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

HOPE BAY, NUNAVUT

AUGUST 2016

PLAN LANGUAGE SUMMARY

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.

REVISION HISTORY

Revision #	Date	Section	Summary of Changes	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		

GLOSSARY AND ACRONYMS

TERM	DEFINITION
AEP	Annual Exceedance Probability
CDA	Canadian Dam Association
CTP	Concentrate Treatment Plant
DSI	Dam Safety Inspection
DSR	Dam Safety Review
EOR	Engineer of Record
ERP	Emergency Response Plan
FSL	Full Supply Level
GCL	Geosynthetic Clay Liner
IDF	Inflow Design Flood
INAC	Indigenous and Northern Affairs Canada
KIA	Kitikmeot Inuit Association
MAP	Mean Annual Precipitation
MAR	Mean Annual Runoff
MMER	Metal Mining Effluent Regulations
NIRB	Nunavut Impact Review Board
NMC	Newmont Mining Corporation
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.
SWE	Snow Water Equivalent
TIA	Tailings Impoundment Area
TMAC	TMAC Resources Inc.
TPD	Tonne Per Day
WMMP	Wildlife Monitoring and Management Plan
WSCC	Workers Safety and Compensation Commission

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1. INTRODUCTION

1.1. PURPOSE OF 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 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.

1.2. 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 Tailings Impoundment Area (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.

1.3. 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. Printed copies of the OMS Manual found at other locations will be considered uncontrolled versions.

Table 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

1.4. 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:

- KIA;
- Indigenous and Northern Affairs Canada (INAC);
- Nunavut Water Board (NWB);
- Nunavut Impact Review Board (NIRB); and
- Workers Safety and Compensation Commission (WSCC) Chief Mines Inspector as per 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 (NWB 2013);
- KIA Commercial Lease #KTCL#313D001; and
- Schedule 2 of the Metal Mining Effluent Regulations (MMER).

Table 2 provides a list of licence requirements and guidelines that govern the structure and content of this OMS Manual.

Table 2: License Requirements and Guidelines Governing the OMS Manual

Regulation/Guideline	Year	Governing Body	Relevance
Water License No: 2AM-DOH1323	2013	Nunavut Water Board	License to operate. Expires August 15, 2023.
Dam Safety Guidelines	2013	Canadian Dam Association	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

1.5. Related TMAC Documents

The documents listed in Table 3 are expected to be referenced and utilized in conjunction with the OMS Manual.

Table 3: List of TMAC documents Related to the OMS 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 (ERP 2016c)
Water Management Plan	2016	Describes the water management procedures including discharge from the TIA and associated water quality criteria (TMAC 2016a)
Groundwater Management Plan	2016	Describes the groundwater inflow predictions and associated management procedures for handling this water (TMAC 2016b)
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	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)
Site-Wide Water and Load Balance	2015	Water and load balance to evaluate water management needs and predict water quality at the Project and downstream receptors (SRK 2015d)

Document Title	Year	Relevance
TIA Interim Dike – Filtering Requirements	2015	Filter design for the Interim Dike (SRK 2015e)
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)

2. Roles and Responsibilities

2.1. Organization and Individual Responsibilities

The site management structure is outlined in Figure 1. 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 and listed in Table 4.

Table 4: TIA Responsible Persons

Personnel and Contact Information	Position	TIA Responsibilities
Floyd Varley (416) 986-1501 floyd.varley@tmacresources.com	Vice President Operations	• 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.
Paul Christman, PEng (867) 988-6882 ext. 100	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.
Andy Mortimore (TMAC) (867) 988-6882 ext.	Mill (Process) Manager	
Kelly Schwenning (TMAC) (867) 988-6882 ext. 106 Ron Bertrand (TMAC) (867) 988-6882 ext. 101	Surface Manager	
Sarah Warnock (ESC 1) To be Determined (ESC2) (867) 988-6882 ext. 102	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.
To Be Determined (867) 988-6882	Mine Operations Superintendent	• Day-to-day execution of discipline based activities and inspections pertaining to TIA operation, maintenance and surveillance as it relates to tailings deposition and water management in accordance with this OMS Manual.
To Be Determined (867) 988-6882	Mill (Process) Operations Superintendent	

Personnel and Contact Information	Position	TIA Responsibilities
To Be Determined (867) 988-6882	Surface Operations Superintendent	
To Be Determined (867) 988-6882	Health and Safety Superintendent	• Functional site based lead for assigning and applying appropriate resources towards health and safety procedures for the TIA construction, operation, maintenance, surveillance and closure.
Kris Carrington Bruce Taylor (867) 988-6882 ext. 114	Health and Safety Coordinator	• 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.

Note: At the time of producing this version of the OMS Manual, TMAC has not yet filled all the responsible positions listed in Table 4. As positons are filled this table will be updated in copies identified in Table 1.

2.2. Competency and Training

Specific procedures that will be adopted to ensure that all persons associated with the TIA activities, as outlined in Table 4, are familiar with the contents of this OMS Manual, receive appropriate training, and have a clear understanding of, and competency with their roles and responsibilities 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 will conduct 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

Doris Mine (Doris; the Project) is the northernmost section of an 80 km long north-south trending mineralized Greenstone belt, known as Hope Bay. Doris is located about 4 km due south from Roberts Bay, which forms part of Arctic Coastline in the Kitikmeot Region of Nunavut.

The estimated ore reserve for Doris is approximately 2.5 million tonnes (Mt). Ore is trucked from underground to a surface stockpile, crushed and conveyed to the mill. The ore will be processed initially at a nominal rate of 1,000 tonnes per day (tpd), increasing to nominally 2,000 tpd over the life of the mine. The mineral processing plant will utilize two primary processing circuits, each having a nominal 1,000 tpd capacity, fed by a single primary jaw crusher. The plant consists of secondary and tertiary crushing, grinding, gravity gold recovery, and flotation to produce a gold-containing concentrate. Flotation concentrate will go to a concentrate treatment plant (CTP) for further processing.

The CTP consists of regrinding, cyanidation, resin gold recovery, and doré gold bar production. Tailings, from the CTP process are subjected to cyanide destruction and detoxified tailings are filtered (i.e. dewatered) prior to being returned underground with waste rock as mine backfill. The remaining flotation tailings are pumped to the TIA.

Water supply for the process will be primarily reclaim water from the TIA Reclaim Pond. Raw water from Doris Lake or mine water (if found to be of suitable quality) will be supplemented as required.

The TIA is located approximately 1 km east of Doris Camp, and accessed via an all-weather road (the TIA road) and the Doris Creek bridge. The TIA is comprised of three containment structures: the North Dam, the South Dam, and the Interim Dike. Tailings will be sub-aerially deposited between the Interim Dike and the South Dam using a series of spigots. The Interim Dike is designed to retain tailings solids and to allow for the flow-through of water into the Reclaim Pond. The Reclaim Pond is located between the Interim Dike and the North Dam. Excess water is discharged to Roberts Bay.

Upon closure, the tailings surface will be covered with a nominal 0.3 m thick run of quarry (ROQ) cover. The function of the cover is to prevent aeolian and hydraulic erosion of the tailings. The cover will terminate at the Interim Dike, after it has been levelled to match the elevation of the cover, such that surface water will flow off unhindered towards the Reclaim Pond. Once the water quality in the Reclaim Pond has reached the required discharge criteria, the North Dam will be breached allowing for the unconstrained flow of water through the TIA to the natural receiving environment (SRK 2015a).

3.2. PROJECT HISTORY

Newmont Mining Corporation (NMC) acquired the property in 2007 and built the Doris camp, airstrip, fuel storage, jetty, and started underground development on site before placing the Project in care and maintenance in 2011. In December 2012, NMC signed a Letter of Intent with TMAC and a definitive sale agreement in January 2013. TMAC reopened Doris in March 2013 and commenced exploration and environmental programs. Construction was restarted in 2015 and carried on into 2016. Commercial production is scheduled to start in the first quarter of 2017.

3.3. SITE CONDITIONS

3.3.1. Climate

The mean annual air temperature at the site is -12.4°C. During the winter months, October to May, the daily air temperature typically range from -50°C to +11°C. In the summer months, June through September, the mean daily air temperature ranges between -14°C and +30°C (SRK 2015a).

Prevailing winds for the region are from west and west-northwest and blow from this direction approximately 20% of the time. South-westerly winds blow less than 2% of the time. Winds from the prevailing wind direction have the greatest wind speeds (SRK 2015a).

Precipitation on the site occurs as rainfall and snow fall. The mean annual rainfall is 98.7 mm. The mean annual snowfall is 133.8 mm, or 80.2 mm snow water equivalent (SWE). The total mean annual precipitation (MAP), water equivalent, is 178.9 mm. Annual evaporation, which occurs during the open water season, is 220 mm. The site mean relative humidity is 78% (SRK 2015a).

