Sabina

GOLD & SILVER CORP.

# BACK RIVER PROJECT
# Responses to Primary Pond Report Comments

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# 1. Responses to Comments

## 1.1 RESPONSE TO KITIKMEOT INUIT ASSOCIATION

### KIA-NWB-1

Comments:

Although stability design criteria have been described, and the document states that the minimum design factors of safety have been achieved or exceeded, details of the stability analyses were not presented or referenced. The design includes an HDPE geomembrane liner sandwiched between two layers of non-woven geotextile, which will have a low interface shear strength. It is unclear whether the stability analyses considered a potential failure surface along this interface, during both construction and operations.

Recommendation/Request:

Sabina to provide details on the stability assessment completed, to support that the design minimum factors of safety reported have been achieved.

Sabina Response:

A stability analysis, specific to the Primary Pond facility, has been completed and used as part of the presented designs. This stability analysis is summarized in the attached technical stability memo for the Primary Pond: provided as Attachment 4.

As part of this stability analysis the upstream liner and fill interface was investigated (see runs in Attachment 4). The current designs have a relatively shallow upstream liner slope at 3H:1V (horizontal : vertical), and also include a minimum 2+ meter thick upstream rock shell that has been placed at a shallower 4H:1V to help buttress the upstream slope, while also helping to increase the thermal cover upstream of the key trench.

### KIA-NWB-2

Comments:

Although a thermal design criteria has been described, and was stated to have been considered and achieved, no thermal assessment was presented or referenced. Further, the presence of the enlarged pond may result in the development of a talik within the flooded area. The extent of a potential talik has, based on the information available, not been evaluated.

Recommendation/Request:

Sabina to provide details on the geothermal analysis completed, demonstrating that thermal design criteria have been achieved.

Sabina Response:

A thermal analysis, specific to the Primary Pond facility, has been completed and used as part of the presented designs. An overview of the Thermal analysis is summarized in the attached technical memo; provided as Attachment 3.

An overview and investigation of the subsurface conditions (foundation conditions) below the Primary Pond footprint is provided in Attachment 1. Percolation testing, drilling, sampling, field falling head testing and corresponding laboratory testing (soil index testing, and laboratory testing) is planned to be completed to help further investigate the foundation conditions and allow an opportunity for the key trench and embankment design to be optimized. The percolation testing on site is planned to be completed in late 2022 - late Nov to Dec), immediately in advance of construction, to gain additional foundation characterization information. This information will be used to further updated and refine the subsurface foundation excavations.

Based on the current operational plans, the Primary Pond will only be maintained full (or with a higher water level) for the few initial years of the mine life. For the initial years of the Primary Pond operation, the pond will retain mainly fresh water from surface runoff / and or from the lake dewatering activities. After this initial period, site will aim to keep the water levels in the pond as low as possible during operation. Once waste rock is placed in the catchment, then the pond will transition to more a surge pond for contact water. The long term operational goals will be to keep a lower water level that would be primary withing the existing ponding water extents (i.e. within the current natural shallow ponded water extents that are primary offset from the upstream of the embankment, as shown on the drawings). This operational approach, maintaining as low of a pond level as possible after the initial few year of operations, would be done to limit the thermal loading on the structure and foundation, done in part to mitigate the development of a new potential talik.

As part of the Primary Pond design (as shown in the design drawings, and additional details provided in Attachment 6) detailed thermal monitoring) is planned to be installed (installation of a system of ground temperature cables). This monitoring would allow for the ground temperatures within and below the Primary Pond embankment to be carefully monitored throughout operation, and help to provide advance warning of potential ground warming trends at and below the Primary Pond structure. If unfavourable thermal conditions do result on site, then mitigation measures such as post-construction placement of upstream fill material or installation of thermosyphons could be implemented on this. Comments and some initial thermal checks on mitigation measures related to uncertainty related to water seepage at or below the Primary Pond are provided at the end of the attached thermal memo (Attachment 3). The planned ongoing site monitoring will be key to allow for any advance warning of any warming trends at the Primary Pond, so that proactive mitigation could be completed if /as required.

## KIA-NWB-3

Comments:

Climate conditions shown in Table 2 of the design report, which are the 1981 - 2010 Climate Normals, are outdated and should not be used for design. According to the design report, Sabina has used updated design values that include climate change. However, details are not provided in the design report for the Goose Site Primary Pond. The document refers to SRK 2021 (Updated Feasibility Study - Hydrology Update. Draft memo prepared for Sabina Gold & Silver Corp. Project No. 1CS020.020. Last updated July 2021), which has not been reviewed by BGC. Considering that the design of the dam is based on climate data, including these values in the design report would be helpful. For example, climate change projection scenario and year that was used for the IDF peak flow provided in Section 2.7 are unknown.

Recommendation/Request:

Sabina to provide details on the climate design parameters, including climate change scenarios used and the year for which the annual probability was evaluated, i.e., the 1 in 100-year and 1 in 1000-year events, respectively.

Sabina Response:

The Climate norms from 1981 to 2010, for the two identified Environment Canada meteorological stations, Lupin A and Kugluktuk A that were closest to the site, were included as these sites had more complete historic data sets, and as this data was helpful to describe the average / general climate conditions of the Property. Attachment 2 provides additional information on the climate norms. This write up in the design overview text was more to set the scene and provide a general overview. The specific information on the climate change projections was not included in that document but checks on climate change have been completed.

Attachment 2 provides the memorandum ("Back River: Updated Feasibility Study - Hydrology Update") that overviews the latest hydrology updates completed around the start of 2021 time frame. The data and calculations presented in this memo was used as the basis for the recent design work.

For the latest design work the climate data, including looking at the site-specific precipitation records, up to the end of 2020, were used. An overview of the climate change analysis that has been completed for Back River is presented in Section 4 of Attachment 2. Specifically, climate change for: Air Temperature, Precipitation and Wind Speed were completed. Original 2015 calculations were revisited and then updated with estimates related to the depth-duration-frequency data for extreme events.

Attachment 3 provides an memorandum that overviews some of the thermal modelling completed for the Primary Pond. Section 5.3.2 of this memo (Attachment 3) provides an overviews the climate boundary conditions that were specifically utilized in the thermal models.

Additional information specific to the peak flow calculations is provided below for additional clarity and transparency.

## PEAK FLOW MODELING

### Extreme Event Precipitation

Extreme event precipitation was updated using recent meteorological data available for the Project (see Attachment 2). Design criteria rainfall depths were adjusted to account for potential climate change using a rate of change obtained from the upper range of representative concentration pathway scenario (RCP 8.5). Table 11 displays the precipitation depths for each return period and event duration.

Table 11: Project Climate Change Precipitation-Duration-Frequency Curve

| Storm Duration | | Precipitation **Depth** (mm) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Return Period (years)** | | | | | | |
| min | hours | 2 | 5 | 10 | 25 | 50 | 100 | 200 |
| 5 | 0.08 | 3.5 | 5.2 | 6.4 | 7.7 | 8.1 | 9.6 | 11.6 |
| 10 | 0.17 | 5.5 | 8.2 | 10.1 | 12.0 | 12.6 | 15.0 | 18.0 |
| 15 | 0.25 | 6.4 | 9.5 | 11.7 | 13.9 | 14.6 | 17.5 | 21.0 |
| 30 | 0.5 | 7.0 | 10.5 | 12.9 | 15.4 | 16.1 | 19.3 | 23.1 |
| 60 | 1 | 7.5 | 11.2 | 13.8 | 16.4 | 17.2 | 20.6 | 24.7 |
| 120 | 2 | 10.5 | 15.7 | 19.3 | 23.0 | 24.1 | 28.9 | 34.6 |
| 360 | 6 | 17.5 | 26.1 | 32.1 | 38.3 | 40.2 | 48.1 | 57.7 |
| 720 | 12 | 21.7 | 32.3 | 39.9 | 47.5 | 49.8 | 59.6 | 71.5 |
| 1440 | 24 | 34.6 | 45.1 | 51.5 | 60.8 | 63.8 | 74.5 | 87.0 |
| 4320 | 72 | 42.9 | 53.4 | 69.5 | 85.2 | 90.1 | 107.4 | 126.4 |

Source: SRK 2021

## Modeling Approach

Instantaneous peak flows and volumes for design storm events were generated in HEC-HMS software (US Army Corps of Engineers) using the design criteria summarized in Table 2 along with the respective pond catchment areas. Runoff from precipitation (Table 11) and maximum 24-hour snowmelt and the SCS curve number method (USDA, 1986) were used to estimate peak flows for a range of return periods, as described in the Updated Hydrology Memo (Attachment 2). Peak flows derived for a rain-on-snow event were used to size the required water management infrastructure and required storage volumes.

Table 1: Hydrologic Design Criteria for Formulating Peak Flows

| Item | Value | Unit | Source |
|---|---|---|---|
| SCS Curve Number (Natural Ground) | 67-70 | - | (SRK 2021a) |
| SCS Curve Number (Pit Walls) | 92 | - | (L. George, 2008) |
| Critical Snowmelt Month | June | - | (SRK 2021a) |
| June Average Snowmelt Rate | 28 | mm/day | (SRK 2021a) |
| Rainfall Distribution | Alternating Block | - | (Chow, Maidment, & Mays, Applied Hydrology, 1988) |
| Minimum Time of Concentration | 10 | minutes | Engineering Judgement |

### Modeling Assumptions and Inputs

Precipitation was distributed over a 24-hour period as well as 72-hour period using the depth-duration-frequency data presented in Table 11 and the alternating block distribution. The alternating block method is a simple way of developing a design hyetograph using precipitation depths from a corresponding storm duration (Chow, Maidment, & Mays, Applied Hydrology, 1988).

A snowmelt hydrograph was included to all catchments in addition to rainfall-runoff. The shape of the snowmelt inflow hydrograph was developed using a sinusoidal distribution over a 24-hour period with a peak melt rate at mid-day. The maximum 24-hour snowmelt depth was calculated to be 28 mm/day (SRK 2021a).

The SCS Curve Number method was used to estimate precipitation excess, which is as a function of a Curve Number (CN). The Clark Unit Hydrograph method was used to transform precipitation excess into an outflow hydrograph (USACE 2015). The Clark Unit Hydrograph method uses a Storage Coefficient (R) and time of concentration ($T_c$). $T_c$ was estimated using the empirical equation developed by Watt and Chow (1985) and the storage coefficient was determined as a fraction of $T_c$ (Sabol 1988).

CN values were calibrated for natural catchments in SRK 2021a based on the 1 in 10-year, 50-year and 100-year flood events, resulting in a CN of 70, 67, and 67 respectively. The worst-case peak flow and runoff volume conditions for berms, ponds and sumps was assumed to occur prior to waste rock placement, which would be expected to temporarily store and slow the runoff rates to downstream infrastructure. As such, the natural calibrated CN values were applied to all catchment areas, with the exception of open pits, which were assigned a higher CN of 92.

## KIA-NWB-4

Comments:

BGC agrees with the recommendation regarding the timing of the excavation of the key trench stated in Section 2.6. This recommendation should be explicitly stated in the Technical Specifications (Appendix B of the design report).

Recommendation/Request:

Sabina to update the technical specification and indicate winter criteria stated in Section 2.6 of the design report.

Sabina Response:

Comments noted. Sabina agrees with these comments and will explicitly add in a statement to the next version of the Technical Specifications that excavation of the key trench is required to be completed under winter conditions (specifically when the ambient air temperature is approximately -10ºC or colder).

The next revision of the technical specifications is planned to be released immediately prior to construction. Sabina is also in the process of performing index testing (such as Particle Size Distributions) on the current material stockpiles on site. This material review, and comparison the current technical specifications will also be done before construction. The technical specifications document is expected to be a live document that may have slight changes and updates to it based on encountered site conditions. Any edits to the technical specifications would also be highlight in the as-built report, that will be prepared and submitted approximately 90 days after the completion of construction of the Primary Pond.

KIA-NWB-5

Comments:

The design report, drawings and technical specifications use different terms when describing ground ice. For example, the term "massive ice" is used in drawings to specify excavation requirements, but the foundation preparation section (6.2.3 – 1) does not make any reference to ice or frozen soil, but just states that "Contractor shall prepare an acceptable foundation surface to receive the specified fill material. An acceptable foundation surface is a surface which is clean, sound and firm, and which does not contain any loose, softened or disturbed foundation material as determined by the Engineer." Further, in the construction material specification the criteria states that no "snow and ice" should be in the construction material (5.1.2 – 2). Later, under the transition material, the specification indicate that the material should be free of "frozen soil, snow and ice" (5.2.4 – 1). Finally, under fill placement, the specifications indicate that the fill should be "free of stratifications, ice chunks, lenses or pockets, …". The different terms and specifications used in the design report, the drawings and the technical specifications may be confusing and could result in inconsistency during site preparation and construction.

Recommendation/Request:

Sabina to review the language regarding ground ice in the drawings and technical specifications, and clearly specify criteria, e.g., acceptable volumetric ice content, for foundation and construction material to be placed.

Sabina Response:

Comments noted. Sabina agrees with these comments and will review and correct the language, when referring to ice or ground ice, in the next version of the Technical Specifications and in the next Issued for Construction (Revision 01) version of the drawings.

The next revision of the technical specifications is planned to be released immediately prior to construction. The next version of the drawings are planned to be updated and released following the completion of the percolation testing on site. The percolation testing on site is planned to be completed in late 2022 - late Nov to Dec) to gain additional foundation characterization information that may be used to help update and refine the key trench designs prior to construction.

In general, for the foundation any areas with massive ice within the key trench (typical excavation depths in the range of 2 to 5m below the existing ground surface) will be removed. Overburden foundation areas with massive ground ice below 5m in depth, are currently planned to be left in place. Specific attention would be given to any areas in the foundation where ice contents in excess of 20% (over a 1m depth interval) are encountered. The thermal memo (Attachment 2) should be reviewed for additional information on potential contingency or mitigation measures that may be implements if continuous (goes from the upstream to downstream side of the Primary Pond) or large areas of massive ground ice are encountered. These contingency measure may include placing additional sacrificial overburden fill off the upstream side of the dam to help keep thermal loading further away from the dam liner and key trench, while also stretching out the seepage pathway if any thaw pathways occurred (similar to the use of a sand beach immediately upstream of a conventional tailings dam).

At this time all dam fill material are planned to be constructed from either quarry or (previously thawed) esker sources. Therefore no massive ground ice is expected in the fill material. Onsite quality control and quality assurance is planned to be carried out on site which will help to track and ensure that snow is not incorporated into the fill materials. In general for the coarse rockfill (run-of-quarry) material will need to be placed on a clean surface but if snowfall is resulting on site then up to approximately 1 to 2cm of snow may be allowed to be left in place (at the discretion of the onsite field engineer, and will be documented) if in discrete areas. For any areas where finer crush or sand-like material will be placed immediately above or below the liner element then very detailed 'dental' cleaning will be required to ensure that any surface has as little snow as possible / practical. So above and below the liner expect that accumulated snow would be maintained to less than a few millimetres. Due to the stringent surface material preparation requirements it is expected that the key trench and above ground liner sections may be done in sections so that they can be covered up shortly after placement / installation.

KIA-NWB-6

Comments:

Drawing UM-PP-200 refers to "hypersaline soil" being an unsuitable foundation material, but it is not defined in the technical specifications, nor are quality control/quality assurance (QC/QA) specifications presented to assess the presence of saline soil during foundation preparation.

Recommendation/Request:

Sabina to update the technical specification by defining hyper-salinity and provide details on the QC/QA process for foundation preparation with respect to salinity.

Sabina Response:

Comments noted. Technical specifications will be updated to further discuss 'hypersaline soil'. The next revision of the technical specifications is planned to be released immediately prior to construction.

For the thermal design the foundation was considered to be frozen if colder than -2°C, which represents a conservative freezing point depression for the average overburden pore water salinity measured from samples collected at the Goose Property. Soil pore water salinity has been determined from laboratory testing (from past site investigation programs) to average 23 ppt. The average pore water freezing point depression is calculated to be -1.4°C. Some of this salinity may have been from drilling in the winter with brine (to maintain frozen samples) but for conservatism the uncorrected laboratory values have been adopted (i.e. adopt the highest values). 'Hypersaline soils' for the Primary Pond would be defined at this stage as any areas where salinity values are above 25ppt. Those areas will be each examined and if / as required mitigation would occur (such as additional excavation in those areas to remove those soils from the foundation).

Salinity testing was planned to be done first on the percolation testing samples (collected pre-construction) and then also on the fill material as part of construction. Additional details on this testing will be added into the technical sections (expect to be done with a handheld refractometer and as per ASTM D4542).

KIA-NWB-7

Comments:

The drawings describe percolation testing to be completed at specified locations, but the technical specifications do not describe when they are to be completed relative to the overall construction schedule, how the test results are intended to inform construction and specifically, foundation approval, and how the test holes are to be decommissioned.

