Baffinland Iron Mines Corporation
Mary River Expansion Project

Geotechnical Recommendations for Dumper Load-out Tunnel and Indexer

Date	Rev.	Status	Prepared By	Checked By	Approved By	Approved By
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1. Introduction

Hatch has been retained by Baffinland Iron Mines Ltd. (BIM) to design a Bulk Material Handling (BMH) system at the Milne Inlet Port for the Mary River Expansion Project.

The BMH system consists of a rail car dumper (tippler) located at the terminus of the mine-to-port railway, an indexer to push the rail car in the dumper, a loadout tunnel connecting with the dumper, a raw ore stockpile with embedded loadout tunnel, crushing and screening plants, and conveyor systems to transfer materials from the dumper through the crushing and screen plants to a longitudinal bucket-wheel stacker/reclaimer.

This memo provides geotechnical recommendations to support the design of (1) the foundation of the dumper loadout tunnel and (2) the foundation for the indexer mat and the dumper. Guideline and information from literature and engineering practice were used to develop these recommendations, as well as site conditions obtained from the previous investigation program (Hatch, 2017, Rev. 2). The design assumes that the dumper and the load-out tunnel are non-heated structures.

2. Geotechnical Site Information

The locations of the geotechnical site investigation are shown in the borehole layout drawing in Appendix A2, as well as a cross-section with the boreholes within the footprint of the structures. In summary, a total of five boreholes (BH16-M-007, BH16-M-008, and BH17-M008R, BH17-EBC-1 and BH17-EBC-2) were drilled in the vicinity of the dumper and loadout tunnel. BH17-M008R was drilled at the same location but slightly offset from BH16-M-008 to obtain bedrock information. A series of seismic line surveys were also performed to investigate the bedrock depth with calibration using bedrock information encountered in BH16-M-007, BH16-M-008 and BH16-M-008R. Appendix A3 provides the borehole reports and the seismic line survey data, while borehole reports BH17-EBC-1 and BH17-EBC-2 are presented in “draft” version as the investigation / laboratory testing program is still in progress at the time of this report preparation.

The subsurface conditions encountered at the site are highlighted as follows:

- The deposit at the hill crest comprises of a deposit of glacial fluvial sand to sand and gravel overlying till and then bedrock, while down the hill, the deposit consists of silts, silty sands and sands and gravels overlying till sitting on bedrock. A cobble and gravel layer was encountered right above bedrock in BH17-EBC-1 and BH17-EBC-2.
- Ground ice was encountered in borehole BH17-EBC-1. About 6 m of thick ground ice was encountered close to the surface of the native deposit. BH17- EBC-1 is located on the slope near the crest of the hill. A 3 m thick fill was placed to allow the access of the drilling rig. Under a 0.4 m thick surficial native gravel, the ground ice was encountered from el. 48.2 m to el. 42.2 m, with a 0.3 m thick interbedded sand layer from el. 46.5 m to el. 46.2 m. Below this interbedded sequence is a sand layer and a till deposit overlying a cobble and gravel layer and then bedrock. No ground ice was found at the corresponding elevations in the two nearby boreholes located

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approximately 30 m north (BH16-M-008) and 40 m south (BH17-EBC-2) of BH17-EBC-1. It is possible that the ground ice found in BH17-EBC-1 formed from a run-off stream.

- The bedrock at the site generally dips from east to west down the hill. The bedrock is granitic gneiss with RQD values varying from 64% to 68% as encountered in BH17-M-008R.

3. Climate Conditions

The site is in a continuous permafrost zone with a mean annual air temperature of about -15°C, as per the mean monthly air temperature data from Pond Inlet, NU (1981-2010) extracted from the Government of Canada website. Climate information was summarized in Hatch Geotechnical Design Basis document (H353004-00000-229-210-0001, 2018). The global warming effect was taken into account according to the Intergovernmental Panel on Climate Change (IPCC) long term climate change studies. A temperature adjustment was applied considering global warming for the period spanning from 2010 to 2039 (see details in Hatch, 2018, H353004-00000-229-210-0001).

4. Load-out Tunnel

4.1 Design Input / Criteria

The load-out tunnel is an approximately 5.5 m high arch with a 7 m+/- wide span. It will be constructed by cut-and-cover method. The thin-plate arch will be founded on two (2) concrete footings. The design is being optimized to shorten the length of the tunnel. The total length of the tunnel is not finalized at the time of preparing this report.

The following provides the load-out tunnel footing information:

- Footing Size: 2.5 m (Width) x 0.8 m (Thickness), Reference drawing 2017-01195-S08, dated on 06/17/2017, by AIL (Atlantic Industries Limited).
- Footing Elevation (The upper side of the concrete footings): el. 39.1 m to 39.5 m (Preliminary Design dated November 2017).
- Footing Bearing Capacity: 500 kPa (SLS) as per a clarification email from AIL, dated on 07/20/2017.
- An updated footing bearing capacity sketch was received on May 2, 2018 noting that the bearing loadings for the footing near the dumper (about 16 m long) are increased to 680 kPa (SLS) and 820 kPa (ULS). The recommendations to address the updated loading pressure are provided in Section 4.7.2.
- Total settlement criteria is 75 mm and differential settlement along transverse direction is 25 mm as per a clarification email from AIL, dated on 07/20/2017.
- tkIS specified the settlement criteria for both the dumper loadout reclaim tunnel and the primary stockpile tunnel on 12/10/2017. The total settlement is less than 20 mm.

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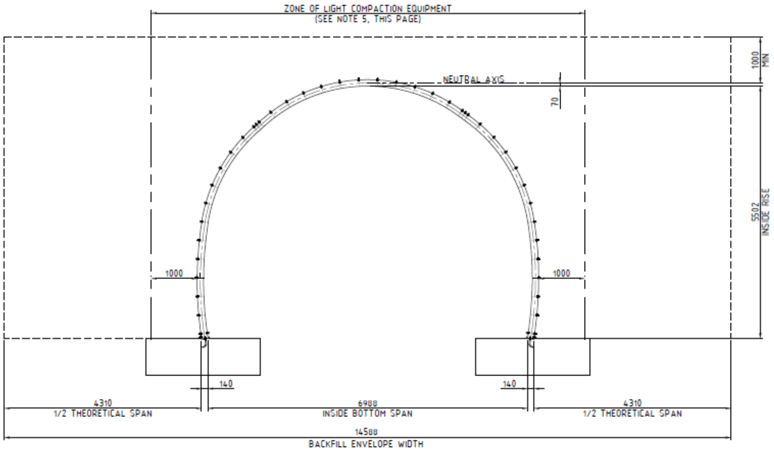

Figure 1: Typical Cross-section of Load-out Tunnel

(Reference drawing 2017-01195-S08, dated on 06/17/2017, by AIL)

4.2 Design Parameters

Table 4-1 summarizes the key design parameters used in the calculations.

Table 4-1: Design Parameter Summary

Material	Unit Weight (kN/m^3)	Effective Friction Angle (°)	Deformation Modulus	Frozen Soil Allowable Bearing Capacity (kPa)
Rockfill	20	40	70 MPa	-
Native Sandy Soil (ice content typically less than 20%)	18	32	80 MPa*	380kPa below – 4° C

Note: * Equivalent deformation modulus for long-term deformation. Applicable for low ice content permafrost(less than 20%), which is likely the native foundation soil below the tunnel footing as per the available borehole investigation. The parameters were estimated as per the literature test studies by Tsytoich et al. (1973) and Zhu and Carbee (1984) (see Hatch Geotechnical Design Basis, 2018).

4.3 Bearing Capacity

The native foundation soil is expected between el. 36.8 m and 37.2 m, considering the concrete footing thickness (0.8 m) and the rockfill pad thickness (1.5 m). At this elevation range, the native foundation soil is expected to be silty sand (till) and possible sand and gravel as inferred from the existing borehole investigation data (see Appendix A2).

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The allowable bearing capacity of the tunnel foundation is estimated based on the following assumptions:

- A factor of safety of 2.5 is applied to the ultimate bearing capacity to obtain the allowable bearing capacity.
- The foundation bearing capacity was checked for the following scenarios:
  (a) Bearing capacity of a two-layer foundation system with a top rockfill layer and an underlying native soil layer. The parameters for the rockfill and underlying soil are listed in Table 4-1. A weighted average friction angle for the two-layer foundation is to be calculated as per the recommendation by Bowles (1988).

$$\phi = \frac{d_1\phi_1 + (H - d_1)\phi_2}{H}$$

  Where the influence depth H = 0.5 x B x tan (45 + ϕ_1 /2), where ϕ_1 is the friction angle for the top layer, ϕ_2 for the bottom layer, d_1 is the thickness of the top layer, B is the footing width.

  (b) Bearing capacity of the lower soil. Its bearing capacity was checked for two scenarios: (b1) bearing capacity assuming the permafrost is unbonded (i.e., friction only), and (b2) bearing capacity assuming the permafrost is well bonded (i.e., cohesion only).

Meyerhof's general bearing capacity equation (Das, 2007) was used to calculate the bearing capacity. Meyerhof's equation is (i.e., for zero cohesion):

$$q_u = qN_qF_{qs}F_{qd} + \gamma' BN_yF_{\gamma s}F_{\gamma d} \qquad \text{(Equation 1)}$$

where q is the surcharge load at the bottom of the foundation, N_q and N_y are bearing capacity factors, B is the foundation width, F_{qs} and F_{rs} are shape factors, and F_{qd} and F_{yd} are depth factors. γ' is the unit weight of soil.

Table 4-2 summarized the analyses results.

4.3.1 *Scenario (a)*

Using Eqn. 1, the allowable bearing capacity of the two-layer system is 500 kPa, satisfying the required design load (500kPa). The parameters for the rockfill and underlying soil are listed in Table 4-1.

4.3.2 *Scenario (b1)*

As the foundation soil contains a relatively low water content and may not develop full ice bond among particles, the foundation bearing capacity was checked assuming it would behave as an unbonded (i.e., cohesionless) granular material. The allowable bearing capacity based on the silty sand (shear strength) is 650 kPa, using the 2:1 stress distribution rule.

$$q_{allow} = q_{soil\_allowable} \times \lfloor (1.5m + B)/B \rfloor = 360kPa \times \lfloor (1.5m + 2.5m)/2.5m \rfloor \approx 650\ kPa$$

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4.3.3 Scenario (b2)

Assuming the permafrost is well bonded, the allowable bearing capacity for the footing is estimated to be 550 kPa assuming the underlying permafrost can be maintained at a temperature below - 4° C. The 2:1 stress distribution rule was used to estimate the stress on the lower permafrost layer.

$$q_{allow} = 380kPa \times [(1.5m + B)/B] \approx 550\ kPa$$

In summary, the 1.5 m thick rockfill pad will satisfy the bearing capacity requirement given that the temperature of underlying permafrost is below -4°C. As shown in the next section, an insulation layer (150 mmm Styrofoam HL 100 or equivalent) is required to achieve the temperature requirement.

Table 4-2: Bearing Capacity Assessment Summary

Case	Case Description	Allowable Bearing Capacity (kPa)	Required Bearing Capacity (kPa)
Case A	Rockfill and Soil	500	500
Case B1	Underlying Soil (Friction Strength)	650	500
Case B2	Underlying Soil (Permafrost Bond Strength)	550	500

4.4 Settlement

For the proposed rockfill pad foundation and the SLS load, the load-out tunnel is expected to be less than 70 mm for total settlement and 35 mm for differential settlement in the transverse direction.

- The expected total and differential settlement satisfies the requirement by AIL (Total settlement is less than 75 mm as per a clarification email from AIL, dated on 07/20/2017).
- The expected total settlement of the rockfill pad foundation exceeds the settlement requirement of 20 mm by tkIS on 12/10/2017. Releveling the conveyor in the load-out tunnel may be required. Alternatively, pile foundation can be considered.

The load-out tunnel is to be constructed by cut-and-cover method. Considering the tunnel's opening size (about 5.5 m high and 7 m span), the overall net loads due to the backfill to foundation soil is expected to be low.

The load-out tunnel is expected to be founded on permafrost for the west section near the tunnel exit and on bedrock for its east end (near the tie-in to the dumper). The transition zone from the permafrost soil to bedrock foundation should be graded in a way to minimize the differential settlement of the tunnel footings.

The thaw settlement is excluded in this report as the design includes a rockfill and insulation pad to prevent permafrost thaw during operation. The construction should be carried out in cold seasons to avoid any potential thaw settlement during construction (see Section 4.7 for details).

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4.5 Bearing Capacity Summary

In summary, for the for the 2.5 m wide footing with a 1.5 m thick rockfill pad, the bearing capacity for serviceability limit state is 500 kPa with the total settlement less than 75 mm and a differential settlement of 25 mm. The factored bearing capacity in ultimate limit state (Factored ULS) is 630 kPa (=500kPa x 2.5 x0.5) with a geotechnical resistance factor of 0.5.

4.6 Thermal Analyses

Thermal analyses were performed to evaluate the temperature regime in the foundation below the tunnel. Appendix A1 summarizes the methodologies and details of the thermal analyses. Figure A-1 presents the general material and boundary conditions.

(1) Case with Insulation: In this case, an insulation pad is used in the model to control the temperature at underlying native sand. With the insulation pad, the temperature of the underlying permafrost is about -6°C (see Figure A2 for the temperature contours 2 years after construction and Figure A3 for 20 years after construction in Appendix A1), which satisfies the temperature requirement of -4° C.

(2) Case Without Insulation: Without insulation, the temperature of the underlying permafrost is about -2°C in the warmest summer (see Figure A4 and Figure A5 in Appendix A1). The permafrost at -2°C will not provide sufficient bearing capacity for the design load.

Based on the thermal modelling, a 150 mm thick insulation pad is required to control the permafrost temperature to ensure the required bearing capacity for the footing.

It is noted that the active zone may temporarily extend to the tunnel base for a short duration in summer (see Figure A6 in Appendix A). Accordingly, the backfill material adjacent to the tunnel must be free-drain granular to allow efficient drainage of any water. The drainage pipe is not recommended as it would be blocked by ice.

4.7 Design Considerations and Recommendations

4.7.1 General - Rockfill Pad Configuration (base-case)

A 1.5 m thick layer of rockfill is required below the loadout tunnel footings to ensure adequate bearing capacity up to 500 kPa.

Figure 2 illustrates the recommended rockfill pad configuration. The rockfill pad consists of mainly coarse rockfill (Type 8 Fill) underlain by a non-woven geotextile placed on the permafrost. The upper surface of the rockfill has a 100mm thick layer of leveling material (Type 9 Fill) underlain by a 150 mm thick transition layer (Type 5 Fill). The insulation pad is placed between the footings with a cushion layer of TY 5.

Near the tunnel exit, the insulation pad should be placed all around the footing and extent to tie-in with the excavation boundary to preserve the underlying permafrost and minimize the water migration, as shown in Figure 3 and Figure 4.

The construction for the rockfill pad shall be carried out in cold seasons to avoid disturbance of the underlying permafrost (see Section 4.7.4 for details).

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The permafrost below the foundation may contain ground ice / ice-rich soil, which may lead large creep settlement of the tunnel. If encountered, the ground ice or ice-rich soil must be removed i.e. over-excavated (see Section 4.7.5 for details) and the excavation backfilled with rockfill. A non-woven geotextile separator is required between rockfill and the permafrost. If the ground ice / ice-rich soil is not removed, large post construction settlement will likely occur induced by ground-ice/ ice-rich soil creep.

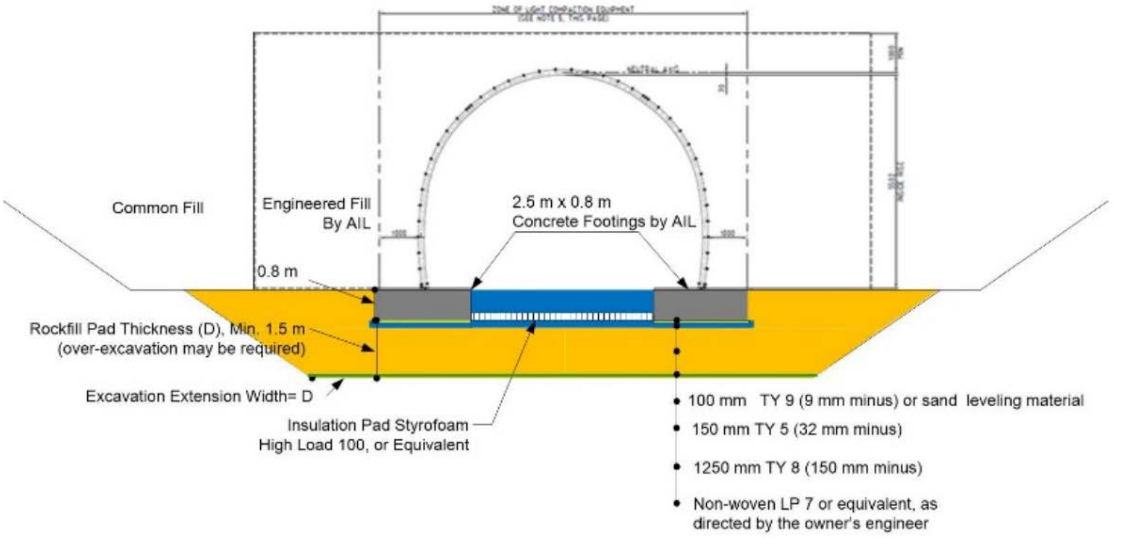

Figure 2: Typical Rockfill Pad Configuration for Load-out Tunnel

(Over-excavation from the underside of the footing may be required if the ground ice / ice-rich soil is encountered)

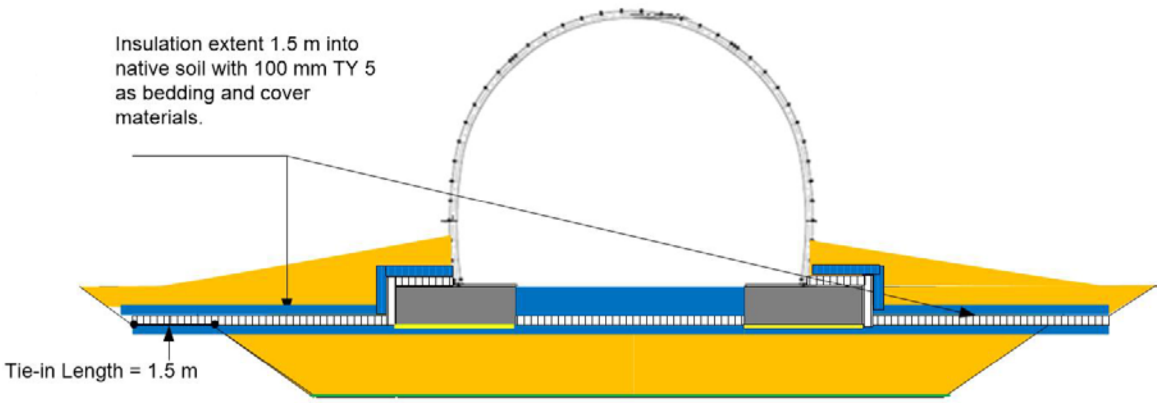

Figure 3: Insulation Pad Configuration (Cross Section) for Load-out Tunnel Segment near the Exit

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(Applicable for the tunnel section 15 m into backfill or extending to where the external backfill over the tunnel foundation is 5 m thick, whichever is longer. The insulation pad shall be placed all round the footing at the exit including the front side).

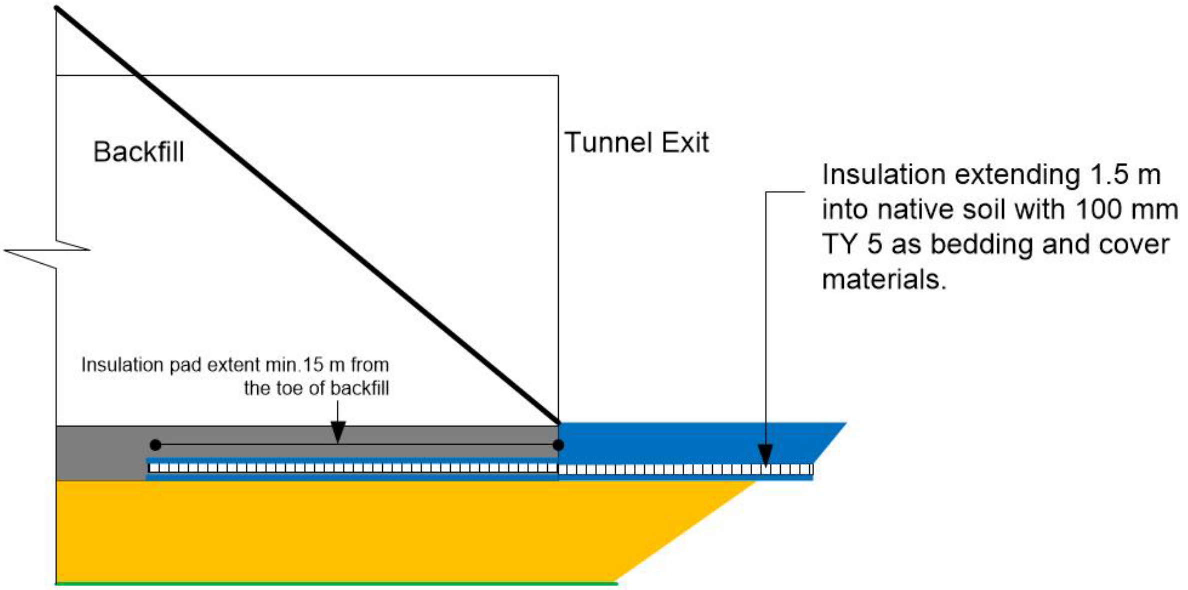

Figure 4: Insulation Pad Configuration (Longitudinal Section) for Load-out Tunnel Segment near the Exit

4.7.2 Rockfill Pad Configuration For Tunnel Footing With High Loading Pressure

An updated footing bearing capacity sketch was received on May 2, 2018, as shown in the Sketch 3 in Appendix A2. For the tunnel section (about 16 m long) near the dumper, the loading pressure are 680 kPa (SLS) and 820 kPa (ULS), which are higher than the loading capacity of the base-case rockfill pad configuration. The following provides geotechnical recommendation to address the high loading pressure expected for the tunnel section near the dumper.