3.3.2. Permafrost

The Project area are underlain by continuous permafrost. The estimated permafrost depth is approximately 500 m. The active layer thickness depend on surface ground conditions, but typically range between 0.5 m to 1.0 m. The North and South Dams will be constructed on permafrost. The Interim Dike will not be constructed on permafrost but on the TIA talik (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 seven to 20 km wide and over 80 km long in a north-south direction. The belt is mainly comprised of mafic metavolcanic (mainly meta-basalts) and meta-sedimentary rocks that are bound by Archean granite intrusives and gneisses. The greenstone package has been deformed during multiple events, and is transected by major north-south trending shear zones that appear to exert a significant control on the occurrence of mineralization, particularly where major flexures are apparent and coincident with antiforms (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. Based on MAP rates, and no losses from infiltration, ice entrainment, evapotranspiration and sublimation (i.e. a runoff coefficient of one), the mean annual runoff (MAR) volume from this basin would be approximately 64,000 m^3 (SRK 2015a).

3.3.5. Hydrogeology

Groundwater flow in a continuous permafrost environment is limited to deep groundwater flow below the permafrost, and in taliks (permafrost free zones) that exist under larger water bodies, as well as shallow seasonal groundwater flow within the active layer. Deep groundwater has elevated salinity due to the fact that 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. Groundwater inflow to the mine has been predicted to be up to 3,000 m^3/day, and this water will be managed via the TIA and/or direct discharge to the ocean (SRK 2015c, d). In the event that the predicted mine inflow is greater than 3,000 m^3/day, excess inflow will either 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 2016b).

The TIA hosts a talik, although it is not known whether it is an open or closed talik. Over the long-term, tailings freeze-back will occur, which will result in a reduction of the talik (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 utilizing a central frozen core with a secondary upstream geosynthetic clay liner (GCL). Complete design parameters are provided in Table 5 and Figure 3. The dam is constructed from local quarry rock and consists of processed fines for the core, 150 mm nominal sized transition material, and a 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 retained between the South Dam and the Interim Dike. The South Dam is a frozen foundation dam consisting of a compacted rock fill dam with an upstream GCL keyed into the permafrost overburden foundation. Design parameters are listed in Table 5 and Figure 4. 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. INTERIM DIKE

The Interim Dike is a homogeneous ROQ rock fill dike constructed with the confines of the TIA, directly on the existing lake bed sediments, without dewatering the TIA. The complete design parameters are provided in Table 5 and Figure 5. The Interim Dike is not required to hold back tailings supernatant water, but is expected to retain tailings solids. To achieve this, the upstream face of the Interim Dike will include a filter zone. The Interim Dike is expected to undergo significant settlement over its operating life and as a result will be constructed in stages. The initial stage will focus on attaining crest elevation of approximately 0.5 m above the normal operating water level in the TIA (SRK 2015a, e, 2016).

The Interim Dike needs to be in place 2.5 years following the start of tailings production (SRK 2016).

3.4.4. SPILLWAY

An operational spillway has been designed for the TIA at the North Dam. This side-spillway has an invert level of 33.5 m, is 18 m wide, and 180 m long along its centerline, with an average gradient of about 0.8%. The Inflow Design Flood (IDF) of 3.3 m^3/sec, will pass through the spillway with a maximum flow depth of about 0.2 m at a sub-critical flow velocity of about 1.1 m/sec (SRK 2007, 2015a).

The water level in the TIA will however be actively managed through pumped discharge of excess water to Roberts Bay. As a result it is not anticipated that the spillway will ever be constructed (SRK 2015a, d).

3.4.5. TAILINGS DEPOSITION SYSTEM

Tailings with an initial solids content of about 35% (nominal production rate of 1,000 TPD) increasing to 65% (nominal production rate of 2,000 TPD) will be pumped to the TIA via a heat-traced and insulated pipeline. Deposition will be subaerial using single point spigots which will be relocated over the life of the project. The tailings pipeline will follow the Secondary Road from the Doris mill to the South Dam. 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).

3.4.6. RECLAIM WATER SYSTEM

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).

3.4.7. TIA DISCHARGE SYSTEM

Annually during the open water season excess, TIA water will be discharged to Roberts Bay. The discharge pump will be adjacent to the Reclaim pump, and will pump water along a pipeline following the same route as the Reclaim water pipeline. This pipeline will not be heat traced and insulated, but will be double walled as it crosses Doris Creek. The TIA discharge water may merge 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).

3.5. CONSTRUCTION HISTORY

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).

3.6. TAILINGS PROPERTIES

3.6.1. Tailings Geotechnical Characteristics

The TIA design was completed with one sample of total combined mill tailings (i.e. flotation and detoxified tailings) from a pilot metallurgical test conducted by Bateman Engineering subjected to geotechnical characterization. Considering the small volume of detoxified tailings, the properties are dominated by the flotation tailings characteristics and as a result the data remain suitable for design.

The total tailings are composed of sandy fine to coarse silt with 56% passing the No. 200 sieve (75 micron). The percent by weight of clay sized particles (less than 2 microns) in the tailings sample was approximately 11%. The tailings were found to be non-plastic and the measured tailings particle density was 2.74 g/cm^3 (SRK 2007, 2015a).

3.6.2. Tailings Geochemistry

Complete tailings geochemical characterization was carried out on flotation tailings, detoxified tailings and total tailings. Since the tailings management plan entails separate management of flotation and detoxified tailings, only those results are relevant.

Both flotation and detoxified tailings have abundant neutralization potential and thus buffering capacity typically in the form of ferroan dolomite with minor calcite and/or siderite. Sulphide content, in the form of pyrite, was dependent on tailings type with high levels in the detoxified tailings, and relatively low levels in the flotation tailings.

The results of static and humidity cell tests indicate that the detoxified tailings are potentially acid generating (PAG) and the flotation tailings are non-PAG.

Screening of the elemental content of the tailings solids indicate consistently elevated silver, arsenic, gold, cadmium, lead and selenium, and inconsistently elevated copper, molybdenum and tungsten in the detoxified tailings, and elevated gold in the flotation tailings. Elevated levels are not necessarily indicative of leaching behaviour. Furthermore, many of these metals are associated with sulphides and as indicated will primarily partition into the detoxified tailings.

The detoxified tailings also showed a propensity for leaching of several metals in the humidity cell tests. In addition to arsenic, neutral pH metal leaching of ammonia, cadmium, copper, iron, selenium and silver was reported in the Doris North detoxified tailings, and cadmium and selenium in the Doris Central detoxified tailings. Acidic conditions developed in the Doris Central detoxified tailings after 202 weeks of testing. At acidic pH, increased metal leaching of Cd, Co, Cu, Fe, Mn, Ni, Pb, and Zn was noted. Under the proposed mine plan, detoxified tailings will be disposed underground, where it is projected they will be flooded prior to the onset of acidic pH conditions.

Marginally elevated median concentrations of copper and lead in the Doris Central flotation tailings humidity cell tests may indicate possible leaching of these metals from the Doris Central flotation tailings.

Process water chemistry associated with the tailings slurry samples, analyzed to provide an indication of possible water chemistry to be discharged to the tailings facility, indicated elevated levels for several aqueous phase metals that varied by tailings type and ore zone.

Process water associated with the detoxified tailings was alkaline and typically elevated in sulphate, total cyanide, ammonia, silver, cadmium, copper, chromium, and likely selenium. Process water from the Doris North detoxified tailings was also marginally elevated in arsenic, iron, molybdenum, nickel, lead and zinc. Aging tests on the tailings process water were conducted to simulate the chemical evolution of process water chemistry in the TIA and in particular the degradation of cyanide. Aging test data indicate that process water, chemistry generally improved with decreases in cyanide, cyanide degradation products and most metals in particular silver, arsenic, copper, nickel and selenium.

Process water chemistry between the Doris Central and Connector solutions was notably different with the Doris Central process water characterized by higher metals. Molybdenum, iron and chromium were elevated in both solutions, but the Doris Central flotation tailings water was also elevated in silver, cadmium, copper, lead and zinc. The Doris North flotation tailings process water was not available for analysis (SRK 2015b).

3.7. Dam Hazard Classification

The North Dam, South Dam and Interim Dike 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 5 (SRK 2015a).

Table 5: 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
Interim Dike	LOW	LOW	LOW	LOW	LOW

3.8. Overall TIA Design Criteria and Parameters

The basis of design, design criteria, and design parameters for the TIA are outlined in Table 6 (SRK 2015a).

