



APPENDIX E

JAY PROJECT PRE-FEASIBILITY DIKE DESIGN



December 8, 2014

**DOMINION DIAMOND EKATI CORPORATION
LAC DU SAUVAGE
NORTHWEST TERRITORIES
CANADA**

Jay Project Pre-feasibility Dike Design

Submitted to:

Dominion Diamond Ekati Corporation
PO Box 2190
Yellowknife, Northwest Territories
X1A 2P6

Attention: Mr. Mats Heimersson

REPORT



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Executive Summary

Dominion Diamond Ekati Corporation has retained Golder Associates Ltd. to develop a pre-feasibility level design for mining the Jay kimberlite pipe deposit at its Ekati Diamond Mine (Ekati Mine) in the Northwest Territories. This is referred to as the Jay Project and is seen as an extension of the existing Ekati Mine. The Jay Project pre-feasibility designs include water management planning, mine planning, road design, pipeline design, pit design, and dike design. This report presents the pre-feasibility design for the Jay Dike and will be included in the overall Jay Project pre-feasibility design as an appendix.

The design intent for the dike is to isolate the portion of Lac du Sauvage containing the Jay kimberlite pipe so that dewatering can occur to allow open-pit mining of the kimberlite. The dike is designed to minimize seepage from Lac du Sauvage into the open pit during operation. The dike will be situated in such a manner that the potential for pit wall instability to affect the performance of the dike is low.

Kimberlite extracted from the Jay pipe will be transported to the main Ekati Mine for processing. The waste rock will be placed in a storage area on the western shore of Lac du Sauvage. Processed kimberlite will be stored within the existing open pits near the process plant. The current operating life of the Ekati Mine is scheduled to end in 2019. The proposed development of the Jay kimberlite pipe is estimated to extend the mine life by 10 years. If underground development occurs, then the mine life could be extended by up to 16 years.

The objectives of this pre-feasibility engineering assessment are to understand constraints or identify any fatal flaws in the proposed Jay Dike with respect to cost, engineering, and construction, as well as to identify work required to advance the design to a feasibility or detailed design level. The pre-feasibility design of the Jay Dike includes typical dike sections, construction method and sequence, material and earthworks quantity estimates, and geotechnical monitoring requirements. The estimated construction costs for the Jay Dike are presented as part of the overall Jay Project pre-feasibility design and construction cost estimate.

The selected alignment of the Jay Dike follows areas of shallower water and crosses islands where possible. The total length of the dike is approximately 5,050 metres (m), with approximately 650 m of the dike crossing existing islands. The dike alignment results in the following approximate lengths:

- 1,300 m length, where the bedrock elevation, along the cut-off wall alignment, is at or above 408 metres above sea level (masl) (shallow section);
- 2,180 m length, where the bedrock elevation is between 408 and 402 masl (intermediate section); and,
- 1,000 m length, where the bedrock elevation is below 402 masl (deep section).

Along the cut-off wall alignment, the lowest bedrock elevation is approximately 393 masl and the maximum water depth is approximately 13 m.



The Jay Dike will consist of a broad rockfill shell, with granular fine and coarse filters, and a composite low permeability element. The low permeability element will be constructed through the fine filter and will consist of a combination of a cement-soil-bentonite cut-off wall, jet grout columns, and grouting of the shallow bedrock. The cement-soil-bentonite cut-off wall will extend down to bedrock along the majority of the dike alignment. In areas where the cut-off wall is founded on competent soil, assumed to be at an elevation of 402 masl, then jet grout columns will be constructed to extend the low permeability element from the base of the cut-off wall to bedrock.

An estimated 3.5 million cubic metres (m³) of rockfill and 1.5 million m³ of granular filter material will be required to construct the Jay Dike. Granular filters will be produced on site by crushers to be located near the Misery waste rock storage area. Roughly 56,000 m³ of till will be required for use in the construction of the cement-soil-bentonite cut-off wall. Approximately 3,200 square metres (m²) of jet grout columns will be built and 49,000 m² of curtain grouting will be conducted, as measured in profile along the centreline of the dike.

Waste rock, from the mining of the Lynx Pit, will be used as the source of rockfill for dike construction and as a source of material to be crushed to produce the granular filters. A quarry may be developed within the Jay waste rock storage area to provide a portion of the rockfill for dike construction. Suitable till material, obtained during pre-stripping of the Lynx Pit, will be stockpiled and managed for use in the cut-off wall construction.

Assuming that permits are granted for pre-construction activities and the Water Licence Permit is granted by mid-July 2016, dike construction and dewatering are scheduled to be complete by late 2019. The earthworks construction components of the Jay Dike are scheduled to occur over three summers and one winter. Jet grouting and curtain grouting will occur between November 2016 and April 2019. The overall schedule does not account for delays due to extreme weather conditions, environmental concerns, permitting, and wildlife. Geotechnical instrumentation will be installed in the dike and to have stabilized before the initiation of dewatering. Monitoring of the instrumentation is to continue throughout the dewatering phase and through operations and into closure, until the dike is locally breached.

Although a low permeability element will be constructed as part of the dike, the management of seepage through the dike following dewatering and during operations will still be necessary. The water management plan requires dike seepage to be collected for eventual discharge into Lac du Sauvage or King Pond, depending on the water licence. Depending on the performance of the dike, local seepage collection ditches and sumps may be required to manage areas of seepage. During the summer months, areas of seepage will be regularly monitored and weirs or other devices will be installed to measure the seepage flow and permit visual inspection.

Foundation conditions along the Jay Dike are based on 11 boreholes and geophysical surveying that has provided interpreted depths of water, lakebed sediments, competent material, and bedrock. Although interpretations of the geophysical survey have been calibrated to borehole data, due to the large distance between some of the boreholes, the variable quality of the geophysical reflections recorded, and potential for influence/interference of the geophysical signal, actual conditions are expected to vary from those used in the design. The variation between the assumed and actual conditions will affect the accuracy of the estimated material quantities required to construct the dike and, in turn, the estimated costs. Additional geotechnical investigations are required to reduce the uncertainty in the foundation conditions and improve confidence in the material quantity estimate.



Study Limitations

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1.0 INTRODUCTION

Dominion Diamond Ekati Corporation (Dominion Diamond) has retained Golder Associates Ltd. (Golder) to develop a pre-feasibility level design for the mining of the Jay kimberlite pipe deposit (Jay Project) at its Ekati Diamond Mine (Ekati Mine) in the Northwest Territories (NWT).

This report presents the pre-feasibility level design for the dike surrounding the Jay kimberlite pipe. The dike would isolate a portion of Lac du Sauvage to allow open pit development and diamond extraction from the Jay kimberlite pipe. The dike is referred to as the Jay Dike.

The reader is referred to the “Study Limitations,” which precedes the text and forms an integral part of this document.

1.1 Report Outline

The outline of this report is as follows:

- **Section 2** presents a summary of the overall Jay Project.
- **Section 3** provides details of previous studies carried out for the Jay Project.
- **Section 4** summarizes the general geological site conditions and presents the geotechnical conditions beneath the dike.
- **Section 5** presents the dike design criteria.
- **Section 6** describes the dike design.
- **Section 7** provides a summary of analyses carried out for filter compatibility, stability, and seepage.
- **Section 8** provides a summary of the turbidity management plan during winter and summer dike construction seasons.
- **Section 9** discusses the instrumentation and monitoring plan.
- **Section 10** provides a summary of the dike construction schedule and describes the portions of the dike constructed during each construction season.
- **Section 11** summarizes the results of the construction quantity estimate.
- **Section 12** describes the quality assurance and quality control plan for the construction of the dike.
- **Section 13** discusses the closure and reclamation of the dike.
- **Section 14** discusses the limitations of the pre-feasibility dike design based on the assumptions made.
- **Section 15** provides recommendations for future work.
- **Appendix A** contains design drawings.
- **Appendix B** provides the design criteria.



- **Appendix C** presents the seepage and stability analyses.
- **Appendix D** presents the filter compatibility assessment.
- **Appendix E** provides bid quantity sheets.

1.2 Site Description

The Ekati Mine is located approximately 300 kilometres (km) northeast of Yellowknife, NWT, as shown in Drawing 100-1 (Appendix A). The Ekati Mine consists of a series of open pits with some underground workings that have been developed for the mining of various kimberlite pipes near the main portion of the Ekati Mine and of satellite pipes as shown in Drawing 100-2. The main Ekati Mine consists of the processing plant, main camp, and processed kimberlite containment facility. Supplies for the Ekati Mine are generally mobilized using the seasonal winter road that is built between Yellowknife and the project site. Drawing 200-1 presents the general location plan, including the existing Ekati Mine, Misery Road, Misery Pit, and Misery camp facilities. Drawing 200-1 also shows Lac du Sauvage and the general location of the Jay kimberlite pipe within the lake.

The Jay kimberlite pipe is located approximately 1.2 km from the western shoreline of Lac du Sauvage in a bathymetric low that is covered by about 35 metres (m) of water, based on the 2013 Lac du Sauvage bathymetric survey data.

The Ekati Mine's Misery Pit operations are located approximately 7 km to the southwest of the Jay kimberlite pipe. There is an existing haul road between the Misery camp and the Ekati main camp and processing plant. The Ekati main camp is located approximately 30 km northwest of the Misery camp.



2.0 PROJECT DESCRIPTION

Dominion Diamond is proposing to develop the Jay Project as an extension of the existing Ekati Mine. The Jay Project involves the extraction of ore from the Jay kimberlite pipe, located beneath Lac du Sauvage, using open-pit mining methods. The potential for additional extraction through underground mining methods will be assessed separately. The extracted kimberlite will be hauled to processing plant at the main Ekati Mine. Processed kimberlite will be stored within the existing open pits near the Ekati processing plant, and then capped with a layer of fresh water. Waste rock will be placed in a storage area on the western shore of Lac du Sauvage.

A water retaining dike will be constructed to isolate the local portion of Lac du Sauvage containing the Jay kimberlite pipe. Dewatering of the isolated portion of the lake will occur to expose the pipe and permit kimberlite extraction. Water management will occur during dewatering, throughout the operational life of the mine, and during closure.

The current operating life of the Ekati Mine is scheduled to be completed in 2019. The proposed development of the Jay kimberlite pipe is estimated to extend the mine life by 10 years for open-pit development and up to 16 years for the combined open-pit and underground development. Construction of the required infrastructure to permit mining of the Jay pipe is estimated to take three years. Pre-construction activities, such as the construction of access roads, are scheduled to commence in early 2016, with dike construction commencing in July 2016 and being completed in April 2019. This schedule will be dependent on the permitting processes.



3.0 BACKGROUND AND SUPPORTING STUDIES

3.1 Climate

The Jay Project site is located in a region of the NWT that experiences a sub-Arctic climate characterized by long, dark, very cold winters and short, cool to mild summers with long daylight hours.

The annual air temperature at the site ranges from -12 degrees Celsius (°C) to -6°C in the 55-year record, with a mean annual air temperature of -9.6°C. Seasonal air temperatures remain below zero for eight months per year (October through May). The mean monthly low air temperature is -29°C in January, and the mean monthly high temperature is 12.5°C in July (Dominion Diamond 2014, Annex X).

Annual total precipitation averages 345 millimetres (mm) and is composed of almost equal amounts of rainfall and snowfall. The largest amount of precipitation occurs between June and September and is primarily in the form of rainfall. The variability of seasonal precipitation is highest in the summer (Dominion Diamond 2014, Annex X).

3.2 Hydrology

A Hydrology Baseline Report (Dominion Diamond 2014, Annex X) was prepared to evaluate the existing hydroclimate and hydrology conditions of basins flowing into and downstream of Lac du Sauvage. Based on the results of regional water balance modelling for the Lac du Sauvage basin, the lake elevation on average and during a 1 in 1,000 year flood event is 416.1 and 416.9 metres above sea level (masl), respectively (Dominion Diamond 2014, Annex X; Golder 2014a). As Lac du Sauvage drains into Lac de Gras via an outlet located to the southeast of the proposed dike, the water level in Lac du Sauvage is governed in part by the water level in Lac de Gras.

The Jay Mine Water Management Plan (Golder 2014b) describes how minewater and surface water are to be managed during the dewatering and operational phases of the Jay Project. Surface water that would normally flow into the dewatered area will be diverted through the construction of a diversion channel, Sub-Basin B Diversion Channel, and other runoff that is not diverted will be collected and conveyed to a sump system (i.e., Jay Runoff Sump) and then pumped to the Misery Pit.

3.3 Hydrogeology

As identified in the Hydrogeology Baseline Report (Dominion Diamond 2014, Annex IX), four hydrostratigraphic units underlay the Jay Dike: lakebed soil, weathered rock, competent rock, and an enhanced permeability zone. Weathered bedrock is limited to the upper 10 to 30 m of the bedrock profile, and is composed of highly fractured zones of rock with corresponding hydraulic conductivities greater than those of the underlying competent rock.

Based on an interpretation of the structural geology and hydrogeological testing, a potential well-connected enhanced permeability zone may be associated with structural geological features near the Jay kimberlite pipe (Dominion Diamond 2014, Annex IX). Similar structural features have been found to be present at both the Diavik Diamond Mine and at existing open pits elsewhere within the Ekati claim block.



Results from the in situ hydrogeological testing program, including estimated hydraulic conductivities of the various hydrostratigraphic units, are summarized in Section 4.2, and additional information is provided in the 2014 winter geotechnical investigation program report (Golder 2014c).

3.4 Permafrost

The Jay Project is located within a region of continuous permafrost. In this region, the layer of permanently frozen subsoil and rock is generally deep and overlain by an active layer that thaws during summer and refreezes in the winter. The depth of the active layer in the Misery Pit area ranges from approximately 1 to 2.7 m. Based on available thermistor data, the permafrost conditions at the site indicate a depth of permafrost that is estimated to be about 320 to 485 m at locations that are not affected by waterbodies (Dominion Diamond 2014, Annex IV).

Unfrozen zones (talik zones) occur beneath waterbodies, and permafrost is expected to be absent below the majority of Lac du Sauvage (Dominion Diamond 2014, Annex IV). Permafrost usually exists under islands and along the shoreline where the depth of water is less than about 1 to 2 m and ice freezes to the lake bottom. The depth of permafrost at these locations is expected to be less than that at locations located further from waterbodies. Variation in the depth of permafrost below islands and peninsulas in Lac du Sauvage is anticipated.

The permafrost map of Canada (Natural Resources Canada 1995) indicates that the ground ice content in the region is expected to be between 0 percent (%) and 10% (dry permafrost) based on regional scale compilation data. Ice lenses (small bodies of ice in frozen soils) and ice wedges are likely to be present locally on land, as indicated by ground conductivity and by permafrost features such as palsas (mounds of alternating layers of ice and mineral soils). These areas of local ground ice are generally associated with low-lying areas of poor drainage.

3.5 Topographic Data

In August 2013, Aurora Geosciences Ltd. (Aurora) subcontracted LiDAR Services International Inc. to conduct an airborne light detection and ranging (LiDAR) survey that covered the Jay Project area. LiDAR surveys are able to detect subtle topographic features and measure the land surface elevation beneath the vegetation canopy, and are able to resolve spatial derivatives of elevation. The LiDAR survey data was used to provide topographic elevations for this pre-feasibility design, and these data are shown in the drawings in Appendix A of this report.

3.6 Bathymetry Survey

Aurora conducted a bathymetric survey of Lac du Sauvage and neighbouring lakes in June and July of 2013 to provide information on the depth of water (Aurora 2013). The bathymetric survey was completed at 50 m line spacing with a sonar frequency of 200 kilohertz (kHz). The bathymetric survey information was used for this pre-feasibility design to provide water depths along the Jay Dike alignment and is shown in the drawings in Appendix A of this report.



Bathymetric survey data were also collected by Golder as part of the geophysical survey conducted during the summer of 2014. As the area covered by the Golder survey was less than the Aurora survey, the Aurora data were used in this report.

3.7 Geotechnical and Hydrogeological Investigations

Geotechnical and hydrogeological field investigations were carried out between February and April 2014 at the Jay Project site. These included evaluation of soil and bedrock conditions, thermal characterization, and laboratory testing of soil samples. Results of the investigations, as well as preliminary geotechnical engineering comments, are presented in the factual report (Golder 2014c).

A total of 26 sonic and 22 diamond boreholes were drilled along the proposed dike alignments identified in the Jay Project conceptual design report (Golder 2014d) and the Jay-Cardinal Project conceptual design report (Golder 2014e). Eight of the boreholes were drilled on land and 40 were drilled from the frozen surface of Lac du Sauvage. A total of seven sonic boreholes and six diamond drilled boreholes were drilled along the pre-feasibility Jay Dike alignment. Borehole locations are shown in plan in Drawing 300-2 and in profile along the dike alignments in Drawing 300-5 and Drawing 300-6 (Appendix A). Geotechnical laboratory tests were carried out on selected soil samples recovered during the sonic drilling. Testing included particle size distribution, Atterberg limits hydraulic conductivity, consolidation, and triaxial tests.

Hydrogeological testing of the soil, soil/bedrock contact, and shallow bedrock was carried out concurrently as part of the field investigation program. Depending on the type of borehole and conditions encountered, the testing was carried out as a combination of slug injection, slug withdrawal, and constant rate injection using either temporary standpipe piezometers or pneumatic packers.

Thermistor cables were installed in select boreholes on the abutments of the proposed dikes. The thermistors were installed to record ground temperatures with depth and over time.

3.8 Geophysical Investigations

Aurora carried out ground penetrating radar (GPR) geophysical survey in and around Lac du Sauvage during 2013 (Aurora 2013). The survey was conducted with the intent of identifying the bedrock contact and, if possible, the contact between lakebed sediments and competent soil. A comparison of the GPR data with that collected during the 2014 winter geotechnical investigation indicated that the GPR survey did not provide reliable information regarding the bedrock contact or the contact between lakebed sediment and competent soil. It was determined that the reflectors could not consistently be defined (Aurora 2014).

During the summer of 2014, Golder carried out sub-bottom profiling survey along the Jay Dike alignment to try and assess the contact between lakebed sediments, competent soil, and bedrock (Golder 2014f). Sub-bottom profiling is a remote sensing method that provides information on the relative depths of acoustically contrasting reflectors. The general method of marine sub-bottom profiling involves an acoustic source-receiver pair. The source emits a sound-pulse of characteristic frequency that is transmitted through the water column into the seabed. The transmitted sound energy reflects off of interfaces with contrasting acoustic properties, and the receiver records the incoming train of echoes.



Sub-bottom reflection data were acquired using two systems: a Datasonics Bubble Pulser seismic system and a Geoacoustics GeoChirp sub-bottom profiler. The Datasonics Bubble Pulser is a low frequency system that operates between approximately 0.4 and 1.2 kHz. The Bubble Pulser system typically provides sufficient sub-bottom penetration through fine-grained and coarse-grained sediment to image subsurface structures, including bedrock.

A high frequency (3.5 to 12 kHz) Geoacoustics GeoChirp sub-bottom profiler was run concurrently with the Bubble Pulser. The higher-frequency source typically provides better resolution in delineating between sediment layers, although it provides less penetration, especially through coarser sediments.

During the summer of 2014, Golder also conducted a sidescan sonar survey to identify the presence of boulders. The sidescan sonar was operated in two modes: a low-frequency (330 kHz) mode and a high-frequency (900 kHz) mode. Multiple swaths were collected, resulting in a coverage strip along the alignment of 150 to 200 m.

Data collected during this survey were then interpreted to provide the depth to each contact. Borehole data were utilized for calibration and to aid in the interpretation.

Drawing 300-2 (Appendix A) shows the location of the geophysical survey lines. In total, 35.5 km of surveying was carried out in the vicinity of the Jay Dike and Jay Pit.

Due to the limited number of existing geotechnical boreholes and quality of the reflections obtained from the surveys, the accuracy of the interpreted contact depths along the dike varies. The interpreted surfaces obtained from the Golder geophysical survey have been used in this design; however, it is anticipated that actual field conditions will vary.

3.9 Conceptual Design Studies

A conceptual design report (Golder 2014d), which evaluated two potential dike alignment options, was prepared in May 2014 for the Jay Project. It included a conceptual level quantity and cost estimate. The Option 2 dike alignment presented in the conceptual design report has been carried forward for this pre-feasibility level design.

The conceptual design report also included assessment of the water management strategies and closure options.



4.0 EXISTING GEOLOGICAL, GEOTECHNICAL, AND HYDROGEOTECHNICAL INFORMATION

The following sections present a summary of the local site geology and geotechnical information, based on information obtained from the 2014 winter geotechnical investigation and summer 2014 geophysical surveys. Additional details are presented in the factual report and geophysical survey summary (Golder 2014c, 2014f).

4.1 Local Site Geology

The Ekati Mine, including the Jay Project, is located within the eastward dipping Archean suture in the central Slave Province. The bedrock geology comprises metamorphosed greywacke-mudstone turbidites of the Yellowknife Supergroup that are intruded by syn- to post-tectonic plutons (Nowicki et al. 2004; Helmstaedt 2009) made up predominantly of granite, granodiorite, and tonalite. In addition, five mafic Proterozoic dike swarms intrude the area (LeCheminant and van Breemen 1994; Kjarsgaard 2001; Nowicki et al. 2004; Helmstaedt 2009).

The Lac du Sauvage area has four principal rock types in addition to the kimberlite pipe: metasedimentary rocks, two-mica granite, tonalite, and mafic dikes. Based on previous studies (Wright 1999; Mineral Services Canada Inc. 2002) and interpretations of recent airborne laser scanning (Dominion Diamond 2014, Annex III), the lithology outcropping in the Lac du Sauvage area is crosscut by discrete fractures (both faults and joints). Drawing 300-4 (Appendix A) shows the interpreted bedrock geology and brittle structures (faults, joints, lineaments) within the project area.

Multiple glaciation events occurred during the Quaternary era and have affected the Lac du Sauvage area (Dredge et al. 1994; Nowicki et al. 2004). Glacial deposits are predominantly tills ranging in thickness from 2 to 15 m. Glaciofluvial deposits are also present, with the most prominent being a network of sinuous eskers that connect into a large southeast–northwest trending trunk esker. Eskers are present along both the east and west sides of Lac du Sauvage and merge to the northwest. Lacustrine deposits occur in association with the numerous lakes.

The site geology is described in greater detail in the Geology Baseline Report (Dominion Diamond 2014, Annex III).

4.2 Dike Foundation

Information related to the thickness of dike foundation materials is currently based on data collected from seven sonic boreholes, six diamond core boreholes, and the geophysical surveys carried out along the proposed dike alignment. The locations of the geotechnical boreholes and geophysical survey lines are shown in plan in Drawing 300-2 (Appendix A). Drawing 300-5 and Drawing 300-6 present geotechnical borehole locations as well as the interpreted dike foundation material thicknesses in profile. The interpreted thickness of each material is based on very limited borehole data and variable quality of geophysical data. The accuracy of the material thickness data between borehole locations is expected to vary.

The stratigraphic sequence of the dike foundation generally consists of the following:

- lakebed sediments or boulders/cobbles
- competent soil, and,
- bedrock.



Further geotechnical characterization of the materials that may form part of the dike foundation has been obtained from data collected during the winter 2014 investigation program from the boreholes along the dike alignment and additional boreholes drilled outside of the dike alignment but within Lac du Sauvage (Golder 2014c).

4.2.1 Water Depth

In boreholes drilled along the centreline of the dike alignment, the water depth varies between 1.3 and 12.7 m below the average lake water level (416.1 m). Based on lakebed bathymetry data, as seen in Drawing 300-5 (Appendix A), the maximum water depth beneath the centreline of the dike is approximately 13 m, located near Station 0+550.

4.2.2 Lakebed Sediments

Lakebed sediments are very soft to soft, non-cohesive to slightly cohesive, silty clay to clayey silt, and may have a trace amount of fine-grained sand. This material is generally believed to have been derived from the erosion of fine particles present in the glacial till around the lake and shallow waters and subsequently deposited within the lake (Golder 2014c). From the drilling observations and visual descriptions of the recovered materials, the lakebed sediments are inferred to have a low in situ density, be highly compressible, and have lower shear strength. The presence of lakebed sediments will contribute to turbidity during dike construction and dewatering.

From the seven sonic boreholes drilled along the Jay Dike alignment, sediment thicknesses were found to range from 0 to 5.8 m, when encountered, with the average thickness of 2.5 m. No noticeable lakebed sediment unit was encountered in two of the sonic boreholes (JP5-SD-04 near Station 3+650 and JP5-SD-06 near Station 0+700). Based on lakebed bathymetry and geophysical survey data, the lakebed sediments may be up to 6.7 m thick in the vicinity of Station 3+925, as shown in Drawing 300-6 (Appendix A).

A single in situ hydrogeological test was carried out in the lakebed sediment layer in borehole JP5-SD-05 (near Station 1+300) during the 2014 winter investigation program. An approximate permeability of 7×10^{-8} metres per second (m/s) was measured. In the laboratory, a hydraulic conductivity of 5×10^{-9} m/s was measured on a composite sample of lakebed sediments from along the dike alignment.

4.2.3 Boulders and Cobbles

Along portions of the dike alignment a surficial layer of boulders and cobbles is present. At these locations limited to no lakebed sediments are present. In general, this layer of boulders and cobbles is found in shallower water, either along portions of the shoreline or near islands. In some cases, these areas can be identified from aerial views of the proposed dike alignment and also from the sidescan sonar survey (Golder 2014f) as shown in Figure 1 and Figure 2.



4.2.4 Competent Soil

Based on drilling observations and laboratory characterization, the competent soil is generally well graded and is composed of a mixture of gravel, sand, and fine-grained particles (i.e., silt and clay), which vary in their respective proportions (Golder 2014c). Typical visual descriptions of the observed competent soil range from sandy gravel to gravelly sand with varying proportions of fine-grained particles. Cobble and boulder sized particles (greater than 75 mm) were observed at various depths and frequencies within the competent soil. This competent soil is generally understood to be either a glacial till, glacial outwash, or glacial fluvial deposit.

A fine-grained, competent soil layer 7.6 m in thickness was encountered in a single borehole (JP5-SD-08) near Station 4+700. The continuity and extent of this layer is unknown. The fine-grained competent soil was visually described as silty clay to clayey silt, with some sand. No in situ permeability testing of this unit was carried out. One sample of this material was tested in the laboratory at a dry density of 1,720 kilograms per cubic metre (kg/m^3), and the permeability was measured to be 3×10^{-10} m/s.

The thickness of competent soil ranges between 0.6 to 10.9 m, with an average of 4.7 m, based on information obtained from the boreholes. A similar range of competent soil thickness was interpreted from the geophysical survey.

In situ hydrogeology testing was carried out as part of the 2014 winter investigation program within the competent soil. The permeability results ranged from 1×10^{-7} to 4×10^{-4} m/s with a geometric mean of 2×10^{-6} m/s. Samples tested in the laboratory measured hydraulic conductivities over a similar range from 6×10^{-4} to 2×10^{-8} m/s.

4.2.5 Bedrock

Bedrock is interpreted to exist at depths ranging between 4 and 23 m below the lake level, with an average depth of 14.2 m, along the dike centreline, based on borehole data. As seen in Drawing 300-5 and Drawing 300-6 (Appendix A), boreholes JP5-SD-04 (Station 3+650) and JP5-SD-08 (Station 4+700) had the shallowest and deepest depths to bedrock, respectively. The interpreted depth to bedrock from the geophysical survey data indicated a similar range to that observed from the borehole data.

As seen in Drawing 300-4, the bedrock underlying the dike is composed of granite and metasediments, with the contact between the two bedrock types located just to the west of the Jay kimberlite pipe. This main structural contact trends in the northwest–southeast direction. Regional fault sets trending northwest–southeast and northeast–southwest underlay the dike area, with some having been intersected during the 2014 winter geotechnical investigation at JP5-SD-08 (36.4 to 37.7 m below ice) near Station 4+700 and JP5-SD-09 (20.4 to 21.4 m below ice) near Station 4+200. Gouge was observed within the fault zone in JP5-SD-09 (Golder 2014c).

Observations of core samples obtained from diamond drilling of the bedrock underlying the dike indicate that the bedrock mass is competent, as 75% of the rock encountered had a rock quality designation (RQD) of 90% or greater. Only slight to moderate weathering of the bedrock was observed, with an RQD in the range of 70% to 100%. Weathered zones between 15 and 20 m in thickness were found at JP5-SD-06 (Station 0+700), JP5-SD-07 (Station 0+200), JP5-SD-09 (Station 4+200), and JP5-SD-10 (Station 3+950). Strength of the rock core varied from medium-strong to extremely strong for the un-weathered rock and from medium-strong to strong for the weathered rock. Overall, the rock is competent but can break, sometimes easily, along foliation planes or healed microfractures.



Average fracture spacing was about 400 mm, and varied between 10 and 3,000 mm. No apparent reduction in fracture spacing was observed in these locations over the depth drilled.

The metasediment foliation exhibits dips between 70 degrees (°) and 80° to the west-southwest in JP5-GT-01 (near Station 0+750). A minor joint set dips between 0° and 20° to the northeast.

The orientation data from the remaining diamond holes in the JP5 area were obtained from granitoid rock and indicate a large variability in the feature orientations. Holes JP5-GT-02 (Station 1+350) and JP5-GT-03 (Station 2+400) indicate mostly shallow dipping joints ranging between 0° and 40°, with dip directions to the northeast, southeast, and northwest. Also observed were possible joint sets that dip to the southwest and northeast between 60° and 90° and a set that dips between 40° and 70° to the northwest, but there are insufficient data to confirm these sets. Hole JP5-GT-04 (Station 3+200) indicates a strong joint set that dips between 0° and 40° to the southwest. This joint set may be associated with a localized foliated zone in the granite.

In situ hydraulic conductivity testing results in bedrock varied between 3×10^{-6} m/s and 6×10^{-8} m/s, with a geometric mean of 6×10^{-7} m/s. The results of a single test, carried out across a noted fault, resulted in measured in situ permeability similar to the geometric mean (Golder 2014c).

4.2.6 Permafrost

During the 2014 winter geotechnical investigation, a total of seven thermistors were installed, two along the proposed Jay Dike alignment and five at locations elsewhere along the Lac du Sauvage shoreline. A single thermistor cable was installed within each of these boreholes: JGT-01 and JGT-07 (near Station 2+000). These thermistors, as seen in Drawing 300-2 (Appendix A), are located along the dike alignment in the island west of the Jay kimberlite pipe (known as Westbay Island). The remaining five thermistors were installed in boreholes located several kilometres to the northwest and to the southeast of the proposed dike. Refer to the winter 2014 factual report for further thermistor details (Golder 2014c).

Thermistor data is currently being collected at regular intervals by Dominion Diamond and will be summarized and analyzed in future design studies once at least one annual cycle of data is available. A summary of the initially collected thermistor data, as well as additional thermistor installation information, is presented in the winter 2014 factual report (Golder 2014c).



5.0 DESIGN CRITERIA

The pre-feasibility dike design was prepared using the design criteria identified in Appendix B. A summary of the main design criteria is provided in Table 1.

Table 1: Design Criteria Summary

Design Criteria		Value/Description	Source/Comment
Dike Design Life		20 years (open pit and underground)	Dominion Diamond
Dam Classification		High	CDA (2007)
Lac du Sauvage Water Level	Average	416.1 masl	Dominion Diamond (2014, Annex X) Golder (2014a)
	Inflow design flood	416.9 masl	
Freeboard ^(A)	Normal	2.5 m	Appendix B
	Minimum	2.6 m	
Design Earthquake	Return period	1:2,475 years	CDA (2007, 2013)
	EDGM	0.036 g	NBCC (2010)

a) As measured above average Lac du Sauvage water level of 416.1 masl.

m = metres; masl = metres above sea level; EDGM = earthquake design ground motion ; g = gravitational acceleration.



6.0 DIKE DESIGN

6.1 General Design

The pre-feasibility dike design includes the following general components:

- a broad rockfill shell;
- a central zone of crushed granular fine and coarse filters; and,
- a composite low permeability element.

The composite low permeability element consists of a combination of elements, based on bedrock elevation:

- cement-soil-bentonite (CSB) cut-off wall;
- jet grouted columns extending from the base of the CSB cut-off wall to the bedrock, in locations where the CSB cut-off wall does not extend to bedrock; and,
- grouting of the near-surface bedrock and bedrock contact.

6.2 Typical Sections

Three typical dike sections have been developed for the pre-feasibility design based on the bedrock elevation along the dike centreline alignment:

- **Shallow Section** (Section 1 in Drawing 300-10, Appendix A) – applies to locations where the bedrock is interpreted to exist at or above an elevation of 408 masl. A continuous rockfill platform will be placed, and then the central trench will be excavated through the rockfill platform to the bedrock surface. The central trench will have a minimum width of 8 m. Fine filter will be placed at the base of the trench. The cut-off wall will extend to the bedrock contact. Grouting of the near-surface bedrock and CSB cut-off wall / bedrock interface will be carried out.
- **Intermediate Section** (Section 2 in Drawing 300-10, Appendix A) – applies to locations where the bedrock is interpreted to exist below an elevation of 408 masl and at or above an elevation of 402 masl. Similar to the shallow section, a continuous rockfill platform will be placed, and then the central trench will be excavated through the rockfill platform to the bedrock surface. The central trench will have a minimum width of 10 m. Fine filter will be placed at the base of the trench. The cut-off wall will extend to the bedrock contact. Grouting of the near-surface bedrock and CSB cut-off wall / bedrock interface will be carried out.
- **Deep Section** (Section 3 in Drawing 300-10, Appendix A) – applies to locations where the bedrock is interpreted to exist below an elevation of 402 masl. Rockfill will be placed as two individual platforms, with a space left between the two platforms to form the central trench. Lakebed sediments and a portion of the competent soil will be removed from the central trench. The central trench will have a minimum width of 10 m. Fine filter will be placed at the base of the trench. The cut-off wall will be extended to an elevation of 402 masl. Jet grouted columns will be constructed from the base of the cut-off wall to bedrock contact. Grouting of the near-surface bedrock and jet grout / bedrock interface will be carried out.



The primary design variations between the three typical sections are summarized in Table 2.

Table 2: Summary of Design Variations between Typical Sections

Design Section	Bedrock Elevation	Base Width of Central Trench Excavation	Compaction Method	Cut-off System	Cut-off Wall Termination
Shallow	Greater than or equal to 408 masl	8 m	Dynamic compaction	CSB	Bedrock
Intermediate	Between 408 and 402 masl	10 m	Vibro-densification and dynamic compaction	CSB	Bedrock
Deep	Below 402 masl	10 m	Vibro-densification and dynamic compaction	CSB and jet grouting	Competent soil surface

CSB = cement-soil-bentonite; masl = metres above sea level; m = metre

The dike will be constructed within the lake, prior to any dewatering.

The rockfill shell will provide structural support for the filters and low permeability elements of the dike and a working surface for the remainder of the dike construction and grouting activities. Rockfill will be placed to an elevation of 0.4 m above the lake water elevation (assumed 416.1 masl). The width of the rockfill shell will vary along the dike alignment based on the depth to competent soil or bedrock. The crest width will facilitate for two-way traffic of 180-tonne haul trucks, a minimum of 37.1 m. The downstream shell will have a nominal width of 13.9 m for the shallow and intermediate sections. For the deep sections, the downstream shell will be 29.3 m wide to allow for one-way traffic of 180-tonne haul trucks.

One-way haul traffic is required along the downstream shell in the deep sections as the upstream and downstream shells will be placed separately. In the shallow and intermediate sections, a continuous rockfill platform will be placed.

A central zone of the dike will consist of fine filter, with coarse filter on the upstream and downstream sides. The fine filter will be compacted.

A 1 m wide trench will be excavated through the fine filter to bedrock or competent soil surface using slurry trench technology. Bentonite slurry will be maintained within the trench during excavation to provide wall stability. The trench will be excavated from a platform about 2.5 m above the lake elevation to provide a positive hydraulic head between the trench and lake for further wall support. A mixture of CSB will be prepared. For the purpose of the pre-feasibility design, it is assumed that the CSB will consist of till mixed with approximately 2% dry bentonite powder (by weight of till), 7% dry cement (by weight of till), and bentonite slurry (6% bentonite by volume). Mix design testing will be performed as part of future design work to select mix ratios. The CSB will be placed within the trench to form the cut-off wall.

Jet grouting will be carried out in the deeper areas where the cut-off wall is not founded on bedrock. Jet grouted columns will be constructed to extend the low permeability element from the base of the CSB cut-off wall to the bedrock contact (Section 6.4.2).



A grout curtain will be constructed to extend the low permeability element into the near surface bedrock in shallow, intermediate, and deep areas of the dike. Grouting of the bedrock interface is considered a critical component of the dike design to prevent erosion at the base of the cut-off or jet grout column under the expected seepage gradients. The depth of the grouting will vary based on the imposed hydraulic head and ground conditions (see Section 6.4.3).

6.3 Construction Material

The primary materials to be used for the construction of the dike are as follows:

- rockfill;
- fine filter;
- coarse filter;
- till; and,
- bentonite, cement, and other additives.

The following sub-sections provide further details on the source, gradation, and requirements for each material type.

6.3.1 Rockfill

Rockfill will be required to form the structural shell of the dike.

It is anticipated that the rockfill will be sourced from the waste rock obtained during the development of the Lynx Pit. The Lynx Pit will be located south of the Misery Pit, approximately 1 km west of the existing winter road. It is understood that the Lynx waste rock will be stockpiled on the west side of the Misery waste rock storage area as shown in Drawing 200-1 and Drawing 200-2 (Appendix A). Rockfill will be loaded into haul trucks and transported to the dike for placement.

It is assumed that the waste rock will be a coarse and poorly graded material with a maximum particle size of about 1 m and will have minimal fines content, typically less than 5% by mass passing the No. 200 sieve (0.075 mm). The rockfill will be non-potentially acid generating (non-PAG) rock.

Lynx Pit mining is estimated to generate approximately 10.7 million tonnes of granitic waste rock that is non-PAG.

Alternatively, a quarry may be developed within the proposed Jay waste rock storage area footprint to provide a portion of the granitic, non-PAG rockfill to be used for dike construction.



6.3.2 Fine and Coarse Filter

The fine and coarse filter material will be produced by crushing rockfill at a dedicated crushing operation established on site. It is assumed that the dedicated crushing operation will be set up on the north side of the Misery Road across from the Misery/Lynx waste rock storage area. The general location of the crushing facility and stockpile area is shown in Drawing 200-1 and Drawing 200-2 (Appendix A).

The crushing operation will be fed with waste rock from the Lynx waste rock storage area. It is anticipated that crushing and stockpiling of materials in advance of the summer dike construction seasons will be necessary to provide the required amount and quality of crushed aggregates at a rate that will not hinder the construction schedule. Depending on construction scheduling, multiple crushing units could be required due to the anticipated amount of aggregates required. Stockpiles for each of the various crushed aggregates produced will require management to minimize segregation and maintain gradations within the specified envelopes. It is anticipated that these stockpiles will be created in the vicinity of the crusher, on the north side of the Misery Road.

The typical gradation envelopes proposed for the fine filter and coarse filter are presented in Chart 1. Section 7.3 discusses the filter compatibility assessment for the fine and coarse filter.

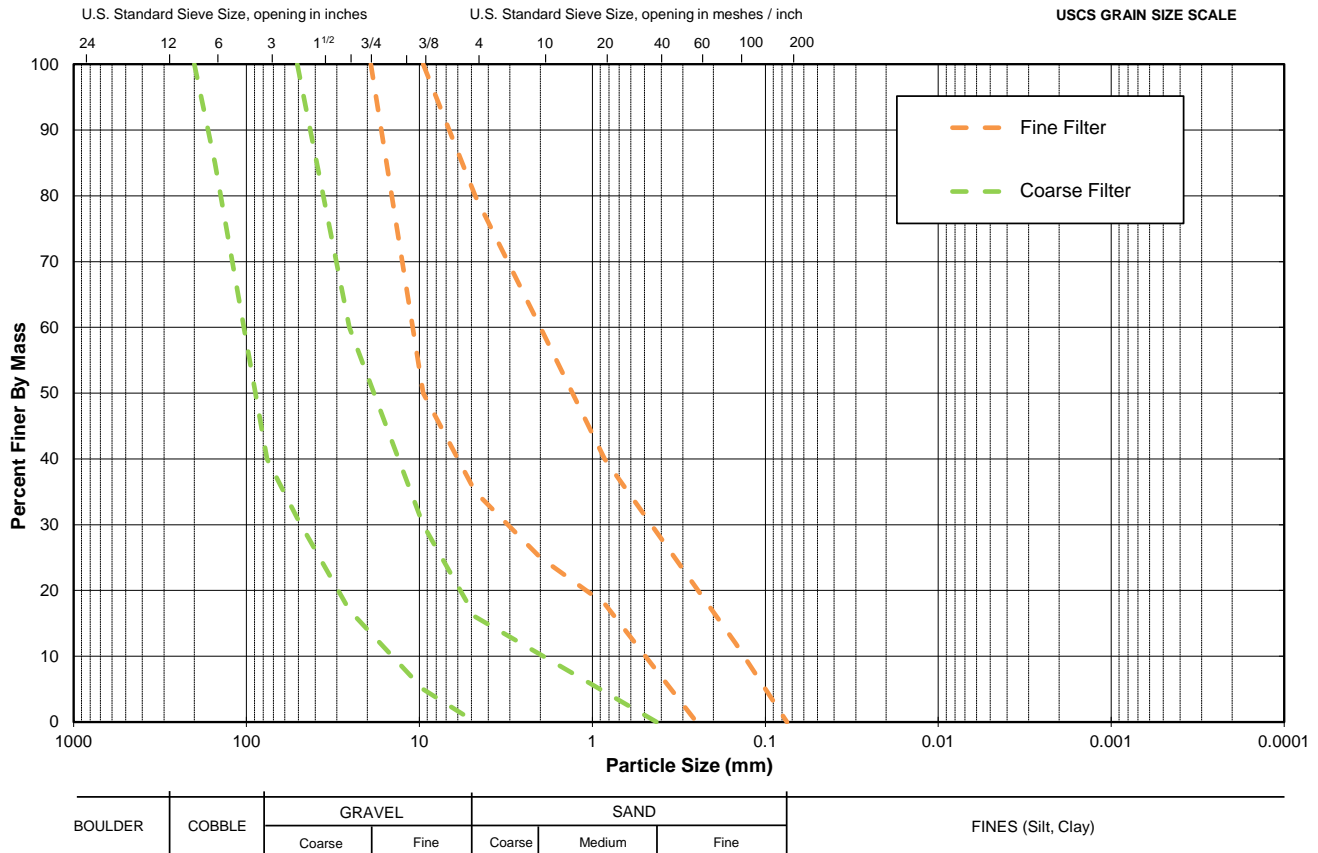


Chart 1: Proposed Fine Filter and Coarse Filter Particle Size Distribution Envelopes



The fine filter material will have a maximum particle size of 20 mm and no to minimal fines (particle size less than 0.075 mm). The fine filter will contain fine gravel and sand sized particles.

The coarse filter material will have a maximum particle size of 200 mm and no fines. Generally, coarse filter will be composed of coarse and fine sized gravel particles and contain less than 16% sand sized particles by mass.

6.3.3 Till

Till is proposed to be the primary component used in the construction of the CSB cut-off wall.

The till is proposed to be sourced from the lakebed area and pre-stripping activities associated with the development of the Lynx Pit. To preserve the natural moisture content, the till will need to be placed in well-managed stockpiles until it is used in the construction of the dike. Before using the till for dike construction, oversized particles will need to be removed and some reworking may be required. Removal of particles generally greater than 150 mm is assumed for the pre-feasibility design; the upper limit of particles for CSB construction will ultimately be dependent on the batching process selected for preparing the mixture.

A drilling and sampling program should be conducted in the Lynx Pit area to delineate the amount and quality of till available, and to provide samples for mix design testing. For the purpose of the pre-feasibility design, the gradation of the till is assumed to be similar to that noted in samples collected from the 2014 geotechnical investigation from Lac du Sauvage (Golder 2014c).

6.3.4 Bentonite, Cement, and Other Additives

Cement will be sourced from a single, continuous manufacturer for the duration of construction to maintain consistent quality and material compatibility. Partial hydration of the cement, bentonite, or other additives will be prevented during shipment and temporary storage on site.

The following materials are to be used for the construction of the CSB cut-off wall and jet grout columns:

- Bentonite, used for the CSB cut-off wall, will be pulverized (powder or granular) premium grade sodium cation montmorillonite and is to meet American Petroleum Institute (API) Specification 13A (API 2010). Peptized bentonite is not acceptable.
- Cement, used for the CSB cut-off wall and jet grouting, will be Type GU (i.e., Type 10) Portland cement per CSA A3000-03 Cementitious Materials Compendium.

The following materials will be used for the construction of the grout curtain:

- Cement will be Type HE (i.e., Type 30), high early strength, normal Portland cement per CSA A3000-03 Cementitious Materials Compendium. Ultrafine cement will be Spinor A12 or approved equivalent.
- Bentonite, if used, will be high-yielding, polymer-free, untreated, finely ground (less than 200-mesh) premium grade sodium cation montmorillonite (Wyoming sodium bentonite) and meet API Standard 13A specifications.



- Superplasticizers will be a high-range water-reducing admixture used as a dispersion agent and are to comply with ASTM C494 Types A, and F. Superplasticizers must be compatible with the selected viscosity modifying admixtures.
- Viscosity modifying admixtures may be Diutan Gum (in combination with pre-hydrated bentonite) or alternatively, the BASF admixture MasterMatrix UW 450 (formerly Rheomac UW 450) or approved equivalent.
- Non-chloride set time accelerators, such as BASF admixture MasterSet FP 20 (formerly Pozzutec 20+) or approved equivalent, will comply with ASTM C494 Type C and Type E and be suitable for use in freezing temperatures.
- Thixotropic admixtures, such as Minova Americas Inc.'s Celbex 653 or approved equivalent, will be capable of creating low-mobility cement grouts and prevent washout when flowing conditions are believed to exist.

6.4 Construction Method and Sequence

In general, multiple activities will occur simultaneously during construction of the dike. The activities will also vary depending on the depth to bedrock at any particular location along the dike alignment. The general sequence for dike construction is shown in Drawing 300-11 and Drawing 300-12 for the shallow and intermediate sections and in Drawing 300-13 to Drawing 300-16 for the deep sections (Appendix A).

The general sequence of dike construction is as follows:

- **Construction of the Rockfill Platform** – The rockfill platform will be constructed in two stages, with the exception of the first summer construction season (summer 2016). The upstream portion of the rockfill platform will be placed during the winter, while ice exists over the lake, to minimize the generation of turbidity within the lake. A slow rate of placement will be used and modified based on turbidity measurements. The remaining portion of the platform will be placed during the summer, at a rapid rate. For the first summer of construction (2016), the entire rockfill platform will be placed. For the shallow and intermediate sections, one continuous rockfill platform will be placed. For deep sections, an opening will be left between the upstream and downstream platforms. The platform will be placed to a crest elevation of 416.5 masl.
- **Excavation of the Central Trench** – For the shallow and intermediate sections, the trench will be excavated through the rockfill platform down to bedrock. This excavation will commence behind the advancing rockfill platform placement front, with excavated rockfill, free of fines, being reused to build the platform. Rockfill mixed with soil and the excavated lakebed soils will be hauled away from the dike area and disposed of in Jay waste rock storage area.

For the deeper sections, lakebed sediments and a portion of the competent material from the area between the upstream and downstream rockfill platforms will be removed. Potential methods that may be used to remove these materials include long-reach excavators, cranes with a clam shells, and dredging. For the purpose of the pre-feasibility design, it has been assumed that a crane with a clam shell will be utilized. The material removed is to be disposed of in the Jay waste rock storage area or within the Misery Pit or King Pond if dredging is carried out.



- **Foundation Approval** – Surveying of 1) the bedrock surface at the base of the excavated trench in shallow and intermediate sections and 2) the competent soil surface in deep sections will be conducted and approved prior to granular material being placed.
- **Backfilling of the Trench with Granular Material** (fine and coarse filters) – Backfilling of the central trench with fine and coarse filter will occur simultaneously. The fine filter front will be advanced slightly ahead of the coarse filter. An excavator will sit at the face of the central trench and push fine filter material at the water surface downslope into the excavation to minimize segregation. An excavator, dozer, or loader will be used to advance the coarse filter by pushing the material from the water surface into the trench, upstream and downstream of fine filter.

In some locations, based on the geometry of the excavation and soils, additional fine filter may be required to be placed on the downstream slope of the trench. This placement would occur prior to the general backfilling operations described above.

- **Vibro-densification of the Fine Filter** – This is required in areas where dynamic compaction alone will not provide adequate compaction of the fine filter to permit excavation of the slurry trench. Prior to vibro-densification, the width of fine filter material will be locally increased at the dike crest to provide a continuous overall width of 8 m. Vibro-densification will be performed from the initial rockfill platform elevation, with probe holes either side of the centreline. For the purpose of the pre-feasibility design, it has been assumed that probe holes approximately 3 m centre to centre will be required. Vibro-densification is to be used to compact the lower portion of the fine filter. It is anticipated that vibro-densification will be necessary in intermediate and deep sections.
- **Construction of Densification Platform** – Above the central trench, the platform elevation of the dike will be locally raised to an elevation of 418.5 masl. The densification platform will consist of zones of fine filter, coarse filter, and rockfill.
- **Dynamic Compaction of Fine Filter** – Dynamic compaction of the fine filter along the crest of the densification platform will be done, to permit excavation of the slurry trench. For the purpose of the pre-feasibility design, it is assumed that a crane would be used to drop a 15- to 20-tonne weight from a height of approximately 18 m for the dynamic compaction. Multiple passes will be required. Craters will be measured and backfilled prior to the next round of densification.
- **Excavation of the Slurry Trench** – A 1 m wide trench will be excavated through the fine filter down to bedrock or competent soil. A combination of excavation equipment will be used, based on target excavation depth, including long-reach excavator and clam shell methods. A slurry mixture containing 6% bentonite by volume will be pumped into the trench as excavation is carried out, and continually maintained to provide wall support. The base of the trench will be surveyed and approved prior to placement of backfill. To avoid ice formation within the slurry, the excavation and backfill of the slurry trench is to be completed before the onset of freezing conditions, assumed to be the last week of September or first week of October of each construction season, when the mean temperatures generally drop below zero.



- **Backfilling of the Slurry Trench with CSB** – Farmed and prepared till will be mixed with dry bentonite, measured at 2% (by weight of till). The till mixed with bentonite will be hauled to the batching location. Measured volumes of bentonite slurry and till will then be combined and blended based on the pre-approved mix design. Dry cement will also be added at approximately 7% (by weight of till) and mixed to form a consistent material. Regular quality control / quality assurance testing of the prepared CSB backfill material will be conducted. The material will then be transported and placed by excavator or other suitable method into the trench, from the crest to minimize segregation.
- **Jet Grouting** – In the deep sections, where the cut-off wall is not extended to the bedrock surface, jet grouting will be conducted to extend the cut-off system from the base of the cut-off wall to bedrock. Further details are provided in Section 6.4.2.
- **Interface and near Surface Bedrock Grouting (curtain grouting)** – Treatment of near surface bedrock and bedrock contact will be carried out along the entire alignment of the constructed dike, with the exception of where frozen conditions are encountered near islands and abutments. Further details are provided in Section 6.4.3.

A large portion of the construction will be limited to the open water season of each year. Ice typically melts from the surface of the lakes in early to mid-July and begins to re-form by mid-October. Only the placement of the upstream portion of the rockfill shell, jet grouting, and curtain grouting will be carried out during periods when ice covers the lake.

Following completion of curtain grouting, instrumentation to monitor the performance of the dike will be installed at select locations along the dike alignment. Readings will be are to be stabilized prior to the initiation of dewatering.

6.4.1 Lakebed Sediment Excavation

In shallow and intermediate sections of the dike, rockfill lakebed sediments and competent till will be excavated to create the central trench with a conventional excavator and/or long-reach excavator.

For the deeper sections, where the bedrock exists below elevation 402 masl, rockfill will be placed upstream and downstream, leaving the central portion open. Within the central portion, between the upstream and downstream rockfill shell, the lakebed sediments and a portion of the competent soil will be removed down to a target surface.

Three possible excavation methods have been identified for removal of the lakebed soils:

- **A long-reach Excavator and Bucket** – A long-reach boom and large excavator would be needed to reach the required depths. The excavator may be located on a barge providing greater reach, or on the edge of the trench.
- **Wire Supported Clamshell Bucket** – A conventional crane would operate the clam shell bucket. The crane may be mounted on a barge or on the edge of the trench. The bucket may be open or closed to reduce re-suspension.



- Hydraulic Cutter Suction Dredger** – A conventional hydraulic pipeline dredge with rotating cutting head at the end of a ladder. Hydraulic dredges remove and transport sediments with entrained water in the form of a slurry, with typically 10% to 20% solids by weight. Speciality hydraulic dredges are available that may remove sediments with higher solids content, lower sediment re-suspension, and/or lower residual sediment left behind.

Table 3 provides a comparison of each of the three methods against the criteria listed.

Table 3: Comparison of Methods for Lakebed Soil Removal

Criteria	Long-Reach Excavator and Bucket	Wire Supported Clam Shell Bucket	Cutter Suction Dredger
Operating Production Rate	Typically lower than comparably sized hydraulic dredges. Clam shell may have increased production at deeper depths where a smaller bucket size is required for the long-reach excavator.		Typically higher than mechanical dredges of comparable size.
Maximum Reach	Dependant on excavator used. Maximum depth based on elevation of 402 masl assumed for the current pre-feasibility design.	No restriction.	Dependant on pump size.
Sediment Re-suspension Control	Re-suspension due to bank sloughing, leakage, and spillage from open buckets has potential to generate high levels of suspended sediment over the entire water depth. This can be reduced using an enclosed clam shell bucket or excavator bucket with an enclosed top.		Typically generates lower sediment re-suspension, and is limited to the lakebed.
Cleanup Level	The articulated bucket offers significant advantage for more effective removal and less residual formation.	High potential to leave residual sediment.	Highest potential to leave residual sediment unless specialty dredgeheads are used.
Sediment Transport	Conventional haul truck, with disposal at an assigned location.		By pipeline to Misery Pit or King Pond, as a slurry.
Boulders	Suitable but limited by the size of bucket.	An additional grab bucket may be required specifically suited to removal of boulders.	Unsuitable for boulders and rarely used in cobbles where effectiveness is low.
Maneuverability	Can work in confined and tight areas.		A swinger ladder cutterhead will be required to operate in the confined central trench.
Sloping Bottom	Can effectively remove material along a sloping lakebed.	Limited effectiveness removing sediments from sloping lakebed.	A swinger ladder cutterhead will be required for sloping lakebed.

masl = metres above sea level.

For this pre-feasibility level design it has been assumed that a clam shell bucket will be utilized for sediment and competent soil removal in deep sections.



The clam shell requires non-specialized equipment that can be mobilized to site relatively easily, and it will utilize the same trucks for sediment disposal as the long-reach excavator. The crane will be situated along the edge of central trench and will directly load the sediment into haul trucks. The use of barges is not currently included in the design.

Removal methods may be re-evaluated at future design stages when additional site characterization information becomes available.

6.4.2 Jet Grouting

Jet grouting will be carried out in deep sections of the Jay Dike where bedrock lies below elevation 402 masl to extend the cut-off system from the base of the cut-off wall to bedrock. Jet grouting areas are shown in profile in Drawing 300-23, Drawing 300-26, and Drawing 300-28 and in plan in Drawing 300-50 (Appendix A). Drilling and delivery of grout at high velocity to erode, mix, and stabilize in situ soils will be carried out in a manner suitable to protect the constructed CSB cut-off wall materials. Treatment will extend 0.5 m below the bedrock interface and 1 m above the base of the CSB cut-off wall as shown in Drawing 300-51.

Because a portion of the jet grouting works will be carried out in the winter, a single rig setup for drilling and subsequent jet grouting will be implemented at each jet grout column location. This will involve pre-drilling a pilot hole with a water-actuated down-the-hole hammer, retrieval of the rod string, and re-entry of the pre-drilled hole with a tricone bit mounted below the jet grout monitor. Once the drill string has been reamed back to the bottom of the hole, the tricone bit will be plugged off and jet grouting of the freshly drilled hole carried out.

Jet grouting operations will be executed using a double fluid technique with a 1:1 cement:water ratio neat grout, a centre-to-centre jet grout column spacing of approximately 1.2 m in a primary-secondary sequence, a two-nozzle jet grout monitor, and jet grouting pressures in excess of 350 bar. These parameters, along with flow and withdrawal rates, will be confirmed and adjusted, as necessary, through execution of a means and methods trial at the outset of the works. A test panel will be set out along the dike alignment, within one of the selected deep sections requiring jet grouting below the cut-off wall. Thereafter, parameters such as hole spacing and withdrawal rates will be adjusted for the encountered in situ soil conditions to provide a contiguous jet grout wall within the deep sections of the dike.

To reduce potential delays caused by freezing, equipment will be winterized during the winter and shoulder seasons. Each jet grouting activity, including batching and pre-drilling, will be carried out from within mobile steel frame canvas shrouding. All hose lines will be fully insulated and, if necessary, buried to protect them from freezing during jet grouting.

A minimum of 0.5 m sub-drill will be carried out into competent rock to allow the upper nozzle of the jet grouting monitor to be below the bedrock/till (or base of very soft material/bedrock) interface, so that the weathered bedrock, if present, will also be treated.



6.4.3 Curtain Grouting

For treatment of the near surface bedrock and the interface between bedrock and the base of the CSB cut-off wall and/or jet grout columns (i.e., the contact zone), the Jay Dike will be divided into separate working areas by similar average head of water characteristics. The curtain depth into rock will be set to match the anticipated average head at the base of the cut-off wall for each working area. Curtain depths will range between 5 m in rock for areas of low head, and upwards of approximately 25 m for areas of higher head. The grout curtain extension is shown in profile in Drawing 300-23, Drawing 300-26, and Drawing 300-28 and in plan in Drawing 300-50 (Appendix A). Drawing 300-51 shows typical grout curtain details.