The foundation soil below the footing of this section is likely silty sand till with a thickness less than 10 m overlying bedrock as shown in the Sketch 2 in Appendix A2.

The footing of this tunnel section should be founded either on bedrock or on a thicker rockfill pad.

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- A **2.5 m** thick rockfill pad below the 2.5 m wide footing will provide a factored ultimate limit state capacity of 850 kPa and a serviceability limit state bearing capacity of 700kPa (SLS) corresponding a settlement less than 70 mm and a differential settlement less than 35 mm. The alternative options are to use a larger-size footing or use pile foundation to reduce the settlement, likely with a higher cost.
- For the bedrock foundation, the recommended bearing capacities are 1.0 MPa for the SLS state corresponding to a settlement less than 25 mm and 1.5 MPa for the Factored ULS state.

4.7.3 *Insulation*

The backfill for the load-out tunnel will serve as insulation for the foundation permafrost. Additionally, the temperature of the permafrost below the tunnel floor is expected to rise during the summer due to the air temperature fluctuations in the tunnel. A styrofoam insulation layer (insulation material) was been designed to control the temperature of the native permafrost, which is required to ensure sufficient bearing capacity as specified in Section 4.1. Accordingly, proper installation of the insulation material is critical to ensure satisfactory performance of the tunnel.

The insulation layer will be placed at the base level of the tunnel with layers placed such that the panels overlap the joints in the underlying layer. It is noted that the insulation material should not be placed directly beneath the footing, due to the insufficient long-term compressive strength of insulation pads (230 kPa for Styrofoam HL 100, with a factor of safety 3 as per product sheet recommendation to avoid long-term creep).

4.7.4 *Construction Schedule*

The excavation and foundation backfill placement for the loadout tunnel should be carried out during the cold seasons (October to April) when the daytime temperatures are below 0°C. Construction during the summer (June to September) will significantly increase the risk of thawing the underlying permafrost, instability of the high side slopes over 10 m, and the cost of the work. As such, the construction for foundation in the summer (June to September) is not recommended.

4.7.5 *Excavation /Backfill*

The contractor should be fully responsible for construction safety. The safe slope gradient for temporary excavations depends on the construction methodology, permafrost material, and the season/temperature during construction. In general, an overall slope gradient of 1.5H:1V should be adequate for the temporary cut into the permafrost with blasting.

The limited geotechnical investigations undertaken for design indicate the presence of random ground ice. As a result, the side slopes for the cut may need to be locally laid back at flatter gradients than 1.5H:1V if ground ice is encountered.

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Furthermore, the excavation may need to be deepened to remove ground ice below the rockfill pad. Since the excavation will be done by drill and blast method, this may be difficult to do if the excavation has progressed significantly prior to encountering the ground ice. Accordingly, the contractor should probe the ground with drill rigs prior to executing the excavation to adequately plan and adapt to the presence of ground ice. Sonic drill rigs give the best results. An excavation plan (i.e. depth and slope gradients) should be developed based on the probe hole drilling prior to commencing production drill-and-blast excavation.

During excavation construction, shallow slope sloughing should be expected and a maintenance program should be carried out to maintain the slopes. The contractor will probably need to cover the excavated slope with insulation materials and/or a layer of crushed rock as the excavation is advanced to protect the slopes.

The contractor should remove snow efficiently during the backfill construction.

If the general backfill construction of the load-out tunnel extends to the spring freshet, then run-off will need to be controlled and diverted away from the work area. The introduction of water and warmer temperatures to the base of the excavation will lead to disturbance of the permafrost and contribute to poor performance of the tunnel after construction.

A qualified engineer with artic construction experience should be on site supervising the construction to ensure QA/QC. After completing the excavation, periodical inspections will be required during construction of the plate-arch tunnel.

4.7.6 Foundation Preparation

Ground ice or ice rich permafrost, if encountered below the foundation base from the probing program, should be completely excavated. Over excavated areas should be backfilled with a 150 mm cushion granular material at the base followed by rockfill.

A qualified geotechnical engineer shall inspect and approve the foundation base prior to backfilling.

4.7.7 Tunnel Cover (i.e., Backfill) Materials

The tunnel cover (i.e., backfill) material will be specified by the tunnel supplier (AIL).

The common fill can be rockfill (run of quarry) or pit-run materials free of ice and snow, as approved by the Engineer.

The backfill material for the rockfill pad are either crusher-run granular fill, rockfill or approved material by the Engineer.

It is critical to properly place and compact the foundation rockfill pad as per the project specifications (Hatch, H353004-00000-221-078-0001, Rev. 1). A test rockfill compaction pad is recommended to verify the compaction achieved at site.

As a minimum the following shall be satisfied:

a. Rockfill shall be compacted by 5 passes of a 10 ton vibratory roller with vibrations in the range of 1200 to 1500 vpm and the roller speed of about 2 mph (3.2 km/h). One

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pass is defined as a full cover the fill area. Alternative compactors such as heavy loaded rubber-tired haul trucks can only be used as per a written approval from the Engineer.

b. TYPE 5 Fill (crusher-run 32 mm minus material) or TYPE 9 Fill (9 mm minus): the material must be placed in lifts not exceeding 200 mm.

c. TYPE 8 Fill (crusher-run 150 mm minus): the rockfill must be placed in lifts not exceeding 500 mm. The placement shall avoid segregation and nesting of coarse particles.

d. TYPE 12 (run-of-mine, typically 600 mm minus): the rockfill must be placed in lift not exceeding 1000 mm, or as approved by the Engineer.

4.7.8 Permanent Cut Slope

Permanent cut slope is required near the tunnel exit.

The overall slope of the permanent cut less than 15 m is recommended to be executed at a gradient of 2.5H:1V or flatter. A benched slope is recommended to better control the erosion (i.e., 5 m high and 2.5 m wide bench with a 2H:1V side slope may be considered). Locally flattening of the slope will be required where ice and very ice-rich soil is encountered.

A thermal protection layer should be placed on the slopes of permanent cuts into native soil and engineered fill. The protection layer should comprise a 1 to 2 m thick layer of rockfill (run of quarry or jaw-run rockfill) or equivalent as approved by the engineer. A toe-berm may be required to protect the toe from causing local slope instability due to potentially softening of the toe during thaw seasons, particularly where ice-rich permafrost is encountered.

4.7.9 Drainage

Proper drainage is an important component to ensure a satisfactory performance of the load-out tunnel.

(1) Grade the tunnel base downward from the dumper toward the exit. Crown the backfill granular between the tunnel footings.

(2) Runoff collection and diversion systems should be provided to efficiently direct run off away from the tunnel and slope benches. Grade the ground surface away from the tunnel exit at a 2% minimum gradient.

(3) For the backfill above the tunnel, it is recommended to cap the tunnel backfill (i.e., the rockfill and crusher run fills specified by AIL) with select thawed native material collected from the excavation. A geotextile separator should be installed between the cap material and the underling coarse rockfills and granular materials. The cap should be sloped and graded such that water does not pond or collect on top of the tunnel. Design the finished grades around the works to minimize the amount of run-off that may enter the area after putting the tunnel into service.

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(4) A sufficient temporary drainage system should be provided during excavation construction, if the construction period extends in above-zero-temperature seasons, to avoid any ponding water in the excavated areas. Drainage ditch, sump and pump should be prepared to efficiently drain the run off or meltwater to avoid any ponding water at the base of the excavation during construction. The ditches with concentrated waterflow and sumps at the base should be lined.

5. Indexer Foundation

5.1 Structural Design Input

The indexer slab is a mat foundation consisting of pre-casted concrete blocks reinforced by post-tensioned cables. Appendix B provides the preliminary design drawings for the indexer.

The preliminary structure design input is summarized below:

- Foundation Size: 8 m wide, 25 m long, and 1 m thick (Preliminary)
- Foundation Shear Key: 1 m wide and 3 m deep (Preliminary).

5.2 Bearing Capacity

The indexer slab is expected to be found on well compacted rockfill. The rockfill below the indexer mat is about 15 m thick to the bedrock.

The factored geotechnical resistance at the ultimate limit state is very high (over 500 kPa) for the mat foundation. Typically, the ultimate limit resistance will not govern the design for mat foundations.

Serviceability Limit State (SLS) geotechnical reaction is 200 kPa corresponding to 25 mm elastic settlement.

The creep-related settlement of the rockfills is likely small in the light of the following conditions:

(1) The rockfill is laterally confined by the dumper wall and the adjacent soil.

(2) The rockfill below the active zone is kept frozen.

(3) The parent rock for the rockfill is granite gneiss with a high to very high strength. The rockfill is to be well compacted.

There are very few studies for the creep settlement of frozen rockfills. A recent case-study for the Doris Dam (10 m high dam on permafrost with rockfill shells and a cut-off core, see Miller and Rykaart 2016) concluded that there is negligible creep settlement at the crest (less than the survey accuracy of 10 mm) 4 years after construction. For unfrozen rockfill, the study by Clements (1984) suggests the range of post-construction long-term settlement of compacted rockfill dams is from 0% to 0.25% of dam height (the dam height in the study ranging from approximate 60 m to 180 m) provided the rockfill is placed in lifts and compacted. It is noted that the settlement observations are based on rockfill dams without lateral confinement and with impacts of water impounding. Sherard and Cooke

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(1987) suggested that the half of the rockfill creep occurs during the first 5 years and the other half in 100 years.

As such, the creep settlement of the backfilled rockfill (about 15 m thick) is expected to be in the order of 30 mm for the design life of 20 years. As a result, the indexer should be designed taking into account the elastic and creep settlements.

5.3 Subgrade Modulus

The mat foundation with an 8 m width can be designed base on a modulus of subgrade reaction of 10 MPa/m for compacted rockfill.

5.4 Sliding Friction Angle

For the pre-cast concrete foundation founded on granular or rockfill, the friction angle of 24 degrees (friction coefficient of 0.45) is recommended as per Hatch geotechnical design criteria (Hatch, 2017, H352004-0000-229-078-0001).

5.5 Lateral Resistance of Shear Key

It is understood that a shear key may be used in the mat foundation design to resist the lateral load. The shear key should be designed using a coefficient of lateral earth pressure K from K_0 (0.36) upto K_p /5 (0.9) in order to limit the lateral movement required to mobilize the lateral resistance of the key. A lower factor of safety to K_p can be used if the lateral deflection of the shear key is allowed within the design tolerance level as determined by the structural design engineer.

Figure 5 illustrates the relationship between the deflection and lateral earth pressure coefficient for reference (CFEM,2006).

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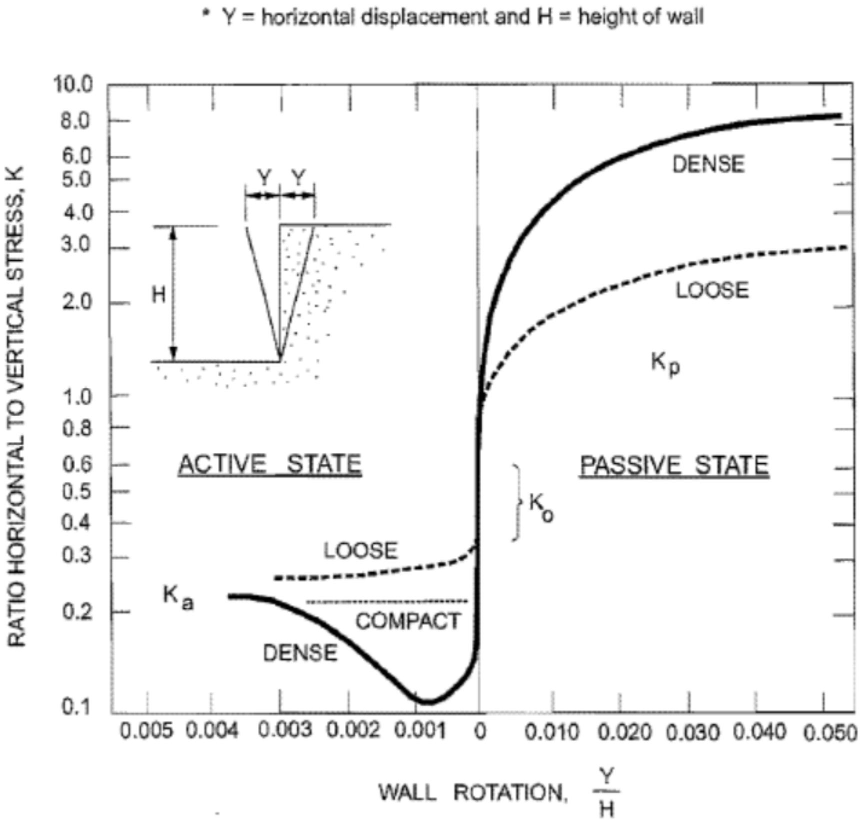

Figure 5: Effect of Deformation on Earth Pressure in Cohesionless Material

5.6 Lateral Earth Pressures

The lateral earth pressure on the shear key and dumper walls should be calculated as per the following expression, assuming a triangular pressure distribution:

$$p = k(\gamma h + q)$$

where p= the pressure in kPa acting against the wall surface at depth, h, below the finished ground surface

k = lateral earth pressure coefficient;

γ = the bulk unit weight of the retained backfill;

h = depth below the ground surface at which the pressure, p, is to computed; and

q = the value of any adjacent surcharge in kPa which may acting close to the wall (including traffic loads).

The above equation assumes that a non-frost susceptible and free-draining granular backfill adjacent to the dumper's wall, to prevent the frost heave pressure behind the wall.

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The physical properties of well compacted rockfill are presented as follows:

Compacted Rockfill

Angle of Internal Friction (ϕ) = 40° (unfactored)

Coefficient of Lateral Earth Pressures:

K_a = 0.22 (unfactored)

K_0 = 0.36 (unfactored)

K_p = 4.6 (unfactored)

Notes:

K_a is the active earth pressure coefficient for a soil loading an unrestrained structure; and

K_o is the earth pressure coefficient at rest for a soil loading a restrained structure.

K_p is the earth pressure coefficient a soil loading to a passive failure state.

The dumper structure design shall account for the additional lateral earth pressure caused by the surcharge of the indexer and the lateral load transferred from the indexer to the dumper wall.

5.7 Backfill

The backfill below the mat foundation should be crusher-run, free-drained, and non-frost susceptible rockfills.

A layer of TYPE 5 (32 mm minus), minimum 300 mm thick, should be placed immediately below the indexer foundation as a leveling course.

TYPE 5 (typically 3 m wide) is recommended to be placed adjacent to any vertical concrete/steel structures to serve as a protection layer from direct contact with large-sized rockfills.

The general backfill rockfill should be TYPE 8 (150 mm minus). A geotextile should be used to separate the native soil and the rockfill backfill.

The backfill should be placed and compacted as per Hatch specification and the notes in the construction drawings.

5.8 Drainage

Runoff collection and diversions systems should be provided to efficiently direct run off away from the dumper and the mat foundation.

6. Dumper Foundation

6.1 Bearing Capacity

The dumper should be found directly on bedrock. The bedrock properties below the dumper foundation are expected to be similar to the rock mass encountered in BH 17-008R, BH17-EBC-1 and BH17-EBC-2.

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The bearing capacity of sound rock foundation was estimated using the approach recommended by CFEM (2006)

$$q_{allowable} = K_{sp} \times q_{u-core}$$

where q_{u-core} is the unconfined compression strength of the intact rock (i.e., 23.6MPa as per BH 17-008R). The coefficient of K_{sp} is selected as 0.05, as per the bedrock condition.

Serviceability Limit State (SLS) geotechnical reaction is 1 MPa for the bedrock foundation.

The rock surface should be prepared by removing loose or weathered materials for a competent surface. The bedrock foundation condition should be inspected and approved by a qualified geologist or geotechnical engineer prior to foundation construction. The blasting should be designed and performed in a way to minimize over-blasting. A lean concrete slab is recommended to level the blasted surface below the pre-cast concrete structure. If using granular leveling materials as alternative, the differential settlement due to the compression of the granular in depression should be taken into account in the structure design.

6.2 Drainage

Runoff collection, and ground grading should be provided to efficiently direct run off away from the dumper. Temperately drainage during construction should be provided to sufficiently control run-off water from ponding at foundation level.

6.3 Backfill

The backfill below the mat foundation should be crusher-run, free-drained, and non-frost susceptible rockfills.

TYPE 5 (typically 3 m wide) is recommended to be placed adjacent to any vertical concrete/steel structures to serve as a protection layer from direct contacting with large-sized rockfills.

An insulation pad (two layers of Styrofoam HL 100) is recommended to be placed against the wall to keep the permafrost state of the backfill and minimize potential degradation from the freeze/thaw effect.

The general backfill rockfill should be TYPE 8 (150 mm minus). TYPE 12 (run of quarry) may be used where the settlement is not a concern. A geotextile should be used to separate the native soil and the rockfill backfill.

The backfill should be placed and compacted as per Hatch specification and the notes in the construction drawings.

7. Assumptions and Limitations

This report and the engineering described herein is based on five boreholes advanced into the permafrost near the project site. The boreholes indicate the presence of ground ice in the permafrost; the distribution of the ground ice appears to be random. As a result, construction should be coupled with sufficient pre-drilling and probing at major cuts and in

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the foundation of major structures to delineate the ground ice to reduce uncertainties. Based on the results of the probing, excavations for the foundations and load out tunnels may need to be adjusted to take into account the presence of ground ice or ice rich soil. The construction approach will need to be observational or adaptive.

Additionally, the recommendations in this report are based on the results of calculations performed using deformation and creep properties for permafrost from the literature. Site specific creep tests have not been performed, and as a result, there is residual risk of applying the engineering parameters from literature to assess the performance of the infrastructure. Hatch has used reasonable judgment and has consulted with experts to develop parameters for the permafrost. During construction, site-specific load tests and creep tests should be conducted on the permafrost to verify design parameters. The tests should consist of in situ plate load tests with temperature monitoring and/or temperature controlled triaxial compression tests on the permafrost, to confirm the strength, deformation and creep parameters used for design. Some adaptation of the design may be required based on these tests.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report.

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8. References

1. *Hatch, 2012, "Geotechnical Data Report -Infrastructure" (ref H337697-0000-15-1240004, Rev. C), April 05, 2012.*
2. *Hatch, 2016, "Geotechnical Criteria for Building Foundations at Milne Inlet", H352004-0000-229-078-0001, Rev. 0, Dec. 15, 2016.*
3. *Hatch, 2016, "Preliminary Geotechnical Recommendation for Infrastructures at Milne Inlet", H352004-0000-229-230-0002, Rev. 0, Sept. 01, 2016.*
4. *Hatch, 2017, "2016 Milne Port Geotechnical Investigation Factual Data Report", (ref H352034-1000-229-230-0002), Rev.2.*
5. *Hatch, 2018, "Hatch Geotechnical Design Basis", H353004-00000-229-210-0001, Rev. A, 2018.*
6. *Das, Braja, 2007, "Principles of Foundation Engineering", Sixth Edition, Thomson.*
7. *Andersland, B.A., Ladani, B., 2004, "Frozen Ground Engineering", Second Edition, ASCE, John Wiley and Sons, Inc.*
8. *Canadian Geotechnical Society, 2006, "Canadian Foundation Engineering Manual", Fourth Edition.*
9. *Bowles,J.E. “Foundation Analyses And Design” Fourth Edition.*
10. *Johnston G.H.,1971, “ Permafrost Engineering Design and Construction”.*
11. *Tsytovich, N.A., Kronik, Ya.A., Markin, K.F., Aksenov, V.I. Physical and Mechanical Properties of Saline Soils. Proc. 2nd International Conference on Permafrost (1973), Yakutsk, USSR Contributin, U.S. National Academy of Sciences, pp. 238-247.*
12. *Zhu, Y. and Carbee, D.L., 1984. Uniaxial compressive strength of frozen silt under constant deformation rates. Cold Regions Science and Technology, 9(1), pp.3-15.*
13. *Clements, R.P. 1984 Post-construction deformation of rockfill dams. Journal of Geotechnical Engineering, 110: 1384-1414.*
14. *Sherard, J.L. and Cooke, J.B. 1987. Concrete-face rockfill dam I. Assessment. Journal of Geotechncail Engineering, 113: 1096-1112.*
15. *Miller, M. and Rykaart, M. 2016, Frozen core dam performance : four years post construction. Canadian Dam Association, Halifax.*

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Appendix A1
Thermal Analyses

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Appendix A1

Thermal Analyses

Two-dimensional finite element modelling, with commercially available software (Temp/W), was used to predict the thermal regime for the tunnel foundation.

The air temperature is based on the mean monthly air temperature from Pond Inlet, NU (1981-2010) extracted from the government of Canada website, see Figure A-1.

The global warming effect was taken into account according to the Intergovernmental Panel on Climate Change (IPCC) long term climate change studies. A temperature adjustment was applied considering to global warming for the period spanning from 2010 to 2039 (Hatch 2018).