Recommendation/Request:

Sabina to provide details in the technical specifications on the percolation testing procedure, how the results inform foundation approval, and how the percolation test holes will be decommissioned after testing.

Sabina Response:

The percolation testing will be completed prior to the start of construction. Currently the percolation testing on site is planned to be completed in late 2022 - late Nov to Dec) to gain additional foundation characterization information that may be used to help update and refine the key trench designs prior to construction. The design drawings will be updated (and revisions numbers increased) prior to the start of the key trench construction.

The percolation testing will be comprised of:

- Drilling relatively tightly spaced hole (typically 25 to 50m spaced holes). All holes drilled down at least one run (a couple meters) into bedrock
- Collection of samples (typically samples collected every 0.5m in the top approx. 5m of each hole and then at approximately 1m intervals below that.
- Completing laboratory testing on all of the collected samples. This will be mainly index testing (i.e. visual identifications, moisture contents, some particle size distribution and Atterberg Limit testing as applicable, and salinity testing on subset of the sample).
- Completing of the percolation (more falling head) type testing on site. This will involve filling the holes with lukewarm water (typically more in the 15°C range) and then measuring the drop in head (elevation) with time.

Any remaining voids at the top of the holes (that are not filled with frozen water from the percolation falling head testing) will be backfilled with a sand and water mixture. Typically the percolation holes will be small discrete points and will not be drilled in rows across (from upstream to downstream) or perpendicular to the dam centerline to limit the potential for an increase thaw or seepage pathway in the foundation to form (i.e. will be drilled at discrete points, typically in the center of the key trench alignment).

## KIA-NWB-8

### Comments:

The drawings include HDPE geomembrane liner and nonwoven geotextile, and some construction details for liner installation are presented as notes to Drawing UM-PP-201. However, the material, installation, and QC/QA specifications for the geosynthetic products have not been included with the technical specifications.

### Recommendation/Request:

Sabina to include sections on the material, installation and QC/QA process for the HDPE geomembrane liner and the non-woven geotextile in the technical specifications.

### Sabina Response:

Comments noted. Technical specifications will be updated to further discuss the HDPE and nonwoven geotextile QC/QA specifications.

At this time A&A Technical Services (Yellowknife based) have been consulted and were part of the design review for the Primary Pond designs. As part of the as-built reporting all liner QA/QC will be documented and attached. This is expected to include:

- Panel layout drawings
- Panel dimension log
- Quality control documentation from the manufactures (i.e. roll certifications)
- Wedge and extrusion welder qualification data
- Non-destruct air pressure seam testing and vac box test data

The next revision of the technical specifications is planned to be released immediately prior to construction.

KIA-NWB-9

Comments:

The drawings include "bedding" as a fill material type, but the material and placement specifications have not been included in the technical specifications.

Recommendation/Request:

Sabina to include details on the bedding material and placement procedures in the technical specifications.

Sabina Response:

Comments noted. Technical specifications will be updated to include "bedding" material. This was an oversight. Thanks for catching this.

The next revision of the technical specifications is planned to be released immediately prior to construction.

In general the bedding material is expected to be a 19mm minus type material (somewhat similar to what listed in the technical sections as the surfacing material) but with a greater sand content. Sabina is currently in the process of performing index testing (such as Particle Size Distributions) on the current material stockpiles on site. This material review, and comparison the current technical specifications will be also be done before construction (to ensure that current materials on site meet the technical specification requirements and design intent).

KIA-NWB-10

Comments:

The drawings show the liner system being covered with 0.3 m thickness of bedding material, but Note 6 in Drawing UM- PP- 206 states that "a minimum thickness of 600 mm is required to be placed over any area where heavy equipment will be trafficking over the liner". The technical specifications provide no guidance for how the bedding cover can be placed without inducing shear stresses that could damage the liner system.

Recommendation/Request:

Sabina to clarify in the technical specifications how the bedding material is to be placed over the liner system.

Sabina Response:

Comments noted. Technical specifications will be updated to include additional details on the overline material placement. Full time site supervision and associated QA/QC checks will be done on site for all overline material placement.

Sabina has experience with overline material placement on site from the various tank farm liners and the camp pad pond liner that are being installed on site. This experience will be used for this construction work as well. Typically material will be placed from the bottom of the slope working upwards in elevation to reduce the chance for liner damage or 'slippage' that might cause damage. If access over a lined area is required then typically a fill of greater than 0.6m (600mm) will be used to help distribute the vehicle loads. Typically material will be placed in an even greater lift thickness (say 1m) and the pulled back / reduced to the design thickness as equipment works over and then out of an area with underlying liner.

### KIA-NWB-11

Comments:

The technical specifications for riprap are based primarily on particle gradation. Material specifications for durability are not included in the technical specification.

Recommendation/Request:

Sabina to provide additional specifications regarding the durability in the technical specifications.

Sabina Response:

Comments noted. Technical specifications will be updated to include additional details rip-rap material durability.

This noted, for the Primary Pond, as the emergency overflow channel / spillway is planned to blasted almost fully out of bedrock it is expected that the requirements for the rip-rap not be a driving factor (e.g. if excavation was out of overburden then the rip-rap would be serving a more critical design function).

### KIA-NWB-12

Comments:

The drawings do not indicate where riprap may be placed, nor provide any details regarding its use.

Recommendation/Request:

Sabina to show the use of riprap in the construction drawings.

Sabina Response:

See comments on KIA-NWB-12. As it stands now the Primary Pond, as the emergency overflow channel / spillway is planned to blasted almost fully out of bedrock. Rip-rap placement would be focused primary on areas where the spillway excavation is not entirely in competent bedrock, or at the outlet of the spillway to assist with increased energy dissipation. The spillway is not planned to be routinely used and therefore would be primary for emergency use. If flow through / over the spillway is every triggered then a site inspection (post use / triggering) would be completed to ensure that no additional maintenance activities would be required.

## KIA-NWB-13

Comments:

The spillway is planned to be excavated in bedrock. It is unclear whether the bedrock has been confirmed as nonpotentially acid generating (NPAG), and the technical specifications provide no details about whether it will be. The typical spillway section (F) on Drawing UM-PP-301 shows the spillway berms being constructed of run-of-quarry (ROQ) rock that appears to be approximately 0.5 m thick. Section 5.2.3 of the technical specifications specifies that the maximum boulder size of ROQ is 500 mm when the fill thickness is less than 0.85 m.

Recommendation/Request:

Sabina to confirm that bedrock at spillway location is to be NPAG. Sabina to clarify that ROQ rock with the proposed specifications are planned to construct the berms.

Sabina Response:

Sabina confirms that the spillway (emergency overflow channel) is planned to be excavated in bedrock. Bedrock outcrops can be seen from field mapping of this area, i.e. when this area is walked over in the field.

Some of the spillway berms may be required to be constructed of rockfill material. The final geometry of these berms would likely be field fit, at the discretion and guidance of the design engineer, and based on site conditions encountered as part of the initial spillway drilling, blasting and excavation. For any areas where spillway rock fill berms are required then ‘select’ ROQ will be required to be used. The select ROQ material would be a sorted material where the largest fraction of the ROQ blast rock is removed. This will effectively result in a lowering of the maximum boulder size that will be acceptable for the spillway berms (moving more towards a coarse cobble size material). Additional details specific to the potential spillway ROQ berms will be added to the next revision of the technical specifications; which planned to be released immediately prior to construction.

Geochemical testing will be completed on the bedrock material from the spillway excavation. This confirmatory testing and segregation will be done as per the approaches outlined in Sabina’s approved Borrow Pits and Quarry Management Plan.

From some of the select blast holes drilled in the spillway (similar to what is done in the rock quarries prior to quarry excavation), additional samples can be collected for geochemical analysis. Samples will be collected the same manner that they are collected for the quarry samples. Specifically this would be as follows:

- Each sample should weigh no less than 1 kg.
- Each sample should be labeled with a unique sample identification number.
- Each sample should be documented in terms of sample depth and location within the quarry, and the blast hole number in the case of rock quarries.
- Composite samples (more than one lithology) should be avoided where possible.

All samples will be submitted for total sulphur and total inorganic carbon analysis at an off-site, accredited laboratory, using LECO furnace analyser or a similar appropriate technique. Analytical methods must achieve a suitable detection limit for classification. Total sulphur will be used to calculate acid potential (AP) and TIC will be used to calculate neutralization potential (NP). Additional laboratory testing on a subset of the samples collected will include acid base accounting and net acid generation (NAG) testing to confirm geochemical ARD classification.

### KIA-NWB-14

Comments:

Drawings and technical specifications do not provide details on the temperature monitoring equipment, such as sensor type and accuracy, reading frequencies, data loggers; nor how they should be installed and protected during construction. In addition, the construction drawings do not provide information regarding the location of the terminal boxes for data logger or how the thermistor strings are leading to those boxes.

Recommendation/Request:

Sabina to provide details on the thermistor strings and the installation in the technical specifications.

Sabina Response:

Additional drawings have been included in / as Attachment 6, to show further details on the expected cable layouts. Sabina is in contact with BeadedStream and is in the process of procuring the required ground temperature cables. Once the manufacturer details are confirmed, and these cables have been ordered, then additional details on the ground temperature cable installations will be added into the next revision of the technical specifications. Typically the cables will be surrounded by finer crush (bedding material) to help limit the potential for damage.

The specifications for the BeadedStream digital temperature cables, as well as some additional potential cable protection measures, are provided in Attachment 6. At this time solar powered BeadedStream data loggers (with telemetry capabilities) are expected to be used. The specification sheet for these data loggers is also included in Attachment 6.

## KIA-NWB-15

### Comments:

No details are provided on the two, ~150 m long horizontal thermistor strings shown in Drawing UM-PP-501 that are placed on the east and the west sections of the dam. It is further noted that no horizontal thermistor string is proposed under the highest section of the dam, i.e., in the middle. The intent of the two horizontal thermistor strings is unclear based on the information provided.

### Recommendation/Request:

Sabina to provide details on these horizontal thermistor strings including the monitoring objective and rationale for their specific locations, e.g., upstream vs. downstream, and sides vs. centre.

### Sabina Response:

The two ~150 m long horizontal ground temperature cables (GTC) shown in Drawing UM-PP-501 would be installed along the upstream base of the key trench. The ground temperature cables are located across two sections of the key trench that would be founded in overburden soil, with the start and end position of each cable extending across approximately 10 m of the key trench portions that would be constructed in bedrock. The GTC will provide additional monitoring to evaluate thermal performance of the dam, including the potential thermal influence from water seepage (if it was to occur) into the key trench. The indirect detection of water seepage using ground temperature measurements would be thermally unique to that of heat transfer from thermal conduction alone. The cable does not extend beneath the thickest section of the dam fill due to the expectation that the key trench will be founded in bedrock at that location. The GTC length would be adjusted to meet actual ground conditions at this location should the lateral extent of overburden within the key trench be greater than expected. The quantity of ground temperature cables would not be expected to notably change but the locations may be slight adjusted / optimized based on the additional data collected as part of the pre-construction percolation testing. Any updates to the instrumentation locations would be updated on the construction drawings (revision increased) and the final details compiled and submitted as part of the as-built construction report.

KIA-NWB-16

Comments:

Drawing UM-PP-01, Details 07 and 08, describes the use of bentonite or fly ash amended sand fill, but the document does not describe its purpose, and material, preparation (mixing), and placement specifications for the bentonite, fly ash, and sand fill were not described in the technical specifications. Furthermore, material quantities are not listed on Drawing UM-PP-209 with the rest of the construction materials.

Recommendation/Request:

Sabina to provide details on the material, preparation, placement, and QC/QA procedures for the bentonite, fly ash, and sand fill in the technical specifications.

Sabina Response:

The use of bentonite or fly ash amended sand fill would only be used to help fill in discrete pockets in the upstream slope of the blasted key trench. The intention is not to place full layers of this material and to only use this material (if / as necessary) to help fill in small voids or undulations at the upstream key trench slope. The approach would be try to limit the use of this material in the key trench foundation.

This, lower permeability material, would therefor be used primary to help prepare the upstream slope / surface for the liner placement (to help ensure the liner subbase is appropriate for installation). Sabina is currently working with the design engineer to find a 'mix' that will work well with the currently available material on site. Note that this material would not be needed until after the key trench excavation has been completed (or at least portions of the key trench excavation completed). There are various site access, spillway, and construction preparation activities that will result on site before this material is required.

Ultimately the bentonite or fly ash amended sand is expected to be prepared / mixed at the site batch plant and the hauled to the Primary Pond area.

An example of a working fly ash amended design (trial) would be:

1. Mix Design - 4 parts sandy aggregate : 1 part fly-ash : 1 part cement
2. Quality Control testing is required as follows:
    a. For each individual batch mixed, at least 2 samples each of the aggregate and fly-ash prior to mixing must be submitted for particle size analysis (hydrometer not required);
    b. For each individual batch mixed at least 2 completely mixed samples of the 4:1:1 blend must be submitted for particle size analysis (hydrometer not required).
3. Quality Assurance testing is required as follows:
    a. For each individual batch mixed, at least 1 completely mixed sample of the 4:1:1 blend, taken from the placed location must be submitted for particle size analysis (hydrometer not required).
4. The mix design must be placed in lifts no greater than 200 mm (loose density) and compacted using a method specification that will ensure a firm competent surface.

A rush order expected to placed on the samples collected from the first mixed batch as the lab results will be needed to confirm the mix design.

When the final site specific design (or 'mix') details are constrained on site then they will also be added into one of the future revisions of the construction technical specifications. All QC and QC testing on this material will be presented in the final as-built report that will be completed for this pond construction.

## 1.2 RESPONSE TO CROWN-INDIGENOUS RELATIONS AND NORTHERN AFFAIRS CANADA

### CIRNAC-NWB-1: Design Report Composition and Delivery

Comments:

The design document titled "*BACK RIVER PROJECT Primary Pond – Goose Site Design Report and Drawings"* (the Design Report) was prepared by Sabina. It includes two appendices prepared by SRK Consulting (Canada) Inc. (SRK) that include drawings and specifications. Appendix A includes Issued for Permit Drawings titled "*Engineering Drawings for the Primary Pond Dam, Back River Project, Nunavut, Canada (Revision A)"* (the Drawings). Appendix B includes Technical Specifications titled "*Technical Specifications Earthworks and Geotechnical Engineering, Back River Gold Project, Nunavut, Canada (Revision 01 – Issue for Construction)"* (the Specifications) The Design Report appears to be a summary document prepared by Sabina that is supplemented by the Drawings and Specifications prepared by SRK. The report includes limited details on the design parameters, analysis, methods, and assumptions for the Primary Pond; however, it is anticipated that these details are available in other reporting prepared by SRK (i.e., a detailed design report) given the level of detail provided in the Drawings and Specifications that was not included in the package submitted to the NWB for review but which may be necessary for a complete evaluation of the project to occur.

Recommendation:

CIRNAC recommends that Sabina provide a copy of the Drawings and Specifications prepared by SRK including all details on the design parameters, all analysis, methods, and assumptions for the Primary Pond.

Sabina Response:

In additional to the drawings and technical specifications provided in the original package Sabina has included the following set of technical attachments, to provide additional details on design parameters and analysis completed, for the Primary Pond design.

1. Attachment 1 – Subsurface Model – SRK Memo
2. Attachment 2 – Hydrology Update – SRK Memo
3. Attachment 3 – Thermal Analysis – SRK Memo
4. Attachment 4 - Stability Analysis – SRK Memo
5. Attachment 5 – Seepage Analysis – SRK Memo
6. Attachment 6 – Additional Monitoring Details - Drawings, and Instrumentation Specification Sheets

These have been separated out in sections for clarity and to help to more readily respond to the IRs received from both the KIA, and CIRNAC.

### CIRNAC-NWB-2: Design Criteria

Comments:

The design criteria for the Primary Pond are described in Sections 2.3 (Dam Classification), 2.4 (Design Life), 2.5 (Stability Criteria), and 2.6 (Thermal Criteria) of the Design Report. Sections 2.4, 2.5, and 2.6 of the Design Report appear to satisfy the Design Criteria requirement of Part D, Item 3a of the Water Licence.

With respect to Section 2.3 (Dam Classification), the following clarifications are not obvious enough to the reader to satisfy the Design Criteria requirements of Part D, Item 3a of the Water Licence: Specifically;

- It is unclear if Dam Breach Analysis and Inundation Mapping analyses for the Primary Pond are included in the package for review , which would better inform the dam class assigned to both Population at Risk and Loss of Life.
- The dam class assigned for the Environmental and Cultural Values category is *High* indicating that, in the event of a Primary Pond failure, the downstream environment is considered *important for* fish or wildlife habitat and that restoration or compensation is *highly possible*; however, no justification is provided on how this dam class was determined and finally;
- The dam class assigned for the Infrastructure and Economics category is *Significant* indicating that a Primary Pond failure would impact seasonal workplaces and infrequently used transportation routes. Failure of the dam would affect the Goose All-Weather Road which appears to provide the only access to the Llama deposit and would be expected to be used regularly during operations. Additionally, failure of the Primary Pond dam may impact operations at the Umwelt Pit (scheduled to last approximately 2.5 years) which could represent significant economic losses to Sabina.

