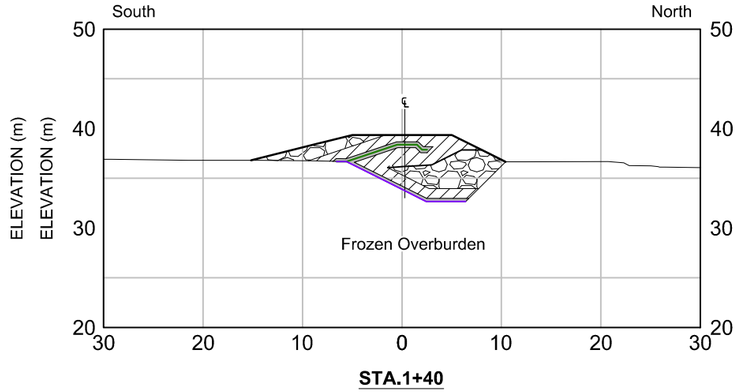

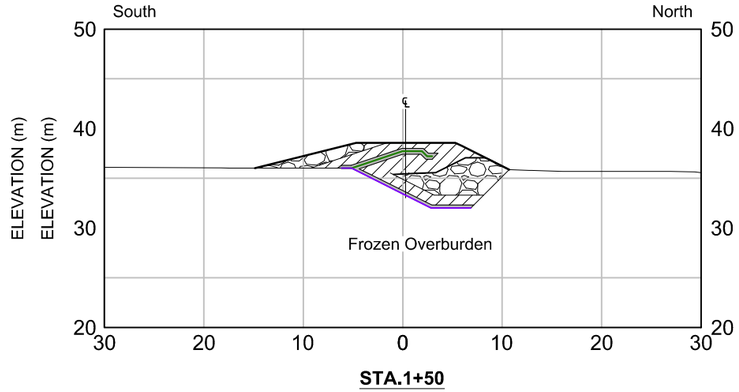

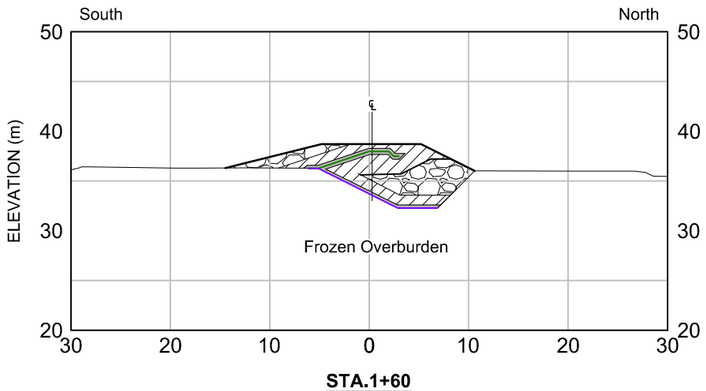

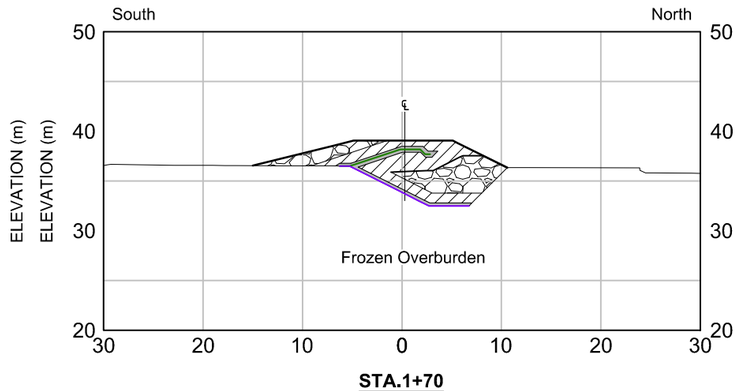

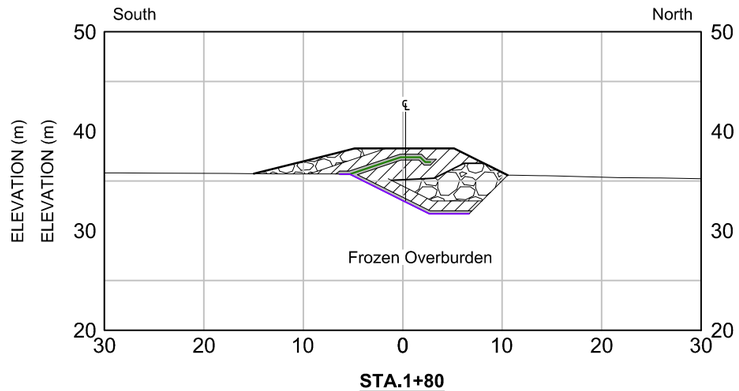

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.

0m 6 12 18 24

REVISIONS										
NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-								
					0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.1+00 to 1+80 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-14	14 OF 18	0

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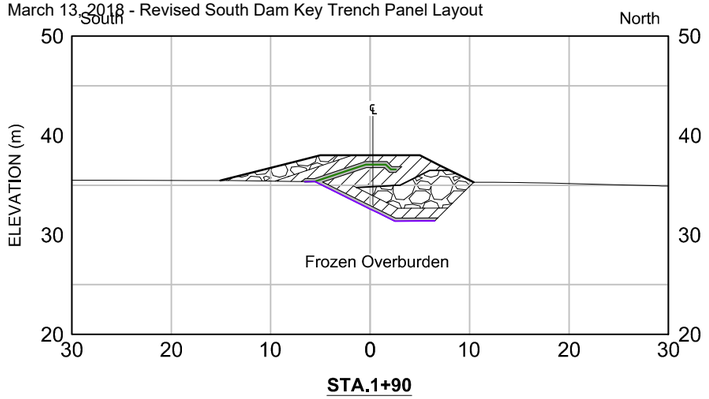
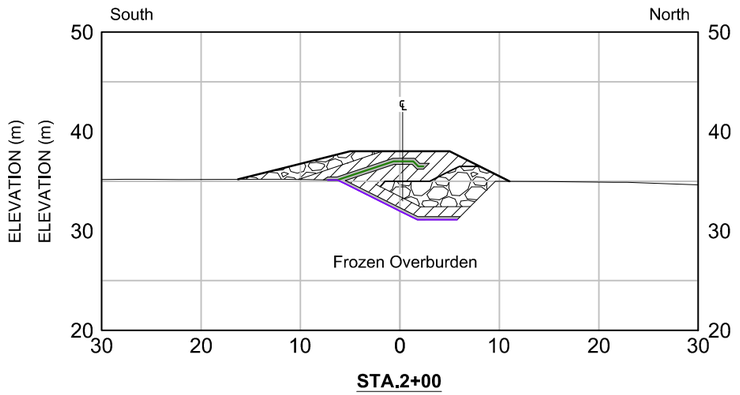


STA.1+90



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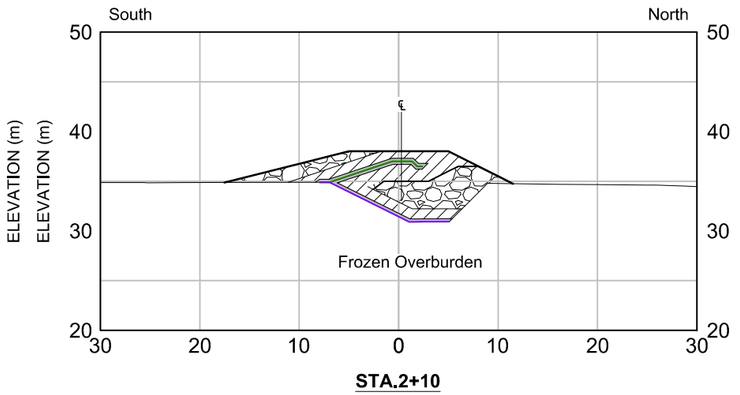

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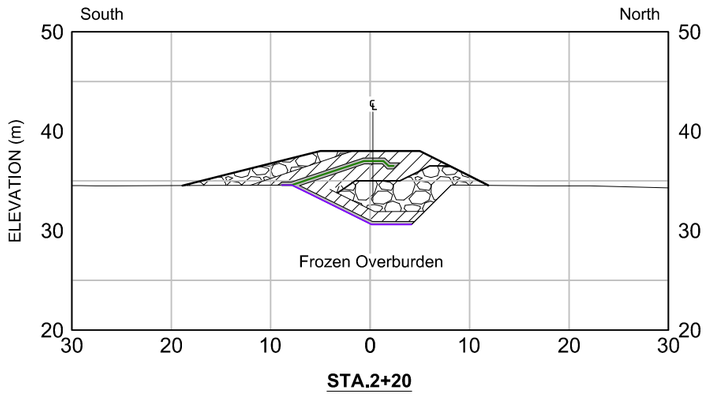

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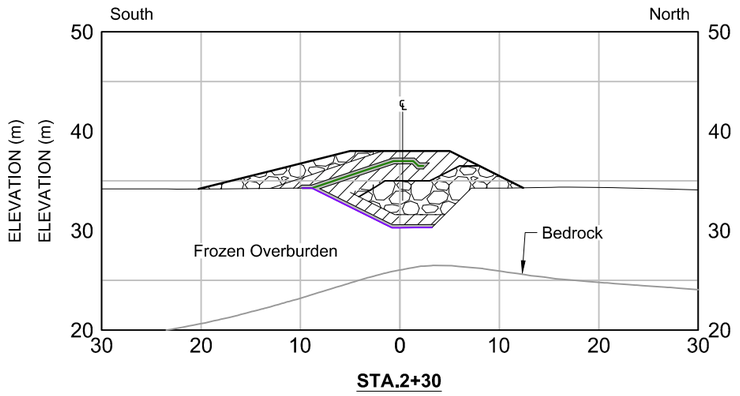

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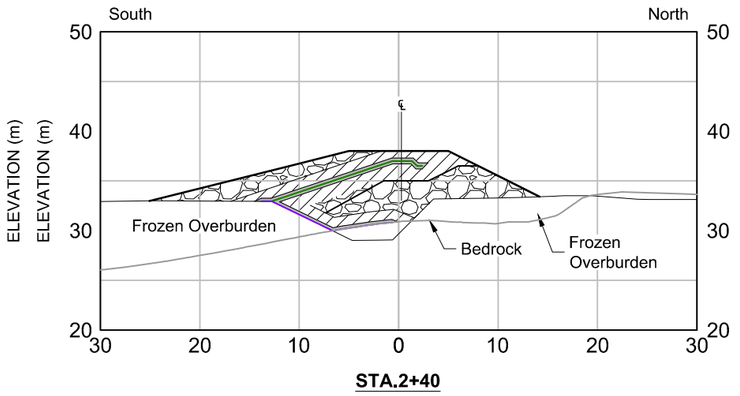
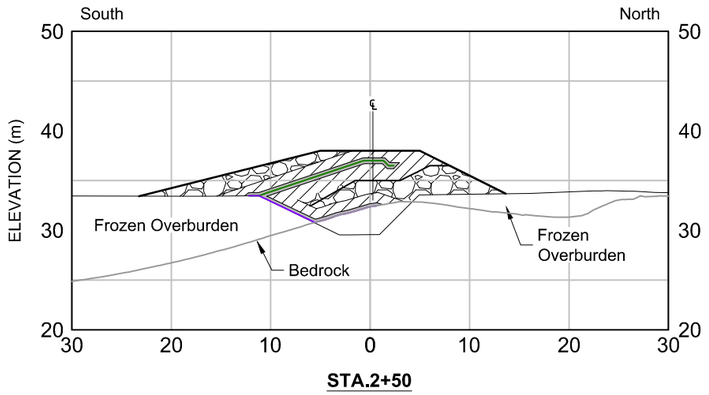


STA.2+40



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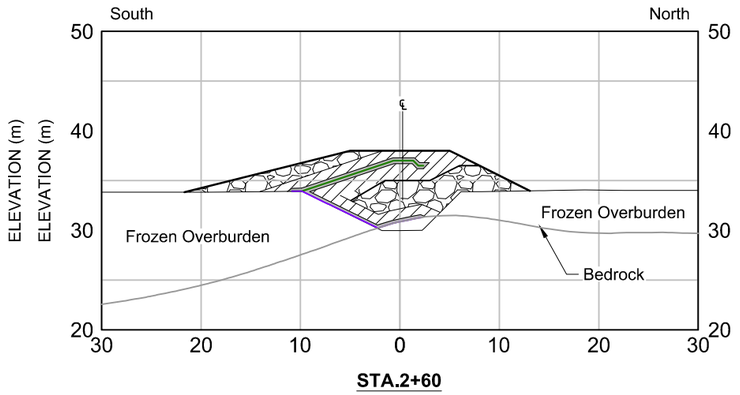

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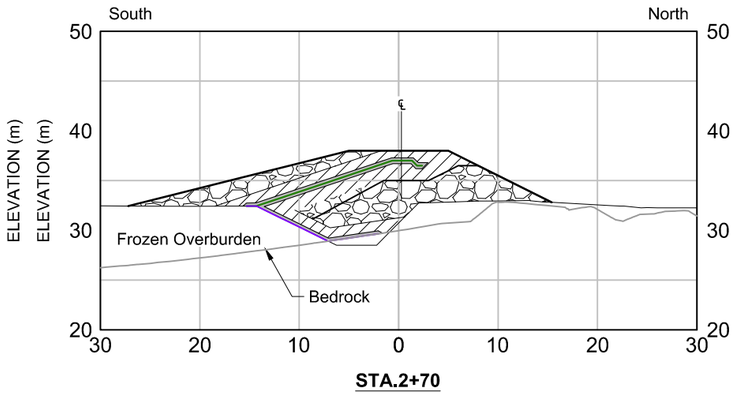

STA.2+70

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.

0m 6 12 18 24

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29
-	-										

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.1+90 to 2+70 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-15	15 OF 18	0

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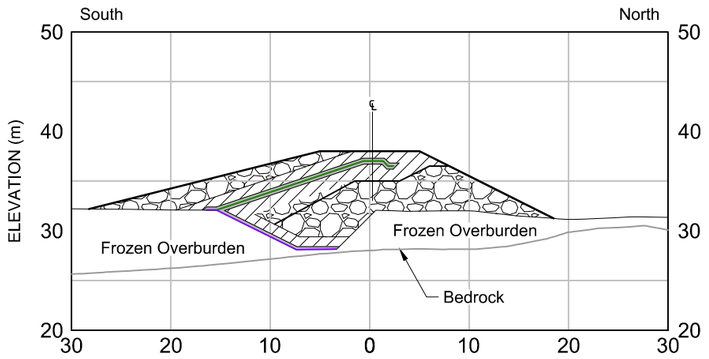

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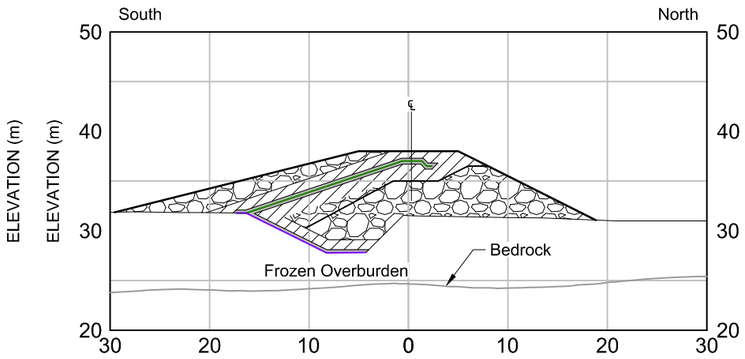

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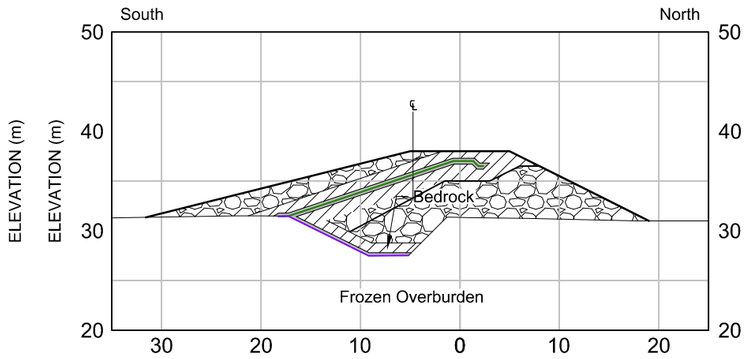

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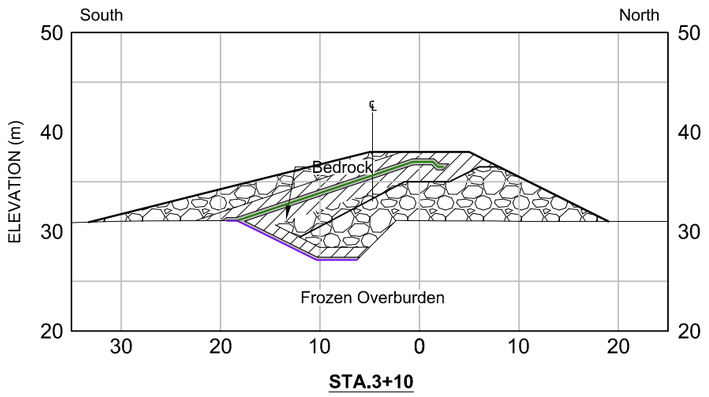

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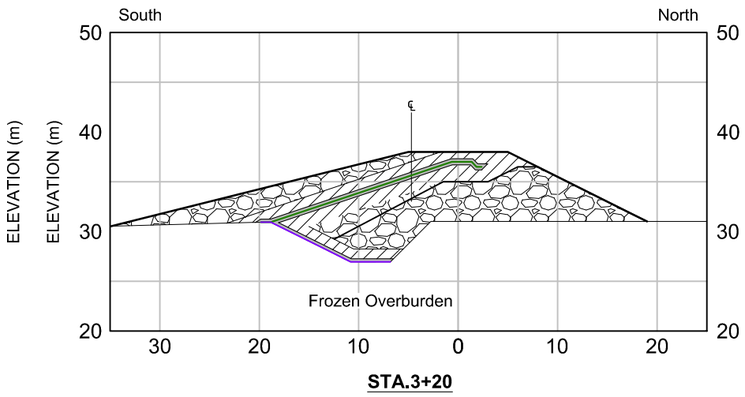
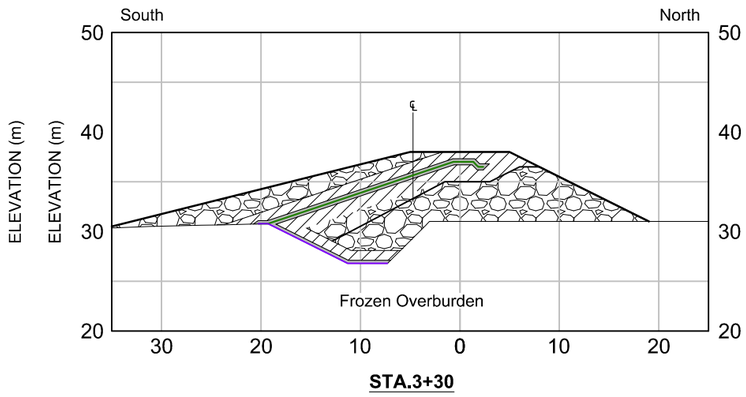


STA.3+20



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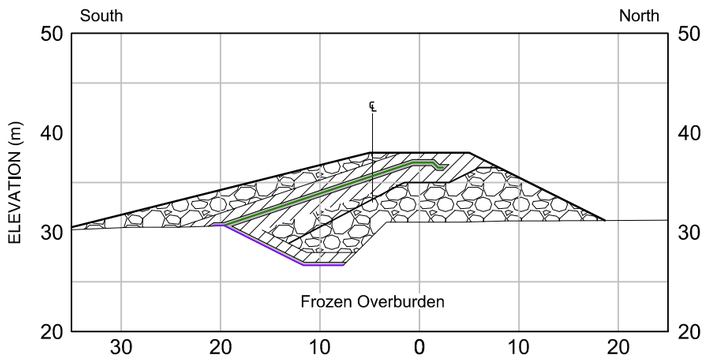
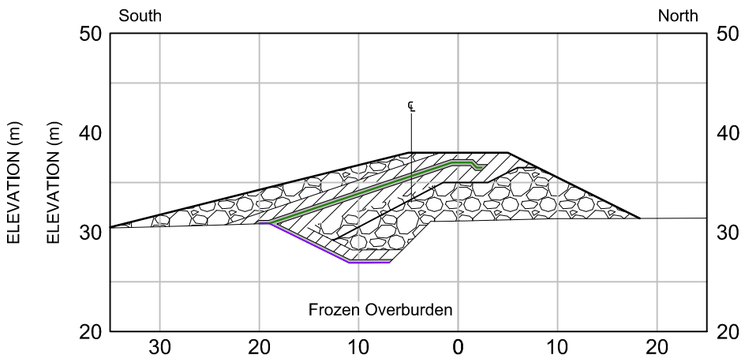


STA.3+40



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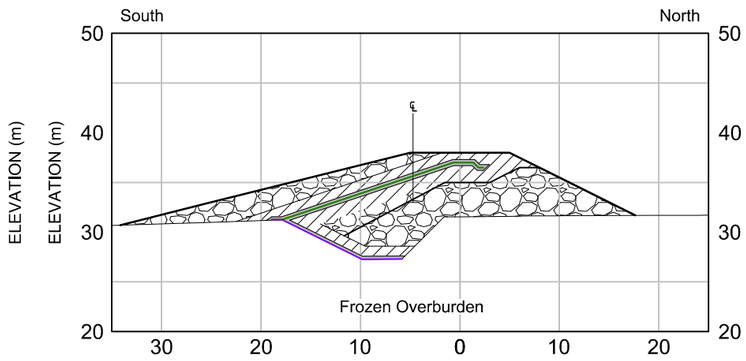

STA.3+60

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.

0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
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DN-SD-02 — Phase 1 General Arrangement

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JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

DRAWING TITLE: South Dam
Sections
Sta.2+80 to 3+60
Phase 1 Dam

DRAWING NO.: DN-SD-16

SHEET: 16 OF 18

REVISION NO.: 0

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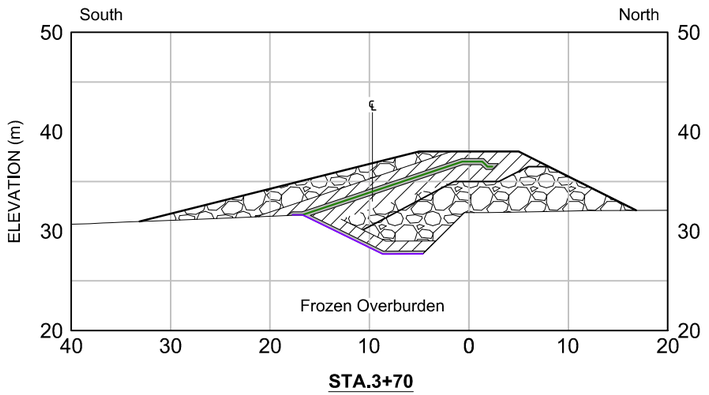

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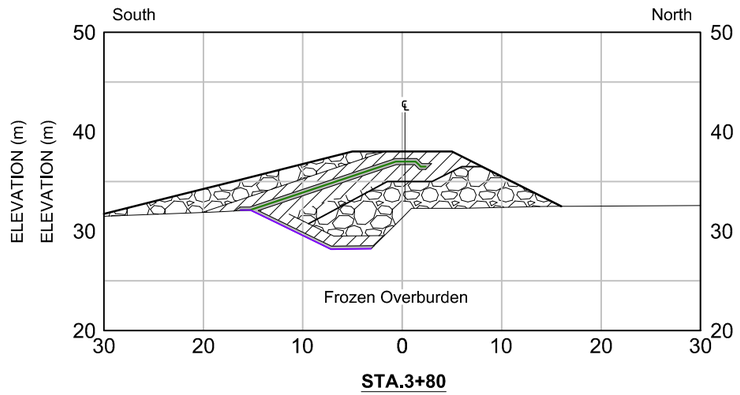

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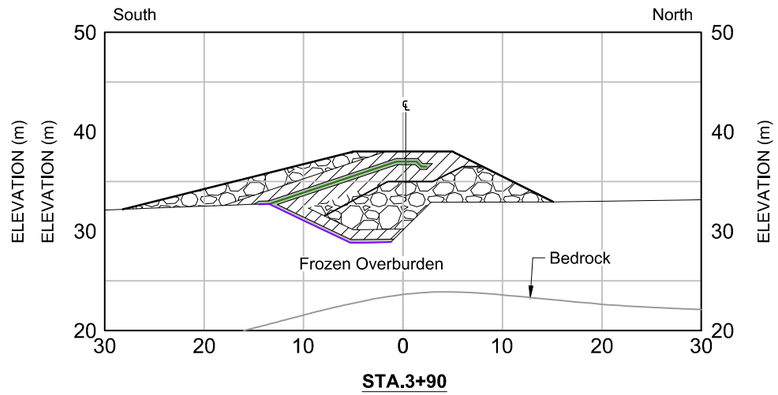

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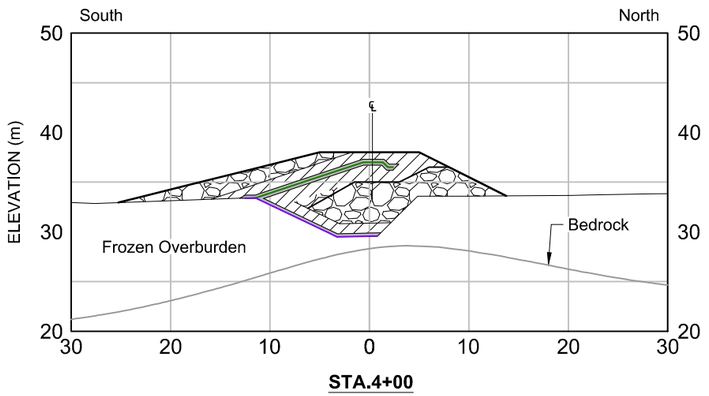

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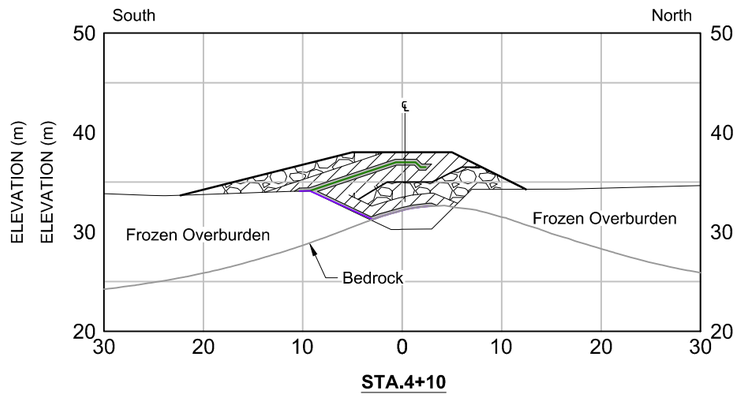
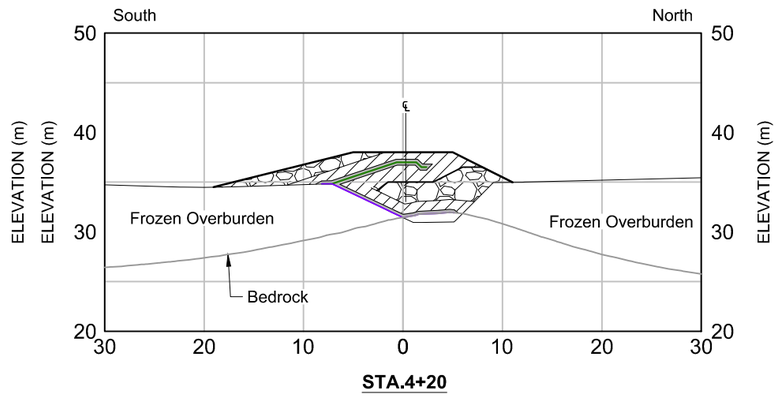


STA.4+10



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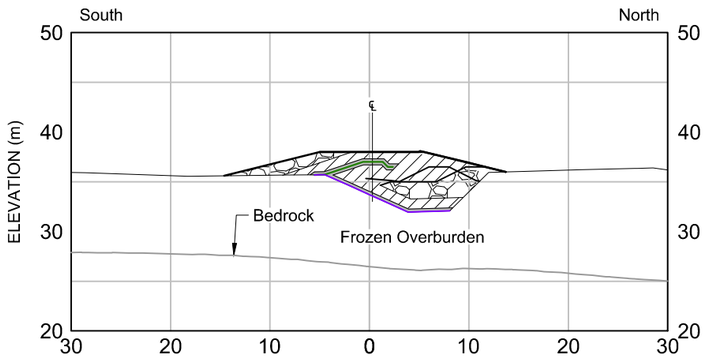

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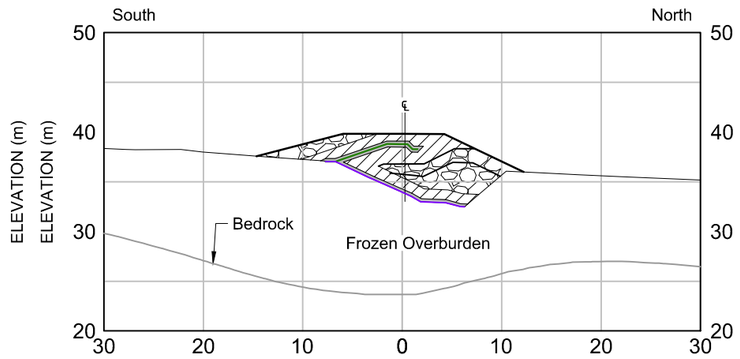

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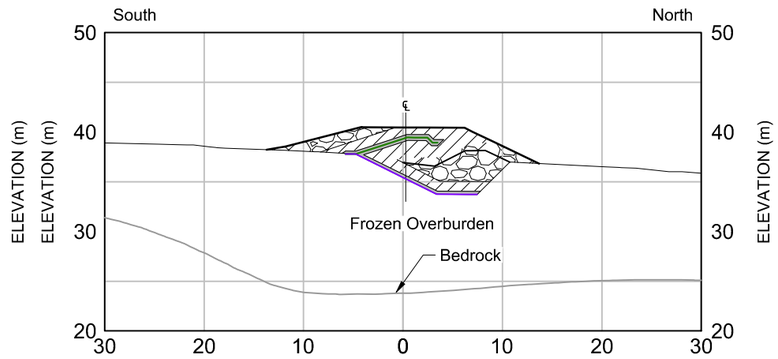

STA.4+50

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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NO.	DESCRIPTION	CHK'D	APP'D	DATE
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DN-SD-02 — Phase 1 General Arrangement

REFERENCE DRAWINGS — REVISIONS

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.3+70 to 4+50 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-17	17 OF 18	0

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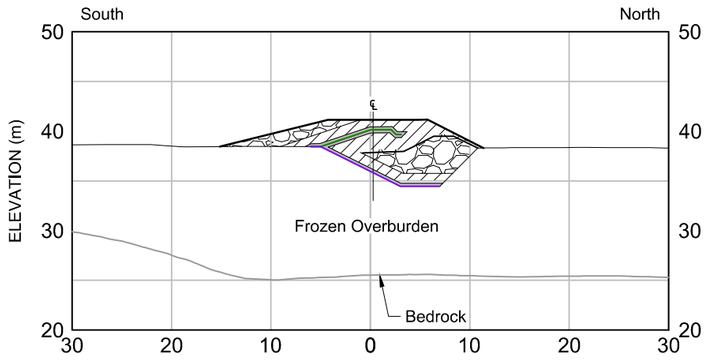

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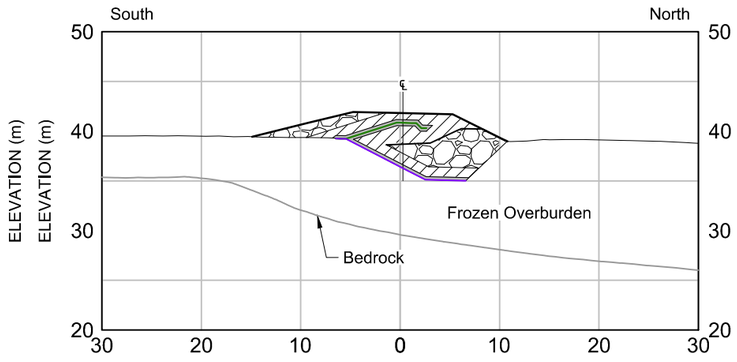

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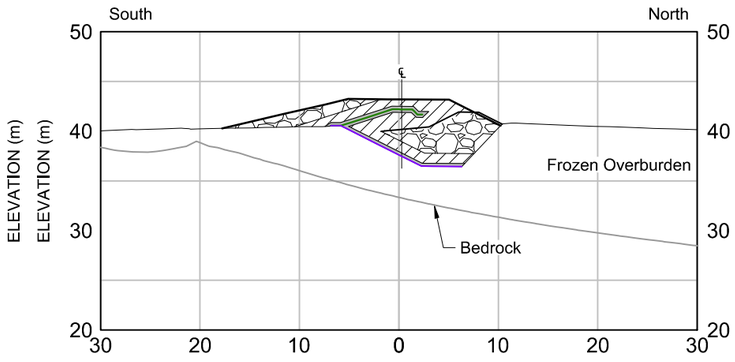

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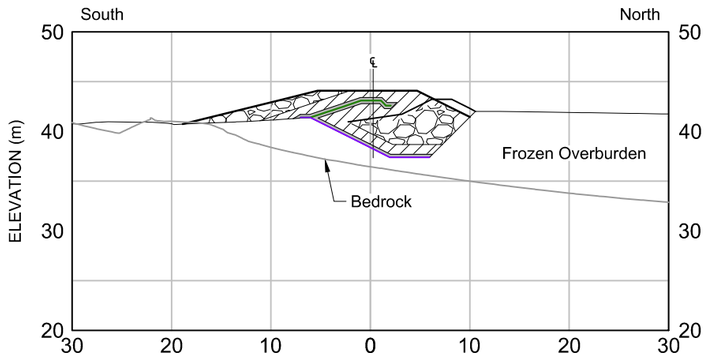

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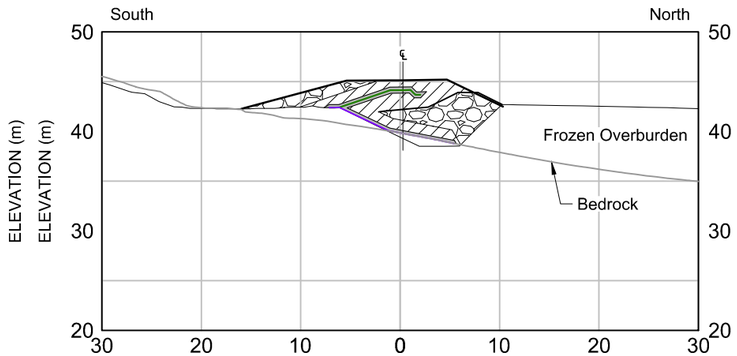
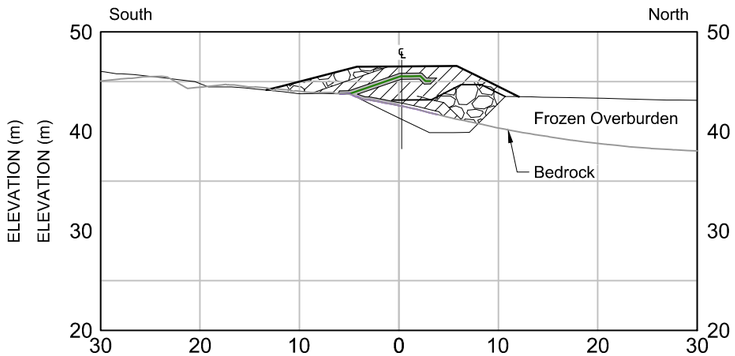
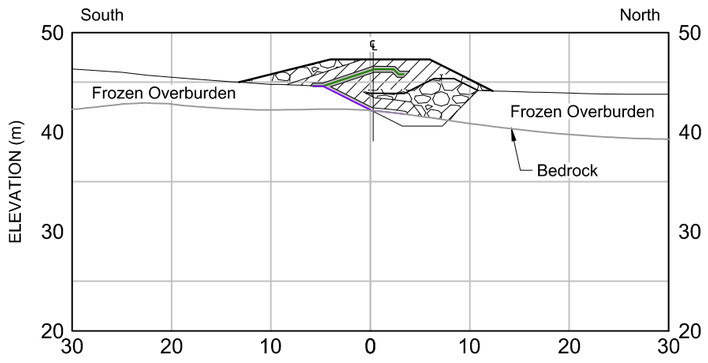




STA.5+00



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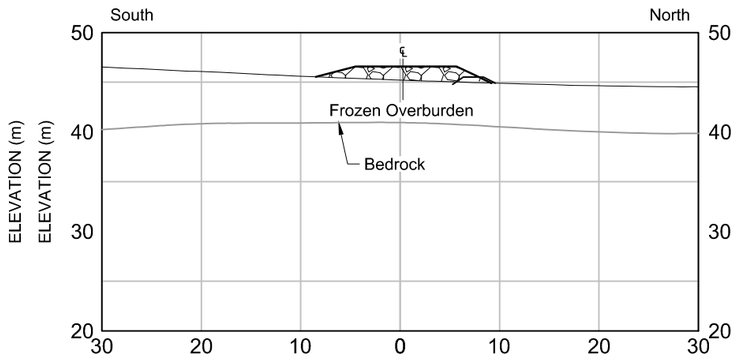

STA.5+30

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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0m 6 12 18 24

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DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-02	Phase 1 General Arrangement	-	-			
		0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS | REVISIONS

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	17/11/29

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.4+60 to 5+30 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-18	18 OF 18	0

BLOMBERG BUILDING

South Dam Phase 1
Quality Assurance/Quality Control

Manager/Supervisor: Workers must review and be familiar with GCL Deployment procedures. Quality Control Supervisor must understand guidelines, standards and equipment used in the full process of GCL Liner and Liner systems.
Company Name: Blomberg Building Group
Site Name: Doris North, Hope Bay
Work area: South Dam Phase 1
Job/task: Deployment of GCL and bentonite for Phase 1 of south dam and key trench.
Supervisor name: Nikolas Blomberg Signature:

Quality control

Photo documentation is required for all stages of the project.

Earthworks:

Surface Inspection - Survey is to shoot locations and dimensions, grade to be uniformly compacted with no protrusions exceeding 12mm of surface height. The engineer must sign off on the subgrade before any GCL can be laid down.

-Pictures are required before the deployment of all GCL liner.

GCL inspection:

Roll Inspection – Inspect all rolls upon site arrival, during storage, and delivery to south dam. If any of the GCL rolls have been mishandled, improperly stored, or encountered moisture they are to be tagged, documented and placed aside for engineer inspection. They may be used if engineer deems damage is negligible during deployment.

GCL Deployment:

Roll/panel Identification – All rolls must have manufacturer tags on sleeve or GCL roll.
The roll tag must be kept on hand, and according

Method of Deployment – All panels are to be placed in accordance with engineer approved panel layout, and roll tags are to be documented with corresponding panel ID. Deployment strategy can be found in the operational work plan. GCL is not to be excessively dragged over subgrade and the deployment of the GCL liner will halt if any form of precipitation is present. All Exposed seams and panels will be covered with geotextile and plywood. Exposed GCL shall not be exposed for more than 12 hours except with the engineer's approval. Sandbags will be used as ballasts to secure the edge of the GCL material and a Spreader bar system held by the reach stacker will allow workers to pull the material out to its desired length.

GCL Lapping and Joining:

Overlap – The overlapping panel must always be higher in elevation. A minimum overlap of 0.5m is required unless otherwise stated on approved drawings. All joints and laps will be measured every 2 meters to ensure 0.5m overlap is attained.

Joining – Powdered bentonite will be applied to all seams at a minimum rate of 1.1kg/m. Bentonite powder will be Placed no closer than 300mm to the underlying panels edge on horizontal seams, all longitude seams must have had a 75mm overlap.

Bentonite Powder – Bentonite powder that is used to treat the overlap must be the same bentonite as used in the manufacture of GCL liner.

Cover:

Backfill – Backfill will be performed by Nuna West Contracting, Refer to Nuna's Operational Work Plan for Specifications. All Panels are to be backfilled from the overlapping panel.

Seema Kang

From: Cameron Hore
Sent: Wednesday, March 14, 2018 8:50 PM
To: Kyle Scale; Kendell Cator
Cc: John Kurylo
Subject: FW: Revised South Dam Key Trench Panel Layout
Attachments: South Dam Key Trench Panel Layout.pdf

Hi Guys,

FYI in case you have any conversations with Patrick and he starts referring to Panel numbers etc.

Cheers

Cameron Hore *CPEng P.Eng*
srk consulting
Direct: +1-604-235-8533

From: Eric Blomberg [mailto:eric@blombergbuilding.com]
Sent: Tuesday, March 13, 2018 4:54 PM
To: Cameron Hore <chore@srk.com>
Subject: RE: Revised South Dam Key Trench Panel Layout

This sender failed our fraud detection checks and may not be who they appear to be. Learn about spoofing Feedback

Ok. We are happy to provide you with a more detailed layout plan but I think everything should be relatively straight forward for the key trench. I will add to our work plan a note on being very careful about panel length since there will be no excess. I also found out from Larry that 87 total rolls have been ordered. If we use a conservative estimate of 44-45 rolls for the key trench, I feel its safe to assume we will need more? If so I would like to give him as much notice as possible.

Thanks,
Patrick

Eric Blomberg
Director
Blomberg Building Group
W:867-988-6882 ext. 134
C:604-841 9858
H:604-947 0110

BLOMBERG BUILDING

From: Cameron Hore [mailto:chore@srk.com]
Sent: March-13-18 5:37 PM
To: Eric Blomberg <eric@blombergbuilding.com>

Cc: John Kurylo <jkurylo@srk.com>
Subject: RE: Revised South Dam Key Trench Panel Layout

Thanks for this Patrick,

It's still not really what I had in mind, but what I had in mind is probably overkill for this project.

I've normally specified a detailed panel layout accompanied by a table with each panel width & length and notes on angled seams required and what size sheet is required to make any odd shapes. However, this one is so simple field fitting can't really go wrong.

My only concern about the liner layout is what I mentioned last night; the length of each key trench panel running along the base, up the slope and then with overlap is about 15m which is almost exactly 1/3 of the roll length. If you assume everything is perfect then you need about 44 rolls, as you get 3 panels per roll. However, as soon as you go over by a little bit on one panel you now can only get two full panels per roll. So the potential for large proportions of wastage and therefore running out of liner exists. Unless we use a horizontal seam on the upstream slope of the key trench, which I wouldn't normally but will look into.

However, as we've discussed we have plenty of liner available for the key trench and if needed can order more prior to the upper liner placement.

Cheers

Cameron Hore *CPEng P.Eng*
srk consulting
Direct: +1-604-235-8533

From: Eric Blomberg <eric@blombergbuilding.com>
Sent: Tuesday, March 13, 2018 2:23 PM
To: Cameron Hore
Subject: Revised South Dam Key Trench Panel Layout

Hi Cameron,

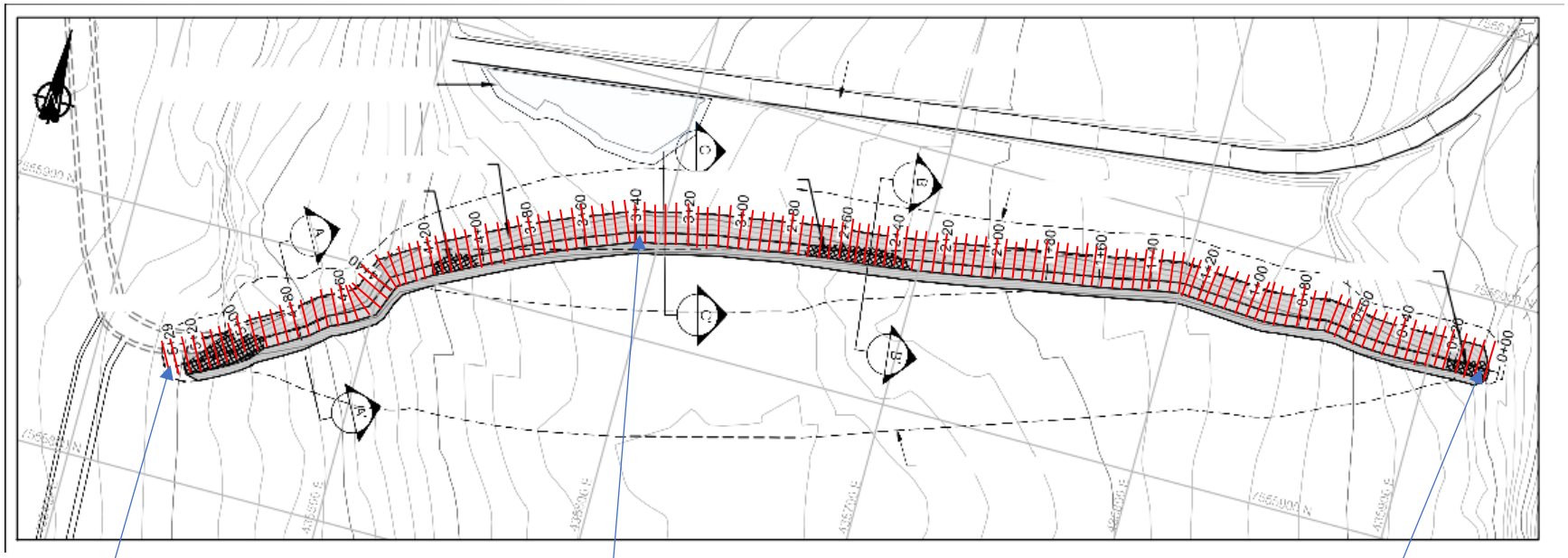
Here is the panel layout for the key trench. Let me know if we should make any changes.

Thanks,
Patrick

Eric Blomberg
Director
Blomberg Building Group
W:867-988-6882 ext. 134
C:604-841 9858
H:604-947 0110

BLOMBERG BUILDING

South Dam Key Trench Panel Layout



*Actual panel numbers could vary due to bedrock, greater overlaps, and turns in the key trench.

Seema Kang

From: Kendell Cator
Sent: Sunday, March 18, 2018 8:22 AM
To: Jake Chisholm
Cc: John Kurylo; Cameron Hore; Kyle Scale; Mark Doucette
Subject: Offset Upstream KT Crest Points - East Abutment
Attachments: OffsetUpstreamKTCrestPts_East Abutment.xlsx

Jake,

As discussed yesterday, due to the difference in elevation between the OG survey on the east abutment (approx. 0+00 to 0+95) and the base topo used in design, further upstream excavation is required in this area to achieve the 2:1 upstream design slope. Based on my preliminary checks this change leads to a maximum offset from the current as-built upstream KT crest of about 2 m. The northings in the attached spreadsheet are modified from the as-built survey you shot of this area on March 16 by projecting the 2:1 upstream design slope from the design toe of the upstream key trench slope to the OG survey.

In the hopes of moving forward with this field-fit modification I was hoping that you might be able to perform a QC check of these points - prior to surveying them in.

If you have any additional questions on this then please let me know. Thanks for your efforts.

Thanks,

Kendell

Kendell Cator *EIT.*
Consultant (Geotechnical Engineering)
srk consulting
SRK Consulting (Canada) Inc.
Suite 205, 2100 Airport Drive, Saskatoon, Saskatchewan, S7L 6M6, Canada
Direct: +1-306-955-4773; **Mobile**:+ 1-306-587-7757
Email: kcator@srk.com
www.srk.com

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Northing	Easting
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7555982.013	435842.229
7555982.649	435849.34
7555983.204	435856.378
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7555981.584	435885.868
7555981.025	435893.567
7555981.152	435901.216
7555981.296	435907.735
7555980.992	435914.445
7555980.115	435919.905

Seema Kang

From: Kendell Cator
Sent: Monday, March 19, 2018 10:55 AM
To: Jake Chisholm
Cc: John Kurylo; Kyle Scale; Mark Doucette; Cameron Hore; gramozr@nunalogistics.com; georgel@sub-arctic.ca
Subject: Updated Key Trench in East/West Abutments
Attachments: 180319 - South Dam - Key Trench.xml; KTUpdated180319.dxf; W-KTmod.pdf

Jake,

Please find attached the key trench modification required for both the east and west abutments. To summarize, the base of the key trench in the east abutment remains as it was prior, but the 2H:1V upstream slope has been projected to intersect the OG referenced from the as-built survey taken of the east abutment on March 16, 2018. The complete key trench design in the west abutment (including base) was raised to intersect the OG surface, while maintaining the same key trench depth as it was prior. The attached PDF displays where changes have occurred in plan view.

Let me know if you have any questions prior to staking in the field.

Kendell

Kendell Cator *EIT.*
Consultant (Geotechnical Engineering)
srk consulting
SRK Consulting (Canada) Inc.
Suite 205, 2100 Airport Drive, Saskatoon, Saskatchewan, S7L 6M6, Canada
Direct: +1-306-955-4773; **Mobile**:+ 1-306-587-7757
Email: kcator@srk.com
www.srk.com

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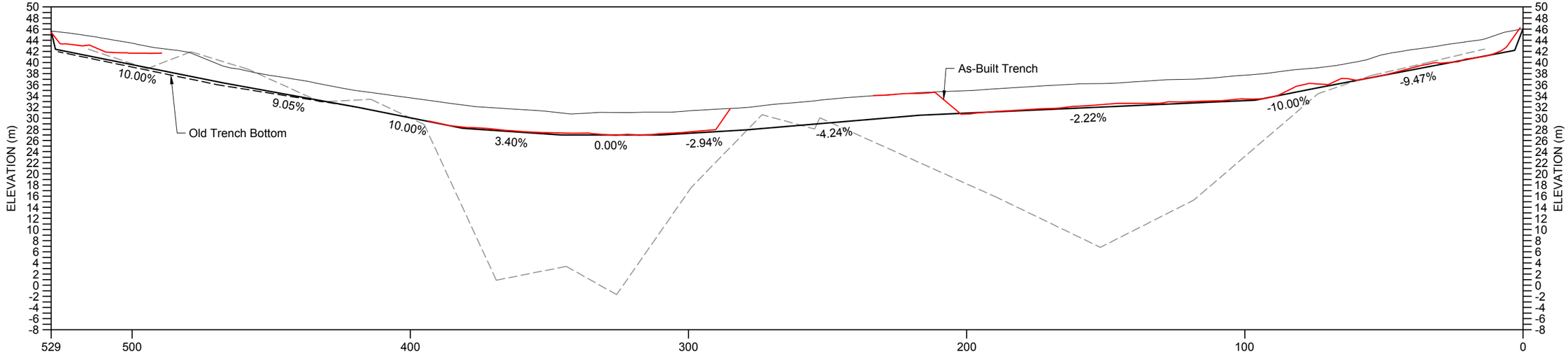

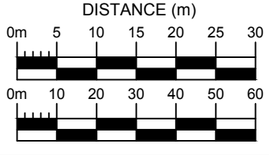

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REFERENCE DRAWINGS		REVISIONS									

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CHECKED:	APPROVED:	DATE: 2018/03/19

FILE NAME: KTUpdated180319.dxf

Hope Bay

SRK JOB NO.: -

South Dam - Phase 1

DRAWING TITLE: Key Trench

DRAWING NO.	SHEET	REVISION NO.
01	X OF X	A

P:\01_SITES\Hope Bay\ACAD\Reference\Outbox\20180319 - KT Update\KTUpdated180319.dxf

Seema Kang

From: Gramoz Rexhepi <GramozR@nunalogistics.com>
Sent: Thursday, March 22, 2018 8:24 PM
To: Jake Chisholm; George Lochead; Mark Doucette; janied@sub-arctic.ca
Cc: Darko Filipic; Roland Jones; Boyd Barstad; Kendell Cator; Kaitlyn Kooy; Kyle Scale; Julian Sobkow; Olivier Sonier
Subject: Standardized Asbuilt Process
Attachments: QC 170207 D1 Excavation 0+450 to 0+480 cut-fill design to excavation.pdf; QC 170210 D1 KT EXCAVATION 0+570-0+580.pdf; QC 170210 D1 KT EXCAVATION 0+550-0+560.pdf

Team,

Based on previous discussions, it is important to standardize the asbuilt process. In efforts to speed up the approval process, the attached examples are what should be presented to SRK. The only addition that needs be included is the slopes and Key Trench crest on the cut and fill map. The stations should also be added to the file names so they can be referenced in the future.

Furthermore, it is important that grades, toes and crests are being checked periodically in the areas that are being worked. Rework like what happened from station 2+30 to 1+30 a few days ago, needs to be mitigated. We **cannot** afford to go back and excavate a section that has already been cleaned.

Below is the process that should be followed:

1. Sub-Arctic is to periodically check the areas that Nuna has been working on till it has met all design requirements.
2. Once all design requirements are met, Nuna should be informed so detail cleaning can commence.
3. While detail cleaning, the next section should be marked.
4. Then Nuna can move to the next section and the area that has been cleaned can be asbuilt.
5. As the asbuilts are being processed, SRK will inspect the section and confirm that it has been adequately cleaned.
6. The asbuilts will be distributed to this list so everyone involved can review them.
7. SRK will reply with an email verifying that the section is approved and the next work front can commence.
8. Back to step One.

It is important that this process is followed because the project is getting to a point were multiple work fronts are occurring and SRK will require asbuilts for each material change on the Dam.

If you have any questions, feel free to ask.

Regards,

Gramoz Rexhepi
Project Coordinator
Site: 867-988-6882 ext 123
Cell: 587-920-9486

NUNA WEST MINING LTD
TMAC Resources – Hope Bay South Dam Project
GramozR@nunalogistics.com
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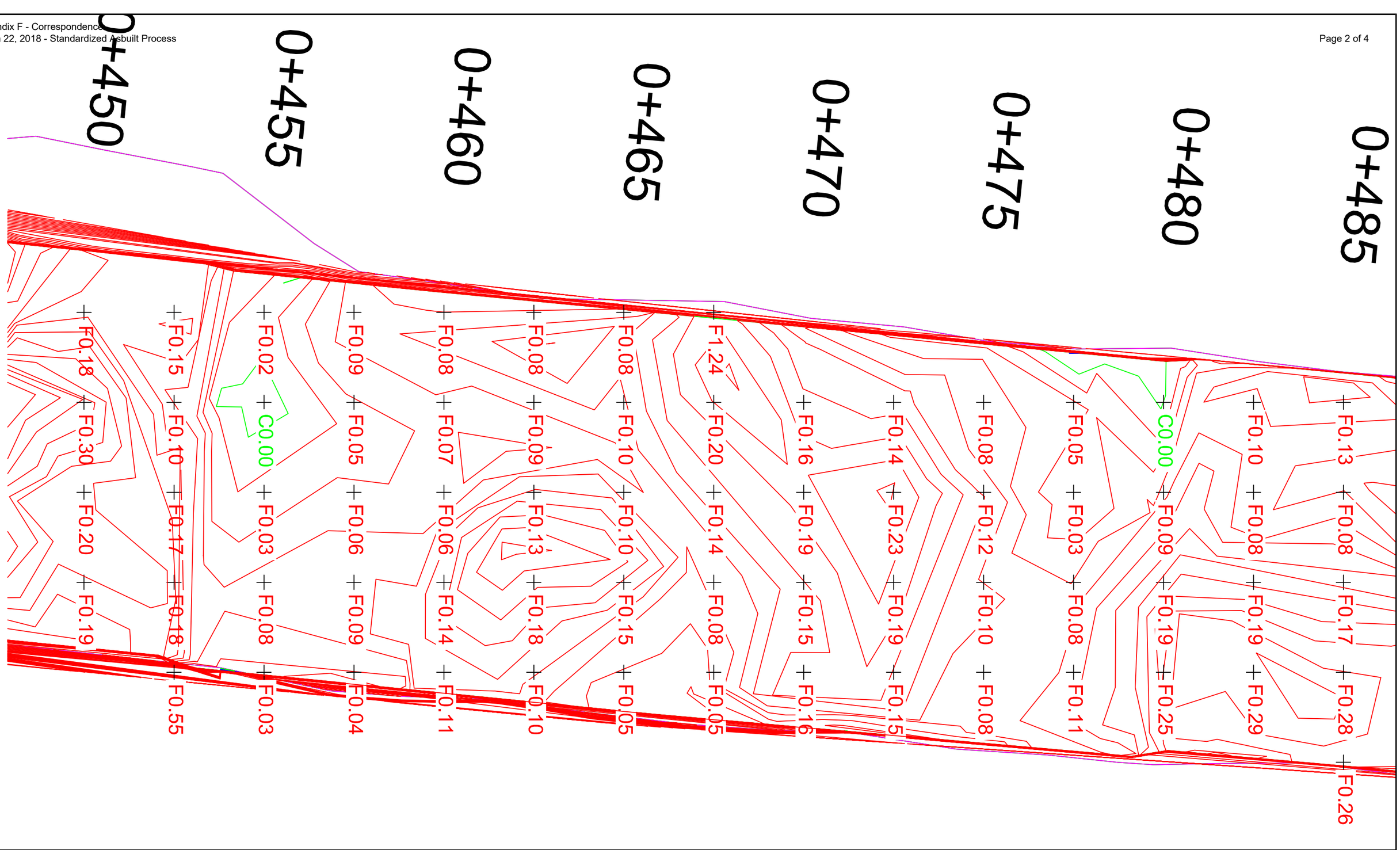
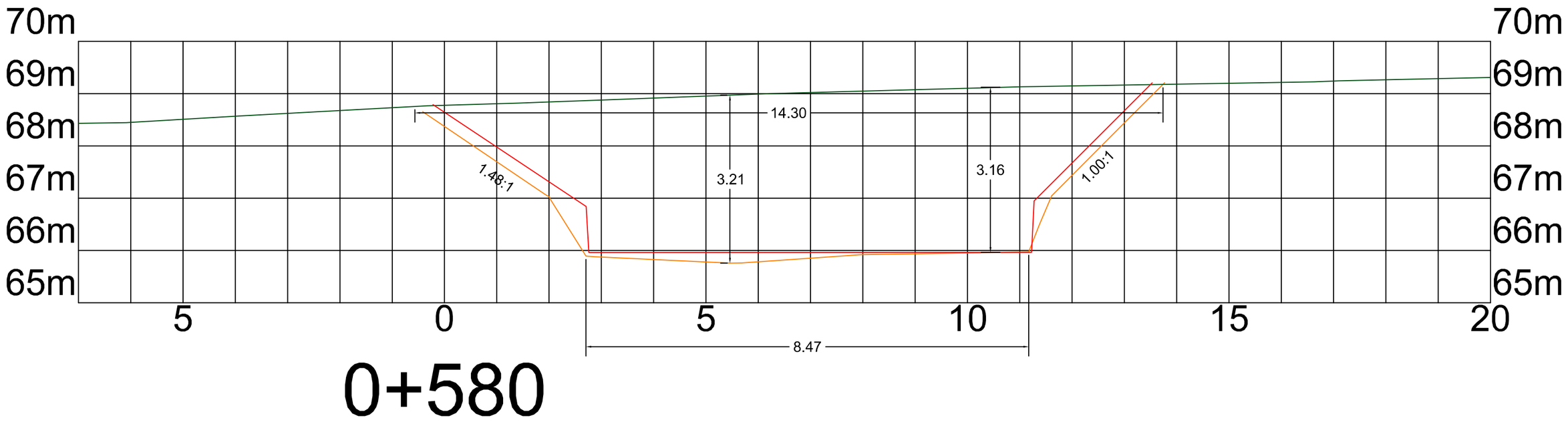


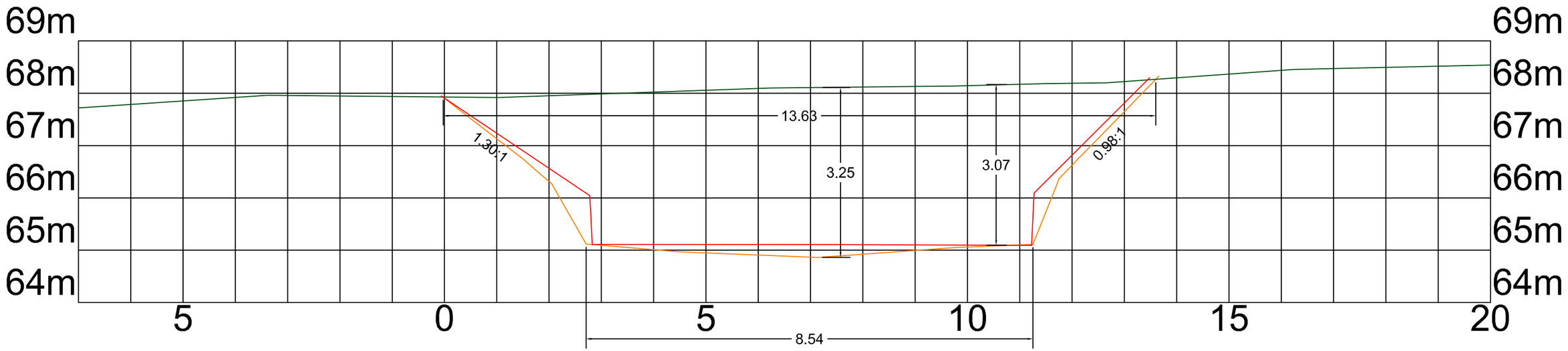
NOTES:

- Exc Line
- Fill Contour up to -2.9m EL
- Grade Contour

CLIENT: AGNICO EAGLE Meliadine Gold Project	PREPARED BY: MTKSL Contracting Joint Venture 19-41 Street South PO Box 809 Rankin Inlet, Nunavut Y0C 0G0	MTKSL CONTRACTING JOINT VENTURE	DCP-1
PROJECT: Agnico Eagle Meliadine Civil Works Dike Construction 2016-2017	DRAWN BY: LF	SCALE: As Shown / DATE: Feb 07 2017	DRAWING TITLE: Key Trench Excavation 0+450 - 0+500
			DRAWING NAME (YYMMDD): QC 170207 D1 Excavation 0+450 to 0+480.dwg



0+580



0+570

NOTES:
- Excavation As-Built
- Hamel Original Ground
- Design

CLIENT: AGNICO EAGLE
Meliadine Gold Project

PROJECT: Agnico Eagle Meliadine Civil Works
Dike Construction 2016-2017

PREPARED BY:
MTKSL Contracting Joint Venture
19-41 Street South PO Box 809
Rankin Inlet, Nunavut
Y0C 0G0

DRAWN BY: LF

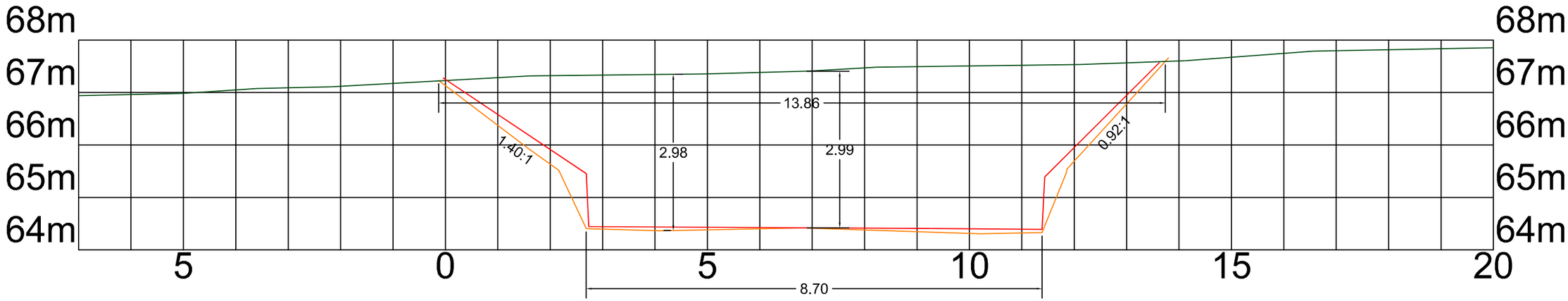
SCALE: As Shown

DATE: Feb 12 2017

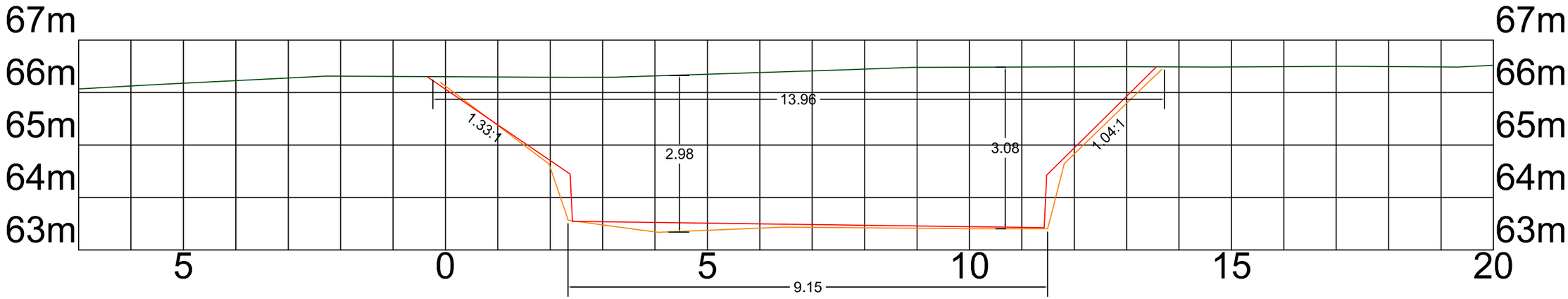
DCP-1

DRAWING TITLE: Key Trench Excavation 0+570 - 0+580

DRAWING NAME (YYMMDD): QC 170210 D1 Excavation 0+550 - 0+580.dwg



0+560



0+550

NOTES:
- Excavation As-Built
- Hamel Original Ground
- Design

CLIENT: AGNICO EAGLE
Meliadine Gold Project

PROJECT: Agnico Eagle Meliadine Civil Works
Dike Construction 2016-2017

PREPARED BY: MTKSL Contracting Joint Venture
19-41 Street South PO Box 809
Rankin Inlet, Nunavut
Y0C 0G0

DRAWN BY: LF

SCALE: As Shown

DATE: Feb 12 2017

DCP-1

DRAWING TITLE: Key Trench Excavation 0+550 - 0+560

DRAWING NAME (YYMMDD): QC 170210 D1 Excavation 0+550 to 0+580.dwg

Seema Kang

From: Cameron Hore
Sent: Sunday, March 25, 2018 1:30 PM
To: Kaitlyn Kooy; Kendell Cator
Cc: NA 1CT022.031 HopeBay; John Kurylo
Subject: FW: Updated QA/Qc documents
Attachments: GCL Documentation.xlsx; Daily Construction Summary Report Template.docx; Inspection and Testing Reports Template.docx; Problem Identification and Corrective Measures Reports Template.docx

Hi Guys,

Please have a look at this documentation and let John know if you see any issues. This is not a critical task that needs to be done today. But in the next couple of days.

Cheers

Cameron Hore *CPEng P.Eng*
srk consulting
Direct: +1-604-235-8533

From: Nikolas [mailto:nikolas@blombergbuilding.com]
Sent: Sunday, March 25, 2018 11:40 AM
To: Cameron Hore <chore@srk.com>
Cc: 'Gramoz Rexhepi' <GramozR@nunalogistics.com>
Subject: Updated QA/Qc documents

Hello Cameron,
I have made some new QA/QC documents for the south dam. I have updated our documentation protocol as well, please let me know if you think these are sufficient to uphold the quality of the project.

Cheers,

Nikolas Blomberg
Supervisor
Blomberg Building group
W: 867-988-6882 ext. 134
C: *604-910-2330*
BLOMBERG BUILDING

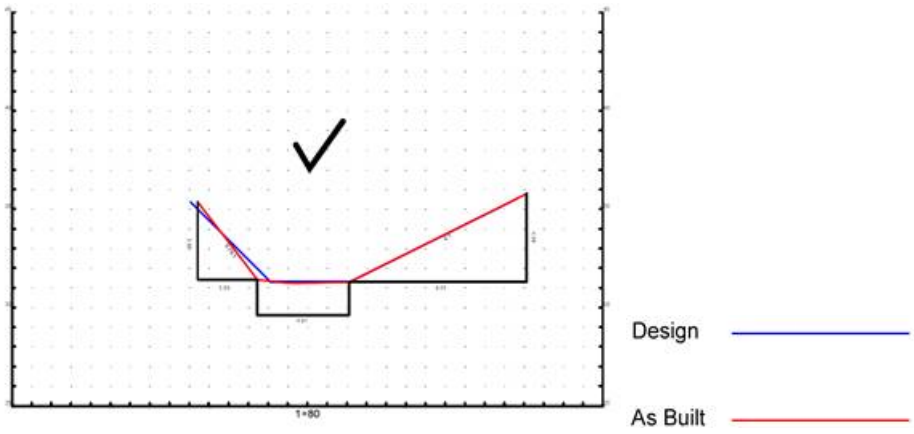
Seema Kang

From: John Kurylo
Sent: Sunday, March 25, 2018 12:30 PM
To: Gramoz Rexhepi; Cameron Hore
Cc: Kelly Schwenning; Rob Cook; Darko Filipic; Boyd Barstad; 'Murray Weddell'; Maritz Rykaart; Kendell Cator; Kaitlyn Kooy; NA 1CT022.031 HopeBay
Subject: RE: SRK Review of Key Trench Excavation As-built from 0+90 to 2+00 - March 25, 2018
Attachments: 0223-SD KT ASB CS_SRK.PDF

Hi Gramoz,

The guidance on approvals was given to our site staff by Cam and myself. In general our tolerances for approval started more in the range of +- 5cm (not mm) and were already relaxed more to 10cm from design lines in most area. So the comment of going back and forth over a few millimeters is misleading and incorrect.

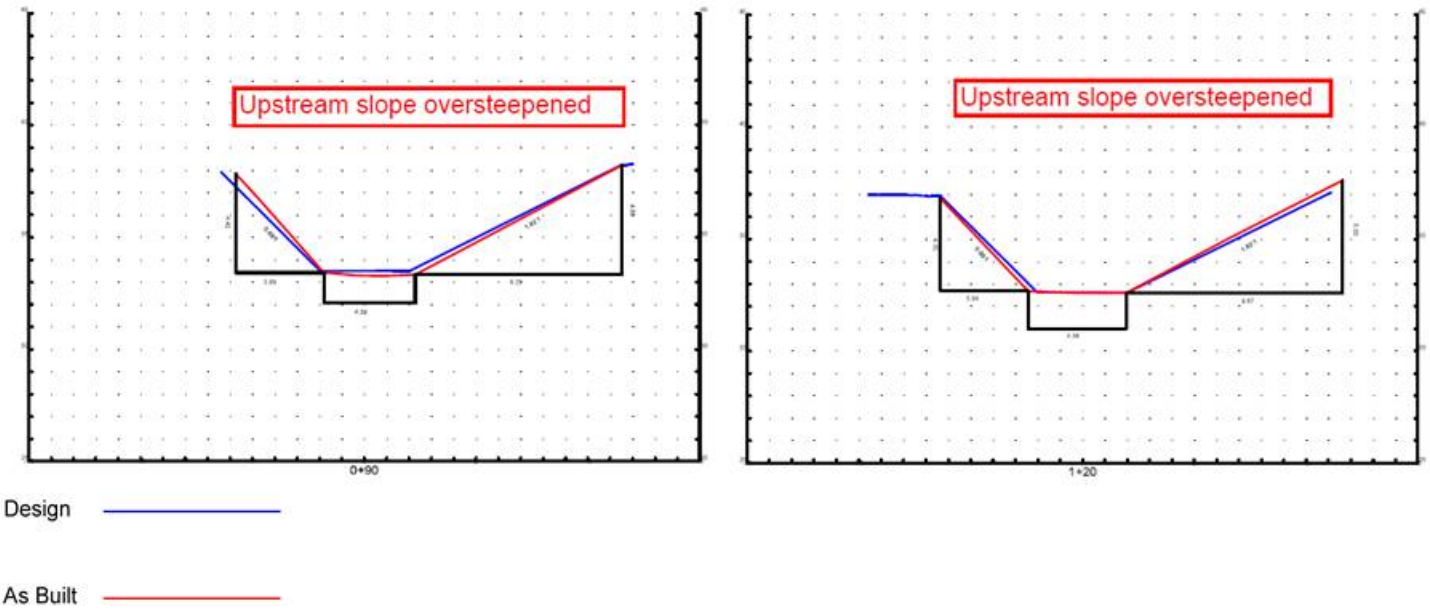
As you will see in the as-builts there are multiple portions of the downstream slope that are slightly oversteepened however, these have been accepted as field fit modifications based on existing conditions. An example of an oversteeped portion of the downstream slope that was already accepted is shown in the section screenshot below (where the red line is the as-built surface.



This being noted, for the key trench, we have focuses on looking at the upstream slopes to make sure that we have our minimum 2H:1V slopes in the overburden areas for liner placement and long term stability. If we went with a steeper upstream slope then we would have to backfill the bedding material in lifts over the liner to ensure we have adaquate slopes stability, and we were not planning to do this approach.

The upstream slope design of 2H:1V is already near the desing limits for our overliner material. Going steeper than this increaes the risk of material slumping over the liner (which could result in rework and also could pull down and damage the GCL liner). For example, the angle of internal shearing resistance of the GCL itself is expected to be in the reange of 28° (peak) and much much lower for residual or under larger displacements. This of course also assumed ideal conditions and there are many possible things that could assit to reduce this interface shearing angle. A slope of 1.9H:1V gives us 28° [arctan(1/1.9)] which would theoretically put us at a FOS of 1. This would gives us absolutely no buffer for any field variations (and put a lot of faith that the GLC we have on site has the same angle of internal shearing resistance as the literature). Areas with overall upstream slope angles between 1.9H:1V and 2H:1V can be looked at on a case by case basis in the field but any larger areas that are steeper than 2H:1V would need to be revisited. In general upstream slopes that are close to 1.9H:1V or steeper are unacceptable. Upstream key trench slopes that are 2H:1V or

shallower are ok. Based on the current as-built, as detailed in Kendell's note, around sections 0+90 and 1+20 are the worse areas where the upstream slopes are oversteepeded. I.e.



I will take another look over all the as-built data this morning but overall we have already incorporated some leniency on the slope tolerances. If any changes in approval result these will come through our onsite staff however, unless you hear otherwise our original approvals, and areas requiring additional work, stand.

Regards,
John

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

From: Gramoz Rexhepi [mailto:GramozR@nunalogistics.com]
Sent: Sunday, March 2018 10:05
To: Cameron Hore <chore@srk.com>; John Kurylo <jkurylo@srk.com>
Cc: Kelly Schwenning <kelly.schwenning@tmacresources.com>; Rob Cook <robc@nunalogistics.com>; Darko Filipic <DarkoF@nunalogistics.com>; Boyd Barstad <boydb@nunalogistics.com>; 'Murray Weddell' <murray.weddell@tmacresources.com>
Subject: FW: SRK Review of Key Trench Excavation As-built from 0+90 to 2+00 - March 25, 2018
Importance: High

Gents,

I think there needs to be more leniency on these tolerances. It is very difficult to achieve this level of detail on a ripped frozen slope.

This area has been ripped and as built multiple times and it still hasn't been fully approved. It was almost ready for detail cleaning and liner placement last week and we are still going back and forth over a few millimeters

Let me know your thoughts.

Regards,

Gramoz Rexhepi
Project Coordinator
Site: 867-988-6882 ext 123
Cell: 587-920-9486

NUNA WEST MINING LTD
TMAC Resources – Hope Bay South Dam Project
GramozR@nunalogistics.com
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From: Kendell Cator [mailto:kcator@srk.com]
Sent: Sunday, March 25, 2018 9:49 AM
To: Jake Chisholm <jakec@sub-arctic.ca>; Kaitlyn Kooy <kkooy@srk.com>; Gramoz Rexhepi <GramozR@nunalogistics.com>; Julian Sobkow <julians@nunalogistics.com>
Cc: Mark Doucette <markd@sub-arctic.ca>; georgel@sub-arctic.ca; janied@sub-arctic.ca; samb@sub-arctic.ca; Cameron Hore <chore@srk.com>; John Kurylo <jkurylo@srk.com>; Kyle Scale <kscale@srk.com>
Subject: SRK Review of Key Trench Excavation As-built from 0+90 to 2+00 - March 25, 2018

All,

Attached is the as-built survey of key trench excavation from ~0+90 to 2+00 received on March 24, 2018. SRK's comments have been included on the attached, describing:

- SRK approves the excavation of key trench from stations 1+00 to 1+10 and from 1+30 to 1+90.
- Due to an over steepened upstream slope, SRK does not approve key trench excavation at stations 0+90, 1+20, and 2+00.

Thanks,

Kendell

Kendell Cator *EIT.*
Consultant (Geotechnical Engineering)
srk consulting
SRK Consulting (Canada) Inc.
Suite 205, 2100 Airport Drive, Saskatoon, Saskatchewan, S7L 6M6, Canada
Direct: +1-306-955-4773; **Mobile**:+ 1-306-587-7757
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www.srk.com

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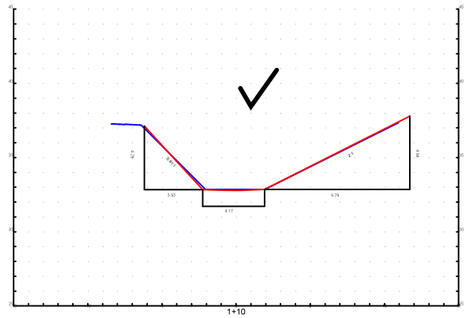

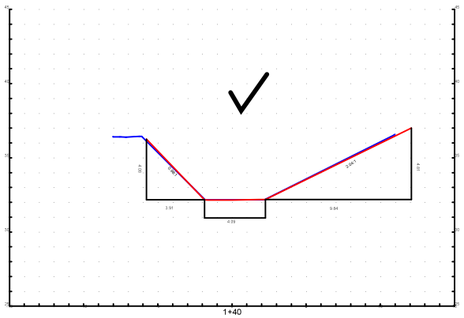

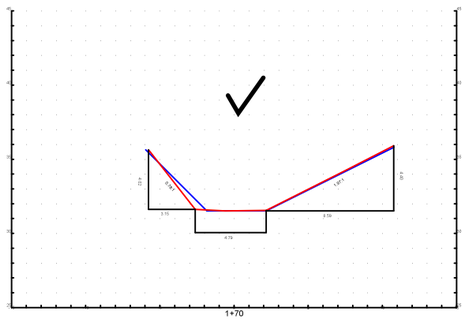

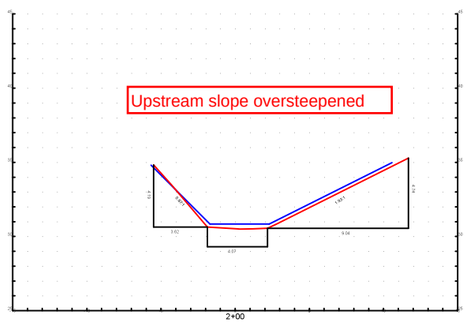

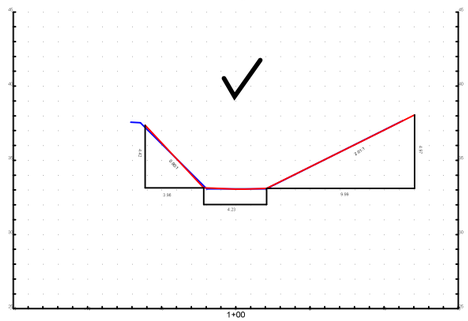

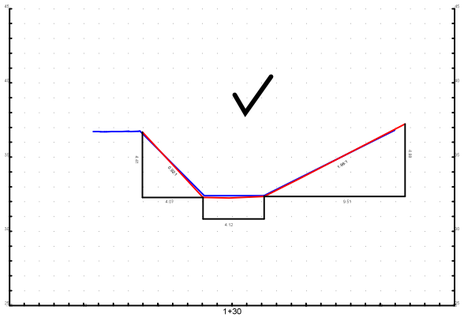

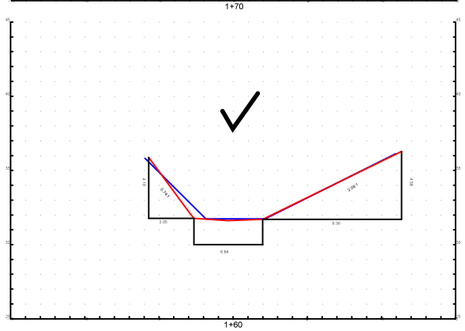

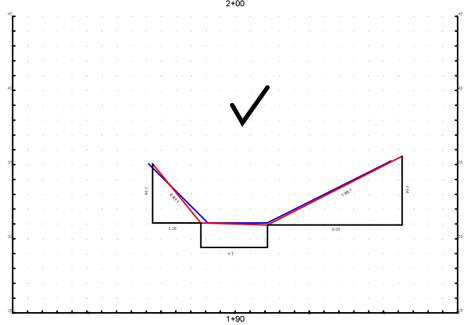

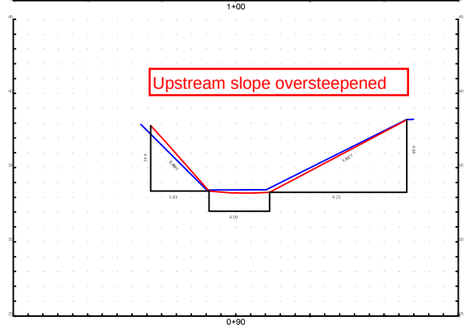

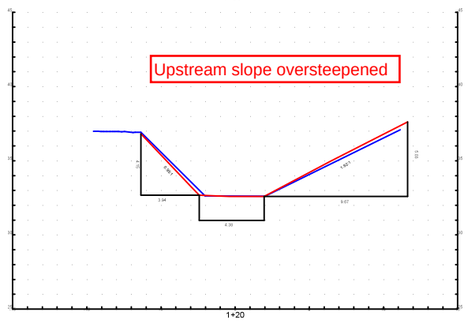

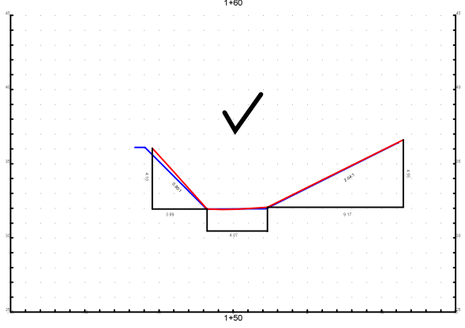

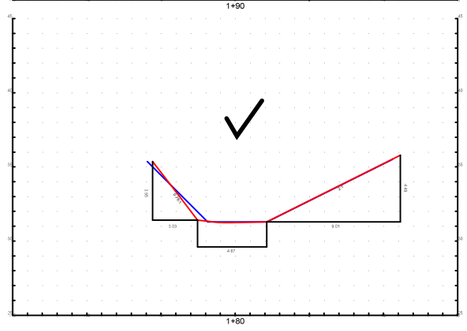

NOTES

Horizontal Scale 25

Vertical Scale 25

Design

As Built

NO.	REVISION\ISSUE	DATE:

DRAWN BY: JC

CHECKED BY: JC

TMAC RESOURCES

SOUTH DAM
KEY TRENCH AS BUILD
0+90 to 2+05

HOPE BAY MINE – N.U.

FILE NO.: 0323–SD KT ASB

DATE: MARCH 23, 2018

SCALE: NTS

SUB–ARCTIC GEOMATICS LTD.
a CHALLENGER GEOMATICS LTD. company
BOX 2441 YELLOWKNIFE
NORTHWEST TERRITORIES X1A 2P8
PHONE: 873–2047 FAX: 873–9079
WEB PAGE www.sub–arctic.ca
E–MAIL sas@sub–arctic.ca

Seema Kang

From: Kaitlyn Kooy
Sent: Thursday, March 29, 2018 7:39 PM
To: 'Eric Blomberg'; Gramoz Rexhepi; Boyd Barstad; Darko Filipic; Roland Jones
Cc: Maritz Rykaart; John Kurylo; Cameron Hore; Kendell Cator; Kyle Scale; Ryan Williams
Subject: Dry Cement / Fly Ash Mix Design and Specification

Hi All,

The use of a dry cement / fly ash mix as a means to prepare the key trench slopes for liner placement in blasted bedrock areas has been approved by SRK. The design and specifications are as follows:

1. Mix Design - 4 parts aggregate : 1 part fly-ash : 1 part cement

2. Quality Control testing is required as follows:
    a. For each individual batch mixed, at least 2 samples each of the aggregate and fly-ash prior to mixing must be submitted for particle size analysis (hydrometer not required);
    b. For each individual batch mixed at least 2 completely mixed samples of the 4:1:1 blend must be submitted for particle size analysis (hydrometer not required).

3. Quality Assurance testing is required as follows:
    a. For each individual batch mixed, at least 1 completely mixed sample of the 4:1:1 blend, taken from the placed location must be submitted for particle size analysis (hydrometer not required).

4. The mix design must be placed in lifts no greater than 200 mm (loose density) and compacted using a method specification that will ensure a firm competent surface.

Note: A rush order should be placed on the samples collected from the first mixed batch as the lab results are needed as soon as possible to confirm the mix design.

Please let me know if you have any questions.

Regards,
Kaitlyn

Kaitlyn Kooy, *EIT*
Staff Consultant
srk consulting
SRK Consulting (Canada) Inc.
22nd Floor, 1066 West Hastings Street, Vancouver, BC, V6E 3X2, Canada
Tel: +1-604-681-4196; **Fax**: +1-604-687-5532
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Seema Kang

From: Kaitlyn Kooy
Sent: Sunday, April 1, 2018 9:24 AM
To: John Kurylo; Cameron Hore
Cc: Kendell Cator; Kyle Scale; Ryan Williams
Subject: FW: South Dam Key Trench
Attachments: Operational Work Plan GCL South dam.docx; GCL Documentation.xlsx

FYI

From: Nikolas [mailto:nikolas@blombergbuilding.com]
Sent: Sunday, April 1, 2018 8:54 AM
To: Kaitlyn Kooy <kkooy@srk.com>; 'Gramoz Rexhepi' <GramozR@nunalogistics.com>; DarkoF@nunalogistics.com; 'Boyd Barstad' <boydb@nunalogistics.com>; 'Eric Blomberg' <eric@blombergbuilding.com>; jonas@blombergbuilding.com; kelly.schwenning@tmacresources.com
Subject: South Dam Key Trench

Hello all,

Boyd, Darko, Kaitlyn and I had a quick meeting this morning where we discussed our plans for today. As per discussions we will laying liner in the afternoon, before we lay liner we have a little more surface preparation. Included is a quick blow off of the surface (2+00 -1+50), after which we will be filling voids in the slope surface. Kaitlyn said she will be present for the filling of voids as her discretion is necessary. The Procedures and details for filling can be found in 2.4 – 2.8 of our attached operation work plan. Boyd has given us the permission to use an operator for the 349 to assist in deployment of the GCL liner. I have also attached our signoff and documentation required for each phase of the project. Please let me know if you have any questions!

Regards,

Nikolas Blomberg
Supervisor
Blomberg Building group
W: 867-988-6882 ext. 134
C: *604-910-2330*

BLOMBERG BUILDING

Operational Work Plan

Project: South Dam Phase 1 GCL	Revision: 2
Description: South dam Phase 1 (DN-SD-00 – DN-SD-18)	Date: March 31, 2018

Safety

Description	Potential Hazards	Controls	Notes:
Environmental hazard	Slippery/unstable surfaces	Waddle, watch footing, three points of contact when exiting vehicles and on slopes.	
Environmental hazard	Limited access	Walk in operator's line of sight; don't walk through blind spots. Three points of contact on steep grades.	
Exposure hazards	Weather Conditions	Dress appropriately, wear proper winter gear, check weather daily, buddy system, and follow whiteout procedures.	SEE SWP 0008 Cold weather safety.
Exposure hazards	Bentonite dust inhalation	Wear proper respirator, have fit test complete. Only use approved cartridges, Use in well-ventilated area.	See Section 17 In BBG safety Manual.
Personal Work limits	Overexertion, complacency and Fatigue.	Don't over lift, proper lifting techniques, ask for assistance. Micro breaks, review safe work Practices, mind on task.	
Equipment hazards	Hand tools	Keep blades sharp to avoid skipping, do not walk with blade out, cut away from you.	
Equipment hazards	Mobile equipment	Use spotter; keep in eye contact with machine operator. Use proper horn signals, proper radio communication. Have clean hi visibility PPE.	SEE SWP 0015 for universal hand signals.
Equipment hazards	Rigging material	Use proper rigging techniques, don't walk under load, use taglines, and inspect slings before use.	
Physical energy hazards	Manual lifting, awkward lifting, bending/twisting, repetitive	Use proper lifting technique, don't lift more than 50lbs, Have stable footing, spine in line, lift with your legs, stretch regularly, and stay clear of uphill material.	See

BLOMBERG BUILDING

Operational Work Plan

	motions, unstable positions, pushing/pulling, potential for falling objects.		
Wildlife hazards	Wildlife encounters	Report all sightings, stay in equipment, DON'T FEED ANIMALS, and follow proper bear response protocol.	

Quality Control			
Control description	Critical Items	Actions taken	Notes
Earthworks	Cleaning	Cleaning of surface to ensure, all snow debris, and protruding material is taken off grade. Voids will be blown and clear of foreign material.	On site engineer is to establish acceptable area (2+00 – 1+50). All other surfaces will be prepared to same standard.
Earthworks	Void Fill	The filling of voids is to be done with engineer's approval. Either scrap GCL, or a fly ash and cement mix will be used.	Engineer will be present for process, survey is to shoot all voids that need fill.
Earthworks	Surface inspection	Survey is to shoot locations and dimensions, grade to be uniform with no protrusions.	Take pictures of subgrade before laying GCL down.
GCL inspection	Inspect rolls that arrive to site	Go through rolls; check to see they have been properly handled in accordance with manufactured specifications.	Damaged rolls shall be marked, pictures shall be taken
GCL deployment	GCL	Panels are in accordance with GCL panel layout, overlaps meet spec, all materials are properly inspected, and pictures are taken for visual confirmation.	Photo documentation

BLOMBERG BUILDING

Operational Work Plan

Lapping and joining	Minimum overlap	Overlap is checked frequently, and remains 0.5m min.	Photo documentation
Lapping and joining	Bentonite seam	Bentonite is properly distributed, and is in accordance with the engineer's specs.	Photo documentation
Cover	Fill distribution	All fill is to be properly placed with no deviations from engineer spec.	BBG employee to monitor fill over GCL

Procedure

1.0 Material Storage and handling

1.1 All lot and roll numbers should be recorded. Each roll of GCL should also be visually inspected to determine if any packaging has been damaged. Damage is to be recorded and the affected rolls marked.

1.2 To load and unload the rolls from the flatbed with a spreader bar. Place the core pipe inside the roll tube and then around the spreader bar. Watch to see that slings around the spreader bar do not pinch the GCL material.

1.3 Forks shall not be used to lift carry or place GCL liner.

1.4 If slings are attached to rolls when they arrive you may use slings to lift with Stinger and Hook.

1.5 To Unload rolls from planes an extendable boom forklift must be used (telehandler), rolls that are center or near the front of the cargo bay can be gently pulled toward the door of the aircraft.

1.6 Rolls shall never be stacked on end, and shall be chocked on the bottom layer to prevent rolling or sliding while in storage or transportation. Rolls can be stacked no more than four high.

BLOMBERG BUILDING

Operational Work Plan

2.0 Earthworks

2.1 Once survey of the trench has shown acceptable slope we are able to start the cleaning process.

2.2 The cleaning process will start with employees blowing all snow, loose and protruding material into the bottom of the trench. Any material, or high spots that remain will be taken down with a broom.

2.3 The south face will be cleared of all material, this is a precaution we are taking to ensure no material or snow falls on the deployed liner.

2.4 The third part of slope preparation includes filling voids left in frozen ground. The larger voids will be filled with a cement and fly ash mix. This process will be monitored by the onsite engineer.

2.5 Void filling will be done using buckets on sloped areas, half buckets shall be used to prevent strain on body. The void is to be filled level with surrounding surface.

2.6 Using the steel plate tamping tools, the fill will be compacted into the frozen slope. A bentonite ring around the void may be necessary depending on the size of void (engineers discretion).

2.7 Small networks and channels in the slope may be covered with sacrificial GCL panel or will be filled with dry bentonite powder (engineers discretion).

2.8 Once all the voids have been filled surveyors will shoot voids for an as built design.

3.0 GCL deployment

3.1 For our method of deployment, the roll will be connected to a spreader bar. There will be a metal tube that extends through the roll, two pins will be slid into the tube, slings will connect them to the spreader bar. Two 16ft slings will connect the Spreader to the Excavator. The slings must be able to hold a minimum 10t.

3.2 We will extend the liner as far as possible into the key trench, the ground crew will then pull the liner back to the south toe of the key trench where the liner will be anchored. The excavator will then pull the roll upslope while it is anchored

BLOMBERG BUILDING

Operational Work Plan

at the bottom. Once the liner extends a meter past the crest it will be cut.

3.3 Each successive piece would then be unrolled with a 500mm overlap at the smallest point (indicated with spray paint). Rough maneuvering may be required, this would be done by ground crew. Measuring the overlap every meter to ensure appropriate lapping is achieved.

4.0 Lapping and joining

4.1 For uniform distribution we will use a bentonite spreader. Walking downslope with the spreader, an even amount of bentonite will be dispersed. Folding back the overlapping panel to expose the area for the bentonite seam.

4.2 This will be done once the overlap is acceptable. The bottom edge, will have a bead of bentonite between the frozen ground and GCL liner, this bead will be the same as the longitudinal bentonite seam.

4.3 Panel deployment will be starting at the 2+00 mark and moving east, after which we will move west. Working from panel 2+00 and 3+50 we will have to fold back the panel edge to place the higher panel overlapping.

4.4 The first panel laid will be panel 0, each successive panel deployed will be labeled in chronological order followed by a capital E, or W depending on direction from panel 0. Ex) Panel 0 followed by panel 1E, 2E, 3E… for east, and 1W, 2W, 3W… for west.

4.5 All areas that require repair will be recorded by the engineer, the engineer shall proscribe the method of repair to be used. *Repairs will be done with a 500mm overlap from the damaged area. *

BLOMBERG BUILDING

Operational Work Plan

5.0 GCL cover

5.1 The meter of exposed liner at the hinge point would be covered with geotextile and 100mm of bedding material. The hinge point will be barricaded and taped off as to ensure no vehicles are driven on top if it.

5.2 When the liner is in place and ready for fill, we will spray-paint horizontal marks across the seams. This will show any shifting of the GCL liner during backfill.

5.3 GCL cover will be cast into the bottom of the trench with, a 349 excavator from the south side of the dam. The 308, and skid steer will be used to flatten and push material.

5.4 On the exposed edge of liner, a piece of Geotextile will be placed, it will then be filled with 300mm of bedding material, so we can drive the Skid steer and the 308 onto the covered panels.

5.5 The bedding material is to be pushed or pulled from the overlapping panel to the underlying panel. This may be done with the 308 excavator. No material is to be dropped on liner on the slope all material must be pushed up the liner using the blade on the 308.

Task Description	Material	Quantity	Notes
Key Trench	GCL Liner - Cetco Bentomat CLT	8395m^2	Area + 15% Overlap (m^2)
Liner for Phase 1 Dam	GCL Liner - Cetco Bentomat CLT	8855m^2	Area + 15% Overlap (m^2)

Seema Kang

From: John Kurylo
Sent: Friday, April 6, 2018 4:44 PM
To: Kelly Schwenning; 'Murray Weddell'; Darko Filipic; Gramoz Rexhepi; Boyd Barstad; Roland Jones
Cc: NA 1CT022.031 HopeBay; Silkie Wong; Kendell Cator; Kyle Scale; Ryan Williams; Maritz Rykaart; Kaitlyn Kooy; Cameron Hore; John Kurylo; 'Mark Doucette'; Jake Chisholm; janied@sub-arctic.ca; George Lochead
Subject: Hope Bay - Technical Specifications - IFC - Revision H
Attachments: HopeBay_TechSpecs_1CT022.031_20180406_KC_IM_JK_EMR.PDF

Hi all,

For completeness, attached to this email please find an updated version of the Hope Bay Technical Specifications - Issued For Construction – Revision H. This latest version of the technical specifications supersedes all previous version. Note that this specification document is a document that outlines many of the "rules" and "constraints" of earthworks construction at Hope Bay. This technical specification will be for future projects as well the current South Dam construction (i.e. not all sections will be relevant to the current South Dam work).

Overall the main changes in this document is that it has been updated to reflect the current parties on site (i.e. TMAC, Nuna and SRK), this spec removes a few items that are no longer relevant, and it complements the QC and QA work that is already being currently implemented on site.

If you have any questions when you review the attached then please let myself or one of the onsite SRK personnel know.

Kind Regards,
John

John Kurylo *MSc (DIC), PEng*
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Technical Specifications
Earthworks and Geotechnical Engineering
Hope Bay Project, Nunavut Canada
Revision H – Issue for Construction

Prepared for

TMAC Resources

Prepared by

SRK Consulting (Canada) Inc.
1CT022.031
April 2018

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

April 2018

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File Name: HopeBay_TechSpecs_1CT022.031_20180406_KC_IM_JK_EMR.docx

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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

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 TMAC Resources Inc., or an authorized representative of the company. TMAC Resources Inc, Owner, TMAC 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 spillway.

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

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

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

(25) 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; and
   (6) Core.
2. All construction materials shall be non-acid generating, free of organic matter or similar impurities, as well as snow and ice.
3. 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.
4. 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

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.

5.2.4 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.

5.3 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

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QC Test Frequency	Submittal
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 Thermometer or Temperature Gun)	At Source	Immediate	Ongoing	None

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

Material Type	Sample Location	Sample Type	Test Type	Test Location	Expected Turnaround Time	QA Test Frequency	Submittal
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
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 water tight 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 work day 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 work day.

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 ----------

Seema Kang

From: John Kurylo
Sent: Friday, April 6, 2018 8:25 AM
To: 'Mark Doucette'; Jake Chisholm; janied@sub-arctic.ca; George Lochead
Cc: NA 1CT022.031 HopeBay; Ryan Williams; Kendell Cator; Kaitlyn Kooy; Kyle Scale; Darko Filipic; Gramoz Rexhepi
Subject: South Dam - updated KT bedding and transition surfaces for guidance
Attachments: 180403 - updated KT Bedding.dxf; 180403 - updated KT Transition.dxf; 180403 - updated KT Bedding.xml; 180403 - updated KT Transition.xml

Hi Mark and Jake,

Attached please find dxf files and LandXML surface files for updated Key Trench Bedding and Transition material surfaces. Note that these surfaces match the latest / updated key trench design that was done when the updated original ground topo was sent out by you guys last month.

What you have been doing on site for the bedding (checking that we have a minimum 0.3m cover) has been working well in the overburden portions of the key trench slopes that we have recently working on. This being noted, all of the areas we have been working on recently had the underlying subgrade slope at an overall as-built grade of 2H:1V. I expect that in the areas where we have bedrock in the key trench (and not overburden) there will be a few areas where the blasted rock slopes are greater than 2H:1V. Therefore when it comes to placing the bedding material over the liner in these steeper bedrock areas we will want to make sure that that the overliner bedding material is a minimum of 2H:1V or shallower.

Therefore for these steeper bedrock areas in the key trench, the attached updated design surfaces may be helpful / more relevant to use than just adding 0.3m of fill over the liner everywhere. I will pop by later on today and we can overlap on this in person.

Cheers,
John

John Kurylo *MSc (DIC), PEng*
Senior Consultant (Geotechnical)
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Please consider the environment before printing this e-mail.

Seema Kang

From: Ryan Williams
Sent: Sunday, April 15, 2018 10:51 AM
To: John Kurylo; Kendell Cator; Kaitlyn Kooy; Kyle Scale
Subject: Hope Bay South Dam - Installed GTCs at 2+40

Hey guys,

I went to get the cable for SD-HTC-240-KT but it wasn't labelled correctly in Beaded Stream's order sheet. I believe they named it SD-VTS-240-KT (serial ID 3256). The sensor spacing looks correct though, it's just named incorrectly.

However in my haste to get out there and install it, the mislabeled name confused me and instead I looked for a different cable that had the exact same sensor spacing. I took GTC cable #3254, which was panned for 4+60.

So when we come to 4+60 to install SD-HTS-460-KT, don't be worried that you can't find #3254, just use #3256.

Hope that makes sense. Give me a shout if you have any questions.

Thanks,
Ryan

Ryan Williams *BEng (Civil)*
Direct:+1-604-235-8546 **Mobile**:+1-778-834-0524
Email: rwilliams@srk.com; **Skype**: willir05

Seema Kang

Subject: FW: Hope Bay - South Dam - IFC Rev1 Drawings
Attachments: 1CT022.031_HB_SDam_IFC_Rev1_20180413_compiled.pdf

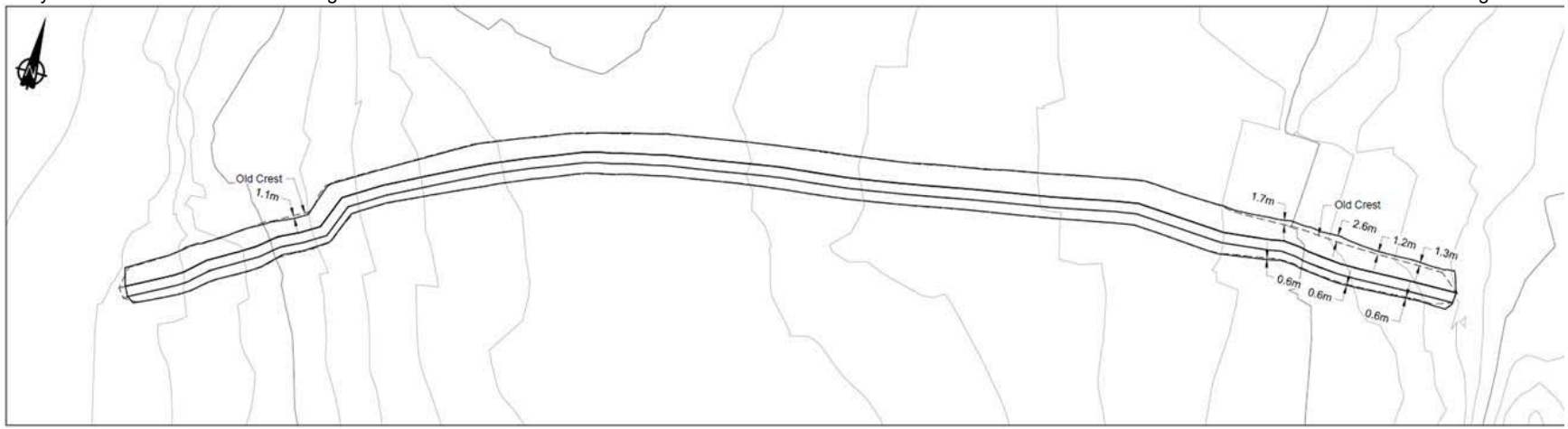
From: John Kurylo
Sent: Wednesday, April 18, 2018 12:28 AM
To: 'Kelly Schwenning' <kelly.schwenning@tmacresources.com>; 'Murray Weddell' <murray.weddell@tmacresources.com>; Gramoz Rexhepi <GramozR@nunalogistics.com>; Darko Filipic <DarkoF@nunalogistics.com>; Roland Jones <RolandJ@nunalogistics.com>; Boyd Barstad <boydb@nunalogistics.com>; Mark Doucette <markd@sub-arctic.ca>; Jake Chisholm <jakec@sub-arctic.ca>; George Lochead <georgel@sub-arctic.ca>; janied@sub-arctic.ca; samb@sub-arctic.ca; Rob Cook <robc@nunalogistics.com>
Cc: Maritz Rykaart <mrykaart@srk.com>; Kyle Scale <kscale@srk.com>; Kaitlyn Kooy <kkooy@srk.com>; Christopher Stevens <cstevens@srk.com>; Silkie Wong <swong@srk.com>; Cameron Hore <chore@srk.com>; Kendell Cator <kcator@srk.com>; Ryan Williams <rwilliams@srk.com>; John Kurylo <jkurylo@srk.com>
Subject: Hope Bay - South Dam - IFC Rev1 Drawings

Hi everyone,

Attached to this email please find an updated “Issued for Construction” (IFC), Revision 1, drawing package. These drawings supersede the previous (original) South Dam IFC drawing revisions submitted.

Note that the main updates in these drawings are as follows:

1. Details on the instrumentation are included (which SRK and site personnel have already started installing on site);
2. Additional ROQ material has been added to the designs of the downstream (DS) slope of the dam (which shallows the slope and assist to create access on the DS – as previously discussed);
3. The outside slopes (Transition and ROQ) has been updated based on the updated original ground topography survey for the east and west abutment (updates as shown in the screenshot below);



4. The updated key trench design updates which were previously communicated and provided (and what has been constructed on site) are documented in these drawings; and
5. As-built drawings for the percolation testing and sonic / infill drilling completed in January and February are included

The attached IFC drawings show the neat-line design lines for the South Dam. As is being currently completed on site the as-built key trench surface should continue to be used to make the field fit adjustments (as per the discussions that have resulted with SRK site staff on site, and as per the Revision H Technical Specifications).

If you have any questions when you review the attached then please let myself or SRK site staff know.

Regards,
John

John Kurylo *MSc (DIC), PEng*
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Hope Bay Mining Ltd.

Doris North Project

Engineering Drawings for the South Dam - Phase 1

Drawing Number	Drawing Title	Issue	Date	Revision	Old / Replaced Revisions
DN-SD-01	Phase 1 General Arrangement (with Orthophoto)	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-02	Phase 1 General Arrangement	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-03	Typical Sections (General)	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-04	Key Trench Excavation Plan and Profile	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-05	Liner Placement Plan and Details - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-06	Liner and Bedding Placement Details	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-07	Bedding Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-08	Transition Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-11	Construction Access Road and Turn Around - Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-12	Final Phase 1 Dam Plan, Profile and Sections	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-13	Sections Sta. 0+10 to 0+90 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-14	Sections Sta. 1+00 to 1+80 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-15	Sections Sta. 1+90 to 2+70 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-16	Sections Sta. 2+80 to 3+60 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-17	Sections Sta. 3+70 to 4+50 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-18	Sections Sta. 4+60 to 5+30 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29
DN-SD-19	Infill Foundation Drilling - Phase 1	Issued for Construction	March 7, 2018	AB	Rev 0, 2018/02/16
DN-SD-20	Percolation Borehole / Test Locations	Issued for Construction	March 7, 2018	AB	Rev 0, 2018/02/16
DN-SD-21	Instrumentation Plan - Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07
DN-SD-22	GTC backfilled Cable Trench - Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07
DN-SD-23	Vertical GTC Layout - Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07
DN-SD-24	Horizontal GTC - Upstream Base / Toe of Key Trench	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07
DN-SD-25	GTC Layout Along Upstream Above Ground Liner Slope	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07
DN-SD-26	Sloped GTC - Above Ground Liner Slope	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07
DN-SD-27	Instrumentation Details at Sta. 0+65 and 1+55	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07
DN-SD-28	Instrumentation Details at Sta. 2+40 and 3+65	Issued for Construction	March 7, 2018	0	
DN-SD-29	Instrumentation Details at Sta. 4+65 and 5+10	Issued for Construction	March 7, 2018	0	
DN-SD-30	Typical Monitoring Point Details	Issued for Construction	March 7, 2018	0	

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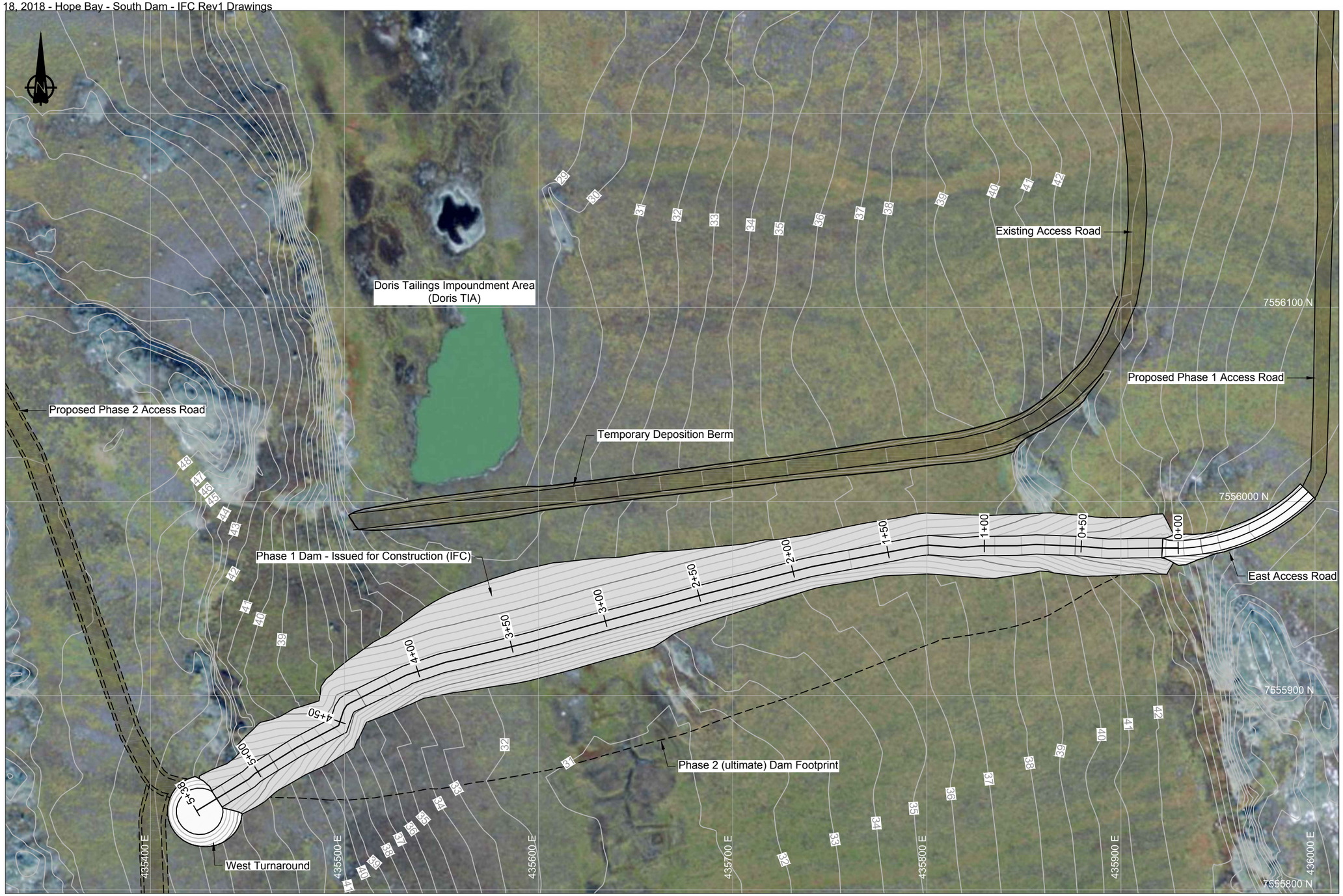


LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Imagery (from 2010 PhotoSat compilation) provided by client.
5. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

0m 20 40 60 80

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

Original Drawings Stamped and Signed by Engineer

This drawing is uncontrolled when printed unless stamped and signed with original ink and recorded on a Distribution Register.

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam GA - with ortho.dwg

TMAC RESOURCES

Hope Bay Project

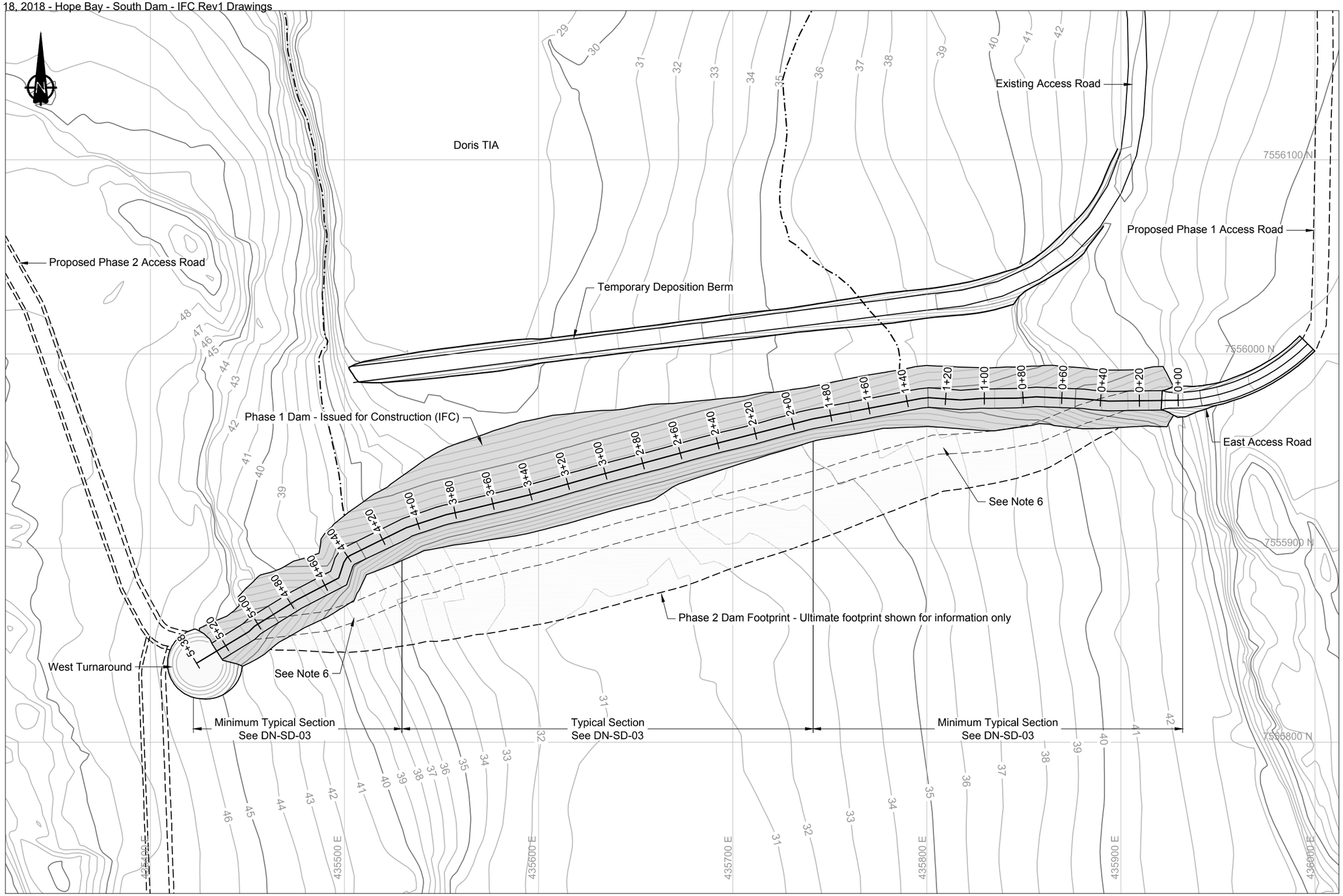
SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:
Phase 1 General Arrangement (with Orthophoto)

DRAWING NO.	SHEET	REVISION NO.
DN-SD-01	1 OF 30	1

P:\01_SITES\Hope Bay\AGA\DI\FC\South Dam - Phase 1 r1\1CT0022.017 - South Dam GA - with ortho.dwg



LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Volumes presented based on neat-lines only and are approximate. These include no over-excavation or over-blasting allowance of the key trench.
5. All units shown are in meters unless otherwise stated.
6. Bend in the dam crest is to accommodate Phase 2 liner tie-in.
7. All snow roads placed on the upstream as a temporary construction measure, to help facilitate construction of the dam, must be completely removed before tailings deposition may commence.

REFERENCES

NAD83 UTM Zone 13.

TABLE OF QUANTITIES (NEAT-LINE)

Key Trench Bulk Excavation :	19,500m³
Total Phase 1 Fill:	68,500m³
ROQ:	36,800m³
Transition:	26,100m³
Bedding:	5,600m³
Total Liner:	14,300m
West Turnaround (bulk):	2,000m³
East Access Road (bulk):	1,200m³

*all volumes presented are to neat-lines and do not allow / account for bulking and compaction.

0m 20 40 60 80

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

Original Drawings Stamped and Signed by Engineer

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam GA.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Phase 1 General Arrangement

DRAWING NO.	SHEET	REVISION NO.
DN-SD-02	2 OF 30	2

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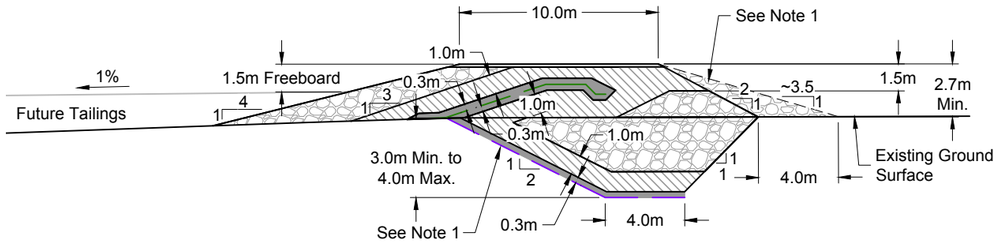
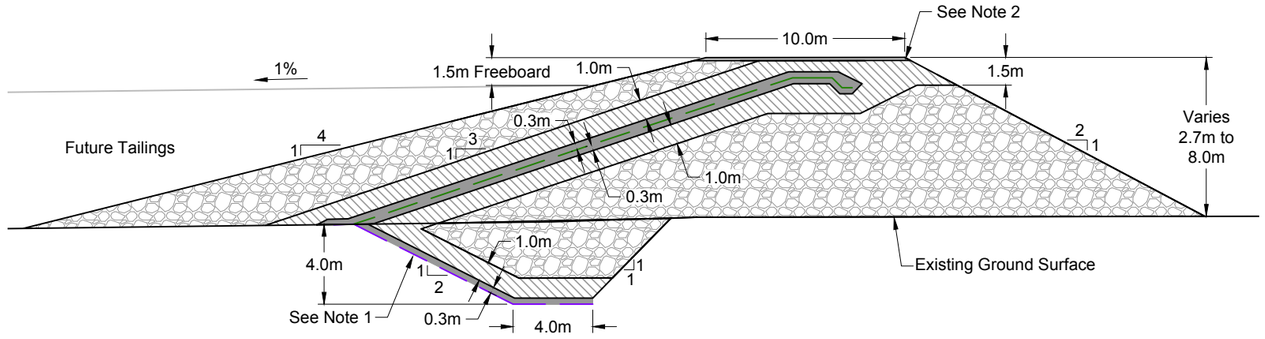


Minimum Typical Cover Section
STA.0+00 to 1+92 & 4+15 to 5+42

0m 3 6 9 12

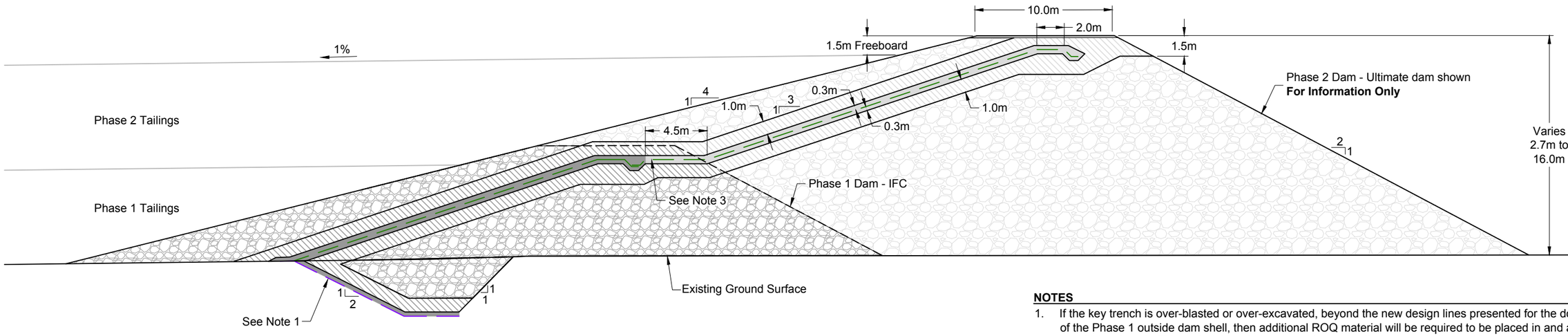
ISSUED FOR CONSTRUCTION



Phase 1 Typical Dam Section
STA. 1+92 to 4+15

0m 3 6 9 12

ISSUED FOR CONSTRUCTION



Phase 2 Typical Dam Section
STA. 0+25 to 5+25

0m 3 6 9 12

ISSUED FOR INFORMATION

LEGEND

- Key Trench Liner
- Phase 1 & 2 Dam Liner
- Bedding Material
- Transition Material
- Run of Quarry

NOTES

1. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench. This material would be placed to ensure that adequate thermal insulation of the key trench is maintained in all sections. See Detail 10 on drawing DN-SD-09 for additional details.
2. The top road surfacing (bedding material) for the Phase 1 dam is to be fully removed (upstream and downstream) before Phase 2 construction commences.
3. To allow for a proper tie-in the transition material around the top downstream portion of the Phase 1 dam will be required to be stripped back. Once the bedding material around the top liner anchor trench is reached hand excavation should be expected to result down to expose the liner. The on-site engineer will be required to inspect all exposed liner, to ensure that it is not damaged or in need of repairs before Phase 2 liner tie-ins result.
4. All units shown are in meters unless otherwise stated.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

DN-SD-02 — Phase 1 General Arrangement

REFERENCE DRAWINGS | REVISIONS

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Typ Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Typical Sections (General)

DRAWING NO. DN-SD-03 | SHEET 3 OF 30 | REVISION NO. 1

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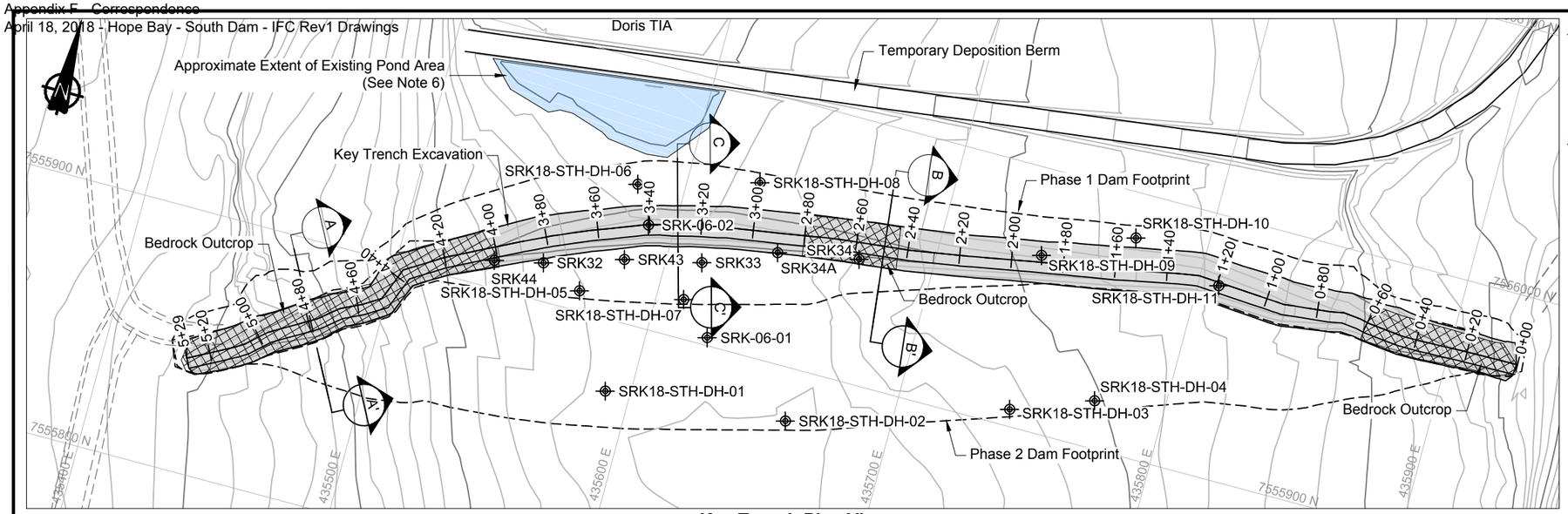
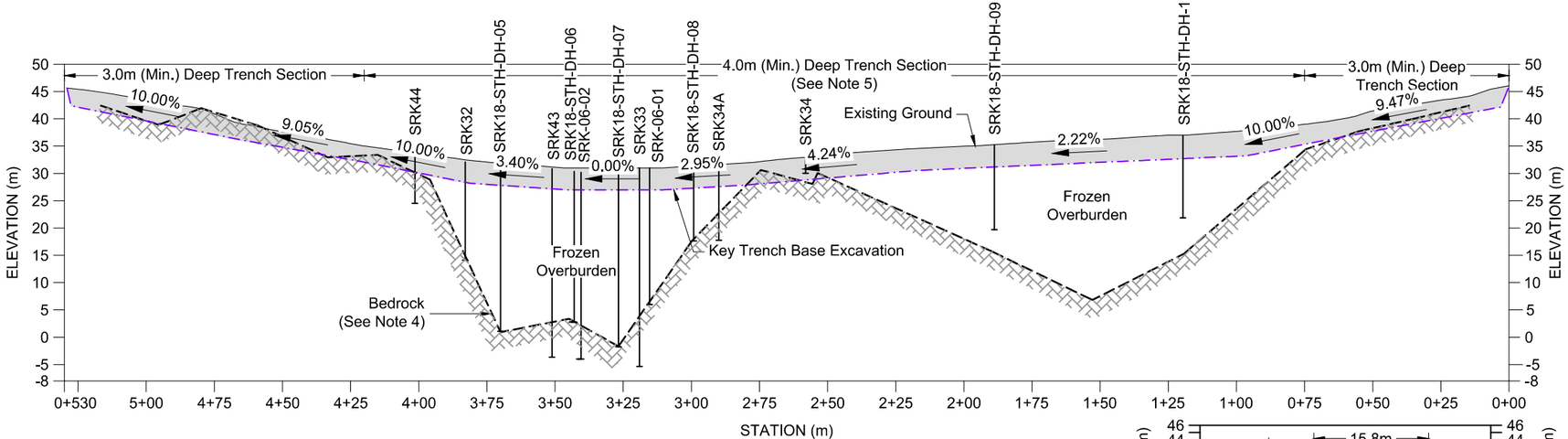


Key Trench Plan View

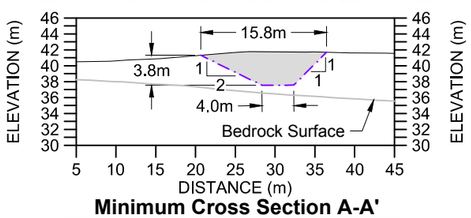
0m 20 40 60 80



Key Trench Profile View

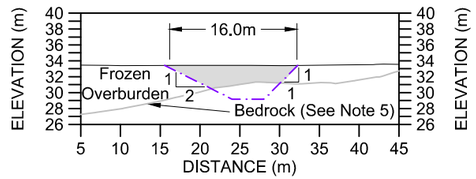
Vertical 0m 10 20 30 40

Horizontal 0m 20 40 60 80



Minimum Cross Section A-A'
Shallow Overburden over Bedrock

0m 5 10 15 20 25 30



Cross Section B-B'
Bedrock Outcropping in Key Trench

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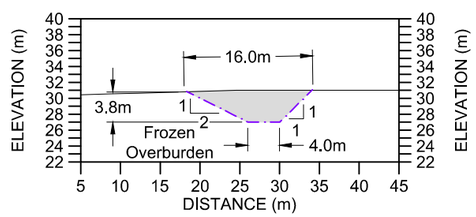

Cross Section C-C'
Deep Frozen Overburden

0m 5 10 15 20 25 30

LEGEND

- Drill Hole Location
- Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Trench Excavation Extent
- 1.00% Base Grades

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profile shown correspond to the upstream toe of the key trench.
4. The subsurface geology has been inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A , SRK43, SRK 44, SRK18-STH-DH01-11 and SRK18-WST-DH01-03), airphoto interpretations, and from limited available geophysical surveys around the Tails Lake area. This data was then used to create a bedrock surface with the Gemcom GEMS software. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.
5. The final key trench extent and depth will be determined in the field by the Engineer. Typical excavation depth is 4.0m, unless massive ice, hypersaline soil or bedrock encountered. The Engineer will inspect all excavations and approve the foundation conditions.
6. Ponded area to removed (frozen massive ice excavated or drained if possible). Up to approximately 4,700 m3 of (frozen) water may be expected to be removed from this area. Exact water levels are not known so the volume estimate above should be treated as a rough estimate based on topography.
7. If any area of the key trench is over-blasted or over-excavated then the extra excavation will need to be backfilled in thin lifts (*see 'Technical Specifications'*) until the key trench design lines and grades are reached.
8. Overblasting and/or overexcavation of the key trench beyond the design lines (as presented on this figure) should be avoided if at all possible. Extra care should be taken during the key trench excavation to ensure that the excavation can result as close to the design lines as possible. Excavation beyond the key trench design lines may require that the overall Phase 1 dam footprint be enlarged to provide the necessary thermal coverage and to uphold design requirements.

REFERENCES

NAD83 UTM Zone 13.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS | REVISIONS

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FILE NAME: 1CT0022.017 - South Dam - Key Trench.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Key Trench Excavation Plan and Profile

DRAWING NO.: DN-SD-04 | SHEET: 4 OF 30 | REVISION NO.: 1

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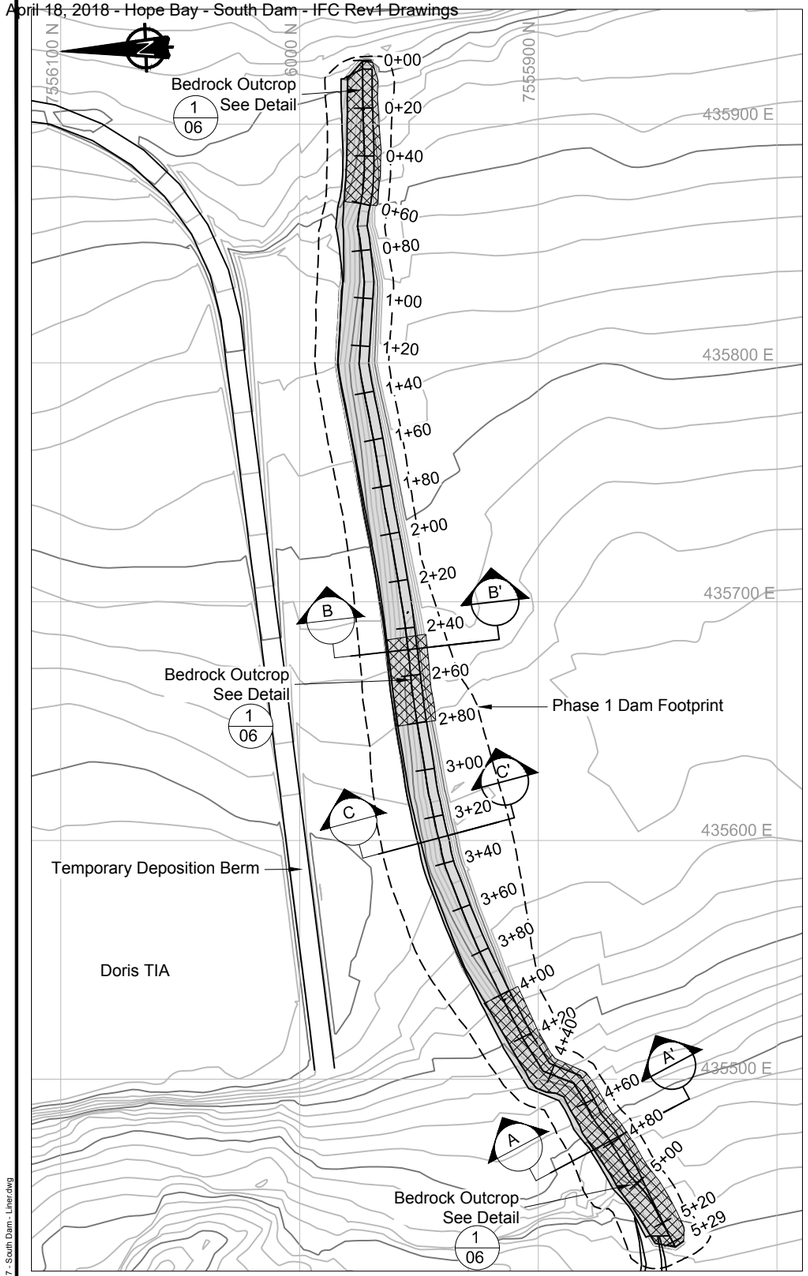
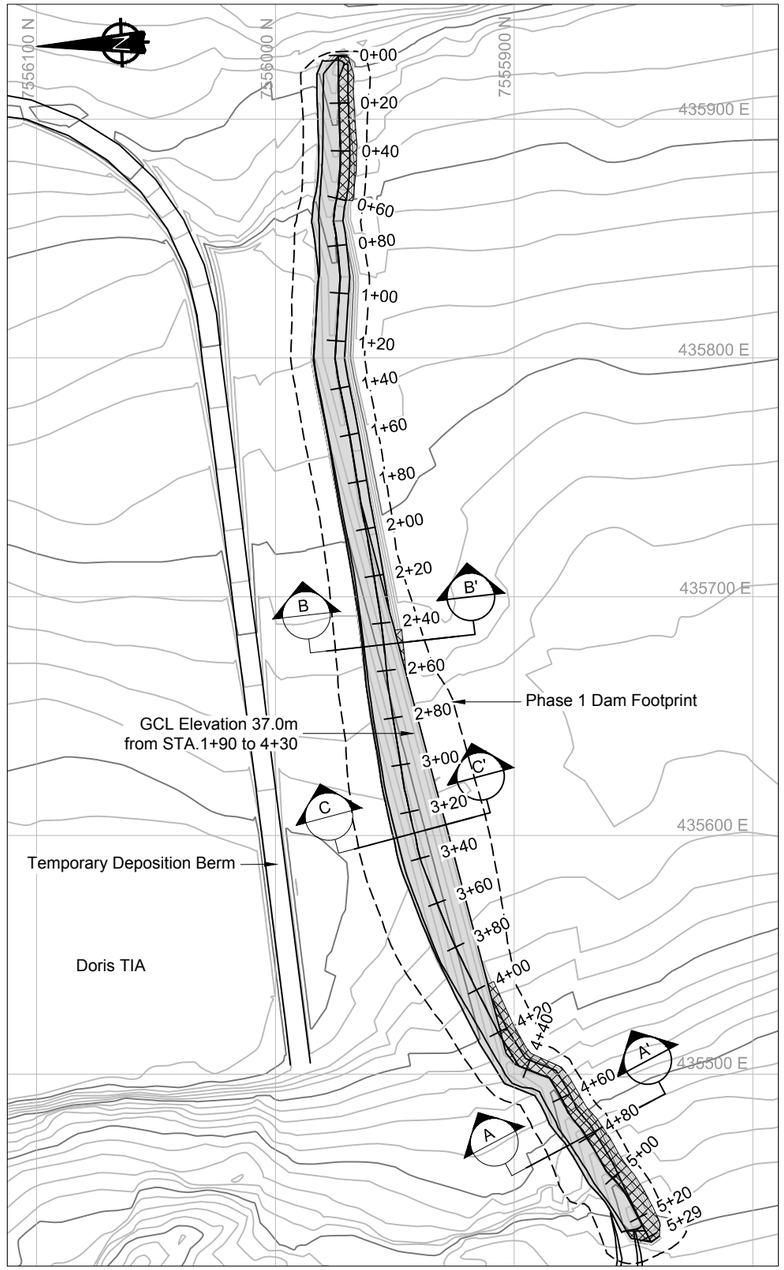


Lower Liner Plan - Placement in Key Trench

0m 20 40 60 80 100



Upper Phase 1 Liner Plan - Above Ground Upstream Slope Placement

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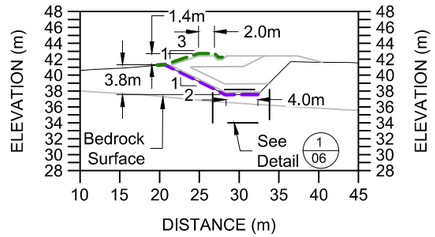

Minimum Cross Section A-A'

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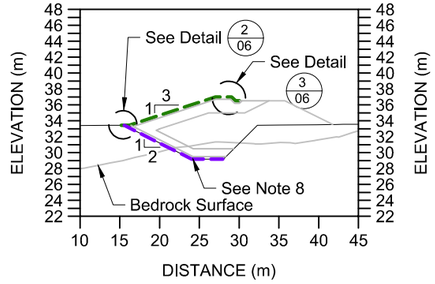

Cross Section B-B' - Bedrock Encountered in Trench

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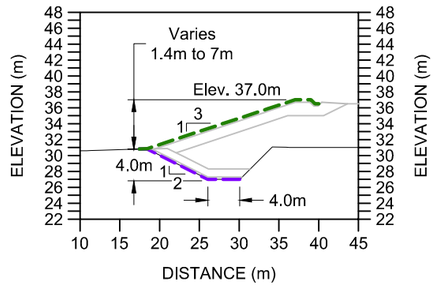

Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

- Key Trench Liner
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent
- GCL Liner Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The upstream slope of the key trench excavation need to be scraped and smoothed to prepare a suitable subbase for the GCL liner as determined by field Engineer. If any voids larger than 0.15m or undulation exist then they will need to be backfilled with compacted bedding material fill, placed in thin 0.15m lifts.
4. The subgrade surface must be free of vegetation, sharp-edged rocks, stones, sticks, construction debris, and other foreign material that could contact the GCL. Furthermore, all protrusions extending more than 12 mm from the subgrade surface shall either be removed, crushed, or pushed into the surface with a smooth-drum compactor.
5. GCL should not be placed over massive ice or standing water (both need to be removed prior to placement).
6. All Geosynthetic Clay Liner (GCL) liner sections / panels will be required to have a minimum 0.5m overlap on every edge. See Detail 2, 3, 5 and 6 on DN-SD-06 for additional information.
7. At the locations where bedrock is encountered in the key trench then these areas will be required to be ripped down to competent bedrock or scrapped smooth and then bentonite powder will be placed between the bedrock contact and the GCL liner (see Detail 1, DN-SD-06).
8. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m in depth), until competent bedrock is encountered, or as directed by Engineer.

REFERENCES

NAD83 UTM Zone 13.

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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DN-SD-06	Liner and Bedding Placement Details	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Liner Placement Plan and Details Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-05	5 OF 30	1

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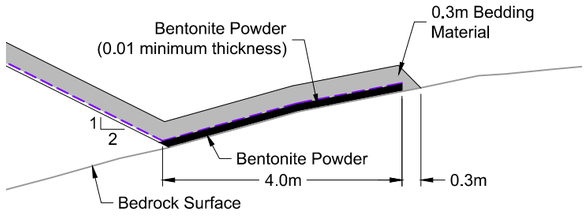
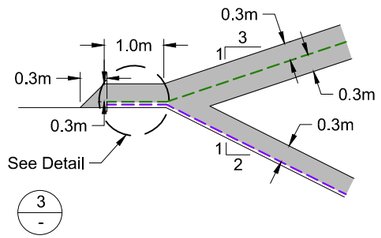
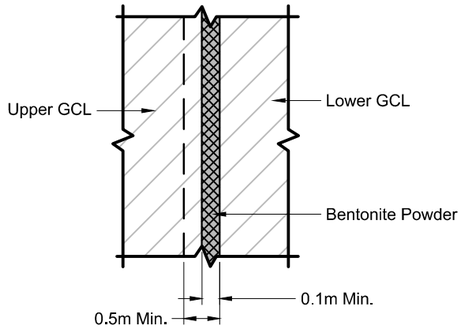
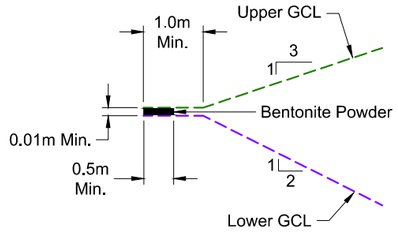


Detail 1 - Liner Attachment at Bedrock

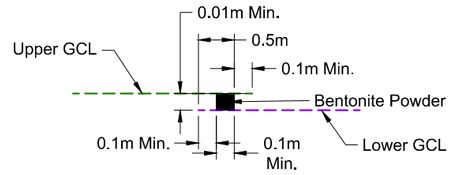


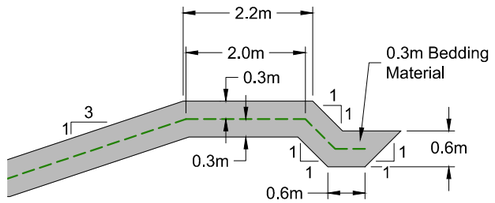
Detail 2 - Liner Overlap - Bedding





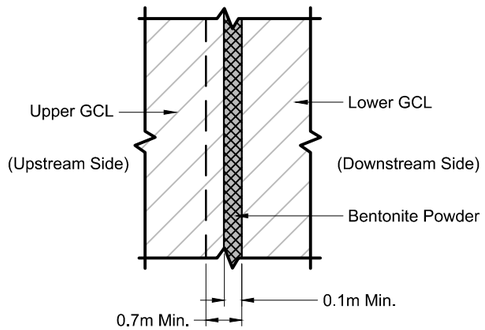
Detail 3 - Typical Upper and Lower GCL Joint



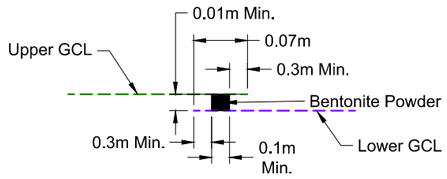


Detail 4 - Liner Anchor Trench Bedding

Detail 5 - Typical Longitudinal GCL Overlap - Plan



Detail 6 - Typical Longitudinal GCL Overlap - Section
Not To Scale



Detail 7 - Typical End of Panel GCL Overlap - Plan

Detail 8 - Typical End of Panel GCL Overlap - Section
Not To Scale

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material

NOTES

1. All units shown are in meters unless otherwise stated.
2. One end of the GCL roll should be anchored at the top of the slope. The front edge of the key trench (see Detail 4) shall be rounded so as to eliminate any sharp corners that could cause excessive stress on the GCL. Loose soil should be removed.
3. The GCL should be placed in the key trench such that it covers the entire key trench floor but does not extend up the rear trench wall (see Detail 4).
4. GCL seams are constructed by overlapping their adjacent edges (see Detail 5). Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris.
5. If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by placing a patch over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 500 mm is achieved around all parts of the damaged area. Bentonite mastic / powder should be applied around the damaged area prior to placement of the patch. It may be necessary to use an adhesive such as wood glue, or by hand placing material over the patch, to fix the patch in place so that it is not moved during overliner bedding material placement. Smaller patches also may be tucked under the damaged area to prevent patch movement.
6. Bedding shall be free of angular stones or other foreign matter which could damage the GCL. Cover soils should be approved by the Engineer, with respect to particle size and uniformity (as per the 'Technical Specifications').
7. Surface for the liner placement must be smooth competent 'virgin' ground with no loose or fractured material.

REFERENCES

NAD83 UTM Zone 13.

DRAWING NO.	DRAWING TITLE
-	-

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Liner and Bedding Placement Details

DRAWING NO.	SHEET	REVISION NO.
DN-SD-06	6 OF 30	1

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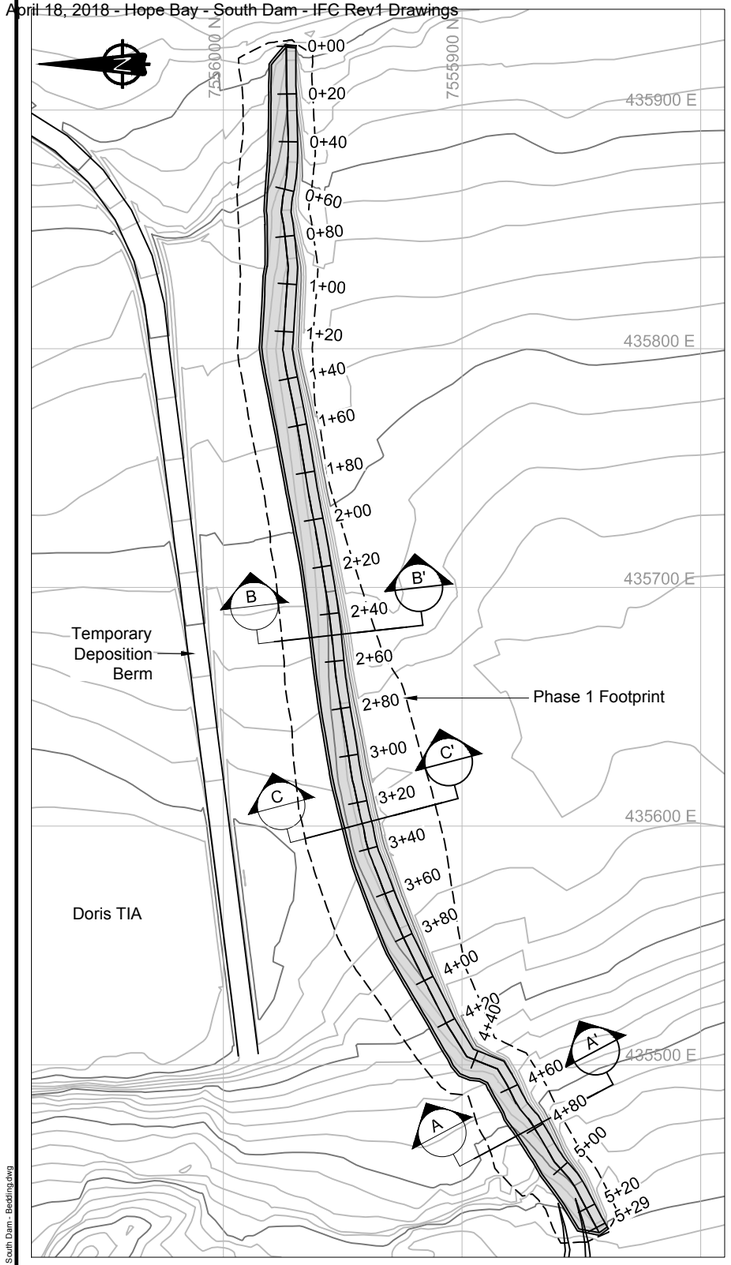

Key Trench Bedding Placement Plan View

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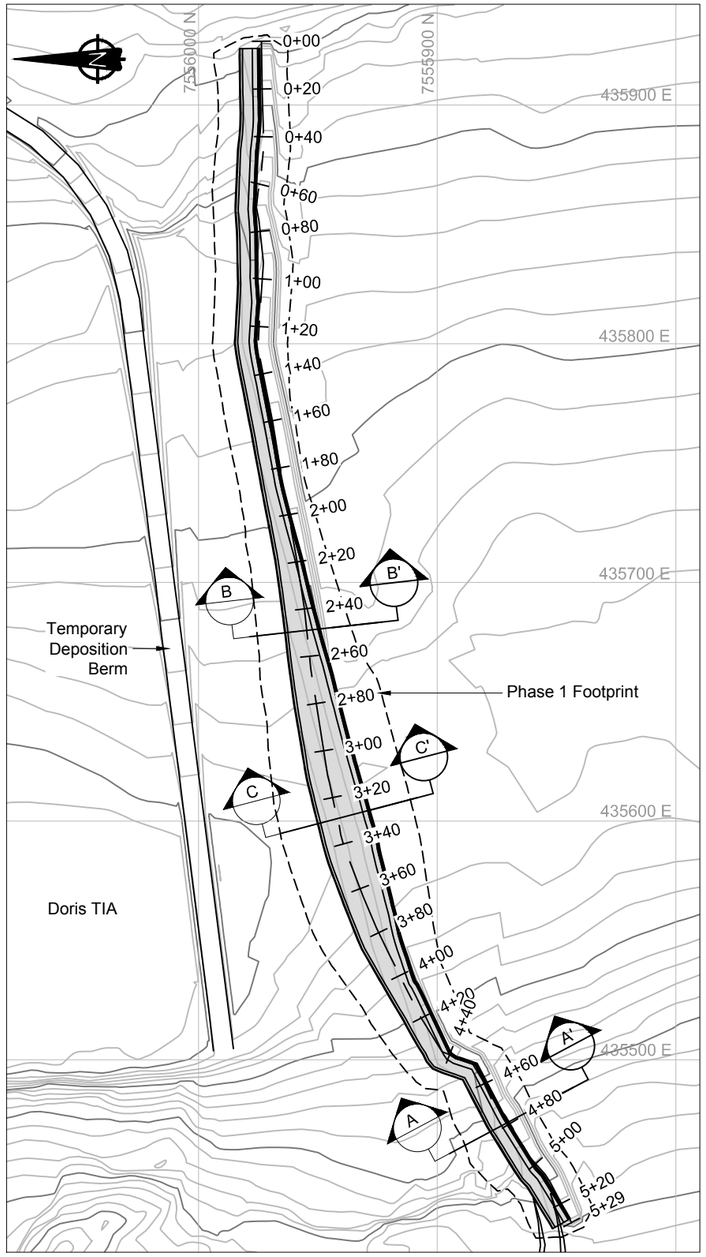

Phase 1 Dam Bedding Placement Plan View

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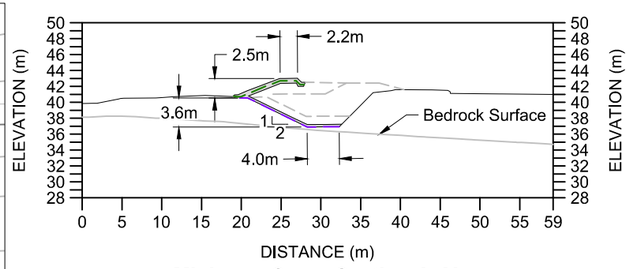

Minimum Cross Section A-A'

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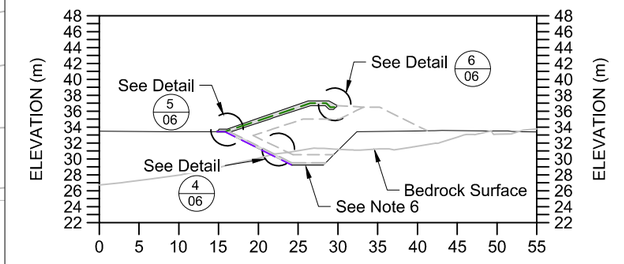

Cross Section B-B' - Bedrock Encountered in Trench

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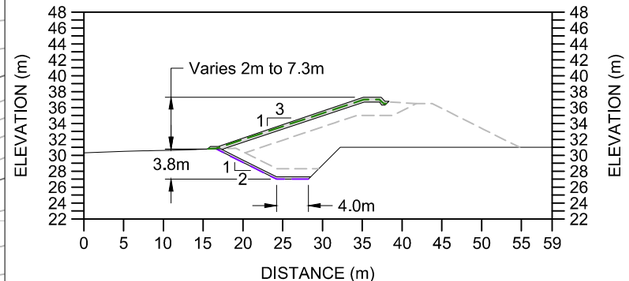

Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

- Phase 1 Dam Liner
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Bedding Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Bedding layer to be placed in 0.15m lifts and compacted before liner placement. The subsurface below the liner should be free of protrusions or any sharp / angular cobbles or larger size material. See the Technical Specifications document for more details ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK)*.
4. Bedding material cover shall be placed over the GCL using construction equipment that minimizes stresses on the GCL. Unless otherwise approved / directed by the Engineer a minimum thickness of 600mm or greater is required to be placed over any areas where heavy equipment will be trafficking over the liner. Thickness requirement are related to equipment type. For light equipment (which will have to be directly approved by the Engineer), as an absolute minimum a thickness of 300mm of cover must be maintained between light tracked equipment (e.g. skid-steer or 30 excavator) tracks/tires, and the GCL at all times during the covering process.
5. Soil cover should be placed in a manner that prevents the soil from entering/disturbing the GCL overlap zones.
6. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

REFERENCES

NAD83 UTM Zone 13.

REFERENCE DRAWINGS		REVISIONS									
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-06	Liner and Bedding Placement Details	-	-				0	Issued for Construction	JBK	EMR	17/11/29
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FILE NAME: 1CT0022.017 - South Dam - Bedding.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Bedding Material Placement Plan and Sections - Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-07	7 OF 30	1

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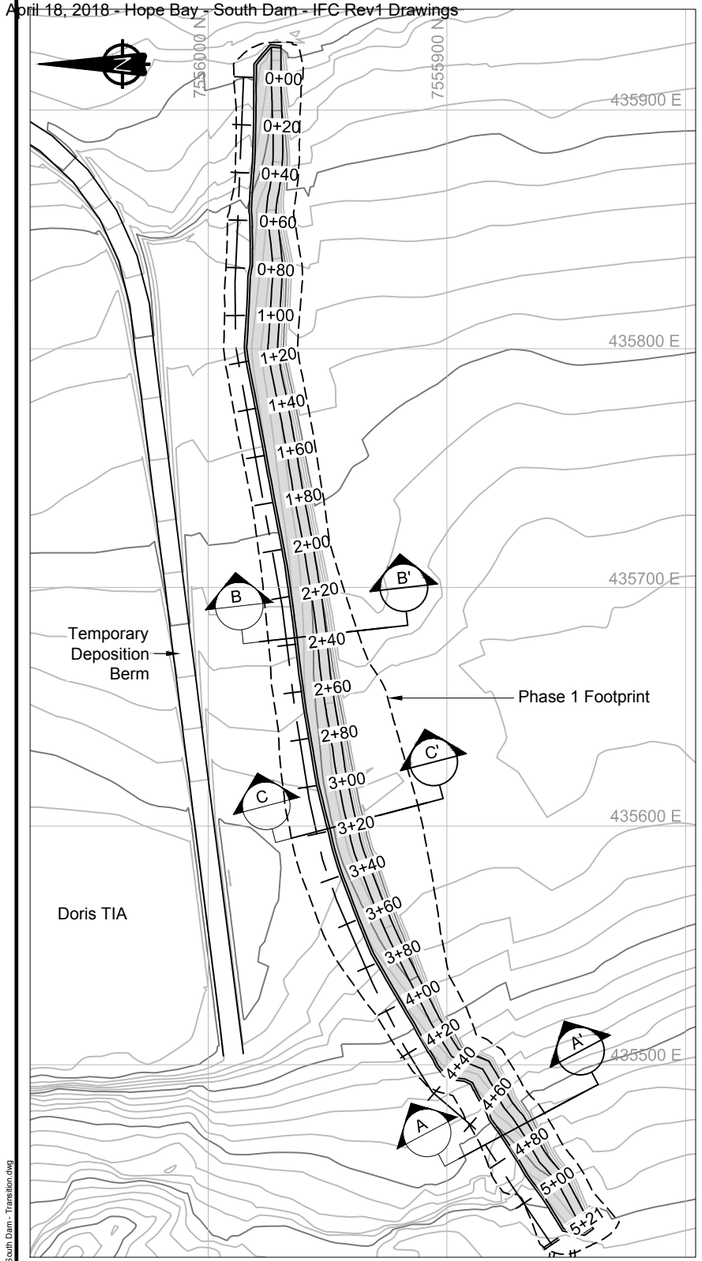
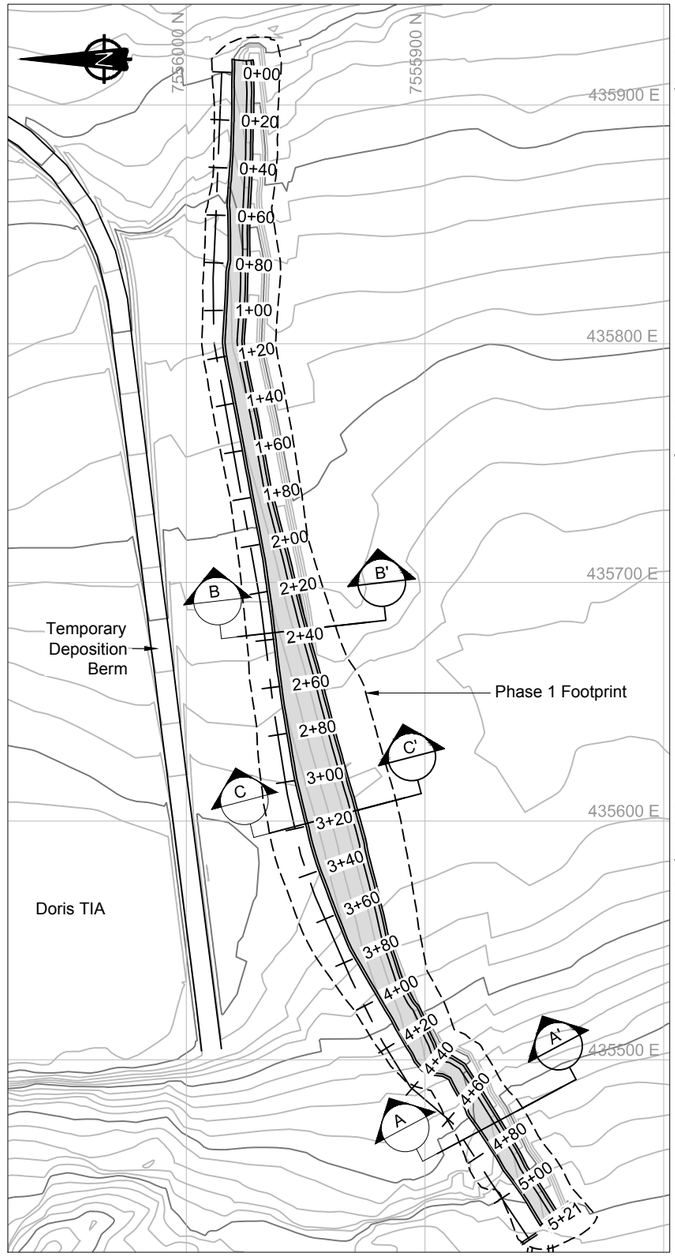


Key Trench Bedding Placement Plan View

0m 20 40 60 80 100



Phase 1 Dam Bedding Placement Plan View

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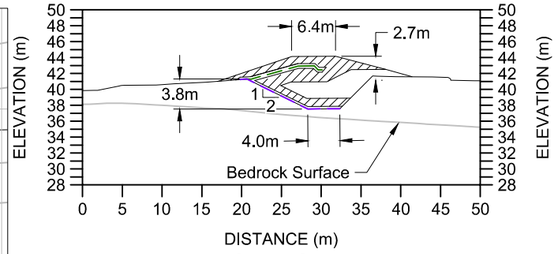

Minimum Cross Section A-A'

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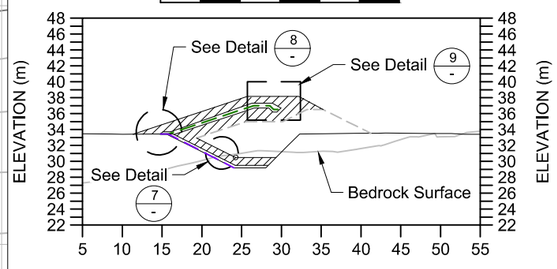
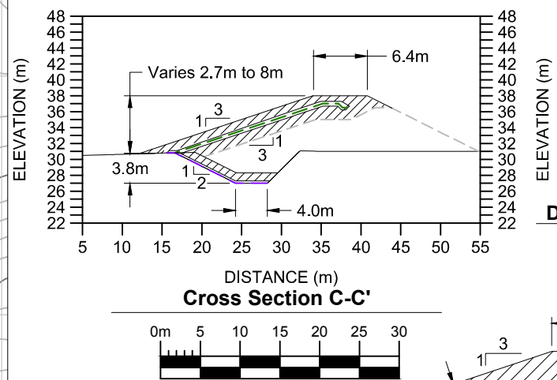


Cross Section B-B' - Bedrock Encountered in Trench

0m 5 10 15 20 25 30



Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND Page 11 of 33

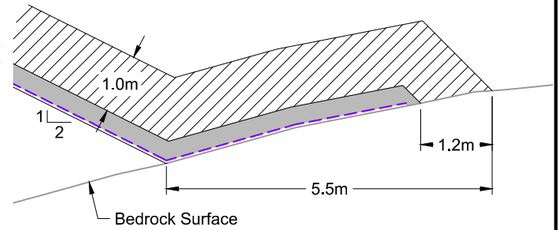
- Phase 1 Dam Liner
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Bedding Material
- Transition Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.

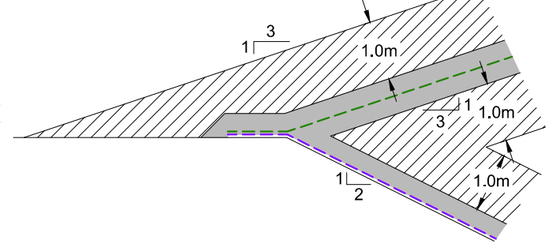
REFERENCES

NAD83 UTM Zone 13.



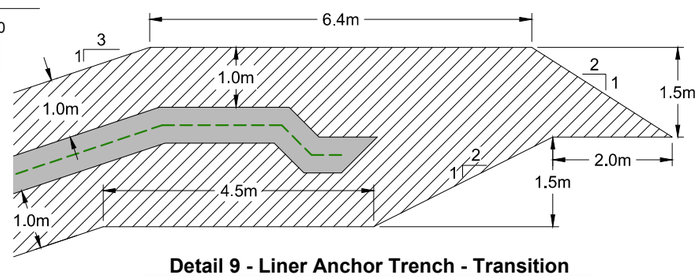
Detail 7 - Key Trench Bedrock Interface - Transition

0m 1 2 3 4



Detail 8 - Upper and Lower GCL Liner Overlap - Transition

0m 1 2 3 4



Detail 9 - Liner Anchor Trench - Transition

0m 1 2 3 4

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

Original Drawings Stamped and Signed by Engineer

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Transition.dwg

TMAC RESOURCES

Hope Bay Project

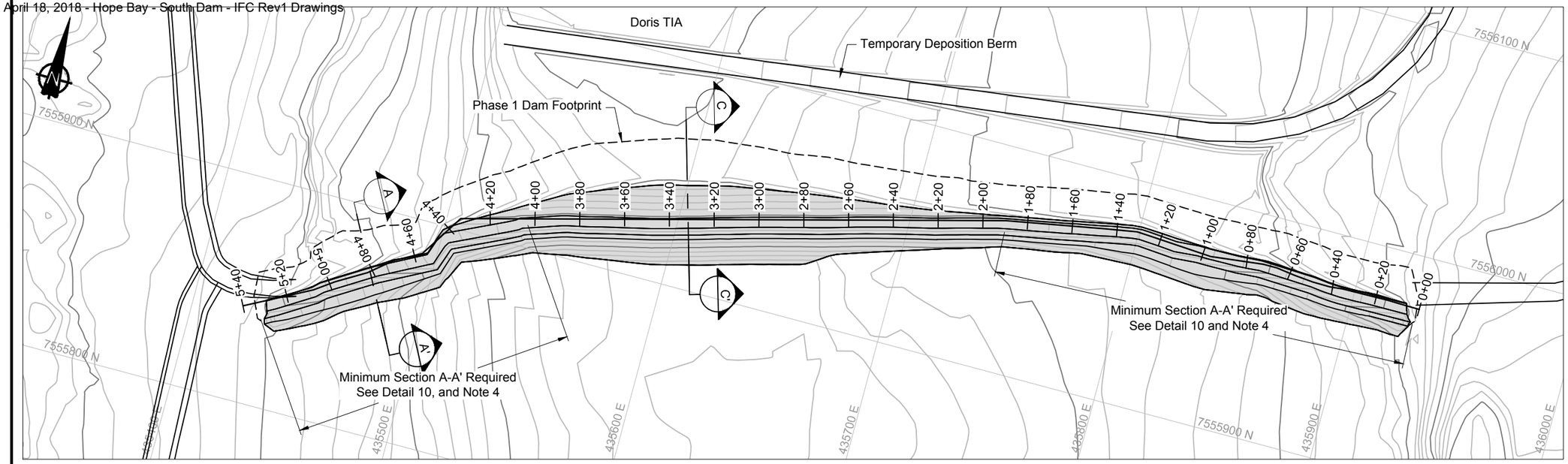
SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Transition Material Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-08	7 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1\1CT0022.017 - South Dam - Transition.dwg



Run of Quarry Placement Plan View

0m 20 40 60 80

LEGEND

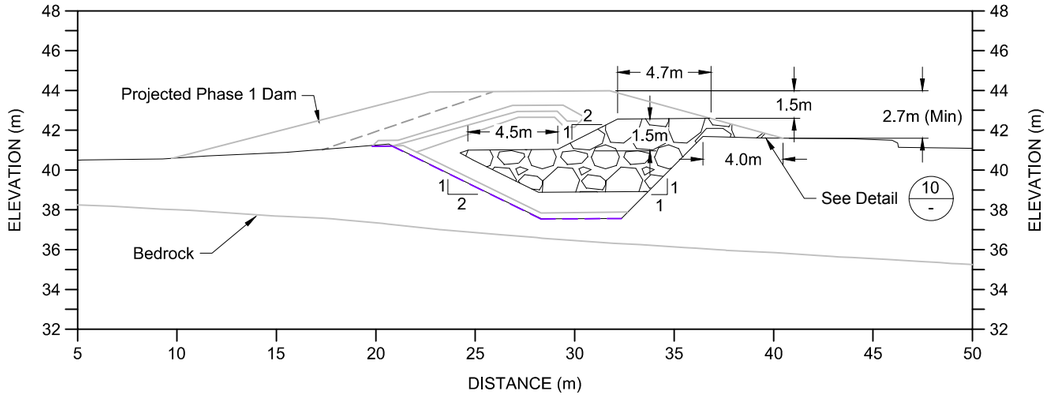
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Run of Quarry Backfill Extent
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profiles shown correspond to the upstream toe of the key trench.
4. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench. See Detail 10 on drawing DN-SD-09 for additional details.
5. The outside downstream ROQ should be sloped at 2H:1V or shallower.

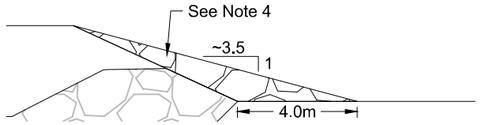
REFERENCES

NAD83 UTM Zone 13.



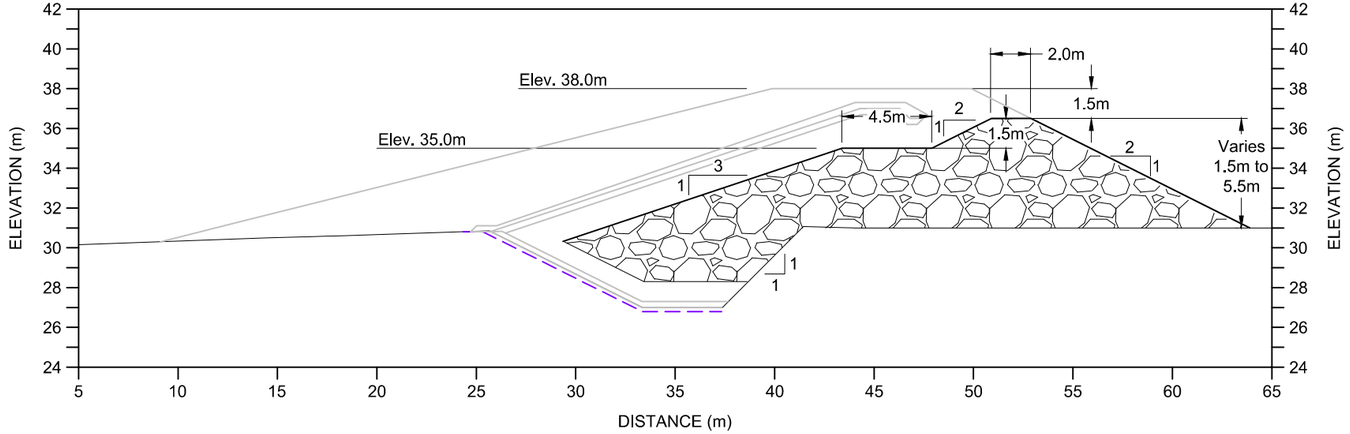
Minimum Cross Section A-A'

0m 3 6 9 12



Detail 10 - Contingency ROQ Thermal Barrier Design

0m 2 4 6 8



Typical Cross Section C-C'

0m 3 6 9 12

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1	-	-				0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS — REVISIONS

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO. DN-SD-09 | SHEET 9 OF 30 | REVISION NO. 1

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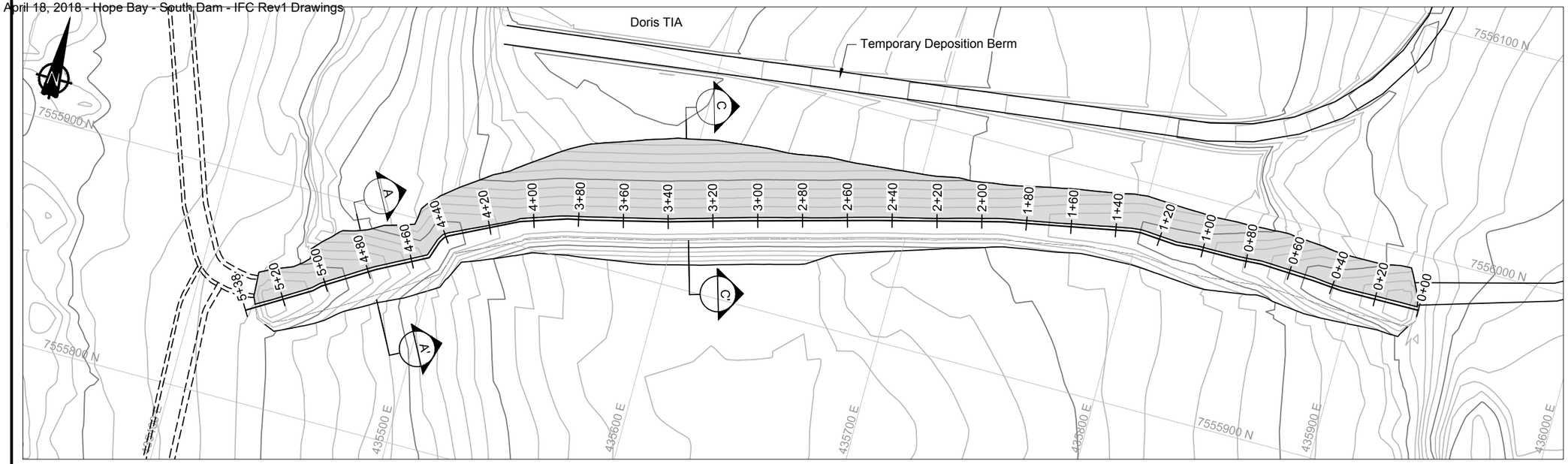


Run of Quarry Placement Plan View

0m 20 40 60 80

LEGEND

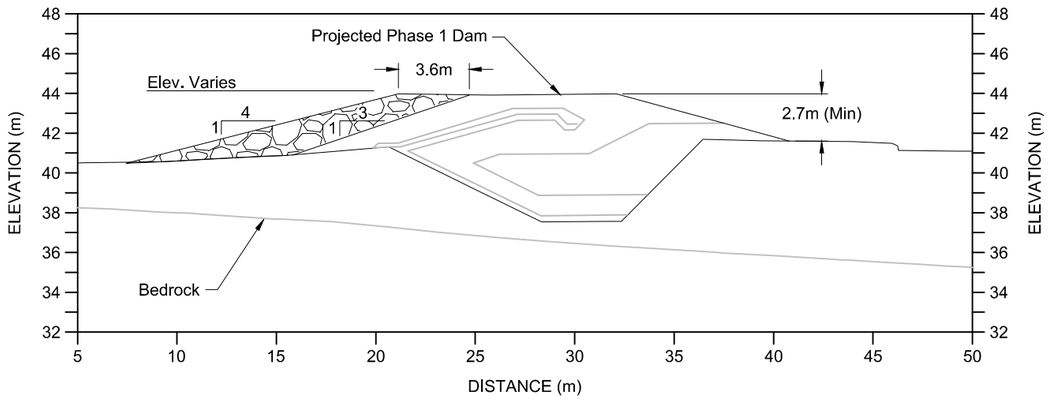
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Run of Quarry Backfill Extent
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The outside upstream dam ROQ should be sloped at 4H:1V or shallower.

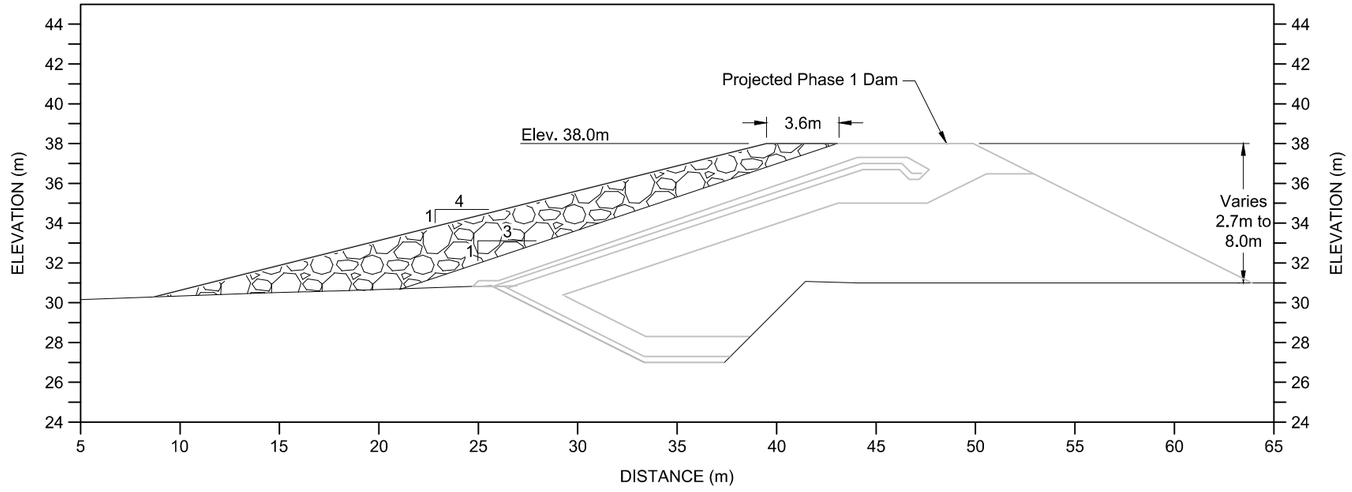
REFERENCES

NAD83 UTM Zone 13.



Minimum Cross Section A-A'

0m 3 6 9 12



Typical Cross Section C-C'

0m 3 6 9 12

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1			
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1	-	-	
DRAWING NO.	DRAWING TITLE			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ-us.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-10	10 OF 30	1

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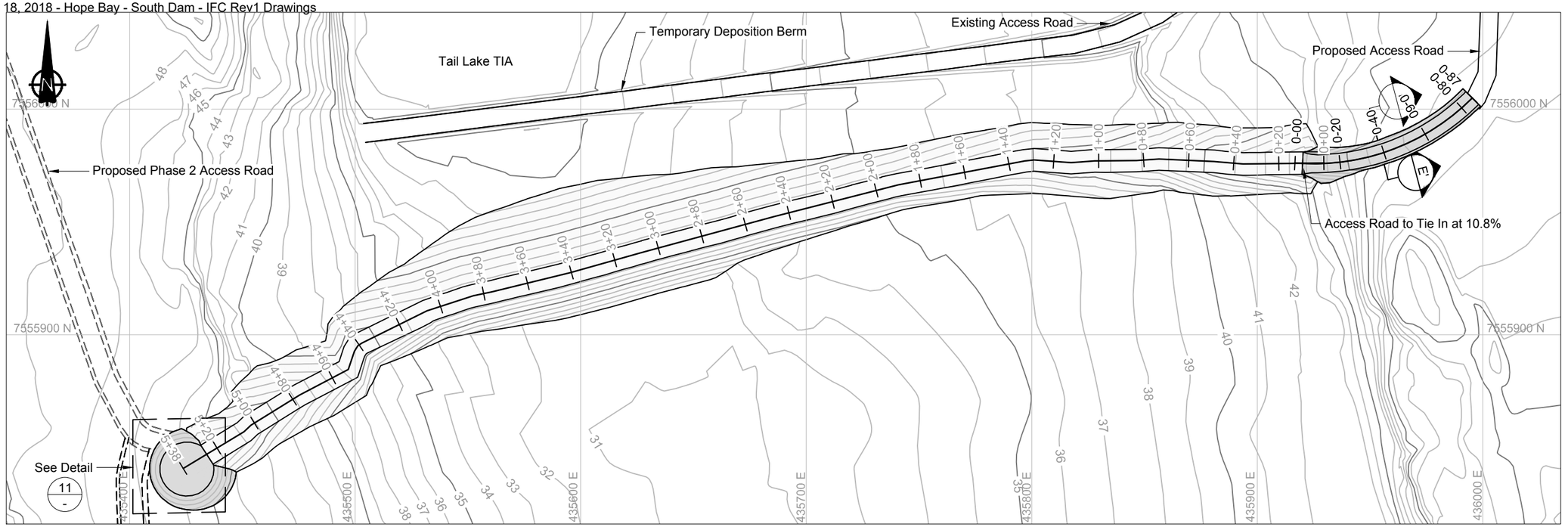


LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Access Road
- Run of Quarry
- Surfacing Material

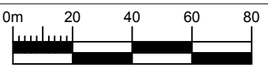
NOTES

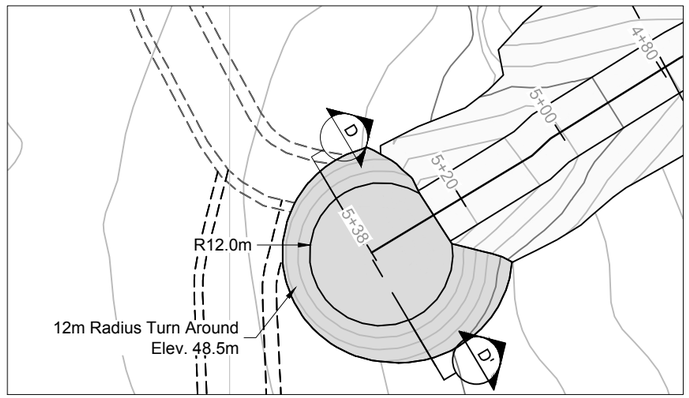
1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Approximately 3,300m³ of surfacing / bedding material is estimated (to neat lines) to be needed for the Access Road and Turn Around.
4. Minimum fill thickness for Access Road and Turn Around is 1.0m

REFERENCES

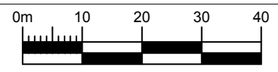
NAD83 UTM Zone 13.

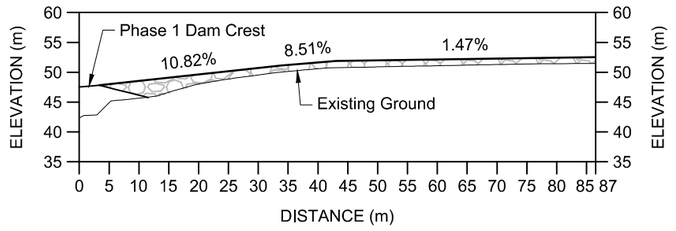
East Access Road and West Turn Around



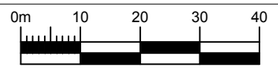


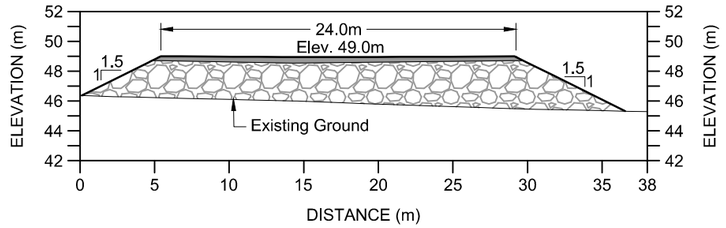
Detail 11 - Turn Around



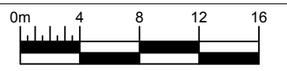


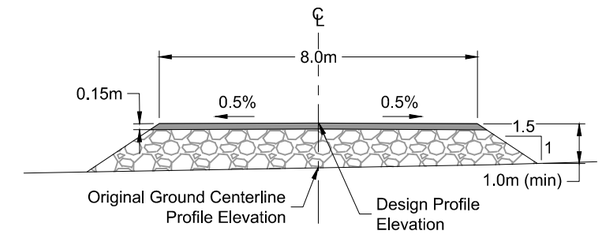
East Access Road Profile





Section D-D' - Turn Around





Section E-E' - Typical Road Section

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-03	Typical Sections (General)					
DN-SD-02	Phase 1 General Arrangement	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam AR.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Construction Access Road and Turnaround - Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-11	11 OF 26	1

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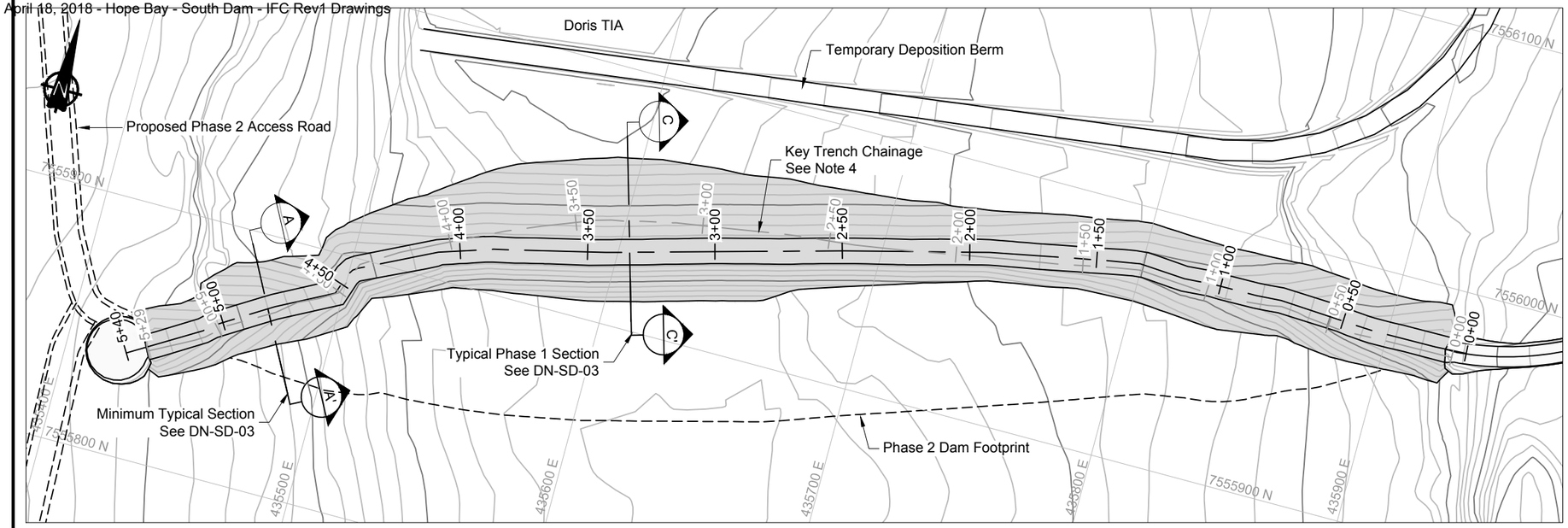


Phase 1 Dam Plan View

0m 20 40 60 80

LEGEND

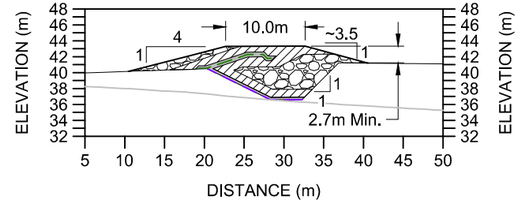
- Key Trench Excavation
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The Phase 2 dam elevations are shown for information purposes only. Note that only Phase 1 dam designs and elevations are issued for construction use.
4. Base of key trench on this profile is based on a section down the centerline of the dam crest. Note that the key trench centerline and the dam crest centerline do not share the exact same alignment and overall the chainages vary in any given location (between the key trench and dam crest shown in these drawings) in the range of 5m.

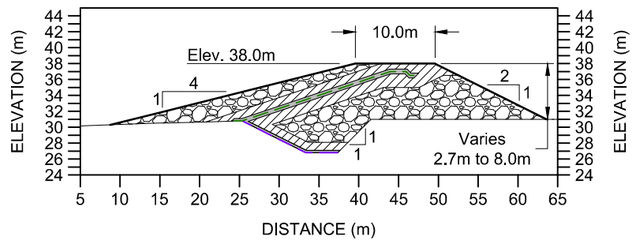
REFERENCES

NAD83 UTM Zone 13.



Minimum Cross Section A-A'

0m 5 10 15 20 25 30



Cross Section C-C'

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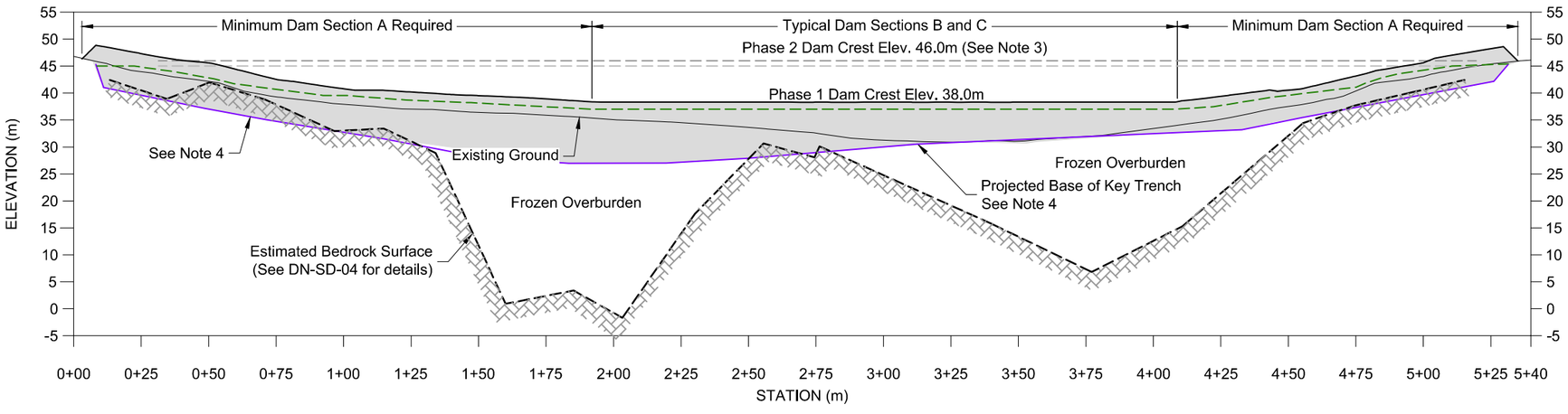

Phase 1 Dam Profile View - Through Crest Centerline

Horizontal: 0m 10 20 30 40

Vertical: 0m 20 40 60 80

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-04	Key Trench Excavation Plan and Profile										
DN-SD-03	Typical Sections (General)						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Phase 1 Dam.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Final Phase 1 Dam Plan, Profile and Sections

DRAWING NO.	SHEET	REVISION NO.
DN-SD-12	12 OF 30	1

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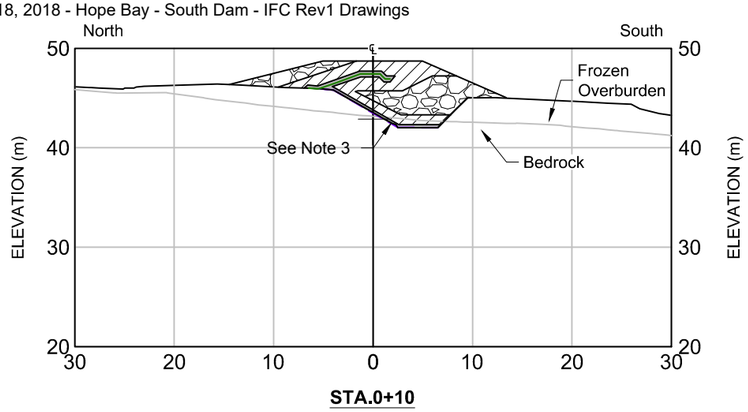

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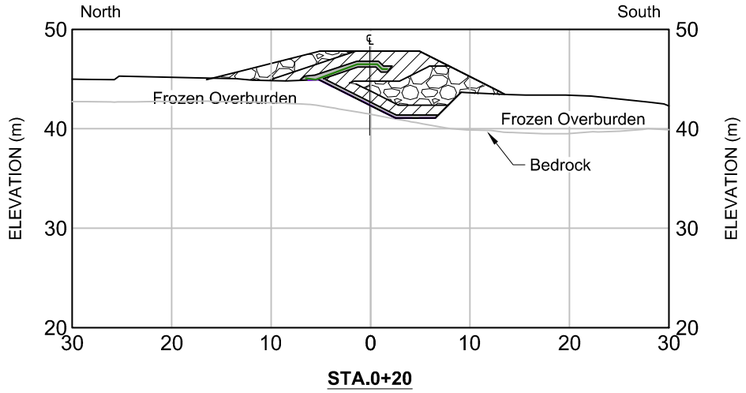

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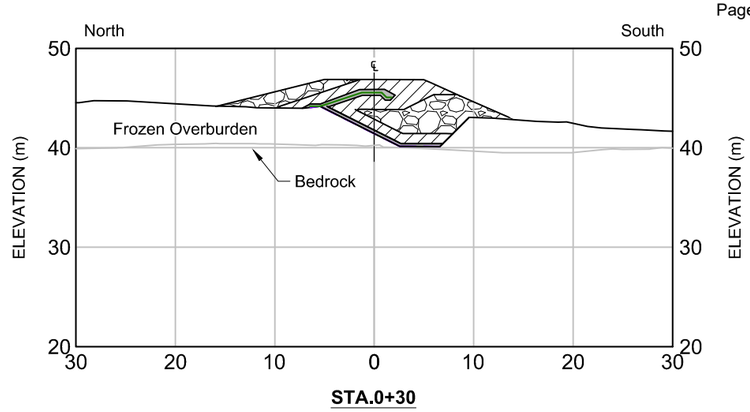

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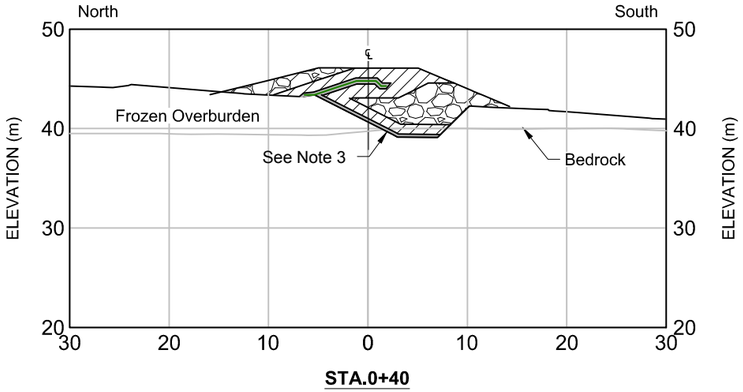

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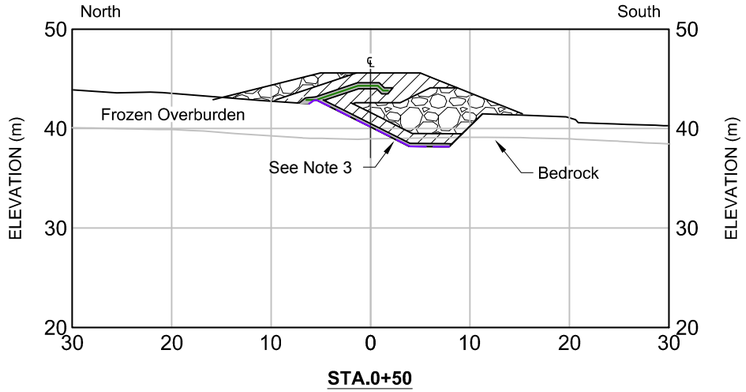

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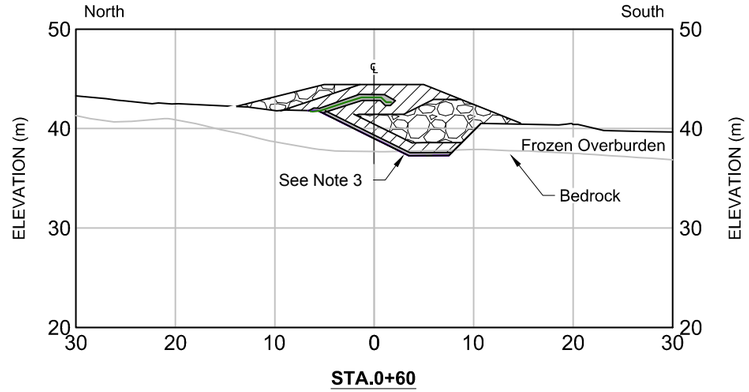

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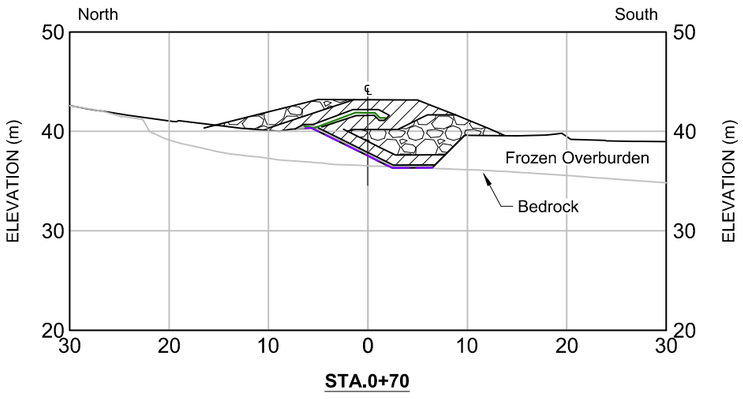

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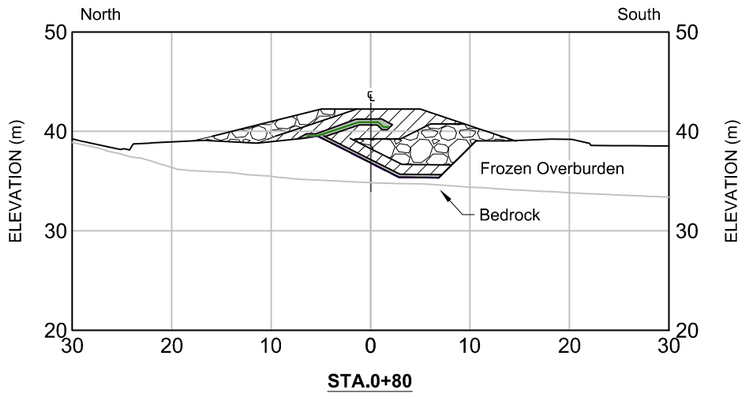

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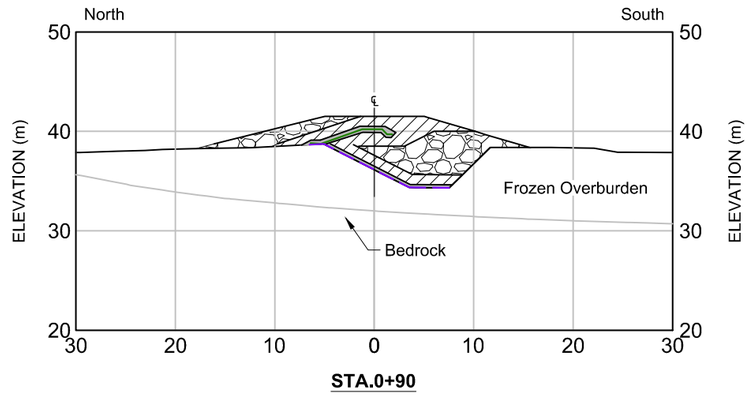

STA.0+90

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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0m 6 12 18 24

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

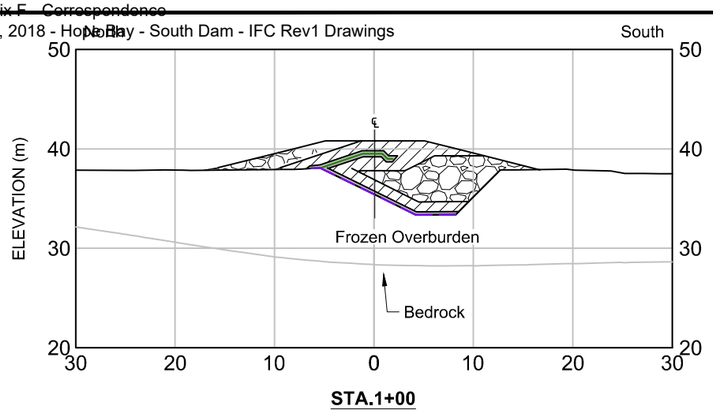
SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.0+10 to 0+90 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-13	13 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1\1CT0022.017 - South Dam - Sections.dwg



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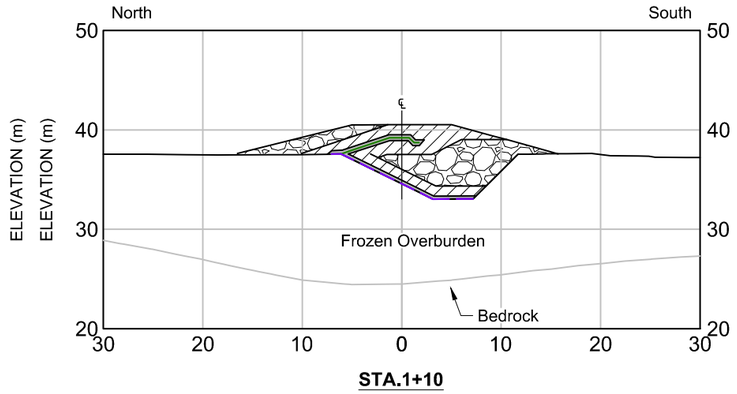

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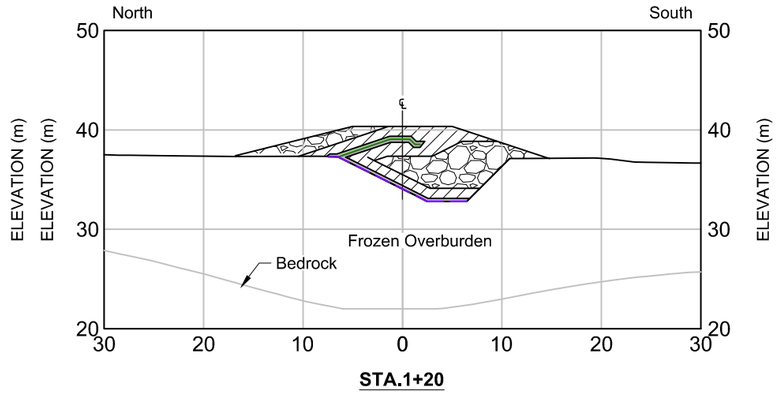
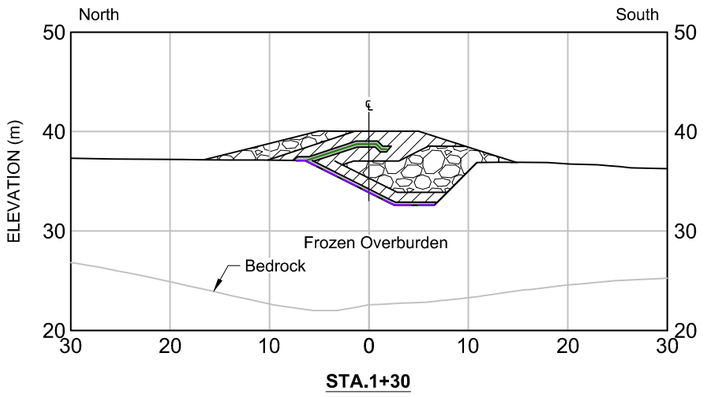
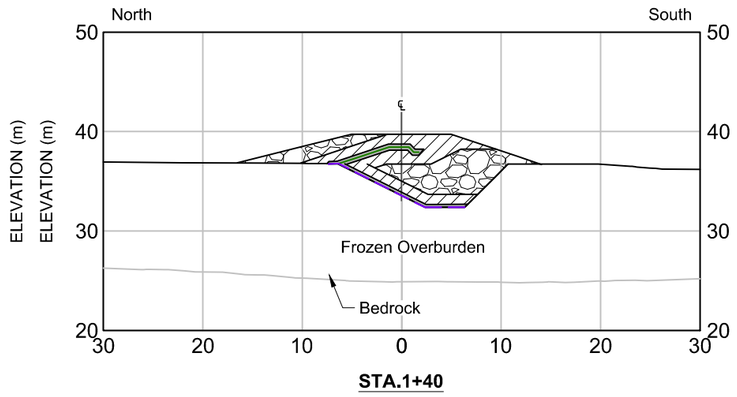


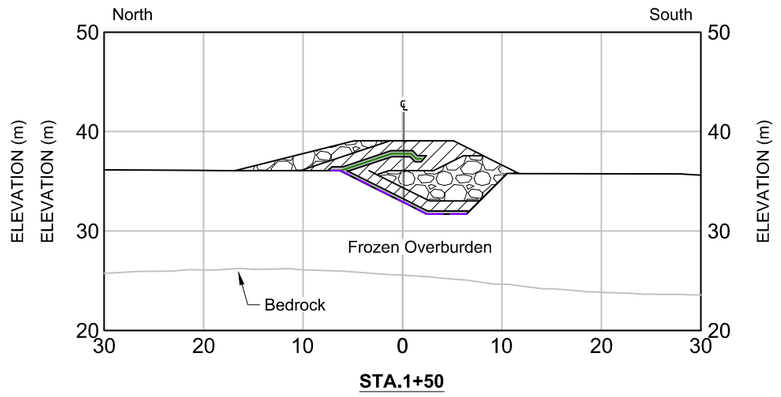
STA.1+20



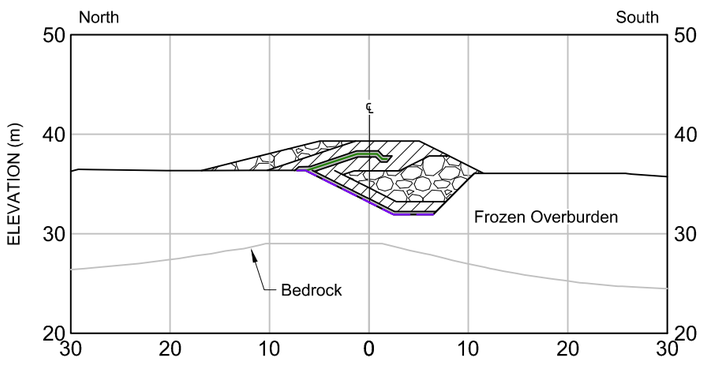
STA.1+30



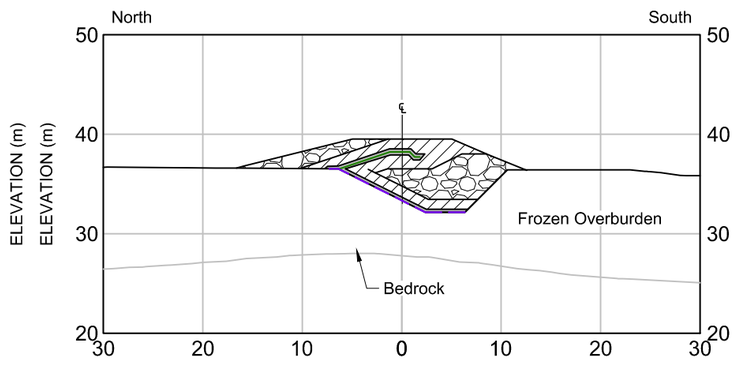
STA.1+40



STA.1+50



STA.1+60



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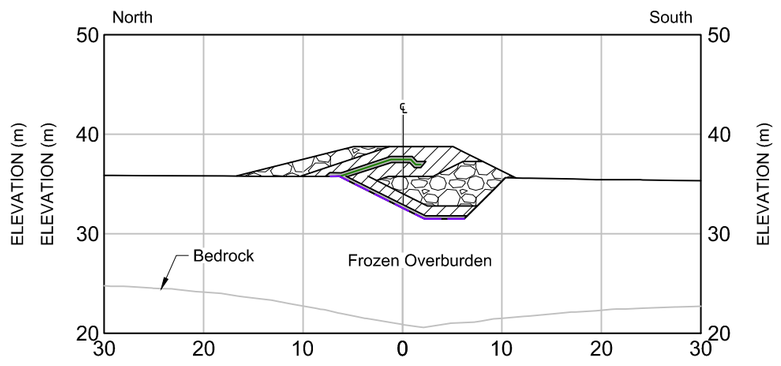

STA.1+80

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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0m 6 12 18 24

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-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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PROFESSIONAL ENGINEERS STAMP

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.1+00 to 1+80 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-14	14 OF 30	1

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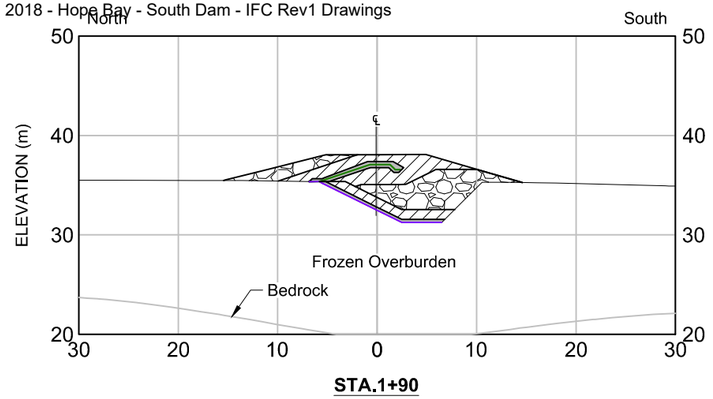

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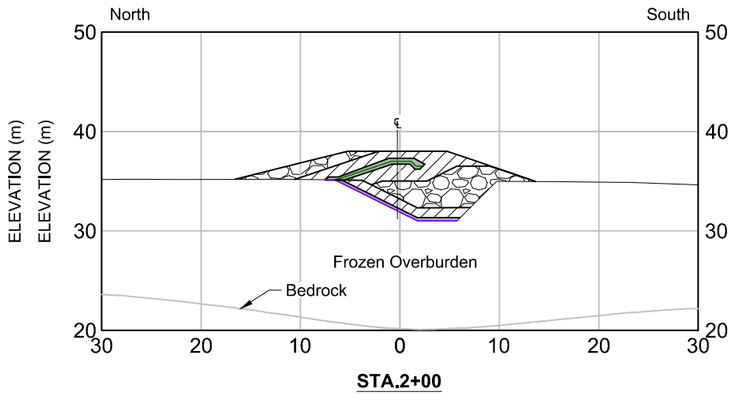

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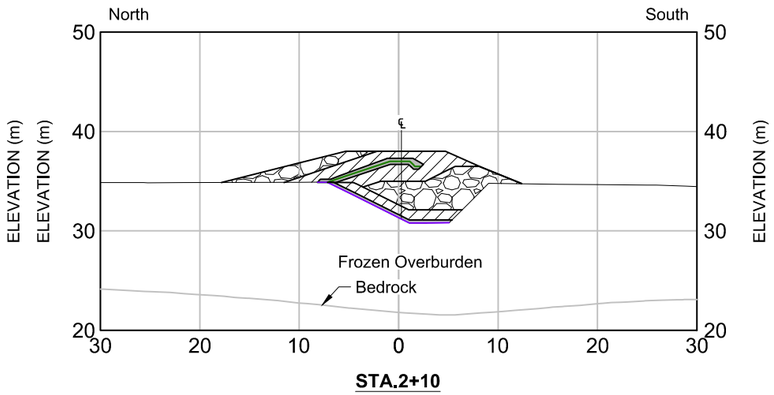
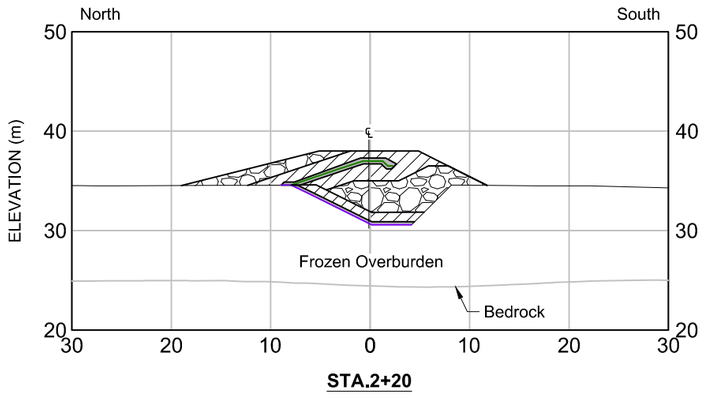
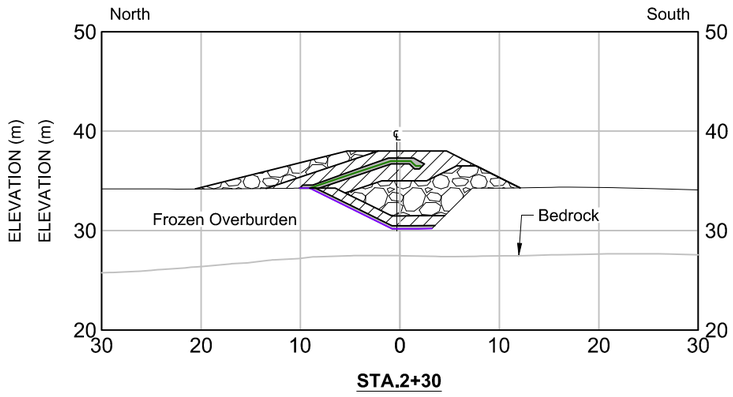


STA.2+10



STA.2+20



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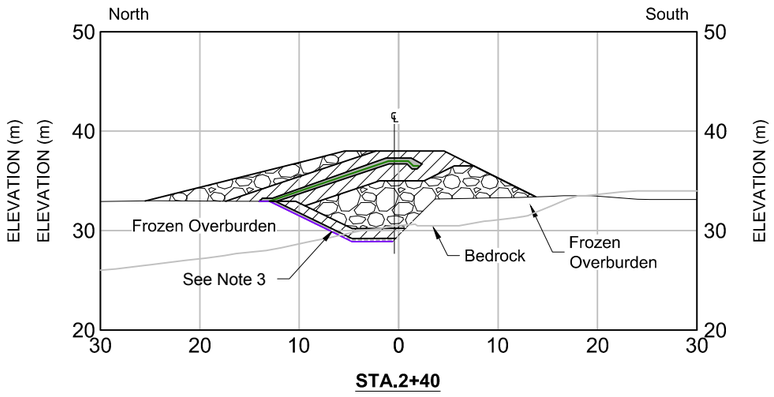

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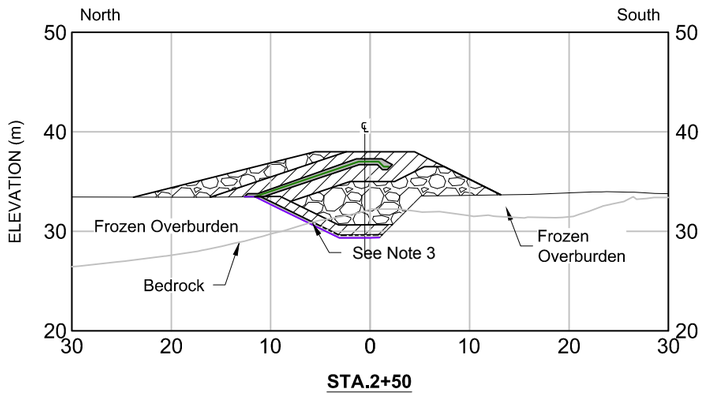
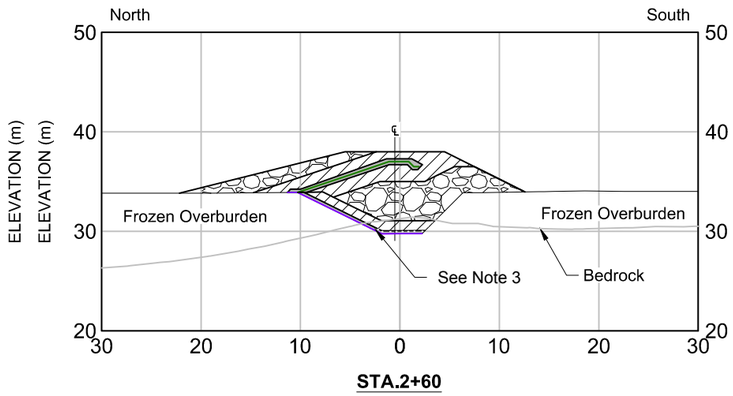
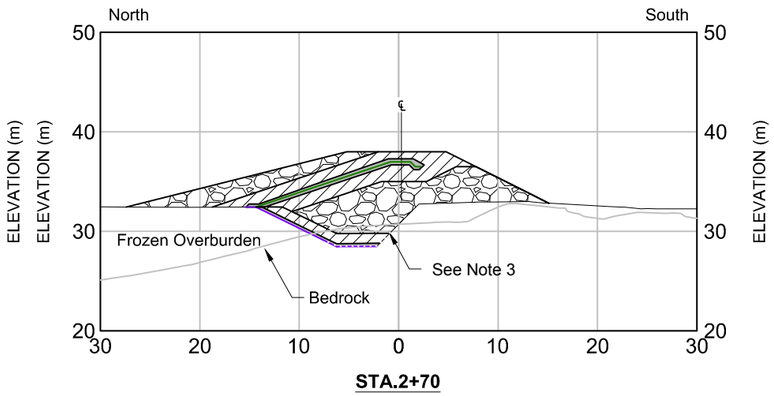


STA.2+50



STA.2+60



STA.2+70

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.1+90 to 2+70 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-15	15 OF 30	1

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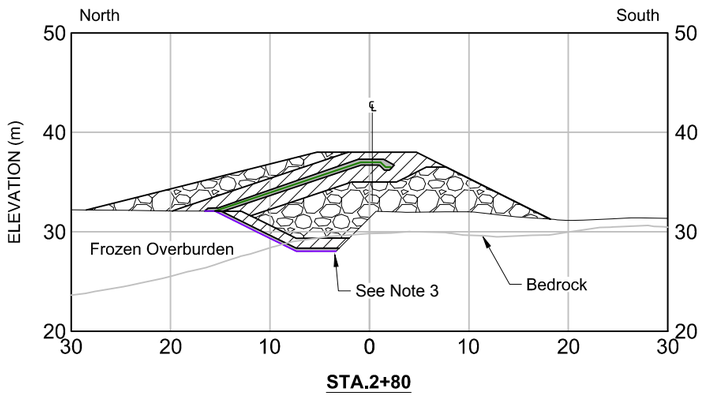

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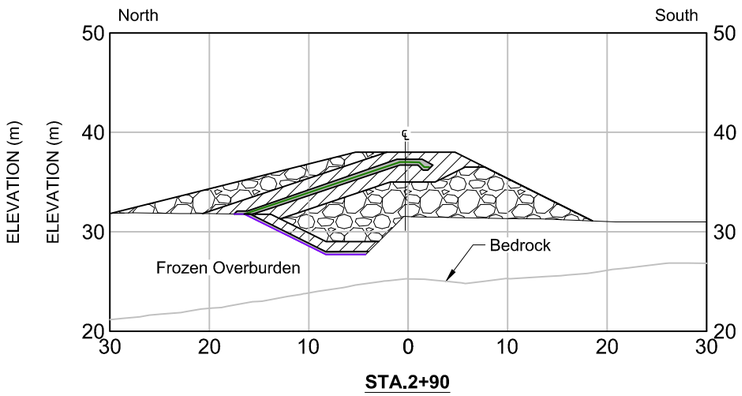
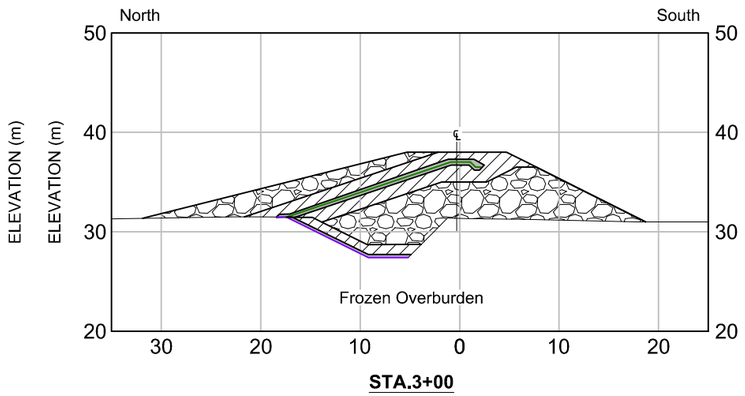
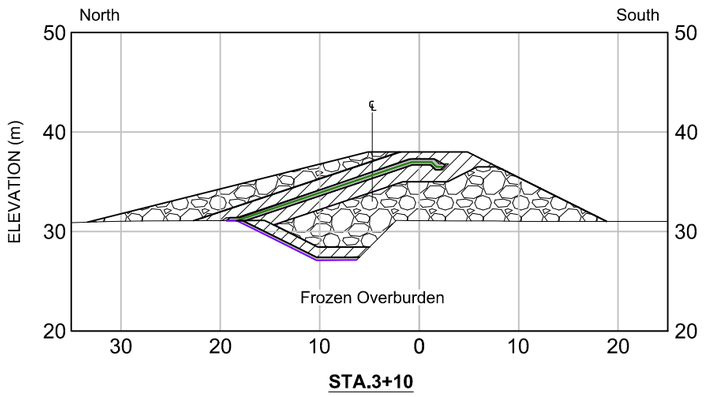


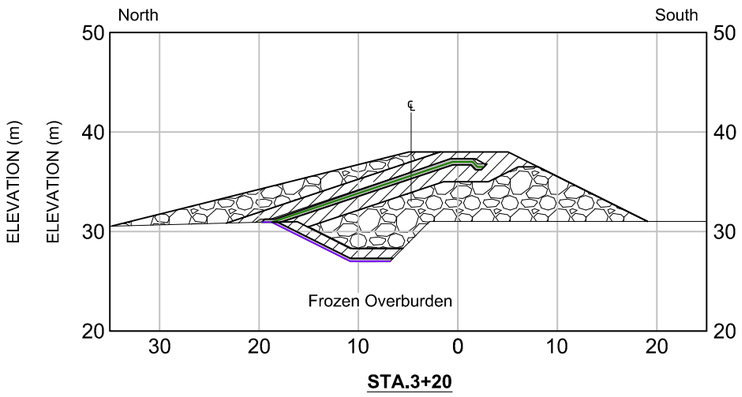
STA.2+90



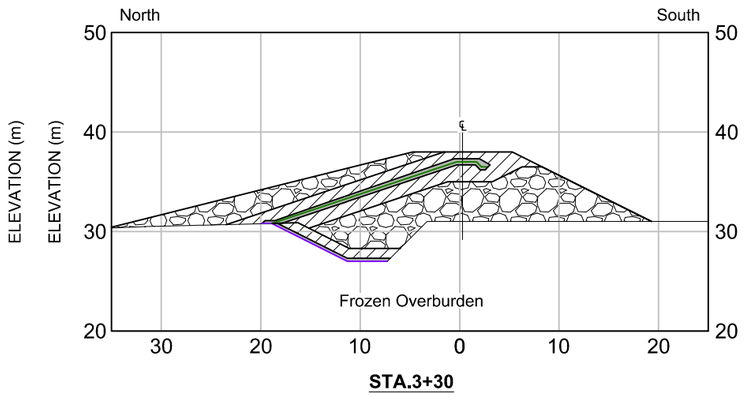
STA.3+00



STA.3+10



STA.3+20



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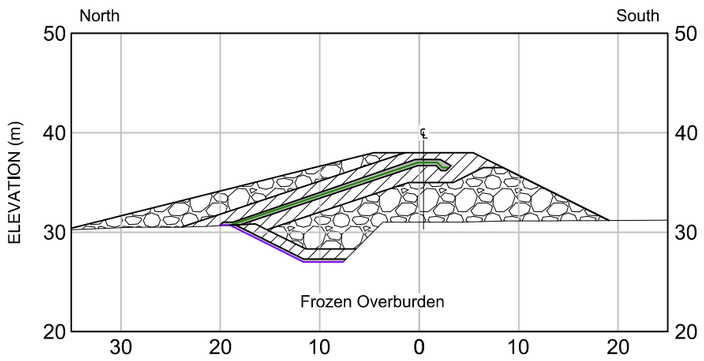
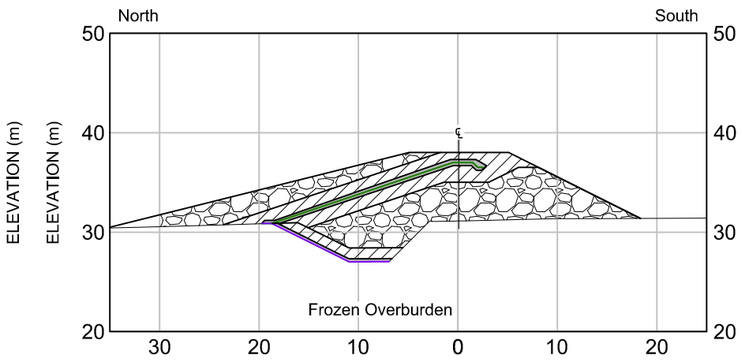
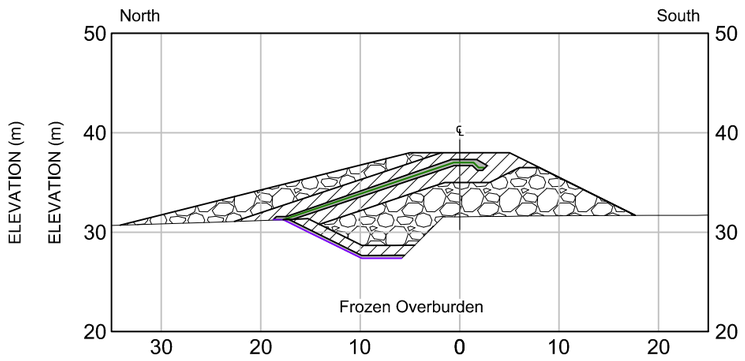


STA.3+40



STA.3+50



STA.3+60

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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0m 6 12 18 24

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-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

REVISIONS

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

DRAWING TITLE: South Dam
Sections
Sta.2+80 to 3+60
Phase 1 Dam

DRAWING NO.: DN-SD-16

SHEET: 16 OF 30

REVISION NO.: 1

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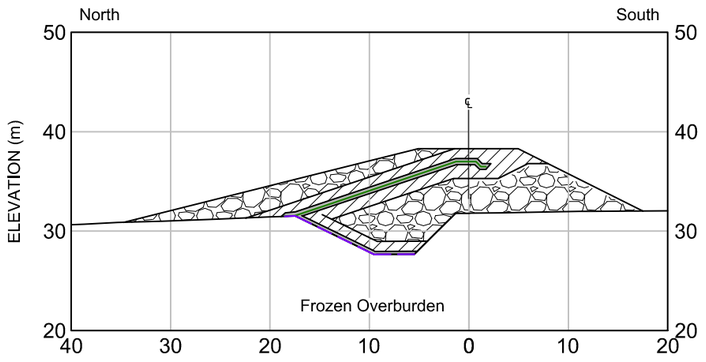
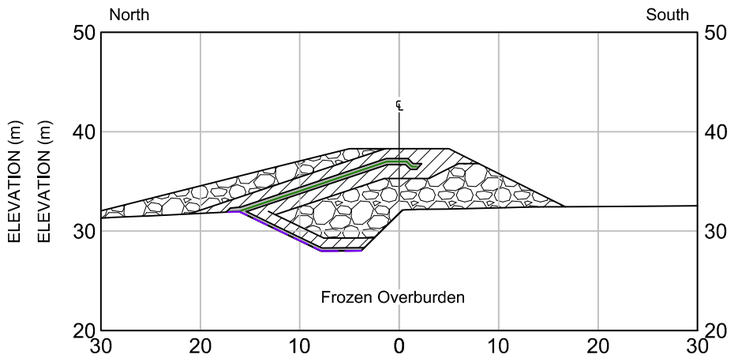


STA.3+70



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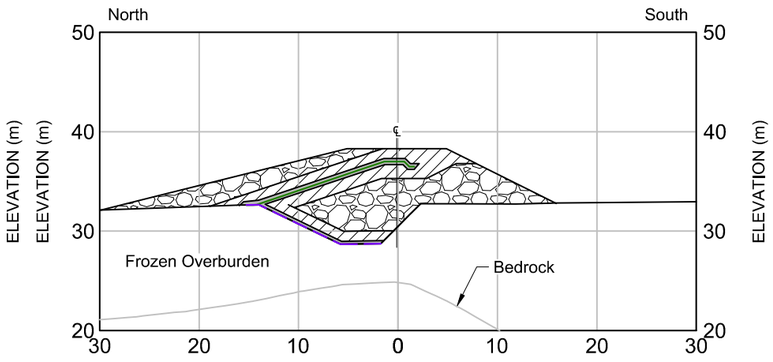
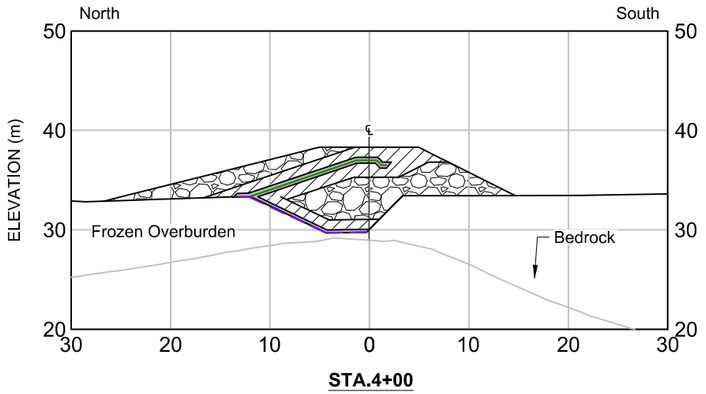
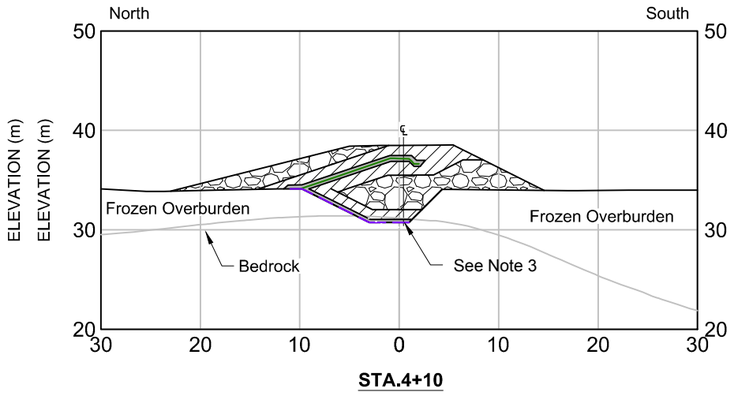


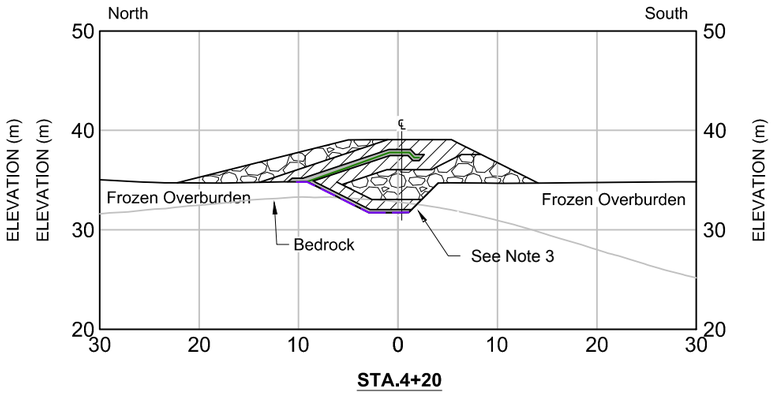
STA.3+90



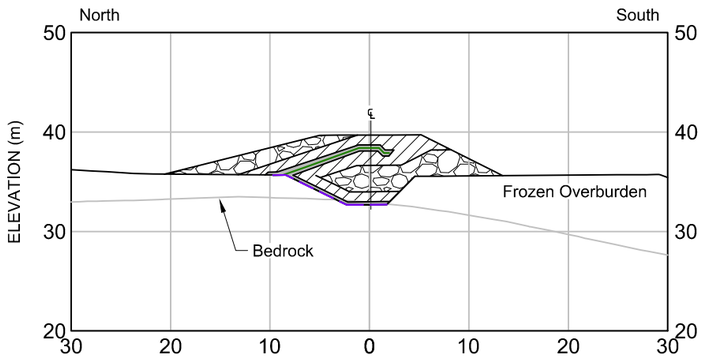
STA.4+00



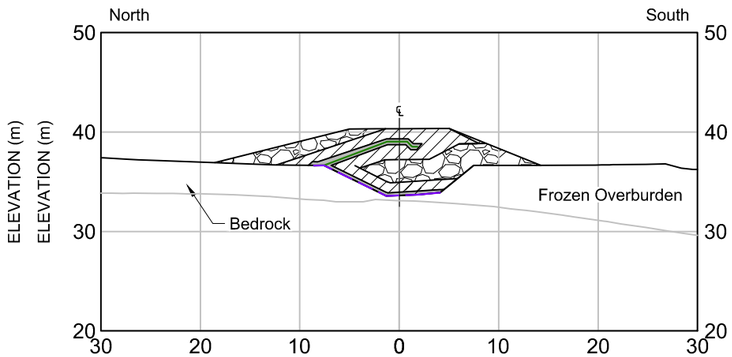
STA.4+10



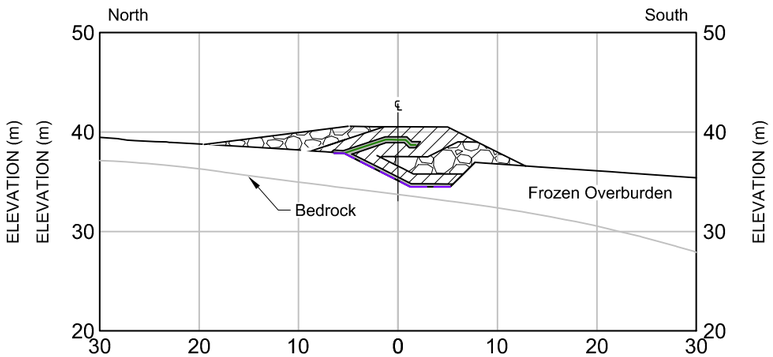
STA.4+20



STA.4+30



STA.4+40



STA.4+50

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

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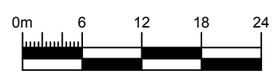

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29
REFERENCE DRAWINGS		REVISIONS									

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PROFESSIONAL ENGINEERS STAMP

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.3+70 to 4+50 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-17	17 OF 30	1

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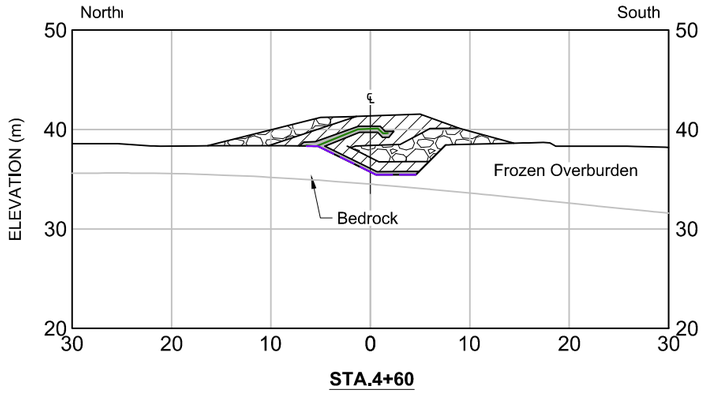
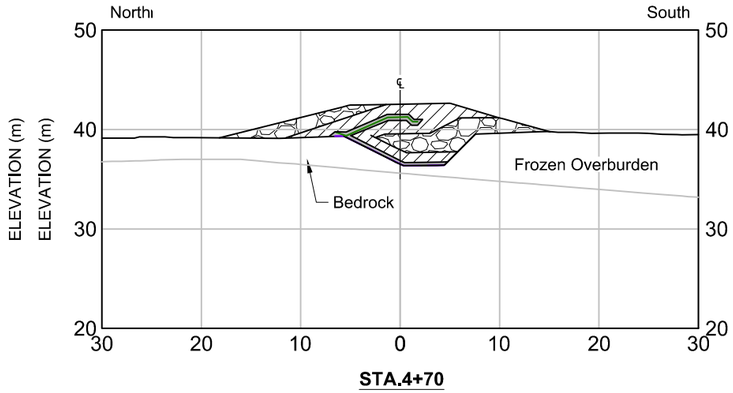
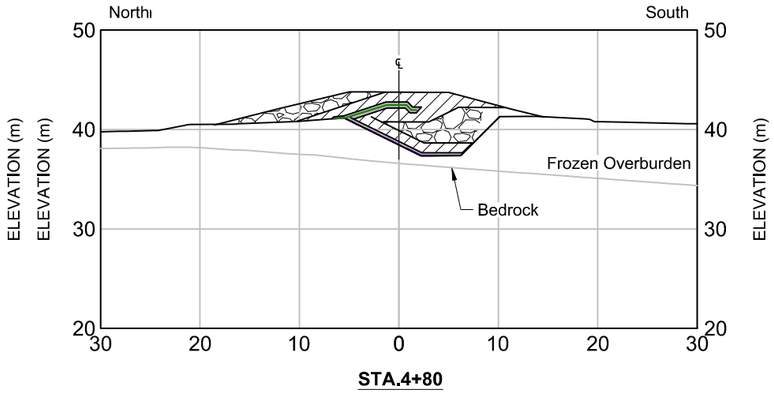


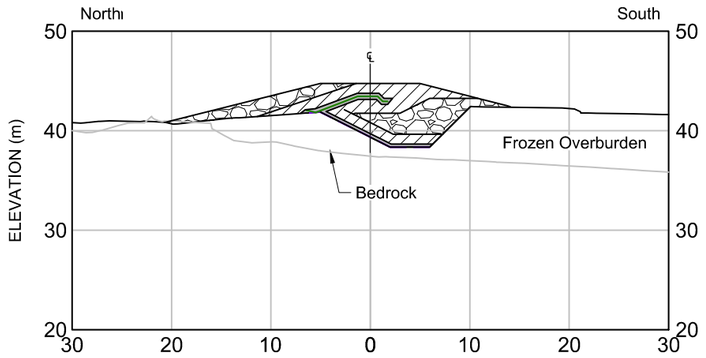
STA.4+60



STA.4+70



STA.4+80



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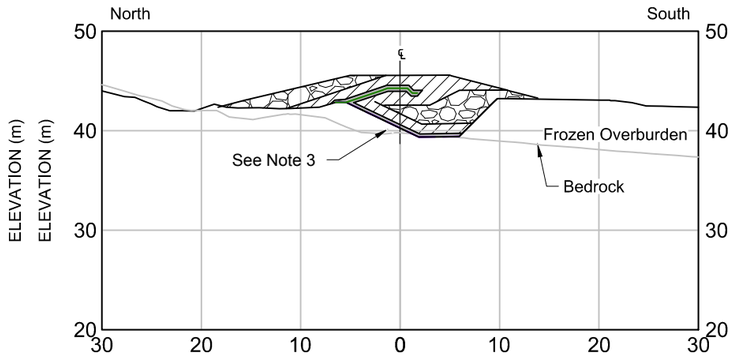
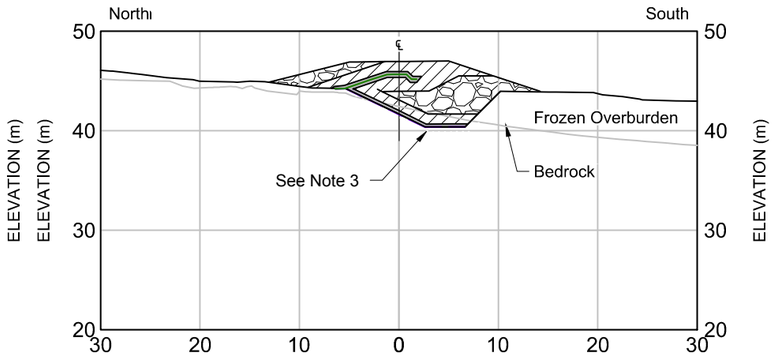
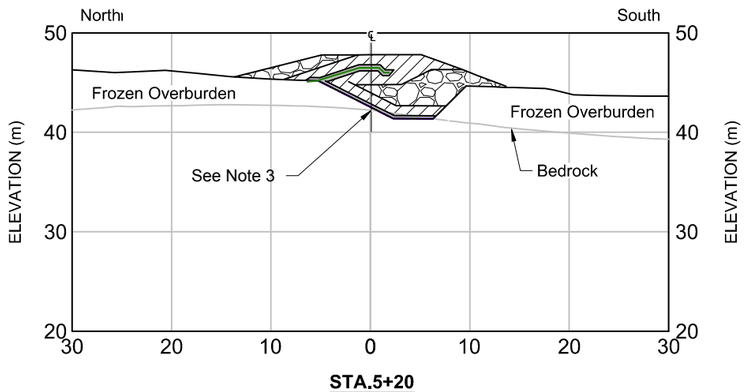


STA.5+00



STA.5+10



STA.5+20

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.
3. Depth of key trench intersection with bedrock estimated (see DN-SD-04 for additional details). Actual depth may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

REFERENCE DRAWINGS			REVISIONS								
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CH'K'D	APP'D	DATE	NO.	DESCRIPTION	CH'K'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.4+60 to 5+30 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-18	18 OF 30	1

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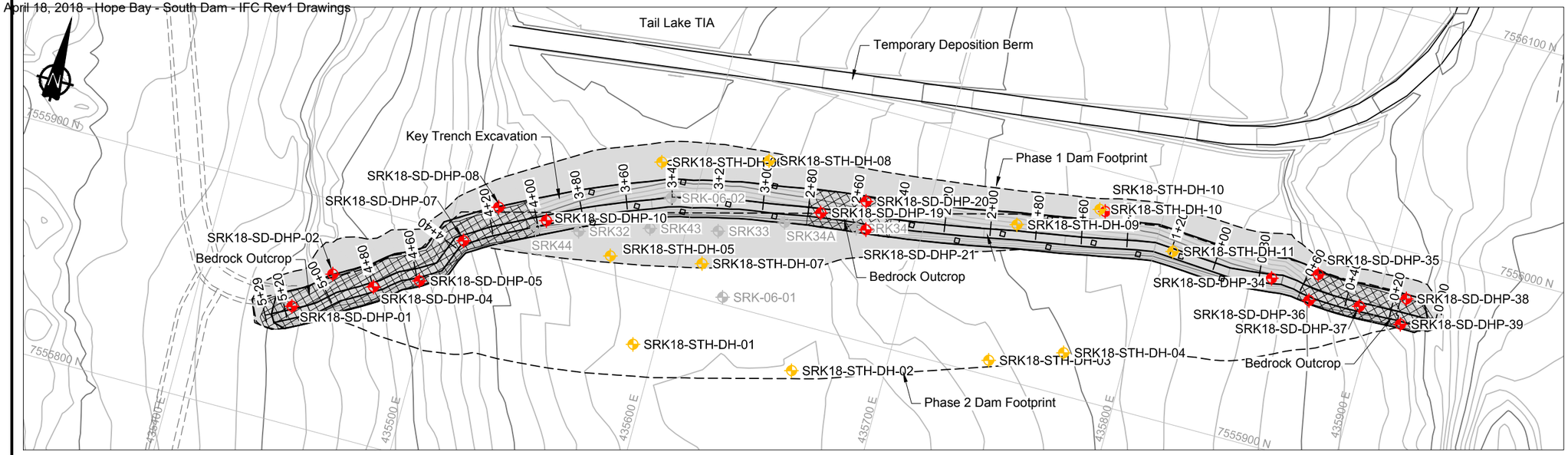
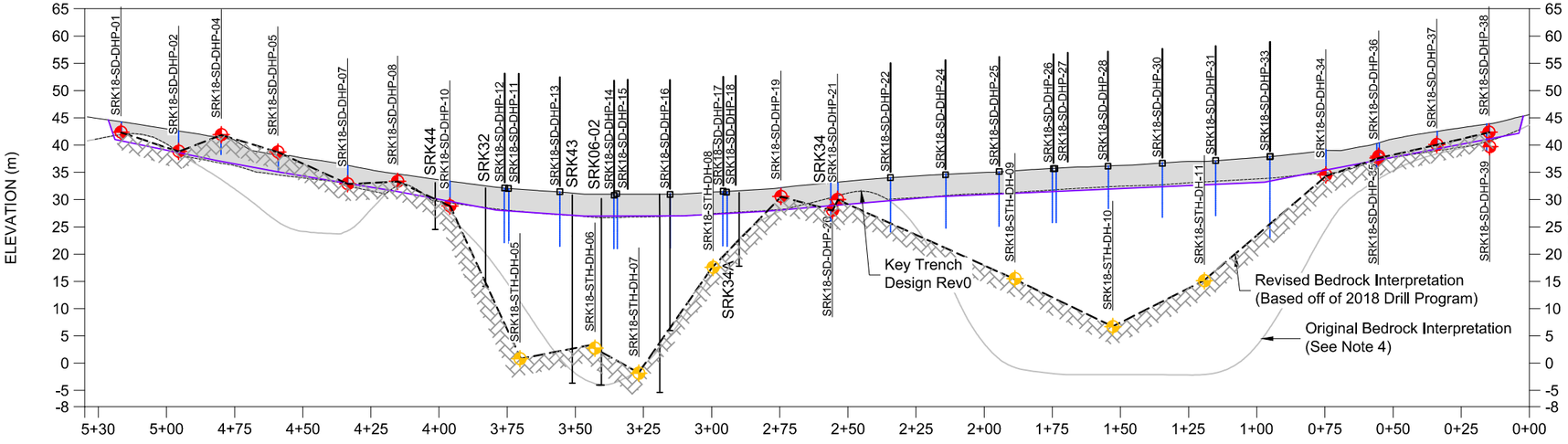


Key Trench Plan View

0m 20 40 60 80



Key Trench Profile View

Vertical 0m 10 20 30 40

Horizontal 0m 20 40 60 80

LEGEND

- Previous Investigation Hole Location
- 2018 Percolation Hole Location Intercepted Bedrock
- 2018 Percolation Hole Location Did Not Intercept Bedrock
- 2018 Borehole Location
- Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Trench Excavation Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profile shown correspond to the upstream toe of the key trench.
4. The subsurface geology has been inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A , SRK43, SRK 44, SRK18-STH-DH-01 to 11, and SRK18-WST-DH-01 to 03), airphoto interpretations, and from limited available geophysical surveys around the Tails Lake area. This data was then used to create a bedrock surface with the Gemcom GEMS software. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.
5. Infill drilling is planned to be completed to reduce the uncertainty and associated risks with the Phase 1 South Dam key trench excavation and overall dam performance (e.g. stability, seepage, settlement, and creep).
6. Depths of infill drill boreholes estimated based on available information (Note 4 and as noted on DN-SD-04). Boreholes should be drilled 3m into bedrock unless terminated earlier as directed by the onsite Engineer.
7. Inferred bedrock contact based off exploration and percolation testing holes drilled January / February 2018 by SRK Consulting.

REFERENCES

NAD83 UTM Zone 13.

AS-BUILT BOREHOLE LOCATIONS

Point ID	Northing	Easting	Collar Elevation	Depth to Bedrock
SRK18-STH-DH-01	7555,873	435,590	31.34	29.9
SRK18-STH-DH-02	7555,880	435,660	30.69	3.0
SRK18-STH-DH-03	7,555,907	435,742	33.59	13.5
SRK18-STH-DH-04	7,555,918	435,773	34.82	10.4
SRK18-STH-DH-05	7,555,908	435,571	31.81	31.0
SRK18-STH-DH-06	7,555,953	435,582	30.35	27.6
SRK18-STH-DH-07	7,555,915	435,610	30.86	32.7
SRK18-STH-DH-08	7,555,966	435,627	31.07	13.5
SRK18-STH-DH-09	7,555,967	435,739	35.03	15.5
SRK18-STH-DH-10	7,555,983	435,772	6.10	6.7
SRK18-STH-DH-11	7,555,973	435,808	36.82	15.1
SRK18-WST-DH-01	7,556,486	435,113	43.25	7.1
SRK18-WST-DH-02	7,556,296	435,200	41.42	1.1
SRK18-WST-DH-03	7,556,195	435,257	42.71	5.4

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
AB	As-Built	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/12/11

DN-SD-04 — Key Trench Excavation Plan and Profile

REFERENCE DRAWINGS

Original Drawings Stamped and Signed by Engineer

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DESIGN: JBK | DRAWN: TAH | REVIEWED: EMR
CHECKED: JBK | APPROVED: EMR | DATE: 2018/04/13
FILE NAME: 1CT0022.017 - South Dam - Infill Foundation Drilling.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Infill Foundation Drilling Phase 1

DRAWING NO.: DN-SD-19 | SHEET: 19 OF 30 | REVISION NO.: AB

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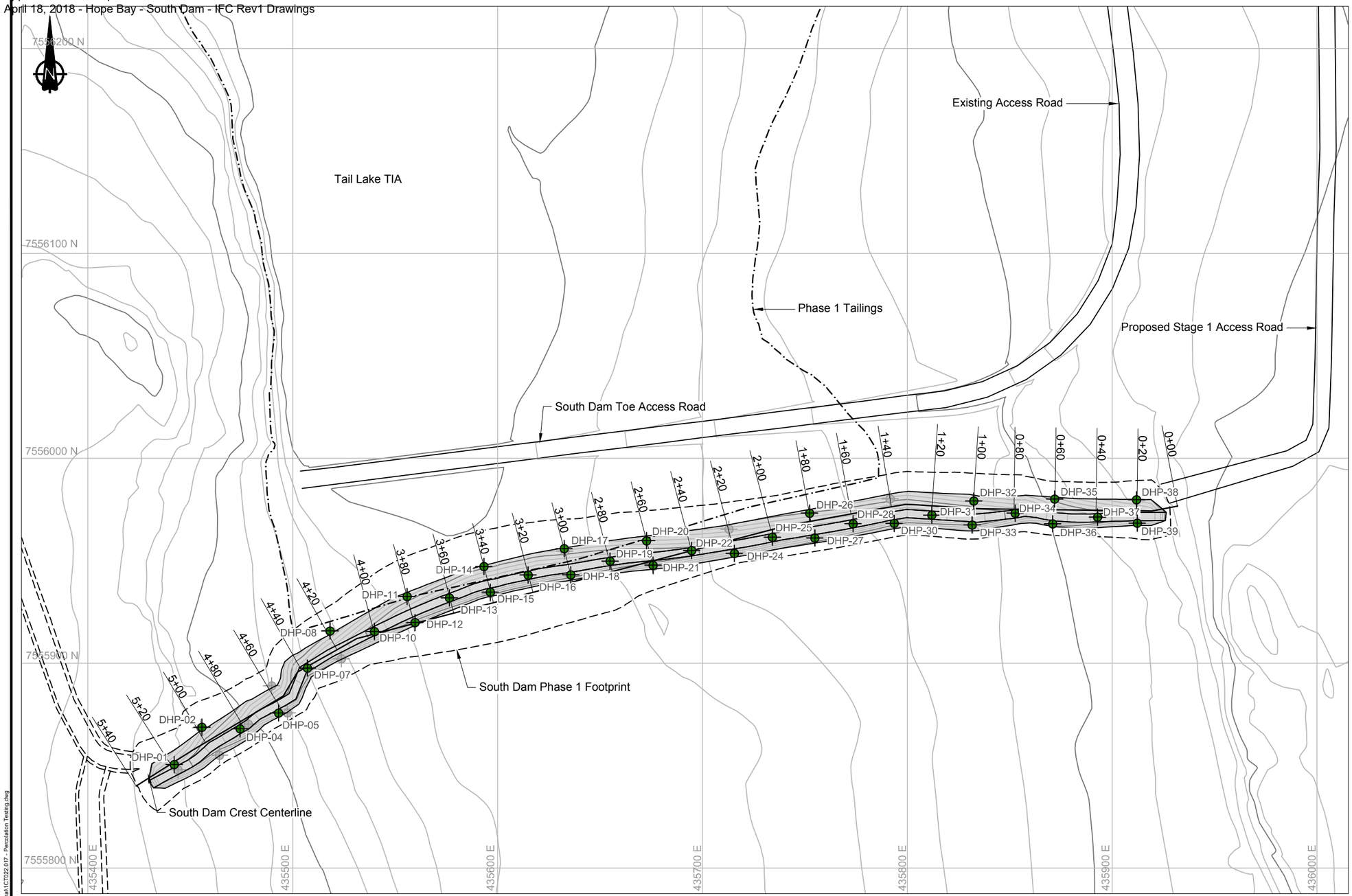

LEGEND

- Proposed Drill Hole Location
- As-Built Drill Hole Location
- Proposed Road Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Outline

NOTES

1. Contours shown at a 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. All percolation test boreholes should be a minimum 8.0m deep.
4. Percolation test boreholes should be a minimum of 4-6 inches (100-150mm) in diameter.
5. It is suggested that an air-track drill (quarry drill) be used to complete the percolation testing.
6. Once all percolation test locations are drilled the testing will be completed on site as directed by the Engineer.

REFERENCES

NAD83 UTM Zone 13.

AS-BUILT PERCOLATION BOREHOLE LOCATIONS

Point ID	Northing	Easting	Elevation
SRK18-SD-DHP1	7555850.42	435442.14	44.2
SRK18-SD-DHP2	7555868.68	435455.71	42.1
SRK18-SD-DHP4	7555867.85	435474.33	41.0
SRK18-SD-DHP5	7555875.60	435493.08	37.9
SRK18-SD-DHP7	7555897.52	435507.19	36.0
SRK18-SD-DHP8	7555915.67	435518.25	34.3
SRK18-SD-DHP10	7555915.40	435539.87	32.8
SRK18-SD-DHP11	7555932.47	435555.80	31.6
SRK18-SD-DHP12	7555919.75	435559.69	31.8
SRK18-SD-DHP13	7555931.76	435576.48	31.1
SRK18-SD-DHP14	7555947.08	435593.31	30.5
SRK18-SD-DHP15	7555934.56	435596.45	30.7
SRK18-SD-DHP16	7555942.92	435614.88	31.2
SRK18-SD-DHP17	7555955.86	435632.48	31.6
SRK18-SD-DHP18	7555943.01	435635.74	31.5
SRK18-SD-DHP19	7555949.72	435654.89	32.0
SRK18-SD-DHP20	7555959.68	435672.72	33.0
SRK18-SD-DHP21	7555947.75	435675.88	33.1
SRK18-SD-DHP22	7555954.90	435694.71	33.7
SRK18-SD-DHP24	7555953.48	435715.55	34.4
SRK18-SD-DHP25	7555961.44	435734.11	35.0
SRK18-SD-DHP26	7555973.14	435752.28	35.5
SRK18-SD-DHP27	7555961.00	435754.88	35.4
SRK18-SD-DHP28	7555967.97	435773.53	35.9
SRK18-SD-DHP30	7555968.15	435793.60	36.4
SRK18-SD-DHP31	7555972.15	435812.00	37.1
SRK18-SD-DHP32	7555979.10	435832.48	37.7
SRK18-SD-DHP33	7555967.38	435831.61	37.6
SRK18-SD-DHP34	7555973.14	435852.65	38.6
SRK18-SD-DHP35	7555980.03	435871.93	40.9
SRK18-SD-DHP36	7555967.95	435870.94	40.1
SRK18-SD-DHP37	7555971.21	435892.86	42.4
SRK18-SD-DHP38	7555979.68	435911.87	44.3
SRK18-SD-DHP39	7555968.28	435912.27	43.5

REFERENCE DRAWINGS		REVISIONS								
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-04	Key Trench Excavation Plan and Profile	--	--	--	--	--	AB	As-Built	JBK	EMR	18/04/13
							0	Issued for Construction	JBK	EMR	17/12/11

Original Drawings Stamped and Signed by Engineer

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JBK	TAH	EMR
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JBK	EMR	2018/04/13

FILE NAME: 1CT022.017 - Percolation Testing.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Percolation Borehole / Test Locations

DRAWING NO.	SHEET	REVISION NO.
DN-SD-20	20 OF 30	AB

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Doris TIA

Existing Access Road

Proposed Stage 1 Access Road

Proposed Stage 2 Access Road

Temporary Deposition Berm

Phase 1 Dam - Issued for Construction (IFC)

Phase 2 Dam Footprint - Ultimate footprint shown for information only

7556100 N
7556000 N
7555900 N
7555800 N

435400 E
435500 E
435600 E
435700 E
435800 E
435900 E
436000 E

0m 20 40 60 80

LEGEND

- Fixed Survey Monitoring Poind
- Surficial Survey Monitoring Point
- Deep Monitoring Point
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

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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							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/02/16

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Plan Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-21	21 OF 30	1

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LEGEND

- Monitoring Section
- Cable Trench
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Ground Temperature Cable backfilled cable trenches to be excavated through final dam shell - See drawings DN-SD-27, 28 and 29.

REFERENCES

NAD83 UTM Zone 13.

0m 20 40 60 80

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-29	Instrumentation Details at Sta. 4+65 and 5+10										
DN-SD-28	Instrumentation Details at Sta. 2+40 and 3+65										
DN-SD-27	Instrumentation Details at Sta. 0+65 and 1+55						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/02/16

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - GTC Trenches.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: GTC Backfilled Cable Trenches Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-22	22 OF 30	1

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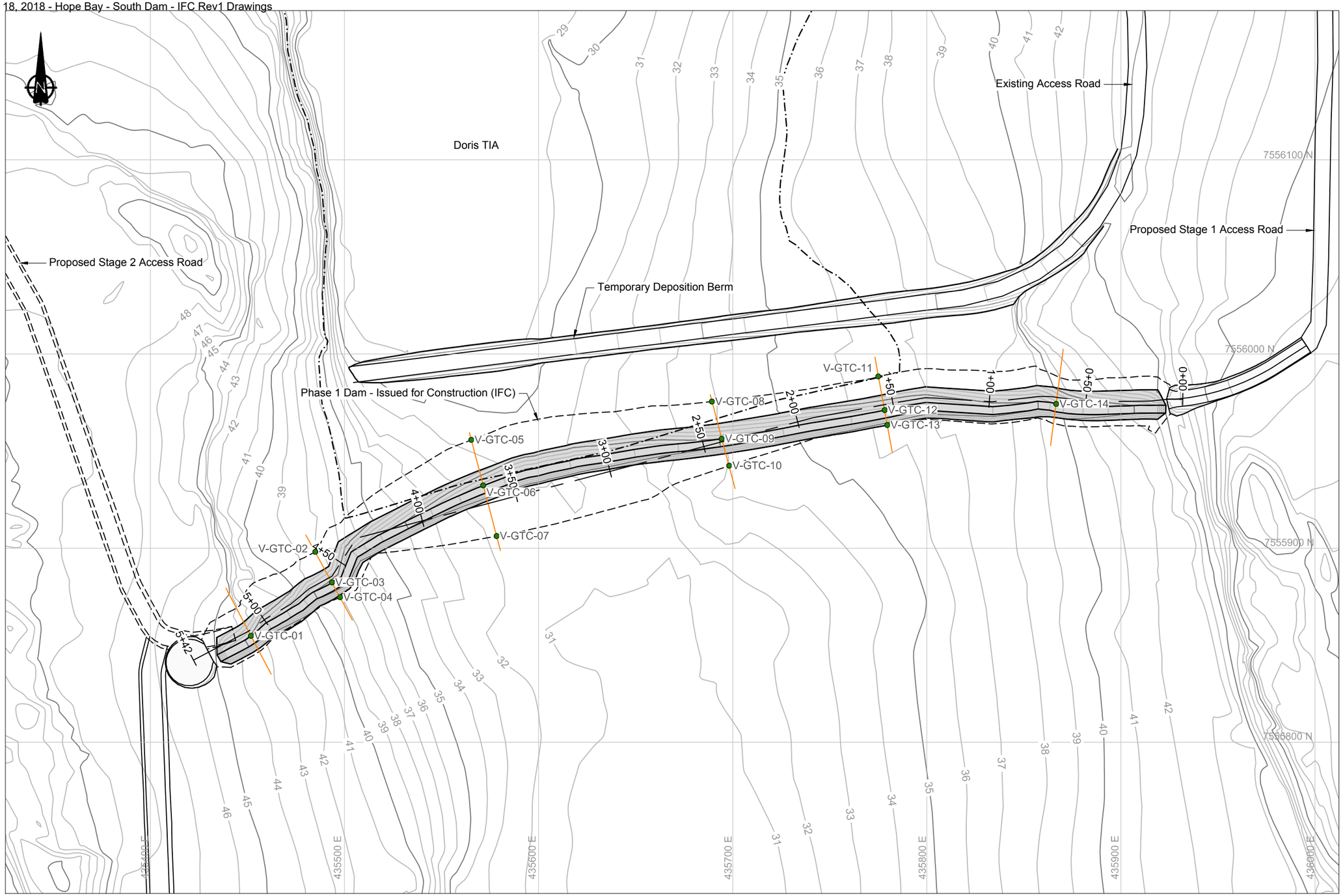

LEGEND

- Vertical Ground Temperature Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

I.D.	Northing	Easting
V-GTC-01	7555854.81	435451.79
V-GTC-02	7555898.07	435484.95
V-GTC-03	7555882.32	435493.54
V-GTC-04	7555874.72	435497.69
V-GTC-05	7555955.78	435565.30
V-GTC-06	7555932.32	435571.39
V-GTC-07	7555906.23	435578.34
V-GTC-08	7555975.51	435689.29
V-GTC-09	7555956.36	435694.32
V-GTC-10	7555942.48	435698.15
V-GTC-11	7555988.45	435775.01
V-GTC-12	7555971.08	435778.29
V-GTC-13	7555963.40	435779.65
V-GTC-14	7555974.28	435866.64

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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DN-SD-03	Typical Sections	-	-	
DRAWING NO.	DRAWING TITLE			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/12/15

REVISIONS

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Vertical GTC LO.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Vertical GTC Layout Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-23	23 OF 30	1

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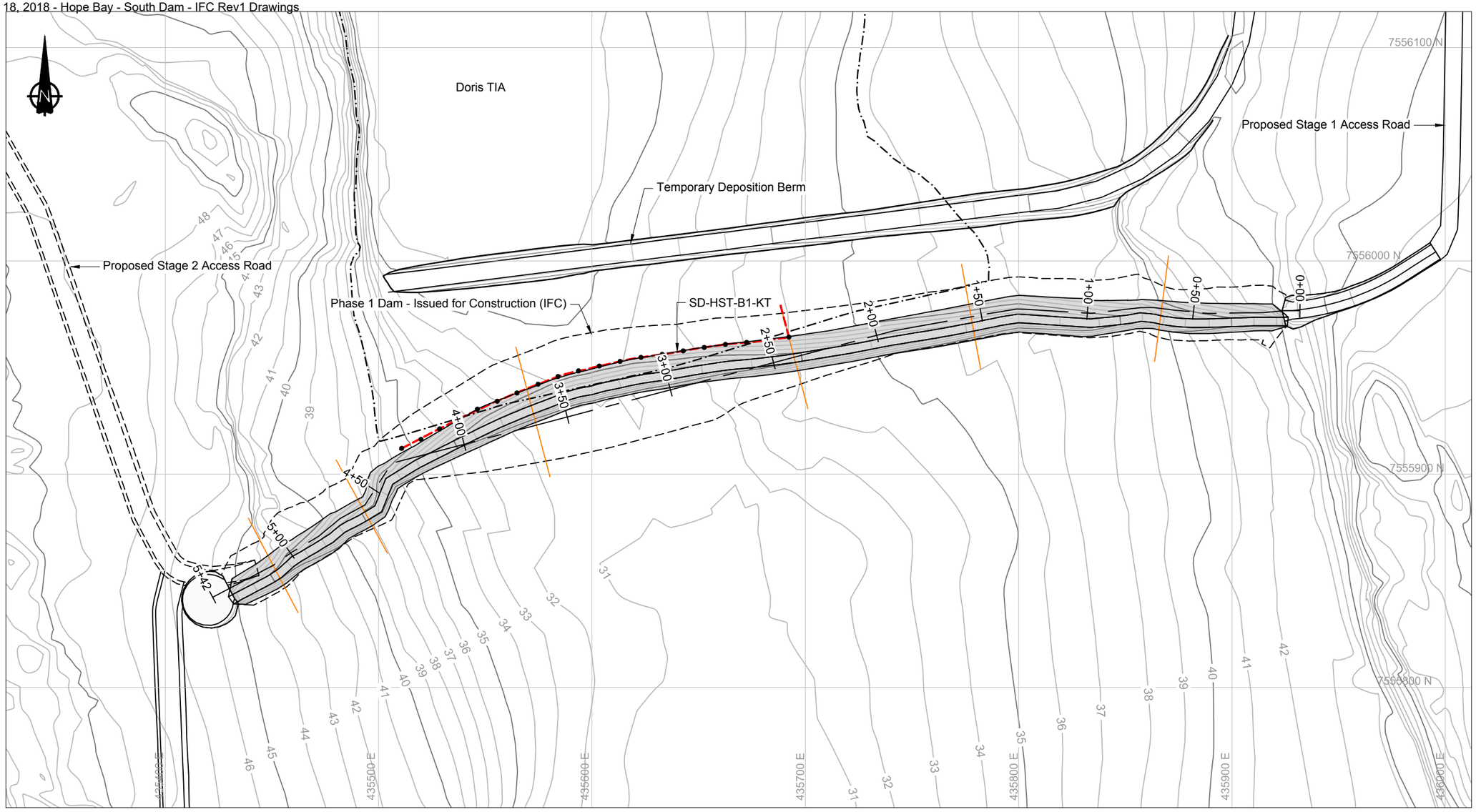

LEGEND

- Horizontal Ground Temperature Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Key Trench Footprint
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

ID	Northing	Easting
HST20098	7555964.28	435692.33
HST20099	7555962.86	435682.43
HST20100	7555961.78	435672.49
HST20101	7555960.86	435662.54
HST20102	7555959.44	435652.64
HST20103	7555957.83	435642.77
HST20104	7555956.14	435632.91
HST20105	7555954.75	435623.01
HST20106	7555952.88	435613.20
HST20107	7555950.71	435603.43
HST20108	7555948.45	435593.71
HST20109	7555945.81	435584.08
HST20110	7555942.19	435574.76
HST20111	7555938.05	435564.84
HST20112	7555934.18	435555.62
HST20113	7555930.47	435546.33
HST20114	7555925.96	435537.40
HST20115	7555921.21	435528.59
HST20116	7555916.34	435519.87
HST20117	7555912.10	435510.79

0m 20 40 60 80

Ground Temperature Cable Details - Center Base

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
1	SD-HST-B1-KT	A	Horizontal	Center	235	Top of Key Trench	20 beads spaced every 10m from the zero line on the cable, i.e. first bead at 0m										

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
REFERENCE DRAWINGS		REVISIONS				
DN-SD-03	Typical Sections	-	-			
-	-					

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	18/02/15

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Lower H&II GTC LO.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:
Horizontal GTC
Upstream Base / Toe of Key Trench

DRAWING NO.	SHEET	REVISION NO.
DN-SD-24	24 OF 30	1

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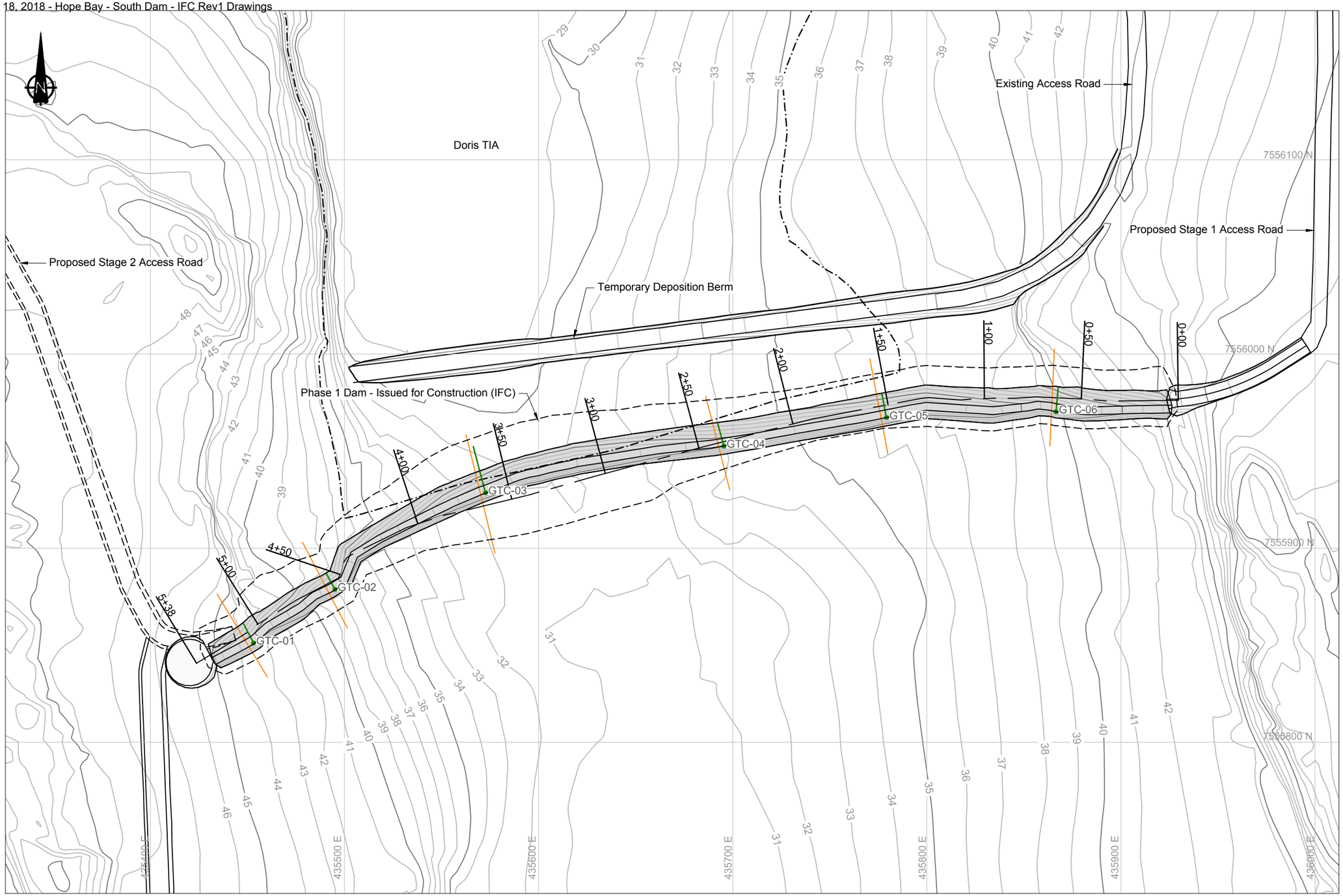

LEGEND

- Leak Detection Instrumentation
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

I.D.	Northing	Easting
GTC-01	7555851	435453
GTC-02	7555879	435495
GTC-03	7555929	435573
GTC-04	7555953	435695
GTC-05	7555937	435779
GTC-06	7555970	435867

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
-	-
DN-SD-03	Typical Sections

REVISIONS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/12/11

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Leak Detection.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

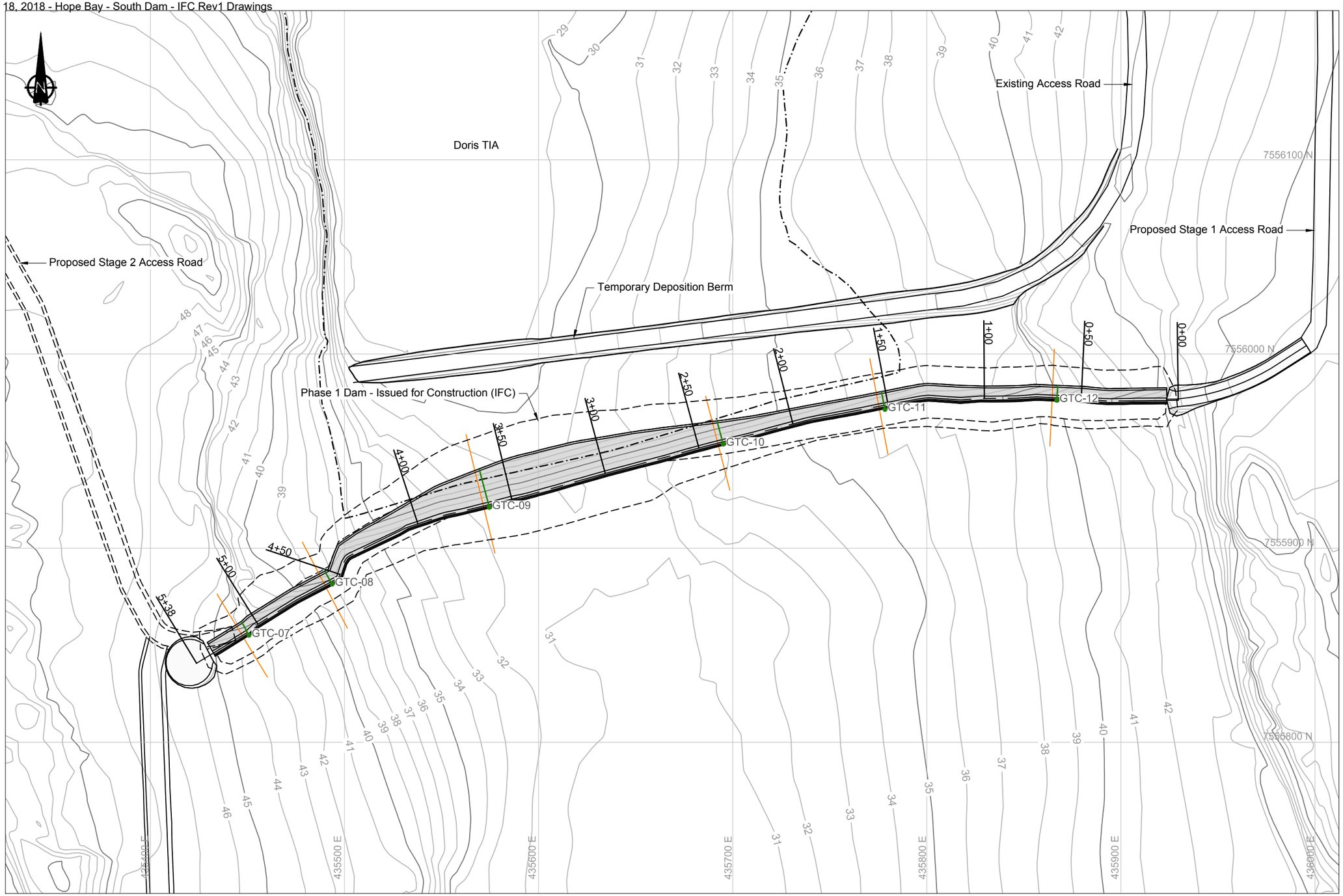
South Dam

DRAWING TITLE:

GTC Layout Along Upstream Slope of Key Trench

DRAWING NO.	SHEET	REVISION NO.
DN-SD-25	25 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1\1CT0022.017 - Leak Detection.dwg



LEGEND

- Ground Temperature Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

I.D.	Northing	Easting
GTC-07	7555855	435451
GTC-08	7555882	435494
GTC-09	7555921	435575
GTC-10	7555954	435695
GTC-11	7555972	435778
GTC-12	7555976	435867

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	17/12/11

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Liner GTC.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

GTC Layout Along Upstream Above Ground Liner Slope

DRAWING NO.	SHEET	REVISION NO.
DN-SD-26	26 OF 30	1

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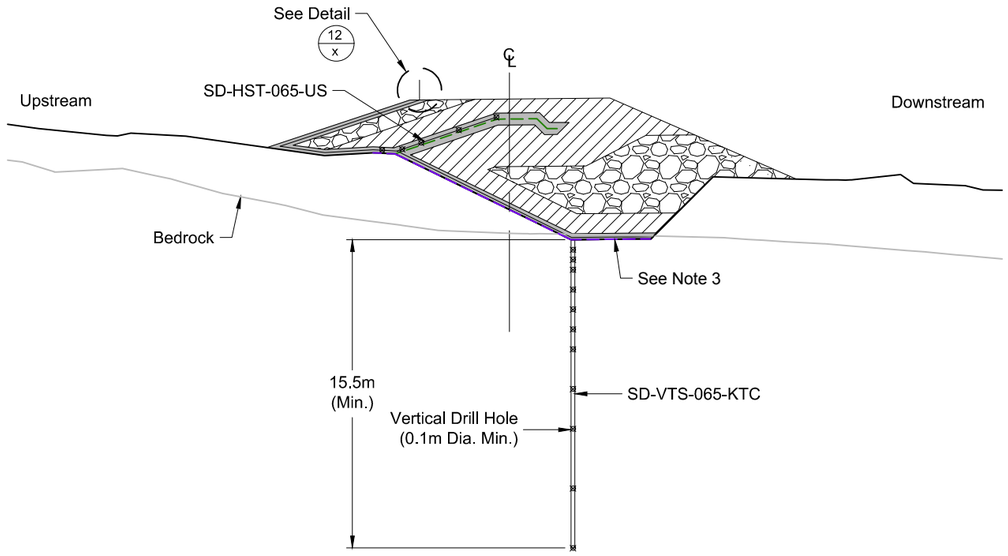
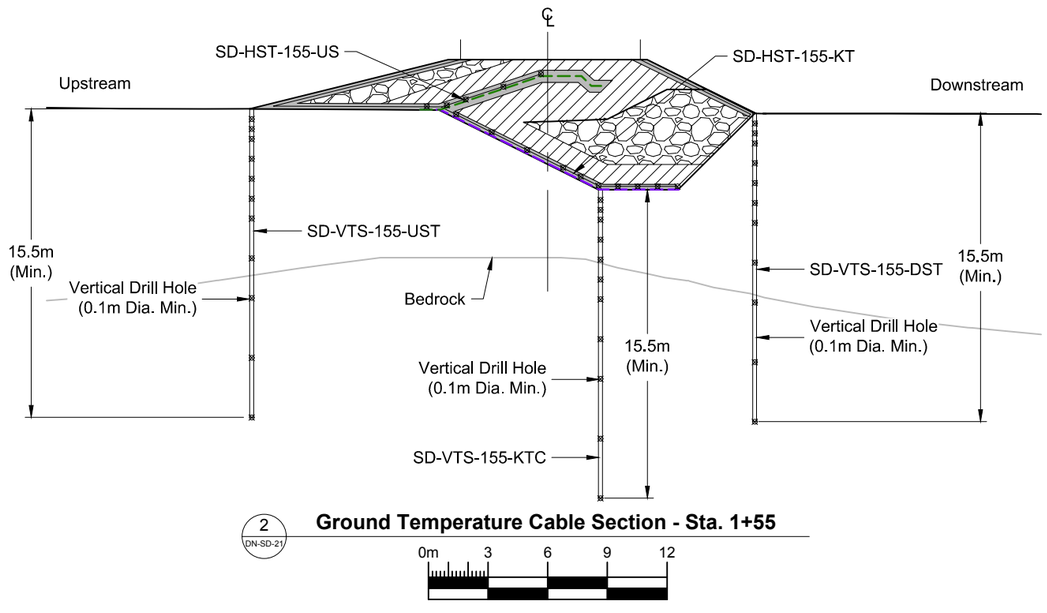


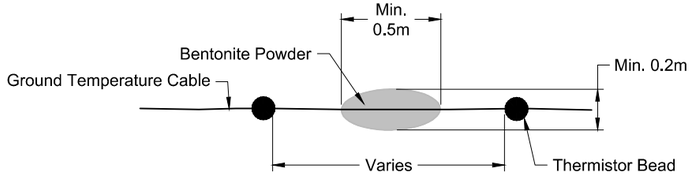
1 DN-SD-21 **Ground Temperature Cable Section - Sta. 0+65**

0m 3 6 9 12



2 DN-SD-21 **Ground Temperature Cable Section - Sta. 1+55**

0m 3 6 9 12



Detail 12 - Typical Water Stop Detail

0m 0.3 0.6 0.9 1.2

LEGEND

- Thermistor Bead Location
- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. Vertical cable boreholes to be filled with grout or backfilled with finer (sand size) material.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

Ground Temperature Cable Details - Monitoring Section 0+65 and 1+55

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
2	SD-VTS-65-KTC	A	Vertical	0+65	42	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
3	SD-HTS-065-US	B	Horizontal & Inclined	0+65	121	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
4	SD-VTS-155-KTC	A	Vertical	1+55	50	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
5	SD-VTS-155-UST	A	Vertical	1+55	41	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
6	SD-VTS-155-DST	A	Vertical	1+55	53	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
7	SD-HTS-155-US	B	Horizontal & Inclined	1+55	41	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
8	SD-HTS-155-KT	C	Horizontal & Inclined	1+55	39	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13
9	SD-HST-B1-KT	C	Horizontal	Center Base	235	Center Base	20 beads spaced every 10m from the zero line on the cable i.e. first bead at 0m										
10	Extension for SD-VTS-065-KTC	D	Vertical	0+65	90		Extension for existing cable. No beads needed.										

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	JBK	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Details at Sta. 0+65 and 1+55

DRAWING NO.	SHEET	REVISION NO.
DN-SD-27	27 OF 30	1

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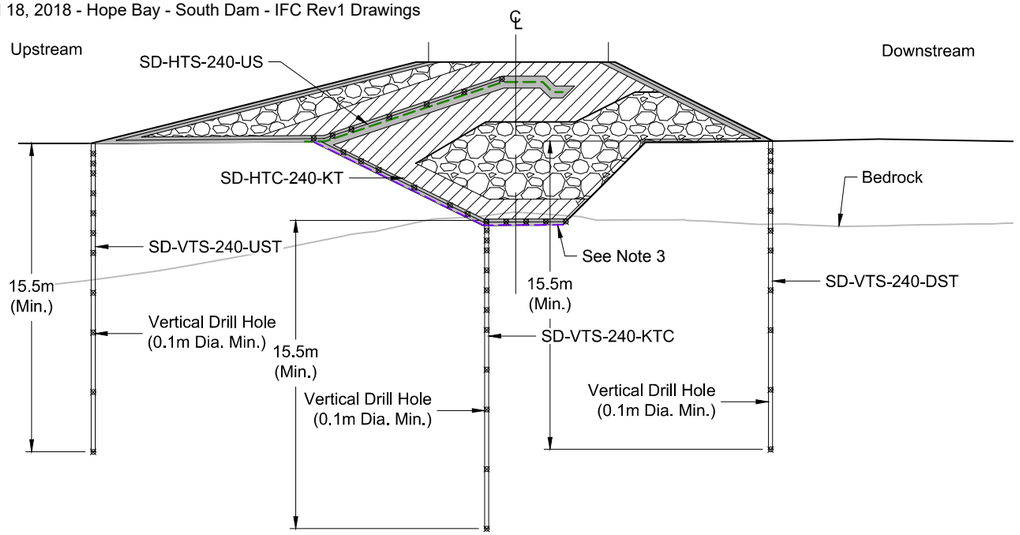
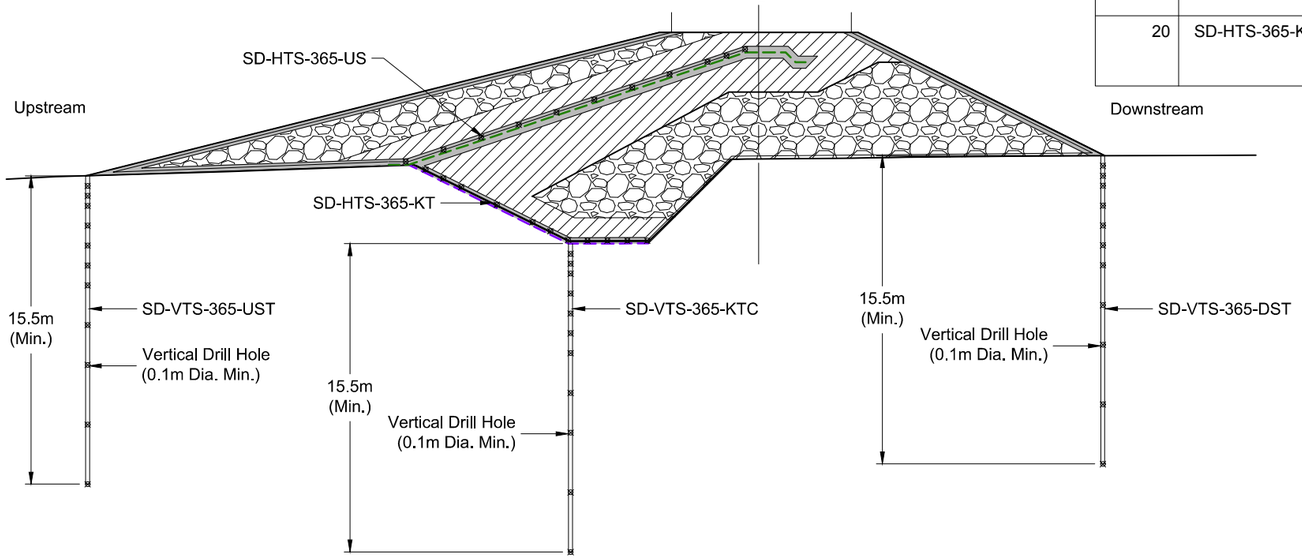


3 DN-SD-21

Ground Temperature Cable Section - Sta. 2+40

0m 3 6 9 12



4 DN-SD-21

Ground Temperature Cable Section - Sta. 3+65

0m 3 6 9 12

Ground Temperature Cable Details - Monitoring Section 2+40 and 3+65

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
11	SD-VTS-240-KTC	A	Vertical	2+40	58	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
12	SD-VTS-240-UST	A	Vertical	2+40	46	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
13	SD-VTS-240-DST	A	Vertical	2+40	53	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
14	SD-HTS-240-US	B	Horizontal & Inclined	2+40	50	Upstream Slope	0	2	4	6	8	9	10	-	-	-	-
15	SK-HTC-240-KT	B	Horizontal & Inclined	2+40	48	Upstream Slope	0	1	3	5	7	8	9	10	11	12	13
16	SD-VTS-365-KTC	A	Vertical	3+65	75	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
17	SD-VTS-365-UST	A	Vertical	3+65	57	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
18	SD-VTS-365-DST	A	Vertical	3+65	58	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
19	SD-HTS-365-US	B	Horizontal & Inclined	3+65	76	Upstream Slope	0	2	4	6	8	10	12	14	15	17	18
20	SD-HTS-365-KT	C	Horizontal & Inclined	3+65	65	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13

LEGEND

- Thermistor Bead Location
- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

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DESIGN: CH | DRAWN: TAH | REVIEWED: JBK | CHECKED: JBK | APPROVED: EMR | DATE: 2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Details at Sta. 2+40 and 3+65

DRAWING NO. DN-SD-28 | SHEET 28 OF 30 | REVISION NO. 1

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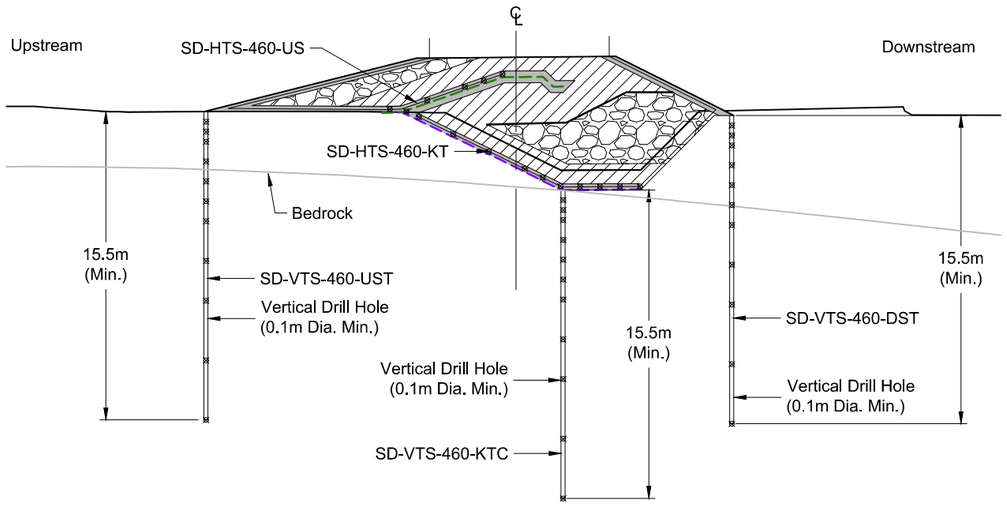
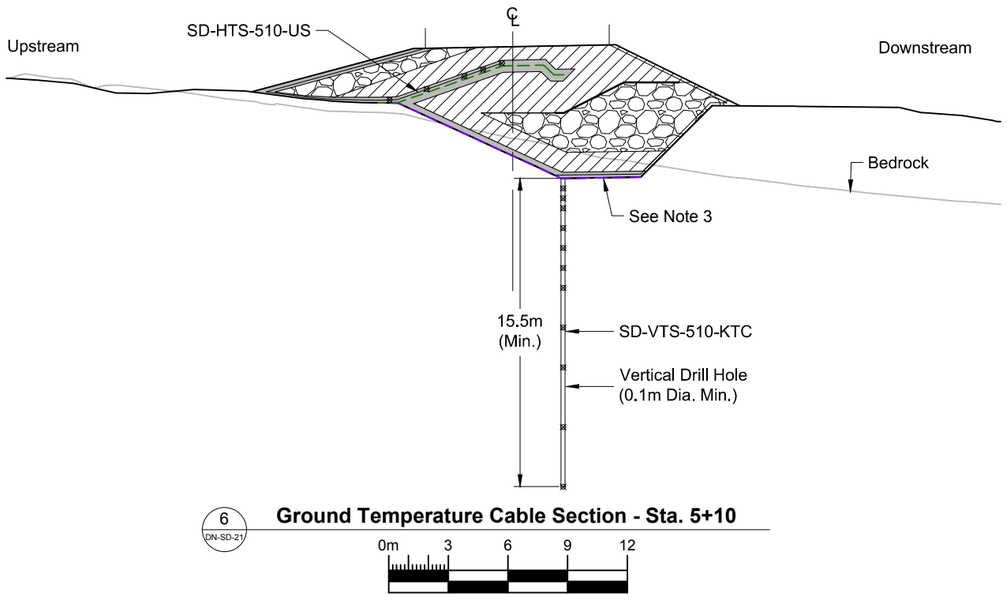


5 DN-SD-21 **Ground Temperature Cable Section - Sta. 4+60**



6 DN-SD-21 **Ground Temperature Cable Section - Sta. 5+10**

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

Ground Temperature Cable Details - Monitoring Section 4+60 and 5+10

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
21	SD-VTS-460-KTC	A	Vertical	4+60	50	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
22	SD-VTS-460-UST	A	Vertical	4+60	41	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
23	SD-VTS-460-DST	A	Vertical	4+60	58	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
24	SD-HTS-460-US	B	Horizontal & Inclined	4+60	41	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
25	SD-HTS-460-KT	C	Horizontal & Inclined	4+60	39	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13
26	SD-VTS-510-KTC	A	Vertical	5+10	48	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
27	SD-HTS-510-US	B	Horizontal & Inclined	5+10	86	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
28	Extension for SD-VTS-510-KTC	D	Vertical	5+10	90		Extension for existing cable. No beads needed.										

REFERENCE DRAWINGS			REVISIONS								
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

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DESIGN: CH | DRAWN: TAH | REVIEWED: JBK
CHECKED: JBK | APPROVED: EMR | DATE: 2018/04/13
FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Details at Sta. 4+65 and 5+10

DRAWING NO. DN-SD-29 | SHEET 29 OF 30 | REVISION NO. 1

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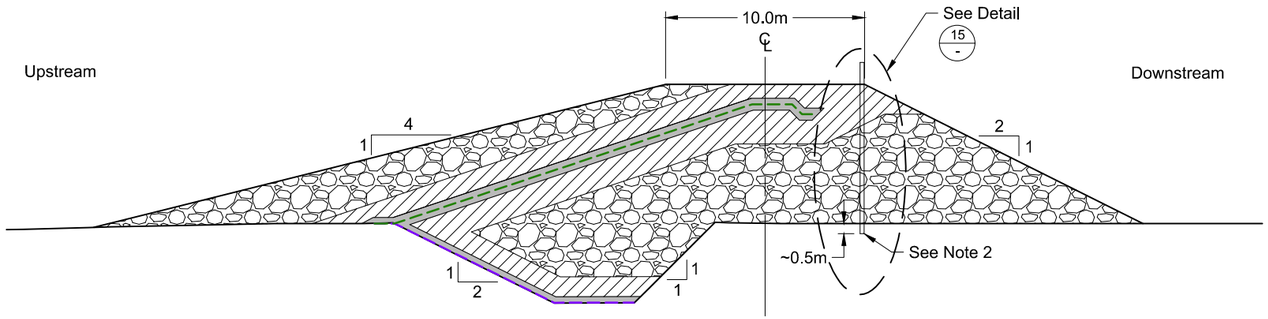
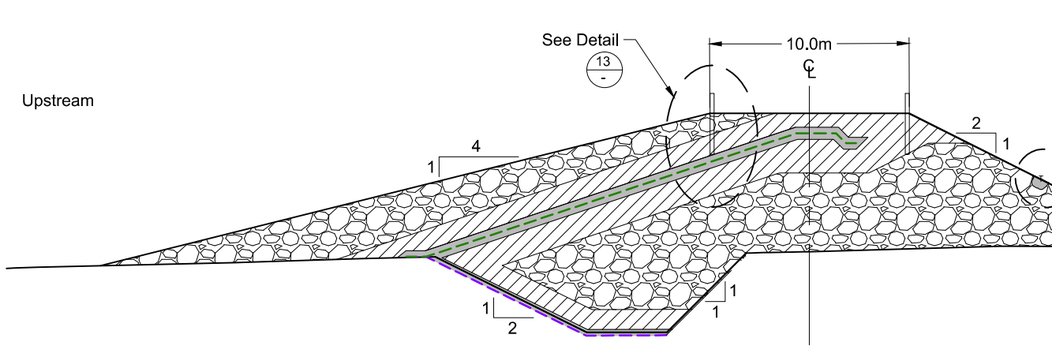


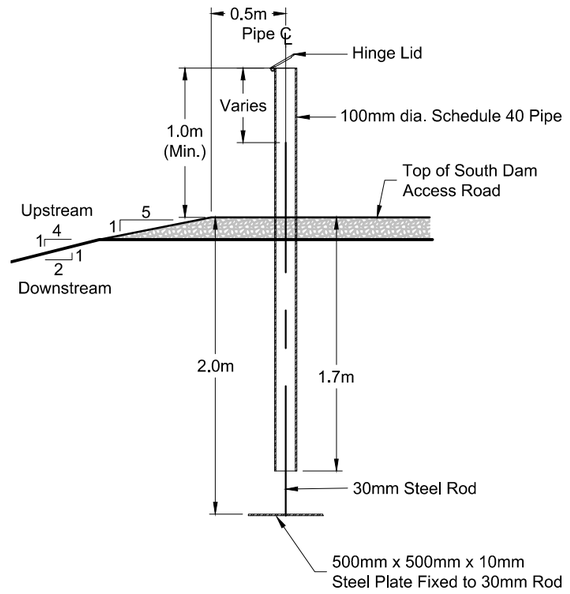
Surficial Survey Point - Sta. 3+15

0m 3 6 9 12



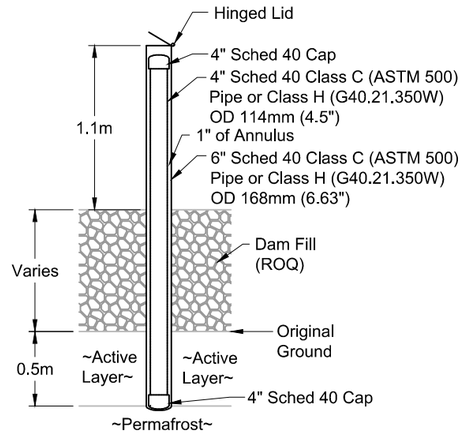
Deep Settlement Point - Sta. 3+50

0m 3 6 9 12



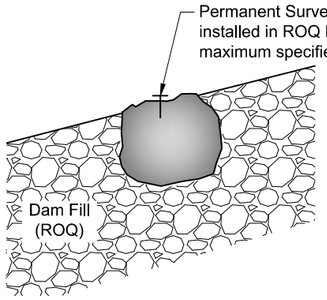
Detail 13 - Survey Monitoring Point Detail

0m 0.25 0.5 0.75 1.0



Detail 15 - Deep Settlement Point Installation

0m 0.25 0.5 0.75 1.0



Detail 14 - Surficial Survey Point Installation

0m 0.25 0.5 0.75 1.0

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. Deep settlement point installation depth to be directed by the field Engineer. Aim is to be near the active layer - permafrost contact.

