Volume 1 Annex V1-7 Type A Water Licence Applications

Package P4-9

Hope Bay Project, Phase 2, Doris-Madrid Tailings Impoundment Area Operations, Maintenance, and Surveillance Manual

HOPE BAY PROJECT, PHASE 2, DORIS TAILINGS IMPOUNDMENT AREA - OPERATIONS, MAINTENANCE AND SURVEILLANCE MANUAL

HOPE BAY, NUNAVUT

DECEMBER 2017

Hope Bay Project, Phase 2, Doris Tailings Impoundment Area - Operations, Maintenance and Surveillance Manual

Plain Language Overview:

This Tailings Impoundment Area (TIA) Operation, Maintenance and Surveillance Manual (OMS Manual) is also known as the Tailings Management Plan. This OMS Manual describes how TMAC will manage and monitor the tailings impoundment area, including the impoundment dams, tailings and water pump and pipeline systems. This document describes how tailings deposition will be carried out and demonstrates how TMAC will ensure the TIA remains safe.

Hope Bay, Nunavut

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Revisions

Revision #	Date	Section	Changes Summary	Author	Approver
0	June 2016	Entire Document	Initial Document	SRK	TMAC
1	August 2016	Entire Document	References added	SRK	TMAC
		Section 1.5, Table 3	List updated		
		Section 2.1, Table 4	List updated		
		Section 3.3.5, 3.10	Added contingency pumping for excess mine water		
		Section 3.4.3, Section 3.8, Table 6	Removed optionality of constructing Interim Dike; Added construction timing of Interim Dike		
		Section 4.4	Added approval process for alternate chemical dust suppressants		
		Section 4.5	Reference water management during Care and Maintenance		
		Section 5.3.1	Added Figure 12 pertaining to shoreline protection measures		
		Section 6.4, 6.5.4	Added tailings geochemical monitoring		
		Section 6.5.3	Referenced TIA water quality monitoring		
		Section 7	List updated		
		Figures	Added new Figure 12 and renumbered remaining Figures 13 through 17		
		Appendix A	Included appendix information previously omitted		
2	November 2017	Entire Document	Changes made to account for Phase 2 TIA requirements	SRK	

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Glossary

Term	Definition
AEP	Annual exceedance probability
ARD	Acid rock drainage
CDA	Canadian Dam Association
DSI	Dam safety inspection
DSR	Dam safety review
EOR	Engineer of Record
FSL	Full supply level
GCL	Geosynthetic clay liner
IDF	Inflow design flood
INAC	Indigenous and Northern Affairs Canada
KIA	Kitikmeot Inuit Association
MAAT	Mean annual air temperature
MAP	Mean annual precipitation
MAR	Mean annual runoff
MMER	Metal mining effluent regulations
NIRB	Nunavut Impact Review Board
NWB	Nunavut Water Board
OMS	Operations, maintenance and surveillance
PAG	Potentially acid generating
PGA	Peak ground acceleration
PMF	Probable maximum flood
ROQ	Run of quarry
SOP	Standard operating procedures
SRK	SRK Consulting (Canada) Inc.
TIA	Tailings impoundment area
TMA	Tailings management area
TMS	Tailings management system
TMAC	TMAC Resources Inc.
TPD	Tonne per day
WAD	Weak Acid Dissociable
WMMP	Wildlife monitoring and management plan

1 Introduction

This Hope Bay Project, Phase 2, Doris Tailings Impoundment Area - Operations, Maintenance and Surveillance Manual (OMS Manual) (the Plan) has been prepared by TMAC Resources Inc. (TMAC) in accordance with various water licences held by TMAC which are associated with developments throughout the Hope Bay region.

The Plan is intended primarily for use by TMAC and its contractors to ensure that best practices for minimizing potential environmental impacts and potential environmental liabilities with respect to the Doris Tailings Impoundment Area (TIA), and to ensure that the conditions of water licences are met.

This Plan is structured in a manner such that one document pertaining to the Doris TIA can be approved and implemented to address the site- and licence-specific needs. In the event of a new water licence, or an existing licence amendment, only the specific portions of this manual pertaining to that licence will need to be revised in this TIA OMS Manual.

This Doris Tailings Impoundment Area Operations, Maintenance and Surveillance (OMS) Manual (OMS Manual) has been prepared by SRK Consulting (Canada) Inc. (SRK) on behalf of TMAC Resources Inc. (TMAC). The OMS Manual specifically outlines the framework and procedures that TMAC and its contractors will use to ensure safe design, construction, operation, maintenance, surveillance and closure of the Doris TIA.

1.1 Objectives

The OMS Manual defines and describes:

- Roles and responsibilities of personnel assigned to the TIA;
- Procedures and processes for managing change;
- Key components of the TIA;
- Procedures required to operate, monitor the performance of, and maintain the TIA to ensure that it functions in accordance its design, meets regulatory and corporate policy obligations, and links to emergency planning and response; and
- Requirements for analysis and documentation of the performance of the TIA.

1.2 Change Management and OMS Manual Updates

The procedures required to operate and maintain the TIA can change, and since this OMS Manual is a controlled document, it is revised or updated when necessary.

Revisions to the OMS Manual can be triggered by activities such as changes in dam classification, operational performance, personnel or organizational structure, mine ownership, regulatory or social considerations, and life cycle or design philosophy. The OMS Manual will be formally reviewed as part of the annual Engineer of Record's (EOR) Dam Safety Inspection (DSI), and by third parties during Dam Safety Reviews (DSR). These inspections and reviews may lead to recommendations for OMS Manual updates.

OMS Manual updates will be the responsibility of TMAC, specifically the Mill Manager, and will be executed in the following manner:

- Proposed changes will be submitted to the Mine General Manager for review and authorization;
- If changes are related to design elements (as stipulated in Section 3.8 of this document) of the TIA, authorized changes will be submitted to the EOR for review and approval; and
- Implement and document the authorized and approved changes by revising the OMS Manual.

A printed copy of this OMS Manual is available at each of the locations listed in Table 1.1. Printed copies of the OMS Manual found at other locations will be considered uncontrolled versions.

Table 1.1: Physical Distribution of OMS Manual

Location	Responsible Party
Site Main Office	Mine General Manager
Environmental Department	Environmental Coordinator
Mill	Mill Manager
	Mill General Foreman
External	Engineer of Record

1.3 Relevant Legislation and Guidance

The Project falls under the jurisdiction of both the Government of Canada, and the Kitikmeot Inuit Association (KIA). Authorities involved with permitting and regulating the design, construction, operation, maintenance, surveillance and closure of the TIA include:

- The KIA;
- Indigenous and Northern Affairs Canada (INAC);
- The Nunavut Water Board (NWB);
- The Nunavut Impact Review Board (NIRB); and
- The Workers Safety and Compensation Commission Chief Mines Inspector as per the Mine Health and Safety Act, and its associated Regulations (Government of Nunavut, 1995).

Use of the TIA is authorized by the following:

- The Doris North Project NIRB Project Certificate No. 003 (NIRB 2006);
- The Doris North Project Type A Water Licence 2AM-DOH1323 – Amendment No. 1 (NWB 2016);
- KIA Commercial Lease #KTCL#313D001 (KIA 2015); and
- Schedule 2 of the Metal Mining Effluent Regulations (MMER).

Table 1.2 provides a list of licence requirements and guidelines that govern the structure and content of this OMS Manual.

Table 1.2. List of federal and territorial regulations governing the Hope Bay Project, Phase 2, Doris Tailings Impoundment Area - Operations, Maintenance and Surveillance Manual

Regulation	Year	Governing Body	Relevance
Water License No: 2AM-DOH1323 – Amendment No.1 – Doris North Project, Nunavut	2016	Nunavut Water Board (NWB)	License to operate. Expires August 15, 2023. License updated November 4, 2016 with approval of amendment
A Guide to the Management of Tailings Facilities, Third Edition	2017	Mining Association of Canada (MAC)	Guidance related to the management of Tailings Facilities
Dam Safety Guidelines	2013	Canadian Dam Association (CDA)	Guidance related to design and operation of dams
Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams	2014	Canadian Dam Association	Guidance related to design, operation and closure of tailings dams
Developing an Operation, Maintenance and Surveillance Manual for Tailings and Water Management Facilities	2011	Mining Association of Canada	Guidance for structure and content of tailings OMS manuals
Management of tailings facilities	2011	Mining Association of Canada	Guidance for management and operation of tailings facilities
Audit and assessment of tailings facilities	2011	Mining Association of Canada	Guidance for audit and inspection of tailings facilities

1.4 Related Documents

The documents listed in Table 1.3 are expected to be referenced and utilized in conjunction with the OMS Manual.

Table 1.3. List of documents related to the Hope Bay Project, Phase 2, Doris Tailings Impoundment Area - Operations, Maintenance and Surveillance Manual

Document Title	Year	Relevance
Emergency Response Plan	2016	Describes Incident Command System and actions relating to all surface emergencies. This Plan will replace the current Emergency Response Plan (TMAC 2016)
Doris and Madrid Water Management Plan	2017	Describes the water management procedures including discharge from the TIA and associated water quality criteria (TMAC 2017a)
Groundwater Management Plan	2017	Describes the groundwater inflow predictions and associated management procedures for handling this water (TMAC 2017b)
Preliminary Tailings Dam Design	2007	North Dam design documentation (SRK 2007)
North Dam As-Built Report	2012	North Dam as-built documentation (SRK 2012)
North Dam Monitoring: Standard Operating Procedures – Revision 1	2013	North Dam Monitoring Standard Operating Procedures (SOP) (SRK 2013)
Doris North Project Tailings Management System Design	2015	South Dam and Interim Dike design and tailings management plan (SRK 2015a)
Geochemical Characterization of Tailings from the Doris Deposits and FEIS Characterization	2015	Geochemical characterization of the tailings to be deposited into the TIA (SRK 2015b)
Groundwater Inflow and Quality Model	2015	Describes results of hydrogeological modeling to estimate the potential quantity and quality of groundwater flow into the mine (SRK 2015c)
TIA Interim Dike – Filtering Requirements	2015	Filter design for the Interim Dike (SRK 2015d)
Doris Tailings Impoundment Area Interim Dike Filter Trade-off Study	2016	Memo clarifying the purpose of the Interim Dike and a trade-off study of two different filter designs (SRK 2016). Interim dike not part of Phase 2 plans.
Site-Wide Water and Load Balance	2017	Water and load balance to evaluate water management needs and predict water quality at the Project and downstream receptors (SRK 2017a)
Doris Tailings Management System Phase 2 Design, Hope Bay Project	2017	Report documents TMAC's proposed changes to currently permitted TMS to accommodate additional volume of tailings produced as part of Phase 2 development (SRK 2017b)
Hope Bay Waste Rock and Ore Management Plan	2017	Management plans for waste rock and ore at the Hope Bay project sites (TMAC 2017c).
Engineering Drawings for the South Dam – Phase 1	2017	South Dam – Phase 1 Issued For Construction Engineering Drawings.
Climate and Hydrological Parameters Summary Report	2017	Climate and hydrological parameters and analysis for the Doris and Boston sites (SRK 2017c).
Doris Tailings Management System Phase 2 Design	2017	Report overviews the Phase 2 design of the Doris Tailings Management System / Facility (SRK 2017b).

2 Roles and Responsibilities

2.1 Organization and Individual Responsibilities

The site management structure is outlined in Attachment A at the end of this manual. Individuals (including external advisors and service providers) having responsibilities for operation, maintenance, surveillance, or emergency preparedness and response of the TIA are highlighted in Figure 1 in Module A and are listed in Table 2.1 below.

Table 2.1: TIA Responsible persons

Personnel and Contact Information	Position	TIA Responsibilities
Gil Lawson, PEng 416-561-0363 gil.lawson@tmacresources.com	Chief Operating Officer	Corporate overall operational lead for ensuring that the TIA construction, operation, maintenance, surveillance and closure are carried out in accordance with this OMS Manual.
John Roberts, PEng (416) 628-0216 john.roberts@tmacresources.com	Vice President Environmental Affairs	Corporate overall regulatory lead for ensuring that the TIA construction, operation, maintenance, surveillance and closure are carried out in accordance with approved licenses and permits.
Jason McKenzie (TMAC) (867) 988-6882 ext. 100 Jason.mckenzie@tmacresources.com	Mine Manager	Functional site based discipline leads for assigning and applying appropriate resources to execute TIA construction, operation, maintenance, surveillance and closure in accordance with this OMS Manual.
Chad Parent (TMAC) (867) 988-6882 ext. 141 chad.parent@tmacresources.com	Mill (Process) Manager	
Kelly Schwenning (TMAC) (867) 988-6882 ext. 106 kelly.schwenning@tmacresources.com Ron Bertrand (TMAC) (867) 988-6882 ext. 101 Ron.bertrand@tmacresources.com	Surface Manager	
Sarah Warnock (ESC 1) Kyle Conway (ESC 2) (867) 988-6882 ext. 102 enviro@tmacresouces.com	Environmental Site Coordinator	Day-to-Day execution of environmental monitoring and compliance activities pertaining to TIA construction, operation, maintenance, surveillance and closure in accordance with approved licenses and permits.
Vince Kapinus (867) 988-6882 ext. 155 vince.kapinus@tmacresources.com	Mine Operations Superintendent	Day-to-day execution of discipline based activities and inspections Pertaining to TIA operation, maintenance and

Personnel and Contact Information	Position	TIA Responsibilities
Dave Archibald dave.archibald@tmacresources.com Brad Starcheski brad.starcheski@tmacresources.com (867) 988-6882 ext. 145	Mill (Process) Operations Superintendent	surveillance as it relates to tailings deposition and water management in accordance with this OMS Manual.
Jason Lanoue jason.lanoue@tmacresources.com Murray Weddell murray.weddell@tmacresources.com (867) 988-6882 ext. 131	Surface Operations Superintendent	
Doug Brown (867) 988-6882 ext. 138 doug.brown@tmacresouces.com	Health and Safety Manager	Functional site based lead for assigning and applying appropriate resources towards health and safety procedures for the TIA construction, operation, maintenance, surveillance and closure.
Ken Cook (867) 988-6882 ext. 138 ken.cook@tmacresources.com	Health and Safety Superintendent	Day-to-Day execution of site health and safety procedures related to TIA construction, operation, maintenance, surveillance and closure activities as outlined in all appropriate site health and safety procedures.
Maritz Rykaart, PhD, PEng (SRK) (604) 601-8426 mrykaart@srk.com	Facility Designer and Engineer of Record	Detailed design of TIA components in accordance with industry best practice; Construction quality assurance and associated as-built reporting; Conduct annual DSI, including a review of the OMS Manual.

2.2 Competencies and Training

Specific procedures will be adopted to ensure that all persons associated with the TIA activities (as per Table 2.1) are familiar with the contents of this OMS Manual. This will include receiving appropriate training, and having a clear understanding of, and adequate competency for their roles and responsibilities. Procedures for competency and training for TIA personnel will include:

- Requiring previous tailings management experience for specific job descriptions prior to appointing persons in that role;
- If a person's general tailings management experience is deemed insufficient relevant to his/her appointed responsibilities, he/she will be required to complete formal, external training such as on-line tailings management courses offered by Edu-Mine;
- TMAC will develop, and require persons to annually attend a detailed site-specific TIA orientation and training module based on this OMS Manual;
- On-the-job training to persons for specific tasks, such as those outlined in appropriate Standard Operating Procedures (SOPs); and
- Annually, as part of the EOR's DSI, the EOR, if requested, will conduct a workshop for site staff based on the OMS Manual, but focussed on the review findings.

Notwithstanding the specific procedures outlined above, focussed on persons associated with the TIA activities, TMAC will also ensure that all site personnel are familiar with the general TIA management principles, and understand the need to be continually aware of visual indications of the TIA performance. This will be achieved through inclusion of information in the general site orientation.

3 Facility Overview

3.1 Project Description

The Hope Bay Project (the Project) consists of two phases: Phase 1 (Doris project), which is currently being carried out under an existing Water Licence, and Phase 2 (Madrid-Boston project) which is in the environmental assessment and regulatory stage. Phase 1 includes mining and infrastructure at Doris, while Phase 2 includes mining and infrastructure at Madrid and Boston located approximately 10 and 60 km due south from Doris, respectively (SRK 2017a).

The Project is a gold mining and milling undertaking of TMAC Resources Inc. located 705 km northeast of Yellowknife and 153 km southwest of Cambridge Bay in Nunavut Territory, and is situated east of Bathurst Inlet (Figure 1). The Project is comprised of three distinct areas of known mineralization plus extensive exploration potential and targets. The three areas hosting known mineral resources are Doris, Madrid, and Boston (Figure 2).

Ore processing includes cyanidation and flotation methods, with two separate streams of tailings being produced, both captured under the tailings management system (TMS). The cyanidation tailings will be detoxified (cyanide destruction) then filtered and blended with waste rock to be returned underground as backfill. At the Doris and Madrid processing facilities, the flotation tailings will be deposited in the Doris TIA, and at the Boston processing facility, the flotation tailings will be filtered and deposited in the Boston tailings management area (TMA).

The currently licensed Phase 1 TMS (SRK 2015b) was designed for subaerial deposition of about 2.5 Mt of tailings into the designated Doris TIA. This TIA is a former natural lake (Tail Lake), which has been listed on Schedule 2 of the MMER. Phase 2 development will see the expansion of the TIA to accommodate the increased volume of tailings (Figure 3).

The TIA would be impounded through three dams to ensure environmental containment: North Dam, South Dam, and West Dam (Figure 3). The North Dam, which is unchanged from the Phase 1 design, will function as a water retaining dam. Alternatively, the South and West dams will have tailings deposited against their upstream face to keep the Reclaim Pond away from these structures (Figure 3). The North Dam was constructed in 2012 (SRK 2012) as a water retaining frozen core dam, while the South and West dams were designed as frozen foundation rock fill dams incorporating a geosynthetic clay liner (GCL). The South Dam is part of Phase 1 and will be raised as part of the Phase 2 development. The West Dam, on the other hand, is a new structure.

The TIA will be closed through application of a 0.3 m thick quarry rock isolation cover intended to mitigate against tailings dust, and prevent direct contact of tailings with terrestrial wildlife. Water quality modeling (SRK 2017a) confirms once the cover has been applied, water discharge from the TIA will meet environmental discharge criteria. Once that has been demonstrated to occur, the North Dam will be breached, returning the natural outflow to the pre-mining elevation of 28.3 m.

3.2 Project History

Work at the Project site dates back to 1964 when the first exploration was carried out in the area focusing on showings at Ida Point, Ida Bay and Roberts Lake to the north. Three different exploration companies continued exploration through the 1970s and 1980s, but the first exploration drilling only started in 1992. This exploration drilling led to the first site infrastructure at Boston, in the form of an exploration camp on the northeastern shores of Aimaokatalok Lake in 1993. Subsequently, underground development was carried out at Boston in 1996 and 1997 to extract a bulk sample. Exploration drilling expanded to Madrid and Doris in 1999, and a new exploration camp was constructed on the eastern shore of Windy Lake. In 2006, a Project Certificate (NIRB No. 003) was obtained to start a mine at Doris, and the associated Water Licence (2AM-DOH0713) was issued in 2007.

Construction commenced the same year. Construction was slowed down as the Project transitioned in ownership in 2008, but resumed in 2010; however, in 2012 the Project was placed in care and maintenance prior to starting commercial production. Another ownership change in 2013 resulted in recommencement of construction, with planned commercial production scheduled for early 2017. The current water license for the Doris Project is 2AM-DOH1323 – Amendment 1 was issued in 2016.

3.3 Site Conditions

3.3.1 Climate

The mean annual air temperature (MAAT) for 1981 to 2016 is estimated to be -11.9°C at Doris and -11.7°C at Boston. This is similar to the MAAT for the regional stations during the same period with MAAT of -13.9°C, -10.3°C, and -10.9°C at Cambridge Bay A, Kugaluktuk A, and Lupin A respectively.

Doris and Boston have predominant wind directions of west and west-northwest, respectively. Doris and Boston both show the tendencies with the highest wind speed recorded from December to April, in addition to a predominant westerly wind direction. During May to October, there is a reduction in wind velocities, with no predominant direction exhibited; however, there is a tendency to be on the East-West axis. Lastly, in November and December, the winds are predominantly westerly.

Precipitation occurs as rainfall and snowfall. The mean annual rainfall for both Doris and Boston is approximately 89 mm. The mean annual snowfall is 120 mm snow water equivalent. The estimated mean annual precipitation (MAP), water equivalent, is 210 mm.

Finally, the overall lake evaporation has been estimated to be 284 mm/year at Doris and 291 mm/year at Boston (SRK 2017c).

3.3.2 Permafrost

The Project is located in the region of the Canadian Arctic that is underlain by continuous permafrost. The estimated continuous permafrost depth is 570 m (SRK 2017a). The near surface temperature of the permafrost is -8°C. The active layer thickness depends on surface ground conditions, but typically ranges from 0.5-1.0 m (SRK 2015a).

3.3.3 Regional Geology

The Project area is in the faulted Bathurst Block, forming the northeast portion of the Slave Structural Province, a geological sub-province of the Canadian Shield. The region is underlain by the late Archean Hope Bay Greenstone belt, which is 7-20 km wide and more than 80 km long in a north-south direction. The belt is mainly comprised of mafic meta-volcanic (mainly meta-basalts) and meta-sedimentary rocks that are bound by Archean granite intrusive and gneisses. The Greenstone package has been deformed during multiple events, and is transected by major north-south trending shear zones that appear to exert a significant control on the occurrence of mineralization, particularly where major flexures are apparent and coincident with anti-forms (SRK 2015a).