Recommendation:

CIRNAC recommends that:

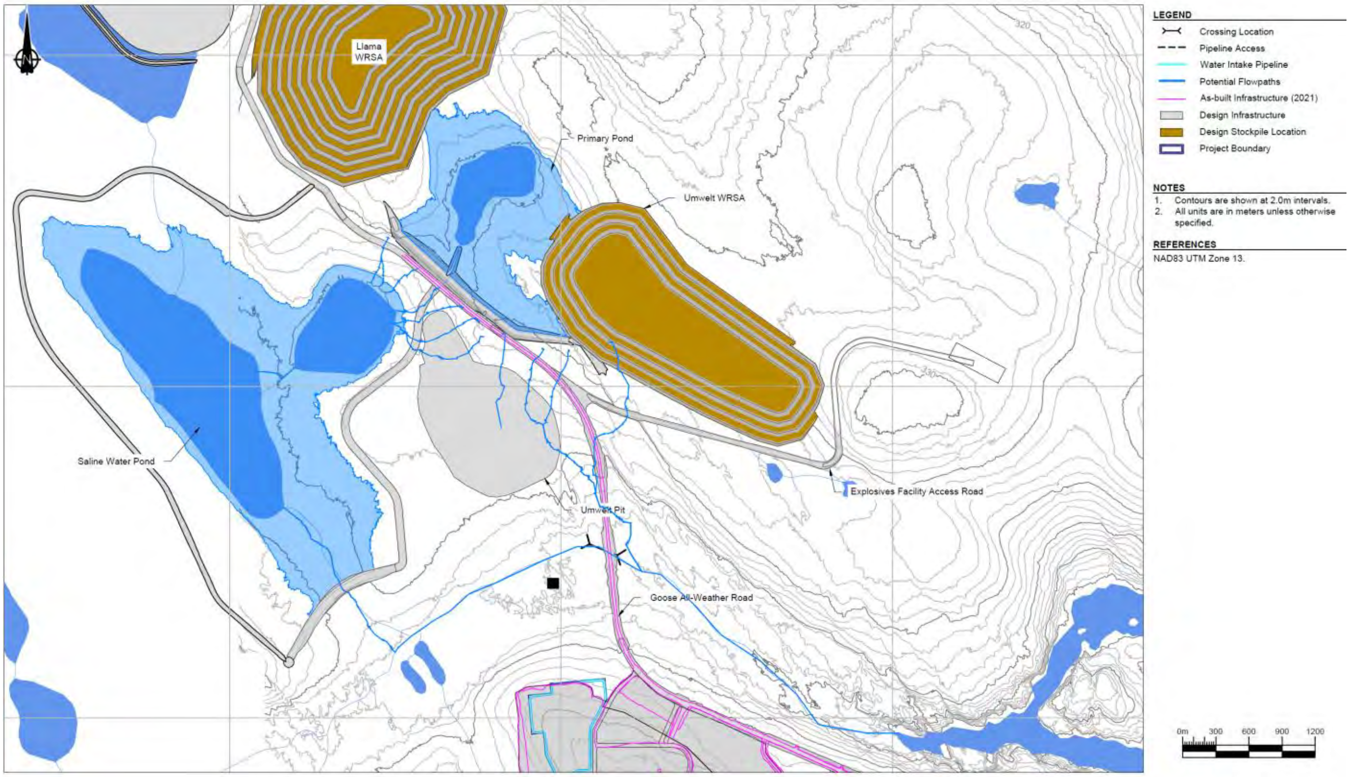
A. If inundation mapping has been completed it should be included in the Design Report to support the dam class selected for Population at Risk and Loss of Life;
B. Sabina clarify and provide justification for the dam class selected for Population at Risk and Loss of Life;
C. Sabina provide justification as to how it selected the Environmental and Cultural Values dam class; and
D. Sabina provide justification as to how it selected the Infrastructure and Economics dam class.

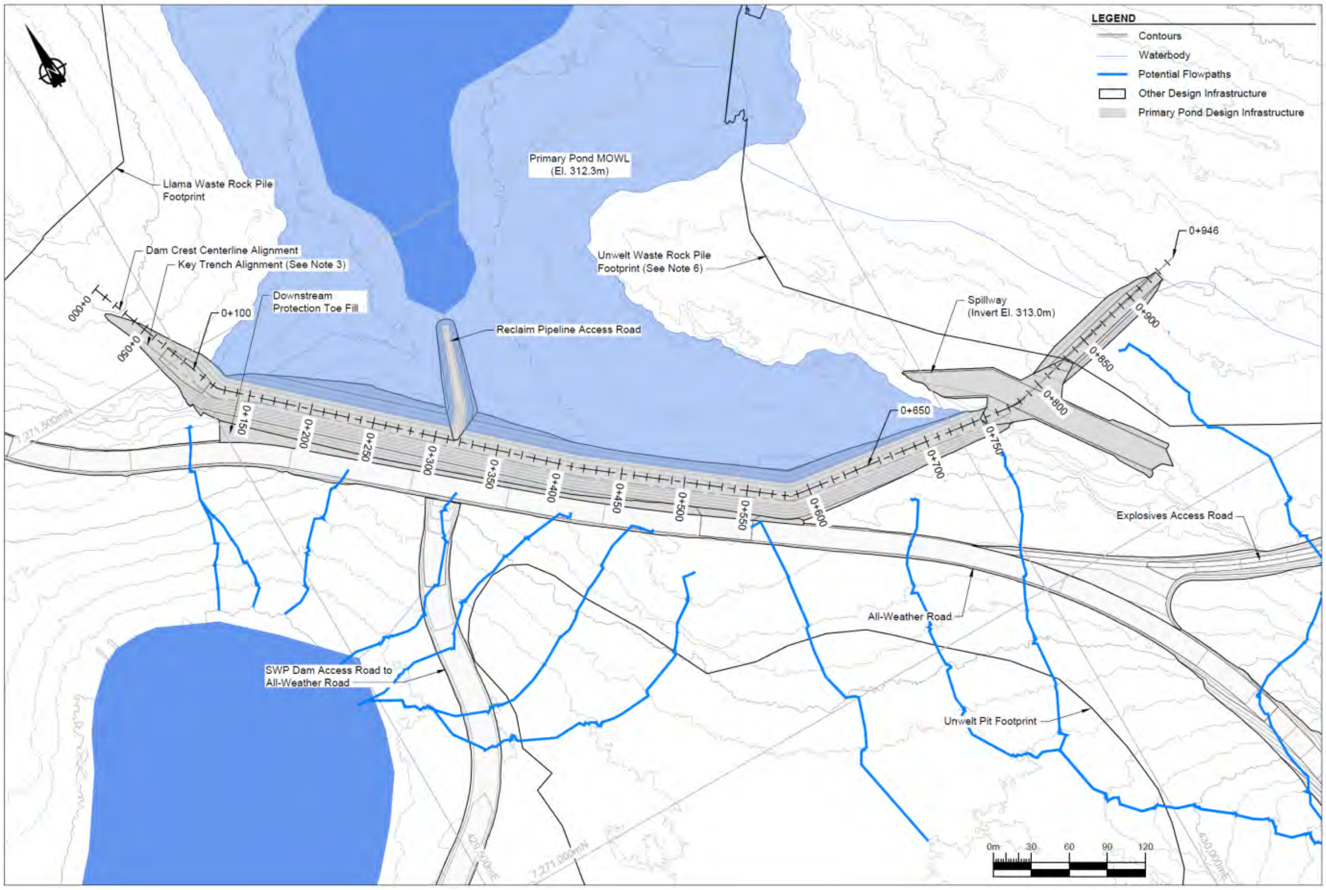
Sabina Response:

A careful evaluation of the dam consequence classification has been completed by Sabina and the design engineer. The original evaluation in fact had the dam classified as a lower classification, as *Significant*, but for conservatism (to adopt high design standards) and to highlight the importance Sabina places on the environment, the dam classification was increased to *High*. This *High* dam classification is driven by the Environmental and Cultural Values pillar / category.

A detailed dam break and associated inundation mapping has not been completed and is not being provided at this time. A detailed dam break assessment is however, planned to be completed immediately following construction. This dam break will then be based on the as-built geometry, and based on improved survey information of the surrounding area and topography. This dam break assessment would be primarily used as one of the main pieces of information to help guide the development of Sabina's future Emergency Response Plan (ERP) for the Primary Pond. The key to development of the ERP will be to understand all as-constructed systems that are in place at that time, and to get the input and engagement from onsite personnel and Sabina's emergency response teams; as the Emergency Response Team would ultimately be responsible for executing any ERP plans on site.

As seen from the screenshot below, the topography downstream of the dam would drive the direction that any flow would go, in the unlikely and unplanned event that a dam breach was to occur. A conservatively sized spillway, larger than what is required by the design hydrotechnical calculations alone, has also been included in the design to provide further mitigation to "Population and Risk and Loss of Life". This spillway (emergency overflow channel), as per design, would never be planned to be actively used and therefore would only be triggered if very large storm events, exact storm dependent on the operating level at the time, were to result on site. Each year an operational level would be set for the Primary Pond structure, that would be below the spillway invert / inlet elevation. This will allow for additional capacity and ultimately for an inflow design flood to be accommodated on site. This approach will allow Sabina the flexibility to increase the inflow design flood event during operation if / as required to reduce the downstream risk. For example, Sabina could decide to store a value / volume approaching the Probably Maximum Flood volume for the relatively short period (intermittently over a couple years), when people are actively working in the downstream Umwelt Pit. This could be accommodated with the current design and set operational water levels.


Llama WRSA
Primary Pond
Umwelt WRSA
Saline Water Pond
Umwelt Pit
Explosives Facility Access Road
Goose All-Weather Road
320
LEGEND
Crossing Location
Pipeline Access
Water Intake Pipeline
Potential Flowpaths
As-built Infrastructure (2021)
Design Infrastructure
Design Stockpile Location
Project Boundary
NOTES
1. Contours are shown at 2.0m intervals.
2. All units are in meters unless otherwise specified.
REFERENCES
NAD83 UTM Zone 13.
0m 300 600 900 1200


LEGEND
Contours
Waterbody
Potential Flowpaths
Other Design Infrastructure
Primary Pond Design Infrastructure
Primary Pond MOWL (El. 312.3m)
Llama Waste Rock Pile Footprint
Dam Crest Centerline Alignment
Key Trench Alignment (See Note 3)
Downstream Protection Toe Fill
Reclaim Pipeline Access Road
Unwelt Waste Rock Pile Footprint (See Note 6)
Spillway (Invert El. 313.0m)
0+000
0+050
0+100
0+150
0+200
0+250
0+300
0+350
0+400
0+450
0+500
0+550
0+600
0+650
0+700
0+750
0+800
0+850
0+900
0+946
Explosives Access Road
All-Weather Road
SWP Dam Access Road to All-Weather Road
Unwelt Pit Footprint
7,271,500mN
7,271,000mN
429,500mE
430,000mE
0m 30 60 90 120

Depending on the breach locations (if a dam breach was to occur) then the Primary Pond water would go either to Umwelt Lake (or the Saline Water Pond when that is constructed), to Goose Lake (entering upstream at the 'Goose beak' / west side of the lake), or to the Umwelt Pit. The current operational plans for the Primary Pond is that it would have the highest water level when it is being used / associated with the dewatering of Llama and Umwelt Lakes. During these periods the Umwelt Pit will not yet exist and there will be a very limited amount of personnel working downstream of this pond (and for very infrequent and short intervals). The water managed in the pond at this time, during lake dewatering, would be only fresh water (unimpacted) from the lakes. After the initial few years of use the Primary Pond water levels are planned to be notably reduced. At this time there will be waste rock in the same catchment area and the pond will transition to acting more as a surge pond for contact water. When the pond is being used for contact water the water is currently planned to be managed primary in the small depression upstream of the Primary Pond embankment (where water currently naturally collects).This will help to limit the thermal loading on the embankment structure and will also allow for very large volume for storm water control (100,000s of $m^3$ available). To evaluate the potential environmental impacts Sabina as not assumed the expected operating conditions but has assumed that the pond would be full of contact water. This is not an excepted condition but under that scenario it has conservatively been assumed that there would be some signature in Goose Lake if a dam break was to occur. For this reason a value of *High* was adopted.

If a failure of the Primary Pond occurred, and resulting in flooding of the Umwelt Pit, there would be an impact to operations. This impact however would be expected to only be a short term impact. Again the time period that this may occur would only be over a couple years (2 to 2.5 years), as Umwelt Pit is mined. Following that Umwelt Pit will be used to help with tailings and water management. During the initial years of the Umwelt Pit development, the water stored in Primary Pond would be non contact (fresh water). Also Sabina will have notable pumping capacity on site (from the tailings pipelines and from the earlier lake dewatering) and a mined out Echo Pit, Saline Water Pond, and Camp Pad Pond, would exist on site at that time. These latter area could assist with temporary storage or management of this water to help expedite the dewatering of Umwelt Pit. Based on the expected piping, pumping and infrastructure planned to be on site at the time of the Umwelt Pit development, and based on the expected water quality in the Primary Pond, the impacts to the mining operations would be expected to be only short term.

If a Primary Pond dam breach was to occur later in the mine life, then the main infrastructure that would be impacted would be the all-weather haul and access road. As there would be large mining equipment on site and various construction borrow sources already developed, it would be a relatively short task (days to maximum weeks) to rebuild any access roadways. Impacts from the loss of the rockfill access roadways would therefore again be expected to be short term. Sabina believes that for "Infrastructure and Economics' that Significant is appropriate.

Again a *High* consequence classification has ultimately been adopted for the Primary Pond.

## CIRNAC-NWB-3: Design Parameters

Comments:

Design parameters for the Primary Pond's Emergency Spillway, including the Inflow Design Flood (IDF), are provided in Section 2.7 (Emergency Overflow Channel) of the Design Report; however, no other sections of the Design Report identify the design parameters used for the other engineering analyses undertaken (e.g., seepage, stability, and thermal analyses)

Recommendation:

CIRNAC recommends that Sabina provide a Design Report that includes the design inputs, parameters, and values used to perform any seepage, stability, and thermal analyses in support of design of the Primary Pond to satisfy the Design Parameters requirement of Part D, Item 3a of the Water Licence.

Sabina Response:

See response in CIRNAC-NWB-1. Sabina has included the following set of technical attachments, to provide additional details on design parameters and analysis completed, for the Primary Pond design.

1. Attachment 1 – Subsurface Model – SRK Memo
2. Attachment 2 – Hydrology Update – SRK Memo
3. Attachment 3 – Thermal Analysis – SRK Memo
4. Attachment 4 - Stability Analysis – SRK Memo
5. Attachment 5 – Seepage Analysis – SRK Memo
6. Attachment 6 – Additional Monitoring Details - Drawings, and Instrumentation Specification Sheets

An overview of the seepage analysis is provided in Attachment 5, an overview of the stability analysis provided in attachment 4, and an overview of the thermal analysis is provided in Attachment 3.

### CIRNAC-NWB-4: Design Analysis and Methods

Comments:

No sections of the Design Report describe any of the analysis and methods undertaken in support of the design of the Primary Pond (e.g., seepage, stability, and thermal analyses)

Recommendation:

CIRNAC recommends that the Design Report include a description of the design analyses, methodologies, and results undertaken in support of the design of the Primary Pond to satisfy the Design Analysis and Methods requirement of Part D, Item 3a of the Water Licence. Specifically;

A. Seepage parameters, methods, analysis, and results be provided in the Design Report;
B. Stability parameters, methods, analysis, and results be provided in the Design Report;
C. Thermal parameters, methods, analysis, and results be provided in the Design Report;

Sabina Response:

See the response in response in CIRNAC-NWB-, An overview of the:

A. Seepage analysis is provided in Attachment 5; an overview of the
B. Stability analysis provided in Attachment 4; and an overview of the
**C.** Thermal analysis is provided in Attachment 3

### CIRNAC-NWB-5: Design Assumptions and Limitations

Comments:

CIRNAC notes that the Design Report for the Primary Pond provided for review does not contain a section related to any design assumptions or limitations or, if any assumptions or limitations were made during design of the Primary Pond.

Recommendation:

CIRNAC recommends that Sabina identify in the Design Report these items to satisfy the Design assumptions and Limitations requirement of Part D, Item 3a of the Water Licence

Sabina Response:

Additional details on the design assumptions and limitation are detailed (by technical subject) in the attached technical memorandums (see CIRNAC-NWB-1 for a list of all attachments).