REFERENCE DRAWINGS		REVISIONS										
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/04/13
DN-SD-21	Instrumentation Plan - Phase 1										

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Typical Monitoring Point Details

DRAWING NO.	SHEET	REVISION NO.
DN-SD-30	30 OF 30	1

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Seema Kang

From: John Kurylo
Sent: Wednesday, April 18, 2018 11:28 AM
To: Mark Doucette; Jake Chisholm; George Lochead; janied@sub-arctic.ca; samb@sub-arctic.ca
Cc: Kyle Scale; Kaitlyn Kooy; Christopher Stevens; Silkie Wong; Cameron Hore; Kendell Cator; Ryan Williams; 'Kelly Schwenning'; Darko Filipic; Roland Jones; Rob Cook; 'Murray Weddell'; NA 1CT022.031 HopeBay; John Kurylo
Subject: RE: Hope Bay - South Dam - IFC Rev1 Drawings
Attachments: 180409 - US ROQ.XML; 180409 - DamLiner.xml; 180409 - DamTransition.xml; 180409 - DS Beddint.xml; 180409 - DS ROQ.XML; 180409 - KTBedding.xml; 180409 - KTtrans.xml; 180409 - US Beddint.xml; 180319 - South Dam - Key Trench.xml; P1 Dam Shell.xml; Phase 1 DamCL.XML

Hi Sub-Arctic,

To follow-up with the update IFC drawings that I sent our yesterday attached please find the associated CAD files (LandXML) for the various updated IFC design surface. The main surfaces that might be helpful for your layouts I expect will be the updated above ground Transition and ROQ surfaces - as these have been adjusted based on the latest original ground survey around the East and West abutment areas (as shown in the screenshot in the email chain below). So surfaces:

- US ROQ
- Dam Transition
- DS ROQ

The key trench and bedding makes sense to continue with how you have been doing the layouts and checks on site. Thanks again for all your time, support and efforts. If you have any questions about the attached then please let me know.

Kind Regards,
John

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

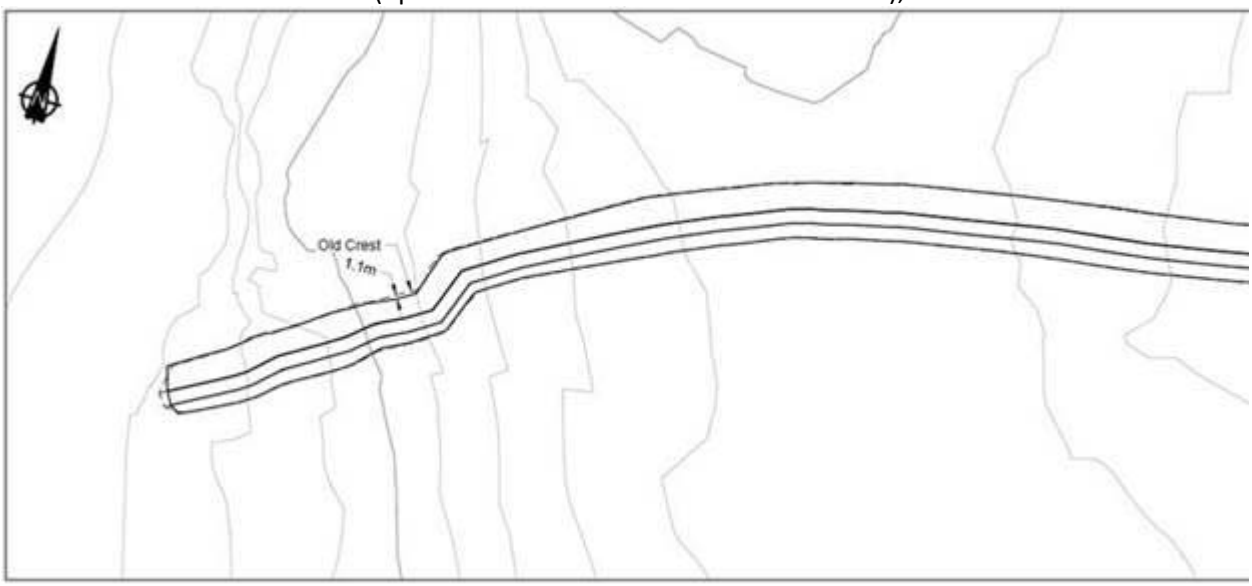
From: John Kurylo
Sent: Tuesday, April 17, 2018 23:26
To: 'Kelly Schwenning' <kelly.schwenning@tmacresources.com>; 'Murray Weddell' <murray.weddell@tmacresources.com>; Gramoz Rexhepi <GramozR@nunalogistics.com>; 'Darko Filipic' <DarkoF@nunalogistics.com>; Roland Jones <RolandJ@nunalogistics.com>; Boyd Barstad <boydb@nunalogistics.com>; Mark Doucette <markd@sub-arctic.ca>; Jake Chisholm <jakec@sub-arctic.ca>; George Lochead <georgel@sub-arctic.ca>; janied@sub-arctic.ca; samb@sub-arctic.ca; 'Rob Cook' <robc@nunalogistics.com>
Cc: Maritz Rykaart <mrykaart@srk.com>; Kyle Scale <kscale@srk.com>; Kaitlyn Kooy <kkooy@srk.com>; Christopher Stevens <cstevens@srk.com>; Silkie Wong <swong@srk.com>; Cameron Hore <chore@srk.com>; Kendell Cator <kcator@srk.com>; Ryan Williams <rwilliams@srk.com>; John Kurylo <jkurylo@srk.com>
Subject: Hope Bay - South Dam - IFC Rev1 Drawings

Hi everyone,

Attached to this email please find an updated "Issued for Construction" (IFC), Revision 1, drawing package. These drawings supersede the previous (original) South Dam IFC drawing revisions submitted.

Note that the main updates in these drawings are as follows:

1. Details on the instrumentation are included (which SRK and site personnel have already started installing on site);
2. Additional ROQ material has been added to the designs of the downstream (DS) slope of the dam (which shallows the slope and assist to create access on the DS – as previously discussed);
3. The outside slopes (Transition and ROQ) has been updated based on the updated original ground topography survey for the east and west abutment (updates as shown in the screenshot below);



4. The updated key trench design updates which were previously communicated and provided (and what has been constructed on site) are documented in these drawings; and
5. As-built drawings for the percolation testing and sonic / infill drilling completed in January and February are included

The attached IFC drawings show the neat-line design lines for the South Dam. As is being currently completed on site the as-built key trench surface should continue to be used to make the field fit adjustments (as per the discussions that have resulted with SRK site staff on site, and as per the Revision H Technical Specifications).

If you have any questions when you review the attached then please let myself or SRK site staff know.

Regards,
John

John Kurylo *MSc (DIC), PEng*
Senior Consultant (Geotechnical)

srk consulting

SRK Consulting (Canada) Inc.

22nd Floor, 1066 West Hastings Street, Vancouver, BC, V6E 3X2, Canada

Tel: +1-604-681-4196; **Fax**: +1-604-687-5532
Mobile:+ 1-604-345-2211; **Direct**: +1-604-235-8541
Email: jkurylo@srk.com

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Seema Kang

From: Gramoz Rexhepi <GramozR@nunalogistics.com>
Sent: Friday, April 20, 2018 11:15 AM
To: John Kurylo; Cameron Hore
Cc: Kendell Cator; Kyle Scale; Ryan Williams; Kaitlyn Kooy; Darko Filipic; Roland Jones; Olivier Sonier; Julian Sobkow; Rob Cook; NA 1CT022.031 HopeBay
Subject: RE: Diagonal lifts above OG

Hi John,

The bedding above liner (upstream face) will be placed with a Skid Steer and/or 308 excavator and nothing larger will be sitting on it till we start the first lift of transition. I just wanted to keep multiple options open.

Thanks for the timely response.

Regards,

GR

From: John Kurylo [mailto:jkurylo@srk.com]
Sent: Thursday, April 19, 2018 7:21 PM
To: Gramoz Rexhepi <GramozR@nunalogistics.com>; Cameron Hore <chore@srk.com>
Cc: Kendell Cator <kcator@srk.com>; Kyle Scale <kscale@srk.com>; Ryan Williams <rwilliams@srk.com>; Kaitlyn Kooy <kkooy@srk.com>; Darko Filipic <DarkoF@nunalogistics.com>; Roland Jones <RolandJ@nunalogistics.com>; Olivier Sonier <Oliviers@nunalogistics.com>; Julian Sobkow <julians@nunalogistics.com>; Rob Cook <robc@nunalogistics.com>; NA 1CT022.031 HopeBay <HopeBay@srk.com>
Subject: RE: Diagonal lifts above OG

Hi Gramoz,

Placing the bedding and transition in thin lifts, at the slope angle of 3H:1V (i.e. at the same slope as the above ground liner) is acceptable. The bulk fill areas below the liner (liner subbase above the original ground and bulkd downstream ROQ) are less sensitive to what equipment you use (as long as it placed in the specified maximum lift thicknesses as per the latest Technical Specifications document). For fill material placed over the above ground GCL you will have to follow a similar procedure to what has been resulting on site in the key trench. This means that the skidsteer or 308C mini-excavator could work over the liner once 0.3m of fill has been placed (over the liner) however, you will need at least 0.6m thickness of material over the liner before the dozer can be used. For the fill material over the liner (upstream face) using an excavator to gently place this material may still be the superior method.

Regards,
John

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

From: Gramoz Rexhepi [mailto:GramozR@nunalogistics.com]
Sent: Thursday, April 19, 2018 15:52

To: John Kurylo <jkurylo@srk.com>; Cameron Hore <chore@srk.com>
Cc: Kendell Cator <kcator@srk.com>; Kyle Scale <kscale@srk.com>; Ryan Williams <rwilliams@srk.com>; Kaitlyn Kooy <kkooy@srk.com>; Darko Filipic <DarkoF@nunalogistics.com>; Roland Jones <RolandJ@nunalogistics.com>; Olivier Sonier <Oliviers@nunalogistics.com>; Julian Sobkow <julians@nunalogistics.com>; Rob Cook <robc@nunalogistics.com>
Subject: Diagonal lifts above OG

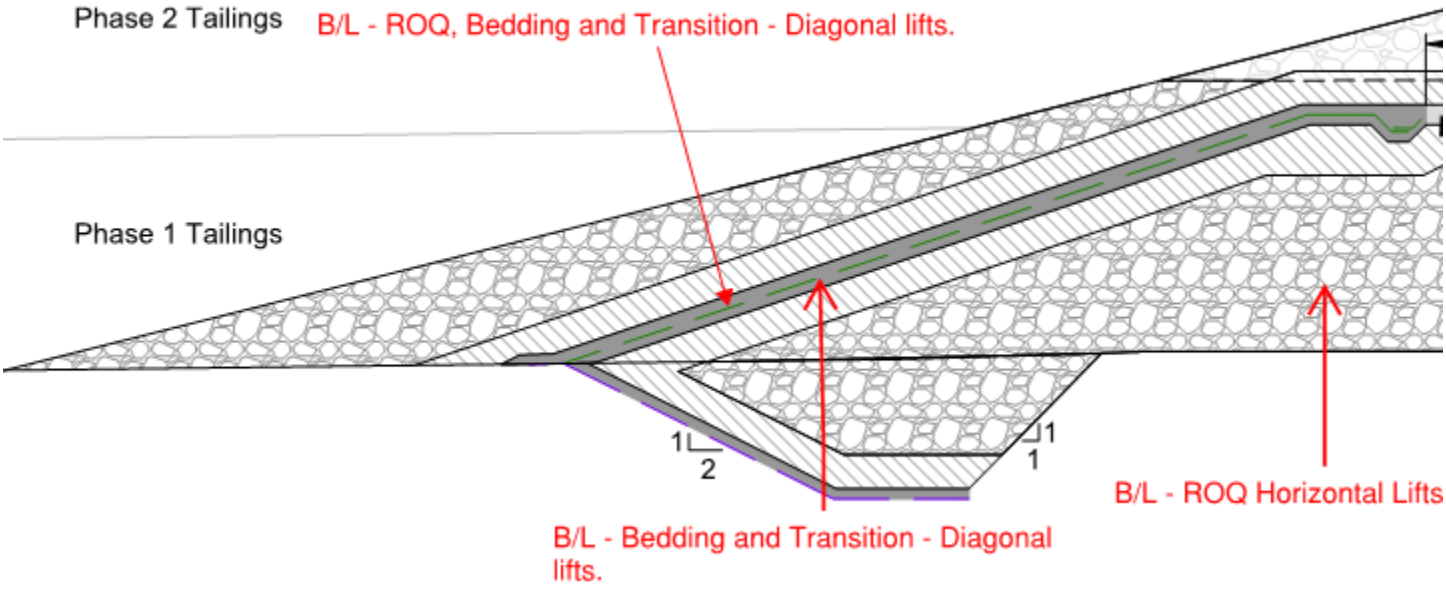
Good afternoon,

In the spec below it calls for horizontal lifts or as directed by herein.

7.2.12 Tolerances

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

In efforts to use a dozer/skid steer to do the placement above OG we recommend placing the Downstream ROQ in horizontal lifts and all the following materials diagonally. The excavator will still be required for some detail work, but not nearly as much as if we had to do each material type horizontally. This would significantly increase production and make constructability more simple and efficient.



Let me know your thoughts.

Regards,

Gramoz Rexhepi
Project Coordinator
Site: 867-988-6882 ext 123
Cell: 587-920-9486

NUNA WEST MINING LTD
TMAC Resources – Hope Bay South Dam Project

Seema Kang

From: Cameron Hore
Sent: Wednesday, May 2, 2018 11:29 AM
To: John Kurylo; 'Kelly Schwenning'; 'Murray Weddell'; Gramoz Rexhepi; Darko Filipic; Roland Jones; Boyd Barstad; Mark Doucette; Jake Chisholm; George Lochead; janied@sub-arctic.ca; samb@sub-arctic.ca; Rob Cook
Cc: Maritz Rykaart; Kyle Scale; Kaitlyn Kooy; Christopher Stevens; Silkie Wong; Kendell Cator; Ryan Williams
Subject: Hope Bay - South Dam - IFC Rev2 Drawings
Attachments: 1CT0022.017_HB_South Dam_IFC-1_Rev2_20180501.pdf; 1CT0022.017_HB_South Dam_IFC_Rev2_20180501_compiled.pdf; 180430 - East AR.XML

Hi All,

I have attached an updated set of IFC drawings for the South Dam, this is Rev 2 and should be used going forward.

The changes made in this revision are:

1. Updated East Access Road design to join with existing TIA road (Shown on Drawings DN-SD-01, DN-SD-02 and DN-SD-011)
2. Updated cable and data logger layout for GTC monitoring (Shown on Drawings DN-SD-22)

I have attached the following files for use:

1. PDF with updated drawings only for quick reference
2. PDF with full set of now current IFC drawings
3. The associated CAD file (LandXML) for the East Access Road for survey use

If you have any queries when you review the attached files then please let myself, John or any SRK site staff know.

Cheers

Cameron Hore *CPEng P.Eng*
Senior Consultant (Geotechnical Engineering)
srk consulting
SRK Consulting (Canada) Inc.
22nd Floor, 1066 West Hastings Street, Vancouver, BC, V6E 3X2, Canada
Tel: +1-604-681-4196; **Direct:** +1-604-235-8533
Email: chore@srk.com; **Skype:** cameron.hore
www.srk.com

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Engineering Drawings for the South Dam - Phase 1
Doris North Project, Nunavut, Canada

Drawing Number	Drawing Title	Issue	Date	Revision	Old / Replaced Revisions	
DN-SD-01	Phase 1 General Arrangement (with Orthophoto)	Issued for Construction	April 30, 2018	2	Rev 0, 2017/11/29	Rev 1, March 7, 2018
DN-SD-02	Phase 1 General Arrangement	Issued for Construction	April 30, 2018	2	Rev 0, 2017/11/29	Rev 1, March 7, 2018
DN-SD-03	Typical Sections (General)	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-04	Key Trench Excavation Plan and Profile	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-05	Liner Placement Plan and Details - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-06	Liner and Bedding Placement Details	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-07	Bedding Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-08	Transition Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-11	Construction Access Road and Turn Around - Phase 1	Issued for Construction	April 30, 2018	2	Rev 0, 2017/11/29	Rev 1, March 7, 2018
DN-SD-12	Final Phase 1 Dam Plan, Profile and Sections	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-13	Sections Sta. 0+10 to 0+90 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-14	Sections Sta. 1+00 to 1+80 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-15	Sections Sta. 1+90 to 2+70 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-16	Sections Sta. 2+80 to 3+60 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-17	Sections Sta. 3+70 to 4+50 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-18	Sections Sta. 4+60 to 5+30 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-19	Infill Foundation Drilling - Phase 1	Issued for Construction	March 7, 2018	AB	Rev 0, 2018/02/16	
DN-SD-20	Percolation Borehole / Test Locations	Issued for Construction	March 7, 2018	AB	Rev 0, 2018/02/16	
DN-SD-21	Instrumentation Plan - Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-22	GTC backfilled Cable Trench - Phase 1	Issued for Construction	April 26, 2018	2	Rev 0, 2018/03/07	Rev 1, March 7, 2018
DN-SD-23	Vertical GTC Layout - Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-24	Horizontal GTC - Upstream Base / Toe of Key Trench	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-25	GTC Layout Along Upstream Above Ground Liner Slope	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-26	Sloped GTC - Above Ground Liner Slope	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-27	Instrumentation Details at Sta. 0+65 and 1+55	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-28	Instrumentation Details at Sta. 2+40 and 3+65	Issued for Construction	March 7, 2018	0		
DN-SD-29	Instrumentation Details at Sta. 4+65 and 5+10	Issued for Construction	March 7, 2018	0		
DN-SD-30	Typical Monitoring Point Details	Issued for Construction	March 7, 2018	0		

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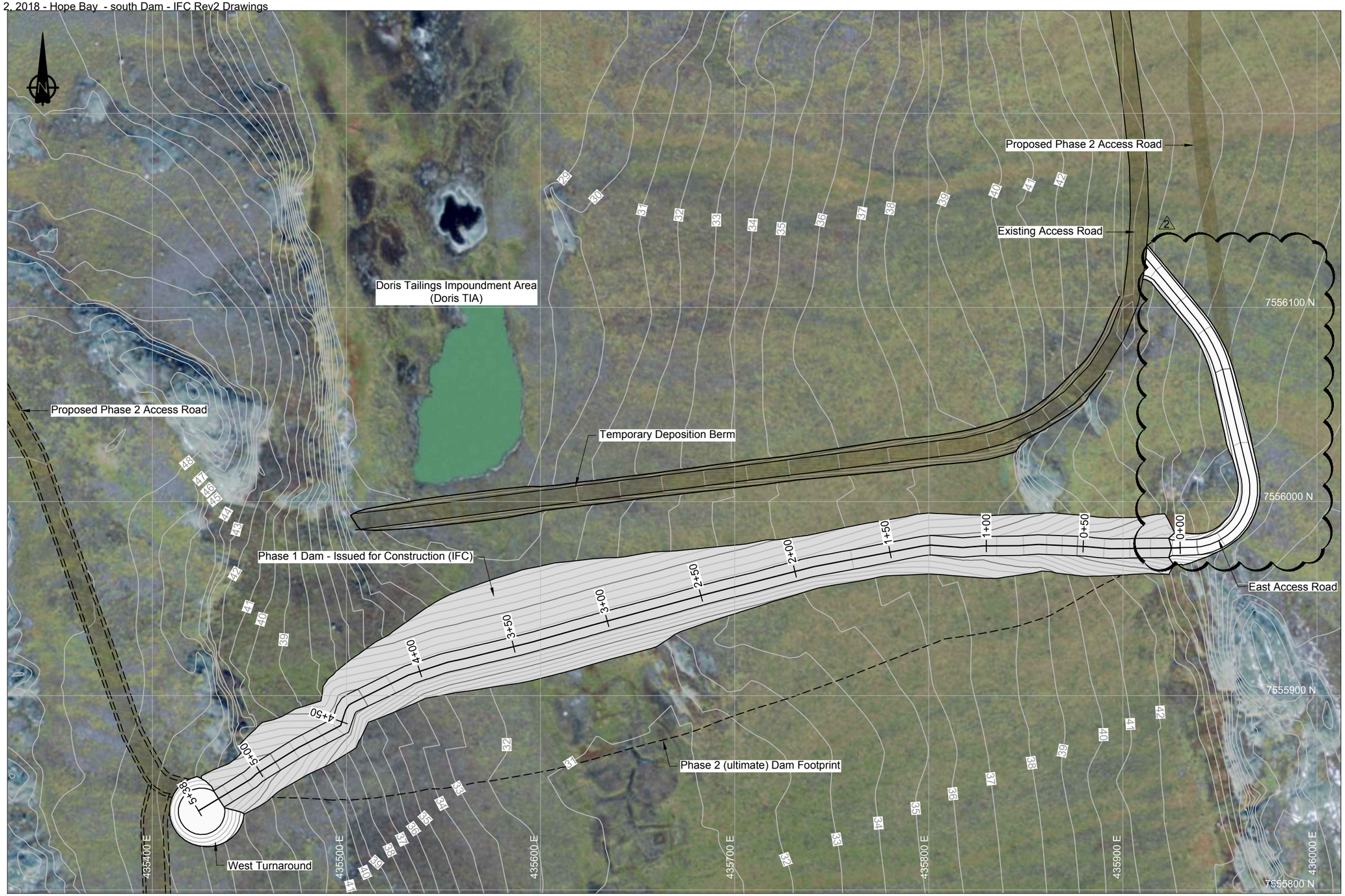

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Imagery (from 2010 PhotoSat compilation) provided by client.
5. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

0m 20 40 60 80

-	-										
							1	Issued for Construction	JBK	EMR	18/04/30
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
REFERENCE DRAWINGS		REVISIONS									

Original Drawings Stamped and Signed by Engineer

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DESIGN: CH	DRAWN: TAH	REVIEWED: JBK
CHECKED: JBK	APPROVED: EMR	DATE: 2018/04/30

FILE NAME: 1CT0022.017 - South Dam GA - with ortho.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:
Phase 1 General Arrangement (with Orthophoto)

DRAWING NO.	SHEET	REVISION NO.
DN-SD-01	1 OF 30	2

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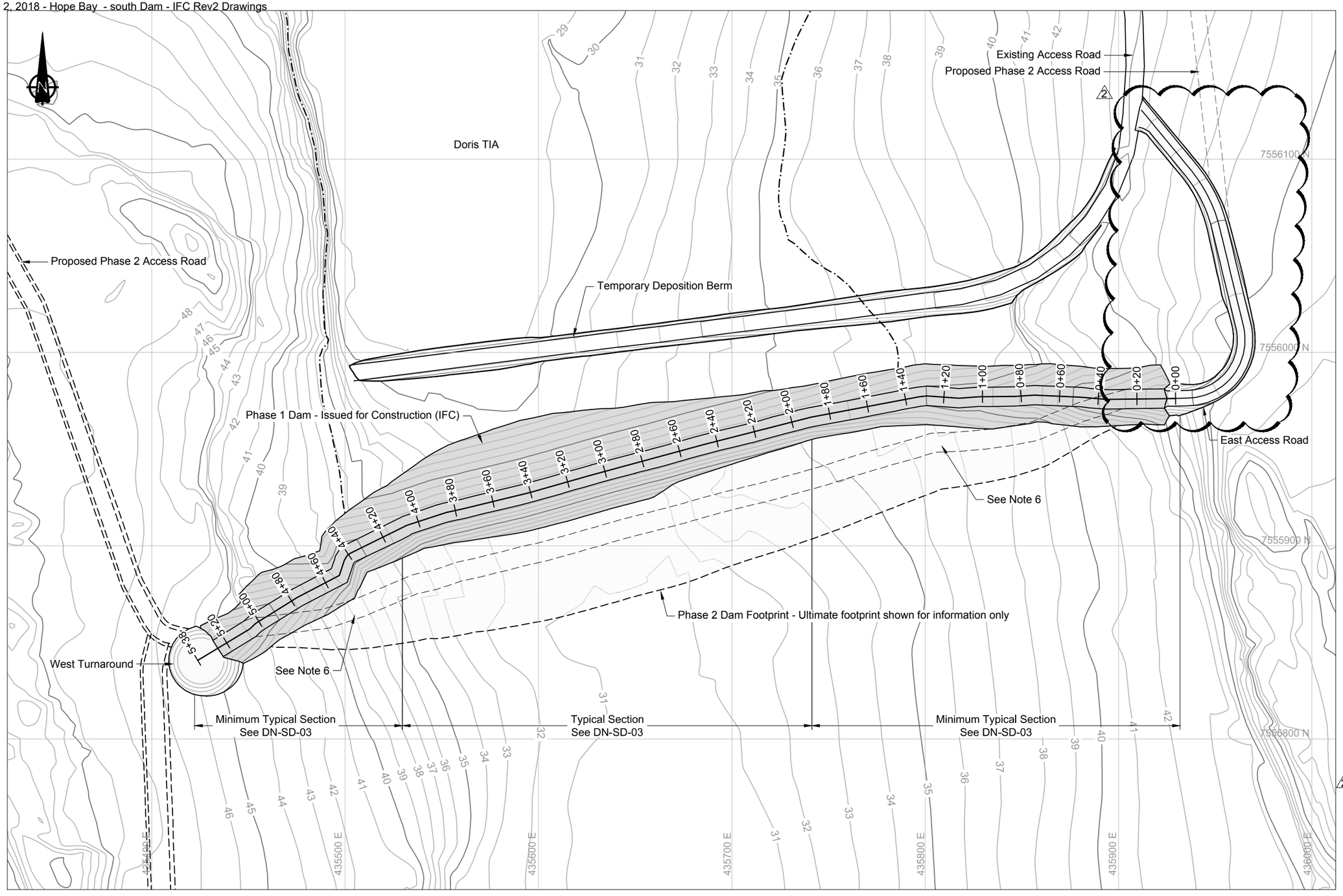

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
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3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Volumes presented based on neat-lines only and are approximate. These include no over-excavation or over-blasting allowance of the key trench.
5. All units shown are in meters unless otherwise stated.
6. Bend in the dam crest is to accommodate Phase 2 liner tie-in.
7. All snow roads placed on the upstream as a temporary construction measure, to help facilitate construction of the dam, must be completely removed before tailings deposition may commence.

REFERENCES

NAD83 UTM Zone 13.

TABLE OF QUANTITIES (NEAT-LINE)

Key Trench Bulk Excavation :	19,500m³
Total Phase 1 Fill:	68,500m³
ROQ:	36,800m³
Transition:	26,100m³
Bedding:	5,600m³
Total Liner:	14,300m
West Turnaround (bulk):	2,000m³
East Access Road (bulk):	2,440m³

2

*all volumes presented are to neat-lines and do not allow / account for bulking and compaction.

0m 20 40 60 80

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
2	Issued for Construction	JBK	EMR	18/04/30
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/30

FILE NAME: 1CT0022.017 - South Dam GA.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Phase 1 General Arrangement

DRAWING NO.	SHEET	REVISION NO.
DN-SD-02	2 OF 30	2

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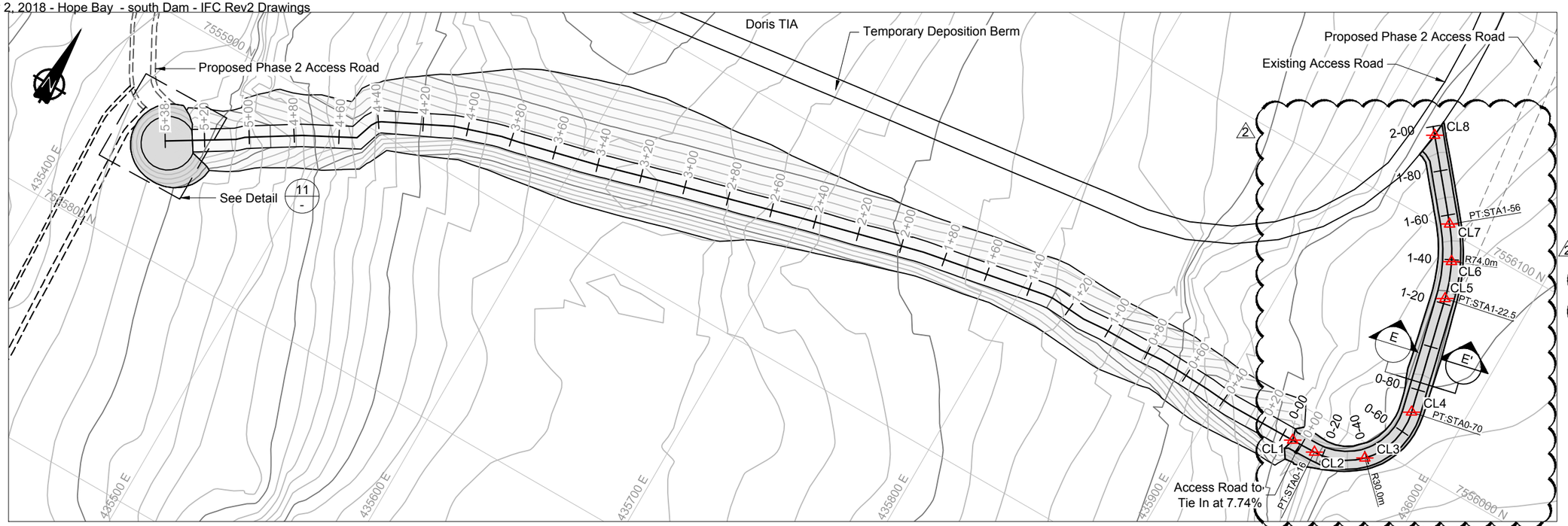
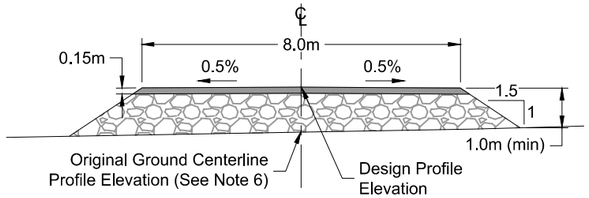
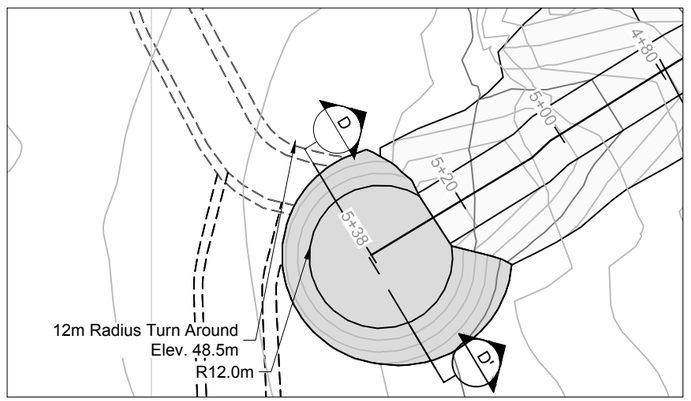


East Access Road and West Turn Around

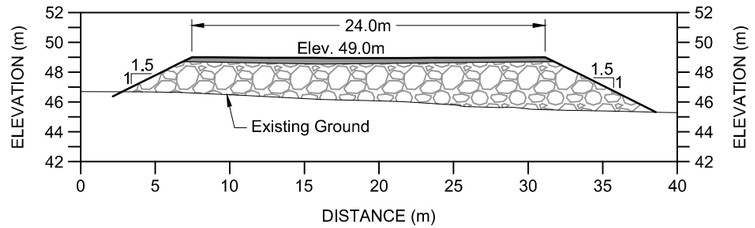
0m 20 40 60 80





Detail 11 - Turn Around

0m 10 20 30 40

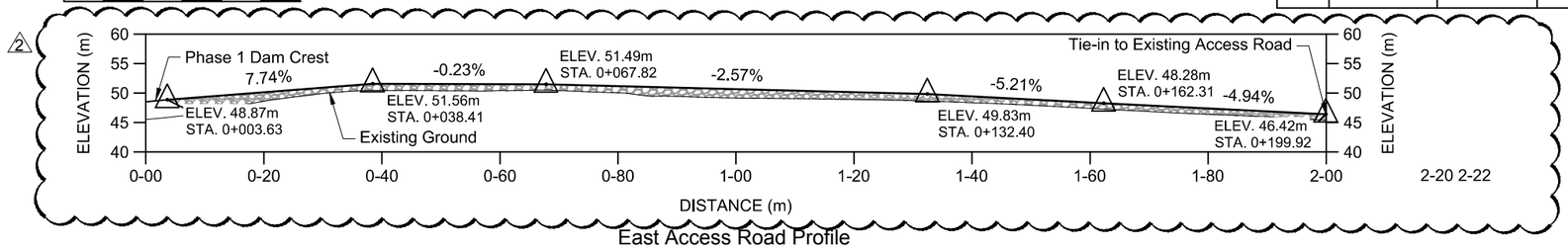


Section D-D' - Turn Around

0m 4 8 12 16

Section E-E' - Typical Road Section

0m 1 2 3 4 5 6



East Access Road Profile

0m 10 20 30 40

LEGEND

- Stakeout Point
- Vertical Inflection Point
- Proposed Road / Dam Infrastructure
- Phase 1 Access Road
- Run of Quarry
- Surfacing Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Approximately 2,440m³ of Fill material is estimated (to neat lines) to be needed for the Access Road and Turn Around.
4. Minimum fill thickness for Access Road and Turn Around is 1.0m
5. Construction shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction.
6. Profile based on available topography. Existing ground level to be surveyed prior to construction to confirm design thickness achieved.

REFERENCES

NAD83 UTM Zone 13.

STAKEOUT POINTS

ID	Northing	Easting	Elev. (m)
CL1	7555976.16	435925.08	48.97
CL2	7555976.39	435936.14	49.83
CL3	7555985.34	435956.86	51.56
CL4	7556013.44	435964.66	51.45
CL5	7556064.69	435952.27	51.09
CL6	7556080.41	435946.53	49.48
CL7	7556094.44	435937.41	48.61
CL8	7556125.37	435911.91	46.61

NO.	DESCRIPTION	CHK'D	APP'D	DATE
2	Issued for Construction	JBK	EMR	18/04/30
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-03	Typical Sections (General)
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/30

FILE NAME: 1CT0022.017 - South Dam AR.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:
Construction Access Road and Turnaround - Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-11	11 OF 26	2

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LEGEND

- Data Logger Location
- Monitoring Section
- Cable Trench
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Ground Temperature Cable backfilled cable trenches to be excavated through final dam shell - See drawings DN-SD-27, 28 and 29.

REFERENCES

NAD83 UTM Zone 13.

DATA LOGGERS

SD-DL01Reporting Cables:
- SD-VTS-065-KTC
- SD-HTS-065-US
- SD-VTS-155-KTC
- SD-HTS-155-KT
- SD-HTS-155-US
- SD-VTS-155-UST
- SD-VTS-155-DST

SD-DL02 Reporting Cables
- SD-VTS-240-KTC
- SD-VTS-240-KT
- SD-HTS-240-US
- SD-VTS-240-UST
- SD-VTS-240-DST
- SD-HST-B1-KT

SD-DL03 Reporting Cables
- SD-HTS-365-KT
- SD-VTS-365-KTC
- SD-HTS-365-US
- SD-VTS-365-UST
- SD-VTS-365-DST

SD-DL04 Reporting Cables
- SD-HTS-460-KT
- SD-VTS-460-KTC
- SD-HTS-460-US
- SD-HTS-460-UST
- SD-VTS-460-DST
- SD-VTS-510-KTC
- SD-HTS-510-US

STAKE-OUT POINTS

ID	Northing	Easting
SD-DL01	7555978.14	435776.94
SD-DL02	7555959.13	435693.79
SD-DL03	7555927.20	435572.83
SD-DL04	7555887.49	435490.36

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
DN-SD-29	Instrumentation Details at Sta. 4+65 and 5+10
DN-SD-28	Instrumentation Details at Sta. 2+40 and 3+65
DN-SD-27	Instrumentation Details at Sta. 0+65 and 1+55
DN-SD-03	Typical Sections

REVISIONS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
2	Issued for Construction	JBK	EMR	18/04/26
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	18/02/16

Original Drawings Stamped and Signed by Engineer

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/26

FILE NAME: 1CT0022.017 - GTC Trenches.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: GTC Backfilled Cable Trenches Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-22	22 OF 30	2

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Engineering Drawings for the South Dam - Phase 1
Doris North Project, Nunavut, Canada

Drawing Number	Drawing Title	Issue	Date	Revision	Old / Replaced Revisions	
DN-SD-01	Phase 1 General Arrangement (with Orthophoto)	Issued for Construction	April 30, 2018	2	Rev 0, 2017/11/29	Rev 1, March 7, 2018
DN-SD-02	Phase 1 General Arrangement	Issued for Construction	April 30, 2018	2	Rev 0, 2017/11/29	Rev 1, March 7, 2018
DN-SD-03	Typical Sections (General)	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-04	Key Trench Excavation Plan and Profile	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-05	Liner Placement Plan and Details - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-06	Liner and Bedding Placement Details	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-07	Bedding Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-08	Transition Material Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-11	Construction Access Road and Turn Around - Phase 1	Issued for Construction	April 30, 2018	2	Rev 0, 2017/11/29	Rev 1, March 7, 2018
DN-SD-12	Final Phase 1 Dam Plan, Profile and Sections	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-13	Sections Sta. 0+10 to 0+90 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-14	Sections Sta. 1+00 to 1+80 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-15	Sections Sta. 1+90 to 2+70 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-16	Sections Sta. 2+80 to 3+60 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-17	Sections Sta. 3+70 to 4+50 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-18	Sections Sta. 4+60 to 5+30 - Phase 1 Dam	Issued for Construction	March 7, 2018	1	Rev 0, 2017/11/29	
DN-SD-19	Infill Foundation Drilling - Phase 1	Issued for Construction	March 7, 2018	AB	Rev 0, 2018/02/16	
DN-SD-20	Percolation Borehole / Test Locations	Issued for Construction	March 7, 2018	AB	Rev 0, 2018/02/16	
DN-SD-21	Instrumentation Plan - Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-22	GTC backfilled Cable Trench - Phase 1	Issued for Construction	April 26, 2018	2	Rev 0, 2018/03/07	Rev 1, March 7, 2018
DN-SD-23	Vertical GTC Layout - Phase 1	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-24	Horizontal GTC - Upstream Base / Toe of Key Trench	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-25	GTC Layout Along Upstream Above Ground Liner Slope	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-26	Sloped GTC - Above Ground Liner Slope	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-27	Instrumentation Details at Sta. 0+65 and 1+55	Issued for Construction	March 7, 2018	1	Rev 0, 2018/03/07	
DN-SD-28	Instrumentation Details at Sta. 2+40 and 3+65	Issued for Construction	March 7, 2018	0		
DN-SD-29	Instrumentation Details at Sta. 4+65 and 5+10	Issued for Construction	March 7, 2018	0		
DN-SD-30	Typical Monitoring Point Details	Issued for Construction	March 7, 2018	0		

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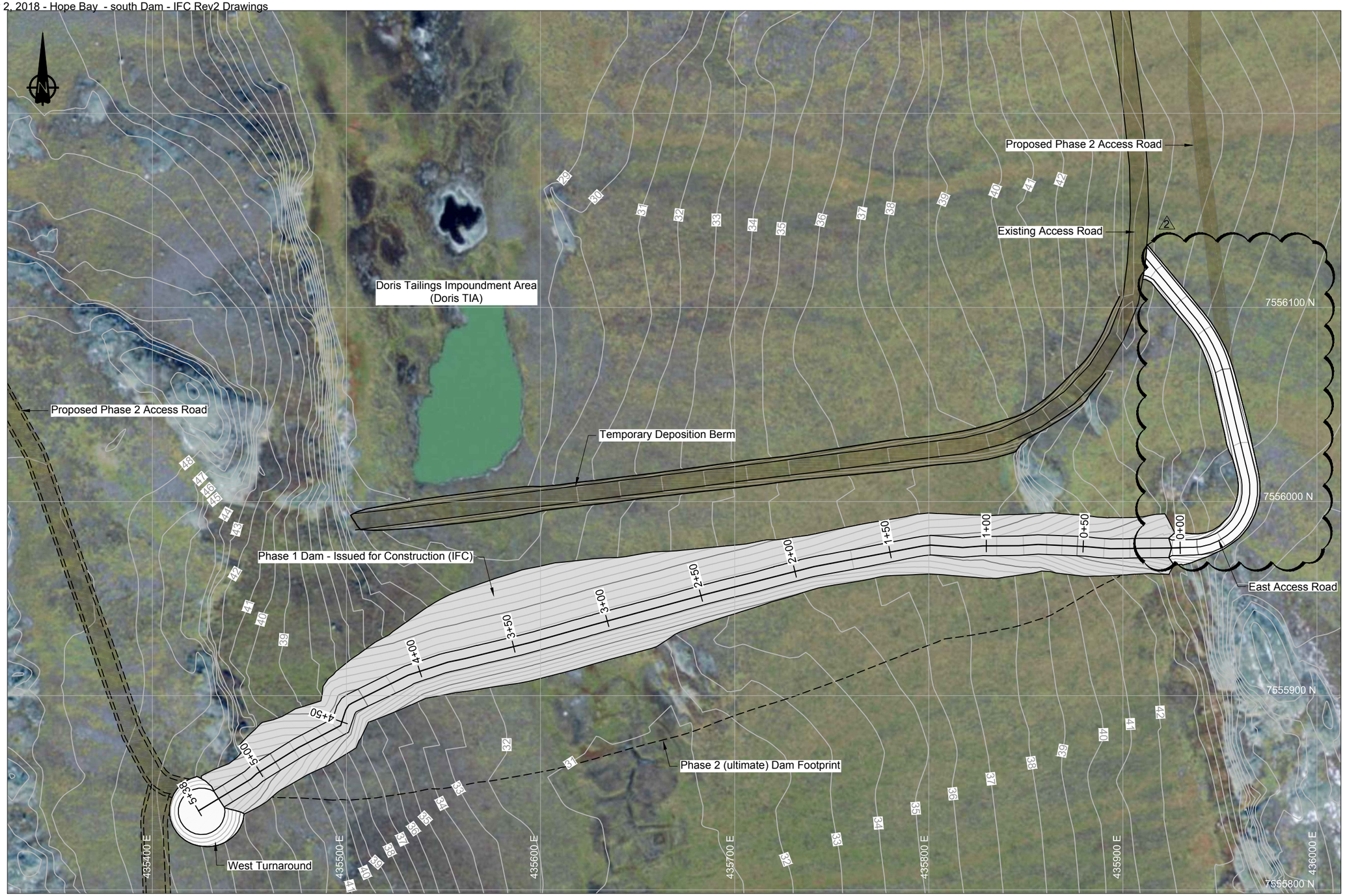

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Imagery (from 2010 PhotoSat compilation) provided by client.
5. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

0m 20 40 60 80

-	-										
							1	Issued for Construction	JBK	EMR	18/04/30
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
REFERENCE DRAWINGS		REVISIONS									

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CHECKED: JBK	APPROVED: EMR	DATE: 2018/04/30

FILE NAME: 1CT0022.017 - South Dam GA - with ortho.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:
Phase 1 General Arrangement (with Orthophoto)

DRAWING NO.	SHEET	REVISION NO.
DN-SD-01	1 OF 30	2

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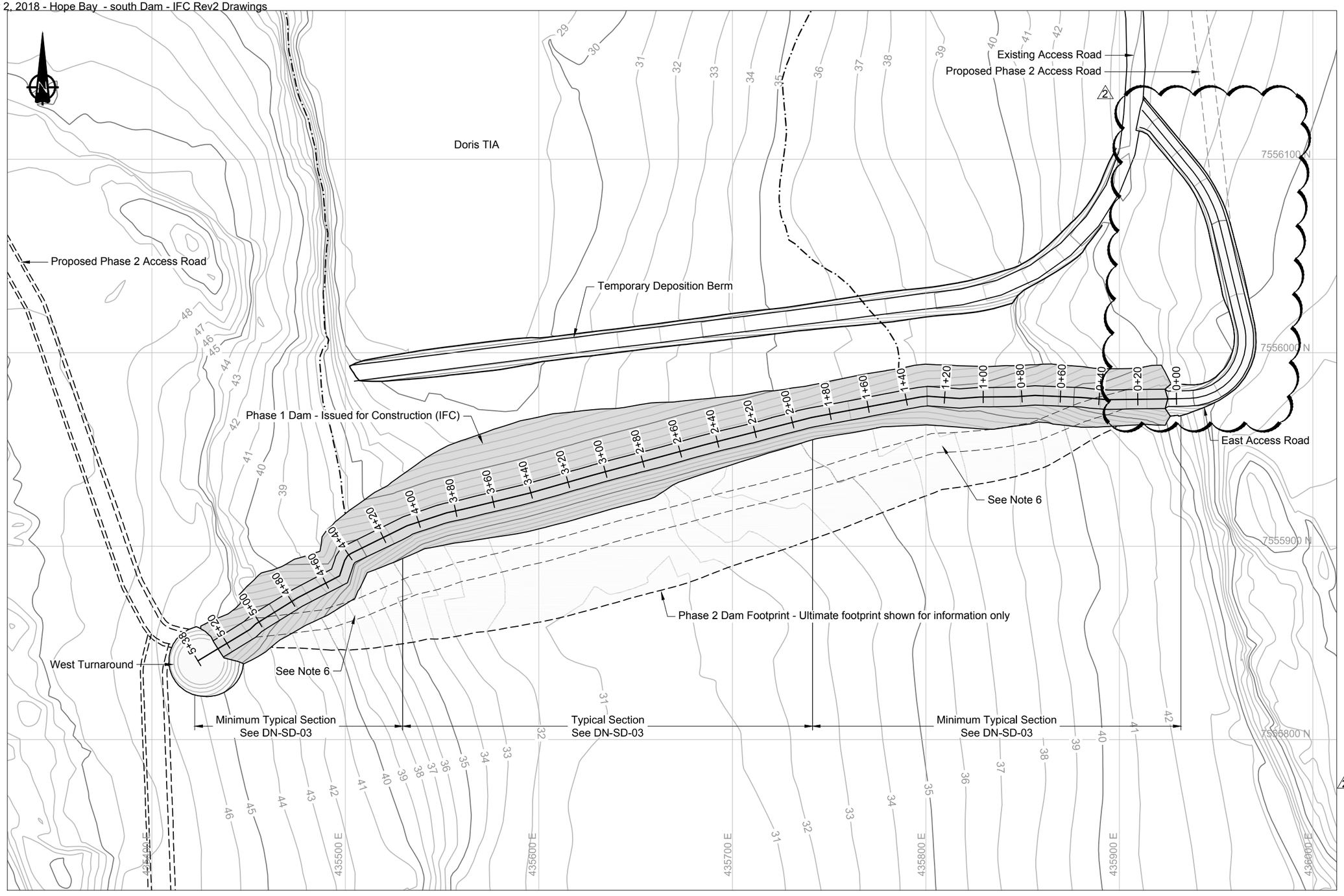

LEGEND

- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Volumes presented based on neat-lines only and are approximate. These include no over-excavation or over-blasting allowance of the key trench.
5. All units shown are in meters unless otherwise stated.
6. Bend in the dam crest is to accommodate Phase 2 liner tie-in.
7. All snow roads placed on the upstream as a temporary construction measure, to help facilitate construction of the dam, must be completely removed before tailings deposition may commence.

REFERENCES

NAD83 UTM Zone 13.

TABLE OF QUANTITIES (NEAT-LINE)

Key Trench Bulk Excavation :	19,500m³
Total Phase 1 Fill:	68,500m³
ROQ:	36,800m³
Transition:	26,100m³
Bedding:	5,600m³
Total Liner:	14,300m
West Turnaround (bulk):	2,000m³
East Access Road (bulk):	2,440m³

*all volumes presented are to neat-lines and do not allow / account for bulking and compaction.

0m 20 40 60 80

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
2	Issued for Construction	JBK	EMR	18/04/30
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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CHECKED: JBK | APPROVED: EMR | DATE: 2018/04/30
FILE NAME: 1CT0022.017 - South Dam GA.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Phase 1 General Arrangement

DRAWING NO. DN-SD-02 | SHEET 2 OF 30 | REVISION NO. 2

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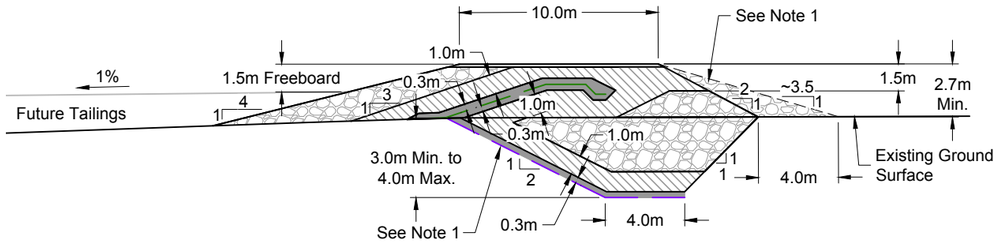
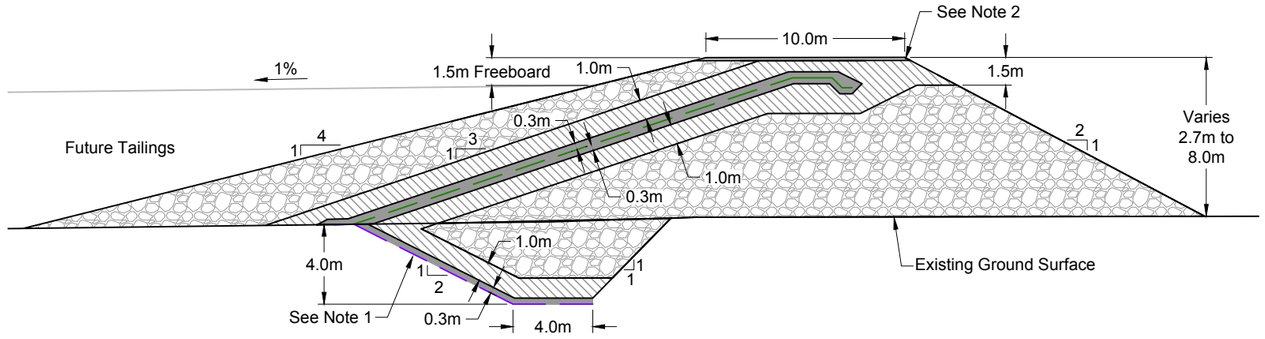


Minimum Typical Cover Section
STA.0+00 to 1+92 & 4+15 to 5+42

0m 3 6 9 12

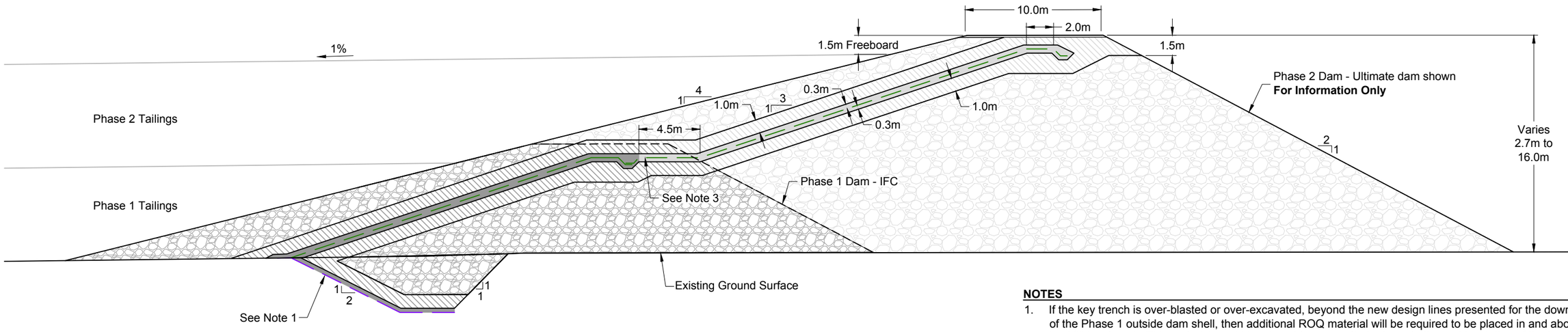
ISSUED FOR CONSTRUCTION



Phase 1 Typical Dam Section
STA. 1+92 to 4+15

0m 3 6 9 12

ISSUED FOR CONSTRUCTION



Phase 2 Typical Dam Section
STA. 0+25 to 5+25

0m 3 6 9 12

ISSUED FOR INFORMATION

LEGEND

- Key Trench Liner
- Phase 1 & 2 Dam Liner
- Bedding Material
- Transition Material
- Run of Quarry

NOTES

1. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench. This material would be placed to ensure that adequate thermal insulation of the key trench is maintained in all sections. See Detail 10 on drawing DN-SD-09 for additional details.
2. The top road surfacing (bedding material) for the Phase 1 dam is to be fully removed (upstream and downstream) before Phase 2 construction commences.
3. To allow for a proper tie-in the transition material around the top downstream portion of the Phase 1 dam will be required to be stripped back. Once the bedding material around the top liner anchor trench is reached hand excavation should be expected to result down to expose the liner. The on-site engineer will be required to inspect all exposed liner, to ensure that it is not damaged or in need of repairs before Phase 2 liner tie-ins result.
4. All units shown are in meters unless otherwise stated.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

DN-SD-02 — Phase 1 General Arrangement

REFERENCE DRAWINGS | REVISIONS

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DESIGN: CH | DRAWN: TAH | REVIEWED: JBK
CHECKED: JBK | APPROVED: EMR | DATE: 2018/04/13
FILE NAME: 1CT0022.017 - South Dam - Typ Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Typical Sections (General)

DRAWING NO. DN-SD-03 | SHEET 3 OF 30 | REVISION NO. 1

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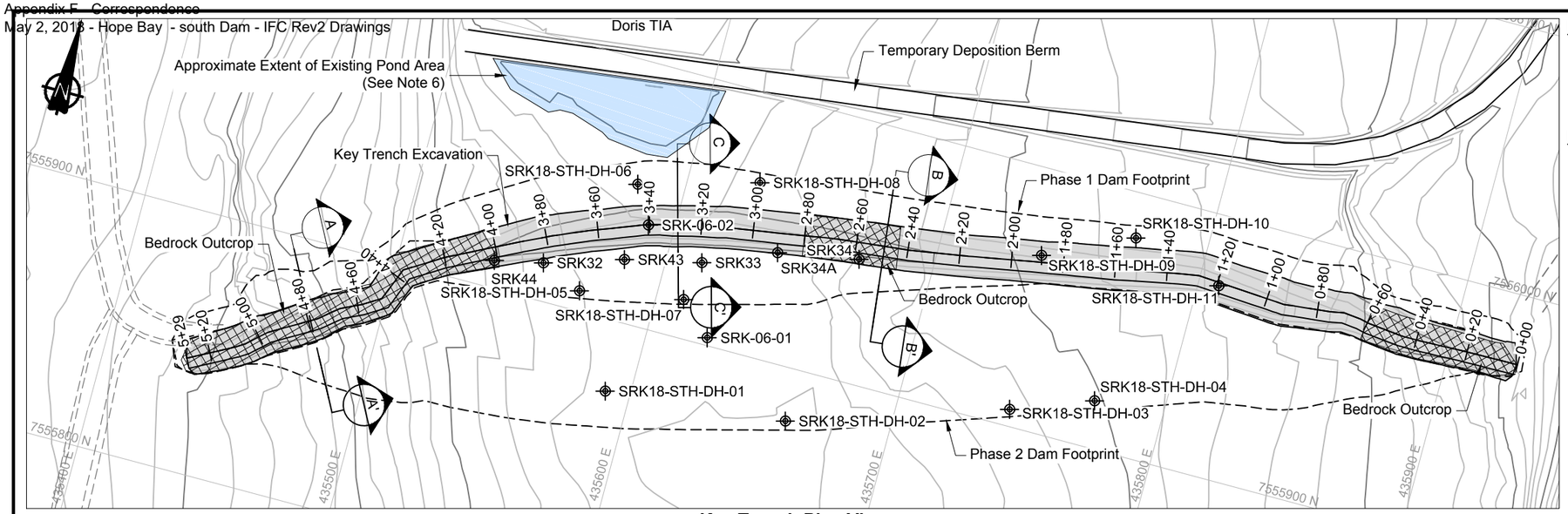
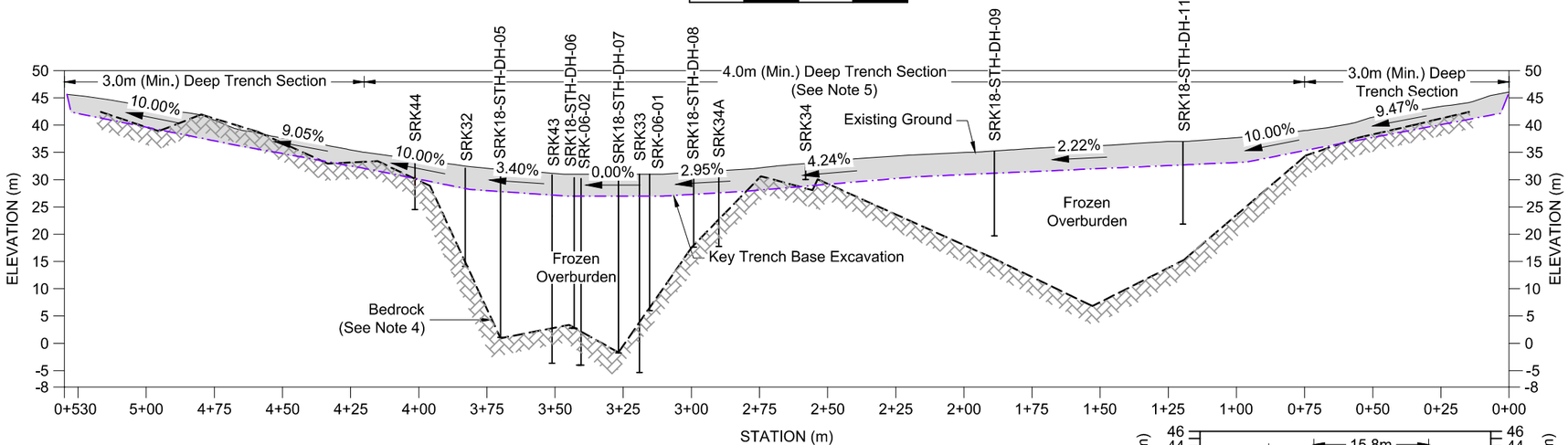


Key Trench Plan View

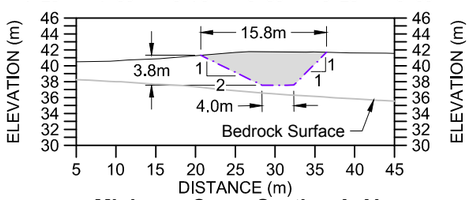
0m 20 40 60 80



Key Trench Profile View

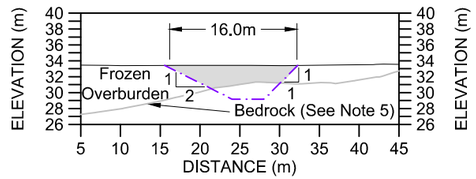
Vertical 0m 10 20 30 40

Horizontal 0m 20 40 60 80



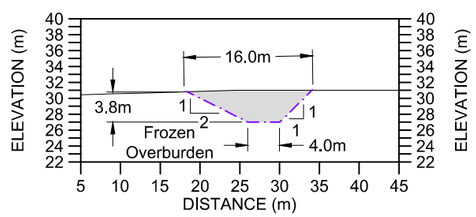
Minimum Cross Section A-A'
Shallow Overburden over Bedrock

0m 5 10 15 20 25 30



Cross Section B-B'
Bedrock Outcropping in Key Trench

0m 5 10 15 20 25 30



Cross Section C-C'
Deep Frozen Overburden

0m 5 10 15 20 25 30

LEGEND

- Drill Hole Location
- Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Trench Excavation Extent
- 1.00% Base Grades

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profile shown correspond to the upstream toe of the key trench.
4. The subsurface geology has been inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A , SRK43, SRK 44, SRK18-STH-DH01-11 and SRK18-WST-DH01-03), airphoto interpretations, and from limited available geophysical surveys around the Tails Lake area. This data was then used to create a bedrock surface with the Gemcom GEMS software. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.
5. The final key trench extent and depth will be determined in the field by the Engineer. Typical excavation depth is 4.0m, unless massive ice, hypersaline soil or bedrock encountered. The Engineer will inspect all excavations and approve the foundation conditions.
6. Ponded area to removed (frozen massive ice excavated or drained if possible). Up to approximately 4,700 m3 of (frozen) water may be expected to be removed from this area. Exact water levels are not known so the volume estimate above should be treated as a rough estimate based on topography.
7. If any area of the key trench is over-blasted or over-excavated then the extra excavation will need to be backfilled in thin lifts (*see 'Technical Specifications'*) until the key trench design lines and grades are reached.
8. Overblasting and/or overexcavation of the key trench beyond the design lines (as presented on this figure) should be avoided if at all possible. Extra care should be taken during the key trench excavation to ensure that the excavation can result as close to the design lines as possible. Excavation beyond the key trench design lines may require that the overall Phase 1 dam footprint be enlarged to provide the necessary thermal coverage and to uphold design requirements.

REFERENCES

NAD83 UTM Zone 13.

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS | REVISIONS

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Key Trench.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Key Trench Excavation Plan and Profile

DRAWING NO. DN-SD-04 | SHEET 4 OF 30 | REVISION NO. 1

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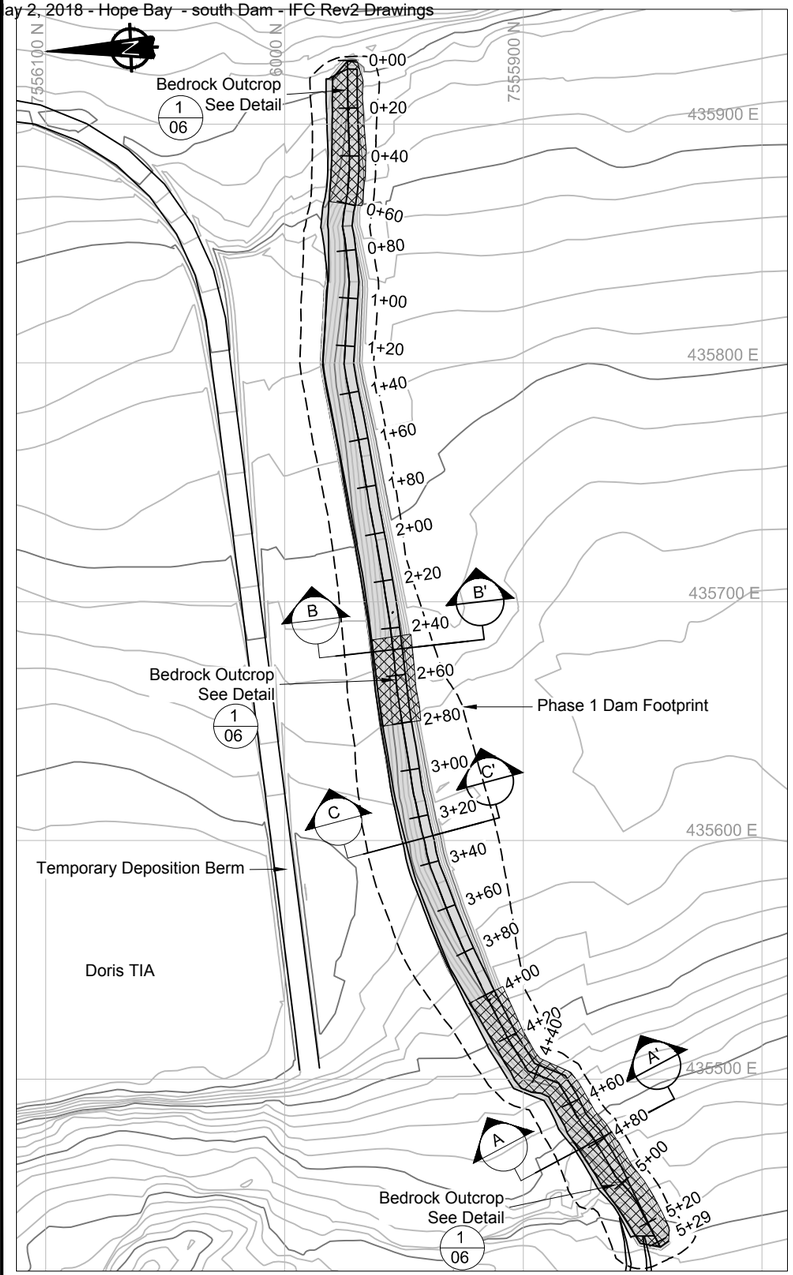
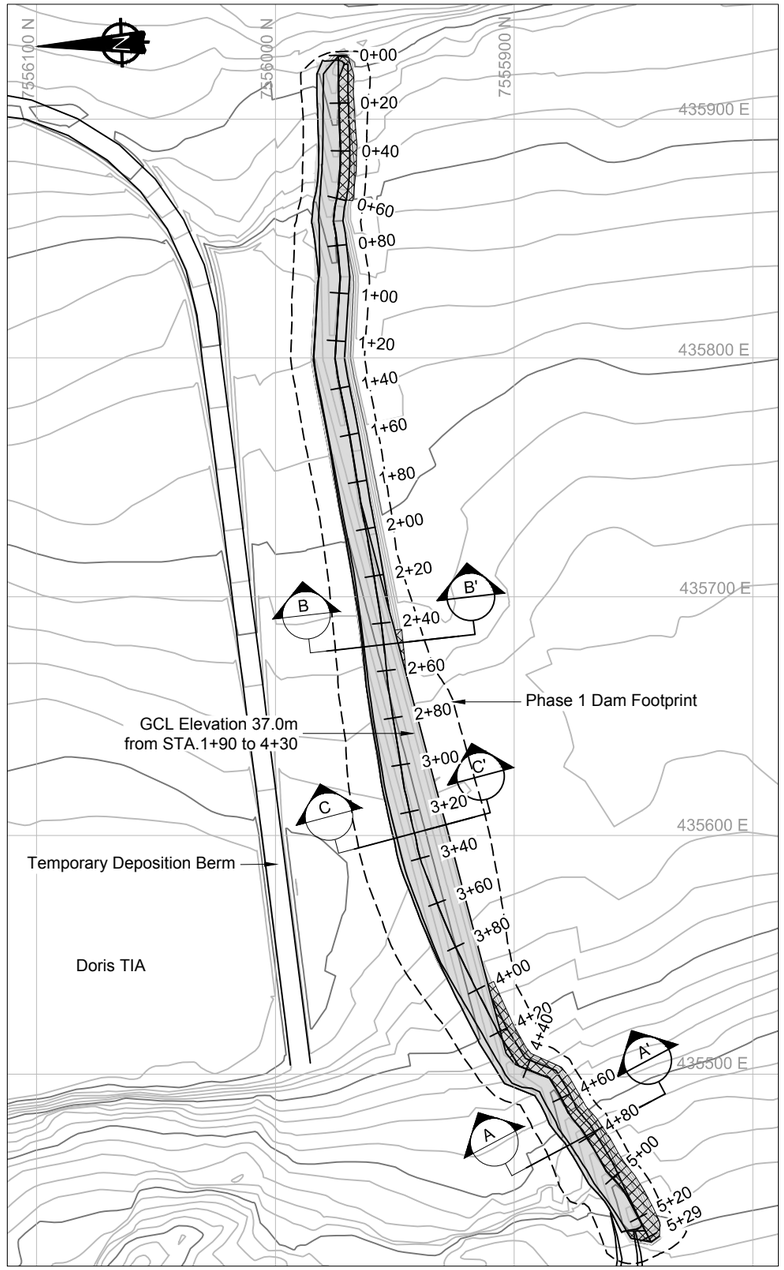


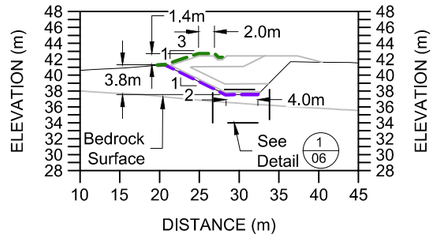
Lower Liner Plan - Placement in Key Trench

0m 20 40 60 80 100



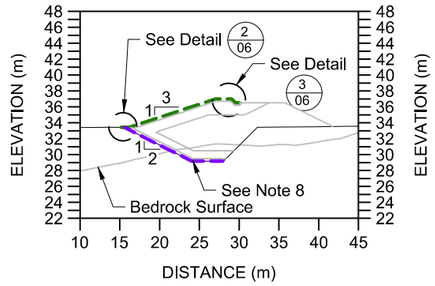
Upper Phase 1 Liner Plan - Above Ground Upstream Slope Placement

0m 20 40 60 80 100



Minimum Cross Section A-A'

0m 5 10 15 20 25 30



Cross Section B-B' - Bedrock Encountered in Trench

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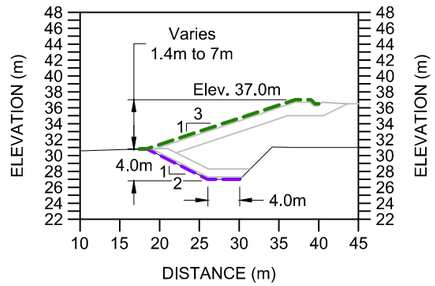

Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

- Key Trench Liner
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent
- GCL Liner Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The upstream slope of the key trench excavation need to be scraped and smoothed to prepare a suitable subbase for the GCL liner as determined by field Engineer. If any voids larger than 0.15m or undulation exist then they will need to be backfilled with compacted bedding material fill, placed in thin 0.15m lifts.
4. The subgrade surface must be free of vegetation, sharp-edged rocks, stones, sticks, construction debris, and other foreign material that could contact the GCL. Furthermore, all protrusions extending more than 12 mm from the subgrade surface shall either be removed, crushed, or pushed into the surface with a smooth-drum compactor.
5. GCL should not be placed over massive ice or standing water (both need to be removed prior to placement).
6. All Geosynthetic Clay Liner (GCL) liner sections / panels will be required to have a minimum 0.5m overlap on every edge. See Detail 2, 3, 5 and 6 on DN-SD-06 for additional information.
7. At the locations where bedrock is encountered in the key trench then these areas will be required to be ripped down to competent bedrock or scrapped smooth and then bentonite powder will be placed between the bedrock contact and the GCL liner (see Detail 1, DN-SD-06).
8. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m in depth), until competent bedrock is encountered, or as directed by Engineer.

REFERENCES

NAD83 UTM Zone 13.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-06	Liner and Bedding Placement Details	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Liner Placement Plan and Details Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-05	5 OF 30	1

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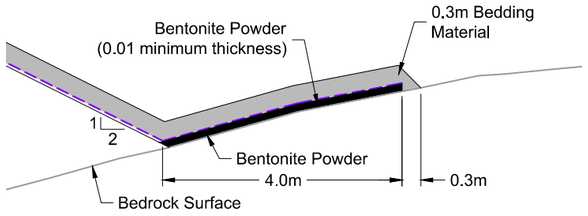
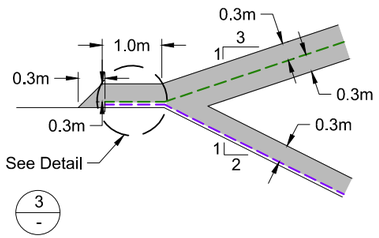
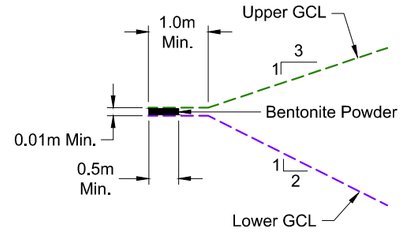


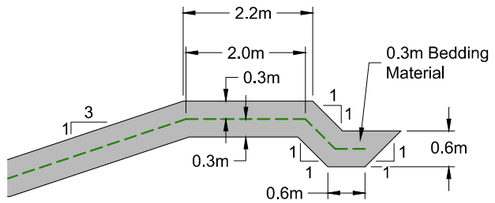
Detail 1 - Liner Attachment at Bedrock

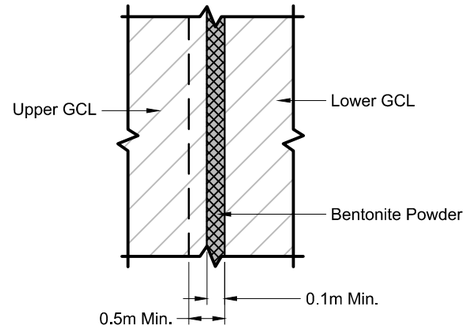


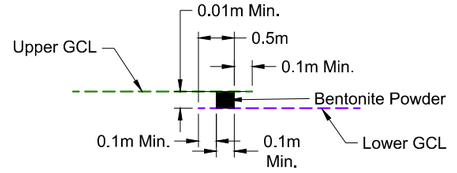
Detail 2 - Liner Overlap - Bedding



Detail 3 - Typical Upper and Lower GCL Joint

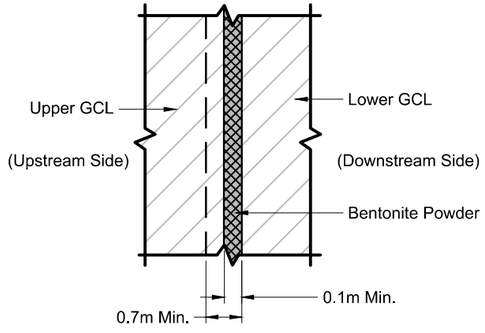






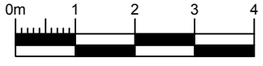
Detail 4 - Liner Anchor Trench Bedding

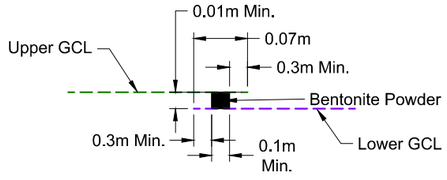
Detail 5 - Typical Longitudinal GCL Overlap - Plan



Detail 6 - Typical Longitudinal GCL Overlap - Section
Not To Scale

Detail 7 - Typical End of Panel GCL Overlap - Plan





Detail 8 - Typical End of Panel GCL Overlap - Section
Not To Scale

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material

NOTES

1. All units shown are in meters unless otherwise stated.
2. One end of the GCL roll should be anchored at the top of the slope. The front edge of the key trench (see Detail 4) shall be rounded so as to eliminate any sharp corners that could cause excessive stress on the GCL. Loose soil should be removed.
3. The GCL should be placed in the key trench such that it covers the entire key trench floor but does not extend up the rear trench wall (see Detail 4).
4. GCL seams are constructed by overlapping their adjacent edges (see Detail 5). Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris.
5. If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by placing a patch over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 500 mm is achieved around all parts of the damaged area. Bentonite mastic / powder should be applied around the damaged area prior to placement of the patch. It may be necessary to use an adhesive such as wood glue, or by hand placing material over the patch, to fix the patch in place so that it is not moved during overliner bedding material placement. Smaller patches also may be tucked under the damaged area to prevent patch movement.
6. Bedding shall be free of angular stones or other foreign matter which could damage the GCL. Cover soils should be approved by the Engineer, with respect to particle size and uniformity (as per the 'Technical Specifications').
7. Surface for the liner placement must be smooth competent 'virgin' ground with no loose or fractured material.

REFERENCES

NAD83 UTM Zone 13.

DRAWING NO.	DRAWING TITLE
-	-

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

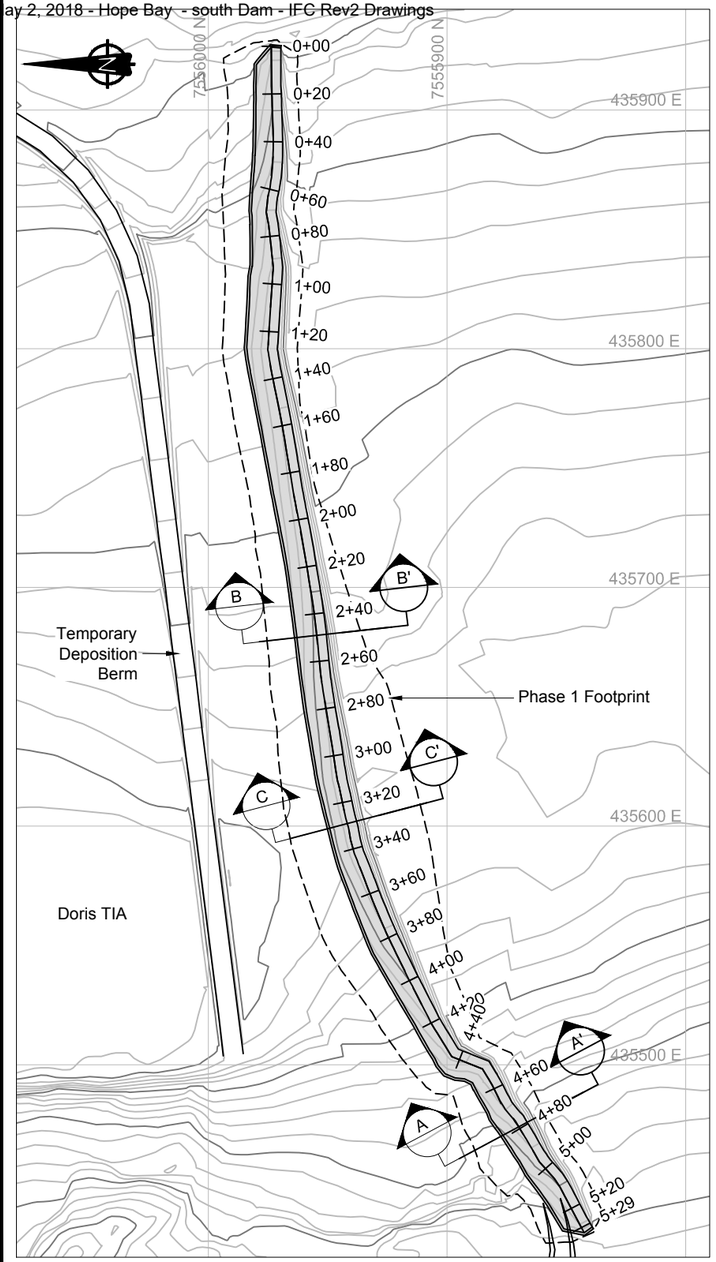
South Dam

DRAWING TITLE:

Liner and Bedding Placement Details

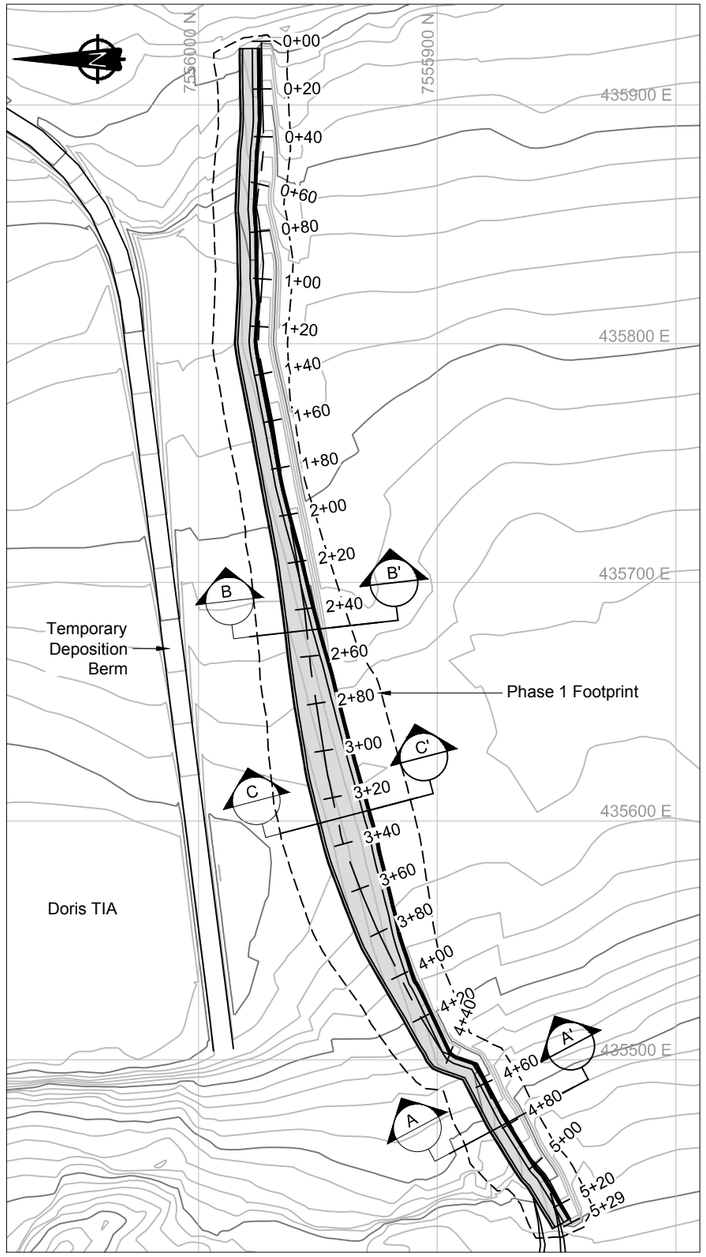
DRAWING NO.	SHEET	REVISION NO.
DN-SD-06	6 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1\1CT0022.017 - South Dam - Liner.dwg



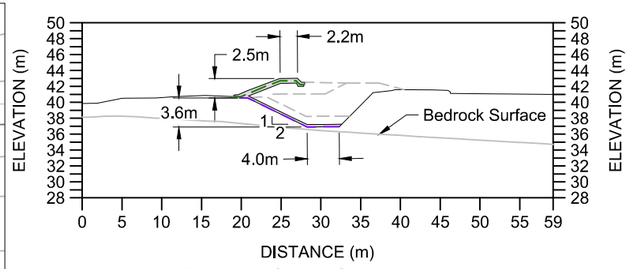
Key Trench Bedding Placement Plan View

0m 20 40 60 80 100



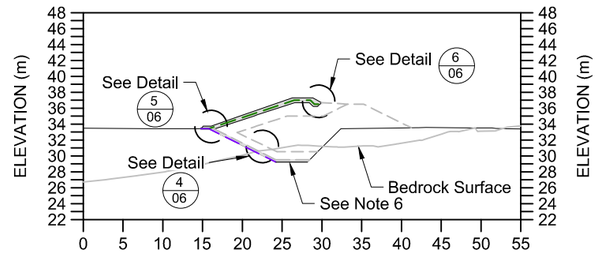
Phase 1 Dam Bedding Placement Plan View

0m 20 40 60 80 100



Minimum Cross Section A-A'

0m 5 10 15 20 25 30



Cross Section B-B' - Bedrock Encountered in Trench

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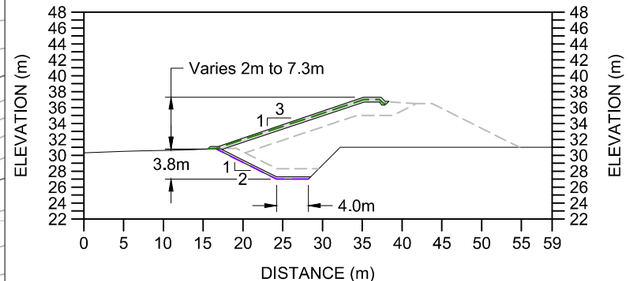

Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

- Phase 1 Dam Liner
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Bedding Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Bedding layer to be placed in 0.15m lifts and compacted before liner placement. The subsurface below the liner should be free of protrusions or any sharp / angular cobbles or larger size material. See the Technical Specifications document for more details ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK).*
4. Bedding material cover shall be placed over the GCL using construction equipment that minimizes stresses on the GCL. Unless otherwise approved / directed by the Engineer a minimum thickness of 600mm or greater is required to be placed over any areas where heavy equipment will be trafficking over the liner. Thickness requirement are related to equipment type. For light equipment (which will have to be directly approved by the Engineer), as an absolute minimum a thickness of 300mm of cover must be maintained between light tracked equipment (e.g. skid-steer or 30 excavator) tracks/tires, and the GCL at all times during the covering process.
5. Soil cover should be placed in a manner that prevents the soil from entering/disturbing the GCL overlap zones.
6. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

REFERENCES

NAD83 UTM Zone 13.

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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							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-06	Liner and Bedding Placement Details	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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JKB	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Bedding.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Bedding Material Placement Plan and Sections - Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-07	7 OF 30	1

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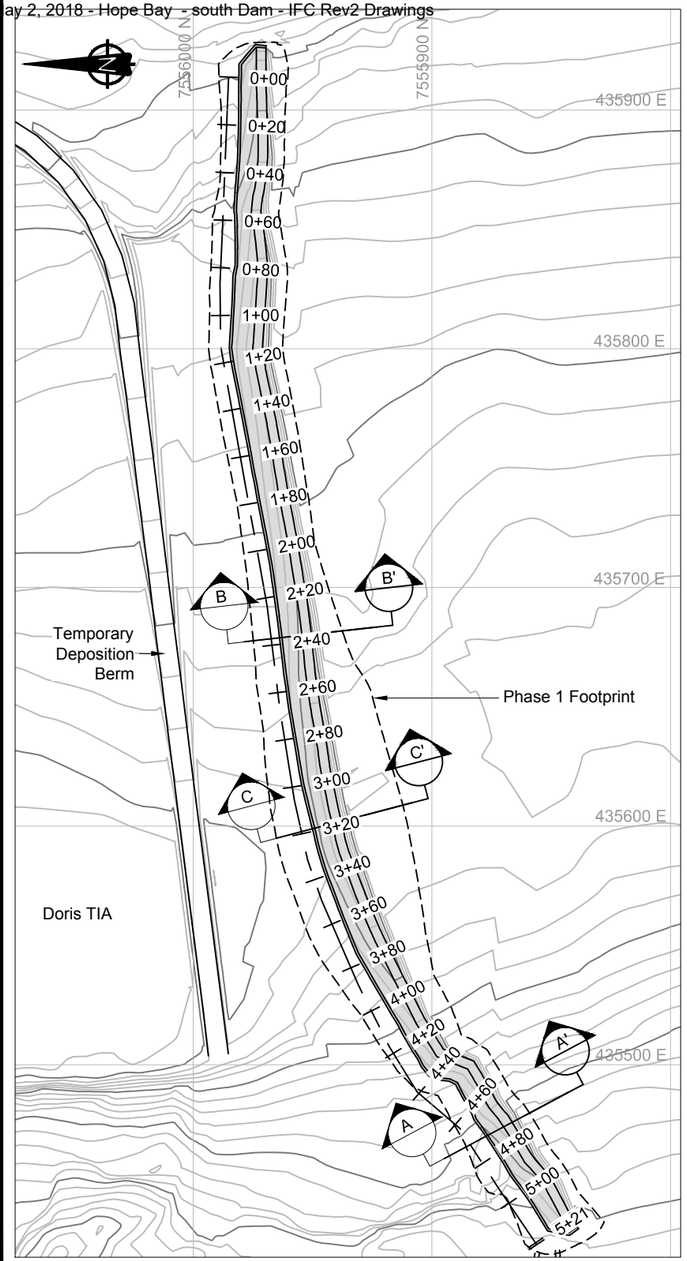
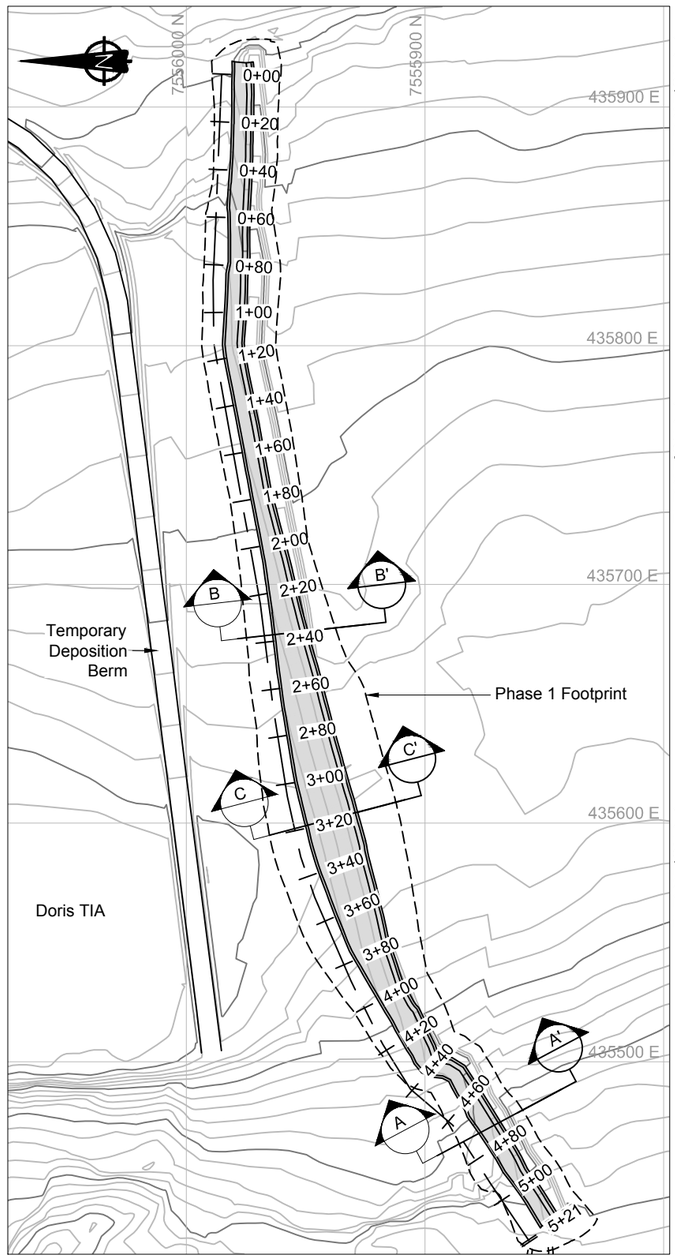


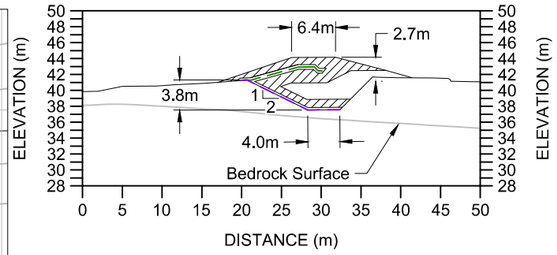
Key Trench Bedding Placement Plan View

0m 20 40 60 80 100



Phase 1 Dam Bedding Placement Plan View

0m 20 40 60 80 100



Minimum Cross Section A-A'

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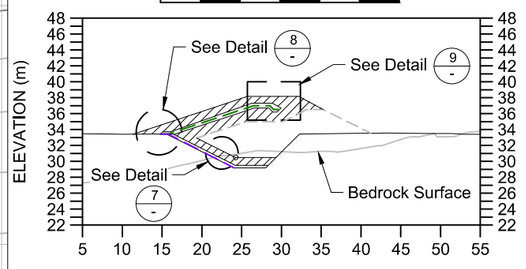

Cross Section B-B' - Bedrock Encountered in Trench

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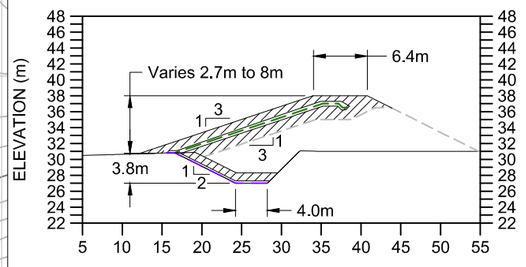


Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND Page 15 of 37

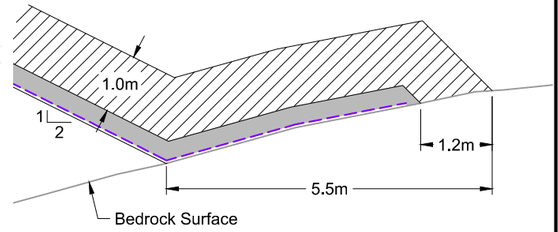
- Phase 1 Dam Liner
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Bedding Material
- Transition Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.

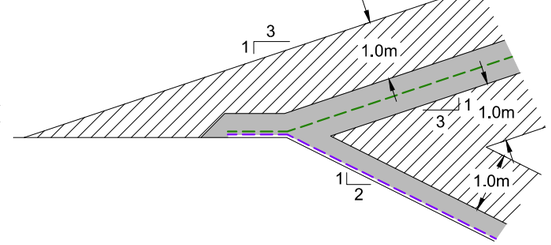
REFERENCES

NAD83 UTM Zone 13.



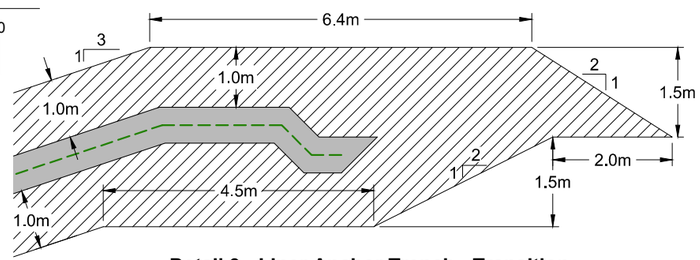
Detail 7 - Key Trench Bedrock Interface - Transition

0m 1 2 3 4



Detail 8 - Upper and Lower GCL Liner Overlap - Transition

0m 1 2 3 4



Detail 9 - Liner Anchor Trench - Transition

0m 1 2 3 4

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

DRAWING NO. | DRAWING TITLE

REFERENCE DRAWINGS

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Transition.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Transition Material Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-08	7 OF 30	1

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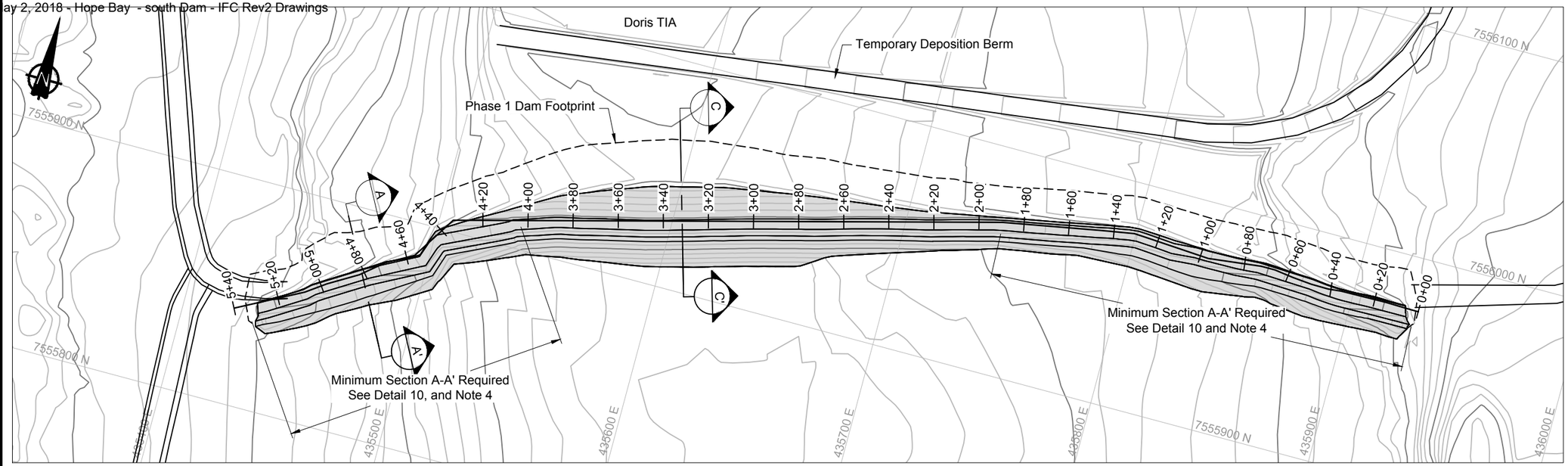


Run of Quarry Placement Plan View

0m 20 40 60 80

LEGEND

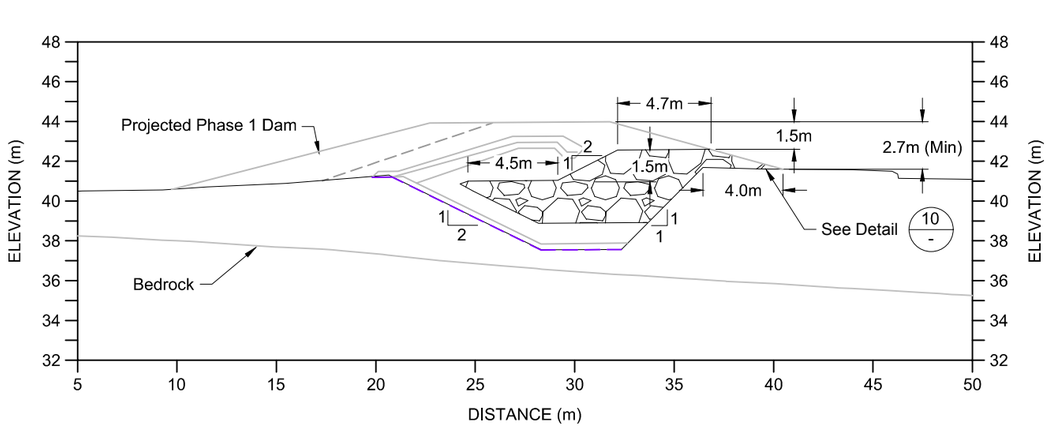
- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Run of Quarry Backfill Extent
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profiles shown correspond to the upstream toe of the key trench.
4. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench. See Detail 10 on drawing DN-SD-09 for additional details.
5. The outside downstream ROQ should be sloped at 2H:1V or shallower.

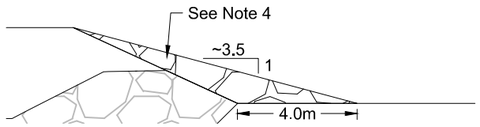
REFERENCES

NAD83 UTM Zone 13.



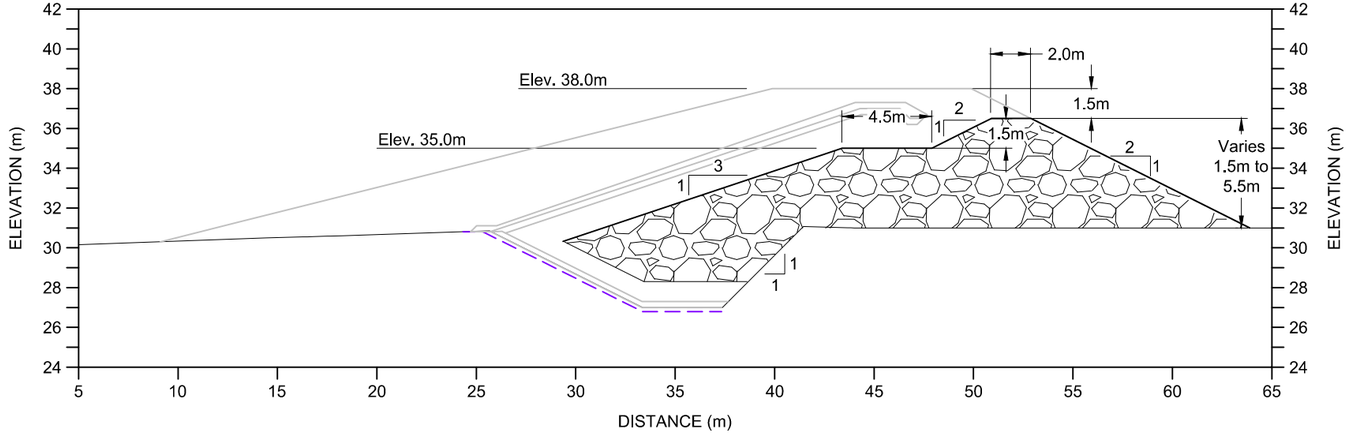
Minimum Cross Section A-A'

0m 3 6 9 12



Detail 10 - Contingency ROQ Thermal Barrier Design

0m 2 4 6 8



Typical Cross Section C-C'

0m 3 6 9 12

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1	-	-				0	Issued for Construction	JBK	EMR	17/11/29
REFERENCE DRAWINGS		REVISIONS									

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CHECKED: JBK | APPROVED: EMR | DATE: 2018/04/13
FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO. DN-SD-09 | SHEET 9 OF 30 | REVISION NO. 1

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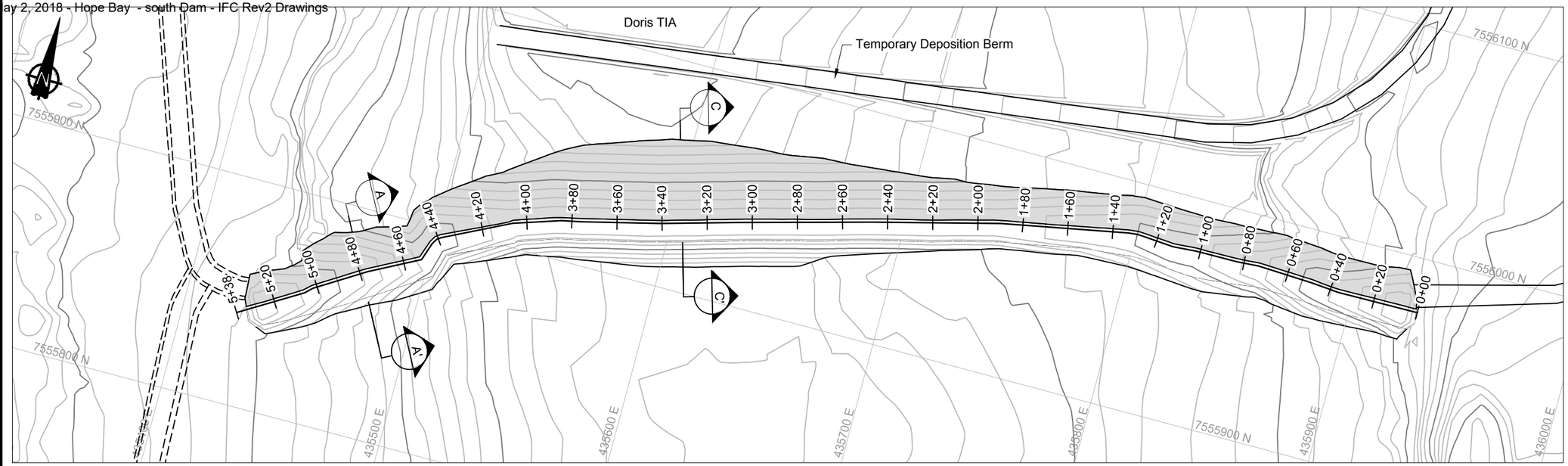
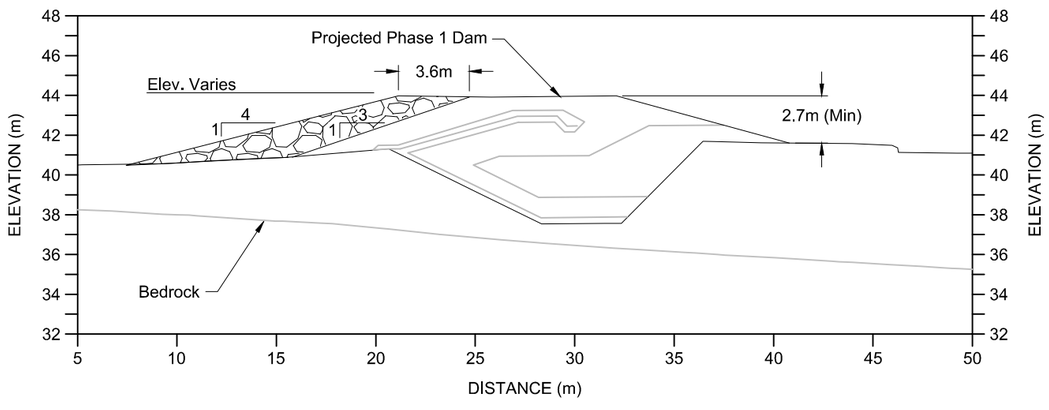


Run of Quarry Placement Plan View

0m 20 40 60 80



Minimum Cross Section A-A'

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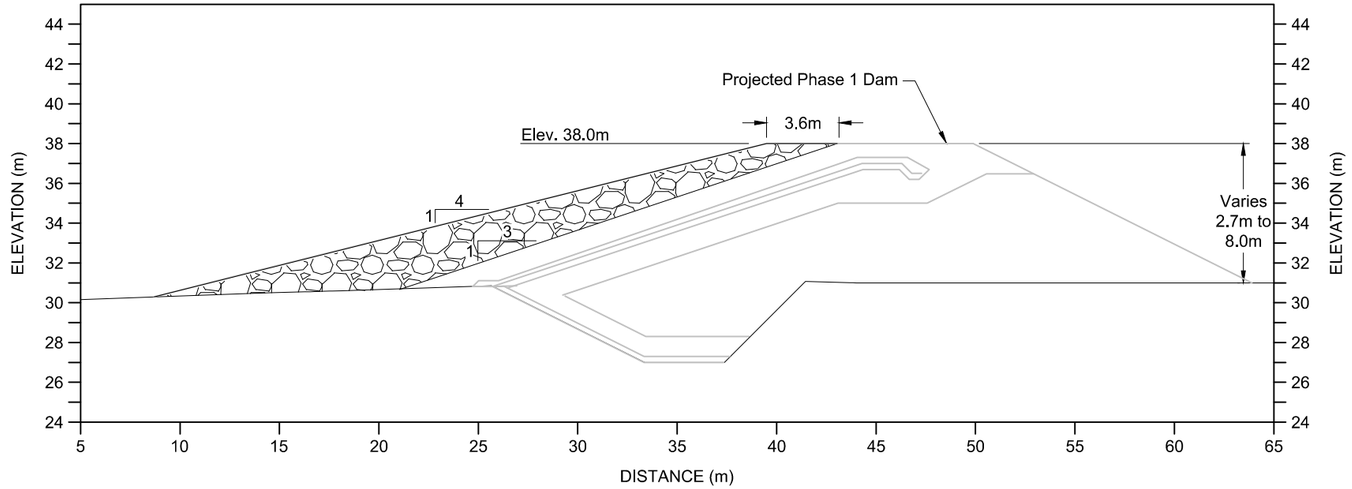

Typical Cross Section C-C'

0m 3 6 9 12

LEGEND

- Key Trench Liner
- Proposed Road / Dam Infrastructure
- Run of Quarry Backfill Extent
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The outside upstream dam ROQ should be sloped at 4H:1V or shallower.

REFERENCES

NAD83 UTM Zone 13.

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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DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ-us.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-10	10 OF 30	1

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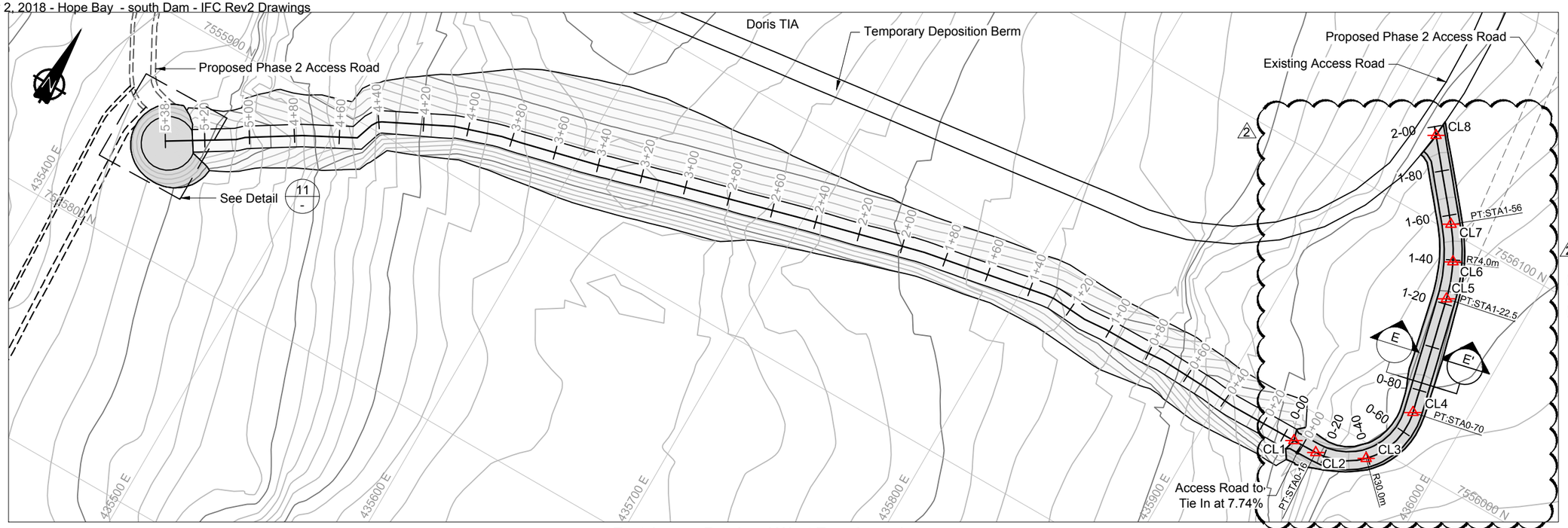
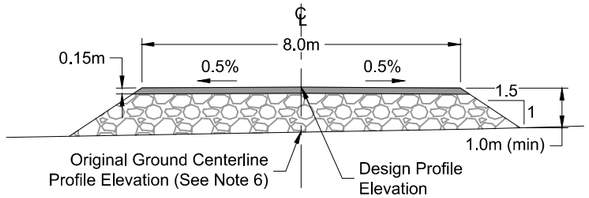
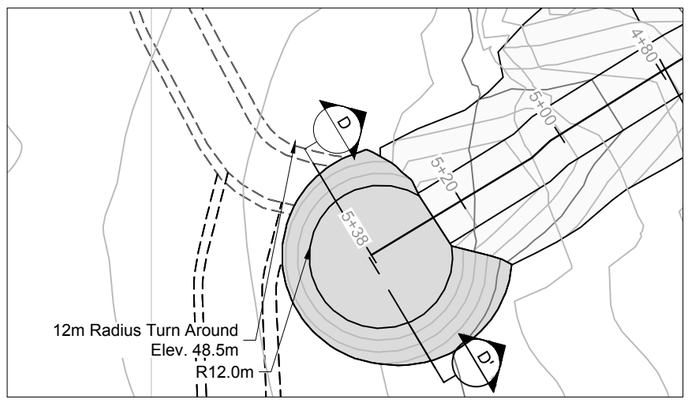


East Access Road and West Turn Around

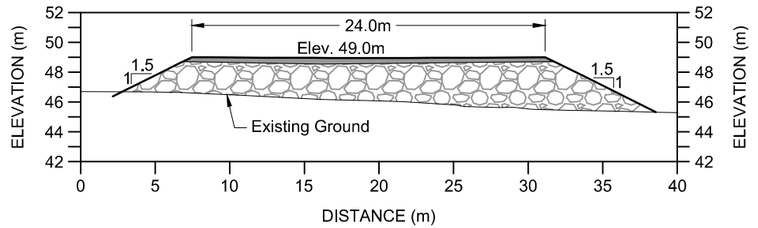
0m 20 40 60 80





Detail 11 - Turn Around

0m 10 20 30 40

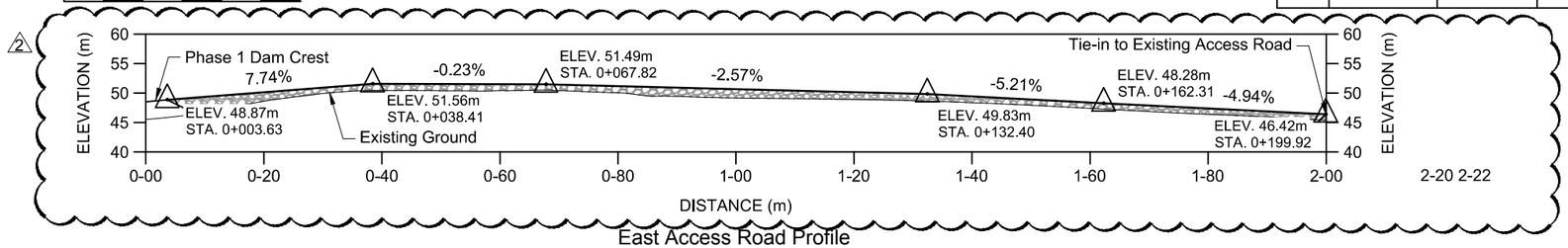


Section D-D' - Turn Around

0m 4 8 12 16

Section E-E' - Typical Road Section

0m 1 2 3 4 5 6



East Access Road Profile

0m 10 20 30 40

LEGEND

- Stakeout Point
- Vertical Inflection Point
- Proposed Road / Dam Infrastructure
- Phase 1 Access Road
- Run of Quarry
- Surfacing Material

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Approximately 2,440m³ of Fill material is estimated (to neat lines) to be needed for the Access Road and Turn Around.
4. Minimum fill thickness for Access Road and Turn Around is 1.0m
5. Construction shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction.
6. Profile based on available topography. Existing ground level to be surveyed prior to construction to confirm design thickness achieved.

REFERENCES

NAD83 UTM Zone 13.

STAKEOUT POINTS

ID	Northing	Easting	Elev. (m)
CL1	7555976.16	435925.08	48.97
CL2	7555976.39	435936.14	49.83
CL3	7555985.34	435956.86	51.56
CL4	7556013.44	435964.66	51.45
CL5	7556064.69	435952.27	51.09
CL6	7556080.41	435946.53	49.48
CL7	7556094.44	435937.41	48.61
CL8	7556125.37	435911.91	46.61

NO.	DESCRIPTION	CHK'D	APP'D	DATE
2	Issued for Construction	JBK	EMR	18/04/30
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-03	Typical Sections (General)
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

Original Drawings Stamped and Signed by Engineer

This drawing is uncontrolled when printed unless stamped and signed with original ink and recorded on a Distribution Register.

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srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/30

FILE NAME: 1CT0022.017 - South Dam AR.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:
Construction Access Road and Turnaround - Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-11	11 OF 26	2

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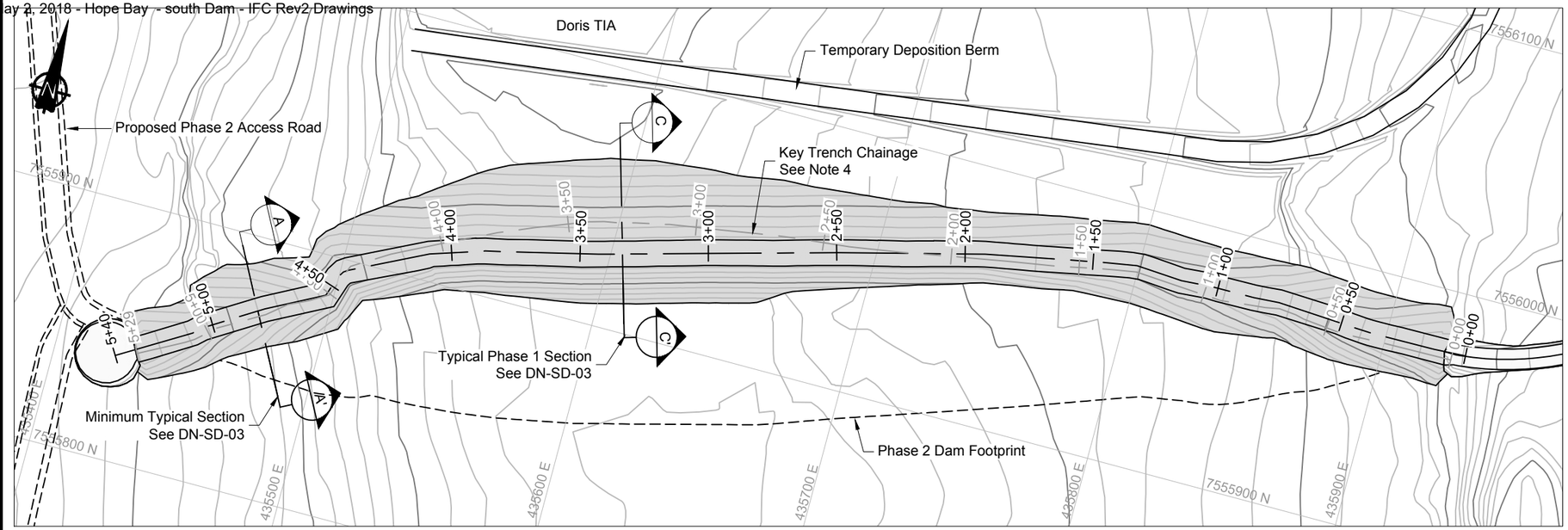


Phase 1 Dam Plan View

0m 20 40 60 80

LEGEND

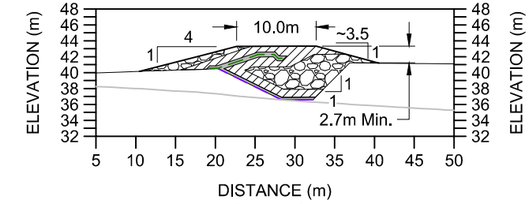
- Key Trench Excavation
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The Phase 2 dam elevations are shown for information purposes only. Note that only Phase 1 dam designs and elevations are issued for construction use.
4. Base of key trench on this profile is based on a section down the centerline of the dam crest. Note that the key trench centerline and the dam crest centerline do not share the exact same alignment and overall the chainages vary in any given location (between the key trench and dam crest shown in these drawings) in the range of 5m.

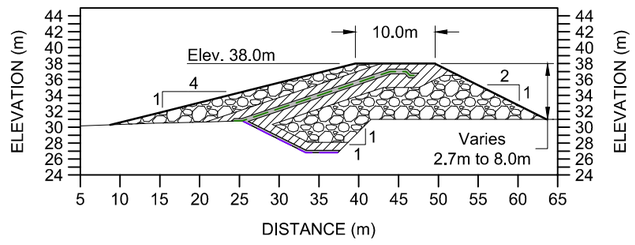
REFERENCES

NAD83 UTM Zone 13.



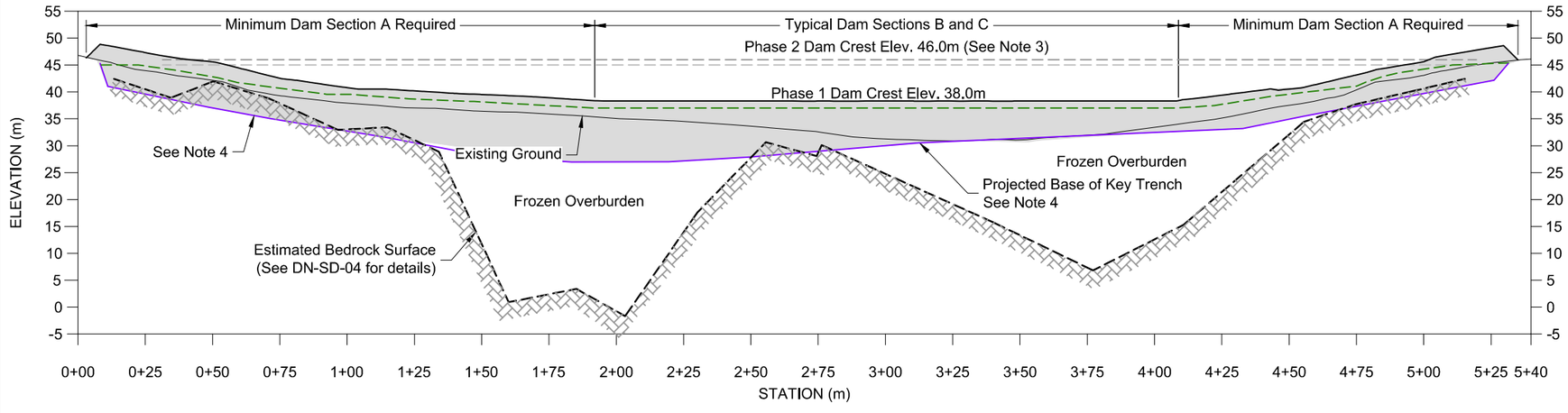
Minimum Cross Section A-A'

0m 5 10 15 20 25 30



Cross Section C-C'

0m 5 10 15 20 25 30



Phase 1 Dam Profile View - Through Crest Centerline

Horizontal: 0m 10 20 30 40

Vertical: 0m 20 40 60 80

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-04	Key Trench Excavation Plan and Profile										
DN-SD-03	Typical Sections (General)						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

Original Drawings Stamped and Signed by Engineer

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Phase 1 Dam.dwg

MAC RESOURCES

Hope Bay Project

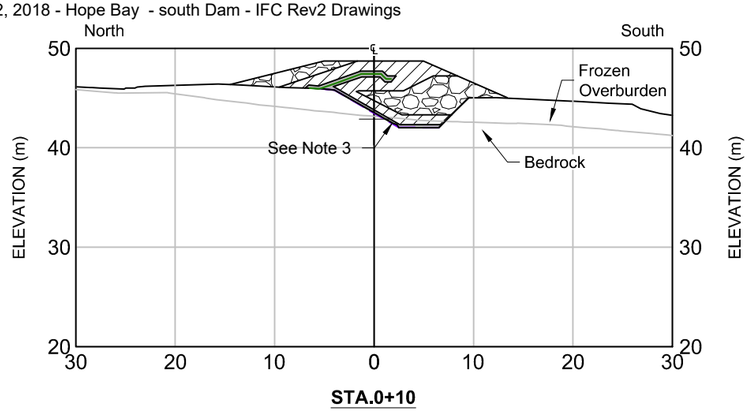
SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Final Phase 1 Dam Plan, Profile and Sections

DRAWING NO.	SHEET	REVISION NO.
DN-SD-12	12 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1\1CT0022.017 - South Dam - Phase 1 Dam.dwg



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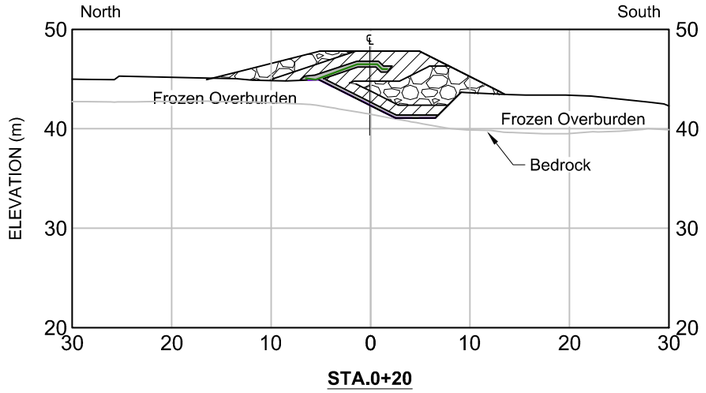

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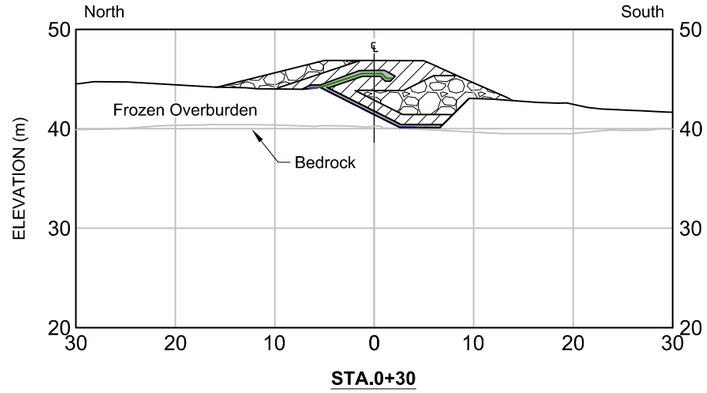

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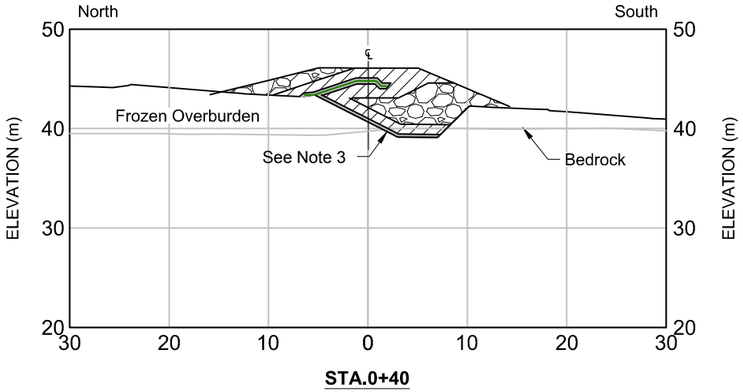

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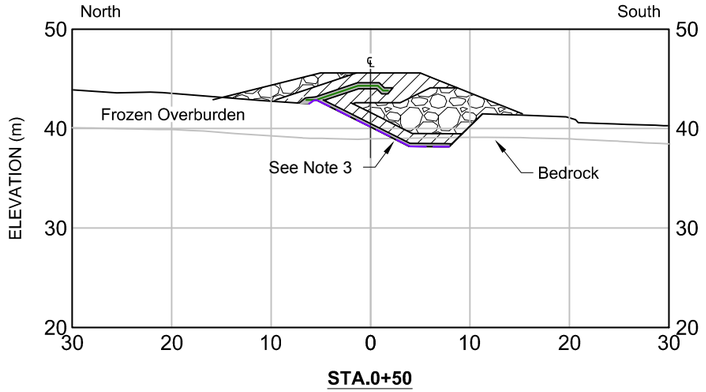

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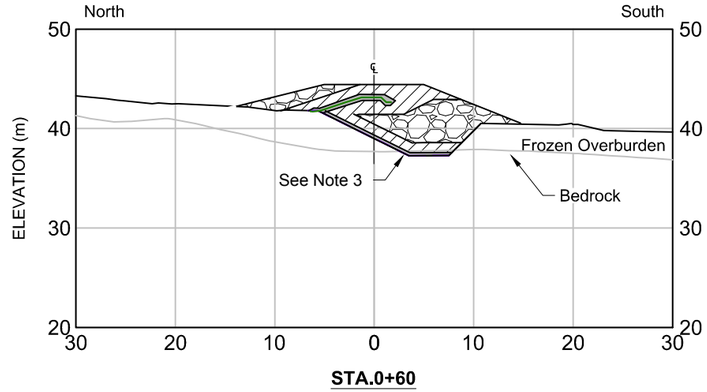

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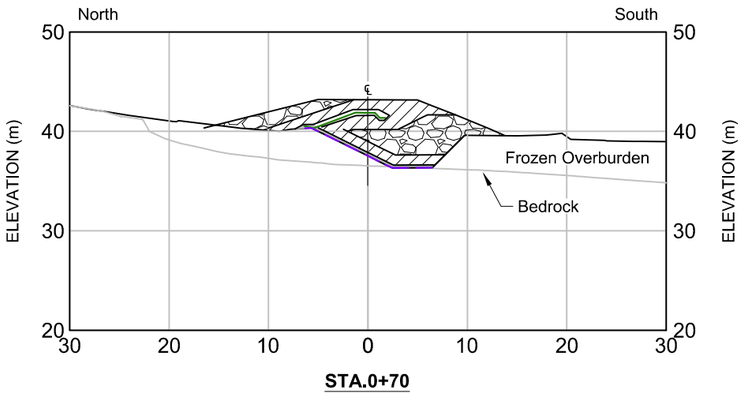

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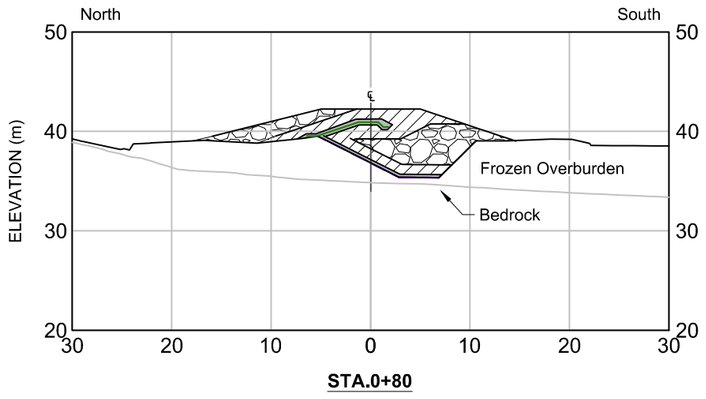

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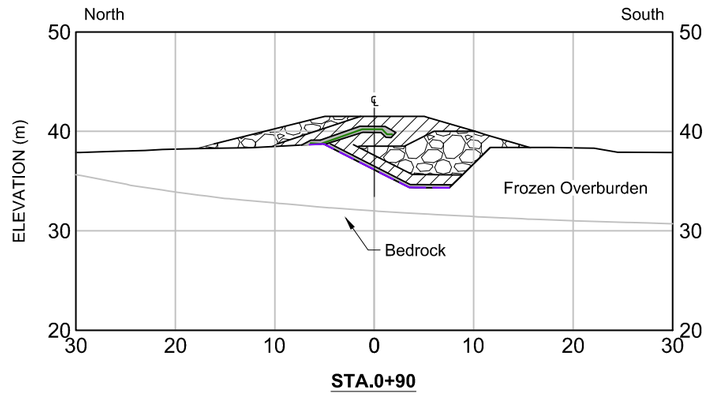

STA.0+90

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
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3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth of bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

0m 6 12 18 24

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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							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.0+10 to 0+90 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-13	13 OF 30	1

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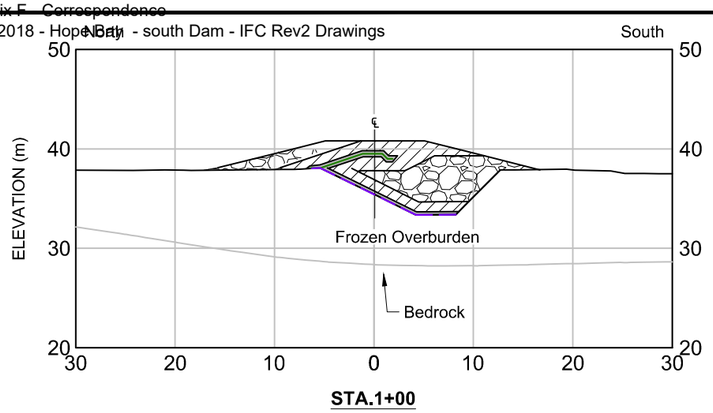

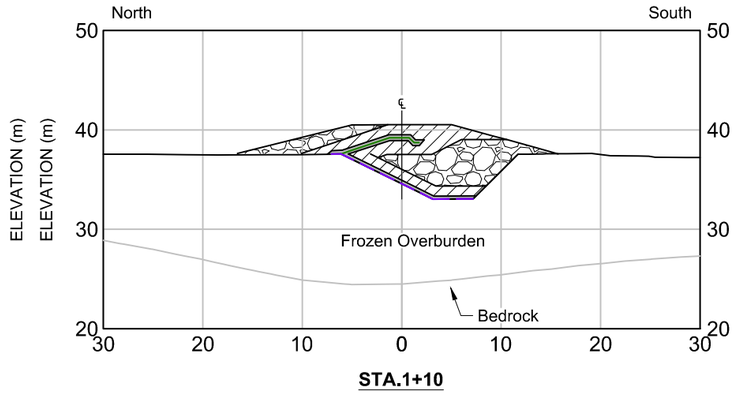

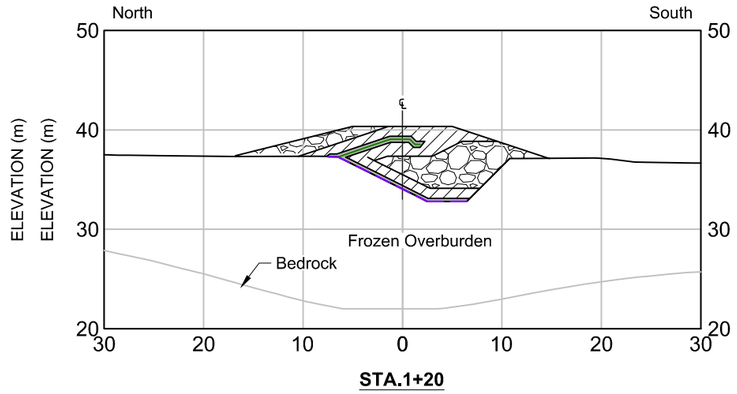

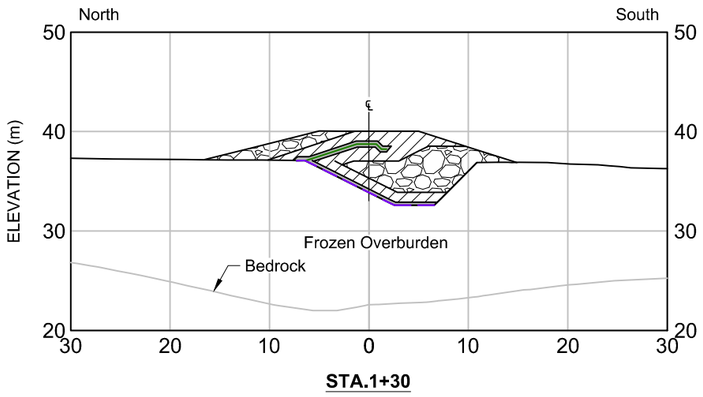

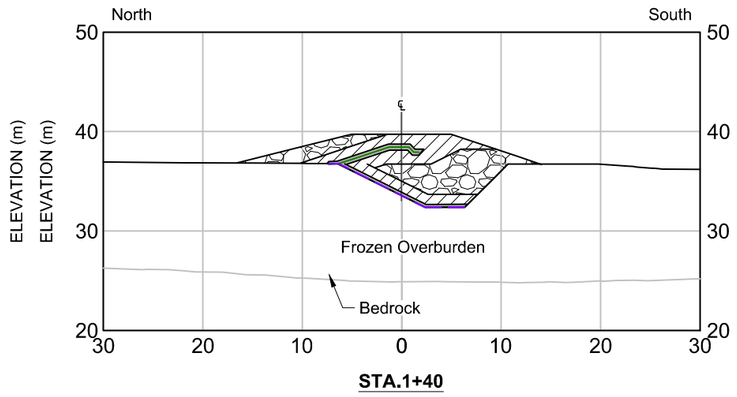

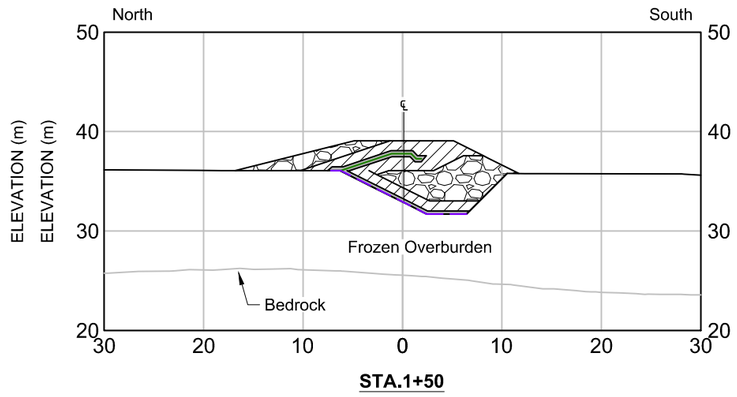

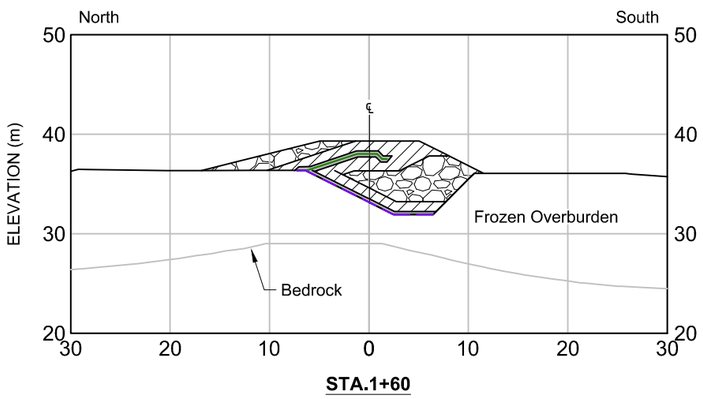

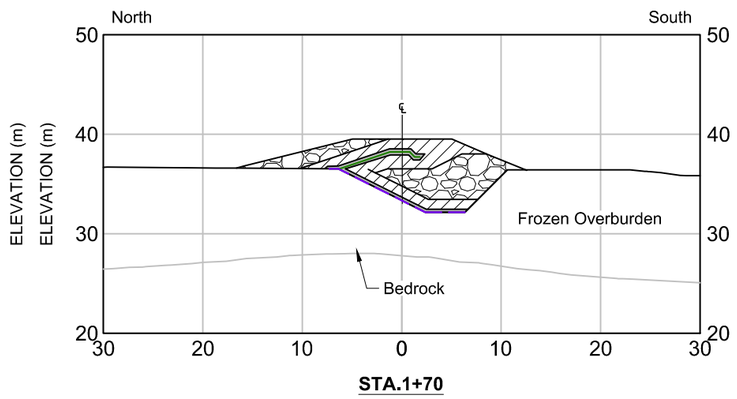

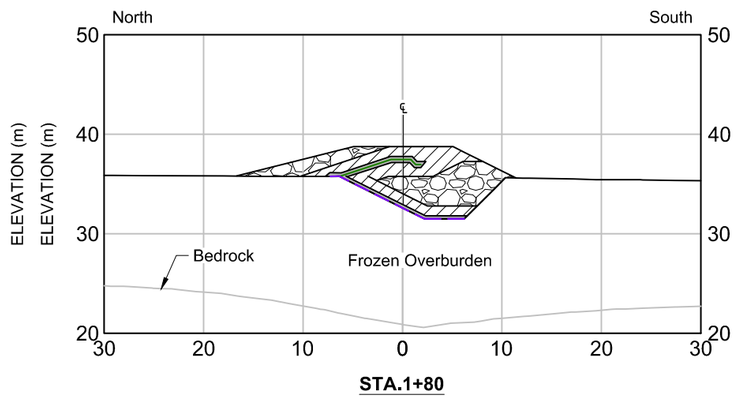

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
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3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

0m 6 12 18 24

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

Original Drawings Stamped and Signed by Engineer

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.1+00 to 1+80 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-14	14 OF 30	1

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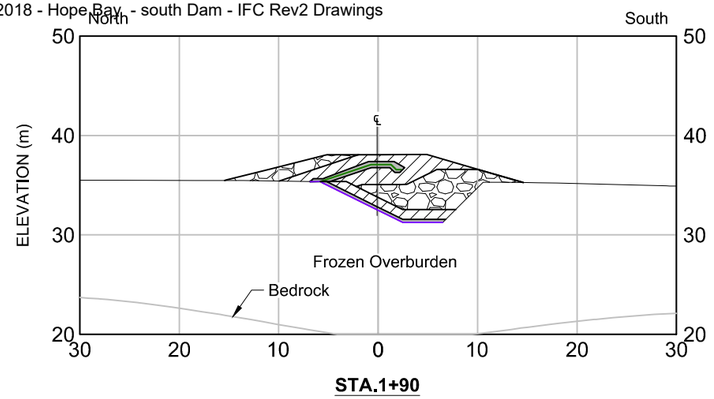

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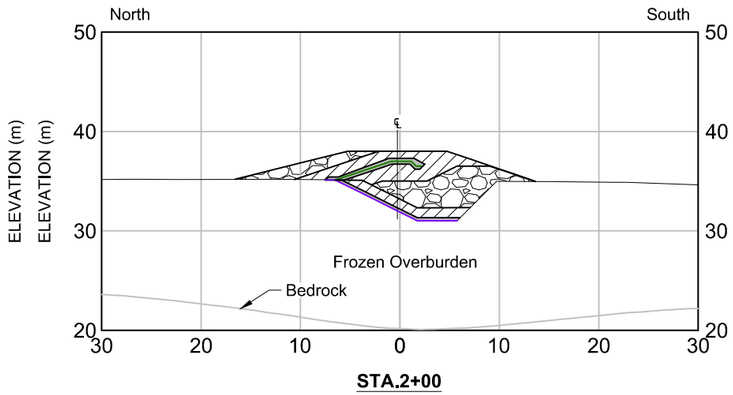

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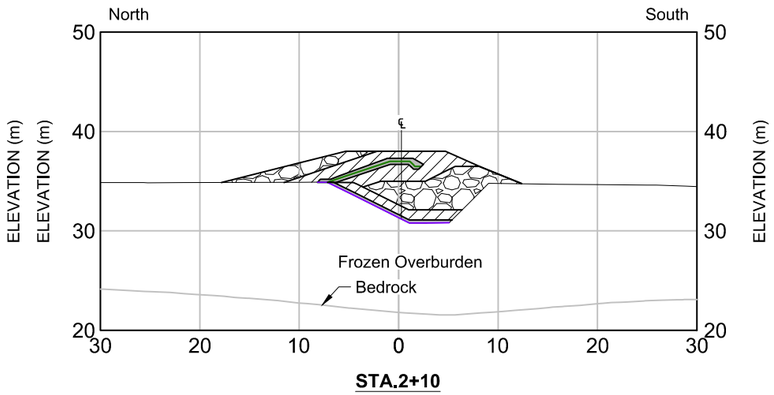

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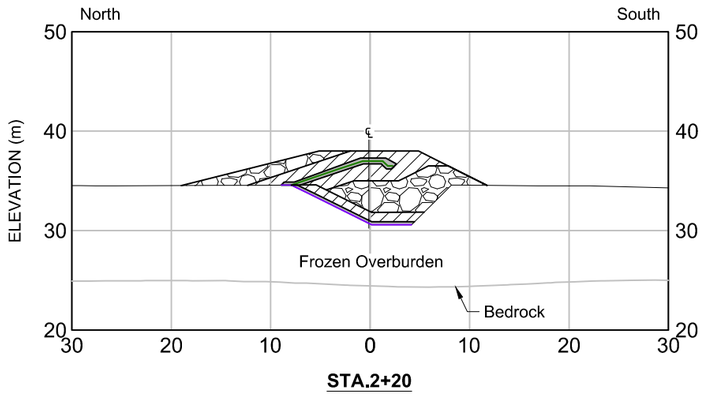

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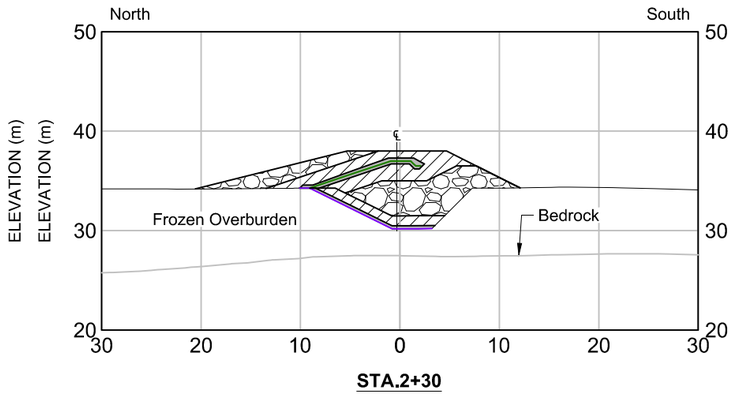

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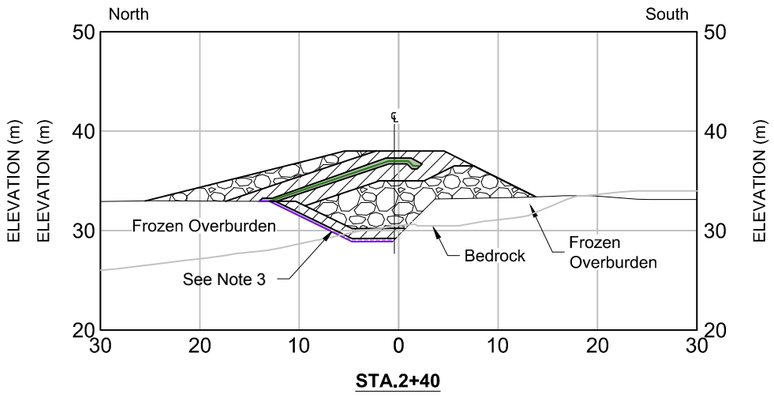

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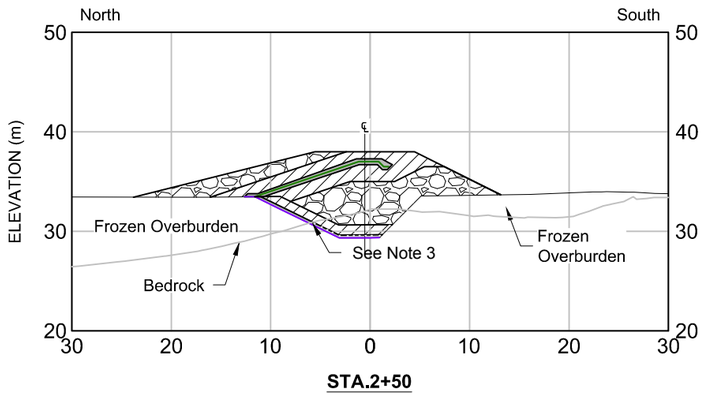

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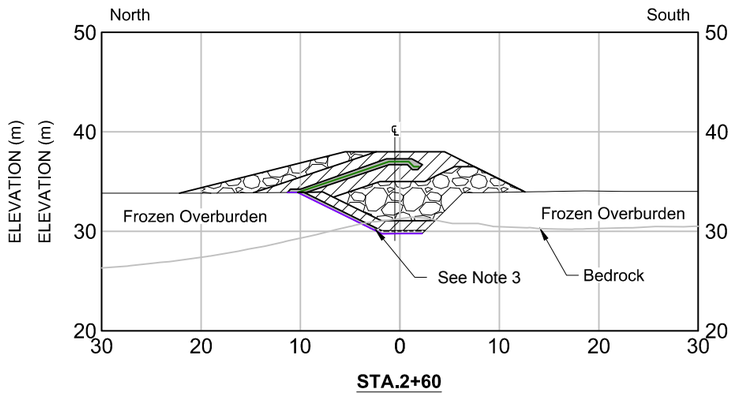

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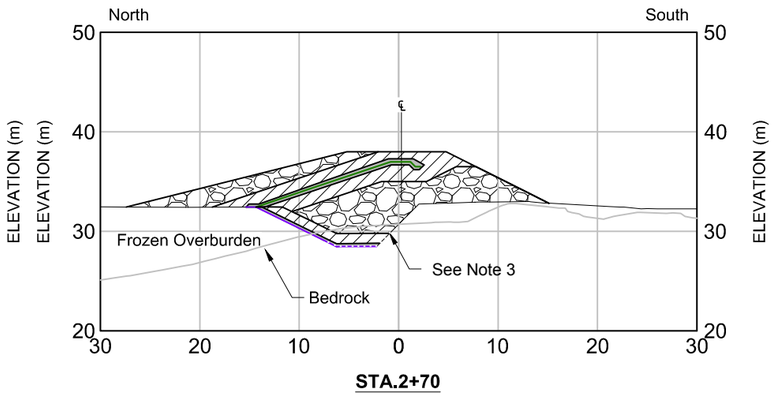

STA.2+70

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

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0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.1+90 to 2+70 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-15	15 OF 30	1

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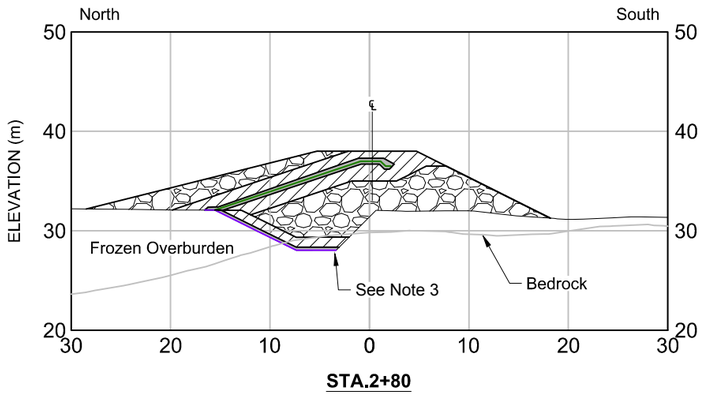

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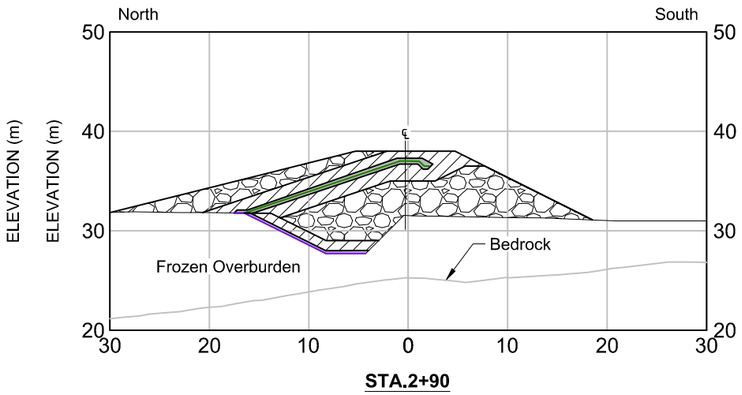

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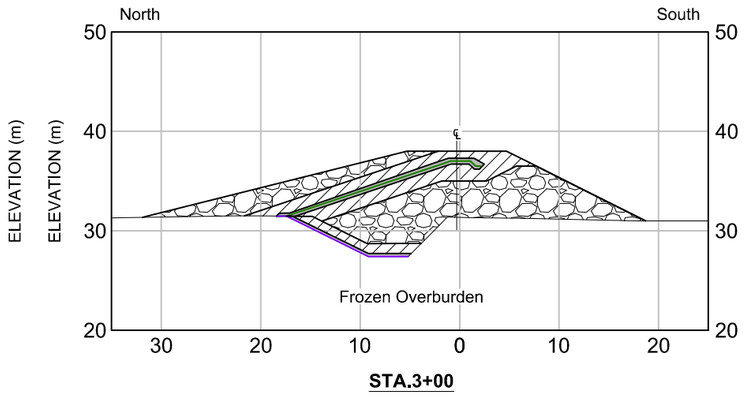

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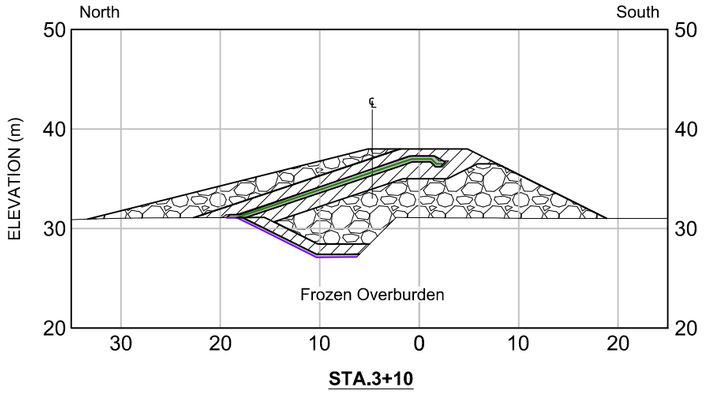

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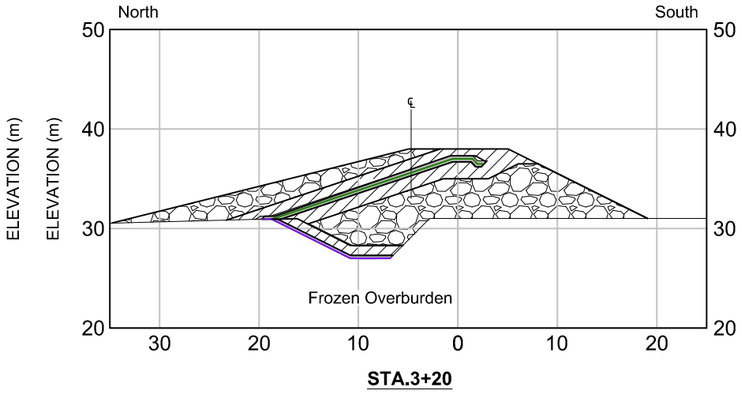

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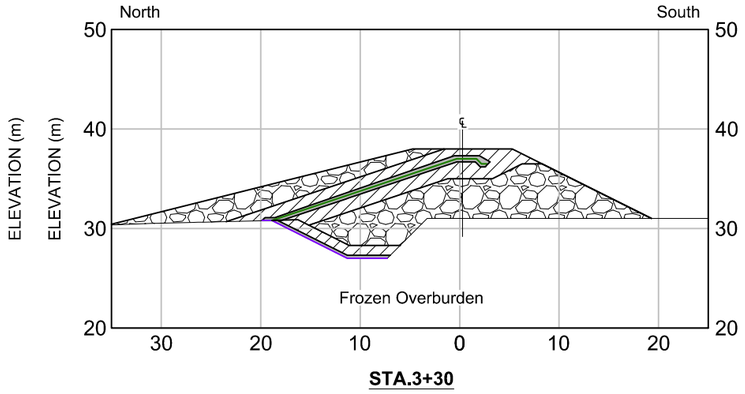

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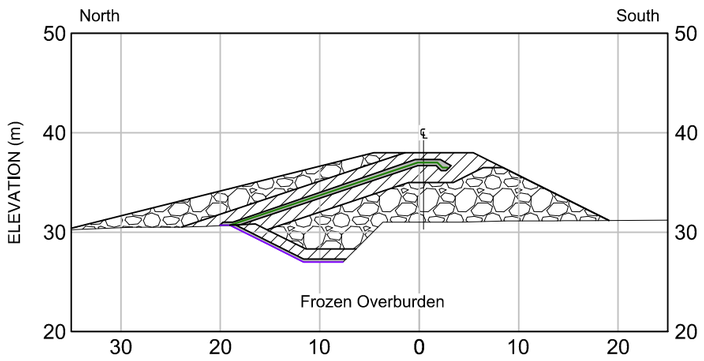
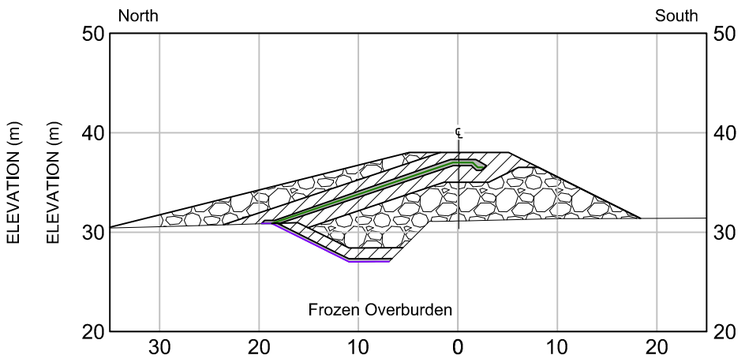
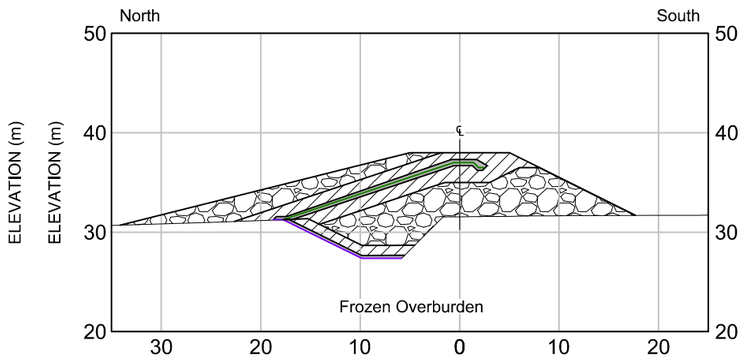


STA.3+40



STA.3+50



STA.3+60

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

REVISIONS

Original Drawings Stamped and Signed by Engineer

This drawing is uncontrolled when printed unless stamped and signed with original ink and recorded on a Distribution Register.

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

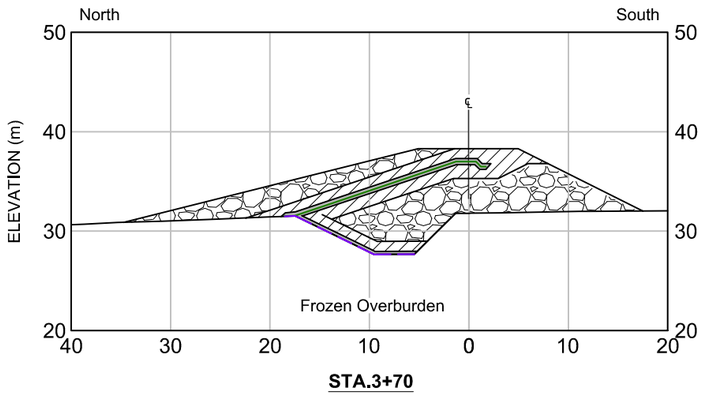
SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.2+80 to 3+60 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-16	16 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1-internal\1CT0022.017 - South Dam - Sections.dwg



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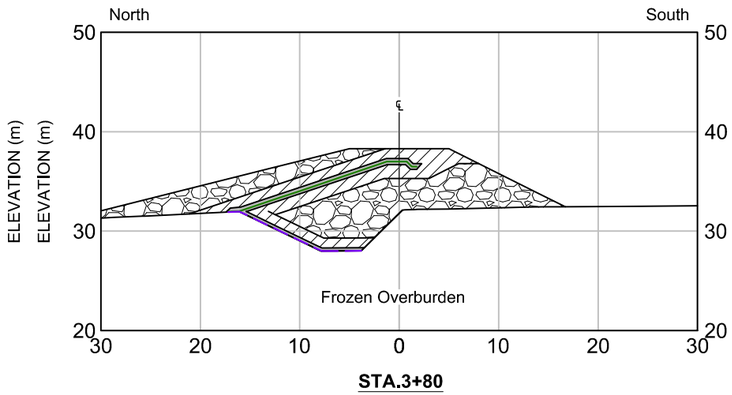

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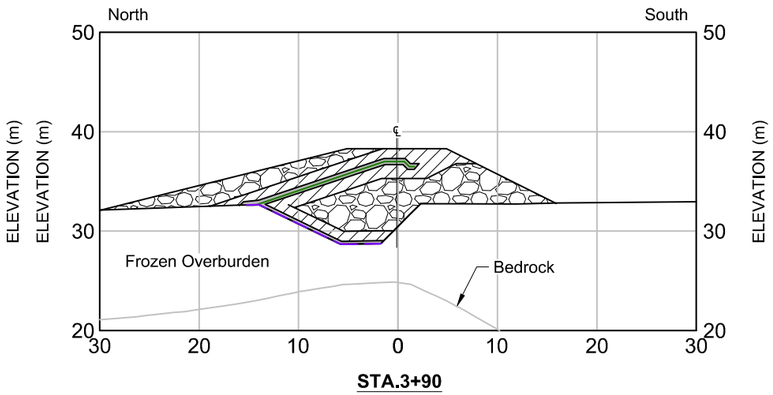

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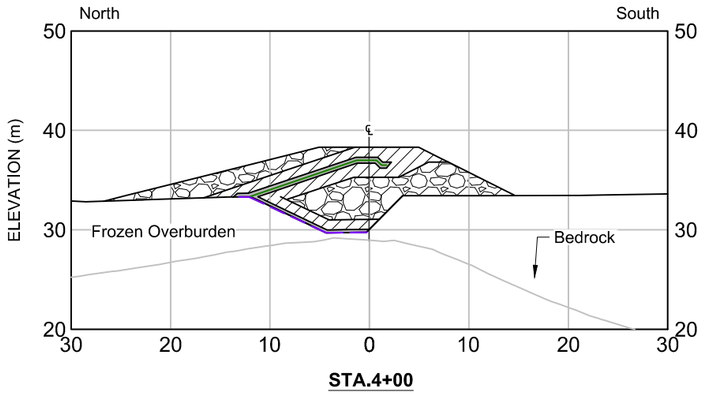

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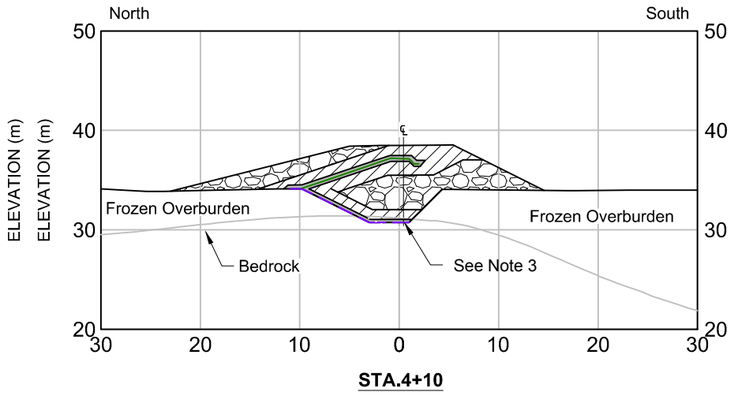

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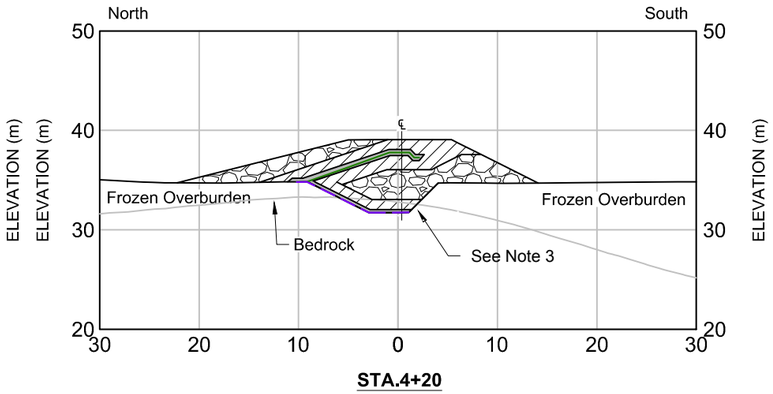

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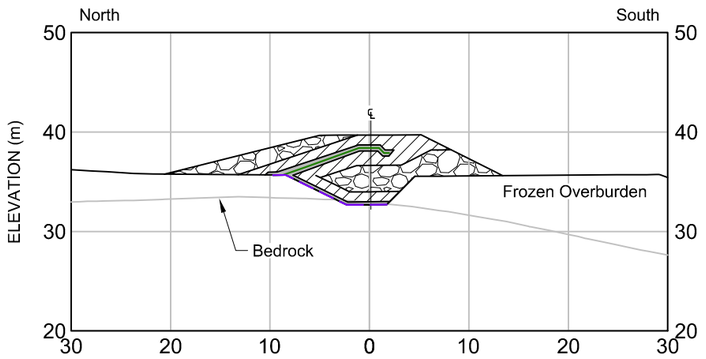

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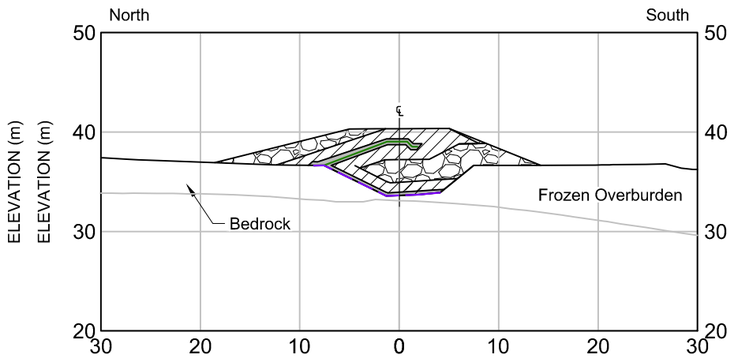

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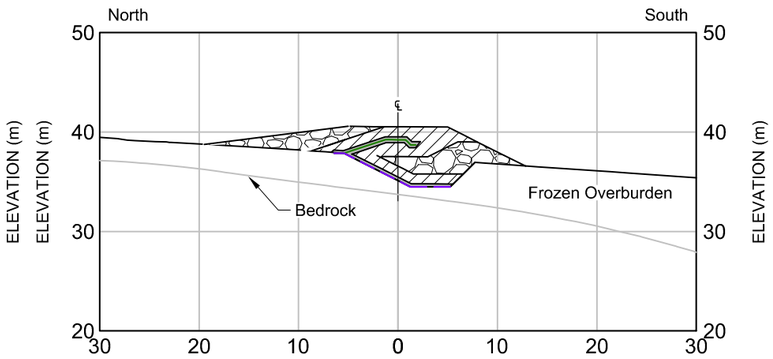

STA.4+50

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

REVISIONS

Original Drawings Stamped and Signed by Engineer

This drawing is uncontrolled when printed unless stamped and signed with original ink and recorded on a Distribution Register.

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.3+70 to 4+50 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-17	17 OF 30	1

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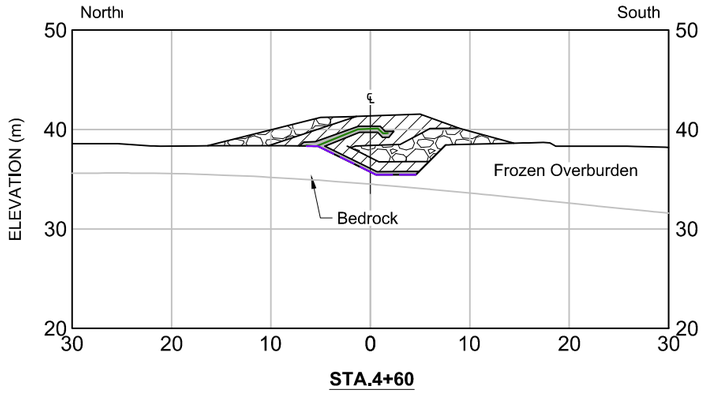

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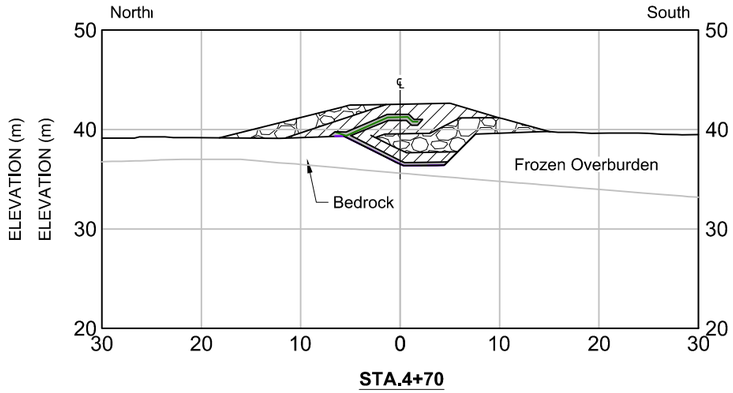

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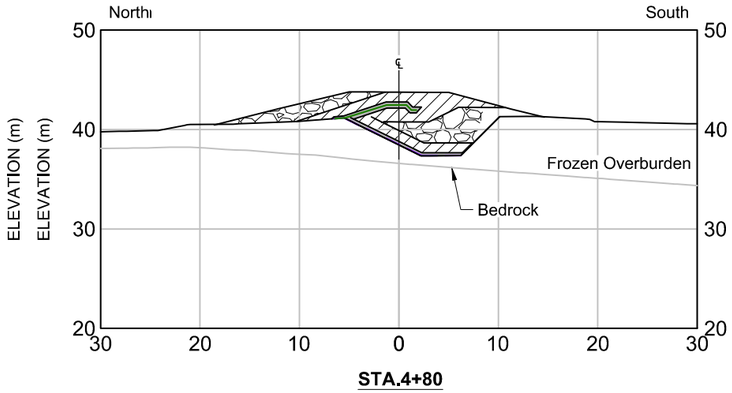

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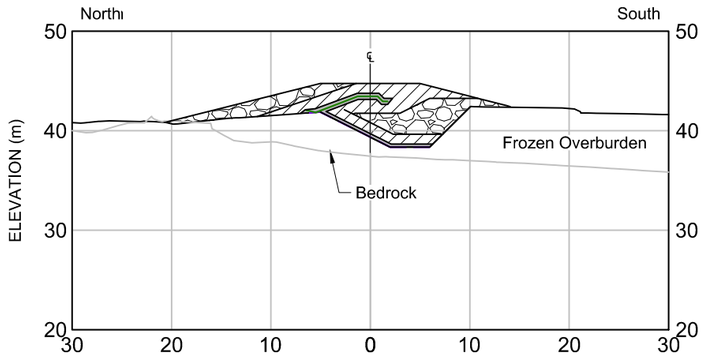

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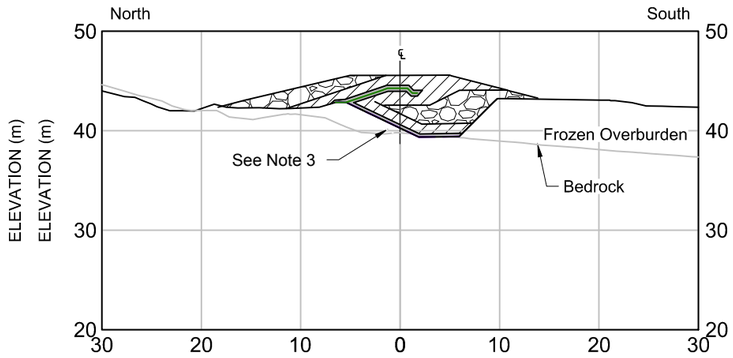

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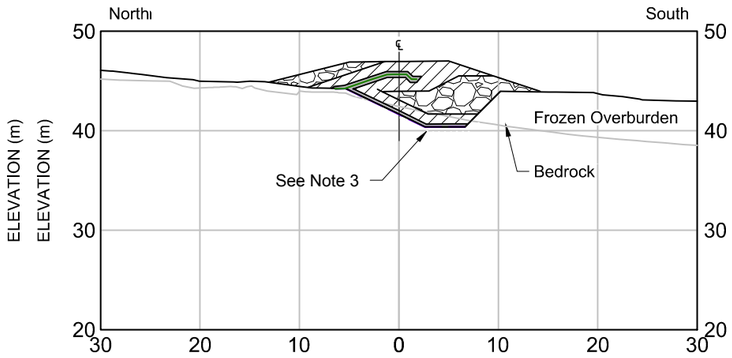

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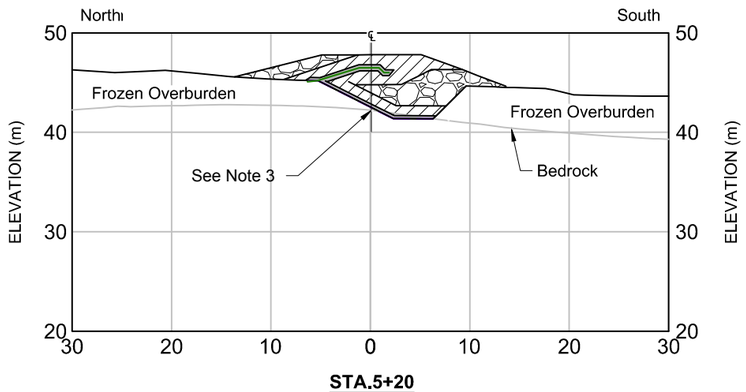

STA.5+20

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.
3. Depth of key trench intersection with bedrock estimated (see DN-SD-04 for additional details). Actual depth may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

REFERENCE DRAWINGS			REVISIONS								
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CH'K'D	APP'D	DATE	NO.	DESCRIPTION	CH'K'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

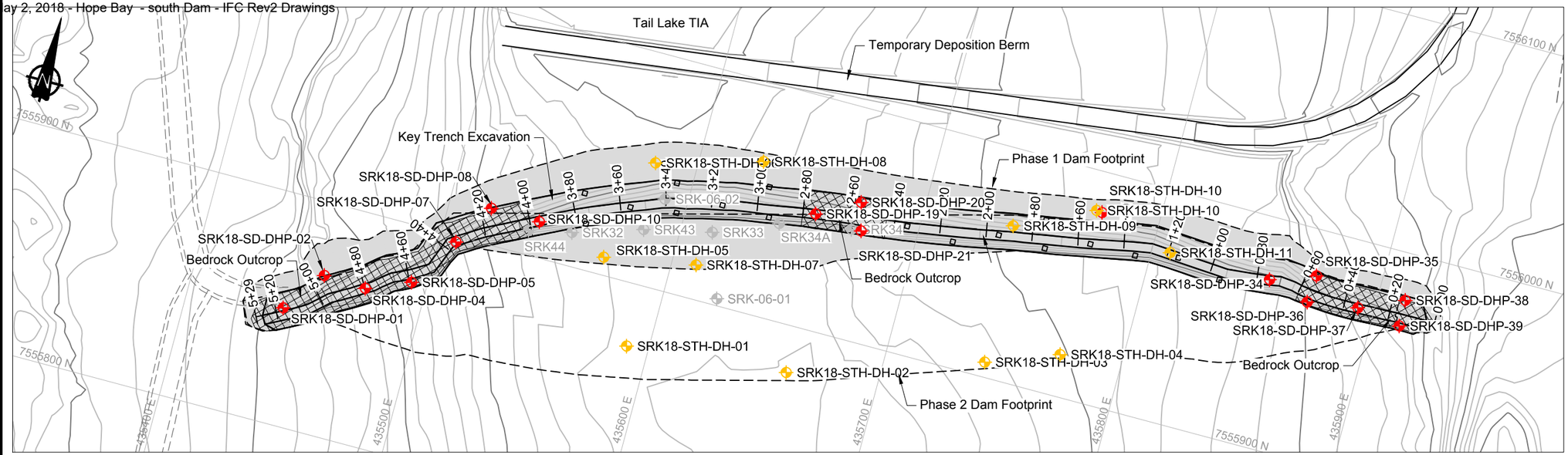
SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.4+60 to 5+30 Phase 1 Dam

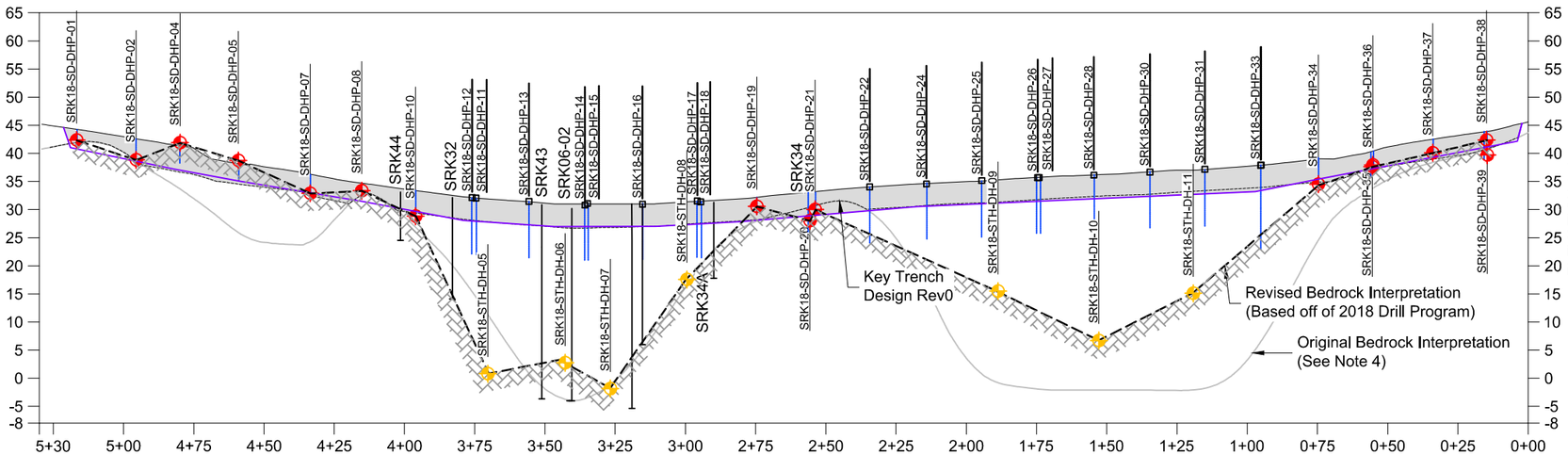
DRAWING NO.	SHEET	REVISION NO.
DN-SD-18	18 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 r1\1CT0022.017 - South Dam - Sections.dwg



Key Trench Plan View

0m 20 40 60 80



Key Trench Profile View

Vertical 0m 10 20 30 40

Horizontal 0m 20 40 60 80

LEGEND

- Previous Investigation Hole Location
- 2018 Percolation Hole Location Intercepted Bedrock
- 2018 Percolation Hole Location Did Not Intercept Bedrock
- 2018 Borehole Location
- Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Trench Excavation Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profile shown correspond to the upstream toe of the key trench.
4. The subsurface geology has been inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A , SRK43, SRK 44, SRK18-STH-DH-01 to 11, and SRK18-WST-DH-01 to 03), airphoto interpretations, and from limited available geophysical surveys around the Tails Lake area. This data was then used to create a bedrock surface with the Gemcom GEMS software. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.
5. Infill drilling is planned to be completed to reduce the uncertainty and associated risks with the Phase 1 South Dam key trench excavation and overall dam performance (e.g. stability, seepage, settlement, and creep).
6. Depths of infill drill boreholes estimated based on available information (Note 4 and as noted on DN-SD-04). Boreholes should be drilled 3m into bedrock unless terminated earlier as directed by the onsite Engineer.
7. Inferred bedrock contact based off exploration and percolation testing holes drilled January / February 2018 by SRK Consulting.

REFERENCES

NAD83 UTM Zone 13.

AS-BUILT BOREHOLE LOCATIONS

Point ID	Northing	Easting	Collar Elevation	Depth to Bedrock
SRK18-STH-DH-01	7555,873	435,590	31.34	29.9
SRK18-STH-DH-02	7555,880	435,660	30.69	3.0
SRK18-STH-DH-03	7,555,907	435,742	33.59	13.5
SRK18-STH-DH-04	7,555,918	435,773	34.82	10.4
SRK18-STH-DH-05	7,555,908	435,571	31.81	31.0
SRK18-STH-DH-06	7,555,953	435,582	30.35	27.6
SRK18-STH-DH-07	7,555,915	435,610	30.86	32.7
SRK18-STH-DH-08	7,555,966	435,627	31.07	13.5
SRK18-STH-DH-09	7,555,967	435,739	35.03	15.5
SRK18-STH-DH-10	7,555,983	435,772	6.10	6.7
SRK18-STH-DH-11	7,555,973	435,808	36.82	15.1
SRK18-WST-DH-01	7,556,486	435,113	43.25	7.1
SRK18-WST-DH-02	7,556,296	435,200	41.42	1.1
SRK18-WST-DH-03	7,556,195	435,257	42.71	5.4

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
AB	As-Built	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/12/11

DN-SD-04 — Key Trench Excavation Plan and Profile

REFERENCE DRAWINGS

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN: JBK | DRAWN: TAH | REVIEWED: EMR
CHECKED: JBK | APPROVED: EMR | DATE: 2018/04/13
FILE NAME: 1CT0022.017 - South Dam - Infill Foundation Drilling.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Infill Foundation Drilling Phase 1

DRAWING NO. DN-SD-19 | SHEET 19 OF 30 | REVISION NO. AB

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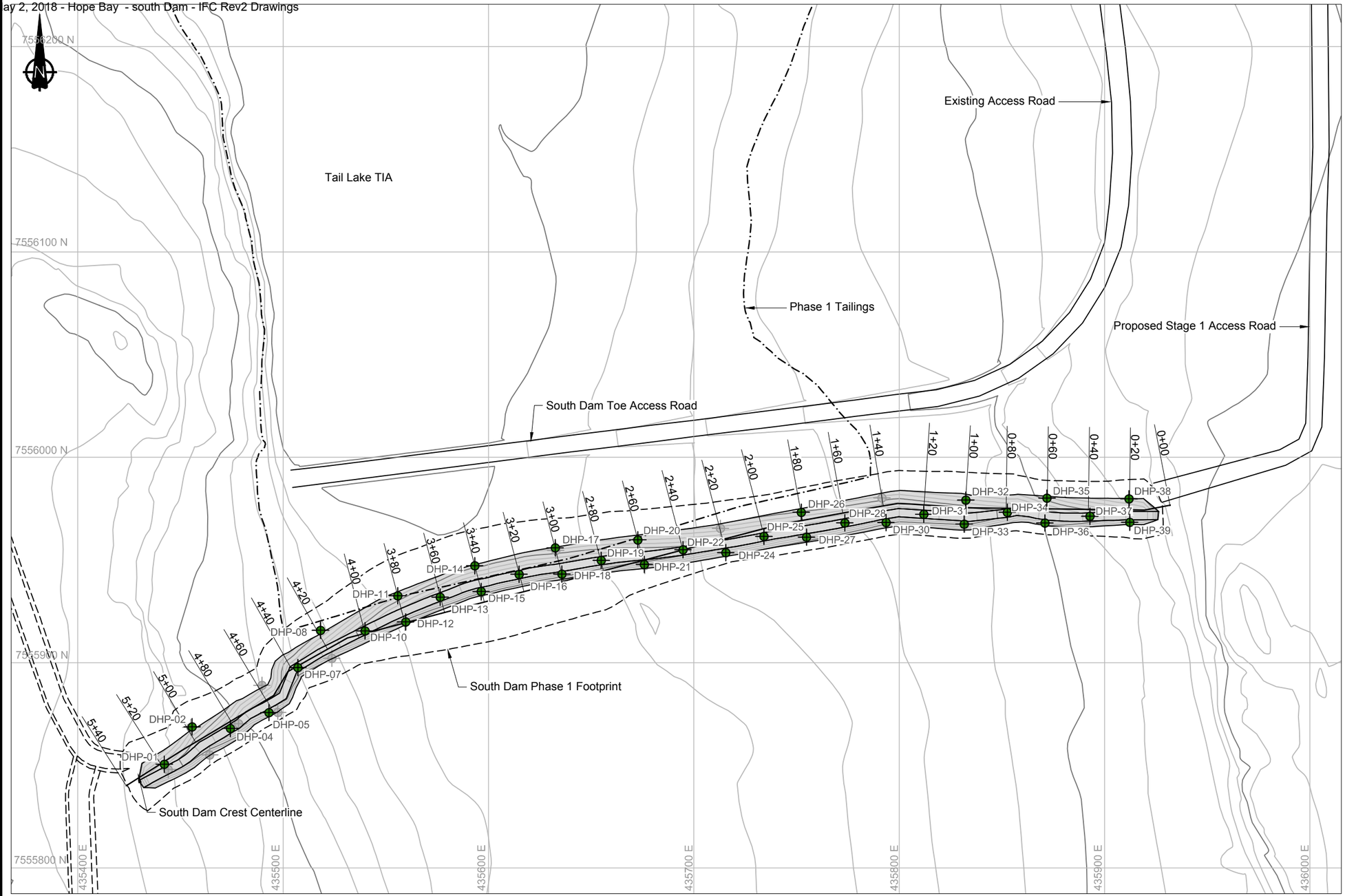

LEGEND

- Proposed Drill Hole Location
- As-Built Drill Hole Location
- Proposed Road Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Outline

NOTES

1. Contours shown at a 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. All percolation test boreholes should be a minimum 8.0m deep.
4. Percolation test boreholes should be a minimum of 4-6 inches (100-150mm) in diameter.
5. It is suggested that an air-track drill (quarry drill) be used to complete the percolation testing.
6. Once all percolation test locations are drilled the testing will be completed on site as directed by the Engineer.

REFERENCES

NAD83 UTM Zone 13.

AS-BUILT PERCOLATION BOREHOLE LOCATIONS

Point ID	Northing	Easting	Elevation
SRK18-SD-DHP1	7555850.42	435442.14	44.2
SRK18-SD-DHP2	7555868.68	435455.71	42.1
SRK18-SD-DHP4	7555867.85	435474.33	41.0
SRK18-SD-DHP5	7555875.60	435493.08	37.9
SRK18-SD-DHP7	7555897.52	435507.19	36.0
SRK18-SD-DHP8	7555915.67	435518.25	34.3
SRK18-SD-DHP10	7555915.40	435539.87	32.8
SRK18-SD-DHP11	7555932.47	435555.80	31.6
SRK18-SD-DHP12	7555919.75	435559.69	31.8
SRK18-SD-DHP13	7555931.76	435576.48	31.1
SRK18-SD-DHP14	7555947.08	435593.31	30.5
SRK18-SD-DHP15	7555934.56	435596.45	30.7
SRK18-SD-DHP16	7555942.92	435614.88	31.2
SRK18-SD-DHP17	7555955.86	435632.48	31.6
SRK18-SD-DHP18	7555943.01	435635.74	31.5
SRK18-SD-DHP19	7555949.72	435654.89	32.0
SRK18-SD-DHP20	7555959.68	435672.72	33.0
SRK18-SD-DHP21	7555947.75	435675.88	33.1
SRK18-SD-DHP22	7555954.90	435694.71	33.7
SRK18-SD-DHP24	7555953.48	435715.55	34.4
SRK18-SD-DHP25	7555961.44	435734.11	35.0
SRK18-SD-DHP26	7555973.14	435752.28	35.5
SRK18-SD-DHP27	7555961.00	435754.88	35.4
SRK18-SD-DHP28	7555967.97	435773.53	35.9
SRK18-SD-DHP30	7555968.15	435793.60	36.4
SRK18-SD-DHP31	7555972.15	435812.00	37.1
SRK18-SD-DHP32	7555979.10	435832.48	37.7
SRK18-SD-DHP33	7555967.38	435831.61	37.6
SRK18-SD-DHP34	7555973.14	435852.65	38.6
SRK18-SD-DHP35	7555980.03	435871.93	40.9
SRK18-SD-DHP36	7555967.95	435870.94	40.1
SRK18-SD-DHP37	7555971.21	435892.86	42.4
SRK18-SD-DHP38	7555979.68	435911.87	44.3
SRK18-SD-DHP39	7555968.28	435912.27	43.5

REFERENCE DRAWINGS		REVISIONS								
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-04	Key Trench Excavation Plan and Profile	--	--	--	--	--	AB	As-Built	JBK	EMR	18/04/13
							0	Issued for Construction	JBK	EMR	17/12/11

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
JBK	TAH	EMR
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT022.017 - Percolation Testing.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Percolation Borehole / Test Locations

DRAWING NO.	SHEET	REVISION NO.
DN-SD-20	20 OF 30	AB

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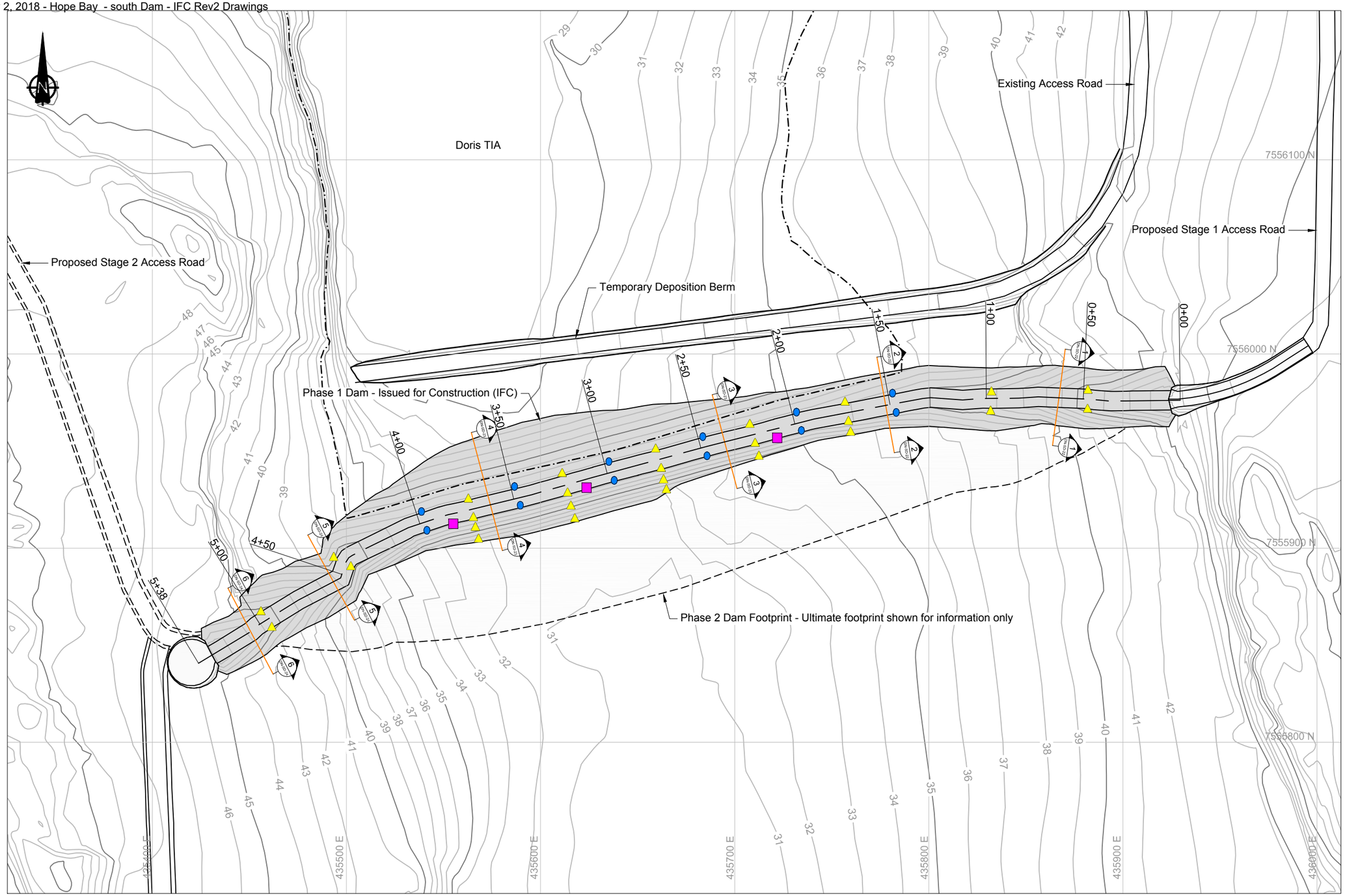

LEGEND

- Fixed Survey Monitoring Poind
- Surficial Survey Monitoring Point
- Deep Monitoring Point
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

0m 20 40 60 80

REFERENCE DRAWINGS			REVISIONS								
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/02/16

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Plan Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-21	21 OF 30	1

P:\01_SITES\Hope Bay\ACAD\IFC\South Dam - Phase 1 rl\1CT0022.017 - Instrumentation Plan.dwg

LEGEND

- Data Logger Location
- Monitoring Section
- Cable Trench
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Ground Temperature Cable backfilled cable trenches to be excavated through final dam shell - See drawings DN-SD-27, 28 and 29.

REFERENCES

NAD83 UTM Zone 13.

DATA LOGGERS

SD-DL01Reporting Cables:
- SD-VTS-065-KTC
- SD-HTS-065-US
- SD-VTS-155-KTC
- SD-HTS-155-KT
- SD-HTS-155-US
- SD-VTS-155-UST
- SD-VTS-155-DST

SD-DL02 Reporting Cables
- SD-VTS-240-KTC
- SD-VTS-240-KT
- SD-HTS-240-US
- SD-VTS-240-UST
- SD-VTS-240-DST
- SD-HST-B1-KT

SD-DL03 Reporting Cables
- SD-HTS-365-KT
- SD-VTS-365-KTC
- SD-HTS-365-US
- SD-VTS-365-UST
- SD-VTS-365-DST

SD-DL04 Reporting Cables
- SD-HTS-460-KT
- SD-VTS-460-KTC
- SD-HTS-460-US
- SD-HTS-460-UST
- SD-VTS-460-DST
- SD-VTS-510-KTC
- SD-HTS-510-US

STAKE-OUT POINTS

ID	Northing	Easting
SD-DL01	7555978.14	435776.94
SD-DL02	7555959.13	435693.79
SD-DL03	7555927.20	435572.83
SD-DL04	7555887.49	435490.36

DRAWING NO.	DRAWING TITLE
DN-SD-29	Instrumentation Details at Sta. 4+65 and 5+10
DN-SD-28	Instrumentation Details at Sta. 2+40 and 3+65
DN-SD-27	Instrumentation Details at Sta. 0+65 and 1+55
DN-SD-03	Typical Sections

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			

NO.	DESCRIPTION	CHK'D	APP'D	DATE
2	Issued for Construction	JBK	EMR	18/04/26
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	18/02/16

REVISIONS

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JBK	EMR	2018/04/26

FILE NAME: 1CT0022.017 - GTC Trenches.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:
GTC Backfilled Cable Trenches Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-22	22 OF 30	2

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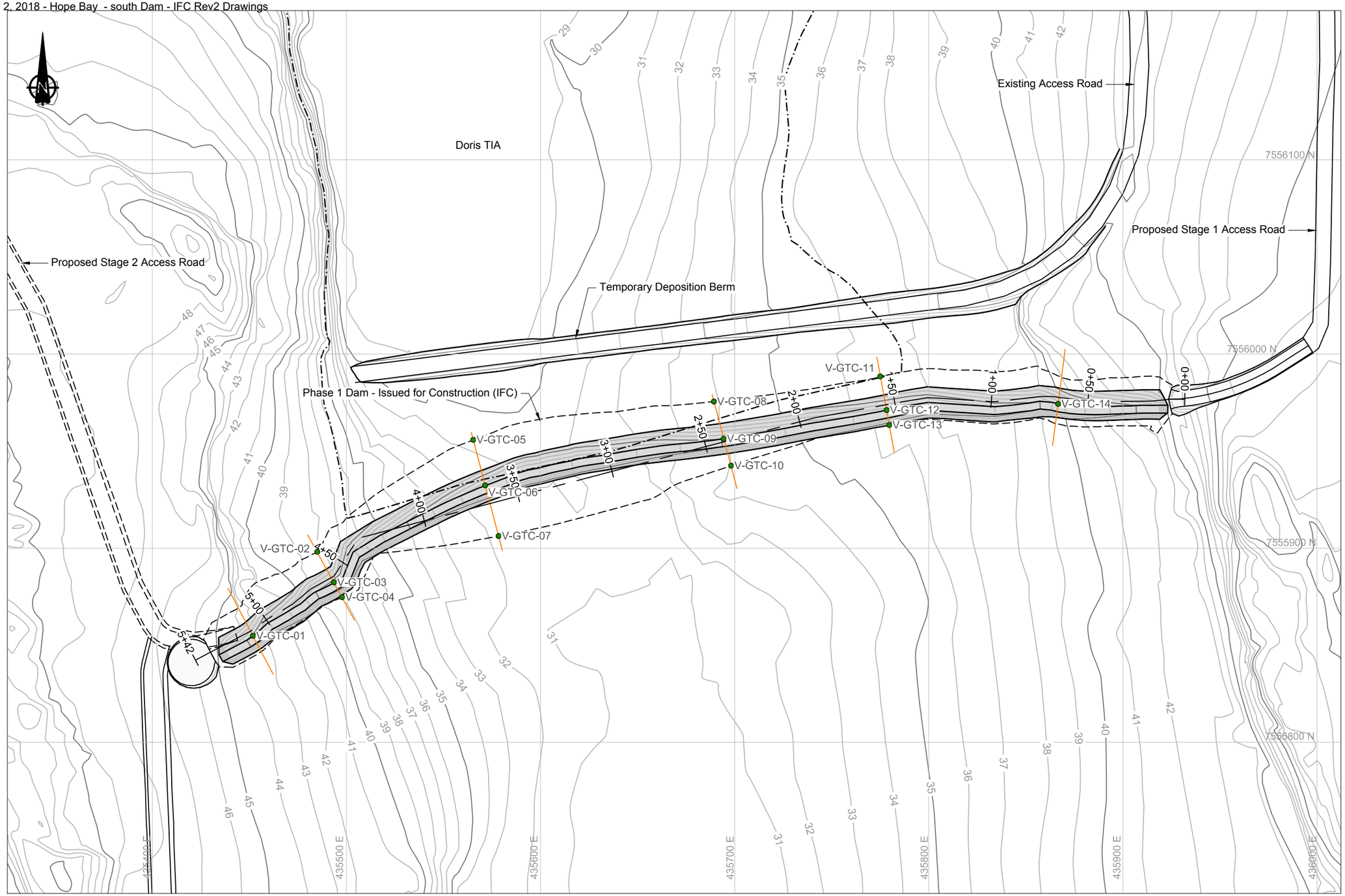

LEGEND

- Vertical Ground Temperature Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

I.D.	Northing	Easting
V-GTC-01	7555854.81	435451.79
V-GTC-02	7555898.07	435484.95
V-GTC-03	7555882.32	435493.54
V-GTC-04	7555874.72	435497.69
V-GTC-05	7555955.78	435565.30
V-GTC-06	7555932.32	435571.39
V-GTC-07	7555906.23	435578.34
V-GTC-08	7555975.51	435689.29
V-GTC-09	7555956.36	435694.32
V-GTC-10	7555942.48	435698.15
V-GTC-11	7555988.45	435775.01
V-GTC-12	7555971.08	435778.29
V-GTC-13	7555963.40	435779.65
V-GTC-14	7555974.28	435866.64

0m 20 40 60 80

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/12/15

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
DN-SD-03	Typical Sections

REVISIONS

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Vertical GTC LO.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:
Vertical GTC Layout
Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-23	23 OF 30	1

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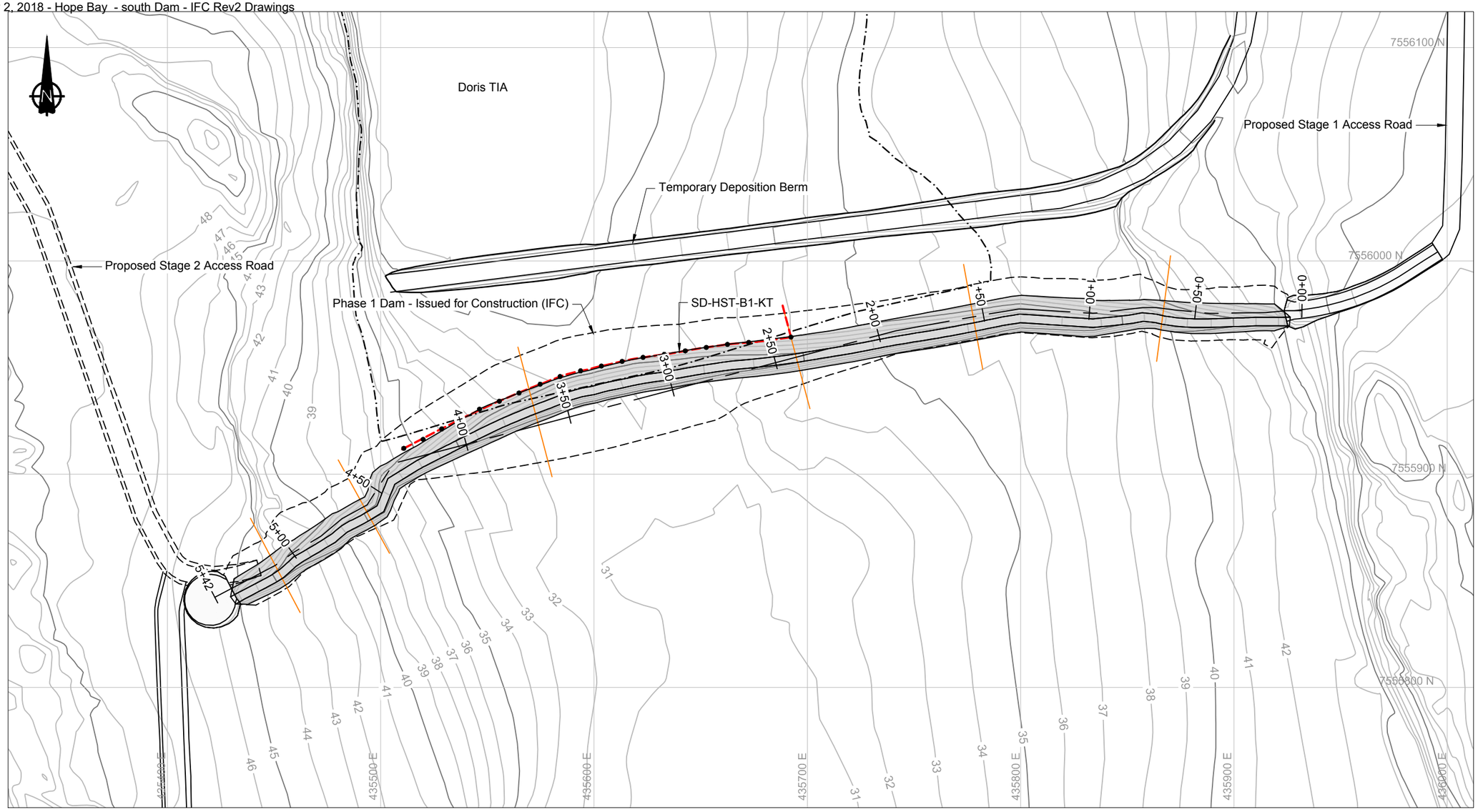

LEGEND

- Horizontal Ground Temperature Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Key Trench Footprint
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

ID	Northing	Easting
HST20098	7555964.28	435692.33
HST20099	7555962.86	435682.43
HST20100	7555961.78	435672.49
HST20101	7555960.86	435662.54
HST20102	7555959.44	435652.64
HST20103	7555957.83	435642.77
HST20104	7555956.14	435632.91
HST20105	7555954.75	435623.01
HST20106	7555952.88	435613.20
HST20107	7555950.71	435603.43
HST20108	7555948.45	435593.71
HST20109	7555945.81	435584.08
HST20110	7555942.19	435574.76
HST20111	7555938.05	435564.84
HST20112	7555934.18	435555.62
HST20113	7555930.47	435546.33
HST20114	7555925.96	435537.40
HST20115	7555921.21	435528.59
HST20116	7555916.34	435519.87
HST20117	7555912.10	435510.79

0m 20 40 60 80

Ground Temperature Cable Details - Center Base

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
1	SD-HST-B1-KT	A	Horizontal	Center	235	Top of Key Trench	20 beads spaced every 10m from the zero line on the cable, i.e. first bead at 0m										

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	18/02/15

REVISIONS

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Lower H&II GTC LO.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:
Horizontal GTC
Upstream Base / Toe of Key Trench

DRAWING NO.	SHEET	REVISION NO.
DN-SD-24	24 OF 30	1

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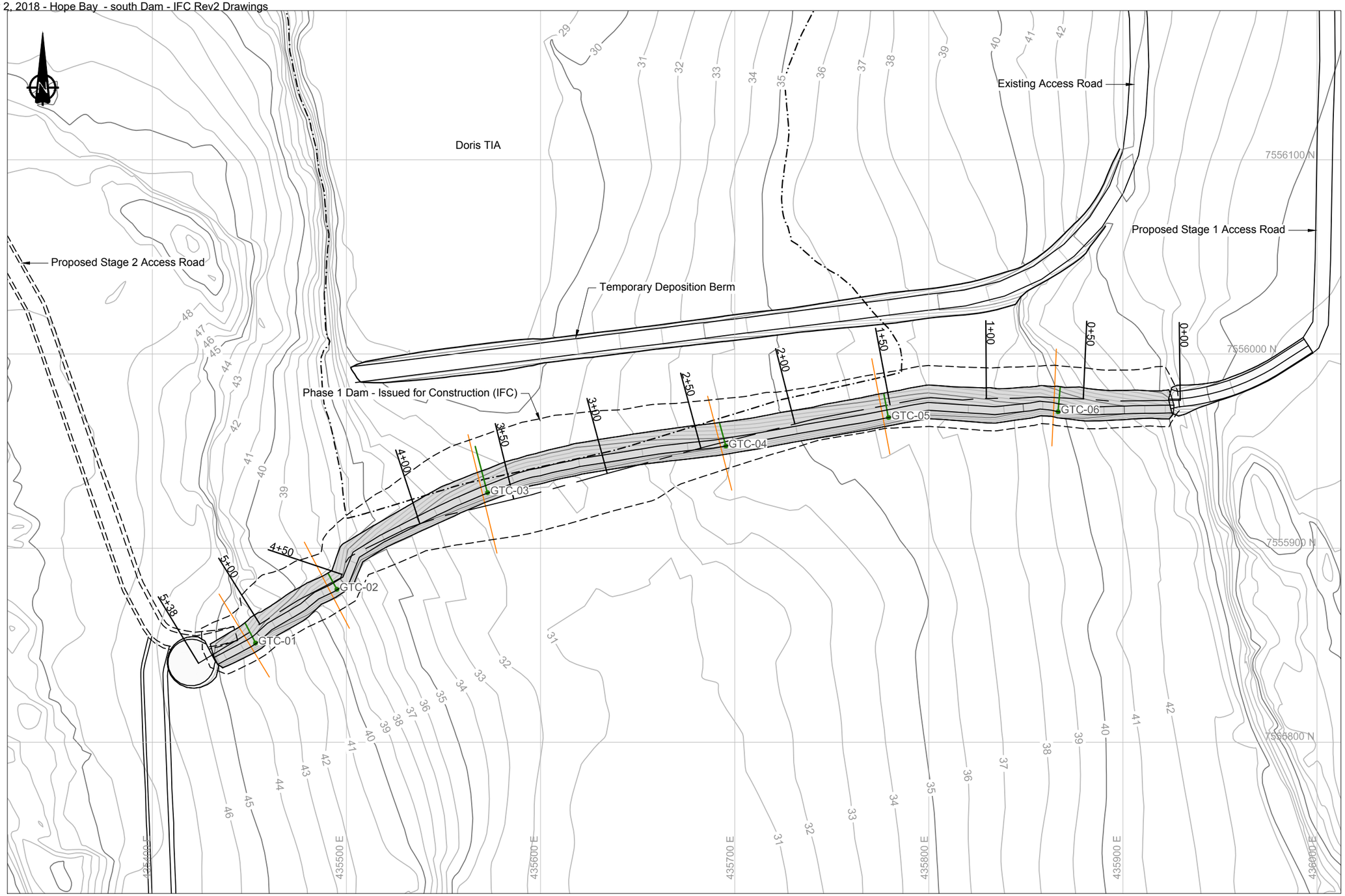

LEGEND

- Leak Detection Instrumentation
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

I.D.	Northing	Easting
GTC-01	7555851	435453
GTC-02	7555879	435495
GTC-03	7555929	435573
GTC-04	7555953	435695
GTC-05	7555937	435779
GTC-06	7555970	435867

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	17/12/11

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Leak Detection.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

GTC Layout Along Upstream Slope of Key Trench

DRAWING NO.	SHEET	REVISION NO.
DN-SD-25	25 OF 30	1

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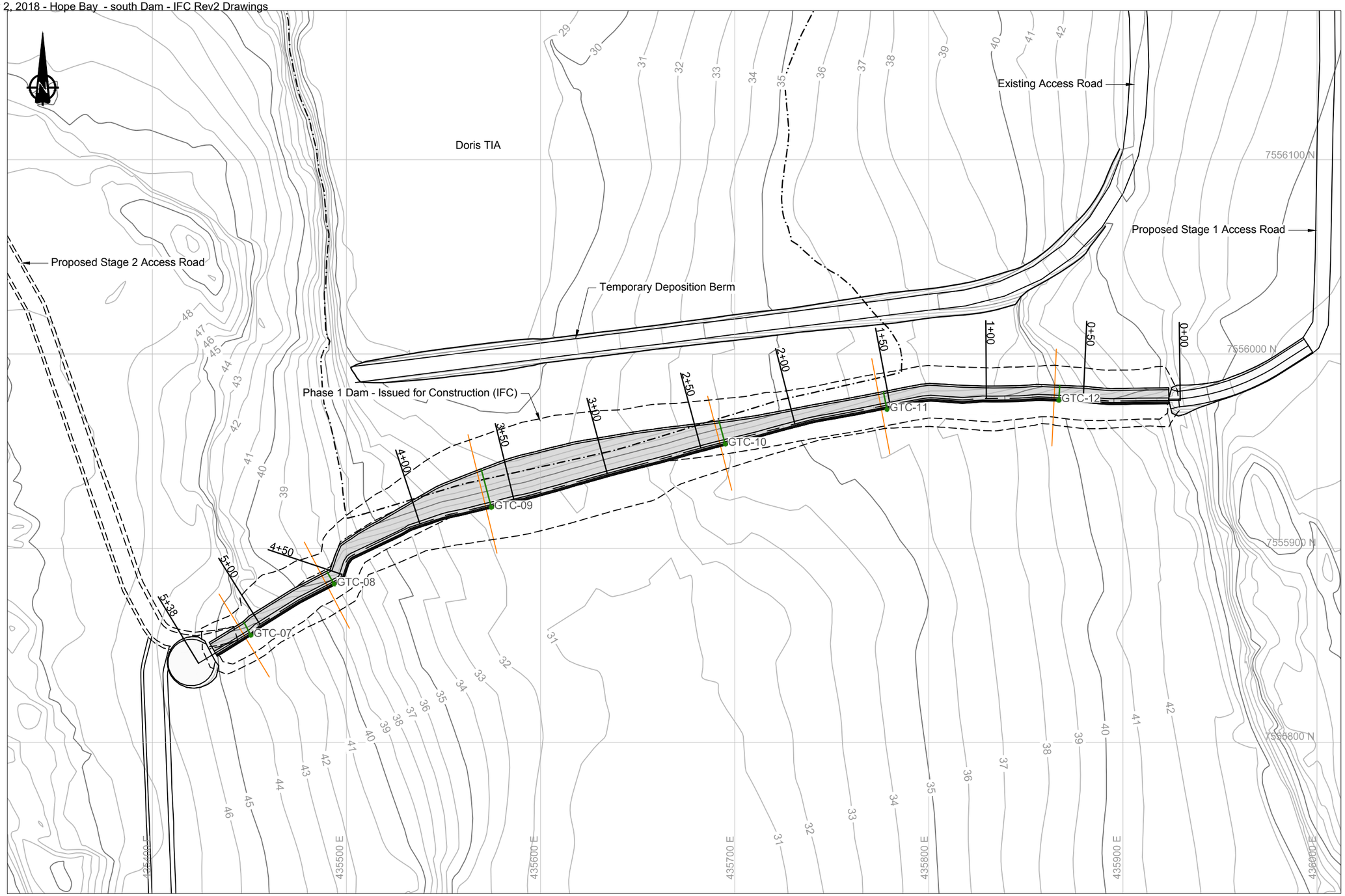

0m 20 40 60 80

LEGEND

- Ground Temperature Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

STAKE-OUT POINTS

I.D.	Northing	Easting
GTC-07	7555855	435451
GTC-08	7555882	435494
GTC-09	7555921	435575
GTC-10	7555954	435695
GTC-11	7555972	435778
GTC-12	7555976	435867

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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							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	17/12/11

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Liner GTC.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:
GTC Layout Along Upstream Above Ground Liner Slope

DRAWING NO.	SHEET	REVISION NO.
DN-SD-26	26 OF 30	1

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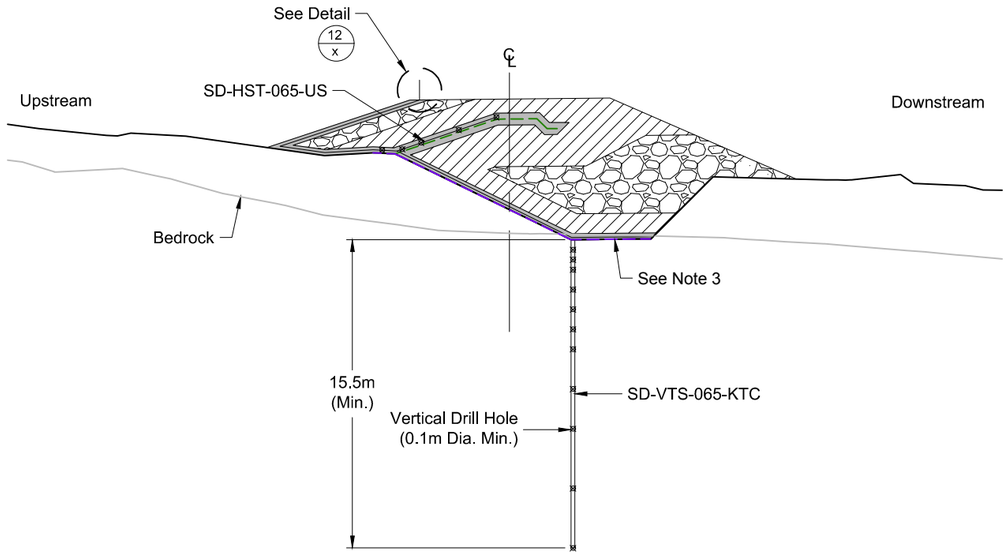
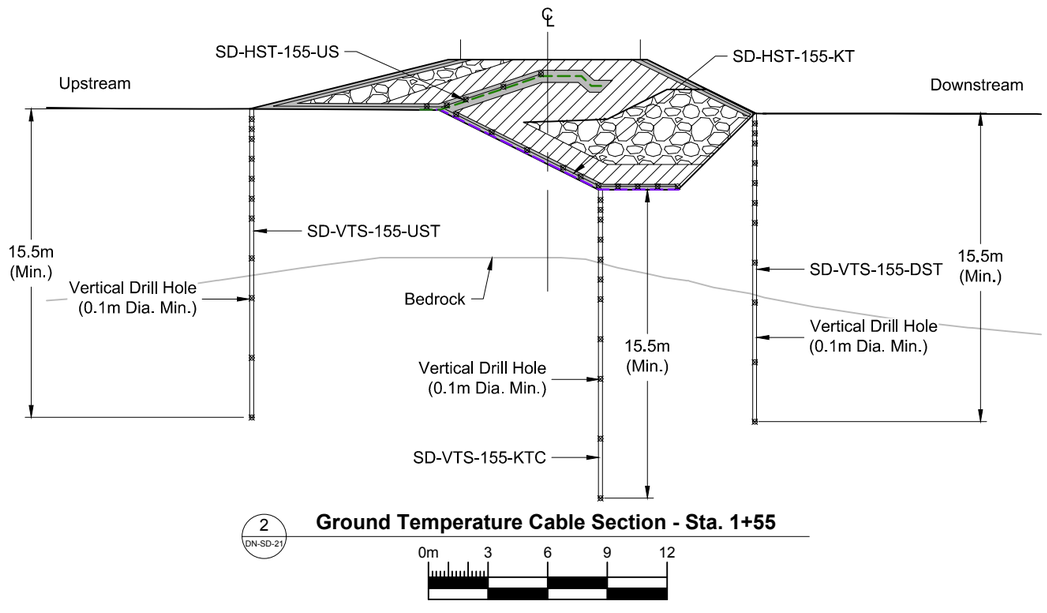


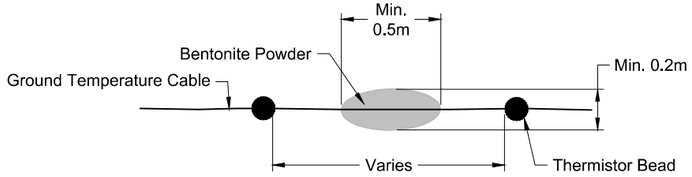
1 DN-SD-21 **Ground Temperature Cable Section - Sta. 0+65**

0m 3 6 9 12



2 DN-SD-21 **Ground Temperature Cable Section - Sta. 1+55**

0m 3 6 9 12



Detail 12 - Typical Water Stop Detail

0m 0.3 0.6 0.9 1.2

LEGEND

- Thermistor Bead Location
- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. Vertical cable boreholes to be filled with grout or backfilled with finer (sand size) material.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

Ground Temperature Cable Details - Monitoring Section 0+65 and 1+55

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
2	SD-VTS-65-KTC	A	Vertical	0+65	42	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
3	SD-HTS-065-US	B	Horizontal & Inclined	0+65	121	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
4	SD-VTS-155-KTC	A	Vertical	1+55	50	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
5	SD-VTS-155-UST	A	Vertical	1+55	41	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
6	SD-VTS-155-DST	A	Vertical	1+55	53	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
7	SD-HTS-155-US	B	Horizontal & Inclined	1+55	41	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
8	SD-HTS-155-KT	C	Horizontal & Inclined	1+55	39	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13
9	SD-HST-B1-KT	C	Horizontal	Center Base	235	Center Base	20 beads spaced every 10m from the zero line on the cable i.e. first bead at 0m										
10	Extension for SD-VTS-065-KTC	D	Vertical	0+65	90		Extension for existing cable. No beads needed.										

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	JBK	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

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FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Details at Sta. 0+65 and 1+55

DRAWING NO. DN-SD-27 | SHEET 27 OF 30 | REVISION NO. 1

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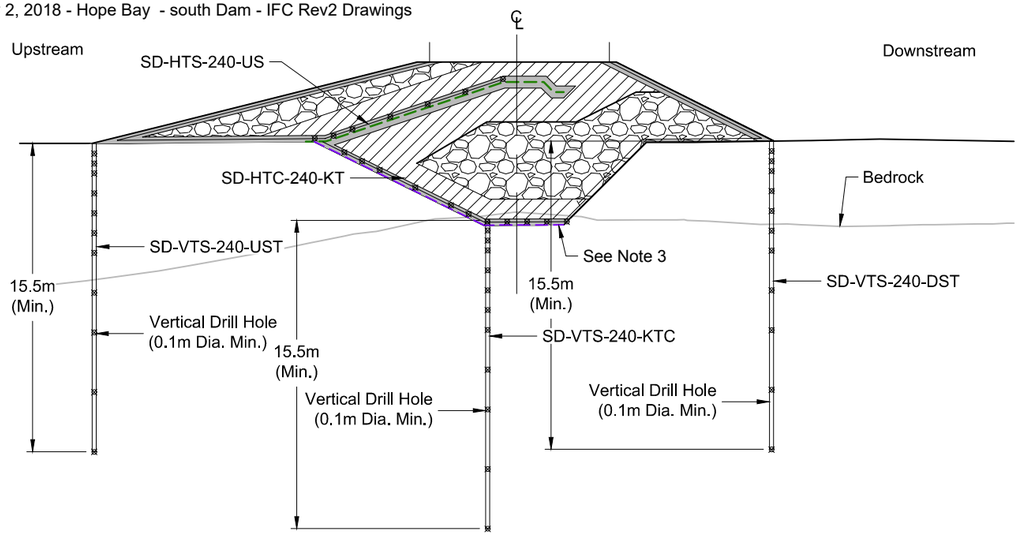
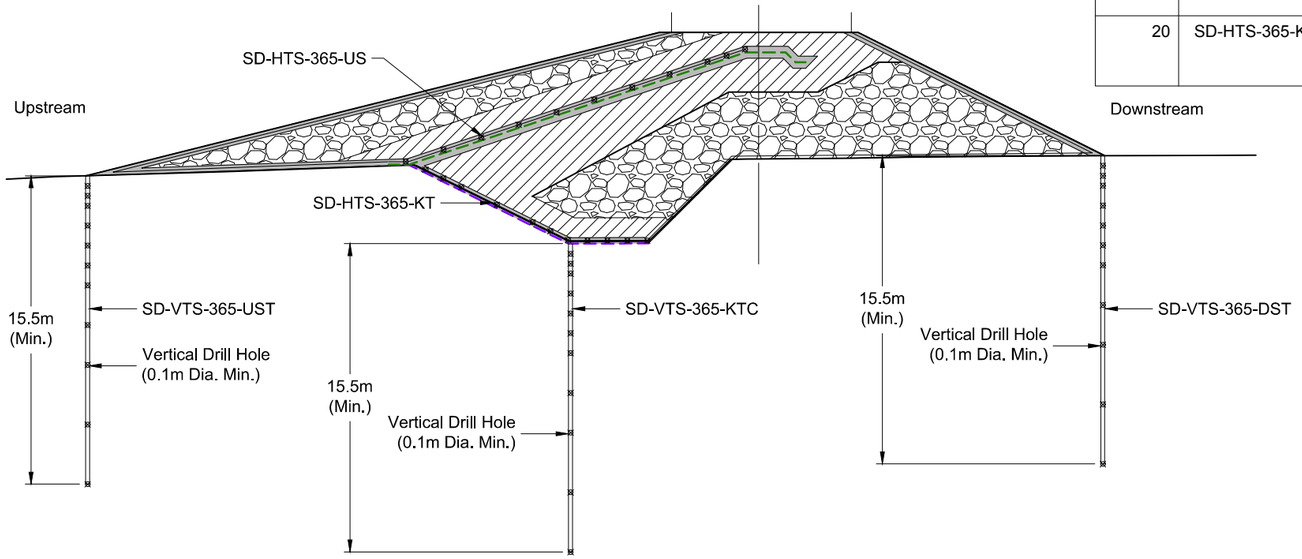


3 DN-SD-21

Ground Temperature Cable Section - Sta. 2+40

0m 3 6 9 12



4 DN-SD-21

Ground Temperature Cable Section - Sta. 3+65

0m 3 6 9 12

Ground Temperature Cable Details - Monitoring Section 2+40 and 3+65

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
11	SD-VTS-240-KTC	A	Vertical	2+40	58	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
12	SD-VTS-240-UST	A	Vertical	2+40	46	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
13	SD-VTS-240-DST	A	Vertical	2+40	53	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
14	SD-HTS-240-US	B	Horizontal & Inclined	2+40	50	Upstream Slope	0	2	4	6	8	9	10	-	-	-	-
15	SK-HTC-240-KT	B	Horizontal & Inclined	2+40	48	Upstream Slope	0	1	3	5	7	8	9	10	11	12	13
16	SD-VTS-365-KTC	A	Vertical	3+65	75	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
17	SD-VTS-365-UST	A	Vertical	3+65	57	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
18	SD-VTS-365-DST	A	Vertical	3+65	58	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
19	SD-HTS-365-US	B	Horizontal & Inclined	3+65	76	Upstream Slope	0	2	4	6	8	10	12	14	15	17	18
20	SD-HTS-365-KT	C	Horizontal & Inclined	3+65	65	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13

LEGEND

- Thermistor Bead Location
- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

REFERENCE DRAWINGS | REVISIONS

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DESIGN: CH | DRAWN: TAH | REVIEWED: JBK | CHECKED: JBK | APPROVED: EMR | DATE: 2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Details at Sta. 2+40 and 3+65

DRAWING NO. DN-SD-28 | SHEET 28 OF 30 | REVISION NO. 1

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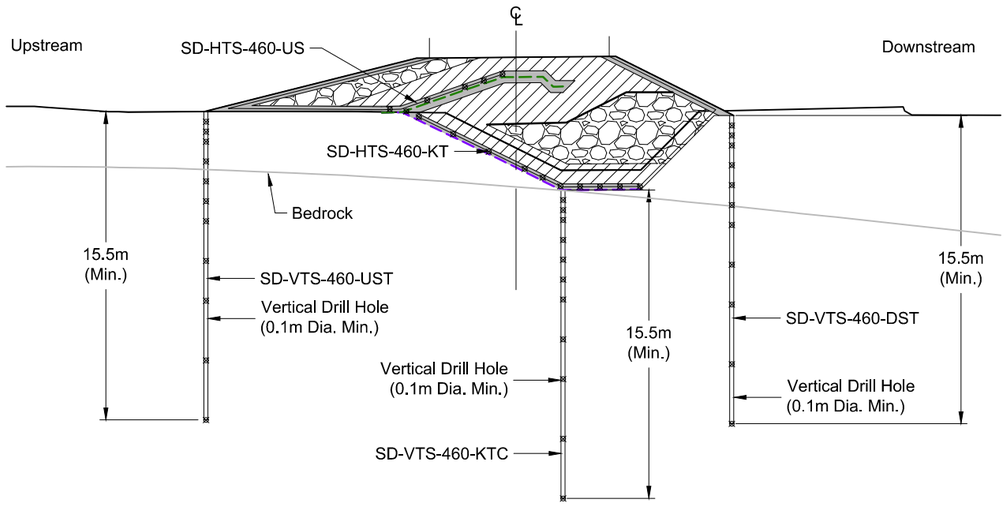
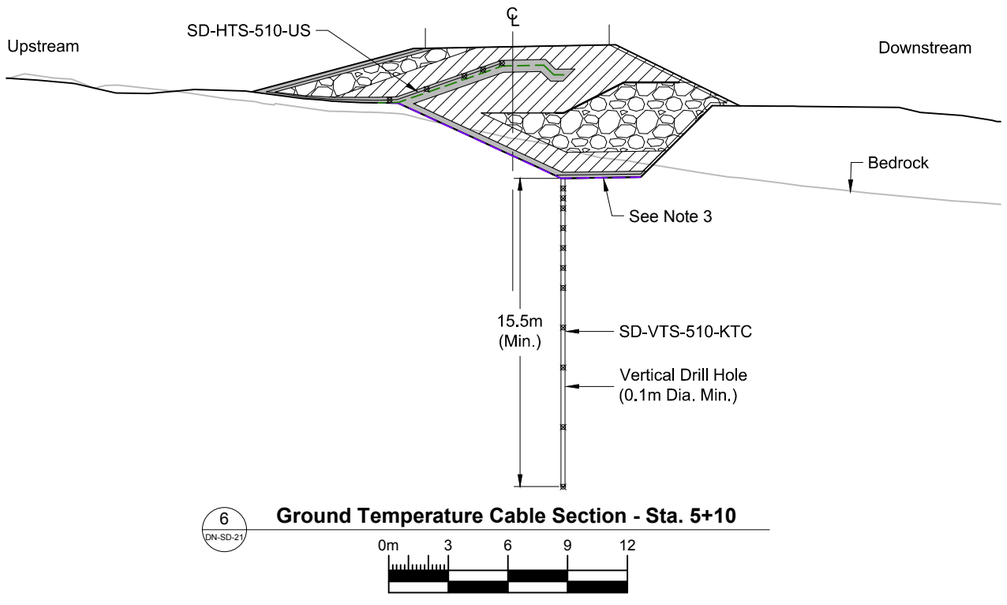


5 DN-SD-21 **Ground Temperature Cable Section - Sta. 4+60**



6 DN-SD-21 **Ground Temperature Cable Section - Sta. 5+10**

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

Ground Temperature Cable Details - Monitoring Section 4+60 and 5+10

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
21	SD-VTS-460-KTC	A	Vertical	4+60	50	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
22	SD-VTS-460-UST	A	Vertical	4+60	41	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
23	SD-VTS-460-DST	A	Vertical	4+60	58	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
24	SD-HTS-460-US	B	Horizontal & Inclined	4+60	41	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
25	SD-HTS-460-KT	C	Horizontal & Inclined	4+60	39	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13
26	SD-VTS-510-KTC	A	Vertical	5+10	48	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
27	SD-HTS-510-US	B	Horizontal & Inclined	5+10	86	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
28	Extension for SD-VTS-510-KTC	D	Vertical	5+10	90		Extension for existing cable. No beads needed.										

REFERENCE DRAWINGS			REVISIONS								
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

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CHECKED: JBK | APPROVED: EMR | DATE: 2018/04/13
FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Details at Sta. 4+65 and 5+10

DRAWING NO. DN-SD-29 | SHEET 29 OF 30 | REVISION NO. 1

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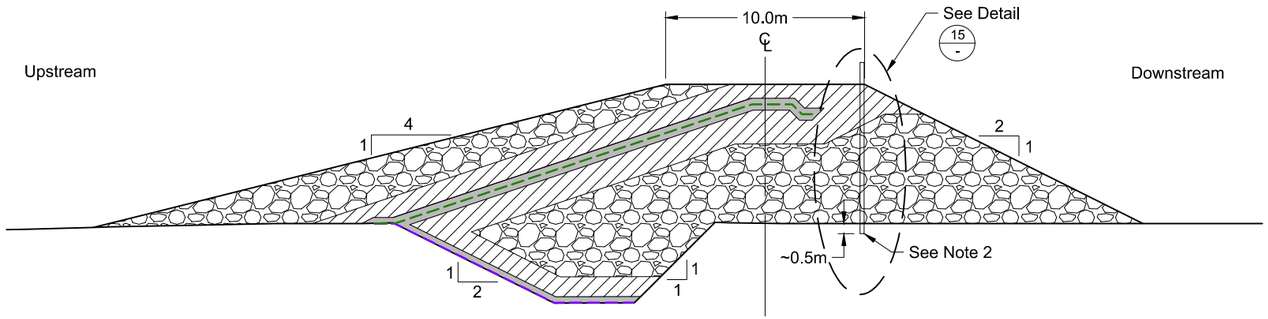
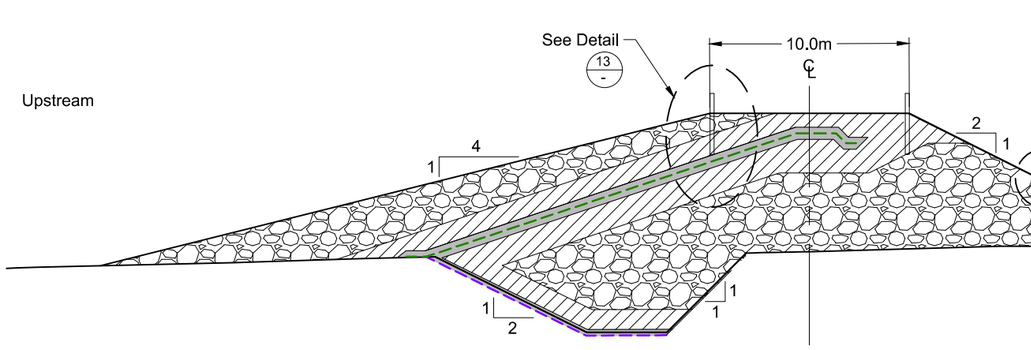


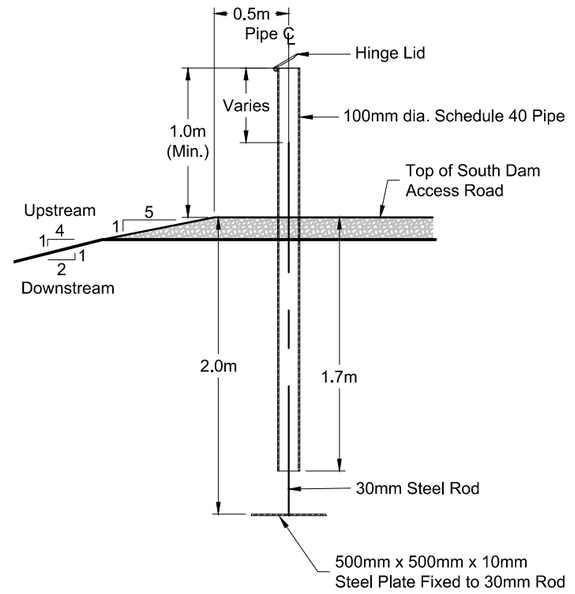
Surficial Survey Point - Sta. 3+15

0m 3 6 9 12



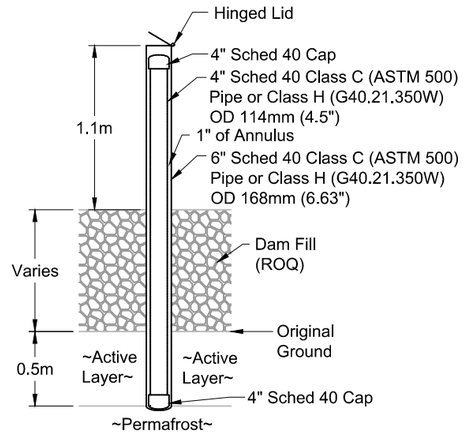
Deep Settlement Point - Sta. 3+50

0m 3 6 9 12



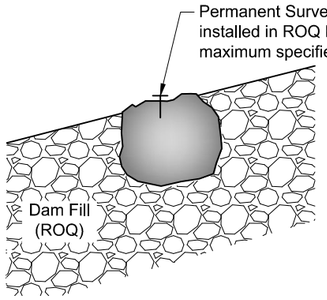
Detail 13 - Survey Monitoring Point Detail

0m 0.25 0.5 0.75 1.0



Detail 15 - Deep Settlement Point Installation

0m 0.25 0.5 0.75 1.0



Detail 14 - Surficial Survey Point Installation

0m 0.25 0.5 0.75 1.0

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. Deep settlement point installation depth to be directed by the field Engineer. Aim is to be near the active layer - permafrost contact.

DRAWING NO.	DRAWING TITLE
DN-SD-21	Instrumentation Plan - Phase 1
DN-SD-03	Typical Sections

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
0	Issued for Construction	JBK	EMR	18/04/13

REVISIONS

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JBK	EMR	2018/04/13

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Typical Monitoring Point Details

DRAWING NO.	SHEET	REVISION NO.
DN-SD-30	30 OF 30	1

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Seema Kang

From: Cameron Hore
Sent: Thursday, May 3, 2018 11:07 PM
To: Kendell Cator; John Kurylo
Cc: Ryan Williams; Kyle Scale; Kaitlyn Kooy; NA 1CT022.031 HopeBay
Subject: Re: Long Horizontal Thermistor Cable Install (SD-HST-B1-KT)

Hi guys,

Option 2 makes sense to me. Good thoughts.

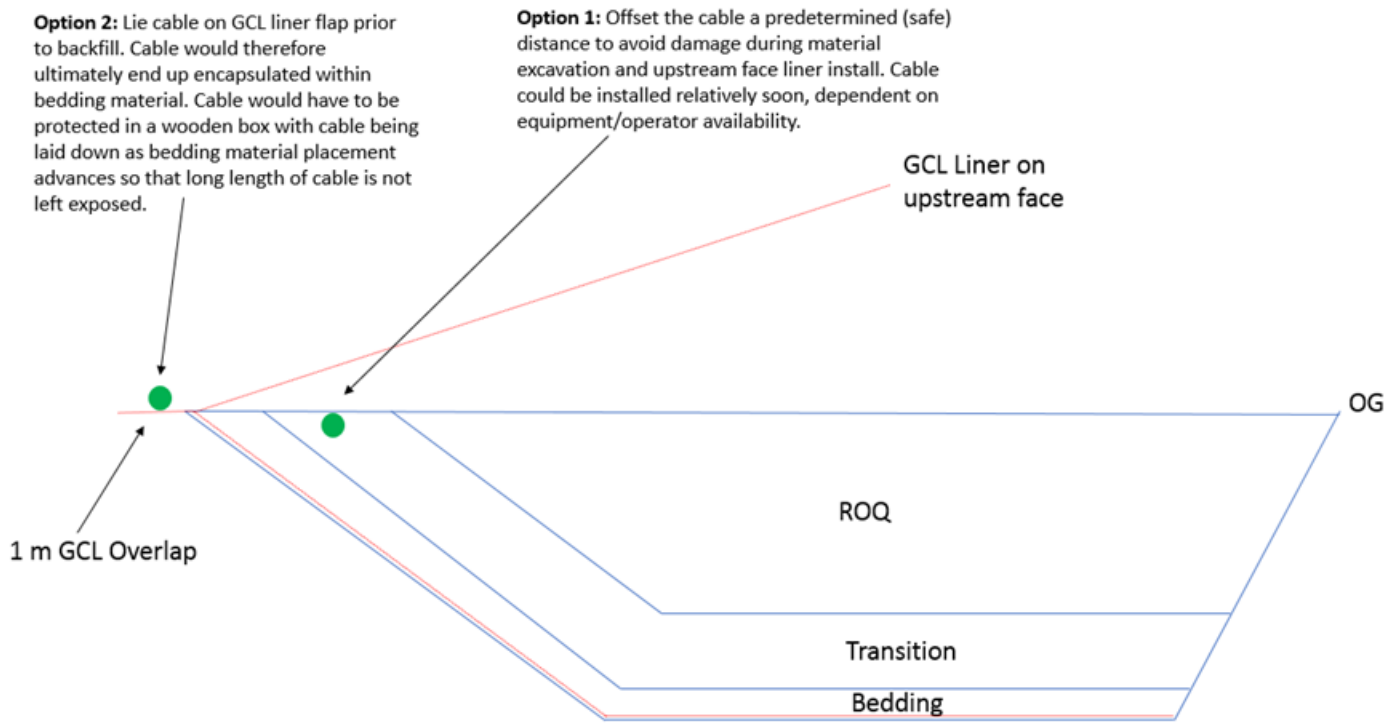
Cheers

Cam

From: Kendell Cator
Sent: Thursday, May 3, 2018 9:59 PM
To: John Kurylo
Cc: Ryan Williams; Kyle Scale; Kaitlyn Kooy; NA 1CT022.031 HopeBay
Subject: Long Horizontal Thermistor Cable Install (SD-HST-B1-KT)

Hey John,

Ryan and I were discussing the installation of the long (190m) thermistor cable that was supposed to be installed near the upstream toe within the key trench base. Ryan mentioned that you had suggested installing it instead along the upstream crest? Today Ryan and I took a look at options in the field and due to the logistics of having to pull material back and expose the 1m of GCL at the crest, installing the cable in this area now could lead to difficulty and cable damage in the near future. We discussed the option of offsetting the cable slightly (to the south) and digging a shallow trench within the transition material in the key trench - however this would be a significant amount of work and would require equipment assistance (most likely the 308 excavator) in order to dig a deep enough trench that the cable is adequately protected. The idea Ryan and I came up with was to potentially install the cable along the horizontal lying GCL flap (1m) after the GCL on the upstream face has been installed and before being backfilled with bedding material. The cable would therefore end up being ran very near to the upstream crest between stations 2+45 and 4+25 (original stations planned for this cable). This idea is depicted in the sketch below. If this plan was to be initiated, the cable would not be installed for some time as there is a lot of material placement required prior to installation of the GCL on the upstream face. The other option, however, could potentially be initiated relatively soon.



Thanks,

Kendell

Kendell Cator *EIT.*
Consultant (Geotechnical Engineering)
srk consulting
SRK Consulting (Canada) Inc.
Suite 205, 2100 Airport Drive, Saskatoon, Saskatchewan, S7L 6M6, Canada
Direct: +1-306-955-4773; **Mobile**:+ 1-306-587-7757
Email: kcator@srk.com
www.srk.com

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Seema Kang

From: Kendell Cator
Sent: Thursday, May 10, 2018 11:07 AM
To: Eric Blomberg
Cc: John Kurylo; Cameron Hore
Subject: RE: South Dam Material Shortages

Patrick/BBG:

Upon review of the material quantities, SRK agrees with the requirement of 45 rolls for completion of the above ground GCL liner based on:

- Roll dimensions of 4.6m x 45.7 m = 210 m2 per roll
- 6,810 m2 (estimated above ground area) plus 20% contingency = 8,172 m2
- 8,172 m2 / 210 m2 = 39 rolls. Increased to 45 rolls as the condition of the hinge point liner is not yet known and may require sacrificial liner for repair:
    - 6 additional rolls = 210 m2 x 6 = 1,260m2
    - Worst case scenario 2m of sacrificial liner is required along the hinge point (1m above and 1m below) = 530m x 2 m = 1,060 m2.

Based on the assumption that all 21 rolls remaining on site are ok for use, an additional 24 rolls should be transported to site.

Patrick, when you get a chance in the next day or two it would be great to lift a few of the rolls up in the batch plant, unroll a few meters, and make a fresh cut in order to better inspect the presence of bentonite hydration in the 21 rolls on site. During liner installation in the key trench, Kaitlyn noted that it was quite hard to tell the degree of hydration from the outside and was often not fully understood until a fresh cut was made part way into the roll. The level of hydration, if present, will determine if/where the rolls can be used.

My estimation of bentonite required also corresponds with yours and came out to 3825 kg based on:

- Linear seam length = 45.7 m x 45 rolls = 2056.5 m
- Application rate on a 5mmx100mm (linear) seam = 0.52 kg/m
- Horizontal upstream crest seam length = 530m
- Application rate on a 10mmx500mm (horizontal upstream crest) seam = 5.2 kg/m

Let me know if you have any questions.

Thanks,

Kendell

From: Eric Blomberg [mailto:eric@blombergbuilding.com]
Sent: Tuesday, May 08, 2018 4:44 PM
To: Kendell Cator <kcator@srk.com>
Subject: South Dam Material Shortages

Hi Kendell,

I did some calculations for the additional materials required for the dam and I was hoping you could check my numbers before we get TMac to order more in by plane. I estimated that we would need 45 rolls total for the rest of phase 1 and 3800 kg of bentonite. Most of the bentonite is for the seam which you already calculated for us at 5.2 kg/m. It is the GCL estimate which I am more concerned with as we often had an overlap of slightly more than 500mm and there are turns in the dam which result in greater overlap as well.

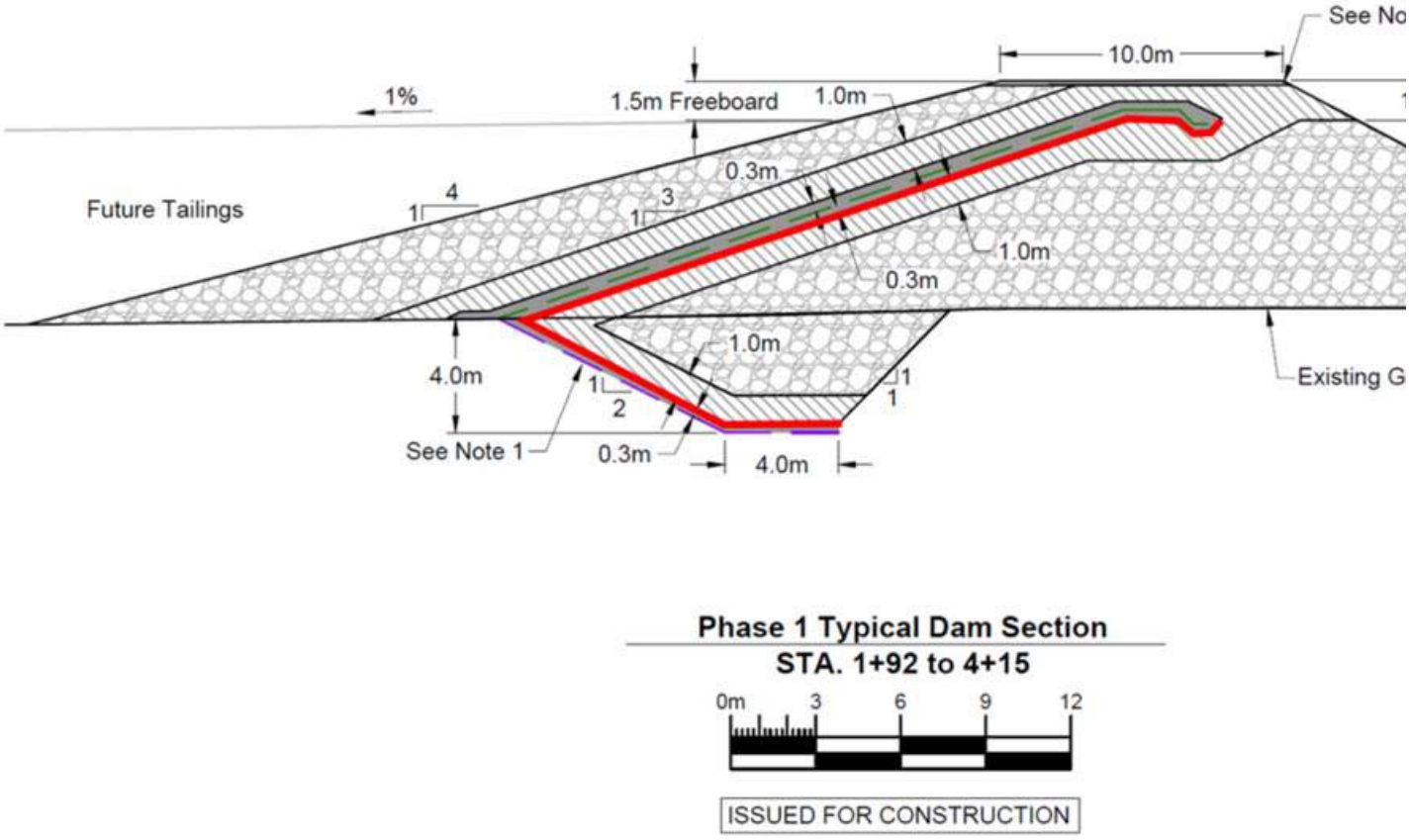
Eric Blomberg
Director
Blomberg Building Group
W:867-988-6882 ext. 134
C:604-841 9858
H:604-947 0110

Seema Kang

From: John Kurylo
Sent: Monday, May 14, 2018 7:16 PM
To: Mark Doucette
Cc: Kaitlyn Kooy; Kendell Cator; Kyle Scale; Ryan Williams; jakec@sub-arctic.ca; Cameron Hore; NA 1CT022.031 HopeBay
Subject: RE: Dam Surfaces Issues - CORRECTED
Attachments: 180514 - DS Bedding.dxf; 180514 - DS Bedding.xml; 180409 - DamTransition.xml; Chainage Check_SouthDam.dwg

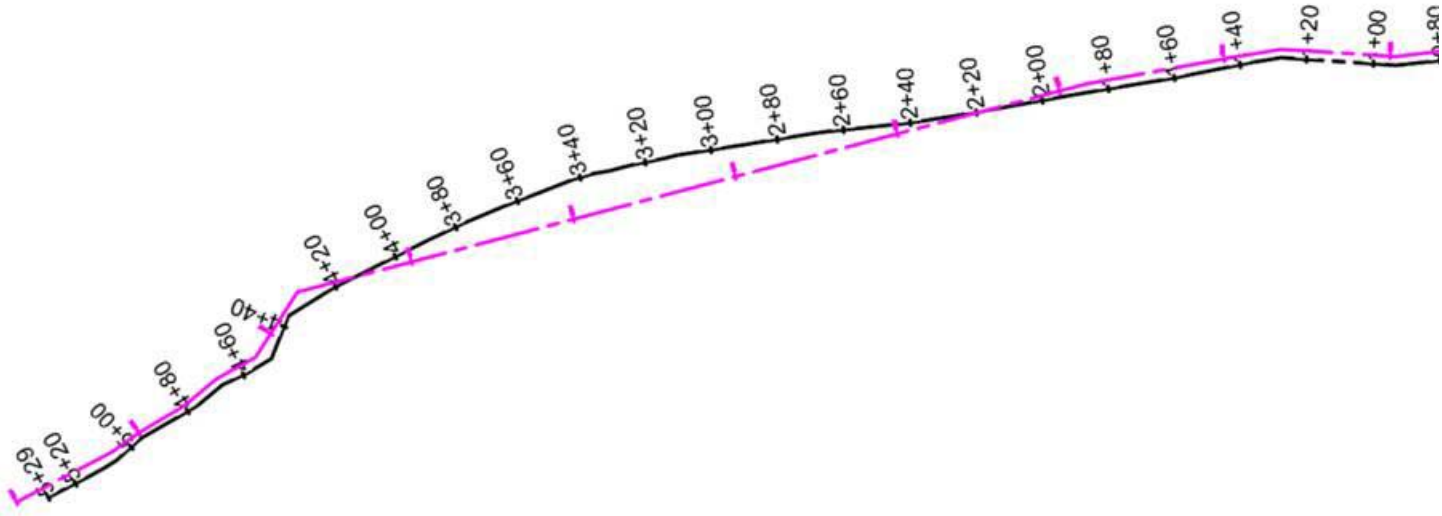
Hi Mark

Upon closer inspection, you are correct that the model surfaces are crossing at 4+60 and 4+70 with the downstream liner bedding. I'm not quite sure what happened here, as the issue looks to be isolated to that location. It look like the issue is just with the *downstream bedding toe*. The downstream bedding toe should be in line with the design lines of the bedding that is in the key trench i.e. red line in the screenshot below:



I believe that the rest of the thickness differences is mainly due to the fact that we were tying in a curvy upper surface with an equally curvy lower surface. We're trying to cut a section perpendicular though it all but the alignment of the sections you cut may be slightly different than the sections the dam was designed. If the sections are exactly perpendicular, then section appear to show this slightly off. Not sure if you used the key trench alignment or the centerline alignment but the attached CAD files has both alignments and shows the difference between these two i.e

black line below is the key trench alignment and the magenta line is the crest alignment (slightly different in the central area where the thickness of the dam dill is greater).



For the below liner bedding having thicknesses as low as 0.25m is ok (0.3m outlined on the drawings and should be the target but ok if +- 5cm for this). Similar for the Transition material (specifically near the bends in the alignment) having minimum thickness of 1m is required but having some areas thicker (say up to 1.25 or even up to 1.5m) is ok. When in doubt if you just use the ROQ surface and then offset it 1m that should be close enough to the outside of the transition surface. Then we can just take the as-built for the transition and just smooth it if / as necessary before we place the bedding material. The final Phase 1 top elevation of the liner needs to be at least 37m or higher (CANNOT be lower than this elevation in any area). The side flanks / abutments the liner elevation will be higher than this elevation (as they are more for Phase 2) so it is less critical to be exact once we are above the 37m elevation (as this is the top of liner elevation required for the Phase 1 dam and we will raise this liner again above this once we get to Phase 2).

Attached to this email is an updated above ground lower bedding surface (i.e. below the liner). This surface should fix the surface crossing that was noted. You can use this to help guide the survey layouts. If you have any questions on any of this or if you require any clarity then please let me know.

Kind Regards,
John

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

From: Mark Doucette [mailto:markd@sub-arctic.ca]
Sent: Sunday, May 13, 2018 12:05
To: John Kurylo <jkurylo@srk.com>
Cc: Kaitlyn Kooy <kkooy@srk.com>; Kendell Cator <kcator@srk.com>; Kyle Scale <kscale@srk.com>; Ryan Williams <rwilliams@srk.com>; jakec@sub-arctic.ca
Subject: RE: Dam Surfaces Issues

John,

We've started placing transition on the upstream slope of the ROQ. On the slopes we can use a .5m offset for the first lift, but without a design for the final lift of transition we're not quite sure where the toe and crest will be. The toe is key to the tie in with existing liner so a design surface is needed. The location of the crest is important too assuming the 2m of liner across the top, from crest to key in (see detail 4 on drawing DN-SD-06), is needed.
I'm wondering if there has been any progress on this front.

Mark Doucette
Geomatics Technologist
Sub-Arctic Geomatics Ltd.
a CHALLENGER GEOMATICS LTD. company
226 Utsingi Drive | Yellowknife, NT | X1A 0E7
O 867-873-2047 | F 867-873-9079
markd@sub-arctic.ca
www.sub-arctic.ca

From: John Kurylo [mailto:jkurylo@srk.com]
Sent: May-09-18 3:54 PM
To: Mark Doucette
Cc: Kaitlyn Kooy; Kendell Cator; Kyle Scale; Ryan Williams
Subject: RE: Dam Surfaces Issues

Hi Mark,

Sorry for the delay in answering this note. I am looking into this now. Hope to be able to report back in the next day or so on this. Looks like an error in our surfaces that we need to fix. The ROQ surface you have should be good to go. Just need to sort out the areas for the bedding and liner that you pointed out. Thanks for the note and the CAD file with all the sections.

John

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

From: Mark Doucette [mailto:markd@sub-arctic.ca]
Sent: Tuesday, May 8, 2018 07:34
To: John Kurylo <jkurylo@srk.com>
Cc: Kaitlyn Kooy <kkooy@srk.com>; Kendell Cator <kcator@srk.com>; Kyle Scale <kscale@srk.com>; Ryan Williams <rwilliams@srk.com>
Subject: Dam Surfaces Issues

John,

I've had a close look at the surfaces you provided on April 18th. Some of the thicknesses of the lifts in the surfaces don't really match what is called for in the drawings. In some cases the surfaces actually cross.

I've attached a .dwg of the sections I made and highlighted the stations with obvious problems. I put some dimensions on a few to show what I am seeing.
The main concern is the crossing surfaces. I noticed the transition material of the dam that is under the liner is shown in the drawings to be 1m thick, but in the sections it is closer to 1.25m. The bedding on top of the liner is supposed to be 0.3m but in most spots I checked it is more like 0.25m or so.

Thanks,

Mark Doucette
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Seema Kang

From: Cameron Hore
Sent: Tuesday, May 15, 2018 11:08 PM
To: Kelly Schwenning
Cc: Maritz Rykaart; John Kurylo; NA 1CT022.031 HopeBay; Roland Jones; Murray Weddell; rodt@nunalogistics.com
Subject: South Dam Foundation Contingency Plan
Attachments: 1CT022.031_South Dam Contingency Measures Memo_20180515.pdf

Hi Kelly,

As discussed earlier today please see attached memo and drawings describing the reasoning and plan for the South Dam foundation contingency plan. This is as described earlier, no changes made since talking to Rolly and Rod.

Plan is to action this by the end of the week.

Cheers

Cameron Hore *CPEng P.Eng*
Senior Consultant (Geotechnical Engineering)
srk consulting
SRK Consulting (Canada) Inc.
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Memo

To:	Kelly Schwenning, TMAC Resources	**Client:**	TMAC Resources Inc.
From:	Cameron Hore, PEng	**Project No:**	1CT022.030
Reviewed By	Maritz Rykaart, PEng	**Date:**	May 15, 2018
Subject:	South Dam Foundation Contingency Mitigation Measures		

1 Introduction

The South Dam, as part of the Doris Tailings Impoundment Area (TIA) at Hope Bay, is currently under construction. SRK Consulting (Canada) Inc. undertook the design and prepared the issue for construction (IFC) drawings (SRK 2018) for the South Dam and has been retained by TMAC Resources Inc. (TMAC) to provide construction supervision and quality assurance.

Delays to the dam construction and installation of the Roberts Bay Discharge Systems (RBDS) has resulted in the potential risk of ponded water against the upstream face of the South Dam following freshet leading to the potential development of a high flow seepage pathway through the dam foundation. The South Dam is designed as a frozen foundation dam with the intent to continuously develop a tailings beach along the upstream face to limit water and heat transfer to the foundation.

To prevent this, ponded water must be kept off the area immediately upstream of the South Dam. The delay in the South Dam construction means that tailings deposition as per the original design may not be achievable prior to freshet. The delay in installation of the RBDS means that the active reduction in water level by discharge, to avoid ponding in this area will not be achievable. As such, additional measures are required to be taken to prevent ponded water within this area.

This memo presents an implementation plan for contingency measures to overcome this potential risk. This memo is not intended to provide a comprehensive analysis of the potential risks, nor be a reference document for the investigative work undertaken. Additional documentation on the identified conditions and analyses will be provided under separate cover as part of the as-built documentation.

Attached to this memo are three drawings (SDTD-01 to SDTD-03) that present the design of the contingency measures described in the Section 3.

2 Identified Issues

2.1 South Dam Foundation

The South Dam construction included additional foundation investigation works consisting of percolation testing and mapping of ice rich zones within the key trench excavation. The investigation found significant zones of ice rich soil and the presence of ice wedges within the footprint of the dam and the key trench. The ice wedges are potentially interconnected and potentially form a continuous ice 'path' extending from upstream of the dam, beneath the key trench, to downstream of the dam.

The key trench depth of 4 m below the original ground surface was selected as thermal modelling has shown that the ground will remain frozen (<-2 degrees Celsius) below this depth. The thermal modelling assumes tailings is deposited from the South Dam to provide a thermal barrier and a low permeability material overlying the natural ground, which contains the ice wedges. Should water be allowed to pond immediately upstream of the South Dam without tailings deposition, this would result in potential thawing of the ice wedges, and thawing of the foundation below the key trench. This would cause thaw induced settlement of the dam foundation and opening of a potentially high flow seepage pathway beneath the key trench.

Thaw induced settlement of the South Dam is not expected to cause a catastrophic failure of the Dam or affect the long-term performance assuming an adequate tailings beach is developed, and could be mitigated by additional fill placement to compensate for the settlement.

Potential development of a high flow seepage pathway beneath the key trench has the potential to cause a catastrophic failure of the dam and would result in release of impounded water which may or may not meet discharge requirements. Therefore, measures must be taken to mitigate this risk.

2.2 South Dam Construction Completion

The South Dam was planned to be completed by the end of May 2018 and prior to freshet. Tailings deposition from the South Dam can not begin until construction is completed. If construction is not completed prior to freshet there will be a significant risk to the dam performance, due to impounded water directly upstream of the dam that could result in thawing of the dam foundation and development of high flow seepage pathways through the foundation.

2.3 Delay of RBDS installation

The RBDS is the permitted system for discharge of excess water in the tailings impoundment area (TIA) and excess water from the underground mine to the ocean. The RBDS was intended to be operational during 2017; however, TMAC decided to defer construction to the 2018 open water season. As a result, a temporary deposition berm was constructed to protect the South Dam foundation prior to its construction. The installation of the RBDS has further been delayed to late 2018 with the planned operation by March 2019.

As the RBDS will not be operational until 2019, there is further risk of water ponding against the South Dam. The delay in the installation and operation of the RBDS will result in a temporarily higher TIA water level, as no discharge will occur during the 2018 open water season as was originally planned.

SRK has undertaken stochastic water balance modelling to calculate the likely water level within the TIA without discharge in 2018. The results indicate a 95-percentile open water level of 31.7 m in October 2018 (end of open water season). It is therefore recommended that a temporary water retainment structure to a minimum elevation of 32 m be constructed.

It is important to note that this does not change the overall TIA full supply level (33.5 m) or freeboard calculations. This relates only to the temporary containment of water within the bounds of the TIA upstream of the South Dam.

3 Mitigation Measures

The proposed mitigation measures are to raise the temporary deposition berm (berm) north of the South Dam to allow further tailings deposition and creation of a tailings beach up to a level of 32 m.

The existing berm and extent of the existing tailings beach is illustrated in Drawing SDTD-01. The berm was originally constructed in 2017 north of the South Dam, to protect the South Dam foundation prior to its construction. The existing tailings beach slope was estimated to be approximately 1.5% in the upper beach adjacent to the berm.

The existing berm will be raised by 1.5 m to an elevation of 32.5 m using the same methodology as the existing berm, for a higher level of containment, as shown in Drawing SDTD-02. Additionally, a small rockfill windrow will be constructed immediately south of the current lake ice boundary on the frozen tailings beach. This windrow will withhold the majority of the tailings solids, minimising the volume of tailings required to provide containment and preventing a thick layer of tailings developing over the existing lake ice. This windrow must be constructed while the existing tailings beach is frozen and trafficable. SRK has modelled the deposition of tailings from the proposed raised berm to the windrow and calculated an additional tailings volume of 9,000 m^3 to develop the beach up to the 32 m elevation level. At the current production rate of approximately 1,000 tpd and tailings density of 1.3 t/m^3 it will take approximately 12 days to develop the required beach, assuming no spill through the windrow. Multiple deposition points will be required across the berm to ensure even development of the beach level as shown on Drawing SDTD-02. It is noted that the windrow will likely sink into the existing tailings, as the tailings thaws. This is not a concern as the purpose of the windrow (initial withholding of tailings solids) will have already been utilised.

With containment provided by the temporary deposition berm and tailings beach, the area between the berm and the South Dam will be able to have surface water collected and pumped to the TIA, removing ponded water from the area adjacent to the South Dam. Provision of a low permeability barrier adjacent to the South Dam, enclosing the identified ice wedges, can be achieved by tailings deposition within the area between the temporary deposition berm and the

South Dam following completion of the South Dam, as illustrated on Drawing SDTD-03. This can be undertaken by either slurry deposition or by excavation and placement of previously deposited tailings (method to be determined by the supervising engineer).

Once the area between the temporary deposition berm and the South Dam has been filled with tailings up to the level of the berm. Tailings deposition may be able to commence from the South Dam as per the original intent of the design and deposition plan.

The South Dam design includes ground temperature cables (GTC) to monitoring the thermal performance of the dam and foundation. SRK is currently installing and monitoring the planned GTCs. In addition to the planned GTCs, the mitigation measures would include the installation of two additional ground temperature cables immediately upstream of the South Dam within the approximate location of ice wedges near the lowest elevation of the original ground surface, as shown in Drawing SDTD-02. The additional GTCs would provide ground thermal monitoring in an area with the potential to develop a high flow seepage pathway and provide an early warning of ground thermal changes that warrant further mitigation measures.

4 Execution Plan

The steps required to implement the mitigation measures are listed in execution order below.

- Construction of berm raise and windrow (3,500 m^3 of rock fill, either ROQ or waste rock may be used in this specific case) approximately 2-3 days.
- Drill and install two GTC at locations per Drawing SDTD-02 (Attachment 1), following installation specifications provided in the South Dam design.
- Reconnection and slight relocation of tailings deposition pipeline and spigot points to raised berm crest.
- Commission and operate deposition from temporary deposition berm as per Drawing SDTD-02 (Attachment 1).
- Concurrently and as required, remove surface water by trash pump from area between the berm and the South Dam.
- Once South Dam construction is complete, or on the instruction of the supervising engineer; Commence placement of tailings within area between the berm and the South Dam. This may be by slurry deposition or by excavation and placement of previously deposited tailings, as directed by the supervising engineer. The supervising engineer will consider the status of the South Dam construction, the time of year and climatic conditions, and the tailings deposition performance amongst other things when specifying the placement method.
- On approval from the facility Engineer of Record (Maritz Rykaart) commence deposition from the South Dam as per the original intent of the design and deposition plan or as directed.

Construction of the temporary deposition berm raise and windrow should commence by 20 May 2018.

It is recognised that construction of the temporary deposition berm raise requires use of the same equipment and potentially materials (ROQ) as for the South Dam construction. Therefore, construction of the berm raise may cause additional delays to the South Dam completion. However, given the volume of material required (3,500 m^3) and the simplicity if the construction it is considered that this should not exceed 3 days. SRK considers that with adequate scheduling and resource planning the construction of the berm raise should not impact the overall South Dam schedule.

SRK Consulting (Canada) Inc.

Cameron Hore, PEng
Senior Consultant

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The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

5 References

SRK Consulting (Canada) Inc., 2018. Engineering Drawings for the South Dam - Phase 1 Doris North Project, Nunavut, Canada. Revision 1. Prepared for TMAC Resources. Project Number 1CT022.017. April 2018.

Attachment 1: Drawings

Doris North Project
South Dam Temporary Deposition Berm Raise

Drawing Number	Drawing Title	Issue	Date	Revision
SDTD-01	Existing Temporary Deposition Berm - Plan, Profile and Typical Section	Issued for Review	4/20/2018	A
SDTD-02	Temporary Deposition Berm Raise - Plan, Profile and Typical Section	Issued for Review	5/11/2018	A
SDTD-03	South Dam Tailings In-fill - Plan, Profile and Typical Section	Issued for Review	5/11/2018	A

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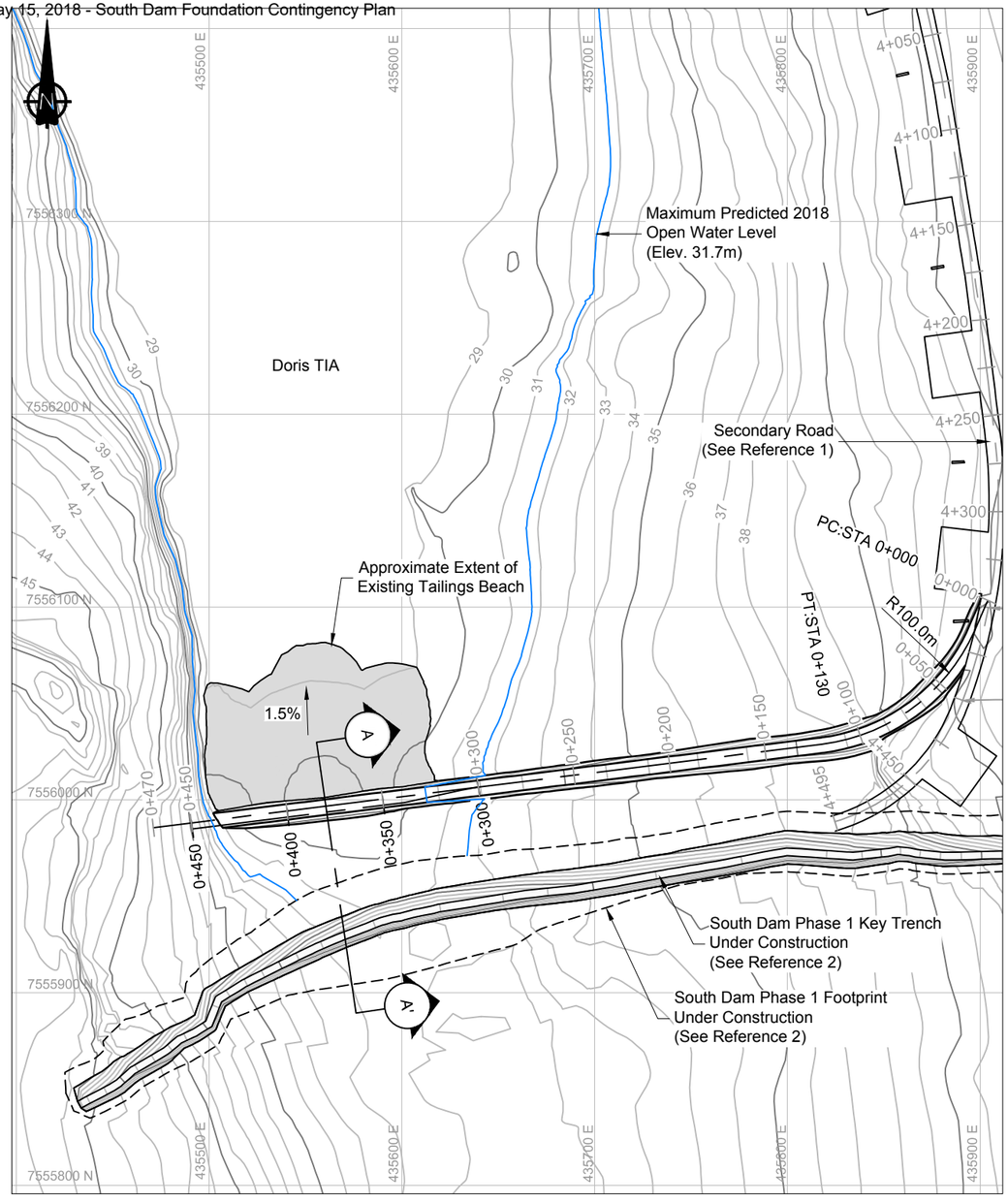
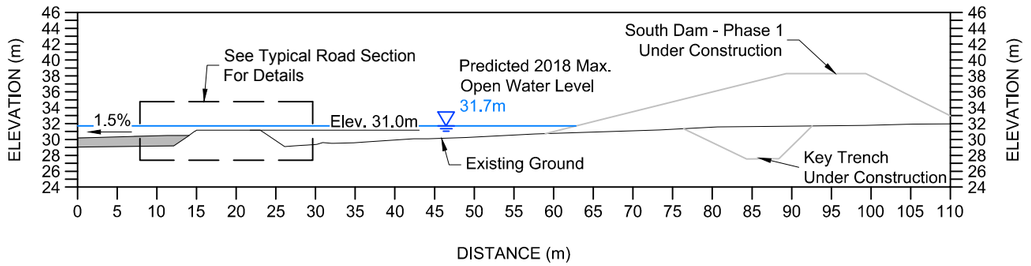


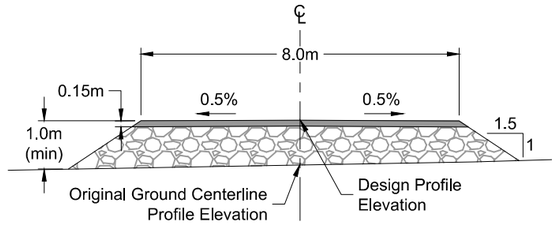
Existing Temporary Deposition Berm Plan

0m 30 60 90 120



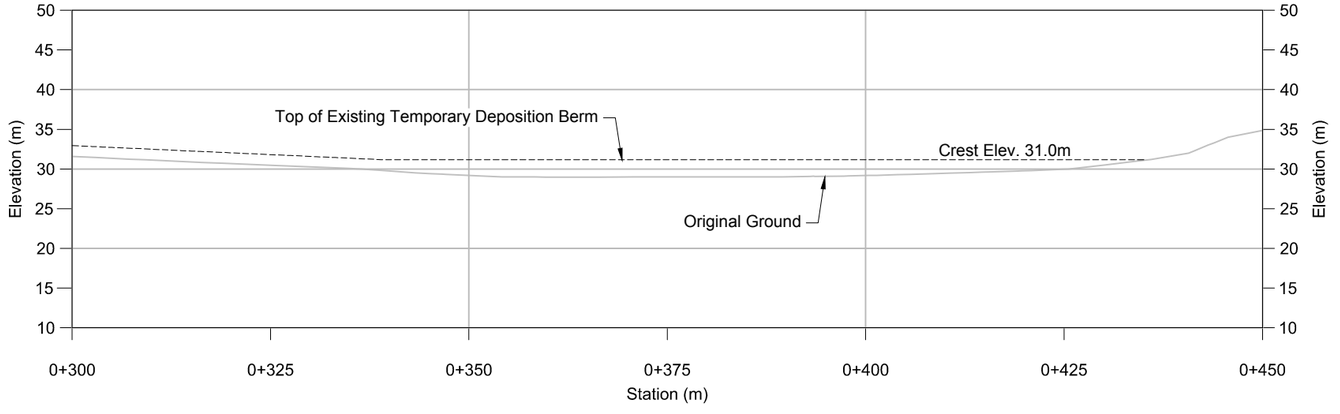
Cross Section A-A'

0m 5 10 15 20 25 30



Typical Berm Section

0m 1 2 3 4 5 6



Existing Temporary Deposition Berm - Profile

0m 5 10 15 20 25 30

LEGEND

- Surfacing Material
- Run of Quarry Material
- South Dam Footprint

NOTES

1. All dimensions are in metres unless noted otherwise.
2. Contours shown at 2.0m interval.
3. Additional topography under the proposed South Dam surveyed on June 30, 2017 and March 2018.

REFERENCE

1. SRK Consulting (Canada) Inc., 2011. Engineering Drawings for Doris North Secondary Road, Doris North Project, Nunavut, Canada. Revision 3. Prepared for Hope Bay Mining Ltd. Project Number 1CH008.003. November 9, 2011.
2. SRK Consulting (Canada) Inc., 2018. Engineering Drawings for the South Dam - Phase 1 Doris North Project, Nunavut, Canada. Revision 1. Prepared for TMAC Resources. Project Number 1CT022.017. April 2018.

REVISIONS											
NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-								
-	-								
					A	Issued for Review	CH		18/04/18

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
HB+T-CIV-CIV-OND-0010	Secondary Road from Doris Creek Bridge to South Dam 3+750 to 4+495

Original Drawings Stamped and Signed by Engineer

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		2018/04/18

FILE NAME: HBTIAroad - EC.dwg

TMAC RESOURCES

Hope Bay

SRK JOB NO.: 1CT022.020

Doris North Project

DRAWING TITLE:
Existing Temporary Deposition Berm Plan, Profile and Typical Section

DRAWING NO.	SHEET	REVISION NO.
SDTD-01	1 OF 3	A

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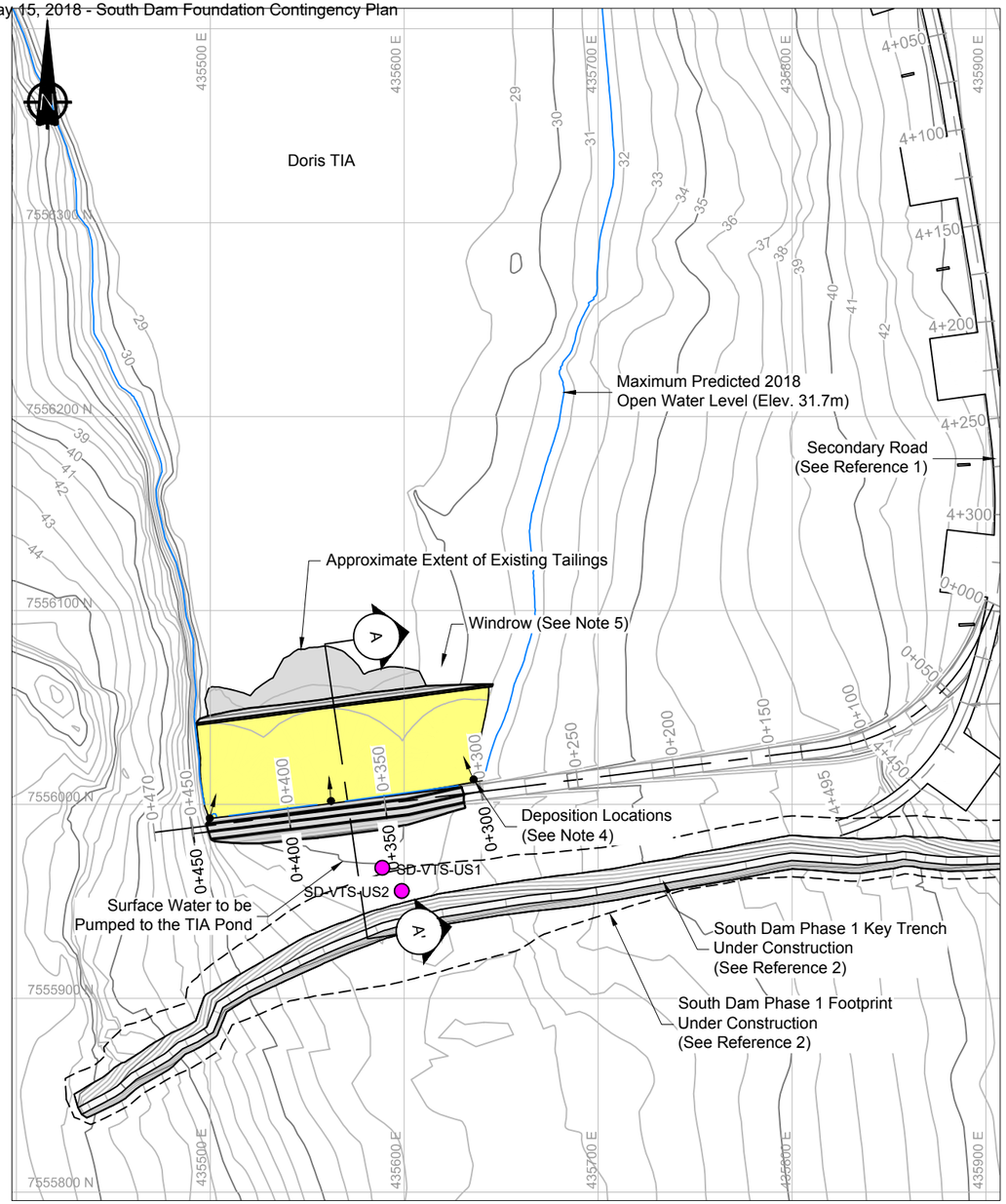
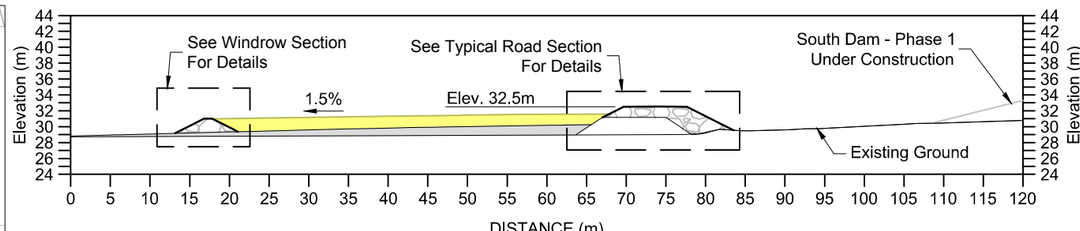


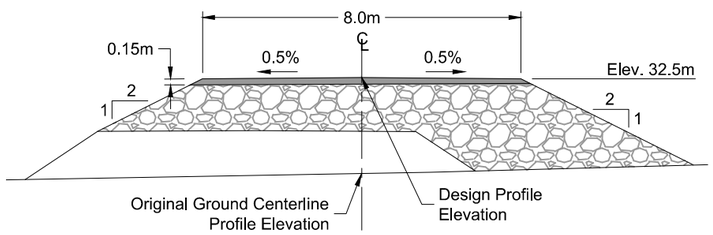
Proposed Temporary Deposition Berm Raise Plan

0m 30 60 90 120



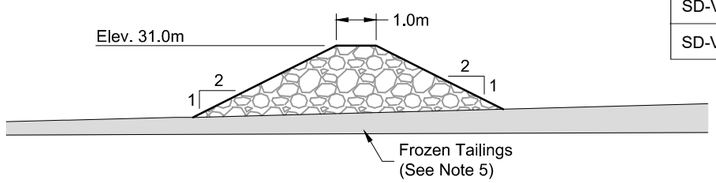
Cross Section A-A'

0m 5 10 15 20 25 30



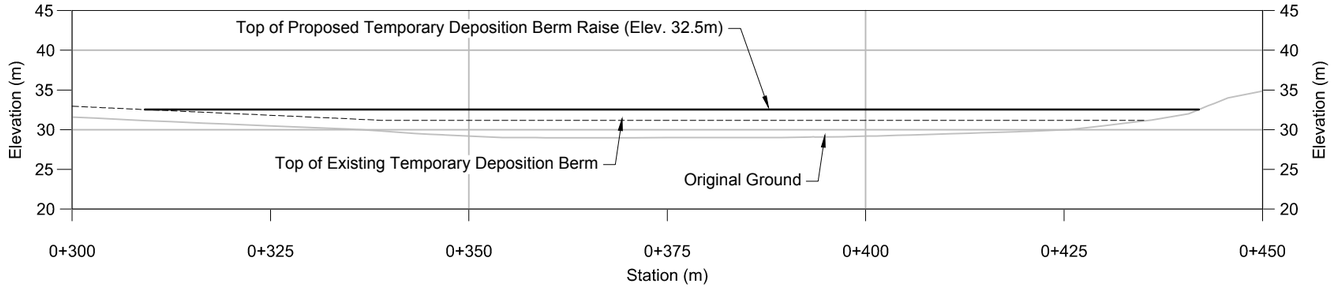
Typical Berm Raise

0m 1 2 3 4 5 6



Typical Windrow Section

0m 1 2 3 4 5 6



Proposed Temporary Deposition Berm - Profile

0m 5 10 15 20 25 30

MATERIALS AND QUANTITIES

Material	Quantity
ROQ	2,520m³
Road Surfacing	160m³
Tailings Beach Deposition	8,700m³
Windrow	1,050m³

MONITORING LOCATION LAYOUT

ID	Northing	Easting
SD-VTS-US1	7555967.30	435588.70
SD-VTS-US2	7555955.25	435598.65

LEGEND

- Monitoring Location
- Existing Deposited Tailings
- Proposed Deposited Tailings
- Surfacing Material
- Run of Quarry Material
- South Dam Footprint

NOTES

1. All dimensions are in metres unless noted otherwise.
2. Contours shown at 2.0m interval.
3. Additional topography under the proposed South Dam surveyed on June 30, 2017 and March 2018.
4. Multiple deposition points will be required across the interim berm to ensure even development of the beach level.
5. The windrow should be constructed immediately south of the lake ice boundary on the existing frozen tailings.

REFERENCE

1. SRK Consulting (Canada) Inc., 2011. Engineering Drawings for Doris North Secondary Road, Doris North Project, Nunavut, Canada. Revision 3. Prepared for Hope Bay Mining Ltd. Project Number 1CH008.003. November 9, 2011.
2. SRK Consulting (Canada) Inc., 2018. Engineering Drawings for the South Dam - Phase 1 Doris North Project, Nunavut, Canada. Revision 1. Prepared for TMAC Resources. Project Number 1CT022.017. April 2018.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
HB-T-CIV-CIV-OND-0010	Secondary Road from Doris Creek Bridge to South Dam 3+750 to 4+495	-	-				A	Issued for Review	CH		18/05/11

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		2018/05/11

FILE NAME: HBTIAroad.dwg

TMAC RESOURCES

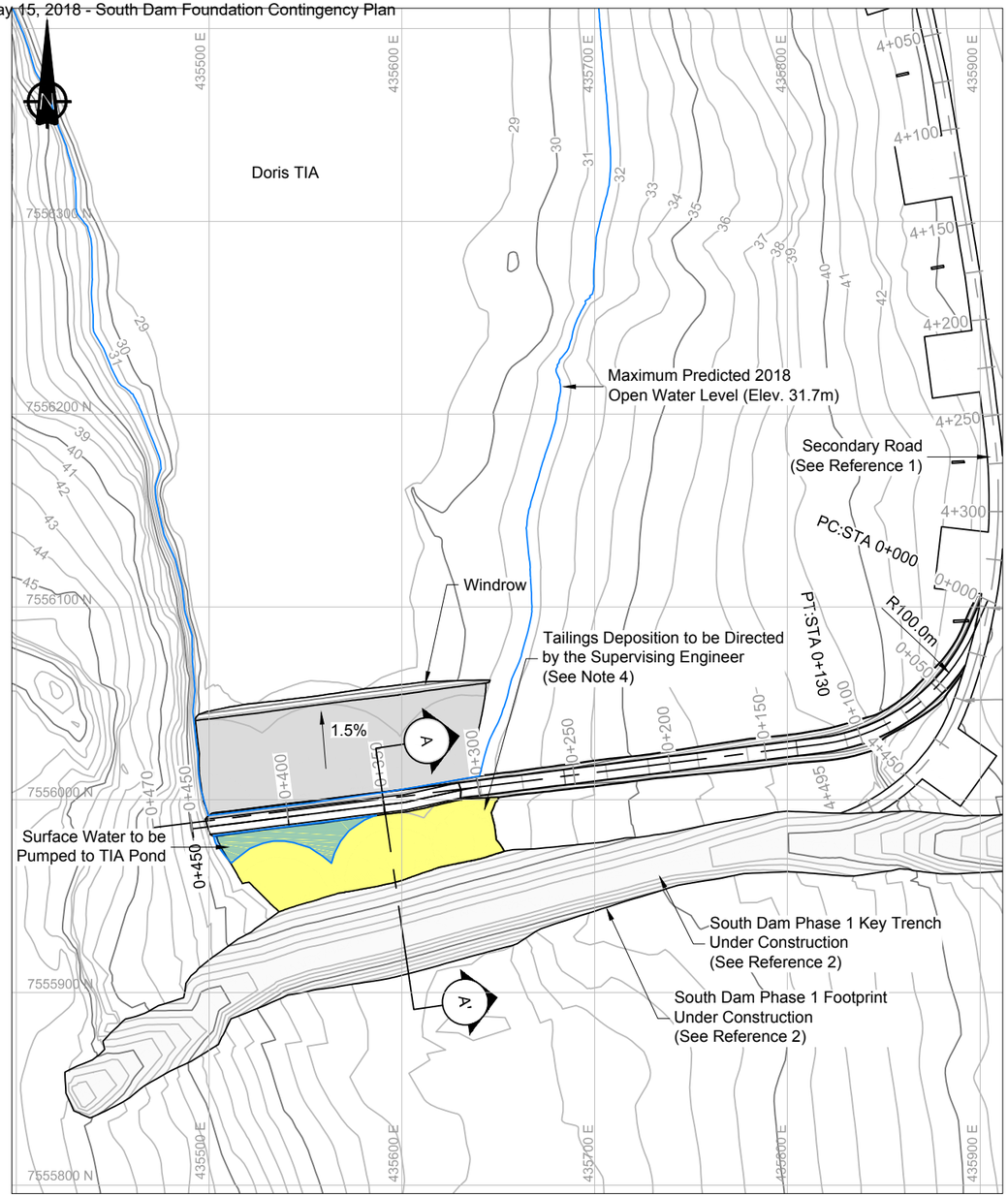
Hope Bay

SRK JOB NO.: 1CT022.020

Doris North Project

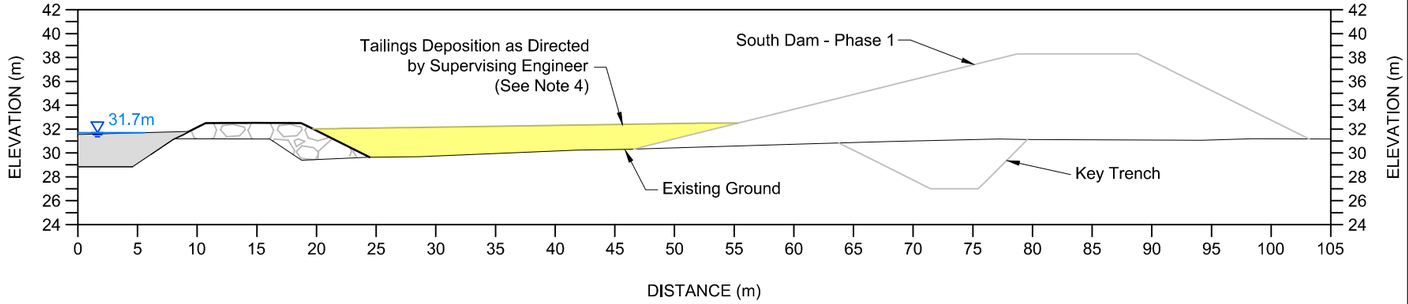
DRAWING TITLE: Temporary Deposition Berm Raise Plan, Profile and Typical Section

DRAWING NO.	SHEET	REVISION NO.
SDTD-02	2 OF 3	A



South Dam Tailings In-fill Plan

0m 30 60 90 120



Cross Section A-A'

0m 5 10 15 20 25 30

LEGEND

- Existing Deposited Tailings
- Proposed Deposited Tailings
- Surfacing Material
- Run of Quarry Material
- South Dam Footprint

NOTES

1. All dimensions are in metres unless noted otherwise.
2. Contours shown at 2.0m interval.
3. Additional topography under the proposed South Dam surveyed on June 30, 2017 and March 2018.
4. Tailings placement may be by slurry deposition or by excavation and placement of previously deposited tailings, as directed by the supervising Engineer.

REFERENCE

1. SRK Consulting (Canada) Inc., 2011. Engineering Drawings for Doris North Secondary Road, Doris North Project, Nunavut, Canada. Revision 3. Prepared for Hope Bay Mining Ltd. Project Number 1CH008.003. November 9, 2011.
2. SRK Consulting (Canada) Inc., 2018. Engineering Drawings for the South Dam - Phase 1 Doris North Project, Nunavut, Canada. Revision 1. Prepared for TMAC Resources. Project Number 1CT022.0017. April 2018.

MATERIALS AND QUANTITIES

Material	Quantity
Tailings Capacity	6,100m³

DRAWING NO.	DRAWING TITLE
-	-
HB+T-CIV-CIV-OND-0010	Secondary Road from Doris Creek Bridge to South Dam 3+750 to 4+495

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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		2018/05/11

FILE NAME: HBTIAroad-S2.dwg

TMAC RESOURCES

Hope Bay

SRK JOB NO.: 1CT022.020

Doris North Project

DRAWING TITLE:
South Dam Tailings In-fill
Plan, Profile and Typical Section

DRAWING NO.	SHEET	REVISION NO.
SDTD-03	3 OF 3	A

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Seema Kang

From: Cameron Hore
Sent: Thursday, May 17, 2018 7:49 AM
To: rodt@nunalogistics.com; Jake Chisholm
Cc: Roland Jones; NA 1CT022.031 HopeBay
Subject: Design Files for Temporary Deposition Berm Raise
Attachments: HBTIAroad.xml; HBTIAroad.dxf

Hi All,

Please see attached design files Temporary Deposition Berm Raise.

The windrow downstream can be placed in an alignment with the temporary deposition berm at the position I marked with an elevation of 31m. Note that this will cross the OVB dump access road.

Cheers

Cameron Hore *CPEng P.Eng*
Senior Consultant (Geotechnical Engineering)
srk consulting
SRK Consulting (Canada) Inc.
22nd Floor, 1066 West Hastings Street, Vancouver, BC, V6E 3X2, Canada
Tel: +1-604-681-4196; **Direct:** +1-604-235-8533
Email: chore@srk.com; **Skype:** cameron.hore
www.srk.com

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To stop receiving messages from **NA 1CT022.031 HopeBay** group, **stop following it**.

Seema Kang

From: Christopher Stevens
Sent: Monday, May 21, 2018 11:44 AM
To: Kaitlyn Kooy; Kendell Cator
Cc: John Kurylo; Cameron Hore; Ryan Williams
Subject: RE: Drilling through massive ice
Attachments: SRK CableBuild_Approved.pdf; Invoice_1260_from_BeadedStream.pdf; DTC Order Sheet - SN 2839-2843 (14) - Hope Bay Phase 1 - SRK - 011518.pdf

Kaitlyn,

Attached is the design drawing for the sonic GTC and the invoice. You should be able to match up the serial numbers with the drawings to make it easier in picking the cables needed for the ice wedge contingency holes.

- Spare #1 might be a good option if it is still available. It has 2 m of surface lead and would be 18 m long assuming the first node gets installed at 5 cm bgs. You can also fold the cable at the bottom if you drill to a depth less than 18 m
- Spare #2 might also be a good option if it is still available. The cable is a bit shorter than Spare#1. It would has 2 m of surface lead and would be 14 m long assuming you install the first node at 5 cm bgs. The cable is a bit shorter than the target install depth of 15.5 m. If you use this cable I would install it in the hole that is furthest upstream away from the toe of the dam.

Christopher Stevens, *PhD.*
Senior Consultant (Permafrost)
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SRK Consulting (U.S.), Inc.
Suite E-12, 4700 Business Park Blvd, Anchorage, Alaska, 99503, USA
Tel: +1-907-677-3520; **Fax**: +1-907-677-3620
Mobile:+ 1-907-301-8718; **Direct**: +1-907-273-3607
Email: cstevens@srk.com
www.srk.com
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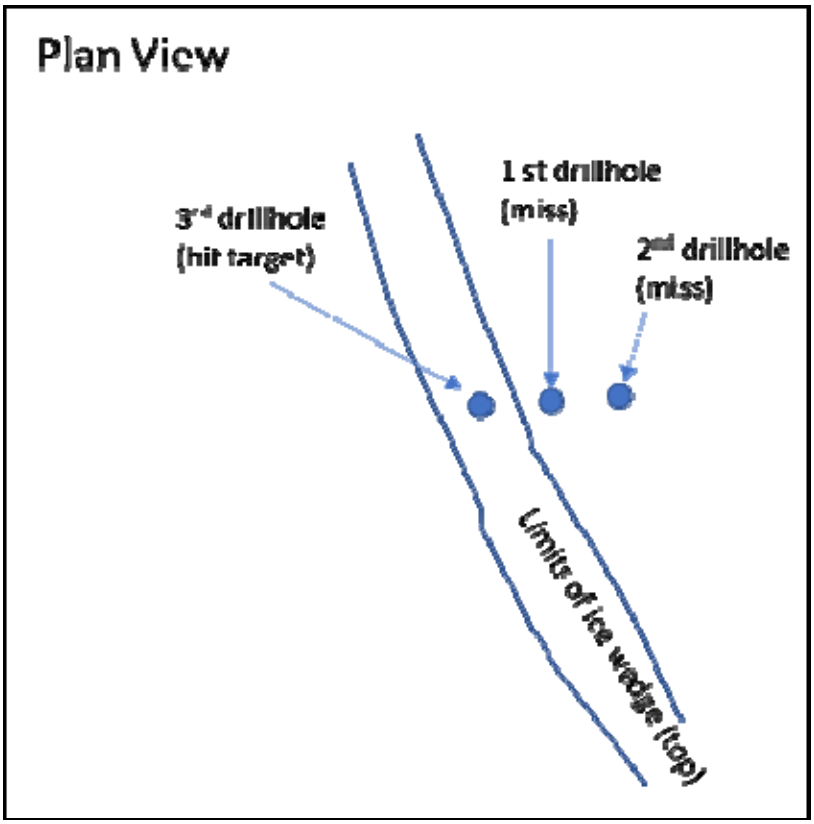
From: Christopher Stevens
Sent: Sunday, May 20, 2018 9:08 PM
To: Kaitlyn Kooy <kkooy@srk.com>; Kendell Cator <kcator@srk.com>
Cc: John Kurylo <jkurylo@srk.com>; Cameron Hore <chore@srk.com>; Ryan Williams <rwilliams@srk.com>
Subject: RE: Drilling through massive ice

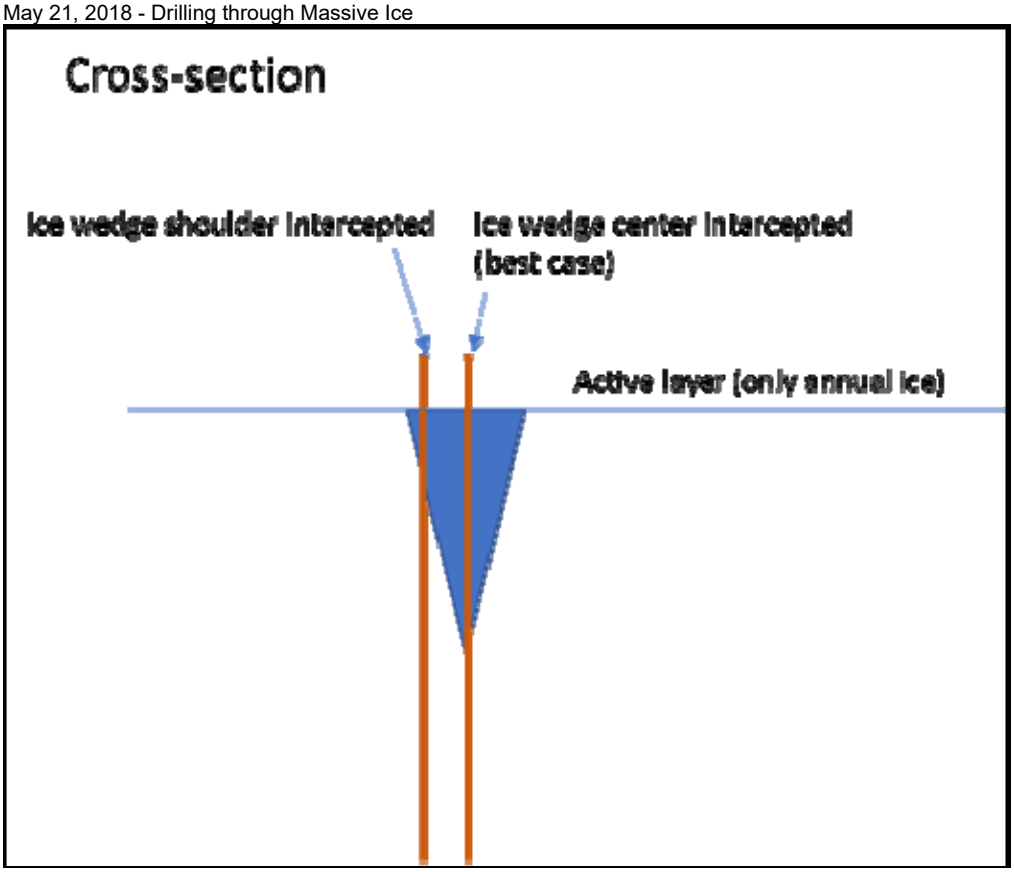
Hi Kaitlyn,

I agree with John's comments in the email strings below. Below are a couple additional points.

- The massive ice with the hammer drill should come up as crushed ice that looks like snow (as John mentioned). Note some mineral material will likely get mixed into the crushed ice and it might not be 100% clean.

- We should install the cable to 15.5 m so that the installations are similar to the vertical cable depths beneath the upstream toe. From looking at the design drawings, the VTC were to be installed to 15.5 m. I assume that matches the as-built for the upstream GTCs.
- The sensor spacing on the Sonic GTC may not be exactly the same those used in the VTC holes on the South Dam. But the sonic GTC were designed to monitor shallow ground temperatures and are therefore suitable for our application in the ice wedge.
- If possible, I would install the uppermost surface sensor at 5 cm bgs to ensure we have a good density of sensor in the near surface wedge and to provide us with some additional value from the data collected.
- I would start by drilling the location provided. As John mentioned, if you drill to 5 m and do not see massive ice then we are likely not in the wedge. We would want to move the drill perpendicular to the expected long axis of the wedge for the second attempt. If the target is not hit in the second hole then the third attempt might be on the opposite side. At least that is the strategy I have used in the past for drilling winter wedges (see drawing below). If you keep stepping out the drillholes in the same direction you might be moving away from the wedge.
- See cross section drawing for a best case. We might hit the shoulder of the wedge and see a bit of ice. The wedges are often not a perfect wedge of ice. In the past I have used airphotos to locate the wedge and in some cases thermal contraction cracks in the snow can be observed to confirm the exact location in the field. I assume the snow will be disturbed at site, but if not look for a linear crack that extends through the hardpack snow.