3.3.4 Hydrology

The TIA is in a sub-basin of the Doris Lake drainage basin. The catchment naturally drains northwest towards Doris Lake. Flows in this sub-basin are consistent with all drainage basins within the Project area with peak flows occurring during freshet. The mean annual runoff (MAR) volume from this basin is approximately 640,000 m^3 (SRK 2017a)

3.3.5 Hydrogeology

Groundwater flow in a continuous permafrost environment is limited to shallow (seasonal) and deep groundwater flow. Shallow seasonal groundwater flow takes place within the active layer. Deep groundwater flow, on the other hand, takes place below the permafrost and in taliks (permafrost free zones) under larger water bodies. Deep groundwater has elevated salinity since the groundwater is ancient trapped seawater (connate water).

The Doris Mine will include mining in permafrost, as well as mining in the Doris Lake talik. Peak groundwater inflow to the mine is predicted to be 3,000 m^3/day. This water will be managed via the TIA and/or direct discharge to the ocean (SRK 2015c, 2017a). In the event that predicted mine inflow exceeds 3,000 m^3/day, the excess inflow will be temporarily stored in designated areas of the mine or pumped to the TIA. In the case of the latter, excess pump capacity will be available on site to divert excess flow to the TIA (TMAC 2017b).

The TIA hosts a talik, however, it is not known whether it is an open or closed talik. The talik is expected to reduce over the long-term as tailings freeze-back occurs (SRK 2015a).

3.4 Facility Components

3.4.1 North Dam

The North Dam impounds the Reclaim Pond and was designed as a water retaining structure. The dam has a central frozen core with a secondary upstream GCL. Complete design parameters are provided in Table 3.3 and Figure 4. The dam is constructed from local quarry rock and consists of processed fines for the core, 150 mm nominal sized transition material, and a run of quarry (ROQ) outer shell. To ensure maintenance of frozen foundation conditions, the key trench of the dam is equipped with 12 horizontal thermosyphon evaporators (SRK 2007, 2012, 2013, 2015a).

3.4.2 South Dam

Tailings will be deposited as a beach from the face of the South Dam. The South Dam is a frozen foundation dam consisting of a compacted rock fill with an upstream GCL keyed into the permafrost overburden foundation. Design parameters are provided in Table 6 and Figure 5. To accommodate the increased tailings quantities in Phase 2, the South Dam will be raised by 8 m in a downstream configuration to reach a crest elevation of 46.0 m. Construction materials will be sourced from local rock quarries and will include ROQ material as well as different grades of processed material attained through crushing and screening (SRK 2015a).

3.4.3 West Dam

The West Dam is a frozen foundation dam with a key trench and a GCL liner keyed into permafrost. The complete design parameters are provided in Table 6 and Figure 6. This dam will be constructed in a single raise, and will be about 470 m long with a maximum height of 5 m (crest elevation 46.0 m). Construction material for the West Dam consists of bedding, transition and ROQ material. The granular fill will be produced on site from one of many local approved quarries, with Quarry #3 likely being the primary source. Complete geological, mineralogical and geochemical details of these quarry sites are documented in SRK (2007, 2008).

3.4.4 Interim Dike

The interim Dike was proposed as a homogeneous ROQ rock fill dike, with an upstream filter zone. This was planned to be constructed within the confines of the TIA, directly on the existing lake bed sediment, without dewatering the TIA. The interim dike was originally planned to help retain tailings solids while allowing for tailings supernatant water to pass through the interim dike (this water then being stored towards the upstream face of the North Dam). This dike was originally planned to placed 2.5 years following the start of tailings production (SRK 2016).

The Interim Dike is not required as part of the Phase 2 tailings deposition plan and therefore has not been presented in this manual.

3.4.5 Spillway

An operational spillway was originally designed for the TIA at the North Dam, but is no longer required due to the freeboard of the North Dam being adjusted to inflow design flood (IDF) of probable maximum flood.

3.4.6 Tailings Deposition System

Tailings with an initial solids content of about 38% will be pumped to the TIA via a heat-traced and insulated pipeline. Daily tailings production rates are projected to be 1,200 tonnes per day (TPD) for the first year; 2,400 TPD for the next 2 years; 3,600 TPD for the remaining mine life; and 2,400 TPD during the final year of mining.

Deposition will be subaerial using single point spigots. Deposition will start from the crest of the South and West dams to create beaches that would push the supernatant water away from these structures. Once these beaches are created, the spigot points will be moved to the east flank of the TIA, where deposition will begin from elevation 49.5 m. This will create a long and even tailings surface sloping toward the North Dam, ensuring that the water in the original Tail Lake is displaced towards the north. Where the pipeline crosses Doris Creek at the Doris Creek bridge, the pipeline will be double walled to contain spills, as an added environmental protection measure (SRK 2015a).

3.4.7 Reclaim Water System

Reclaim water will be drawn from the TIA Reclaim Pond for re-use in the Process Plant. Reclaim water will be drawn from submerged suction lines feeding a low suction head pump installed in an on-shore enclosure located at the Reclaim Pond. This heat traced and insulated pipeline will follow the Secondary Road from the Reclaim Pond to the Doris mill. The pipeline will be double walled where it crosses Doris Creek (SRK 2015a, 2017d).

The Reclaim Pond will reduce in size over the life of the Project. For all but the last few years of the Project, the Reclaim Pond will have sufficient capacity to allow year-round reclaim water to be drawn from the TIA, including under ice conditions in the winter. Near the end of the Project life, however, this condition cannot be satisfied. As a result, increased volumes of fresh make-up water and more TIA discharge will be required and the full supply level (FSL) may have to be lowered to accommodate the IDF.

Water in the Reclaim Pond will continue to be managed via active pumping to the Roberts Bay Discharge System until the environmental discharge criteria can be met within the Reclaim Pond. At that time, the water in the Reclaim Pond will be pumped down to its pre-mining elevation of 28.3 m, and the North Dam will be breached.

3.4.8 TIA Discharge System

TIA water will be discharged during the open water season to Roberts Bay. The discharge pump will be located adjacent to the Reclaim pump and will pump water along a pipeline following the same route as the Reclaim water pipeline. This pipeline will be neither heat traced nor insulated, however, it will be double walled where it crosses Doris Creek. The TIA discharge water may mix with Doris Mine underground flows and continue along an overland pipeline to the Robert Bay Outfall Structure, before being pumped along the submarine pipeline to the Roberts Bay diffuser (SRK 2015a).

In addition to the discharge pump and line, a pipeline will be installed from Madrid North to the Doris North TIA. As part of this route there is a series of three stream crossings (SRK 2017d). At each of these stream crossing locations the pipelines will be doubled walled (similar to what is done at Doris Creek as outlined above).

3.5 Construction Timing

The North Dam was constructed during the winter months of 2010/2011 and 2011/2012. Construction was carried out by an experienced earthworks contractor with rigorous quality control. Quality assurance was carried out by the EOR (SRK 2012).

Extension of the South Dam key trench excavation and backfill must be completed in the winter to eliminate potential issues caused by thawing of the soft overburden soils, as well as to ensure that a thermal blanket is completed to protect the permafrost in the foundation. The bulk of the fill can be completed during any season. The construction of the South Dam is currently scheduled to occur in Quarter 1 of 2018.

Similarly, excavation of the West Dam key trench must be completed in the winter while the bulk fill can be completed during any season.

3.6 Tailings Properties

3.6.1 Tailings Geotechnical Characteristics

There have been multiple campaigns of tailings geotechnical testing carried out for the Project dating back to 2003. The definitive geotechnical design data for the Project with respect to tailings properties are listed in Table 3.1:

Table 3.1: Summarized tailings geotechnical properties

Parameter	Value
Specific gravity	2.85
% Fines (<0.075 mm)	65%
% Silt	52%
% Clay	13%
Void ratio (e) – slurried tailings	1.2
Void ratio (e) – drystack tailings	0.6
Deposited dry density (tonnes/m^3) – slurried tailings	1.30

3.6.2 Tailings Geochemistry

Phase 1 of the Project includes deposition of flotation tailings from the Doris deposit whereas Phase 2 includes the Doris, Madrid and Boston deposits. Based on the mine schedule, tailings from the Madrid South deposit is scheduled to be on the surface of the TIA at closure. The geochemical characterization programs for tailings and process water from Doris, Madrid North, Madrid South and Boston are documented in SRK 2015b and SRK 2017e.

Flotation tailings from all deposits are classified as non-Potential Acid Generating (PAG) with sulphur content highest for Madrid North, which was higher than Boston and Doris (which are roughly equivalent), which were typically higher than Madrid South. Pyrite was the primary sulphide mineral in all tailings types from all deposit areas.

The pH of all humidity cell tests of flotation tailing remained neutral to alkaline for the duration of the tests. Arsenic leaching is the primary metal leaching concern for both Madrid North and Boston and was highest for Madrid North flotation tailings. Arsenic leaching was not related to tailings type, sulphide content or arsenic content.

Process water from the mill will be a mixture of flotation and detoxified tailings process water and will be discharged to the TIA. A comparison of the mixed tailings process waters for Doris, Madrid North, Madrid South[1] and Boston metallurgical samples were roughly equivalent with the following exceptions:

- Arsenic levels for Madrid North and Boston were approximately two orders of magnitude higher than Doris, with concentrations from Madrid North slightly higher than Boston.
- Madrid North and Boston were higher than Doris for the following parameters: sulphate, antimony (Boston only), chromium, selenium (Madrid North only), and vanadium (Boston only).
- Doris had the highest levels of manganese.
- Cyanide is a reagent additive that is part of the milling process thus explaining the presence of total and WAD cyanide in the detoxified tailings process water only. Decreases in total and weak acid dissociable (WAD) cyanide were observed over the duration of both the oxic and anoxic tests indicating degradation of residual cyanide in the samples. Ammonia is a degradation product of cyanide thus explaining the elevated ammonia levels.

3.7 Dam Hazard Classification

The North Dam, South Dam, and West Dam was assigned a dam hazard classification in accordance with the Canadian Dam Association (CDA) Dam Safety Guidelines. The assigned hazard classification is listed in Table 3.2 (SRK 2017f).

Table 3.2: Dam hazard classification of TIA containment structures

Dam Class	Population at Risk	Loss of Life	Environmental and Cultural Values	Infrastructure and Economics	Overall Hazard Classification
North Dam	SIGNIFICANT	SIGNIFICANT	HIGH	LOW	HIGH
South Dam	SIGNIFICANT	SIGNIFICANT	HIGH	LOW	HIGH
West Dam	SIGNIFICANT	SIGNIFICANT	HIGH	LOW	HIGH

3.8 Overall TIA Design Criteria and Parameters

The basis of design, design criteria, and design parameters for the TIA are outlined in Table 3.3 (SRK 2017f).

[1] Where Boston is an analog for Madrid South

Table 3.3: TIA design criteria and design parameters

Description	Values		
	North Dam	South Dam	West Dam
Structure Type	Frozen core rock fill dam with GCL	Downstream raise of the frozen foundation rock fill dam with geomembrane	Frozen foundation rock fill dam with geomembrane
Secondary Seepage Barrier	GCL	GCL	GCL
GCL Deployment Slope	2.5H:1V	3H:1V (4H:1V for the raise)	3H:1V
Crest Centerline Length	220 m	515 m	470 m
Maximum Height	11.0 m	14.0 m	5.0 m
Final Crest Elevation	37.5 m	46.0 masl	46.0 masl
Initial Crest Elevation	n/a	n/a	n/a
Core/GCL Elevation	35.0 m	45.0 m	45.0 m
Full Supply Level		44.5 masl	44.5 masl
Normal Water Level			
Maximum Water Level			
Total Freeboard	3.3 m	1.5 m	1.5 m
Hydraulic Freeboard	1.8 m	0.5 m	0.5 m
Thermal Protection above Frozen Core	2.5 m	n/a	n/a
Settlement and Allowance Foundation thaw of 1 m (partial thaw) Foundation thaw of 7 m (full thaw)	1 m	 0.47-0.67 m 2.45-3.85 m	 0.40-0.60 m 2.03-3.43 m
Deformation Allowance (Total Strain due to Creep)	<2%	n/a	n/a
Crest Width	13 m	10 m	10 m
Upstream Structure Slope	6H:1V	4H:1V	4H:1V
Downstream Structure Slope	4H:1V	2H:1V	2H:1V
Key Trench Depth	Varies	4.0 m	4.0 m
Key Trench Upstream Slope	0.5H:1V	2H:1V	2H:1V
Key Trench Downstream Slope	0.5H:1V	1H:1V	1H:1V
Dam Hazard Classification	HIGH	HIGH	HIGH
Design Life: Active use period as water retaining structure Design basis as active water retaining structure Active use period as solids retaining structure Design basis as solids retaining structure Total life until breach	 17 years 22 years 22 years	 17 years 25 years 	 17 years 25 years
Tailings Production Rate	1,200 tpd for first year; 2,400 tpd for next 2 years; 3,600 tpd for remaining mine life except last year of mining when production rate drops to 2,400 tpd		
Tailings Storage Requirement: By Mass By volume			
Production Life	17 years		
Tailings Solids Content	35% solids (by weight) initially, increasing to 65%	37.5% solids (by weight)	37.5% solids (by weight)
Tailings Specific Gravity	2.85		
Deposited Tailings Dry Density	1.3 t/m^3 (1)		
Ice Entrainment Allowance: Percentage of tailings capacity By volume	 20% 2.4 Mm^3		
Tailings Beach Slope: Subaerial tailings Sub-aqueous tailings	 1.0% 1.0%		
Annual Exceedance Probability (AEP) for Risk Based IDF	1/2475 (0.0004)		
AEP for Standards Based IDF	1/3 between 1/1000 and the Probable Maximum Flood (PMF)(1)		
Static Stability Factor of Safety Long-term (Drained Conditions)	1.3 during construction 1.5 during operation and closure 1.2 to 1.3 partial or rapid drawdown		
Stability Factors of Safety (Pseudo-Static)	1.0 during earthquake		
AEP for Earthquake Design Ground Motion	1.2 post earthquake		
Peak Ground Acceleration (PGA)	0.060g(2)	0.036g	0.043g
Mean Annual Air Temperature Climate Change	+6.8°C up to year 2100		
Thermal Design Freezing Point Depression Tailings Overburden Frozen core	 n/a -8°C -2°C	 0 to -1°C -2°C n/a	 0 to -1°C -2°C n/a
Seepage Allowance	78 m^3/day	50 m^3/day	<1 m^3/day

Notes:
(1) Value based on experiential engineered judgement.
(2) A peak ground acceleration for a 1/2475 return period was not available at the time of design of the North Dam, and therefore the PGA of 0.06 g was selected based on published data for Kugluktuk. This is further described in SRK (2007).

3.9 Dam Break Analysis

In determining the dam hazard classification, consideration was given to tailings supernatant water and tailings solids reaching the receiving environment. The North Dam will include Tail Lake outflow, Doris Lake, Doris Creek and further downstream Little Roberts Lake. The South Dam will include Ogama Lake, Ogama Lake outflow and subsequently Doris Lake, while tailings breaching the West Dam will reach Doris Lake.

There is no conceivable chance of tailings solids being released as a result of a breach of the North Dam. Supernatant water; however, could conceivably reach the entire downstream catchment all the way to Roberts Bay.

A breach of the South Dam could result in release of tailings solids into Ogama Lake. There is a remote chance that some solids may find their way into the Ogama Lake outflow, and ultimately Doris Lake. The tailings solids will not be transported any further. Supernatant water will; however, progress all the way along the drainage network to Roberts Bay.

Tailings solids from a breach of the West Dam could reach Doris Lake, but at a location about 3.5 km away from the Doris Lake outflow, it is not expected the solids would migrate any further. Supernatant water could progress all the way along the drainage network to Roberts Bay. The breach scenarios described above are intuitive, although likely extremely conservative. Nonetheless, these scenarios were adopted in assigning the dam hazard classification for the structures. A rigorous dam breach analysis will not result in a different conclusion, and therefore was not done.

3.10 Water Management

All site contact water will be pumped or trucked to the TIA. Saline underground water (i.e., mine water) may also be pumped to the TIA or Roberts Bay at an expected maximum rate of 3,000 m^3/day (SRK 2015c). Standby pump capacity will be available on site in the event of mine water inflows greater than 3,000 m^3/day wherein excess mine water may be pumped to the TIA (TMAC 2017b). Mill make-up water will be drawn from the Reclaim Pond to the extent possible. During the open water season, any excess water in the TIA during Operations will be discharged to Roberts Bay for ocean discharge at a rate of 6,750 m^3/day. Prior to discharge to Roberts Bay, all water must meet MMER limits (SRK 2017a, TMAC 2017a).

There are no non-contact surface water diversions upstream of the TIA. The TIA is located in an isolated catchment, and the benefits of any diversions are outweighed by the relative cost and complexity of constructing them.

A site wide water and load balance, including the TIA, has been developed for the Project and forms the basis for the Water Management Plan (SRK 2017a, TMAC 2017a).

4 Operations

4.1 Objective

Operation of the TIA involves subaerial deposition of tailings slurry into the TIA, and simultaneous recovery of reclaim water from the Reclaim Pond. At closure, water in the Reclaim Pond will continue to be discharged directly to Roberts Bay until water quality in the TIA meets Doris Creek water quality discharge criteria as listed in the Water Licence (SRK 2017a). Once criteria are met, the North Dam will be breached. During this period the exposed tailings surface will be covered with a ROQ rock cover and the Interim Dike (if constructed) lowered to match the cover elevation (SRK 2015a).

During operation, and active closure, performance of the North Dam, South Dam, West Dam, Interim Dike (if constructed), tailings feed pipelines, reclaim water pipelines and discharge pipeline require surveillance and maintenance to ensure that they are operated within the stipulated design and operating limits. Triggers indicating that post-closure monitoring may cease, will be determined by TMAC as part of future Closure Plan updates, and submitted to the NWB for approval. After a period of post-closure confirmatory monitoring, site presence will cease.

Should any of the TIA systems be identified to be outside of the required design or operating range, the conditions will be investigated and remedied by considering one or more of the following actions:

- Modifying surveillance methods;
- Conducting appropriate maintenance;
- Revising operational procedures;
- Implementing remedial measures; or
- Revisiting the design.

4.2 Operating Criteria and Constraints

Table 4.1 shows the operating criteria and constraints for the Doris TIA.

Table 4.1: Operating Constraints

Concern	Trigger	Operational and Preventative Maintenance Considerations	Mitigation Strategies
North Dam deformation and seepage	Excessive thaw of foundation	• Maintain lowest possible water level in TIA. • Ensure thermosiphons are operational. • Maintain core at -2°C and foundation at -8°C. • Implement seepage pump-back system.	• Clear snow at downstream toe during winter. • Construct coarse rock convection berm at downstream toe. • Convert thermosiphons to active thermosiphons. • Retrofit dam with vertical thermosiphons.
South Dam deformation and seepage	Excessive thaw of foundation	• Maximize beach development from dam. • Maintain lowest possible water level in TIA. • Maintain foundation at -2°C. • Implement seepage pump-back system.	• Flatten downstream dam slope. • Clear snow at downstream toe during winter. • Construct coarse rock convection berm at downstream toe. • Retrofit dam with vertical thermosiphons.
West Dam deformation and seepage	Excessive thaw of foundation	• Maximize beach development from dam. • Maintain lowest possible water level in TIA. • Maintain foundation at -2°C. • Implement seepage pump-back system.	• Flatten downstream dam slope. • Clear snow at downstream toe during winter. • Construct coarse rock convection berm at downstream toe. • Retrofit dam with vertical thermosiphons.
Overtopping	Severe storm runoff	• Maintain lowest possible water level in TIA. • Maximize beach development from South Dam. • Ensure discharge system is operational.	• Increase discharge capacity. • Construct North Dam spillway.
Water balance	Reclaim water shortage	• Manage annual discharge to maintain minimum required operating water level.	• Increase make-up water demand from Doris Lake.
	Excessive inventory	• Manage discharge to not exceed maximum required operating water level.	• Increase discharge capacity.
Load balance	Water unsuitable for reclaim	• Retain water provided capacity is available.	• Develop strategy to treat water.
	Water unsuitable for discharge	• Retain water provided capacity is available.	• Develop strategy to treat water.
Tailings deposition	Improper beach development	• Survey existing beaches and used data to recalibrate deposition modeling to develop new deposition plan.	• Add additional spigot points as required by the revised deposition plan.

Concern	Trigger	Operational and Preventative Maintenance Considerations	Mitigation Strategies
Pipeline (tailings, reclaim and discharge) freezing	Winter period pump stoppage	• Maintain minimum flow velocities of 1 m/sec. • Heat tracing and insulation of pipelines. • Mobile backup pumps.	• Installation of secondary pipeline(s).
Tailings pipeline sanding up	Pump stoppage for extended periods	• Mobile backup pumps. • Flush pipeline immediately following pump stoppage.	• Installation of secondary pipeline. • Dismantling affected section of pipeline and flushing or replace.
Pipeline breakage/leakage (tailings, reclaim and discharge)	Fatigue, corrosion, or accident	• Implement visual inspection procedure. • Establish barricades where appropriate. • Provide secondary containment in high risk areas.	• Stop pumping and implement site spill response plan.
Tailings dust	Wind and equipment traffic	• Minimize use of equipment on tailings beaches. • Apply water.	• Apply chemical dust suppressants as appropriate.
Animal access	Terrestrial mammals accessing TIA area	• Implement Wildlife Monitoring and Mitigation Plan (WMMP).	• Refer to WMMP.
People safety	Uninformed people accessing TIA area	• Conduct site specific orientation and training.	• Implement access controls through signs and road barricades.