Curtain grouting activities will be completed using the split-spaced closure method (i.e., completing all grout holes in one sequence before injecting adjacent higher order holes in the same work area). As a minimum, all primary, secondary, and tertiary order grouting will be completed at a 1.5 m centre-to-centre hole spacing, as shown in Drawing 300-51 (Appendix A). Where required, additional higher order holes will be installed and deepened based on elevated grout takes. Water pressure testing within higher order holes will be compared against pre-treatment testing as a means of assessing progressive improvement.

Casing Installation

Steel casing installation will be carried out along the centreline of the cut-off wall. Water-flush, rotary triconing will be advanced through the CSB and jet grouted materials to bedrock. The tricone bit will then be extracted and the steel casing advanced in the pre-drilled open hole, activating a down-the-hole hammer when cobbles or other material that has collapsed back into the hole is encountered, and 0.5 m into bedrock.

Bedrock Drilling and Grouting

Generally, grouting activities will be carried out employing upstage techniques. This will comprise drilling with rotary-percussive methods to the prescribed depth (5 to 25 m) into bedrock beneath the end of the installed steel casing, and carrying out staged grouting, as shown in Drawing 300-52 (Appendix A). If poor ground conditions are encountered, downstage techniques will be implemented. This will comprise advancing the hole in shortened stages, carrying out consolidation grouting of the fractured bedrock, and allowing grout to cure prior to re-drilling through the set grout. Drilling will then be advanced to either the bottom of the hole or the next required downstage interval.

Because a portion of the curtain grouting works will be carried out in winter, injection will be executed from within warm, dry mobile grout shelters. Each will comprise a pair of specially outfitted intermodal shipping containers housing heat, water and power supply, mixing plant, grout materials, and real-time monitoring equipment. Access to grout holes will be provided via removable floor panels. The use of multiple grout shelters will allow simultaneous grouting at different work areas along the dike. Shelters will be mobilized along the dike by pulling with a loader or similar large equipment (e.g., Timberjack).



Interface Grouting

A two-stage technique will be used to seal the interface of the base of the cut-off / jet grout wall and bedrock. The first will comprise a shortened 1 m stage out the end of the installed steel casing, executed in sequence with bedrock grouting operations. Thereafter, grout hole casings will be perforated to carry out injection of a second interface stage. A specialized perforator tool will be outfitted onto the drill string and pushed using a heavy drill rig (e.g., Atlas Copco DM45). To perforate as close to the interface as possible, grout hole casings will be reamed out after the injected grout from the first interface stage / bedrock has cured.

Perforations will be punched as rows of approximately 6 mm x 30 mm slots spaced 35 mm apart. Four rows of slots will be perforated in each casing over a length of approximately 1.5 m or greater depending on the presence of any soft sediments intersected at the base of the cut-off wall during the installation of steel casings and/or the distance between the base of the cut-off wall and the interpreted depth to bedrock. The four rows will be oriented at 90° to each other, parallel and perpendicular to the longitudinal axis of the dike. For injection purposes, a single pneumatic packer will be set immediately above the perforations. Grouting will then be executed as a single stage across the perforated length of casing.

Grout Mix Designs

Grouting will be carried out using high mobility grouts with Type HE (high early strength) cement as the basic injectable material. Pressure grouting will be carried out both in bedrock and across the cut-off / jet grout wall / bedrock interface using a step-wise thickening sequence employing a full suite of grout mixes. All mixes will be balanced and stable with 5% or less bleed (sedimentation) measured over a two-hour period, and a pressure filtration coefficient (K_{pf}) of less than 0.04 min^{-1/2}. Grouting admixtures such as superplasticizers, bentonite, and anti-washout additives will be incorporated into the mix designs as necessary in order to achieve both bleed and K_{pf} requirements while maintaining design viscosities. Thixotropically controlled mixes will be used during instances of elevated grout takes. An ultrafine cement based mix will be used to initiate higher order (tertiary and quaternary level) interface grouting. A cold weather admixture will be used to control grout set times, as required.



7.0 DESIGN ANALYSES

Seepage analyses were carried out to estimate the potential seepage through the dike and to calculate hydraulic gradients that may exist after dewatering and after excavation of the Jay Pit to a base elevation of 45 m.

Stability analyses were carried out to calculate the factors of safety for several critical sections, immediately following construction and under operational conditions. Both static and pseudo-static loading conditions were analyzed.

Finite element seepage modelling and limit equilibrium slope stability modelling were carried out using the commercially available computer software, SEEP/W and SLOPE/W (version 7.23), developed by GEO-SLOPE International. The results of the stability and seepage analyses are discussed in further detail in Appendix C.

The pit wall stability was analyzed as part of the pre-feasibility pit design (Golder 2014g).

7.1 Seepage Analysis

The typical cross-section for the Jay Dike varies based on the bedrock elevation as shown in Drawing 300-10 (Appendix A). Therefore, the following sections were considered representative and were used for seepage analysis:

- Deep Section A at Station 3+410;
- Deep Section B at Station 0+750;
- Intermediate Section at Station 1+340; and,
- Shallow Section at Station 2+420.

For each section, two steady-state seepage scenarios were modelled: dewatered downstream prior to pit development, and a final configuration after the pit has been developed to a base depth of 45 m. In each typical section, seepage fluxes were calculated at the downstream toe of the dike. These were then used to estimate total seepage through the dike, following dewatering, by assigning representative dike lengths to each of the typical sections modelled. The seepage models do not consider the influence of enhanced permeability zones within the bedrock (e.g., faults, shear zones, etc.).

The configuration of the seepage models and assumed material parameters used in the analyses are provided in Appendix C.

Based on the results of the seepage analyses, for the dewatered scenario, the estimated total seepage at the downstream toe of the dike is 6,100 cubic metres per day (m^3/day). Once the pit has been developed to a base elevation of 45 m, the estimated total seepage at the downstream toe decreases to 3,200 m^3/day .

For the evaluation of hydraulic gradients, a critical gradient of 1 was used as the criterion for potential internal erosion. In the seepage models, hydraulic gradients were measured along the downstream side of the central trench (where fine filter is in contact with either bedrock or competent soil) and at the downstream toe of the dike.



In the deep sections, the maximum hydraulic gradient along the central trench is 0.8, but declines rapidly to a value of 0.3. In most sections modelled, the hydraulic gradient along the downstream central trench is less than 0.4. In all sections, the hydraulic gradient at the downstream toe is less than 0.1.

Parameters associated with bedrock seepage have been simplified in the seepage models. Therefore, the models have not considered the influence of enhanced permeability zones in the rock mass. The Jay Pit hydrogeological modelling (Dominion Diamond 2014, Appendix 8A) provides details regarding potential seepage flows into the proposed Jay Pit.

A detailed summary of results and figures showing seepage patterns for the various scenarios modelled are provided in Appendix C.

7.2 Stability Analysis

The stability of the Jay Dike was considered both during ongoing construction and during mining operations. These scenarios are summarized as follows:

- **Ongoing Construction** – As dike construction will occur over multiple years, haul truck traffic will operate on portions of the dike already completed. In this scenario, the stability of the dike has been assessed with a loaded haul truck travelling on the dike, once the central trench has been backfilled, but prior to dewatering.
- **During Operations** – The dike construction is complete, and the basin downstream is dewatered. Only light vehicle traffic is anticipated to be used on the dike.

Dike cross-sections were selected for the stability analyses based on the steepness of the existing lakebed surface and interpreted foundation conditions. Sections modelled were taken at a deep section at Station 4+700 and an intermediate section at Station 3+520. Station 4+700 was selected due to the thickness of fine-grained competent soil identified at this location. The stability of the upstream and downstream slopes was evaluated in both sections.

During construction of the rockfill platform, it is anticipated that rockfill will penetrate and/or displace the soft lakebed sediment. Therefore, in the stability models, the rockfill is founded on competent soil. As a conservative approach, the stability models also considered scenarios where a 1 m layer of lakebed sediment remains beneath the rockfill.

The results of the dike stability analysis indicate that during ongoing construction, haul trucks need to maintain a minimum distance of 8 to 10 m away from the dike crest to achieve the minimum factor of safety criteria. For the deep section at Station 4+700, a minimum distance of 15 m is required. These restrictions are not anticipated to hinder ongoing construction as the dike crest will still provide adequate space for two-way haul traffic (WCBNT 1996).

During operations, the dike sections modelled met or exceeded the minimum factor of safety criteria, in both static and pseudo-static conditions. Potential failure surfaces with a factor of safety equal to or less than the minimum factor of safety criteria were limited to within the rockfill shell and did not intersect the filter materials.



The assumptions and model configurations used in the stability analyses should be re-evaluated following the completion of future geotechnical investigations. In particular, cone penetration testing should be carried out to evaluate the material characteristics of the lakebed sediment and the fine-grained competent soil.

Future design studies should consider the stability of the rockfill platform during rockfill placement. The impact of construction equipment on the stability of the rockfill in the vicinity of the working front should be included in the assessment. A construction monitoring plan should be developed for the placement of rockfill, particularly in areas where the predicted factor of safety is lower.

7.3 Filter Compatibility Assessment

The fine and coarse filters located downstream of the low permeability elements allow seepage to pass through the dike while minimizing erosion of soil particles.

The following material transitions were assessed for filter compatibility using USDA (1994):

- competent soil interface with fine filter; and,
- fine filter interface with coarse filter.

In addition, the internal stability of the competent soil was assessed to evaluate the potential for erosion under the imposed hydraulic gradients based on methods developed by Sherard (1979); Li and Fannin (2008); and Wan and Fell (2008).

Particle size distributions of fine filter, coarse filter, and competent soil were used to carry out the filter assessment. The gradation envelopes presented in Chart 1 (Section 6.3.2) were used for the fine and coarse filters. Laboratory test results of samples collected during the 2014 winter investigation were used for the competent soil.

The competent soil is interpreted to generally be compatible with the fine filter. The coarse filter presented in Chart 1 is compatible with the fine filter.

Additional details regarding methods, evaluation criteria, competent soil particle size distributions, and results of the filter compatibility assessment are provided in Appendix D.

Further filter compatibility assessments should be carried out in future design studies following the completion of additional geotechnical investigations, and should incorporate results of seepage analyses that identify areas of the dike where the predicted hydraulic gradients are higher and where the competent soil may be susceptible to erosion.



8.0 TURBIDITY MANAGEMENT

Dike construction and dewatering activities within Lac du Sauvage will generate turbidity and therefore require management. Turbidity will primarily be generated as a result of the following activities:

- rockfill placement;
- central trench excavation in shallow and intermediate sections;
- lakebed sediment and lakebed soil excavation from deeper sections; and,
- placement of the fine and coarse filters.

As a result, measures will be implemented to monitor and control the area over which elevated levels of suspended solids occur. Rockfill will be placed during both the winter and summer months. The remaining activities listed above will only occur during the open water summer construction season. Turbidity control measures for winter and summer work are described in Sections 8.1 and 8.2.

8.1 Summer Turbidity Management

Turbidity control during the summer months will involve the installation of silt curtains to provide a barrier and limit turbidity movement beyond the curtains. Proposed locations for turbidity curtain installation, for each summer construction year, are shown in Drawing 300-22, Drawing 300-25, and Drawing 300-27 (Appendix A). Turbidity curtains will be installed both upstream and downstream of the dike to limit the area impacted by high levels of suspended solids. The turbidity curtains will be installed in two rows, where possible, forming primary and secondary barriers. The secondary barriers will be deployed beyond the primary barriers, and will serve as a backup in the event that one of the primary curtains is broken. The primary barriers will be deployed in cells, where possible. The turbidity curtains will be installed for each summer construction season following ice breakup and prior to dike construction.

During the first summer of construction in 2016, as no upstream rockfill shell will be in place, the turbidity curtains will be installed and anchored to islands, as seen in Drawing 300-22.

The turbidity barrier deployment plan for the summer 2017 and summer 2018, are shown in Drawing 300-25 and Drawing 300-27, respectively. Deployment is summarized as follows:

- **Upstream of the Dike** – Primary turbidity curtains will be deployed in cells to form the primary line of protection. Each cell will be anchored to the crest of the upstream rockfill platform and extend out a minimum of 25 m from the toe of the dike. The bottom of the turbidity curtains will be anchored to the lakebed at spot locations. By using a cell formation for the primary barrier a single breach of a turbidity curtain would limit the release of suspended solids and allow for rapid repair.

The secondary turbidity curtains will be deployed beyond the primary curtains to serve as a backup.

- **Downstream of the Dike (within isolated portion of Lac du Sauvage)** – Until fish-out of the isolated portion of the lake is complete, turbidity barriers will be installed in a single row downstream of the dike. The turbidity curtains will be anchored to islands, where possible, and to the lakebed surface in spot locations.



Each year, following steps will be taken to install the turbidity barriers:

- Anchors will be placed on the ice during the winter months, at the spacing recommended by the manufacturer. This allows the anchors to be placed in a cost-effective manner, with a dozer or other mobile piece of equipment as compared to using other placement techniques, such as via helicopter. The anchors may be large boulders with anchoring points attached. The location of each anchor will be surveyed. The boulders will act as a heat sink and promote more rapid breakup of the ice sheet locally. Guide ropes and buoys will be tied to each anchor.
- Once ice has melted, the curtains will be towed into position via boats.
- The curtains will be attached to the previously installed anchors with the use of the guide ropes. This will be done without the need for divers.
- The curtains will also be anchored at the shore, along the dike crest and abutments.

Turbidity barriers will be removed prior to the formation of ice on the lake, where possible. Following removal, the barriers will be inspected for damage and an assessment made whether any curtain or portion of curtain may be reused during subsequent construction seasons. For the purpose of the cost estimate, no reuse of turbidity curtains has been assumed.

8.2 Winter Turbidity Management

Due to ice cover during the winter, the deployment of turbidity barriers will not be possible. However, the ice cover will limit the transportation of disturbed sediments via wind and wave action. As a result, if placement is carried out at a sufficiently slow rate, it is anticipated that rockfill could be placed during the winter and meet the required turbidity levels. The placement of rockfill will, however, be subject to the results of ongoing turbidity monitoring.

The rockfill placed in the winter of 2016/2017 will form the upstream crest of the dike. The primary purpose of placing the upstream portion of rockfill platform during the winter is to provide an anchoring spot for the primary upstream turbidity barriers. The upstream rockfill shell will also provide protection to the barriers from wind, waves, and currents.



9.0 INSTRUMENTATION

It is recognized that extreme winter conditions exist at the Jay Project site for a significant portion of the year (November to May), including sub-zero temperatures, ice, and snow accumulation. These conditions will reduce the effectiveness of visual inspections to assess the performance of the Jay Dike. Therefore, a key design feature of the facility is the use of instrumentation for monitoring dike performance during dewatering, operation, and into closure, until the dike is locally breached. The instrumentation will be installed prior to dewatering to monitor the physical performance of the dike and to confirm that the structure is operating according to the design intent.

The following instrumentation is to be installed:

- **Vibrating Wire Piezometers**, both single and array piezometers, will be installed to measure pore pressure and temperature within the embankment, foundation, and shallow bedrock. An additional piezometer will be installed downstream to measure drawdown.
- **Thermistor Strings** with beads located at select elevations will be installed to measure thermal conditions within the low permeability element and shallow bedrock. An additional thermistor string will be installed upstream to provide data regarding thermal variation in the lake.
- **Inclinometers** may be installed at select locations along the deeper sections of the dike and into the foundation to monitor differential movement of the low permeability elements.
- **Weirs** or other suitable methods will be installed to visually inspect and measure the rate of seepage, once dewatering is complete.
- **Crest Survey Monuments** may be installed along the alignment at select locations to measure potential lateral and vertical (settlement) movement of the cut-off wall; additional survey monuments may be installed along the toe or downstream crest.
- **Blast Vibration Monitoring** locations will be established along the dike.

The system for measuring and recording values at each piezometer and thermistor string will be automated, so that readings can be taken at regular intervals (i.e., every three hours), and data stored and transferred to permit critical review and assessment in a timely manner. Inclinometer measurements will be obtained manually, on an approximate monthly basis. Seepage flow measurements and visual inspection will be taken when flow is observed, either manually or automatically, depending on conditions.

Further details of the instrument monitoring frequency will be included in the Dike Operation Maintenance and Surveillance (OMS) manual to be developed as part of the detailed design. A preliminary instrumentation plan and profile will be provided as part of the future detailed design. Finalization of the exact instrument installation locations and depths would be made following construction and grouting works to target specific areas based on conditions encountered in the field.

Further detail on the layout of select monitoring instruments is provided in Sections 9.1, 9.2, and 9.3.



9.1 Pore Pressure Monitoring

Pore pressure monitoring will be carried out with the installation and use of vibrating wire piezometers, which are to be installed as follows:

- piezometer arrays composed of multi-level piezometers with one immediately upstream, immediately downstream of the low permeability element, and one further downstream of the low permeability element; and,
- single level piezometers installed immediately downstream of the low permeability element; an additional single piezometer is required to monitor the water level downstream of the dike during dewatering.

The multi-level vibrating wire piezometers will be used to measure the pore pressures that may develop within the embankment, foundation, and shallow bedrock. Three typical piezometer installation sections are shown in Drawing 300-63 (Appendix A). The data will be collected and reviewed to monitor the phreatic levels and identify whether unusual pore pressure levels are present, which may indicate zones of seepage.

In addition to measuring the phreatic levels, the vibrating wire piezometer sensors also provide a measurement of temperature at the sensor location. Temperature patterns will also be utilized to detect potential zones of seepage.

9.2 Thermal Monitoring

Thermal monitoring will be carried out with installed thermistor strings to measure the thermal profile variation at given locations. These will be installed within the low permeability element. An additional thermistor will be installed on the upstream crest of the dike to monitor the lake water temperature over time.

Temperature data provided by the installed thermistor strings will be utilized to assess the thermal conditions of the low permeability element to track any changes, thawing, or freeze-back that may occur during the operational life of the structure. Three typical thermistor installation configurations are shown in Drawing 300-64 (Appendix A).

9.3 Dike Stability and Deformation Monitoring

Inclinometers will be installed at select locations in deeper sections of the dike. The inclinometers will be installed through the low permeability element and into the foundation to monitor lateral movements.

Crest survey monuments may be installed on the crest at select locations along the dike alignment, or at the downstream toe or along the downstream slope of the dike, if deemed necessary during future design stages or during operation. The monuments could be used to measure the potential surficial lateral and vertical (settlement) movement of the cut-off wall.

Blast vibration monitoring will be used to assess the vibrations that the low permeability elements are subjected to as a result of the mining operations.



10.0 CONSTRUCTION SCHEDULE

A preliminary Jay Project dike construction schedule has been developed and is shown graphically in Figure 3. This schedule has been developed to allow completion of the dike as soon as feasible once a Water Licence Permit is issued. This in turn allows dewatering, pre-stripping, and pit development to occur as soon as practical, so that an ongoing source of ore will be supplied to the processing plant.

The dike construction schedule has been developed on the assumption that a pre-works construction permit will be obtained that allows initial construction activities, which are generally referred to as pre-works, to be carried out. These activities include the following:

- construction of necessary access roads, pipeline benches, and laydown areas;
- production and stockpiling of a sufficient quantity of aggregate materials (fine and coarse filters) required for the first summer of dike construction; and,
- installation of turbidity barriers.

Furthermore, the schedule assumes that a Water Licence Permit will be granted by mid-July 2016, so that dike construction activities within Lac du Sauvage could commence no later than the end of July 2016.

The schedule also assumes that Lynx Pit mining will be sufficiently advanced that there is an adequate supply of rockfill and till. It is understood that mining in the Lynx Pit will begin in November 2015 and, therefore, an adequate supply of material should be available for the initiation of Jay Project construction activities. Waste rock produced from the Lynx Pit will also provide a supply of material for crushing and production of aggregates (fine and coarse filters) for the dike. The location of the Lynx waste rock and overburden stockpile area is shown in Drawing 200-1 (Appendix A).

The dike construction, fish-out, and dewatering is scheduled to take approximately 3.5 years, from mid-2016 through mid to late 2019. The estimated schedule for the fish-out and dewatering of the isolated portion of Lac du Sauvage is discussed in the Jay Mine Water Management Plan (Golder 2014b).

The following is a summary of the activities by year and season:

- **Summer 2016:**
 - Primary and secondary turbidity barriers will be installed near the portion of the alignment where dike construction will occur, as shown in Drawing 300-22 (Appendix A). These will generally be removed prior to ice formation on the lake.
 - Dike earthworks construction is planned to occur between Station 5+057 and Station 4+150. This portion of the dike is shown in plan in Drawing 300-22 and in profile in Drawing 300-23. Construction includes placement of rockfill over the full width of the dike, excavation of the central trench to bedrock or target surface, placement of granular filters within the central trench, densification of the fine filter (through a combination of vibro-densification and dynamic compaction), excavation of the slurry trench, and construction of the CSB cut-off wall.



■ Winter 2016/2017:

- The upstream portion of the rockfill shell will be placed during the winter of 2016/2017, once ice has formed on Lac du Sauvage. Rockfill placement will occur along the remaining dike alignment, from Station 0+000 to Station 4+150, as shown in Drawing 300-24 (Appendix A). To minimize turbidity, rockfill placement will be done at a slow rate and from two placement fronts: south abutment and north portion of the dike. Ice will be broken and removed or pushed aside to avoid having it become entrapped within the rockfill as it is placed. The rate of placement will be subject to results from turbidity monitoring.
- Curtain grouting will be carried out in the shallow and intermediate sections where the CSB cut-off wall was constructed during the summer of 2016 and founded on bedrock. All steel casing installation and grouting related activities will be completed ahead of the summer 2017 construction season.

■ Summer 2017:

- Primary and secondary turbidity barriers will be installed along portions of the alignment where dike construction will occur (Drawing 300-25, Appendix A). The barriers will generally be removed prior to the formation of ice on the lake.
- Dike earthworks construction will be carried out from two work fronts: from Station 0+000 to Station 1+200 and from Station 2+900 to Station 4+150. The construction locations are shown in plan in Drawing 300-25 and in profile in Drawing 300-26.
- Work in the two portions will occur simultaneously. Construction includes placement of the rockfill platform, excavation of the central trench to bedrock or target surface, placement of granular filters within the central trench, densification of the fine filter (through a combination of vibro-densification and dynamic compaction), excavation of the slurry trench, and construction of the CSB cut-off wall.
- Instrumentation will be installed in portions of the dike where curtain grouting is complete.

■ Winter 2017/2018:

- The jet grouting will start along the deep sections where the CSB cut-off wall does not extend to bedrock. It is assumed that jet grouting equipment will be mobilized to site using the ice road.
- Curtain grouting will continue along the shallow and intermediate sections where the CSB cut-off wall is complete and extended to bedrock.
- Curtain grouting will begin in the deep sections as jet grouted areas are completed.

■ Summer 2018:

- Primary and secondary turbidity barriers will be installed along the portion of the alignment where dike construction will occur (Drawing 300-27, Appendix A). The barriers will generally be removed prior to the formation of ice on the lake.



- The final portion of the dike earthworks will be constructed between Station 1+200 and Station 2+900. The construction location is shown in plan in Drawing 300-27 and in profile in Drawing 300-28 (Appendix A). The construction includes placement of rockfill, excavation of the central trench to bedrock or target surface, placement of granular filters within the central trench, densification of the fine filter (through a combination of vibro-densification and dynamic compaction), excavation of the slurry trench, and construction of the CSB cut-off wall.
- Jet grouting and curtain grouting will continue along portions of the dike where the CSB cut-off wall has been completed.
- Instrumentation will be installed in portions of the dike where curtain grouting is complete.
- **Winter 2018/2019:**
 - Jet grouting will be completed, ideally prior to the closing of the ice road to allow the equipment to be demobilized from site.
 - Curtain grouting will continue and is estimated to be completed in April 2019.
 - Installation of instrumentation will occur following completion of curtain grouting, and is estimated to be completed in May 2019.
- **Spring to Fall 2019**
 - The dewatering of the isolated portion of Lac du Sauvage will start following completion of the curtain grouting, instrumentation installation, and stabilization. The drawdown is anticipated to commence in May 2019 and will take approximately six months to complete.

Pre-stripping for pit development will begin following completion of the dewatering in October 2019, based on the above schedule.



11.0 CONSTRUCTION QUANTITIES

This section provides the pre-feasibility estimate of the material and earthworks quantities for the construction of the Jay Dike. The quantities presented in this section do not include material or earthworks quantities associated with laydown areas, access roads, or dewatering structures. The overall Jay Project pre-feasibility design report provides quantities for these items.

11.1 Assumptions

The following information is available and was used in estimating construction quantities along the dike alignment:

- A bathymetric survey of Lac du Sauvage, carried out in 2013, provides a profile of the lakebed surface beneath the dike alignment (Section 3.6).
- Borehole data collected during the 2014 winter geotechnical investigation provides detailed stratigraphy at select points along the dike alignment (Sections 3.7 and 4.2).
- Sub-bottom profiling survey data and sidescan sonar survey data along the dike alignment, collected in the summer of 2014, provide interpreted stratigraphy in between borehole locations and identify potential locations of boulders (Sections 3.8 and 4.2).

The results of the 2014 geophysical survey were used to infer the stratigraphy under the centreline of the proposed dike alignment, which forms the basis of the quantity estimate. The geophysical data was calibrated using existing geotechnical borehole data, where available. Due to the limited number of boreholes drilled, the large spacing between the boreholes, the quality of reflection obtained from the geophysical survey, and the potential interferences that may affect the reflection, the accuracy of the geophysical survey between borehole locations is uncertain and should be confirmed in a future stage of design.

For the purpose of developing the construction quantity estimate, the following assumptions have been made:

- The action of placing rockfill will displace the loose lakebed sediment, resulting in the rockfill platform being founded on the competent soil surface.
- In the shallow and intermediate sections, the lakebed sediment and competent soil can be excavated and removed down to bedrock within the central trench excavation. A long-reach excavator will be required to excavate a portion of this material.
- In the deep sections, lakebed sediments can be excavated from within the central trench to the target competent soil surface using a crane and clam shell.
- During the excavation of the central trench, 70% of the rockfill excavated is suitable for reuse. The remainder of the rockfill is assumed to contain lakebed sediment and is therefore unsuitable. This unsuitable material is to be disposed of in the Jay waste rock storage area.



- Vibro-densification is required in the intermediate and deep sections where the base of the fine filter is below an elevation of 408 masl. Vibro-densification is assumed to treat material in the intermediate and deep sections below and elevation of 410.5 masl, and dynamic compaction will be used to densify material above this elevation.
- Dynamic compaction is conducted over a 6 m width of the dike along the centreline for all sections. The effective depth is assumed to be up to 10.5 m in shallow sections and 8 m in intermediate and deep sections.
- The CSB cut-off wall can be placed effectively to bedrock for the shallow and intermediate sections where the bedrock elevation is 402 masl or higher. For the deep sections where bedrock exists deeper than elevation 402 masl, jet grouting will be conducted to extend the low permeability element to the bedrock.
- The jet grout column will overlap the CSB cut-off wall by 1 m and extend 0.5 m into bedrock.
- The centre-to-centre spacing of jet grout holes is 1.2 m, to be confirmed during a trial at the outset of the works.
- The depth of the curtain grouting will be equal to the average hydraulic head for given work areas along the dike alignment.
- The centre-to-centre spacing of curtain grouting holes is 1.5 m at the tertiary order. At minimum, all primary, secondary, and tertiary order holes will be completed. Additional higher order holes will be required based on grout takes and water pressure testing results. An allowance for 15% of quaternary holes was included.
- The CSB cut-off wall and grout curtain is not required in the area of islands and the abutments where frozen conditions and low hydraulic heads are expected. The CSB cut-off wall and grout curtain will extend 12 m into each of these areas to provide a tie-in.

11.2 Summary of Quantities

This section provides a summary of material quantities, required for each year of construction, for the following:

- turbidity curtains; and,
- rockfill, fine filter, coarse filter, and till.

Total quantities are provided for the following:

- jet grouting, curtain grouting, associated works, and material supplies;
- curtain grouting and associated works; and,
- overall construction works.



Table 4 provides an estimate of the required length and area of turbidity curtain required for each construction season.

Table 4: Turbidity Curtain Material Quantity Estimate

Construction Season	Total Turbidity Curtain Length (m)	Total Turbidity Curtain Area ^(a) (m ²)
Summer 2016	4,000	20,300
Summer 2017	11,000	69,300
Summer 2018	5,300	24,800
Total	20,300	114,400

Note: No allowance has been made for reuse or replacement of damaged curtains.

a) Estimated area of curtain along the proposed barrier centrelines.

m = metre; m² = square metre.

The material quantities for the dike construction are provided in Table 5, by construction season.

Table 5: Summary of Dike Material Quantities by Season

Material	Material Quantity (m ³)					Total
	Summer 2016	Winter 2016/2017	Summer 2017	Winter 2017/2018	Summer 2018	
Rockfill ^(a)	621,000	1,534,000	1,003,000	-	325,000	3,483,000
Fine Filter	119,000	-	397,000	-	133,000	649,000
Coarse Filter	149,000	-	510,000	-	159,000	818,000
Total Volume of Rockfill, Fine Filter, and Coarse Filter	889,000	1,534,000	1,910,000	-	617,000	4,950,000
Till ^(b)	10,000	-	33,000	-	13,000	56,000
Approximate Dike Length (m)	900	-	2,450	-	1,700	5,050

a) Quantity includes rockfill used for construction of initial platform, densification platform, and safety berms. Quantity as shown accounts for rockfill that can be reused from the excavation of the central trench.

b) Quantity does not include a bulking factor.

m³ = cubic metre; m = metre; - = not applicable.

Total estimated material quantities for jet grouting and curtain grouting are provided in Table 6. The grouting activities are considered to be semi-continuous in nature and, therefore, only total material quantities are provided.



Table 6: Summary of Grouting Material Quantities

	Material	Unit	Quantity
Jet Grouting	Drilling	m	15,000
	Reaming	m	15,000
	Treatment area	m ²	3,200
	Type 10 cement	t	2,000
Curtain Grouting	Tricone drilling	m	48,000
	Steel casing installation	m	51,000
	Bedrock drilling	m	36,000
	Perforations	ea.	3,600
	Type HE cement	t	5,100
	Ultrafine cement	t	300
	Premium grade bentonite	t	260
	Superplasticizer	t	60
	Celbex 653	t	0.5
	Cold weather set time accelerator	t	4

Note: Material quantities are rounded.
 m = metre; m² = square metre; t = tonne; ea. = each.

A summary of the dike earthwork quantities listed by construction activity are presented in Table 7. This includes quantities for placement and excavation. For vibro-densification, the quantities are summarized as a volume while for dynamic compaction; a plan surface area is used to summarize the quantity. Grouting quantities are provided as liner metres along the dike alignment that require grouting.

Table 7: Summary of Total Construction Quantities

	Item	Unit	Quantity
Placement of Rockfill Platform ^(A)	Summer	m ³	2,420,000
	Winter	m ³	1,534,000
Central Trench Excavation	Lakebed sediments ^(B)	m ³	60,000
	Competent soil	m ³	200,000
	Rockfill	m ³	752,000
Central Trench Backfill Placement	Fine filter	m ³	540,000
	Coarse filter	m ³	763,000
Vibro-densification		m ³	78,000
Densification Platform	Fine filter	m ³	55,000
	Coarse filter	m ³	55,000
	Rockfill	m ³	55,000
Dynamic Compaction		m ²	26,000
CSB Cut-off Wall		m ³	56,000
Grouting	Jet grouting ^(C)	m	960
	Bedrock curtain grouting ^(C)	m	4,560

Note: Values are rounded to the nearest 10,000, with the exception of grouting lengths, which are rounded to the nearest 10 m.

- a) Includes placement of safety berms.
 - b) Only required in the deep sections.
 - c) Estimated length of dike to be grouted along the proposed dike centreline.
- m= metre; m² = square metre; m³ = cubic metre; CSB = cement soil bentonite.



A detailed breakdown of the total construction quantities, by construction season, is provided in Appendix E. Quantities presented have been rounded and therefore may not match exactly with the quantities in Appendix E.

11.3 Discussion

Turbidity Barriers

Depending on the construction season, between 4,000 and 11,000 linear metres of turbidity barriers are required to be installed, maintained, and removed during each summer. Overall, a total of 20,300 linear metres of turbidity barriers is required. The longest length of curtains to be installed is associated with construction in the summer of 2017, where up to 11,000 linear metres is required. The estimates provided do not account for reuse or the replacement of damaged barriers. The length of each curtain varies from 2 to 16 m based on water depth.

During the winter, large rockfill boulders will be placed on the ice surface for use as anchors for the turbidity barriers installed in the following summer's construction season.

Stripping of Dike Footprint

A total of 1,000 m³ of vegetation and topsoil is estimated to be stripped to tie the central trench into the south abutment, north abutment, and the large island located between Stations 1+900 and 2+300. For the purpose of the quantity estimate, it has been assumed that stripping will be carried out to a depth of 2 m.

Rockfill

The rockfill platform requires a total of 3,954,000 m³ of rockfill to be placed. Due to the construction method, a portion of rockfill is reused (approximately 526,000 m³); therefore, only 3,428,000 m³ of rockfill is required for the construction of the rockfill platform. Approximately 1,534,000 m³ of the rockfill is to be placed during the winter of 2016/2017.

In the summer of 2017, approximately 973,000 m³ of rockfill is required for the construction of the rockfill platform.

Central Trench Excavation and Backfilling

Excavation of the central trench for the shallow and intermediate sections requires the removal of a total of 1,012,000 m³ of rockfill and lakebed soils. In the shallow and intermediate sections, approximately 752,000 m³ of rockfill and 175,000 m³ of competent soil will be excavated to reach bedrock. In the deep sections, where the excavation method differs, roughly 60,000 m³ of lakebed sediment and 25,000 m³ of competent soil will be excavated. A breakdown of the excavation quantities by material type, per construction season are provided in Appendix E.

The central trench will be backfilled with 540,000 m³ of fine filter material and 763,000 m³ of coarse filter material following the completion of excavation.



Densification of Fine Filter

Vibro-densification will be required to compact the fine filter for the intermediate and deep sections where the base of the fine filter is below elevation 408 masl. Prior to vibro-densification, a small trench will be excavated into the coarse filter material immediately upstream and downstream of the fine filter along the dike crest. This trench will then be backfilled with fine filter, so that an 8 m width of fine filter exists where vibro-densification will be conducted. The placement of a total of 52,000 m³ of fine filter is estimated to be required in the trenches for the widening operation.

Overall, a total volume of 78,000 m³ of fine filter will be vibro-densified, of which 53,000 m³ will be vibro-densified during the summer of 2017. During the summers of 2016 and 2018, 13,000 m³ and 12,000 m³, respectively, are estimated to be vibro-densified.

The densification platform will be placed along the alignment. A total of 165,000 m³ of material is required to construct the platform consisting of fine filter, coarse filter, and rockfill. Approximately 55,000 m³ of each material type is required for the densification platform.

Dynamic compaction of the fine filter will be conducted over a total plan area of 26,000 m², of which roughly 14,000 m² will be completed during the summer of 2017.

Cut-off Wall

The slurry trench estimated total volume is 56,000 m³, of which 45,000 m³ will be excavated from the intermediate and deep sections. The quantity of bentonite slurry required to maintain a stable trench excavation is dependent on the gap between the excavation of the slurry trench and backfilling of the trench with CSB.

Approximately 56,000 m³ of till is required for the CSB backfill. In the summer of 2017, approximately 33,000 m³ of cut-off wall is to be constructed, with 10,000 m³ and 13,000 m³ estimated for the summers of 2016 and 2018, respectively. The CSB will be prepared in a batch plant.

Jet Grouting

Jet grouting activities will consist of approximately 800 jet grout holes. A total of approximately 15,000 linear metres of both down-the-hole hammer drilling and tricone reaming through the cut-off wall and foundation soils is anticipated. It is estimated that an approximate profile of 3,200 m² of jet grout columns will be constructed in the winter, summer, and shoulder seasons of 2018. It is anticipated that approximately 2,000 tonnes of cement will be required for jet grouting.

Curtain Grouting

Curtain grouting will consist of approximately 3,600 grout holes. Totals of approximately 48,000 linear metres of triconing, 51,000 linear metres of steel casing installation, and 36,000 linear metres of bedrock drilling are anticipated. It is anticipated that approximately 5,100 tonnes of Type HE cement and 300 tonnes of ultrafine cement will be required for the grouting. It is anticipated that approximately 8,200 hours will be spent on grouting of the CSB / jet grout / bedrock interface and 10,300 hours will be spent on near surface bedrock grouting over the span of the grouting works in 2016, 2017, and 2018.



12.0 CONSTRUCTION QUALITY ASSURANCE AND QUALITY CONTROL

A quality assurance (QA) / Quality Control (QC) plan is an integral part of the construction process to confirm the construction is to the specified quality, and that the owner has an assurance the structure has been constructed in accordance with the design intent. The QA/QC plan will be outlined in the technical specifications, completed as part of detailed design, and will be implemented by the contractor and engineer's representative.

A contractor experienced with the construction of zoned rockfill embankments and familiar with arctic conditions is to be used for the construction of Jay Dike. The contractor will be responsible for the QC of all work undertaken. The contractor will appoint a QC Manager to be responsible for checking the work as construction proceeds and aiding the contractor in completing the work in accordance with the design drawings and technical specifications.

A QA Manager will be present on site during construction, representing the engineer, and be responsible for all QA monitoring and testing. The QA Manager will be responsible for approving aspects of the work as compliant with the drawings and specifications and for capturing the intent of the design. The work will be inspected regularly to confirm that the conditions encountered during construction are consistent with the conditions assumed in the design. Daily reporting will be carried out to document the progress of the work and will form part of the as-built documentation.

The QA/QC plan will cover the following activities carried out during construction:

- All fill materials will be inspected for quality prior to and during placement to confirm they meet the technical specifications. An on-site materials testing laboratory will be established to analyze materials at regular intervals according to the frequencies and testing standards specified.
- The work will be laid out in the field by a qualified surveyor, according to the set out points and information shown in the construction drawings. The survey layout will be checked in the field by the QA Manager for any errors or omissions before proceeding with construction activities.
- The turbidity curtain will be inspected to confirm it remains undamaged and correctly anchored over the entire summer construction period. Water quality testing will be carried out during summer construction.
- Water quality testing will be carried out during winter construction. The rate of winter rockfill placement will be varied such that turbidity measurements meet criteria.
- Central trench excavation will be inspected to confirm that it is founded on bedrock or target surface and that the elevation of the excavation is accurately recorded. When founded on bedrock, it needs to be confirmed that the base of the trench is continuously founded on bedrock, so that all lakebed soils have been removed, and that the bedrock surface, along the alignment of the cut-off wall is relatively smooth. When the base of the excavation is terminated at a target elevation, it needs to be confirmed that the elevation is achieved across the width of the trench, and the engineer's representative is satisfied with the soil at the base of the trench is competent. The excavation will be monitored regularly, and an engineer's representative will visually observe the equipment working on the base of the excavation. A detailed bathymetric survey of the trench, verified with dip tape and rod sounding measurements, will be conducted and approved by the QA Manager before backfill is placed.



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- Fine filter and coarse filter are placed within the central trench are to be monitored to confirm that they are in accordance with the drawings and in a manner to minimize segregation of materials.
- Placement of additional fine filter for intermediate and deep sections is required, so that vibro-densification can be carried out. Placement will be monitored and surveyed.
- Placement of the densification platform is to be monitored to confirm that it is constructed to the lines and grades indicated in the construction drawings.
- Densification of the fine filter will be monitored to confirm that it is carried out to the extent required in order for the slurry trench to be successfully excavated to the bedrock or target surface and that the CSB cut-off wall can be constructed.
- A slurry trench specialist will be employed by the contractor for the cut-off wall construction to supervise the excavation, slurry preparation, CSB preparation, and backfill and to perform QC testing.
- Measurements of the density of the prepared slurry placed in the trench will be monitored.
- The base of the slurry trench will be surveyed to verify that it has reached bedrock or the target surface. The engineer's representative will confirm and approve the base of the excavation before CSB backfill is placed. The CSB material will be sampled and tested for QC/QA following frequencies identified in the technical specifications. Testing will include permeability and unconfined compression testing. The location and slope of the CSB backfill placed within the trench will be surveyed, as a minimum, at the beginning of each shift.
- During jet hole pre-drilling, observations will be recorded related to the type of material encountered, extent of the CSB cut-off wall, relative density, flush return, presence of boulders or cobbles, depth to bedrock, quality of the bedrock, hole connections, and any other relevant information. Additionally, penetration rates, down thrust pressures, rod torque, rotation rates, and drilling fluid pressures will be recorded via a drilling parameter recorder. Hole orientation surveys will be carried out to full depth.
- During jet grouting, starting depths and the height to which jet grouting is to be pulled will be monitored on a hole-by-hole basis to confirm that minimum overlaps of 0.5 m and 1.0 m are achieved into bedrock and across the CSB cut-off wall, respectively. Additionally, a real-time data acquisition system will be monitored and recorded for parameters such as time, depth, withdrawal/insertion and rotation speed of the jet grouting string, grout pressures, flow rates and volumes, and mast inclination. The specific gravity of the grout mix will be determined and recorded in real time at the batch plant with confirmatory manual measurements via mud balance. Jet grout spoils will be collected for unconfined compressive strength testing.
- Post-jet grouting, probe holes will be drilled on centreline through the CSB and jet grout columns within the jet grouted zones. The drilling parameter recorder will be utilized for comparative purposes to pre-jet grouting conditions to note the improved conditions beneath the CSB cut-off wall. During subsequent steel casing installation for curtain grouting, hydraulic conductivity testing will be carried out within open triconed holes in the jet-grouted materials by either air-lifting standing water from the hole or filling the hole with water and measuring the recovering/falling water level.



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- During triconing and subsequent casing installation for curtain grouting, measurements will be recorded for as-built hole locations, depths to bedrock, final installed casing lengths and depths, observed communication to adjacent casings, flush return losses and observation of drilling resistance, and noted presence of any cobbles, boulders, and/or very soft materials lying above bedrock.
- During bedrock and interface grouting operations, quality of the grout mix will be maintained by producing mixes in as repeatable a manner as possible. This will be monitored by regularly sampling the mixed grout and carrying out measurements of Marsh funnel apparent viscosity, density, bleed, temperature, and resistance to pressure filtration. Real-time monitoring of the injection process will be carried out using a grout monitoring system. The set-up will allowed for supervision of the grouting and real-time control of grouting parameters (flow rate, pressure, penetrability, and injected volume), timely mix thickening decisions, and the detection of jacking (or fracturing) of the ground.
- The progress of all grouting activities, which are key to scheduling, daily planning, and determining the need for additional, higher order grout holes, will be monitored daily. Following the completion of primary, secondary, and tertiary grouting in each work area, requirements for quaternary order grout holes will be specified based on grout takes and water pressure testing results. Curtain closure will be assessed on an ongoing basis.
- The contractor will provide suitable qualified technicians familiar with the instrumentation and installation procedures. The contractor will provide the instrumentation, supporting equipment and software, and operating manuals, and demonstrate to the owner's representative that the instrumentation has been properly installed.



13.0 JAY DIKE CLOSURE AND RECLAMATION

The overall goal for the Closure and Reclamation Plan for the Ekati Mine is to return the affected areas to viable, and wherever practicable, self-sustaining ecosystems that are compatible with a healthy environment and with human activities. The preliminary closure and reclamation activities are based on the approved Interim Closure and Reclamation Plan prepared by BHP Billiton Canada Inc. (BHP Billiton 2011). The Ekati Mine has adopted a progressive reclamation policy; reclamation will begin as early as possible, starting with areas no longer needed for mine operations. Reclamation is scheduled to continue throughout the life of the mine. This policy will continue to be applied for the Jay Project.

Golder (2014h) presents a conceptual closure and reclamation plan for the Jay Project, including the Jay Dike. The closure concept for the Jay Dike is shown in Drawing 300-70 (Appendix A). During closure, the isolated and dewatered portion of Lac du Sauvage will gradually be back-flooded and the water quality will be monitored. Once adequate water quality is demonstrated, local breaches through the dike will be constructed.



14.0 PRE-FEASIBILITY DESIGN LIMITATIONS

The pre-feasibility design for the Jay Dike was completed using available information where possible as well as assumptions where additional information was required. Limitations of the pre-feasibility design are presented in the Sections 14.1 to 14.3.

14.1 Dike Alignment

The proposed dike alignment for the Jay Project was selected following areas with shallower water as much as possible and crossing islands where feasible, while maintaining a minimum setback from the pit crest. It is anticipated that bedrock elevation will likely be higher in areas with shallow water, and therefore more favourable for dike construction/operation as hydraulic gradient applied to the structure will be less.

Additional site investigations, carried out as part of later design stages, will be used to optimize and adjust the dike alignment, as required. The minimum setback from the pit will also be verified in later design stages by conducting additional geotechnical and geomechanical assessments to evaluate potential interactions between the pit and dike.

14.2 Dike Design

Foundation conditions for the pre-feasibility dike design were derived from data obtained from the 2013 bathymetry survey and 2014 geophysical surveys. These include material thickness of the lakebed sediments and competent soil, and depth to bedrock. In addition, average material properties for soil units and bedrock were derived from the 2014 winter geotechnical investigation program.

The foundation conditions and stratigraphy are based on the results of the 2014 geophysical surveys, which was calibrated with existing boreholes along the centreline of the proposed dike alignment. Due to the limited number of existing boreholes, the quality of reflections obtained, and the potential for interference with reflectors, the accuracy of the interpreted stratigraphy between the boreholes is uncertain.

The derived foundation conditions primarily affect the following:

- the volume of construction material needed, which includes rockfill and crushed rockfill (fine and coarse filter);
- the volume of material to be excavated;
- the method of compaction for the fine filter material within the central trench;
- the length and depth of jet grouting zone; and,
- the depth of bedrock curtain grouting.



All of these have an effect on the cost of the construction and the timeline required to build the dike.

For the deeper sections, it is assumed that the granular core will be founded on a competent surface. Removal of the loose lakebed sediments will be required. The thickness of loose sediments is anticipated to be greater in deeper areas of the lake and further concentrated due to the placement of the upstream and downstream rockfill platforms. Optimal methods for the removal, which may be either mechanical excavation or dredging, will be evaluated in later design stages. At some locations this material may be left in place and additional treatment (e.g., jet grouting or grouting) to limit erosion of this zone when subjected to a hydraulic gradient may be required.

Other limitations of the pre-feasibility dike design include the following:

- The CSB cut-off wall mix design was assumed based on past experience. The mix design will need to be confirmed through a mix design trial and testing in a later design stage when sufficient till samples are available.
- The filter compatibility between the produced construction materials and lakebed soils has been preliminarily assessed based on the available information. Filter compatibility will need to be confirmed in a later design stage when additional samples of the lakebed soils and produced construction materials are available.
- Average material properties for the in situ materials were obtained from the results of the 2014 geotechnical investigation. The material properties for the in situ materials will need to be confirmed in a later design stage when additional investigation and samples are available, including in situ density.
- The crushed aggregates can consistently be produced to meet the specifications.
- Faults were encountered within two of the boreholes along the dike alignment. The effect these faults may have on the construction and operation of the dike will be evaluated during future design stages.
- The grout takes for curtain grouting were assumed based on limited hydraulic conductivity information for the bedrock and weathered bedrock zones. Additional hydraulic conductivity testing in discrete zones for the bedrock and weathered bedrock zones is required for future design stages.
- The depth of the grout curtain was assumed to be equal to the head acting on the base of the cut-off wall due to limited hydraulic conductivity information for the bedrock and weathered bedrock zones. Additional hydraulic conductivity testing in discrete zones for the bedrock and weathered bedrock zones is required for future design stages.
- The jet grouting hole spacing and grout takes were assumed based on past experience in similar conditions. These will be confirmed or altered during the trial at the outset of the works.

Further geotechnical investigations are recommended for future design stages to improve the understanding of the foundation conditions along the dike alignment, in particular the bedrock elevation and till thickness. This will refine the design of the dike, particularly as it relates to material quantities, construction schedule, and grouting requirements.



14.3 Construction Schedule

The dike construction has been identified as one of the critical components in the Jay Project schedule, as the dike completion is required for the start of dewatering and pit development. The current dike construction and dewatering schedule is presented in Section 10.0. The schedule assumes a start date of July 2016 for the in-lake dike construction activities.

The current schedule has been developed to complete the dike construction in as short a time frame as possible. The construction schedule assumes all required permits are in place prior to dike construction. No significant delays in the construction have been allowed for in the current schedule. Potential delays in the construction may, however, occur due to the following:

- extreme weather conditions, particularly during winter construction, which result in decreased productivity;
- environmental concerns, which include higher than allowable turbidity in Lac du Sauvage during construction;
- mobilization using the ice road;
- wildlife concerns, which include restricted access to work fronts due to the presence of wildlife;
- insufficient rockfill or filter material; and,
- breakdown in equipment, as a number of pieces of specialized equipment are required in the dike construction.

These items are to be addressed in a later design stage to limit the potential for delays in the dike construction.



15.0 RECOMMENDATIONS FOR FUTURE WORK

Several items for future work have been identified to advance the design of the Jay Dike through the feasibility and detailed design stages. The purpose of the work is to improve the understanding of the dike foundation conditions and to evaluate potential sources of materials for dike construction. Items proposed for future work are described below.

Evaluation of Foundation Conditions

- An underwater visual assessment comprising photographs and video of the lakebed surface should be carried out along the Jay Dike alignment. This will provide an indication of the number of cobbles and boulders visible on the lakebed surface.
- A cone penetration test (CPT) program should be carried out to better characterize the geotechnical parameters of the lakebed sediment and fine-grained competent soil. It is assumed that the CPT will reach refusal in the competent soil/till, due to the higher density and granular nature of this material. To perform CPTs in the fine-grained competent drill, pre-drilling through the granular competent soil may be required. The CPT data will be used to refine interpreted material thickness and assumed material properties. The CPTs can be carried in combination with the sonic drilling.
- Closely spaced bedrock profile drilling should be carried out to evaluate lakebed soil thickness and bedrock depth. An air track rotary percussive drill rig (i.e., Sandvik DX500, formerly known as the Tamrock Ranger 500) could be used to determine the depth of bedrock.
- Drilling and coring along the dike alignment should be carried out using a sonic drill rig in areas where air track drilling is not possible, which will generally be in intermediate and deeper zones, to obtain stratigraphic information and characterization of the underlying lakebed soils. As part of the drilling, downhole hydrogeological testing is to be carried out at select locations within the bedrock and select samples collected for geotechnical laboratory testing.
- Diamond drilling (HQ3, triple-tube system) should be carried out to characterize shallow bedrock and conduct hydrogeological testing (slug injection, slug withdrawal, and constant rate injection) in the bedrock using pneumatic packers. Testing would be carried out over shorter intervals of the shallow bedrock would be tested to characterize changes in the permeability of the shallow bedrock.
- Additional bedrock drilling could be conducted to assess or characterize the presence of bedrock structures with the potential to have higher hydraulic conductivity (i.e., faults).
- Installation of thermistor strings at select islands and abutments along the dike alignment is recommended. The data obtained from the thermistors will help to better understand the ground thermal profile changes with time.
- Geotechnical laboratory testing of samples collected during sonic drilling should be conducted.



Evaluation of Potential Construction Materials

- Sonic drilling and sampling should be performed within the proposed Lynx pit pre-stripping area. This material is intended to characterize and estimate the quantity and quality of competent soil material available. Representative samples of competent soil obtained from Lynx drilling will be used to carry out mix design testing for the CSB backfill.
- As an interim measure, mix design testing with competent soil obtained from stripping of the Pigeon Pit will be used for initial mix design testing.
- Crushed waste rock material should be evaluated for use as fine filter and coarse filter.

In support of the recommendations for future work, Golder has proposed to Dominion Diamond a winter 2015 geotechnical and hydrogeological investigation program which includes borehole locations, drilling equipment, on-site field testing, instrumentation, and geotechnical laboratory testing for the Jay Dike and Lynx Pit pre-stripping projects. Refer to the draft Winter 2015 Jay Dike Geotechnical and Hydrogeological Investigation Program report for further details regarding the proposed investigation (Golder 2014i).

The results of the 2015 winter geotechnical investigation should be used to refine the interpreted stratigraphy along the dike alignment. Furthermore, the assumptions used in the pre-feasibility design analyses should be compared with the geotechnical investigation results and additional analyses be performed as necessary.



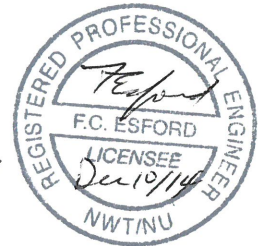
16.0 CLOSURE

We trust that this report meets your current requirements. Please do not hesitate to contact the undersigned if you require additional information.

GOLDER ASSOCIATES LTD.

Chad Mundle, P.Eng. (BC)
Geotechnical Engineer

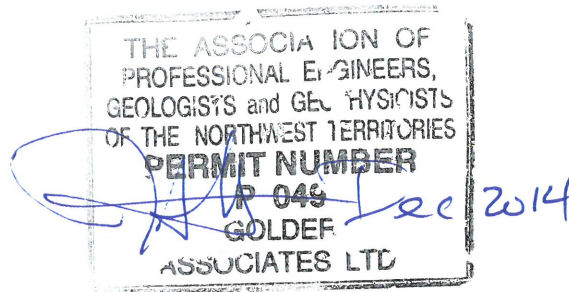
Fiona Esford, P.Eng.
Associate, Senior Geotechnical Engineer



John Cunning, P.Eng.
Principal, Senior Geotechnical Engineer

Ermanno Rambelli, P.Geo. (BC)
Associate, Senior Engineering Geologist
Project Manager

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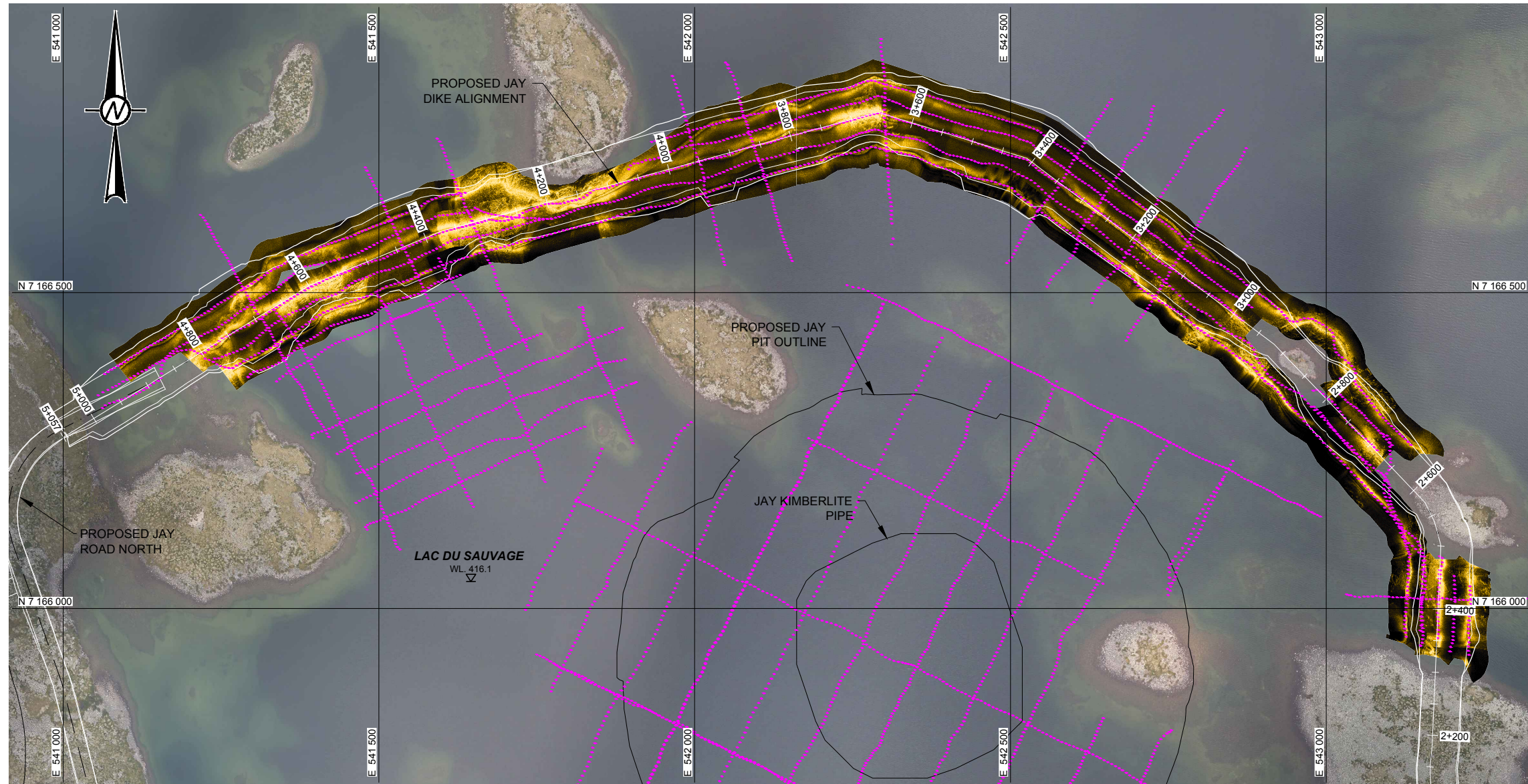
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
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JAY PROJECT PRE-FEASIBILITY DIKE DESIGN

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- LEGEND**
-  GEOPHYSICAL SURVEY LINES (SUB-BOTTOM PROFILE)
 -  SIDESCAN SONAR IMAGERY OF SOUTH DIKE. GENERALLY, BRIGHT, SPECKLED AREAS INDICATE SHALLOW BOULDER FIELDS

- NOTES**
1. ALL UNITS ARE IN METRES UNLESS OTHERWISE NOTED
 2. COORDINATES ARE SHOWN DATUM: NAD 83, PROJECTION: UTM ZONE 12.
 3. FIGURE TO BE READ IN CONJUNCTION WITH TECHNICAL MEMORANDUM E14063-TM-REV.0.

- REFERENCE**
1. ORTHOPHOTO PROVIDED BY AURORA GEOSCIENCES LTD. DATED: AUGUST 21, 2013.