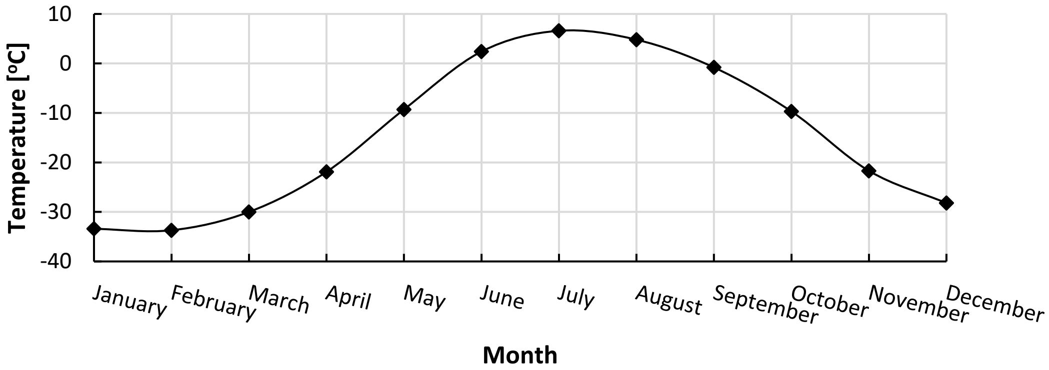

Figure A-1: Mean Monthly Temperatures for Pond Inlet, NU (1981-2010)

Surface boundary conditions at the site were obtained based on the n-factors which was used to correlate air temperatures to ground surface temperatures during cold seasons (n_f) and thaw seasons (n_t). Values of n_t and n_f used in the analysis were summarized in Table A-1. Typically, n_f is less than 1 considering the impact of snow accumulation/insulation over ground surface during winter while n_t is more than 1 considering the impact of radiation.

Inside the tunnel, the n factor of 1 was used assuming that the ground surface temperature is same as the air temperature. It is noted that in summer the air temperature in the tunnel could be colder than the air temperature outside while in winter, the inside air temperature in the tunnel becomes is likely warmer than the outside air temperature. There is no sufficient data/study to quantify the two opposite effects. As such, this study assumed that the air temperature in tunnel is same.

The available thermistor data from the Mary River site (Hatch, 2012) indicate that ground temperature reaches equilibrium (at -10° C) below 15m depth, thus the bottom boundary was assumed to be 15m below the ground surface, with a constant temperature of -10° C.

The initial temperature of the foundation rockfill is -3° C degree and the other backfill materials are set as 0° C degree.

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Table A-1: N-factors to be Used in Modelling

Material	N – factors	
	Freezing (n_f)	Thawing (n_t)
Native Sand	0.7	1.2
Rockfill / Granular Backfill	0.8	1.5
Tunnel Inside Boundary	1	1

The following two cases were analyzed:

(1) Thermal model of load-out tunnel with 100 mm insulation pad.

(2) Thermal model of load-out tunnel without insulation.

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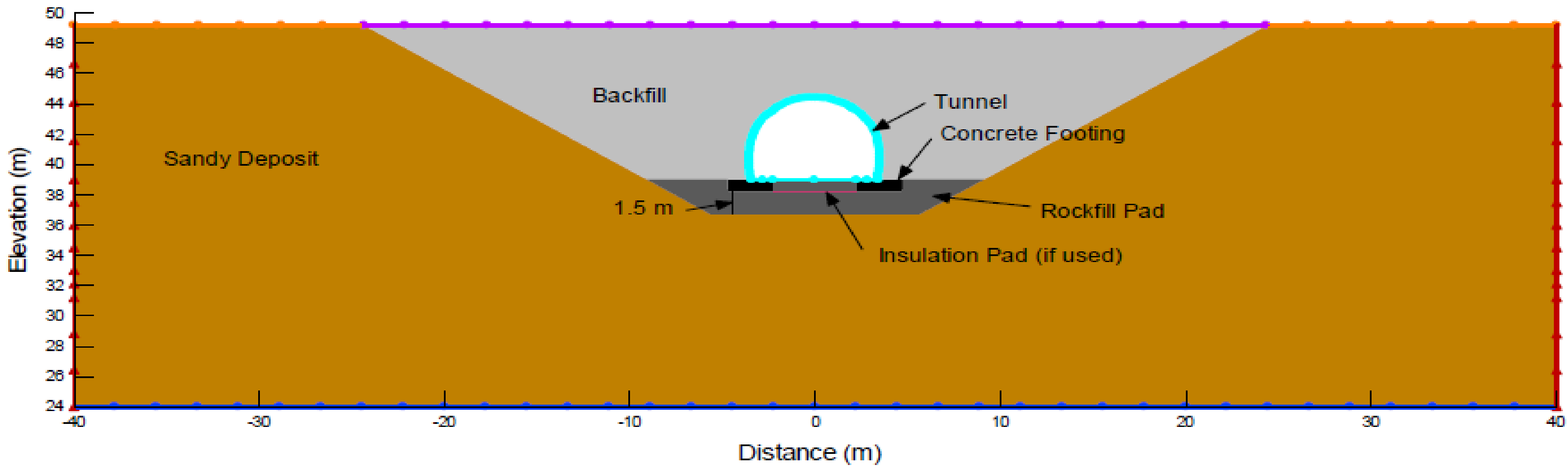
Color	Name	Unfrozen Thermal Conductivity (J/sec/m/°C)	Frozen Thermal Conductivity (J/sec/m/°C)	Unfrozen Volumetric Heat Capacity (J/m³/°C)	Frozen Volumetric Heat Capacity (J/m³/°C)	Vol W/C (m³/m³)	Initial Temperature (°C)
	Granular Back Fill	3	4.5	3,000,000	2,400,000	0.036	0
	Rockfill Pad	3	4.5	3,000,000	2,400,000	0.036	-3
	Sandy Deposit	2	3	2,600,000	2,600,000	0.255	
	Concrete	1.5	1.5	2,000,000	2,000,000	0.024	-3
	Insulation	0.035	0.035	37,500	37,500	0	-3



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Ref	Tippler Load-out Tunnel		Thermal Model		Milne Inlet Port
By	Lk	0	02-Apr-18		
Revision	A	02-Apr-18			FIGURE A1

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Date: 4/2/2018
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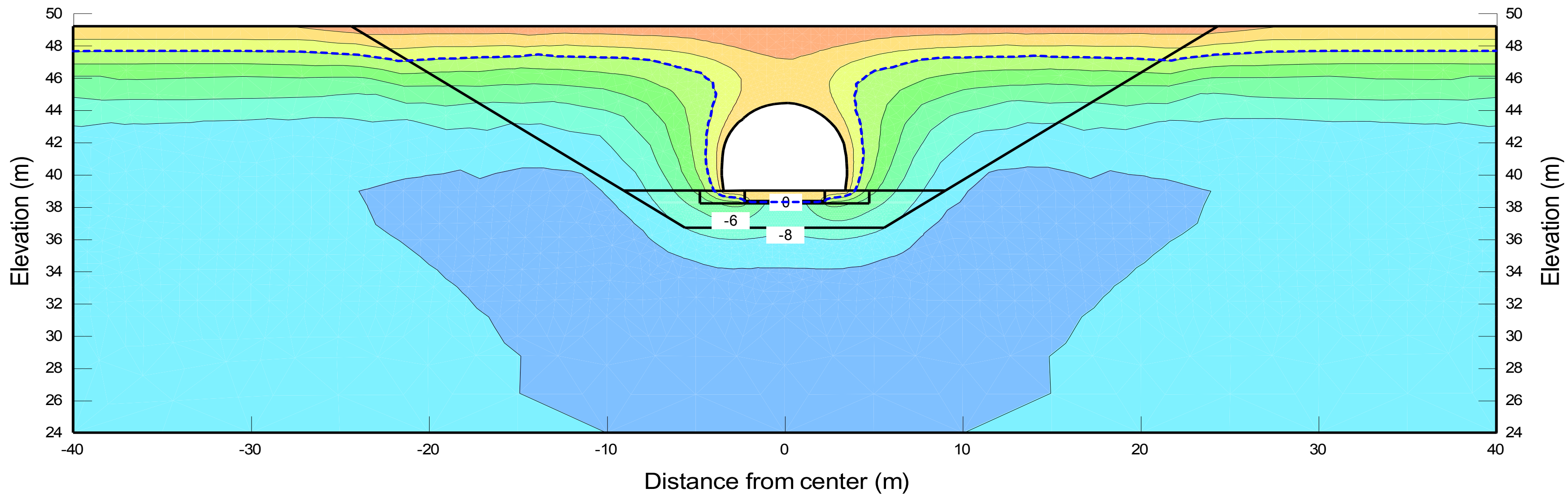

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Ref	Tippler Load-out Tunnel		Insulation Temperature Contour In Summer (2 yr after construction)		Milne Inlet Port
By	Lk	0 02-Apr-18			
Revision	A	02-Apr-18			FIGURE A2

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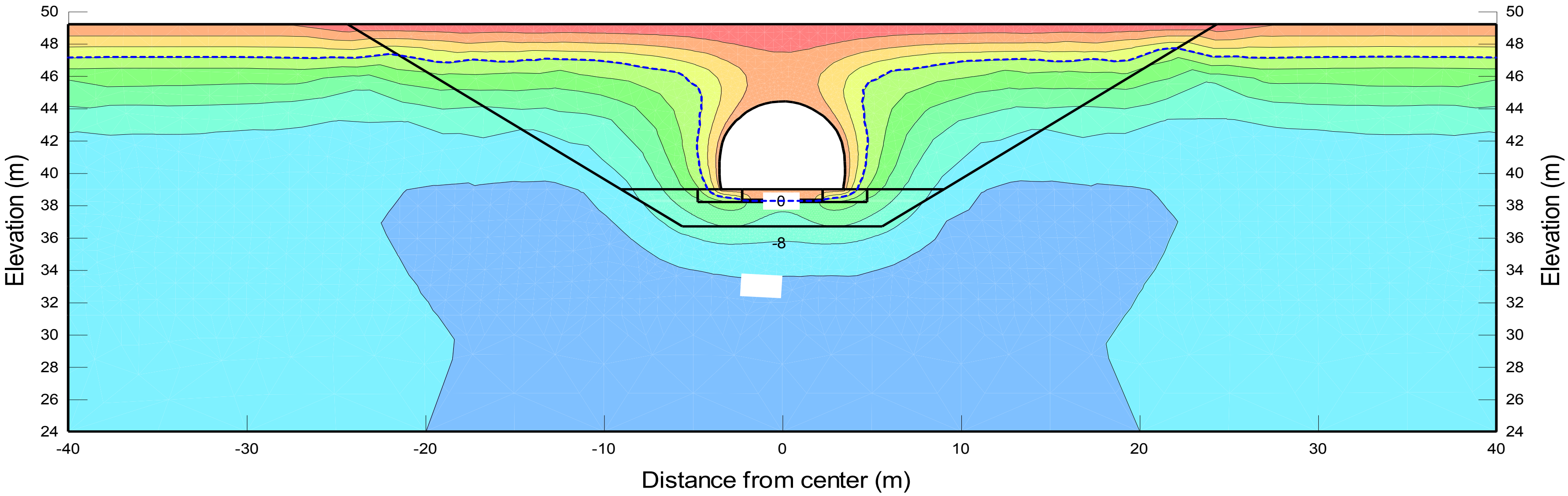

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Ref	Tippler Load-out Tunnel			Insulation Temperature Contour In Summer (20 yr after construction)		Milne Inlet Port
By	Lk	0	02-Apr-18			
Revision	A		02-Apr-18			FIGURE A3

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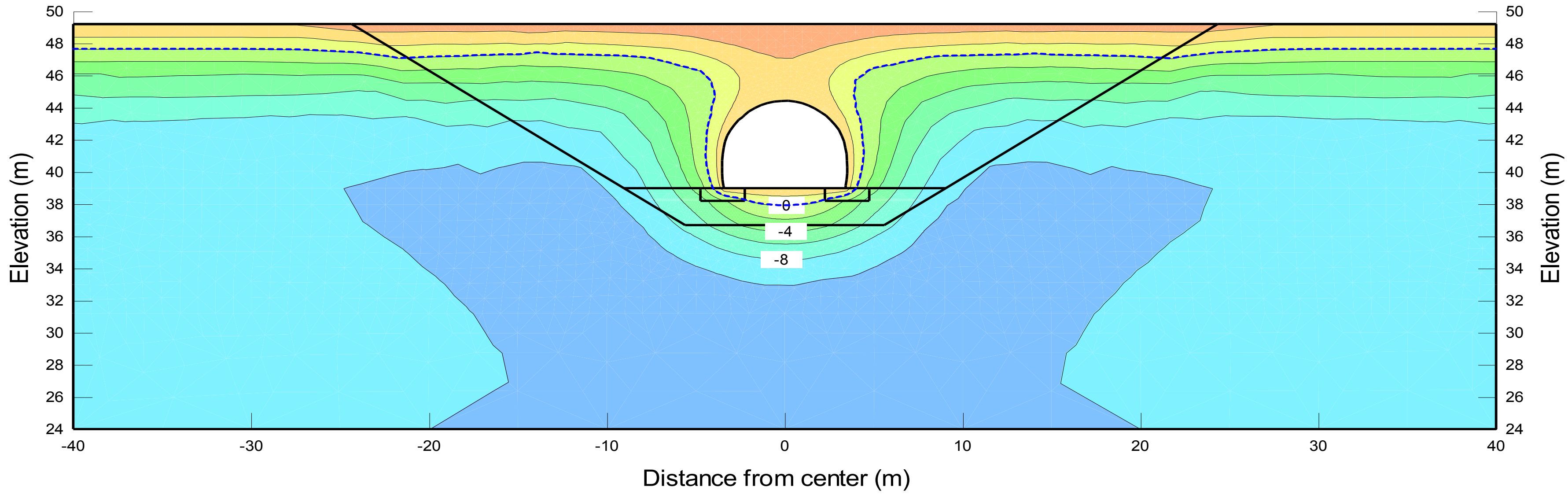

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By	Lk	0	02-Apr-18			
Revision		A	02-Apr-18			FIGURE A4

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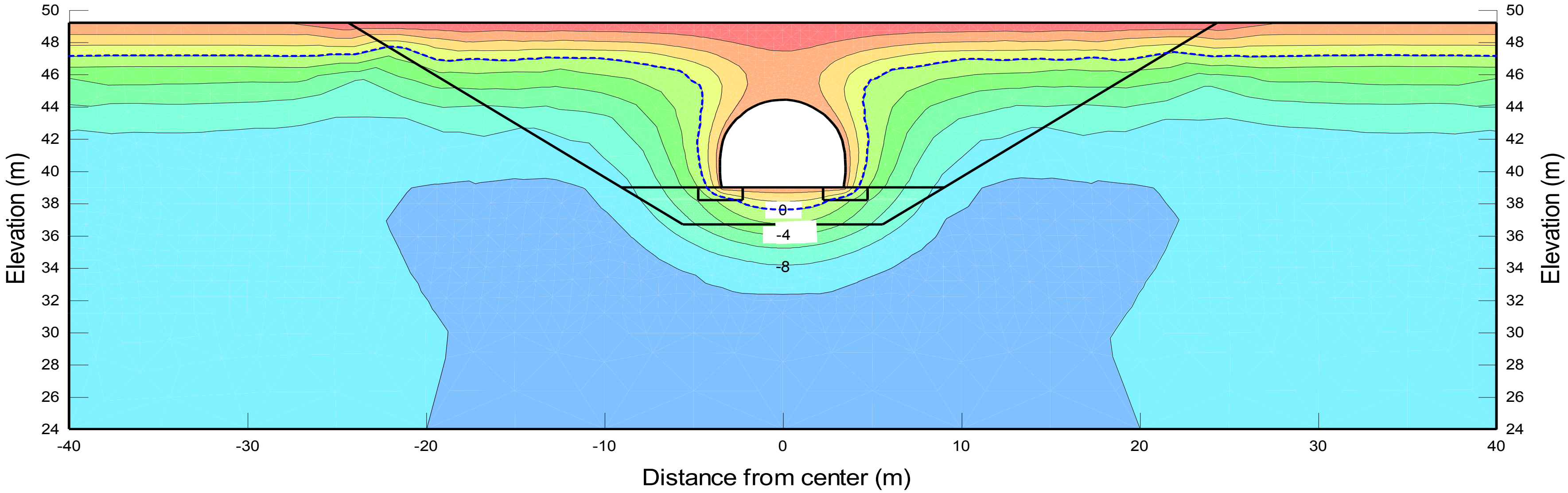

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By	Lk	0	02-Apr-18			
Revision		A	02-Apr-18			FIGURE A5

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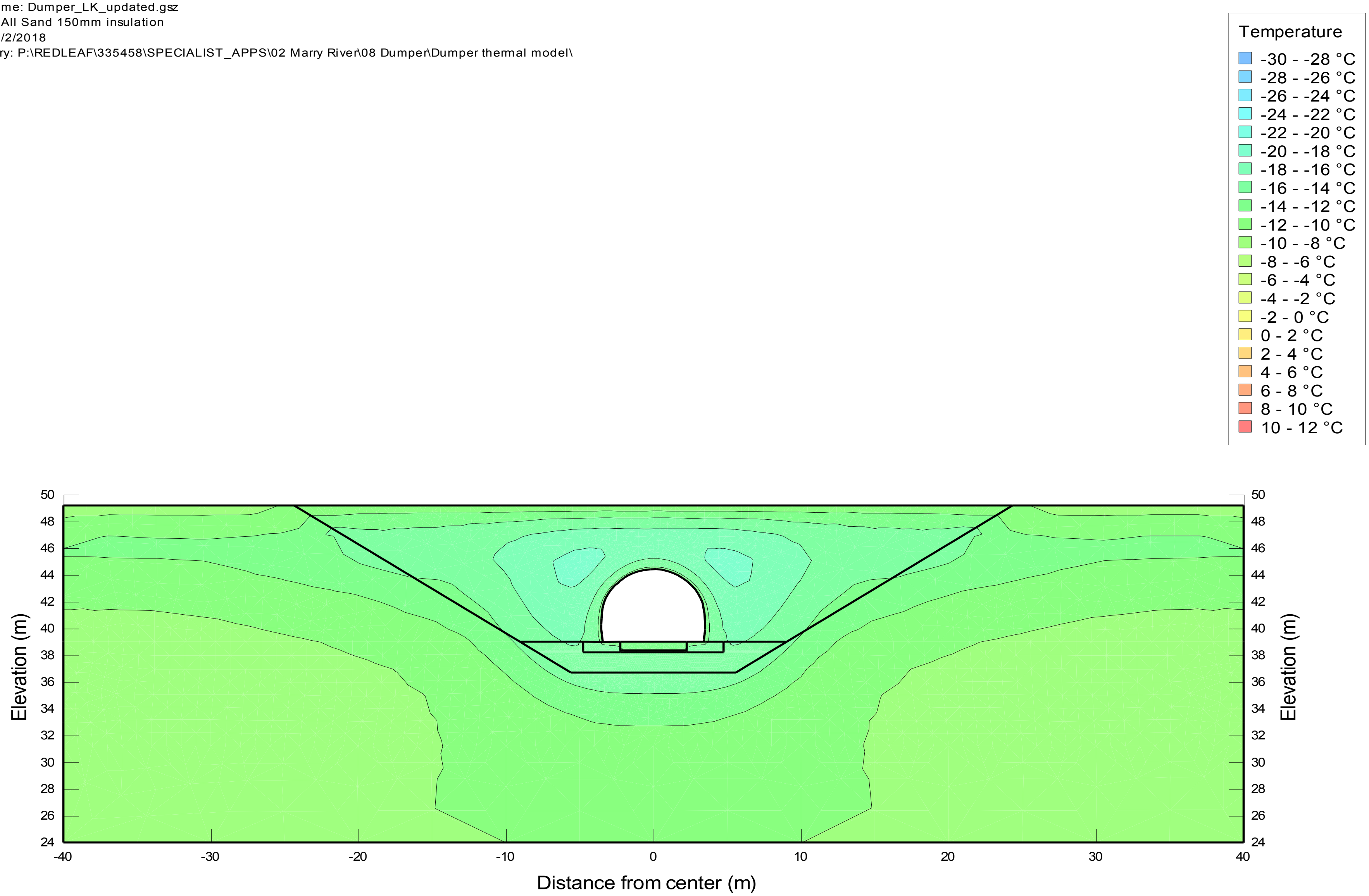

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By	Lk	0	02-Apr-18			
Revision	A		02-Apr-18			FIGURE A6a