4.3 Tailings Transport and Deposition

Deposition will be subaerial using single point spigots. Deposition will start from the crest of the South and West dams to create beaches that would push the supernatant water away from these structures.

Once these beaches are created, the spigot points will be moved to the east flank of the TIA, where deposition will begin from elevation 49.5 m. This will create a long and even tailings surface sloping toward the North Dam, ensuring that the water in the original Tail Lake is displaced towards the north. Where the pipeline crosses Doris Creek at the Doris Creek bridge, and at the three locations along the Doris to Windy all-weather road between Madrid North and the Doris North TIA (SRK 2017d), the pipeline will be double walled to contain spills, as an added environmental protection measure (SRK 2015a).

A plan showing the staged tailings deposition for every three years up to year 16 (e.g., 2017 to 2032) is presented in Table 4.2. The details are summarized in Table 9. Discharge durations were based on the average production rates plus ice entrainment (20% of tailings volume) for all years of deposition. The total storage requirement inclusive of ice entrainment equals 13.9 Mm^3.

Table 4.2: Summary of tailings deposition details per three-year period

Period	Active Spigots (Elevation)	Cumulative Discharge Volume(1)	Active Deposited Tailings Surface Area (km^2)(2)	Previous Tailings Surface Area not Impacted by Active Deposition (km^2)(3)	Total Tailings Surface Area (Cumulative – km^2)
Year 2023	Spigot #1 (44.5 m) Spigot #2 (44.5 m) Spigot #3 (44.5 m) Spigot #4 (44.5 m)	3.1 Mm^3 / 4.0 Mt	0.9	0	0.9
Year 2026	Spigot #5 (44.5 m) Spigot #6 (44.5 m) Spigot #7 (46.5 m)	6.1 Mm^3 / 7.9 Mt	1.16	0.14	1.3
Year 2029	Spigot #7 (49.5 m) Spigot #8 (45.5 m)	9.1 Mm^3 / 11.9 Mt	1.4	0.1	1.5
End of Phase 2 (Year 2032)	Spigot #8 (48.5 m)	11.6 Mm^3 / 15.1 Mt	1.14	0.56	1.7

Notes:
(1) Cumulative discharge volumes are tailings only and do not include ice entrainment volumes.
(2) The deposited tailings surface area (shown in yellow in Figure 07) is the resultant surface area from active tailings deposition for the period indicated.
(3) Tailings surface area (shown in grey in Figure 07) is the exposed tailings surface that is not covered by deposition.

4.4 Dust Management

A comprehensive assessment of possible dust management practices for the tailings surface is presented Attachment B. The tailings deposition plan has been developed, as far as practical, to minimize the area of exposed inactive tailings surface that may be prone to dusting. Beyond such mitigation by design, the primary dust control measure of the Project site TIA will be the use of environmentally suitable chemical dust suppressants. The application of these suppressants will be reviewed on an ongoing basis to ensure any areas that may be at risk will be adequately covered. Generally, annual application of chemical suppressants will be applied; however, it is recognized that more frequent applications may be required as discharge locations are changed throughout any year.

Attachment C contains a list of currently available commercial products suitable for use at the Doris TIA. Use of alternate products is permitted upon receipt of approval from the Nunavut Water Board.
In addition to chemical dust suppressants, natural dust control in the form of packed snow when available, will be used as far as practical. Again, the effectiveness will fluctuate on a year by year basis depending on how deposition points vary for any given winter season. Finally, if for any reason the above dust control methods prove to be temporally ineffective, a suitable water cannon will be available to allow for dust suppression by wetting the areas of concern.

4.5 Water Management

During operations, in addition to tailings slurry, the following sources of mine contact water may be pumped to the TIA: underground mine water, pollution control pond water, sedimentation pond water, landfill sump water, bulk fuel storage sump water, treated sewage effluent, and any other industrial contact water collected at site from various locations (Figure 8).

The tailings supernatant water will drain into the TIA Reclaim Pond where process water will be reclaimed for mill operations. During the open water season (June – September inclusive), excess TIA water will be discharged to Roberts Bay. Complete water management procedures are provided in the Water Management Plan (SRK 2017a, TMAC 2017a,b).

If the project goes into Care and Maintenance, excess TIA water will be discharged to Roberts Bay via the Marine Outfall Mixing box annually during the open water season. Complete water management procedures are provided in the Water Management Plan (TMAC 2017a).

4.6 Emergency Management

The following emergency operation procedures are directed mainly at avoiding injury or death of persons employed on pipeline systems. A secondary objective is to prevent or minimize environmental damage.

The following emergency operation procedures are directed mainly at avoiding injury or death of persons employed on pipeline systems. A secondary objective is to prevent or minimize environmental damage.

4.6.1 Punctured/Burst Pipeline

In the event of a puncture/burst to the TIA pipeline systems, the emergency procedure is as follows:

- TIA operator notifies the Mill Manager immediately. Should other personnel not related to the TIA management notice the problem, they notify the Surface Operations Supervisor who in turn notify the Mill Manager.
- Mill Manager will inspect the pipeline and determine whether the pipe can be repaired without ceasing operations, or not.
- If the mill is required to shut down, the Mill Manager co-ordinates an emergency mill shut down.
- Repairs are performed by the TIA operator or specialist contractor.

4.6.2 Leakage of Pipelines

In the event of a leakage of the pipelines, the emergency procedure is as follows:

- TIA operator is to notify the Mill Manager immediately. Should other personnel not related to the TIA management notice the problem, they notify the Surface Operations Supervisor who in turn notify the Mill Manager.
- Mill Manager will inspect the pipeline, assess how significant the leakage is, and determine whether the pipe can be repaired without ceasing operations or not.
- If the mill is required to shut down, the Mill Manager co-ordinates an emergency mill shut down.
- Repairs are performed by the TIA operator or specialist contractor.

4.6.3 Malfunction of the Heat Tracing Cable

Heat tracing is only required for: no-flow conditions under freezing temperatures, flow conditions below -30^{o}C, and extended shutdowns (i.e., greater than 24 hours). The heat tracing will therefore normally be switched off with the primary preventative maintenance being to maintain flow in all pipes. In the event of a malfunction of the heat tracing cable inside of the required operating periods, the emergency procedure is as follows:

- TIA operator will notify the Mill Manager immediately.
- Mill Manager will inspect the pipeline, determine the extent of the malfunction, and assess how long a repair might take.
- Repairs are performed by the TIA operator or specialist contractor.

4.7 Environmental Protection

Protection of the aquatic environment has been incorporated into the design of the facility through the selection of a dam classification criterion, dust management system, water management planning, the incorporation of an impermeable liner within the North, South and West Dams, as well as secondary pipeline containment along the extent of the Doris Creek crossing, as well as long the creek crossing form Madrid North to the Doris TIA (along the all-weather access road (SRK 2015a, d, 2017d, TMAC 2016).

4.8 Freeboard Requirements

The North Dam will be operated as a water retaining dam. It has a crest elevation of 37.5 m. The top of the frozen core and GCL is at elevation 35.3 m. The FSL for the North Dam is 33.5 m, which provides for a total freeboard of 4.2 m, and a normal freeboard of 2 m. These freeboard numbers however include a 1 m allowance for dam deformation (SRK 2015a).

The South and West dams are not water retaining structures. Tailings beaches will be developed along the upstream slope of these dams to create a final topography free-draining towards the Reclaim Pond ensuring no water will pond adjacent to these structures. The GCL in both dams will terminate at elevation 45.0 m, 11.5 m above the TIA FSL. Tailings deposition will commence from discharge points located near the dam crest at elevation 44.5 m for both the South and West dams, leaving a freeboard of 1.5 m.

4.9 Concurrent Closure

The overall objectives of the conceptual closure and reclamation plan are to leave the site in a manner safe for humans, wildlife and the environment that meets future land use goals. This will be done by establishing stable chemical and physical conditions and ensuring the future use and aesthetics of the site following reclamation meet the requirements of Aboriginal, Federal and Territorial governments, landowners, local communities and regulatory authorities.

The tailings surface will be covered with a nominal waste rock cover of 0.3 m thickness. The function of the cover is to prevent dust and to minimize direct contact by terrestrial wildlife. Once the water quality in the Reclaim Pond has reached the required discharge criteria, the North Dam will be breached as originally intended for Phase 1. The TIA, once breached will discharge into Doris Lake which in turn discharges into Doris Creek.

The TIA will only contain flotation tailings which are non-PAG with abundant neutralization potential and thus buffering capacity. Although several metals in the tailings solids occur at concentrations more than crustal abundances, many of these metals are associated with sulphides and as such will primarily partition into the detoxified tailings which means they will not be of concern in the TIA.

Long-term humidity cell tests indicate that after the initial flushing of the samples, an increased tendency for neutral pH metal leaching may develop, with arsenic being of concern. The TIA water and load balance (SRK 2017a) suggests that possible neutral metal leaching does not pose a limitation in ensuring that the water quality in the TIA meet site specific closure water quality criteria, and therefore no infiltration reduction cover is required on the exposed tailings surface. The tailings surface will however be susceptible to wind erosion with the resultant effect of dust exposure. Similarly, although the tailings surface is landscaped to allow free drainage, the tailings are susceptible to hydraulic erosion, which will mobilize tailings towards the Reclaim Pond with a resultant increase in total suspended solids.

The tailings cover that functions to prevent wind and water erosion will be constructed over the entire tailings surface. The minimum thickness of cover that can practically be placed over the tailings surface would be about 0.3 m thick, and therefore the cover design has been set at 0.3 m thick ROQ material.

4.10 Safety and Security

The Doris project is accessed by air, with use of an all-weather air strip, and with an annual barge sealift re-supply in Roberts Bay during the open water season. Within the mine site, access to the TIA is restricted to authorized employees, contractors and consultants. All workers accessing or operating the facility are trained and knowledgeable about workplace hazards at and near the TIA.

5 Maintenance

5.1 Objective

The objective of the maintenance program is to ensure all TIA components are operating according to their performance criteria.

5.2 Maintenance Parameters

The Doris TIA components that require maintenance include:

- North Dam, South Dam, and West Dam; and
- Pumps and pipelines.

5.3 Maintenance Procedures

5.3.1 Routine and Preventative Maintenance

Dam maintenance will be determined each year after completion of the DSI; however, it is likely that the following maintenance items will be required annually:

- Some dam monitoring instrumentation may get damaged, either through natural wear and tear or perhaps as a result of animal damage, vandalism or accidents. Damaged instrumentation is repaired or replaced as needed. Some instrumentation need annual recalibration (SRK 2013).
- Thermal modeling for the dams has shown that although the dam core and its foundation will remain frozen, the upstream and downstream foundations will gradually thaw, and lead to settlement of those sections of the dam. Based on the findings of the DSI, areas that have undergone settlement may have to be repaired by adding more fill (SRK 2007, 2013, 2015a).
- Snow drifts on the downstream toe of the dams will result in an insulating effect on the downstream toe, which may lead to more rapid thaw of the downstream foundation. If the snow is continuously cleared from this area, the dam may perform much better than the thermal modeling suggests, and therefore regular clearing of snow in this area may be recommended.
- Every year the thermosyphons are visually inspected. Ongoing monitoring of their performance occurs to determine if any of the thermosyphons need to be recharged with CO_2. Any damaged radiator fins must also be repaired or replaced (SRK 2013).

Routine pipeline system maintenance tasks are as follows:

- Pipelines: At least once every six months the tailings pipelines are completely flushed with fresh water. Once every year, every pipeline is pressure tested to check for leaks.
- Drain outlets: Drain outlet pipes are monitored during pipe drainage. Should a drop off in the flow rate be detected, the pipe is flushed using hydraulic cleaning equipment.
- Pumps: Maintenance of the pumps, seals, controls, instrumentation and electrics is carried in accordance with manufacturer's specifications.
- Valves: Maintenance of the isolating and check valves is performed in accordance with manufacturer's specifications.
- Flow- and hour meters: Flow and hour meters are serviced annually and recalibrated according to manufacturer's specifications.

5.3.2 Event Driven Maintenance

In addition to planned inspections and preventative maintenance, the TIA is inspected after any unusual or extreme events such as heavy rainfall, flooding, windstorm, severe icing, rapid snow melt, earthquakes, and exceedance of the maximum water level. Triggers for such unusual events are when design criteria as listed in Table 7 are exceeded; however, to a large extent judgement of the responsible on-site parties would govern.

Event-driven maintenance for the TIA components will be directed by the TIA manager and Mine General Manager under the consultation of the EOR.

5.4 Documenting and Reporting

Maintenance records of each component are kept by the Mill Manager and include:

- Up to date logs of in service equipment and facilities;
- Maintenance schedules;
- Maintenance history;
- Inspection logs;
- Repair records;
- Frequency and cause of problems, and planned mitigation;
- Component reliability records;
- Photographic evidence of repairs;
- Inventory of spares, material, tools and equipment; and
- Critical spares list.

6 Surveillance

6.1 Objective

Surveillance information is gathered through visual inspections, monitoring performance, safety audits, and data collection. Ongoing review of both qualitative and quantitative surveillance information informs appropriate preventative maintenance. The objectives of the surveillance program are to:

- Regularly monitor the operational performance of the TIA and its components,
- Consistently report observations, and
- Regularly review and interpret surveillance data.

Throughout the operational phase of the Project, the containment structures (North, South and West dams) will be subject to rigorous monitoring to evaluate their performance. This will include thermal, settlement and other general deformation monitoring. In addition, thermal monitoring of the tailings profile will be carried out to confirm tailings freeze-back assumptions. All of the above will be subject to annual inspections by a qualified professional engineer as part of routine annual inspections.
The frequency of these inspections may be reduced as time progresses in accordance with the inspection engineer’s recommendations.

6.2 Frequency and Responsibility

The Mill Manager is responsible for ensuring that the ongoing monitoring as documented in the dam surveillance SOP is carried out (SRK 2013). If determined necessary, the Mill Manager may consult with the EOR to complete a safety inspection outside of the routine annual DSI.

Annually, the EOR, or an authorized representative, undertakes a physical inspection of the TIA.
This inspection is carried out in the summer and culminates in a detailed DSI report. The report includes findings and recommendations on the TIA performance taking into account inspection observations, interviews with operations staff responsible for the TIA, as well as a review and analysis of all monitoring data collected. This report is delivered in a timely manner so that, if required, maintenance and mitigation can be carried out to address areas of concern. Should important matters be observed, those will be communicated to TMAC at the time of the DSI.

In addition to the annual inspections, the DSR is arranged every seven years. The DSR is carried out by an independent third party and is a systematic assessment of all aspects of design, construction, maintenance, operation, processes, and systems affecting the safety of the TIA. This review encompasses all elements of the TIA, but focuses on the North Dam, South Dam and West Dam, and is based on the state-of-practice at the time of the inspection as opposed to when the facilities may have been designed. The first DSR needs to be completed in 2019.

6.3 Monitoring Data Management Protocols

All monitoring data is stored electronically with backup. Manual notes are scanned and the raw data saved together with any transposed data. Data is reviewed by qualified staff immediately following collection to confirm integrity of the instrumentation, as well as to ensure that the TIA performance is consistent with expectations and the monitoring guidelines specified in the dam surveillance SOP (SRK 2013).

6.4 Surveillance Components

The surveillance elements for the Doris TIA includes:

- Visual observation;
- Instrumentation (thermal, deformation and water balance);
- Water quality monitoring; and
- Tailings geochemistry monitoring.

6.5 Surveillance Procedures

6.5.1 Visual Inspections

Plant operations staff carry out daily visual inspections of the TIA structures, taking note of any signs of settlement, unaccounted for drops in water levels, signs of seepage, or any signs of damage or vandalism to instrument clusters. Records of these daily inspections are documented in a site diary, completed by the person carrying out the inspection. This inspection may trigger maintenance or operational actions. A monitoring checklist is presented in the dam surveillance SOP.

The EOR is notified immediately after any inspection where notable changes to any of the TIA facilities outside of normal operating constraints are observed. The EOR will, in consultation with operations staff, assess the situation and develop any actions plans if deemed appropriate.

Operations staff also carry out daily visual inspections of all TIA pipeline systems. The following information is recorded in dedicated site logbooks:

- Pump stations: Document which pumps are operational, how many hours each pump has operated and note the discharge and suction pressures of operational pumps. Carry out checks for leaks and spillages, and confirm oil levels for all pumps, and seals on water pumps for the tailings pumps. Take note of any alarms and messages.
- Pipelines: Record which pipelines are operational, and for how long they have been operating. Record the flowmeter data and the operating pressures along the pipelines. Check pipelines for any leaks and blockages and take note of any hazards along the pipeline route. Check the system for any alarms and messages (such as malfunction of the electric heat tracing cable inside the pipeline during freezing temperatures). Record where actual tailings deposition has taken place in the previous 24-hour period.

- Spigots: Stringent monitoring of the two spigots situated on the east flank of the TIA is required since both spigots are above the crest elevation of the South Dam (note that spigot elevations are typically lower than the crest elevation of containment structures).
- Creep: Deformation monitoring during operational phase of the South Dam and West Dam will be undertaken since these structures may be susceptible to creep deformation in the long term.

6.5.2 Instrumentation

Details on the North Dam instrumentation plan are presented in the dam surveillance SOP. The locations of North Dam monitoring instruments are shown in Figures 9 to 12.

A series of ground temperature cables and survey prisms will be installed during Phase 1 at the South Dam to monitor the thermal regime of the foundation and overall deformation performance.
The proposed (minimum) locations of South Dam monitoring instruments are shown in Figure 13.

Ground temperature cables installed in the key trench of the Phase 1 dam will be protected during construction and maintained for continuous monitoring of the dam performance. The thermal monitoring will be supplemented by new ground temperature cables located within the dam raise as well as the extended key trench. Some of the survey prisms of the Phase 1 dam will be destroyed during construction, and the overall deformation monitoring will rely on new prisms installed in appropriate locations in the raised portion of the dam. Vertical ground temperature cables will be installed in boreholes drilled through the dam fill after the completion of the dam raise and the new cables will extend to the original ground level. The portion of the boreholes within the ROQ fill may require temporary casing. Horizontal ground temperature cables will be placed within the liner bedding layer along the upstream side of the key trench. Survey prisms will be permanently installed in large boulders within the dam shell.

A series of ground temperature cables and survey prisms will be installed at the West Dam to monitor the thermal regime of the foundation and overall deformation performance. Vertical ground temperature cables will be installed in boreholes drilled through the dam fill after the completion of the dam. The portion of the boreholes within the rock fill may require temporary casing. Horizontal ground temperature cables will be placed within the geomembrane bedding layer along the upstream side of the key trench. Survey prisms will be permanently installed in large boulders within the dam shell.

6.5.3 Water Quality Monitoring

Water quality monitoring for the TIA is described in the Doris and Madrid Water Management Plan (TMAC 2017a**)**.

6.5.4 Tailings Geochemistry Monitoring

Flotation tailings geochemical characterization testing (SRK 2015b and SRK 2017e) has confirmed that due to the high neutralization potential and low sulfur content, Acid Rock Drainage (ARD) potential is considered low but that there is potential for neutral pH metal leaching, particularly for arsenic. Confirmatory monitoring includes weekly sample collection for the preparation of a monthly composite sample to be analysed for total metals by aqua regia digestion followed by ICP finish, total sulphur by Leco furnace and direct measurement of total inorganic carbon.

6.6 Documenting and Reporting

Templates for the daily visual inspection report, and monthly instrumentation report forms are included in the SOP. This surveillance and inspection reporting as specified in the dam surveillance SOP, are carried out by a qualified person under the supervision of the Mill Manager. These reports are submitted to the EOR on a monthly basis.