Table 6: TIA Design Criteria and Design Parameters

Description	Value		
	North Dam	South Dam	Interim Dike(7)
Structure Type	Frozen core rock fill dam with GCL	Frozen foundation rock fill dam with GCL	Homogeneous rock fill dike
Secondary Seepage Barrier	GCL	GCL	None
GCL Deployment Slope	2.5H:1V	3H:1V	n/a
Crest Centerline Length	220 m	375 m	225 m
Maximum Height	11.0 m	6.0 m	7.5 m
Final Crest Elevation	37.5 m	38.0 m	35.3 m
Initial Crest Elevation	n/a	n/a	31.0 m
Core/GCL Elevation	35.0 m	37.0 m	n/a
Full Supply Level (FSL)	33.5 m		

Description	Value		
	North Dam	South Dam	Interim Dike[7]
Normal Water Level	29.0 m		
Maximum Water Level	29.3 m		
Total Freeboard	4.0 m	1.5 m	1.8 m
Hydraulic Freeboard	1.8 m	0.5 m	n/a
Thermal Protection above Frozen Core	2.5 m	n/a	n/a
Settlement and Allowance	1 m	n/a	up to 4.1 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	3H:1V
Downstream Structure Slope	4H:1V	2H:1V	3H:1V
Key Trench Depth	Varies	4 m	n/a
Key Trench Upstream Slope	0.5H:1V	2H:1V	n/a
Key Trench Downstream Slope	0.5H:1V	1H:1V	n/a
Dam Hazard Classification	HIGH	HIGH	LOW
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	10 years[1] 20 years 10 years	1 year 5 years 5 years 100 years	5 years 100 years
Tailings Production Rate	Nominally 1,000 TPD initially, increasing to 2,000 TPD		
Tailings Storage Requirement: • By mass • By volume	2.5 Mt 1.93 Mm^3		
Production Life	4 years, 5 months		
Tailings Solids Content	35% solids (by weight) initially, increasing to 65%		
Tailings Specific Gravity	2.7		
Deposited Tailings Dry Density	1.29 t/m^3[2]		
Ice Entrainment Allowance: • Percentage of tailings capacity • By volume	20% 0.39 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)		1/100 (0.01)

Description	Value		
	North Dam	South Dam	Interim Dike[7]
AEP for Standards Based IDF	1/3 between 1/1000 and the Probable Maximum Flood (PMF)[3]		1/100 (0.01)
North Dam Spillway IDF	1/500 (0.002). Assumes no attenuation and 100% runoff[4]		
Static Stability Factor of Safety Long-term (Drained Conditions)	≥1.3 during construction ≥1.5 during operation and closure ≥1.2 partial or rapid drawdown		
Stability Factors of Safety (Pseudo-Static)	≥1.0 during earthquake ≥1.2 post earthquake		
AEP for Earthquake Design Ground Motion	1/2475 (0.0004)	1/2475 (0.0004)	1/100 (0.01)[5]
Peak Ground Acceleration (PGA)	0.060g[6]	0.036g	
Mean Annual Air Temperature Climate Change	+6.8oC up to year 2100	+4.1°C over 100 years	n/a
Thermal Design Freezing Point Depression • Tailings • Overburden • Frozen core	 n/a -8°C -2°C	 0°C -2.3°C n/a	n/a
Seepage Allowance	78 m^3/day	0.6 m^3/day	n/a

Notes:

(1) The active use design period excludes the period between completion of the North Dam construction and start of operations. Performance monitoring however confirm that the dam is not degrading and therefore the design period remain valid.

(2) Value based on experiential engineered judgement.

(3) PMF has no associated AEP.

(4) IDF for North Dam Spillway does not meet minimum design criteria. Water level management is controlled through active pumping discharge and freeboard exceeds IDF containment capacity so there is no risk of overtopping.

(5) The Interim Dam was designed for a 1/2475 design ground motion, consistent with the South and North Dams.

(6) 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).

(7) The Interim Dike has to be in place 2.5 years following start of tailings deposition into the TIA.

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. A dam break analysis was not completed, as it was determined that the analysis would not change the intuitive outcome based on a qualitative assessment of conditions

A breach of the Interim Dike would not result in any loss of containment of tailings solids or supernatant water. Should a breach of the Interim Dike result in a breach of the North Dam, the North Dam breach scenario described below would apply.

The probability of tailings solids being released as a result of a breach of the North Dam is very low as the North Dam is a water retaining structure, and there are no tailings solids against it, as all tailings solids are retained behind the Interim Dike, 2 km to the south. However, a breach of North Dam would conceivably result in supernatant water reaching the entire downstream catchment which includes Tail Lake outflow, Doris Lake, Doris Creek, Little Roberts Lake and Roberts Bay.

A breach of the South Dam would result in release of tailings solids into Ogama Lake. There is a very remote chance that some solids may find their way into the Ogama Lake outflow, and ultimately Doris

Lake. Tailings solids would however not be transported any further. Supernatant water would however progress all the way along the water system to Roberts Bay (SRK 2015a).

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 2016b). 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 4,000 m^3/day. Prior to discharge to Roberts Bay, all water must meet MMER limits (SRK 2015d, TMAC 2016a).

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 2015d, TMAC 2016a).

4. OPERATION

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 2015d). 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 lowered to match the cover elevation (SRK 2015a).

During operation, and active closure, performance of the North Dam, South Dam, Interim Dike, tailings feed pipeline, reclaim water pipeline 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 7 shows the operating criteria and constraints for the Doris TIA.

Table 7: 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.

Concern	Trigger	Operational and Preventative Maintenance Considerations	Mitigation Strategies
Interim Dike deformation	Undrained foundation failure and excessive foundation settlement	• Slow down construction rate (i.e. foundation loading rate) as much as practical. • Construct in stages.	• Widen crest width and flatten side slopes.
Interim Dike flow-through	Water ponded upstream of Interim Dike	• Construct Interim Dike and upstream filter in accordance with design specifications.	• Implement pump-back system to Reclaim Pond.
	Tailings solids transported through to Reclaim Pond	• Protect upstream filter integrity from wave and ice damage.	• Conduct filter replacement/repair campaign if tailings beach has not reached Interim Dike toe. • Deploy silt curtain downstream of Interim Dike. • Deploy silt curtain around Reclaim Pond pump.
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.
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).

Concern	Trigger	Operational and Preventative Maintenance Considerations	Mitigation Strategies
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.
Shoreline erosion	Vegetation dieback	• Maintain lowest possible water level in TIA.	• Deploy silt curtain in water downstream of affected areas • Deploy silt curtain around Reclaim Pond pump. • Clad affected area with ROQ rock.
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

Tailings will be deposited sub-aerially. The preferred deposition plan requires the installation of a series of spigot points (Figure 6) along the eastern perimeter of the TIA and from the crest of the South Dam creating a landscape that drains towards the Interim Dike at an average slope of about 1% (SRK 2015a).

Tailings deposition is required from the crest of the South Dam, so that a continuous beach is formed along the upstream face of the structure. This configuration is important to ensure the foundation of the South Dam remains frozen. It is however possible to start deposition from the eastern perimeter of the TIA prior to completion of construction of the South Dam.

A tailings beach slope of 1% was assumed in the deposition plan; however, it is possible that this slope could be as steep as 4% for tailings that are deposited into the supernatant pond, retained by the Interim Dike. Monitoring of the tailings deposition and retained supernatant pond levels will be required to assess actual conditions that can be compared to the deposition plan. If the average slope is steeper than 1%, additional spigot locations may be required to achieve the required storage capacity.

A plan of the final deposition surface is shown in Figure 6. Two sections that illustrate the typical surface profile of the tailings deposition plan is presented in Figure 7. Figure 8, Figure 9 and Figure 10 present the staged tailings depositional surface for each year of tailings deposition.

4.4. Dust Management

The tailings deposition plan has been developed to, as far as practical, minimize the area of exposed inactive tailings surface that might be prone to dusting. Dust management will only be undertaken if unacceptable dust fall levels are observed at the dust fall monitoring stations. Beyond such mitigation by design, the primary dust control measure of the TIA will be the use of natural dust control in the form of sprayed water in the summer and winter snow pack. The effectiveness of this is expected to vary on a year by year basis depending on how tailings deposition points change; and therefore, will require ongoing re-evaluation.

Should this be proven to be ineffective, environmentally suitable chemical dust suppressants will be used. Specific suitable products will be sought at that time and applied in accordance with manufacturers recommendations. Appendix A 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.

The application of dust suppressants will be reviewed on an ongoing basis to ensure that any areas that may be at risk will be adequately covered.

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 11).

The tailings supernatant water will drain through the Interim Dike 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 2015d, TMAC 2016a, b).

Should the project go into Care and Maintenance prior to any tailings being deposited in the TIA, excess water will be discharged annually during the open water season to Doris Creek provided it meets discharge criteria. If the project goes into Care and Maintenance after tailings deposition has started, 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 2016a).

4.6. Emergency Operations

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 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 and determine whether the pipe can be repaired without ceasing operations, or not.
- In the event that 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 Pipeline

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

- TIA operator 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.
- In the event that 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°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 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 and South Dams, as well as secondary pipeline containment along the extent of the Doris Creek crossing (SRK 2015a, d, TMAC 2016a).

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).

Once the tailings beach develops at the South Dam, there will not be any water adjacent to the structure. The dam has a crest elevation of 38.0 m and the GCL terminates at elevation 37.0 m. Tailings deposition will terminate at elevation 36.5 m at the South Dam, which leaves a total freeboard of 1.5 m (SRK 2015a).