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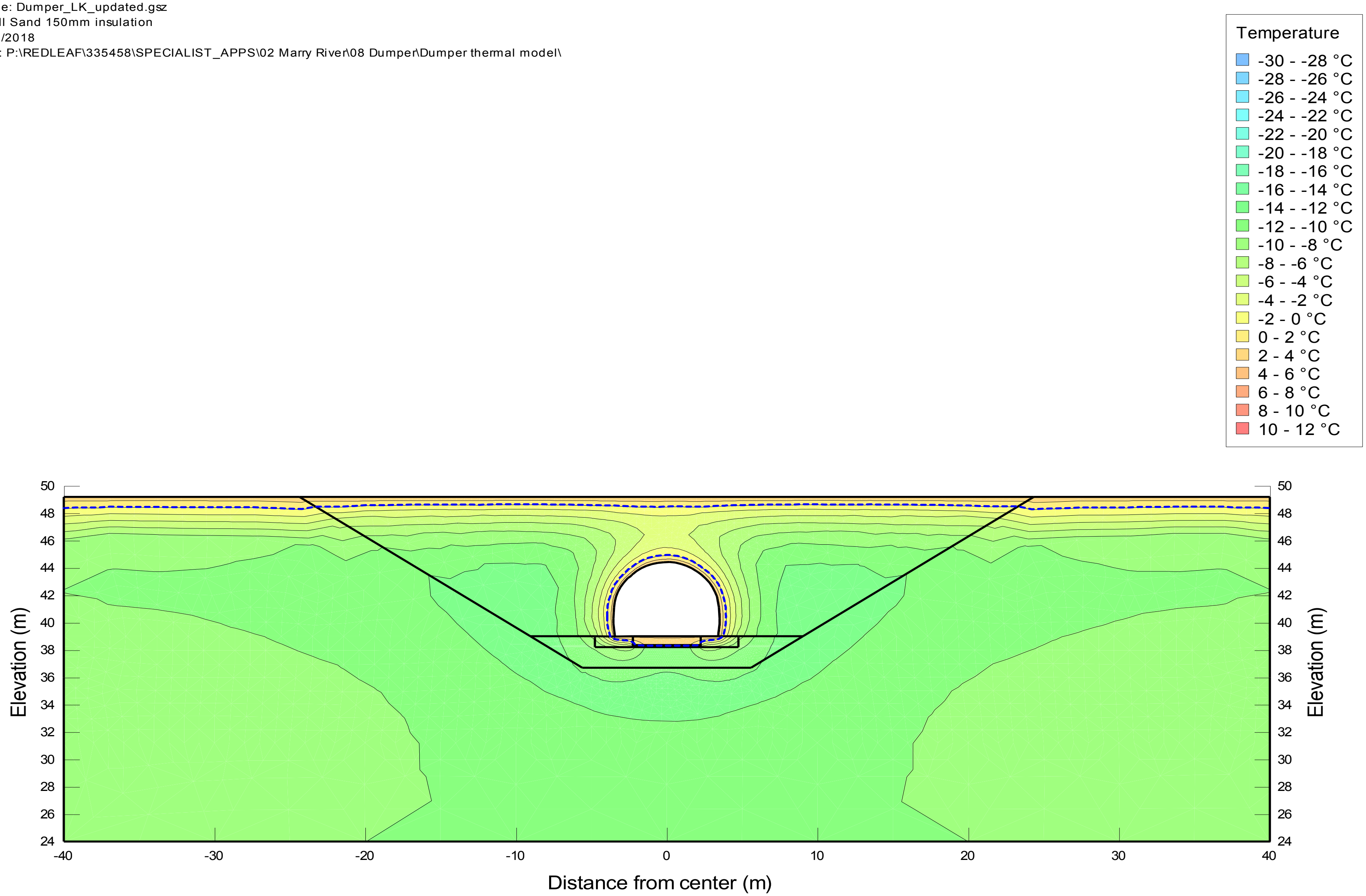

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By	Lk	0	02-Apr-18			
Revision		A	02-Apr-18			**FIGURE A6b**

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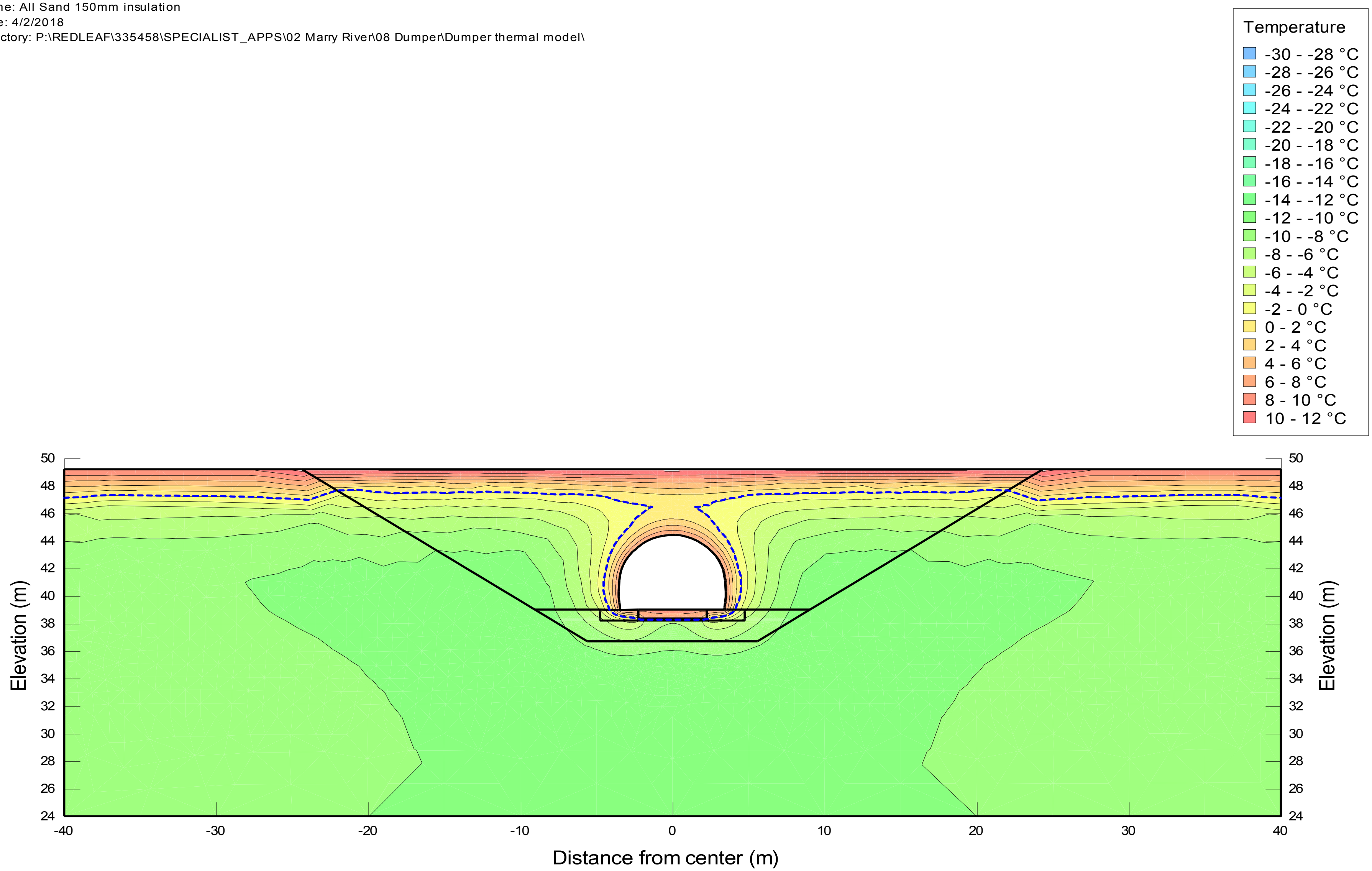

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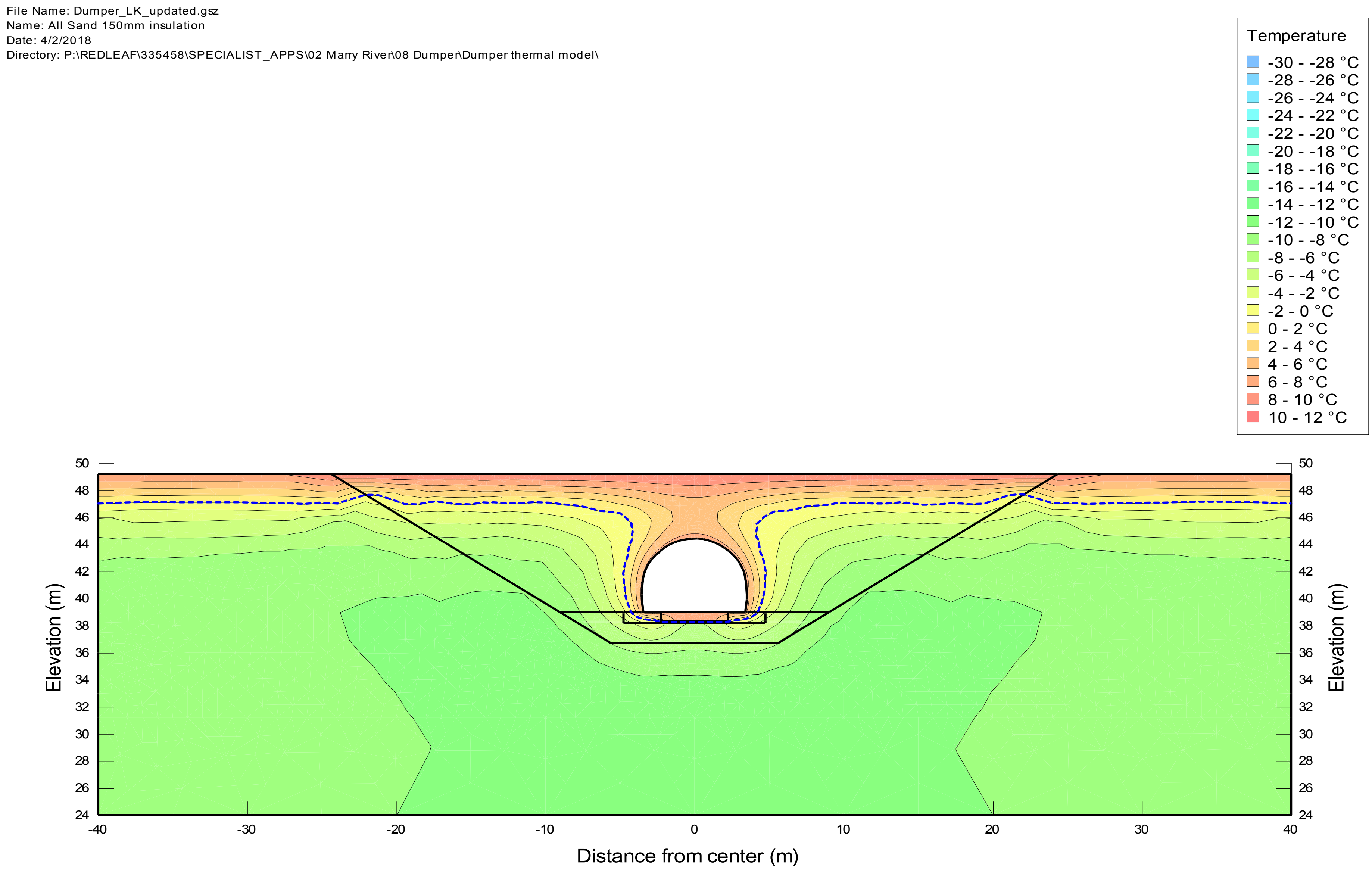
Revision		A	02-Apr-18			FIGURE A6c



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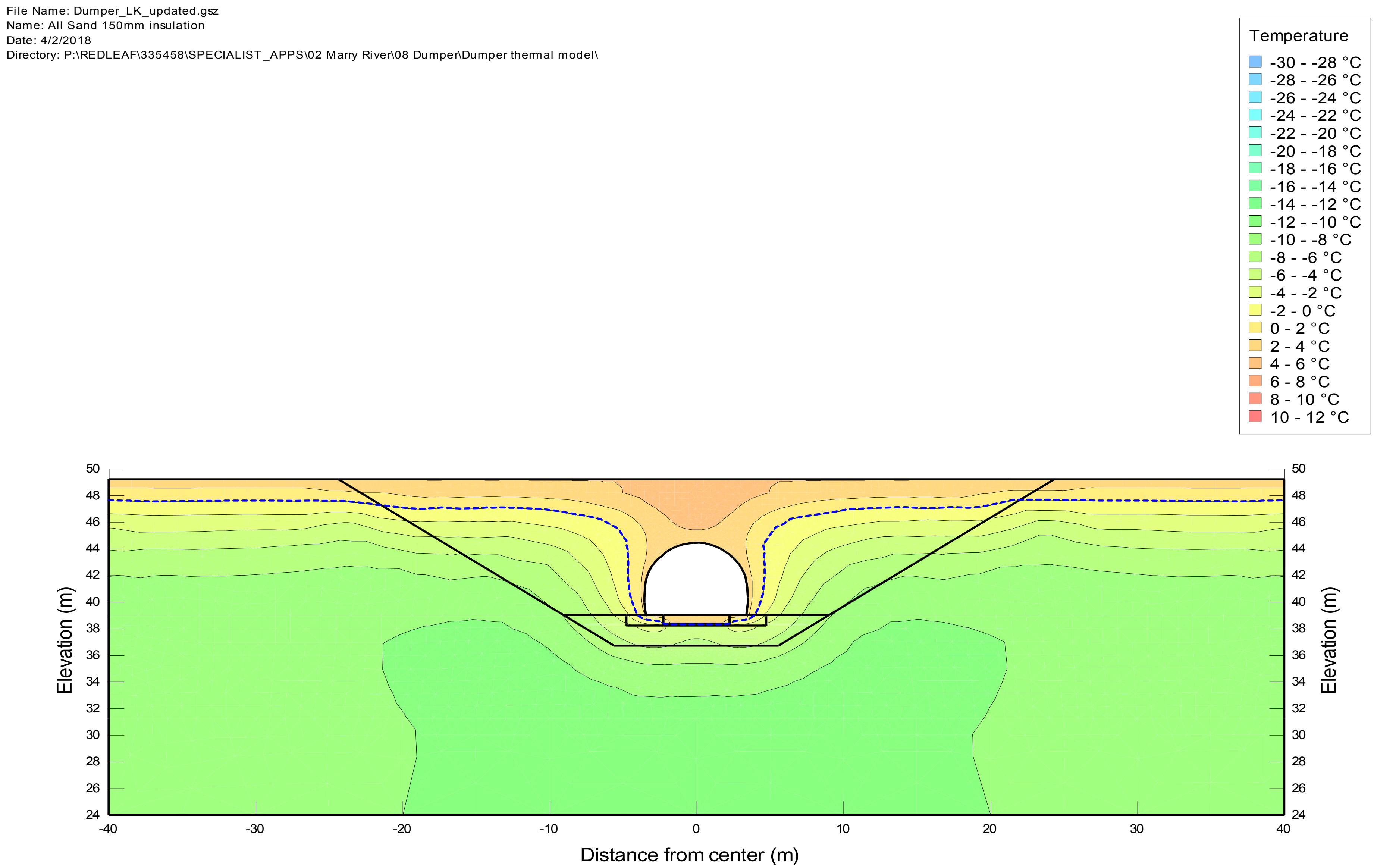
Ref	Tippler Load-out Tunnel		Insulation Temperature Contour In August (20 yr after construction)	Milne Inlet Port
By	Lk	0	02-Apr-18	
Revision	A		02-Apr-18	FIGURE A6d

HATCH



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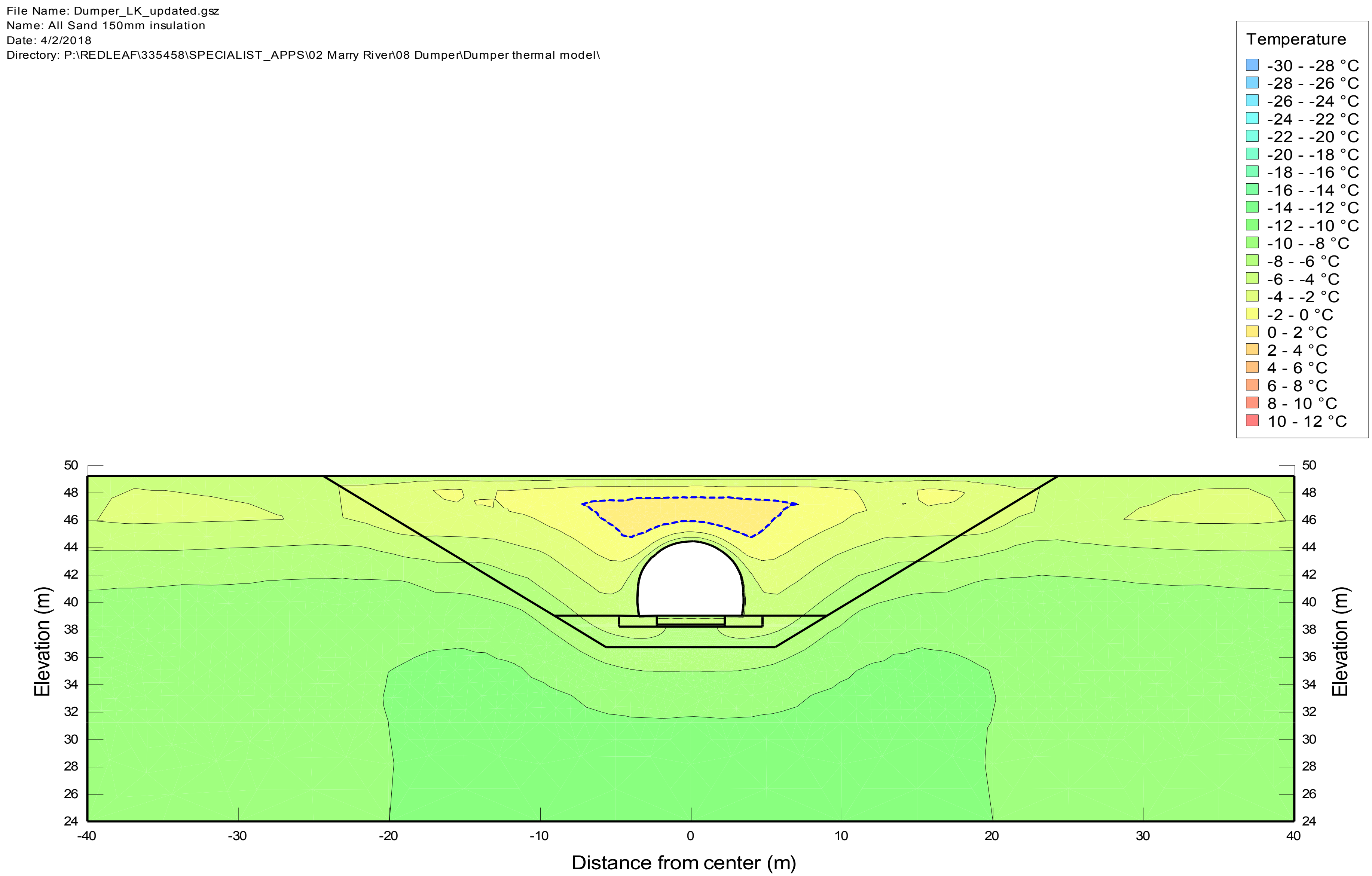
By	Lk	0	02-Apr-18		
Revision	A	02-Apr-18			**FIGURE A6e**



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By	Lk	0	02-Apr-18			
Revision		A	02-Apr-18			FIGURE A6f

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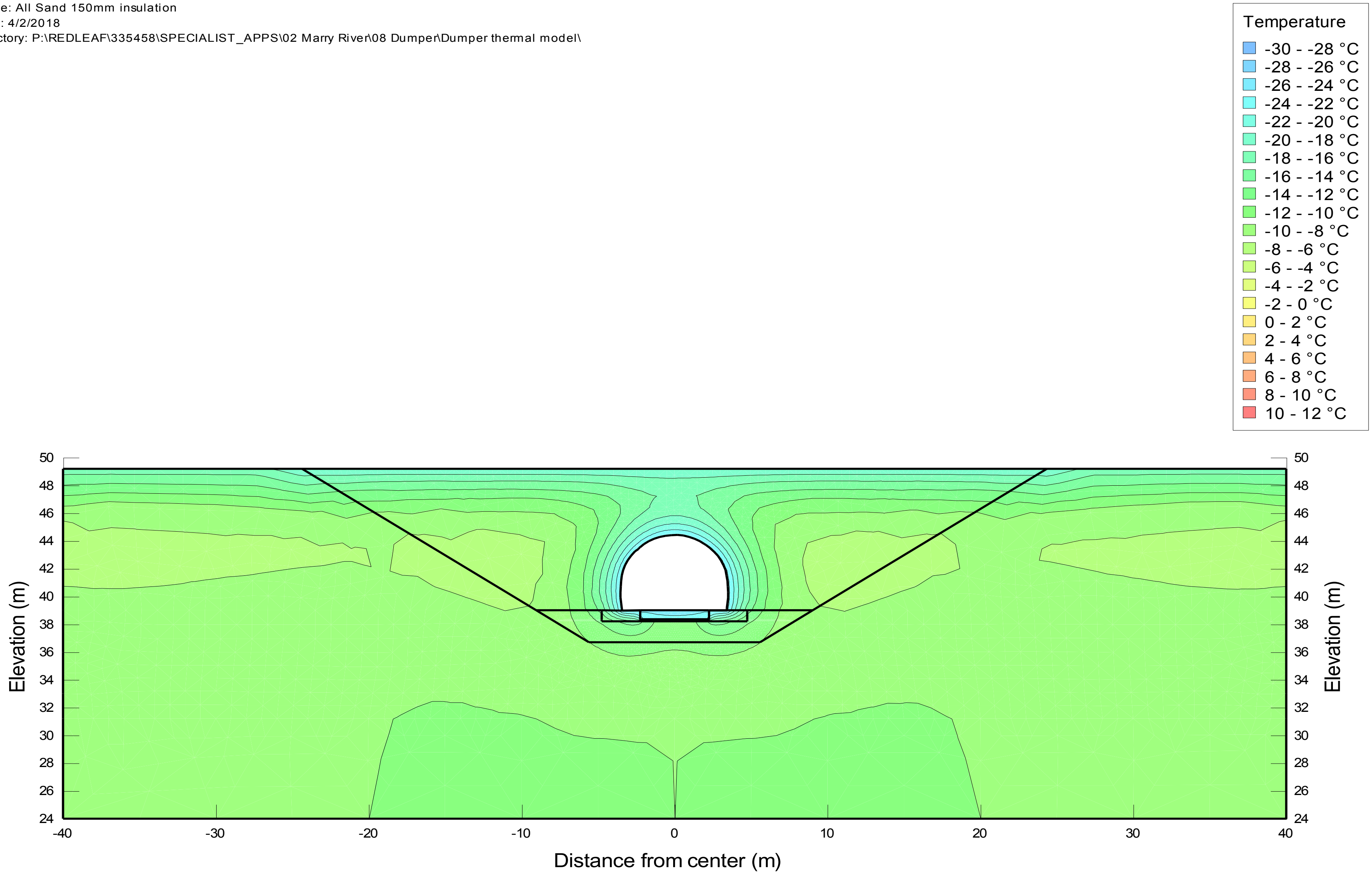