The following reports will be prepared in accordance with the relevant water licences and submitted no later than March 31 of the year following monitoring:

- Annual Tailings Geochemical Monitoring Report.
- Annual Geotechnical Inspection Report

7 References

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Figures

N

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TMAC RESOURCES

DORIS TIA OMS MANUAL

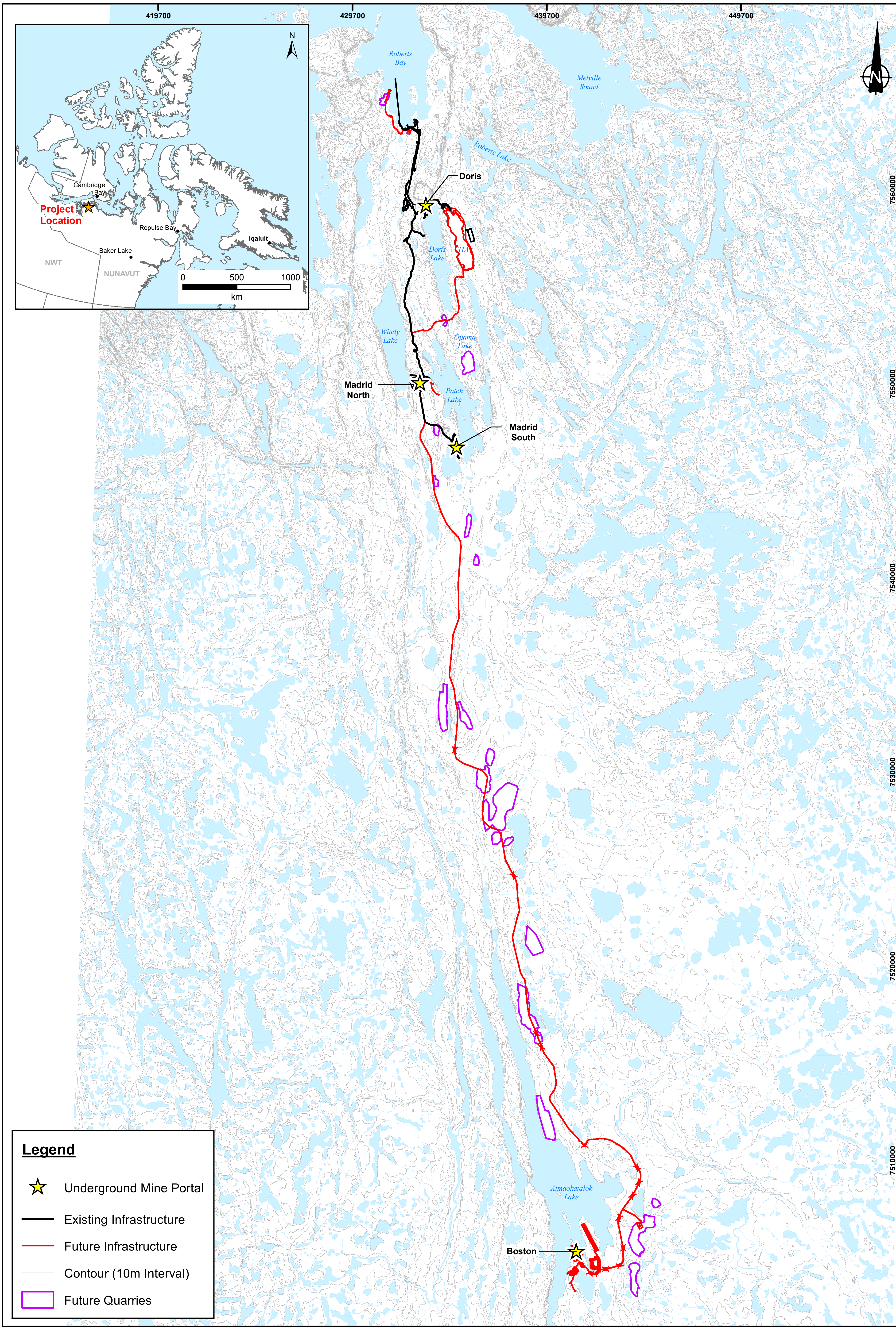
Site Location Plan

SRK JOB NO.: 1CT022.004.600.10

FILE NAME: 1CT022.004.600.10 - FIGURE 1.dwg

HOPE BAY PROJECT

DATE:	APPROVED:	FIGURE:
May 2016	IM	1



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0 2 4 6 8 10

Kilometres

Notes:
1. Coordinate System: NAD 1983 UTM Zone 13N
2. Base Topo Data: CanVec, Natural Resources Canada

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TMAC RESOURCES

DORIS TIA OMS MANUAL

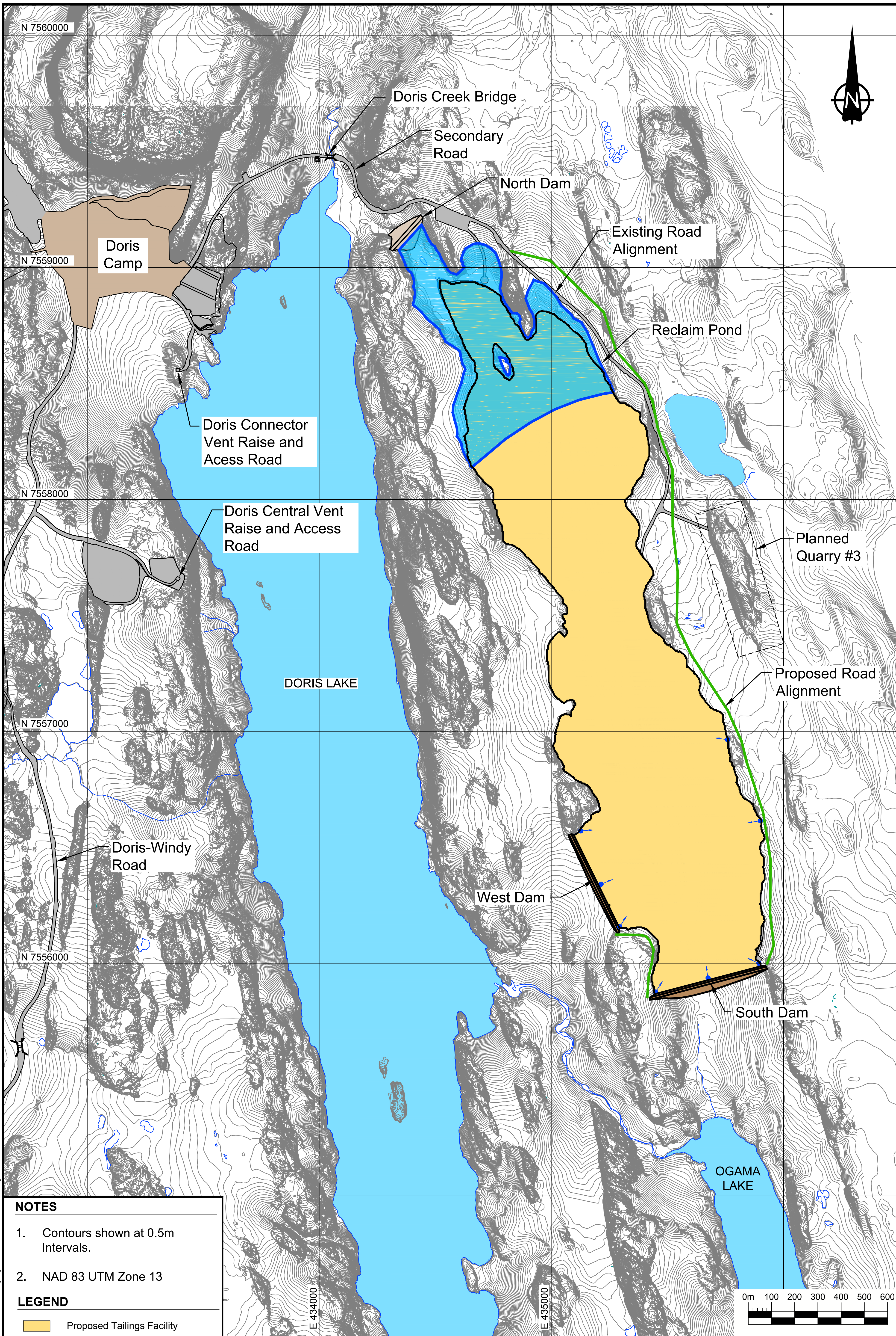
Site Location Map

Project No: 1CT022.004.200.10

Filename: 1CT022.004.200.10_Fig_2_TIASiteLocationMap_mzs

HOPE BAY PROJECT

Date:	Approved:	Figure:
Nov. 2016	MMM	2



NOTES

1. Contours shown at 0.5m Intervals.
2. NAD 83 UTM Zone 13

LEGEND

- Proposed Tailings Facility
- Proposed Dam/Dikes
- Existing Facilities
- Existing Doris Camp
- Proposed Road Realignment

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SRK JOB NO.: 1CT022.004.600.010

FILE NAME: 1CT022.004.600.10 - FIGURE 3.dwg

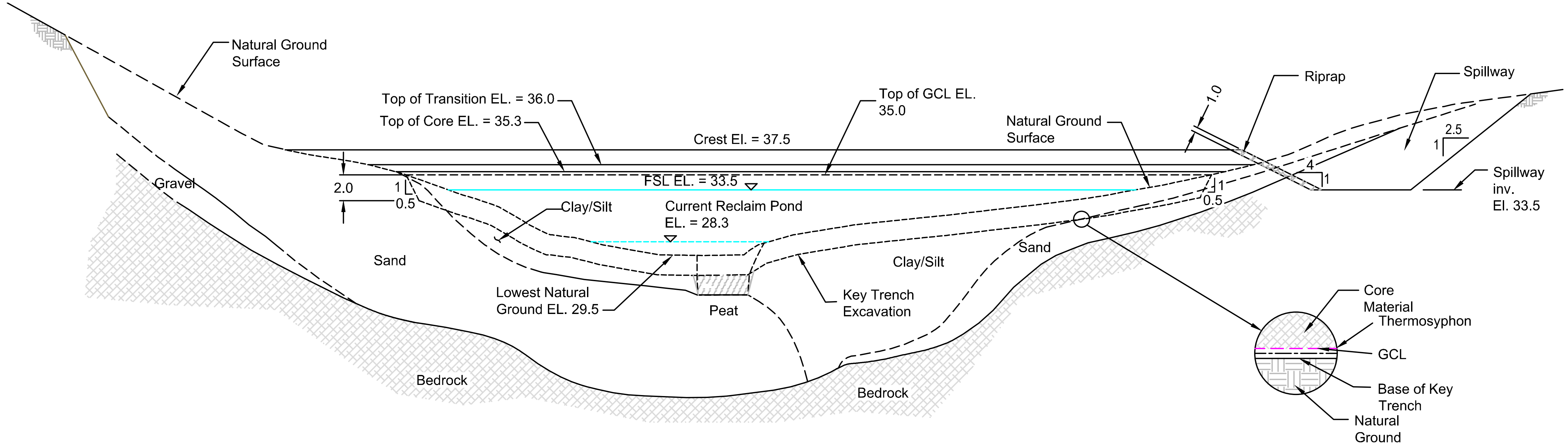
MAC RESOURCES

HOPE BAY PROJECT

DORIS TIA OMS MANUAL

General Site Plan

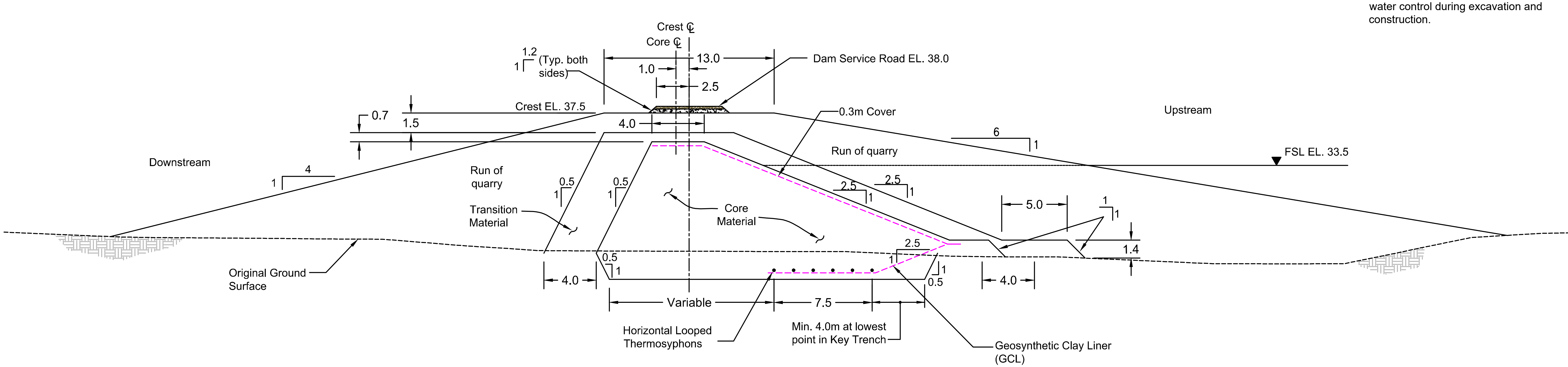
DATE:	APPROVED:	FIGURE:
May 2016	IM	3



A 05 North Dam Longitudinal Section

0m 2 4 6 8 10 Vertical

0m 5 10 15 20 Horizontal



North Dam Typical Cross Section

0m 0.5 1.0 1.5 2.0 2.5 3.0 Vertical

0m 1 2 3 4 5 6 Horizontal

LEGEND

- Overburden
- Natural ground
- Surfacing material
- Select Subgrade
- Run of quarry
- Core material
- Peat

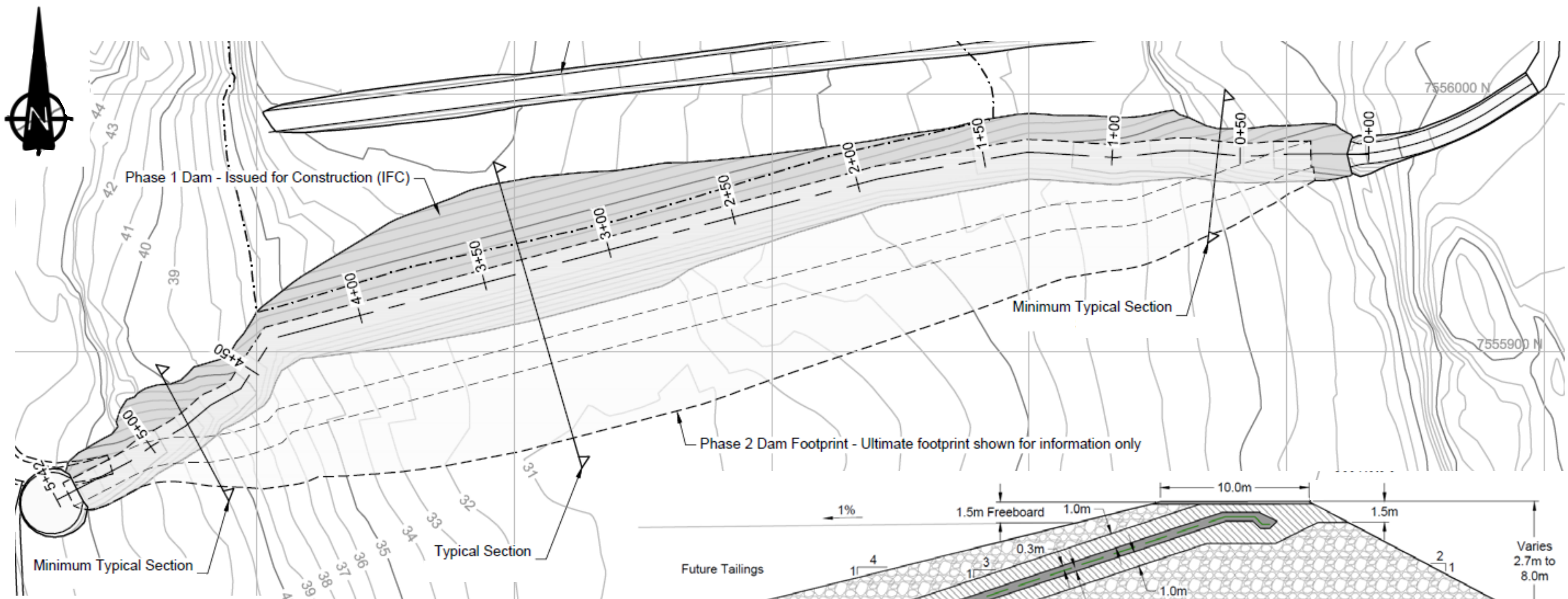
NOTES

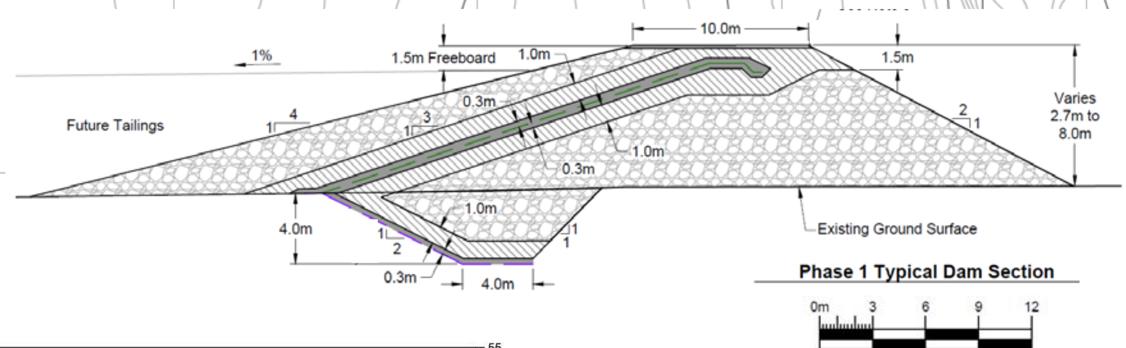
1. The subsurface geology has been extrapolated from a series of geotechnical investigations consisting of drill holes, auger holes and shallow test pits. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation. The Engineer will inspect all excavations and approve the foundation conditions.
2. The actual extent of the key trench excavation will be confirmed on site by the Engineer after bulk excavation as indicated by the drawings.
3. The Contractor must ensure that all organic matter and peat is excavated from the dam foundation.
4. Overburden soils from the key trench must be stockpiled in an area designated by the Engineer.
5. The Contractor shall be responsible for water control during excavation and construction.

srk consulting	MAC RESOURCES	DORIS NORTH TIA OMS MANUAL
SRK JOB NO.: 1CT022.002		NORTH DAM CROSS SECTION
FILE NAME: 1CT022.002 - North Dam_Figure4.dwg	HOPE BAY PROJECT	DATE: May 2016 / APPROVED: EK/SA / FIGURE: 4

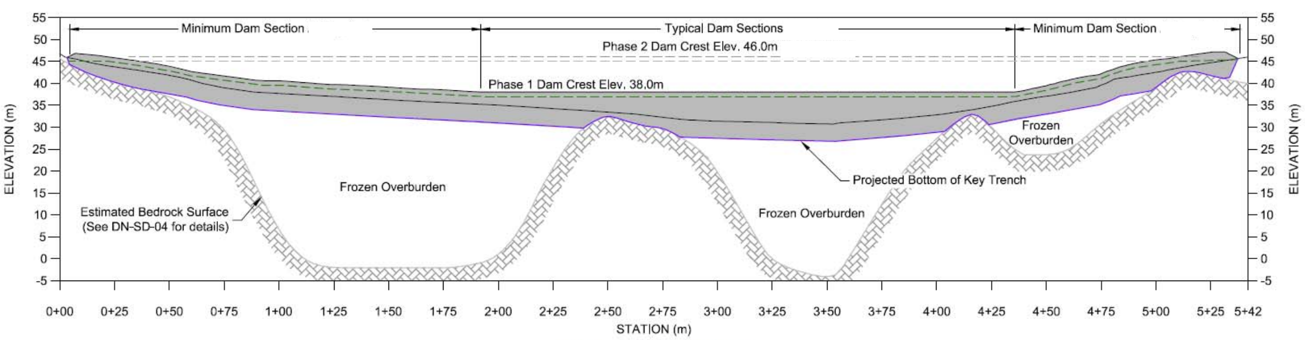
X:\1CT022.002_2015_Hope Bay Ongoing Support\200_Type_A_Water_License\2000_Tailings_Management_Plan\040_AutoCAD\1CT022.002 - North Dam_Figure4.dwg

P:\01_SITES\Hope.Bay\!ACAD\South Dam – Phase 1\1CT0022.017 – South Dam – Typ Sections.dwg





Phase 1 Typical Dam Section



Phase 1 Dam Profile View

NOTES

1. All dimensions and elevations are in meters unless stated otherwise.
2. The subsurface geology has been extrapolated from a series of geotechnical investigations. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.