The Interim Dike freeboard is 1.8 m, which at the FSL of 33.5 m, require the Interim Dike to have a crest elevation of 35.3 m. Overtopping or even complete inundation of this structure is however not a concern as long as the structure remains in place. Therefore, the goal is not to ensure maintenance of the full hydraulic freeboard of this structure at all times. The normal operating level of the TIA is expected to be between 27.3 m and 32.5 m under normal operating conditions and as a result, the Interim Dike will initially be constructed to an elevation of 31.0 m. This structure may be raised over the life of the Project if required (SRK 2015a).

4.9. 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 Interim Dike;
- Pumps and pipelines; and
- Shoreline erosion protection (if installed).

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:

- Pipeline: At least once every six months the tailings pipeline is 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.

Maintenance tasks associated with the shoreline erosion protection works are as follows:

- As part of the annual DSI, the entire TIA shoreline is inspected and areas where shoreline erosion is detected are marked such that those areas can be clad with ROQ when the ground is frozen. (Figure 12 provided typical details pertaining to the shoreline erosion protection measures (SRK 2007).
- At any time during the summer months, if areas are detected along the TIA shoreline that are undergoing active shoreline erosion, silt curtains are deployed such that any suspended matter will be contained, either at source, or at the Reclaim and/or Discharge pump. Physical erosion protection works are carried out in those areas as soon possible (SRK 2007).
- The four shoreline erosion monitoring transects, located between the North Dam and Interim Dike, as shown in Figure 12, must be inspected, surveyed and routine maintenance must be carried out on the instrumentation to ensure that the instruments are in working order (SRK 2007).

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 6 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.

A comprehensive SOP for carrying out surveillance at the North Dam is in use (SRK 2013). Following completion of construction of the remaining facilities, this SOP will be expanded as necessary.

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 focusses on the North Dam, South Dam and Interim Dike, 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.

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 13 to 16.

A series of ground temperature cables and survey prisms will be installed at the South Dam to monitor the thermal regime of the foundation and overall deformation performance. The proposed locations of South Dam monitoring instruments are shown in Figure 17.

A series of survey pins permanently embedded into large boulders will be installed on the crest, and along the upstream and downstream slopes of the Interim Dike to monitor settlement and deformation of the structure. The locations of the survey pins will be determined at the detailed engineering stage of the Project.

Following construction of the South Dam and Interim Dike, the dam surveillance SOP (SRK 2013) will be updated as required.

6.5.3. Water Quality Monitoring

Water quality monitoring for the TIA is described in the Water Management Plan (TMAC 2016a).

6.5.4. Tailings Geochemistry Monitoring

Flotation tailings geochemical characterization testing (SRK 2015b) has confirmed that due to the high neutralization potential and low sulfur content, Acid Rock Drainage (ARD) potential is considered very low. Confirmatory monitoring of this will be carried out during Year 1 of Operations, which will include weekly sample collection for the preparation of a monthly composite sample to be analysed for total metals, sulphur and total inorganic carbon.

TMAC believes that the current requirement is sufficient for confirmation monitoring of the tailings, but would like to request moving the monitoring requirement from the water licence to the TIA OMS

Following Year 1 of monitoring, frequency of sampling and testing will be revisited and any adjustments to the tailings geochemistry monitoring program will be justified and reported to the NWB in the annual report.

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.

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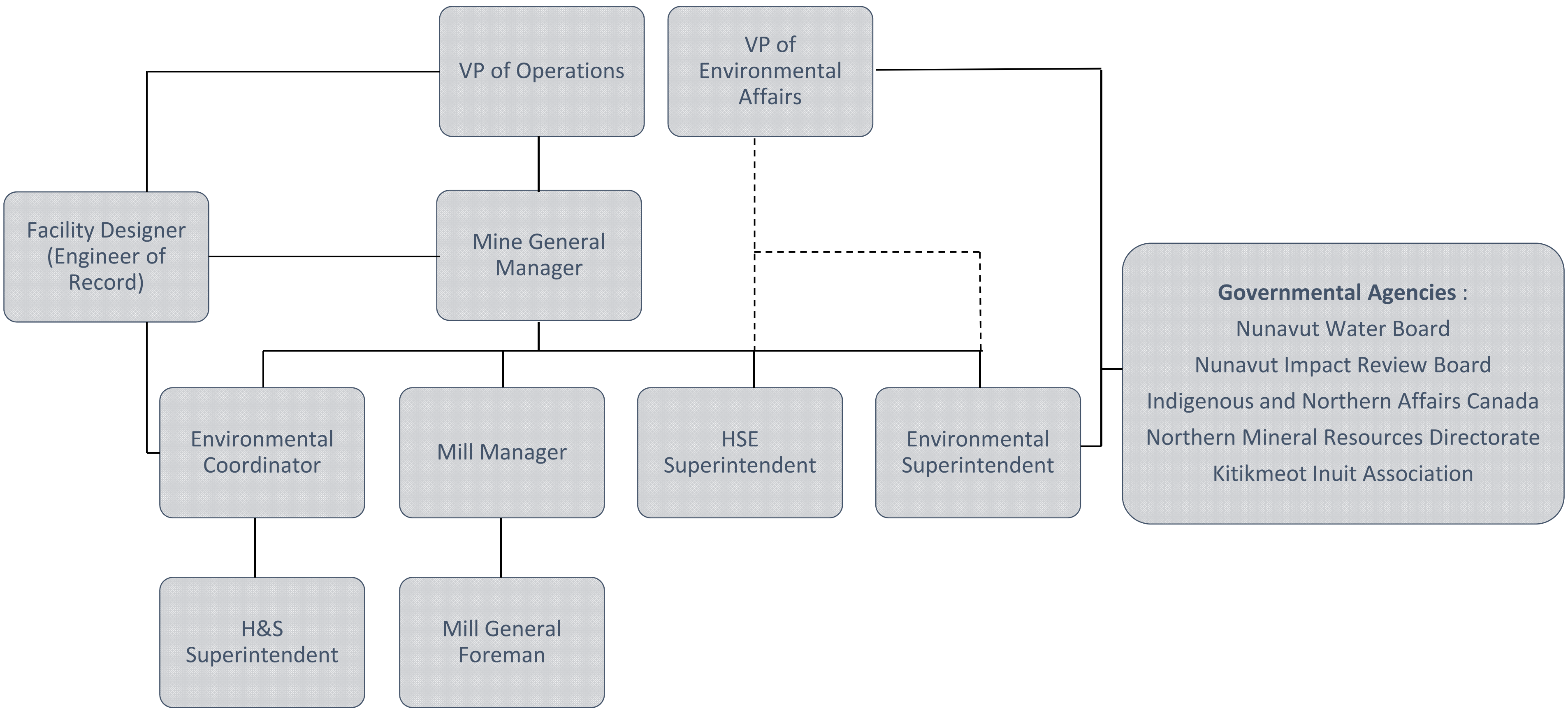
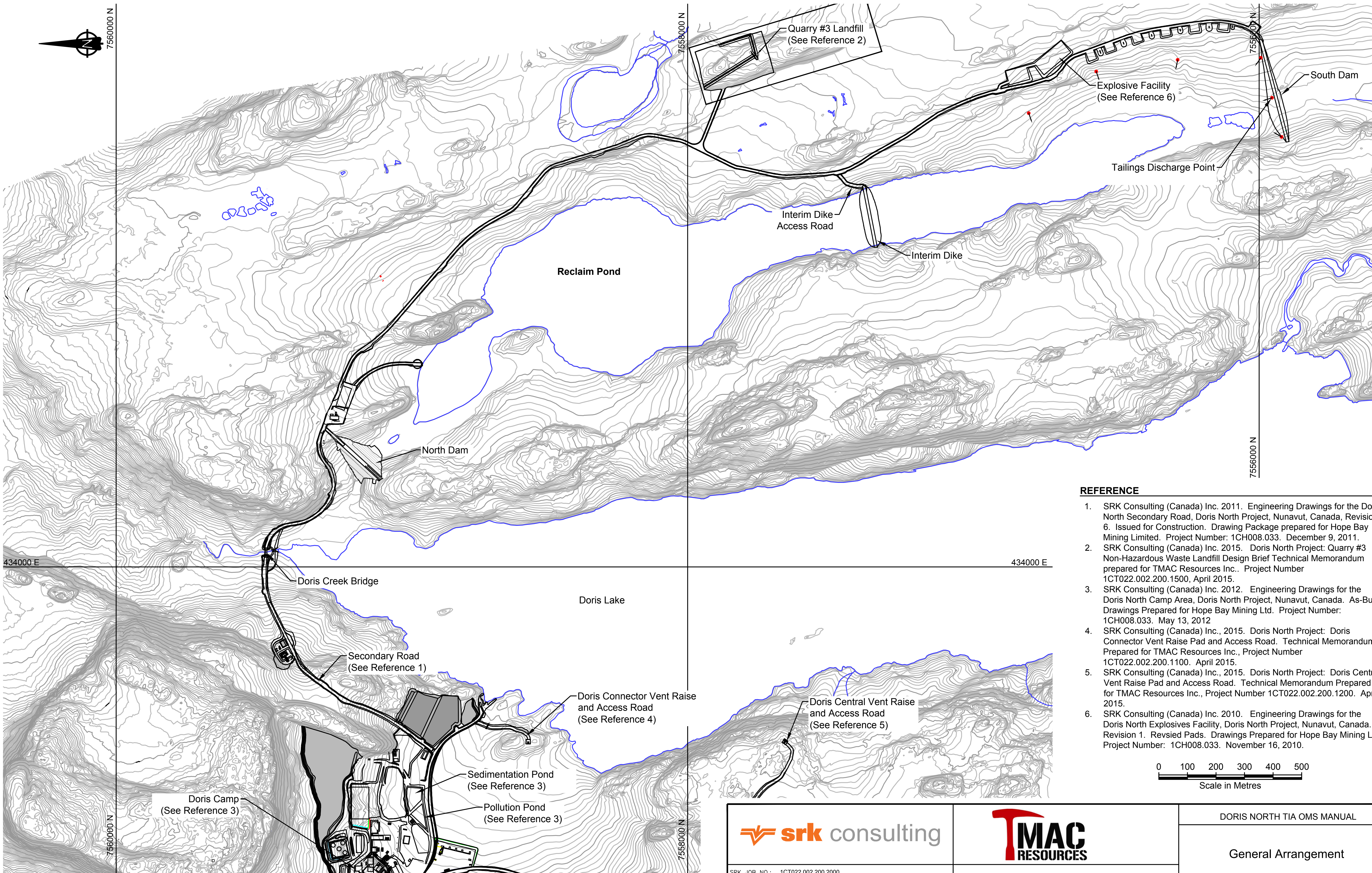
FIGURES