To help confirm the foundation assumptions percolation testing will be completed prior to the start of construction. Currently the percolation testing on site is planned to be completed in late 2022 - late Nov to Dec) to gain additional foundation characterization information that may be used to help update and refine the key trench designs prior to construction. Additional discussions around the pre-construction percolation testing are provided in responses to KIA-NWB-2 and KIA-NWB-7.

A detailed monitoring program (see the last few design drawings and details in Attachment 6) will be installed and set-up as part of the Primary Pond construction. This monitoring will allow for ongoing performance monitoring and for calibration and checks against any design assumptions and performance criteria. A review of the instrumentation monitoring for the Primary Pond will be included as part of the required annual geotechnical inspection reporting.

## CIRNAC-NWB-6: Site specific data and analysis in support of design and management decisions

Comments:

The Design Report submitted to the NWB provides site-wide characterization data for Back River; however, limited data and analysis specific to the Primary Pond are provided. The information provided in the subsections on Climate (2.8.i) and Seismicity (2.8.v) are considered applicable to design and management of the Primary Pond. However, data and analysis specific to the Primary Pond should be provided for the subsections on Bedrock (2.8.ii), Overburden (2.8.iii), and Permafrost (2.8.iv). The data and analysis should include geotechnical and permafrost information on the subsurface conditions of the Primary Pond's foundation including: borehole logs, laboratory test results and instrumentation measurements used in support of the Primary Pond's design.

Recommendation:

CIRNAC recommends that Sabina provide site-specific geotechnical and permafrost characterization data, including borehole logs, laboratory test results, and instrumentation measurements, used in support of the Primary Pond's design to satisfy Part D, Item 3b of the Water Licence.

Sabina Response:

An overview and investigation of the subsurface conditions (foundation conditions) below the Primary Pond footprint is provided in Attachment 1. This includes an overview summary of past drilling information and logs.

Before construction a detailed percolation testing (drilling, sampling, field falling head testing and corresponding laboratory testing - soil index testing, and laboratory testing) is planned to be completed to help further investigate the foundation conditions and allow an opportunity for the key trench and embankment design to be optimized. The percolation testing on site is planned to be completed in late 2022 - late Nov to Dec), immediately in advance of construction, to gain additional foundation characterization information. This information will be used to further updated and refine the subsurface foundation excavations.

In addition, and as part of the Primary Pond design (as shown in the design drawings, and additional details provided in Attachment 6), a detailed monitoring systems is planned to be installed (installation of a system of ground temperature cables, deformation and settlement monitoring). This monitoring would allow for the Primary Pond embankment to be carefully monitored throughout operation, and help to provide advance warning of potential deformation of thermal trends so mitigation measures can be implement if / as required to maintain the embankment functionality and performance.

## CIRNAC-NWB-7: Source Locations of Construction Materials

Comments:

Section C of the submitted Design Report provides a general overview of the acid rock drainage and metal leaching (ARD/ML) studies carried out at Back River as well as Sabina's sampling procedure for geochemical analysis of waste rock materials at the Project. The Design Report does not identify where the rock for the construction of the Primary Pond will be sourced. Additionally, the Design Report does not provide any geochemical data or analysis specific to the proposed rock source (i.e., quarry, borrow pit) that demonstrates the source's ARD/ML characteristics.

Recommendation:

CIRNAC recommends that the Design Report identify the rock source(s) to be utilized for the Primary Pond's construction materials and provide the specific geochemical data or analysis demonstrating the source's ARD/ML characteristics to satisfy Part D, Item 3c of the Water Licence.

Sabina Response:

All construction rock will be sources from:

- Approved and permitted quarry locations (which have been confirmed through geochemical sampling and testing to be geochemically suitable for construction)
- A sand esker that has been located and used in past years for construction (material collected in the winter, immediately north of the Goose airstrip and on the north side of Goose Lake)
- From the Echo Pit pre-development work (i.e. pit stripping above or outside of the contact with the ore body in that area – ongoing geochemical sampling being completed on this rock to confirm the geochemical suitability for construction).

To meet the material specifications for this project (as outlined in the provided technical specifications) materials from the sources above may also be run through the site screens and crusher.

The geochemical testing characteristics of quarry, construction materials and waste materials are documented as part of the annual reporting submissions (submitted around the end of March each year).

### CIRNAC-NWB-8: Signature and Seal of Engineer on Drawings

Comments:

Section G of the Design Report notes that Permit Drawings are provided in Appendix A; however, the Design Report and Drawings are not signed and sealed by a Professional Engineer registered in the Northwest Territories and Nunavut Association of Professional Engineers and Geoscientists (NAPEG)

Recommendation:

CIRNAC recommends that Sabina provide any separate detailed design reporting for the Primary Pond that have been signed and stamped by a Professional Engineer registered with NAPEG to satisfy Part D, Item 3g of the Water Licence.

Sabina Response:

Attachment 7 provided signed and stamped version of the Issued for Permit drawings for the Primary Pond. Technical design appendices, reviewed and prepared under the supervision of a NAPEG Professional Engineer have also been included in these Information Request response to provide additional details on the technical analyses completed to inform the current Primary Pond design.

### CIRNAC-NWB-9: Primary Pond Dam Key Trench Liner Plan and Sections

Comments:

Contained within section 2.8.1 , Drawing Number UM-PP-201, The Cross Sections and Notes make no mention that a “Bentonite / Fly Ash Sand Fill” layer is required to be placed prior to the installation of the HDPE liner system. However, this is later identified in Drawing Number UM-PP- 401. For completeness and to avoid confusion, it would be advisable to identify placement of this layer on the Cross Section drawing.

Recommendation:

CIRNAC recommends that it would be advisable to identify placement of this layer on the Cross Section drawings and add it for future reviews so that all information is available when completing the review.

Sabina Response:

Comments are noted and acknowledged. Additional details and clarifications on the use of “Bentonite / Fly Ash Sand Fill” will be included / added as part of the next revision of the construction drawings.

Note that the next revision of the construction drawings is planned to be issued immediately prior to construction and following the additional foundation percolation testing planned to be completed around the end of November to early December 2022.

Additional comments and clarifications on the purpose and use of the Bentonite / Fly Ash Sand Fill material is provided in the information request response KIA-NWB-16.

## 1.3 RESPONSE TO ENVIRONMENT AND CLIMATE CHANGE CANADA

### ECCC-NWB-1

Comments:

ECCC has reviewed the documents provided for the Goose Site Design Report and Drawings regarding licence 2AM-BRP1830, and has no comments.

Sabina Response:

Sabina thanks ECCC for their review.

# ATTACHMENT 1

srk consulting

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# Memo

| | | | |
|---|---|---|---|
| **To** | File | **Project** | 1CS020.020 |
| **From** | Jasur Umarov, John Kurylo | **Reg. No.** | EGBC 1003655 |
| **Reviewed By** | Christopher Stevens | **Date** | November 29, 2022 |
| **Client** | Sabina Gold and Silver Corp. | | |

**Subject** Primary Pond Dam – Subsurface Model Overview

---

# 1 Introduction

SRK Consulting (Canada) Inc. was retained by Sabina Gold & Silver Corp. (Sabina) to complete the detailed geotechnical engineering of the Primary Pond Dam (the Dam) at the Goose Property which is part of the Back River Project. SRK has reviewed the available geotechnical investigation data and overburden isopach models (developed by Sabina) to develop 2D subsurface models (cross-sections) in support of detail design of the Primary Pond Dam.

Previous subsurface models have been limited to overburden isopach models developed by Sabina's geology team using exploration and geotechnical drillholes completed between 1992 to 2020 (Figure 1). These models lack description of overburden material type and ground ice conditions which are important aspects of the subsurface stratigraphy to consider during design of the Primary Pond Dam. A geotechnical investigation program has also been completed more recently near the proposed dam in 2021 (SRK 2022).

This memorandum documents relevant geotechnical information used to develop an updated subsurface model of foundation conditions near the Primary Pond. The specific objectives were to:

- Develop representative cross-sections along the proposed Primary Pond Dam profile (in 2D);
- Update the existing bedrock contact surface with additional geotechnical drillhole data;
- Update the overburden stratigraphy with additional drillhole and laboratory testing; and
- Update the ground ice and permafrost conditions with recent field observations and drillhole data.

# 2 Subsurface Model

## 2.1 Available Information

The subsurface model presented in this memorandum is based on the geotechnical drillholes investigated by SRK between 2015 and 2021 (SRK 2015; SRK 2018; SRK 2022). The subsurface models also incorporate the bedrock contact through review of existing overburden isopach models developed by Sabina, which incorporate exploration and geotechnical drilling programs completed from 1992 to 2020.

Figure 1 shows the location of available drillhole and test pit locations around the proposed Primary Pond Dam. SRK's review of the exploration drillhole database and geotechnical drillholes was limited to locations where drillhole logs were available. This included geotechnical logs for those completed by SRK in 2015, 2018 and 2021 (Figure 2). Information from other exploration and geotechnical drillholes was limited to collar locations and the bedrock contact provided by Sabina.

## 2.2 Section Locations

A two-dimensional subsurface model was developed along four (4) representative cross-sections through the proposed Primary Pond Dam (Sections A-A' to D-D') and one (1) profile section along the length of the dam (Section E-E'). The rationale for selection of each cross-section is presented in Table 1. Figure 2 shows the location of the cross-sections.

**Table 1: Subsurface Model Cross-Sections and Rationale**

| Cross-Section Name | Rationale |
|---|---|
| Section A-A' | Section intersects the greatest fill thickness for the proposed embankment (approximately 9 m) and is inferred to have that greatest overburden thickness (approximately 10 m) along the dam alignment. |
| Section B-B' | Section intersects the reclaim road, which is proposed to be placed over an existing tundra creek channel with relatively thick overburden. |
| Section C-C' | Section intersects undulating bedrock with moderate overburden thickness. |
| Section D-D' | Section with the deepest expected overburden and section to allow some correlation to drillholes located upstream of the dam. |
| Section E-E' | Section located along the proposed dam centerline. |

## 2.3 Methodology

### Material Type and Ground Ice

The 2D cross-sections with interpretive stratigraphy were developed to show the primary material type and ground ice conditions (ground ice type and visible excess ground ice content). Material type was based on geotechnical logging of the recovered soil core using ASTM D2488-17 (ASTM 2017). Field descriptions of the material type have been confirmed with particle size distribution results completed on select samples in the laboratory. Ground ice type and visible estimation of excess ground ice content were based on ASTM D4083 (ASTM 2016). Additional detail is provided in the corresponding geotechnical field investigation reports in Attachment 2.

The drill datasets were screened to determine which drillholes were suitable for analysis based on proximity to the proximity to the sections and data availability. Typically, drillholes were only used if located within 100 m of the proposed 2D section (Figure 4).

After preliminary screening of the datasets, the subsurface model sections were developed as follows:

- Step 1: Identify all the material types reported in the geotechnical investigation drillhole logs.
- Step 2: Generate ‘stick logs’ of the selected drillholes for each section, using the primary material type, ground ice type, and excess ground ice content determined by visual field inspection of the recovered core.
- Step 3: Extrapolate between the primary material types to create an interpreted sub-surface layer.

## Bedrock Contact

The interpreted bedrock surface (contact) for the Back River Goose property was refined in the 2D cross-sections around the proposed Primary Pond Dam area using 2021 geotechnical drillholes (SRK 2022). The interpreted bedrock surface was inferred from the overburden isopach models created by Sabina’s geology personnel.

In April 2021, SRK was provided with the following geological model files that correspond to various areas around the site:

- *OVB EC_OVB_surface copy.dxf*
- *OVB EC_OVB_24Jul2014 copy.dxf*
- *OVB_LL.dxf*
- *OVB_UM.dxf*
- *Overburden_CK.dxf*
- *Overburden_GM.dxf*
- *Overburden_NUV.dxf*
- *Overburden_SLSH.dxf*

The boundaries of each model is provided in Figure 1. The models relevant to the Primary Pond Dam are shown in Figure 2:

- *OVB_LL.dxf* (west area of the Primary Pond Dam)
- *OVB_UM.dxf* (center and area of the Primary Pond Dam)

The bedrock surface was inferred by extracting the bottom boundary of the overburden isopach model, assuming that the bottom of overburden would correspond to bedrock contact. The inferred bedrock surface was then updated based on the 2021 drillholes (SRK 2022) in the 2D cross-sections around the proposed Primary Pond Dam.

The top of bedrock for 2021 drillholes was defined as the top of the weathered bedrock layer. Where data regarding weathered bedrock was not available, intact bedrock was used. It was assumed that the overburden models created by Sabina are based on all investigation holes prior to and including drillholes completed in 2020.

The surficial extent of bedrock and areas with a relatively thin veneer of overburden (0 to 3 m) was mapped from air photos (Figure 5). The map provides an additional dataset used to interpret subsurface conditions along the cross-sections.

## 2.4 Results

The subsurface model developed for each cross-section is shown in Figures A.1 to E.2. Two figures have been generated for each cross-section. The first figure shows the cross-section with primary material type, ground ice type, and visible estimation of excess ground ice. The second figure shows the same cross-section information with the interpreted subsurface layers added. The existing ground surface (top of the overburden surface) is based on the topographic survey completed Sabina and provided to SRK in April 2021. The proposed Primary Pond Dam shell and key trench are provided for additional context.

SRK's review of the data indicates that the Primary Pond Dam profile extends across exposed bedrock, bedrock with thin overburden, and several depressions in the bedrock surface with relatively thick overburden soil (Figure E.2). For some of the cross-sections, the drillholes are offset to the section line and the bedrock surface may differ from the confirmed drillhole intersect. The three geotechnical investigations also confirmed that the foundation is characterized by relatively thin organics that are typically underlain by coarse-grained sand and gravel with intervals of boulders, followed by silt above the top of bedrock. Soil pore water salinity has been determined from laboratory testing to average 23 ppt. The average pore water freezing point depression is calculated to be -1.4°C. Visible ground ice more than 60% by volume has been observed to occur within the overburden soil. Relatively high ground ice content is associated with Vs, ICE, and ICE w/ Soil. There is not a clear association of ice content with primary material type.

Drillhole logs and core box photos of the drillholes used in the subsurface model development are provided in Attachments 2 and 3, respectively.

### Attachments:

| | |
|---|---|
| Attachment 1 | Figures |
| Attachment 2 | Drillhole Logs |
| Attachment 3 | Core Box Photos |

# References

ASTM. 2016. ASTM D4083-89 (2016) Standard Practice for Description of Frozen Soils (Visual-Manual Procedure).

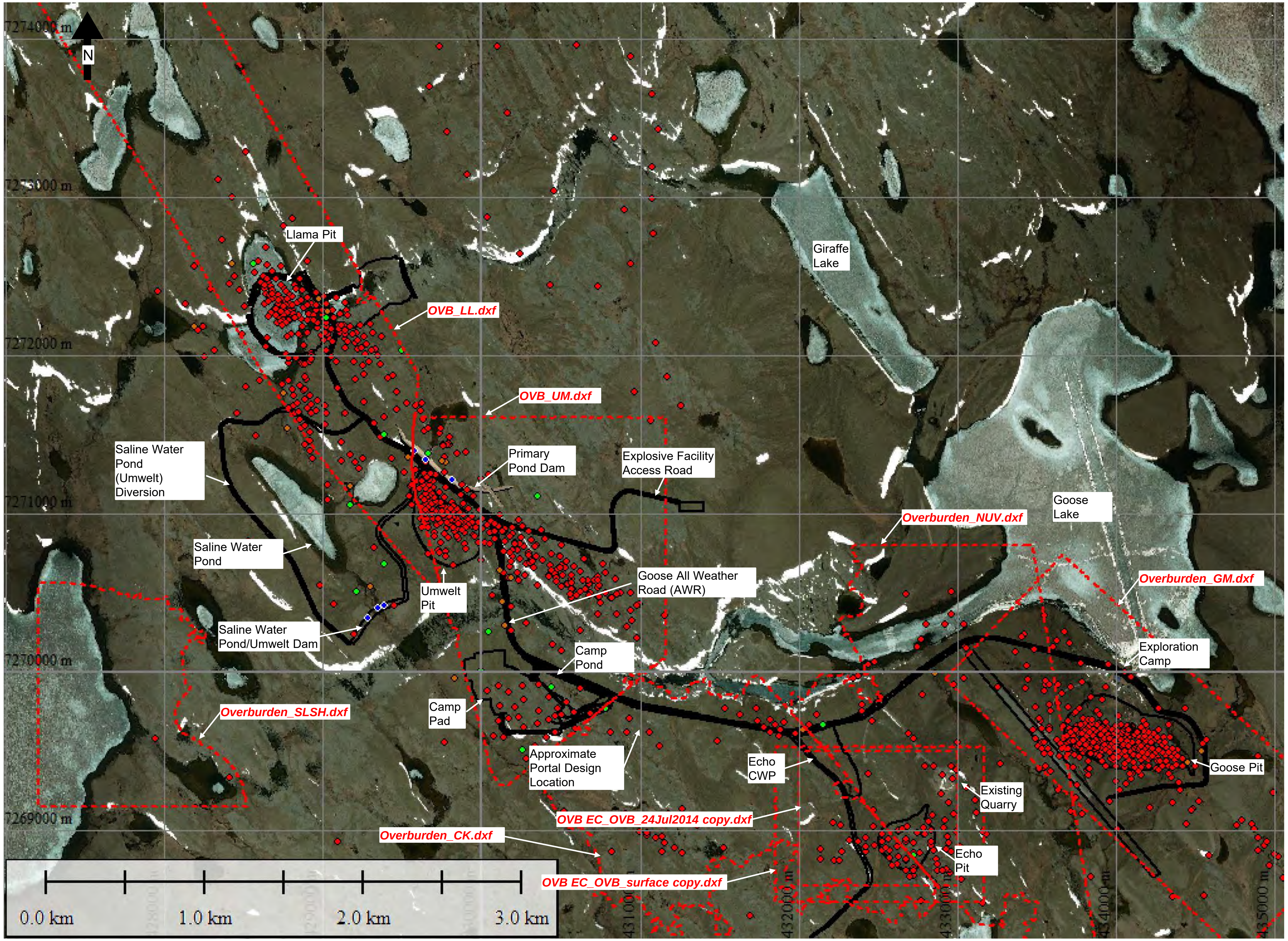
ASTM. 2017. ASTM D2488-17 Standard Practice for Description and Identification of Soils (Visual-Manual Procedures). ASTM International. West Conshohocken, PA. 2017.