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MAC RESOURCES

DORIS TIA OMS MANUAL

South Dam Profile and Cross Sections

Job No: 1CT022.013

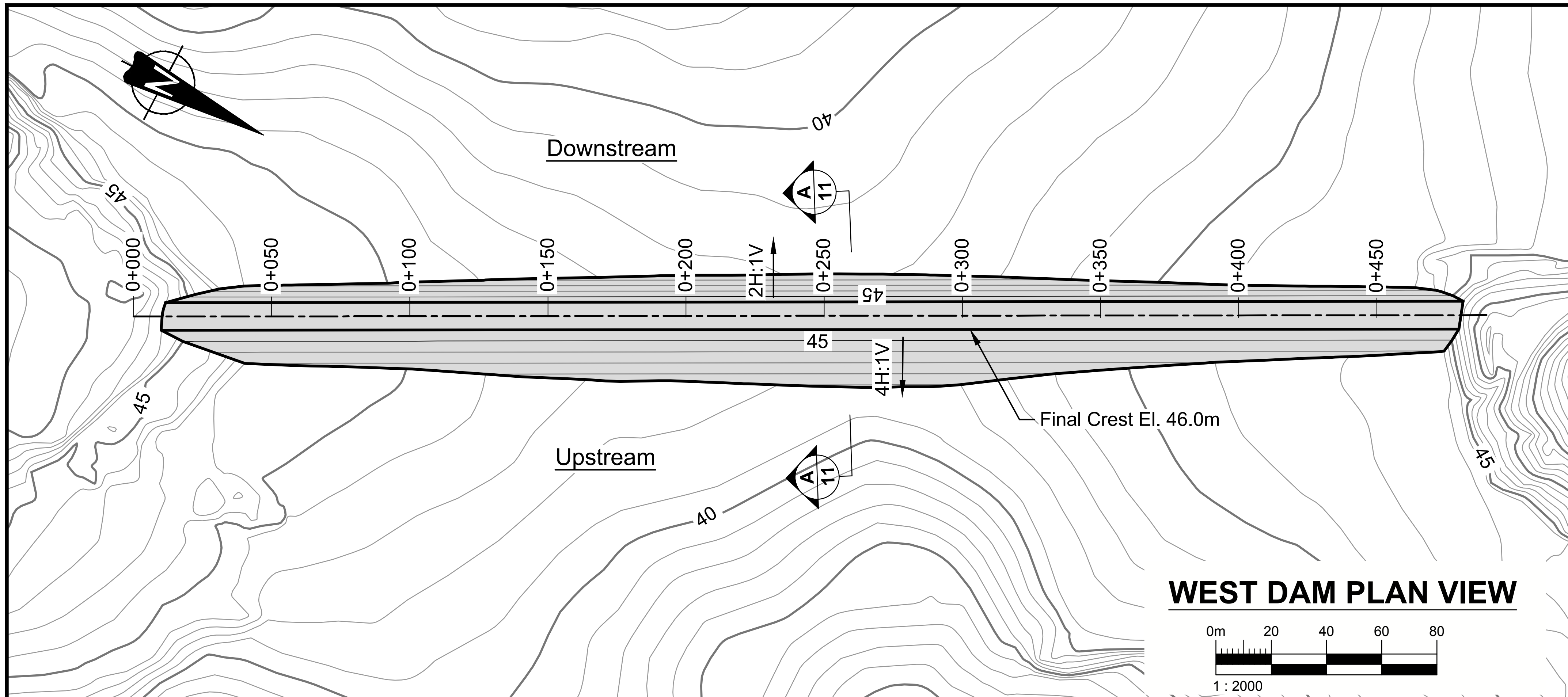
Filename: HB_DorisNorthTIA_OMSManual_Figure 5

HOPE BAY PROJECT

Date: Nov 2017

Approved: JBK

Figure: 5



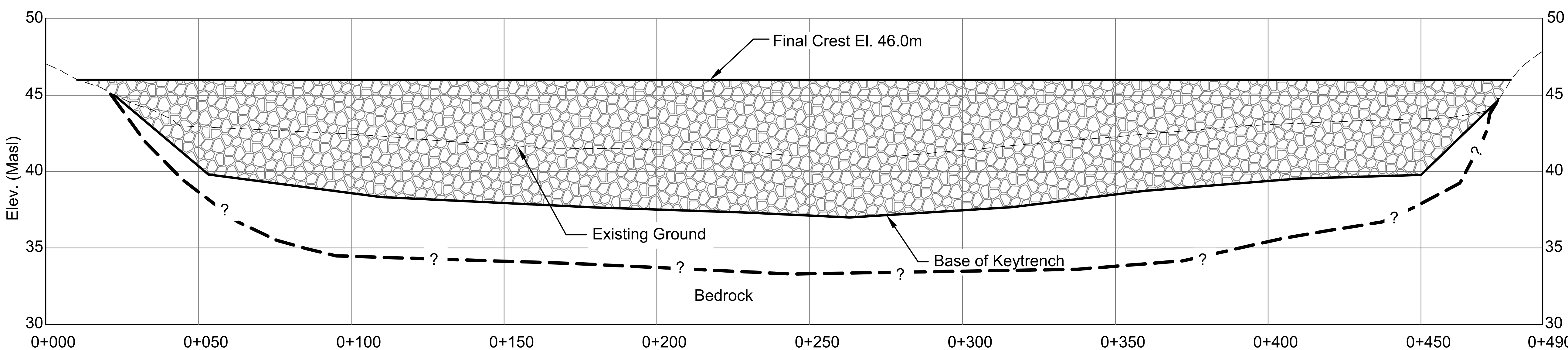
WEST DAM PLAN VIEW

LEGEND

- Natural Ground
- Approximate Stratigraphic Boundary
- Run of Quarry (ROQ)

NOTES

1. All dimensions and elevations are in meters unless stated otherwise.
2. The subsurface geology has been extrapolated from a series of geotechnical investigations. Bedrock contact and geological unit contacts are therefore likely to vary somewhat during final excavation.



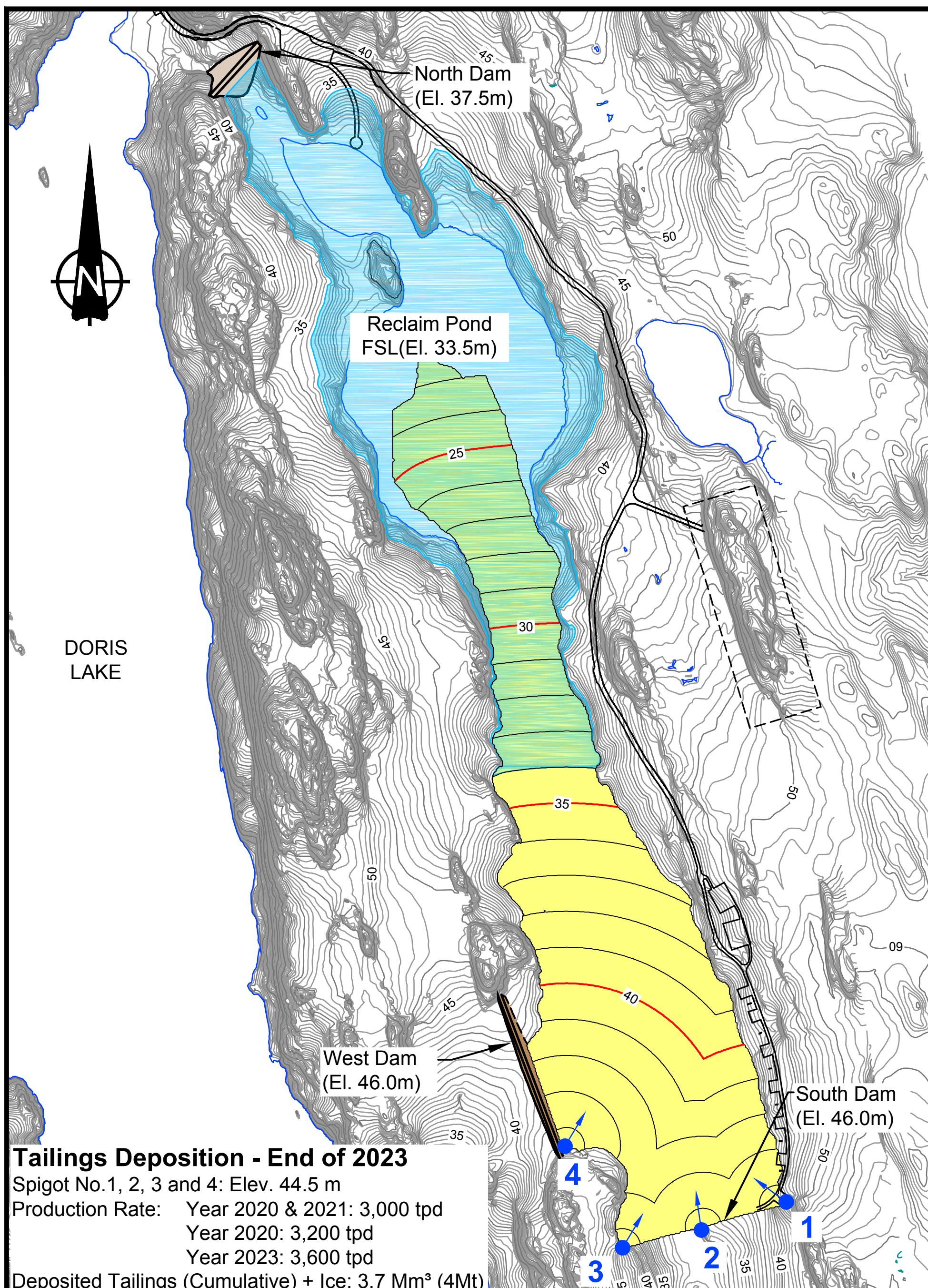
WEST DAM PROFILE

5x EXAGGERATION

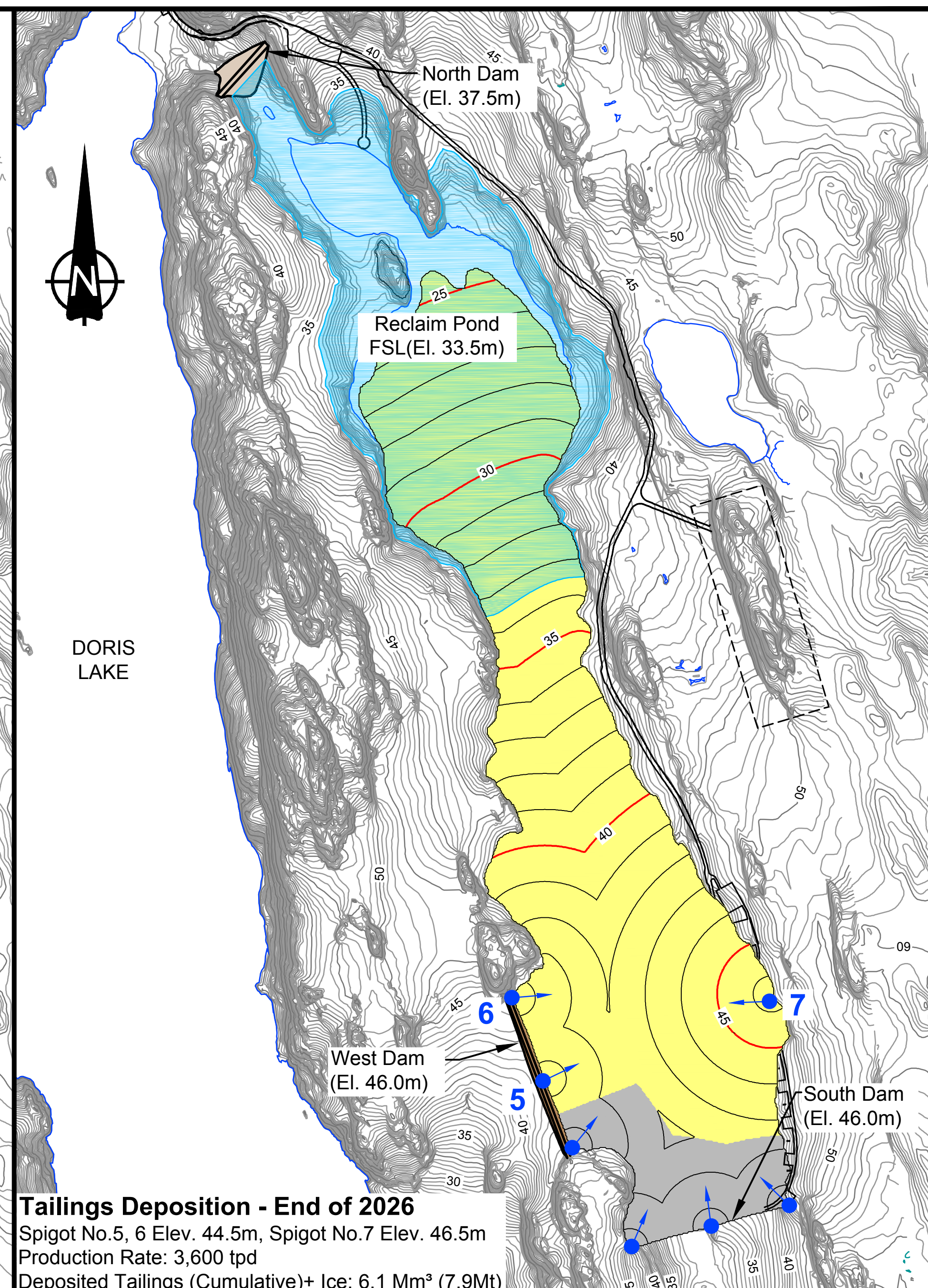
0m 10 20 30 40 50 60

Horizontal Scale

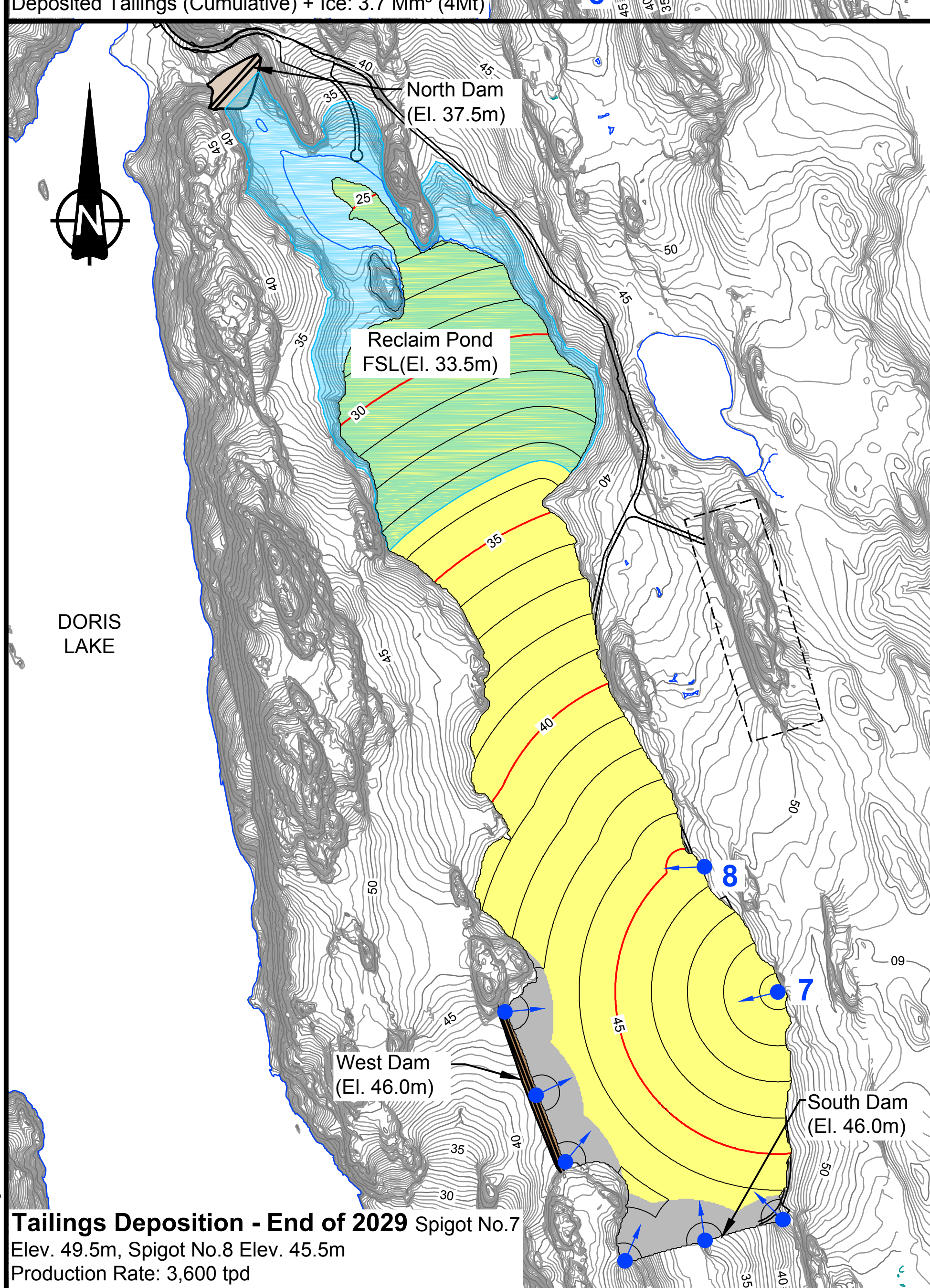
srk consulting	MAC RESOURCES	DORIS TIA OMS MANUAL
		West Dam Plan and Profile
SRK JOB NO.: 1CT022.004.600.10	HOPE BAY PROJECT	DATE: May 2016
FILE NAME: 1CT022.004.600.10 - FIGURE 10_11.dwg		APPROVED: IM
		FIGURE: 6



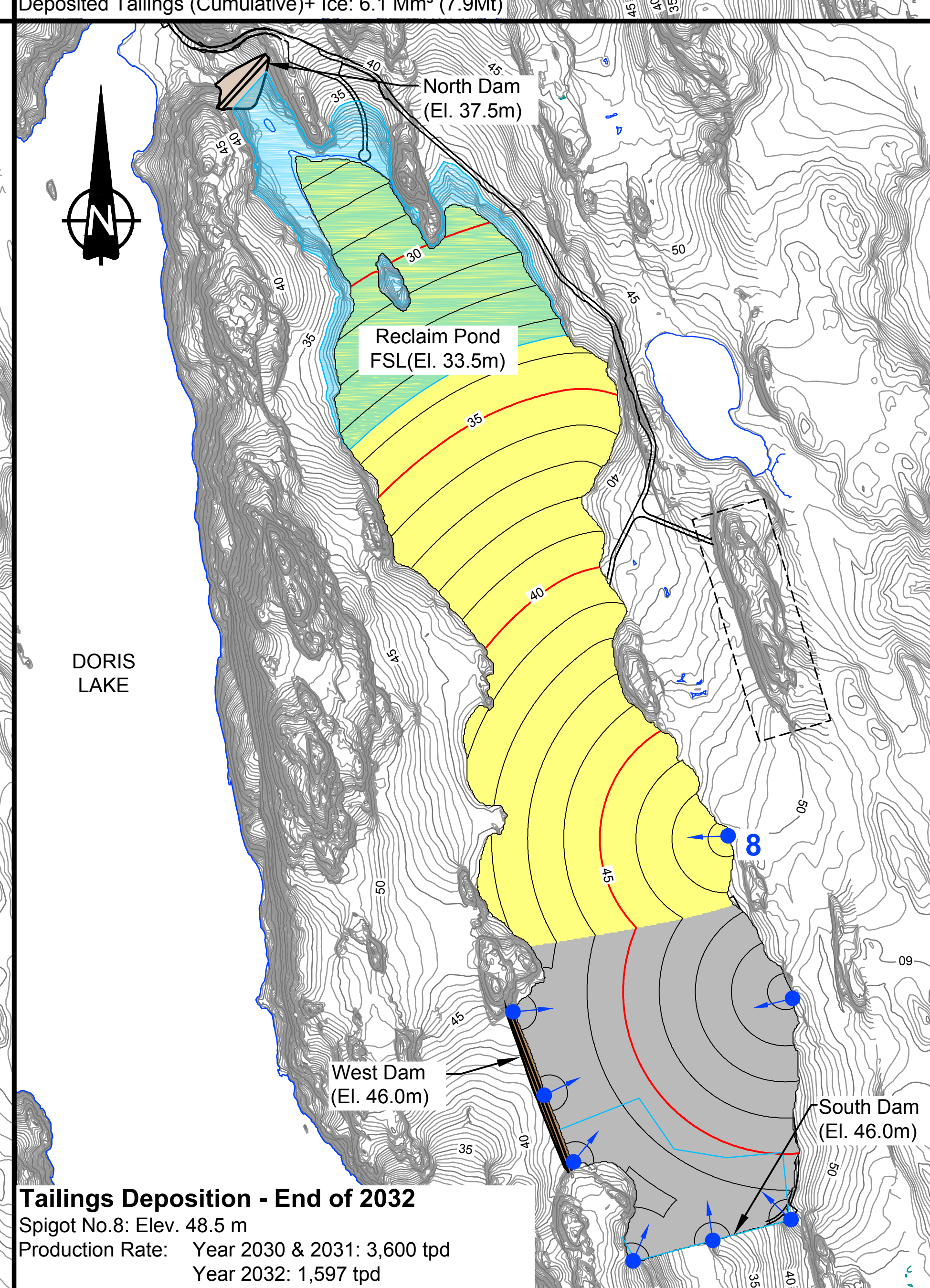
Tailings Deposition - End of 2023
Spigot No.1, 2, 3 and 4: Elev. 44.5 m
Production Rate: Year 2020 & 2021: 3,000 tpd
Year 2020: 3,200 tpd
Year 2023: 3,600 tpd
Deposited Tailings (Cumulative) + Ice: 3.7 Mm^3 (4Mt)



Tailings Deposition - End of 2026
Spigot No.5, 6 Elev. 44.5m, Spigot No.7 Elev. 46.5m
Production Rate: 3,600 tpd
Deposited Tailings (Cumulative)+ Ice: 6.1 Mm^3 (7.9Mt)



Tailings Deposition - End of 2029 Spigot No.7 Elev. 49.5m, Spigot No.8 Elev. 45.5m
Production Rate: 3,600 tpd
Deposited Tailings (Cumulative) + Ice: 9.1 Mm^3 (11.9Mt)



Tailings Deposition - End of 2032
Spigot No.8: Elev. 48.5 m
Production Rate: Year 2030 & 2031: 3,600 tpd
Year 2032: 1,597 tpd
Deposited Tailings (Cumulative) + Ice: 11.6 Mm^3 (15.1Mt)

General Notes:

1. Deposition durations are approximate and were based the Mine Plan average production rates provided by TMAC.
2. Assumed an average deposited tailings beach slope of 1.0%.
3. A deposited tailings dry density of 1.3t/m3 was used.
4. All tailings volumes presented include ice entrainment at 20% of production.
5. Dam and dike elevations shown were assumed constant throughout deposition.
6. Total storage requirement includes Madrid and Boston Tailings (Tailings 11.6Mm^3 + Ice entrainment 2.3Mm^3)

LEGEND

- Spigot Location
- Deposited Tailings
- Dam/Dike
- Previously Deposited Tailings
- Proposed Tailings Topography