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



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1. SRK Consulting (Canada) Inc. 2011. Engineering Drawings for the Doris North Secondary Road, Doris North Project, Nunavut, Canada, Revision 6. Issued for Construction. Drawing Package prepared for Hope Bay Mining Limited. Project Number: 1CH008.033. December 9, 2011.
2. SRK Consulting (Canada) Inc. 2015. Doris North Project: Quarry #3 Non-Hazardous Waste Landfill Design Brief Technical Memorandum prepared for TMAC Resources Inc.. Project Number 1CT022.002.200.1500, April 2015.
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4. SRK Consulting (Canada) Inc., 2015. Doris North Project: Doris Connector Vent Raise Pad and Access Road. Technical Memorandum Prepared for TMAC Resources Inc., Project Number 1CT022.002.200.1100. April 2015.
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SRK JOB NO.: 1CT022.002.200.2000

FILE NAME: 1CT022.002 – GeneralArrangement_Figure3.dwg

TMAC RESOURCES

HOPE BAY PROJECT

DORIS NORTH TIA OMS MANUAL

General Arrangement

DATE: May 2016 | APPROVED: EK/SA | FIGURE: 2

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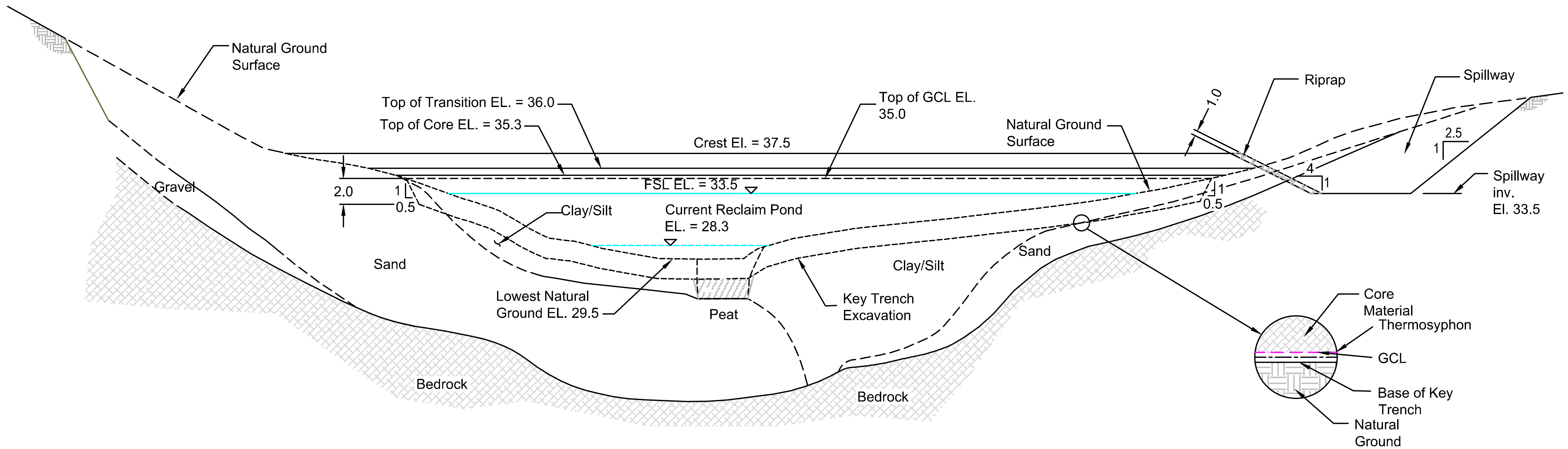
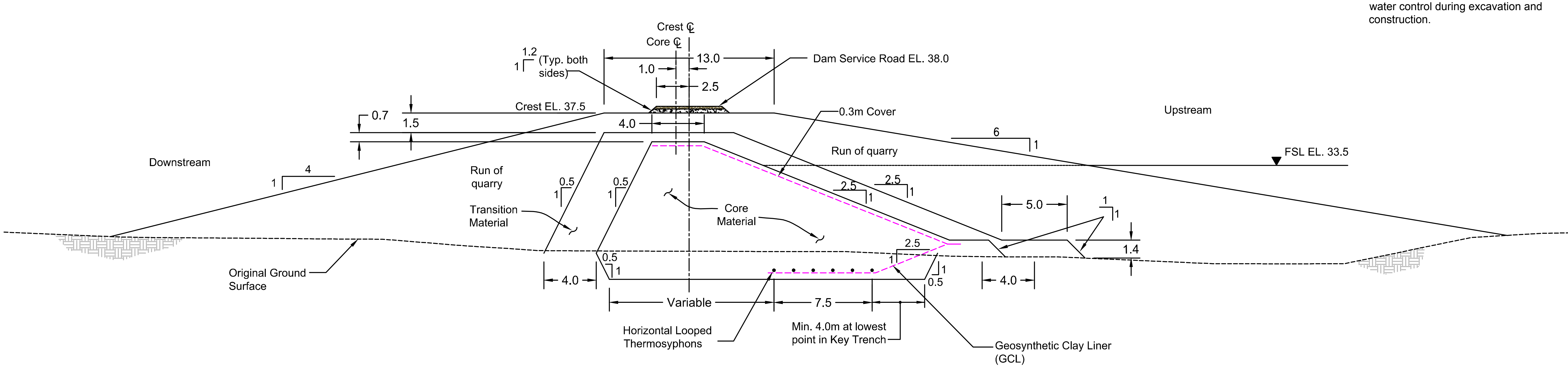


A
05

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.

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FILE NAME: 1CT022.002 - North Dam_Figure4.dwg