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NOT FOR CONSTRUCTION



2014-12-03	ISSUED FOR PFS	FA	JD	CM	FE
2014-10-10	ISSUED FOR REVIEW	FA	JD	-	-
REV	DATE	DES	CADD	CHK	RWW



PROJECT
 DOMINION DIAMOND
 JAY PROJECT
 NORTHWEST TERRITORIES, CANADA

TITLE
 SIDESCAN SONAR MOSAIC
 - NORTH JAY DIKE

	PROJECT No.	13-1328-0041_2020.35	FILE No.	1313280041-2020-35-1	
	DESIGN	FA	2014-10-01	SCALE	AS SHOWN
	CADD	JD	2014-10-02	FIGURE	
	CHECK	CM	2014-12-03		
	REVIEW	FE	2014-12-03		
				1	



LEGEND

-  GEOPHYSICAL SURVEY LINES (SUB-BOTTOM PROFILE)
-  SIDESCAN SONAR IMAGERY OF SOUTH DIKE. GENERALLY, BRIGHT, SPECKLED AREAS INDICATE SHALLOW BOULDER FIELDS

NOTES

1. ALL UNITS ARE IN METRES UNLESS OTHERWISE NOTED
2. COORDINATES ARE SHOWN DATUM: NAD 83, PROJECTION: UTM ZONE 12.
3. FIGURE TO BE READ IN CONJUNCTION WITH TECHNICAL MEMORANDUM E14063-TM-REV.0.

REFERENCE

1. ORTHOPHOTO PROVIDED BY AURORA GEOSCIENCES LTD. DATED: AUGUST 21, 2013.


NOT FOR CONSTRUCTION

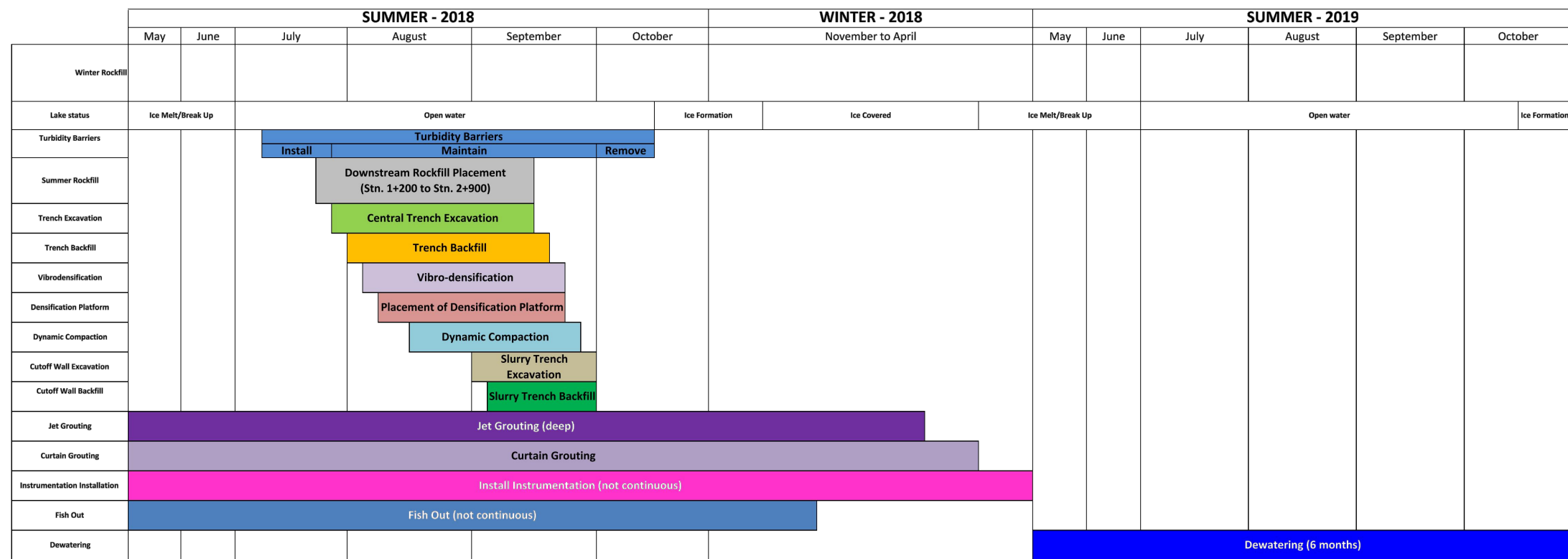
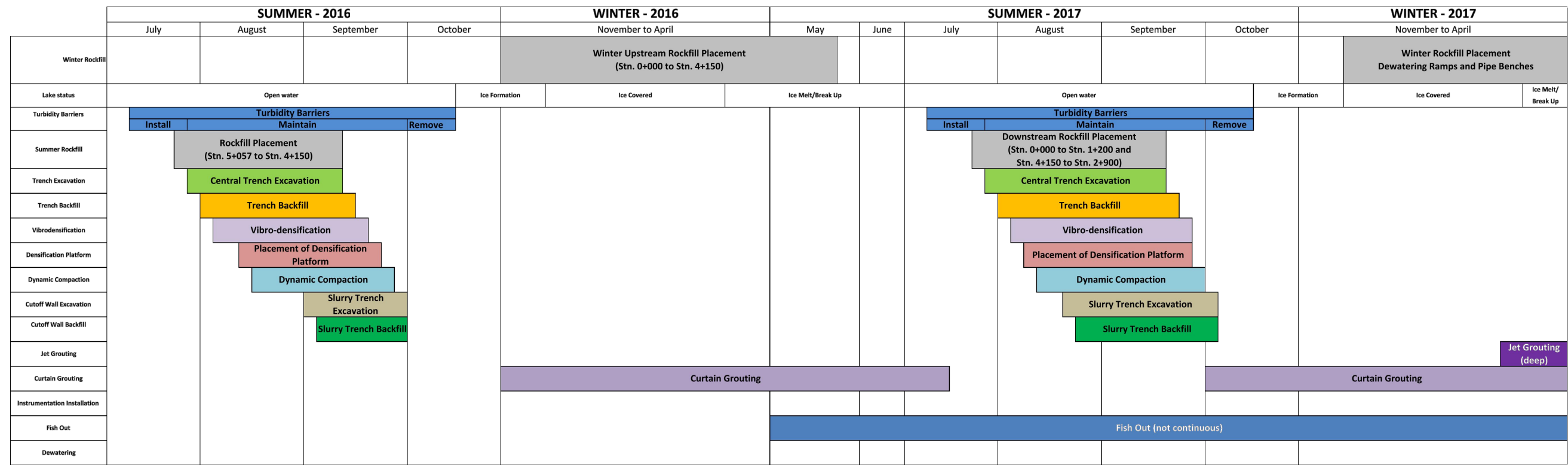


2014-12-03	ISSUED FOR PFS	FA	JD	CM	FE
2014-10-10	ISSUED FOR REVIEW	FA	JD	-	-
REV	DATE	DES	CADD	CHK	RWW

PROJECT  **DOMINION DIAMOND** JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE **SIDESCAN SONAR MOSAIC - SOUTH JAY DIKE**

	PROJECT No.	13-1328-0041_2020.35	FILE No.	1313280041-2020-35-2	
	DESIGN	FA	2014-10-01	SCALE	AS SHOWN
	CADD	JD	2014-10-02	FIGURE	
	CHECK	CM	2014-12-03		
	REVIEW	FE	2014-12-03		2



NOTE

- FIGURE TO BE READ IN CONJUNCTION WITH TECHNICAL MEMORANDUM E14063-TM-REV.0.

NOT FOR CONSTRUCTION

2014-12-03	ISSUED FOR PFS	FA	JD	CM	FE
2014-10-10	ISSUED FOR REVIEW	FA	JD	-	-
REV	DATE	DES	CADD	CHK	RVW
PROJECT		JAY PROJECT NORTHWEST TERRITORIES, CANADA			
TITLE		JAY DIKE CONSTRUCTION AND DEWATERING SCHEDULE			
PROJECT No. 13-1328-0041.2020.35		FILE No. 1313280041-2020-35-3			
DESIGN	FA	2014-09-30	SCALE AS SHOWN		
CADD	JD	2014-09-30	FIGURE		
CHECK	CM	2014-12-03	3		
REVIEW	FE	2014-12-03			

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APPENDIX A

Pre-feasibility Design Drawings

DOMINION DIAMOND CORPORATION

JAY PROJECT

NORTHWEST TERRITORIES, CANADA

PRE-FEASIBILITY DESIGN DRAWINGS

DRAWING INDEX			
DWG. NO.	DRAWING TITLE	REVISION	REVISION DATE
100-1	TITLE SHEET AND PROJECT LOCATION PLAN	0	2014-12-03
100-2	GENERAL LOCATION PLAN	B	2014-10-15
200-1	CONSTRUCTION AND DEWATERING ROAD PLAN	0	2014-10-10
200-2	OPERATION ROAD PLAN	0	2014-10-10
200-3	ACCESS ROAD AND PIPE BENCH TYPICAL DETAILS	0	2014-10-10
300-1	DIKE ALIGNMENT PLAN LAYOUT	0	2014-12-03
300-2	2014 INVESTIGATION BOREHOLE LOCATIONS AND GEOPHYSICAL SURVEY LINES	0	2014-12-03
300-4	BEDROCK GEOLOGY	0	2014-12-03
300-5	CENTERLINE STRATIGRAPHIC PROFILE (1 OF 2)	0	2014-12-03
300-6	CENTERLINE STRATIGRAPHY PROFILE (2 OF 2)	0	2014-12-03
300-10	TYPICAL DIKE SECTIONS	0	2014-12-03
300-11	CONSTRUCTION SEQUENCE SHALLOW AND INTERMEDIATE SECTIONS (1 OF 2)	0	2014-12-03
300-12	CONSTRUCTION SEQUENCE SHALLOW AND INTERMEDIATE SECTIONS (2 OF 2)	0	2014-12-03
300-13	CONSTRUCTION SEQUENCE DEEP SECTIONS (1 OF 4)	0	2014-12-03
300-14	CONSTRUCTION SEQUENCE DEEP SECTIONS (2 OF 4)	0	2014-12-03
300-15	CONSTRUCTION SEQUENCE DEEP SECTIONS (3 OF 4)	0	2014-12-03
300-16	CONSTRUCTION SEQUENCE DEEP SECTIONS (4 OF 4)	0	2014-12-03
300-22	CONSTRUCTION SUMMER 2016	0	2014-12-03
300-23	SUMMER 2016 CUT-OFF WALL PROFILE	0	2014-12-03
300-24	CONSTRUCTION WINTER 2016/2017	0	2014-12-03
300-25	CONSTRUCTION SUMMER 2017	0	2014-12-03
300-26	SUMMER 2017 CUT-OFF WALL PROFILE	0	2014-12-03
300-27	CONSTRUCTION SUMMER 2018	0	2014-12-03
300-28	SUMMER 2018 CUT-OFF WALL PROFILE	0	2014-12-03
300-50	GROUTING WORK AREAS	0	2014-12-03
300-51	GROUTING DETAILS	0	2014-12-03
300-52	CURTAIN GROUTING SEQUENCE	0	2014-12-03
300-63	INSTRUMENTATION TYPICAL DIKE SECTIONS (1 OF 2)	0	2014-12-03
300-64	INSTRUMENTATION TYPICAL DIKE SECTIONS (2 OF 2)	0	2014-12-03
300-70	CLOSURE PLAN	0	2014-12-03
400-1	SUB-BASIN B DIVERSION CHANNEL SITE PLAN	1	2014-10-10
400-2	SUB-BASIN B DIVERSION CHANNEL PLAN AND PROFILE	1	2014-10-10
400-3	CULVERTS & DISCHARGE STRUCTURES TYPICAL SECTIONS	1	2014-10-10
500-1	PUMPING SYSTEMS PROCESS FLOW DIAGRAM DEWATERING AND OPERATIONS	B	2014-10-08
500-2	GENERAL ARRANGEMENT DEWATERING AND OPERATIONS	B	2014-10-08
500-3	DETAILED ARRANGEMENT DEWATERING AND OPERATIONS	B	2014-10-08
500-4	PIPELINE PROFILE SECTIONS A TO C	B	2014-10-08
500-5	PIPELINE PROFILE SECTIONS D AND E	B	2014-10-08
500-6	PIPELINE PROFILE SECTION F	B	2014-10-08
500-7	PUMP BARGE TYPICAL DETAILS	B	2014-10-08
500-8	SUMP PUMP TYPICAL DETAILS	B	2014-10-08
600-1	OVERALL SITE PLAN	0	2014-10-10
600-2	JAY WASTE ROCK STORAGE AREA PLAN	0	2014-10-10
600-3	JAY WASTE ROCK STORAGE AREA TYPICAL CROSS-SECTIONS	0	2014-10-10



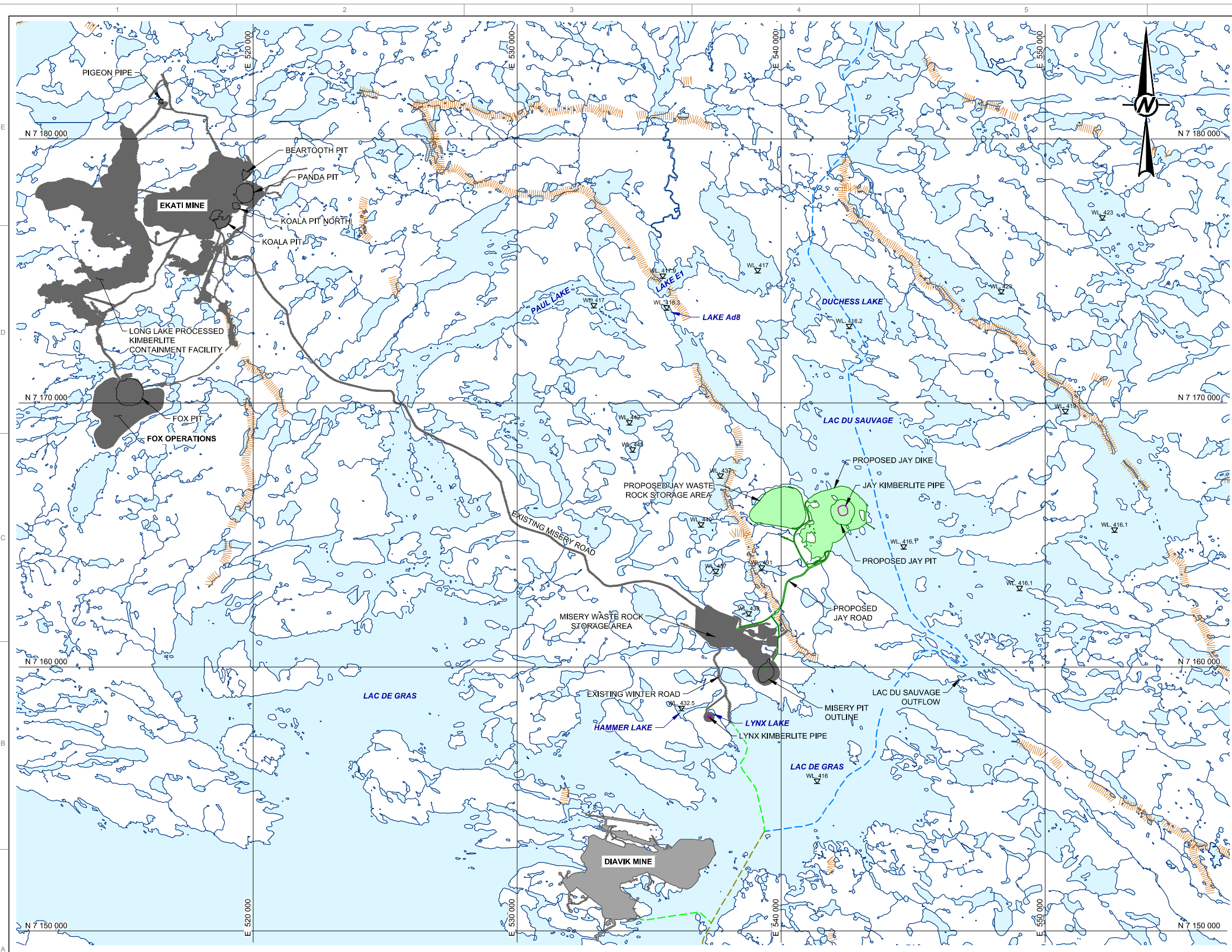
PROJECT LOCATION PLAN
SCALE: NTS

Refer to the overall project pre-feasibility report for the 400, 500, and 600 series drawings.
(Jay Project Pre-feasibility Level Design and Construction Cost Estimate, Reference No.: 1313280041-E14072-R-Rev0-2060)

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CONSULTANT 		TITLE TITLE SHEET AND PROJECT LOCATION PLAN																										
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SHEET SIZE ANSI D 25 mm																												

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LEGEND

- WATERBODY
- WATERCOURSE
- NORTHERN PORTION OF TIBBITT TO CONTWOYTO WINTER ROAD
- TIBBITT TO CONTWOYTO WINTER ROAD
- WINTER ROAD
- APPROXIMATE ESKER
- KIMBERLITE PIPE LOCATION
- WATER LEVEL ELEVATION
- PROPOSED JAY FOOTPRINT
- EKATI MINE FOOTPRINT
- DIAVIK MINE FOOTPRINT

NOTES

1. ALL UNITS ARE IN METRES UNLESS OTHERWISE NOTED.
2. ELEVATIONS ARE IN METRES ABOVE SEA LEVEL.
3. COORDINATES ARE SHOWN IN DATUM: NAD 83, PROJECTION: UTM ZONE 12.

REFERENCES

1. JAY PIPE LOCATION RECEIVED FROM DOMINION DIAMOND CORPORATION, FILE: jay_kimberlite_pipe_OL.dxf, DATED: JULY 19, 2013.
2. LYNX PIPE LOCATION RECEIVED FROM DOMINION DIAMOND CORPORATION, FILE: lynx_polyline.dxf, DATED: JUNE 25, 2013.



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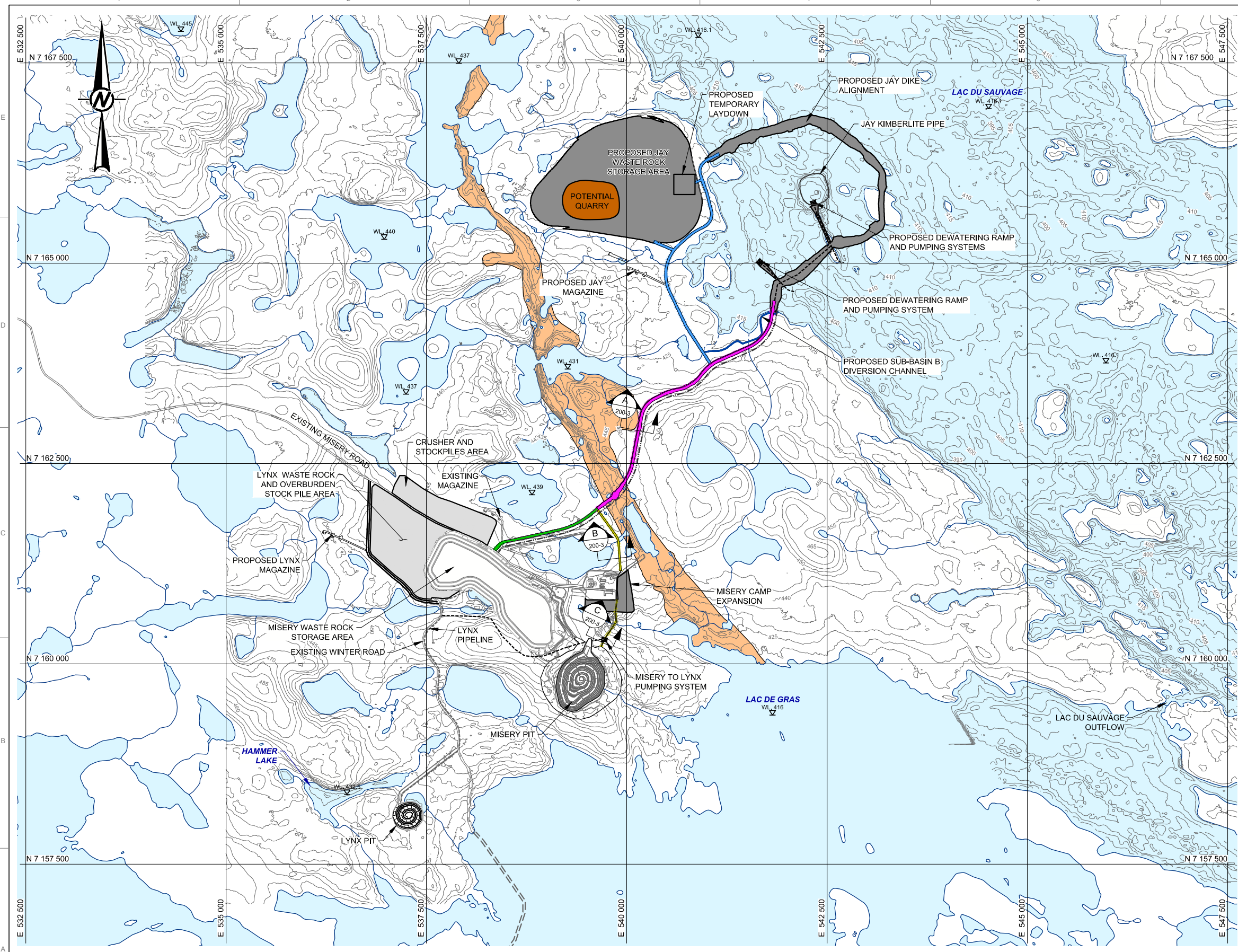
ISSUED FOR REVIEW
DRAFT

CLIENT

CONSULTANT

PROJECT	13-1328-0041.2060.10	
	JAY PROJECT NORTHWEST TERRITORIES, CANADA	
TITLE	GENERAL LOCATION PLAN	
DRAWING No.	100-2	SHEET No. 2 OF 2
SHEET SIZE ANSI D 25 mm		

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LEGEND

- WATERBODY
- WATERCOURSE
- ROAD
- WINTER ROAD - YEARLY CONSTRUCTION
- PROPOSED PUMPING SYSTEM
- PROPOSED POWER LINE
- WATER LEVEL ELEVATION
- ESKER (APPROXIMATE)

- JAY PROJECT FOOTPRINT**
- PROPOSED SUB-BASIN B DIVERSION CHANNEL
 - PROPOSED JAY PROJECT INFRASTRUCTURE
 - PROPOSED JAY ROAD NORTH (HAUL ROAD)
 - PROPOSED JAY ROAD (HAUL ROAD AND POWER LINE)
 - PROPOSED JAY ROAD (HAUL ROAD, PIPELINE AND POWER LINE)
 - PROPOSED JAY PIPELINE ROAD (ACCESS ROAD AND PIPELINE)
 - POTENTIAL QUARRY

- LYNX PROJECT FOOTPRINT**
- LYNX PROJECT INFRASTRUCTURE

NOTES

1. ELEVATIONS ARE IN METERS ABOVE SEA LEVEL (masl).
2. GROUND SURFACE AND BATHYMETRY CONTOURS ARE SHOWN AT 5 m INTERVALS.
3. COORDINATES ARE SHOWN IN DATUM: NAD 83, PROJECTION: UTM ZONE 12.
4. POTENTIAL QUARRY MAY BE REQUIRED WITHIN THE FOOTPRINT OF THE PROPOSED JAY WASTE ROCK STORAGE AREA.
5. LOCATION OF WILDLIFE CROSSINGS ALONG THE ROAD ALIGNMENT ARE NOT SHOWN. WILDLIFE CROSSING LOCATIONS TO BE FINALIZED DURING FUTURE STAGES OF DESIGN BASED ON EXISTING CARIBOU TRAIL MAPPING AND DISCUSSIONS DURING COMMUNITY ENGAGEMENT.
6. DRAWING TO BE READ IN CONJUNCTION WITH TECHNICAL MEMORANDUM E14031-TM-REV.0.

REFERENCES

1. CONTOUR AND BATHYMETRIC DATA PROVIDED BY AURORA GEOSCIENCES LTD., FILE: Final 1m Contours - Priority Area.dxf, DATE RECEIVED: OCTOBER 29, 2013.
2. WATER OBTAINED FROM CANVEC NATURAL RESOURCES CANADA, 2012.
3. JAY PIPE LOCATION RECEIVED FROM DOMINION DIAMOND CORPORATION, FILE: jay_kimberlite_pipe_OL.dxf, DATED: JULY 19, 2013.



REV	DATE	DESCRIPTION	DRW	DES	CHK	RWW
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SEAL / PERMIT
NOT FOR CONSTRUCTION

CLIENT
DOMINION DIAMOND

CONSULTANT
Golder Associates




PROJECT
13-128-0041.2020.20
**JAY PROJECT
NORTHWEST TERRITORIES, CANADA**

TITLE
**CONSTRUCTION AND DEWATERING
ROAD PLAN**

DRAWING No. **200-1** SHEET No. **1 OF 3**

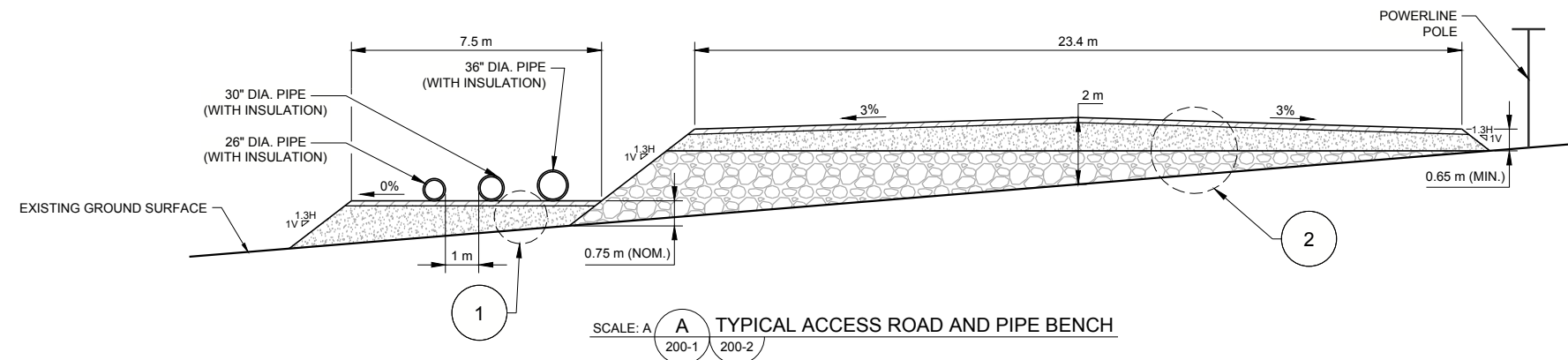
SHEET SIZE ANSI D 25 mm

LEGEND

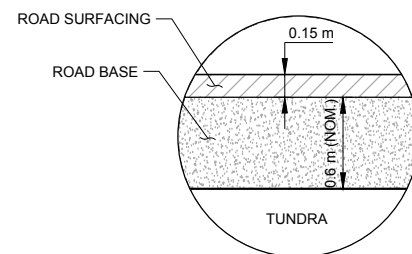
-  200 mm MINUS CRUSH (ROAD BASE)
-  56 mm MINUS FINE CRUSH (ROAD SURFACING)
-  ROCKFILL

NOTES

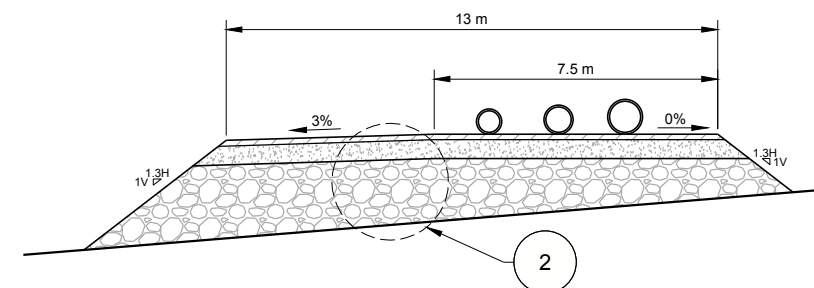
1. ALL UNITS IN METRES UNLESS OTHERWISE NOTED.
2. ELEVATION IN METRES ABOVE SEA LEVEL.
3. PIPE DIAMETER SHOWN INCLUDES 3" OF INSULATION.
4. BERM TO BE ADDED WHERE ROAD FILL THICKNESS EXCEEDS 3 m. MINIMUM OPERATION WIDTH TO BE MAINTAINED.
5. DRAWING TO BE READ IN CONJUNCTION WITH TECHNICAL MEMORANDUM E14031-TM-REV.0.



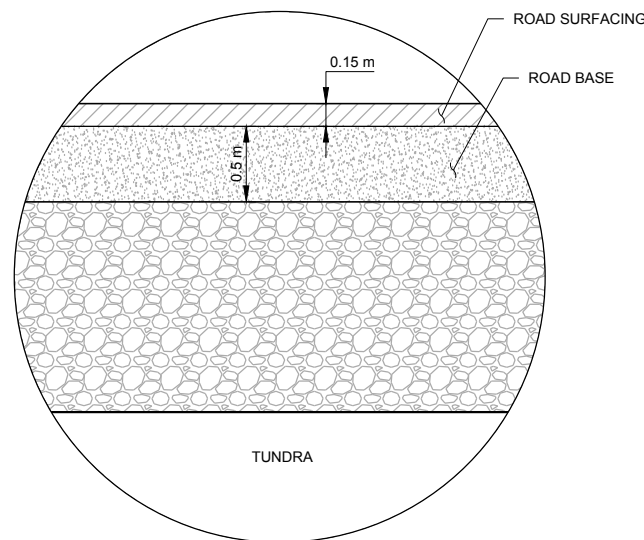
SCALE: A **A** TYPICAL ACCESS ROAD AND PIPE BENCH
200-1 200-2



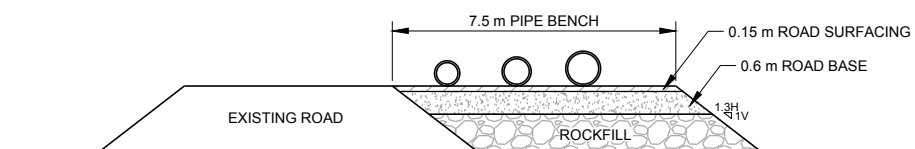
1 DETAIL 1 - TYPICAL PIPE BENCH MATERIAL PLACEMENT
SCALE: B



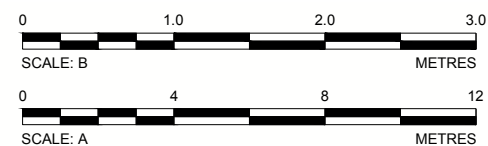
SCALE: A **B** TYPICAL JAY PIPELINE ROAD
200-1 200-2



2 DETAIL 2 - TYPICAL ACCESS ROAD MATERIAL PLACEMENT
SCALE: B



SCALE: A **C** TYPICAL JAY PIPELINE ROAD
200-1 200-2



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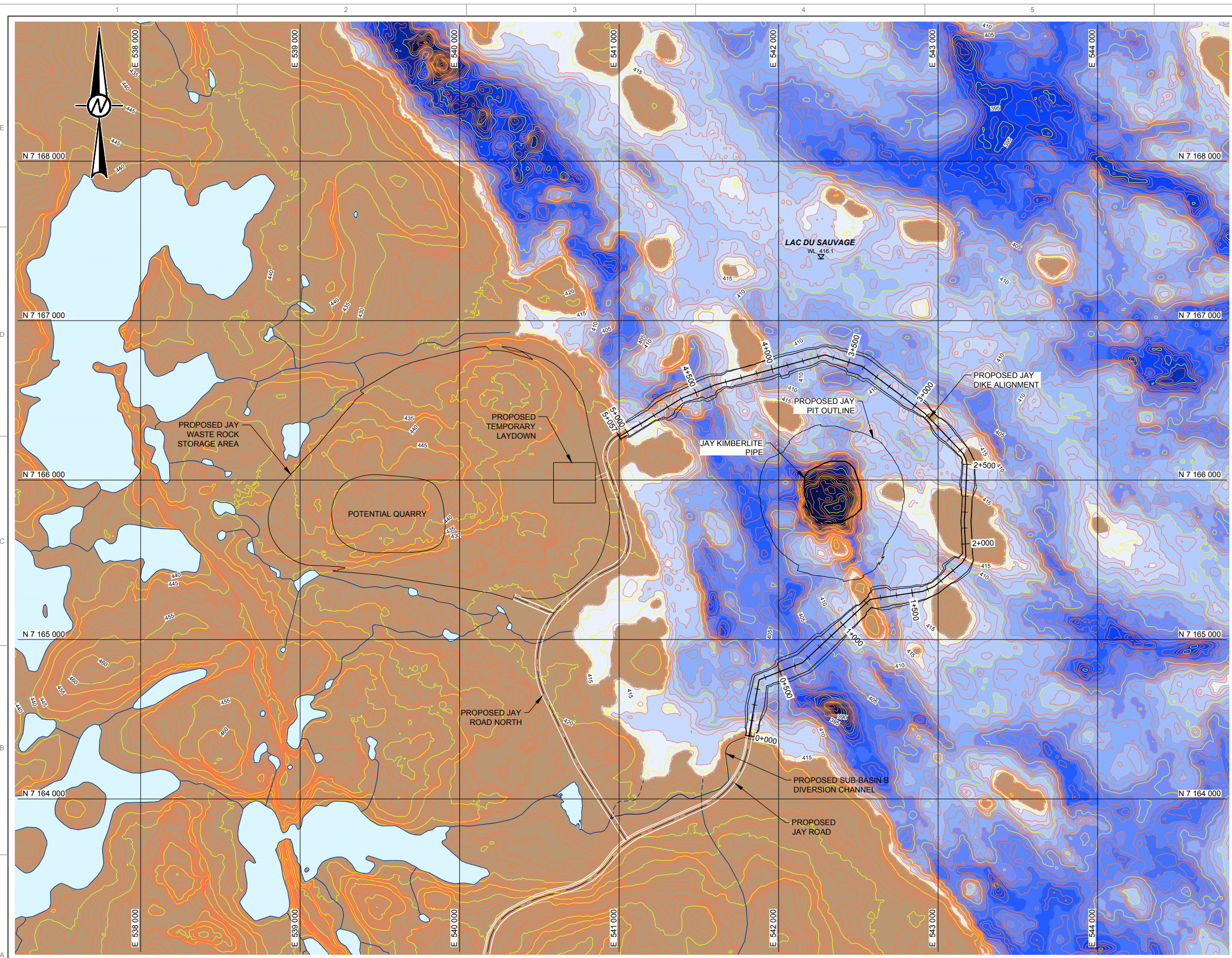
SEAL / PERMIT
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CLIENT
 DOMINION DIAMOND

CONSULTANT
 Golder Associates

PROJECT	13-1328-0041.2020.20
JAY PROJECT NORTHWEST TERRITORIES, CANADA	
TITLE	ACCESS ROAD AND PIPE BENCH TYPICAL DETAILS
DRAWING No.	200-3
SHEET No.	3 OF 3

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LEGEND

- WATERBODY
- WATERCOURSE
- DIVERTED NATURAL RUNOFF FLOW
- WATER LEVEL ELEVATION

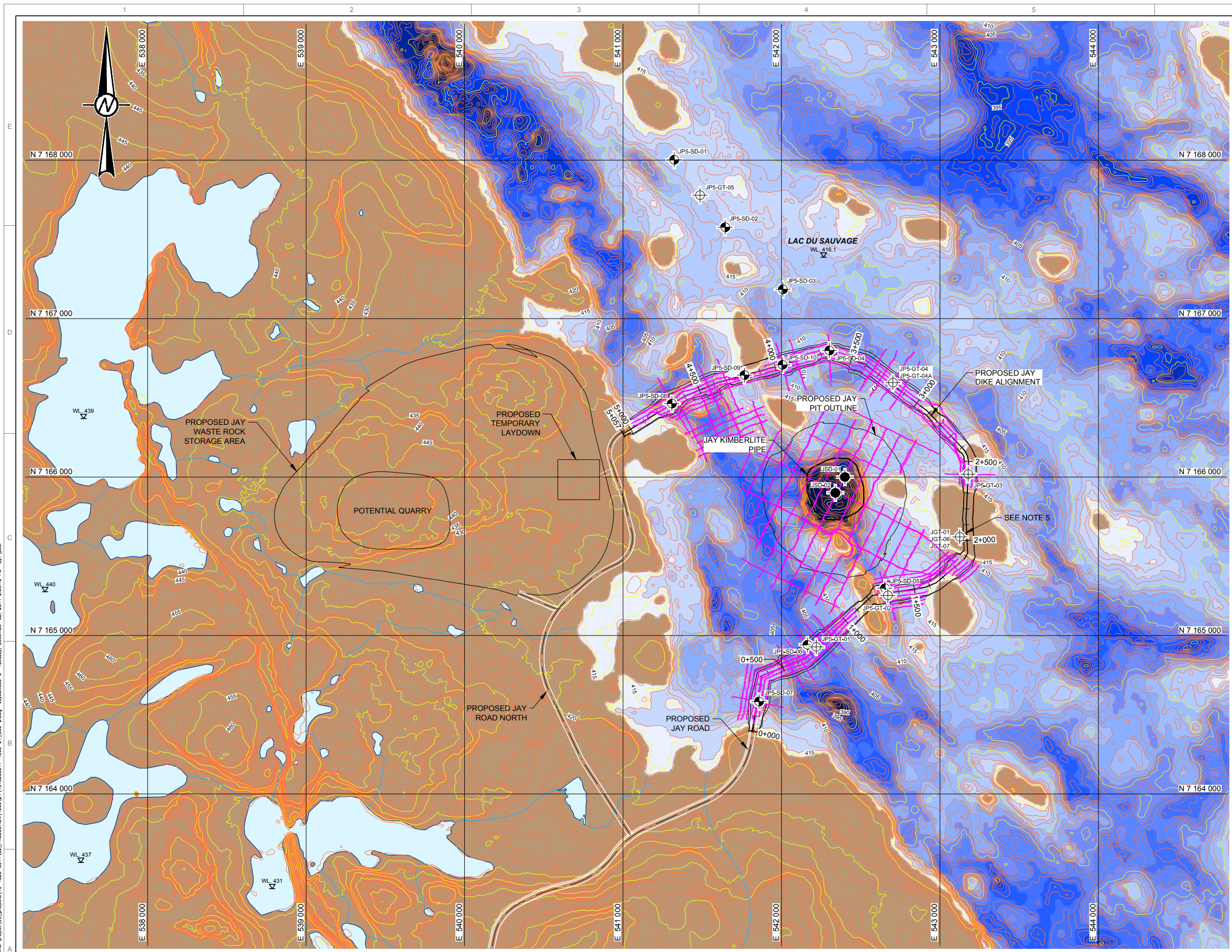
- NOTES**
- ALL UNITS IN METRES UNLESS OTHERWISE NOTED.
 - ELEVATION IN METRES ABOVE SEA LEVEL.
 - GROUND SURFACE AND BATHYMETRY CONTOURS ARE SHOWN AT 1 m INTERVALS.
 - COORDINATES ARE SHOWN IN DATUM: NAD 83, PROJECTION: UTM ZONE 12.
 - DRAWING TO BE READ IN CONJUNCTION WITH REPORT E14069-R-REV.0.

- REFERENCES**
- CONTOUR AND BATHYMETRIC DATA PROVIDED BY AURORA GEOSCIENCES LTD., FILE: Final 1m Contours - Priority Area.dxf, DATE RECEIVED: OCTOBER 29, 2013.
 - WATER OBTAINED FROM CANVEC NATURAL RESOURCES CANADA, 2012.
 - JAY PIT MODEL: GOLDR ASSOCIATES LTD., 2014. DOMINION DIAMOND JAY PIT - PRE-FEASIBILITY MINE DESIGN STUDY. SUBMITTED TO DOMINION DIAMOND EKATI CORPORATION, DATED OCTOBER 7, 2014. REFERENCE NO: 1313280041-E14065-R-Rev0-2020. (FILE NAME: pit_v6_OL.dxf)
 - JAY PIPE LOCATION RECEIVED FROM DOMINION DIAMOND CORPORATION, FILE: jay_kimberlite_pipe_OL.dxf, DATED: JULY 19, 2013.

WATER DEPTH TABLE			
DEPTH RANGE	COLOR	MINIMUM DEPTH (m)	MAXIMUM DEPTH (m)
1		0	2
2		2	4
3		4	6
4		6	8
5		8	10
6		10	12
7		12	14
8		14	16
9		16	18
10		18	20
11		20	22
12		22	24
13		24	26
14		26	28
15		28	40



<p>SEAL / PERMIT</p> <p>NOT FOR CONSTRUCTION</p>	<p>CLIENT</p>	<p>PROJECT 13-1328-0041.2020.35</p> <p style="text-align: center;">JAY PROJECT NORTHWEST TERRITORIES, CANADA</p>
<p>0 2014-12-03 ISSUED FOR PFS JD FA CM FE</p> <p>B 2014-10-15 ISSUED FOR REVIEW JD FA - -</p> <p>REV DATE DESCRIPTION DRW DES CHK RVW</p>	<p>CONSULTANT</p>	<p>TITLE</p> <p style="text-align: center;">DIKE ALIGNMENT PLAN LAYOUT</p>
<p>SCALE 0 500 1,000 1,500 METRES</p>		<p>DRAWING No. 300-1 SHEET No. 1 OF 25</p> <p style="text-align: right;">SHEET SIZE ANSI D 25 mm</p>



LEGEND

- WATERBODY
- WATERCOURSE
- WATER LEVEL ELEVATION
- GEOPHYSICAL SURVEY LINES (SUB-BOTTOM PROFILE)
- SONIC DRILL HOLE LOCATION (AURORA)
- SONIC DRILL HOLE LOCATION
- DIAMOND DRILL HOLE LOCATION

- ### NOTES
- ALL UNITS ARE IN METRES UNLESS OTHERWISE NOTED.
 - ELEVATIONS ARE IN METRES ABOVE SEA LEVEL.
 - GROUND SURFACE AND BATHYMETRY CONTOURS ARE SHOWN AT 1 m INTERVALS.
 - COORDINATES ARE SHOWN IN DATUM: NAD 83, PROJECTION: UTM ZONE 12.
 - SHALLOW THERMISTOR INSTALLED IN JGT-07, DEEP THERMISTOR INSTALLED IN JGT-01, AND WESTBAY MULTIPIPT WELL INSTALLED IN JGT-06. ONLY ONE BOREHOLE LOCATION IS SHOWN FOR SIMPLICITY.
 - AURORA GEOSCIENCES LTD DRILLED TWO SONIC HOLES IN PIT AREA. OTHER DIAMOND DRILLED HOLE LOCATIONS IN PIT AREA NOT SHOWN.
 - DRAWING TO BE READ IN CONJUNCTION WITH REPORT E14069-R-REV.0.

- ### REFERENCES
- CONTOUR AND BATHYMETRIC DATA PROVIDED BY AURORA GEOSCIENCES LTD., FILE: Final 1m Contours - Priority Area.dxf, DATE RECEIVED: OCTOBER 29, 2013.
 - WATER OBTAINED FROM CANVEC NATURAL RESOURCES CANADA, 2012.
 - JAY PIT MODEL: GOLDR ASSOCIATES LTD., 2014. DOMINION DIAMOND JAY PIT - PRE-FEASIBILITY MINE DESIGN STUDY. SUBMITTED TO DOMINION DIAMOND EKATI CORPORATION, DATED OCTOBER 7, 2014. REFERENCE NO: 1313280041-E14065-R-Rev0-2020. (FILE NAME: pit_v6_OL.dxf).
 - BOREHOLE AS-BUILT SURVEY PROVIDED BY AURORA GEOSCIENCES LTD. RECEIVED ON APRIL 22, 2014.
 - JAY PIPE LOCATION RECEIVED FROM DOMINION DIAMOND CORPORATION, FILE: jay_kimberlite_pipe_OL.dxf, DATED: JULY 19, 2013.

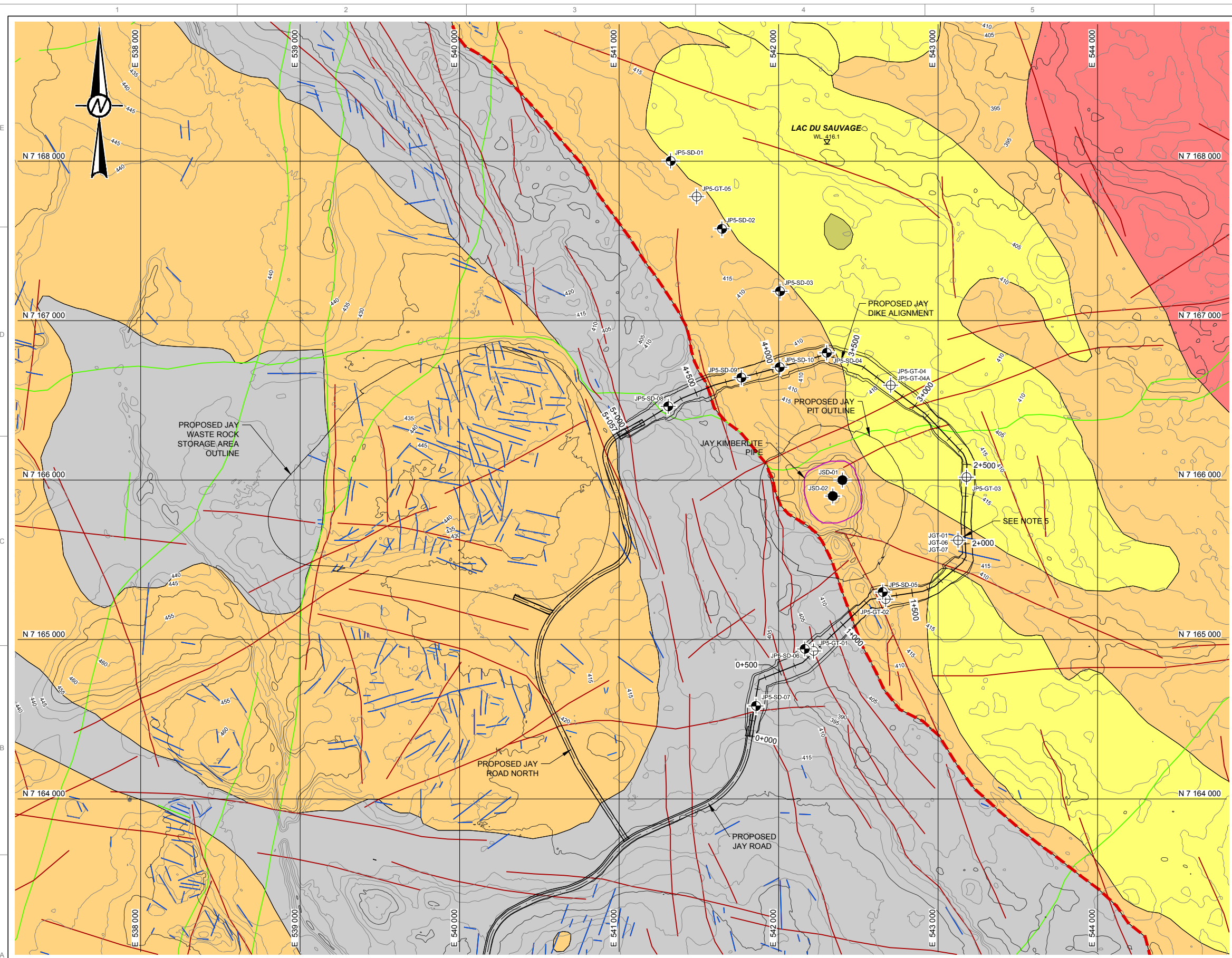
WATER DEPTH TABLE			
DEPTH RANGE	COLOR	MINIMUM DEPTH (m)	MAXIMUM DEPTH (m)
1		0	2
2		2	4
3		4	6
4		6	8
5		8	10
6		10	12
7		12	14
8		14	16
9		16	18
10		18	20
11		20	22
12		22	24
13		24	26
14		26	28
15		28	40

Drawing File: H:\Client\dominion diamond\jpr-cardinal project\jpr_cardinal project\jpr_projects\13-1328-0041\02_PRODUCTION\406021\1313280041-4060-21_300-2.dwg Layout:300-2 Tuesday, December 02, 2014 2:39:12 PM By: jdel



SEAL / PERMIT NOT FOR CONSTRUCTION	CLIENT 	PROJECT 13-1328-0041.2020.35 JAY PROJECT NORTHWEST TERRITORIES, CANADA																					
<table border="1" style="width: 100%; font-size: small;"> <tr> <td>0</td> <td>2014-12-03</td> <td>ISSUED FOR PFS</td> <td>JD</td> <td>FA</td> <td>CM</td> <td>FE</td> </tr> <tr> <td>B</td> <td>2014-10-15</td> <td>ISSUED FOR REVIEW</td> <td>JD</td> <td>FA</td> <td>-</td> <td>-</td> </tr> <tr> <td>REV</td> <td>DATE</td> <td>DESCRIPTION</td> <td>DRW</td> <td>DES</td> <td>CHK</td> <td>RVW</td> </tr> </table>	0	2014-12-03	ISSUED FOR PFS	JD	FA	CM	FE	B	2014-10-15	ISSUED FOR REVIEW	JD	FA	-	-	REV	DATE	DESCRIPTION	DRW	DES	CHK	RVW	CONSULTANT 	TITLE 2014 INVESTIGATION BOREHOLE LOCATIONS AND GEOPHYSICAL SURVEY LINES DRAWING No. 300-2 SHEET No. 2 OF 25 SHEET SIZE ANSI D 25 mm
0	2014-12-03	ISSUED FOR PFS	JD	FA	CM	FE																	
B	2014-10-15	ISSUED FOR REVIEW	JD	FA	-	-																	
REV	DATE	DESCRIPTION	DRW	DES	CHK	RVW																	

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LEGEND

- ROAD
- SONIC DRILL HOLE LOCATION (AURORA)
- SONIC DRILL HOLE LOCATION
- DIAMOND DRILL HOLE LOCATION
- DYKES
- FAULTS
- STRUCTURALLY CONTROLLED CONTACT
- JOINTS
- JAY KIMBERLITE PIPE
- METASEDIMENTS
- PORPHYRITIC BIOTITE GRANITE
- TONALITE
- TWO MICA GRANITE
- UNDEFINED

- ### NOTES
1. ALL UNITS ARE IN METRES UNLESS OTHERWISE NOTED.
 2. ELEVATIONS ARE IN METRES ABOVE SEA LEVEL.
 3. GROUND SURFACE AND BATHYMETRY CONTOURS ARE SHOWN AT 1 m INTERVALS.
 4. COORDINATES ARE SHOWN IN DATUM: NAD 83, PROJECTION: UTM ZONE 12.
 5. SHALLOW THERMISTOR INSTALLED IN JGT-07, DEEP THERMISTOR INSTALLED IN JGT-01, AND WESTBAY MULTIPOINT WELL INSTALLED IN JGT-06. ONLY ONE BOREHOLE LOCATION IS SHOWN FOR SIMPLICITY.
 6. DRAWING TO BE READ IN CONJUNCTION WITH REPORT E14069-R-REV.0.

- ### REFERENCES
1. CONTOUR AND BATHYMETRIC DATA PROVIDED BY AURORA GEOSCIENCES LTD., FILE: Final 1m Contours - Priority Area.dxf, DATE RECEIVED: OCTOBER 29, 2013.
 2. JAY PIT MODEL: GOLDER ASSOCIATES LTD., 2014. DOMINION DIAMOND JAY PIT - PRE-FEASIBILITY MINE DESIGN STUDY. SUBMITTED TO DOMINION DIAMOND EKATI CORPORATION, DATED OCTOBER 7, 2014. REFERENCE NO: 1313280041-E14065-R-Rev0-2020. (FILE NAME: pit_v6_OL.dxf).
 3. BOREHOLE AS-BUILT SURVEY PROVIDED BY AURORA GEOSCIENCES LTD. RECEIVED ON APRIL 22, 2014.
 4. JAY PIPE LOCATION RECEIVED FROM DOMINION DIAMOND CORPORATION, FILE: jay_kimberlite_pipe_OL.dxf, DATED: JULY 19, 2013.
 5. BEDROCK GEOLOGY INTERPRETED BY GOLDER BASED ON DATA FROM MINERAL SERVICES CANADA INC., 2002 AND AURORA GEOSCIENCES LTD., 2013.



REV	DATE	DESCRIPTION	DRW	DES	CHK	RVW
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B	2014-10-15	ISSUED FOR REVIEW	JD	FA	-	-

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NOT FOR CONSTRUCTION

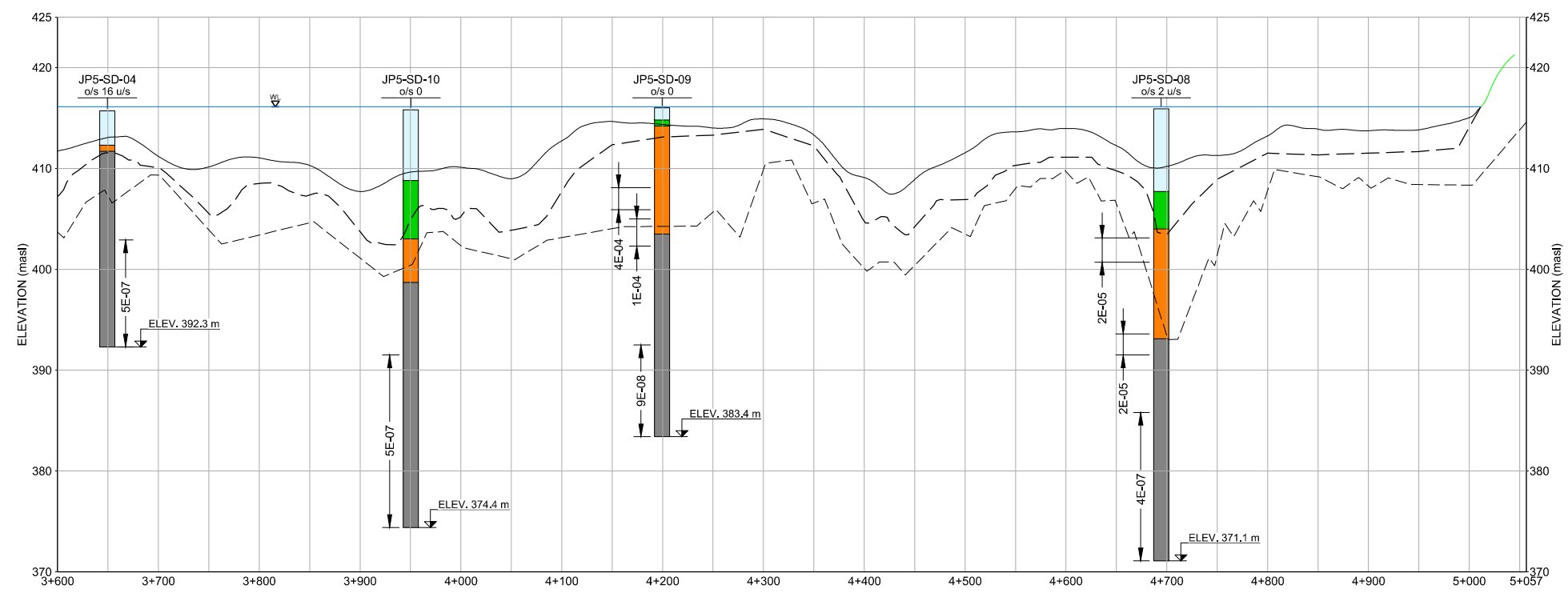
CLIENT
 DOMINION DIAMOND

CONSULTANT
 Golder Associates

PROJECT 13-1328-0041.2020.35
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
BEDROCK GEOLOGY

DRAWING No. 300-4 SHEET No. 3 OF 25
SHEET SIZE ANSI D 25 mm



STATION 3+600 TO 5+057
VERTICAL EXAGGERATION 10X

- LEGEND**
- LAKE LEVEL (416.1 masl)
 - TOPOGRAPHY SURFACE
 - LAKEBED SURFACE
 - INFERRED COMPETENT SOIL SURFACE
 - INFERRED BEDROCK SURFACE

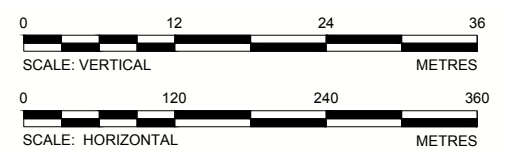
- W/L
- LAKE WATER
- SEDIMENT
- COMPETENT SOIL
- SOIL (SEE NOTE 3)
- BEDROCK

IN SITU HYDRAULIC CONDUCTIVITY TEST RESULTS (m/s)

- JP5-SD-01 SONIC DRILL HOLE
- JP5-GT-01 DIAMOND DRILL HOLE
- JTG-07
- o/s 2 u/s OFFSET 2 m UPSTREAM

- NOTES**
1. ALL UNITS IN METRES UNLESS OTHERWISE NOTED.
 2. ELEVATION IN METRES ABOVE SEA LEVEL.
 3. INFORMATION FROM DIAMOND DRILLING DOES NOT PROVIDE A DISTINCTION BETWEEN SEDIMENT AND COMPETENT SOIL MATERIAL.
 4. COMPETENT SOIL AND BEDROCK SURFACES INFERRED FROM 2014 GEOTECHNICAL INVESTIGATION AND 2014 GEOPHYSICS SURVEY.
 5. IN-SITU HYDRAULIC CONDUCTIVITY MEASURED FROM PACKER AND STAND PIPE PIEZOMETER TESTING.
 6. STRATIGRAPHY FOR JGT-01 AND JGT-06 OVERLAP WITH JGT-07 AND ARE NOT SHOWN FOR SIMPLICITY.
 7. DRAWING TO BE READ IN CONJUNCTION WITH REPORT E-14069-R-REV.0.

- REFERENCES**
1. SURFACE DATA PROVIDED BY AURORA GEOSCIENCES LTD., FILE: Final 1m Contours - Priority Area.dxf, DATE RECEIVED: OCTOBER 29, 2013.
 2. BOREHOLE AS-BUILT SURVEY PROVIDED BY AURORA GEOSCIENCES LTD. RECEIVED ON APRIL 22, 2014.