0m 200 400 600 800

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MAC RESOURCES

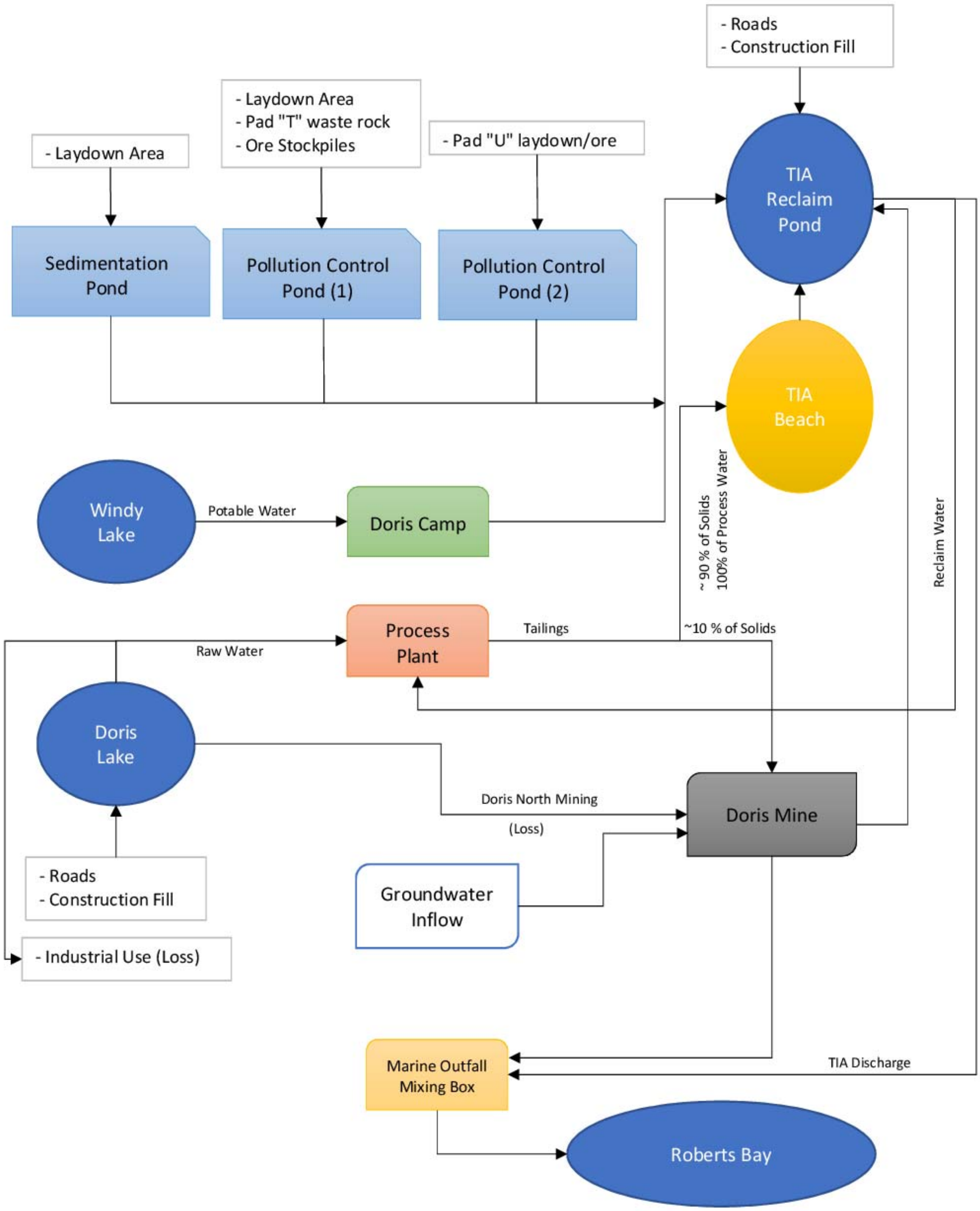
DORIS TIA OMS MANUAL

TAILINGS DEPOSITION PLAN - PHASE 2 (TOTAL TIA STORAGE 17.6 Mt)

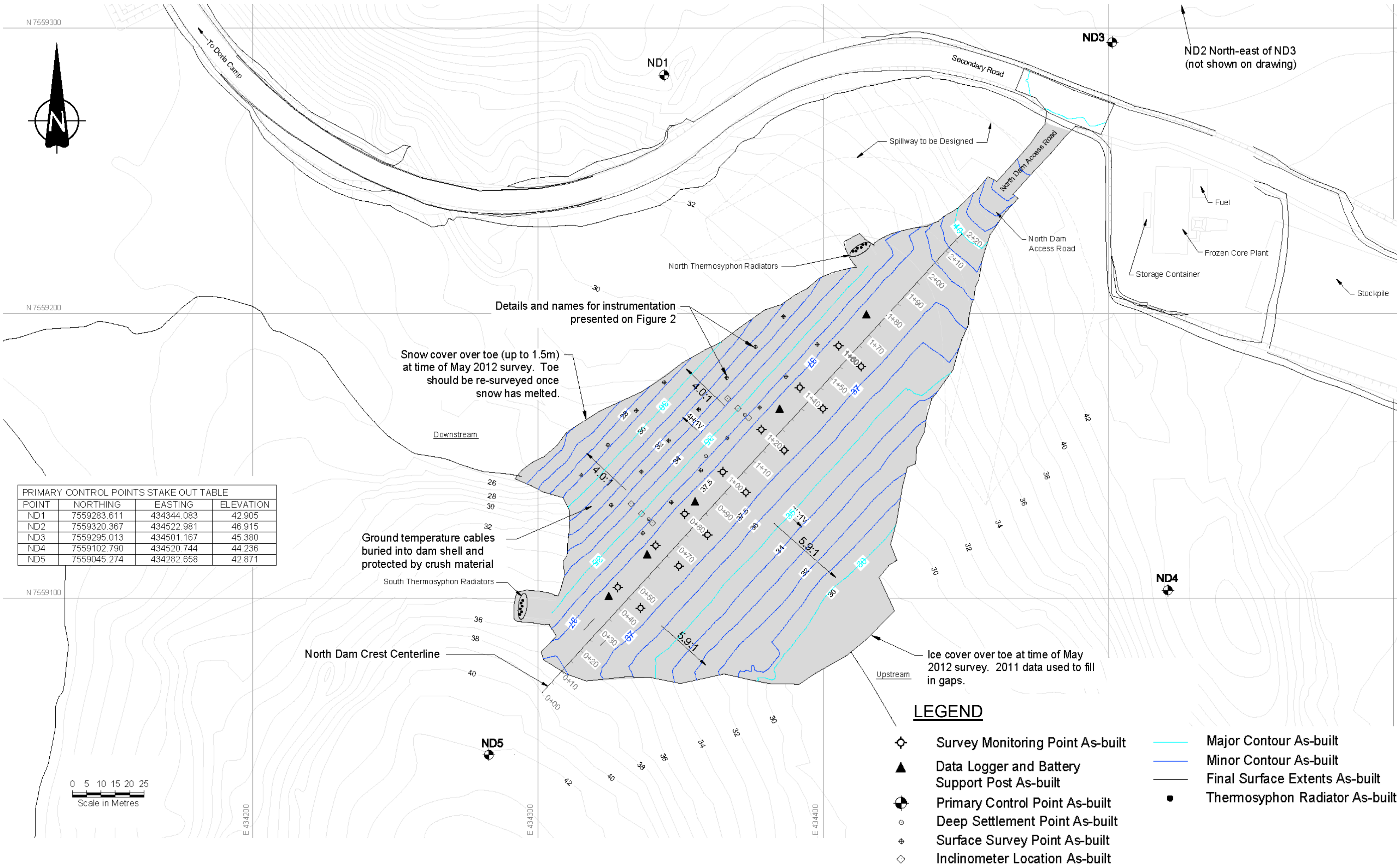
HOPE BAY PROJECT

SRK JOB NO.:	1CT022.004.600.010	DATE:	APPROVED:	FIGURE:
FILE NAME:	HB PH2 DEPOSITION FIGURE 9.dwg	2016/10/27	TPP	7

P:\01_SITES\Hope Bay\ACAD\2015 Deposition Planning\Phase 2 Options\HB PH2 DEPOSITION FIGURE 9.dwg



srk consulting	TMAC RESOURCES	DORIS TIA OMS MANUAL **Water Management - Operations**
Job No: 1CT022.002.200.2000 Filename: 1CT022.022.200.2000_Figure14.pptx	Hope Bay Project	Date: May 2016 / Approved: EK/SA / Figure: **8**



PRIMARY CONTROL POINTS STAKE OUT TABLE

POINT	NORTHING	EASTING	ELEVATION
ND1	7559283.611	434344.083	42.905
ND2	7559320.367	434522.981	46.915
ND3	7559295.013	434501.167	45.380
ND4	7559102.790	434520.744	44.236
ND5	7559045.274	434282.658	42.871

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TMAC RESOURCES

DORIS TIA OMS MANUAL

North Dam General Arrangement and Primary Control Points

Job No: 1CT022.002.200 Task 2000

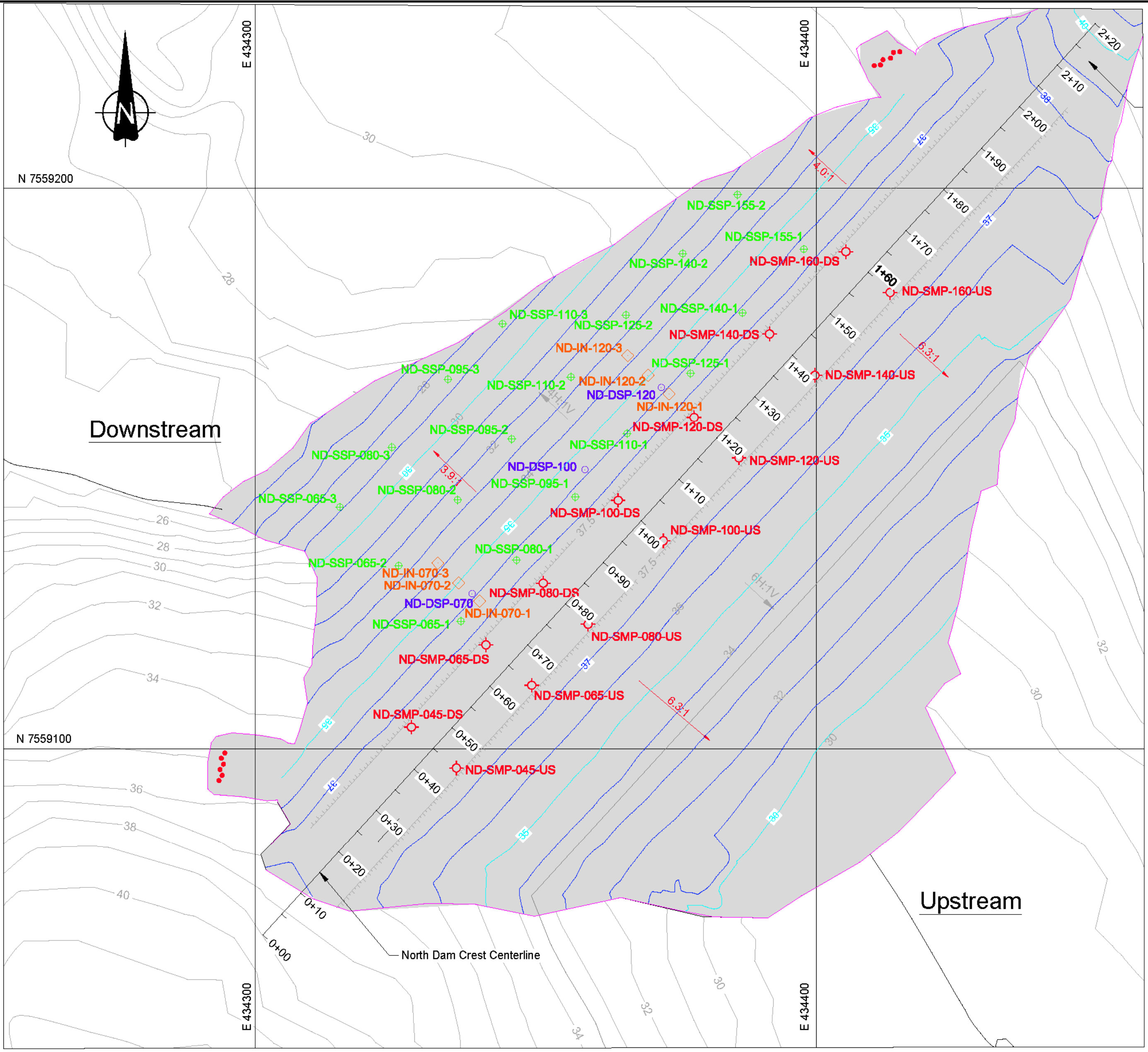
Filename: HopeBay_DorisNorthTIA_OMS_Manaul_SA.pptx

HOPE BAY PROJECT

Date: May 2016

Approved: EK/SA

Figure: 9



LEGEND

- Survey Monitoring Point As-built
- Deep Settlement Point As-built
- Surface Survey Point As-built
- Inclinometer Location As-built
- Major Contour As-built
- Minor Contour As-built
- Final Surface Extents As-built
- Thermosyphon Radiator As-built

AS-BUILT DEEP SETTLEMENT POINTS STAKEOUT TABLE

ID	Northing	Easting	Elev. (m)
ND-DSP-070	7559127.69	434338.65	36.95
ND-DSP-100	7559149.78	434358.75	36.86
ND-DSP-120	7559164.46	434372.37	36.92

AS-BUILT INCLINOMETER LOCATION STAKEOUT TABLE

ID	Northing	Easting	Elev. (m)
ND-IN-070-1	7559126.41	434340.00	37.44
ND-IN-070-2	7559129.63	434336.27	36.20
ND-IN-070-3	7559133.13	434332.57	34.85
ND-IN-120-1	7559163.31	434373.78	37.44
ND-IN-120-2	7559166.64	434370.03	36.05
ND-IN-120-3	7559170.15	434366.40	34.95

AS-BUILT SURFICIAL SURVEY POINTS STAKEOUT TABLE

ID	Northing	Easting	Elev. (m)
ND-SSP-065-1	7559122.80	434336.67	36.77
ND-SSP-065-2	7559132.67	434325.55	32.81
ND-SSP-065-3	7559143.10	434315.11	29.43
ND-SSP-080-1	7559133.65	434346.59	36.79
ND-SSP-080-2	7559144.37	434336.10	32.92
ND-SSP-080-3	7559153.75	434324.36	29.33
ND-SSP-095-1	7559144.90	434357.04	36.58
ND-SSP-095-2	7559155.21	434345.72	32.85
ND-SSP-095-3	7559165.92	434334.35	28.70
ND-SSP-110-1	7559156.20	434366.29	36.32
ND-SSP-110-2	7559166.31	434356.29	32.88
ND-SSP-110-3	7559175.79	434344.10	28.97
ND-SSP-125-1	7559166.97	434377.61	36.77
ND-SSP-125-2	7559177.37	434366.08	32.91
ND-SSP-140-1	7559177.75	434386.85	36.48
ND-SSP-140-2	7559188.28	434376.19	32.84
ND-SSP-155-1	7559189.07	434397.79	36.80
ND-SSP-155-2	7559198.85	434385.98	32.91

AS-BUILT SURVEY MONITORING POINTS STAKEOUT TABLE

ID	Northing	Easting	Elev. (m)
ND-SMP-065-DS	7559118.52	434341.14	38.46
ND-SMP-065-US	7559111.31	434349.30	38.36
ND-SMP-080-DS	7559129.57	434351.35	38.41
ND-SMP-080-US	7559122.27	434359.34	38.40
ND-SMP-100-DS	7559144.32	434364.71	38.39
ND-SMP-100-US	7559137.12	434372.77	38.46
ND-SMP-120-DS	7559159.12	434378.24	38.41
ND-SMP-120-US	7559151.88	434386.24	38.46
ND-SMP-140-DS	7559173.98	434391.69	38.39
ND-SMP-140-US	7559166.62	434399.77	38.42
ND-SMP-160-DS	7559188.64	434405.30	38.40
ND-SMP-160-US	7559181.37	434413.18	38.43

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MAC RESOURCES

Job No: 1CT022.002.200 Task 2000

Filename: HopeBay_DorisNorthTIA_OMS_Manaul_SA.pptx

HOPE BAY PROJECT

DORIS TIA OMS MANUAL

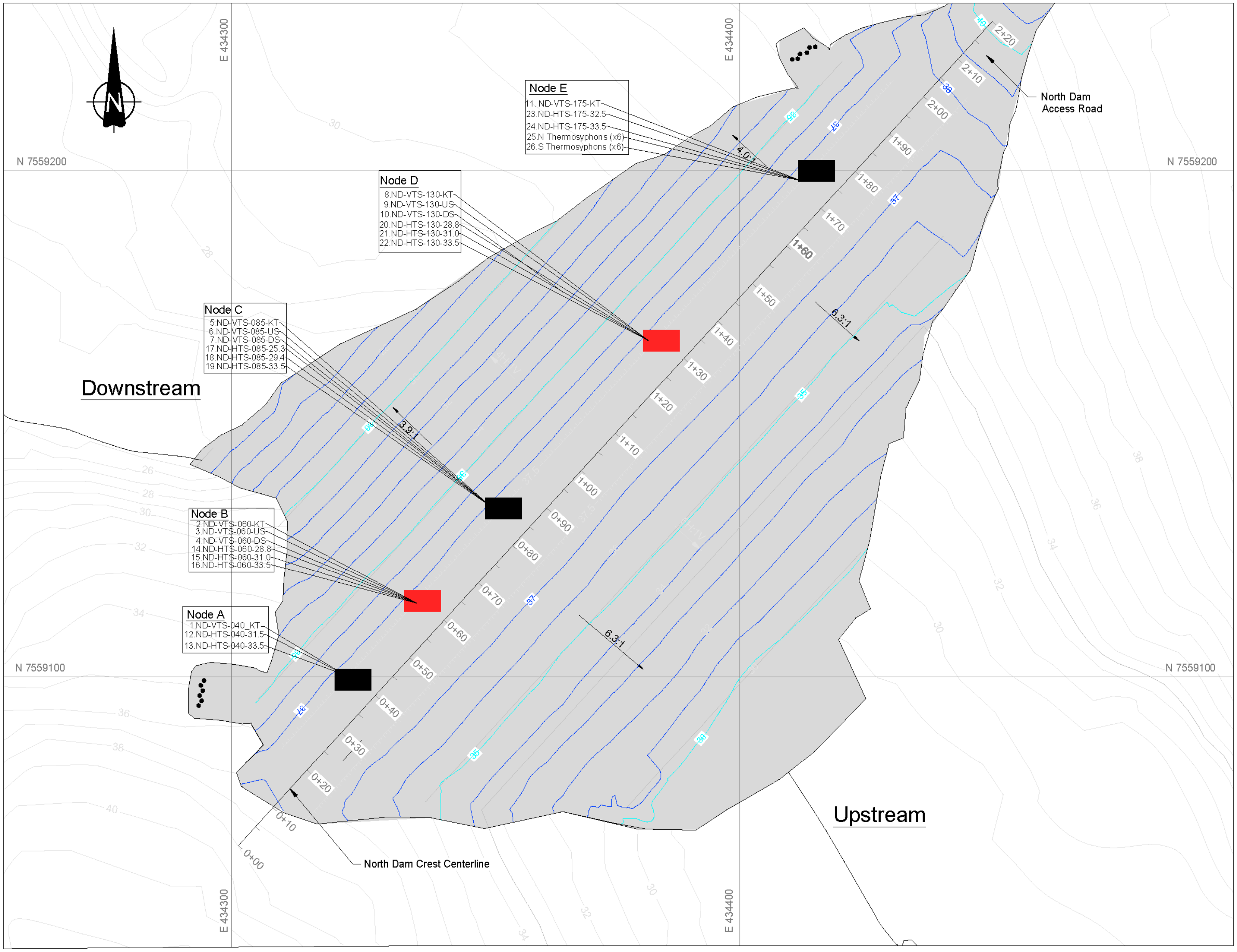
North Dam Instrumentation Layout

Date: May 2016

Approved: EK/SA

Figure: 10

J:\01_SITES\Hope.Bay\!ACAD\2013 Drawings\North Dam

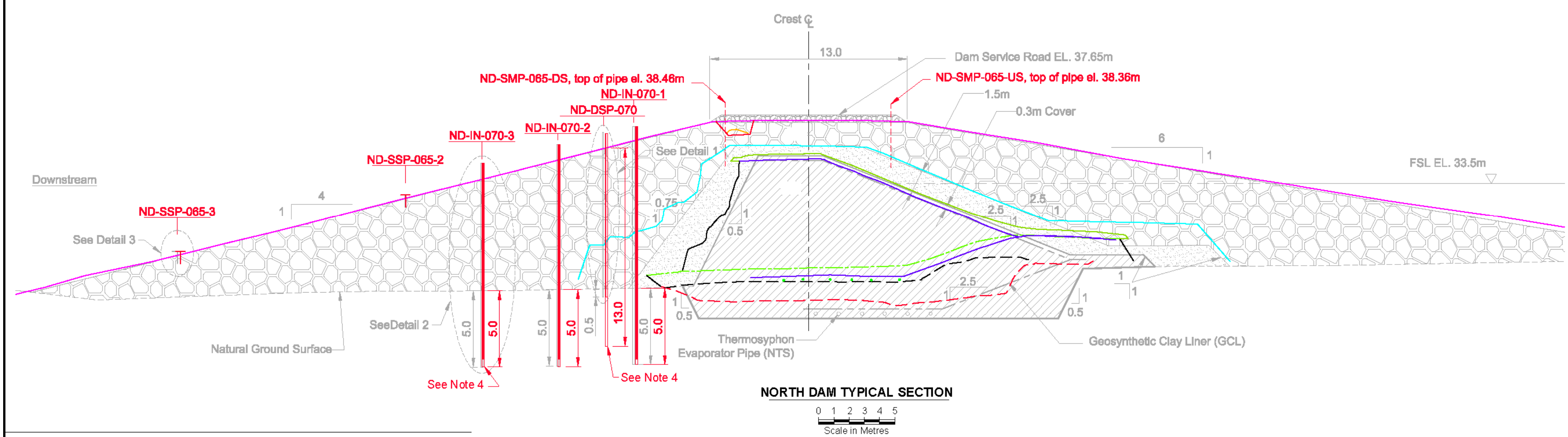


LEGEND

- Major Contour As-built (5m)
- Major Contour As-built (1m)
- Final Surface Extents As-built
- Thermosyphon Radiator As-Built

Note: the two weatherproof enclosures which house the data loggers are shown in red.

srk consulting	MAC RESOURCES	DORIS TIA OMS MANUAL **North Dam Ground and Thermosyphon Temperature Cable Locations**
Job No: 1CT022.002.200 Task 2000 Filename: HopeBay_DorisNorthTIA_OMS_Manaul_SA.pptx	HOPE BAY PROJECT	Date: May 2016 / Approved: EK/SA / Figure: 11



Core Material	GCL As-built
Transition Material	Core Material As-built
Run of Quarry (ROQ)	Core Material (2011) As-built
Surfacing Material	Levelling Course (Core Material) As-built
Bedrock	Instrumentation Trench Cover As-built
Peat	Key Trench / Instrumentation Trench As-built
	GCL Cover Material As-built
	Transition Material As-built
	ROQ Material As-built
	Thermosyphon Evaporator Pipes As-built

Example of as-built instrumentation installed on the downstream of dam.