MAC RESOURCES

HOPE BAY PROJECT

DORIS NORTH TIA OMS MANUAL

NORTH DAM CROSS SECTION

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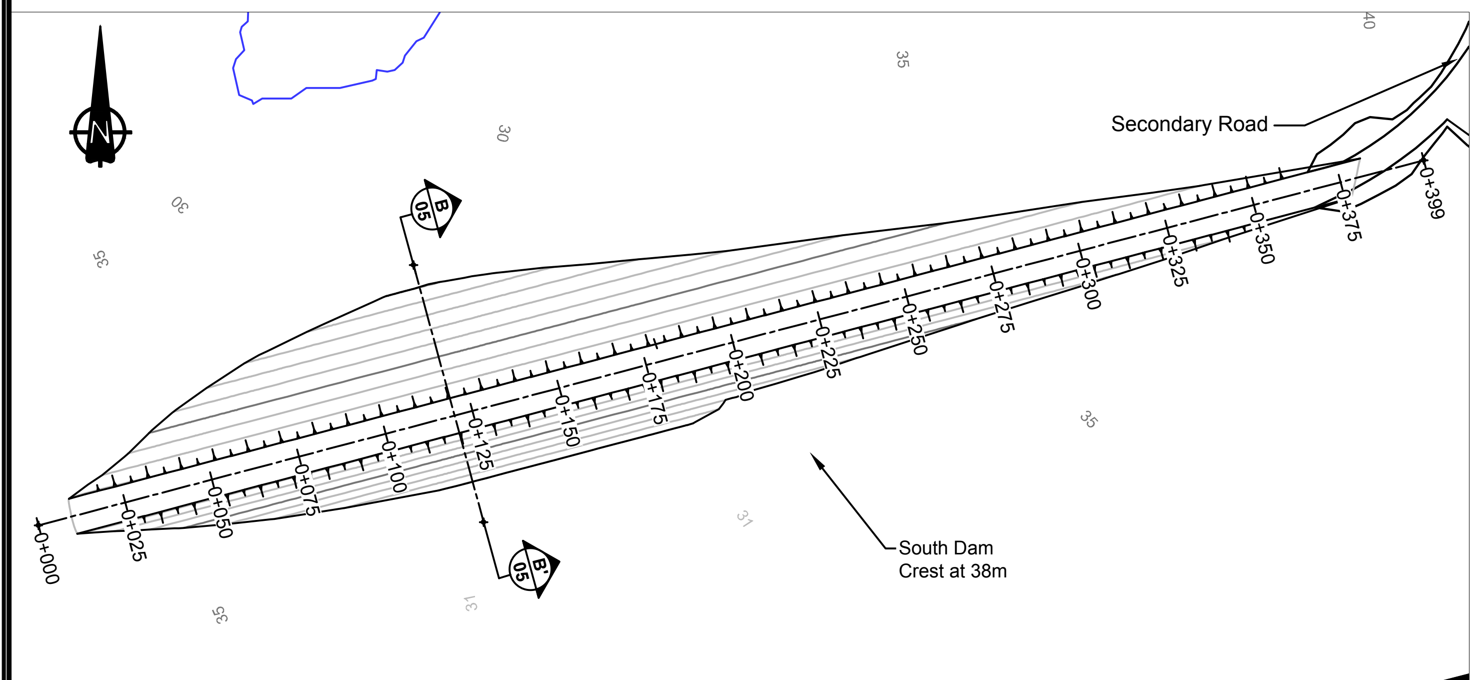
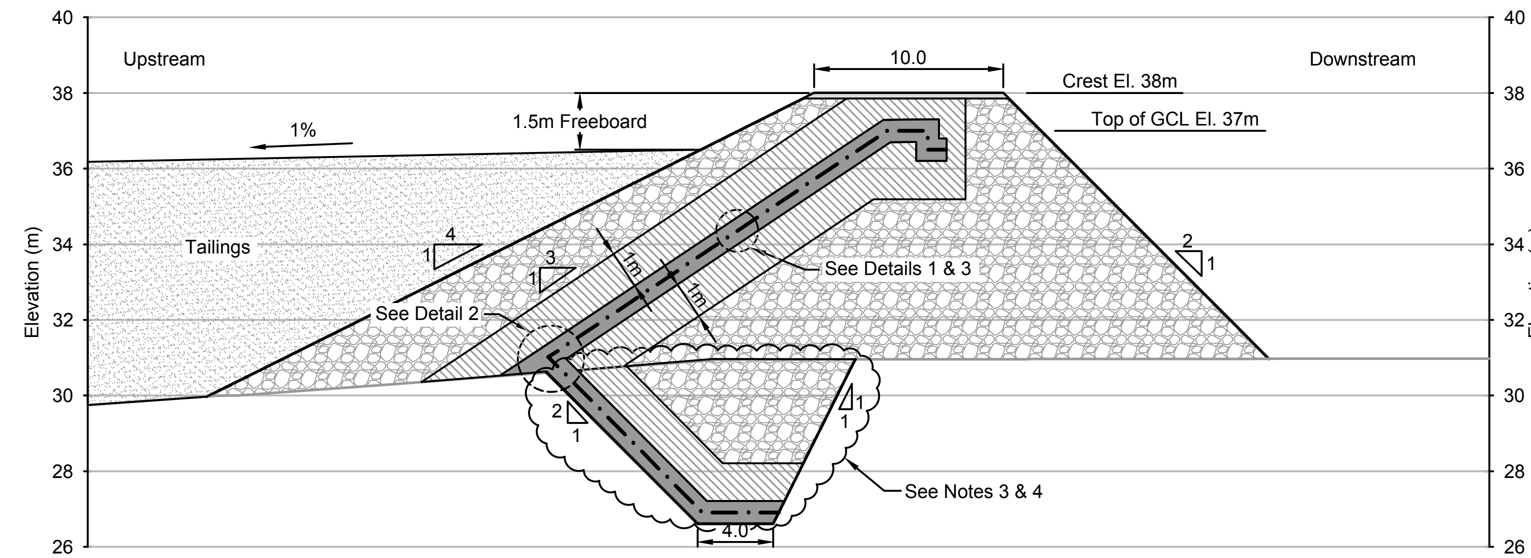


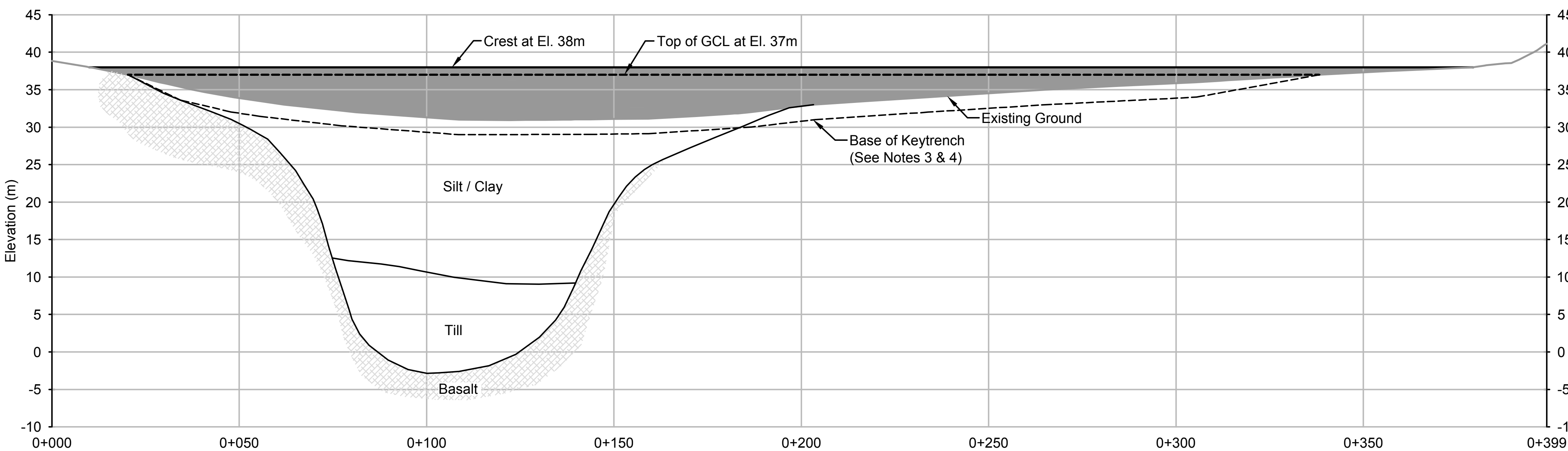
SOUTH DAM PLAN VIEW

0 10 20 30 40 50
Scale in Metres



B 05 SOUTH DAM SECTION

0 2 4 6 8 10
Horizontal Scale in Metres
Vertical Scale X2



SOUTH DAM PROFILE

0 5 10 15 20 25
Horizontal Scale in Metres
Vertical Scale X2

LEGEND

- Surfacing Material
- Liner Bedding Material
- Transition Material
- Run of Quarry (ROQ)
- Tailings
- Geosynthetic Clay Liner (GCL)

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 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.
3. The extents of the key trench excavation will be confirmed on site by the Engineer after bulk excavation as indicated by the drawings.
4. Additional excavation may be required as the Contractor must ensure that all organic matter and peat is excavated from the dam foundation.
5. Overburden soils from the key trench must be stockpiled in an area designated by the Engineer.
6. The Contractor shall be responsible for water control during excavation and construction.