REV	DATE	DESCRIPTION	DRW	DES	CHK	RWW
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B	2014-10-15	ISSUED FOR REVIEW	JD	FA	-	-

SEAL / PERMIT
NOT FOR CONSTRUCTION

CLIENT
DOMINION DIAMOND

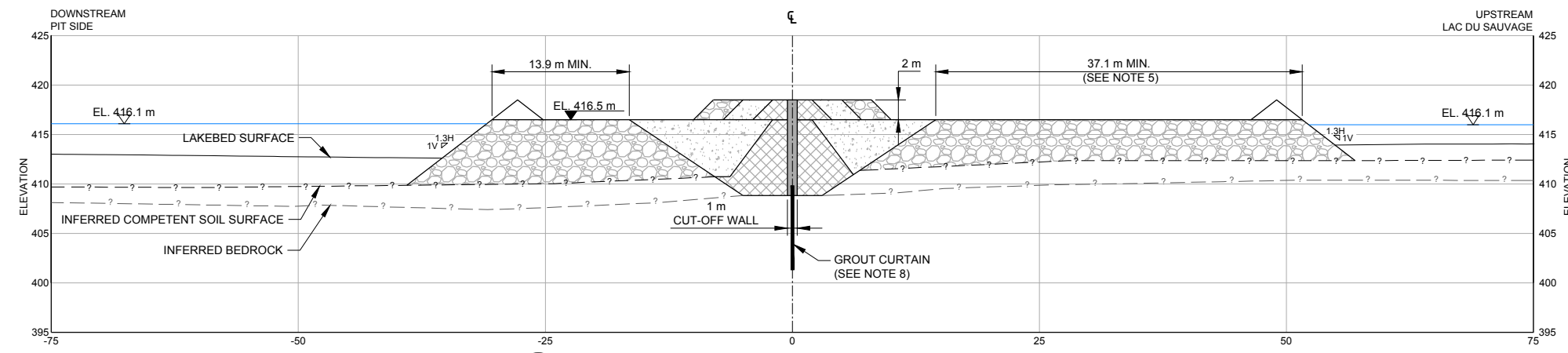
CONSULTANT
Golder Associates

PROJECT 13-1328-0041.2020.35
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

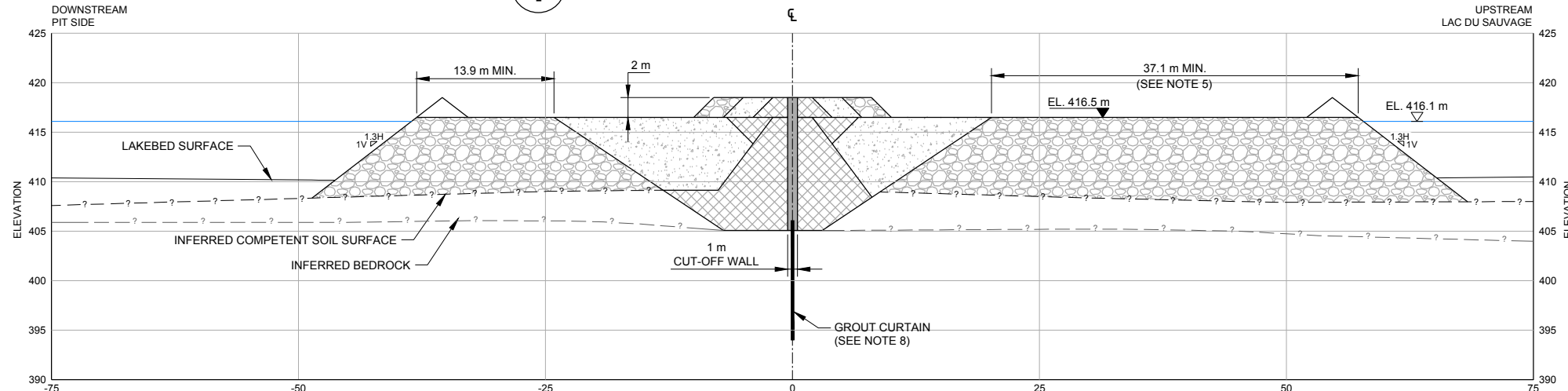
TITLE
CENTERLINE STRATIGRAPHY PROFILE
(2 OF 2)

DRAWING No. 300-6 SHEET No. 5 OF 25
SHEET SIZE ANSI D 25 mm

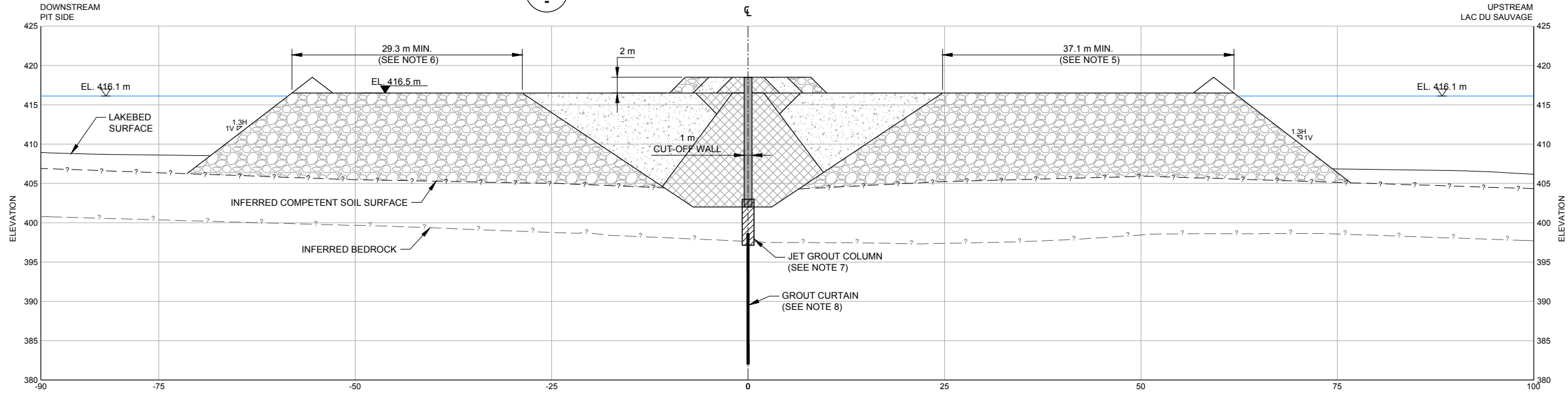
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1 SHALLOW SECTION - BEDROCK ABOVE 408 masl
SCALE: A



2 INTERMEDIATE SECTION - BEDROCK BETWEEN 408 AND 402 masl
SCALE: A



3 DEEP SECTION - BEDROCK BELOW 402 masl
SCALE: A

- LEGEND**
- COARSE FILTER
 - FINE FILTER
 - ROCKFILL
 - SAFETY BERM
 - CUT-OFF WALL (CEMENT SOIL BENTONITE)
 - JET GROUT COLUMN
 - GROUT CURTAIN
 - LAKE LEVEL
 - LAKEBED SURFACE
 - INFERRED COMPETENT SOIL SURFACE
 - INFERRED BEDROCK SURFACE

- NOTES**
1. ALL UNITS IN METRES UNLESS OTHERWISE NOTED.
 2. ELEVATION IN METRES ABOVE SEA LEVEL.
 3. COMPETENT SOIL AND BEDROCK SURFACES INFERRED FROM 2014 GEOTECHNICAL INVESTIGATION AND 2014 GEOPHYSICS SURVEY.
 4. UPSTREAM WIDTH OF 37.1 m IS REQUIRED TO ALLOW 2-WAY HAULAGE. DOWNSTREAM WIDTH OF 29.3 m IS REQUIRED FOR THE DOWNSTREAM SIDE OF THE DEEP SECTION TO ALLOW 1-WAY HAULAGE.
 5. A 23.4 m WIDE HAUL ROAD WILL BE MAINTAINED AT ALL TIMES.
 6. A 15.6 m WIDE HAUL ROAD WILL BE MAINTAINED AT ALL TIMES.
 7. JET GROUTING TO TIE INTO CUT-OFF WALL AND BEDROCK BY A MINIMUM OF 1.0 m AND 0.5 m RESPECTIVELY. LENGTH OF JET GROUT COLUMN VARIES BASED ON DEPTH TO BEDROCK.
 8. GROUT CURTAIN TO TIE INTO CUT-OFF WALL OR JET GROUTING BY A MINIMUM OF 1.0 m. DEPTH OF GROUT CURTAIN WILL VARY BASED ON HYDRAULIC HEAD AND ROCK QUALITY.
 9. DRAWING TO BE READ IN CONJUNCTION WITH REPORT E-14069-R-REV.0.



0	2014-12-03	ISSUED FOR PFS	JD	FA	CM	FE
B	2014-10-15	ISSUED FOR REVIEW	JD	FA	-	-
REV	DATE	DESCRIPTION	DRW	DES	CHK	RWW

SEAL / PERMIT
NOT FOR CONSTRUCTION

CLIENT
DOMINION DIAMOND

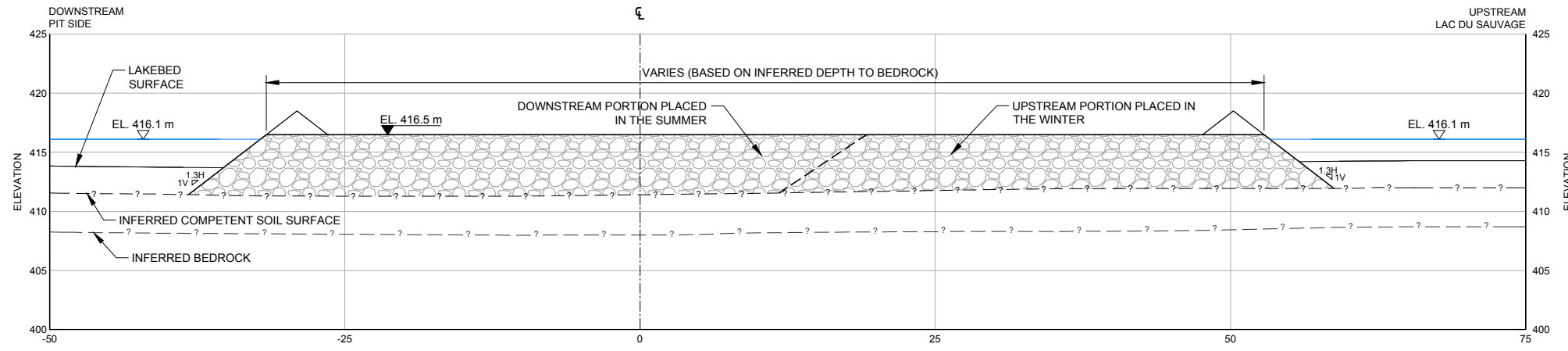
CONSULTANT
Golder Associates

PROJECT
13-1328-0041.2020.35
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

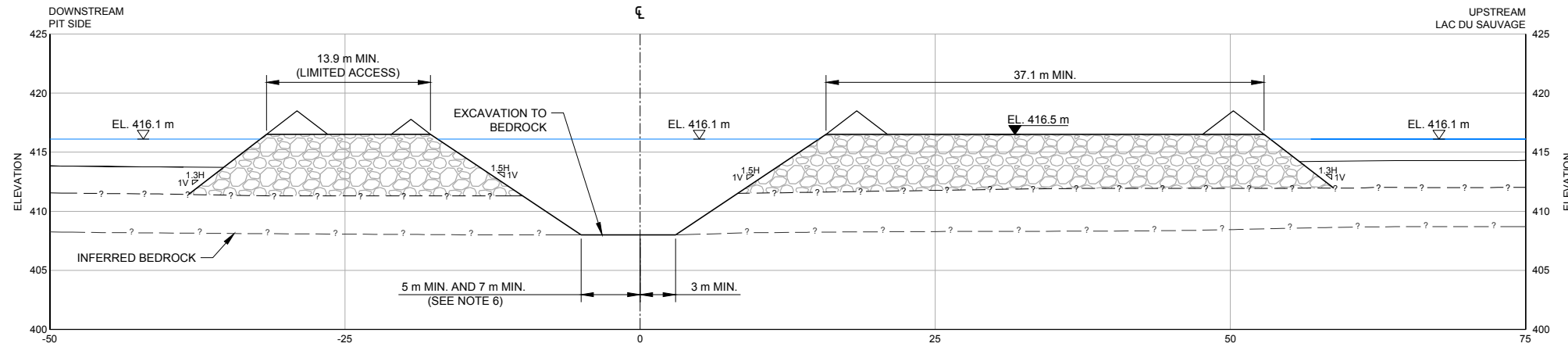
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TYPICAL DIKE SECTIONS

DRAWING No. **300-10** SHEET No. **6 OF 25**

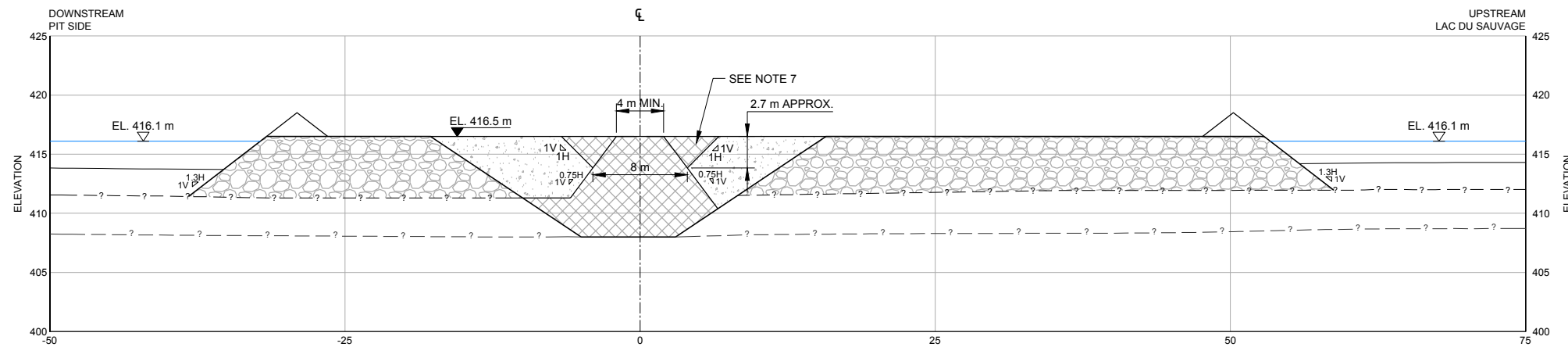
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A INITIAL ROCKFILL PLACEMENT SECTION
SCALE: A



B CENTRAL TRENCH EXCAVATION SECTION
SCALE: A



C FINE AND COARSE FILTER PLACEMENT SECTION
SCALE: A

- LEGEND**
- LAKE LEVEL
 - - - - - INFERRED BEDROCK SURFACE
 - LAKEBED SURFACE
 - - - - - INFERRED COMPETENT SOIL SURFACE
 - [Pattern] COARSE FILTER
 - [Pattern] FINE FILTER
 - [Pattern] ROCKFILL
 - △ SAFETY BERM

- NOTES**
1. ALL UNITS IN METRES UNLESS OTHERWISE NOTED.
 2. ELEVATION IN METRES ABOVE SEA LEVEL.
 3. UPSTREAM WIDTH OF 37.1 m IS REQUIRED TO ALLOW 2-WAY HAULAGE. DOWNSTREAM WIDTH OF 13.9 m PROVIDES LIMITED ACCESS TO THE DOWNSTREAM SHELL.
 4. COMPETENT SOIL AND BEDROCK SURFACES INFERRED FROM 2014 GEOTECHNICAL INVESTIGATION AND 2014 GEOPHYSICS SURVEY.
 5. WHERE POSSIBLE, THE UPSTREAM PORTION OF THE ROCKFILL SHELL IS PLACED IN THE WINTER PRIOR TO OTHER CONSTRUCTION ACTIVITIES TO ASSIST WITH TURBIDITY CONTROL DURING SUMMER CONSTRUCTION.
 6. MINIMUM DOWNSTREAM EXCAVATION BASE WIDTH FOR SHALLOW SECTION (BEDROCK ABOVE 408 masl) IS 5 m AND 7 m FOR INTERMEDIATE SECTION (BEDROCK BETWEEN 408 AND 402 masl).
 7. CONTINUOUS 8 m FINE FILTER CORE WIDTH NEEDED FOR INTERMEDIATE SECTIONS (BEDROCK BETWEEN 408 AND 402 masl).
 8. DRAWING TO BE READ IN CONJUNCTION WITH REPORT E14069-R-REV.0.

Drawing File: \\c:\client\dominion\dominion\project\13-1328-0041\02_PRODUCTION\13-1328-0041-0002-21_300-11.dwg Layout: 300-11 Tuesday, December 02, 2014 2:57:16 PM By: jhal



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B	2014-10-15	ISSUED FOR REVIEW		JD	FA	- -

SEAL / PERMIT
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CLIENT
DOMINION DIAMOND

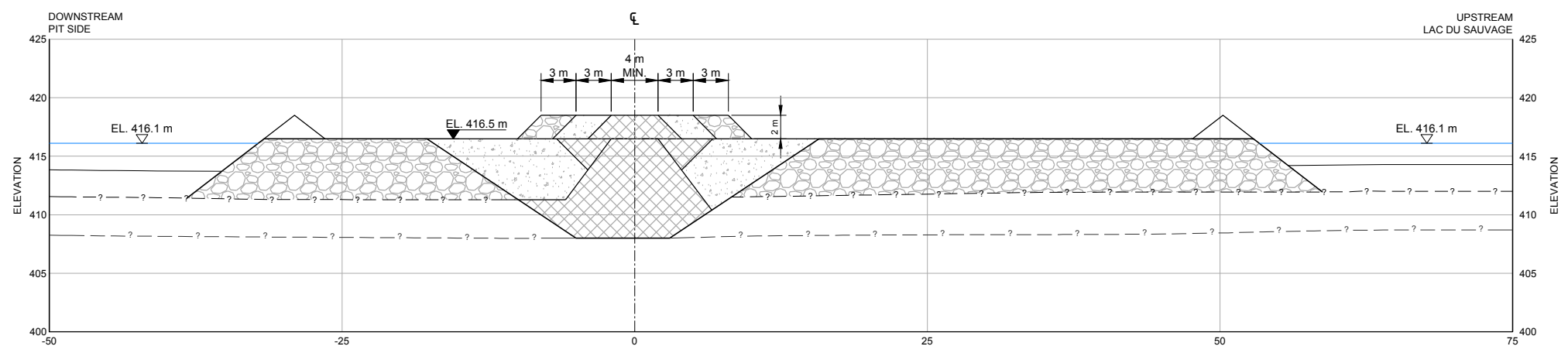
CONSULTANT
Golder Associates

PROJECT 13-1328-0041.2020.35
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

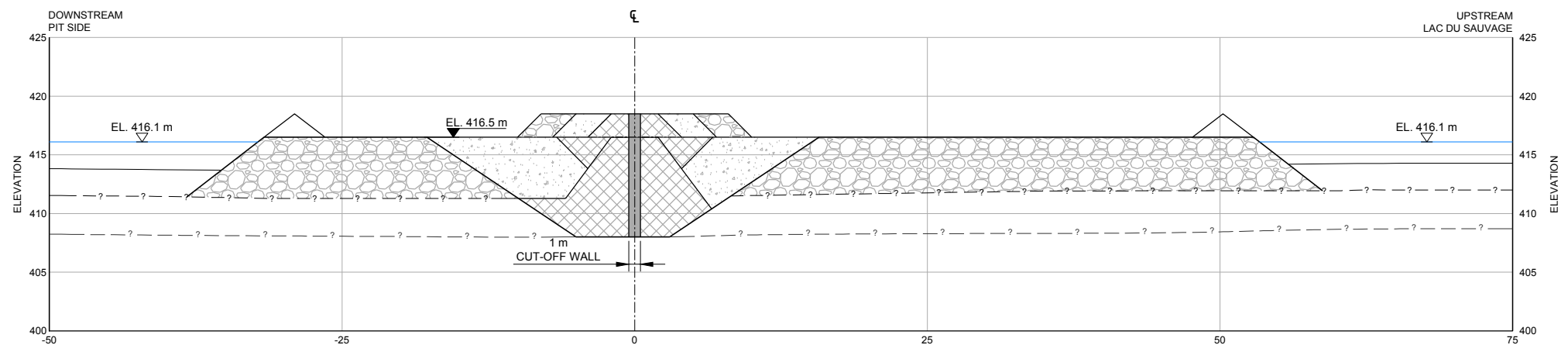
TITLE
CONSTRUCTION SEQUENCE
SHALLOW AND INTERMEDIATE SECTIONS
(1 OF 2)

DRAWING No. 300-11 SHEET No. 7 OF 25
SHEET SIZE ANSI D 25 mm

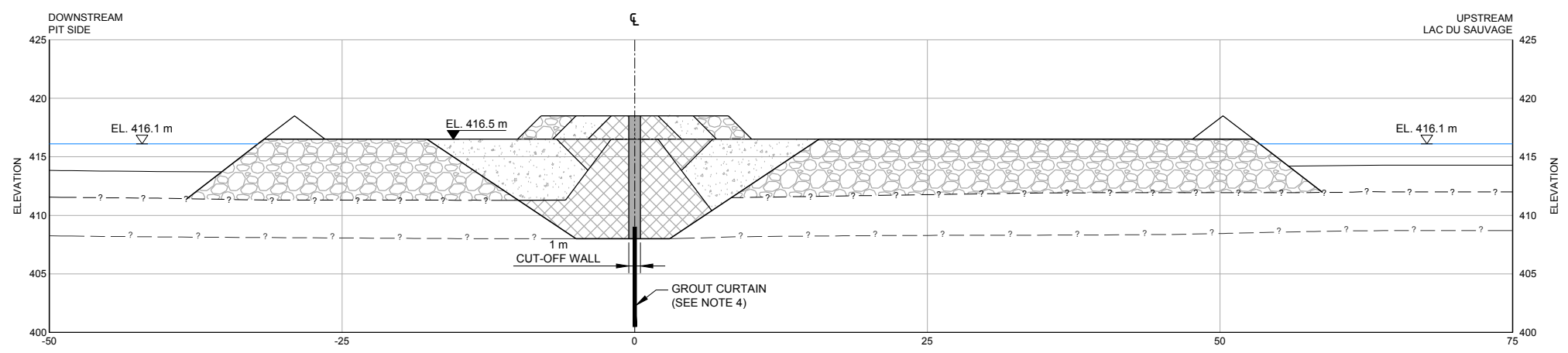
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D DENSIFICATION PLATFORM PLACEMENT SECTION
SCALE: A



E CUT-OFF WALL EXCAVATION AND PLACEMENT SECTION
SCALE: A



F CURTAIN GROUTING SECTION
SCALE: A

- LEGEND**
- LAKE LEVEL
 - - - - - INFERRED BEDROCK
 - - - - - LAKEBED SURFACE
 - - - - - INFERRED COMPETENT SOIL SURFACE
 - [Pattern] COARSE FILTER
 - [Pattern] FINE FILTER
 - [Pattern] ROCKFILL
 - [Symbol] SAFETY BERM
 - [Symbol] GROUT CURTAIN
 - [Symbol] CUT-OFF WALL (CEMENT SOIL BENTONITE)

- NOTES**
1. ALL UNITS IN METRES UNLESS OTHERWISE NOTED.
 2. ELEVATION IN METRES ABOVE SEA LEVEL.
 3. COMPETENT SOIL AND BEDROCK SURFACES INFERRED FROM 2014 GEOTECHNICAL INVESTIGATION AND 2014 GEOPHYSICS SURVEY.
 4. GROUT CURTAIN TO TIE INTO CUT-OFF WALL BY A MINIMUM OF 1 m.
 5. DRAWING TO BE READ IN CONJUNCTION WITH REPORT E14069-R-REV.0.



REV	DATE	DESCRIPTION	DRW	DES	CHK	RWW
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B	2014-10-15	ISSUED FOR REVIEW	JD	FA	-	-

SEAL / PERMIT
NOT FOR CONSTRUCTION

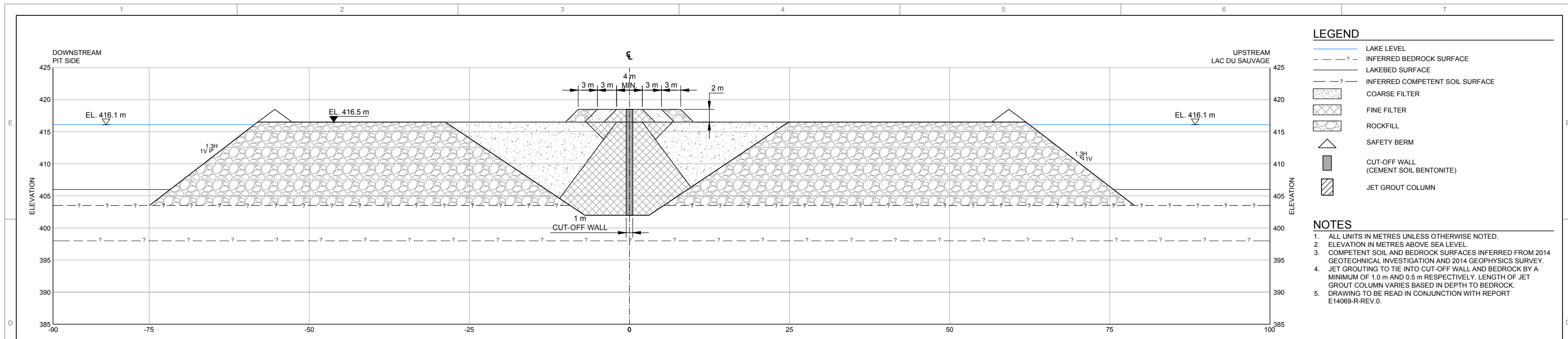
CLIENT
DOMINION DIAMOND

CONSULTANT
Golder Associates

PROJECT 13-1328-0041.2020.35
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
CONSTRUCTION SEQUENCE
SHALLOW AND INTERMEDIATE SECTIONS
(2 OF 2)

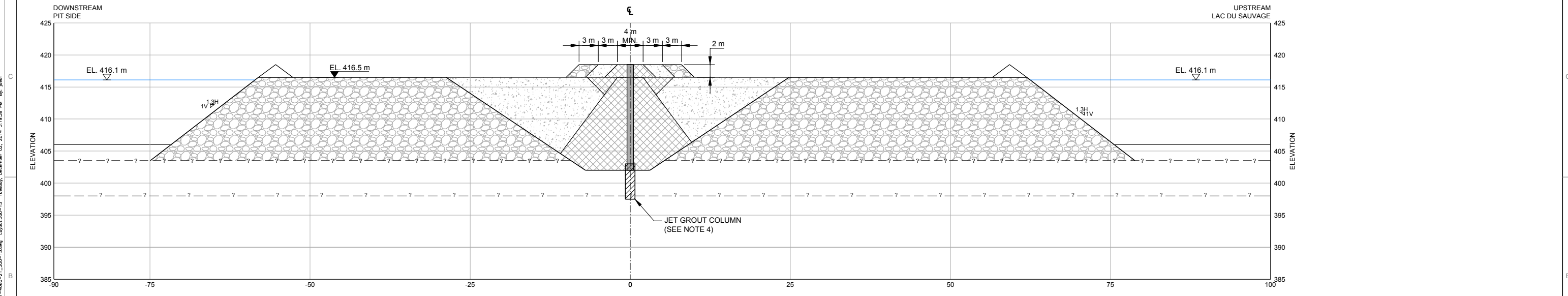
DRAWING No. 300-12 SHEET No. 8 OF 25
SHEET SIZE ANSI D 25 mm



E CUT-OFF WALL EXCAVATION AND PLACEMENT SECTION
SCALE: A

- LEGEND**
- LAKE LEVEL
 - - - ? - - INFERRED BEDROCK SURFACE
 - LAKEBED SURFACE
 - - - ? - - INFERRED COMPETENT SOIL SURFACE
 - [Pattern] COARSE FILTER
 - [Pattern] FINE FILTER
 - [Pattern] ROCKFILL
 - [Symbol] SAFETY BERM
 - [Symbol] CUT-OFF WALL (CEMENT SOIL BENTONITE)
 - [Symbol] JET GROUT COLUMN

- NOTES**
1. ALL UNITS IN METRES UNLESS OTHERWISE NOTED.
 2. ELEVATION IN METRES ABOVE SEA LEVEL.
 3. COMPETENT SOIL AND BEDROCK SURFACES INFERRED FROM 2014 GEOTECHNICAL INVESTIGATION AND 2014 GEOPHYSICS SURVEY.
 4. JET GROUTING TO TIE INTO CUT-OFF WALL AND BEDROCK BY A MINIMUM OF 1.0 m AND 0.5 m RESPECTIVELY. LENGTH OF JET GROUT COLUMN VARIES BASED IN DEPTH TO BEDROCK.
 5. DRAWING TO BE READ IN CONJUNCTION WITH REPORT E14069-R-REV.0.



F JET GROUTING SECTION
SCALE: A

Drawing File: H:\Client\dominion diamond\project\99_caribou\project\13-1328-0041\02_PRODUCTION\406021\1313280041-0002-21_300-15.dwg Layout:300-15 By: jleal



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B	2014-10-15	ISSUED FOR REVIEW	JD	FA	-	-

SEAL / PERMIT
NOT FOR CONSTRUCTION

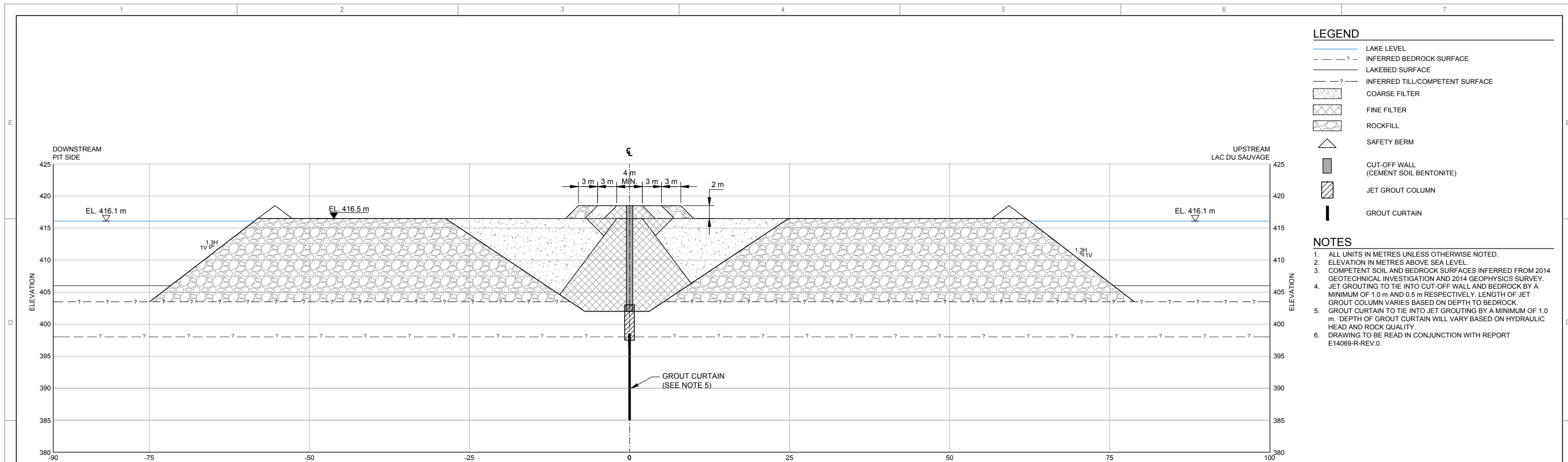
CLIENT
DOMINION DIAMOND

CONSULTANT
Golder Associates

PROJECT
13-1328-0041.2020.35
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
CONSTRUCTION SEQUENCE
DEEP SECTIONS (3 OF 4)

DRAWING No. **300-15** SHEET No. **11** OF **25**
SHEET SIZE ANSI D 25 mm



- LEGEND**
- LAKE LEVEL
 - INFERRED BEDROCK SURFACE
 - LAKEBED SURFACE
 - INFERRED TILL/COMPETENT SURFACE
 - COARSE FILTER
 - FINE FILTER
 - ROCKFILL
 - SAFETY BERM
 - CUT-OFF WALL (CEMENT SOIL BENTONITE)
 - JET GROUT COLUMN
 - GROUT CURTAIN

- NOTES**
1. ALL UNITS IN METRES UNLESS OTHERWISE NOTED.
 2. ELEVATION IN METRES ABOVE SEA LEVEL.
 3. COMPETENT SOIL AND BEDROCK SURFACES INFERRED FROM 2014 GEOTECHNICAL INVESTIGATION AND 2014 GEOPHYSICS SURVEY.
 4. JET GROUTING TO TIE INTO CUT-OFF WALL AND BEDROCK BY A MINIMUM OF 1.0 m AND 0.5 m RESPECTIVELY. LENGTH OF JET GROUT COLUMN VARIES BASED ON DEPTH TO BEDROCK.
 5. GROUT CURTAIN TO TIE INTO JET GROUTING BY A MINIMUM OF 1.0 m. DEPTH OF GROUT CURTAIN WILL VARY BASED ON HYDRAULIC HEAD AND ROCK QUALITY.
 6. DRAWING TO BE READ IN CONJUNCTION WITH REPORT E14069-R-REV.0.

G CURTAIN GROUTING BENEATH JET GROUT COLUMN
SCALE: A

Drawing File: H:\Client\dominion diamond\project\99_cardinal\project\13-1328-0041\02_PRODUCTION\406021\1313280041-0002-21_300-16.dwg Layout:300-16 Tuesday, December 02, 2014 3:24:32 PM By: jheal



REV	DATE	DESCRIPTION	DRW	DES	CHK	RWW
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SEAL / PERMIT
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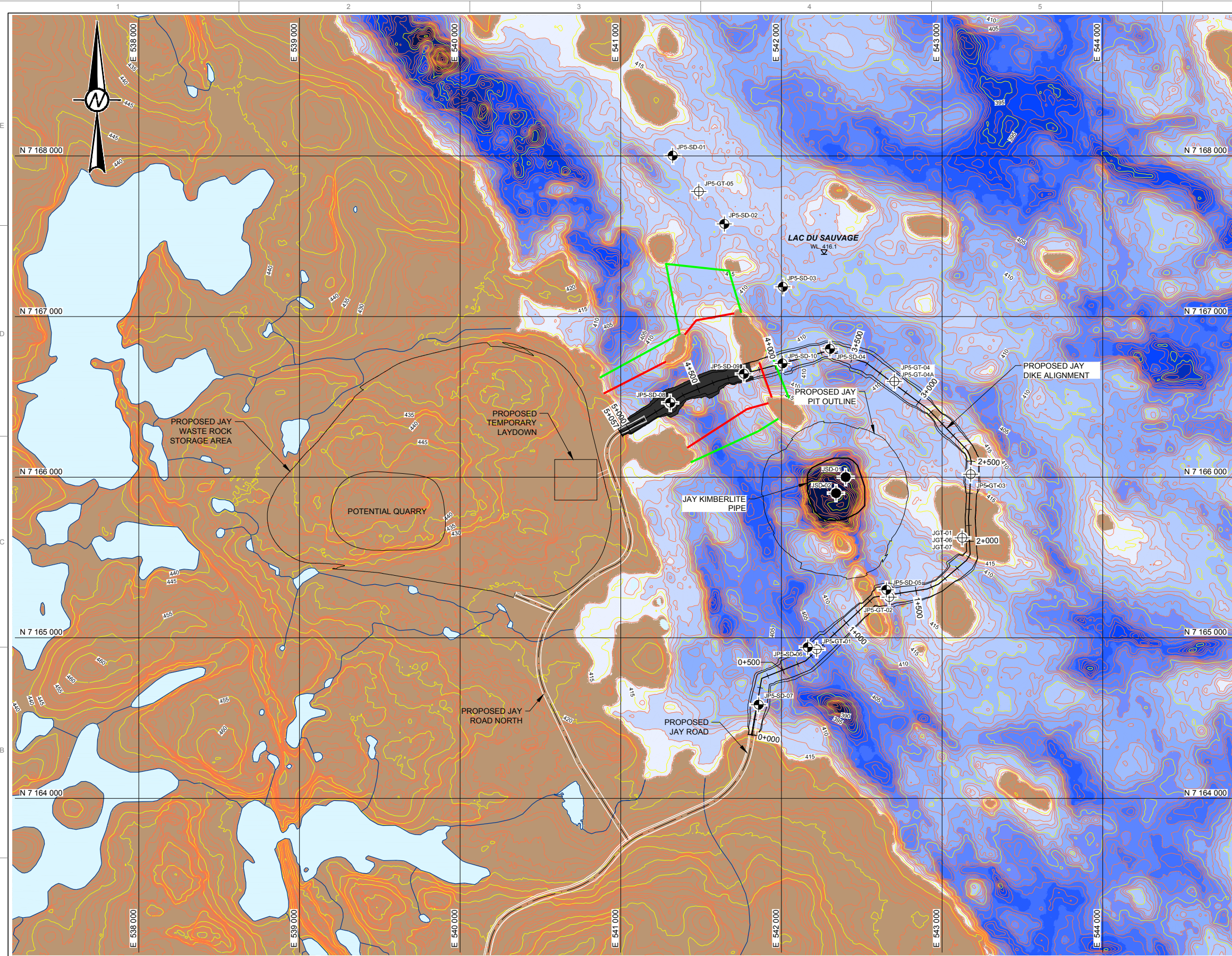
CLIENT
 DOMINION DIAMOND

CONSULTANT
 Golder Associates

PROJECT 13-1328-0041.2020.35
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
CONSTRUCTION SEQUENCE
DEEP SECTIONS (4 OF 4)

DRAWING No. 300-16 SHEET No. 12 OF 25
SHEET SIZE ANSI D 25 mm



LEGEND

	WATERBODY		SONIC DRILL HOLE LOCATION (AURORA)
	WATERCOURSE		SONIC DRILL HOLE LOCATION
	WATER LEVEL ELEVATION		DIAMOND DRILL HOLE LOCATION
	CONSTRUCTION IN PROGRESS		PRIMARY TURBIDITY CURTAIN (APPROXIMATE LOCATION)
	NOT YET CONSTRUCTED		SECONDARY TURBIDITY CURTAIN (APPROXIMATE LOCATION)

- NOTES**
1. ALL UNITS IN METRES UNLESS OTHERWISE NOTED.
 2. ELEVATION IN METRES ABOVE SEA LEVEL.
 3. GROUND SURFACE AND BATHYMETRY CONTOURS ARE SHOWN AT 1 m INTERVALS.
 4. COORDINATES ARE SHOWN IN DATUM: NAD 83, PROJECTION: UTM ZONE 12.
 5. THIS DRAWING ONLY SHOWS THE EARTHWORKS COMPONENT OF THE DIKE CONSTRUCTION. THE JET GROUTING AND CURTAIN GROUTING WILL START FOLLOWING COMPLETION OF THE CUT-OFF WALL AND GROUTING PLATFORM.
 6. DRAWING TO BE READ IN CONJUNCTION WITH REPORT E14069-R-REV.0.

- REFERENCES**
1. CONTOUR AND BATHYMETRIC DATA PROVIDED BY AURORA GEOSCIENCES LTD., FILE: Final 1m Contours - Priority Area.dxf, DATE RECEIVED: OCTOBER 29, 2013.
 2. WATER OBTAINED FROM CANVEC NATURAL RESOURCES CANADA, 2012.
 3. JAY PIT MODEL: GOLDR ASSOCIATES LTD., 2014. DOMINION DIAMOND JAY PIT - PRE-FEASIBILITY MINE DESIGN STUDY. SUBMITTED TO DOMINION DIAMOND EKATI CORPORATION, DATED OCTOBER 7, 2014. REFERENCE NO: 1313280041-E14065-R-Rev0-2020. (FILE NAME: pit_v6_OL.dxf).
 4. BOREHOLE AS-BUILT SURVEY PROVIDED BY AURORA GEOSCIENCES LTD. RECEIVED ON APRIL 22, 2014.
 5. JAY PIPE LOCATION RECEIVED FROM DOMINION DIAMOND CORPORATION, FILE: jay_kimberlite_pipe_OL.dxf, DATED: JULY 19, 2013.

WATER DEPTH TABLE

DEPTH RANGE	COLOR	MINIMUM DEPTH (m)	MAXIMUM DEPTH (m)
1		0	2
2		2	4
3		4	6
4		6	8
5		8	10
6		10	12
7		12	14
8		14	16
9		16	18
10		18	20
11		20	22
12		22	24
13		24	26
14		26	28
15		28	40

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0	2014-12-03	ISSUED FOR PFS	TAK	FA	CM	FE
B	2014-10-15	ISSUED FOR REVIEW	TAK	FA	-	-

SEAL / PERMIT
NOT FOR CONSTRUCTION

CLIENT
 DOMINION DIAMOND

CONSULTANT
 Golder Associates

PROJECT 13-1328-0041.2020.35
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
CONSTRUCTION SUMMER 2016

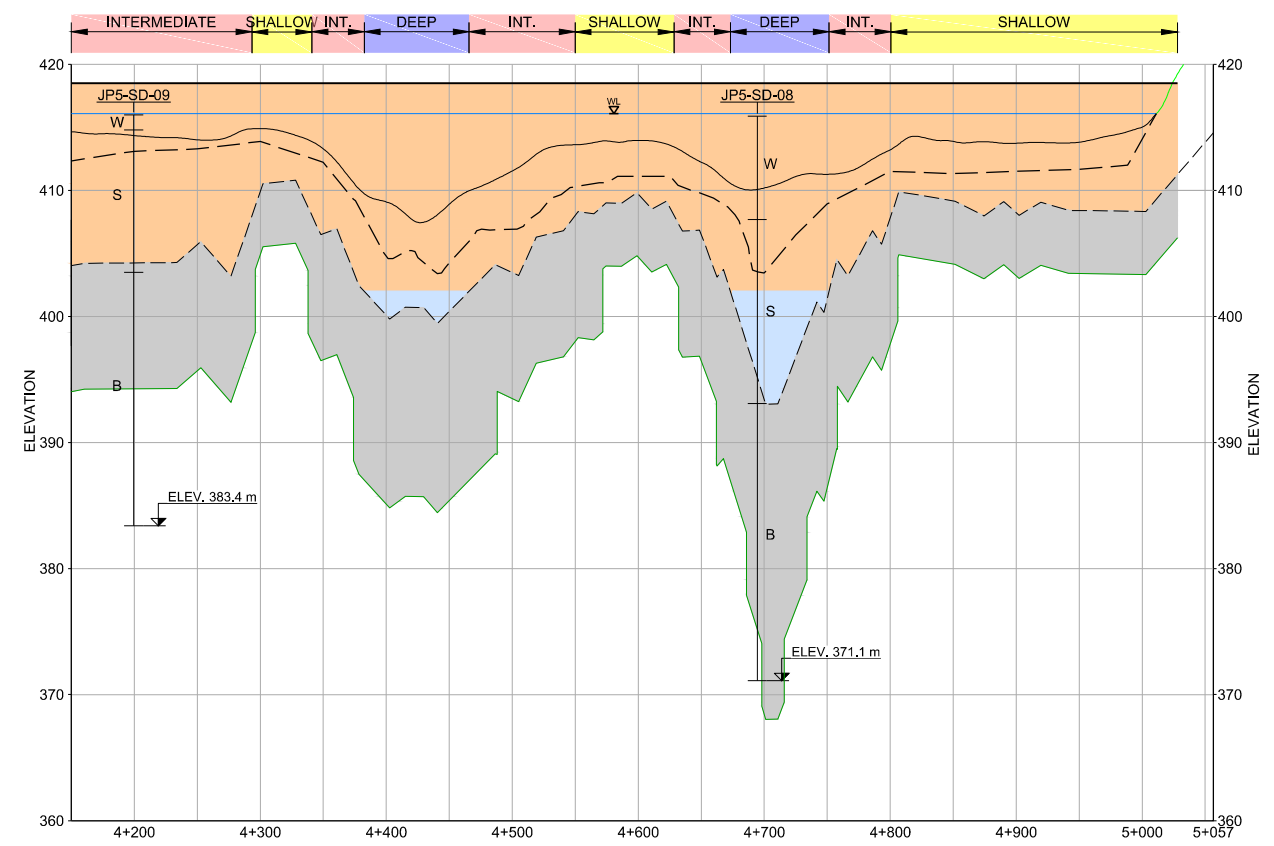
DRAWING No. 300-22 SHEET No. 13 OF 25
SHEET SIZE ANSI D 25 mm

- LEGEND**
- DIKE CREST (418.5 masl)
 - LAKE LEVEL (416.1 masl)
 - TOPOGRAPHY SURFACE
 - LAKEBED SURFACE
 - INFERRED COMPETENT SOIL SURFACE
 - INFERRED BEDROCK SURFACE
 - PROPOSED DEPTH OF GROUT CURTAIN
 - ASSUMED WATER LEVEL (416.1 masl.)
 - LAKE WATER
 - SOIL
 - BEDROCK
 - CUT-OFF WALL
 - JET GROUTING TREATMENT AREA
 - CURTAIN GROUTING
 - JP5 -SD-01 SONIC DRILL HOLE
 - JP5 -GT-01 DIAMOND DRILL HOLE

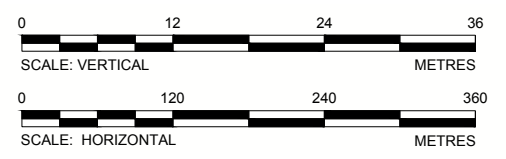
- NOTES**
1. ALL UNITS IN METRES UNLESS OTHERWISE NOTED.
 2. ELEVATION IN METRES ABOVE SEA LEVEL.
 3. COMPETENT SOIL AND BEDROCK SURFACES INFERRED FROM 2014 GEOTECHNICAL INVESTIGATION AND 2014 GEOPHYSICS SURVEY.
 4. CEMENT SOIL BENTONITE CUT-OFF WALL IS COMPLETED IN THE SUMMER OF 2016.
 5. THE LOW PERMEABILITY ELEMENT WILL BE EXTENDED INTO ISLANDS. BUT MAY NOT BE EXTENDED THROUGH THE ENTIRE ISLAND.
 6. CURTAIN GROUTING WILL FOLLOW COMPLETION OF THE CUT-OFF WALL IN THE SHALLOW SECTIONS ONLY, AND BE CARRIED OUT IN THE WINTER OF 2016 TO THE SUMMER OF 2017. JET GROUTING WILL START IN WINTER 2017.
 7. SHALLOW SECTION APPLIES WHERE BEDROCK IS ABOVE 408 masl.
 8. INTERMEDIATE SECTION APPLIES WHERE BEDROCK IS LOCATED BETWEEN 408 AND 402 masl.
 9. DEEP SECTION APPLIES WHERE BEDROCK IS LOCATED BELOW 402 masl.
 10. BASE OF CUT-OFF WALL WILL BE THE BEDROCK SURFACE IF BEDROCK SURFACE IS LOCATED ABOVE 402 masl, OTHERWISE WILL BE THE COMPETENT SOIL SURFACE.
 11. JET GROUTING SHALL BE CONDUCTED WHERE CUT-OFF WALL DOES NOT REACH BEDROCK SURFACE. LENGTH OF JET GROUT COLUMN VARIES BASED ON DEPTH TO BEDROCK.
 12. DEPTH OF GROUT CURTAIN WILL VARY BASED ON HYDRAULIC HEAD AND ROCK QUALITY.
 13. JET GROUTING TO EXTEND 0.5 m BELOW BEDROCK INTERFACE AND 1.0 m ABOVE THE BASE OF THE CSB CUT-OFF WALL.
 14. DRAWING TO BE READ IN CONJUNCTION WITH REPORT E14069-R-REV.0.

- REFERENCES**
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 2. BOREHOLE AS-BUILT SURVEY PROVIDED BY AURORA GEOSCIENCES LTD. RECEIVED ON APRIL 22, 2014.

SEE DRAWING 300-26 FOR STA. 0+000 TO 1+200 AND 2+900 TO 4+150 AND SEE DRAWING 300-28 FOR STA. 1+200 TO 2+900



STATION 4+150 TO 5+057
VERTICAL EXAGGERATION 10X



REV	DATE	DESCRIPTION	DRW	DES	CHK	RVW
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B	2014-10-15	ISSUED FOR REVIEW	JD	FA	-	-

SEAL / PERMIT
NOT FOR CONSTRUCTION

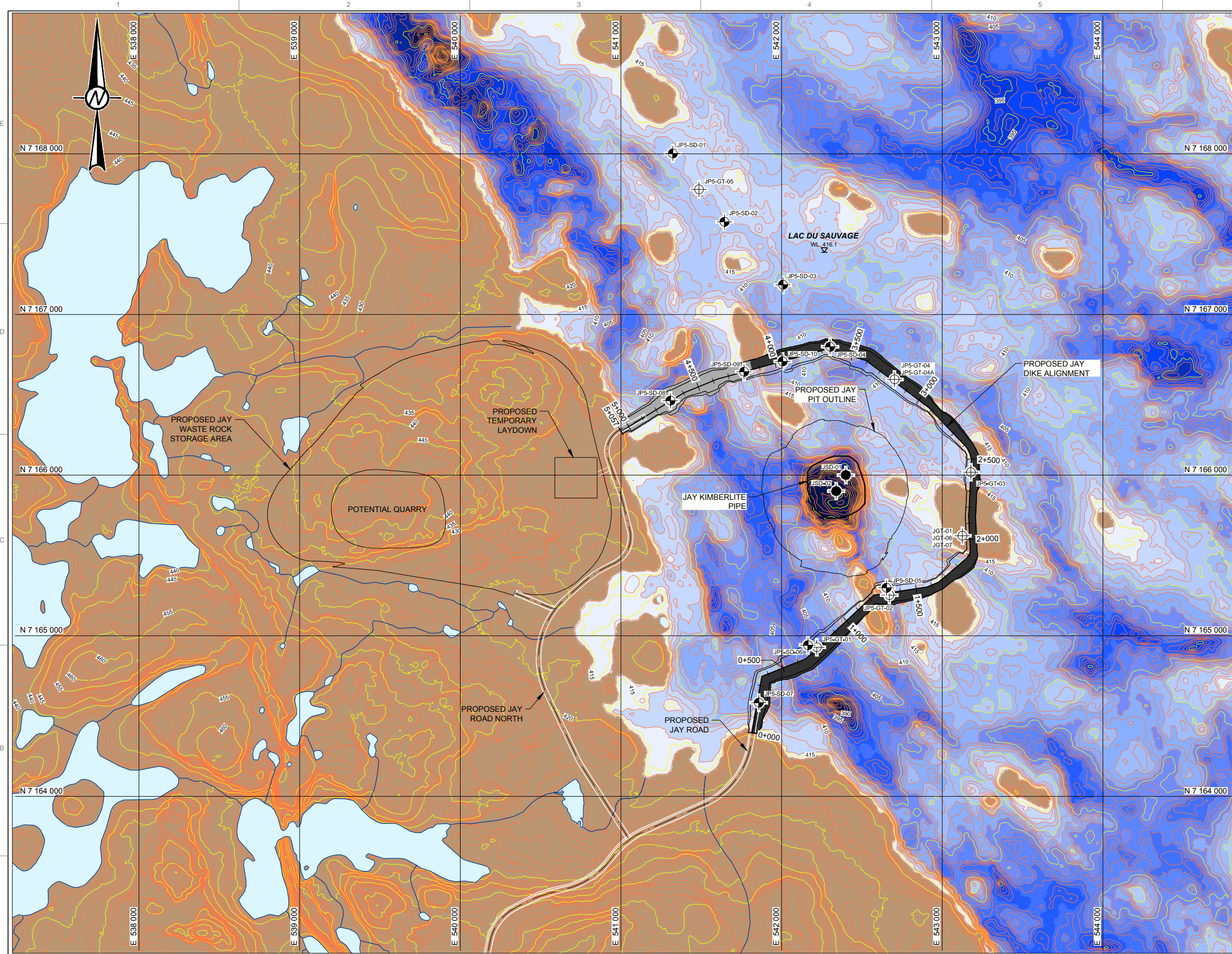
CLIENT
DOMINION DIAMOND

CONSULTANT
Golden Associates

PROJECT 13-1328-0041.2020.35
**JAY PROJECT
NORTHWEST TERRITORIES, CANADA**

TITLE
**SUMMER 2016
CUT-OFF WALL PROFILE**

DRAWING No. **300-23** SHEET No. **14** OF **25**
SHEET SIZE ANSI D 25 mm



LEGEND

	WATERBODY		SONIC DRILL HOLE LOCATION (AURORA)
	WATERCOURSE		SONIC DRILL HOLE LOCATION
	WATER LEVEL ELEVATION		DIAMOND DRILL HOLE LOCATION
	CONSTRUCTION IN PROGRESS		
	NOT YET CONSTRUCTED		

- NOTES**
1. ALL UNITS IN METRES UNLESS OTHERWISE NOTED.
 2. ELEVATION IN METRES ABOVE SEA LEVEL.
 3. GROUND SURFACE AND BATHYMETRY CONTOURS ARE SHOWN AT 1 m INTERVALS.
 4. COORDINATES ARE SHOWN IN DATUM: NAD 83, PROJECTION: UTM ZONE 12.
 5. THIS DRAWING ONLY SHOWS THE EARTHWORKS COMPONENT OF THE DIKE CONSTRUCTION. THE JET GROUTING AND CURTAIN GROUTING WILL START FOLLOWING COMPLETION OF THE CUT-OFF WALL AND GROUTING PLATFORM.
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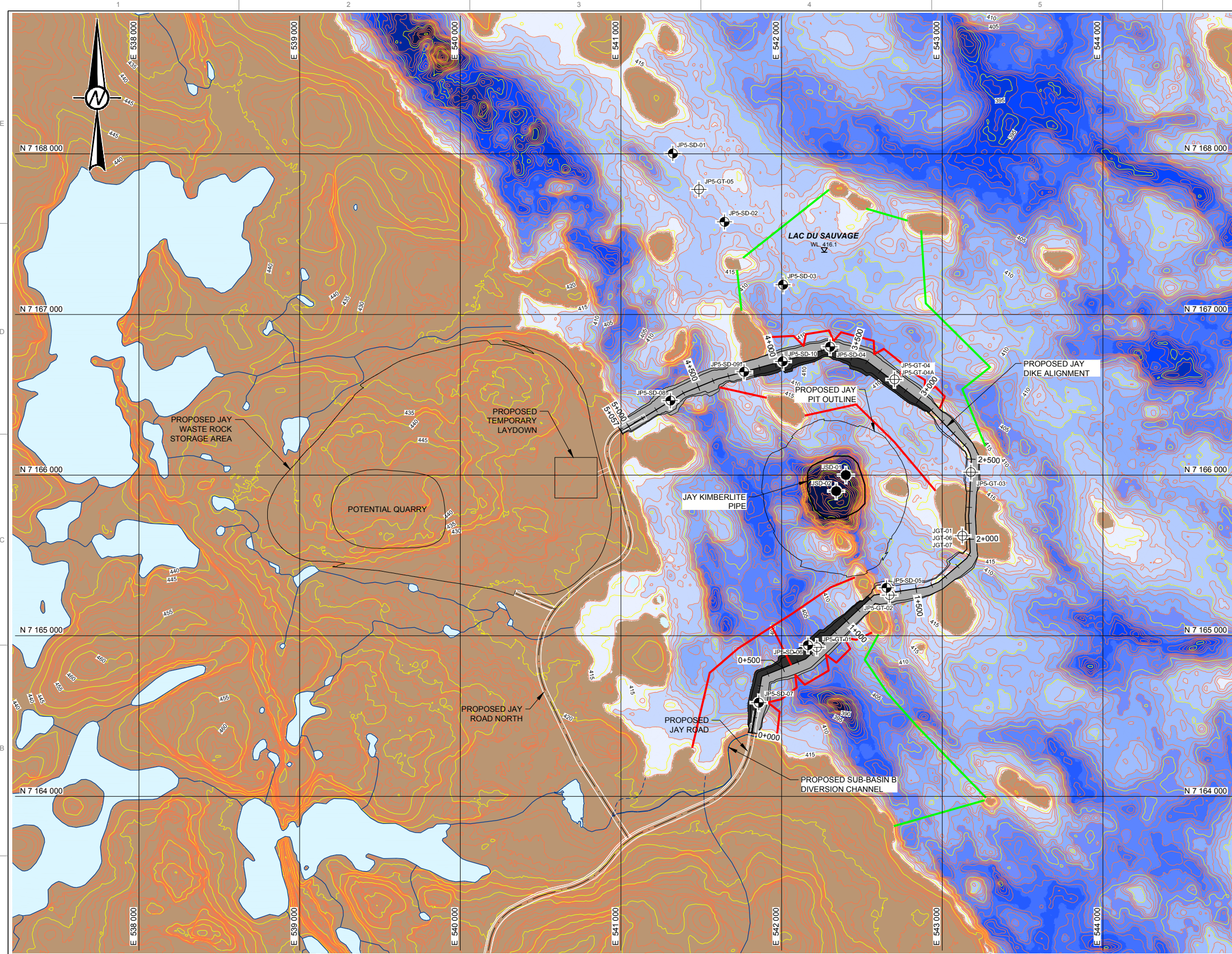
WATER DEPTH TABLE

DEPTH RANGE	COLOR	MINIMUM DEPTH (m)	MAXIMUM DEPTH (m)
1		0	2
2		2	4
3		4	6
4		6	8
5		8	10
6		10	12
7		12	14
8		14	16
9		16	18
10		18	20
11		20	22
12		22	24
13		24	26
14		26	28
15		28	40