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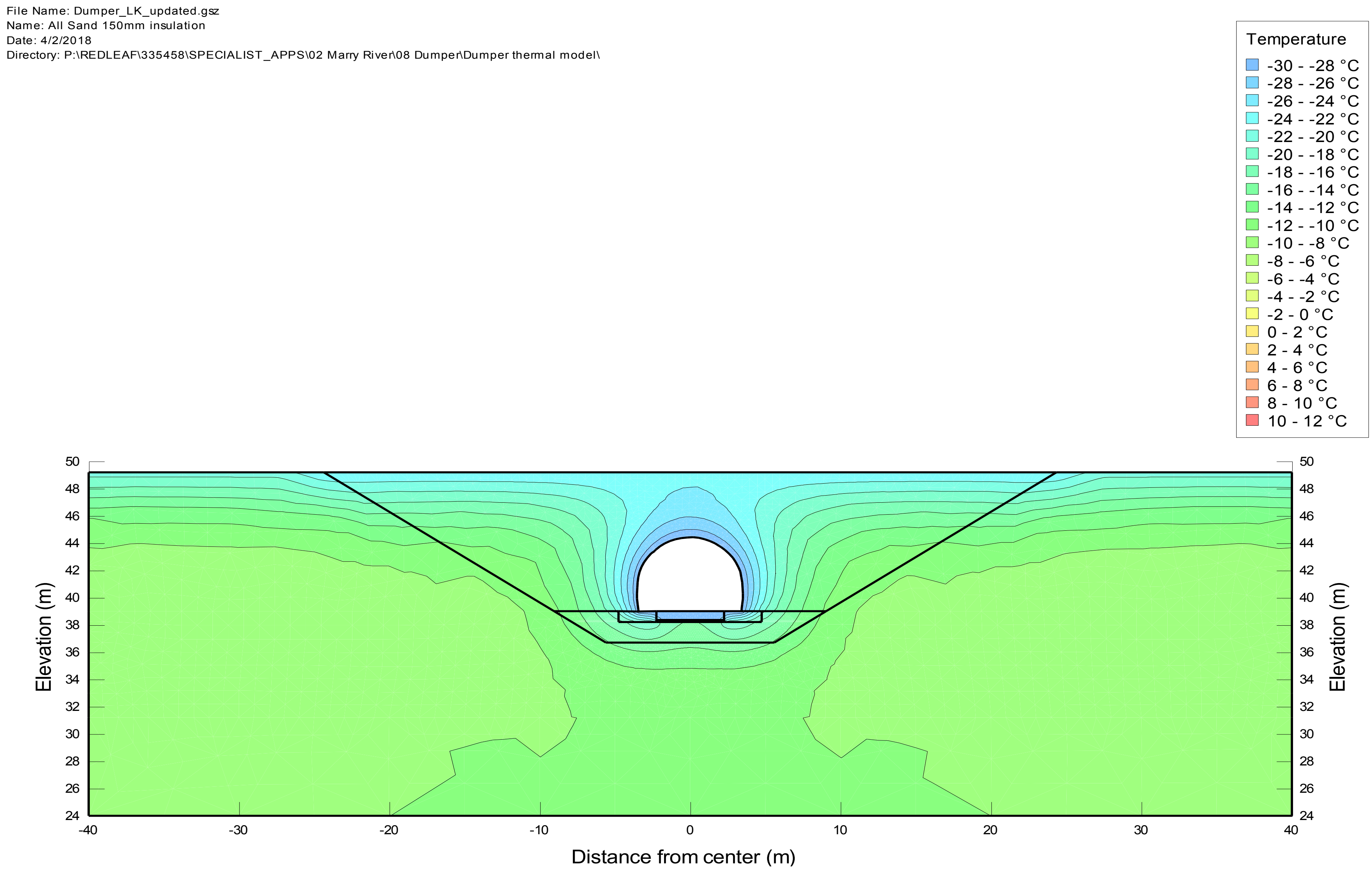
Revision	A		02-Apr-18			FIGURE A6g



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By	Lk	0	02-Apr-18			
Revision	A	02-Apr-18				FIGURE A6h

Appendix A2
Geotechnical Profile, Load-out Tunnel Configuration and Load Update

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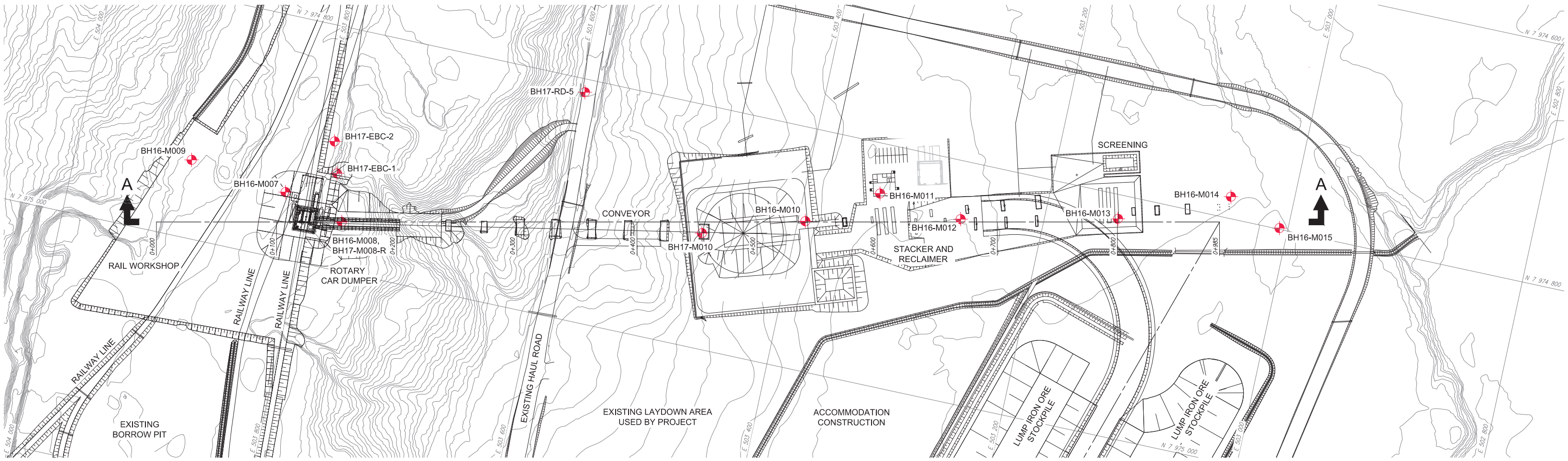
DWG. No.



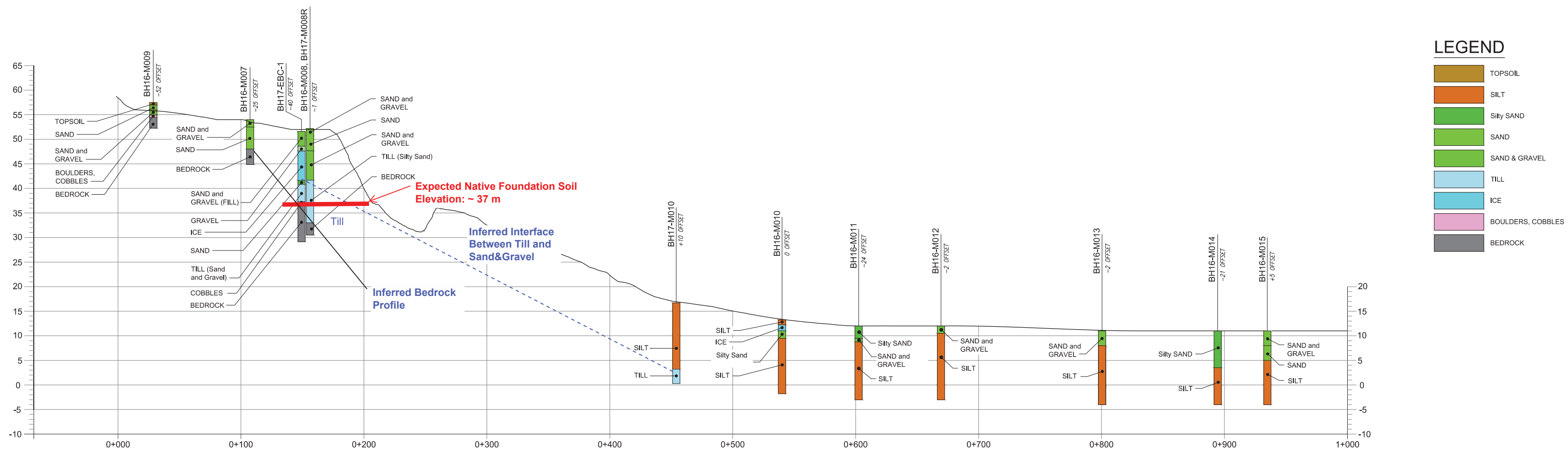
PLAN

0 50 100 150 200 METRES

SCALE: 1:2000

NOTE

PROCESSING LINE LAYOUT UPDATED LAST ON FEBRUARY 6TH., 2018



SECTION A-A

1:2000 HORIZONTAL 0 50 100 150 200 METRES

1:500 VERTICAL 0 10 20 30 40 50 METRES

Sketch 1

DRAWING No.	DRAWING TITLE
REFERENCE DRAWINGS	

NAME

SIGNATURE

ENG REG NUMBER

REVISION DATE

ORIGINAL DATE

REGISTERED PROFESSIONAL

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DESIGNER		NR	
CHECKER			2018-02-07
DESIGN COORD.			
RESP. ENG.	G QU		
LEAD DISC. ENG.			
ENG. MANAGER			
PROJ. MANAGER			
DRAWING APPROVAL STATUS:		INTERNAL REVIEW	

Baffinland

BAFFINLAND EXPANSION 12 MTPA MINE OPTION
PRE FEASIBILITY STUDY

PORT SITE
PROCESSING LINE
GEOLOGICAL PROFILE

SCALE	DWG. No.	REV
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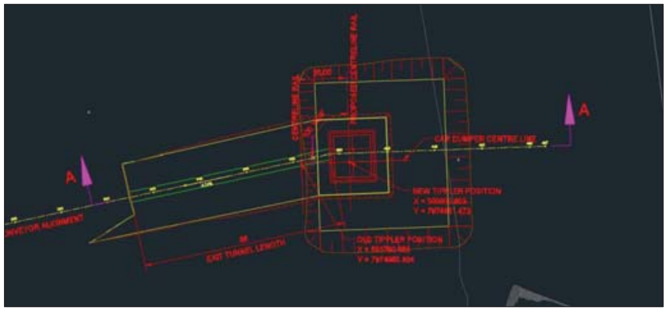
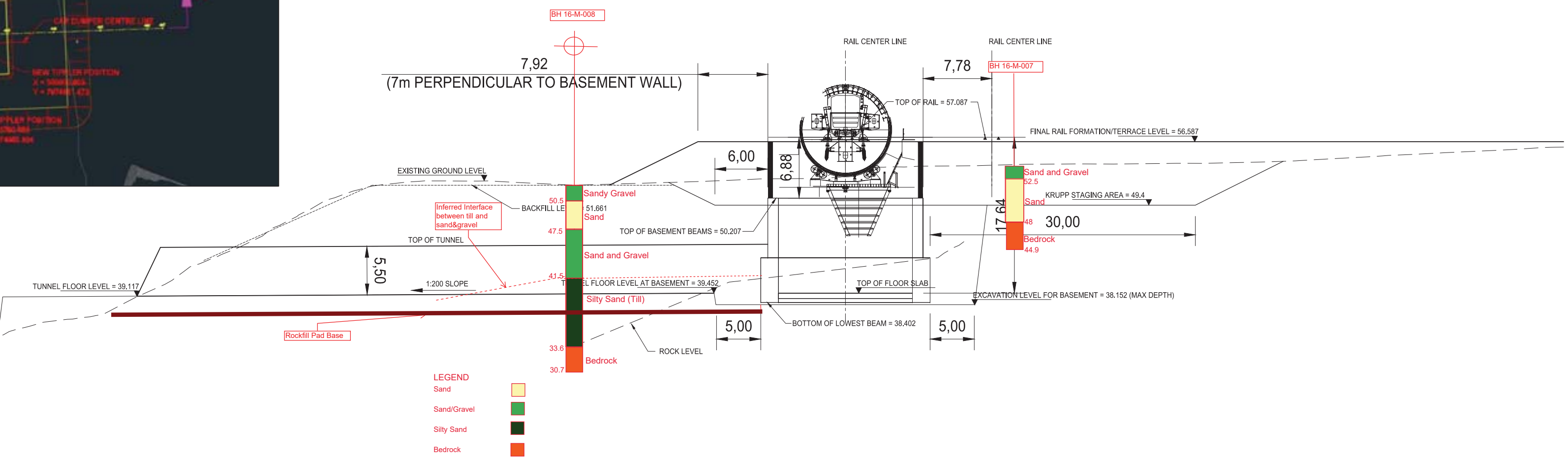
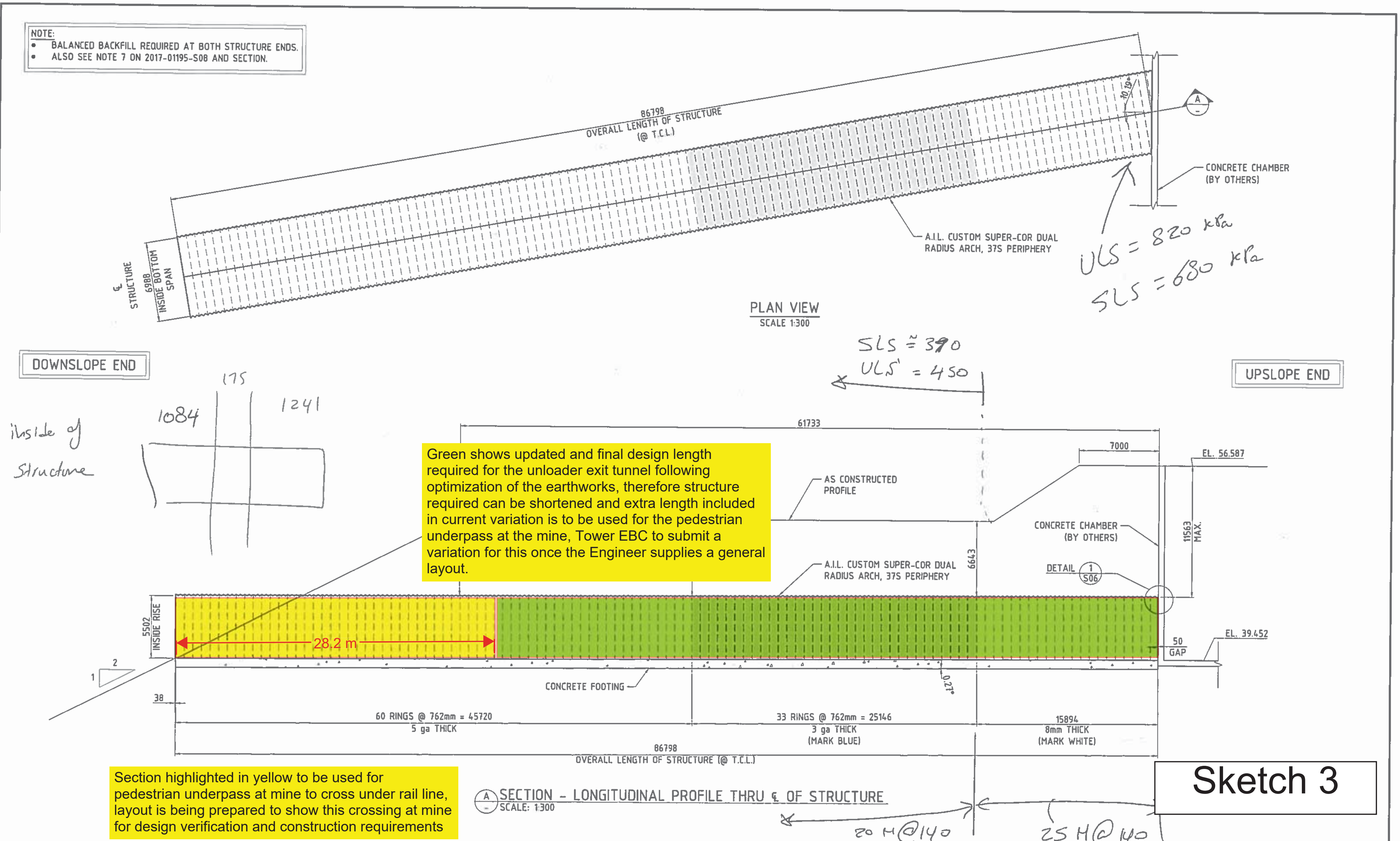




EXISTING GROUND LEVELS AT 5m INTERVAL	ROCK LEVELS AT 5m INTERVAL	BASEMENT/TUNNEL EXCAVATION LEVELS AT 5m INTERVAL
35.284		
32.854		
31.019		
31.125		
31.791		
32.212		
32.977		
33.728		
34.702		38.738
36.210		39.061
36.796		39.088
38.943		39.115
41.514		39.142
43.917		39.169
46.403		39.195
49.038		39.222
51.083		39.249
51.933		39.274
52.145		39.299
52.152		39.324
51.885		39.349
51.682	33.580	39.374
51.819	35.657	39.399
51.968	37.725	39.424
52.130	39.793	39.450
52.342	41.019	38.152
52.413	41.593	38.152
52.615	42.185	38.152
53.712	42.776	38.152
53.822	43.368	38.152
53.870		38.646
54.012		
54.061		
54.062		
54.106		
54.136		
54.233		
54.370		
54.635		
54.906		
55.176		
55.427		
55.656		
55.956		
55.976		

Sketch 2



\\AILENGINEERING\PROJECTS\2017\01195 - SC - RAIL CAR DUMPER CONVEYOR TUNNEL, NU\ORDER\DRAFTING\2017-01195 (R.1 NOT REL)

BRIAN HEANEY

Thursday, August 3, 2017 9:46:46 AM

REV NO.	DATE	BY	DESCRIPTION
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Atlantic Industries Limited
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BAFFINLAND IRON MINES CORPORATION
RAIL CAR DUMPER CONVEYOR TUNNEL - BAFFIN ISLAND, NU
PLAN VIEW & LONGITUDINAL PROFILE

DESIGNED	MME	19 JUN 17
DES. CHK	KW	21 JUN 17
DRAWN BY	BH	19 JUN 17
DWG. CHK	LM	21 JUN 17

BRANCH P.O.: -
CUSTOMER REF.: -
PROJECT NUMBER 2017-01195
DWG NO. G02
REV. 0

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Appendix A3
Borehole Logs and Geophysical Survey Data

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BOREHOLE REPORT

BH17-EBC-1

Client:	Baffinland Iron Mines Corporation	**Project No.:**	H353004
Project:	Mary River Expansion Project	**Datum:**	NAD 83
Location:	Rail Indexer Foundation	**Platform:**	Ground

Easting:	503,783.4 m
Northing:	7,974,920.8 m
Surface Elevation:	51.59 m
Bottom Elevation:	29.92 m
Total Depth:	21.7 m
Logged By:	R.S
Reviewed By:	G.Q

Contractor: Boart Longyear **Rig Type/ Mounting:** MiniSonic Rig **Date Logged:** 9/19/2017

Driller: Brent McAndrew **Hole Diameter (mm):** 100 mm **Date Reviewed:** 1/26/2018

Elevation (m)	Depth (m)	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Frozen Soil Description
51.59	0.0	SAND and GRAVEL (FILL): Brown. Material placed to create level drilling platform.	Unfrozen
48.6	3.0	SAND and GRAVEL with Silt: Brown and grey, frozen.	Nbn
		ICE, trace Silt: Grey to white.	ICE
		SAND, trace Silt: Brown, frozen. Ice poor soil.	Nbn
		ICE, trace Silt: White/clear.	ICE
		SAND, trace Silt: Light brown, occasional thin ice lenses. Ice poor soil.	Nbn-Vs

Elevation scale: 50.6, 49.6, 48.6, 47.6, 46.6, 45.6, 44.6, 43.6, 42.6, 41.6

Depth scale: 1.0, 2.0, 3.0, 4.0, 5.0, 6.0, 7.0, 8.0, 9.0, 10.0

Columns: Water, Elevation (m), Depth (m), Method, Casing, Graphic Log, Soil Description, Frozen Soil Description, Recovery, Sample Type, Moisture Content Profile (0, 50, 100), Other Tests

Notes:

BOREHOLE REPORT

BH17-EBC-1

Client: Baffinland Iron Mines Corporation
Project: Mary River Expansion Project
Location: Rail Indexer Foundation
Project No.: H353004
Datum: NAD 83
Platform: Ground

Easting:	503,783.4 m
Northing:	7,974,920.8 m
Surface Elevation:	51.59 m
Bottom Elevation:	29.92 m
Total Depth:	21.7 m
Logged By:	R.S
Reviewed By:	G.Q