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MAC RESOURCES

DORIS TIA OMS MANUAL

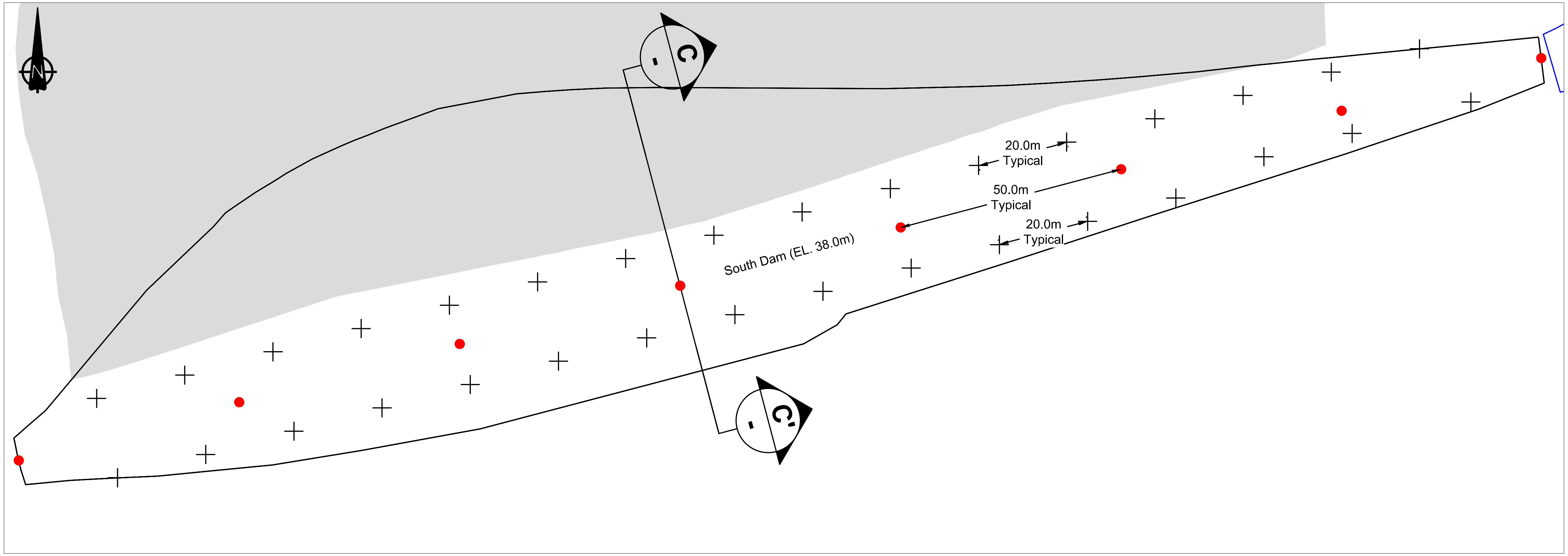
North Dam Deformation Monitoring Instrumentation Layout

Job No: 1CT022.002.200 Task 2000

Filename: HopeBay_DorisNorthTIA_OMS_Manaul_SA.pptx

HOPE BAY PROJECT

Date:	Approved:	Figure:
May 2016	EK/SA	12



LEGEND

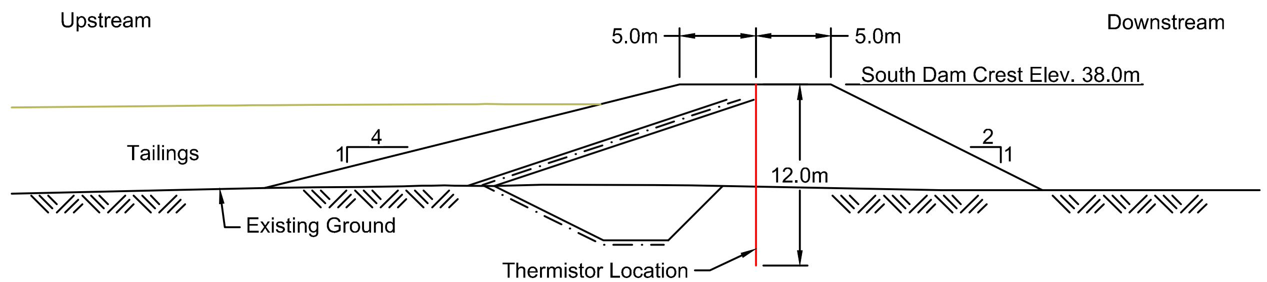
- ● Proposed Thermistor Location
- + Proposed Monitoring Point Location
- ▭ Proposed Tailings Surface

NOTES

1. Contours shown at 1.0m interval.
2. Thermistors shall be installed through the centerline of the dam every 50m to a depth of 12m.
3. The dam crest shall have survey monitoring points at 20m intervals on the upstream and downstream sides.

PROPOSED (MINIMUM) SOUTH DAM INSTRUMENTATION REQUIREMENTS

0m 10 20 30 40



C - TYPICAL SECTION THROUGH SOUTH DAM

0m 10 20 30 40

srk consulting

MAC RESOURCES

DORIS NORTH TIA OMS MANUAL

South Dam Monitoring Instrumentation

SRK JOB NO.:	1CT022.002.2000
FILE NAME:	1CT022.002 - Instrumentation Plan_Figure21.dwg

HOPE BAY PROJECT

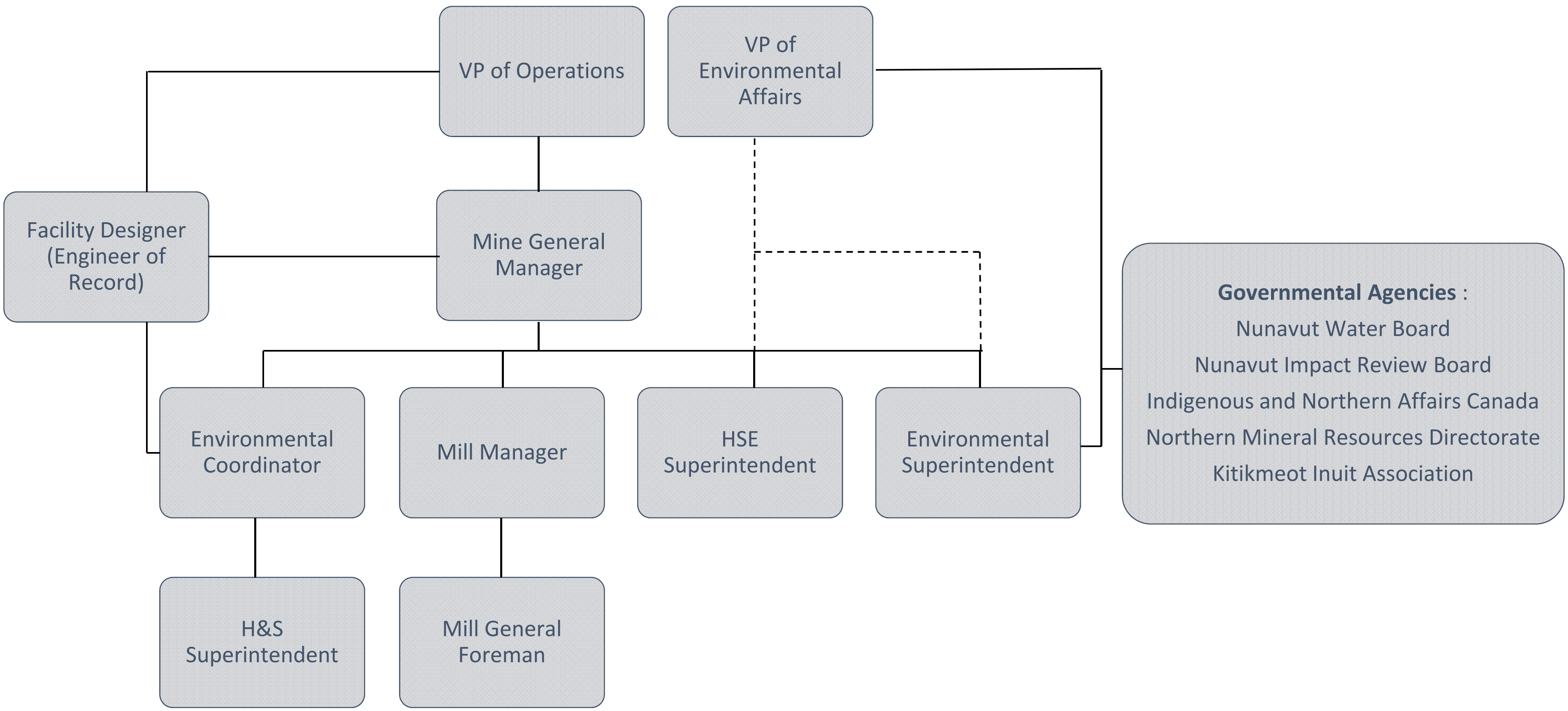
DATE:	APPROVED:	DRAWING:
May 2016	EK/SA	13

X:\1CT022.002_2015_Hope Bay Ongoing Support\200_Type_A_ Water_License\2000_Tailings_Management_Plan\040_AutoCAD\1CT022.002 - Instrumentation Plan_Figure21.dwg

HOPE BAY PROJECT, PHASE 2, DORIS TAILINGS IMPOUNDMENT AREA - OPERATIONS, MAINTENANCE AND SURVEILLANCE MANUAL

HOPE BAY, NUNAVUT

Attachment A: Site Management Structure



srk consulting

TMAC RESOURCES

Doris TIA OMS Manual

Organization Chart

Job No: 1CT022.006.200

Filename: Figure 1_OrgChart_20160527

Hope Bay Project

Date: May 2016

Approved: EK

Figure: 1

HOPE BAY PROJECT, PHASE 2, DORIS TAILINGS IMPOUNDMENT AREA - OPERATIONS, MAINTENANCE AND SURVEILLANCE MANUAL

HOPE BAY, NUNAVUT

Attachment B: Tailings Area Dust Control Strategy for Doris TIA

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Memo

To:	Project File	**Client:**	TMAC Resources Inc.
From:	Iozsef Miskolczi, PEng	**Project No:**	1CT022.004
Reviewed By:	Maritz Rykaart, PhD, PEng	**Date:**	December 13, 2016
Subject:	Hope Bay Project: Tailings Area Dust Control Strategy for Doris TIA		

1 Introduction

The Hope Bay Project (the Project) is a gold mining and milling undertaking of TMAC Resources Inc. The Project is located 705 km northeast of Yellowknife and 153 km southwest of Cambridge Bay in Nunavut Territory, and is situated east of Bathurst Inlet. The Project comprises of three distinct areas of known mineralization plus extensive exploration potential and targets. The three areas that host mineral resources are Doris, Madrid, and Boston.

The Project consists of two phases; Phase 1 (Doris project), which is currently being carried out under an existing Water Licence, and Phase 2 which is in the environmental assessment stage. Phase 1 includes mining and infrastructure at Doris, while Phase 2 includes mining and infrastructure at Madrid and Boston located approximately 10 and 60 km due south from Doris, respectively.

Two tailings storage areas are planned for Phase 2. The existing Doris tailings impoundment area (TIA) will be expanded, and a new Boston tailings management area (TMA) will be developed. The Doris TIA tailings deposition will consist of subaerial tailings deposition, while the Boston TMA will be comprised of filtered tailings developed as a dry-stack. This memo is addressing dust management strategies for the Doris TIA.

Two tailings streams will be produced; flotation tailings, comprising approximately 92-94% of the overall volume, and detoxified leach tailings (following cyanidation, and subsequent cyanide destruction), comprising about 6-8% of the overall volume. Only flotation tailings will be deposited in the Doris TIA. The detoxified leach tailings will be filtered, mixed with mine waste rock and used for underground mine backfill.

Upon closure, the tailings surface of the Doris TIA will be covered with a nominal waste rock cover of about 0.3 m thick. The function of the cover is to prevent dust and to minimize direct contact by terrestrial animals. Once the water quality in the Reclaim Pond has reached the required discharge criteria, the North Dam will be breached allowing the TIA to return to its pre-mining elevation of 28.3 m.

Throughout the operational phase, portions of the tailings surface will be exposed, and sufficiently inactive such that they would dry out and pose a dusting risk. This memo describes alternative dust management strategies that have been considered and presents the rationale for selection of the preferred strategy.

2 Definition of Dust

2.1 Fugitive Dust

Fugitive dust is particulate matter suspended in air by wind action and human activities. Within the Doris TIA, tailings will be deposited by hydraulic placement of a tailings slurry which does not generate any fugitive dust. Fugitive tailings dust will however be generated during the period when the tailings closure cover is being constructed.

2.2 Aeolian Dust

Aeolian dust is defined as particles that are transported as suspended load due to wind action on a surface. Although tailings are discharged wet, the surface eventually dries out as a result of evaporation or freezing of the tailings surface. As a result, at any given time, large areas of the tailings surface would expose dry tailings. Aeolian tailings dust is expected because the Project site is prone to high winds and the moderate surrounding topography does not offer effective protection from wind.

3 Typical Dust Control Methods

3.1 State of Practice

Dust control from operating and closed tailings impoundments is a significant concern in the mining industry, and as a result, the state of practice is quite advanced. There are three primary dust control strategies for fugitive and aeolian dust from exposed tailings areas: natural dust control, physical dust control and chemical dust control. Natural dust control specifically relies on maximizing the benefits offered by nature in the form of precipitation (rain and snow). While highly effective, these benefits are opportunistic and may not always be available at the times when it may be needed.

Physical dust control is by far the most effective strategy, as it relies on creating a physical barrier, such as a cover, that would preclude dusting. This may however not be a cost efficient strategy for an operating tailings impoundment, since any interim cover would occupy space within a tailings impoundment that would otherwise be required for tailings.

Chemical dust control relies on modification of the tailings surface that generates the dust. The effectiveness of this method is temporary, but its application is typically simple, making it a very good alternative for managing dust from an operating tailings impoundment.

The sections that follow provide a detailed description of all the dust control methods that are currently being used in the industry, with a specific focus towards their potential applicability for this Project.

3.2 Natural Methods

3.2.1 Snow Cover

If early in the fall season, wet snow falls directly on the exposed tailings surface and subsequently freezes, it will remain in place all winter protecting the tailing surface from dusting. Snow that falls later in the season is typically drier and more powdery and it tends to be subject to wind transport and redistribution (drifting). This means that portions of the tailings surface will become exposed and opportunity for dust release increases. This is exacerbated by the fact that during the winter the tailings surface gets extremely dry as a result of freezing, making it highly susceptible to dusting.

To maximize the potential benefits offered by snow as a natural dust control method, any snow that does fall on the tailings surface can be track compacted in areas where the tailings surface is trafficable. By mechanically compacting the snow, it will stay in place longer and will melt at a much slower rate in the spring, extending the useful life of the snow as a dust control method.

It is however important to minimize the amount of tailings that gets deposited over the compacted snow. If the compacted snow does not melt during the subsequent summer season due to the insulating blanket of the overlying tailings, ice lenses within the tailings impoundment are created which result in a loss of tailings storage space and possible instability.

There is sufficient snowfall at the Project site that this dust control method could be effectively used. In addition, there is a requirement at the Project site for snow removal in specific areas. Snow that is removed could be hauled to the TIA and used specifically for the purpose of creating a compacted snow cover over any temporarily inactive tailings surface areas. Due to the temporary nature of this dust control method, it will not be a complete solution, but would be a practical and complementary method.

3.2.2 Ice Cover

Similar to compacted snow, an ice cover will remain in place for the duration of the winter and thus temporarily mitigate dust migration. Ice cover on exposed tailing surfaces can be achieved by various methods, including ponding water during freezing weather and mechanical placement of ice blocks imported from a different source (contact water ponds).

Water can be held back in specified locations and retained there during the shoulder seasons when freezing weather will create an ice cap. Once the ice cap is achieved the open water beneath the ice can be drained off, leaving an ice cap.

The ice cap can also be created mechanically by loading ice from contact water ponds (or fresh water streams) into haul trucks and dumping the ice on the tailings surface.

Similar to compacted snow, care must be taken to ensure that the amount of tailings deposited over an ice cover is limited to avoid entraining long-term ice in the TIA.

There are several contact water ponds throughout the Project site all of which must be managed such that they are normally empty. Contact water ponds are; therefore, unable to provide a reliable source of water to use to create an ice cover. Fresh water cannot be readily hauled to the TIA to create an ice cover as the use of fresh water is governed by the Water License (2AM-DOH1323); therefore, creating an ice cover for dust control is not considered a viable practical alternative for application at the Project.

3.3 Physical Methods

3.3.1 Water – Surface Wetting

Water is by far the most common temporary dust control measure used in areas where water shortage is not of concern. The exposed surface is wetted up, preventing particles from becoming airborne. Since the water rapidly evaporates (in a matter of hours or days), it needs to be reapplied at a frequent interval to be effective. The surface wetting can be done using a conventional water truck, a water cannon fitted to a water truck, or a stationary sprinkler system. Naturally this dust control method is only applicable during non-freezing periods of the year.

For the Project, water could readily be obtained from the Reclaim Pond or can be hauled via water truck from other site contact water ponds. The tailings surface is however not expected to be trafficable in the short term and the only viable means of frequent tailings wetting would be via a water cannon, or a sprinkler system. While both of these methods are viable, the short useful life of every wetting cycle makes this a very labor intensive dust control method which is not preferred. This method will however be reserved as a last line of defence should any of the other dust control methods prove to be ineffective.

3.3.2 Water – Flooding

Flooding the tailings surface will naturally preclude any dust concerns. This is however not a viable strategy for the Project since the objective is to place tailings subaerially. At Doris, TIA portions of the tailings may be seasonally flooded as the water level in the Reclaim Pond rises; however, the water level will be managed such that a perpetual water cover will not be present.

3.3.3 Permanent Dry Cover

The most effective permanent dust control system is a permanent physical dust cover. Typically this is in the form of a layer of soil, or other suitable readily available cover material. This is however not practical until the tailings surface has reached its final elevation. In order to facilitate placement of a final dust cover as expediently as possible, any tailings deposition plan should be designed taking into consideration all opportunities for progressive reclamation.

In the context of the Doris TIA, the tailings deposition plan provides limited opportunity for progressive reclamation during the early Project life. This is predominantly driven by the surface topography and as a result there are no practical means to improve the design. The only viable permanent dust cover would be geochemically suitable waste rock, or quarry rock. Since all the Project waste rock is designated for use as structural underground backfill, only quarry rock can be considered a viable source for a permanent dust cover. While this will be the final closure dust control method, it is not considered a viable method during the operational phase of the Project.

3.3.4 Sacrificial Dry Cover

In extreme cases, nominal sacrificial covers such as a layer of sand or gravel are used to manage tailings dust when the final tailings surface has not yet been reached, but the period until tailings deposition might resume at any particular spot may be extensive. When tailings deposition eventually returns to the covered area, these materials are not removed and tailings deposition proceeds to overtop the sacrificial cover. This can be very cost intensive and will only be practical if the tailings surface is readily trafficable.

There are no suitable natural sacrificial cover materials readily available at the Project site. Gravel could be produced from quarry rock; however, at great cost. This is therefore not considered a viable dust control strategy for the Project TIA.