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SEAL / PERMIT NOT FOR CONSTRUCTION	CLIENT 	PROJECT 13-1328-0041.2020.35 JAY PROJECT NORTHWEST TERRITORIES, CANADA TITLE CONSTRUCTION WINTER 2016/2017																					
<table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th>REV</th> <th>DATE</th> <th>DESCRIPTION</th> <th>DRW</th> <th>DES</th> <th>CHK</th> <th>RVW</th> </tr> </thead> <tbody> <tr> <td>0</td> <td>2014-12-03</td> <td>ISSUED FOR PFS</td> <td>JD</td> <td>FA</td> <td>CM</td> <td>FE</td> </tr> <tr> <td>B</td> <td>2014-10-15</td> <td>ISSUED FOR REVIEW</td> <td>JD</td> <td>FA</td> <td>-</td> <td>-</td> </tr> </tbody> </table>	REV	DATE	DESCRIPTION	DRW	DES	CHK	RVW	0	2014-12-03	ISSUED FOR PFS	JD	FA	CM	FE	B	2014-10-15	ISSUED FOR REVIEW	JD	FA	-	-	CONSULTANT 	DRAWING No. 300-24 SHEET No. 15 OF 25 SHEET SIZE ANSI D 25 mm
REV	DATE	DESCRIPTION	DRW	DES	CHK	RVW																	
0	2014-12-03	ISSUED FOR PFS	JD	FA	CM	FE																	
B	2014-10-15	ISSUED FOR REVIEW	JD	FA	-	-																	



LEGEND

	WATERBODY		SONIC DRILL HOLE LOCATION (AURORA)
	WATERCOURSE		SONIC DRILL HOLE LOCATION
	DIVERTED NATURAL RUNOFF FLOW		DIAMOND DRILL HOLE LOCATION
	WATER LEVEL ELEVATION		PRIMARY TURBIDITY CURTAIN (APPROXIMATE LOCATION)
	CONSTRUCTION IN PROGRESS		SECONDARY TURBIDITY CURTAIN (APPROXIMATE LOCATION)
	NOT YET CONSTRUCTED		

- NOTES**
1. ALL UNITS IN METRES UNLESS OTHERWISE NOTED.
 2. ELEVATION IN METRES ABOVE SEA LEVEL.
 3. GROUND SURFACE AND BATHYMETRY CONTOURS ARE SHOWN AT 1 m INTERVALS.
 4. COORDINATES ARE SHOWN IN DATUM: NAD 83, PROJECTION: UTM ZONE 12.
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- REFERENCES**
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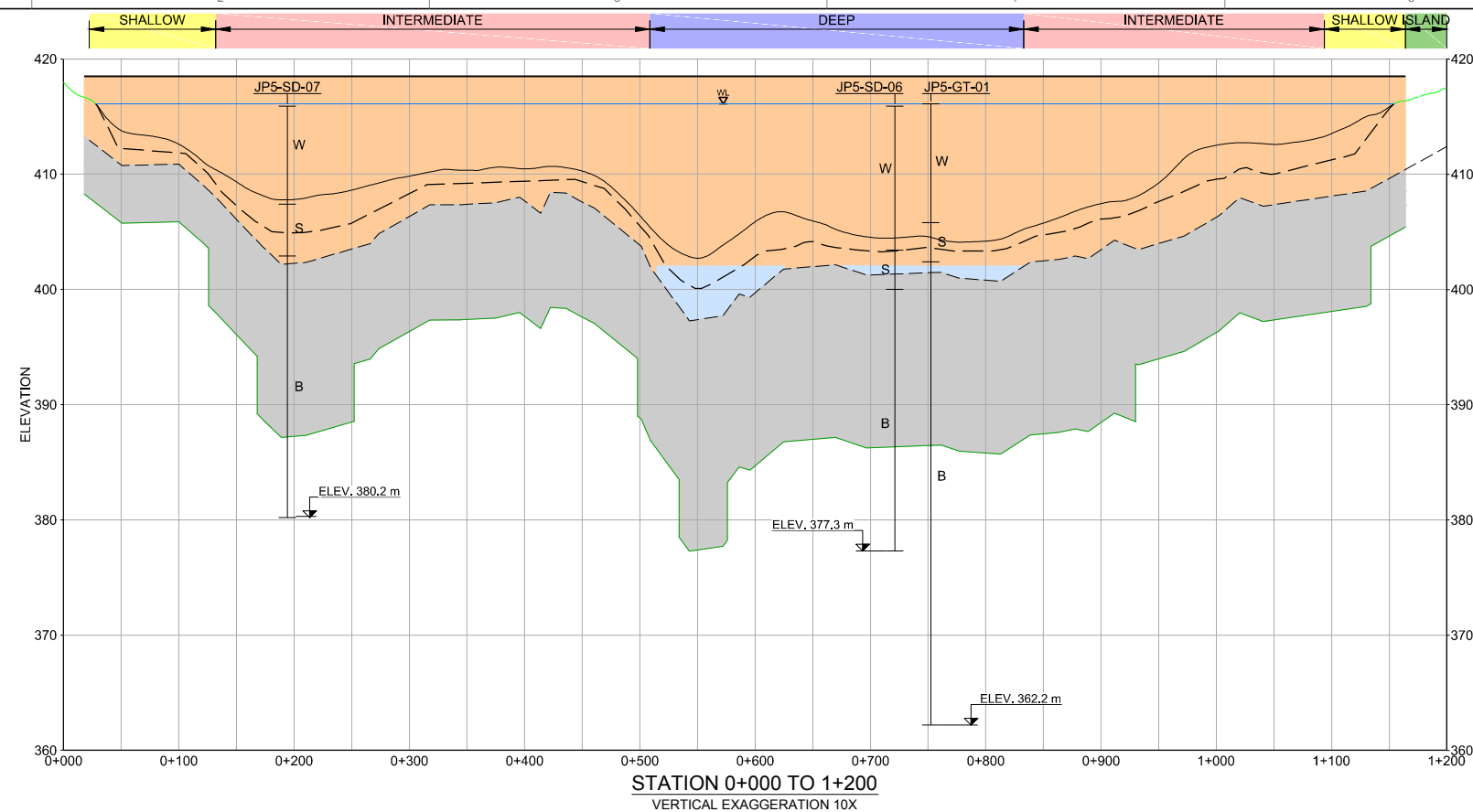
WATER DEPTH TABLE

DEPTH RANGE	COLOR	MINIMUM DEPTH (m)	MAXIMUM DEPTH (m)
1		0	2
2		2	4
3		4	6
4		6	8
5		8	10
6		10	12
7		12	14
8		14	16
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12		22	24
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14		26	28
15		28	40

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SEAL / PERMIT <p style="text-align: center; color: red;">NOT FOR CONSTRUCTION</p>		CLIENT 	PROJECT 13-1328-0041.2020.35																		
REV <table border="1"> <tr> <th>DATE</th> <th>DESCRIPTION</th> <th>DRW</th> <th>DES</th> <th>CHK</th> <th>RVW</th> </tr> <tr> <td>0 2014-12-03</td> <td>ISSUED FOR PFS</td> <td>JD</td> <td>FA</td> <td>CM</td> <td>FE</td> </tr> <tr> <td>B 2014-10-15</td> <td>ISSUED FOR REVIEW</td> <td>JD</td> <td>FA</td> <td>-</td> <td>-</td> </tr> </table>		DATE	DESCRIPTION	DRW	DES	CHK	RVW	0 2014-12-03	ISSUED FOR PFS	JD	FA	CM	FE	B 2014-10-15	ISSUED FOR REVIEW	JD	FA	-	-	CONSULTANT 	TITLE JAY PROJECT NORTHWEST TERRITORIES, CANADA CONSTRUCTION SUMMER 2017
DATE	DESCRIPTION	DRW	DES	CHK	RVW																
0 2014-12-03	ISSUED FOR PFS	JD	FA	CM	FE																
B 2014-10-15	ISSUED FOR REVIEW	JD	FA	-	-																
SCALE 0 500 1,000 1,500 METRES		DRAWING No. 300-25 SHEET No. 16 OF 25 SHEET SIZE ANSI D 25 mm																			



LEGEND

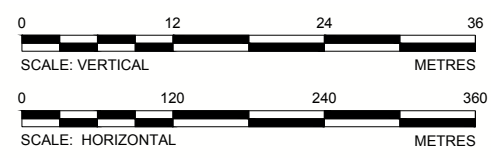
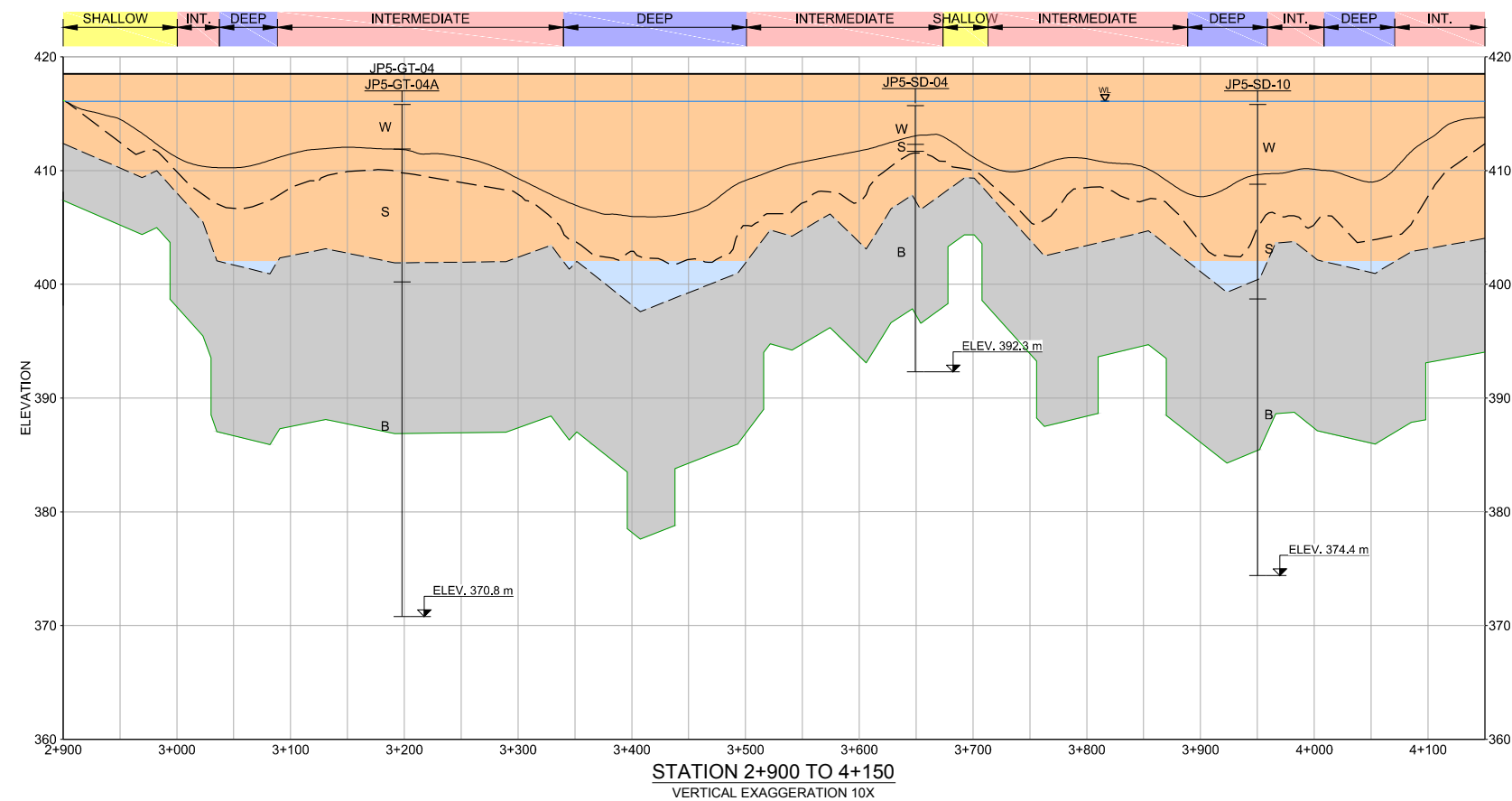
- DIKE CREST (418.5 masl)
- LAKE LEVEL (416.1 masl)
- TOPOGRAPHY SURFACE
- LAKEBED SURFACE
- INFERRED COMPETENT SOIL SURFACE
- INFERRED BEDROCK SURFACE
- PROPOSED DEPTH OF GROUT CURTAIN
- ASSUMED WATER LEVEL (416.1 masl.)
- LAKE WATER
- SOIL
- BEDROCK
- CUT-OFF WALL
- JET GROUTING TREATMENT AREA
- CURTAIN GROUTING
- JP5 -SD-01 SONIC DRILL HOLE
- JP5 -GT-01 DIAMOND DRILL HOLE

NOTES

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7. SHALLOW SECTION APPLIES WHERE BEDROCK IS ABOVE 408 masl.
8. INTERMEDIATE SECTION APPLIES WHERE BEDROCK IS LOCATED BETWEEN 408 AND 402 masl.
9. DEEP SECTION APPLIES WHERE BEDROCK IS LOCATED BELOW 402 masl.
10. BASE OF CUT-OFF WALL WILL BE THE BEDROCK SURFACE IF BEDROCK SURFACE IS LOCATED ABOVE 402 masl, OTHERWISE WILL BE THE COMPETENT SOIL SURFACE.
11. JET GROUTING SHALL BE CONDUCTED WHERE CUT-OFF WALL DOES NOT REACH BEDROCK SURFACE. LENGTH OF JET GROUT COLUMN VARIES BASED ON DEPTH TO BEDROCK.
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SEAL / PERMIT
NOT FOR CONSTRUCTION

CLIENT
DOMINION DIAMOND

CONSULTANT
Golder Associates

PROJECT
13-1328-0041.2020.35

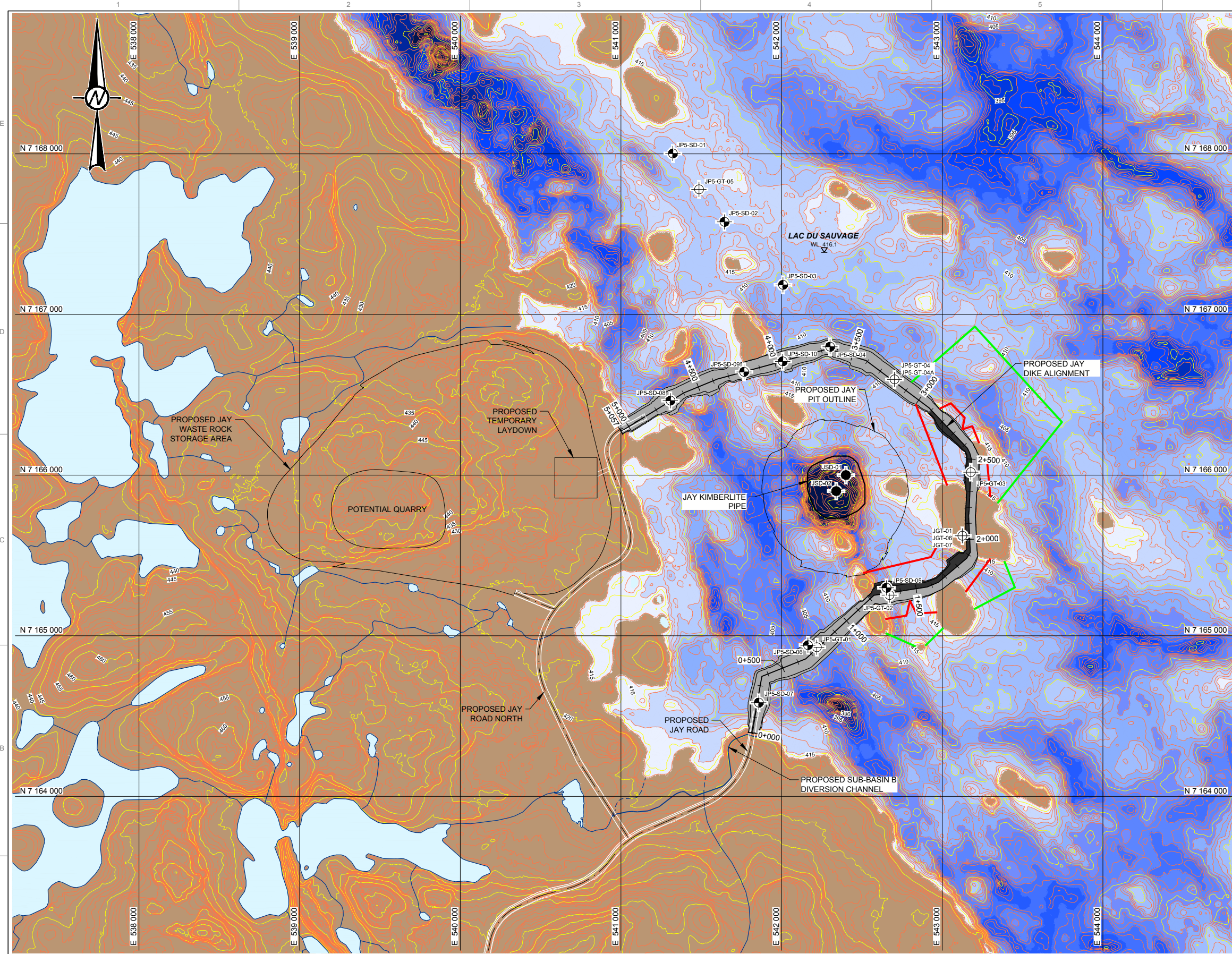
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
SUMMER 2017
CUT-OFF WALL PROFILE

DRAWING No. **300-26** SHEET No. **17** OF **25**

SHEET SIZE ANSI D 25 mm

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LEGEND

	WATERBODY		SONIC DRILL HOLE LOCATION (AURORA)
	WATERCOURSE		SONIC DRILL HOLE LOCATION
	DIVERTED NATURAL RUNOFF FLOW		DIAMOND DRILL HOLE LOCATION
	WATER LEVEL ELEVATION		PRIMARY TURBIDITY CURTAIN (APPROXIMATE LOCATION)
	CONSTRUCTION IN PROGRESS		SECONDARY TURBIDITY CURTAIN (APPROXIMATE LOCATION)
	NOT YET CONSTRUCTED		

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WATER DEPTH TABLE

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1		0	2
2		2	4
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4		6	8
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8		14	16
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12		22	24
13		24	26
14		26	28
15		28	40

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REV	DATE	DESCRIPTION	DRW	DES	CHK	RVW

SEAL / PERMIT
NOT FOR CONSTRUCTION

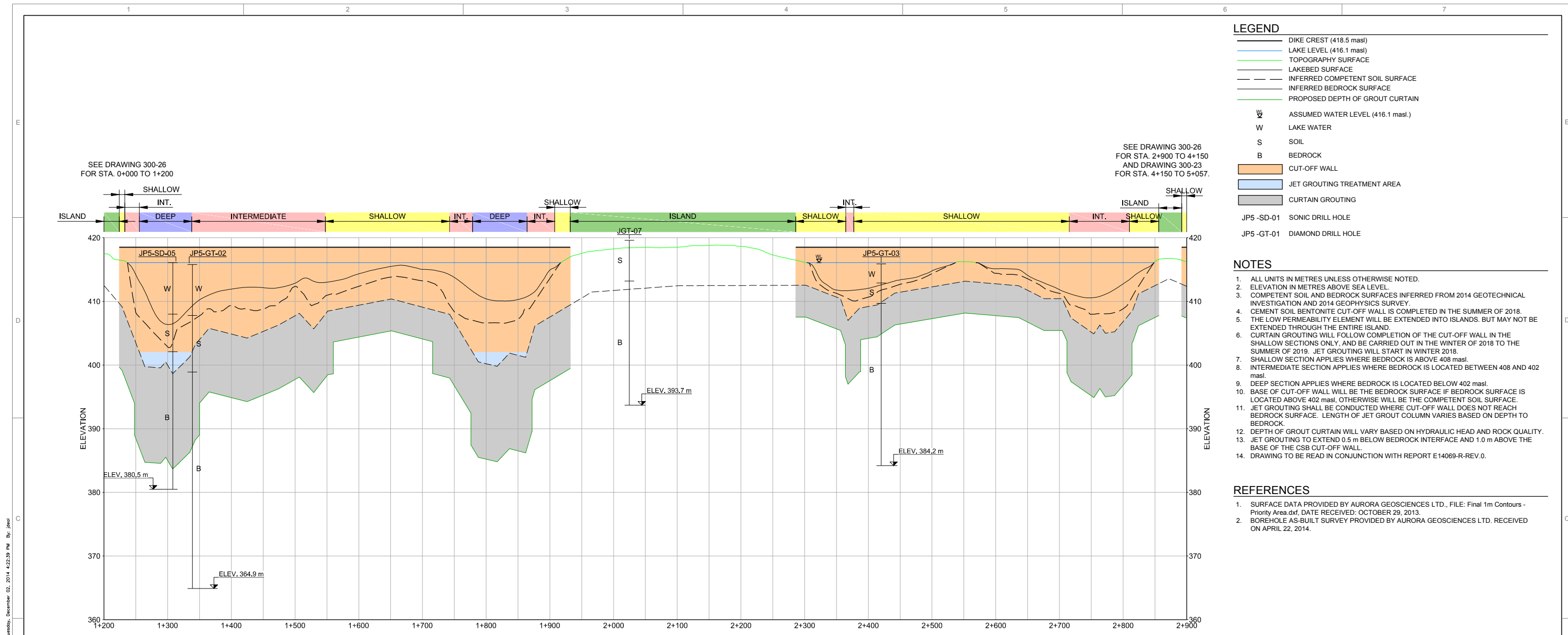
CLIENT
DOMINION DIAMOND

CONSULTANT
Goldier Associates

PROJECT
13-1328-0041.2020.35
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
CONSTRUCTION SUMMER 2018

DRAWING No. **300-27** SHEET No. **18** OF **25**
SHEET SIZE ANSI D 25 mm



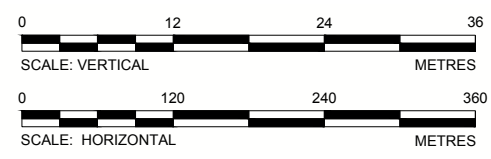
STATION 1+200 TO 2+900
VERTICAL EXAGGERATION 10X

- LEGEND**
- DIKE CREST (418.5 masl)
 - LAKE LEVEL (416.1 masl)
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 8. INTERMEDIATE SECTION APPLIES WHERE BEDROCK IS LOCATED BETWEEN 408 AND 402 masl.
 9. DEEP SECTION APPLIES WHERE BEDROCK IS LOCATED BELOW 402 masl.
 10. BASE OF CUT-OFF WALL WILL BE THE BEDROCK SURFACE IF BEDROCK SURFACE IS LOCATED ABOVE 402 masl, OTHERWISE WILL BE THE COMPETENT SOIL SURFACE.
 11. JET GROUTING SHALL BE CONDUCTED WHERE CUT-OFF WALL DOES NOT REACH BEDROCK SURFACE. LENGTH OF JET GROUT COLUMN VARIES BASED ON DEPTH TO BEDROCK.
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1. SURFACE DATA PROVIDED BY AURORA GEOSCIENCES LTD., FILE: Final 1m Contours - Priority Area.dxf, DATE RECEIVED: OCTOBER 29, 2013.
 2. BOREHOLE AS-BUILT SURVEY PROVIDED BY AURORA GEOSCIENCES LTD. RECEIVED ON APRIL 22, 2014.

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B	2014-10-15	ISSUED FOR REVIEW	JD	FA	-	-

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NOT FOR CONSTRUCTION

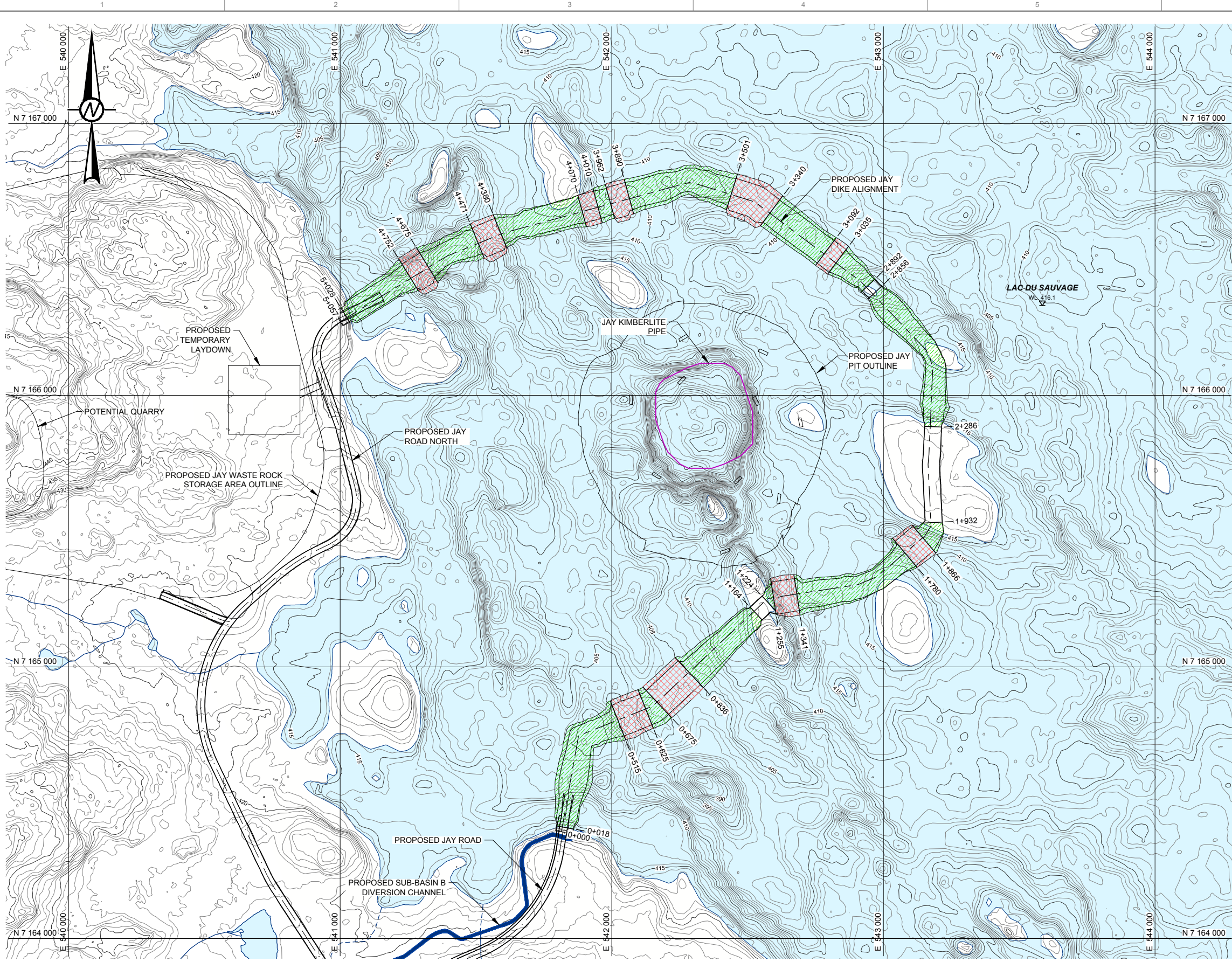
CLIENT
DOMINION DIAMOND

CONSULTANT
Golder Associates

PROJECT 13-1328-0041.2020.35
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
SUMMER 2018
CUT-OFF WALL PROFILE

DRAWING No. 300-28 SHEET No. 19 OF 25
SHEET SIZE ANSI D 25 mm



LEGEND

- WATERBODY
- WATERCOURSE
- DIVERTED CHANNEL
- CURTAIN GROUTING
- JET AND CURTAIN GROUTING
- WL WATER LEVEL ELEVATION

NOTES

1. ALL UNITS IN METRES UNLESS OTHERWISE NOTED.
2. ELEVATION IN METRES ABOVE SEA LEVEL.
3. DRAWING TO BE READ IN CONJUNCTION WITH REPORT E14069-R-REV.0.

REFERENCE

1. CONTOUR AND BATHYMETRIC DATA PROVIDED BY AURORA GEOSCIENCES LTD., FILE: Final 1m Contours - Priority Area.dxf. DATE RECEIVED: OCTOBER 29, 2013.
2. WATER OBTAINED FROM CANVEC NATURAL RESOURCES CANADA, 2012.
3. JAY PIT MODEL: GOLDR ASSOCIATES LTD., 2014. DOMINION DIAMOND JAY PIT - PRE-FEASIBILITY MINE DESIGN STUDY. SUBMITTED TO DOMINION DIAMOND EKATI CORPORATION, DATED OCTOBER 7, 2014. REFERENCE NO: 1313280041-E14065-R-Rev0-2020. (FILE NAME: pit_v6_OL.dxf).
4. JAY KIMBERLITE PIPE LOCATION RECEIVED FROM DOMINION DIAMOND CORPORATION, FILE: jay_kimberlite_pipe_OL.dxf, DATED: JULY 19, 2013.

Drawing File: H:\Client\dominion diamond\jpr-cardinal\project\99_projects\13-1328-0041\02_PRODUCTION\4660\21\1313280041-6660-21_300-50.dwg Layout: 300-50 Tuesday, December 02, 2014 4:26:08 PM By: jheal



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SEAL / PERMIT
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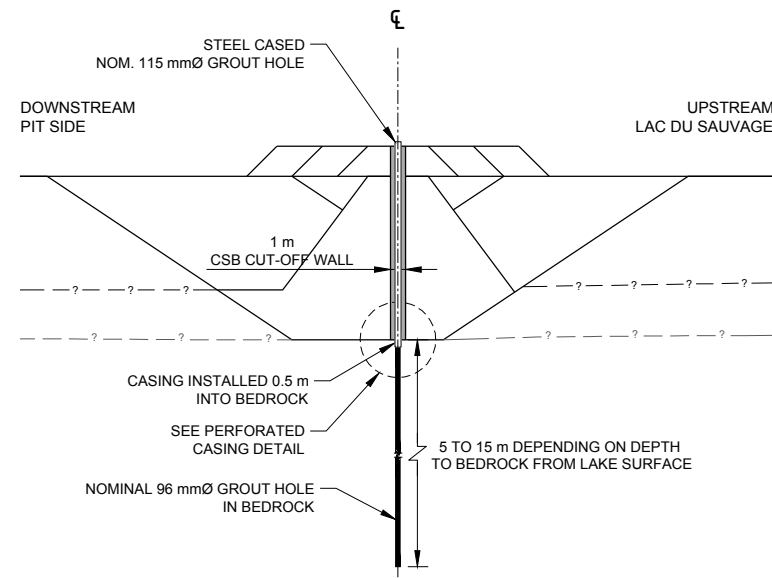
CLIENT
DOMINION DIAMOND

CONSULTANT
Golder Associates

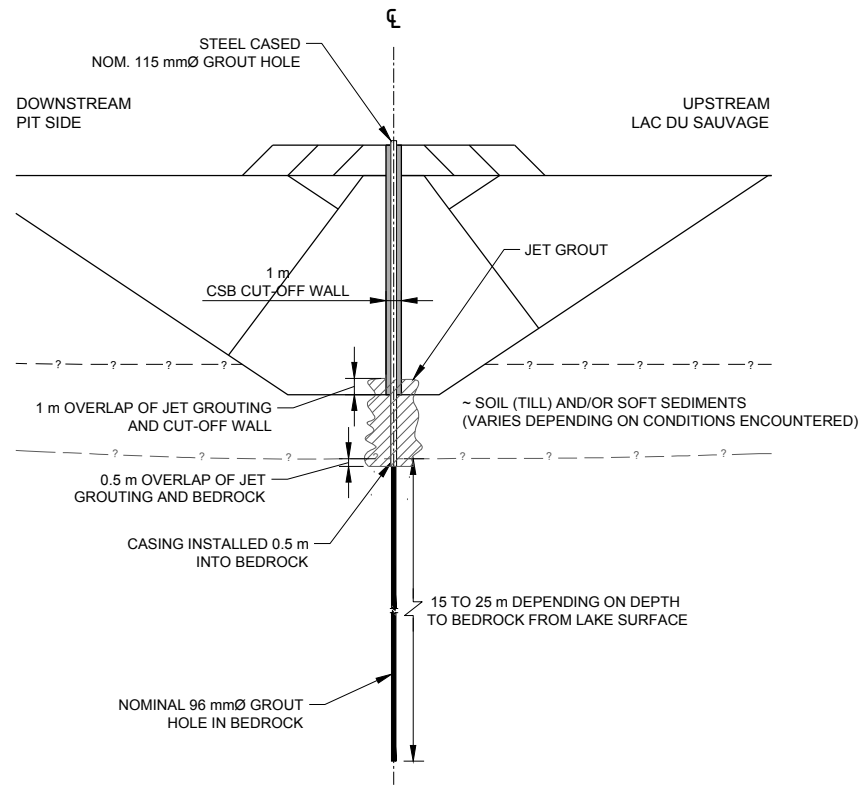
PROJECT
13-1328-0041.2020.35
**JAY PROJECT
NORTHWEST TERRITORIES, CANADA**

TITLE
GROUTING WORK AREAS

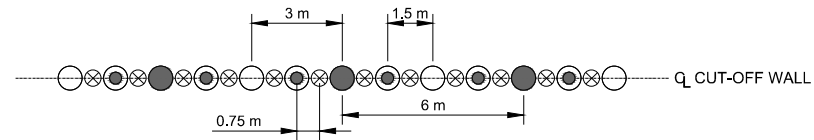
DRAWING No. **300-50** SHEET No. **20** OF **25**
SHEET SIZE ANSI D 25 mm



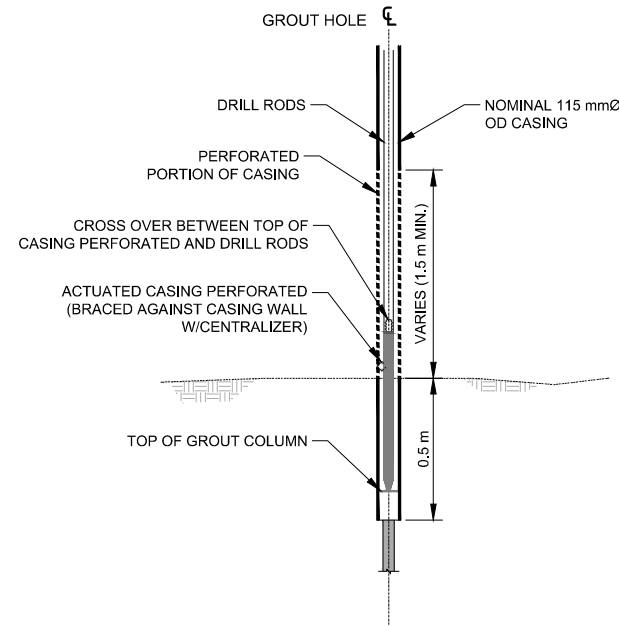
TYPICAL GROUT CURTAIN DETAIL FOR BEDROCK ABOVE 402 masl
SCHEMATIC ONLY (NOT TO SCALE)



TYPICAL GROUT CURTAIN DETAIL FOR BEDROCK BELOW 402 masl
SCHEMATIC ONLY (NOT TO SCALE)



TYPICAL GROUT CURTAIN HOLE SPACING
SCHEMATIC ONLY (NOT TO SCALE)



PERFORATED CASING DETAIL
SCHEMATIC ONLY (NOT TO SCALE)

LEGEND

- ?--- INFERRED COMPETENT SOIL SURFACE
- - - ? - - INFERRED BEDROCK SURFACE
- PRIMARY HOLES (6.0 SPACING)
- SECONDARY HOLES (3.0 FROM PRIMARY HOLES)
- ⊙ TERTIARY HOLES (1.5 FROM SECONDARY HOLES)
- ⊗ QUATERNARY HOLES - AS REQUIRED (0.75 FROM TERTIARY HOLES)

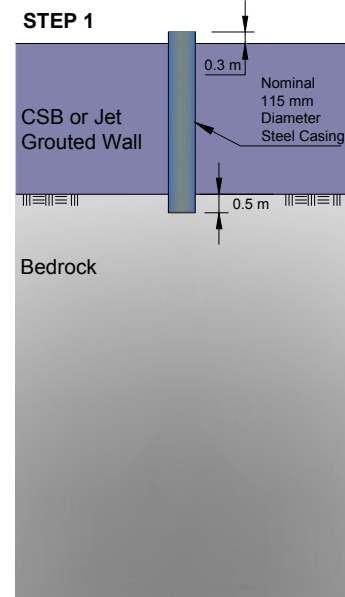
NOTES

1. ALL UNITS IN METRES UNLESS OTHERWISE NOTED.
2. ELEVATION IN METRES ABOVE SEA LEVEL.
3. REFER TO DRAWING 300-52 FOR DETAILS ON CURTAIN GROUTING SEQUENCE.
4. THE PERFORATOR SHALL BE CAPABLE OF PUNCTURING SINGLE ROWS OF 2.5mm (0.1") WIDE, 25mm (1") LONG SLOTS THROUGH STEEL CASINGS OF UP TO 11mm (0.45") THICKNESS.
5. QUATERNARY GROUT HOLES SHALL BE INSTALLED AND GROUTED, WHERE REQUIRED, BASED ON OBSERVED WATER PRESSURE TESTING RESULTS AND GROUT TAKES IN ADJACENT HOLES.
6. JET GROUTING TO OVERLAP CEMENT-SOIL-BENTONITE (CSB) CUT-OFF WALL AND BEDROCK BY A MINIMUM OF 1.0 m AND 0.5 m, RESPECTIVELY. THE LENGTH OF OVERLAP OF GROUTING ACTIVITIES WITH THE CUT-OFF WALL WILL DEPEND ON THE THICKNESS OF SOIL MATERIALS, IF ANY, LEFT IN PLACE BENEATH THE CUT-OFF WALL DURING CONSTRUCTION, AND ON CONDITIONS ENCOUNTERED DURING THE INSTALLATION OF STEEL CASING THROUGH THE COMPLETED CUT-OFF WALL.
7. THE DEPTH OF THE GROUT CURTAIN INTO BEDROCK BENEATH THE CUT-OFF WALL/JET GROUT/BEDROCK INTERFACE WILL DEPEND ON THE DEPTH OF ANTICIPATED HYDRAULIC HEAD AND BEDROCK CONDITIONS ENCOUNTERED. CONCEPTUAL DELINEATION OF DEPTH OF CURTAIN INTO BEDROCK ARE PROVIDED ON DRAWINGS 300-23, 300-26 AND 300-28.
8. DRAWING TO BE READ IN CONJUNCTION WITH REPORT E14069-R-REV.0.

Drawing File: H:\Client\dominion diamond\project\99-cardinal\project\13-1328-0041\02_PRODUCTION\4060\21\1313280041-0600-21_300-51.dwg Layout:300-51 Tuesday, December 02, 2014 4:27:27 PM By: jleal

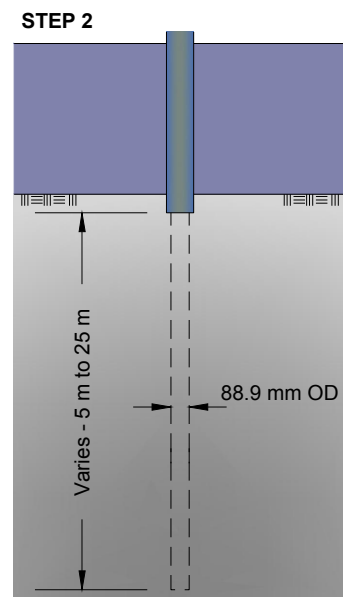
	NOT FOR CONSTRUCTION	CLIENT DOMINION DIAMOND	PROJECT 13-1328-0041.2020.35 JAY PROJECT NORTHWEST TERRITORIES, CANADA
		CONSULTANT Golder Associates	TITLE GROUTING DETAILS
			DRAWING No. 300-51 SHEET No. 21 OF 25
			SHEET SIZE ANSI D 25 mm

REV	DATE	DESCRIPTION	DRW	DES	CHK	RWW
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B	2014-10-15	ISSUED FOR REVIEW	JD	VR	-	-



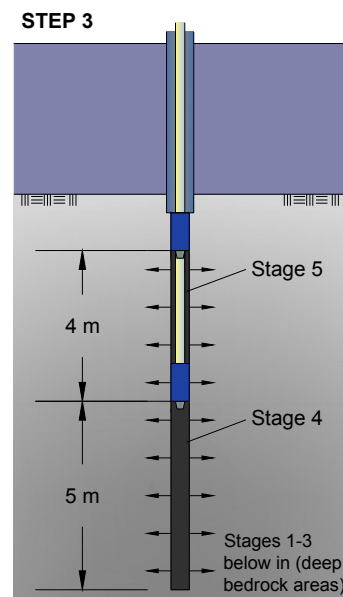
STEP 1

INSTALL STEEL CASING
 -TRICONE DRILL TO TOP OF BEDROCK FOLLOWED BY ADVANCE OF STEEL CASING WITH DOWN THE HOLE HAMMER



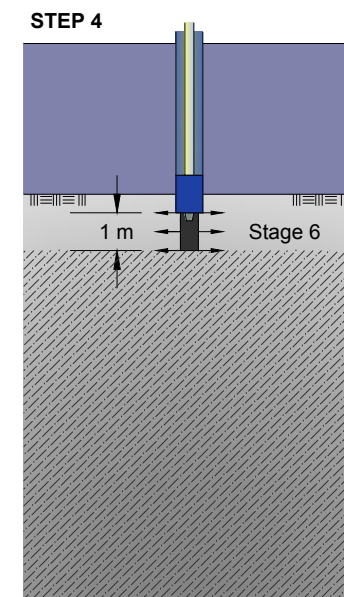
STEP 2

DRILL BEDROCK
 -TOTAL DEPTH TO BE DRILLED VARIES WITH WORKING AREA ALONG DIKE AND BEDROCK CONDITIONS ENCOUNTERED



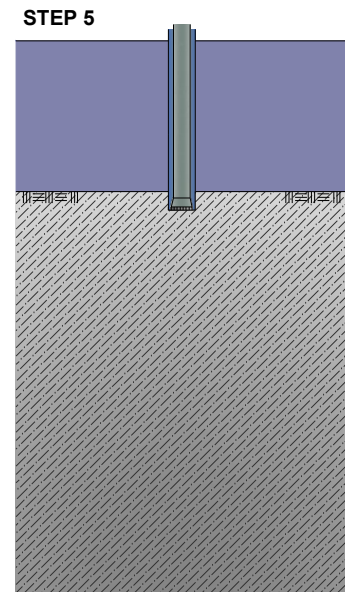
STEP 3

WPT / GROUT BEDROCK
 -5 m STAGE LENGTHS FOR STAGES 1 TO 4
 -4 m STAGE LENGTH FOR STAGE 5
 -WATER PRESSURE TEST WITH DOUBLE PACKER SETUP (SINGLE PACKER FOR BOTTOM STAGE)
 -WPT SEQUENCE TO INCLUDE STAGE 6 AHEAD OF GROUTING
 -GROUT WITH SINGLE PACKER IN UPSTAGE SEQUENCE UNLESS GROUND CONDITIONS REQUIRE DOWNSTAGE WORK



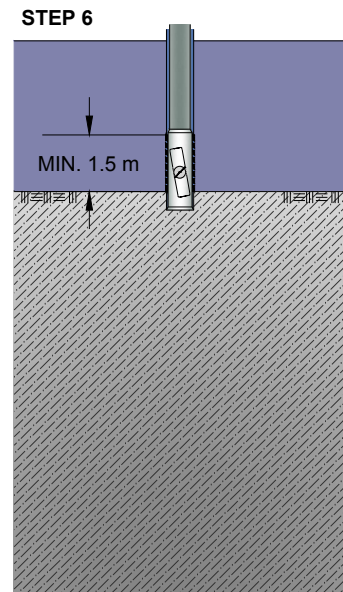
STEP 4

GROUT FIRST INTERFACE STAGE
 -1 m STAGE LENGTH
 -WATER PRESSURE TEST CARRIED OUT DURING STEP 3
 -GROUT WITH SINGLE PACKER FULLY INFLATED INSIDE CASING
 -ALLOW GROUT MINIMUM 48 HOURS SET TIME PRIOR TO PROCEEDING TO STEP 5



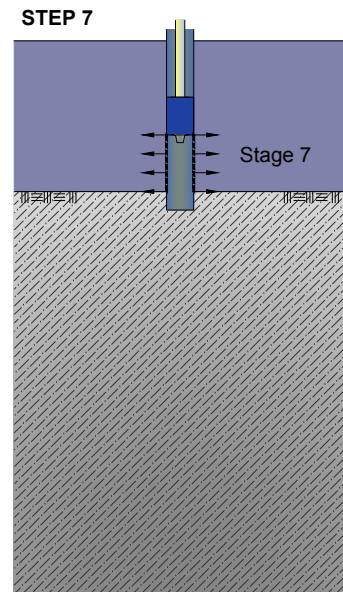
STEP 5

CLEAN CASING
 -RE-DRILL ICE BUILDUP AND REMOVE ANY GROUT REMAINING IN CASING FROM INJECTION CARRIED OUT IN STEPS 3 AND 4
 -SET GROUT BELOW END OF CASING NOT TO BE DRILLED



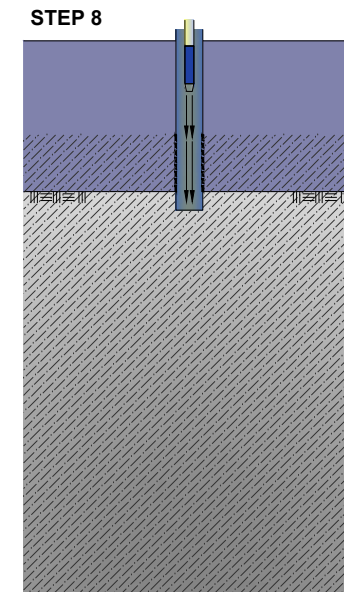
STEP 6

PERFORATE CASING
 -PERFORATOR TOOL RESTS ON CASING SHOE
 -LENGTH OF PERFORATED STAGE VARIES (MINIMUM 1.5 m)
 -HOLES PUNCHED WITHIN CSB / JET GROUT WALL ONLY
 -FOUR ROWS OF HOLES ORIENTED AT 90° TO EACH OTHER, PARALLEL AND PERPENDICULAR TO LONGITUDINAL AXIS OF DIKE.



STEP 7

GROUT SECOND INTERFACE STAGE
 -MINIMUM 1.5 m STAGE LENGTH
 -NO WATER PRESSURE TESTING IN CSB / JET GROUT WALL
 -GROUT WITH SINGLE PACKER FULLY INFLATED INSIDE CASING, ABOVE HIGHEST PERFORATION



STEP 8

TREMIE BACKFILL
 -TO BE CARRIED OUT AT COMPLETION OF STAGE 7 WITH PACKER DEFLATED

LEGEND

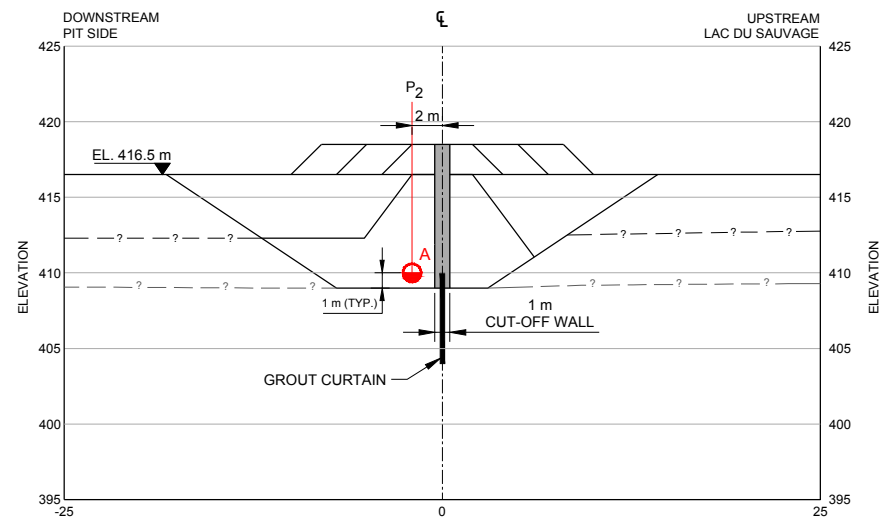
- CSB OR JET GROUTED MATERIAL
- UNTREATED BEDROCK
- GROUTED BEDROCK

NOTES

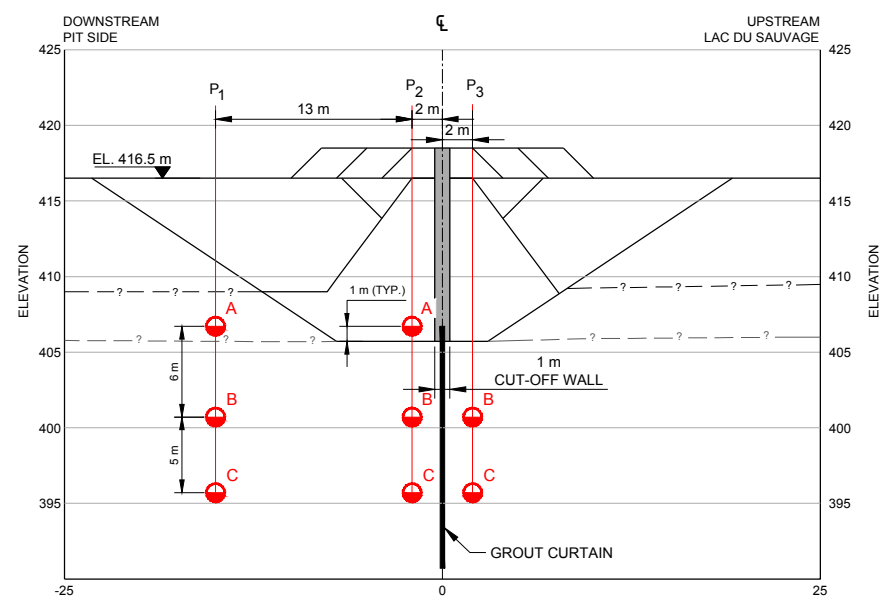
1. CURTAIN GROUTING IS COMPRISED OF THREE DISTINCT ZONES: THE BASE OF CEMENT-SOIL-BENTONITE (CSB) CUT-OFF WALL/TOP OF BEDROCK INTERFACE, THE JET GROUTING/BEDROCK INTERFACE, AND THE CURTAIN GROUTING IN BEDROCK.
2. THE LENGTH OF OVERLAP OF GROUTING ACTIVITIES WITH THE CUT-OFF WALL WILL DEPEND ON THE THICKNESS OF SOIL MATERIALS, IF ANY, LEFT IN PLACE BENEATH THE CUT-OFF WALL DURING CONSTRUCTION, AND ON CONDITIONS ENCOUNTERED DURING THE INSTALLATION OF STEEL CASING THROUGH THE COMPLETED CUT-OFF WALL.
3. THE DEPTH OF THE GROUT CURTAIN INTO BEDROCK BENEATH THE CUT-OFF WALL/JET GROUT/BEDROCK INTERFACE WILL DEPEND ON THE DEPTH OF ANTICIPATED HYDRAULIC HEAD AND BEDROCK CONDITIONS ENCOUNTERED. CONCEPTUAL DELINEATION OF DEPTH OF CURTAIN INTO BEDROCK ARE PROVIDED ON DRAWINGS 300-23, 300-26 AND 300-28.
4. HOLE TARGET DEPTHS TO BE TO BE INCREASED, AS REQUIRED, BASED ON OBSERVED WATER PRESSURE TESTING RESULTS AND GROUT TAKES IN ADJACENT, LOWER ORDER HOLES.
5. DRAWINGS TO BE READ IN CONJUNCTION WITH REPORT E14069-R-REV.0.

Drawing File: H:\Client\dominion diamond\project\99\project\13-1328-0041\02_PRODUCTION\4960\21\1313280041-4960-21_300-52.dwg Layout:300-52 Tuesday, December 02, 2014 4:28:44 PM By: jled

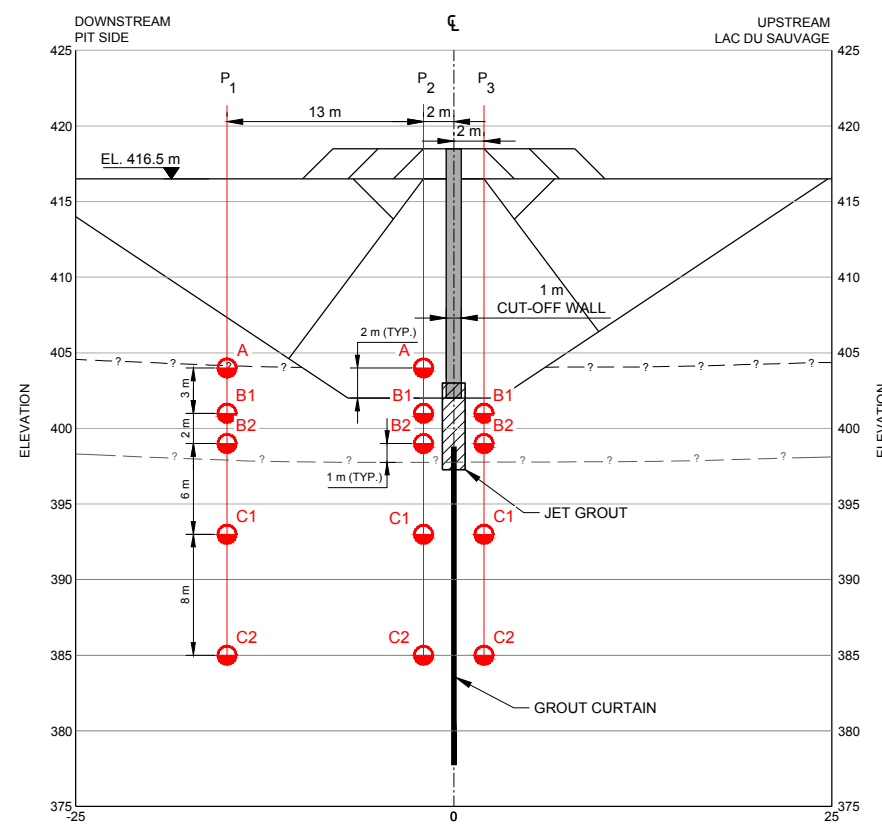
NOT FOR CONSTRUCTION				SEAL / PERMIT		CLIENT 		PROJECT 13-1328-0041.2020.35 JAY PROJECT NORTHWEST TERRITORIES, CANADA																				
				CONSULTANT 		TITLE CURTAIN GROUTING SEQUENCE																						
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1	2014-10-15	ISSUED FOR REVIEW	JD	VR	-	-																						
REV	DATE	DESCRIPTION	DRW	DES	CHK	RWW																						



1 TYPICAL PIEZOMETER CONFIGURATION FOR BEDROCK ABOVE 408 masl
SCALE AS SHOWN



2 TYPICAL PIEZOMETERS CONFIGURATION FOR BEDROCK BETWEEN 408 AND 402 masl
SCALE AS SHOWN



3 TYPICAL PIEZOMETERS CONFIGURATION FOR BEDROCK BELOW 402 masl
SCALE AS SHOWN

LEGEND

- CUT-OFF WALL (CEMENT SOIL BENTONITE)
- JET GROUT
- GROUT CURTAIN
- PIEZOMETER BEAD
- THERMISTOR BEAD
- PIEZOMETER STRING
- INFERRED BEDROCK
- INFERRED COMPETENT SURFACE

- NOTES**
1. ALL UNITS IN METRES UNLESS OTHERWISE NOTED.
 2. ELEVATION IN METRES ABOVE SEA LEVEL.
 3. DRAWING TO BE READ IN CONJUNCTION WITH REPORT E14069-R-REV.0.