SRK Consulting (Canada) Inc. 2015. Goose Property - 2015 Overburden Geotechnical Investigation Program. Report prepared for Sabina Gold & Silver Corp. Project No. 1CS020.009.

SRK Consulting (Canada) Inc. 2018. Goose Property - 2018 Overburden Geotechnical Investigation Program. DRAFT Report prepared for Sabina Gold & Silver Corp. Project No. 1CS020.016.

SRK Consulting (Canada) Inc. 2022. 2021 Geotechnical Field Investigation. DRAFT Report prepared for Sabina Gold & Silver Corp. Project No. 1CS020.020. In Progress.

# Attachment 1 Figures



## LEGEND:

- ● Drillholes Used in Generating Bedrock Surface (provided by Sabina)
- ● Goose Property - 2015 Overburden Geotechnical Investigation Program (SRK 2015)
- ● Goose Property - 2018 Overburden Geotechnical Investigation (SRK 2018)
- ● Goose Property - 2021 Overburden Geotechnical Investigation (SRK 2022)
- — Proposed Back River Infrastructure Linework
- ◌ Boundary of Generated Bedrock Surfaces (provided and generated by Sabina)
- ▭ Proposed Primary Pond Dam

Note: The proposed Primary Pond Dam geometry shown in the figures is for reference. The design will be confirmed during completion of the detailed design.

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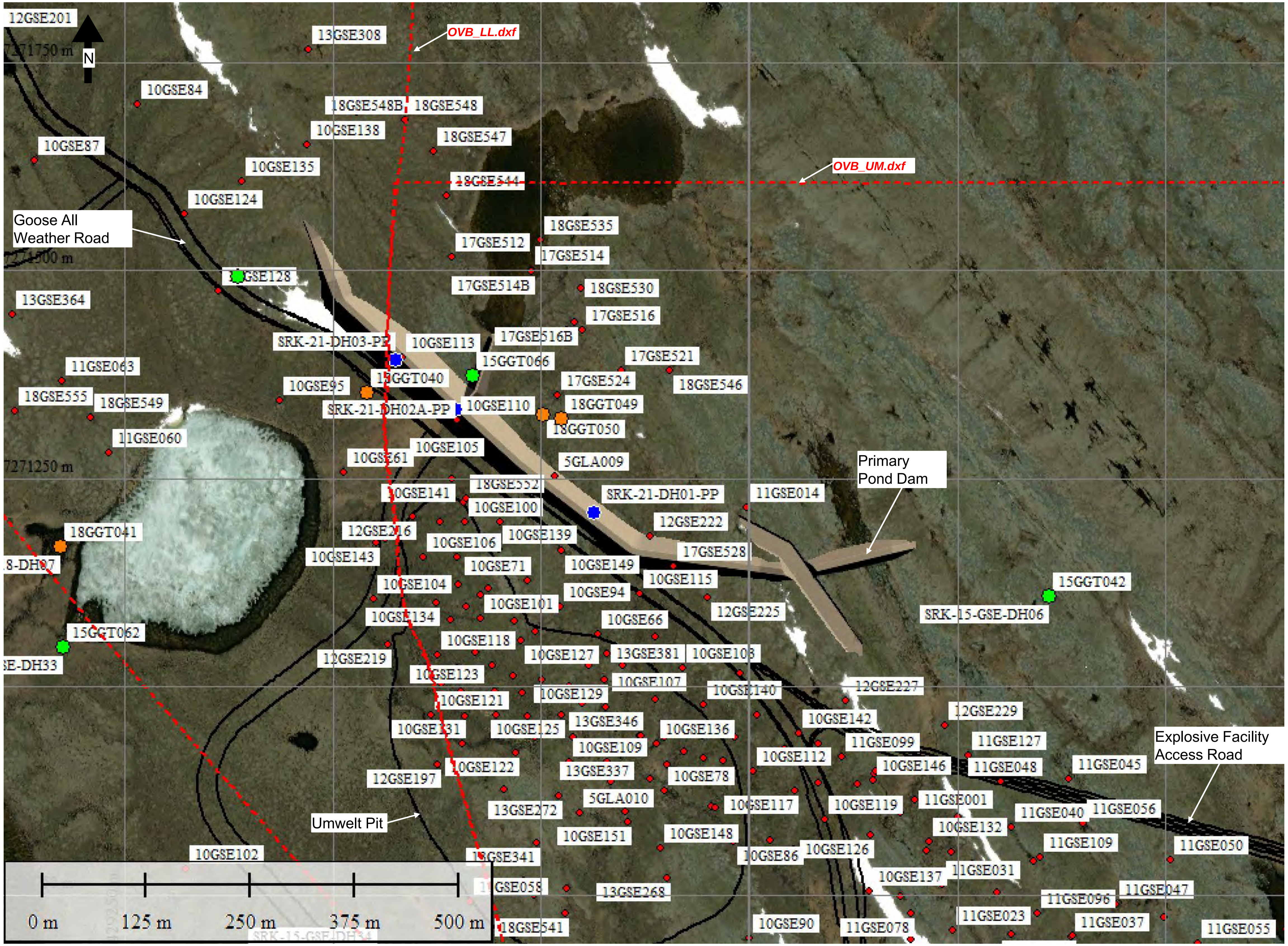
Primary Pond Dam
Subsurface Model Overview

**Overview of Available Drillholes**

Job No: 1CS020.020
Filename: BackRiver_SubsurfaceModel_Figures.pptx

Back River Project

Date: Nov 2022
Approved: JBK
Figure: 1



## LEGEND:

- 🔴 Drillholes Used in Generating Bedrock Surface (provided by Sabina)
- 🟠 Goose Property - 2015 Overburden Geotechnical Investigation Program (SRK 2015)
- 🟢 Goose Property - 2018 Overburden Geotechnical Investigation (SRK 2018)
- 🔵 Goose Property - 2021 Overburden Geotechnical Investigation (SRK 2022)
- — Proposed Back River Infrastructure Linework
- ⬭ Boundary of Generated Bedrock Surfaces (provided and generated by Sabina)
- ▭ Proposed Primary Pond Dam

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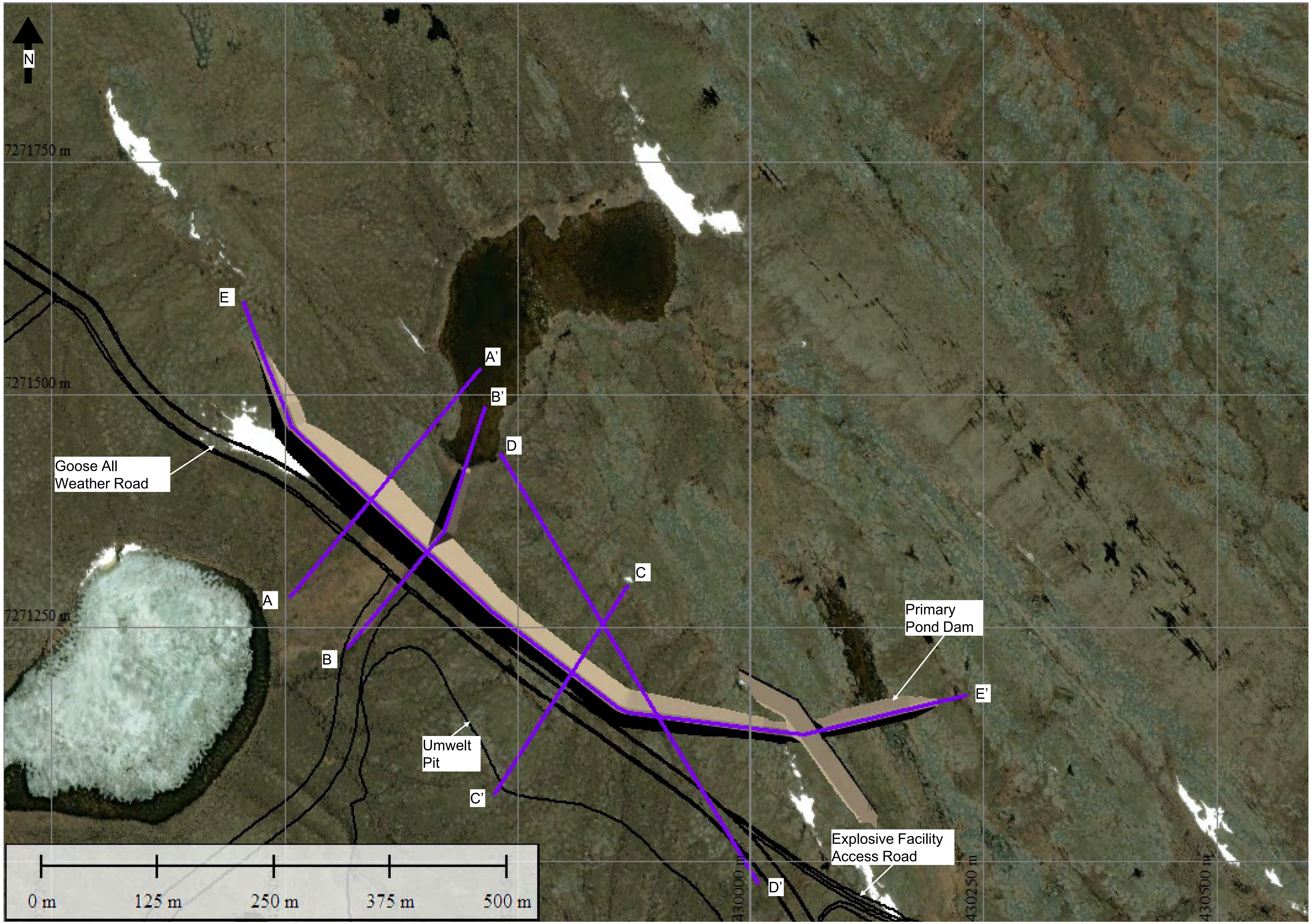
| | |
|---|---|
| Job No: | 1CS020.020 |
| Filename: | BackRiver_SubsurfaceModel_Figures.pptx |

Back River Project

Primary Pond Dam Subsurface Model Overview

**Overview of Available Drillholes at the Primary Pond Dam Area**

| Date: | Approved: | Figure: |
|---|---|---|
| Nov 2022 | JBK | 2 |



## LEGEND:

— Proposed Back River Infrastructure Linework

▭ Proposed Primary Pond Dam

— Section Location

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Job No: 1CS020.020

Filename: BackRiver_SubsurfaceModel_Figures.pptx

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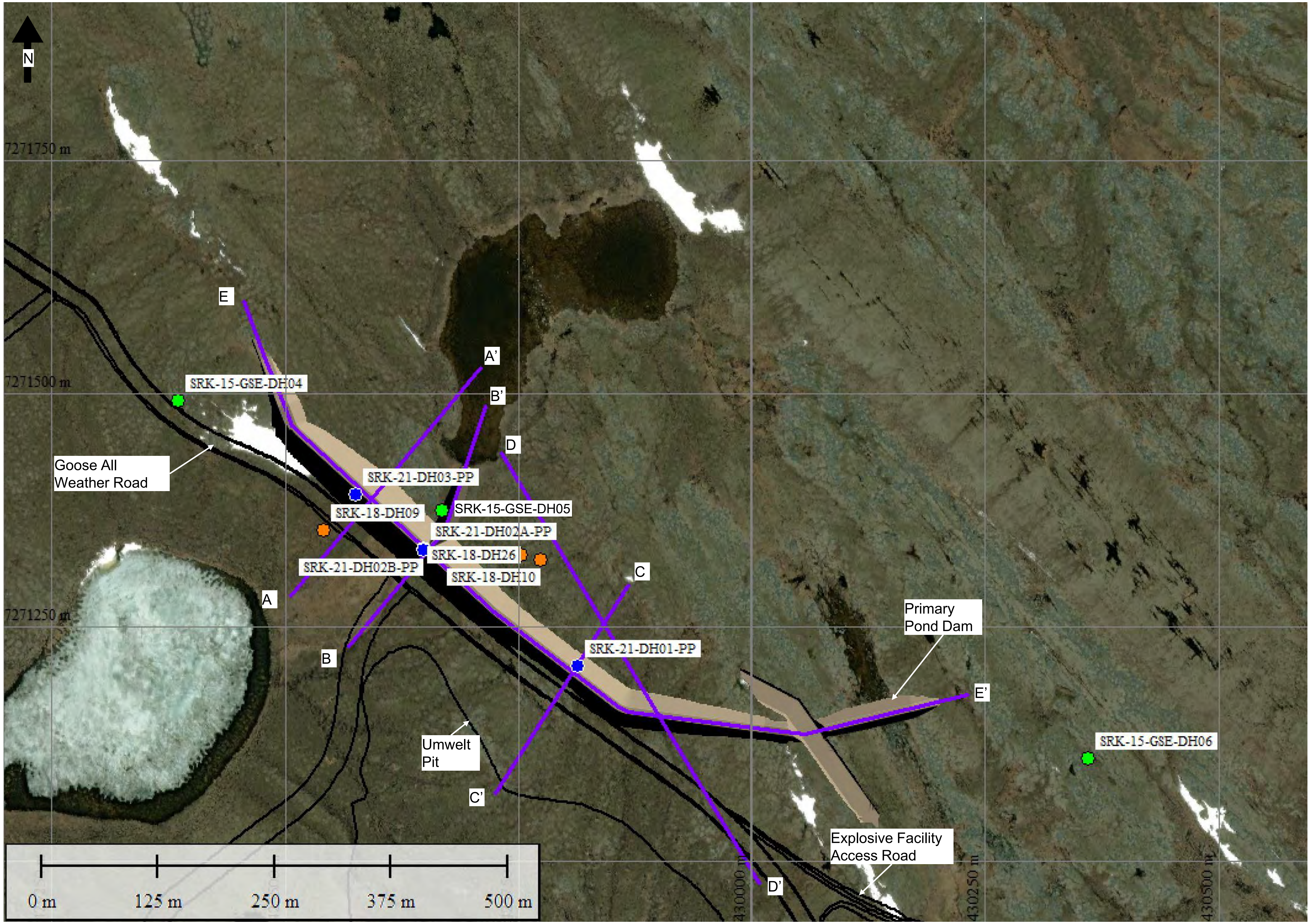
Back River Project

Primary Pond Dam
Subsurface Model Overview

**Location of Selected Cross-Sections**

| | | |
|---|---|---|
| Date: Nov 2022 | Approved: JBK | Figure: 3 |



**LEGEND:**

- ● Goose Property - 2015 Overburden Geotechnical Investigation Program (SRK 2015)
- ● Goose Property - 2018 Overburden Geotechnical Investigation (SRK 2018)
- ● Goose Property - 2021 Overburden Geotechnical Investigation (SRK 2022)
- — Proposed Back River Infrastructure Linework
- ▭ Proposed Primary Pond Dam
- — Section Location

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Job No: 1CS020.020
Filename: BackRiver_SubsurfaceModel_Figures.pptx