Christopher Stevens, *PhD.*
Senior Consultant (Permafrost)
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Mobile:+ 1-907-301-8718; **Direct**: +1-907-273-3607
Email: cstevens@srk.com
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Please consider the environment before printing this e-mail.

From: John Kurylo
Sent: Sunday, May 20, 2018 8:15 PM
To: Kaitlyn Kooy <kkooy@srk.com>; Kendell Cator <kcator@srk.com>
Cc: Cameron Hore <chore@srk.com>; Ryan Williams <rwilliams@srk.com>; Christopher Stevens <cstevens@srk.com>
Subject: RE: Drilling through massive ice

Hey Kaitlyn,

Yes, use the GTCs planned for the sonic program. They are different lengths I believe. Can you look at what cables are remaining and then detail the lengths? I cc'd Chris as well in case he has any thoughts about depth for this monitoring My first thought was something around the 15m depth for the ice wedge GTC would be good.

So… would want to drill a hole about 0.5m past the last bead of the strings you install. Then install it similar to what you did for the vertical GTCs in the key trench.

Cheers,
John

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

From: Kaitlyn Kooy
Sent: Sunday, May 20, 2018 15:16
To: John Kurylo <jkurylo@srk.com>; Kendell Cator <kcator@srk.com>
Cc: Cameron Hore <chore@srk.com>; Ryan Williams <rwilliams@srk.com>
Subject: RE: Drilling through massive ice

Okay thanks, good to know.

The last couple pieces of information I will need are:

- Total depth of the holes; and
- Which cables I'm meant to use. Chris mentions in his email that we are to use the ones planned for the sonic program? If yes which ones? Are they all the same?

Thanks,
Kaitlyn

From: John Kurylo
Sent: Sunday, May 20, 2018 3:57 PM
To: Kaitlyn Kooy <kkooy@srk.com>; Kendell Cator <kcator@srk.com>
Cc: Cameron Hore <chore@srk.com>; Ryan Williams <rwilliams@srk.com>
Subject: RE: Drilling through massive ice

Hey Kaitlyn,

No there was some additional survey pickups of ice in the key trench that we did when we were installing the liner around the central portion of the dam. Back when Ryan, Kendell and I were all on site around April 8th ish I think. Maybe just go as ask survey if they have any ice pickups around the same time the liner was installed (so would be likely in the same survey dump / cvs file as the panel corner points done around station 3+20-ish.

The drill should just smash up the ice and not really melt it. This being noted if it is warm out the ice might melt quite quickly.

I think Scott just hates drilling the overburden. I have a hard time thinking exactly why the overburden would be harder on the bit than the rock. I guess because it gets so plugged up with overburden and does not rotate as much? Not sure I fully buy into this but this is beyond the point.

If you hit 5m and have not really seen any massive ice then might move to a new spot. Use your judgment but if you have say drilled 6 short holes and site / the driller is starting to loose it then yeah when in doubt just install in the hole locations that Chris provided (unless we can get a bit more detail from the survey data about where to target).

Cheers,
John

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

From: Kaitlyn Kooy
Sent: Sunday, May 20, 2018 14:48
To: John Kurylo <jkurylo@srk.com>; Kendell Cator <kcator@srk.com>
Cc: Cameron Hore <chore@srk.com>; Ryan Williams <rwilliams@srk.com>
Subject: RE: Drilling through massive ice

Thanks John,

So the drill won't end up melting most of the ice?

Is the attached file what you mean? Though this survey was done on March 15. I don't see anything else on the hard drive or in my inbox. I'll double check with survey if they have anything else.

As an aside, I just talked to Kelly and Scott about getting the drill out to the South Dam and they agreed that it can be done on Tuesday. They are generally pretty reluctant to use the hammer drill for this purpose as it's only really designed for drilling in rock and apparently the other instrumentation holes did a bit of a number on the drill bit. Cam mentioned that we should poke around until we find the ice wedge but in the interest of time and taking Scott's concerns about the drill into consideration am I able to call it quits at some point if we can't find the ice wedge? Chris made a comment in the email chain that you just forwarded where he indicated that the thermistor would still be of value if it wasn't drilled directly into the ice wedge.

Thanks,
Kaitlyn

From: John Kurylo
Sent: Sunday, May 20, 2018 3:22 PM
To: Kaitlyn Kooy <kkooy@srk.com>; Kendell Cator <kcator@srk.com>
Cc: Cameron Hore <chore@srk.com>; Ryan Williams <rwilliams@srk.com>
Subject: RE: Drilling through massive ice

Hey Kaitlyn,

Massive ice should come up looking more like snow after it has been drilled with the downhole hammer rig. When in doubt pull out one of the hot plates and do a moisture content to check. If we are over 100% (and into the multiple 100%s) then likely at least it is very ice rich. I also just forwarded you some email from Chris S that show the initial point locations he had estimated from the aerial imagery and drilling data we have.

We might have this data already, but can you ask survey to send up the 'ice' pickups that they had for the key trench again. We could try to use this data to try and help define where we might drill these ice wedges. In the central area of the dam there was two distinct angular ice lenses. These were around station 3+20 to 3+40 and went in opposite directions so looked like they would have formed a wedge. This survey of the ice pick-ups in this area of the key trench would have been done around April 8th.

Regards,
John

John Kurylo
Direct: +1-604-235-8541
Email: jkurylo@srk.com

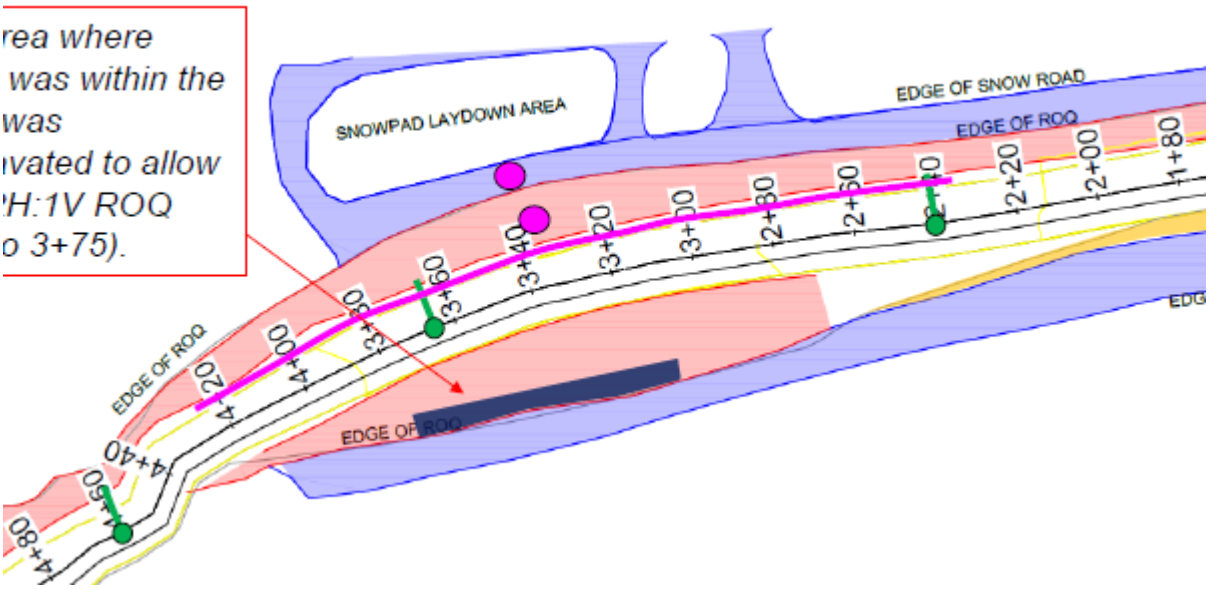
From: Kaitlyn Kooy
Sent: Sunday, May 20, 2018 09:43
To: Kendell Cator <kcator@srk.com>
Cc: John Kurylo <jkurylo@srk.com>; Cameron Hore <chore@srk.com>
Subject: Drilling through massive ice

Hi Kendell,

It looks like we may be drilling the two GTC holes tomorrow on the upstream side of the dam (indicated in figure below). These are meant to be installed in ice wedges.

When you were drilling the perc test holes was it quite obvious when you were drilling through massive ice? So far I've only drilled through ice rich overburden and observed some moisture on the rods but not a lot.

In general I'm assuming that while drilling through massive ice we see more water and little to no actual drill chips. Is that what you observed?



Thanks,
Kaitlyn

beadedstream

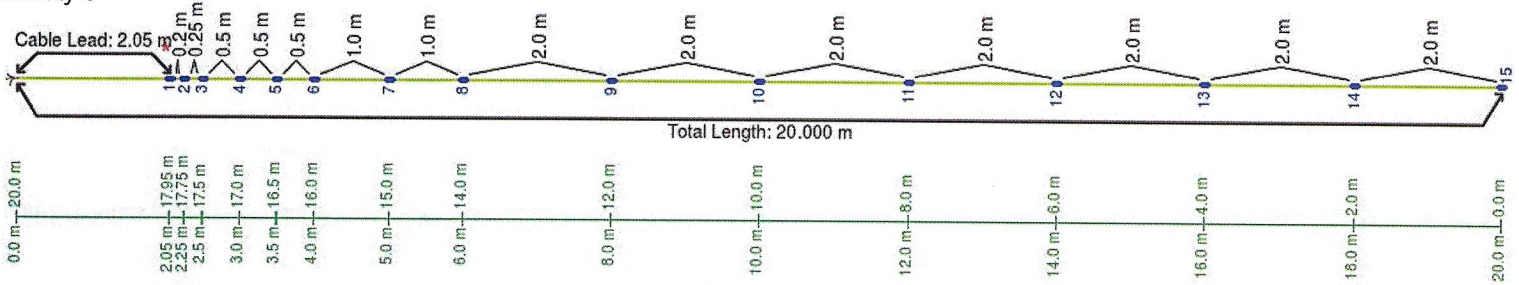
DTC Order Sheet

Customer: SRK Consulting
Project Name: 2018 - Point Hope Phase 1
Order Date:

DTC Name: 15 sensor profiler for the following locations: SRK17-STH-DH-02, SRK17-STH-DH-03, Spare #1
Serial Number: 2839
Units: meters

Object	Mold	Cable	Distance
Bare Leads		Yellow	2.05m
Protection/Sensor 1	Straight	Yellow	0.2m
Sensor 2	Straight	Yellow	0.25m
Sensor 3	Straight	Yellow	0.5m
Sensor 4	Straight	Yellow	0.5m
Sensor 5	Straight	Yellow	0.5m
Sensor 6	Straight	Yellow	1.0m
Sensor 7	Straight	Yellow	1.0m
Sensor 8	Straight	Yellow	2.0m
Sensor 9	Straight	Yellow	2.0m
Sensor 10	Straight	Yellow	2.0m
Sensor 11	Straight	Yellow	2.0m
Sensor 12	Straight	Yellow	2.0m
Sensor 13	Straight	Yellow	2.0m
Sensor 14	Straight	Yellow	2.0m
Sensor 15	End	N/A	N/A

Comments: Quantity 3



* indicates that this sensor contains a protection unit

Return signed order sheet to BeadedStream at
e-mail: contact@beadedstream.com
call: 844-488-4880 for support

Approved

1/15/2018
Date

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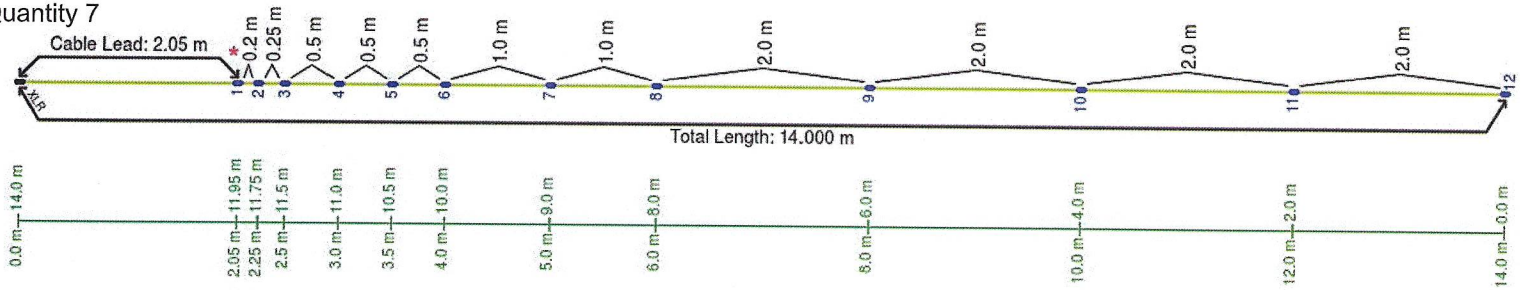
DTC Order Sheet

Customer: SRK Consulting
Project Name: 2018 - Point Hope Phase 1
Order Date:

DTC Name: 12 sensor profiler for the following locations: SRK17-WST-DH-01, SRK17-WST-DH-03, SRK17-MSPCP-DH-01, SRK17-MSPCP-DH-02, SRK17-TMA-DH-01, SRK17-TMA-DH-05, Spare #3
Serial Number: 2840
Units: meters

Object	Mold	Cable	Distance
XLRConnector	XLR Mold	Yellow	2.05m
Protection/Sensor 1	Straight	Yellow	0.2m
Sensor 2	Straight	Yellow	0.25m
Sensor 3	Straight	Yellow	0.5m
Sensor 4	Straight	Yellow	0.5m
Sensor 5	Straight	Yellow	0.5m
Sensor 6	Straight	Yellow	1.0m
Sensor 7	Straight	Yellow	1.0m
Sensor 8	Straight	Yellow	2.0m
Sensor 9	Straight	Yellow	2.0m
Sensor 10	Straight	Yellow	2.0m
Sensor 11	Straight	Yellow	2.0m
Sensor 12	End	N/A	N/A

Comments: Quantity 7



* Indicates that this sensor contains a protection unit

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11/15/2018
Date

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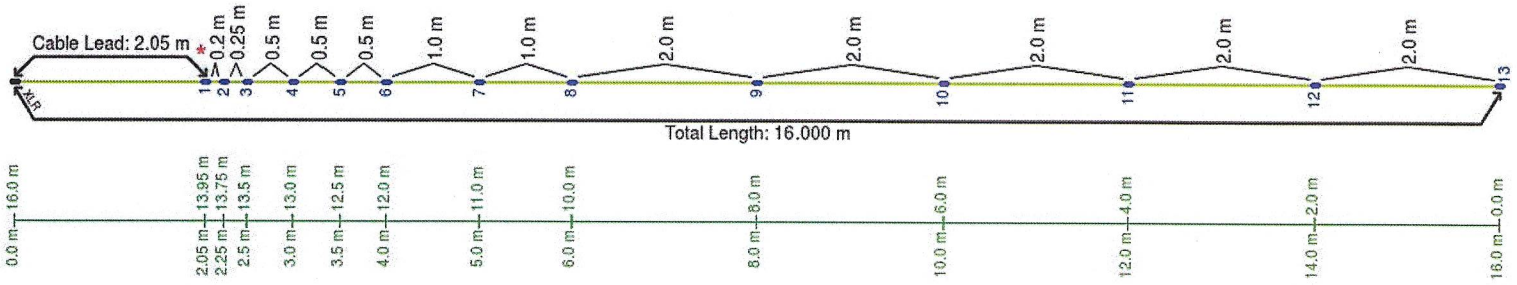
DTC Order Sheet

Customer: SRK Consulting
Project Name: 2018 - Point Hope Phase 1
Order Date:

DTC Name: 13 sensor profiler for: SRK17-BWRP-DH-01, Spare #2
Serial Number: 2841
Units: meters

Object	Mold	Cable	Distance
XLRConnector	XLR Mold	Yellow	2.05m
Protection/Sensor 1	Straight	Yellow	0.2m
Sensor 2	Straight	Yellow	0.25m
Sensor 3	Straight	Yellow	0.5m
Sensor 4	Straight	Yellow	0.5m
Sensor 5	Straight	Yellow	0.5m
Sensor 6	Straight	Yellow	1.0m
Sensor 7	Straight	Yellow	1.0m
Sensor 8	Straight	Yellow	2.0m
Sensor 9	Straight	Yellow	2.0m
Sensor 10	Straight	Yellow	2.0m
Sensor 11	Straight	Yellow	2.0m
Sensor 12	Straight	Yellow	2.0m
Sensor 13	End	N/A	N/A

Comments: Quantity 2



* indicates that this sensor contains a protection unit

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1/15/2018
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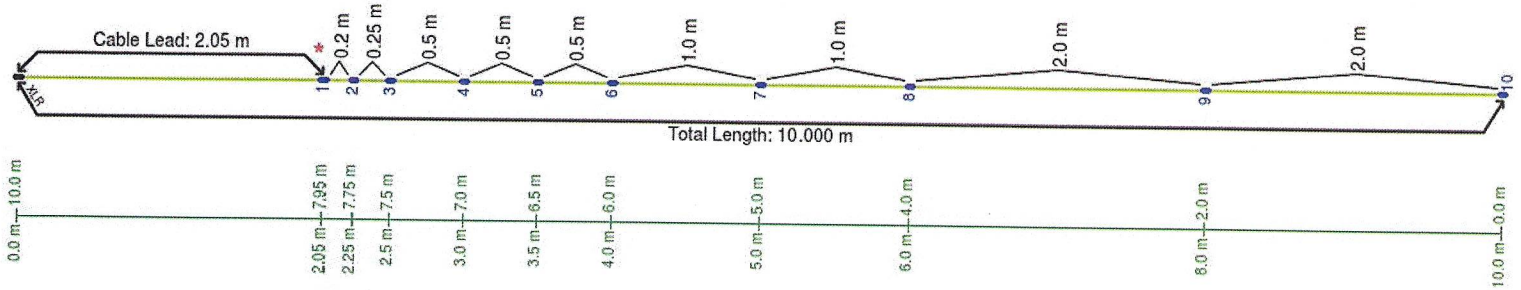
DTC Order Sheet

Customer: SRK Consulting
Project Name: 2018 - Point Hope Phase 1
Order Date:

DTC Name: 10 sensor profiler for SRK17-BCWP-DH-01
Serial Number: 2842
Units: meters

Object	Mold	Cable	Distance
XLRConnector	XLR Mold	Yellow	2.05m
Protection/Sensor 1	Straight	Yellow	0.2m
Sensor 2	Straight	Yellow	0.25m
Sensor 3	Straight	Yellow	0.5m
Sensor 4	Straight	Yellow	0.5m
Sensor 5	Straight	Yellow	0.5m
Sensor 6	Straight	Yellow	1.0m
Sensor 7	Straight	Yellow	1.0m
Sensor 8	Straight	Yellow	2.0m
Sensor 9	Straight	Yellow	2.0m
Sensor 10	End	N/A	N/A

Comments: Quantity 1



* indicates that this sensor contains a protection unit

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Approved

1/15/2018
Date

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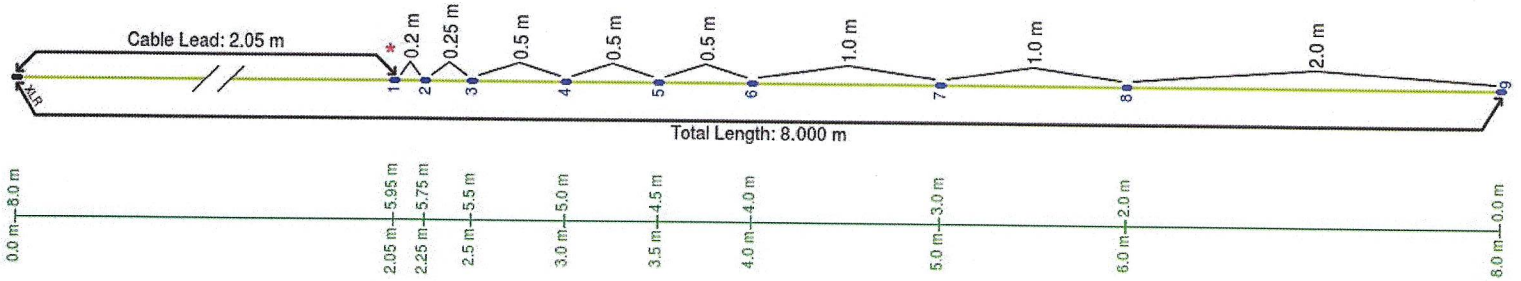
DTC Order Sheet

Customer: SRK Consulting
Project Name: 2018 - Point Hope Phase 1
Order Date:

DTC Name: 9 sensor profiler for SRK17-MNPCP-DH-02
Serial Number: 2843
Units: meters

Object	Mold	Cable	Distance
XLRConnector	XLR Mold	Yellow	2.05m
Protection/Sensor 1	Straight	Yellow	0.2m
Sensor 2	Straight	Yellow	0.25m
Sensor 3	Straight	Yellow	0.5m
Sensor 4	Straight	Yellow	0.5m
Sensor 5	Straight	Yellow	0.5m
Sensor 6	Straight	Yellow	1.0m
Sensor 7	Straight	Yellow	1.0m
Sensor 8	Straight	Yellow	2.0m
Sensor 9	End	N/A	N/A

Comments: Quantity 1



* indicates that this sensor contains a protection unit

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e-mail: contact@beadedstream.com
call: 844-488-4880 for support

Approved

1/15/2018
Date

beadedstream

P.O. Box 190311
Anchorage, AK 99519
(907)227-9769
contact@beadedstream.com

INVOICE

BILL TO
SRK Consulting
4700 Business Park Blvd
Suite E-12
Anchorage, AK 99503 USA

SHIP TO
SRK Consulting
4700 Business Park Blvd
Suite E-12
Anchorage, AK 99503
USA

INVOICE # 1260
DATE 01/29/2018

TERMS Net 30

SHIP DATE	SHIP VIA	TRACKING NO.	P.O. #	REFERENCE	CONTACT
01/25/2018	FedEx	771329236278		Hope Bay Phase 1	Chris Stevens

ITEM	QTY	RATE	EXTENDED
CUSTOM DTC 9 sensor DTC (2.05 m lead 8 m total) for SRK17-MNPCP-DH-02	1	1,143.00	1,143.00
CUSTOM DTC 10 Sensor DTC (2.05 m lead 10 m total) SRK17-BCWP-DH-01	1	1,415.00	1,415.00
CUSTOM DTC 12 Sensor DTC (2.05 m lead 14 m total) SRK17-WST-DH-01, SRK17-WST-DH-03, SRK17-MSPCP-DH-01, SRK17-MSPCP-DH-02, SRK17-TMA-DH-01, SRK17-TMA-DH-05, Spare #3	7	1,849.00	12,943.00
CUSTOM DTC 13 Sensor DTC (2.05 m lead 16 m total) for SRK17-BWRP-DH-01, Spare #2	2	2,011.00	4,022.00
CUSTOM DTC 15 Sensor DTC (2.05 m lead 20 m total) SRK17-STH-DH-02, SRK17-STH-DH-03, Spare #1 *** The third of these is in repair and has not shipped***	3	2,335.00	7,005.00
EXPEDITED DTC PRODUCTION SERVICE	1	2,125.00	2,125.00
D405 DATA LOGGER Measure and log data from up to 2 BeadedStream DTCs. Satellite ready. Activate Data-to-Web for near real-time telemetry.Small size. Very low installation cost. Global communication.	1	2,875.00	2,875.00
SHIPPING Shipped via FedEx (Priority). Priority needed for an (estimated) Friday 11/26 delivery.	1	425.00	425.00

All prices are USD

BALANCE DUE **$31,953.00**

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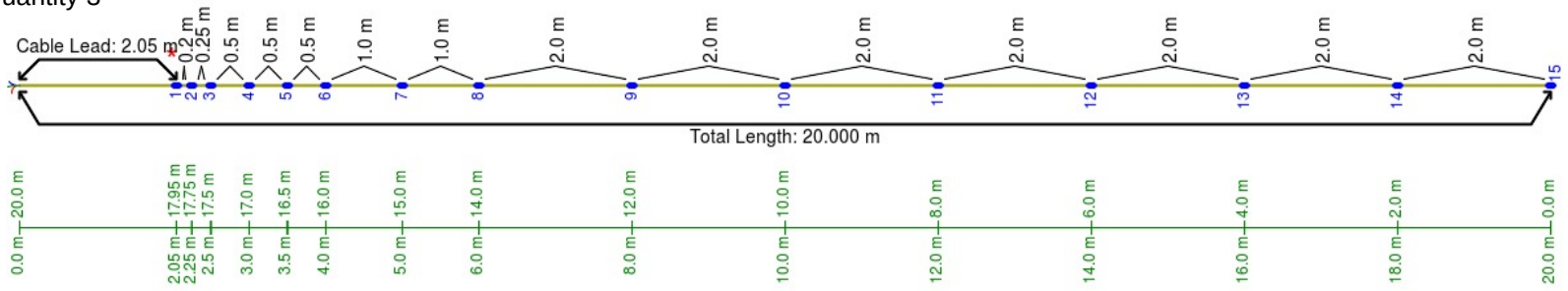
DTC Order Sheet

Customer: SRK Consulting
Project Name: 2018 - Point Hope Phase 1
Order Date:

DTC Name: 15 sensor profiler for the following locations: SRK17-STH-DH-02, SRK17-STH-DH-03, Spare #1
Serial Number: 2839
Units: meters

Object	Mold	Cable	Distance
Bare Leads		Yellow	2.05m
Protection/Sensor 1	Straight	Yellow	0.2m
Sensor 2	Straight	Yellow	0.25m
Sensor 3	Straight	Yellow	0.5m
Sensor 4	Straight	Yellow	0.5m
Sensor 5	Straight	Yellow	0.5m
Sensor 6	Straight	Yellow	1.0m
Sensor 7	Straight	Yellow	1.0m
Sensor 8	Straight	Yellow	2.0m
Sensor 9	Straight	Yellow	2.0m
Sensor 10	Straight	Yellow	2.0m
Sensor 11	Straight	Yellow	2.0m
Sensor 12	Straight	Yellow	2.0m
Sensor 13	Straight	Yellow	2.0m
Sensor 14	Straight	Yellow	2.0m
Sensor 15	End	N/A	N/A

Comments: Quantity 3



* indicates that this sensor contains a protection unit

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Approved

Date

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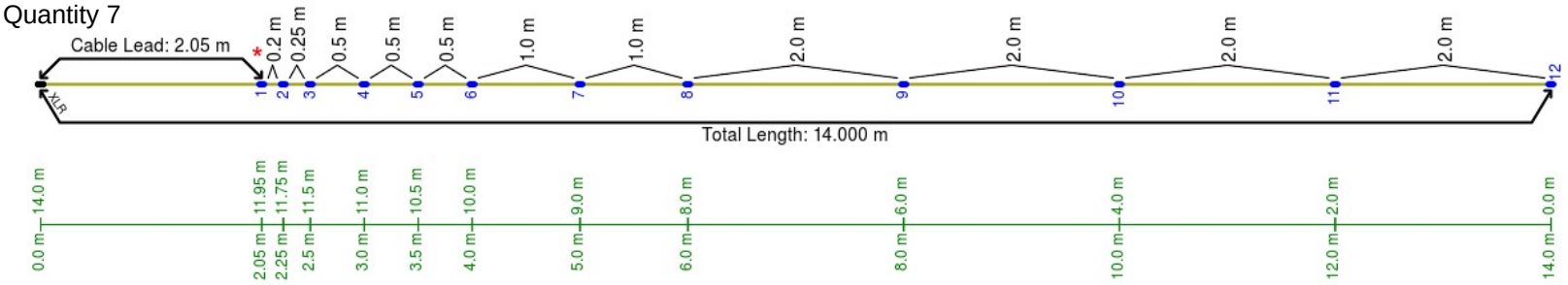
DTC Order Sheet

Customer: SRK Consulting
Project Name: 2018 - Point Hope Phase 1
Order Date:

DTC Name: 12 sensor profiler for the following locations: SRK17-WST-DH-01, SRK17-WST-DH-03, SRK17-MSPCP-DH-01, SRK17-MSPCP-DH-02, SRK17-TMA-DH-01, SRK17-TMA-DH-05, Spare #3
Serial Number: 2840
Units: meters

Object	Mold	Cable	Distance
XLRConnector	XLR Mold	Yellow	2.05m
Protection/Sensor 1	Straight	Yellow	0.2m
Sensor 2	Straight	Yellow	0.25m
Sensor 3	Straight	Yellow	0.5m
Sensor 4	Straight	Yellow	0.5m
Sensor 5	Straight	Yellow	0.5m
Sensor 6	Straight	Yellow	1.0m
Sensor 7	Straight	Yellow	1.0m
Sensor 8	Straight	Yellow	2.0m
Sensor 9	Straight	Yellow	2.0m
Sensor 10	Straight	Yellow	2.0m
Sensor 11	Straight	Yellow	2.0m
Sensor 12	End	N/A	N/A

Comments: Quantity 7



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Date

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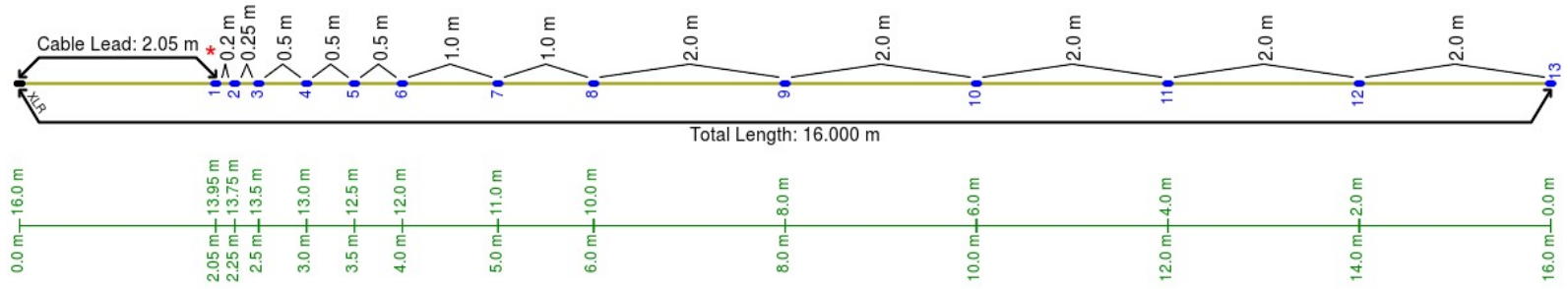
DTC Order Sheet

Customer: SRK Consulting
Project Name: 2018 - Point Hope Phase 1
Order Date:

DTC Name: 13 sensor profiler for: SRK17-BWRP-DH-01, Spare #2
Serial Number: 2841
Units: meters

Object	Mold	Cable	Distance
XLRConnector	XLR Mold	Yellow	2.05m
Protection/Sensor 1	Straight	Yellow	0.2m
Sensor 2	Straight	Yellow	0.25m
Sensor 3	Straight	Yellow	0.5m
Sensor 4	Straight	Yellow	0.5m
Sensor 5	Straight	Yellow	0.5m
Sensor 6	Straight	Yellow	1.0m
Sensor 7	Straight	Yellow	1.0m
Sensor 8	Straight	Yellow	2.0m
Sensor 9	Straight	Yellow	2.0m
Sensor 10	Straight	Yellow	2.0m
Sensor 11	Straight	Yellow	2.0m
Sensor 12	Straight	Yellow	2.0m
Sensor 13	End	N/A	N/A

Comments: Quantity 2



* indicates that this sensor contains a protection unit

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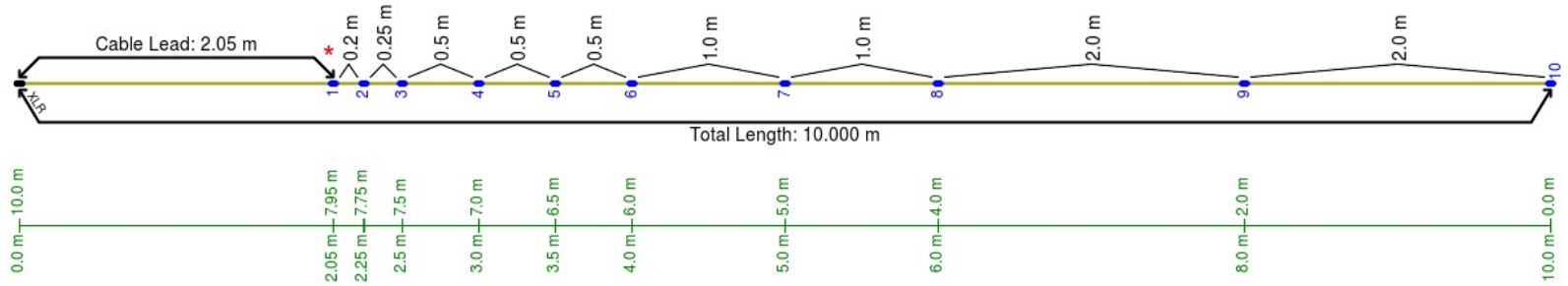
DTC Order Sheet

Customer: SRK Consulting
Project Name: 2018 - Point Hope Phase 1
Order Date:

DTC Name: 10 sensor profiler for SRK17-BCWP-DH-01
Serial Number: 2842
Units: meters

Object	Mold	Cable	Distance
XLRConnector	XLR Mold	Yellow	2.05m
Protection/Sensor 1	Straight	Yellow	0.2m
Sensor 2	Straight	Yellow	0.25m
Sensor 3	Straight	Yellow	0.5m
Sensor 4	Straight	Yellow	0.5m
Sensor 5	Straight	Yellow	0.5m
Sensor 6	Straight	Yellow	1.0m
Sensor 7	Straight	Yellow	1.0m
Sensor 8	Straight	Yellow	2.0m
Sensor 9	Straight	Yellow	2.0m
Sensor 10	End	N/A	N/A

Comments: Quantity 1



* indicates that this sensor contains a protection unit

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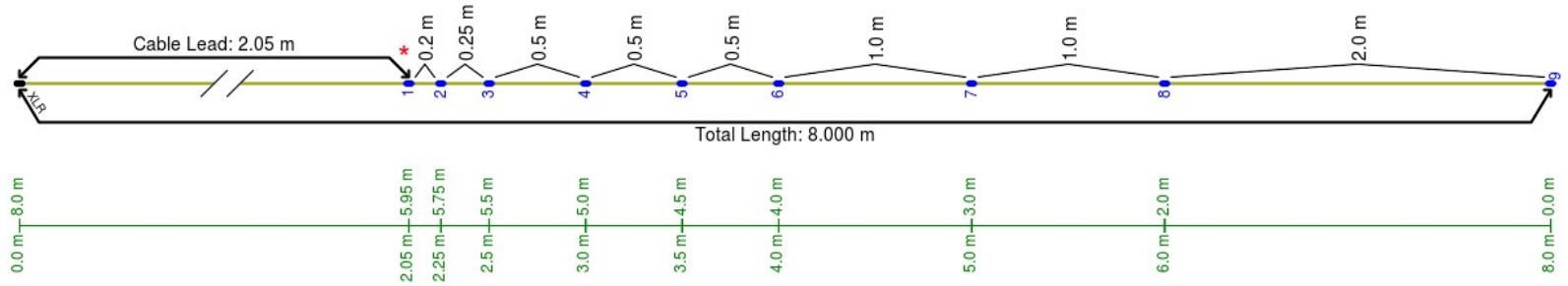
DTC Order Sheet

Customer: SRK Consulting
Project Name: 2018 - Point Hope Phase 1
Order Date:

DTC Name: 9 sensor profiler for SRK17-MNPCP-DH-02
Serial Number: 2843
Units: meters

Object	Mold	Cable	Distance
XLRConnector	XLR Mold	Yellow	2.05m
Protection/Sensor 1	Straight	Yellow	0.2m
Sensor 2	Straight	Yellow	0.25m
Sensor 3	Straight	Yellow	0.5m
Sensor 4	Straight	Yellow	0.5m
Sensor 5	Straight	Yellow	0.5m
Sensor 6	Straight	Yellow	1.0m
Sensor 7	Straight	Yellow	1.0m
Sensor 8	Straight	Yellow	2.0m
Sensor 9	End	N/A	N/A

Comments: Quantity 1



* indicates that this sensor contains a protection unit

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Approved

Date

Seema Kang

From: John Kurylo
Sent: Monday, June 4, 2018 4:54 PM
To: Cameron Hore; 'Kelly Schwenning'; 'Murray Weddell'; Darko Filipic; Roland Jones; Mark Doucette; Jake Chisholm; George Lochead; janied@sub-arctic.ca; samb@sub-arctic.ca; Rob Cook
Cc: Maritz Rykaart; Kyle Scale; Kaitlyn Kooy; Christopher Stevens; Silkie Wong; Kendell Cator; Ryan Williams; Osvaldo Nicolás Ledesma; NA 1CT022.031 HopeBay
Subject: Hope Bay - South Dam - IFC Rev2 Instrumentation Drawings
Attachments: 1CT022.031_South Dam Inst_W.Points_20180604.pdf; 1CT0022.017_HB_South Dam_IFC_Rev2_20180604_compiled.pdf

Hi All,

Attached is an updated set of IFC drawings for the South Dam. The changes made in this revision are only to the tile page, to drawing DN-SD-21, and to drawing DN-SD-30. Overall these changes are fairly minor but are being submitted for completeness and to assist with the future instrumentation layouts.

1. DN-SD-21 – added in stake out points for the various instrumentation
2. DN-SD-30 – corrected some labels and titles to better match the points shown on drawing DN-SD-21.

I have attached the following files for use:

1. PDF with updated drawings only for quick reference
2. PDF with full set of now current IFC drawings

If you have any queries when you review the attached files then please let myself, or any SRK site personnel know.

Kind Regards,
John

John Kurylo *MSc (DIC), PEng*
Senior Consultant (Geotechnical)
srk consulting
SRK Consulting (Canada) Inc.
22nd Floor, 1066 West Hastings Street, Vancouver, BC, V6E 3X2, Canada
Tel: +1-604-681-4196; **Fax**: +1-604-687-5532
Mobile:+ 1-604-345-2211; **Direct**: +1-604-235-8541
Email: jkurylo@srk.com
www.srk.com

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Seema Kang

From: Cameron Hore
Sent: Wednesday, June 13, 2018 9:19 AM
To: Jake Chisholm; George Lochead
Cc: Kendell Cator; NA 1CT022.031 HopeBay
Subject: Transition surfaces updated to match as-built key trench
Attachments: WestAbutmentTransition.xml; EastAbutmentTransition.dxf; EastAbutmentTransition.xml; WestAbutmentTransition.dxf

Hi Jake, George,

Please see attached transition surfaces updated to match as-built key trench for the abutments.

As discussed this morning the section 0+00 to approx 0+15 we can add a liner panel to achieve required overlap.

Apologies for the delay in getting this to you.

Cheers

Cameron Hore *CPEng P.Eng*
Senior Consultant (Geotechnical Engineering)
srk consulting
SRK Consulting (Canada) Inc.
22nd Floor, 1066 West Hastings Street, Vancouver, BC, V6E 3X2, Canada
Tel: +1-604-681-4196; **Direct:** +1-604-235-8533
Email: chore@srk.com; **Skype:** cameron.hore
www.srk.com

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Appendix G – Memorandums

Appendix G.1 – Liner Comparison Memo

SRK Consulting (Canada) Inc.
22nd Floor - 1066 West Hastings Street
Vancouver, BC V6E 3X2

T: +1.604.681.4196
F: +1.604.687.5532
vancouver@srk.com
www.srk.com

Memo

To:	Kelly Schwenning, Manager, Surface Operations	**Client:**	TMAC Resources Inc.
From:	Cameron Hore, CPEng, PEng and Kendell Cator, EIT	**Project No:**	1CT022.017
Reviewed By:	John Kurylo, PEng, Maritz Rykaart, PhD PEng	**Date:**	November 17, 2017
Subject:	2017 South Dam Design – Liner Comparison		

1 Introduction

SRK Consulting (Canada) Inc. was requested by TMAC Resources Inc. to undertake the detailed design of the frozen foundation South Dam, as part of the Doris TIA at the Hope Bay Project. The intent of this memo is to present a comparison to assist in selecting a liner for use in construction of the South Dam. The liner will provide a low permeability element to minimise seepage through the dam.

This memo provides an overview of each liner type considered and includes a brief comparison in terms of constructability in cold climates and required quantities; taking into considering the liner supple currently on hand at the project. All liner material options presented below are considered technically suitable for purpose in the South Dam design. The decision on which liner to use therefore comes down primary to constructability, shipping requirements, and cost.

Recommendations for the preferred liner are presented at the end of the memorandum.

2 Liner Options

This section provides a brief overview of each of the liner options under consideration.

2.1 High Density Polyethylene (HDPE)

HDPE geomembrane liners are comprised of densely packed crystalline polymer chains. HDPE is the most commonly used geomembrane material world-wide, primarily due to price. The low cost of material not only results in common usage, but also allows designers and engineers to select thicker HDPE liners that have greater puncture resistance. A shortcoming of HDPE is that it lacks the flexibility and ability to maintain good contact with uneven surfaces in comparison to other liners. The use of HDPE liner in the South Dam would also require its pairing with a non-woven geotextile to protect the HDPE from over and underlying coarse aggregate.

A linear-low density polyethylene (LLDPE) which provides additional flexibility relative to HDPE could also be used, however this would not make use of the HDPE currently on site, as discussed

in Section 4.1. Due to the additional material requirements LLDPE is expected to end up being more expensive than the HDPE and, with only marginal benefits in terms of workability, has not been carried further forward in this comparison.

2.2 Geosynthetic Clay Liner (GCL)

GCLs consist of two layers of geotextiles, surrounding a layer of low permeability sodium bentonite, that are needle punched together to increase internal shear resistance (Nilex, 2010). GCL's can replace significantly thicker compacted clay liners, decreasing installation and construction efforts while achieving the same desired result.

2.3 Bituminous Geomembrane (BGM)

Bituminous geomembrane liners (BGM) consist of a polyester root barrier, a fiberglass structural reinforcing layer, a bitumen impregnated non-woven geotextile core, and an additional layer of oxidized bitumen. BGM's are heavy, thick and therefore fairly resistant to punctures, tearing, and stress cracking. Their weight and physical properties also allow them flexibility and the ability to maintain intimate contact with a properly prepared substrate. Since they are bitumen based, they are generally UV resistant and weather resistant (they may soften under high temperatures, but are slow to degrade), as well as chemically resistant. The coefficient of thermal expansion is essentially zero: BGMs are not susceptible to folding or wrinkling (leading to cracking) unlike most 'poly' liners and are able to a small extent self-heal (with limitations) due to the bituminous properties.

3 Construction Considerations

Several constructability factors should be considered when selecting a geomembrane including: the climate and weather (particularly extreme temperature ranges and high wind), chemical resistance, whether specialized equipment or crews are required, flexibility and workability of the material, and the method and ease in which the material is tied into the existing surface or bedrock.

3.1 HDPE

HDPE liners are moderately suited for deployment and installation in cold climates. These products become rigid and brittle when subject to sub-zero temperatures and they become harder to handle. It is typically required that HDPE liner is stored in a heated environment up to and immediately prior to use to remain flexible and free of moisture. The complexity and effort required to form the liner to irregular surfaces (exposed bedrock, etc.) can become increasingly difficult as temperatures progress further below 0°C. Due to HDPE liners light weight, it can be difficult to install them during windy conditions. This can become a major issue when installing a liner in an open and un-shielded setting. Welding (seaming) of individual product panels also becomes difficult in cold temperatures. HDPE (60 mil) normally has a practical welding restriction of -25˚C (Layfield, 2011). HDPE liner requires specialized equipment and crews to ensure successful joining of seams, and welding requires that no moisture is present on the seam in the form of frost or snow.

Backfilling against HDPE liners in cold temperatures requires significant care be taken in ensuring that backfill is free of frozen materials and that the backfill is cautiously placed on the liner to prevent localised destruction upon impact. In summary, installation of an HDPE liner may be more difficult than that of other liners due to its relative rigidity at low temperatures, its light weight, and the fact that it requires a considerable amount of intricate seam welding in the field.

HDPE liners can be installed in cold climates and in fact have already been installed previously (although on smaller areas) when SRK was on site during the construction of some of the ditches and ponds at the Doris North site. HDPE liners would be required to be 'textured' to ensure that they are easier to install (less slipping hazard), increase the frictional performance, and get better adhesion against underlying nonwoven geotextile.

3.2 GCL

Due to GCL weight, in comparison to HDPE, they can be installed in windier conditions with minimal additional effort (eliminates weighting the panels with sandbags, etc.). Welding seams of GCLs does not require specialized equipment or personnel, but requires the placement of bentonite powder between overlap seams and, if chosen, sewing seams shut.

A key consideration for GCLs is that they perform best when allowed to saturate under confinement following installation. A GCL does not function as a barrier until hydration takes place. The GCLs are ideally hydrated with clean water prior to use. As detailed in the Bentotext GCL Installation Guide (Geosynthetics, 2012) hydration is usually accomplished by natural rainfall if the GCL is covered by a permeable material. Care needs to be taken during installation to ensure that moisture is not introduced during installation (and snow removal is able to be carried out prior to installation). To limit the potential for the outside of the GCLs liner rolls to be come saturated before installation it is recommended that the GCL be kept under cover until deployed / installed. GCLs will not function as designed if the bentonite is allowed to free swell, i.e., if the bentonite swells after absorbing water during or before installation and before being confined in place

As detailed in the US EPA guidance (2001) free and thaw cycles do not affect GCLs when installed below the frost line (or 0°C isotherm). As far as the authors are aware, only a small number of laboratory and field testing of freeze and thaw cycles for bentonite blankets have been completed to date. This being noted, the limited laboratory tests that have been performed on a bentonitic blanket do indicate that hydraulic conductivity before freezing of 2 x 10^{-11} cm/sec was unaltered after five freeze and thaw cycles (US EPA 2001).

Also, as the rigidity of the GCL liners are not notably affected by cold weather they are overall fairly easy to install in cold weather. The North Dam at Hope Bay was successfully constructed with a GCL liner during winter on the Doris North site (SRK, 2012). SRK also successfully installed a secondary GCL liner at the Dam 1B on the Colomac site in the Northwest Territories. Another case study that supports GCL liners installation in extreme cold conditions is a case history form one of the Suncor oil sands tailings ponds (Athanassopoulos et al, 2011).

3.3 BGM

Due to the chemical and strength properties of BGM liners, they are able to be installed in cold climates. BGM liners have been proven to be installed in cold climates with installation up to - 40˚C. BGM liners are only moderately flexible but can be heated once laid down to better conform to the underlying subgrade. Like HDPE, BGM liner must be stored in a heated facility up to and immediately prior to use to remain flexible and free of moisture to ensure that the rolls are not damaged and will be able to be unrolled on site when needed. For the same reasons as a GCL, BGM liners can be installed during windier conditions. Welding seams between panels of BGM liners is a relatively straight forward process simply requiring propane torches, or similar tools, to heat the material prior to its adhesion to the adjacent panel. This being noted overall the installation of BGM liners is typically more labour intensive than installing GCL liners. Note that a bedding layer and a cover layer (above and below the liner) would still be expected to be maintained for a BGM liner. This bedding layer, if constructed with ROQ material crushed to pea gravel size (1" minus), can potential eliminate the need for a non-woven geotextile to be paired with the BGM liner (as confirmed by talking with Nilex Saskatoon, November 2017). This being noted based on SRKs past experiences the BGM installers can be somewhat particular about the subgrade and therefore a geotextile product is often required to be placed to avoid meticulous liner subgrade preparation and to ensure that the supplier will guarantee their placed product. Due to the time delays that would result if the liner supplier did not approve the subgrade or overline material before BGM placement it would suggested that geotextile be planned to be installed with the BGM to minimize schedule risks / impacts.

SRK has monitored the successful installation of a BGM liner in temperatures as low as - 40˚C at the Giant Mine in the Northwest Territories (SRK, 2008). For an additional case history example, BGM liners were also used in the construction of one of the dams at Diavik (Cunning et al, 2008).

4 Material Quantities

4.1 Currently on Site

It is SRK's understanding that materials currently available on site can be summarized as presented in Table 1. The condition of these materials (geotextile and HDPE) is not known. If the HDPE and/or the non-woven geotextile on site are to be used for construction, they must be inspected to ensure they are acceptable for use prior to placing the remaining material order. If the liner materials on site are damaged in any way they should be expected to not be able to be used.

Table 1: Material Quantities on Site

Material	Quantity (rolls)	Roll Dimension (m x m)	Total Area (roll - m^2)	Total Area (on site - m^2)	Storage Location on Site
HDPE Liner - SOLMAX 460ST (60 mil)[3]	6	6.8 x 159.5	1,083	6,500	Flat rack in Roberts Bay
Geotextile – 1200N non-woven (12oz)[2]	18	4.6 x 91.5[1]	418	15,000	CAN 389066 - Lower Reagent Pad
	18				CAN 291172 - Lower Reagent Pad

Notes:

1. Roll dimension based off WINFAB 1200N non-woven product data sheet.
2. It is assumed that the non-woven present on site is a 12 oz material produced by WINFAB (should be confirmed by site).

4.2 Required

Preliminary estimate for the liner requirement equates to 15,000 m^2, not including overlap between panels or wastage. The preliminary estimate for the non-woven geotextile requirement equates to 26,000 m^2 when paired with an HDPE liner (required above the HDPE liner in the key trench and on both sides within the dam shell). SRK has assumed a preliminary overlap and wastage allowance of 15%. A detailed panel layout should be developed once a liner is selected based on the dimensions of the rolls that will be taken to site. Based on the preliminary overlap and wastage allowance of 15% the total liner requirement equals 17,250 m^2. Table 2 summarizes the material requirements for each type of material, considering the HDPE liner and non-woven geotextile already present on site (Table 1).

For the HDPE and BGL liner options (Option A and C respectively) it is assumed that a crushed (sand and gravel or finer 1” minus or smaller) material will be used as a bedding layer for the liner. Therefore, a 12 oz (385 g/m^2) geotextile is assumed to be appropriate. If a bedding layer is not used on site, or if the bedding layer is coarse (i.e. primarily coarser than 1” gravel size), then the geotextile listed above would need to be increased in thickness to 16 oz or greater.

Table 2: Materials Required in Addition to Those Present on Site

Scenario	Material	Roll Dimension (panel - m x m)	Total Area (roll - m^2)	Quantity Required		Roll Weight (kg)	Total Shipment Weight (kg)	Roll Volume (m^3)	Total Shipment Volume (m^3)
				Area (m^2)	Rolls				
A*	HDPE Liner - SOLMAX 460T-2000 (60 mil)	6.8 x 164.6	1119.3	10,750[7]	10	1578	15,780	3.7	37
	Geotextile - 1200N non-woven (12 oz)	4.6 x 91.5	418	11,000[7]	27	170	4,590	0.9	44
	Total			21,750[7]	37	-	20,370		81
	*Scenario A - HDPE liner and geotextile quantities presented above are in addition to what is available on site. This assumes that all materials currently on site are suitable for use. Note that HDPE available on site is SOLMAX 460ST which is a one-sided slingle textured HDPE. This material is seen as suitable for the key trench but a double sided textured HDPE has been specified above for the portions of the liner systems that is above ground level.								
B	GCL Liner - Cetco Bentomat CLT	4.6 x 45.7	210	17,250	83	1,338	111,054	1.7	141
C**	BGM Liner - Coletanche ES4	5.1 x 55	280.5	17,250	62	1,795	111,290	3.3	206
	SUGGESTED Geotextile - 1200N non-woven (12 oz)	4.6 x 91.5	418	11,000[7]	27	170	4,590	0.9	44
	Total			28,250[7]	37	-	115,880		250
	**Scenario C – The BGM liner has been assumed to also require the placement of geotextile. Additional comments on this assumption are presented in Section 3.3. Similar to Case A all geotextile quantities presented above are in addition to what is available on site. This assumes that all materials currently on site are suitable for use.								

Other Notes:

1. HDPE Liner and non-woven geotextile are required together; the combined shipment weight of Option A is therefore approximately 20,370 kg and combined shipment volume is 81 m^3.
2. For Option B no geotextile is currently planned to be used (based on the expected liner subgrade preparation). Therefore, the total shipment weight for this option is approximately 111,054 kg and total shipment volume of 141 m^3.
3. For Option C a non-woven geotextile in addition to the BGM has been assumed. Therefore, the combined shipment weight of Option C is therefore approximately 115,880 kg with a combined shipment volume of 250 m^3.
4. The total material requirement for non-woven geotextile is 26,000 m^2 (required above the HDPE liner in the key trench and on both sides within the dam shell, including 15% wastage and overlap).
5. Materials specified for GCL liner and BGM liner were chosen for comparison purposes only, actual product specified if use in construction may vary.
6. Shipment weight does not include the steel core pipe of each roll.
7. Represents an additional quantity to that already present on site.
8. Technical Data Sheets for materials incorporated in Table 2 can be found in Attachment 1.

5 Recommendation

Due to logistics of constructing a frozen foundation dam, it is required that construction takes place in the winter months. Installation of an appropriate liner system is an important and integral part of the project, and must be completed correctly. There are many considerations and modified installation procedures that must be followed when installing liner in cold temperatures. Doing so can decrease installation effort and increase project success. Selecting the correct liner for the job is the first consideration which must be addressed.

Based on the comparison presented in this memorandum it is recommended that a GCL liner is selected for use in South Dam construction due to:

- Proven success of these liners on past cold climate projects completed by SRK,
- Ease of installation in cold/windy weather; and as it
- Does not require specialized equipment/crew for installation

Once a final decision has been made on the liner, SRK should also be supplied with planned purchase and shipping information. Specifically, SRK is interested in receiving the roll dimensions (length and width) for any liner material that is planned to be ordered. Following the receipt of this information a preliminary liner panel layout can be completed by SRK to confirm that the assumed 15% contingency for panel overlap and wastage is correct, thereby ensuring that enough liner material is shipped to site.

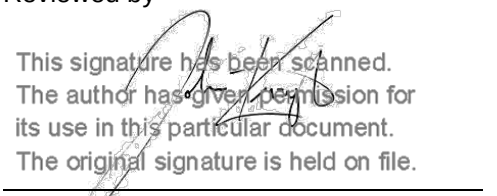
Finally, once the liner is shipped to site arrangements should be made to store the liner at a covered location on site.

Regards,

SRK Consulting (Canada) Inc.

Cameron Hore, CPEng.
Senior Consultant

Reviewed by



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The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

6 References

Athanassopoulos, C, Wells, P.S, Trinca S, Urchik, W. (Athanassopoulos et al 2011). The use of geosynthetics in the reclamation of an old sands tailings pond. Conference paper from Tailings and Mine Waste ’10. 2011 Taylor & Francis Group. ISBN 978-0-415-61455-9

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SRK Consulting (SRK, 2012). Hope Bay Project, North Dam As-Built Report. Prepared for Hope Bay Mining Ltd. October 2012.

United Stated Environmental Protection Agency. (US EPA 2001). Geosynthetic Clay Liners Used In Municipal Sold Waste Landfills. Solid Waste and Emergency Response pamphlet (5306W). EPA530-F-97-002, Revised December 2001.

Attachment 1
Technical Data Sheets

SOLMAX

TECHNICAL DATA SHEET

Solmax HDPE Smooth - Imperial Values

Solmax International Inc., 2801 Boul. Marie-Victorin, Varennes, Qc, Canada, J3X 1P7
Tel.: (450) 929-1234 Fax: (450) 929-2550 www.solmax.com

PROPERTY	TEST METHOD	FREQUENCY(1)	UNIT Imperial	Solmax 430-1000	Solmax 440-1000	Solmax 460-1000	Solmax 480-1000	Solmax 500-1000
SPECIFICATIONS								
Thickness (min. avg.)	ASTM D-5199	Every roll	mils	30.0	40.0	60.0	80.0	100.0
Thickness (min.)	ASTM D-5199	Every roll	mils	27.0	36.0	54.0	72.0	90.0
Resin Density	ASTM D-1505	1/Batch	g/cc	> 0.932	> 0.932	> 0.932	> 0.932	> 0.932
Melt Index - 190/2.16 (max.)	ASTM D-1238	1/Batch	g/10 min	1.0	1.0	1.0	1.0	1.0
Sheet Density (8)	ASTM D-1505	Every 2 rolls	g/cc	≥ 0.940	≥ 0.940	≥ 0.940	≥ 0.940	≥ 0.940
Carbon Black Content (9)	ASTM D-4218	Every 2 rolls	%	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D-5596	Every 6 rolls	Category	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2
OIT - standard (avg.)	ASTM D-3895	1/Batch	min	100	100	100	100	100
Tensile Properties (min. avg) (2)	ASTM D-6693	Every 2 rolls						
Strength at Yield			ppi	66	84	130	177	210
Elongation at Yield			%	13	13	13	13	12
Strength at Break			ppi	122	162	243	326	380
Elongation at Break			%	700	700	700	700	700
Tear Resistance (min. avg.)	ASTM D-1004	Every 6 rolls	lbf	21	28	42	57	70
Puncture Resistance (min. avg.)	ASTM D-4833	Every 6 rolls	lbf	60	80	122	155	180
Dimensional Stability	ASTM D-1204	Certification	%	± 2	± 2	± 2	± 2	± 2
Stress Crack Resistance (SP-NCTL)	ASTM D-5397	1/Batch	hr	500	500	500	500	500
Oven Aging - % retained after 90 days	ASTM D-5721	Per formulation						
HP OIT (min. avg.)	ASTM D-5885		%	80	80	80	80	80
UV Resistance - % retained after 1600 hr	GRI-GM-11	Per formulation						
HP-OIT (min. avg.)	ASTM D-5885		%	50	50	50	50	50
SUPPLY SPECIFICATIONS	(Roll dimensions may vary ±1%)							
Roll Dimension - Width	-		ft	22.3	22.3	22.3	22.3	22.3
Roll Dimension - Length	-		ft	1,000	780	520	400	320
Area (Surface/Roll)	-		sf	20,494	17,394	11,596	8,920	7,136

NOTES

1. Testing frequency based on standard roll dimensions and one batch is approximately 180,000 lbs (or one railcar).
2. Machine Direction (MD) and Cross Machine Direction (XMD or TD) average values should be on the basis of 5 specimens each direction.
8. Correlation table is available for ASTM D792 vs ASTM D1505. Both methods give the same results.
9. Correlation table is available for ASTM D1603 vs ASTM D4218. Both methods give the same results.

* All values are nominal test results, except when specified as minimum or maximum.
* The information contained herein is provided for reference purposes only and is not intended as a warranty of guarantee. Final determination of suitability for use contemplated is the sole responsability of the user. SOLMAX assumes no liability in connection with the use of this information.

SOLMAX

TECHNICAL DATA SHEET

Solmax Single-Sided Textured - Imperial Values

Solmax International Inc., 2801 Boul. Marie-Victorin, Varennes, Qc, Canada, J3X 1P7
Tel.: (450) 929-1234 Fax: (450) 929-2550 www.solmax.com

PROPERTY	TEST METHOD	FREQUENCY(1)	UNIT Imperial	Solmax 430ST-1000	Solmax 440ST-1000	Solmax 460ST-1000	Solmax 480ST-1000	Solmax 500ST-1000
SPECIFICATIONS								
Nominal Thickness	-	-	mils	30.0	40.0	60.0	80.0	100.0
Thickness (min. avg.)	ASTM D-5994	Every roll	mils	28.5	38.0	57.0	76.0	95.0
Lowest individual for 8 out of 10 values			mils	27.0	36.0	54.0	72.0	90.0
Lowest individual for 10 out of 10 values			mils	26.0	34.0	51.0	68.0	85.0
Asperity Height (min. avg.) (3)	ASTM D-7466	Every roll	mils	16	16	16	16	16
Resin Density	ASTM D-1505	1/Batch	g/cc	> 0.932	> 0.932	> 0.932	> 0.932	> 0.932
Melt Index - 190/2.16 (max.)	ASTM D-1238	1/Batch	g/10 min	1.0	1.0	1.0	1.0	1.0
Sheet Density (8)	ASTM D-1505	Every 2 rolls	g/cc	≥ 0.940	≥ 0.940	≥ 0.940	≥ 0.940	≥ 0.940
Carbon Black Content (9)	ASTM D-4218	Every 2 rolls	%	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D-5596	Every 6 rolls	Category	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2
OIT - standard (avg.)	ASTM D-3895	1/Batch	min	100	100	100	100	100
Tensile Properties (min. avg) (2)	ASTM D-6693	Every 2 rolls						
Strength at Yield			ppi	63	88	132	176	210
Elongation at Yield			%	12	13	13	13	12
Strength at Break			ppi	46	88	132	167	150
Elongation at Break			%	100	150	150	150	100
Tear Resistance (min. avg.)	ASTM D-1004	Every 6 rolls	lbf	21	30	45	60	70
Puncture Resistance (min. avg.)	ASTM D-4833	Every 6 rolls	lbf	45	90	120	150	150
Dimensional Stability	ASTM D-1204	Certification	%	± 2	± 2	± 2	± 2	± 2
Stress Crack Resistance (SP-NCTL)	ASTM D-5397	1/Batch	hr	500	500	500	500	500
Oven Aging - % retained after 90 days	ASTM D-5721	Per formulation						
HP OIT (min. avg.)	ASTM D-5885		%	80	80	80	80	80
UV Resistance - % retained after 1600 hr	GRI-GM-11	Per formulation						
HP-OIT (min. avg.)	ASTM D-5885		%	50	50	50	50	50
SUPPLY SPECIFICATIONS	(Roll dimensions may vary ±1%)							
Roll Dimension - Width	-		ft	22.3	22.3	22.3	22.3	22.3
Roll Dimension - Length	-		ft	1,000	780	560	440	320
Area (Surface/Roll)	-		sf	22,300	17,394	12,488	9,812	7,136

SOLMAX

TECHNICAL DATA SHEET

Solmax Single-Sided Textured - Imperial Values

Solmax International Inc., 2801 Boul. Marie-Victorin, Varennes, Qc, Canada, J3X 1P7
Tel.: (450) 929-1234 Fax: (450) 929-2550 www.solmax.com

PROPERTY	TEST METHOD	FREQUENCY(1)	UNIT Imperial	Solmax 430ST-1000	Solmax 440ST-1000	Solmax 460ST-1000	Solmax 480ST-1000	Solmax 500ST-1000

NOTES

1. Testing frequency based on standard roll dimensions and one batch is approximately 180,000 lbs (or one railcar).
2. Machine Direction (MD) and Cross Machine Direction (XMD or TD) average values should be on the basis of 5 specimens each direction.
3. Lowest individual and 8 out of 10 readings as per GRI-GM13 / 17, latest version.
8. Correlation table is available for ASTM D792 vs ASTM D1505. Both methods give the same results.
9. Correlation table is available for ASTM D1603 vs ASTM D4218. Both methods give the same results.

* All values are nominal test results, except when specified as minimum or maximum.
* The information contained herein is provided for reference purposes only and is not intended as a warranty of guarantee. Final determination of suitability for use contemplated is the sole responsability of the user. SOLMAX assumes no liability in connection with the use of this information.

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TECHNICAL DATA SHEET

Solmax HDPE Textured - Imperial Values

Solmax International Inc., 2801 Boul. Marie-Victorin, Varennes, Qc, Canada, J3X 1P7
Tel.: (450) 929-1234 Fax: (450) 929-2550 www.solmax.com

PROPERTY	TEST METHOD	FREQUENCY(1)	UNIT Imperial	Solmax 430T-1000	Solmax 440T-1000	Solmax 460T-1000	Solmax 480T-1000	Solmax 500T-1000
SPECIFICATIONS								
Nominal Thickness	-	-	mils	30.0	40.0	60.0	80.0	100.0
Thickness (min. avg.)	ASTM D-5994	Every roll	mils	28.5	38.0	57.0	76.0	95.0
Lowest individual for 8 out of 10 values			mils	27.0	36.0	54.0	72.0	90.0
Lowest individual for 10 out of 10 values			mils	26.0	34.0	51.0	68.0	85.0
Asperity Height (min. avg.) (3)	ASTM D-7466	Every roll	mils	16	16	16	16	16
Resin Density	ASTM D-1505	1/Batch	g/cc	> 0.932	> 0.932	> 0.932	> 0.932	> 0.932
Melt Index - 190/2.16 (max.)	ASTM D-1238	1/Batch	g/10 min	1.0	1.0	1.0	1.0	1.0
Sheet Density (8)	ASTM D-1505	Every 2 rolls	g/cc	≥ 0.940	≥ 0.940	≥ 0.940	≥ 0.940	≥ 0.940
Carbon Black Content (9)	ASTM D-4218	Every 2 rolls	%	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0	2.0 - 3.0
Carbon Black Dispersion	ASTM D-5596	Every 6 rolls	Category	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2	Cat. 1 & Cat. 2
OIT - standard (avg.)	ASTM D-3895	1/Batch	min	100	100	100	100	100
Tensile Properties (min. avg) (2)	ASTM D-6693	Every 2 rolls						
Strength at Yield			ppi	66	88	132	176	210
Elongation at Yield			%	12	12	13	13	12
Strength at Break			ppi	66	88	132	167	150
Elongation at Break			%	150	150	150	150	150
Tear Resistance (min. avg.)	ASTM D-1004	Every 6 rolls	lbf	23	30	45	60	70
Puncture Resistance (min. avg.)	ASTM D-4833	Every 6 rolls	lbf	60	90	120	150	150
Dimensional Stability	ASTM D-1204	Certification	%	± 2	± 2	± 2	± 2	± 2
Stress Crack Resistance (SP-NCTL)	ASTM D-5397	1/Batch	hr	500	500	500	500	500
Oven Aging - % retained after 90 days	ASTM D-5721	Per formulation						
HP OIT (min. avg.)	ASTM D-5885		%	80	80	80	80	80
UV Resistance - % retained after 1600 hr	GRI-GM-11	Per formulation						
HP-OIT (min. avg.)	ASTM D-5885		%	50	50	50	50	50
SUPPLY SPECIFICATIONS	(Roll dimensions may vary ±1%)							
Roll Dimension - Width	-		ft	22.3	22.3	22.3	22.3	22.3
Roll Dimension - Length	-		ft	1,000	780	540	420	320
Area (Surface/Roll)	-		sf	22,300	17,394	12,042	9,366	7,136

SOLMAX

TECHNICAL DATA SHEET

Solmax HDPE Textured - Imperial Values

Solmax International Inc., 2801 Boul. Marie-Victorin, Varennes, Qc, Canada, J3X 1P7
Tel.: (450) 929-1234 Fax: (450) 929-2550 www.solmax.com

PROPERTY	TEST METHOD	FREQUENCY(1)	UNIT Imperial	Solmax 430T-1000	Solmax 440T-1000	Solmax 460T-1000	Solmax 480T-1000	Solmax 500T-1000

NOTES

1. Testing frequency based on standard roll dimensions and one batch is approximately 180,000 lbs (or one railcar).
2. Machine Direction (MD) and Cross Machine Direction (XMD or TD) average values should be on the basis of 5 specimens each direction.
3. Lowest individual and 8 out of 10 readings as per GRI-GM13 / 17, latest version.
8. Correlation table is available for ASTM D792 vs ASTM D1505. Both methods give the same results.
9. Correlation table is available for ASTM D1603 vs ASTM D4218. Both methods give the same results.

* All values are nominal test results, except when specified as minimum or maximum.
* The information contained herein is provided for reference purposes only and is not intended as a warranty of guarantee. Final determination of suitability for use contemplated is the sole responsability of the user. SOLMAX assumes no liability in connection with the use of this information.

SOLMAX

TECHNICAL DATA SHEET

HDPE Series, 1.50 mm

Black, Textured

2801 Marie-Victorin Blvd. Varennes, Quebec Canada J3X 1P7
Tel: (450) 929-1234 Sales: (450) 929-2544 Toll free in North America:1-800-571-3904 www.Solmax.com www.solmax.com

PROPERTY	TEST METHOD	FREQUENCY(1)	UNIT Metric	1042792
SPECIFICATIONS				
Nominal Thickness	-	-	mm	1.50
Thickness (min. avg.)	ASTM D-5994	Every roll	mm	1.43
Lowest ind. for 8 out of 10 values			mm	1.35
Lowest ind. for 10 out of 10 values			mm	1.28
Asperity Height (min. avg.) (3)	ASTM D-7466	Every roll	mm	0.40
Resin Density	ASTM D-1505	1/Batch	g/cc	> 0.932
Sheet Density (8)	ASTM D-792	Every 10 rolls	g/cc	≥ 0.940
Carbon Black Content (9)	ASTM D-4218	Every 2 rolls	%	2.0 - 3.0
Carbon Black Dispersion	ASTM D-5596	Every 10 rolls	Category	Cat. 1 / Cat. 2
OIT - standard (avg.)	ASTM D-3895	Per formulation	min	100
Tensile Properties (min. avg) (2)	ASTM D-6693	Every 2 rolls		
Strength at Yield			kN/m	23
Elongation at Yield			%	13
Strength at Break			kN/m	23
Elongation at Break			%	150
Tear Resistance (min. avg.)	ASTM D-1004	Every 5 rolls	N	200
Puncture Resistance (min. avg.)	ASTM D-4833	Every 5 rolls	N	535
Dimensional Stability	ASTM D-1204	Certified	%	± 2
Stress Crack Resistance (SP-NCTL)	ASTM D-5397	1/Batch	hr	500
Oven Aging - % retained after 90 days	ASTM D-5721	Per formulation		
HP OIT (min. avg.)	ASTM D-5885		%	80
UV Res. - % retained after 1600 hr	GRI-GM-11	Per formulation		
HP-OIT (min. avg.)	ASTM D-5885		%	50
SUPPLY SPECIFICATIONS (Roll dimensions may vary ±1%)				
Roll Dimension - Width	-		m	6.80
Roll Dimension - Length	-		m	164.6
Area (Surface/Roll)	-		m^2	1119.3

NOTES

1. Testing frequency based on standard roll dimension and one batch is approximately 180,000 lbs (or one railcar).
2. Machine Direction (MD) and Cross Machine Direction (XMD or TD) average values should be on the basis of 5 specimens each direction.
3. Lowest individual and 8 out of 10 readings as per GRI-GM13 / 17, latest version.
8. Correlation table is available for ASTM D792 vs ASTM D1505. Both methods give the same results.
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WINFAB INDUSTRIAL FABRICS

PRODUCT DATA SHEET

WINFAB 1200N

FILTRATION | EROSION PROTECTION | DRAINAGE | SEPARATION

WINFAB 1200N is a needlepunched nonwoven geotextile manufactured using polypropylene fibers that are formed into a dimensionally stable network, which allows the fibers to maintain their relative position.
WINFAB 1200N resists ultraviolet deterioration, rotting, and biological degradation and is inert to commonly encountered soil chemicals.

PROPERTY	TEST METHOD	MARV English	MARV Metric
Tensile Strength (Grab)	ASTM D4632	300 x 300 lbs	1335 x 1335 N
Elongation	ASTM D4632	50%	50%
CBR Puncture	ASTM D6241	825 lbs	3670 N
Trapezoidal Tear	ASTM D4533	115 x 115 lbs	511 x 511 N
UV Resistance (500 hrs)	ASTM D4355	70%	70%
Apparent Opening Size (AOS)*	ASTM D4751	100 US Std. Sieve	0.150 mm
Permittivity	ASTM D4491	1.0 sec^{-1}	1.0 sec^{-1}
Water Flow Rate	ASTM D4491	75 gpm/ft^2	3055 lpm/m^2

***Maximum Average Roll Valve**

Notes:
- Mullen Burst ASTM D3786 has been removed. It is not recognized by ASTM D35 on Geosynthetics.
- Puncture ASTM D4833 has been removed. It is not recognized by AASHTO M288 and has been replaced with CBR Puncture ASTM D6241

PROPERTY	Typical English	Typical Metric
Roll Dimensions	15 x 300 ft	4.6 x 91.5 m
Roll Area	500 yd^2	418 m^2

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GMA Geosynthetic Materials Association

CETCO® LINING TECHNOLOGIES

BENTOMAT® & CLAYMAX® PANEL & ROLL SPECIFICATIONS

Panel Specifications

PRODUCTS	DIMENSIONS WIDTH x LENGTH	AREA	EFFECTIVE AREA
BENTOMAT® ST	15 ft x 150 ft (4.6 m x 45.7 m)	2,250 ft^2 (209 m^2)	2,145 ft^2 (200 m^2)
BENTOMAT SDN	14.5 ft x 150 ft (4.4 m x 45.7 m)	2,175 ft^2 (202 m^2)	2,071 ft^2 (193 m^2)
BENTOMAT DN	14.5 ft x 150 ft (4.4 m x 45.7 m)	2,175 ft^2 (202 m^2)	2,071 ft^2 (193 m^2)
BENTOMAT CL	15 ft x 150 ft (4.6 m x 45.7 m)	2,250 ft^2 (209 m^2)	2,070 ft^2 (193 m^2)
BENTOMAT CLT	15 ft x 150 ft (4.6 m x 45.7 m)	2,250 ft^2 (209 m^2)	2,070 ft^2 (193 m^2)
BENTOMAT 200R	15 ft x 150 ft (4.6 m x 45.7 m)	2,250 ft^2 (209 m^2)	2,145 ft^2 (200 m^2)
CLAYMAX 200R (Lovell)	15 ft x 150 ft (4.6 m x 45.7 m)	2,250 ft^2 (209 m^2)	2,040 ft^2 (190 m^2)

Roll Specifications

PRODUCTS	DIMENSIONS Length x Diameter (Avg.)	NOMINAL WEIGHT	ROLLS / TRUCKLOAD
BENTOMAT ST	16 ft x 24 in (4.9 m x 610 mm)	2,650 lbs (1204 kg)	17 rolls per truckload
BENTOMAT SDN	16 ft x 24 in (4.9 m x 610 mm)	2,650 lbs (1204 kg)	16 rolls per truckload
BENTOMAT DN	16 ft x 24 in (4.9 m x 610 mm)	2,700 lbs (1227 kg)	16 rolls per truckload
BENTOMAT CL	16 ft x 25 in (4.9 m x 635 mm)	2,750 lbs (1250 kg)	15 rolls per truckload
BENTOMAT CLT	16 ft x 26 in (4.9 m x 660 mm)	2,950 lbs (1340 kg)	15 rolls per truckload
BENTOMAT 200R	16 ft x 24 in (4.9 m x 610 mm)	2,650 lbs (1204 kg)	17 rolls per truckload
CLAYMAX 200R (Lovell)	16 ft x 20 in (4.9 m x 510 mm)	3,000 lbs (1363 kg)	15 rolls per truckload

Unloading and handling equipment for all GCL products:

- Spreader bar and core pipe: Spreader bar 17 ft (5.2 m) long; core pipe 20 ft (6.1 m) long, nominal pipe size, XXH.
- A solid 3.5 in. (90 mm) O.D. x 14.5 ft (4.4 m) solid steel pipe stinger attachment for a forklift.
- Slings: 2 Polyester slings are required, approximately 12 ft (3.7 m) long x 2 in (50 mm) wide each.
- Vehicle needed: Front end loader or forklift (are typical).

Standard Roll Specifications:

- Packaging: U.V. resistant polyethylene sleeve.

800.527.9948 Fax 847.577.5566

For the most up-to-date product information, please visit our website, www.cetco.com.
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BENTOMAT® CLT

GEOSYNTHETIC CLAY LINER

BENTOMAT CLT CERTIFIED PROPERTIES			
MATERIAL PROPERTY	**TEST METHOD**	**TEST FREQUENCY ft²(m²)**	**REQUIRED VALUES**
Bentonite Swell Index[1]	ASTM D 5890	1 per 50 tonnes	24 mL/2g min.
Bentonite Fluid Loss[1]	ASTM D 5891	1 per 50 tonnes	18 mL max.
Bentonite Mass/Area[2]	ASTM D 5993	40,000 ft² (4,000 m²)	0.75 lb/ft² (3.6 kg/m²) min
GCL Grab Strength[3]	ASTM D 6768	200,000 ft² (20,000 m²)	45 lbs/in (70 N/cm) MARV
GCL Peel Strength[3]	ASTM D 6496	40,000 ft² (4,000 m²)	3.5 lbs/in (6.1 N/cm) min
GCL Hydraulic Conductivity[4]	ASTM D 5887	Periodic	5 x 10^{-10} cm/sec max
GCL Hydrated Internal Shear Strength[5]	ASTM D 5321 ASTM D 6243	Periodic	500 psf (24 kPa) typical

Bentomat CLT is a reinforced GCL consisting of a layer of sodium bentonite between two geotextiles, which are needlepunched together and laminated to a 20-mil (0.5mm) double-sided textured HDPE geomembrane. Bentomat CLT is also available with textured HDPE geomembrane thicknesses of 30-mils (0.75mm), 40-mils (1.0mm) and 60-mils (1.5mm). The geomembrane component of Bentomat CLT is compliant with the GRI-GM-13 specification for HDPE geomembranes.

Notes

[1] Bentonite property tests performed at a bentonite processing facility before shipment to CETCO's GCL production facilities.

[2] Bentonite mass/area reported at 0 percent moisture content.

[3] All tensile strength testing is performed in the machine direction using ASTM D 6768. All peel strength testing is performed using ASTM D 6496. Upon request, tensile and peel results can be reported per modified ASTM D 4632 using 4 inch grips.

[4] ASTM D5887 Index flux and hydraulic conductivity testing with deaired distilled/deionized water at 80 psi (551 kPa) cell pressure, 77 psi (531 kPa) headwater pressure and 75 psi (517 kPa) tailwater pressure. ASTM D 5887 testing is performed only on a periodic basis because the geomembrane is essentially impermeable. The GCL component alone (without the geomembrane) has a hydraulic conductivity of 5 x 10^{-9} cm/s.

[5] Peak value measured at 200 psf (10 kPa) normal stress for a specimen hydrated for 48 hours. Site-specific materials, GCL products, and test conditions must be used to verify internal and interface strength of the proposed design.

TR 401-BMCLT 09/13

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TDS_BENTOMATCLT_AM_EN_201402_v1

CETCO®
OUR STANDARDS. YOUR PEACE OF MIND.
A Minerals Technologies Company

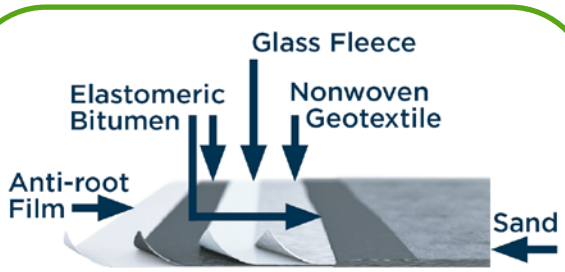
COLETANCHE BITUMINOUS GEOMEMBRANE (BGM) LINERS

Bituminous Geomembrane (BGM) liners are an extremely versatile flame-resistant containment solution. The U.S. Nuclear Safety Agency qualifies them for a 1,000 year life span, based on UV resistance and physical durability. Highly resistant to punctures and tearing, they're also highly flexible and can hold a friction angle of 34 degrees. They are compatible with most materials, which makes them safe for direct installation on most soil types.

Some other BGM features include:

- Meets ULC-S668-12 flammability requirements
- Capable of direct cover by vegetation, poured concrete and hot mix asphalt -- temperature is not a concern
- Flexibility and dimensional stability provide permanent contact with substrate and makes it ideal for differential settlement
- Resistance to chemicals (including VOCs), biological agents and oxidation
- UV resistance means it can be left exposed indefinitely
- Self-sealing bituminous internal mass can flow and seal penetrations
- Installation on 2" compacted subgrade significantly reduces site preparation costs
- High surface mass allows installation in strong wind or underwater and saves on ballasting costs and effort
- Easy to weld and bond and can be welded to other membranes (HDPE, LLDPE, Polypropylene or PVC), other types of BGM, concrete or steel
- Can be installed at conditions as low as -40°C

Product Specifications are included on the back of this sample card



- Sanded finish aids site safety by providing worker traction, and helps hold soil in place.
- The combination of glass fleece and nonwoven polyester gives BGM liners superior puncture resistance and tensile strength.

PRODUCT SPECIFICATIONS

Coletanche Bituminous Geomembrane (BGM) Liners

Properties for the five product layers:	**ES1**	**ES2**	**ES3**	**ES4**
Glass Mat Reinforcement:	• 50 g/m²	• 50 g/m²	• 50 g/m²	• 50 g/m²
Nonwoven Geotextile Reinforcement:	• 200 g/m²	• 250 g/m²	• 300 g/m²	• 400 g/m²
Binder:	• 3,800 g/m²	• 4,300 g/m²	• 4,800 g/m²	• 5,400 g/m²
Surface Finish:	• Sand, 200 g/m²	• Sand, 200 g/m²	• Sand, 200 g/m²	• Sand, 200 g/m²
Under Surface Finish, 15 g/m²:	• Polyester	• Polyester anti-root	• Polyester anti-root	• Polyester anti-root
Roll dimensions (W x L):	• 5.10 m x 90 m	• 5.10 m x 80 m	• 5.10 m x 65 m	• 5.10 m x 55 m
Uses	• Ditches • Landfill covers • Waste tip covers of moderate height	• Landfill covers • Hydraulic ponds • Industrial liquid waste containment • Canals • Contaminated Land	• Railways, directly under ballast • Dams	• Railways, directly under ballast • Dams
Thickness ASTM D5199 (mm, incl. Min/Max)	4.00 3.80 / 4.40	4.00 3.80 / 4.40	4.80 4.56 / 5.28	5.60 5.32 / 6.16
Surface Mass ASTM D3776 (kg/m² incl. Min/Max)	4.20 3.89 / 4.50	4.85 4.50 / 5.20	5.80 5.37 / 6.20	6.40 6.10 / 7.00
Max. Tensile Strength ASTM D7275 (kN/m)	Longitudinal: 22 Cross-Direction: 18	Longitudinal: 27 Cross-Direction: 24	Longitudinal: 33 Cross-Direction: 29	Longitudinal: 39 Cross-Direction: 31
Tensile Elongation ASTM D7275 (%)	Longitudinal: 60 Cross-Direction: 60	Longitudinal: 60 Cross-Direction: 60	Longitudinal: 60 Cross-Direction: 60	Longitudinal: 60 Cross-Direction: 60
Water Permeability ASTM E96 (m/s)	6.10^{-14}	4.10^{-14}	6.10^{-14}	6.10^{-14}
Gas Permeability ASTM D1434-82 [m³/(m².j.atm)]	< 2, 3.10^{-14}	< 2, 3.10^{-14}	< 2, 3.10^{-14}	< 2, 3.10^{-14}
Oxidation EN 14575 (Max. Tensile Strength / Elongation, %)	100 / 100	100 / 100	100 / 100	100 / 100

Rolls must not be stored directly on the ground. They must be supported on concrete blocks, trestles or timber beams of a minimum 35 cm height, placed under the mandrel ends.

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COLETANCHE®

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CANADA

Prepared:
05/07/2013
Cancels and replaces:
29/04/2013
Code :
1878001
Manufacture source
Courchelettes (59-France)
Technical ref:
FT AXTER ES4 ASTM

PRODUCT DATA SHEET

COLETANCHE ES 4

DESCRIPTION

COLETANCHE ES 4 is an SBS elastomeric modified bituminous geomembrane.

USE

Extreme level of mechanical resistance, for use as environmental protection and droungworks waterproofing (aggressive materials,reinforced precautions), in particular :
- Railways, directly under ballast,
- Dams,

Product use must be validated by Axter.

APPLICATION METHOD

Torched

STORAGE

Rolls must not be stored directly on the ground. They must be laid supported on concrete blocks, trestles or timber beams) min 35 cm height, placed under the mandrel ends.

COMPOSITION

(indicative)

Reinforcement (g/m²) :	Glass mat	50
Reinforcement (g/m²) :	Non-woven geotextile	400
Binder (g/m²) :	Elastomeric SBS	5400
Surface finish (g/m²) :	Sand	200
Under surface finish (g/m²) :	Polyester antiroot film	15

CHARACTERISTICS

		STANDARD	UNITS	VALUES	Tolerance Min	Tolerance Max
Dimensions	Length	-	*m*	54	≥	
	Width		*m*	5.01	≥	
Thickness (on finished product)		*ASTM D 5199*	mm	5.60	*5.32*	*6.16*
Surface mass		*ASTM D 3776*	kg/m²	6.40	*6.10*	*7.00*
Resistance to tearing	Longitudinal	*ASTM D 4073*	N	1225	*919*	
	Cross direction			1025	*769*	
Tensile properties : maximum tensile strength	Longitudinal	*ASTM D 7275*	kN/m	39	*29.2*	
	Cross direction			31	*23.2*	
Tensile properties : elongation	Longitudinal		%	60	*48*	
	Cross direction			60	*48*	
Tensile properties : maximum tensile strength	Longitudinal	*ASTM D 4595*	kN/m	32	*24*	
	Cross direction			28	*21*	
Tensile properties : elongation	Longitudinal		%	90	*60*	
	Cross direction			90	*60*	
Static Puncture		*ASTM D 4833*	N	650	*585*	
Flexibility at low temperature	Surface	*ASTM D 5147*	°C	-20		
	Under surface			-20		
Water permeability (liquid tightness)		*ASTM E 96*	*m/s*	6.10^{-14}		
Gas permeability (gas tightness)		*ASTM D 1434-82*	*m3/(m².j.atm)*	$< 2{,}3.10^{-14}$		

NOTE: AXTER COLETANCHE INC. may modify the composition and/or utilisation of its products without prior notice. Consequently orders will be filled according to the latest specification.
The manufacturer reserves the right to modify, at any time, the characteristics of its products.

Appendix G.2 – Contingency Measures Memo

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Vancouver, BC V6E 3X2

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Memo

To:	Kelly Schwenning, TMAC Resources	**Client:**	TMAC Resources Inc.
From:	Cameron Hore, PEng	**Project No:**	1CT022.030
Reviewed By	Maritz Rykaart, PEng	**Date:**	May 15, 2018
Subject:	South Dam Foundation Contingency Mitigation Measures		

1 Introduction

The South Dam, as part of the Doris Tailings Impoundment Area (TIA) at Hope Bay, is currently under construction. SRK Consulting (Canada) Inc. undertook the design and prepared the issue for construction (IFC) drawings (SRK 2018) for the South Dam and has been retained by TMAC Resources Inc. (TMAC) to provide construction supervision and quality assurance.

Delays to the dam construction and installation of the Roberts Bay Discharge Systems (RBDS) has resulted in the potential risk of ponded water against the upstream face of the South Dam following freshet leading to the potential development of a high flow seepage pathway through the dam foundation. The South Dam is designed as a frozen foundation dam with the intent to continuously develop a tailings beach along the upstream face to limit water and heat transfer to the foundation.

To prevent this, ponded water must be kept off the area immediately upstream of the South Dam. The delay in the South Dam construction means that tailings deposition as per the original design may not be achievable prior to freshet. The delay in installation of the RBDS means that the active reduction in water level by discharge, to avoid ponding in this area will not be achievable. As such, additional measures are required to be taken to prevent ponded water within this area.

This memo presents an implementation plan for contingency measures to overcome this potential risk. This memo is not intended to provide a comprehensive analysis of the potential risks, nor be a reference document for the investigative work undertaken. Additional documentation on the identified conditions and analyses will be provided under separate cover as part of the as-built documentation.

Attached to this memo are three drawings (SDTD-01 to SDTD-03) that present the design of the contingency measures described in the Section 3.

2 Identified Issues

2.1 South Dam Foundation

The South Dam construction included additional foundation investigation works consisting of percolation testing and mapping of ice rich zones within the key trench excavation. The investigation found significant zones of ice rich soil and the presence of ice wedges within the footprint of the dam and the key trench. The ice wedges are potentially interconnected and potentially form a continuous ice 'path' extending from upstream of the dam, beneath the key trench, to downstream of the dam.

The key trench depth of 4 m below the original ground surface was selected as thermal modelling has shown that the ground will remain frozen (<-2 degrees Celsius) below this depth. The thermal modelling assumes tailings is deposited from the South Dam to provide a thermal barrier and a low permeability material overlying the natural ground, which contains the ice wedges. Should water be allowed to pond immediately upstream of the South Dam without tailings deposition, this would result in potential thawing of the ice wedges, and thawing of the foundation below the key trench. This would cause thaw induced settlement of the dam foundation and opening of a potentially high flow seepage pathway beneath the key trench.

Thaw induced settlement of the South Dam is not expected to cause a catastrophic failure of the Dam or affect the long-term performance assuming an adequate tailings beach is developed, and could be mitigated by additional fill placement to compensate for the settlement.

Potential development of a high flow seepage pathway beneath the key trench has the potential to cause a catastrophic failure of the dam and would result in release of impounded water which may or may not meet discharge requirements. Therefore, measures must be taken to mitigate this risk.

2.2 South Dam Construction Completion

The South Dam was planned to be completed by the end of May 2018 and prior to freshet. Tailings deposition from the South Dam can not begin until construction is completed. If construction is not completed prior to freshet there will be a significant risk to the dam performance, due to impounded water directly upstream of the dam that could result in thawing of the dam foundation and development of high flow seepage pathways through the foundation.

2.3 Delay of RBDS installation

The RBDS is the permitted system for discharge of excess water in the tailings impoundment area (TIA) and excess water from the underground mine to the ocean. The RBDS was intended to be operational during 2017; however, TMAC decided to defer construction to the 2018 open water season. As a result, a temporary deposition berm was constructed to protect the South Dam foundation prior to its construction. The installation of the RBDS has further been delayed to late 2018 with the planned operation by March 2019.

As the RBDS will not be operational until 2019, there is further risk of water ponding against the South Dam. The delay in the installation and operation of the RBDS will result in a temporarily higher TIA water level, as no discharge will occur during the 2018 open water season as was originally planned.

SRK has undertaken stochastic water balance modelling to calculate the likely water level within the TIA without discharge in 2018. The results indicate a 95-percentile open water level of 31.7 m in October 2018 (end of open water season). It is therefore recommended that a temporary water retainment structure to a minimum elevation of 32 m be constructed.

It is important to note that this does not change the overall TIA full supply level (33.5 m) or freeboard calculations. This relates only to the temporary containment of water within the bounds of the TIA upstream of the South Dam.

3 Mitigation Measures

The proposed mitigation measures are to raise the temporary deposition berm (berm) north of the South Dam to allow further tailings deposition and creation of a tailings beach up to a level of 32 m.

The existing berm and extent of the existing tailings beach is illustrated in Drawing SDTD-01. The berm was originally constructed in 2017 north of the South Dam, to protect the South Dam foundation prior to its construction. The existing tailings beach slope was estimated to be approximately 1.5% in the upper beach adjacent to the berm.

The existing berm will be raised by 1.5 m to an elevation of 32.5 m using the same methodology as the existing berm, for a higher level of containment, as shown in Drawing SDTD-02. Additionally, a small rockfill windrow will be constructed immediately south of the current lake ice boundary on the frozen tailings beach. This windrow will withhold the majority of the tailings solids, minimising the volume of tailings required to provide containment and preventing a thick layer of tailings developing over the existing lake ice. This windrow must be constructed while the existing tailings beach is frozen and trafficable. SRK has modelled the deposition of tailings from the proposed raised berm to the windrow and calculated an additional tailings volume of 9,000 m^3 to develop the beach up to the 32 m elevation level. At the current production rate of approximately 1,000 tpd and tailings density of 1.3 t/m^3 it will take approximately 12 days to develop the required beach, assuming no spill through the windrow. Multiple deposition points will be required across the berm to ensure even development of the beach level as shown on Drawing SDTD-02. It is noted that the windrow will likely sink into the existing tailings, as the tailings thaws. This is not a concern as the purpose of the windrow (initial withholding of tailings solids) will have already been utilised.

With containment provided by the temporary deposition berm and tailings beach, the area between the berm and the South Dam will be able to have surface water collected and pumped to the TIA, removing ponded water from the area adjacent to the South Dam. Provision of a low permeability barrier adjacent to the South Dam, enclosing the identified ice wedges, can be achieved by tailings deposition within the area between the temporary deposition berm and the

South Dam following completion of the South Dam, as illustrated on Drawing SDTD-03. This can be undertaken by either slurry deposition or by excavation and placement of previously deposited tailings (method to be determined by the supervising engineer).

Once the area between the temporary deposition berm and the South Dam has been filled with tailings up to the level of the berm. Tailings deposition may be able to commence from the South Dam as per the original intent of the design and deposition plan.

The South Dam design includes ground temperature cables (GTC) to monitoring the thermal performance of the dam and foundation. SRK is currently installing and monitoring the planned GTCs. In addition to the planned GTCs, the mitigation measures would include the installation of two additional ground temperature cables immediately upstream of the South Dam within the approximate location of ice wedges near the lowest elevation of the original ground surface, as shown in Drawing SDTD-02. The additional GTCs would provide ground thermal monitoring in an area with the potential to develop a high flow seepage pathway and provide an early warning of ground thermal changes that warrant further mitigation measures.

4 Execution Plan

The steps required to implement the mitigation measures are listed in execution order below.

- Construction of berm raise and windrow (3,500 m^3 of rock fill, either ROQ or waste rock may be used in this specific case) approximately 2-3 days.
- Drill and install two GTC at locations per Drawing SDTD-02 (Attachment 1), following installation specifications provided in the South Dam design.
- Reconnection and slight relocation of tailings deposition pipeline and spigot points to raised berm crest.
- Commission and operate deposition from temporary deposition berm as per Drawing SDTD-02 (Attachment 1).
- Concurrently and as required, remove surface water by trash pump from area between the berm and the South Dam.
- Once South Dam construction is complete, or on the instruction of the supervising engineer; Commence placement of tailings within area between the berm and the South Dam. This may be by slurry deposition or by excavation and placement of previously deposited tailings, as directed by the supervising engineer. The supervising engineer will consider the status of the South Dam construction, the time of year and climatic conditions, and the tailings deposition performance amongst other things when specifying the placement method.
- On approval from the facility Engineer of Record (Maritz Rykaart) commence deposition from the South Dam as per the original intent of the design and deposition plan or as directed.

Construction of the temporary deposition berm raise and windrow should commence by 20 May 2018.

It is recognised that construction of the temporary deposition berm raise requires use of the same equipment and potentially materials (ROQ) as for the South Dam construction. Therefore, construction of the berm raise may cause additional delays to the South Dam completion. However, given the volume of material required (3,500 m^3) and the simplicity if the construction it is considered that this should not exceed 3 days. SRK considers that with adequate scheduling and resource planning the construction of the berm raise should not impact the overall South Dam schedule.

SRK Consulting (Canada) Inc.

Cameron Hore, PEng
Senior Consultant

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The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

5 References

SRK Consulting (Canada) Inc., 2018. Engineering Drawings for the South Dam - Phase 1 Doris North Project, Nunavut, Canada. Revision 1. Prepared for TMAC Resources. Project Number 1CT022.017. April 2018.

Attachment 1: Drawings

Doris North Project
South Dam Temporary Deposition Berm Raise

Drawing Number	Drawing Title	Issue	Date	Revision
SDTD-01	Existing Temporary Deposition Berm - Plan, Profile and Typical Section	Issued for Review	4/20/2018	A
SDTD-02	Temporary Deposition Berm Raise - Plan, Profile and Typical Section	Issued for Review	5/11/2018	A
SDTD-03	South Dam Tailings In-fill - Plan, Profile and Typical Section	Issued for Review	5/11/2018	A

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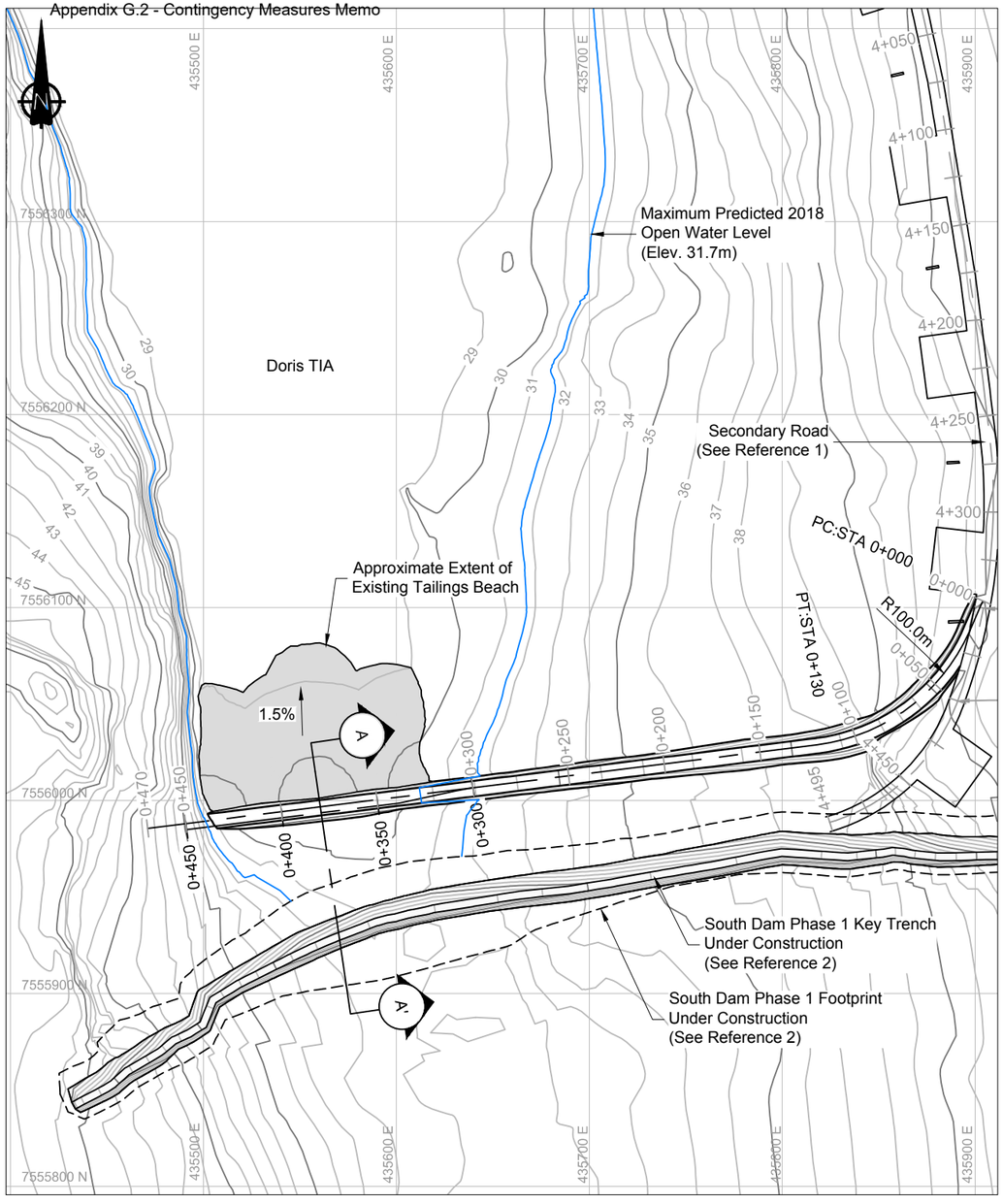

Existing Temporary Deposition Berm Plan

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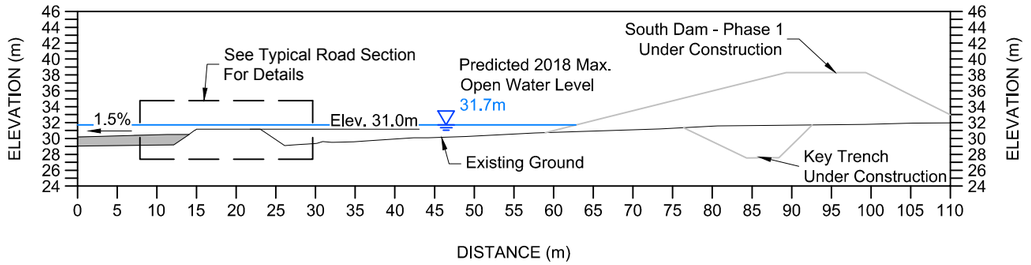

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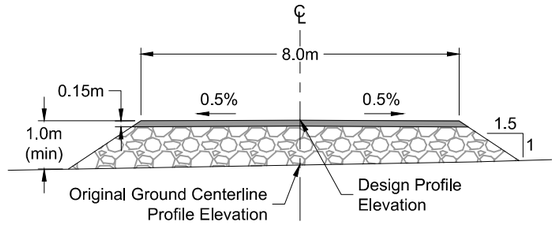

Typical Berm Section

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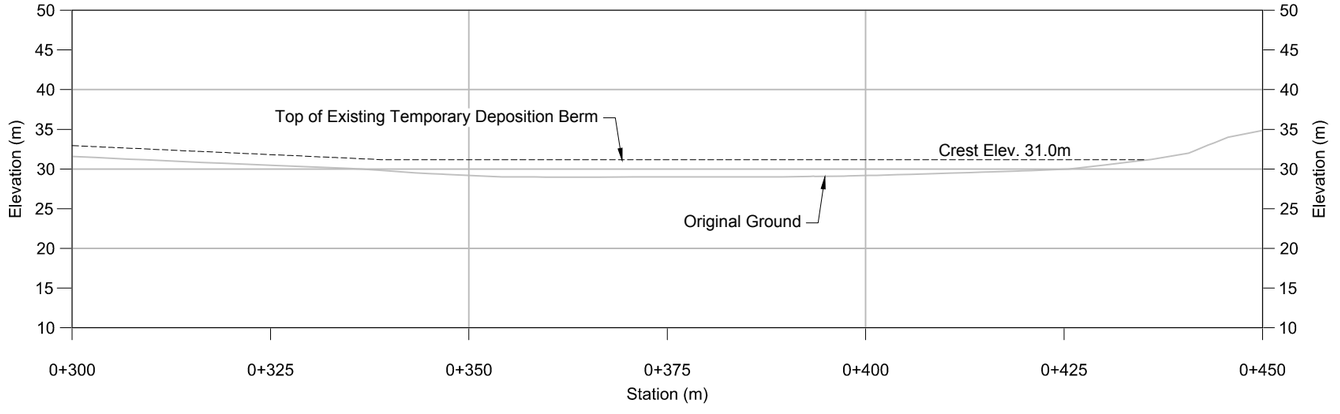

Existing Temporary Deposition Berm - Profile

0m 5 10 15 20 25 30

LEGEND

- Surfacing Material
- Run of Quarry Material
- South Dam Footprint

NOTES

1. All dimensions are in metres unless noted otherwise.
2. Contours shown at 2.0m interval.
3. Additional topography under the proposed South Dam surveyed on June 30, 2017 and March 2018.

REFERENCE

1. SRK Consulting (Canada) Inc., 2011. Engineering Drawings for Doris North Secondary Road, Doris North Project, Nunavut, Canada. Revision 3. Prepared for Hope Bay Mining Ltd. Project Number 1CH008.003. November 9, 2011.
2. SRK Consulting (Canada) Inc., 2018. Engineering Drawings for the South Dam - Phase 1 Doris North Project, Nunavut, Canada. Revision 1. Prepared for TMAC Resources. Project Number 1CT022.017. April 2018.

REVISIONS											
NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-								
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					A.	Issued for Review	CH		18/04/18

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
HB+T-CIV-CIV-OND-0010	Secondary Road from Doris Creek Bridge to South Dam 3+750 to 4+495

Original Drawings Stamped and Signed by Engineer

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		2018/04/18

FILE NAME: HBTIAroad - EC.dwg

TMAC RESOURCES

Hope Bay

SRK JOB NO.: 1CT022.020

Doris North Project

DRAWING TITLE:
Existing Temporary Deposition Berm Plan, Profile and Typical Section

DRAWING NO.	SHEET	REVISION NO.
SDTD-01	1 OF 3	A

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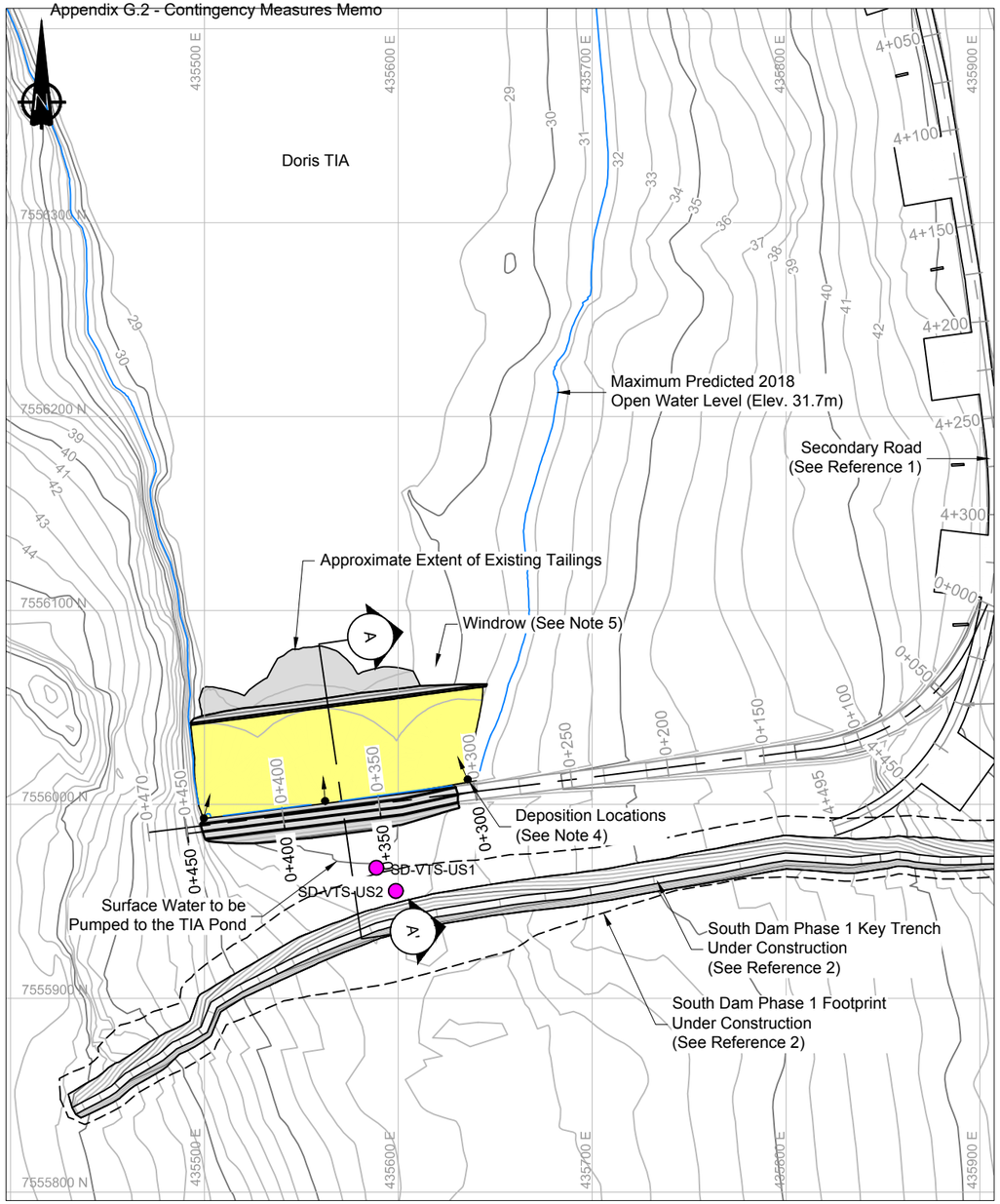

Proposed Temporary Deposition Berm Raise Plan

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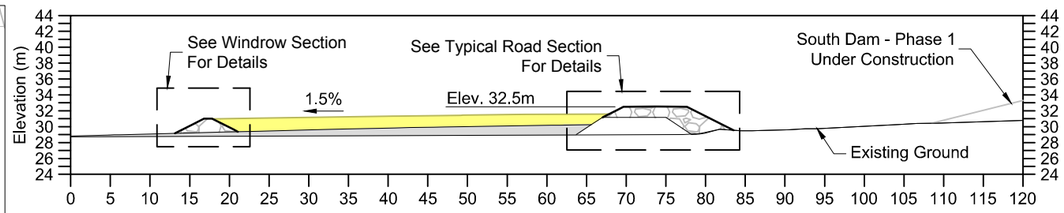

Cross Section A-A'

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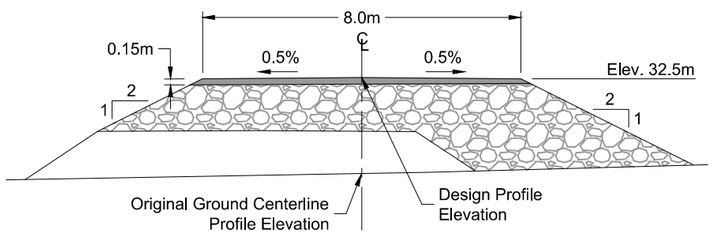

Typical Berm Raise

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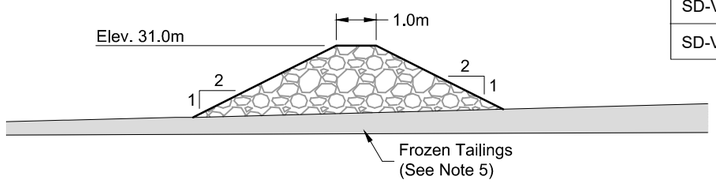

Typical Windrow Section

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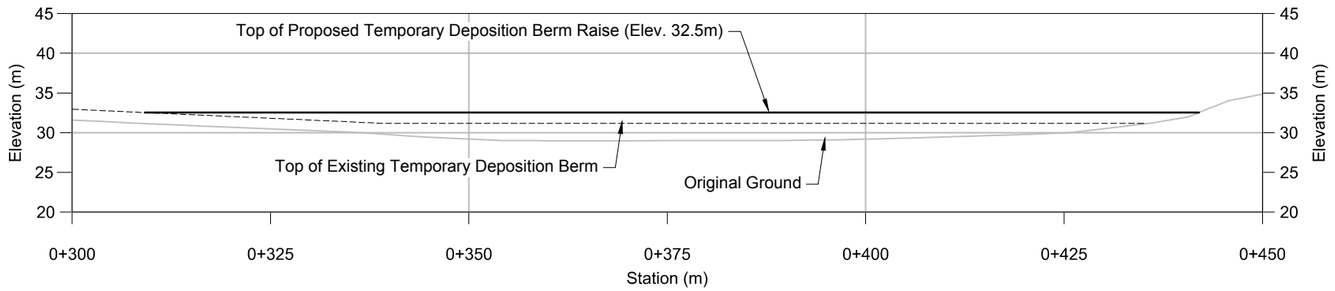

Proposed Temporary Deposition Berm - Profile

0m 5 10 15 20 25 30

MATERIALS AND QUANTITIES

Material	Quantity
ROQ	2,520m³
Road Surfacing	160m³
Tailings Beach Deposition	8,700m³
Windrow	1,050m³

MONITORING LOCATION LAYOUT

ID	Northing	Easting
SD-VTS-US1	7555967.30	435588.70
SD-VTS-US2	7555955.25	435598.65

LEGEND

- Monitoring Location
- Existing Deposited Tailings
- Proposed Deposited Tailings
- Surfacing Material
- Run of Quarry Material
- South Dam Footprint

NOTES

1. All dimensions are in metres unless noted otherwise.
2. Contours shown at 2.0m interval.
3. Additional topography under the proposed South Dam surveyed on June 30, 2017 and March 2018.
4. Multiple deposition points will be required across the interim berm to ensure even development of the beach level.
5. The windrow should be constructed immediately south of the lake ice boundary on the existing frozen tailings.

REFERENCE

1. SRK Consulting (Canada) Inc., 2011. Engineering Drawings for Doris North Secondary Road, Doris North Project, Nunavut, Canada. Revision 3. Prepared for Hope Bay Mining Ltd. Project Number 1CH008.003. November 9, 2011.
2. SRK Consulting (Canada) Inc., 2018. Engineering Drawings for the South Dam - Phase 1 Doris North Project, Nunavut, Canada. Revision 1. Prepared for TMAC Resources. Project Number 1CT022.017. April 2018.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
HB-T-CIV-CIV-OND-0010	Secondary Road from Doris Creek Bridge to South Dam 3+750 to 4+495	-	-				A	Issued for Review	CH		18/05/11

Original Drawings Stamped and Signed by Engineer

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PROFESSIONAL ENGINEERS STAMP

srk consulting

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CHECKED: | APPROVED: | DATE: 2018/05/11
FILE NAME: HBTIAroad.dwg

TMAC RESOURCES

Hope Bay

SRK JOB NO.: 1CT022.020

Doris North Project

DRAWING TITLE: Temporary Deposition Berm Raise Plan, Profile and Typical Section

DRAWING NO. SDTD-02 | SHEET 2 OF 3 | REVISION NO. A

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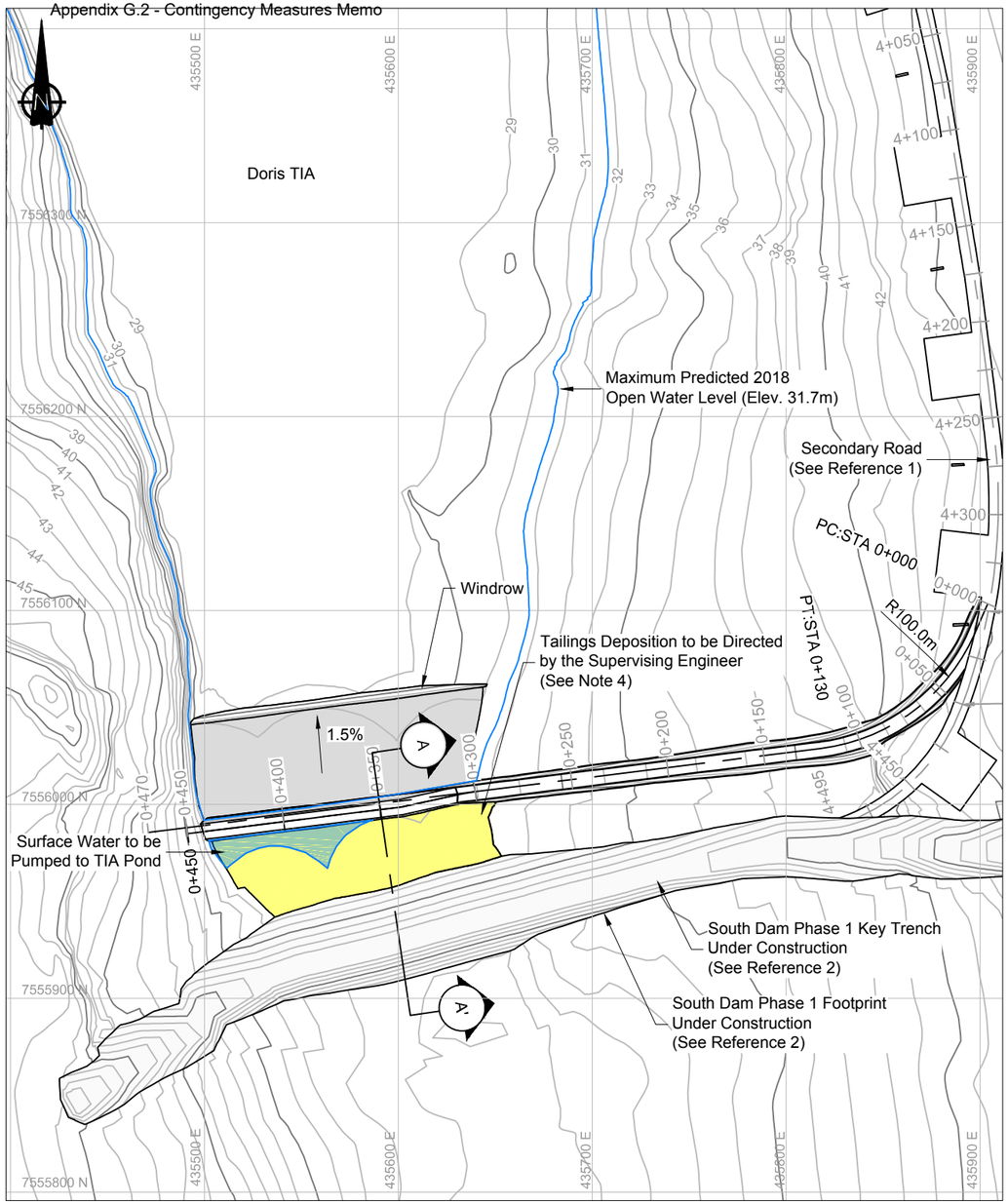

South Dam Tailings In-fill Plan

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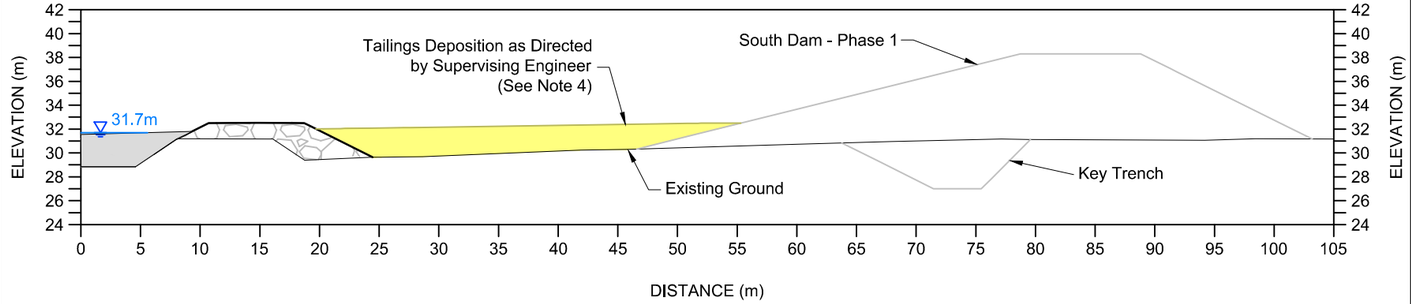

Cross Section A-A'

0m 5 10 15 20 25 30

LEGEND

- Existing Deposited Tailings
- Proposed Deposited Tailings
- Surfacing Material
- Run of Quarry Material
- South Dam Footprint

NOTES

1. All dimensions are in metres unless noted otherwise.
2. Contours shown at 2.0m interval.
3. Additional topography under the proposed South Dam surveyed on June 30, 2017 and March 2018.
4. Tailings placement may be by slurry deposition or by excavation and placement of previously deposited tailings, as directed by the supervising Engineer.

REFERENCE

1. SRK Consulting (Canada) Inc., 2011. Engineering Drawings for Doris North Secondary Road, Doris North Project, Nunavut, Canada. Revision 3. Prepared for Hope Bay Mining Ltd. Project Number 1CH008.003. November 9, 2011.
2. SRK Consulting (Canada) Inc., 2018. Engineering Drawings for the South Dam - Phase 1 Doris North Project, Nunavut, Canada. Revision 1. Prepared for TMAC Resources. Project Number 1CT022.0017. April 2018.

MATERIALS AND QUANTITIES

Material	Quantity
Tailings Capacity	6,100m³

DRAWING NO.	DRAWING TITLE
-	-
HB+T-CIV-CIV-OND-0010	Secondary Road from Doris Creek Bridge to South Dam 3+750 to 4+495

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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A	Issued for Review	CH		18/05/11

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		2018/05/11

FILE NAME: HBTIAroad-S2.dwg

TMAC RESOURCES

Hope Bay

SRK JOB NO.: 1CT022.020

Doris North Project

DRAWING TITLE:
South Dam Tailings In-fill
Plan, Profile and Typical Section

DRAWING NO.	SHEET	REVISION NO.
SDTD-03	3 OF 3	A

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Appendix G.3 – Ground Ice Memo

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Memo

To:	Project File	**Client:**	TMAC Resources Inc.
From:	Christopher Stevens, PhD	**Project No:**	1CT022.031
Reviewed By:	John Kurylo, MSc. PEng; Maritz Rykaart, PhD, PEng	**Date:**	March 8, 2019
Subject:	Hope Bay Project: South Dam Ground Ice		

1 Introduction

The tailings management system (TMS) for the Hope Bay Project, in Nunavut, Canada, includes sub-aerial tailings deposition into the Doris tailings impoundment area (TIA). The South Dam is one of three dams that will be constructed to form the ultimate Tail Lake TIA. The TIA currently consists of the water retaining, frozen core North Dam commissioned in 2012 and the frozen foundation South Dam to retain tailings solids (Figure 1). Phase-1 construction of the South Dam was complete over the winter of 2018 (SRK 2019).

The South Dam was designed as a frozen foundation dam with the intent to continuously develop a tailings beach along the upstream face to limit water and heat transfer to the foundation. A geosynthetic clay liner (GCL) incorporated into the upstream face of the dam that has been keyed into the permafrost foundation to achieve containment. The general stability of the dam foundation is reliant of the frozen state of ice-rich permafrost soils since it was not practical to excavate to bedrock at the site.

At some locations, massive ground ice was observed during excavation of the key trench, which prompted the need to determine whether to leave the ground ice in place or over-excavate to more suitable, lower ice content material.

This memo documents the ground ice conditions observed within the South Dam key trench and the basis of decision to not over-excavate the massive ground ice.

2 Ground Ice

2.1 Type and Origin

Ground ice may be annually formed within seasonally frozen soils or represent ice that is perennial sustained within permafrost. Perennial ground ice within permafrost can be divided into five major types; pore ice, segregated ice, buried ice, wedge ice, and injection ice.

2.1.1 Pore Ice

Pore ice forms in the pore space of soil and rock from the freezing of in-site pore water. The amount of ice is a function of the initial water content and the available pore space. Soil with pore ice is typically considered to have a relatively low total ice content when compared to other forms of ground ice. A relatively minor amount of thaw-settlement is expected from thawing of soil with pore ice.

2.1.2 Segregated ice

Segregated ice is ground ice that forms due to moisture transfer caused by thermally induced pressure gradients in the ground. This form of ground ice has been observed in both the laboratory and field settings (e.g. Mackay 1983; Konrad and Morgenstern 1980; Smith 1985). Ice segregation takes place by either “primary segregation” that occurs behind an advancing freezing front, or by “secondary segregation” that continues to take place within already frozen sediments. The former process involves water migration through the frozen fringe due to suction or negative pressure produced at the freezing front (also referred to as cryosuction).

Secondary ice segregation involves much slower rates of moisture migration through capillaries within frozen sediment and/or by the molecular movement of ice from regelation (Hoekstra 1966; Williams 1967). Long-term secondary ice segregation, in part, depends on the hydraulic conductivity of the frozen sediment, which is controlled by the sediment texture, the temperature gradient and the unfrozen water content below freezing temperatures (Williams and Burt 1974; Burt and Williams 1976). The larger volume of ground ice observed within terrestrial permafrost environments has been partially attributed to secondary segregation of ice.

Fine-grained silt and clay are typically frost susceptible and favorable to ice segregation. Whereas, coarse-grained sand and gravel deposits are typically less favorable to ice segregation. Long-term secondary segregation may take place over hundreds to thousands of years and result in large volumes of ice in the ground upwards of 15 m in thickness. Segregated ice lenses greater than 6.35 cm in thickness are typically considered to be massive ground ice (van Everdingen, 2005).

2.1.3 Buried ice

Buried ice is ground ice that was deposited on the ground surface and later covered by soil. Buried ice is typically considered to represent buried glacial ice or snowbanks, and less commonly preserved surface ice from waterbodies (lakes, rivers) or aufeis (icings) (van Everdingen 2005).

Buried glacial ice commonly contains fine to coarse sediment inclusions and tectonic structures such as thrust faults and folds from glacial deformation of the ice body (French and Harry 1990; Dallimore and Wolfe 1988).

2.1.4 Wedge Ice

Wedge ice is typically vertical to sub-vertical veins of ground ice that have formed from thermal contraction cracking of the soil. The crack is in-filled with snow and or surface water that refreezes to form an ice wedge, known as wedge ice. This process may occur over tens to thousands of years and contribute to ice wedges that are several meters wide and deep.

The wedge ice is commonly discoloured by intra-ice soil particles and contains air bubbles that tend to be arranged in nearly vertical bands, forming vertical to sub-vertical foliation of the ice. The presence of many small bubbles may give the ice an opaque appearance. Ice wedges are a type of massive ground ice.

Ice wedges are divided into three types: epigenetic, syngenetic, and anti-syngenetic wedges. Epigenetic ice wedges grow in pre-existing permafrost where the ground surface remains at the same elevation overtime, forming a wide v-shaped wedge of ice. An epigenetic ice wedge grows progressively wider but shows little to no evidence for upward or downward growth of the wedge (Mackay 1974). Whereas, syngenetic ice wedges grow as the upper permafrost surface rises in response to the addition of material deposited on the ground surface, such as material sourced from rivers, slopes, and peat accumulation (Mackay 1990). A new ice veinlet at the top of the syngenetic wedge will form as the additional mineral or organic material is deposited at the surface, representing vertical growth of the ice wedge. Lastly, an anti-syngenetic ice wedges grow on receding slopes where the ground surface is progressively lowered by erosion of material, common to slopes. The new ice veinlet will contribute to downward growth of the ice wedge over time.

2.1.5 Intrusive Ice

Intrusive ice forms from the injection of pressurized water into frozen or freezing permafrost, representing a form of massive ground ice (van Everdingen 2005). In most cases, frozen ground presents an impedance to water-flow, causing upstream pressure to build within a confined, unfrozen soil layer. Eventually the water is injected into the surrounding frozen soil and refreezes to form a discrete body of massive ice. Intrusive ice is typically clear with some air inclusions (air bubbles) elongated perpendicular to the freezing front.

2.2 Ground Ice Distribution

Ground ice in soil and bedrock is naturally heterogenous due to difference in material type, moisture content, and past thermal gradients, among other site-specific factors that contribute to some forms of ground ice development. The amount of ice in the ground is often higher at the top of permafrost (Pollard and French, 1980) due to the annual gain of water in this region of the ground (Cheng, 1983; Mackay 1983), the formation of aggradational ice and the occurrence of ice wedges (Mackay, 1972). However, relatively high amounts of ground ice can occur with depth, especially in areas with buried glacial ice or intrusive ice from pressurized groundwater flow.

3 South Dam Ground Ice

3.1 Airphoto Mapping

Airphoto mapping of the local terrain and ground ice features was completed using colored satellite airphoto, historical monochromatic airphoto, and a recently acquired unmanned aerial vehicle (UAV) airphoto supplied by TMAC Resources Inc.

3.1.1 Local Terrain

The South Dam is located on the south end of the former Tail Lake on the watershed boundary that separates the TIA from Ogama Lake. The dam alignment extends across a local valley, with slightly higher surface elevation on either side of the valley (Figures 1 and 2).

The mapped bedrock outcrops were combined with geophysical surveys results (SRK 2016) and previous geotechnical drillholes to infer the depth to bedrock along the dam alignment (Figure 2). Bedrock within the key trench was further defined following completion of additional drilling and excavation (see Section 3.2).

Relatively shallow bedrock was inferred on the west and eastern abutments, with a well-defined central outcrop of bedrock within the valley bottom (Figure 2). Thicker overburden soil was inferred to be present within two bedrock-defined toughs on either side of the central outcrop. These troughs were later validated by percolation and sonic drillholes completed prior to dam construction.

3.1.2 Ground Ice Features

Ice wedge polygon troughs were visible from both recent and historical airphotos using image texture and contrast of vegetation. At some locations, the ice wedge trough was resolved based on changes in surface relief using a digital surface model (DSM).

Ice wedge polygons were mapped with relatively high confidence toward the center of the dam alignment between Sta. 2+85 and Sta. 3+50 (Figure 1). The polygonal terrain is interpreted to occupy a former lake basin, possibly resulting from a higher Tail Lake water level. Ice wedges subsequently formed over hundreds to thousands of years following lowering of the water level and direct exposure of the ground surface to atmospheric conditions. It is likely that other, less prominent ice wedge troughs are present within the area.

3.2 Geotechnical Investigations

Geotechnical programs were completed under four separate investigations to inform design of the South Dam (Table 1). The investigations included recovery of frozen soil core and cuttings, the logging and sampling of the soil and rock, laboratory testing of soil index properties, percolation testing of the foundation, and installation of ground temperature cables in select boreholes. An in-depth description of the methods and results of each program is provided in each of the investigation reports (see Table 1 for references). Figure 2 shows the location of the South Dam drillholes for each program.

Table 1: Geotechnical Investigation Prior to Phase-1 Construction of the South Dam

Program	Drillhole Description[1]	Investigation Report	Description
Winter 2003	Previous Drillholes	SRK (2003)	- Winter of 2003 and 2006 drill programs completed - Eight drillholes within the assumed footprint of the South Dam - Four ground temperature cables installed within select boreholes
Winter 2006		SRK (2006)	
Winter 2018	Percolation Drillholes	SRK (2019)	- Program was undertaken between January and February of 2018 - Thirty-four drillholes completed with a Sandvik DX-800 Air Track drill - Drillholes were located within the planned footprint of the key trench to allow for characterization and percolation testing of the foundation
Winter 2018	Sonic Drillholes	SRK (2018a)	- Program was undertaken between January and February of 2018 - A total of eleven sonic drillholes were drilled at the South Dam - Seven of the drillholes were located within the Phase 1 dam footprint. Four of the drillholes were located within the Phase 2 dam footprint

Notes:

Drillhole description used in Figure 2

3.2.1 General Stratigraphy

The cross-valley alignment of the dam is characterized by a thin veneer of hummocky organic soil (OL/OH), underlain by saline marine silty clay (CI/CL) which transitions to saline clayey and silt (ML) (Table 2). The clayey silt is underlain by a sand and gravel till that overlies the top of bedrock. Regional studies provide additional evidence for sea level rise following glacial retreat which resulted in inundation of the land and deposition of the saline, fine-grained marine soils.

Table 2: Summary of Lithological Units and Description of Frozen Soil

Lithological Unit[1]	Frozen Soil Description[2]
Organics (OL/OH)	N_f, few V_x, some snow present
Marine silty clay (CI/CL)	Ice-rich, predominantly Vs and V_x, with sections of ICE + Soil
Marine clayey silt (ML)	N_{be} and N_f, little V_x
Sand/gravel (SM/SW/SW-SM/SP-SM/GM)	N_f

Notes:

1. Soil classification for each lithological unit based on the Unified Soil Classification System
2. Most common frozen soil description for each lithological unit based on ASTM D4083-89(2016) (ASTM 2016)

The drillholes completed during the various geotechnical investigations confirm the general thickness of overburden and depth to bedrock previously inferred from airphoto mapping, geophysical surveys, and more limited drill data (Figure 2). Within the key trench footprint percolation drillholes indicate shallow bedrock along the west and east abutments and within the center of the alignment between approximately Sta. 0+254 to Sta. 0+275 (Note: chainage refers to the key trench and not crest of the dam). The approximate extent of bedrock outcrop in the key trench is shown in Figure 2.

3.2.2 Ground Ice

Frozen soil core was used to visually estimated excess ground ice. The excess ground ice was up to approximately 90%, with some discrete bodies of nearly pure massive ground (ICE) near 100%.

The gravimetric water content obtained from percolation drillhole cuttings provides an indication of the relative amount of ground ice within key trench footprint (Figure 3). Review of the data indicates soil with a moisture content greater than approximately 60% may be described as ice-rich, and below this threshold the material typically has relatively low ground ice content. Soil samples with a gravimetric moisture at least 250% is considered to represent massive ground ice (van Everdingen 2005). These thresholds provide context for interpreting the relative amount of ground ice within the footprint of the key trench.

The west and east abutments of the key trench generally consist of relatively low moisture content soil over shallow bedrock, indicating a generally low ground ice soil (Figure 3). The moisture content generally increases across regions of the key trench where thicker, finer-grained soils (Silty Clay and Clayey Silt) are present.

The highest moisture content soils samples recovered from the key trench are within the upper 4 m (Figure 4). Below a depth of 4 m the moisture content was less than 100%, with exception of two samples collected from 5.5. and 6.5 m below the surface. The data suggest most of the very ice-rich soil (ICE + Soil) and massive ground ice (ICE) is in the top 4 m of soil of the key trench.

3.3 Key Trench Observations

SRK Site Engineer(s) were present for the entire six-month duration of construction at the South Dam, with exception of a one-week period between February 8 and 15, 2018. A detail account of construction of the dam is provided by SRK (2019). Visual ground ice observations were made in the key trench during construction. Photographs and survey mapping was completed for some bodies of massive ground ice.

Figures 5 to 8 show the typical ground ice observed within the excavated key trench. Visible ground ice was observed to include random orientated ice (Vr) forming reticulate ice structures, stratified ice lenses and distinctly oriented ice structures (Vs), ice with soil inclusions (ICE + Soil), and massive ice in the form of sub-vertical ice veins (ICE) interpreted to generally represent wedge ice.

Figure 9 shows the location of massive ground ice (ICE) that was identified within the key trench. Several of the massive ground ice locations agree with the location of ice wedge troughs mapped from airphotos. Detail survey of each massive ground ice feature was not possible which limits the ability to fully understand the extent of the ground ice bodies. Soil characterized by ice with soil inclusion (ICE + Soil) was observed to be common within the trench.

Figures 10 to 19 show field photographs from sixteen massive ground ice locations surveyed during inspection of the key trench. Several massive ground ice features were unable to be clearly mapped and were described to be local in extent (Massive Ground Ice Locations 1, 3, 6, and 7). The remaining massive ground ice features were mapped as sub-vertical veins of nearly pure ground ice (ICE), with individual ice bodies ranging from 0.4 m to 2.0 m in width. The ice was often brown to clear with some evidence of ice striations that are common to wedge ice (Figure 19). The massive ground ice extended from the top of the key trench to the bottom in most cases.

4 Ground Ice Decision

A meeting was held on March 19, 2018 to discuss the ground ice observed within the key trench and its potential implication on performance of the dam. The meeting participants included Dr. Maritz Rykaart (PhD, PEng), Mr. Cameron Hore (CEng, PEng), and Dr. Christopher Stevens (PhD). It was decided to not over-excavate massive ground ice observed in the key trench. Further to the meeting, a discussion of the information and decision took place between Dr. Rykaart and Mr. John Kurylo (PEng).

4.1 Basis of Decision

The decision to not over-excavate ground ice in the key trench was based on:

- Observed ground ice type and distribution;
- Design and operation of the dam;
- Contingency monitoring planned for the dam (SRK 2018b); and
- Required inspection and monitor over the life of the dam.

4.1.1 Key Trench Ground Ice

The greatest amount of ground ice in the key trench was identified to be within the upper four meters of soil based on percolation drillhole results. The higher amounts of near-surface ground ice are consistent with permafrost characteristics at other sites (Pollard and French, 1980; Cheng, 1983; Mackay, 1972; Mackay 1983). In most cases, the key trench was excavated to the base of the ice-rich soil observed to be in the form of Vs, Vr, and ICE + Soil. It can be inferred that these types of ground ice are laterally continuous given the segregated origin of the ice. Over-excavation of ice-rich soil to laterally intersect low ground ice soil would unlikely be achievable.

Massive ground ice (ICE) was intersected by several percolation drillholes (Figure 3) and visually identified by Site Engineers (Figure 9). A majority of the massive ground ice features

corresponded to the location of ice-wedge troughs mapped from airphotos. The characteristics of the massive ice (geometry, orientation, structure) were generally consistent with wedge ice. It was therefore inferred that most of massive ice represented ice-wedges intersected by key trench.

Ice wedges were expected to be laterally continuous based on the type of ice and delineation of these ice-wedge troughs from airphotos. It was therefore not practical to over-excavate the wedge ice to soils with lower ground ice. Over-excavation would led to a larger key trench with run-of-quarry rock (ROQ) that is less thermally favorable to the dam's performance when compared to the ice-rich overburden soil of relatively higher heat capacity and latent heat.

4.1.2 Design and Operation

The design and operation of the South Dam was discussed in the context of ground ice. The dam is to be operated with a tailings beach continuously developed along the upstream face to limit water and heat transfer to the foundation. The GCL incorporated into the upstream face of the South Dam was keyed into the permafrost foundation to also achieve containment.

The development of a low permeability tailings beach against the upstream face of the dam was considered to reduce the risk of vertical water movement and related advection of heat, which could otherwise lead to thermal erosion of massive ground ice and development of thermokarst conduits. The tailings beach is also expected to increase the distance between the ponded water and act to migrate transfer to the frozen foundation. Over time, it is expected that the exposed tailings beach will freezeback due to heat loss to the atmosphere, which further mitigates the risk of seepage and thermal erosion of massive ground ice.

4.1.3 Contingency Measures

The basis of decision to not over-excavate massive ground ice considered implementation of a contingency measures to limit ponding of water against the upstream face of the dam caused by delayed completion of construction and increasing air temperature contributing to meltwater and precipitation in the form of rainfall (SRK 2018b; 2019). Water against the upstream face of the dam was not part of the intended design of the structure and therefore meltwater and tailings water could thermally impact the foundation and potentially contribute to melt of massive ground ice.

The contingency measures implemented to limit ponding of water and provide additional ground thermal monitoring included:

- Raise of a temporary deposition berm raise that was previously constructed in 2017;
- Construction of a small windrow parallel to and north of the temporary deposition berm; and
- Additional installation of two contingency ground temperature cables (GTC) near the upstream toe at the location of inferred ground ice wedges (Figure 1).

The GTC cables were installed to monitor thermal conditions two locations most susceptible to the melt of massive ground ice; i.e. the lowest elevation of the dam alignment where surface

water would pond and where ice wedges were observed to form a polygonal network that extended upstream.

The abovementioned contingency measures were implemented in May 2018. The design and implementation of contingency measures are documented in SRK (2018b).

4.1.4 Inspection and Monitoring

The South Dam will be routinely inspected by TMAC during operation and include an annual inspection completed by the Engineer of Record. In addition, monitoring points have been installed as part of the design to evaluate deformation and thermal regime of the dam and foundation. This monitoring has been developed to allow for evaluation of dam performance over time and implementation of mitigation measures, if required.

5 Closure

This memo documents ice-rich soil and massive ground ice that was observed in the key trench of the South Dam. Our understanding of the origin of the massive ground ice was supported by field data collected from the key trench and the surround dam footprint. The available information was considered in the context of the dam design, operation, and monitoring to inform the decision to not over-excavate ground ice in the key trench. It was determined that over-excavation would not guarantee intersection of lower ground ice soils and would result in a large, less thermally favorable key trench constructed with ROQ material. Contingency measures were implemented to control surface water during completion of the dam and allow for detect of thermal erosion that could potentially occur prior to tailings beaching along the upstream face. The required inspection and monitoring will allow for evaluation of dam performance and time to implement future mitigation measures, if required.

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The opinions expressed in this report have been based on the information available to SRK at the time of preparation. SRK has exercised all due care in reviewing information supplied by others for use on this project. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information, except to the extent that SRK was hired to verify the data.

6 References

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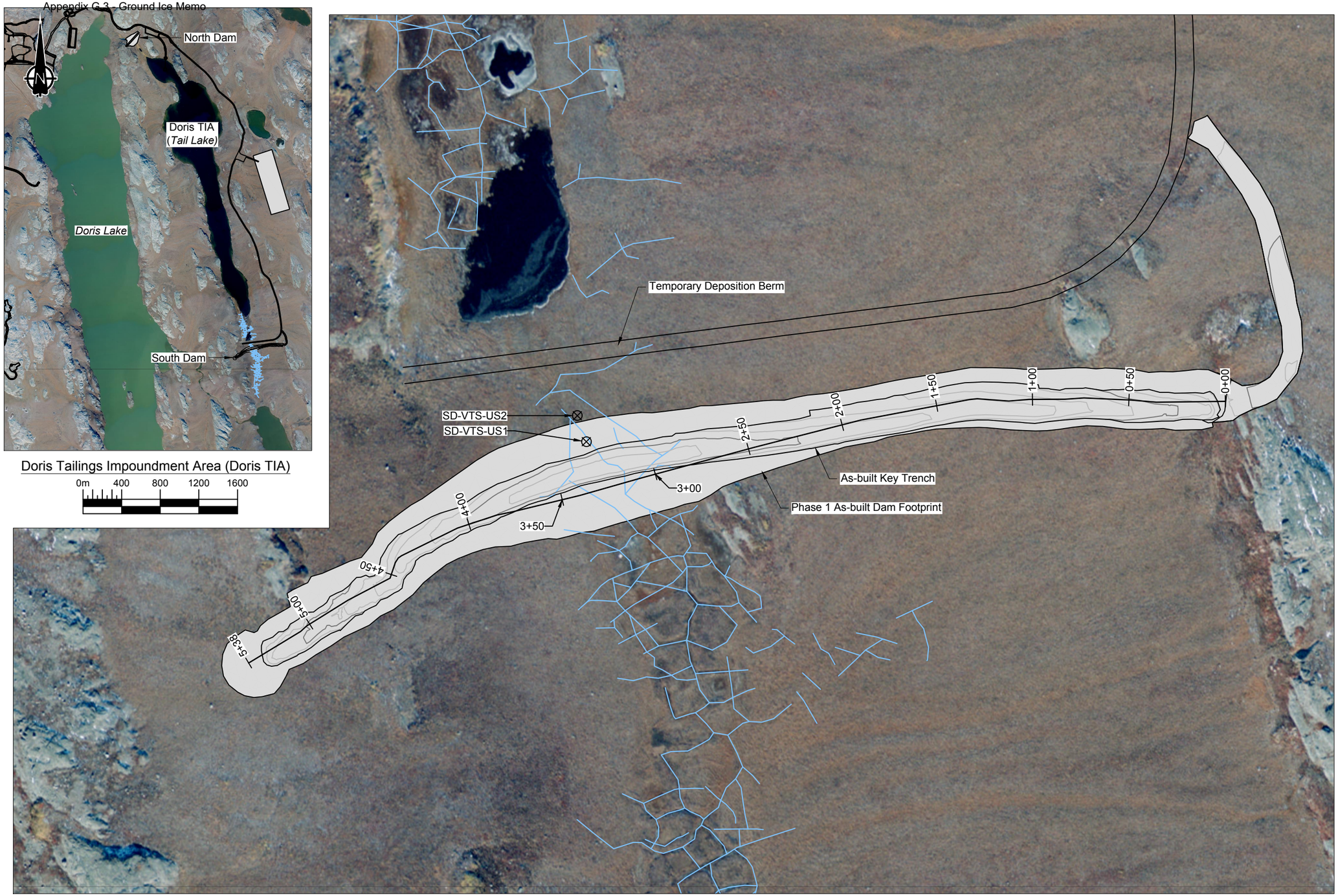
Figures

Doris Tailings Impoundment Area (Doris TIA)

0m 400 800 1200 1600



LEGEND

- Contingency Ground Temperature Cables
- Ice Wedge Location (See Note 2)
- Phase 1 As-Built Footprint

NOTES

1. All dimensions shown in meters unless otherwise stated.
2. Ice wedge locations mapped from airphotos photos prior to the 2018 drill program.

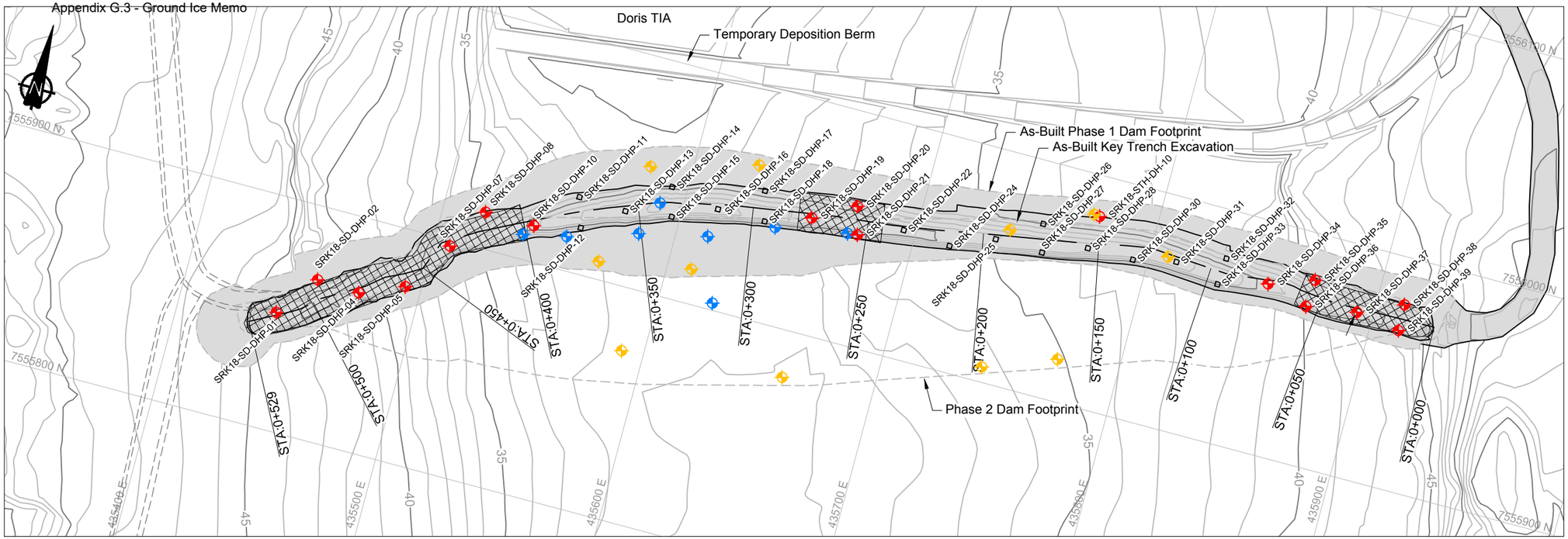
REFERENCE

NAD83 UTM Zone 13.
Imagery provided by client.

0m 20 40 60 80

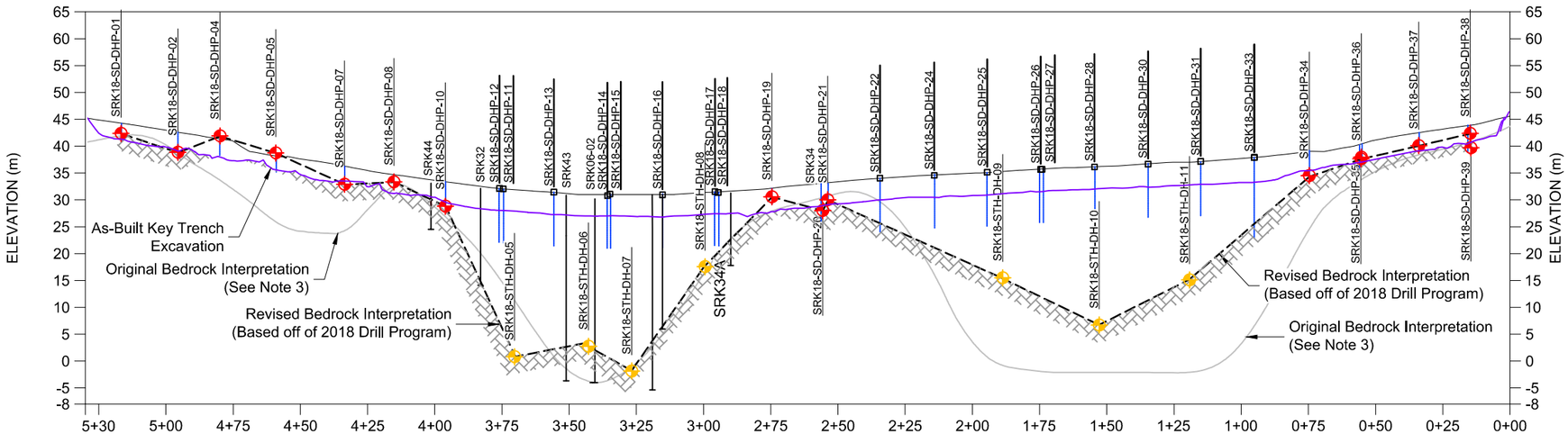
srk consulting	TMAC RESOURCES	South Dam Ground Ice
SRK JOB NO.: 1CT022.031	Hope Bay Project	General Arrangement
FILE NAME: 1CT022.031 - GA.dwg		DATE: January 2019 / APPROVED: / FIGURE: 1

P:\01_SITES\Hope Bay\ACAD\2018 Drawings\South Dam Reporting\1CT022.031 - GA.dwg



Key Trench Plan View

0m 20 40 60 80



Key Trench Profile View

Vertical: 0m 10 20 30 40

Horizontal: 0m 20 40 60 80

LEGEND

- Previous Investigation Drillhole Location
- 2018 Percolation Drillhole Location Intercepted Bedrock
- 2018 Percolation Drillhole Location Did Not Intercept Bedrock
- 2018 Sonic Drillhole Location
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Phase 1 As-Built Footprint

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The original bedrock interpretation subsurface geology was inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A, SRK43, SRK44, SRK18-STH-DH-01 to 11, and SRK18-WST-DH-01 to 03), airphoto interpretations, and from limited available geophysical surveys around the Tail Lake area. This data was then used to create the original bedrock interpretation surface with the Gemcom GEMS software.

REFERENCES

NAD83 UTM Zone 13.

srk consulting

SRK JOB NO.: 1CT022.031

FILE NAME: 1CT022.031 - Percolation Testing.dwg

TMAC RESOURCES

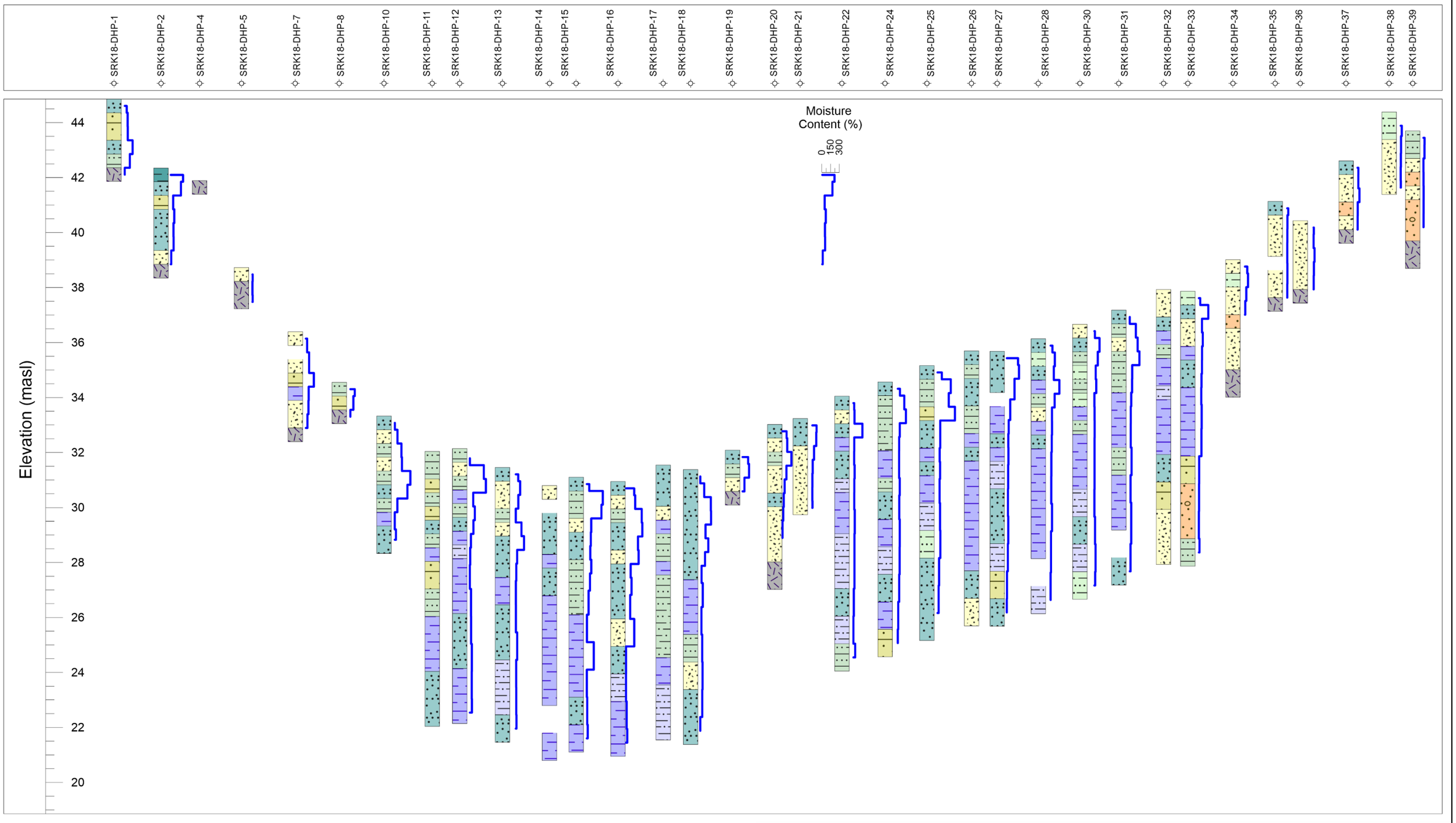
Hope Bay Mining Ltd.

South Dam Ground Ice

Percolation Drillhole Locations

DATE: January 2019 | APPROVED: | FIGURE: 2

P:\01_SITES\Hope Bay\ACAD\2018 Drawings\South Dam Reporting\1CT022.031 - Percolation Testing.dwg



Legend

Moisture Content (%) 0 150 300

- CLAY
- CLAY AND SILT
- SILTY PEAT
- SILT
- SILT AND CLAY
- SILT AND SAND
- SAND
- SAND AND SILT
- SAND AND GRAVEL
- BEDROCK

srk consulting

Job No: 1CT022.031

Filename: SouthDam_Ground_Ice_Figures_FNL.pptx

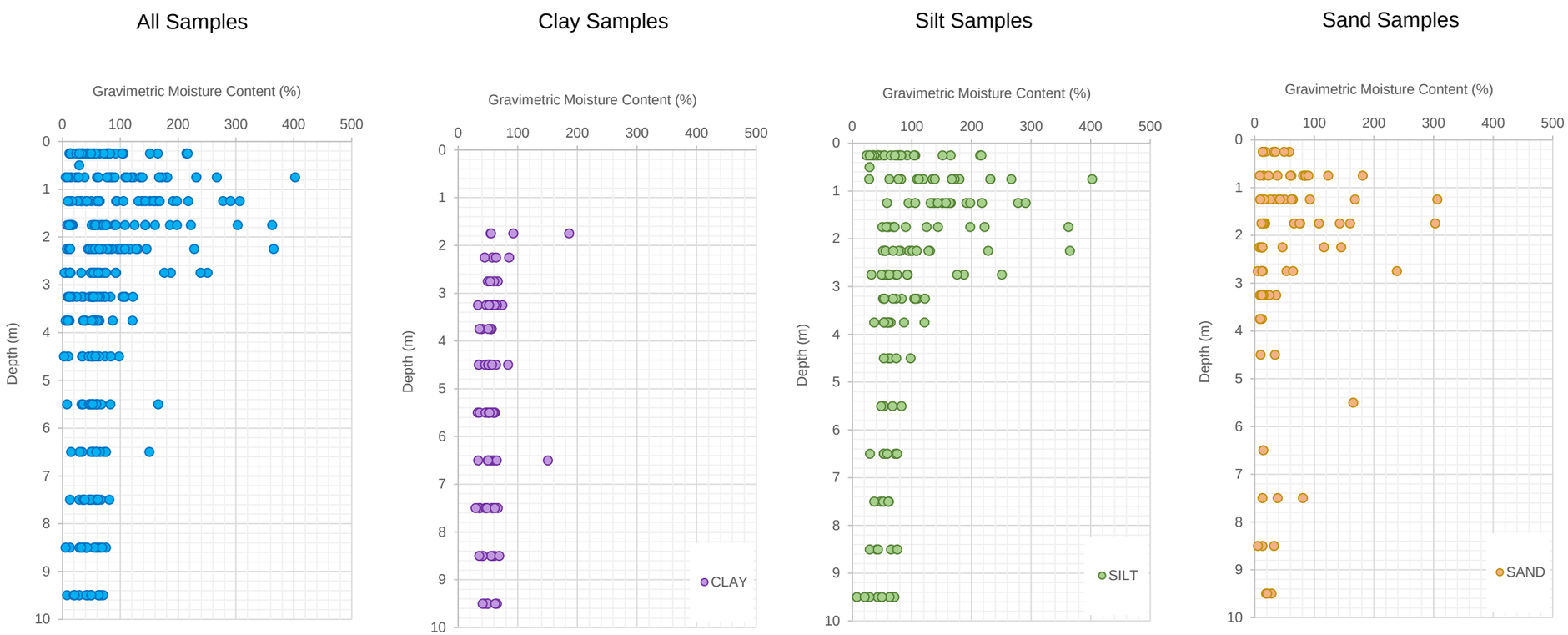
TMAC RESOURCES

TMAC Resources Inc.

South Dam Ground Ice

Percolation Drillholes – Material Type and Moisture Content

Date:	Approved:	Figure:
1/1/2019	CWS	3



Notes:
1. Percolation drillhole gravimetric moisture content plotted as mid-point of sample depth interval
2. Samples organized by primary material type described as Clay, Silt, or Sand

srk consulting	TMAC RESOURCES	South Dam Ground Ice
		Gravimetric Moisture Content – Percolation Drillholes
Job No: 1CT022.031 Filename: SouthDam_Ground_Ice_Figures_FNL.pptx	TMAC Resources Inc.	Date: 1/1/2019 | Approved: CWS | Figure: **4**

Photo A

Photo B

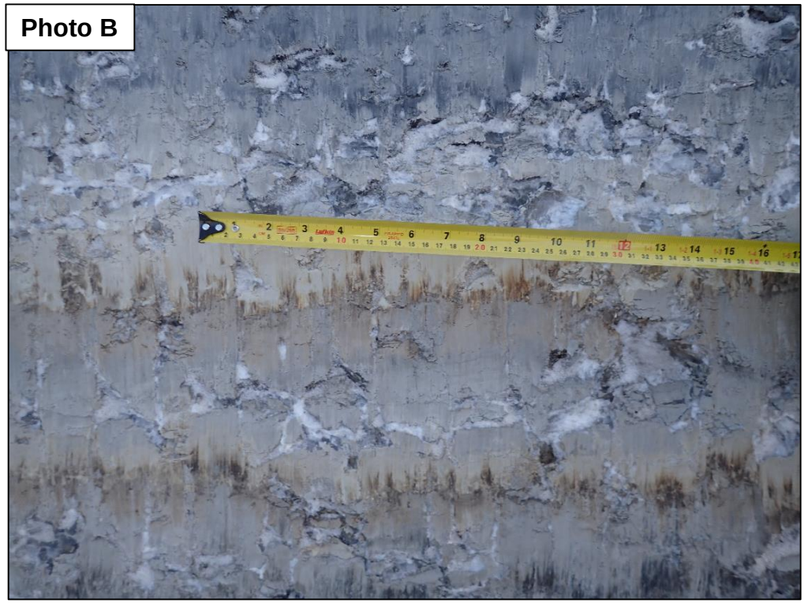


Photo C

Photo A:
- Photograph of key trench slope
- Ice-rich silt and clay with random orientated ice (Vr) forming reticulate ice structure
- Photograph is representative of the upstream and downstream key trench slope

Photo B:
- Random orientated ice (Vr) forming reticulate ice structure

Photo C:
- Ice-rich silt (Ice + Soil) immediately below end of ruler

srk consulting	TMAC RESOURCES	South Dam Ground Ice
		Key Trench Ground Ice (Vr and ICE + Soil)
Job No: 1CT022.031 Filename: SouthDam_Ground_Ice_Figures_FNL.pptx	TMAC Resources Inc.	Date: 1/1/2019 | Approved: CWS | Figure: **5**

Photo A

Photo B

Photo C

Photo A:

- Ice-rich silt and clay with less than 1 cm thick stratified ice lenses (Vs) forming lenticular structures
- Photograph is representative of ground ice observed within key trench slope

Photos B and C:

- Ice-rich silt and clay (ICE + Soil) representative of ground ice observed within key trench slope

srk consulting	TMAC RESOURCES	South Dam Ground Ice
		Key Trench Ground Ice (Vs and ICE + Soil)
Job No: 1CT022.031 Filename: SouthDam_Ground_Ice_Figures_FNL.pptx	TMAC Resources Inc.	Date: 1/1/2019 · Approved: CWS · Figure: **6**

Photo A

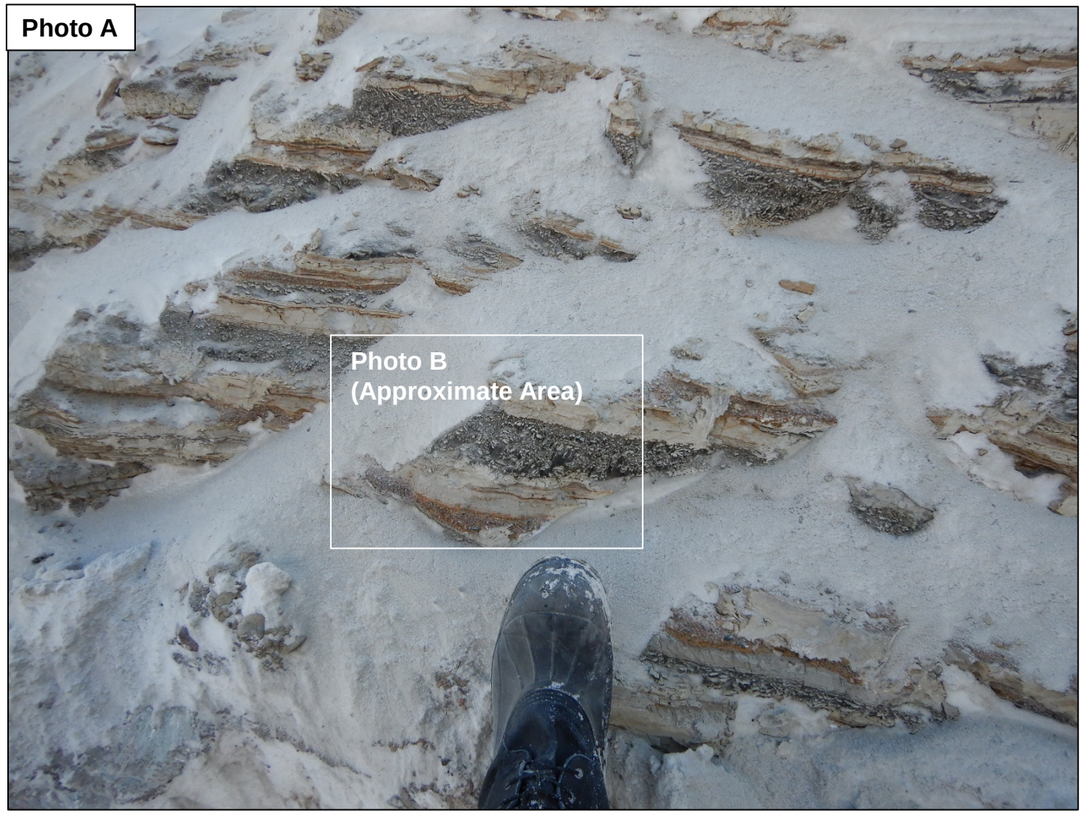


Photo B

Photo A:

- Photograph taken between station 0+60 and 0+90 (approximate)
- Gently dipping interbedded silt and sand
- Ice with soil inclusion (ICE + Soil) resulting from ice segregation
- Photographs are representative of the upstream and downstream key trench slope

Photo B:

- View of ICE + Soil immediately above glove

srk consulting	TMAC RESOURCES	South Dam Ground Ice
		Key Trench Ground Ice (ICE + Soil)
Job No: 1CT022.031 Filename: SouthDam_Ground_Ice_Figures_FNL.pptx	TMAC Resources Inc.	Date: 1/1/2019 | Approved: CWS | Figure: 7

Photo A

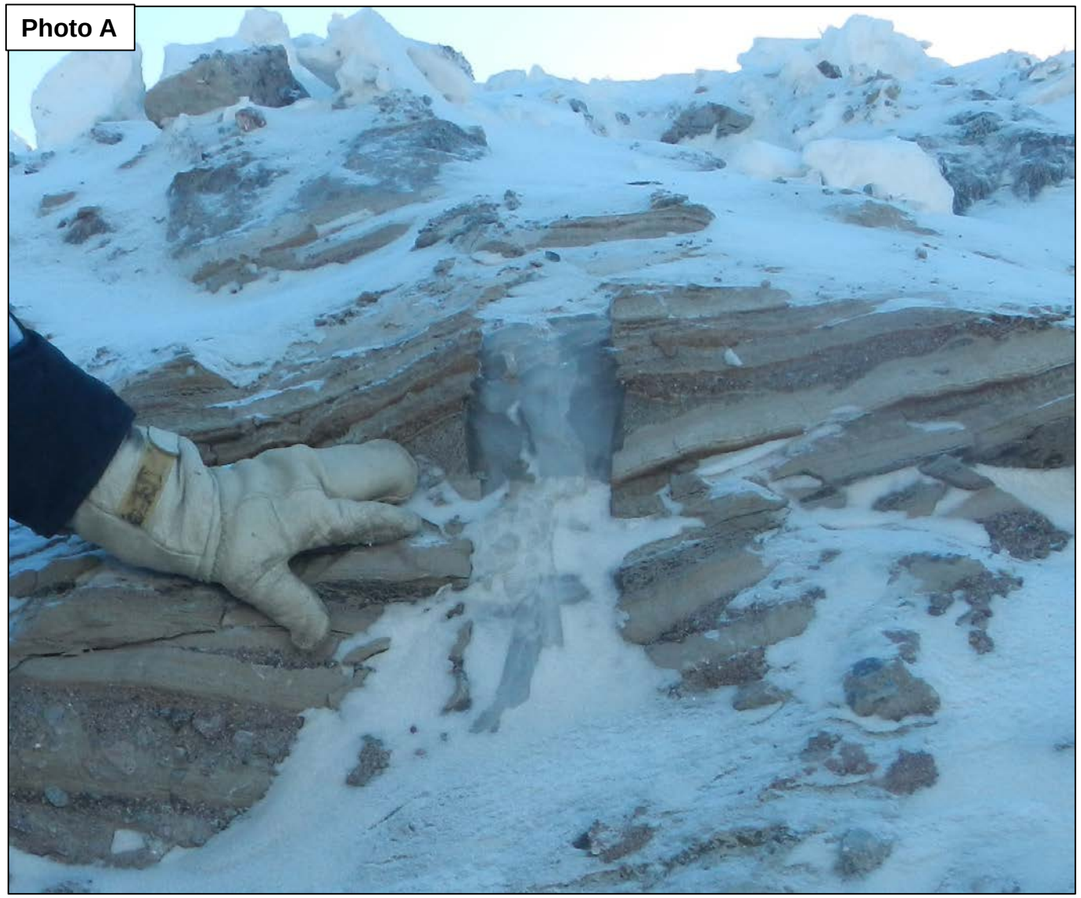


Photo B

Photo A:

- Photograph from downstream key trench slope at Station 2+70 (approximate)
- Vertical ice vein approximately 25 cm in width representing massive ice (ICE)
- Ice feature interpreted to represent the top of an ice wedge that cross-cuts interbedded silt and sand

Photo B:

- Photograph taken between Station 1+05 and 1+30 (approximate)
- Silt with distinctly orientated ice (Vs) forming regularly orientated reticulate ice structures
- Ground ice structures observed on the base of the key trench

srk consulting	TMAC RESOURCES	South Dam Ground Ice
		Key Trench Ground Ice (ICE and Vs)
Job No: 1CT022.031 Filename: SouthDam_Ground_Ice_Figures_FNL.pptx	TMAC Resources Inc.	Date: 1/1/2019 | Approved: CWS | Figure: **8**

LEGEND

- Massive Ground Ice Survey Location
- Massive Ground Ice Photo Location
- 2018 Percolation Drillhole Location
- Ice Wedge Location (See Note 4)
- As-Built Key Trench Extent

NOTES

1. Contours shown at 1.0m intervals.
2. All dimensions in meters unless otherwise stated.
3. Chainage shown on drawing is indicative of the South Dam crest centerline.
4. Ice wedge locations mapped from airphotos prior to the 2018 drill program.

REFERENCE

NAD83 UTM Zone 13.
Massive ice survey locations provided by Sub-Arctic Geomatics Ltd.

0m 5 10 15 20 25 30

srk consulting	TMAC RESOURCES	South Dam Ground Ice
SRK JOB NO.: 1CT022.031	Hope Bay Project	Key Trench Ground Ice Survey Locations
FILE NAME: 1CT022.031 - Ice Locations.dwg		DATE: January 2019 / APPROVED: / FIGURE: 9

P:\01_SITES\Hope Bay\ACAD\2018 Drawings\South Dam Reporting\1CT022.031 - Ice Locations.dwg

Photo A

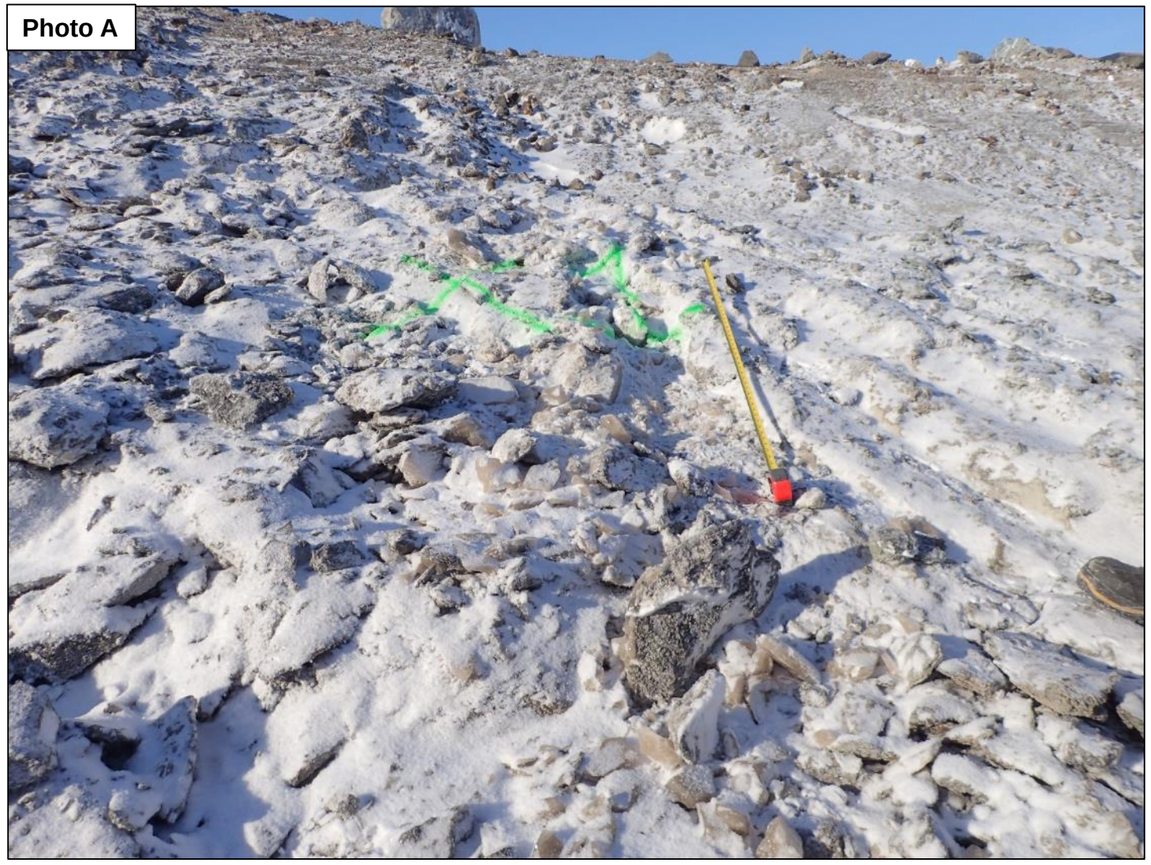


Photo B

Photo A:

- Photograph of upstream key trench slope at Massive Ground Ice Location 1 (see Figure 9)
- Massive ground ice (ICE) observed to be localized in extent
- Feature unable to be clearly mapped by field personnel

Photo B:

- Photograph of massive ice from Massive Ground Ice Location 1
- Ice observed to be cloudy to brown in color

srk consulting	TMAC RESOURCES	South Dam Ground Ice
Job No: 1CT022.031 Filename: SouthDam_Ground_Ice_Figures_FNL.pptx	TMAC Resources Inc.	**Key Trench – Massive Ground, Location 1** Date: 1/1/2019 · Approved: CWS · Figure: **10**

Photo A

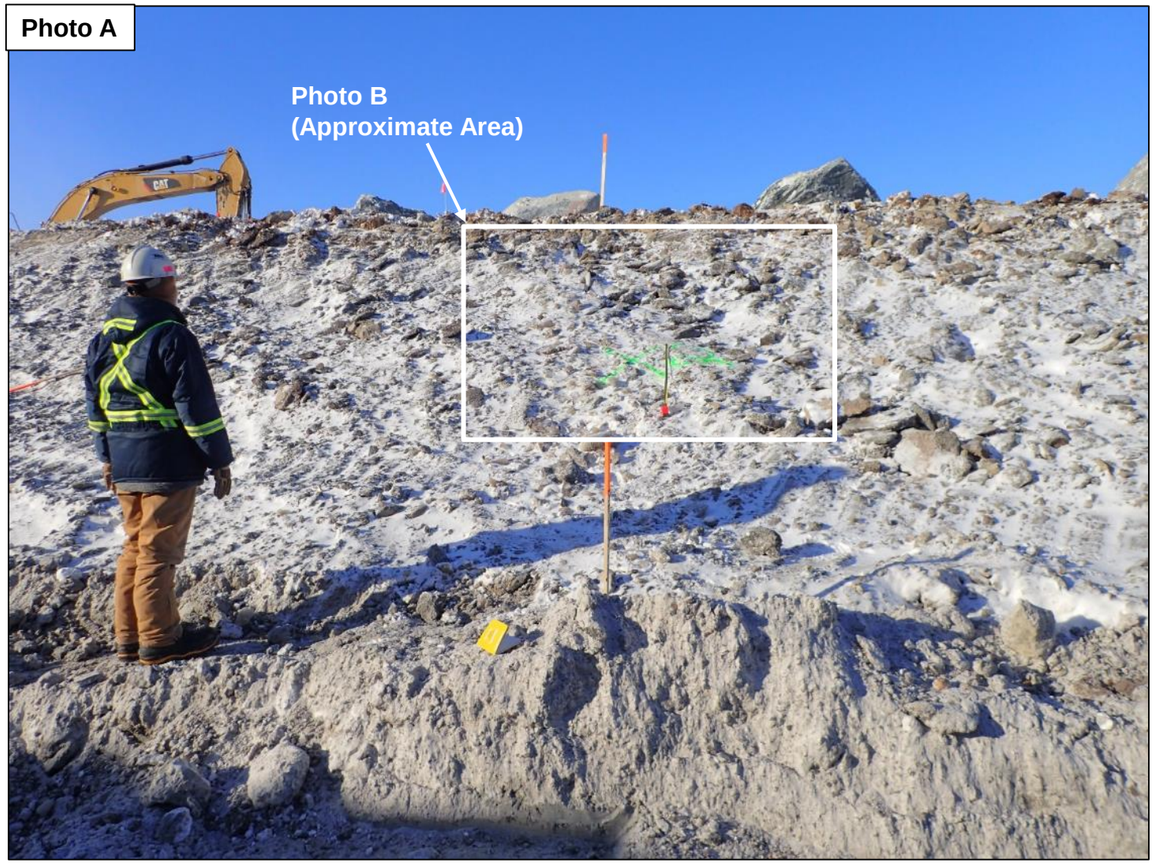


Photo B

Photo A:
- Photograph of upstream key trench slope at Massive Ground Ice Location 2 (see Figure 9)
- Massive ground ice (ICE) observed at location

Photo B:
- Solid red line indicates recognizable extent of massive ice interpreted by field personnel
- Ice body observed to be sub-vertical and approximately 1.2 m in width

srk consulting	TMAC RESOURCES	South Dam Ground Ice
		Key Trench – Massive Ground, Location 2
Job No: 1CT022.031 Filename: SouthDam_Ground_Ice_Figures_FNL.pptx	TMAC Resources Inc.	Date: 1/1/2019 | Approved: CWS | Figure: **11**

Photo A

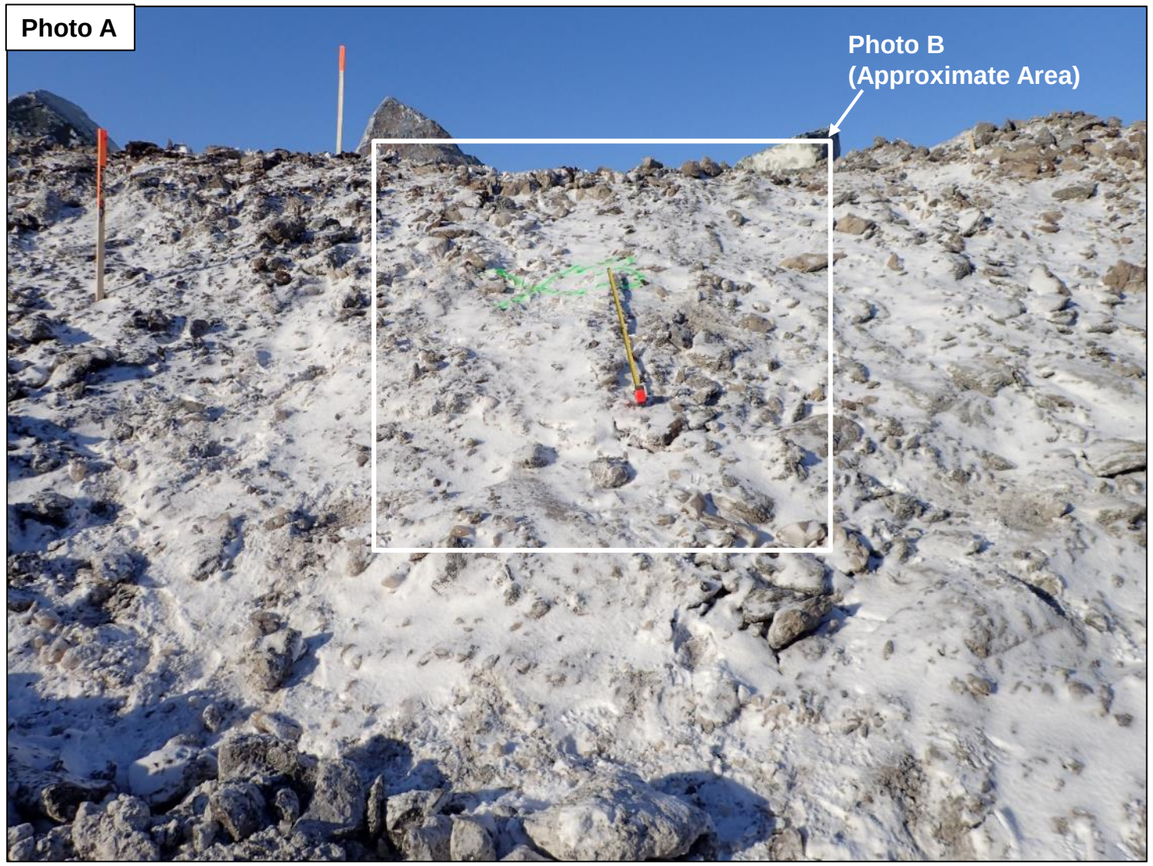
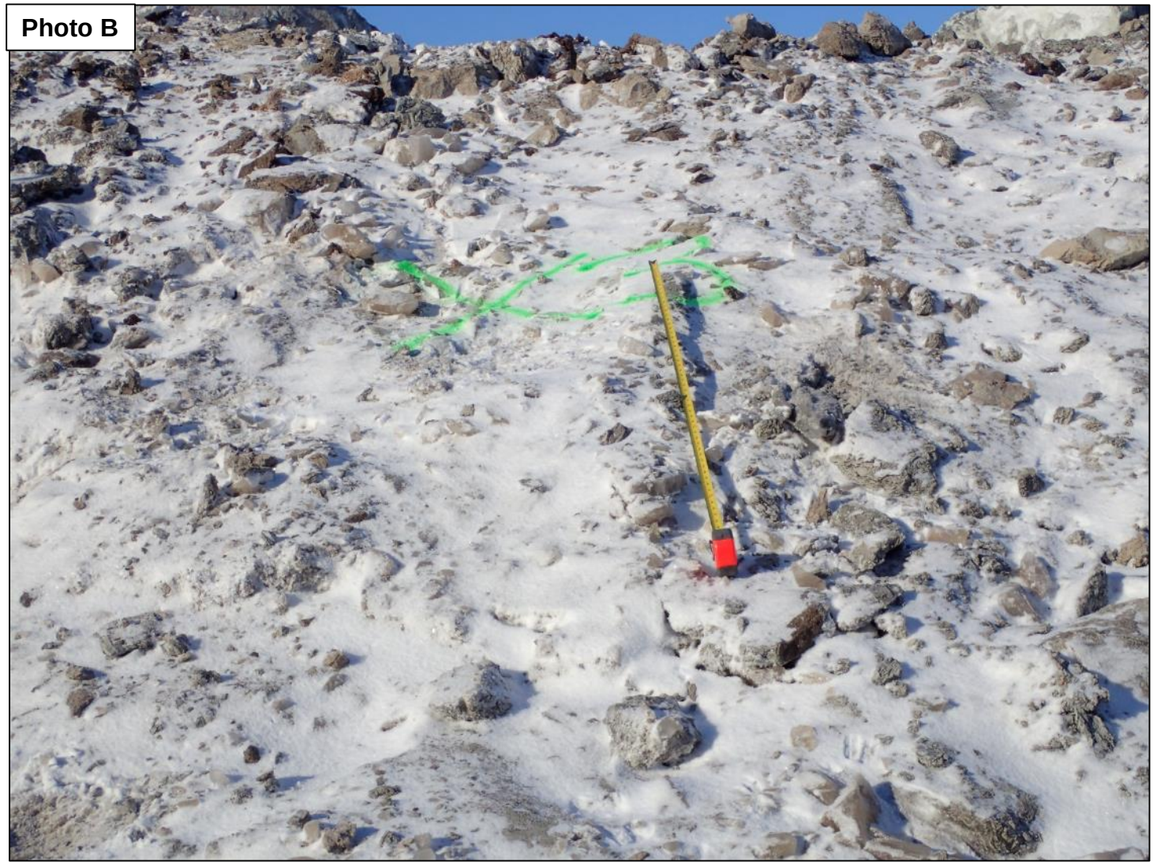


Photo B



Photos A and B:

- Photograph of upstream key trench slope at Massive Ground Ice Location 3 (see Figure 9)
- Massive ground ice (ICE) observed to be localized in extent, similar to Location 1
- Feature unable to be clearly mapped by field personnel

srk consulting	TMAC RESOURCES	South Dam Ground Ice
		Key Trench – Massive Ground, Location 3
Job No: 1CT022.031 Filename: SouthDam_Ground_Ice_Figures_FNL.pptx	TMAC Resources Inc.	Date: 1/1/2019 | Approved: CWS | Figure: **12**

Photo A

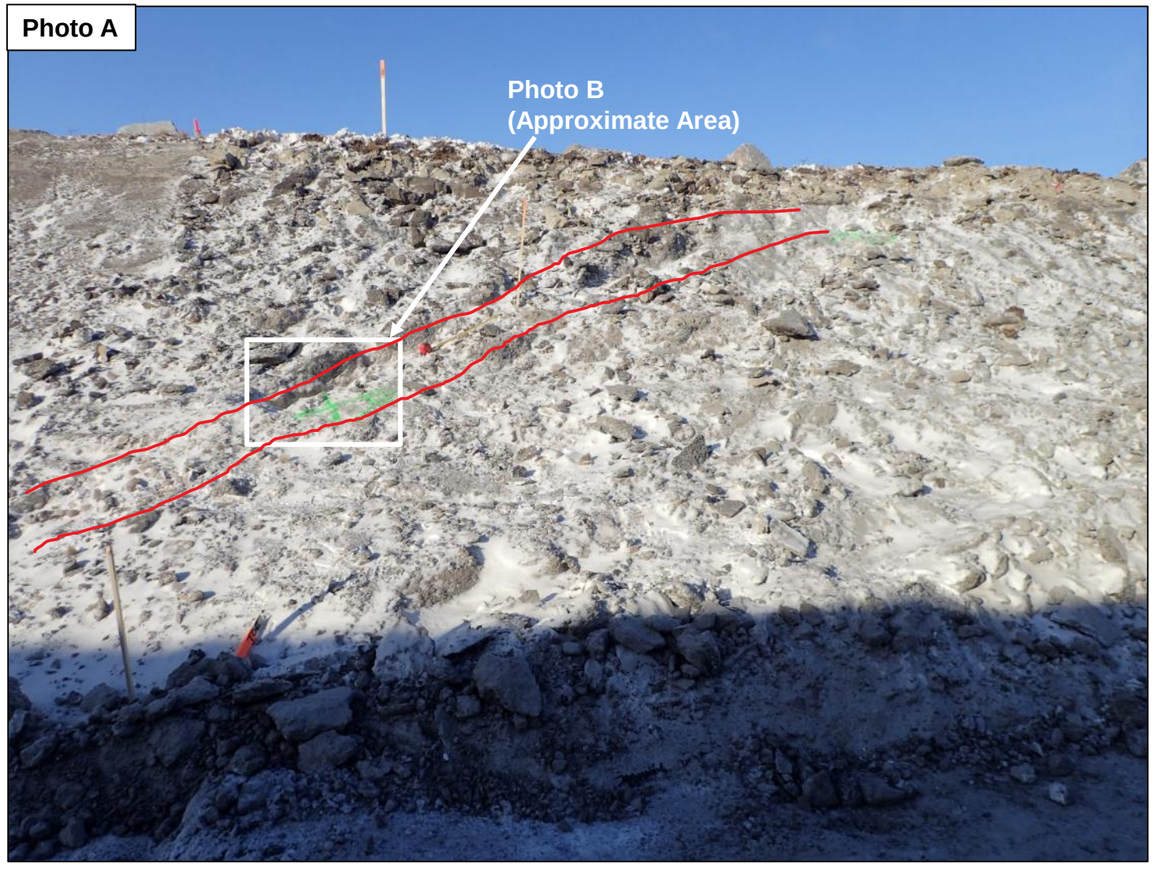


Photo B

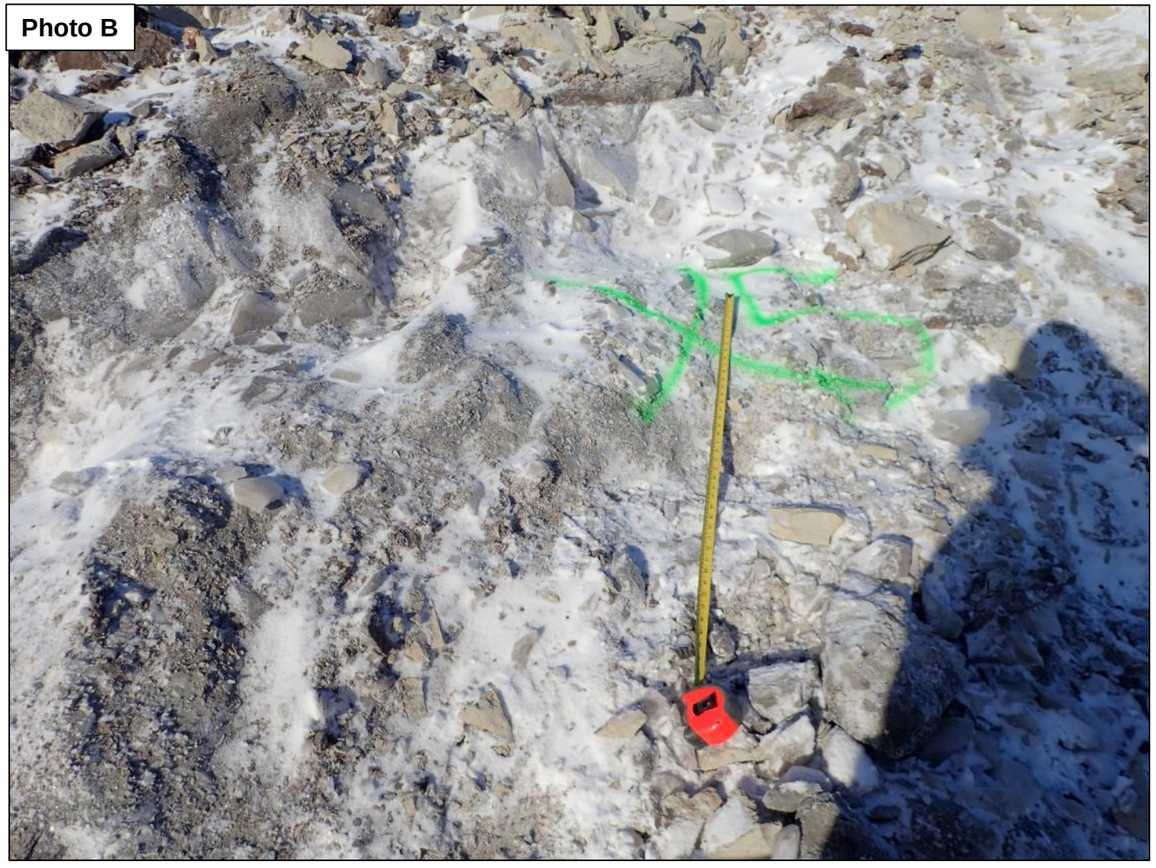


Photo A:

- Photograph of upstream key trench slope at Massive Ground Ice Locations 4,5, and 10 (see Figure 9)
- Massive ground ice (ICE) observed to be approximately 0.4 m wide and 15 m in total length from Location 4 to Location 10
- Solid red line indicates recognizable extent of massive ice interpreted by field personnel

Photo B:

- Photograph of massive ice observed to be cloudy

srk consulting	TMAC RESOURCES	South Dam Ground Ice
		Key Trench – Massive Ground, Location 4, 5,10
Job No: 1CT022.031 Filename: SouthDam_Ground_Ice_Figures_FNL.pptx	TMAC Resources Inc.	Date: 1/1/2019 | Approved: CWS | Figure: **13**

Photo A

Photo B

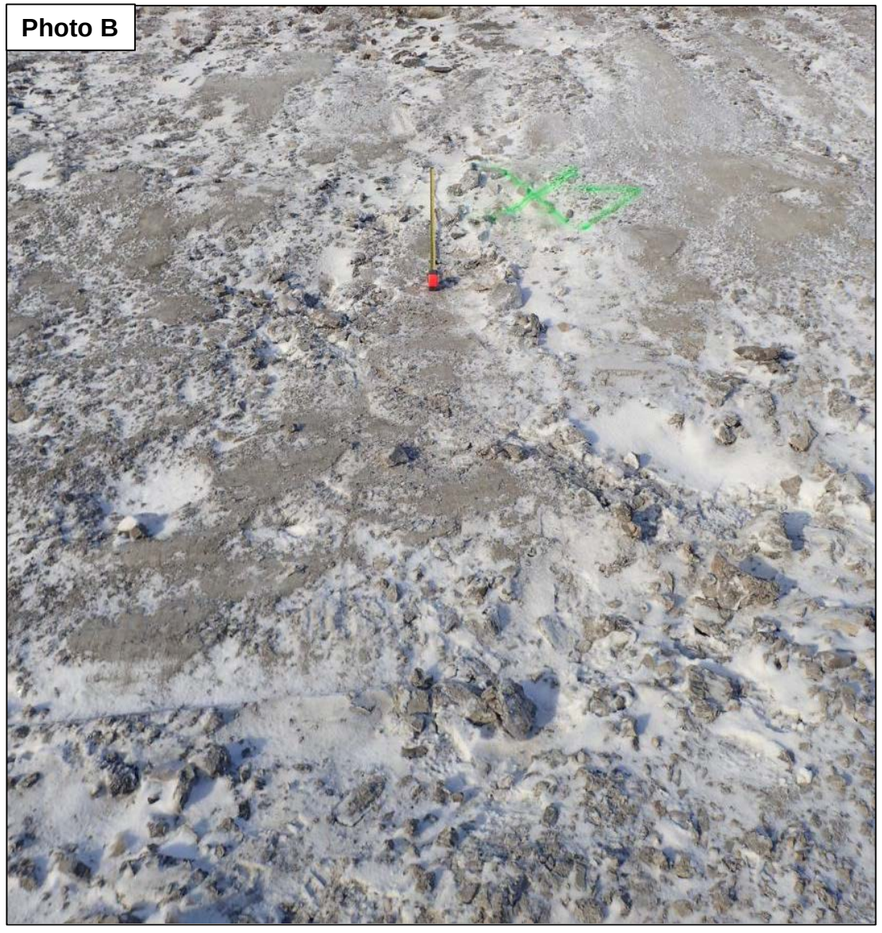


Photo A:

- Photograph of upstream key trench slope at Massive Ground Ice Location 6 (see Figure 9)
- Massive ground ice (ICE) observed to be narrow vein of ice
- Feature unable to be clearly mapped by field personnel

Photo B:

- Photograph of upstream key trench slope at Massive Ground Ice Location 7 (see Figure 9)
- Massive ground ice (ICE) observed to be narrow vein of ice
- Feature unable to be clearly mapped by field personnel

srk consulting	TMAC RESOURCES	South Dam Ground Ice
		Key Trench – Massive Ground, Locations 6 & 7
Job No: 1CT022.031 Filename: SouthDam_Ground_Ice_Figures_FNL.pptx	TMAC Resources Inc.	Date: 1/1/2019 | Approved: CWS | Figure: **14**

Photo A

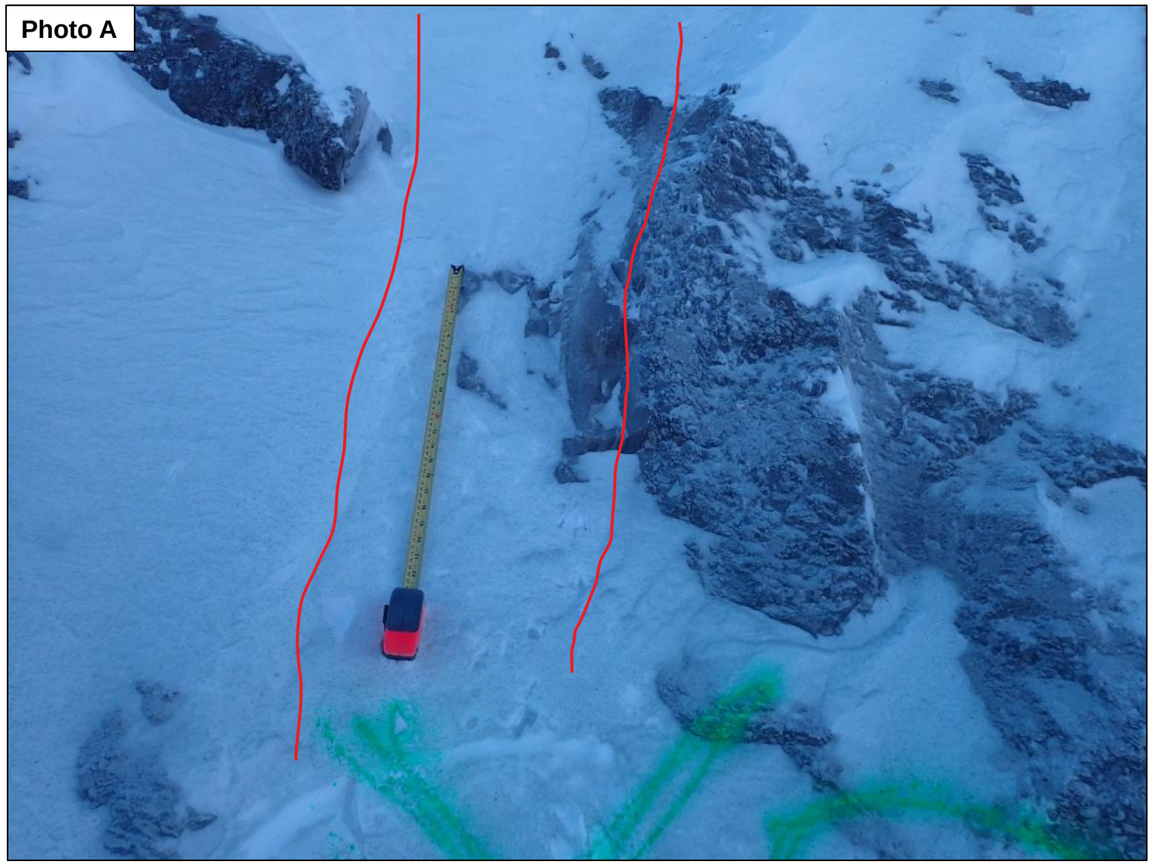
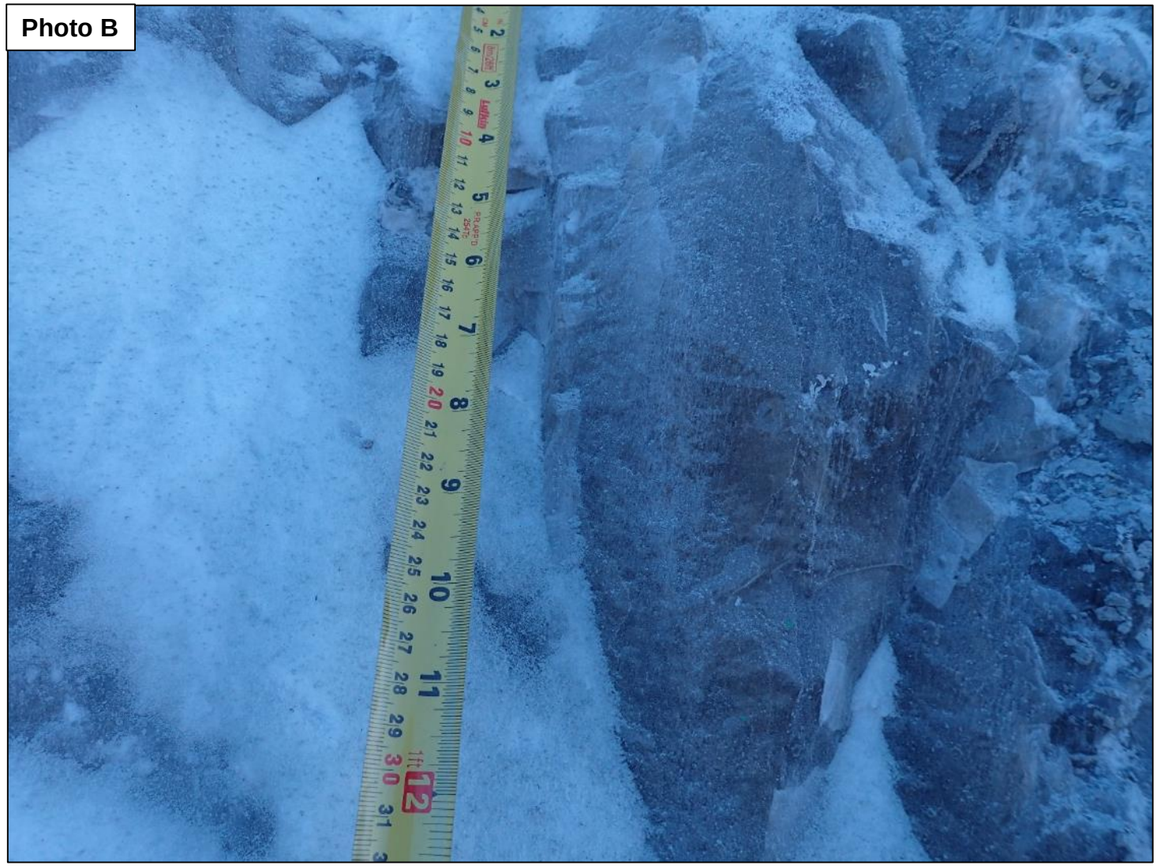


Photo B



Photos A and B:

- Photograph of downstream key trench slope at Massive Ground Ice Location 8 (see Figure 9)
- Massive ground ice (ICE) observed to be sub-vertical and 0.8 wide, with ice extent from top to bottom of key trench
- Ice cloudy to blown in color

srk consulting	TMAC RESOURCES	South Dam Ground Ice
		Key Trench – Massive Ground, Location 8
Job No: 1CT022.031 Filename: SouthDam_Ground_Ice_Figures_FNL.pptx	TMAC Resources Inc.	Date: 1/1/2019 | Approved: CWS | Figure: **15**

Photo A

Photo B

Photos A and B:

- Photograph of downstream key trench slope at Massive Ground Ice Location 9 (see Figure 9)
- Massive ground ice (ICE) observed to be sub-vertical and 0.8 wide, with ice extent from top to bottom of key trench

srk consulting	TMAC RESOURCES	South Dam Ground Ice
		Key Trench – Massive Ground, Location 9
Job No: 1CT022.031 Filename: SouthDam_Ground_Ice_Figures_FNL.pptx	TMAC Resources Inc.	Date: 1/1/2019 | Approved: CWS | Figure: **16**

Photo A

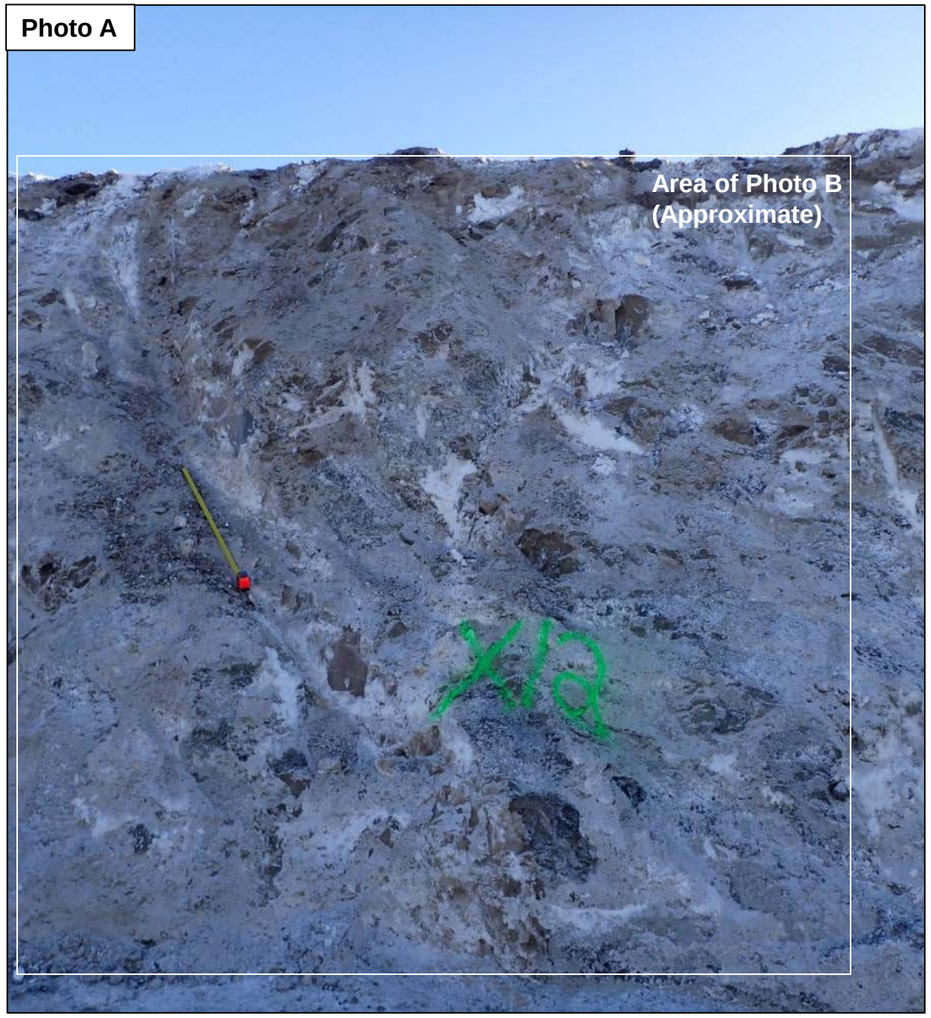
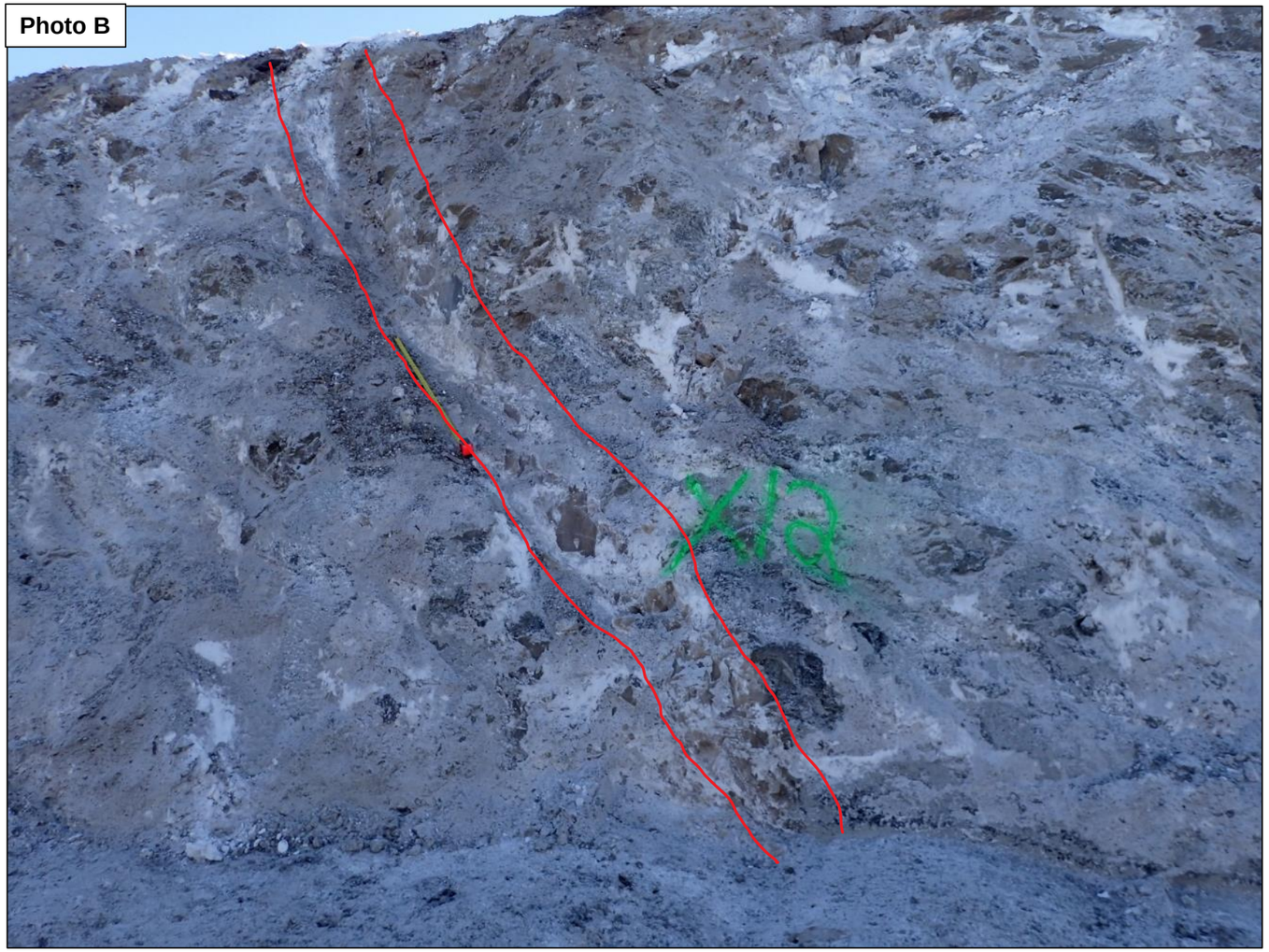


Photo B



Photos A and B:

- Photograph of downstream key trench slope at Massive Ground Ice Location 12 (see Figure 9)
- Massive ground ice (ICE) observed to be sub-vertical and 0.7 wide, with ice extent from top to bottom of key trench

srk consulting	TMAC RESOURCES	South Dam Ground Ice
		Key Trench – Massive Ground, Location 12
Job No: 1CT022.031 Filename: SouthDam_Ground_Ice_Figures_FNL.pptx	TMAC Resources Inc.	Date: 1/1/2019 | Approved: CWS | Figure: **17**

Photo A

Photo B

Photo A:

- Photograph of downstream key trench slope at Massive Ground Ice Locations 13, 14, and 15 (see Figure 9)
- Massive ground ice (ICE) observed to be approximately 2.0 m wide
- Solid red line indicates recognizable extent of massive ice interpreted by field personnel

Photo B:

- Ice observed to be brown in color

srk consulting	TMAC RESOURCES	South Dam Ground Ice
		Key Trench – Massive Ground, Location 13, 14, 15
Job No: 1CT022.031 Filename: SouthDam_Ground_Ice_Figures_FNL.pptx	TMAC Resources Inc.	Date: 1/1/2019 | Approved: CWS | Figure: **18**

Photo A

Photo B

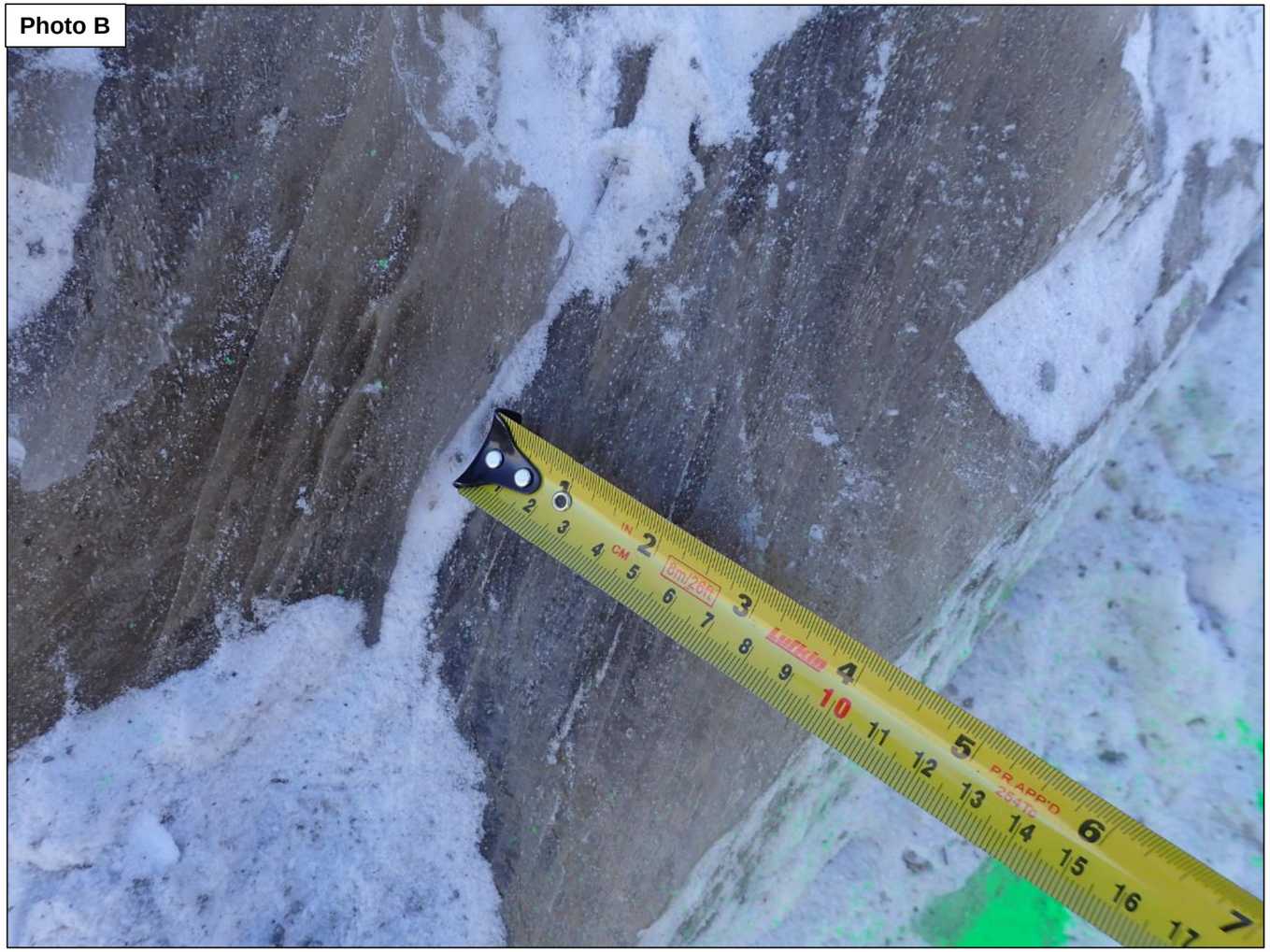


Photo A:

- Photograph of downstream key trench slope at Massive Ground Ice Location 16 (see Figure 9)
- Massive ground ice (ICE) observed to be sub-vertical and approximately 0.7 m wide
- Solid red line indicates recognizable extent of massive ice interpreted by field personnel

Photo B:

- Ice observed to be brown in color with ice striations

srk consulting	TMAC RESOURCES	South Dam Ground Ice
		Key Trench – Massive Ground, Location 16
Job No: 1CT022.031 Filename: SouthDam_Ground_Ice_Figures_FNL.pptx	TMAC Resources Inc.	Date: 1/1/2019 | Approved: CWS | Figure: **19**

Appendix H – As-built Drawings

Engineering Drawings for the South Dam - Phase 1
Doris North Project, Nunavut, Canada

Drawing Number	Drawing Title	Date	Revision	Old / Replaced Revisions
DN-SD-01	Phase 1 General Arrangement (with Orthophoto)	2019/03/11	AB	Rev 2, April 30, 2018
DN-SD-02	Phase 1 General Arrangement	2019/03/11	AB	Rev 2, April 30, 2018
DN-SD-03	Typical Sections (General)	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-04	Key Trench Excavation Plan and Profile	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-05	Liner Placement Plan and Details - Key Trench and Phase 1	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-06	Liner and Bedding Placement Details	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-07	Bedding Material Placement Plan and Sections - Key Trench and Phase 1	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-08	Transition Material Placement Plan and Sections - Key Trench and Phase 1	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections - Key Trench and Phase 1	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-11	Construction Access Road and Turn Around - Phase 1	2019/03/11	AB	Rev 2, April 30, 2018
DN-SD-12	Final Phase 1 Dam Plan, Profile and Sections	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-13	Sections Sta. 0+10 to 0+90 - Phase 1 Dam	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-14	Sections Sta. 1+00 to 1+80 - Phase 1 Dam	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-15	Sections Sta. 1+90 to 2+70 - Phase 1 Dam	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-16	Sections Sta. 2+80 to 3+60 - Phase 1 Dam	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-17	Sections Sta. 3+70 to 4+50 - Phase 1 Dam	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-18	Sections Sta. 4+60 to 5+30 - Phase 1 Dam	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-19	Infill Foundation Drilling - Phase 1	2018/03/07	AB	Rev 0, 2018/02/16
DN-SD-20	Percolation Borehole / Test Locations	2018/03/07	AB	Rev 0, 2018/02/16
DN-SD-21	Instrumentation Plan - Phase 1	2019/03/11	AB	Rev 2, May 24, 2018
DN-SD-22	GTC backfilled Cable Trench - Phase 1	2019/03/11	AB	Rev 2, April 26, 2018
DN-SD-23	Vertical GTC Layout - Phase 1	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-24	Horizontal GTC - Upstream Base / Toe of Key Trench	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-25	GTC Layout Along Upstream Above Ground Liner Slope	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-26	Sloped GTC - Above Ground Liner Slope	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-27	Instrumentation Details at Sta. 0+65 and 1+55	2019/03/11	AB	Rev 1, March 7, 2018
DN-SD-28	Instrumentation Details at Sta. 2+40 and 3+65	2019/03/11	AB	Rev 0, March 7, 2018
DN-SD-29	Instrumentation Details at Sta. 4+65 and 5+10	2019/03/11	AB	Rev 0, March 7, 2018
DN-SD-30	Typical Monitoring Point Details	2019/03/11	AB	Rev 1, May 24, 2018

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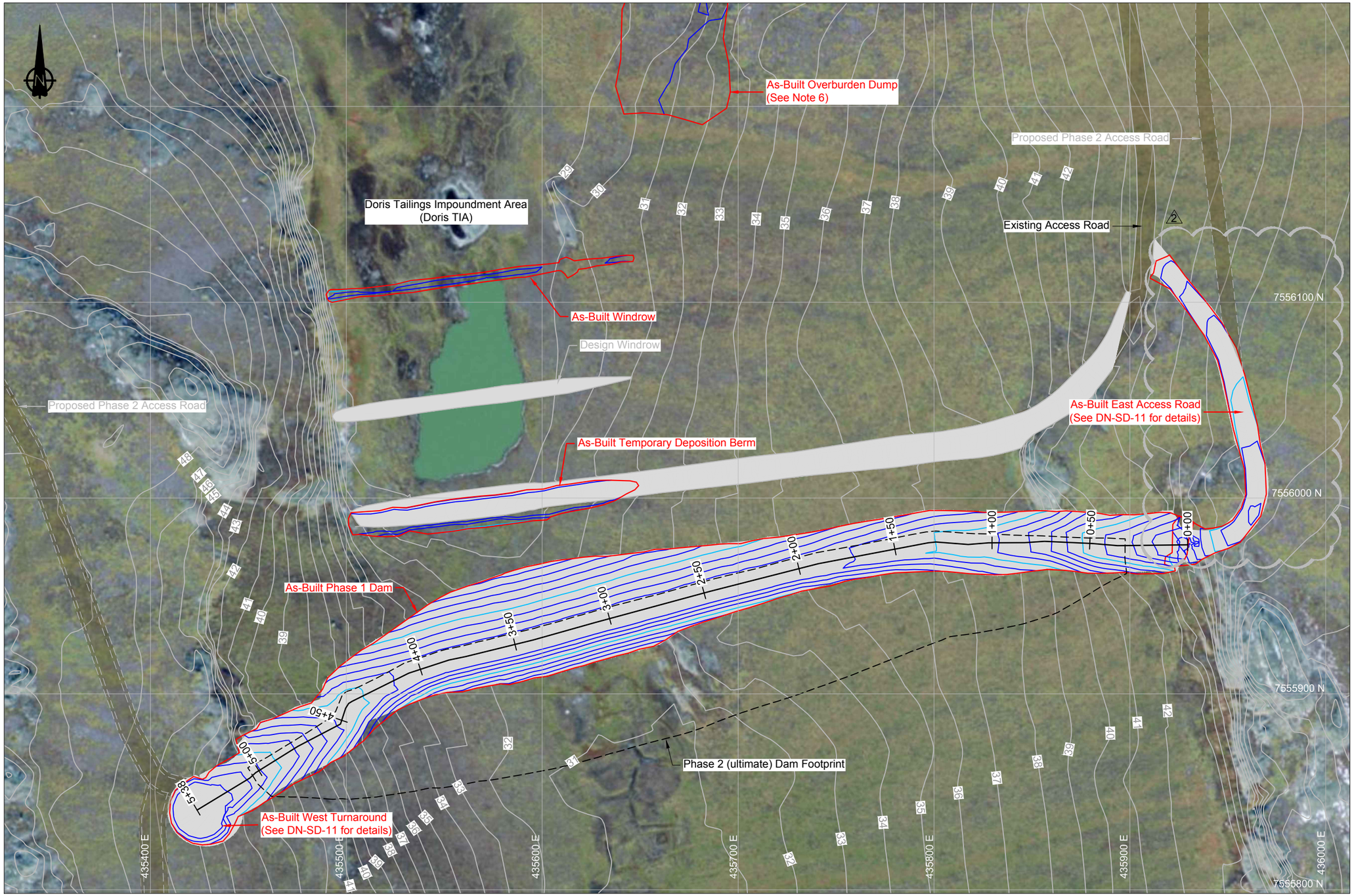

LEGEND

- Proposed Road / Dam Infrastructure
- As-Built Contours
- Design Footprint
- As-Built Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Imagery (from 2010 PhotoSat compilation) provided by client.
5. All units shown are in meters unless otherwise stated.
6. Only southern extent of as-built Overburden Dump shown. Final grading of overburden dump below 33 m to accommodate the tailings deposition plan.

REFERENCES

NAD83 UTM Zone 13.

0m 20 40 60 80

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
AB	As-Built	JBK	EMR	19/03/11
2	Issued for Construction	JBK	EMR	18/04/30
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

DRAWING NO.: DN-SD-02 | DRAWING TITLE: Phase 1 General Arrangement

REFERENCE DRAWINGS | REVISIONS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam GA - with ortho.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Phase 1 General Arrangement (with Orthophoto)

DRAWING NO.: DN-SD-01 | SHEET: 1 OF 30 | REVISION NO.: AB

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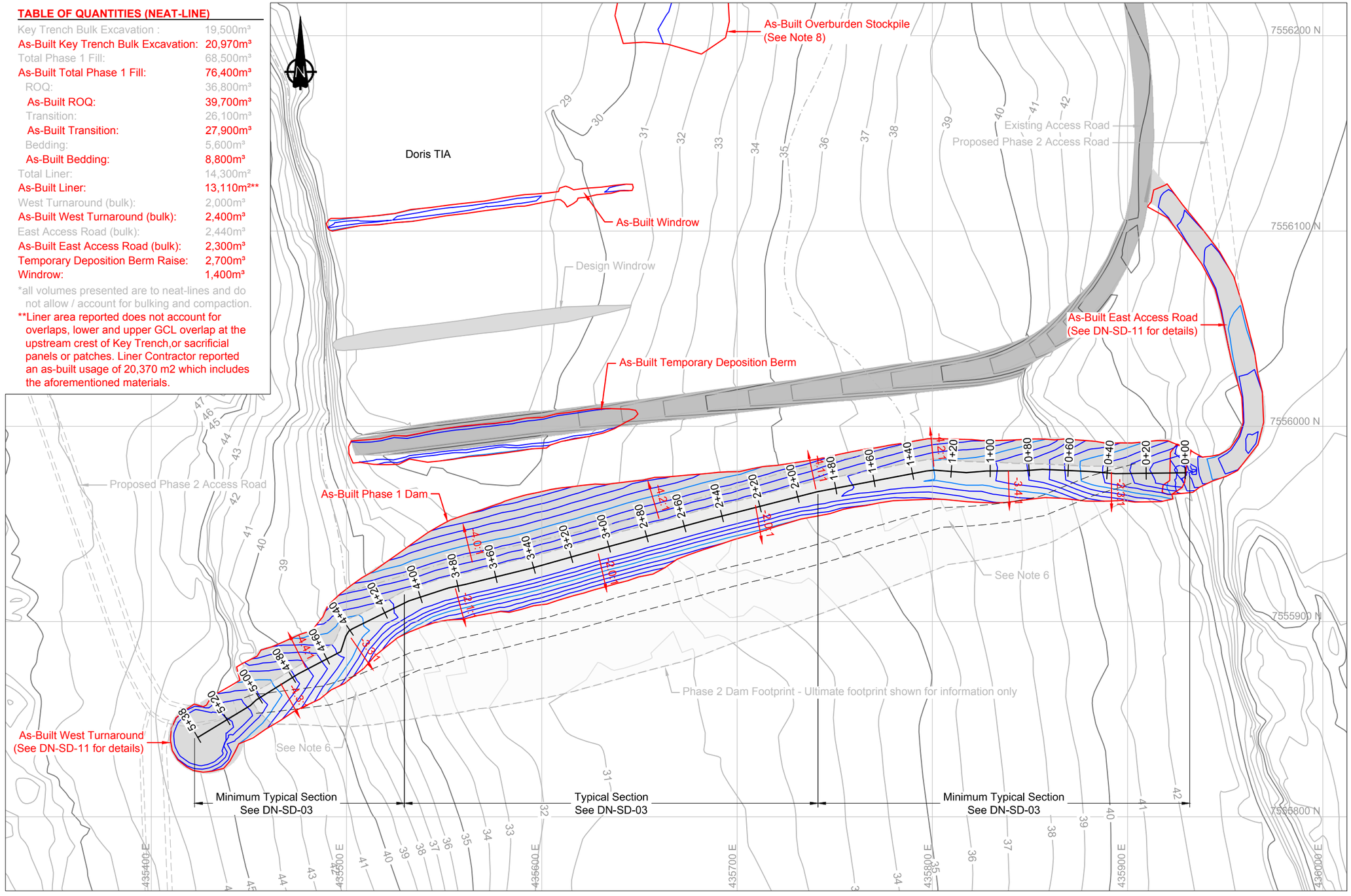
TABLE OF QUANTITIES (NEAT-LINE)

Key Trench Bulk Excavation :	19,500m³
As-Built Key Trench Bulk Excavation:	20,970m³
Total Phase 1 Fill:	68,500m³
As-Built Total Phase 1 Fill:	76,400m³
ROQ:	36,800m³
As-Built ROQ:	39,700m³
Transition:	26,100m³
As-Built Transition:	27,900m³
Bedding:	5,600m³
As-Built Bedding:	8,800m³
Total Liner:	14,300m²
As-Built Liner:	13,110m²**
West Turnaround (bulk):	2,000m³
As-Built West Turnaround (bulk):	2,400m³
East Access Road (bulk):	2,440m³
As-Built East Access Road (bulk):	2,300m³
Temporary Deposition Berm Raise:	2,700m³
Windrow:	1,400m³

*all volumes presented are to neat-lines and do not allow / account for bulking and compaction.

**Liner area reported does not account for overlaps, lower and upper GCL overlap at the upstream crest of Key Trench,or sacrificial panels or patches. Liner Contractor reported an as-built usage of 20,370 m2 which includes the aforementioned materials.



LEGEND

- Proposed Road / Dam Infrastructure
- As-Built Contours
- As-Built Footprint
- Design Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
3. All drawings should be read in conjunction with the latest technical specifications document ('*Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*) . The onsite engineer representative should be consulted to determine what the latest revision of the technical specifications is.
4. Volumes presented based on neat-lines only and are approximate. These include no over-excavation or over-blasting allowance of the key trench.
5. All units shown are in meters unless otherwise stated.
6. Bend in the dam crest is to accommodate Phase 2 liner tie-in.
7. All snow roads placed on the upstream as a temporary construction measure, to help facilitate construction of the dam, must be completely removed before tailings deposition may commence.
8. Only southern extent of as-built Overburden Dump shown. Final grading of overburden dump below 33 m to accommodate the tailings deposition plan.

REFERENCES

NAD83 UTM Zone 13.

0m 20 40 60 80

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
AB	As-Built	JBK	EMR	19/03/11
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1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

DRAWING NO.	DRAWING TITLE
DN-SD-03	Typical Sections

REFERENCE DRAWINGS

REVISIONS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam GA.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Phase 1 General Arrangement

DRAWING NO.	SHEET	REVISION NO.
DN-SD-02	2 OF 30	AB

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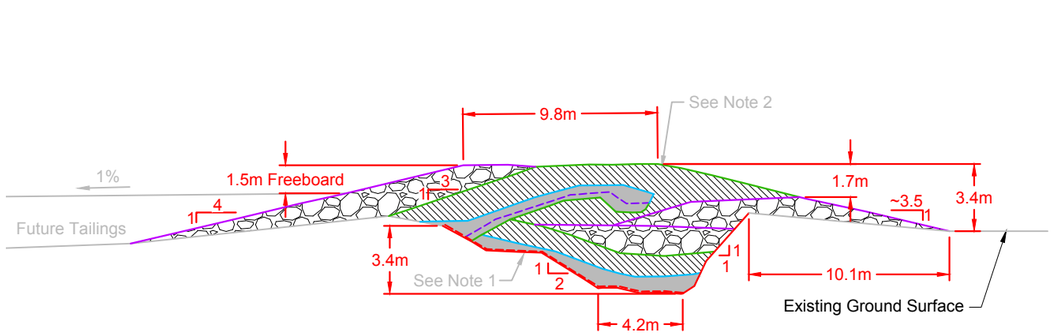
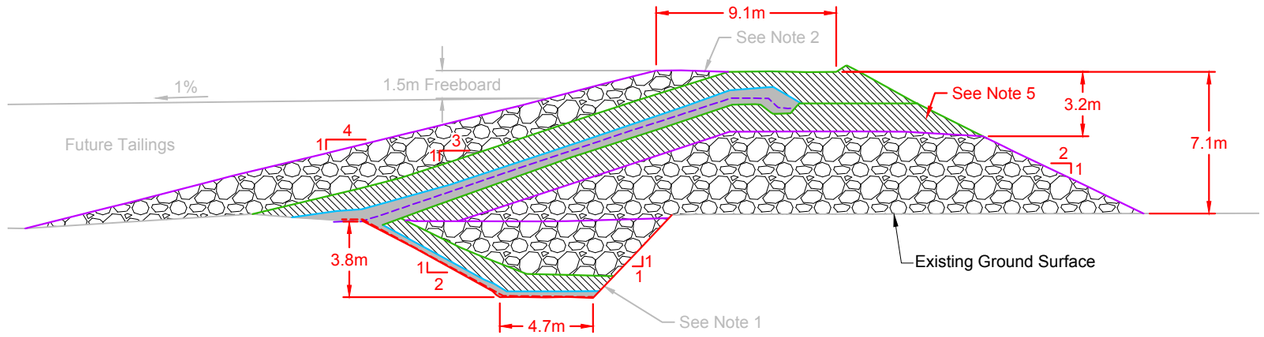


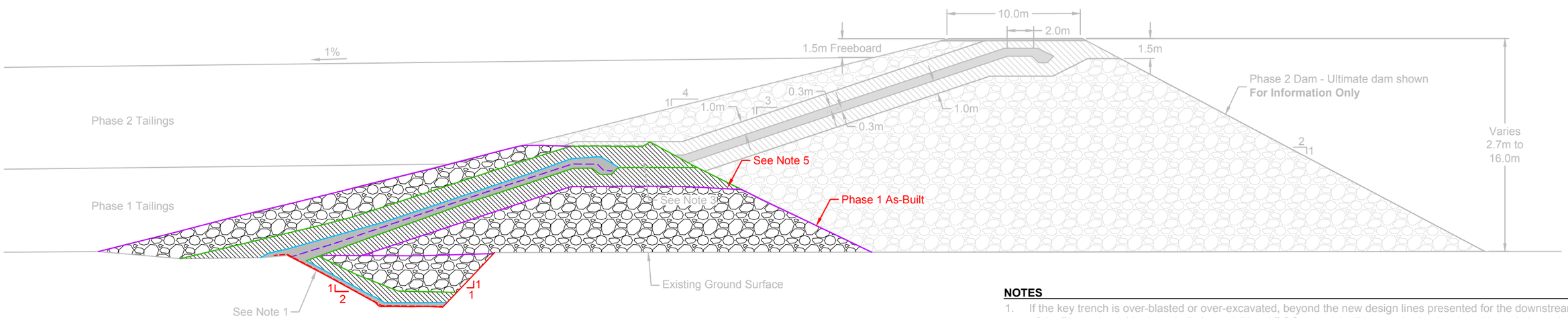
Minimum Typical Cover Section
STA.0+00 to 1+92 & 4+15 to 5+42

0m 3 6 9 12



Phase 1 Typical Dam Section
STA. 1+92 to 4+15

0m 3 6 9 12



Phase 2 Typical Dam Section
STA. 0+25 to 5+25

0m 3 6 9 12

ISSUED FOR INFORMATION

LEGEND

- As-Built Key Trench Liner
- As-Built Phase 1 Liner
- As-Built Bedding Material
- As-Built Transition Material
- As-Built Run of Quarry (ROQ) Material

NOTES

1. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench. This material would be placed to ensure that adequate thermal insulation of the key trench is maintained in all sections. See Detail 10 on drawing DN-SD-09 for additional details.
2. The top road surfacing (bedding material) for the Phase 1 dam is to be fully removed (upstream and downstream) before Phase 2 construction commences.
3. To allow for a proper tie-in the transition material around the top downstream portion of the Phase 1 dam will be required to be stripped back. Once the bedding material around the top liner anchor trench is reached hand excavation should be expected to result down to expose the liner. The on-site engineer will be required to inspect all exposed liner, to ensure that it is not damaged or in need of repairs before Phase 2 liner tie-ins result.
4. All units shown are in meters unless otherwise stated.
5. ROQ material was generally replaced with transition material for constructability.

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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							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam - Typ Sections.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Typical Sections (General)

DRAWING NO.	SHEET	REVISION NO.
DN-SD-03	3 OF 30	AB

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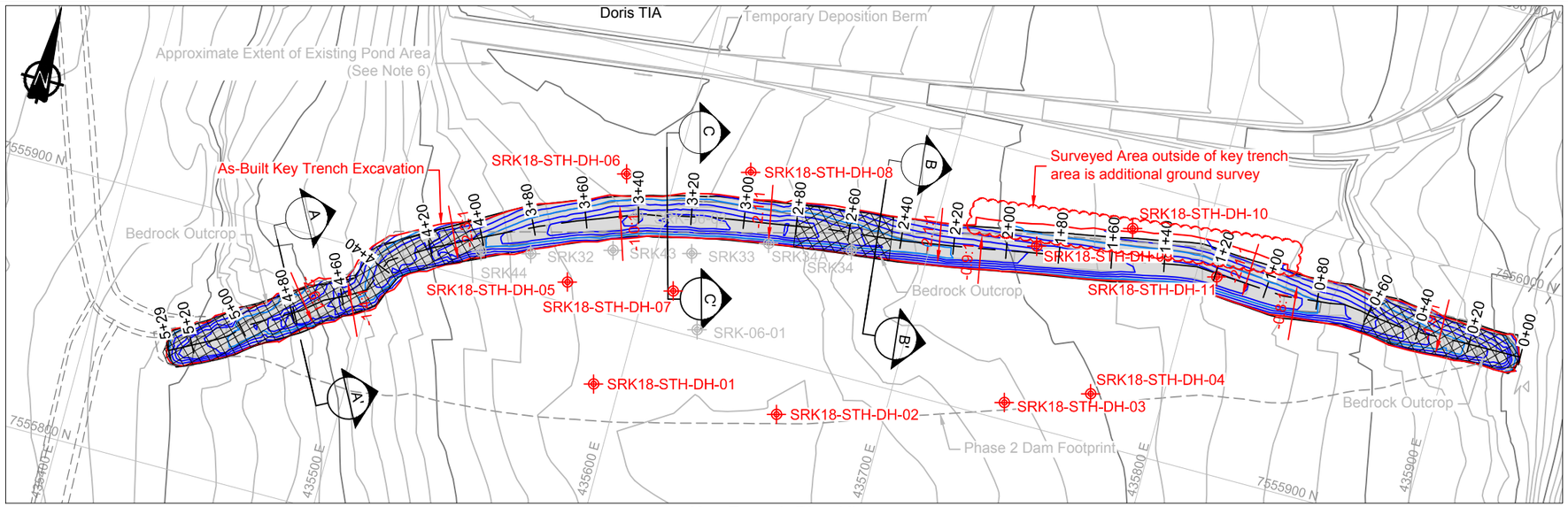
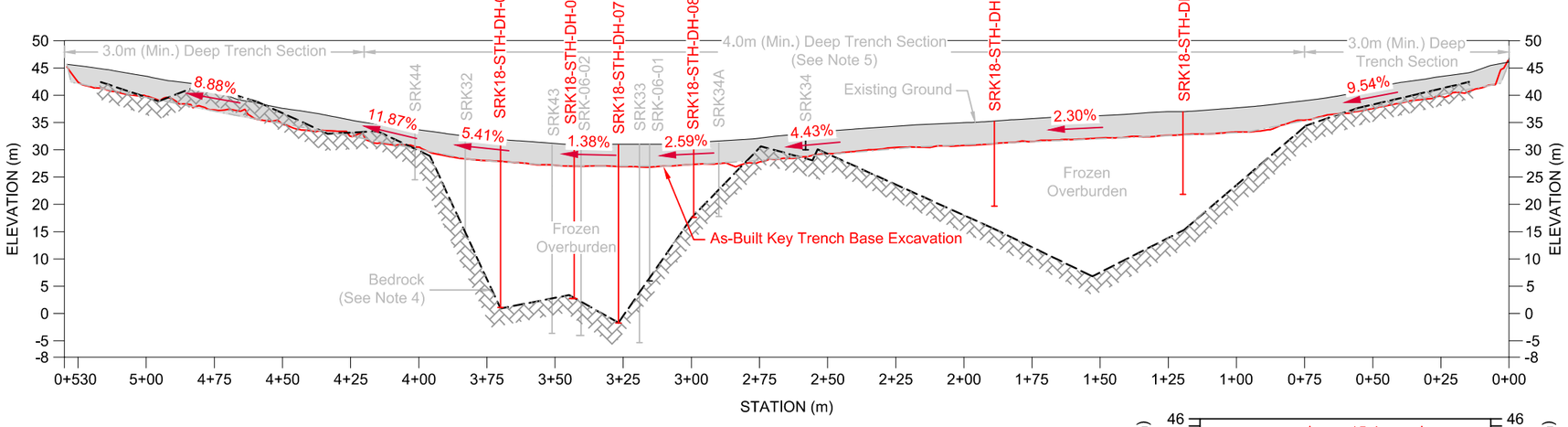


Key Trench Plan View

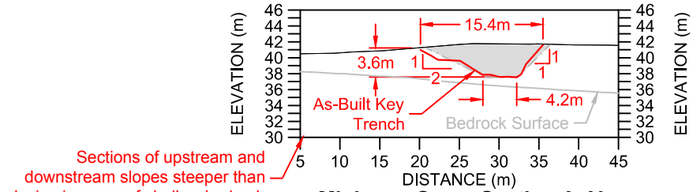
0m 20 40 60 80



Key Trench Profile View

Vertical 0m 10 20 30 40

Horizontal 0m 20 40 60 80



Sections of upstream and downstream slopes steeper than design in areas of shallow bedrock

Minimum Cross Section A-A'
Shallow Overburden over Bedrock

0m 5 10 15 20 25 30

LEGEND

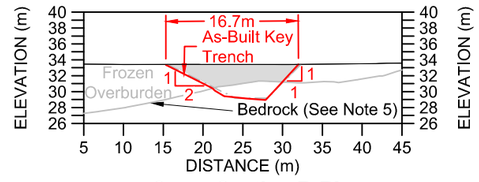
- Previously Existing Drill Hole Location
- 2018 Infill As-Built Drill Hole Location
- Design Trench Excavation
- As-Built Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Design Trench Excavation Extent
- As-Built Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profile shown correspond to the upstream toe of the key trench.
4. The subsurface geology has been inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A , SRK43, SRK 44, SRK18-STH-DH01-11 and SRK18-WST-DH01-03), airphoto interpretations, and from limited available geophysical surveys around the Tails Lake area. This data was then used to create a bedrock surface with the Gemcom GEMS software. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.
5. The final key trench extent and depth will be determined in the field by the Engineer. Typical excavation depth is 4.0m, unless massive ice, hypersaline soil or bedrock encountered. The Engineer will inspect all excavations and approve the foundation conditions.
6. Ponded area to removed (frozen massive ice excavated or drained if possible). Up to approximately 4,700 m3 of (frozen) water may be expected to be removed from this area. Exact water levels are not known so the volume estimate above should be treated as a rough estimate based on topography.
7. If any area of the key trench is over-blasted or over-excavated then the extra excavation will need to be backfilled in thin lifts (*see 'Technical Specifications'*) until the key trench design lines and grades are reached.
8. Overblasting and/or overexcavation of the key trench beyond the design lines (as presented on this figure) should be avoided if at all possible. Extra care should be taken during the key trench excavation to ensure that the excavation can result as close to the design lines as possible. Excavation beyond the key trench design lines may require that the overall Phase 1 dam footprint be enlarged to provide the necessary thermal coverage and to uphold design requirements.

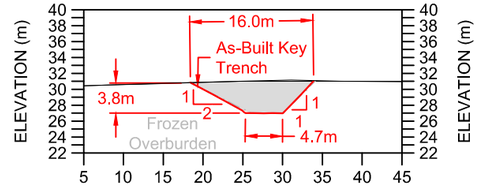
REFERENCES

NAD83 UTM Zone 13.



Cross Section B-B'
Bedrock Outcropping in Key Trench

0m 5 10 15 20 25 30



Cross Section C-C'
Deep Frozen Overburden

0m 5 10 15 20 25 30

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
AB	As-Built	JBK	EMR	19/03/11
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam - Key Trench.dwg

SRK JOB NO.: 1CT022.017

TMAC RESOURCES

Hope Bay Project

South Dam

DRAWING TITLE: Key Trench Excavation Plan and Profile

DRAWING NO. DN-SD-04 | SHEET 4 OF 30 | REVISION NO. AB

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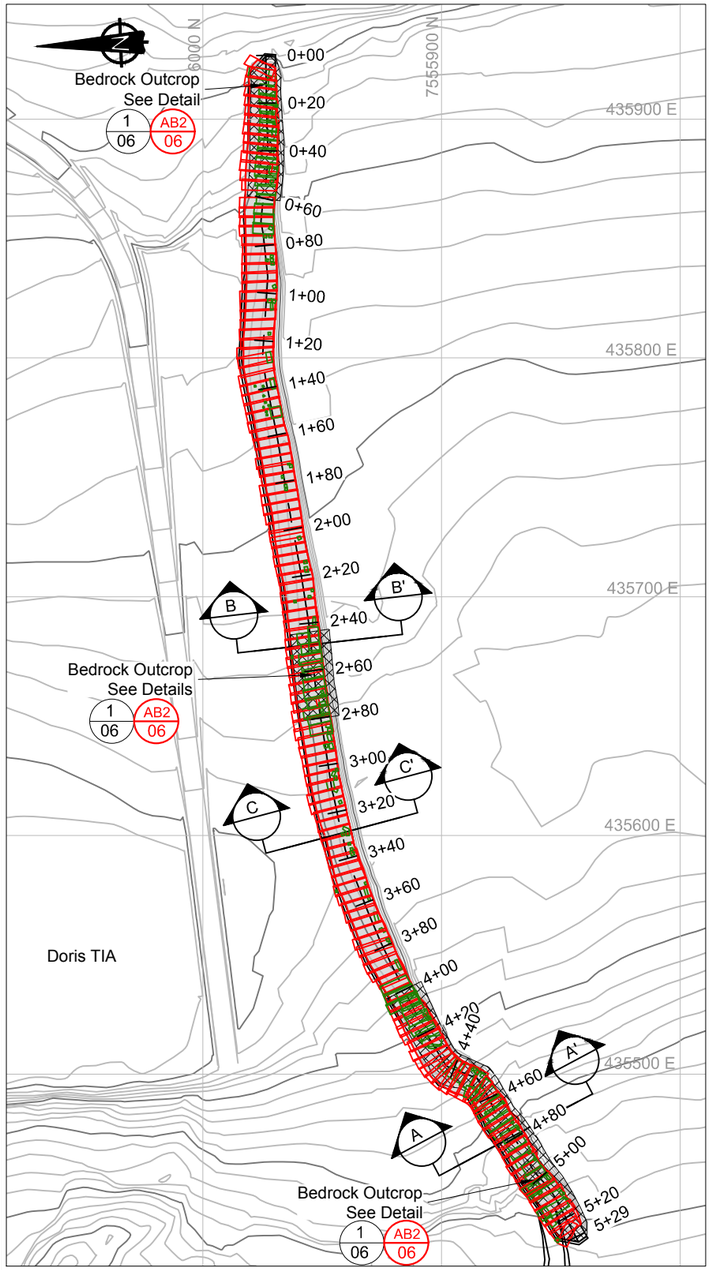
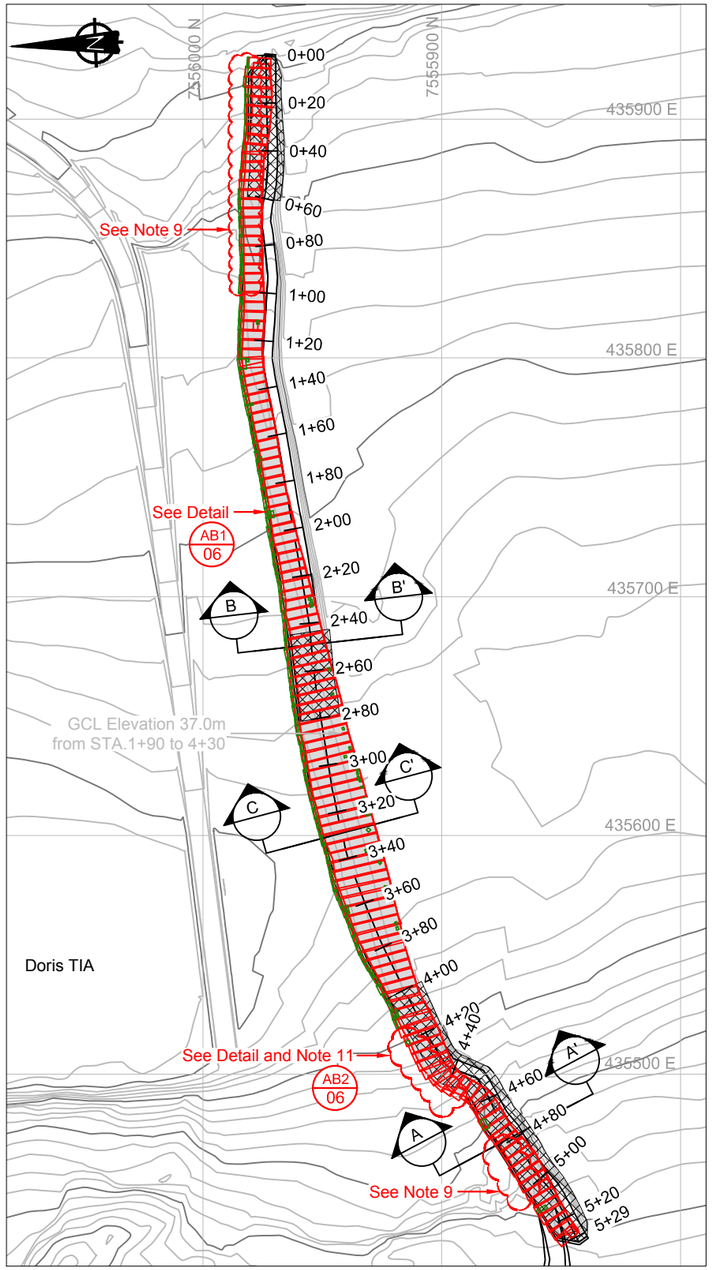


Lower Liner Plan - Placement in Key Trench

0m 20 40 60 80 100



Upper Phase 1 Liner Plan - Above Ground Upstream Slope Placement

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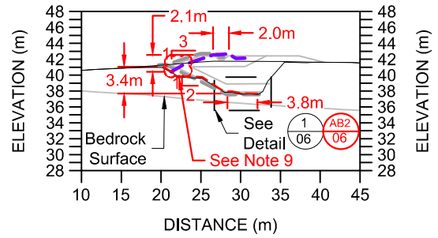

Minimum Cross Section A-A'

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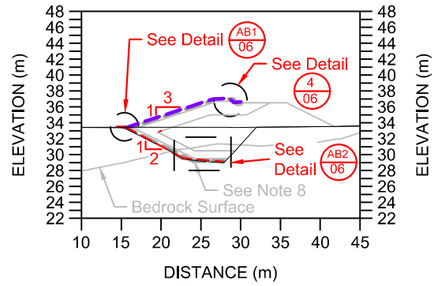

Cross Section B-B' - Bedrock Encountered in Trench

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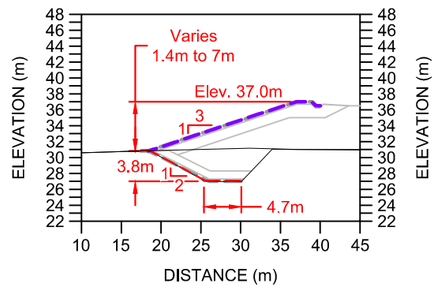

Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

- Design Liner
- As-Built Liner
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent
- As-Built GCL Liner Panel
- As-Built Patch / Sacrificial Liner Panel
- Design GCL Liner Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The upstream slope of the key trench excavation need to be scraped and smoothed to prepare a suitable subbase for the GCL liner as determined by field Engineer. If any voids larger than 0.15m or undulation exist then they will need to be backfilled with compacted bedding material fill, placed in thin 0.15m lifts.
4. The subgrade surface must be free of vegetation, sharp-edged rocks, stones, sticks, construction debris, and other foreign material that could contact the GCL. Furthermore, all protrusions extending more than 12 mm from the subgrade surface shall either be removed, crushed, or pushed into the surface with a smooth-drum compactor.
5. GCL should not be placed over massive ice or standing water (both need to be removed prior to placement).
6. All Geosynthetic Clay Liner (GCL) liner sections / panels will be required to have a minimum 0.5m overlap on every edge. See Detail 2, 3, 5 and 6 on DN-SD-06 for additional information.
7. At the locations where bedrock is encountered in the key trench then these areas will be required to be ripped down to competent bedrock or scrapped smooth and then bentonite powder will be placed between the bedrock contact and the GCL liner (see Detail 1, DN-SD-06).
8. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m in depth), until competent bedrock is encountered, or as directed by Engineer.
9. Above ground bedding material over-steepened between Stations 0+00 through 1+00 and 4+80 through 5+00 to account for discrepancy in original ground topography and to maintain upstream design toe. See detail AB3 on Drawing DN-SD-07.
10. Higher density of sacrificial patches and fly-ash mixture subgrade material used in sections excavated in shallow bedrock. For further details on locations of sacrificial panels and patches, see as-built panel layout in the Liner Construction Summary (Appendix I).
11. Additional sacrificial liner not placed over joint in this area.

REFERENCES

NAD83 UTM Zone 13.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							AB	As-Built	JBK	EMR	19/03/11
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-06	Liner and Bedding Placement Details	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Liner Placement Plan and Details
Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-05	5 OF 30	AB

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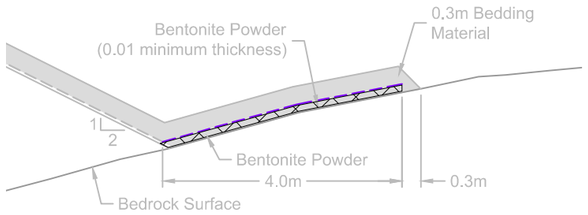
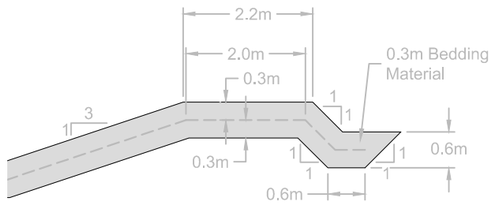
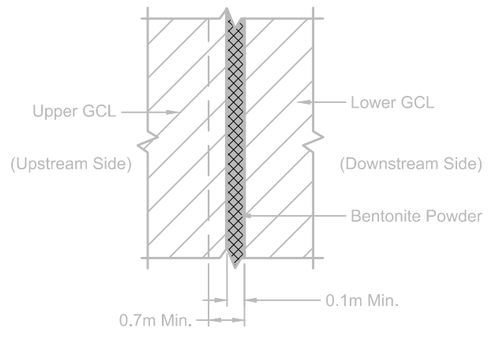


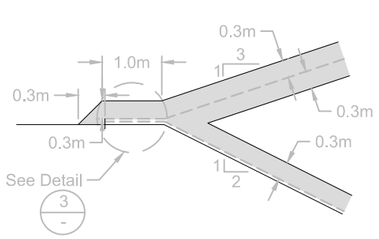
Detail 1 - Liner Attachment at Bedrock



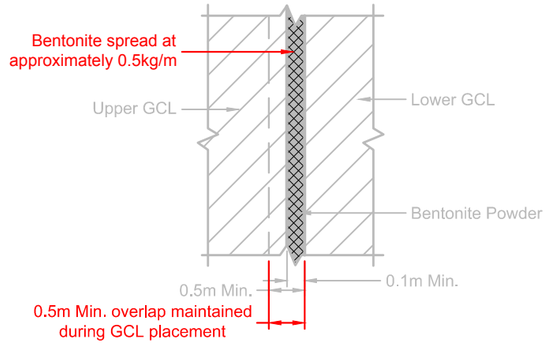
Detail 4 - Liner Anchor Trench Bedding



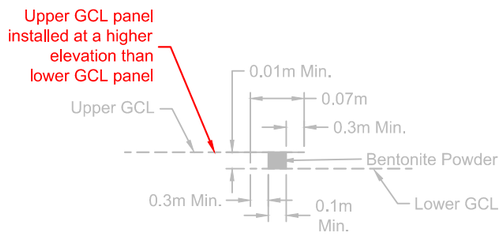
Detail 7 - Typical End of Panel GCL Overlap - Plan



Detail 2 - Liner Overlap - Bedding

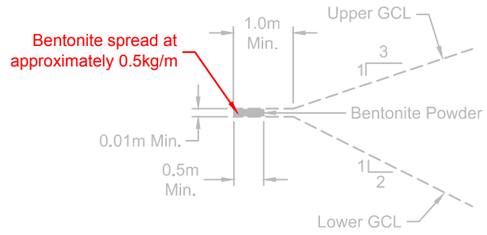


Detail 5 - Typical Longitudinal GCL Overlap - Plan

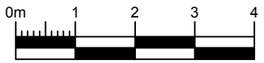


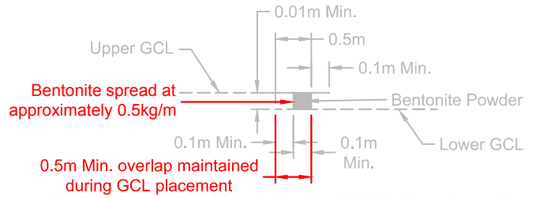
Detail 8 - Typical End of Panel GCL Overlap - Section

Not To Scale



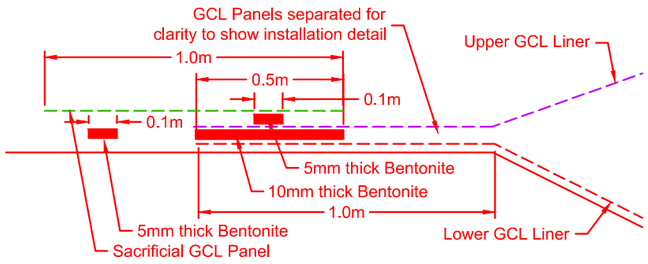
Detail 3 - Typical Upper and Lower GCL Joint





Detail 6 - Typical Longitudinal GCL Overlap - Section

Not To Scale



Detail AB1 - Amended Upper and Lower GCL Joint

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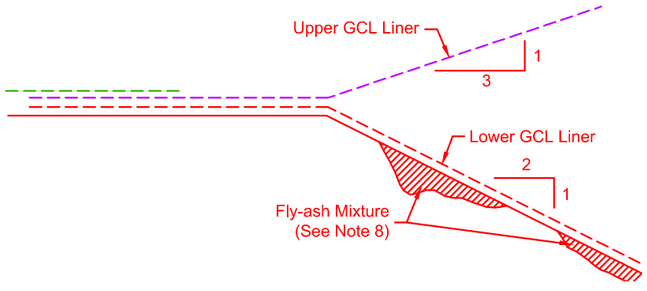

Detail AB2 - Amended Liner Attachement to Bedrock

Not To Scale

LEGEND

- Design GCL Liner
- As-Built GCL Liner
- Design Bedding Material

NOTES

1. All units shown are in meters unless otherwise stated.
2. One end of the GCL roll should be anchored at the top of the slope. The front edge of the key trench (see Detail 4) shall be rounded so as to eliminate any sharp corners that could cause excessive stress on the GCL. Loose soil should be removed.
3. The GCL should be placed in the key trench such that it covers the entire key trench floor but does not extend up the rear trench wall (see Detail 4).
4. GCL seams are constructed by overlapping their adjacent edges (see Detail 5). Care should be taken to ensure that the overlap zone is not contaminated with loose soil or other debris.
5. If the GCL is damaged (torn, punctured, perforated, etc.) during installation, it may be possible to repair it by placing a patch over the damaged area. The patch shall be obtained from a new GCL roll and shall be cut to size such that a minimum overlap of 500 mm is achieved around all parts of the damaged area. Bentonite mastic / powder should be applied around the damaged area prior to placement of the patch. It may be necessary to use an adhesive such as wood glue, or by hand placing material over the patch, to fix the patch in place so that it is not moved during overliner bedding material placement. Smaller patches also may be tucked under the damaged area to prevent patch movement.
6. Bedding shall be free of angular stones or other foreign matter which could damage the GCL. Cover soils should be approved by the Engineer, with respect to particle size and uniformity (as per the 'Technical Specifications').
7. Surface for the liner placement must be smooth competent 'virgin' ground with no loose or fractured material.
8. Fly-ash mixture material approved by SRK for use during sub-grade preparation to achieve surface acceptable for GCL installation.

REFERENCES

NAD83 UTM Zone 13.

DRAWING NO.	DRAWING TITLE
-	-

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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NO.	DESCRIPTION	CHK'D	APP'D	DATE
AB	As-Built	JBK	EMR	19/03/11
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam - Liner.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Liner and Bedding Placement Details

DRAWING NO.	SHEET	REVISION NO.
DN-SD-06	6 OF 30	AB

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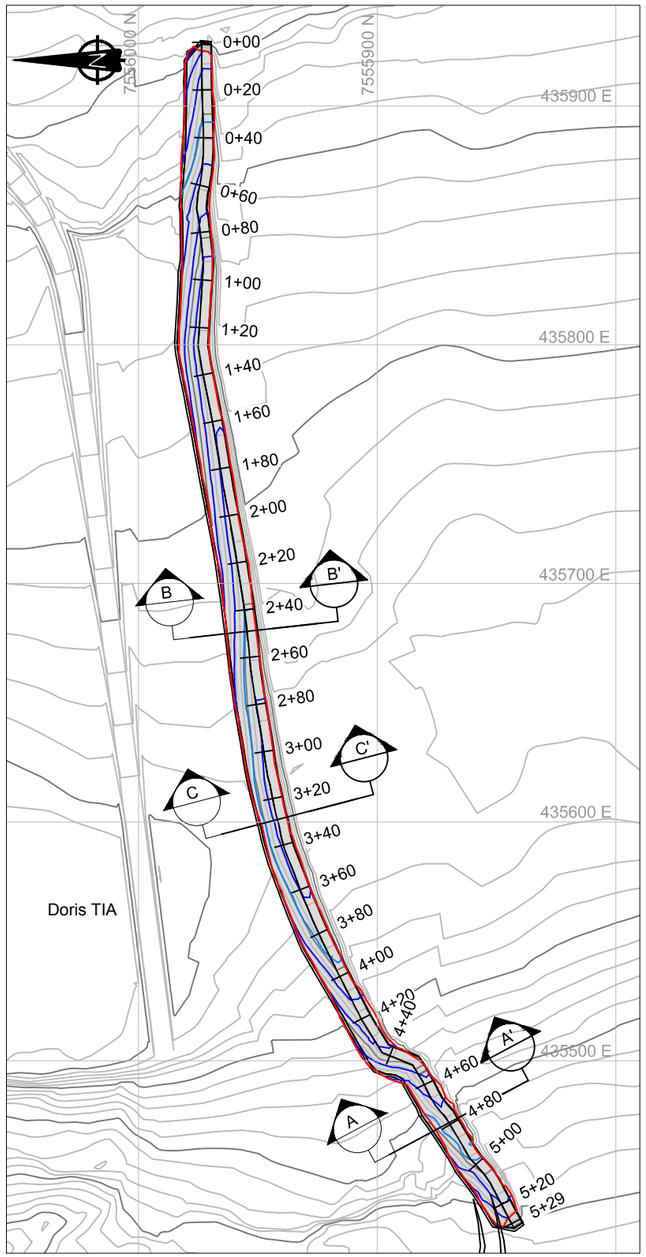

Key Trench Bedding Placement Plan View

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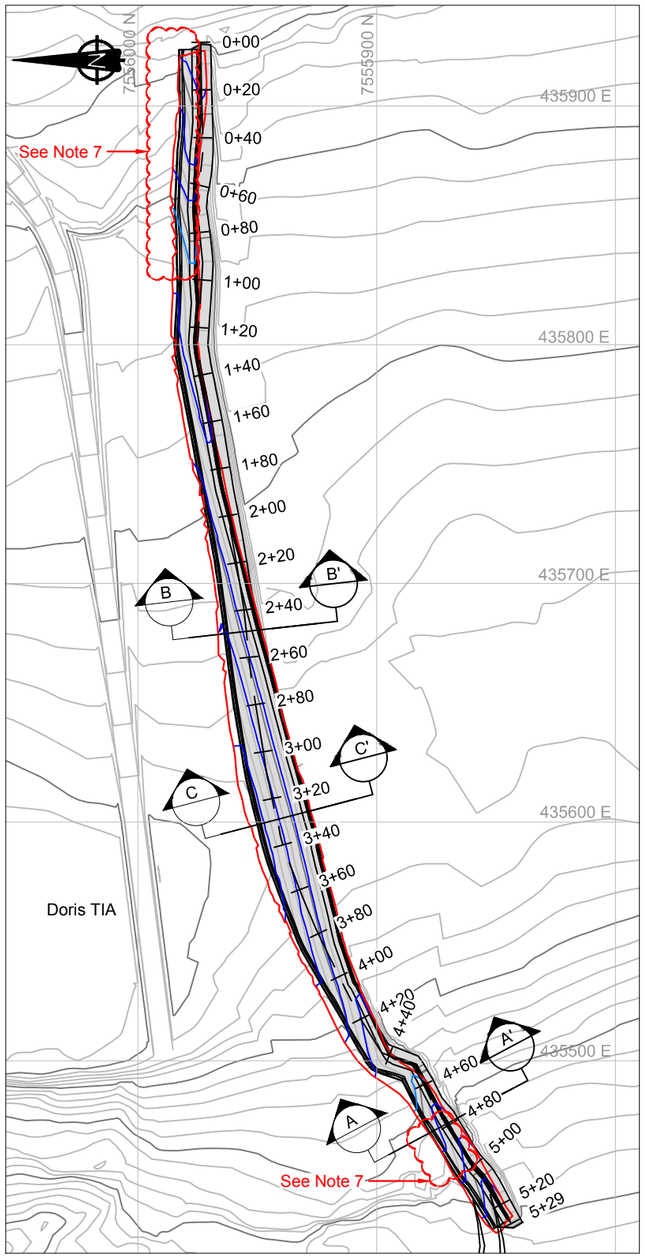

Phase 1 Dam Bedding Placement Plan View

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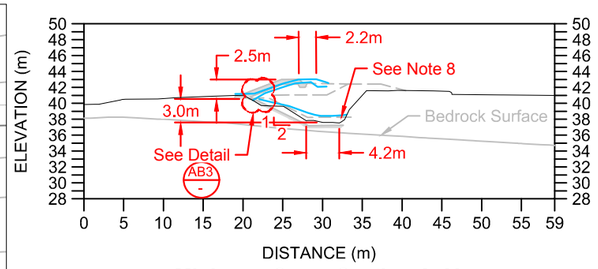

Minimum Cross Section A-A'

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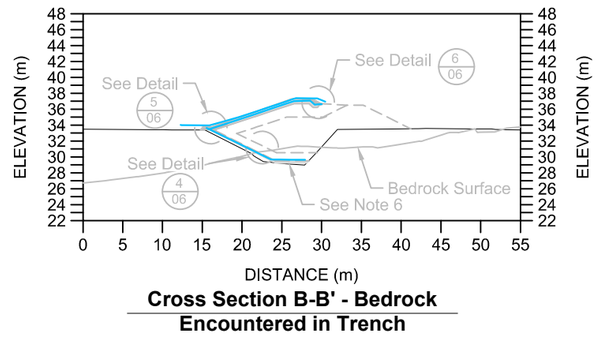

Cross Section B-B' - Bedrock Encountered in Trench

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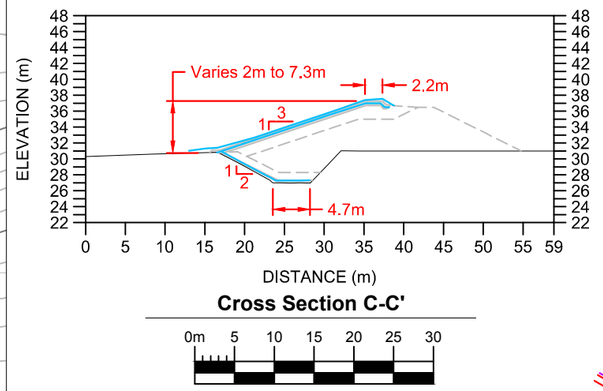


Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

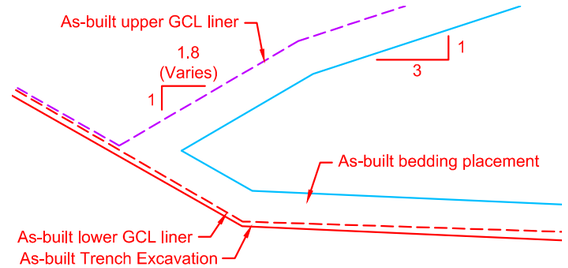
- As-Built Bedding Material Contours
- As-Built Bedding Material
- Proposed Road / Dam Infrastructure
- Design Bedding Material Footprint
- As-Built Bedding Material Footprint

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Bedding layer to be placed in 0.15m lifts and compacted before liner placement. The subsurface below the liner should be free of protrusions or any sharp / angular cobbles or larger size material. See the Technical Specifications document for more details (*'Technical Specifications - earthworks and geotechnical Engineering - Hope Bay Project, Nunavut Canada - Issue for Construction' prepared by SRK*).
4. Bedding material cover shall be placed over the GCL using construction equipment that minimizes stresses on the GCL. Unless otherwise approved / directed by the Engineer a minimum thickness of 600mm or greater is required to be placed over any areas where heavy equipment will be trafficking over the liner. Thickness requirement are related to equipment type. For light equipment (which will have to be directly approved by the Engineer), as an absolute minimum a thickness of 300mm of cover must be maintained between light tracked equipment (e.g. skid-steer or 30 excavator) tracks/tires, and the GCL at all times during the covering process.
5. Soil cover should be placed in a manner that prevents the soil from entering/disturbing the GCL overlap zones.
6. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.
7. Lower portion of above ground bedding material over-steepened between Stations 0+00 through 1+00 and 4+80 through 5+00 to account for discrepancy in original ground topography and to maintain upstream design toe. See Detail AB3 on Drawing DN-SD-07.
8. Total bedding material thickness increased above 300mm in select areas of the key trench excavated in shallow bedrock.

REFERENCES

NAD83 UTM Zone 13.



Detail AB3 - Oversteepened Bedding Material Area

Not To Scale

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-06	Liner and Bedding Placement Details	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
AB	As-Built	JBK	EMR	19/03/11
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

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JKB	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam - Bedding.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Bedding Material Placement Plan and Sections - Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-07	7 OF 30	AB

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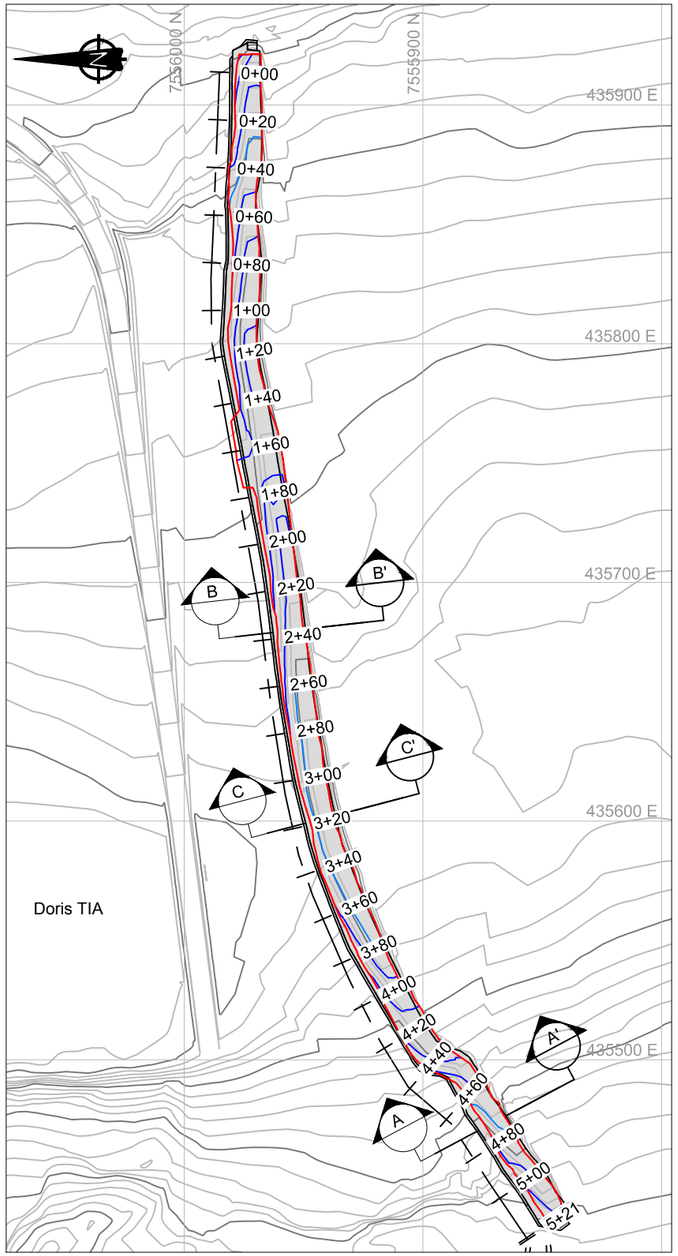
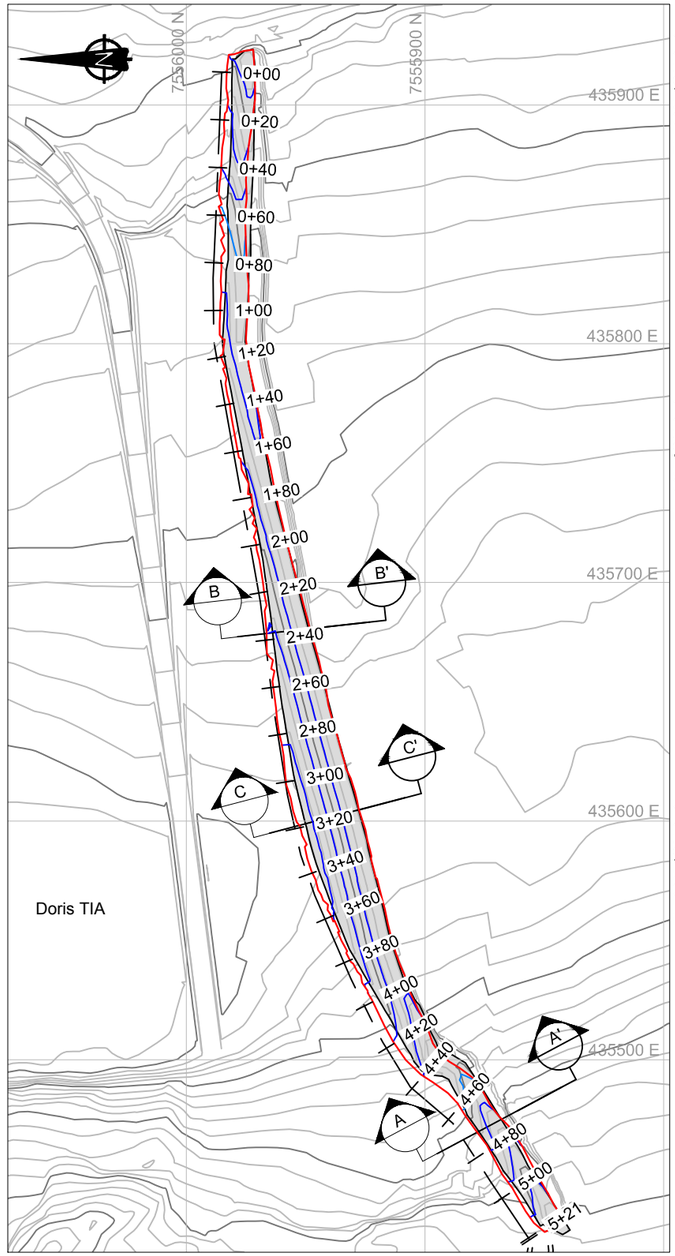


Key Trench Upstream Transition Placement Plan View

0m 20 40 60 80 100



Phase 1 Dam Upstream Transition Placement Plan View

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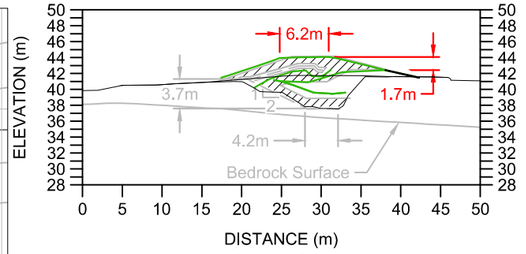

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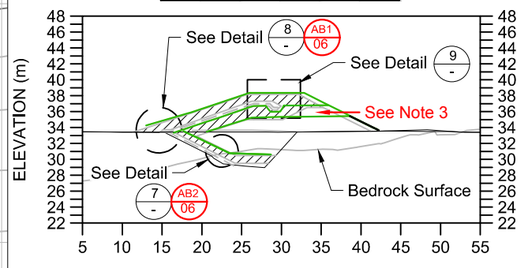

Cross Section B-B' - Bedrock Encountered in Trench

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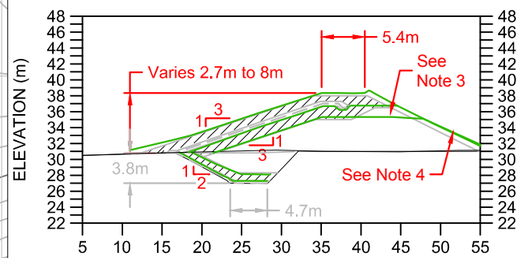


Cross Section C-C'

0m 5 10 15 20 25 30

LEGEND

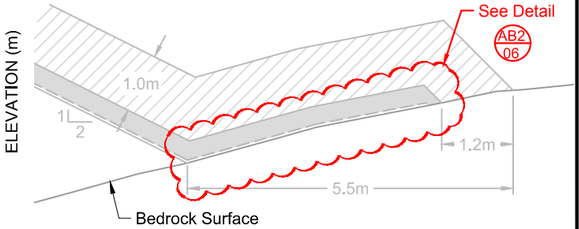
- As-Built Transition Contours
- As-Built Transition material
- Proposed Road / Dam Infrastructure
- Design Transition Material Footprint
- As-Built Transition Material Footprint
- Design Bedding Material (Section View)
- Design Transition Material (Section View

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. ROQ material was generally replaced with transition material.
4. Downstream dam face is not entirely constructed from transition material by appears so due to how the surface was as-built. See drawing DN-SD-09 for the presence of ROQ material on the downstream face.

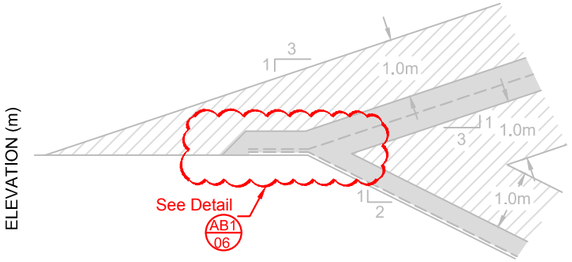
REFERENCES

NAD83 UTM Zone 13.



Detail 7 - Key Trench Bedrock Interface - Transition

0m 1 2 3 4



Detail 8 - Upper and Lower GCL Liner Overlap - Transition

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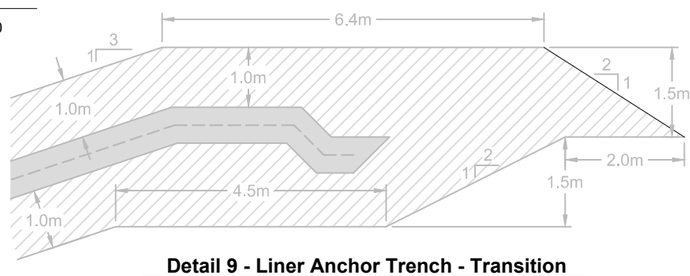

Detail 9 - Liner Anchor Trench - Transition

0m 1 2 3 4

NO.	DESCRIPTION	CHK'D	APP'D	DATE
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1	Issued for Construction	JBK	EMR	18/04/13
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FILE NAME: 1CT0022.017 - South Dam - Transition.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Transition Material Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-08	7 OF 30	AB

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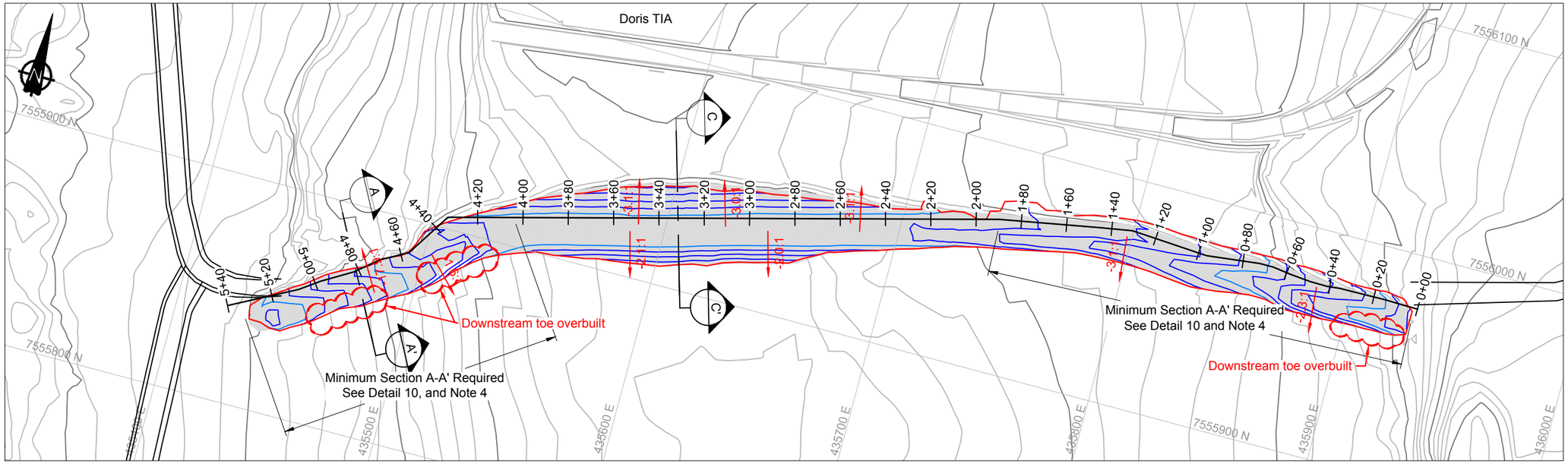

Run of Quarry Placement Plan View

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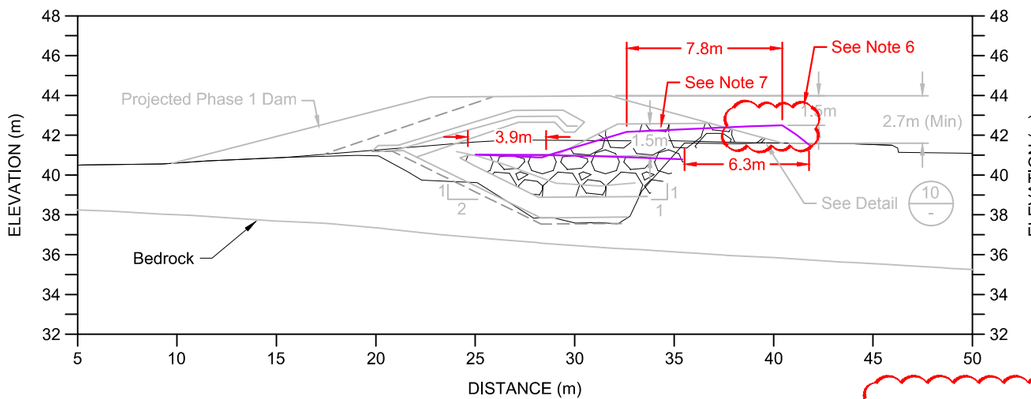

Minimum Cross Section A-A'

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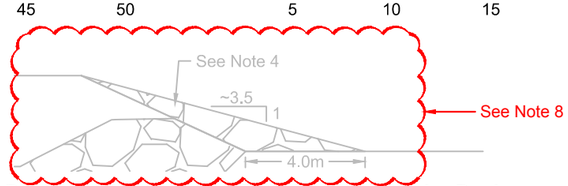
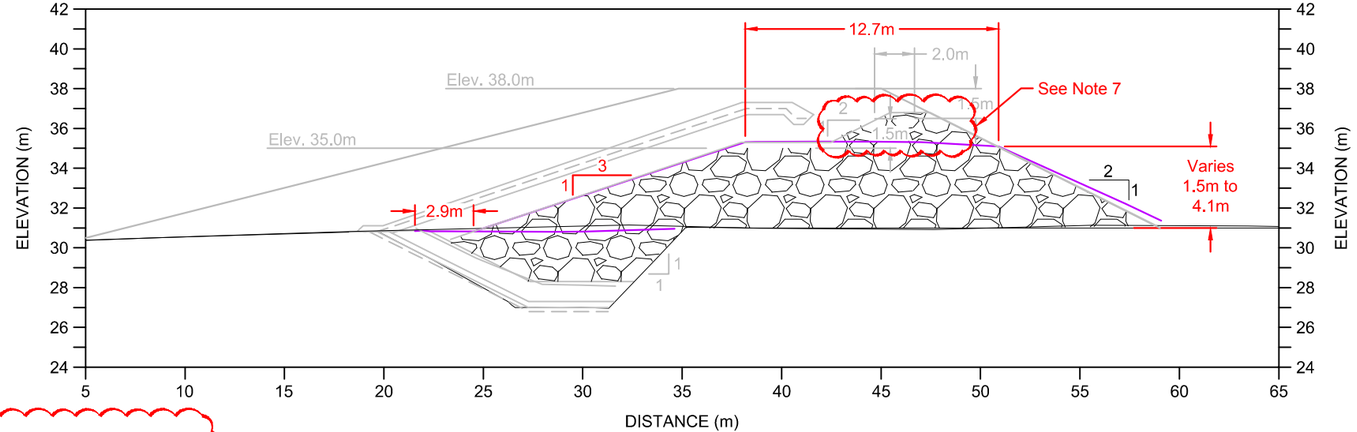


Detail 10 - Contingency ROQ Thermal Barrier Design

0m 2 4 6 8



Typical Cross Section C-C'

0m 3 6 9 12

LEGEND

- As-Built Downstream Run of Quarry Contours
- Proposed Road / Dam Infrastructure
- Design Run of Quarry Backfill
- Design Run of Quarry Backfill

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profiles shown correspond to the upstream toe of the key trench.
4. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the Phase 1 outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench. See Detail 10 on drawing DN-SD-09 for additional details.
5. The outside downstream ROQ should be sloped at 2H:1V or shallower.
6. ROQ downstream slope was generally overbuilt and/or oversteepened in the minimum cover sections and resloped to meet design grades at end of project.
7. Transition material substituted for ROQ material.
8. Contingency ROQ thermal barrier design was not implemented.

REFERENCES

NAD83 UTM Zone 13.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
							AB	As-built	JBK	EMR	19/03/11
DN-SD-10	Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO. DN-SD-09 | SHEET 9 OF 30 | REVISION NO. AB

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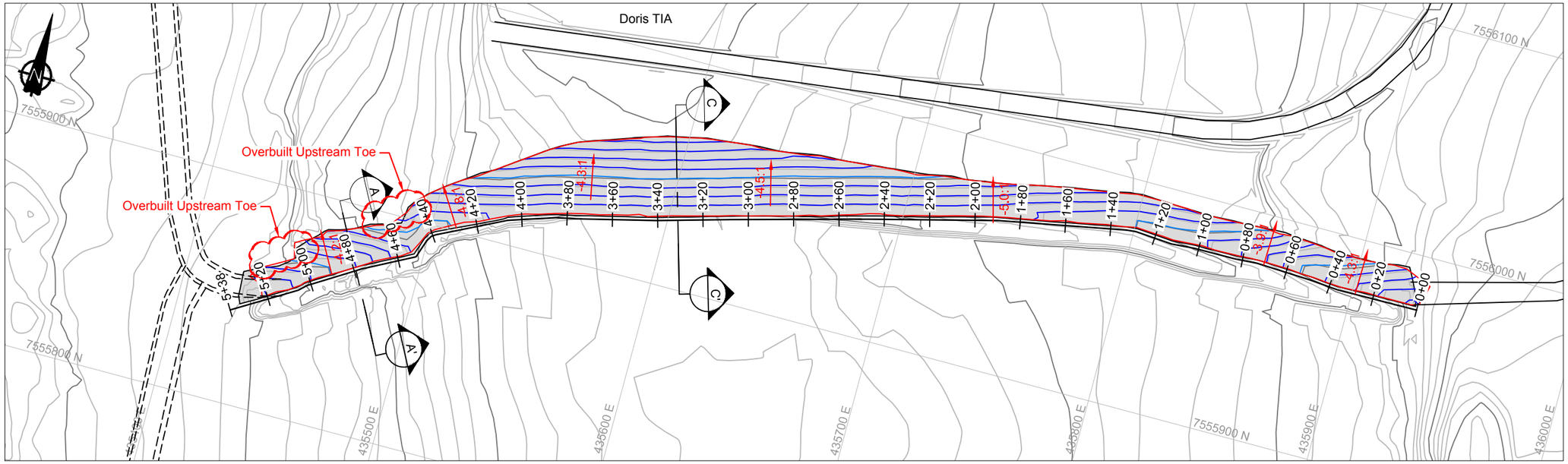
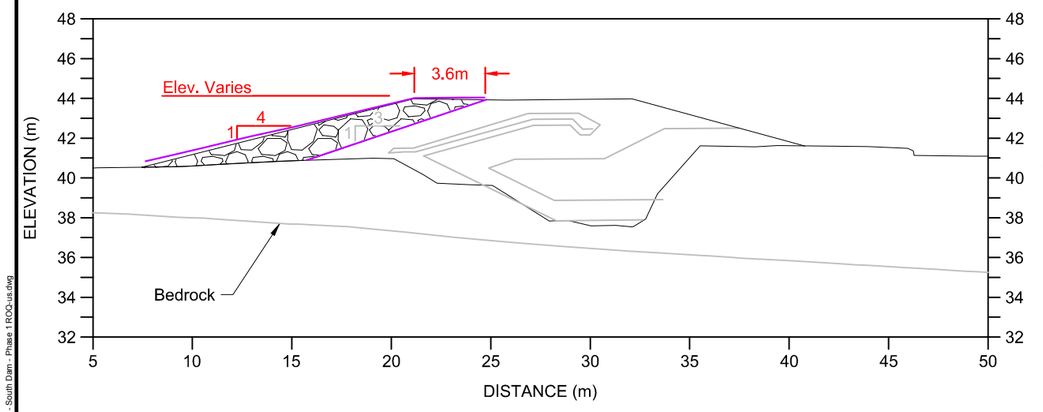


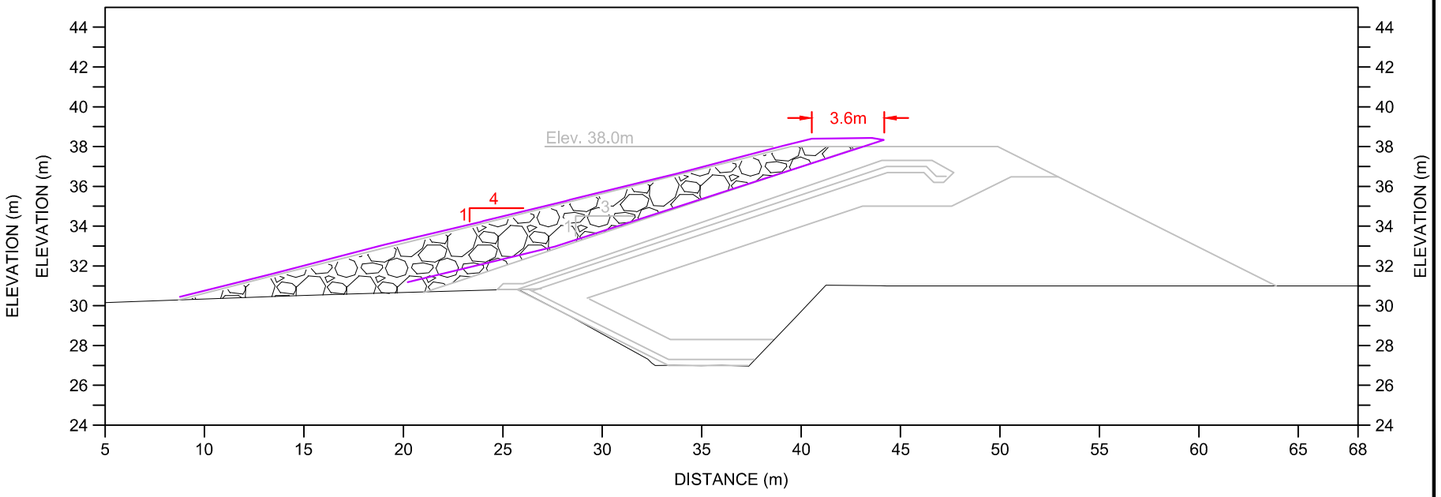
Upstream Run of Quarry Placement Plan View

0m 20 40 60 80



Minimum Cross Section A-A'

0m 3 6 9 12



Typical Cross Section C-C'

0m 3 6 9 12

LEGEND

- As-Built Run of Quarry Contours
- Proposed Road / Dam Infrastructure
- Design Upstream Run of Quarry Extent
- Design Run of Quarry Backfill
- As-built Upstream Run of Quarry Footprint

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The outside upstream dam ROQ should be sloped at 4H:1V or shallower.

REFERENCES

NAD83 UTM Zone 13.

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							AB	As-Built	JBK	EMR	19/03/11
DN-SD-09	Downstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-08	Transition Material Placement Plan and Sections Key Trench and Phase 1	-	-				0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS | REVISIONS

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JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam - Phase 1 ROQ-us.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Upstream Run-of-Quarry Placement Plan and Sections Key Trench and Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-10	10 OF 30	AB

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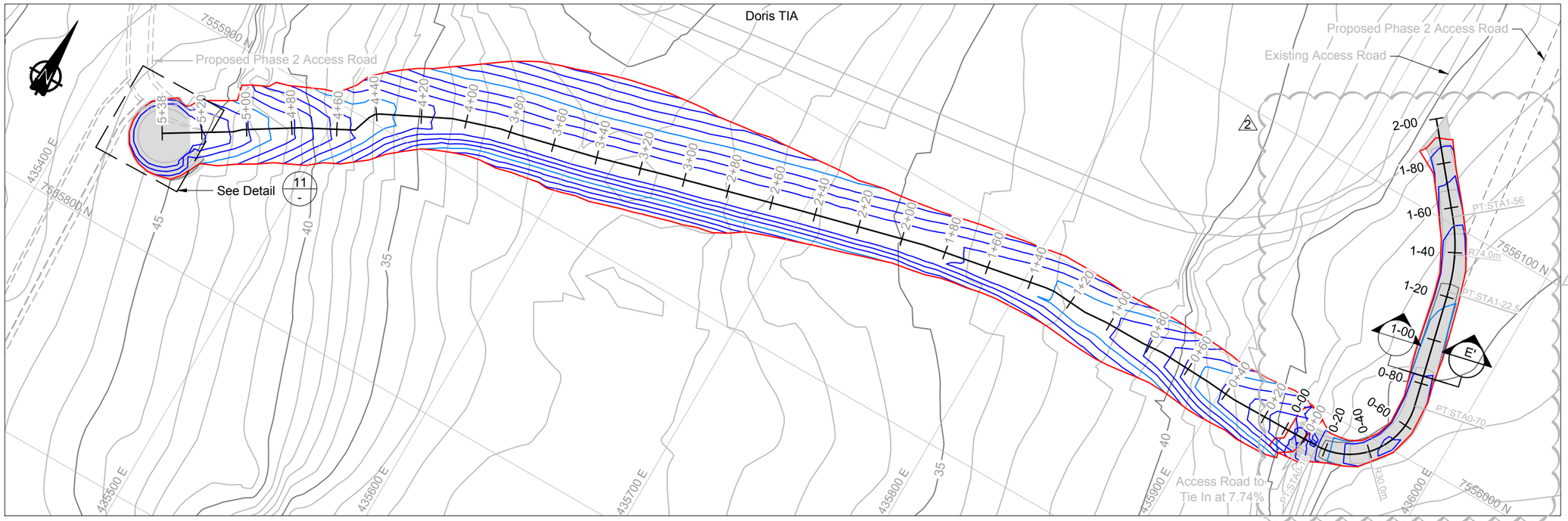
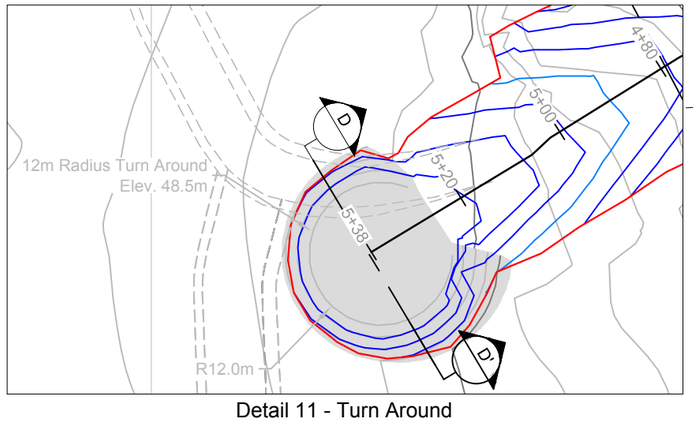


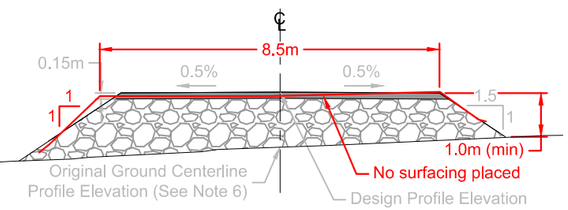
East Access Road and West Turn Around

0m 20 40 60 80



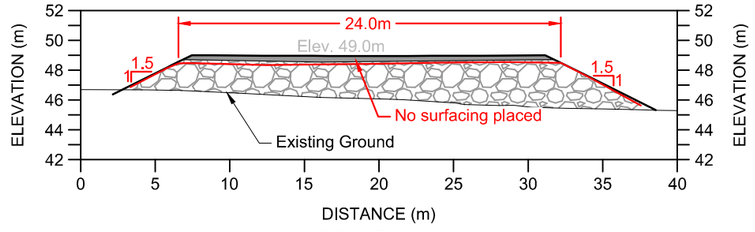
Detail 11 - Turn Around

0m 10 20 30 40



Section E-E' - Typical Road Section

0m 1 2 3 4 5 6



Section D-D' - Turn Around

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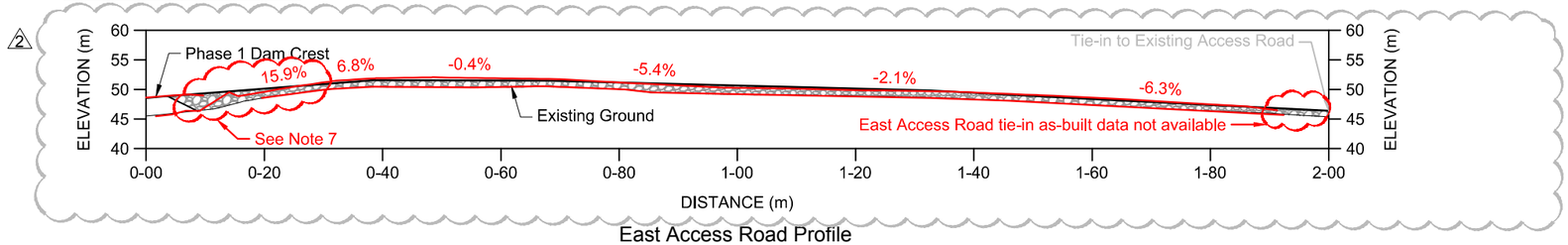

East Access Road Profile

0m 10 20 30 40

LEGEND

- 1.0% — As-built Average Grade
- Vertical Inflection Point
- Proposed Road / Dam Infrastructure
- Phase 1 Access Road
- Run of Quarry
- Surfacing Material
- As-built Extents

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Approximately 2,440m³ of Fill material is estimated (to neat lines) to be needed for the Access Road and Turn Around.
4. Minimum fill thickness for Access Road and Turn Around is 1.0m
5. Construction shall be in accordance with the following Technical Specifications: Earthworks and Geotechnical Engineering. Hope Bay Project, Nunavut, Canada. Revision H - Issued for Construction.
6. Profile based on available topography. Existing ground level to be surveyed prior to construction to confirm design thickness achieved.
7. As-built survey of east access road completed prior to final tie in with dam crest.