REV	DATE	DESCRIPTION	DRW	DES	CHK	RWW
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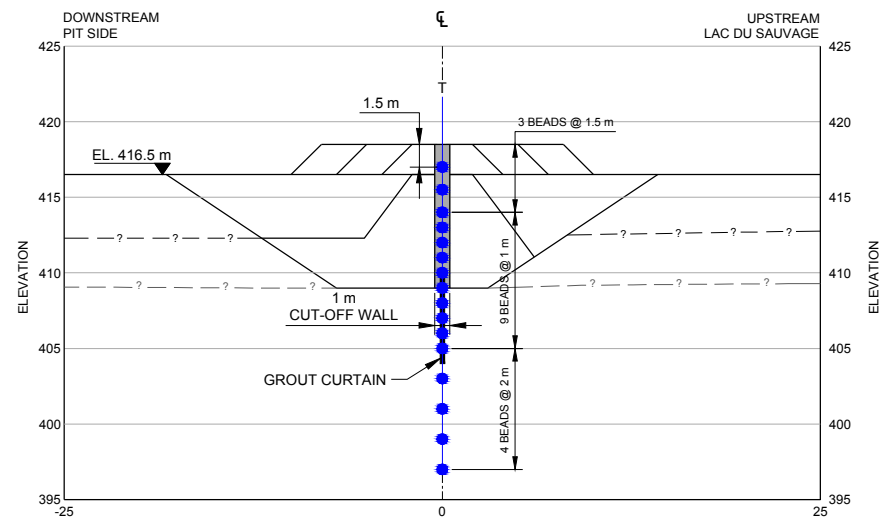
SEAL / PERMIT
NOT FOR CONSTRUCTION

CLIENT
 DOMINION DIAMOND

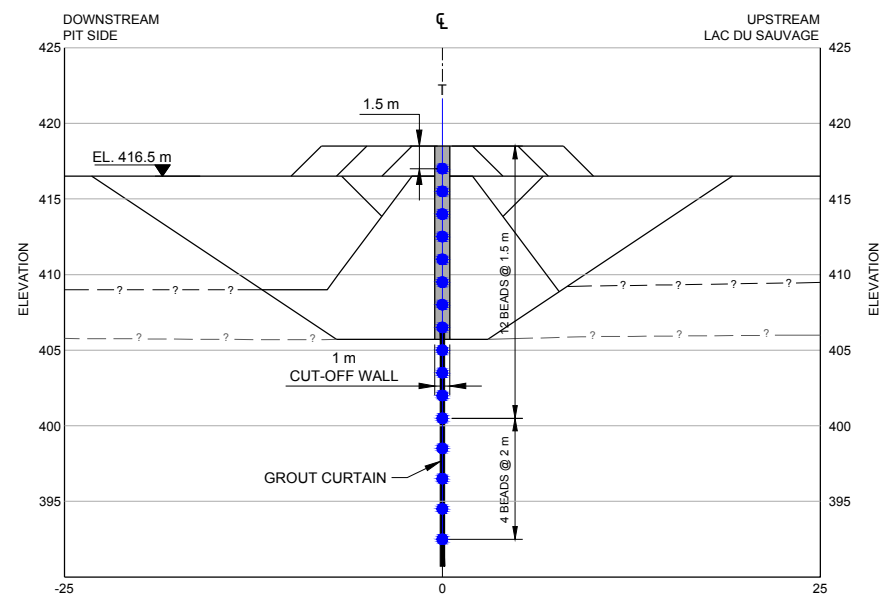
CONSULTANT
 Golder Associates

PROJECT	13-1328-0041.2020.35	
	JAY PROJECT NORTHWEST TERRITORIES, CANADA	
TITLE	INSTRUMENTATION TYPICAL DIKE SECTIONS (1 OF 2)	
DRAWING No.	300-63	SHEET No. 23 OF 25
SHEET SIZE ANSI D 25 mm		

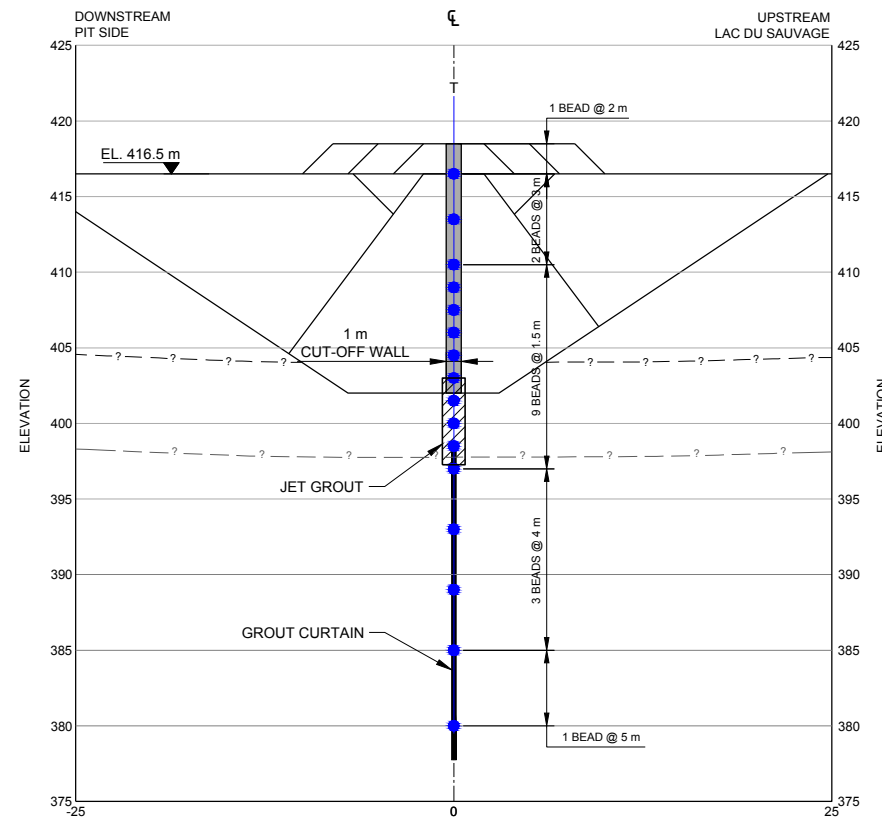
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4
TYPICAL THERMISTOR CONFIGURATION
FOR BEDROCK ABOVE 408 masl
SCALE AS SHOWN



5
TYPICAL THERMISTOR CONFIGURATION
FOR BEDROCK BETWEEN 408 AND 402 masl
SCALE AS SHOWN



6
TYPICAL THERMISTOR CONFIGURATION
FOR BEDROCK BELOW 402 masl
SCALE AS SHOWN

- LEGEND**
- CUT-OFF WALL (CEMENT SOIL BENTONITE)
 - JET GROUT
 - GROUT CURTAIN
 - PIEZOMETER BEAD
 - THERMISTOR BEAD
 - THERMISTOR STRING
 - ASSUMED BEDROCK
 - ASSUMED COMPETENT SURFACE

- NOTES**
1. ALL UNITS IN METRES UNLESS OTHERWISE NOTED.
 2. ELEVATION IN METRES ABOVE SEA LEVEL.
 3. DRAWING TO BE READ IN CONJUNCTION WITH REPORT E14069-R-REV.0.



REV	DATE	DESCRIPTION	DRW	DES	CHK	RWW
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B	2014-10-15	ISSUED FOR REVIEW	JD	FA	-	-

SEAL / PERMIT
NOT FOR CONSTRUCTION

CLIENT
DOMINION DIAMOND

CONSULTANT
Golder Associates

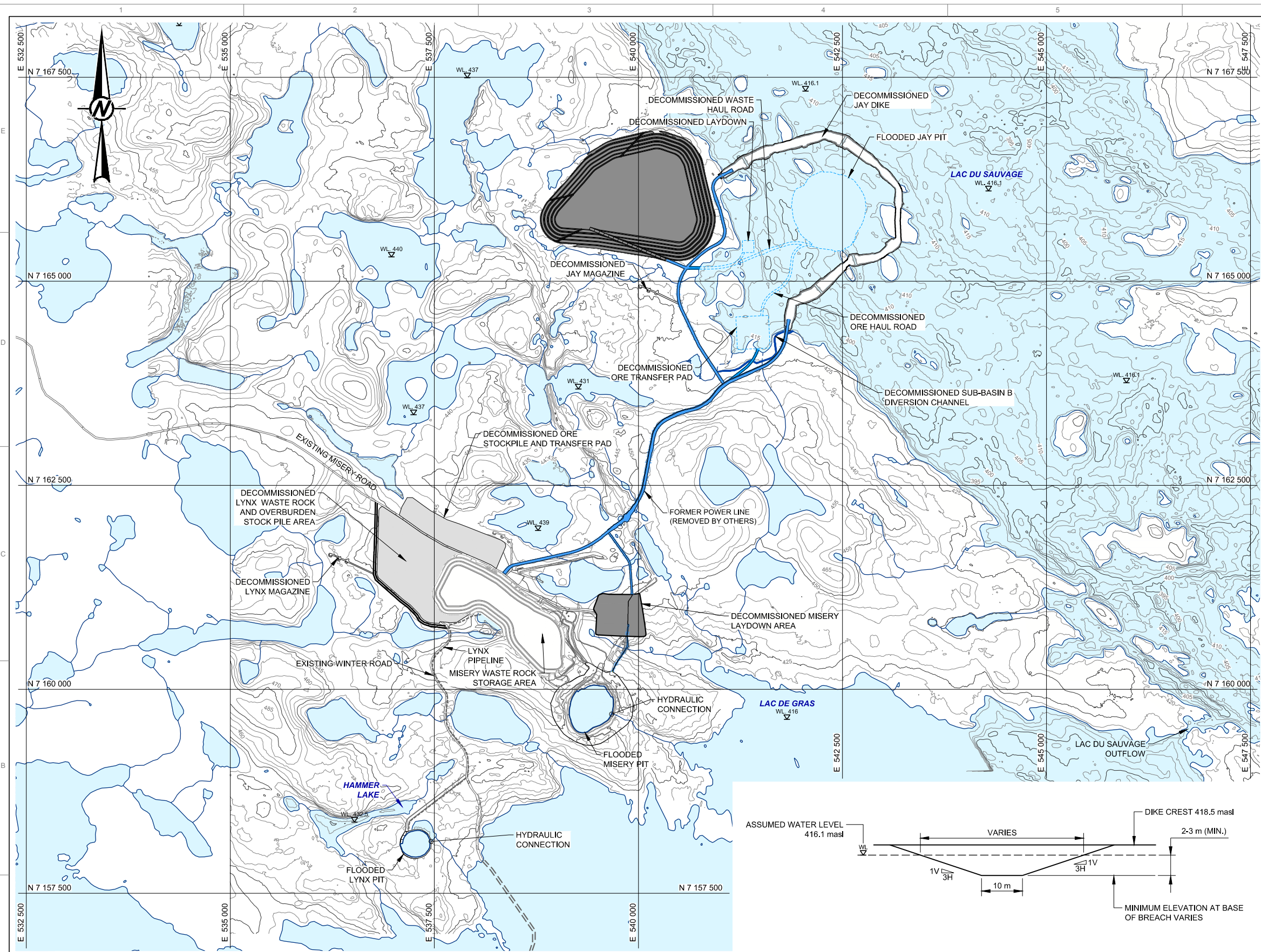
PROJECT
13-1328-0041.2020.35
JAY PROJECT
NORTHWEST TERRITORIES, CANADA

TITLE
INSTRUMENTATION
TYPICAL DIKE SECTIONS (2 OF 2)

DRAWING No. **300-64** SHEET No. **24** OF **25**

SHEET SIZE ANS I D 25 mm

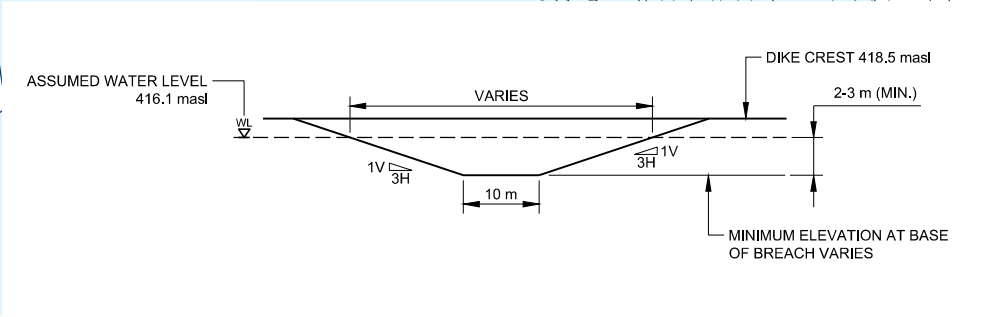
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- LEGEND**
- ▭ WATERBODY
 - WATERCOURSE
 - ROAD
 - = = WINTER ROAD - YEARLY CONSTRUCTION
 - ▽ WATER LEVEL ELEVATION
 - ▭ PROPOSED DIKE BREACHING LOCATION
- JAY PROJECT FOOTPRINT**
- DECOMMISSIONED DIVERSION CHANNEL
 - ▭ DECOMMISSIONED JAY PROJECT INFRASTRUCTURE
 - ▭ DECOMMISSIONED JAY ROADS
 - - - JAY ROADS / PIT OUTLINE UNDER WATER
- LYNX PROJECT FOOTPRINT**
- ▭ LYNX PROJECT INFRASTRUCTURE

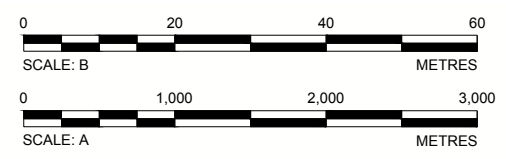
- NOTES**
1. ELEVATIONS ARE IN METERS ABOVE SEA LEVEL (masl).
 2. GROUND SURFACE AND BATHYMETRY CONTOURS ARE SHOWN AT 5 m INTERVALS.
 3. COORDINATES ARE SHOWN IN DATUM: NAD 83, PROJECTION: UTM ZONE 12.
 4. FINAL LOCATION OF DIKE BREACHES TO BE DETERMINED IN DETAILED DESIGN.
 5. CLOSURE PLAN AND RECLAMATION DETAILS FOR LYNX, MISERY AND OTHER EKATI MINE PROJECT FACILITIES ARE DESCRIBED IN OTHER DOCUMENTS. (THEIR CONDITIONS AFTER CLOSURE ARE SHOWN IN THIS FIGURE FOR INFORMATION ONLY) BACK FLOODING OF LYNX AND MISERY OPEN PITS ARE IN THE SCOPE OF WORK OF THIS CLOSURE PLAN.
 6. DRAWING TO BE READ IN CONJUNCTION WITH REPORT E14069-R-REV.0.

- REFERENCES**
1. CONTOUR AND BATHYMETRIC DATA PROVIDED BY AURORA GEOSCIENCES LTD., FILE: Final 1m Contours - Priority Area.dxf, DATE RECEIVED: OCTOBER 29, 2013.
 2. WATER OBTAINED FROM CANVEC NATURAL RESOURCES CANADA, 2012.



PLAN
SCALE: A

TYPICAL DIKE BREACHING PROFILE
SCALE: B



0	2014-12-03	ISSUED FOR PFS	JD	FA	CM	FE
B	2014-10-15	ISSUED FOR REVIEW	JD	FA	-	-
REV	DATE	DESCRIPTION	DRW	DES	CHK	RWW

SEAL / PERMIT
NOT FOR CONSTRUCTION

CLIENT
DOMINION DIAMOND

CONSULTANT
Golder Associates

PROJECT	13-1328-0041.2020.35	
	JAY PROJECT NORTHWEST TERRITORIES, CANADA	
TITLE	CLOSURE PLAN	
DRAWING No.	300-70	SHEET No. 25 OF 25
SHEET SIZE ANSI D 25 mm		

Drawing File: \\Client\dominion\dominion\project\13-1328-0041\02_PRODUCTION\4180\21\131280041-6002-21_500-70.dwg Layout: 300-70 Wednesday, December 03, 2014 11:56:31 AM By: jhad



APPENDIX B

Design Criteria



APPENDIX B Design Criteria

The dike design was prepared using the design criteria identified in Table B1. A description of the selected criteria is described in further detail in the sub-sections that follow.

Table B1: Design Criteria

Design Criteria		Value/Description	Source/Comment
Dike Design Life		Up to 20 years (open pit and underground)	Dominion Diamond
Months when Winter Operation Applies		November to April	Golder
Dam Classification		High	CDA (2007) Refer to Section B1.1
Minimum Setback from Pit to Dike			Refer to Section B1.2
Crest Width	One-way haul road width (including berms)	29.3 m	Refer to Section B1.3
	Two-way haul road width (including berms)	37.1 m	WCBNT (1996)
Lac du Sauvage Water Level	Average	416.1 masl	Dominion Diamond (2014, Annex X)
	With inflow design flood	416.9 masl	Golder (2014); CDA (2013)
Freeboard ^(a)	Normal freeboard	2.5 m	Refer to Section B1.4
	Minimum freeboard	2.6 m	
Design Earthquake	Return period	1:2,475 years	For high consequence classification CDA (2013)
	EDGM	0.036 g	NBCC (2010) Refer to Section B1.5
Slope Stability Criteria	End of construction, prior to dewatering (static)	1.3	CDA (2007)
	During operation, steady state seepage (static)	1.5	
	During operation, steady state seepage (pseudo-static)	1.0	
	Rapid filling	1.2 to 1.3	
Start of Dike Construction		July 2016	Dominion Diamond
Dewatering		May 2019	n/a

a) As measured above average Lac du Sauvage water level of 416.1 masl.

m = metres; masl = metres above sea level; EDGM = earthquake design ground motion; g = gravitational acceleration; n/a = not applicable.



B1.1 Dam Classification

The Canadian Dam Association (CDA) Dam Safety Guidelines (CDA 2007) present the classification of dams in terms of the estimates of potential consequence of dam failure considering the population at risk, environmental and cultural values, and infrastructure and economics. According to the Dam Safety Guidelines, the Jay Dike would be classified as High for the potential loss of life and Significant for environmental and economic losses. The consequence classification is determined by the highest potential consequence and, therefore, the dike is classified as a high consequence structure.

B1.2 Setback

The setback is the distance between the pit crest, at the lakebed surface, and the critical component of the dike (downstream filters and sufficient rockfill shell to provide support). The purpose of the setback is to achieve the following:

- minimize the effect of potential pit wall failures on the stability of the dike, at the ultimate depth of the pit;
- minimize the effect of any underground mine development, if it were to occur, on the stability of the dike;
- provide a buffer to reduce potential effects due to blasting on the low permeability element within the dike;
- provide adequate area for creating stable slopes within the lakebed soils adjacent to the Jay Pit, so that dike stability is not negatively impacted; and,
- provide an area for seepage water collection and management.

Potential interaction between the Jay Pit and dike has not been assessed to confirm the minimum setback distance at this time. This assessment will be carried out as part of future design stages.

B1.3 Crest Width

The overall dike crest width is dependent on the following requirements:

- roadway width for the haul trucks used in the dike construction;
- access for construction equipment; and,
- bedrock or target surface elevation and base width of central trench.

The haul trucks used for the dike construction will also be used for the pit development following construction. It is understood that Dominion Diamond Ekati Corporation (Dominion Diamond) proposes to use 180-tonne haul trucks for the pit development. The haul trucks have, therefore, been used to dimension the crest widths of the proposed dike. The dike widths to allow one-way and two-way traffic, including a safety berm, are 29.3 and 37.1 metres (m), respectively. The widths are based on the mine health and safety regulations for the Northwest Territories and Nunavut (WCBNT 1996). The safety berm height is assumed to be 2.7 m and was determined based on three-quarters of the haul truck tire height.



A rockfill platform width that allows two-way haul truck will be provided on the upstream side of the dike. The rockfill width on the downstream side will be 13.9 m for the shallow and intermediate sections to provide access for construction equipment (i.e., excavator) and wide enough to allow one-way haul truck traffic (29.3 m) for the deep sections.

The combination of the elevation of the bedrock or target surface for the bottom of the trench and specified minimum width of the trench will also affect the rockfill platform width.

B1.4 Freeboard

Freeboard is the minimum vertical distance between the still water surface elevation in the lake and the top of the containment structure. The top of the containment structure is interpreted to be the top of the cut-off wall for the dike.

The dike is to meet the following freeboard conditions as defined by the CDA (2013):

- **Normal Freeboard** is such that the dam is protected against overtopping by 95 percent (%) of the waves caused by the most critical wind with a return period of 1 in 1,000 years with the lake at its average elevation.
- **Minimum Freeboard** is such that the dam is protected against overtopping by 95% of the waves caused by the most critical wind with a return period of 1 in 2 years, with the pond at the inflow design flood elevation.

The minimum freeboard condition was identified as critical (Golder 2014). A minimum dike crest elevation of 418.7 metres above sea level (masl) was calculated, providing a freeboard of 2.6 m. The calculation determined a lake elevation of 416.9 masl during an inflow design flood event, plus a wave run-up and wind setup of 1.8 m. The wave run-up assumes that the rockfill shell is impermeable, and it does not take into account the wide upstream rockfill crest of 37.1 m and the 2.7 m high safety berms along the crest. For the normal freeboard condition, a dike crest elevation of 418.6 masl was calculated, just under the minimum freeboard condition.

Currently, the maximum crest elevation for the dike design is 418.5 masl. Although this is 0.2 m below the calculated minimum freeboard, it is considered reasonable at this stage of design given the assumptions used in the analysis of wave run-up. The permeable nature of the rockfill, along with the width of the rockfill shell and safety berms, should assist in reducing the height of the wave run-up.

B1.5 Seismicity

The CDA guidelines (CDA 2013) state that dams must be designed to withstand an earthquake design ground motion (EDGM) without release of the reservoir. The CDA guidelines recommend an EDGM with a return period of 1 in 2,475 years for high consequence classification structure.

Site seismicity has been obtained from the fourth generation seismic hazard maps developed for the 2010 National Building Code of Canada (NBCC 2010). Horizontal peak ground accelerations (PGA) for the site were obtained from the Hazard Calculator of the Geological Survey of Canada. A summary of the PGA values over a range of return periods is presented in Table B2. The site is located in the relatively low seismic central part of Canada and is a low seismic hazard area.



Table B2: Peak Ground Acceleration for Various Return Periods

Return Period (years)	Peak Ground Acceleration (g) ^(a)
1 in 100	0.003
1 in 475	0.011
1 in 1,000	0.019
1 in 2,475	0.036

Note: PGA based on the Geological Survey of Canada Hazard Calculator using coordinates of the Jay kimberlite pipe.

a) Spectral and peak hazard values are determined for firm ground (NBCC 2010 soil class C – average shear wave velocity 360 to 750 m/s). g = gravitational acceleration; PGA = peak ground acceleration; m/s = metres per second.

The EDGM used in the analysis is, therefore, equivalent to a PGA of 0.036 g.

B1.6 Slope Stability Criteria

The upstream and downstream sections of the dike are to be stable throughout the construction and operational life of the structure and under various lake and downstream pool levels. The CDA guidelines (CDA 2007) for static and seismic assessment of slope stability are summarized in Table B3.

Table B3: Factors of Safety for Slope Stability Analysis

Loading Conditions		Minimum Factor of Safety
End of Construction	Static	1.3
Long-term (steady-state seepage, normal reservoir level)	Static	1.5
	Pseudo-static	1.0
	Post-earthquake	1.3
Full or Partial Rapid Drawdown	Static	1.2 to 1.3

The CDA guidelines were developed for typical water retaining dams, which are filled following construction and are subject to reservoir level fluctuations. The end of construction for the Jay Dike assumes average lake levels on the upstream and downstream sides. Drawdown is also likely to occur only once during the dewatering phase of the project. The minimum factors of safety were, therefore, applied as considered appropriate to the Jay Dike stability analysis.



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APPENDIX C

Seepage and Stability Analysis



C1.0 INTRODUCTION

Golder Associates Ltd. (Golder) is preparing a pre-feasibility study design for the Jay Project at the Ekati Diamond Mine, which is owned by Dominion Diamond Ekati Corporation (Dominion Diamond). In support of the pre-feasibility study Jay Dike design, this technical memorandum has been prepared to present the seepage and stability analyses that have been carried out to do the following:

- estimate the seepage through the dike and examine downstream hydraulic gradients; and,
- calculate dike slope stability factors of safety for several critical sections under both static and seismic loading conditions.

Two-dimensional finite element seepage modelling and limit equilibrium slope stability modelling were carried out using the commercially available computer software SEEP/W and SLOPE/W (Version 7.23), developed by GEO-SLOPE International Ltd. (Geo-Slope 2010a,b).

C2.0 ANALYSIS CRITERIA

The criteria and requirements for the seepage and stability analyses are discussed in this section.

The Canadian Dam Association (CDA) Dam Safety Guidelines (CDA 2007) recommend minimum factors of safety values for slope stability under a number of static and seismic loading conditions as summarized in Table C1 and Table C2.

Table C1: Factors of Safety of Slope Stability for Static Assessment

Loading Condition	Minimum Factor of Safety
End of Construction before Reservoir Filling (dewatering) ^(a)	1.3
Long-term (steady-state seepage, normal reservoir level)	1.5

Source: CDA (2007).

a) In the case of the Jay Dike, end of construction factor of safety applies prior to dewatering, as this is equivalent to the initial reservoir filling for other dams.

Table C2: Factors of Safety for Slope Stability for Seismic Assessment

Loading Conditions	Minimum Factor of Safety
Pseudo-static	1.0
Post-earthquake	1.2-1.3

Source: CDA (2007).

The CDA guidelines suggest values for earthquake design ground motion based on the consequence of the dam failure. The Jay Dike has been classified as a High consequence structure. For such a structure, the suggested design earthquake has an annual exceedance probability of 1 in 2,475 years (CDA 2013). The corresponding design peak ground acceleration obtained from the 2010 National Building Code Seismic Hazard Calculation (NBCC 2010) for the Ekati Mine site is 0.04 g with the return period of 1 in 2,475 years. Refer to Attachment C1 for the output from National Building Code Seismic Hazard Calculation.



The pre-feasibility design for the Jay Dike includes key components consisting of the low permeability elements (cut-off wall, jet grouting, and grouting), fine filter and coarse filter, and a portion of the rockfill on the downstream and upstream side to provide support for the filters and low permeability element. Minimum static and seismic factors of safety must be achieved to be protective of these key components and have been assessed in through the analyses presented in this memorandum.

The CDA recommends that a geotechnical assessment be carried out to confirm that seepage exit gradients are within acceptable limits for the embankment and foundation materials to limit the potential for internal erosion (CDA 2007). At this stage of design, a criterion of 1 for the maximum hydraulic exit gradient has been used when reviewing of the results of the seepage analyses.

C3.0 MATERIAL PROPERTIES

Hydraulic conductivities and strength parameters for the materials used in the analyses are presented in Table C3, Table C4, and Table C5. The material properties used in the modelling were selected based on information obtained from the site investigation carried out in Lac du Sauvage (Golder 2014), the Hydrogeology Baseline Report (Dominion Diamond 2014, Annex IX), and past project experience at the Diavik Diamond Mine and Meadowbank Gold Mine.

Table C3: Material Properties for Seepage Modelling

Material	Saturated Hydraulic Conductivity (m/s)
Rockfill	1×10^{-2}
Coarse Filter	1×10^{-2}
Compacted Fine Filter	1×10^{-5}
Lakebed Sediment	1×10^{-7}
Competent Soil	2×10^{-6}
Cement Soil Bentonite (CSB) Cut-off Wall	1×10^{-8}
Jet Grout Columns	5×10^{-8}
Grouted Bedrock	5×10^{-7}
Weathered Bedrock (0 to 25 m)	$k_{\text{horizontal}} 4 \times 10^{-6}$
	$k_{\text{vertical}} 2 \times 10^{-6}$
Deep Bedrock (>25 m)	1×10^{-7}

m = metre; m/s = metres per second; $k_{\text{horizontal}}$ = saturated horizontal hydraulic conductivity; k_{vertical} = saturated vertical hydraulic conductivity; > = greater than.



Table C4: Material Properties for Stability Modelling

Material	Unit Weight (kN/m ³)	Friction Angle (degrees)	Cohesion (kPa)
Rockfill	22	Strength function (see Table C5)	0
Coarse Filter	21	36	0
Compacted Fine Filter	24	38	0
Lakebed Sediment	17	28	0
Competent Soil – Granular	21	35	0
Competent Soil – Fine Grained	21	30	0
Cement Soil Bentonite (CSB) Cut-off Wall	21	32	200
Jet Grout Columns	21	35	500
Grouted Bedrock		Impenetrable	
Bedrock		Impenetrable	

kN/m³ = kiloNewtons per cubic metre; kPa = kilopascal.

Table C5: Rockfill Strength Function

Friction Angle (degrees)	Normal Stress (kPa)	Shear Stress ^(a) (kPa)
43	0	0
43	19	18
43	38	35
43	76	71
43	133	124
40.5	342	292
38	684	534
36	1,368	994

Source: Leps (1970).

a) Based on Mohr-Coulomb criteria and zero cohesion.

kPa = kilopascal

C4.0 MODEL CONFIGURATION AND ANALYSIS METHOD

This section summarizes model configurations and analysis methods used.

4.1 Seepage Model

The typical cross-section for the Jay Dike varies based on the bedrock elevation as shown in Drawing 300-10 (Appendix A). Therefore, the following sections were considered representative and were used in the analyses:

- Deep Section A at Station 3+410 (with jet grout columns);
- Deep Section B at Station 0+750 (thin competent soil);
- Intermediate Section at Station 1+340; and,
- Shallow Section at Station 2+420.



Table C6 summarizes the key differences in model configuration for each of the representative sections.

Table C6: Summary of Typical Seepage Sections

Model Section	Section at Station (m)	Cut-off Wall Termination	Base Width of Central Trench Excavation (m)	Bedrock Surface Elevation (masl)
Deep A	3+410	Competent soil	10	398
Deep B	0+750	Bedrock	10	402
Intermediate	1+340	Bedrock	10	402.5
Shallow	2+420	Bedrock	8	409.7

m = metre; masl = metres above sea level.

For each section, modelling considered two steady-state seepage scenarios: 1) dewatered downstream prior to pit development and 2) a final configuration, once the pit has been fully developed to a base elevation of 45 metres (m). Typical model sections with the seepage material properties summarized for these scenarios are presented in Figure C1.

The configuration of the seepage models is summarized as follows:

- dike crest elevation of 416.5 m, as the densification platform (418.5 m) was excluded;
- Lac du Sauvage water elevation of 416.1 m;
- a width of 1 m for the cut-off wall, jet grouted columns, and grouted bedrock;
- no lakebed sediments beneath the rockfill; the removal of this low permeability layer from the model is conservative; and,
- the lakebed sediments located downstream of the dike were excluded, as these materials are anticipated to consolidate into a very thin layer, during dewatering.

The location of the downstream phreatic level was determined in the model.

Seepage fluxes were calculated at the downstream toe of the dike. These were then used to estimate total seepage through the dike, following dewatering, by assigning representative dike lengths to each of the typical sections modelled. The seepage models do not consider the influence of enhanced permeability zones within the bedrock (e.g., faults, shear zones). Furthermore, the seepage models do not consider the potential reduction in seepage fluxes from permafrost at the dike abutments or near islands.



4.2 Dike Stability Model

The dike design sections modelled for slope stability, following construction, are taken from the following locations:

- Deep Section at Station 4+700; and,
- Intermediate Section at Station 3+520.

The stability sections at Station 4+700 and Station 3+520 were selected for the analyses based on the steepness of the existing lakebed surface at these locations. Station 4+700 was also selected to evaluate the potential impact of the fine-grained soil that was encountered at this location during the 2014 winter investigation (Golder 2014) on dike stability. A typical section presenting the modelled materials and strength parameters used in the stability assessment is shown in Figure C2.

For each representative section, two scenarios were considered and are summarized as follows.

- **Ongoing Construction:** As dike construction will occur over multiple years, with haul truck traffic operating on the dike, stability of the dike has been assessed with a loaded haul truck, prior to dewatering. For completeness, stability assessments of both the downstream and upstream slopes have been conducted.
- **During Operations:** The dike construction is complete and the basin downstream is dewatered.

During construction of the rockfill platform, it is anticipated that rockfill will penetrate and/or displace the soft lakebed sediment. Therefore, in the dike stability models, the rockfill is founded on competent soil. To be conservative, the dike stability models also considered scenarios where a 1 m layer of lakebed sediment remains beneath the rockfill. It is unlikely that soft lakebed sediment will remain beneath the rockfill, but this will be confirmed following future geotechnical investigations.

In all stability models, the lakebed sediment upstream and downstream of the dike has been assumed to not provide any resistance to the potential failure surfaces. Therefore, lakebed sediments in these locations have been removed from the models.

For the construction scenario, the dike stability models included a loaded 180-tonne haul truck travelling on the dike with the following mass and geometry:

- a total operating weight of 325 tonnes (131 tonnes machinery weight and 194 tonnes of loading);
- a weight distribution of 67 percent (%) of the weight on the rear axle (near edge when dumping) and 33% of the weight on the front axle;
- for the haul truck point load closest to the dike crest, an approximate distance of 7.2 m includes the width of the safety berm and haul truck tire; and,
- 5.7 m wheel base.



The Morgenstern-Price method was used to assess factors of safety. In all analyses, both circular and block slip surfaces were analyzed.

C5.0 RESULTS

5.1 Seepage Quantity Estimate and Hydraulic Gradients

The steady state seepage fluxes for each modelled section are summarized in Table C7 and Table C8. By calculating representative lengths for each section based on the design dike profile, the total seepage volume through the dike after dewatering and prior to pit excavation has been estimated and is summarized in Table C7 and Table C8. The total length of the dike is about 4,400 m, excluding the length of dike crossing islands. The seepage patterns with total head contours for the modelled sections are shown in Figure C3 through Figure C6.

After dewatering and prior to pit excavation, the majority of the seepage is anticipated to occur through the weathered bedrock, as the weathered bedrock has an assumed saturated hydraulic conductivity that is one to two orders of magnitude greater than the underlying competent bedrock and the low permeability elements (cut-off wall, jet grouting, and curtain grouting) of the dike.

As the pit is excavated, the seepage through the weathered bedrock increases slightly and decreases at the downstream toe of the dike.



APPENDIX C Seepage and Stability Analyses

Table C7: Total Seepage through Dike after Dewatering Prior to Pit Excavation

Model Section	Section at Station (m)	Bedrock Surface Elevation (m)	Graphical Summary of Results	Seepage Reporting to Downstream Toe (m ³ /day/m)	Representative Length (m)	Estimated Total Seepage Reporting to Downstream Toe (m ³ /day)
Deep A	3+410	398	Figure C3	2.2	672	6,100
Deep B	0+750	402	Figure C4	2.1	213	
Intermediate	1+340	402.5	Figure C5	1.4	2,298	
Shallow	2+420	409.7	Figure C6	0.8	1,235	

m = metre; m³/day/m = cubic metres per day, per linear metre of dike; m³/day = cubic metres per day.

Table C8: Total Seepage through Dike after Pit Development to Elevation 45 masl

Model Section	Section at Station (m)	Bedrock Surface Elevation (m)	Graphical Summary of Results	Seepage Reporting to Downstream Toe (m ³ /day/m)	Representative Length (m)	Estimated Total Seepage Reporting to Downstream Toe (m ³ /day)
Deep A	3+410	398	Figure C3	1.6	672	3,200
Deep B	0+750	402	Figure C4	1.8	213	
Intermediate	1+340	402.5	Figure C5	0.6	2,298	
Shallow	2+420	409.7	Figure C6	0.3	1,235	

m = metre; masl = metres above sea level; m³/day/m = cubic metres per day, per linear metre of dike; m³/day = cubic metres per day.



APPENDIX C Seepage and Stability Analyses

As part of the seepage analyses, hydraulic gradients were evaluated in two locations, which are described as follows:

- Along the base of the fine filter, immediately downstream of the cut-off wall: At this location, there is a horizontal interface between the fine filter and either bedrock or competent soil. Hydraulic gradients were evaluated in the upward direction.
- At the downstream toe of the dike: At this location, there is an interface of rockfill and lakebed sediment. Hydraulic gradients were evaluated in two dimensions (vertical and horizontal direction).

Table C9 presents the upward hydraulic gradients along the base of the fine filter. These results indicate that for sections at Stations 1+340, 2+420, and 3+410, the hydraulic gradients are less than 0.5. In Deep Section B at Station 0+750, the hydraulic gradient immediately downstream of the cut-off wall is around 0.8 and declines rapidly to a value of about 0.3 at a distance of approximately 3 m downstream of the cut-off wall. The vertical hydraulic gradient along the base of the fine filter for the section at Station 0+750 is presented in Figure C7.

Table C9: Summary of Vertical Hydraulic Gradients (Y)

Model Section	Section at Station (m)	Bedrock Surface Elevation (m)	Interface With	Upward Hydraulic Gradient Along Downstream Trench Base ^(a)
Deep A	3+410	398	Competent soil	0.4 to 0.1
Deep B	0+750	402	Bedrock	0.8 to 0.3
Intermediate	1+340	402.5	Bedrock	0.4 to 0.2
Shallow	2+420	409.7	Bedrock	0.4 to 0.1

a) Downstream trench width of 5 m for shallow sections and 7 m for intermediate and deep sections.

m = metres.

Table C10 presents the two-dimensional hydraulic gradients at the downstream toe. The downstream exit gradient is 0.1 or less for all sections modelled.

Table C10: Summary of Two-Dimensional Hydraulic Gradients (XY)

Model Section	Section at Station (m)	Bedrock Surface Elevation (m)	Exit Gradient (XY) at Downstream Toe
Deep A	3+410	398	0.1
Deep B	0+750	402	0.04
Intermediate	1+340	402.5	0.1
Shallow	2+420	409.7	0.04

m = metres.



In addition to the results in Table C10, the sensitivity of the downstream hydraulic gradient to the lakebed sediments was evaluated. When it was assumed that lakebed sediment underlies the rockfill, the maximum exit gradient was between 0.4 and 0.1. The hydraulic gradient of 0.4 was measured at the shallow section at Station 2+420.

5.2 Seepage Analyses Limitations

The results of the seepage analyses presented are based on two-dimensional analyses using estimates for the material properties and design geometry of the sections considered. The analyses did not consider potential construction defects within the dike or variability in the soil or bedrock properties.

The primary goal of the seepage analyses is to assess the seepage fluxes and hydraulic gradients through the earthfill zones and at the interfaces between different earthfill zones. As the modelling is primarily focused on soil, some parameters associated with bedrock seepage have been simplified. The seepage rate with the fully excavated pit does not consider the influence of seepage through enhanced permeability zones in the rock mass. A detailed seepage model considering these enhanced permeability zones is beyond the scope of this analysis, but has been addressed in hydrogeological modelling of the Jay Pit. Refer to the Developer's Assessment Report for the results of the Jay Pit hydrogeology modelling (Dominion Diamond 2014, Appendix 8A).

5.3 Slope Stability

Table C11 and Table C12 present a summary of the minimum factor of safety obtained from the stability models during the scenarios of ongoing construction and following dewatering, respectively. The minimum potential failure surface for each section modelled both on the upstream and downstream side is shown in Figures C8 through Figure C11. Both circular and block failure surfaces were analyzed and in the majority of cases were equivalent. In select cases, predicted factors of safety differed. The potential failure surface with the lowest factor of safety is presented in the Figure C8 to C11 and Table C11 to Table C13.



APPENDIX C Seepage and Stability Analyses

Table C11: Dike Slope Stability Factors of Safety – Ongoing Construction

Model Section	Section at Station (m)	Side	Average Lakebed Slope (degrees)	Graphical Summary of Results	Factor of Safety		
					Static		Minimum Requirement
					No Lakebed Sediment ^(a)	1 m Lakebed Sediment ^(b)	
Deep	4+700	Upstream	14	Figure C8	1.2	1.1	1.3
	4+700	Downstream	5	Figure C9	1.2	1.1	
Intermediate	3+520	Downstream	5	Figure C10	1.1	1.0	
	3+520	Upstream	3	Figure C11	1.2	1.0	

a) Static factors of safety for cases where rockfill is founded on competent soil.

b) Static factors of safety for cases where 1 m of lakebed sediment assumed beneath rockfill.

m = metre.

Table C12: Dike Slope Stability Factors of Safety – Following Dewatering

Model Section	Section at Station (m)	Side	Average Lakebed Slope (degrees)	Graphical Summary of Results	Factor of Safety				
					Static		Minimum Requirement	Pseudo-static ^(c)	Minimum Requirement
					No Lakebed Sediment ^(a)	1 m Lakebed Sediment ^(b)			
Deep	4+700	Upstream	14	Figure C8	1.5	1.5	1.5	1.2	1.0
	4+700	Downstream	5	Figure C9	1.8	1.7		1.6	
Intermediate	3+520	Downstream	5	Figure C10	1.6	1.5		1.4	
	3+520	Upstream	3	Figure C11	1.8	1.6		1.4	

a) Static factors of safety for cases where rockfill is founded on competent soil.

b) Static factors of safety for cases where 1 m of lakebed sediment assumed beneath rockfill.

c) Factors of safety for pseudo-static conditions shown are for cases where 1 m of lakebed sediment beneath rockfill is assumed.

m = metre.



APPENDIX C Seepage and Stability Analyses

During ongoing construction, the upstream and downstream sections at Station 4+700 and Station 3+520 do not meet the minimum stability criteria. Additional scenarios were modelled where the distance from the crest to the haul truck was increased from 7.2 m. Table C13 presents a comparison of the minimum factor of safety during ongoing construction with varying haul truck locations such as no haul truck, haul truck 7.2 m from dike crest, and haul truck at the distance required to achieve the minimum factor of safety criteria.

Table C13: Comparison of Dike Slope Stability Factors of Safety during Ongoing Construction

Model Section	Section at Station (m)	Side	Average Lakebed Slope (degrees)	Haul Truck Location ^(a)	Factor of Safety ^(b)
Deep	4+700	Upstream	14	No truck	1.5
				7.2 m	1.2
				15 m	1.3
	4+700	Downstream	5	No truck	2.0
				7.2 m	1.2
				8 m	1.3
Intermediate	3+520	Downstream	5	No truck	1.7
				7.2 m	1.1
				10 m	1.3
	3+520	Upstream	3	No truck	1.8
				7.2 m	1.2
				9 m	1.3

a) Distance from the crest to the haul truck point load.

b) Static factors of safety for cases where rockfill is founded on competent soil.

m = metre.

By increasing the distance by 1 to 3 m, roughly 8 to 10 m from the crest, the minimum factor of safety criteria is achieved in all sections except at Station 4+700 – upstream slope. For Station 4+700 – upstream, by increasing the haul truck distance by 8 m, to roughly 15 m from the upstream crest, the minimum factor of safety of 1.3 is achieved.

In the ongoing construction scenario, backfilling of the central core is complete. For the upstream stability sections, the adjusted haul truck locations presented in Table C13 satisfy minimum two-way road width for the haul trucks (WCBNT 1996).

Following dewatering of the basin, the minimum factor of safety criteria are met or exceeded in all sections. For all sections modelled, potential failure surfaces within the rockfill shell have a factor of safety of 1.5 or higher. The minimum factor of safety criteria for pseudo-static conditions were satisfied in all sections analyzed.



C6.0 SUMMARY AND CONCLUSIONS

Seepage Analyses

- Following dewatering of the basin, the estimated total seepage at the downstream toe of the dike is 6,100 cubic metres per day (m³/day).
- Following complete development of the pit, the estimated total seepage at the downstream toe of the dike is 3,200 m³/day.
- Parameters associated with bedrock seepage have been simplified in the seepage models. As such, the models do not consider the influence of enhanced permeability zones in the rock mass. The findings of Jay Pit hydrogeological modelling (Dominion Diamond 2014, Appendix 8A) should be referred to in regard to potential seepage flows into the proposed Jay Pit.
- The hydraulic gradient in the upward direction at the base of the fine filter decreases with increasing distance from the cut-off wall.
- At sections of the dike where the competent soil is thin, such as Deep Section B at Station 0+750, hydraulic gradients in the upward direction at the base of the fine filter may be as high as 0.8 and decrease to 0.3 within the filter zone. For all other sections modelled, the hydraulic gradient is 0.4 or less.
- Under the assumed downstream dewatering conditions, the hydraulic gradient at the downstream toe of the dike is less than 0.1 in all sections.

Stability Analyses

- During ongoing construction, the dike sections modelled did not meet the minimum factor of safety criteria for static conditions. Further stability analyses indicated that the minimum factor of safety criteria are satisfied if the distance between the dike crest and haul truck is increased to 8 to 10 m, from 7.2 m. In one particular case (section at Station 4+700 – upstream), the distance was increased to 15 m to achieve the minimum factor of safety criteria.
- During operations, the dike sections modelled met or exceeded the minimum factor of safety criteria. Potential failure surfaces with a factor of safety of 1.5 or less were limited to within the rockfill shell and did not intersect the central core materials.
- When it is assumed that the rockfill is founded on 1 m of lakebed sediment, the modelled factors of safety are slightly lower than when rockfill is founded on competent soil. This assumption should be re-evaluated following future geotechnical investigations.
- The most critical dike stability section modelled is the upstream section at Station 4+700. At this location, the average upstream lakebed slope is approximately 14 degrees and the foundation may contain fine grained competent soil. This section should be re-evaluated in future studies using the results of future geotechnical investigations.
- Under pseudo-static conditions, all sections modelled satisfied the minimum factor of safety criteria.



C7.0 RECOMMENDATIONS

- Cone penetration testing should be carried out during future geotechnical investigations to evaluate the material characteristics of the lakebed sediment and the fine grained competent soil.
- The assumptions and model configurations used in these analyses should be re-evaluated following the completion of future geotechnical investigations.
- Although some of the modelled dike stability sections did not meet the minimum factor of safety criteria, several assumptions were made regarding the thickness, continuity, and material properties. These assumptions should be re-evaluated in future design studies using data from any additional geotechnical investigations.
- In future design studies when additional geotechnical information is available, the stability of the rockfill platform during rockfill placement in the lake should be evaluated. The impact of construction equipment on the stability of the rockfill platform in the vicinity of the working front should be included in this assessment. Depending on the findings of future geotechnical investigations, the undrained strength of lakebed soils could be included in this assessment.
- In future design studies, a construction monitoring plan should be developed for the placement of rockfill, particularly in areas of the dike where it may be difficult to achieve the minimum factor of safety criteria.

Attachments: Figures C1 to C11

Attachment C1: 2010 National Building Code Seismic Hazard Calculation

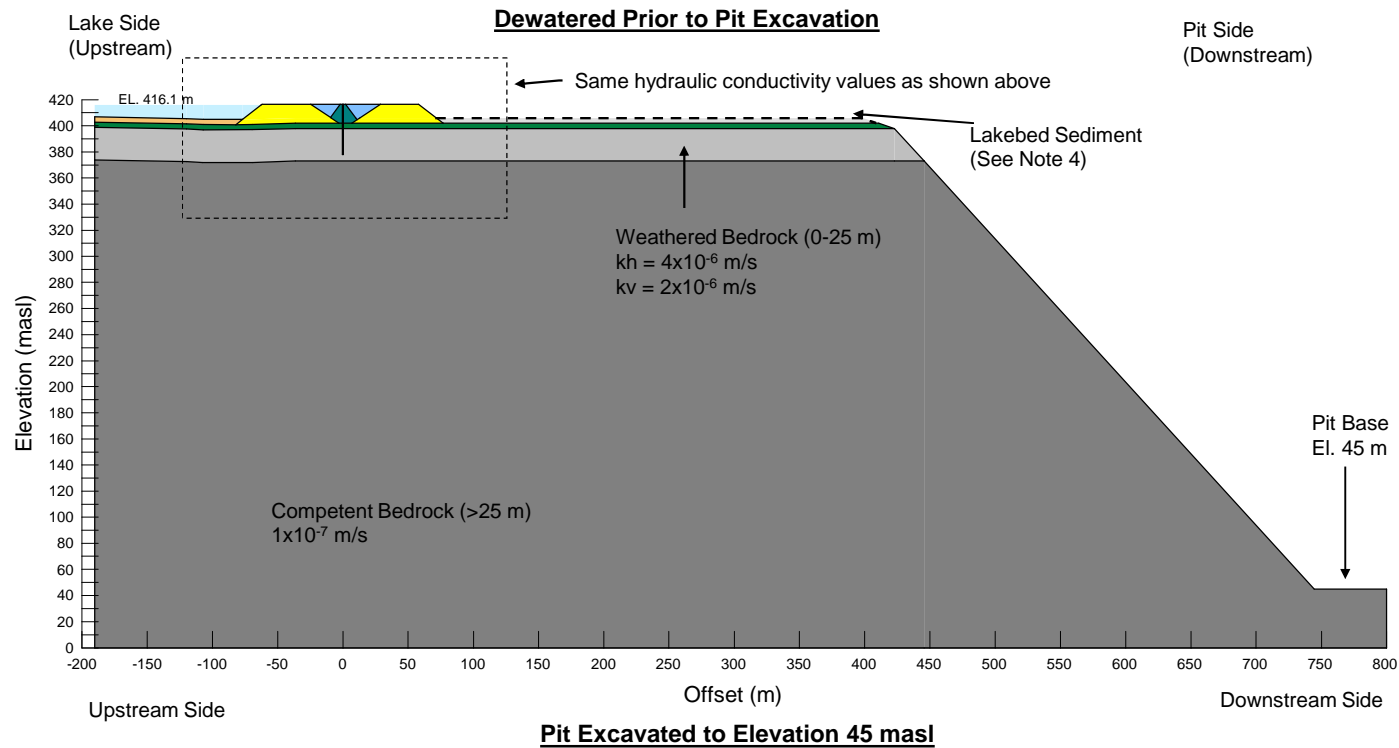
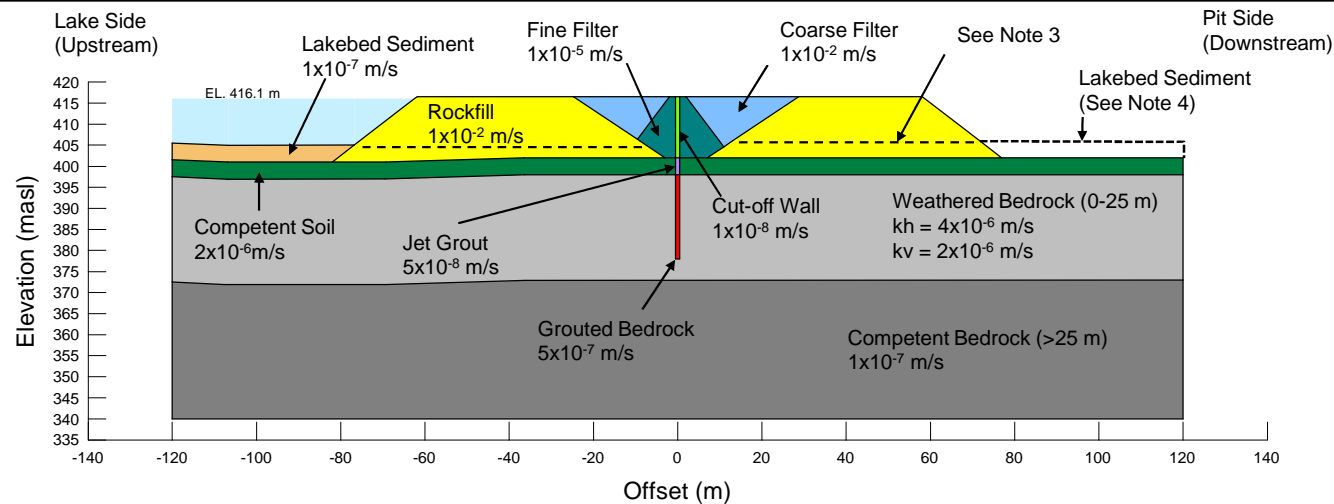
o:\final\2013\1328\13-1328-0041\1313280041-e14069-r-rev0-2020\appendices\appendix c - seepage and stability\appendix c - seepage and stability (8dec2014).docx



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- CDA. 2013. Dam Safety Guidelines, 2007 (Revised 2013).
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- Golder (Golder Associates Ltd.). 2014. Jay Project Geotechnical and Hydrogeological Field Investigation Factual Report Vol.1: Proposed Dikes. Prepared for Dominion Diamond Corporation, Yellowknife NWT, Canada.
- Leps TM. 1970. Review of shearing strength of rockfill. Journal of Soil Mechanics and Foundation Division, Proceedings of the American Society of Civil Engineers. 96 SM4:1159-1170.
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- WCBNT (Workers' Compensation Board of the Northwest Territories and Nunavut). 1996. Consolidation of Mine Health and Safety Regulations of the Northwest Territories.

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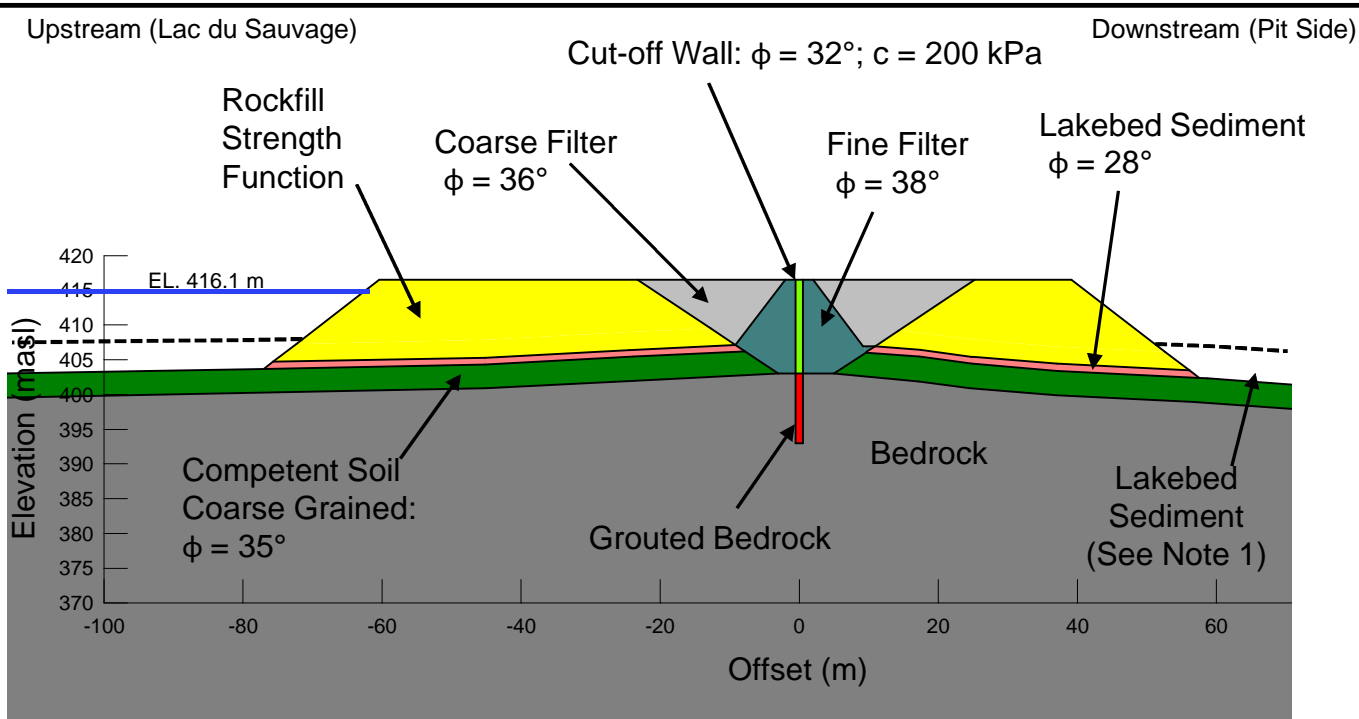
- Notes:**
1. Open pit wall geometry shown is simplified.
 2. Enhanced permeability zones (e.g. faults, shear zones, etc.) not included in seepage models.
 3. Seepage models assume no lakebed sediment underlying rockfill.
 4. Downstream lakebed sediment removed for seepage modelling purposes. Considered representative of condition following dewatering when material will have consolidated.
 5. Densification platform along dike crest not shown for presentation purposes.

PROJECT	DOMINION DIAMOND CORPORATION JAY PROJECT NORTHWEST TERRITORIES		
TITLE	SEEPAGE ANALYSIS TYPICAL MODEL SECTIONS AND HYDRAULIC CONDUCTIVITIES		
PROJECT No.	13-1328-0041	PHASE No.	2020/35
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CHECK	JFC	SDEC14	
REVIEW	FE	SDEC14	

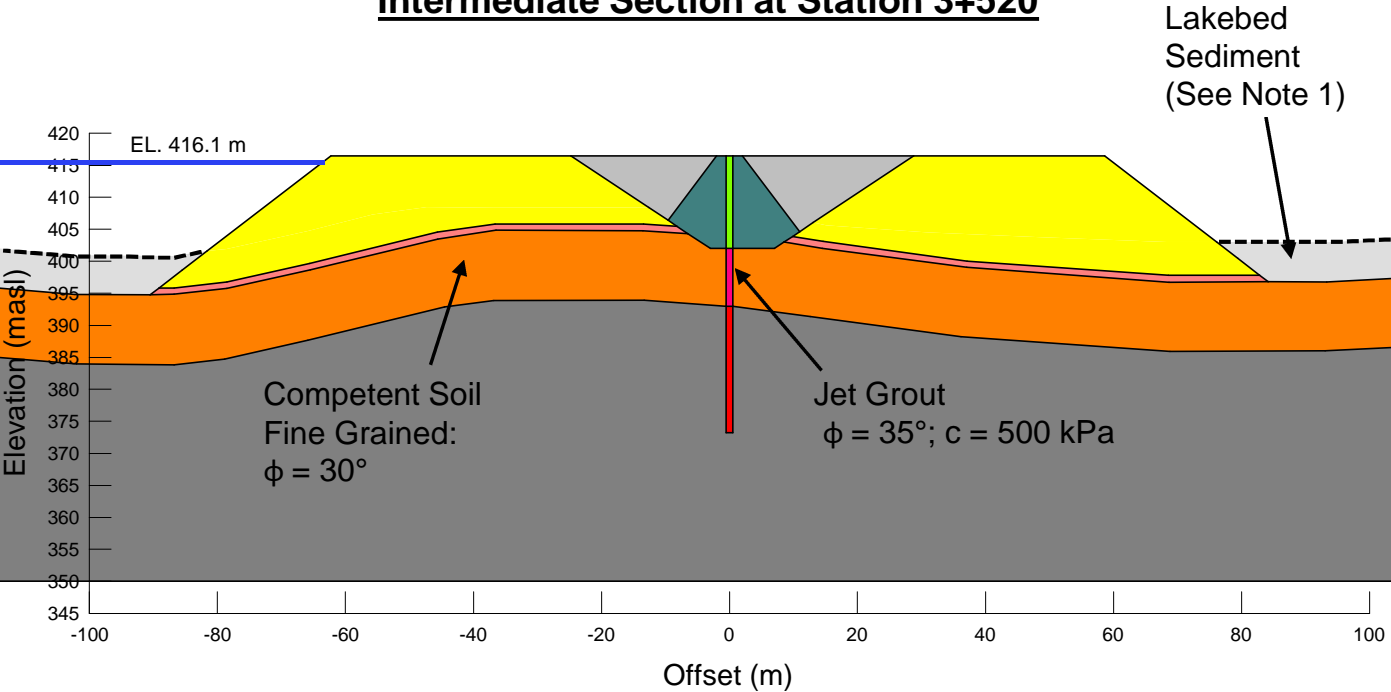


FIGURE C1

FILE: \\golder.gds\gall\Burnaby\Active\2013\1328\13-1328-0041_2000 DD Eng\2020 Pre-Feasibility\35 Dike Design\02 - Dike Analyses\Seepage and Stability\Write-up Rev B\Stability Figures - 1Oct2014.ppt



Intermediate Section at Station 3+520



Deep Section at Station 4+700

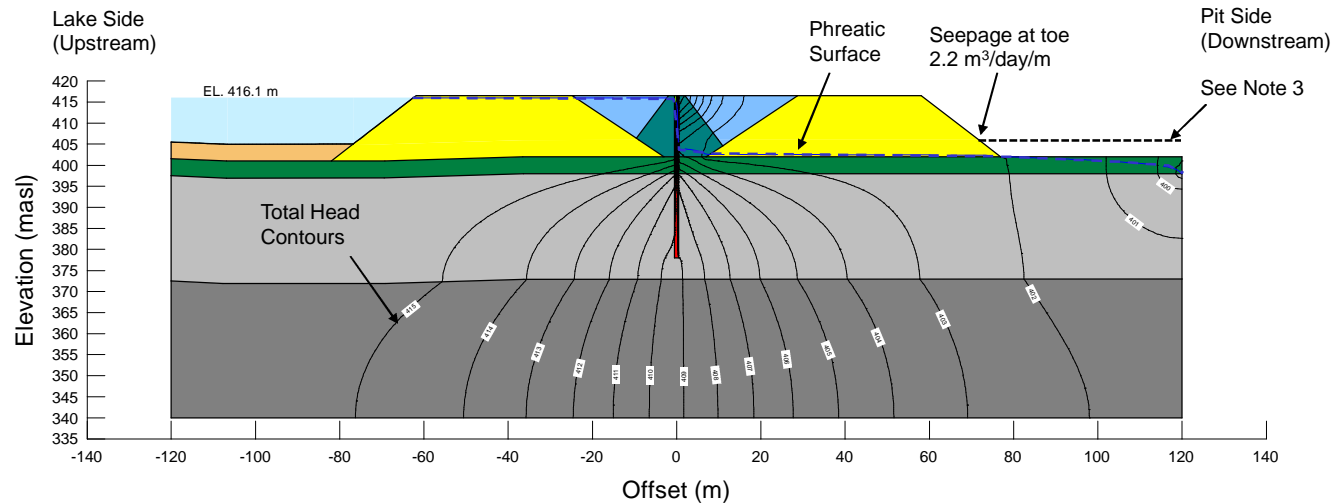
Notes:

1. Lakebed sediment has been removed from the upstream and downstream of the dike toe for dike stability modelling purposes. In the models, the region as shown is modelled with no unit weight or strength.