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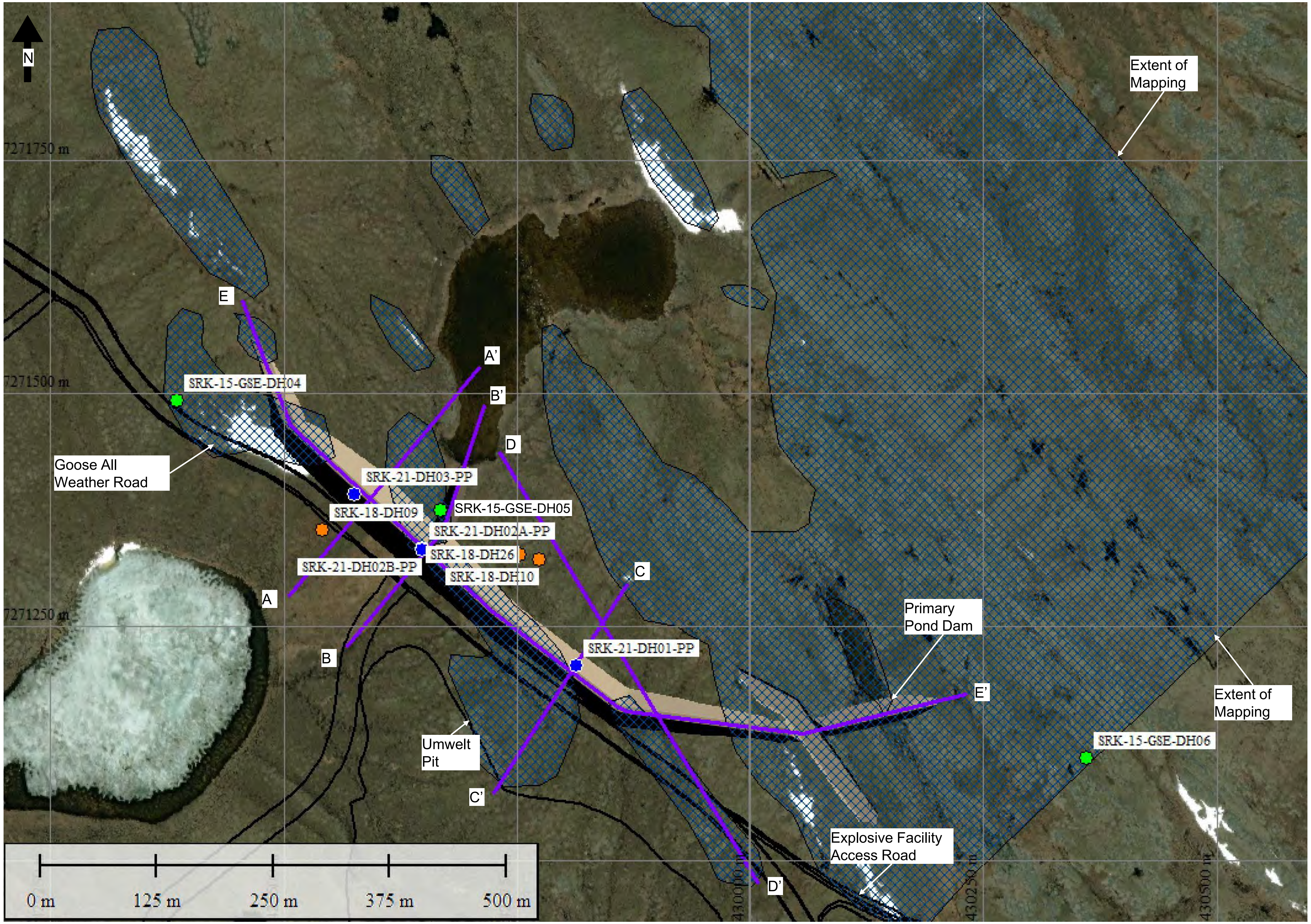
Back River Project

Primary Pond Dam
Subsurface Model Overview

**Geotechnical Drillholes Used to Develop the Subsurface Model Sections**

Date: Nov 2022
Approved: JBK
Figure: 4



## LEGEND:

| | |
|---|---|
| ● | Goose Property - 2015 Overburden Geotechnical Investigation Program (SRK 2015) |
| ● | Goose Property - 2018 Overburden Geotechnical Investigation (SRK 2018) |
| ● | Goose Property - 2021 Overburden Geotechnical Investigation (SRK 2022) |
| — | Proposed Back River Infrastructure Linework |
| ▭ | Proposed Primary Pond Dam |
| — | Section Location |
| ▨ | Bedrock Outcrop and Till Veneer (0 to 3 m) |

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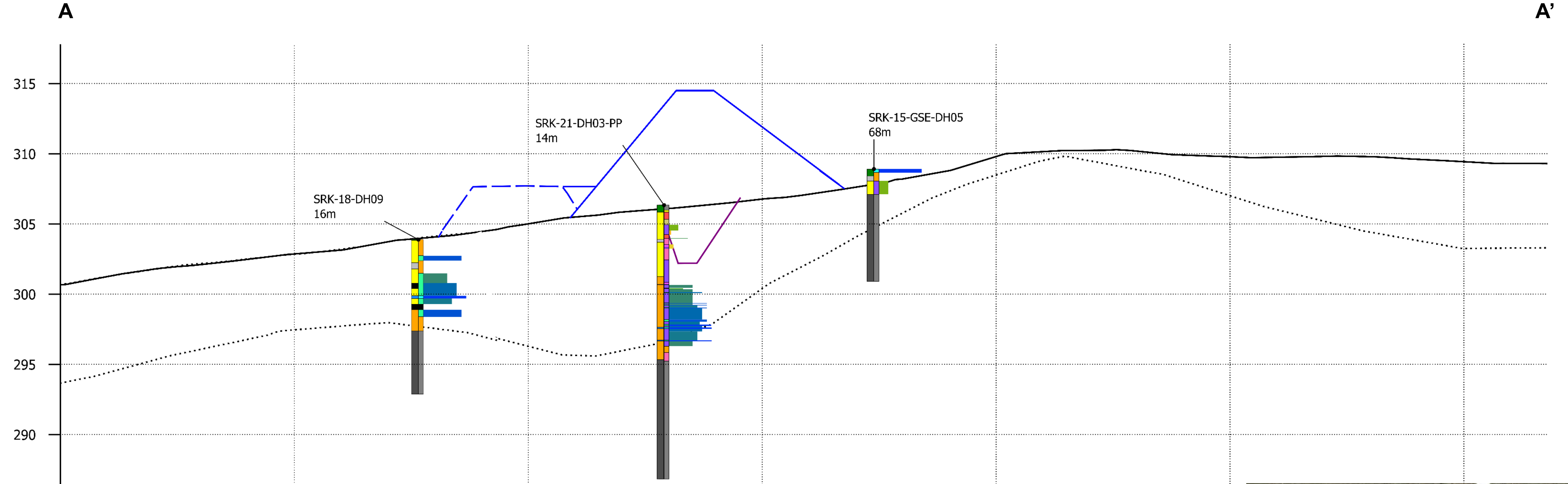
Primary Pond Dam
Subsurface Model Overview

**Bedrock Outcrop and Till Veneer (0 to 3 m) from Air Photos**

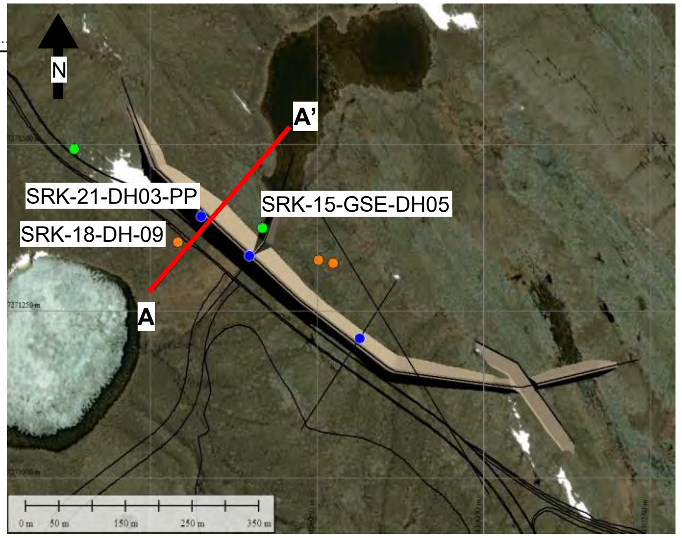
Job No: 1CS020.020
Filename: BackRiver_SubsurfaceModel_Figures.pptx

Back River Project

Date: Nov 2022
Approved: JBK
Figure: 5



## Section A-A'



## Legend

**Primary Material Type - Left Side of the Stick Log**

⬛ Bedrock 🟥 Gravel ⬛ No Recovery 🟨 Sand
⬜ Boulder/Cobbles 🟦 Ice 🟩 Organics 🟧 Silt

**Ground Ice Type - Middle of the Stick Log**

🟦 Ice ▨ Nbn ⬛ Uf 🟪 Vs
🟩 Ice w/ Soil 🟨 Nf 🟥 Vc 🟪 Vx
🟧 Nbe ⬛ No Recovery 🟪 Vr

**Excess Ground Ice Content (%) - Right Side of the Stick Log**

0 25 50 75 100

**Surfaces**

—— Ground Surface - From Sabina
– – Goose AWR
—— Proposed Primary Pond Dam Shell
······· Bedrock Surface - from Sabina
—— Proposed Primary Pond Dam Key Trench
······· Estimated Bedrock Surface Based on 2021 Drilling

Note: Excess ice content is determined by visual estimations in the field

### Ground Ice Type Description

Uf: Unfrozen
Nf: Poorly Bonded
Nbn: Well Bonded - No Excess Ice
Nbe: Well Bonded - Excess Ice
ICE: Ice without soil inclusions
ICE w/ soil: Ice with soil inclusions
Vx: Individual Ice Inclusions
Vc: Ice Coatings on Particles
Vr: Randomly Oriented Ice Formations
Vs: Stratified Ice Formations

**Location**

**A:** 429505, 7271283
**A':** 429709, 7271528

Scale: 1:850
Vertical exaggeration: 3x

0m 100m

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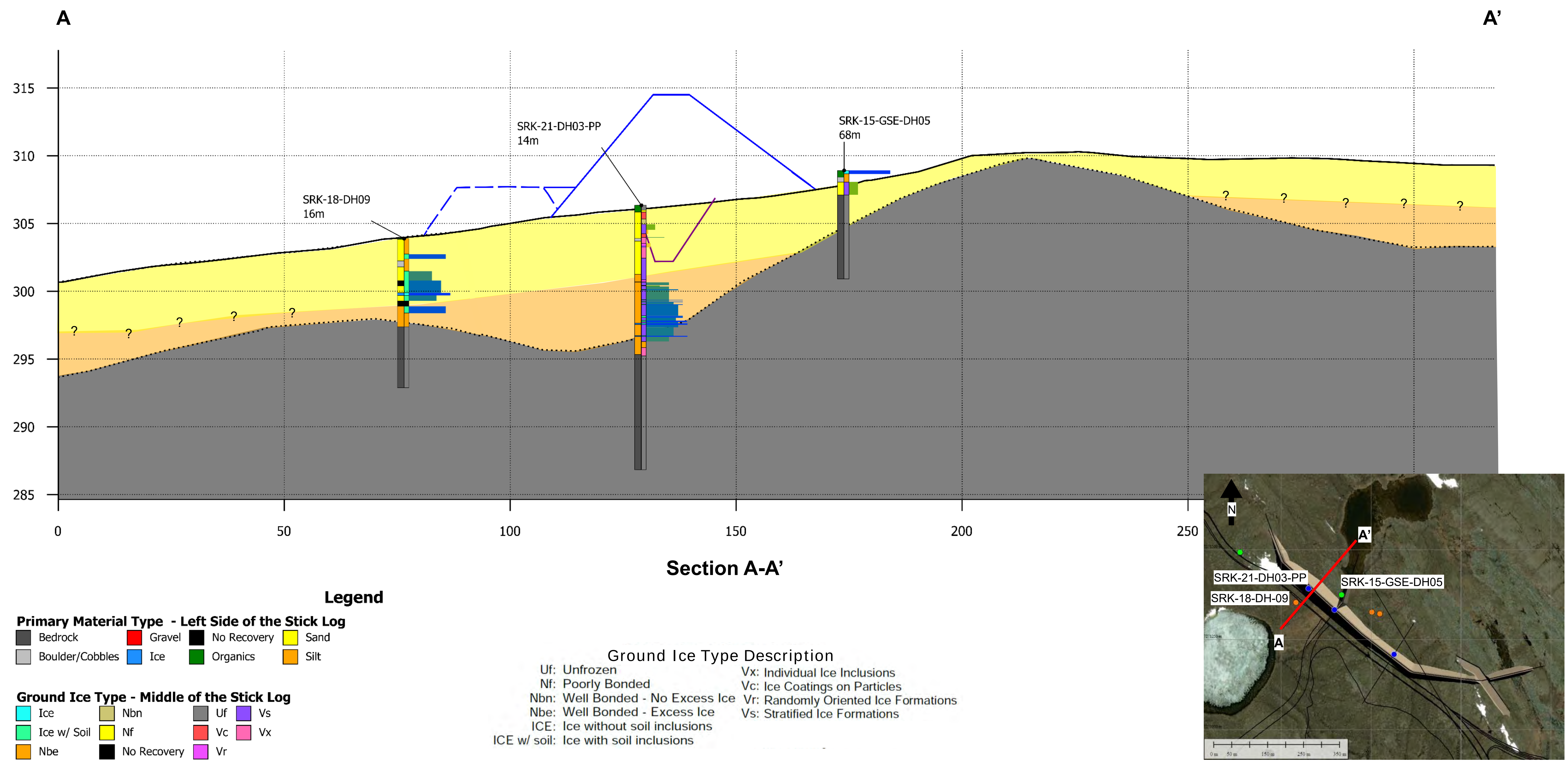
Primary Pond Dam
Subsurface Model Overview

**Section A-A'**
**Stick Logs**

Job No: 1CS020.020
Filename: BackRiver_SubsurfaceModel_Figures.pptx

Back River Project

Date: Nov 2022
Approved: JBK
Figure: **A.1**



## Section A-A'

## Legend

**Primary Material Type - Left Side of the Stick Log**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ■ | Bedrock | 🟥 | Gravel | ■ | No Recovery | 🟨 | Sand |
| ▨ | Boulder/Cobbles | 🟦 | Ice | 🟩 | Organics | 🟧 | Silt |

**Ground Ice Type - Middle of the Stick Log**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 🟦 | Ice | ▨ | Nbn | ■ | Uf | 🟪 | Vs | | |
| 🟩 | Ice w/ Soil | 🟨 | Nf | 🟥 | Vc | 🟪 | Vx | | |
| 🟧 | Nbe | ■ | No Recovery | 🟪 | Vr | | | | |

Ground Ice Type Description

Uf: Unfrozen
Nf: Poorly Bonded
Nbn: Well Bonded - No Excess Ice
Nbe: Well Bonded - Excess Ice
ICE: Ice without soil inclusions
ICE w/ soil: Ice with soil inclusions

Vx: Individual Ice Inclusions
Vc: Ice Coatings on Particles
Vr: Randomly Oriented Ice Formations
Vs: Stratified Ice Formations

**Excess Ground Ice Content (%) - Right Side of the Stick Log**

0 25 50 75 100

**Surfaces**

——— Ground Surface - From Sabina
— — Goose AWR
——— Proposed Primary Pond Dam Shell
········ Bedrock Surface - from Sabina
——— Proposed Primary Pond Dam Key Trench
········ Estimated Bedrock Surface Based on 2021 Drilling
--?--? Layer interpretation with greatest uncertainly or extrapolation with limited data