Contractor: Boart Longyear **Rig Type/ Mounting:** MiniSonic Rig **Date Logged:** 9/19/2017
Driller: Brent McAndrew **Hole Diameter (mm):** 100 mm **Date Reviewed:** 1/26/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 50 100)	Other Tests
						SAND and GRAVEL some Silt: Brown. Ice poor soil.	Nbn				
	40.6	11.0									
	39.6	12.0									
	38.6	13.0									
						COBBLES and BEDROCK: Biege and brown, pulverized cobbles and bedrock, dry powdery, with layers of brown silty sand and gravel, moist. Top of poor quality bedrock, 14.04 m.					
	37.6	14.0				***Start of Coring at 14.0m. Continued on Rock Core Log sheet.***					
	36.6	15.0									
	35.6	16.0									
	34.6	17.0									
	33.6	18.0									
	32.6	19.0									
	31.6	20.0									

Notes:

BAFFINLAND GINT LIBRARY.GLB Log ICE BOREHOLE RAIL INDEXER BOREHOLES 2017_REV B.GPJ <<DrawingFile>> 04/04/2018 14:30

HATCH

BOREHOLE LOG

ROCK CORE FORMAT

BH17-EBC-1

Client:	Baffinland Iron Mines Corporation	**Project No.:**	H353004
Project:	Mary River Expansion Project	**Datum:**	NAD 83
Location:	Rail Indexer Foundation	**Platform:**	Ground

Easting:	503,783.4 m
Northing:	7,974,920.8 m
Surface Elevation:	51.59 m
Bottom Elevation:	29.92 m
Total Depth:	21.7 m
Logged By:	R.S
Reviewed By:	G.Q

Contractor: Boart Longyear **Rig Type/ Mounting:** MiniSonic Rig **Bearing:** N/A **Date Logged:** 9/19/2017

Driller: Brent McAndrew **Hole Diameter (mm):** 100 mm **Plunge:** Vertical **Date Checked:** 1/26/2018

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength EH VH H M L VL EL	Is(50) [UCS] MPa	Defect Spacing mm 2000 600 200 [100] 60 20	RQD %	Defect Log	Defect Description Inclination, type, infill, amount, aperture, planarity, roughness, frequency Specific / General
	40.6	11.0												
	39.6	12.0												
	38.6	13.0												
	37.6	14.0		2 / 100			***Resuming in Rock Core Format 14.0m.*** BEDROCK: Granitic Gneiss, medium to coarse grained, hard to very hard, pinkish-grey colour. Fractures are generally vertical, between 0 to 15 degrees and horizontal, from 70 to 90 degrees. Numerous joints and fractures infilled with clayey-silt and fine sand throughout.					0		Cz 70° Jt Pl Sm Silt sn Cz
				3 / 96						Dia 75.5		44		80° Jt Pl Sm sn Cz Jt 10° Dl Ir Ro 75° Jt Pl Sm 1 -2 mm clay sn
	36.6	15.0												0° Dl Ir Ro 10° Dl Ir Ro Cz
	35.6	16.0		4 / 88						Dia 182.5		6		
	34.6	17.0		5 / 106								56		60° Jt Pl Sm 1 -2 mm clay sn Fz 20° Jt Pl Sm 1 mm clay sn 40° Jt Pl Sm 1 mm clay sn 10° Dl Ir Ro 0° Dl Ir Ro 70° Jt Pl Sm 1 -2 mm clay sn
	33.6	18.0												60° Jt Pl Sm 1 mm clay cn 90° Dl Ir Ro
	32.6	19.0		6 / 99						Dia 151.7 [164] Dia 119.6		62		0° Dl Ir Ro 0° Dl Ir Ro 0° Dl Ir Ro 0° Dl Ir Ro 0° Dl Ir Ro 60° Jt Pl Sm 1 mm clay sn 10° Jt Pl Sm sn Jt 10° Jt Pl Sm 5mm Clay sn 10° Jt Pl Sm Silt sn 10° Jt Pl Sm Silt sn
	31.6	20.0												

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

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BOREHOLE LOG

ROCK CORE FORMAT

BH17-EBC-1

Client:	Baffinland Iron Mines Corporation	**Project No.:**	H353004
Project:	Mary River Expansion Project	**Datum:**	NAD 83
Location:	Rail Indexer Foundation	**Platform:**	Ground

Easting:	503,783.4 m
Northing:	7,974,920.8 m
Surface Elevation:	51.59 m
Bottom Elevation:	29.92 m
Total Depth:	21.7 m
Logged By:	R.S
Reviewed By:	G.Q

Contractor: Boart Longyear **Rig Type/ Mounting:** MiniSonic Rig **Bearing:** N/A **Date Logged:** 9/19/2017

Driller: Brent McAndrew **Hole Diameter (mm):** 100 mm **Plunge:** Vertical **Date Checked:** 1/26/2018

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength EH VH H M L VL EL	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm 2000 600 200 [100] 60 20	RQD %	Defect Log	Defect Description Inclination, type, infill, amount, aperture, planarity, roughness, frequency Specific / General
	30.6	21.0		7 / 100			BEDROCK: Granitic Gneiss, medium to coarse grained, hard to very hard, pinkish-grey colour. Fractures are generally vertical, between 0 to 15 degrees and horizontal, from 70 to 90 degrees. *(Continued)*			Dia 147.9		66		85° Jt Pl Sm Silt sn 85° Jt Pl Sm Silt sn 85° Jt Pl Sm Silt sn 85° Jt Pl Sm Silt sn 85° Jt Pl Sm 1 mm clay sn 85° Jt Pl Sm Silt sn 85° Jt Pl Sm Silt sn 85° Jt Pl Sm Silt sn 85° Jt Pl Sm Silt sn 85° Jt Pl Sm Silt sn 85° Jt Pl Sm Silt sn 10° Cz Ir Ro Silt 10° Dl Ir Ro Silt 10° Dl Ir Ro Silt 10° Dl Ir Ro Silt 10° Dl Ir Ro Silt
	29.6	22.0					To Target Depth. **Drillhole BH17-EBC-1 terminated at 21.7m.**							
	28.6	23.0												
	27.6	24.0												
	26.6	25.0												
	25.6	26.0												
	24.6	27.0												
	23.6	28.0												
	22.6	29.0												
	21.6	30.0												

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

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HATCH BOREHOLE REPORT

BH17-EBC-2

Sheet 1 of 4

Client:	Baffinland Iron Mines Corporation	**Project No.:**	H353004
Project:	Mary River Expansion Project	**Datum:**	NAD 83
Location:	Rail Indexer Foundation	**Platform:**	Ground

Easting:	503,790.9 m
Northing:	7,974,895.2 m
Surface Elevation:	54.05 m
Bottom Elevation:	32.21 m
Total Depth:	21.8 m
Logged By:	R.S
Reviewed By:	G.Q

Contractor: Boart Longyear **Rig Type/ Mounting:** MiniSonic Rig **Date Logged:** 9/24/2017

Driller: Brent McAndrew **Hole Diameter (mm):** 100 mm **Date Reviewed:** 1/26/2018

Elevation (m)	Depth (m)	Soil Description — TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description
		SAND and GRAVEL trace Cobbles: Brown, well graded up to 75 mm. Cobbles recovered are partially pulveriszed to dry, beige rock flour. Ice poor soil.	Unfrozen
53.1	1.0		
		SAND trace Silt: Brown, well graded. Ice poor soil.	Nbn
52.1	2.0		
51.1	3.0		
		SAND and GRAVEL trace Silt: Brown, wet, well graded. Ice poor soil.	Nbn
		GRAVEL with SAND, trace Silt. Brown, well graded. Ice poor soil.	Nbn
50.1	4.0		
49.1	5.0		
48.1	6.0		
47.1	7.0		
46.1	8.0		
		GRAVEL and SAND with SAND, some Sit: Brown and grey. Recovery by HQ core barrel. Silt and sand content is estimated from wash water recovery.	
45.1	9.0		
44.1	10.0		

Other columns: Water, Method, Casing, Graphic Log, Recovery, Sample Type, Moisture Content Profile (0, 50, 100), Other Tests

Notes:

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HATCH BOREHOLE REPORT

BH17-EBC-2

Client:	Baffinland Iron Mines Corporation	**Project No.:**	H353004
Project:	Mary River Expansion Project	**Datum:**	NAD 83
Location:	Rail Indexer Foundation	**Platform:**	Ground

Easting:	503,790.9 m
Northing:	7,974,895.2 m
Surface Elevation:	54.05 m
Bottom Elevation:	32.21 m
Total Depth:	21.8 m
Logged By:	R.S
Reviewed By:	G.Q

Contractor: Boart Longyear **Rig Type/ Mounting:** MiniSonic Rig **Date Logged:** 9/24/2017

Driller: Brent McAndrew **Hole Diameter (mm):** 100 mm **Date Reviewed:** 1/26/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Other Tests
	43.1	11.0				GRAVEL and SAND with SAND, some Sit: Brown and grey. Recovery by HQ core barrel. Silt and sand content is estimated from wash water recovery. *(Continued)*					
	42.1	12.0									
	41.1	13.0									
						Start of Coring at 13.3m. ***Continued on Rock Core Log sheet.***					
	40.1	14.0									
	39.1	15.0									
	38.1	16.0									
	37.1	17.0									
	36.1	18.0									
	35.1	19.0									
	34.1	20.0									

Notes:

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BOREHOLE LOG
ROCK CORE FORMAT

BH17-EBC-2

Client:	Baffinland Iron Mines Corporation	**Project No.:**	H353004
Project:	Mary River Expansion Project	**Datum:**	NAD 83
Location:	Rail Indexer Foundation	**Platform:**	Ground

Easting:	503,790.9 m
Northing:	7,974,895.2 m
Surface Elevation:	54.05 m
Bottom Elevation:	32.21 m
Total Depth:	21.8 m
Logged By:	R.S
Reviewed By:	G.Q

Contractor: Boart Longyear **Rig Type/ Mounting:** MiniSonic Rig **Bearing:** N/A **Date Logged:** 9/24/2017

Driller: Brent McAndrew **Hole Diameter (mm):** 100 mm **Plunge:** Vertical **Date Checked:** 1/26/2018

Column headings: Water | Elevation (m) | Depth (m) | Method | Run #/TCR | Graphic Log | Geological Unit | **Rock Description** (ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.) | Weathering/ Cementation | Estimated Strength (EH VH H M L VL EL) | $Is_{(50)}$ [UCS] MPa | Defect Spacing mm (2000 600 200 [100] 60 20) | RQD % | Defect Log | **Defect Description** (Inclination, type, infill, amount, aperture, planarity, roughness, frequency; Specific / General)

Elevation (m)	Depth (m)
43.1	11.0
42.1	12.0
41.1	13.0
40.1	14.0
39.1	15.0
38.1	16.0
37.1	17.0
36.1	18.0
35.1	19.0
34.1	20.0

Resuming in Rock Core Format 13.3m.

BEDROCK: Granitic Gneiss, medium to coarse grained, hard to very hard, pinkish-grey colour. Fractures are generally vertical, between 0 to 15 degrees and horizontal, from 70 to 90 degrees.

Numerous joints and fractures infilled with clayey-silt and fine sand throughout.

Run #/TCR: 9 / 107; 10 / 103; 11 / 130; 12 / 105; 13 / 97

RQD %: 48; 74; 39; 59; 42

$Is_{(50)}$ [UCS] MPa: Dia 100.7; Dia 157.4; [161.5]; Dia 133.8; Dia 70.81

Defect Description:
- DI
- 10° DI Ir Ro
- 10° Cz Ir Ro Silt
- 10° Jt Pl Ro 3 mm clay sn
- 10° Jt Pl Ro Silt sn
- 10° Cz Ir Ro
- 65° Jt Pl Sm Silt
- Cz
- 10° Jt Pl Sm Silt
- 10° Jt Pl Sm Silt
- 10° DI Ir Ro Silt
- 10° DI Ir Ro Silt
- 10° DI Ir Ro Silt
- 10° DI Ir Ro Silt
- 10° DI Ir Ro Silt
- 10° DI Ir Ro Silt
- 10° DI Ir Ro Silt
- Cz
- 75° Jt Pl Sm 4mm Clayey sn
- 10° Jt Pl Sm Silt
- 10° Jt Pl Sm Silt sn
- Cz
- 75° Jt Pl Ro sn
- 10° Jt Pl Sm Silt sn
- 10° Jt Pl Sm Silt sn
- 5° Jt Pl Sm Silt sn
- 0° Jt Pl Sm Silt sn
- 0° DI Ir Ro
- 60° Jt Pl Sm Silt cg
- 0° DI Ir Ro
- 15° Jt Pl Sm Silt sn
- 20° Jt Pl Sm Silt sn
- 20° DI Ir Ro
- 85° Jt Pl Sm Silt sn
- 20° Jt Pl
- DI
- 20° Jt Pl Sm Silt sn
- 10° Jt Pl Sm Silt sn
- Cz
- 85° Jt Pl Sm Silt sn
- DI

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	DI	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

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BOREHOLE LOG

ROCK CORE FORMAT

BH17-EBC-2

Client:	Baffinland Iron Mines Corporation	**Project No.:**	H353004
Project:	Mary River Expansion Project	**Datum:**	NAD 83
Location:	Rail Indexer Foundation	**Platform:**	Ground

Easting:	503,790.9 m
Northing:	7,974,895.2 m
Surface Elevation:	54.05 m
Bottom Elevation:	32.21 m
Total Depth:	21.8 m
Logged By:	R.S
Reviewed By:	G.Q

Contractor:	Boart Longyear	**Rig Type/ Mounting:**	MiniSonic Rig	**Bearing:**	N/A	**Date Logged:**	9/24/2017
Driller:	Brent McAndrew	**Hole Diameter (mm):**	100 mm	**Plunge:**	Vertical	**Date Checked:**	1/26/2018

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description: ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	$Is_{(50)}$ [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log
				14 / 100	+ + +		BEDROCK: Granitic Gneiss, medium to coarse grained, hard to very hard, pinkish-grey colour. Fractures are generally vertical, between 0 to 15 degrees and horizontal, from 70 to 90 degrees. *(Continued)*					42	
	33.1	21.0										42	
	32.1	22.0					To Target Depth. **Drillhole BH17-EBC-2 terminated at 21.8m.**						
	31.1	23.0											
	30.1	24.0											
	29.1	25.0											
	28.1	26.0											
	27.1	27.0											
	26.1	28.0											
	25.1	29.0											
	24.1	30.0											

Defect Description

Inclination, type, infill, amount, aperture, planarity, roughness, frequency

Specific / General

- 85° Jt Pl Sm Silt sn
- 20° Jt Pl Sm Silt sn
- 15° Jt Pl Sm Silt sn
- 30° Jt Pl Sm Silt sn
- 0° Dl Ir Ro
- 85° Jt Pl Sm Silt sn
- 0° Dl Ir Ro
- 20° Jt Pl Sm Silt sn
- 15° Jt Pl Sm Silt sn
- 25° Dl Ir Ro
- 10° Jt Pl Sm Silt sn
- Cz
- 5° Jt Pl Sl vn
- Cz
- 0° Dl Ir Ro
- 0° Dl Ir Ro
- 0° Dl Ir Ro
- 0° Dl Ir Ro
- 0° Jt Pl Ro Silt sn
- 0° Jt Pl Ro Silt sn
- 0° Jt Pl Ro Silt sn
- 0° Jt Pl Ro Silt sn
- 0° Dl Ir Ro

Notes:

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

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BOREHOLE REPORT

BH17-M008-R

Client: Baffinland Iron Mines Corporation

Project: Mary River Expansion Project

Location: Rail Indexer Foundation

Project No.: H353004

Datum: NAD 83

Platform: Ground

Easting:	503,772.0 m
Northing:	7,974,960.0 m
Surface Elevation:	52.00 m
Bottom Elevation:	30.01 m
Total Depth:	22.0 m
Logged By:	R.S
Reviewed By:	G.Q

Contractor: Boart Longyear | **Rig Type/ Mounting:** MiniSonic Rig | **Date Logged:** 9/17/2017

Driller: Brent McAndrew | **Hole Diameter (mm):** 100 mm | **Date Reviewed:** 1/26/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)						Other Tests
						NO SAMPLES TAKEN IN OVERBURDEN. Advanced sonic tube to refusal and began diamond coring bedrock.										
	51.0	1.0														
	50.0	2.0														
	49.0	3.0														
	48.0	4.0														
	47.0	5.0														
	46.0	6.0														
	45.0	7.0														
	44.0	8.0														
	43.0	9.0														
	42.0	10.0														

Notes: Redrill of BH16-M008. Elevation is approximate.

HATCH

BOREHOLE REPORT

BH17-M008-R

Client: Baffinland Iron Mines Corporation
Project No.: H353004
Project: Mary River Expansion Project
Datum: NAD 83
Location: Rail Indexer Foundation
Platform: Ground

Easting: 503,772.0 m
Northing: 7,974,960.0 m
Surface Elevation: 52.00 m
Bottom Elevation: 30.01 m
Total Depth: 22.0 m
Logged By: R.S
Reviewed By: G.Q

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 9/17/2017
Driller: Brent McAndrew
Hole Diameter (mm): 100 mm
Date Reviewed: 1/26/2018

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Frozen Soil Description	Recovery	Sample Type	Moisture Content Profile (0 – 50 – 100)	Other Tests
						NO SAMPLES TAKEN IN OVERBURDEN. Advanced sonic tube to refusal and began diamond coring bedrock. *(Continued)*					
	41.0	11.0									
	40.0	12.0									
	39.0	13.0									
	38.0	14.0									
	37.0	15.0									
	36.0	16.0									
	35.0	17.0									
						Start of Coring at 17.4m. Continued on Rock Core Log sheet.					
	34.0	18.0									
	33.0	19.0									
	32.0	20.0									

Notes: Redrill of BH16-M008. Elevation is approximate.

BAFFINLAND GINT LIBRARY.GLB Log ICE BOREHOLE RAIL INDEXER BOREHOLES 2017_REV B.GPJ <<DrawingFile>> 04/04/2018 14:30

BOREHOLE LOG
ROCK CORE FORMAT

BH17-M008-R

Client: Baffinland Iron Mines Corporation
Project No.: H353004
Project: Mary River Expansion Project
Datum: NAD 83
Location: Rail Indexer Foundation
Platform: Ground

Easting: 503,772.0 m
Northing: 7,974,960.0 m
Surface Elevation: 52.00 m
Bottom Elevation: 30.01 m
Total Depth: 22.0 m
Logged By: R.S
Reviewed By: G.Q

Contractor: Boart Longyear **Rig Type/ Mounting:** MiniSonic Rig **Bearing:** N/A **Date Logged:** 9/17/2017
Driller: Brent McAndrew **Hole Diameter (mm):** 100 mm **Plunge:** Vertical **Date Checked:** 1/26/2018

Water	Elevation (m)	Depth (m)	Method	Run #/TCR	Graphic Log	Geological Unit	Rock Description: ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.	Weathering/ Cementation	Estimated Strength (EH VH H M L VL EL)	Is(50) [UCS] MPa	Defect Spacing mm (2000 600 200 [100] 60 20)	RQD %	Defect Log	Defect Description (Inclination, type, infill, amount, aperture, planarity, roughness, frequency) Specific / General
	41.0	11.0												
	40.0	12.0												
	39.0	13.0												
	38.0	14.0												
	37.0	15.0												
	36.0	16.0												
	35.0	17.0					***Resuming in Rock Core Format 17.4m.***							Fz
	34.0	18.0		1 / 101			BEDROCK: Granitic Gneiss, medium to coarse grained, hard to very hard, pinkish-grey colour. Fractures are generally vertical, between 0 to 15 degrees and horizontal, from 70 to 90 degrees. Numerous joints and fractures infilled with clayey-silt and fine sand throughout.					0		
	33.0	19.0		2 / 98						Dia 70.8; Dia 47.2; Dia 23.6		64		10° Dl Ir Ro; 10° Jt Ir Sm Clay infill 40mm sn; Dl; Dl; Fz; 10° Jt Pl Sm Silt sn
	32.0	20.0												

Notes: Redrill of BH16-M008. Elevation is approximate.

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	Dl	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

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BOREHOLE LOG

ROCK CORE FORMAT

BH17-M008-R

Client:	Baffinland Iron Mines Corporation	**Project No.:**	H353004
Project:	Mary River Expansion Project	**Datum:**	NAD 83
Location:	Rail Indexer Foundation	**Platform:**	Ground

Easting:	503,772.0 m
Northing:	7,974,960.0 m
Surface Elevation:	52.00 m
Bottom Elevation:	30.01 m
Total Depth:	22.0 m
Logged By:	R.S
Reviewed By:	G.Q

Contractor: Boart Longyear **Rig Type/ Mounting:** MiniSonic Rig **Bearing:** N/A **Date Logged:** 9/17/2017

Driller: Brent McAndrew **Hole Diameter (mm):** 100 mm **Plunge:** Vertical **Date Checked:** 1/26/2018

Elevation (m)	Depth (m)	Run #/TCR	Rock Description (ROCK TYPE; Grain size, texture and fabric, colour, general defect conditions, minor constituents.)	Is(50) [UCS] MPa	RQD %	Defect Description (Inclination, type, infill, amount, aperture, planarity, roughness, frequency)
31.0	21.0	2 / 98 3 / 97	BEDROCK: Granitic Gneiss, medium to coarse grained, hard to very hard, pinkish-grey colour. Fractures are generally vertical, between 0 to 15 degrees and horizontal, from 70 to 90 degrees. *(Continued)*	Dia 94.4 [57.9] [46.1] [94.8] Dia 100.7	64 68	10° DI Ir Ro 10° DI Ir Ro 10° DI Ir Ro 10° DI Ir Ro 30° Jt Pl Sm Silt sn 10° DI Ir Ro 10° DI Ir Ro 10° Jt Cu Sm Silt sn 45° DI Ir Ro 0° DI Ir Ro 10° Jt Ir Ro Silt sn 50° Jt Ir Ro Silt sn 0° DI Ir Ro 0° Jt Ir Sm Silt sn 10° DI Ir Ro
30.0	22.0		To Target Depth. **Drillhole BH17-M008-R terminated at 22.0m.**			
29.0	23.0					
28.0	24.0					
27.0	25.0					
26.0	26.0					
25.0	27.0					
24.0	28.0					
23.0	29.0					
22.0	30.0					

Estimated Strength: EH VH H M L VL EL

Defect Spacing mm: 2000 600 200 [100] 60 20

Notes: Redrill of BH16-M008. Elevation is approximate.