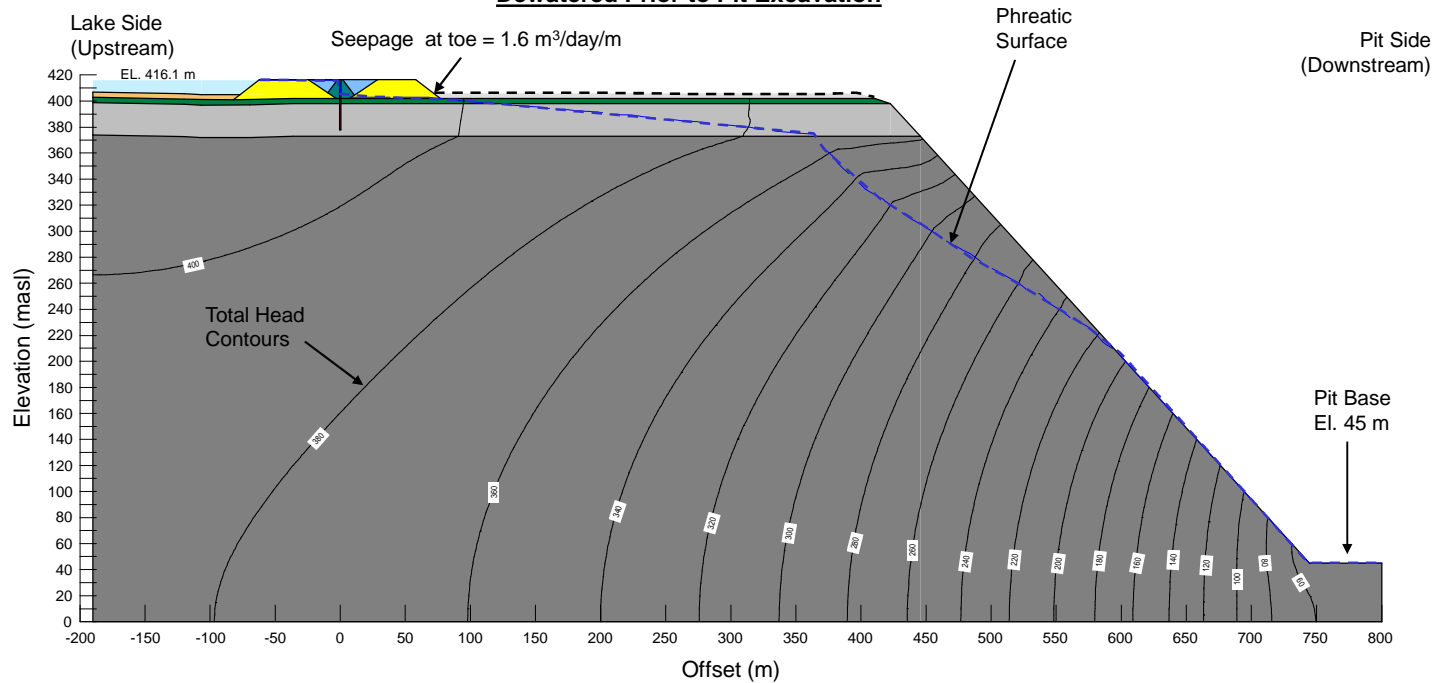
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CHECK	JFC	5DEC14	FIGURE C2		
REVIEW	JFC	5DEC14			



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Dewatered Prior to Pit Excavation



Pit Excavated to Elevation 45 masl

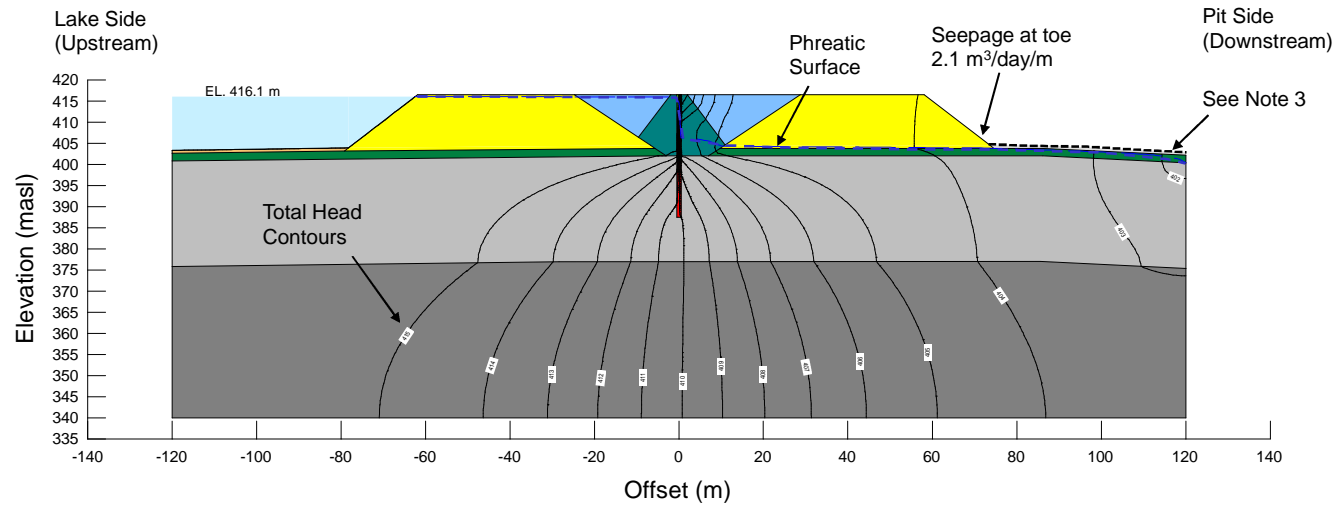
- Notes:**
1. Open pit wall geometry shown is simplified.
 2. Enhanced permeability zones (e.g. faults, shear zones, etc.) not included in seepage models.
 3. Top of lakebed surface from bathymetry survey.

PROJECT	DOMINION DIAMOND CORPORATION JAY PROJECT NORTHWEST TERRITORIES		
TITLE	SEEPAGE ANALYSIS RESULTS DEEP A SECTION STATION 3+410		
	PROJECT No. 13-1328-0041	PHASE No. 2020/35	
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REVIEW	FE	SDEC14	

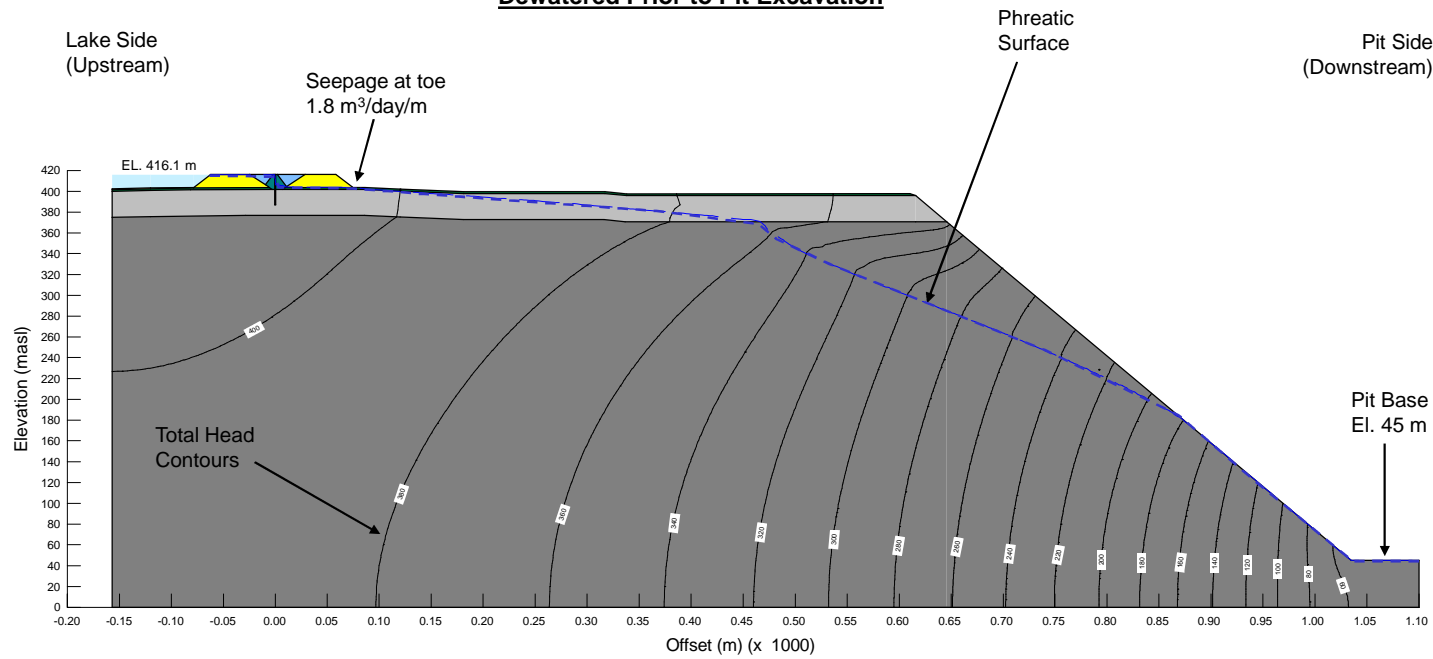


FIGURE C3

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Dewatered Prior to Pit Excavation



Pit Excavated to Elevation 45 masl

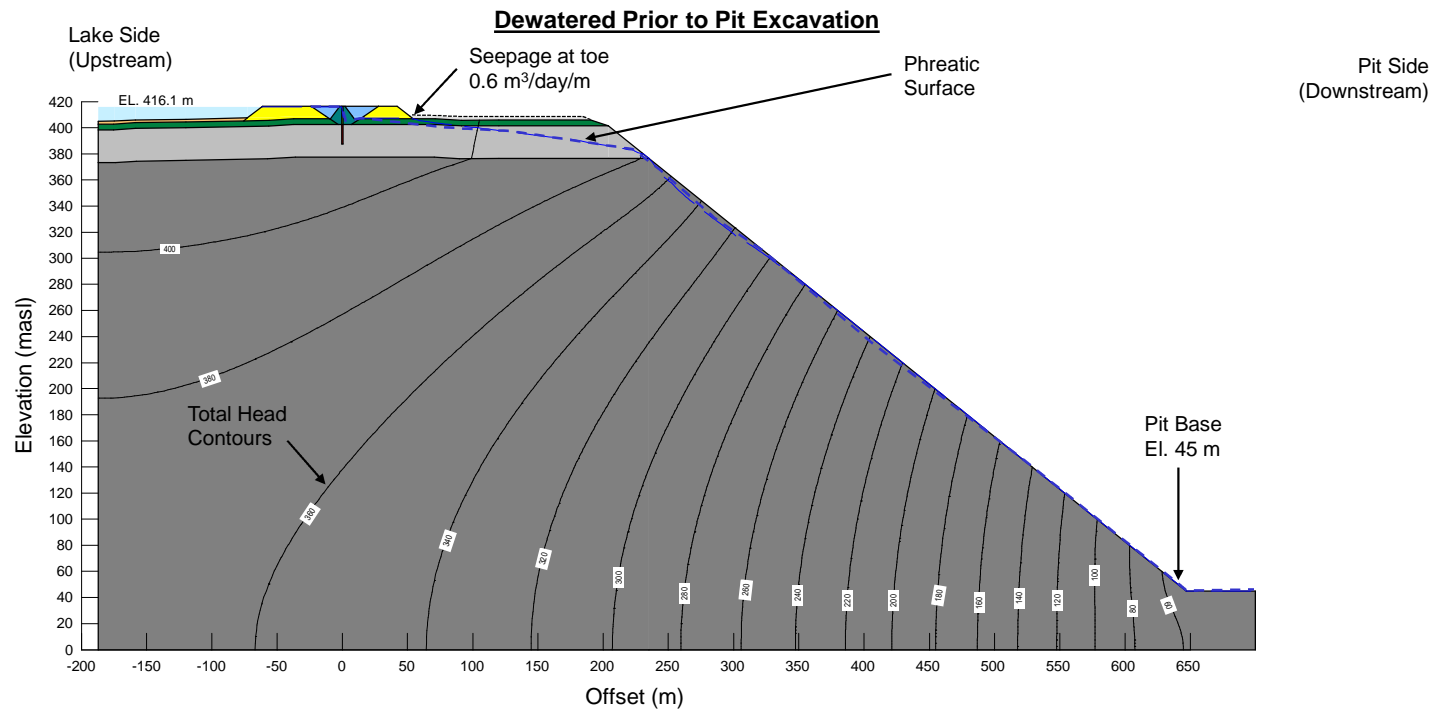
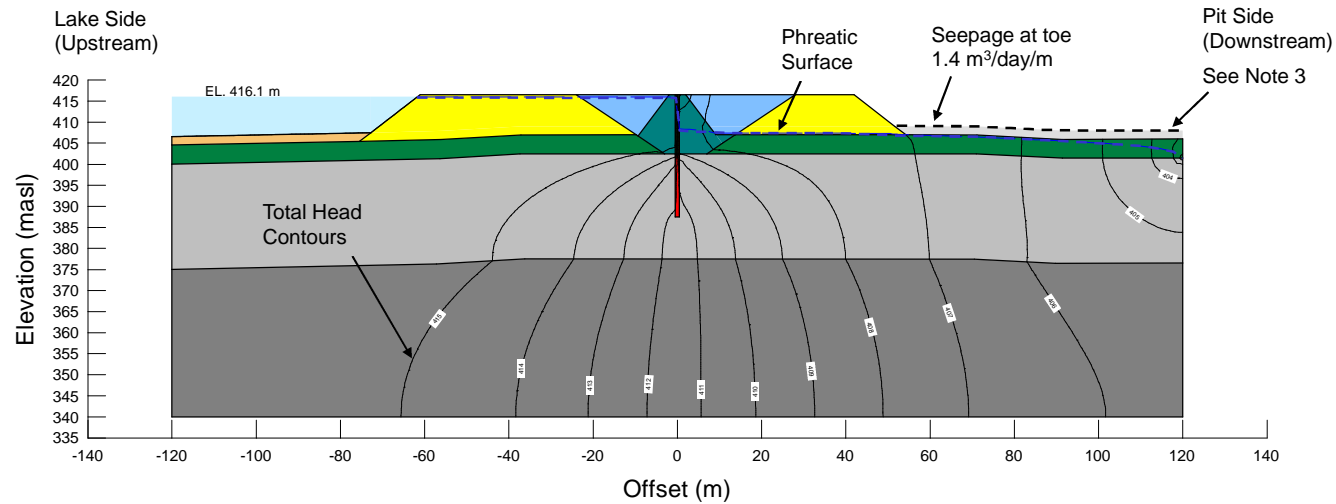
- Notes:**
1. Open pit wall geometry shown is simplified.
 2. Enhanced permeability zones (e.g. faults, shear zones, etc.) not included in seepage models.
 3. Top of lakebed surface from bathymetry survey.

PROJECT	DOMINION DIAMOND CORPORATION JAY PROJECT NORTHWEST TERRITORIES		
TITLE	SEEPAGE ANALYSIS RESULTS DEEP B SECTION STATION 0+750		
	PROJECT No. 13-1328-0041	PHASE No. 2020/35	
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CADD	CM	10CT14	
CHECK	JFC	SDEC14	
REVIEW	FE	SDEC14	



FIGURE C4

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Pit Excavated to Elevation 45 masl

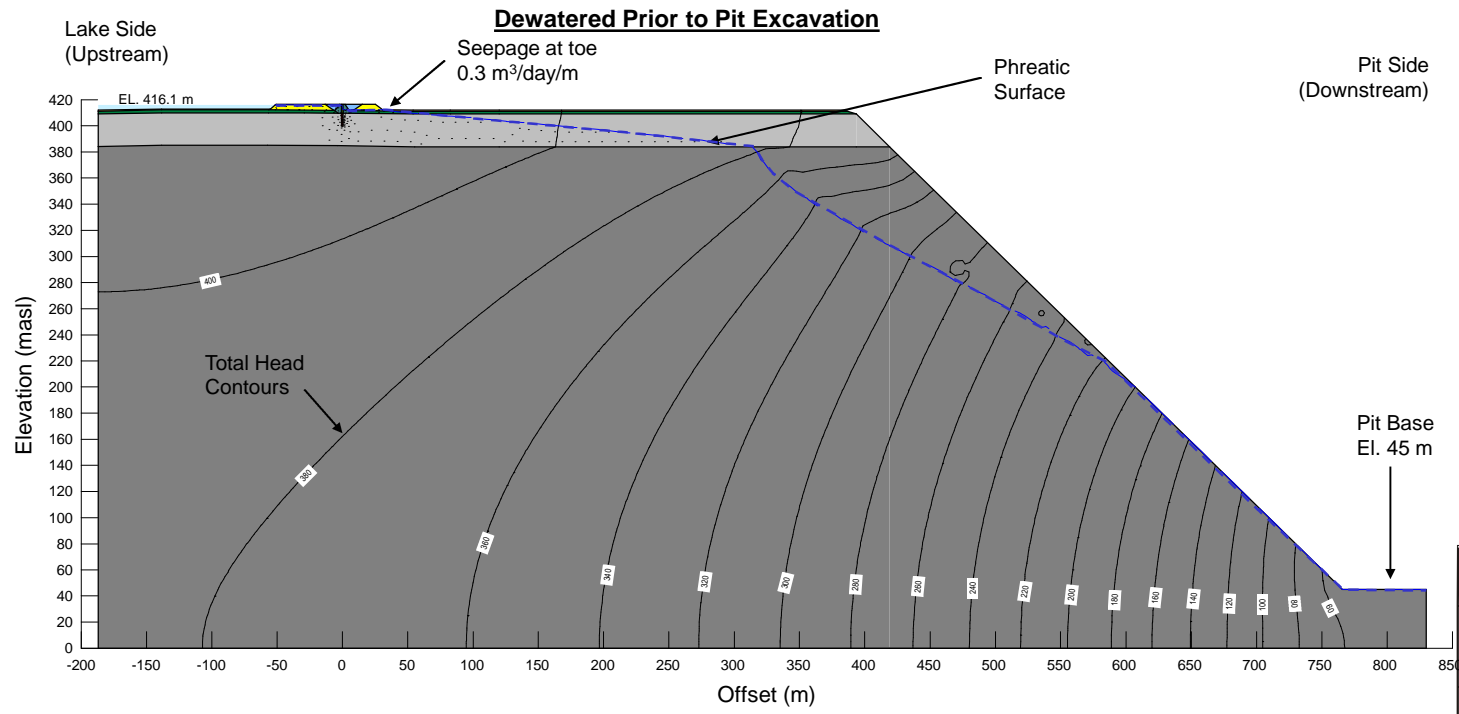
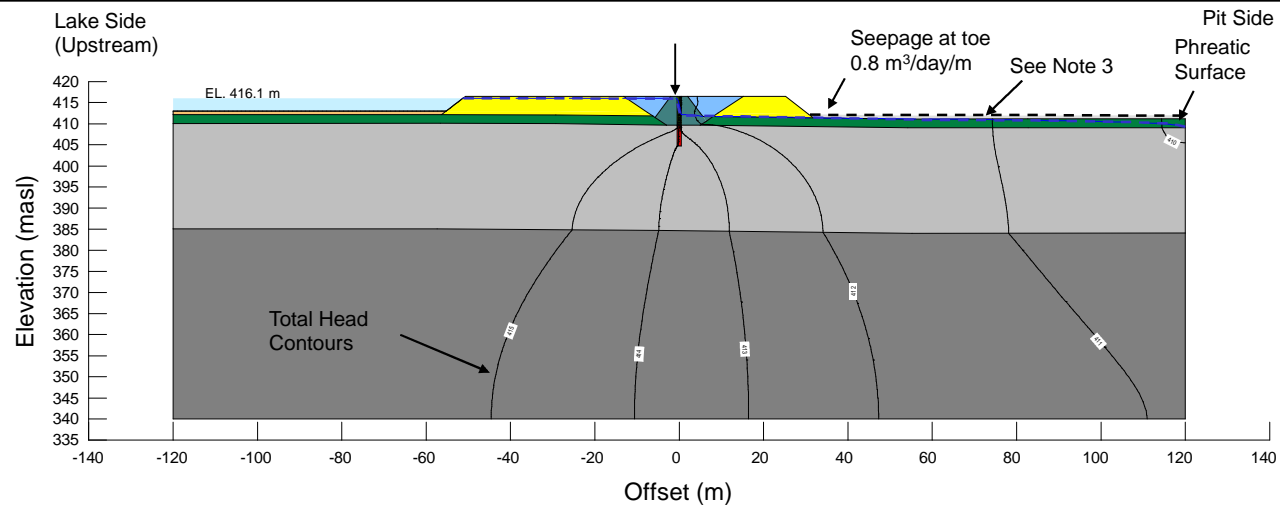
- Notes:**
1. Open pit wall geometry shown is simplified.
 2. Enhanced permeability zones (e.g. faults, shear zones, etc.) not included in seepage models.
 3. Top of lakebed surface from bathymetry survey.

PROJECT	DOMINION DIAMOND CORPORATION JAY PROJECT NORTHWEST TERRITORIES		
TITLE	SEEPAGE ANALYSIS RESULTS MEDIUM SECTION STATION 1+340		
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	CADD CM 10CT14		
	CHECK JFC SDEC14		
	REVIEW FE SDEC14		



FIGURE C5

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Pit Excavated to Elevation 45 masl

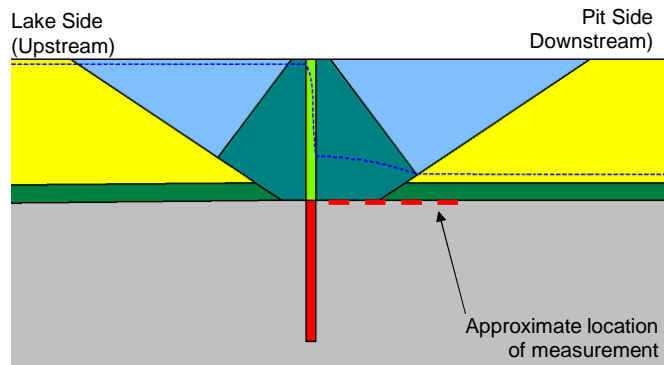
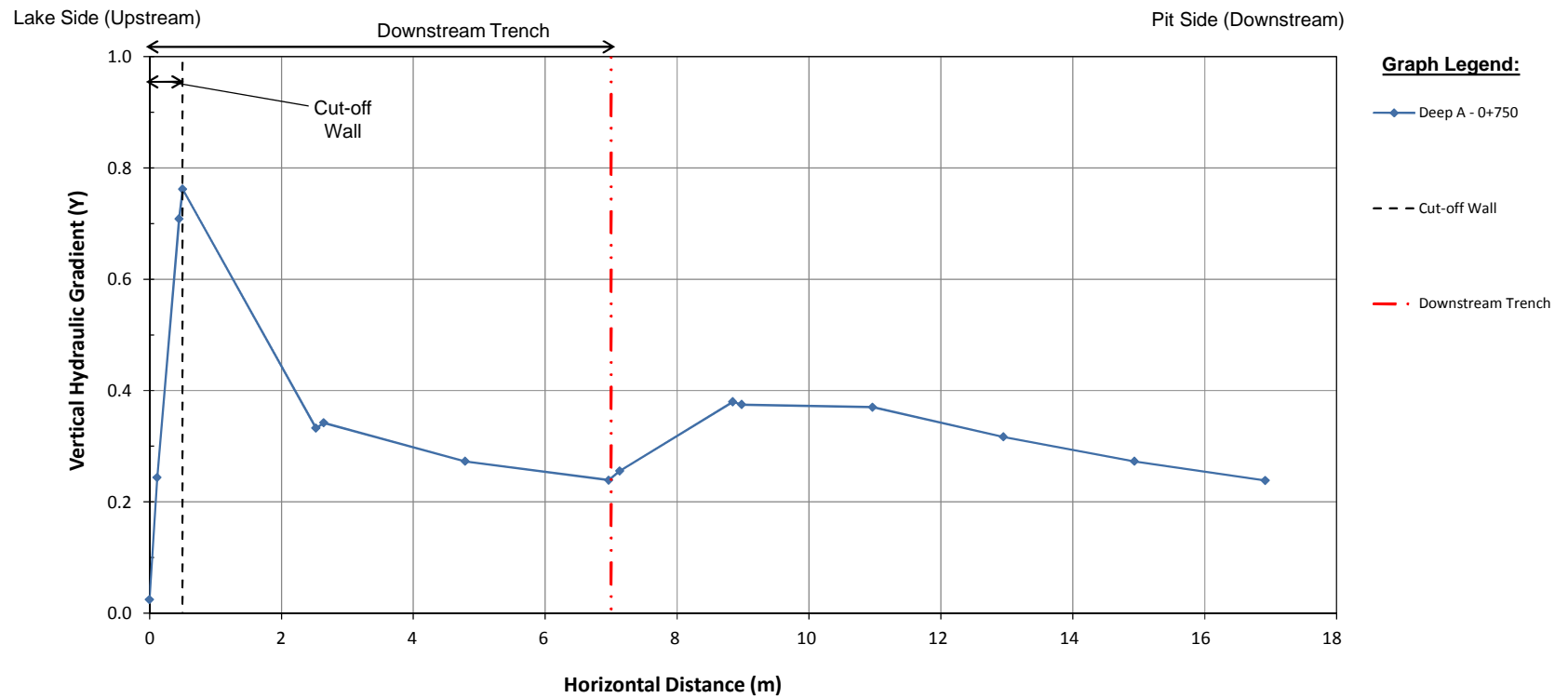
- Notes:**
1. Open pit wall geometry shown is simplified.
 2. Enhanced permeability zones (e.g. faults, shear zones, etc.) not included in seepage models.
 3. Top of lakebed surface from bathymetry survey.

PROJECT	DOMINION DIAMOND CORPORATION JAY PROJECT NORTHWEST TERRITORIES		
TITLE	SEEPAGE ANALYSIS RESULTS SHALLOW SECTION STATION 2+420		
PROJECT No.	13-1328-0041	PHASE No.	2020/35
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CADD	CM	10CT14	
CHECK	JFC	SDEC14	
REVIEW	FE	SDEC14	



FIGURE C6

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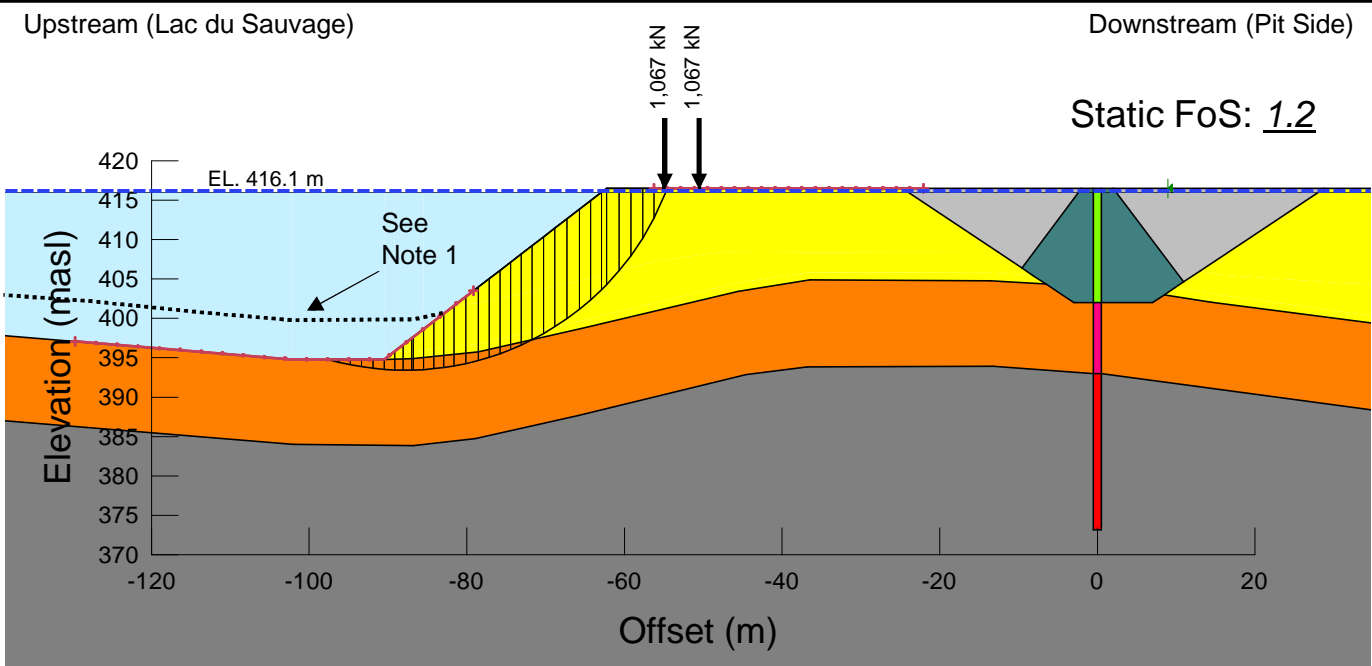
Station 0+750 – Cross-Section

PROJECT	DOMINION DIAMOND CORPORATION JAY PROJECT NORTHWEST TERRITORIES		
TITLE	SEEPAGE ANALYSIS RESULTS HYDRAULIC GRADIENTS DEEP B STATION 0+750		
	PROJECT No. 13-1328-0041	PHASE No. 2020/35	
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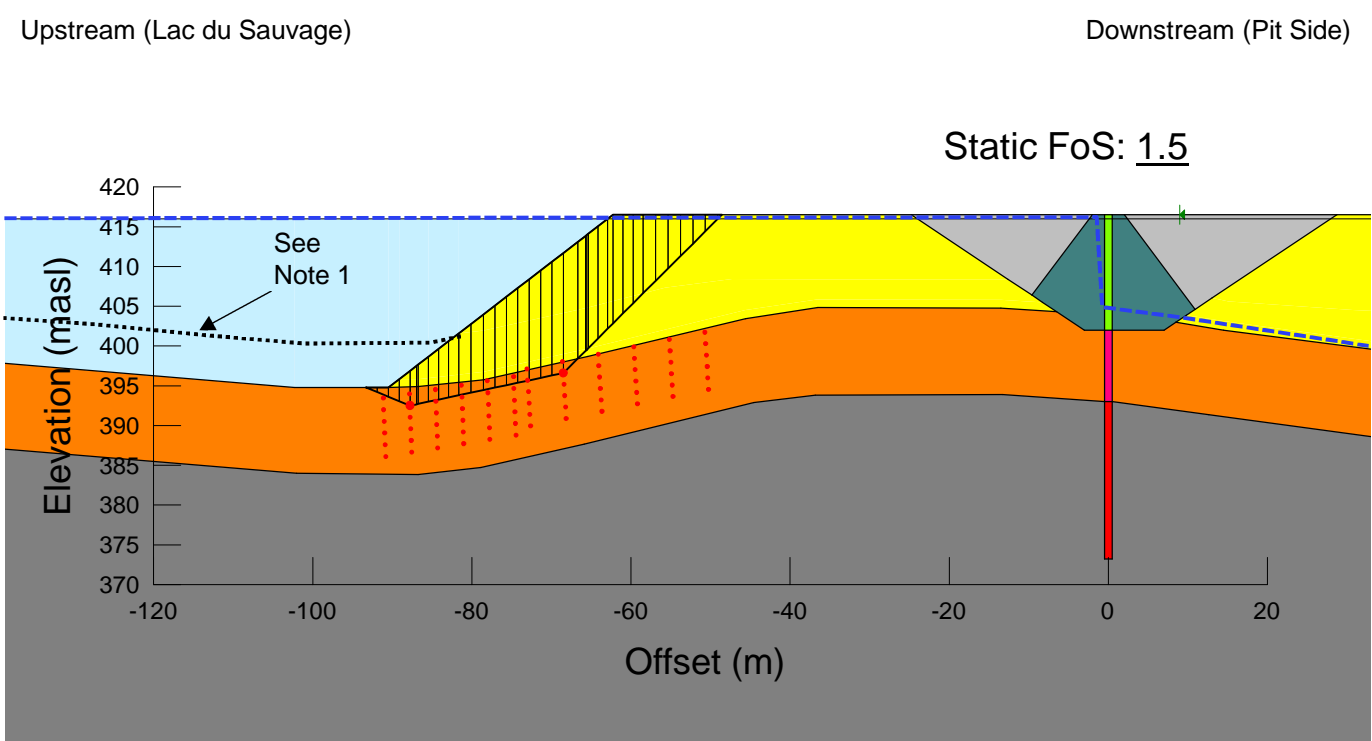


FIGURE C7

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On-going Construction



During Operations

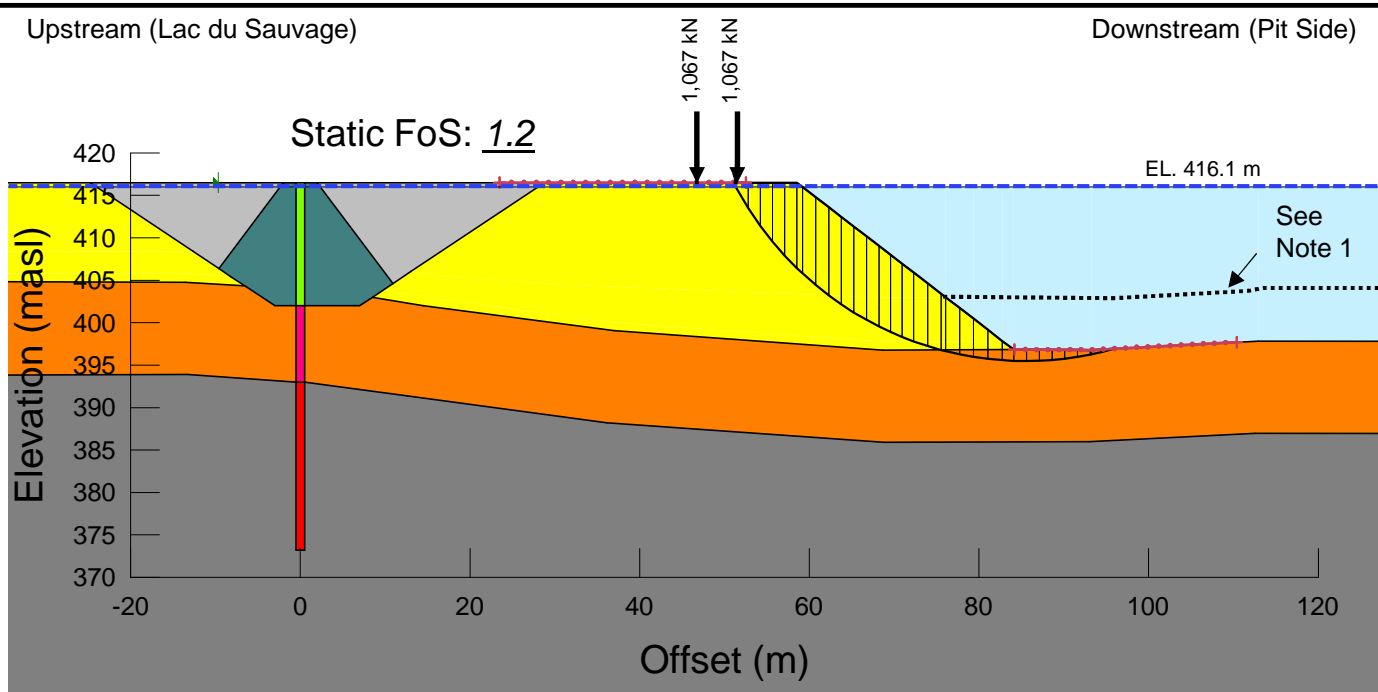
Notes:

1. Top of lakebed surface from bathymetry survey.
2. The potential failure surface shown are from static stability models.
3. FoS = Factor of Safety

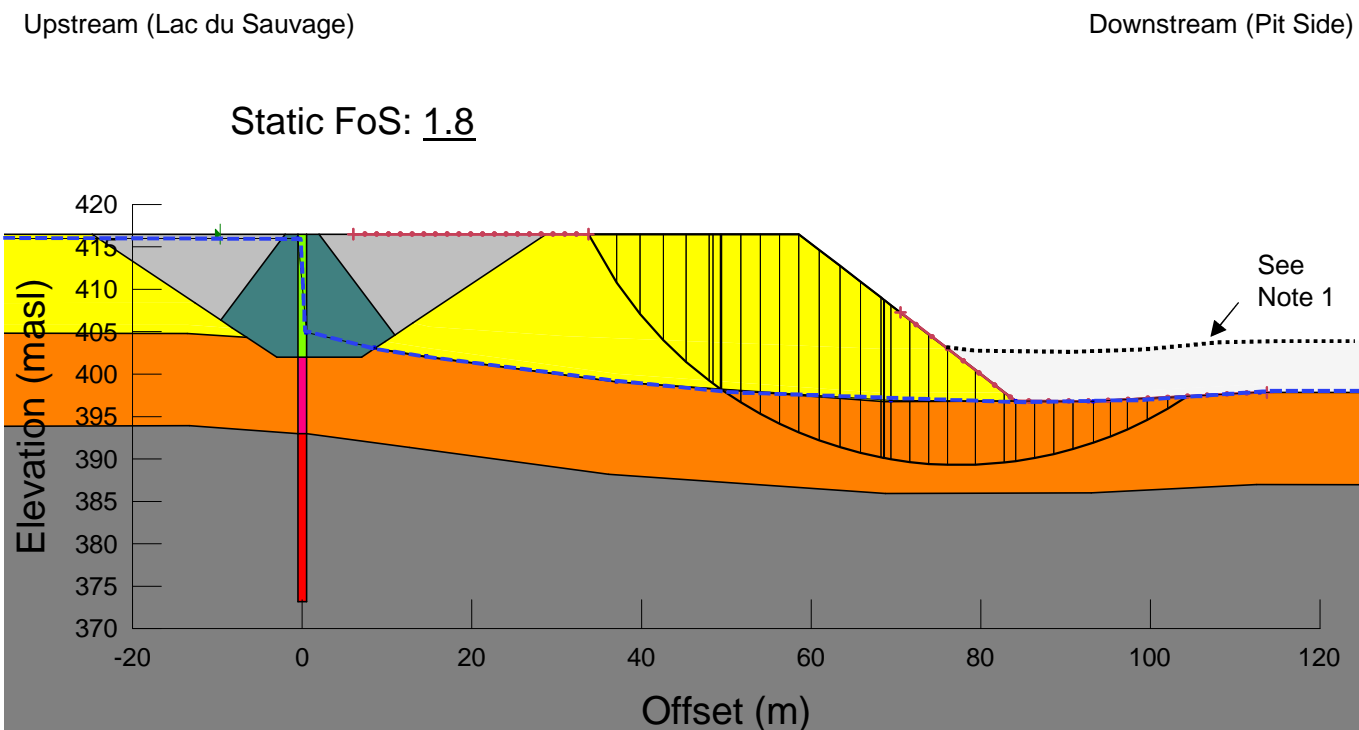
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		PROJECT No. 13-1328-0041		PHASE/TASK No. 2020/35			
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CHECK	JFC	5DEC14					
REVIEW	JFC	5DEC14					



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On-going Construction



During Operations

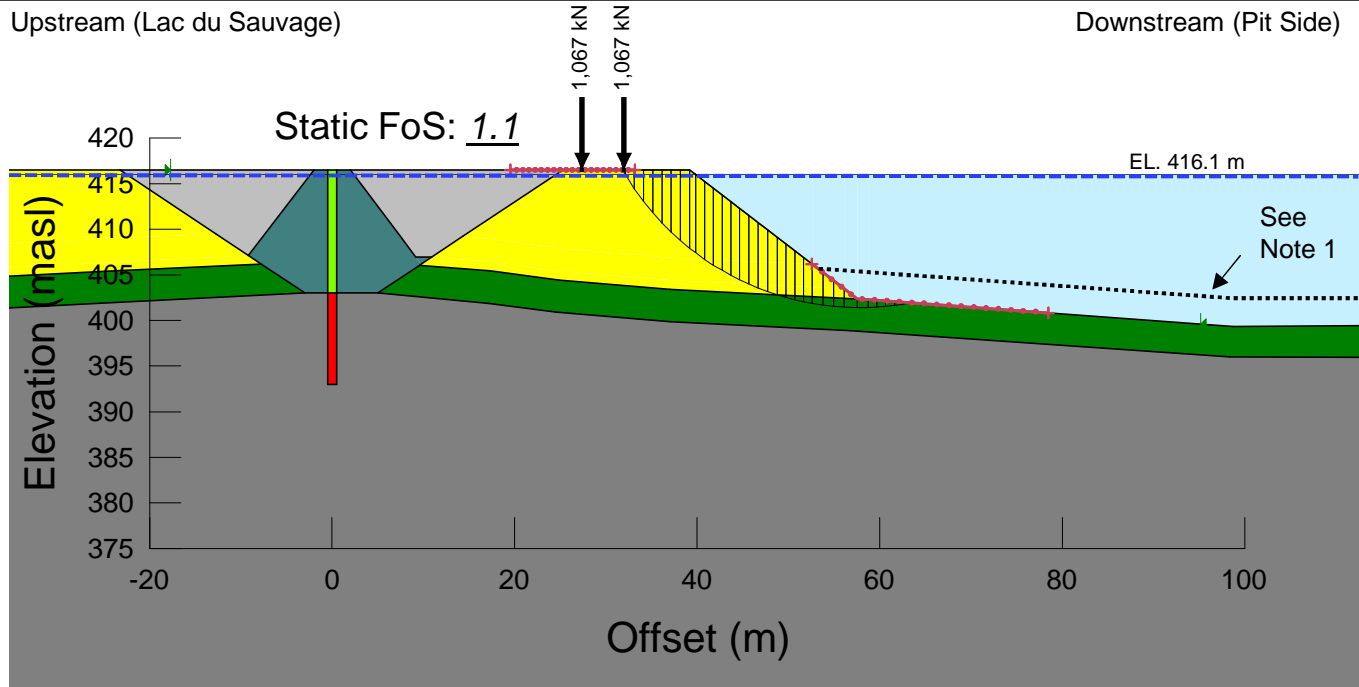
Notes:

1. Top of lakebed surface from bathymetry survey.
2. The potential failure surface shown are from static stability models.
3. FoS = Factor of Safety

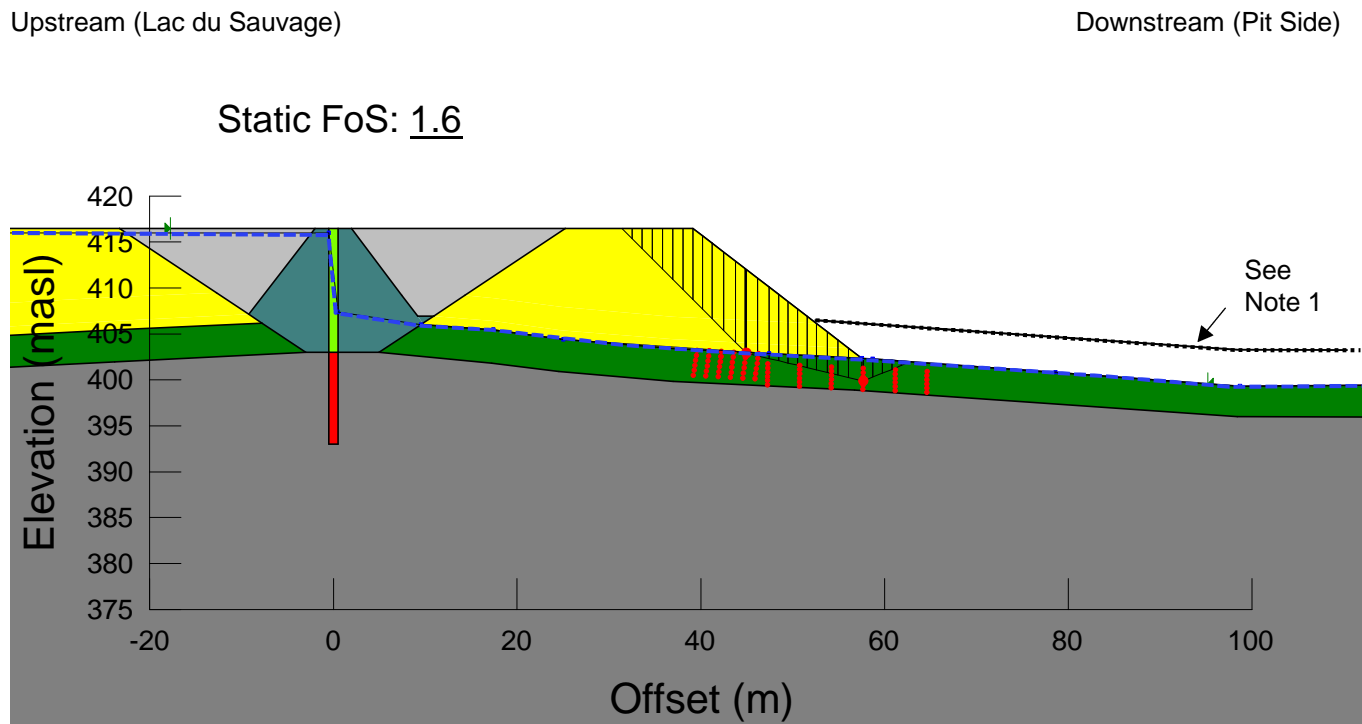
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On-going Construction



During Operations

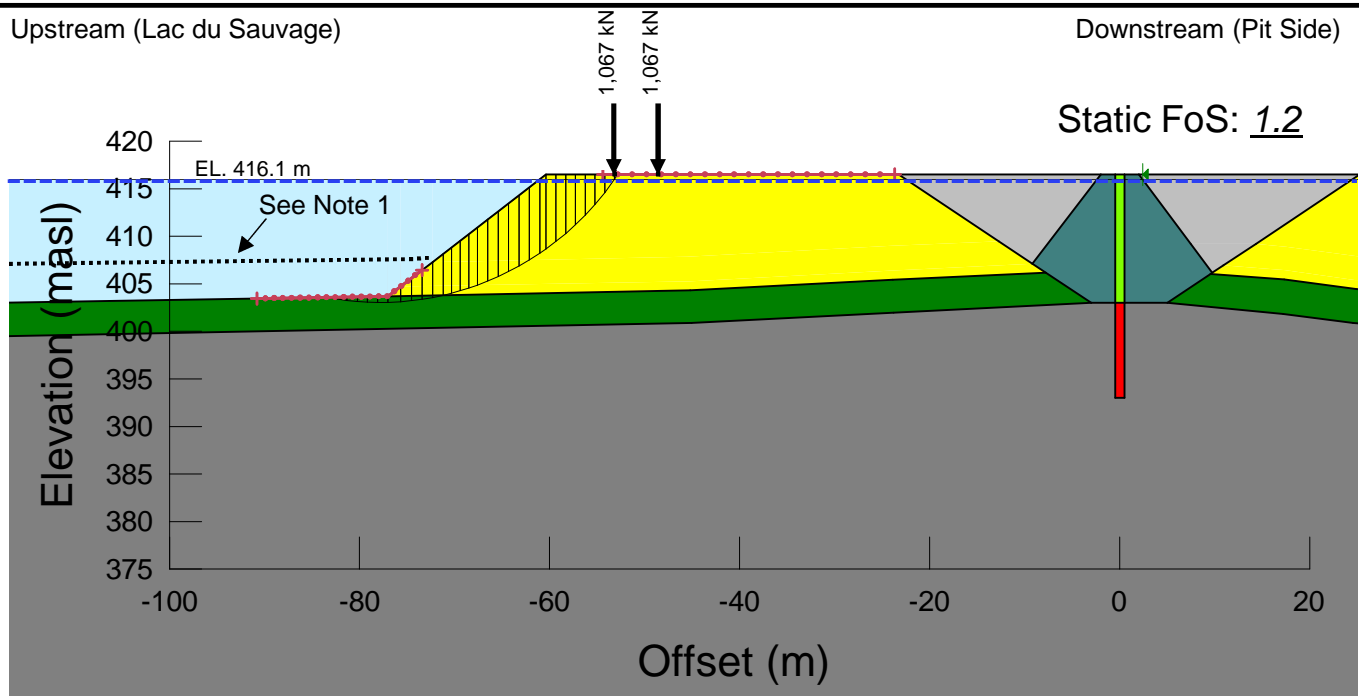
Notes:

1. Top of lakebed surface from bathymetry survey.
2. The potential failure surface shown are from static stability models.
3. FoS = Factor of Safety

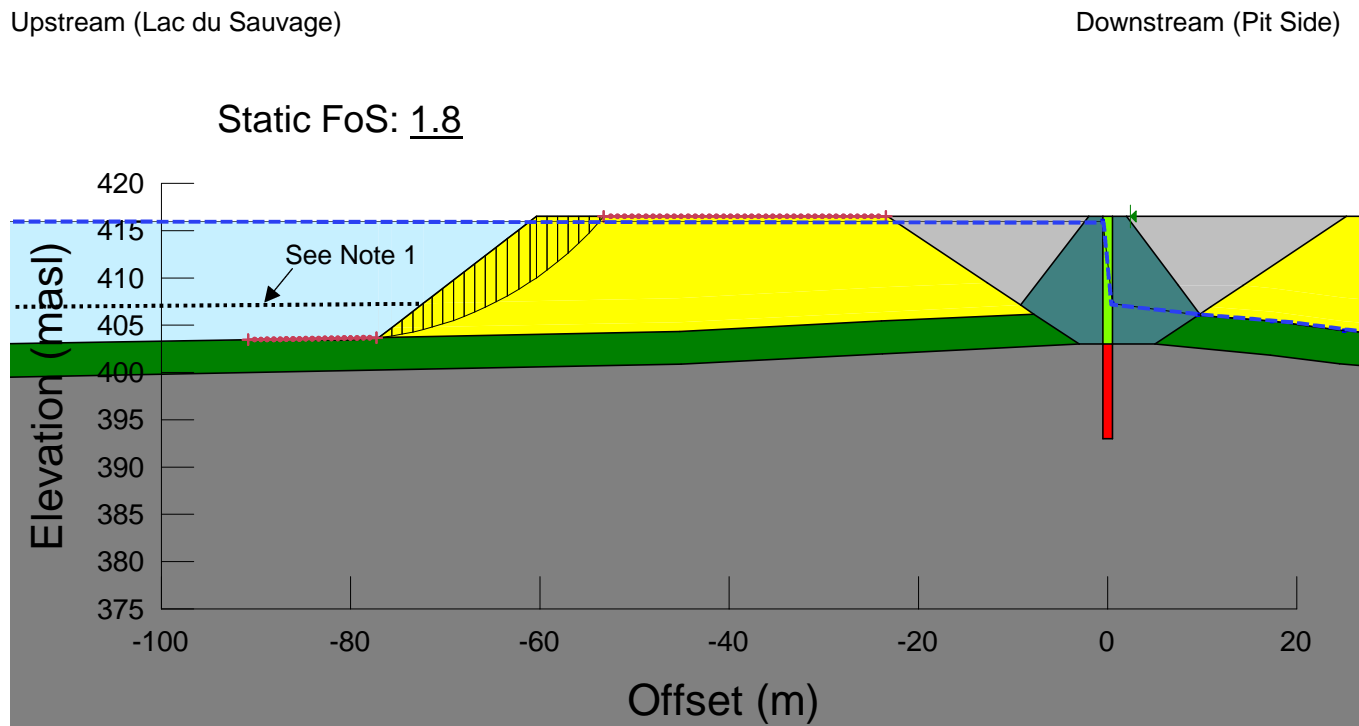
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DESIGN	CM	1OCT14	SCALE	NTS	REV.0	FIGURE C10					
CADD	CM	1OCT14									
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On-going Construction



During Operations

Notes:

1. Top of lakebed surface from bathymetry survey.
2. The potential failure surface shown are from static stability models.
3. FoS = Factor of Safety

PROJECT						DOMINION DIAMOND CORPORATION JAY PROJECT NORTHWEST TERRITORIES					
TITLE						DIKE STABILITY RESULTS INTERMEDIATE SECTION STATION 3+520 - UPSTREAM					
PROJECT No. 13-1328-0041						PHASE/TASK No. 2020/35					
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CHECK	JFC	5DEC14									
REVIEW	JFC	5DEC14									
											

ATTACHMENT C1
2010 National Building Code Seismic Hazard Calculation

2010 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Requested by: Chad Mundle, Golder Associates Ltd.

July 08, 2014

Site Coordinates: 64.62 North 110.12 West

User File Reference: Mine Site

National Building Code ground motions:

2% probability of exceedance in 50 years (0.000404 per annum)

Sa(0.2)	Sa(0.5)	Sa(1.0)	Sa(2.0)	PGA (g)
0.095	0.057	0.026	0.008	0.036

Notes. Spectral and peak hazard values are determined for firm ground (NBCC 2010 soil class C - average shear wave velocity 360-750 m/s). Median (50th percentile) values are given in units of g. 5% damped spectral acceleration (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are tabulated. Only 2 significant figures are to be used. **These values have been interpolated from a 10 km spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the calculated values.**

Ground motions for other probabilities:

Probability of exceedance per annum	0.010	0.0021	0.001
Probability of exceedance in 50 years	40%	10%	5%
Sa(0.2)	0.011	0.035	0.055
Sa(0.5)	0.007	0.022	0.034
Sa(1.0)	0.003	0.010	0.016
Sa(2.0)	0.001	0.003	0.005
PGA	0.003	0.011	0.019

References

National Building Code of Canada 2010 NRCC no. 53301; sections 4.1.8, 9.20.1.2, 9.23.10.2, 9.31.6.2, and 6.2.1.3

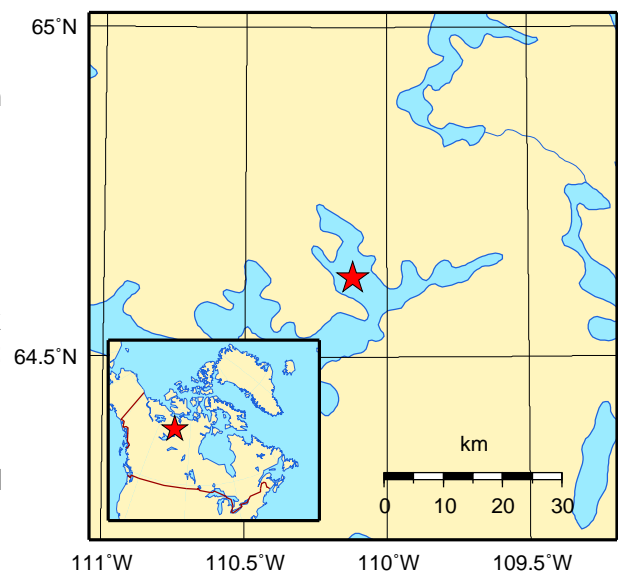
Appendix C: Climatic Information for Building Design in Canada - table in Appendix C starting on page C-11 of Division B, volume 2

User's Guide - NBC 2010, Structural Commentaries NRCC no. 53543 (in preparation)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File xxxx
Fourth generation seismic hazard maps of Canada: Maps and grid values to be used with the 2010 National Building Code of Canada (in preparation)

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information

Aussi disponible en français





APPENDIX D

Filter Compatibility Assessment



D1.0 INTRODUCTION

The pre-feasibility design for the Jay Dike includes the following general components:

- a broad rockfill shell;
- a central zone of crushed granular fine and coarse filters; and,
- a composite low permeability element.

Three typical dike sections (shallow, intermediate, and deep) have been developed for the pre-feasibility design based on the bedrock elevation along the dike cut-off wall alignment as described in Section 6.2 of the report and as presented in Drawing 300-10.

The composite low permeability cut-off wall will be constructed within the fine filter. The coarse filter will be located downstream between the fine filter and the rockfill shell. The fine filter located downstream of the cut-off wall is designed to allow seepage to pass through the dike while minimizing the potential erosion of particles from the competent soil. The coarse filter is designed to drain seepage from the fine filter.

This appendix describes the methods and criteria used to assess the filter compatibility of the following material transitions:

- competent soil interface with fine filter; and,
- fine filter interface with coarse filter.

In addition, the internal stability of the competent soil was assessed to evaluate the potential for internal erosion under the imposed hydraulic gradients.

D2.0 ANALYSES METHODS AND MATERIALS

D2.1 Definitions and Terminology

This section defines several terms typically used in the literature regarding filter compatibility and internal stability. The definitions are from the United States Department of Agriculture (USDA 1994).