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SRK JOB NO.: 1CT022.002.200.2000
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HOPE BAY PROJECT

DORIS NORTH TIA OMS MANUAL

South Dam Profile and Cross Section

DATE:	APPROVED:	FIGURE:
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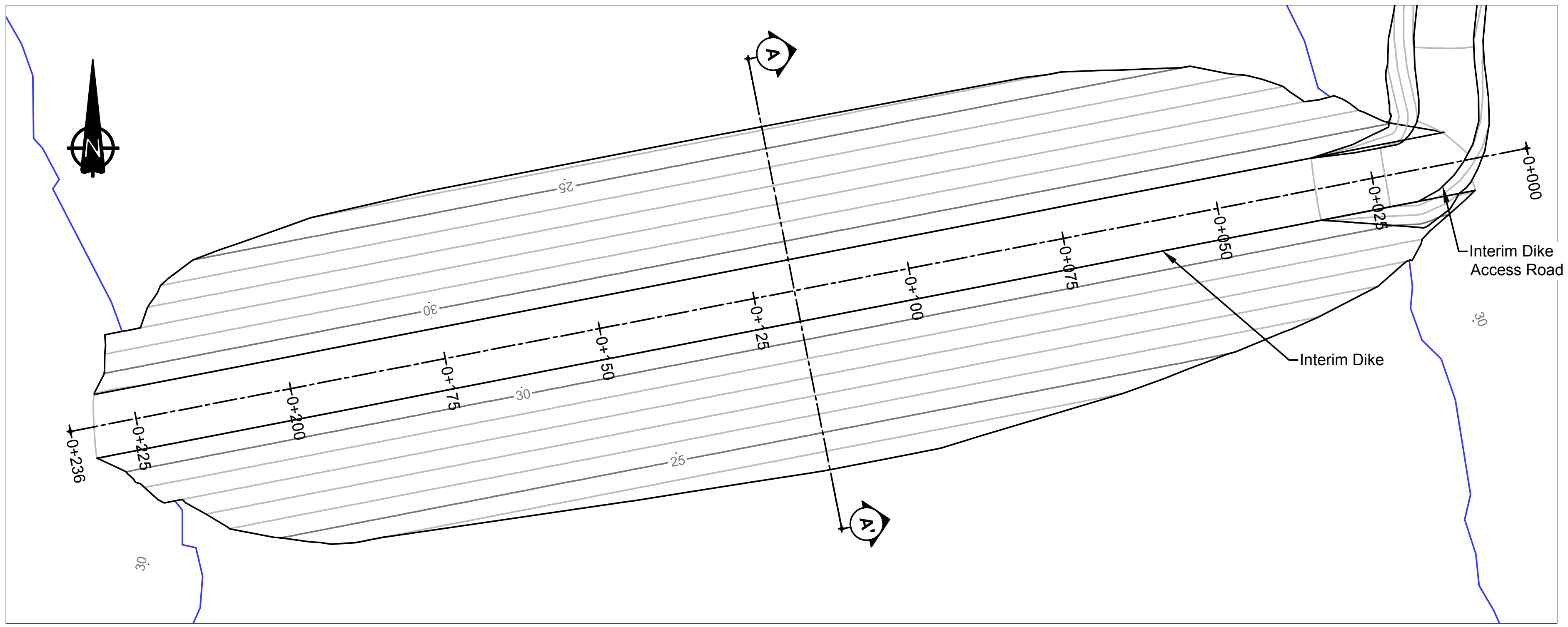
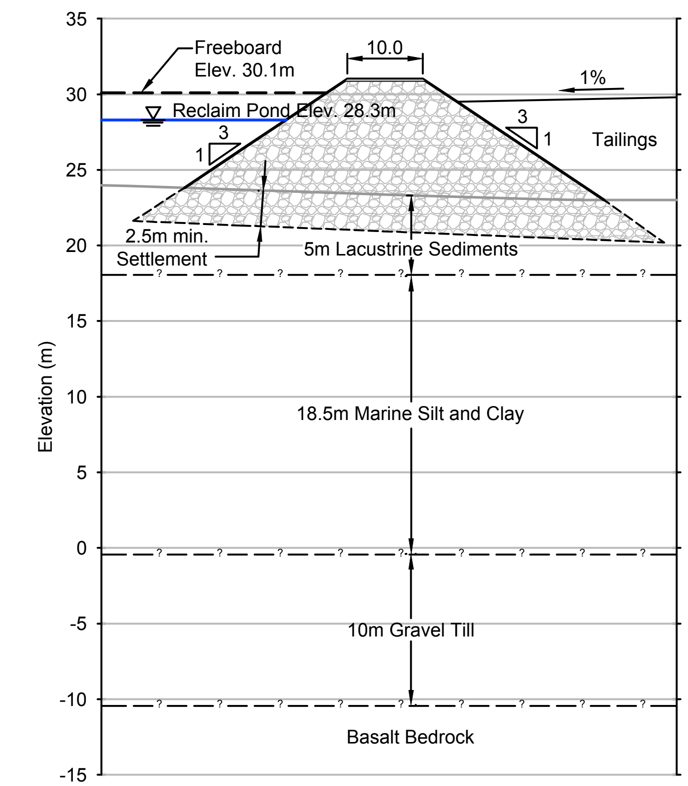


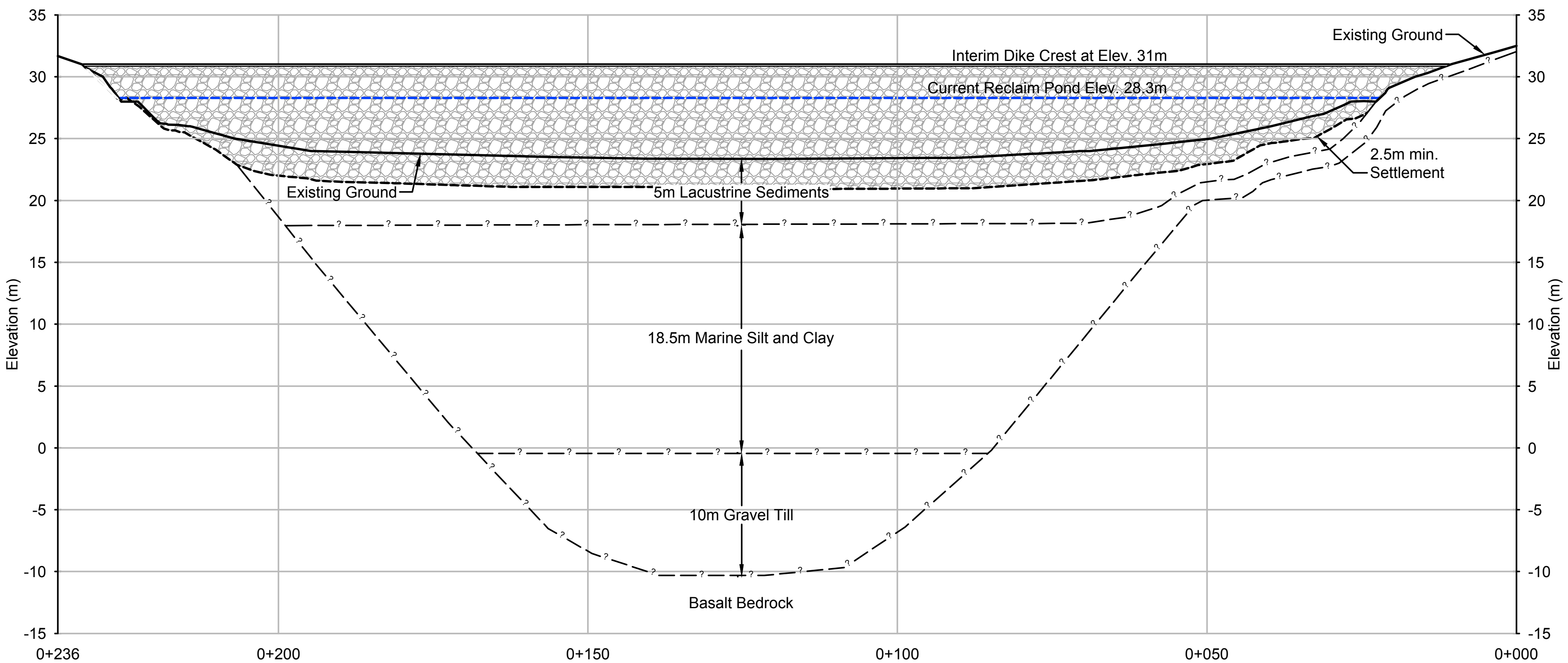
INTERIM DIKE PLAN VIEW

0 5 10 15 20 25
Scale in Metres



A INTERIM DIKE SECTION

0 5 10 15 20 25
Horizontal Scale in Metres
Vertical Scale X2



INTERIM DIKE PROFILE

0 5 10 15 20 25
Horizontal Scale in Metres
Vertical Scale X2

LEGEND

- Surfacing Material
- Run of Quarry (ROQ)

NOTES

1. All dimensions and elevations are in meters unless stated otherwise.
2. The Contractor must ensure that all organic matter and peat is excavated from the dam foundation.