REFERENCES

NAD83 UTM Zone 13.

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-03	Typical Sections (General)					
DN-SD-02	Phase 1 General Arrangement	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
AB	As-Built	JBK	EMR	19/03/11
2	Issued for Construction	JBK	EMR	18/04/30
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

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JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam AR.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Construction Access Road and Turnaround - Phase 1

DRAWING NO. DN-SD-11 | SHEET 11 OF 26 | REVISION NO. AB

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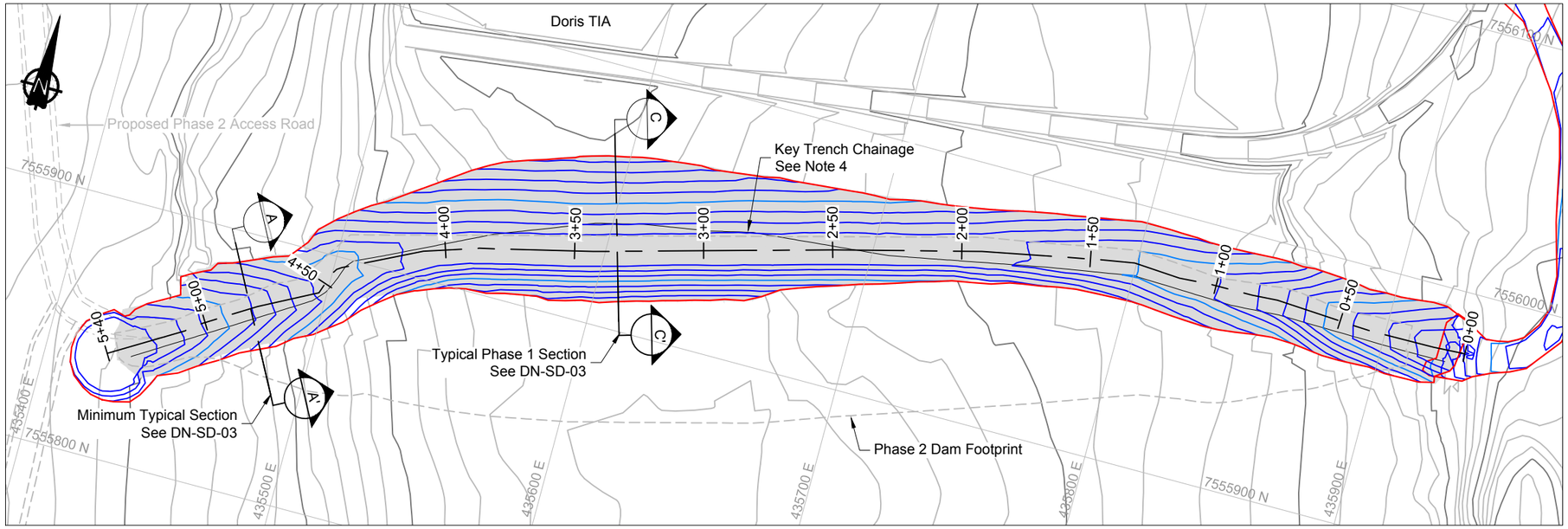


Phase 1 Dam Plan View

0m 20 40 60 80

LEGEND

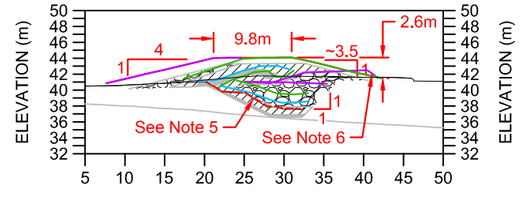
- Key Trench Excavation
- Phase 1 Dam Liner
- Proposed Road / Dam Infrastructure
- As-built Phase 1 Dam Contours
- As-Built Bedding
- As-Built Transition
- As-Built ROQ
- Bedding Material
- Transition Material
- Run of Quarry Backfill
- Design Footprint
- As-Built Footprint

REFERENCES

NAD83 UTM Zone 13.

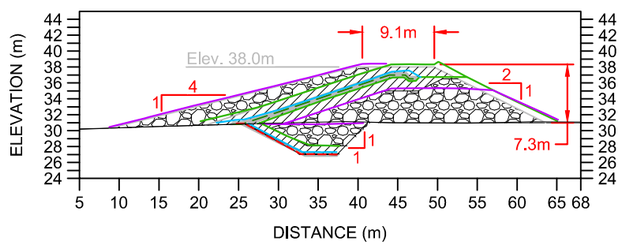
NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. The Phase 2 dam elevations are shown for information purposes only. Note that only Phase 1 dam designs and elevations are issued for construction use.
4. Base of key trench on this profile is based on a section down the centerline of the dam crest. Note that the key trench centerline and the dam crest centerline do not share the exact same alignment and overall the chainages vary in any given location (between the key trench and dam crest shown in these drawings) in the range of ±5m.
5. Sections of upstream and downstream slopes steeper than design in areas of shallow bedrock.
6. ROQ downstream slope was overbuilt and/or oversteepened in the cover sections and resloped to meet design grades at end of project.



Minimum Cross Section A-A'

0m 5 10 15 20 25 30



Cross Section C-C'

0m 5 10 15 20 25 30

Phase 1 Dam Profile View

Horizontal 0m 10 20 30 40

Vertical 0m 20 40 60 80

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
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DN-SD-03	Typical Sections (General)						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

REFERENCE DRAWINGS | REVISIONS

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JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam - Phase 1 Dam.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Final Phase 1 Dam Plan, Profile and Sections

DRAWING NO.	SHEET	REVISION NO.
DN-SD-12	12 OF 30	AB

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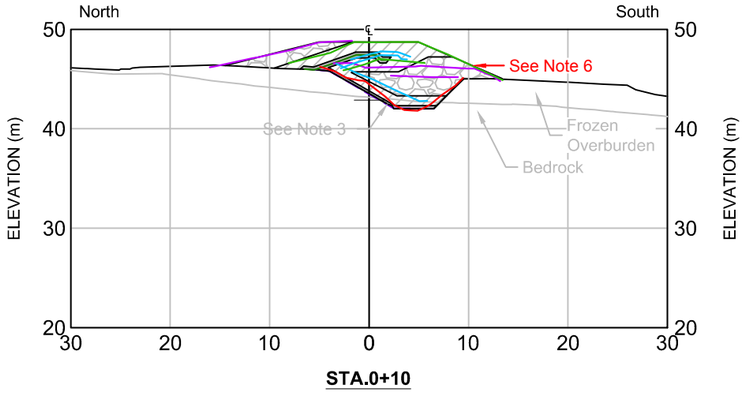

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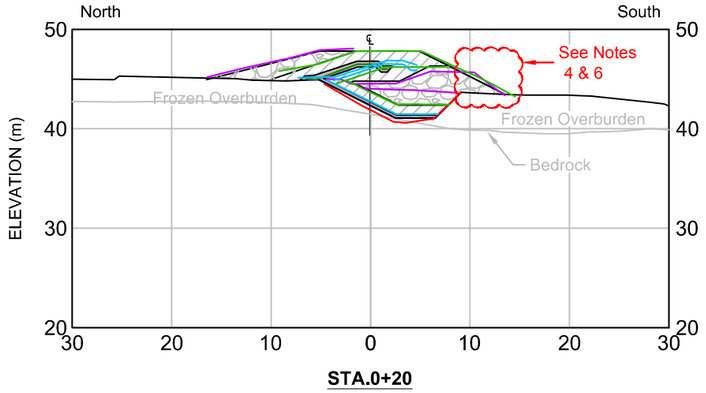

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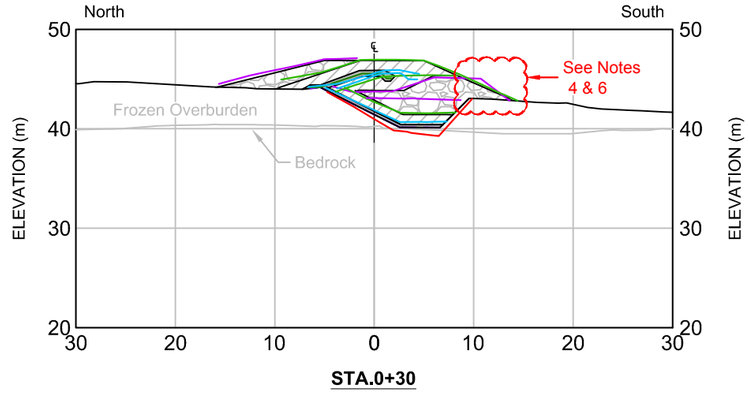

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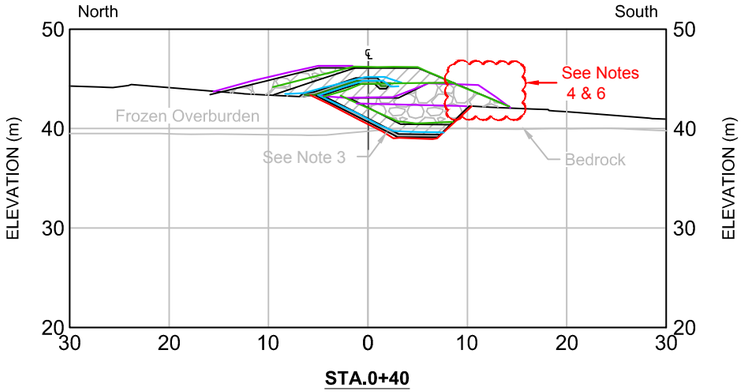

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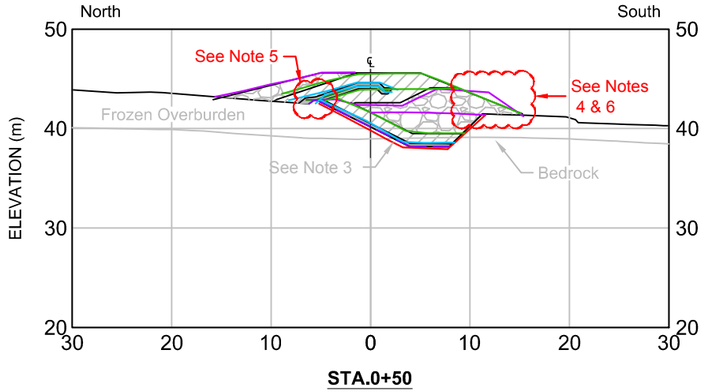

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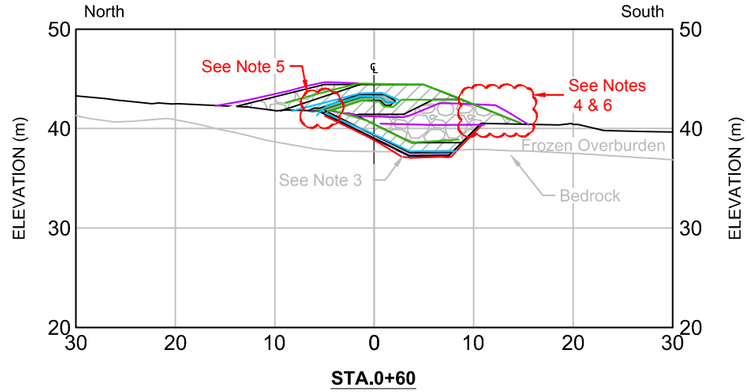

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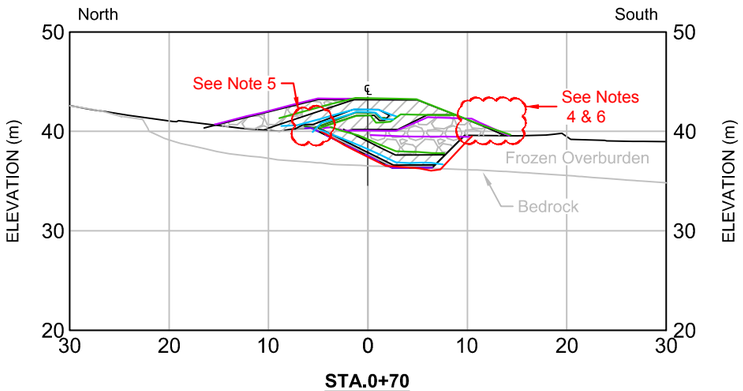

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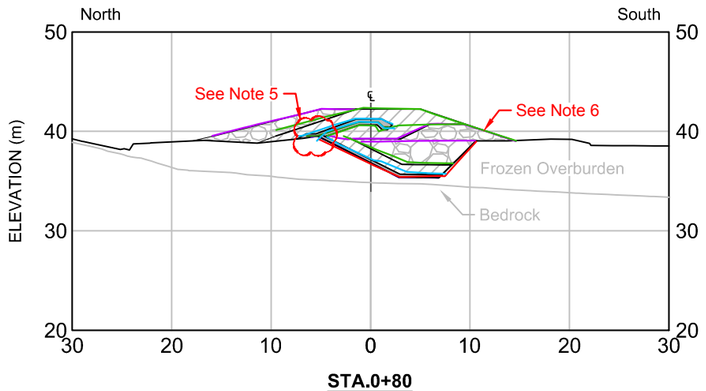

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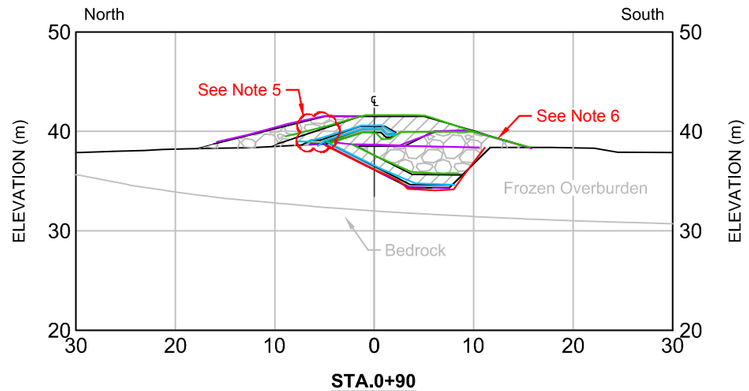

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LEGEND

- Phase 1 Design Lines
- As-Built Bedding
- As-Built Transition
- As-Built Run of Quarry
- As-Built Key Trench Excavation
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth of bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.
4. ROQ downstream slope was overbuilt and/or oversteepened in the cover sections and resloped to meet design grades at end of project.
5. Lower portion of above ground bedding material lifts oversteepened to account for discrepancy in original ground topography and to maintain upstream design toe.
6. Downstream dam face is not entirely constructed from transition material but appears so due to how the surface was as-built. See drawing DN-SD-09 for presence of ROQ material on the downstream face.

0m 6 12 18 24

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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							AB	As-Built	JBK	EMR	19/03/11
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.0+10 to 0+90 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-13	13 OF 30	AB

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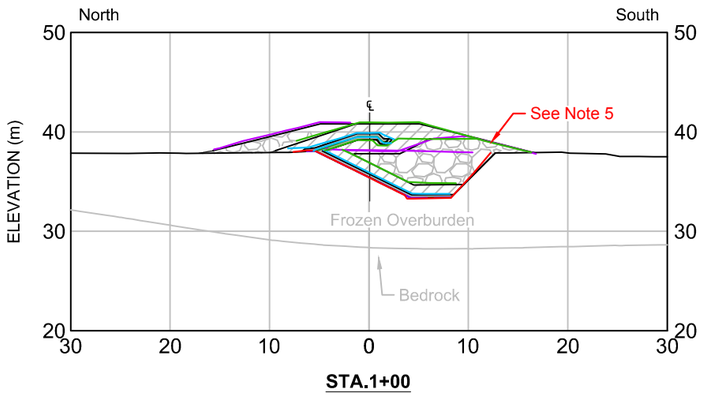

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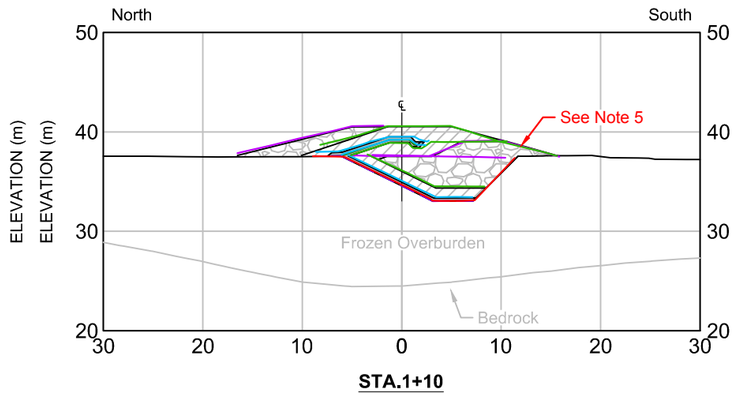

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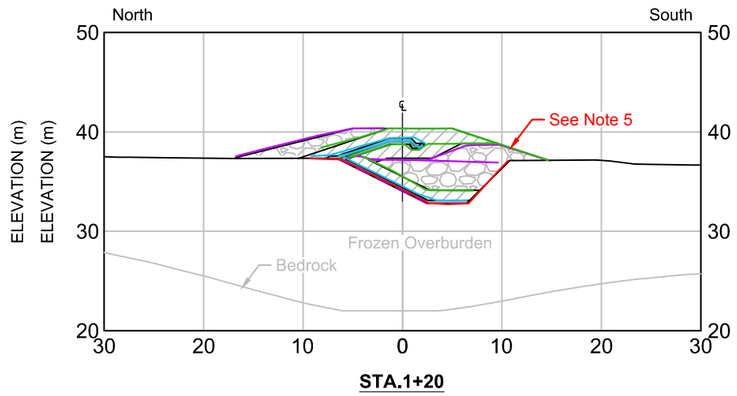

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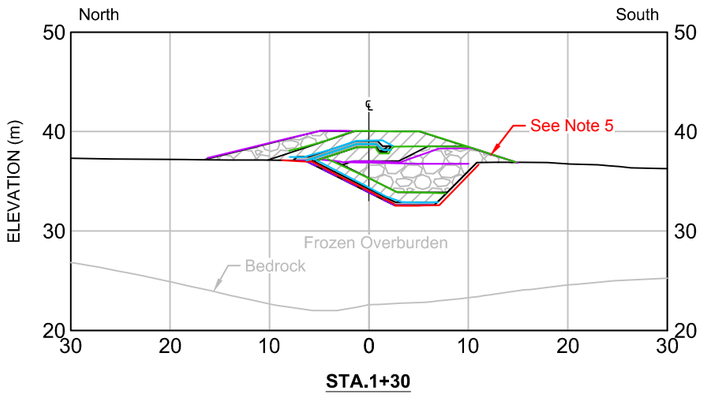

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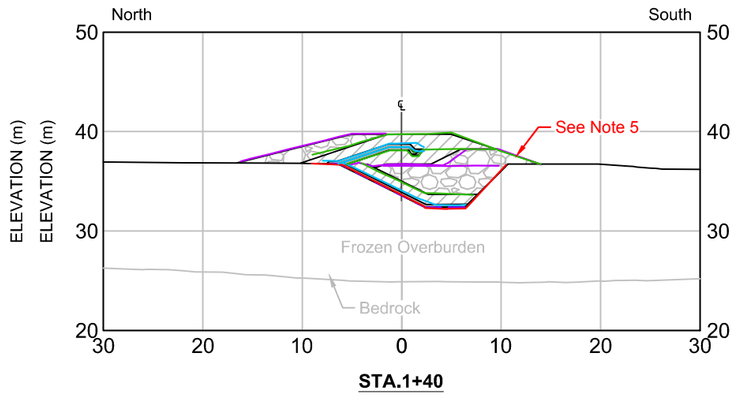

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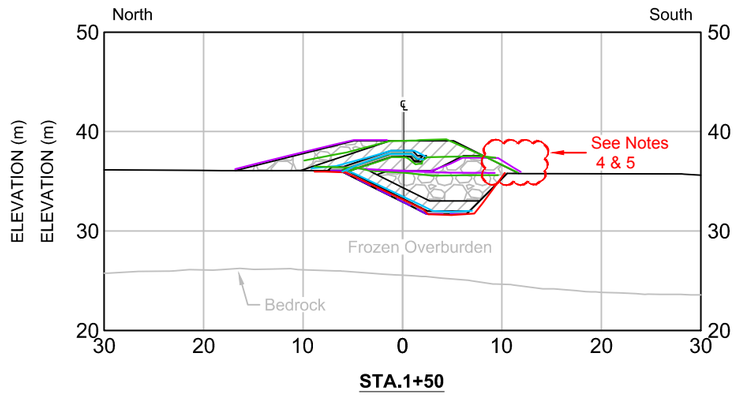

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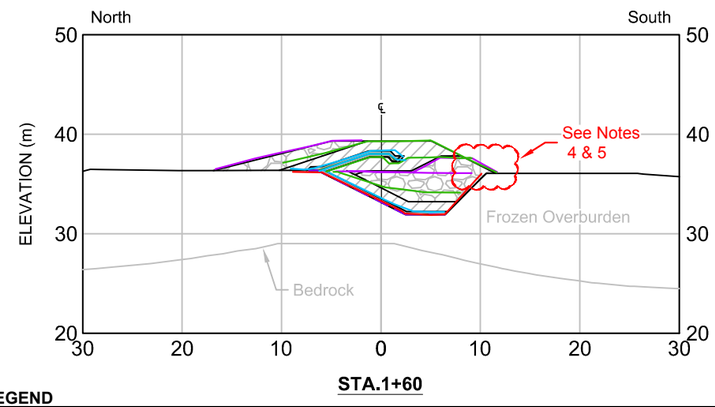

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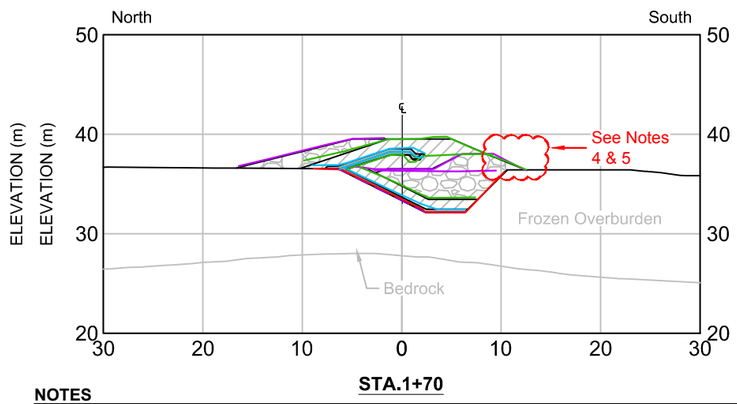

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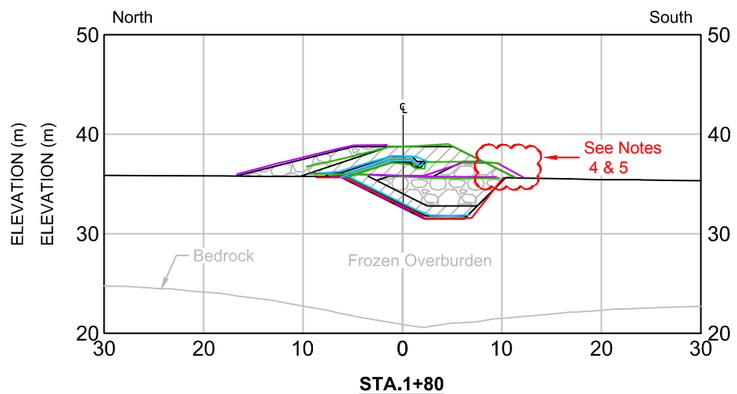

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LEGEND

- Phase 1 Design Lines
- As-Built Bedding
- As-Built Transition
- As-Built Run of Quarry
- As-Built Key Trench Excavation
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth of bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.
4. ROQ downstream slope was overbuilt and/or oversteepened in the cover sections and resloped to meet design grades at end of project.
5. Downstream dam face is not entirely constructed from transition material but appears so due to how the surface was as-built. See drawing DN-Se-09 for the presence of ROQ material on the downstream face.

0m 6 12 18 24

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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							AB	As-Built	JBK	EMR	19/03/11
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.1+00 to 1+80 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-14	14 OF 30	AB

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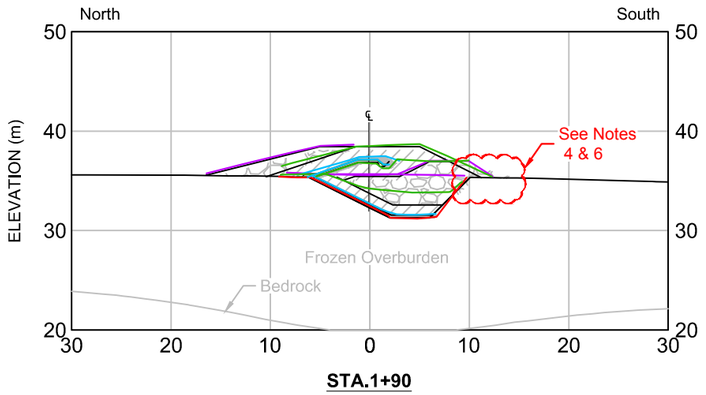
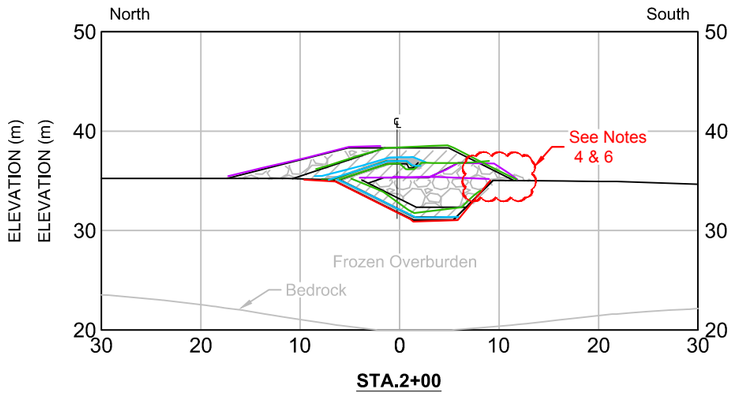
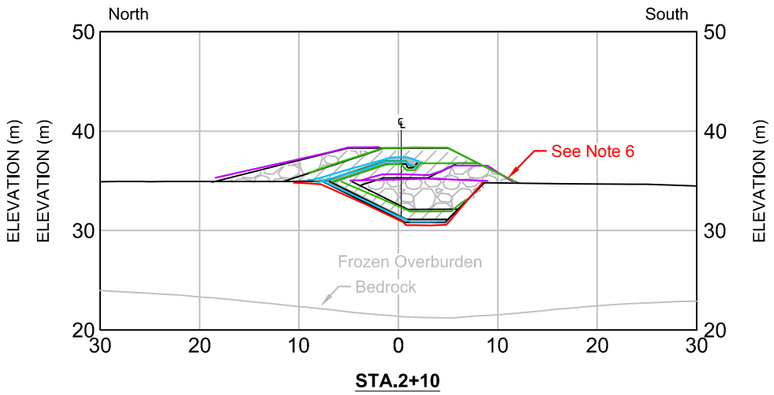


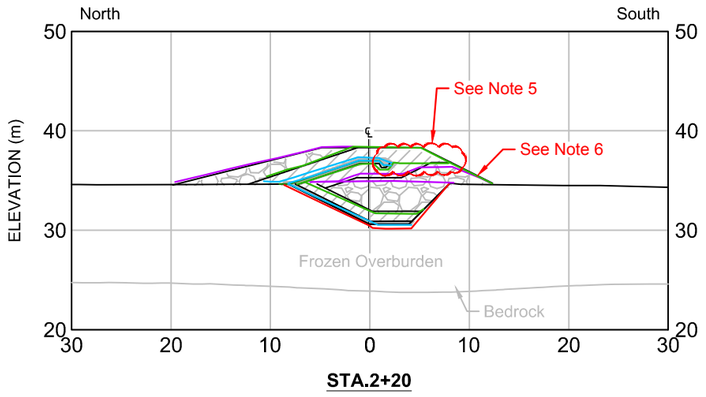
STA.1+90



STA.2+00



STA.2+10



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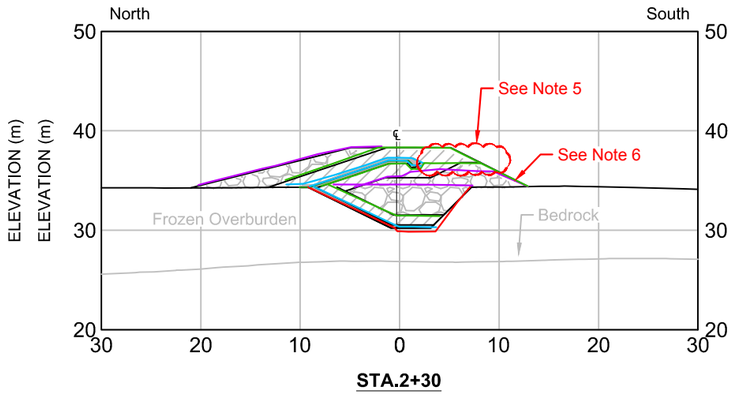
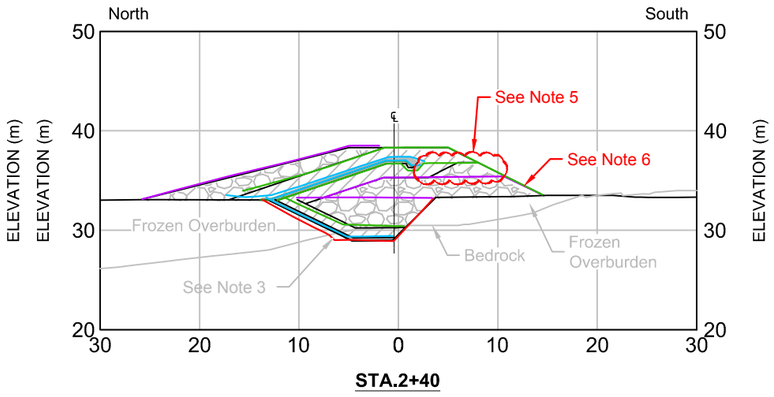


STA.2+30



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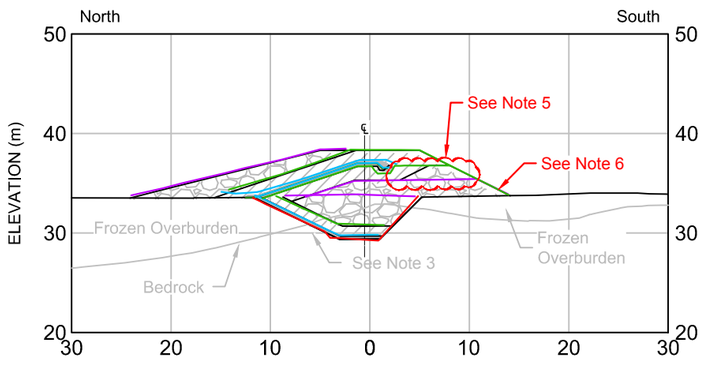

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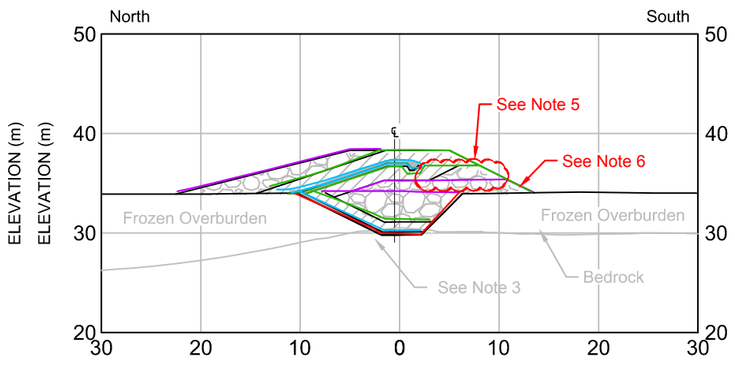
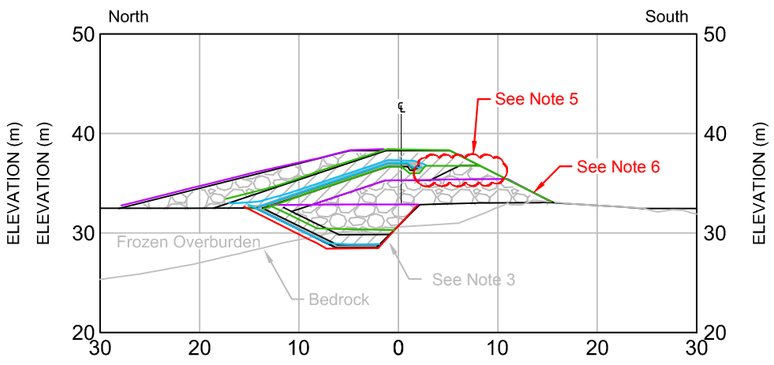


STA.2+60



STA.2+70

LEGEND

- Phase 1 Design Lines
- As-Built Bedding
- As-Built Transition
- As-Built Run of Quarry
- As-Built Key Trench Excavation
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth of bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.
4. ROQ downstream slope was overbuilt and/or oversteepened in the cover sections and resloped to meet design grades at end of project.
5. Transition material substituted for ROQ material for constructability.
6. Downstream dam face is not entirely constructed from transition material by appears so due to how the surface was as-built. See drawing DN-SD-09 for the presence of ROQ material on the downstream face.

0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
AB	As-Built	JBK	EMR	19/03/11
1	Issued for Construction	JBK	EMR	18/03/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.1+90 to 2+70 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-15	15 OF 30	AB

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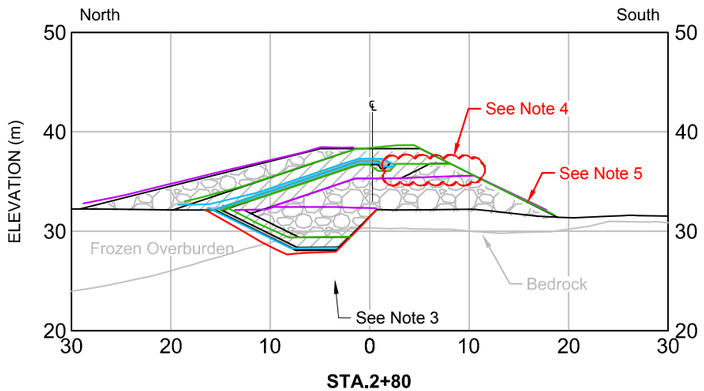

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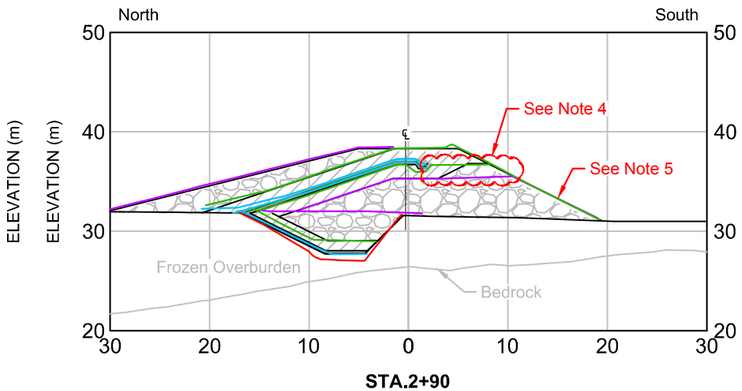

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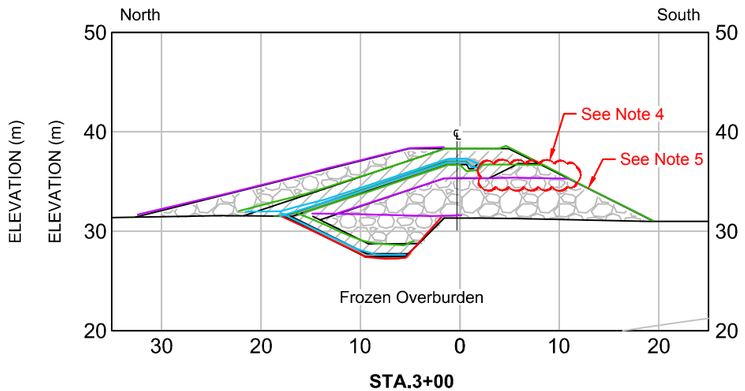

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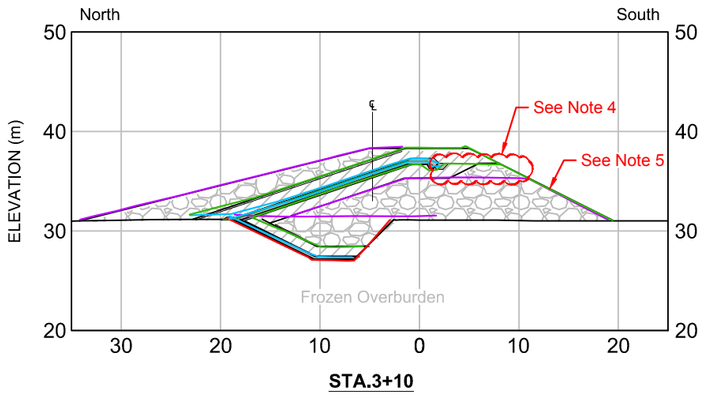

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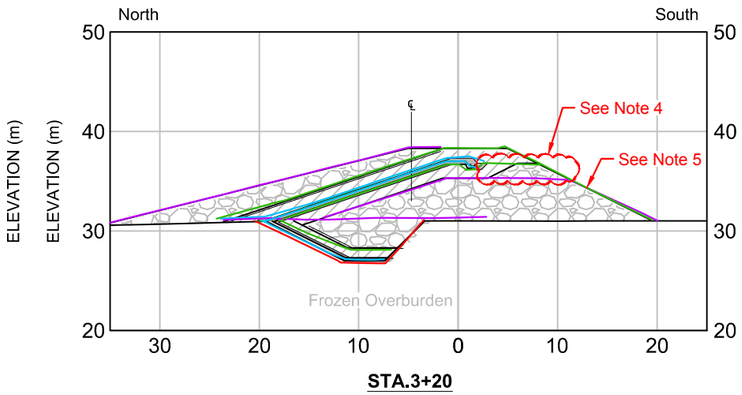
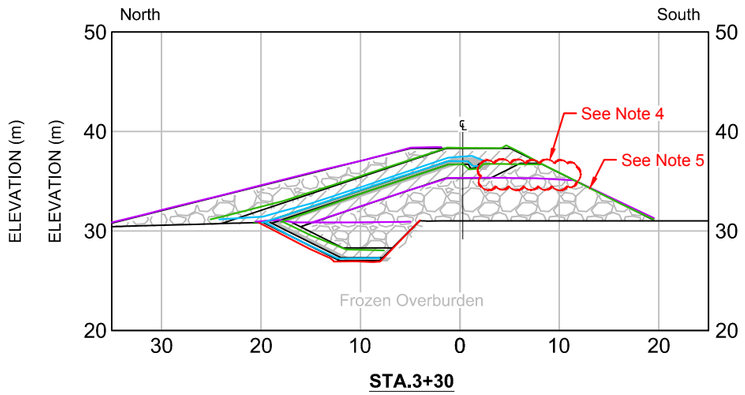


STA.3+20



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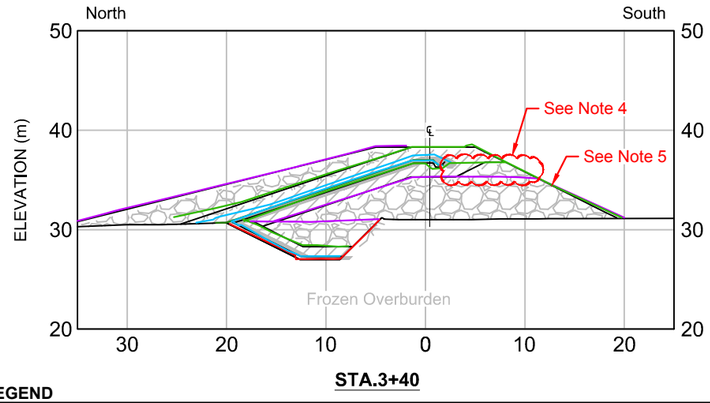

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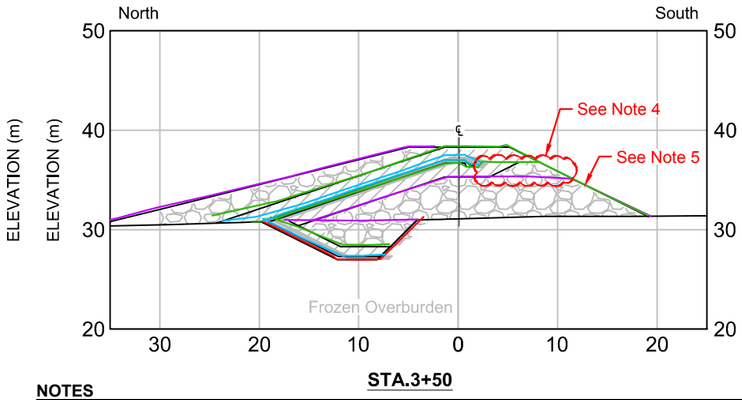

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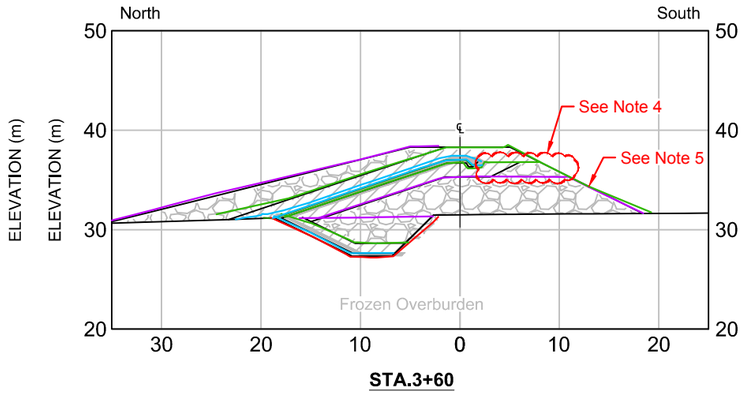

STA.3+60

LEGEND

- Phase 1 Design Lines
- As-Built Bedding
- As-Built Transition
- As-Built Run of Quarry
- As-Built Key Trench Excavation
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth of bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.
4. Transition material substituted for ROQ material for constructability.
5. Downstream dam face is not entirely constructed from transition material but appears so due to how the surface was as-built. See drawing DN-SD-09 for the presence of ROQ material on the downstream face.

0m 6 12 18 24

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
AB	As-Built	JBK	EMR	19/03/11
1	Issued for Construction	JBK	EMR	18/03/13
0	Issued for Construction	JBK	EMR	17/11/29

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-02	Phase 1 General Arrangement

REFERENCE DRAWINGS

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.2+80 to 3+60 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-16	16 OF 30	AB

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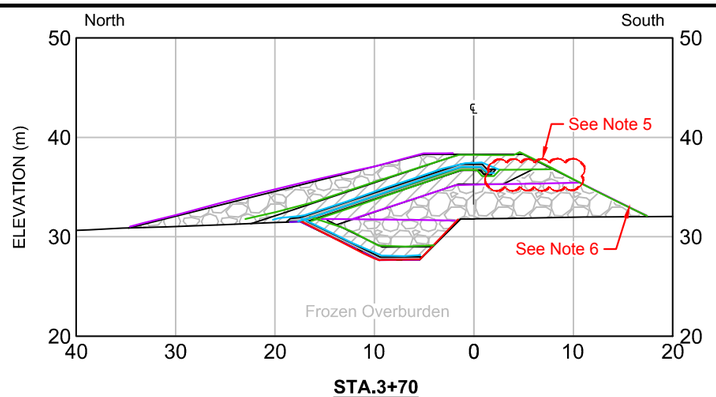

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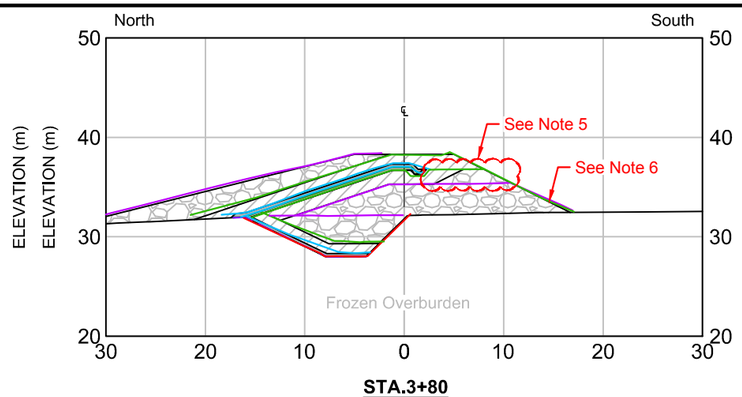

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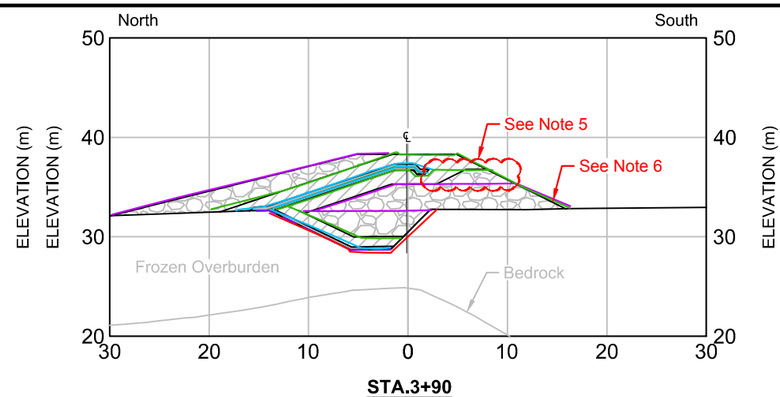

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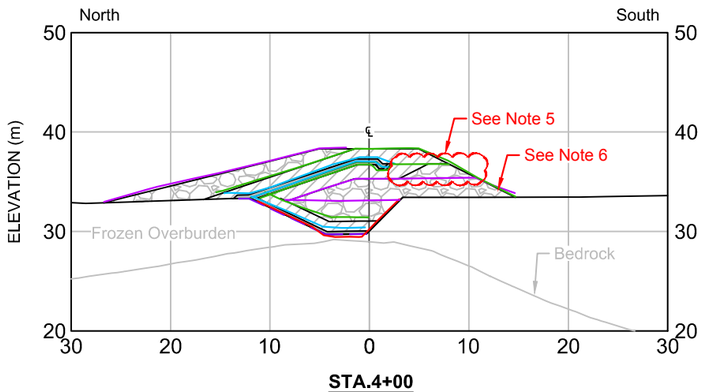

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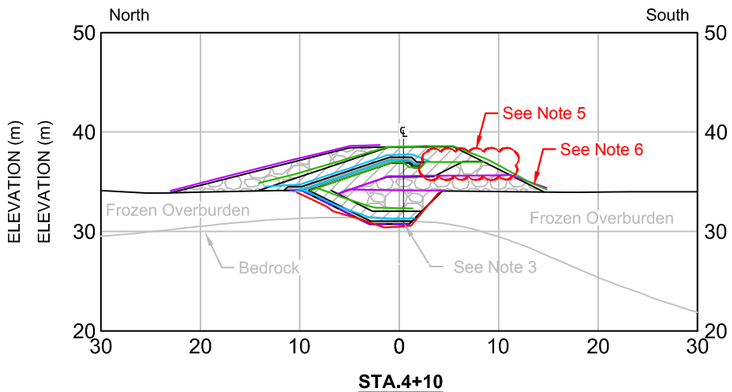

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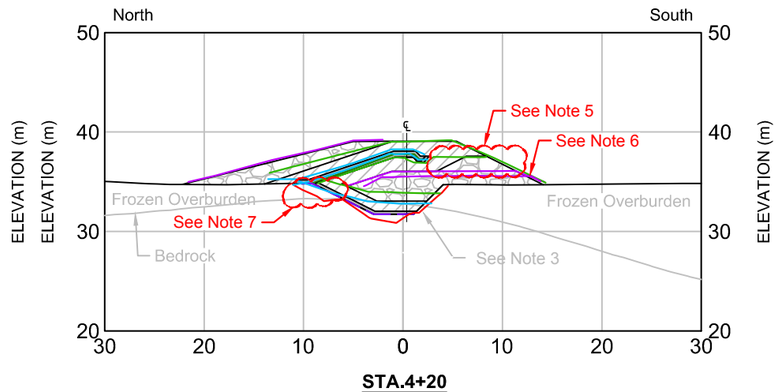

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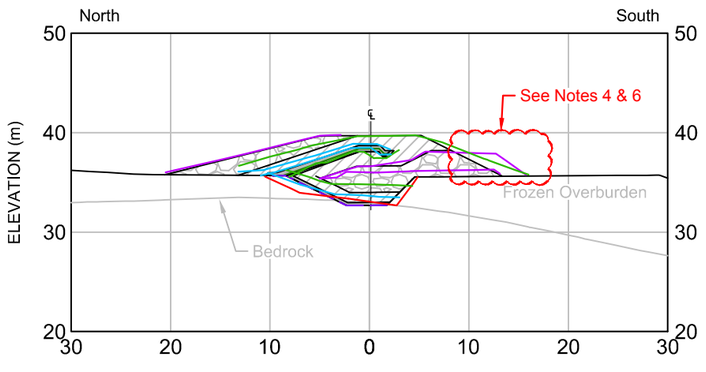

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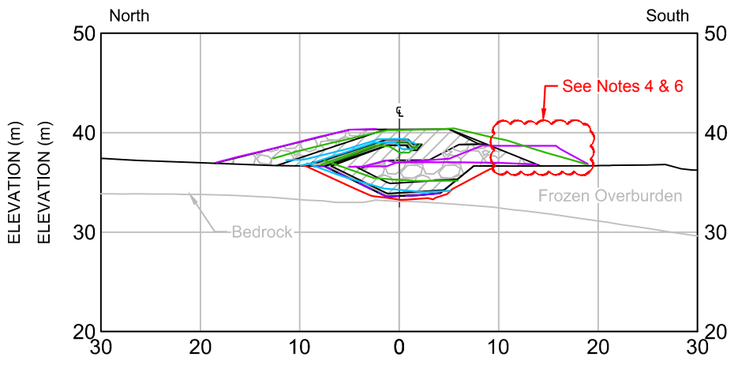

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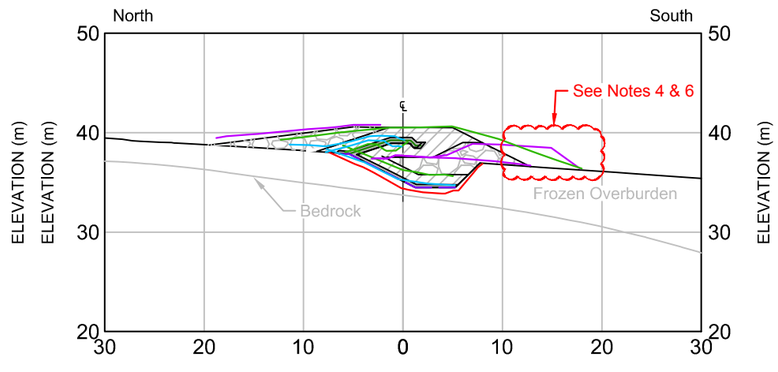

STA.4+50

LEGEND

- Phase 1 Design Lines
- As-Built Bedding
- As-Built Transition
- As-Built Run of Quarry
- As-Built Key Trench Excavation
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth of bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.
4. ROQ downstream slope was overbuilt and/or oversteepened in the cover sections and resloped to meet design grades at end of project.
5. Transition material substituted for ROQ material for constructability.
6. Downstream dam face is not entirely constructed from transition material but appears so due to how the surface was as-built. See drawing DN-SD-09 for the presence of ROQ material on the downstream face.
7. Lower portion of above ground bedding material lifts oversteppened to account for discrepancy in original ground topography and to maintain upstream design toe.

0m 6 12 18 24

REFERENCE DRAWINGS		REVISIONS								
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
DN-SD-02	Phase 1 General Arrangement	-	-				AB	As-Built	JBK	EMR	19/03/11
							1	Issued for Construction	JBK	EMR	18/04/13
							0	Issued for Construction	JBK	EMR	17/11/29

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.3+70 to 4+50 Phase 1 Dam

DRAWING NO.	SHEET	REVISION NO.
DN-SD-17	17 OF 30	AB

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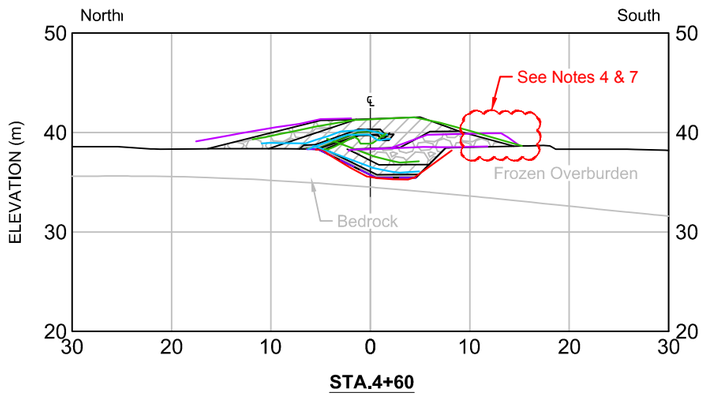

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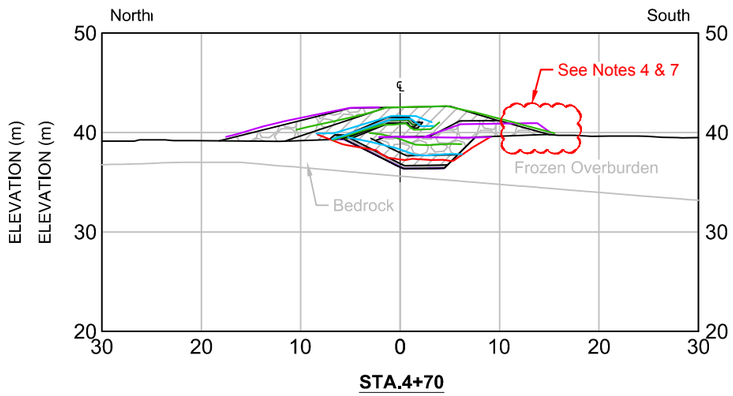

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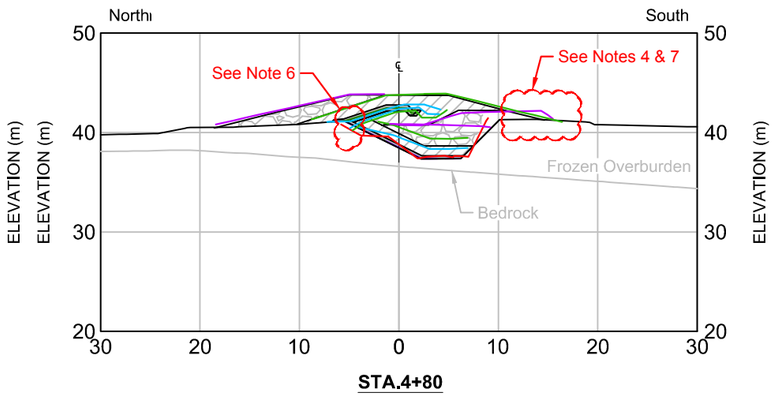

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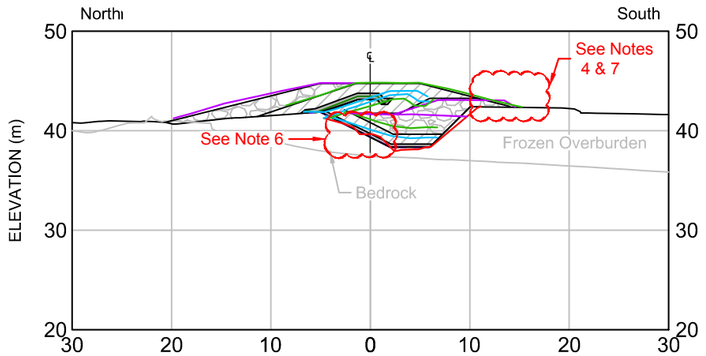

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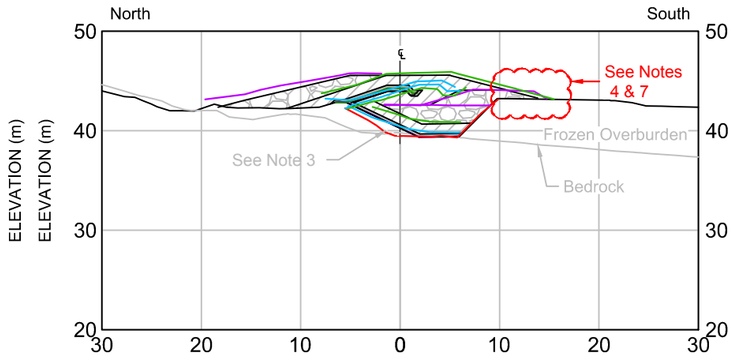
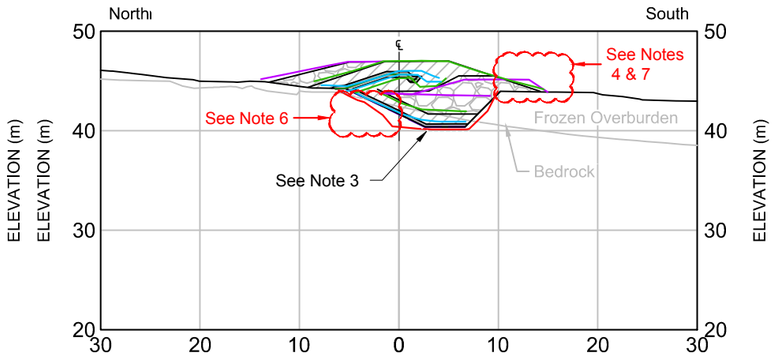


STA.5+00



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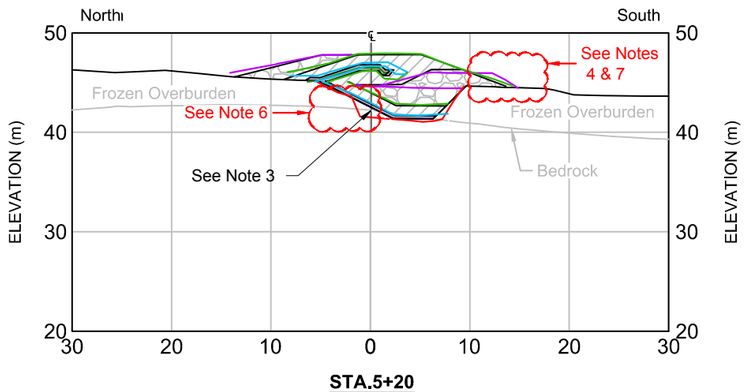


STA.5+20

LEGEND

- Phase 1 Design Lines
- As-Built Bedding
- As-Built Transition
- As-Built Run of Quarry
- As-Built Key Trench Excavation
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. All sections shown are for Phase 1 designs only.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth of bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.
4. ROQ downstream slopes were overbuilt and oversteepened in the minimum section required sections and resloped to match design grades at end of project.
5. Lower portion of above ground bedding material lifts oversteepened to account for discrepancy in original ground topography and to maintain upstream design toe.
6. Sections of upstream and downstream slopes steeper than design in areas of shallow bedrock.
7. Downstream dam face is not entirely constructed from transition material but appears so due to how the surface was as-built. See drawing DN-SD-09 for the presence of ROQ material on the downstream face.

0m 6 12 18 24

REFERENCE DRAWINGS			REVISIONS								
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							AB	As-Built	JBK	EMR	19/03/11
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-02	Phase 1 General Arrangement	-	-				0	Issued for Construction	JBK	EMR	17/11/29

PROFESSIONAL ENGINEERS STAMP

srk consulting

DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - South Dam - Sections.dwg

TMAC RESOURCES

Hope Bay Project

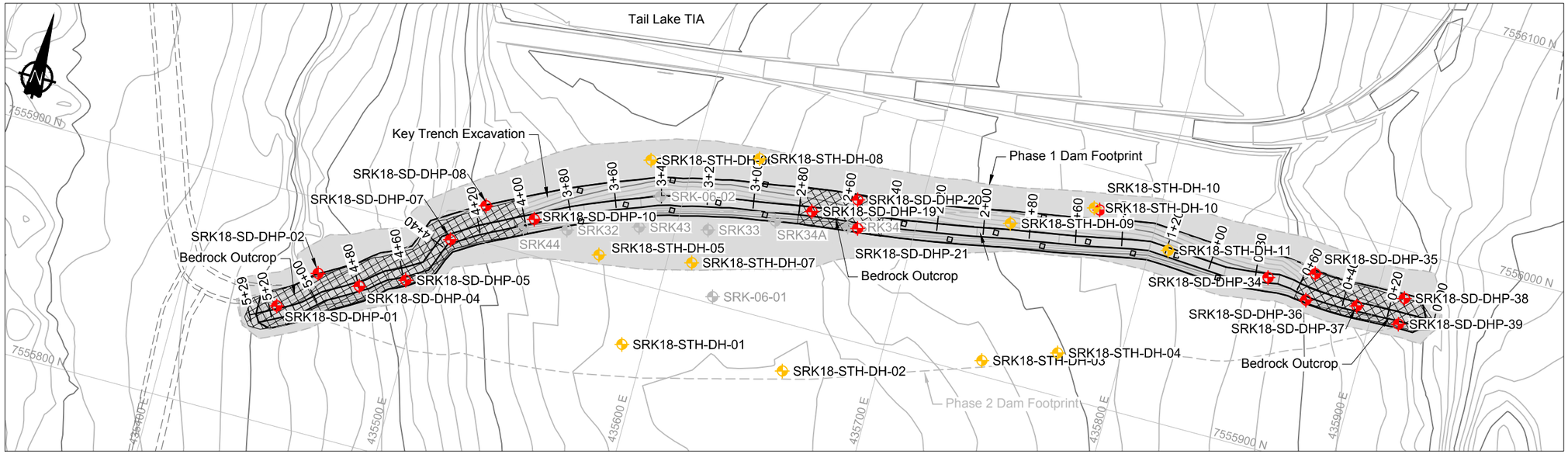
SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Sections Sta.4+60 to 5+30 Phase 1 Dam

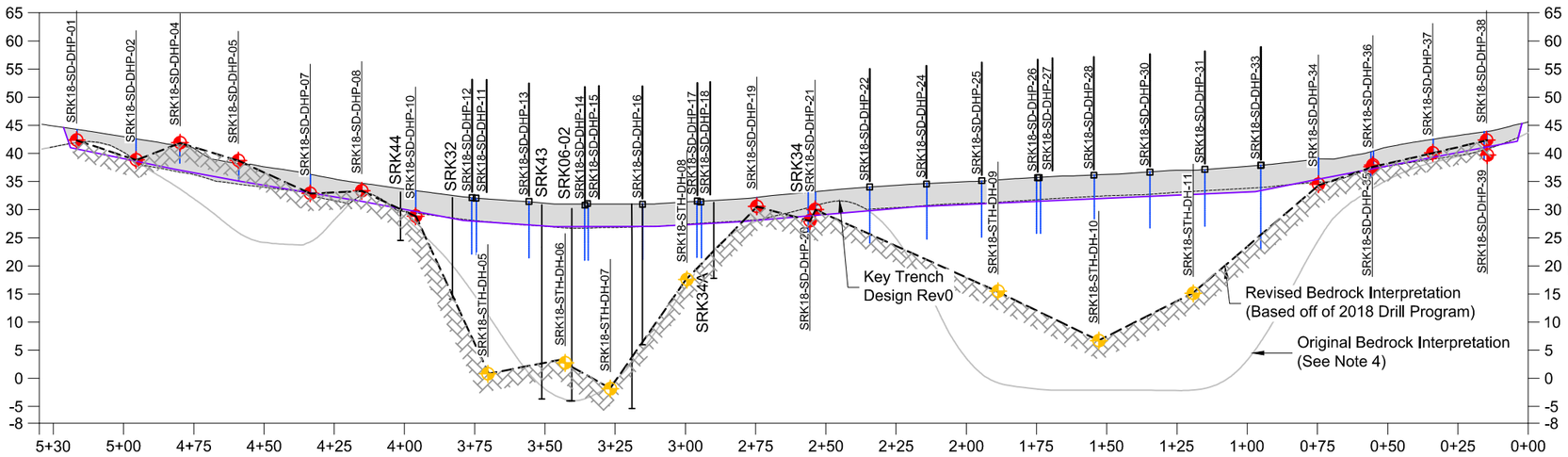
DRAWING NO.	SHEET	REVISION NO.
DN-SD-18	18 OF 30	AB

P:\01_SITES\Hope Bay\ACAD\As-Builts\South Dam - As-Built\1CT0022.017 - South Dam - Sections.dwg



Key Trench Plan View

0m 20 40 60 80



Key Trench Profile View

Vertical: 0m 10 20 30 40

Horizontal: 0m 20 40 60 80

LEGEND

- Previous Investigation Hole Location
- 2018 Percolation Hole Location Intercepted Bedrock
- 2018 Percolation Hole Location Did Not Intercept Bedrock
- 2018 Borehole Location
- Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Trench Excavation Extent

NOTES

1. Contours shown at 1.0m interval.
2. All units shown are in meters unless otherwise stated.
3. Alignment and profile shown correspond to the upstream toe of the key trench.
4. The subsurface geology has been inferred from geotechnical investigations (primarily boreholes SRK-06-01, SRK06-02, SRK32, SRK33, SRK34, SRK34A , SRK43, SRK 44, SRK18-STH-DH-01 to 11, and SRK18-WST-DH-01 to 03), airphoto interpretations, and from limited available geophysical surveys around the Tails Lake area. This data was then used to create a bedrock surface with the Gemcom GEMS software. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.
5. Infill drilling is planned to be completed to reduce the uncertainty and associated risks with the Phase 1 South Dam key trench excavation and overall dam performance (e.g. stability, seepage, settlement, and creep).
6. Depths of infill drill boreholes estimated based on available information (Note 4 and as noted on DN-SD-04). Boreholes should be drilled 3m into bedrock unless terminated earlier as directed by the onsite Engineer.
7. Inferred bedrock contact based off exploration and percolation testing holes drilled January / February 2018 by SRK Consulting.

REFERENCES

NAD83 UTM Zone 13.

AS-BUILT BOREHOLE LOCATIONS

Point ID	Northing	Easting	Collar Elevation	Depth to Bedrock
SRK18-STH-DH-01	7555,873	435,590	31.34	29.9
SRK18-STH-DH-02	7555,880	435,660	30.69	3.0
SRK18-STH-DH-03	7,555,907	435,742	33.59	13.5
SRK18-STH-DH-04	7,555,918	435,773	34.82	10.4
SRK18-STH-DH-05	7,555,908	435,571	31.81	31.0
SRK18-STH-DH-06	7,555,953	435,582	30.35	27.6
SRK18-STH-DH-07	7,555,915	435,610	30.86	32.7
SRK18-STH-DH-08	7,555,966	435,627	31.07	13.5
SRK18-STH-DH-09	7,555,967	435,739	35.03	15.5
SRK18-STH-DH-10	7,555,983	435,772	6.10	6.7
SRK18-STH-DH-11	7,555,973	435,808	36.82	15.1
SRK18-WST-DH-01	7,556,486	435,113	43.25	7.1
SRK18-WST-DH-02	7,556,296	435,200	41.42	1.1
SRK18-WST-DH-03	7,556,195	435,257	42.71	5.4

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
AB	As-Built	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/12/11

DN-SD-04 — Key Trench Excavation Plan and Profile

REFERENCE DRAWINGS

Original Drawings Stamped and Signed by Engineer

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DESIGN:	DRAWN:	REVIEWED:
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JBK	EMR	2018/04/13

FILE NAME: 1CT022.017 - South Dam - Infill Foundation Drilling.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Infill Foundation Drilling Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-19	19 OF 30	AB

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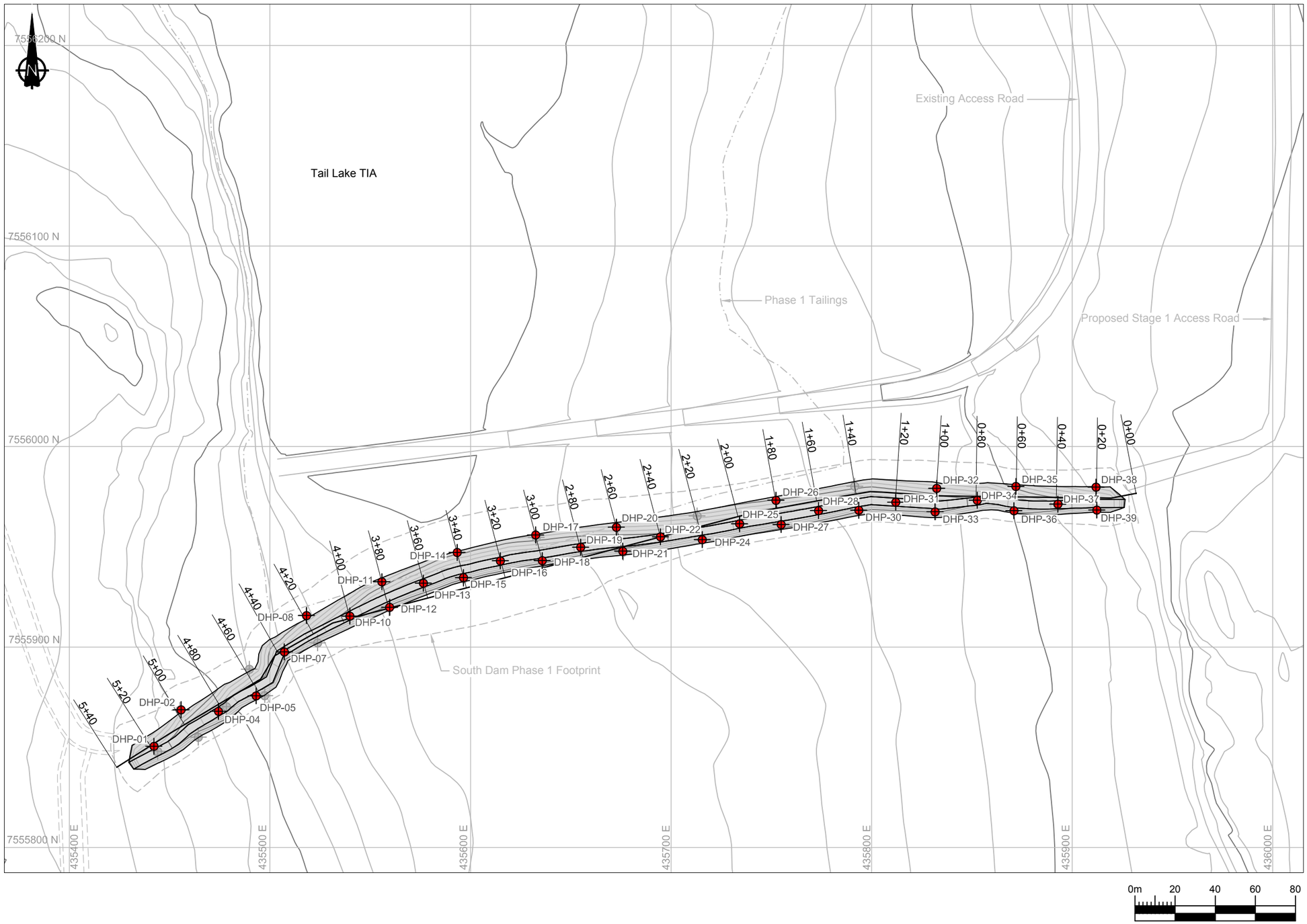

LEGEND

- Proposed Drill Hole Location
- As-Built Drill Hole Location
- Proposed Road Infrastructure
- Phase 1 Dam Footprint
- Phase 1 Tailings Outline

NOTES

1. Contours shown at a 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. All percolation test boreholes should be a minimum 8.0m deep.
4. Percolation test boreholes should be a minimum of 4-6 inches (100-150mm) in diameter.
5. It is suggested that an air-track drill (quarry drill) be used to complete the percolation testing.
6. Once all percolation test locations are drilled the testing will be completed on site as directed by the Engineer.

REFERENCES

NAD83 UTM Zone 13.

AS-BUILT PERCOLATION BOREHOLE LOCATIONS

Point ID	Northing	Easting	Elevation
SRK18-SD-DHP1	7555850.42	435442.14	44.2
SRK18-SD-DHP2	7555868.68	435455.71	42.1
SRK18-SD-DHP4	7555867.85	435474.33	41.0
SRK18-SD-DHP5	7555875.60	435493.08	37.9
SRK18-SD-DHP7	7555897.52	435507.19	36.0
SRK18-SD-DHP8	7555915.67	435518.25	34.3
SRK18-SD-DHP10	7555915.40	435539.87	32.8
SRK18-SD-DHP11	7555932.47	435555.80	31.6
SRK18-SD-DHP12	7555919.75	435559.69	31.8
SRK18-SD-DHP13	7555931.76	435576.48	31.1
SRK18-SD-DHP14	7555947.08	435593.31	30.5
SRK18-SD-DHP15	7555934.56	435596.45	30.7
SRK18-SD-DHP16	7555942.92	435614.88	31.2
SRK18-SD-DHP17	7555955.86	435632.48	31.6
SRK18-SD-DHP18	7555943.01	435635.74	31.5
SRK18-SD-DHP19	7555949.72	435654.89	32.0
SRK18-SD-DHP20	7555959.68	435672.72	33.0
SRK18-SD-DHP21	7555947.75	435675.88	33.1
SRK18-SD-DHP22	7555954.90	435694.71	33.7
SRK18-SD-DHP24	7555953.48	435715.55	34.4
SRK18-SD-DHP25	7555961.44	435734.11	35.0
SRK18-SD-DHP26	7555973.14	435752.28	35.5
SRK18-SD-DHP27	7555961.00	435754.88	35.4
SRK18-SD-DHP28	7555967.97	435773.53	35.9
SRK18-SD-DHP30	7555968.15	435793.60	36.4
SRK18-SD-DHP31	7555972.15	435812.00	37.1
SRK18-SD-DHP32	7555979.10	435832.48	37.7
SRK18-SD-DHP33	7555967.38	435831.61	37.6
SRK18-SD-DHP34	7555973.14	435852.65	38.6
SRK18-SD-DHP35	7555980.03	435871.93	40.9
SRK18-SD-DHP36	7555967.95	435870.94	40.1
SRK18-SD-DHP37	7555971.21	435892.86	42.4
SRK18-SD-DHP38	7555979.68	435911.87	44.3
SRK18-SD-DHP39	7555968.28	435912.27	43.5

REFERENCE DRAWINGS			REVISIONS								
							AB	As-Built	JBK	EMR	18/04/13
DN-SD-04	Key Trench Excavation Plan and Profile	--	--	--	--	--	0	Issued for Construction	JBK	EMR	17/12/11
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE

Original Drawings Stamped and Signed by Engineer

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JBK	EMR	2018/04/13

FILE NAME: 1CT022.017 - Percolation Testing.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Percolation Borehole / Test Locations

DRAWING NO.	SHEET	REVISION NO.
DN-SD-20	20 OF 30	AB

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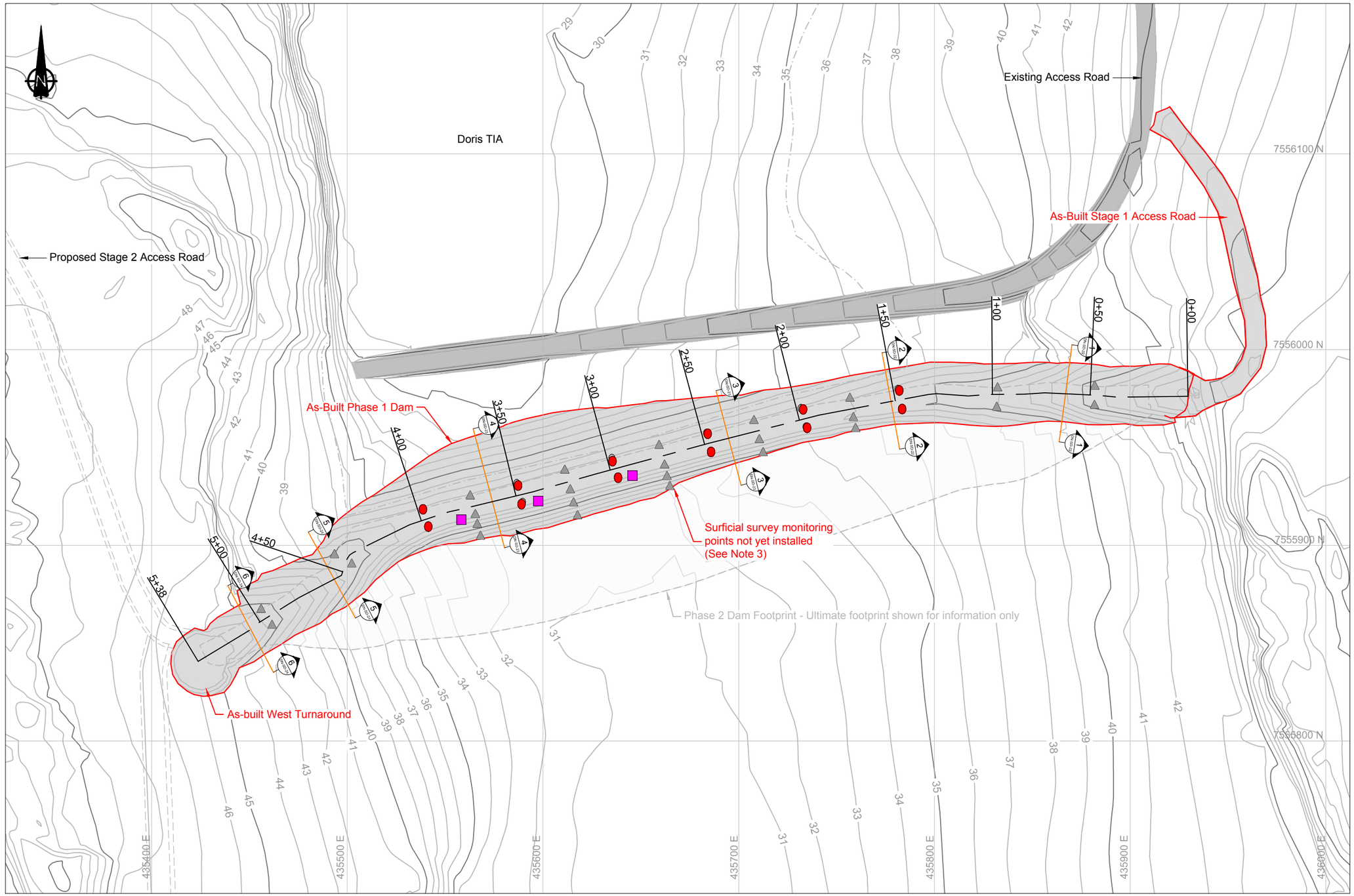

LEGEND

- Design Fixed Survey Monitoring Point
- As-Built Fixed Survey Monitoring Point
- Surficial Survey Monitoring Point (See Note 3)
- Deep Monitoring Point
- Monitoring Section
- Proposed Road / Dam Infrastructure
- As-Built Phase 1 Dam Footprint
- Phase 1 Tailings Footprint
- Phase 2 Dam Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. As-built locations of surficial survey monitoring points not available at the time of this as-built drawing revision.

REFERENCES

NAD83 UTM Zone 13.

AS-BUILT FIXED MONITORING POINTS

Northing	Easting	Elevation (m)
7555930.57	435587.28	38.66
7555918.41	435538.67	38.68
7555957.02	435684.16	38.75
7555947.75	435685.88	38.80
7555943.01	435635.52	38.73
7555934.57	435638.38	38.70
7555969.46	435732.95	38.65
7555960.06	435734.99	38.86
7555979.14	435782.08	39.95
7555909.56	435541.39	38.74
7555969.65	435783.54	40.05
7555921.02	435589.01	38.66

0m 20 40 60 80

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-	JBK	EMR	18/02/16

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
AB	As-Built	JBK	EMR	19/03/11
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	18/02/16

REVISIONS

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Plan Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-21	21 OF 30	AB

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Doris TIA

Existing Access Road

Proposed Stage 2 Access Road

As-Built Stage 1 Access Road

As-Built Phase 1 Dam

SD-DL01

SD-DL02

SD-DL03

SD-DL04

0+00

0+60

1+00

1+50

2+00

2+50

3+00

3+50

4+00

4+50

5+00

5+38

See Note 3

Cable Trench
~18.7m - 1.5m

As-built West Turnaround

7556100 N

7556000 N

7555900 N

7555800 N

435400 E

435500 E

435600 E

435700 E

435800 E

435900 E

436000 E

0m 20 40 60 80

LEGEND

- Data Logger Location
- Monitoring Section
- Design Cable Trench
- As-Built Cable Trench (estimated)
- Proposed Road / Dam Infrastructure
- As-Built Footprint
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Ground Temperature Cable backfilled cable trenches to be excavated through final dam shell - See drawings DN-SD-27, 28 and 29.

REFERENCES

NAD83 UTM Zone 13.

AS-BUILT DATA LOGGERS

SD-DL01Reporting Cables:
- SD-VTS-065-KTC
- SD-HTS-065-US
- SD-VTS-155-KTC
- SD-HTS-155-US
- SD-VTS-155-UST
- SD-VTS-155-DST

SD-DL02 Reporting Cables
- SD-VTS-240-KTC
- SD-HTC-240-KT
- SD-HTS-240-US
- SD-VTS-240-UST
- SD-VTS-240-DST

SD-DL03 Reporting Cables
- SD-HST-365-KT
- SD-VTS-365-KTC
- SD-HTS-365-US
- SD-VTS-365-UST
- SD-VTS-365-DST
- SD-VTS-US1
- SD-VTS-US2

SD-DL04 Reporting Cables
- SD-HST-460-KT
- SD-VTS-460-KTC
- SD-HTS-460-US
- SD-VTS-460-UST
- SD-VTS-460-DST
- SD-VTS-510-KTC
- SD-HTS-510-US
- SD-B1-KT

AS-BUILT DATA LOGGER LOCATION

ID	Northing (m)	Easting (m)
SD-DL01	7,555,978	435,777
SD-DL02	7,555,959	435,693
SD-DL03	7,555,927	435,573
SD-DL04	7,555,987	435,490

REFERENCE DRAWINGS

DRAWING NO.	DRAWING TITLE
DN-SD-29	Instrumentation Details at Sta. 4+65 and 5+10
DN-SD-28	Instrumentation Details at Sta. 2+40 and 3+65
DN-SD-27	Instrumentation Details at Sta. 0+65 and 1+55
DN-SD-03	Typical Sections

REVISIONS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-			
AB	As-Built	JBK	EMR	19/03/11
2	Issued for Construction	JBK	EMR	18/04/26
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	18/02/16

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DESIGN: CH | DRAWN: TAH | REVIEWED: JBK
CHECKED: JBK | APPROVED: EMR | DATE: 2019/03/11
FILE NAME: 1CT0022.017 - GTC Trenches.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: GTC Backfilled Cable Trenches Phase 1

DRAWING NO. DN-SD-22 | SHEET 22 OF 30 | REVISION NO. AB

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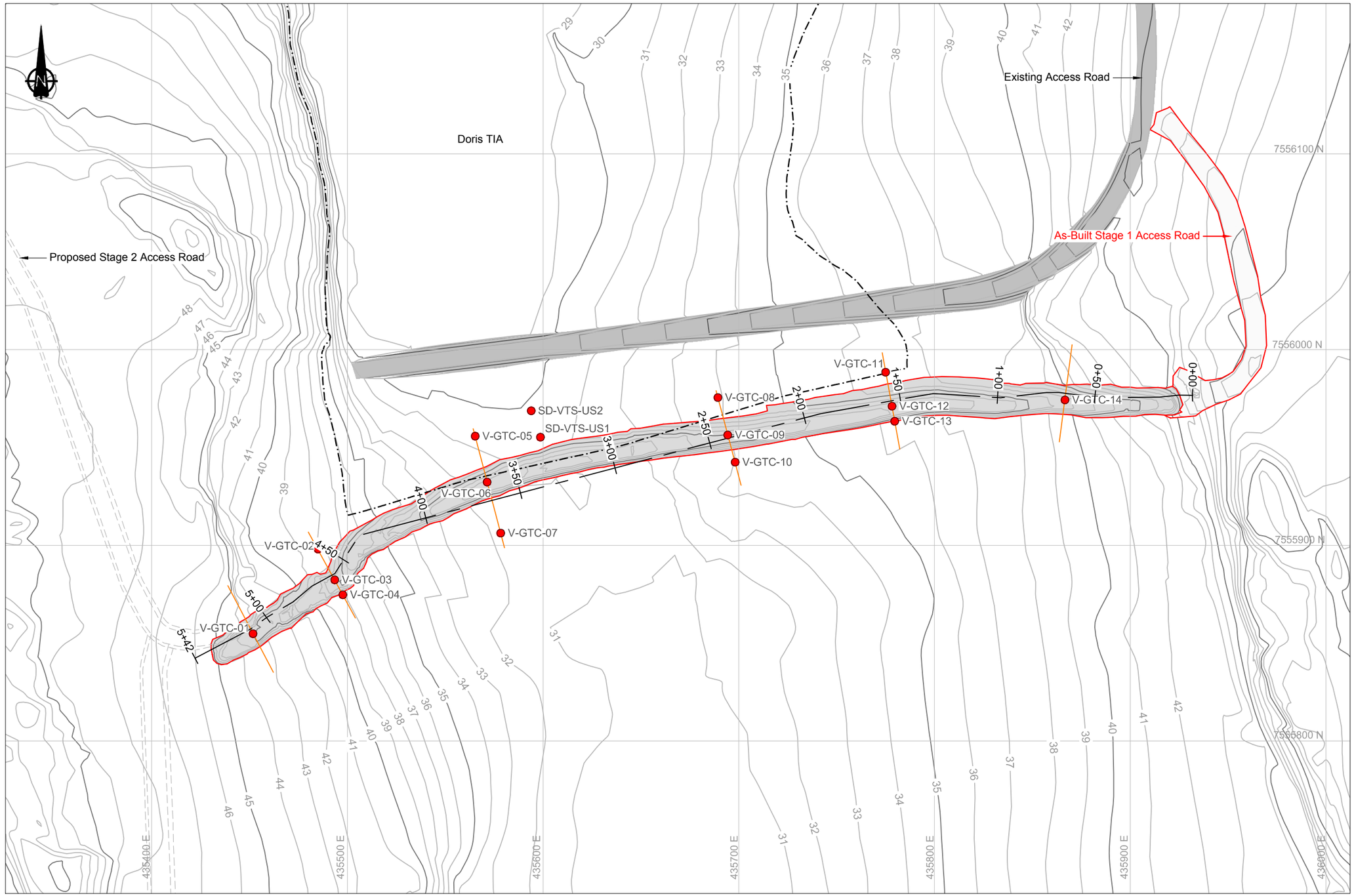

LEGEND

- As-Built Vertical GTCs
- Monitoring Section
- Proposed Road / Dam Infrastructure
- As-Built Key Trench Excavation
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

0m 20 40 60 80

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DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-03	Typical Sections	-	-	JBK	EMR	17/12/15

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
AB	As-Built	JBK	EMR	19/03/11
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	17/12/15

REVISIONS

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - Vertical GTC LO.dwg

TMAC RESOURCES

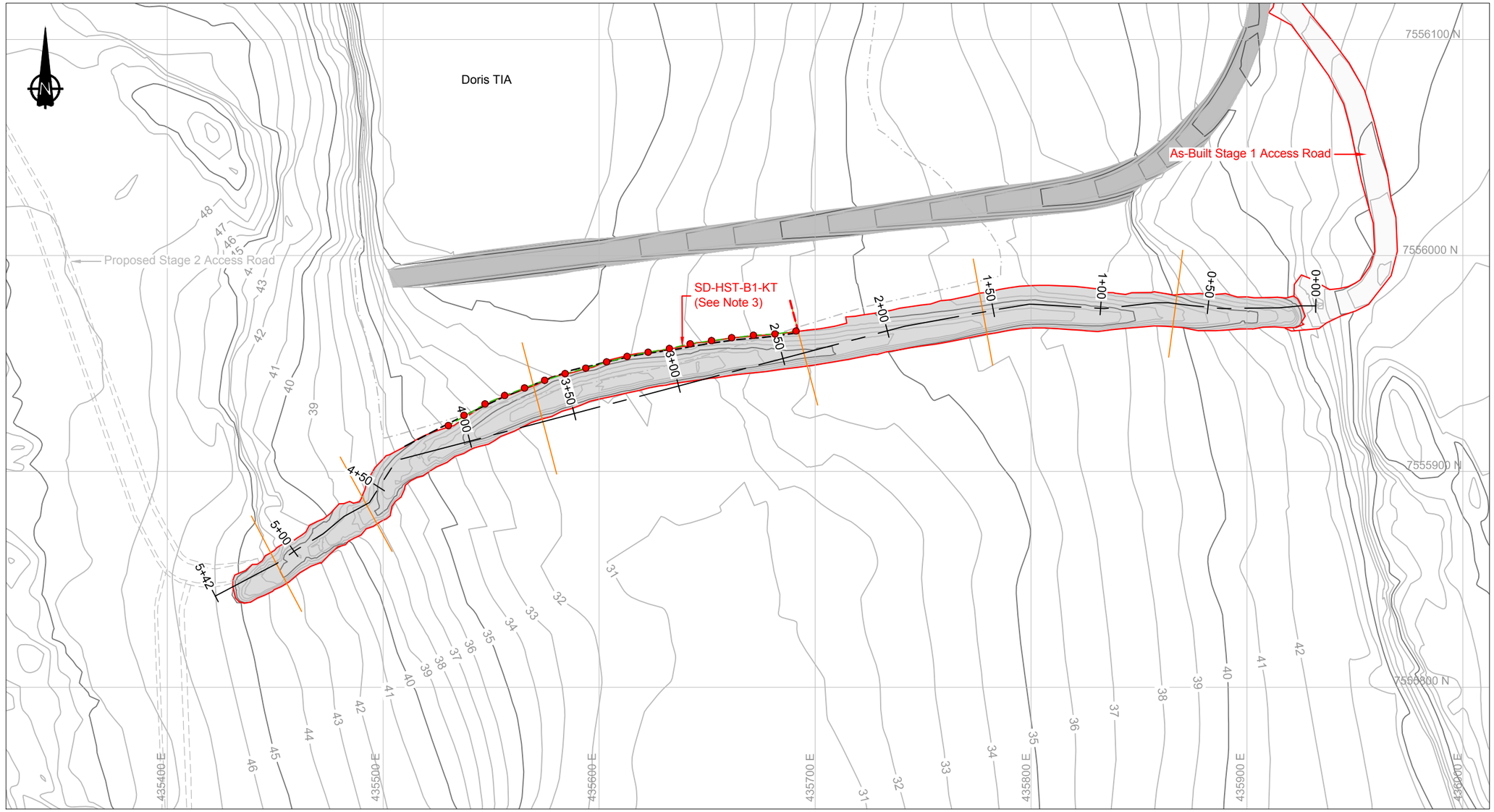
Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Vertical GTC Layout Phase 1

DRAWING NO.	SHEET	REVISION NO.
DN-SD-23	23 OF 30	AB



LEGEND

- As-Built Bead Location
- As-Built Horizontal Ground Temperature Cable
- Design Horizontal Ground Temperature Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- As-Built Key Trench Excavation
- Design Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.
3. Location of SD-HST-B1-KT as-built on top of the lower/upper GCL overlap near the upstream crest of the key trench.

REFERENCES

NAD83 UTM Zone 13.

Ground Temperature Cable Details - Center Base

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)									
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
1	SD-HST-B1-KT	A	Horizontal	Center Base	235	Base of Key Trench	20 beads spaced every 10m from the zero line on the cable, i.e. first bead at 0m										

0m 20 40 60 80

NO.	DESCRIPTION	CHK'D	APP'D	DATE
-				
AB	As-Built	JBK	EMR	19/03/11
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	18/02/15

REVISIONS

DRAWING NO.	DRAWING TITLE
DN-SD-03	Typical Sections

REFERENCE DRAWINGS

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - Lower H&II GTC LO.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Horizontal GTC
Upstream Base / Toe of Key Trench

DRAWING NO.	SHEET	REVISION NO.
DN-SD-24	24 OF 30	AB

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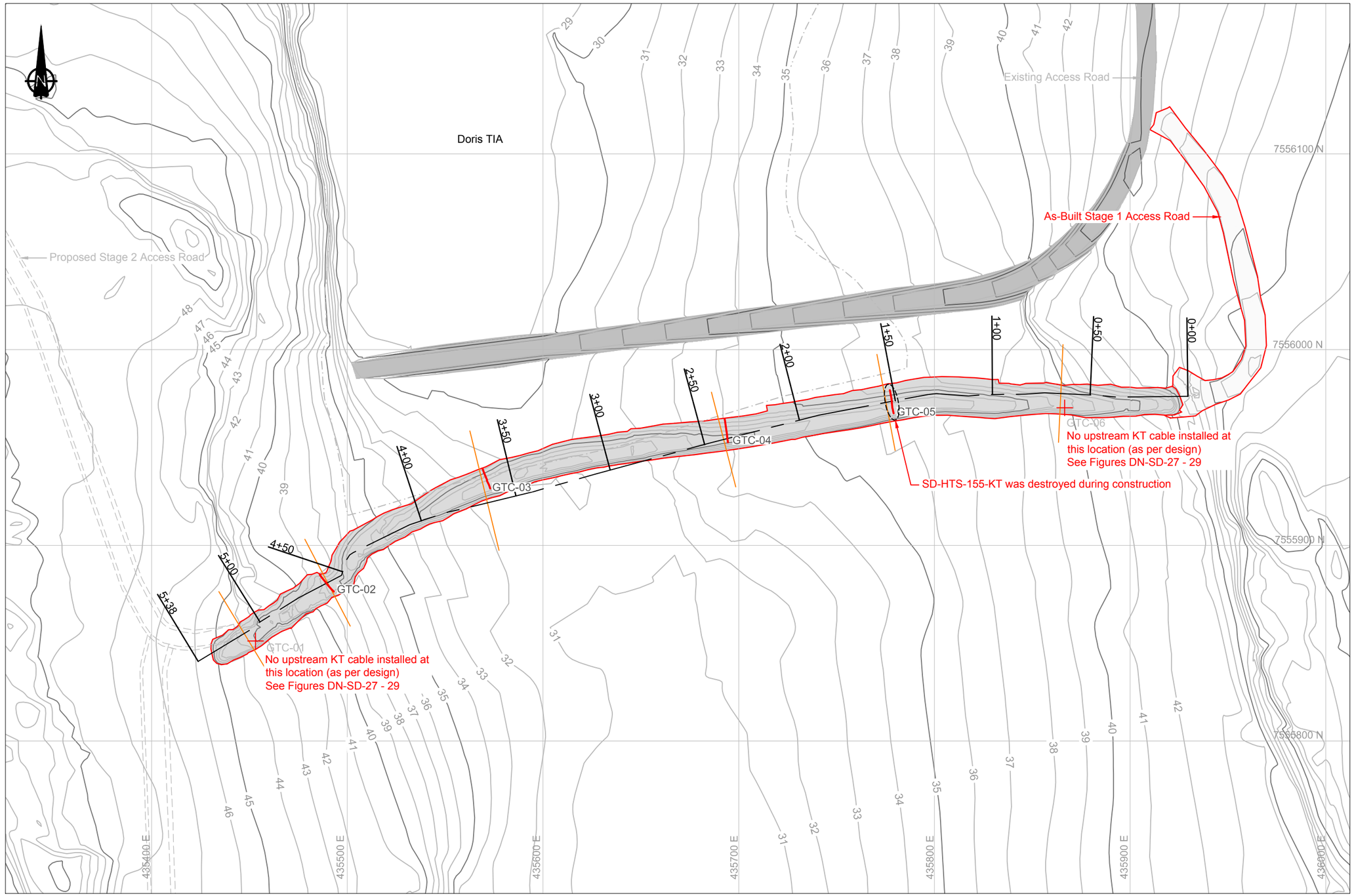

LEGEND

- As- Built Monitoring Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- As-Built Key Trench Excavation
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

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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							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	17/12/11

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CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - Leak Detection.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

GTC Layout Along Upstream Slope of Key Trench

DRAWING NO.	SHEET	REVISION NO.
DN-SD-25	25 OF 30	AB

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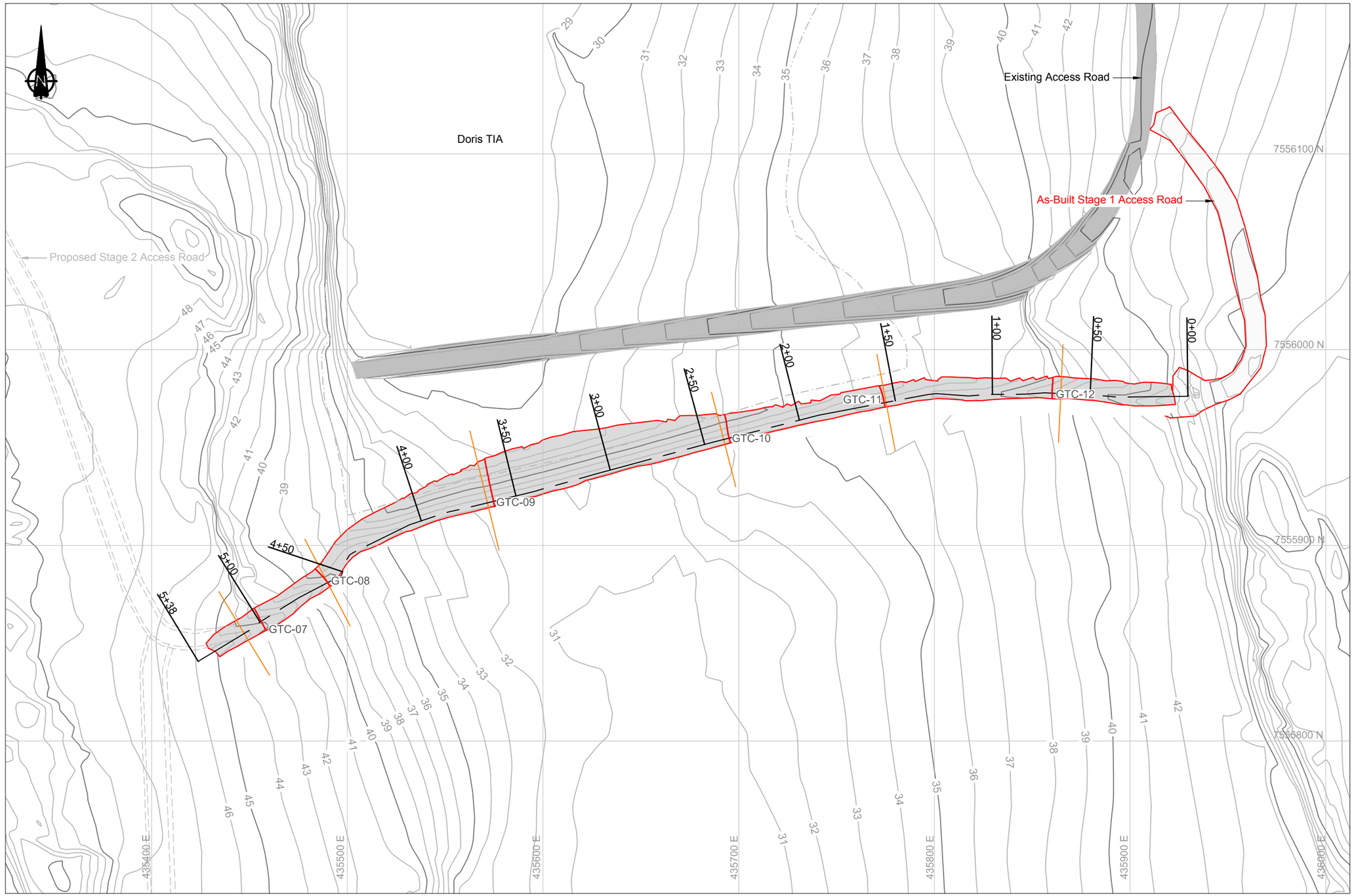

LEGEND

- As-Built Monitoring Cable
- Monitoring Section
- Proposed Road / Dam Infrastructure
- As-Built Above Ground Liner
- Phase 1 Tailings Footprint

NOTES

1. Contours shown at 1.0m interval. Topographic contour data from the terrain model was provided by the Client (TMAC).
2. All units shown are in meters unless otherwise stated.

REFERENCES

NAD83 UTM Zone 13.

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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							AB	As-Built	JBK	EMR	19/03/11
							1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	17/12/11

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DESIGN:	DRAWN:	REVIEWED:
CH	TAH	JBK
CHECKED:	APPROVED:	DATE:
JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - Liner GTC.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

GTC Layout Along Upstream Above Ground Liner Slope

DRAWING NO.	SHEET	REVISION NO.
DN-SD-26	26 OF 30	AB

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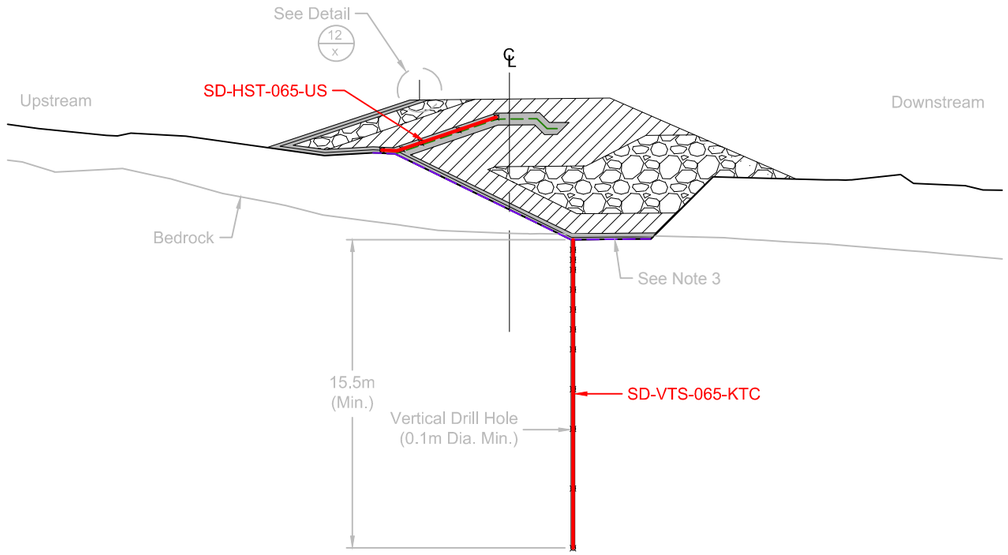
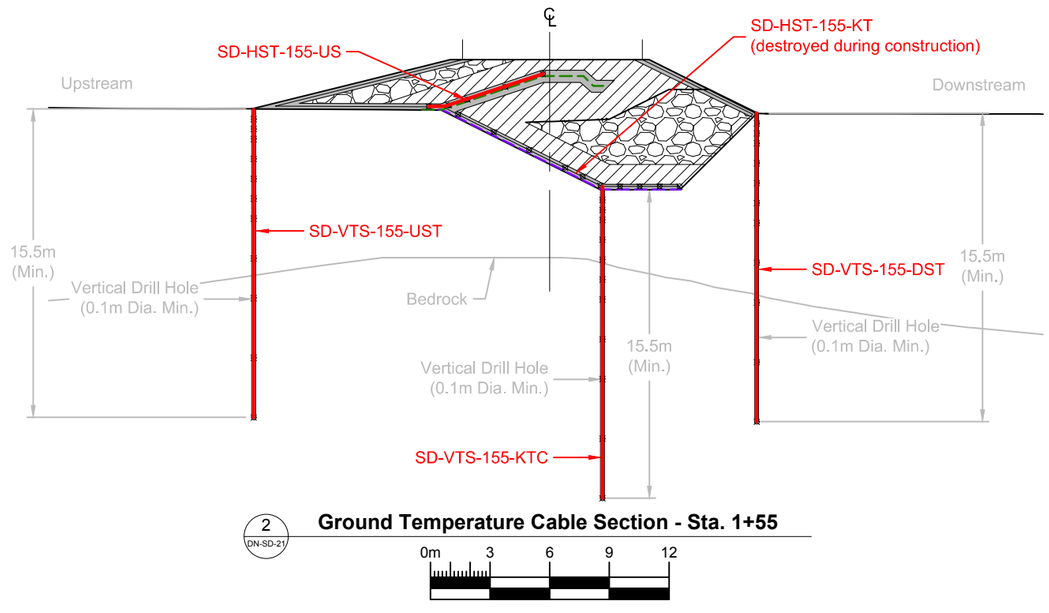


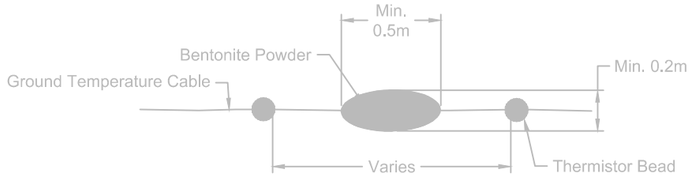
1 DN-SD-21 **Ground Temperature Cable Section - Sta. 0+65**

0m 3 6 9 12



2 DN-SD-21 **Ground Temperature Cable Section - Sta. 1+55**

0m 3 6 9 12



Detail 12 - Typical Water Stop Detail

0m 0.3 0.6 0.9 1.2

LEGEND

- Thermistor Bead Location
- Lower GCL Liner
- Upper GCL Liner
- As-built Cable Location
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. Vertical cable boreholes to be filled with grout or backfilled with finer (sand size) material.
3. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

Ground Temperature Cable Details - Monitoring Section 0+65 and 1+55

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
2	SD-VTS-65-KTC	A	Vertical	0+65	42	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
3	SD-HTS-065-US	B	Horizontal & Inclined	0+65	121	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
4	SD-VTS-155-KTC	A	Vertical	1+55	50	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
5	SD-VTS-155-UST	A	Vertical	1+55	41	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
6	SD-VTS-155-DST	A	Vertical	1+55	53	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
7	SD-HTS-155-US	B	Horizontal & Inclined	1+55	41	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
8	SD-HTS-155-KT	C	Horizontal & Inclined	1+55	39	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13
9	SD-HST-B1-KT	C	Horizontal	Center Base	235	Center Base	20 beads spaced every 10m from the zero line on the cable i.e. first bead at 0m										
10	Extension for SD-VTS-065-KTC	D	Vertical	0+65	90		Extension for existing cable. No beads needed.										

GTCs installed as per designed.

REFERENCE DRAWINGS		REVISIONS									
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-										
							AB	As-Built	JBK	EMR	19/03/11
DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	JBK	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

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FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

MAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Details at Sta. 0+65 and 1+55

DRAWING NO. DN-SD-27 | SHEET 27 OF 30 | REVISION NO. AB

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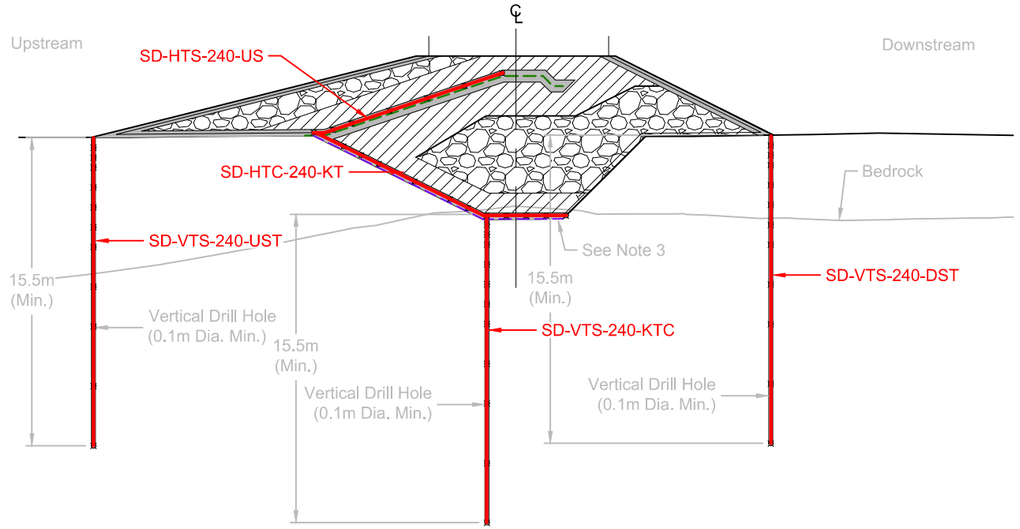
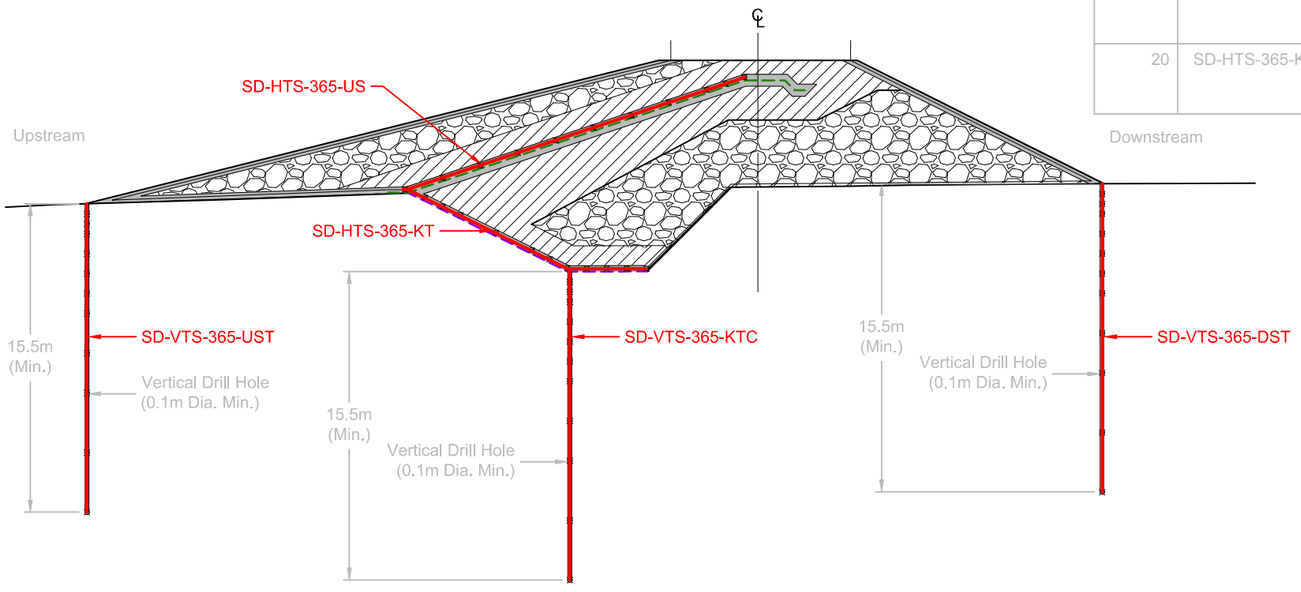


3 DN-SD-21

Ground Temperature Cable Section - Sta. 2+40

0m 3 6 9 12



4 DN-SD-21

Ground Temperature Cable Section - Sta. 3+65

0m 3 6 9 12

Ground Temperature Cable Details - Monitoring Section 2+40 and 3+65

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
11	SD-VTS-240-KTC	A	Vertical	2+40	58	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
12	SD-VTS-240-UST	A	Vertical	2+40	46	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
13	SD-VTS-240-DST	A	Vertical	2+40	53	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
14	SD-HTS-240-US	B	Horizontal & Inclined	2+40	50	Upstream Slope	0	2	4	6	8	9	10	-	-	-	-
15	SK-HTC-240-KT	B	Horizontal & Inclined	2+40	48	Upstream Slope	0	1	3	5	7	8	9	10	11	12	13
16	SD-VTS-365-KTC	A	Vertical	3+65	75	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
17	SD-VTS-365-UST	A	Vertical	3+65	57	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
18	SD-VTS-365-DST	A	Vertical	3+65	58	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
19	SD-HTS-365-US	B	Horizontal & Inclined	3+65	76	Upstream Slope	0	2	4	6	8	10	12	14	15	17	18
20	SD-HTS-365-KT	C	Horizontal & Inclined	3+65	65	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13

GTCs installed as per designed.

LEGEND

- Thermistor Bead Location
- Lower GCL Liner
- Upper GCL Liner
- As-built Cable Location
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE
-	-					
DN-SD-21	Instrumentation Plan - Phase 1					
DN-SD-03	Typical Sections	-	-			

REFERENCE DRAWINGS

NO.	DESCRIPTION	CHK'D	APP'D	DATE
AB	As-Built	JBK	EMR	19/03/11
1	Issued for Construction	JBK	EMR	18/04/13
0	Issued for Construction	JBK	EMR	18/03/13

REVISIONS

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CHECKED:	APPROVED:	DATE:
JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Details at Sta. 2+40 and 3+65

DRAWING NO.	SHEET	REVISION NO.
DN-SD-28	28 OF 30	AB

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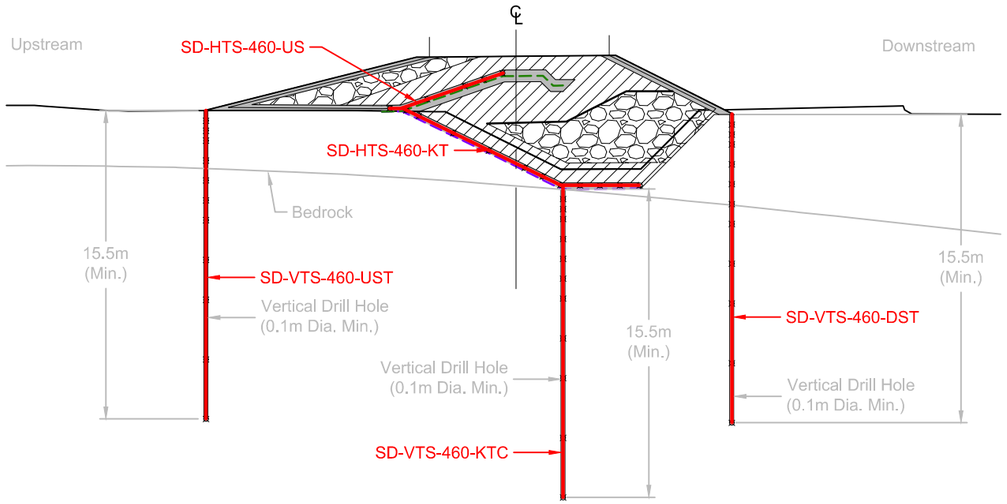
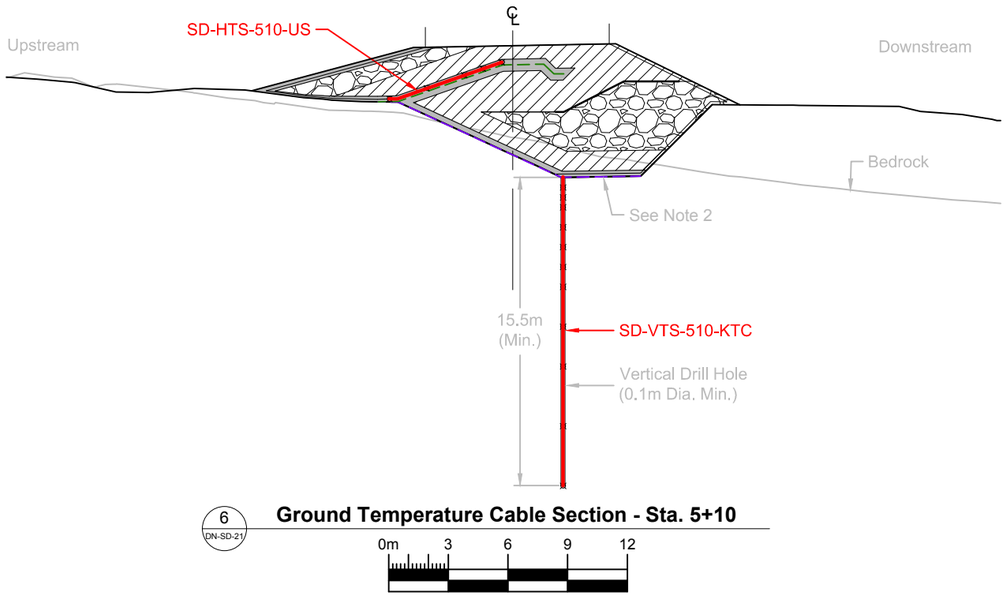


5 DN-SD-21

Ground Temperature Cable Section - Sta. 4+60

0m 3 6 9 12



6 DN-SD-21

Ground Temperature Cable Section - Sta. 5+10

0m 3 6 9 12

Ground Temperature Cable Details - Monitoring Section 4+60 and 5+10

String	String Name	Series	Type	Chainage (m)	Overall Cable Length	Cable Location	Bead Location (meters from end of Cable)										
							#1	#2	#3	#4	#5	#6	#7	#8	#9	#10	#11
21	SD-VTS-460-KTC	A	Vertical	4+60	50	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
22	SD-VTS-460-UST	A	Vertical	4+60	41	Upstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
23	SD-VTS-460-DST	A	Vertical	4+60	58	Downstream Toe	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
24	SD-HTS-460-US	B	Horizontal & Inclined	4+60	41	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
25	SD-HTS-460-KT	C	Horizontal & Inclined	4+60	39	Side Slope of Key Trench	0	1	3	5	7	8	9	10	11	12	13
26	SD-VTS-510-KTC	A	Vertical	5+10	48	Base of Key Trench	0.5	1	1.5	2.5	3.5	4.5	5.5	7.5	9.5	12.5	15.5
27	SD-HTS-510-US	B	Horizontal & Inclined	5+10	86	Upstream Slope	0	2	4	5	6	-	-	-	-	-	-
28	Extension for SD-VTS-510-KTC	D	Vertical	5+10	90		Extension for existing cable. No beads needed.										

GTCs installed as per designed.

LEGEND

- Thermistor Bead Location
- Lower GCL Liner
- Upper GCL Liner
- As-built Cable Location
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. Depth of key trench and bedrock intersection estimated (see DN-SD-04 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines (~3 to 4m depth), until competent bedrock is encountered, or as directed by the Engineer.

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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DN-SD-21	Instrumentation Plan - Phase 1						1	Issued for Construction	JBK	EMR	18/04/13
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/03/13

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FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE: Instrumentation Details at Sta. 4+65 and 5+10

DRAWING NO. DN-SD-29 | SHEET 29 OF 30 | REVISION NO. AB

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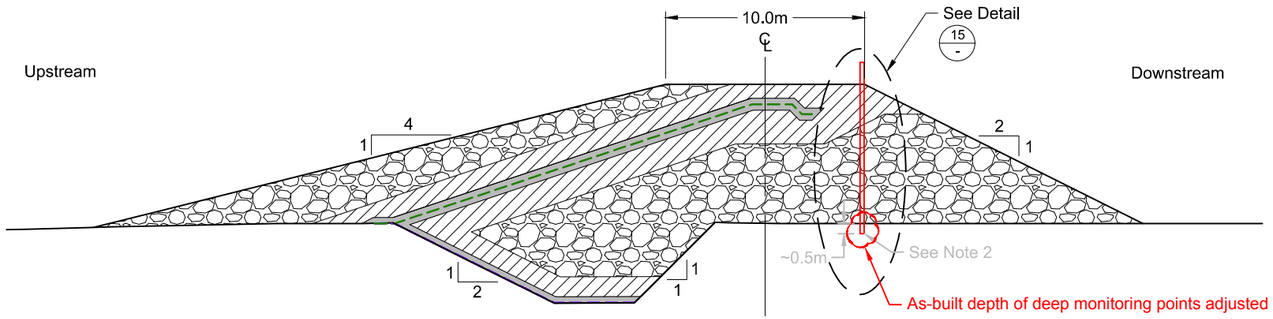
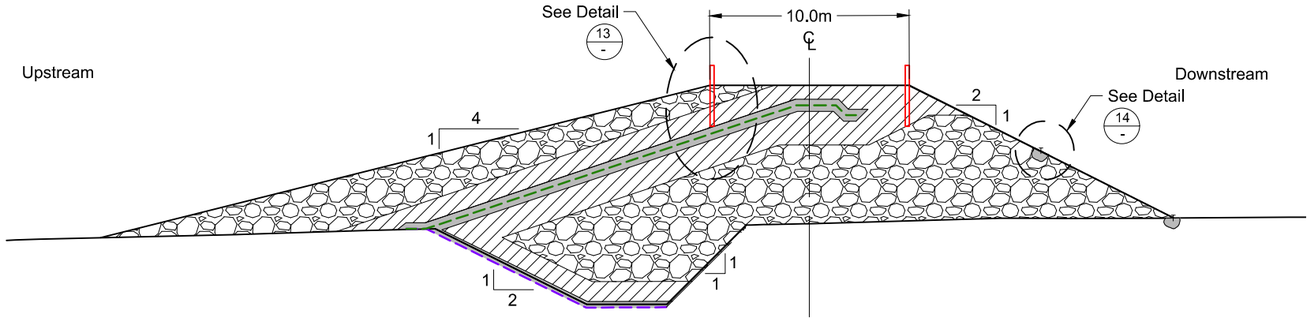


Monitoring Point ID	Depth below Dam Crest (m)	Approximate Elevation (m)
D1 = 3+80	6.2	31.8
D2 = 3+40	8	30
D3 = 2+90	5.4	32.6

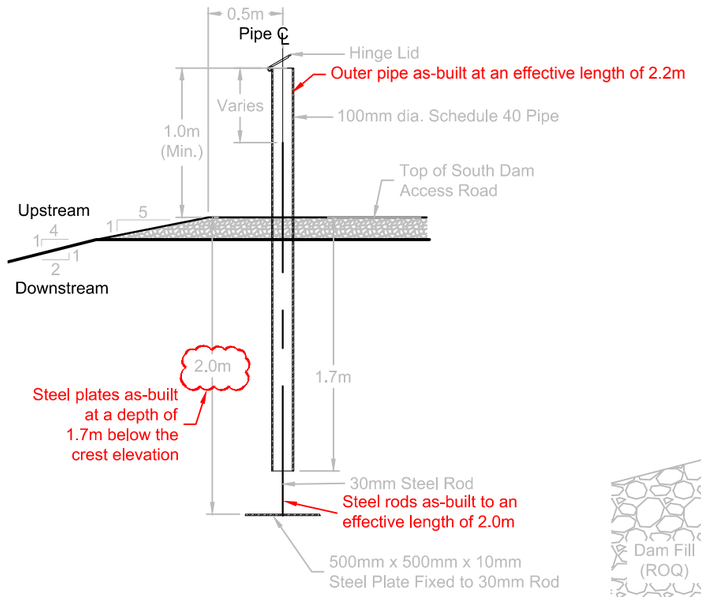
Surficial Survey Point - Sta. 3+15

0m 3 6 9 12



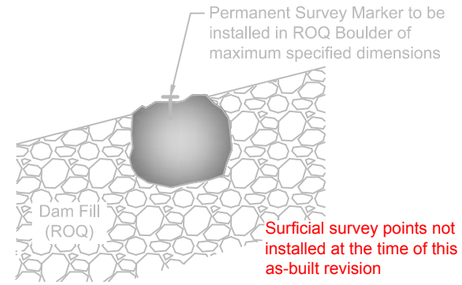
Deep Settlement Point - Sta. 3+50

0m 3 6 9 12



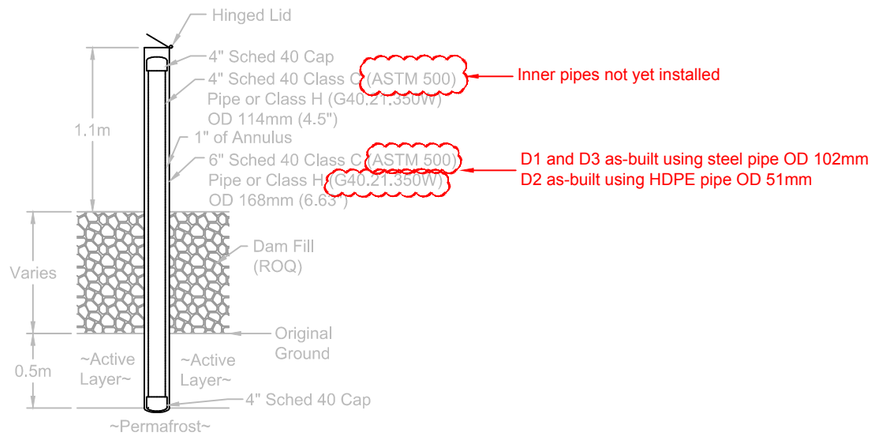
Detail 13 - Survey Monitoring Point Detail

0m 0.25 0.5 0.75 1.0



Detail 14 - Surficial Survey Point Installation

0m 0.25 0.5 0.75 1.0



Detail 15 - Deep Settlement Point Installation

0m 0.25 0.5 0.75 1.0

LEGEND

- Lower GCL Liner
- Upper GCL Liner
- Bedding Material
- Transition Material
- Run of Quarry Backfill

NOTES

1. All units shown are in meters unless otherwise stated.
2. Deep settlement point installation depth to be directed by the field Engineer. Aim is to be near the active layer - permafrost contact.

REFERENCE DRAWINGS			REVISIONS									
-	-		-									
DN-SD-21	Instrumentation Plan - Phase 1						AB	As-Built	JBK	EMR	19/03/11
DN-SD-03	Typical Sections	-	-				0	Issued for Construction	JBK	EMR	18/04/13
DRAWING NO.	DRAWING TITLE	NO.	DESCRIPTION	CHK'D	APP'D	DATE	NO.	DESCRIPTION	CHK'D	APP'D	DATE

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JBK	EMR	2019/03/11

FILE NAME: 1CT0022.017 - Instrumentation Plan.dwg

TMAC RESOURCES

Hope Bay Project

SRK JOB NO.: 1CT022.017

South Dam

DRAWING TITLE:

Typical Monitoring Point Details

DRAWING NO.	SHEET	REVISION NO.
DN-SD-30	30 OF 30	AB

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Appendix I – QC Report for GCL Installation

BLOMBERG BUILDING GROUP

South dam phase 1

Liner construction Summary

March 19th – June 27th, 2018

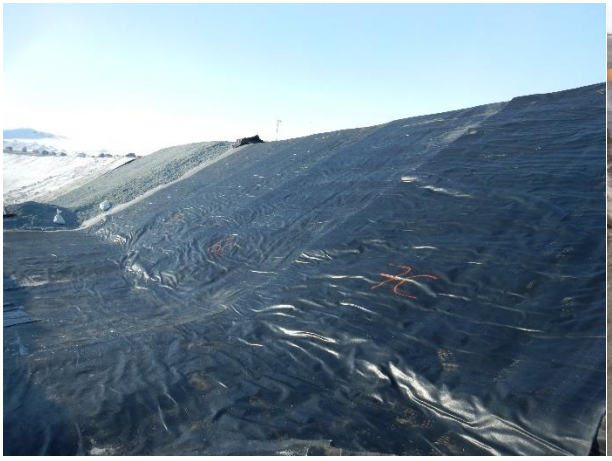
Doris North Project

Hope Bay, Nunavut, Canada

General

Description of Work

Phase 1 of the South dam liner was installed in two sections; first was the key trench a 3-4-meter-deep excavation where liner was placed below surface elevation on permafrost and bedrock, the second portion of liner extended from the hinge point tie-in to the above ground liner portion of the dam (AGL) which was constructed with compact bedding material. Blomberg Building Group started work on the south dam March 19th, 2018 and construction lasted until the 25th of June. We started to install panels in the key trench on April 2nd and completed deployment on May 7th; 140 full panels and an additional 68 sacrificial panels placed over the fragmented bedrock areas. Installation on the above ground portion of the south dam was completed in 19 days ending on the June 25th, with a total of 135 full panels used averaging 7 panels per day. A more detailed description of the installation methods, quality control methods, and processes for the two separate sections of the dam is provided below.



Key Trench (Station 3+10)

Above Ground liner (Station 2+20)

Transporting Materials to Site

During the transportation of rolls to our warm storage facility an initial QC inspection was completed. Upon our inspections we noticed that there was minor damage to most rolls and significant damage to a few rolls, as these damages were incurred in transportation a closer look during deployment revealed that the first layer of GCL was punctured for most of these cases.

Patchwork Specifications

After deployment a ring of bentonite was placed around punctures, tears or any suspect areas. A patch was then placed overtop extending a minimum of 500mm past the defect on all sides. During the deployment of Key Trench panels 16W-18W there was noticeable hydration of the bentonite within the GCL roll. SRK was diligent and requested that we double up the liner layers for these hydrated panels.

Key Trench

Detailed Cleaning Specifications

Prior to laying panels in the key trench, a detail clean was required to ensure an appropriate surface for the liner. Two high powered air lances and a skid steer were used to blow and brush all snow and loose material from the slopes and base of the trench. Once the surface was deemed acceptable for panel installation, SRK signed off on the slope.

Patch Work and Void Filling Specifications

Voids were filled with an approved blend of fly-ash, cement and aggregate and then sacrificial patches were placed over as directed by SRK. The above measures were set by SRK to minimize any damage to the liner during installation. All punctures and tears in the GCL were patched with SRK's approved method.

GCL Panel Installation Method

Overlapping panels were always placed higher in elevation with a minimum overlap of 500mm, a bentonite bead was then placed between the panels, along the base edge at the downstream extent of the key trench and below the hinge point. The bentonite bead varied in thickness depending on the type of seam (overlaps/ back of key trench base – 5mm x 100mm. Hinge point 10mm x 500mm). Deployment in the key trench was completed using an excavator with a spreader bar. First the rolls were lowered into the trench and anchored at base edge of the downstream. Secondly the excavator would slowly retract its boom pulling the roll upslope out of the trench with the liner being cut once the roll had reached the designated overlap at the hinge point (*fig 1*).

GCL Usage Rates

The anticipated usage rates and quantities for the south dam were done by SRK and based on the original design (Rev 0), the quantities were done neat line with an additional 15% for excessive overlap and possible damage. The neat line quantity was 17,250m^2 as build usage rates of the dam were 26.6% more with actual usage totaling 20,370m^3.

The reason for the additional GCL was due to unseen factors at the time of estimation. In the key trench the bedrock areas required many large sacrificial patches as protection from the sharp and uneven terrain (*Fig 2*). The trench was deeper in the east and west bedrock sections in turn reducing the numbers of panels that one roll would cover. In total the key trench used 36 sacrificial panels on the west abutment *(fig 2)*, 12 in the center section of permafrost, and 20 on the east abutment for a total of 68 sacrificial panels an estimated 14 full rolls (2,898m^2). The key trench contained 140 full panels for an average panel length of 3.77m *(see attached As-build).* Thicker overlaps were required in some areas (bedrock, west/ east abutment) and resulted in 9 extra panels being needed to complete the key trench.

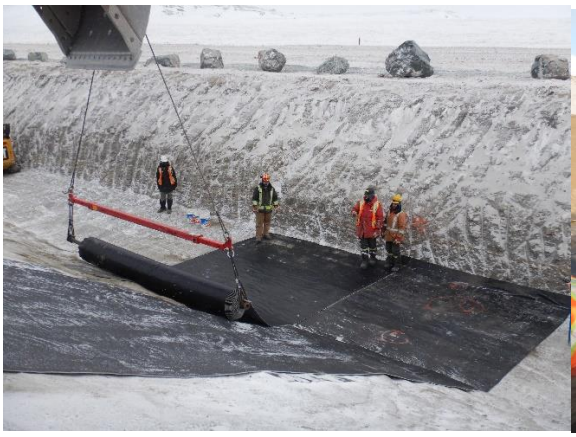


Figure 1

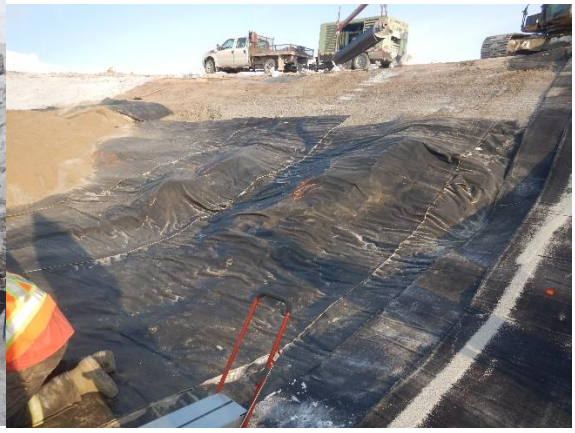


Figure 2

Above Ground Liner (AGL)

Detailed Cleaning Specifications

No detailed cleaning was required for the AGL portion as the GCL was placed atop 20mm compacted crush.

Patch Work and Void Filling Specifications

Patchwork was required for rolls that were damaged during transportation the same patchwork specifications were used for all patches in the Key Trench and AGL. The hinge point had become saturated from the spring thaw and SRK directed us to place an additional one-meter sacrificial patch on the hinge point in part with an additional bentonite bead.

GCL Installation Method

For the above ground liner, we used a crane or excavator (depending on panel length) and the same spreader bar to deploy rolls. First, we anchored the rolls at the top of the dam and pulled them down slope slowly to eliminate dragging the GCL (*fig 3).*

GCL Usage Rates

The above ground liner portion of the dam contained 135 panels for an average of 3.91m per panel, an additional four panels were needed due to the accumulation of excessive overlap. The last unforeseen area of GCL consumption during estimation was the hinge point sacrificial patches (*fig 4*), although these were taken from “short” rolls it had a moderate impact on the overall usage, resulting in an approximate. 200m^2 of GCL.

Figure 3

Figure 4

see pictures for confirmation of patchwork

Fly Ash Mixture

Mixing Details

A fly-ash mixture was approved by SRK and was used to fill voids and pack the jagged rocky terrain. In total we use fourteen trucks of the fly-ash mixture in those fourteen trucks we used forty-two tonnes of type 10GU cement, forty-two tonnes of fly-ash and 168,000kg of aggregate. Mix ratio was one-part fly-ash, one-part cement and four-parts aggregate. Fly-ash and cement were sourced from sea-cans on-site, the aggregate for the mixture was 20mm minus from quarry 2 and was stored in the batch plant.

Transportation

The mixture was blended in Kenworth Barrel Trucks (11m^3 drum size) and loaded into mega bags (1000kg) for transportation. This was required as the barrel trucks could not make it to the dam due to slope of the roadway. The bags were loaded onto a 10-ton truck and transported to site.

Quality Control Measures

Quality Control testing was done for the filler blend, two samples each of the aggregate and fly-ash prior to mixing were taken for particle size analysis. For each individual batch mixed two samples of the 4:1:1 blend was submitted for particle size analysis. One Field test was taken by SRK for every batch that was placed in the key trench. **See attached results*

note: Samples were sent for all batches, results have only been obtained from one batch

Quality control for GCL was done in the field upon arrival to site, and prior to deployment, picture documentation was acquired as to reaffirm the field recordings. Panels were given a numerical value based on the location in which the trench was completed. The key trench had three separate start points due to excavation and backfill requirements. Panel 0 is located at the 2+00 mark, panels 1E-50E extended to 0+00. Panel 1C started at 3+35 and moved east to panel 36C at the 2+00 mark, and Panel 1W extended west from the 3+35-mark west to 5+29 finishing the key trench with panel 53W.

The Above ground portion of the dam was labeled in similar fashion, we started at the lowest elevation and we were able to work east and west and didn't have to fold back the overlapping edge. Two

alphabetic differences followed by the increasing numerical value based off direction east and west. To differentiate from the key trench the sections were labeled DE and DW. There were 88 panels on the East side and 46 panels on the west. Quality control standards were kept the same for the above ground liner install. **see attached Documentation*

All panels were compiled in our QC records with the corresponding roll numbers, roll identification tags had been torn off or the PVC pipe that the rolls came on had been cracked. We used many of the rolls with missing tags for sacrificial panels, although some were used in full panel sections which had gained SRK's approval. We tried to source the missing tags to narrow down the possible rolls but were unable to as the shipping information was unavailable to us.
see attached QC paperwork

Blomberg Building Group would like to thank all people and parties involved as team cohesion was paramount to the project's success. Nuna West was involved in every step of the installation as they consistently provided us with skilled and safe operators who were able to help with deployment in the most adverse conditions. During installation SRK worked with us through inspections, approvals and corrective measures as they arose. The ability to make decisions in the field and work around the obscure nature of the arctic was of the utmost help.

Attachments:

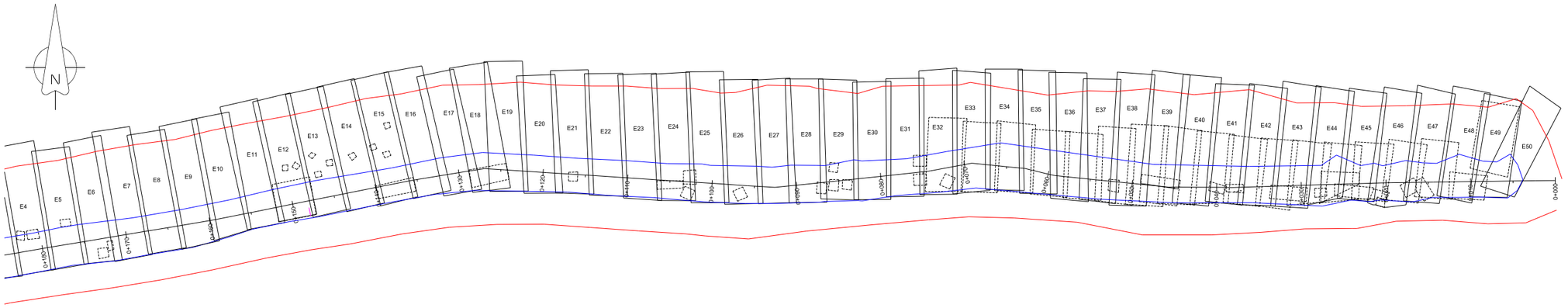
A: As-Built GCL Panel Layout
- A.1: Key Trench Panels
- A.2: Above Ground Panels

B: QC Sign-Off Deployment of GCL Panels in the Key Trench
- B.1: Key Trench Panels
- B.2: Above Ground Panels

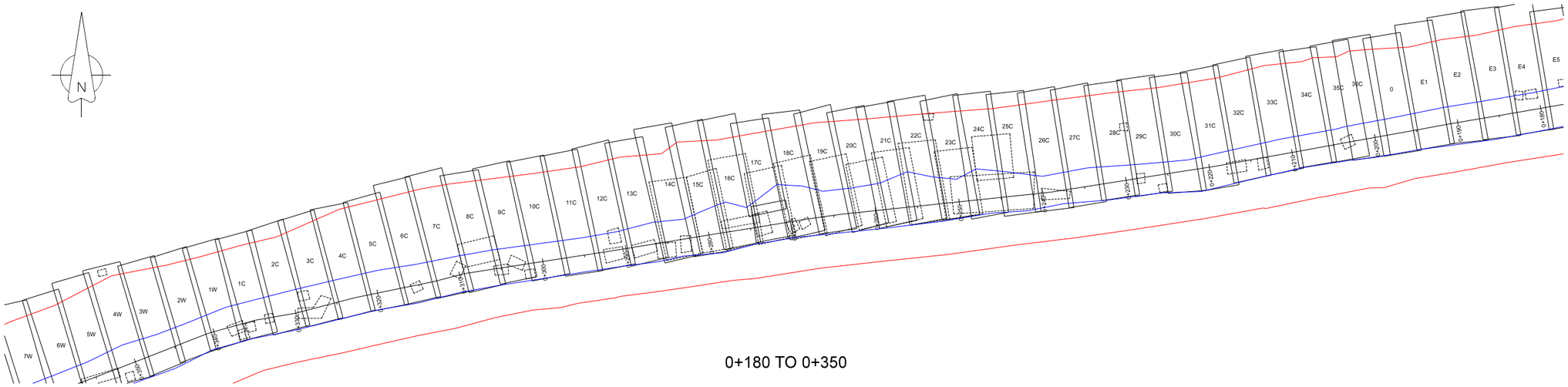
C: QC Sign-Off GCL Delivery Inspection

D: QC Sign-Off Earthworks Inspection

Attachment A.1: Key Trench Liner As-Built Layout



0+000 TO 0+180



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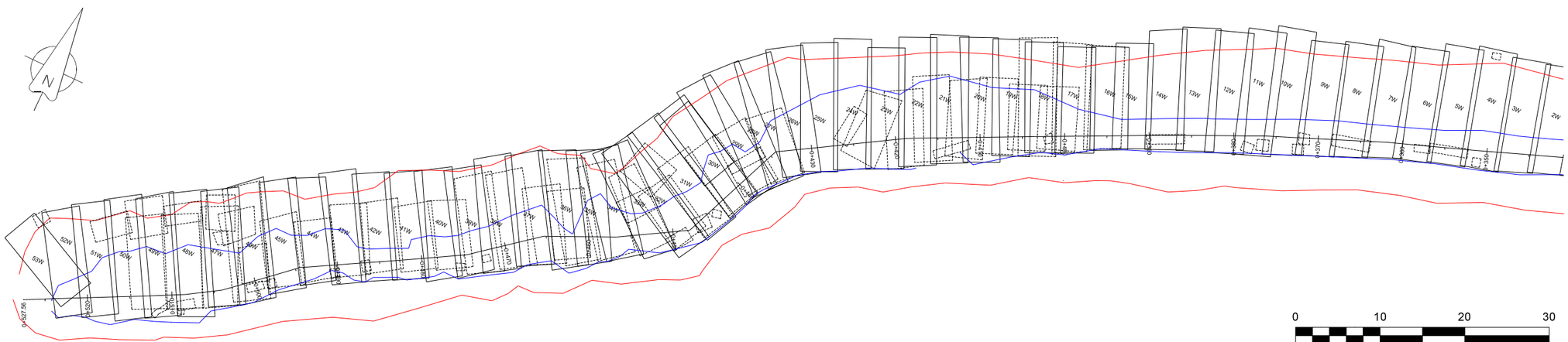

0+350 TO 0+527

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DATE DRAWN: MAY 07, 2018		SURVEYED:			
FILE NAME: LNR AB R0.dwg				SUB-ARCTIC GEOMATICS JOB NO.:	80003

NOTES:
ALL UNITS IN METRES U.N.O.

150 TOTAL PANELS.
DATE STARTED: APRIL 02, 2018
DATE COMPLETE: MAY 07, 2018

Sub-Arctic Geomatics Ltd.
a CHALLENGER GEOMATICS LTD. company

BOX 2441 YELLOWKNIFE
NORTHWEST TERRITORIES
X1A 2P8
PHONE: 867-873-2047 FAX: 867-873-9079
WEB: WWW.SUB-ARCTIC.CA
EMAIL: SAG@SUB-ARCTIC.CA

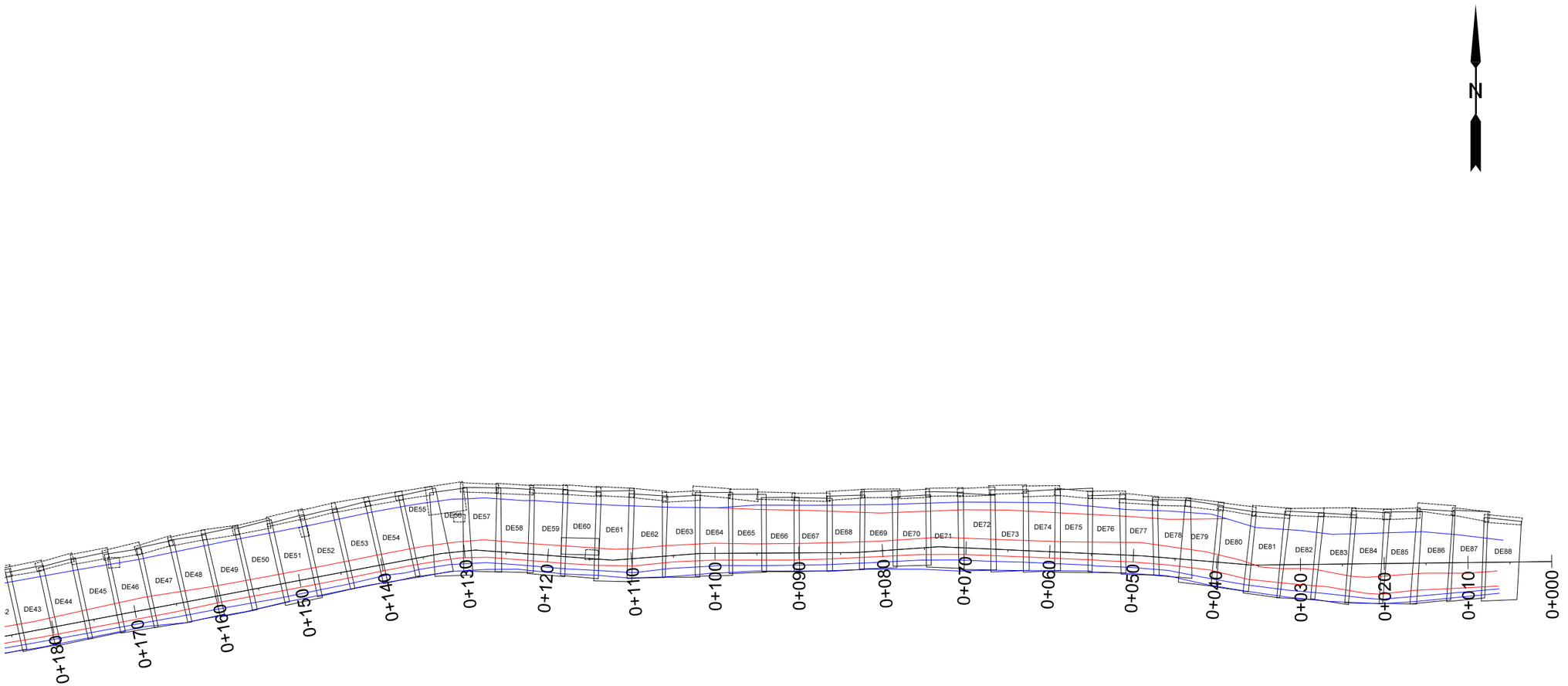
TMAC RESOURCES
HOPE BAY PROJECT

SOUTH DAM

KEY TRENCH
LINER AS-BUILT

DRAWING NO.	SHEET	REVISION NO.
KT LINER AB	1 OF 1	0

Attachment A.2: Above Ground Liner As-Built Layout



NOTES:
ALL UNITS IN METRES U.N.O.

PANELS LAID TODAY:

LINEAR METRES TODAY:

LINEAR METRES TOTAL:

DATA FILE(S):			REV	DESCRIPTION
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DRAWN BY: GL	CHECKED BY: GL	SURVEYED BY:GC		
DATE DRAWN: JUNE 26, 2018		SURVEYED: JUNE 25, 2018		
FILE NAME: 0626-US LINER AB.dwg				SUB-ARCTIC GEOMATICS JOB NO.: 80003

Sub-Arctic Geomatics Ltd.
a CHALLENGER GEOMATICS LTD. company

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NORTHWEST TERRITORIES
X1A 2P8
PHONE: 867-873-2047 FAX: 867-873-9079
WEB: WWW.SUB-ARCTIC.CA
EMAIL: SAG@SUB-ARCTIC.CA

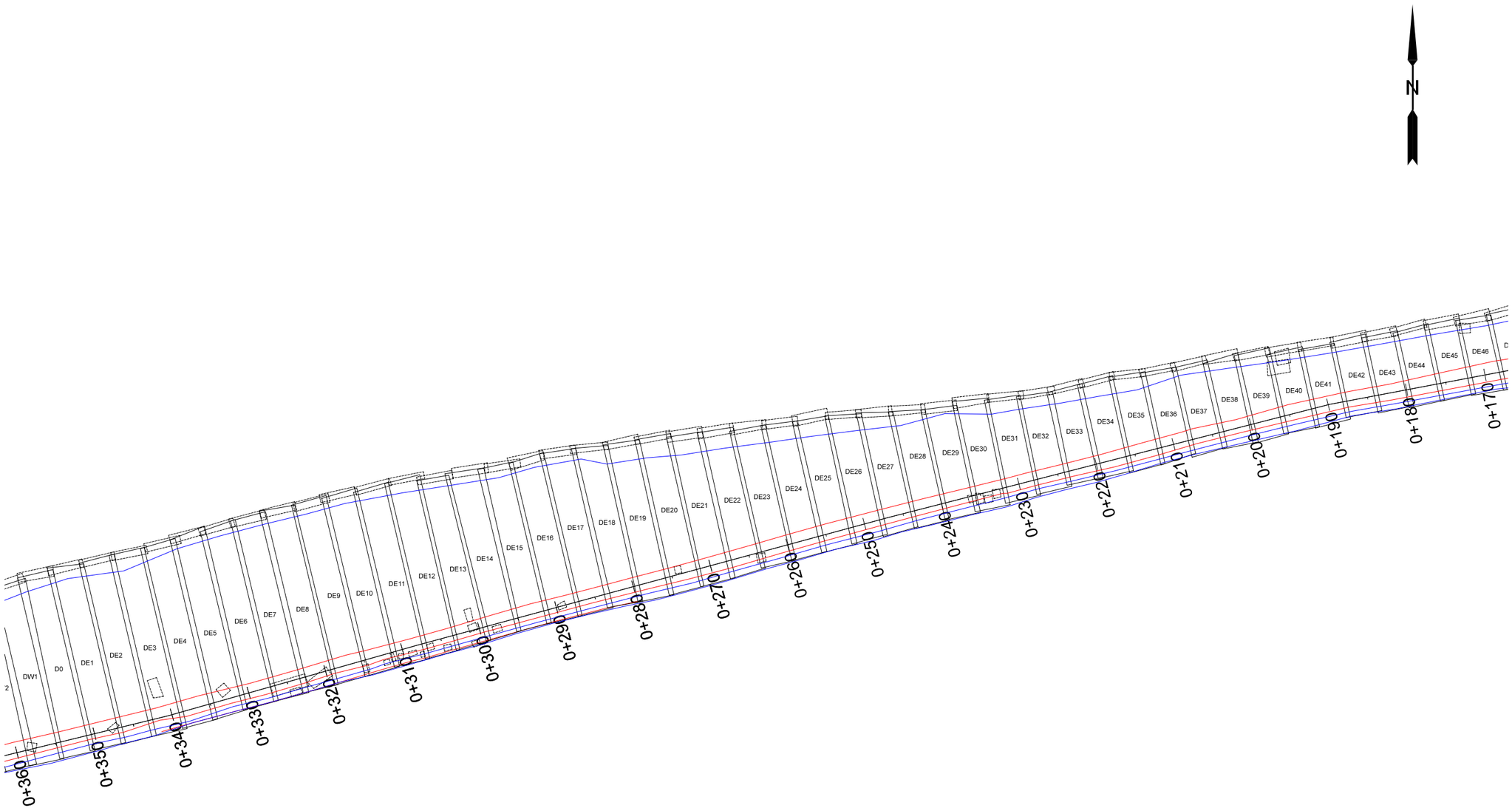
TMAC RESOURCES

HOPE BAY PROJECT

SOUTH DAM

UPSTREAM
LINER AS-BUILT

DRAWING NO.	SHEET	REVISION NO.
0626- US LINER AB	1 OF 2	0



NOTES:
ALL UNITS IN METRES U.N.O.

PANELS LAID TODAY:

LINEAR METRES TODAY:

LINEAR METRES TOTAL:

DATA FILE(S):		REV	DESCRIPTION
		0	

DRAWN BY: GL	CHECKED BY: GL	SURVEYED BY:GC	
DATE DRAWN: JUNE 26 2018		SURVEYED: JUNE 25, 2018	
FILE NAME: 0626-US LINER AB.dwg		SUB-ARCTIC GEOMATICS JOB NO.:	80003

Sub-Arctic Geomatics Ltd.
a CHALLENGER GEOMATICS LTD. company

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NORTHWEST TERRITORIES
X1A 2P8
PHONE: 867-873-2047 FAX: 867-873-9079
WEB: WWW.SUB-ARCTIC.CA
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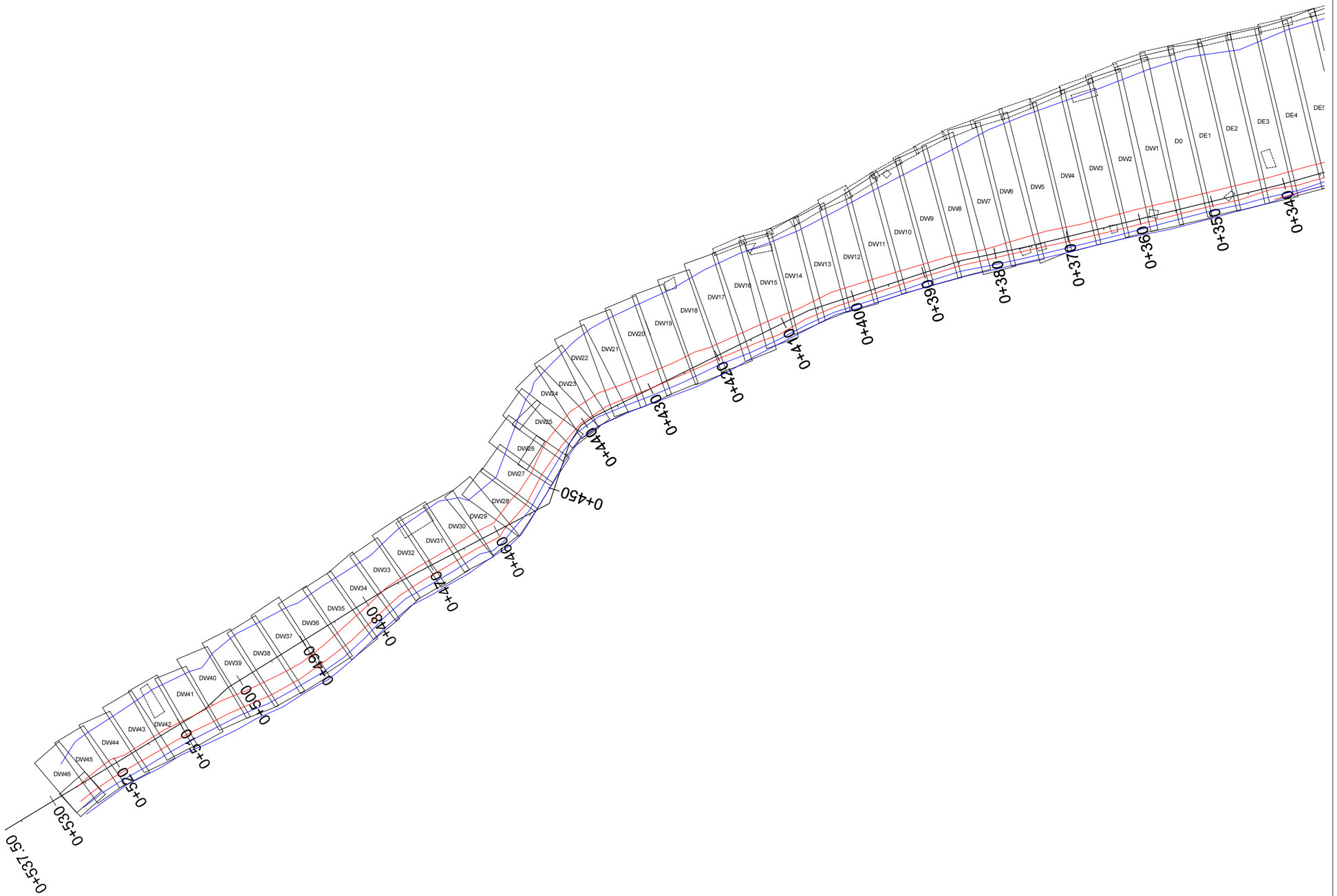
TMAC RESOURCES

HOPE BAY PROJECT

SOUTH DAM

UPSTREAM
LINER AS-BUILT

DRAWING NO.	SHEET	REVISION NO.
0626- US LINER AB	2 OF 3	0



NOTES:
ALL UNITS IN METRES U.N.O.

PANELS LAID TODAY:

LINEAR METRES TODAY:

LINEAR METRES TOTAL:

DATA FILE(S):			REV	DESCRIPTION
			0	
DRAWN BY: GL	CHECKED BY: GL	SURVEYED BY:GC		
DATE DRAWN: JUNE 26 2018		SURVEYED: JUNE 25, 2018		
FILE NAME: 0626-US LINER AB.dwg				SUB-ARCTIC GEOMATICS JOB NO.: 80003

Sub-Arctic Geomatics Ltd.
a CHALLENGER GEOMATICS LTD. company

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NORTHWEST TERRITORIES
X1A 2P8
PHONE: 867-873-2047 FAX: 867-873-9079
WEB: WWW.SUB-ARCTIC.CA
EMAIL: SAG@SUB-ARCTIC.CA

TMAC RESOURCES

HOPE BAY PROJECT

SOUTH DAM

UPSTREAM
LINER AS-BUILT

DRAWING NO.	SHEET	REVISION NO.
0626- US LINER AB	3 OF 3	0

Attachment B.1: QC Sign-Off Deployment of GCL Panels in the Key Trench

Deployment of GCL Rolls

Date	Pannel No.	Roll No. (Cetco)	Photos	Min overlap	Approval (BBG/SRK)
April 2nd, 2018	0	535	Y	530	See Field Document
April 2nd, 2018	1E	535	Y	530	Y
April 2nd, 2018	2E	535	Y	510	Y
April 2nd, 2018	3E	563	Y	550	Y
April 3rd, 2018	4E	563	Y	550	Y
April 3rd, 2018	5E	563	Y	550	Y
April 3rd, 2018	6E	561	Y	550	Y
April 3rd, 2018	7E	561	Y	550	Y
April 3rd, 2018	8E	561	Y	800	Y
April 4th, 2018	9E	9	Y	540	Y
April 4th, 2018	10E	9	Y	540	Y
April 4th, 2018	11E	9	Y	550	Y
April 5th, 2018	12E	Illegable	Y	550	Y
April 5th, 2018	13E	Illegable	Y	550	Y
April 5th, 2018	14E	Illegable	Y	550	Y
April 5th, 2018	15E	Illegable	Y	540	Y
April 5th, 2018	16E	Illegable	Y	540	Y
April 5th, 2018	17E	Illegable	Y	600	Y
April 6th, 2018	18E	35	Y	540	Y
April 6th, 2018	19E	35	Y	540	Y
April 6th, 2018	20E	35	Y	540	Y
April 6th, 2018	21E	14	Y	540	Y
April 6th, 2018	22E	14	Y	540	Y
April 6th, 2018	23E	14	Y	540	Y
April 6th, 2018	28E	529	Y	540	Y
April 7th, 2018	1C	529	Y	540	Y
April 7th, 2018	2C	529	Y	540	Y
April 7th, 2018	3C	224	Y	540	Y
April 7th, 2018	4C	224	Y	540	Y
April 7th, 2018	5C	224	Y	510	Y
April 7th, 2018	6C	29	Y	530	Y
April 7th, 2018	7C	29	Y	550	Y
April 7th, 2018	8C	29	Y	550	Y
April 9th, 2018	9C	27	Y	550	Y
April 9th, 2018	10C	27	Y	520	Y
April 9th, 2018	11C	27	Y	520	Y
April 11th, 2018	12C	34	Y	550	Y
April 11th, 2018	13C	34	Y	500	Y
April 11th, 2018	14C	34	Y	700	Y
April 12th, 2018	15C	527	Y	700	Y
April 12th, 2018	16C	527	Y	700	Y
April 12th, 2018	17C	527	Y	710	Y

Blomberg Building Group

April 13th, 2018	18C	53	Y	660	Y
April 13th, 2018	19C	53	Y	740	Y
April 13th, 2018	20C	53	Y	680	Y
April 13th, 2018	21C	51	Y	950	Y
April 14th, 2018	22C	48	Y	700	Y
April 14th, 2018	23C	33	Y	800	Y
April 14th, 2018	24C	33	Y	550	Y
April 14th, 2018	25C	33	Y	550	Y
April 14th, 2018	26C	30	Y	550	Y
April 14th, 2018	27C	30	Y	550	Y
April 14th, 2018	28C	30	Y	550	Y
April 15th, 2018	29C	23	Y	550	Y
April 15th, 2018	30C	23	Y	550	Y
April 15th, 2018	31C	23	Y	550	Y
April 15th, 2018	32C	24	Y	550	Y
April 15th, 2018	33C	24	Y	530	Y
April 15th, 2018	34C	24	Y	540	Y
April 15th, 2018	35C	21	Y	550	Y
April 15th, 2018	36C	21	Y	1880	Y
April 16th, 2018	25E	21	Y	550	Y
April 16th, 2018	26E	524	Y	550	Y
April 16th, 2018	27E	524	Y	550	Y
April 16th, 2018	28E	524	Y	550	Y
April 16th, 2018	29E	20	Y	550	Y
April 16th, 2018	30E	20	Y	550	Y
April 17th, 2018	31E	Illegable	Y	550	Y
April 17th, 2018	32E	59	Y	550	Y
April 17th, 2018	33E	59	Y	550	Y
April 17th, 2018	34E	59	Y	550	Y
April 18th, 2018	35E	81	Y	540	Y
April 18th, 2018	36E	81	Y	540	Y
April 20th, 2018	37E	81	Y	560	Y
April 20th, 2018	38E	26	Y	530	Y
April 20th, 2018	39E	26	Y	570	Y
April 21st, 2018	40E	26	Y	560	Y
April 21st, 2018	41E	25	Y	600	Y
April 21st, 2018	42E	25	Y	570	Y
April 21st, 2018	1W	25	Y	600	Y
April 21st, 2018	2W	31	Y	570	Y
April 21st, 2018	3W	31	Y	550	Y
April 22nd, 2018	4W	31	Y	550	Y
April 22nd, 2018	5W	Illegable	Y	570	Y
April 22nd, 2018	6W	Illegable	Y	560	Y
April 22nd, 2018	7W	Illegable	Y	550	Y
April 22nd, 2018	8W	79	Y	550	Y
April 22nd, 2018	9W	79	Y	550	Y
April 22nd, 2018	10W	79	Y	550	Y

Blomberg Building Group

April 24th, 2018	43E	22	Y	550	Y
April 24th, 2018	44E	22	Y	550	Y
April 24th, 2018	45E	22	Y	550	Y
April 24th, 2018	46E	536	Y	550	Y
April 24th, 2018	47E	536	Y	550	Y
April 24th, 2018	48E	536	Y	550	Y
April 25th, 2018	49E	Illegable	Y	550	Y
April 25th, 2018	50E	Illegable	Y	550	Y
April 26th, 2018	11W	17	Y	550	Y
April 26th, 2018	12W	17	Y	550	Y
April 26th, 2018	13W	17	Y	550	Y
April 26th, 2018	14W	32	Y	550	Y
April 26th, 2018	15W	32	Y	550	Y
April 27th, 2018	16W-1	73	Y	550	Y
April 27th, 2018	16W-2	65	Y	550	Y
April 28th, 2018	17W-1	73	Y	550	Y
April 28th, 2018	17W-2	73	Y	550	Y
April 28th, 2018	18W-1	65	Y	550	Y
April 28th, 2018	18W-2	65	Y	550	Y
April 28th, 2018	19W	76	Y	550	Y
April 28th, 2018	20W	76	Y	550	Y
April 28th, 2018	21W	76	Y	550	Y
April 29th, 2018	22W	58	Y	550	Y
April 29th, 2018	23W	58	Y	550	Y
April 29th, 2018	24W	58	Y	550	Y
April 29th, 2018	25W	52	Y	550	Y
April 30th, 2018	26W	52	Y	550	Y
April 30th, 2018	27W	55	Y	550	Y
April 30th, 2018	28W	55	Y	550	Y
April 30th, 2018	29W	55	Y	550	Y
May 1st, 2018	30W	49	Y	550	Y
May 1st, 2018	31W	49	Y	550	Y
May 1st, 2018	32W	49	Y	550	Y
May 2nd, 2018	33W	521	Y	550	Y
May 2nd, 2018	34W	521	Y	550	Y
May 2nd, 2018	35W	521	Y	550	Y
May 2nd, 2018	36W	50	Y	550	Y
May 2nd, 2018	37W	50	Y	550	Y
May 2nd, 2018	38W	50	Y	550	Y
May 3rd, 2018	39W	56	Y	550	Y
May 3rd, 2018	40W	56	Y	550	Y
May 3rd, 2018	41W	56	Y	550	Y
May 4th, 2018	42W	Illegable	Y	550	
May 4th, 2018	43W	77	Y	550	
May 4th, 2018	44W	77	Y	550	
May 4th, 2018	45W	77	Y	550	
May 5th, 2018	46W	66	Y	550	

Blomberg Building Group

May 5th, 2018	47W	66	Y	550	
May 6th, 2018	48W	60	Y	550	
May 6th, 2018	49W	72	Y	550	
May 7th, 2018	50W	75	Y	550	
May 7th, 2018	51W	75	Y	550	
May 7th, 2018	52W	75	Y	550	
May 7th, 2018	53W	84	Y	550	

Attachment B.2: QC Sign-Off Deployment of Above Ground GCL Panels

Deployment of GCL Rolls

See scanned copy

Date	Panel No.	Roll No.	Photos	Min overlap	Approval (BBG/SRK)
03/06/2018	D0	115	Y	NA	Y
03/06/2018	DW1	117	Y	550	Y
03/06/2018	DW2	526	Y	525	Y
04/06/2018	DW3	113	Y	500	Y
04/06/2018	DW4	118	Y	500	Y
04/06/2018	DW5	118	Y	550	Y
04/06/2018	DW6	520	Y	530	Y
04/06/2018	DW7	520	Y	550	Y
04/06/2018	DW8	113	Y	550	Y
04/06/2018	DW9	115	Y	550	Y
05/06/2018	DW10	110	Y	550	Y
05/06/2018	DW11	110	Y	550	Y
05/06/2018	DW12	5	Y	550	Y
05/06/2018	DW13	5	Y	550	Y
05/06/2018	DW14	526	Y	570	Y
05/06/2018	DE1	4	Y	550	Y
05/06/2018	DE2	7	Y	540	Y
05/06/2018	DE3	84	Y	550	Y
05/06/2018	DE4	83	Y	550	Y
05/06/2018	DE5	1	Y	550	Y
05/06/2018	DE6	114	Y	550	Y
05/06/2018	DE7	16	Y	550	Y
05/06/2018	DE8	NA	Y	530	Y
05/06/2018	DE9	8	Y	500	Y
08/06/2018	DE10	6	Y	520	Y
08/06/2018	DE11	74	Y	530	Y
08/06/2018	DE12	67	Y	510	Y
08/06/2018	DE13	532	Y	550	Y
08/06/2018	DE14	531	Y	550	Y
08/06/2018	DE15	2	Y	550	Y
09/06/2018	DE16	15	Y	500	Y
09/06/2018	DE17	3	Y	500	Y
09/06/2018	DE18	3	Y	500	Y
09/06/2018	DE19	2	Y	550	Y
09/06/2018	DE20	15	Y	530	Y
09/06/2018	DE21	74	Y	550	Y
09/06/2018	DE22	117	Y	550	Y
10/06/2018	DE23	4	Y	500	Y
10/06/2018	DE24	7	Y	550	Y
10/06/2018	DE25	83	Y	500	Y
10/06/2018	DE26	1	Y	500	Y
10/06/2018	DE27	531	Y	550	Y

10/06/2018	DE28	67	Y	550	Y
10/06/2018	DE29	8	Y	550	Y
13/06/2018	DE30	522	Y	550	Y
13/06/2018	DE31	522	Y	500	Y
13/06/2018	DE32	522	Y	550	Y
13/06/2018	DE33	97	Y	500	Y
13/06/2018	DE34	97	Y	500	Y
13/06/2018	DE35	97	Y	550	Y
13/06/2018	DE36	114	Y	550	Y
13/06/2018	DE37	111	Y	500	Y
15/06/2018	DE38	111	Y	550	Y
15/06/2018	DE39	111	Y	500	Y
15/06/2018	DE40	111	Y	500	Y
15/06/2018	DE41	119	Y	550	Y
15/06/2018	DE42	119	Y	550	Y
15/06/2018	DE43	119	Y	550	Y
15/06/2018	DE44	119	Y	550	Y
15/06/2018	DE45	6	Y	500	Y
16/06/2018	DE46	6	Y	550	Y
16/06/2018	DE47	NA	Y	500	Y
16/06/2018	DE48	16	Y	500	Y
16/06/2018	DE49	16	Y	550	Y
16/06/2018	DE50	NA	Y	500	Y
16/06/2018	DE51	NA	Y	500	Y
16/06/2018	DE52	518	Y	550	Y
16/06/2018	DE53	518	Y	550	Y
16/06/2018	DE54	518	Y	550	Y
16/06/2018	DE55	518	Y	550	Y
16/06/2018	DE56	NA	Y	500	Y
16/06/2018	DE57	NA	Y	550	Y
16/06/2018	DE58	NA	Y	500	Y
16/06/2018	DE59	NA	Y	500	Y
18/06/2018	DE60	119	Y	550	Y
18/06/2018	DE61	119	Y	500	Y
18/06/2018	DE62	119	Y	500	Y
18/06/2018	DE63	119	Y	550	Y
20/06/2018	DE64	NA	Y	550	Y
20/06/2018	DE65	NA	Y	550	Y
20/06/2018	DE66	37	Y	550	Y
20/06/2018	DE67	37	Y	500	Y
20/06/2018	DE68	37	Y	550	Y
20/06/2018	DE69	37	Y	500	Y
20/06/2018	DE70	37	Y	500	Y
20/06/2018	DE71	66	Y	550	Y
20/06/2018	DE72	42	Y	500	Y
20/06/2018	DE73	42	Y	500	Y
20/06/2018	DE74	42	Y	550	Y

21/06/2018	DE75	NA	Y	550	Y
21/06/2018	DE76	38	Y	550	Y
21/06/2018	DE77	38	Y	550	Y
21/06/2018	DE78	38	Y	500	Y
21/06/2018	DE79	38	Y	550	Y
21/06/2018	DE80	120	Y	500	Y
21/06/2018	DE81	120	Y	500	Y
21/06/2018	DE82	120	Y	550	Y
23/06/2018	DE83	120	Y	500	Y
23/06/2018	DE84	NA	Y	500	Y
23/06/2018	DE85	NA	Y	550	Y
23/06/2018	DE86	NA	Y	550	Y
23/06/2018	DE87	NA	Y	550	Y
23/06/2018	DE88	NA	Y	550	Y
25/06/2018	DW15	NA	Y	500	Y
25/06/2018	DW16	NA	Y	550	Y
25/06/2018	DW17	NA	Y	500	Y
25/06/2018	DW18	562	Y	500	Y
25/06/2018	DW19	562	Y	550	Y
25/06/2018	DW20	562	Y	500	Y
25/06/2018	DW21	116	Y	500	Y
25/06/2018	DW22	116	Y	550	Y
25/06/2018	DW23	116	Y	550	Y
25/06/2018	DW24	81	Y	550	Y
25/06/2018	DW25	38	Y	550	Y
25/06/2018	DW26	1	Y	500	Y
25/06/2018	DW27	1	Y	550	Y
25/06/2018	DW28	1	Y	500	Y
25/06/2018	DW29	NA	Y	500	Y
25/06/2018	DW30	NA	Y	500	Y
25/06/2018	DW31	10	Y	500	Y
25/06/2018	DW32	10	Y	500	Y
25/06/2018	DW33	10	Y	500	Y
25/06/2018	DW34	10	Y	500	Y
25/06/2018	DW35	NA	Y	500	Y
25/06/2018	DW36	NA	Y	500	Y
25/06/2018	DW37	NA	Y	500	Y
25/06/2018	DW38	NA	Y	500	Y
25/06/2018	DW39	NA	Y	500	Y
25/06/2018	DW40	NA	Y	500	Y
25/06/2018	DW41	NA	Y	500	Y
25/06/2018	DW42	NA	Y	500	Y
25/06/2018	DW43	NA	Y	500	Y
25/06/2018	DW44	NA	Y	500	Y
25/06/2018	DW45	NA	Y	500	Y
25/06/2018	DW46	NA	Y	500	Y

Attachment C: QC Sign-Off GCL Delivery Inspection

GCL Delivery Inspection

Date of Delivery	*Manufacturer*	*Roll No.*	*Lot No.*	*Inspection pass (Y/N)*	*Notes*
April 2nd, 2018	Cetco	563	LL-48-2017	Y	
April 2nd, 2018	Cetco	535	LL-42-2017	Y	
April 3rd, 2018	Cetco	561	LL-43-2017	Y	
April 4th, 2018	Cetco	9	LL-02-2018	Y	
April 5th, 2018	Cetco	Illegable	Illegable	N	
April 5th, 2018	Cetco	Illegable	Illegable	N	
April 6th, 2018	Cetco	35	LL-02-2018	Y	
April 6th, 2018	Cetco	14	LL-02-2018	Y	
April 6th, 2018	Cetco	529	LL-42-2017	Y	
April 7th, 2018	Cetco	224	Illegable	N	
April 7th, 2018	Cetco	29	LL-02-2018	Y	
April 8th, 2018	Cetco	12	LL-02-2018	Y	
April 9th, 2018	Cetco	27	LL-02-2018	Y	
April 11th, 2018	Cetco	34	LL-02-2018	Y	
April 11th, 2018	Cetco	525	LL-42-2017	Y	Patch
April 12th, 2018	Cetco	527	LL-42-2017	Y	
April 13th, 2018	Cetco	51	LL-07-2018	Y	
April 13th, 2018	Cetco	36	LL-02-2018	Y	Patch
April 13th, 2018	Cetco	53	LL-07-2018	Y	
April 14th, 2018	Cetco	48	LL-07-2018	Y	Patch
April 14th, 2018	Cetco	33	LL-02-2018	Y	
April 14th, 2018	Cetco	30	LL-02-2018	Y	
April 15th, 2018	Cetco	23	LL-02-2018	Y	
April 15th, 2018	Cetco	24	LL-02-2018	Y	
April 15th, 2018	Cetco	21	LL-02-2018	Y	
April 16th, 2018	Cetco	524	LL-42-2018	Y	
April 16th, 2018	Cetco	20	LL-02-2018	Y	
April 17th, 2018	Cetco	Illegable	LL-07-2018	Y	
April 17th, 2018	Cetco	59	LL-07-2018	Y	
April 18th, 2018	Cetco	81	LL-08-2018	Y	
April 20th, 2018	Cetco	26	LL-02-2018	Y	
April 20th, 2018	Cetco	Illegable	Illegable	Y	Patch
April 21st, 2018	Cetco	25	LL-02-2018	Y	
April 21st, 2018	Cetco	31	LL-42-2018	Y	
April 21st, 2018	Cetco	456	LL-35-2017	Y	
April 22nd, 2018	Cetco	79	LL-08-2018	y	
April 22nd, 2018	Cetco	Illegable	Illegable	Y	
April 24th, 2018	Cetco	22	LL-02-2018	y	
April 24th, 2018	Cetco	536	LL-42-2017	y	
April 25th, 2018	Cetco	Illegable	LL-08-2018	y	
April 26th, 2018	Cetco	17	LL-02-2018	y	
April 26th, 2018	Cetco	32	LL-02-2018	y	

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April 27th, 2018	Cetco	65	LL-08-2018	y	
April 27th, 2018	Cetco	73	LL-08-2018	y	
April 28th, 2018	Cetco	76	LL-08-2018	y	
April 29th, 2018	Cetco	58	LL-07-2018	y	
April 30th, 2018	Cetco	52	LL-07-2018	Y	
April 30th, 2018	Cetco	55	LL-07-2018	Y	
May 1st, 2018	Cetco	49	LL-07-2018	Y	
May 2nd, 2018	Cetco	521	LL-42-2017	Y	
May 2nd, 2018	Cetco	50	LL-07-2018	Y	
May 3rd, 2018	Cetco	56	LL-07-2018	Y	
May 4th, 2018	Cetco	Illegable	Illegable	Y	
May 4th, 2018	Cetco	77	LL-08-2018	Y	
May 5th, 2018	Cetco	66	LL-08-2018	Y	
May 6th, 2018	Cetco	72	LL-08-2018	Y	
May 6th, 2018	Cetco	60	LL-07-2018	Y	
May 7th, 2018	Cetco	75	LL-08-2018	Y	
May 7th, 2018	Cetco	84	LL-08-2018	Y	

Attachment D: QC Sign-Off Earthworks Inspection

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Earthwork Inspection

See Asbuild for Accureate panel locations

Date	Area	Sections	Photos	Engineers Approval	BBG Approval
April 2nd, 2018	0	1+00 - 2+00	Y	See Hardcopy	See Hardcopy
April 2nd, 2018	1E	1+00 - 2+00	Y	Y	Y
April 2nd, 2018	2E	1+00 - 2+00	Y	Y	Y
April 2nd, 2018	3E	1+00 - 2+00	Y	Y	Y
April 3rd, 2018	4E	1+00 - 2+00	Y	Y	Y
April 3rd, 2018	5E	1+00 - 2+00	Y	Y	Y
April 3rd, 2018	6E	1+00 - 2+00	Y	Y	Y
April 3rd, 2018	7E	1+00 - 2+00	Y	Y	Y
April 3rd, 2018	8E	1+00 - 2+00	Y	Y	Y
April 4th, 2018	9E	1+00 - 2+00	Y	Y	Y
April 4th, 2018	10E	1+00 - 2+00	Y	Y	Y
April 4th, 2018	11E	1+00 - 2+00	Y	Y	Y
April 5th, 2018	12E	1+00 - 2+00	Y	Y	Y
April 5th, 2018	13E	1+00 - 2+00	Y	Y	Y
April 5th, 2018	14E	1+00 - 2+00	Y	Y	Y
April 5th, 2018	15E	1+00 - 2+00	Y	Y	Y
April 5th, 2018	16E	1+00 - 2+00	Y	Y	Y
April 5th, 2018	17E	1+00 - 2+00	Y	Y	Y
April 6th, 2018	18E	1+00 - 2+00	Y	Y	Y
April 6th, 2018	19E	1+00 - 2+00	Y	Y	Y
April 6th, 2018	20E	1+00 - 2+00	Y	Y	Y
April 6th, 2018	21E	1+00 - 2+00	Y	Y	Y
April 6th, 2018	22E	1+00 - 2+00	Y	Y	Y
April 6th, 2018	23E	1+00 - 2+00	Y	Y	Y
April 6th, 2018	24E	1+00 - 2+00	Y	Y	Y
April 7th, 2018	1C	3+40 - 2+00	Y	Y	Y
April 7th, 2018	2C	3+40 - 2+00	Y	Y	Y
April 7th, 2018	3C	3+40 - 2+00	Y	Y	Y
April 7th, 2018	4C	3+40 - 2+00	Y	Y	Y
April 7th, 2018	5C	3+40 - 2+00	Y	Y	Y
April 7th, 2018	6C	3+40 - 2+00	Y	Y	Y
April 7th, 2018	7C	3+40 - 2+00	Y	Y	Y
April 7th, 2018	8C	3+40 - 2+00	Y	Y	Y
April 9th, 2018	9C	3+40 - 2+00	Y	Y	Y
April 9th, 2018	10C	3+40 - 2+00	Y	Y	Y
April 9th, 2018	11C	3+40 - 2+00	Y	Y	Y
April 11th, 2018	12C	3+40 - 2+00	Y	Y	Y
April 11th, 2018	13C	3+40 - 2+00	Y	Y	Y
April 11th, 2018	14C	3+40 - 2+00	Y	Y	Y
April 12th, 2018	15C	3+40 - 2+00	Y	Y	Y
April 12th, 2018	16C	3+40 - 2+00	Y	Y	Y
April 12th, 2018	17C	3+40 - 2+00	Y	Y	Y

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April 13th, 2018	18C	3+40 - 2+00	Y	Y	Y
April 13th, 2018	19C	3+40 - 2+00	Y	Y	Y
Date	Area	Sections	Photos	Engineers Approval	BBG Approval
April 13th, 2018	20C	3+40 - 2+00	Y	Y	Y
April 13th, 2018	21C	3+40 - 2+00	Y	Y	Y
April 14th, 2018	22C	3+40 - 2+00	Y	Y	Y
April 14th, 2018	23C	3+40 - 2+00	Y	Y	Y
April 14th, 2018	24C	3+40 - 2+00	Y	Y	Y
April 14th, 2018	25C	3+40 - 2+00	Y	Y	Y
April 14th, 2018	26C	3+40 - 2+00	Y	Y	Y
April 14th, 2018	27C	3+40 - 2+00	Y	Y	Y
April 14th, 2018	28C	3+40 - 2+00	Y	Y	Y
April 15th, 2018	29C	3+40 - 2+00	Y	Y	Y
April 15th, 2018	30C	3+40 - 2+00	Y	Y	Y
April 15th, 2018	31C	3+40 - 2+00	Y	Y	Y
April 15th, 2018	32C	3+40 - 2+00	Y	Y	Y
April 15th, 2018	33C	3+40 - 2+00	Y	Y	Y
April 15th, 2018	34C	3+40 - 2+00	Y	Y	Y
April 15th, 2018	35C	3+40 - 2+00	Y	Y	Y
April 15th, 2018	36C	3+40 - 2+00	Y	Y	Y
April 16th, 2018	25E	0+00 - 1+00	Y	Y	Y
April 16th, 2018	26E	0+00 - 1+00	Y	Y	Y
April 16th, 2018	27E	0+00 - 1+00	Y	Y	Y
April 16th, 2018	28E	0+00 - 1+00	Y	Y	Y
April 16th, 2018	29E	0+00 - 1+00	Y	Y	Y
April 16th, 2018	30E	0+00 - 1+00	Y	Y	Y
April 17th, 2018	31E	0+00 - 1+00	Y	Y	Y
April 17th, 2018	32E	0+00 - 1+00	Y	Y	Y
April 17th, 2018	33E	0+00 - 1+00	Y	Y	Y
April 17th, 2018	34E	0+00 - 1+00	Y	Y	Y
April 18th, 2018	35E	0+00 - 1+00	Y	Y	Y
April 18th, 2018	36E	0+00 - 1+00	Y	Y	Y
April 20th, 2018	37E	0+00 - 1+00	Y	Y	Y
April 20th, 2018	38E	0+00 - 1+00	Y	Y	Y
April 20th, 2018	39E	0+00 - 1+00	Y	Y	Y
April 20th, 2018	40E	0+00 - 1+00	Y	Y	Y
April 21st, 2018	41E	0+00 - 1+00	Y	Y	Y
April 21st, 2018	42E	0+00 - 1+00	Y	Y	Y
April 21st, 2018	1W	3+40 - 3+80	Y	Y	Y
April 21st, 2018	2W	3+40 - 3+80	Y	Y	Y
April 21st, 2018	3W	3+40 - 3+80	Y	Y	Y
April 22nd, 2018	4W	3+40 - 3+80	Y	Y	Y
April 22nd, 2018	5W	3+40 - 3+80	Y	Y	Y
April 22nd, 2018	6W	3+40 - 3+80	Y	Y	Y
April 22nd, 2018	7W	3+40 - 3+80	Y	Y	Y
April 22nd, 2018	8W	3+40 - 3+80	Y	Y	Y
April 22nd, 2018	9W	3+40 - 3+80	Y	Y	Y

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April 22nd, 2018	10W	3+40 - 3+80	Y	Y	Y
April 23rd, 2018	43E	0+00 - 0+30	Y	Y	Y
April 23rd, 2018	44E	0+00 - 0+30	Y	Y	Y
April 23rd, 2018	45E	0+00 - 0+30	Y	Y	Y
April 23rd, 2018	46E	0+00 - 0+30	Y	Y	Y
April 24th, 2018	47E	0+00 - 0+30	Y	Y	Y
April 24th, 2018	48E	0+00 - 0+30	Y	Y	Y
April 25th, 2018	49E	0+00 - 0+30	Y	Y	Y
April 25th, 2018	50E	0+00 - 0+30	Y	Y	Y
April 26th, 2018	11W	3+80 -4+00	Y	Y	Y
April 26th, 2018	12W	3+80 -4+00	Y	Y	Y
April 26th, 2018	13W	3+80 -4+00	Y	Y	Y
April 26th, 2018	14W	3+80 -4+00	Y	Y	Y
April 26th, 2018	15W	3+80 -4+00	Y	Y	Y
April 27th, 2018	16W	4+00-4+20	Y	Y	Y
April 27th, 2018	17W	4+00-4+20	Y	Y	Y
April 27th, 2018	18W	4+00-4+20	Y	Y	Y
April 27th, 2018	19W	4+00-4+20	Y	Y	Y
April 27th, 2018	20W	4+00-4+20	Y	Y	Y
April 27th, 2018	21W	4+00-4+20	Y	Y	Y
April 29th, 2018	22W	4+15-4+30	Y	Y	Y
April 29th, 2018	23W	4+15-4+30	Y	Y	Y
April 29th, 2018	24W	4+15-4+30	Y	Y	Y
April 29th, 2018	25W	4+15-4+30	Y	Y	Y
April 30th, 2018	26W	4+30 - 4+80	Y	Y	Y
April 30th, 2018	27W	4+30 - 4+80	Y	Y	Y
April 30th, 2018	28W	4+30 - 4+80	Y	Y	Y
April 30th, 2018	29W	4+30 - 4+80	Y	Y	Y
May 1st, 2018	30W	4+30 - 4+80	Y	Y	Y
May 1st, 2018	31W	4+30 - 4+80	Y	Y	Y
May 1st, 2018	32W	4+30 - 4+80	Y	Y	Y
May 2nd, 2018	33W	4+30 - 4+80	Y	Y	Y
May 2nd, 2018	34W	4+30 - 4+80	Y	Y	Y
May 2nd, 2018	35W	4+30 - 4+80	Y	Y	Y
May 2nd, 2018	36W	4+30 - 4+80	Y	Y	Y
May 2nd, 2018	37W	4+30 - 4+80	Y	Y	Y
May 2nd, 2018	38W	4+30 - 4+80	Y	Y	Y
May 3rd, 2018	39W	4+30 - 4+80	Y	Y	Y
May 3rd, 2018	40W	4+30 - 4+80	Y	Y	Y
May 3rd, 2018	41W	4+30 - 4+80	Y	Y	Y
May 4th, 2018	42W	4+80 - 5+29	Y	Y	Y
May 4th, 2018	43W	4+80 - 5+29	Y	Y	Y
May 4th, 2018	44W	4+80 - 5+29	Y	Y	Y
May 4th, 2018	45W	4+80 - 5+29	Y	Y	Y
May 5th, 2018	46W	4+80 - 5+29	Y	Y	Y
May 5th, 2018	47W	4+80 - 5+29	Y	Y	Y
May 6th, 2018	48W	4+80 - 5+29	Y	Y	Y

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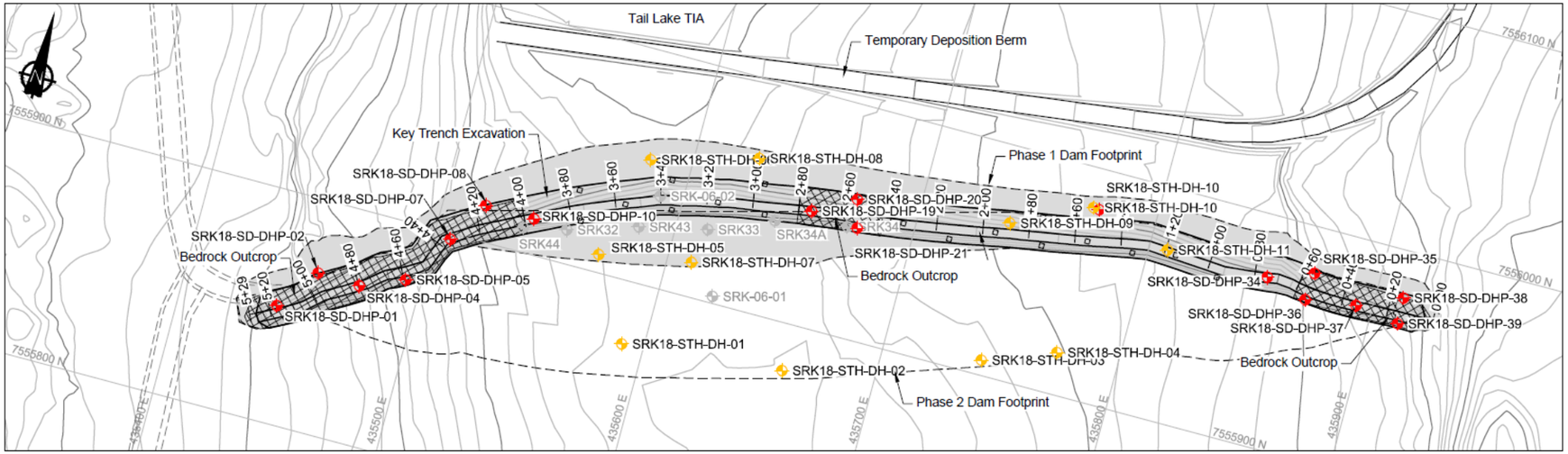
May 6th, 2018	49W	4+80 - 5+29	Y	Y	Y
May 6th, 2018	50W	4+80 - 5+29	Y	Y	Y
May 6th, 2018	51W	4+80 - 5+29	Y	Y	Y
May 6th, 2018	52W	4+80 - 5+29	Y	Y	Y
May 6th, 2018	53W	4+80 - 5+29	Y	Y	Y

Appendix J – Percolation Testing

Appendix J.1 – Percolation Testing Summary

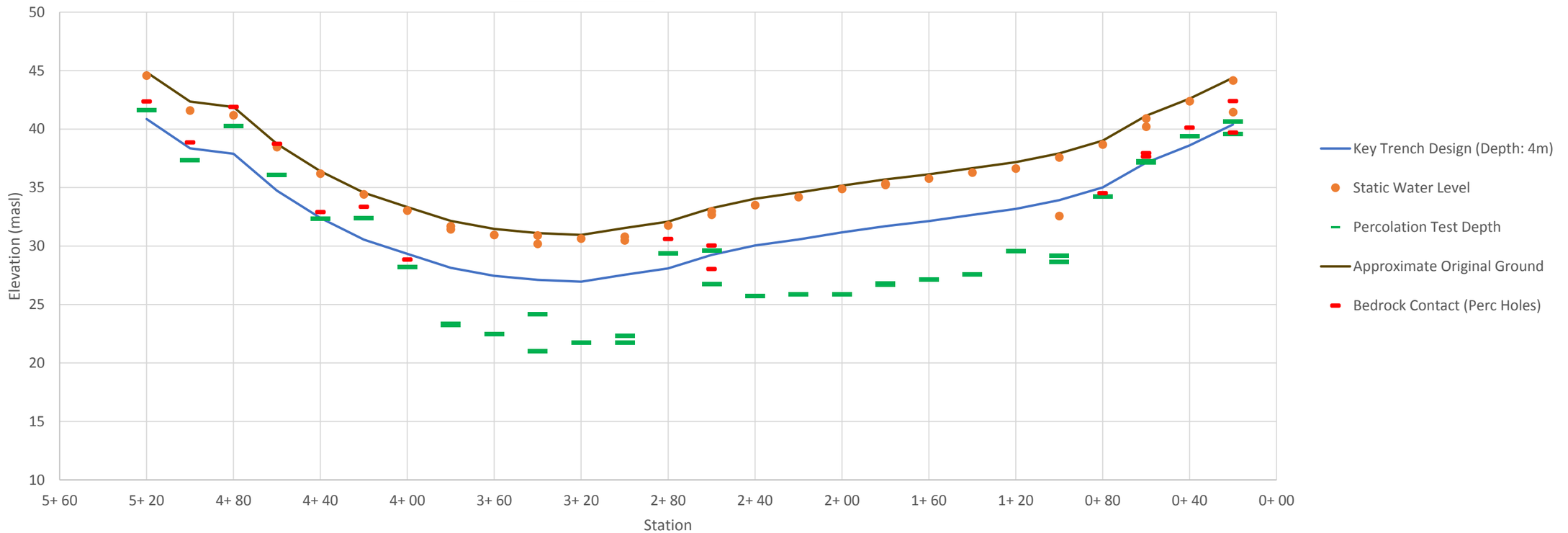


LEGEND

- Previous Investigation Hole Location
- 2018 Percolation Hole Location Intercepted Bedrock
- 2018 Percolation Hole Location Did Not Intercept Bedrock
- 2018 Borehole Location
- Trench Excavation
- Proposed Road / Dam Infrastructure
- Approximate Bedrock Outcrop Extent within Trench
- Trench Excavation Extent

Key Trench Plan View

0m 20 40 60 80



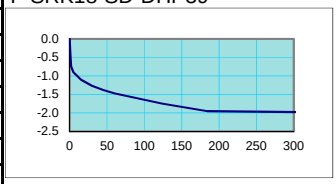
srk consulting	TMAC RESOURCES	Phase 1 South Dam As-Built Report
		Percolation Testing Summary
Job No: 1CT022.031 Filename: Figures_AppendixG.pptx	TMAC Resources Inc.	Date: December 2018 / Approved: KRC / Figure G1

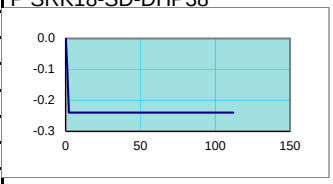
Percolation Test Summary: January 2018

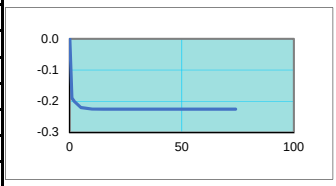
Phase 1 South Dam

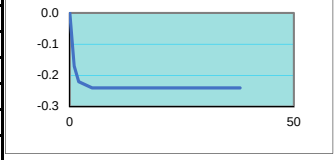
Percolation Hole ID	Approximate Station	Key Trench Design Depth	Base of Key Trench Elevation	Northing	Easting	Sub-Arctic Survey DTM	Percolation Test Depth from OG (Survey)	Percolation Well Base Elevation	Water Level Drop from OG (Survey)	Static Water Level
		(m)	(masl)	m	m	masl	m	masl	m	masl
SRK18-SD-DHP1	5+ 20	4	40.9	7555850	435442.1	44.9	3.25	41.6	-0.29	44.6
SRK18-SD-DHP2	5+ 00	4	38.3	7555869	435455.7	42.3	5	37.3	-0.76	41.6
SRK18-SD-DHP4	4+ 80	4	37.9	7555868	435474.3	41.9	1.65	40.2	-0.72	41.2
SRK18-SD-DHP5	4+ 60	4	34.7	7555876	435493.1	38.7	2.65	36.1	-0.27	38.5
SRK18-SD-DHP7	4+ 40	4	32.4	7555898	435507.2	36.4	4.05	32.3	-0.2	36.2
SRK18-SD-DHP8	4+ 20	4	30.6	7555916	435518.2	34.6	2.15	32.4	-0.14	34.4
SRK18-SD-DHP10	4+ 00	4	29.3	7555915	435539.9	33.3	5.1	28.2	-0.3	33.0
SRK18-SD-DHP11	3+ 80	4	28.0	7555932	435555.8	32.0	8.7	23.3	-0.62	31.4
SRK18-SD-DHP12	3+ 80	4	28.1	7555920	435559.7	32.1	8.9	23.2	-0.46	31.7
SRK18-SD-DHP13	3+ 60	4	27.5	7555932	435576.5	31.5	9	22.5	-0.52	30.9
SRK18-SD-DHP14	3+ 40	4	26.8	7555947	435593.3	30.8	6.6	24.2	-0.62	30.2
SRK18-SD-DHP15	3+ 40	4	27.1	7555935	435596.4	31.1	10.1	21.0	-0.2	30.9
SRK18-SD-DHP16	3+ 20	4	26.9	7555943	435614.9	30.9	9.2	21.7	-0.32	30.6
SRK18-SD-DHP17	3+ 00	4	27.5	7555956	435632.5	31.5	9.2	22.3	-0.75	30.8
SRK18-SD-DHP18	3+ 00	4	27.4	7555943	435635.7	31.4	9.65	21.7	-0.9	30.5
SRK18-SD-DHP19	2+ 80	4	28.1	7555950	435654.9	32.1	2.7	29.4	-0.34	31.7
SRK18-SD-DHP20	2+ 60	4	29.0	7555960	435672.7	33.0	6.3	26.7	-0.35	32.7
SRK18-SD-DHP21	2+ 60	4	29.2	7555948	435675.9	33.2	3.6	29.6	-0.27	33.0
SRK18-SD-DHP22	2+ 40	4	30.0	7555955	435694.7	34.0	8.3	25.7	-0.56	33.5
SRK18-SD-DHP24	2+ 20	4	30.6	7555953	435715.5	34.6	8.7	25.9	-0.39	34.2
SRK18-SD-DHP25	2+ 00	4	31.2	7555961	435734.1	35.2	9.3	25.9	-0.28	34.9
SRK18-SD-DHP26	1+ 80	4	31.7	7555973	435752.3	35.7	8.9	26.8	-0.37	35.3
SRK18-SD-DHP27	1+ 80	4	31.7	7555961	435754.9	35.7	9	26.7	-0.46	35.2
SRK18-SD-DHP28	1+ 60	4	32.1	7555968	435773.5	36.1	9	27.1	-0.38	35.8
SRK18-SD-DHP30	1+ 40	4	32.7	7555968	435793.6	36.7	9.1	27.6	-0.38	36.3
SRK18-SD-DHP31	1+ 20	4	33.2	7555972	435812	37.2	7.6	29.6	-0.56	36.6
SRK18-SD-DHP32	1+ 00	4	33.9	7555979	435832.5	37.9	9.3	28.6	-0.36	37.6
SRK18-SD-DHP33	1+ 00	4	33.9	7555967	435831.6	37.9	8.7	29.2	-5.3	32.6
SRK18-SD-DHP34	0+ 80	4	35.0	7555973	435852.6	39.0	4.8	34.2	-0.34	38.7
SRK18-SD-DHP35	0+ 60	4	37.1	7555980	435871.9	41.1	3.9	37.2	-0.24	40.9
SRK18-SD-DHP36	0+ 60	4	36.4	7555968	435870.9	40.4	3.30	37.1	-0.24	40.2
SRK18-SD-DHP37	0+ 40	4	38.6	7555971	435892.9	42.6	3.20	39.4	-0.225	42.4
SRK18-SD-DHP38	0+ 20	4	40.4	7555980	435911.9	44.4	3.75	40.6	-0.24	44.1
SRK18-SD-DHP39	0+ 20	4	39.7	7555968	435912.3	43.7	4.10	39.6	-2.25	41.4

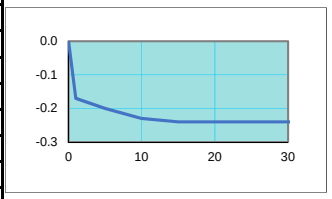
Borehole ID	Northing (m)	Easting (m)	Ground Elev. (m)	Date of Reading	Time of Reading	Elapsed Time (min)	Water Drop (m)	Graph
SRK18-SD-DHP39	7,555,968.3	435,912.3	43.696	25-Jan-18	13:41	0	0.000	P SRK18-SD-DHP39
				25-Jan-18	13:42	1	-0.450	
				25-Jan-18	13:43	2	-0.750	
				25-Jan-18	13:46	5	-0.900	
				25-Jan-18	13:51	10	-1.000	
				25-Jan-18	13:56	15	-1.100	
				25-Jan-18	14:11	30	-1.270	
				25-Jan-18	14:26	45	-1.380	
				25-Jan-18	14:41	60	-1.470	
				25-Jan-18	15:45	124	-1.750	
				25-Jan-18	16:45	184	-1.950	
				26-Jan-18	16:30	1609	-2.250	
				27-Jan-18	17:30	3109	ice	
SRK18-SD-DHP38	7,555,979.7	435,911.9	44.385	25-Jan-18	14:58	0	0.000	P SRK18-SD-DHP38
				25-Jan-18	14:59	1	-0.100	
				25-Jan-18	15:00	2	-0.240	
				25-Jan-18	15:03	5	-0.240	
				25-Jan-18	15:08	10	-0.240	
				25-Jan-18	15:13	15	-0.240	
				25-Jan-18	15:28	30	-0.240	
				25-Jan-18	15:43	45	-0.240	
				25-Jan-18	15:58	60	-0.240	
				25-Jan-18	16:50	112	-0.240	
				26-Jan-18	16:30	1532	ice	
SRK18-SD-DHP37	7,555,971.2	435,892.862	42.607	27-Jan-18	16:31	0	0.000	P SRK18-SD-DHP37
				27-Jan-18	16:32	1	-0.190	
				27-Jan-18	16:33	2	-0.200	
				27-Jan-18	16:36	5	-0.220	
				27-Jan-18	16:41	10	-0.225	
				27-Jan-18	16:46	15	-0.225	
				27-Jan-18	17:01	30	-0.225	
				27-Jan-18	17:16	45	-0.225	
				27-Jan-18	17:30	59	-0.225	
				27-Jan-18	17:45	74	-0.225	
				28-Jan-18	12:30	1199	ice	
SRK18-SD-DHP36	7,555,968.0	435,870.9	40.4	28-Jan-18	17:06	0	0.000	P SRK18-SD-DHP36
				28-Jan-18	17:07	1	-0.170	
				28-Jan-18	17:08	2	-0.220	
				28-Jan-18	17:11	5	-0.240	
				28-Jan-18	17:16	10	-0.240	
				28-Jan-18	17:21	15	-0.240	
				28-Jan-18	17:44	38	-0.240	
				29-Jan-18	12:30	1164	ice	
SRK18-SD-DHP35	7,555,980.0	435,871.9	41.1	29-Jan-18	12:06	0	0.000	P SRK18-SD-DHP35
				29-Jan-18	12:07	1	-0.170	
				29-Jan-18	12:11	5	-0.200	
				29-Jan-18	12:16	10	-0.230	
				29-Jan-18	12:21	15	-0.240	
				29-Jan-18	12:36	30	-0.240	
				29-Jan-18	12:51	45	-0.240	
				29-Jan-18	15:05	179	-0.240	
				29-Jan-18	17:00	294	-0.240	
				30-Jan-18	8:30	1224	ice	





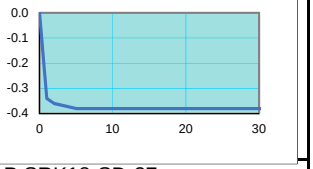


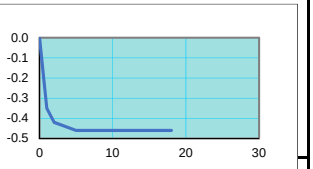


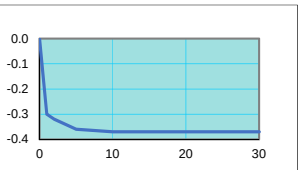


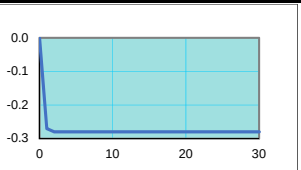
Borehole ID	Northing (m)	Easting (m)	Ground Elev. (m)	Date of Reading	Time of Reading	Elapsed Time (min)	Water Drop (m)	Graph
SRK18-SD-DHP34	7,555,973.1	435,852.6	39.0	29-Jan-18	12:45	0	0.000	P SRK18-SD-DHP34
				29-Jan-18	12:46	1	-0.310	
				29-Jan-18	12:47	2	-0.330	
				29-Jan-18	12:50	5	-0.340	
				29-Jan-18	12:55	10	-0.340	
				29-Jan-18	13:00	15	-0.340	
				30-Jan-18	8:30	1185	ice	
SRK18-SD-DHP33	7,555,967.4	435,831.6	37.9	29-Jan-18	13:11	0	0.000	P SRK18-SD-DHP33
				29-Jan-18	13:13	2	-1.400	
				29-Jan-18	13:16	5	-2.350	
				29-Jan-18	13:21	10	-3.200	
				29-Jan-18	13:26	15	-3.700	
				29-Jan-18	13:41	30	-4.500	
				29-Jan-18	13:56	45	-5.050	
				29-Jan-18	14:11	60	-5.250	
				29-Jan-18	15:04	113	-5.300	
				29-Jan-18	16:50	219	-5.300	
				30-Jan-18	8:30	1159	ice	
SRK18-SD-32	7,555,979.1	435,832.5	37.9	29-Jan-18	14:20	0	0.000	P SRK18-SD-32
				29-Jan-18	14:21	1	-0.320	
				29-Jan-18	14:22	2	-0.330	
				29-Jan-18	14:25	5	-0.340	
				29-Jan-18	14:30	10	-0.360	
				29-Jan-18	14:36	16	-0.360	
				29-Jan-18	14:55	35	-0.360	
				29-Jan-18	16:50	150	-0.360	
				30-Jan-18	8:30	1090	ice	
SRK18-SD-31	7,555,972.2	435,812.0	37.2	29-Jan-18	14:49	0	0.000	P SRK18-SD-31
				29-Jan-18	14:50	1	-0.450	
				29-Jan-18	14:51	2	-0.540	
				29-Jan-18	14:54	5	-0.550	
				29-Jan-18	14:59	10	-0.560	
				30-Jan-18	8:30	1061	ice	
SRK18-SD-30	7,555,968.1	435,793.6	36.7	29-Jan-18	17:16	0	0.000	P SRK18-SD-30
				29-Jan-18	17:17	1	-0.320	
				29-Jan-18	17:18	2	-0.360	
				29-Jan-18	17:21	5	-0.380	
				29-Jan-18	17:26	10	-0.380	
				29-Jan-18	17:31	15	-0.380	
				29-Jan-18	17:46	30	-0.380	
				29-Jan-18	18:15	59	-0.380	
				30-Jan-18	8:30	914	ice	

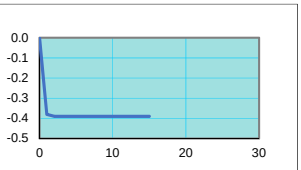
Borehole ID	Northing (m)	Easting (m)	Ground Elev. (m)	Date of Reading	Time of Reading	Elapsed Time (min)	Water Drop (m)	Graph
SRK18-SD-28	7,555,968.0	435,773.5	36.1	29-Jan-18	17:41	0	0.000	P SRK18-SD-28
				29-Jan-18	17:42	1	-0.340	
				29-Jan-18	17:43	2	-0.360	
				29-Jan-18	17:46	5	-0.380	
				29-Jan-18	17:55	14	-0.380	
				29-Jan-18	18:15	34	-0.380	
				30-Jan-18	8:30	889	ice	
SRK18-SD-27	7,555,961.0	435,754.9	35.7	29-Jan-18	18:04	0	0.000	P SRK18-SD-27
				29-Jan-18	18:05	1	-0.350	
				29-Jan-18	18:06	2	-0.420	
				29-Jan-18	18:09	5	-0.460	
				29-Jan-18	18:16	12	-0.460	
				29-Jan-18	18:22	18	-0.460	
				30-Jan-18	8:30	866	ice	
SRK18-SD-26	7,555,973.1	435,752.3	35.7	30-Jan-18	8:55	0	0.000	P SRK18-SD-26
				30-Jan-18	8:56	1	-0.300	
				30-Jan-18	8:57	2	-0.320	
				30-Jan-18	9:00	5	-0.360	
				30-Jan-18	9:05	10	-0.370	
				30-Jan-18	9:10	15	-0.370	
				30-Jan-18	9:25	30	-0.370	
				31-Jan-18	9:56	1501	ice	
SRK18-SD-25	7,555,961.4	435,734.1	35.2	30-Jan-18	9:41	0	0.000	P SRK18-SD-25
				30-Jan-18	9:42	1	-0.270	
				30-Jan-18	9:43	2	-0.280	
				30-Jan-18	9:46	5	-0.280	
				30-Jan-18	9:51	10	-0.280	
				30-Jan-18	9:56	15	-0.280	
				30-Jan-18	10:11	30	-0.280	
				31-Jan-18	9:52	1451	ice	
SRK18-SD-24	7,555,953.5	435,715.5	34.6	30-Jan-18	10:03	0	0.000	P SRK18-SD-24
				30-Jan-18	10:04	1	-0.380	
				30-Jan-18	10:05	2	-0.390	
				30-Jan-18	10:08	5	-0.390	
				30-Jan-18	10:13	10	-0.390	
				30-Jan-18	10:18	15	-0.390	
				31-Jan-18	9:51	1428	ice	



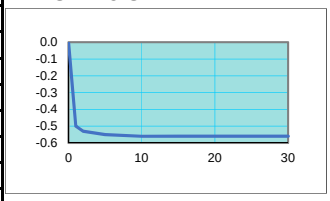


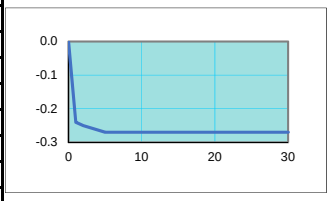


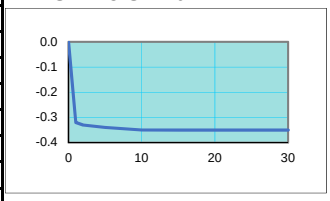


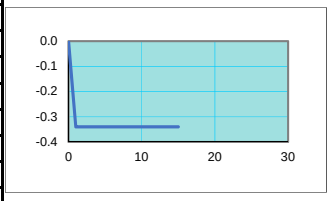


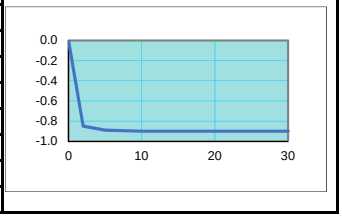
Borehole ID	Northing (m)	Easting (m)	Ground Elev. (m)	Date of Reading	Time of Reading	Elapsed Time (min)	Water Drop (m)	Graph
SRK18-SD-22	7,555,954.9	435,694.7	34.0	30-Jan-18	10:23	0	0.000	P SRK18-SD-22
				30-Jan-18	10:24	1	-0.500	
				30-Jan-18	10:25	2	-0.530	
				30-Jan-18	10:28	5	-0.550	
				30-Jan-18	10:33	10	-0.560	
				30-Jan-18	10:38	15	-0.560	
				30-Jan-18	10:53	30	-0.560	
				31-Jan-18	9:49	1406	ice	
SRK18-SD-21	7,555,947.7	435,675.9	33.2	30-Jan-18	10:46	0	0.000	P SRK18-SD-21
				30-Jan-18	10:47	1	-0.240	
				30-Jan-18	10:48	2	-0.250	
				30-Jan-18	10:51	5	-0.270	
				30-Jan-18	10:56	10	-0.270	
				30-Jan-18	11:01	15	-0.270	
				30-Jan-18	11:16	30	-0.270	
				31-Jan-18	9:47	1381	ice	
SRK18-SD-20	7,555,959.7	435,672.7	33.0	30-Jan-18	12:51	0	0.000	P SRK18-SD-20
				30-Jan-18	12:52	1	-0.320	
				30-Jan-18	12:53	2	-0.330	
				30-Jan-18	12:56	5	-0.340	
				30-Jan-18	13:01	10	-0.350	
				30-Jan-18	13:06	15	-0.350	
				30-Jan-18	13:21	30	-0.350	
				31-Jan-18	9:47	1256	ice	
SRK18-SD-19	7,555,949.7	435,654.9	32.1	30-Jan-18	13:15	0	0.000	P SRK18-SD-19
				30-Jan-18	13:16	1	-0.340	
				30-Jan-18	13:17	2	-0.340	
				30-Jan-18	13:20	5	-0.340	
				30-Jan-18	13:25	10	-0.340	
				30-Jan-18	13:30	15	-0.340	
				31-Jan-18	9:45	1230	ice	
SRK18-SD-18	7,555,943.0	435,635.7	31.4	30-Jan-18	13:35	0	0.000	P SRK18-SD-18
				30-Jan-18	13:37	2	-0.850	
				30-Jan-18	13:40	5	-0.890	
				30-Jan-18	13:45	10	-0.900	
				30-Jan-18	13:50	15	-0.900	
				30-Jan-18	14:05	30	-0.900	
				31-Jan-18	9:41	1206	ice	





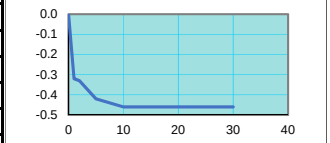


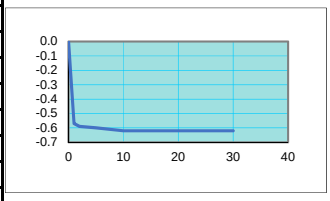


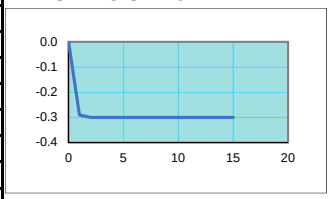


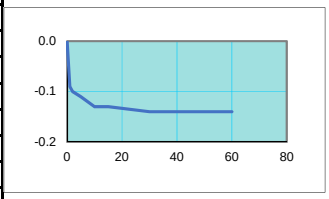
Borehole ID	Northing (m)	Easting (m)	Ground Elev. (m)	Date of Reading	Time of Reading	Elapsed Time (min)	Water Drop (m)	Graph
SRK18-SD-17	7,555,955.9	435,632.5	31.5	30-Jan-18	13:58	0	0.000	P SRK18-SD-17
				30-Jan-18	13:59	1	-0.740	
				30-Jan-18	14:00	2	-0.750	
				30-Jan-18	14:03	5	-0.750	
				30-Jan-18	14:08	10	-0.750	
				30-Jan-18	14:13	15	-0.750	
				31-Jan-18	9:40	1182	ice	
SRK18-SD-16	7,555,942.9	435,614.9	30.9	30-Jan-18	14:32	0	0.000	P SRK18-SD-16
				30-Jan-18	14:33	1	-0.300	
				30-Jan-18	14:34	2	-0.310	
				30-Jan-18	14:37	5	-0.320	
				30-Jan-18	14:42	10	-0.320	
				30-Jan-18	14:47	15	-0.320	
				30-Jan-18	15:02	30	-0.320	
				31-Jan-18	9:40	1148	ice	
SRK18-SD-15	7,555,934.6	435,596.4	31.1	30-Jan-18	16:08	0	0.000	P SRK18-SD-15
				30-Jan-18	16:09	1	-0.180	
				30-Jan-18	16:10	2	-0.190	
				30-Jan-18	16:13	5	-0.200	
				30-Jan-18	16:18	10	-0.200	
				30-Jan-18	16:23	15	-0.200	
				30-Jan-18	16:38	30	-0.200	
				31-Jan-18	9:37	1049	ice	
SRK18-SD-14	7,555,947.1	435,593.3	30.8	30-Jan-18	16:25	0	0.000	P SRK18-SD-14
				30-Jan-18	16:26	1	-0.330	
				30-Jan-18	16:27	2	-0.360	
				30-Jan-18	16:30	5	-0.420	
				30-Jan-18	16:35	10	-0.470	
				30-Jan-18	16:40	15	-0.490	
				30-Jan-18	16:55	30	0.500	
				30-Jan-18	17:10	45	-0.540	
				30-Jan-18	17:25	60	-0.600	
				31-Jan-18	9:32	1027	-0.600	
				31-Jan-18	9:33	1028	ice	
SRK18-SD-13	7,555,931.8	435,576.5	31.5	31-Jan-18	14:46	0	0.000	P SRK18-SD-13
				31-Jan-18	14:47	1	-0.490	
				31-Jan-18	14:48	2	-0.500	
				31-Jan-18	14:51	5	-0.520	
				31-Jan-18	14:56	10	-0.520	
				31-Jan-18	15:01	15	-0.520	
				31-Jan-18	15:16	30	-0.520	
				1-Feb-18	9:00	1094	ice	

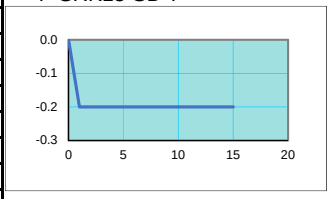
Borehole ID	Northing (m)	Easting (m)	Ground Elev. (m)	Date of Reading	Time of Reading	Elapsed Time (min)	Water Drop (m)	Graph
SRK18-SD-12	7,555,919.7	435,559.7	32.1	31-Jan-18	15:06	0	0.000	P SRK18-SD-12
				31-Jan-18	15:07	1	-0.320	
				31-Jan-18	15:08	2	-0.330	
				31-Jan-18	15:11	5	-0.420	
				31-Jan-18	15:16	10	-0.460	
				31-Jan-18	15:21	15	-0.460	
				31-Jan-18	15:36	30	-0.460	
				1-Feb-18	9:05	1079	ice	
SRK18-SD-11	7,555,932.5	435,555.8	32.0	31-Jan-18	15:26	0	0.000	P SRK18-SD-11
				31-Jan-18	15:27	1	-0.570	
				31-Jan-18	15:28	2	-0.590	
				31-Jan-18	15:31	5	-0.600	
				31-Jan-18	15:36	10	-0.620	
				31-Jan-18	15:41	15	-0.620	
				31-Jan-18	15:56	30	-0.620	
				1-Feb-18	9:03	1057	ice	
SRK18-SD-10	7,555,915.4	435,539.9	33.3	31-Jan-18	15:59	0	0.000	P SRK18-SD-10
				31-Jan-18	16:00	1	-0.290	
				31-Jan-18	16:01	2	-0.300	
				31-Jan-18	16:04	5	-0.300	
				31-Jan-18	16:09	10	-0.300	
				31-Jan-18	16:14	15	-0.300	
				1-Feb-18	9:10	1031	ice	
SRK18-SD-8	7,555,915.7	435,518.2	34.6	31-Jan-18	16:23	0	0.000	P SRK18-SD-8
				31-Jan-18	16:24	1	-0.090	
				31-Jan-18	16:25	2	-0.100	
				31-Jan-18	16:28	5	-0.110	
				31-Jan-18	16:33	10	-0.130	
				31-Jan-18	16:38	15	-0.130	
				31-Jan-18	16:53	30	-0.140	
				31-Jan-18	17:23	60	-0.140	
				1-Feb-18	9:20	1017	ice	
SRK18-SD-7	7,555,897.5	435,507.2	36.4	31-Jan-18	16:41	0	0.000	P SRK18-SD-7
				31-Jan-18	16:42	1	-0.200	
				31-Jan-18	16:43	2	-0.200	
				31-Jan-18	16:46	5	-0.200	
				31-Jan-18	16:51	10	-0.200	
				31-Jan-18	16:56	15	-0.200	
				1-Feb-18	9:15	994	ice	



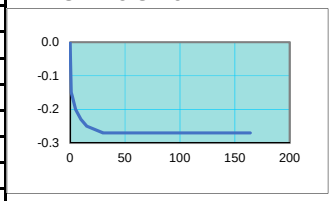


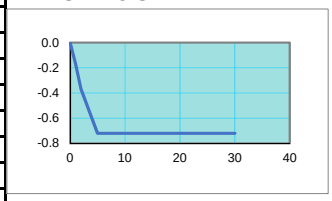


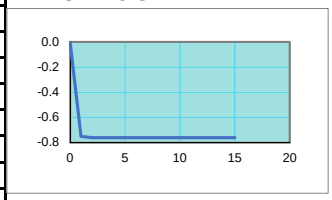


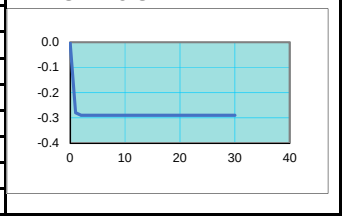


Borehole ID	Northing (m)	Easting (m)	Ground Elev. (m)	Date of Reading	Time of Reading	Elapsed Time (min)	Water Drop (m)	Graph
SRK18-SD-5	7,555,875.6	435,493.1	38.7	1-Feb-18	9:46	0	0.000	P SRK18-SD-5
				1-Feb-18	9:47	1	-0.150	
				1-Feb-18	9:48	2	-0.160	
				1-Feb-18	9:51	5	-0.200	
				1-Feb-18	9:56	10	-0.230	
				1-Feb-18	10:01	15	-0.250	
				1-Feb-18	10:16	30	-0.270	
				1-Feb-18	10:46	60	-0.270	
				1-Feb-18	12:30	164	-0.270	
				2-Feb-18	11:30	1544	ice	
SRK18-SD-4	7,555,867.9	435,474.3	41.9	1-Feb-18	10:22	0	0.000	P SRK18-SD-4
				1-Feb-18	10:23	1	-0.170	
				1-Feb-18	10:24	2	-0.370	
				1-Feb-18	10:27	5	-0.720	
				1-Feb-18	10:32	10	-0.720	
				1-Feb-18	10:37	15	-0.720	
				1-Feb-18	10:52	30	-0.720	
				2-Feb-18	11:30	1508	ice	
SRK18-SD-2	7,555,868.7	435,455.7	42.3	1-Feb-18	10:40	0	0.000	P SRK18-SD-2
				1-Feb-18	10:41	1	-0.750	
				1-Feb-18	10:42	2	-0.760	
				1-Feb-18	10:45	5	-0.760	
				1-Feb-18	10:50	10	-0.760	
				1-Feb-18	10:55	15	-0.760	
				2-Feb-18	11:30	1490	ice	
SRK18-SD-1	7,555,850.4	435,442.1	44.9	1-Feb-18	12:45	0	0.000	P SRK18-SD-1
				1-Feb-18	12:46	1	-0.280	
				1-Feb-18	12:47	2	-0.290	
				1-Feb-18	12:50	5	-0.290	
				1-Feb-18	12:55	10	-0.290	
				1-Feb-18	13:00	15	-0.290	
				1-Feb-18	13:15	30	-0.290	
				2-Feb-18	11:30	1365	ice	









Appendix J.2 – Percolation Sample Descriptions and Moisture Content

Moisture Content Determination and Sample Description

Date Sampled: January 24, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-1	P1.01	0	0.5	Silt, trace to some sand. Poorly graded. Organics present. Medium brown.	46.1	
	P1.02	0.5	1	SAND and SILT, trace clay, trace gravel. Brown.	61.6	
	P1.03	1	1.5	SAND and SILT, trace clay, trace gravel. Brown.	64.1	
	P1.04	1.5	2	SILT, trace clay, sand, gravel, grey	143.7	0.80
	P1.05	2	2.5	Silt and clay, trace sand, trace gravel. High visible ice content. Greyey brown soil component of sample.	98.4	
	P1.06	2.5	3	Bedrock Chips	13.6	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 24, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-2	P2.01	0	0.5	Silty peat moss type soil. Some visible ice present. Organics present. Dark brown.	214.3	
	P2.02	0.5	1	Silt, trace sand, trace organics. High content of visible ice. Soil fraction of sample is dark grey.	179.5	
	P2.03	1	1.5	SAND and SILT, some clay, trace clay. Brownish grey.	50.1	
	P2.04	1.5	2	Silt, sandy, trace clay. Poorly graded. Visible ice present. Light brown.	68.4	
	P2.05	2	2.5	SILT, some sand, trace clay, gravel, greyish brown	55.2	0.80
	P2.06	2.5	3	Silt, sandy, trace clay. Poorly graded. Some visible ice present. Light brown.	57.1	
	P2.07	3	3.5	SAND, some gravel, trace silt and clay. Brown and red.	18.5	
	P2.08	3.5	4	Bedrock chips	6.3	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 24, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-4	P4.01	0	0.5	Bedrock chips.	12.0	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 24, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-5	P5.01	0	0.5	Sand and bedrock chips.	13.7	
	P5.02	0.5	1	Bedrock cuttings. Gravel with sand, well graded. Grey.	5.8	
	P5.03	1	1.5	Bedrock chips.	13.3	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 24, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-7	P7.01	0	0.5	SAND with silt, little gravel. Poorly graded. Sporadic ice fragemtns and organics + rootlets noted. Dark brown.	30.9	
	P7.03	1	1.5	SAND, some silt, trace clay, trace grave. Brownish grey.	63.9	
	P7.04	1.5	2	Sand and silt. Poorly graded. Light grey brown	142.9	
	P7.05	2	2.5	CLAY, silty, some sand,trace gravel, greyish brown	57.0	4.40
	P7.06	2.5	3	Sand, silty. Poorly graded. Light grey brown	53.2	
	P7.07	3	3.5	SAND, silty, trace to some clay. Brown.	36.1	
	P7.08	3.5	4	Bedrock chips.	5.2	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 24, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-8	P8.01	0	0.5	Silt and clay, trace sand, some organics. Some visible ice present. Medium greyey brown.	105.5	
	P8.02	0.5	1	SAND and SILT, trace clay, trace gravel. Roots in sample. Brownish grey.	81.4	
	P8.03	1	1.5	Bedrock chips.	31.9	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 24, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-10	P10.01	0	0.5	Silt, trace sand, some organics. Poorly graded. Medium brown.	41.8	
	P10.02	0.5	1	SAND, silty, trace gravel, trace clay. Greyish brown.	84.8	
	P10.03	1	1.5	Silt and clay, trace sand. High content of visible ice. Soil fraction of sample is greyey brown.	151.2	
	P10.04	1.5	2	SAND, trace gravel, trace silt, trace clay. Grey. Visible ice in sample.	160.0	
	P10.05	2	2.5	Silt and clay, trace sand. Very high content of visible ice. Sample dominated by ice. Soil fraction of sample is greyey brown.	365.0	
	P10.06	2.5	3	SILT, sandy, trace clay, trace gravel. Grey.	250.7	
	P10.07	3	3.5	Silt and clay, trace coarse grained sand. Poorly graded. Light grey (when dry).	83.0	
	P10.08	3.5	4	CLAY, silty, sandy, trace gravel, grey	39.9	3.10
	P10.09	4	5	Silt, sandy. Some visible ice present. Greyey brown.	60.3	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 25, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-11	P11.01	0	0.5	Silt and clay, trace sand, trace orgaincs. Dark brown.	34.6	
	P11.02	0.5	1	Silt and clay, trace sand. Very high content of visible ice present. Soil fraction of sample is greyey brown.	266.7	
	P11.03	1	1.5	SAND and SILT, trace gravel, trace clay. Grey.	306.2	
	P11.04	1.5	2	Silt and clay. Visible ice content present. Soil fraction of sample greyey brown.	89.4	
	P11.05	2	2.5	SAND and SILT, trace gravel, trace clay. Grey.	116.3	
	P11.06	2.5	3	Silt and fine-grained sand. Poorly graded. Light greyey brown.	92.8	
	P11.07	3	3.5	Silt and clay, trace sand. Some visible ice present. Greyey brown.	51.5	
	P11.08	3.5	4	CLAY, silty, trace sand, grey	38.9	2.90
	P11.09	4	5	SAND and SILT, trace gravel, trace clay. Brownish grey.	33.8	
	P11.10	5	6	Silt and clay, trace sand. Poorly graded. Dark grey.	52.6	
	P11.11	6	7	CLAY, some silt, some sand. Grey. Organic smell. Medium plasticity.	54.1	
	P11.12	7	8	CLAY, some silt, some sand. Roots in sample. Grey. Organic smell. Medium plasticity.	66.4	
	P11.13	8	9	SILT, sandy, some clay. Brown. Roots in sample. Low to medium plasticity.	65.0	
	P11.14	9	10	SILT, sandy, some clay. Grey and black streaks. Organic smell.	67.3	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 23, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-12	P12.01	0	0.5	Silt and clay, trace sand, some organics. Small amount of visible ice. Medium brown.	77.1	
	P12.02	0.5	1	SAND, silty, trace gravel, trace clay. Brown.	85.4	
	P12.03	1	1.5	Silt and clay, trace sand. High content of visible ice present. Soil fraction of sample is greyey brown.	137.3	
	P12.04	1.5	2	CLAY, silty, trace sand, grey	54.2	2.40
	P12.05	2	2.5	Silt and clay, trace sand. Visible ice present. Greyey brown soil.	95.0	
	P12.06	2.5	3	SILT, clayey, some sand, trace gravel. Roots in sample. Greyish brown.	52.0	
	P12.07	3	3.5	CLAY, silty, trace sand, dark greyish brown	33.1	9.80
	P12.08	3.5	4	CLAY and SILT, trace sand. Dark brown to black. Organic smell. Medium plasticity.	35.6	
	P12.09	4	5	CLAY, silty, trace sand, grey	34.5	6.80
	P12.10	5	6	CLAY, silty, some sand. Grey. Organic smell.	48.0	
	P12.11	6	7	SILT, clayey, some sand. Grey. Organic smell. Low to medium plasticity.	52.4	
	P12.12	7	8	SILT, sandy, some clay, trace gravel. Grey. Organic smell.	61.3	
	P12.13	8	9	CLAY, some silt, some sand, trace gravel. Grey.	60.6	
	P12.14	9	10	CLAY, some silt, some sand. Grey.	65.0	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 23, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-13	P13.01	0	0.5	Silt, some sand to sandy, organics present. Some visible ice present. Medium brown.	91.9	
	P13.02	0.5	1	SAND, silty, trace clay, trace gravel. Roots in sample. Organic smell. Greyish brown.	123.3	
	P13.03	1	1.5	SAND, silty, trace clay, trace gravel. Roots in sample. Greyish brown. Organic smell.	92.6	
	P13.04	1.5	2	Silt and clay, trace sand. Visible ice present. Light brown.	50.5	
	P13.05	2	2.5	SAND, silty, trace clay, trace gravel. Roots in sample. Greyish brown. Organic smell.	145.3	
	P13.06	2.5	3	Silt, trace sand. Visible ice. Grey.	187.5	
	P13.07	3	3.5	SILT, trace clay, sand, gravel, grey	73.1	0.50
	P13.08	3.5	4	SILT, some sand, some clay. Grey. Organic smell.	58.8	
	P13.09	4	5	CLAY, silty, trace sand, grey	51.7	3.30
	P13.10	5	6	SILT, sandy, some clay. Grey. Organic smell.	52.3	
	P13.11	6	7	SILT, sandy, some clay. Grey. Organic smell.	74.2	
	P13.12	7	8	CLAY and SILT, some sand. Grey and brown. Organic smell. Medium plasticity.	56.9	
	P13.13	8	9	CLAY and SILT, some sand. Grey and brown. Organic smell. Medium plasticity. // CLAY, silty, some sand. Grey and brown streaks. Organic smell. Medium to high plasticity.	56.9 // 58.2	
	P13.14	9	10	SILT, sandy, some clay. Grey.	62.4	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 23, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-14	P14.01	0	0.5	SAND, silty, trace clay, trace gravel. Brown.	35.0	
	P14.03	1	1.5	Silt, trace sand. Poorly graded. Visible ice present. Light brown.	131.3	
	P14.04	1.5	2	Silt, trace sand. Poorly graded. Visible ice present. Light brown.	124.7	
	P14.05	2	2.5	Silt, trace sand. Poorly graded. Visible ice present. Light brown.	107.1	
	P14.06	2.5	3	CLAY, silty, trace sand, grey	66.2	0.80
	P14.07	3	3.5	Silt, trace sand. Poorly graded. Visible ice present. Light brown.	103.6	
	P14.08	3.5	4	SILT, clayey, some sand. Twigs in sample. Organic smell. Brown. Medium plasticity.	36.6	
	P14.09	4	5	CLAY, silty, trace sand, grey	34.6	11.10
	P14.10	5	6	CLAY, some silt, some sand. Twigs in sample. Grey. Organic smell. Medium plasticity.	32.8	
	P14.11	6	7	CLAY, silty, trace sand, grey	33.5	11.70
	P14.12	7	8	CLAY, some silt, some sand. Twigs in sample. Organic smell. Black with brown streaks. Organic smell.	36.5	
	P14.14	9	10	CLAY, some silt, trace sand. Black and grey. Organic smell. Medium to high plasticity.	44.4	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 24, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-15	P15.01	0	0.5	Silt, some sand, some organics. Visible ice content. Dark brown.	75.0	
	P15.02	0.5	1	Silt and clay, trace sand. High visible ice content. Greyey brown.	402.2	
	P15.03	1	1.5	Silt and clay, trace sand. High visible ice content. Greyey brown.	277.8	
	P15.04	1.5	2	SAND, silty, trace clay, trace gravel. Dark grey.	107.9	
	P15.05	2	2.5	Silt, some sand to sandy. Poorly graded. Light brown.	100.8	
	P15.06	2.5	3	Silt, trace fine to coarse grained sand. Poorly graded. Light brown.	92.0	
	P15.07	3	3.5	Silt and clay, trace sand. High visible ice content. Greyey brown.	109.1	
	P15.08	3.5	4	Silt and clay. Poorly graded. Visible ice present. Light greyey brown.	86.9	
	P15.09	4	5	Silt and clay. Poorly graded. Some Visible ice present. Dark grey.	63.3	
	P15.10	5	6	CLAY, silty, trace sand. Brown. Roots in sample. Grey and black. Medium to high plasticity.	35.8	
	P15.11	6	7	CLAY, some silt, trace sand. Roots in sample. Grey-black.	150.3	
	P15.12	7	8	CLAY, silty, trace sand, grey	34.5	4.80
	P15.13	8	9	Silt, trace fine to coarse grained sand. Poorly graded. Light brown.	40.9	
	P15.14	9	10	CLAY, some silt, trace sand. Organic smell. Grey and black. Medium to high plasticity.	49.1	

Indicates that a sample was test by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 23, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-16	P16.01	0	0.5	Silt, some sand, some organics. Visible ice content. Dark brown.	164.8	
	P16.02	0.5	1	SAND, silty, some clay. Roots in sample. Brown.	181.1	
	P16.03	1	1.5	Silt and clay. Poorly graded.	290.5	
	P16.04	1.5	2	Silt, trace sand. Poorly graded. Visible ice present. Light browney grey.	362.5	
	P16.05	2	2.5	Silt, trace sand. Poorly graded. Visible ice present. Light browney grey.	227.8	
	P16.06	2.5	3	SAND, silty, some clay. Brownish grey.	238.5	
	P16.07	3	3.5	SILT, trace sand, clay, grey	106.0	0.40
	P16.08	3.5	4	SILT, some clay, trace sand, grey	121.2	1.00
	P16.09	4	5	SILT, trace clay, sand, grey	97.8	5.10
	P16.10	5	6	SAND, some clay, some silt, trace gravel. Medium brown. Organic smell.	165.5	
	P16.11	6	7	Silt, sandy, trace fine grained gravel. Dark grey.	29.6	
	P16.12	7	8	CLAY and SILT, trace sand. Organic smell. Brownish grey. Medium to high plasticity.	29.0	
	P16.13	8	9	CLAY , some silt, trace sand, trace gravel. Dark grey. Organic smell.	39.7	
	P16.14	9	10	CLAY, some silt, trace sand, trace gravel. Dark grey. Organic smell.	49.6	

Indicates that a sample was test by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 25, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-17	P17.01	0	0.5	Silt, some fine grained sand, some organics. Visible ice present. Poorly graded. Brown	53.6	
	P17.02	0.5	1	Silt, some fine grained sand. Visible ice present. Poorly graded. Brown	81.9	
	P17.03	1	1.5	Silt, some fine grained sand. Poorly graded. Light grey.	165.1	
	P17.04	1.5	2	SAND, silty, trace clay, trace gravel. Grass and roots in sample. Grey.	66.2	
	P17.05	2	2.5	CLAY, silty, some sand, trace gravel, grey	44.2	0.60
	P17.06	2.5	3	Silt and clay, trace sand. Poorly graded. Dark grey.	60.4	
	P17.07	3	3.5	Silt and clay, trace sand. Poorly graded. Dark grey.	68.1	
	P17.08	3.5	4	CLAY, silty, trace sand, grey	55.7	3.40
	P17.09	4	5	Silt and clay, trace sand. Poorly graded. Dark grey.	73.7	
	P17.10	5	6	Silt and clay, trace sand. Poorly graded. Dark grey.	82.7	
	P17.11	6	7	Silt and clay, trace sand. Poorly graded. Dark grey.	71.6	
	P17.12	7	8	CLAY, silty, trace sand. Grey.	57.7	
	P17.13	8	9	CLAY and SILT, some sand. Organic smell. Brownish grey. Medium plasticity.	54.8	
	P17.14	9	10	CLAY and SILT, some sand. Roots in sample. Grey. Organic smell.	62.2	

Indicates that a sample was test by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 23, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-18	P18.01	0	0.5	Silt, trace fine-grained sand, organics present. Some visible ice present. Light brown	42.7	
	P18.02	0.5	1	Silt, trace fine-grained sand. Light brown	108.8	
	P18.03	1	1.5	Silt, trace sand. High visible ice content. Greyey brown soil.	217.6	
	P18.04	1.5	2	Silt, trace sand. High visible ice content. Greyey brown soil.	221.9	
	P18.05	2	2.5	Silt, trace sand. High visible ice content. Greyey brown soil.	130.1	
	P18.06	2.5	3	Silt, trace sand. High visible ice content. Greyey brown soil.	175.9	
	P18.07	3	3.5	SILT, trace clay, sand, grey	121.8	1.20
	P18.08	3.5	4	SILT, sandy, some clay. Brown.	64.0	
	P18.09	4	5	CLAY, silty, trace sand, gravel, greyish brown	83.6	1.60
	P18.10	5	6	CLAY, silty, some sand. Grey.	61.6	
	P18.11	6	7	Silt and clay. Poorly graded. Medium Brown.	75.0	
	P18.12	7	8	SAND, silty, some clay, trace gravel. Grey.	80.9	
	P18.13	8	9	SILT, some clay, sand, grey	75.3	3.60
	P18.14	9	10	SILT, clayey, some sand. Grey. Medium plasticity.	42.5	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 23, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-19	P19.01	0	0.5	Silt, trace fine to coarse grained sand. Organics present. Light brown (when dry).	103.3	
	P19.02	0.5	1	Silt and clay, trace sand, trace organics. High visible ice content. Soil fraction of sample is a greyey brown.	118.8	
	P19.03	1	1.5	Sand, silty. Visible ice present. Light greyey brown.	42.3	
	P19.04	1.5	2	Bedrock chips.	8.1	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 23, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-20	P20.01	0	0.5	Silt, trace sand, some organics. Some visible ice present. Medium brown.	78.8	
	P20.02	0.5	1	SAND, some silt, trace clay, trace gravel. Brown. Low plasticity.	90.2	
	P20.03	1	1.5	Silt and clay, trace sand. High visible ice content. Greyey brown soil component of sample.	159.6	
	P20.04	1.5	2	SAND, some silt, trace clay, trace gravel. Brown. Low plasticity.	76.4	
	P20.05	2	2.5	SAND, silty, some clay. Brown. Medium plasticity.	46.7	
	P20.06	2.5	3	Silt, trace fine to coarse grained sand. Light brown	32.1	
	P20.07	3	3.5	Sand (fine grained to coarse grained), silty, trace fine grained gravel. Poorly graded. Light brown (when dry)	24.7	
	P20.08	3.5	4	Sand (fine grained to coarse grained), silty, trace fine grained gravel. Poorly graded. Light greyey brown (wet)	12.1	
	P20.09	4	5	Sand (fine grained to coarse grained), silty, trace fine grained gravel. Poorly graded. Light greyey brown (wet)	9.9	
	P20.10	5	6	Bedrock cuttings/chips	7.9	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 25, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-21	P21.01	0	0.5	Silt, some sand. Fine grained to coarse grained sand. Some organics. Some visible ice present. Medium brown.	82.0	
	P21.02	0.5	1	Silt, sandy. Fine grained to coarse grained sand. Some visible ice present. Light browney grey.	77.1	
	P21.03	1	1.5	SAND, silty, some clay, trace gravel. Brown.	40.1	
	P21.04	1.5	2	Sand, silty, trace fine grained gravel. Well graded. Light greyey brown.	17.6	
	P21.05	2	2.5	Sand, silty. Poorly graded. Light greyey brown.	12.7	
	P21.06	2.5	3	Sand, silty. Poorly graded. Light greyey brown.	11.4	
	P21.07	3	3.5	Sand and bedrock chips.	14.4	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 22, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-22	P22.01	0	0.5	Silt , trace sand, trace organics. Some visible ice present. Greyey brown.	54.1	
	P22.02	0.5	1	SAND, silty, trace clay, trace gravel. Roots in sample. Brown. Organic smell.	59.6	
	P22.03	1	1.5	Silt , some clay, trace sand, trace organics. High content of visible ice present. Greyey brown.	191.3	
	P22.04	1.5	2	CLAY, silty, trace sand, grey	54.9	3.50
	P22.05	2	2.5	Silt and clay. Poorly graded. Dark greyey brown.	53.4	
	P22.06	2.5	3	Silt and clay. Poorly graded. Dark greyey brown.	61.1	
	P22.07	3	3.5	CLAY and SILT, some sand. Grey. Organic smell. Medium plasticity.	56.5	
	P22.08	3.5	4	CLAY, silty, trace sand, grey	55.2	6.00
	P22.09	4	5	CLAY, silty, trace sand, grey	63.3	6.20
	P22.10	5	6	CLAY and SILT, some sand. Grey. Organic smell. Medium plasticity	58.5	
	P22.11	6	7	CLAY and SILT, some sand. Grey. Organic smell. Medium plasticity	58.5	8.20
	P22.12	7	8	SILT, sandy, some clay. Grey. Medium plasticity.	47.5	
	P22.13	8	9	CLAY and SILT, some sand. Grey. Organic smell. Medium plasticity.	41.2	
	P22.14	9	10	Silt and clay, trace sand. Poorly graded. Dark greyey brown.	70.4	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 22, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-24	P24.01	0	0.5	Silt , trace sand, some organics. Some visible ice present. Brown	64.4	
	P24.02	0.5	1	Silt and clay. Poorly graded. Medium greyey brown.	135.8	
	P24.03	1	1.5	Silt and clay, trace sand. High content of visible ice. Soil fraction of sample is grey	163.6	
	P24.04	1.5	2	Silt and clay. Poorly graded. Medium greyey brown.	61.3	
	P24.05	2	2.5	Silt and clay. Poorly graded. Medium greyey brown.	51.4	
	P24.06	2.5	3	CLAY, silty, trace sand. Brown. Medium to high plasticity.	49.7	
	P24.07	3	3.5	CLAY, silty, trace sand, gravel, grey	50.1	6.60
	P24.08	3.5	4	Silt and clay. Poorly graded. Dark grey	60.8	
	P24.09	4	5	SILT, some clay, trace sand, grey	53.0	3.00
	P24.10	5	6	CLAY, silty, trace sand, grey	60.5	5.40
	P24.11	6	7	CLAY and SILT, some sand. Grey. Medium plasticity.	59.1	
	P24.12	7	8	SILT, clayey, some sand. Grey with dark grey streaks. Organic smell.	51.6	
	P24.13	8	9	CLAY, silty, trace sand, gravel, grey	35.2	7.30
	P24.14	9	10	SAND and SILT, some clay. Twigs in sample. Grey and brown streaks. Low to non-plastic.	28.3	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 22, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-25	P25.01	0	0.5	silt, some sand, some organics. Small amount of visible ice present. Brown.	82.0	
	P25.02	0.5	1	Silt and clay, trace sand. Visible ice present. Poorly graded. Soil fraction of sample dark grey.	231.5	
	P25.03	1	1.5	Silt and clay, trace sand. Visible ice present. Poorly graded. Soil fraction of sample dark grey.	197.8	
	P25.04	1.5	2	SAND and SILT, some clay. Brownish grey.	302.7	
	P25.05	2	2.5	Silty, clayey, some sand. Grey. Medium plasticity.	55.8	
	P25.06	2.5	3	SILT, clayey, some sand. Brownish grey. Grass in sample. Medium plasticty.	55.9	
	P25.07	3	3.5	CLAY, silty, trace sand, grey	46.7	7.70
	P25.08	3.5	4	SILT, clayey, some sand. Grey. Medium plasticity.	52.9	
	P25.09	4	5	CLAY, silty, trace sand, grey	45.2	4.20
	P25.10	5	6	CLAY and SILT, some sand. Grey and black streaks. Medium plasticity.	52.5	
	P25.11	6	7	SILT and SAND, trace clay. Dark grey. Organic smell.	57.9	
	P25.12	7	8	SILT, sandy, some clay. Grey with black streaks. Organic smell. Medium plasticity.	36.4	
	P25.13	8	9	SILT, clayey, some sand, trace gravel. Grey. Medium plasticity.	29.3	
	P25.14	9	10	SILT, clayey, some sand, trace gravel. Grey. Medium plasticity.	7.7	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 22, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-26	P26.01	0	0.5	Silt, trace sand. Some visible ice present. Dark brown.	151.3	
	P26.02	0.5	1	Silt and clay, trace sand. High content of visible ice present. Soil fraction of sample is dark grey .	171.6	
	P26.03	1	1.5	SILT, some sand, some clay. Low to medium plasticity. Brown.	58.3	
	P26.04	1.5	2	SILT, some sand, some clay. Low to medium plasticity. Brown.	57.0	
	P26.05	2	2.5	Silt and clay, trace fine grained to medium grained sand. Poorly graded. Visible ice present. Light brown.	127.6	
	P26.06	2.5	3	Silt and clay. Poorly graded. Light brown with sight oxidation present (when dry).	72.6	
	P26.07	3	3.5	CLAY, silty, trace sand, greyish brown	73.9	6.40
	P26.08	3.5	4	SILT, clayey, trace sand. Brown. Medium plasticity.	54.8	
	P26.09	4	5	CLAY, some silt, some sand. Grey. Medium plasticity.	50.3	
	P26.10	5	6	CLAY, silty, some sand. Grey and black streaks. Medium plasticity.	45.8	
	P26.11	6	7	CLAY, silty, trace sand, grey	52.5	8.50
	P26.12	7	8	CLAY, some silt, some sand. Grey. Medium plasticity.	45.5	
	P26.13	8	9	SILT, sandy, some clay. Grey. Low to medium plasticity.	42.8	
	P26.14	9	10	Sand, silty. Poorly graded. Greyey brown.	18.9	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 24, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-27	P27.01	0	0.5	Silt, some sand. Fine grained to coarse grained sand. Some organics. Some visible ice present. Medium brown.	216.4	
	P27.02	0.5	1	Silt, some sand. Fine grained to coarse grained sand. Some organics. Some visible ice present. Medium brown.	231.3	
	P27.03	1	1.5	Silt and clay, trace sand. High content of visible ice. Soil component greyey brown.	157.0	
	P27.05	2	2.5	CLAY, some sand, trace silt, trace gravel. Dark grey.	85.4	
	P27.06	2.5	3	CLAY, some sand, trace silt, trace gravel. Dark grey.	60.1	
	P27.07	3	3.5	SILT, some clay, trace sand. Organic smell. Brown. Low to medium plasticity.	54.0	
	P27.08	3.5	4	CLAY, silty, trace sand, gravel, grey	56.2	6.30
	P27.09	4	5	CLAY and SILT, some sand. Organic smell. Grey. Medium to high plasticity.	51.1	
	P27.10	5	6	SILT, sandy, some clay. Grey. Organic smell.	48.3	
	P27.11	6	7	SILT, sandy, some clay. Grey.	52.8	
	P27.12	7	8	CLAY and SILT, some sand. Roots in sample. Grey. Medium plasticity.	46.2	
	P27.13	8	9	SAND and SILT, clayey, trace gravel. Grey.	32.4	
	P27.14	9	10	SILT, sandy, trace clay, trace gravel. Grey.	28.9	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 22, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-28	P28.01	0	0.5	Silt, some sand, some organics. Visible ice present. Soil fraction of sample is medium brown.	71.3	
	P28.02	0.5	1	SILT and SAND, some clay, trace gravel. Grey. Low plasticity.	111.6	
	P28.03	1	1.5	SILT, some clay, trace sand, greyish brown	94.3	4.00
	P28.04	1.5	2	ICE RICH, medium to high plasticity fat CLAY, little silt. Grey.	186.0	
	P28.05	2	2.5	Silt and clay, trace sand. Some visible ice present. Soil fraction of sample is greyey brown.	108.1	
	P28.06	2.5	3	SAND, silty, some clay. Brown. Low plasticity.	64.3	
	P28.07	3	3.5	CLAY, silty, trace sand, grey	64.8	2.30
	P28.08	3.5	4	SILT, some sand, some clay. Brown. Low to medium plasticity.	59.8	
	P28.09	4	5	CLAY, silty, trace sand, grey	53.0	6.90
	P28.10	5	6	CLAY, some silt, trace sand, trace gravel. Grey. Medium to high plasticity.	51.3	
	P28.11	6	7	CLAY, some silt, trace sand, trace gravel. Grey. Medium to high plasticity.	64.6	
	P28.12	7	8	CLAY, silty, trace sand, gravel, grey	48.3	7.60
	P28.14	9	10	CLAY and SILT, sandy, trace gravel. Grey. Organic smell.	40.9	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 22, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-30	P30.01	0	0.5	SAND, silty, clayey. Peat, twigs and grass in sample. Brown.	57.8	
	P30.02	0.5	1	Silt, trace sand, trace organics. Small amount of visible ice. Poorly graded. Dark grey.	134.4	
	P30.03	1	1.5	Silt and clay, trace sand. High content of visible ice. Soil fraction of sample is greyey brown.	105.6	
	P30.04	1.5	2	SILT and SAND, some clay, trace gravel. Grey. Low to medium plasticity.	71.0	
	P30.05	2	2.5	Silt and clay, trace sand. High content of visible ice. Soil fraction of sample is greyey brown.	80.6	
	P30.06	2.5	3	SILT and SAND, some clay, trace gravel. Grey. Low to medium plasticity.	48.8	
	P30.07	3	3.5	CLAY, silty, trace sand, grey	52.0	3.20
	P30.08	3.5	4	Silt and clay, trace sand. Poorly graded. Dark grey.	53.1	
	P30.09	4	5	CLAY, silty, trace sand, grey	51.6	3.60
	P30.10	5	6	CLAY, silty, some sand. Grey. Organic smell. Medium plasticity.	51.5	
	P30.11	6	7	CLAY and SILT, some sand. Grey and brown streaks. Organic smell. Medium plasticity.	49.2	
	P30.12	7	8	SILT, some clay, trace to some sand. Brown with dark grey streaks. Low to medium plasticity.	60.3	
	P30.13	8	9	CLAY and SILT, some sand. Organic smell. Grey and black. Medium plasticity.	68.6	
	P30.14	9	10	SILT and SAND, some clay. Organic smell. Brown with black streaks. Low plasticity.	62.3	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 21, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-31	P31.01	0	0.5	SILT, sandy, some clay. Brown	36.8	
	P31.02	0.5	1	Silt and clay, trace sand. Poorly graded. Small amount of visible ice present. Grey.	138.3	
	P31.03	1	1.5	SAND, silty, trace clay, trace gravel. Grey. Visible ice in sample.	168.1	
	P31.04	1.5	2	Silt and clay, trace sand, trace fine grained gravel. Poorly graded. Visible ice present. Grey.	197.7	
	P31.05	2	2.5	Silt and clay, trace sand. Poorly graded. Dark grey	77.5	
	P31.06	2.5	3	Silt and clay, trace sand. Poorly graded. Dark grey	75.0	
	P31.07	3	3.5	CLAY, silty, sandy, grey	60.8	4.00
	P31.08	3.5	4	CLAY, silty, some sand, grey	54.0	7.00
	P31.09	4	5	CLAY, silty, trace sand, grey	53.1	2.70
	P31.10	5	6	Silt and clay, trace sand. Poorly graded. Dark grey	67.2	
	P31.11	6	7	CLAY, silty, trace sand, gravel, grey	50.1	7.80
	P31.12	7	8	CLAY, silty, trace sand. Grey.	61.2	
	P31.14	9	10	SILT, sandy, some clay. Grey and brown.	49.8	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 21, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-32	P32.01	0	0.5	Sand, silty, organics present. Poorly graded. Light brown.	17.6	
	P32.02	0.5	1	Sand, silty, organics present. Poorly graded. Light brown.	38.0	
	P32.03	1	1.5	Silt, trace sand. Poorly graded. Visible ice present. Soil matrix light brown.	143.2	
	P32.04	1.5	2	CLAY, silty, trace sand, grey	92.3	4.00
	P32.05	2	2.5	Silt and clay, trace sand. Poorly graded. Grey brown.	68.2	
	P32.06	2.5	3	CLAY, some sand, some silt, trace gravel. Twigs and roots in sample. Grey.	53.7	
	P32.07	3	3.5	CLAY, silty, trace sand, grey	51.7	4.00
	P32.08	3.5	4	CLAY and SILT, trace sand, trace gravel. Grey. Medium plasticity.	53.7	
	P32.09	4	5	CLAY, silty, trace sand, gravel, grey	50.3	4.40
	P32.10	5	6	CLAY, some sand, some silt, trace gravel. Twigs and roots in sample. Grey.	58.6	
	P32.11	6	7	SILT, sandy, some clay. Organic smell. Grey. Low plasticity.	58.5	
	P32.12	7	8	Sand and silt. Poorly graded. Dark grey	38.6	
	P32.13	8	9	Sand, some silt to silty. Well graded. Light greyey brown.	13.1	
	P32.14	9	10	Sand, some silt to silty. Well graded. Light greyey brown.	20.9	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 21, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-33	P33.01	0	0.5	Silt and sand, trace clay. No visible ice. Poorly graded. Dark brown.	33.2	
	P33.02	0.5	1	Silt, trace to some sand, trace clay. Small amoujnt of visible ice. Poorly graded. Dark brown.	167.1	
	P33.03	1	1.5	SAND, silty, trace clay. Brown.	61.9	
	P33.04	1.5	2	SAND, silty, trace clay. Brown.	75.2	
	P33.05	2	2.5	CLAY, silty, sandy, grey	63.4	4.00
	P33.06	2.5	3	Silt, some sand. Predominantly fine grained sand, trace coarse grained sand. Poorly graded. Dark grey.	61.9	
	P33.07	3	3.5	SILT, clayey, some sand. Greyish brown. Medium plasticty.	53.7	
	P33.08	3.5	4	CLAY, some silt, trace sand, trace gravel. Grey. Medium to high plasticity.	50.5	
	P33.09	4	5	CLAY, some silt, trace sand, trace gravel. Grey. Medium to high plasticity.	56.8	
	P33.10	5	6	CLAY, silty, trace sand, grey	52.4	6.70
	P33.11	6	7	SAND with silt, well graded. Grey.	14.6	
	P33.12	7	8	SAND & GRAVEL, some silt, greyish brown	13.1	1.40
	P33.13	8	9	SAND and GRAVEL, trace silt, trace clay. Grey.	5.3	
	P33.14	9	10	Silt and clay, some sand. No visible ice. Poorly graded. Dark greyey brown.	20.5	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 21, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-34	P34.01	0	0.5	SAND, silty, clayey to some clay. Brown. Peat, twigs, and grass in sample.	49.3	
	P34.02	0.5	1	Silt and sand, trace fine grained gravel, trace organics. Some visible ice present. Medium grey brown.	61.9	
	P34.03	1	1.5	Fine to coarse grained sand, some silt to silty. Well graded. Medium goldy brown.	32.6	
	P34.04	1.5	2	SAND, silty, trace clay, trace gravel. Light brown.	16.1	
	P34.05	2	2.5	SAND & GRAVEL, some silt, greyish brown	7.6	5.60
	P34.06	2.5	3	Sand, some silt to silty, trace fine grained gravel. No visible ice present. Well graded. Light goldy brown.	5.0	
	P34.07	3	3.5	Sand, some silt to silty, trace fine grained gravel. No visible ice present. Well graded. Light goldy brown.	9.0	
	P34.08	3.5	4	SAND, silty, trace clay, trace gravel. Light brown.	8.9	
	P34.09	4	5	Bedrock chips.	2.7	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 21, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-35	P35.01	0	0.5	Silt, trace sand, some organics. No visible ice present. Dark brown.	27.8	
	P35.02	0.5	1	Sand, some silt to silty, trace fine grained gravel. No visible ice present. Well graded. Light goldy brown.	14.4	
	P35.03	1	1.5	Sand, some silt to silty, trace fine grained gravel. No visible ice present. Well graded. Light goldy brown.	12.6	
	P35.04	1.5	2	Sand, some silt to silty, trace fine grained gravel. Well graded. Light grey.	11.6	
	P35.06	2.5	3	Sand, silty. Well graded. Goldy light brown.	13.5	
	P35.07	3	3.5	Sand, silty. Well graded. Goldy light brown.	11.1	
	P35.08	3.5	4	Bedrock chips.	9.4	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 21, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-36	P36.01	0	0.5	Sand, some silt to silty, trace gravel. Well graded. Light brown.	13.5	
	P36.02	0.5	1	Sand, some silt to silty, trace gravel. Well graded. Light brown.	8.6	
	P36.03	1	1.5	Sand, some silt to silty, trace gravel. Well graded. Light brown.	26.1	
	P36.04	1.5	2	Sand, some silt to silty, trace gravel. Well graded. Light brown.	14.7	
	P36.05	2	2.5	SAND, some gravel, trace silt, trace clay.	12.2	
	P36.06	2.5	3	Bedrock Chips.	5.6	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 21, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-37	P37.01	0	0.5	Silt, trace sand, trace fine grained gravel.some organics. Chunks of peat moss type soil present in sample. Some visible ice present. Medium brown.	23.8	
	P37.02	0.5	1	Sand, silty, trace fine grained gravel. Well graded. Fine to coarse grained sand. No visible ice. Light goldy brown.	23.4	
	P37.03	1	1.5	Sand, silty. Well graded. Fine to coarse grained sand. No visible ice.	42.3	
	P37.04	1.5	2	SAND & GRAVEL, some silt, greyish brown	13.7	0.30
	P37.05	2	2.5	Sand, silty. Well graded. Fine to coarse grained sand. No visible ice.	12.4	
	P37.06	2.5	3	Bedrock chips.	3.4	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 20, 2018

By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-38	P38.01	0	1	Silt and sand, trace fine grained gravel. Poorly graded. Medium grey brown.	28.8	
	P38.03	1	1.5	Sand, silty, trace fine grained gravel. Well graded. Light goldy brown.	16.4	
	P38.04	1.5	2	Sand, silty, trace fine grained gravel. Well graded. Light goldy brown.	14.1	
	P38.05	2	2.5	Sand, silty. Well graded. Light goldy brown.	10.9	
	P38.06	2.5	3	Sand, silty. Well graded. Light goldy brown.	13.3	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Moisture Content Determination and Sample Description

Date Sampled: January 21, 2018

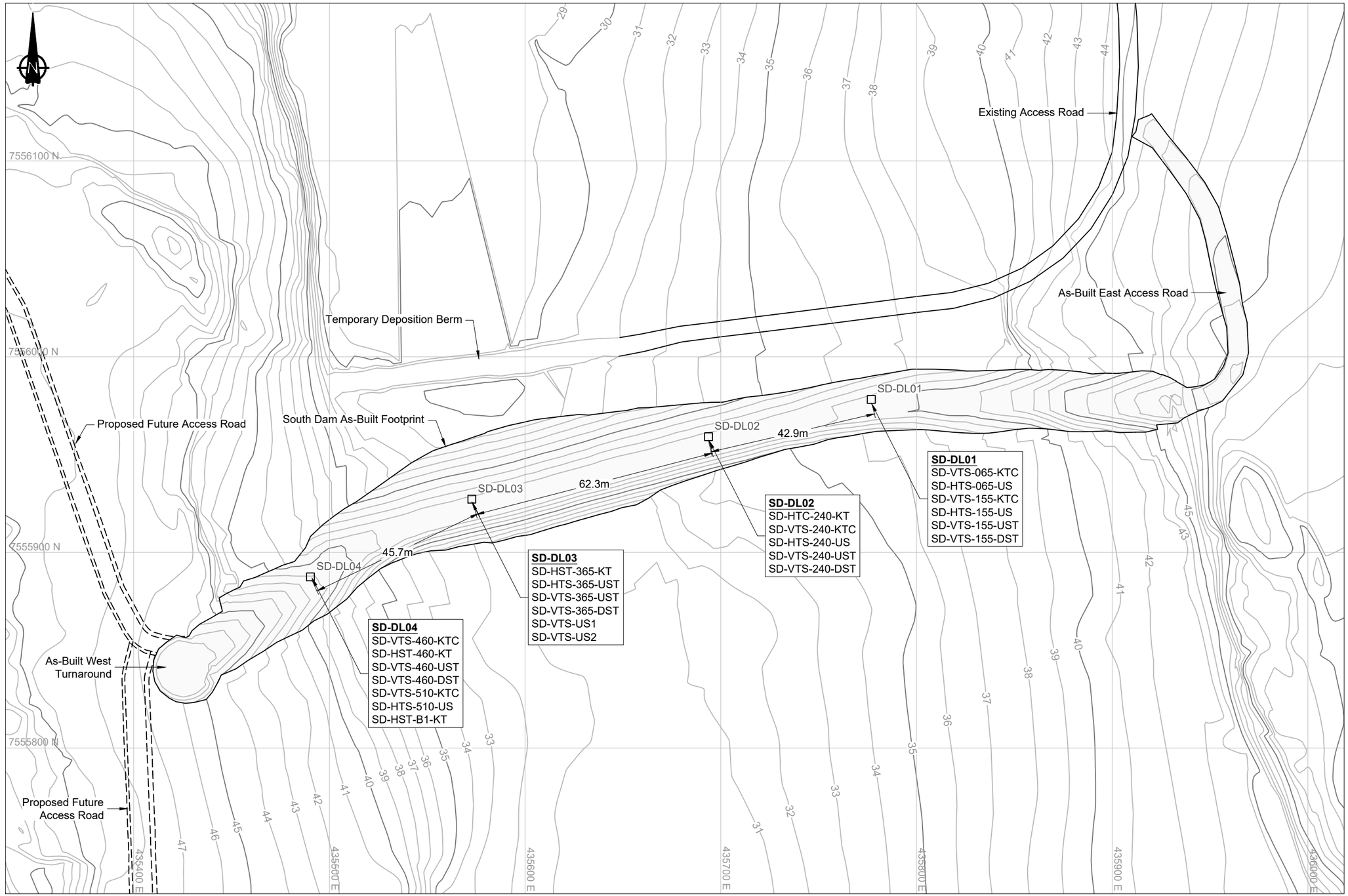
By: Kendell Cator

Hole ID	Sample #	Depth (m) From	Depth (m) To	Sample Description	M/C (%)	Salinity (ppt)
SRK18-DHP-39	P39.01	0	0.5	Silt and clay, trace sand. Poorly graded. Dark brown.	29.0	
	P39.02	0.5	1	Silt and clay, trace sand. Poorly graded. Dark brown.	28.0	
	P39.03	1	1.5	SAND, some silt, trace gravel, trace clay. Brown.	9.3	
	P39.04	1.5	2	SAND & GRAVEL, some silt, greyish brown	11.3	3.60
	P39.05	2	2.5	SAND, some silt, trace gravel, trace clay. Grey.	13.2	
	P39.06	2.5	3	SAND & GRAVEL, some silt, greyish brown	12.5	4.20
	P39.07	3	3.5	Sand and gravel. Well graded. Greyey brown.	11.9	
	P39.08	3.5	4	Sand and gravel. Well graded. Greyey brown.	9.2	
	P39.09	4	5	Bedrock Chips.	2.9	

Indicates that a sample was tested by EBA in their Yellowknife, NWT Laboratory

Appendix K – Instrumentation

Appendix K.1 – Instrumentation Layout



LEGEND

□ Data Logger Location

NOTES

1. Contours shown at 1.0m intervals.
2. All dimensions in meters unless otherwise noted.
3. As-built survey information provided by Sub-Arctic Geomatics Ltd., 2018.

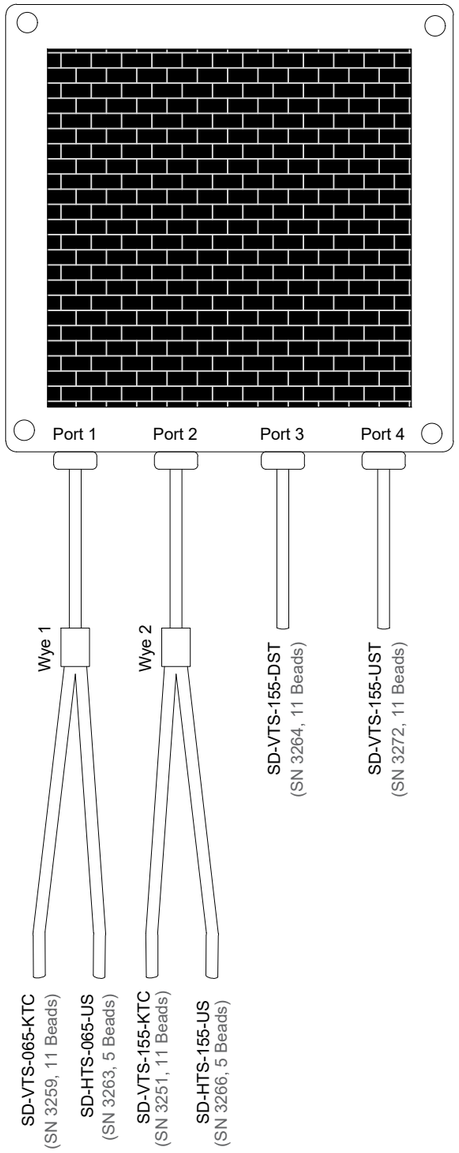
REFERENCE

NAD83 UTM Zone 13.

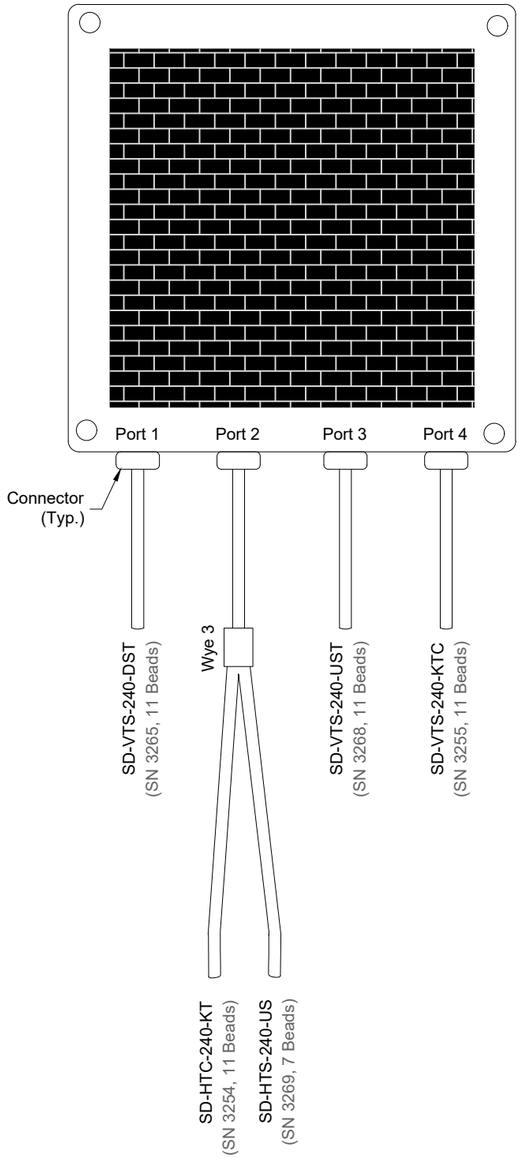
P:\01. SITES\Hope Bay\IACAD\2018 Drawings\South Dam Reporting\1CT022.031 - South Dam Monitoring.dwg

srk consulting	TMAC RESOURCES	Ground Temperature Monitoring Instrumentation
SRK JOB NO.: 1CT022.031		Phase 1 South Dam Ground Temperature Cable Locations
FILE NAME: 1CT022.031 - South Dam Monitoring.dwg	Hope Bay Mining Ltd.	DATE: December 2018 / APPROVED: / FIGURE: 1

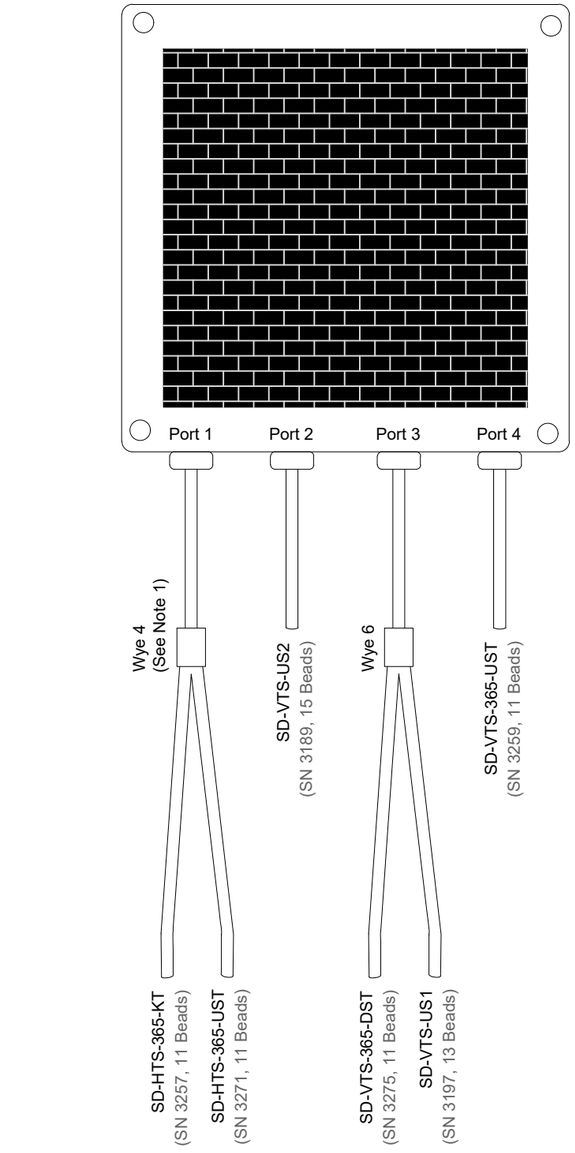
SD-D01
Sta. 1+55



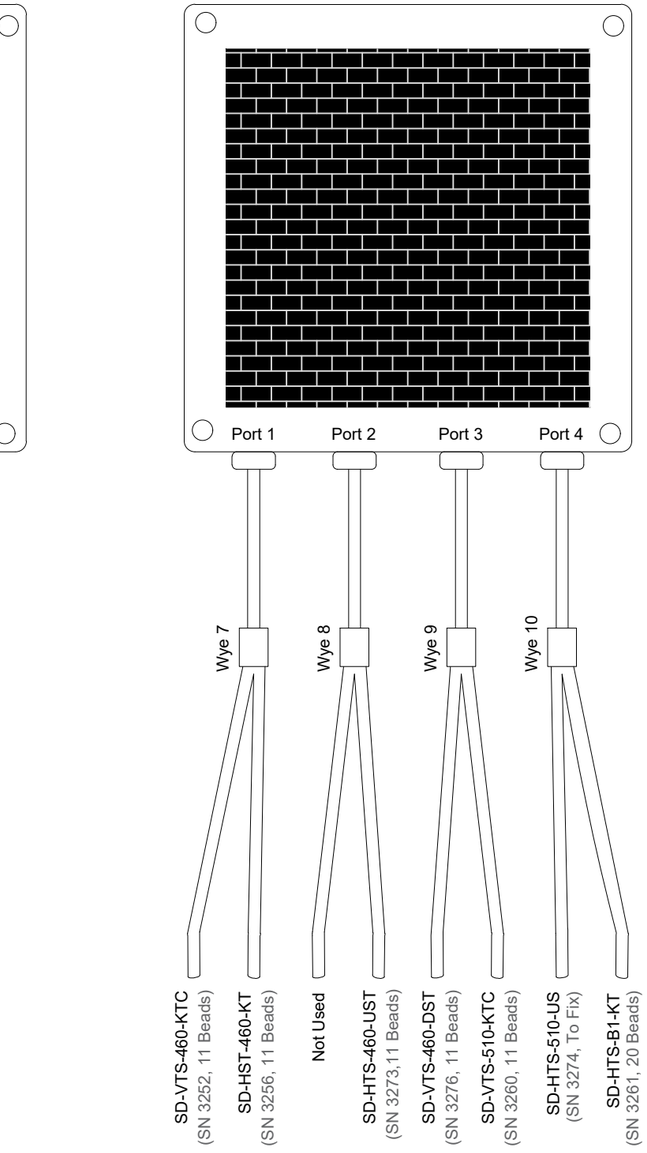
SD-DL02
Sta. 2+40



SD-DL03
Sta. 3+65



SD-DL04
Sta. 4+60



LEGEND

3-watt solar panel with temperature compensated charge control circuit.

NOTES

1. Wye connectors allow two GTCs to download through one connector port on the Data Logger.
2. Wye 5 not used.

srk consulting

SRK JOB NO.: 1CT022.031

FILE NAME: 1CT022.031 - South Dam Monitoring.dwg

TMAC RESOURCES

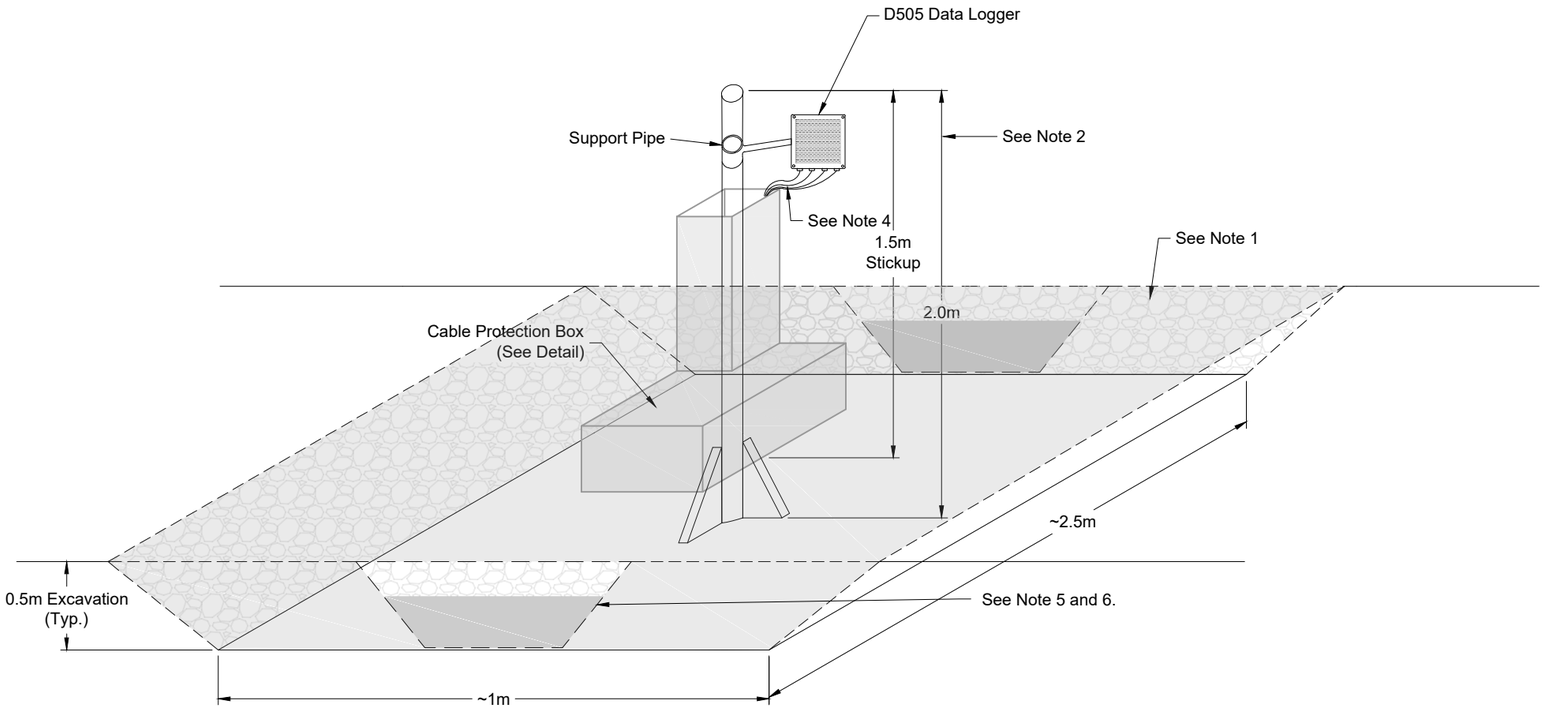
Hope Bay Mining Ltd.

Ground Temperature Monitoring Instrumentation

Phase 1 South Dam Monitoring nodes
SD-DL01 through SD-DL04

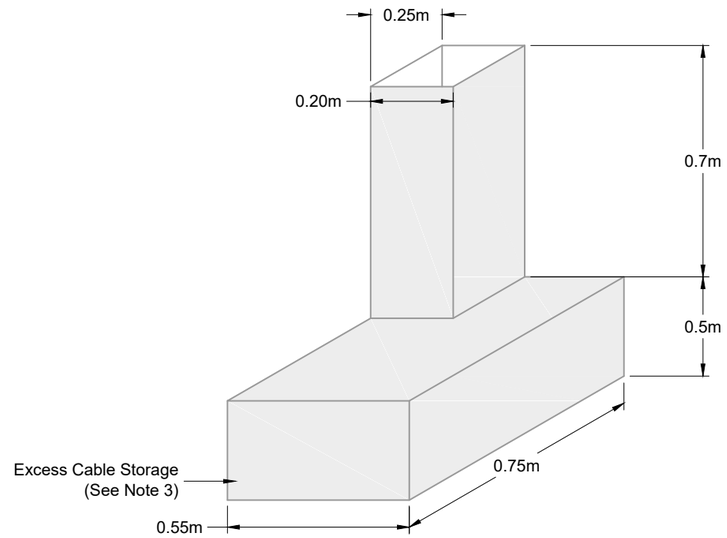
DATE: December 2018 | APPROVED: | FIGURE: 2

P:\01_SITES\Hope Bay\IACAD\2018 Drawings\South Dam Reporting\1CT022.031 - South Dam Monitoring.dwg



Typical Installation Detail of Data Loggers SD-DL01 through SD-DL04

Not To Scale



Wood Cable Protection Box

Not To Scale

NOTES

1. Following installation of the support pipe, the excavation was backfilled with ROQ material prior to installation of the cable protection box.
2. All dimensions are approximate.
3. Additional lead cable stored for protection from wildlife and the outdoor elements in Cable Protection Box.
4. Limited lead cable exposed between the Cable Protection Box and the Data Logger for protection from wildlife and the outdoor elements.
5. Ground temperature cables enter the Cable Protection Box through shallow trenches located near the upstream dam crest.
6. Crushed rock placed under and around ground temperature cables then backfilled with select ROQ.

srk consulting	TMAC RESOURCES	Ground Temperature Monitoring Instrumentation
SRK JOB NO.: 1CT022.031	Hope Bay Mining Ltd.	Phase 1 South Dam - Data logger Installation Details
FILE NAME: 1CT022.031 - South Dam Monitoring.dwg		DATE: December 2018 / APPROVED: / FIGURE: 3

P:\01_SITES\Hope Bay\ACAD\2018 Drawings\South Dam Reporting\1CT022.031 - South Dam Monitoring.dwg

Appendix K.2 – GTC Order Sheets

beadedstream

35140-01

D505 | Our latest satellite data logger.

Log your data without logging the miles. The BeadedStream D505 Data Logger is purpose built for remote deployments and reliable performance in extreme conditions. Now with enhanced solar and Bluetooth performance.

Specifications

Hardware / Firmware	• Ultra low-power, high performance industrial microcontroller. • Multi-threaded custom embedded OS. Free firmware updates.
Storage	• Capacity for over 1 million temperature readings. • Non-volatile flash memory survives even if battery dies.
Real Time Clock	• ± 5 minutes per year (temperature compensated). • Periodically synchronizes with GPS network.
Communication	• Bluetooth 4.2 wireless interface. • Compatible with *Capture*, our all new iOS app.
Connections	• Up to 4 DTC ports, up to 2 additional ports for other sensors, power, etc. • 5V driver available to power DTC sensors if needed.
Ultra Low Power	• 6 to 10 VDC (max) input. • Sleep mode: 90 µA typical. Active mode: 70 mA typical.
Battery	• Rechargeable 6V 5.5 Ah sealed lead-acid battery. • 2 months typical w/o solar recharge (Transmitting hourly).
GPS	• Embedded 40-channel dedicated GPS processing module. • 34-second time to first fix (typical). Integrated 1575.42 MHz antenna.
Worldwide Telemetry	• Embedded two-way satellite transceiver and Iridium antenna. • Uses Iridium's mesh network, 66 satellites, 100% pole to pole coverage.
Operating Range	• -40° C to +85° C (-40° F to +185° F). NEMA Type 4X/IP68.
Weight and Dimensions	• 2.3 kg (5.1 lbs) (*without mount*). 7.1" x 7.1"x 3.1" (18 cm x 18 cm x 7.9 cm).
Mounting	• Multi-function pivoting arm mount comes standard.

beadedstream

35140-01

Specifications (continued)

Integrated Solar	• 3 Watt nominal solar panel with temperature compensated charge control circuit to protect and prolong battery life.
Contactless Switch	• Built-in magnetic switch is immune to dust, dirt, mud and water. • Triggers through the case for spot readings and Bluetooth wake.
Optional Rangefinder	• Small, lightweight, rugged. An ultrasonic outdoor sensor for snow and water level measurement. IP67 rated. • Long narrow detection zone with a 1 cm resolution, minimum detection range of 50 cm, 1 meter maximum. • Filtering algorithms yield excellent noise tolerance and clutter rejection.

beadedstream

35110-04

Digital Temperature Cable (DTC)

Standard High Visibility Yellow

It all starts with BeadedStream's all-digital temperature cables. DTCs increase the speed and ease of obtaining temperature data and deliver accurate, highly resolved measurements in digital form.