3.3.5 Biodegradable Cover

Biodegradable material such as hay, wood mulch or sewage treatment sludge can be applied over exposed tailings surfaces to mitigate dust for a limited period (i.e. requiring occasional reapplication). Naturally this option is only economically viable if the organic source is readily available. The tailings surface must also be sufficiently trafficable to allow equipment to spread these materials. As these materials biodegrade and dry out, they themselves become prone to being part of the dust hazard.

There is no viable source of biodegradable materials at the Project site, and therefore this is not considered a viable dust control strategy for the Project.

3.3.6 Wind Barriers

A wind barrier (aka windbreak or shelterbelt) is a physical structure used to reduce the wind speed, which will reduce tailings from being re-mobilized from the TIA. Typically, a wind barrier consists of one or more rows of trees or shrubs. Trees and shrubs don't grow at the Project site (at least not to the size where they would be effective wind barriers), therefore, any wind barriers would have to be engineered structures. The efficiency of wind barriers is also a function of wind speed, and often, at very high wind speeds, wind barriers can fail since it is simply not cost effective to design and build these structures to withstand large wind velocities. As well, wind barriers only work effectively over a very narrow range of wind directions. Multiple wind barriers would need to be installed to cover all of the Project's prevalent wind directions so as to provide a comprehensive dust management system for the TIA.

Given the very high wind speeds and the multiple wind directions, experienced at the Project's TIA, engineered wind barriers are not be considered a viable dust control strategy for the Project's TIA.

3.3.7 Vegetation

Revegetating an exposed tailings surface is a very effective way to mitigate dust. In an arctic setting such as at the Project site, this is not a practical option since the growth season is simply too short to allow for rapid onset of effective vegetation. In addition, the tailings material may not be amenable to supporting vegetation without the addition of supplemental nutrients, which might preclude establishment of natural successional vegetation species. This is therefore not a viable dust control method for the Project.

3.4 Chemical Methods

3.4.1 Salt (Calcium Chloride)

"Salted" sand will not freeze at temperatures above -10˚C, and can be spread in a thin layer over exposed frozen tailings surfaces during the shoulder seasons when frost penetration is enough to support the spreader truck (or other suitable spreader mechanism). The calcium chloride in the sand acts to melt the frost on the exposed tailing surface and stops the fine particulate dust particles from becoming airborne.

There are no sources of sand at the Project site, requiring that both sand and salt would have to be imported at great cost. As runoff occurs from the tailings surface, the salt will dissolve reducing the efficiency; however, since this mitigation method is best used during freezing conditions this risk is limited. However, during freshet the salt is washed off towards the Reclaim Pond which results in an increased salt load to the TIA, which may limit the use of TIA reclaim water to the mill. This is therefore not a viable dust control strategy for the Project TIA.

3.4.2 Chemical Suppressants

There are many environmentally safe commercial chemical dust suppressants on the market. Although originally developed for other forms of fugitive dust management, they are routinely used for dust control on tailings surfaces. These products work in different ways, but principally they all either chemically bind dust, or alternately facilitate towards development of a crust to prevent particles from separating and becoming airborne.

The chemical suppressants are normally supplied in concentrated liquid form in containers of various sizes. They are typically water based and are diluted before application at a ratio of about nine parts water to one part suppressant. The solution is applied by means of a spray cannon mounted on a modified water truck, but can also be done via hand held sprayers. The application rate is typically about four liters per square metre.

Chemical suppressants have a useful life which is dependent on the concentration applied and local weather conditions. Normally, products are applied at a concentration which would render a useful life of approximately one year.

Of all the dust control methods, chemical suppressants offer the greatest flexibility for application at the Project TIA. The concentrated liquid can be shipped to site on an annual basis and solution can be mixed an applied on site as required. The relatively long useful life limits the amount of effort that needs to be exerted and therefore makes the dust control method practical.

4 Dust Control Procedures for Tailings

The primary dust control measures of the Project site tailings facilities will be the use of environmentally suitable chemical dust suppressants. The application of these suppressants will be reviewed on an ongoing basis to ensure that any areas that may be at risk will be adequately covered. Generally, annual application of chemical suppressants will be applied; however it is recognized that more frequent applications may be required as discharge locations are changed throughout any year.

In addition to chemical dust suppressants, natural dust control in the form of packed snow when available will be used as far as practical. Again, the effectiveness will vary on a year by year basis depending on how deposition points vary for any given winter season.

Finally, if for any reason, any of the above dust control methods prove to be temporally ineffective, a suitable water cannon will be available to allow for dust suppression in the form of spraying of the areas of concern.

HOPE BAY PROJECT, PHASE 2, DORIS TAILINGS IMPOUNDMENT AREA - OPERATIONS, MAINTENANCE AND SURVEILLANCE MANUAL

HOPE BAY, NUNAVUT

Attachment C: Summary of Currently Available Dust Control Products

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Memo

To:	John Roberts	**Client:**	TMAC Resources Inc.
From:	Erik Ketilson, Maritz Rykaart	**Project No:**	1CT022.002
Cc:		**Date:**	June 13, 2016
Subject:	Summary of Currently Available Dust Control Products		

Dust Management

TMAC's primary dust mitigation method for the TIA, will be the use of water. However, should this not achieve the required results, TMAC will make use of commercial chemical dust suppressants. Chemical dust suppressants are routinely used at mining projects as dust mitigation strategy for tailings, roads and airstrips.

The table below summarize three of the most commonly used chemical dust suppressants, and Attachments 1, 2 and 3 includes commercial reference material for each. TMAC has consulted with these manufacturers, who have confirmed that based on the typical particle size distribution testing available for the tailings, these products will all be suitable. The Doris tailings particle size distribution consists of sandy fine to coarse silt, with 56% (46% silt and 10% clay) passing the No. 200 sieve (75 micron). They will however not provide TMAC with a mixing and application rate, until they complete material specific testing in their in-house testing laboratories. TMAC will defer such testing until full-scale tailings production is in place and representative samples can be collected.

EK-35, listed in the table below is currently approved for use by TMAC at the Hope Bay site. This product has been used as a dust suppressant on roads and the airstrip.

Chemical Suppressant	Example Clients	Comments	Manufacturer	Reference Material
Soil-Sement	NewGold; Glencore; Asarco; Capstone; FMI; INAC (Giant Mine)	Water soluble product used at most mines for tailings dusting issues. Observed to be successful at the appropriate application rate irrespective of tailings particle size distribution. Not suitable for areas of vehicle traffic. Manufacturer offers site specific testing to confirm, if required.	Midwest Industrial Supply, Inc. (303) 456-3121	Attachment 1
EK-35	HudBay (underground mine roads); Baffinland Mary River Mine (surface gravel roads)	Synthetic fluid used in road applications, and capable of withstanding vehicle traffic. Observed to be successful at the appropriate application rate irrespective of particle size distribution.	Midwest Industrial Supply, Inc. (303) 456-3121	Attachment 2

Chemical Suppressant	Example Clients	Comments	Manufacturer	Reference Material
DustCap	Confidential (Supplier will not divulge client names without prior approval)	Biodegradable product. Appropriate application rate specified for various particle size distributions. Not suitable for areas of vehicle traffic. Manufacturer offers site specific testing to confirm application rates, if required.	Terra Novo (888) 843-1029	Attachment 3

Attachment 1: Soil-Sement

Soil-Sement®

Control Dust, Erosion, Unstable Soil

Enjoy a customized solution for better performance.

When it comes to clothing, "one size fits all" is truly an ominous label because unless your body is in line with what the manufacturer considers the norm, that hat, tee shirt, or underwear is not going to fit you!

One reason Midwest's environmentally safe Soil-Sement polymer emulsion for controlling dust, erosion and unstable soil is used across dozens of industries and on many different soils is that it is not a one-size-fits-all product. It is custom-engineered to perform optimally on your soil taking into account a range of factors including dry strength, wet strength, ductility, elasticity, UV resistance, climate, and many others.

Nanotechnology enables Soil-Sement to be as strong as steel or as resilient as rubber.

In test after independent test, Soil-Sement has proved to be the most effective – and cost-effective – soil stabilizer for controlling PM10 and PM2.5 dust emissions.

Vital statistics

- Is non-toxic, non-corrosive, non-flammable
- Does not pollute groundwater
- Stabilizes surface to resist shifting, breaking up and sink failures
- Stands up to wind, rain, UV light, and other weather conditions
- Increases load-bearing strength
- Prevents water from destabilizing road surface
- Dries clear for an aesthetically pleasing appearance
- Keeps you in regulatory compliance.

MIDWEST
Consider it done.

A different kind of molecule

Nanotechnology enables our scientists to control matter on an atomic and molecular scale. Soil-Sement's effectiveness results from the length and strength of its unique polymer molecule formulation, which enables molecules to bond well with surface materials. Its molecules link to one another in relatively straight chains, which cross-link with other chains or grids forming a matrix that may be 1,000,000 molecules long.

This structure creates surfaces that are stronger and more flexible than the smaller molecular structure of oil, calcium, petroleum resin and asphalt emulsion products, which range from 100 to 10,000 molecules.

Independent testing – the key to buyer confidence

Soil-Sement is the only polymer emulsion certified and verified by so many independent agencies:

- US EPA ETV
- Cal-Cert
- CARB (California Air Resources Board Documentation)
- Canada ETV
- US Army Corp of Engineers
- ADEMA (Arizona Department of Emergency and Military Affairs)
- San Diego State University
- Midwest Research Institute
- ERDC (Engineer Research and Development Center)
- Desert Research Institute

Easy to be green

With chemists in our lab and experts on our customers' sites, Midwest has the home-grown ability to manufacture products that will not harm the environment and, in many instances, will help it. Our chemists think green from source materials all the way to application.

Learn more about Midwest

Midwest is a world leader in effective and environmentally-sound dust control, erosion control, soil stabilization and anti-icing solutions. To learn more or ask us any questions, contact us at 1.800.321.0699.

1.800.321.0699
www.midwestind.com

MIDWEST
Consider it done.

SOIL-SEMENT CASE STUDY

Dust Control

Curbing fugitive dust problems at a Canadian mine disposal site

Background.
Winter freezing causes the surface at mine tailing disposal sites to freeze dry, which makes it a source of fugitive dust.

Problem.
A 400-acre Canadian disposal site needed treatment to eliminate dust in the winter months preceding the arrival of snow.

Solution.
Midwest used conventional vehicles and tracked units to apply a durable Soil-Sement sealed surface. Soil-Sement has the unique ability to eliminate fugitive dust and airborne particles because it chemically bonds and seals the surface to prevent wind from lifting fines and creating dust. Depending on site objectives, Soil-Sement applications can be tailored to be effective for just several months or for up to a year or longer.

Soil-Sement® has the unique ability to eliminate fugitive dust and airborne particles because it chemically bonds and seals the surface to prevent wind from lifting fines and creating dust.

Midwest Industrial Supply, Inc.
1101 3rd Street Southeast
Canton, Ohio 44711

www.midwestind.com

Tel 330.456.3121
Fax 330.456.3247
Toll Free 1.800.321.0699

MIDWEST

Attachment 2: EnviroKleen and EK35

EnviroKleen® and EK35®
Synthetic Organic Dust Control®

Tough on Dust, Easy on the Environment

Runway or roadway, concert venue to construction site to unpaved open area, if the problem is fugitive dust or an unstable surface, the antidote is Midwest's EnviroKleen or EK35. Like all Midwest products, these powerful synthetic organic fluids are reliably consistent and consistently reliable month-to-month, season-to-season, and year-to-year.

EnviroKleen and EK35 are ranked first in all categories tested by the US Army Corps of Engineers.

Created in Midwest's own laboratory, EnviroKleen and EK35 were the first Synthetic Organic Dust Control products on the market. Unique in the industry, both products have binder systems that capture fines and keep them locked into the surface, preventing dust from escaping. We formulated both products to be as gentle on the environment as they are tough on dust and unstable surfaces.

Vital statistics

- EPA-verified safe for people and the environment
- EPA-verified effective for reducing PM_{10} and $PM_{2.5}$
- Certified non-corrosive by Boeing
- Creates pavement-like strength; enhanced by traffic
- Can be reworked without reapplication
- Does not evaporate or leach out of the surface
- Performs well at extreme temperatures
- Can be stored at temperatures down to -50° F
- Readily biodegradable in natural environments
- Works with all types of soils and aggregates

MIDWEST

Why EnviroKleen and EK35?

Treating a symptom like dust is a temporary band-aid. Midwest goes after the *root cause* of a problem like surface instability and works tenaciously and without compromise until we find the optimal solution. In this case, the solution is the Synthetic Organic Dust Control and the binding technology we invented for use in the manufacture of EnviroKleen and EK35.

EnviroKleen is formulated with a polymeric binder; EK35 with a resin binder made from renewable resources. Both products are superior choices for industrial, construction, and municipal applications. They quickly penetrate dust and remain actively effective on clay, sand, gravel, limestone, and most native soils regardless of the weather or how severe the traffic. That is because their binder systems interlock and durably bind surface aggregate and fines together through both cohesive and adhesive mechanisms. As fines are generated, they are captured, preventing them from escaping as dust. EnviroKleen and EK35 are cost-effective for controlling PM10 and PM2.5 from open fugitive dust sources, and unlike other available products they will not track onto public roadways or stick to vehicles. Both products provide longer-lasting performance and require fewer applications than other dust control and surface stabilization methods - regardless of season.

Managing fines with EnviroKleen and EK35 can save tens of thousands of dollars annually during the lifecycle of a surface.

Compare EnviroKleen and EK35 to Other Dust Control Methods

Performance Benefits	EnviroKleen and EK35 Synthetic Organic Fluids	Water	Road Salts[1]	Asphalt Emulsions	Petroleum Resins	Lignin
Longer lasting	●			●	●	
Year-round protection	●[2]		●			
Passes EPA static sheen test	●	●	●			
Non-petroleum product	●	●	●			●
Colorless	●[2]	●	●			
Not water-soluble/cannot be diluted	●					
No poly-nuclear aromatic hydrocarbons (PAH)	●	●				●
Will track				●	●	●
Sprayable gallons required for a 1-mile x 30' wide road	1,800	550,000	8,825	18,480	13,200	5,280
Storm drain risk	Low	Low	High	High	High	High

[1]Road salts are sodium chloride, calcium chloride, potassium chloride, magnesium chloride and ferrocyanide salts.
[2]EnviroKleen passes the EPA static sheen test and is colorless.

Conventional dust control methods can create greater problems than the dust itself —lingering environmental and health concerns, for example. Alternatives like water provide short-term solutions that involve labor-intensive, multiple applications.

Easy to be green

With chemists in our lab and experts on our customers' worksites, Midwest has the home-grown ability to manufacture products that will not harm the environment and, in many instances, will help it. Our chemists think green from source materials to formulation and from product to application.

Special Delivery — The E-Sprayer™ System

The "E" in E-Sprayer System, an efficient product-dispensing solution, stands for EnviroKleen and EK35, the products for which it was specifically designed. Portable, versatile and compact, the E-Sprayer can be mounted on any light-duty truck from an F-150 flatbed one-ton trailer to a military Humvee. Powered by a 4.7-hp Diesel/JP8 fuel electric start engine and Gorman-Rupp pump, the E-Sprayer requires only one person to operate and facilitates universal application with an 8-foot spray bar. Flow is easily controlled with the throttle or motorized regulator.

Tested and verified - independently

Midwest believes in proving claims, rather than just making them, so our clients can be sure they are getting what they pay for from both performance and environmental perspectives.

- US EPA ETV* test data verifies that EnviroKleen and EK35 are safe for people and the environment as well as effective in suppressing PM_{10} and $PM_{2.5}$ levels. No other synthetic fluids have achieved this designation.
- EnviroKleen and EK35 comply with requirements of the Clean Water Act and National Pollution Discharge Elimination System and realize fines preservation for surface stability and dust control.
- The synthetic organic fluid in each product meets the criteria for the term synthetic as established by the US EPA for sediment toxicity, biodegradability, PAH content, aquatic toxicity, and being oil-sheen free.
- The non-corrosive properties of EnviroKleen and EK-35 have been certified by Boeing Document D6-17487, the most stringent corrosion standard in the United States.

The protocols Midwest uses in testing its products under US EPA guidelines are 200 times more stringent than those used by our competitors. Proof of these verifications and certifications are available any time from Midwest. Before considering other dust-control solutions, remember to ask for such proof to protect yourself from false claims.

**U.S. Environmental Protection Agency's Environmental Technology Verification Program*

Choice of the Military: EnviroKleen and EK35 in Action

Clear vision is a military necessity, but the conditions in which our forces operate fly in the face of that need. Dust, sand and dirt obstruct vision and also attack and weaken critical vehicle and aircraft parts. The US Military chooses EnviroKleen and EK35, ranked first in all categories tested by the US Army Corps of Engineers, to enhance safety and visibility for CH-46 Chinook and CH-53 Sea Stallion helicopter pilots.

Preserving Gravel Runways in Cold Regions

EnviroKleen and EK35, the backbone of Midwest's Fines Preservation programs, are able to stabilize gravel runway surfaces, increase their strength, and preserve service life by keeping the fines bound to the surface. Applied in extreme temperatures, both products are applied neat and remain active and re-workable. The result? Fines preservation programs can achieve an 80% decrease in dust levels for up to four years and a decrease in runway lifecycle costs of 70%, or up to $40,000 in annual savings. As many as two- to five cubic meters of fines are saved at every take-off and landing on treated runways. Learn more about our gravel runway resources at www.gravelrunway.com.

If the shoe doesn't fit...

One size fits all does not always make for a good fit; unique problems require unique solutions. Midwest is a particle-control pioneer, not a me-too company. Our product development begins with a challenge and ends when we produce a solution that proves its worth in the field. Off-the-shelf is fine when it works, but when it does not, Midwest has the capability and tenacity to engineer a formula for your specific needs.

More reasons to choose Midwest

Midwest is the world leader in environmentally-sound, dust-control technology for every application where fugitive dust is a problem. We bring our customers more solutions, documentation and support than any other manufacturer. On a daily basis, we challenge ourselves to become even more accessible problem solvers so we can set a new industry standard for proactive and responsive service. Pushing the envelope is part of our corporate DNA, and we strive, always, to develop cutting-edge processes, products and services; stay on top of the learning curve, and educate our customers for our mutual success.

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MIDWEST

Attachment 3: DustCap

DustCap

Dust Suppressant

Dust Suppression Without Limits

It has been known for many years that soil particles owe their stability in part to the presence of naturally occurring polymeric materials which bind to the soil. DustCap is a polymeric soil stabilizer designed to hold together soil structure, similar to the effect of the organic matter found in most soils. DustCap protects the soil structure by binding to soil crumbs, reducing crumb breakdown, and by creating a cap to further resist environmental attack. Application of DustCap reduces erosion up to 95% and creates excellent resistance to weatherability. DustCap is a superior choice for capping dirt fields and construction sites, yielding months of protection against wind and water erosion.

BENEFITS

- *Reduces Wind Erosion*
- *Highly Efficient*
- *Soil Stabilizer*
- *Biodegradable*
- *Non-Toxic*

APPLICATIONS

Construction Sites
Oil Fields
Roads
Ag Land
Stockpiles
Campgrounds

ECTC Directing Member

IECA Member

www.terranovo.com/dust

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DustCap
Dust Suppressant

Application Rates & Techniques

APPLICATION
As with all dust suppressants, application rates and methods depend upon the site, environment, soil type, and more. Each site is unique, and as such, the following application rates are based on averages in the field. In some situations such as high wind, powdery soil, etc., increasing application rates by 1.25-1.5 times may be required.

Soil Type	Gallons / Acre	Minimum Dilution Rate
Clay	*15*	*150:1*
Silt	*10*	*200:1*
Sand	*5*	*300:1*

Some circulation is needed to complete the inversion of the product. The product is readily dispersible in water and it is advised to have the ability to recirculate the water tank on itself to mix. About 5 minutes of mixing is adequate.

Cure time for DustCap is just under four hours on a typical sunny day.

SURFACE PREPARATION
When possible, grading the surface soil will greatly improve DustCap's penetration, thereby enhancing the lifetime of the product. The product can also be applied directly onto the soil without any surface preparation.

SAND SIEVE ANALYSIS
Sand Sieve Analysis is a practice or procedure used to assess the particle size distribution of granular material. The size distribution is critical in determining the type of dust suppressant needed and application rates to be used. The practice of Sieving is quick and accurate, measuring the maximum diameter of a sediment grain. There are four aspects of this proven test, including sizing, sorting, kurtosis, and skewness. After the analysis, we can determine the percent sand, silt and clay in your soil, and textural class, thereby recommended an accurate application rate and method for your needs.

Particle Grade	Size (mm)	Surface Preparation
very coarse	1-2	Optional grading of the surface to extend product lifetime, but not necessary.
medium sand	0.25-0.50	
fine sand	0.125-0.25	
silt	0.0039-0.0625	
clay	less than 0.0039	

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ABOUT US
Terra Novo is dedicated to helping the Storm Water and Erosion Control industry comply with strict Federal Clean Water regulations. We provide cost-effective Best Management Practice solutions that more and more erosion control and storm water specialists are turning to. Our engineers and chemists pride themselves by maintaining a hands on approach to solving site-specific problems. We have developed product lines for erosion control, dust control and storm water run-off with the end user in mind. All of our products are highly effective, extremely affordable, and environmentally friendly.

For technical services, call 1-888-843-1029 or visit us online at www.terranovo.com.

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