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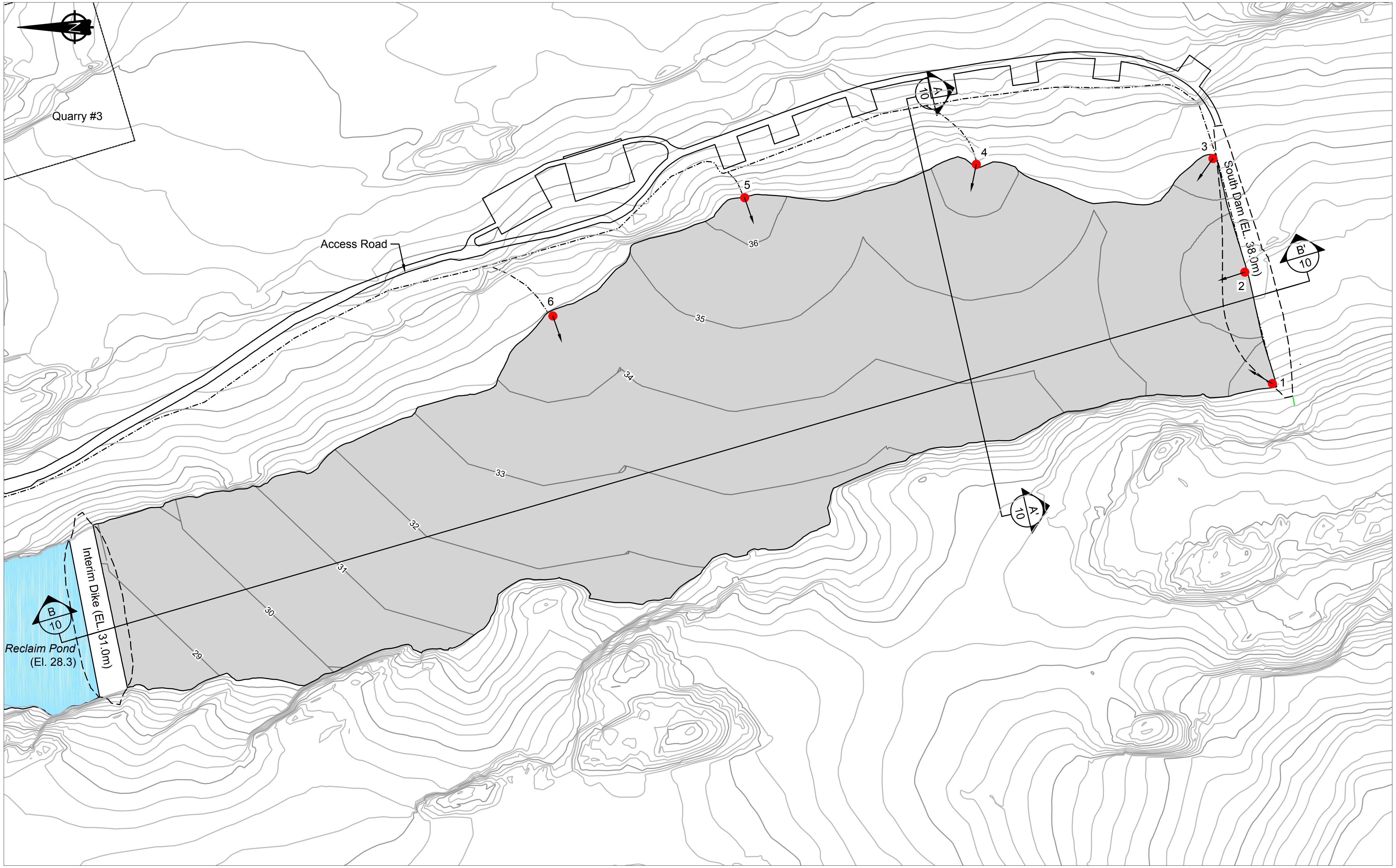
HOPE BAY PROJECT

DORIS NORTH TIA OMS MANUAL

Interim Dike Profile and Cross Section

SRK JOB NO.: 1CT022.002.200.2000	DATE: May 2016	APPROVED: EK/SA	FIGURE: 5
FILE NAME: 1CT022.002 – SouthDam_InterimDike_Figures5_6_rev2.dwg			



LEGEND

- Spigot Location
- Major Contour (5m)
- Minor Contour (1m)
- Approximate Tailings Line
- Proposed Tailings Deposition
- Proposed Dam / Dike

NOTES

1. Assumed an average deposited tailings beach slope of 1.0%.
2. A deposited tailings dry density of 1.29t/m³ was used (based on laboratory testing).
3. Ice entrainment was assumed at 20% of production.
4. Dam and dike elevations shown were assumed constant for all deposition stages.
5. Total storage requirement is 2.32Mm³ (tailings 1.93Mm³ + ice entrainment 0.39Mm³).

REFERENCE

NAD83 UTM Zone 13.

Preferred Deposition Option

Max. Tailings Volume: 2.34Mm³
Spigot Elevation: 36.5m (Locations 1-5), 35.0 (Location 6)
Tailings Surface Area: 0.44km²
Approx. Interim Dike Volume: 42,000m²
Approx. Tailings Line Length: 5,580m

0m 50 100 150 200

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FILE NAME: 1CT022.002 - DepositionPlan_Figure6-7.dwg

MAC RESOURCES

HOPE BAY PROJECT

DORIS NORTH TIA OMS MANUAL

Preferred Deposition Option

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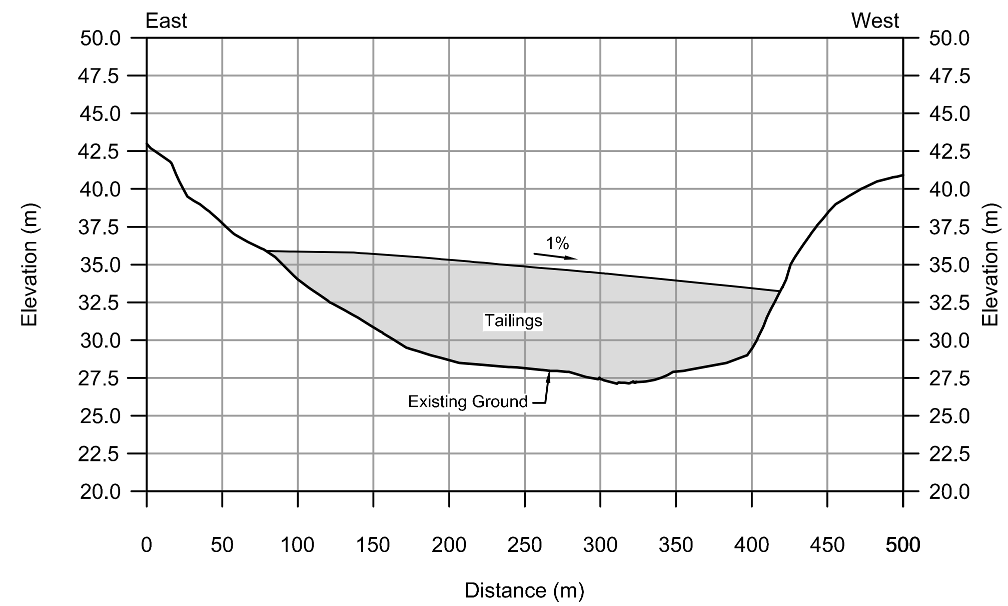
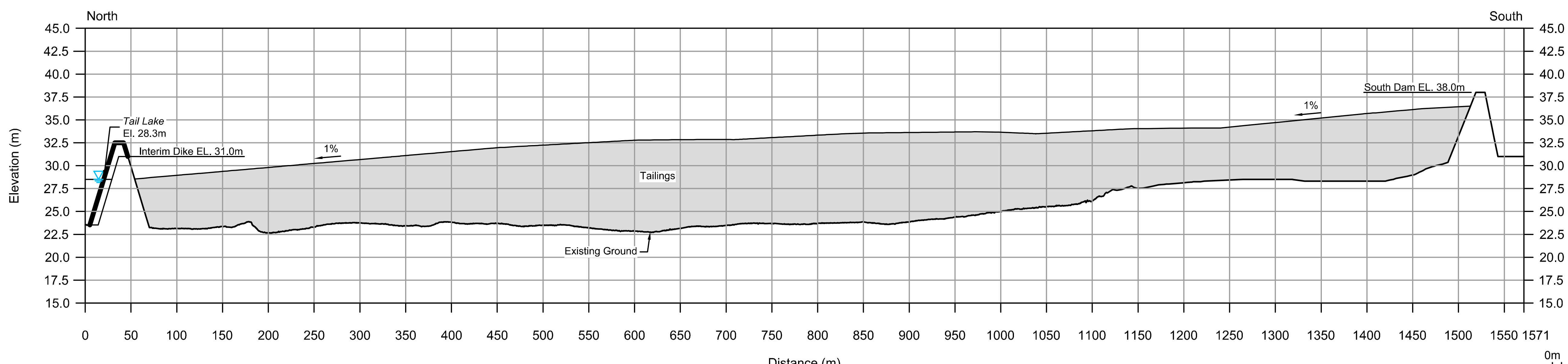


A
09

CROSS SECTION A-A'



B
09

CROSS SECTION B-B'

Vertical: 0m 5 10 15 20

Horizontal: 0m 50 100 150 200

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MAC RESOURCES

SRK JOB NO.:	1CT022.002.200.500
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HOPE BAY PROJECT

DORIS NORTH TIA OMS MANUAL

Preferred Deposition Option
CROSS SECTIONS

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