Note: Excess ice content is determined by visual estimations in the field

**Location**

| | |
|---|---|
| **A:** | 429505, 7271283 |
| **A':** | 429709, 7271528 |

Scale: 1:850
Vertical exaggeration: 3x

0m 100m

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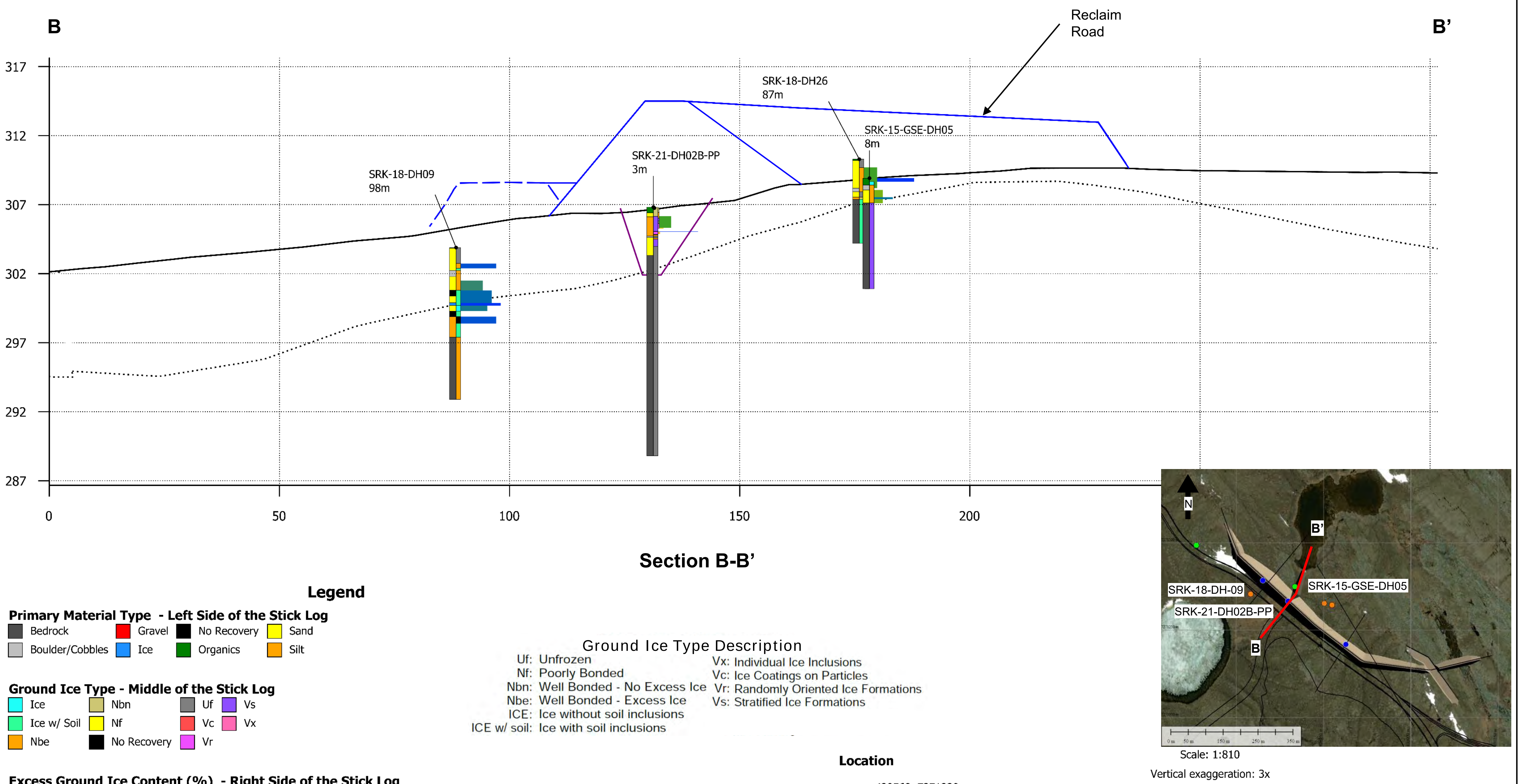
Job No: 1CS020.020
Filename: BackRiver_SubsurfaceModel_Figures.pptx

Back River Project

Primary Pond Dam
Subsurface Model Overview
**Section A-A'**
**Interpreted Subsurface Stratigraphy**

Date: Nov 2022
Approved: JBK
Figure: **A.2**



## Section B-B'

## Legend

**Primary Material Type - Left Side of the Stick Log**

- ⬛ Bedrock
- 🟥 Gravel
- ⬛ No Recovery
- 🟨 Sand
- ⬜ Boulder/Cobbles
- 🟦 Ice
- 🟩 Organics
- 🟧 Silt

**Ground Ice Type - Middle of the Stick Log**

- 🟦 Ice
- ▨ Nbn
- ⬛ Uf
- 🟪 Vs
- 🟩 Ice w/ Soil
- 🟨 Nf
- 🟥 Vc
- ▨ Vx
- 🟧 Nbe
- ⬛ No Recovery
- 🟪 Vr

**Excess Ground Ice Content (%) - Right Side of the Stick Log**

0 25 50 75 100

**Surfaces**

- Ground Surface - From Sabina
- Bedrock Surface - from Sabina
- Goose AWR
- Proposed Primary Pond Dam Key Trench
- Proposed Primary Pond Dam Shell
- Estimated Bedrock Surface Based on 2021 Drilling

Note: Excess ice content is determined by visual estimations in the field

Ground Ice Type Description

Uf: Unfrozen
Nf: Poorly Bonded
Nbn: Well Bonded - No Excess Ice
Nbe: Well Bonded - Excess Ice
ICE: Ice without soil inclusions
ICE w/ soil: Ice with soil inclusions
Vx: Individual Ice Inclusions
Vc: Ice Coatings on Particles
Vr: Randomly Oriented Ice Formations
Vs: Stratified Ice Formations

**Location**

| | |
|---|---|
| **B:** | 429568, 7271229 |
| **B':** | 429715, 7271487 |

0m 100m

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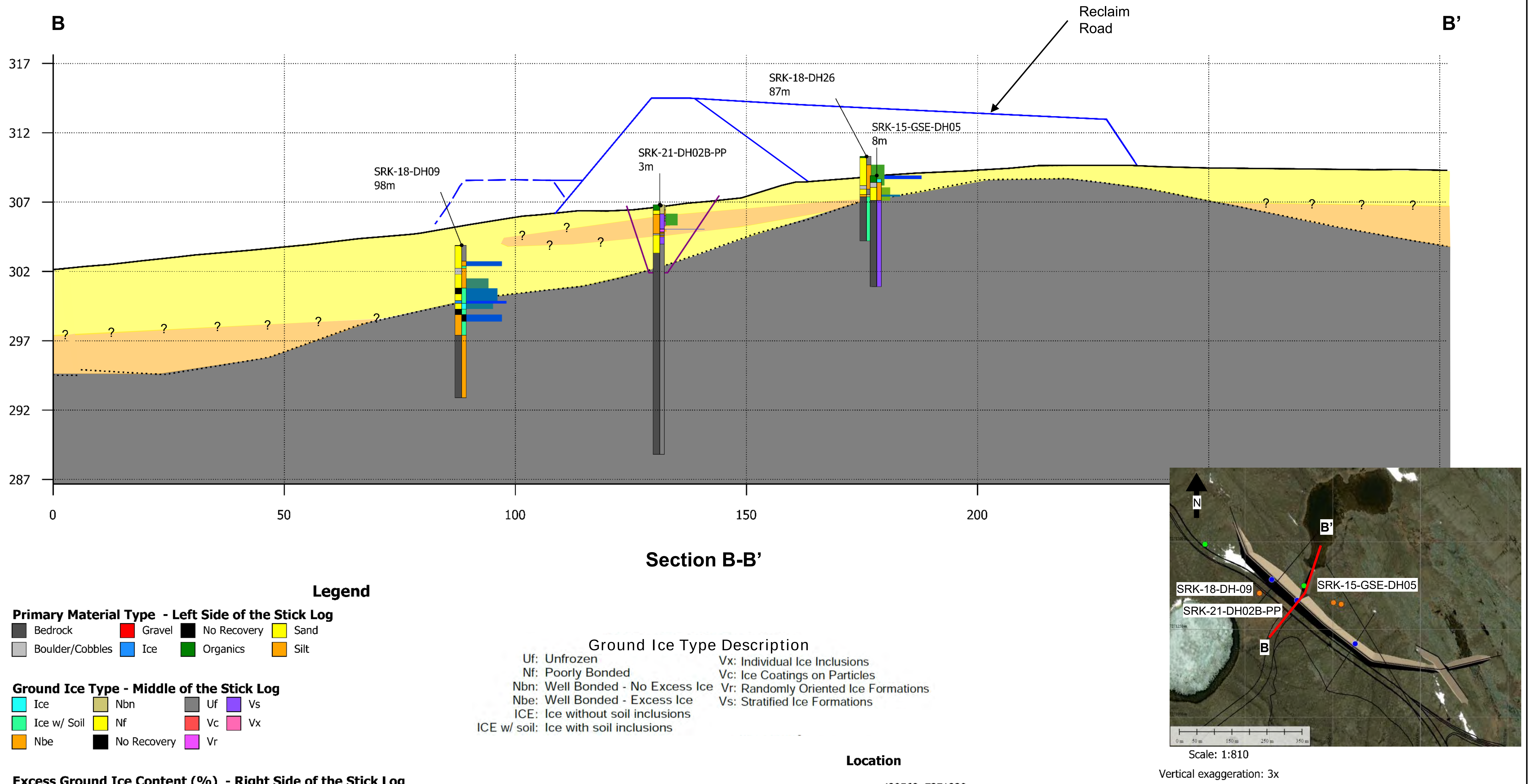
Job No: 1CS020.020
Filename: BackRiver_SubsurfaceModel_Figures.pptx

Back River Project

Primary Pond Dam
Subsurface Model Overview

**Section B-B'**
**Stick Logs**

Date: Nov 2022
Approved: JBK
Figure: **B.1**



## Section B-B'

Scale: 1:810

Vertical exaggeration: 3x

0m 100m

## Legend

**Primary Material Type - Left Side of the Stick Log**

- ⬛ Bedrock
- 🟥 Gravel
- ⬛ No Recovery
- 🟨 Sand
- ⬜ Boulder/Cobbles
- 🟦 Ice
- 🟩 Organics
- 🟧 Silt

**Ground Ice Type - Middle of the Stick Log**

- 🟦 Ice
- 🟫 Nbn
- ⬛ Uf
- 🟪 Vs
- 🟩 Ice w/ Soil
- 🟨 Nf
- 🟥 Vc
- 🟪 Vx
- 🟧 Nbe
- ⬛ No Recovery
- 🟪 Vr

**Excess Ground Ice Content (%) - Right Side of the Stick Log**

0 25 50 75 100

**Surfaces**

- —— Ground Surface - From Sabina
- – – Goose AWR
- —— Proposed Primary Pond Dam Shell
- ········ Bedrock Surface - from Sabina
- —— Proposed Primary Pond Dam Key Trench
- ········ Estimated Bedrock Surface Based on 2021 Drilling
- --?--? Layer interpretation with greatest uncertainly or extrapolation with limited data

Note: Excess ice content is determined by visual estimations in the field

### Ground Ice Type Description

| | | | |
|---|---|---|---|
| Uf: | Unfrozen | Vx: | Individual Ice Inclusions |
| Nf: | Poorly Bonded | Vc: | Ice Coatings on Particles |
| Nbn: | Well Bonded - No Excess Ice | Vr: | Randomly Oriented Ice Formations |
| Nbe: | Well Bonded - Excess Ice | Vs: | Stratified Ice Formations |
| ICE: | Ice without soil inclusions | | |
| ICE w/ soil: | Ice with soil inclusions | | |

**Location**

| | |
|---|---|
| **B:** | 429568, 7271229 |
| **B':** | 429715, 7271487 |

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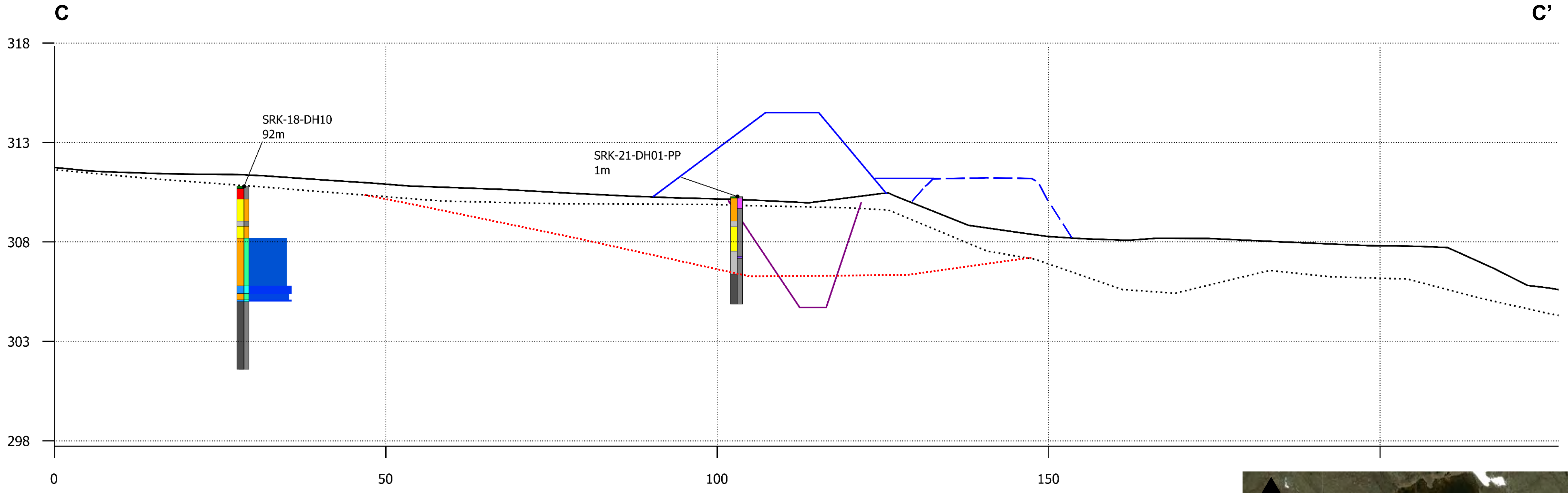
Primary Pond Dam
Subsurface Model Overview
**Section B-B'**
**Interpreted Subsurface Stratigraphy**

Job No: 1CS020.020
Filename: BackRiver_SubsurfaceModel_Figures.pptx

Back River Project

Date: Nov 2022
Approved: JBK
Figure: **B.2**



## Section C-C'

### Legend

**Primary Material Type - Left Side of the Stick Log**

- ■ Bedrock
- ■ Boulder/Cobbles
- 🟥 Gravel
- 🟦 Ice
- ■ No Recovery
- 🟩 Organics
- 🟨 Sand
- 🟧 Silt

**Ground Ice Type - Middle of the Stick Log**

- ■ Ice
- ■ Ice w/ Soil
- 🟧 Nbe
- ■ Nbn
- 🟨 Nf
- ■ No Recovery
- ■ Uf
- 🟥 Vc
- 🟪 Vr
- 🟪 Vs
- ■ Vx

**Excess Ground Ice Content (%) - Right Side of the Stick Log**

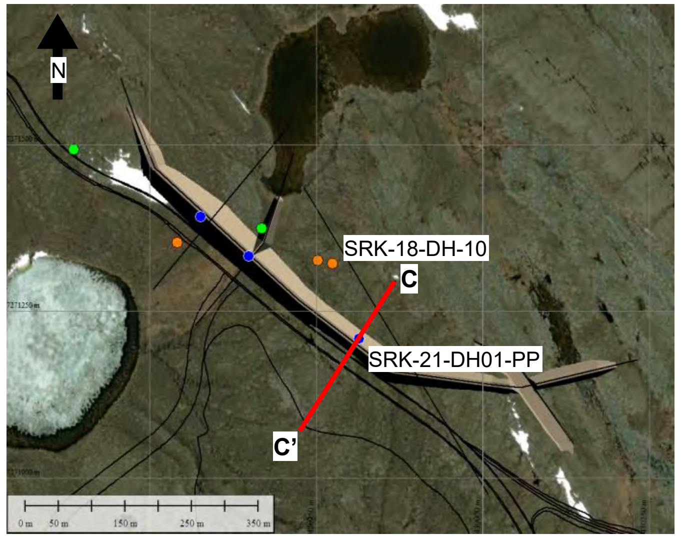
0 25 50 75 100

**Surfaces**

- —— Ground Surface - From Sabina
- ······ Bedrock Surface - from Sabina
- – – Goose AWR
- —— Proposed Primary Pond Dam Key Trench
- —— Proposed Primary Pond Dam Shell
- ······ Estimated Bedrock Surface Based on 2021 Drilling

Ground Ice Type Description

| | | | |
|---|---|---|---|
| Uf: | Unfrozen | Vx: | Individual Ice Inclusions |
| Nf: | Poorly Bonded | Vc: | Ice Coatings on Particles |
| Nbn: | Well Bonded - No Excess Ice | Vr: | Randomly Oriented Ice Formations |
| Nbe: | Well Bonded - Excess Ice | Vs: | Stratified Ice Formations |
| ICE: | Ice without soil inclusions | | |
| ICE w/ soil: | Ice with soil inclusions | | |