Specifications

Application	• Multi-use industrial temperature monitoring
Length	• Customizable; user specified • Standard maximum length of 450 m (1500 ft)
Diameter	• Cable is 7.0 mm ± 0.1 mm • Straight sensor housing is 11 mm ± 0.5 mm
Maximum Operating Temperature Range	• -55° C to 125° C (-67° F to 257° F)
Field Conditions	• Wet / Dry / Frozen
Colors	• High-visibility yellow; gray (reinforced cable); white • Black or white heat shrink available for sensor sections
Outer Jacket	• BeadedStream S724EX polyurethane jacket formulated for low temperature durability and flex with reduced diameter and weight • Gray option with reinforced shielding for added protection from wildlife and improved crush resistance • UV stabilized • Cut and abrasion resistant • Flexing minimum temperature -40° C/F
Central Strength Member	• Built-in Aramid fibers increase strength in tension and minimize cable stretch
Conductors	• Stranded tinned copper; 22 AWG; Number: 3
Maximum # of Sensors	• 110
Sensor Accuracy	• ± 0.1° C from -10° C to 30° C (14° F to 86° F)

beadedstream

35110-04

DTC Specifications (continued)

Sensor Spacing	• Customizable; user specified • Variable spacing available upon request • Minimum standard spacing: 10 cm • Closer spacing available – please inquire
Additional Sensor Features	• Requires only one signal line for bidirectional communication • Each sensor has a unique ID for individual communication • Operates using input voltage between 3.0 V and 5.5 V • Converts temperatures in 750 ms (max)

beadedstream

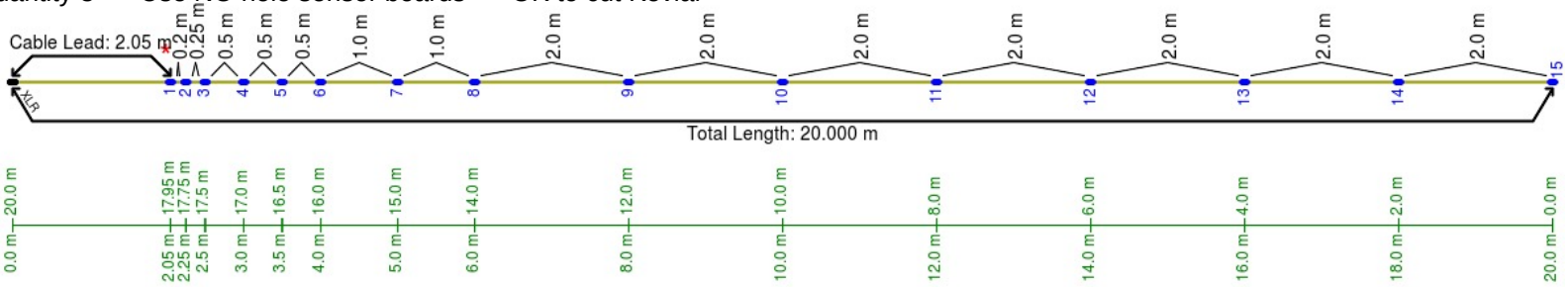
DTC Order Sheet

Customer: SRK Consulting
Project Name: 2018 - Point Hope Phase 1
Order Date:

DTC Name: 15 sensor profiler for the following locations: SRK17-STH-DH-02, SRK17-STH-DH-03, Spare #1
Serial Number: 2839
Units: meters

Object	Mold	Cable	Distance
XLRConnector	XLR Mold	Yellow	2.05m
Protection/Sensor 1	Straight	Yellow	0.2m
Sensor 2	Straight	Yellow	0.25m
Sensor 3	Straight	Yellow	0.5m
Sensor 4	Straight	Yellow	0.5m
Sensor 5	Straight	Yellow	0.5m
Sensor 6	Straight	Yellow	1.0m
Sensor 7	Straight	Yellow	1.0m
Sensor 8	Straight	Yellow	2.0m
Sensor 9	Straight	Yellow	2.0m
Sensor 10	Straight	Yellow	2.0m
Sensor 11	Straight	Yellow	2.0m
Sensor 12	Straight	Yellow	2.0m
Sensor 13	Straight	Yellow	2.0m
Sensor 14	Straight	Yellow	2.0m
Sensor 15	End	N/A	N/A

Comments: Quantity 3 *** Use NO hole sensor boards *** OK to cut Kevlar



* indicates that this sensor contains a protection unit

Return signed order sheet to BeadedStream at
e-mail: contact@beadedstream.com
call: 844-488-4880 for support

Approved

Date

beadedstream

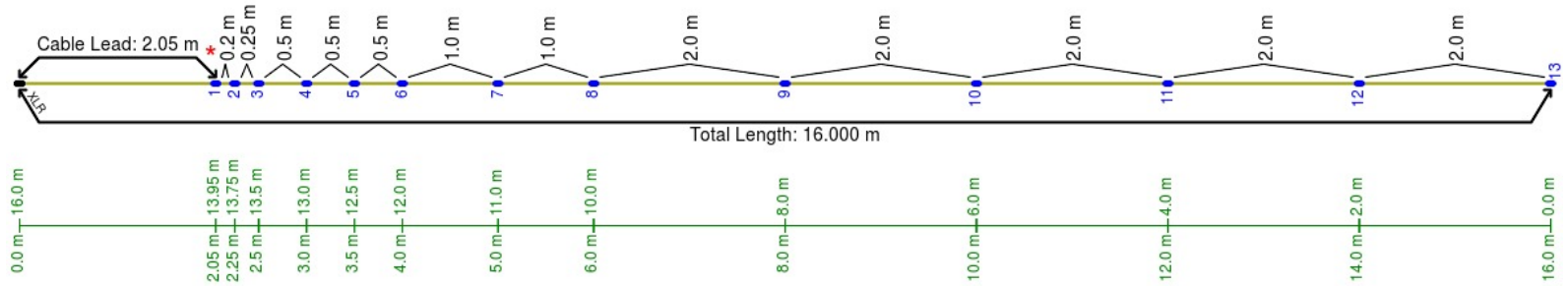
DTC Order Sheet

Customer: SRK Consulting
Project Name: 2018 - Point Hope Phase 1
Order Date:

DTC Name: 13 sensor profiler for: SRK17-BWRP-DH-01, Spare #2
Serial Number: 2841
Units: meters

Object	Mold	Cable	Distance
XLRConnector	XLR Mold	Yellow	2.05m
Protection/Sensor 1	Straight	Yellow	0.2m
Sensor 2	Straight	Yellow	0.25m
Sensor 3	Straight	Yellow	0.5m
Sensor 4	Straight	Yellow	0.5m
Sensor 5	Straight	Yellow	0.5m
Sensor 6	Straight	Yellow	1.0m
Sensor 7	Straight	Yellow	1.0m
Sensor 8	Straight	Yellow	2.0m
Sensor 9	Straight	Yellow	2.0m
Sensor 10	Straight	Yellow	2.0m
Sensor 11	Straight	Yellow	2.0m
Sensor 12	Straight	Yellow	2.0m
Sensor 13	End	N/A	N/A

Comments: Quantity 2 *** Use NO hole sensor boards *** OK to cut Kevlar



* indicates that this sensor contains a protection unit

Return signed order sheet to BeadedStream at
e-mail: contact@beadedstream.com
call: 844-488-4880 for support

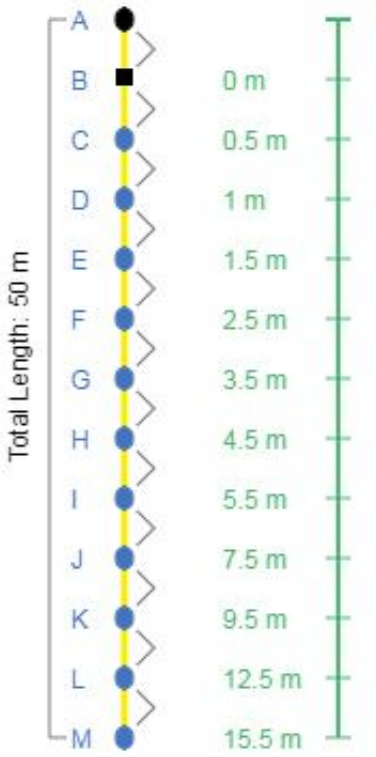
Approved

Date

Customer: SRK Consulting (Alaska)	Date Generated: 02-20-2018
Project: Hope Bay - South Dam	DTC Name: SD-VTS-155-KTC and SD-VTS-460-KTC
Quantity: 2	Serial Number(s): 3251, 3252

Client Notes:
Priority 1

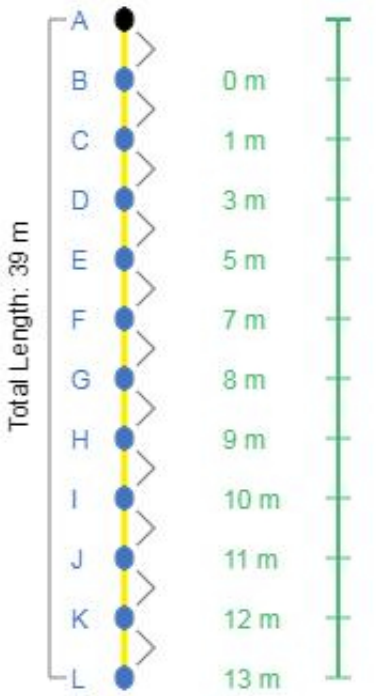
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	34.5 m	yellow
Zero Marker	None	0 m	0.5 m	yellow
Protection/Sensor 1	Straight	0.5 m	0.5 m	yellow
Sensor 2	Straight	1 m	0.5 m	yellow
Sensor 3	Straight	1.5 m	1 m	yellow
Sensor 4	Straight	2.5 m	1 m	yellow
Sensor 5	Straight	3.5 m	1 m	yellow
Sensor 6	Straight	4.5 m	1 m	yellow
Sensor 7	Straight	5.5 m	2 m	yellow
Sensor 8	Straight	7.5 m	2 m	yellow
Sensor 9	Straight	9.5 m	3 m	yellow
Sensor 10	Straight	12.5 m	3 m	yellow
Sensor 11	End Mold	15.5 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 02-20-2018
Project: Hope Bay - South Dam	DTC Name: SD-HTS-155-KT and SD-HTS-460-KT
Quantity: 2	Serial Number(s): 3253, 3254

Client Notes:
Priority 2

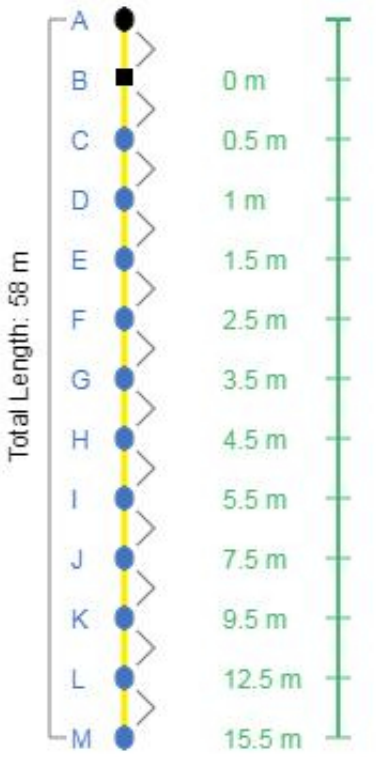
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	26 m	yellow
Protection/Sensor 1	Straight	0 m	1 m	yellow
Sensor 2	Straight	1 m	2 m	yellow
Sensor 3	Straight	3 m	2 m	yellow
Sensor 4	Straight	5 m	2 m	yellow
Sensor 5	Straight	7 m	1 m	yellow
Sensor 6	Straight	8 m	1 m	yellow
Sensor 7	Straight	9 m	1 m	yellow
Sensor 8	Straight	10 m	1 m	yellow
Sensor 9	Straight	11 m	1 m	yellow
Sensor 10	Straight	12 m	1 m	yellow
Sensor 11	End Mold	13 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 02-20-2018
Project: Hope Bay - South Dam	DTC Name: SD-VTS-240-KTC
Quantity: 1	Serial Number(s): 3255

Client Notes:
Priority 1

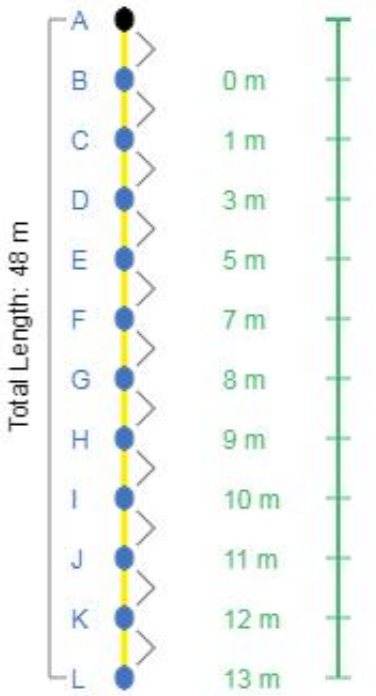
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	42.5 m	yellow
Zero Marker	None	0 m	0.5 m	yellow
Protection/Sensor 1	Straight	0.5 m	0.5 m	yellow
Sensor 2	Straight	1 m	0.5 m	yellow
Sensor 3	Straight	1.5 m	1 m	yellow
Sensor 4	Straight	2.5 m	1 m	yellow
Sensor 5	Straight	3.5 m	1 m	yellow
Sensor 6	Straight	4.5 m	1 m	yellow
Sensor 7	Straight	5.5 m	2 m	yellow
Sensor 8	Straight	7.5 m	2 m	yellow
Sensor 9	Straight	9.5 m	3 m	yellow
Sensor 10	Straight	12.5 m	3 m	yellow
Sensor 11	End Mold	15.5 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 02-20-2018
Project: Hope Bay - South Dam	DTC Name: SD-VTS-240-KT
Quantity: 1	Serial Number(s): 3256

Client Notes:
Priority 2

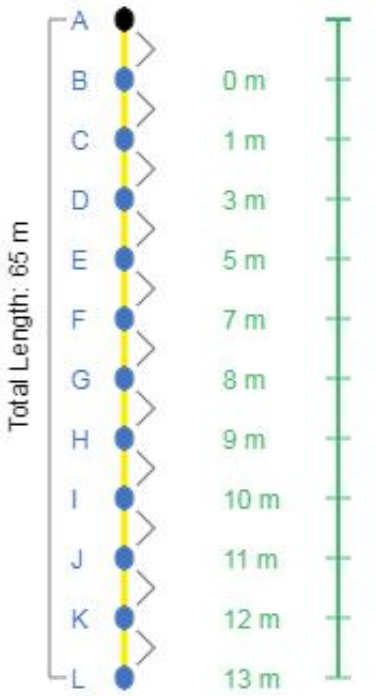
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	35 m	yellow
Protection/Sensor 1	Straight	0 m	1 m	yellow
Sensor 2	Straight	1 m	2 m	yellow
Sensor 3	Straight	3 m	2 m	yellow
Sensor 4	Straight	5 m	2 m	yellow
Sensor 5	Straight	7 m	1 m	yellow
Sensor 6	Straight	8 m	1 m	yellow
Sensor 7	Straight	9 m	1 m	yellow
Sensor 8	Straight	10 m	1 m	yellow
Sensor 9	Straight	11 m	1 m	yellow
Sensor 10	Straight	12 m	1 m	yellow
Sensor 11	End Mold	13 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 02-20-2018
Project: Hope Bay - South Dam	DTC Name: SD-HTS-365-KT
Quantity: 1	Serial Number(s): 3257

Client Notes:
Priority 2

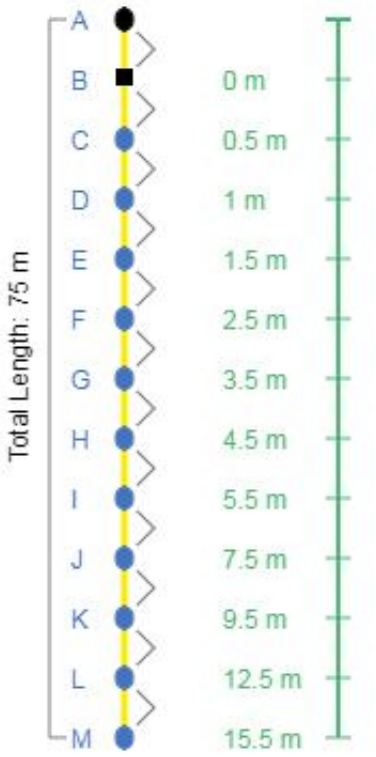
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	52 m	yellow
Protection/Sensor 1	Straight	0 m	1 m	yellow
Sensor 2	Straight	1 m	2 m	yellow
Sensor 3	Straight	3 m	2 m	yellow
Sensor 4	Straight	5 m	2 m	yellow
Sensor 5	Straight	7 m	1 m	yellow
Sensor 6	Straight	8 m	1 m	yellow
Sensor 7	Straight	9 m	1 m	yellow
Sensor 8	Straight	10 m	1 m	yellow
Sensor 9	Straight	11 m	1 m	yellow
Sensor 10	Straight	12 m	1 m	yellow
Sensor 11	End Mold	13 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 02-20-2018
Project: Hope Bay - South Dam	DTC Name: SD-VTS-365-KTC
Quantity: 1	Serial Number(s): 3258

Client Notes:
Priority 1

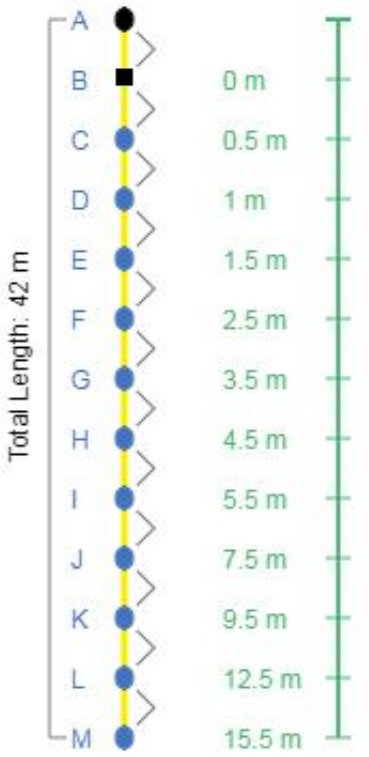
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	59.5 m	yellow
Zero Marker	None	0 m	0.5 m	yellow
Protection/Sensor 1	Straight	0.5 m	0.5 m	yellow
Sensor 2	Straight	1 m	0.5 m	yellow
Sensor 3	Straight	1.5 m	1 m	yellow
Sensor 4	Straight	2.5 m	1 m	yellow
Sensor 5	Straight	3.5 m	1 m	yellow
Sensor 6	Straight	4.5 m	1 m	yellow
Sensor 7	Straight	5.5 m	2 m	yellow
Sensor 8	Straight	7.5 m	2 m	yellow
Sensor 9	Straight	9.5 m	3 m	yellow
Sensor 10	Straight	12.5 m	3 m	yellow
Sensor 11	End Mold	15.5 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 02-20-2018
Project: Hope Bay - South Dam	DTC Name: SD-VTS-065-KTC
Quantity: 1	Serial Number(s): 3259

Client Notes:
Priority 1

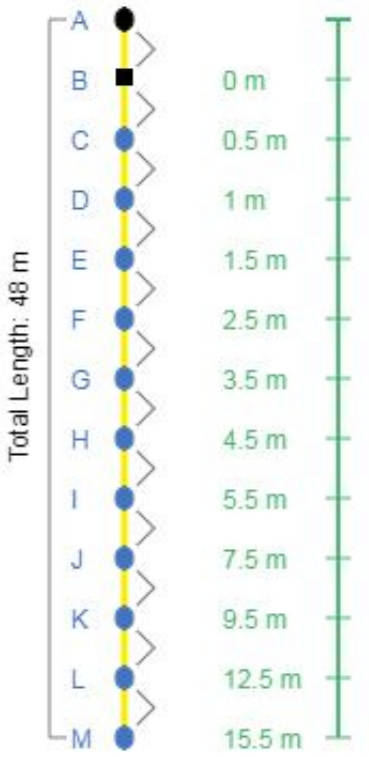
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	26.5 m	yellow
Zero Marker	None	0 m	0.5 m	yellow
Protection/Sensor 1	Straight	0.5 m	0.5 m	yellow
Sensor 2	Straight	1 m	0.5 m	yellow
Sensor 3	Straight	1.5 m	1 m	yellow
Sensor 4	Straight	2.5 m	1 m	yellow
Sensor 5	Straight	3.5 m	1 m	yellow
Sensor 6	Straight	4.5 m	1 m	yellow
Sensor 7	Straight	5.5 m	2 m	yellow
Sensor 8	Straight	7.5 m	2 m	yellow
Sensor 9	Straight	9.5 m	3 m	yellow
Sensor 10	Straight	12.5 m	3 m	yellow
Sensor 11	End Mold	15.5 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 02-20-2018
Project: Hope Bay - South Dam	DTC Name: SD-VTS-510-KTC
Quantity: 1	Serial Number(s): 3260

Client Notes:
Priority 1

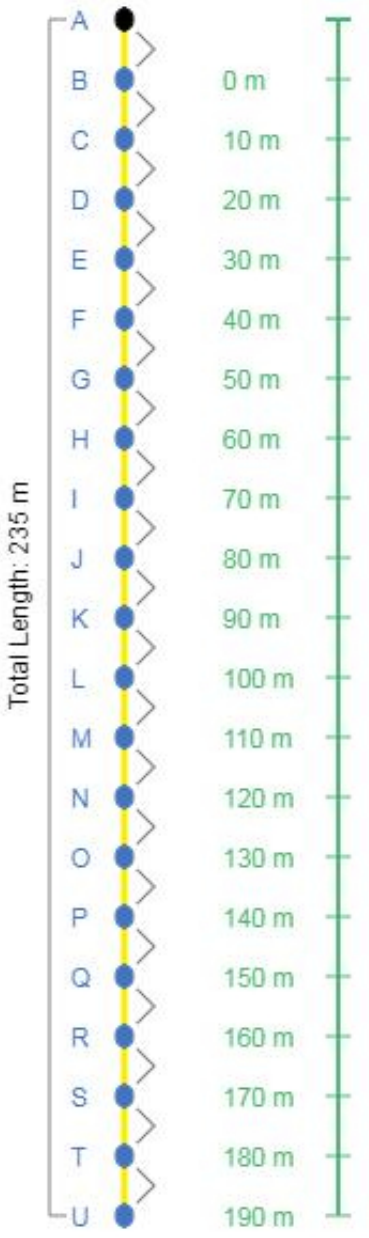
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	32.5 m	yellow
Zero Marker	None	0 m	0.5 m	yellow
Protection/Sensor 1	Straight	0.5 m	0.5 m	yellow
Sensor 2	Straight	1 m	0.5 m	yellow
Sensor 3	Straight	1.5 m	1 m	yellow
Sensor 4	Straight	2.5 m	1 m	yellow
Sensor 5	Straight	3.5 m	1 m	yellow
Sensor 6	Straight	4.5 m	1 m	yellow
Sensor 7	Straight	5.5 m	2 m	yellow
Sensor 8	Straight	7.5 m	2 m	yellow
Sensor 9	Straight	9.5 m	3 m	yellow
Sensor 10	Straight	12.5 m	3 m	yellow
Sensor 11	End Mold	15.5 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 02-20-2018
Project: Hope Bay - South Dam	DTC Name: SD-HST-B1-KT
Quantity: 1	Serial Number(s): 3261

Client Notes:
Priority 3

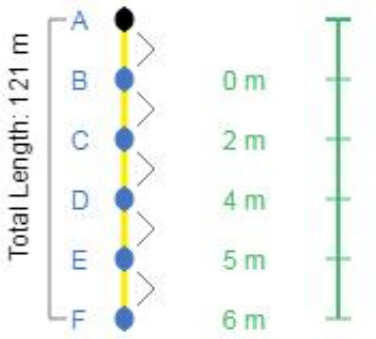
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	45 m	yellow
Protection/Sensor 1	Straight	0 m	10 m	yellow
Sensor 2	Straight	10 m	10 m	yellow
Sensor 3	Straight	20 m	10 m	yellow
Sensor 4	Straight	30 m	10 m	yellow
Sensor 5	Straight	40 m	10 m	yellow
Sensor 6	Straight	50 m	10 m	yellow
Sensor 7	Straight	60 m	10 m	yellow
Sensor 8	Straight	70 m	10 m	yellow
Sensor 9	Straight	80 m	10 m	yellow
Sensor 10	Straight	90 m	10 m	yellow
Sensor 11	Straight	100 m	10 m	yellow
Sensor 12	Straight	110 m	10 m	yellow
Sensor 13	Straight	120 m	10 m	yellow
Sensor 14	Straight	130 m	10 m	yellow
Sensor 15	Straight	140 m	10 m	yellow
Sensor 16	Straight	150 m	10 m	yellow
Sensor 17	Straight	160 m	10 m	yellow
Sensor 18	Straight	170 m	10 m	yellow
Sensor 19	Straight	180 m	10 m	yellow
Sensor 20	End Mold	190 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 03-14-2018
Project: Hope Bay - South Dam - Order 2	DTC Name: SD-HTS-065-US
Quantity: 1	Serial Number(s): 3263

Client Notes:
Priority 1

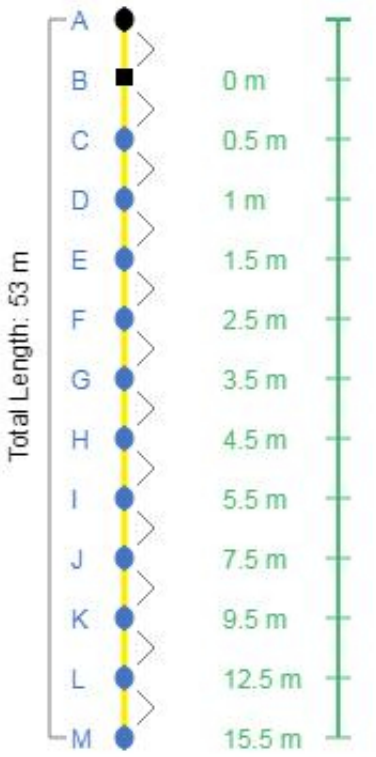
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	115 m	yellow
Protection/Sensor 1	Straight	0 m	2 m	yellow
Sensor 2	Straight	2 m	2 m	yellow
Sensor 3	Straight	4 m	1 m	yellow
Sensor 4	Straight	5 m	1 m	yellow
Sensor 5	End Mold	6 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 03-14-2018
Project: Hope Bay - South Dam - Order 2	DTC Name: SD-VTS-155-DST and SD-VTS-240-DST
Quantity: 2	Serial Number(s): 3264, 3265

Client Notes:
Priority 3

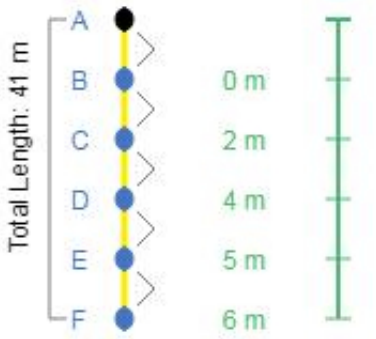
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	37.5 m	yellow
Zero Marker	None	0 m	0.5 m	yellow
Protection/Sensor 1	Straight	0.5 m	0.5 m	yellow
Sensor 2	Straight	1 m	0.5 m	yellow
Sensor 3	Straight	1.5 m	1 m	yellow
Sensor 4	Straight	2.5 m	1 m	yellow
Sensor 5	Straight	3.5 m	1 m	yellow
Sensor 6	Straight	4.5 m	1 m	yellow
Sensor 7	Straight	5.5 m	2 m	yellow
Sensor 8	Straight	7.5 m	2 m	yellow
Sensor 9	Straight	9.5 m	3 m	yellow
Sensor 10	Straight	12.5 m	3 m	yellow
Sensor 11	End Mold	15.5 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 03-14-2018
Project: Hope Bay - South Dam - Order 2	DTC Name: SD-HTS-155-US and SD-HTS-460-US
Quantity: 2	Serial Number(s): 3266, 3267

Client Notes:
Priority 1

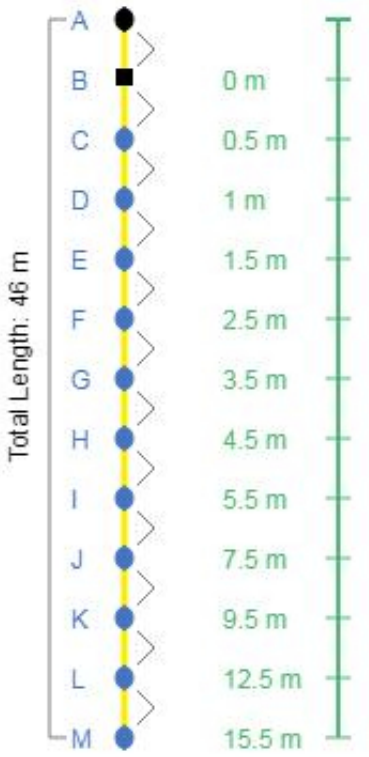
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	35 m	yellow
Protection/Sensor 1	Straight	0 m	2 m	yellow
Sensor 2	Straight	2 m	2 m	yellow
Sensor 3	Straight	4 m	1 m	yellow
Sensor 4	Straight	5 m	1 m	yellow
Sensor 5	End Mold	6 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 03-14-2018
Project: Hope Bay - South Dam - Order 2	DTC Name: SD-VTS-240-UST
Quantity: 1	Serial Number(s): 3268

Client Notes:
Priority 2

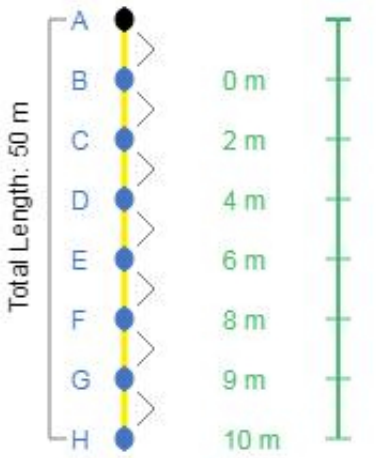
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	30.5 m	yellow
Zero Marker	None	0 m	0.5 m	yellow
Protection/Sensor 1	Straight	0.5 m	0.5 m	yellow
Sensor 2	Straight	1 m	0.5 m	yellow
Sensor 3	Straight	1.5 m	1 m	yellow
Sensor 4	Straight	2.5 m	1 m	yellow
Sensor 5	Straight	3.5 m	1 m	yellow
Sensor 6	Straight	4.5 m	1 m	yellow
Sensor 7	Straight	5.5 m	2 m	yellow
Sensor 8	Straight	7.5 m	2 m	yellow
Sensor 9	Straight	9.5 m	3 m	yellow
Sensor 10	Straight	12.5 m	3 m	yellow
Sensor 11	End Mold	15.5 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 03-14-2018
Project: Hope Bay - South Dam - Order 2	DTC Name: SD-HTS-240-US
Quantity: 1	Serial Number(s): 3269

Client Notes:
Priority 1

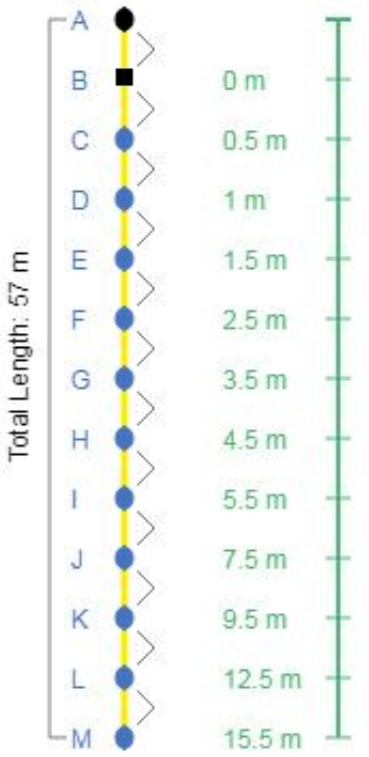
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	40 m	yellow
Protection/Sensor 1	Straight	0 m	2 m	yellow
Sensor 2	Straight	2 m	2 m	yellow
Sensor 3	Straight	4 m	2 m	yellow
Sensor 4	Straight	6 m	2 m	yellow
Sensor 5	Straight	8 m	1 m	yellow
Sensor 6	Straight	9 m	1 m	yellow
Sensor 7	End Mold	10 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 03-14-2018
Project: Hope Bay - South Dam - Order 2	DTC Name: SD-VTS-365-UST
Quantity: 1	Serial Number(s): 3270

Client Notes:
Priority 2

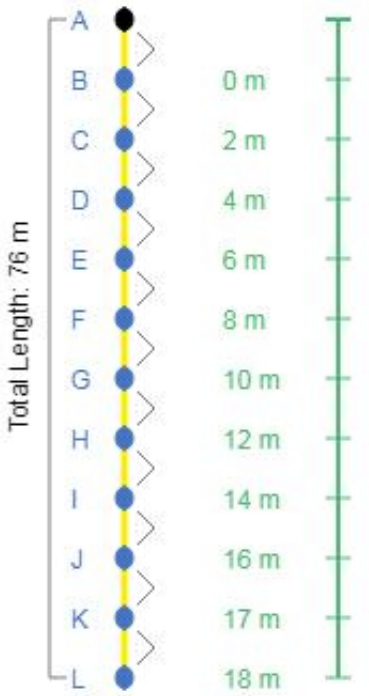
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	41.5 m	yellow
Zero Marker	None	0 m	0.5 m	yellow
Protection/Sensor 1	Straight	0.5 m	0.5 m	yellow
Sensor 2	Straight	1 m	0.5 m	yellow
Sensor 3	Straight	1.5 m	1 m	yellow
Sensor 4	Straight	2.5 m	1 m	yellow
Sensor 5	Straight	3.5 m	1 m	yellow
Sensor 6	Straight	4.5 m	1 m	yellow
Sensor 7	Straight	5.5 m	2 m	yellow
Sensor 8	Straight	7.5 m	2 m	yellow
Sensor 9	Straight	9.5 m	3 m	yellow
Sensor 10	Straight	12.5 m	3 m	yellow
Sensor 11	End Mold	15.5 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 03-14-2018
Project: Hope Bay - South Dam - Order 2	DTC Name: SD-HTS-365-US
Quantity: 1	Serial Number(s): 3271

Client Notes:
Priority 1

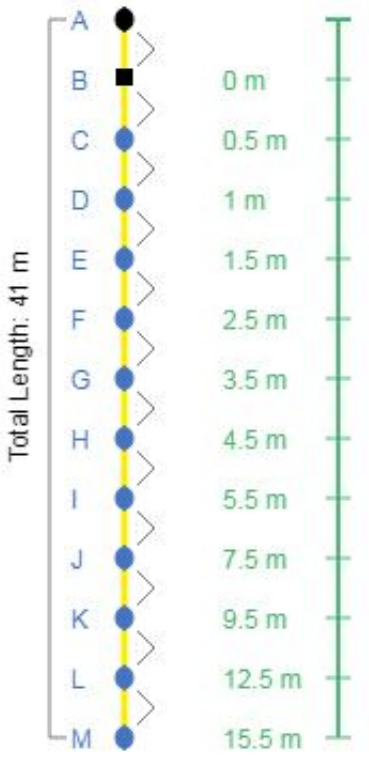
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	58 m	yellow
Protection/Sensor 1	Straight	0 m	2 m	yellow
Sensor 2	Straight	2 m	2 m	yellow
Sensor 3	Straight	4 m	2 m	yellow
Sensor 4	Straight	6 m	2 m	yellow
Sensor 5	Straight	8 m	2 m	yellow
Sensor 6	Straight	10 m	2 m	yellow
Sensor 7	Straight	12 m	2 m	yellow
Sensor 8	Straight	14 m	2 m	yellow
Sensor 9	Straight	16 m	1 m	yellow
Sensor 10	Straight	17 m	1 m	yellow
Sensor 11	End Mold	18 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 03-14-2018
Project: Hope Bay - South Dam - Order 2	DTC Name: SD-VTS-155-UST, SD-VTS-460-UST
Quantity: 2	Serial Number(s): 3272, 3273

Client Notes:
Priority 2

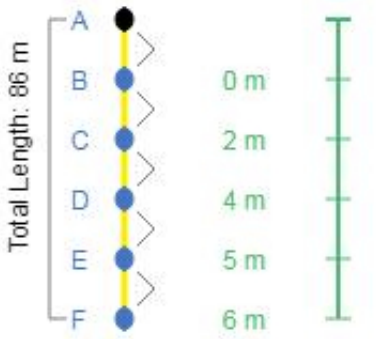
Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	25.5 m	yellow
Zero Marker	None	0 m	0.5 m	yellow
Protection/Sensor 1	Straight	0.5 m	0.5 m	yellow
Sensor 2	Straight	1 m	0.5 m	yellow
Sensor 3	Straight	1.5 m	1 m	yellow
Sensor 4	Straight	2.5 m	1 m	yellow
Sensor 5	Straight	3.5 m	1 m	yellow
Sensor 6	Straight	4.5 m	1 m	yellow
Sensor 7	Straight	5.5 m	2 m	yellow
Sensor 8	Straight	7.5 m	2 m	yellow
Sensor 9	Straight	9.5 m	3 m	yellow
Sensor 10	Straight	12.5 m	3 m	yellow
Sensor 11	End Mold	15.5 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 03-14-2018
Project: Hope Bay - South Dam - Order 2	DTC Name: SD-HTS-510-US
Quantity: 1	Serial Number(s): 3274

Client Notes:
Priority 1

Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	80 m	yellow
Protection/Sensor 1	Straight	0 m	2 m	yellow
Sensor 2	Straight	2 m	2 m	yellow
Sensor 3	Straight	4 m	1 m	yellow
Sensor 4	Straight	5 m	1 m	yellow
Sensor 5	End Mold	6 m	- m	-



Customer: SRK Consulting (Alaska)	Date Generated: 03-16-2018
Project: Hope Bay - South Dam - Order 2	DTC Name: Extensions for SD-VTS-065-KTC, 510-KTC
Quantity: 2	Serial Number(s): 3277, 3278

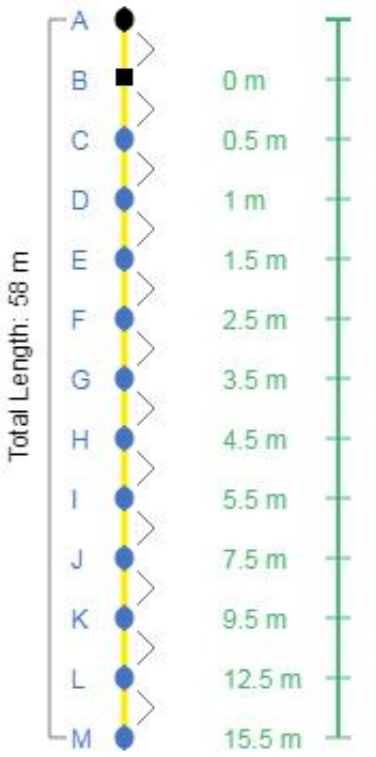
Client Notes:
The "zero marker" on the end of this extension represents the opposite gender XLR connector.

Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	90 m	yellow
Zero Marker	None	0 m	- m	-

Customer: SRK Consulting (Alaska)	Date Generated: 03-16-2018
Project: Hope Bay - South Dam - Order 2	DTC Name: SD-VTS-365-DST, SD-VTS-460-DST
Quantity: 2	Serial Number(s): 3275, 3276

Client Notes:
Priority 3

Component	Mold	Position	Section	Cable
XLR	XLR Mold	-	42.5 m	yellow
Zero Marker	None	0 m	0.5 m	yellow
Protection/Sensor 1	Straight	0.5 m	0.5 m	yellow
Sensor 2	Straight	1 m	0.5 m	yellow
Sensor 3	Straight	1.5 m	1 m	yellow
Sensor 4	Straight	2.5 m	1 m	yellow
Sensor 5	Straight	3.5 m	1 m	yellow
Sensor 6	Straight	4.5 m	1 m	yellow
Sensor 7	Straight	5.5 m	2 m	yellow
Sensor 8	Straight	7.5 m	2 m	yellow
Sensor 9	Straight	9.5 m	3 m	yellow
Sensor 10	Straight	12.5 m	3 m	yellow
Sensor 11	End Mold	15.5 m	- m	-



Appendix K.3 – GTC Calibration Certificates

DTC Calibration Certificate
SRK - Hope Bay Phase 1

This certificate verifies and displays the results of calibration for the digital temperature cables with serial numbers **3187 to 3201**. **3188** had repair work started but was then superseded by replacement cable **3201**. The values are shown in the tables below.

Offset values are a result of BeadedStream's rigorous calibration process where each offset is determined with measurement in a **0.000 °C ice bath** confirmed with our NIST traceable secondary reference platinum RTD (Resistance temperature detector).

When temperature readings are taken with a D405 Datalogger or NetGate (Ethernet Bridge), the offset values are first subtracted from the raw temperature and then are driven to **+/- 0.1 °C accuracy** using BeadedStream's proprietary characteristic error curve correction algorithm.

Sensor	Sensor ID	Offset
	Serial 3187	
1	E6 00 00 07 12 68 2F 28	0.250
2	BC 00 00 08 40 A4 88 28	1.000
3	94 00 00 08 40 4C 14 28	0.438
4	2B 00 00 08 40 EA 8C 28	0.375
5	A3 00 00 08 40 A4 EC 28	0.875
6	66 00 00 08 40 B6 02 28	0.938
7	2F 00 00 08 41 31 A2 28	0.438
8	65 00 00 08 41 06 62 28	0.250
9	37 00 00 08 40 C5 F2 28	0.438
10	29 00 00 08 41 4C B6 28	0.375
11	78 00 00 08 41 30 C1 28	0.375
12	2C 00 00 08 41 06 F9 28	0.375
13	45 00 00 08 40 9D 55 28	1.000
14	DE 00 00 08 40 6B 5D 28	0.438
15	15 00 00 08 41 36 03 28	0.375
	Serial 3189	
1	29 00 00 07 12 09 21 28	0.375
2	B2 00 00 08 40 4C 08 28	0.500

*Calibrations performed by **Lindsey Bohnert** (Tech Ops Associate) on **January 24th 2018***
*Cable 3201 calibrated and added and certificate completed by **Paul Harren** (Project Manager) on **February 1st 2018***

3	F1 00 00 08 40 6B 88 28	0.438
4	EE 00 00 08 40 5D 38 28	1.000
5	D1 00 00 08 40 8F F4 28	0.375
6	52 00 00 08 41 22 0C 28	0.438
7	98 00 00 08 41 38 D6 28	0.438
8	C0 00 00 08 3F F1 41 28	0.563
9	BD 00 00 08 41 49 D1 28	0.313
10	E0 00 00 08 40 A5 31 28	1.000
11	87 00 00 08 40 64 D9 28	0.750
12	05 00 00 08 41 30 CD 28	0.438
13	3A 00 00 08 40 64 23 28	0.813
14	EE 00 00 08 40 64 6B 28	1.000
15	EF 00 00 08 41 36 1B 28	0.313
	Serial 3190	
1	65 00 00 07 12 67 9A 28	0.188
2	A5 00 00 08 40 5D B0 28	0.938
3	38 00 00 08 41 22 28 28	0.250
4	DB 00 00 08 40 19 58 28	0.875
5	CA 00 00 08 40 64 64 28	0.938
6	D5 00 00 08 3F CD 54 28	0.313
7	76 00 00 08 40 11 F2 28	0.563
8	55 00 00 08 40 92 4A 28	0.500
9	59 00 00 08 40 64 CE 28	1.000
10	F4 00 00 08 40 8F 7E 28	0.125
11	65 00 00 08 41 22 0D 28	0.375
12	3B 00 00 08 3F B0 D3 28	0.875
	Serial 3191	
1	A0 00 00 07 12 7A F3 28	0.250
2	70 00 00 08 41 49 C8 28	0.625
3	D5 00 00 08 41 22 18 28	0.313
4	E4 00 00 08 40 64 34 28	0.875
5	6E 00 00 08 40 38 FC 28	0.750
6	AC 00 00 08 3F FD FC 28	0.313
7	C6 00 00 08 3F B1 62 28	1.125

*Calibrations performed by **Lindsey Bohnert** (Tech Ops Associate) on **January 24th 2018***
*Cable 3201 calibrated and added and certificate completed by **Paul Harren** (Project Manager) on **February 1st 2018***

11	CE 00 00 08 40 19 63 28	1.000
12	B0 00 00 08 41 38 B3 28	0.500
	Serial 3197	
1	B0 00 00 07 12 08 CD 28	0.438
2	2E 00 00 08 3F D1 EC 28	0.375
3	57 00 00 08 40 EB 1C 28	0.438
4	4B 00 00 08 40 59 72 28	0.250
5	53 00 00 08 40 7A 86 28	1.125
6	F7 00 00 08 3F B1 56 28	0.938
7	3A 00 00 08 40 EA 91 28	0.438
8	03 00 00 08 40 8F 89 28	0.500
9	F6 00 00 08 40 A4 85 28	0.938
10	25 00 00 08 40 8F 95 28	0.375
11	41 00 00 08 40 11 F3 28	0.438
12	89 00 00 08 41 38 CB 28	0.375
13	79 00 00 08 40 90 3B 28	0.063
	Serial 3198	
1	2F 00 00 07 12 09 14 28	0.250
2	66 00 00 08 40 D9 98 28	0.375
3	32 00 00 08 40 7A 78 28	0.875
4	47 00 00 08 40 A5 0C 28	1.000
5	3E 00 00 08 40 9D 6C 28	0.813
6	E7 00 00 08 40 A5 81 28	1.000
7	2C 00 00 08 40 72 51 28	0.250
8	72 00 00 08 3F CD 69 28	0.500
9	4A 00 00 08 40 57 69 28	0.438
10	97 00 00 08 41 22 59 28	0.375
11	AC 00 00 08 40 FE 75 28	0.563
12	53 00 00 08 40 D6 0D 28	0.375
13	2C 00 00 08 40 D1 5D 28	0.938
	Serial 3199	
1	29 00 00 07 12 AF 50 28	0.188
2	9C 00 00 08 40 D9 80 28	0.188
3	43 00 00 08 40 9D 60 28	0.938

*Calibrations performed by **Lindsey Bohnert** (Tech Ops Associate) on **January 24th 2018***
*Cable 3201 calibrated and added and certificate completed by **Paul Harren** (Project Manager) on **February 1st 2018***

DTC Calibration Certificate
SRK - Hope Bay South Dam

This certificate verifies and displays the results of calibration for the digital temperature cables with serial numbers **3251 to 3261**. The values are shown in the tables below.

Offset values are a result of BeadedStream's rigorous calibration process where each offset is determined with measurement in a **0.000 °C ice bath** confirmed with our NIST traceable secondary reference platinum RTD (Resistance temperature detector).

When temperature readings are taken with a D405 Datalogger, NetGate, or Recite, the offset values are first subtracted from the raw temperature and then are driven to **+/- 0.1 °C accuracy** using BeadedStream's proprietary characteristic error curve correction algorithm.

Sensor	Sensor ID	Offset
	Serial 3251	
1	B2 00 00 07 11 F6 10 28	0.250
2	EA 00 00 07 12 11 00 28	0.188
3	C3 00 00 07 12 46 30 28	0.375
4	21 00 00 07 12 42 98 28	0.250
5	37 00 00 07 12 46 51 28	0.125
6	43 00 00 07 12 60 C9 28	0.250
7	A7 00 00 07 12 27 69 28	0.250
8	CF 00 00 07 12 24 75 28	0.375
9	35 00 00 07 12 7B 75 28	0.250
10	88 00 00 07 12 9E C3 28	0.188
11	73 00 00 07 12 51 E3 28	0.250
	Serial 3252	
1	54 00 00 07 12 09 2D 28	0.313
2	C5 00 00 07 12 1C 60 28	0.250
3	C8 00 00 07 12 AD 38 28	0.125
4	7D 00 00 07 12 19 44 28	0.250
5	84 00 00 07 12 9D 82 28	0.188
6	D3 00 00 07 12 6F 72 28	0.250
7	23 00 00 07 12 01 B6 28	0.250

*Calibrations performed by **Lindsey Bohnert** (Tech Ops Associate) on **March 2nd 2018***

8	2A 00 00 07 12 2B 8E 28	0.250
9	DD 00 00 07 12 9A CE 28	0.313
10	6D 00 00 07 11 FD 61 28	0.188
11	22 00 00 07 12 77 F1 28	0.250
	Serial 3253	
1	60 00 00 07 12 A0 4C 28	0.313
2	1C 00 00 07 11 E3 10 28	0.313
3	46 00 00 07 12 49 B0 28	0.063
4	8F 00 00 07 12 A3 44 28	0.313
5	C8 00 00 07 11 F8 32 28	0.250
6	16 00 00 07 11 F3 C6 28	0.313
7	52 00 00 07 12 3D FE 28	0.375
8	B0 00 00 07 12 42 21 28	0.250
9	B1 00 00 07 12 01 99 28	0.313
10	91 00 00 07 12 42 8D 28	0.188
11	8C 00 00 07 12 96 2D 28	0.188
	Serial 3254	
1	20 00 00 07 12 A1 07 28	0.313
2	26 00 00 07 12 78 50 28	0.250
3	4B 00 00 07 11 FC 64 28	0.250
4	9E 00 00 07 12 64 2C 28	0.188
5	35 00 00 07 12 74 F2 28	0.125
6	5C 00 00 07 12 5E B1 28	0.313
7	5B 00 00 07 12 10 89 28	0.188
8	18 00 00 07 12 49 03 28	0.063
9	D3 00 00 07 12 AC 63 28	0.188
10	DE 00 00 07 12 78 5B 28	0.188
11	07 00 00 07 12 2C 07 28	0.188
	Serial 3255	
1	41 00 00 07 12 6A 20 28	0.250
2	17 00 00 07 12 4E B0 28	0.250
3	6A 00 00 07 12 78 68 28	0.125
4	36 00 00 07 11 F0 C4 28	0.250
5	1B 00 00 07 12 48 8C 28	0.188

*Calibrations performed by **Lindsey Bohnert** (Tech Ops Associate) on **March 2nd 2018***

6	53 00 00 07 12 2D F2 28	0.313
7	81 00 00 07 12 45 5A 28	0.313
8	34 00 00 07 12 2A 76 28	0.375
9	CC 00 00 07 12 60 91 28	0.188
10	4A 00 00 07 12 19 45 28	0.250
11	96 00 00 07 12 27 5D 28	0.125
	Serial 3256	
1	94 00 00 07 12 93 84 28	0.250
2	55 00 00 07 11 EC 0C 28	0.188
3	61 00 00 07 11 E3 1C 28	0.188
4	C8 00 00 07 12 A7 C2 28	0.125
5	35 00 00 07 12 42 26 28	0.250
6	92 00 00 07 12 33 96 28	0.250
7	A2 00 00 07 12 00 8E 28	0.125
8	D5 00 00 07 12 8C 5D 28	0.125
9	56 00 00 07 12 0C 43 28	0.125
10	03 00 00 07 12 5A E3 28	0.188
11	0F 00 00 07 12 50 73 28	0.188
	Serial 3257	
1	B4 00 00 07 12 91 9F 28	0.063
2	E8 00 00 07 12 AC 08 28	0.125
3	11 00 00 07 12 90 A8 28	0.188
4	C6 00 00 07 12 AC 58 28	0.250
5	37 00 00 07 12 14 FC 28	0.313
6	78 00 00 07 12 A2 AA 28	0.313
7	82 00 00 07 11 E8 B6 28	0.313
8	19 00 00 07 12 A7 29 28	0.250
9	2F 00 00 07 12 78 99 28	0.250
10	24 00 00 07 11 F8 87 28	0.313
11	95 00 00 07 12 08 47 28	0.188
	Serial 3258	
1	27 00 00 07 12 7A E7 28	0.313
2	F3 00 00 07 11 F9 40 28	0.188
3	25 00 00 07 12 38 D0 28	0.000

*Calibrations performed by **Lindsey Bohnert** (Tech Ops Associate) on **March 2nd 2018***

4	05 00 00 07 12 77 68 28	0.313
5	94 00 00 07 12 2B E2 28	0.313
6	0D 00 00 07 11 F1 B6 28	0.313
7	3D 00 00 07 12 00 4E 28	0.438
8	5D 00 00 07 12 15 C1 28	0.313
9	78 00 00 07 12 0A 45 28	0.250
10	62 00 00 07 11 EC 0D 28	0.313
11	E9 00 00 07 12 33 AF 28	0.250
	Serial 3259	
1	20 00 00 07 11 E9 31 28	0.313
2	64 00 00 07 12 98 20 28	0.250
3	28 00 00 07 12 2A 84 28	0.188
4	70 00 00 07 12 9A AC 28	0.250
5	2A 00 00 07 12 36 B2 28	0.313
6	E0 00 00 07 12 0D 7A 28	0.313
7	42 00 00 07 12 16 8E 28	0.250
8	03 00 00 07 12 08 4E 28	0.250
9	AD 00 00 07 12 3E 6E 28	0.313
10	27 00 00 07 12 00 89 28	0.188
11	B9 00 00 07 12 A8 23 28	0.313
	Serial 3260	
1	BB 00 00 07 12 9D CF 28	0.313
2	DB 00 00 07 11 FC 58 28	0.250
3	86 00 00 07 12 45 EA 28	0.250
4	57 00 00 07 11 ED 06 28	0.188
5	58 00 00 07 11 F0 C6 28	0.250
6	85 00 00 07 12 01 0E 28	0.250
7	8A 00 00 07 12 97 01 28	0.375
8	5A 00 00 07 11 F0 D5 28	0.313
9	04 00 00 07 12 4B C3 28	0.563
10	8B 00 00 07 12 01 77 28	0.250
11	94 00 00 07 11 FD EF 28	0.438
	Serial 3261	
1	A6 00 00 07 12 39 FB 28	0.250

*Calibrations performed by **Lindsey Bohnert** (Tech Ops Associate) on **March 2nd 2018***

2	27 00 00 07 12 01 90 28	0.313
3	FD 00 00 07 12 A7 D0 28	0.563
4	22 00 00 07 12 55 C8 28	0.563
5	7B 00 00 07 12 2A D8 28	0.500
6	53 00 00 07 11 E9 44 28	0.375
7	63 00 00 07 11 F1 B4 28	0.563
8	F7 00 00 07 12 2E 72 28	0.688
9	F3 00 00 07 11 FB 72 28	0.500
10	51 00 00 07 12 4B AA 28	0.563
11	AA 00 00 07 12 A7 AA 28	0.250
12	94 00 00 07 12 42 2E 28	0.375
13	68 00 00 07 12 10 AE 28	0.313
14	B7 00 00 07 12 45 DE 28	0.438
15	6F 00 00 07 12 17 51 28	0.438
16	36 00 00 07 12 79 D1 28	0.125
17	26 00 00 07 12 01 15 28	0.313
18	12 00 00 07 12 08 53 28	0.375
19	1D 00 00 07 11 ED 0B 28	0.375
20	BF 00 00 07 12 44 8B 28	0.375

DTC Calibration Certificate
SRK - Hope Bay South Dam Order 2

This certificate verifies and displays the results of calibration for the digital temperature cables with serial numbers **3263 to 3276**. The values are shown in the tables below.

Offset values are a result of BeadedStream's rigorous calibration process where each offset is determined with measurement in a **0.000 °C ice bath** confirmed with our NIST traceable secondary reference platinum RTD (Resistance temperature detector).

When temperature readings are taken with a D405 Datalogger, NetGate, or Recite, the offset values are first subtracted from the raw temperature and then are driven to **+/- 0.1 °C accuracy** using BeadedStream's proprietary characteristic error curve correction algorithm.

Sensor	Sensor ID	Offset
	Serial 3263	
1	9D 00 00 07 12 7F D0 28	0.188
2	92 00 00 07 11 F3 44 28	0.375
3	E7 00 00 07 12 39 2C 28	0.125
4	04 00 00 07 12 29 EC 28	0.188
5	DE 00 00 07 11 F6 01 28	0.250
	Serial 3264	
1	5D 00 00 07 11 E9 3D 28	0.188
2	36 00 00 07 11 F8 0C 28	0.313
3	CF 00 00 07 11 F8 82 28	0.313
4	D8 00 00 07 12 AF 92 28	0.313
5	B4 00 00 07 12 2A D2 28	0.188
6	23 00 00 07 12 5A CA 28	0.250
7	1F 00 00 07 11 EC 01 28	0.063
8	4C 00 00 07 12 87 4B 28	0.188
9	00 00 00 07 11 F3 6B 28	0.188
10	AD 00 00 07 12 0D C7 28	0.250
11	2E 00 00 07 12 7B 37 28	0.188
	Serial 3265	

*Calibrations performed by **Lindsey Bohnert and Trevor Sprague** (Tech Ops Associates) on **April 7th 2018***

1	0B 00 00 07 12 32 7A 28	0.063
2	38 00 00 07 12 9C E4 28	0.250
3	37 00 00 07 11 F5 3C 28	0.313
4	C7 00 00 07 12 61 52 28	-0.063
5	42 00 00 07 12 87 32 28	0.125
6	F3 00 00 07 11 F3 BA 28	0.375
7	C9 00 00 07 12 2A DE 28	-0.063
8	4C 00 00 07 12 10 A1 28	0.125
9	6F 00 00 07 12 0E 09 28	0.125
10	AE 00 00 07 12 A8 0B 28	0.250
11	AD 00 00 07 12 8D EB 28	0.250
	Serial 3266	
1	7B 00 00 07 12 7F 3A 28	0.313
2	8E 00 00 07 12 4B 38 28	0.188
3	0F 00 00 07 12 75 05 28	0.188
4	39 00 00 07 12 14 85 28	0.125
5	5D 00 00 07 12 46 75 28	0.125
	Serial 3267	
1	CB 00 00 07 11 E9 34 28	0.250
2	46 00 00 07 12 3D 40 28	0.125
3	DB 00 00 07 12 91 18 28	0.438
4	2A 00 00 07 12 2D D8 28	0.125
5	DC 00 00 07 12 02 26 28	0.250
	Serial 3268	
1	87 00 00 07 12 08 CC 28	0.313
2	19 00 00 07 12 64 38 28	0.188
3	FF 00 00 07 12 A8 44 28	0.125
4	9A 00 00 07 12 64 0A 28	0.313
5	C5 00 00 07 12 87 26 28	0.063
6	17 00 00 07 11 F6 3E 28	0.188
7	95 00 00 07 12 3C A1 28	0.438
8	E5 00 00 07 11 EC 19 28	0.250
9	65 00 00 07 11 F5 E5 28	0.125
10	6A 00 00 07 12 33 9D 28	0.125

*Calibrations performed by **Lindsey Bohnert and Trevor Sprague** (Tech Ops Associates) on **April 7th 2018***

11	C6 00 00 07 12 32 63 28	0.125
	Serial 3269	
1	6E 00 00 07 12 93 9C 28	0.188
2	F5 00 00 07 11 FC 08 28	0.250
3	09 00 00 07 12 3B B8 28	0.188
4	4B 00 00 07 11 F4 AC 28	0.313
5	EA 00 00 07 12 17 56 28	0.125
6	5F 00 00 07 12 AC AD 28	0.000
7	CE 00 00 07 11 FC 63 28	0.188
	Serial 3270	
1	18 00 00 07 12 09 15 28	0.313
2	8C 00 00 07 12 2D 60 28	0.438
3	10 00 00 07 12 4A 64 28	0.250
4	44 00 00 07 12 2B 8C 28	0.063
5	3F 00 00 07 12 A6 2C 28	0.250
6	2B 00 00 07 12 75 0A 28	0.188
7	24 00 00 07 12 10 96 28	0.188
8	BD 00 00 07 12 04 8E 28	0.188
9	55 00 00 07 12 74 89 28	0.250
10	BB 00 00 07 12 A5 85 28	0.250
11	DF 00 00 07 12 85 D3 28	0.125
	Serial 3271	
1	2B 00 00 07 12 AF 43 28	0.375
2	52 00 00 07 12 01 D0 28	0.438
3	FC 00 00 07 12 81 08 28	0.313
4	16 00 00 07 12 5A D8 28	0.125
5	86 00 00 07 12 5A E4 28	0.125
6	3F 00 00 07 12 7B 2A 28	0.125
7	7E 00 00 07 11 ED E6 28	0.375
8	2D 00 00 07 11 F8 4E 28	0.125
9	71 00 00 07 12 3D 41 28	0.250
10	4B 00 00 07 12 2A 69 28	0.250
11	7C 00 00 07 12 91 25 28	0.063
	Serial 3272	

*Calibrations performed by **Lindsey Bohnert and Trevor Sprague** (Tech Ops Associates) on **April 7th 2018***

1	ED 00 00 07 11 F0 70 28	0.125
2	98 00 00 07 12 9D 70 28	0.125
3	22 00 00 07 12 02 18 28	0.250
4	ED 00 00 07 11 F8 B8 28	0.375
5	56 00 00 07 12 AC 64 28	0.313
6	4D 00 00 07 12 01 B4 28	0.125
7	5B 00 00 07 12 1B 6A 28	0.313
8	4C 00 00 07 12 02 1A 28	0.188
9	BA 00 00 07 12 99 2E 28	0.313
10	5C 00 00 07 12 01 A9 28	0.125
11	F7 00 00 07 12 6F 7D 28	0.125
	Serial 3273	
1	98 00 00 07 12 AF C0 28	0.188
2	BF 00 00 07 12 9C F0 28	0.250
3	B1 00 00 07 11 F8 18 28	0.250
4	AB 00 00 07 12 16 98 28	0.125
5	D6 00 00 07 12 2C EC 28	0.250
6	54 00 00 07 12 A1 C2 28	0.188
7	CE 00 00 07 12 85 CE 28	0.250
8	B8 00 00 07 12 95 91 28	0.188
9	54 00 00 07 12 2E 69 28	0.125
10	D5 00 00 07 11 F4 E9 28	0.250
11	26 00 00 07 12 2E 99 28	0.250
	Serial 3274	
1	7B 00 00 07 12 90 8C 28	0.250
2	EA 00 00 07 12 4A 7C 28	0.125
3	0F 00 00 07 12 59 A2 28	0.188
4	4B 00 00 07 12 5D B2 28	0.000
5	B6 00 00 07 11 F6 36 28	0.188
	Serial 3275	
1	41 00 00 07 11 E8 D6 28	0.250
2	FB 00 00 07 12 60 90 28	0.188
3	AA 00 00 07 12 6F 58 28	0.125
4	9F 00 00 07 12 04 B4 28	0.313

*Calibrations performed by **Lindsey Bohnert and Trevor Sprague** (Tech Ops Associates) on **April 7th 2018***

5	E6 00 00 07 12 23 DA 28	0.250
6	49 00 00 07 12 A2 9E 28	0.188
7	92 00 00 07 12 02 0D 28	0.250
8	54 00 00 07 12 18 BD 28	0.250
9	31 00 00 07 11 FF F3 28	0.375
10	6C 00 00 07 12 1B 6B 28	0.063
11	AD 00 00 07 11 FD 97 28	0.313
	Serial 3276	
1	54 00 00 07 12 8B 33 28	0.125
2	09 00 00 07 12 75 30 28	0.188
3	CC 00 00 07 11 FC 70 28	0.438
4	12 00 00 07 12 9A C4 28	0.188
5	D5 00 00 07 12 01 C4 28	0.250
6	CD 00 00 07 12 2E 9C 28	0.250
7	23 00 00 07 11 EC DA 28	0.313
8	E4 00 00 07 12 00 E9 28	0.125
9	75 00 00 07 11 EC 25 28	0.250
10	30 00 00 07 11 EB 9B 28	0.188
11	69 00 00 07 12 52 0F 28	0.188

Appendix L – Material Testing Results

Appendix L.1 – Particle Size Distributions and Hydrometers

Particle Size (mm)	Percentage Passing Allowance (%)
200	100
100	60-100
50	40-70
20	20-50
10	0-30
5	0-10

Specification for Transition Material

srk consulting	TMAC RESOURCES	**South Dam**
		Transition Material Field Level PSD Photos
Project No: 1CT022.031	Hope Bay	Date: March 14, 2018 / Approved: KC / Photo Sheet: **n/a**

Photo 1: Overview of sample. Finer fraction of material nearer camera.

Photo 2: Overview of sample. Coarser fraction of material nearer camera.

*Sample was segregated by hand to allow an easier visual comprehension of the particle size distribution present.

** White measuring stick is 1 m in length.

srk consulting	TMAC RESOURCES	**South Dam** **Transition Material Field Level PSD Photos**
Project No: 1CT022.031	Hope Bay	Date: March 14, 2018 / Approved: KC / Photo Sheet: **1**

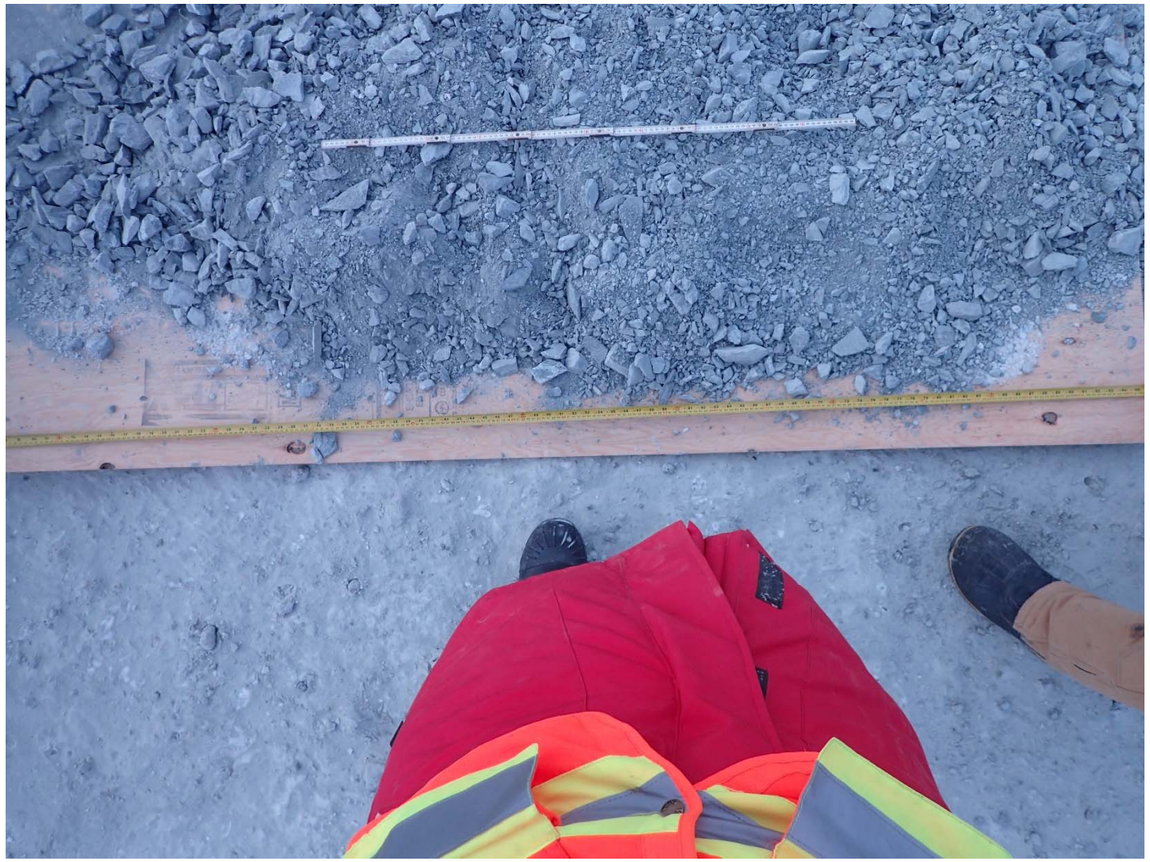


Photo 3: Closer view of finer fraction of sample.

Photo 4: Closer view of finer fraction of sample.

** White measuring stick is 1 m in length.

srk consulting	TMAC RESOURCES	**South Dam**
		Transition Material Field Level PSD Photos
Project No: 1CT022.031	Hope Bay	Date: March 14, 2018 / Approved: KC / Photo Sheet: **2**

Photo 5: Closer view of coarser fraction of sample.

There was approximately 5 oversized particles each with one-dimension greater than 200mm. Over-sized particles were measured to have one dimension ranging from 300 mm to 350 mm.

srk consulting	TMAC RESOURCES	South Dam		
		Transition Material Field Level PSD Photos		
Project No: 1CT022.031	Hope Bay	Date: March 14, 2018	Approved: KC	Photo Sheet: 3

Photo 6: Transition material coming off the crusher belt. Some fines blowing off belt/pile (in slight breeze – approximately 5 knots at the time of test).

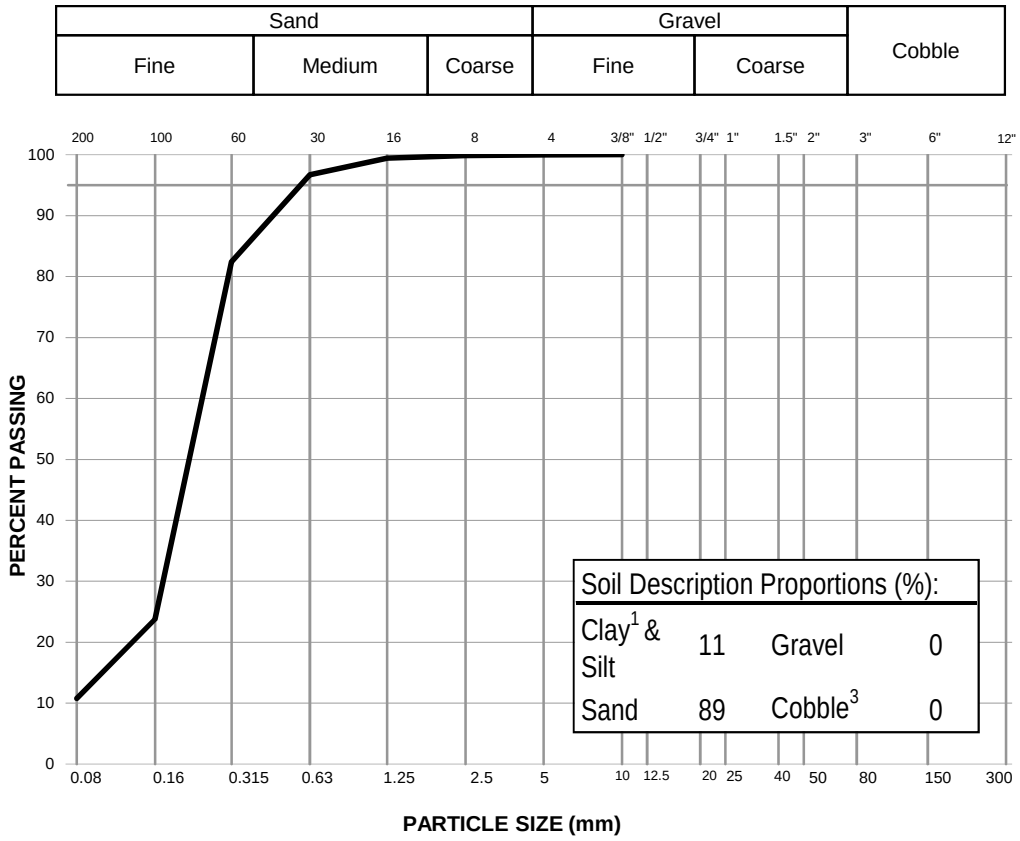
srk consulting	MAC RESOURCES	South Dam		
		Transition Material Field Level PSD Photos		
Project No: 1CT022.031	Hope Bay	Date: March 14, 2018	Approved: KC	Photo Sheet: 4

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29633
Project No.:	Y14103336-02.003	Material Type:	
Site:	Hope Bay, NU	Sample Loc.:	SRK18-STH-DH-09
Client:	TMAC Resources Inc.	Sample Depth:	8.2-9.2 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	March 15, 2018 By: WM	Date sampled:	February 26, 2018
Soil Description[2]:	SAND, some silt/clay.	Sampled By:	Client
		USC Classification:	SP Cu: #N/A
Moisture Content:	23.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
200	
150	
100	
75	
50	
40	
25	
20	
16	
12.5	
10	100
5	100
2.5	100
1.25	99
0.63	97
0.315	82
0.16	24
0.08	10.8



Notes:
[1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to Tetra Tech description protocols
[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: _____

Remarks: _____

_____

Reviewed By: _____ P.Geol

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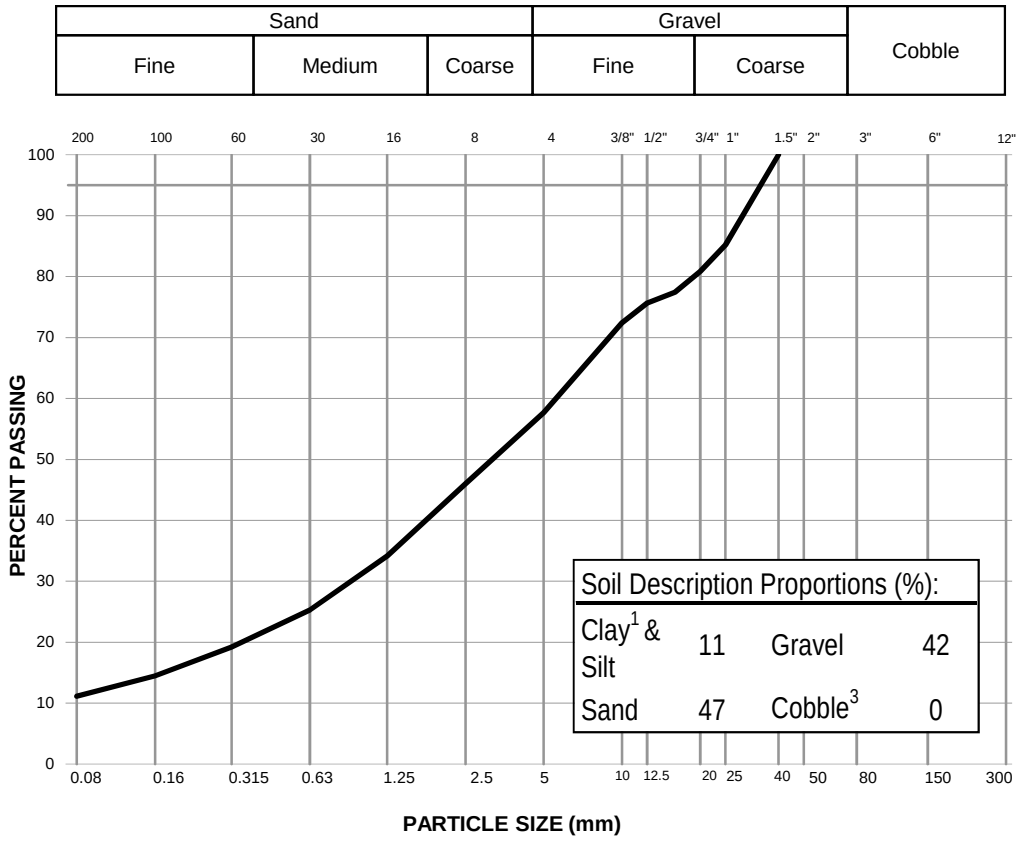
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205969
Project No.:	Y14103336-02.003	Material Type:	
Site:	Hope Bay, NU	Sample Loc.:	SRK18-STH-DH-04
Client:	TMAC Resources Inc.	Sample Depth:	10.2-10.4 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	March 15, 2018 By: WM	Date sampled:	February 20, 2018
Soil Description[2]:	SAND and GRAVEL, some silt/clay.	Sampled By:	Client
		USC Classification:	SW Cu: #N/A
Moisture Content:	7.2%		Cc: #N/A

Particle Size (mm)	Percent Passing
200	
150	
100	
75	
50	
40	100
25	85
20	81
16	77
12.5	76
10	72
5	58
2.5	46
1.25	34
0.63	25
0.315	19
0.16	14
0.08	11.1



Notes:
[1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to Tetra Tech description protocols
[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: _____

Remarks: _____

_____

Reviewed By: _____ P.Geol

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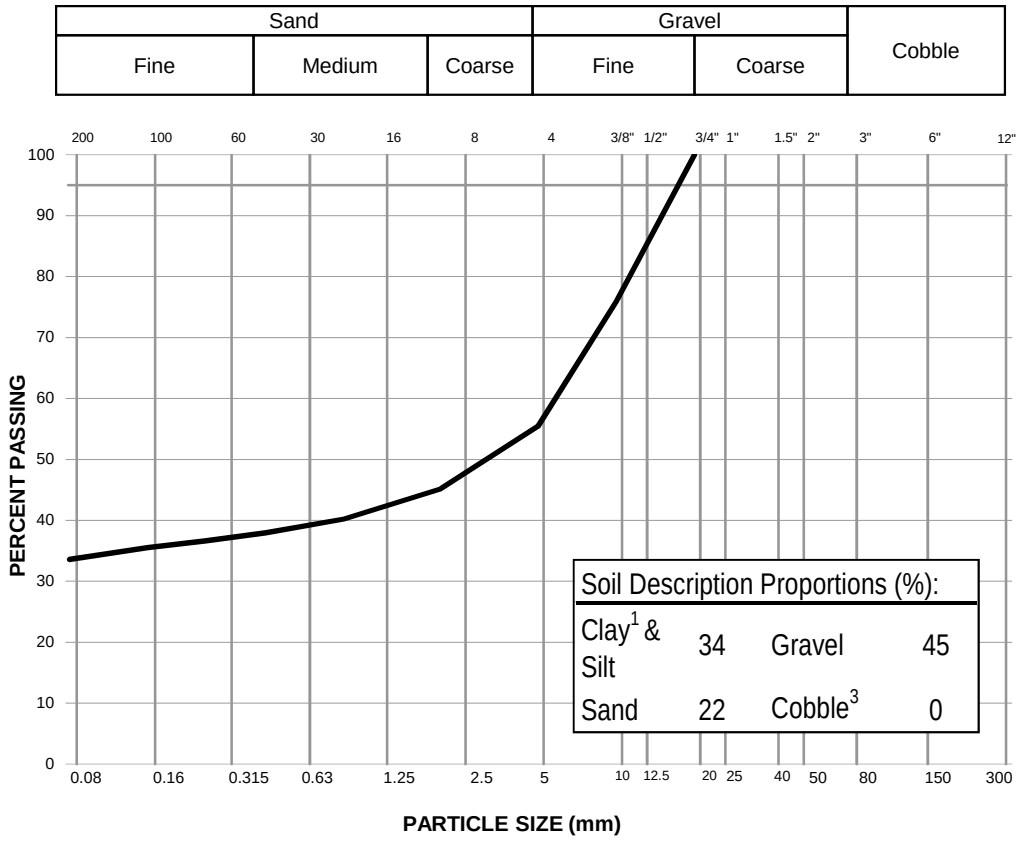
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6672-206028
Project No.:	Y14103336-02.003	Material Type:	Concrete Blend
Site:	Hope Bay, NU	Sample Loc.:	Hope Bay Batch Plant
Client:	TMAC Resources Inc.	Sample Depth:	
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 11, 2018 By: WM	Date sampled:	March 27, 2018
Soil Description[2]:	Concrete rock, manufactured sand, and cementitious materials	Sampled By:	Client
		USC Classification:	Cu: #N/A
Moisture Content:	0.6%		Cc: #N/A

Particle Size (mm)	Percent Passing
0	
0	
0	
0	
0	
0	
50	
37.5	
28	
19	100
9.5	76
4.75	55
2	45
0.85	40
0.425	38
0.25	37
0.15	36
0.075	33.6



Notes:
[1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to Tetra Tech description protocols
[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: _____

Remarks: _____

_____

Reviewed By: _____ P.Geol

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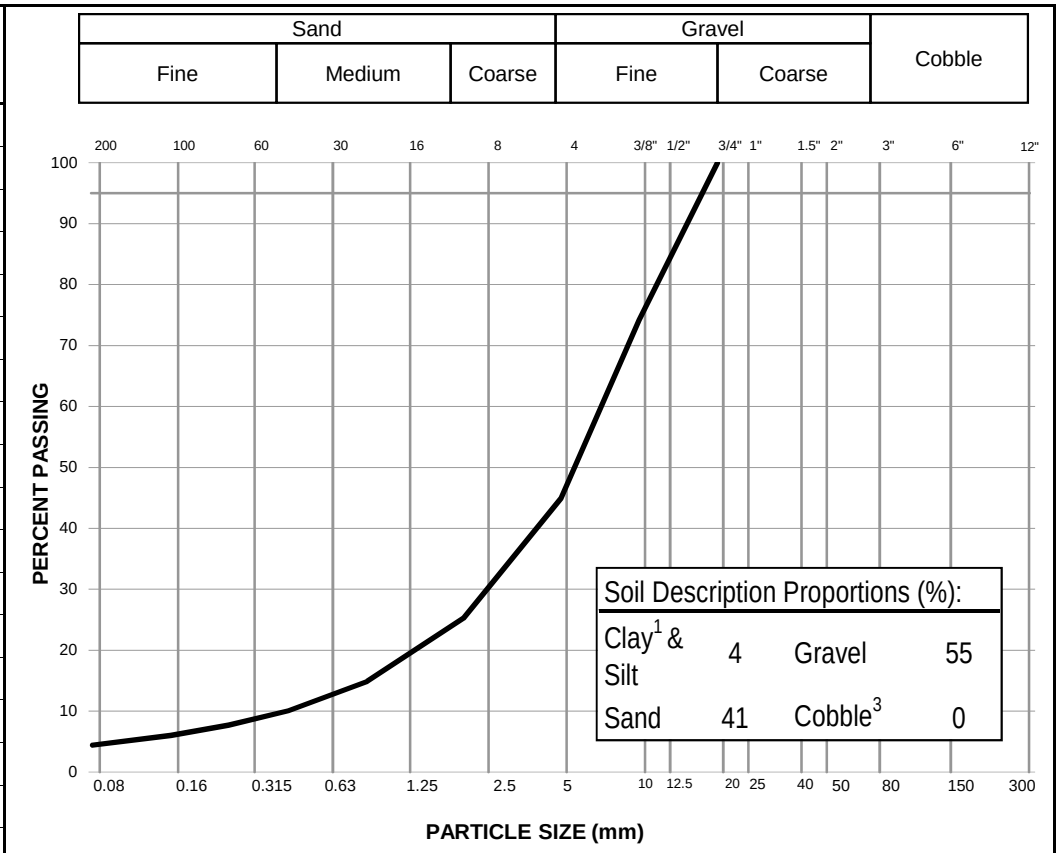
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6672-A
Project No.:	Y14103336-02.003	Material Type:	Concrete Aggregate Blend
Site:	Hope Bay, NU	Sample Loc.:	Hope Bay Batch Plant
Client:	TMAC Resources Inc.	Sample Depth:	
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 11, 2018 By: WM	Date sampled:	March 30, 2018
Soil Description[2]:	Concrete rock and manufactured sand	Sampled By:	Client
		USC Classification:	GW Cu: 17.1
Moisture Content:	1.5%		Cc: 2.3

Particle Size (mm)	Percent Passing
0	
0	
0	
0	
0	
0	
50	
37.5	
28	
19	100
9.5	74
4.75	45
2	25
0.85	15
0.425	10
0.25	8
0.15	6
0.075	4.4



Notes:
[1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to Tetra Tech description protocols
[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: _____

Remarks: _____

_____

Reviewed By: _____ P.Geol

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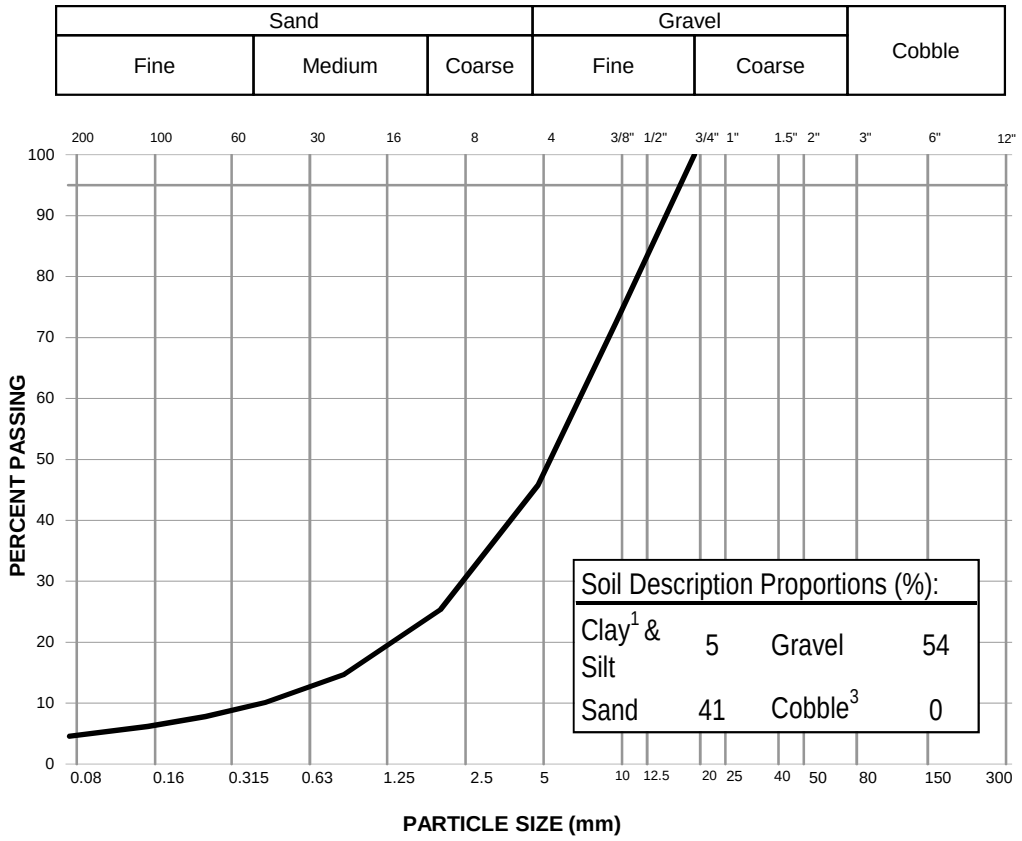
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6672-B
Project No.:	Y14103336-02.003	Material Type:	Concrete Aggregate Blend
Site:	Hope Bay, NU	Sample Loc.:	Hope Bay Batch Plant
Client:	TMAC Resources Inc.	Sample Depth:	
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 11, 2018 By: WM	Date sampled:	March 30, 2018
Soil Description[2]:	GRAVEL and SAND, trace silt/clay.	Sampled By:	Client
		USC Classification:	GW Cu: 17.5
Moisture Content:	1.5%		Cc: 2.3

Particle Size (mm)	Percent Passing
0	
0	
0	
0	
0	
0	
50	
37.5	
28	
19	100
9.5	73
4.75	46
2	25
0.85	15
0.425	10
0.25	8
0.15	6
0.075	4.6



Notes:
[1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to Tetra Tech description protocols
[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: _____

Remarks: _____

_____

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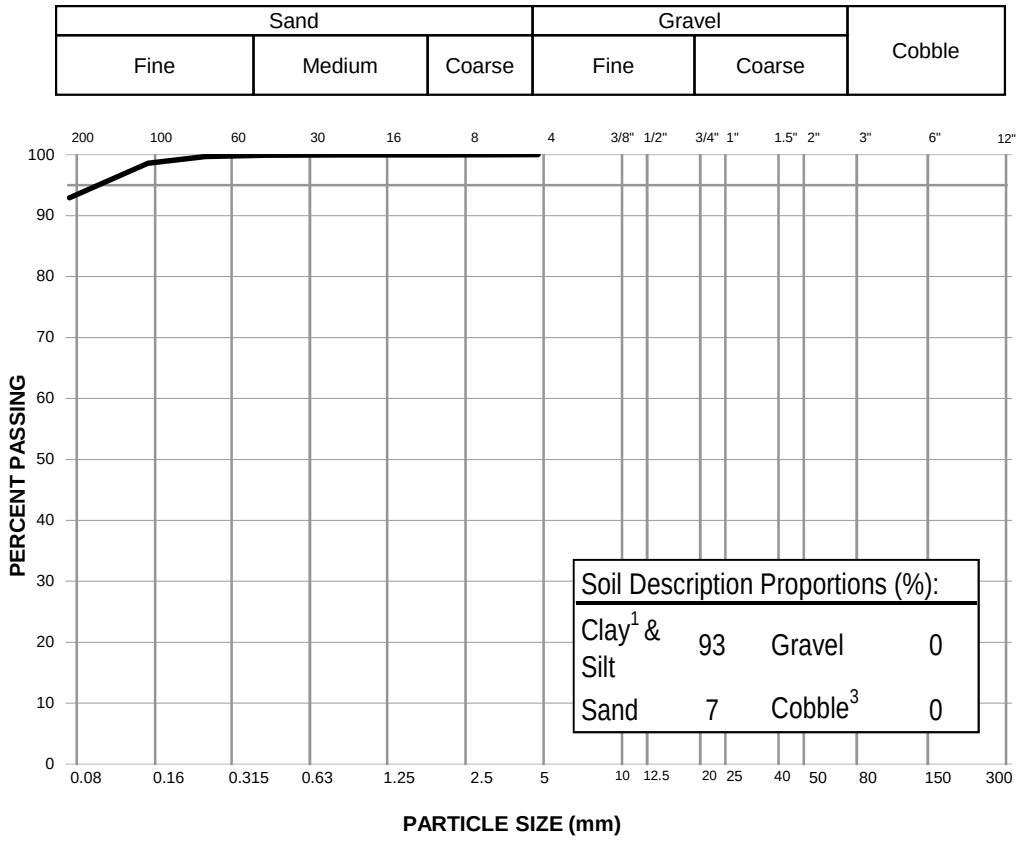
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6672-C
Project No.:	Y14103336-02.003	Material Type:	Fly Ash
Site:	Hope Bay, NU	Sample Loc.:	Hope Bay Batch Plant
Client:	TMAC Resources Inc.	Sample Depth:	
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 11, 2018 By: WM	Date sampled:	March 30, 2018
Soil Description[2]:	Fly Ash	Sampled By:	Client
		USC Classification:	Cu: #N/A
Moisture Content:	0.2%		Cc: #N/A

Particle Size (mm)	Percent Passing
50	
37.5	
28	
19	
9.5	
4.75	100
2	100
0.85	100
0.425	100
0.25	100
0.15	99
0.075	92.9



Notes:
[1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to Tetra Tech description protocols
[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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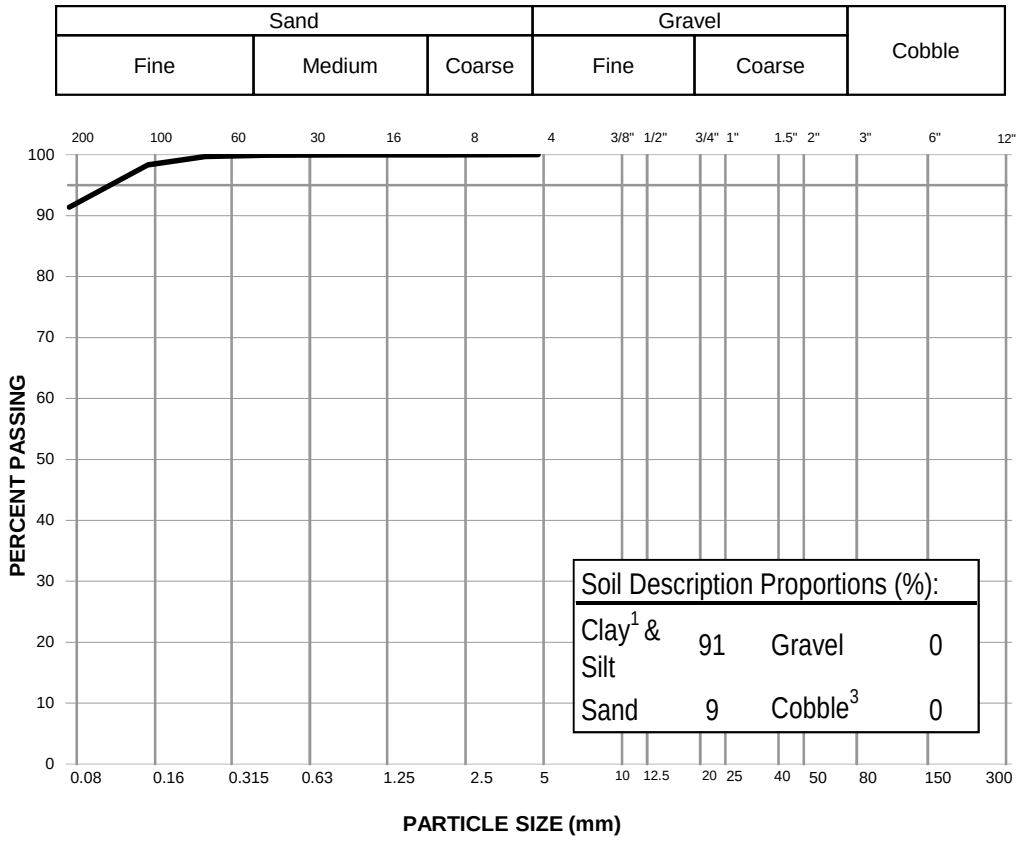
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6672-D
Project No.:	Y14103336-02.003	Material Type:	Fly Ash
Site:	Hope Bay, NU	Sample Loc.:	Hope Bay Batch Plant
Client:	TMAC Resources Inc.	Sample Depth:	
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 11, 2018 By: WM	Date sampled:	March 30, 2018
Soil Description[2]:	Fly Ash	Sampled By:	Client
		USC Classification:	Cu: #N/A
Moisture Content:	0.0%		Cc: #N/A

Particle Size (mm)	Percent Passing
50	
37.5	
28	
19	
9.5	
4.75	100
2	100
0.85	100
0.425	100
0.25	100
0.15	98
0.075	91.4



Notes:
[1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to Tetra Tech description protocols
[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: _____

Remarks: _____

_____

Reviewed By: _____ P.Geol

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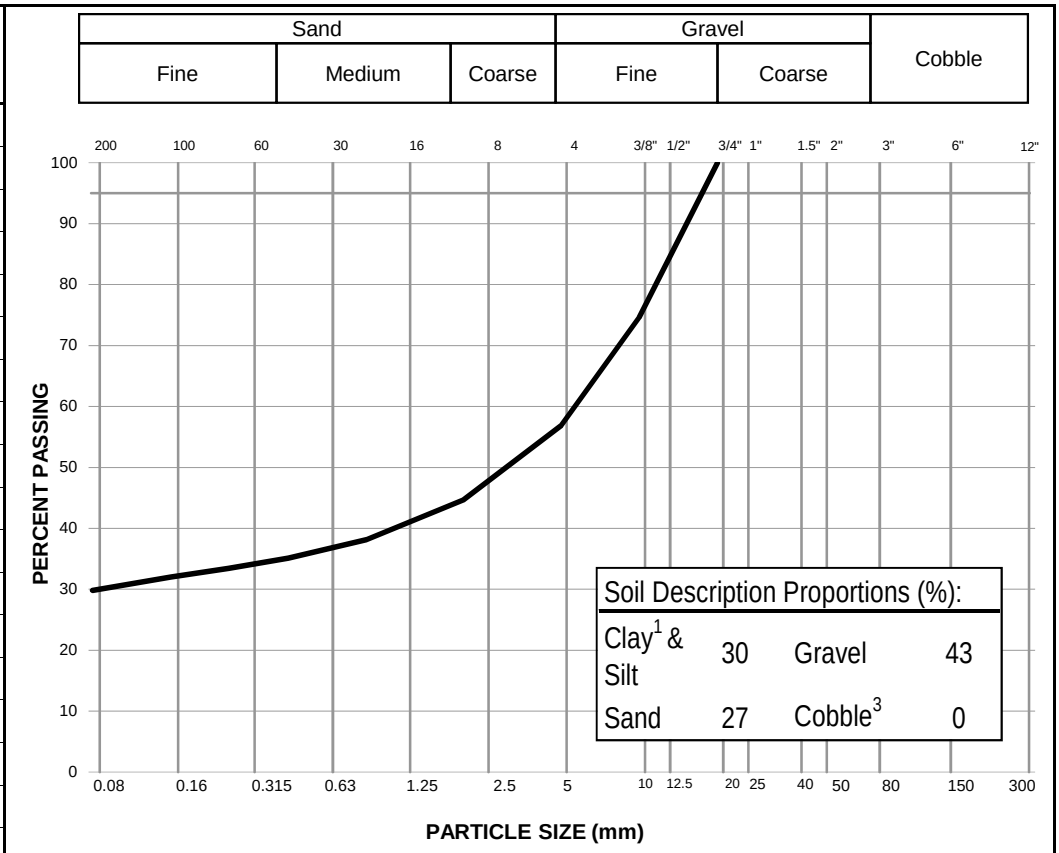
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6672-E
Project No.:	Y14103336-02.003	Material Type:	Concrete Blend
Site:	Hope Bay, NU	Sample Loc.:	Hope Bay Batch Plant
Client:	TMAC Resources Inc.	Sample Depth:	
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 11, 2018 By: WM	Date sampled:	March 30, 2018
Soil Description[2]:	Concrete rock, manufactured sand, and cementitious materials	Sampled By:	Client
		USC Classification:	Cu: #N/A
Moisture Content:	0.6%		Cc: #N/A

Particle Size (mm)	Percent Passing
0	
0	
0	
0	
0	
0	
50	
37.5	
28	
19	100
9.5	75
4.75	57
2	45
0.85	38
0.425	35
0.25	33
0.15	32
0.075	29.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to Tetra Tech description protocols

[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: _____

Remarks: _____

_____

Reviewed By: _____ P.Geol

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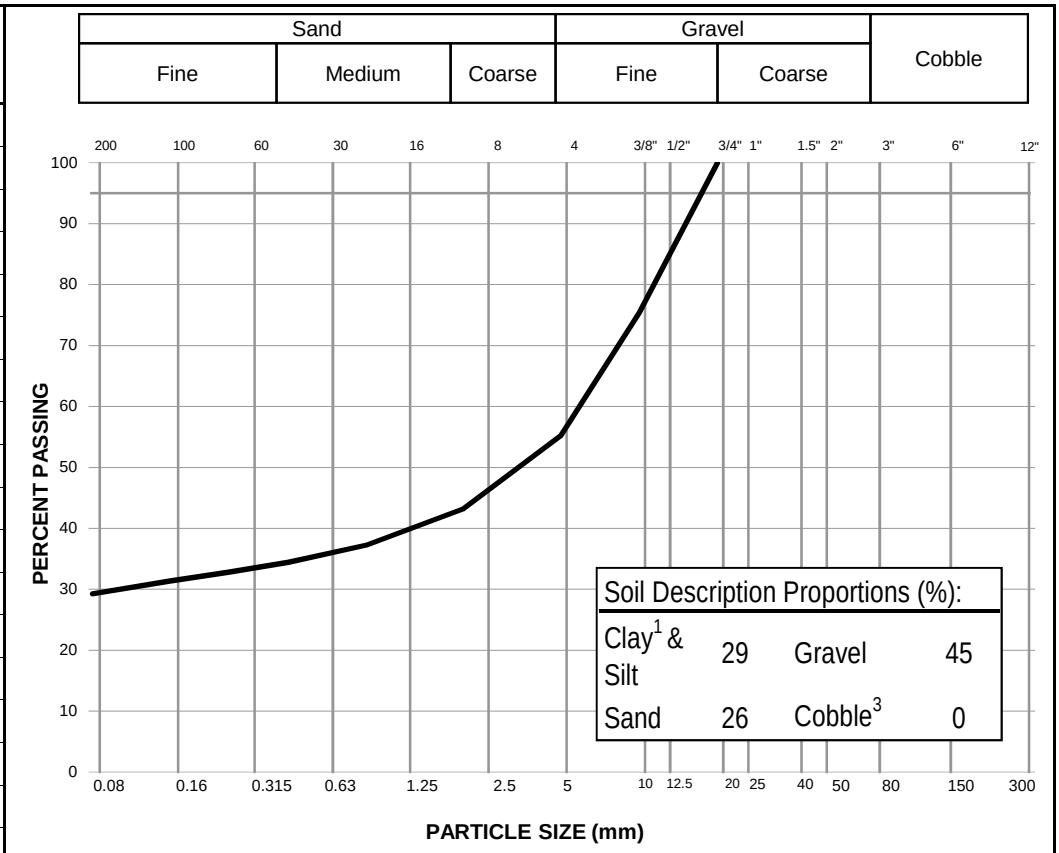
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D422, C136 & C117

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6672-F
Project No.:	Y14103336-02.003	Material Type:	Concrete Blend
Site:	Hope Bay, NU	Sample Loc.:	Hope Bay Batch Plant
Client:	TMAC Resources Inc.	Sample Depth:	
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 11, 2018 By: WM	Date sampled:	March 30, 2018
Soil Description[2]:	Concrete rock, manufactured sand, and cementitious materials	Sampled By:	Client
		USC Classification:	Cu: #N/A
Moisture Content:	0.6%		Cc: #N/A

Particle Size (mm)	Percent Passing
0	
0	
0	
0	
0	
0	
50	
37.5	
28	
19	100
9.5	75
4.75	55
2	43
0.85	37
0.425	34
0.25	33
0.15	31
0.075	29.3



Notes:
[1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual
[2] The description is visually based & subject to Tetra Tech description protocols
[3] If cobbles are present, sampling procedure may not meet ASTM C702 & D75

Specification: _____

Remarks: _____

_____

Reviewed By: _____ P.Geol

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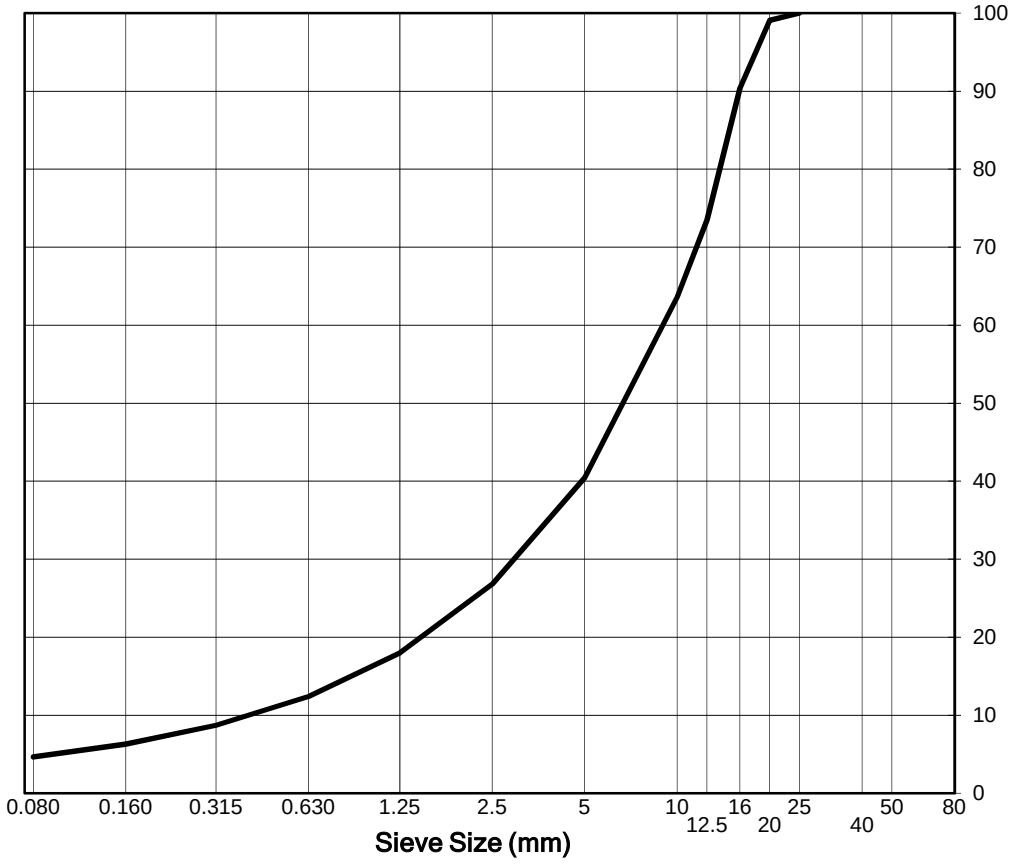
TETRA TECH

SIEVE ANALYSIS REPORT

ASTM C136

Project No.:	Y14103336-02.003	Sample No.:	6673
Project:	Hope Bay Overburden Soils Testing	Date Sampled:	April 7, 2018
Client:	TMAC Resources Inc	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	April 25, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	ELN Office: Yellowknife
Description:	25 mm (-) Crush	Moisture Content (as received):	3.4%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Hope Bay, NU	By Particle Mass:	
Supplier:	TMAC Resources		
Sample Location:	Station 1 + 25		
Specification:			

Sieve Size	Percent Passing
25	100
20	99
16	90
12.5	73
10	64
5	40
2.5	27
1.25	18
0.630	12
0.315	9
0.160	6
0.080	4.6



Remarks: Client Sample #206031

Reviewed By: _____ P.Geol.

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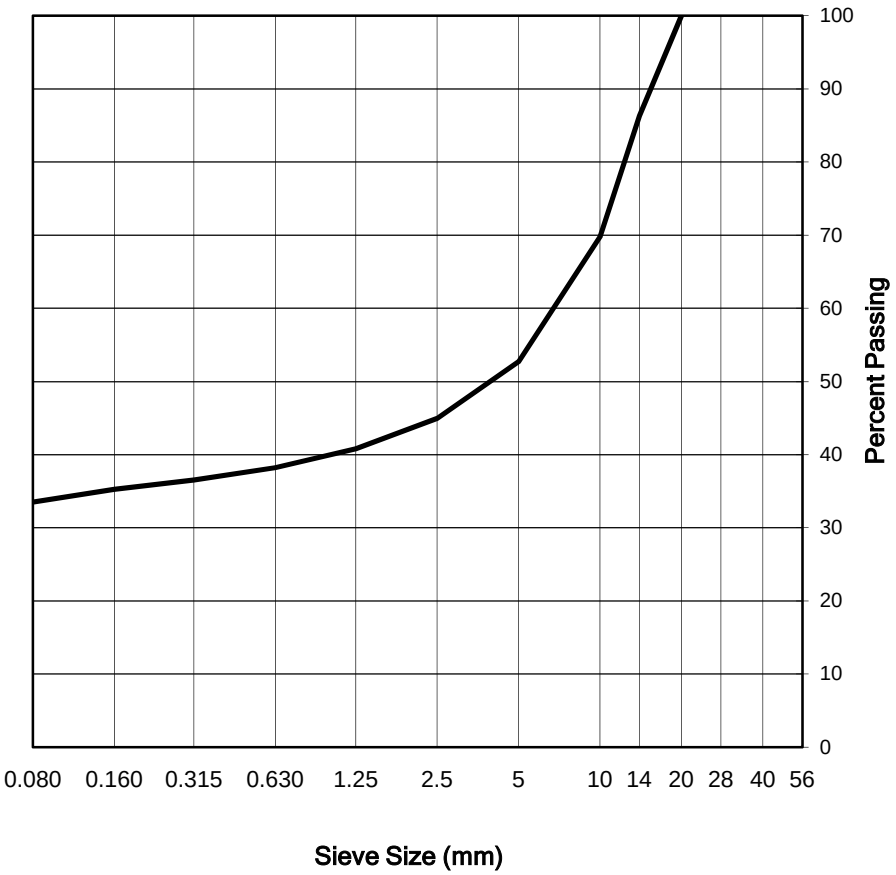
TETRA TECH

CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6676-29404
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 11, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 7, 2018
Attention:	Kelly Schwenning	**Tested by:** SS	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.4%
Description:	Batch #3 Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	86
10	70
5	53
2.5	45
1.25	41
0.630	38
0.315	37
0.160	35
0.080	33.5



Remarks:

Reviewed By: P.Geol.

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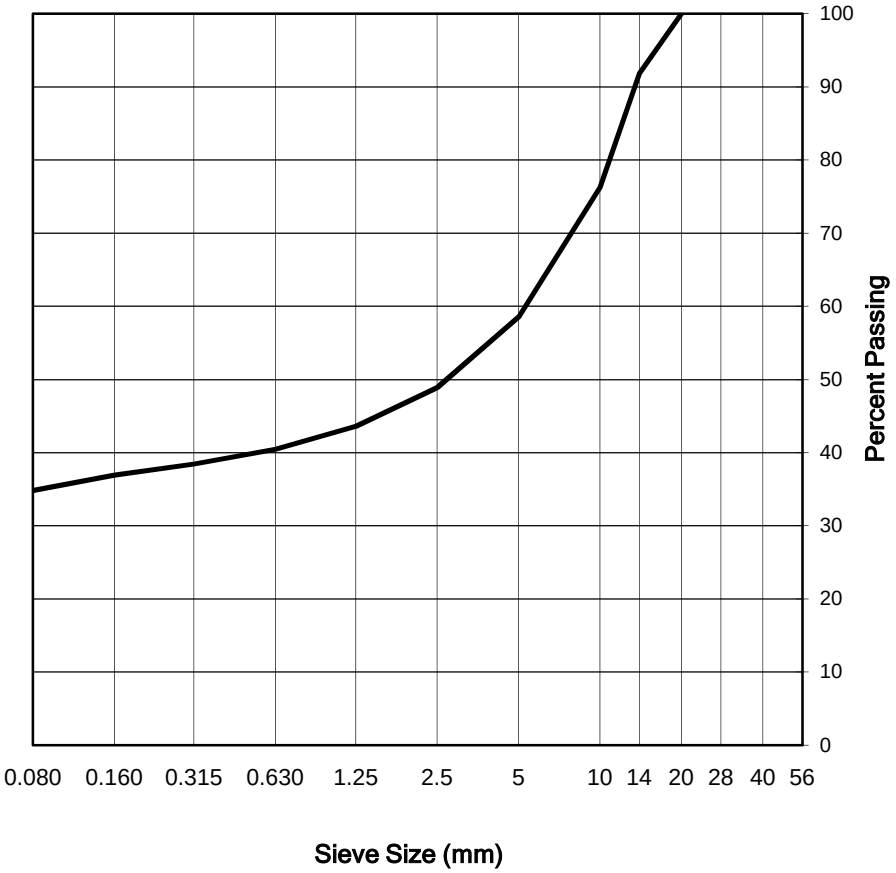
TETRA TECH

CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6676-29405
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 14, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 7, 2018
Attention:	Kelly Schwenning	**Tested by:** SS	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.5%
Description:	Batch #2 Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	92
10	76
5	59
2.5	49
1.25	44
0.630	40
0.315	38
0.160	37
0.080	34.8



Remarks:

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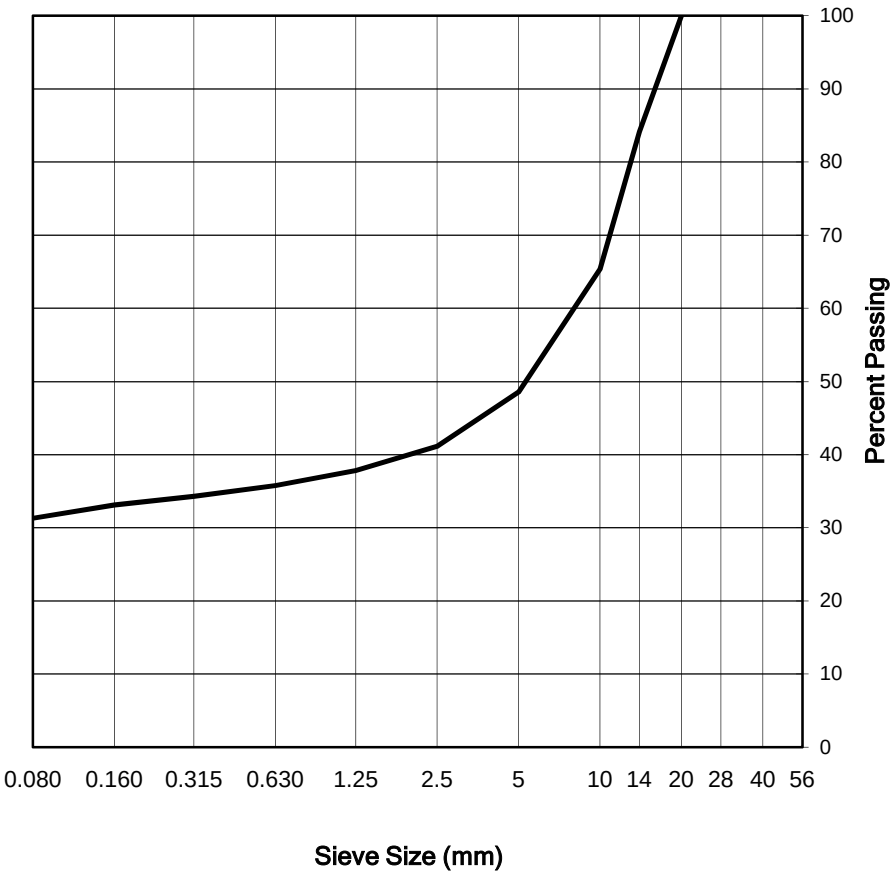
TETRA TECH

CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6676-29406
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 14, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 7, 2018
Attention:	Kelly Schwenning	**Tested by:** SS	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.5%
Description:	Batch #4 Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	84
10	65
5	49
2.5	41
1.25	38
0.630	36
0.315	34
0.160	33
0.080	31.3



Remarks:

Reviewed By: _____ P.Geol.

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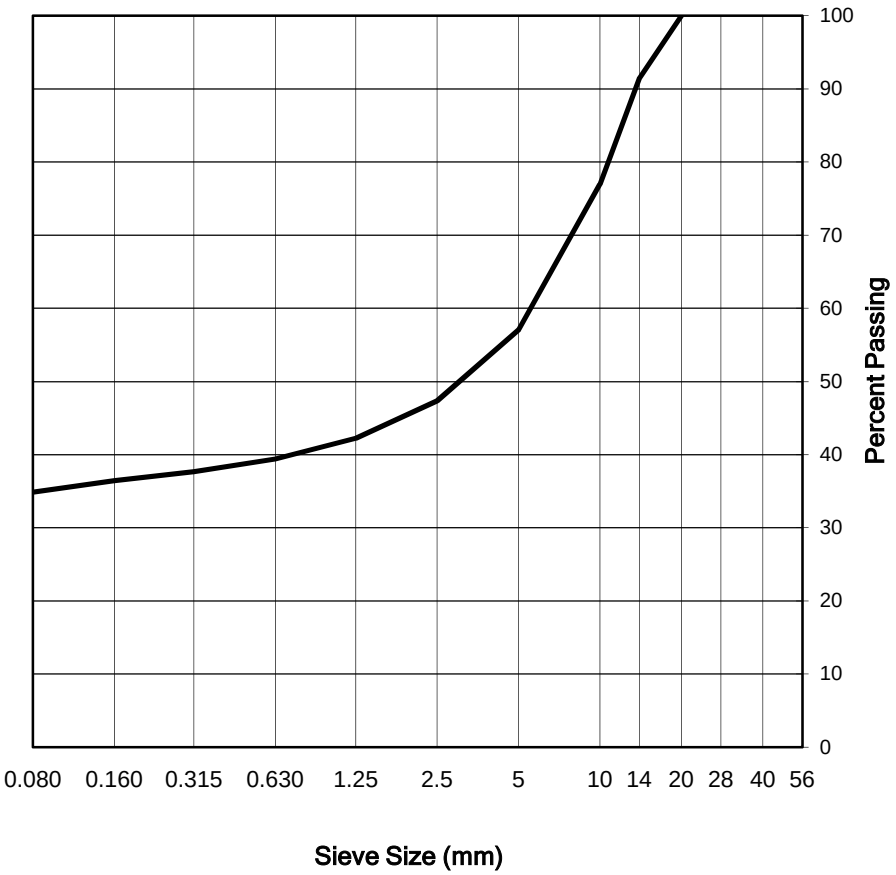
TETRA TECH

CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6676-29407
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 16, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 7, 2018
Attention:	Kelly Schwenning	**Tested by:** SS	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.3%
Description:	Batch #5 Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	91
10	77
5	57
2.5	47
1.25	42
0.630	39
0.315	38
0.160	36
0.080	34.9



Remarks:

Reviewed By: _____ P.Geol.

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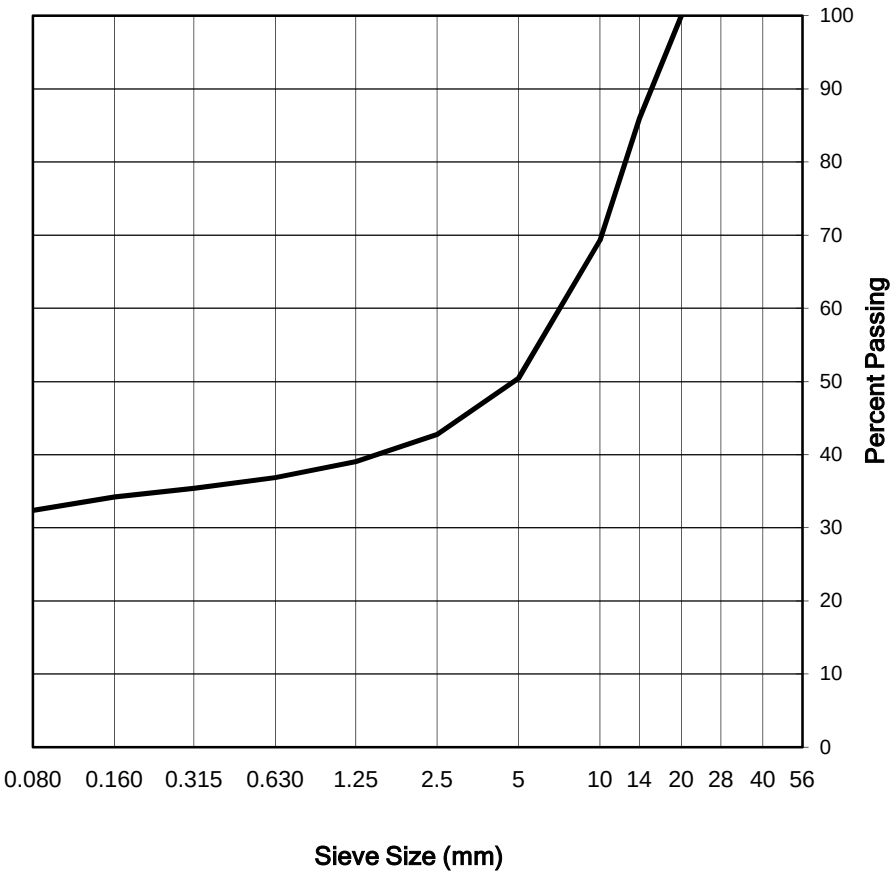
TETRA TECH

CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6676-29408
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 20, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 7, 2018
Attention:	Kelly Schwenning	**Tested by:** SS	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.9%
Description:	Batch #6 Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	86
10	69
5	50
2.5	43
1.25	39
0.630	37
0.315	35
0.160	34
0.080	32.4



Remarks:

Reviewed By: _____ P.Geol.

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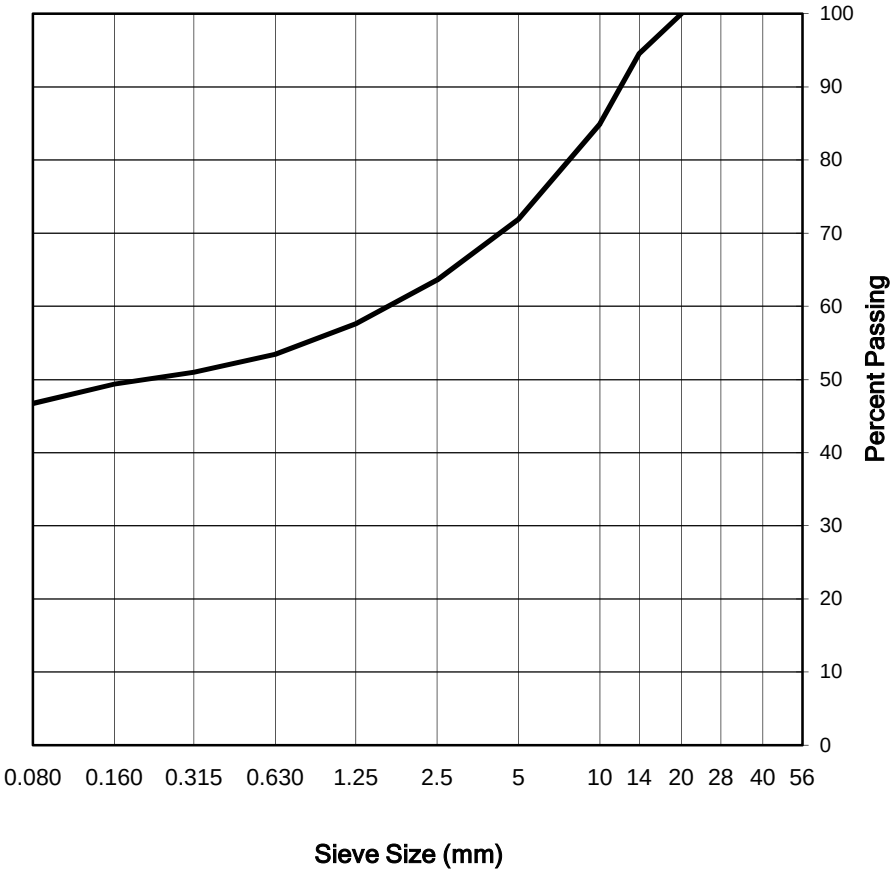
TETRA TECH

CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6676-29409
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 21, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 7, 2018
Attention:	Kelly Schwenning	**Tested by:** SS	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	1.0%
Description:	Batch #7 Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	95
10	85
5	72
2.5	64
1.25	58
0.630	53
0.315	51
0.160	49
0.080	46.7



Remarks:

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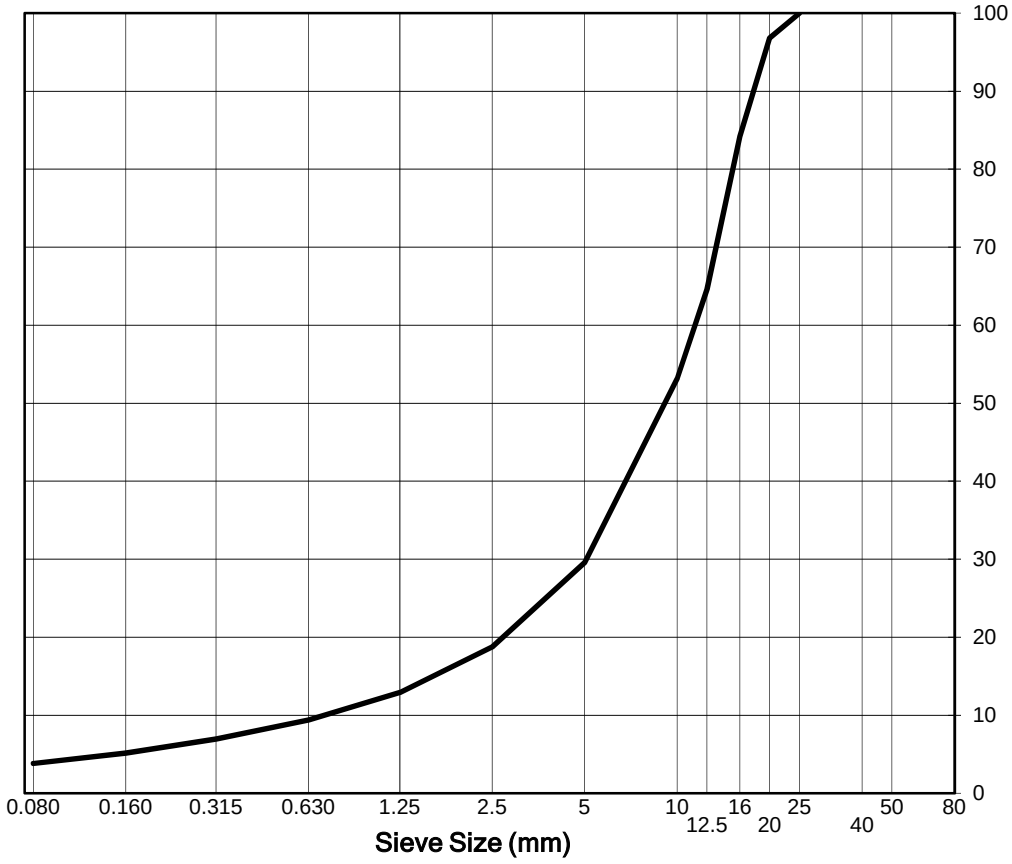
TETRA TECH

SIEVE ANALYSIS REPORT

ASTM C136

Project No.:	Y14103336-02.003	Sample No.:	6676-29410
Project:	Hope Bay Overburden Soils Testing	Date Sampled:	April 21, 2018
Client:	TMAC Resources Inc	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	May 7, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	SS Office: Yellowknife
Description:	25 mm (-) Crush	Moisture Content (as received):	2.6%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Hope Bay, NU	By Particle Mass:	
Supplier:	TMAC Resources Inc.		
Sample Location:			
Specification:			

Sieve Size	Percent Passing
25	100
20	97
16	84
12.5	65
10	53
5	30
2.5	19
1.25	13
0.630	9
0.315	7
0.160	5
0.080	3.8



Remarks: Client Sample #206031

Reviewed By: _____ P.Geol.

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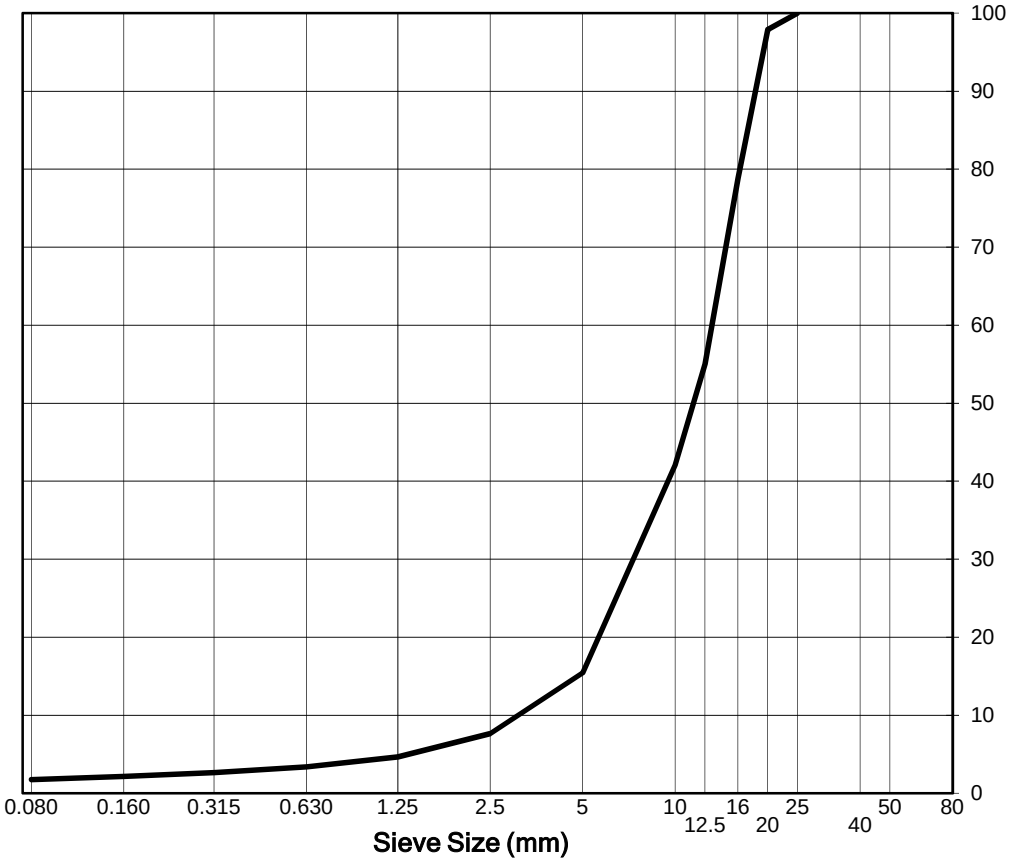
TETRA TECH

SIEVE ANALYSIS REPORT

ASTM C136

Project No.:	Y14103336-02.003	Sample No.:	6681-1
Project:	Hope Bay Overburden Soils Testing	Date Sampled:	April 11, 2018
Client:	TMAC Resources Inc	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	May 11, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	JRC Office: Yellowknife
Description:	25 mm (-) Crush	Moisture Content (as received):	1.0%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Hope Bay, NU	By Particle Mass:	
Supplier:	TMAC Resources Inc.		
Sample Location:	Key Trench at 1 + 03		
Specification:			

Sieve Size	Percent Passing
25	100
20	98
16	79
12.5	55
10	42
5	15
2.5	8
1.25	5
0.630	3
0.315	3
0.160	2
0.080	1.7



Remarks: Client Bedding Sample #1

Reviewed By: _____ P.Geol.

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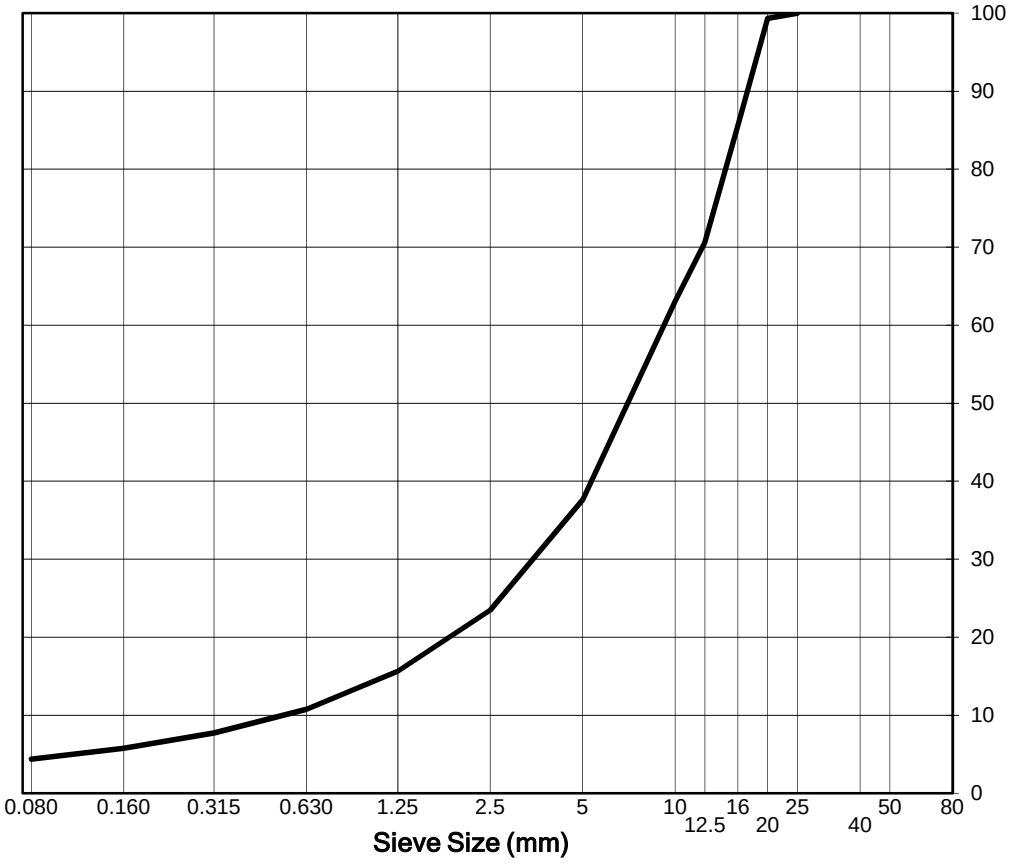
TETRA TECH

SIEVE ANALYSIS REPORT

ASTM C136

Project No.:	Y14103336-02.003	Sample No.:	6681-2
Project:	Hope Bay Overburden Soils Testing	Date Sampled:	April 11, 2018
Client:	TMAC Resources Inc.	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	May 11, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	JRC Office: Yellowknife
Description:	25 mm (-) Crush	Moisture Content (as received):	3.7%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Hope Bay, NU	By Particle Mass:	
Supplier:	TMAC Resources Inc.		
Sample Location:	Key Trench at 2 + 25		
Specification:			

Sieve Size	Percent Passing
25	100
20	99
16	86
12.5	71
10	63
5	38
2.5	24
1.25	16
0.630	11
0.315	8
0.160	6
0.080	4.4



Remarks: Client Bedding Sample #2

Reviewed By: _____ P.Geol.

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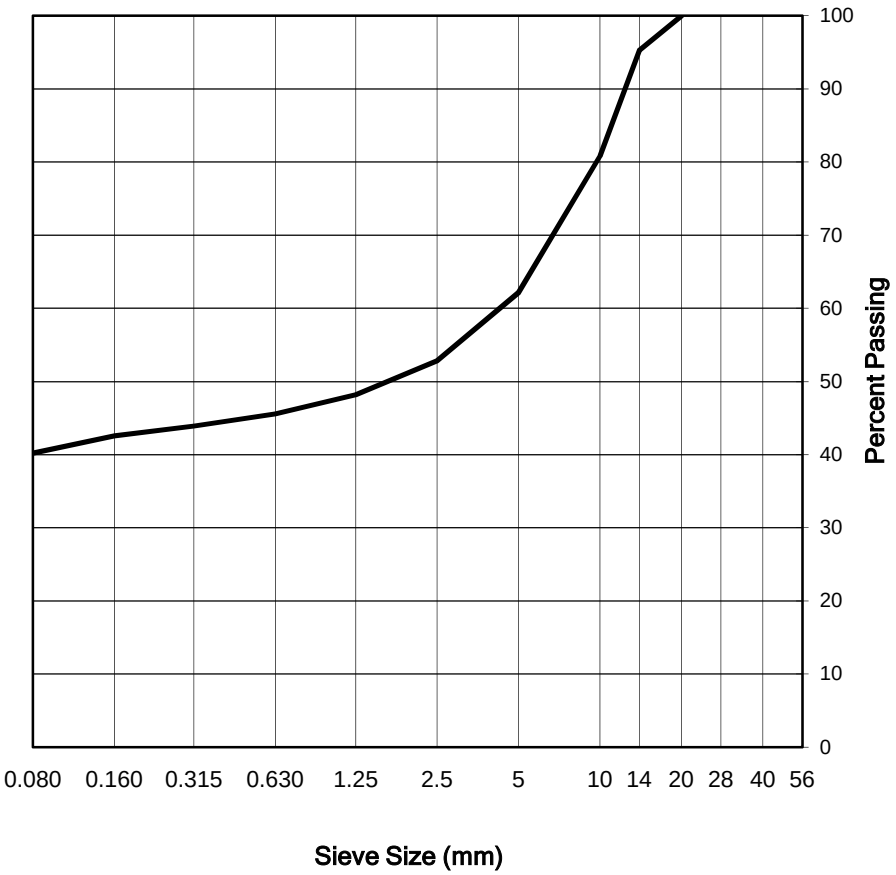
TETRA TECH

CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6689-29411
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 27, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 29, 2018
Attention:	Kelly Schwenning	**Tested by:** JRC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.7%
Description:	Fly Ash Batch #8	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	95
10	81
5	62
2.5	53
1.25	48
0.630	46
0.315	44
0.160	43
0.080	40.2



Remarks: Client Sample #29411

Reviewed By: _____ P.Geol.

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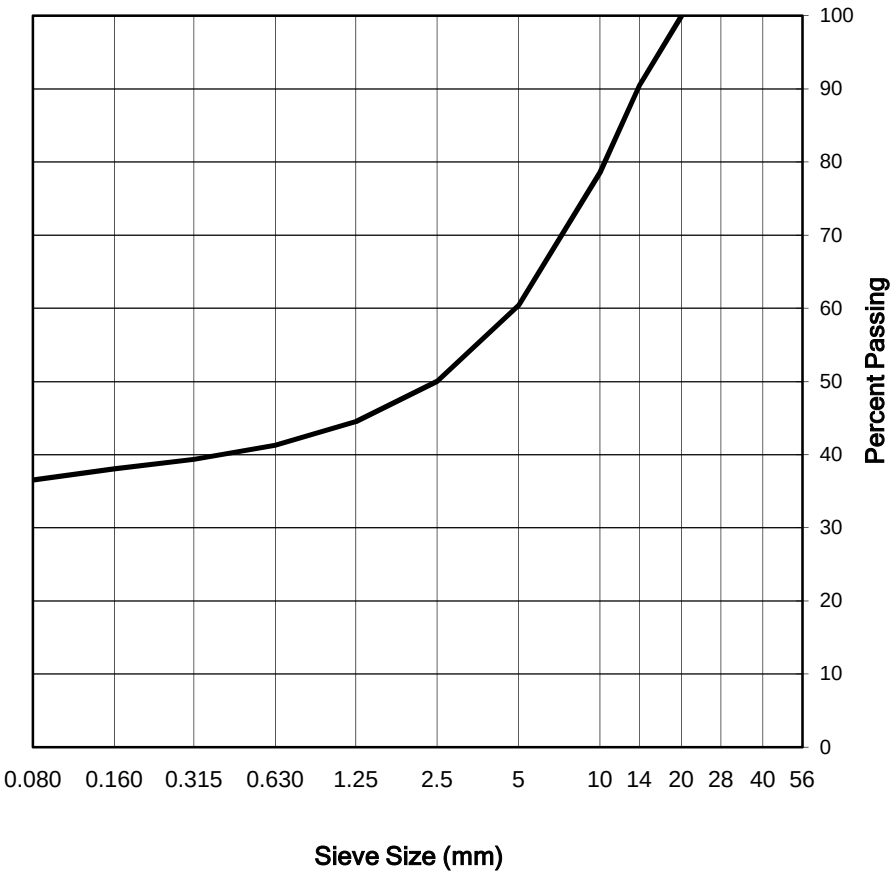
TETRA TECH

CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6689-29412
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 30, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 29, 2018
Attention:	Kelly Schwenning	**Tested by:** JRC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.4%
Description:	Fly Ash Batch #9	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	90
10	79
5	60
2.5	50
1.25	45
0.630	41
0.315	39
0.160	38
0.080	36.5



Remarks: Client Sample #29412

Reviewed By: _____ P.Geol.

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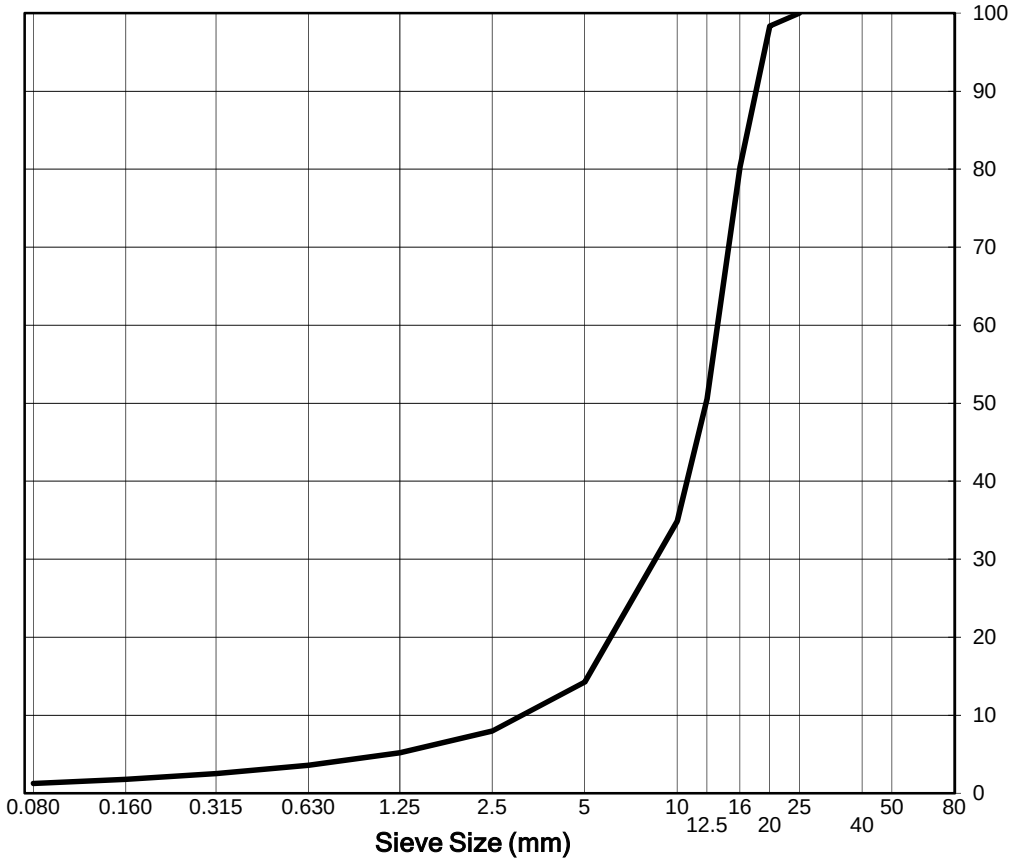
TETRA TECH

SIEVE ANALYSIS REPORT

ASTM C136

Project No.:	Y14103336-02.003	Sample No.:	6689-29413
Project:	Hope Bay Overburden Soils Testing	Date Sampled:	April 21, 2018
Client:	TMAC Resources Inc	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	May 18, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	JRC Office: Yellowknife
Description:	25 mm (-) Crush	Moisture Content (as received):	0.4%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Hope Bay, NU	By Particle Mass:	
Supplier:	TMAC Resources Inc.		
Sample Location:	Not provided		
Specification:			

Sieve Size	Percent Passing
25	100
20	98
16	80
12.5	51
10	35
5	14
2.5	8
1.25	5
0.630	4
0.315	3
0.160	2
0.080	1.3



Remarks: Client Sample #29413

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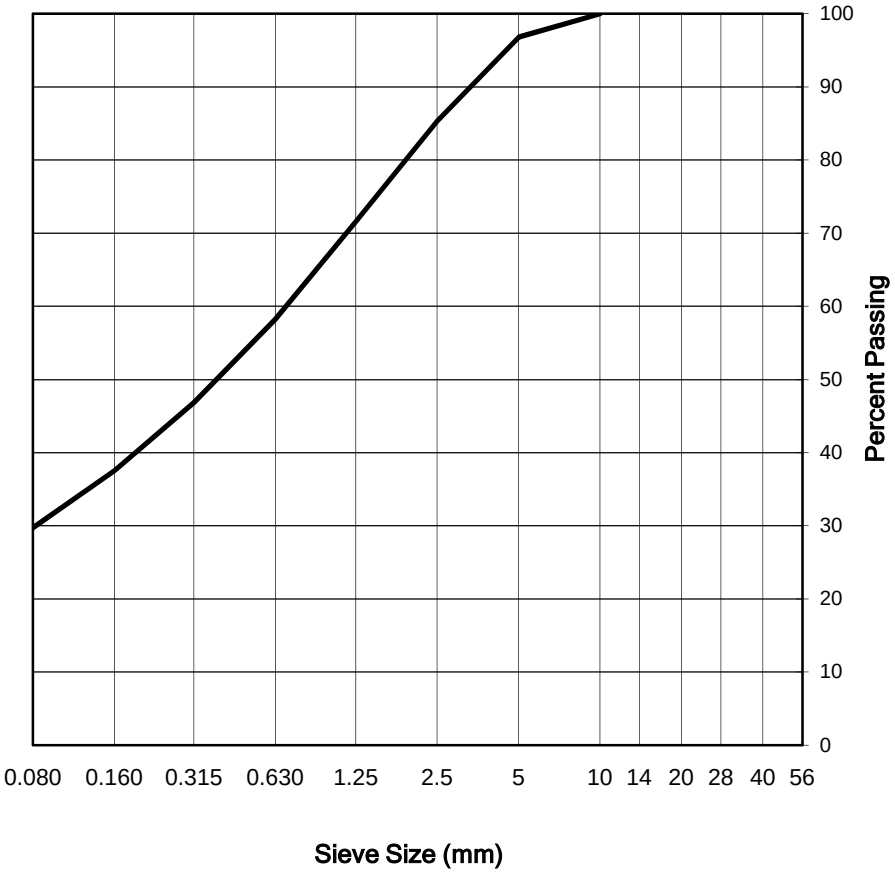
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6689-29414
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 20, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 7, 2018
Attention:	Kelly Schwenning	**Tested by:** SS	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	6.0%
Description:	VTC-460 , 0-1 m	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
10	100
5	97
2.5	85
1.25	72
0.630	58
0.315	47
0.160	38
0.080	29.7



Remarks: Client Sample #29414

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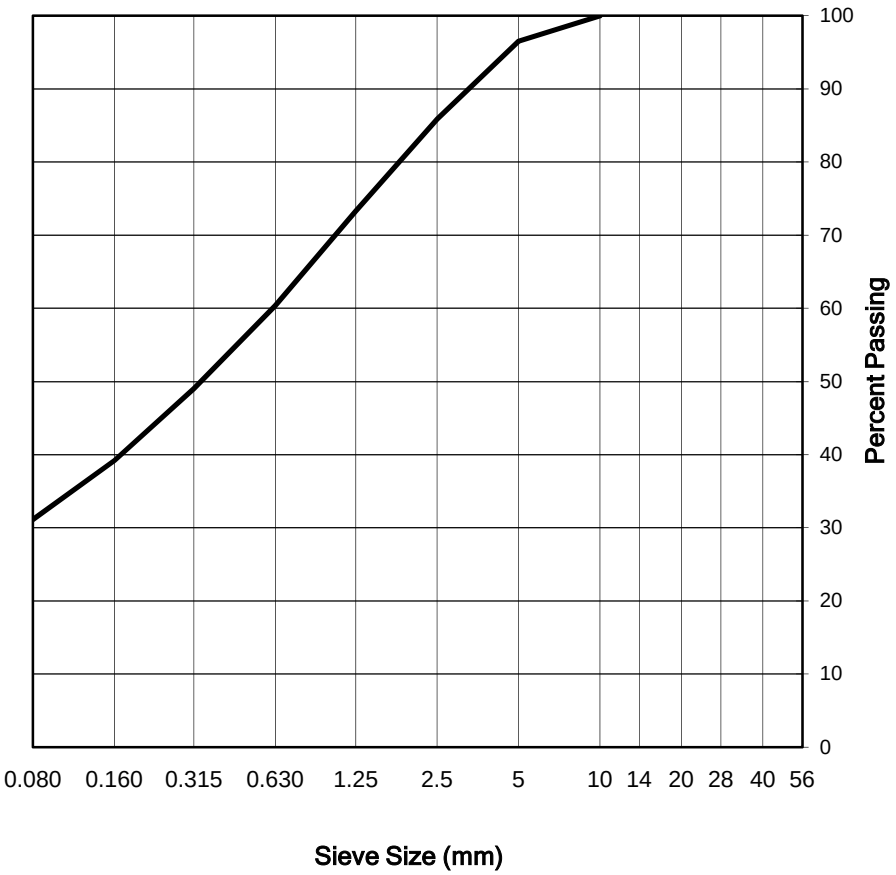
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6689-29415
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 30, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 29, 2018
Attention:	Kelly Schwenning	**Tested by:** JRC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	7.7%
Description:	VTC-460, 1-2 m	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
10	100
5	97
2.5	86
1.25	73
0.630	60
0.315	49
0.160	39
0.080	31.1



Remarks: Client Sample #29415

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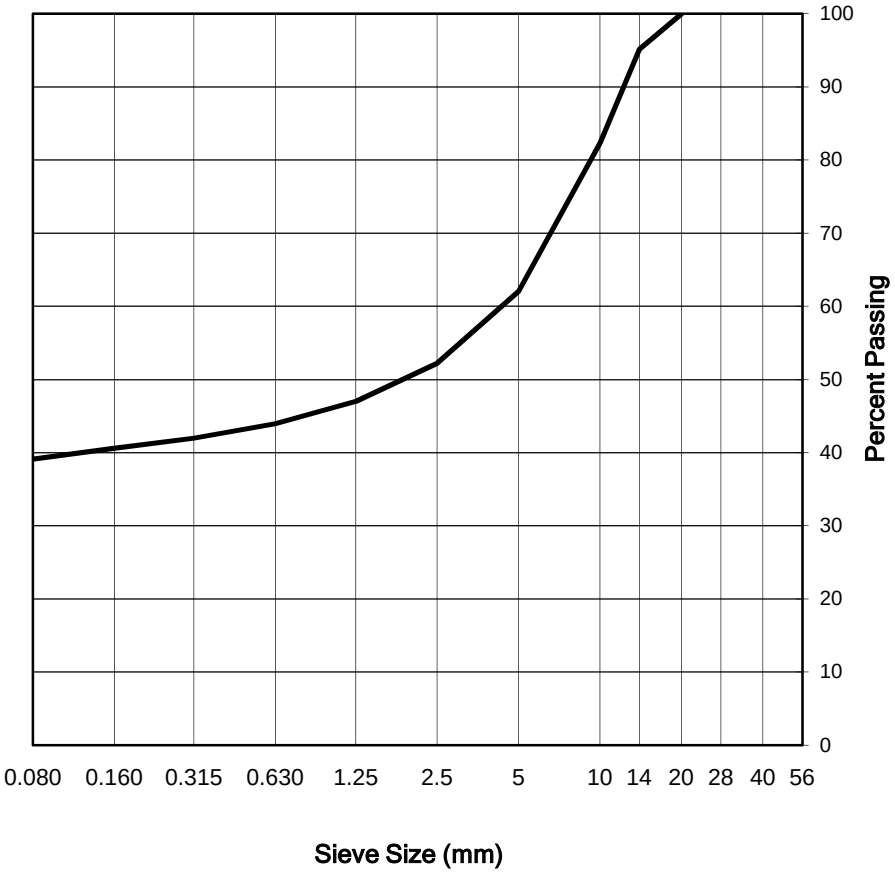
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6689-29416
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 2, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 29, 2018
Attention:	Kelly Schwenning	**Tested by:** JRC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.2%
Description:	Fly Ash Batch #11	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	95
10	82
5	62
2.5	52
1.25	47
0.630	44
0.315	42
0.160	41
0.080	39.1



Remarks: Client Sample #29416

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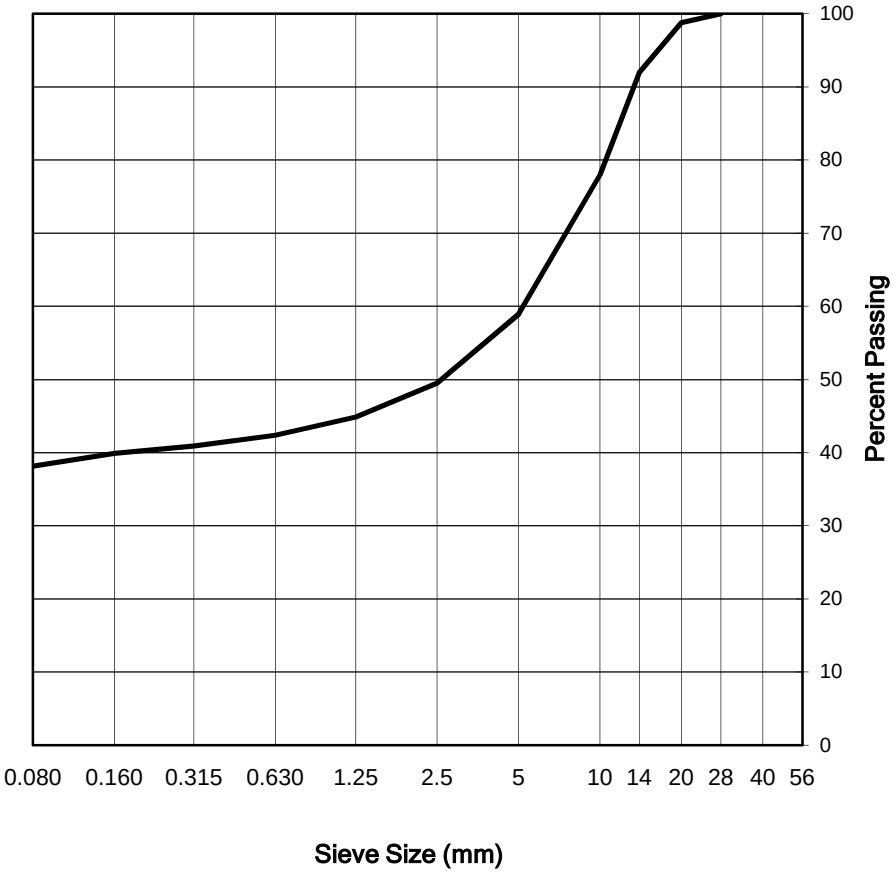
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6689-29417
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 5, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 29, 2018
Attention:	Kelly Schwenning	**Tested by:** JRC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	1.3%
Description:	Fly Ash Mix Batch #12	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
28	100
20	99
14	92
10	78
5	59
2.5	50
1.25	45
0.630	42
0.315	41
0.160	40
0.080	38.2



Remarks: Client Sample #29417

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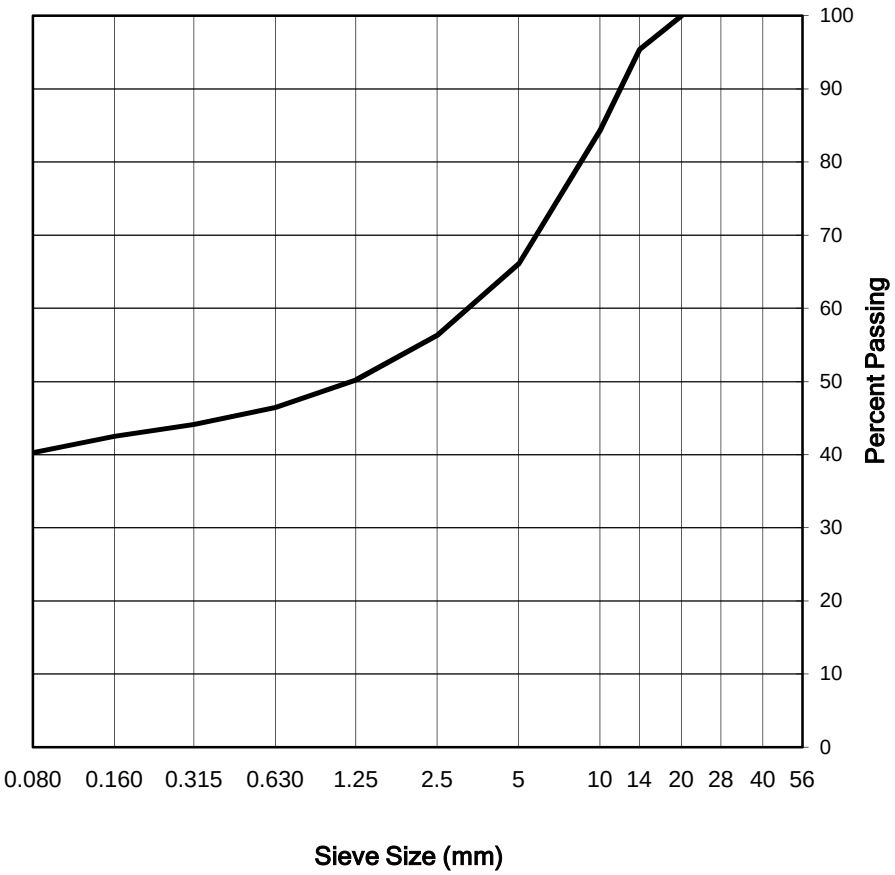
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6689-29418
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 6, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 29, 2018
Attention:	Kelly Schwenning	**Tested by:** JRC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	1.2%
Description:	Fly Ash Mix Batch #13	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	95
10	84
5	66
2.5	56
1.25	50
0.630	46
0.315	44
0.160	42
0.080	40.3



Remarks: Client Sample #29418

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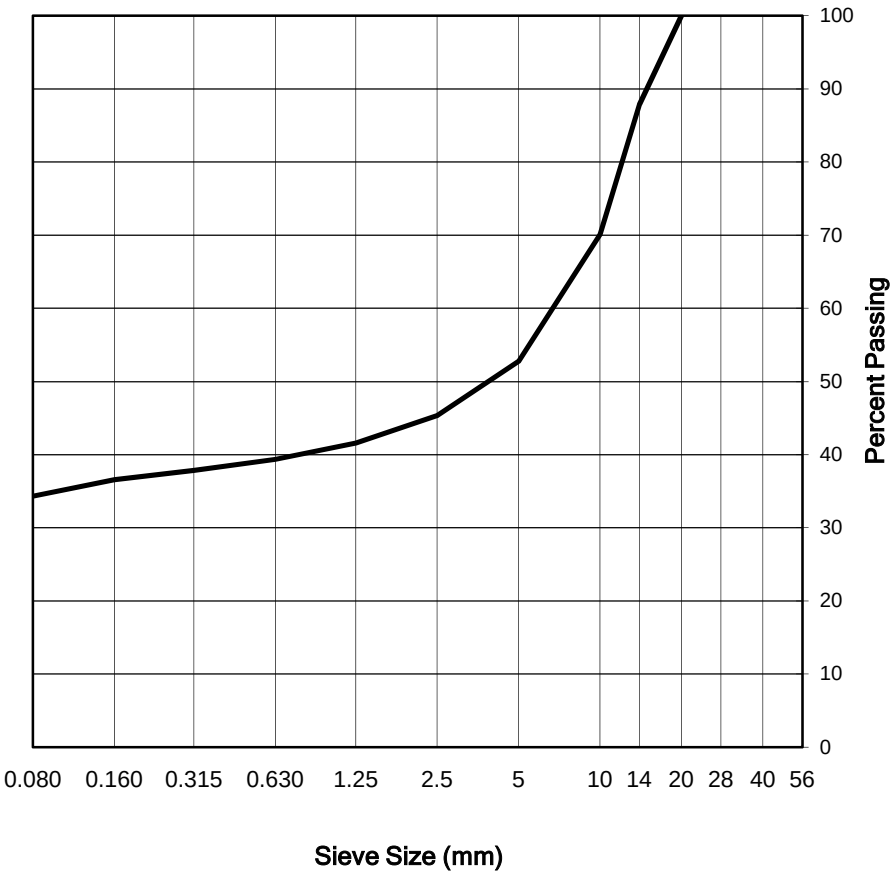
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6689-29419
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 7, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 29, 2018
Attention:	Kelly Schwenning	**Tested by:** JRC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.6%
Description:	Fly Ash Mix Batch #14	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	88
10	70
5	53
2.5	45
1.25	42
0.630	39
0.315	38
0.160	37
0.080	34.3



Remarks: Client Sample #29419

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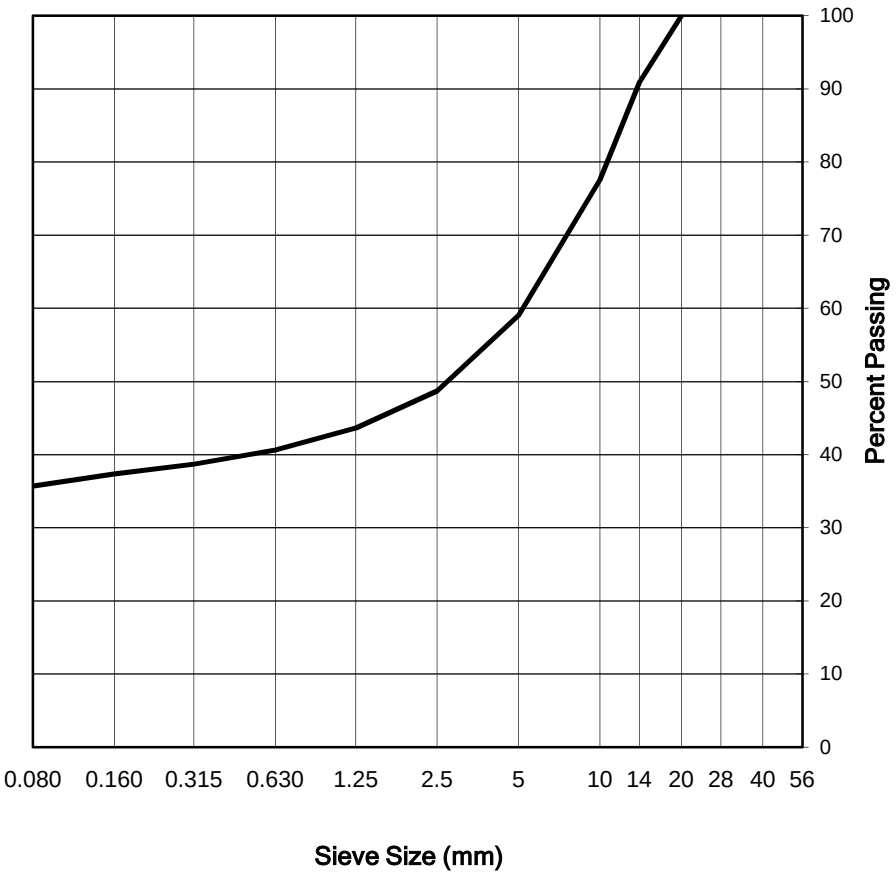
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-1
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 27, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 31, 2018
Attention:	Kelly Schwenning	**Tested by:**	JC/ELN **Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.6%
Description:	Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	91
10	78
5	59
2.5	49
1.25	44
0.630	41
0.315	39
0.160	37
0.080	35.7



Remarks: No client sample tag in sample bag.

Reviewed By: _____ P.Geol.

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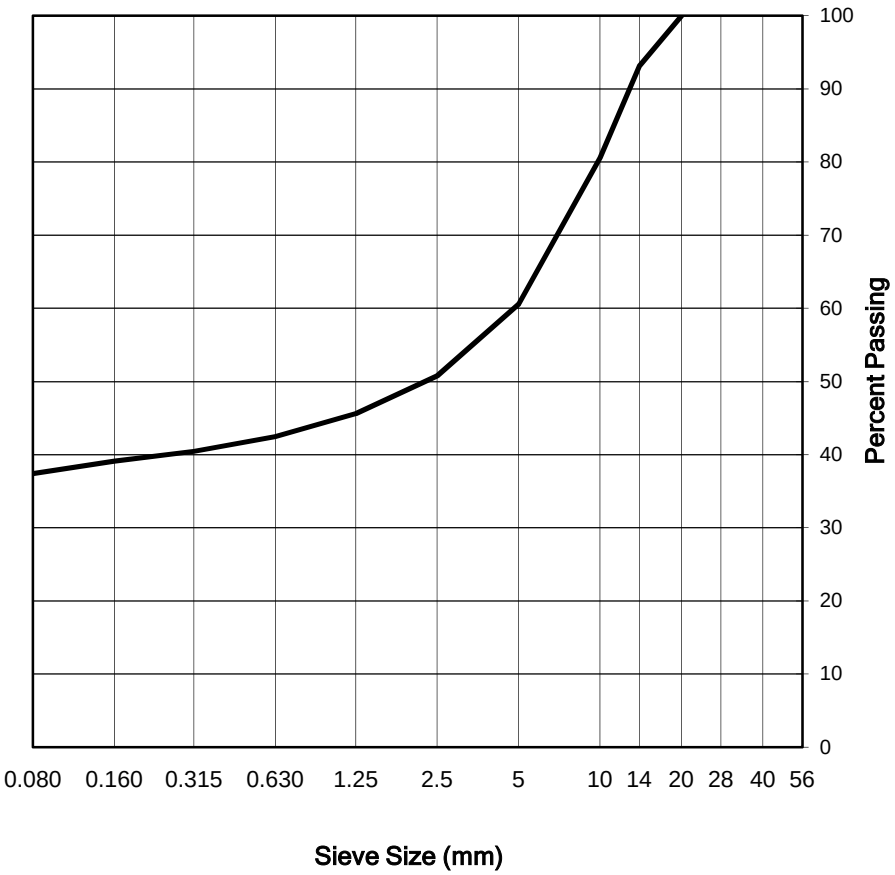
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-2
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 27, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 31, 2018
Attention:	Kelly Schwenning	**Tested by:**	JC/ELN **Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.6%
Description:	Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	93
10	81
5	61
2.5	51
1.25	46
0.630	42
0.315	40
0.160	39
0.080	37.4



Remarks: No client sample tag in sample bag.

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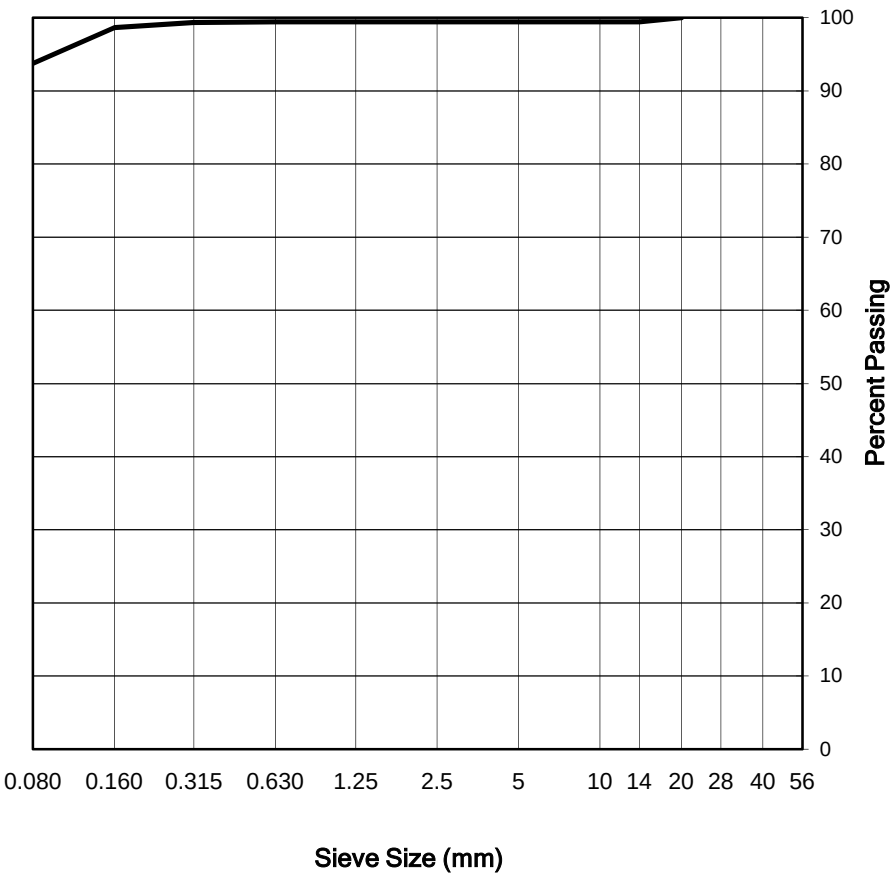
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-3
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 27, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 31, 2018
Attention:	Kelly Schwenning	**Tested by:**	JC/ELN **Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.3%
Description:	Fly Ash	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	99
10	99
5	99
2.5	99
1.25	99
0.630	99
0.315	99
0.160	99
0.080	93.8



Remarks: No client sample tag in sample bag.

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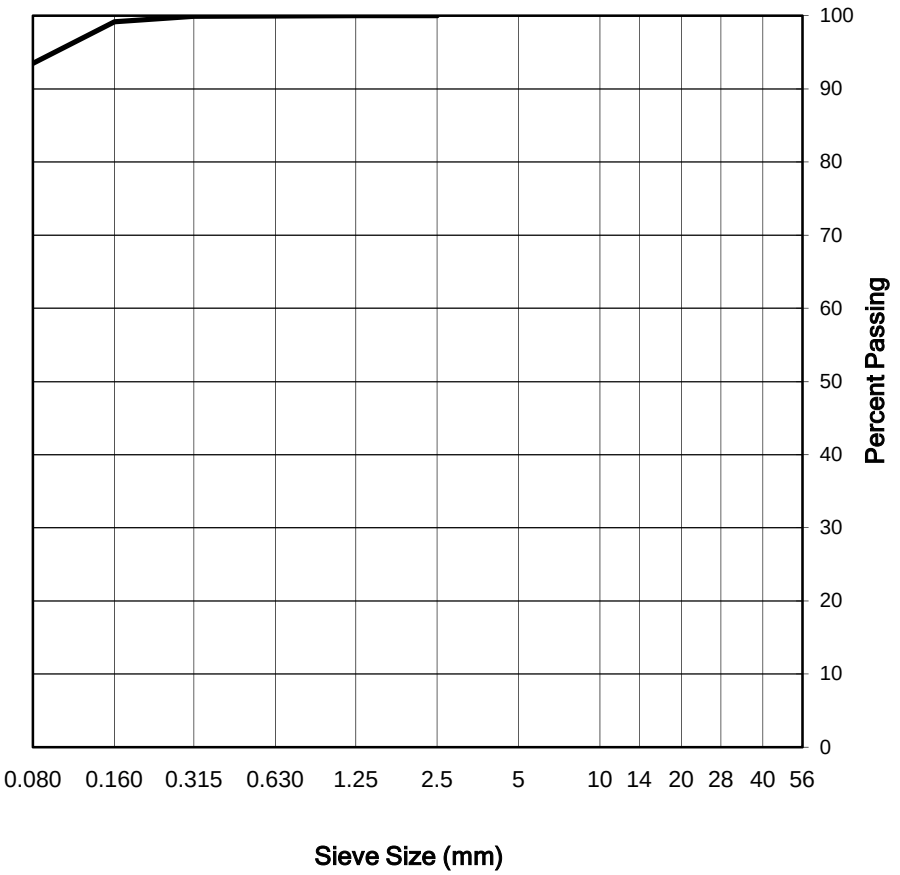
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-4
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 27, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 31, 2018
Attention:	Kelly Schwenning	**Tested by:**	JC/ELN **Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.3%
Description:	Fly Ash	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
2.5	100
1.25	100
0.630	100
0.315	100
0.160	99
0.080	93.5



Remarks: No client sample tag in sample bag.

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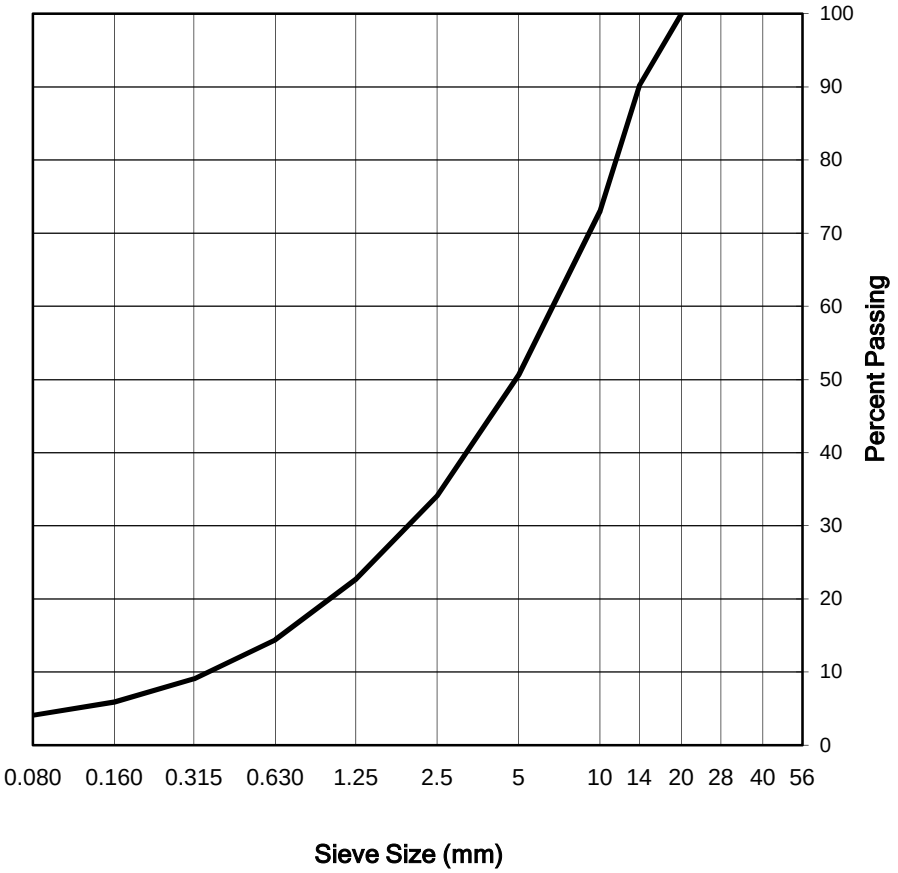
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-5
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 27, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 31, 2018
Attention:	Kelly Schwenning	**Tested by:**	JC/ELN **Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	1.1%
Description:	Aggregate	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	90
10	73
5	51
2.5	34
1.25	23
0.630	14
0.315	9
0.160	6
0.080	4.1



Remarks: No client sample tag in sample bag.

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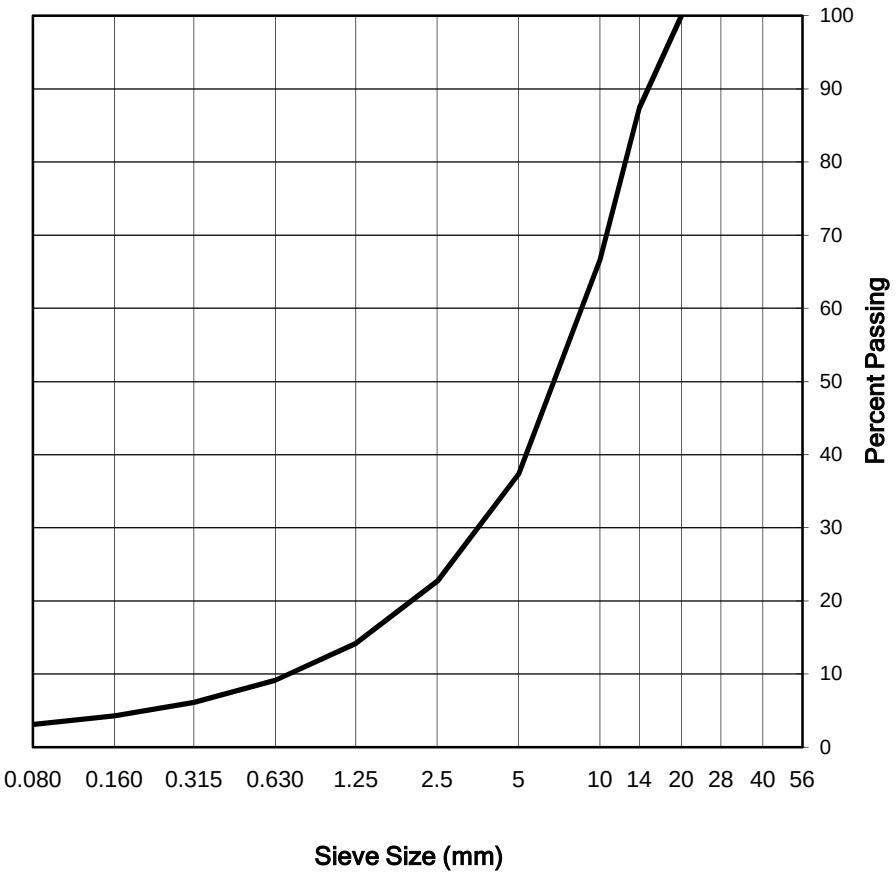
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-6
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 27, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	May 31, 2018
Attention:	Kelly Schwenning	**Tested by:**	JC/ELN **Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.8%
Description:	Aggregate	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	87
10	67
5	37
2.5	23
1.25	14
0.630	9
0.315	6
0.160	4
0.080	3.1



Remarks: No client sample tag in sample bag.

Reviewed By: _____ P.Geol.

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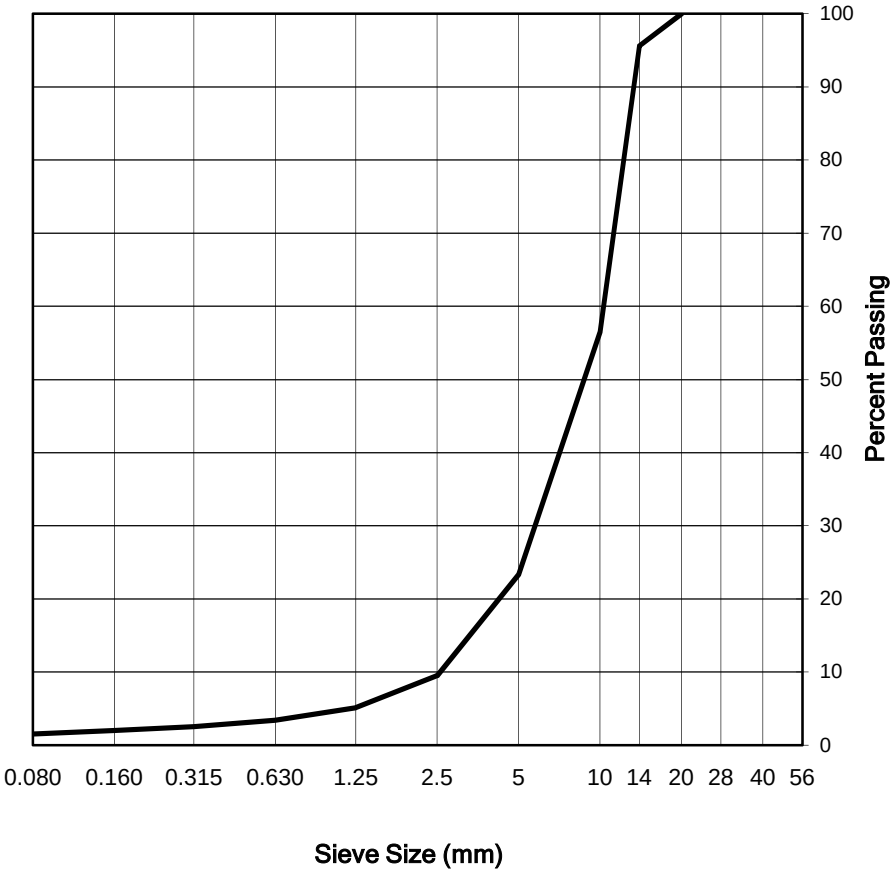
TETRA TECH

CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-7
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 4, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 6, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.1%
Description:	Aggregate D	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	96
10	56
5	23
2.5	9
1.25	5
0.630	3
0.315	3
0.160	2
0.080	1.5



Remarks:

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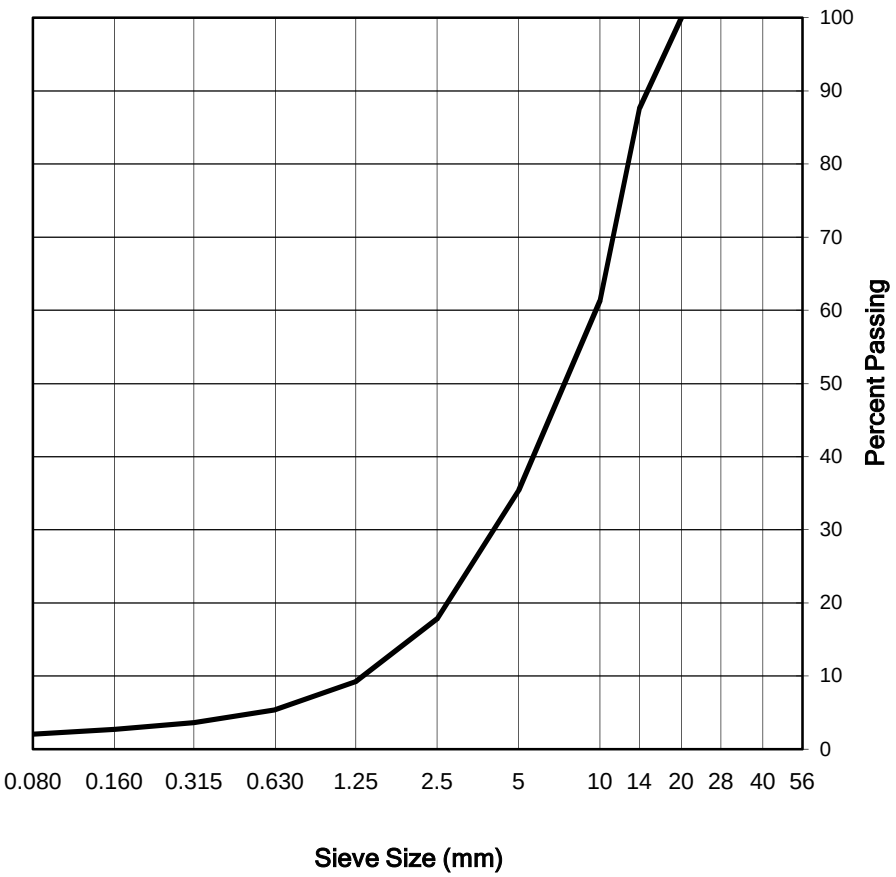
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-8
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 4, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 6, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.3%
Description:	Aggregate C	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	88
10	61
5	35
2.5	18
1.25	9
0.630	5
0.315	4
0.160	3
0.080	2.0



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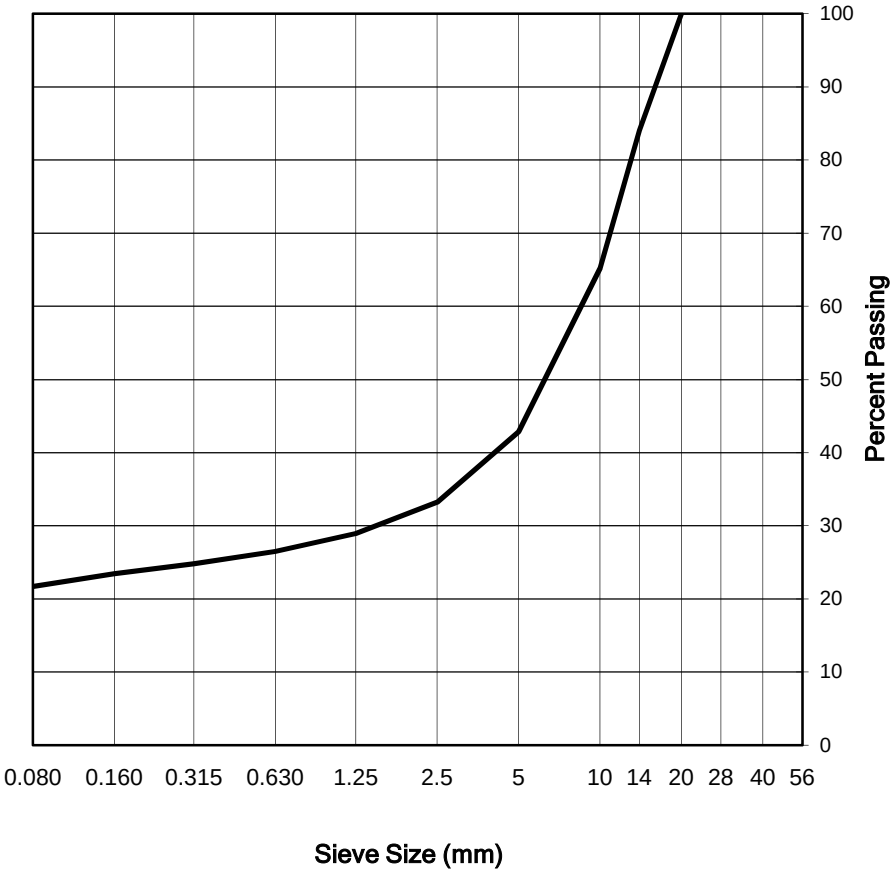
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-9
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 4, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 6, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.2%
Description:	Aggregate E	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	84
10	65
5	43
2.5	33
1.25	29
0.630	26
0.315	25
0.160	23
0.080	21.7



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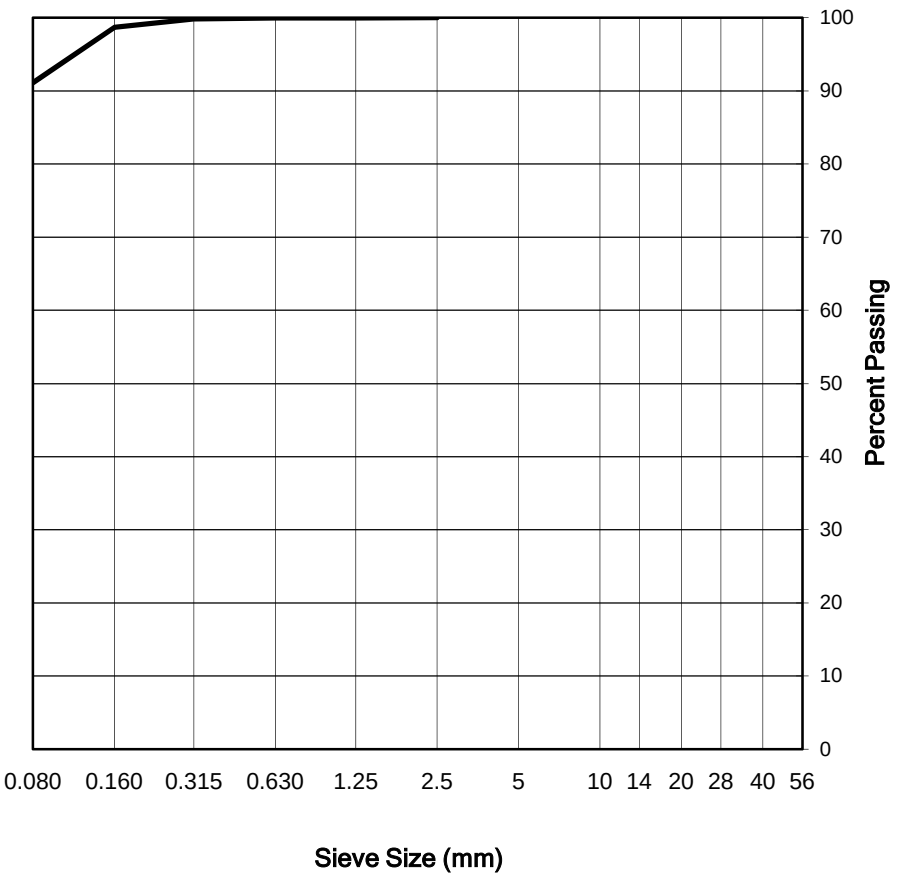
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-10
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 4, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 11, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.4%
Description:	Fly Ash B	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
2.5	100
1.25	100
0.630	100
0.315	100
0.160	99
0.080	91.1



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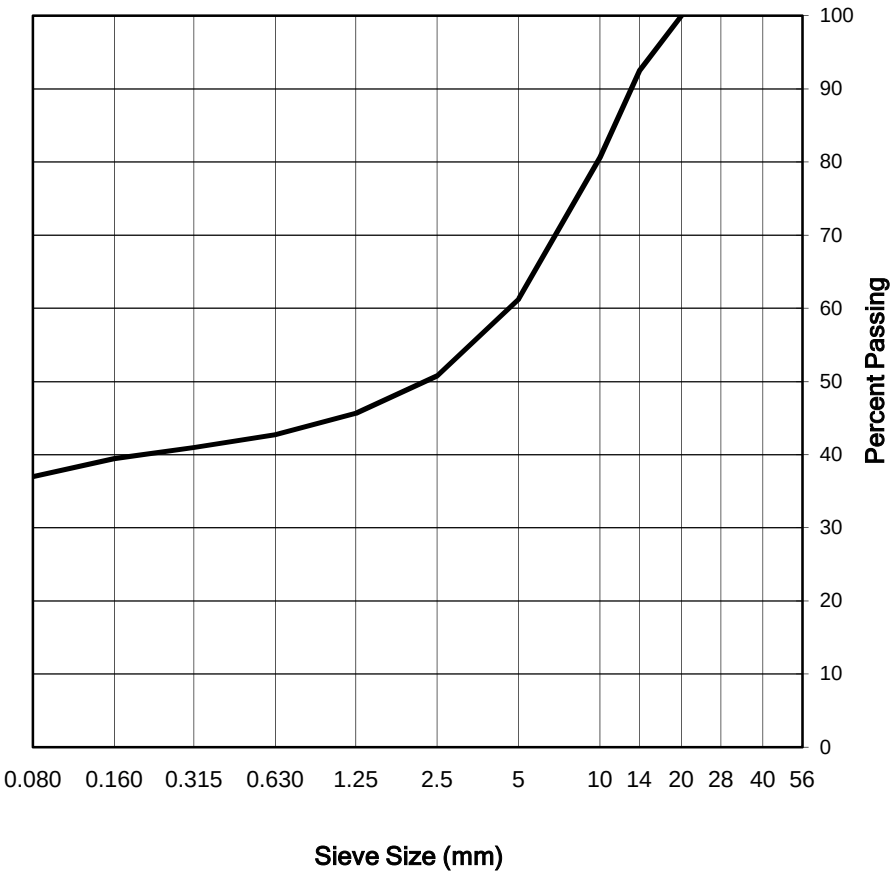
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-11
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 4, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 11, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	1.5%
Description:	2018 Mix F	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	92
10	81
5	61
2.5	51
1.25	46
0.630	43
0.315	41
0.160	39
0.080	37.0



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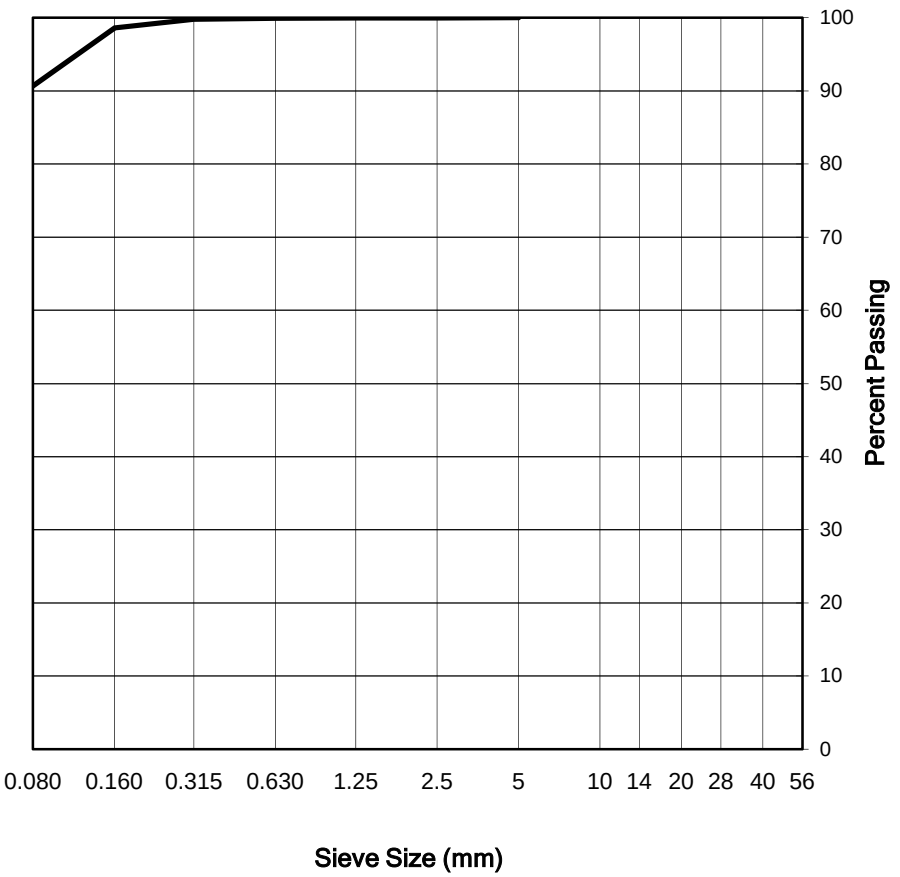
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-12
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 4, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 11, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.3%
Description:	Fly Ash A	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
5	100
2.5	100
1.25	100
0.630	100
0.315	100
0.160	99
0.080	90.7



Remarks:

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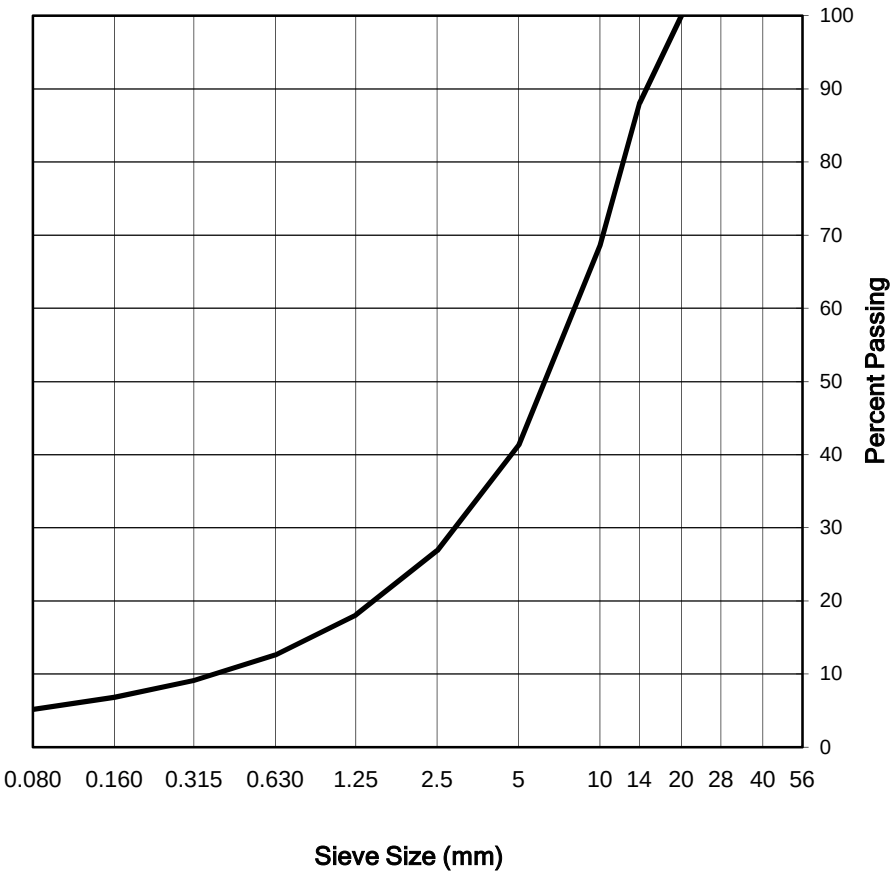
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-13
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 1, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 11, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.5%
Description:	Aggregate	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	88
10	69
5	41
2.5	27
1.25	18
0.630	13
0.315	9
0.160	7
0.080	5.2



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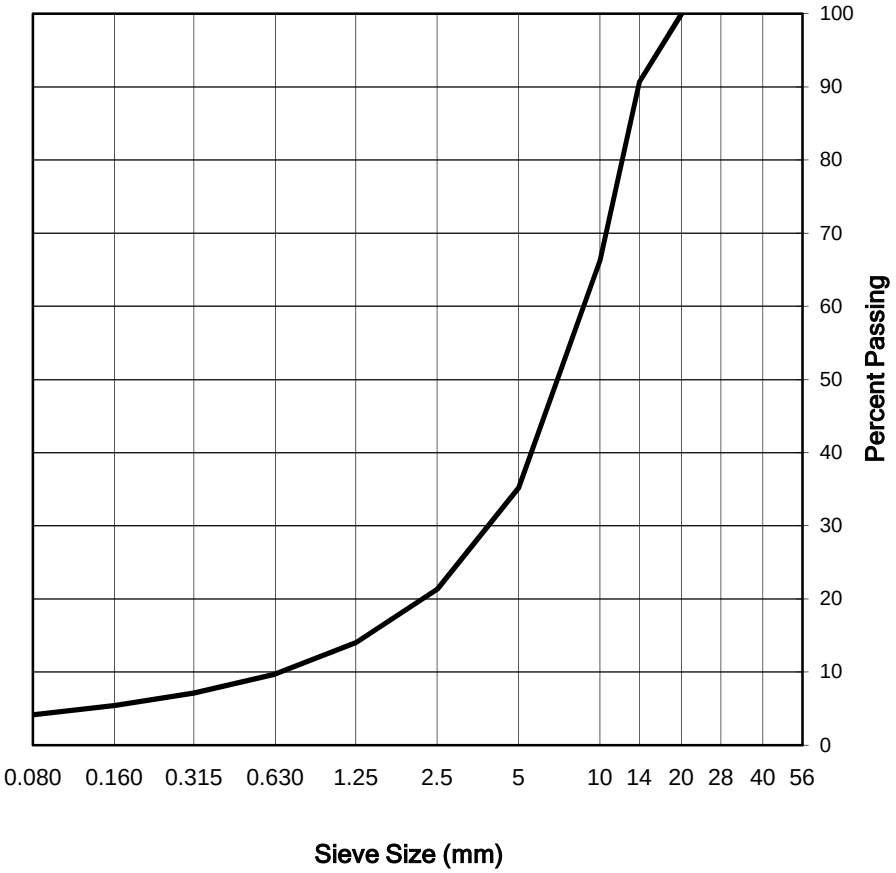
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-14
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 1, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 11, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.3%
Description:	Aggregate	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	91
10	66
5	35
2.5	21
1.25	14
0.630	10
0.315	7
0.160	5
0.080	4.2



Remarks:

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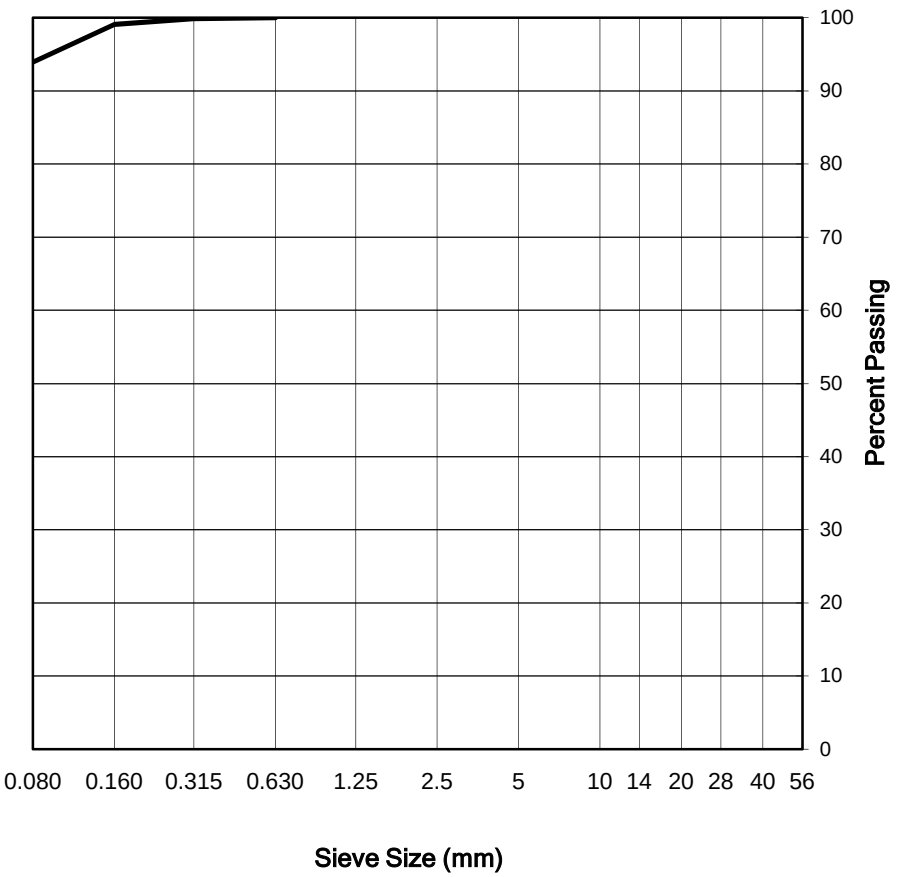
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-15
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 1, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 12, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	5.7%
Description:	Fly Ash	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
2.5	#N/A
1.25	#N/A
0.630	100
0.315	100
0.160	99
0.080	93.9



Remarks: Material present on the 0.630 sieve, but not enough material to register weight on the scale.

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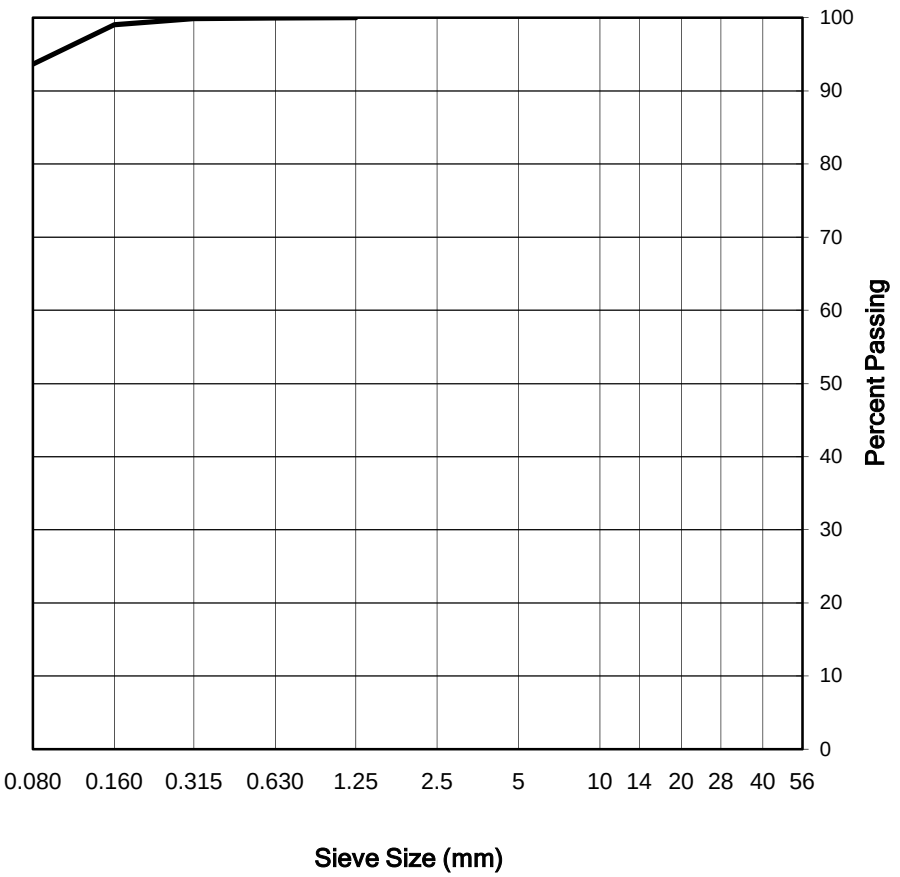
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-16
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 1, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 12, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.5%
Description:	Fly Ash	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
2.5	#N/A
1.25	100
0.630	100
0.315	100
0.160	99
0.080	93.7



Remarks:

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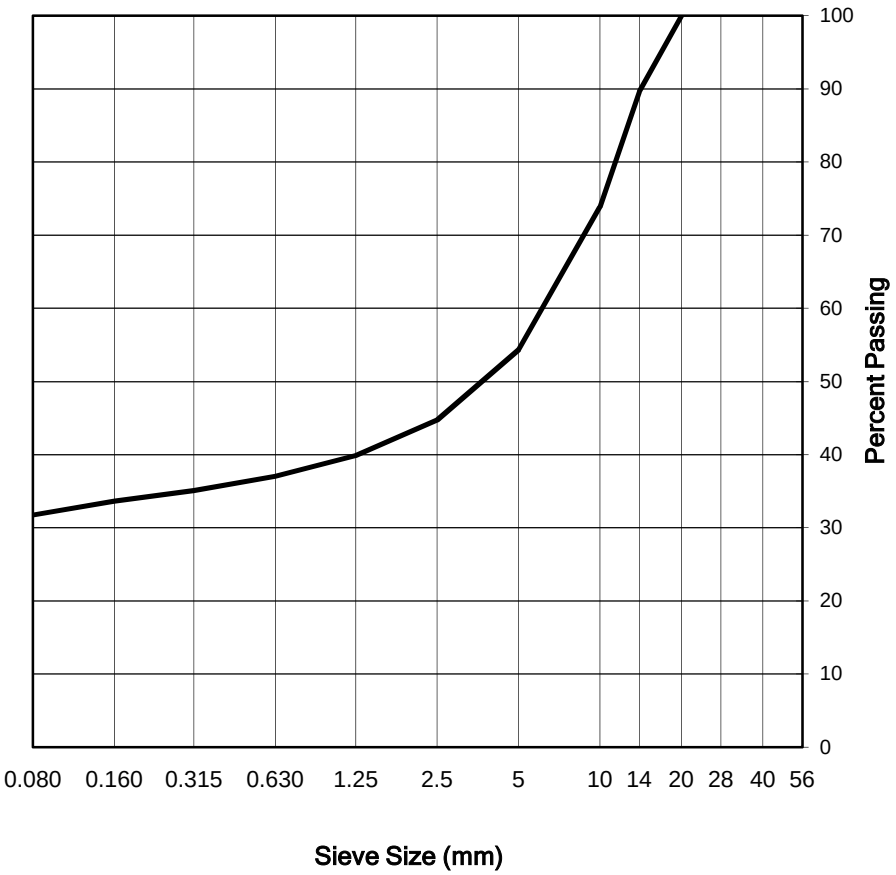
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-17
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 1, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 12, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.4%
Description:	Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	90
10	74
5	54
2.5	45
1.25	40
0.630	37
0.315	35
0.160	34
0.080	31.7



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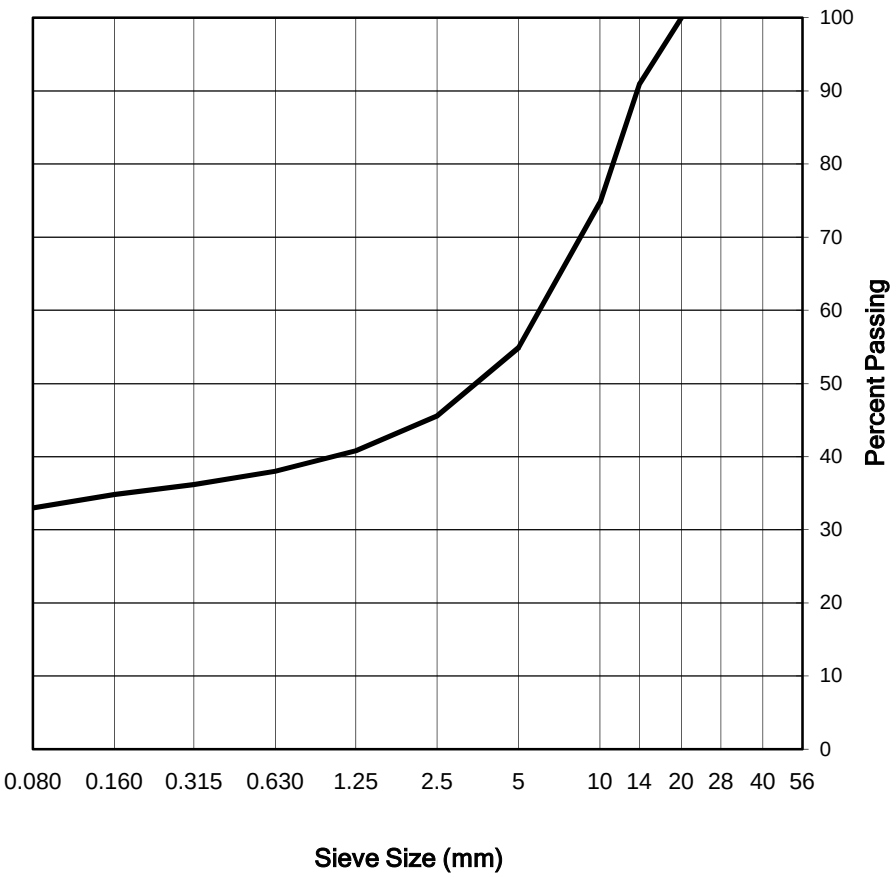
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-18
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 1, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 13, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.5%
Description:	Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	91
10	75
5	55
2.5	46
1.25	41
0.630	38
0.315	36
0.160	35
0.080	33.0



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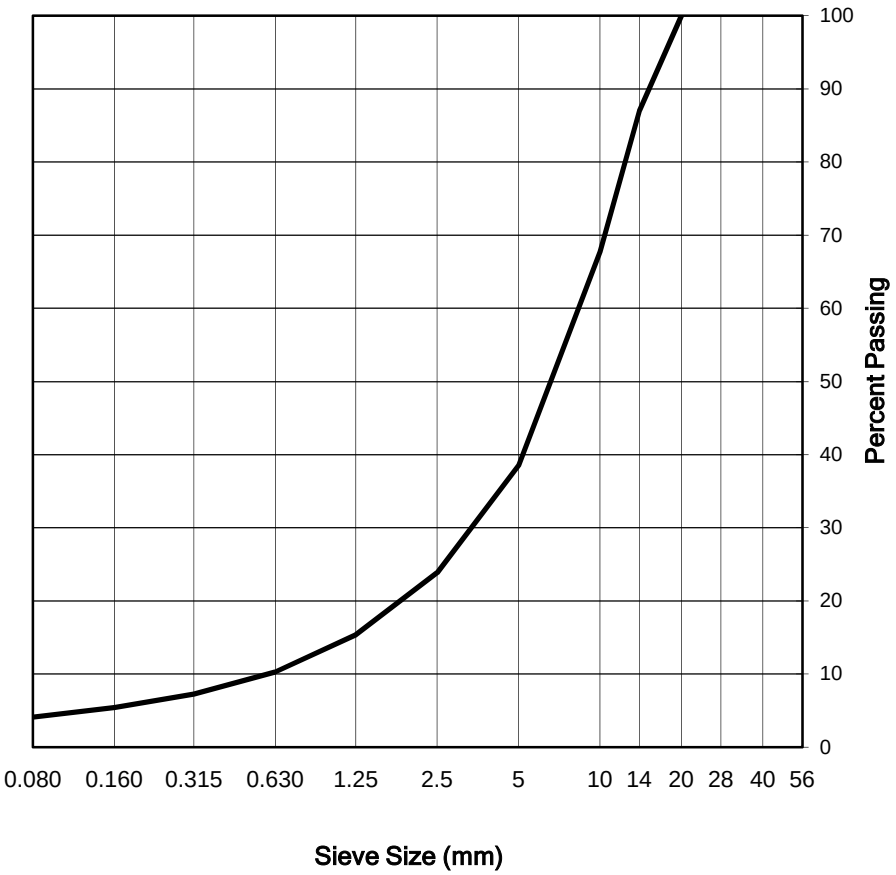
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-19
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 1, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 13, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.2%
Description:	Aggregate	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	87
10	68
5	39
2.5	24
1.25	15
0.630	10
0.315	7
0.160	5
0.080	4.1



Remarks:

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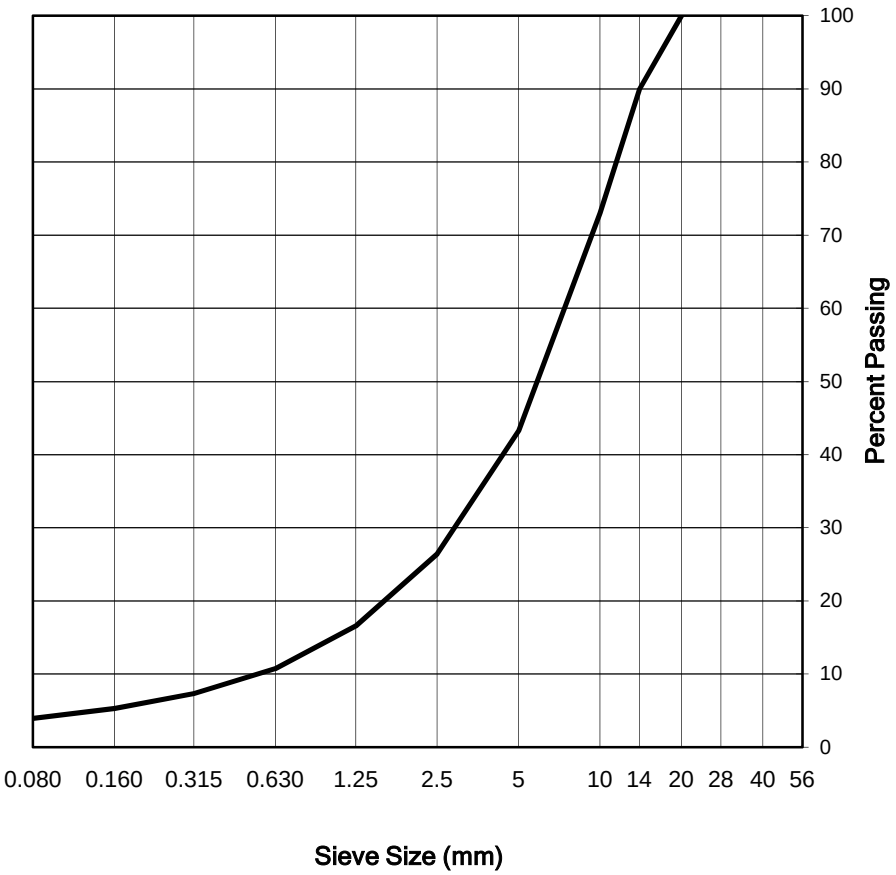
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-20
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 5, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 13, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.1%
Description:	Aggregate	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	90
10	73
5	43
2.5	26
1.25	17
0.630	11
0.315	7
0.160	5
0.080	3.9



Remarks:

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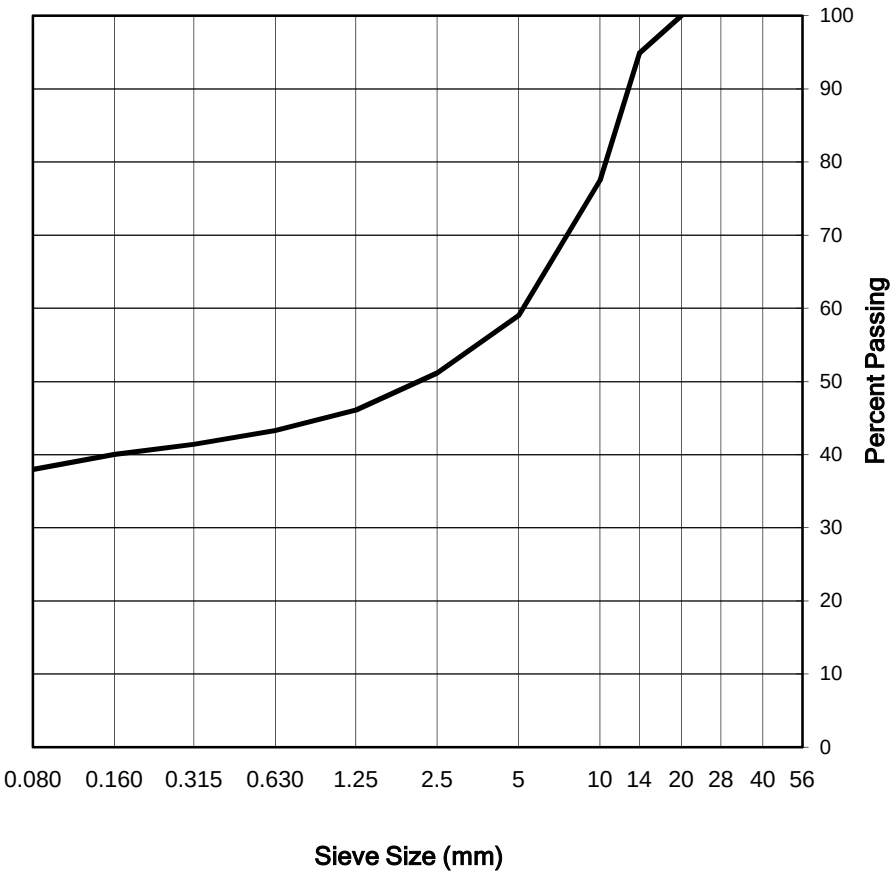
TETRA TECH

CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-21
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 1, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 15, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.3%
Description:	Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	95
10	78
5	59
2.5	51
1.25	46
0.630	43
0.315	41
0.160	40
0.080	38.0



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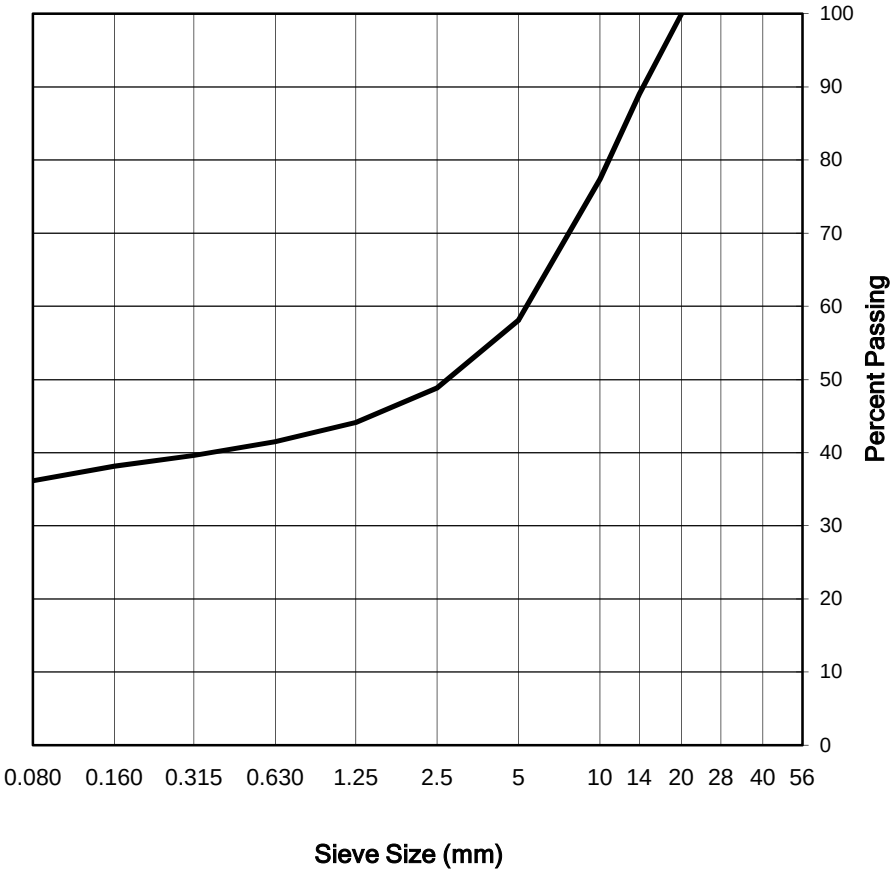
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-22
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 1, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 15, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.6%
Description:	Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	89
10	77
5	58
2.5	49
1.25	44
0.630	42
0.315	40
0.160	38
0.080	36.1



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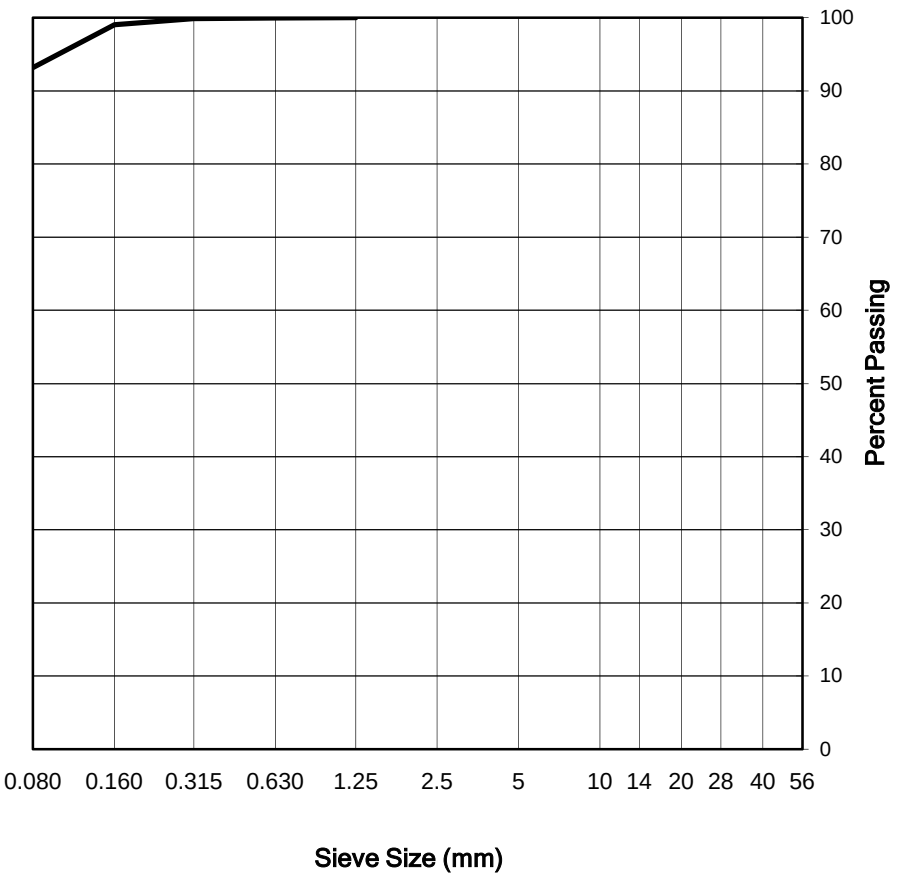
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-23
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 1, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 15, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.4%
Description:	Fly Ash	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
2.5	#N/A
1.25	100
0.630	100
0.315	100
0.160	99
0.080	93.2



Remarks: Material present on 1.25 cm sieve, but not enough material to register weight.

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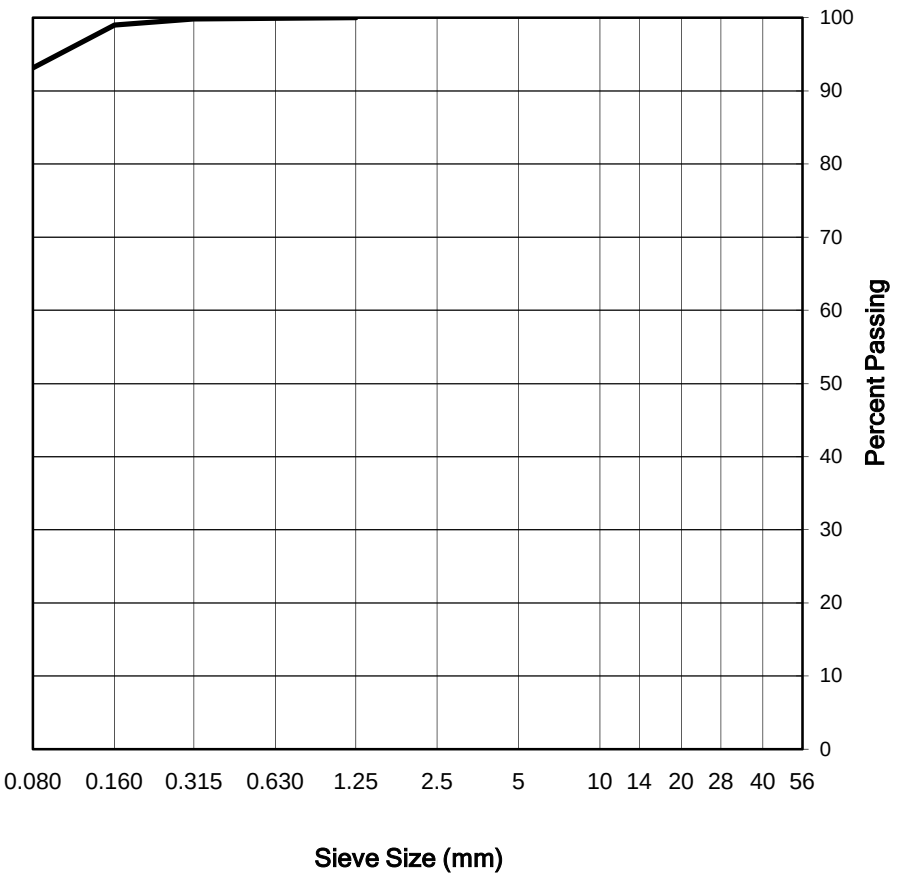
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-24
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 1, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 15, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.1%
Description:	Fly Ash	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
2.5	#N/A
1.25	100
0.630	100
0.315	100
0.160	99
0.080	93.2



Remarks:

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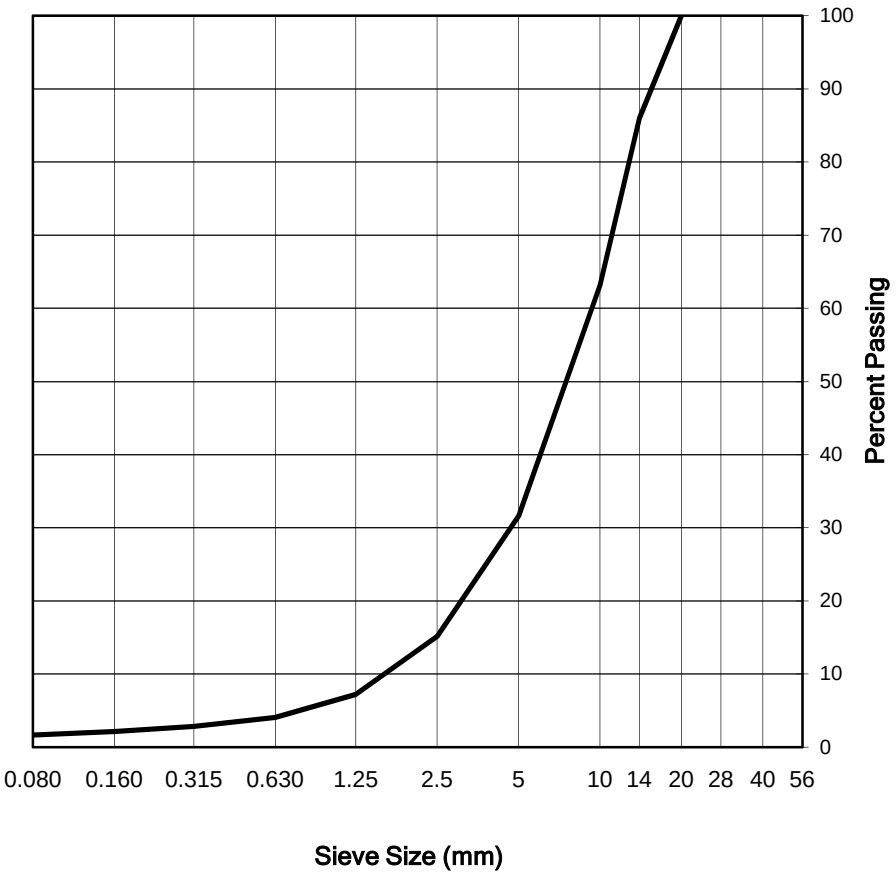
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-25
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 5, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 18, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.3%
Description:	C-Aggregate	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	86
10	63
5	32
2.5	15
1.25	7
0.630	4
0.315	3
0.160	2
0.080	1.6



Remarks:

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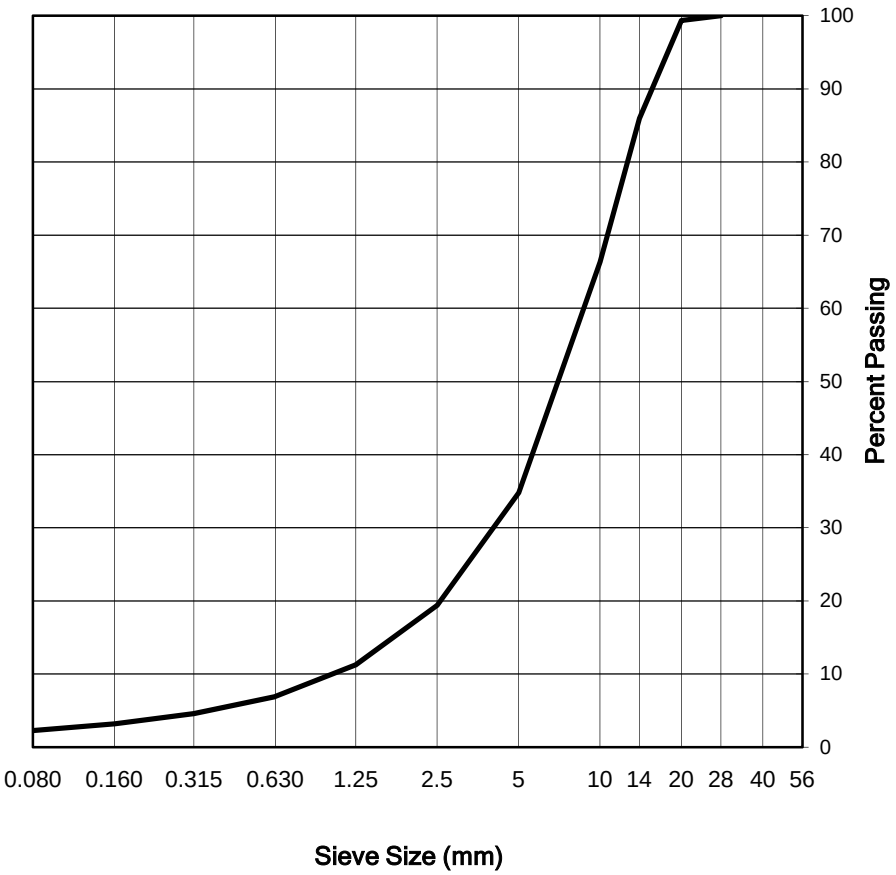
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-26
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 5, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 18, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.8%
Description:	D-Aggregate	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
28	100
20	99
14	86
10	66
5	35
2.5	19
1.25	11
0.630	7
0.315	5
0.160	3
0.080	2.3



Remarks:

Reviewed By: BF. P.Geol.

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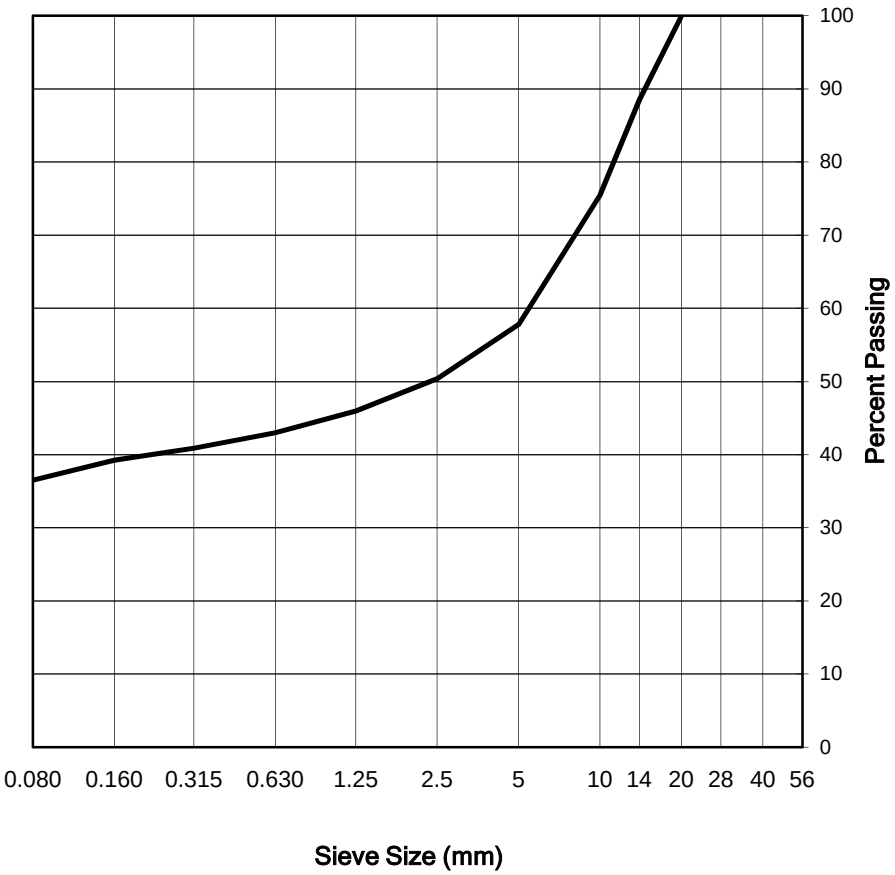
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-27
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 5, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 18, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	1.0%
Description:	Mix F	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	89
10	75
5	58
2.5	50
1.25	46
0.630	43
0.315	41
0.160	39
0.080	36.5



Remarks:

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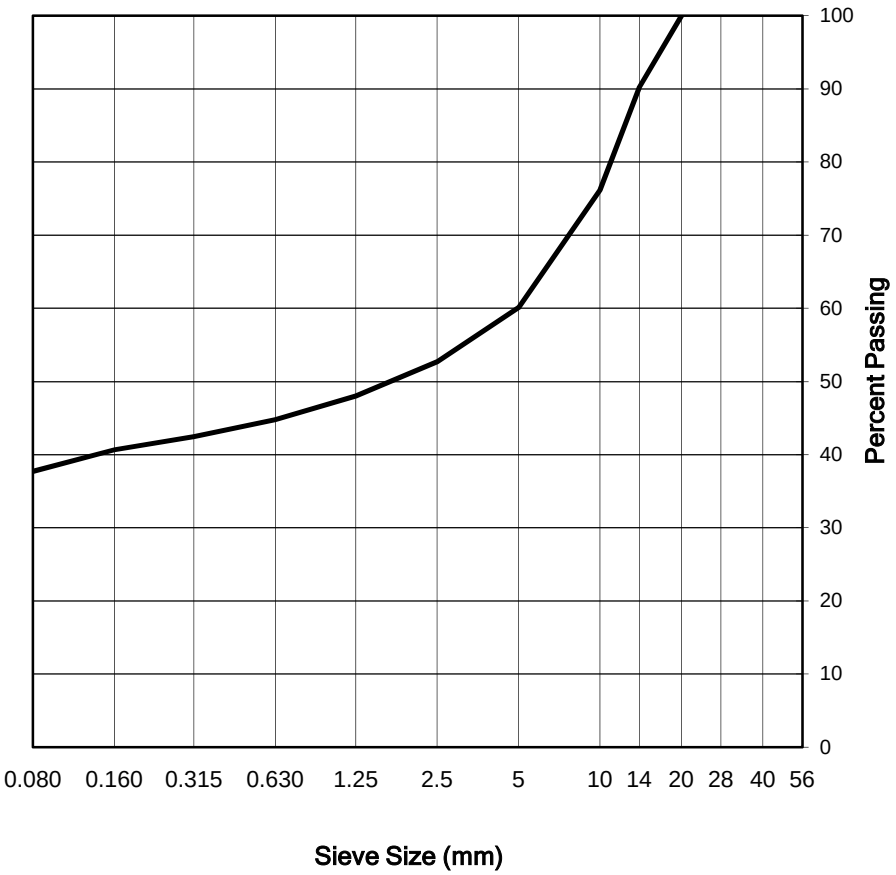
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-28
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 5, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 19, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	1.0%
Description:	Mix E	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	90
10	76
5	60
2.5	53
1.25	48
0.630	45
0.315	42
0.160	41
0.080	37.7



Remarks: Moderate amount of fines stuck to rocks, could not be removed by washing.

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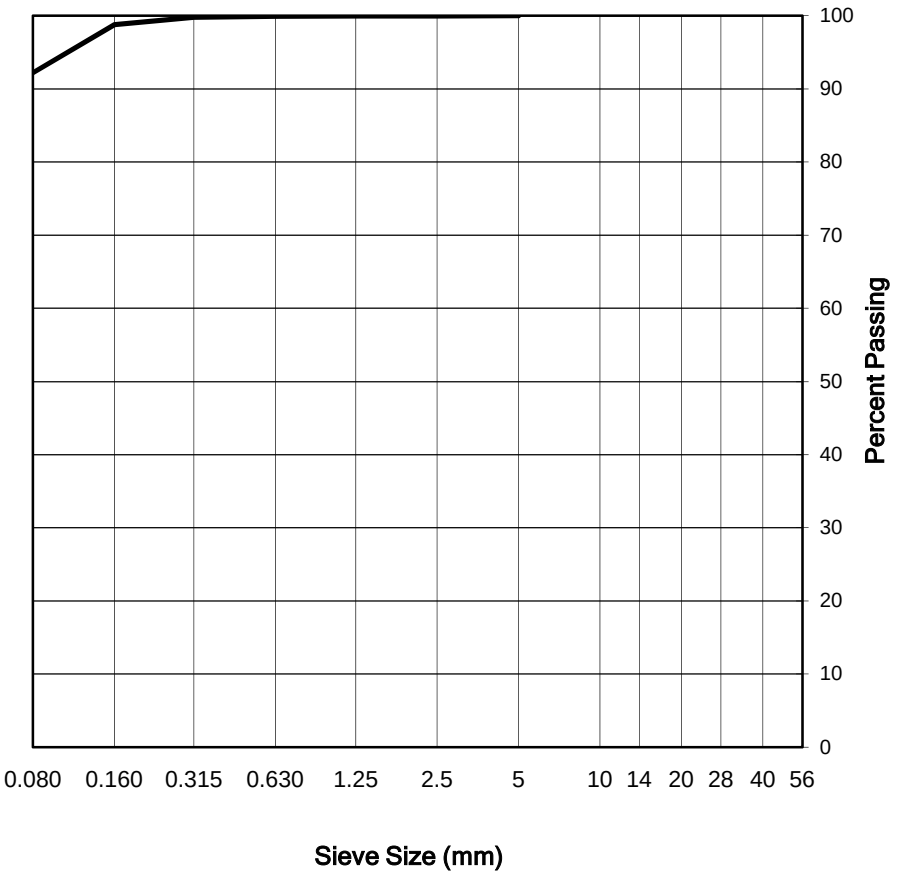
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-29
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 5, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 19, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.3%
Description:	Fly Ash A	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
5	100
2.5	100
1.25	100
0.630	100
0.315	100
0.160	99
0.080	92.2



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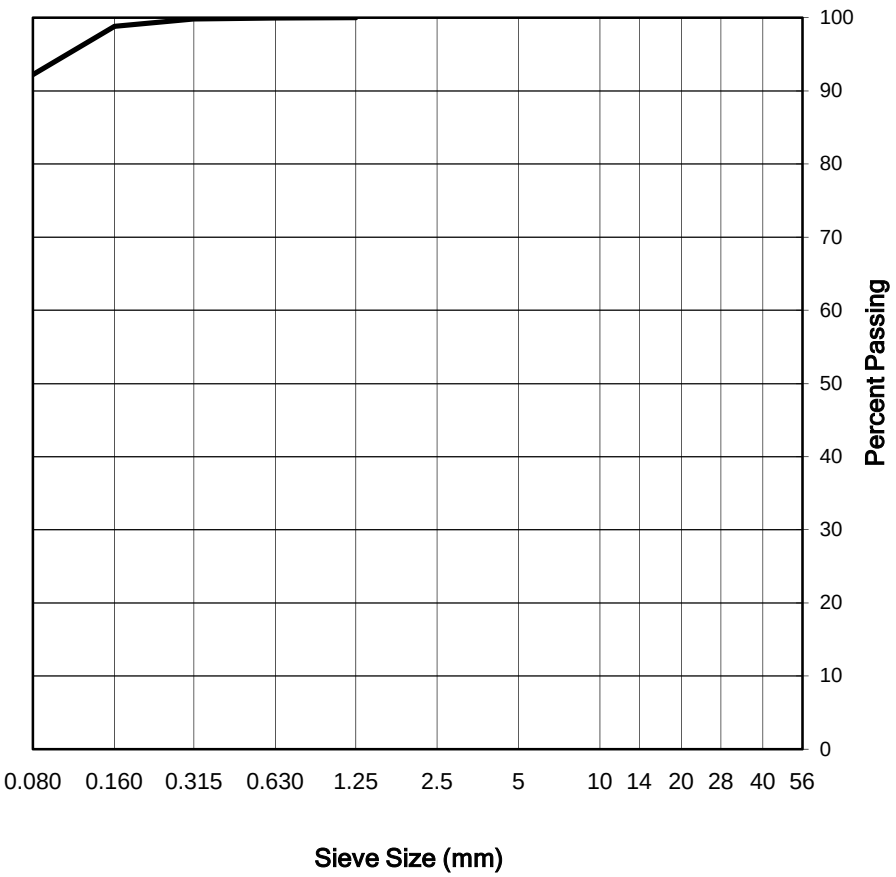
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-30
Project:	Hope Bay South Dam Project	**Date Sampled:**	May 5, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 20, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.4%
Description:	Fly Ash B	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
2.5	#N/A
1.25	100
0.630	100
0.315	100
0.160	99
0.080	92.2



Remarks:

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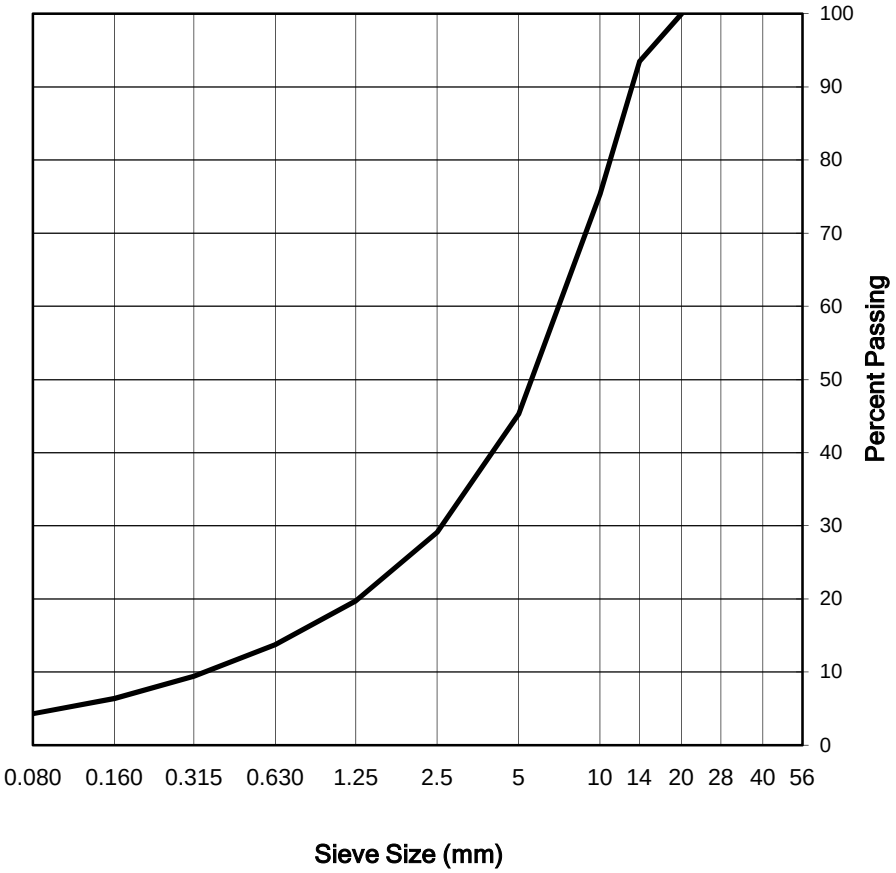
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-31
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 24, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 20, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.9%
Description:	Aggregate	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	93
10	75
5	45
2.5	29
1.25	20
0.630	14
0.315	9
0.160	6
0.080	4.3



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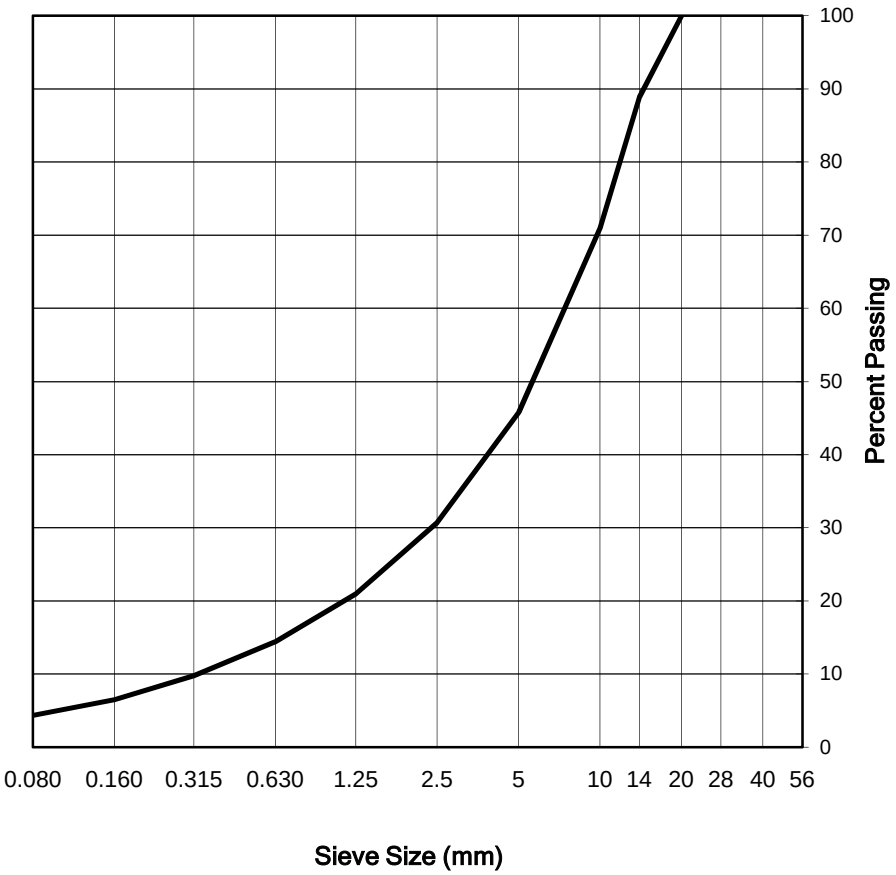
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-32
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 24, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 20, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	1.2%
Description:	Aggregate	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	89
10	71
5	46
2.5	31
1.25	21
0.630	14
0.315	10
0.160	6
0.080	4.3



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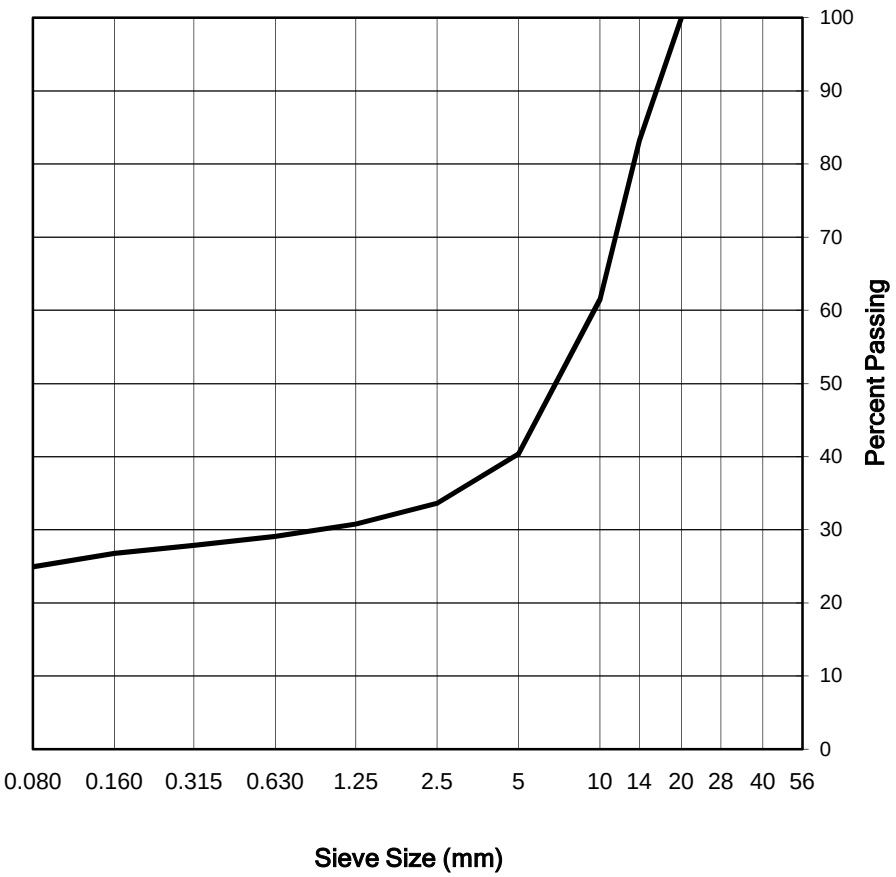
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-33
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 24, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 20, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.4%
Description:	Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	83
10	62
5	40
2.5	34
1.25	31
0.630	29
0.315	28
0.160	27
0.080	24.9



Remarks:

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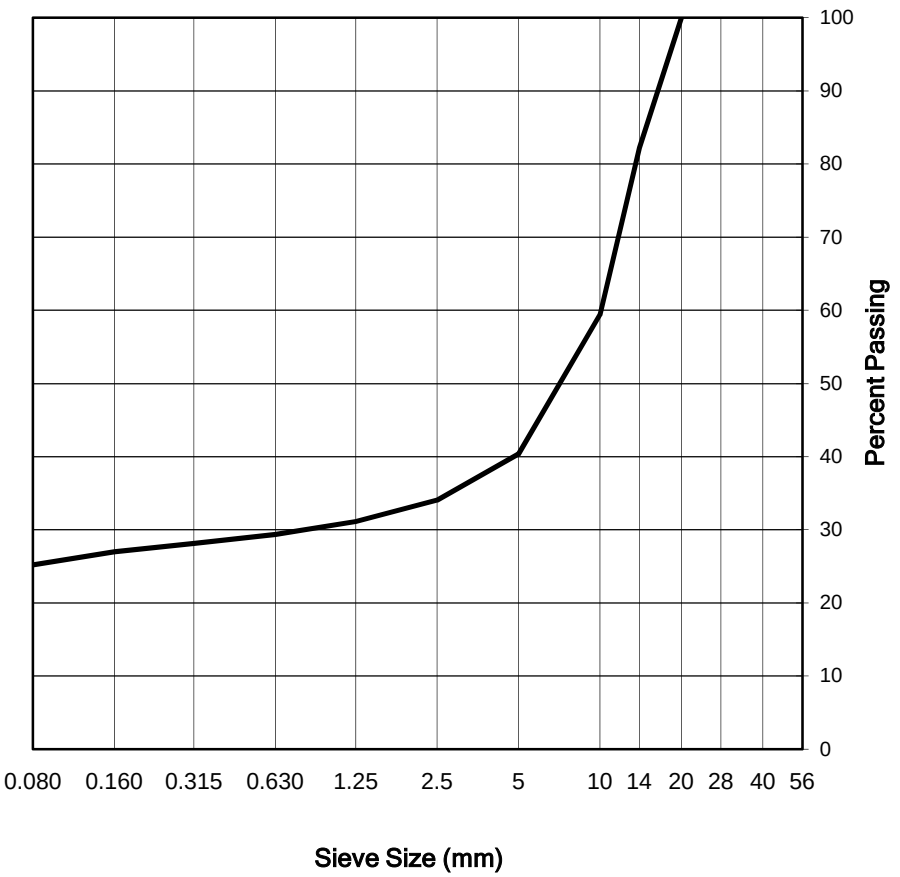
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-34
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 24, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 21, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.6%
Description:	Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	82
10	59
5	40
2.5	34
1.25	31
0.630	29
0.315	28
0.160	27
0.080	25.2



Remarks:

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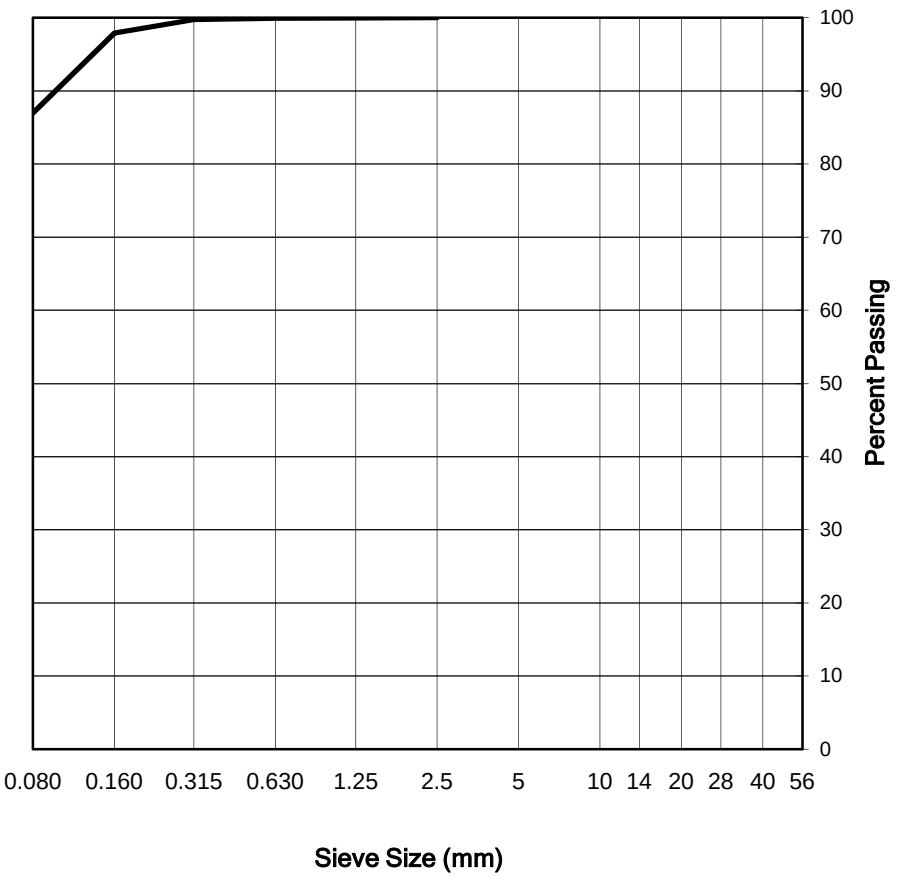
TETRA TECH

CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-35
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 24, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 21, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.4%
Description:	Fly Ash	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
2.5	100
1.25	100
0.630	100
0.315	100
0.160	98
0.080	87.0



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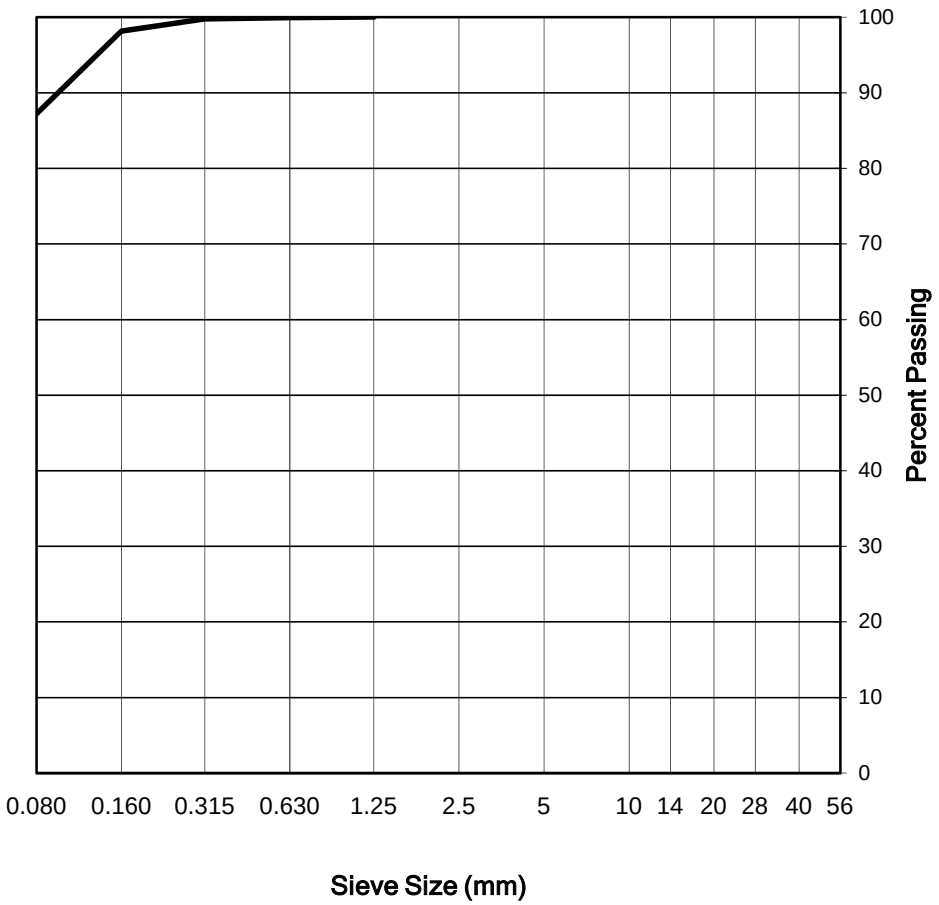
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-36
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 24, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 21, 2018
Attention:	Kelly Schwenning	**Tested by:** JC **Office:**	Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.4%
Description:	Fly Ash	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
2.5	#N/A
1.25	100
0.630	100
0.315	100
0.160	98
0.080	87.2



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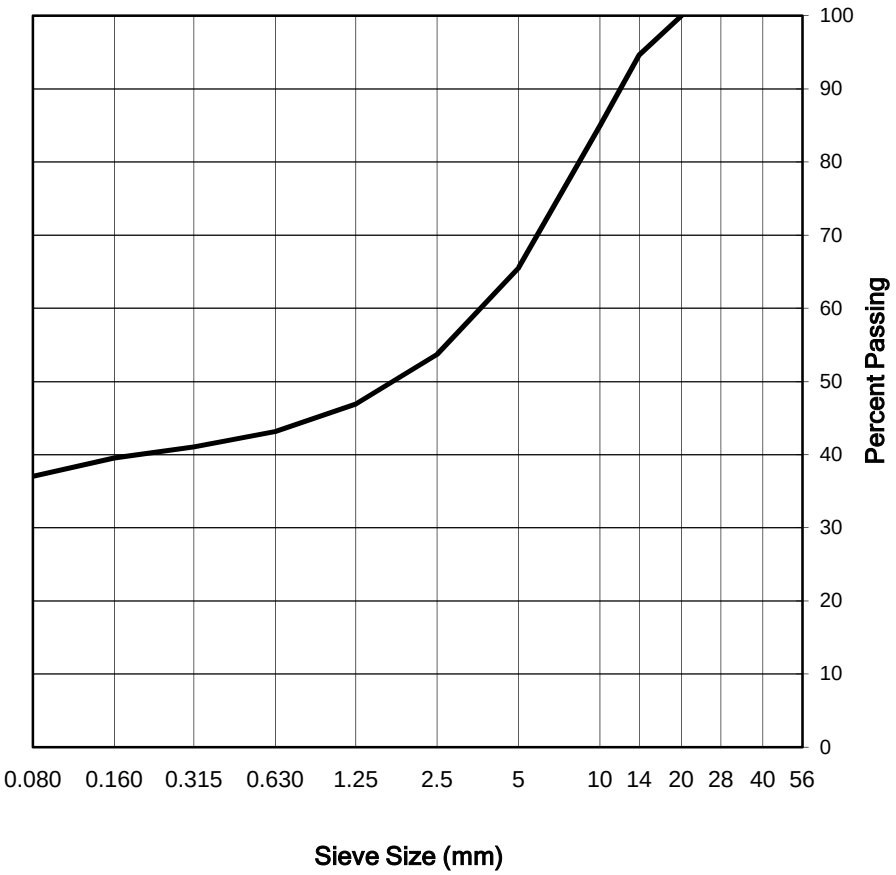
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-37
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 17, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 21, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.6%
Description:	Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	95
10	85
5	66
2.5	54
1.25	47
0.630	43
0.315	41
0.160	40
0.080	37.0



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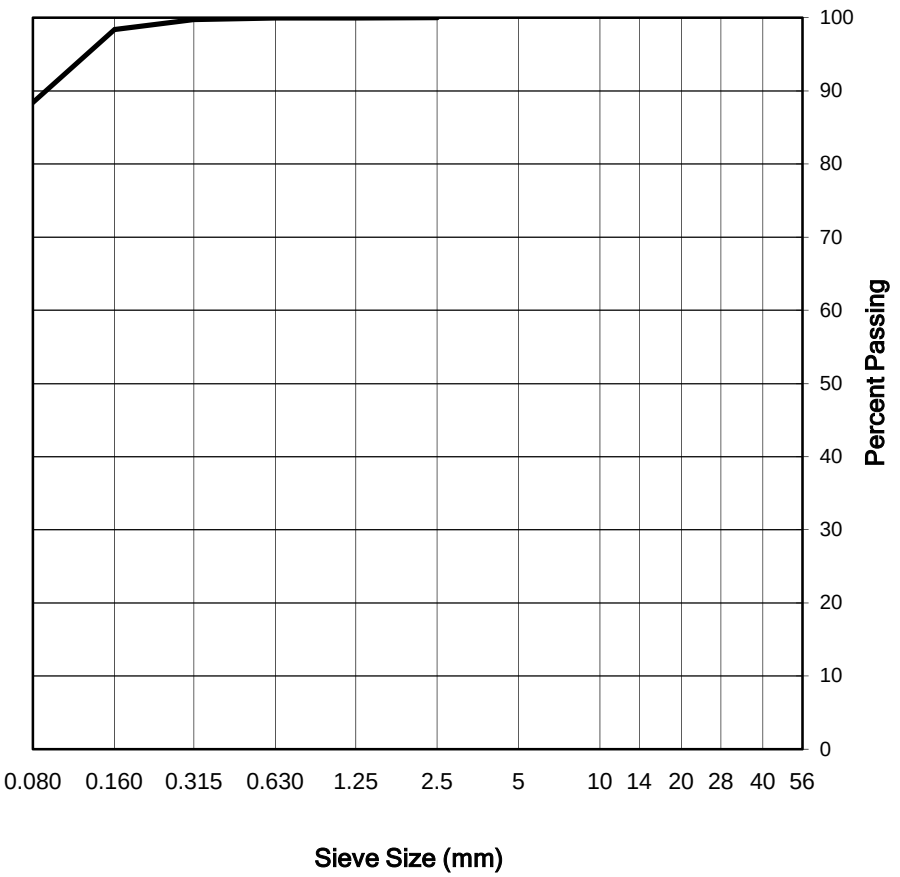
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-38
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 17, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 22, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.5%
Description:	Fly Ash	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
2.5	100
1.25	100
0.630	100
0.315	100
0.160	98
0.080	88.4



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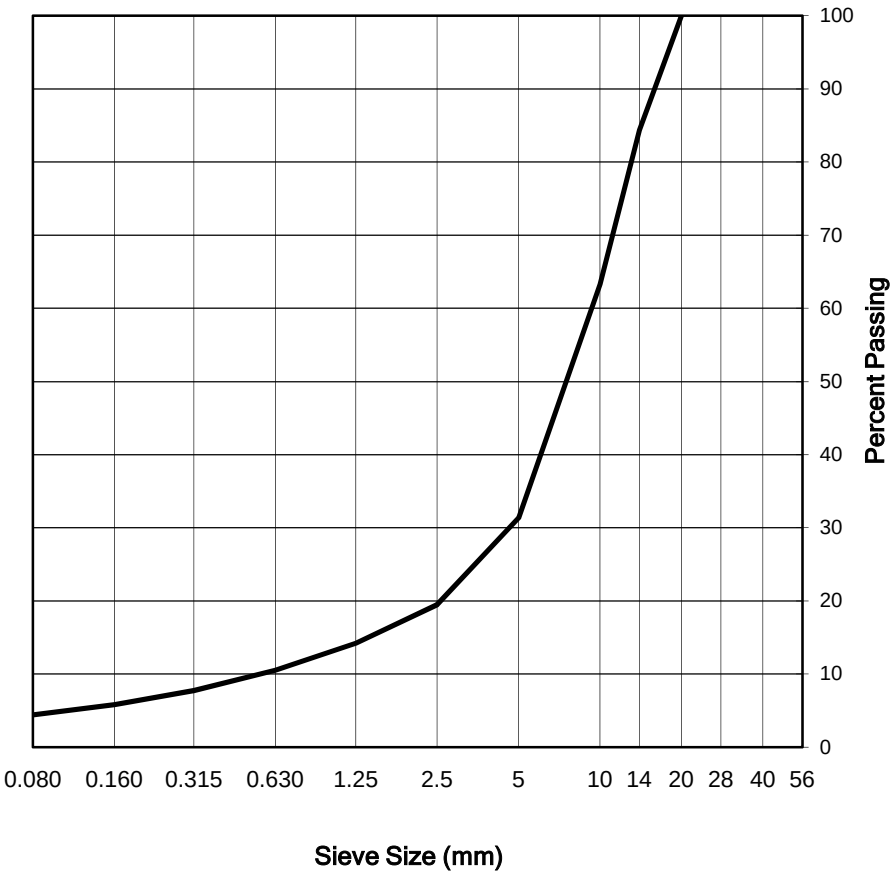
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-39
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 17, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 22, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	1.3%
Description:	Aggregate	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	84
10	63
5	31
2.5	19
1.25	14
0.630	10
0.315	8
0.160	6
0.080	4.4



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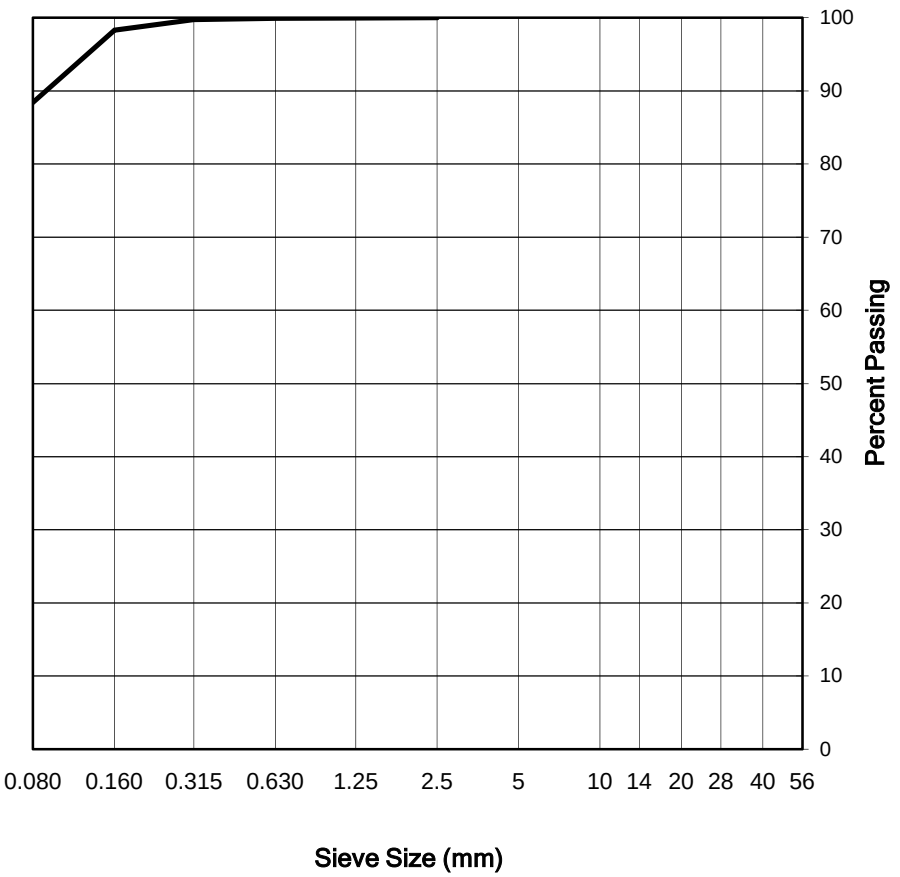
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-40
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 17, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	June 22, 2018
Attention:	Kelly Schwenning	**Tested by:** JC	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.4%
Description:	Fly Ash	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
2.5	100
1.25	100
0.630	100
0.315	100
0.160	98
0.080	88.4



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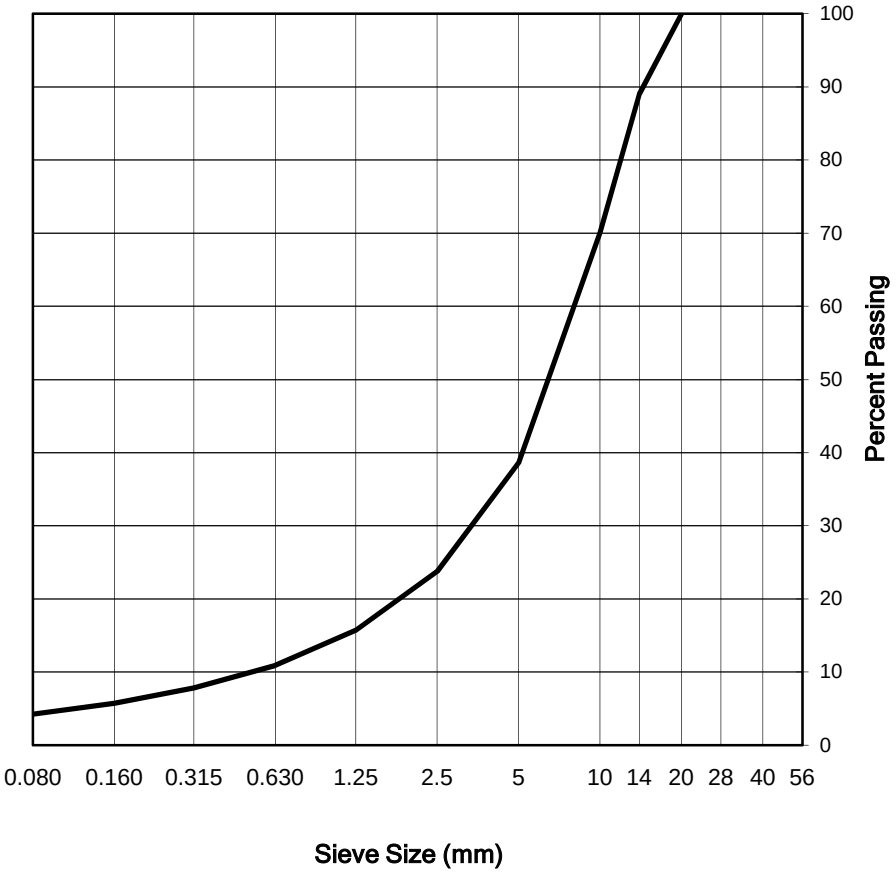
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-41
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 17, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	July 10, 2018
Attention:	Kelly Schwenning	**Tested by:** WB	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	1.6%
Description:	Aggregate	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	89
10	70
5	39
2.5	24
1.25	16
0.630	11
0.315	8
0.160	6
0.080	4.2



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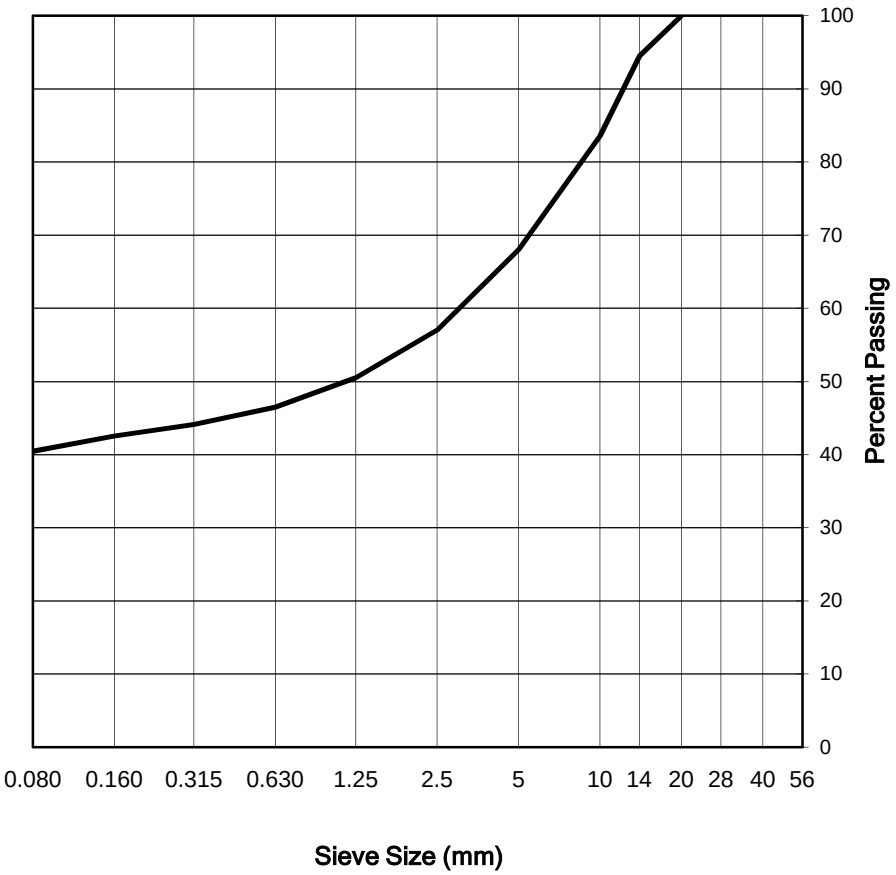
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-42
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 17, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	July 11, 2018
Attention:	Kelly Schwenning	**Tested by:** WB	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	1.1%
Description:	Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	94
10	84
5	68
2.5	57
1.25	50
0.630	46
0.315	44
0.160	43
0.080	40.5



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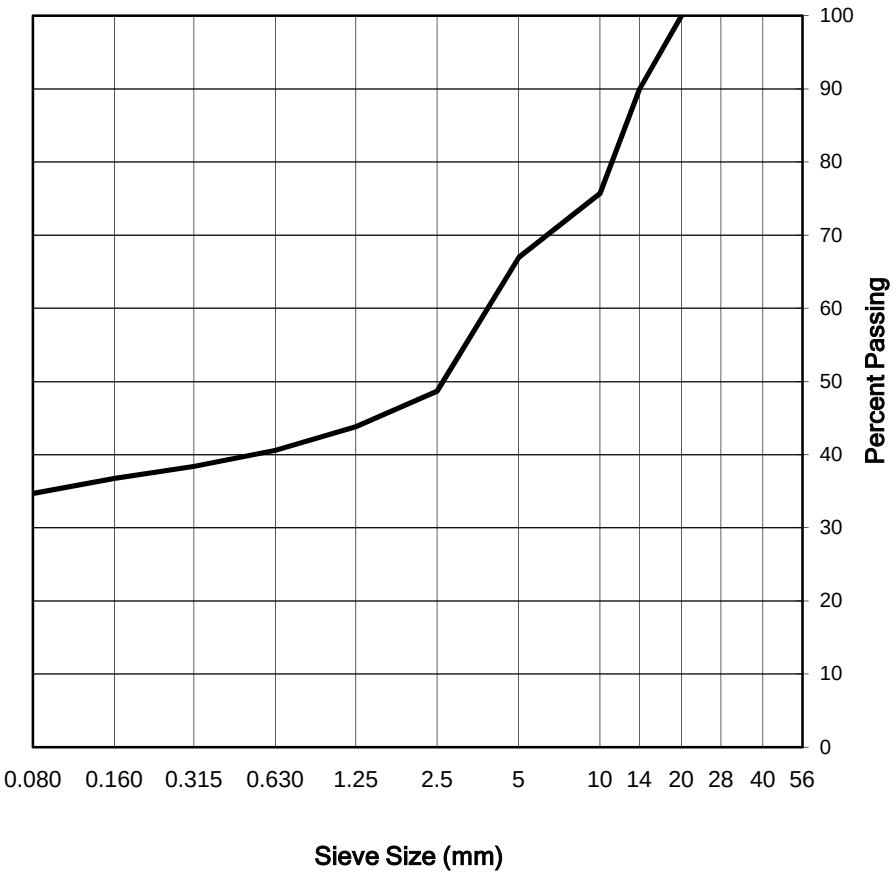
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-43
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 25, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	July 10, 2018
Attention:	Kelly Schwenning	**Tested by:** WB	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.5%
Description:	Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	90
10	76
5	67
2.5	49
1.25	44
0.630	41
0.315	38
0.160	37
0.080	34.7



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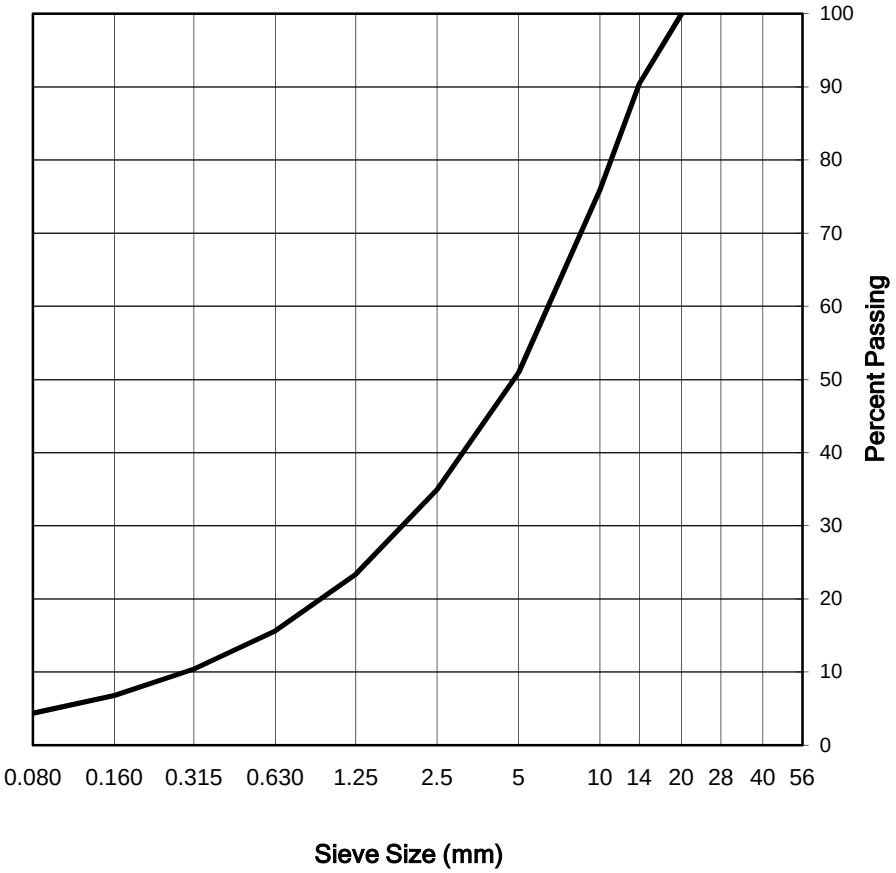
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-44
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 25, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	July 10, 2018
Attention:	Kelly Schwenning	**Tested by:** WB	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.2%
Description:	Aggregate	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	90
10	76
5	51
2.5	35
1.25	23
0.630	16
0.315	10
0.160	7
0.080	4.4



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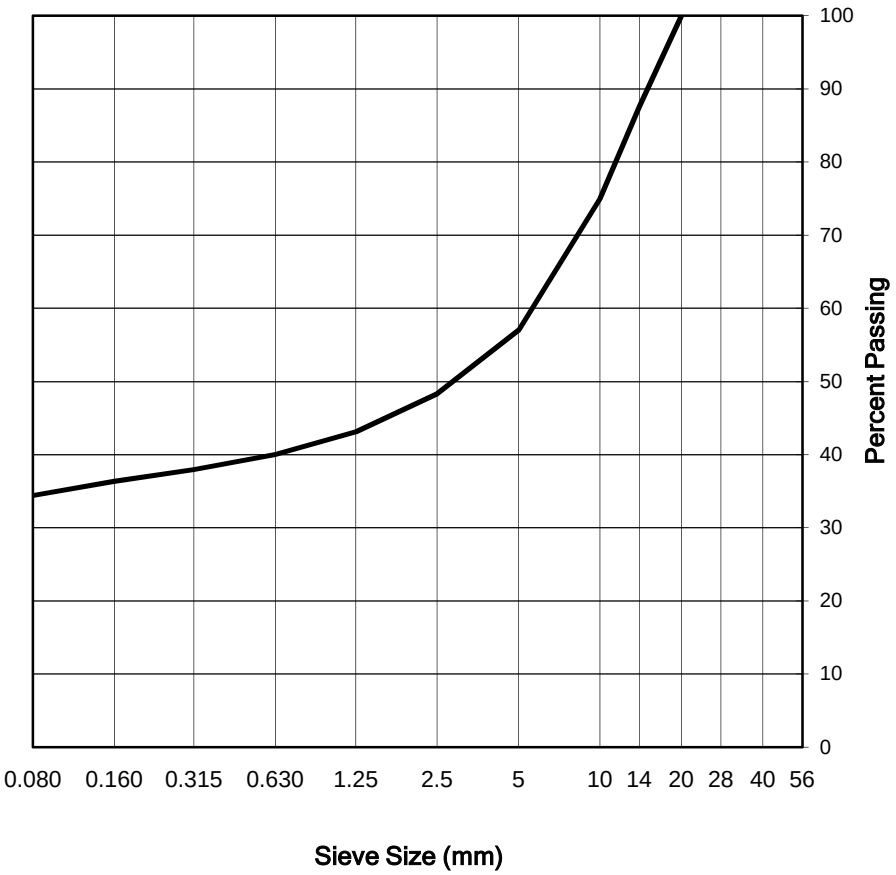
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-45
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 25, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	July 11, 2018
Attention:	Kelly Schwenning	**Tested by:** WB	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.6%
Description:	Blend	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	88
10	75
5	57
2.5	48
1.25	43
0.630	40
0.315	38
0.160	36
0.080	34.4



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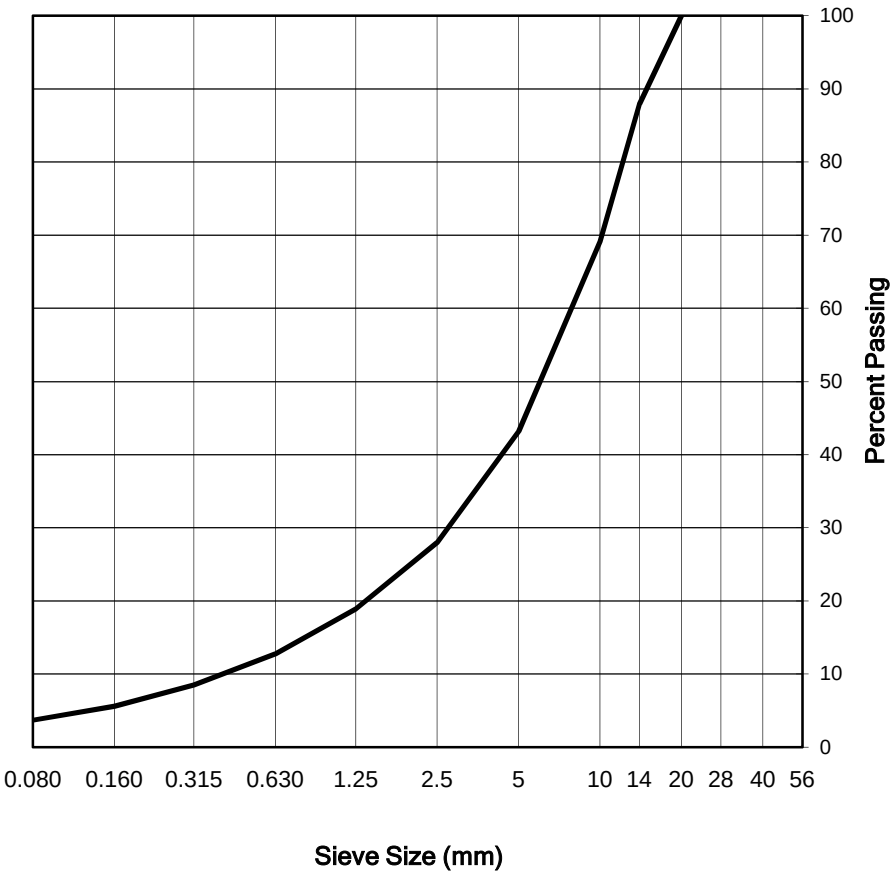
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-46
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 25, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	July 11, 2018
Attention:	Kelly Schwenning	**Tested by:** WB	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.4%
Description:	Aggregate	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
20	100
14	88
10	69
5	43
2.5	28
1.25	19
0.630	13
0.315	8
0.160	6
0.080	3.7



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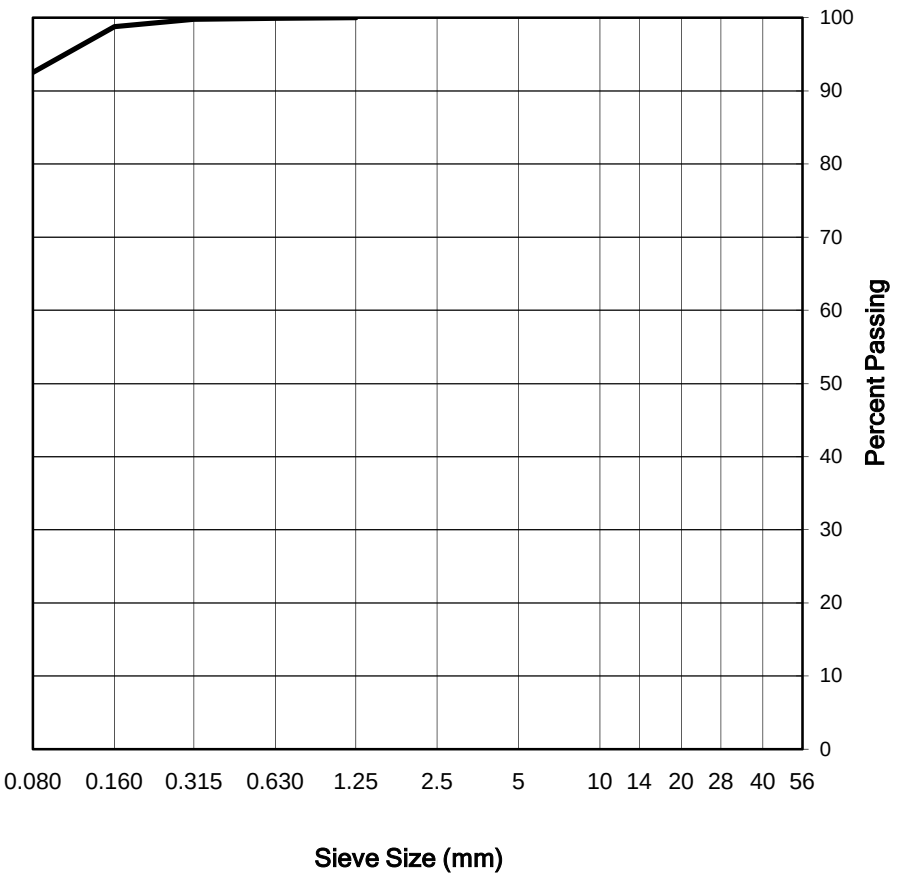
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-47
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 25, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	July 11, 2018
Attention:	Kelly Schwenning	**Tested by:** WB	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.5%
Description:	Fly Ash	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
2.5	#N/A
1.25	100
0.630	100
0.315	100
0.160	99
0.080	92.5



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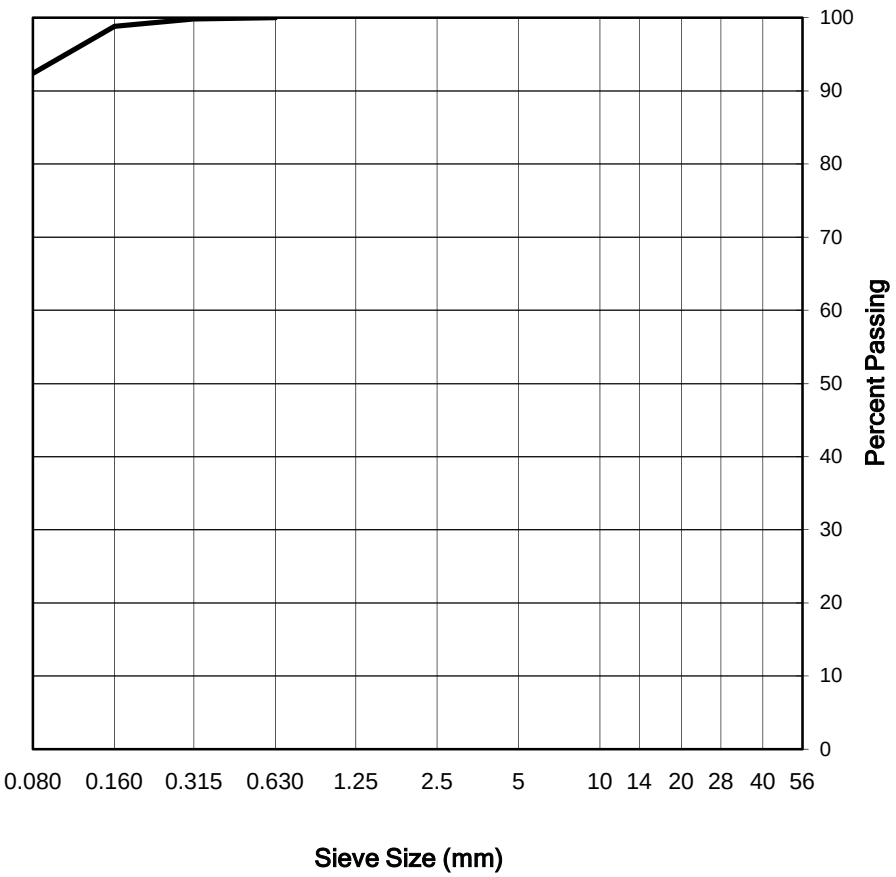
CONCRETE AGGREGATE ANALYSIS REPORT

CSA A23.2-2A and CSA A23.2-5A

Project No.:	704-Y14103336-02.003	**Sample No.:**	6705-48
Project:	Hope Bay South Dam Project	**Date Sampled:**	April 25, 2018
Client:	TMAC Resources Inc.	**Date Tested:**	July 13, 2018
Attention:	Kelly Schwenning	**Tested by:** TO	**Office:** Yellowknife
Email:	kelly.schwenning@tmacresources.com	**Moisture Content:**	0.3%
Description:	Fly Ash	**Colour Plate No.:**	
Source:	Batch Plant	**Bulk Relative Density:**	
Location:	Batch Plant	**Bulk Relative Density (SSD):**	
Supplier:	TMAC Resources Inc.	**Apparent Relative Density:**	
Specification:		**Absorption:**	

Sieve Sizes	Percent Passing
2.5	#N/A
1.25	#N/A
0.630	100
0.315	100
0.160	99
0.080	92.4



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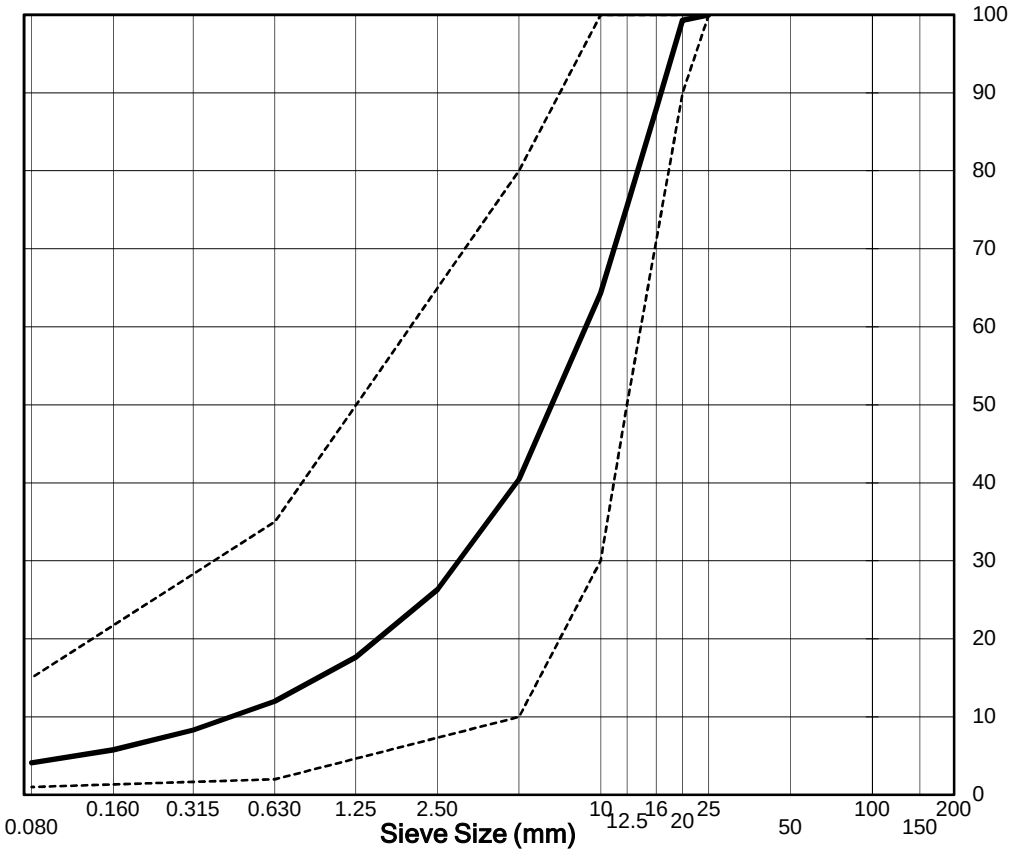
TETRA TECH

SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103336-02.003	Sample No.:	6693-1
Project:	Hope Bay South Dam Project	Date Sampled:	May 2, 2018
Client:	TMAC Resources Inc.	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	May 23, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	WM/IS Office: Yellowknife
Description:	25 mm (-) crush bedding	Moisture Content (as received):	1.4%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Hope Bay	By particle mass:	
Supplier:	TMAC Resources Inc.		
Sample Location:	South Dam, Sta. 4+55		
Specification:	SRK 25(-) Crush Bedding		

Sieve Size	Percent Passing
25	100
20	99
16	88
13	75
10	64
5	40
2.5	26
1.25	18
0.630	12
0.315	8
0.160	6
0.080	4.1



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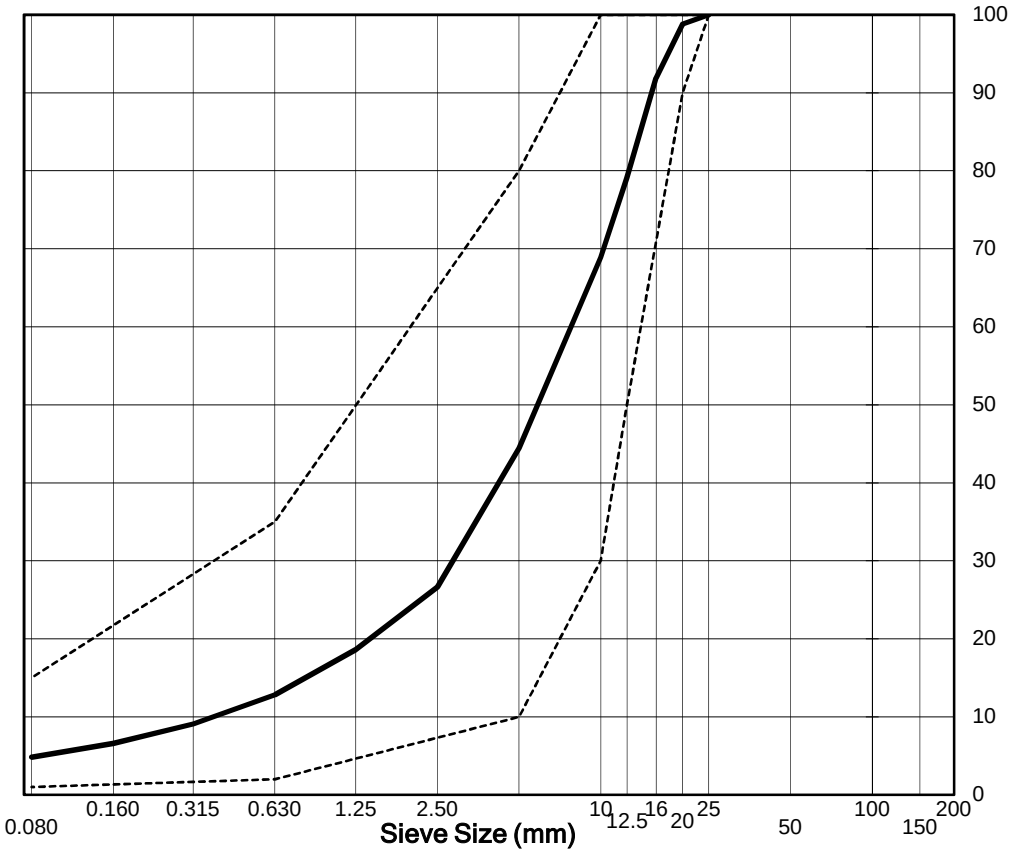
TETRA TECH

SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103336-02.003	Sample No.:	6693-2
Project:	Hope Bay South Dam Project	Date Sampled:	May 2, 2018
Client:	TMAC Resources Inc.	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	May 22, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	WM/IS Office: Yellowknife
Description:	25 mm (-) crush bedding	Moisture Content (as received):	1.4%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Hope Bay	By particle mass:	
Supplier:	TMAC Resources Inc.		
Sample Location:	Crusher		
Specification:	SRK 25(-) Crush Bedding		

Sieve Size	Percent Passing
25	100
20	99
16	92
13	79
10	69
5	44
2.5	27
1.25	19
0.630	13
0.315	9
0.160	7
0.080	4.8



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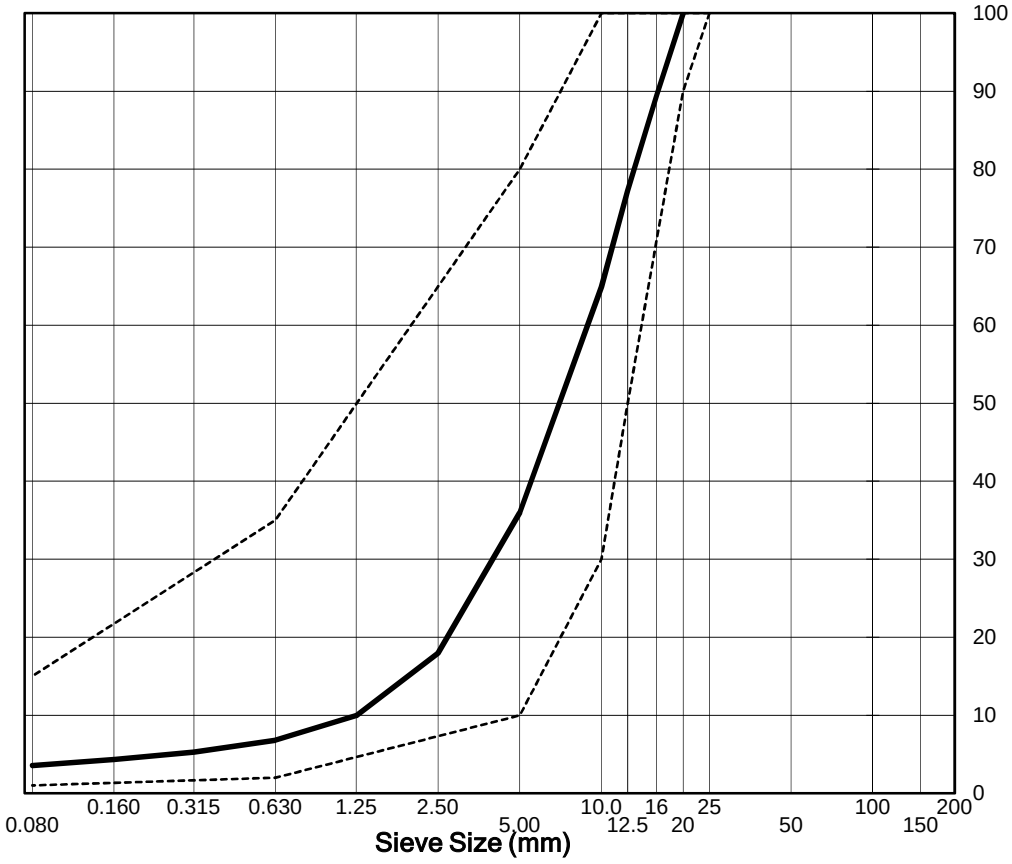
TETRA TECH

SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103336-02.003	Sample No.:	6652-A
Project:	Hope Bay South Dam Project	Date Sampled:	February 14, 2018
Client:	TMAC Resources	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	February 17, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	WM Office: Yellowknife
Description:	25mm(-) crush bedding	Moisture Content (as received):	2.5%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Quarry 2	By particle mass:	100% 100%
Supplier:	TMAC Resources	ASTM D5821	
Sample Location:			
Specification:	SRK 25(-) Crush Bedding		

Sieve Size	Percent Passing
20	100
16	90
13	77
10	65
5	36.0
2.5	17.9
1.25	9.9
0.630	6.8
0.315	5.3
0.160	4.3
0.080	3.6



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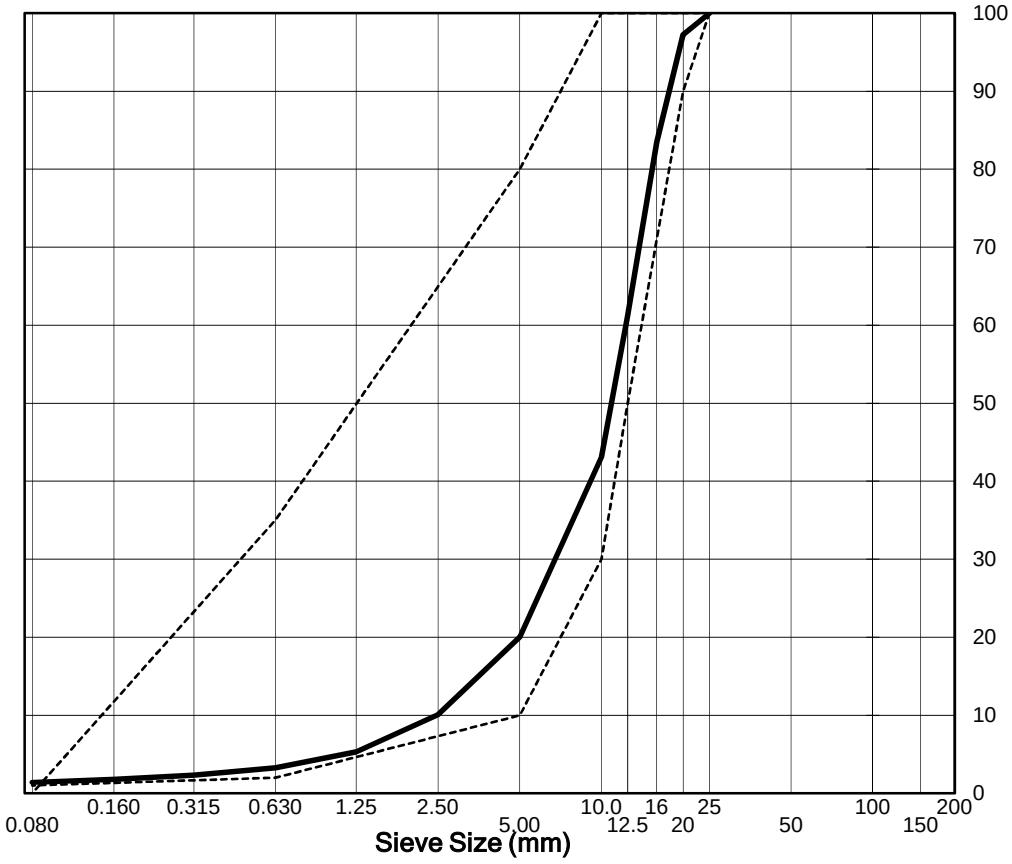
TETRA TECH

SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103336-02.003	Sample No.:	6652-B
Project:	Hope Bay South Dam Project	Date Sampled:	February 14, 2018
Client:	TMAC Resources	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	February 17, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	WM Office: Yellowknife
Description:	25mm(-) crush bedding	Moisture Content (as received):	1.0%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Quarry 2	By particle mass:	
Supplier:	TMAC Resources		
Sample Location:			
Specification:	SRK 25(-) Crush Bedding		

Sieve Size	Percent Passing
25	100.0
20	97
16	84
13	61
10	43
5	20.0
2.5	10.1
1.25	5.3
0.630	3.3
0.315	2.3
0.160	1.8
0.080	1.4



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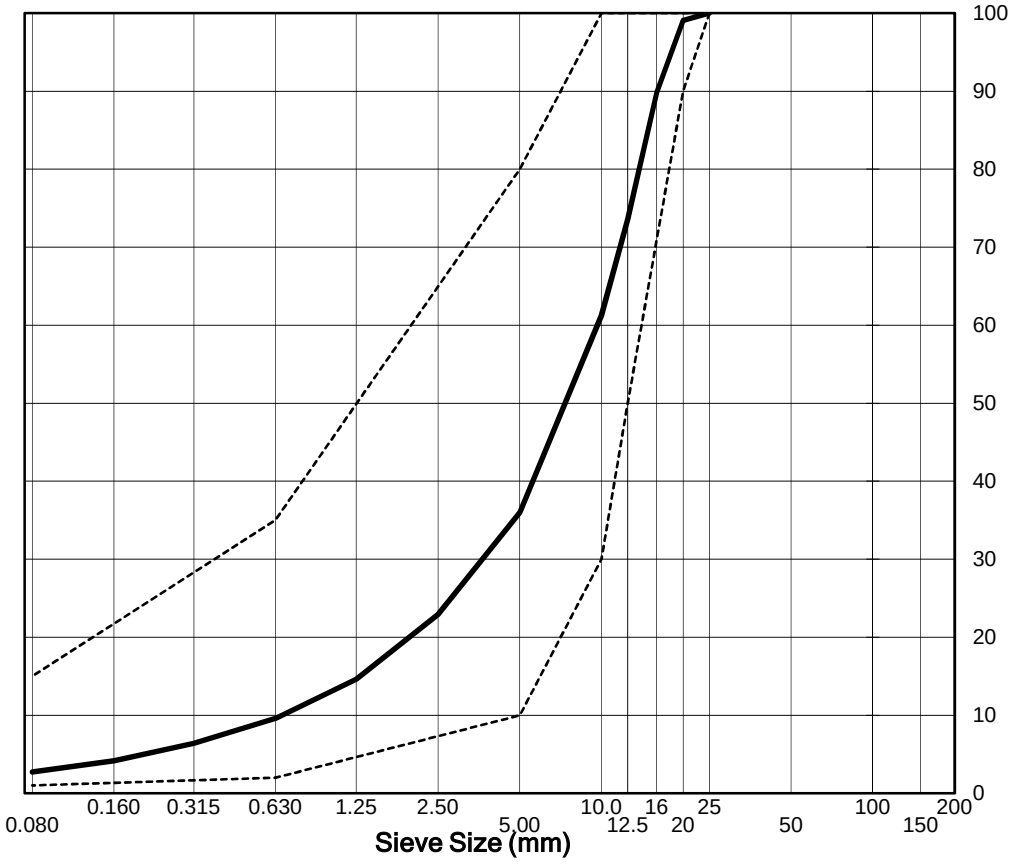
TETRA TECH

SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103336-02.003	Sample No.:	6653-1
Project:	Hope Bay South Dam Project	Date Sampled:	February 13, 2018
Client:	TMAC Resources	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	SS Office: Yellowknife
Description:	25mm(-) crush bedding	Moisture Content (as received):	0.6%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Sample #1, 1000 m3	By particle mass:	100% 100%
Supplier:	TMAC Resources	ASTM D5821	
Sample Location:			
Specification:	SRK 25(-) Crush Bedding		

Sieve Size	Percent Passing
25	100.0
20	99
16	90
13	74
10	61
5	36.0
2.5	22.9
1.25	14.6
0.630	9.6
0.315	6.4
0.160	4.2
0.080	2.7



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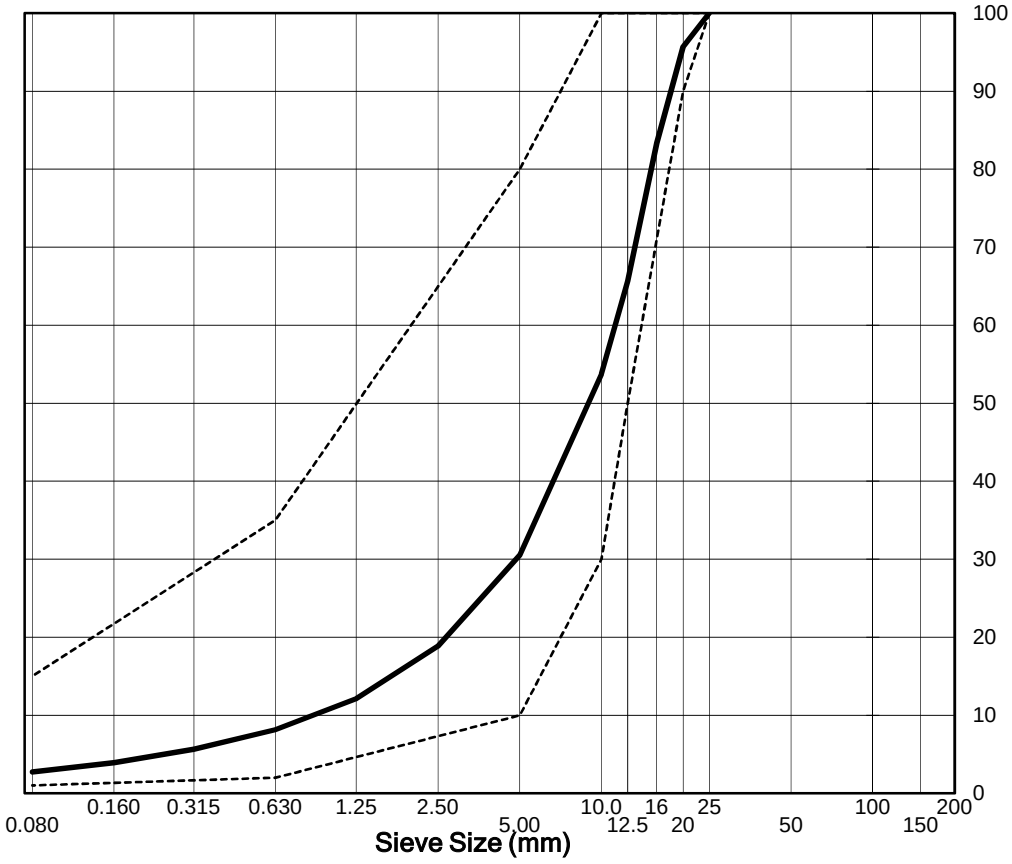
SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103336-02.003	Sample No.:	6653-2
Project:	Hope Bay South Dam Project	Date Sampled:	February 17, 2018
Client:	TMAC Resources	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	SS Office: Yellowknife
Description:	25mm(-) crush bedding	Moisture Content (as received):	0.4%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Sample #2, 2000 m3	By particle mass:	100% 100%
Supplier:	TMAC Resources	ASTM D5821	
Sample Location:			
Specification:	SRK 25(-) Crush Bedding		

Sieve Size	Percent Passing
25	100.0
20	96
16	83
13	66
10	54
5	30.5
2.5	18.8
1.25	12.1
0.630	8.2
0.315	5.7
0.160	3.9
0.080	2.7



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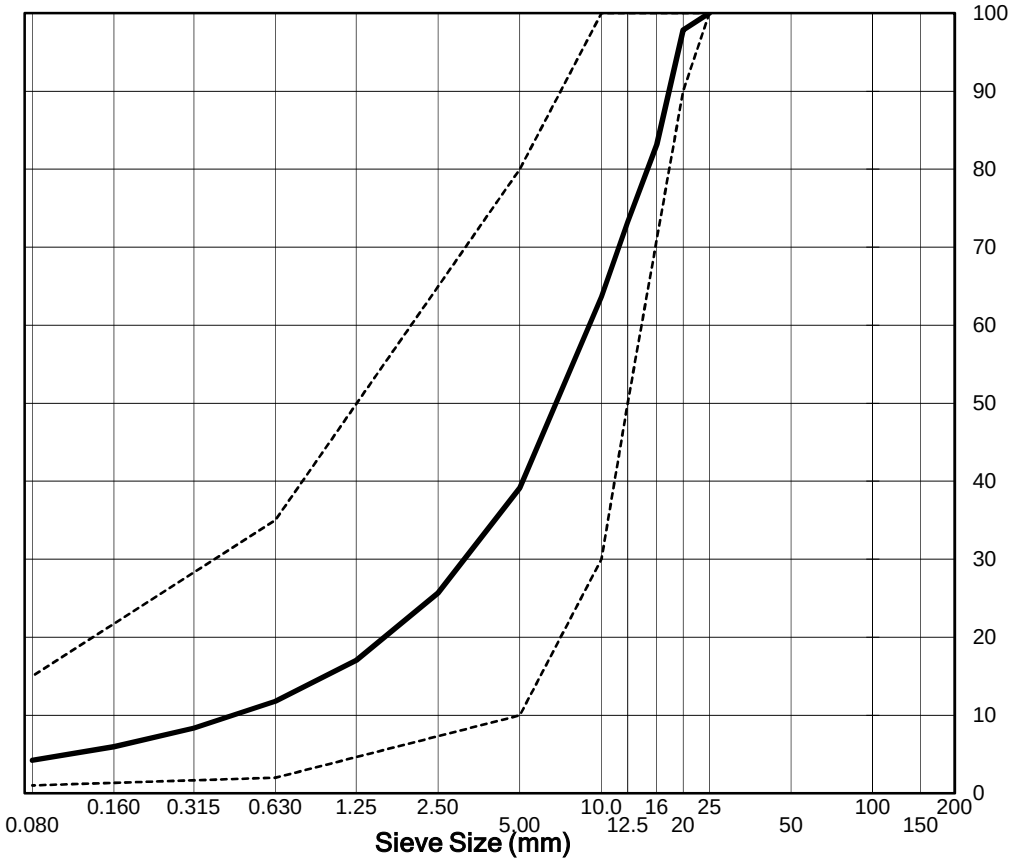
SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103336-02.003	Sample No.:	6653-3
Project:	Hope Bay South Dam Project	Date Sampled:	February 18, 2018
Client:	TMAC Resources	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	SS Office: Yellowknife
Description:	25mm(-) crush bedding	Moisture Content (as received):	6.1%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Sample #3, 3000 m3	By particle mass:	100% 100%
Supplier:	TMAC Resources	ASTM D5821	
Sample Location:			
Specification:	SRK 25(-) Crush Bedding		

Sieve Size	Percent Passing
25	100.0
20	98
16	83
13	73
10	64
5	39.1
2.5	25.7
1.25	17.0
0.630	11.8
0.315	8.4
0.160	6.0
0.080	4.2



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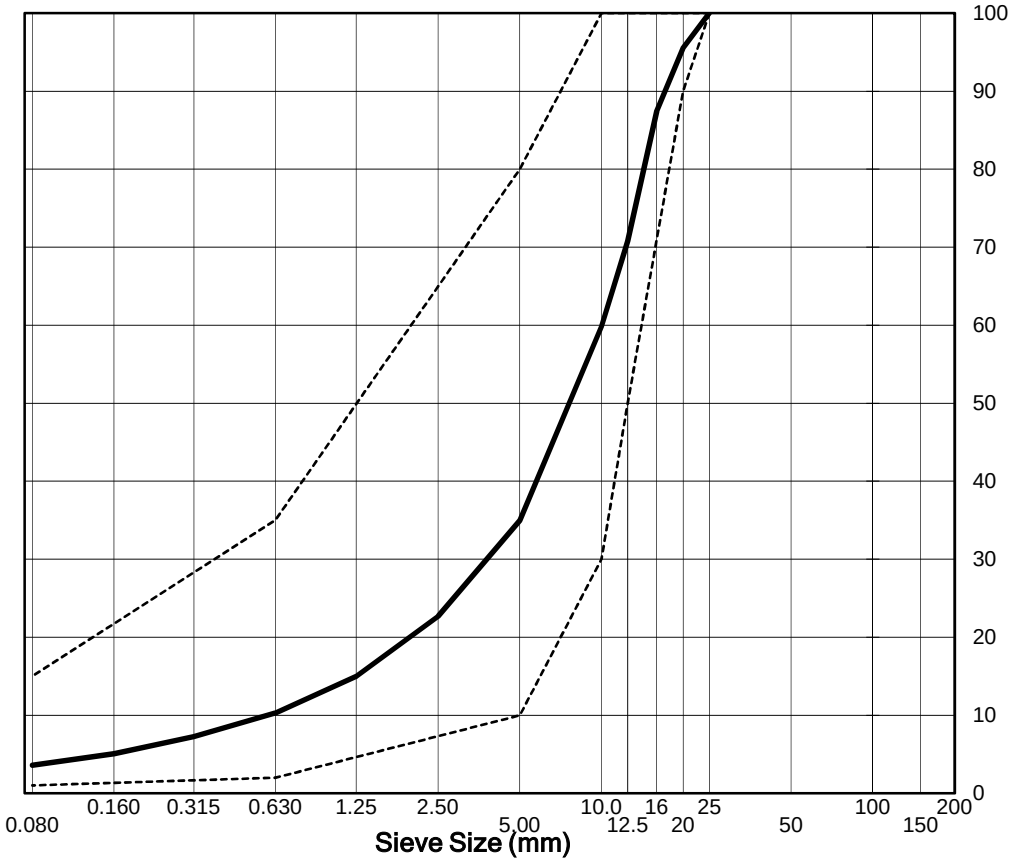
SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103336-02.003	Sample No.:	6653-4
Project:	Hope Bay South Dam Project	Date Sampled:	February 19, 2018
Client:	TMAC Resources	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	SS Office: Yellowknife
Description:	25mm(-) crush bedding	Moisture Content (as received):	1.7%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Sample #4, 4000 m3	By particle mass:	100% 100%
Supplier:	TMAC Resources	ASTM D5821	
Sample Location:			
Specification:	SRK 25(-) Crush Bedding		

Sieve Size	Percent Passing
25	100.0
20	96
16	87
13	71
10	60
5	35.0
2.5	22.7
1.25	15.0
0.630	10.3
0.315	7.2
0.160	5.1
0.080	3.6



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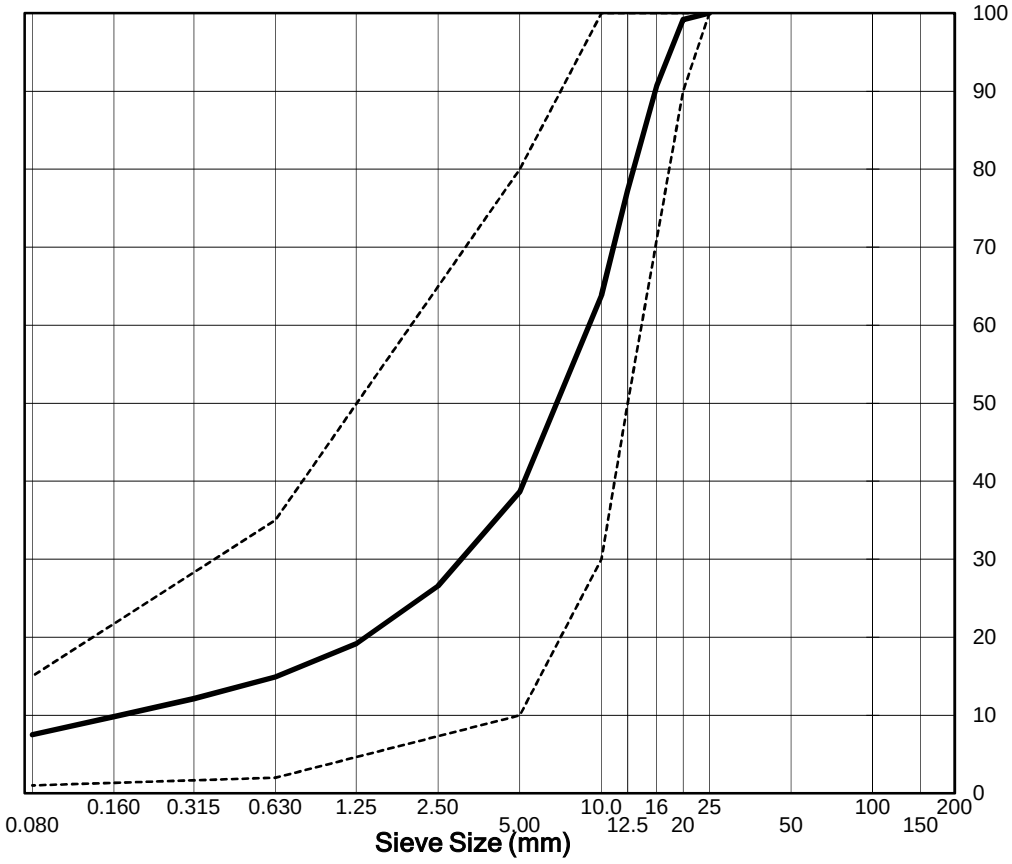
SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103336-02.003	Sample No.:	6653-5
Project:	Hope Bay South Dam Project	Date Sampled:	February 19, 2018
Client:	TMAC Resources	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	SS Office: Yellowknife
Description:	25mm(-) crush bedding	Moisture Content (as received):	7.3%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Sample #5, 5000 m3	By particle mass:	100% 100%
Supplier:	TMAC Resources	ASTM D5821	
Sample Location:			
Specification:	SRK 25(-) Crush Bedding		

Sieve Size	Percent Passing
25	100.0
20	99
16	91
13	77
10	64
5	38.7
2.5	26.5
1.25	19.2
0.630	14.9
0.315	12.1
0.160	9.8
0.080	7.5



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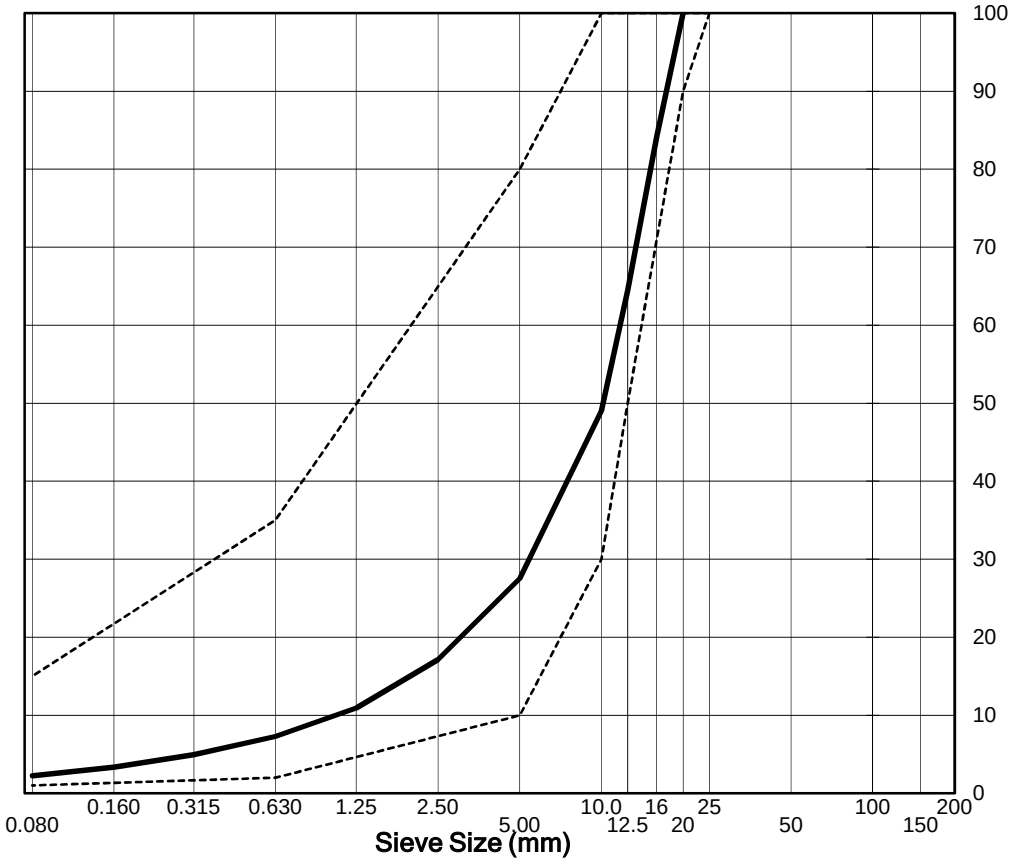
SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103336-02.003	Sample No.:	6653-6
Project:	Hope Bay South Dam Project	Date Sampled:	February 20, 2018
Client:	TMAC Resources	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	SS Office: Yellowknife
Description:	25mm(-) crush bedding	Moisture Content (as received):	0.4%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Sample #6, 6000 m3	By particle mass:	100% 100%
Supplier:	TMAC Resources	ASTM D5821	
Sample Location:			
Specification:	SRK 25(-) Crush Bedding		

Sieve Size	Percent Passing
20	100
16	84
13	64
10	49
5	27.6
2.5	17.1
1.25	10.9
0.630	7.3
0.315	4.9
0.160	3.3
0.080	2.2



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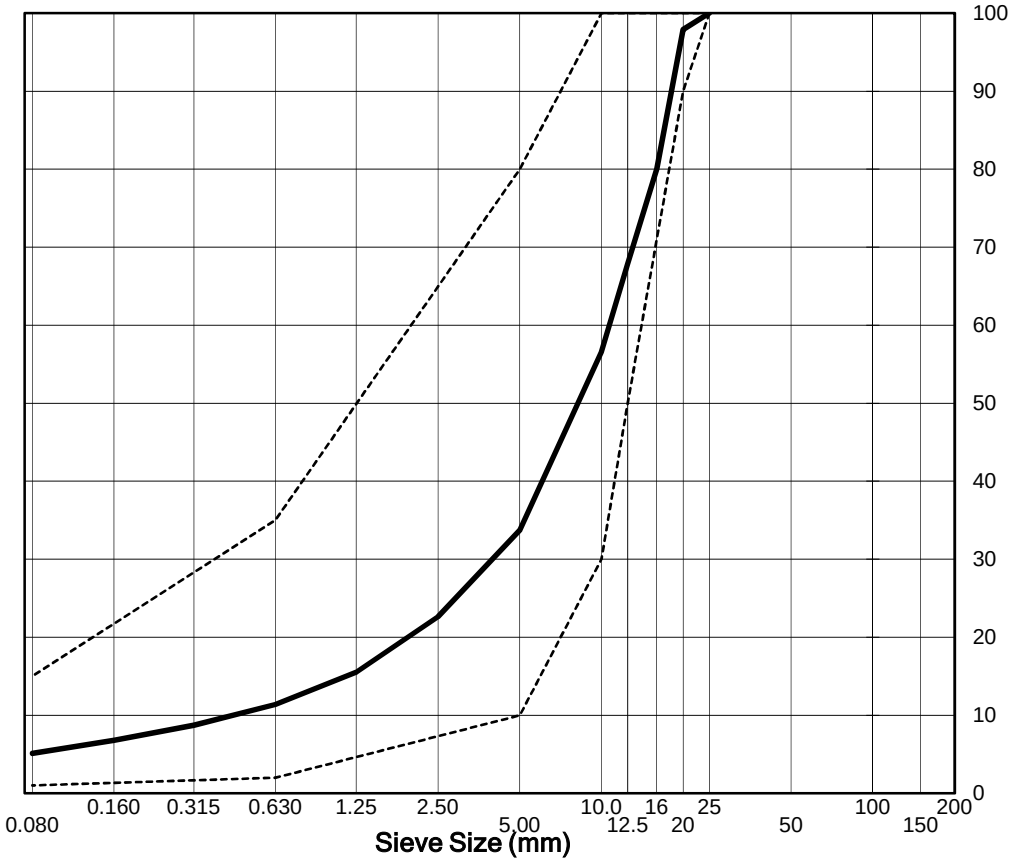
TETRA TECH

SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103336-02.003	Sample No.:	6653-7
Project:	Hope Bay South Dam Project	Date Sampled:	February 20, 2018
Client:	TMAC Resources	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	SS Office: Yellowknife
Description:	25mm(-) crush bedding	Moisture Content (as received):	1.2%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Sample #7, 7000 m3	By particle mass:	100% 100%
Supplier:	TMAC Resources	ASTM D5821	
Sample Location:			
Specification:	SRK 25(-) Crush Bedding		

Sieve Size	Percent Passing
25	100.0
20	98
16	80
13	68
10	57
5	33.7
2.5	22.6
1.25	15.5
0.630	11.4
0.315	8.7
0.160	6.8
0.080	5.1



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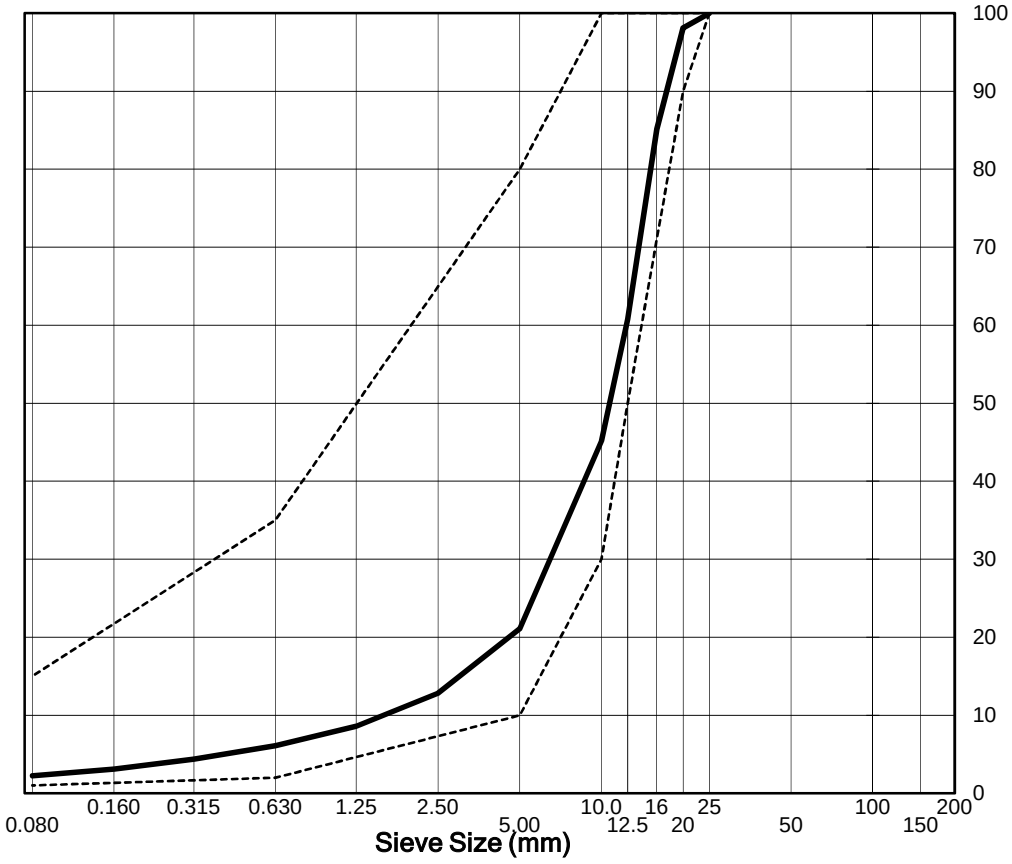
TETRA TECH

SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103336-02.003	Sample No.:	6655-A
Project:	Hope Bay South Dam Project	Date Sampled:	February 23, 2018
Client:	TMAC Resources	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	March 2, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by: SS	Office: Yellowknife
Description:	25mm(-) crush bedding	Moisture Content (as received):	1.2%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Sample #29601	By particle mass:	100% 100%
Supplier:	TMAC Resources	ASTM D5821	
Sample Location:			
Specification:	SRK 25(-) Crush Bedding		

Sieve Size	Percent Passing
25	100.0
20	98
16	85
13	61
10	45
5	21.1
2.5	12.8
1.25	8.6
0.630	6.1
0.315	4.4
0.160	3.1
0.080	2.2



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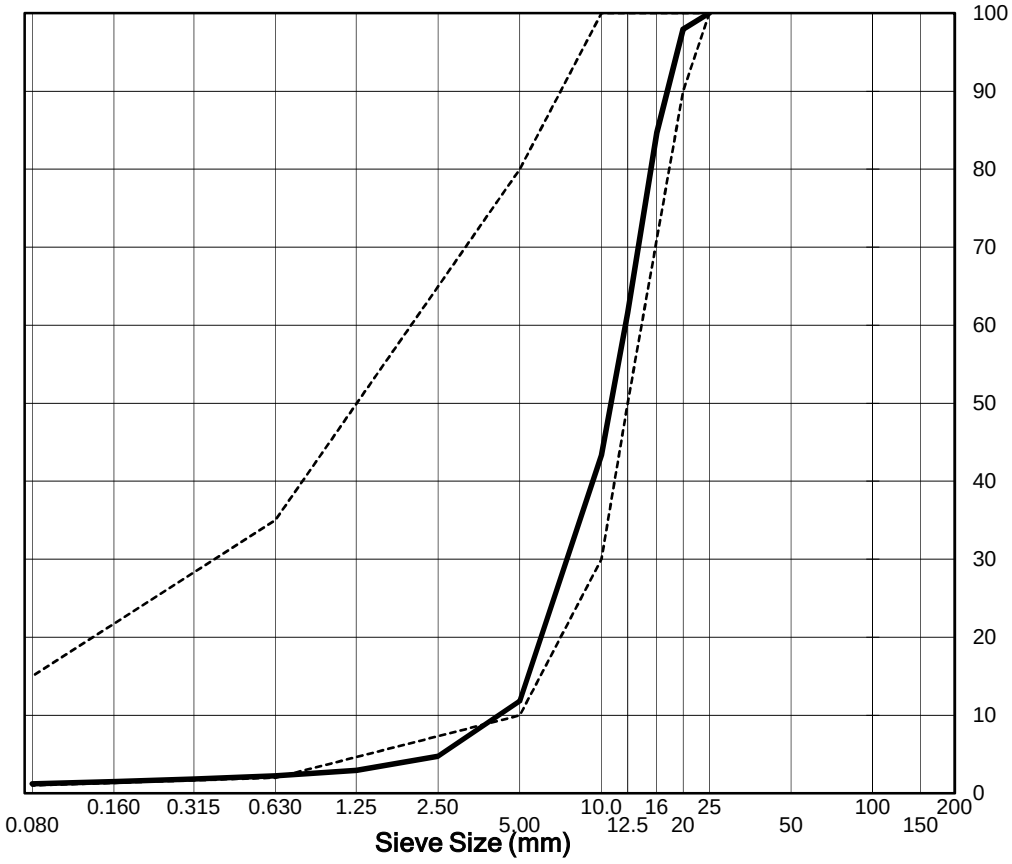
TETRA TECH

SIEVE ANALYSIS REPORT

Washed Sieve: ASTM C136 and C117

Project No.:	Y14103336-02.003	Sample No.:	6655-B
Project:	Hope Bay South Dam Project	Date Sampled:	February 23, 2018
Client:	TMAC Resources	Sampled by:	Client
Attention:	Kelly Schwenning	Date Tested:	March 2, 2018
Email:	kelly.schwenning@tmacresources.com	Tested by:	SS Office: Yellowknife
Description:	25mm(-) crush bedding	Moisture Content (as received):	0.7%
		No. Crushed Faces:	Two (2) or Three (3)
Source:	Sample #29602	By particle mass:	100% 100%
Supplier:	TMAC Resources	ASTM D5821	
Sample Location:			
Specification:	SRK 25(-) Crush Bedding		

Sieve Size	Percent Passing
25	100.0
20	98
16	85
13	62
10	43
5	11.8
2.5	4.8
1.25	2.9
0.630	2.2
0.315	1.8
0.160	1.5
0.080	1.2



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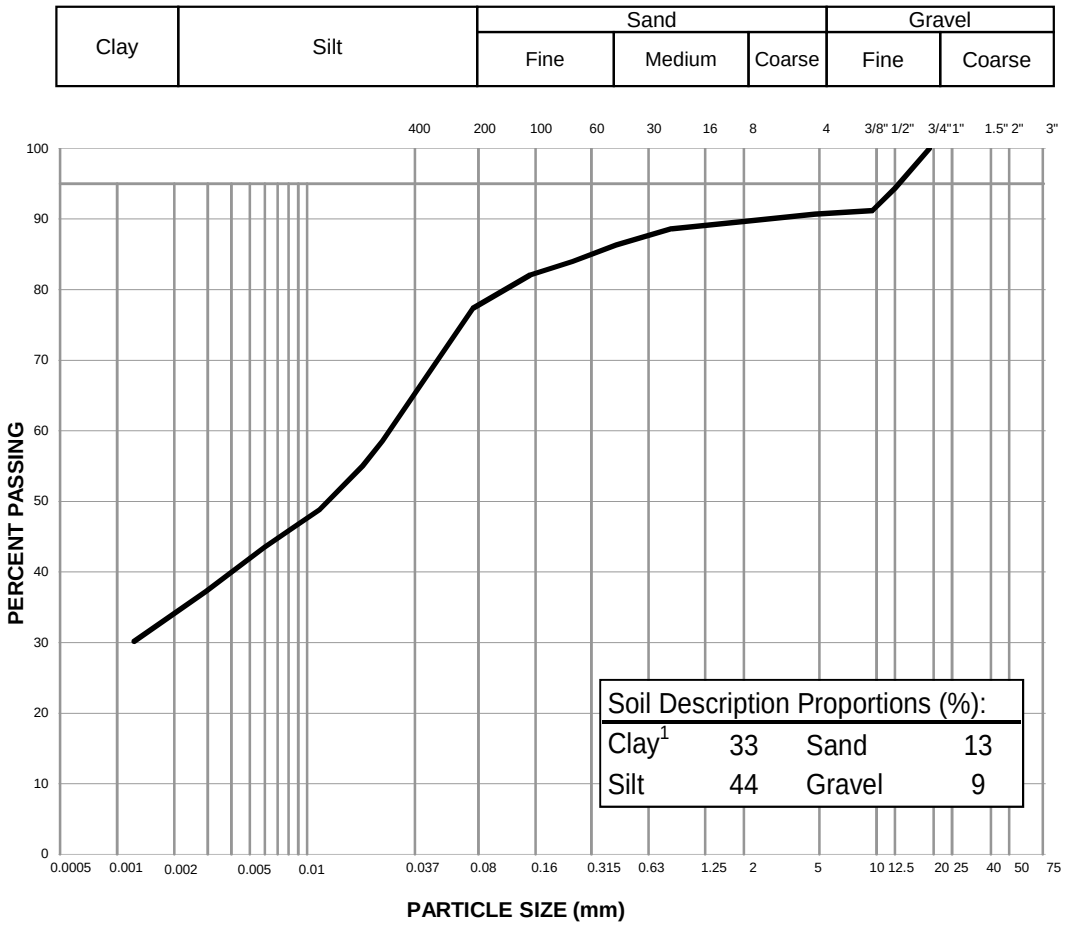
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6875-29443
Project No.:	Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	V-GTC-05
Client:	TMAC Resources Inc.	Sample Depth:	4.0 - 6.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Not Reported
Date Tested:	December 3, 2018 By: SS	Date sampled:	July 13, 2018
Soil Description[2]:	CLAY, silty, some sand, trace gravel.	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	35.0%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	94
9.5	91
4.75	91
2	90
0.83	89
0.425	86
0.25	84
0.15	82
0.075	77.4
0.0250	58.6
0.0196	55.0
0.0116	48.8
0.0083	46.1
0.0059	43.5
0.0029	37.3
0.0012	30.2



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to Tetra Tech description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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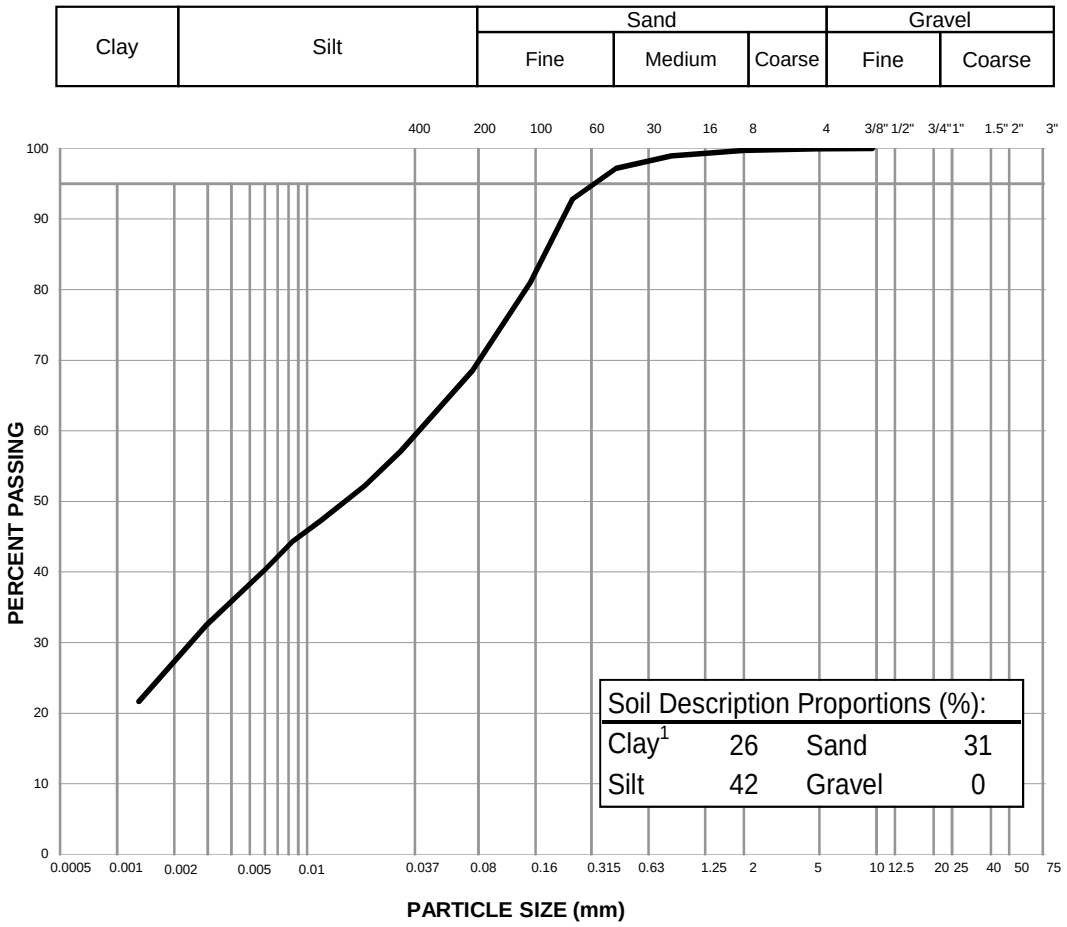
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29515
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	SRK18-MNWRP-DH-02
Client:	TMAC Resources Inc.	Sample Depth:	0.4-0.7 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 5, 2018 By: JPC/SS	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, sandy	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	22.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	99
0.425	97
0.25	93
0.15	81
0.075	68.6
0.0311	57.1
0.0201	52.2
0.0118	47.3
0.0084	44.3
0.0060	40.4
0.0030	32.5
0.0013	21.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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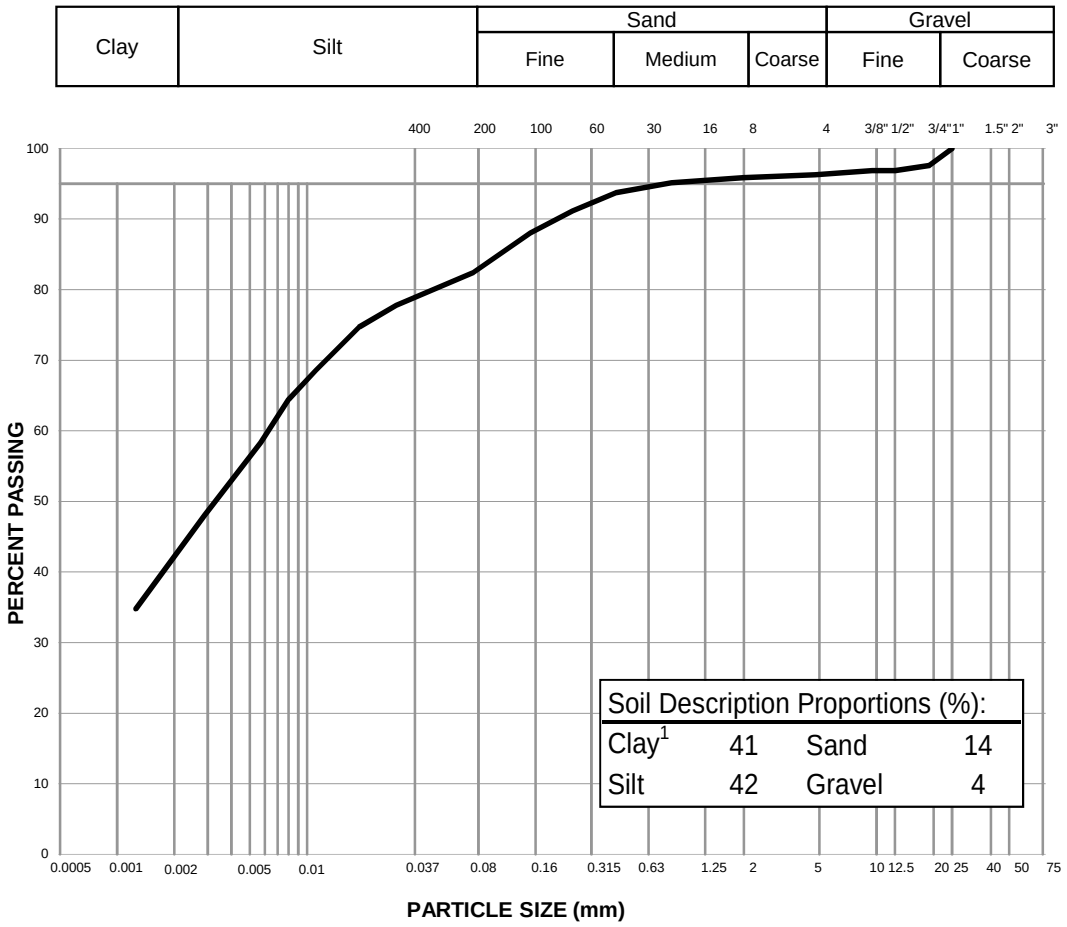
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29518
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	SRK18-MNWRP-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	1.1-2.3 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 5, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand, trace gravel	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	36.1%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	100
19	98
12.5	97
9.5	97
4.75	96
2	96
0.83	95
0.425	94
0.25	91
0.15	88
0.075	82.4
0.0295	77.8
0.0188	74.7
0.0111	68.6
0.0080	64.5
0.0057	58.3
0.0029	48.1
0.0013	34.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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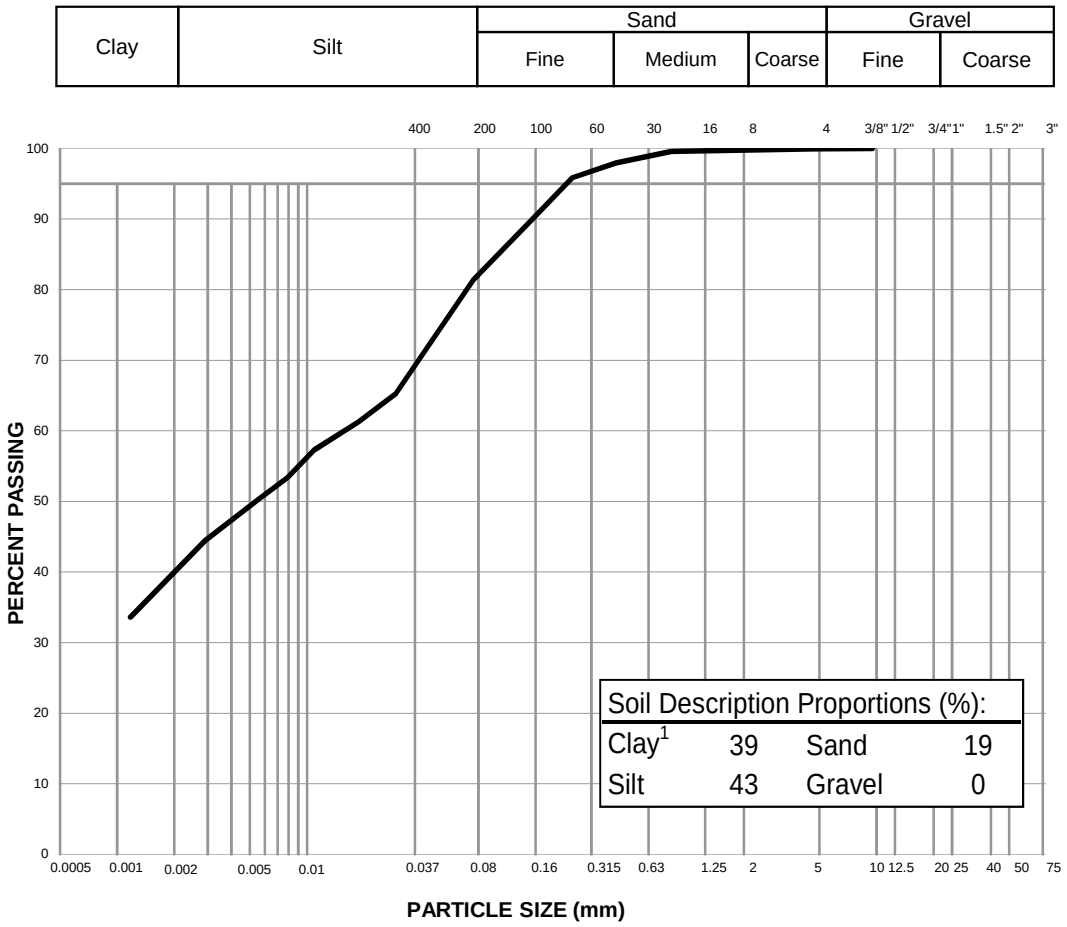
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29519
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNWRP-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	2.5-3.2 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	45.1%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	98
0.25	96
0.15	90
0.075	81.3
0.0293	65.2
0.0188	61.3
0.0110	57.3
0.0079	53.4
0.0056	50.4
0.0029	44.5
0.0012	33.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

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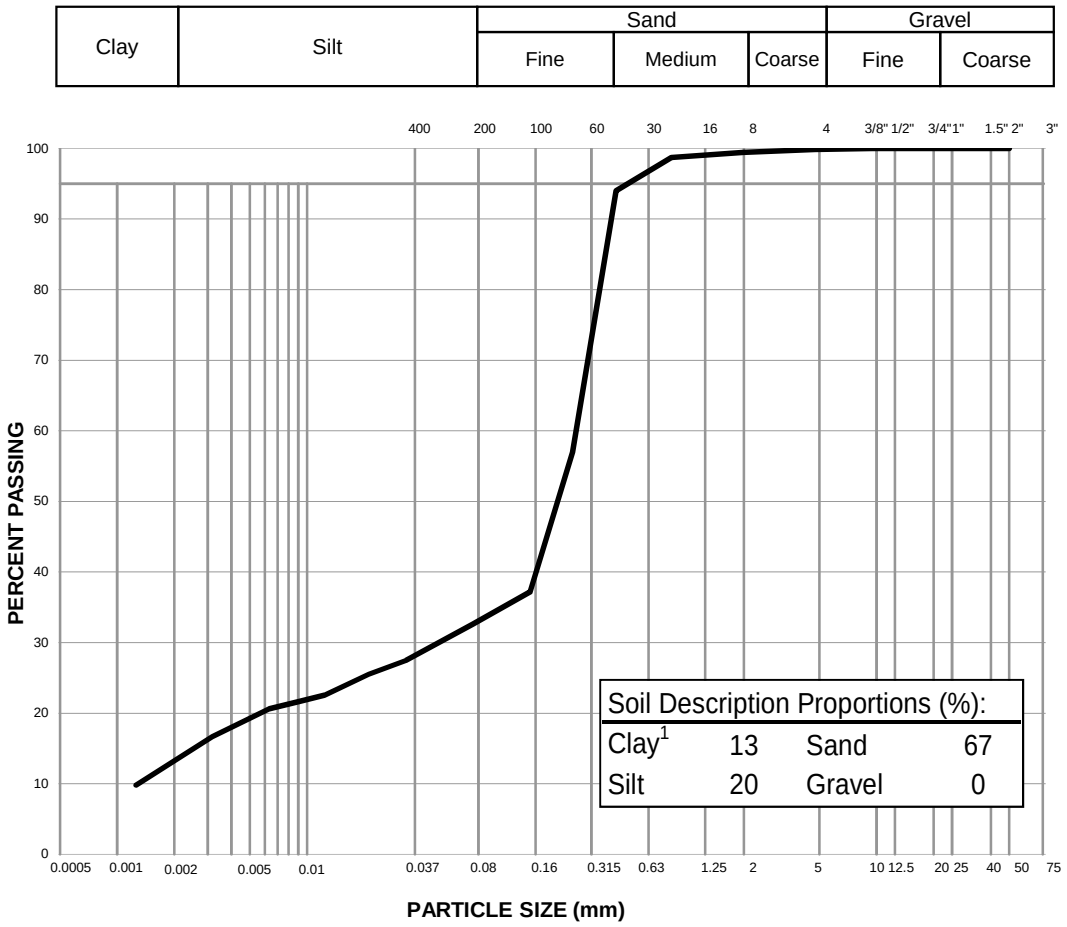
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29521
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNWRP-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	4.2-5.2 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 24, 2018
Soil Description[2]:	SAND, some silt, some clay	Sampled By:	Client
		USC Classification:	SM Cu: 201.6
Moisture Content:	25.9%		Cc: 8.3

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	100
12.5	100
9.5	100
4.75	100
2	99
0.83	99
0.425	94
0.25	57
0.15	37
0.075	32.6
0.0332	27.5
0.0211	25.5
0.0124	22.6
0.0088	21.6
0.0063	20.6
0.0032	16.7
0.0013	9.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

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Remarks: _____

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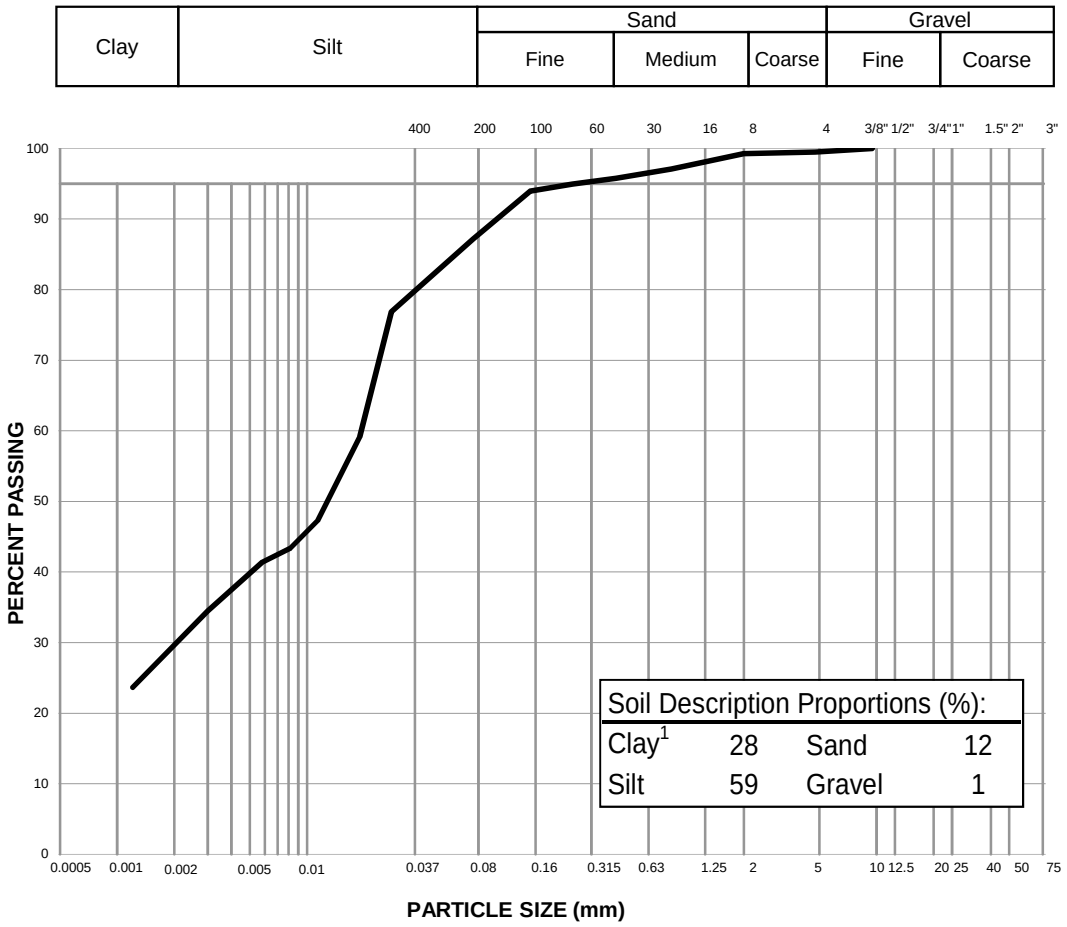
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29523
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNPCP-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	0.2-0.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand, trace gravel	Sampled By:	Client
		USC Classification:	OH Cu: #N/A
Moisture Content:	91.9%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	99
2	99
0.83	97
0.425	96
0.25	95
0.15	94
0.075	87.2
0.0279	76.9
0.0189	59.1
0.0114	47.3
0.0082	43.4
0.0058	41.4
0.0030	34.5
0.0012	23.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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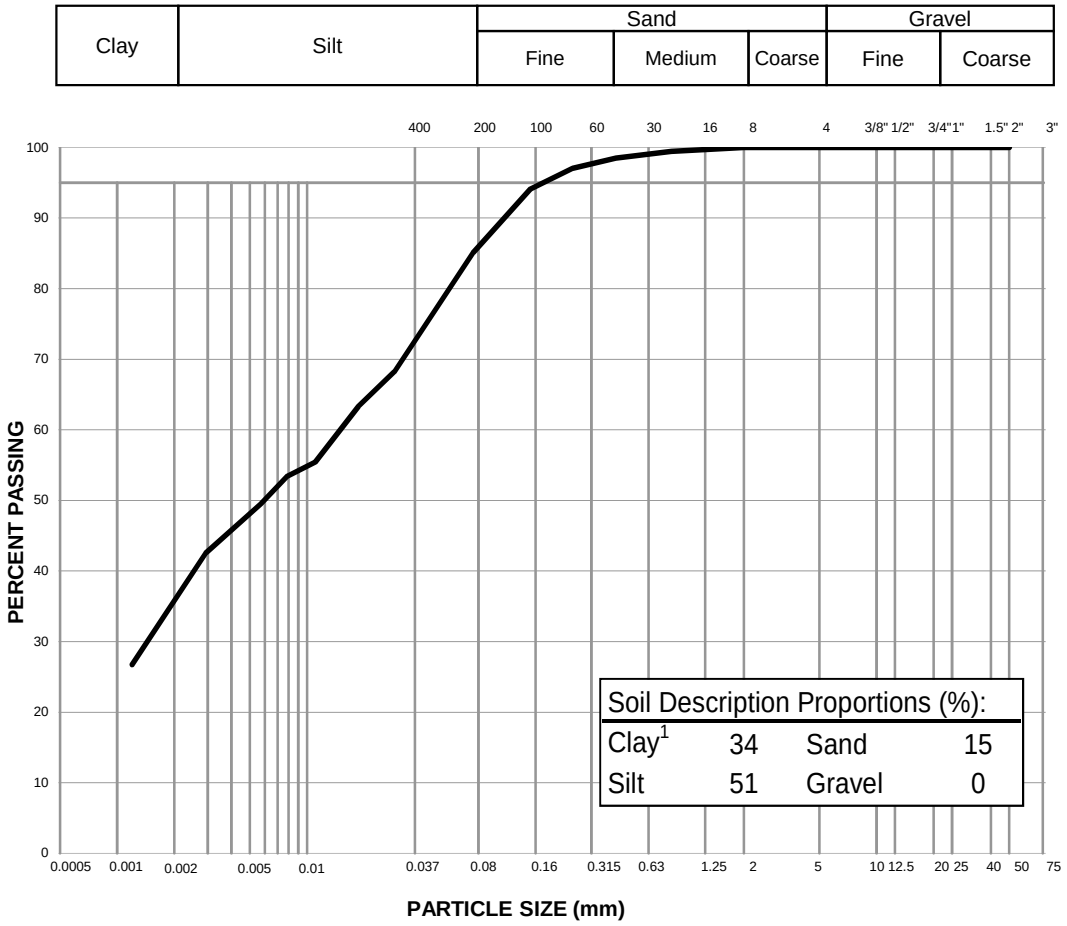
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29524
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNPCP-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	2.9-3.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	72.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	100
12.5	100
9.5	100
4.75	100
2	100
0.83	99
0.425	99
0.25	97
0.15	94
0.075	85.1
0.0289	68.3
0.0187	63.3
0.0111	55.4
0.0079	53.4
0.0057	49.5
0.0029	42.5
0.0012	26.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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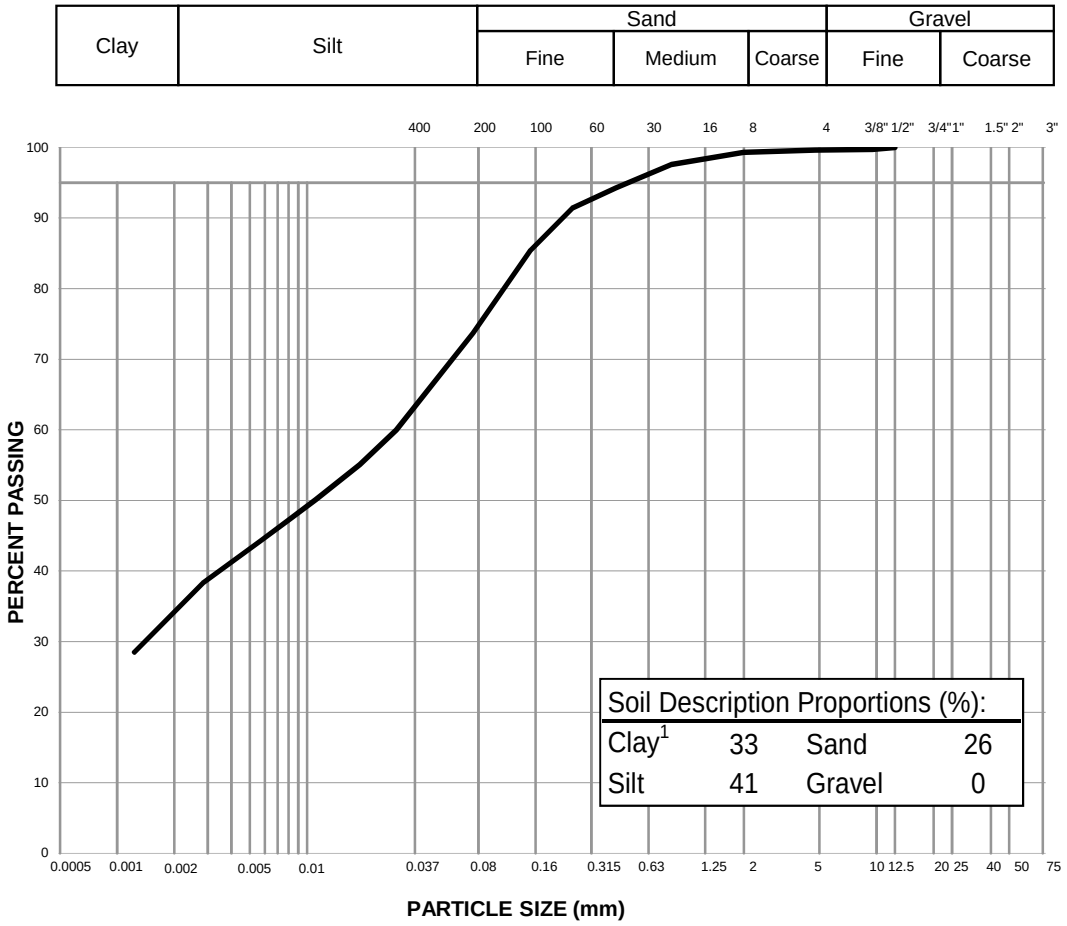
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29526
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNPCP-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	4.1-4.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 12, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, sandy	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	47.6%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	100
9.5	100
4.75	100
2	99
0.83	98
0.425	94
0.25	91
0.15	85
0.075	73.7
0.0295	60.0
0.0190	55.0
0.0111	50.1
0.0080	47.2
0.0057	44.2
0.0028	38.3
0.0012	28.5



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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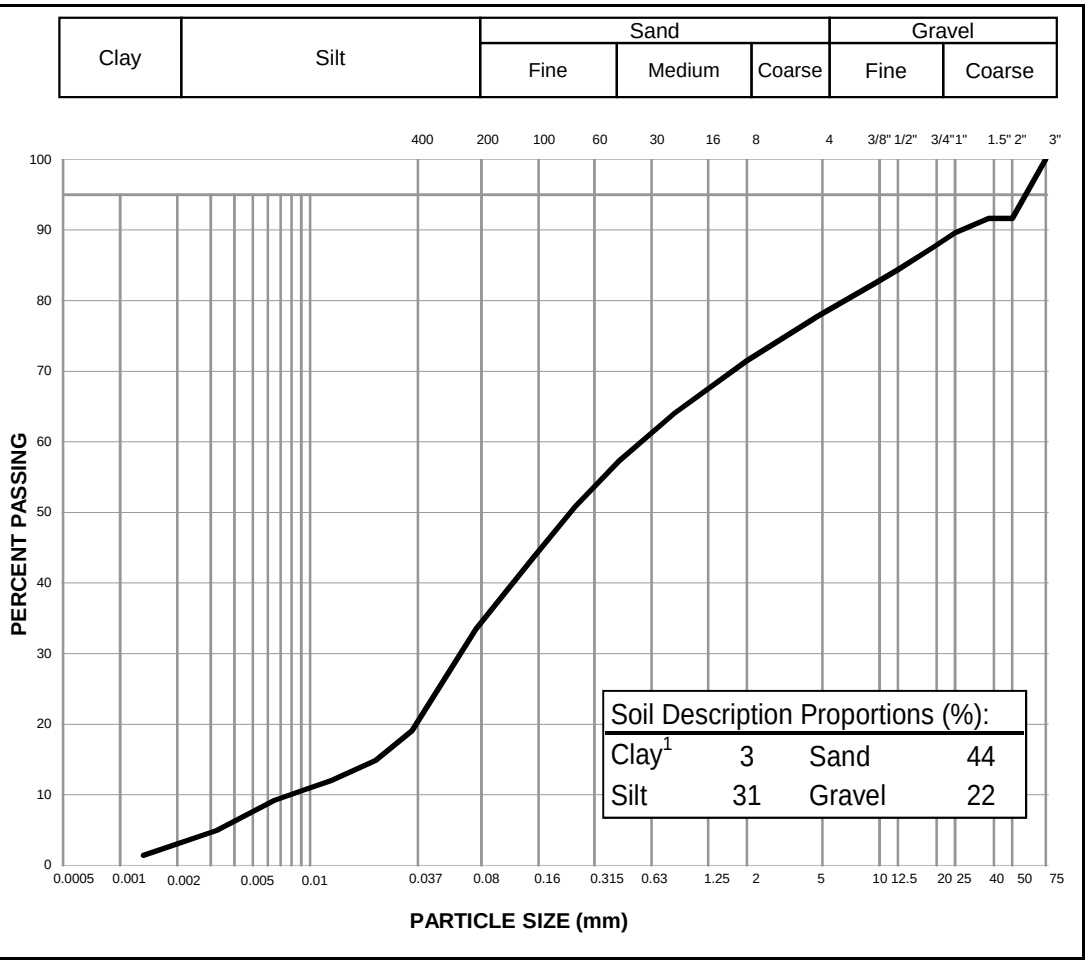
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29527
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNPCP-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	4.5-5.1 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 2, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	SAND, silty, some gravel, trace clay	Sampled By:	Client
		USC Classification:	SM Cu: 73.7
Moisture Content:	11.0%		Cc: 0.9

Particle Size (mm)	Percent Passing
75	100
50	92
37.5	92
25	90
19	87
12.5	84
9.5	83
4.75	78
2	71
0.83	64
0.425	57
0.25	51
0.15	44
0.075	33.5
0.0344	19.1
0.0222	14.8
0.0129	12.0
0.0091	10.6
0.0065	9.2
0.0032	4.9
0.0013	1.4



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

_____

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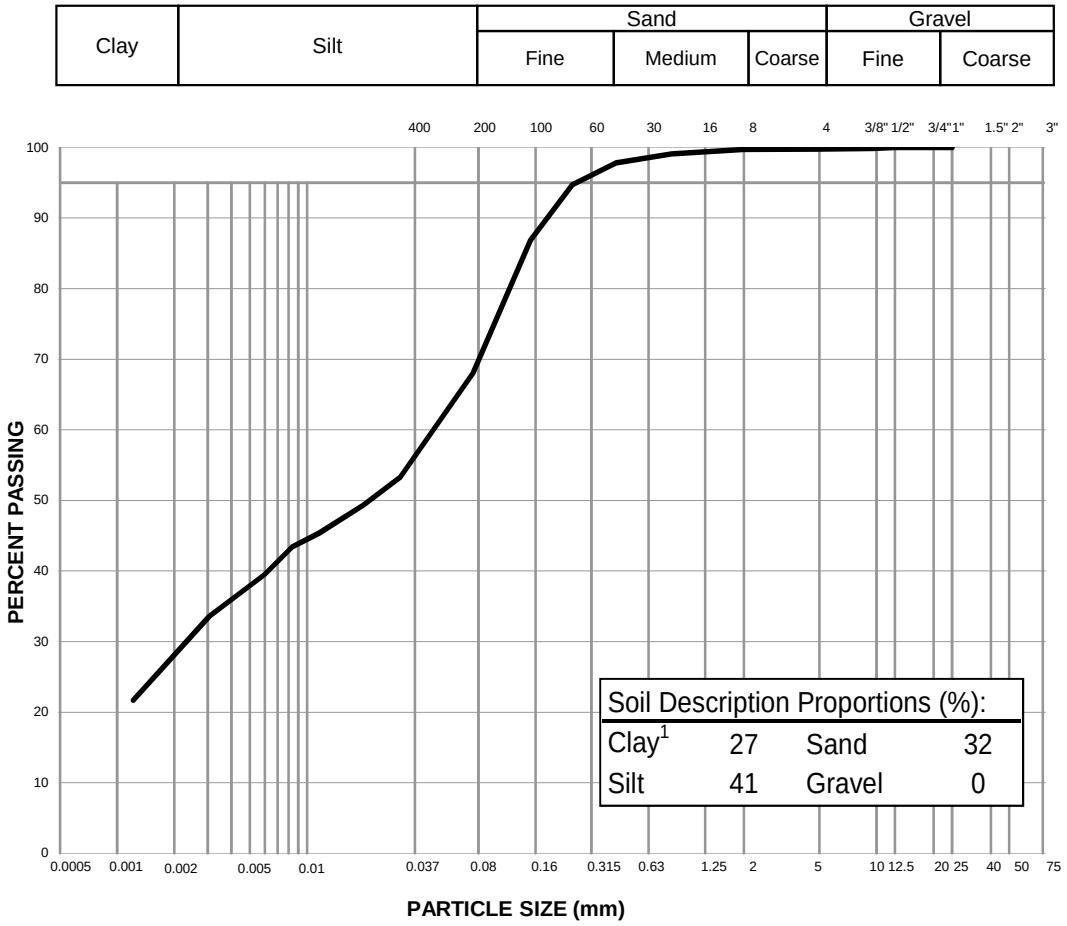
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29529
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNPCP-DH-02
Client:	TMAC Resources Inc.	Sample Depth:	1.3-2.8 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, sandy	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	44.1%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	100
19	100
12.5	100
9.5	100
4.75	100
2	100
0.83	99
0.425	98
0.25	95
0.15	87
0.075	68.0
0.0309	53.3
0.0198	49.3
0.0116	45.4
0.0083	43.4
0.0060	39.5
0.0030	33.5
0.0012	21.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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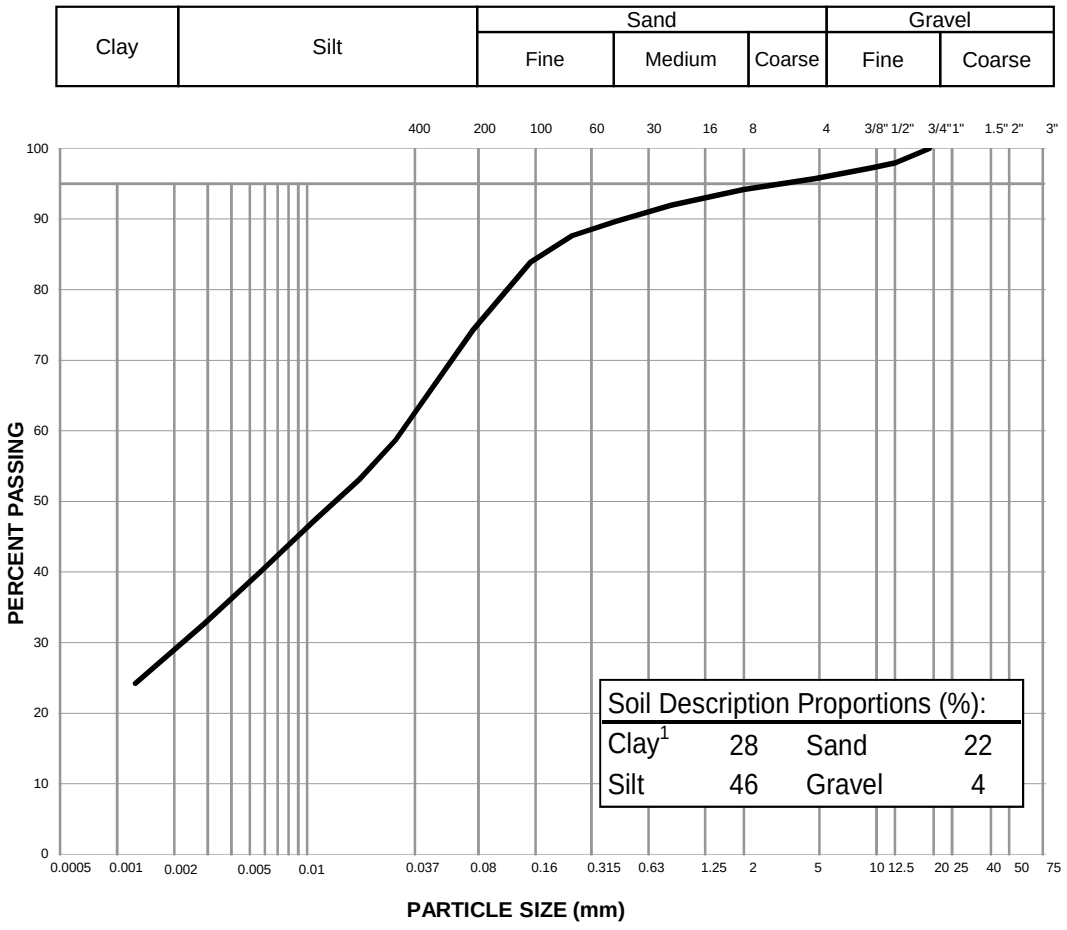
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29530
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNPCP-DH-02
Client:	TMAC Resources Inc.	Sample Depth:	3.0-4.3 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 12, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, sandy, trace gravel	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	52.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	98
9.5	97
4.75	96
2	94
0.83	92
0.425	90
0.25	88
0.15	84
0.075	74.3
0.0293	58.7
0.0189	53.1
0.0111	47.5
0.0080	43.8
0.0057	40.1
0.0029	32.6
0.0012	24.2



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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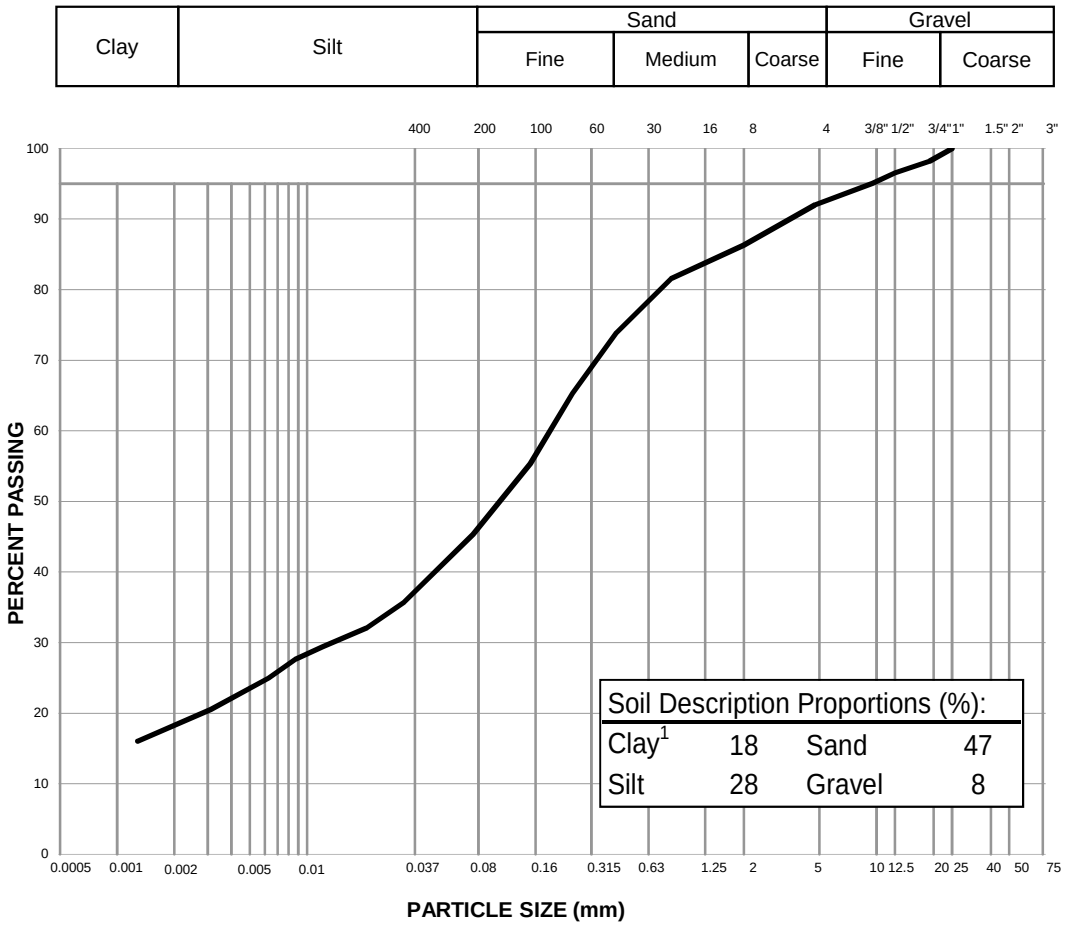
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29531
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNPCP-DH-02
Client:	TMAC Resources Inc.	Sample Depth:	4.6-5.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 12, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	SAND, silty, some clay, trace gravel	Sampled By:	Client
		USC Classification:	SM Cu: #N/A
Moisture Content:	32.8%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	100
19	98
12.5	97
9.5	95
4.75	92
2	86
0.83	82
0.425	74
0.25	65
0.15	55
0.075	45.3
0.0323	35.7
0.0207	32.1
0.0121	29.4
0.0087	27.6
0.0063	25.0
0.0031	20.5
0.0013	16.0



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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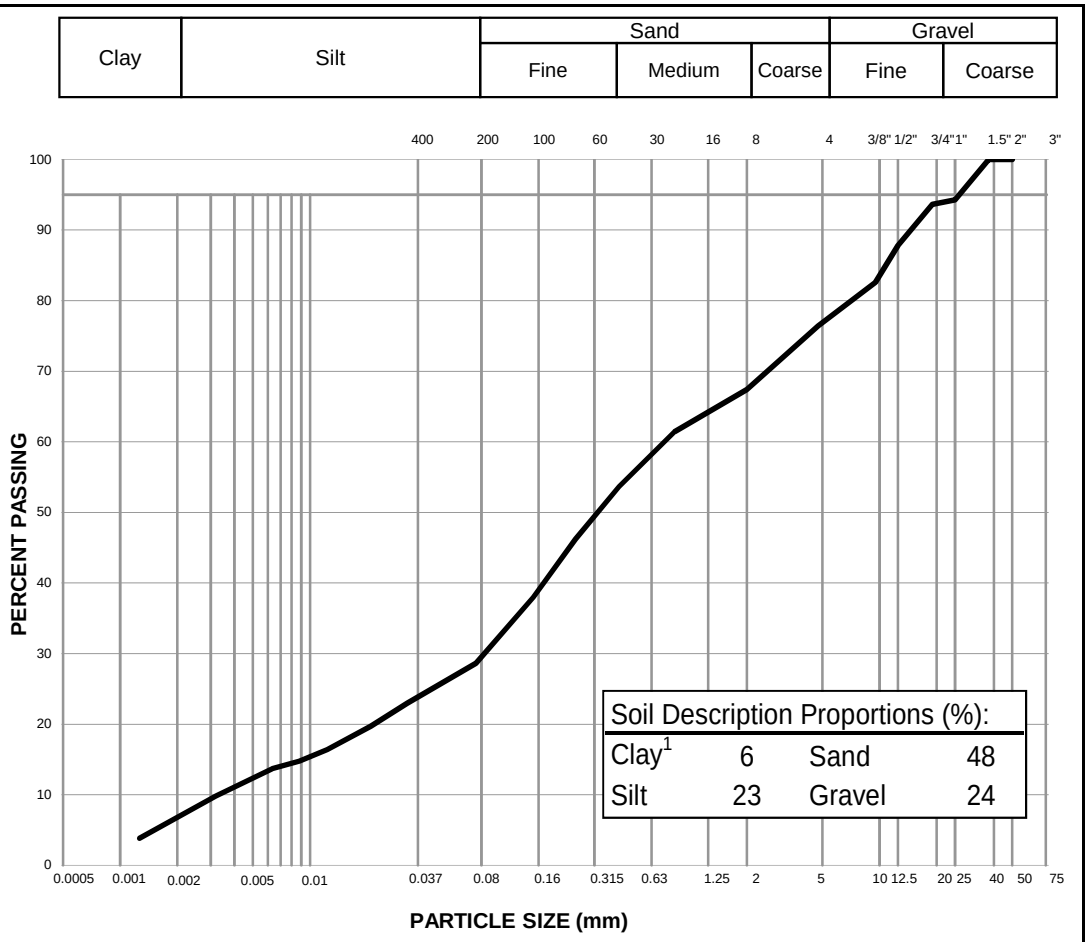
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29533
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNPCP-DH-02
Client:	TMAC Resources Inc.	Sample Depth:	6.0-6.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 24, 2018
Soil Description[2]:	SAND, gravelly, silty, trace clay	Sampled By:	Client
		USC Classification:	SM Cu: 227.6
Moisture Content:	8.1%		Cc: 2.9

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	94
19	94
12.5	88
9.5	83
4.75	76
2	67
0.83	61
0.425	54
0.25	46
0.15	38
0.075	28.7
0.0326	23.0
0.0209	19.7
0.0123	16.4
0.0088	14.8
0.0063	13.7
0.0032	9.8
0.0013	3.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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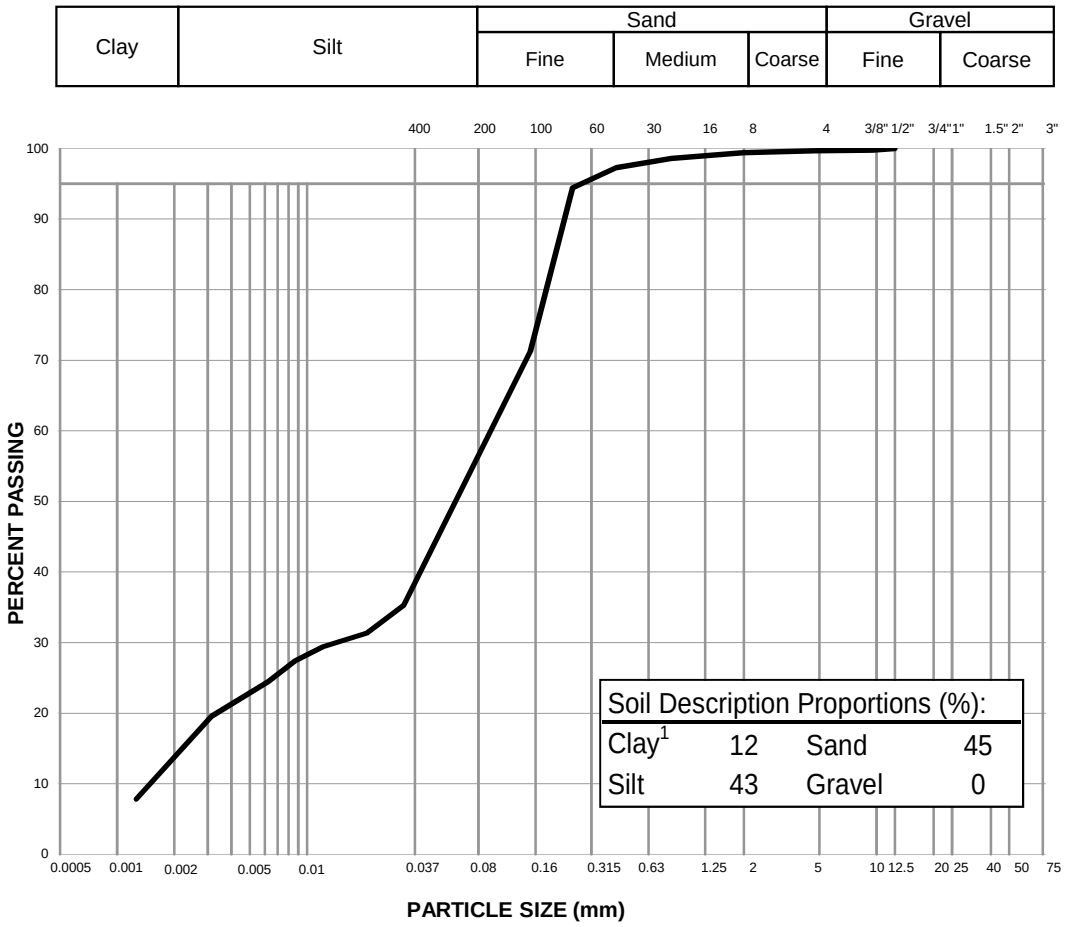
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29544
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-18
Client:	TMAC Resources Inc.	Sample Depth:	0.2-0.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 24, 2018
Soil Description[2]:	SAND, SILT, some clay	Sampled By:	Client
		USC Classification:	SM Cu: 61.0
Moisture Content:	24.5%		Cc: 1.4

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	100
9.5	100
4.75	100
2	99
0.83	99
0.425	97
0.25	94
0.15	71
0.075	55.0
0.0323	35.3
0.0207	31.3
0.0122	29.4
0.0087	27.4
0.0062	24.5
0.0031	19.6
0.0013	7.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

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Remarks: _____

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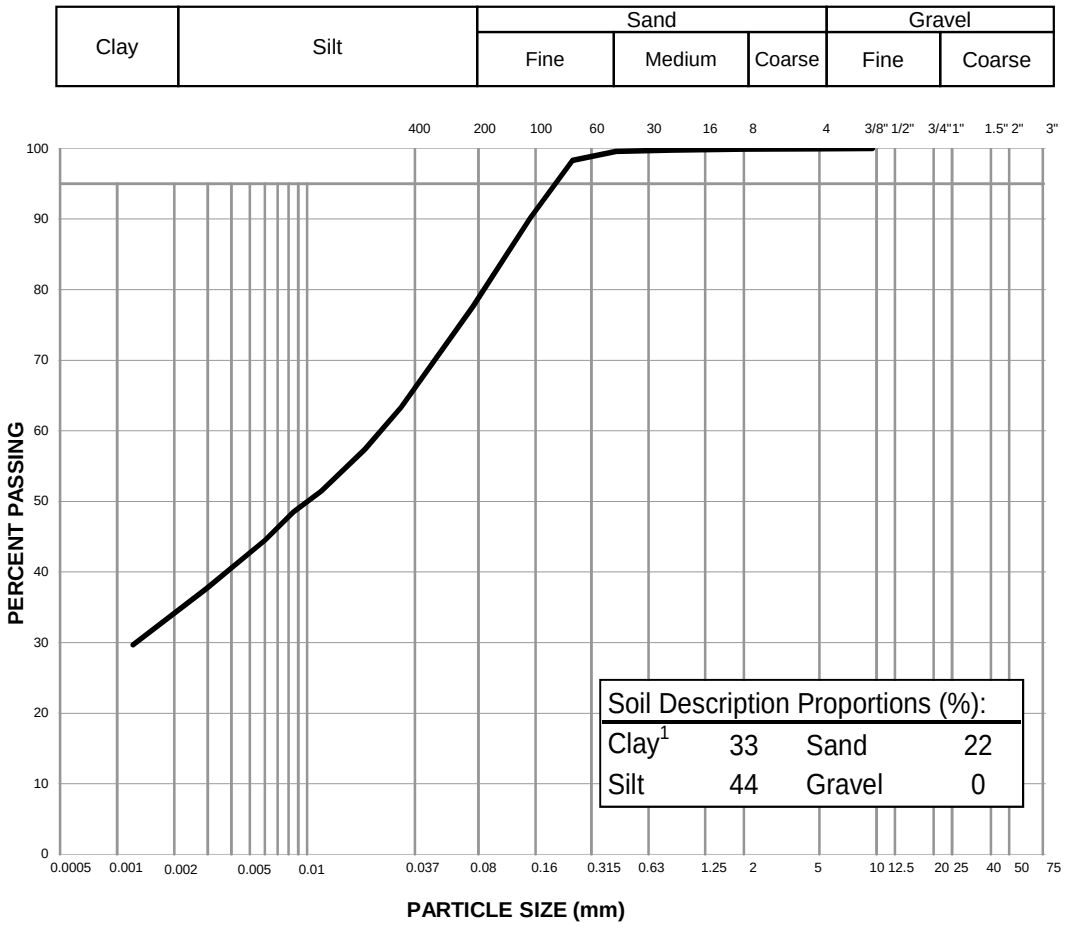
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29546
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-18
Client:	TMAC Resources Inc.	Sample Depth:	11.4-11.8 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand.	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	44.4%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	100
0.25	98
0.15	90
0.075	77.6
0.0313	63.3
0.0201	57.4
0.0119	51.5
0.0085	48.5
0.0060	44.5
0.0029	37.6
0.0012	29.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

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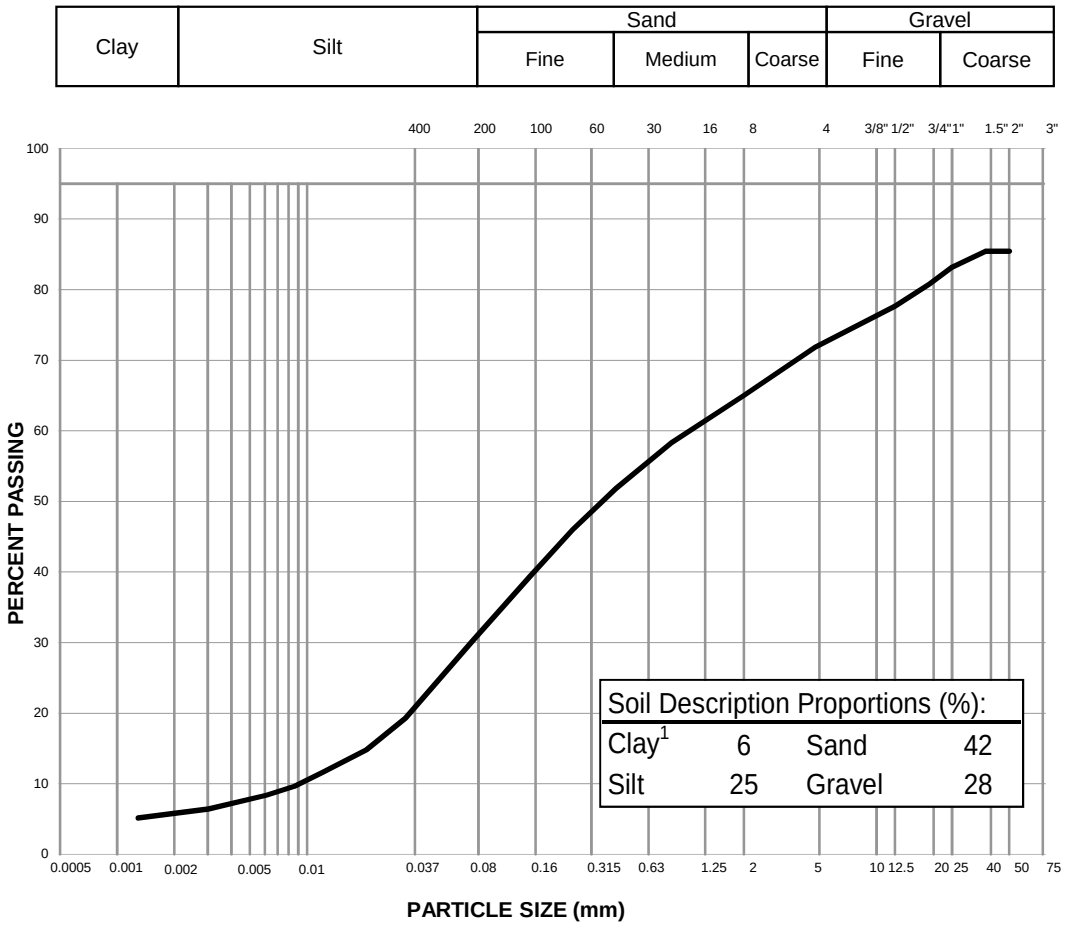
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29547
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-18
Client:	TMAC Resources Inc.	Sample Depth:	12.9-13.4 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 20, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	SAND, gravelly, silty, trace clay	Sampled By:	Client
		USC Classification:	SM Cu: 122.3
Moisture Content:	8.9%		Cc: 0.5

Particle Size (mm)	Percent Passing
75	
50	85
37.5	85
25	83
19	81
12.5	78
9.5	76
4.75	72
2	65
0.83	58
0.425	52
0.25	46
0.15	39
0.075	30.3
0.0330	19.3
0.0206	14.8
0.0120	11.6
0.0086	9.7
0.0061	8.4
0.0030	6.4
0.0013	5.1



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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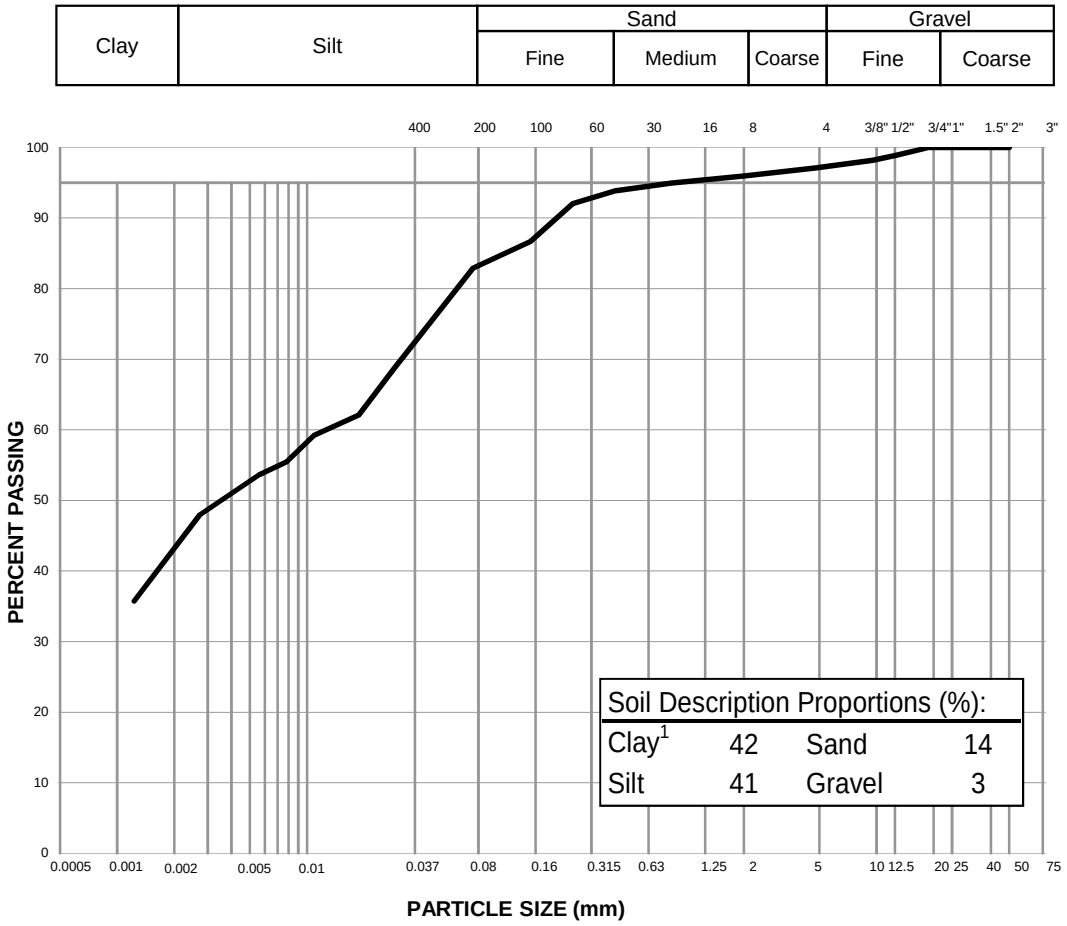
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29548
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-17
Client:	TMAC Resources Inc.	Sample Depth:	0.5-0.9 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 31, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand, trace gravel	Sampled By:	Client
		USC Classification:	ML Cu: #N/A
Moisture Content:	63.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	100
12.5	99
9.5	98
4.75	97
2	96
0.83	95
0.425	94
0.25	92
0.15	87
0.075	82.9
0.0288	68.7
0.0187	62.1
0.0109	59.3
0.0078	55.5
0.0056	53.6
0.0027	48.0
0.0012	35.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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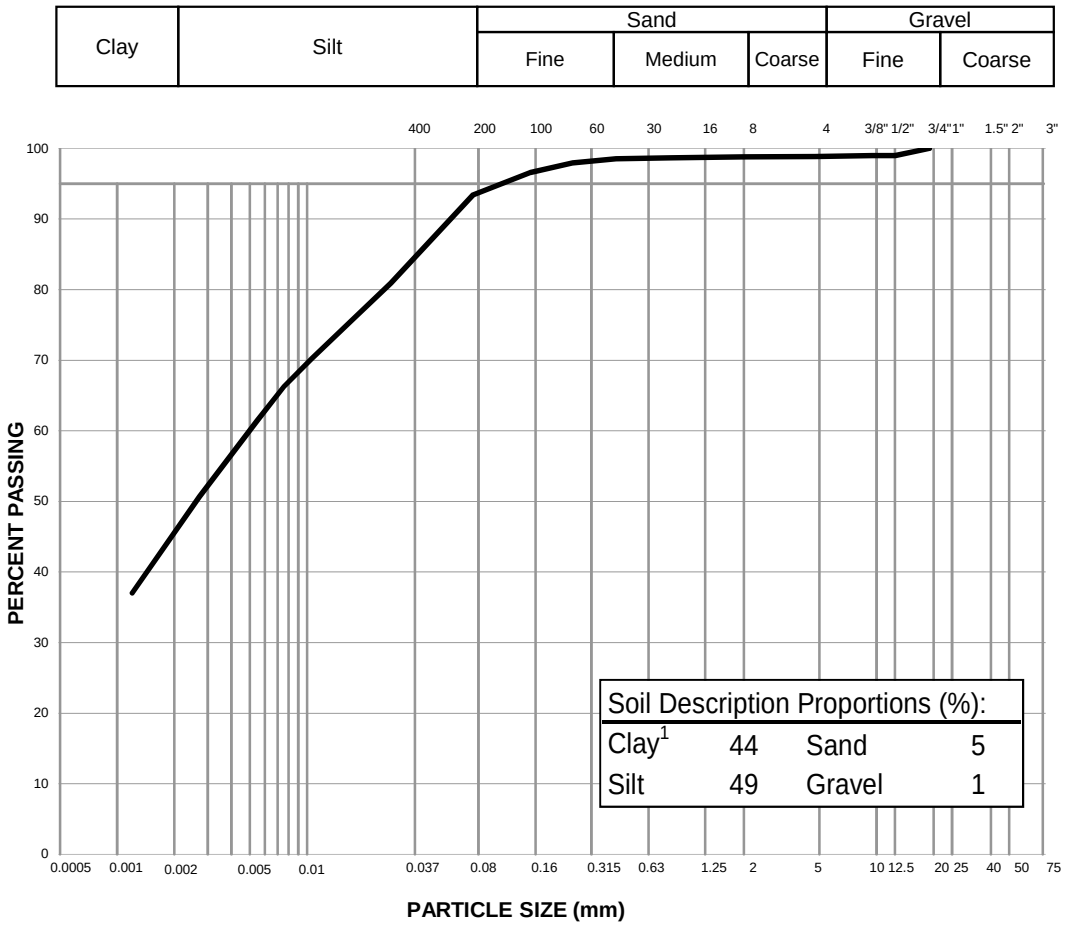
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29549
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-17
Client:	TMAC Resources Inc.	Sample Depth:	3.7-4.1 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 14, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, trace sand, trace gravel	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	33.5%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	99
9.5	99
4.75	99
2	99
0.83	99
0.425	99
0.25	98
0.15	97
0.075	93.4
0.0276	80.9
0.0178	76.0
0.0105	70.2
0.0076	66.3
0.0055	61.4
0.0027	50.7
0.0012	37.0



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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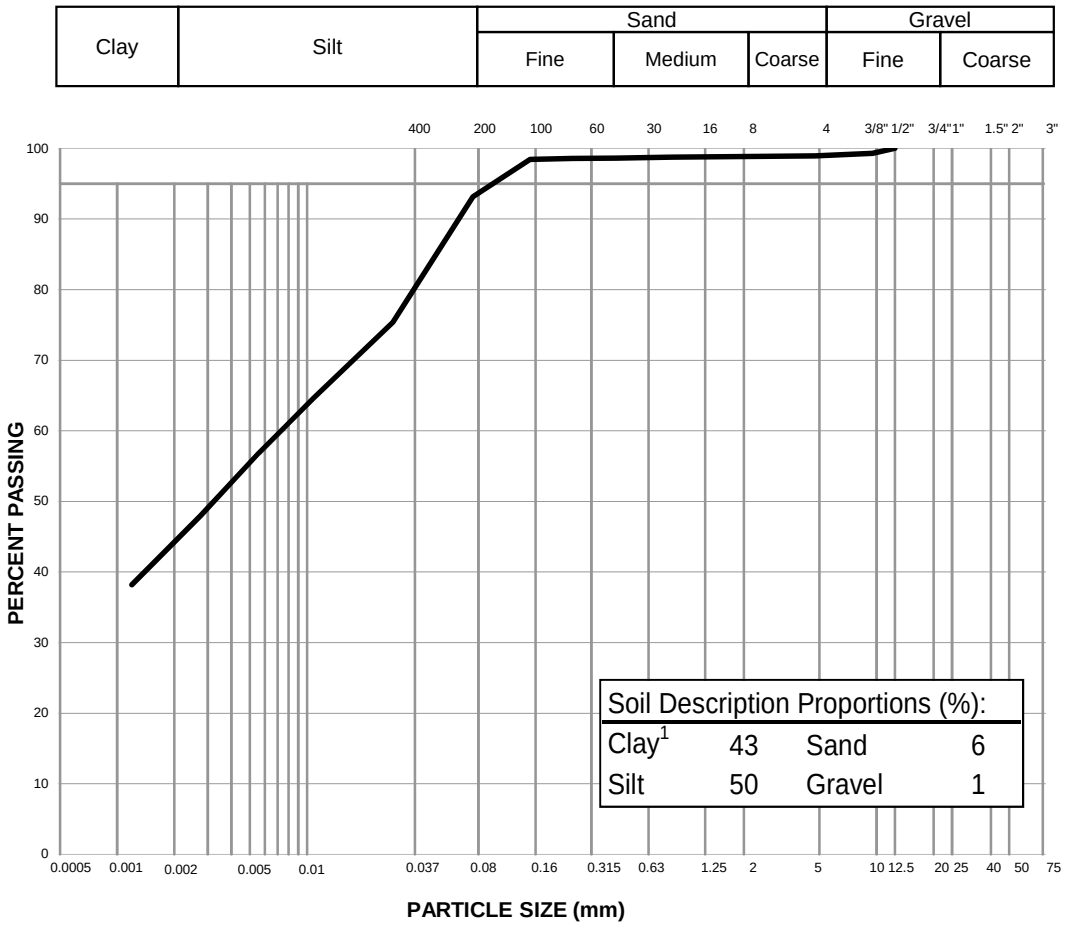
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29550
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-17
Client:	TMAC Resources Inc.	Sample Depth:	8.7-9.1 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 14, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, trace sand, trace gravel	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	41.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	100
9.5	99
4.75	99
2	99
0.83	99
0.425	99
0.25	99
0.15	98
0.075	93.2
0.0283	75.4
0.0183	70.5
0.0108	64.6
0.0077	60.7
0.0055	56.8
0.0027	48.0
0.0012	38.2



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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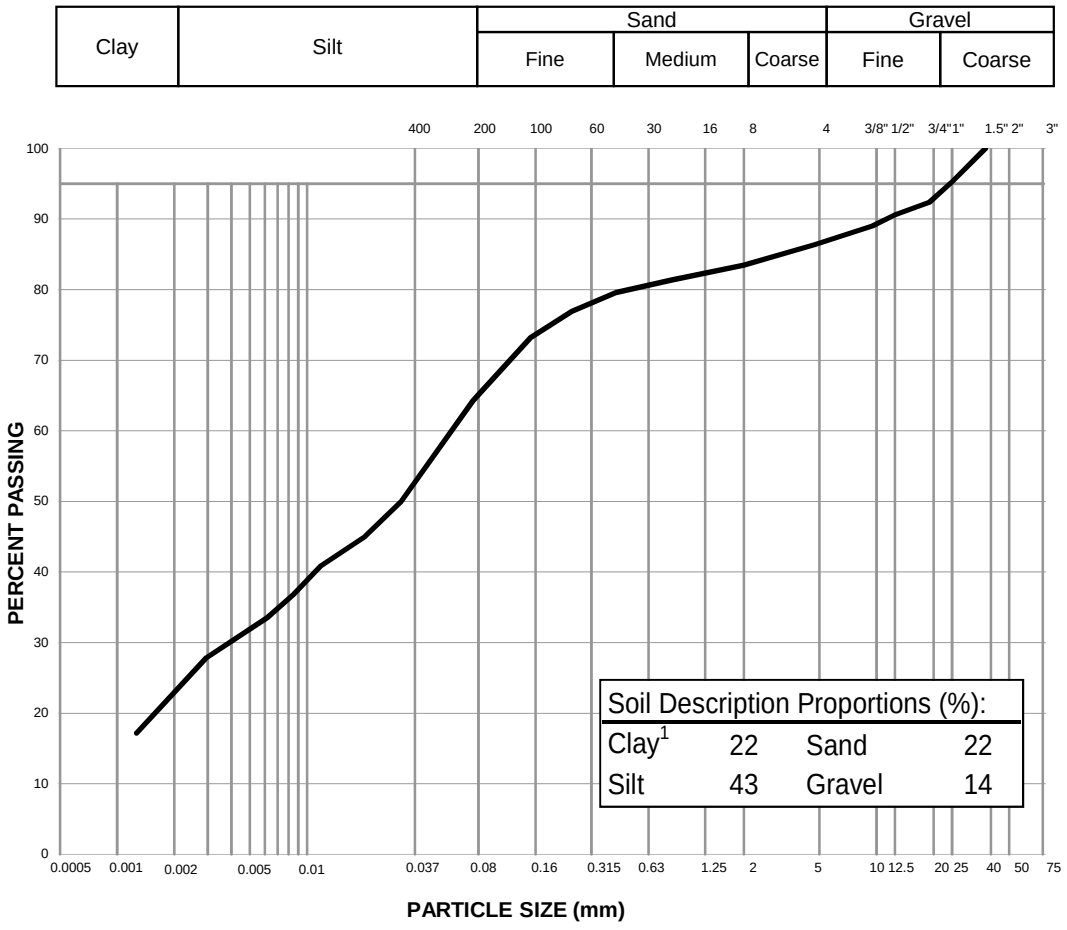
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29551
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-17
Client:	TMAC Resources Inc.	Sample Depth:	12.9-13.3 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	SILT, clayey, sandy, some gravel.	Sampled By:	Client
		USC Classification:	ML Cu: #N/A
Moisture Content:	44.6%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	100
25	95
19	92
12.5	91
9.5	89
4.75	86
2	83
0.83	81
0.425	80
0.25	77
0.15	73
0.075	64.3
0.0312	49.9
0.0202	45.0
0.0118	40.9
0.0085	36.8
0.0062	33.5
0.0029	27.8
0.0013	17.2



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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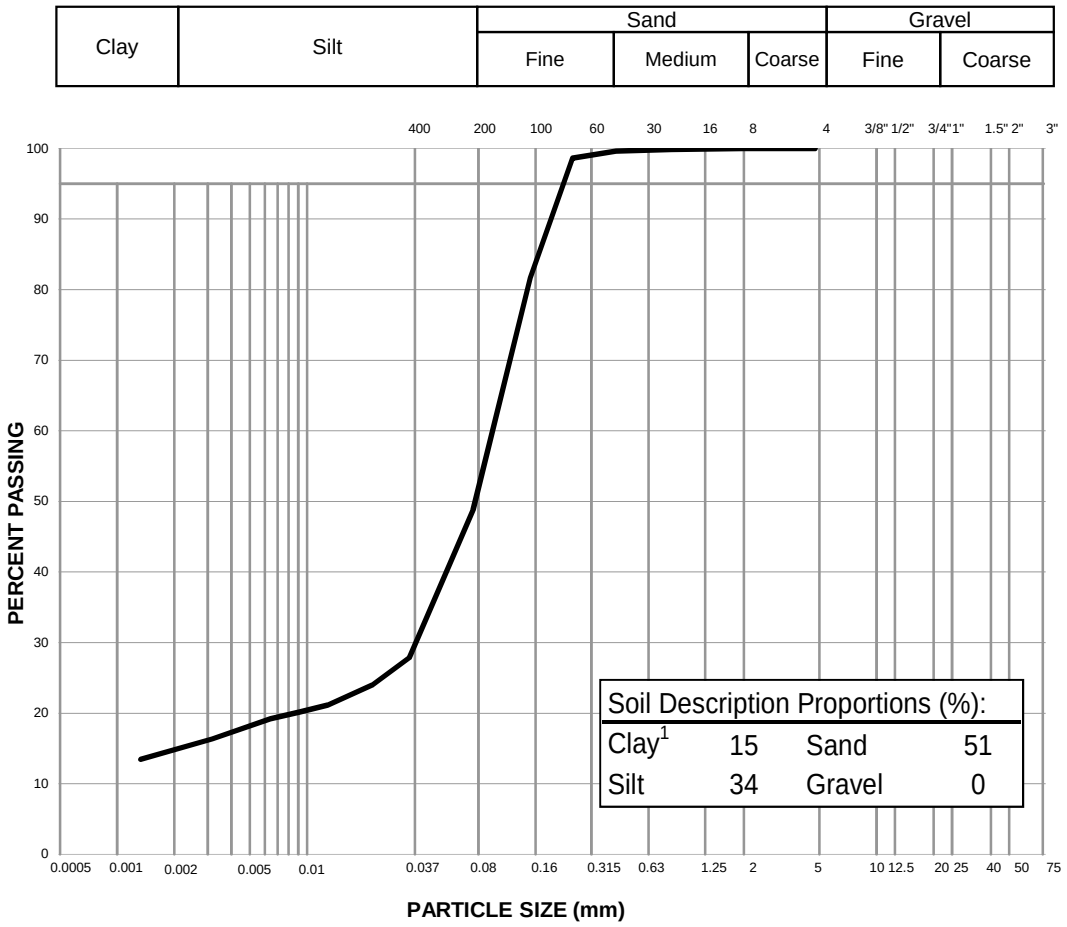
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29570
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	SRK18-STH-DH-03
Client:	TMAC Resources Inc.	Sample Depth:	0.7-2.2 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 5, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SAND, silty, some clay	Sampled By:	Client
		USC Classification:	SM Cu: #N/A
Moisture Content:	30.6%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	100
2	100
0.83	100
0.425	100
0.25	99
0.15	82
0.075	48.8
0.0346	27.9
0.0221	24.0
0.0129	21.1
0.0092	20.2
0.0064	19.2
0.0032	16.3
0.0013	13.5



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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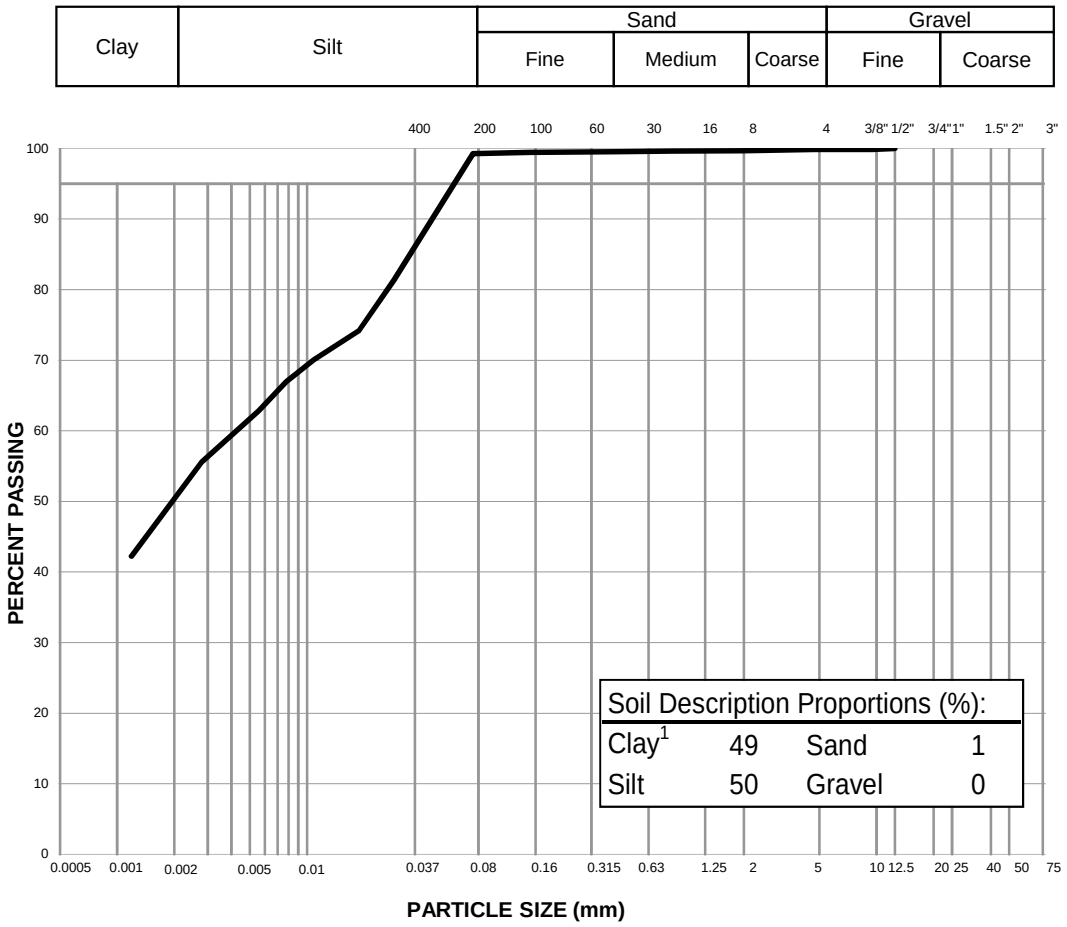
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29572
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-03
Client:	TMAC Resources Inc.	Sample Depth:	5.8-6.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 2, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	59.8%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	100
9.5	100
4.75	100
2	100
0.83	100
0.425	100
0.25	100
0.15	99
0.075	99.3
0.0287	81.4
0.0187	74.2
0.0108	70.0
0.0078	66.9
0.0056	62.8
0.0028	55.6
0.0012	42.2



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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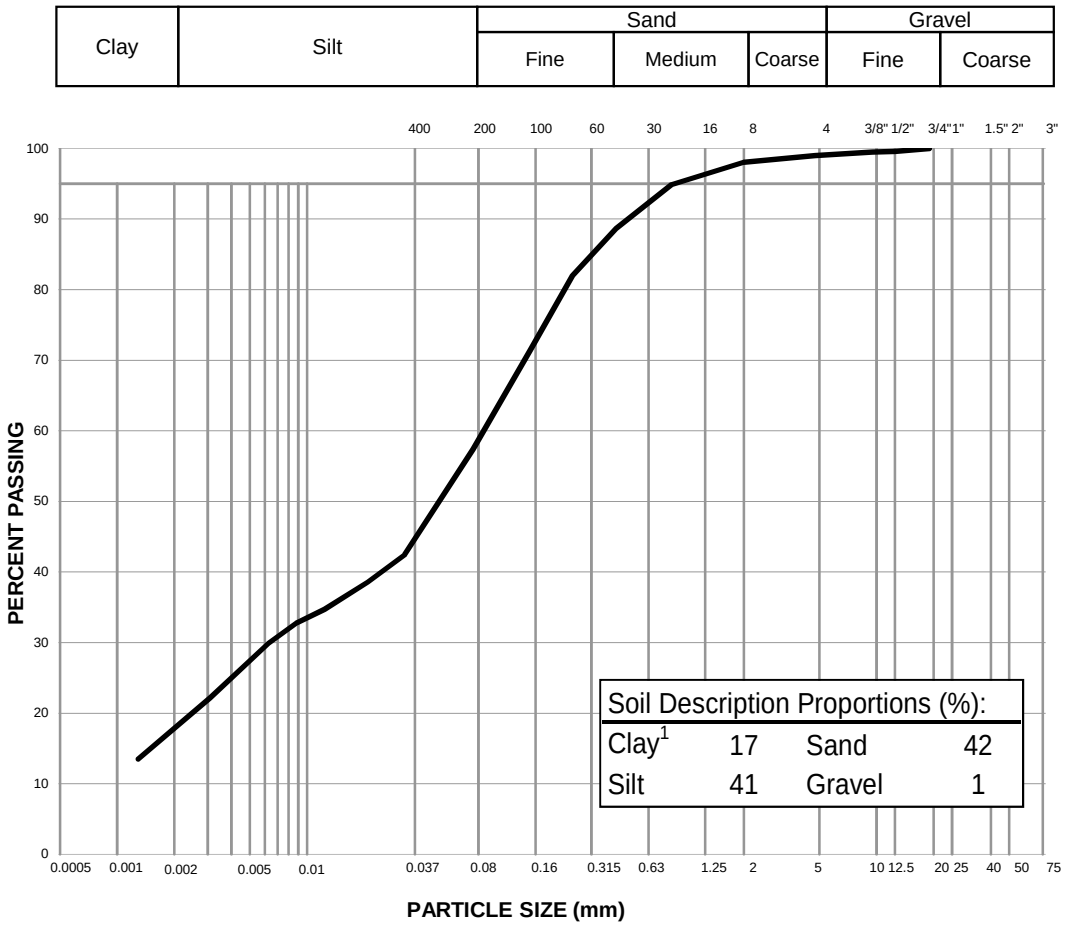
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29574
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-03
Client:	TMAC Resources Inc.	Sample Depth:	8.1-9.1 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SAND, SILT, some clay, trace gravel	Sampled By:	Client
		USC Classification:	SM Cu: #N/A
Moisture Content:	45.8%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	100
9.5	99
4.75	99
2	98
0.83	95
0.425	89
0.25	82
0.15	71
0.075	57.4
0.0327	42.4
0.0209	38.6
0.0124	34.7
0.0088	32.8
0.0063	29.9
0.0031	22.2
0.0013	13.5



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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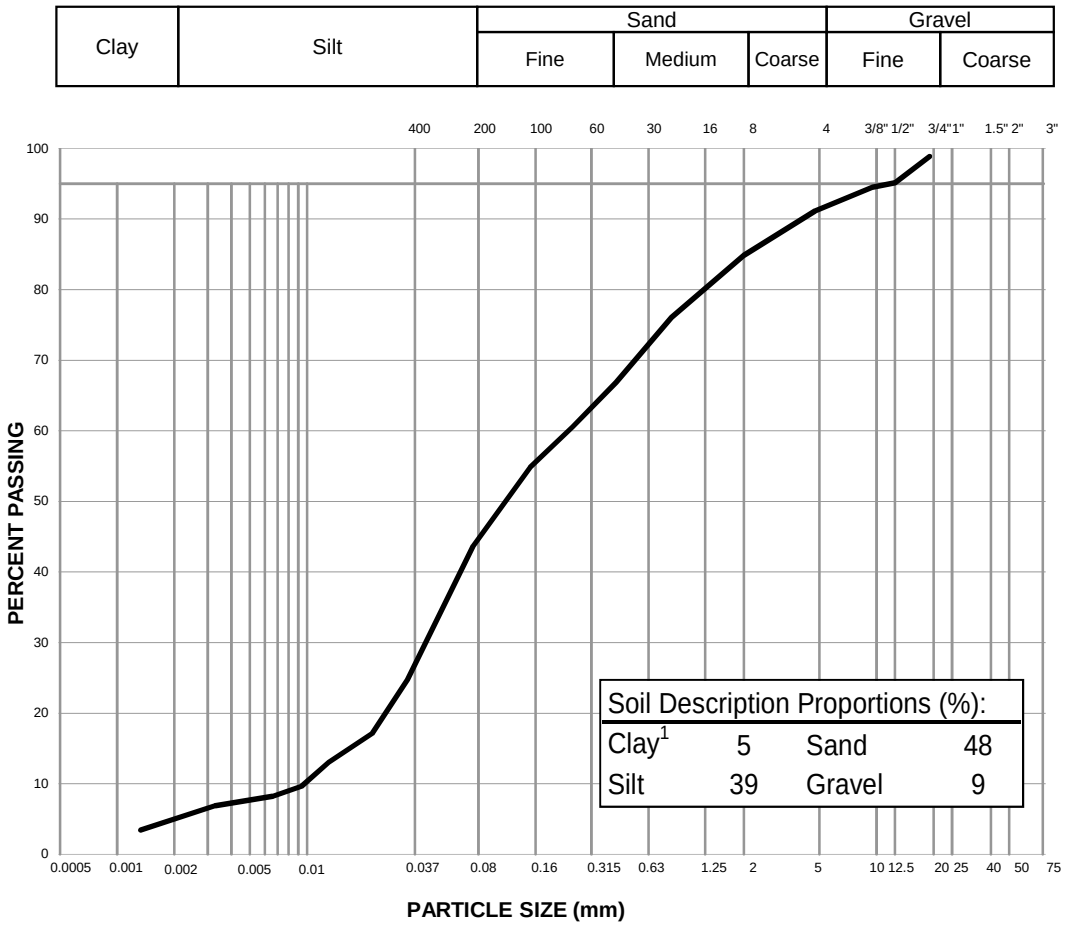
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29575
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-03
Client:	TMAC Resources Inc.	Sample Depth:	9.1-10.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SAND, SILT, trace gravel, trace clay.	Sampled By:	Client
		USC Classification:	SM Cu: 24.7
Moisture Content:	10.9%		Cc: 0.9

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	99
12.5	95
9.5	94
4.75	91
2	85
0.83	76
0.425	67
0.25	61
0.15	55
0.075	43.7
0.0338	24.8
0.0221	17.2
0.0130	13.1
0.0093	9.6
0.0066	8.3
0.0033	6.9
0.0013	3.4



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

_____

Reviewed By: _____ P.Geol

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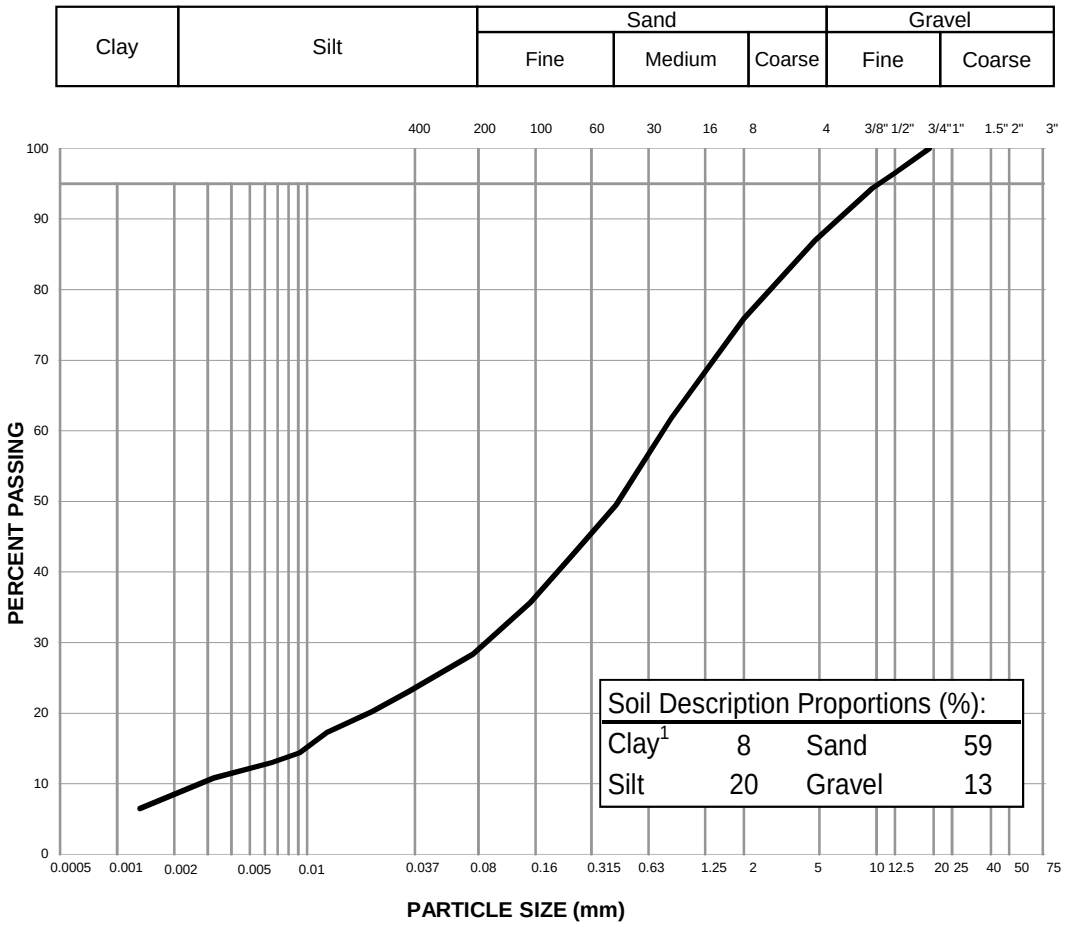
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29577
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-03
Client:	TMAC Resources Inc.	Sample Depth:	11.7-13.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SAND, some silt, some gravel, trace clay.	Sampled By:	Client
		USC Classification:	SM Cu: 268.7
Moisture Content:	7.8%		Cc: 3.8

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	97
9.5	94
4.75	87
2	76
0.83	62
0.425	50
0.25	42
0.15	36
0.075	28.4
0.0343	23.1
0.0220	20.2
0.0128	17.3
0.0092	14.4
0.0065	13.0
0.0032	10.8
0.0013	6.5



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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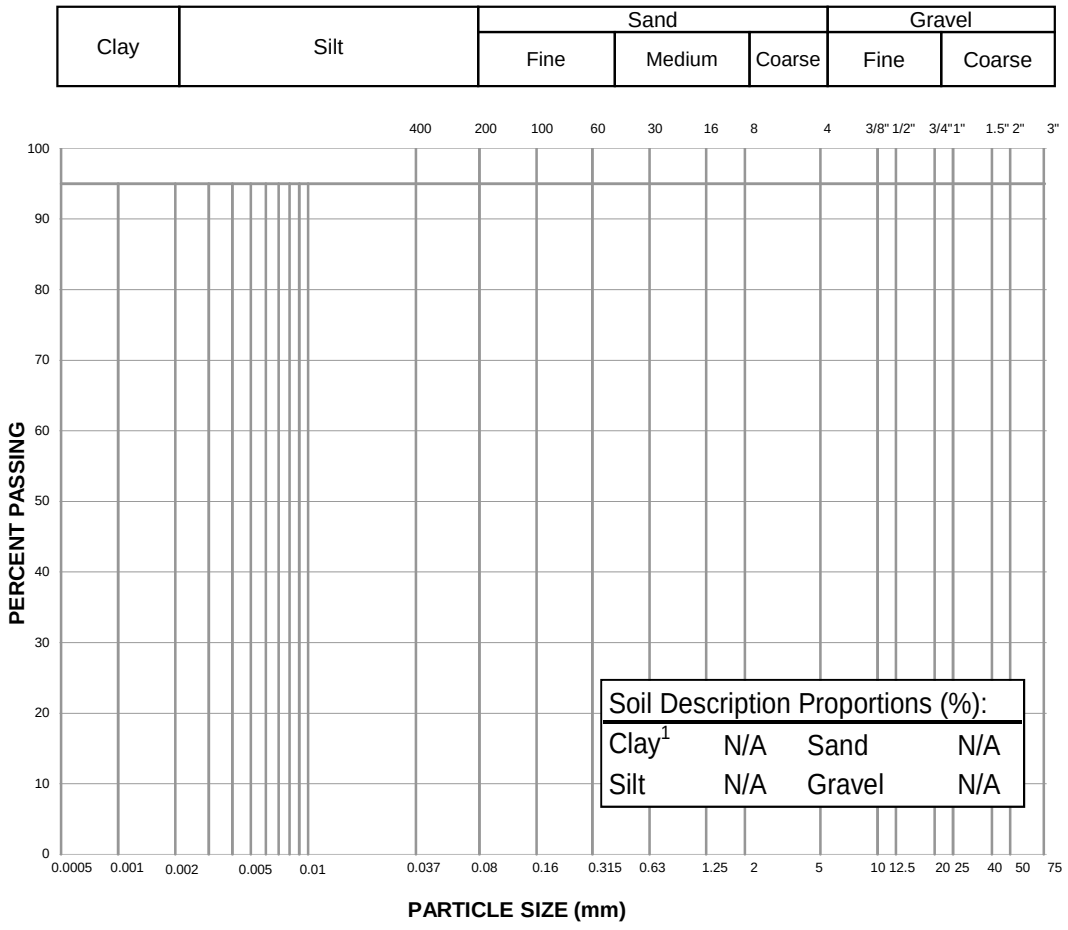
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29578
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-02
Client:	TMAC Resources Inc.	Sample Depth:	0.2-0.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 20, 2018 By: JPC	Date sampled:	February 25, 2018
Soil Description[2]:	Peat, trace fine sand, trace silt.	Sampled By:	Client
		USC Classification:	Cu: #N/A
Moisture Content:	108.8%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	
0.83	
0.425	
0.25	
0.15	
0.075	
0.0358	
0.0219	
0.0126	
0.0089	
0.0063	
0.0031	
0.0013	



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks: No hydrometer run. Sample is peat, trace fine sand, trace silt.

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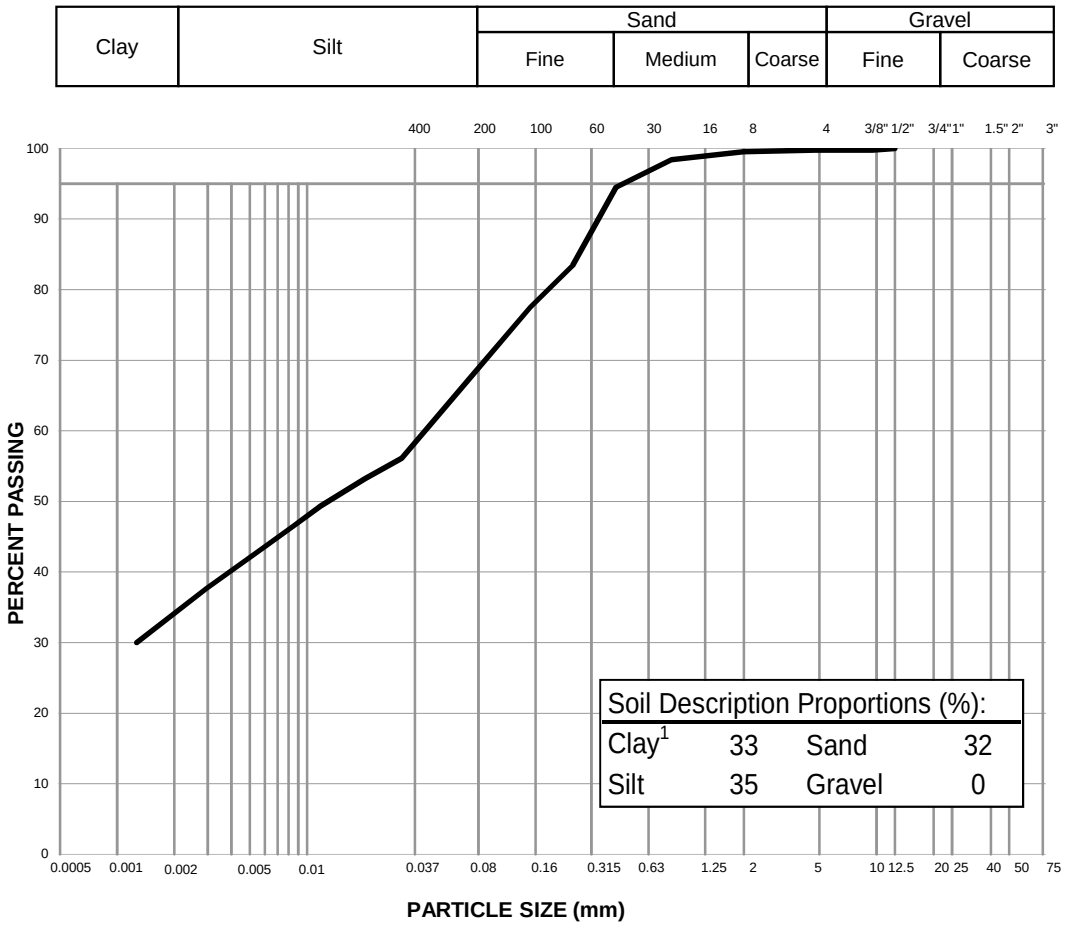
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29579
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	SRK18-STH-DH-02
Client:	TMAC Resources Inc.	Sample Depth:	2.5-2.9 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 5, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, sandy	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	71.2%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	100
9.5	100
4.75	100
2	100
0.83	98
0.425	94
0.25	83
0.15	78
0.075	68.0
0.0315	56.1
0.0202	53.2
0.0118	49.3
0.0084	46.4
0.0059	43.5
0.0030	37.7
0.0013	30.0



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

_____

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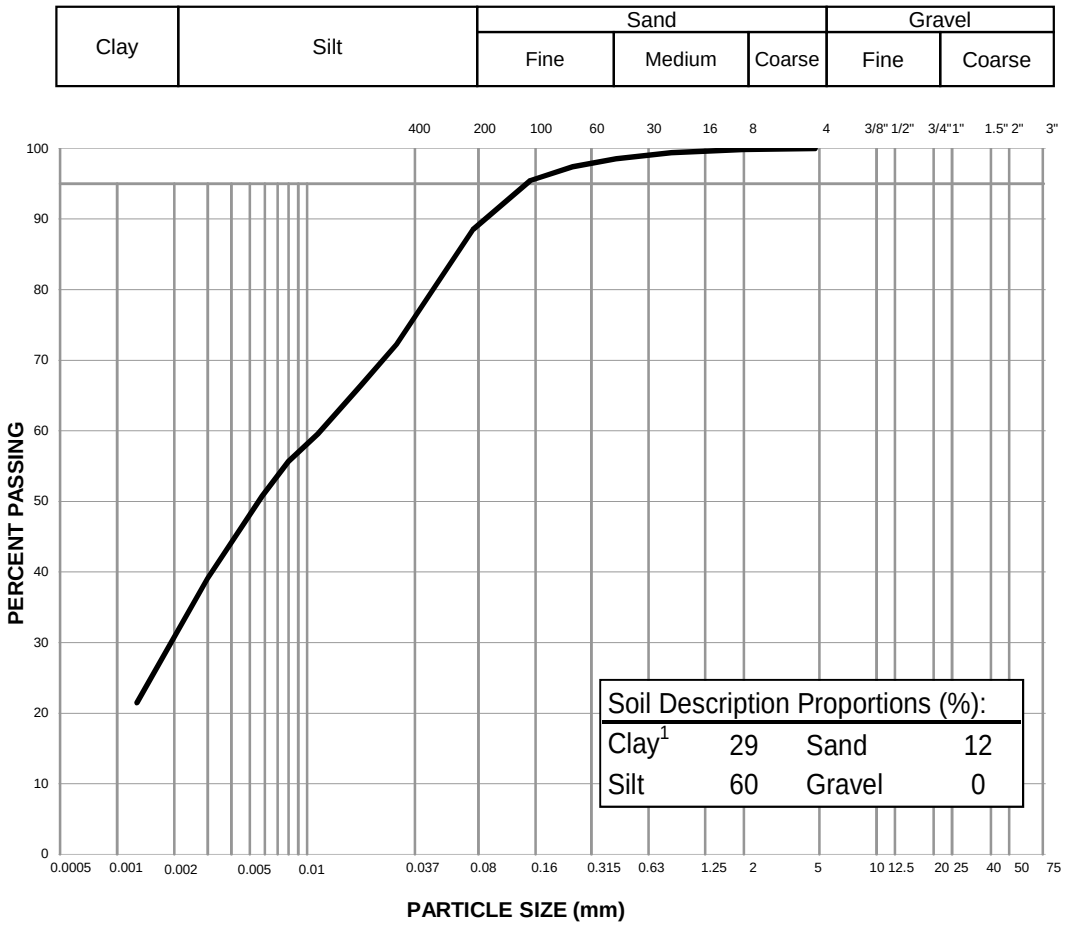
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29606
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	0.1-0.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	27.6%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	100
2	100
0.83	99
0.425	99
0.25	97
0.15	95
0.075	88.5
0.0296	72.3
0.0192	66.4
0.0114	59.6
0.0080	55.7
0.0058	50.8
0.0030	39.1
0.0013	21.5



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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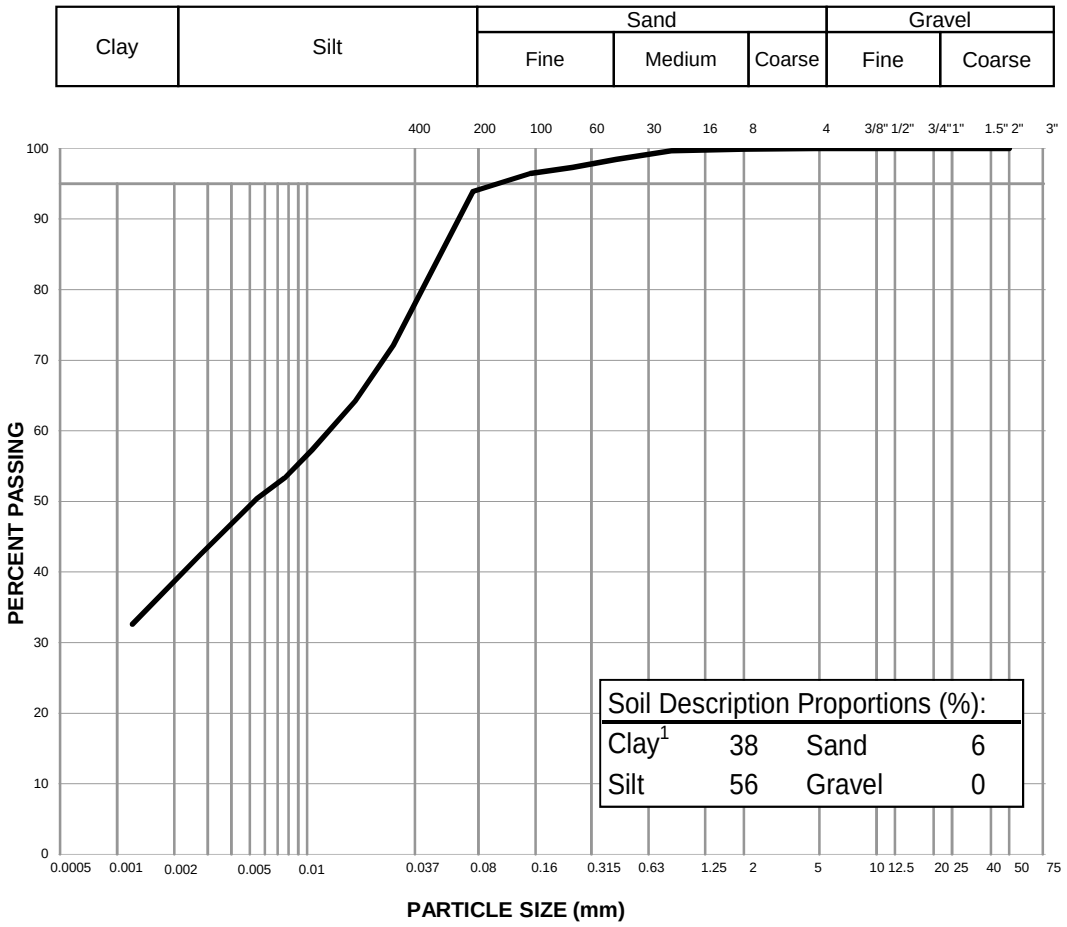
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29607
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	3.5-3.9 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 20, 2018 By: JPC	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, trace sand.	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	45.5%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	100
12.5	100
9.5	100
4.75	100
2	100
0.83	100
0.425	98
0.25	97
0.15	96
0.075	93.9
0.0285	72.1
0.0180	64.2
0.0106	57.3
0.0076	53.4
0.0054	50.4
0.0027	42.5
0.0012	32.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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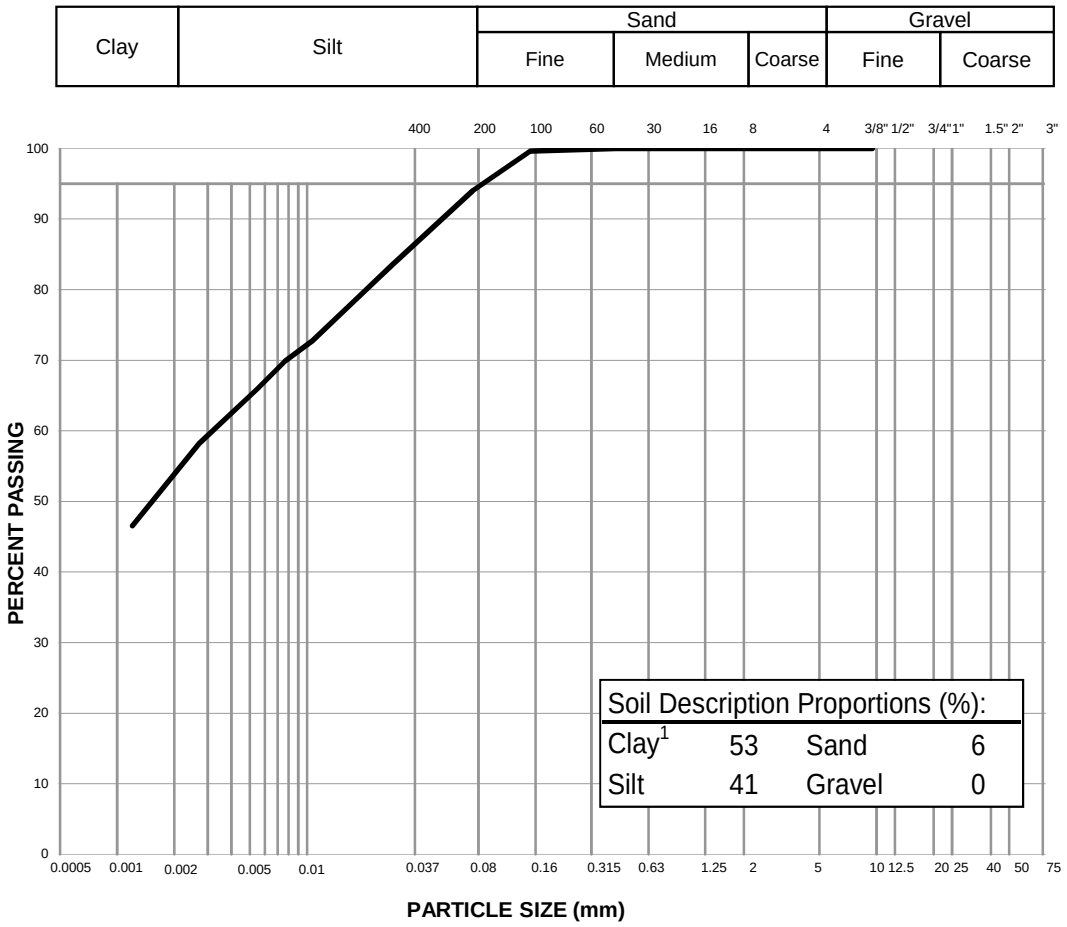
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29609
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	SRK18-STH-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	17.0-18.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 5, 2018 By: JPC/SS	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	44.5%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	100
0.25	100
0.15	100
0.075	94.0
0.0278	83.4
0.0180	78.6
0.0107	72.7
0.0076	69.8
0.0055	66.0
0.0027	58.2
0.0012	46.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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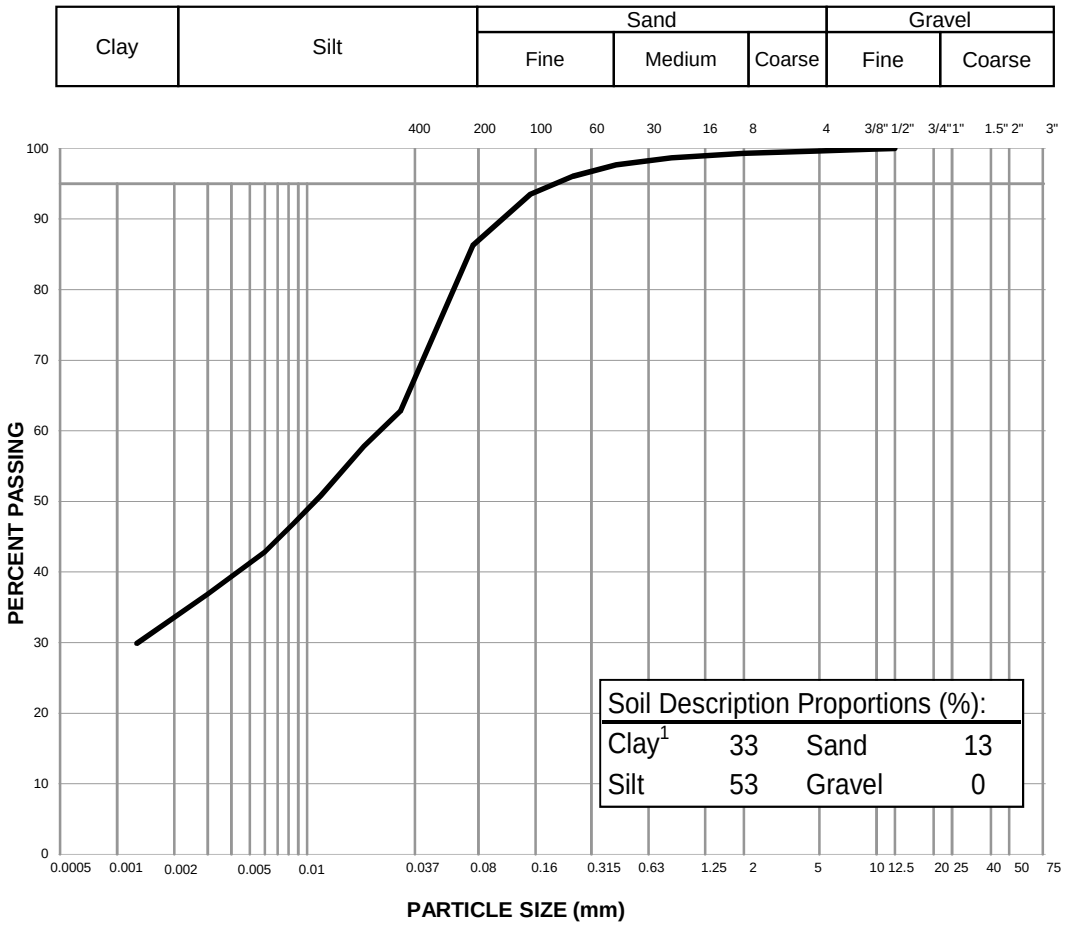
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29610
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	SRK18-STH-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	21.5-22.8 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 5, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	33.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	100
9.5	100
4.75	100
2	99
0.83	99
0.425	98
0.25	96
0.15	94
0.075	86.3
0.0310	62.8
0.0199	57.8
0.0118	50.8
0.0085	46.8
0.0060	42.8
0.0030	36.9
0.0013	29.9



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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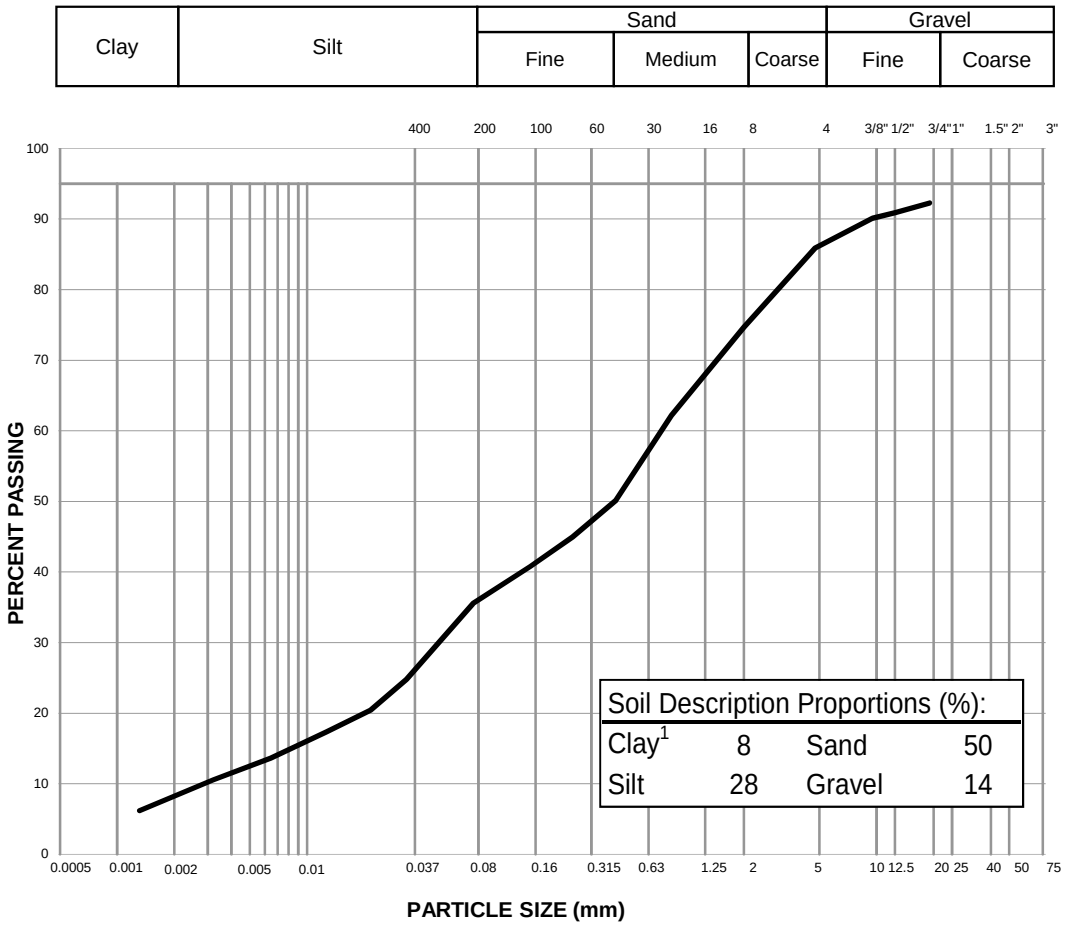
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29611
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	25.2-25.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SAND, silty, some gravel, trace clay.	Sampled By:	Client
		USC Classification:	SM Cu: 254.7
Moisture Content:	11.4%		Cc: 1.3

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	92
12.5	91
9.5	90
4.75	86
2	75
0.83	62
0.425	50
0.25	45
0.15	41
0.075	35.5
0.0334	24.8
0.0216	20.5
0.0127	17.4
0.0090	15.5
0.0064	13.6
0.0032	10.5
0.0013	6.2



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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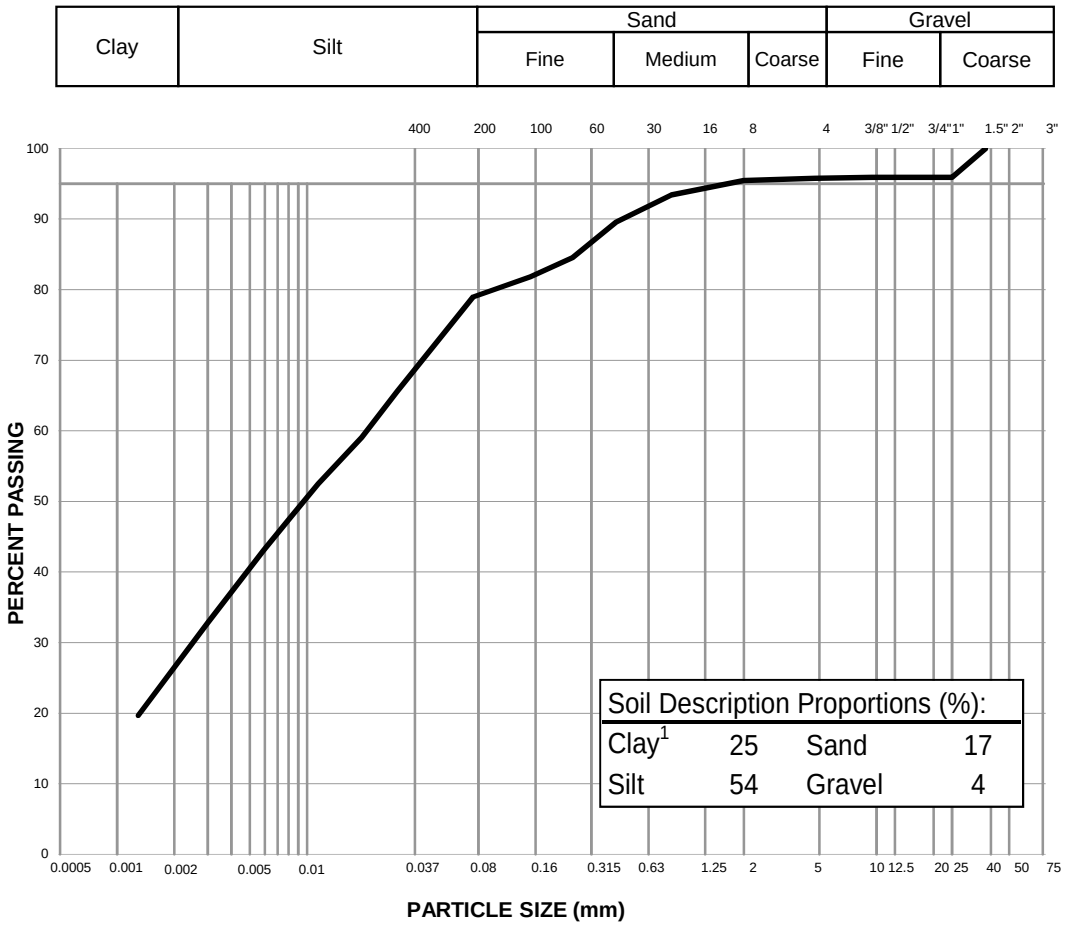
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29612
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-10
Client:	TMAC Resources Inc.	Sample Depth:	0.3-0.7 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 25, 2018 By: JPC	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, some sand, trace gravel	Sampled By:	Client
		USC Classification:	ML Cu: #N/A
Moisture Content:	45.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	100
25	96
19	96
12.5	96
9.5	96
4.75	96
2	95
0.83	93
0.425	90
0.25	85
0.15	82
0.075	79.0
0.0299	65.6
0.0194	59.0
0.0115	52.5
0.0082	47.8
0.0059	43.1
0.0030	32.8
0.0013	19.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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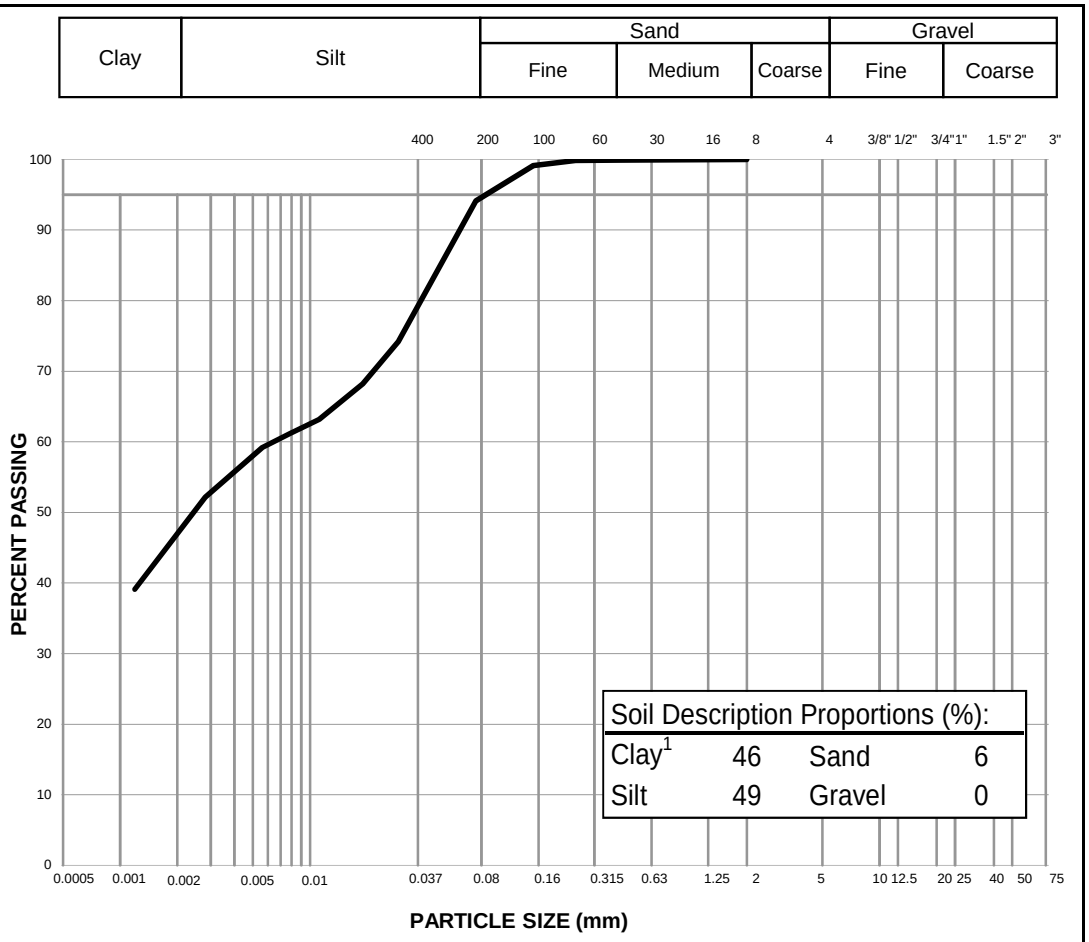
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29613
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-10
Client:	TMAC Resources Inc.	Sample Depth:	3.5-3.9 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 2, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	39.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	100
0.83	100
0.425	100
0.25	100
0.15	99
0.075	94.2
0.0293	74.2
0.0190	68.2
0.0112	63.2
0.0079	61.2
0.0056	59.2
0.0028	52.2
0.0012	39.1



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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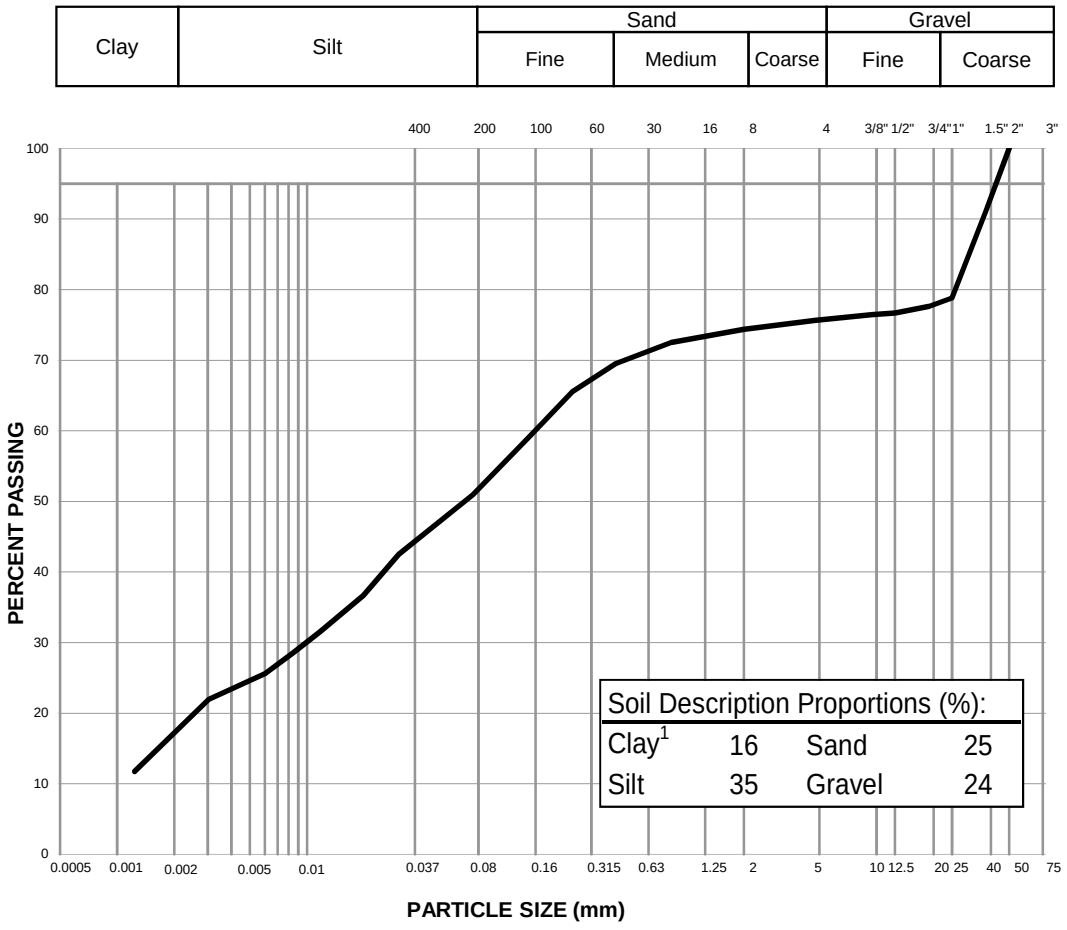
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29614
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-10
Client:	TMAC Resources Inc.	Sample Depth:	5.8-6.1 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 25, 2018
Soil Description[2]:	SILT, sandy, gravelly, some clay	Sampled By:	Client
		USC Classification:	ML Cu: #N/A
Moisture Content:	19.4%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	91
25	79
19	78
12.5	77
9.5	76
4.75	76
2	74
0.83	73
0.425	70
0.25	66
0.15	59
0.075	51.0
0.0304	42.5
0.0198	36.7
0.0117	31.5
0.0085	28.6
0.0061	25.7
0.0030	22.0
0.0012	11.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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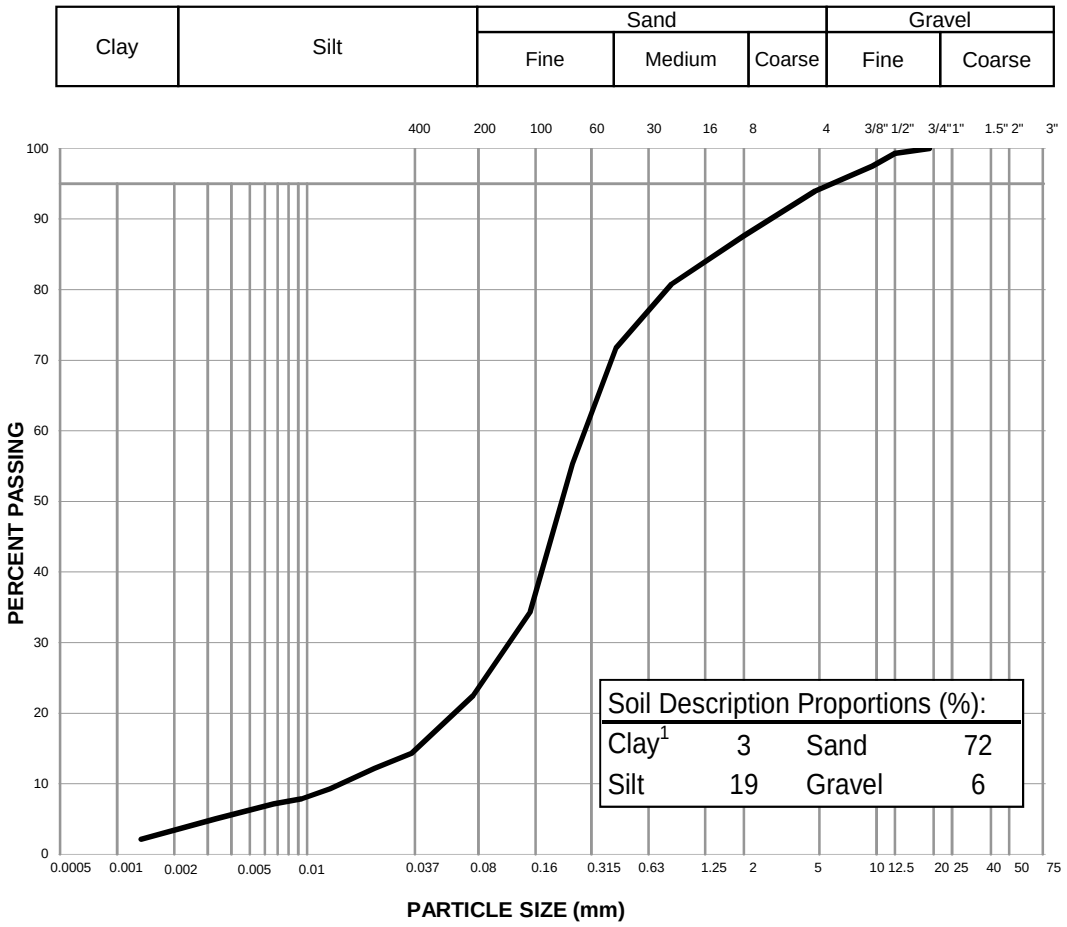
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29615
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-10
Client:	TMAC Resources Inc.	Sample Depth:	7.0-7.4 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SAND, some silt, trace gravel, trace clay.	Sampled By:	Client
		USC Classification:	SM Cu: 19.3
Moisture Content:	19.0%		Cc: 3.2

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	99
9.5	98
4.75	94
2	88
0.83	81
0.425	72
0.25	55
0.15	34
0.075	22.5
0.0356	14.3
0.0226	12.2
0.0132	9.3
0.0094	7.9
0.0067	7.2
0.0033	5.0
0.0013	2.1



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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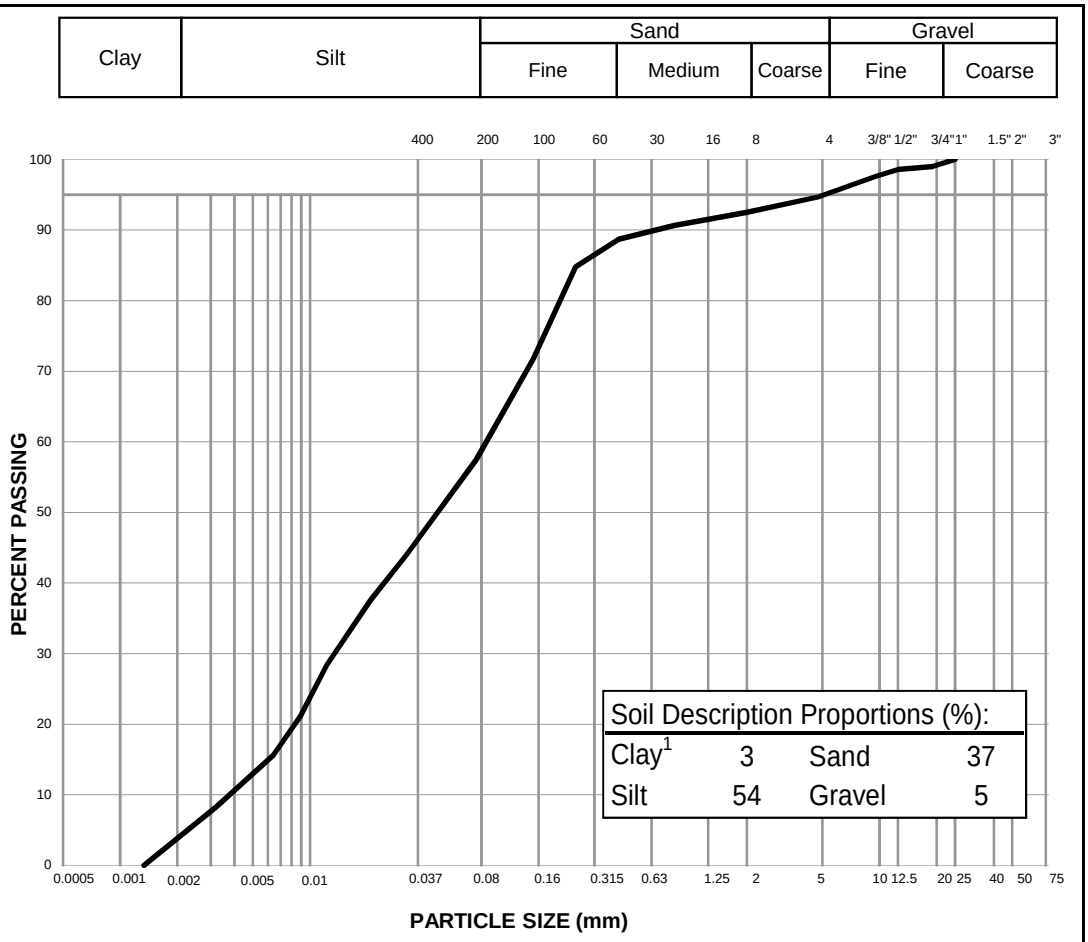
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29616
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-08
Client:	TMAC Resources Inc.	Sample Depth:	0.9-1.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 2, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SILT and SAND, trace gravel, trace clay	Sampled By:	Client
		USC Classification:	ML Cu: 22.4
Moisture Content:	55.9%		Cc: 0.5

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	100
19	99
12.5	99
9.5	98
4.75	95
2	93
0.83	91
0.425	89
0.25	85
0.15	72
0.075	57.4
0.0323	44.0
0.0209	37.6
0.0123	28.4
0.0089	21.1
0.0064	15.6
0.0032	8.3
0.0013	0.0



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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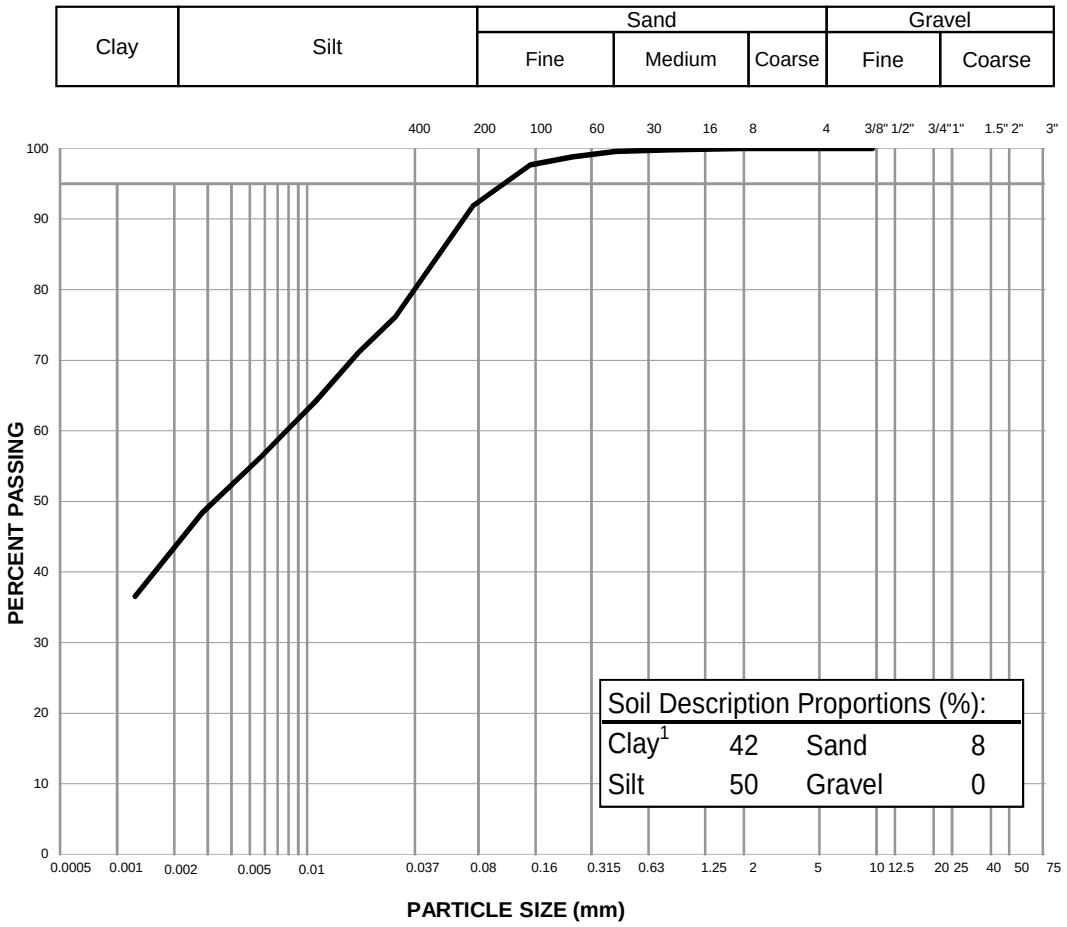
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29619
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-08
Client:	TMAC Resources Inc.	Sample Depth:	12.7-13.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 5, 2018 By: JPC/SS	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	45.6%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	100
0.25	99
0.15	98
0.075	91.9
0.0290	76.0
0.0187	71.1
0.0111	64.2
0.0080	60.2
0.0057	56.3
0.0028	48.4
0.0012	36.5



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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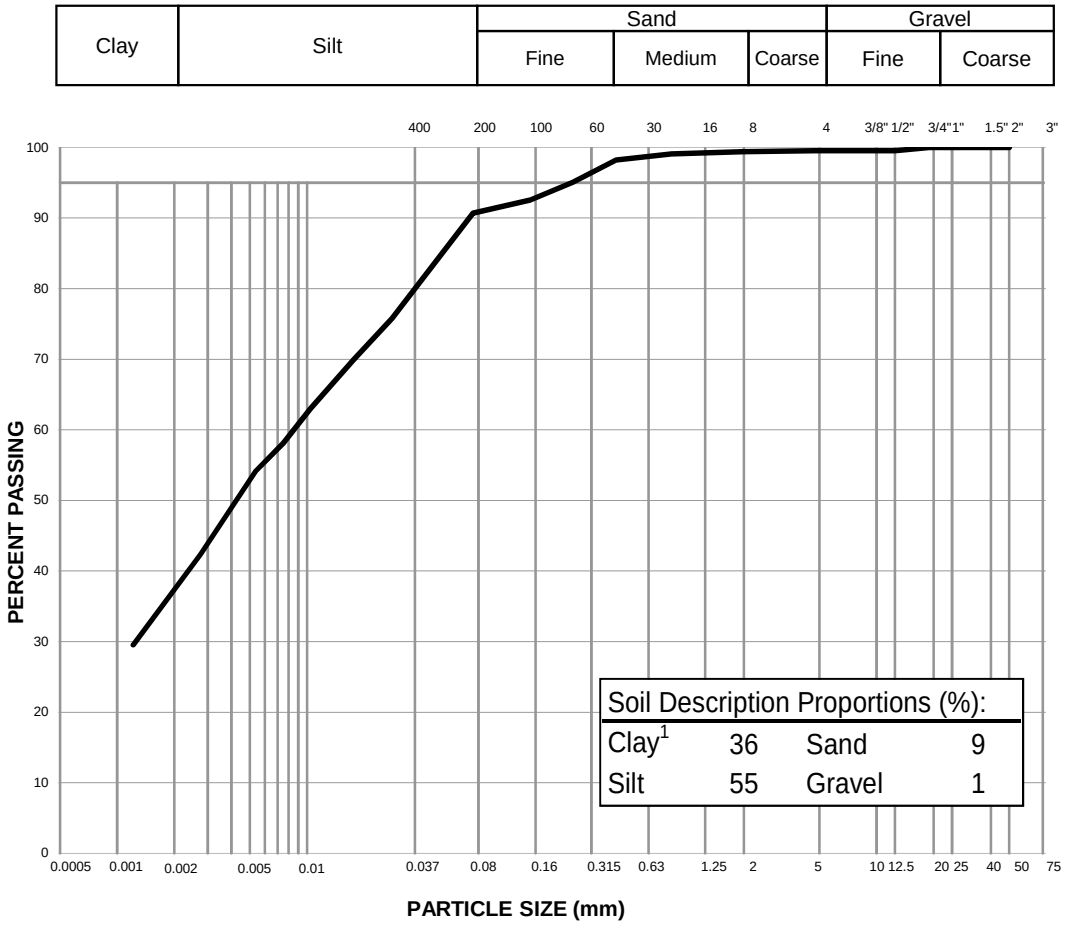
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29621
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-11
Client:	TMAC Resources Inc.	Sample Depth:	2.2-3.4 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 20, 2018 By: JPC	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, trace sand, trace gravel	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	46.4%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	100
12.5	100
9.5	100
4.75	100
2	99
0.83	99
0.425	98
0.25	95
0.15	93
0.075	90.7
0.0281	75.8
0.0176	69.9
0.0104	63.0
0.0075	58.1
0.0054	54.1
0.0027	42.3
0.0012	29.5



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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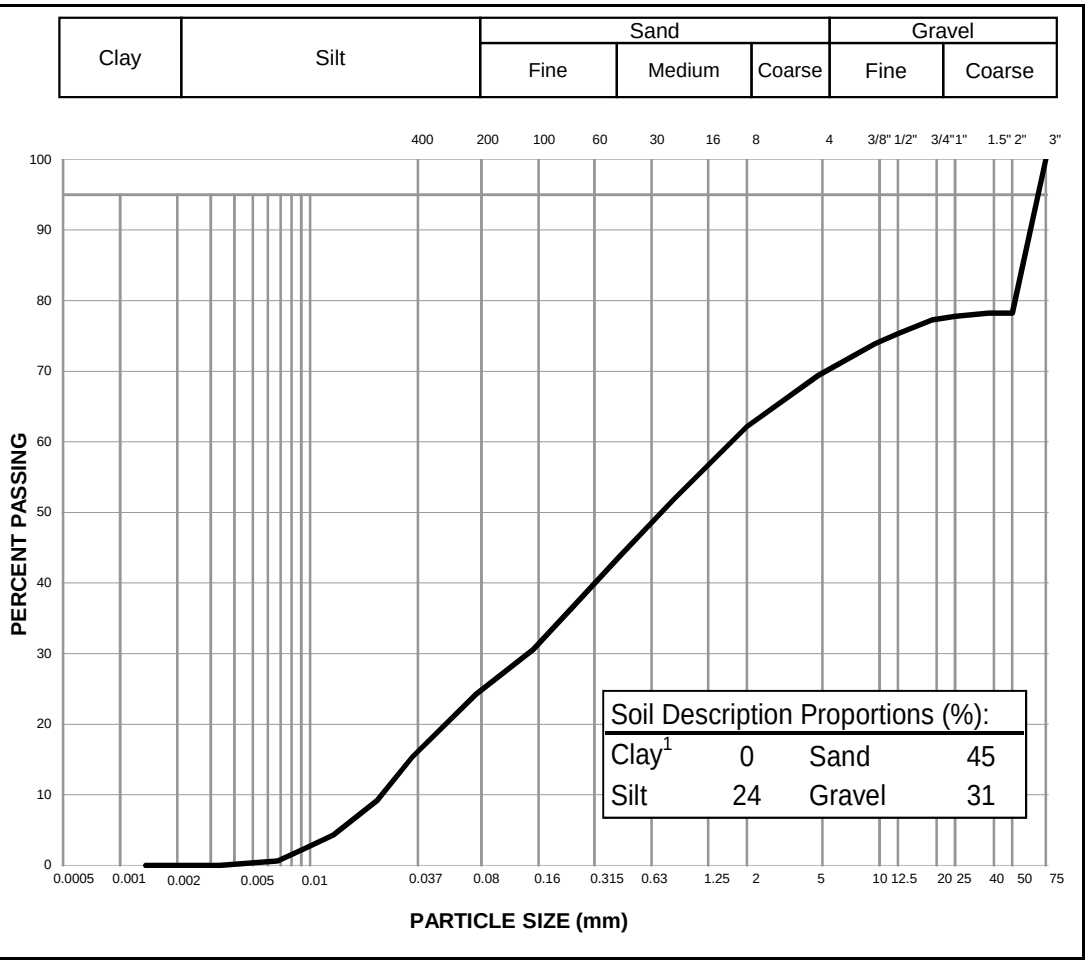
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29622
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-11
Client:	TMAC Resources Inc.	Sample Depth:	9.5-10.8 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 25, 2018 By: JPC	Date sampled:	February 25, 2018
Soil Description[2]:	SAND, gravelly, silty	Sampled By:	Client
		USC Classification:	SM Cu: 72.8
Moisture Content:	6.5%		Cc: 0.5

Particle Size (mm)	Percent Passing
75	100
50	78
37.5	78
25	78
19	77
12.5	75
9.5	74
4.75	69
2	62
0.83	52
0.425	44
0.25	37
0.15	31
0.075	24.3
0.0346	15.4
0.0225	9.2
0.0133	4.3
0.0095	2.5
0.0067	0.6
0.0033	0.0
0.0014	0.0



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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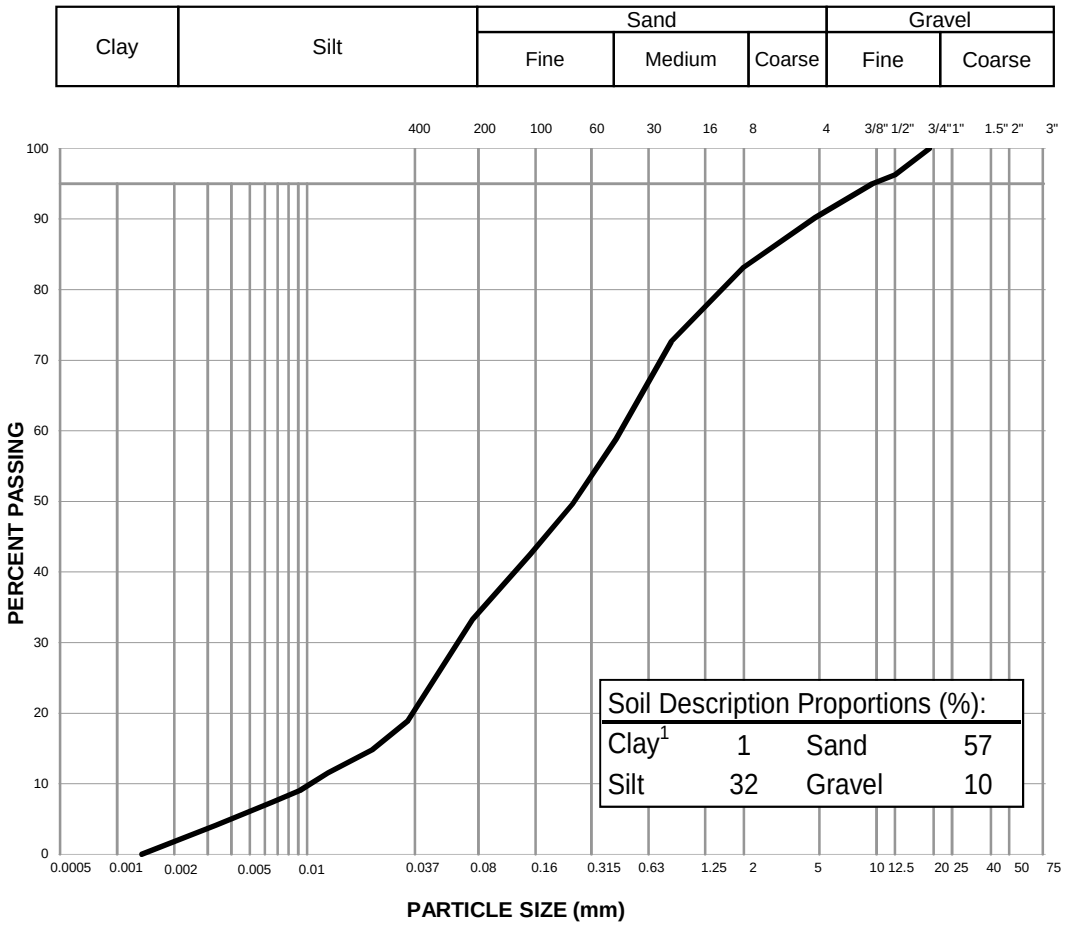
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29623
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-11
Client:	TMAC Resources Inc.	Sample Depth:	11.2-14.7 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 12, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SAND, SILT, trace gravel, trace clay	Sampled By:	Client
		USC Classification:	SM Cu: 43.4
Moisture Content:	11.1%		Cc: 0.9

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	96
9.5	95
4.75	90
2	83
0.83	73
0.425	59
0.25	50
0.15	42
0.075	33.3
0.0340	18.9
0.0221	14.8
0.0129	11.5
0.0092	9.1
0.0066	7.4
0.0033	4.1
0.0013	0.0



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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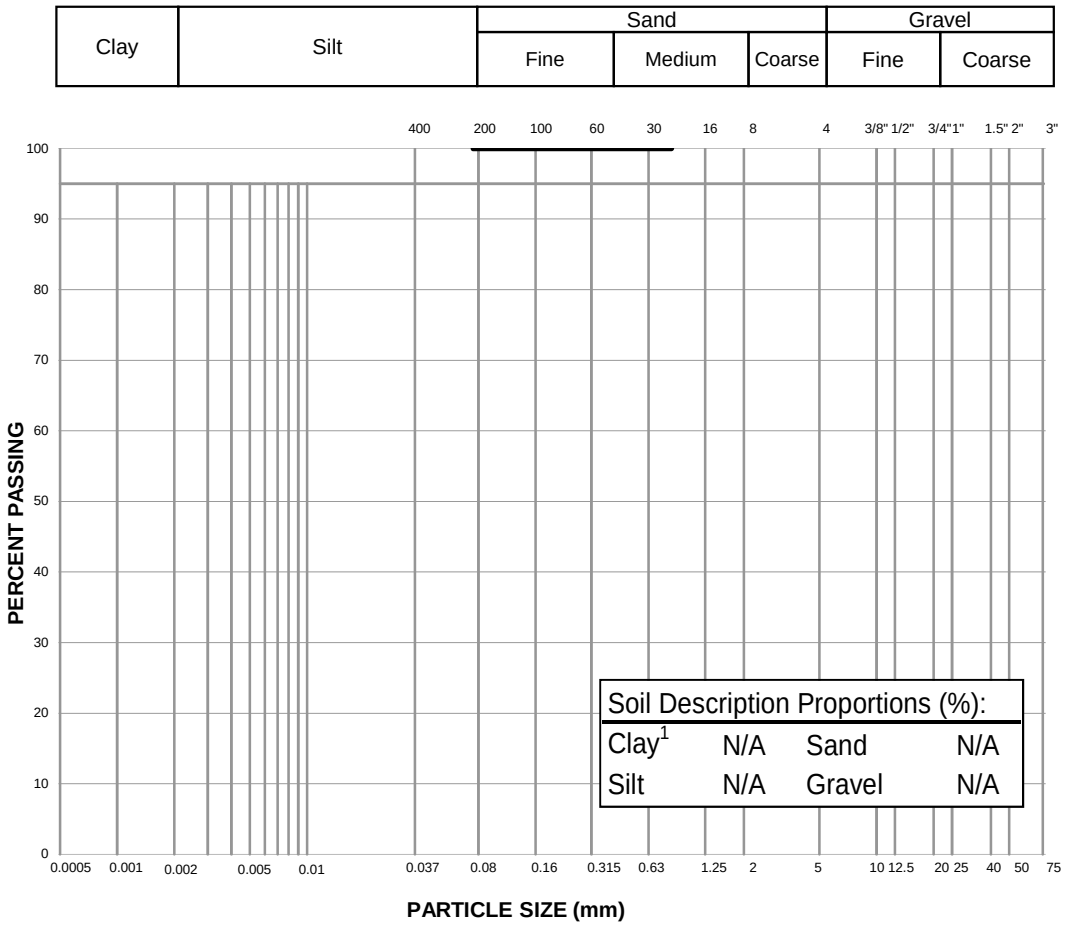
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29624
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-07
Client:	TMAC Resources Inc.	Sample Depth:	1.1-2.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 27, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	Peat.	Sampled By:	Client
		USC Classification:	Cu: #N/A
Moisture Content:	274.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	
0.83	100
0.425	100
0.25	100
0.15	100
0.075	100.0
0.0296	
0.0194	
0.0116	
0.0083	
0.0059	
0.0029	
0.0012	



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks: Sample is peat. Particle Size Analysis not possible.

Reviewed By: _____ P.Geol

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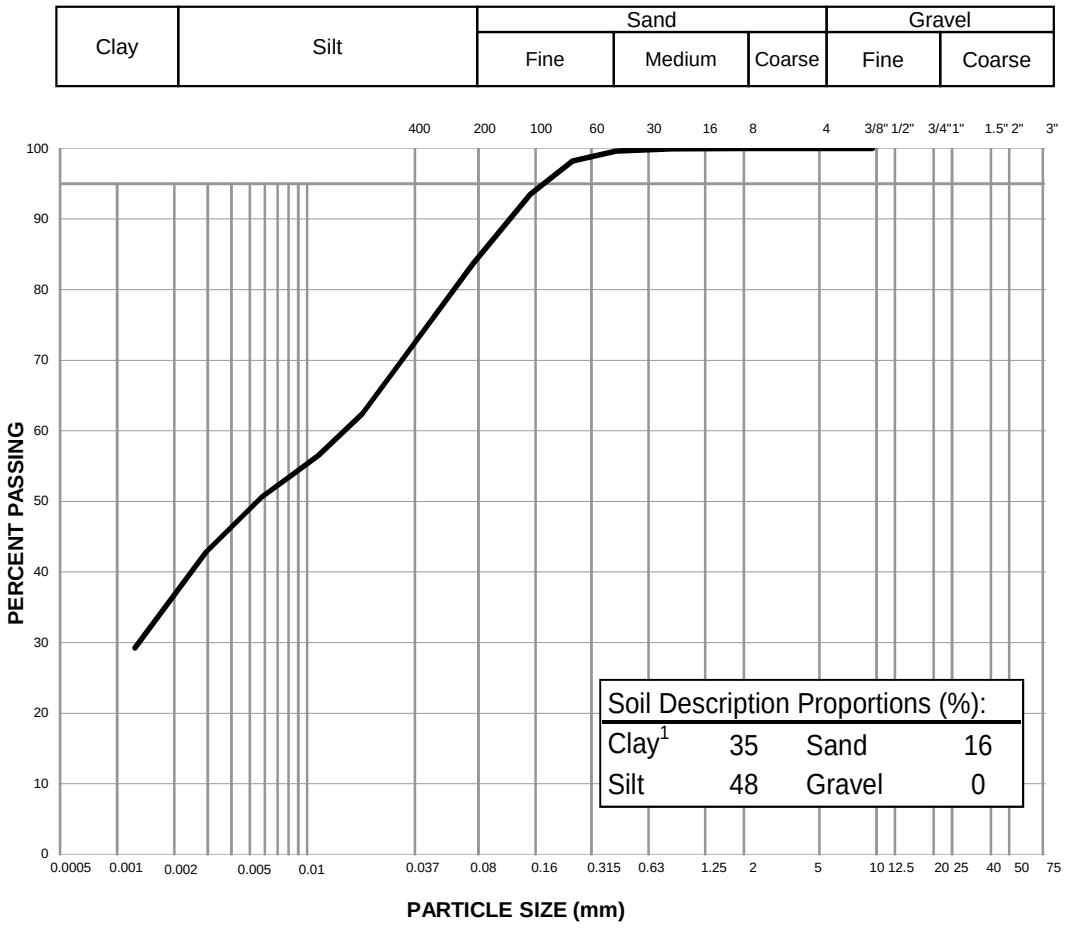
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29625
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-07
Client:	TMAC Resources Inc.	Sample Depth:	5.2-6.7 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	26.9%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	100
0.25	98
0.15	94
0.075	83.7
0.0301	69.2
0.0195	62.4
0.0115	56.5
0.0082	53.6
0.0058	50.7
0.0030	42.9
0.0012	29.2



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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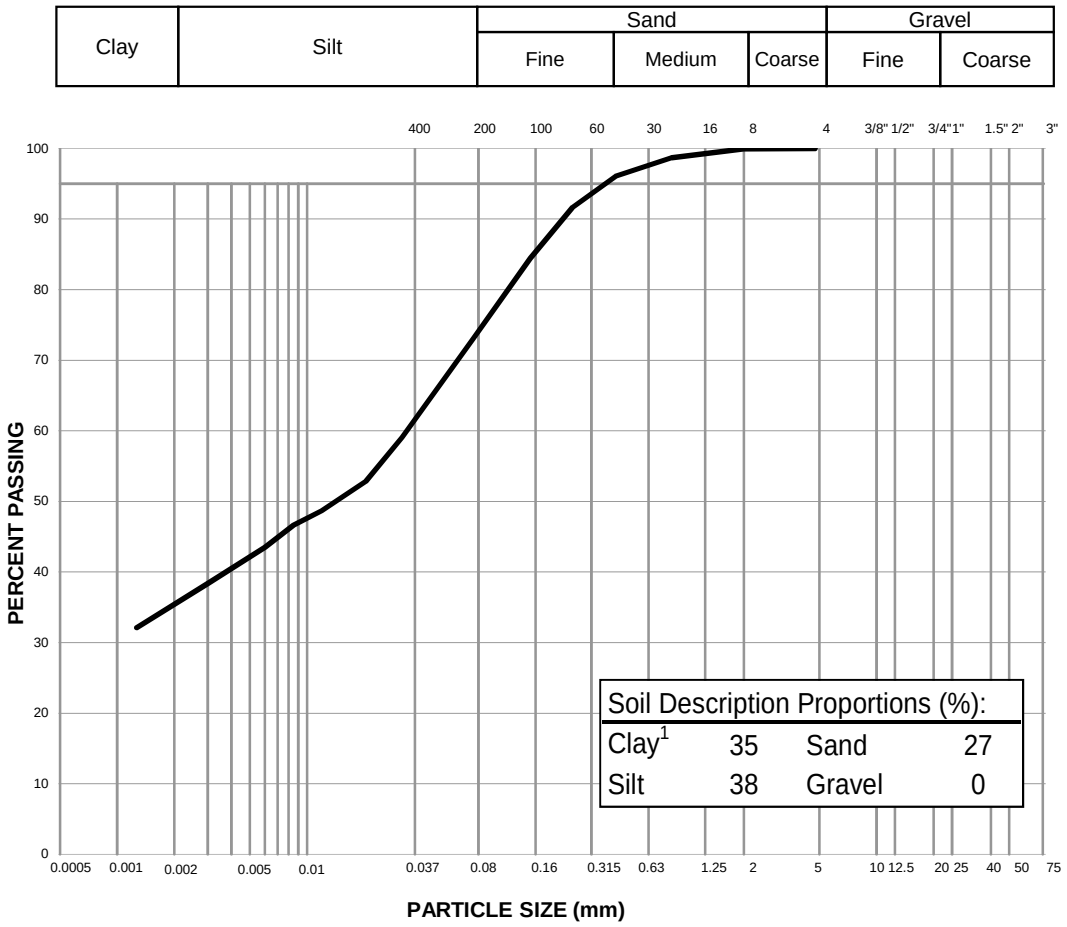
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29627
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	SRK18-STH-DH-07
Client:	TMAC Resources Inc.	Sample Depth:	20.4-21.7 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 5, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, sandy	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	42.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	100
2	100
0.83	99
0.425	96
0.25	92
0.15	84
0.075	73.0
0.0316	59.0
0.0204	52.8
0.0120	48.7
0.0085	46.6
0.0060	43.5
0.0030	38.3
0.0013	32.1



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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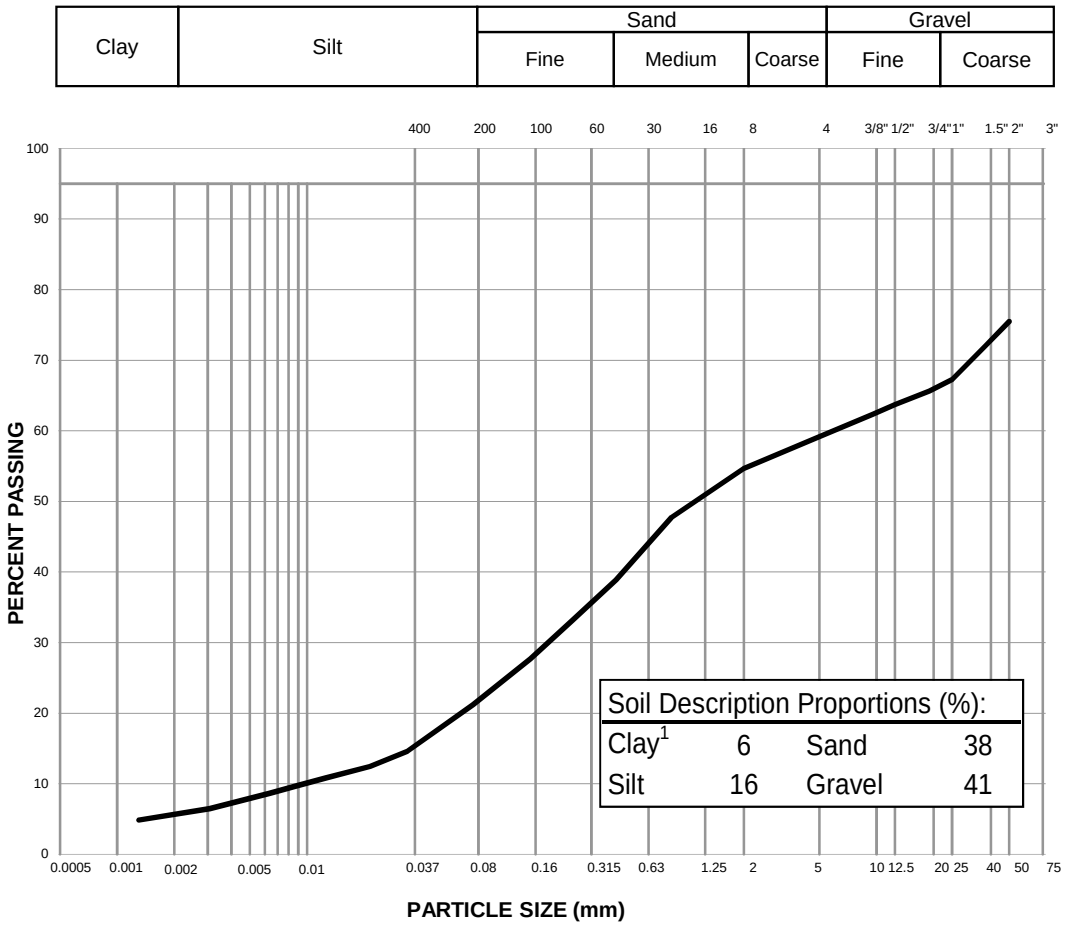
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29628
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-07
Client:	TMAC Resources Inc.	Sample Depth:	26.3-27.2 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 14, 2018 By: JPC	Date sampled:	February 25, 2018
Soil Description[2]:	GRAVEL and SAND, some silt,trace clay	Sampled By:	Client
		USC Classification:	GP Cu: 639.1
Moisture Content:	10.1%		Cc: 0.6

Particle Size (mm)	Percent Passing
75	
50	75
37.5	72
25	67
19	66
12.5	64
9.5	62
4.75	59
2	55
0.83	48
0.425	39
0.25	33
0.15	28
0.075	21.2
0.0336	14.6
0.0215	12.4
0.0125	10.8
0.0089	9.7
0.0063	8.7
0.0031	6.5
0.0013	4.9



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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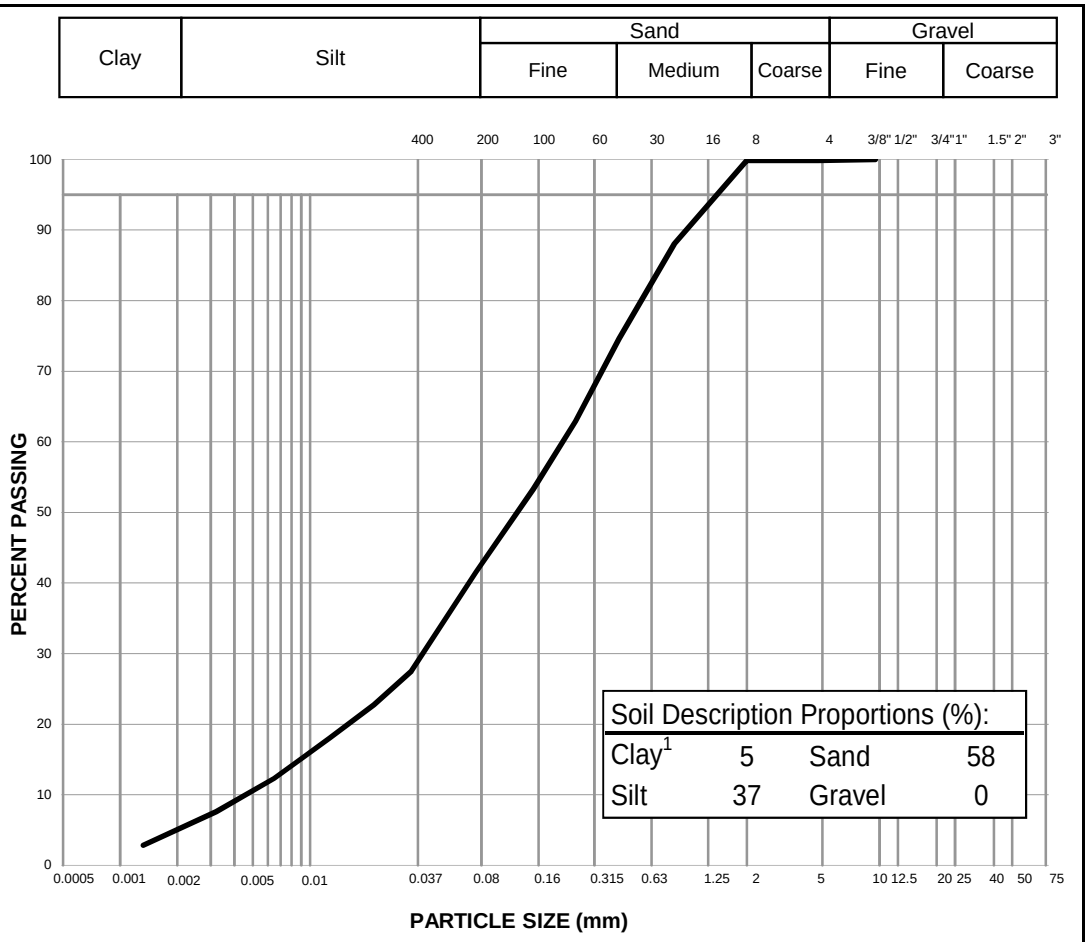
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29629
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-07
Client:	TMAC Resources Inc.	Sample Depth:	31.0-32.2 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 2, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SAND and SILT, trace clay	Sampled By:	Client
		USC Classification:	SM Cu: 45.2
Moisture Content:	7.2%		Cc: 1.6

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	88
0.425	75
0.25	63
0.15	53
0.075	41.6
0.0342	27.5
0.0217	22.8
0.0127	18.0
0.0091	15.2
0.0065	12.3
0.0032	7.6
0.0013	2.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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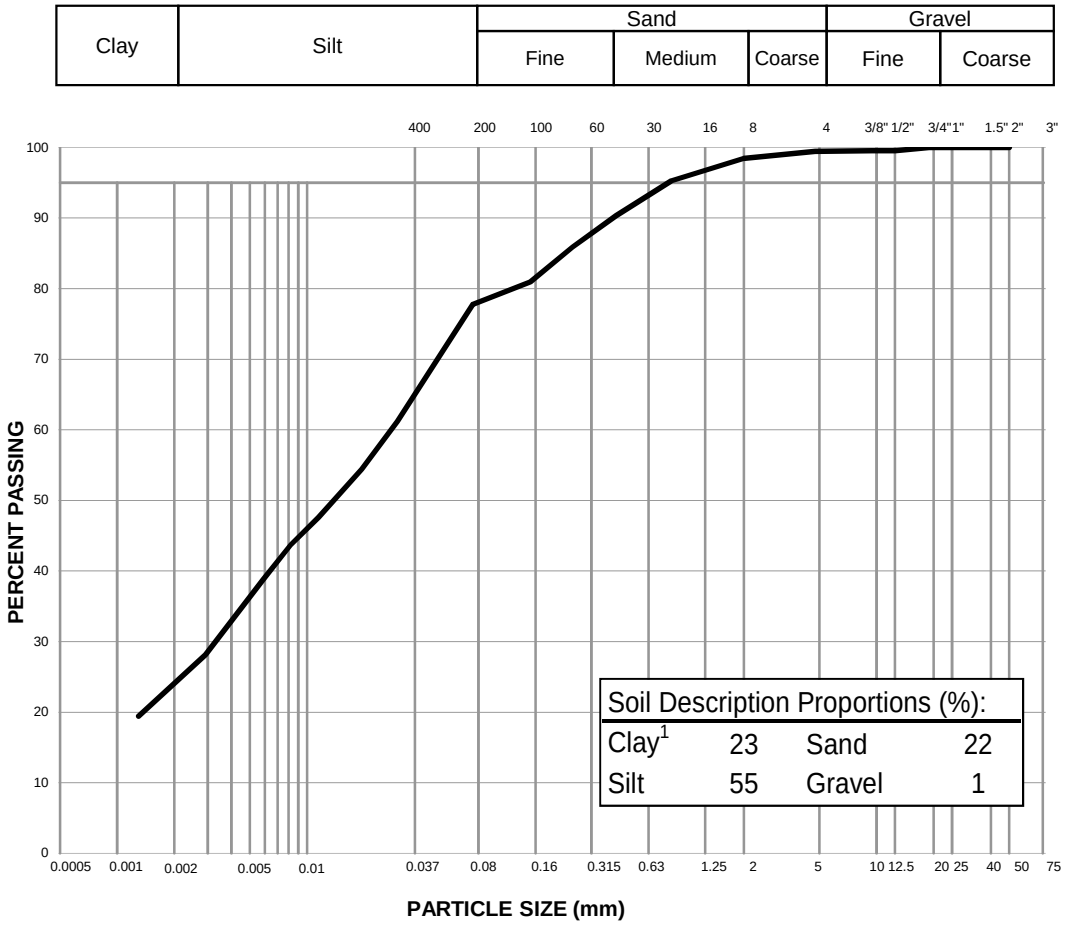
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29631
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-09
Client:	TMAC Resources Inc.	Sample Depth:	0.3-0.9 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 22, 2018 By: JPC	Date sampled:	February 26, 2018
Soil Description[2]:	CLAY, silty, sandy, trace gravel	Sampled By:	Client
		USC Classification:	CI Cu: #N/A
Moisture Content:	42.1%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	100
12.5	100
9.5	100
4.75	99
2	98
0.83	95
0.425	90
0.25	86
0.15	81
0.075	77.8
0.0299	61.2
0.0194	54.4
0.0115	47.6
0.0082	43.7
0.0059	38.8
0.0029	28.2
0.0013	19.4



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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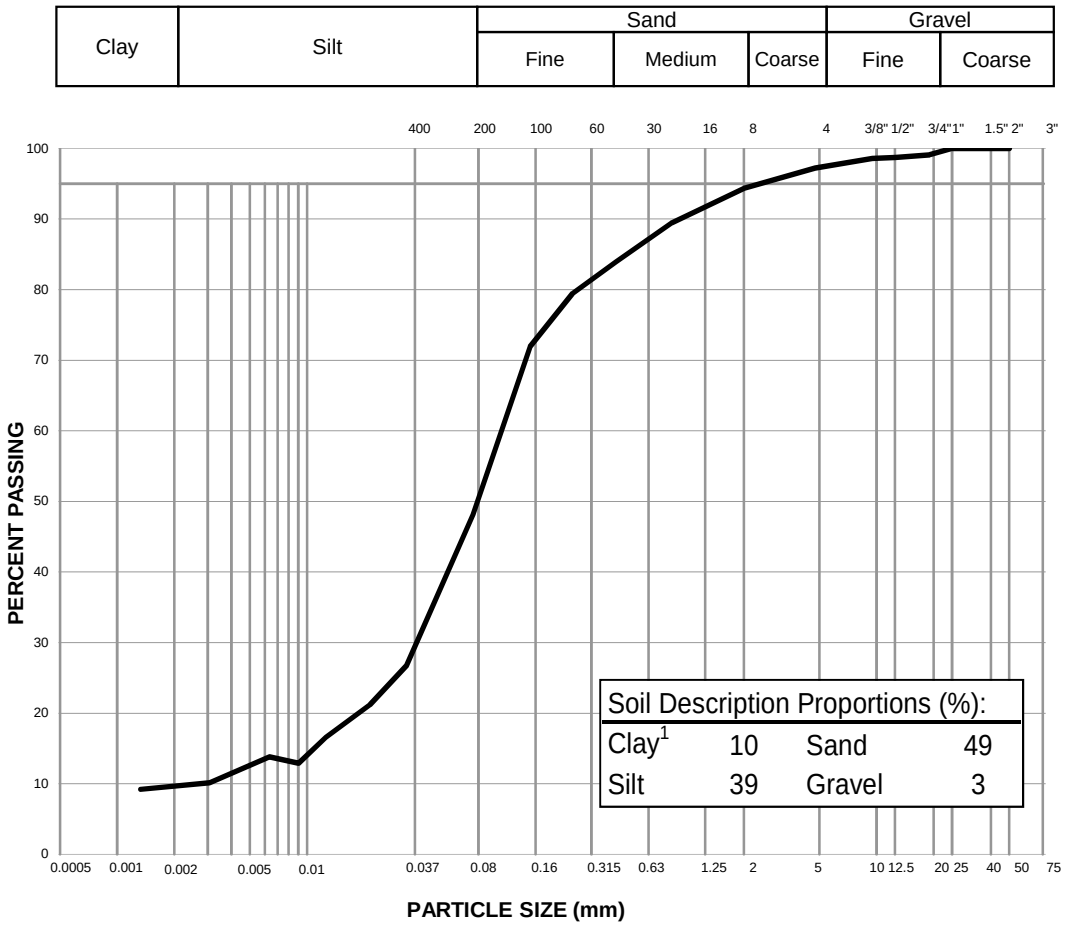
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29634
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-09
Client:	TMAC Resources Inc.	Sample Depth:	13.5-14.2 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 22, 2018 By: JPC	Date sampled:	February 26, 2018
Soil Description[2]:	SAND and SILT, trace clay, trace gravel	Sampled By:	Client
		USC Classification:	SM Cu: 40.1
Moisture Content:	13.3%		Cc: 5.0

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	99
12.5	99
9.5	99
4.75	97
2	94
0.83	89
0.425	84
0.25	79
0.15	72
0.075	48.1
0.0334	26.7
0.0215	21.2
0.0126	16.6
0.0090	12.9
0.0064	13.8
0.0031	10.1
0.0013	9.2



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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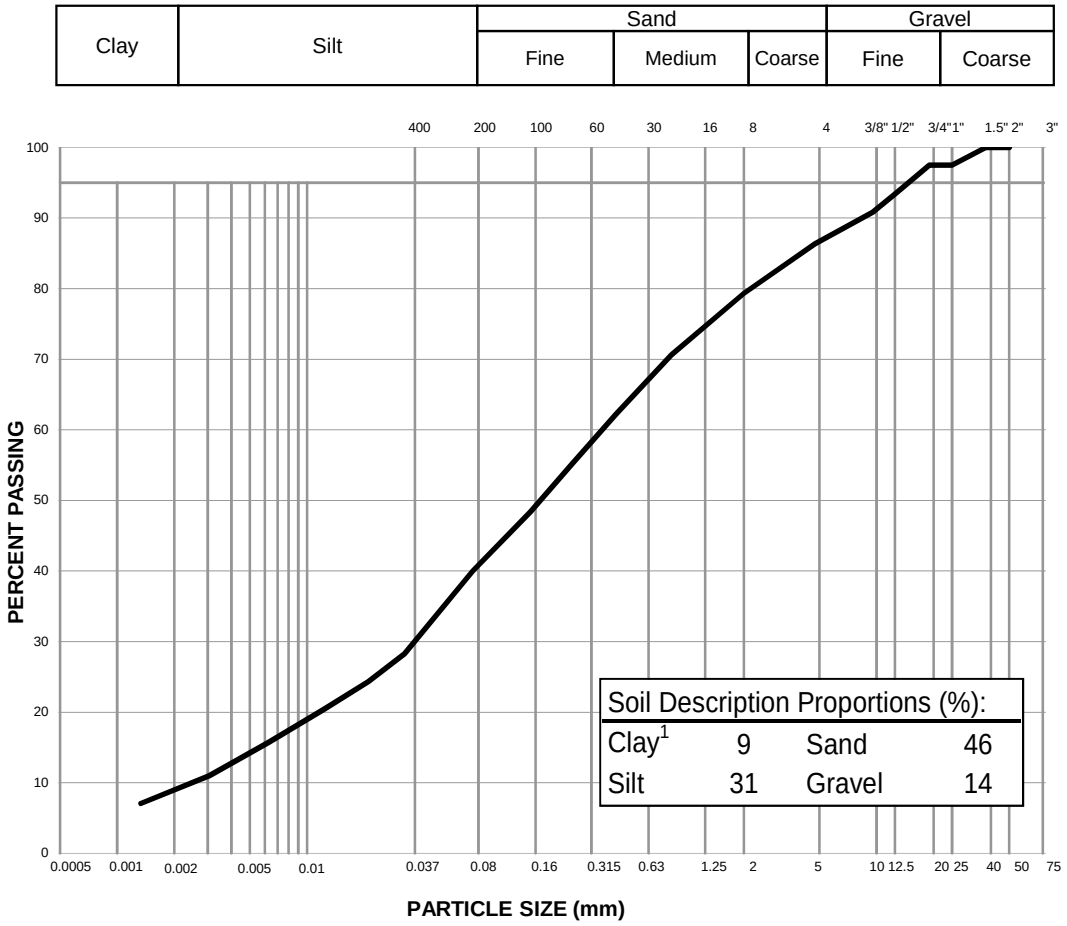
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29635
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-09
Client:	TMAC Resources Inc.	Sample Depth:	15.0-15.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 22, 2018 By: JPC	Date sampled:	February 26, 2018
Soil Description[2]:	SAND, silty, some gravel, trace clay	Sampled By:	Client
		USC Classification:	SM Cu: 141.0
Moisture Content:	8.4%		Cc: 1.6

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	98
19	98
12.5	93
9.5	91
4.75	86
2	79
0.83	71
0.425	62
0.25	55
0.15	48
0.075	40.0
0.0327	28.3
0.0210	24.3
0.0123	20.4
0.0088	18.1
0.0063	15.7
0.0031	11.0
0.0013	7.1



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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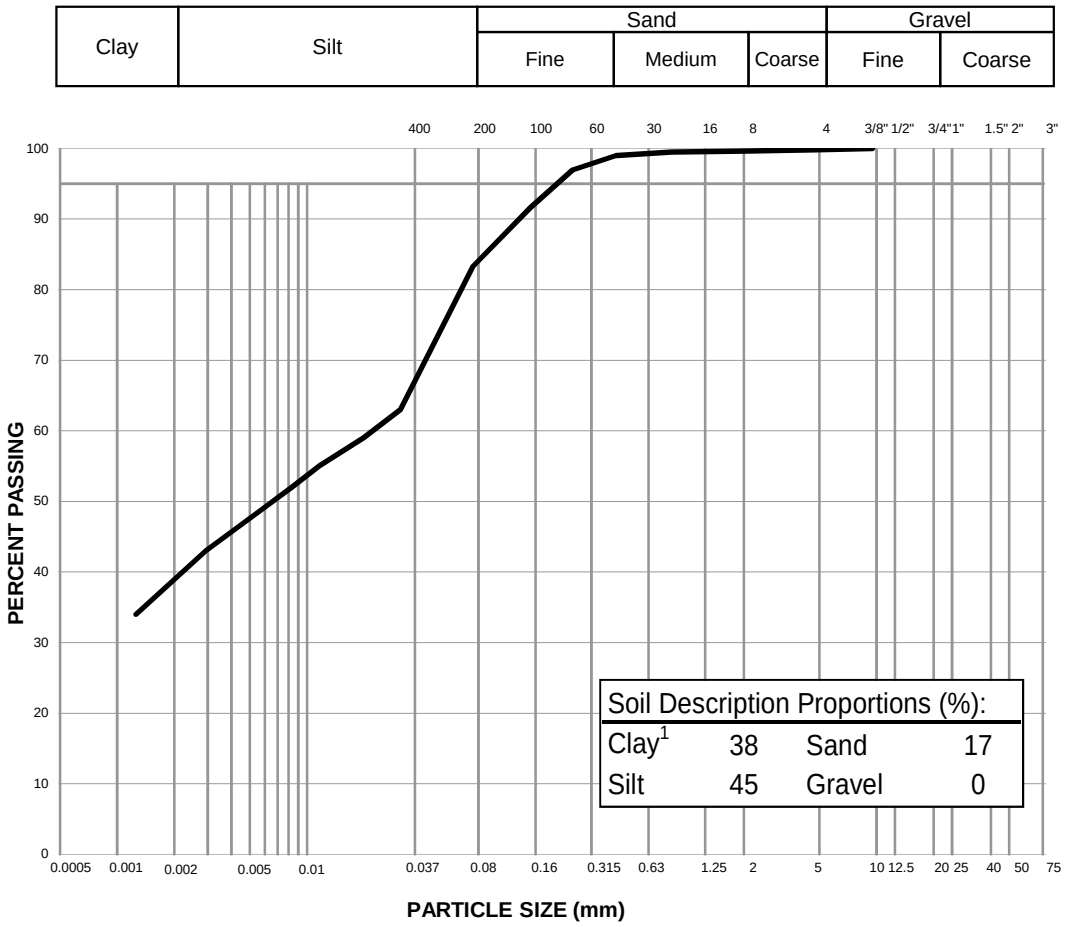
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29636
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	SRK18-STH-DH-05
Client:	TMAC Resources Inc.	Sample Depth:	1.1-2.3 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 5, 2018 By: WM	Date sampled:	February 26, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	53.8%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	99
0.425	99
0.25	97
0.15	92
0.075	83.3
0.0310	63.0
0.0199	59.0
0.0116	55.0
0.0083	52.0
0.0059	49.0
0.0029	43.0
0.0013	34.0



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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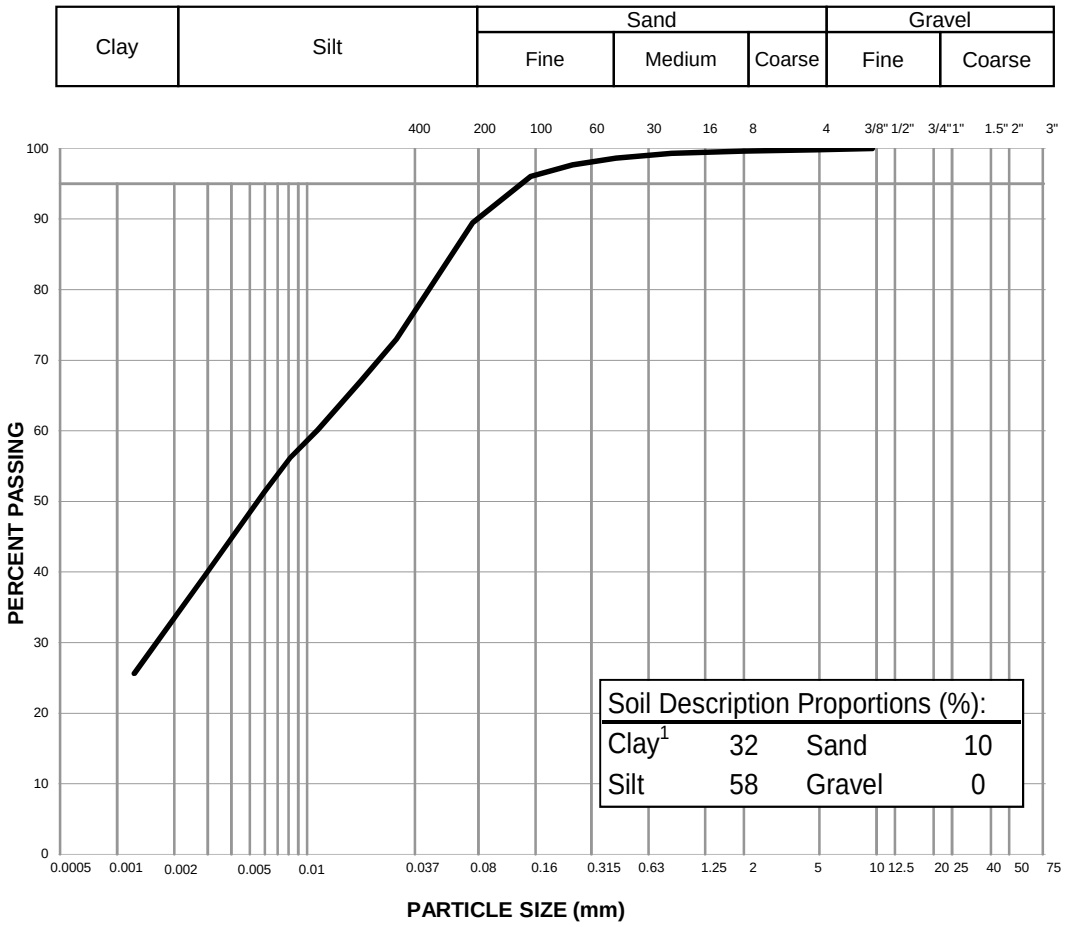
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29637
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-05
Client:	TMAC Resources Inc.	Sample Depth:	4.3-5.3 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 26, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	CI Cu: #N/A
Moisture Content:	36.4%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	99
0.425	99
0.25	98
0.15	96
0.075	89.5
0.0296	73.0
0.0192	67.0
0.0114	60.1
0.0082	56.2
0.0059	51.3
0.0029	39.4
0.0012	25.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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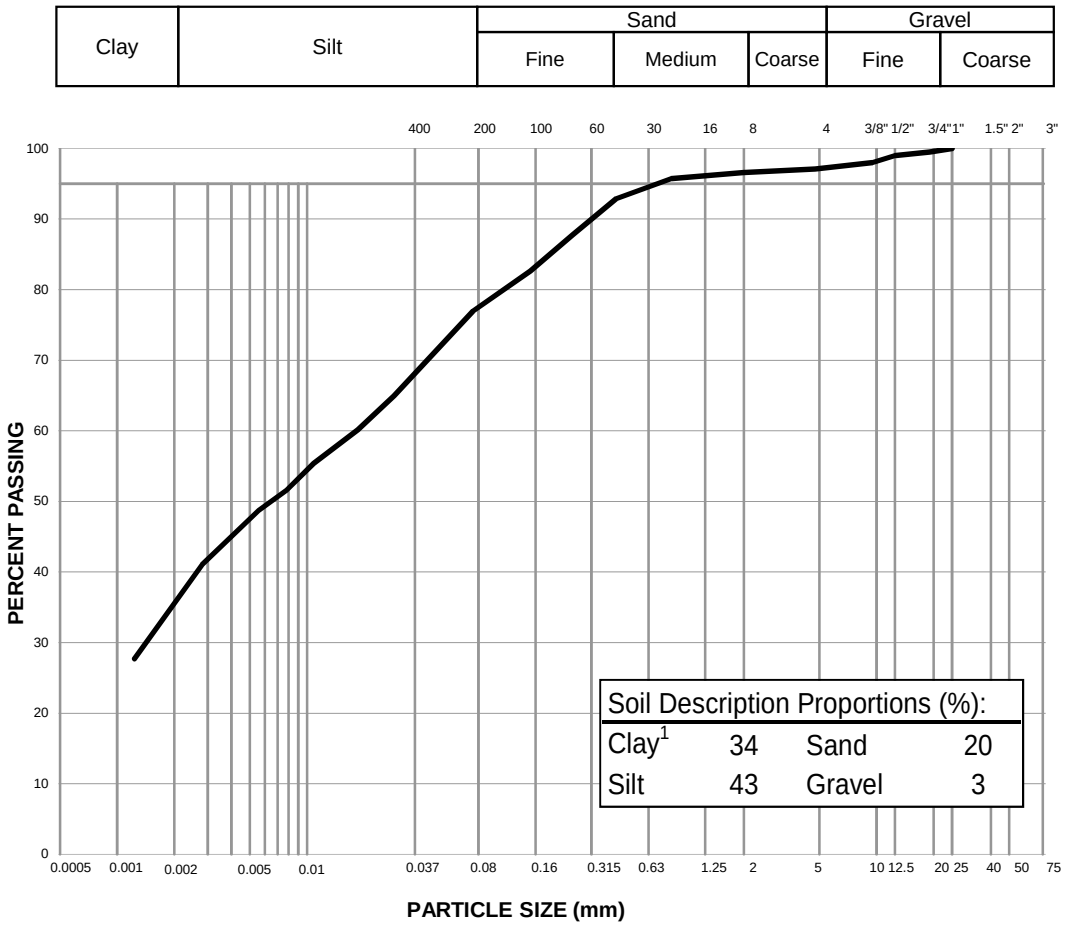
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29638
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-05
Client:	TMAC Resources Inc.	Sample Depth:	11.8-12.7 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 12, 2018 By: JPC	Date sampled:	February 26, 2018
Soil Description[2]:	CLAY, silty, some sand, trace gravel	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	40.4%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	100
19	99
12.5	99
9.5	98
4.75	97
2	97
0.83	96
0.425	93
0.25	88
0.15	83
0.075	77.0
0.0287	64.9
0.0185	60.2
0.0108	55.4
0.0078	51.6
0.0056	48.7
0.0028	41.1
0.0012	27.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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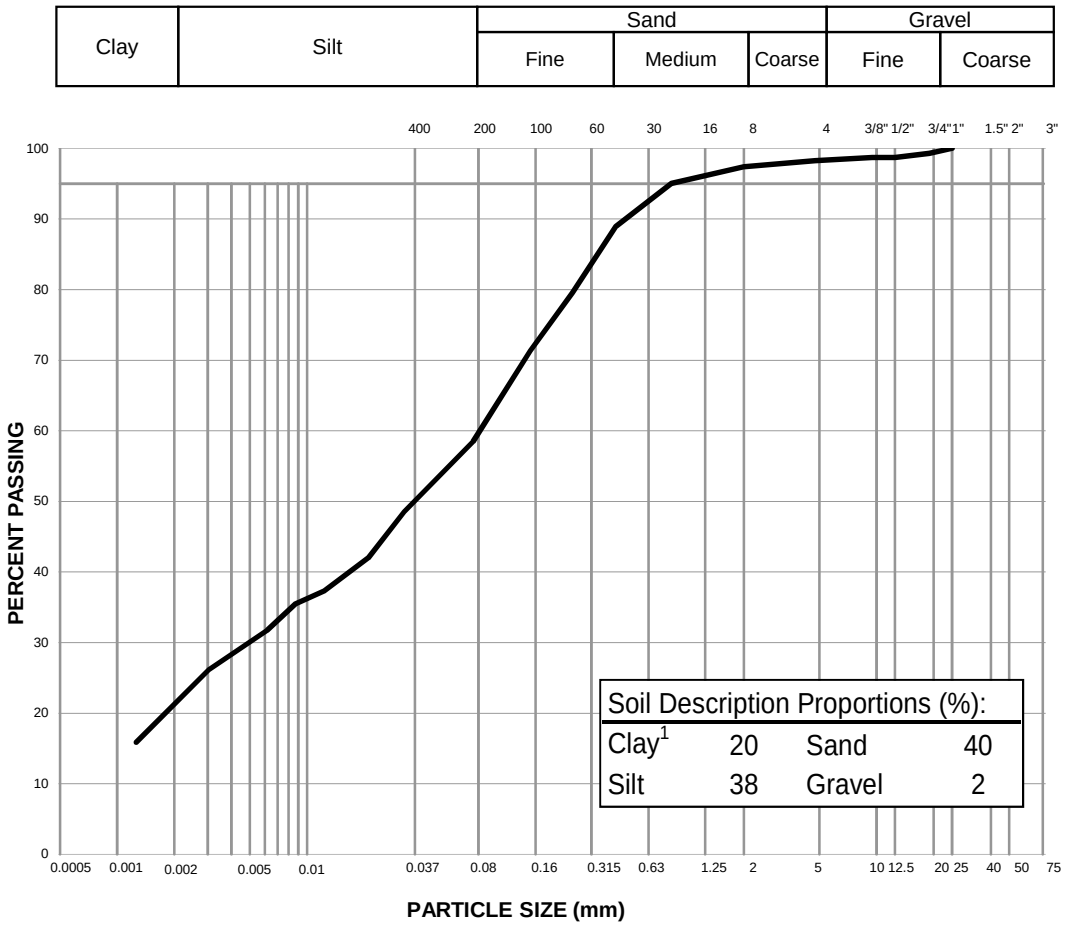
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29641
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-05
Client:	TMAC Resources Inc.	Sample Depth:	24.1-24.8 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	SAND, SILT, clayey, trace gravel.	Sampled By:	Client
		USC Classification:	SM Cu: #N/A
Moisture Content:	31.5%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	100
19	99
12.5	99
9.5	99
4.75	98
2	97
0.83	95
0.425	89
0.25	80
0.15	71
0.075	58.4
0.0325	48.5
0.0211	42.0
0.0124	37.3
0.0087	35.5
0.0062	31.7
0.0030	26.1
0.0013	15.9



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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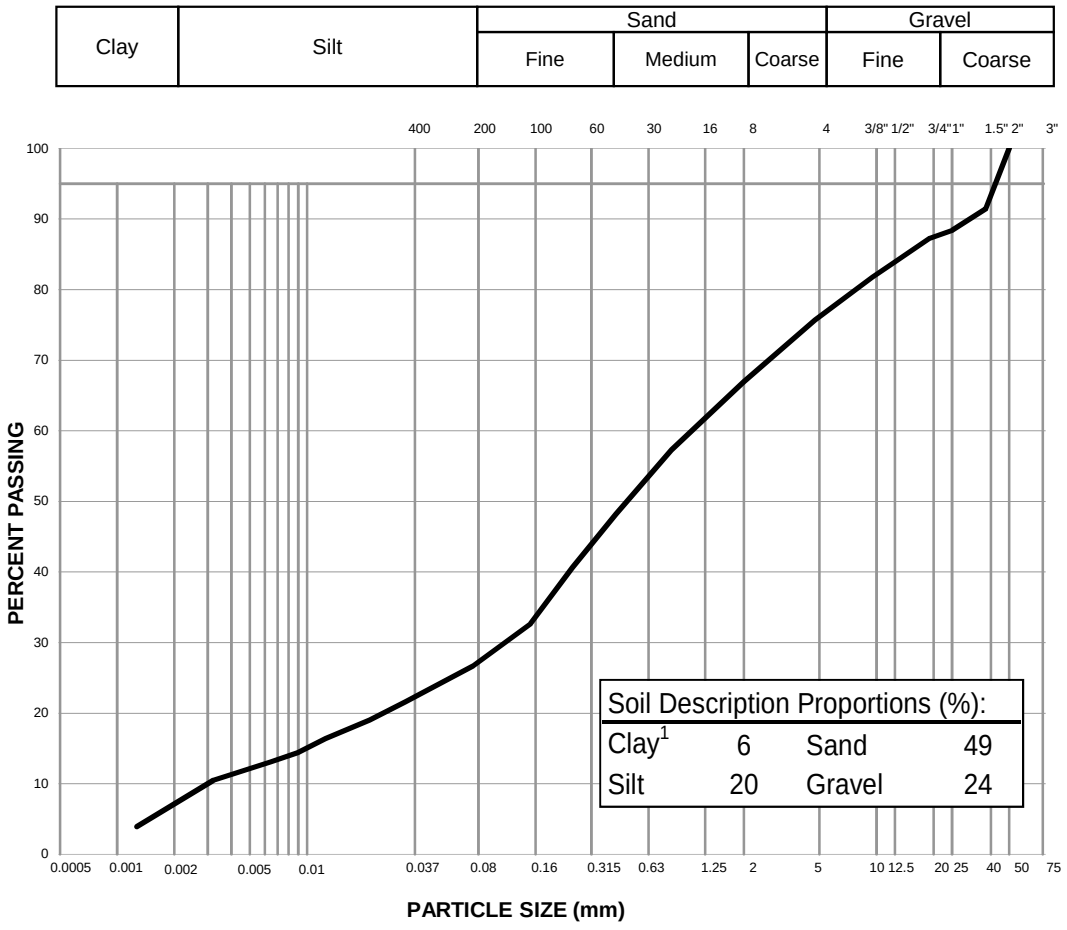
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29642
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-05
Client:	TMAC Resources Inc.	Sample Depth:	29.3-31.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 26, 2018
Soil Description[2]:	SAND, gravelly, some silt, trace clay	Sampled By:	Client
		USC Classification:	SM Cu: 377.5
Moisture Content:	7.1%		Cc: 3.8

Particle Size (mm)	Percent Passing
75	
50	100
37.5	91
25	88
19	87
12.5	84
9.5	82
4.75	76
2	67
0.83	57
0.425	48
0.25	41
0.15	33
0.075	26.7
0.0330	21.6
0.0214	19.0
0.0125	16.4
0.0089	14.4
0.0064	13.1
0.0032	10.5
0.0013	3.9



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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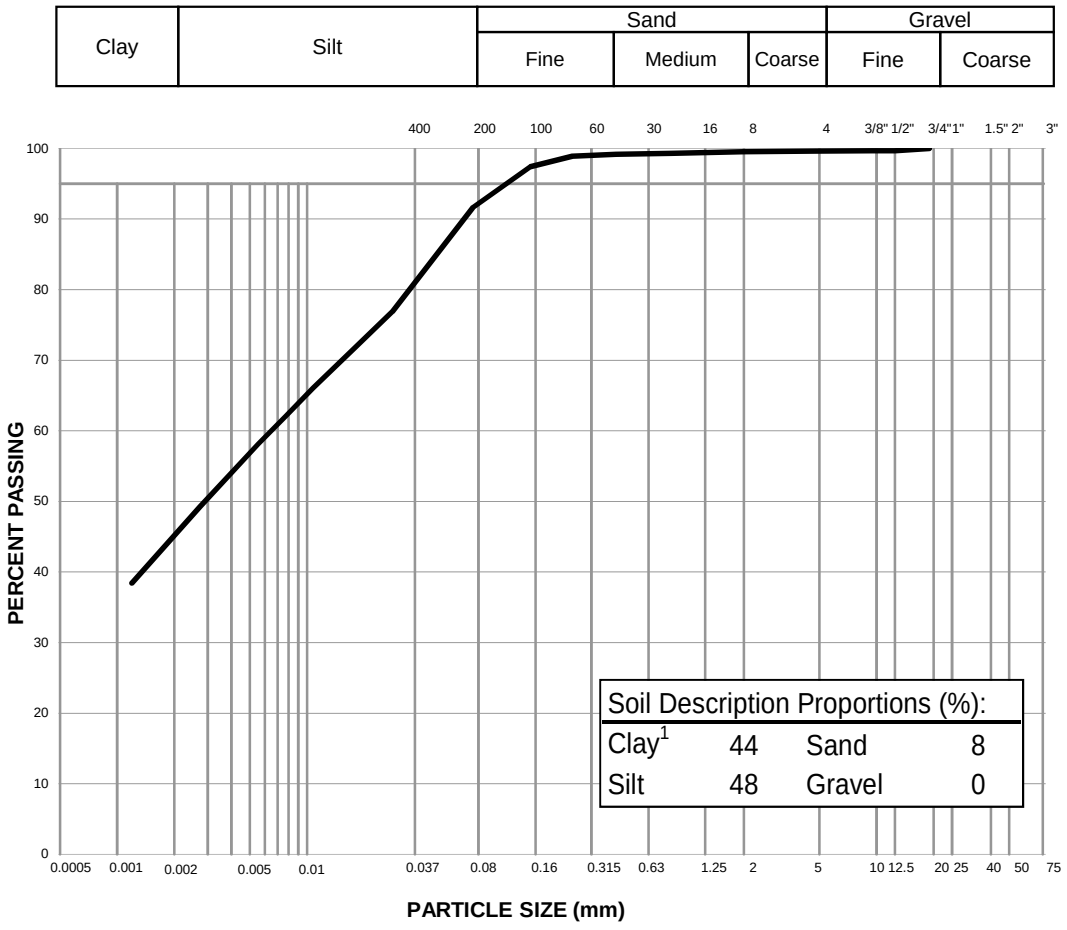
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29644
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-06
Client:	TMAC Resources Inc.	Sample Depth:	4.5-6.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 14, 2018 By: JPC	Date sampled:	February 26, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	38.4%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	100
9.5	100
4.75	100
2	100
0.83	99
0.425	99
0.25	99
0.15	97
0.075	91.7
0.0282	76.9
0.0182	71.9
0.0108	66.0
0.0077	62.1
0.0055	58.1
0.0027	49.3
0.0012	38.4



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

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Specification: _____

Remarks: _____

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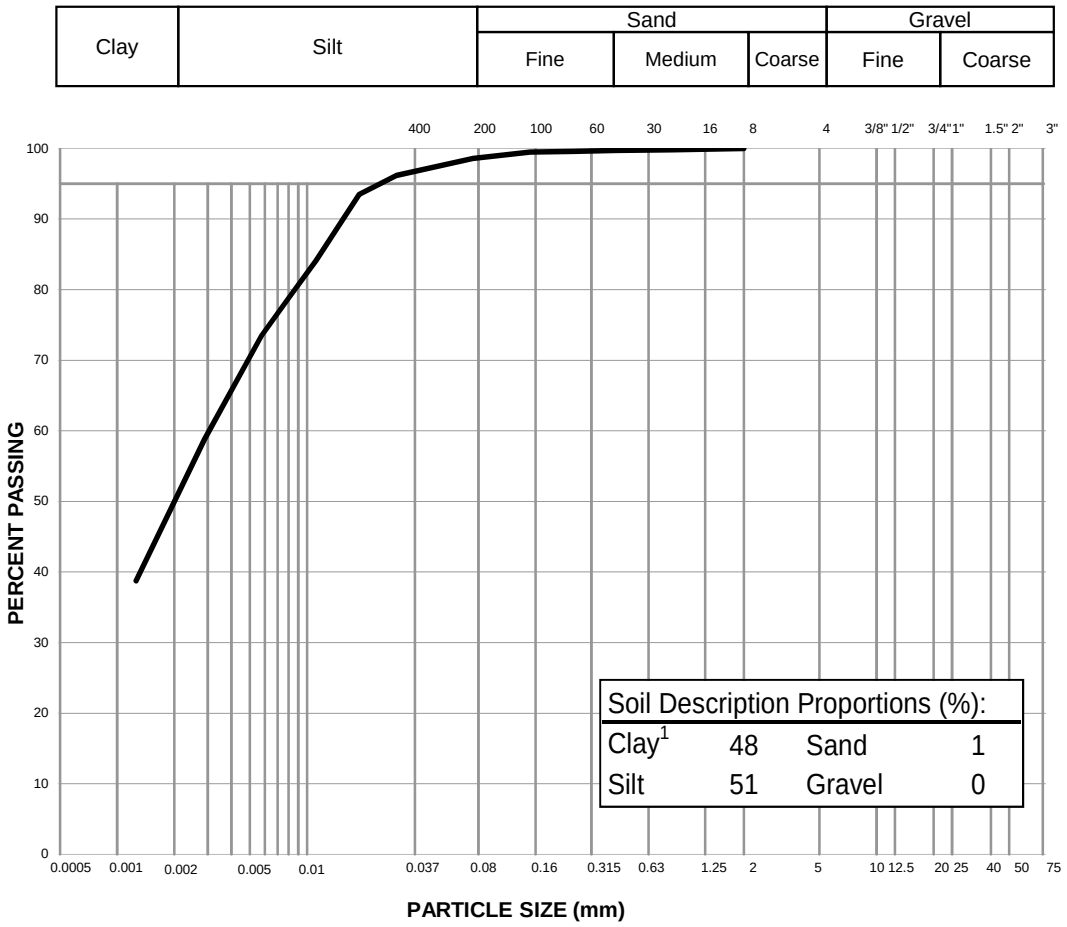
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29645
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-06
Client:	TMAC Resources Inc.	Sample Depth:	8.2-9.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 25, 2018 By: JPC	Date sampled:	February 26, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	CI Cu: #N/A
Moisture Content:	43.4%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	100
0.83	100
0.425	100
0.25	100
0.15	99
0.075	98.6
0.0296	96.2
0.0189	93.5
0.0112	84.1
0.0080	78.8
0.0058	73.5
0.0029	58.8
0.0013	38.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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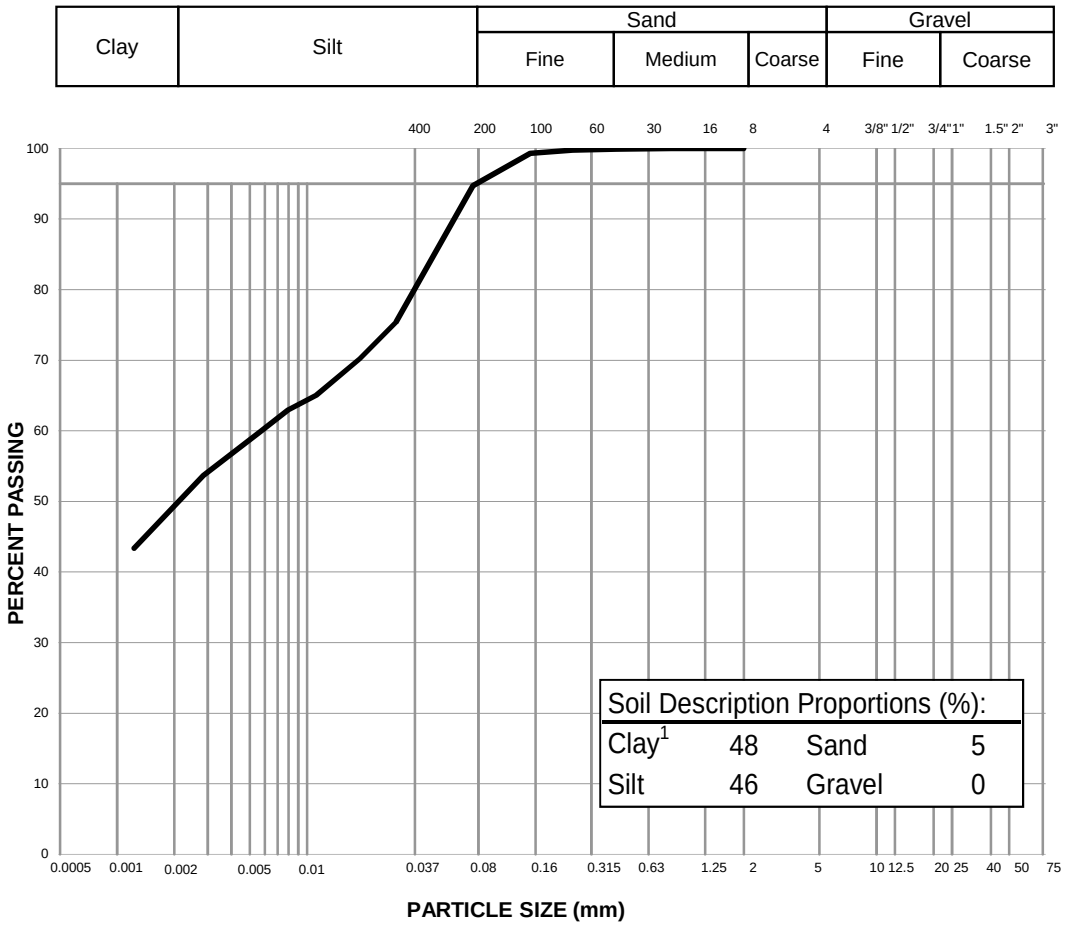
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29647
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-06
Client:	TMAC Resources Inc.	Sample Depth:	21.1-21.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 10, 2018 By: WM	Date sampled:	February 26, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	48.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	100
0.83	100
0.425	100
0.25	100
0.15	99
0.075	94.7
0.0294	75.4
0.0190	70.2
0.0112	65.0
0.0080	63.0
0.0057	59.9
0.0028	53.7
0.0012	43.4



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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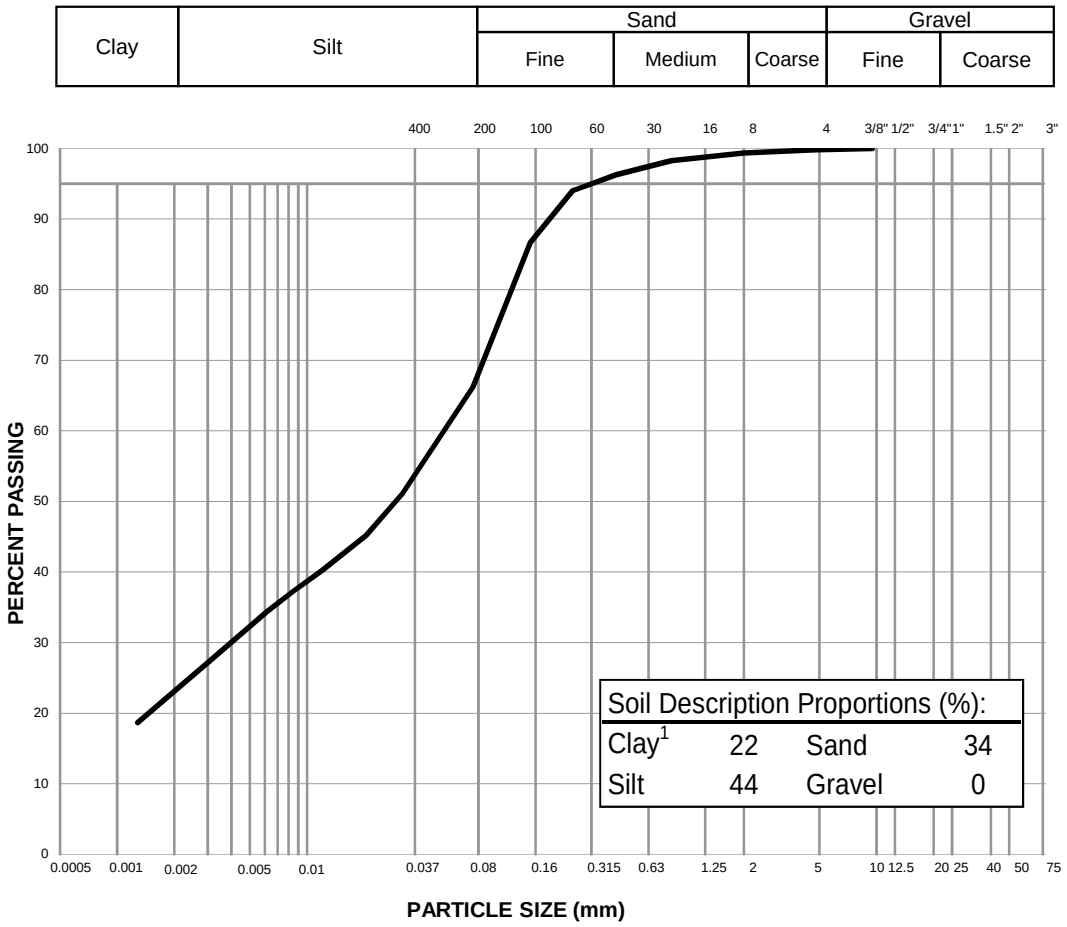
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29648
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-06
Client:	TMAC Resources Inc.	Sample Depth:	24.0-25.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, sandy	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	35.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	99
0.83	98
0.425	96
0.25	94
0.15	87
0.075	66.2
0.0318	51.1
0.0205	45.2
0.0121	40.3
0.0085	37.3
0.0061	34.4
0.0031	27.5
0.0013	18.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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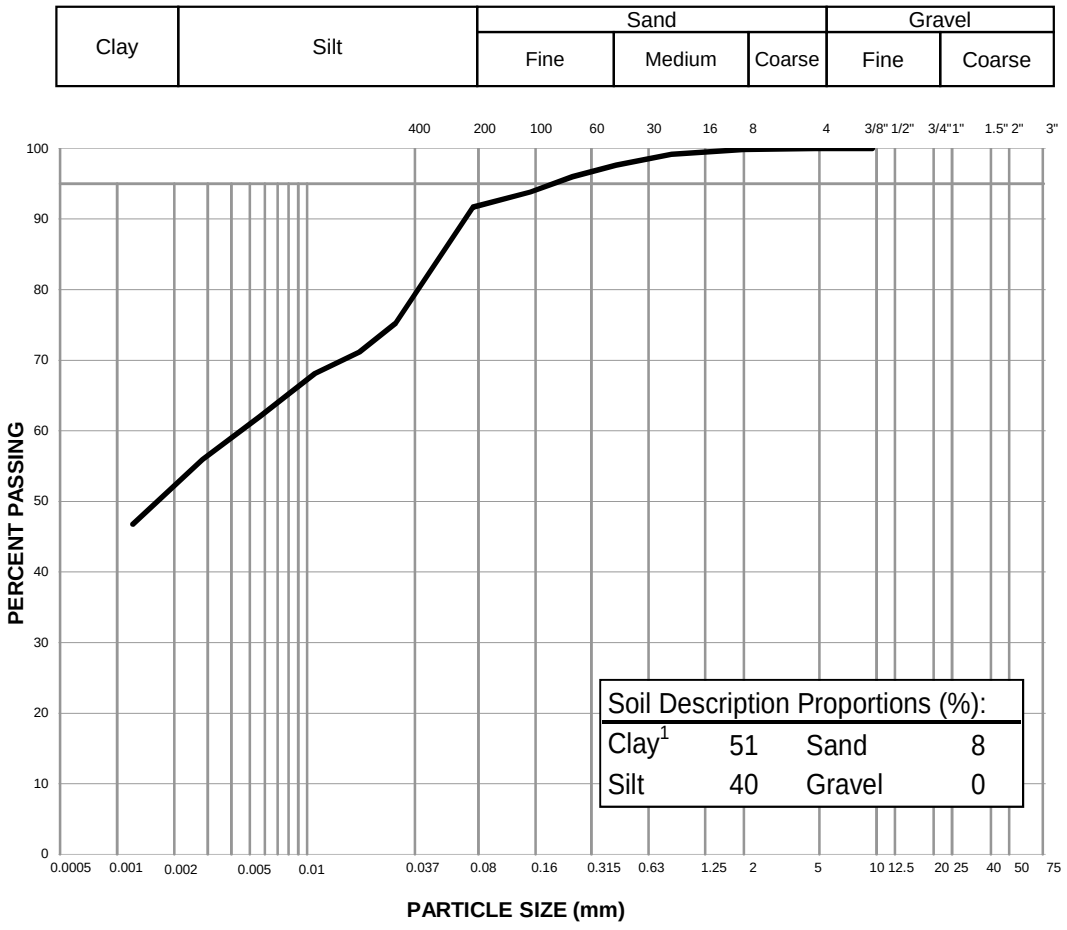
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29649
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-06
Client:	TMAC Resources Inc.	Sample Depth:	26.4-27.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 10, 2018 By: WM	Date sampled:	February 26, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	41.8%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	99
0.425	98
0.25	96
0.15	94
0.075	91.7
0.0293	75.2
0.0189	71.2
0.0110	68.1
0.0079	65.1
0.0056	62.0
0.0028	55.9
0.0012	46.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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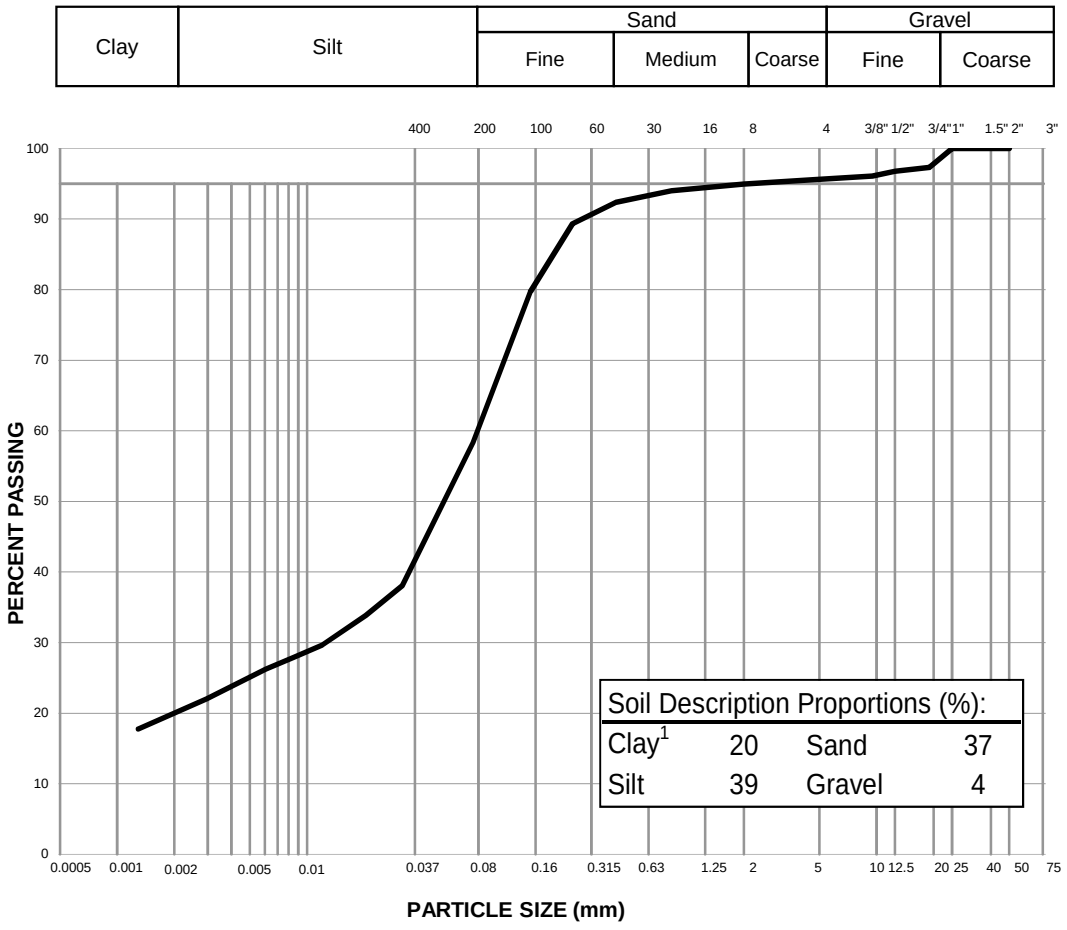
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205954
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-DH-DH-04
Client:	TMAC Resources Inc.	Sample Depth:	0.9-1.4 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 31, 2018 By: WM	Date sampled:	February 20, 2018
Soil Description[2]:	SILT and SAND, some clay, trace gravel	Sampled By:	Client
		USC Classification:	CL-ML Cu: #N/A
Moisture Content:	41.2%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	97
12.5	97
9.5	96
4.75	96
2	95
0.83	94
0.425	92
0.25	89
0.15	80
0.075	58.3
0.0318	38.1
0.0204	33.8
0.0120	29.6
0.0085	27.9
0.0061	26.2
0.0030	22.0
0.0013	17.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

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Remarks: _____

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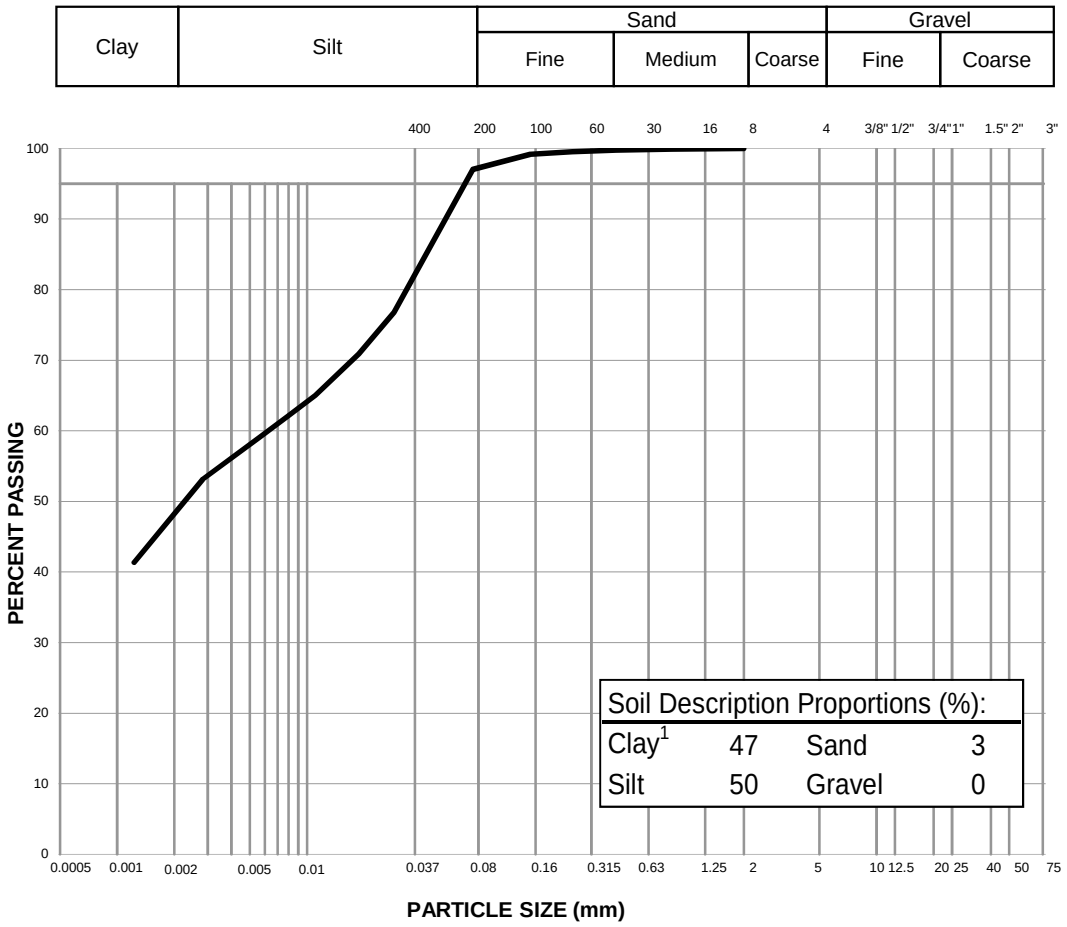
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205978
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-WST-DH-03
Client:	TMAC Resources Inc.	Sample Depth:	2.0-2.4 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 10, 2018 By: WM	Date sampled:	February 23, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	59.5%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	100
0.83	100
0.425	100
0.25	100
0.15	99
0.075	97.0
0.0289	76.8
0.0187	70.9
0.0111	65.0
0.0079	62.0
0.0057	59.1
0.0028	53.2
0.0012	41.4



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

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Remarks: _____

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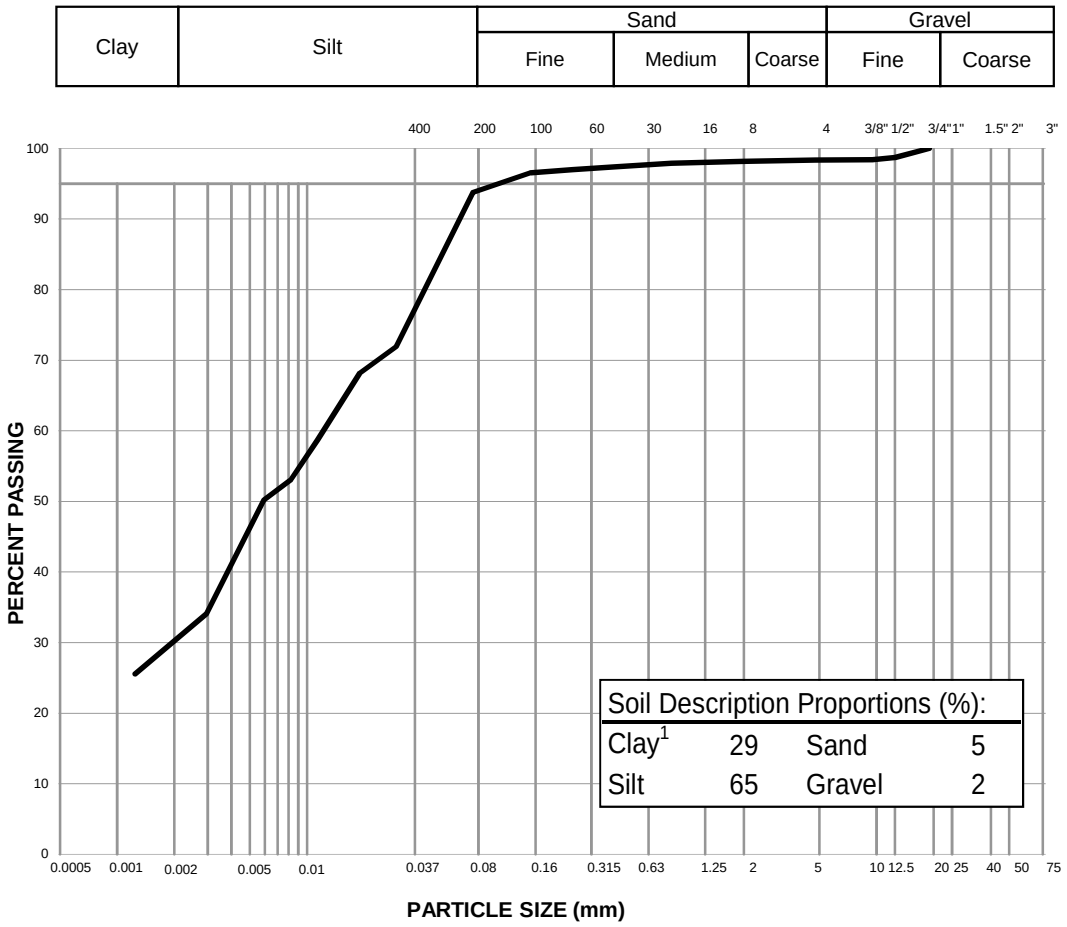
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-205979
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-WST-DH-03
Client:	TMAC Resources Inc.	Sample Depth:	3.1-3.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 23, 2018
Soil Description[2]:	CLAY, silty, trace sand, trace gravel	Sampled By:	Client
		USC Classification:	OL Cu: #N/A
Moisture Content:	56.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	99
9.5	98
4.75	98
2	98
0.83	98
0.425	97
0.25	97
0.15	97
0.075	93.8
0.0295	71.9
0.0189	68.2
0.0113	58.7
0.0082	53.0
0.0059	50.2
0.0030	34.1
0.0012	25.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

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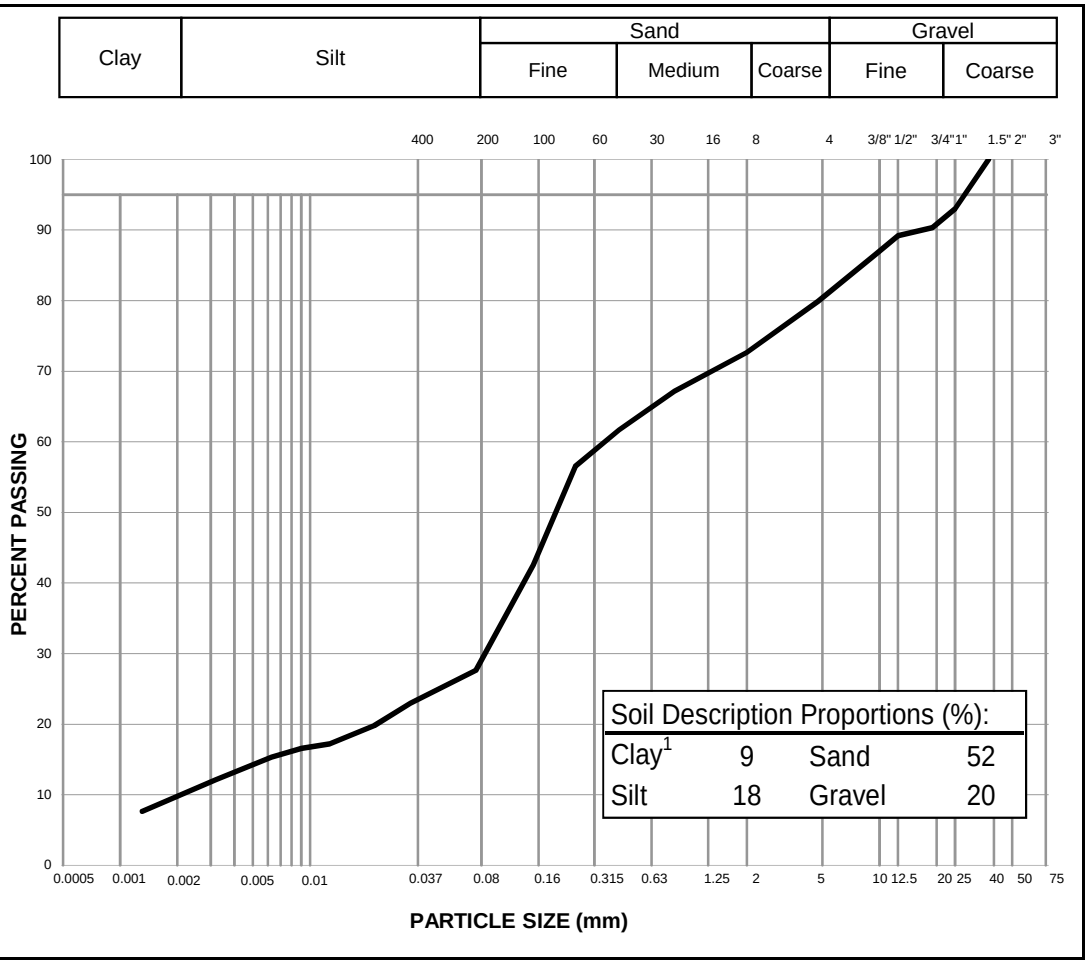
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205980
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-WST-DH-03
Client:	TMAC Resources Inc.	Sample Depth:	4.6-5.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 23, 2018
Soil Description[2]:	SAND, some gravel, some silt, trace clay.	Sampled By:	Client
		USC Classification:	SM Cu: 160.5
Moisture Content:	16.7%		Cc: 9.0

Particle Size (mm)	Percent Passing
75	
50	
37.5	100
25	93
19	90
12.5	89
9.5	87
4.75	80
2	73
0.83	67
0.425	62
0.25	57
0.15	43
0.075	27.6
0.0338	23.0
0.0218	19.8
0.0127	17.2
0.0090	16.6
0.0063	15.3
0.0032	12.1
0.0013	7.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

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Remarks: _____

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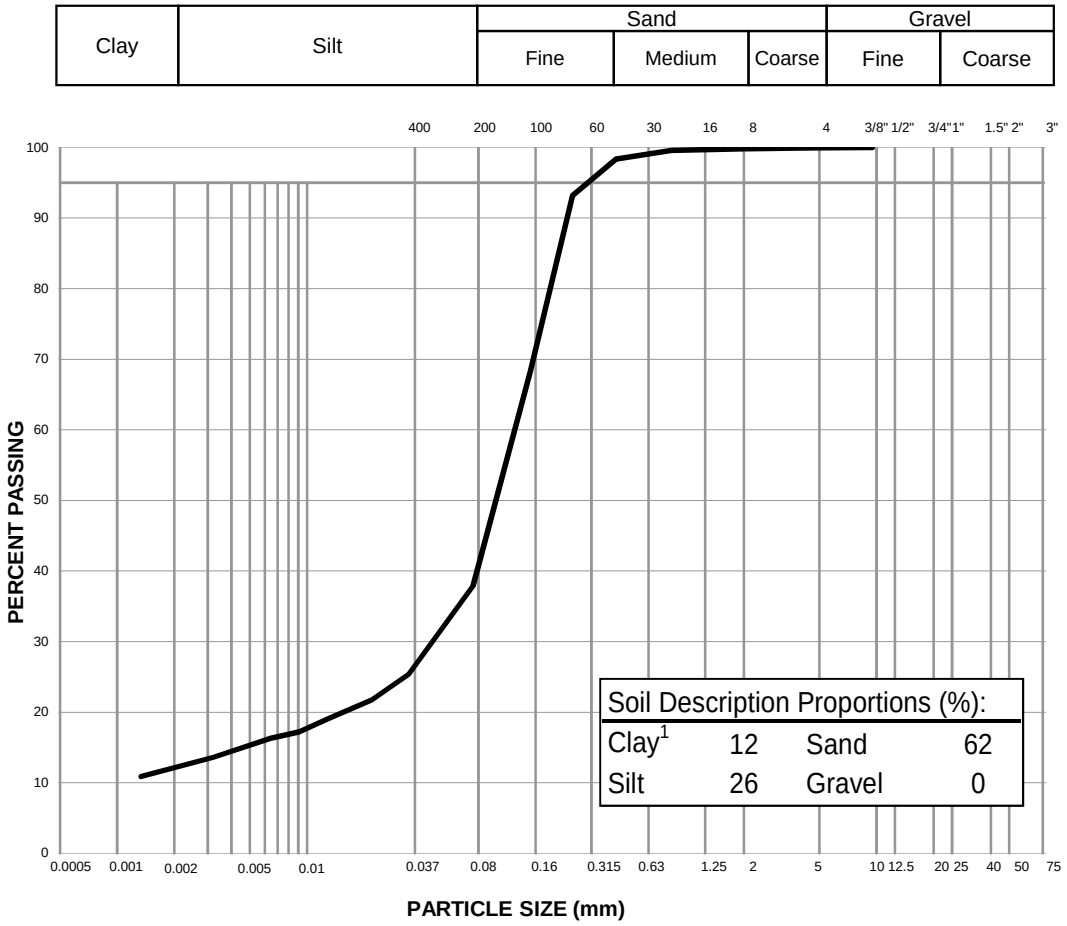
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205982
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-WST-DH-02
Client:	TMAC Resources Inc.	Sample Depth:	0.8-1.1 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 10, 2018 By: WM	Date sampled:	February 23, 2018
Soil Description[2]:	SAND, silty, some clay	Sampled By:	Client
		USC Classification:	SM Cu: #N/A
Moisture Content:	60.8%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	98
0.25	93
0.15	68
0.075	37.9
0.0343	25.4
0.0219	21.8
0.0128	19.0
0.0091	17.2
0.0064	16.3
0.0032	13.6
0.0013	10.9



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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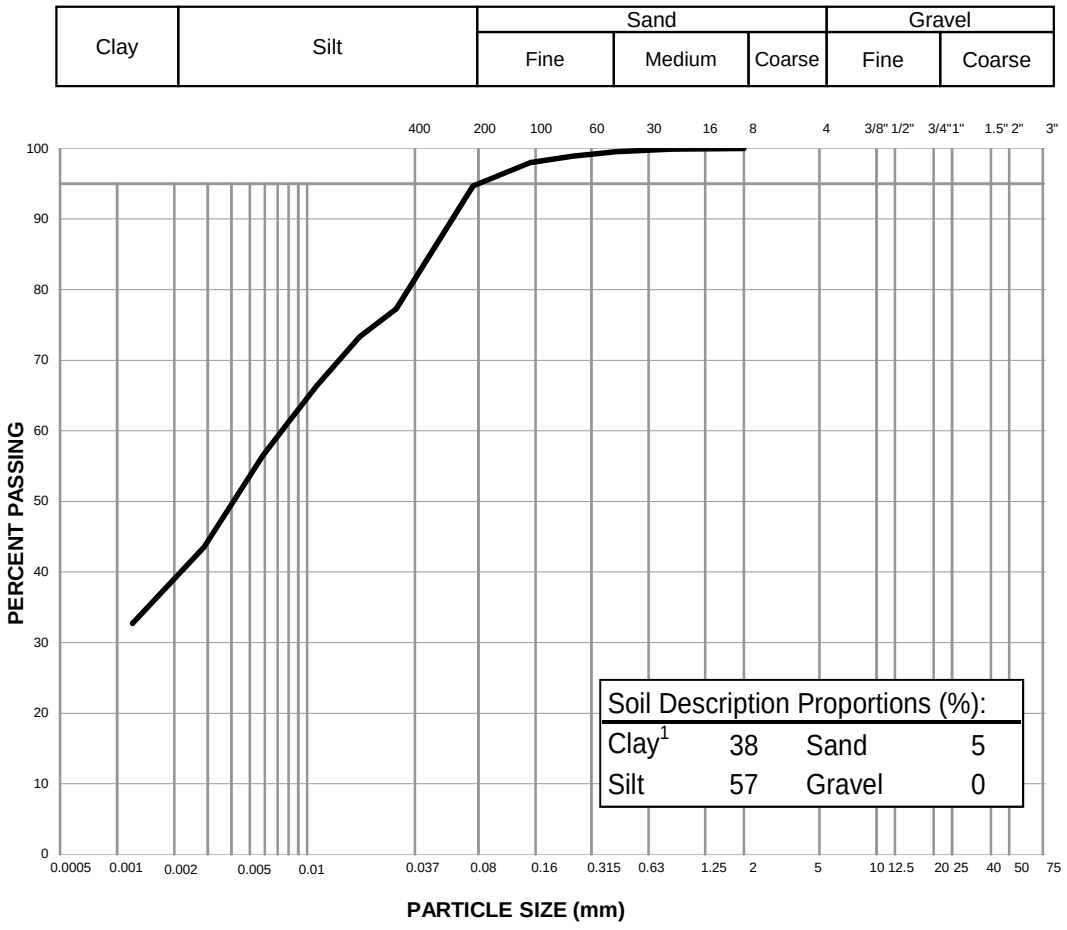
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205984
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-16
Client:	TMAC Resources Inc.	Sample Depth:	14.2-14.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	36.5%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	100
0.83	100
0.425	100
0.25	99
0.15	98
0.075	94.7
0.0295	77.3
0.0190	73.3
0.0113	66.4
0.0081	61.4
0.0058	56.5
0.0029	43.6
0.0012	32.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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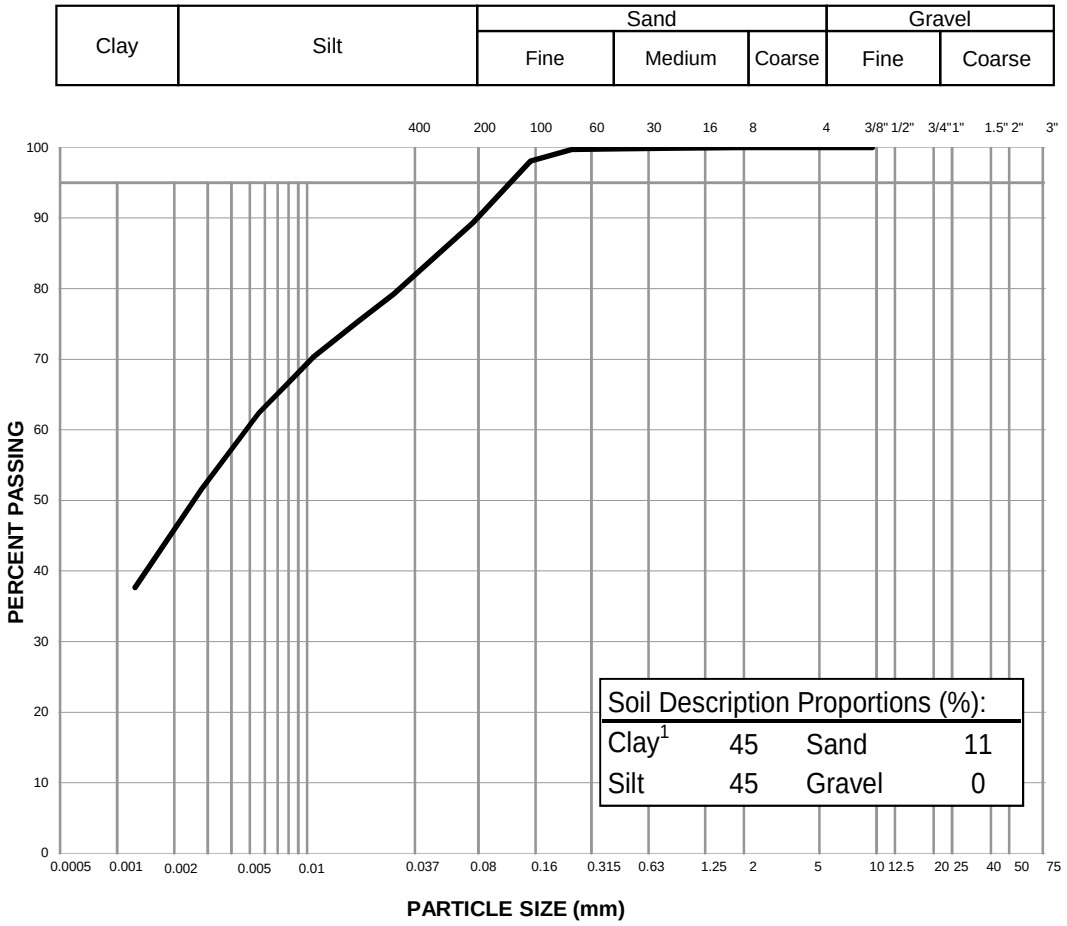
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205985
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-16
Client:	TMAC Resources Inc.	Sample Depth:	14.7-15.1 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 5, 2018 By: JPC/SS	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	45.9%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	100
0.25	100
0.15	98
0.075	89.4
0.0286	79.2
0.0184	75.3
0.0109	70.3
0.0078	66.4
0.0056	62.4
0.0028	51.5
0.0012	37.6



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Remarks: _____

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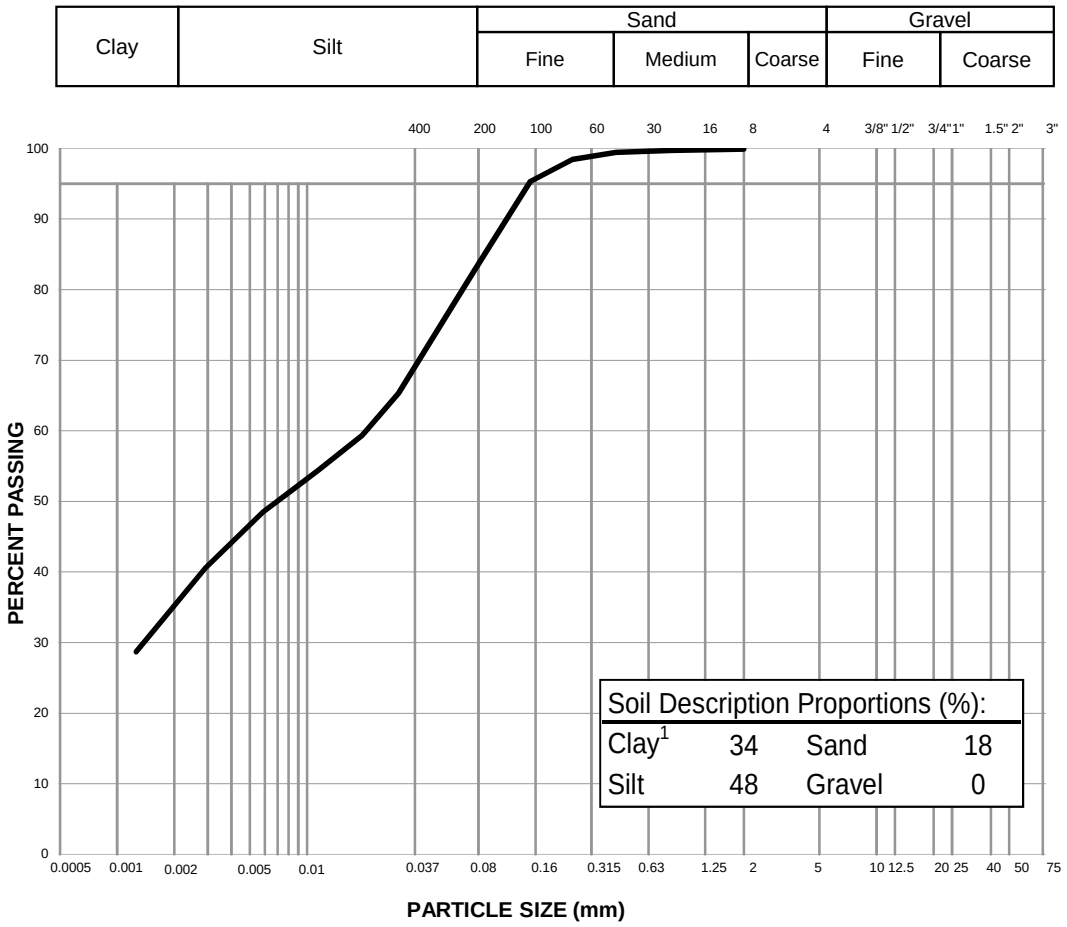
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205986
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-16
Client:	TMAC Resources Inc.	Sample Depth:	21.3-21.7 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 25, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	CL-CI Cu: #N/A
Moisture Content:	34.1%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	100
0.83	100
0.425	99
0.25	98
0.15	95
0.075	82.4
0.0303	65.3
0.0196	59.4
0.0115	54.4
0.0082	51.4
0.0059	48.5
0.0029	40.6
0.0013	28.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

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Remarks: _____

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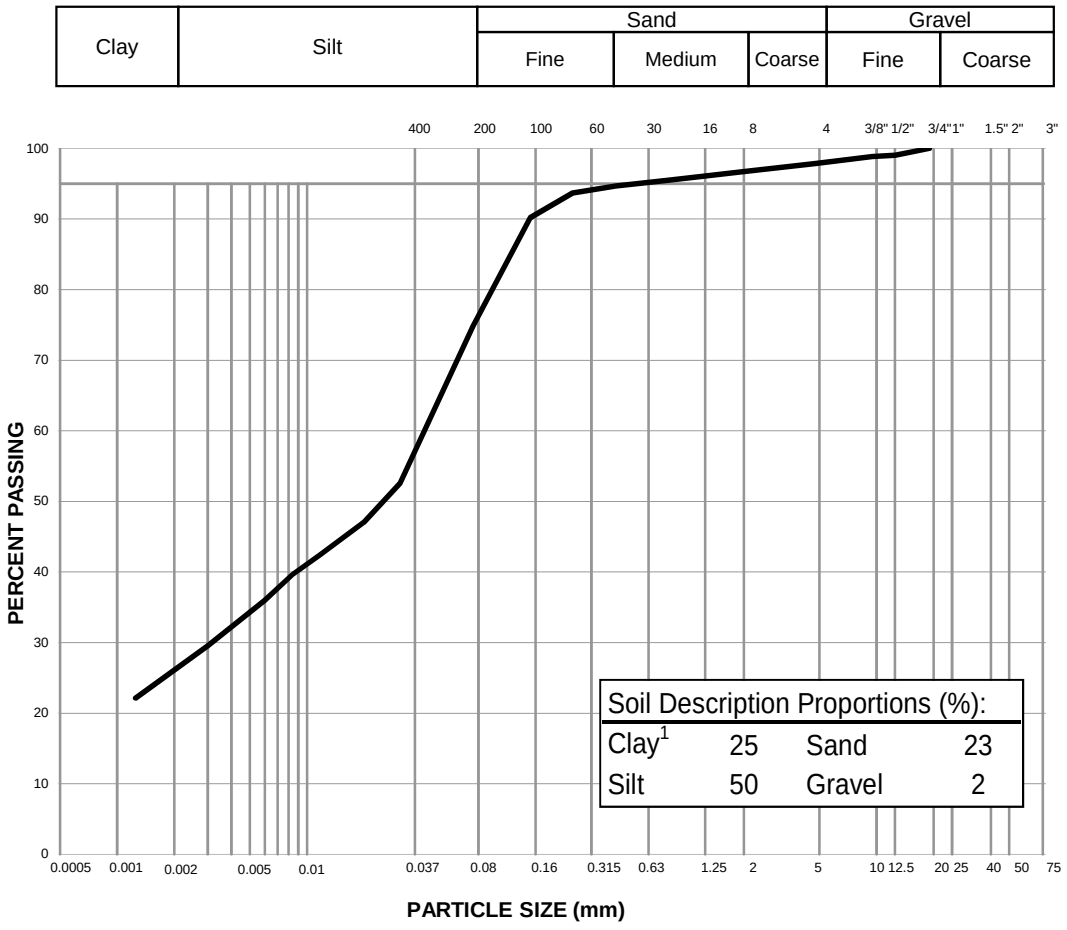
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205987
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-16
Client:	TMAC Resources Inc.	Sample Depth:	23.2-23.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 2, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, sandy, trace gravel	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	34.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	99
9.5	99
4.75	98
2	97
0.83	96
0.425	95
0.25	94
0.15	90
0.075	74.8
0.0309	52.6
0.0199	47.1
0.0117	42.4
0.0084	39.7
0.0060	36.0
0.0030	29.5
0.0012	22.1



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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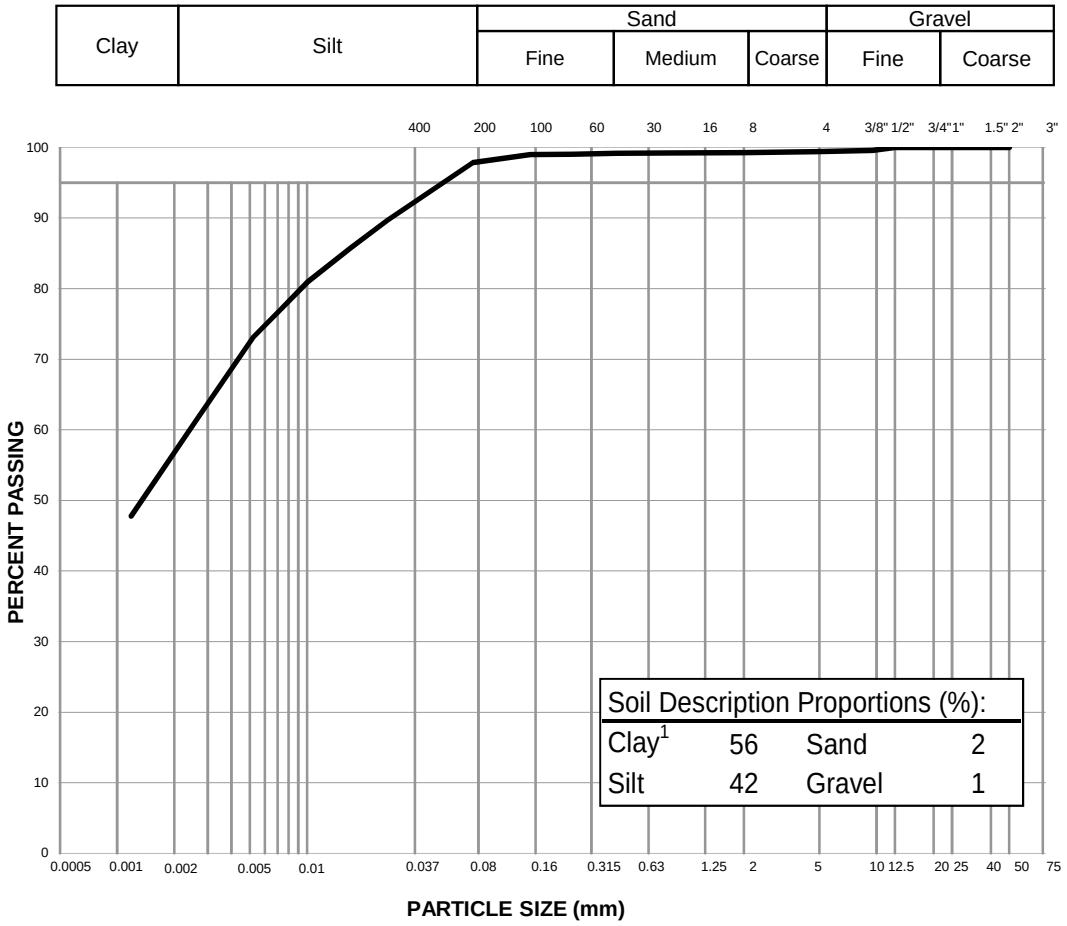
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205988
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-15
Client:	TMAC Resources Inc.	Sample Depth:	2.3-6.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 22, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, trace sand, trace gravel	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	41.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	100
12.5	100
9.5	100
4.75	99
2	99
0.83	99
0.425	99
0.25	99
0.15	99
0.075	97.9
0.0266	89.7
0.0171	85.8
0.0101	80.9
0.0072	77.0
0.0052	73.1
0.0026	61.4
0.0012	47.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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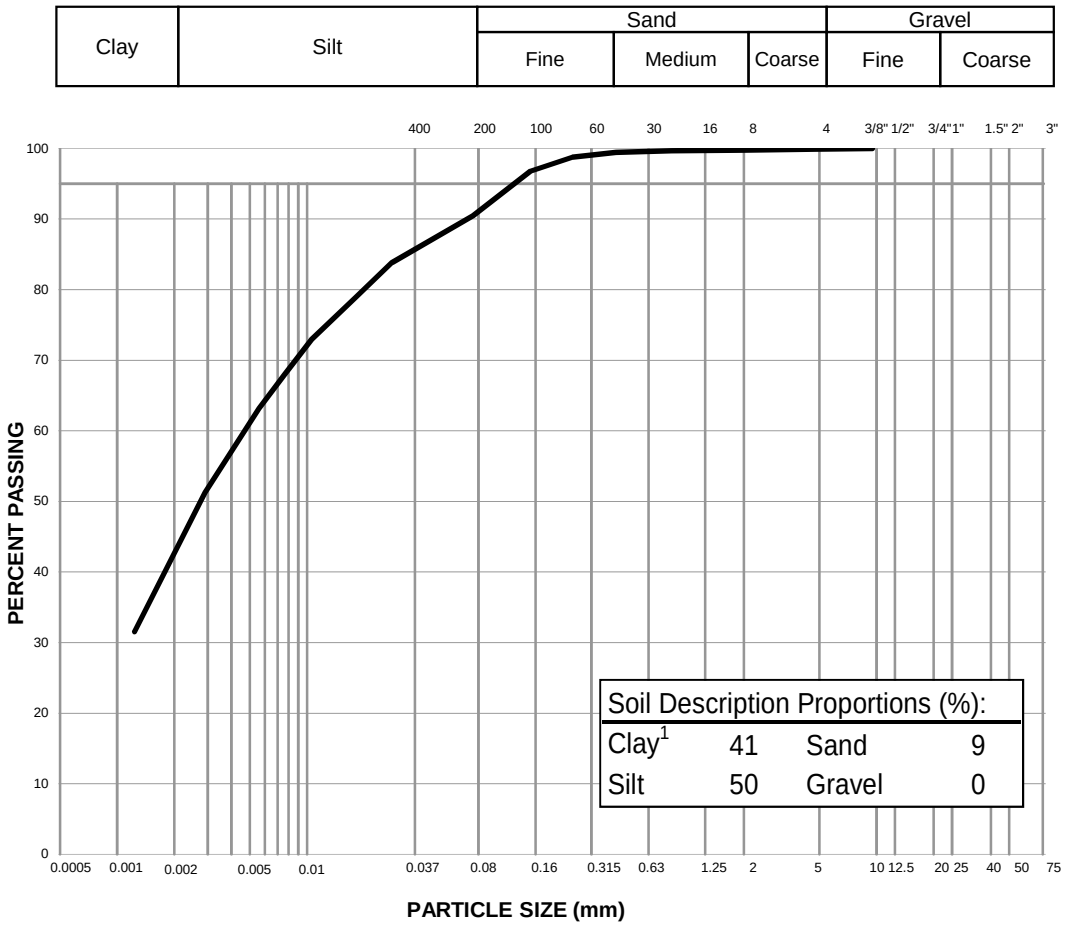
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205990
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-15
Client:	TMAC Resources Inc.	Sample Depth:	11.3-14.3 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	47.4%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	99
0.25	99
0.15	97
0.075	90.5
0.0280	83.8
0.0181	78.9
0.0106	73.0
0.0076	68.0
0.0056	63.1
0.0029	51.3
0.0012	31.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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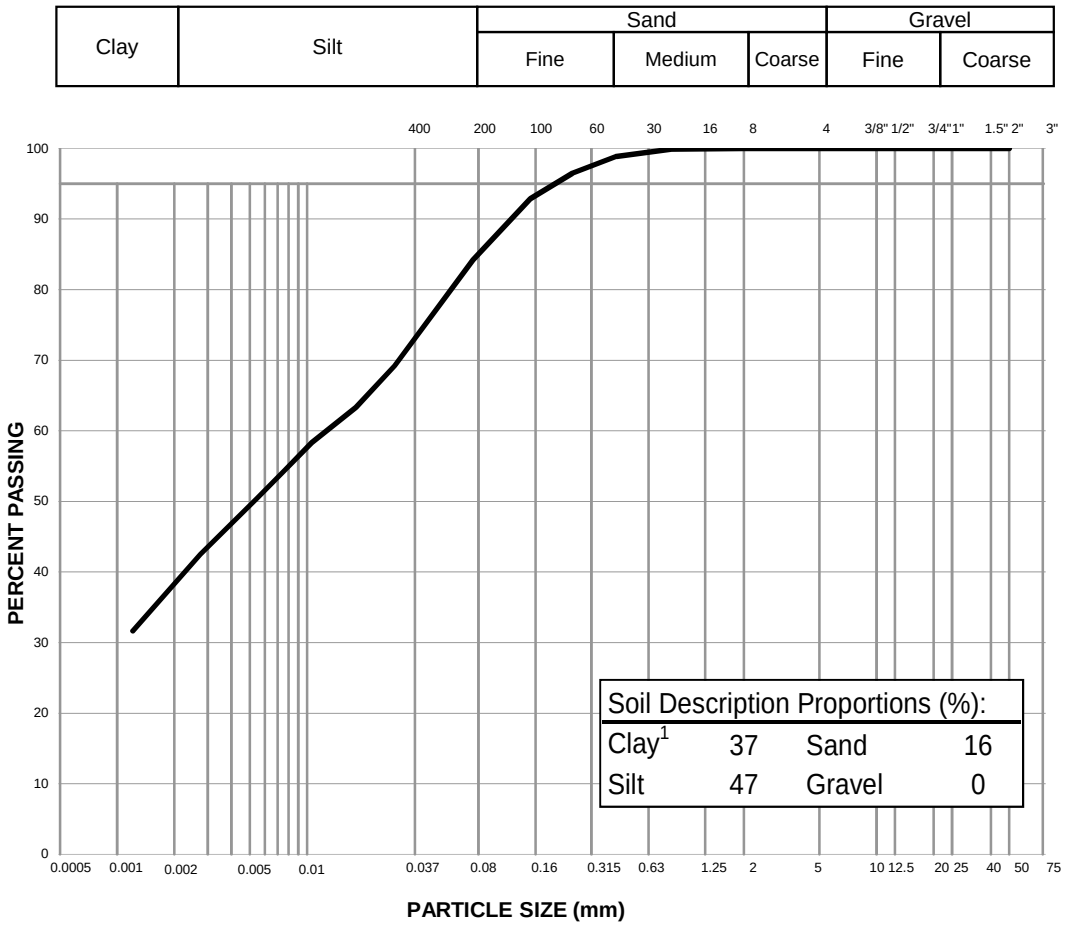
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205991
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-15
Client:	TMAC Resources Inc.	Sample Depth:	14.3-18.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 20, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	Cu: #N/A
Moisture Content:	48.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	100
12.5	100
9.5	100
4.75	100
2	100
0.83	100
0.425	99
0.25	96
0.15	93
0.075	84.2
0.0289	69.2
0.0181	63.3
0.0106	58.4
0.0076	54.4
0.0054	50.4
0.0027	42.5
0.0012	31.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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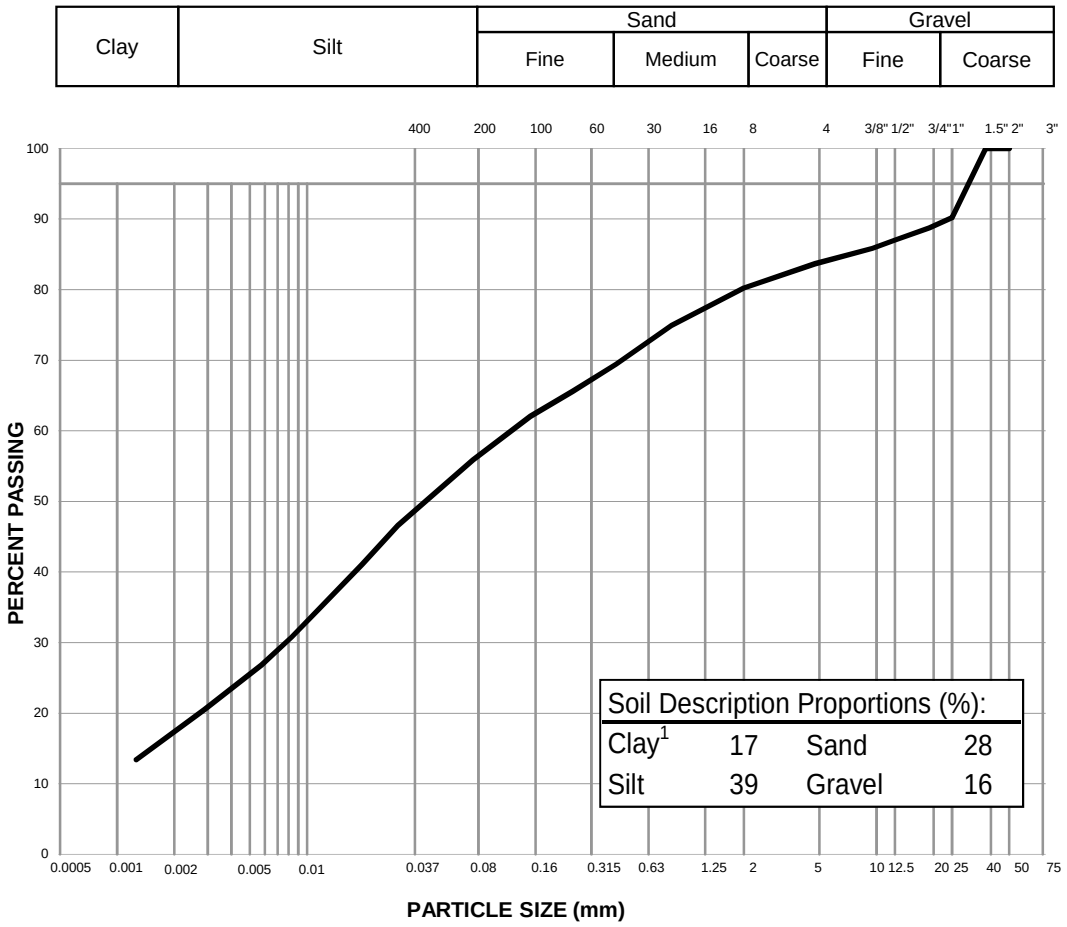
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205992
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-15
Client:	TMAC Resources Inc.	Sample Depth:	21.2-24.8 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 20, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	SILT, sandy, some clay, some gravel	Sampled By:	Client
		USC Classification:	ML Cu: #N/A
Moisture Content:	23.0%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	90
19	89
12.5	87
9.5	86
4.75	84
2	80
0.83	75
0.425	69
0.25	66
0.15	62
0.075	55.9
0.0300	46.6
0.0194	41.0
0.0115	34.7
0.0083	30.8
0.0057	26.8
0.0029	20.5
0.0013	13.4