Defect Description Legend

Planarity		Type				Roughness		Infill Amount	
Pl	Planar	DI	Drilling Induced	Sm	Seam	Ro	Rough	cn	Clean
Ir	Irregular	Jt	Joint	Cz	Crushed Zone	Sm	Smooth	sn	Stained
Cu	Curved	Pt	Parting on Contact	Fz	Fractured Zone	Po	Polished	vn	Veneer
Un	Undulose	Sh	Shear Seam	Band	Weak Band	Sl	Slickenside	cg	Coating
St	Stepped	Cs	Crushed Seam						

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HATCH

BOREHOLE REPORT

BH16-M008

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Milne Port Train Unloading

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 503,771.0 m
Northing: 7,974,959.0 m
Surface Elevation: 52.00 m
Bottom Elevation: 30.66 m
Total Depth: 21.3 m
Logged By: UK
Reviewed By: SH/WH

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 10/4/2016
Driller: E.Beachamp
Hole Diameter (mm): 96
Date Reviewed: 2/10/2017

Water: Unobserved due to Permafrost
Method: Vibracore
Casing: H-Casing [18.8]

Elevation (m)	Depth (m)	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Moisture Condition	Consistency/ Density	Sample Type	Recovery %	Blows	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
		SANDY GRAVEL: Rounded to sub angular gravel, coarse grained sand, well graded												
50.0	2.0	SAND: Coarse to fine grained												
		3.00 m to 4.60 m: Some SILT						18	0	73	27			
48.0	4.0													
		SAND and GRAVEL: Coarse grained sand												
46.0	6.0													
		6.90 m to 7.60 m: Zone of inferred cobbles												
44.0	8.0							20						
42.0	10.0													
		SILTY SAND, some GRAVEL: Fine to coarse, subangular gravel						9						
40.0	12.0							12						
		12.20 m to 12.60 m: GRAVELLY SILTY SAND												
38.0	14.0	13.80 m to 15.40 m: SILTY SAND												
36.0	16.0													
34.0	18.0													
		Start of Coring at 18.8m.												
32.0	20.0	***Continued on Rock Core Log sheet.***												

Notes:

HATCH — BOREHOLE REPORT

BH16-M009

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Milne Port Train Unloading
Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 503,904.0 m
Northing: 7,974,935.0 m
Surface Elevation: 57.50 m
Bottom Elevation: 52.32 m
Total Depth: 5.2 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 10/4/2016
Driller: Samuel Flynn
Hole Diameter (mm): 96
Date Reviewed: 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Moisture Condition	Consistency/ Density	Sample Type	Recovery %	Blows	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
Unobserved due to Permafrost			Vibracore	H-Casing		ORGANICS: Organic soil												
						GRAVELLY SAND: Light brown to grey, angular to subgranular gravel, medium to coarse grained sand												
	55.5	2.0				SAND and GRAVEL: Grey to light brown, Fine to coarse grained sand, angular to subangular gravel												
				[3.7]		Inferred BOULDERS with SAND: Coarse to fine grained sand												
	53.5	4.0				***Start of Coring at 3.7m.***												
						Continued on Rock Core Log sheet.												
	51.5	6.0																
	49.5	8.0																
	47.5	10.0																
	45.5	12.0																
	43.5	14.0																
	41.5	16.0																
	39.5	18.0																
	37.5	20.0																

Notes:

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BOREHOLE REPORT

BH16-M010
Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Milne Port Crusher
Project No.: H352034
Datum: NAD83
Platform: Ground
Easting: 503,394.0 m
Northing: 7,974,877.0 m
Surface Elevation: 13.30 m
Bottom Elevation: -1.90 m
Total Depth: 15.2 m
Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 12/9/2016
Logged By: MR
Driller: Michael Scott
Hole Diameter (mm): 96
Date Reviewed: 2/10/2017
Reviewed By: SH/WH

Method: Vibrocore; Casing: H-Casing [15.2]

Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines
SILT, some SAND: Brown, moist				
ICE: Soft, white, cloudy texture	28	0	16	84
GRAVELLY SILTY SAND: Light brown and grey				
SILT and SAND: Organic silt, brown, moist				
SILT, trace SAND: Organic, dark grey to brown, moist	100	0	4	96
	32			

Elevation (m): 11.3, 9.3, 7.3, 5.3, 3.3, 1.3, -0.7, -2.7, -4.7, -6.7
Depth (m): 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0

To Target Depth.
Drillhole BH16-M010 terminated at 15.2m.

Notes:

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BOREHOLE REPORT

HATCH

BH16-M011

Sheet 1 of 1

Client: Baffinland Iron Mines
Project No.: H352034
Project: Mary River Expansion Study Stage 2
Datum: NAD83
Location: Milne Port Crusher
Platform: Ground

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 12/4/2016
Driller: Michael Scott
Hole Diameter (mm): 96
Date Reviewed: 2/10/2017

Easting:	503,339.0 m
Northing:	7,974,868.0 m
Surface Elevation:	12.00 m
Bottom Elevation:	-3.20 m
Total Depth:	15.2 m
Logged By:	MR
Reviewed By:	SH/WH

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Moisture Condition	Consistency/ Density	Sample Type	Recovery %	Blows	Moisture Content Profile	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	12.0 to 9.0	0.0 to 3.0	Vibrocore	H-Casing		SILTY SAND: Light brown, moist							16	0	68	32			
	9.0 to 8.3	3.0 to 3.7				SAND and GRAVEL: Light brown, moist, subangular gravel							10						
	8.3 to -3.2	3.7 to 15.2		[15.2]		SILT, trace SAND: Dark grey, moist													
						To Target Depth. **Drillhole BH16-M011 terminated at 15.2m.**													

Elevation scale (m): 10.0, 8.0, 6.0, 4.0, 2.0, 0.0, -2.0, -4.0, -6.0, -8.0
Depth scale (m): 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0

Notes:

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HATCH BOREHOLE REPORT

BH16-M012

Sheet 1 of 1

Client: Baffinland Iron Mines

Project: Mary River Expansion Study Stage 2

Location: Milne Port Generator

Project No.: H352034

Datum: NAD83

Platform: Ground

Easting: 503,268.0 m

Northing: 7,974,848.0 m

Surface Elevation: 12.00 m

Bottom Elevation: -3.20 m

Total Depth: 15.2 m

Logged By: MR

Reviewed By: SH/WH

Contractor: Boart Longyear | **Rig Type/ Mounting:** MiniSonic Rig | **Date Logged:** 12/8/2016

Driller: Michael Scott | **Hole Diameter (mm):** 96 | **Date Reviewed:** 2/10/2017

Water	Elevation (m)	Depth (m)	Method	Casing	Graphic Log	Soil Description: TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.	Moisture Condition	Consistency/ Density	Sample Type	Recovery %	Blows	Moisture Content Profile	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
	12.0–10.5	0.0–1.5	Vibrocore	H-Casing		SAND and GRAVEL, some SILT, trace COBBLES: Light brown, rounded							6	39	45	17			
	10.5–(-3.2)	1.5–15.2	Vibrocore	H-Casing [15.2]		SILT, some SAND: Dark grey							21	0	16	84			
		15.2				To Target Depth. **Drillhole BH16-M012 terminated at 15.2m.**													

Elevation scale: 10.0, 8.0, 6.0, 4.0, 2.0, 0.0, -2.0, -4.0, -6.0, -8.0

Depth scale: 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0

Notes:

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BOREHOLE REPORT

HATCH

BH16-M013
Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Milne Port Screening
Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 503,140.0 m
Northing: 7,974,820.0 m
Surface Elevation: 11.00 m
Bottom Elevation: -4.20 m
Total Depth: 15.2 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 12/5/2016
Driller: Michael Scott
Hole Diameter (mm): 96
Date Reviewed: 2/10/2017

Method: Vibrocore
Casing: H-Casing [15.2]

Elevation (m)	Depth (m)	Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines
		Organic soil and GRAVEL				
		GRAVELLY SAND, some SILT: Light brown, medium to coarse grained sand, rounded to subangular gravel	25	32	48	20
		SILT, some SAND: Dark grey	21	5	33	61
	15.2	To Target Depth. **Drillhole BH16-M013 terminated at 15.2m.**				

Other column headings: Water, Graphic Log, Moisture Condition, Consistency/ Density, Sample Type, Recovery %, Blows, Moisture Content Profile, Liquid Limit, Plastic Index, Other Tests

Elevation scale (m): 9.0, 7.0, 5.0, 3.0, 1.0, -1.0, -3.0, -5.0, -7.0, -9.0
Depth scale (m): 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0

Notes:

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BOREHOLE REPORT

BH16-M014

Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Milne Port Tail Pulley
Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 503,052.0 m
Northing: 7,974,782.0 m
Surface Elevation: 11.00 m
Bottom Elevation: -4.20 m
Total Depth: 15.2 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged: 12/5/2016
Driller: Michael Scott
Hole Diameter (mm): 96
Date Reviewed: 2/10/2017

Method: Vibrocore
Casing: H-Casing [15.2]

Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
GRAVELLY SILTY SAND: Grey to brown, angular to subangular gravel	6	22	52	26			
SILTY SAND: Grey	21	0	78	22			
SILT, some SAND: Dark grey, fine grained sand							
To Target Depth. **Drillhole BH16-M014 terminated at 15.2m.**							

Column headings: Water, Elevation (m), Depth (m), Method, Casing, Graphic Log, Soil Description, Moisture Condition, Consistency/ Density, Sample Type, Recovery %, Blows, Moisture Content Profile, Field Water Content, Percent Gravel, Percent Sand, Percent Fines, Liquid Limit, Plastic Index, Other Tests

Elevation (m) scale: 9.0, 7.0, 5.0, 3.0, 1.0, -1.0, -3.0, -5.0, -7.0, -9.0
Depth (m) scale: 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0

Notes:

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BOREHOLE REPORT

BH16-M015

Sheet 1 of 1

Client: Baffinland Iron Mines
Project: Mary River Expansion Study Stage 2
Location: Milne Port Tail Pulley Alt.

Project No.: H352034
Datum: NAD83
Platform: Ground

Easting: 503,007.0 m
Northing: 7,974,799.0 m
Surface Elevation: 11.00 m
Bottom Elevation: -4.20 m
Total Depth: 15.2 m
Logged By: MR
Reviewed By: SH/WH

Contractor: Boart Longyear
Rig Type/ Mounting: MiniSonic Rig
Date Logged:
Driller: Michael Scott
Hole Diameter (mm): 96
Date Reviewed: 2/10/2017

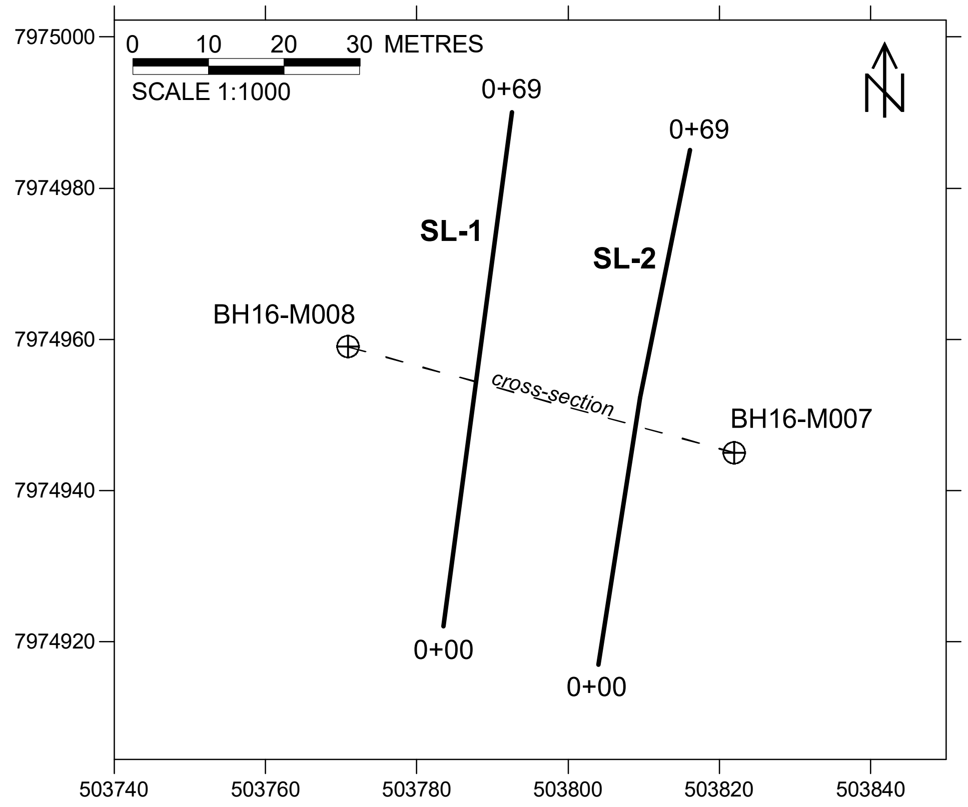
Method: Vibrocore; Casing: H-Casing [15.2]

Soil Description (TYPE; plasticity or particle characteristics (size, grading, shape, roundness), colour, structure, accessory components.)	Field Water Content	Percent Gravel	Percent Sand	Percent Fines	Liquid Limit	Plastic Index	Other Tests
SAND and GRAVEL, trace SILT, trace COBBLES: Light brown to grey, fine to coarse grained sand, rounded gravel	1	32	59	10			
SAND, trace SILT: Light brown, fine to coarse grained sand,	14	15	71	14			
SILT, some SAND: Dark grey to brown	24						
	27						
To Target Depth. **Drillhole BH16-M015 terminated at 15.2m.**							

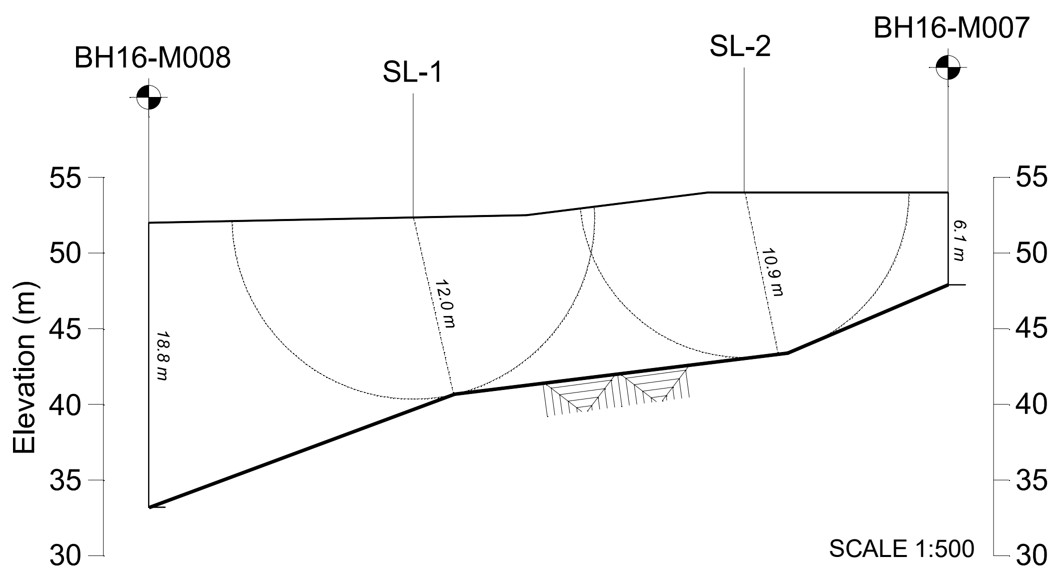
Depth (m): 2.0, 4.0, 6.0, 8.0, 10.0, 12.0, 14.0, 16.0, 18.0, 20.0
Elevation (m): 9.0, 7.0, 5.0, 3.0, 1.0, -1.0, -3.0, -5.0, -7.0, -9.0

Notes:

BAFFINLAND GINT LIBRARY.GLB Log SOIL BOREHOLE RAIL ALIGNMENT ALL_WITH ICE LOG_REV 3.GPJ <<DrawingFile>> 02/10/2017 17:43



Cross-section



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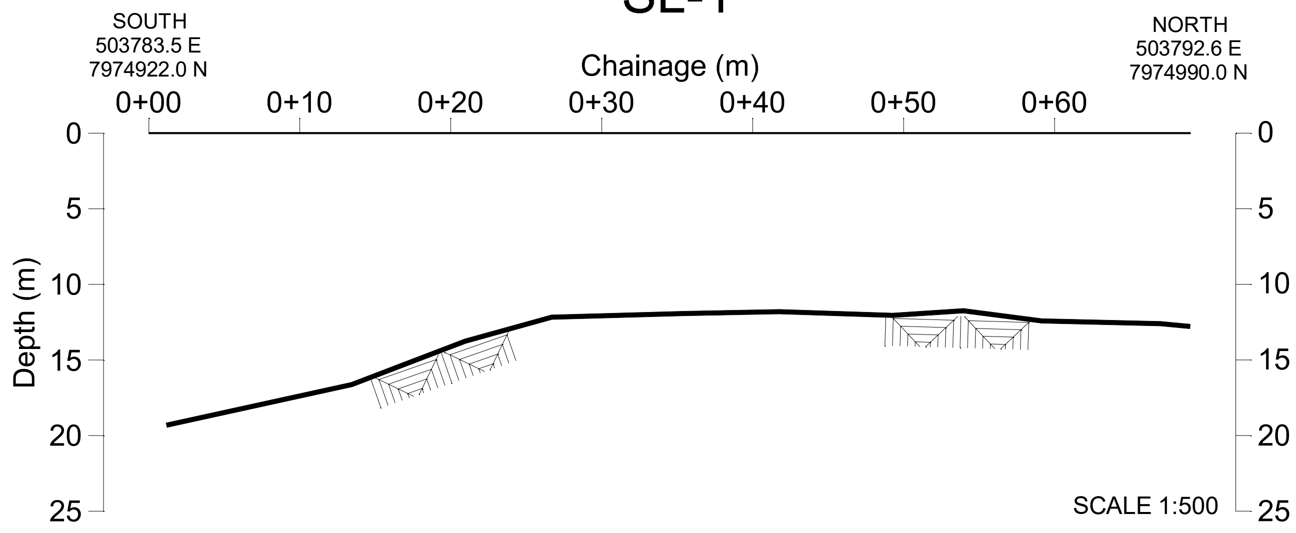
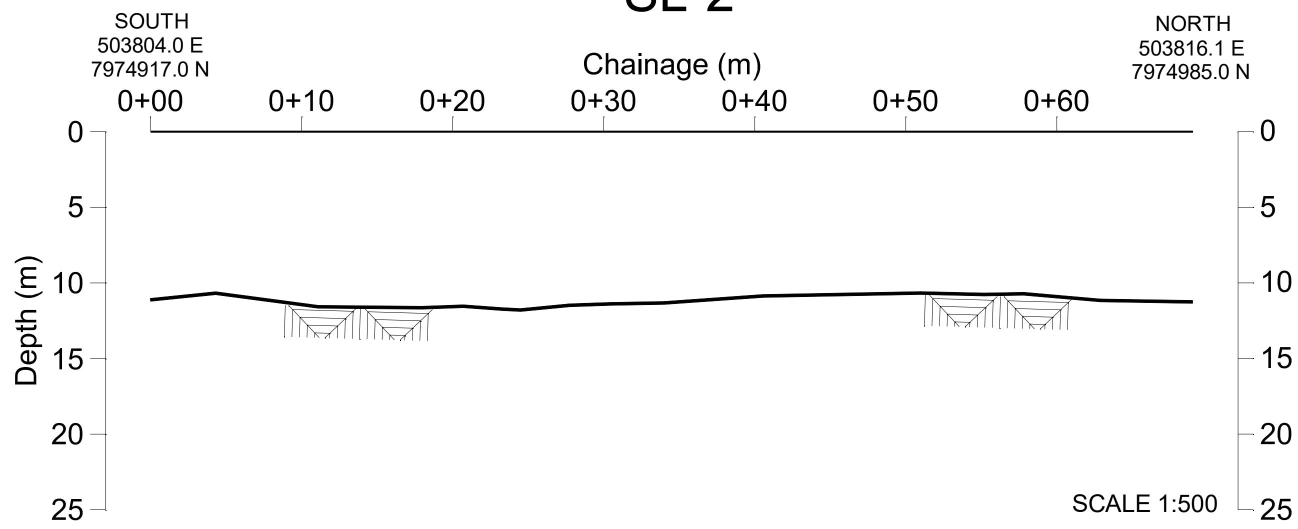


SL-2



NOT VALID FOR CONSTRUCTION

No	NOTES
1	THE SEISMIC SURVEY WAS EXECUTED BY GEOPHYSICS GPR INTERNATIONAL INC. APRIL 2017
2	COORDINATE SYSTEM: WGS84 UTM ZONE 17W. POSITIONING ACCURACY +/- 2 METRES
3	ELEVATION DATA PROVIDED BY THE CLIENT. DEPTHS ARE RELATIVE TO GROUND SURFACE
4	REFER TO FULL REPORT FOR DISCUSSION OF METHODOLOGIES, RESULTS AND LIMITATIONS
5	BOREHOLE DATA PROVIDED BY THE CLIENT FOR REFERENCE PURPOSES
6	

SCEAU PROFESSIONNEL

DRAFT

PROFESSIONAL SEAL

GEOPHYSICS GPR INTERNATIONAL INC.