Base Soil: soil immediately adjacent to a filter or drainage zone through which water may pass;

Filter: soil having a gradation designed to minimize the potential movement of soil particles from the base soil, by flowing water;

Fines: the proportion of soil particles finer than 0.075 millimetres (mm);

d₅, d₁₀, d₁₅, d₂₀, d₆₀ and d₈₅: particle sizes (mm) corresponding to 5, 10, 15, 20, 60, and 85 percent finer than the given value, based on mass; the lower case “d” refers to the particle size distribution of the base soil;



D₁₅, D₉₀, and D₁₀₀: particle sizes (mm) corresponding to 15, 90, and 100 percent finer than the given value, by mass; the upper case “D” refers to the particle size distribution of the filter; and,

Widely Graded Soil: consists of a wide range of particle sizes, including gravel sized (4.75 to 75 mm), sand sized (0.075 to 4.75 mm), and fines (less than 0.075 mm) particles.

D2.2 Materials

Particle size distribution results of competent soil samples collected during the 2014 winter geotechnical investigation program (Golder 2014) were used in the filter compatibility assessment. These samples are considered to represent the range of particle size distributions that may be encountered along the length of the Jay Dike, based on the available information.

Figure D1 presents particle size distributions for widely graded samples of competent soil. These samples are described as well graded and are consists of a mixture of gravel, sand, and fine grained particles (i.e., silt and clay), which vary in their respective proportions. The majority of samples collected during the 2014 winter geotechnical investigation were widely graded.

Particle size distributions of other samples of competent soil collected during the 2014 geotechnical investigation are presented in Figure D2. These particle size distributions are different from the widely graded samples. Particle size distributions presented in Figure D2 have been divided into the following groups:

- **Fine Grained:** consists of predominantly (more than 50 percent [%]) of fines (particle less than 0.075 mm);
- **Coarse Grained:** consists of predominantly of gravel size particles (4.75 mm or greater);
- **Sands:** consists of predominantly of particles between 0.075 and 4.75 mm; and,
- **Gap-graded:** soil with an intermediate particle size absent.

The particle size distributions of 39 competent soil samples were analyzed as part of the 2014 geotechnical investigation program. Of these samples 26 are considered to be widely graded.

The particle size distribution envelopes developed for the fine filter and coarse filter for the proposed Jay Dike are presented in Figure D3. The maximum D₁₅ of the fine filter and coarse filter is 0.7 mm and 22 mm, respectively. The particle size distribution limits for the fine filter and coarse filter are presented in Table D1 and Table D2, respectively.



Table D1: Fine Filter Particle Size Distribution Limits

Particle Size (mm)	Percent Passing (% by mass)
19.1	100
9.5	50 – 100
4.75	35 – 80
2	25 – 60
0.85	18 – 40
0.25	0 – 20
0.149	0

mm = millimetres; % = percent.

Table D2: Coarse Filter Particle Size Distribution Limits

Particle Size (mm)	Percent Passing (% by mass)
200	100
152.4	85 – 100
76.2	40 – 100
50.8	31 – 100
25.4	17 – 60
9.5	5 – 30
4.75	0 – 16
0.425	0

mm = millimetres; % = percent.

D2.3 Filter Compatibility Assessment Methods

The assessment of filter compatibility was completed by using methods and criteria summarized in USDA (1994). The criteria are based on laboratory testing performed by the Soil Conservation Service and research literature available through the American Society for Civil Engineers.

The USDA (1994) provides guidance on filter compatibility depending on the classification of the base soil and the purpose of the filter. Base soils are classified based on the percentage of fines after regrading. Regrading the base soil is a mathematical procedure whereby the proportions of particles greater than 4.75 mm are not considered.

The four soil categories according to the USDA (1994) are summarized in Table D3.

Table D3: Base Soil Classification

Soil Category	Percent Fines ^(a) (%)	Base Soil Description
1	> 85	Fine silt and clays
2	40 – 85	Sands, silts, clays, and silty & clayey sands
3	15 – 39	Silty & clayey sands and gravel
4	< 15	Sands and gravel

Source: USDA (1994).

a) Fines content is the proportion of a sample, by mass, that has a particle size less than 0.075 mm.

% = percent; > = greater than ; < = less than; mm = millimetres.



APPENDIX D
Filter Compatibility Assessment

If the primary purpose of the filter is to prevent erosion (i.e., filtering) of the soil it is protecting (i.e., base soil), the design of the filter is to use the smallest allowable D_{15} . If the primary purpose is for drainage (i.e., permeability), the design of the filter is to use the largest allowable D_{15} .

The fine filter located downstream of the low permeability cut-off wall will be in contact with competent soil, at the base of the fine filter and/or along the downstream limit of the fine filter. Due to the location of the fine filter and the anticipated hydraulic gradients at some of these interfaces, the fine filter is considered to be a critical filter. Therefore, the primary purpose of the fine filter is for filtering purposes (i.e., prevention of erosion) in terms of the USDA (1994) criteria.

Downstream of the fine filter, at the interface between the coarse and fine filter, the hydraulic gradients are anticipated to be much lower. Furthermore, high intergranular friction forces capable of resisting erosion (Sherard and Dunnigan 1989) are anticipated in the fine filter due to its particle size, primarily fine gravel to medium grained sand. Therefore, the primary purpose of the coarse filter is for drainage purposes in terms of the USDA (1994) criteria.

For the assessment of the fine and coarse filter interface, the criteria for the maximum D_{15} of the coarse filter was relaxed based on a review of literature. Three filtering criteria using the d_{85} of the total or regraded base soil are presented in Table D4.

Table D4: Calculation of Maximum D_{15} for the Coarse Filter for a Category 4 Base Soil

Criteria Name	Source of d_{85}	Maximum D_{15} (mm) ^(a)
USDA (1994)	Regraded base soil	$\leq 4 \times d_{85}$
Sherard and Dunnigan (1989)	Total base soil	$\leq 4 \times d_{85}$
No Erosion Boundary (Foster and Fell 2001)		$\leq 7 \times d_{85}$

a) Maximum D_{15} for a Category 4 base soil.

mm = millimetres; d_{85} = particle size for which 85% of the fine filter is finer than, by mass; D_{15} = particle size for which 15% of the coarse filter is finer than, by mass; \leq = less than or equal to; % = percent.

For Category 4 base soils, the USDA (1994) recommends that the maximum D_{15} of the filter be calculated using the d_{85} of the base soil after regrading, thereby limiting the size of the D_{85} to less than 4.75 mm. However, Sherard and Dunnigan (1989) recommend that for soils with less than 15% fines after regrading, the d_{85} can be based on the total particle size distribution with no regrading. Therefore, the maximum D_{15} for the filter calculated using USDA (1994) may be significantly smaller than using the method proposed by Sherard and Dunnigan (1989).

The use of Sherard and Dunnigan (1989) for Category 4 base soils is considered reasonable as it estimates a maximum D_{15} that is still less than the no erosion boundary criteria. In laboratory testing, when the D_{15} of the filter was less than the no erosion criteria in Table D4, no erosion of the base soil into the filter was observed (Foster and Fell 2001). Although Foster and Fell (2001) do not advocate for the relaxation of filter criteria based on their findings, it shows that the D_{15} calculated from Sherard and Dunnigan (1989) for a Category 4 soil is within acceptable limits.



D2.4 Internal Stability of Competent Soil Samples

A material is described as being internally stable if it is able to prevent the loss of its own soil particles due to seepage (Kenney and Lau 1985). In an unstable soil, the soil particles can be lost provided that seepage conditions exist that allow for erosion. The stability of a soil can be assessed by evaluating the shape of its particle size distribution.

Three different methods were used to assess the internal stability of the competent soil samples, due to the variability in the samples particle size distributions. The assessment method used for each type of competent soil sample is presented in Table D5.

Table D5: Method of Internal Stability Assessment for Competent Soil Samples

Competent Soil Sample Category	Fines Content ^(a) (% by mass)	Assessment Method
Widely graded	≥ 15%	Wan and Fell (2008)
	< 15%	Li and Fannin (2008)
Fine grained, coarse grained, and sands	0 – 100%	Li and Fannin (2008)
Gap-graded ^(b)	0 – 100%	Sherard (1979)

a) Fines content is the proportion of a sample, by mass, that has a particle size less than 0.075 mm.

b) A soil is gap-graded when an intermediate particle size is absent.

% = percent; ≥ = greater than or equal to; < = less than; mm = millimetres.

Based on laboratory testing on samples of widely graded silty sand and gravel, Wan and Fell (2008) proposed a method for assessing the internal stability using particle size distribution data. Provided that the d_{90} , d_{60} , d_{20} , and d_5 are available, the method determines if a soil is stable, unstable, or marginally stable. However, the application the method is limited to materials containing more than about 15% to 20% fines.

Li and Fannin (2008) was used to assess the internal stability for competent soil samples with less than 15% fines. The method also evaluates the shape of the particle size distribution curve to assess the internal stability of the soil.

While only three of the competent soil samples are considered gap-graded (Figure D2), these soils are particularly susceptible to erosion. The evaluation method proposed by Sherard (1979) was used to assess the stability of these samples. The use of this method is advocated by Fell et al. (2005).

A detailed summary of each internal stability assessment method is beyond the scope of this appendix and the reader is referred to the references for further information regarding these methods.

D3.0 ASSESSMENT AND RESULTS

D3.1 Fine Filter / Widely Graded Competent Soil Samples

All of the 26 widely graded competent soil samples are classified as either Category 2 or Category 3 soils according to the USDA (1994). For the 14 samples classified as Category 2, the maximum D_{15} of the fine filter is to be 0.7 mm. For the 12 Category 3 samples, the maximum D_{15} of the fine filter ranges between 0.9 and 10.4 mm, with an average of 4.5 mm. These assessment results for the maximum D_{15} values for the fine filter are presented in Figure D4. As the D_{15} of the fine filter is 0.7 mm, this indicates the widely graded samples are filter compatible with the fine filter.



D3.2 Fine Filter / Other Competent Soil Samples

As shown in Figure D5, other non-widely graded soil samples, are grouped as follows according to the USDA (1994):

- Six samples are also classified as a Category 2 soils, with a maximum fine filter D_{15} of 0.7 mm.
- One sample, from borehole JP5-SD-08, is a Category 1 soil, with a maximum fine filter D_{15} of 0.2 mm.
- Six samples are classified as either Category 3 or Category 4 soils, and have a maximum fine filter D_{15} between 1.3 and 18 mm.

All of the Category 2, Category 3, and Category 4 soil samples are filter compatible with the fine filter.

Only the single Category 1 sample is not filter compatible as the maximum fine filter D_{15} is less 0.7 mm.

Due to the incompatibility of sample JP5-SD-08 – S04&05 with the fine filter, the record of borehole for JP5-SD-08 was reviewed to determine whether the fine filter would be contact with the competent soil represented by this sample. Based on the anticipated excavation depth of the cut-off wall at borehole JP5-SD-08, as shown in Drawing 300-6 (Appendix A), the competent soil represented by sample JP5-SD-08 – S04&05 is not anticipated to be in contact with the fine filter, but rather with a layer of silty sand to sand and gravel represented by sample JP5-SD-08 – S02. It is anticipated that material represented by sample JP5-SD-08 – S02 will be in contact with the fine filter. Therefore, the filter compatibility between samples JP5-SD-08 – S04&05, as the base soil, and sample JP5-SD-08 – S02, as the filtering soil, were assessed.

The d_{15} of sample JP5-SD-08 – S02 is approximately 0.2 mm and, therefore, these materials are deemed to be filter compatible. Sample JP5-SD-08 – S02 is filter compatible with the fine filter, as the maximum fine filter D_{15} calculated for this material is greater than 0.7 mm.

D3.3 Coarse Filter / Fine Filter Interface

3.3.1 Coarse Filter / Fine Filter Interface

The maximum D_{15} assessment results using the minimum limit of the fine filter particle size distribution envelope are presented in Figure D6. The minimum limit of the fine filter is classified as a Category 4 soil according to the USDA (1994). The calculated maximum coarse filter D_{15} is 22 mm using the d_{85} of the fine filter without regrading (Sherard and Dunnigan 1989). The minimum coarse filter D_{15} is four times the d_{15} of the base soil (USDA 1994).

The maximum D_{15} of the coarse filter is approximately 22 mm and, therefore, the coarse filter is determined to be compatible with the fine filter.



D3.4 Internal Stability of Competent Soil Samples

The results of the internal stability assessment carried out on the widely graded competent soil samples are presented in Figure D7. Based on the assessment methods, 24 samples were interpreted to be internally stable. Two samples are considered to be potentially internally unstable using the Li and Fannin (2008) method.

The Wan and Fell (2008) method could not be directly applied to the majority of the competent soil samples as a limited number of samples had particle size distribution data for the fines component analyzed. For these samples, the internal stability is inferred based on five samples that have sufficient particle size distribution data. Figure D7 includes the five samples with data for the fines component that were found to be internally stable according to Wan and Fell (2008). Samples without fines component data were inferred to be stable as they have similar particle size distributions as samples directly assessed to be stable.

The internal stability assessment results of the samples that are not widely graded are presented in Figure D8. Five samples were interpreted to be stable and six were potentially unstable according to the assessment methods. All of the gap-graded samples were potential internally unstable according to Sherard (1979).

The single fine grained sample shown in Figure D8 was inferred to be potentially unstable due to containing approximately 35% clay size particles (finer than 0.002 mm).

D4.0 DISCUSSION

The majority of samples of competent soil collected during the 2014 winter geotechnical investigation are filter compatible with the fine filter. The particle size distribution envelope for the fine filter, as seen in Figure D6, is only incompatible with one soil sample.

Of the 39 competent soil samples, 10 were assessed to be potentially internally unstable or had inconclusive results due to limited data. Only the single fine grained sample (JP5-SD-08 – S04&05) was inferred to be internally unstable and filter incompatible with the fine filter. However, as discussed in Section D3.2, it appears that this material will not be in direct contact with the fine filter. It is anticipated that a silty sand and gravel will lie between the fine grained material and the fine filter. The silty sand and gravel material has been determined to be filter compatible with the fine grained soil, and in turn it is compatible with the fine filter.

A summary of the findings of the filter compatibility assessment for the competent soil and fine filter material interface is presented in Table D6.

Table D6: Summary of Fine Filter / Competent Soil Compatibility Assessment

Condition of Competent Soil Sample		Number of Competent Soil Samples
Filter Compatible with Fine Filter	Internally Stable	
Yes	Yes	29
Yes	No ^(a)	9
No	No	1
Total Number of Samples		39

a) Assumes that two samples with insufficient data are potentially internally unstable.



Further geotechnical investigations will be conducted during the winter of 2015. This investigation will include drill hole locations identified to try and assess the continuity of the fine grained soil layer and the silty sand and gravel layer identified in JP5-SD-08. Golder (2014) contains the record of boreholes.

The coarse filter is compatible with the fine filter. However, the maximum size particle of the coarse filter exceeds that recommended by the USDA (1994) and, therefore, during construction, care should be taken to minimize the segregation of particles during placement.

D5.0 LIMITATIONS

The materials used in the filter assessment are based on data available at the time of reporting. All samples of competent soils were obtained during drilling investigations from the ice and through lake water and are subject to possible drilling and sample disturbance. Due to the glacial origin of the competent soil, the particle size distribution of the soil may vary from those used in this assessment.

The particle size distribution envelopes for the fine and coarse filter materials used in this assessment are not based on any site-specific crusher data from the Ekati Mine.

D6.0 RECOMMENDATIONS

The filter compatibility assessment recommendations include the following:

- Further filter compatibility assessment should be carried out as part of the detailed design, following the completion of the 2015 geotechnical investigation program. Assessments should focus on areas of the dike that may be founded on a continuous layer or zone of soil that may be susceptible to erosion.
- The results of seepage analyses carried out as part of the detailed design should be incorporated into the subsequent filter compatibility assessment.
- Hydrometer testing should continue to be included as part of particle size distribution analyses of samples collected during geotechnical investigations. Hydrometer data provides valuable information for the assessment of filter compatibility as well as the potential instability of widely graded materials (Li et al. 2009).

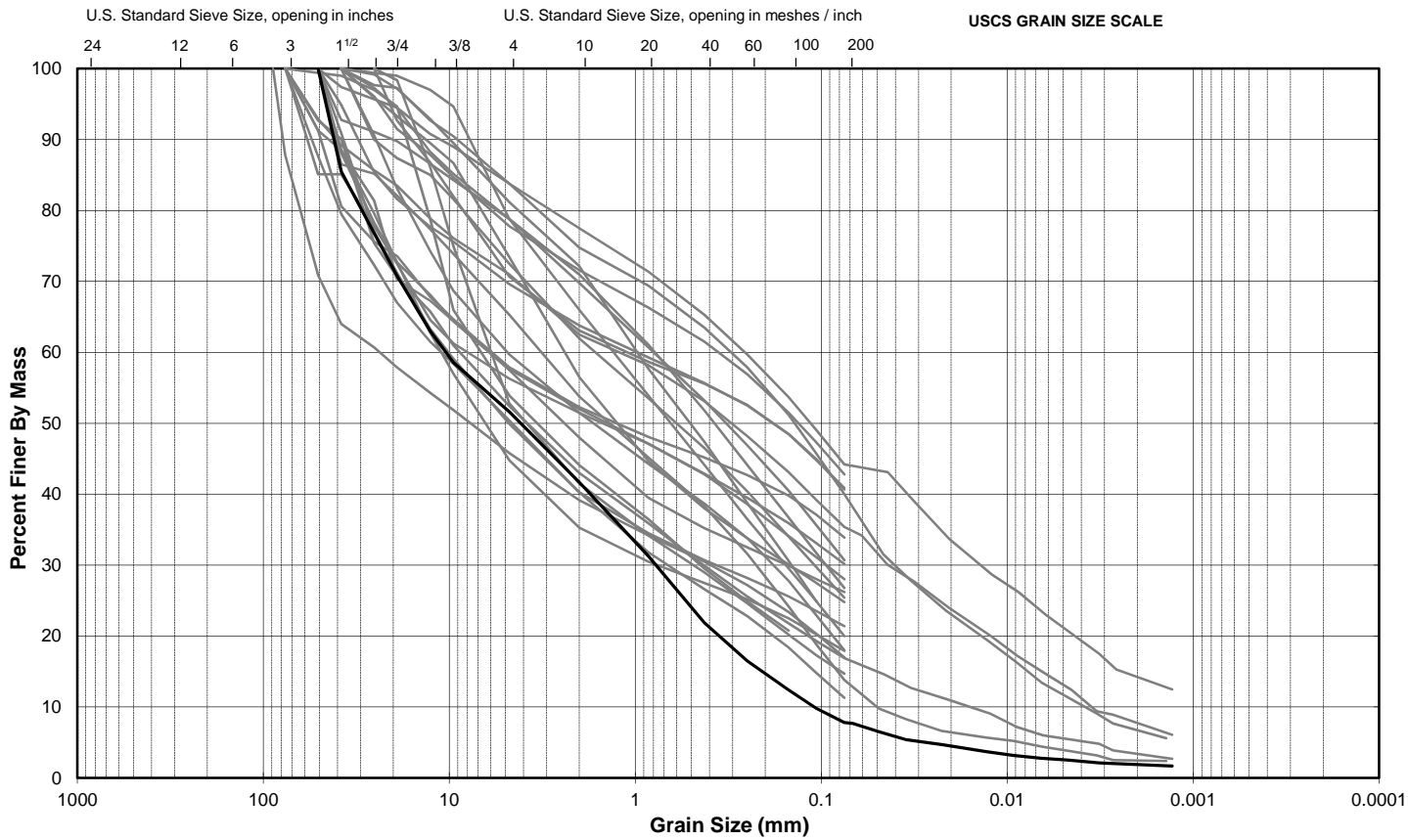
Attachments: Figures D1 to D8

\\golder.gds\gal\burnaby\final\2013\1328\13-1328-0041\1313280041-e14069-r-rev0-2020\appendices\appendix d - filter assessment\appendix d - filter assessment (8dec2014) cf.docx



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LEGEND

- Widely graded competent soil samples (See Note 1)
- Widely graded competent soil sample (JP5-SD-08 – S02)

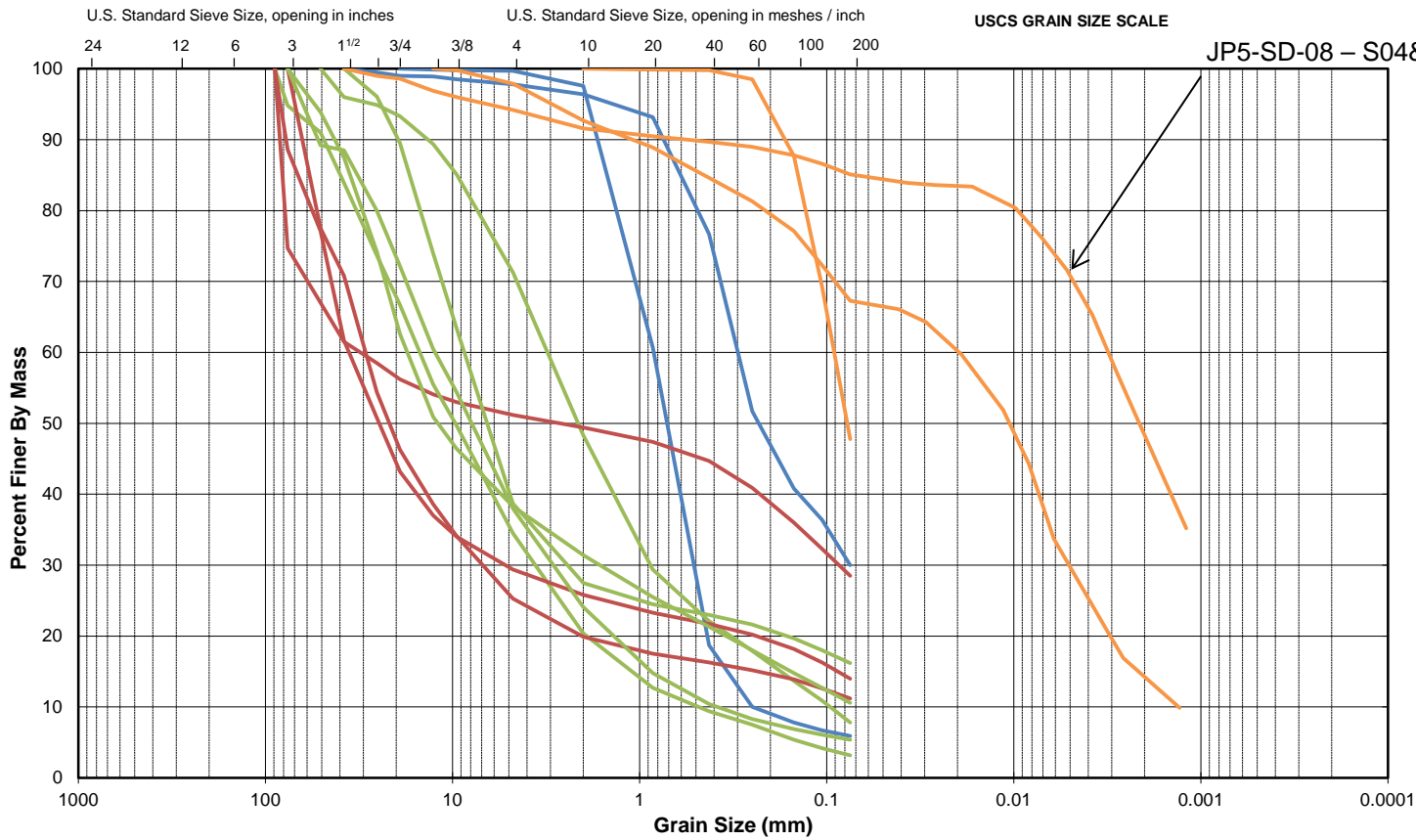
BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

Notes:

- 1) Consists of a wide range of particles, including from gravel sized (4.75 to 75 mm), sand sized (0.075 to 4.75 mm), and fines (less than 0.075 mm).
- 2) Soil category (widely graded) according to USDA (1994).

PROJECT DOMINION DIAMOND EKATI CORPORATION JAY PROJECT NORTHWEST TERRITORIES					
TITLE WIDELY GRADED COMPETENT SOIL SAMPLES PARTICLE SIZE DISTRIBUTIONS					
PROJECT No. 13-1328-0041			PHASE/TASK No. 2020/35		
DESIGN	CM	4DEC14	SCALE	NTS	REV. 0
CADD	CM	4DEC14	FIGURE D1		
CHECK	GJ	5DEC2014			
REVIEW	FE	5DEC2014			





LEGEND

- Fine grained
- Sands
- Gap graded
- Coarse grained

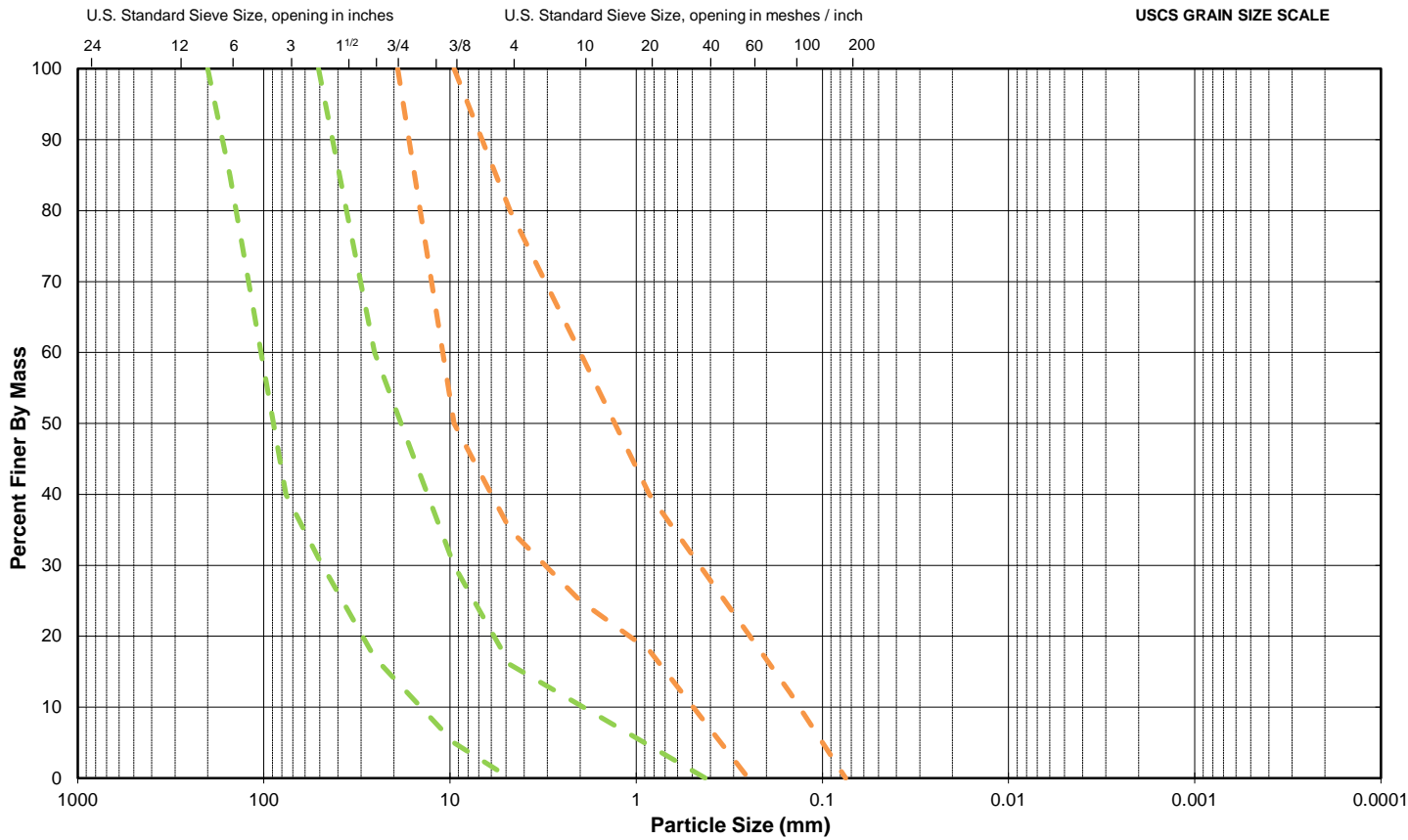
BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

Notes:

- 1) Other competent soil samples, refers to samples which particle size distributions, are not classified as widely graded, according to USDA (1994).

PROJECT DOMINION DIAMOND EKATI CORPORATION JAY PROJECT NORTHWEST TERRITORIES					
TITLE OTHER COMPETENT SOIL SAMPLES PARTICLE SIZE DISTRIBUTIONS					
PROJECT No. 13-1328-0041			PHASE/TASK No. 2020/35		
DESIGN	CM	4DEC14	SCALE	NTS	REV. 0
CADD	CM	4DEC14	FIGURE D2		
CHECK	GJ	5DEC2014			
REVIEW	FE	5DEC2014			





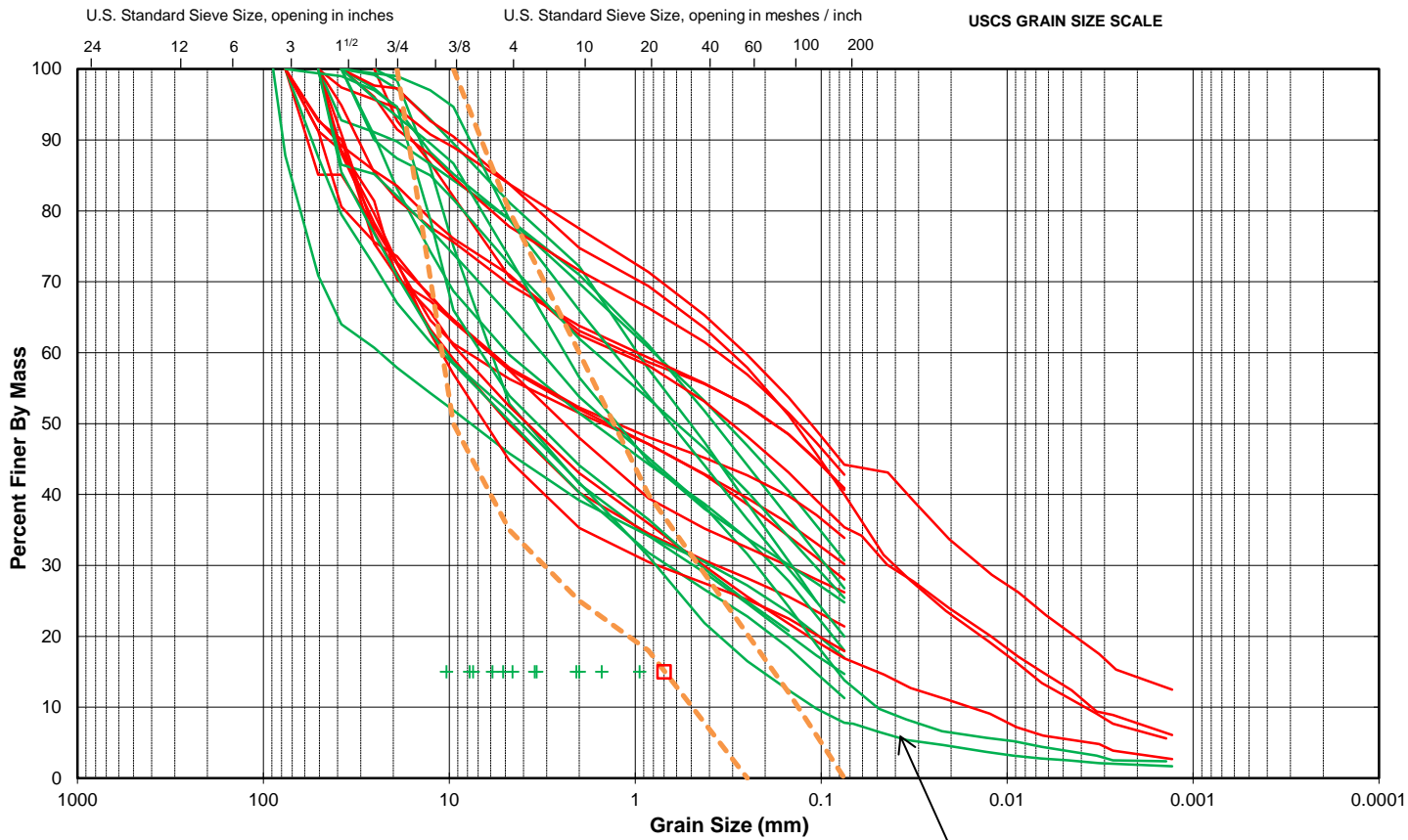
LEGEND

- - - Fine filter particle size distribution envelope
- - - Coarse filter particle size distribution envelope

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

PROJECT DOMINION DIAMOND EKATI CORPORATION JAY PROJECT NORTHWEST TERRITORIES					
TITLE FINE FILTER AND COARSE FILTER PARTICLE SIZE DISTRIBUTION ENVELOPES					
PROJECT No. 13-1328-0041			PHASE/TASK No. 2020/35		
DESIGN	CM	4DEC14	SCALE	NTS	REV. 0
CADD	CM	4DEC14	FIGURE D3		
CHECK	GJ	5DEC2014			
REVIEW	FE	5DEC2014			





LEGEND

- Category 2 Soil Sample (See Note 2)
- Category 3 Soil Sample (See Note 2)
- Fine Filter Maximum D_{15} Category 2 Soil Sample
- + Fine Filter Maximum D_{15} Category 3 Soil Sample
- - - Fine filter particle size distribution envelope

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

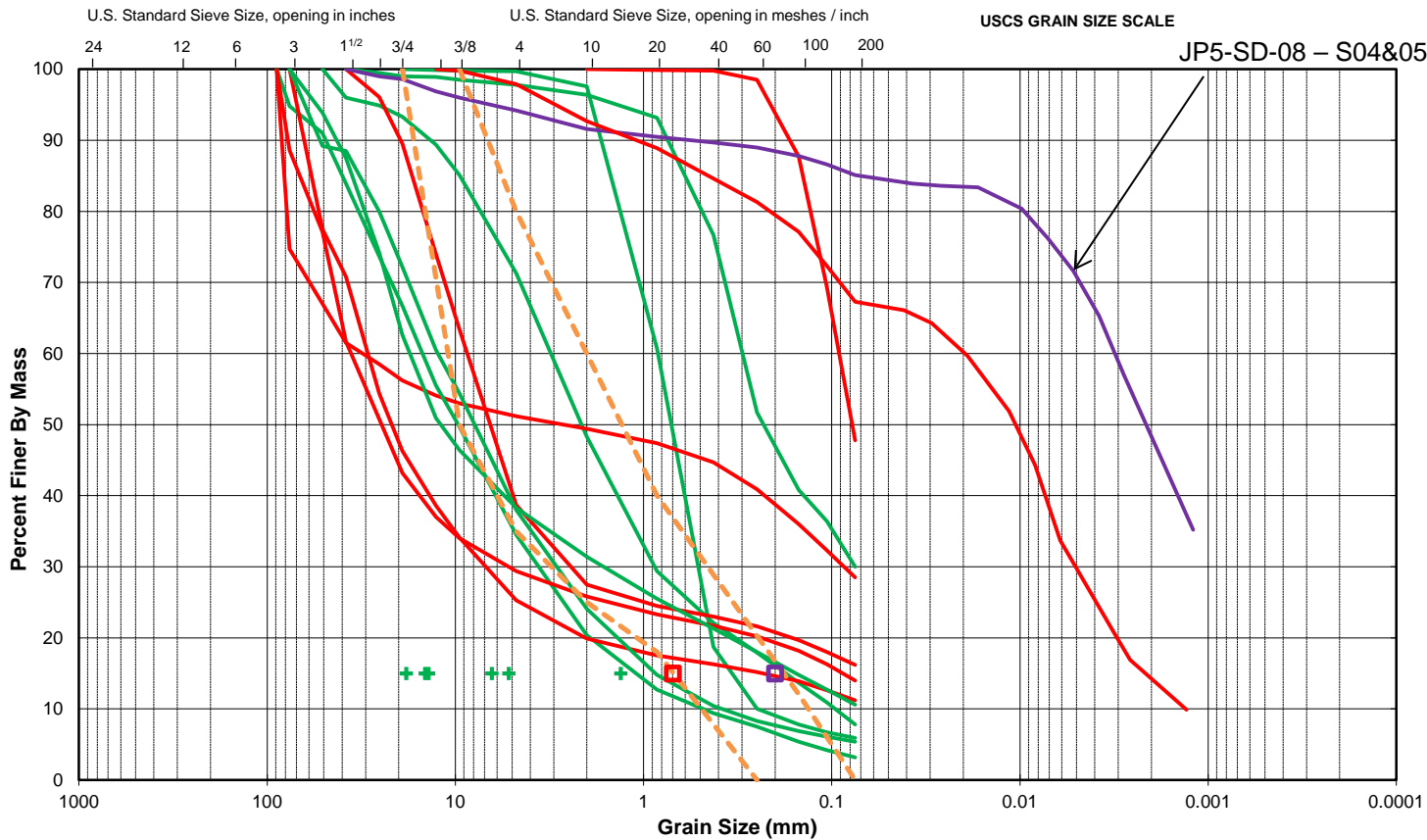
JP5-SD-08 – S02

Notes:

- 1) D_{15} particle size for which 15% of the sample is finer than, by mass.
- 2) Soil category according to USDA (1994).
- 3) Maximum D_{15} of the fine filter calculated according to USDA (1994).

PROJECT DOMINION DIAMOND EKATI CORPORATION JAY PROJECT NORTHWEST TERRITORIES					
TITLE FINE FILTER MAXIMUM D_{15} WIDELY GRADED SAMPLES					
PROJECT No. 13-1328-0041			PHASE/TASK No. 2020/35		
DESIGN	CM	4DEC14	SCALE	NTS	REV. 0
CADD	CM	4DEC14	FIGURE D4		
CHECK	GJ	5DEC2014			
REVIEW	FE	5DEC2014			





LEGEND

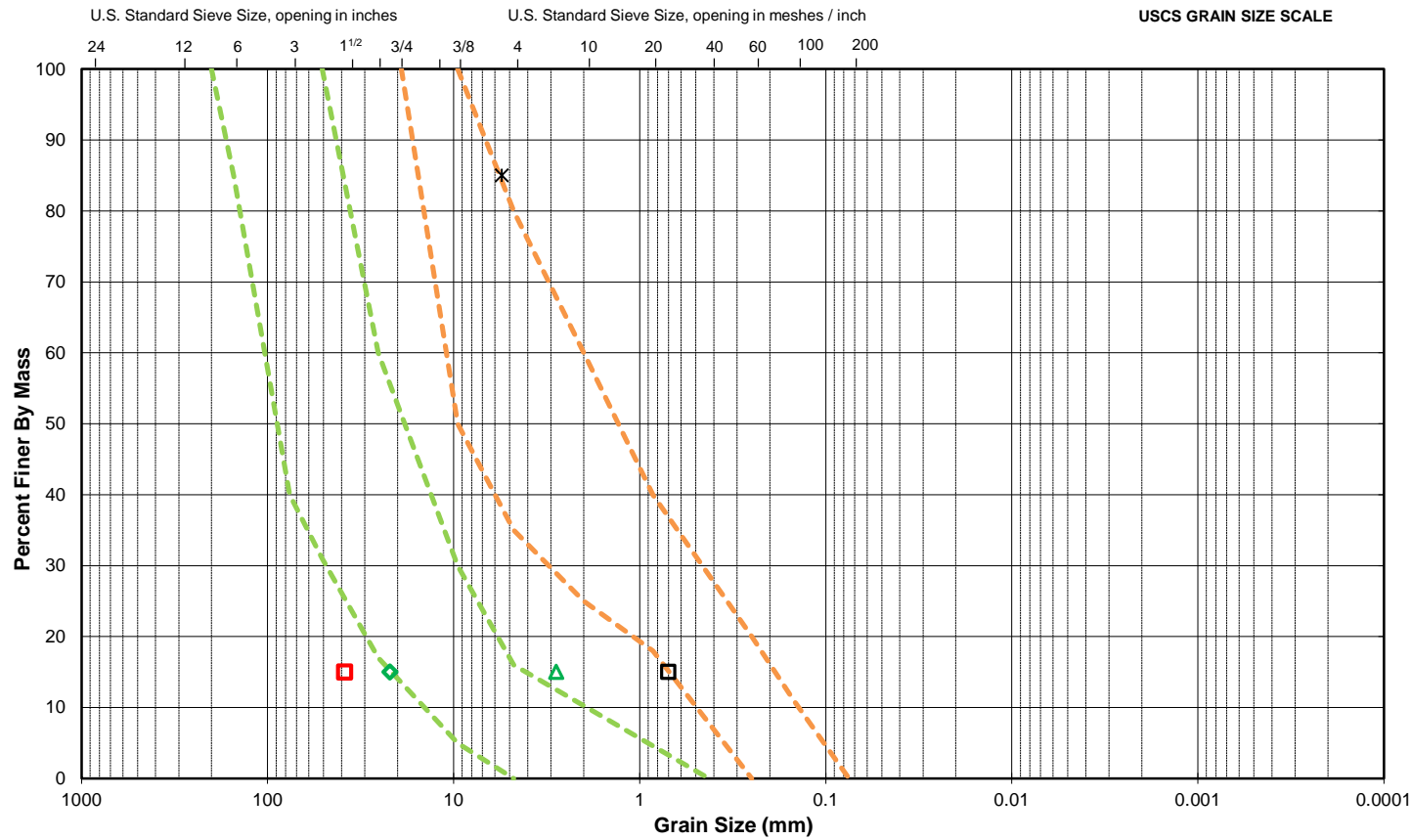
- Category 1 Soil Sample (See Note 2)
- Category 2 Soil Samples (See Note 2)
- Category 3 or Category 4 Soil Samples (See Note 2)
- Fine Filter Maximum D_{15} Category 1 Soil Sample
- Fine Filter Maximum D_{15} Category 2 Soil Samples
- + Fine Filter Maximum D_{15} Category 3 and Category 4 Soils Samples
- - - Fine filter particle size distribution envelope

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

Notes:

- 1) D_{15} particle size for which 15% of the sample is finer than, by mass.
- 2) Soil category according to USDA (1994).
- 3) Maximum D_{15} of the fine filter calculated according to USDA (1994).
- 4) Other competent soil samples, refers to samples which particle size distributions, are not classified as widely graded, according to USDA (1994).

PROJECT DOMINION DIAMOND EKATI CORPORATION JAY PROJECT NORTHWEST TERRITORIES					
TITLE FINE FILTER MAXIMUM D_{15} OTHER COMPETENT SOIL SAMPLES					
Golder Associates			FIGURE D5		
PROJECT No.	13-1328-0041		PHASE/TASK No.	2020/35	
DESIGN	CM	4DEC14	SCALE	NTS	REV. 0
CADD	CM	4DEC14			
CHECK	GJ	5DEC2014			
REVIEW	FE	5DEC2014			



LEGEND

- Fine filter particle size distribution envelope (base soil)
- d₁₅ of base soil (0.7 mm)
- x d₈₅ of base soil (5.5 mm)
- Coarse filter particle size distribution envelope
- ◇ Coarse filter maximum D₁₅ (See Note 3)
- △ Coarse filter minimum D₁₅ (See Note 4)
- Maximum D₁₅ – No Erosion Boundary (See Note 5)

BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

Notes:

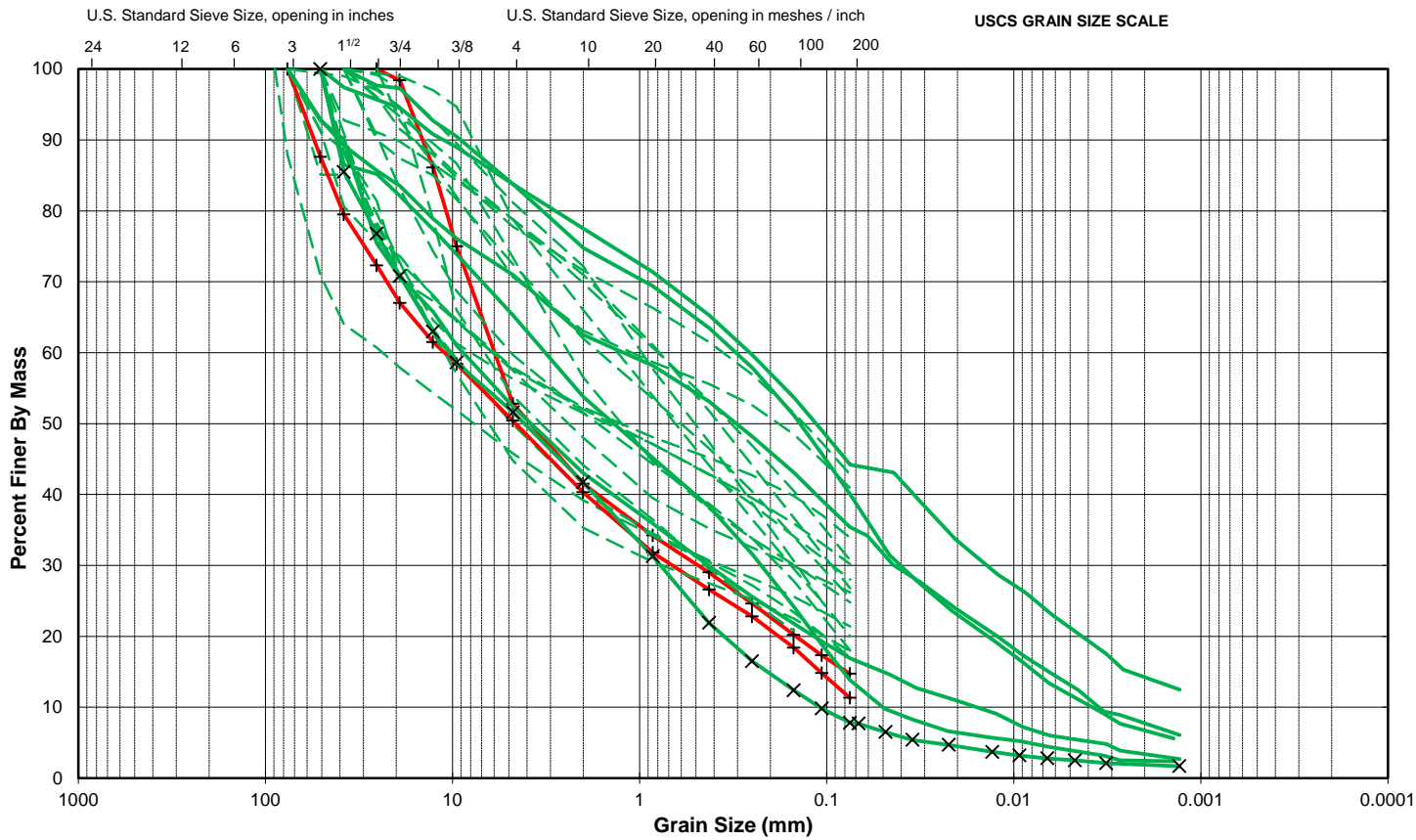
- 1) D₁₅ particle size for which 15% of the sample is finer than, by mass.
- 2) D₈₅ particle size for which 85% of the sample is finer than, by mass.
- 3) According to Sherard and Dunnigan (1989) for a soil containing less than 15% fines by mass.
- 4) According to USDA (1994).
- 5) According to Foster and Fell (2001).

PROJECT **DOMINION DIAMOND EKATI CORPORATION
JAY PROJECT
NORTHWEST TERRITORIES**

TITLE **COARSE FILTER MAXIMUM D₁₅**



PROJECT No. 13-1328-0041			PHASE/TASK No. 2020/35		
DESIGN	CM	4DEC14	SCALE	NTS	REV. 0
CADD	CM	4DEC14	FIGURE D6		
CHECK	GJ	5DEC2014			
REVIEW	FE	5DEC2014			



LEGEND

- Stable (Wan and Fell 2008)
- - - Inferred Stable (Wan and Fell 2008)
- x — Stable (Li and Fannin 2008)
- + — Unstable (Li and Fannin 2008)

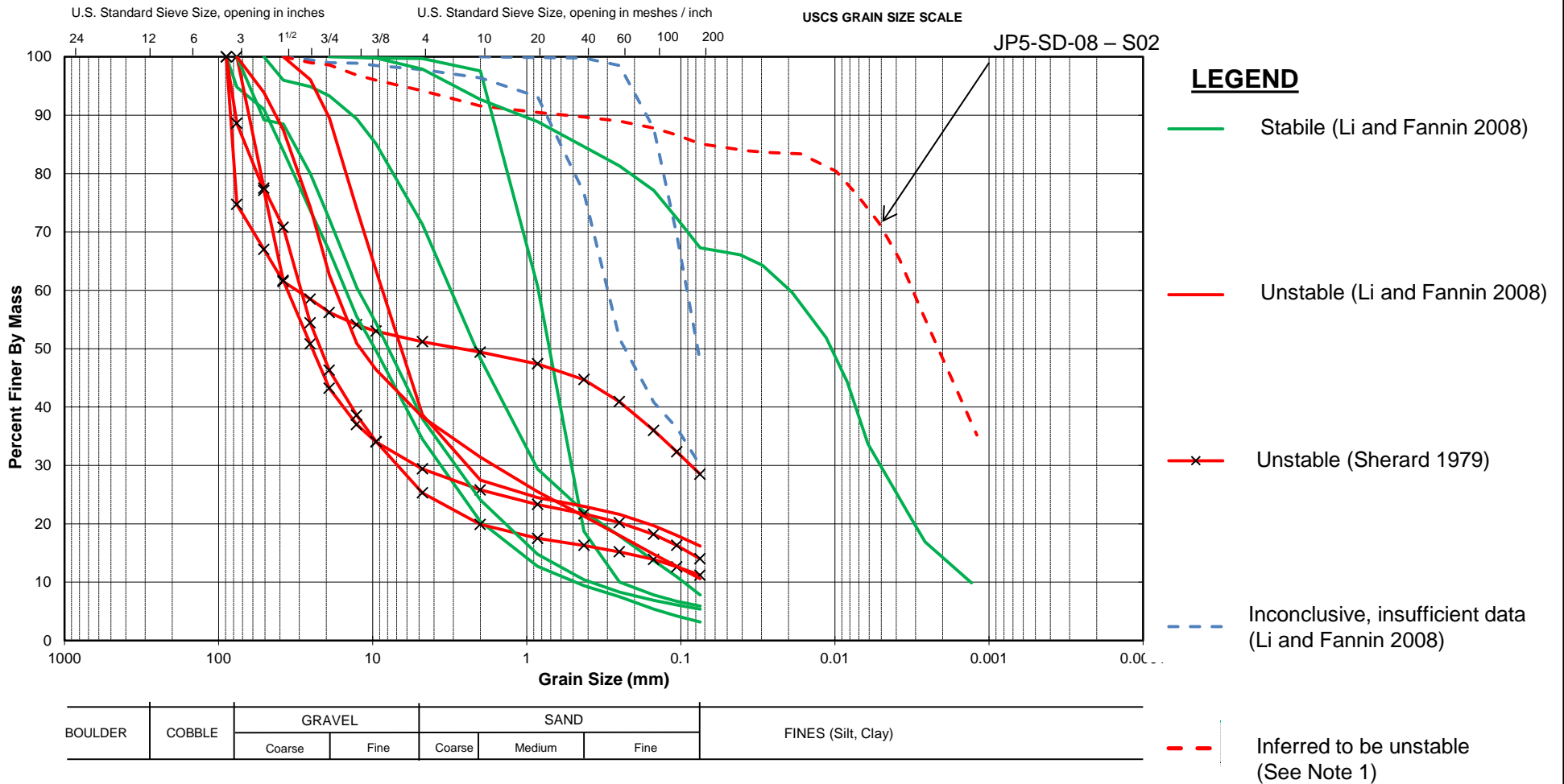
BOULDER	COBBLE	GRAVEL		SAND			FINES (Silt, Clay)
		Coarse	Fine	Coarse	Medium	Fine	

PROJECT **DOMINION DIAMOND EKATI CORPORATION
JAY PROJECT
NORTHWEST TERRITORIES**

TITLE **INTERNAL STABILITY ASSESSMENT
WIDELY GRADED SAMPLES**



PROJECT No. 13-1328-0041			PHASE/TASK No. 2020/35		
DESIGN	CM	4DEC14	SCALE	NTS	REV. 0
CADD	CM	4DEC14	FIGURE D7		
CHECK	GJ	5DEC2014			
REVIEW	FE	5DEC2014			



Notes:

- 1) Inferred to be potentially unstable based on proportion of sample finer than 0.002 mm.
- 2) Other competent soil samples, refers to samples which particle size distributions, are not classified as widely graded, according to USDA (1994).

PROJECT DOMINION DIAMOND EKATI CORPORATION JAY PROJECT NORTHWEST TERRITORIES					
TITLE INTERNAL STABILITY ASSESSMENT OTHER COMPETENT SOIL SAMPLES					
PROJECT No. 13-1328-0041			PHASE/TASK No. 2020/35		
DESIGN	CM	4DEC14	SCALE	NTS	REV. 0
CADD	CM	4DEC14			
CHECK	GJ	5DEC2014	FIGURE D8		
REVIEW	FE	5DEC2014			





APPENDIX E

Construction Quantity Estimate

3.0 Dike Construction Quantities

Item	Unit	Quantity						Total
		Summer 2016	Winter 2016/2017	Summer 2017	Winter 2017/2018	Summer 2018	Winter 2018/2019	
3.1 TURBIDITY CONTROL								
3.1.1 Turbidity Curtain								
2 m curtain depth	No.	78		116		77		271
4 m curtain depth	No.	98		185		139		422
6 m curtain depth	No.	29		138		91		258
8 m curtain depth	No.	31		123		37		191
10 m curtain depth	No.	14		91		10		115
12 m curtain depth	No.	11		55		0		66
14 m curtain depth	No.	3		19		0		22
16 m curtain depth	No.	4		0		0		4
3.2 DIKE CONSTRUCTION								
3.2.1 Rockfill Platform								
Rockfill placement	m ³	670,000	1,461,000	1,289,000		397,000		3,817,000
Safety berm placement	m ³	24,000	73,000	23,000		17,000		137,000
3.2.2 Central Trench Excavation								
Shallow and intermediate sections:								
Rockfill excavation to spoil	m ³	36,000		145,000		45,000		226,000
Rockfill excavation for re-use	m ³	83,000		339,000		104,000		526,000
Soil excavation to target surface	m ³	50,000		87,000		38,000		175,000
Deep sections:								
Silt removal	m ³	16,000		27,000		17,000		60,000
Soil removal to target surface	m ³	8,000		7,000		10,000		25,000
3.2.3 Central Trench Backfill								
Fine filter material	m ³	100,000		334,000		106,000		540,000
Coarse filter material	m ³	139,000		480,000		144,000		763,000
Coarse filter trench excavation for vibro-densification	m ³	9,000		34,000		9,000		52,000
Trench backfill with fine filter for vibro-densification	m ³	9,000		34,000		9,000		52,000
Vibro-densification in intermediate and deep sections	m ³	13,000		53,000		12,000		78,000
3.2.4 Densification Platform								
Fine filter material	m ³	10,000		30,000		15,000		55,000
Coarse filter material	m ³	10,000		30,000		15,000		55,000
Rockfill	m ³	10,000		30,000		15,000		55,000
Dynamic compaction	m ²	5,000		14,000		7,000		26,000
3.2.5 Cut-off Trench								
Slurry trench excavation (shallow sections)	m ³	3,000		3,000		5,000		11,000
Slurry trench excavation (intermediate and deep sections)	m ³	7,000		30,000		8,000		45,000
Bentonite slurry placement	m ³	10,000		33,000		13,000		56,000
Till stockpile	m ³	10,000		33,000		13,000		56,000
CSB mix	m ³	10,000		33,000		13,000		56,000
CSB placement	m ³	10,000		33,000		13,000		56,000
Bentonite for slurry trench and CSB	t	1,050		3,350		1,300		5,700
Cement for CSB	t	1,400		4,450		1,750		7,600
3.3 GROUTING								
3.3.1 Jet Grout Column								
Trial	LS					1		1
Drilling	m					15,000		15,000
Reaming	m					15,000		15,000
Treatment area	m ²					3,200		3,200
Type 10 cement	t					2,000		2,000
3.3.2 Grout Curtain								
Tricone drilling	m			48,000				48,000
Steel casing installation	m			51,000				51,000
Bedrock drilling	m			36,000				36,000
Bedrock grouting	hr			10,300				10,300
Water pressure testing	hr			510				510
Perforations	ea			3,610				3,610
Contact grouting	hr			8,200				8,200
Rising / falling head testing	hr			110				110
Type HE cement	t			5,100				5,100
Ultrafine cement	t			300				300
Premium grade bentonite	t			260				260
Superplasticizer	t			60				60
Celbex 653	t			0.5				0.5
Cold weather set time accelerator	t			4				4
3.4 ISLAND CONSTRUCTION								
Stripping	m ³	240		240		480		1,000

Notes:

Each turbidity curtain has a length of 15 m.

Turbidity anchors are assumed to be run of mine boulders with attachment points installed.

Turbidity curtains will be installed along the alignments as shown on drawings. The contractor will be responsible for curtain installation following ice break up (including anchoring), maintenance during dike construction, removal of the curtains prior to ice formation, and storage. The number of curtains provided does not consider and allowance for replacement of damaged curtains.

Quantities rounded to the nearest thousand

m = metre; CSB = cement-soil-bentonite; No. = number; m³ = cubic metres; t = metric tonne; LS = Lump sum; m² = square metres; hr = hour; ea = each

Bentonite for slurry trench and CSB includes the 6% bentonite cut-off wall slurry, 2% bentonite for till farming and 6% bentonite slurry for CSB preparation

As a global, employee-owned organisation with over 50 years of experience, Golder Associates is driven by our purpose to engineer earth's development while preserving earth's integrity. We deliver solutions that help our clients achieve their sustainable development goals by providing a wide range of independent consulting, design and construction services in our specialist areas of earth, environment and energy.

For more information, visit golder.com

Africa	+ 27 11 254 4800
Asia	+ 86 21 6258 5522
Australasia	+ 61 3 8862 3500
Europe	+ 44 1628 851851
North America	+ 1 800 275 3281
South America	+ 56 2 2616 2000

solutions@golder.com
www.golder.com

Golder Associates Ltd.
500 - 4260 Still Creek Drive
Burnaby, British Columbia, V5C 6C6
Canada
T: +1 (604) 296 4200