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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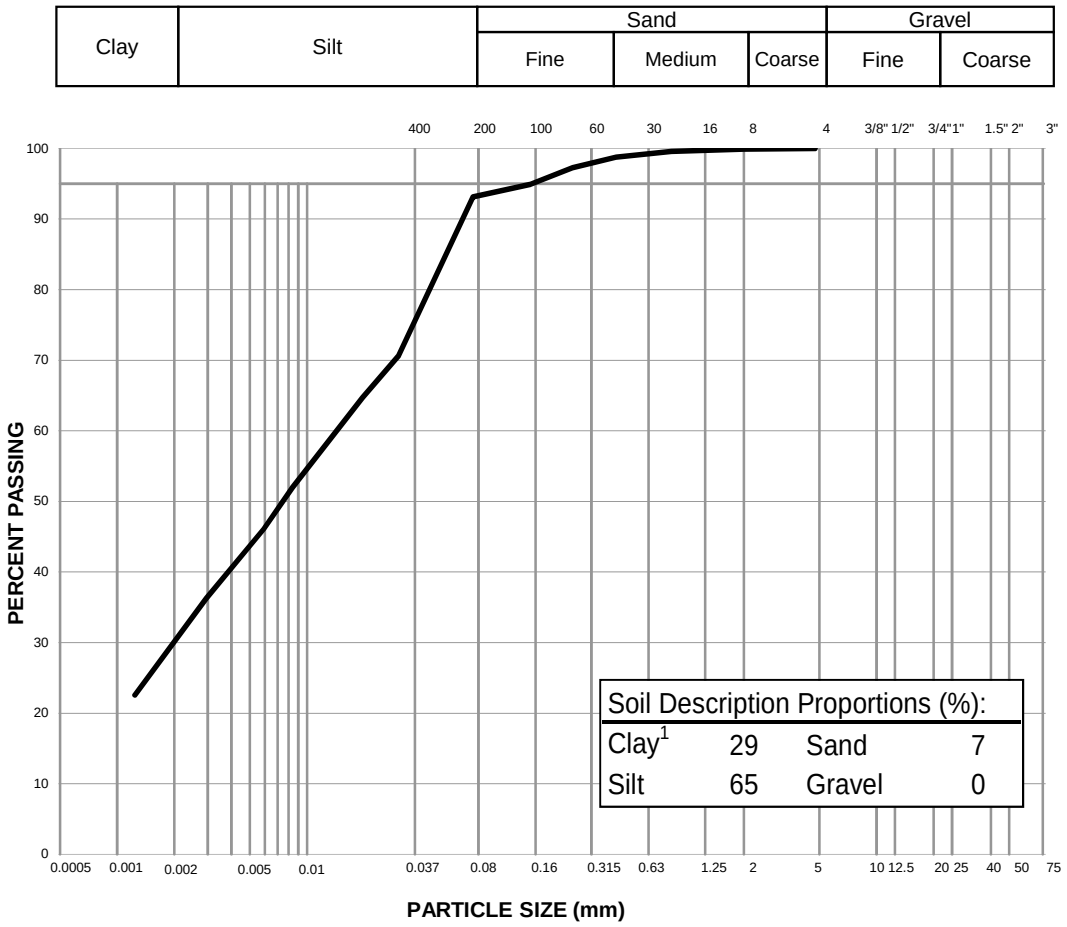
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205994
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-WST-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	0.1-0.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	SILT, clayey, trace sand, rootlets	Sampled By:	Client
		USC Classification:	MH Cu: #N/A
Moisture Content:	38.1%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	100
2	100
0.83	100
0.425	99
0.25	97
0.15	95
0.075	93.2
0.0303	70.6
0.0196	64.7
0.0116	56.9
0.0084	52.0
0.0059	46.1
0.0030	36.3
0.0012	22.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

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Remarks: _____

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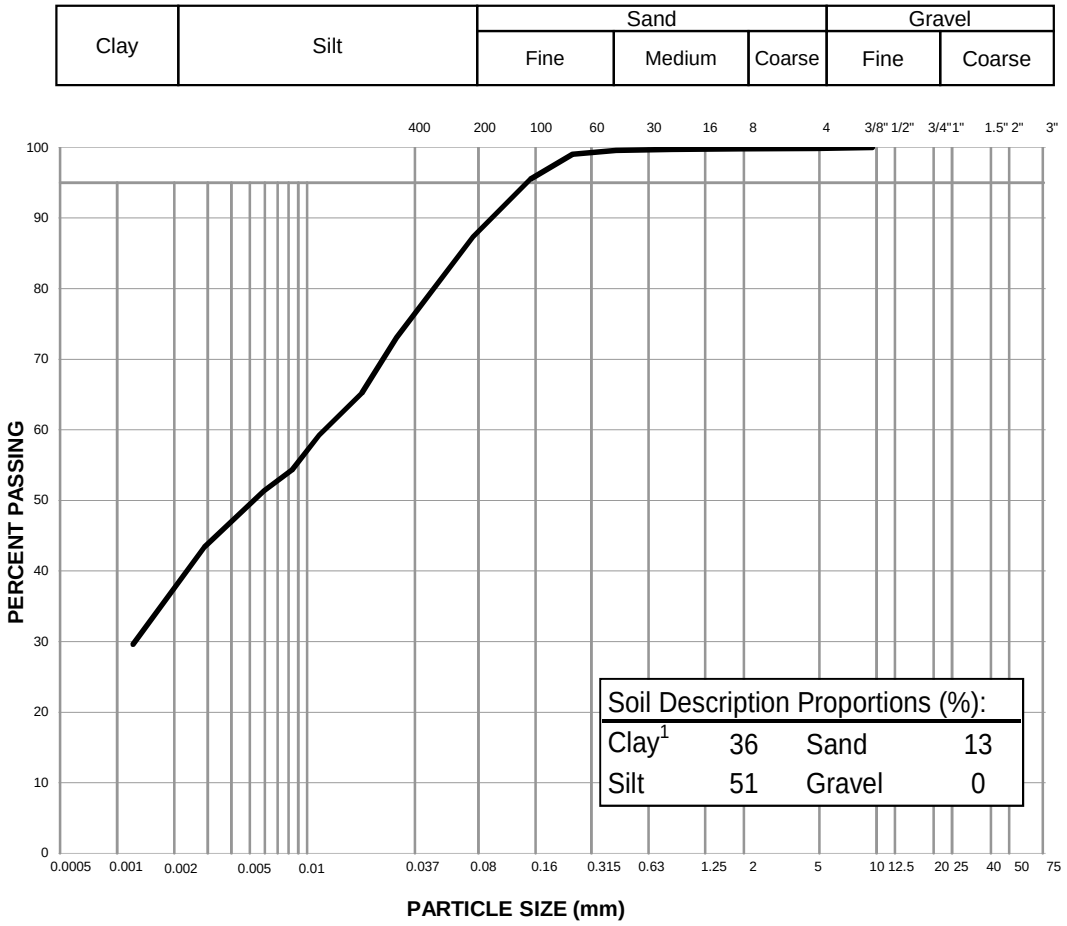
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205997
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-WST-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	2.2-4.3 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	47.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	100
0.25	99
0.15	95
0.075	87.3
0.0296	73.1
0.0194	65.2
0.0116	59.2
0.0083	54.3
0.0059	51.3
0.0029	43.4
0.0012	29.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

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Remarks: _____

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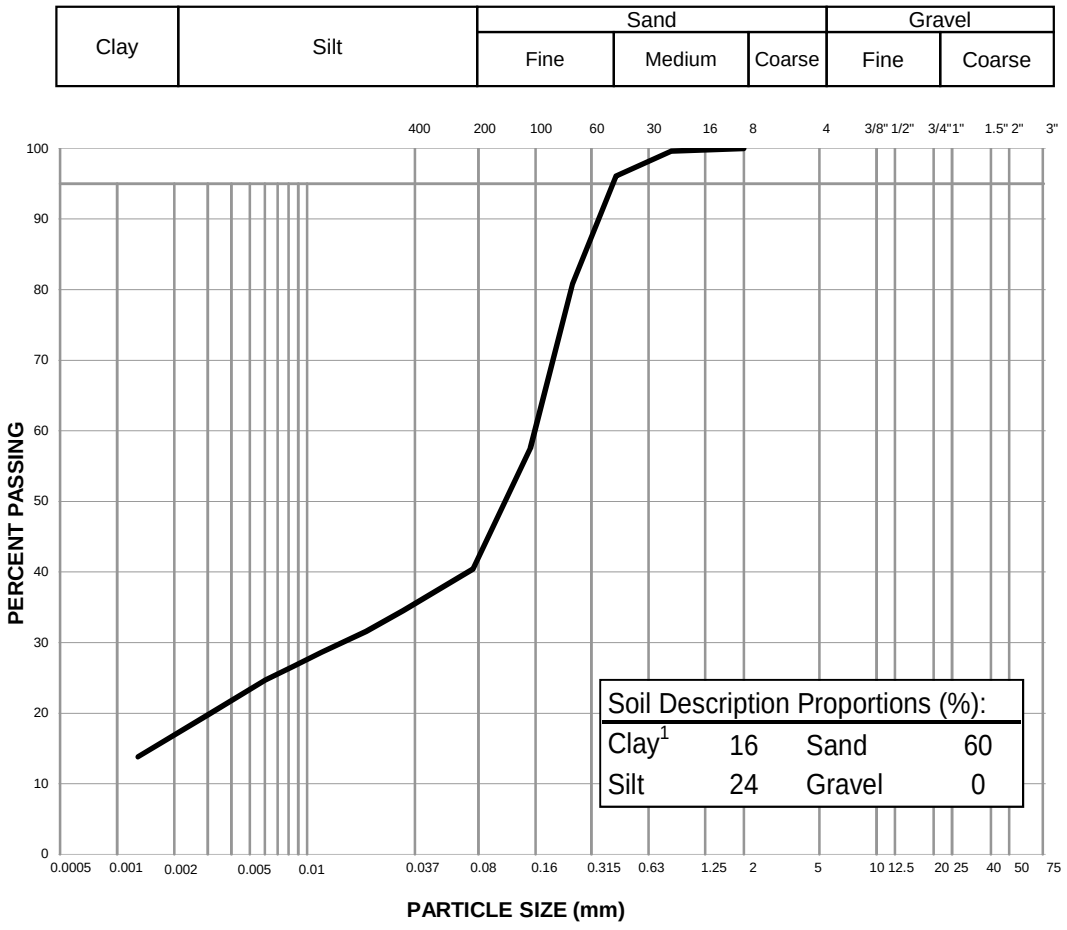
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205999
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-WST-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	6.7-7.1 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 12, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	SAND, silty, some clay	Sampled By:	Client
		USC Classification:	SM Cu: #N/A
Moisture Content:	25.1%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	100
0.83	100
0.425	96
0.25	81
0.15	58
0.075	40.4
0.0321	34.6
0.0205	31.6
0.0119	28.6
0.0085	26.7
0.0060	24.7
0.0030	19.7
0.0013	13.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

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Remarks: _____

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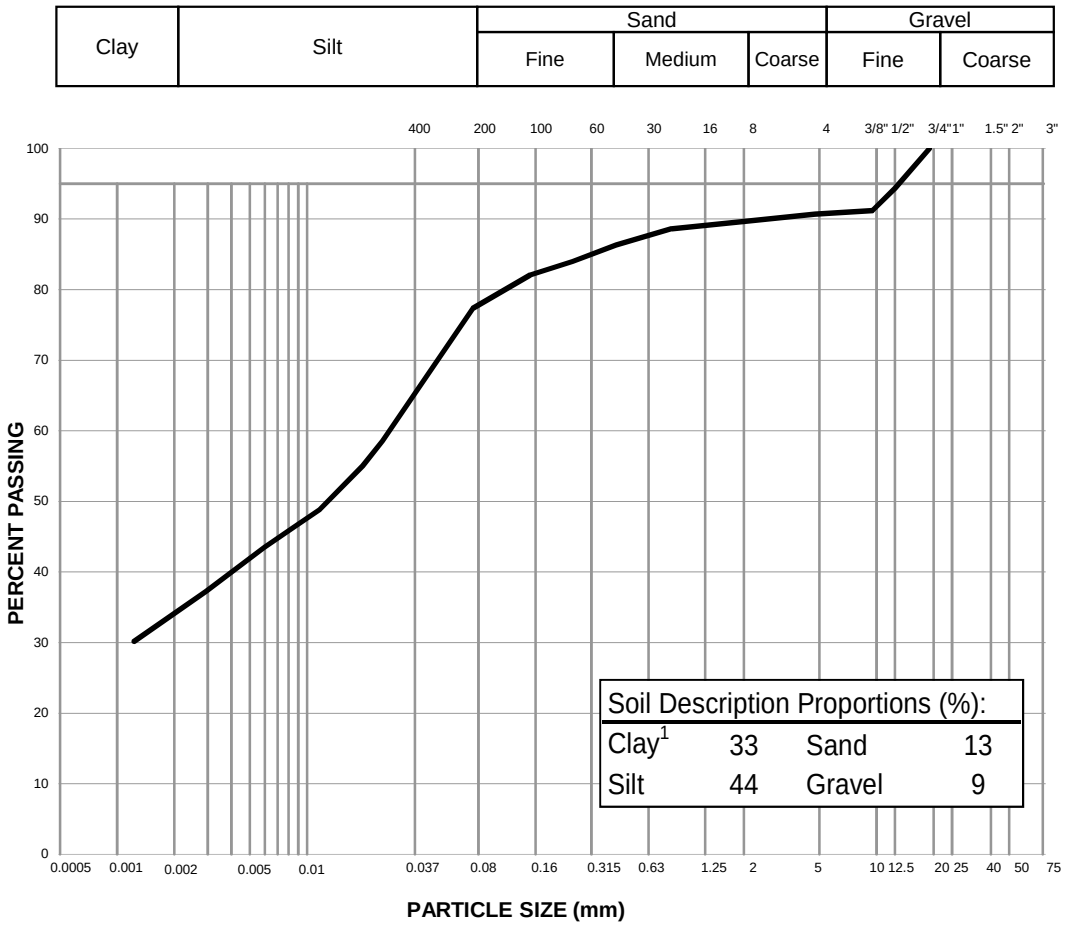
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6875-29443
Project No.:	Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	V-GTC-05
Client:	TMAC Resources Inc.	Sample Depth:	4.0 - 6.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Not Reported
Date Tested:	December 3, 2018 By: SS	Date sampled:	July 13, 2018
Soil Description[2]:	CLAY, silty, some sand, trace gravel.	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	35.0%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	94
9.5	91
4.75	91
2	90
0.83	89
0.425	86
0.25	84
0.15	82
0.075	77.4
0.0250	58.6
0.0196	55.0
0.0116	48.8
0.0083	46.1
0.0059	43.5
0.0029	37.3
0.0012	30.2



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to Tetra Tech description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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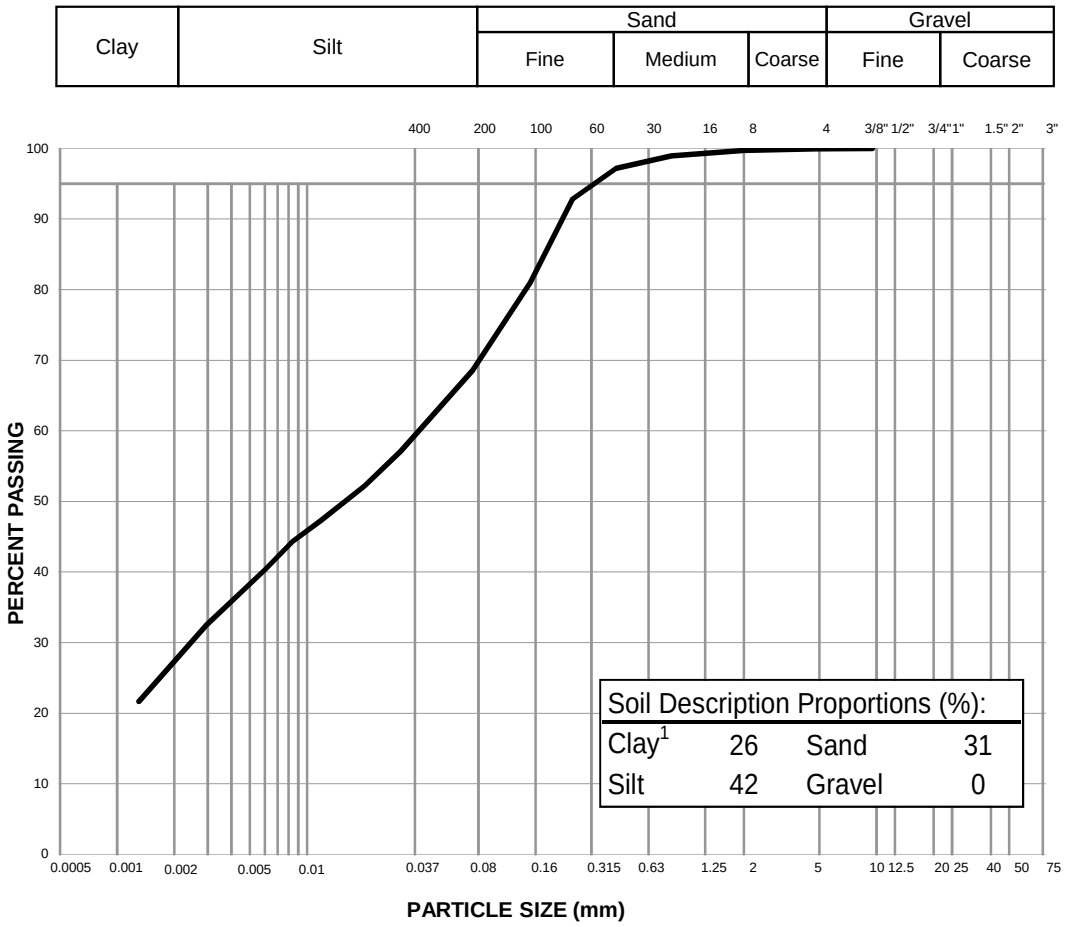
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29515
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	SRK18-MNWRP-DH-02
Client:	TMAC Resources Inc.	Sample Depth:	0.4-0.7 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 5, 2018 By: JPC/SS	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, sandy	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	22.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	99
0.425	97
0.25	93
0.15	81
0.075	68.6
0.0311	57.1
0.0201	52.2
0.0118	47.3
0.0084	44.3
0.0060	40.4
0.0030	32.5
0.0013	21.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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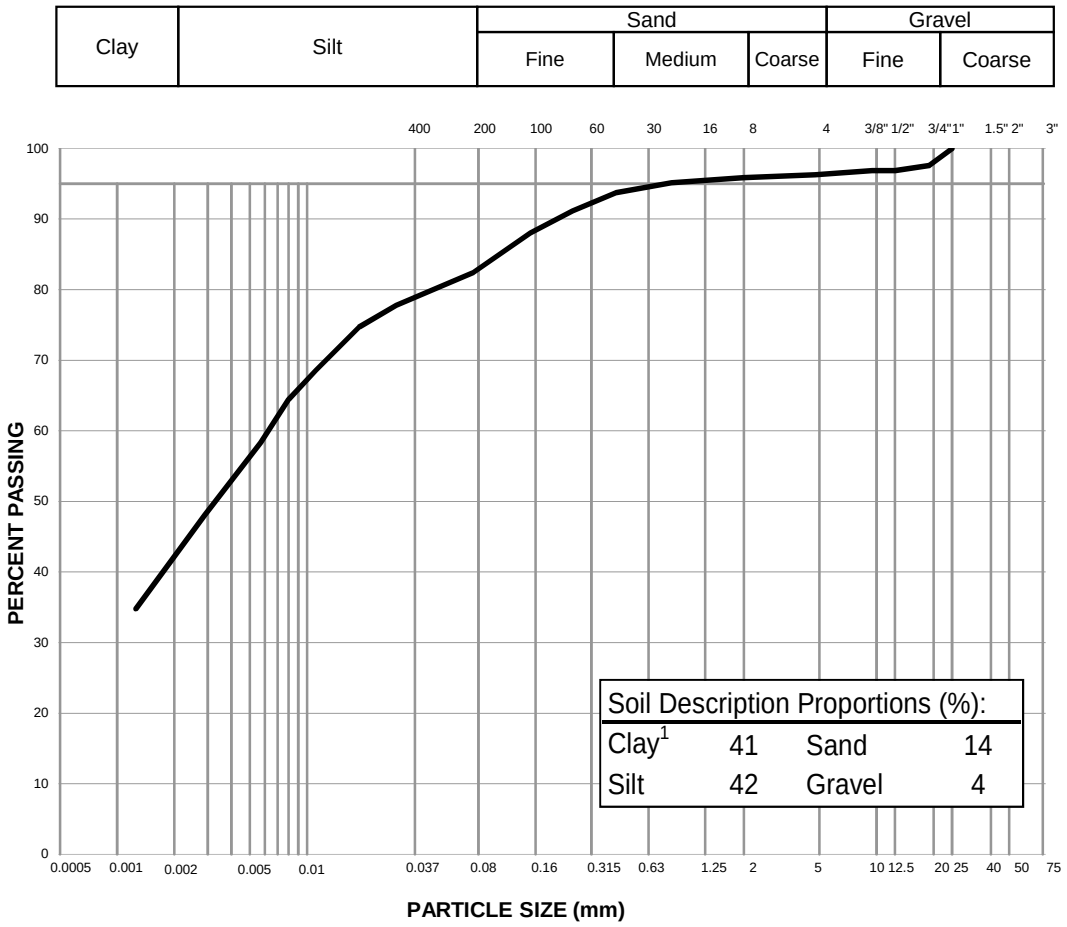
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29518
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	SRK18-MNWRP-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	1.1-2.3 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 5, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand, trace gravel	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	36.1%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	100
19	98
12.5	97
9.5	97
4.75	96
2	96
0.83	95
0.425	94
0.25	91
0.15	88
0.075	82.4
0.0295	77.8
0.0188	74.7
0.0111	68.6
0.0080	64.5
0.0057	58.3
0.0029	48.1
0.0013	34.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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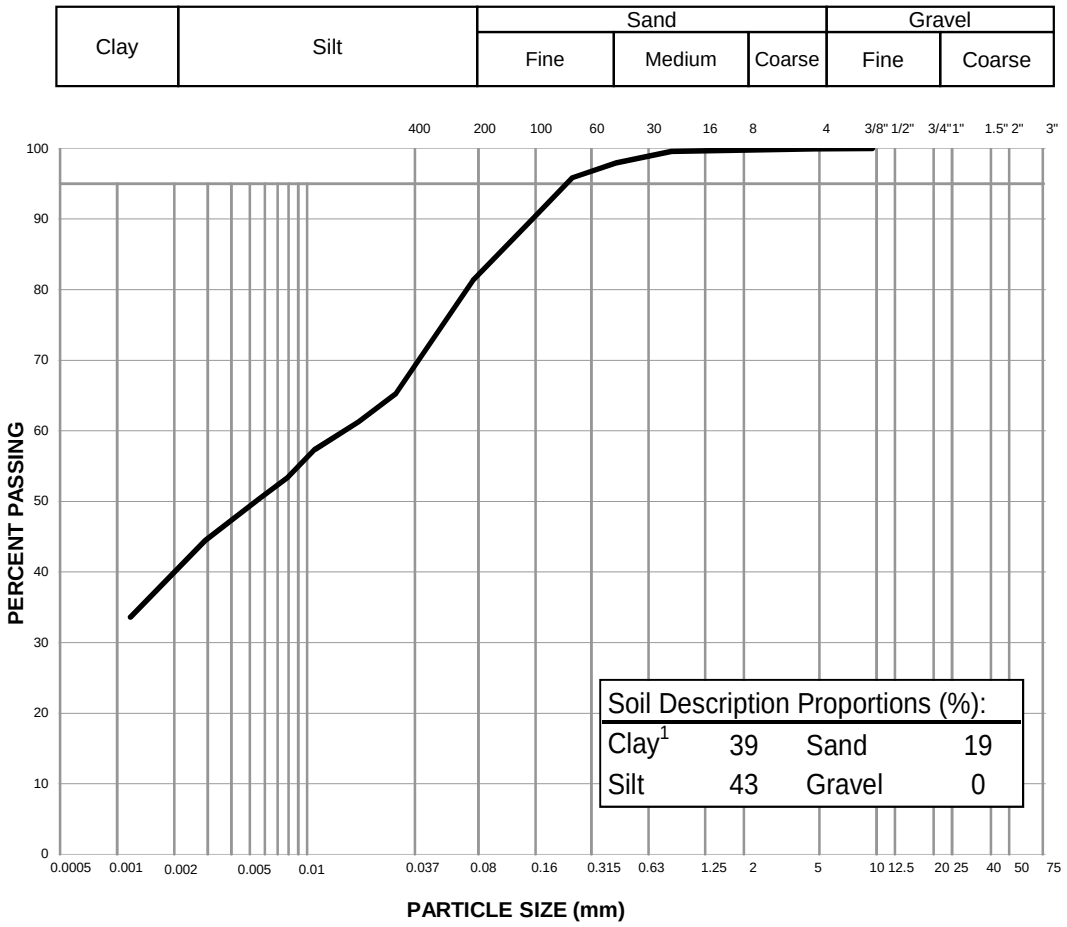
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29519
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNWRP-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	2.5-3.2 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	45.1%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	98
0.25	96
0.15	90
0.075	81.3
0.0293	65.2
0.0188	61.3
0.0110	57.3
0.0079	53.4
0.0056	50.4
0.0029	44.5
0.0012	33.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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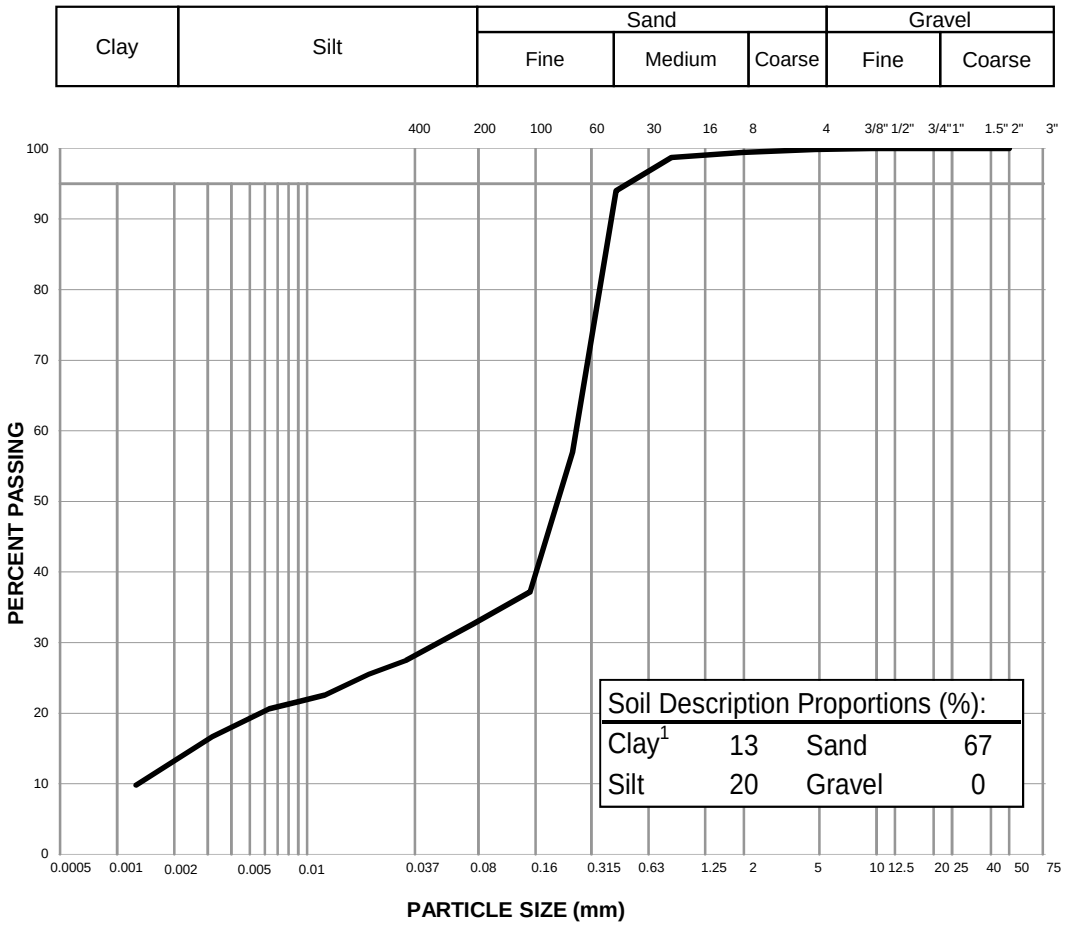
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29521
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNWRP-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	4.2-5.2 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 24, 2018
Soil Description[2]:	SAND, some silt, some clay	Sampled By:	Client
		USC Classification:	SM Cu: 201.6
Moisture Content:	25.9%		Cc: 8.3

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	100
12.5	100
9.5	100
4.75	100
2	99
0.83	99
0.425	94
0.25	57
0.15	37
0.075	32.6
0.0332	27.5
0.0211	25.5
0.0124	22.6
0.0088	21.6
0.0063	20.6
0.0032	16.7
0.0013	9.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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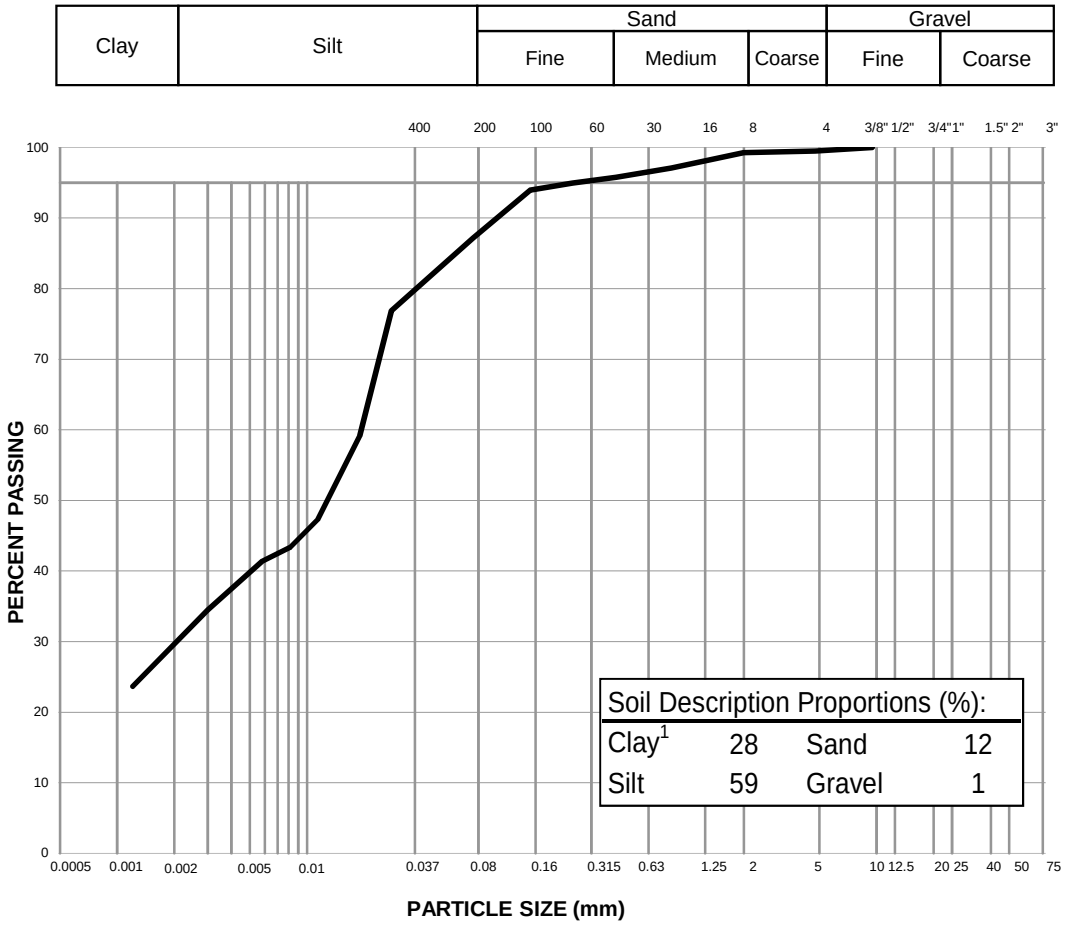
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29523
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNPCP-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	0.2-0.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand, trace gravel	Sampled By:	Client
		USC Classification:	OH Cu: #N/A
Moisture Content:	91.9%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	99
2	99
0.83	97
0.425	96
0.25	95
0.15	94
0.075	87.2
0.0279	76.9
0.0189	59.1
0.0114	47.3
0.0082	43.4
0.0058	41.4
0.0030	34.5
0.0012	23.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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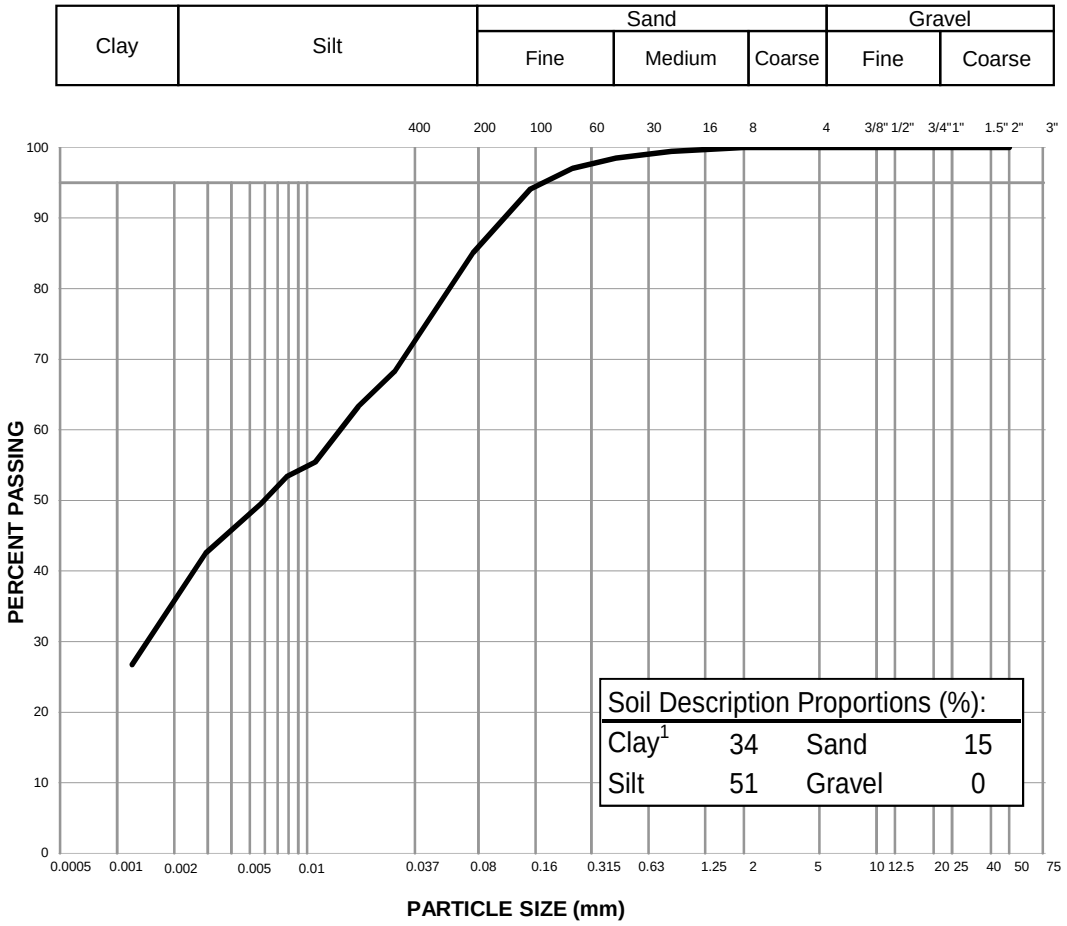
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29524
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNPCP-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	2.9-3.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	72.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	100
12.5	100
9.5	100
4.75	100
2	100
0.83	99
0.425	99
0.25	97
0.15	94
0.075	85.1
0.0289	68.3
0.0187	63.3
0.0111	55.4
0.0079	53.4
0.0057	49.5
0.0029	42.5
0.0012	26.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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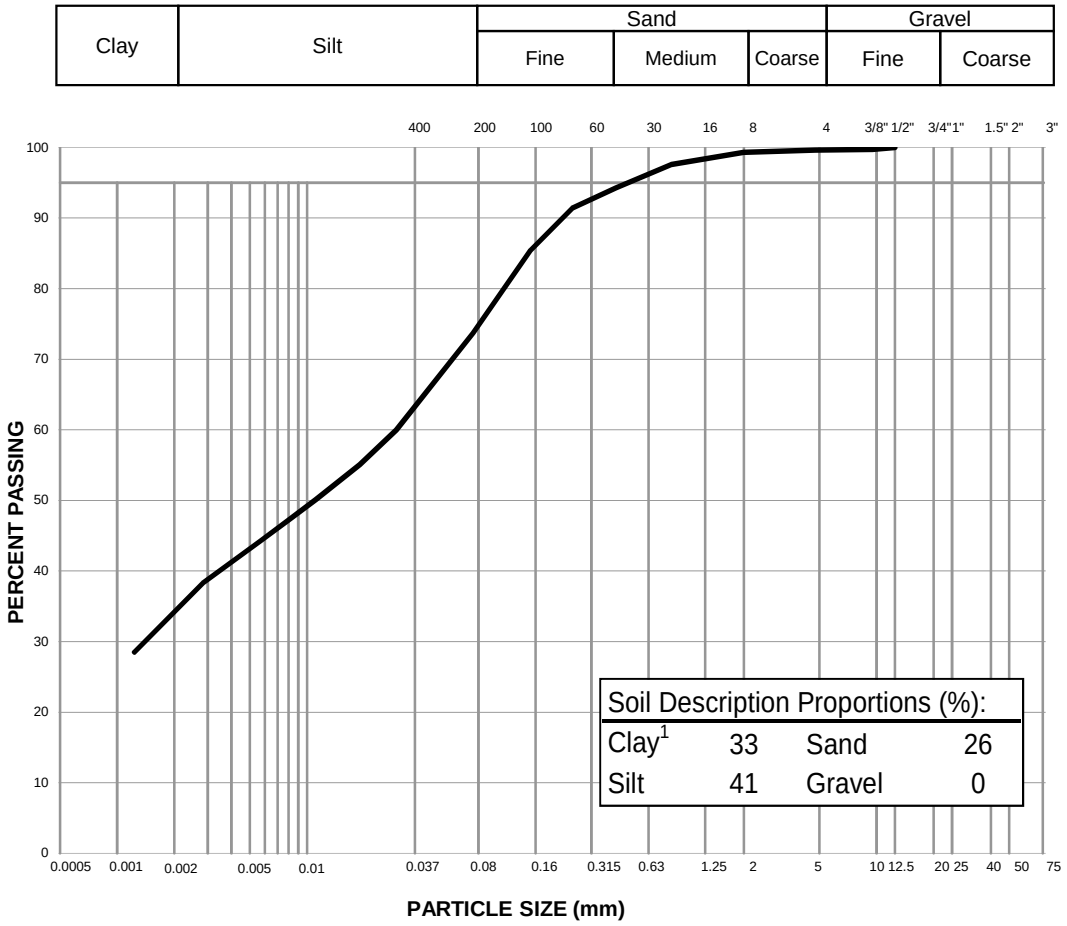
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29526
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNPCP-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	4.1-4.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 12, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, sandy	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	47.6%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	100
9.5	100
4.75	100
2	99
0.83	98
0.425	94
0.25	91
0.15	85
0.075	73.7
0.0295	60.0
0.0190	55.0
0.0111	50.1
0.0080	47.2
0.0057	44.2
0.0028	38.3
0.0012	28.5



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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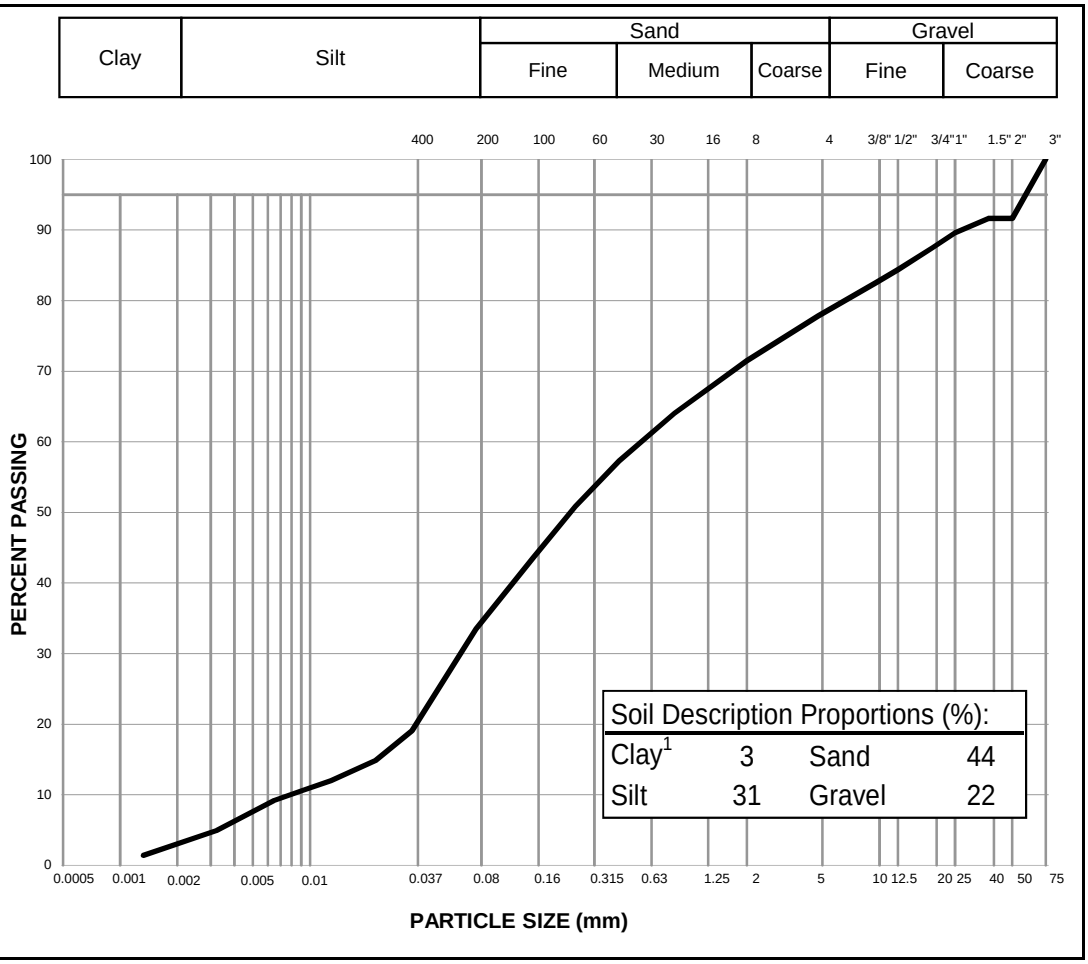
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29527
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNPCP-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	4.5-5.1 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 2, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	SAND, silty, some gravel, trace clay	Sampled By:	Client
		USC Classification:	SM Cu: 73.7
Moisture Content:	11.0%		Cc: 0.9

Particle Size (mm)	Percent Passing
75	100
50	92
37.5	92
25	90
19	87
12.5	84
9.5	83
4.75	78
2	71
0.83	64
0.425	57
0.25	51
0.15	44
0.075	33.5
0.0344	19.1
0.0222	14.8
0.0129	12.0
0.0091	10.6
0.0065	9.2
0.0032	4.9
0.0013	1.4



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

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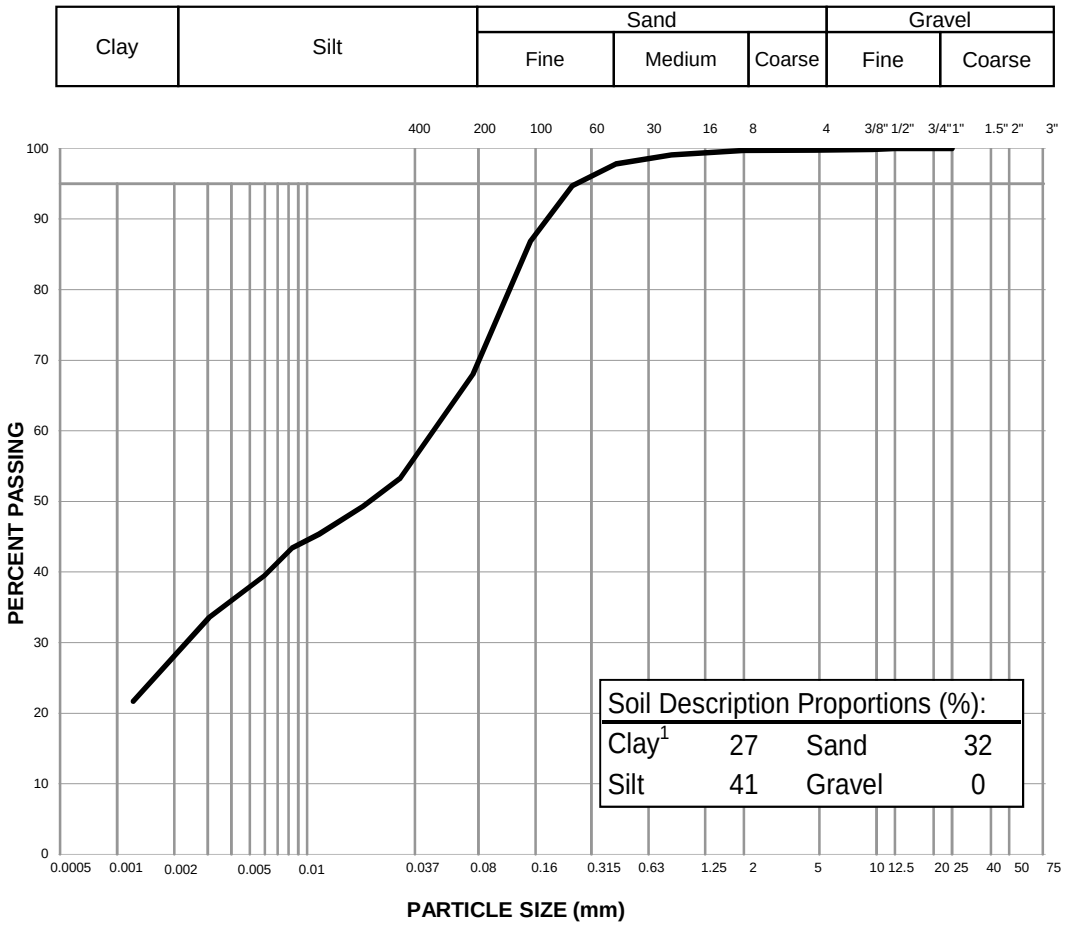
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29529
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNPCP-DH-02
Client:	TMAC Resources Inc.	Sample Depth:	1.3-2.8 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, sandy	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	44.1%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	100
19	100
12.5	100
9.5	100
4.75	100
2	100
0.83	99
0.425	98
0.25	95
0.15	87
0.075	68.0
0.0309	53.3
0.0198	49.3
0.0116	45.4
0.0083	43.4
0.0060	39.5
0.0030	33.5
0.0012	21.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

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Remarks: _____

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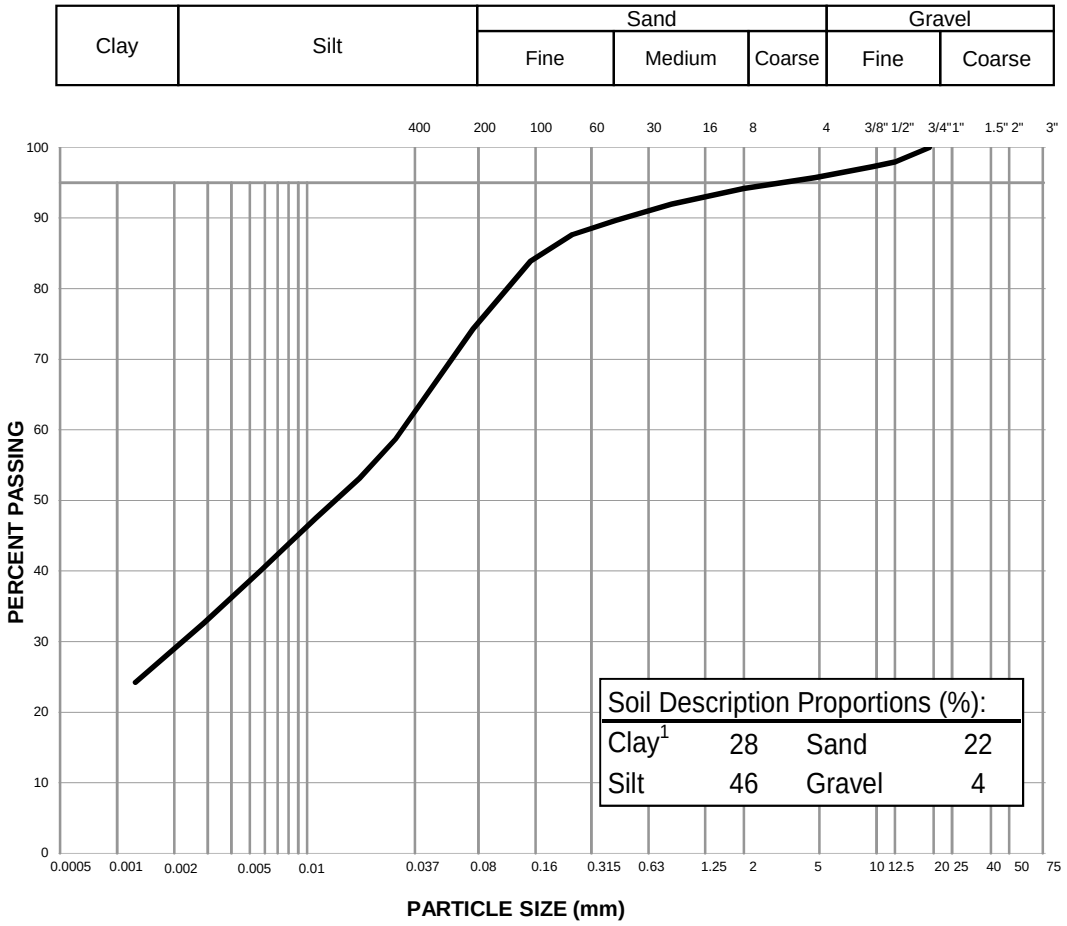
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29530
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNPCP-DH-02
Client:	TMAC Resources Inc.	Sample Depth:	3.0-4.3 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 12, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, sandy, trace gravel	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	52.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	98
9.5	97
4.75	96
2	94
0.83	92
0.425	90
0.25	88
0.15	84
0.075	74.3
0.0293	58.7
0.0189	53.1
0.0111	47.5
0.0080	43.8
0.0057	40.1
0.0029	32.6
0.0012	24.2



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

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Remarks: _____

Reviewed By: _____ P.Geol

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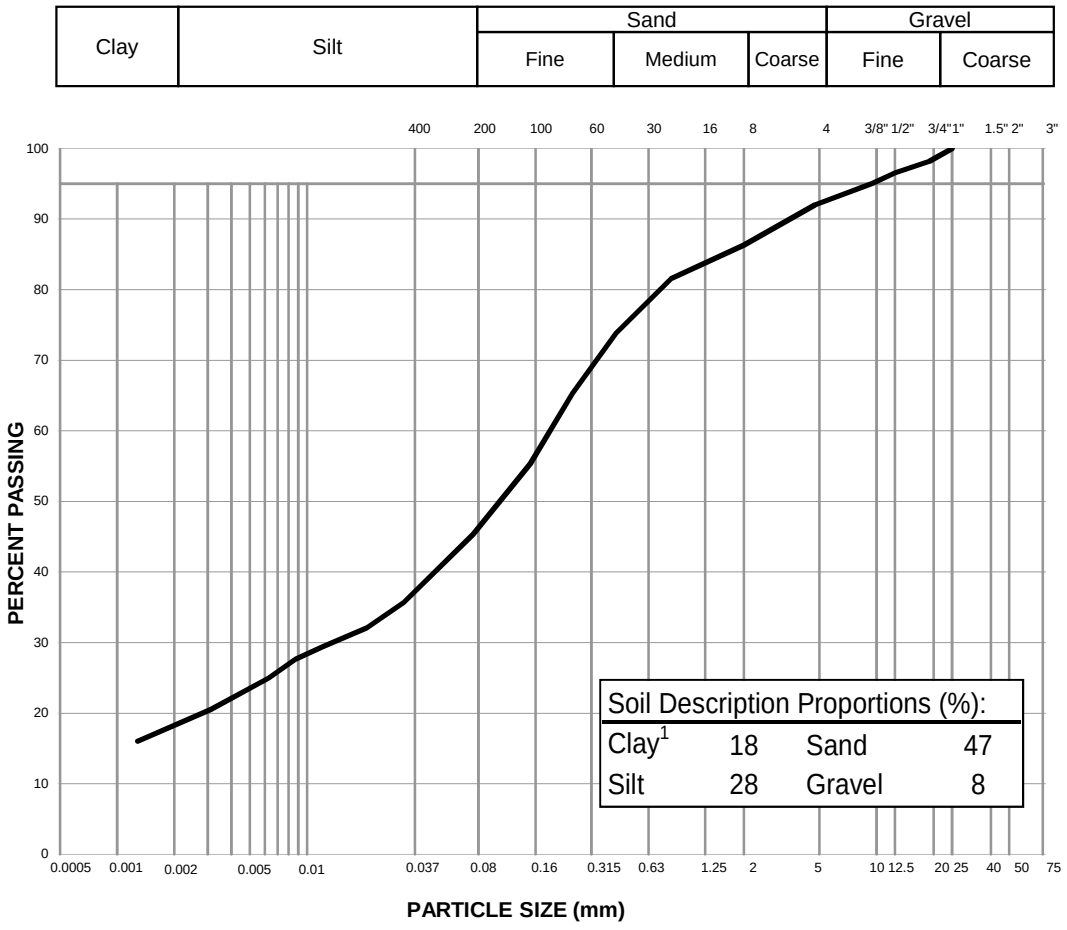
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29531
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNPCP-DH-02
Client:	TMAC Resources Inc.	Sample Depth:	4.6-5.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 12, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	SAND, silty, some clay, trace gravel	Sampled By:	Client
		USC Classification:	SM Cu: #N/A
Moisture Content:	32.8%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	100
19	98
12.5	97
9.5	95
4.75	92
2	86
0.83	82
0.425	74
0.25	65
0.15	55
0.075	45.3
0.0323	35.7
0.0207	32.1
0.0121	29.4
0.0087	27.6
0.0063	25.0
0.0031	20.5
0.0013	16.0



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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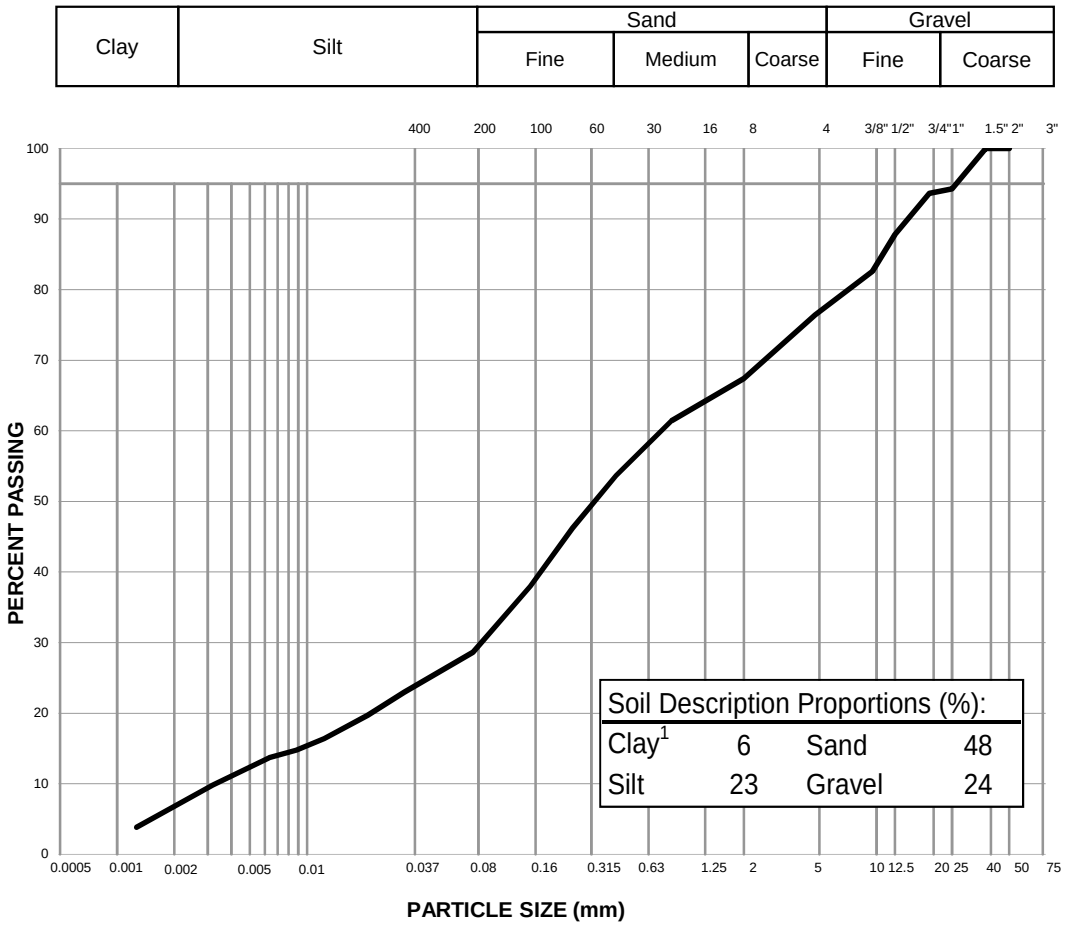
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29533
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-MNPCP-DH-02
Client:	TMAC Resources Inc.	Sample Depth:	6.0-6.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 24, 2018
Soil Description[2]:	SAND, gravelly, silty, trace clay	Sampled By:	Client
		USC Classification:	SM Cu: 227.6
Moisture Content:	8.1%		Cc: 2.9

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	94
19	94
12.5	88
9.5	83
4.75	76
2	67
0.83	61
0.425	54
0.25	46
0.15	38
0.075	28.7
0.0326	23.0
0.0209	19.7
0.0123	16.4
0.0088	14.8
0.0063	13.7
0.0032	9.8
0.0013	3.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

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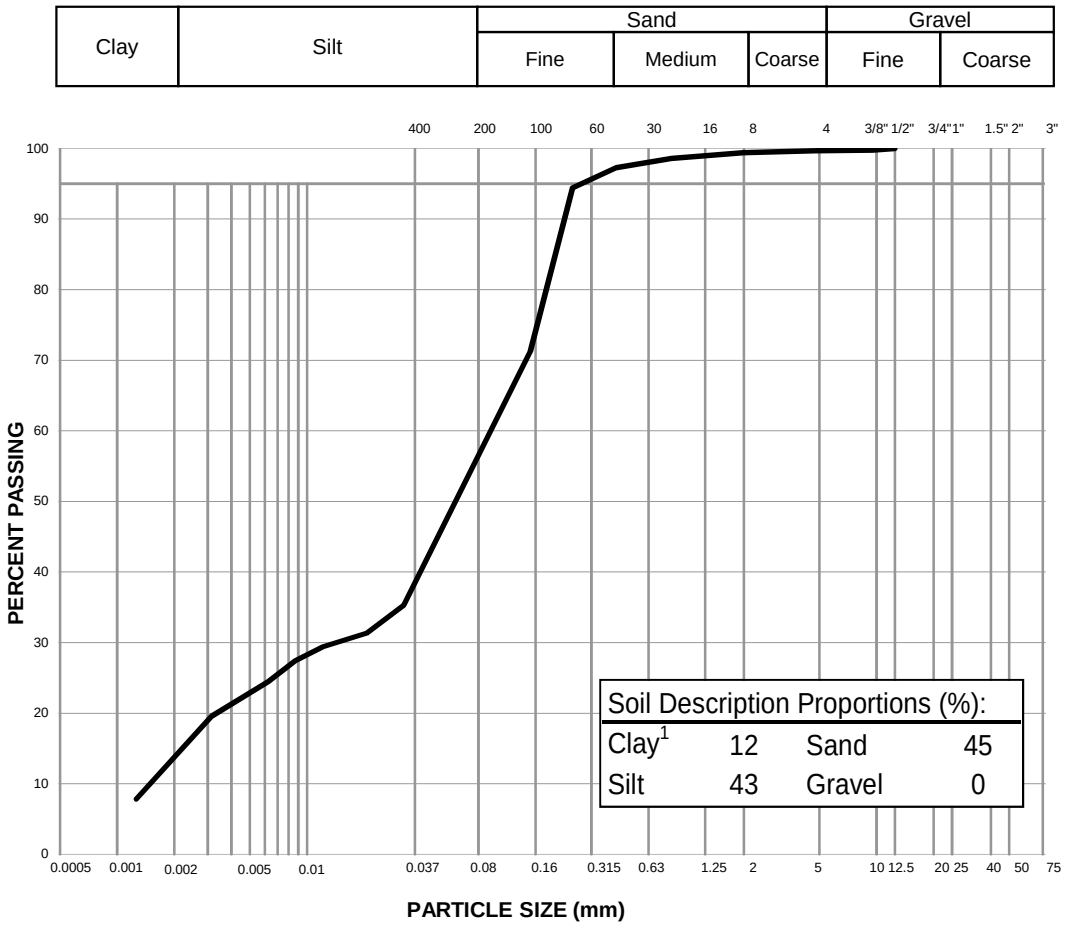
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29544
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-18
Client:	TMAC Resources Inc.	Sample Depth:	0.2-0.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 24, 2018
Soil Description[2]:	SAND, SILT, some clay	Sampled By:	Client
		USC Classification:	SM Cu: 61.0
Moisture Content:	24.5%		Cc: 1.4

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	100
9.5	100
4.75	100
2	99
0.83	99
0.425	97
0.25	94
0.15	71
0.075	55.0
0.0323	35.3
0.0207	31.3
0.0122	29.4
0.0087	27.4
0.0062	24.5
0.0031	19.6
0.0013	7.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

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Specification: _____

Remarks: _____

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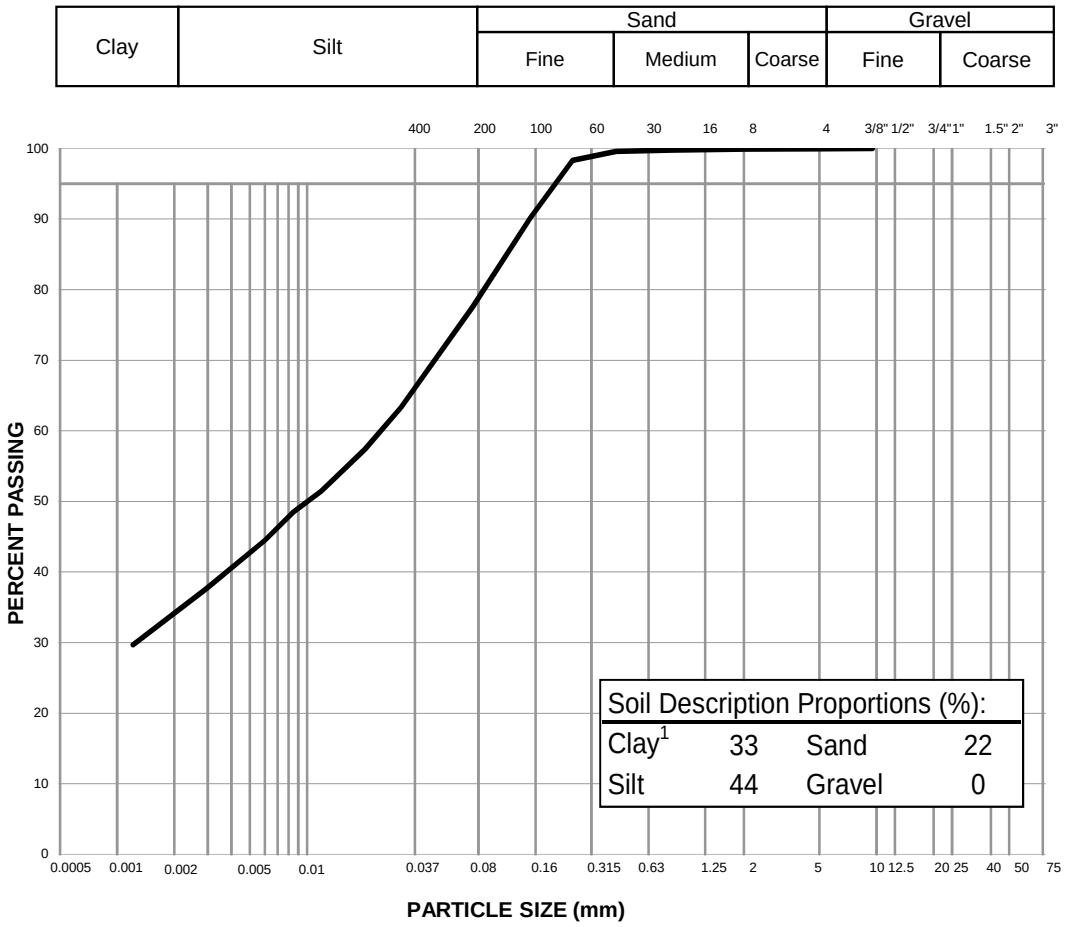
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29546
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-18
Client:	TMAC Resources Inc.	Sample Depth:	11.4-11.8 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand.	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	44.4%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	100
0.25	98
0.15	90
0.075	77.6
0.0313	63.3
0.0201	57.4
0.0119	51.5
0.0085	48.5
0.0060	44.5
0.0029	37.6
0.0012	29.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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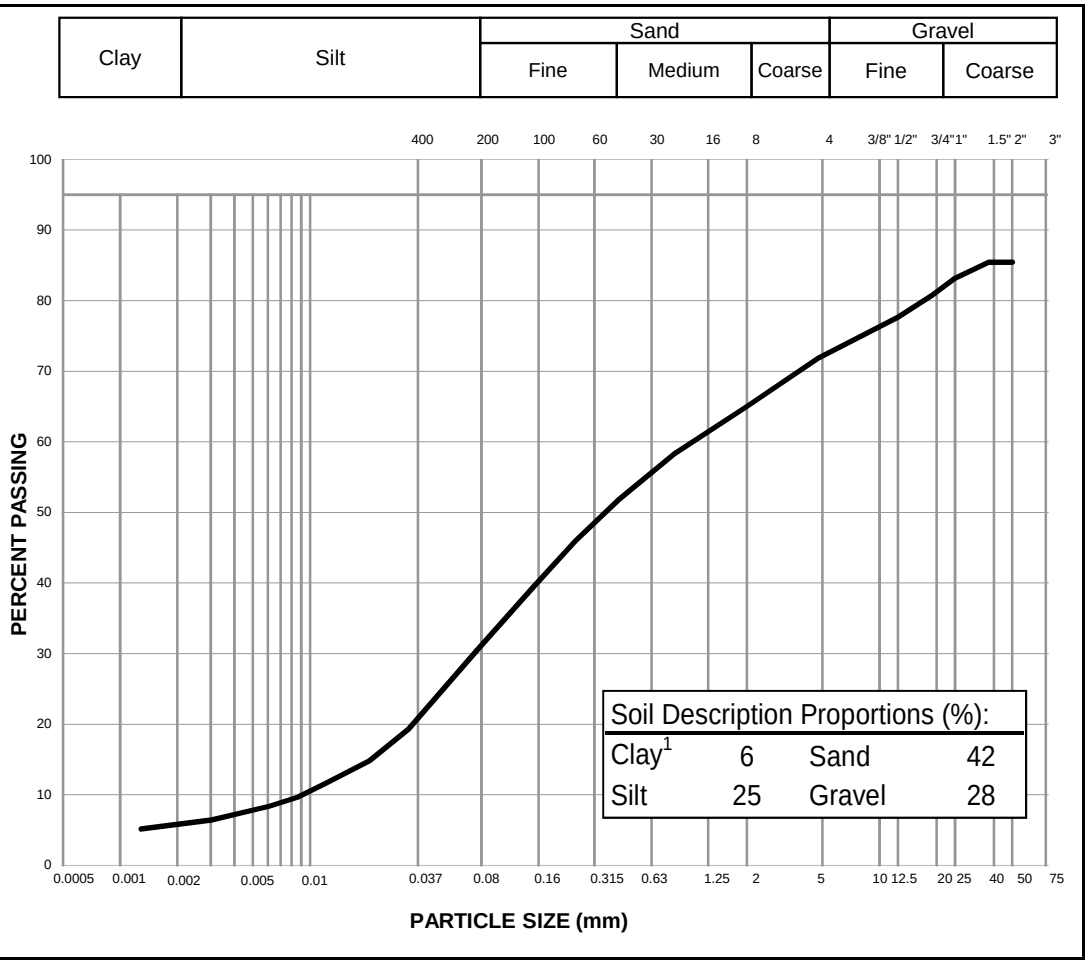
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29547
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-18
Client:	TMAC Resources Inc.	Sample Depth:	12.9-13.4 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 20, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	SAND, gravelly, silty, trace clay	Sampled By:	Client
		USC Classification:	SM Cu: 122.3
Moisture Content:	8.9%		Cc: 0.5

Particle Size (mm)	Percent Passing
75	
50	85
37.5	85
25	83
19	81
12.5	78
9.5	76
4.75	72
2	65
0.83	58
0.425	52
0.25	46
0.15	39
0.075	30.3
0.0330	19.3
0.0206	14.8
0.0120	11.6
0.0086	9.7
0.0061	8.4
0.0030	6.4
0.0013	5.1



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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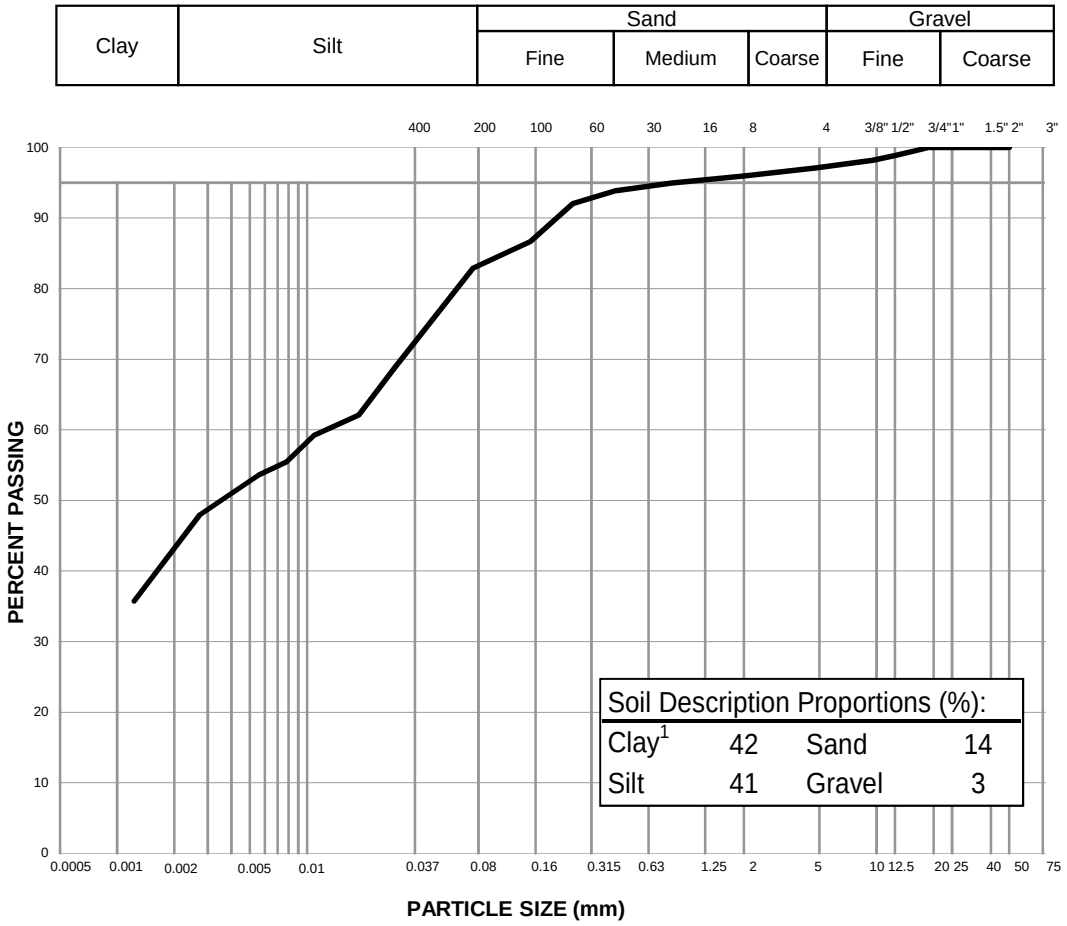
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29548
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-17
Client:	TMAC Resources Inc.	Sample Depth:	0.5-0.9 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 31, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand, trace gravel	Sampled By:	Client
		USC Classification:	ML Cu: #N/A
Moisture Content:	63.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	100
12.5	99
9.5	98
4.75	97
2	96
0.83	95
0.425	94
0.25	92
0.15	87
0.075	82.9
0.0288	68.7
0.0187	62.1
0.0109	59.3
0.0078	55.5
0.0056	53.6
0.0027	48.0
0.0012	35.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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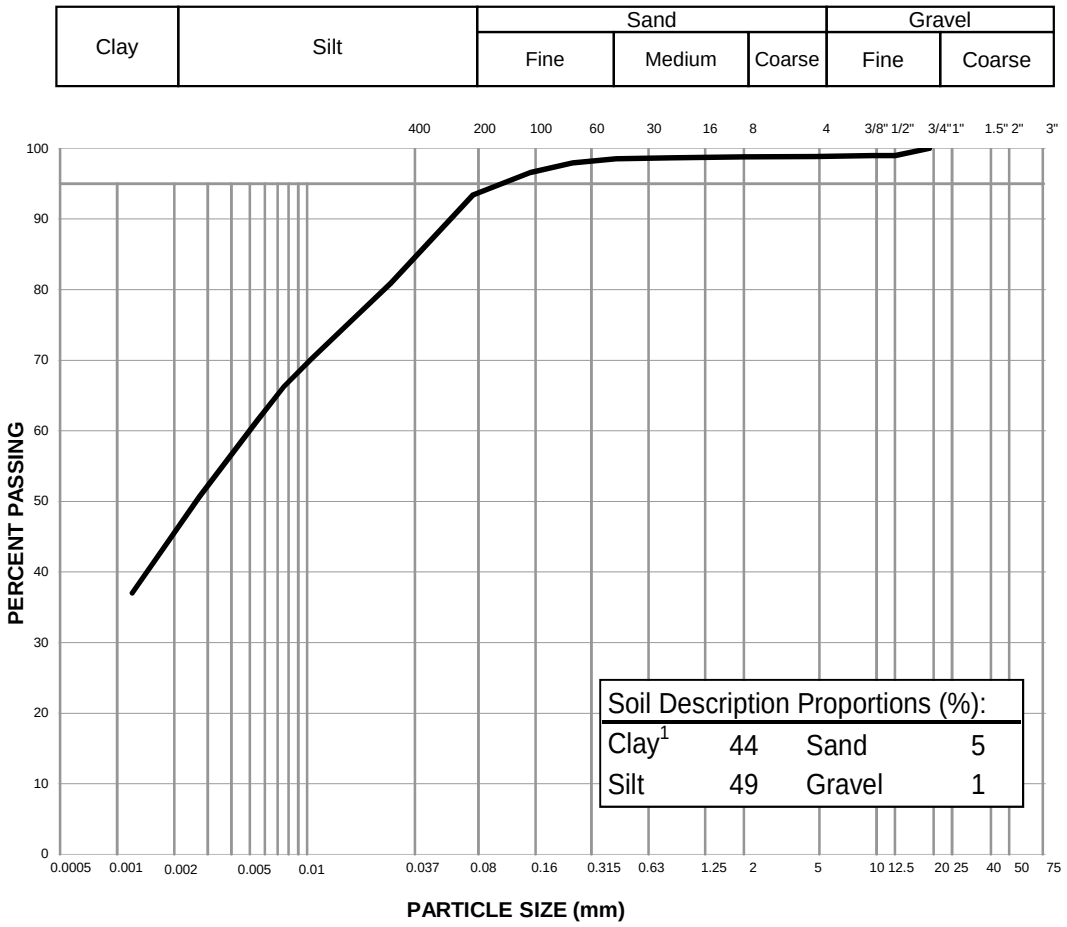
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29549
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-17
Client:	TMAC Resources Inc.	Sample Depth:	3.7-4.1 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 14, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, trace sand, trace gravel	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	33.5%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	99
9.5	99
4.75	99
2	99
0.83	99
0.425	99
0.25	98
0.15	97
0.075	93.4
0.0276	80.9
0.0178	76.0
0.0105	70.2
0.0076	66.3
0.0055	61.4
0.0027	50.7
0.0012	37.0



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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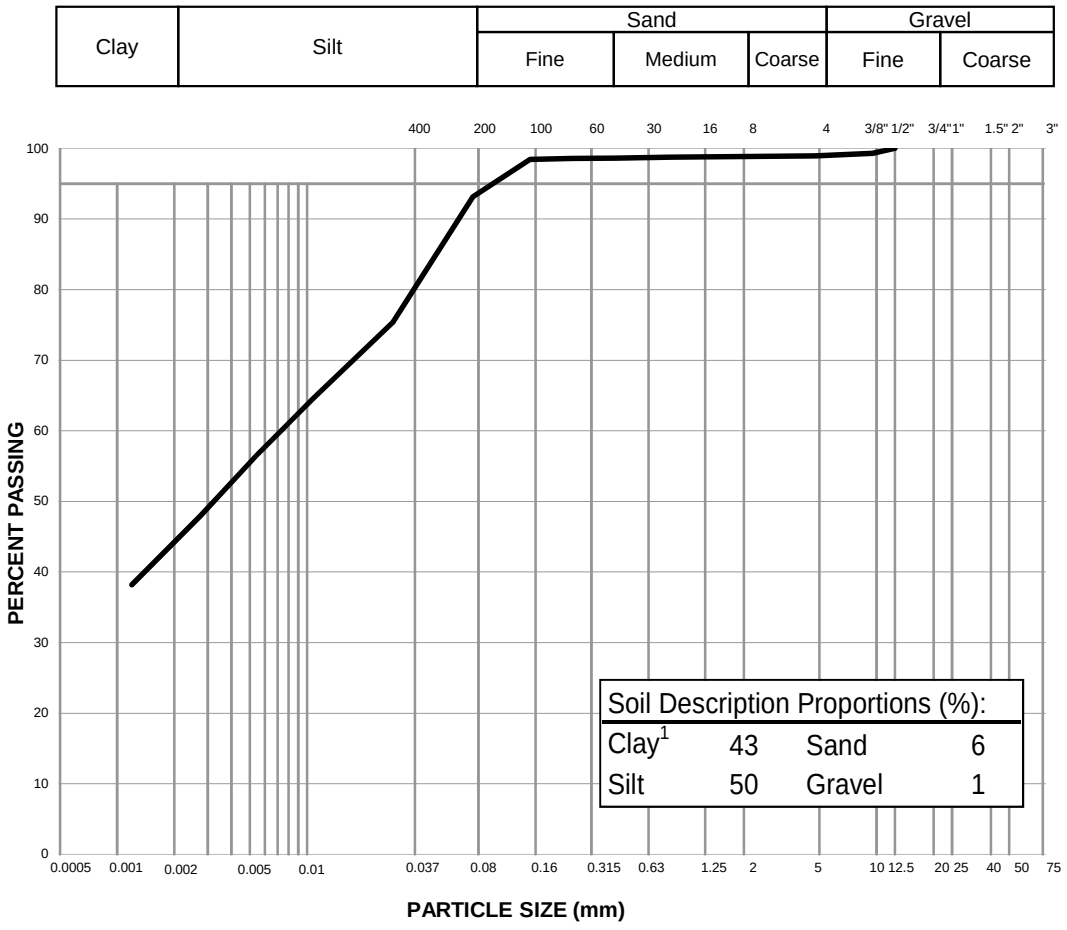
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29550
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-17
Client:	TMAC Resources Inc.	Sample Depth:	8.7-9.1 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 14, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, trace sand, trace gravel	Sampled By:	Client
		USC Classification:	CI Cu: #N/A
Moisture Content:	41.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	100
9.5	99
4.75	99
2	99
0.83	99
0.425	99
0.25	99
0.15	98
0.075	93.2
0.0283	75.4
0.0183	70.5
0.0108	64.6
0.0077	60.7
0.0055	56.8
0.0027	48.0
0.0012	38.2



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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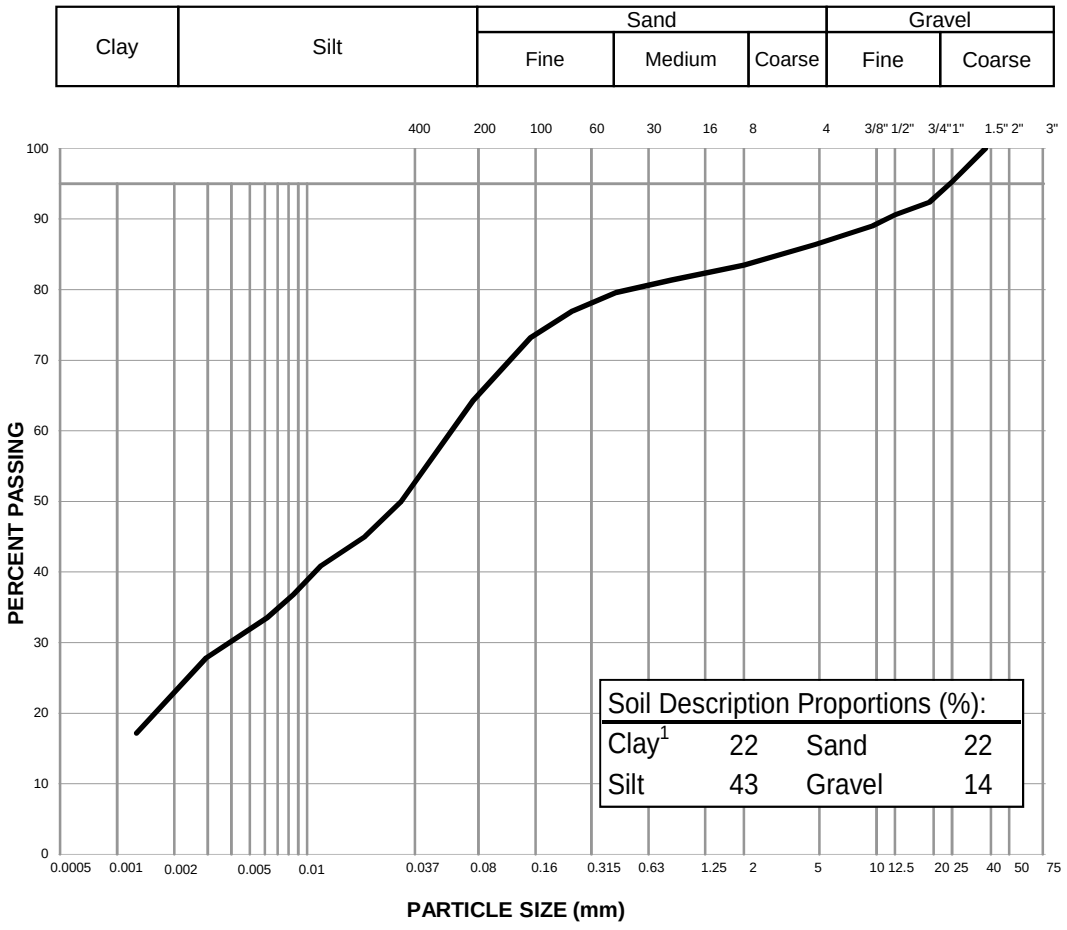
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29551
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-17
Client:	TMAC Resources Inc.	Sample Depth:	12.9-13.3 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	SILT, clayey, sandy, some gravel.	Sampled By:	Client
		USC Classification:	ML Cu: #N/A
Moisture Content:	44.6%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	100
25	95
19	92
12.5	91
9.5	89
4.75	86
2	83
0.83	81
0.425	80
0.25	77
0.15	73
0.075	64.3
0.0312	49.9
0.0202	45.0
0.0118	40.9
0.0085	36.8
0.0062	33.5
0.0029	27.8
0.0013	17.2



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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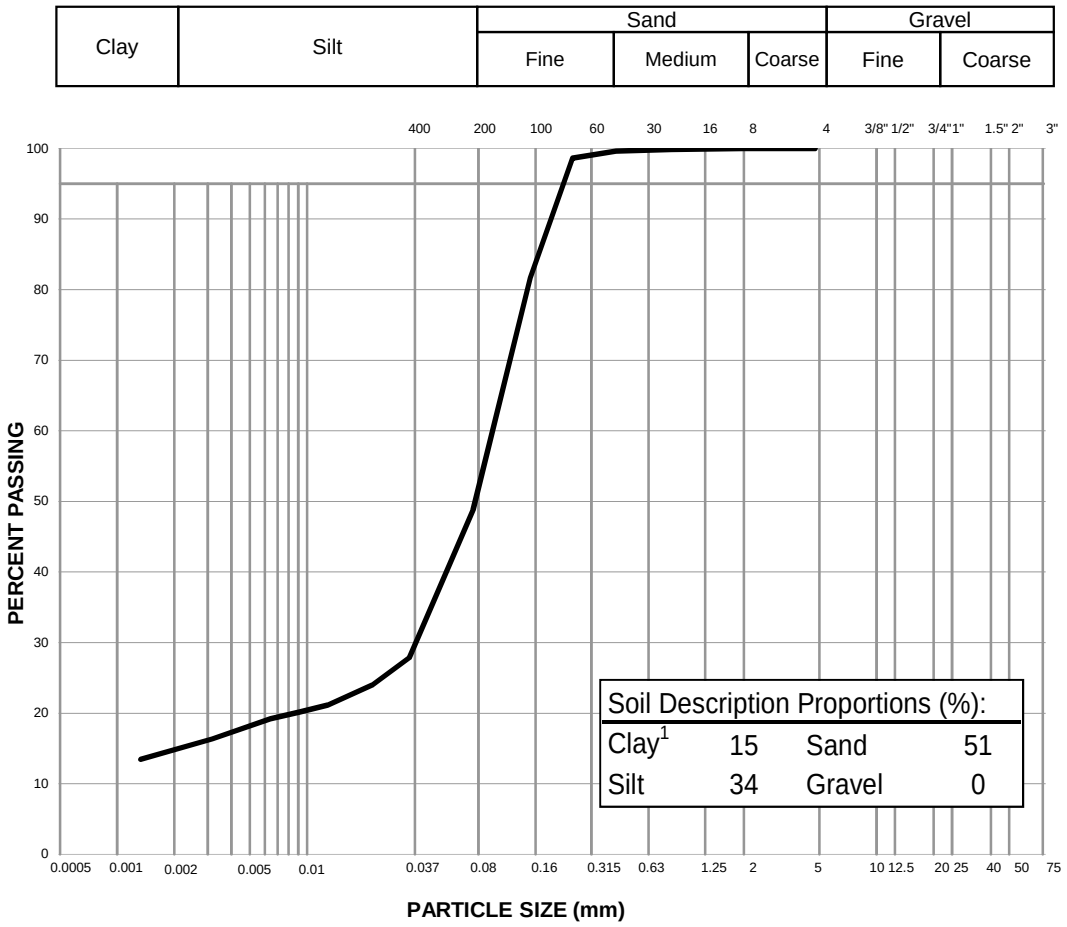
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29570
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	SRK18-STH-DH-03
Client:	TMAC Resources Inc.	Sample Depth:	0.7-2.2 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 5, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SAND, silty, some clay	Sampled By:	Client
		USC Classification:	SM Cu: #N/A
Moisture Content:	30.6%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	100
2	100
0.83	100
0.425	100
0.25	99
0.15	82
0.075	48.8
0.0346	27.9
0.0221	24.0
0.0129	21.1
0.0092	20.2
0.0064	19.2
0.0032	16.3
0.0013	13.5



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

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Remarks: _____

Reviewed By: _____ P.Geol

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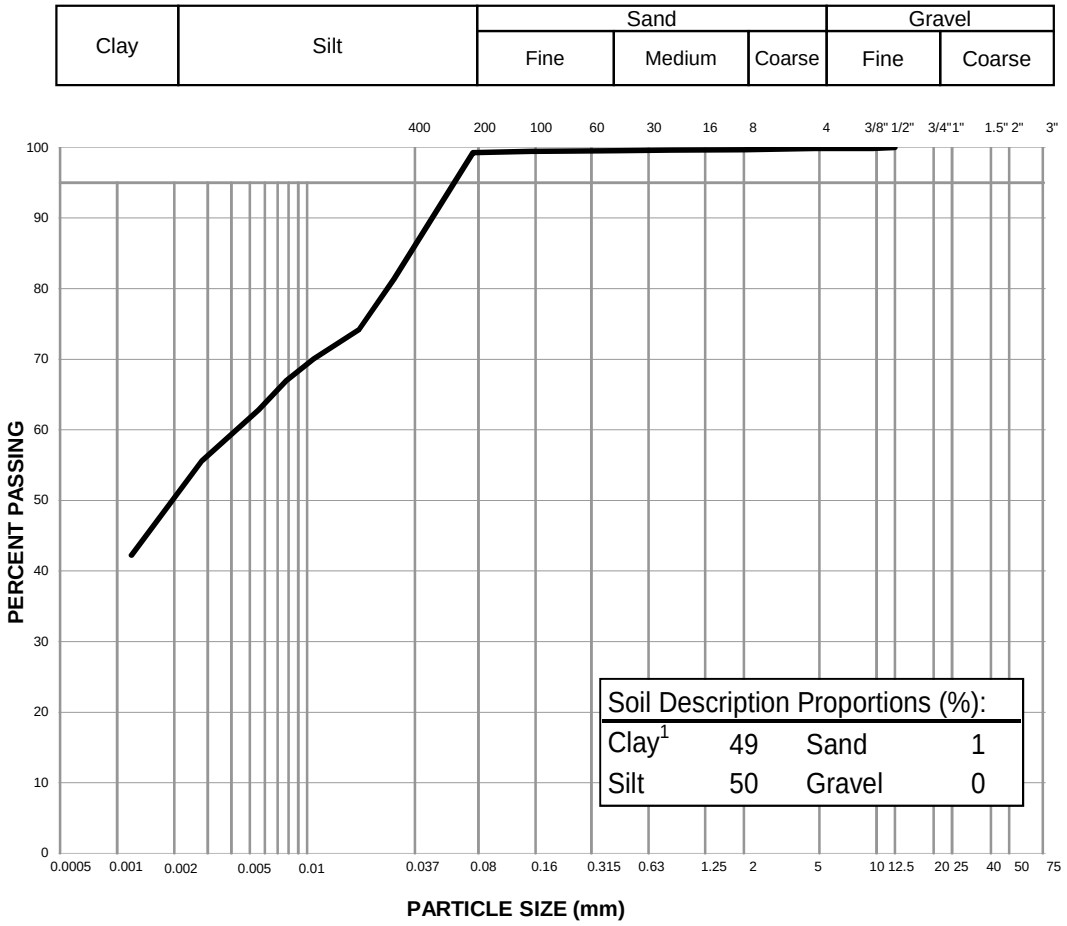
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29572
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-03
Client:	TMAC Resources Inc.	Sample Depth:	5.8-6.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 2, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	59.8%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	100
9.5	100
4.75	100
2	100
0.83	100
0.425	100
0.25	100
0.15	99
0.075	99.3
0.0287	81.4
0.0187	74.2
0.0108	70.0
0.0078	66.9
0.0056	62.8
0.0028	55.6
0.0012	42.2



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

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Remarks: _____

Reviewed By: _____ P.Geol

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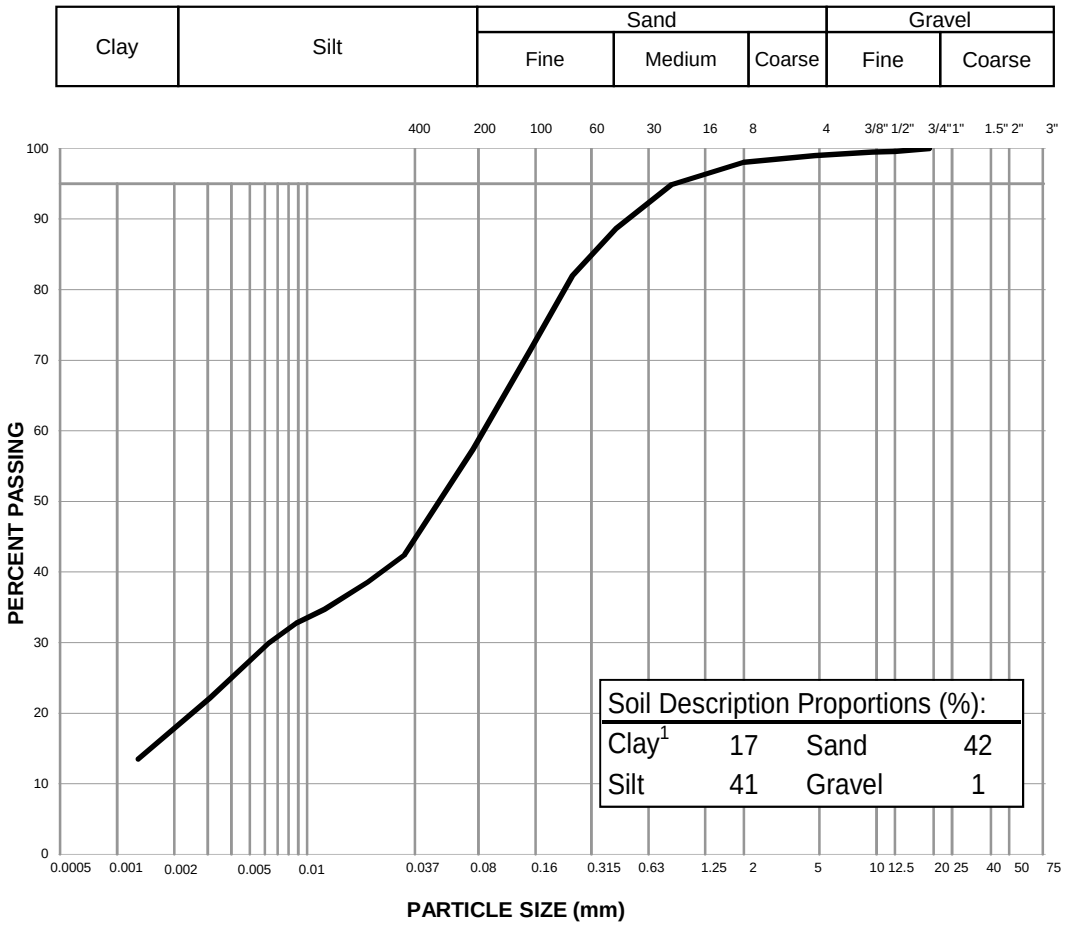
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29574
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-03
Client:	TMAC Resources Inc.	Sample Depth:	8.1-9.1 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SAND, SILT, some clay, trace gravel	Sampled By:	Client
		USC Classification:	SM Cu: #N/A
Moisture Content:	45.8%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	100
9.5	99
4.75	99
2	98
0.83	95
0.425	89
0.25	82
0.15	71
0.075	57.4
0.0327	42.4
0.0209	38.6
0.0124	34.7
0.0088	32.8
0.0063	29.9
0.0031	22.2
0.0013	13.5



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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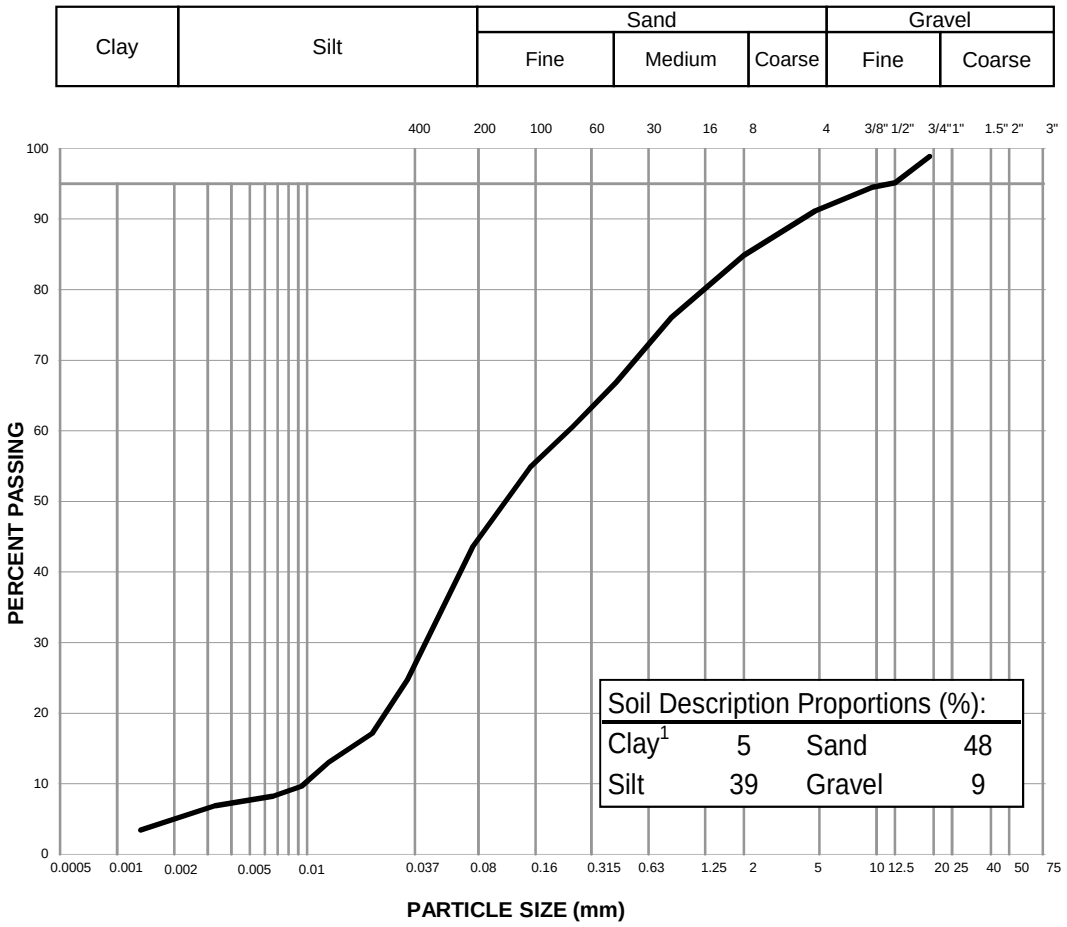
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29575
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-03
Client:	TMAC Resources Inc.	Sample Depth:	9.1-10.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SAND, SILT, trace gravel, trace clay.	Sampled By:	Client
		USC Classification:	SM Cu: 24.7
Moisture Content:	10.9%		Cc: 0.9

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	99
12.5	95
9.5	94
4.75	91
2	85
0.83	76
0.425	67
0.25	61
0.15	55
0.075	43.7
0.0338	24.8
0.0221	17.2
0.0130	13.1
0.0093	9.6
0.0066	8.3
0.0033	6.9
0.0013	3.4



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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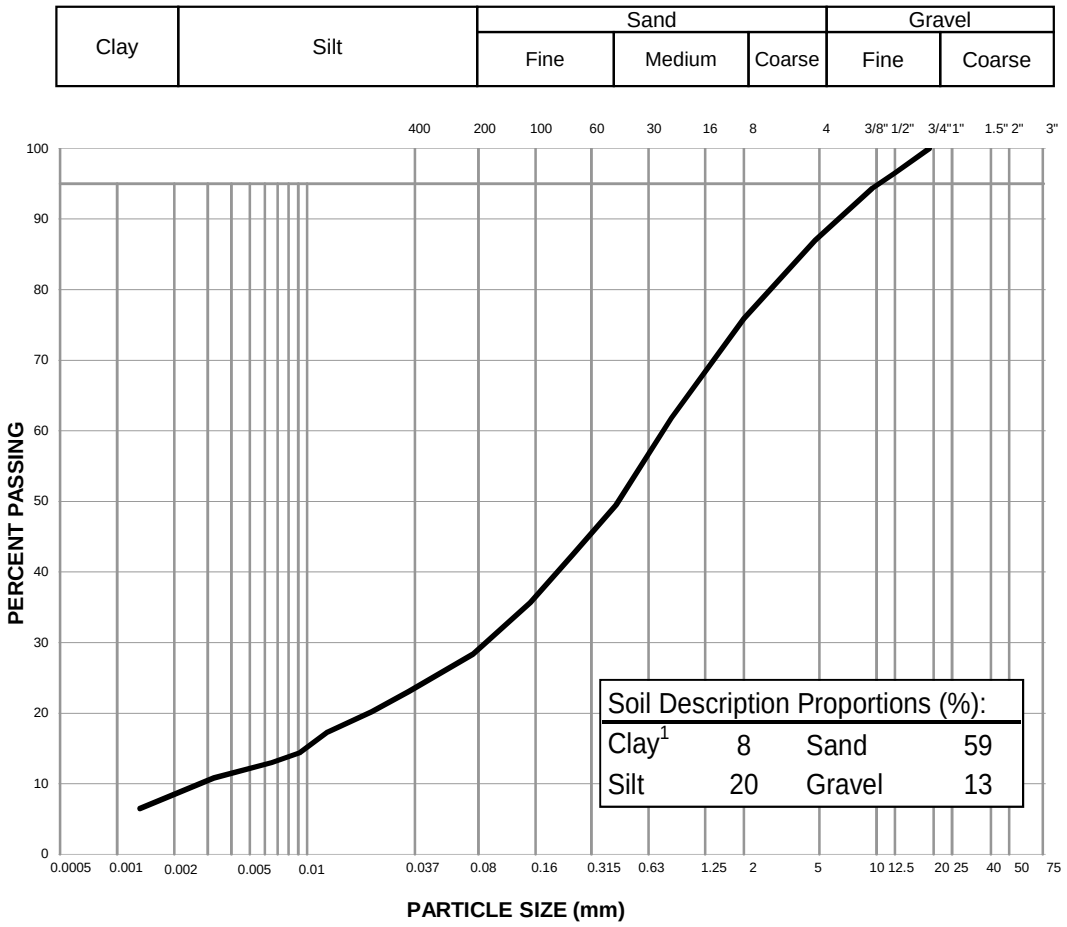
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29577
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-03
Client:	TMAC Resources Inc.	Sample Depth:	11.7-13.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SAND, some silt, some gravel, trace clay.	Sampled By:	Client
		USC Classification:	SM Cu: 268.7
Moisture Content:	7.8%		Cc: 3.8

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	97
9.5	94
4.75	87
2	76
0.83	62
0.425	50
0.25	42
0.15	36
0.075	28.4
0.0343	23.1
0.0220	20.2
0.0128	17.3
0.0092	14.4
0.0065	13.0
0.0032	10.8
0.0013	6.5



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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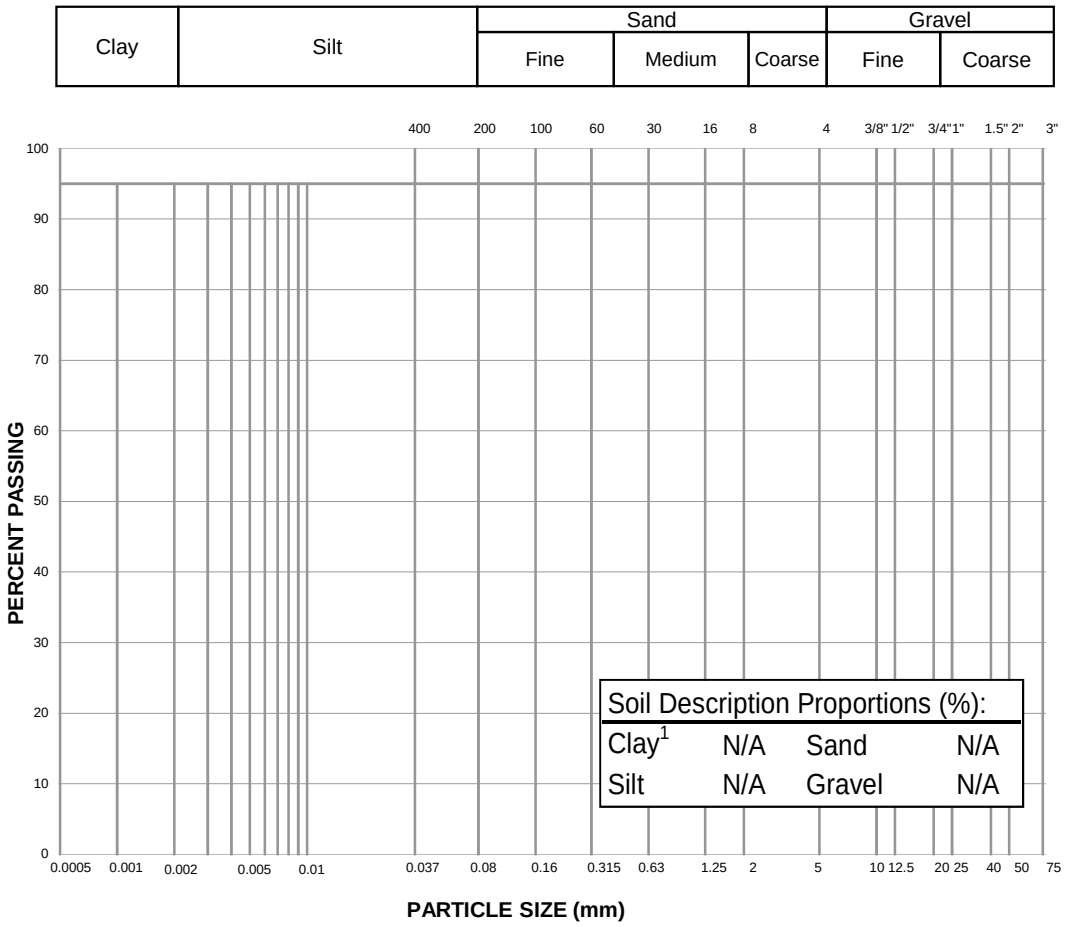
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29578
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-02
Client:	TMAC Resources Inc.	Sample Depth:	0.2-0.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 20, 2018 By: JPC	Date sampled:	February 25, 2018
Soil Description[2]:	Peat, trace fine sand, trace silt.	Sampled By:	Client
		USC Classification:	Cu: #N/A
Moisture Content:	108.8%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	
0.83	
0.425	
0.25	
0.15	
0.075	
0.0358	
0.0219	
0.0126	
0.0089	
0.0063	
0.0031	
0.0013	



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks: No hydrometer run. Sample is peat, trace fine sand, trace silt.

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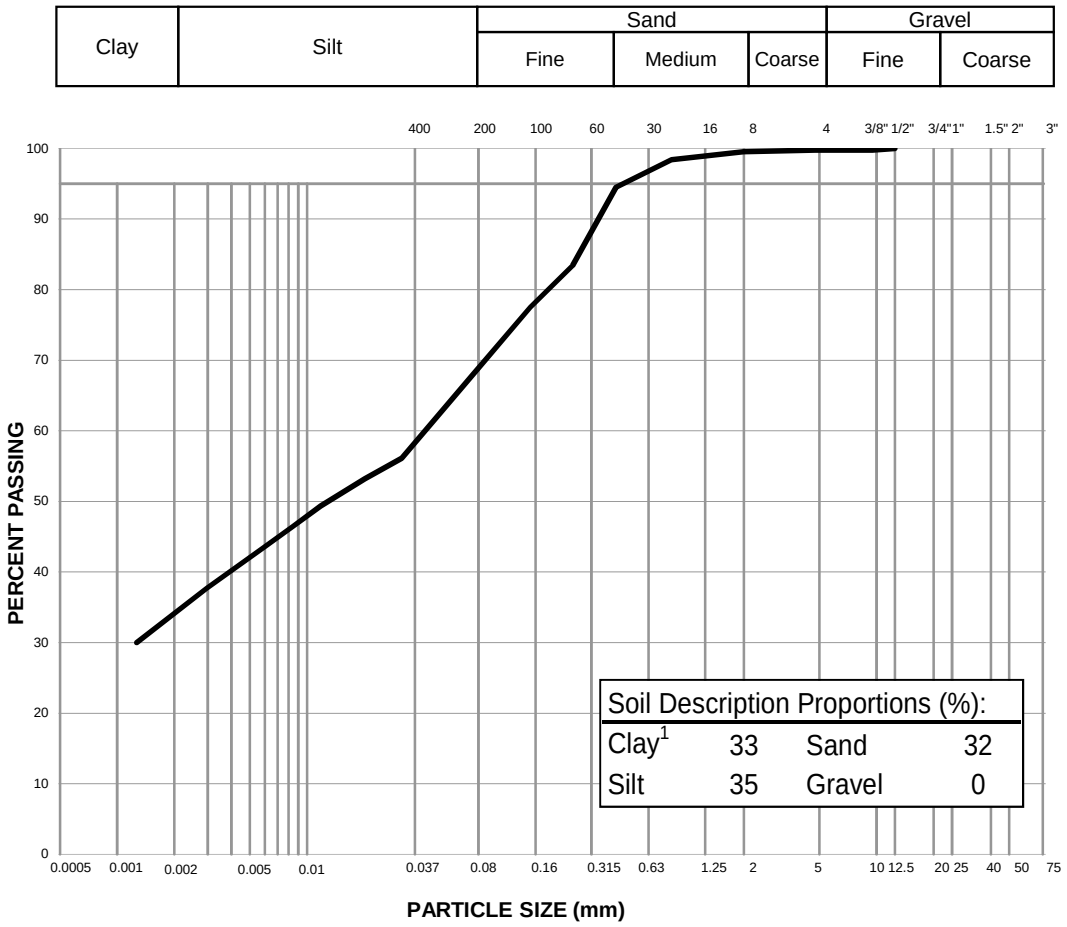
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29579
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	SRK18-STH-DH-02
Client:	TMAC Resources Inc.	Sample Depth:	2.5-2.9 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 5, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, sandy	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	71.2%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	100
9.5	100
4.75	100
2	100
0.83	98
0.425	94
0.25	83
0.15	78
0.075	68.0
0.0315	56.1
0.0202	53.2
0.0118	49.3
0.0084	46.4
0.0059	43.5
0.0030	37.7
0.0013	30.0



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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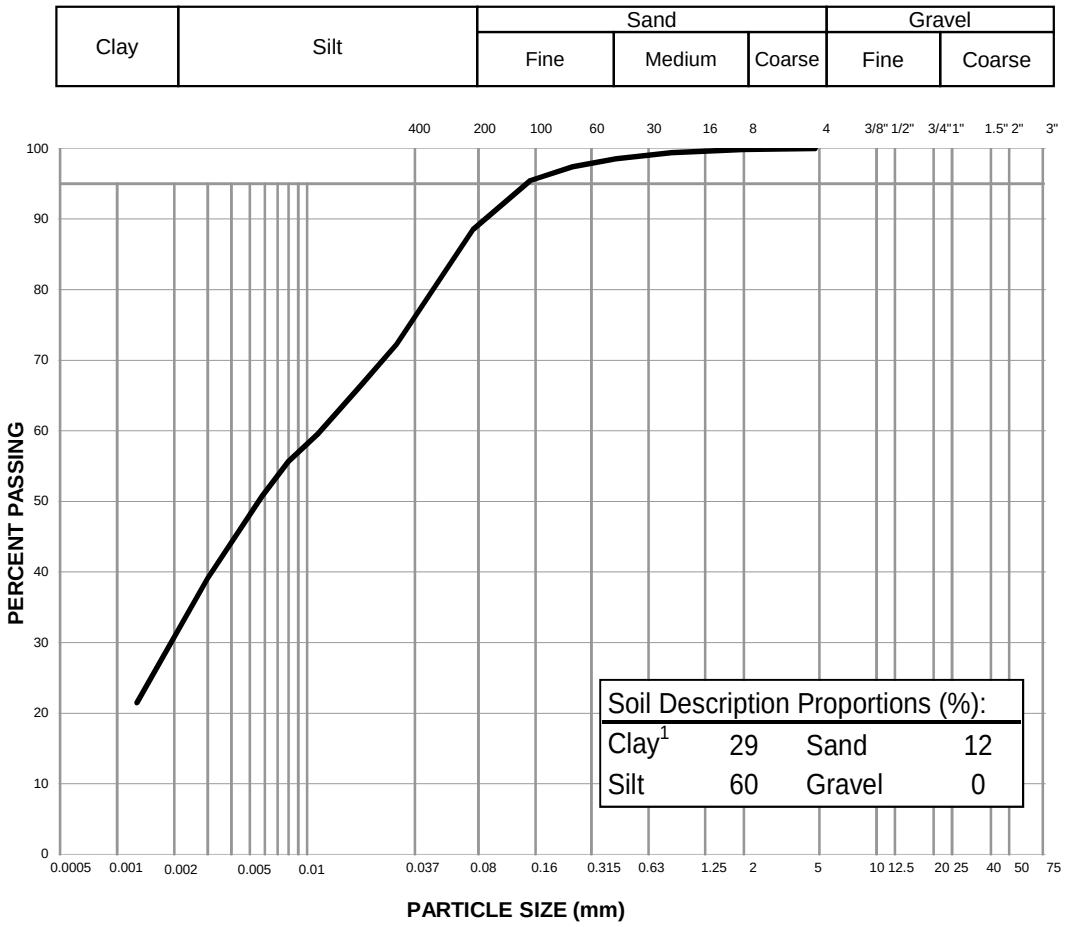
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29606
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	0.1-0.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	27.6%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	100
2	100
0.83	99
0.425	99
0.25	97
0.15	95
0.075	88.5
0.0296	72.3
0.0192	66.4
0.0114	59.6
0.0080	55.7
0.0058	50.8
0.0030	39.1
0.0013	21.5



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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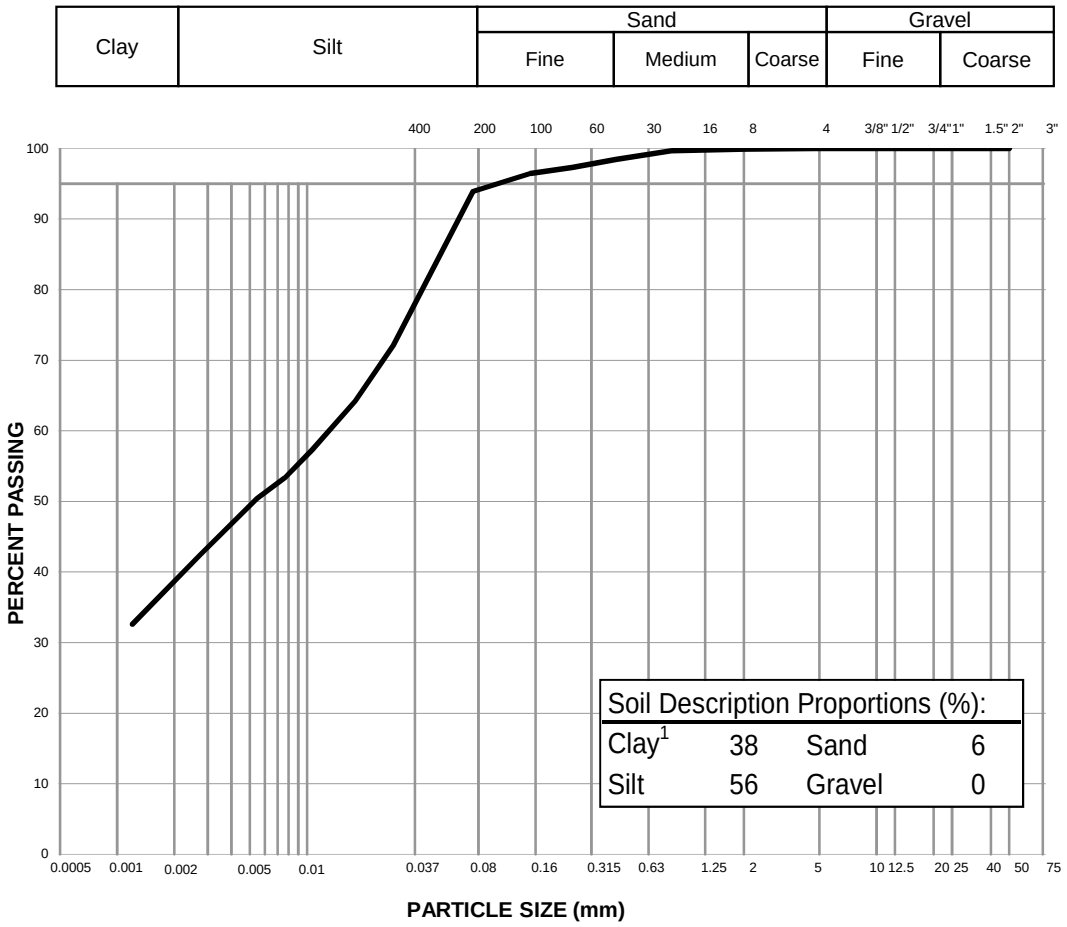
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29607
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	3.5-3.9 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 20, 2018 By: JPC	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, trace sand.	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	45.5%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	100
12.5	100
9.5	100
4.75	100
2	100
0.83	100
0.425	98
0.25	97
0.15	96
0.075	93.9
0.0285	72.1
0.0180	64.2
0.0106	57.3
0.0076	53.4
0.0054	50.4
0.0027	42.5
0.0012	32.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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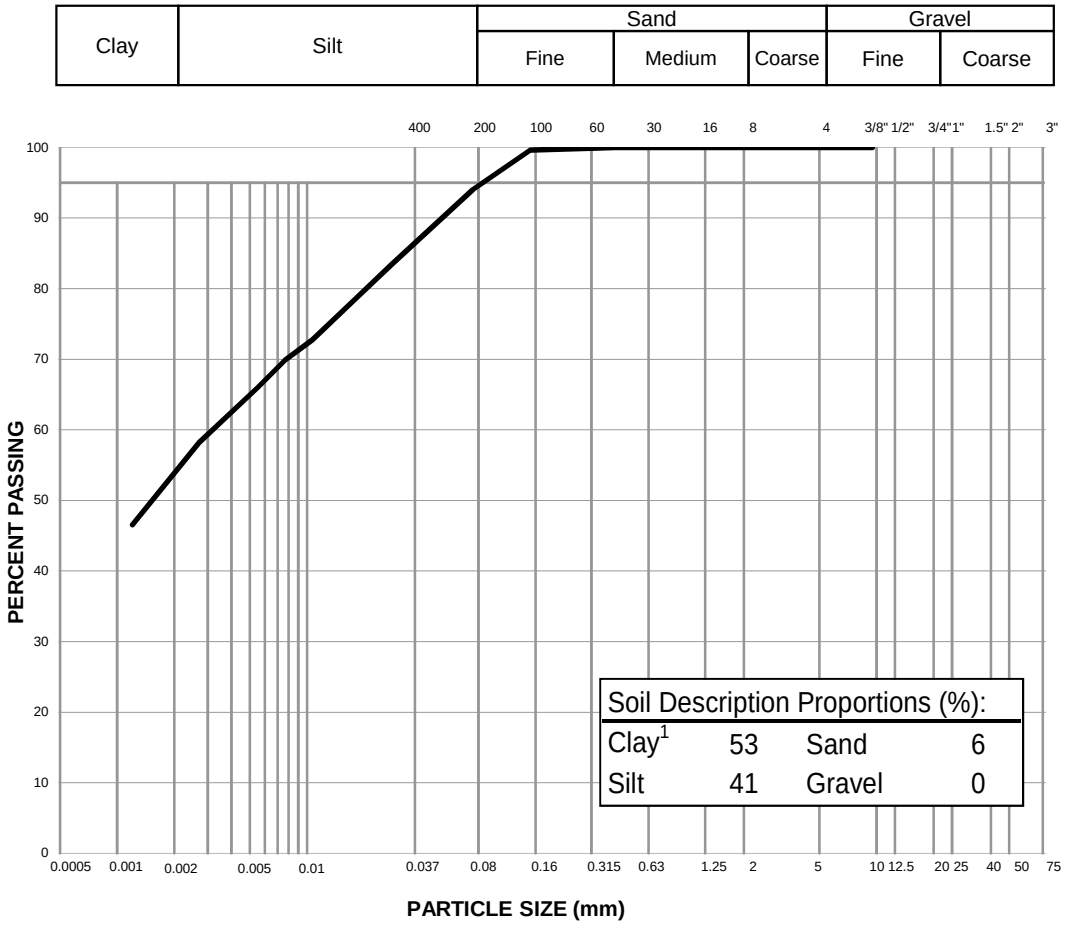
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29609
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	SRK18-STH-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	17.0-18.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 5, 2018 By: JPC/SS	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	44.5%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	100
0.25	100
0.15	100
0.075	94.0
0.0278	83.4
0.0180	78.6
0.0107	72.7
0.0076	69.8
0.0055	66.0
0.0027	58.2
0.0012	46.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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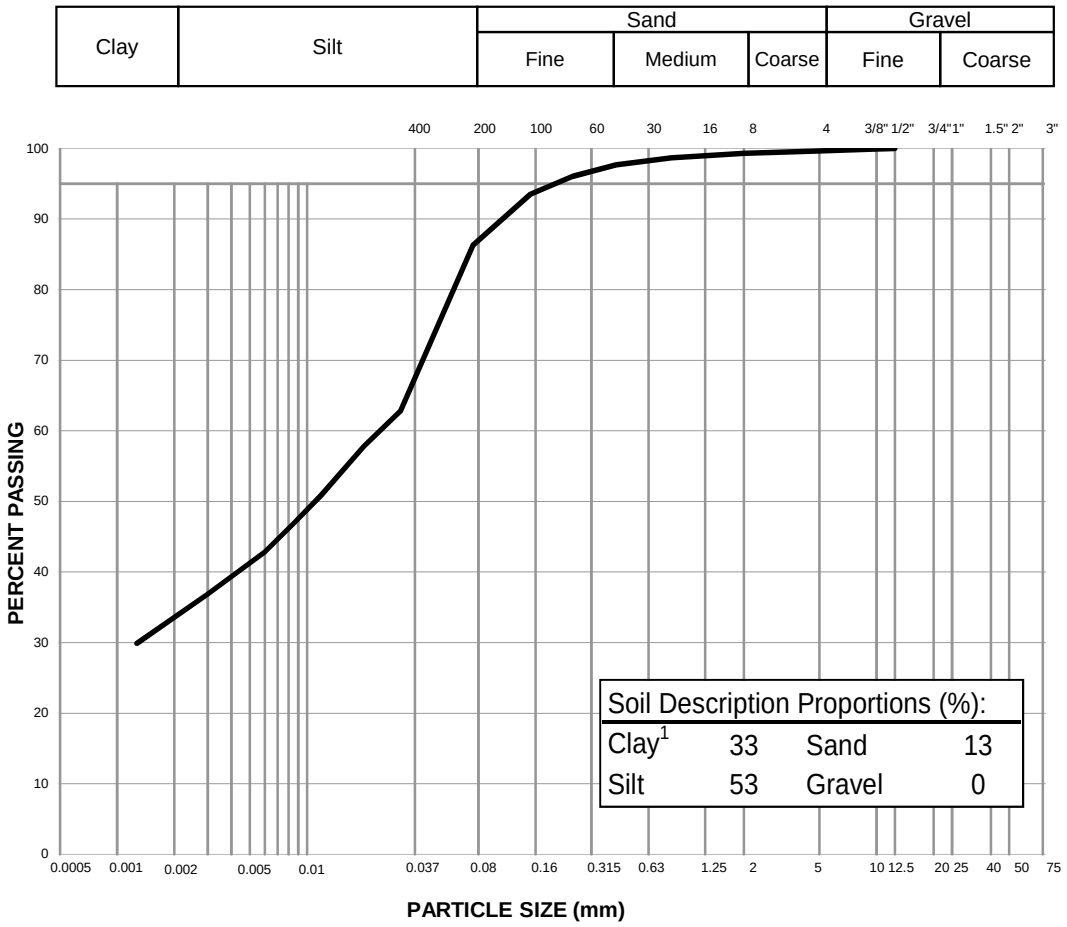
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29610
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	SRK18-STH-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	21.5-22.8 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 5, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	33.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	100
9.5	100
4.75	100
2	99
0.83	99
0.425	98
0.25	96
0.15	94
0.075	86.3
0.0310	62.8
0.0199	57.8
0.0118	50.8
0.0085	46.8
0.0060	42.8
0.0030	36.9
0.0013	29.9



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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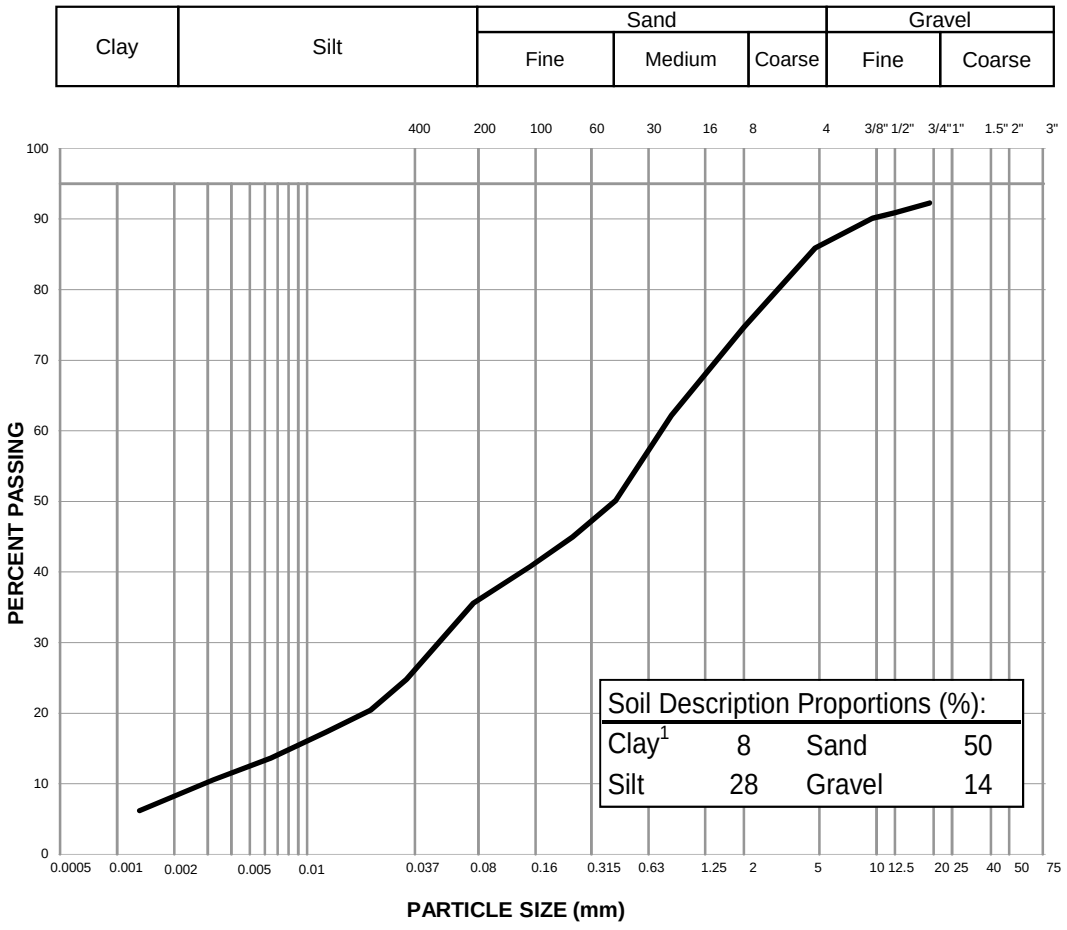
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29611
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	25.2-25.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SAND, silty, some gravel, trace clay.	Sampled By:	Client
		USC Classification:	SM Cu: 254.7
Moisture Content:	11.4%		Cc: 1.3

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	92
12.5	91
9.5	90
4.75	86
2	75
0.83	62
0.425	50
0.25	45
0.15	41
0.075	35.5
0.0334	24.8
0.0216	20.5
0.0127	17.4
0.0090	15.5
0.0064	13.6
0.0032	10.5
0.0013	6.2



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

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Remarks: _____

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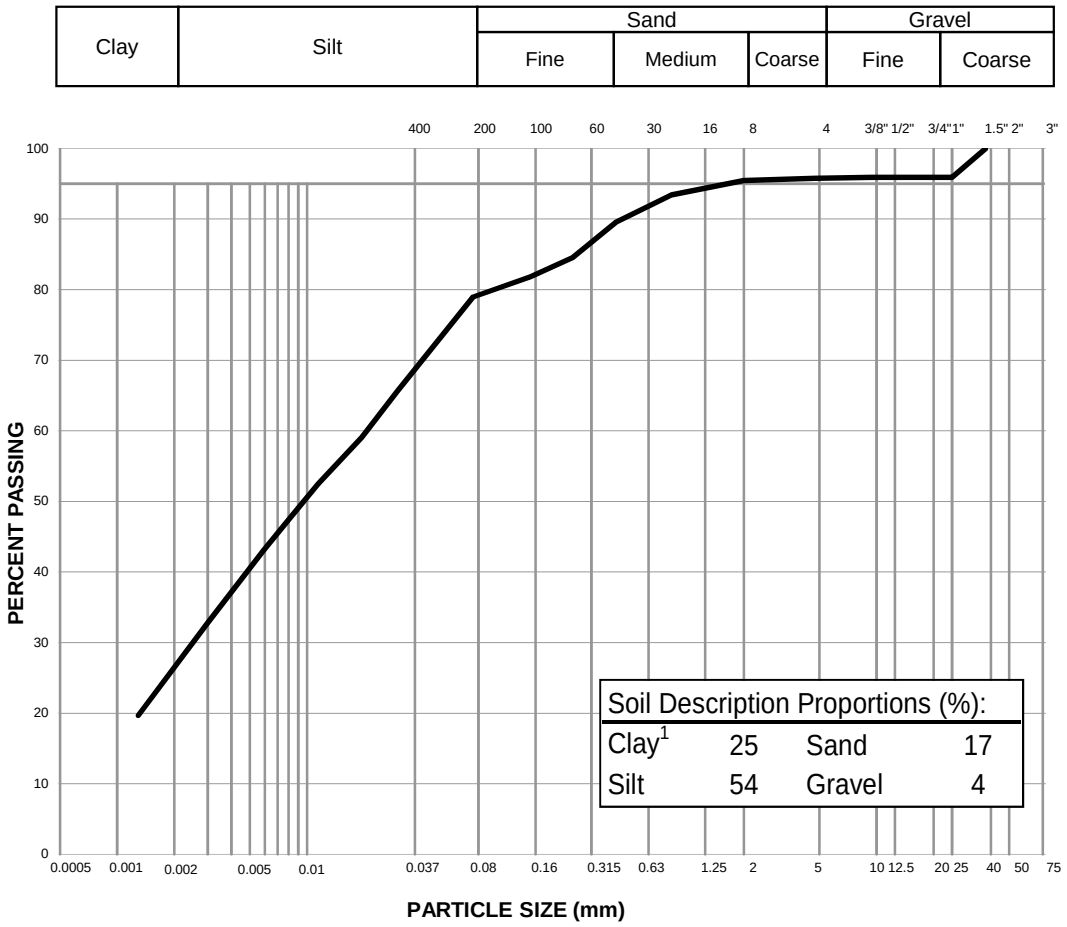
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29612
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-10
Client:	TMAC Resources Inc.	Sample Depth:	0.3-0.7 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 25, 2018 By: JPC	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, some sand, trace gravel	Sampled By:	Client
		USC Classification:	ML Cu: #N/A
Moisture Content:	45.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	100
25	96
19	96
12.5	96
9.5	96
4.75	96
2	95
0.83	93
0.425	90
0.25	85
0.15	82
0.075	79.0
0.0299	65.6
0.0194	59.0
0.0115	52.5
0.0082	47.8
0.0059	43.1
0.0030	32.8
0.0013	19.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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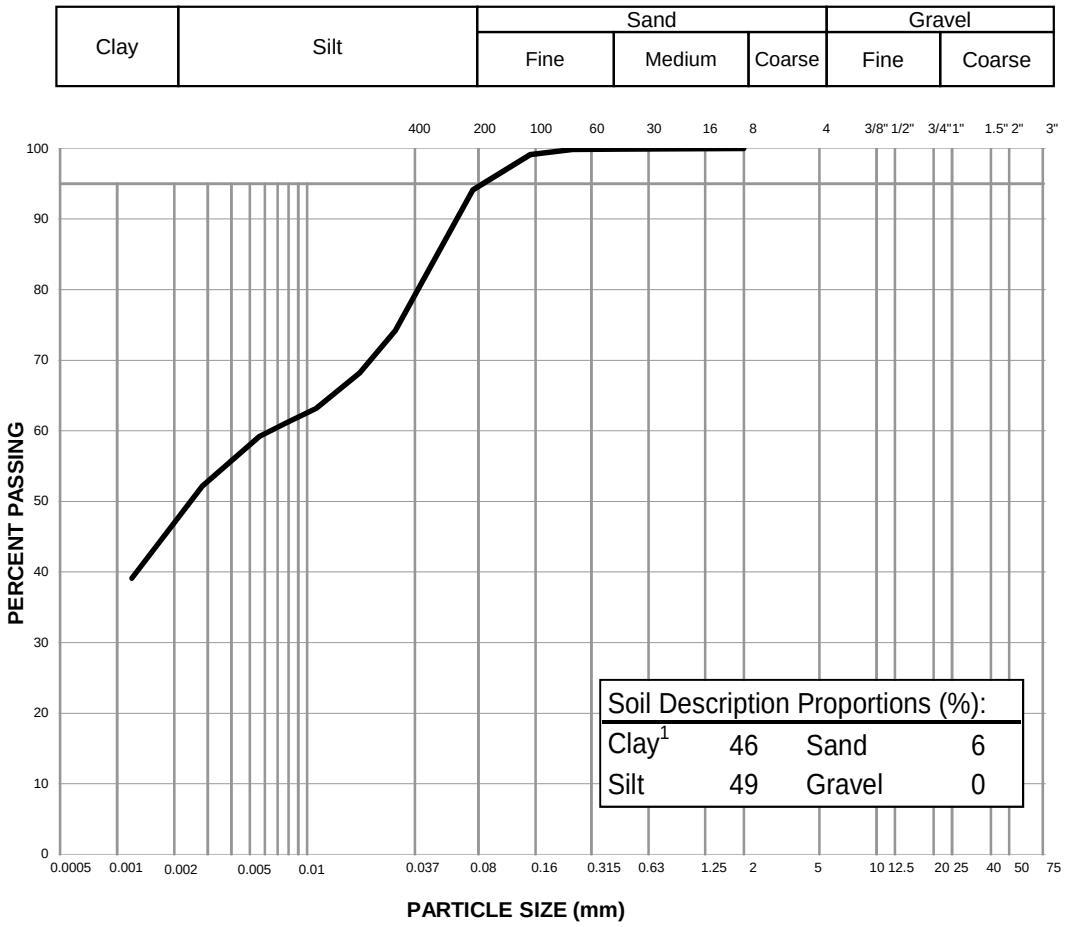
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29613
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-10
Client:	TMAC Resources Inc.	Sample Depth:	3.5-3.9 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 2, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	39.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	100
0.83	100
0.425	100
0.25	100
0.15	99
0.075	94.2
0.0293	74.2
0.0190	68.2
0.0112	63.2
0.0079	61.2
0.0056	59.2
0.0028	52.2
0.0012	39.1



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks:

Reviewed By: P.Geol

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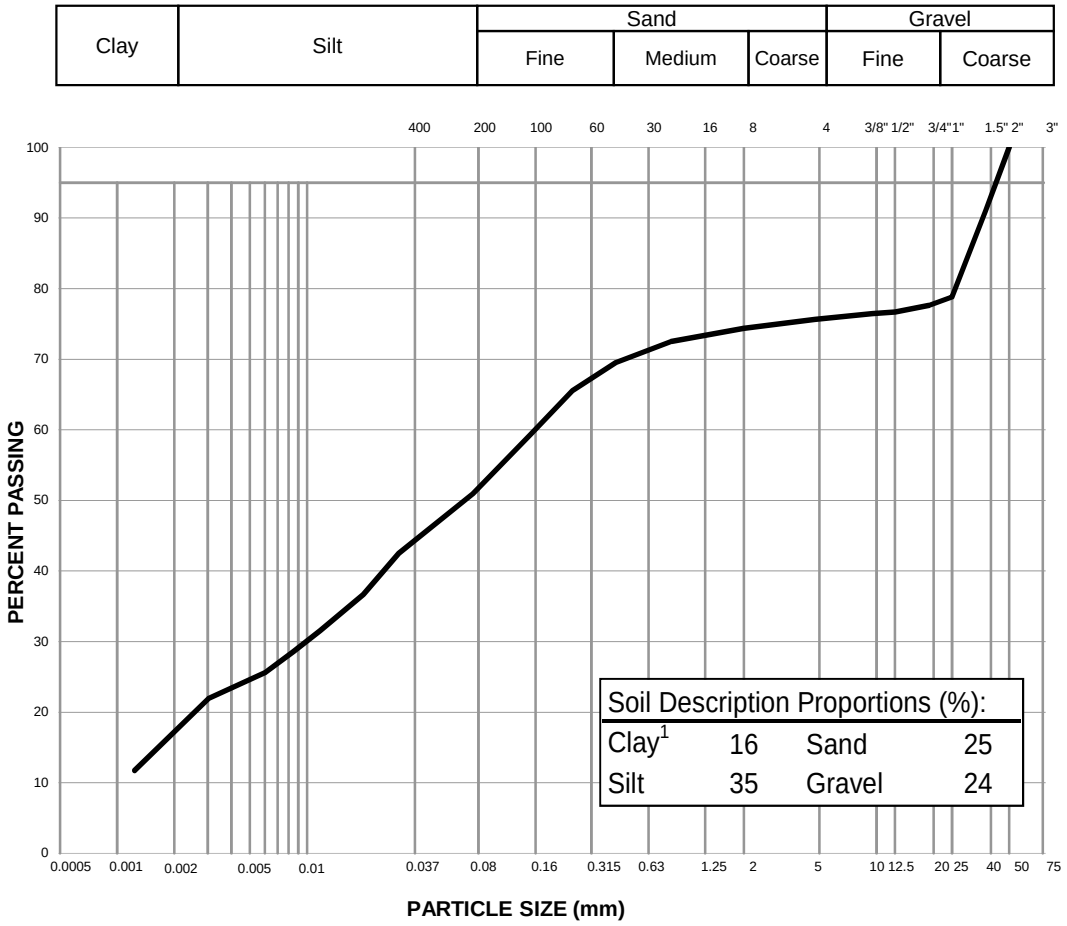
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29614
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-10
Client:	TMAC Resources Inc.	Sample Depth:	5.8-6.1 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 25, 2018
Soil Description[2]:	SILT, sandy, gravelly, some clay	Sampled By:	Client
		USC Classification:	ML Cu: #N/A
Moisture Content:	19.4%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	91
25	79
19	78
12.5	77
9.5	76
4.75	76
2	74
0.83	73
0.425	70
0.25	66
0.15	59
0.075	51.0
0.0304	42.5
0.0198	36.7
0.0117	31.5
0.0085	28.6
0.0061	25.7
0.0030	22.0
0.0012	11.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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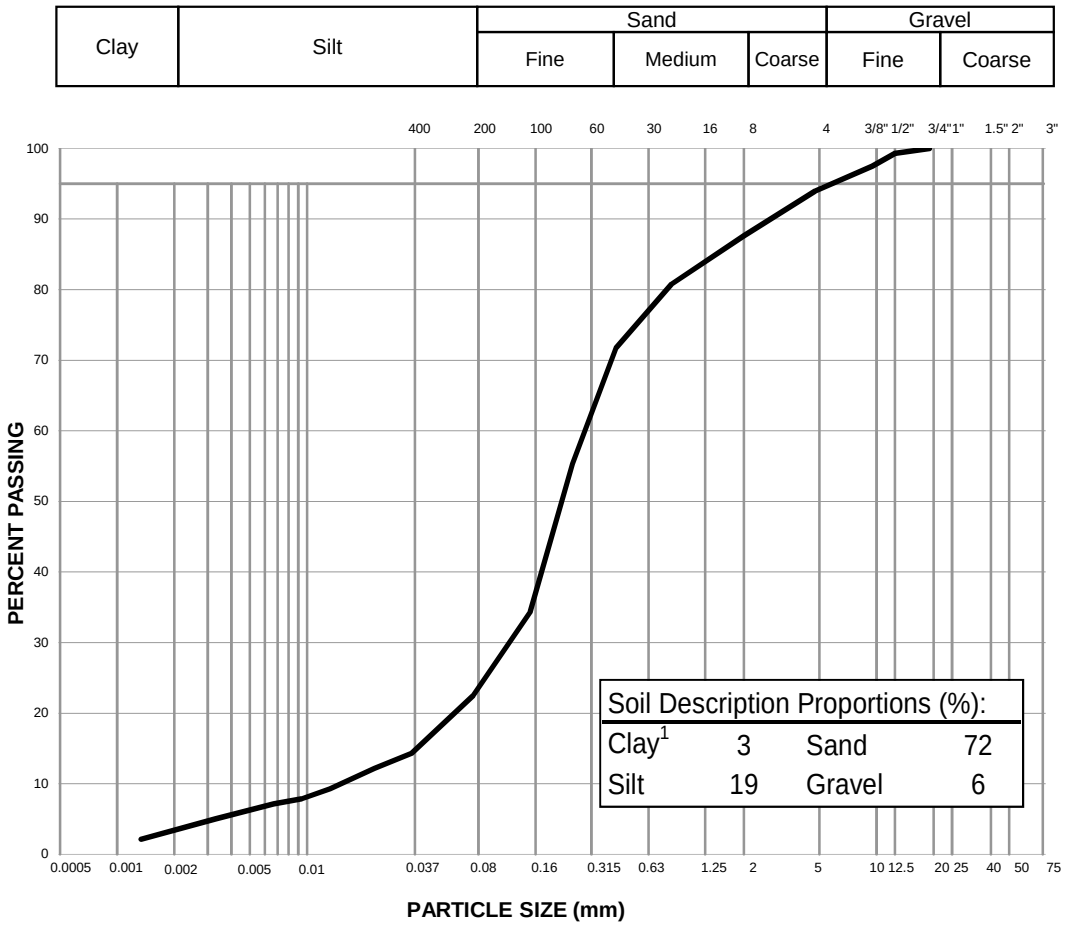
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29615
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-10
Client:	TMAC Resources Inc.	Sample Depth:	7.0-7.4 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SAND, some silt, trace gravel, trace clay.	Sampled By:	Client
		USC Classification:	SM Cu: 19.3
Moisture Content:	19.0%		Cc: 3.2

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	99
9.5	98
4.75	94
2	88
0.83	81
0.425	72
0.25	55
0.15	34
0.075	22.5
0.0356	14.3
0.0226	12.2
0.0132	9.3
0.0094	7.9
0.0067	7.2
0.0033	5.0
0.0013	2.1



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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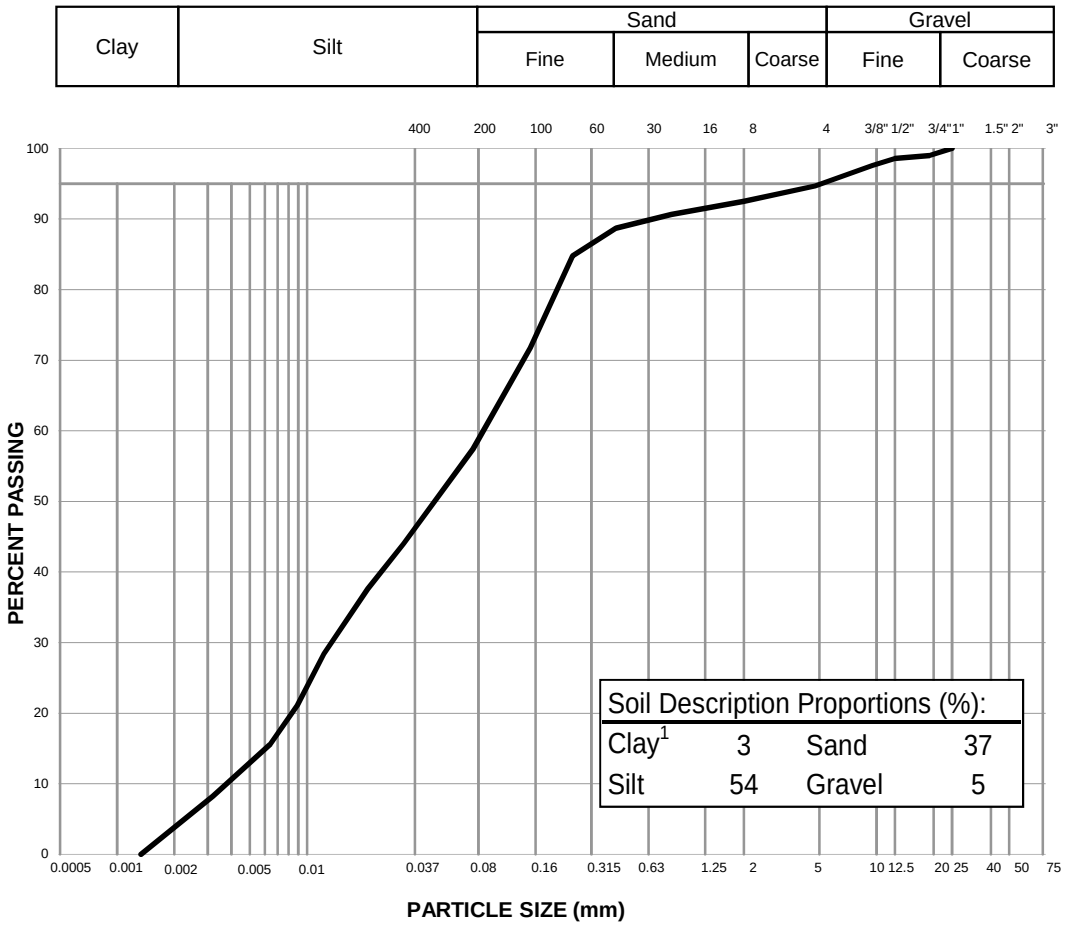
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29616
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-08
Client:	TMAC Resources Inc.	Sample Depth:	0.9-1.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 2, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SILT and SAND, trace gravel, trace clay	Sampled By:	Client
		USC Classification:	ML Cu: 22.4
Moisture Content:	55.9%		Cc: 0.5

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	100
19	99
12.5	99
9.5	98
4.75	95
2	93
0.83	91
0.425	89
0.25	85
0.15	72
0.075	57.4
0.0323	44.0
0.0209	37.6
0.0123	28.4
0.0089	21.1
0.0064	15.6
0.0032	8.3
0.0013	0.0



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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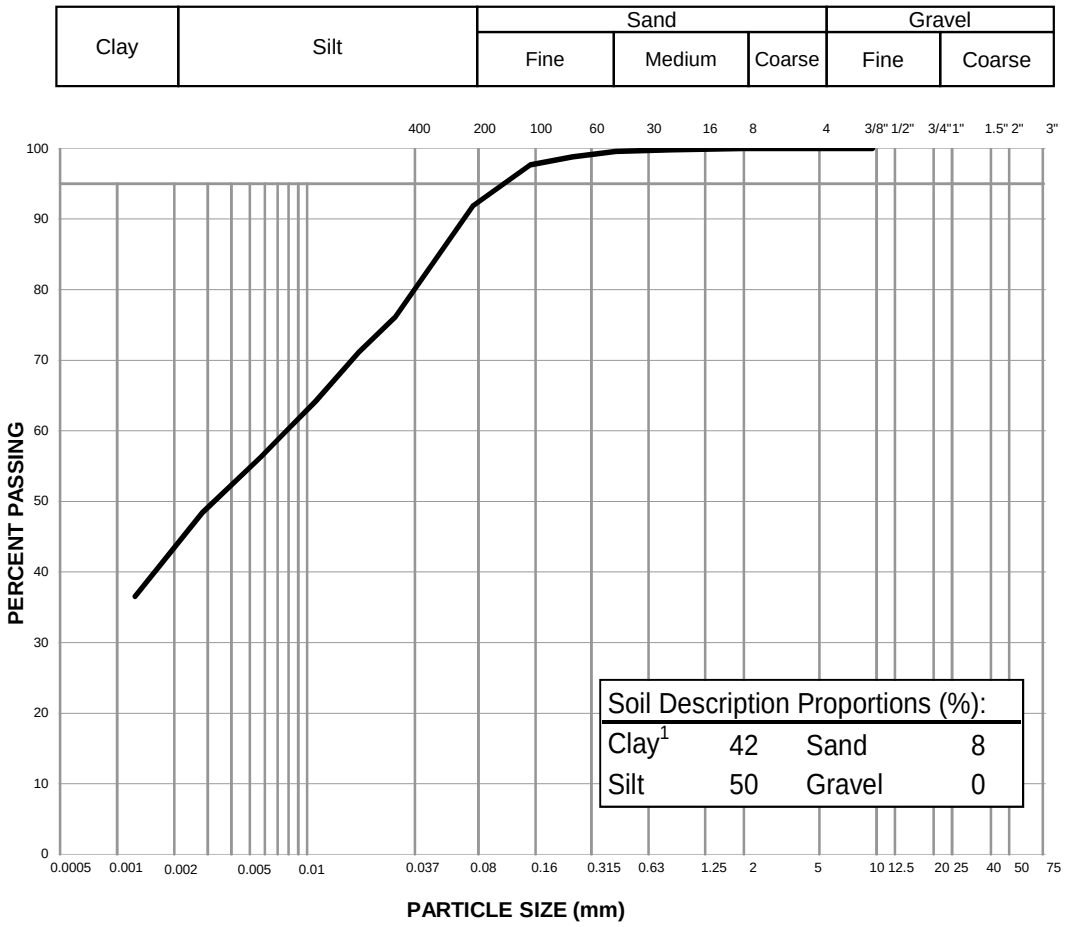
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29619
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-08
Client:	TMAC Resources Inc.	Sample Depth:	12.7-13.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 5, 2018 By: JPC/SS	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	45.6%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	100
0.25	99
0.15	98
0.075	91.9
0.0290	76.0
0.0187	71.1
0.0111	64.2
0.0080	60.2
0.0057	56.3
0.0028	48.4
0.0012	36.5



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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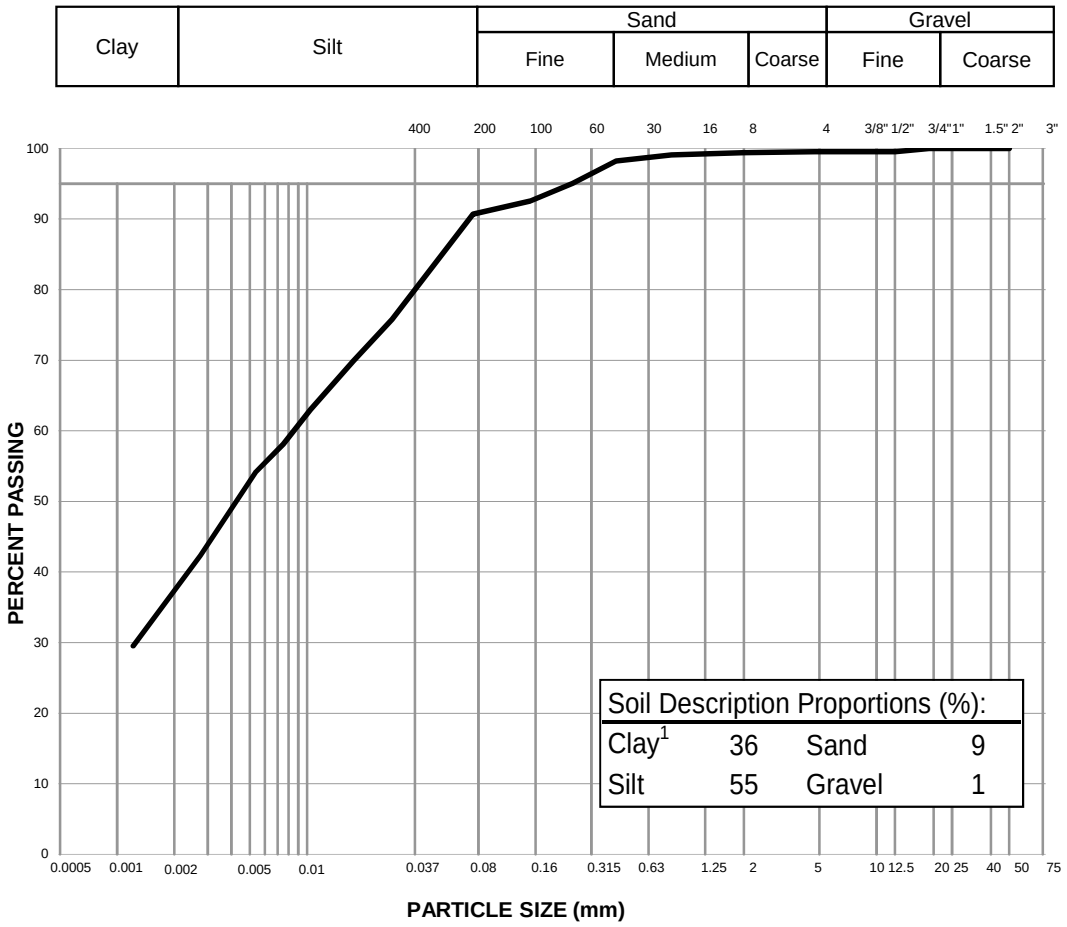
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29621
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-11
Client:	TMAC Resources Inc.	Sample Depth:	2.2-3.4 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 20, 2018 By: JPC	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, trace sand, trace gravel	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	46.4%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	100
12.5	100
9.5	100
4.75	100
2	99
0.83	99
0.425	98
0.25	95
0.15	93
0.075	90.7
0.0281	75.8
0.0176	69.9
0.0104	63.0
0.0075	58.1
0.0054	54.1
0.0027	42.3
0.0012	29.5



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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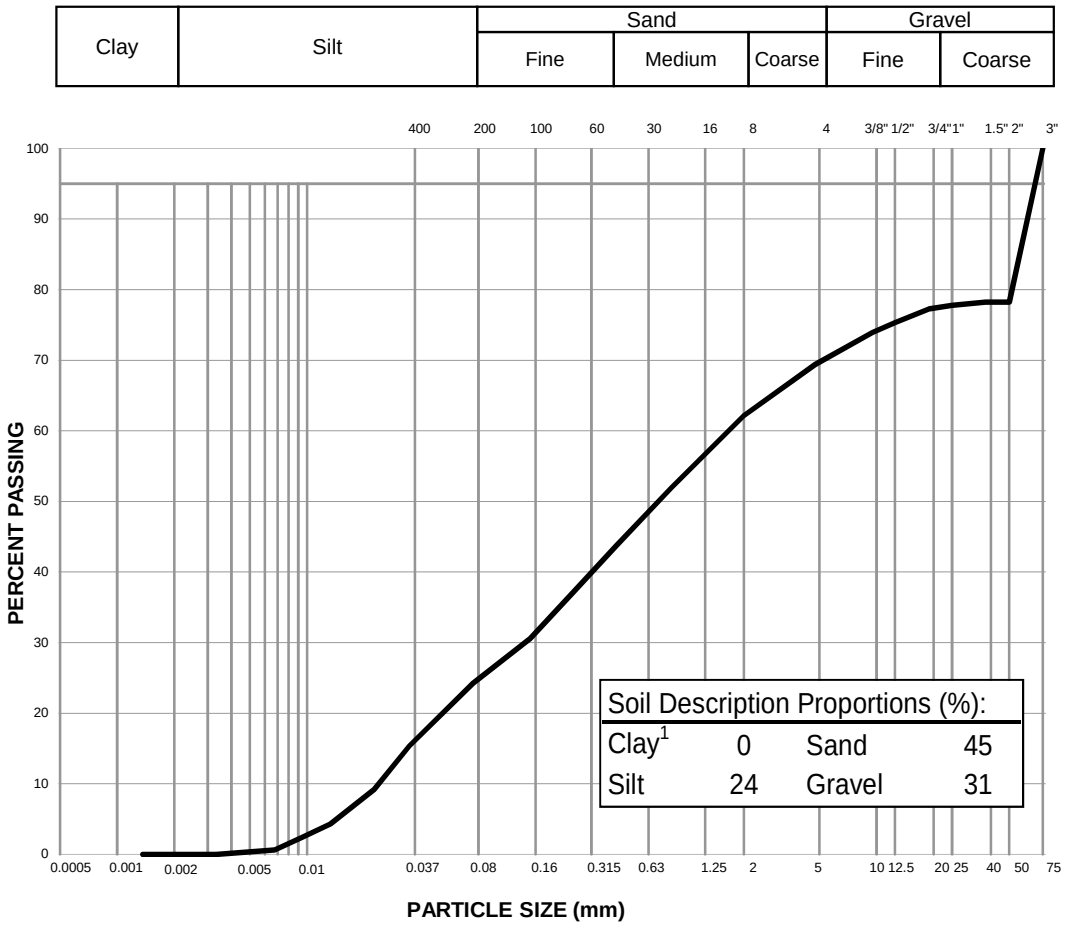
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29622
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-11
Client:	TMAC Resources Inc.	Sample Depth:	9.5-10.8 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 25, 2018 By: JPC	Date sampled:	February 25, 2018
Soil Description[2]:	SAND, gravelly, silty	Sampled By:	Client
		USC Classification:	SM Cu: 72.8
Moisture Content:	6.5%		Cc: 0.5

Particle Size (mm)	Percent Passing
75	100
50	78
37.5	78
25	78
19	77
12.5	75
9.5	74
4.75	69
2	62
0.83	52
0.425	44
0.25	37
0.15	31
0.075	24.3
0.0346	15.4
0.0225	9.2
0.0133	4.3
0.0095	2.5
0.0067	0.6
0.0033	0.0
0.0014	0.0



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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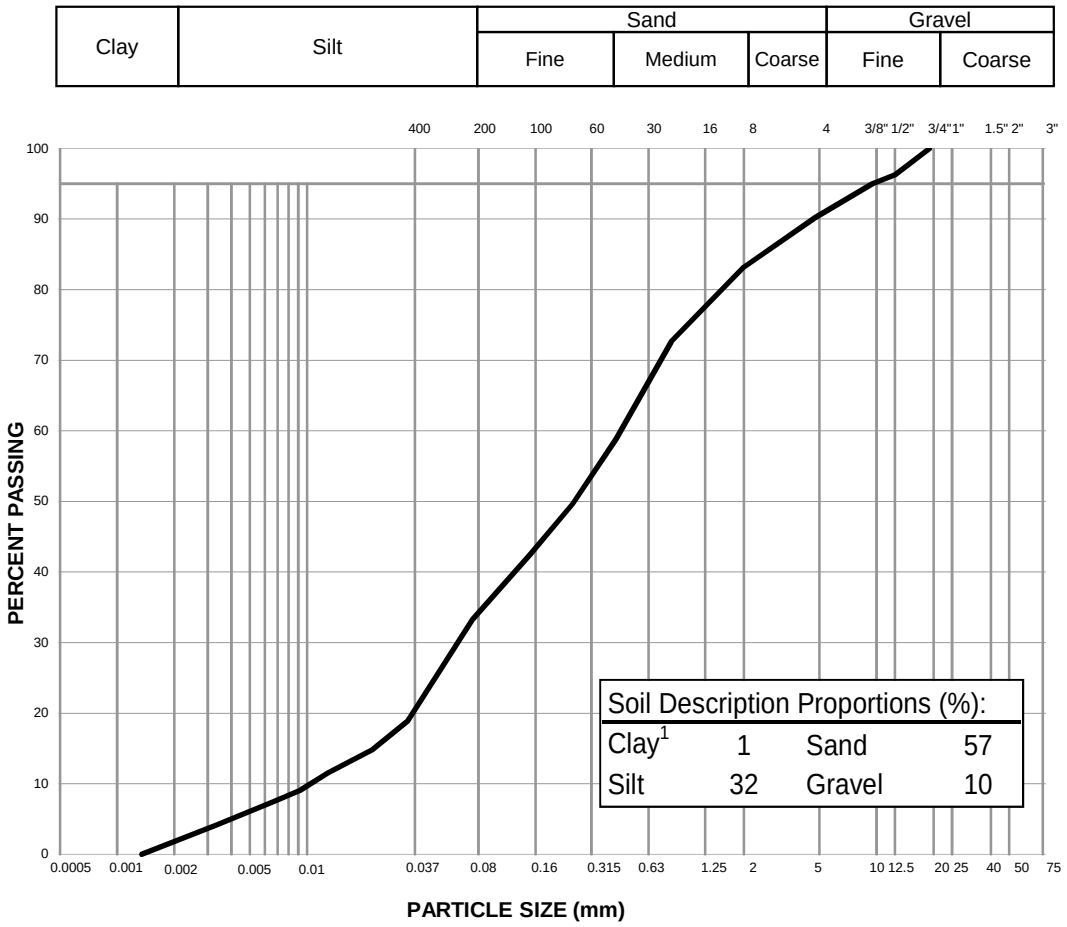
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29623
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-11
Client:	TMAC Resources Inc.	Sample Depth:	11.2-14.7 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 12, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SAND, SILT, trace gravel, trace clay	Sampled By:	Client
		USC Classification:	SM Cu: 43.4
Moisture Content:	11.1%		Cc: 0.9

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	96
9.5	95
4.75	90
2	83
0.83	73
0.425	59
0.25	50
0.15	42
0.075	33.3
0.0340	18.9
0.0221	14.8
0.0129	11.5
0.0092	9.1
0.0066	7.4
0.0033	4.1
0.0013	0.0



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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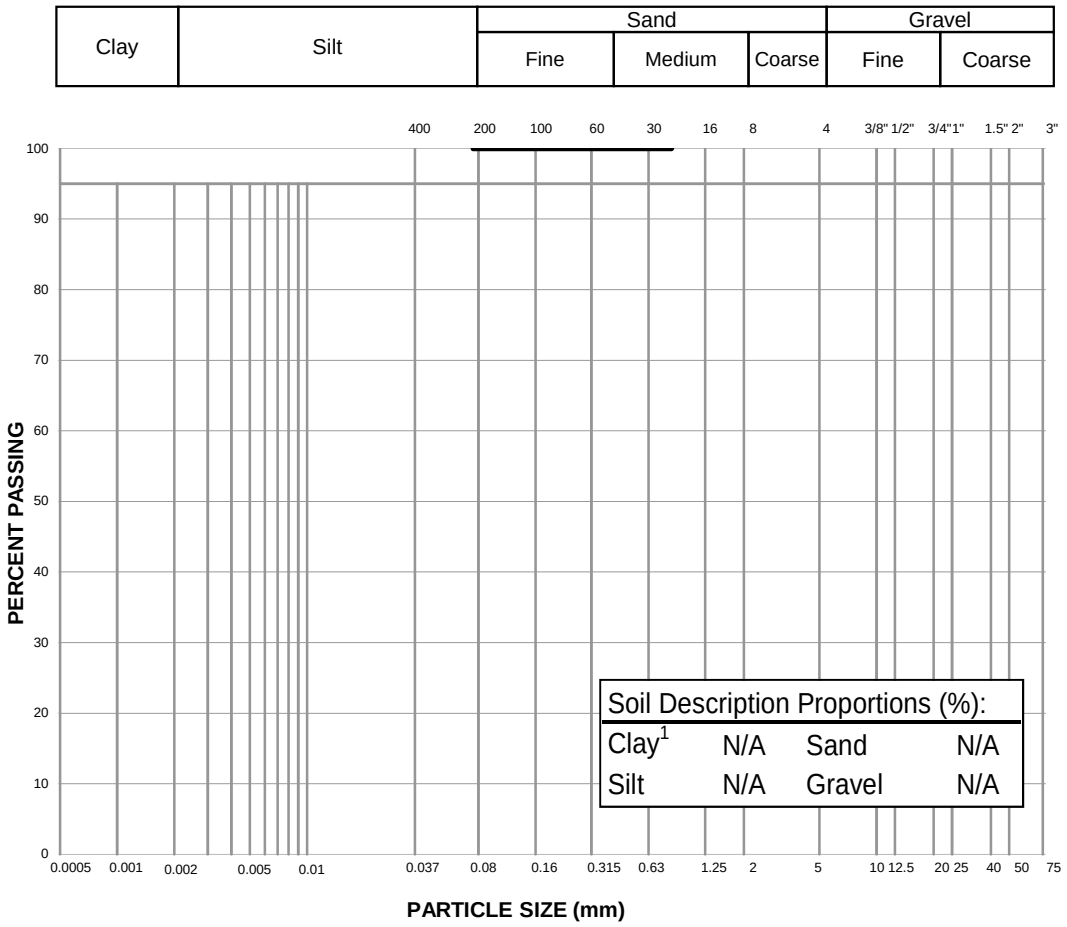
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29624
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-07
Client:	TMAC Resources Inc.	Sample Depth:	1.1-2.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 27, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	Peat.	Sampled By:	Client
		USC Classification:	Cu: #N/A
Moisture Content:	274.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	
0.83	100
0.425	100
0.25	100
0.15	100
0.075	100.0
0.0296	
0.0194	
0.0116	
0.0083	
0.0059	
0.0029	
0.0012	



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks: Sample is peat. Particle Size Analysis not possible.

Reviewed By: _____ P.Geol

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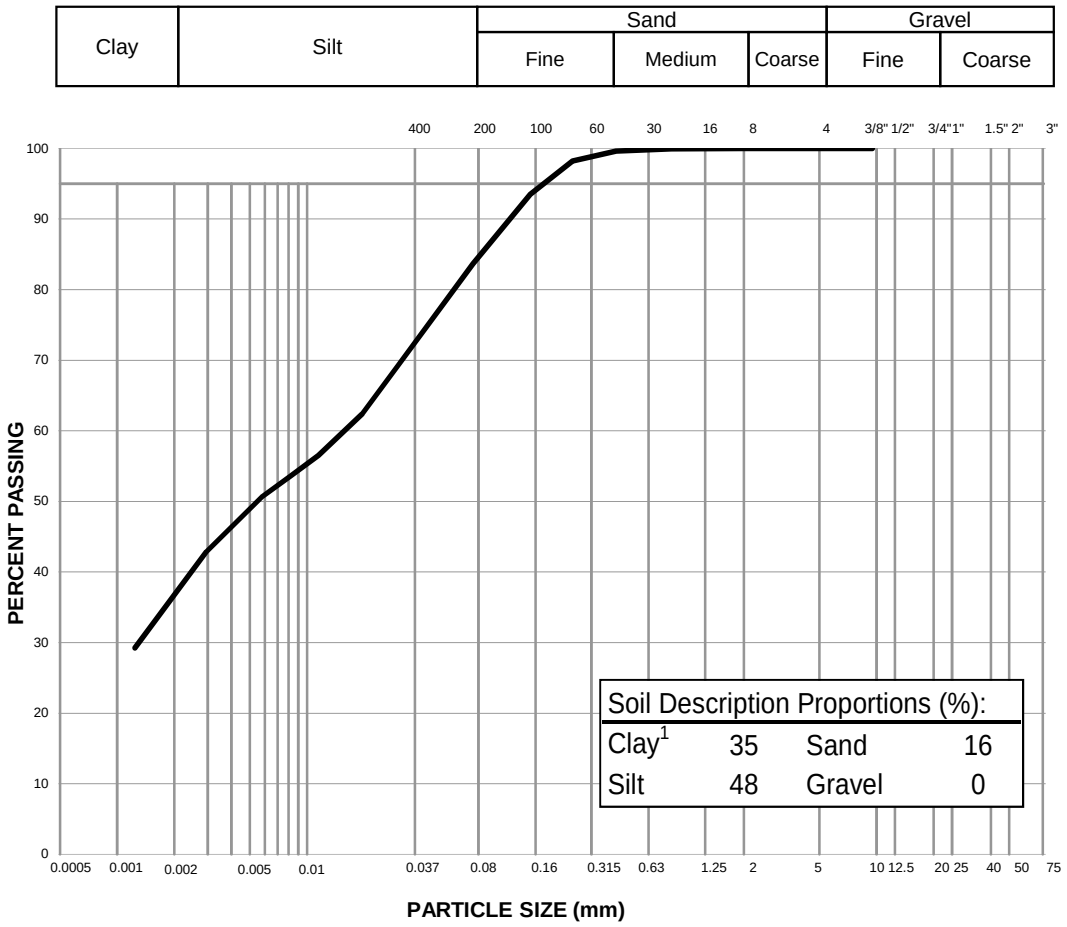
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29625
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-07
Client:	TMAC Resources Inc.	Sample Depth:	5.2-6.7 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	26.9%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	100
0.25	98
0.15	94
0.075	83.7
0.0301	69.2
0.0195	62.4
0.0115	56.5
0.0082	53.6
0.0058	50.7
0.0030	42.9
0.0012	29.2



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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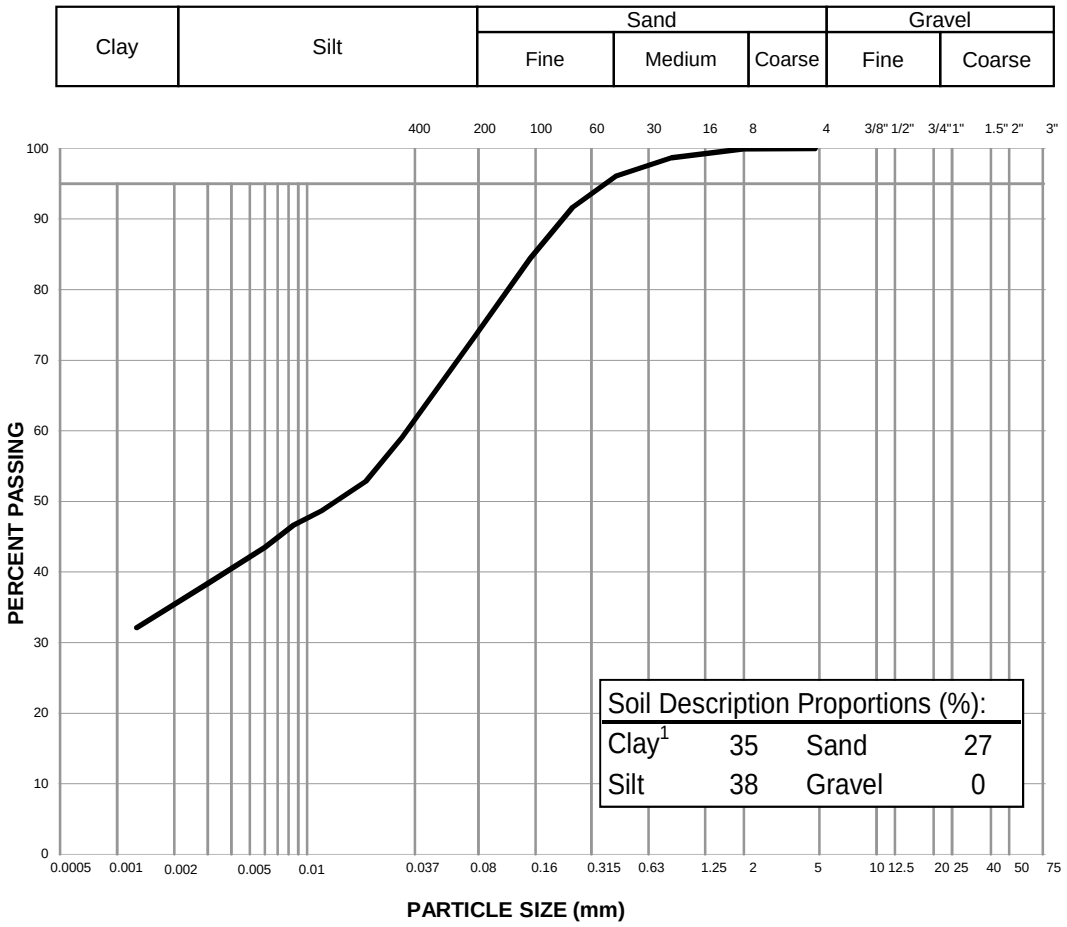
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29627
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	SRK18-STH-DH-07
Client:	TMAC Resources Inc.	Sample Depth:	20.4-21.7 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 5, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, sandy	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	42.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	100
2	100
0.83	99
0.425	96
0.25	92
0.15	84
0.075	73.0
0.0316	59.0
0.0204	52.8
0.0120	48.7
0.0085	46.6
0.0060	43.5
0.0030	38.3
0.0013	32.1



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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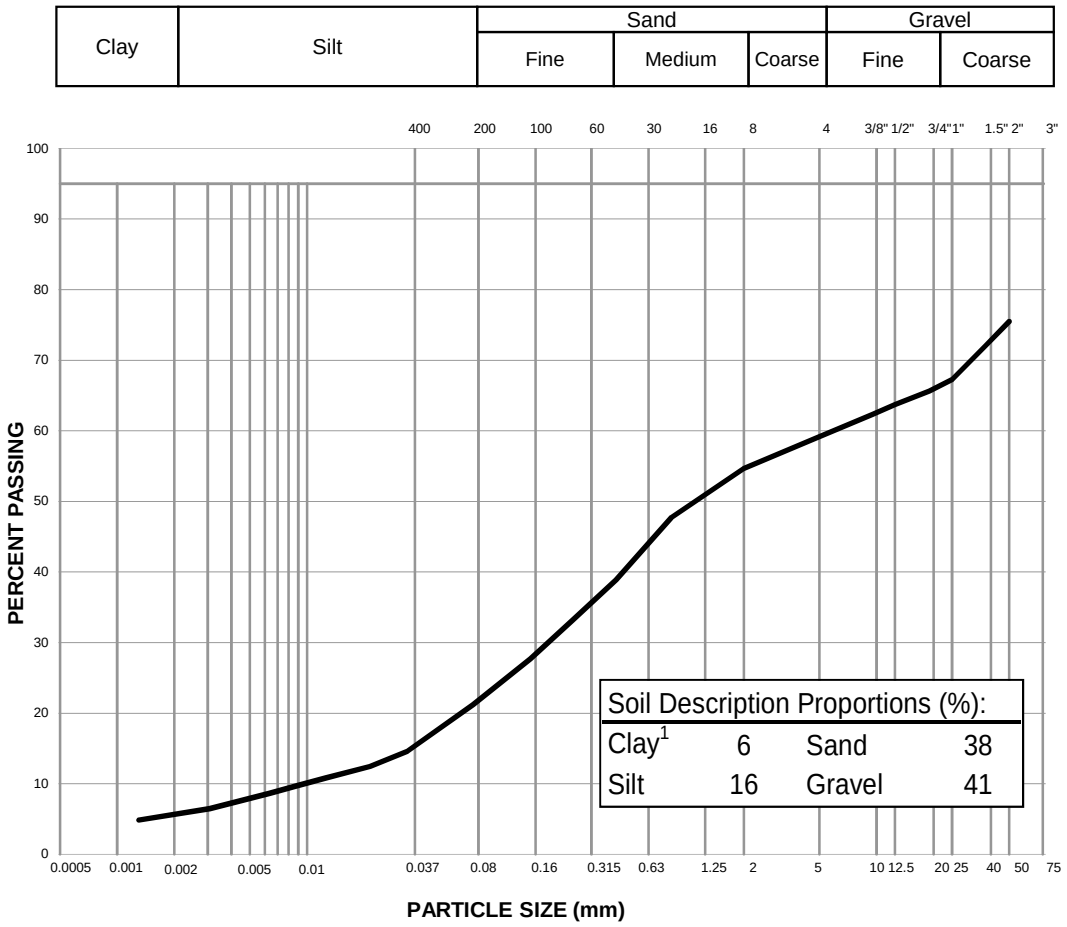
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29628
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-07
Client:	TMAC Resources Inc.	Sample Depth:	26.3-27.2 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 14, 2018 By: JPC	Date sampled:	February 25, 2018
Soil Description[2]:	GRAVEL and SAND, some silt,trace clay	Sampled By:	Client
		USC Classification:	GP Cu: 639.1
Moisture Content:	10.1%		Cc: 0.6

Particle Size (mm)	Percent Passing
75	
50	75
37.5	72
25	67
19	66
12.5	64
9.5	62
4.75	59
2	55
0.83	48
0.425	39
0.25	33
0.15	28
0.075	21.2
0.0336	14.6
0.0215	12.4
0.0125	10.8
0.0089	9.7
0.0063	8.7
0.0031	6.5
0.0013	4.9



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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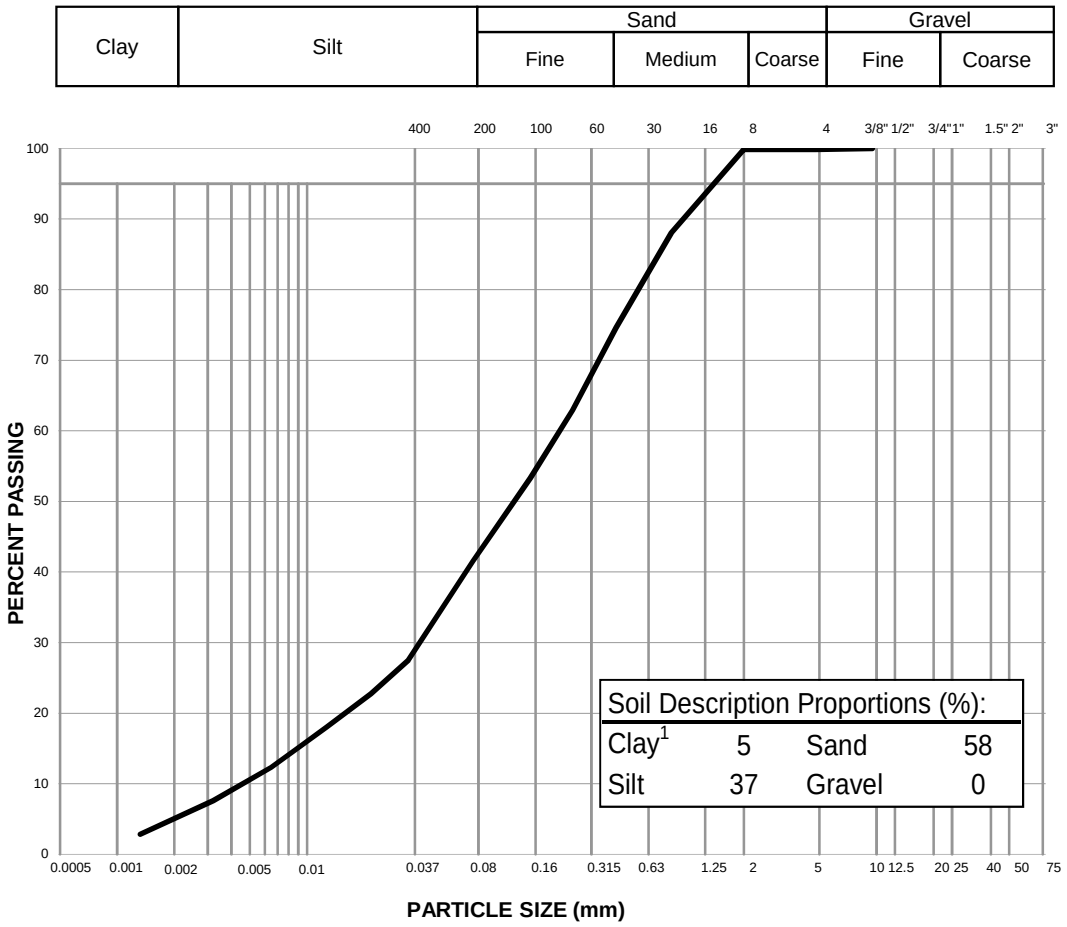
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29629
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-07
Client:	TMAC Resources Inc.	Sample Depth:	31.0-32.2 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 2, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	SAND and SILT, trace clay	Sampled By:	Client
		USC Classification:	SM Cu: 45.2
Moisture Content:	7.2%		Cc: 1.6

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	88
0.425	75
0.25	63
0.15	53
0.075	41.6
0.0342	27.5
0.0217	22.8
0.0127	18.0
0.0091	15.2
0.0065	12.3
0.0032	7.6
0.0013	2.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

_____

Reviewed By: _____ P.Geol

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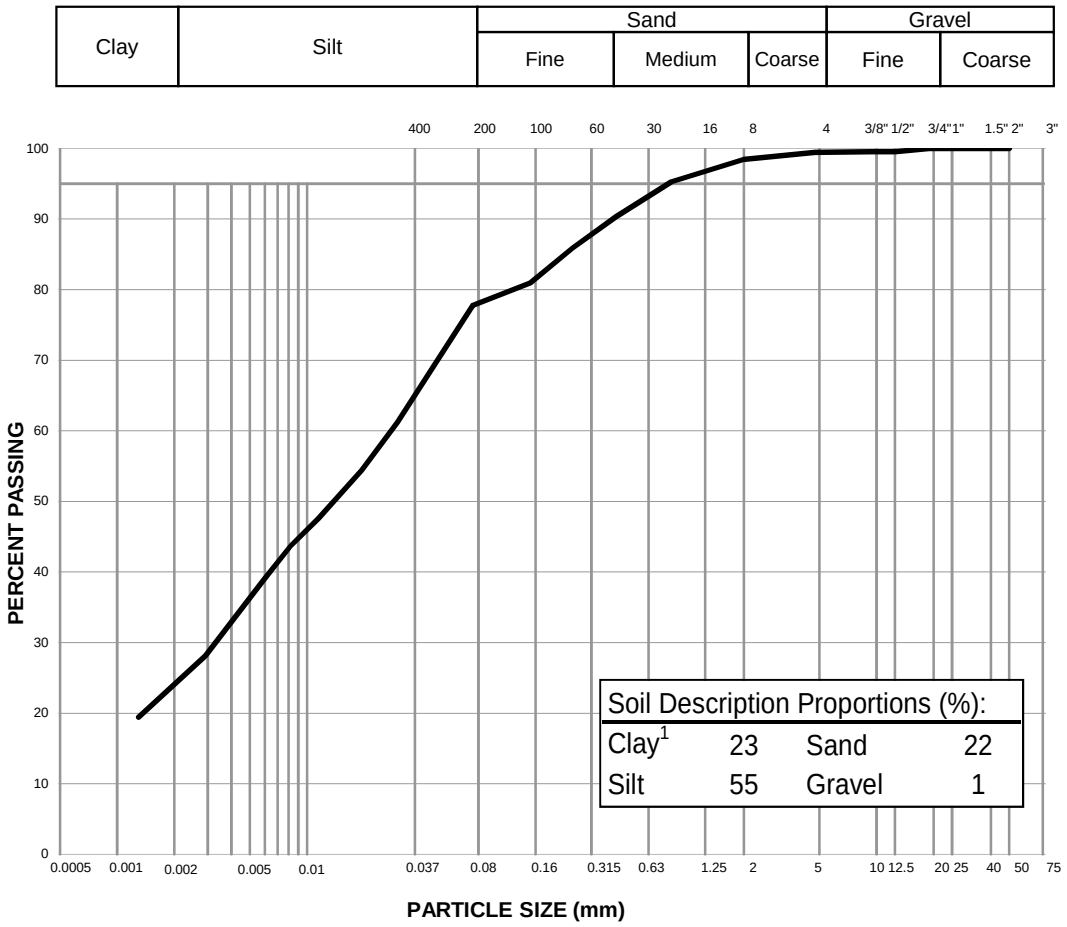
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29631
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-09
Client:	TMAC Resources Inc.	Sample Depth:	0.3-0.9 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 22, 2018 By: JPC	Date sampled:	February 26, 2018
Soil Description[2]:	CLAY, silty, sandy, trace gravel	Sampled By:	Client
		USC Classification:	CI Cu: #N/A
Moisture Content:	42.1%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	100
12.5	100
9.5	100
4.75	99
2	98
0.83	95
0.425	90
0.25	86
0.15	81
0.075	77.8
0.0299	61.2
0.0194	54.4
0.0115	47.6
0.0082	43.7
0.0059	38.8
0.0029	28.2
0.0013	19.4



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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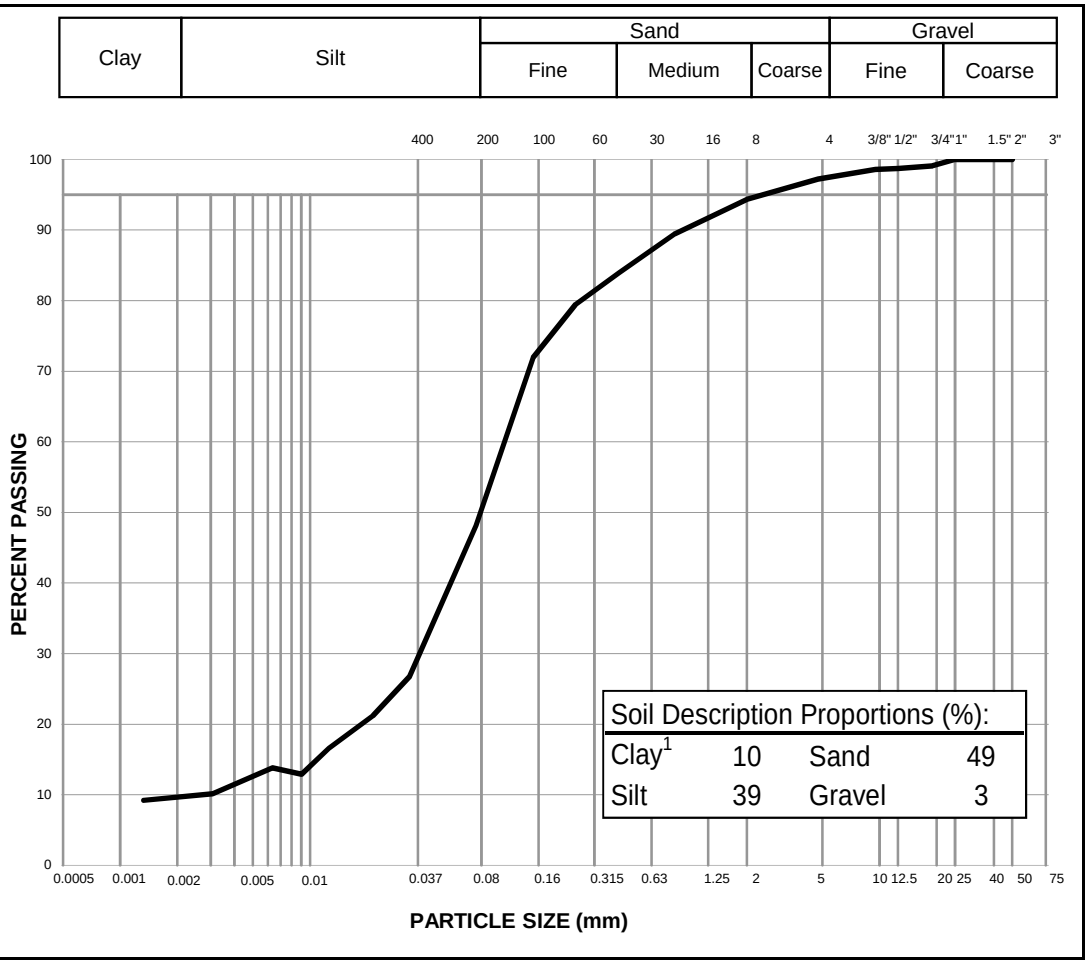
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29634
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-09
Client:	TMAC Resources Inc.	Sample Depth:	13.5-14.2 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 22, 2018 By: JPC	Date sampled:	February 26, 2018
Soil Description[2]:	SAND and SILT, trace clay, trace gravel	Sampled By:	Client
		USC Classification:	SM Cu: 40.1
Moisture Content:	13.3%		Cc: 5.0

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	99
12.5	99
9.5	99
4.75	97
2	94
0.83	89
0.425	84
0.25	79
0.15	72
0.075	48.1
0.0334	26.7
0.0215	21.2
0.0126	16.6
0.0090	12.9
0.0064	13.8
0.0031	10.1
0.0013	9.2



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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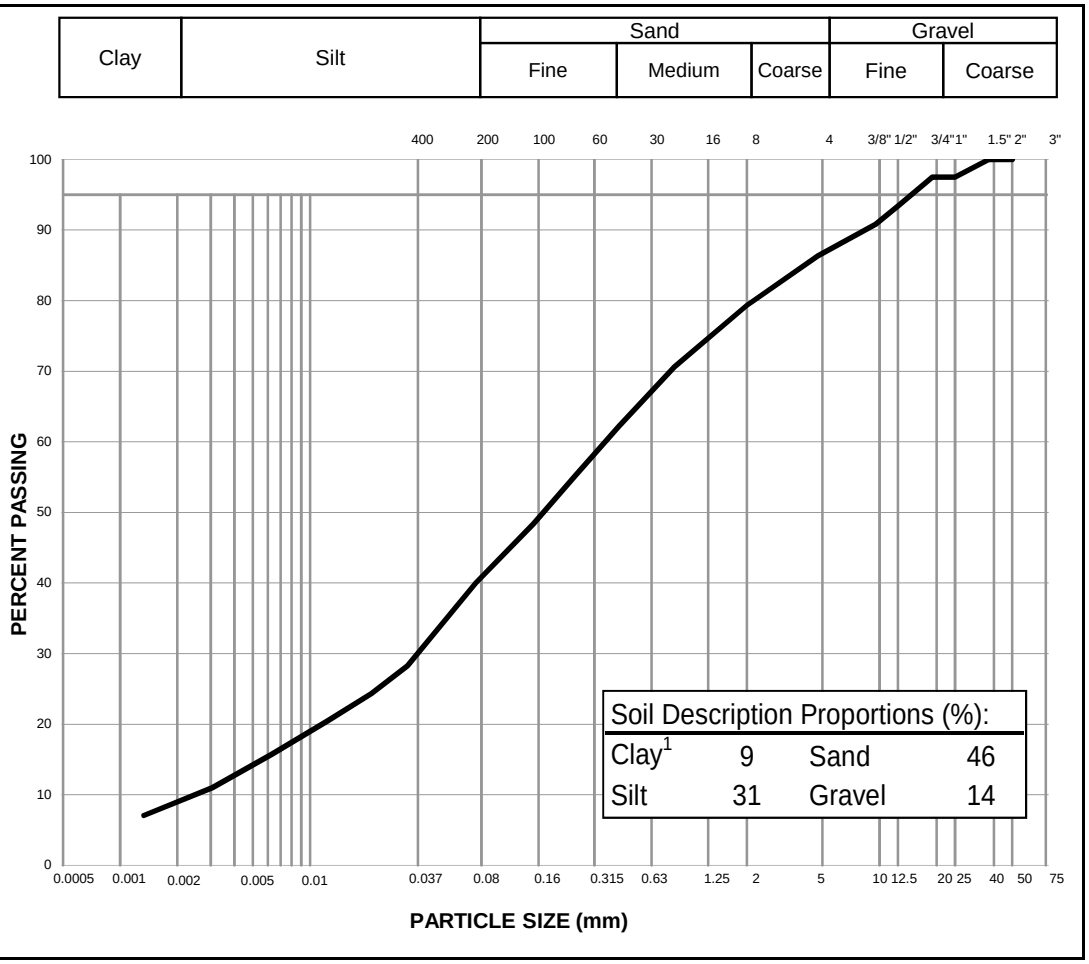
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29635
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-09
Client:	TMAC Resources Inc.	Sample Depth:	15.0-15.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 22, 2018 By: JPC	Date sampled:	February 26, 2018
Soil Description[2]:	SAND, silty, some gravel, trace clay	Sampled By:	Client
		USC Classification:	SM Cu: 141.0
Moisture Content:	8.4%		Cc: 1.6

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	98
19	98
12.5	93
9.5	91
4.75	86
2	79
0.83	71
0.425	62
0.25	55
0.15	48
0.075	40.0
0.0327	28.3
0.0210	24.3
0.0123	20.4
0.0088	18.1
0.0063	15.7
0.0031	11.0
0.0013	7.1



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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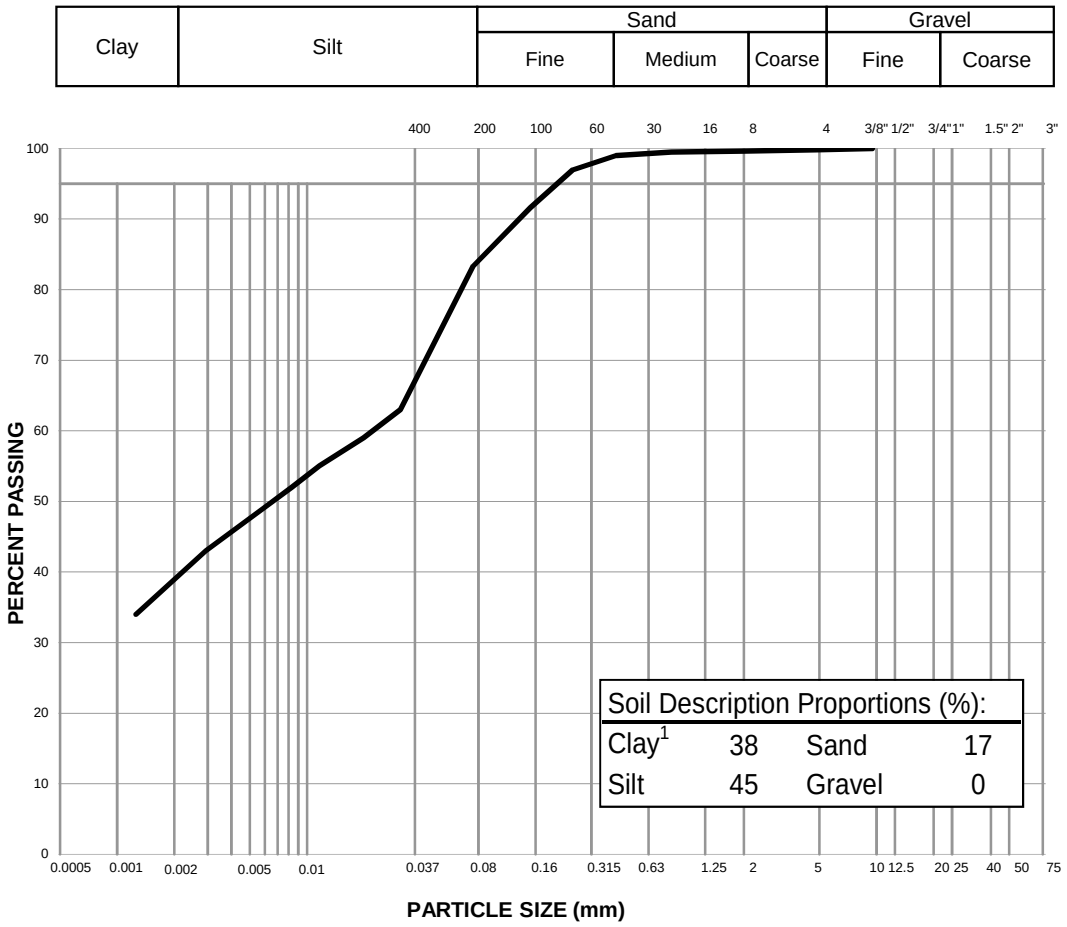
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29636
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay, NU	Sample Loc.:	SRK18-STH-DH-05
Client:	TMAC Resources Inc.	Sample Depth:	1.1-2.3 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 5, 2018 By: WM	Date sampled:	February 26, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	CI Cu: #N/A
Moisture Content:	53.8%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	99
0.425	99
0.25	97
0.15	92
0.075	83.3
0.0310	63.0
0.0199	59.0
0.0116	55.0
0.0083	52.0
0.0059	49.0
0.0029	43.0
0.0013	34.0



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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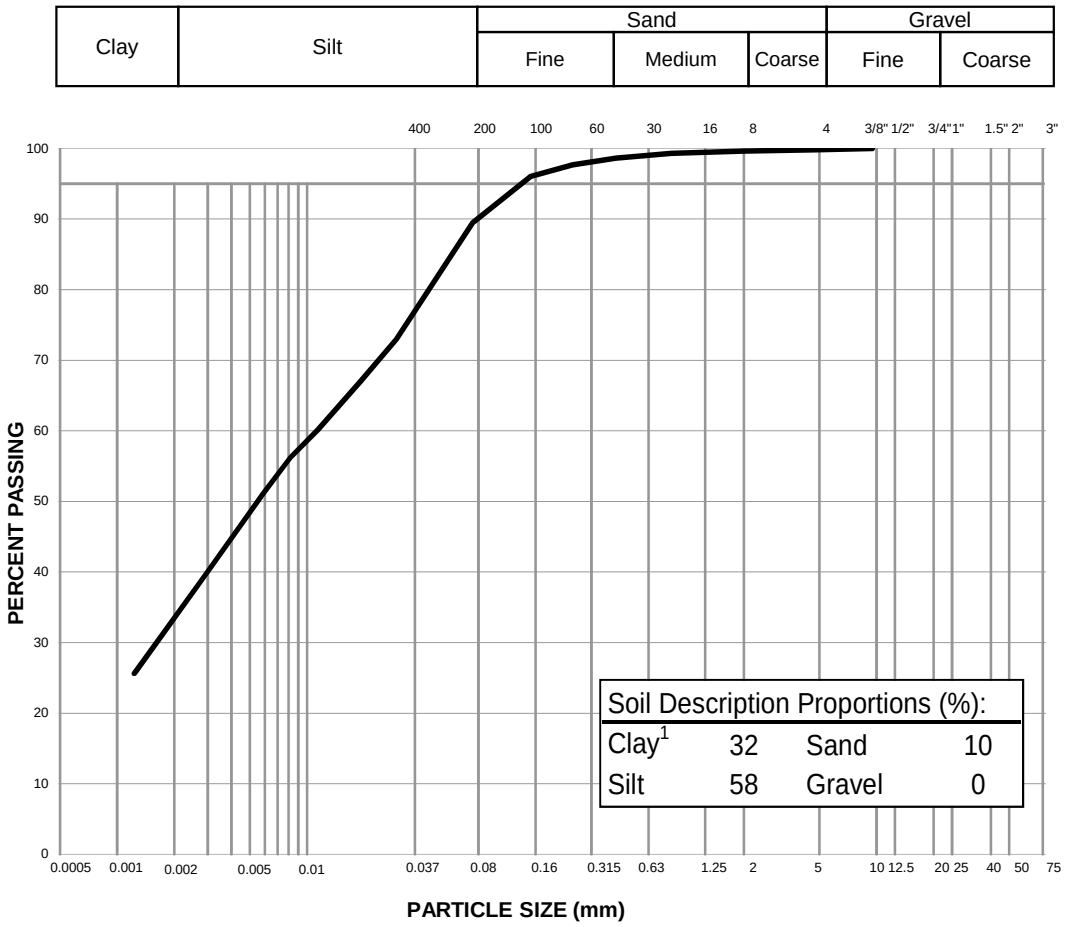
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-29637
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-05
Client:	TMAC Resources Inc.	Sample Depth:	4.3-5.3 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 26, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	36.4%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	99
0.425	99
0.25	98
0.15	96
0.075	89.5
0.0296	73.0
0.0192	67.0
0.0114	60.1
0.0082	56.2
0.0059	51.3
0.0029	39.4
0.0012	25.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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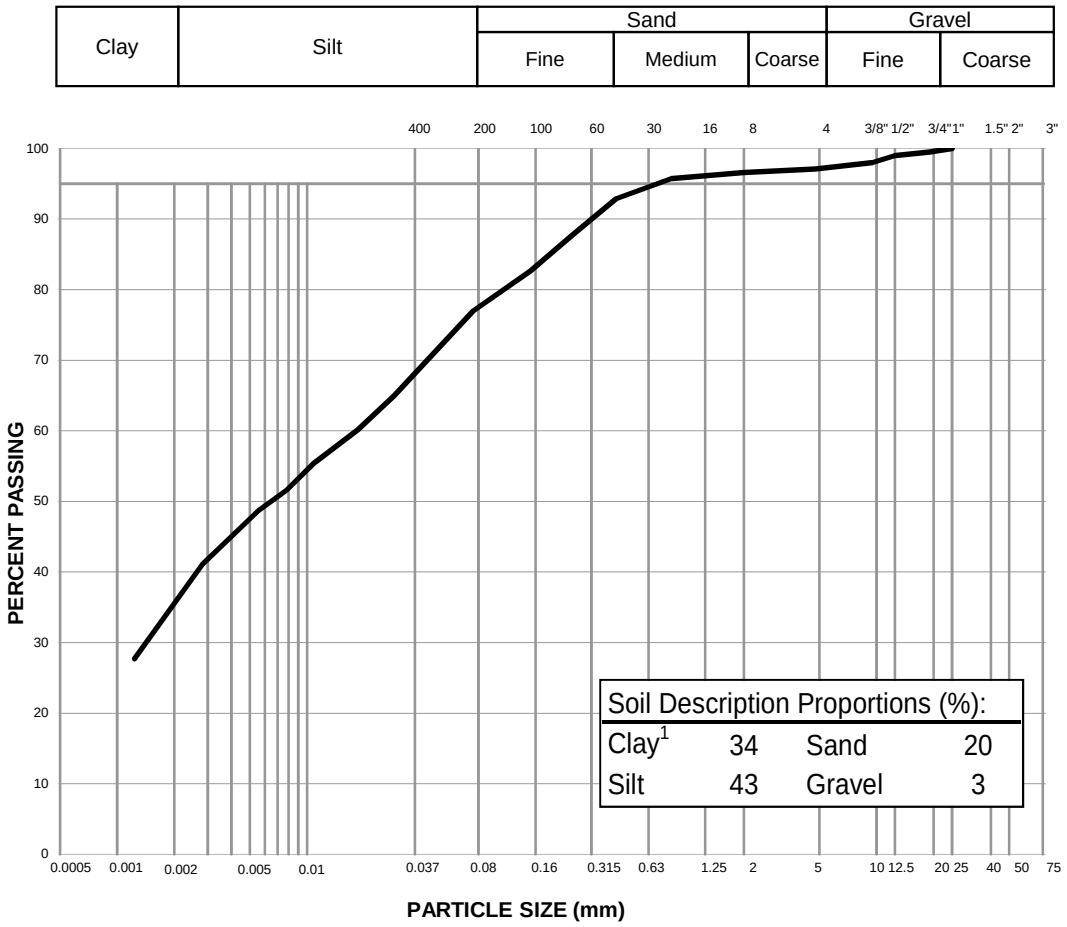
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29638
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-05
Client:	TMAC Resources Inc.	Sample Depth:	11.8-12.7 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 12, 2018 By: JPC	Date sampled:	February 26, 2018
Soil Description[2]:	CLAY, silty, some sand, trace gravel	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	40.4%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	100
19	99
12.5	99
9.5	98
4.75	97
2	97
0.83	96
0.425	93
0.25	88
0.15	83
0.075	77.0
0.0287	64.9
0.0185	60.2
0.0108	55.4
0.0078	51.6
0.0056	48.7
0.0028	41.1
0.0012	27.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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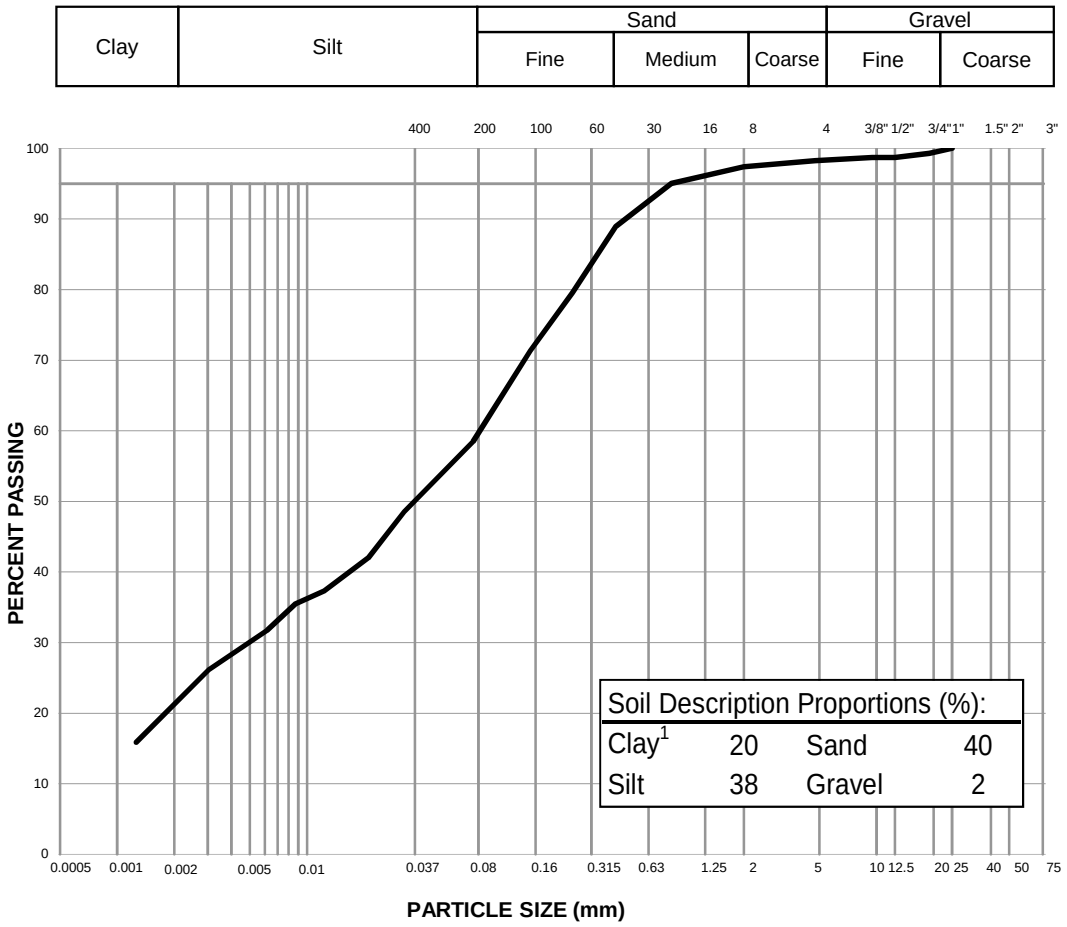
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29641
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-05
Client:	TMAC Resources Inc.	Sample Depth:	24.1-24.8 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	SAND, SILT, clayey, trace gravel.	Sampled By:	Client
		USC Classification:	SM Cu: #N/A
Moisture Content:	31.5%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	100
19	99
12.5	99
9.5	99
4.75	98
2	97
0.83	95
0.425	89
0.25	80
0.15	71
0.075	58.4
0.0325	48.5
0.0211	42.0
0.0124	37.3
0.0087	35.5
0.0062	31.7
0.0030	26.1
0.0013	15.9



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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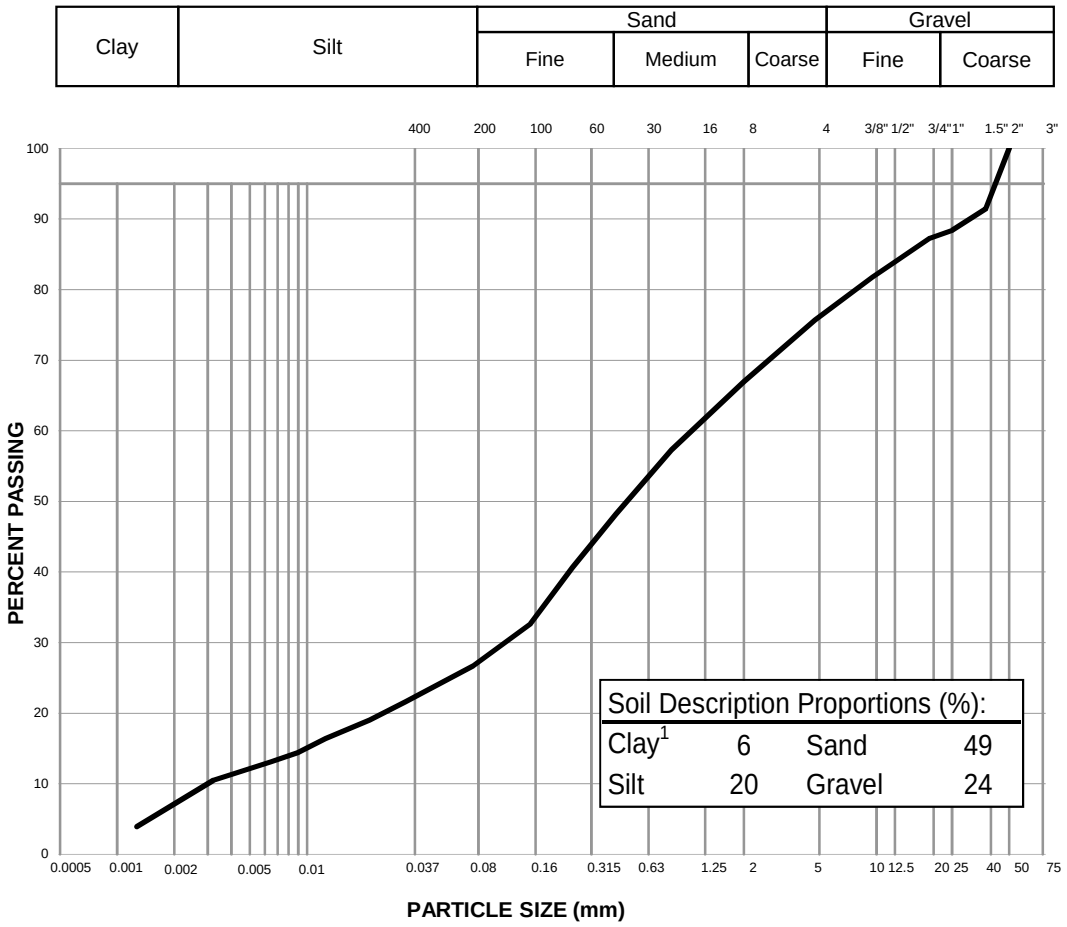
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29642
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-05
Client:	TMAC Resources Inc.	Sample Depth:	29.3-31.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 14, 2018 By: JRC	Date sampled:	February 26, 2018
Soil Description[2]:	SAND, gravelly, some silt, trace clay	Sampled By:	Client
		USC Classification:	SM Cu: 377.5
Moisture Content:	7.1%		Cc: 3.8

Particle Size (mm)	Percent Passing
75	
50	100
37.5	91
25	88
19	87
12.5	84
9.5	82
4.75	76
2	67
0.83	57
0.425	48
0.25	41
0.15	33
0.075	26.7
0.0330	21.6
0.0214	19.0
0.0125	16.4
0.0089	14.4
0.0064	13.1
0.0032	10.5
0.0013	3.9



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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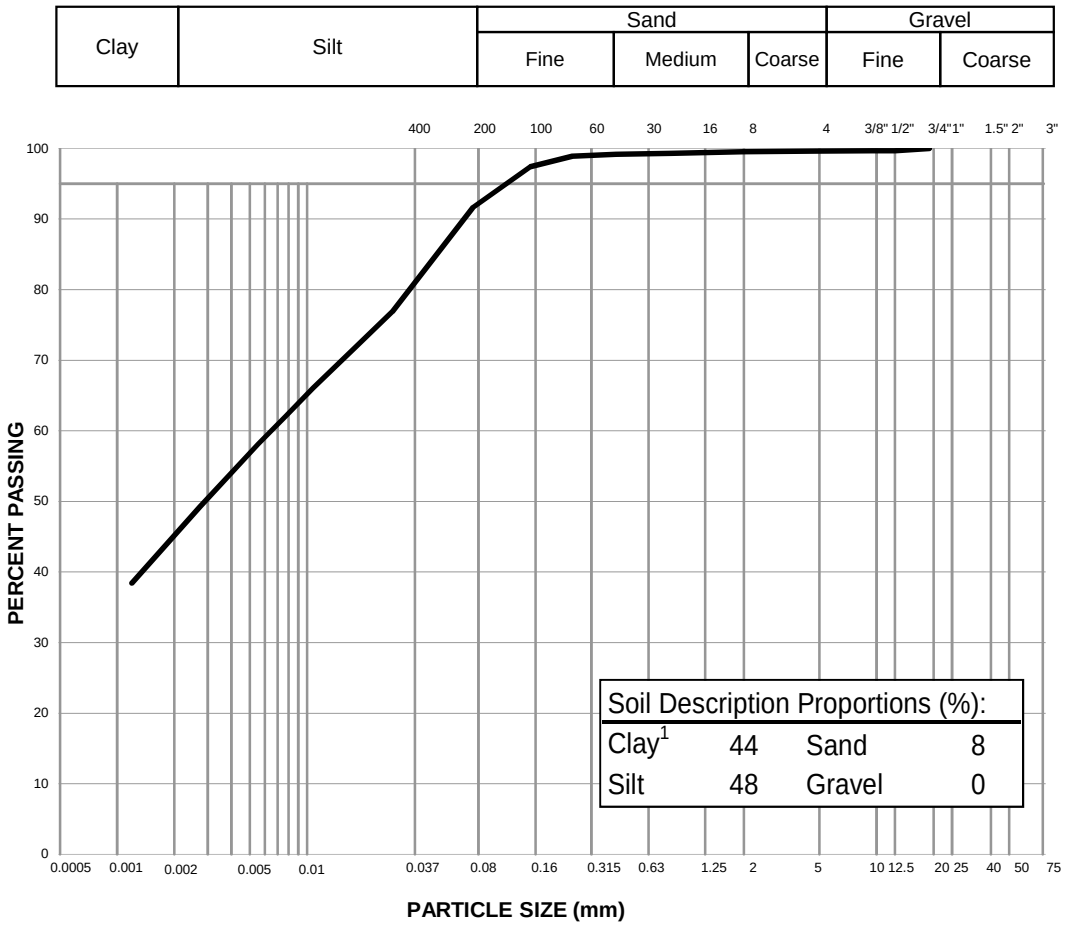
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29644
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-06
Client:	TMAC Resources Inc.	Sample Depth:	4.5-6.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 14, 2018 By: JPC	Date sampled:	February 26, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	38.4%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	100
9.5	100
4.75	100
2	100
0.83	99
0.425	99
0.25	99
0.15	97
0.075	91.7
0.0282	76.9
0.0182	71.9
0.0108	66.0
0.0077	62.1
0.0055	58.1
0.0027	49.3
0.0012	38.4



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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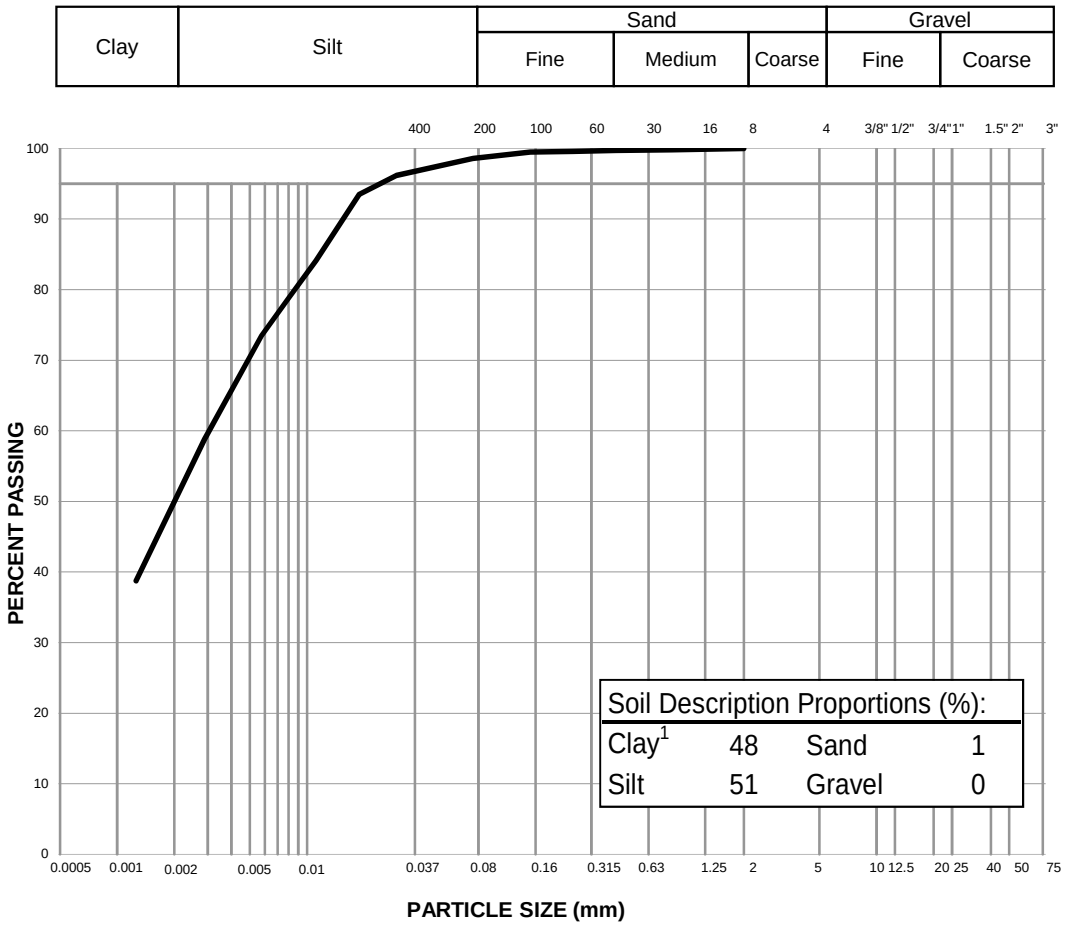
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29645
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-06
Client:	TMAC Resources Inc.	Sample Depth:	8.2-9.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 25, 2018 By: JPC	Date sampled:	February 26, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	CI Cu: #N/A
Moisture Content:	43.4%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	100
0.83	100
0.425	100
0.25	100
0.15	99
0.075	98.6
0.0296	96.2
0.0189	93.5
0.0112	84.1
0.0080	78.8
0.0058	73.5
0.0029	58.8
0.0013	38.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

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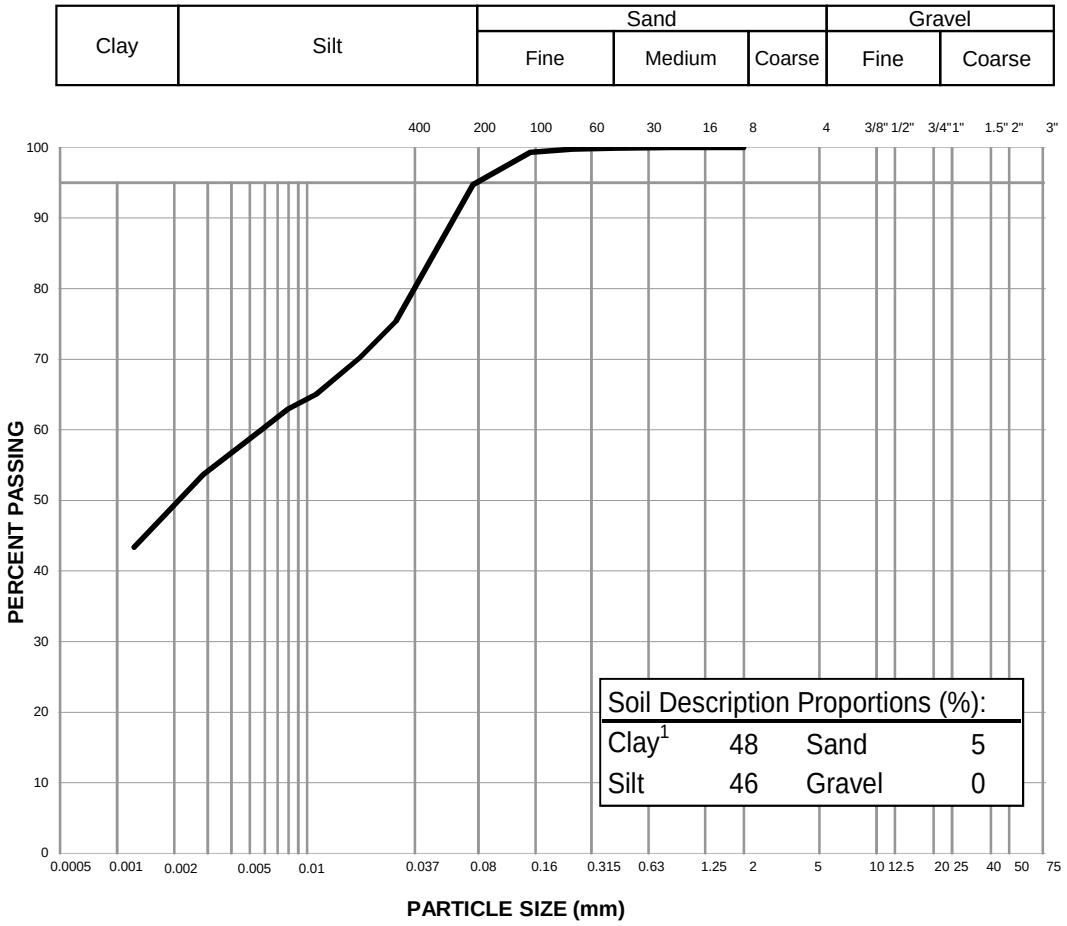
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29647
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-06
Client:	TMAC Resources Inc.	Sample Depth:	21.1-21.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 10, 2018 By: WM	Date sampled:	February 26, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	48.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	100
0.83	100
0.425	100
0.25	100
0.15	99
0.075	94.7
0.0294	75.4
0.0190	70.2
0.0112	65.0
0.0080	63.0
0.0057	59.9
0.0028	53.7
0.0012	43.4



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

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Remarks: _____

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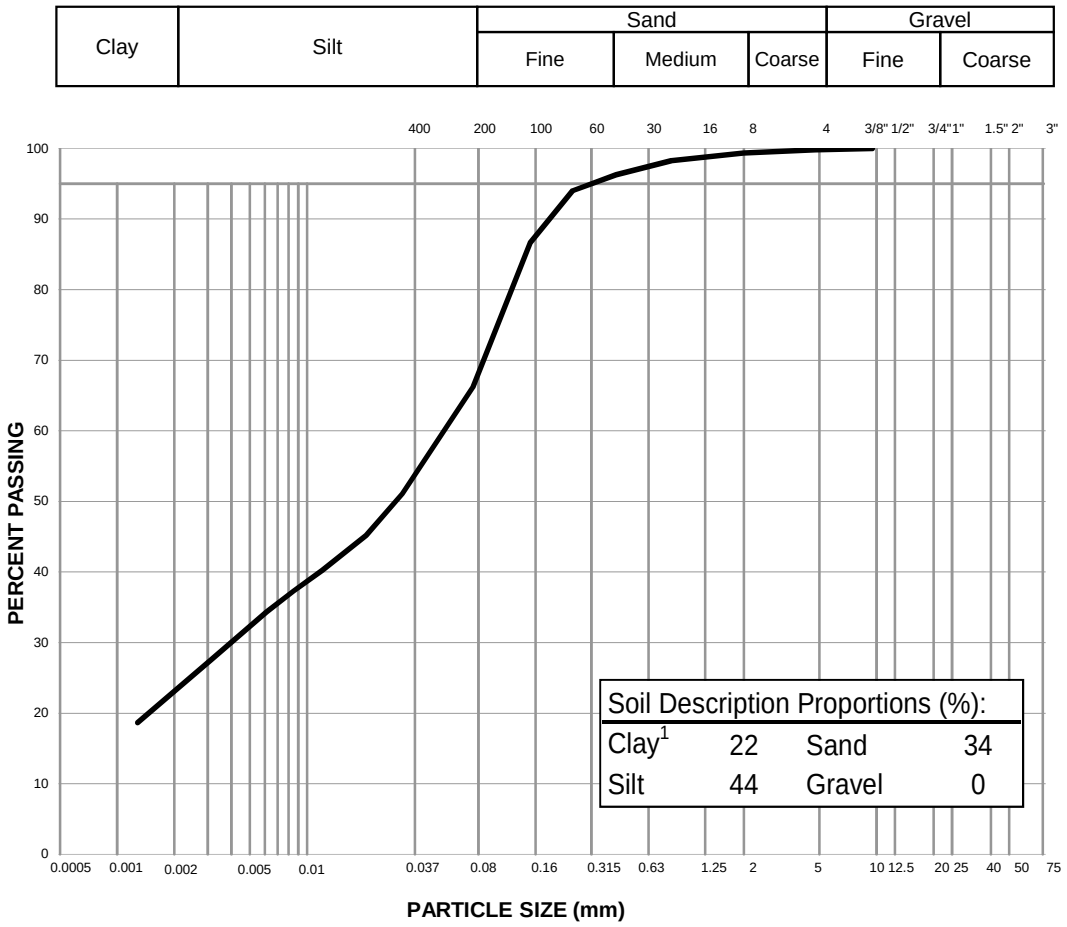
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29648
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-06
Client:	TMAC Resources Inc.	Sample Depth:	24.0-25.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 25, 2018
Soil Description[2]:	CLAY, silty, sandy	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	35.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	99
0.83	98
0.425	96
0.25	94
0.15	87
0.075	66.2
0.0318	51.1
0.0205	45.2
0.0121	40.3
0.0085	37.3
0.0061	34.4
0.0031	27.5
0.0013	18.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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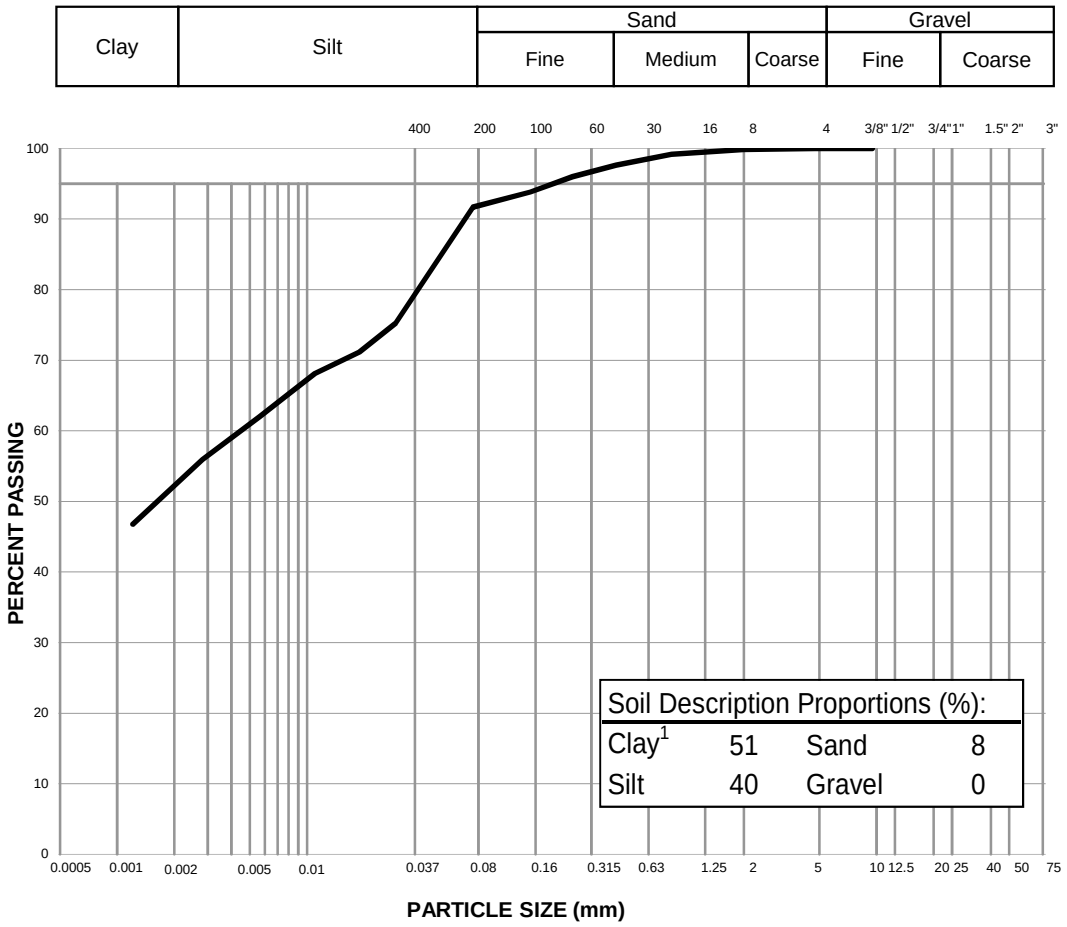
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-29649
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-STH-DH-06
Client:	TMAC Resources Inc.	Sample Depth:	26.4-27.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 10, 2018 By: WM	Date sampled:	February 26, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	41.8%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	99
0.425	98
0.25	96
0.15	94
0.075	91.7
0.0293	75.2
0.0189	71.2
0.0110	68.1
0.0079	65.1
0.0056	62.0
0.0028	55.9
0.0012	46.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks:

Reviewed By: P.Geol

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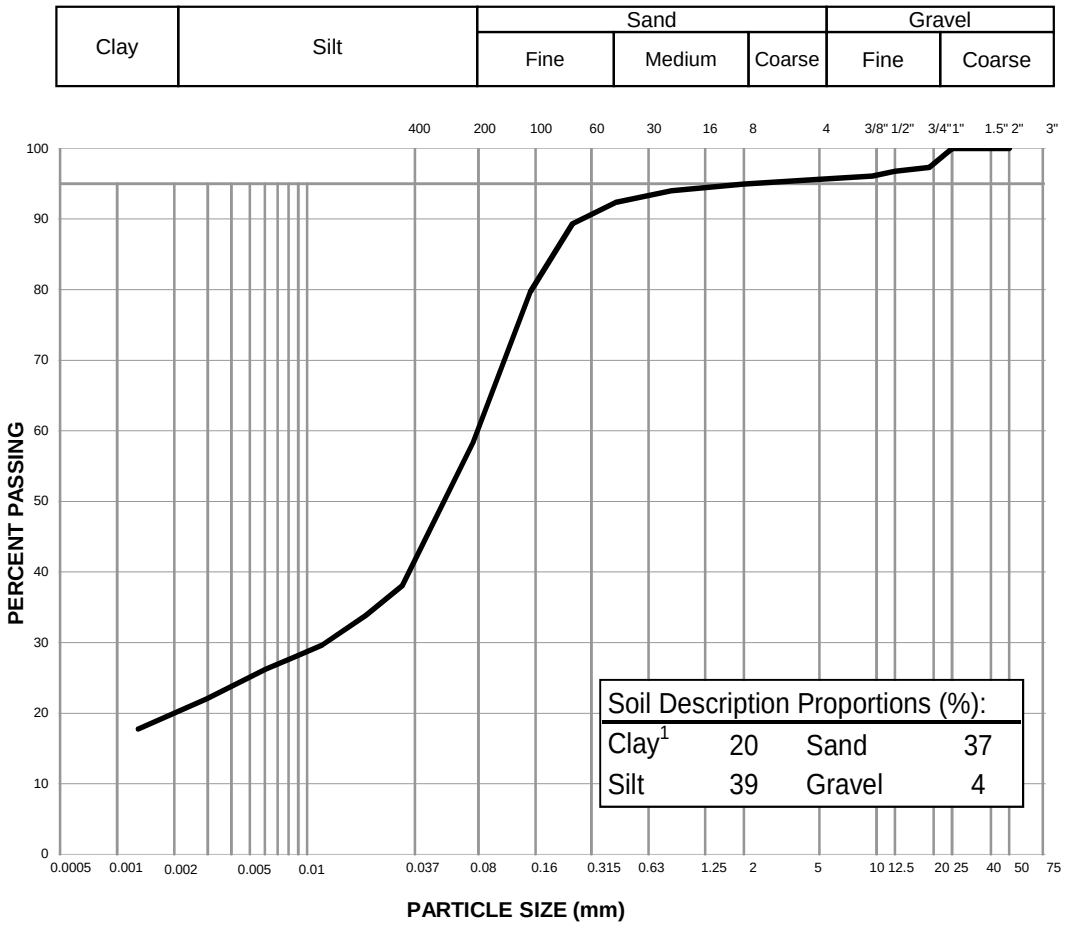
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205954
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-DH-DH-04
Client:	TMAC Resources Inc.	Sample Depth:	0.9-1.4 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 31, 2018 By: WM	Date sampled:	February 20, 2018
Soil Description[2]:	SILT and SAND, some clay, trace gravel	Sampled By:	Client
		USC Classification:	CL-ML Cu: #N/A
Moisture Content:	41.2%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	97
12.5	97
9.5	96
4.75	96
2	95
0.83	94
0.425	92
0.25	89
0.15	80
0.075	58.3
0.0318	38.1
0.0204	33.8
0.0120	29.6
0.0085	27.9
0.0061	26.2
0.0030	22.0
0.0013	17.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks:

Reviewed By: P.Geol

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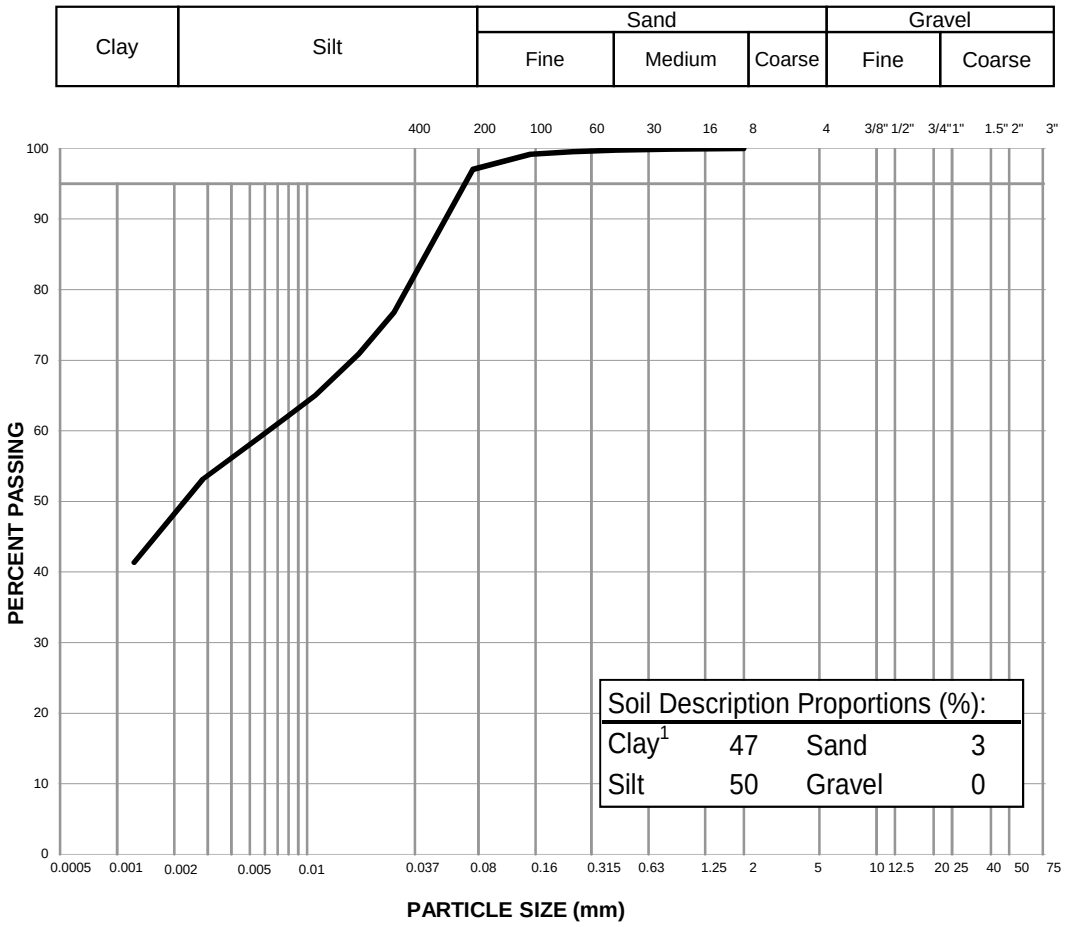
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205978
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-WST-DH-03
Client:	TMAC Resources Inc.	Sample Depth:	2.0-2.4 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 10, 2018 By: WM	Date sampled:	February 23, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	59.5%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	100
0.83	100
0.425	100
0.25	100
0.15	99
0.075	97.0
0.0289	76.8
0.0187	70.9
0.0111	65.0
0.0079	62.0
0.0057	59.1
0.0028	53.2
0.0012	41.4



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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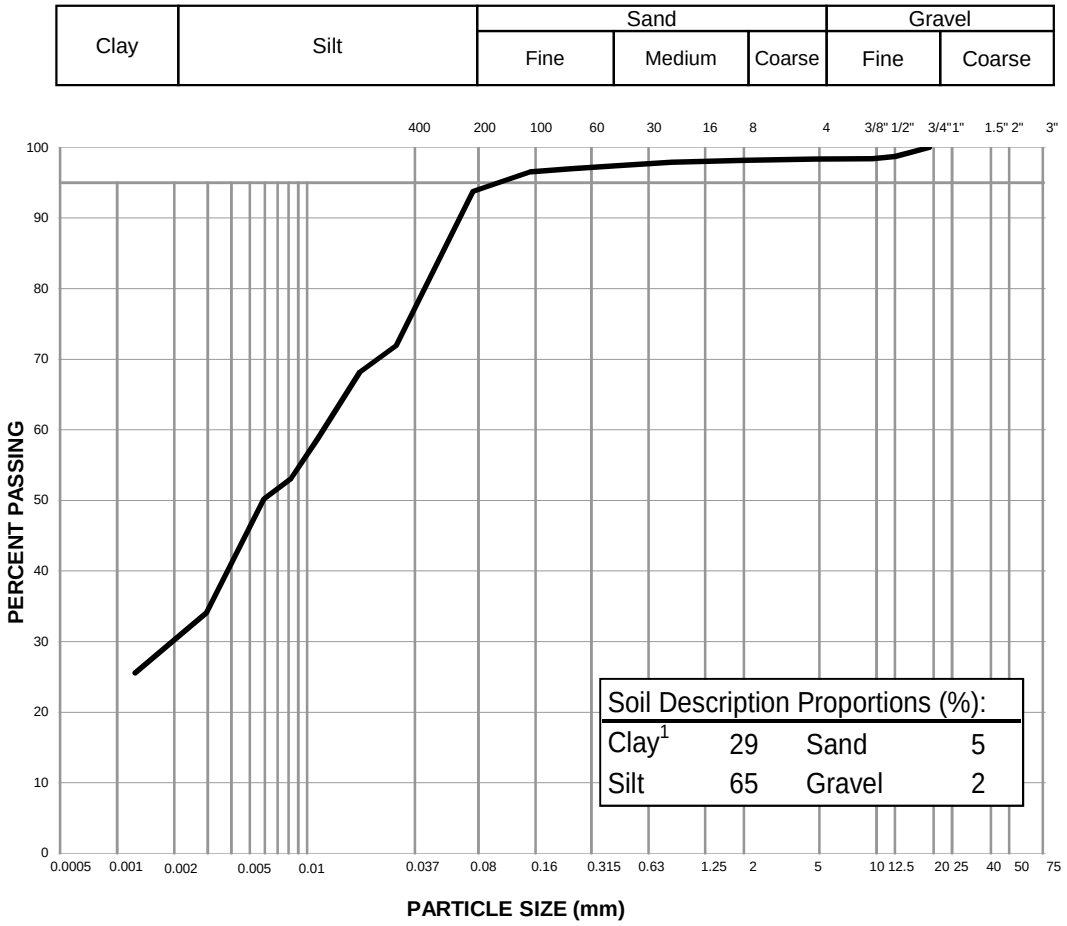
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay South Dam Project	Sample No.:	6667-205979
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-WST-DH-03
Client:	TMAC Resources Inc.	Sample Depth:	3.1-3.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 23, 2018
Soil Description[2]:	CLAY, silty, trace sand, trace gravel	Sampled By:	Client
		USC Classification:	OL Cu: #N/A
Moisture Content:	56.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	99
9.5	98
4.75	98
2	98
0.83	98
0.425	97
0.25	97
0.15	97
0.075	93.8
0.0295	71.9
0.0189	68.2
0.0113	58.7
0.0082	53.0
0.0059	50.2
0.0030	34.1
0.0012	25.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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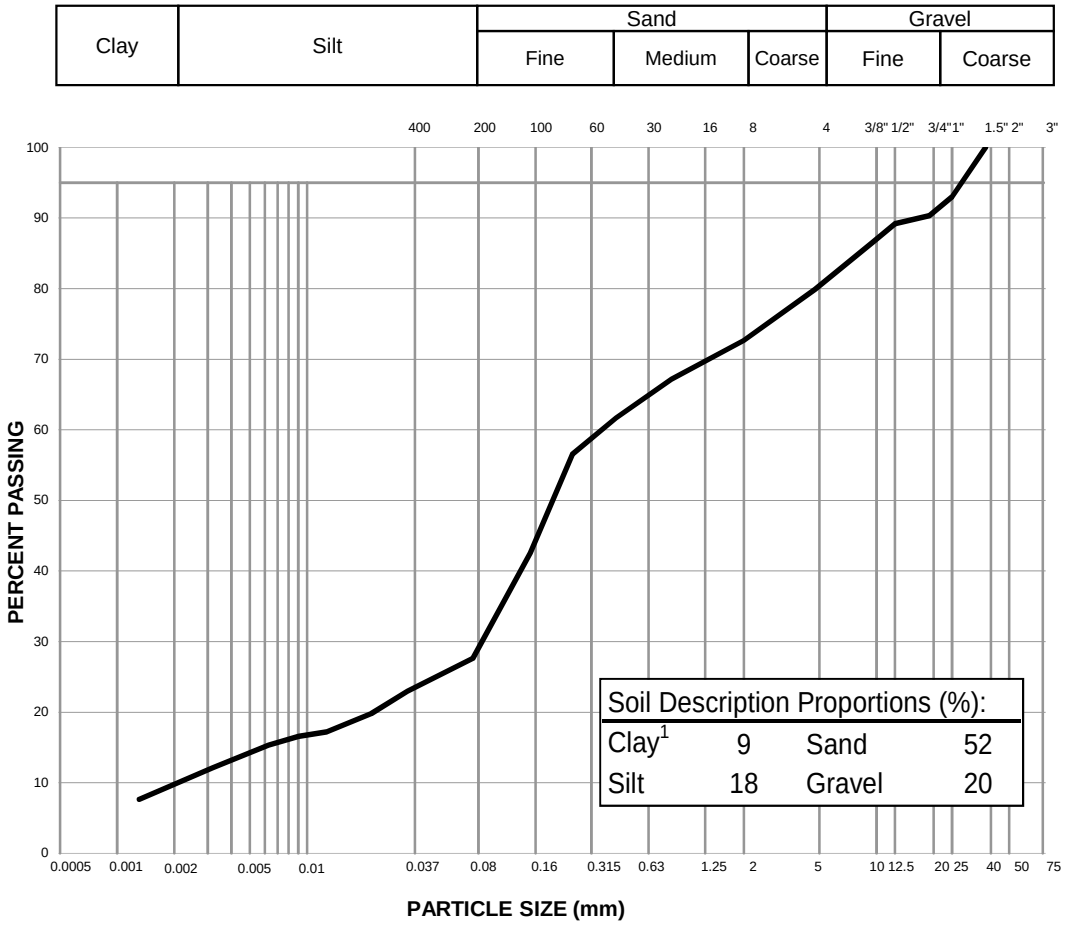
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205980
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-WST-DH-03
Client:	TMAC Resources Inc.	Sample Depth:	4.6-5.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 23, 2018
Soil Description[2]:	SAND, some gravel, some silt, trace clay.	Sampled By:	Client
		USC Classification:	SM Cu: 160.5
Moisture Content:	16.7%		Cc: 9.0

Particle Size (mm)	Percent Passing
75	
50	
37.5	100
25	93
19	90
12.5	89
9.5	87
4.75	80
2	73
0.83	67
0.425	62
0.25	57
0.15	43
0.075	27.6
0.0338	23.0
0.0218	19.8
0.0127	17.2
0.0090	16.6
0.0063	15.3
0.0032	12.1
0.0013	7.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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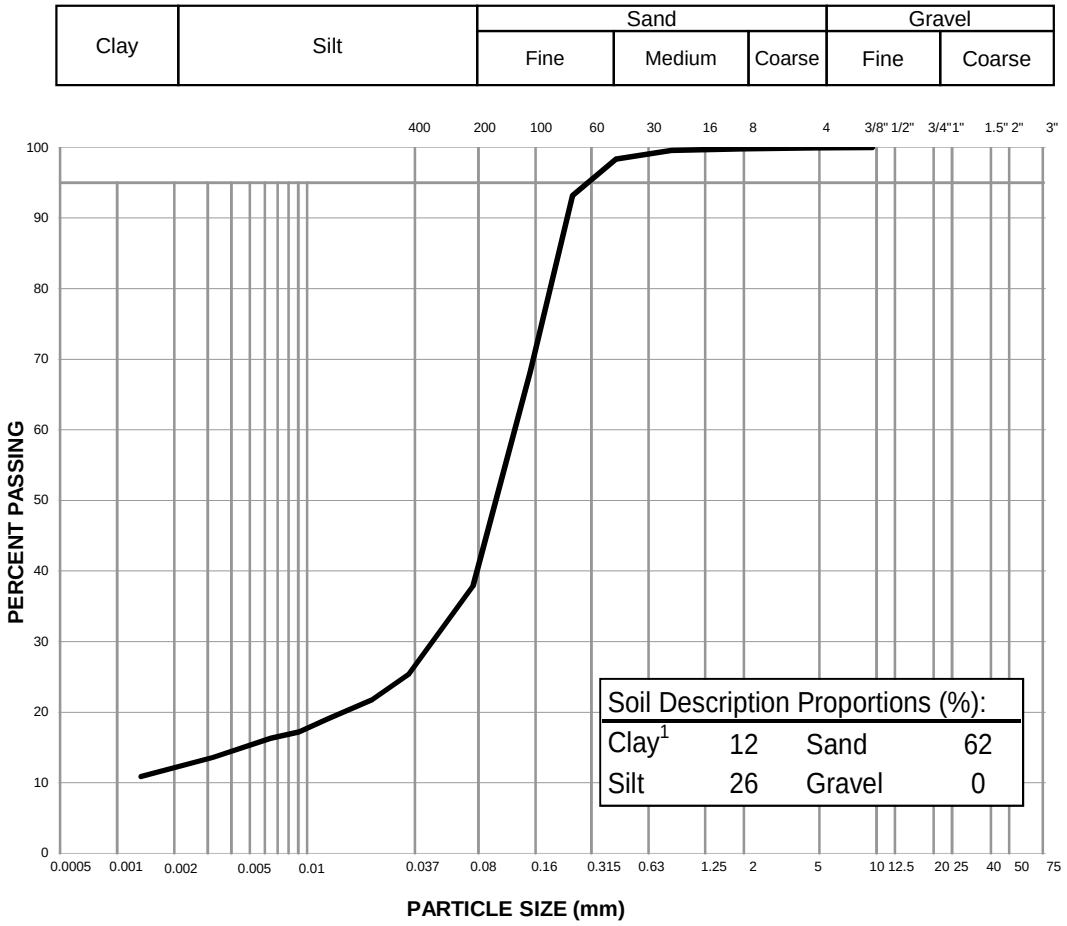
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205982
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-WST-DH-02
Client:	TMAC Resources Inc.	Sample Depth:	0.8-1.1 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	August 10, 2018 By: WM	Date sampled:	February 23, 2018
Soil Description[2]:	SAND, silty, some clay	Sampled By:	Client
		USC Classification:	SM Cu: #N/A
Moisture Content:	60.8%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	98
0.25	93
0.15	68
0.075	37.9
0.0343	25.4
0.0219	21.8
0.0128	19.0
0.0091	17.2
0.0064	16.3
0.0032	13.6
0.0013	10.9



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

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Specification: _____

Remarks: _____

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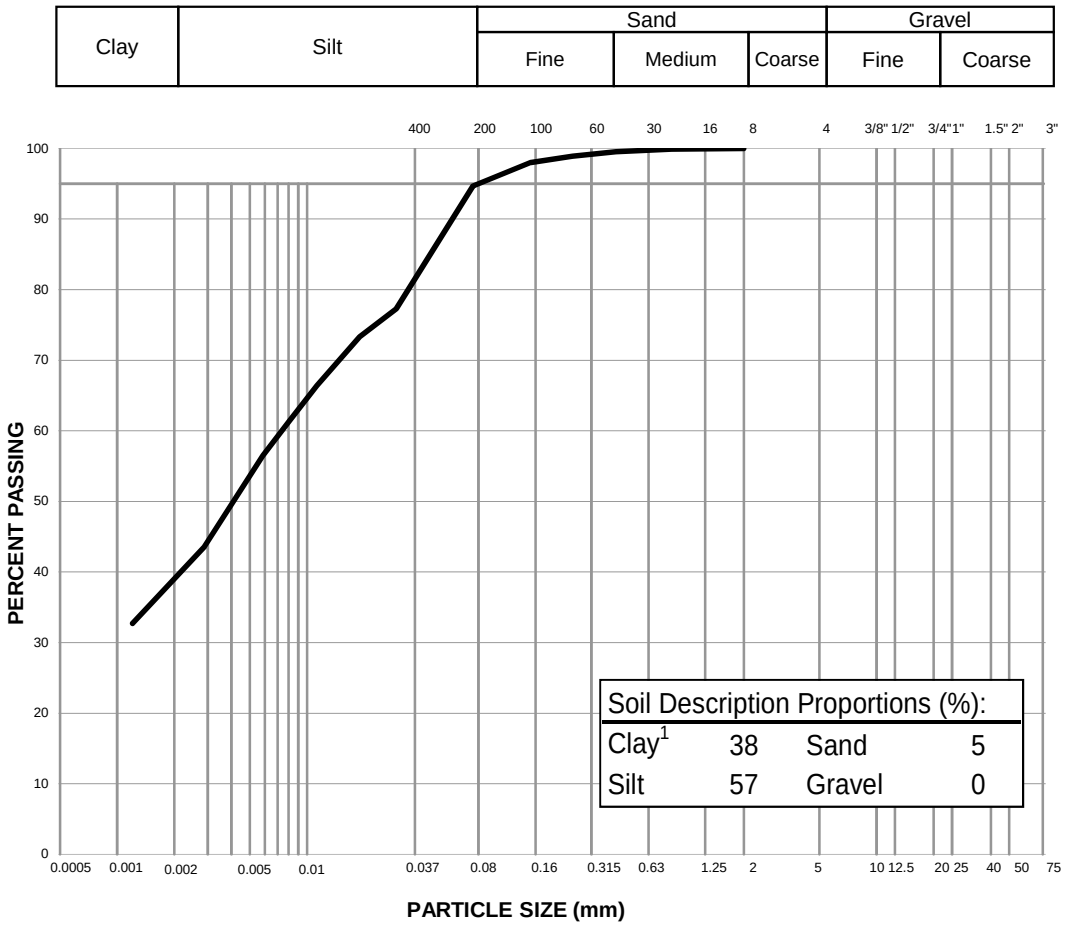
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205984
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-16
Client:	TMAC Resources Inc.	Sample Depth:	14.2-14.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	36.5%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	100
0.83	100
0.425	100
0.25	99
0.15	98
0.075	94.7
0.0295	77.3
0.0190	73.3
0.0113	66.4
0.0081	61.4
0.0058	56.5
0.0029	43.6
0.0012	32.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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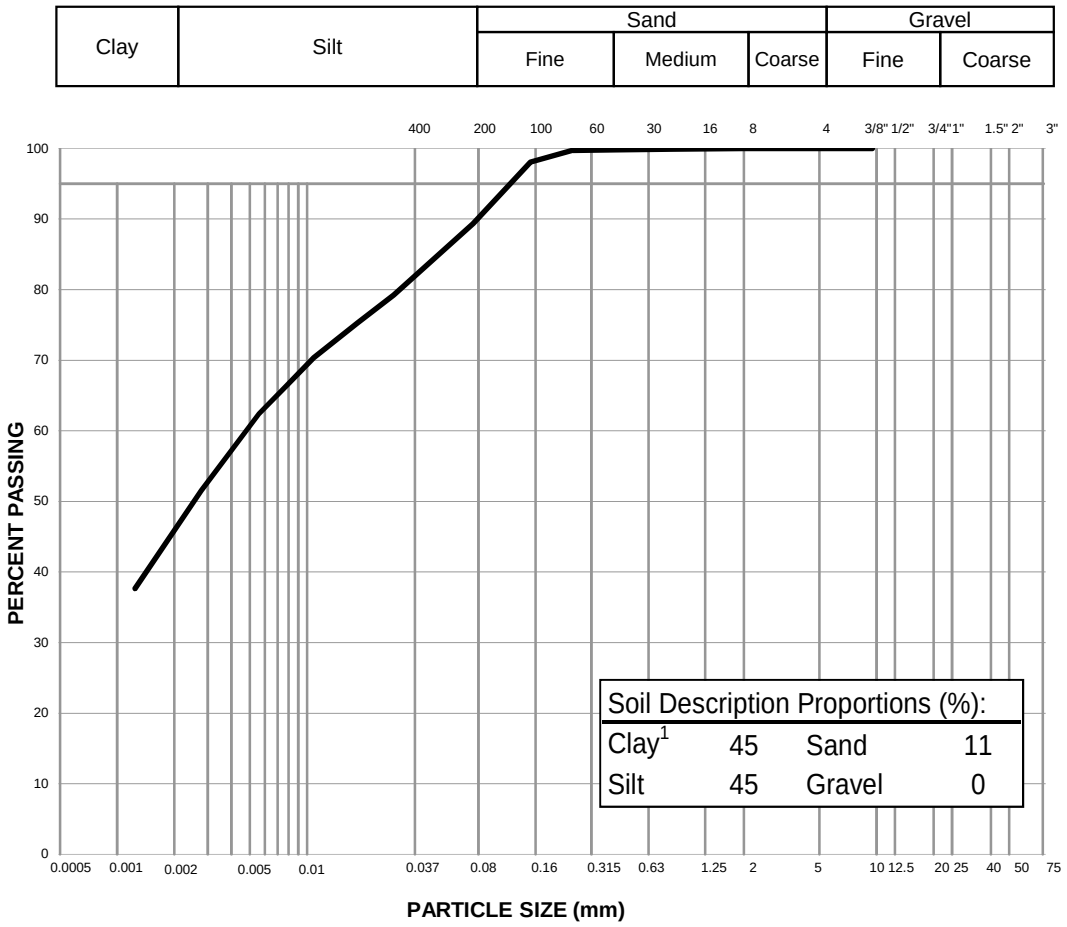
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205985
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-16
Client:	TMAC Resources Inc.	Sample Depth:	14.7-15.1 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 5, 2018 By: JPC/SS	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	45.9%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	100
0.25	100
0.15	98
0.075	89.4
0.0286	79.2
0.0184	75.3
0.0109	70.3
0.0078	66.4
0.0056	62.4
0.0028	51.5
0.0012	37.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification:

Remarks:

Reviewed By: P.Geol

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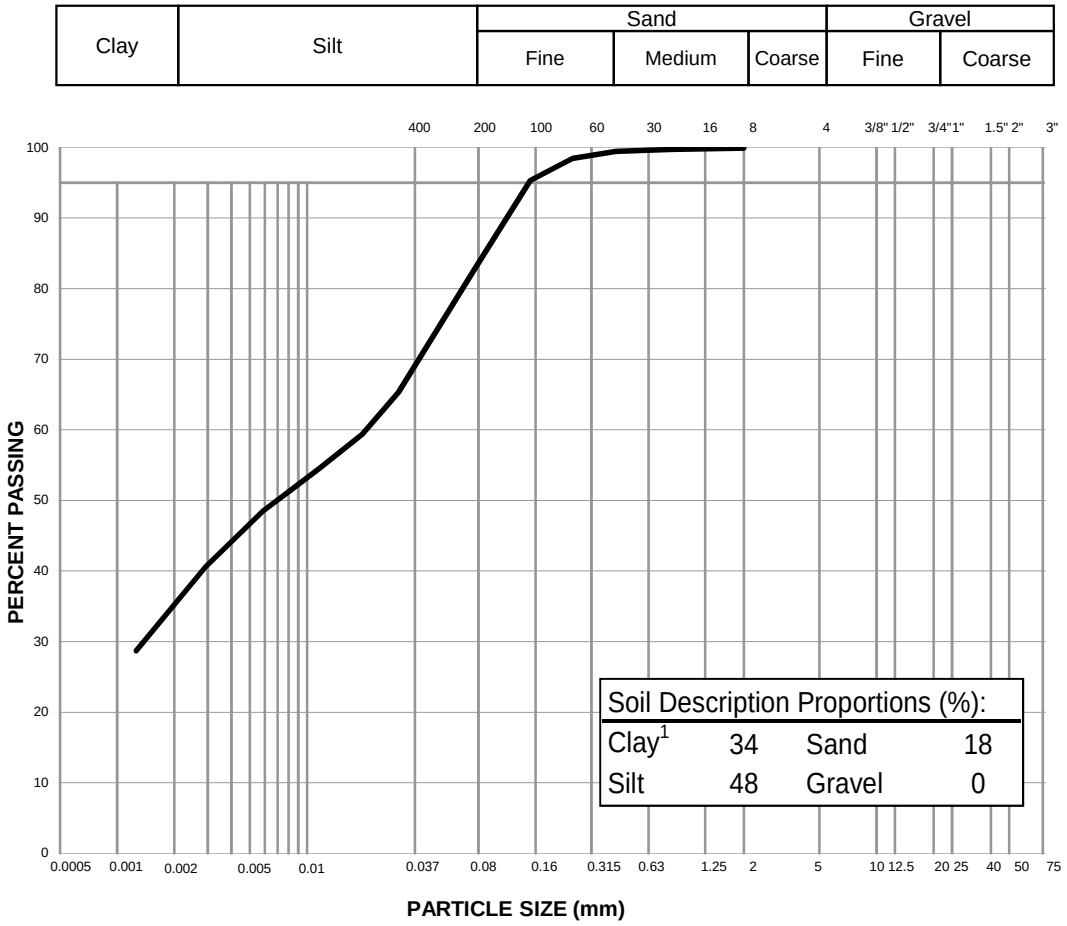
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205986
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-16
Client:	TMAC Resources Inc.	Sample Depth:	21.3-21.7 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 25, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	CL-CI Cu: #N/A
Moisture Content:	34.1%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	100
0.83	100
0.425	99
0.25	98
0.15	95
0.075	82.4
0.0303	65.3
0.0196	59.4
0.0115	54.4
0.0082	51.4
0.0059	48.5
0.0029	40.6
0.0013	28.7



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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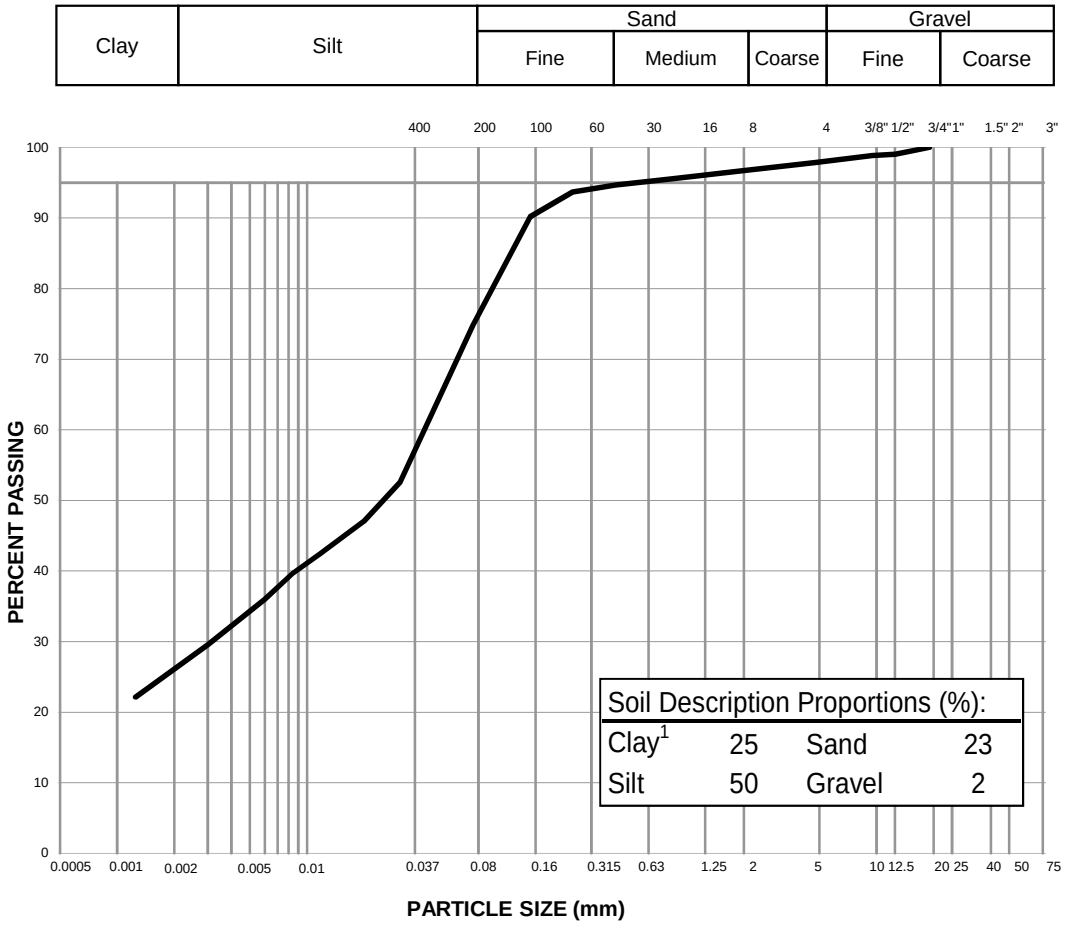
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205987
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-16
Client:	TMAC Resources Inc.	Sample Depth:	23.2-23.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	July 2, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, sandy, trace gravel	Sampled By:	Client
		USC Classification:	CL Cu: #N/A
Moisture Content:	34.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	100
12.5	99
9.5	99
4.75	98
2	97
0.83	96
0.425	95
0.25	94
0.15	90
0.075	74.8
0.0309	52.6
0.0199	47.1
0.0117	42.4
0.0084	39.7
0.0060	36.0
0.0030	29.5
0.0012	22.1



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

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Remarks: _____

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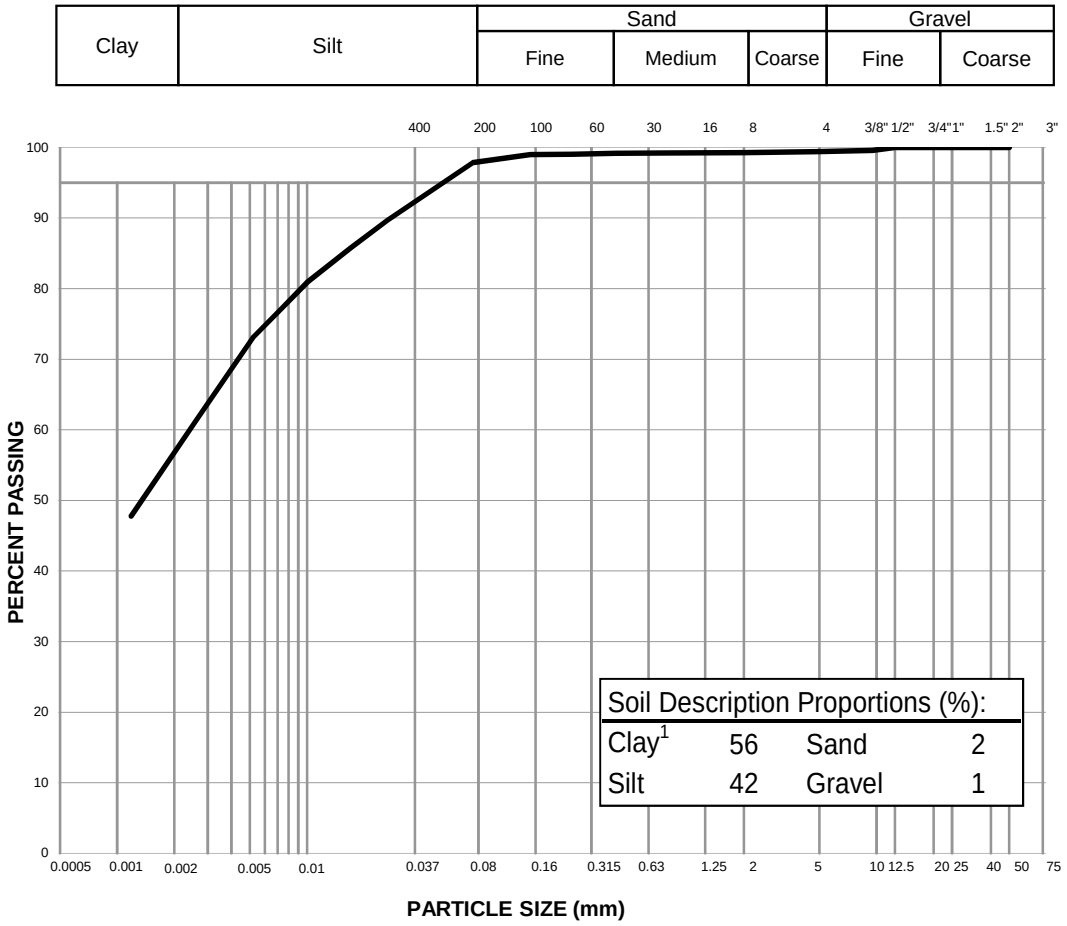
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205988
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-15
Client:	TMAC Resources Inc.	Sample Depth:	2.3-6.5 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 22, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, trace sand, trace gravel	Sampled By:	Client
		USC Classification:	CI Cu: #N/A
Moisture Content:	41.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	100
12.5	100
9.5	100
4.75	99
2	99
0.83	99
0.425	99
0.25	99
0.15	99
0.075	97.9
0.0266	89.7
0.0171	85.8
0.0101	80.9
0.0072	77.0
0.0052	73.1
0.0026	61.4
0.0012	47.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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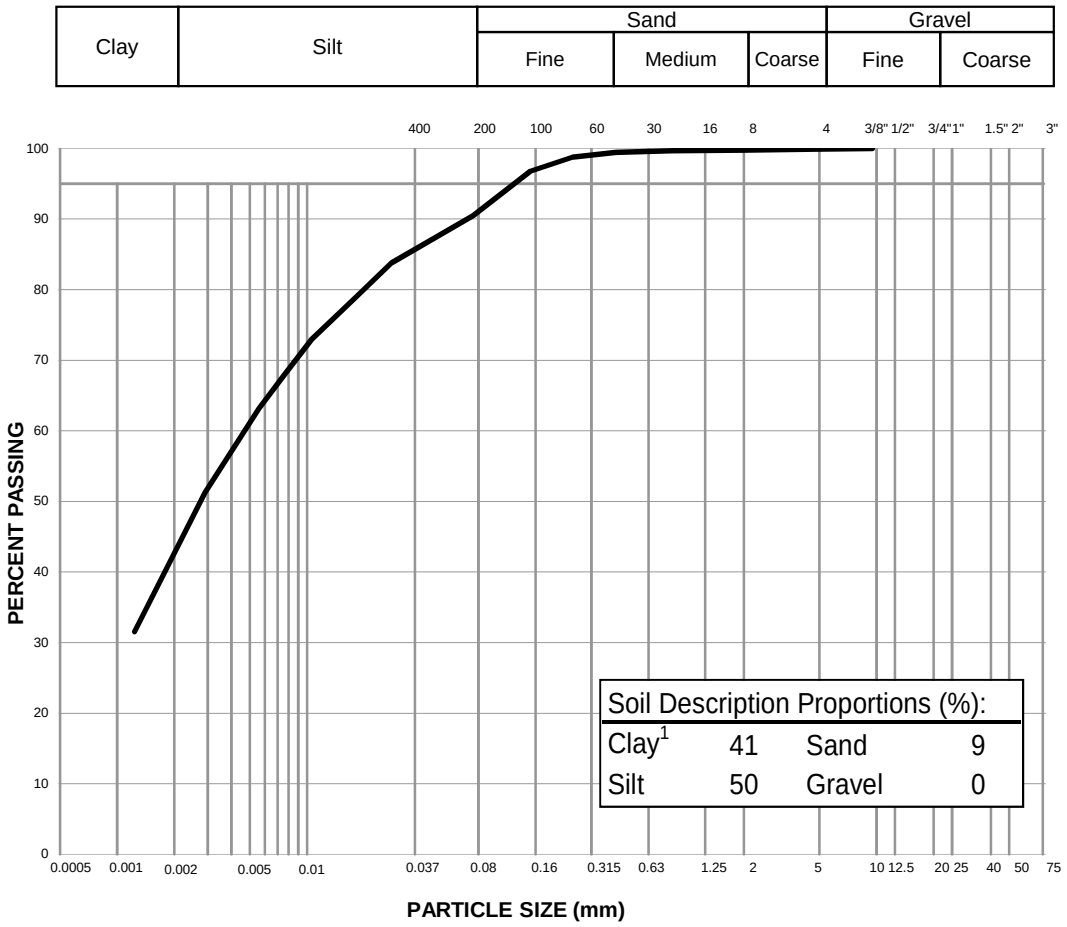
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205990
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-15
Client:	TMAC Resources Inc.	Sample Depth:	11.3-14.3 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	May 1, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, trace sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	47.4%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	99
0.25	99
0.15	97
0.075	90.5
0.0280	83.8
0.0181	78.9
0.0106	73.0
0.0076	68.0
0.0056	63.1
0.0029	51.3
0.0012	31.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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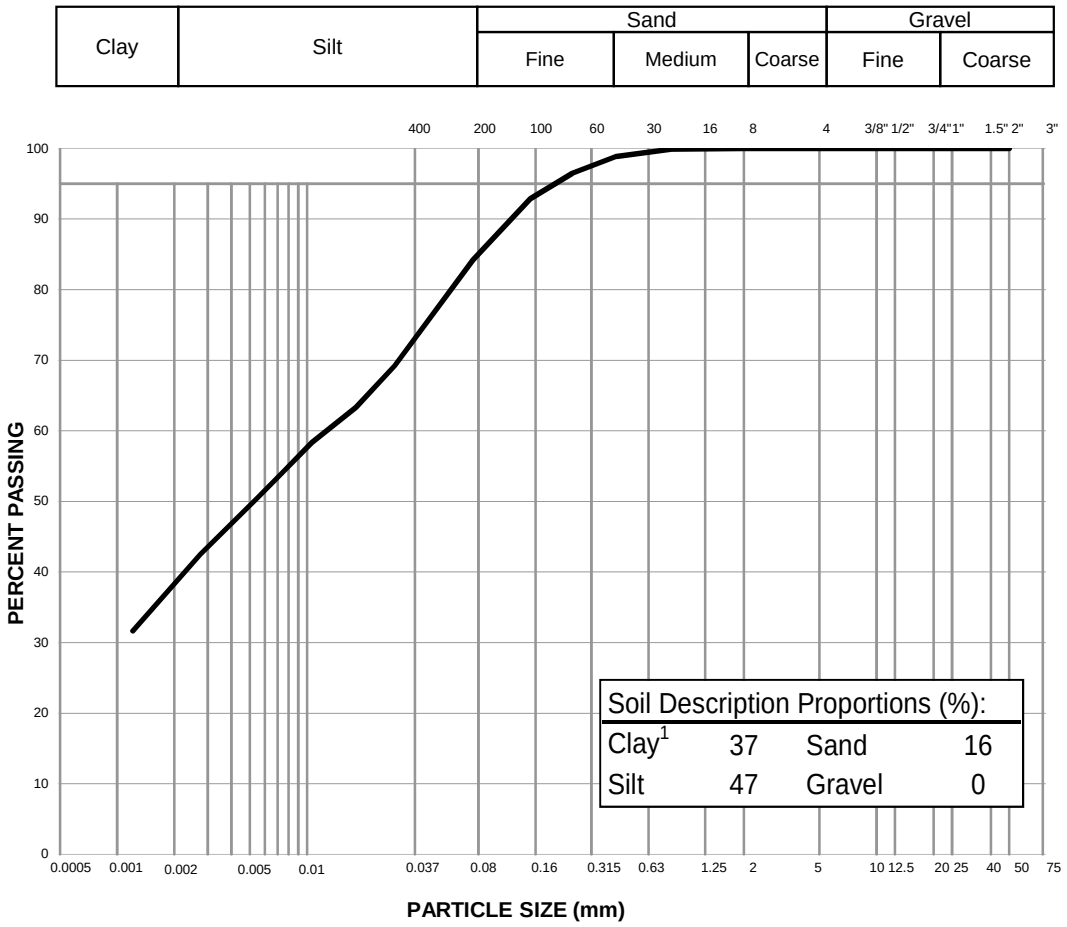
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205991
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-15
Client:	TMAC Resources Inc.	Sample Depth:	14.3-18.0 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 20, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	Cu: #N/A
Moisture Content:	48.7%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	100
19	100
12.5	100
9.5	100
4.75	100
2	100
0.83	100
0.425	99
0.25	96
0.15	93
0.075	84.2
0.0289	69.2
0.0181	63.3
0.0106	58.4
0.0076	54.4
0.0054	50.4
0.0027	42.5
0.0012	31.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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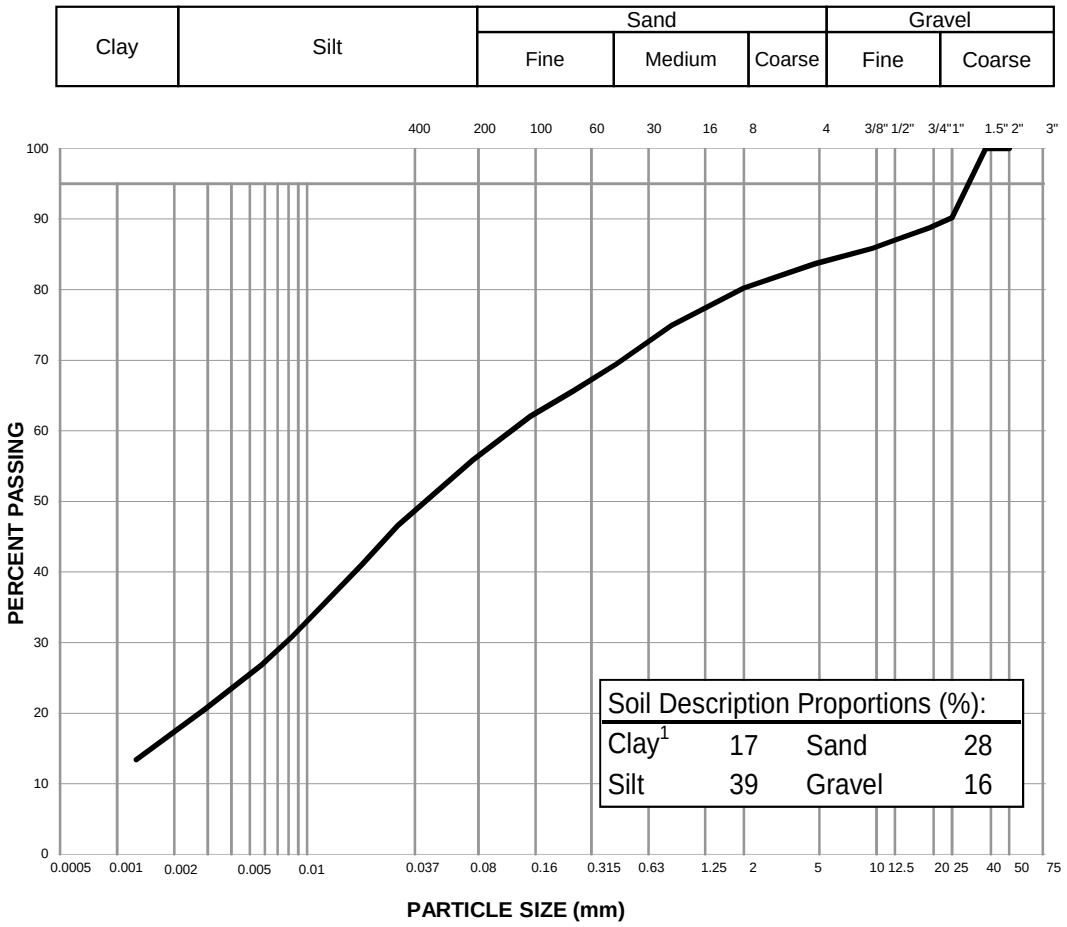
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205992
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-RD-DH-15
Client:	TMAC Resources Inc.	Sample Depth:	21.2-24.8 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 20, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	SILT, sandy, some clay, some gravel	Sampled By:	Client
		USC Classification:	ML Cu: #N/A
Moisture Content:	23.0%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	100
37.5	100
25	90
19	89
12.5	87
9.5	86
4.75	84
2	80
0.83	75
0.425	69
0.25	66
0.15	62
0.075	55.9
0.0300	46.6
0.0194	41.0
0.0115	34.7
0.0083	30.8
0.0057	26.8
0.0029	20.5
0.0013	13.4



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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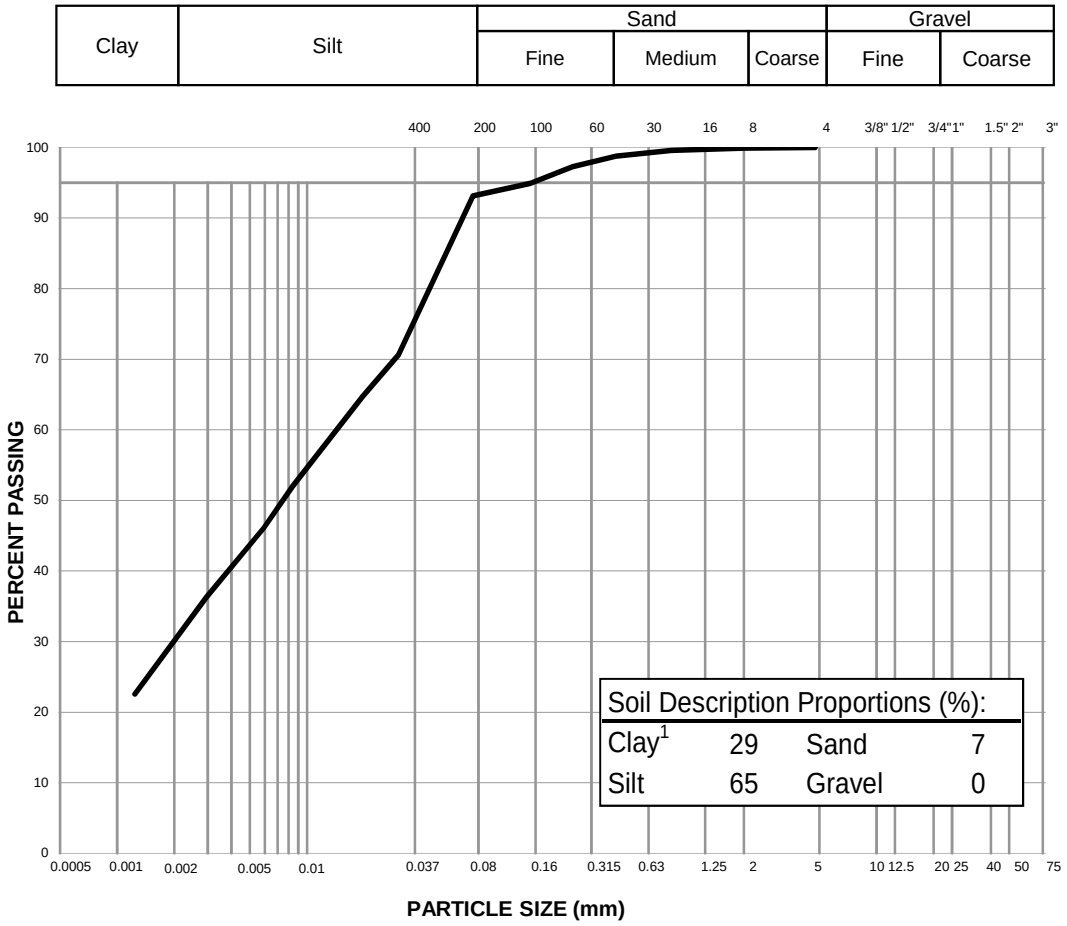
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205994
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-WST-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	0.1-0.6 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	SILT, clayey, trace sand, rootlets	Sampled By:	Client
		USC Classification:	MH Cu: #N/A
Moisture Content:	38.1%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	100
2	100
0.83	100
0.425	99
0.25	97
0.15	95
0.075	93.2
0.0303	70.6
0.0196	64.7
0.0116	56.9
0.0084	52.0
0.0059	46.1
0.0030	36.3
0.0012	22.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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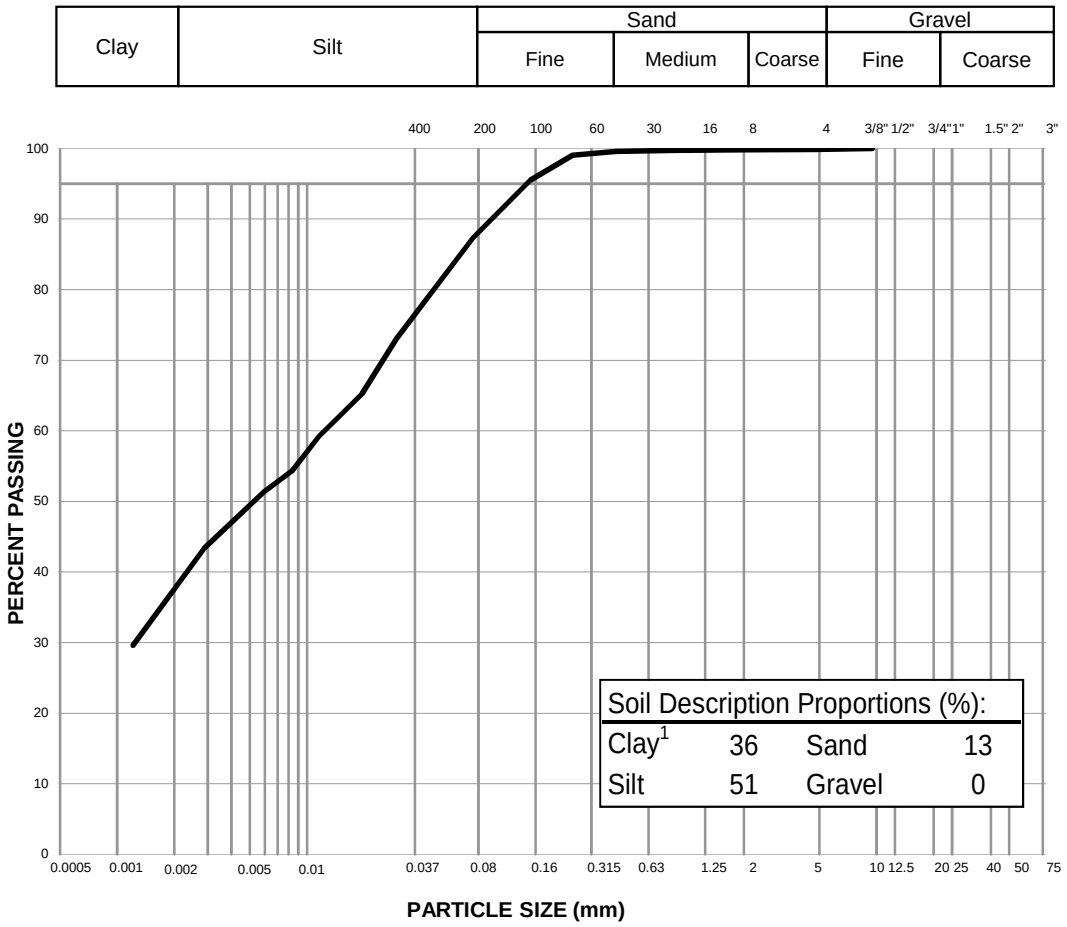
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205997
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-WST-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	2.2-4.3 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	April 28, 2018 By: WM	Date sampled:	February 24, 2018
Soil Description[2]:	CLAY, silty, some sand	Sampled By:	Client
		USC Classification:	Cl Cu: #N/A
Moisture Content:	47.3%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	100
4.75	100
2	100
0.83	100
0.425	100
0.25	99
0.15	95
0.075	87.3
0.0296	73.1
0.0194	65.2
0.0116	59.2
0.0083	54.3
0.0059	51.3
0.0029	43.4
0.0012	29.6



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

Reviewed By: _____ P.Geol

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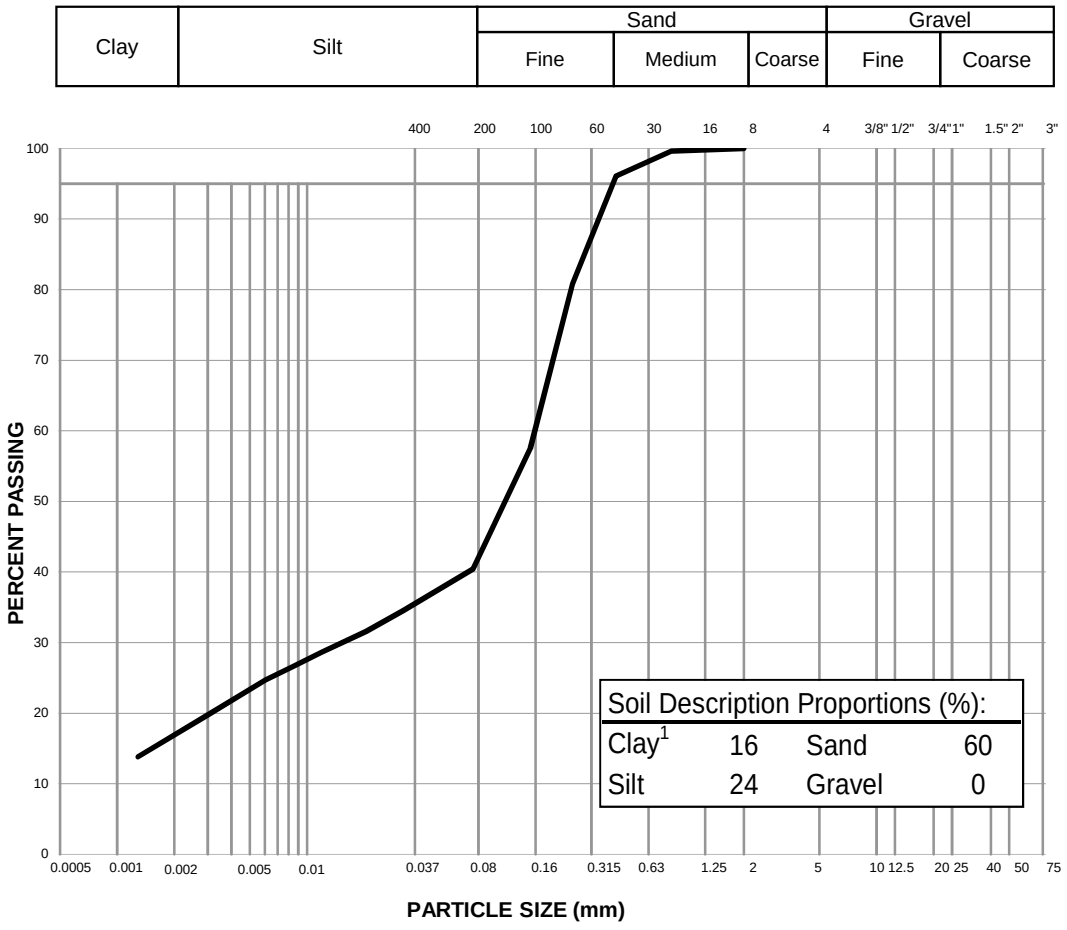
TETRA TECH

PARTICLE SIZE ANALYSIS REPORT

ASTM D7928

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667-205999
Project No.:	704-Y14103336-02.003	Material Type:	Soil
Site:	Hope Bay South Dam	Sample Loc.:	SRK18-WST-DH-01
Client:	TMAC Resources Inc.	Sample Depth:	6.7-7.1 m
Client Rep.:	Kelly Schwenning	Sampling Method:	Grab
Date Tested:	June 12, 2018 By: JPC	Date sampled:	February 24, 2018
Soil Description[2]:	SAND, silty, some clay	Sampled By:	Client
		USC Classification:	SM Cu: #N/A
Moisture Content:	25.1%		Cc: #N/A

Particle Size (mm)	Percent Passing
75	
50	
37.5	
25	
19	
12.5	
9.5	
4.75	
2	100
0.83	100
0.425	96
0.25	81
0.15	58
0.075	40.4
0.0321	34.6
0.0205	31.6
0.0119	28.6
0.0085	26.7
0.0060	24.7
0.0030	19.7
0.0013	13.8



Notes: [1] The upper clay size of 2 um, per the Canadian Foundation Engineering Manual

[2] The description is visually based & subject to EBA description protocols

Specification: _____

Remarks: _____

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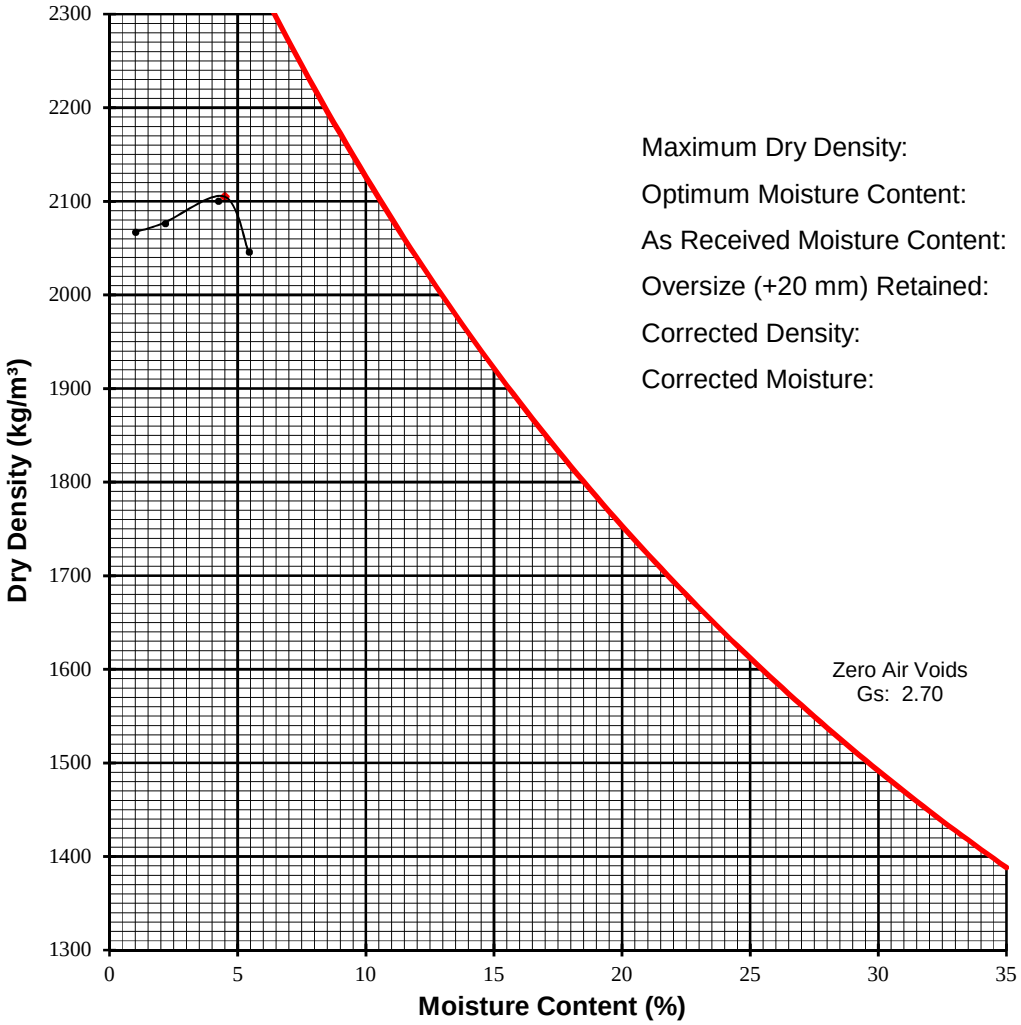
TETRA TECH

Appendix L.2 – Standard Proctor Testing

MOISTURE-DENSITY RELATIONSHIP (Proctor) REPORT

ASTM D698 Standard

Project:	Hope Bay South Dam Project	Sample No.:	6652-A
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Sample Date:	February 14, 2018
Project No.:	Y14103336-02.003	Test Date:	March 6, 2018
Description:	25 mm(-) Crush Bedding, Sample A	Preparation:	Moist
Source:	Hope Bay Quarry	Compaction:	Manual



Maximum Dry Density:	**2105**	kg/m³
Optimum Moisture Content:	**4.5**	%
As Received Moisture Content:	**2.5**	%
Oversize (+20 mm) Retained:	**0**	%
Corrected Density:	**2105**	%
Corrected Moisture:	**4.5**	%

Remarks:

Reviewed By: _____ P.Geo.