DESSINÉ PAR DRAWN BY	I.Gusakov, GIT		
VERIFIÉ PAR CHECKED BY			
APPROUVÉ PAR APPROVED BY	M.Situm, P. Geo		
# CONTRAT CONTRACT #	T17001		
ÉCHELLE SCALE	AS SHOWN	# DESSIN DRAWING #	T17001-A3-1

CLIENT / CLIENT: HATCH

PROJET / PROJECT: BAFFINLAND EXPANSION

TITRE / TITLE: SEISMIC SURVEY RAILWAY UNLOADING AREA

Appendix B
Indexer Slab Drawings

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DWG. No.
H353004-40000-231-292-0001-0001

GENERAL NOTES

1. THIS DRAWING MUST BE READ IN CONJUCTION WITH THE LATEST REFERENCE DRAWINGS FOR SETTING OUT.
2. ALL DIMENSIONS ARE GIVEN IN MILLIMENTRES UNLESS NOTED OTHERWISE.
3. ANY DISCREPANCIES IN DIMENSIONS OR ON THE DRAWING TO BE BROUGHT TO THE ENGINEER'S NOTICE.

DESIGN

4. DESIGN SPECIFICATION: CAN/CSA S6 - 06 INCLUDING SUPPLEMENTS 1, 2 AND 3, UNLESS NOTED OTHERWISE.
5. EARTH PRESSURE: THE FOLLOWING LIMITING ASSUMPTIONS WERE USED FOR THE DESIGN AND THESE DRAWINGS SHALL NOT BE USED WITHOUT APPROPRIATE MODIFICATIONS WHEN ACTUAL SITE CONDITIONS RESULT IN MORE SEVERE LOAD EFFECTS OR LESS EFFECTIVE RESISTANCE.
- UNIT WEIGHT OF SOIL, = 20 kN / m^3
- GRANULAR FILL FRICTION ANGLE, = 40°
- CO-EFFICIENT OF PASSIVE PRESSURE, Kp = 4,6
- ASSUMED ALLOWABLE BEARING PRESSURE = 200 kPa
6. SUBSOIL DRAINAGE TO CIVIL DETAIL, TO BE PROVIDED

PROPOSED CONSTRUCTION SEQUENCE
- INSTALL STEEL COLUMNS OFF RAIL BASEMENT PRECAST BEAMS.
- BACKFILL TO UNDERSIDE OF ANCHOR BEAM LEVEL.
- PLACE ANCHOR BEAM IN POSITION ON SPECIFIED LAYERWORKS.
- CONTINUE BACKFILLING TO UNDERSIDE OF APPROACH SLAB.
- PLACE APPROACH SLAB IN POSITION ON SPECIFIED LAYERWORKS. THE PIN CONNECTION POCKETS IN THE APPROACH SLAB ARE TO ALIGH WITH THE STEEL COLUMN PINS.
- GROUT APRPOACH SLAB POCKETS.
- CONTINUE BACKFILLING TO UNDERSIDE OF INDEXER FOUNDATION.
- PLACE INDEXER FOUNDATION PRECAST PANELS ON SPECIFIED LAYERWORKS.
- ALIGN AND INSTALL DYWIDAG BARS AND DEAD MAN ANCHORS.
- GROUT TRANSVERSE SHEAR KEYS.
- DYWIDAG BARS TO BE STRESSED TO NOMINAL 20% LOAD IN SPECIFIED SEQUENCE.
- DYWIDAG BARS TO BE STRESSED ONLY AFTER MIN. 28 DAY SHEAR KEY GROUT STRENGTH HAS BEEN REACHED.
- INSTALL TRAIN RAILS AND GROUT TRAIN RAILS STUD POCKETS.

EXCAVATION AND BACKFILL

- AFTER THE UNDERSIDE OF THE ANCHOR BEAM LEVEL IS REACHED, BACKFILL MUST BE PLACED EVENLY ACROSS THE PLAN EXTENTS OF THE INDEXER FOUNDATION, AND THE BACKFILL SURFACE ELEVATIONS SHALL NOT DIFFER BY MORE THAN 300MM ACROSS THE PLAN EXTENTS OF THE INDEXER FOUNDATION, AT ANY STAGE OF THE OPERATION.
- BACKFILL SHALL BE PLACED IN SUCH A MANNER AS TO AVOID ANY DAMAGE OR MIS-ALIGNMENT OF THE PRECAST CONCRETE PANELS. BACKFILL COMPACTION SHALL BE PERFORMED SUCH THAT EQUIPMENT MOVES PARALLEL TO THE PRECAST PANELS FINAL POSITION.
- ONLY HAND OPERATED POWER TAMPERS AND VIBRATORS SHALL BE USED FOR COMPACTION WITHIN 1000mm OF ANY STRUCTURAL ELEMENT.

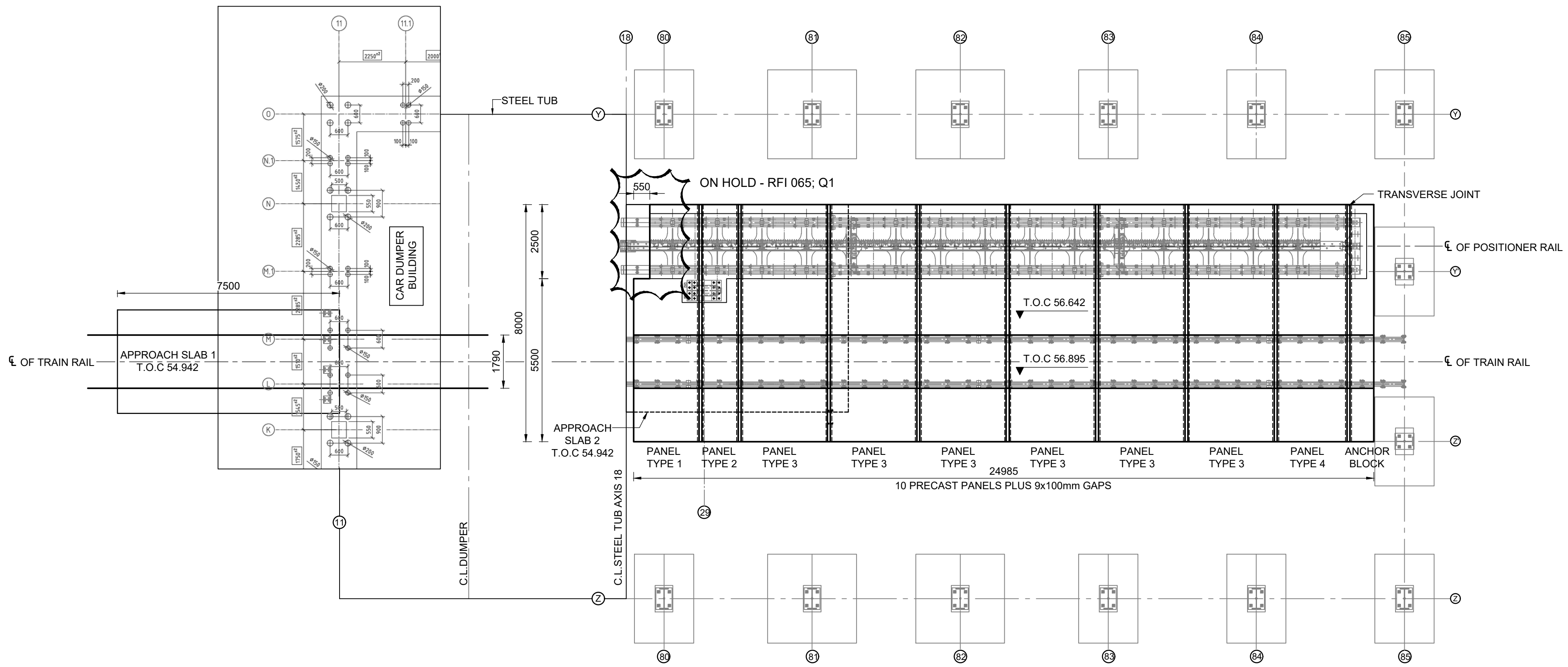
STRUCTURAL STEELWORK
- ALL STRUCTURAL STEELWORK SHALL CONFORM TO CSA G 40.21 M - 350W AT CATEGORY 3 AND SHALL BE HOT-DIP GALVANISED.
- ALL CONCRETE ANCHORS TO BE HILTI GALVANISED M20 GRADE 8.8 HAS-E RODS (OR SIMILAR APPROVED) WITH NOMINAL TENSILE STRENGTH = 800 MPa. EMBEDMENT = 170mm MINIMUM. DRILL AND EPOXY WITH HILTI HIT-RE 500SD (OR SIMILAR APPROVED) IN STRICT CONFORMANCE WITH THE MANUFACTURER'S SPECIFICATIONS.
- ALL WELDING SHAL CONFORM TO THE CURRENT AWS SPECIFICATION D1.5 AND SHALL BE 6 mm CONTINUOUS FILLET WELDS.
- THE CONTRACTOR SHALL BE RESPONSIBLE FOR PROVIDING ADEQUATE MEANS OF MAINTAINING THE STABILITY OF THE STEEL COLUMNS IN THE CORRECT ALIGNMENT UNTIL THE BACKFILLING AROUND THE COLUMNS IS COMPLETE.

PRECAST CONCRETE PANELS

- ALL PANELS ARE TO BE CLEARLY MARKED AS PER THE DRAWINGS IN 50MM LETTERS ON THE BOTTOM EXPOSED FACE WITH AN IDENTIFYING NUMBER AND GRID REFERENCE.
- THE CONTRACTOR IS TO PROVIDE DETAILED DRAWINGS AND REINFORCING SCHEDULES FOR APPROVAL.
- MINIMUM CONCRETE 28 DAY COMPRESSIVE STRENGTH: 40 MPA.
- COVER TO REINFORCING STEEL: 50MM, UNLESS NOTED OTHERWISE.
- ALL REINFORCING STEEL SHALL BE HIGH TENSILE DEFORMED REINFORCING STEEL CONFORMING TO CAN / CSA - G30.18, GRADE 400. PLAIN BARS WILL BE USED FOR SPIRALS ONLY.
- ANY REINFORCING BARS THAT ARE TO BE HOT-DIP GALVANISED SHALL CONFORM TO THE REQUIREMENTS OF CSA G40.21 M GRADE 300W.
- MINIMUM BAR LAP LENGTH = 45 x BAR DIAMETER.
- GROUT FOR PRECAST PANEL TRANSVERSE SHEAR KEYS AND STUD POCKETS, AND APPROACH SLAB POCKETS, SHALL BE SIKADUR LT GROUT (OR SIMILAR APPROVED MAGNESIUM PHOSPHATE BASED FLOWABLE NON-SHRINK GROUT). THE GROUT IS TO BE INSTALLED IN ACCORDANCE WITH THE MANUFACTURER'S SPECIFICATIONS AND IS TO HAVE A MINIMUM 28 DAY COMPRESSIVE STRENGTH OF 40 MPA.
- THE EXPOSED TOP RUNNING SURFACE OF THE PRECAST CONCRETE PANELS SHALL HAVE A SMOOTH-RUBBED FINISH, AND ALL FORMED FACES SHALL HAVE A SMOOTH-FORM FINISH IN ACCRODANCE WITH CLAUSE 7.7.3; CSA STANDRAD A2.3.1 - 04.
- ALL EXPOSED CONCRETE CORNERS INCLUDING THE STUD PCOKETS AND TRANSVERSE SHEAR KEYS, SHALL HAVE A 20mm X 20mm CHAMFER OR FILLET UNLESS NOTED OTHERWISE ON THE DRAWINGS.
- PRECAST CONCRETE PANELS SHALL BE CAST IN A METAL FORM.
- THE MAXIMUM DIMENSIONAL DEVIATION FO THE PRECAST CONCRETE PANELS FROM THE DIMESIONS SHOWN ON THE DRAWING SHALL NOT EXCEED THE FOLLOWING:
  - § LENGTH (MEASURED PERPINDICULAR TO THE PANEL DIVISIONS) = +/-. ??? 5MM
  - § WIDTH (MEASURE PARALELL TO THE PANEL DIVSIONS) = +/-. ??? 5MM
  - § THICKNESS = +/-. ??? 3MM
  - § MAXIMUM DIFFERENCE IN PLAN VIEW DIAGONAL DIMESNIONS (SQUARENNESS) OF RECTANGULAR PANELS = +/-??? 10MM.

- ALL SURFACES THAT WILL BE IN CONTACT WITH SIKADUR LT GROUT, SHALL BE INTENTIONALLY ROUGHENED BY HEAVY SANDBLASTING. THIS INCLUDES THE TRANSVERSE PANEL EDGES THAT FORM THE SHEAR KEY, STUD POCKETS AND THE APPROACH SLAB POCKETS.
- ADJUST REINFORCEMENT WHERE REQUIRED TO CLEAR STUD POCKETS, APPROACH SLAB POCKETS, AND LIFTING HOOK ASSEMBLIES.
- GROUTING FOR TRANSVERSE SHEAR KEYS SHALL START FROM THE OUTSIDE END PANELS TOWARDS THE CENTRE PANELS.
- THE TOP SURFACE OF THE GROUT IN STUD POCKETS, TRANSVERSE SHEAR KEYS LIFTING HOOK POCKETS SHALL BE FLUSH WITH THE TOP FINISHED SURFACE OF THE PANELS.
- GROUT IN ANY LOCATION SHALL BE TOPPED UP AFTER GROUT HAS SETTLED.
- ALL GROUT SHALL BE PLACED AND CURED ACCORDING TO MANUFACTURER SPECIFICATIONS.

ERECTION
- PROVISON FOR LIFTING AND HANDLING ARE THE RESPONSIBILITY OF THE CONTRACTOR, WHO SHALL ENSURE THAT THE DESIGN IS ADEQUATE FOR ALL STAGES OF THE ERECTION PROCEDURE.
- IT IS THE CONTRACTOR'S RESPONSIBILITY TO DETERMINE LIFTING HOOK LOCATIONS.
- AFTER THE PRECAST CONCERTE PANELS HAVE BEEN ERECTED, LIFTING HOOKS SHALL BE CUT OFF FLUSH WITH THE BOTTOM OF THE POCKET.
- PRECAST PANELS SHALL BE MAINTAINED LEVEL DURING HANDLING AND LIFTING FOCES SHALL BE VERTICAL AT ALL TIMES.



PLAN: INDEXER FOUNDATION GENERAL ARRANGEMENT

SCALE 1:100

DRAWING LIST	
H353004-40000-231-292-0001-0001	INDEXER GENERAL ARRANGEMENT AND NOTES
H353004-40000-231-292-0002-0001	INDEXER FOUNDATION CONCRETE ARRANGEMENT
H353004-40000-231-292-0003-0001	INDEXER FOUNDATION PRECAST PANEL CONCRETE DETAILS
H353004-40000-231-292-0004-0001	INDEXER FOUNDATION PRECAST PANEL REINFORCING DETAILS
H353004-40000-231-292-0005-0001	INDEXER FOUNDATION PRECAST PANEL ANCHOR BOLT DETAILS
H353004-40000-231-292-0006-0001	APPROACH SLAB STRUCTURAL STEELWORK DETAILS SHEET 1
H353004-40000-231-292-0007-0001	APPROACH SLAB STRUCTURAL STEELWORK DETAILS SHEET 2
H353004-40000-231-292-0008-0001	APPROACH SLAB REINFORCING DETAILS

NOT FOR CONSTRUCTION

REFERENCE DRAWINGS

DRAWING No.	DRAWING TITLE
H35004-00000-220-272-0001-0001	PORT SITE BLOCK PLAN OVERALL LAYOUT

REG. PROFESSIONAL: NAME / SIGNATURE / ENG REG NUMBER / REVISION DATE / ORIGINAL DATE

REVISIONS

No.	DESCRIPTION	BY	CHK'D	DATE
1	CLIENT REVIEW	R.P	S.H	JAN 18

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HATCH

ROLE	NAME	SIGNATURE	DATE
DRAFTSPERSON	R. PAUL	NR	
DESIGNER	S. HARRYCHUND	NR	
CHECKER	G.HOOPER		
DESIGN COORD.	R. GOOSEN		
RESP. ENG.			
LEAD DISC. ENG.	G.HOOPER		
ENG. MANAGER	N.MASON		
PROJ. MANAGER	S.HEINER		

DRAWING APPROVAL STATUS:

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

PORT SITE
RAIL UNLOADER INDEXER
INDEXER FOUNDATION GENERAL ARRANGEMENT AND NOTES

SCALE: OR AS NOTED
DWG. No. H353004-40000-231-292-0001-0001
REV A

SHEET SIZE: A1

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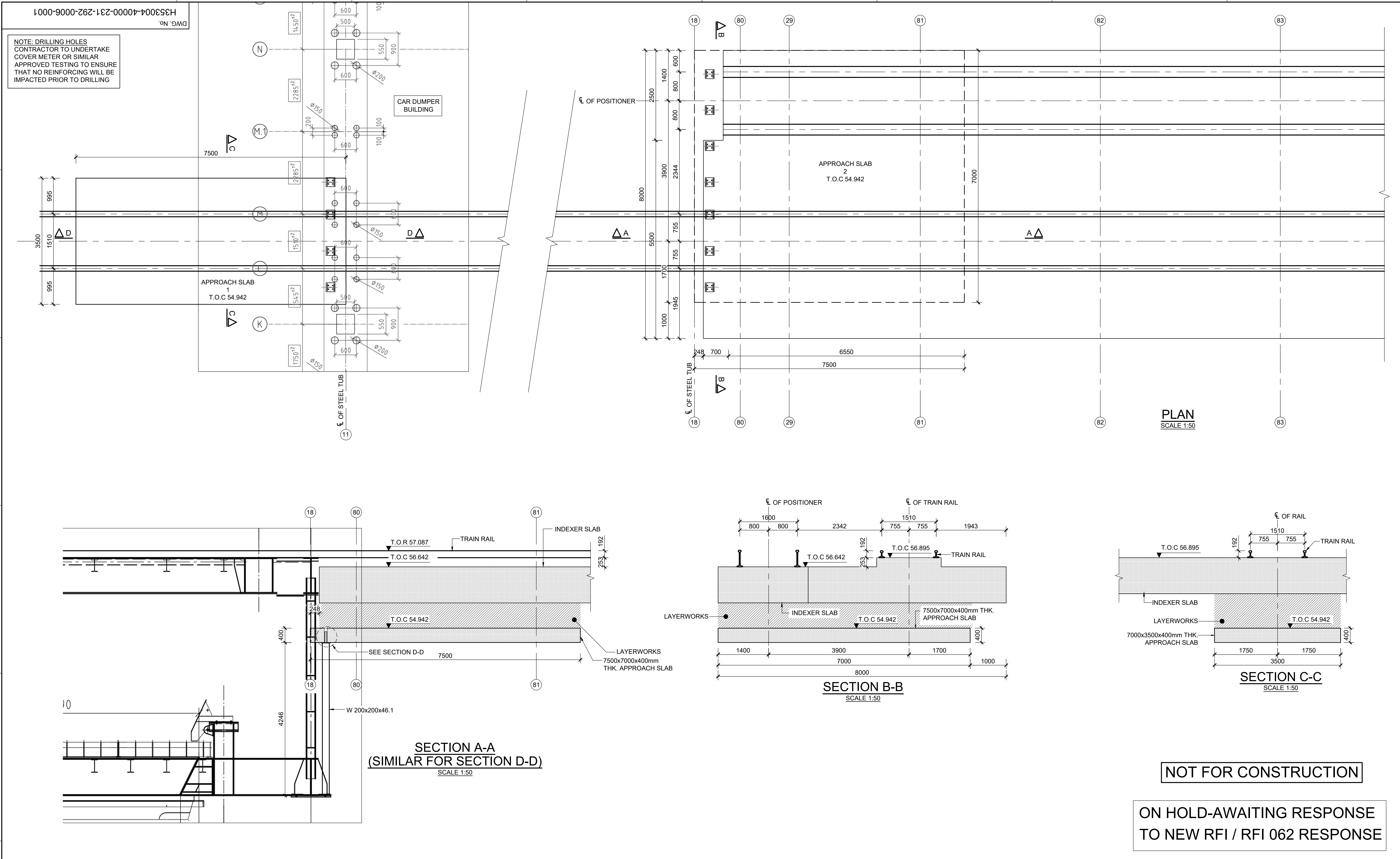

DRAWING No.	DRAWING TITLE
H35004-40000-231-292-0001-0001	INDEXER FOUNDATION GENERAL ARRANGEMENT AND NOTES
H35004-00000-220-272-0001-0001	PORT SITE BLOCK PLAN OVERALL LAYOUT

REFERENCE DRAWINGS

NAME
SIGNATURE
ENG REG NUMBER
REVISION DATE
ORIGINAL DATE
REG. PROFESSIONAL

No.	DESCRIPTION	BY	CHK'D	DATE
1	CLIENT REVIEW	R.P	S.H	JAN 18

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LEAD DISC. ENG.	G.HOOPER		
ENG. MANAGER	N.MASON		
PROJ. MANAGER	S.HEINER		

DRAWING APPROVAL STATUS:

Baffinland

BAFFINLAND IRON MINES LP
MARY RIVER EXPANSION PROJECT

PORT SITE
RAIL UNLOADER INDEXER
APPROACH SLAB CONCRETE AND
STRUCTURAL STEELWORK DETAILS SHEET 1

SCALE: OR AS NOTED | DWG. No. H353004-40000-231-292-0006-0001 | REV A

SHEET SIZE: A1

$USERNAME$ $DATE$ $FILE$ $TIME$