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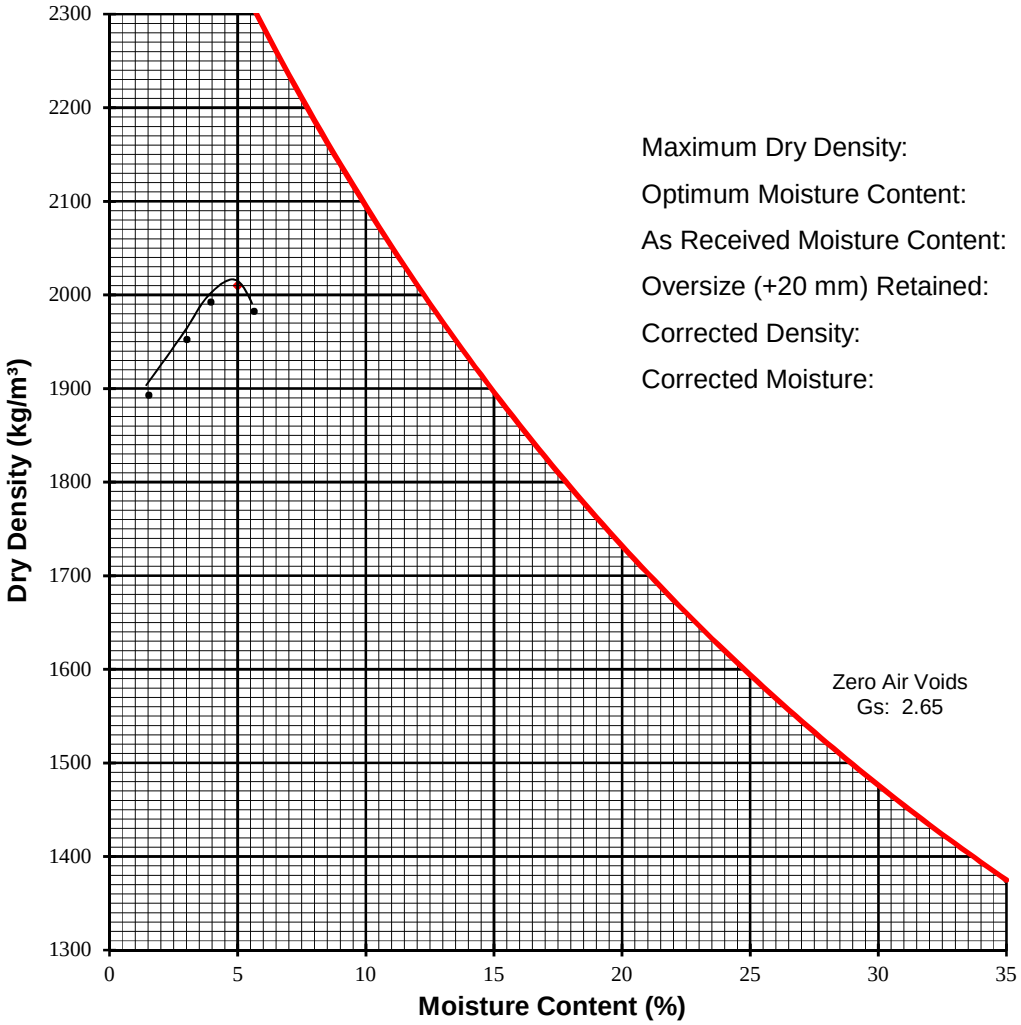
TETRA TECH

MOISTURE-DENSITY RELATIONSHIP (Proctor) REPORT

ASTM D698 Standard

Project:	Hope Bay South Dam Project	Sample No.:	6652B
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Sample Date:	February 14, 2018
Project No.:	Y14103336-02.003	Test Date:	March 5, 2018
Description:	25 mm(-) Crush Bedding, Sample B	Preparation:	Moist
Source:	Hope Bay Quarry	Compaction:	Manual



Maximum Dry Density:	**2010**	kg/m³
Optimum Moisture Content:	**5.0**	%
As Received Moisture Content:	**1.0**	%
Oversize (+20 mm) Retained:	**0**	%
Corrected Density:	**2010**	%
Corrected Moisture:	**5.0**	%

Remarks:

Reviewed By: _____ P.Geo.

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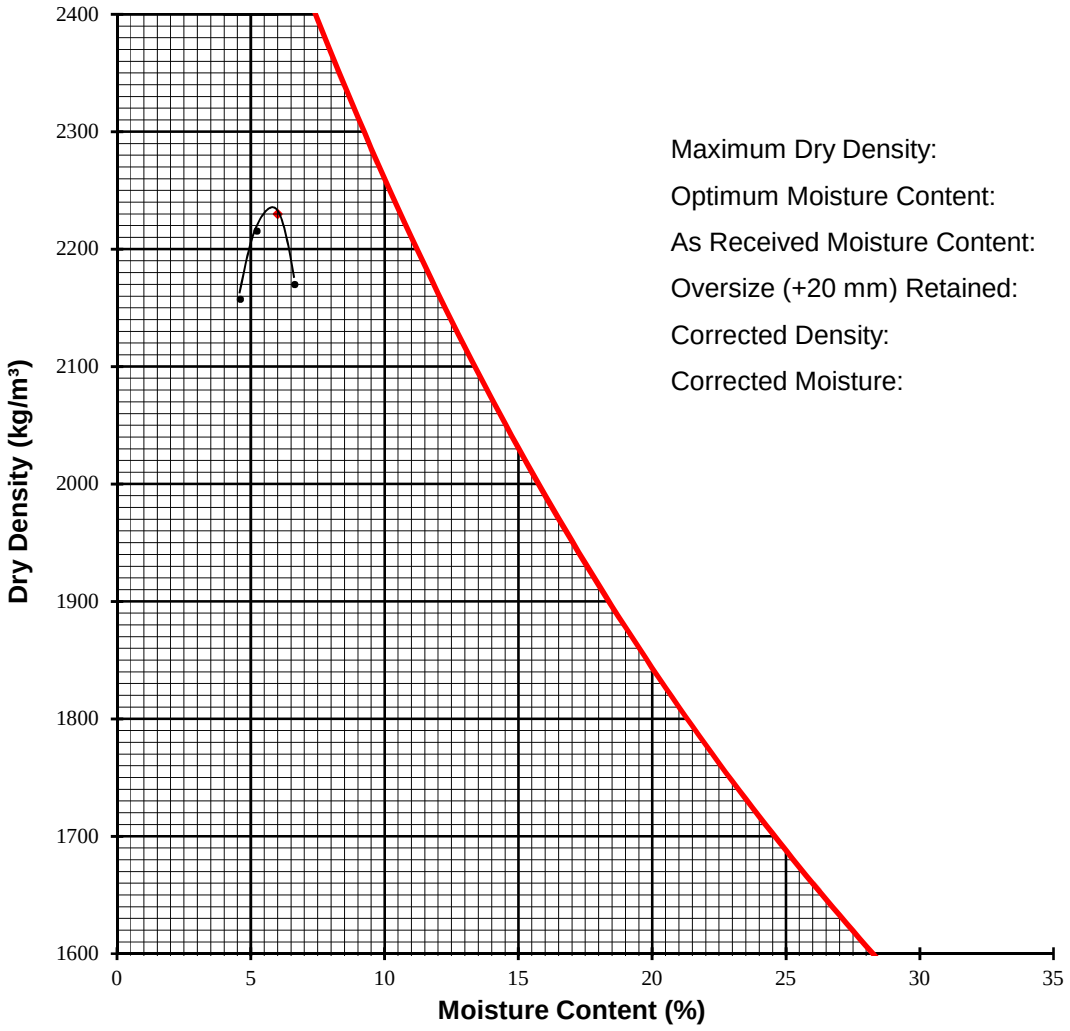
TETRA TECH

MOISTURE-DENSITY RELATIONSHIP (Proctor) REPORT

ASTM D698 Standard

Project:	Hope Bay South Dam Project	Sample No.:	6653-2
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Sample Date:	February 17, 2018
Project No.:	Y14103336-02.003	Test Date:	February 26, 2018
Description:	25 mm (-) Crush Bedding, Sample 2000 m3	Preparation:	Moist
Source:	Hope Bay Quarry	Compaction:	Manual



Maximum Dry Density:	**2230**	kg/m³
Optimum Moisture Content:	**6.0**	%
As Received Moisture Content:	**0.4**	%
Oversize (+20 mm) Retained:	**0**	%
Corrected Density:	**2230**	%
Corrected Moisture:	**6.0**	%

Remarks:

Reviewed By: _____ P.Geo.

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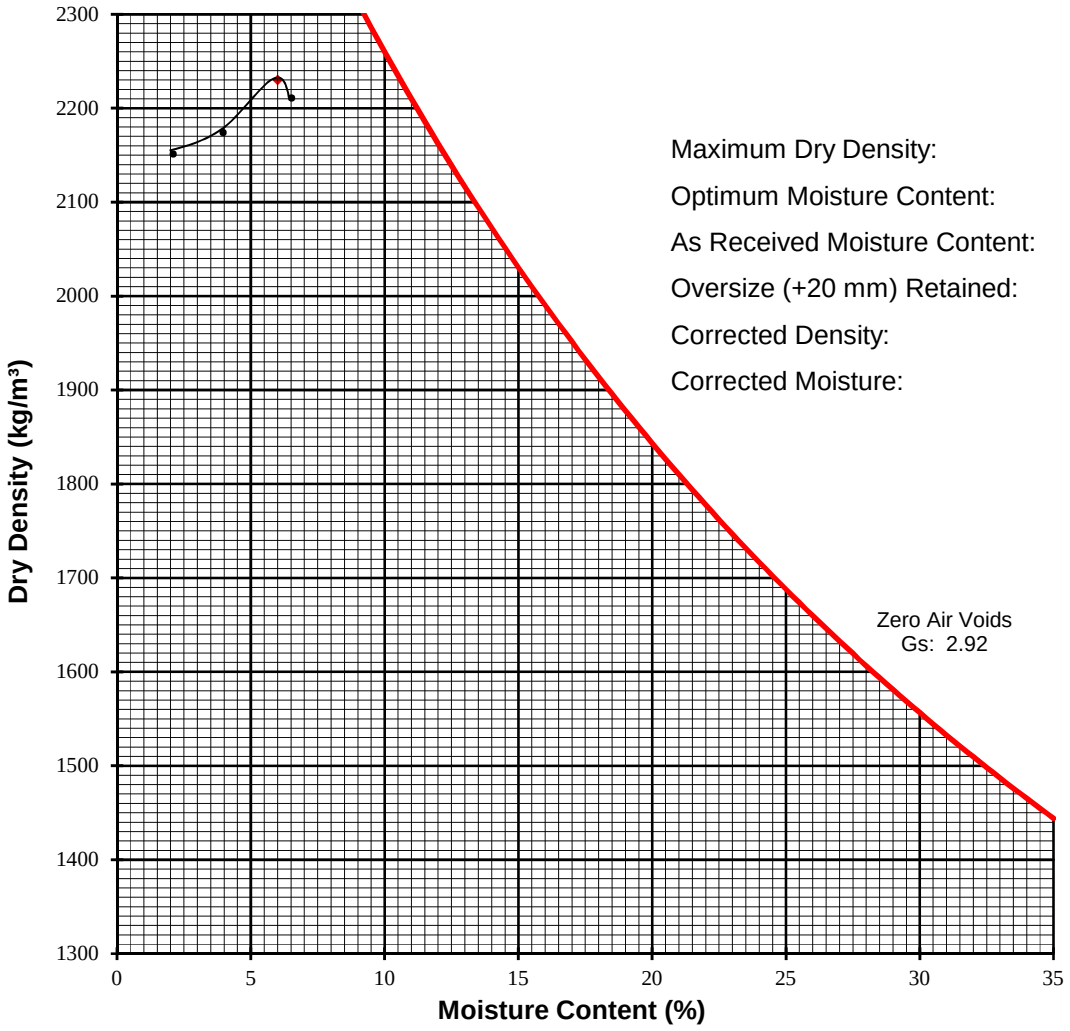
TETRA TECH

MOISTURE-DENSITY RELATIONSHIP (Proctor) REPORT

ASTM D698 Standard

Project:	Hope Bay South Dam Project	Sample No.:	6653-4
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Sample Date:	February 19, 2018
Project No.:	Y14103336-02.003	Test Date:	March 6, 2018
Description:	25 mm (-) Crush Bedding, Sample 4000 m3	Preparation:	Moist
Source:	Hope Bay Quarry	Compaction:	Manual



Maximum Dry Density:	**2230**	kg/m³
Optimum Moisture Content:	**6.0**	%
As Received Moisture Content:	**1.7**	%
Oversize (+20 mm) Retained:	**0**	%
Corrected Density:	**2230**	%
Corrected Moisture:	**6.0**	%

Remarks:

Reviewed By: _____ P.Geo.

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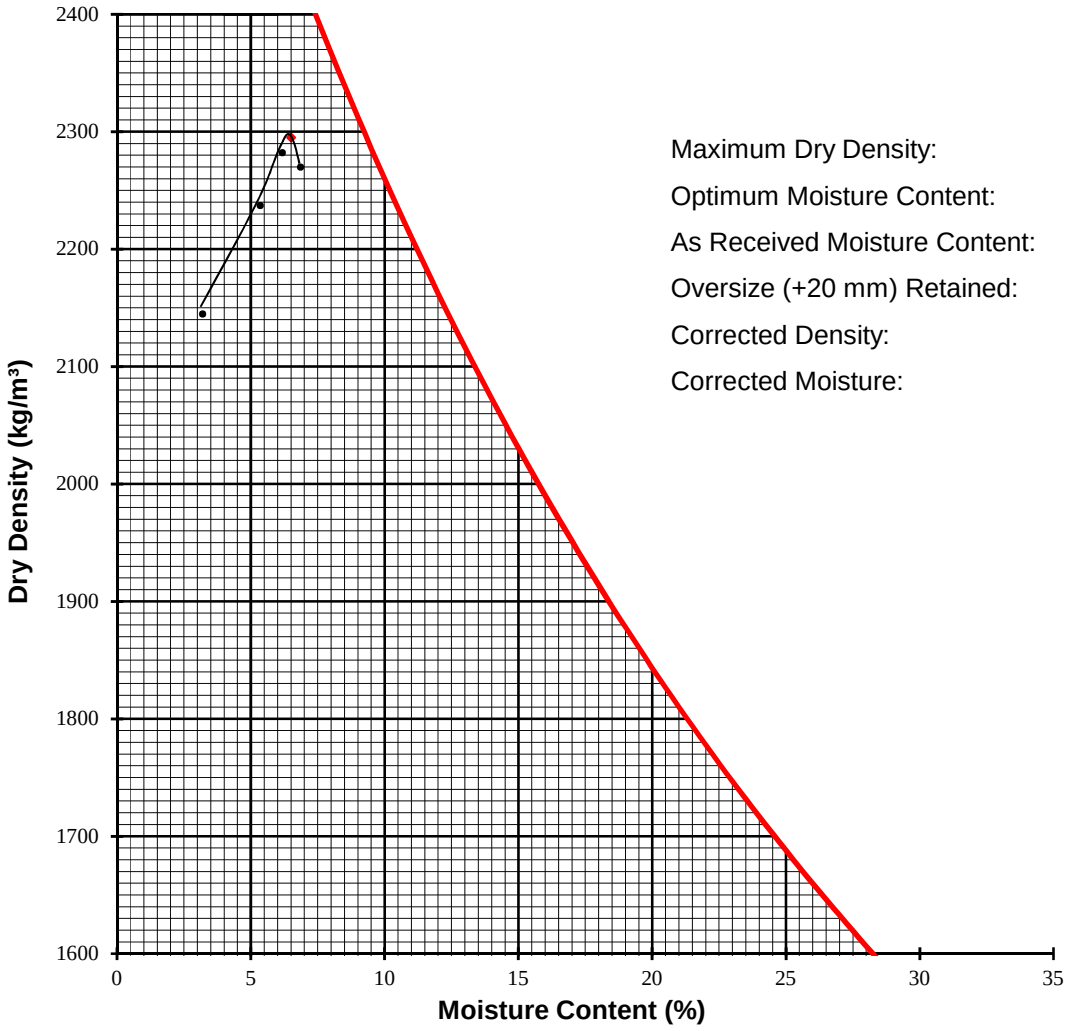
TETRA TECH

MOISTURE-DENSITY RELATIONSHIP (Proctor) REPORT

ASTM D698 Standard

Project:	Hope Bay South Dam Project	Sample No.:	6653-6
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Sample Date:	February 20, 2018
Project No.:	Y14103336-02.003	Test Date:	March 6, 2018
Description:	25 mm (-) Crush Bedding, Sample 6000 m3	Preparation:	Moist
Source:	Hope Bay Quarry	Compaction:	Manual



Maximum Dry Density:	**2295**	kg/m³
Optimum Moisture Content:	**6.5**	%
As Received Moisture Content:	**0.4**	%
Oversize (+20 mm) Retained:	**0**	%
Corrected Density:	**2295**	%
Corrected Moisture:	**6.5**	%

Remarks:

Reviewed By: _____ P.Geo.

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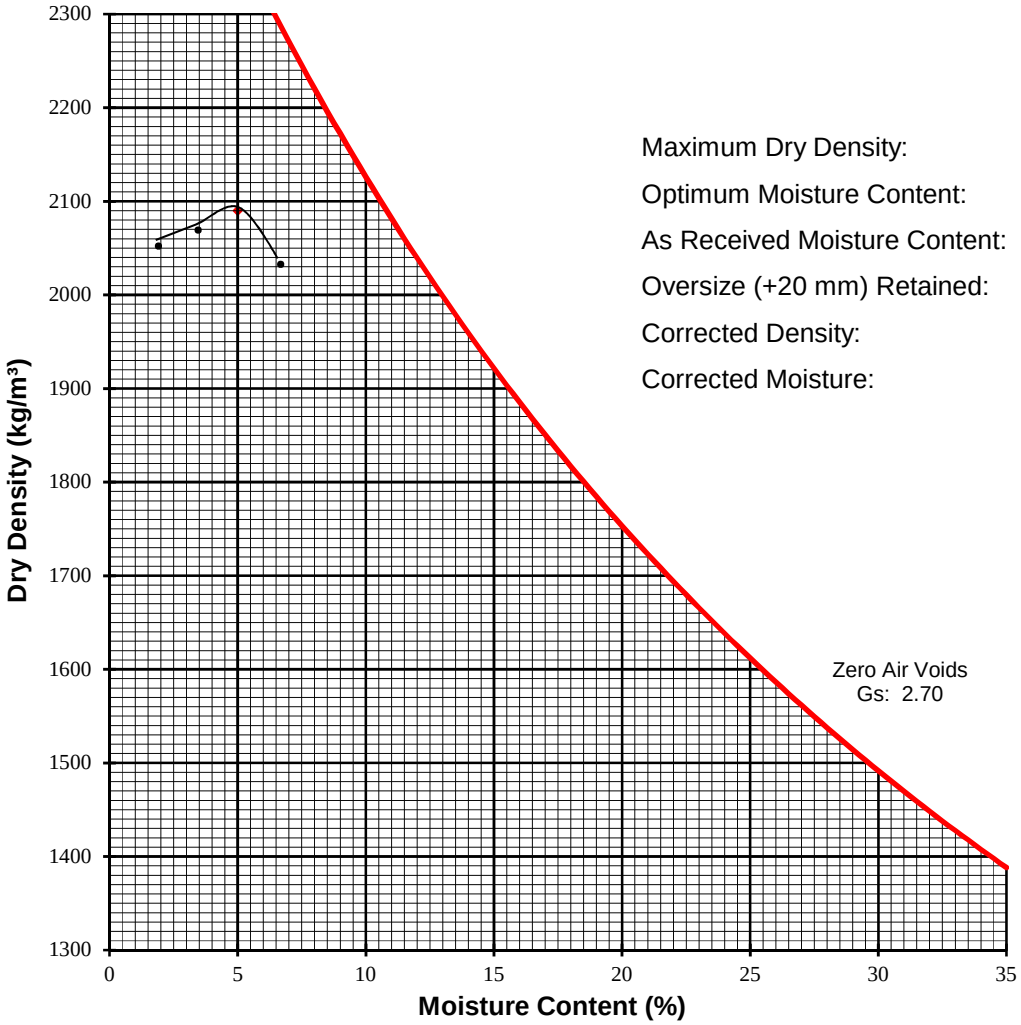
TETRA TECH

MOISTURE-DENSITY RELATIONSHIP (Proctor) REPORT

ASTM D698 Standard

Project:	Hope Bay South Dam Project	Sample No.:	6655-A
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Sample Date:	February 23, 2018
Project No.:	Y14103336-02.003	Test Date:	March 7, 2018
Description:	25 mm(-) Crush Bedding, Sample 29601	Preparation:	Moist
Source:	Hope Bay Quarry Sample 29601	Compaction:	Manual



Maximum Dry Density:	**2090**	kg/m³
Optimum Moisture Content:	**5.0**	%
As Received Moisture Content:	**1.2**	%
Oversize (+20 mm) Retained:	**0**	%
Corrected Density:	**2090**	%
Corrected Moisture:	**5.0**	%

Remarks:

Reviewed By: _____ P.Geo.

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TETRA TECH

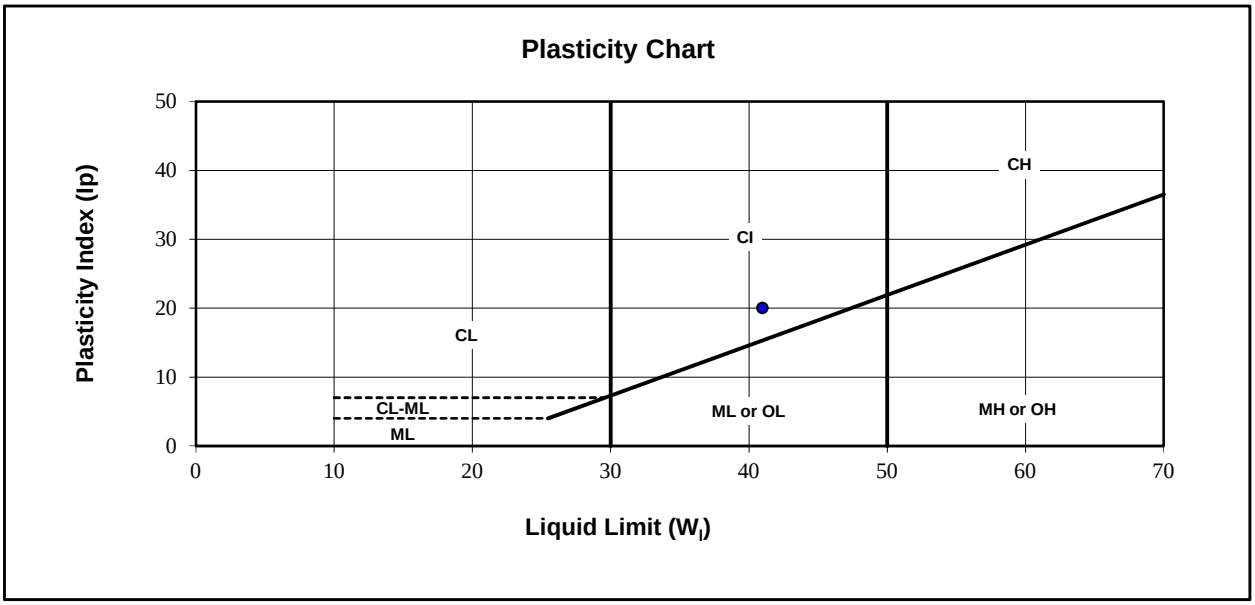
Appendix L.3 – Atterberg Limits

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6875-29442
		Borehole Number:	V-GTC-05
Project No:	Y14103336-02.003	Depth:	2.0 - 4.0 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	SS
Attention:	Kelly Schwenning	Date Sampled:	July 13, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	November 22, 2018

Sample Description: CLAY, silty, sandy, trace gravel



Liquid Limit ($W_{1)}$) :	41	Natural Moisture (%)	51.0
Plastic Limit :	21	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**20**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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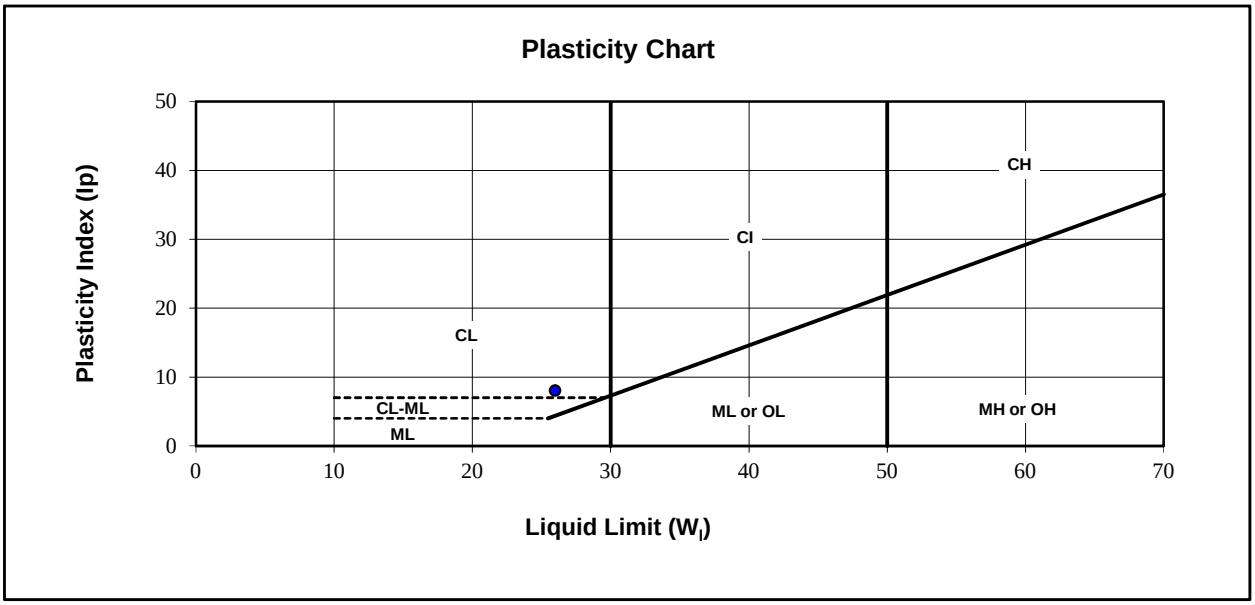
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay South Dam Project	Sample Number:	6667-29515
		Borehole Number:	SRK18-MNWRP-DH-02
Project No:	704-Y14103336-02.003	Depth:	0.4-0.7 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: DY
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 9, 2018

Sample Description: CLAY, silty, sandy



Liquid Limit ($W_{1)}$) :	26	Natural Moisture (%)	22.7
Plastic Limit :	18	Soil Plasticity:	Low
Plasticity Index (Ip) :	**8**	Mod.USCS Symbol:	CL

Remarks:

Reviewed By: P.Geol.

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TETRA TECH

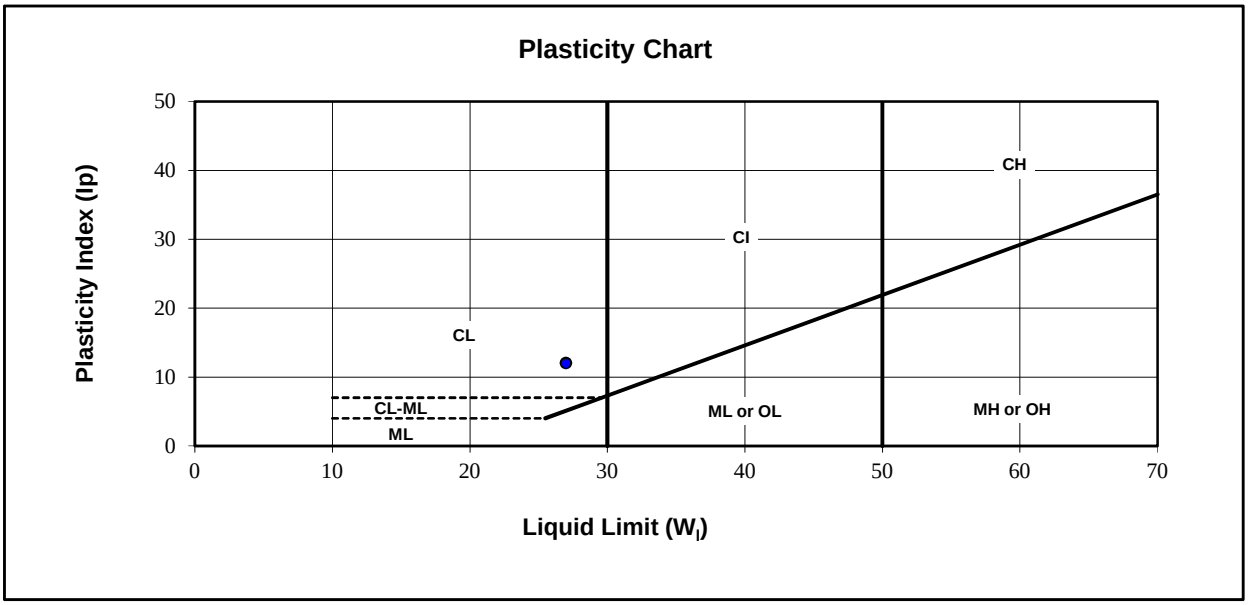
ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29518
		Borehole Number:	SRK18-MNWRP-DH-01
Project No:	704-Y14103336-02.003	Depth:	1.1-2.3 m
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 19, 2018

Tested By: JC

Sample Description: CLAY, silty, some sand, trace gravel, brown with dark grey streaks, organic.



Liquid Limit ($W_{1)}$) :	27	Natural Moisture (%)	37.5
Plastic Limit :	15	Soil Plasticity:	Low
Plasticity Index (Ip) :	**12**	Mod.USCS Symbol:	CL

Remarks:

Reviewed By: P.Geol.

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TETRA TECH

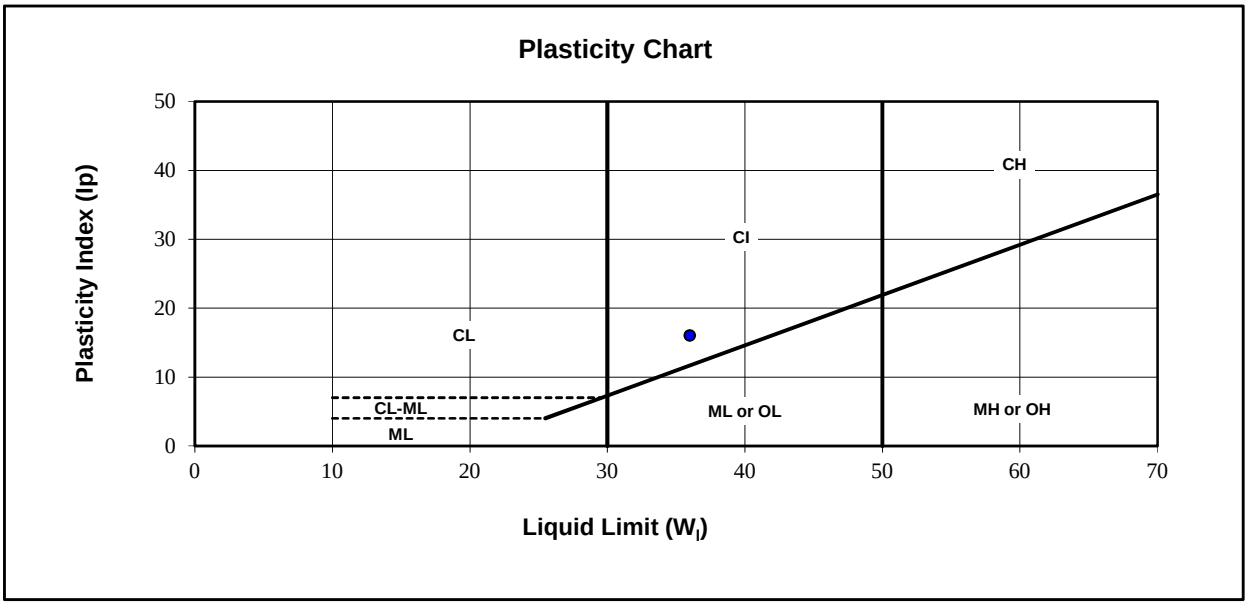
ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29519
		Borehole Number:	SRK18-MNWRP-DH-01
Project No:	704-Y14103336-02.003	Depth:	2.5-3.2 m
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 27, 2018

Tested By: WM

Sample Description: SILT, clayey, some sand, brownish grey with black/grey streaks. Light brown inclusions.



Liquid Limit ($W_{1)}$) :	36	Natural Moisture (%)	45.1
Plastic Limit :	20	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**16**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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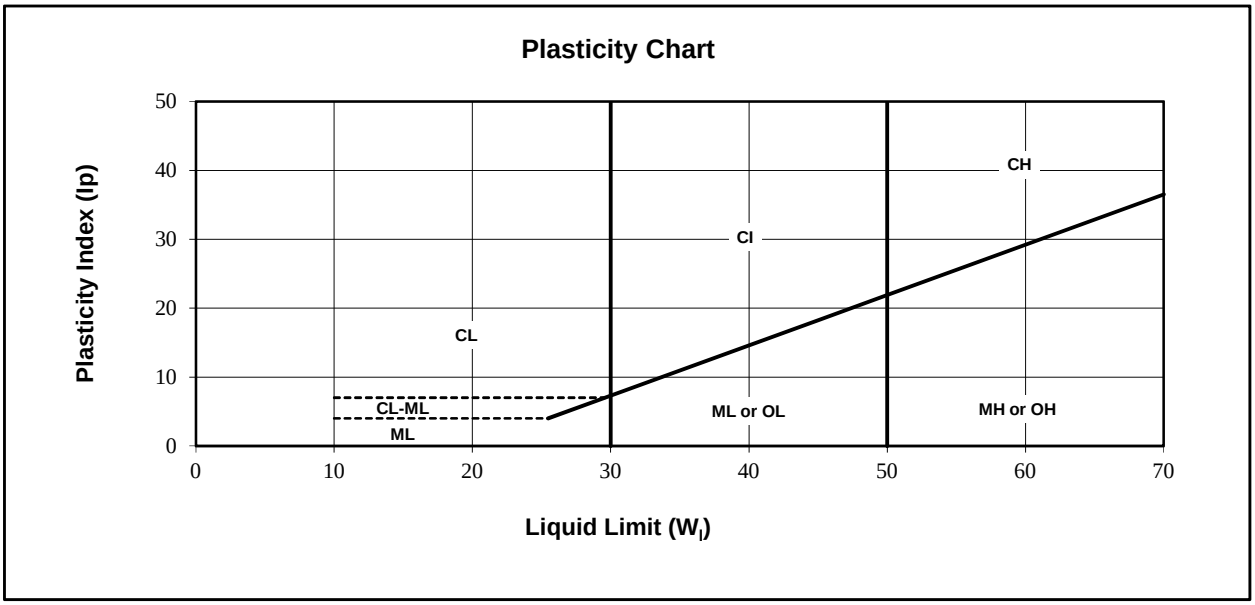
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay South Dam Project	Sample Number:	6667-29521
		Borehole Number:	SRK18-MNWRP-DH-01
Project No:	704-Y14103336-02.003	Depth:	4.2-5.2 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	DY
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 9, 2018

Sample Description: SAND, some silt, some clay



Liquid Limit ($W_{1)}$) :		Natural Moisture (%)	25.9
Plastic Limit :		Soil Plasticity:	Non-Plastic
Plasticity Index (Ip) :		Mod.USCS Symbol:	

Remarks: Non-plastic. Plastic limit was not possible, material will not thread.

Reviewed By: _____ P.Geol.

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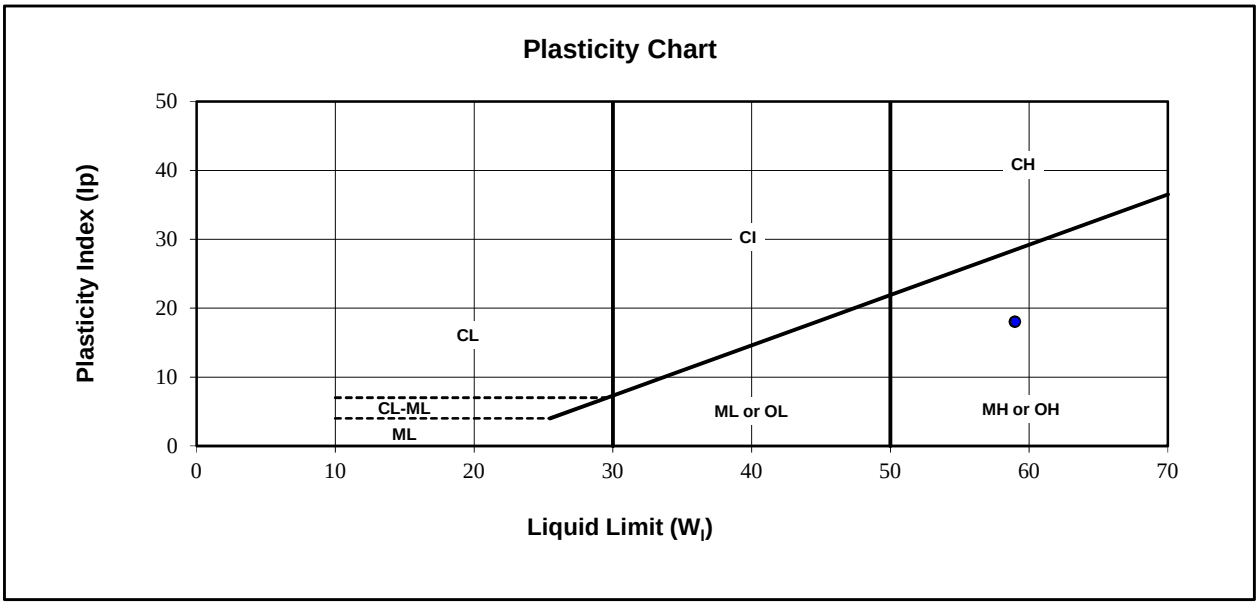
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29523
		Borehole Number:	SRK18-MNPCP-DH-01
Project No:	704-Y14103336-02.003	Depth:	0.2-0.6 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 1, 2018

Sample Description: CLAY, silty, some sand, dark brown to black, organics



Liquid Limit ($W_{1)}$) :	59	Natural Moisture (%)	91.9
Plastic Limit :	41	Soil Plasticity:	High
Plasticity Index (Ip) :	**18**	Mod.USCS Symbol:	OH

Remarks:

Reviewed By: _____ P.Geol.

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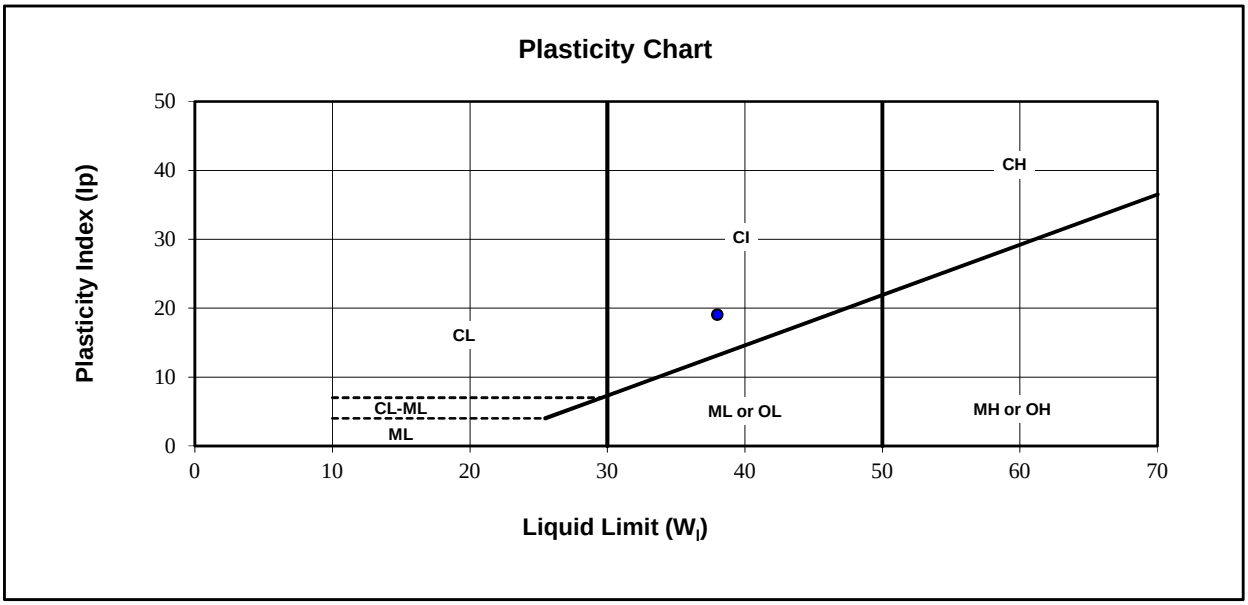
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29524
	South Dam Project	Borehole Number:	SRK18-MNPCP-DH-01
Project No:	704-Y14103336-02.003	Depth:	2.9-3.6 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: JPC
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 23, 2018

Sample Description: CLAY, silty, some sand. Black with brown inclusions. Organics.



Liquid Limit ($W_{1)}$) :	38	Natural Moisture (%)	72.7
Plastic Limit :	19	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**19**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: _____ P.Geol.

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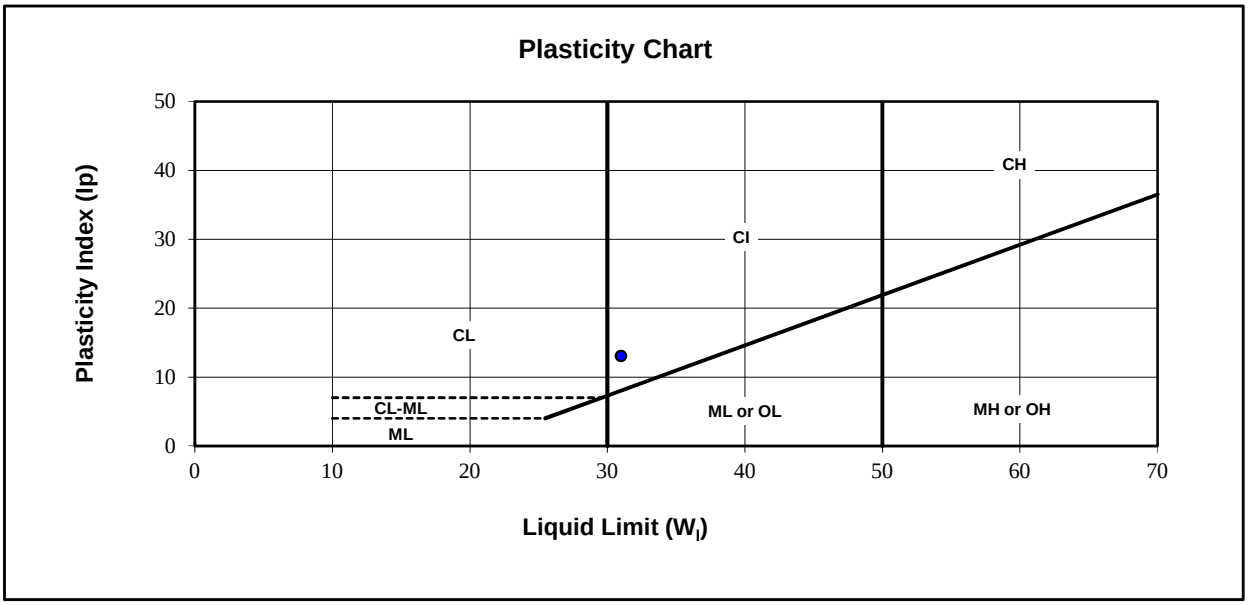
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29526
	South Dam Project	Borehole Number:	SRK18-MNPCP-DH-01
Project No:	704-Y14103336-02.003	Depth:	4.1-4.5 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: WM
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 19, 2018

Sample Description: CLAY, silty, sandy, brown with dark grey streaks, organic.



Liquid Limit ($W_{1)}$) :	31	Natural Moisture (%)	47.6
Plastic Limit :	18	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**13**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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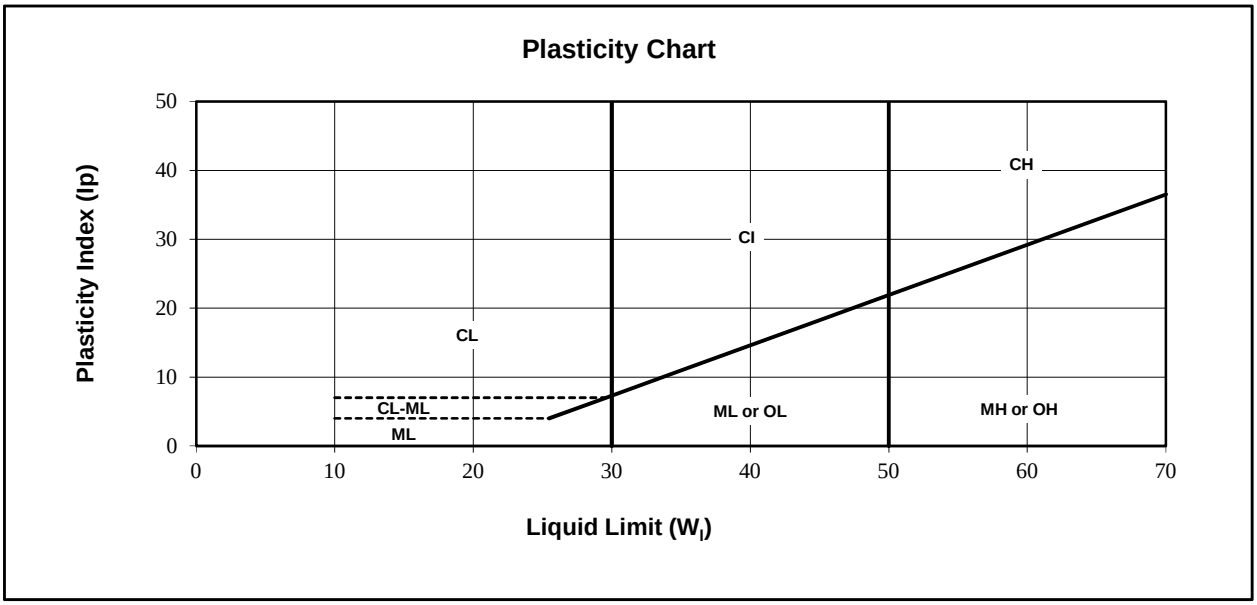
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29527
	South Dam Project	Borehole Number:	SRK18-MNPCP-DH-01
Project No:	704-Y14103336-02.003	Depth:	4.5-5.1 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	JPC
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 23, 2018

Sample Description: SAND, silty, some gravel, trace clay. Greenish grey.



Liquid Limit ($W_{1)}$) :		Natural Moisture (%)	11.0
Plastic Limit :		Soil Plasticity:	Non-Plastic
Plasticity Index (Ip) :		Mod.USCS Symbol:	

Remarks: Non-Plastic. Sample contains fine sand and silt below 0.425 mm.

Reviewed By: _____ P.Geol.

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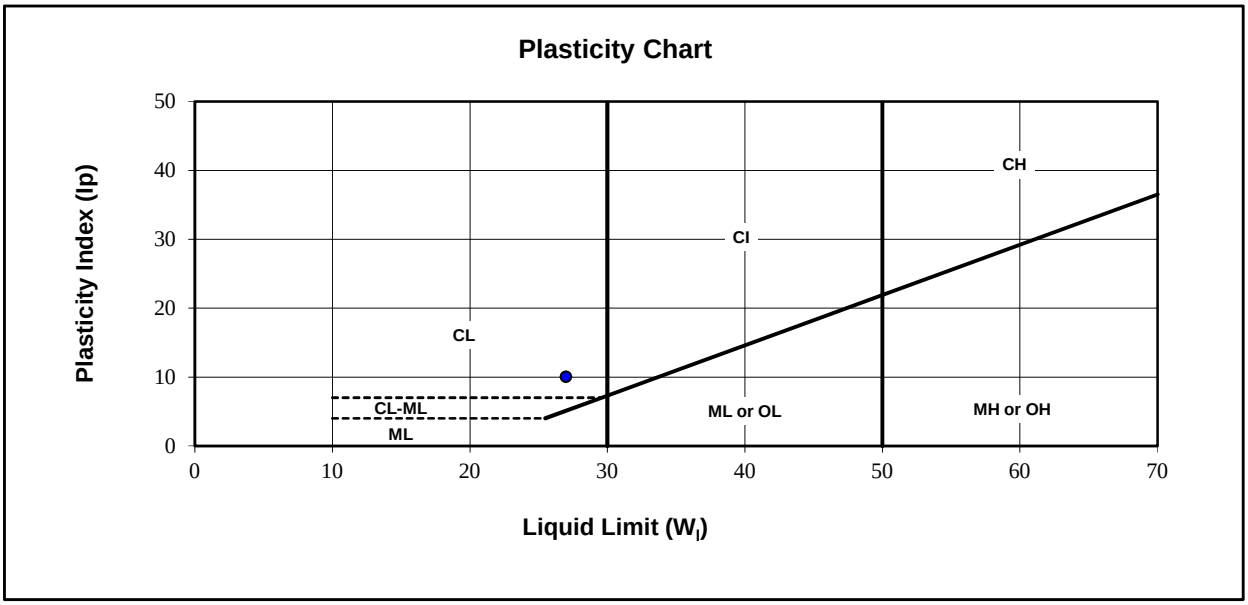
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29529
	South Dam Project	Borehole Number:	SRK18-MNPCP-DH-02
Project No:	704-Y14103336-02.003	Depth:	1.3-2.8 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: DY
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 9, 2018

Sample Description: CLAY, silty, sandy. Mottled brown and light grey organics.



Liquid Limit ($W_{1)}$) :	27	Natural Moisture (%)	30.1
Plastic Limit :	17	Soil Plasticity:	Low
Plasticity Index (Ip) :	**10**	Mod.USCS Symbol:	CL

Remarks:

Reviewed By: BF. P.Geol.

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TETRA TECH

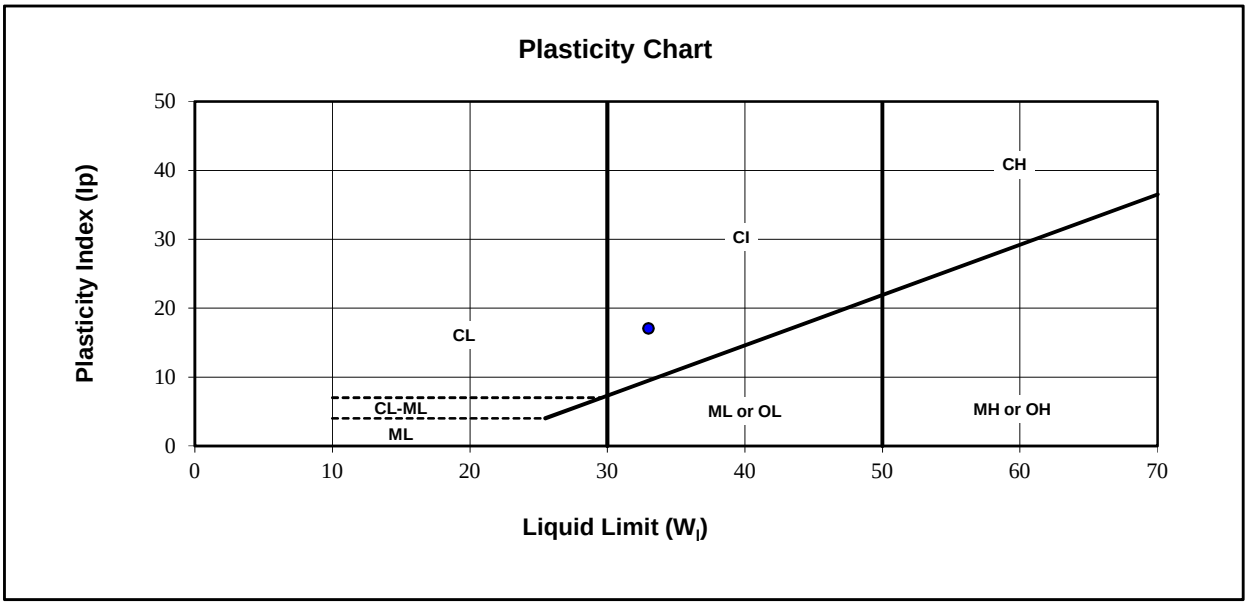
ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29530
	South Dam Project	Borehole Number:	SRK18-MNPCP-DH-02
Project No:	704-Y14103336-02.003	Depth:	3.0-4.3 m
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 23, 2018

Tested By: JPC

Sample Description: CLAY, silty, sandy, trace gravel, dark grey with brown streaks.



Liquid Limit ($W_{1)}$) :	33	Natural Moisture (%)	52.3
Plastic Limit :	16	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**17**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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TETRA TECH

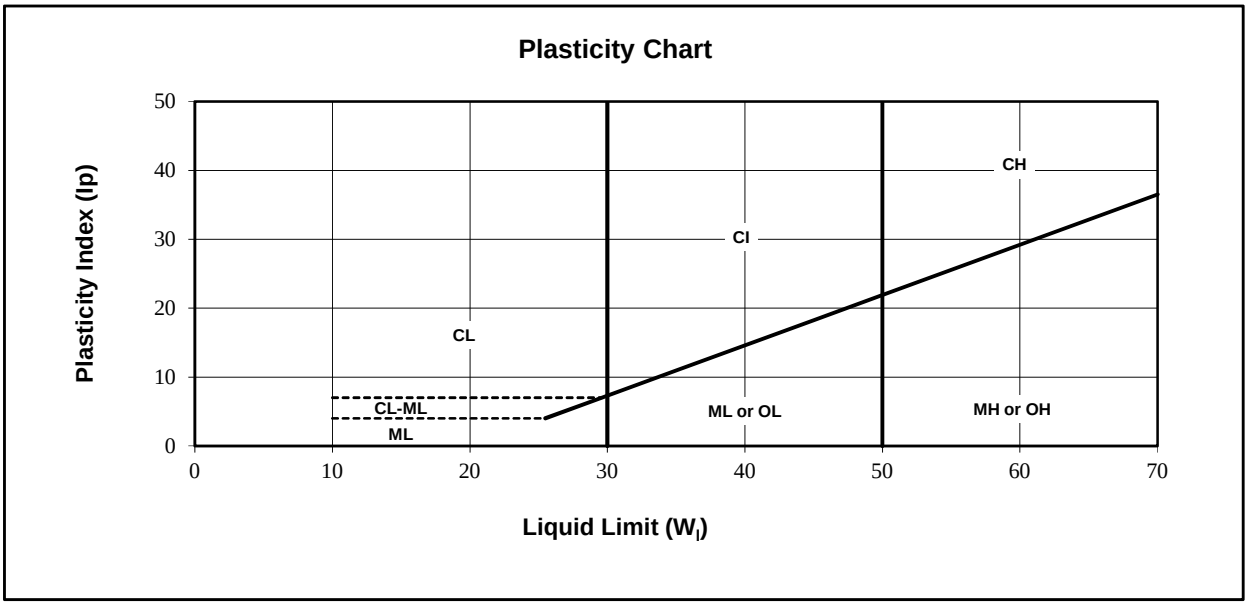
ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29544
		Borehole Number:	SRK18-RD-DH-18
Project No:	704-Y14103336-02.003	Depth:	0.2-0.6 m
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 27, 2018

Tested By: WM

Sample Description: Non-plastic. SILT, fine sand, trace clay.



Liquid Limit ($W_{1)}$) :		Natural Moisture (%)	24.5
Plastic Limit :		Soil Plasticity:	Non-plastic
Plasticity Index (Ip) :		Mod.USCS Symbol:	

Remarks: Sample is non-plastic. Composed of silt, fine sand, with trace clay.

Reviewed By: P.Geol.

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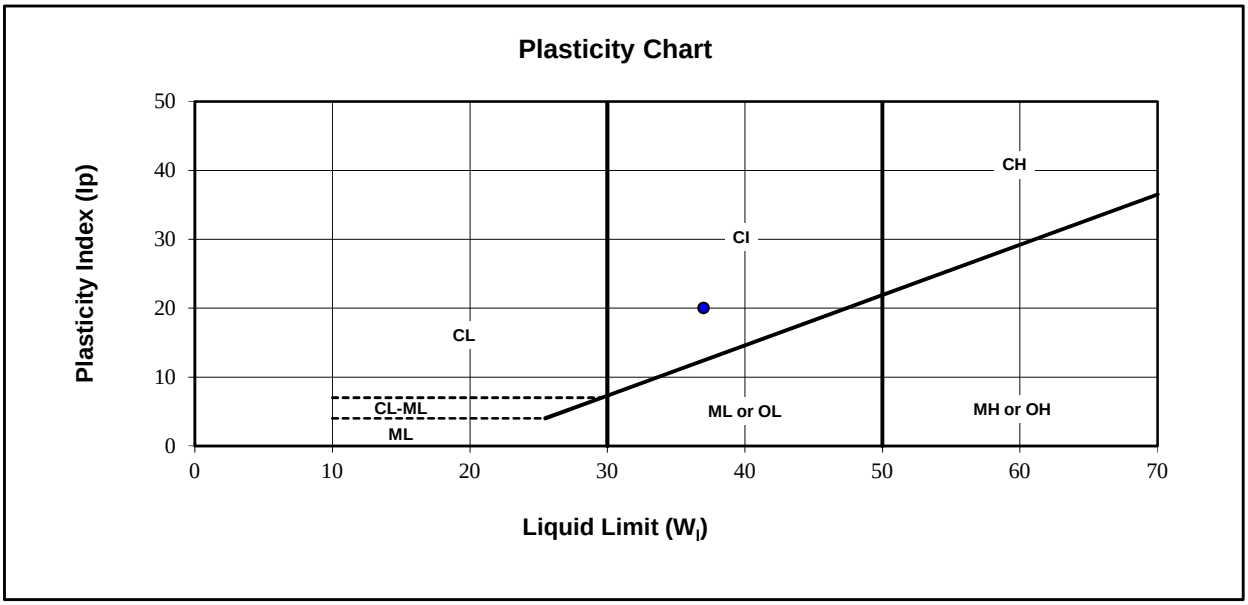
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29546
		Borehole Number:	SRK18-RD-DH-18
Project No:	704-Y14103336-02.003	Depth:	11.4 - 11.8 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	April 28, 2018

Sample Description: CLAY, silty, mottled brown and dark grey, organics.



Liquid Limit ($W_{1)}$) :	37	Natural Moisture (%)	44.4
Plastic Limit :	17	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**20**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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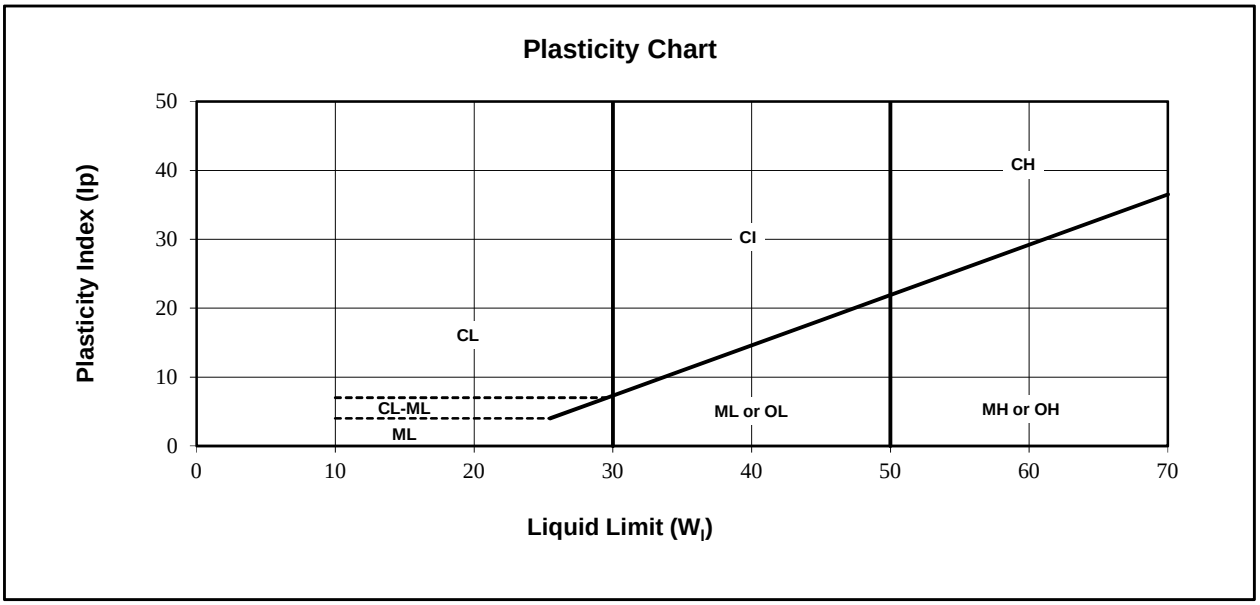
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29547
	South Dam Project	Borehole Number:	SRK18-RD-DH-18
Project No:	704-Y14103336-02.003	Depth:	12.9-13.4 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 15, 2018

Sample Description: SAND, gravelly, silty, trace clay



Liquid Limit ($W_{1)}$) :		Natural Moisture (%)	8.9
Plastic Limit :		Soil Plasticity:	Non-Plastic
Plasticity Index (Ip) :		Mod.USCS Symbol:	

Remarks: Sample is non-plastic. Material smaller than 425 um is mainly fine sand.

Reviewed By: _____ P.Geol.

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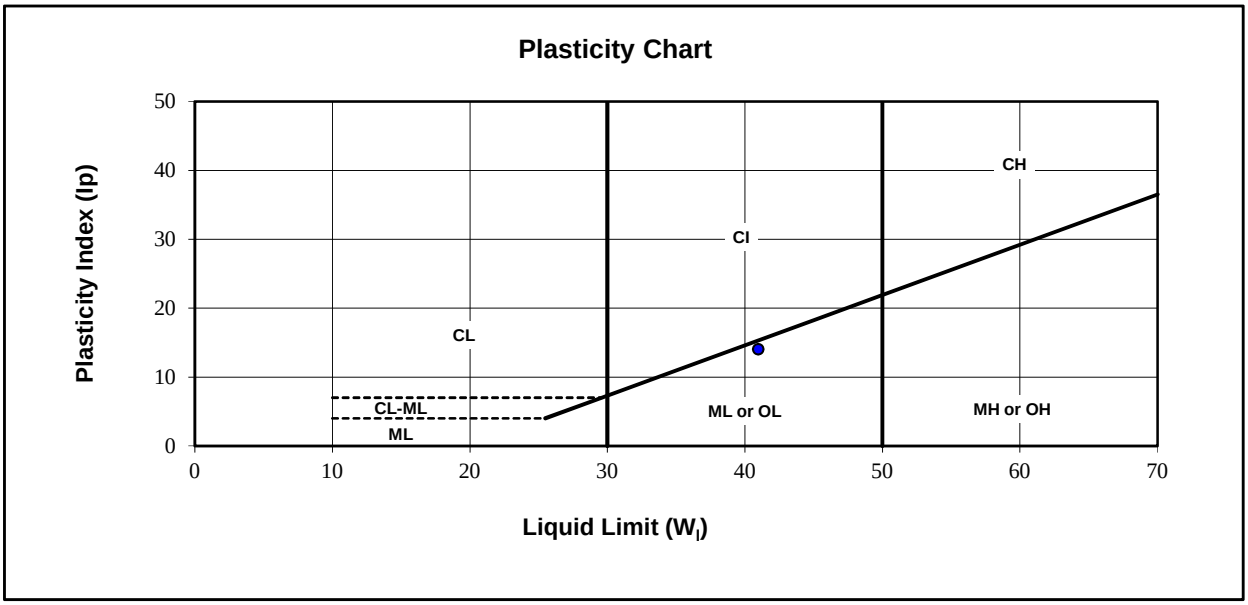
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29548
		Borehole Number:	SRK18-RD-DH-17
Project No:	704-Y14103336-02.003	Depth:	0.5-0.9 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	JPC
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 20, 2018

Sample Description: CLAY, silty, some sand, trace gravel, grey with light brown streaks, organic.



Liquid Limit ($W_{1)}$) :	41	Natural Moisture (%)	63.3
Plastic Limit :	27	Soil Plasticity:	Low
Plasticity Index (Ip) :	**14**	Mod.USCS Symbol:	ML

Remarks:

Reviewed By: P.Geol.

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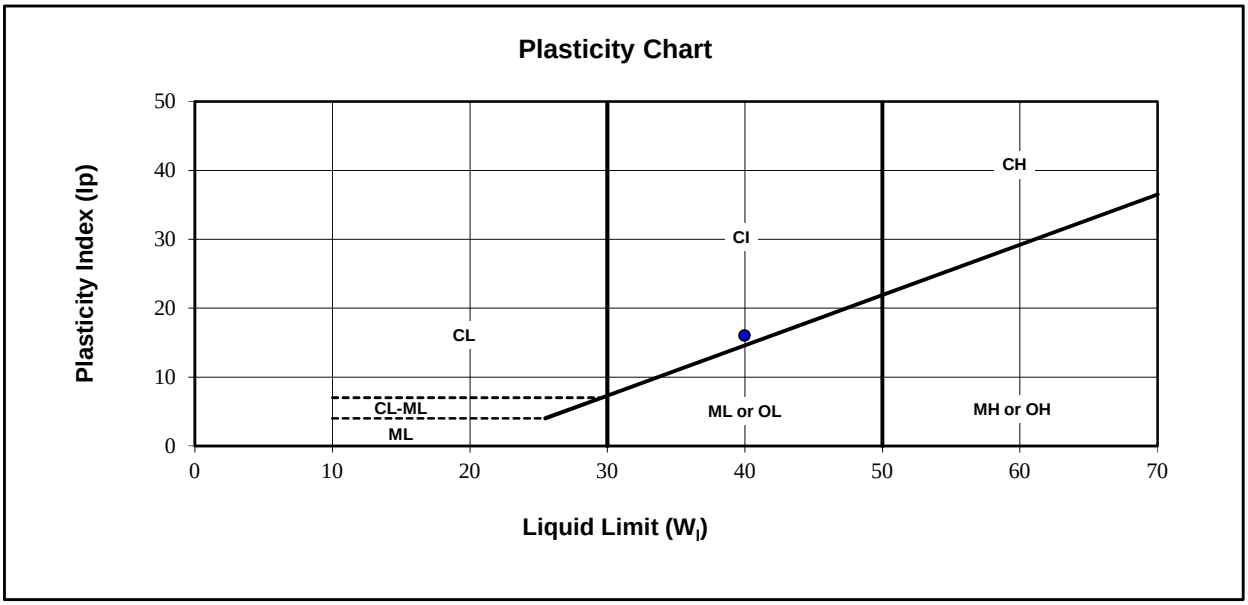
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29549
		Borehole Number:	SRK18-RD-DH-17
Project No:	704-Y14103336-02.003	Depth:	3.7-4.1 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 28, 2018

Sample Description: CLAY, silty, trace sand, trace gravel, brown with dark grey,light brown inclusions.



Liquid Limit ($W_{1)}$) :	40	Natural Moisture (%)	33.5
Plastic Limit :	24	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**16**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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TETRA TECH

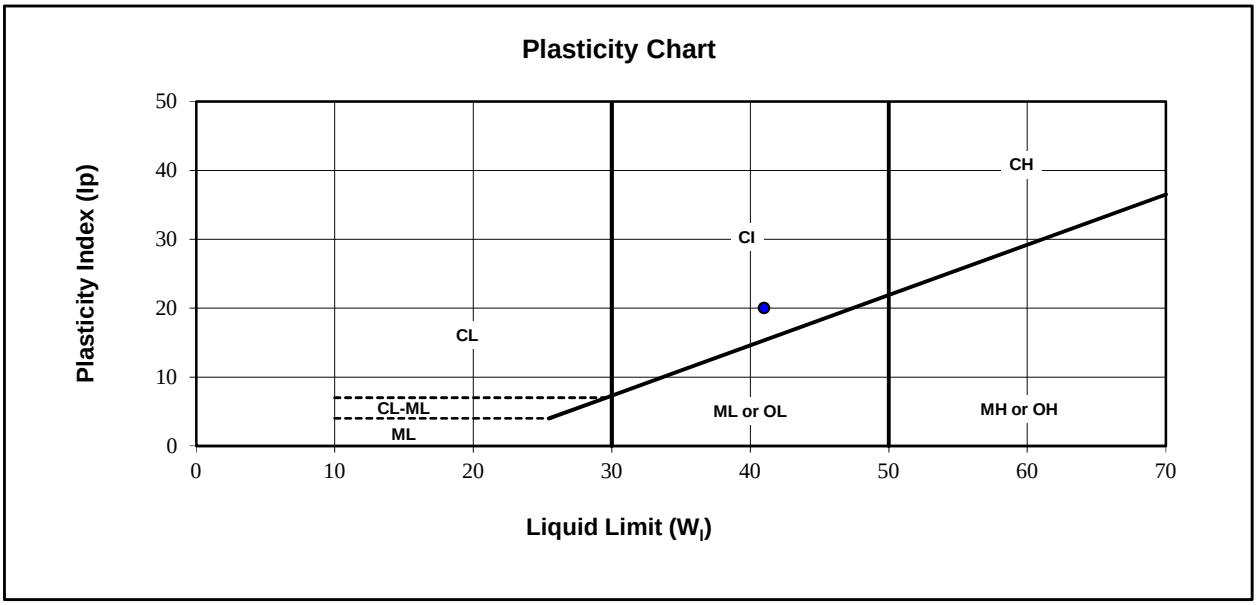
ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29550
	South Dam Project	Borehole Number:	SRK18-RD-DH-17
Project No:	704-Y14103336-02.003	Depth:	8.7-9.1 m
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 23, 2018

Tested By: JPC

Sample Description: CLAY, silty, trace sand, trace gravel, grey with brown streaks, organic.



Liquid Limit ($W_{1)}$) :	41	Natural Moisture (%)	41.7
Plastic Limit :	21	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**20**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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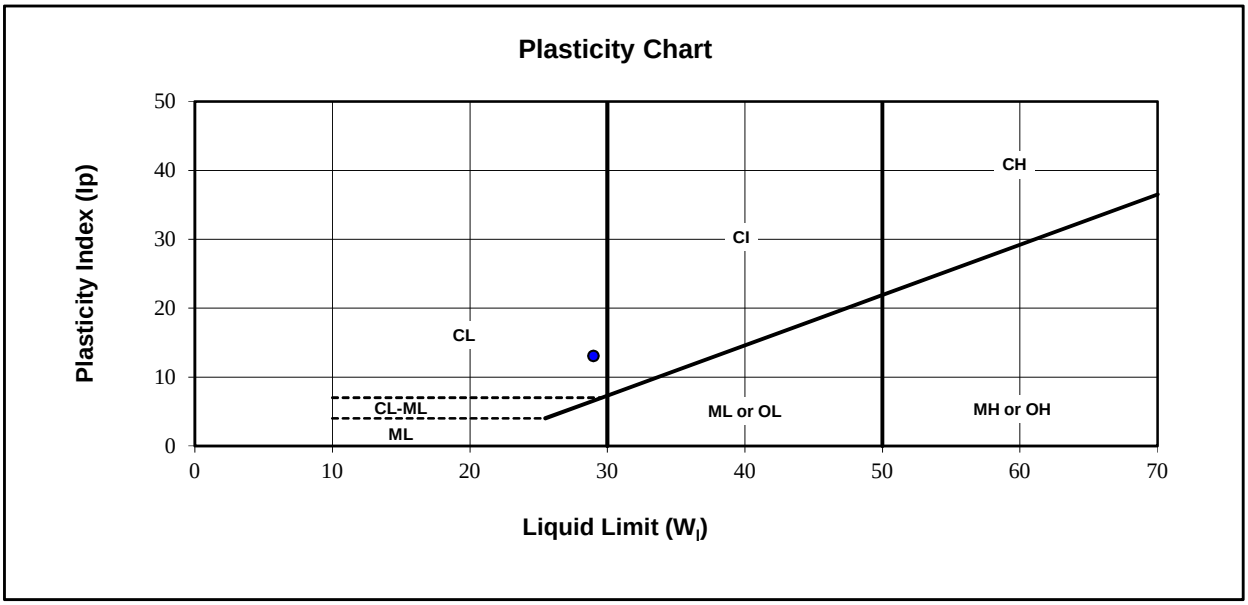
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29551
		Borehole Number:	SRK18-RD-DH-17
Project No:	704-Y14103336-02.003	Depth:	12.9-13.3 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: DY
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 10, 2018

Sample Description: CLAY, silty, sandy, some gravel. Organics. Brown with black inclusions.



Liquid Limit ($W_{1)}$) :	29	Natural Moisture (%)	44.6
Plastic Limit :	16	Soil Plasticity:	Low to Medium
Plasticity Index (Ip) :	**13**	Mod.USCS Symbol:	CL-CI

Remarks:

Reviewed By: P.Geol.

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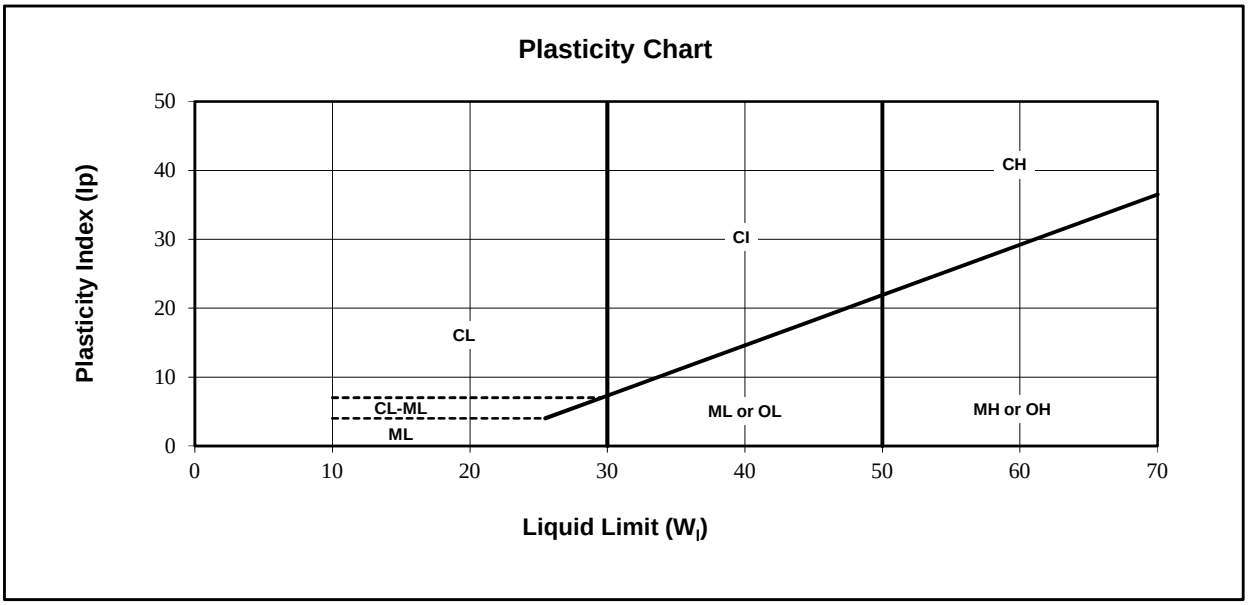
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29570
		Borehole Number:	SRK18-STH-DH-03
Project No:	704-Y14103336-02.003	Depth:	0.7-2.2 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 29, 2018

Sample Description: Non-plastic. Silty fine sand.



Liquid Limit ($W_{1)}$) :		Natural Moisture (%)	30.6
Plastic Limit :		Soil Plasticity:	Non-plastic
Plasticity Index (Ip) :		Mod.USCS Symbol:	

Remarks: Sample is non-plastic. Composed of silty fine sand.

Reviewed By: _____ P.Geol.

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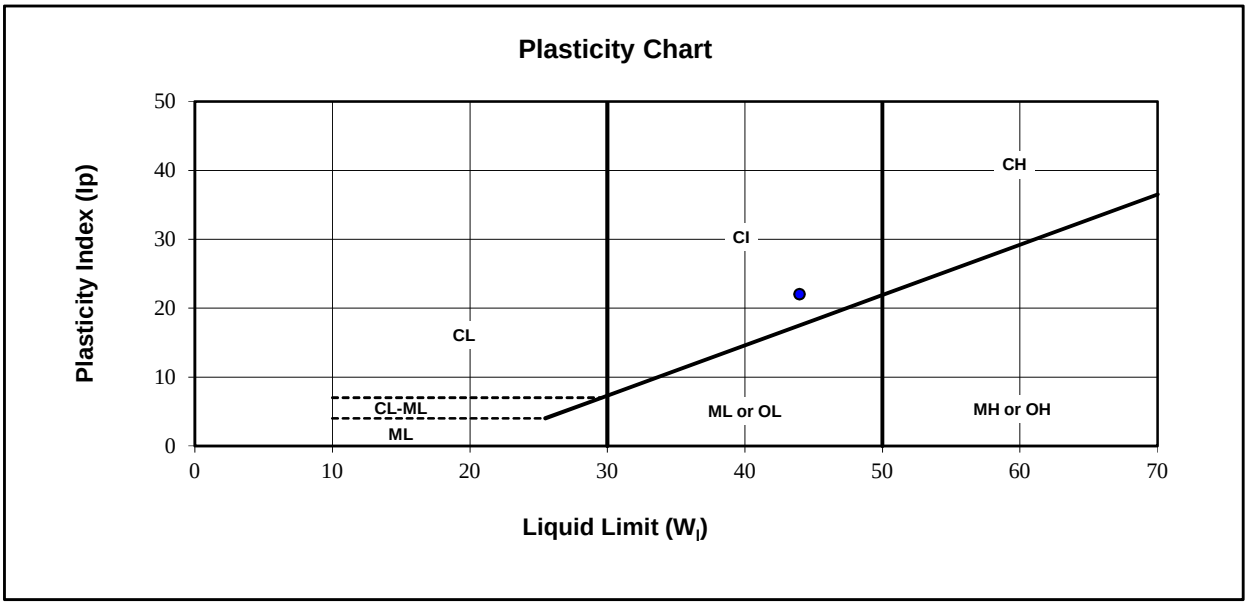
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29572
		Borehole Number:	SRK18-STH-DH-03
Project No:	704-Y14103336-02.003	Depth:	5.8-6.6 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	JC
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 16, 2018

Sample Description: CLAY, silty, trace sand, dark grey with brown streaks.



Liquid Limit ($W_{1)}$) :	44	Natural Moisture (%)	59.8
Plastic Limit :	22	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**22**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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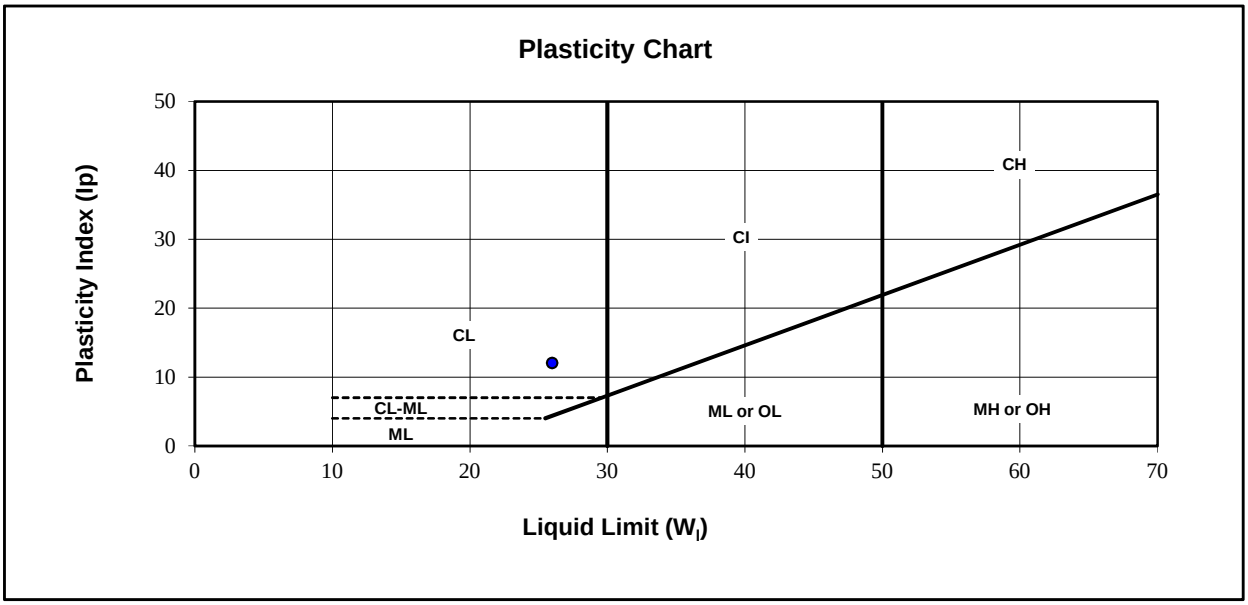
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29574
		Borehole Number:	SRK18-STH-DH-03
Project No:	704-Y14103336-02.003	Depth:	8.1-9.1 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	May 2, 2018

Sample Description: CLAY, silty, some fine sand. Dark grey. Organics.



Liquid Limit ($W_{1)}$) :	26	Natural Moisture (%)	45.8
Plastic Limit :	14	Soil Plasticity:	Low
Plasticity Index (Ip) :	**12**	Mod.USCS Symbol:	CL

Remarks:

Reviewed By: P.Geol.

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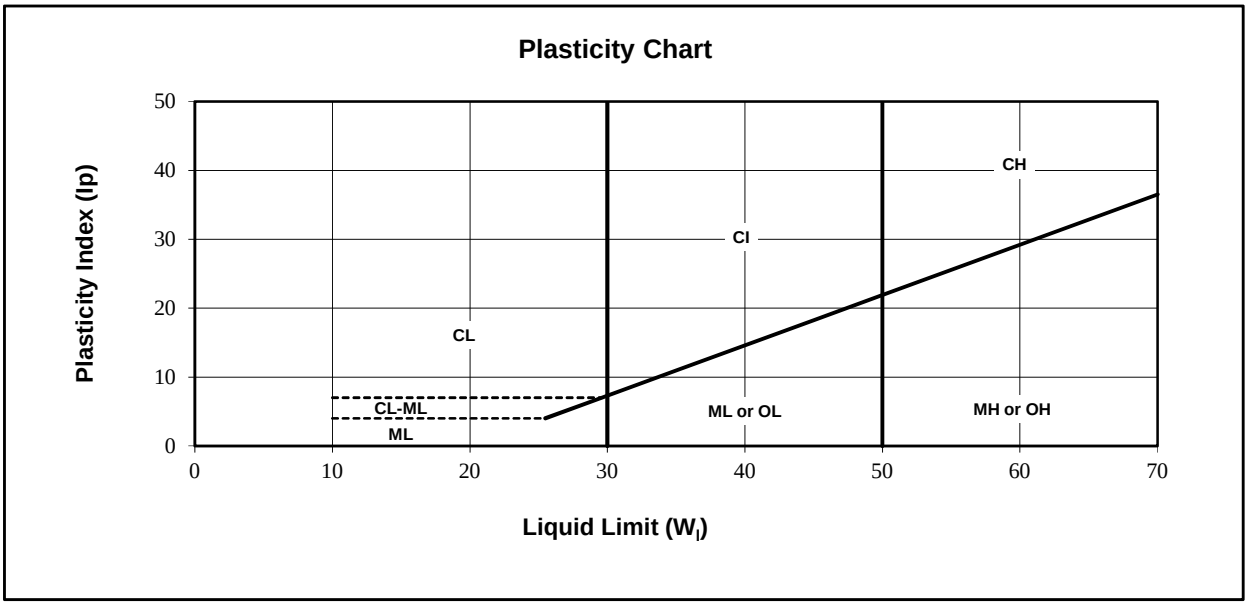
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29578
		Borehole Number:	SRK18-STH-DH-02
Project No:	704-Y14103336-02.003	Depth:	0.2-0.6 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	JPC
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 25, 2018

Sample Description: Peat, trace fine sand, trace silt, topsoil, organic, brown, dark brown olive incl.



Liquid Limit ($W_{1)}$) :		Natural Moisture (%)	108.8
Plastic Limit :		Soil Plasticity:	Non-plastic
Plasticity Index (Ip) :		Mod.USCS Symbol:	

Remarks: Non-plastic, sample is peat, trace silt, trace fine sand.

Reviewed By: P.Geol.

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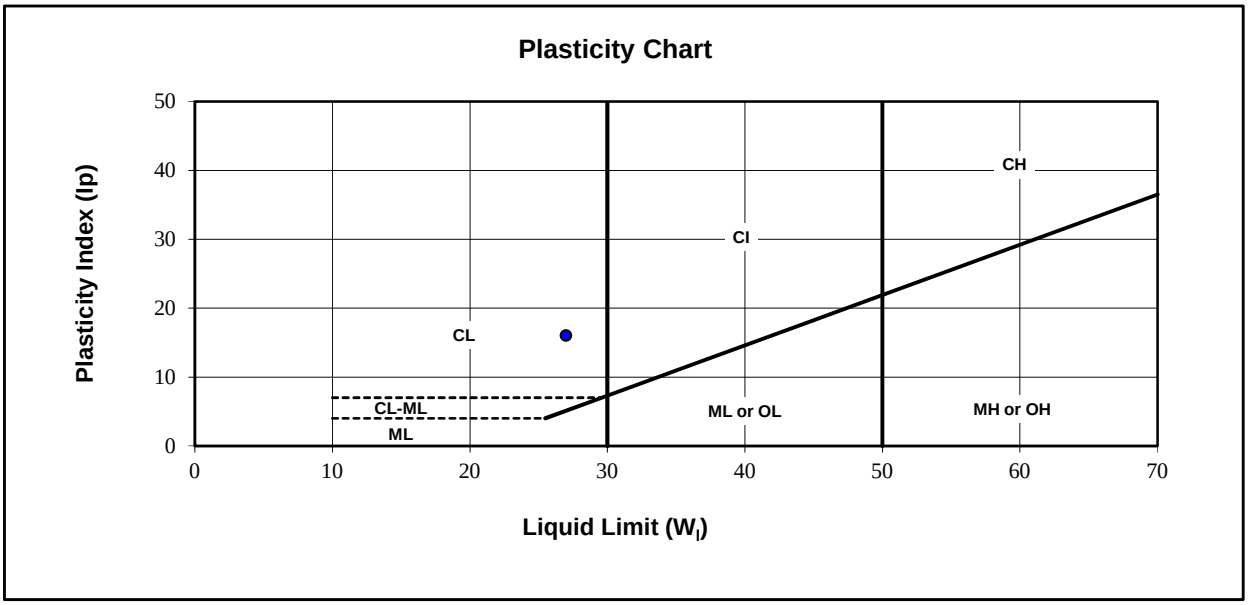
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29579
		Borehole Number:	SRK18-STH-DH-02
Project No:	704-Y14103336-02.003	Depth:	2.5-2.9 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 31, 2018

Sample Description: CLAY, silty, sandy, brownish grey



Liquid Limit ($W_{1)}$) :	27	Natural Moisture (%)	71.2
Plastic Limit :	11	Soil Plasticity:	Low
Plasticity Index (Ip) :	**16**	Mod.USCS Symbol:	CL

Remarks:

Reviewed By: P.Geol.

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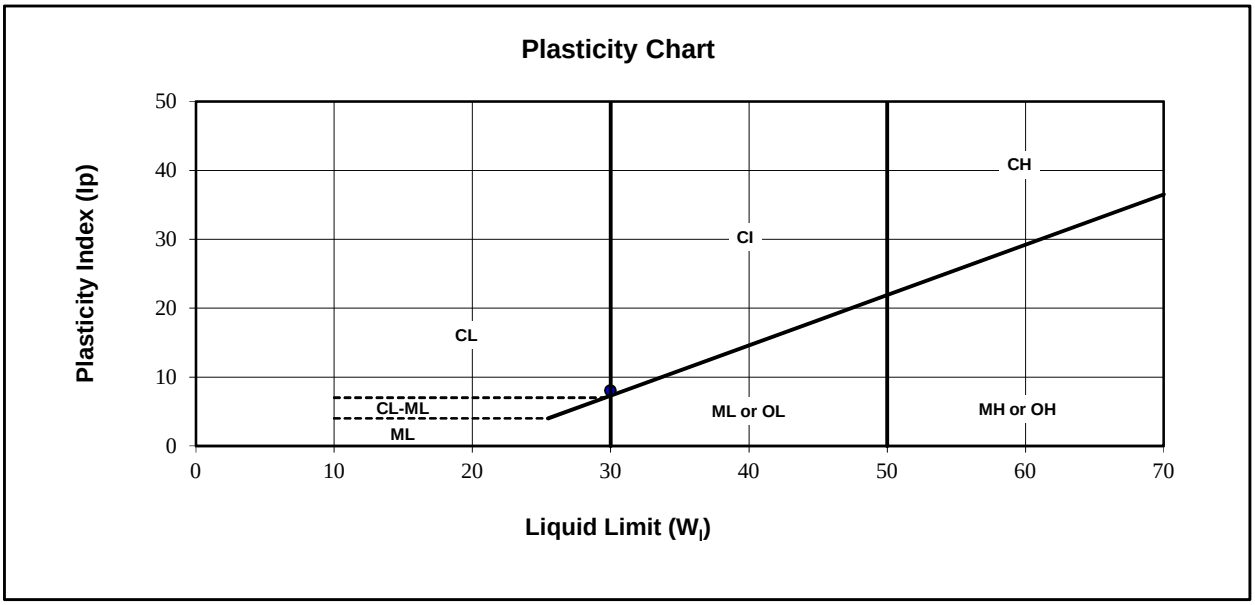
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay South Dam Project	Sample Number:	6667-29606
		Borehole Number:	SRK18-STH-DH-01
Project No:	704-Y14103336-02.003	Depth:	0.1-0.5 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	IS
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 8, 2018

Sample Description: CLAY, silty, some sand



Liquid Limit ($W_{1)}$) :	30	Natural Moisture (%)	27.6
Plastic Limit :	22	Soil Plasticity:	Low to Medium
Plasticity Index (Ip) :	**8**	Mod.USCS Symbol:	CL-CI

Remarks:

Reviewed By: P.Geol.

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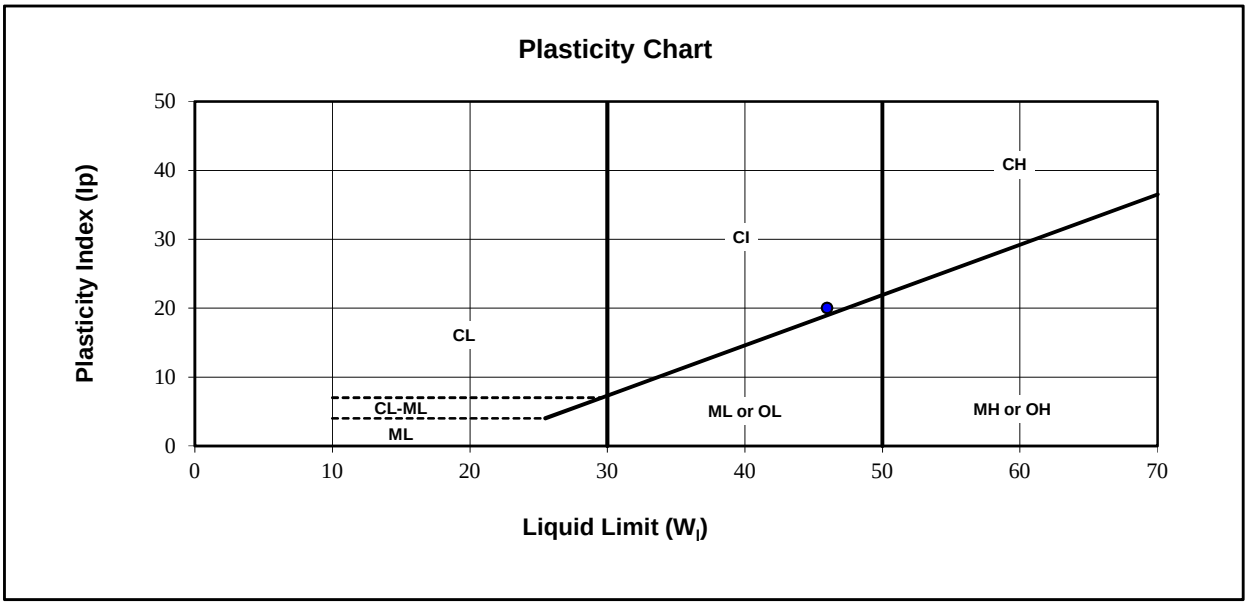
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29607
		Borehole Number:	SRK18-STH-DH-01
Project No:	704-Y14103336-02.003	Depth:	3.5-3.9 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 27, 2018

Sample Description: CLAY, silty, trace sand. Mottled light brown and light grey.



Liquid Limit ($W_{1)}$) :	46	Natural Moisture (%)	45.5
Plastic Limit :	26	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**20**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: BF. P.Geol.

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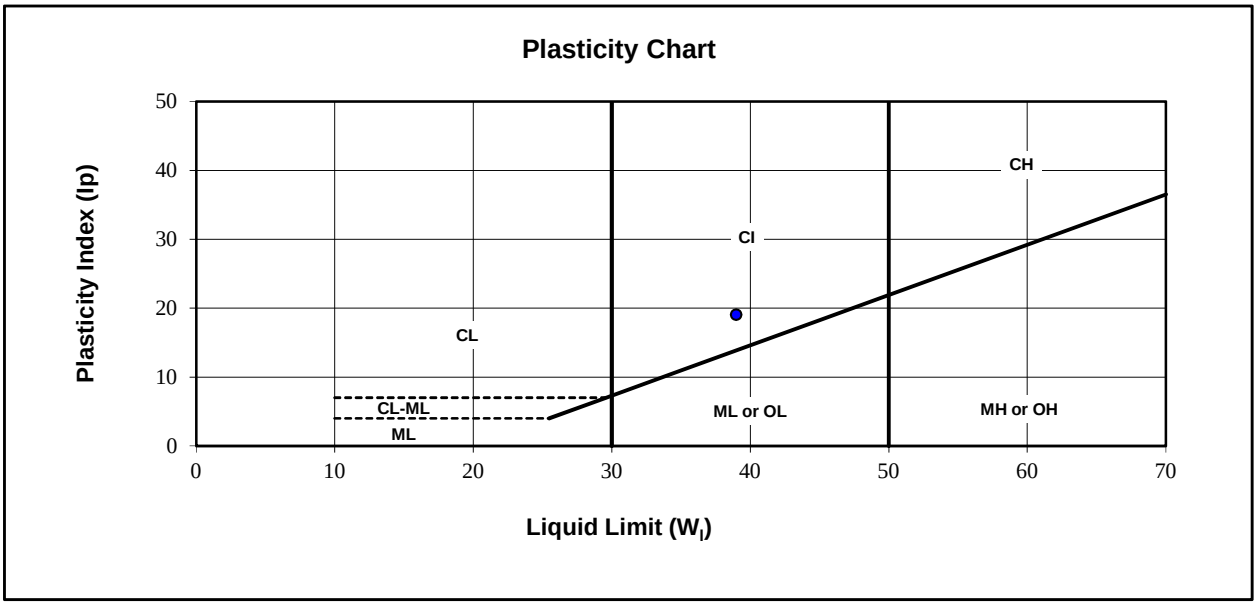
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay South Dam Project	Sample Number:	6667-29609
		Borehole Number:	SRK18-STH-DH-01
Project No:	704-Y14103336-02.003	Depth:	17.0-18.0 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: DY
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 9, 2018

Sample Description: CLAY, silty, trace sand, brown/dark grey with black inclusions



Liquid Limit ($W_{1)}$) :	39	Natural Moisture (%)	44.5
Plastic Limit :	20	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**19**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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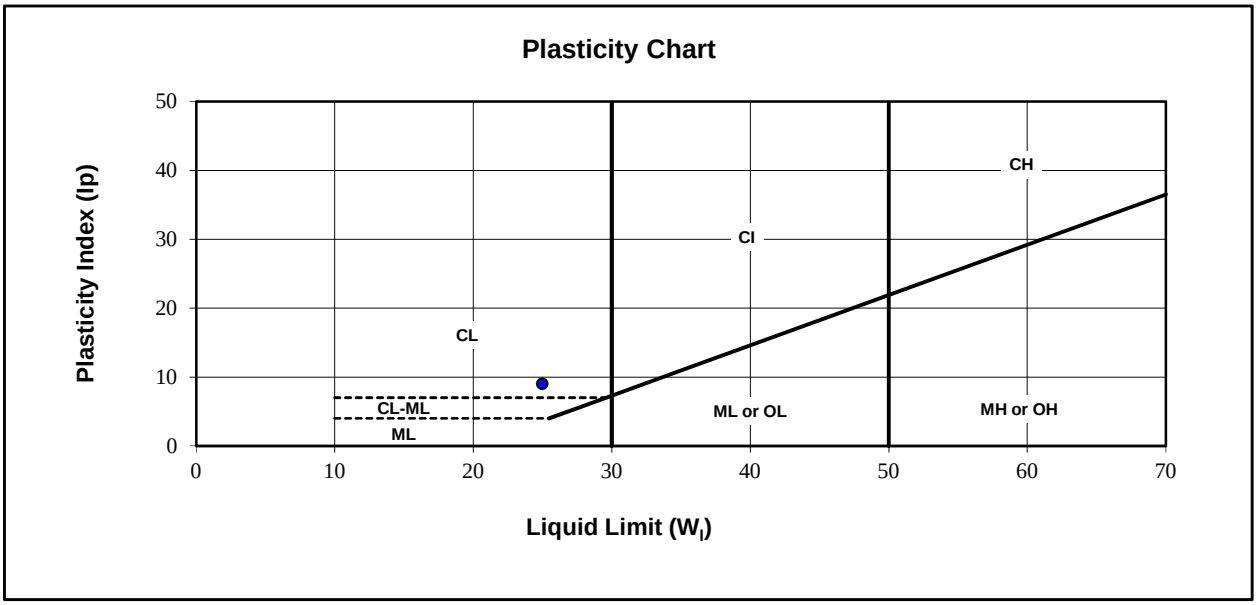
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29610
		Borehole Number:	SRK18-STH-DH-01
Project No:	704-Y14103336-02.003	Depth:	21.5-22.8 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	August 3, 2018

Sample Description: CLAY, silty, some sand, dark grey mottled with brown.



Liquid Limit ($W_{1)}$) :	25	Natural Moisture (%)	33.3
Plastic Limit :	16	Soil Plasticity:	Low
Plasticity Index (Ip) :	**9**	Mod.USCS Symbol:	CL

Remarks:

Reviewed By: P.Geol.

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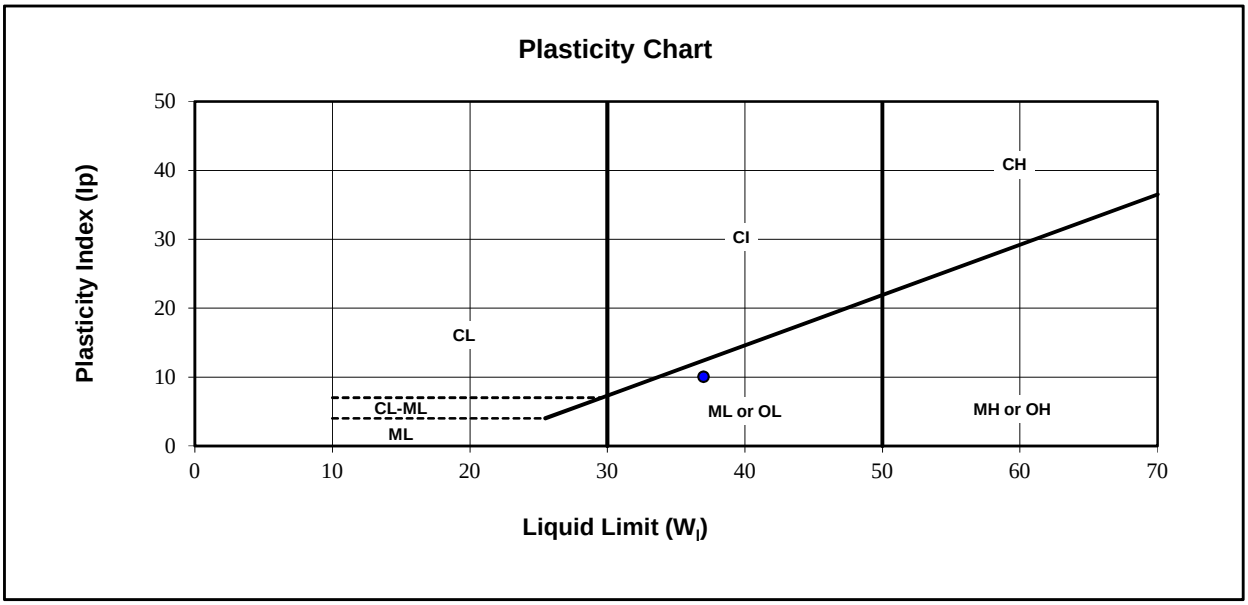
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29612
		Borehole Number:	SRK18-STH-DH-10
Project No:	704-Y14103336-02.003	Depth:	0.3-0.7 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 27, 2018

Sample Description: CLAY, silty, some sand, trace gravel. Brown grey, mottled dark grey. Organics.



Liquid Limit ($W_{1)}$) :	37	Natural Moisture (%)	45.7
Plastic Limit :	27	Soil Plasticity:	Low
Plasticity Index (Ip) :	**10**	Mod.USCS Symbol:	ML

Remarks:

Reviewed By: P.Geol.

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TETRA TECH

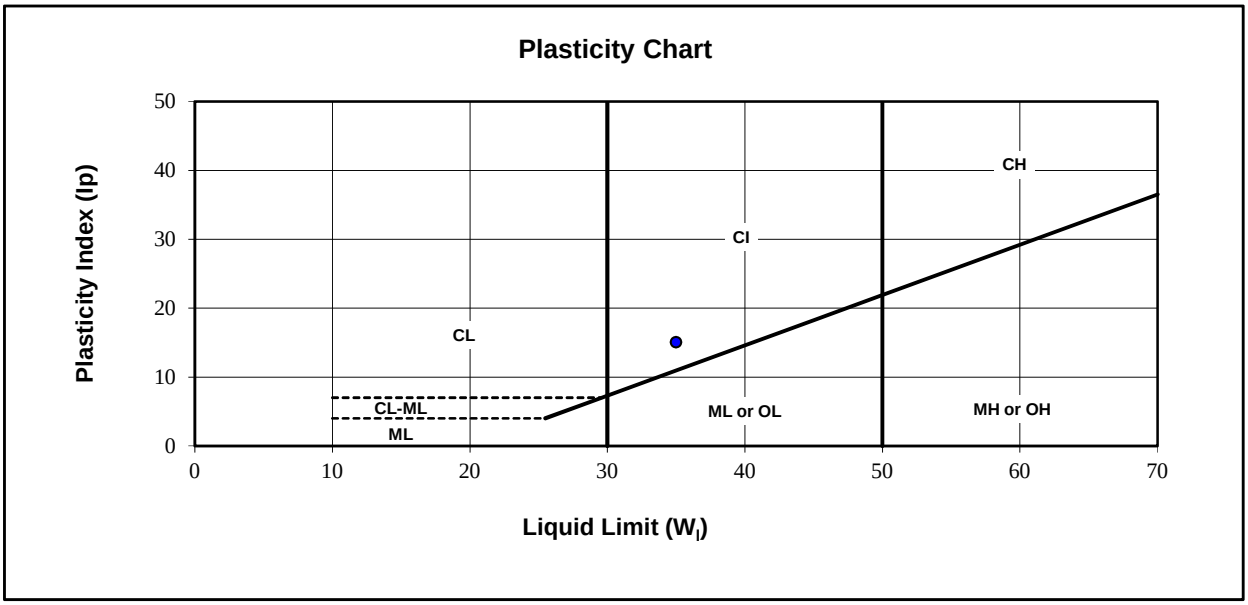
ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29613
	South Dam Project	Borehole Number:	SRK18-STH-DH-10
Project No:	704-Y14103336-02.003	Depth:	3.5-3.9 m
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 15, 2018

Tested By: WM

Sample Description: CLAY, silty, trace sand, brown, dark grey streaks, organics.



Liquid Limit ($W_{1)}$) :	35	Natural Moisture (%)	39.3
Plastic Limit :	20	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**15**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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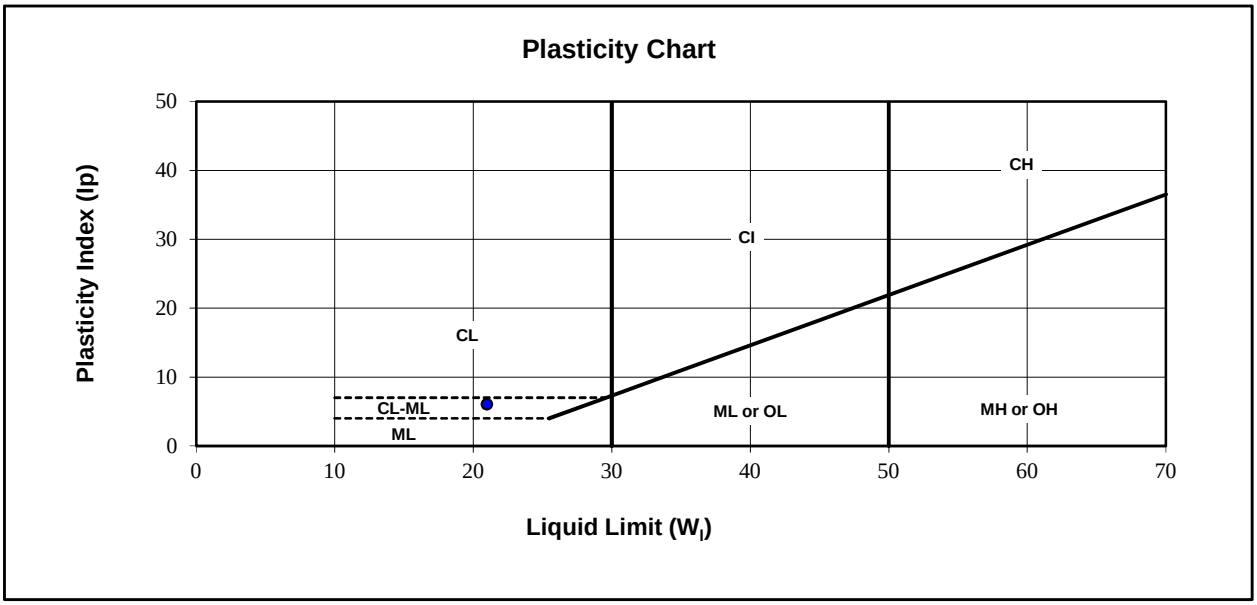
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay South Dam Project	Sample Number:	6667-29614
		Borehole Number:	SRK18-STH-DH-10
Project No:	704-Y14103336-02.003	Depth:	5.8-6.1 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: DY
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 9, 2018

Sample Description: SILT, sandy, gravelly, some clay



Liquid Limit ($W_{1)}$) :	21	Natural Moisture (%)	19.4
Plastic Limit :	15	Soil Plasticity:	Low
Plasticity Index (Ip) :	**6**	Mod.USCS Symbol:	CL-ML

Remarks:

Reviewed By: P.Geol.

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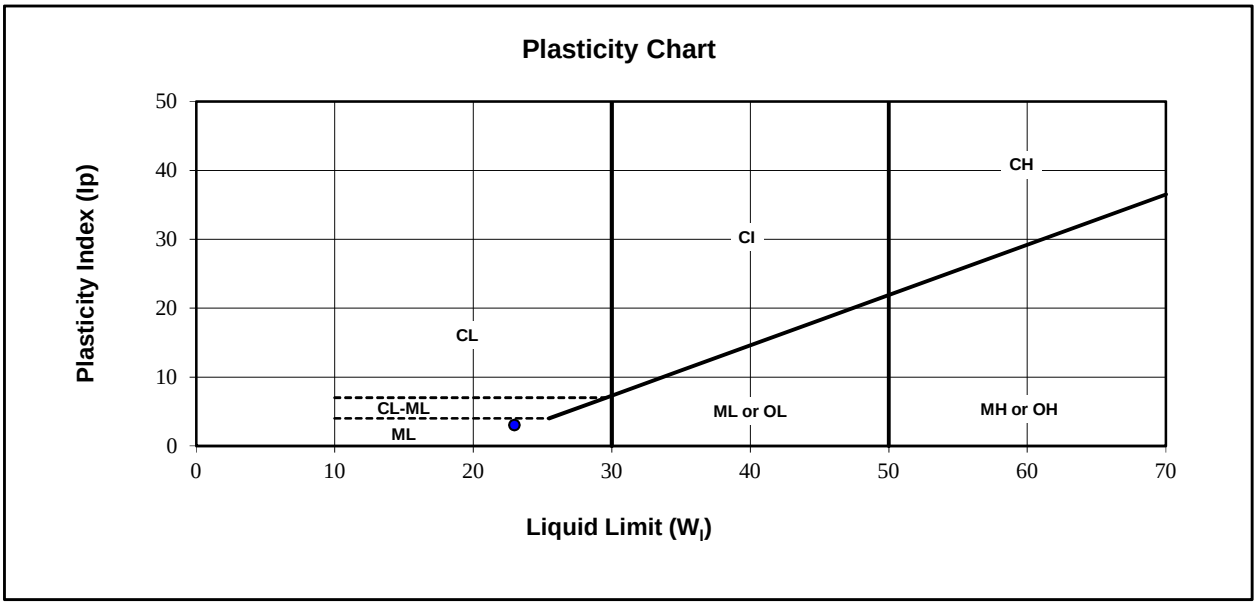
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29616
	South Dam Project	Borehole Number:	SRK18-STH-DH-08
Project No:	704-Y14103336-02.003	Depth:	0.9-1.5 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 1, 2018

Sample Description: SILT and SAND, trace gravel, trace clay, fine sand, dark brown, organics



Liquid Limit ($W_{1)}$) :	23	Natural Moisture (%)	55.9
Plastic Limit :	20	Soil Plasticity:	Low
Plasticity Index (Ip) :	**3**	Mod.USCS Symbol:	ML

Remarks:

Reviewed By: P.Geol.

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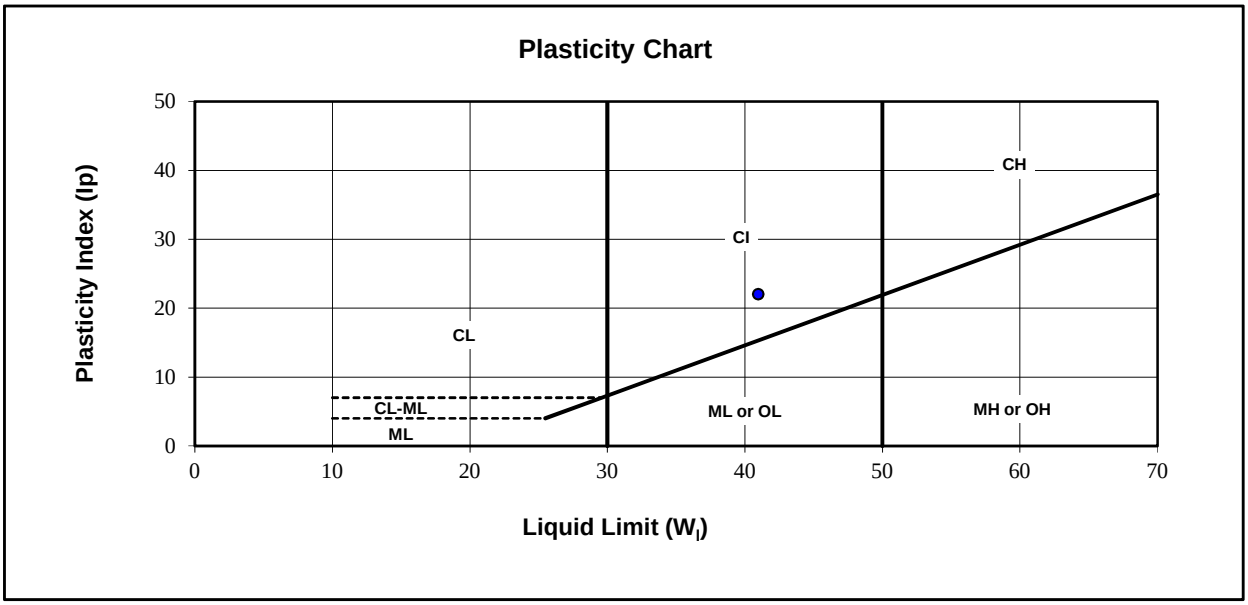
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29619
	South Dam Project	Borehole Number:	SRK18-STH-DH-08
Project No:	704-Y14103336-02.003	Depth:	12.7-13.5 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: JPC
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 25, 2018

Sample Description: CLAY, silty, trace sand, black with brown streaks, organic.



Liquid Limit ($W_{1)}$) :	41	Natural Moisture (%)	45.6
Plastic Limit :	19	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**22**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: _____ P.Geol.

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TETRA TECH

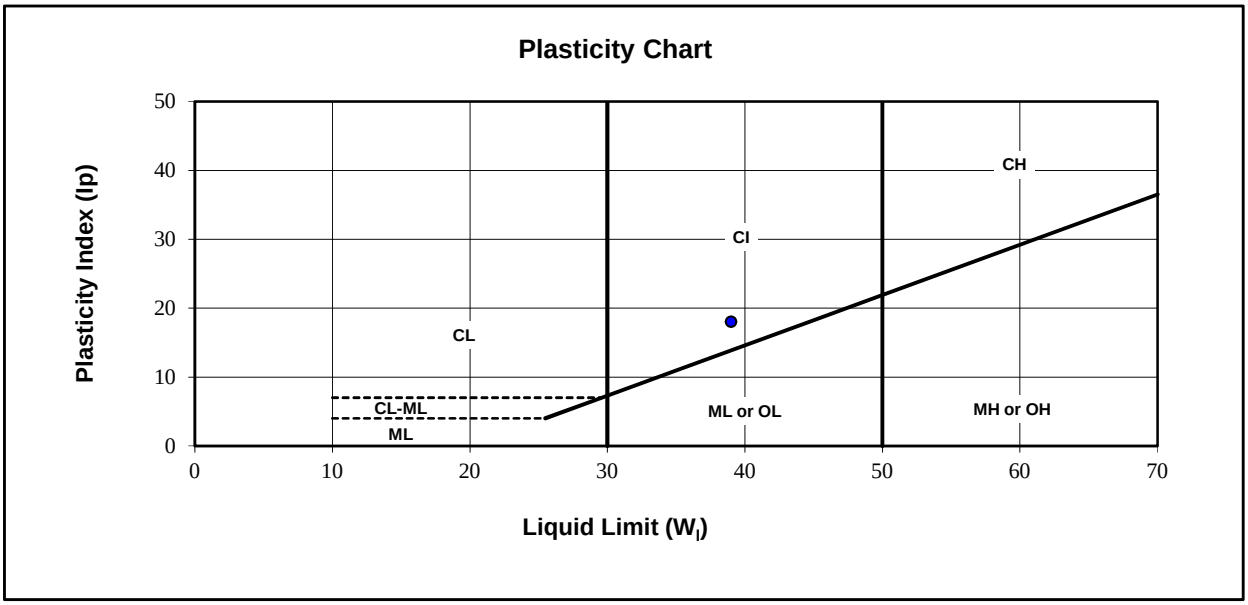
ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29621
	South Dam Project	Borehole Number:	SRK18-STH-DH-11
Project No:	704-Y14103336-02.003	Depth:	2.2-3.4 m
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 25, 2018

Tested By: JPC

Sample Description: CLAY, silty, trace sand, trace gravel. Organics. Mottled brown and dark grey.



Liquid Limit ($W_{1)}$) :	39	Natural Moisture (%)	46.4
Plastic Limit :	21	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**18**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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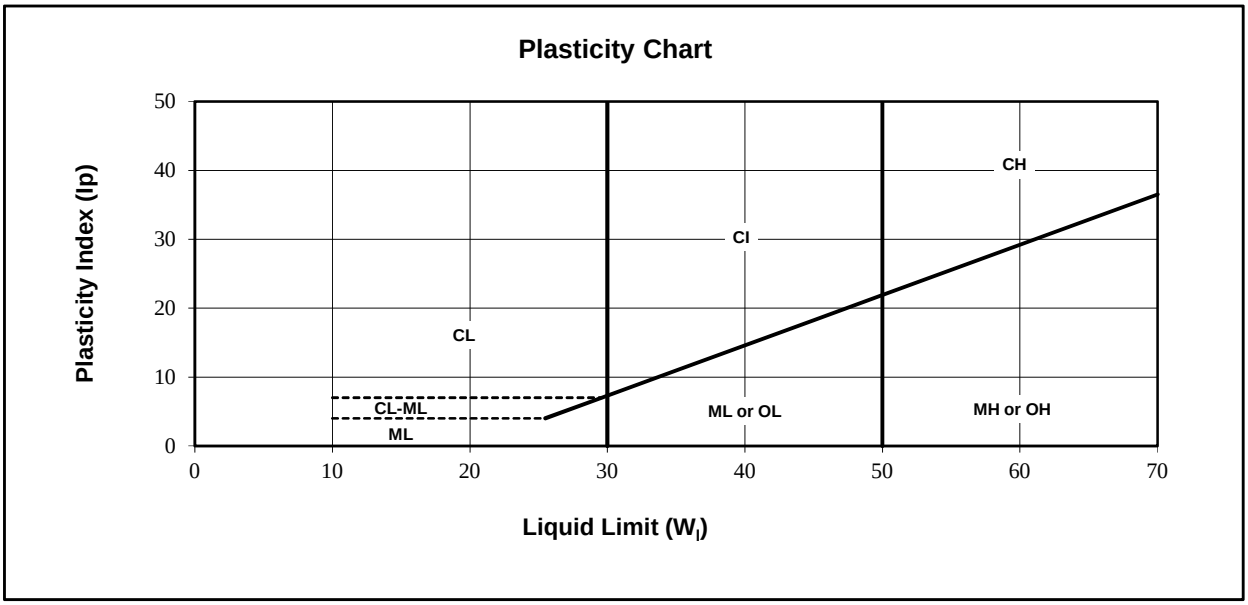
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29622
		Borehole Number:	SRK18-STH-DH-11
Project No:	704-Y14103336-02.003	Depth:	9.5-10.8 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 29, 2018

Sample Description: Non-plastic. SAND, gravelly, silty



Liquid Limit ($W_{1)}$) :		Natural Moisture (%)	6.5
Plastic Limit :		Soil Plasticity:	Non-plastic
Plasticity Index (Ip) :		Mod.USCS Symbol:	

Remarks: Sample is non-plastic. Composed of silt and sand.

Reviewed By: _____ P.Geol.

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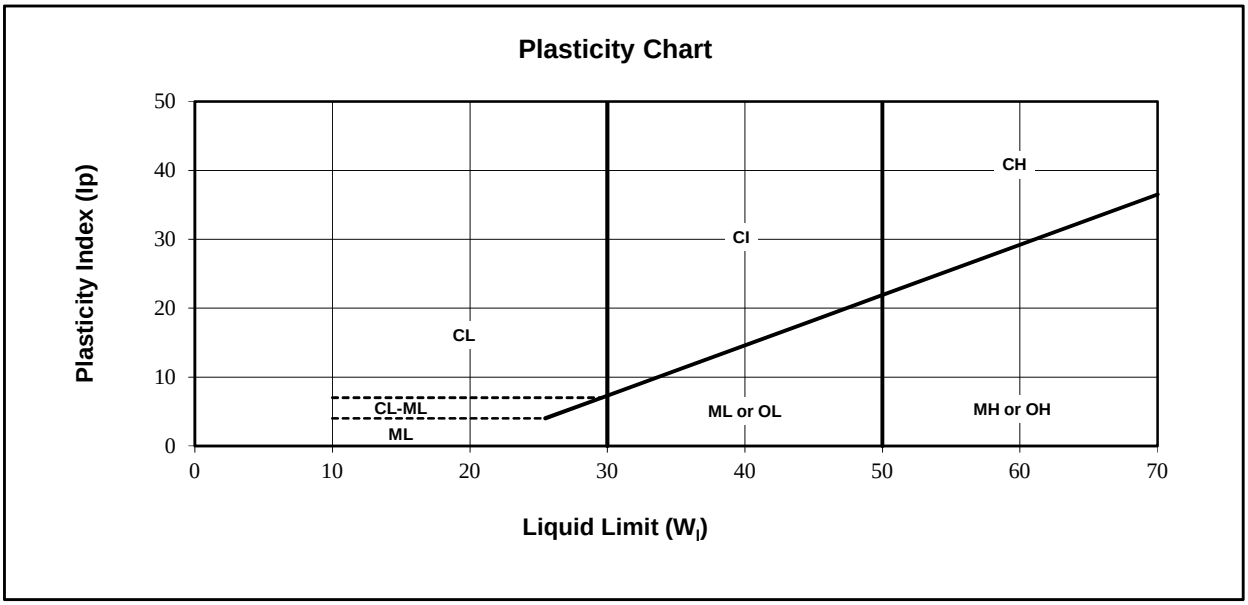
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29624
		Borehole Number:	SRK18-STH-DH-07
Project No:	704-Y14103336-02.003	Depth:	1.1-2.5 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 27, 2018

Sample Description: Non-plastic. Peat.



Liquid Limit ($W_{1)}$) :		Natural Moisture (%)	274.4
Plastic Limit :		Soil Plasticity:	Non-plastic
Plasticity Index (Ip) :		Mod.USCS Symbol:	

Remarks: Sample is non-plastic. Composed of peat.

Reviewed By: P.Geol.

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TETRA TECH

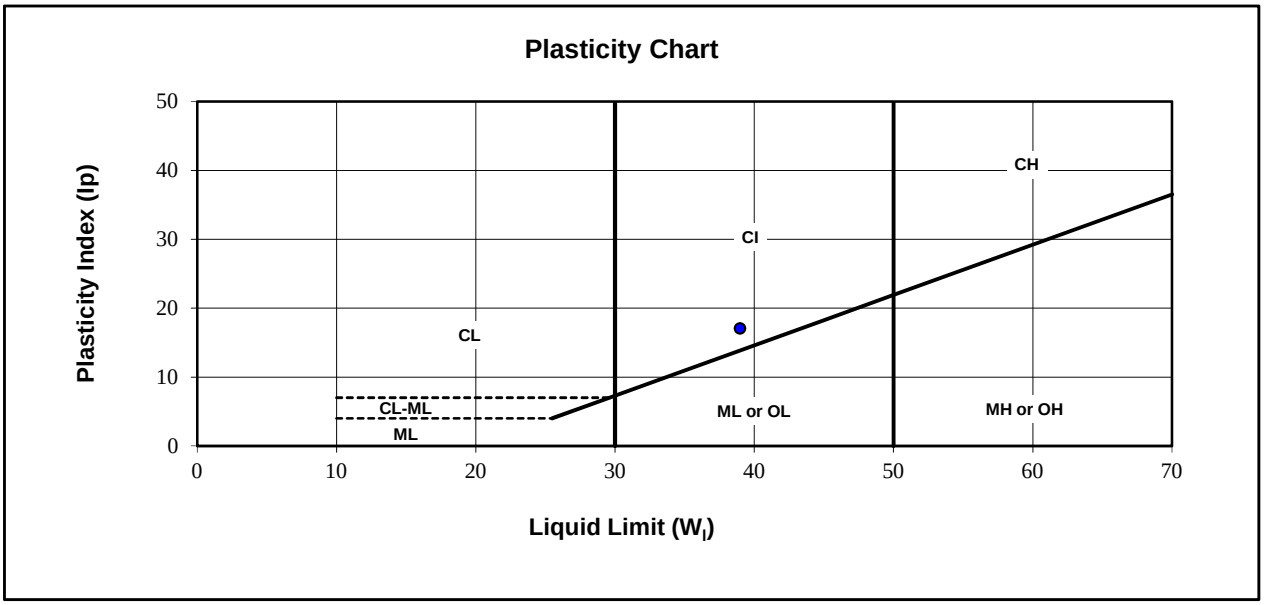
ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay South Dam Project	Sample Number:	6667-29625
		Borehole Number:	SRK18-STH-DH-07
Project No:	704-Y14103336-02.003	Depth:	5.2-6.7 m
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 8, 2018

Tested By: IS

Sample Description: CLAY, silty, some sand



Liquid Limit ($W_{1)}$) :	39	Natural Moisture (%)	26.9
Plastic Limit :	22	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**17**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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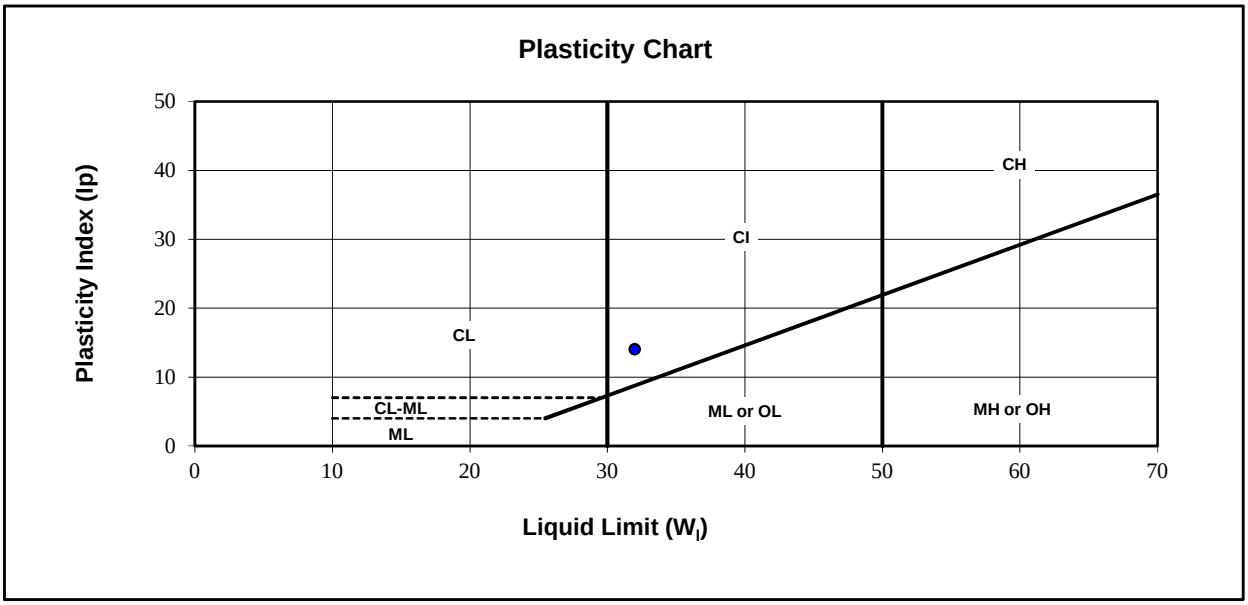
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29627
	South Dam Project	Borehole Number:	SRK18-STH-DH-07
Project No:	704-Y14103336-02.003	Depth:	20.4-21.7 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	JC
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	August 14, 2018

Sample Description: CLAY, silty, sandy, brown with grey streaks, mottled black.



Liquid Limit ($W_{1)}$) :	32	Natural Moisture (%)	38.3
Plastic Limit :	18	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**14**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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TETRA TECH

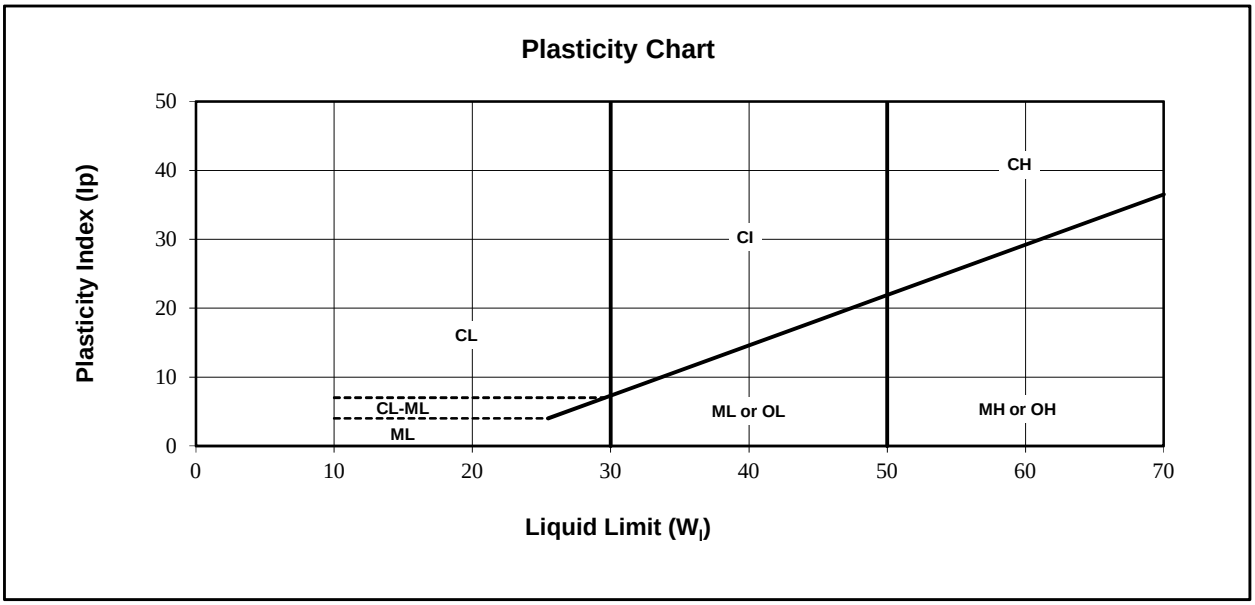
ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29628
	South Dam Project	Borehole Number:	SRK18-STH-DH-07
Project No:	704-Y14103336-02.003	Depth:	26.3-27.2 m
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 23, 2018

Tested By: JPC

Sample Description: GRAVEL and SAND, trace silt, trace clay. Brownish grey.



Liquid Limit ($W_{1)}$) :		Natural Moisture (%)	10.1
Plastic Limit :		Soil Plasticity:	Non-Plastic
Plasticity Index (Ip) :		Mod.USCS Symbol:	

Remarks: Non-Plastic. Sample contains fine sand and silt below 0.425 mm.

Reviewed By: _____ P.Geol.

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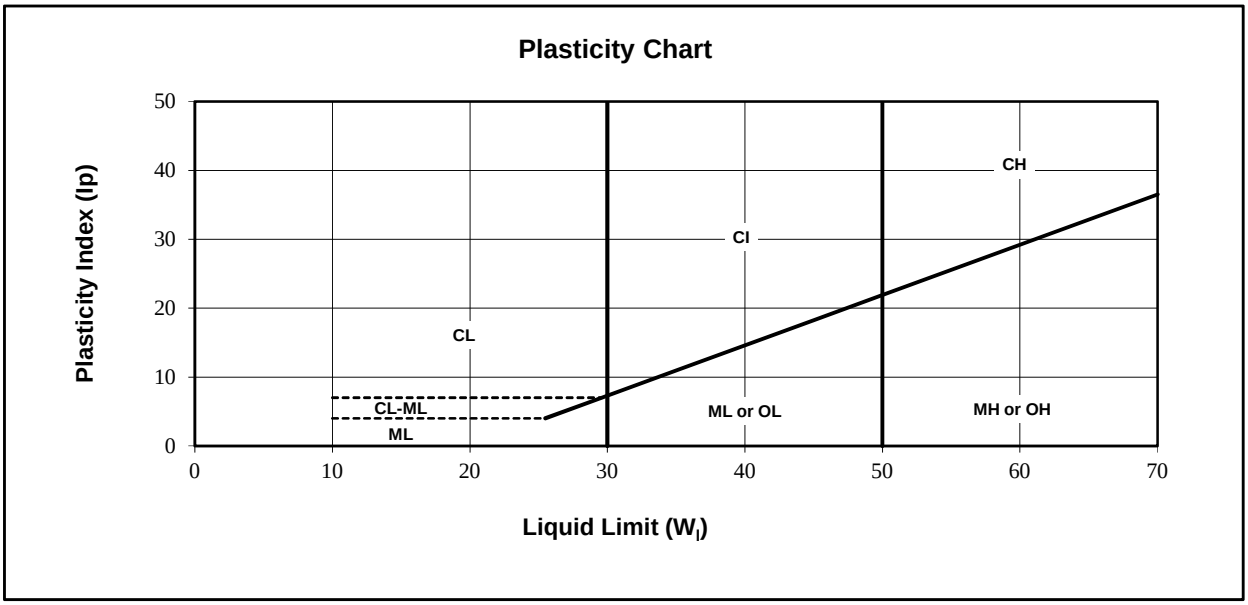
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29629
	South Dam Project	Borehole Number:	SRK18-STH-DH-07
Project No:	704-Y14103336-02.003	Depth:	31.0-32.2 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: DY
Attention:	Kelly Schwenning	Date Sampled:	February 25, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 10, 2018

Sample Description: SAND and SILT, trace clay. Brownish grey.



Liquid Limit ($W_{1)}$) :		Natural Moisture (%)	7.2
Plastic Limit :		Soil Plasticity:	Non-Plastic
Plasticity Index (Ip) :		Mod.USCS Symbol:	

Remarks: Non-plastic. Plastic limit was not possible, material will not thread.

Reviewed By: _____ P.Geol.

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TETRA TECH

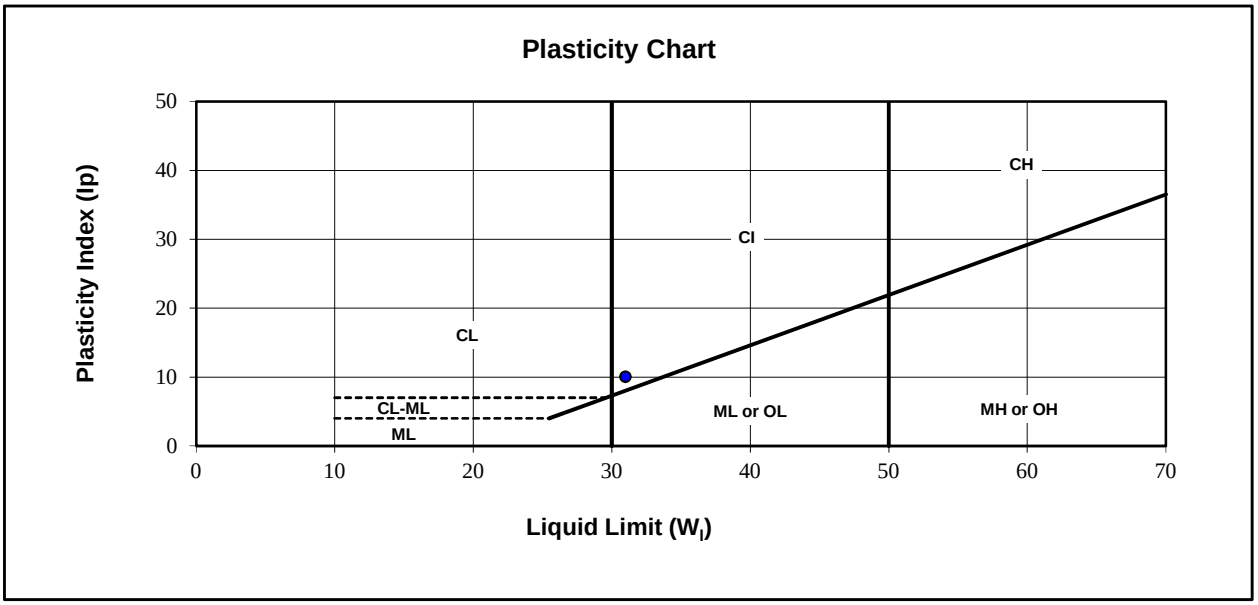
ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29631
	South Dam Project	Borehole Number:	SRK18-STH-DH-09
Project No:	704-Y14103336-02.003	Depth:	0.3-0.9 m
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Date Sampled:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 25, 2018

Tested By: JPC

Sample Description: CLAY, silty, sandy, trace gravel, brownish green-olive, dark grey inclusions



Liquid Limit ($W_{1)}$) :	31	Natural Moisture (%)	42.1
Plastic Limit :	21	Soil Plasticity:	Low to Medium
Plasticity Index (Ip) :	**10**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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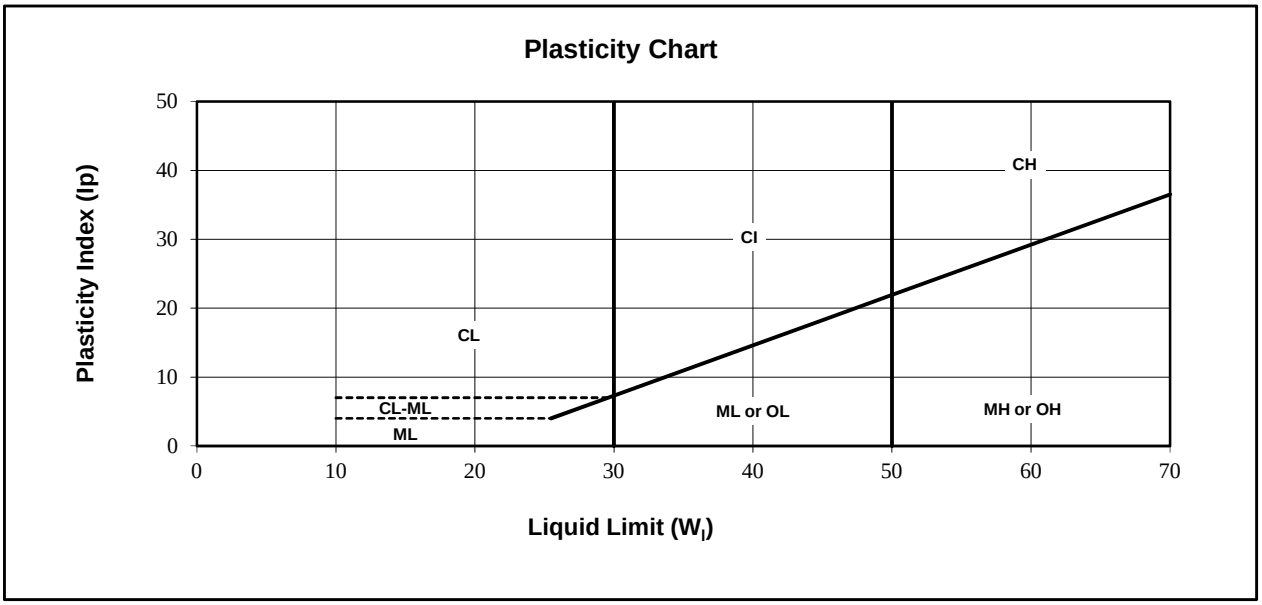
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29634
		Borehole Number:	SRK18-STH-DH-09
Project No:	704-Y14103336-02.003	Depth:	13.5-14.2 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	JPC
Attention:	Kelly Schwenning	Date Sampled:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 25, 2018

Sample Description: SAND and SILT, trace clay, trace gravel, brown with dark grey streaks, organics.



Liquid Limit ($W_{1)}$) :		Natural Moisture (%)	13.3
Plastic Limit :		Soil Plasticity:	Non-Plastic
Plasticity Index (Ip) :		Mod.USCS Symbol:	

Remarks: Non-plastic. Material under 0.425 mm sieve is mainly fine sand.

Reviewed By: _____ P.Geol.

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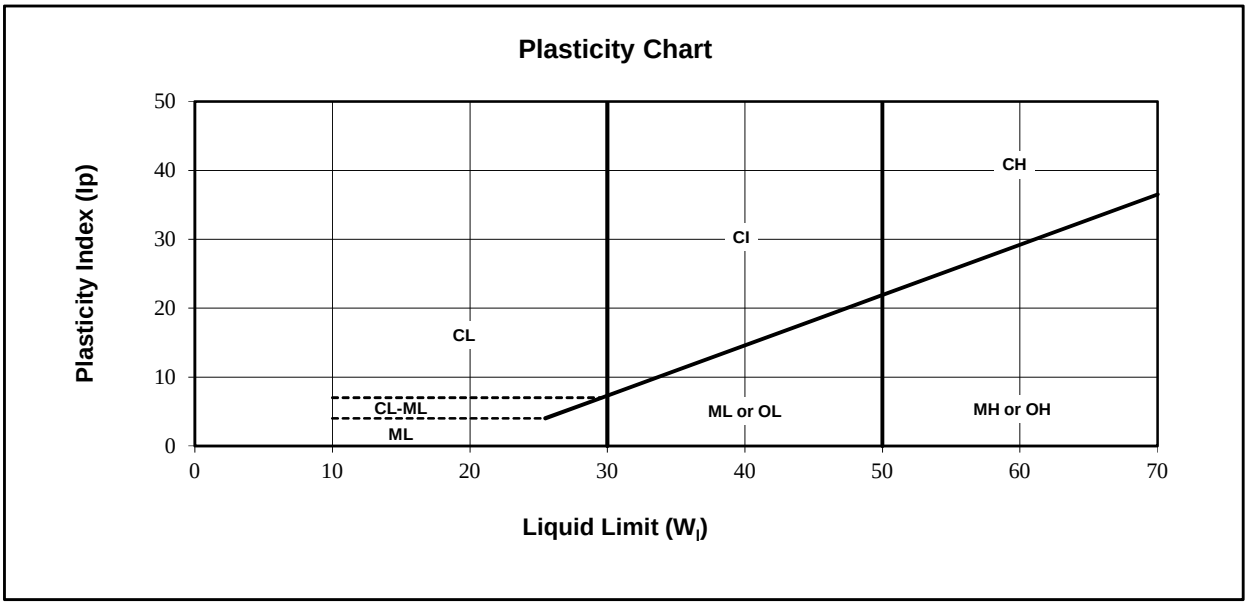
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29635
		Borehole Number:	SRK18-STH-DH-09
Project No:	704-Y14103336-02.003	Depth:	15.0-15.5 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 29, 2018

Sample Description: Non-plastic. SAND, silty, some gravel, trace clay, organics.



Liquid Limit ($W_{1)}$) :		Natural Moisture (%)	8.4
Plastic Limit :		Soil Plasticity:	Non-plastic
Plasticity Index (Ip) :		Mod.USCS Symbol:	

Remarks: Sample is non-plastic. Composed of fine sand, silt.

Reviewed By: _____ P.Geol.

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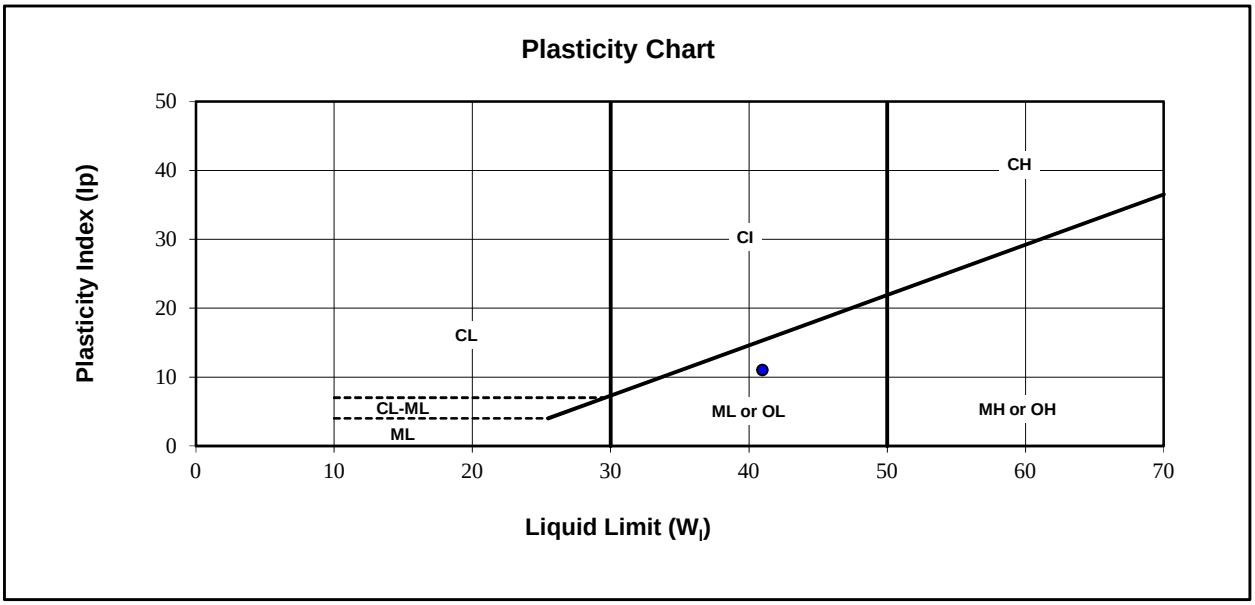
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29636
	South Dam Project	Borehole Number:	SRK18-STH-DH-05
Project No:	704-Y14103336-02.003	Depth:	1.1 - 2.3 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: JC
Attention:	Kelly Schwenning	Date Sampled:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	August 10, 2018

Sample Description: SILT, sandy, some-trace clay, greyish brown.



Liquid Limit ($W_{1)}$) :	41	Natural Moisture (%)	53.8
Plastic Limit :	30	Soil Plasticity:	Low
Plasticity Index (Ip) :	**11**	Mod.USCS Symbol:	ML

Remarks:

Reviewed By: P.Geol.

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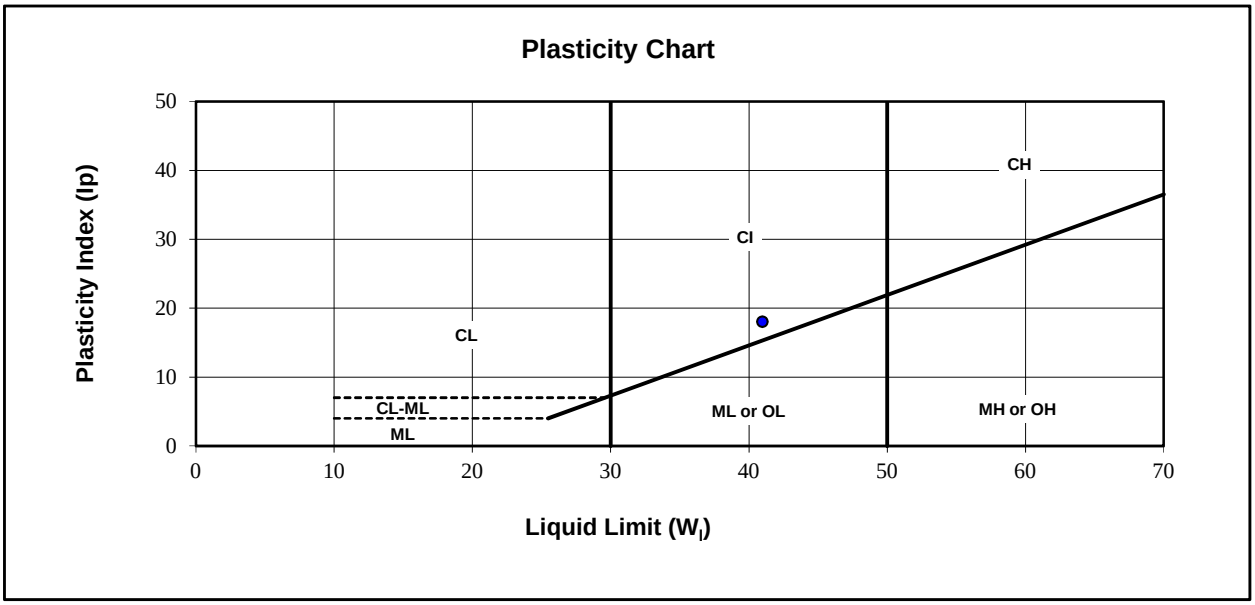
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay South Dam Project	Sample Number:	6667-29637
		Borehole Number:	SRK18-STH-DH-05
Project No:	704-Y14103336-02.003	Depth:	4.3-5.3 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	DY
Attention:	Kelly Schwenning	Date Sampled:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 9, 2018

Sample Description: CLAY, silty, trace sand



Liquid Limit ($W_{1)}$) :	41	Natural Moisture (%)	36.4
Plastic Limit :	23	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**18**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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TETRA TECH

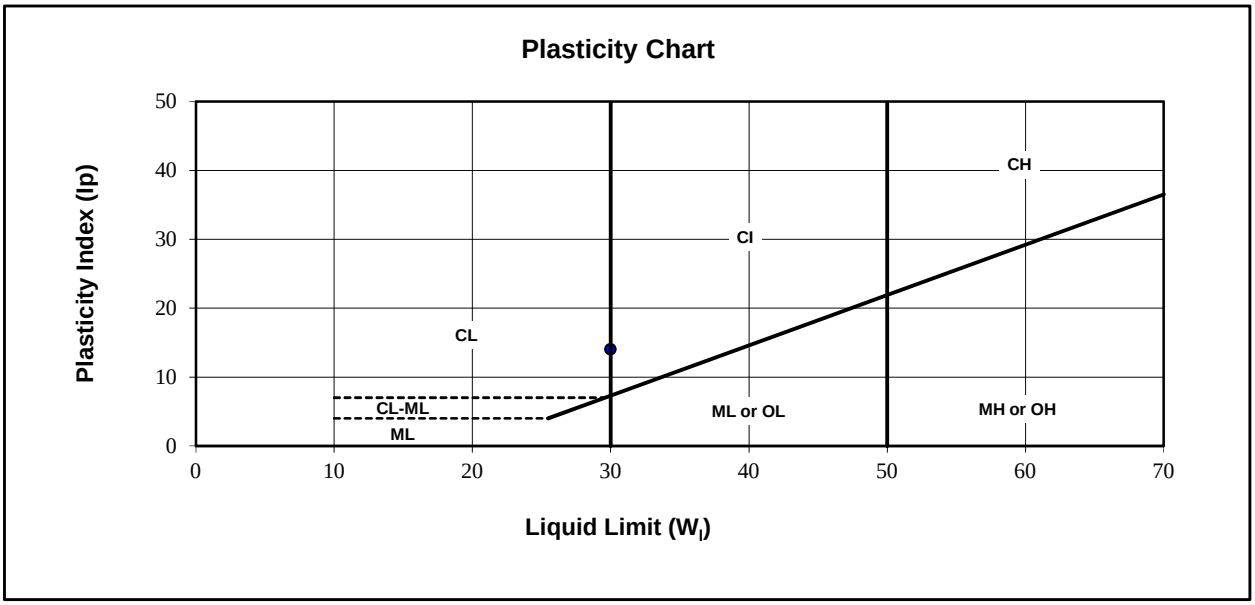
ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29638
	South Dam Project	Borehole Number:	SRK18-STH-DH-05
Project No:	704-Y14103336-02.003	Depth:	11.8-12.7 m
Client:	TMAC Resources Inc.	Sampled By:	Client
Attention:	Kelly Schwenning	Date Sampled:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 25, 2018

Tested By: JPC

Sample Description: CLAY, silty, some sand, trace gravel, grey mottled with brown, organics



Liquid Limit ($W_{1)}$) :	30	Natural Moisture (%)	40.4
Plastic Limit :	16	Soil Plasticity:	Low to Medium
Plasticity Index (Ip) :	**14**	Mod.USCS Symbol:	CL-CI

Remarks:

Reviewed By: P.Geol.

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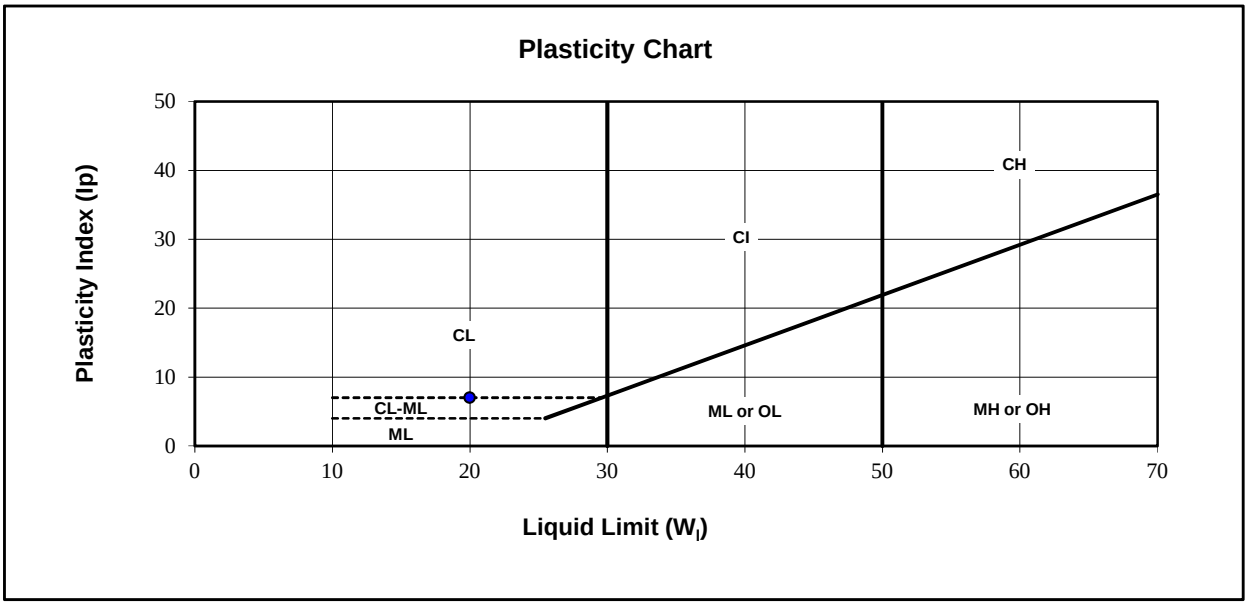
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29641
		Borehole Number:	SRK18-STH-DH-05
Project No:	704-Y14103336-02.003	Depth:	24.1-24.8 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: DY
Attention:	Kelly Schwenning	Date Sampled:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 10, 2018

Sample Description: SAND and SILT, clayey, trace gravel, organic, grey mottled with black.



Liquid Limit ($W_{1)}$) :	20	Natural Moisture (%)	31.5
Plastic Limit :	13	Soil Plasticity:	Low
Plasticity Index (Ip) :	**7**	Mod.USCS Symbol:	CL-ML

Remarks:

Reviewed By: P.Geol.

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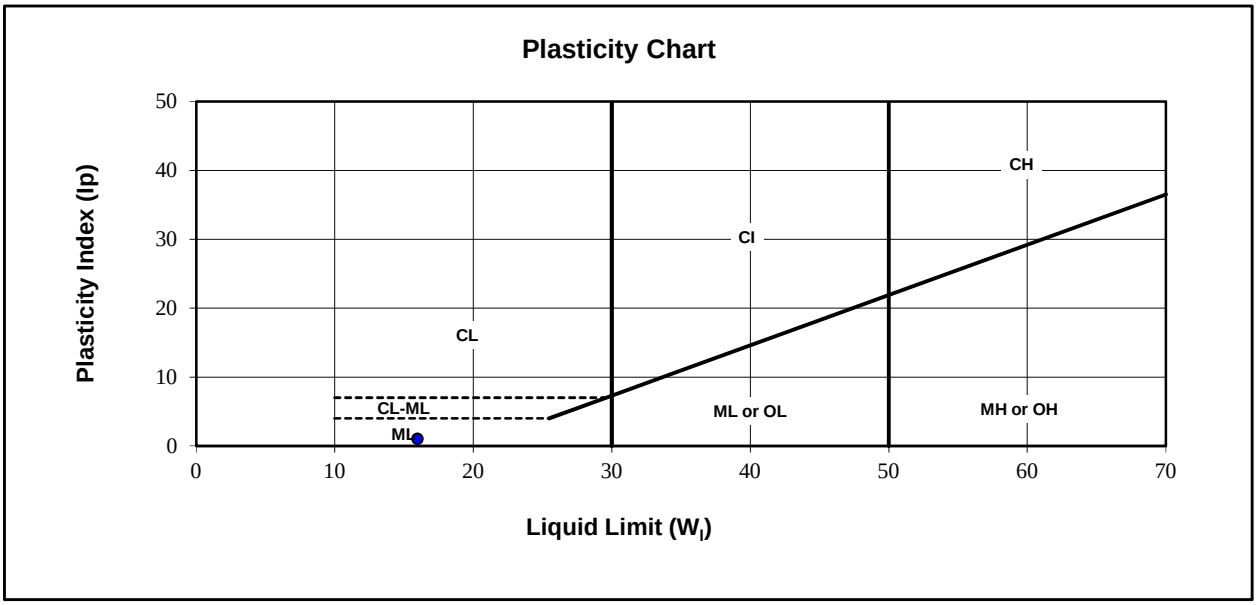
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay South Dam Project	Sample Number:	6667-29642
		Borehole Number:	SRK18-STH-DH-05
Project No:	704-Y14103336-02.003	Depth:	29.3-31.0 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: DY
Attention:	Kelly Schwenning	Date Sampled:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 9, 2018

Sample Description: SAND, gravelly, some silt, trace clay



Liquid Limit ($W_{1)}$) :	16	Natural Moisture (%)	7.1
Plastic Limit :	15	Soil Plasticity:	Low
Plasticity Index (Ip) :	**1**	Mod.USCS Symbol:	ML

Remarks:

Reviewed By: P.Geol.

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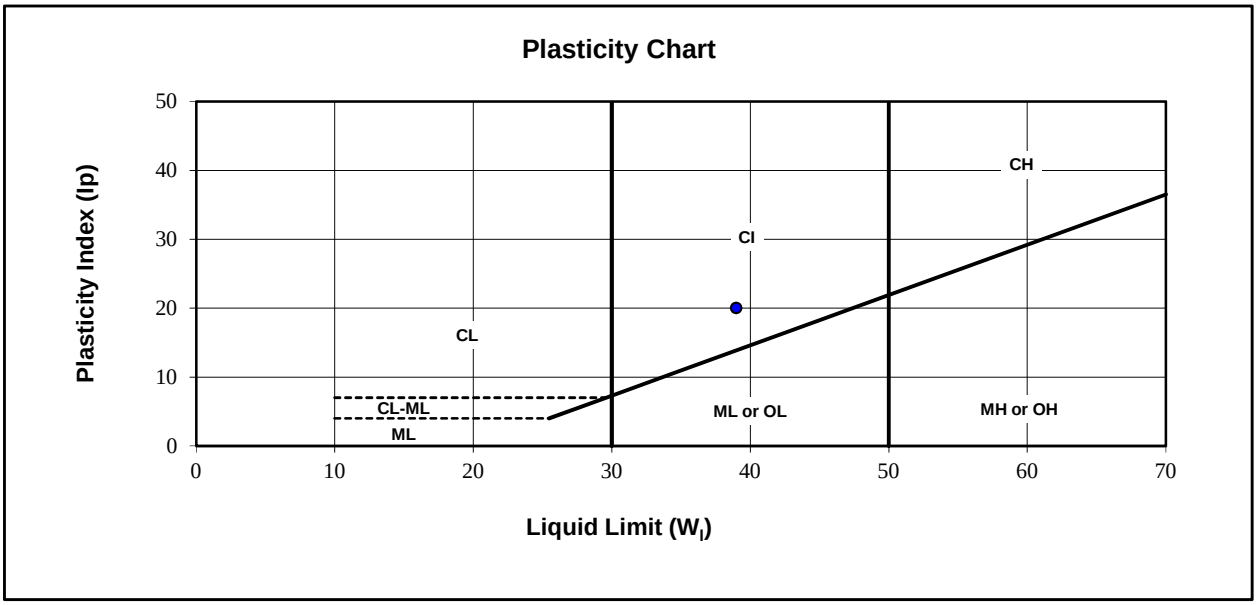
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29644
		Borehole Number:	SRK18-STH-DH-06
Project No:	704-Y14103336-02.003	Depth:	4.5-6.0 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: JPC
Attention:	Kelly Schwenning	Date Sampled:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 25, 2018

Sample Description: CLAY, silty, trace sand, dark grey mottled with brown.



Liquid Limit ($W_{1)}$) :	39	Natural Moisture (%)	38.4
Plastic Limit :	19	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**20**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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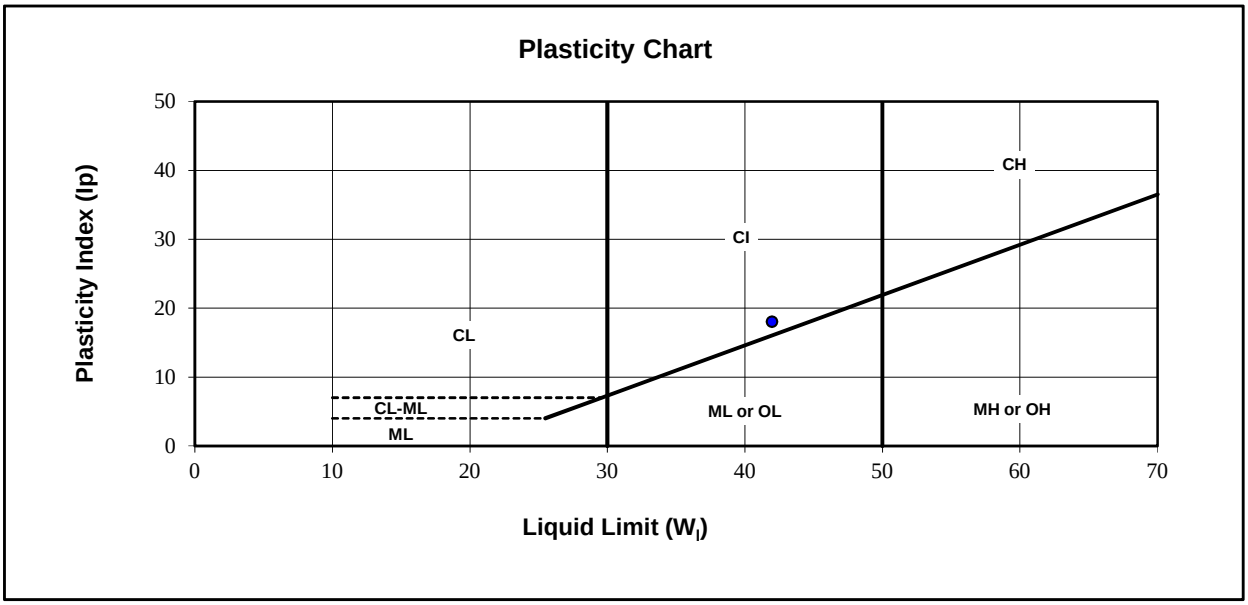
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29645
		Borehole Number:	SRK18-STH-DH-06
Project No:	704-Y14103336-02.003	Depth:	8.2-9.0 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 19, 2018

Sample Description: CLAY, silty, trace sand, brownish grey, dark grey streaks, organic.



Liquid Limit ($W_{1)}$) :	42	Natural Moisture (%)	43.4
Plastic Limit :	24	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**18**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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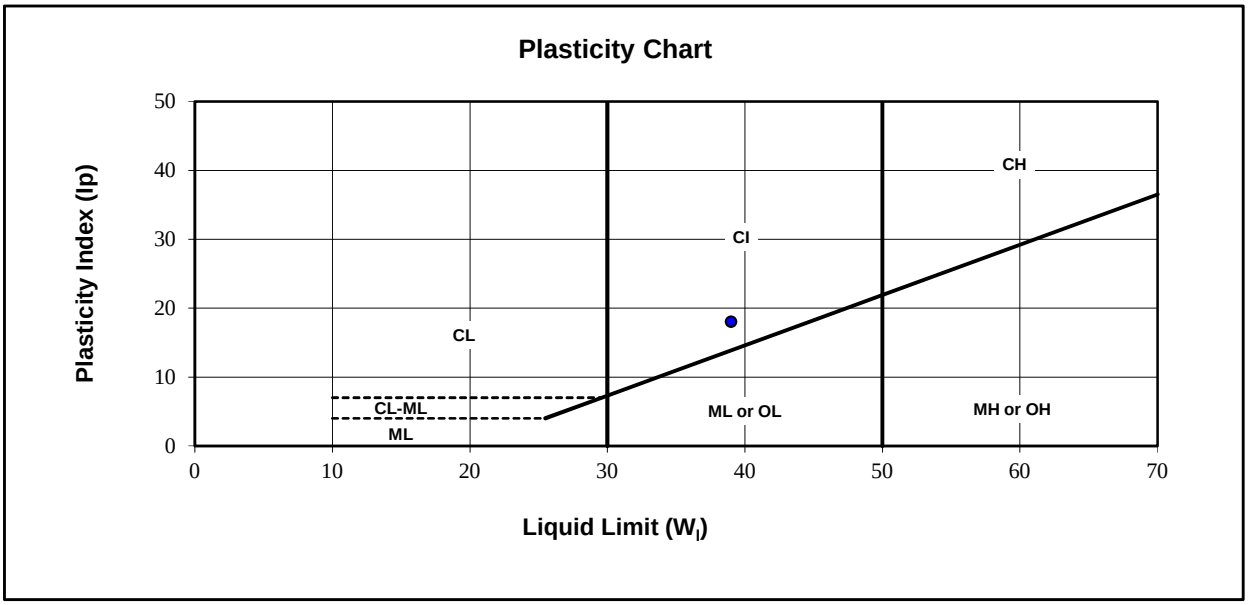
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29647
		Borehole Number:	SRK18-STH-DH-06
Project No:	704-Y14103336-02.003	Depth:	21.1-21.5 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 1, 2018

Sample Description: SILT, clayey, trace sand, grey with brown streaks, organics.



Liquid Limit ($W_{1)}$) :	39	Natural Moisture (%)	48.3
Plastic Limit :	21	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**18**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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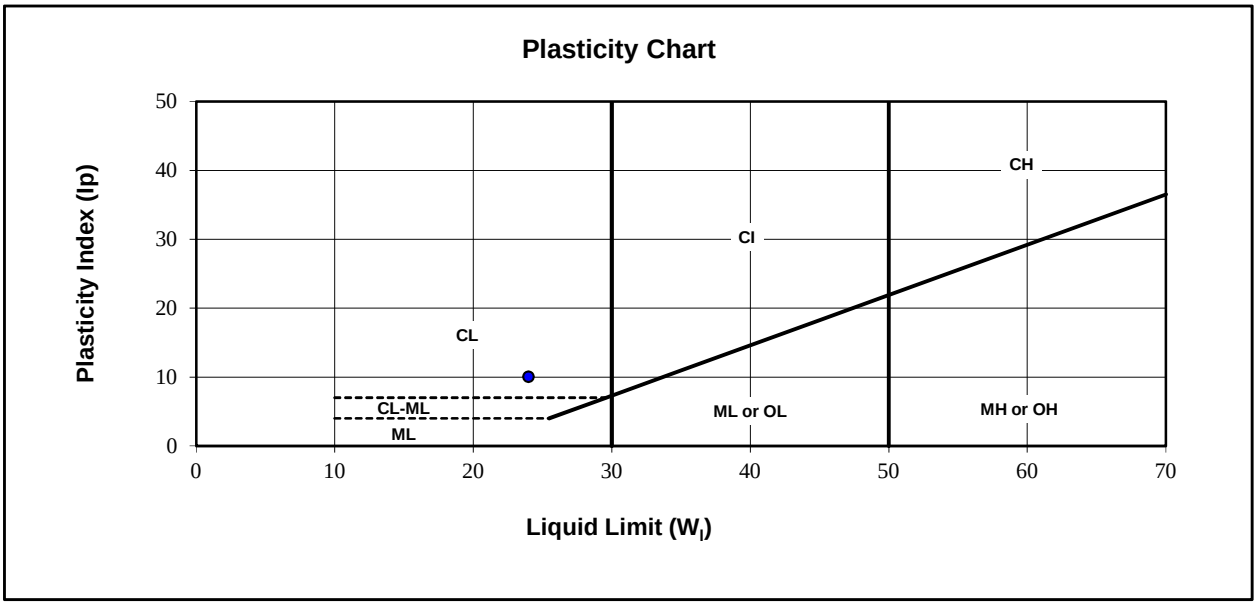
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29648
		Borehole Number:	SRK18-STH-DH-06
Project No:	704-Y14103336-02.003	Depth:	24.0-25.0 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: WM
Attention:	Kelly Schwenning	Date Sampled:	February 6, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	May 11, 2018

Sample Description: CLAY, silty, sandy



Liquid Limit ($W_{1)}$) :	24	Natural Moisture (%)	35.7
Plastic Limit :	14	Soil Plasticity:	Low
Plasticity Index (Ip) :	**10**	Mod.USCS Symbol:	CL

Remarks:

Reviewed By: P.Geol.

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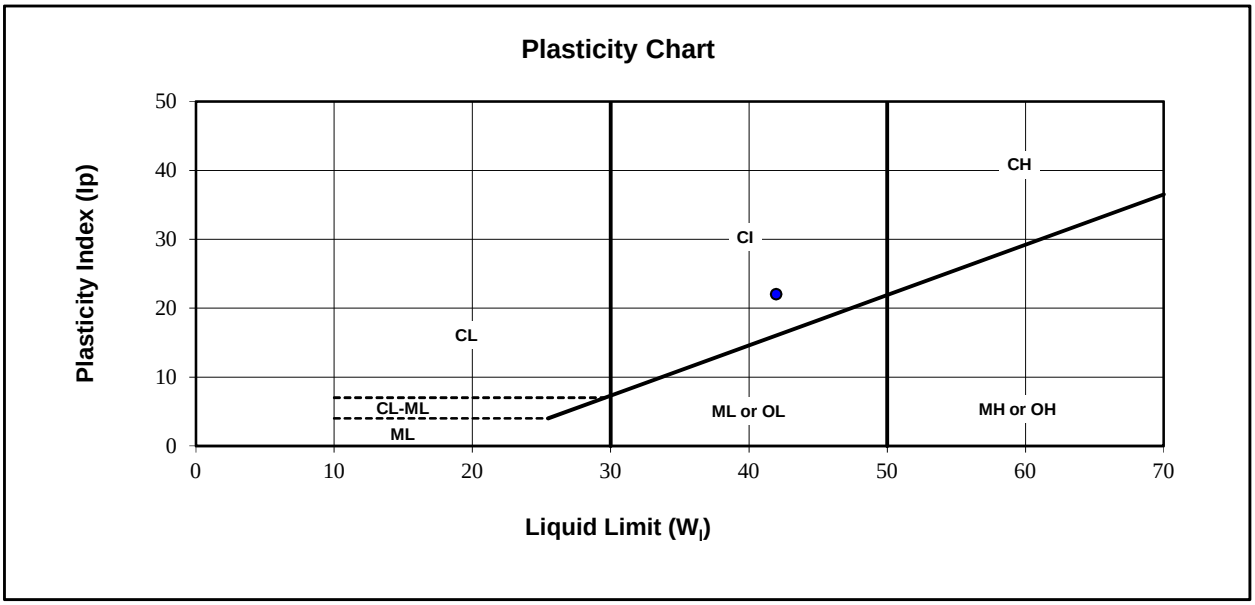
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-29649
	South Dam Project	Borehole Number:	SRK18-STH-DH-06
Project No:	704-Y14103336-02.003	Depth:	26.4 - 27.0 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: JC
Attention:	Kelly Schwenning	Date Sampled:	February 26, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	August 9, 2018

Sample Description: CLAY, silty, trace sand, brown with dark grey streaks, organic.



Liquid Limit ($W_{1)}$) :	42	Natural Moisture (%)	41.8
Plastic Limit :	20	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**22**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: _____ P.Geol.

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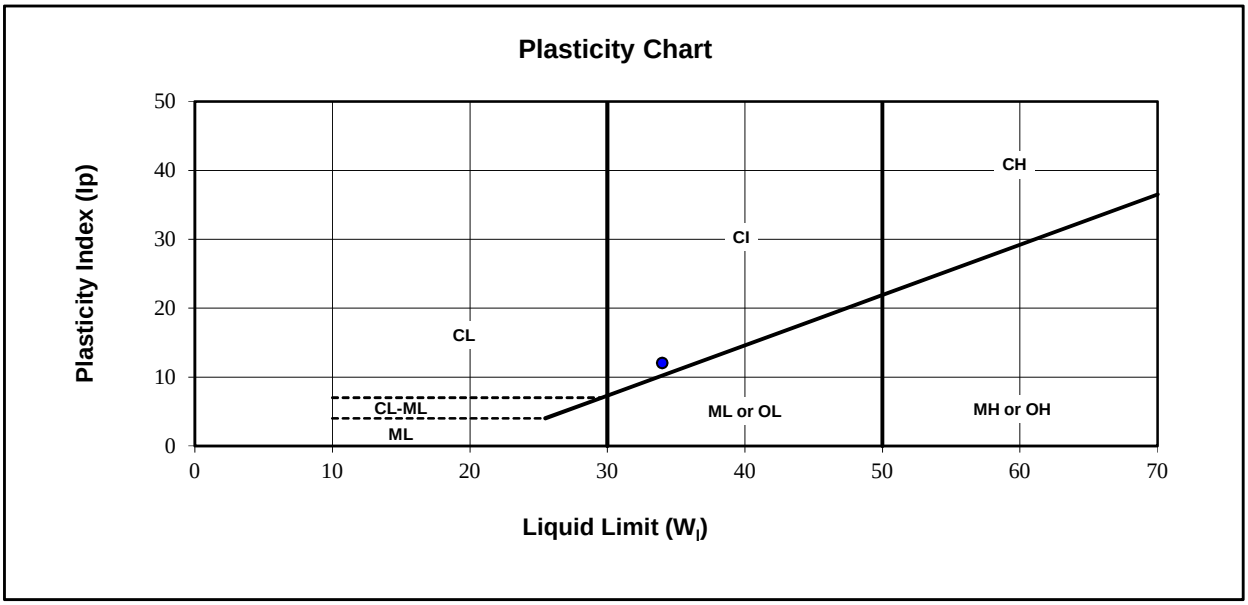
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6875-205904
		Borehole Number:	V-GTC-07
Project No:	Y14103336-02.003	Depth:	6.0 - 10.0 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	SS
Attention:	Kelly Schwenning	Date Sampled:	July 14, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	November 22, 2018

Sample Description: CLAY, some silt, some sand, light grey



Liquid Limit ($W_{1)}$) :	34	Natural Moisture (%)	55.8
Plastic Limit :	22	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**12**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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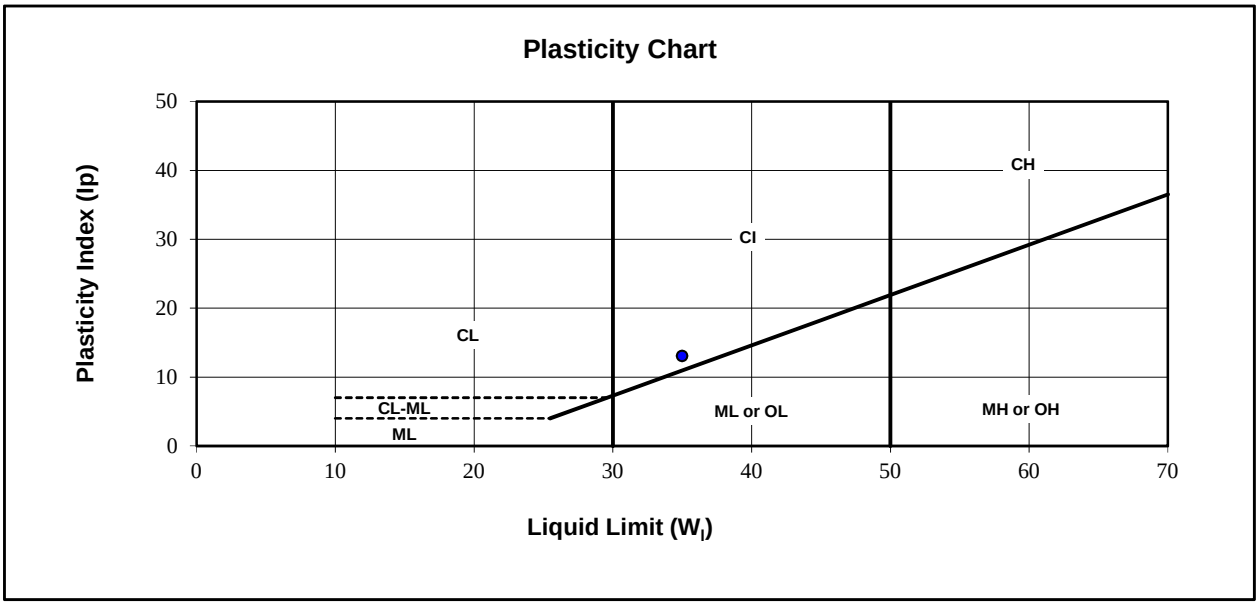
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6875-205905
		Borehole Number:	V-GTC-07
Project No:	Y14103336-02.003	Depth:	10.0 - 15.0 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	SS
Attention:	Kelly Schwenning	Date Sampled:	July 14, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	November 22, 2018

Sample Description: CLAY, some silt, some sand



Liquid Limit ($W_{1)}$) :	35	Natural Moisture (%)	63.0
Plastic Limit :	22	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**13**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: BF. P.Geol.

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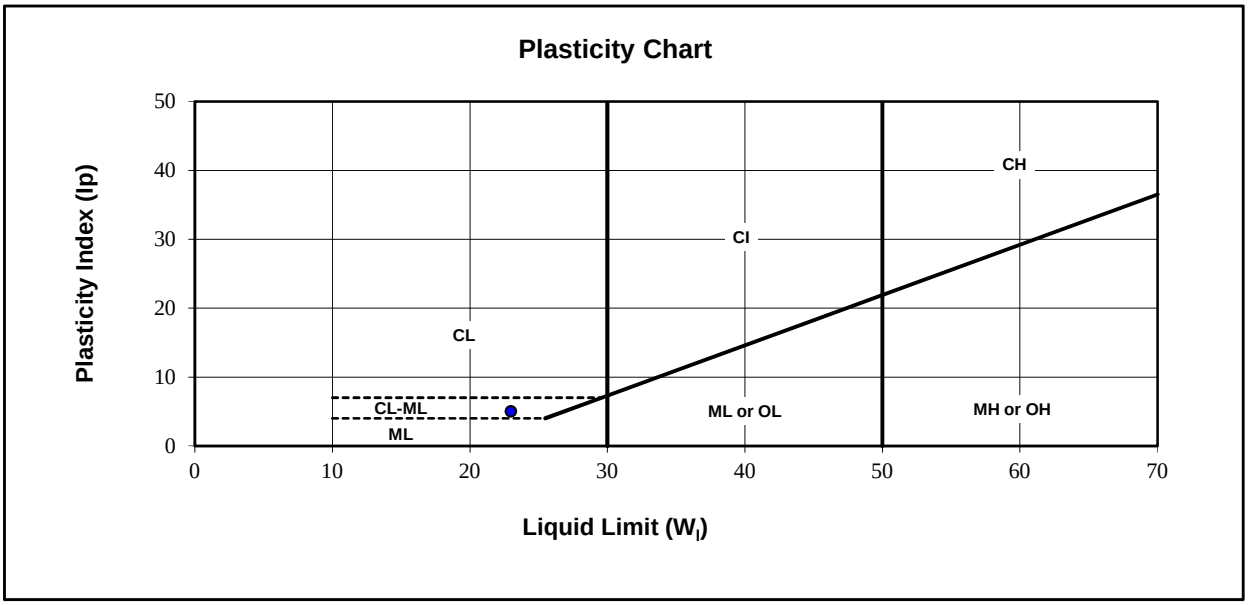
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-205954
		Borehole Number:	SRK18-STH-DH-04
Project No:	704-Y14103336-02.003	Depth:	0.9-1.4 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: JC
Attention:	Kelly Schwenning	Date Sampled:	February 20, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 20, 2018

Sample Description: SILT and SAND, some clay,trace gravel,brown with grey streaks,organics.



Liquid Limit ($W_{1)}$:	23	Natural Moisture (%)	41.2
Plastic Limit :	18	Soil Plasticity:	Low
Plasticity Index (Ip) :	**5**	Mod.USCS Symbol:	CL-ML

Remarks:

Reviewed By: P.Geol.

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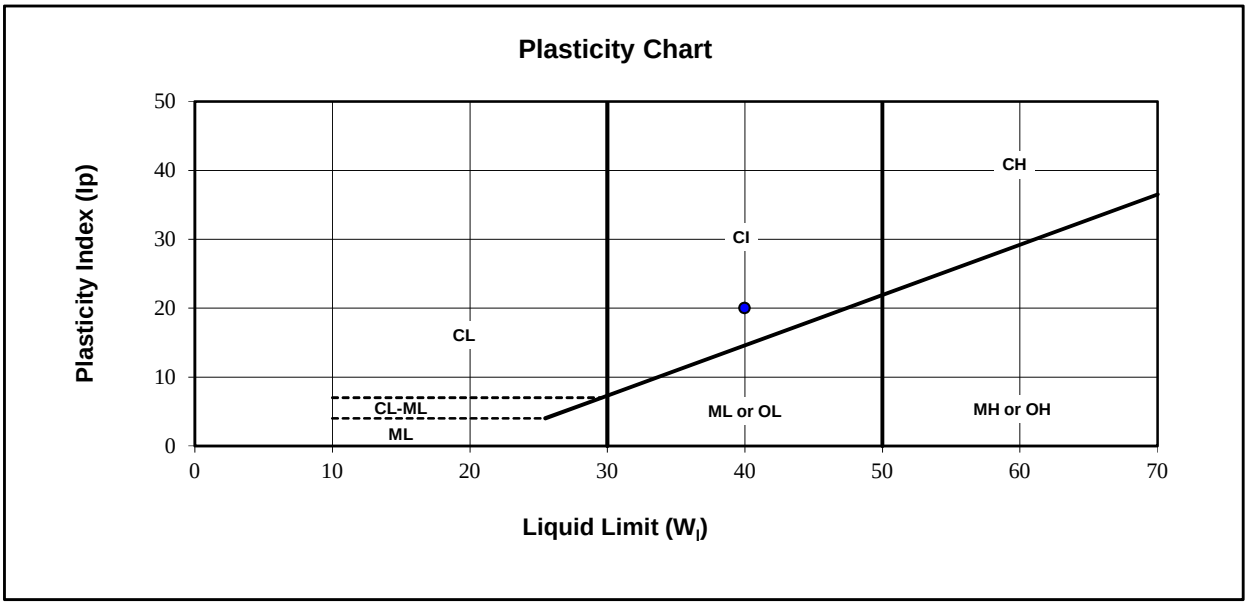
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-205978
		Borehole Number:	SRK18-WST-DH-03
Project No:	704-Y14103336-02.003	Depth:	2.0-2.4 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	JC
Attention:	Kelly Schwenning	Date Sampled:	February 23, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 20, 2018

Sample Description: CLAY, silty, some sand. Brown.



Liquid Limit ($W_{1)}$) :	40	Natural Moisture (%)	59.5
Plastic Limit :	20	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**20**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: _____ P.Eng.

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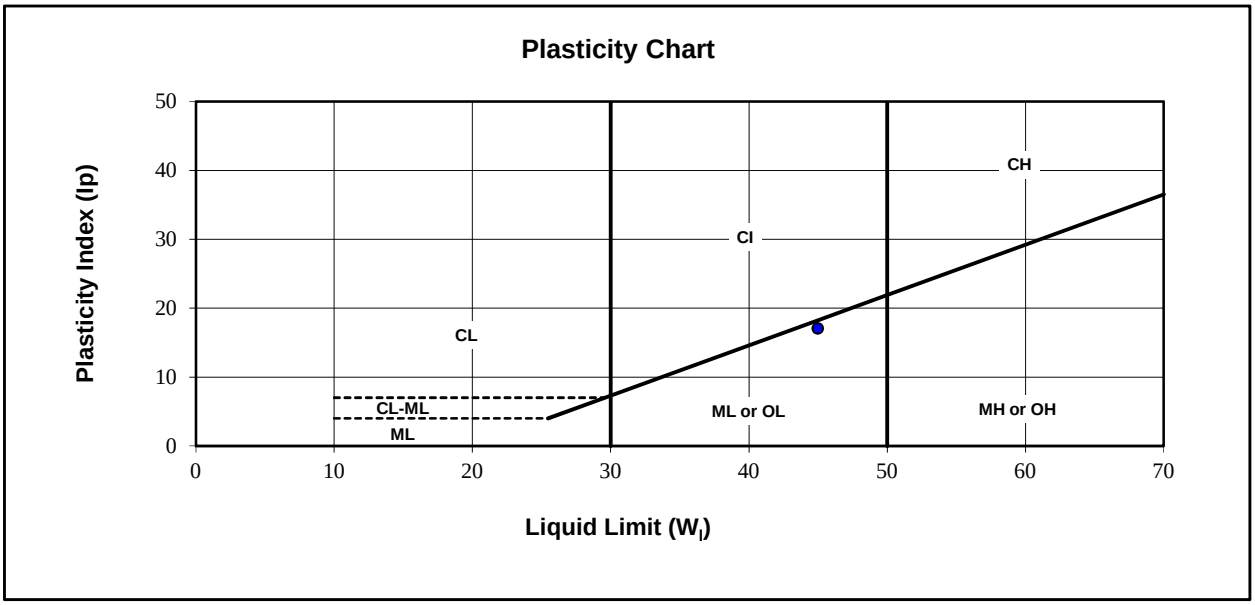
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-205979
		Borehole Number:	SRK18-WST-DH-03
Project No:	704-Y14103336-02.003	Depth:	3.1-3.5 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 23, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	May 11, 2018

Sample Description: CLAY, silty, trace sand, trace gravel, brown with grey inclusions, organics



Liquid Limit ($W_{1)}$) :	45	Natural Moisture (%)	56.7
Plastic Limit :	28	Soil Plasticity:	Low
Plasticity Index (Ip) :	**17**	Mod.USCS Symbol:	OL

Remarks:

Reviewed By: P.Geol.

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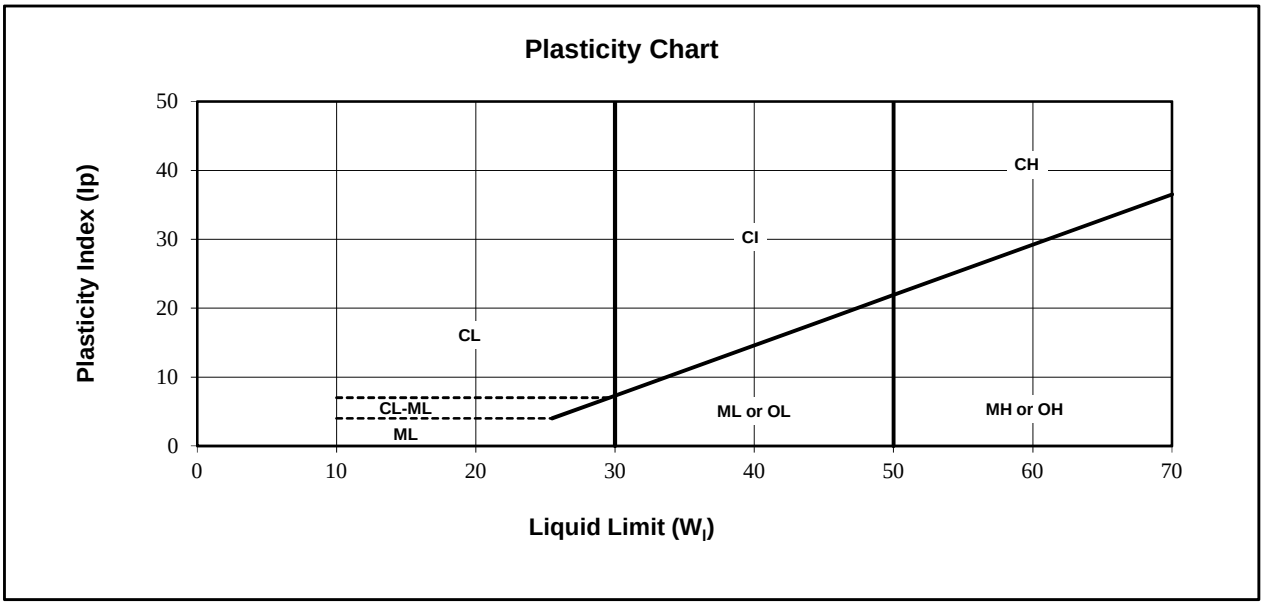
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-205982
	South Dam Project	Borehole Number:	SRK18-WST-DH-02
Project No:	704-Y14103336-02.003	Depth:	0.8 - 1.1 m
Client:	TMAC Resources Inc.	Sampled By:	Client Tested By: JC
Attention:	Kelly Schwenning	Date Sampled:	February 23, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	August 14, 2018

Sample Description: SAND, silty, some clay.



Liquid Limit ($W_{1)}$) :		Natural Moisture (%)	60.8
Plastic Limit :		Soil Plasticity:	Non-Plastic
Plasticity Index (Ip) :		Mod.USCS Symbol:	

Remarks: Sample is non-plastic. Sample is composed of silty sand, not enough clay to roll plastic limit.

Reviewed By: _____ P.Geol.

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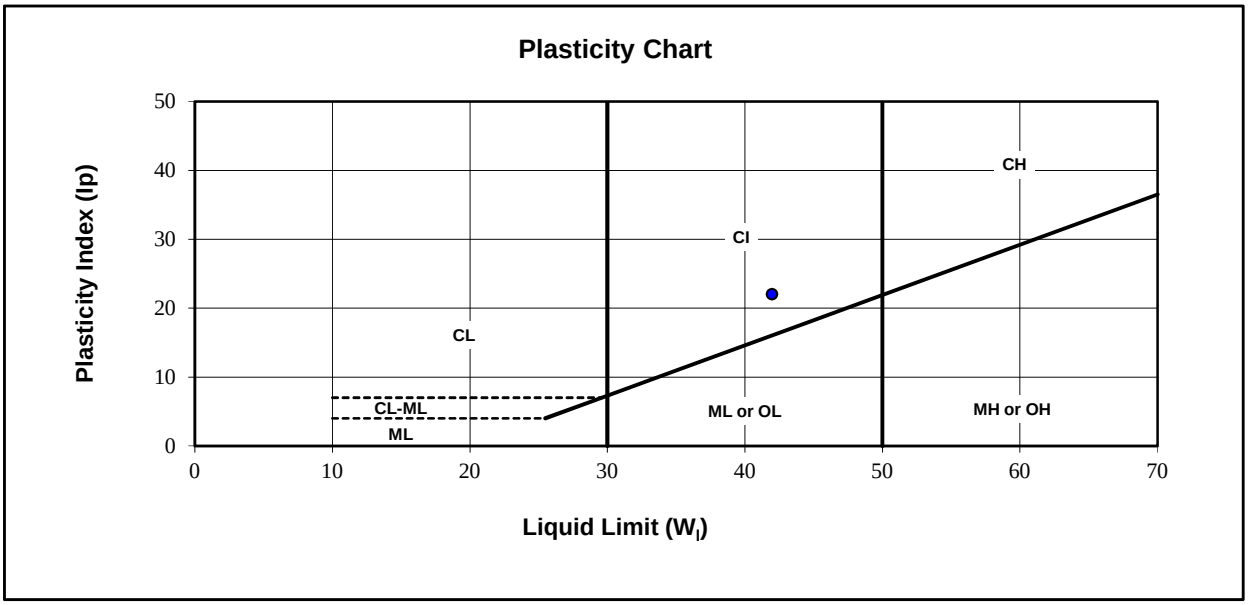
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-205984
		Borehole Number:	SRK18-RD-DH-16
Project No:	704-Y14103336-02.003	Depth:	14.2 - 14.6 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	April 28, 2018

Sample Description: CLAY, silty, trace fine sand, mottled greyish brown-black.



Liquid Limit ($W_{1)}$) :	42	Natural Moisture (%)	36.5
Plastic Limit :	20	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**22**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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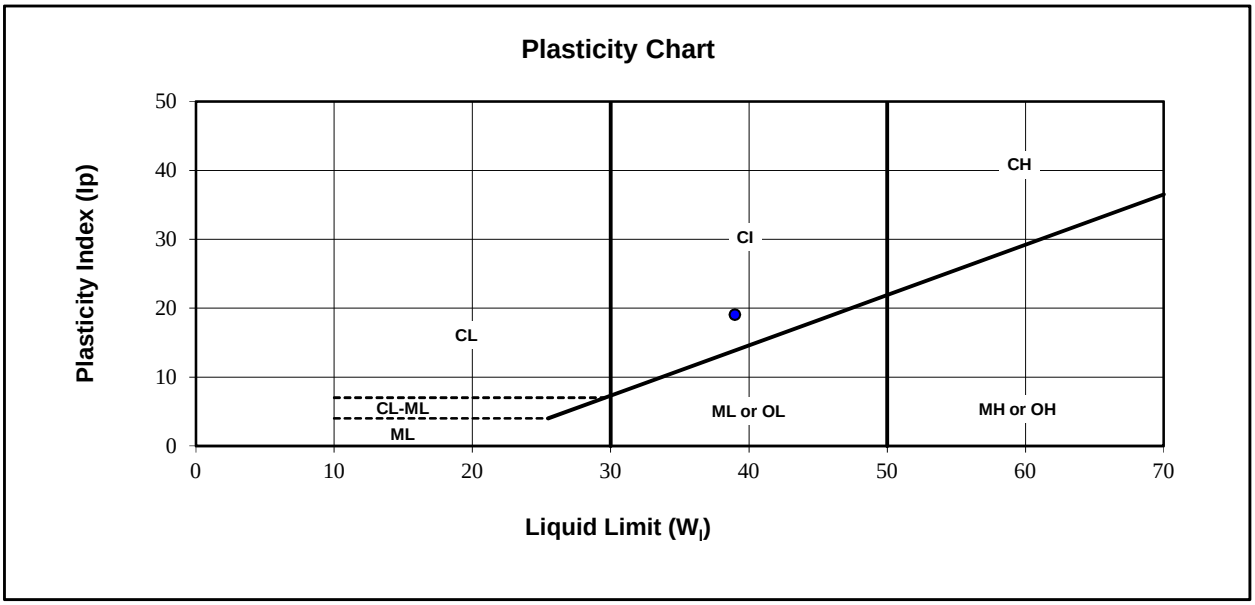
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-205985
	South Dam Project	Borehole Number:	SRK18-RD-DH-16
Project No:	704-Y14103336-02.003	Depth:	14.7-15.1 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	JPC
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 25, 2018

Sample Description: CLAY, silty, some sand, greyish brown with grey streaks.



Liquid Limit ($W_{1)}$) :	39	Natural Moisture (%)	45.9
Plastic Limit :	20	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**19**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: _____ P.Geol.

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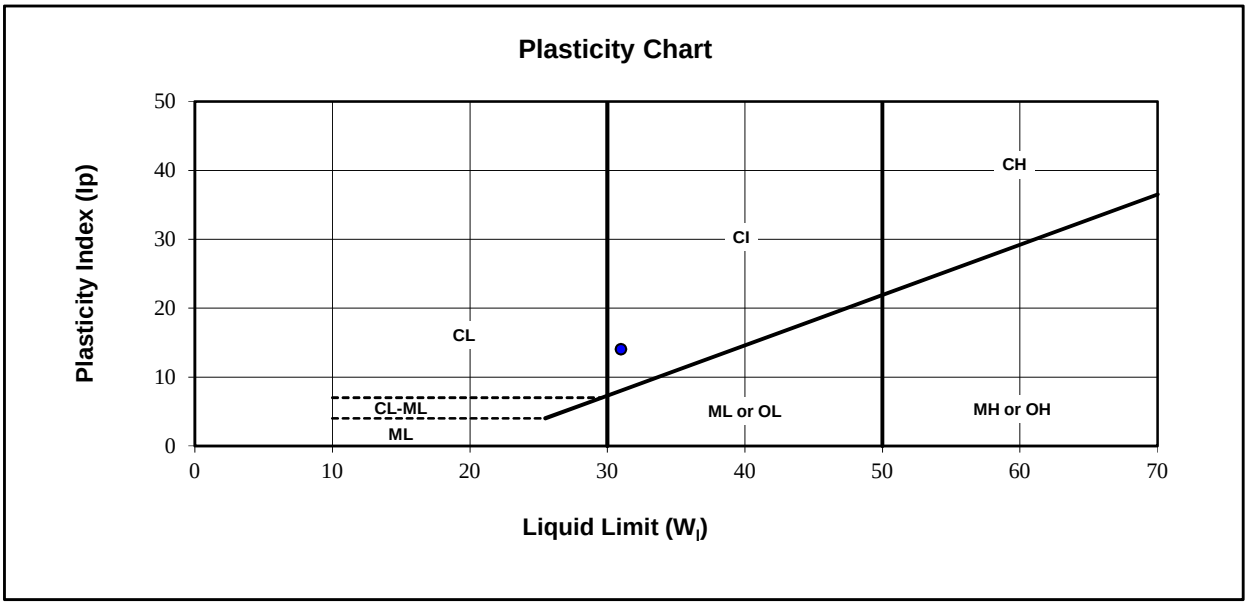
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-205986
		Borehole Number:	SRK18-RD-DH-16
Project No:	704-Y14103336-02.003	Depth:	21.3-21.7 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 29, 2018

Sample Description: CLAY,silty, some sand. Greyish brown with dark grey inclusions. Organics



Liquid Limit ($W_{1)}$) :	31	Natural Moisture (%)	34.1
Plastic Limit :	17	Soil Plasticity:	Low to Medium
Plasticity Index (Ip) :	**14**	Mod.USCS Symbol:	CL-CI

Remarks:

Reviewed By: P.Geol.

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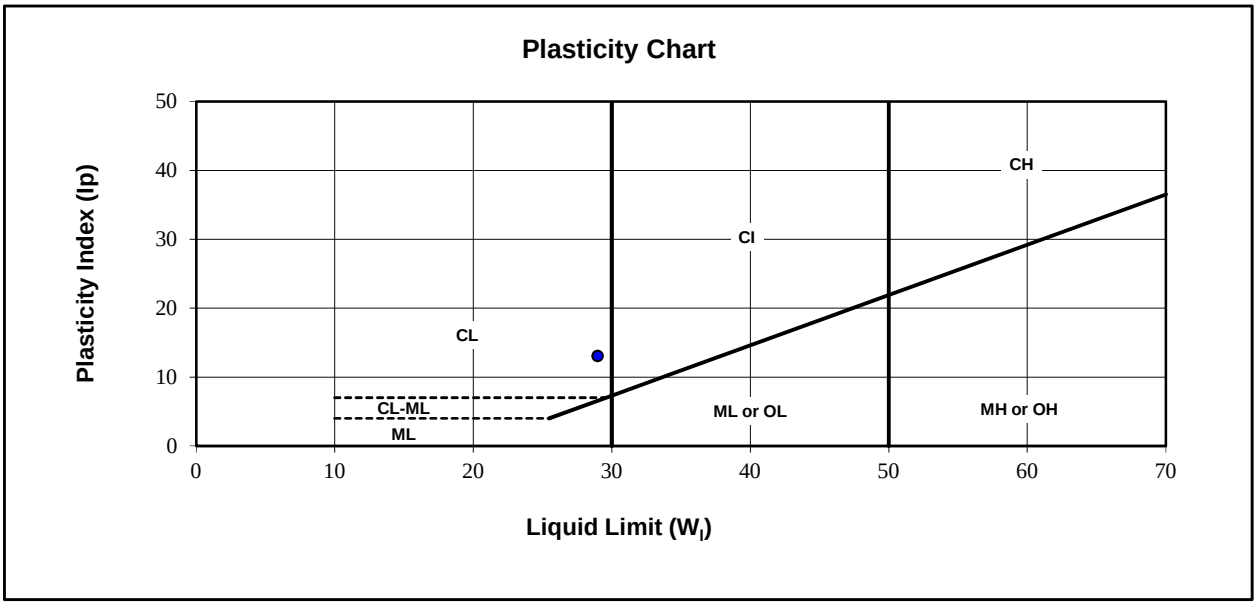
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-205987
	South Dam Project	Borehole Number:	SRK18-RD-DH-16
Project No:	704-Y14103336-02.003	Depth:	23.2-23.6 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	JC
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 11, 2018

Sample Description: CLAY, silty, sandy, trace gravel. Brownish grey with grey streaks.



Liquid Limit ($W_{1)}$) :	29	Natural Moisture (%)	34.3
Plastic Limit :	16	Soil Plasticity:	Low to Medium
Plasticity Index (Ip) :	**13**	Mod.USCS Symbol:	CL

Remarks:

Reviewed By: P.Geol.

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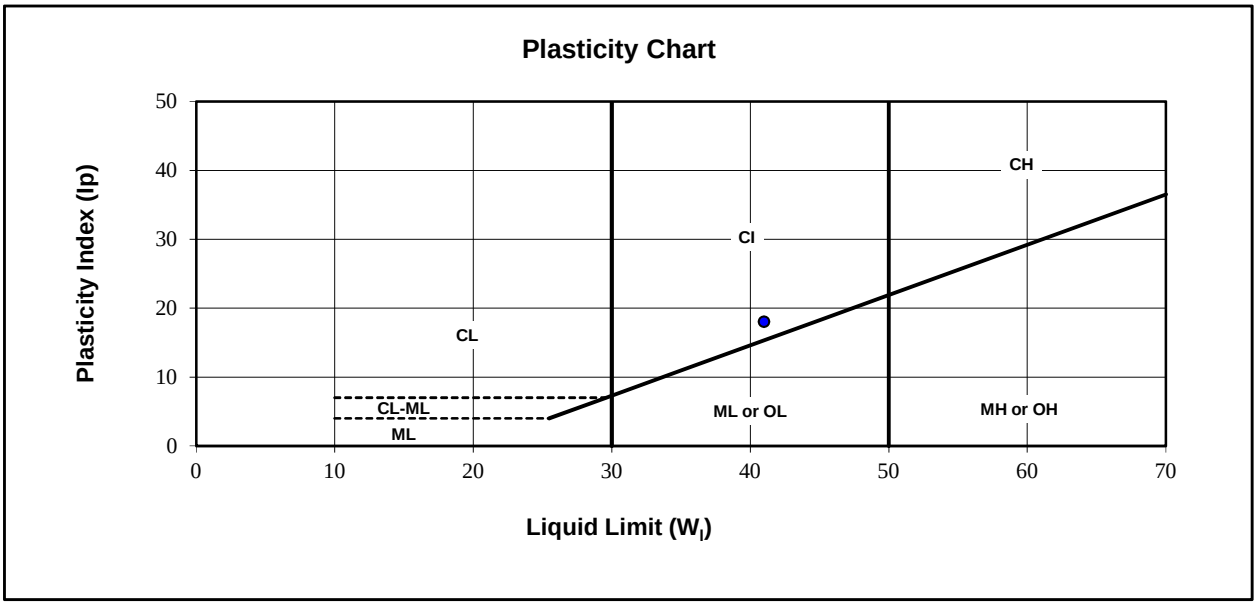
ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-205988
		Borehole Number:	SRK18-RD-DH-15
Project No:	704-Y14103336-02.003	Depth:	2.3-6.5 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 15, 2018

Sample Description: CLAY, silty, trace sand, trace gravel, brownish grey with grey streaks.



Liquid Limit ($W_{1)}$) :	41	Natural Moisture (%)	41.7
Plastic Limit :	23	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**18**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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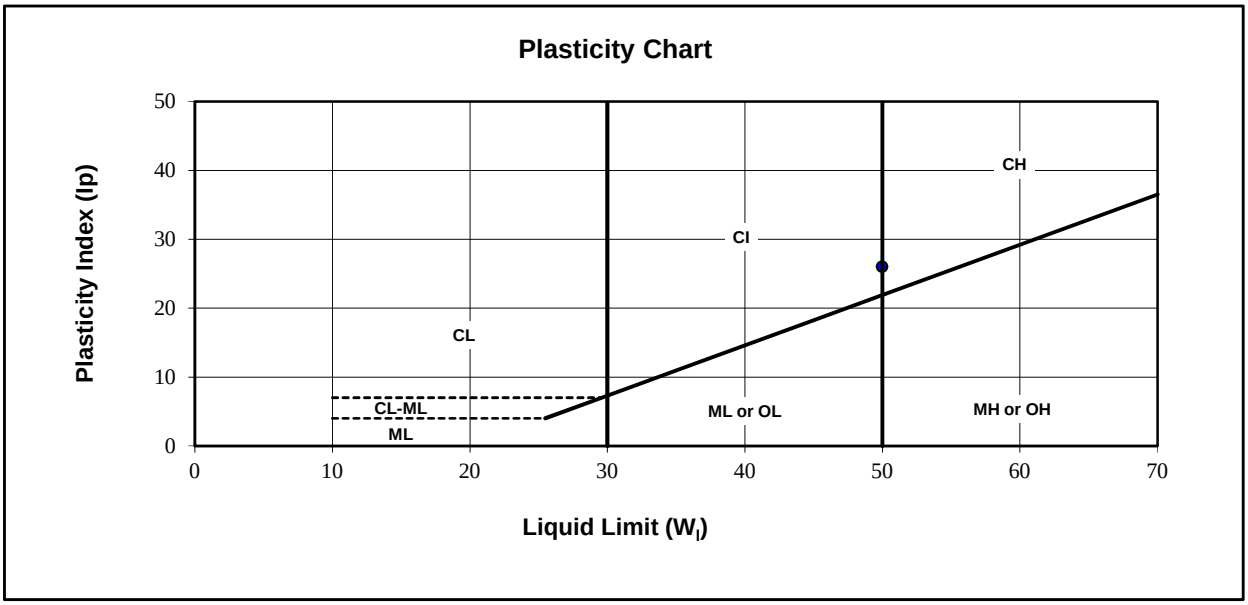
ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-205990
		Borehole Number:	SRK18-RD-DH-15
Project No:	704-Y14103336-02.003	Depth:	11.3-14.3 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	May 2, 2018

Sample Description: CLAY, silty, trace fine sand, trace fine gravel. Dark grey, mottled black, red incl.



Liquid Limit ($W_{1)}$) :	50	Natural Moisture (%)	47.4
Plastic Limit :	24	Soil Plasticity:	Medium to High
Plasticity Index (Ip) :	**26**	Mod.USCS Symbol:	CI-CH

Remarks:

Reviewed By: P.Geol.

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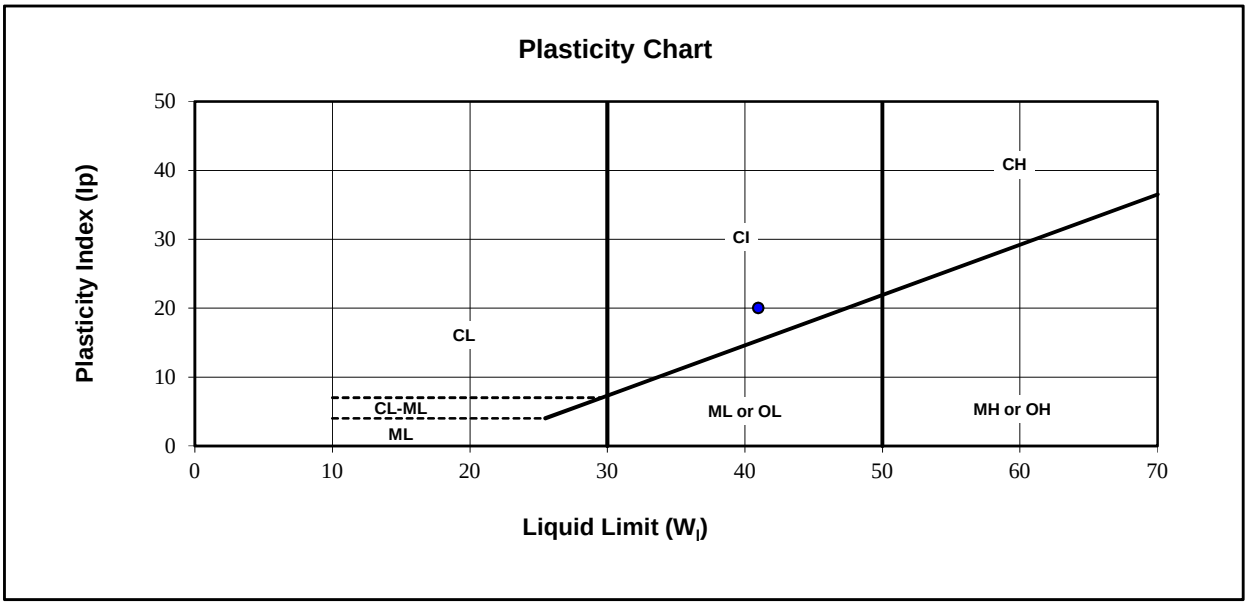
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-205991
		Borehole Number:	SRK18-RD-DH-15
Project No:	704-Y14103336-02.003	Depth:	14.3-18.0 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	JPC
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 20, 2018

Sample Description: CLAY,silty, some sand. Brown with dark grey inclusions. Organics.



Liquid Limit ($W_{1)}$) :	41	Natural Moisture (%)	48.7
Plastic Limit :	21	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**20**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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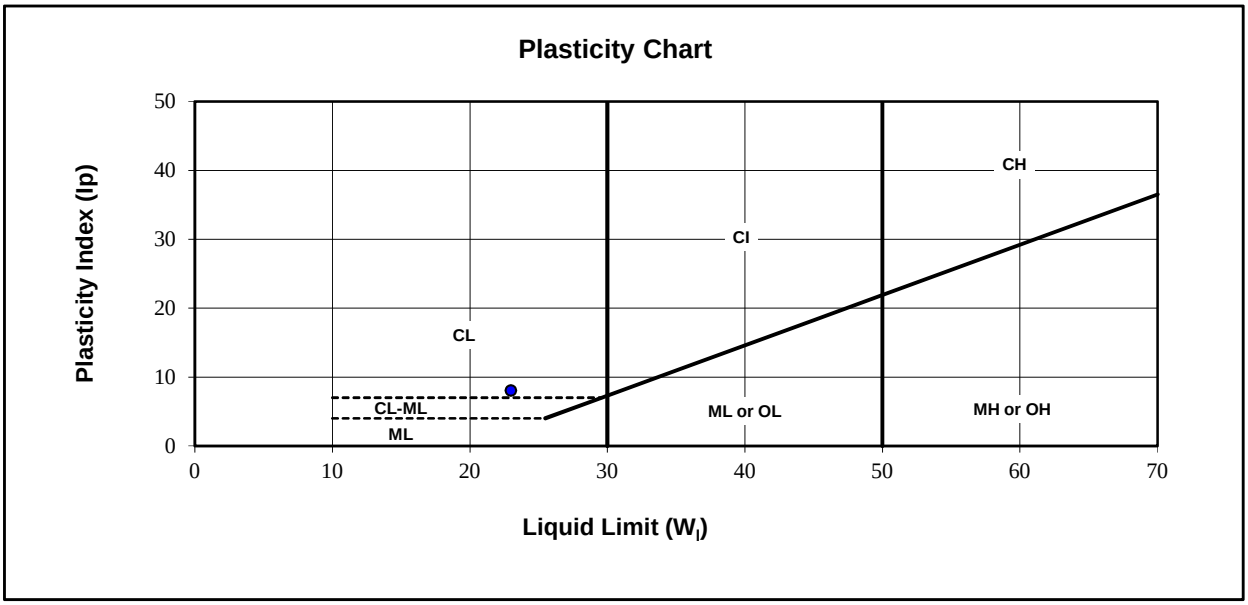
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-205992
	South Dam Project	Borehole Number:	SRK18-RD-DH-15
Project No:	704-Y14103336-02.003	Depth:	21.2-24.8 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 19, 2018

Sample Description: SILT, sandy, some clay, some gravel, brown and grey.



Liquid Limit ($W_{1)}$) :	23	Natural Moisture (%)	23.0
Plastic Limit :	15	Soil Plasticity:	Low
Plasticity Index (Ip) :	**8**	Mod.USCS Symbol:	CL-ML

Remarks:

Reviewed By: BF. P.Geol.

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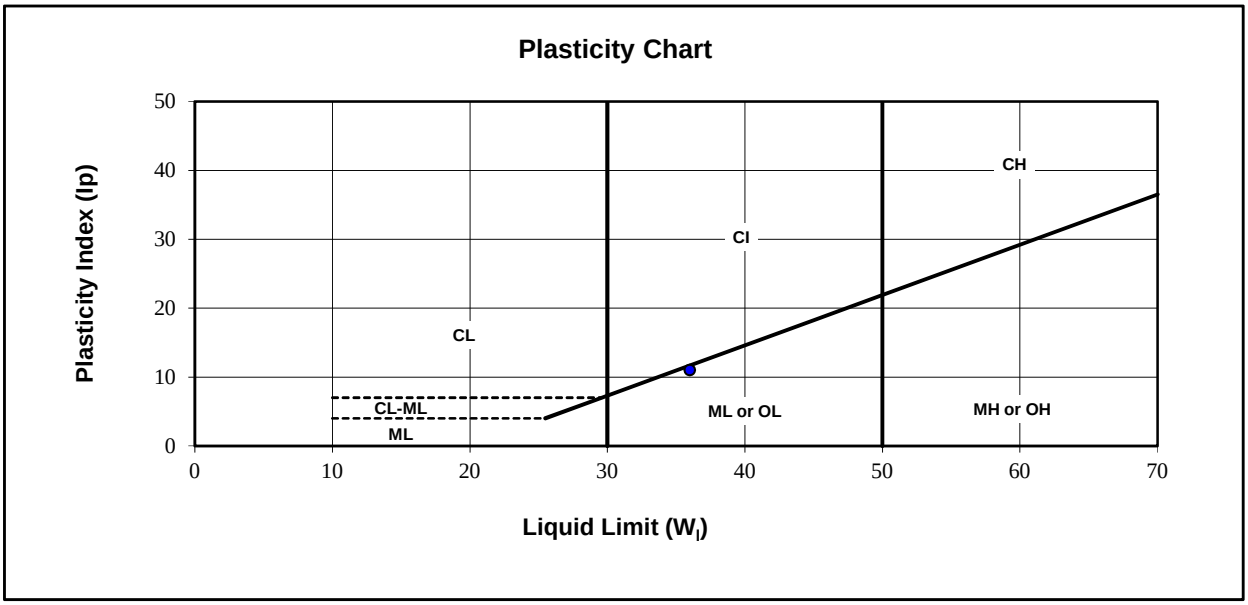
ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-205994
		Borehole Number:	SRK18-WST-DH-01
Project No:	704-Y14103336-02.003	Depth:	0.1-0.6 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	DY/WM
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 19, 2018

Sample Description: CLAY, silty, trace sand, medium reddish brown with white inclusions, rootlets.



Liquid Limit ($W_{1)}$) :	36	Natural Moisture (%)	38.1
Plastic Limit :	25	Soil Plasticity:	Low
Plasticity Index (Ip) :	**11**	Mod.USCS Symbol:	ML

Remarks:

Reviewed By: P.Geol.

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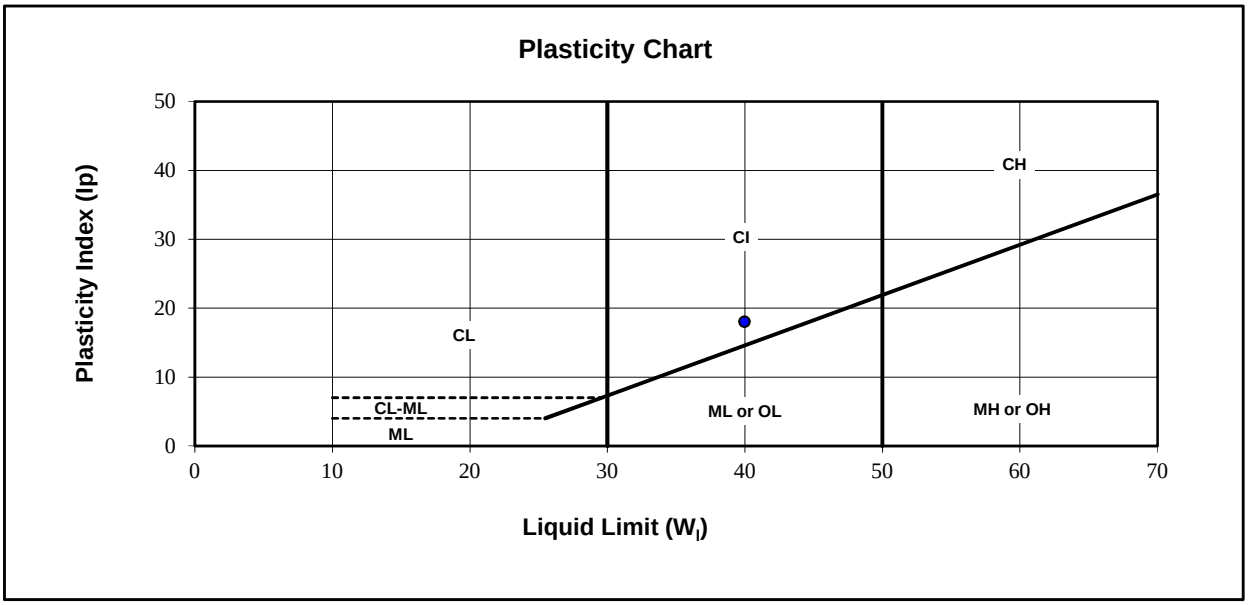
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-205997
		Borehole Number:	SRK18-WST-DH-01
Project No:	704-Y14103336-02.003	Depth:	2.2-4.3 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	WM
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	July 29, 2018

Sample Description: CLAY, silty, some sand. Light greyish brown with black inclusions. Organics.



Liquid Limit ($W_{1)}$) :	40	Natural Moisture (%)	47.3
Plastic Limit :	22	Soil Plasticity:	Medium
Plasticity Index (Ip) :	**18**	Mod.USCS Symbol:	CI

Remarks:

Reviewed By: P.Geol.

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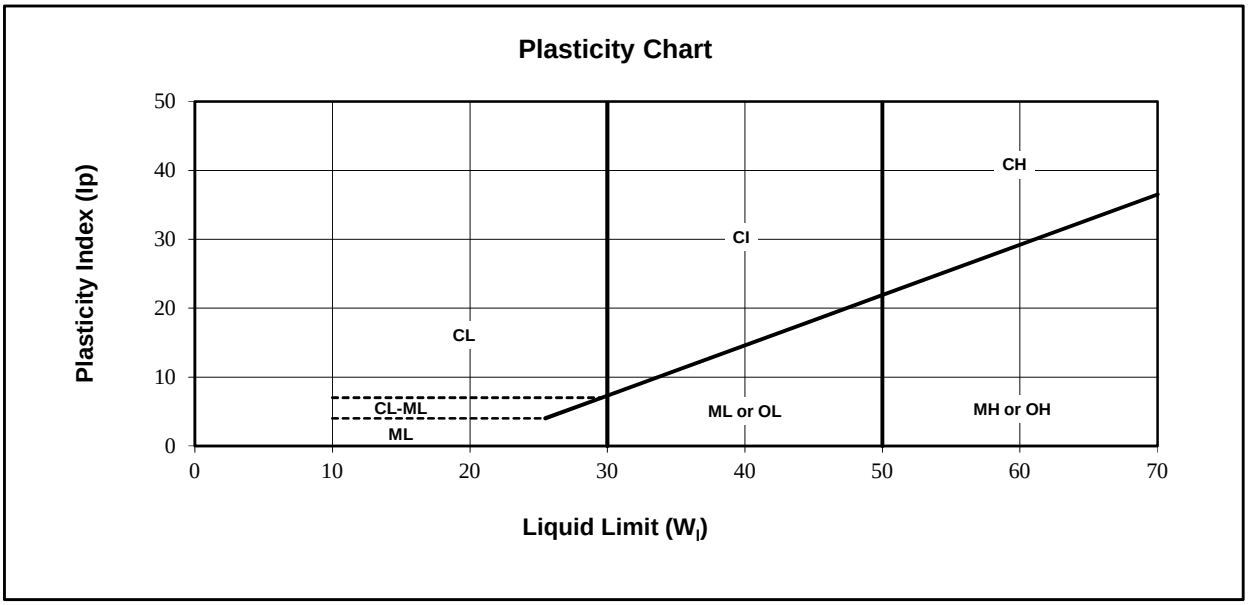
TETRA TECH

ATTERBERG LIMITS TEST REPORT

ASTM D4318

Project:	Hope Bay Overburden Soils Testing	Sample Number:	6667-205999
		Borehole Number:	SRK18-WST-DH-01
Project No:	704-Y14103336-02.003	Depth:	6.7-7.1 m
Client:	TMAC Resources Inc.	Sampled By:	Client
		Tested By:	JPC
Attention:	Kelly Schwenning	Date Sampled:	February 24, 2018
Email:	kelly.schwenning@tmacresources.com	Date Tested:	June 25, 2018

Sample Description: SAND, silty, some clay, greyish brown.



Liquid Limit ($W_{1)}$) :		Natural Moisture (%)	25.1
Plastic Limit :		Soil Plasticity:	Non-Plastic
Plasticity Index (Ip) :		Mod.USCS Symbol:	

Remarks: Non-plastic. Material under 0.425 mm sieve is fine sand.

Reviewed By: _____ P.Geol.

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Appendix L.4 – Moisture Content

MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay South Dam Project	Sample No.:	6651
Project No.:	704-Y14103336-02.003	Date Tested:	February 14, 2018
Client:	TMAC Resources	Tested By:	SS
Address:	Hope Bay, NU	Page:	1 of 2

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
P11.13	8.0-9.0	65.0	SILT, sandy, some clay. Brown. Roots in sample. Low to medium plastic
P12.11	6.0-7.0	52.4	SILT, clayey, some sand. Grey. Organic smell. Low to medium plasticity.
P12.12	7.0-8.0	61.3	SILT, sandy, some clay, trace gravel. Grey. Organic smell.
P13.13	8.0-9.0	58.2	CLAY, silty, some sand. Grey and brown streaks. Organic smell. Medium
P14.01	0.0-0.5	35.0	SAND, silty, trace clay, trace gravel. Brown.
P16.12	7.0-8.0	29.0	CLAY and SILT, trace sand. Organic smell. Brownish grey. Medium to hi
P17.13	8.0-9.0	54.8	CLAY and SILT, some sand. Organic smell. Brownish grey. Medium plas
P22.12	7.0-8.0	47.5	SILT, sandy, some clay. Grey. Medium plasticity.
P24.06	2.5-3.0	49.7	CLAY, silty, trace sand. Brown. Medium to high plasticity.
P24.12	7.0-8.0	51.6	SILT, clayey, some sand. Grey with dark grey streaks. Organic smell.
P24.14	9.0-10.0	28.3	SAND and SILT, some clay. Twigs in sample. Grey and brown streaks. L
P25.06	2.5-3.0	55.9	SILT, clayey, some sand. Brownish grey. Grass in sample. Medium plas
P25.11	6.0-7.0	57.9	SILT and SAND, trace clay. Dark grey. Organic smell.
P25.12	7.0-8.0	36.4	SILT, sandy, some clay. Grey with black streaks. Organic smell. Medium
P26.08	3.5-4.0	54.8	SILT, clayey, trace sand. Brown. Medium plasticity.
P26.10	5.0-6.0	45.8	CLAY, silty, some sand. Grey and black streaks. Medium plasticity.
P26.13	8.0-9.0	42.8	SILT, sandy, some clay. Grey. Low to medium plasticity.
P27.07	3.0-3.5	54.0	SILT, some clay, trace sand. Organic smell. Brown. Low to medium plas
P27.09	4.0-4.5	51.1	CLAY and SILT, some sand. Organic smell. Grey. Medium to high plasti
P30.01	0.0-0.5	57.8	SAND, silty, clayey. Peat, twigs and grass in sample. Brown.
P30.11	6.0-7.0	49.2	CLAY and SILT, some sand. Grey and brown streaks. Organic smell. Me
P30.12	7.0-8.0	60.3	SILT, some clay, trace to some sand. Brown with dark grey streaks. Low
P30.14	9.0-10.0	62.3	SILT and SAND, some clay. Organic smell. Brown with black streaks. Lo
P31.14	9.0-10.0	49.8	SILT, sandy, some clay. Grey and brown.
P32.11	6.0-7.0	58.5	SILT, sandy, some clay. Organic smell. Grey. Low plasticity.

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TETRA TECH

MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay South Dam Project	Sample No.:	6651
Project No.:	704-Y14103336-02.003	Date Tested:	February 14, 2018
Client:	TMAC Resources	Tested By:	SS
Address:	Hope Bay, NU	Page:	2 of 2

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
P33.07	3.0-3.5	53.7	SILT, clayey, some sand. Greyish brown. Medium plasticty.
P34.01	0.0-0.5	49.3	SAND, silty, clayey to some clay. Brown. Peat, twigs, and grass in sampl

Reviewed By: _____ P.Geol.

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TETRA TECH

MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay South Dam Project	Sample No.:	6650
Project No.:	704-Y14103336-02.003	Date Tested:	February 6, 2018
Client:	TMAC Resources	Tested By:	SS
Address:	Hope Bay, NU	Page:	1 of 6

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
P2.03	1.0-1.5	50.1	SAND and SILT, some clay, trace gravel. Brownish grey. Roots present
P2.07	3.0-3.5	18.5	SAND, some gravel, trace silt and clay. Brown and red.
P7.03	1.0-1.5	63.9	SAND, some silt, trace clay, trace gravel. Brownish grey.
P10.04	1.5-2.0	160.0	SAND, trace gravel, trace silt, trace clay. Grey. Visible ice in sample.
P10.06	2.5-3.0	250.7	SILT, sandy, trace clay, trace gravel. Grey.
P11.03	1.0-1.5	306.2	SAND and SILT, trace gravel, trace clay. Grey.
P11.11	6.0-7.0	54.1	CLAY, some silt, some sand. Grey. Organic smell. Medium plasticity.
P12.13	8.0-9.0	60.6	CLAY, some silt, some sand, trace gravel. Grey.
P12.14	9.0-10.0	65.0	CLAY, some silt, some sand. Grey.
P13.11	6.0-7.0	74.2	SILT, sandy, some clay. Grey. Organic smell.
P13.14	9.0-10.0	62.4	SILT, sandy, some clay. Grey.
P14.10	5.0-6.0	32.8	CLAY, some silt, some sand. Twigs in sample. Grey. Organic smell. Mec
P15.04	1.5-2.0	107.9	SAND, silty, trace clay, trace gravel. Dark grey.
P15.11	6.0-7.0	33.9	CLAY, some silt, trace sand. Roots in sample. Grey-black.
P16.06	2.5-3.0	238.5	SAND, silty, some clay. Brownish grey.
P16.10	5.0-6.0	59.0	SAND, some clay, some silt, trace gravel. Medium brown. Organic smell
P16.14	9.0-10.0	49.6	CLAY, some silt, trace sand, trace gravel. Dark grey. Organic smell.
P18.12	7.0-8.0	80.9	SAND, silty, some clay, trace gravel. Grey.
P20.02	0.5-1.0	90.2	SAND, some silt, trace clay, trace gravel. Brown. Low plasticity.
P20.04	1.5-2.0	76.4	SAND, some silt, trace clay, trace gravel. Brown. Low plasticity.
P22.02	0.5-1.0	59.6	SAND, silty, trace clay, trace gravel. Roots in sample. Brown. Organic sr
P22.10	5.0-6.0	58.5	CLAY and SILT, some sand. Grey. Organic smell. Medium plasticity
P24.11	6.0-7.0	59.1	CLAY and SILT, some sand. Grey. Medium plasticity.
P26.09	4.0-5.0	50.3	CLAY, some silt, some sand. Grey. Medium plasticity.
P26.12	7.0-8.0	45.5	CLAY, some silt, some sand. Grey. Medium plasticity.

Reviewed By: _____ P.Geol.

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MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay South Dam Project	Sample No.:	6650
Project No.:	704-Y14103336-02.003	Date Tested:	February 6, 2018
Client:	TMAC Resources	Tested By:	SS
Address:	Hope Bay, NU	Page:	2 of 6

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
P27.05	2.0-2.5	85.4	CLAY, some sand, trace silt, trace gravel. Dark grey.
P27.11	6.0-7.0	52.8	SILT, sandy, some clay. Grey.
P27.14	9.0-10.0	28.9	SILT, sandy, trace clay, trace gravel. Grey.
P28.02	0.5-1.0	111.6	SILT and SAND, some clay, trace gravel. Grey. Low plasticity.
P28.06	2.5-3.0	64.3	SAND, silty, some clay. Brown. Low plasticity.
P28.10	5.0-6.0	51.3	CLAY, some silt, trace sand, trace gravel. Grey. Medium to high plasticit
P32.06	2.5-3.0	53.7	CLAY, some sand, some silt, trace gravel. Twigs and roots in sample. G
P32.10	5.0-6.0	58.6	CLAY, some sand, some silt, trace gravel. Twigs and roots in sample. G
P33.08	3.5-4.0	50.5	CLAY, some silt, trace sand, trace gravel. Grey. Medium to high plasticit
P33.13	8.0-9.0	5.3	SAND and GRAVEL, trace silt, trace clay. Grey.
P39.05	2.0-2.5	13.2	SAND, some silt, trace gravel, trace clay. Grey.

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TETRA TECH

MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay South Dam Project	Sample No.:	6650
Project No.:	704-Y14103336-02.003	Date Tested:	February 7, 2018
Client:	TMAC Resources	Tested By:	SS
Address:	Hope Bay, NU	Page:	3 of 6

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
P10.02	0.5-1.0	84.8	SAND, silty, trace gravel, trace clay. Greyish brown.
P11.05	2.0-2.5	116.3	SAND and SILT, trace gravel, trace clay. Grey.
P11.09	4.0-5.0	33.8	SAND and SILT, trace gravel, trace clay. Brownish grey.
P11.12	7.0-8.0	66.4	CLAY, some silt, some sand. Roots in sample. Grey. Organic smell. Mec
P11.14	9.0-10.0	67.3	SILT, sandy, some clay. Grey and black streaks. Organic smell.
P12.02	0.5-1.0	85.4	SAND, silty, trace gravel, trace clay. Brown.
P12.06	2.5-3.0	52.0	SILT, clayey, some sand, trace gravel. Roots in sample. Greyish brown.
P12.08	3.5-4.0	35.6	CLAY and SILT, trace sand. Dark brown to black. Organic smell. Mediur
P12.10	5.0-6.0	48.0	CLAY, silty, some sand. Grey. Organic smell.
P13.03	1.0-1.5	92.6	SAND, silty, trace clay, trace gravel. Roots in sample. Greyish brown. Or
P13.05	2.0-2.5	145.3	SAND, silty, trace clay, trace gravel. Roots in sample. Greyish brown. Or
P13.08	3.5-4.0	58.8	SILT, some sand, some clay. Grey. Organic smell.
P13.10	5.0-6.0	52.3	SILT, sandy, some clay. Grey. Organic smell.
P16.13	8.0-9.0	39.7	CLAY , some silt, trace sand, trace gravel. Dark grey. Organic smell.
P17.04	1.5-2.0	66.2	SAND, silty, trace clay, trace gravel. Grass and roots in sample. Grey.
P17.14	9.0-10.0	62.2	CLAY and SILT, some sand. Roots in sample. Grey. Organic smell.
P18.10	5.0-6.0	61.6	CLAY, silty, some sand. Grey.
P20.05	2.0-2.5	46.7	SAND, silty, some clay. Brown. Medium plasticity.
P21.03	1.0-1.5	40.1	SAND, silty, some clay, trace gravel. Brown.
P22.07	3.0-3.5	56.5	CLAY and SILT, some sand. Grey. Organic smell. Medium plasticity.
P22.13	8.0-9.0	41.2	CLAY and SILT, some sand. Grey. Organic smell. Medium plasticity.
P25.04	1.5-2.0	302.7	SAND and SILT, some clay. Brownish grey.
P25.10	5.0-6.0	52.5	CLAY and SILT, some sand. Grey and black streaks. Medium plasticity.
P25.13	8.0-9.0	29.3	SILT, clayey, some sand, trace gravel. Grey. Medium plasticity.
P25.14	9.0-10.0	7.7	SILT, clayey, some sand, trace gravel. Grey. Medium plasticity.

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MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay South Dam Project	Sample No.:	6650
Project No.:	704-Y14103336-02.003	Date Tested:	February 7, 2018
Client:	TMAC Resources	Tested By:	SS
Address:	Hope Bay, NU	Page:	4 of 6

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
P28.08	3.5-4.0	59.8	SILT, some sand, some clay. Brown. Low to medium plasticity.
P28.11	6.0-7.0	64.6	CLAY, some silt, trace sand, trace gravel. Grey. Medium to high plasticit
P28.14	9.0-10.0	40.9	CLAY and SILT, sandy, trace gravel. Grey. Organic smell.
P30.06	2.5-3.0	48.8	SILT and SAND, some clay, trace gravel. Grey. Low to medium plasticity
P30.10	5.0-6.0	51.5	CLAY, silty, some sand. Grey. Organic smell. Medium plasticity.
P31.03	1.0-1.5	168.1	SAND, silty, trace clay, trace gravel. Grey. Visible ice in sample.
P31.12	7.0-8.0	61.2	CLAY, silty, trace sand. Grey.
P32.08	3.5-4.0	53.7	CLAY and SILT, trace sand, trace gravel. Grey. Medium plasticity.
P33.04	1.5-2.0	75.2	SAND, silty, trace clay. Brown.
P36.05	2.0-2.5	12.2	SAND, some gravel, trace silt, trace clay.
P39.03	1.0-1.5	9.3	SAND, some silt, trace gravel, trace clay. Brown.

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MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay South Dam Project	Sample No.:	6650
Project No.:	704-Y14103336-02.003	Date Tested:	February 8, 2018
Client:	TMAC Resources	Tested By:	SS
Address:	Hope Bay, NU	Page:	5 of 6

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
P1.02	0.5-1.0	61.6	SAND and SILT, trace clay, trace gravel. Brown.
P1.03	1.0-1.5	64.1	SAND and SILT, trace clay, trace gravel. Brown.
P7.07	3.0-3.5	36.1	SAND, silty, trace to some clay. Brown.
P8.02	0.5-1.0	81.4	SAND and SILT, trace clay, trace gravel. Roots in sample. Brownish gre
P13.02	0.5-1.0	123.3	SAND, silty, trace clay, trace gravel. Roots in sample. Organic smell. Gre
P13.12	7.0-8.0	56.9	CLAY and SILT, some sand. Grey and brown. Organic smell. Medium pl
P14.08	3.5-4.0	36.3	SILT, clayey, some sand. Twigs in sample. Organic smell. Brown. Mediu
P14.12	7.0-8.0	36.5	CLAY, some silt, some sand. Twigs in sample. Organic smell. Black with
P14.14	9.0-10.0	44.4	CLAY, some silt, trace sand. Black and grey. Organic smell. Medium to h
P15.10	5.0-6.0	35.8	CLAY, silty, trace sand. Brown. Roots in sample. Grey and black. Mediu
P15.14	9.0-10.0	49.1	CLAY, some silt, trace sand. Organic smell. Grey and black. Medium to
P16.02	0.5-1.0	181.1	SAND, silty, some clay. Roots in sample. Brown.
P17.12	7.0-8.0	57.7	CLAY, silty, trace sand. Grey.
P18.08	3.5-4.0	64.0	SILT, sandy, some clay. Brown.
P18.14	9.0-10.0	42.5	SILT, clayey, some sand. Grey. Medium plasticity.
P25.05	2.0-2.5	55.8	Silty, clayey, some sand. Grey. Medium plasticity.
P25.08	3.5-4.0	52.9	SILT, clayey, some sand. Grey. Medium plasticity.
P26.03	1.0-1.5	58.3	SILT, some sand, some clay. Low to medium plasticity. Brown.
P26.04	1.5-2.0	57.0	SILT, some sand, some clay. Low to medium plasticity. Brown.
P27.06	2.5-3.0	60.1	CLAY, some sand, trace silt, trace gravel. Dark grey.
P27.10	5.0-6.0	48.3	SILT, sandy, some clay. Grey. Organic smell.
P27.12	7.0-8.0	46.2	CLAY and SILT, some sand. Roots in sample. Grey. Medium plasticity.
P27.13	8.0-9.0	32.4	SAND and SILT, clayey, trace gravel. Grey.
P30.04	1.5-2.0	71.0	SILT and SAND, some clay, trace gravel. Grey. Low to medium plasticity
P30.13	8.0-9.0	68.6	CLAY and SILT, some sand. Organic smell. Grey and black. Medium pla

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MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay South Dam Project	Sample No.:	6650
Project No.:	704-Y14103336-02.003	Date Tested:	February 8, 2018
Client:	TMAC Resources	Tested By:	SS
Address:	Hope Bay, NU	Page:	6 of 6

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
P31.01	0.0-0.5	36.8	SILT, sandy, some clay. Brown.
P33.03	1.0-1.5	61.9	SAND, silty, trace clay. Brown.
P33.09	4.0-5.0	56.8	CLAY, some silt, trace sand, trace gravel. Grey. Medium to high plasticit
P34.04	1.5-2.0	16.1	SAND, silty, trace clay, trace gravel. Light brown.
P34.08	3.5-4.0	8.9	SAND, silty, trace clay, trace gravel. Light brown.

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MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667
Project No.:	Y14103336-02.003	Date Tested:	Various
Client:	TMAC Resources Inc.	Tested By:	Various
Address:	Hope Bay, NU	Page:	1 of 3

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
205967	6.9-7.4 m	46.7	CLAY, silty. Brown with dark grey inclusions. Organics.
205968	9.4-9.9 m	13.7	SAND, some gravel, trace fines. Greyish Brown.
205969	10.2-10.4 m	7.2	GRAVEL and SAND, some silt/clay. Greyish brown.
205979	3.1-3.5 m	56.7	CLAY, silty, light brown with grey inclusions.
205981	0.4-0.7 m	79.7	CLAY,silty, some sand.Mottled dark brown/grey.Organics.Rootlets.
205983	5.6-6.0 m	57.4	CLAY, silty, trace fine sand.Mottled greyish brown-black.Organics.
205984	14.2-14.6 m	36.5	CLAY, silty, trace fine sand. Mottled greyish brown-black.
205986	21.3-21.7 m	38.4	CLAY,silty,trace fine sand.Greyish brown with dark grey inclusions.
205989	6.5-11.3 m	39.0	CLAY, silty, trace fine sand. Mottled brown-black. Organics.
205990	11.3-14.3 m	47.4	CLAY, silty, tr f. sand, tr f. gravel. Dark grey,mottled black,red incl.
205991	14.3-18.0 m	48.7	CLAY,silty. Brown with dark grey inclusions. Organics.
205995	0.7-1.1 m	357.6	Topsoil. CLAY, silty. Dark brown. Wood debris, rootlets. Organics.
205996	1.1-2.2 m	411.0	CLAY, silty. Light greyish brown.
205997	2.2-4.3 m	47.3	CLAY, silty. Light greyish brown with black inclusions. Organics.
205998	5.2-6.3 m	47.4	CLAY, silty, light brown with grey inclusions.
29513	0.2-0.7 m	82.6	Topsoil. CLAY, silty. Dark brown. Wood debris, rootlets. Organics.
29514	0.7-1.8 m	317.9	CLAY, silty, light brown with grey inclusions.
29516	0.7-1.4 m	148.8	CLAY, silty. Brown with dark grey inclusions.Organics and rootlets.
29517	0.6-1.1 m	180.1	CLAY, silty, trace fine sand. Mottled light grey and greyish brown.
29520	3.2-4.2 m	69.5	CLAY, silty, sandy. Organics. Brown with black inclusions.
29521	4.2-5.2 m	7.6	CLAY, silty,sandy. Lenses of reddish-brown sand. Black org. clay.
29522	0.2-0.6 m	42.6	Topsoil. CLAY, silty. Dark brown. Wood debris, rootlets. Organics.
29524	2.9-3.6 m	72.7	CLAY. Black with brown inclusions. Organics.
29525	3.6-4.1 m	67.9	CLAY, silty, trace fine sand. Brown.
29527	4.5-5.1 m	11.0	SAND and GRAVEL, some silt, trace clay. Greenish grey.

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MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667
Project No.:	Y14103336-02.003	Date Tested:	Various
Client:	TMAC Resources Inc.	Tested By:	Various
Address:	Hope Bay, NU	Page:	2 of 3

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
29528	5.4-5.7 m	15.7	GRAVEL and SAND, subrounded gravel to 40 mm,trace fines.Grey.
29529	1.3-2.8 m	30.1	CLAY, silty, trace fine sand. Mottled brown and light grey organics.
29531	4.6-5.0 m	32.8	SAND, silty, tr gravel, tr clay. Mottled black, brown lenses.
29532	5.1-6.0 m	6.7	SAND and GRAVEL,trace fines.Angular,subrounded gravel to 40mm.
29533	6.0-6.6 m	8.1	GRAVEL and SAND,some silt-silty, some-tr clay.Light grey brown.
29544	0.2-0.6 m	24.5	CLAY, silty,trace fine sand.Rootlets.Greyish-brown.1" brown lense.
29545	6.5-6.9 m	56.6	CLAY, silty, light brown with grey inclusions.
29546	11.4-11.8 m	44.4	CLAY, silty. Mottled brown and dark grey. Organics.
29547	12.9-13.4 m	8.9	SAND and GRAVEL, some silt, tr clay. Organics. Dark green grey wit
29551	12.9-13.3 m	44.6	CLAY, silty, some gravel, tr sand. Organics. Brown with black incl.
29569	0.2-0.7 m	40.6	CLAY, silty,tr fine sand,tr fine gravel.Red brown with black incl.Org.
29571	2.2-4.6 m	44.4	CLAY, silty, tr fine sand. Light brown with dark grey incl. Organics.
29573	7.1-8.1 m	58.5	CLAY, silty, tr fine sand. Light brown with dark grey incl. Organics.
29574	8.1-9.1 m	45.8	CLAY, silty, some fine sand. Dark grey. Organics.
29575	9.1-10.5 m	10.9	SAND and GRAVEL, some silty-silty, tr clay. Light greyish brown.
29576	10.5-11.7 m	11.1	SAND and GRAVEL, trace fines. Light brow grey with black incl.Org.
29577	11.7-13.5 m	7.8	SAND and GRAVEL,some silt,some clay.Dark grey brown.Organics
29607	3.5-3.9 m	45.5	CLAY, silty. Mottled light brown and light grey.
29608	11.3-11.7 m	58.3	CLAY, silty. Brown with dark grey inclusions. Organics.
29611	25.2-25.6 m	11.4	SAND and GRAVEL, silty, clayey. Gravel to ~50 mm. Grey brown.
29612	0.3-0.7 m	45.7	CLAY, silty, trace sand, trace gravel. Brow grey, mottled dark grey.
29614	5.8-6.1 m	19.4	CLAY, silty, some sand,some gravel.Light greyish brown. Organics.
29615	7.0-7.4 m	19.0	SAND, fine to coarse, fine gravel, some silt.
29617	3.7-5.2 m	90.7	CLAY, silty. Reddish brown with dark grey inclusions. Organics.
29618	8.7-9.7 m	43.6	CLAY, silty. Brown with dark grey inclusions. Organics.

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MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667
Project No.:	Y14103336-02.003	Date Tested:	Various
Client:	TMAC Resources Inc.	Tested By:	Various
Address:	Hope Bay, NU	Page:	3 of 3

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
29620	0.7-2.1 m	246.4	CLAY, silty. Light grey. Organics.
29621	2.2-3.4 m	52.8	CLAY, silty. Organics. Mottled brown and dark grey.
29622	9.5-10.8 m	6.5	SAND and GRAVEL, trace fines. Light greenbrown. Dark grey incl.
29623	11.2-14.7 m	11.1	GRAVEL and SAND, some fines.Dark greyish brown, reddish grey.
29626	8.2-9.7 m	37.4	CLAY, silty. Brown with dark grey inclusions. Organics.
29630	14.9-15.2 m	49.8	CLAY, silty, light brown with grey inclusions.
29632	4.0-5.2 m	34.2	CLAY, silty, light brown with grey inclusions.
29633	8.2-9.2 m	23.7	SAND, fine, some silt/clay. Mottled reddish grey, light grey-brown.
29635	15.0-15.5 m	8.4	SAND and GRAVEL, trace fines. Greenish grey.
29637	4.3-5.3 m	36.4	CLAY, silty, tr sand. Organics. Mottled reddish brown, olive, black.
29639	13.6-14.3 m	70.1	CLAY, silty, light brown with grey inclusions.
29640	20.9-21.6 m	72.4	CLAY, silty, light brown with grey inclusions.
29642	29.3-31.0 m	7.1	SAND and GRAVEL, trace silt. Olive fines with grey inclusions.
29643	1.5-2.0 m	659.7	CLAY,silty,tr fine sand.Organics & rootlets. Wood. Methane smell. Da
29646	14.5-15.0 m	54.8	CLAY, silty, light brown with grey inclusions.
29648	24.0-25.0 m	35.7	SAND,fine & coarse,silty,tr clay.Dark grey brown,mottled dark grey. C

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MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6673
Project No.:	Y14103336-02.003	Date Tested:	April 25, 2018
Client:	TMAC Resources Inc.	Tested By:	SS
Address:	Hope Bay, NU	Page:	1 of 2

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
206031		3.4	25 mm crush
206019	0-1 m	50.0	CLAY, silty, trace sand. Brown with dark grey inclusions.
206020	1-1.7 m	58.2	CLAY, silty, trace sand. Brown with dark grey inclusions.
206021	1.7-3.15 m	45.4	CLAY,some silt-silty.Light grey mottled with dark grey.High plastic.
206022	3.15-4 m	40.7	CLAY,some silt-silty.Light grey mottled with dark grey.High plasticity.
206023	4-5 m	31.1	SILT, sandy, clayey-some clay. Brownish grey.
206024	5-6 m	13.4	SAND, silty, trace gravel, trace clay.
206025	6-8 m	12.0	SAND, silty, trace gravel.
206026	8-10 m	0.9	Bedrock shavings. Greenish blue/grey.
206027	10-16 m	0.9	Bedrock shavings. Greenish blue/grey.
206032	0-1 m	47.3	CLAY, SILT, trace-some sand. Grey. Topsoil.
206033	1-2 m	56.8	CLAY, SILT, trace sand. Dark grey.
206034	2-3 m	55.1	SILT, CLAY, some sand. Brown with dark grey inclusions.Organics.
206035	3-4 m	42.7	SILT, fine sand, trace-some clay. Brownish grey.
206036	4-5 m	17.2	SAND, gravelly, some silt, trace clay.
206037	5-6 m	6.2	SAND, trace silt, trace gravel.
206038	0-1 m	49.1	CLAY, SILT, trace-some sand. Grey. Topsoil.
206039	1-2 m	52.0	CLAY, SILT, trace-some sand. Brownish grey. Organics.
206040	2-3 m	65.3	SILT, clayey, some sand. Brown. Organics.
206041	3-4 m	62.1	SILT, SAND, some clay.Brownish grey with dark grey inc.Organics.
206042	4-5 m	77.0	SILT, some sand-sandy, some clay.
206043	5-6 m	63.5	SILT, clayey, some sand. Brown-grey with dark grey inc. Organics.
206044	6-7 m	49.0	CLAY, SILT, trace sand. Brown with dark grey inclusions.Organics.
206045	7-8 m	52.9	CLAY, SILT, trace sand. Brown with dark grey inclusions.Organics.
206046	8-9 m	53.1	CLAY, SILT, trace sand. Brown with dark grey inclusions.Organics.

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Data presented hereon is for the sole use of the stipulated client. Tetra Tech is not responsible, nor can be held liable, for use made of this report by any other party, with or without the knowledge of Tetra Tech. The testing services reported herein have been performed to recognized industry standards, unless noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, Tetra Tech will provide it upon written request.

TETRA TECH

MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6673
Project No.:	Y14103336-02.003	Date Tested:	April 25, 2018
Client:	TMAC Resources Inc.	Tested By:	SS
Address:	Hope Bay, NU	Page:	2 of 2

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
206047	9-10 m	61.4	CLAY, silty, trace fine sand. Dark grey mottled brown. Organics.
206048	10-11 m	70.4	CLAY, silty, trace fine sand. Dark grey mottled brown. Organics.
206049	11-12 m	63.5	CLAY, SILT, trace fine sand. Dark grey mottled brown. Organics.
206050	12-13 m	62.8	CLAY, SILT, trace fine sand. Dark grey mottled brown. Organics.
29401	13-14 m	51.8	CLAY, SILT, trace fine sand. Dark grey mottled brown. Organics.
29402	14-15 m	56.8	CLAY, SILT, trace fine sand. Dark grey mottled brown. Organics.
29403	15-16 m	64.6	CLAY, SILT, trace fine sand. Dark grey mottled brown. Organics.

Reviewed By: _____ P.Geol.

Data presented hereon is for the sole use of the stipulated client. Tetra Tech is not responsible, nor can be held liable, for use made of this report by any other party, with or without the knowledge of Tetra Tech. The testing services reported herein have been performed to recognized industry standards, unless noted. No other warranty is made. These data do not include or represent any interpretation or opinion of specification compliance or material suitability. Should engineering interpretation be required, Tetra Tech will provide it upon written request.

TETRA TECH

MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667
Project No.:	Y14103336-02.003	Date Tested:	Various
Client:	TMAC Resources Inc.	Tested By:	Various
Address:	Hope Bay, NU	Page:	1 of 2

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
205954	0.9-1.4 m	41.2	SILT, SAND, trace clay,trace gravel,brown with grey streaks,organics
205978	2.0-2.4 m	59.5	CLAY, silty, some sand. Brown.
205980	4.6-5.0 m	16.7	SAND, some gravel, some silt, trace clay.
205982	0.8-1.1 m	60.8	SAND, SILT, trace clay, brown.
205985	14.7-15.1 m	45.9	SILT, clayey, trace sand, greyish brown with grey streaks.
205987	23.2-23.6 m	34.3	CLAY, silty, sandy, brownish grey with grey streaks.
205988	2.3-6.5 m	41.7	CLAY, silty, trace sand, brownish grey with grey sreaks.
205992	21.1-24.8 m	23.0	CLAY, silty, some sand, some gravel, brown and grey.
205994	0.1-0.6 m	38.1	CLAY, silty, medium reddish brown with white inclusions, rootlets.
205999	6.7-7.1 m	25.1	SAND, silty, trace clay, greyish brown.
29515	0.4-0.7 m	22.7	SILT, sandy, trace clay, fine sand, brown/dark brown, rootlets.
29518	1.1-2.3 m	37.5	SILT, clayey, some sand, brown with dark grey streaks, organic.
29519	2.5-3.2 m	45.1	SILT, clayey, trace fine sand, brownish grey with black/grey streaks.
29523	0.2-0.6 m	91.9	CLAY, silty, some sand, dark brown to black, organic
29526	4.1-4.5 m	47.6	SILT, clayey, some sand, brown with dark grey streaks, organic.
29530	3.0-4.3 m	52.3	CLAY, sandy, silty, brown silt, dark grey with brown streaks.
29548	0.5-0.9 m	63.3	SAND, silty, trace clay, grey with light brown streaks, organic.
29549	3.7-4.1 m	33.5	CLAY, silty, trace sand, brown with dark grey,light brown inclusions.
29550	8.7-9.1 m	41.7	CLAY, silty, trace sand, grey with brown streaks, organic.
29570	0.7-2.2 m	30.6	SILT, SAND, trace clay, dark grey with brown and black inclusions.
29572	5.8-6.6 m	59.8	CLAY, silt, some sand, dark grey with brown streaks.
29578	0.2-0.6 m	108.8	SILT, some sand, peat, topsoil, organic, brown, dark brown olive incl.
29579	2.5-2.9 m	71.2	SILT, some sand-sandy, trace clay, brownish grey.
29606	0.1-0.5 m	27.6	CLAY, silty, fine sand, rootlets, brown with grey streaks and granules.
29609	17.0-18.0 m	44.5	CLAY, silty, trace sand, brown/dark grey with black inclusions.

Reviewed By: _____ P.Geol.

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TETRA TECH

MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6667
Project No.:	Y14103336-02.003	Date Tested:	Various
Client:	TMAC Resources Inc.	Tested By:	Various
Address:	Hope Bay, NU	Page:	2 of 2

B.H. Number	Sample Number	Moisture Content (%)	Visual Description of Soil
29610	21.5-22.8 m	33.3	SILT, sandy, some clay, trace gravel, dark grey mottled with brown.
29613	3.5-3.9 m	39.3	CLAY, silty, trace sand, brown, dark grey streaks, organics.
29616	0.9-1.5 m	55.9	SAND, silty, trace gravel, trace clay, fine sand, dark brown, organic.
29619	12.7-13.5 m	45.6	CLAY, silty, some sand, black with brown streaks, organic.
29624	1.1-2.5 m	274.4	SILT, sandy-some sand, peat, top soil, organic, brown.
29625	5.2-6.7 m	26.9	CLAY, silty, dark greyish brown.
29627	20.4-21.7 m	38.3	SILT, clayey, trace sand, brown with grey streaks, mottled black.
29628	26.3-27.2 m	10.1	GRAVEL and SAND, trace silt, trace clay. Brownish grey.
29629	31.0-32.2 m	7.2	GRAVEL and SAND, trace silt, trace clay. Brownish grey.
29631	0.3-0.9 m	42.1	SILT, sandy, some clay, brownish green-olive, dark grey inclusions
29634	13.5-14.2 m	13.3	SAND, silty, trace clay, trace gravel, brown with dark grey streaks, org
29636	1.1-2.3 m	53.8	SILT, sandy, some-trace clay, greyish brown.
29638	11.8-12.7 m	40.4	SILT, sandy, some clay, grey mottled with brown, organic
29641	24.1-24.8 m	31.5	CLAY, silty, sandy, organic, grey mottled with black.
29644	4.5-6.0 m	38.4	CLAY, silty, trace sand, dark grey mottled with brown.
29645	8.2-9.0 m	43.4	CLAY, silty, trace sand, brownish grey, dark grey streaks, organic.
29647	21.1-21.5 m	48.3	SILT, clayey, trace sand, grey with brown streaks, organics.
29649	26.4-27.0 m	41.8	CLAY, silty, some sand, brown with dark grey streaks, organic.

Reviewed By: _____ P.Geol.

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TETRA TECH

MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6875
Project No.:	Y14103336-02.003	Date Tested:	November 15, 2018
Client:	TMAC Resources Inc.	Tested By:	SS/TO
Address:	Hope Bay, NU	Page:	1 of 2

B.H. Number	Depth (m)	Moisture Content (%)	Visual Description of Soil
V-GTC-11	0 - 2	45.7	CLAY, gravelly, some silt, some sand, organics, greyish brown
V-GTC-11	2 - 4	47.2	CLAY, some silt, some sand, trace gravel, organics, greyish brown.
V-GTC-11	4 - 6	48.5	CLAY, some gravel, some sand, some silt, grey with brown streaks.
			brown.
V-GTC-11	6 - 10	26.1	SAND, clayey, gravelly, greyish brown.
V-GTC-08	0 - 2	69.6	CLAY, sandy, some silt, trace gravel, light brown.
V-GTC-08	2 - 4	40.8	CLAY, some silt, some sand, trace gravel, organics, rootlets,
			medium grey with brown streaks.
V-GTC-08	4 - 6	35.4	CLAY, some silt, some sand, trace gravel, light grey with light
			brown streaks.
V-GTC-08	6 - 10	47.4	CLAY, some silt, some sand, trace gravel, light brownish grey.
V-GTC-13	0 - 2	63.6	SAND, silty, trace clay, trace gravel, rootlets, light brown.
V-GTC-13	2 - 4	58.4	CLAY, some sand, some silt, trace gravel, light greyish brown.
V-GTC-13	4 - 6	54.4	CLAY, some sand, some silt, trace gravel, light greyish brown.
V-GTC-13	6 - 10	46.1	CLAY, some sand, some silt, trace gravel, light greyish brown.
V-GTC-13	10 - 13	22.9	SAND, clayey, some silt, some gravel.
V-TGC-10	0 - 2	57.8	CLAY, some silt, some sand, trace gravel, light greyish brown.
V-TGC-10	2 - 4	47.9	CLAY, some sand, some silt, organics, brownish grey.
V-TGC-10	4 - 6	45.5	CLAY, some silt, some sand, trace gravel, light brownish grey.

Reviewed By: _____ P.Geol.

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TETRA TECH

MOISTURE CONTENT TEST RESULTS

ASTM D2216

Project:	Hope Bay Overburden Soils Testing	Sample No.:	6875
Project No.:	Y14103336-02.003	Date Tested:	November 15, 2018
Client:	TMAC Resources Inc.	Tested By:	SS/TO
Address:	Hope Bay, NU	Page:	2 of 2

B.H. Number	Depth (m)	Moisture Content (%)	Visual Description of Soil
V-TGC-05	0 - 2	34.8	SAND, gravelly, some clay, some silt, greyish brown.
V-TGC-05	2 - 4	51.0	CLAY, silty, sandy, trace gravel, light brownish grey
V-TGC-05	4 - 6	35.0	CLAY, silty, sandy, trace gravel, light brownish grey
V-TGC-05	6 - 10	43.9	CLAY, silty, sandy, trace gravel, light brownish grey
V-GTC-04	0 - 2	11.1	SAND, some silt, trace clay, trace gravel, light greyish brown.
V-GTC-07	0 - 2	74.9	CLAY, sandy, some silt, brownish grey
V-GTC-07	2 - 4	42.4	CLAY, some silt, trace sand, trace gravel, organics, light greyish
			brown.
V-GTC-07	4 - 6	34.1	CLAY, some silt, trace sand, organics, light grey with light brown
			streaks.
V-GTC-07	6 - 10	55.8	CLAY, some silt, some sand, clay lumps, organics, light grey with
			light brown streaks.
V-GTC-07	10 - 15	63.0	CLAY, some silt, some sand, grey with brown streaks.
V-GTC-02	NR	12.5	SAND, some silt, trace clay, light greyish brown.

Reviewed By: _____ P.Geol.

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TETRA TECH

Appendix L.5 – Salinity and Methylene Blue Indices

TETRA TECH

TECHNICAL MEMO

ISSUED FOR USE

To:	Kelly Schwenning – TMAC Resources Inc.	**Date:**	December 4, 2018
c:	Barb Fortin, P.Geo.	**Memo No.:**	01
From:	Edahlia McNeil, P.Chem. Bozena Czarnecki, Ph.D., P.Eng.	**File:**	Y14103336-02.003
Subject:	Methylene Blue Index of Clay		

Pursuant to your request, Tetra Tech Canada Inc. (Tetra Tech) has completed testing soil samples for methylene blue index. The soil samples from Hope Bay, NU were received by Tetra Tech in Calgary laboratory on November 22, 2018. The testing was performed in accordance with American Society for Testing and Materials (ASTM) C837, the standard test method for methylene blue index of clay.

The results are summarized in Table 1 below.

Table 1: Methylene Blue Index Test Results

Borehole Number	Sample Number	Sample Date	Depth (m)	Methylene Blue Index
V-GTC-05	29442	2018-07-13	2.0-4.0	3.1
V-GTC-07	205904	2018-07-14	6.0-10.0	2.9

This technical memo and its contents are intended for the sole use of TMAC Resources Inc. and their agents. Tetra Tech Canada Inc. does not accept any responsibility for the accuracy of any of the data, the analysis, or the recommendations contained or referenced in the technical memo when the technical memo is used or relied upon by any party other than of TMAC Resources Inc. or for any project other than the proposed development at the subject site. Any such unauthorized use of this technical memo is at the sole risk of the user. Use of this technical memo is subject to the terms and conditions stated in Tetra Tech Canada Inc.'s Services Agreement. Tetra Tech Canada Inc. Limitations on the Use of this Document are enclosed with this technical memo.

Tetra Tech Canada Inc.
Suite 700 - 326 11th Avenue SW
Calgary, AB T2R 0C5
Tel 403.930.7700

We trust this technical memo meets your present requirements. If you have any questions or comments, please contact the undersigned.

Respectfully submitted,
Tetra Tech Canada Inc.

Prepared by:
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Construction Services, Engineering Practice
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/kla

Enclosure (1): Tetra Tech's Limitations on the Use of This Document

LIMITATIONS ON USE OF THIS DOCUMENT

CONSTRUCTION MATERIALS ENGINEERING AND TESTING

1.1 USE OF DOCUMENT AND OWNERSHIP

This document pertains to a specific site, a specific development, and a specific scope of work. The document may include plans, drawings, profiles and other supporting documents that collectively constitute the document (the "Professional Document").

The Professional Document is intended for the sole use of TETRA TECH's Client (the "Client") as specifically identified in the TETRA TECH Services Agreement or other Contractual Agreement entered into with the Client (either of which is termed the "Contract" herein). TETRA TECH does not accept any responsibility for the accuracy of any of the data, analyses, recommendations or other contents of the Professional Document when it is used or relied upon by any party other than the Client, unless authorized in writing by TETRA TECH.

Any unauthorized use of the Professional Document is at the sole risk of the user. TETRA TECH accepts no responsibility whatsoever for any loss or damage where such loss or damage is alleged to be or, is in fact, caused by the unauthorized use of the Professional Document.

Where TETRA TECH has expressly authorized the use of the Professional Document by a third party (an "Authorized Party"), consideration for such authorization is the Authorized Party's acceptance of these Limitations on Use of this Document as well as any limitations on liability contained in the Contract with the Client (all of which is collectively termed the "Limitations on Liability"). The Authorized Party should carefully review both these Limitations on Use of this Document and the Contract prior to making any use of the Professional Document. Any use made of the Professional Document by an Authorized Party constitutes the Authorized Party's express acceptance of, and agreement to, the Limitations on Liability.

The Professional Document and any other form or type of data or documents generated by TETRA TECH during the performance of the work are TETRA TECH's professional work product and shall remain the copyright property of TETRA TECH.

The Professional Document is subject to copyright and shall not be reproduced either wholly or in part without the prior, written permission of TETRA TECH. Additional copies of the Document, if required, may be obtained upon request.

1.2 ALTERNATIVE DOCUMENT FORMAT

Where TETRA TECH submits electronic file and/or hard copy versions of the Professional Document or any drawings or other project-related documents and deliverables (collectively termed TETRA TECH's "Instruments of Professional Service"), only the signed and/or sealed versions shall be considered final. The original signed and/or sealed electronic file and/or hard copy version archived by TETRA TECH shall be deemed to be the original. TETRA TECH will archive a protected digital copy of the original signed and/or sealed version for a period of 10 years.

Both electronic file and/or hard copy versions of TETRA TECH's Instruments of Professional Service shall not, under any circumstances, be altered by any party except TETRA TECH. TETRA TECH's Instruments of Professional Service will be used only and exactly as submitted by TETRA TECH.

Electronic files submitted by TETRA TECH have been prepared and submitted using specific software and hardware systems. TETRA TECH makes no representation about the compatibility of these files with the Client's current or future software and hardware systems.

1.3 STANDARD OF CARE

Services performed by TETRA TECH for the Professional Document have been conducted in accordance with the Contract, in a manner consistent with the level of skill ordinarily exercised by members of the profession currently practicing under similar conditions in the jurisdiction in which the services are provided. Professional judgment has been applied in developing the conclusions and/or recommendations provided in this Professional Document. No warranty or guarantee, express or implied, is made concerning the test results, comments, recommendations, or any other portion of the Professional Document.

If any error or omission is detected by the Client or an Authorized Party, the error or omission must be immediately brought to the attention of TETRA TECH.

1.4 DISCLOSURE OF INFORMATION BY CLIENT

The Client acknowledges that it has fully cooperated with TETRA TECH with respect to the provision of all available information on the past, present, and proposed conditions on the site, including historical information respecting the use of the site. The Client further acknowledges that in order for TETRA TECH to properly provide the services contracted for in the Contract, TETRA TECH has relied upon the Client with respect to both the full disclosure and accuracy of any such information.

1.5 INFORMATION PROVIDED TO TETRA TECH BY OTHERS

During the performance of the work and the preparation of this Professional Document, TETRA TECH may have relied on information provided by persons other than the Client.

While TETRA TECH endeavours to verify the accuracy of such information, TETRA TECH accepts no responsibility for the accuracy or the reliability of such information even where inaccurate or unreliable information impacts any recommendations, design or other deliverables and causes the Client or an Authorized Party loss or damage.

1.6 GENERAL LIMITATIONS OF DOCUMENT

This Professional Document is based solely on the conditions presented and the data available to TETRA TECH at the time the data were collected in the field or gathered from available databases.

The Client, and any Authorized Party, acknowledges that the Professional Document is based on limited data and that the conclusions, opinions, and recommendations contained in the Professional Document are the result of the application of professional judgment to such limited data.

The Professional Document is not applicable to any other sites, nor should it be relied upon for types of development other than those to which it refers. Any variation from the site conditions present, or variation in assumed conditions which might form the basis of design or recommendations as outlined in this report, at or on the development proposed as of the date of the Professional Document requires a supplementary investigation and assessment.

TETRA TECH is neither qualified to, nor is it making, any recommendations with respect to the purchase, sale, investment or development of the property, the decisions on which are the sole responsibility of the Client.

1.7 ENVIRONMENTAL AND REGULATORY ISSUES

Unless stipulated in the report, TETRA TECH has not been retained to investigate, address or consider and has not investigated, addressed or considered any environmental, regulatory, or sediment and erosion issues associated with construction on the subject site.

1.8 VARIATION OF MATERIAL CHARACTERISTICS AND CONDITIONS

Observations and standardized sampling, inspection and testing procedures employed by TETRA TECH will indicate conditions of materials and construction activities only at the precise location and time where and when Services were performed. The Client recognizes that conditions of materials and construction activities at other locations may vary from those measured or observed, and that conditions at one location and time do not necessarily indicate the conditions of apparently identical material(s) at other locations and/or times.

Services of TETRA TECH, even if performed on a continuous basis, should not be interpreted to mean that TETRA TECH is observing, verifying, testing or inspecting all materials on the Project. TETRA TECH is responsible only for those data, interpretations, and recommendations regarding the actual materials and construction activities observed, sampled, inspected or tested, and is not responsible for other parties' interpretations or use of the information developed. TETRA TECH may make certain inferences based upon the information derived from these procedures to formulate professional opinions regarding conditions in other areas.

1.9 SAMPLING, OBSERVATION & TEST LOCATIONS

Unless specifically stated otherwise, the Scope of Services does not include surveying the Site or precisely identifying sampling, observation or test locations, depths or elevations. Sampling, observation and test locations, depths and elevations will be based on field estimates and information furnished by the Client and its representatives. Unless stated otherwise in the report, such locations, depths and elevations provided are approximate.

1.10 CONTRACTOR'S PERFORMANCE

TETRA TECH is not responsible for Contractor's means, methods, techniques or sequences during the performance of its Work. TETRA TECH will not supervise or direct Contractor's Work, nor be liable for any failure of Contractor to complete its Work in accordance with the Project's plans, specifications and applicable codes, laws and regulations. The Client understands and agrees that Contractor, not TETRA TECH, has sole responsibility for the safety of persons and property at the Project Site.

1.11 NOTIFICATION AND LEVEL OF SERVICE

Unless the Client requests or the building code requires full-time services, the Client understands that services provided by TETRA TECH are on an "On-Call" basis. The Client shall assume responsibility for adequate notification and scheduling of TETRA TECH services. TETRA TECH will make every reasonable effort to meet the Client's schedule, but will not guarantee service availability without direct confirmation from with the Client or their agent.

1.12 CERTIFICATIONS

The Client will not require TETRA TECH to execute any certification regarding Services performed or the Work tested or observed unless: 1) TETRA TECH believes that it has performed sufficient Services to provide a sufficient basis to issue the certification; 2) TETRA TECH believes that the Services performed and Work tested or observed meet the criteria of the certification; and 3) TETRA TECH has reviewed and approved in writing the exact form of such certification prior to execution of the Service Agreement. Any certification by TETRA TECH is limited to the expression of a professional opinion based upon the Services performed by TETRA TECH, and does not constitute a warranty or guarantee, either express or implied.

1.13 WEATHER AND PROTECTION OF MATERIALS

Performance of the Services by TETRA TECH and/or its designated subcontractor may be delayed or excused when such performance is commercially impossible or impracticable as a result of weather events, strikes, shortages or other causes beyond their reasonable control which may also impact cost estimates.

Excavation and construction operations expose materials to climatic elements (freeze/thaw, wet/dry) and/or mechanical disturbance which can cause severe deterioration. Unless otherwise specifically indicated in this report, the walls and floors of excavations, and stockpiles, must be protected from the elements, particularly moisture, desiccation, frost action and construction activities.

1.14 CALCULATIONS AND DESIGN

Where TETRA TECH has undertaken design calculations and has prepared project specific designs in accordance with terms of reference that were previously set out in consultation with, and agreement of, TETRA TECH's client. These designs have been prepared to a standard that is consistent with industry practice. Notwithstanding, if any error or omission is detected by TETRA TECH's Client or any party that is authorized to use the Design Report, the error or omission should be immediately drawn to the attention of TETRA TECH.

1.15 INFLUENCE OF CONSTRUCTION ACTIVITY

There is a direct correlation between construction activity and structural performance of adjacent buildings and other installations. The influence of all anticipated construction activities should be considered by the contractor, owner, architect and prime engineer in consultation with a geotechnical engineer when the final design and construction techniques are known.

1.16 SAMPLES

The Client will provide samples for testing (at the Client's expense). TETRA TECH will retain unused portions of samples only until such time as internal review is accomplished for intended purpose. Further storage or transfer of samples can be made at the Client's expense upon written request, otherwise samples will be discarded. The duration of sample retention must be discussed in advance.

1.17 GEOTECHNICAL CONDITIONS

A Geotechnical Report is commonly the basis upon which the specific project design or testing has been completed. It is incumbent upon TETRA TECH's Client, and any other authorized party, to be knowledgeable of the level of risk that has been incorporated into the project design, in consideration of the level of the geotechnical information that was reasonably acquired to facilitate completion of the design.

If a Geotechnical Report was prepared for the project by TETRA TECH or others, it will be referenced in the Construction Materials or Materials Design Report. The Geotechnical Report contains General Conditions that should be read in conjunction with these General Conditions for this Report.

Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	
Client:	TMAC Resources	**Sampled By:**	
		Date Tested:	February 9, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
S1 (2127.1)	SRK18-SD-DHP1, P1.04	1.5-2.0	SILT, trace clay, sand, gravel, grey	142.7	0.8
S2 (2127.2)	SRK18-SD-DHP10, P10.08	3.5-4.0	CLAY, silty, sandy, trace gravel, grey	39.7	3.1
S3 (2127.3)	SRK18-SD-DHP16, P16.08	3.5-4.0	SILT, some clay, trace sand, grey	121.2	1.0
S4 (2127.4)	SRK18-SD-DHP18, P18.07	3.0-3.5	SILT, trace clay, sand, grey	121.8	1.2
S5 (2127.5)	SRK18-SD-DHP18, P18.13	8.0-9.0	SILT, some clay, sand, grey	75.3	3.6
S6 (2127.6)	SRK18-SD-DHP22, P22.04	1.5-2.0	CLAY, silty, trace sand, grey	54.9	3.5
S7 (2127.7)	SRK18-SD-DHP31, P31.07	3.0-3.5	CLAY, silty, sandy, grey	60.8	4.0
S8 (2127.8)	SRK18-SD-DHP33, P33.05	2.0-2.5	CLAY, silty, sandy, grey	63.4	4.0

Remarks: **South Dam Project (SRK Project # 1CT022.031)**

Reviewed By: _____ P.Eng.

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TETRA TECH

Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	
Client:	TMAC Resources	**Sampled By:**	
		Date Tested:	February 9-10, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
S9 (2127.9)	SRK18-SD-DHP34, P34.05	2.0-2.5	SAND & GRAVEL, some silt, greyish brown	7.6	5.6
S10 (2127.10)	SRK18-SD-DHP39, P39.04	1.5-2.0	SAND & GRAVEL, some silt, greyish brown	11.3	3.6
S11 (2127.11)	SRK18-SD-DHP7, P7.05	2.0-2.5	CLAY, silty, some sand, trace gravel, greyish brown	57.0	4.4
S12 (2127.12)	SRK18-SD-DHP12, P12.04	1.5-2.0	CLAY, silty, trace sand, grey	54.2	2.4
S13 (2127.13)	SRK18-SD-DHP12, P12.09	4.0-5.0	CLAY, silty, trace sand, grey	34.5	6.8
S14 (2127.14)	SRK18-SD-DHP24, P24.10	5.0-6.0	CLAY, silty, trace sand, grey	60.5	5.4
S15 (2127.15)	SRK18-SD-DHP25, P25.07	3.0-3.5	CLAY, silty, trace sand, grey	46.7	7.7
S16 (2127.16)	SRK18-SD-DHP28, P28.09	4.0-5.0	CLAY, silty, trace sand, grey	53.0	6.9

Remarks: **South Dam Project (SRK Project # 1CT022.031)**

Reviewed By: JDR P.Eng.

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TETRA TECH

Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	
Client:	TMAC Resources	**Sampled By:**	
		Date Tested:	February 10, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
S17 (2127.17)	SRK18-SD-DHP31, P31.11	6.0-7.0	CLAY, silty, trace sand, gravel, grey	50.1	7.8
S18 (2127.18)	SRK18-SD-DHP32, P32.04	1.5-2.0	CLAY, silty, trace sand, grey	92.3	4.0
S19 (2127.19)	SRK18-SD-DHP33, P33.10	5.0-6.0	CLAY, silty, trace sand, grey	52.4	6.7
S20 (2127.20)	SRK18-SD-DHP14, P14.11	6.0-7.0	CLAY, silty, trace sand, grey	33.5	11.7
S21 (2127.21)	SRK18-SD-DHP22, P22.08	3.5-4.0	CLAY, silty, trace sand, grey	55.2	6.0
S22 (2127.22)	SRK18-SD-DHP22, P22.09	4.0-5.0	CLAY, silty, trace sand, grey	63.3	6.2
S23 (2127.23)	SRK18-SD-DHP24, P24.07	3.0-3.5	CLAY, silty, trace sand, gravel, grey	50.1	6.6
S24 (2127.24)	SRK18-SD-DHP24, P24.13	8.0-9.0	CLAY, silty, trace sand, gravel, grey	35.2	7.3

Remarks: **South Dam Project (SRK Project # 1CT022.031)**

Reviewed By: JDR P.Eng.

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Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	
Client:	TMAC Resources	**Sampled By:**	
		Date Tested:	February 10, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
S25 (2127.25)	SRK18-SD-DHP27, P27.08	3.5-4.0	CLAY, silty, trace sand, gravel, grey	56.2	6.3
S26 (2127.26)	SRK18-SD-DHP28, P28.03	1.0-1.5	SILT, some clay, trace sand, greyish brown	94.3	4.0
S27 (2127.27)	SRK18-SD-DHP28, P28.12	7.0-8.0	CLAY, silty, trace sand, gravel, grey	48.3	7.6
S28 (2127.28)	SRK18-SD-DHP31, P31.08	3.5-4.0	CLAY, silty, some sand, grey	54.0	7.0
S29 (2127.29)	SRK18-SD-DHP39, P39.06	2.5-3.0	SAND & GRAVEL, some silt, greyish brown	12.5	4.2
S30 (2127.30)	SRK18-SD-DHP12, P12.07	3.0-3.5	CLAY, silty, trace sand, dark greyish brown	33.1	9.8
S31 (2127.31)	SRK18-SD-DHP14, P14.09	4.0-5.0	CLAY, silty, trace sand, grey	34.6	11.1
S32 (2127.32)	SRK18-SD-DHP16, P16.09	4.0-5.0	SILT, trace clay, sand, grey	97.8	5.1

Remarks: **South Dam Project (SRK Project # 1CT022.031)**

Reviewed By: JDR P.Eng.

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Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	
Client:	TMAC Resources	**Sampled By:**	
		Date Tested:	February 10, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
S33 (2127.33)	SRK18-SD-DHP26, P26.11	6.0-7.0	CLAY, silty, trace sand, grey	52.5	8.5
S34 (2127.34)	SRK18-SD-DHP22, P22.11	6.0-7.0	CLAY, silty, trace sand, grey	53.6	8.2
S35 (2127.35)	SRK18-SD-DHP26, P26.07	3.0-3.5	CLAY, silty, trace sand, greyish brown	73.9	6.4
S36 (2127.36)	SRK18-SD-DHP30, P30.07	3.0-3.5	CLAY, silty, trace sand, grey	52.0	3.2
S37 (2127.37)	SRK18-SD-DHP32, P32.07	3.0-3.5	CLAY, silty, trace sand, grey	51.7	4.0
S38 (2127.38)	SRK18-SD-DHP32, P32.09	4.0-5.0	CLAY, silty, trace sand, gravel, grey	50.3	4.4
S39 (2127.39)	SRK18-SD-DHP33, P33.12	7.0-8.0	SAND & GRAVEL, some silt, greyish brown	13.1	1.4
S40 (2127.40)	SRK18-SD-DHP2, P2.05	2.0-2.5	SILT, some sand, trace clay, gravel, greyish brown	55.2	0.8

Remarks: **South Dam Project (SRK Project # 1CT022.031)**

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Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	
Client:	TMAC Resources	**Sampled By:**	
		Date Tested:	February 10, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
S41 (2127.41)	SRK18-SD-DHP14, P14.06	2.5-3.0	CLAY, silty, trace sand, grey	66.2	0.8
S42 (2127.42)	SRK18-SD-DHP15, P15.12	7.0-8.0	CLAY, silty, trace sand, laminated, grey	34.5	4.8
S43 (2127.43)	SRK18-SD-DHP16, P16.07	3.0-3.5	SILT, trace sand, clay, grey	106.0	0.4
S44 (2127.44)	SRK18-SD-DHP17, P17.05	2.0-2.5	CLAY, silty, some sand, trace gravel, grey	44.2	0.6
S45 (2127.45)	SRK18-SD-DHP17, P17.08	3.5-4.0	CLAY, silty, trace sand, grey	55.7	3.4
S46 (2127.46)	SRK18-SD-DHP25, P25.09	4.0-5.0	CLAY, silty, trace sand, grey	45.2	4.2
S47 (2127.47)	SRK18-SD-DHP30, P30.09	4.0-5.0	CLAY, silty, trace sand, grey	51.6	3.6
S48 (2127.48)	SRK18-SD-DHP31, P31.09	4.0-5.0	CLAY, silty, trace sand, grey	53.1	2.7

Remarks: **South Dam Project (SRK Project # 1CT022.031)**

Reviewed By: JDR P.Eng.

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Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	
Client:	MAC Resources	**Sampled By:**	
		Date Tested:	February 10, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
S49 (2127.49)	SRK18-SD-DHP11, P11.08	3.5-4.0	CLAY, silty, trace sand, grey	38.9	2.9
S50 (2127.50)	SRK18-SD-DHP13, P13.07	3.0-3.5	SILT, trace clay, sand, gravel, grey	73.1	0.5
S51 (2127.51)	SRK18-SD-DHP13, P13.09	4.0-5.0	CLAY, silty, trace sand, grey	51.7	3.3
S52 (2127.52)	SRK18-SD-DHP18, P18.09	4.0-5.0	CLAY, silty, trace sand, gravel, greyish brown	83.6	1.6
S53 (2127.53)	SRK18-SD-DHP24, P24.09	4.0-5.0	SILT, some clay, trace sand, grey	53.0	3.0
S54 (2127.54)	SRK18-SD-DHP28, P28.07	3.0-3.5	CLAY, silty, trace sand, grey	64.8	2.3
S55 (2127.55)	SRK18-SD-DHP37, P37.04	1.5-2.0	SAND & GRAVEL, some silt, greyish brown	13.7	0.3

Remarks: **South Dam Project (SRK Project # 1CT022.031)**

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Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	February 24, 2018
Client:	TMAC Resources Inc.	**Sampled By:**	
		Date Tested:	March 16, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
29501 (2165.1)	SRK18-WST-DH-01	0.6-1.1	CLAY, silty, trace sand, grey	68.0	0.3
29502 (2165.2)	SRK18-WST-DH-01	1.1-1.5	CLAY, silty, trace sand, grey	65.1	0.6
29503 (2165.3)	SRK18-WST-DH-01	1.5-2.2	SILT, some sand, water	114.1	1.0
29504 (2165.4)	SRK18-WST-DH-01	2.2-2.7	CLAY, silty, trace sand, grey	42.0	4.4
29505 (2165.5)	SRK18-WST-DH-01	2.7-3.2	CLAY, silty, trace sand, grey	45.8	3.3
29506 (2165.6)	SRK18-WST-DH-01	3.2-3.7	CLAY, silty, trace sand, grey	50.5	4.0
29507 (2165.7)	SRK18-WST-DH-01	3.7-4.3	CLAY, silty, trace sand, grey	45.9	4.0
29508 (2165.8)	SRK18-WST-DH-01	4.3-4.9	CLAY, silty, trace sand, grey	42.7	3.3

Remarks: **Hope Bay South Dam Project - Overburden Soils Testing**

Reviewed By: IDR P.Eng.

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TETRA TECH

Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	February 24, 2018
Client:	TMAC Resources Inc.	**Sampled By:**	
		Date Tested:	March 16, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
29509 (2165.9)	SRK18-WST-DH-01	4.9-5.2	CLAY, silty, trace sand, grey	56.0	3.1
29510 (2165.10)	SRK18-WST-DH-01	5.2-6.3	CLAY, silty, trace sand, grey	44.4	4.2
29511 (2165.11)	SRK18-WST-DH-01	6.3-6.7	CLAY, silty, trace sand, grey	39.8	5.4
29512 (2165.12)	SRK18-WST-DH-01	6.7-7.1	SAND, silty, greyish brown	19.1	1.4
29534 (2165.13)	SRK18-MNPCP-DH-02	0.2-0.6	CLAY, silty, brown	94.4	0.2
29535 (2165.14)	SRK18-MNPCP-DH-02	0.6-1.3	WATER, trace sand	10915.0	0.2
29536 (2165.15)	SRK18-MNPCP-DH-02	1.3-1.8	CLAY, silty, trace sand, gravel, brown	54.0	0.3
29537 (2165.16)	SRK18-MNPCP-DH-02	1.8-2.3	CLAY, silty, trace sand, greyish brown	70.6	0.8

Remarks: **Hope Bay South Dam Project - Overburden Soils Testing**

Reviewed By: JDR P.Eng.

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Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	February 24, 2018
Client:	TMAC Resources Inc.	**Sampled By:**	
		Date Tested:	March 17, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
29538 (2165.17)	SRK18-MNPCP-DH-02	2.3-2.8	CLAY, silty, trace sand, greyish brown	50.8	1.4
29539 (2165.18)	SRK18-MNPCP-DH-02	2.8-3.6	CLAY, silty, trace sand, grey	66.3	2.2
29540 (2165.19)	SRK18-MNPCP-DH-02	3.6-4.0	CLAY, silty, trace sand, gravel, greyish brown	45.9	2.9
29541 (2165.20)	SRK18-MNPCP-DH-02	4.3-4.8	CLAY, silty, trace sand, gravel, greyish brown	44.0	2.0
29542 (2165.21)	SRK18-MNPCP-DH-02	4.8-5.8	CLAY, silty, some sand, gravel, greyish brown	20.8	2.0
29543 (2165.22)	SRK18-MNPCP-DH-02	5.8-6.6	GRAVEL, sandy, some silt, grey	16.1	0.4
29552 (2165.23)	SRK18-STH-DH-03	0.2-0.7	CLAY, silty, trace sand, greyish brown	60.5	0.0
29553 (2165.24)	SRK18-STH-DH-03	0.7-1.2	CLAY, silty, trace sand, grey	50.9	0.2

Remarks: **Hope Bay South Dam Project - Overburden Soils Testing**

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Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	February 24, 2018
Client:	TMAC Resources Inc.	**Sampled By:**	
		Date Tested:	March 16, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
29554 (2165.25)	SRK18-STH-DH-03	1.2-1.7	CLAY, silty, trace sand, greyish blue	50.9	0.3
29555 (2165.26)	SRK18-STH-DH-03	1.7-2.2	CLAY, silty, trace sand, greyish blue	36.8	1.2
29556 (2165.27)	SRK18-STH-DH-03	2.2-2.7	CLAY, silty, trace sand, gravel, grey	36.7	3.8
29557 (2165.28)	SRK18-STH-DH-03	2.7-3.2	CLAY, silty, trace sand, grey	50.1	4.3
29558 (2165.29)	SRK18-STH-DH-03	3.2-3.6	CLAY, silty, trace sand, grey	71.2	3.4
29559 (2165.30)	SRK18-STH-DH-03	3.6-4.0	CLAY, silty, trace sand, grey	64.3	3.4
29560 (2165.31)	SRK18-STH-DH-03	4.0-5.1	CLAY, silty, trace sand, grey	62.4	3.2
29561 (2165.32)	SRK18-STH-DH-03	5.1-5.8	CLAY, silty, trace sand, grey	54.8	4.2

Remarks: **Hope Bay South Dam Project - Overburden Soils Testing**

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Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	February 24, 2018
Client:	TMAC Resources Inc.	**Sampled By:**	
		Date Tested:	March 16, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
29562 (2165.33)	SRK18-STH-DH-03	5.8-6.6	CLAY, silty, trace sand, grey	54.9	4.4
29563 (2165.34)	SRK18-STH-DH-03	6.6-7.1	CLAY, silty, trace sand, grey	76.1	3.8
29564 (2165.35)	SRK18-STH-DH-03	7.1-8.1	CLAY, silty, trace sand, grey	50.1	4.5
29565 (2165.36)	SRK18-STH-DH-03	8.1-8.8	CLAY, silty, trace sand, grey	34.7	4.0
29566 (2165.37)	SRK18-STH-DH-03	9.1-10.5	SAND, silty, trace gravel, grey	12.7	8.5
29567 (2165.38)	SRK18-STH-DH-03	10.5-11.2	SAND & GRAVEL, silty, greyish brown	9.7	4.2
29568 (2165.39)	SRK18-STH-DH-03	11.7-13.5	SAND, silty, trace gravel, greyish brown	10.0	4.6
29580 (2165.40)	SRK18-STH-DH-01	0.1-0.4	CLAY, silty, trace sand, grey & brown	31.0	0.0

Remarks: **Hope Bay South Dam Project - Overburden Soils Testing**

Reviewed By: IPR P.Eng.

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ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	February 24, 2018
Client:	TMAC Resources Inc.	**Sampled By:**	
		Date Tested:	March 16, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
29581 (2165.41)	SRK18-STH-DH-01	0.5-1.0	CLAY, silty, trace sand, brown & grey	21.3	0.0
29582 (2165.42)	SRK18-STH-DH-01	1.0-1.5	CLAY, silty, trace sand, grey	82.0	0.0
29583 (2165.43)	SRK18-STH-DH-01	1.5-2.0	CLAY, silty, trace sand, grey	75.5	0.0
29584 (2165.44)	SRK18-STH-DH-01	2.0-2.5	CLAY, silty, trace sand, grey	35.3	0.0
29585 (2165.45)	SRK18-STH-DH-01	2.5-3.0	CLAY, silty, trace sand, grey	68.0	0.6
29586 (2165.46)	SRK18-STH-DH-01	3.0-3.5	CLAY, silty, trace sand, grey	39.0	1.7
29587 (2165.47)	SRK18-STH-DH-01	3.5-4.0	CLAY, silty, trace sand, grey	44.6	3.7
29588 (2165.48)	SRK18-STH-DH-01	4.0-5.0	CLAY, silty, trace sand, grey	50.8	3.2

Remarks: **Hope Bay South Dam Project - Overburden Soils Testing**

Reviewed By: JDR P.Eng.

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TETRA TECH

Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	February 24, 2018
Client:	TMAC Resources Inc.	**Sampled By:**	
		Date Tested:	March 16, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
29589 (2165.49)	SRK18-STH-DH-01	5.0-5.9	CLAY, silty, trace sand, grey	46.3	3.6
29590 (2165.50)	SRK18-STH-DH-01	6.5-8.0	CLAY, silty, trace sand, grey	47.5	4.0
29591 (2165.51)	SRK18-STH-DH-01	8.0-9.0	CLAY, silty, trace sand, grey	47.3	3.6
29592 (2165.52)	SRK18-STH-DH-01	9.5-10.0	CLAY, silty, trace sand, grey	53.9	3.3
29593 (2165.53)	SRK18-STH-DH-01	10.4-11.0	CLAY, silty, trace sand, greyish brown	45.8	4.1
29594 (2165.54)	SRK18-STH-DH-01	11.0-12.0	CLAY, silty, trace sand, grey	59.4	4.1
29595 (2165.55)	SRK18-STH-DH-01	12.0-14.0	CLAY, silty, trace sand, grey	54.1	3.1
29596 (2165.56)	SRK18-STH-DH-01	14.0-15.5	CLAY, silty, trace sand, grey	58.0	3.9

Remarks: **Hope Bay South Dam Project - Overburden Soils Testing**

Reviewed By: JPR P.Eng.

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TETRA TECH

Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	February 24, 2018
Client:	TMAC Resources Inc.	**Sampled By:**	
		Date Tested:	March 16, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
29597 (2165.57)	SRK18-STH-DH-01	15.5-17.0	CLAY, silty, trace sand, grey	59.1	3.4
29598 (2165.58)	SRK18-STH-DH-01	17.0-18.0	CLAY, silty, trace sand, grey	51.5	3.5
29599 (2165.59)	SRK18-STH-DH-01	18.0-19.2	CLAY, silty, trace sand, grey	52.3	3.3
29600 (2165.60)	SRK18-STH-DH-01	19.7-21.5	CLAY, silty, trace sand, grey	40.1	5.6
205955 (2165.61)	SRK18-STH-DH-04	0.5-0.7	CLAY, silty, trace sand, brown	16.6	0.3
205956 (2165.62)	SRK18-STH-DH-04	1.4-1.6	SILT, trace clay, sand, grey	49.6	0.3
205957 (2165.63)	SRK18-STH-DH-04	2.1-2.3	SILT, trace sand, grey	23.9	0.9
205958 (2165.64)	SRK18-STH-DH-04	2.6-2.8	SILT, trace clay, sand, grey	32.1	3.8

Remarks: **Hope Bay South Dam Project - Overburden Soils Testing**

Reviewed By: JPR P.Eng.

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Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	February 24, 2018
Client:	TMAC Resources Inc.	**Sampled By:**	
		Date Tested:	March 16, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
205959 (2165.65)	SRK18-STH-DH-04	3.1-3.3	SILT, trace sand, grey	32.6	3.5
205960 (2165.66)	SRK18-STH-DH-04	3.6-3.8	CLAY, silty, trace sand, grey	38.0	3.3
205961 (2165.67)	SRK18-STH-DH-04	4.1-4.3	CLAY, silty, trace sand, gravel, grey	68.2	2.7
205962 (2165.68)	SRK18-STH-DH-04	5.1-5.3	CLAY, silty, trace sand, grey	84.1	2.4
205963 (2165.69)	SRK18-STH-DH-04	6.1-6.3	SILT, some clay, trace gravel, grey	64.1	4.4
205964 (2165.70)	SRK18-STH-DH-04	7.4-7.6	CLAY, silty, trace sand, grey	54.8	4.2
205965 (2165.71)	SRK18-STH-DH-04	8.4-8.6	SAND, silty, trace clay, gravel, grey	18.0	3.6
205966 (2165.72)	SRK18-STH-DH-04	9.9-10.1	SILT, sandy, trace gravel, grey	20.6	2.3

Remarks: **Hope Bay South Dam Project - Overburden Soils Testing**

Reviewed By: JDR P.Eng.

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Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	February 24, 2018
Client:	TMAC Resources Inc.	**Sampled By:**	
		Date Tested:	March 16, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
205970 (2165.73)	SRK18-WST-DH-03	0.3-0.9	SILT, some sand, water	107.9	0.0
205971 (2165.74)	SRK18-WST-DH-03	1.1-1.4	WATER, trace sand	4964.9	0.0
205972 (2165.75)	SRK18-WST-DH-03	1.7-2.0	WATER, some sand	154.3	0.6
205973 (2165.76)	SRK18-WST-DH-03	2.4-2.7	CLAY, silty, trace sand, grey	52.5	4.1
205974 (2165.77)	SRK18-WST-DH-03	2.9-3.1	CLAY, silty, trace sand, grey	46.3	3.5
205975 (2165.78)	SRK18-WST-DH-03	3.5-3.7	CLAY, silty, trace sand, gravel, grey	52.6	4.6
205976 (2165.79)	SRK18-WST-DH-03	4.0-4.2	CLAY, silty, trace sand, grey	41.3	4.0
205977 (2165.80)	SRK18-WST-DH-03	5.0-5.2	SAND & GRAVEL, silty, trace clay, grey	6.4	2.4

Remarks: **Hope Bay South Dam Project - Overburden Soils Testing**

Reviewed By: JDR P.Eng.

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Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Soil Sample Testing	**Sample No.:**	See below
Project No:	Y14103336-02.003	**Date Sampled:**	February 24, 2018
Client:	TMAC Resources Inc.	**Sampled By:**	
		Date Tested:	March 16, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Location	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
205993 (2165.81)	SRK18-RD-DH-15	21.2-23.3	CLAY, silty, some sand, trace gravel, grey	37.7	2.0
206000 (2165.82)	SRK18-WST-DH-01	0.1-0.6	CLAY, silty, trace sand, brown & grey	57.4	0.0
29601 (2165.83)	SRK18-STH-DH-01	21.5-23.0	CLAY, silty, some sand, grey	37.9	5.7
29602 (2165.84)	SRK18-STH-DH-01	23.0-25.2	SAND, silty, some gravel, grey	9.2	4.3
29603 (2165.85)	SRK18-STH-DH-01	25.2-27.2	SAND & GRAVEL, silty, trace clay, grey	10.4	5.1
29604 (2165.86)	SRK18-STH-DH-01	27.2-28.7	SILT, sandy, trace gravel, clay, grey	16.2	7.6
29605 (2165.87)	SRK18-STH-DH-01	28.7-29.9	SILT, sandy, some gravel, grey	6.3	4.0

Remarks: **Hope Bay South Dam Project - Overburden Soils Testing**

Reviewed By: JDR P.Eng.

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Determination of the Soluble Salt Content of Soils by Refractometer

ASTM D4542

Project:	Hope Bay Overburden Soils Testing	**Sample No.:**	6875
Project No:	Y14103336-02.003	**Date Sampled:**	July 13-14, 2018
Client:	TMAC Resources Inc.	**Sampled By:**	
		Date Tested:	November 22, 2018
Attention:	Kelly Schwenning	**Tested By:**	LL
Email:	Kelly.schwenning@tmacresources.com	**Office:**	Edmonton

Sample No.	Borehole Number	Depth (m)	Soil Type	Moisture Content (%)	Salinity (ppt)
29423	V-GTC-11	2.0-4.0	CLAY, some silt, some sand, trace gravel, organics, grey		2.4
29428	V-GTC-08	2.0-4.0	CLAY, some silt, some sand, trace gravel, organics, grey		2.1
29432	V-GTC-13	0.0-2.0	SAND, silty, trace clay, trace gravel, rootlets, brown		0.5
29443	V-GTC-05	4.0-6.0	CLAY, silty, sandy, trace gravel, grey		1.5
29446	V-GTC-04	0.0-2.0	SAND, some silt, trace clay, trace gravel, grey		0.4
205903	V-GTC-07	4.0-6.0	CLAY, some silt, trace sand, organics, grey		3.0
29447	V-GTC-02	NR	SAND, some silt, trace clay, grey		1.5

Remarks: **Hope Bay, NU**

Reviewed By: JDR P.Eng.

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