**Location**

| | |
|---|---|
| C: | 429868, 7271296 |
| C': | 429694, 7271023 |

Scale: 1:600

Vertical exaggeration: 3x

0m 100m

Note: Excess ice content is determined by visual estimations in the field

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Job No: 1CS020.020

Filename: BackRiver_SubsurfaceModel_Figures.pptx

Back River Project

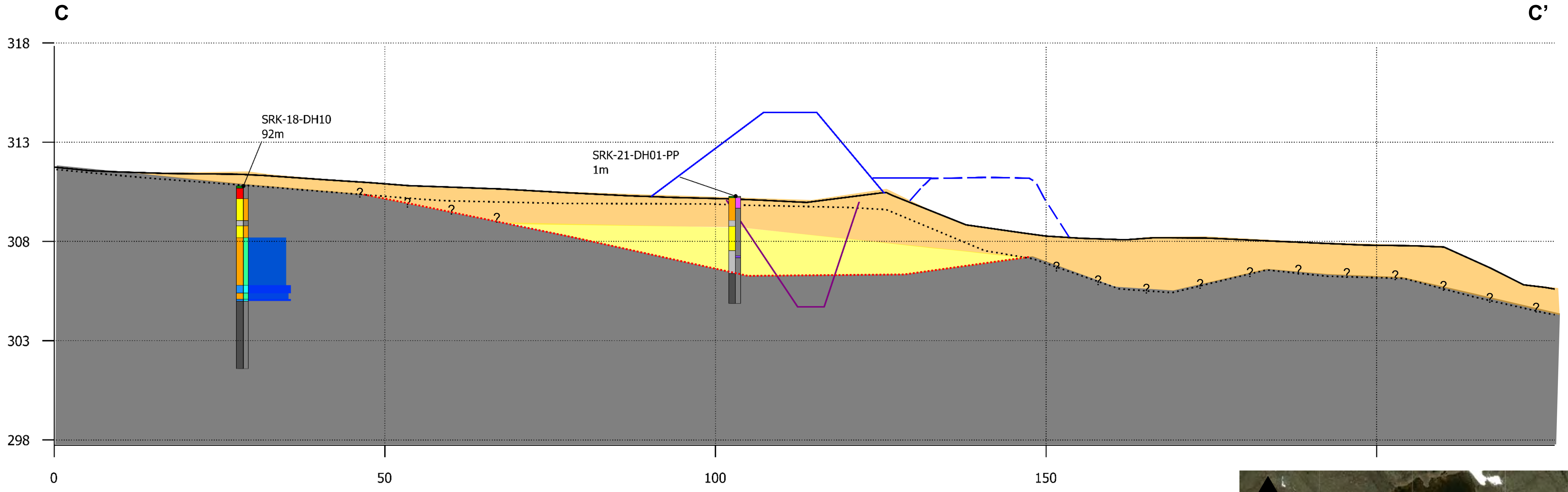
Primary Pond Dam
Subsurface Model Overview

**Section C-C'**
**Stick Logs**

Date: Nov 2022

Approved: JBK

Figure: **C.1**



## Section C-C'

### Legend

**Primary Material Type - Left Side of the Stick Log**

⬛ Bedrock
🟥 Gravel
⬛ No Recovery
🟨 Sand
⬜ Boulder/Cobbles
🟦 Ice
🟩 Organics
🟧 Silt

**Ground Ice Type - Middle of the Stick Log**

🟦 Ice
🟨 Nbn
⬛ Uf
🟪 Vs
🟩 Ice w/ Soil
🟨 Nf
🟥 Vc
🟪 Vx
🟧 Nbe
⬛ No Recovery
🟪 Vr

**Excess Ground Ice Content (%) - Right Side of the Stick Log**

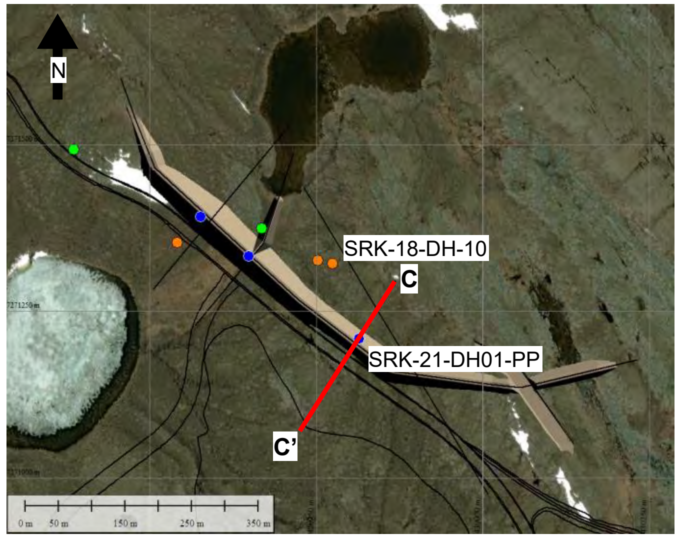
0 25 50 75 100

**Surfaces**

——— Ground Surface - From Sabina
······· Bedrock Surface - from Sabina
--?--? Layer interpretation with greatest uncertainly or extrapolation with limited data
— — Goose AWR
——— Proposed Primary Pond Dam Key Trench
——— Proposed Primary Pond Dam Shell
······· Estimated Bedrock Surface Based on 2021 Drilling

Ground Ice Type Description

Uf: Unfrozen
Nf: Poorly Bonded
Nbn: Well Bonded - No Excess Ice
Nbe: Well Bonded - Excess Ice
ICE: Ice without soil inclusions
ICE w/ soil: Ice with soil inclusions
Vx: Individual Ice Inclusions
Vc: Ice Coatings on Particles
Vr: Randomly Oriented Ice Formations
Vs: Stratified Ice Formations



**Location**

| | |
|---|---|
| **C:** | 429868, 7271296 |
| **C':** | 429694, 7271023 |

Scale: 1:600
Vertical exaggeration: 3x

0m 100m

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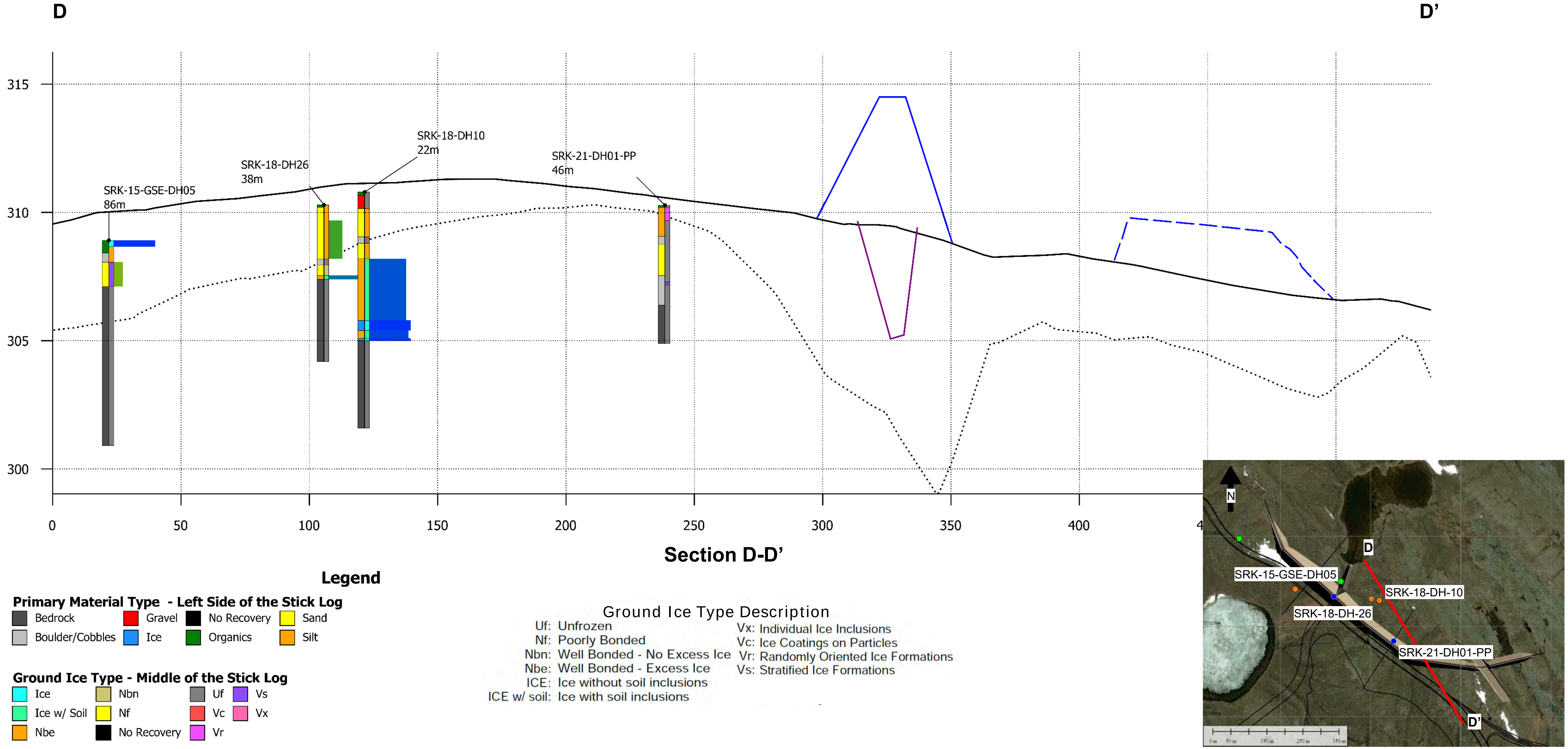
Job No: 1CS020.020
Filename: BackRiver_SubsurfaceModel_Figures.pptx

Back River Project

Primary Pond Dam
Subsurface Model Overview
**Section C-C'**
**Interpreted Subsurface**
**Stratigraphy**

Date: Nov 2022
Approved: JBK
Figure: C.2

Note: Excess ice content is determined by visual estimations in the field



## Section D-D'

### Legend

**Primary Material Type - Left Side of the Stick Log**

| | | | |
|---|---|---|---|
| ⬛ Bedrock | 🟥 Gravel | ⬛ No Recovery | 🟨 Sand |
| ⬜ Boulder/Cobbles | 🟦 Ice | 🟩 Organics | 🟧 Silt |

**Ground Ice Type - Middle of the Stick Log**

| | | | |
|---|---|---|---|
| 🟦 Ice | 🟨 Nbn | ⬛ Uf | 🟪 Vs |
| 🟩 Ice w/ Soil | 🟨 Nf | 🟥 Vc | 🟥 Vx |
| 🟧 Nbe | ⬛ No Recovery | 🟪 Vr | |

**Excess Ground Ice Content (%) - Right Side of the Stick Log**

0 25 50 75 100

**Surfaces**

| | |
|---|---|
| Ground Surface - From Sabina | Goose AWR |
| Bedrock Surface - from Sabina | Proposed Primary Pond Dam Key Trench |
| Proposed Primary Pond Dam Shell | Estimated Bedrock Surface Based on 2021 Drilling |

### Ground Ice Type Description

| | |
|---|---|
| Uf: | Unfrozen |
| Nf: | Poorly Bonded |
| Nbn: | Well Bonded - No Excess Ice |
| Nbe: | Well Bonded - Excess Ice |
| ICE: | Ice without soil inclusions |
| ICE w/ soil: | Ice with soil inclusions |
| Vx: | Individual Ice Inclusions |
| Vc: | Ice Coatings on Particles |
| Vr: | Randomly Oriented Ice Formations |
| Vs: | Stratified Ice Formations |

**Location**

| | |
|---|---|
| D: | 429731, 7271436 |
| D': | 430007, 7270976 |

Scale: 1:1,500

Vertical exaggeration: 10x

0m 100m

Note: Excess ice content is determined by visual estimations in the field

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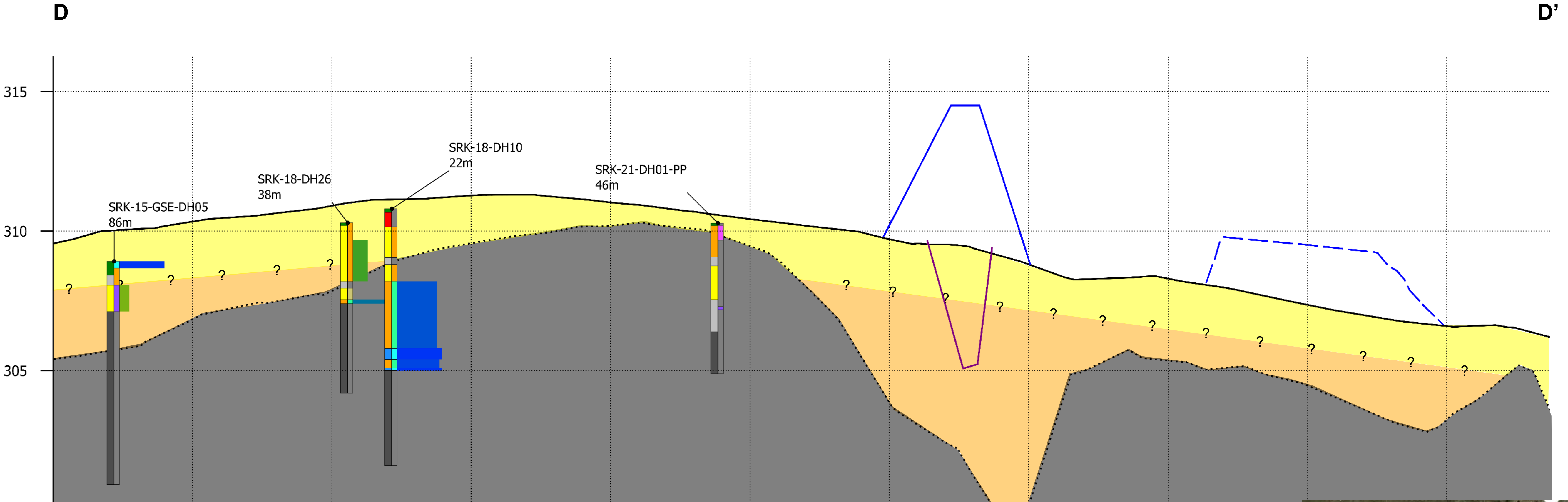
Primary Pond Dam
Subsurface Model Overview

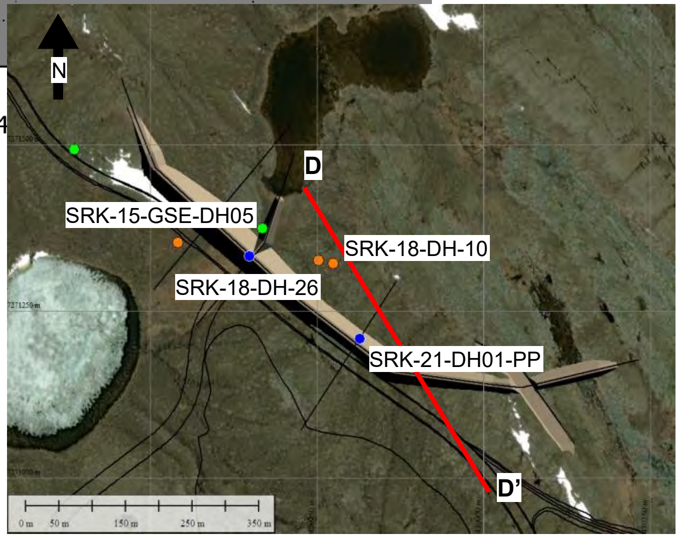
**Section D-D'**
**Stick Logs**

Job No: 1CS020.020
Filename: BackRiver_SubsurfaceModel_Figures.pptx

Back River Project

Date: Nov 2022
Approved: JBK
Figure: **D.1**





## Section D-D'

## Legend

**Primary Material Type - Left Side of the Stick Log**

⬛ Bedrock
⬜ Boulder/Cobbles
🟥 Gravel
🟦 Ice
⬛ No Recovery
🟩 Organics
🟨 Sand
🟧 Silt

**Ground Ice Type - Middle of the Stick Log**

🟦 Ice
🟩 Ice w/ Soil
🟧 Nbe
🟫 Nbn
🟨 Nf
⬛ No Recovery
⬛ Uf
🟥 Vc
🟪 Vr
🟪 Vs
🟥 Vx

**Excess Ground Ice Content (%) - Right Side of the Stick Log**

0 25 50 75 100

**Surfaces**

——— Ground Surface - From Sabina
········ Bedrock Surface - from Sabina
--?--? Layer interpretation with greatest uncertainly or extrapolation with limited data
— — Goose AWR
——— Proposed Primary Pond Dam Key Trench
——— Proposed Primary Pond Dam Shell
········ Estimated Bedrock Surface Based on 2021 Drilling

Note: Excess ice content is determined by visual estimations in the field

### Ground Ice Type Description

Uf: Unfrozen
Nf: Poorly Bonded
Nbn: Well Bonded - No Excess Ice
Nbe: Well Bonded - Excess Ice
ICE: Ice without soil inclusions
ICE w/ soil: Ice with soil inclusions
Vx: Individual Ice Inclusions
Vc: Ice Coatings on Particles
Vr: Randomly Oriented Ice Formations
Vs: Stratified Ice Formations

**Location**

| | |
|---|---|
| **D:** | 429731, 7271436 |
| **D':** | 430007, 7270976 |

Scale: 1:1,500
Vertical exaggeration: 10x
0m 100m

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Sabina
GOLD & SILVER CORP.

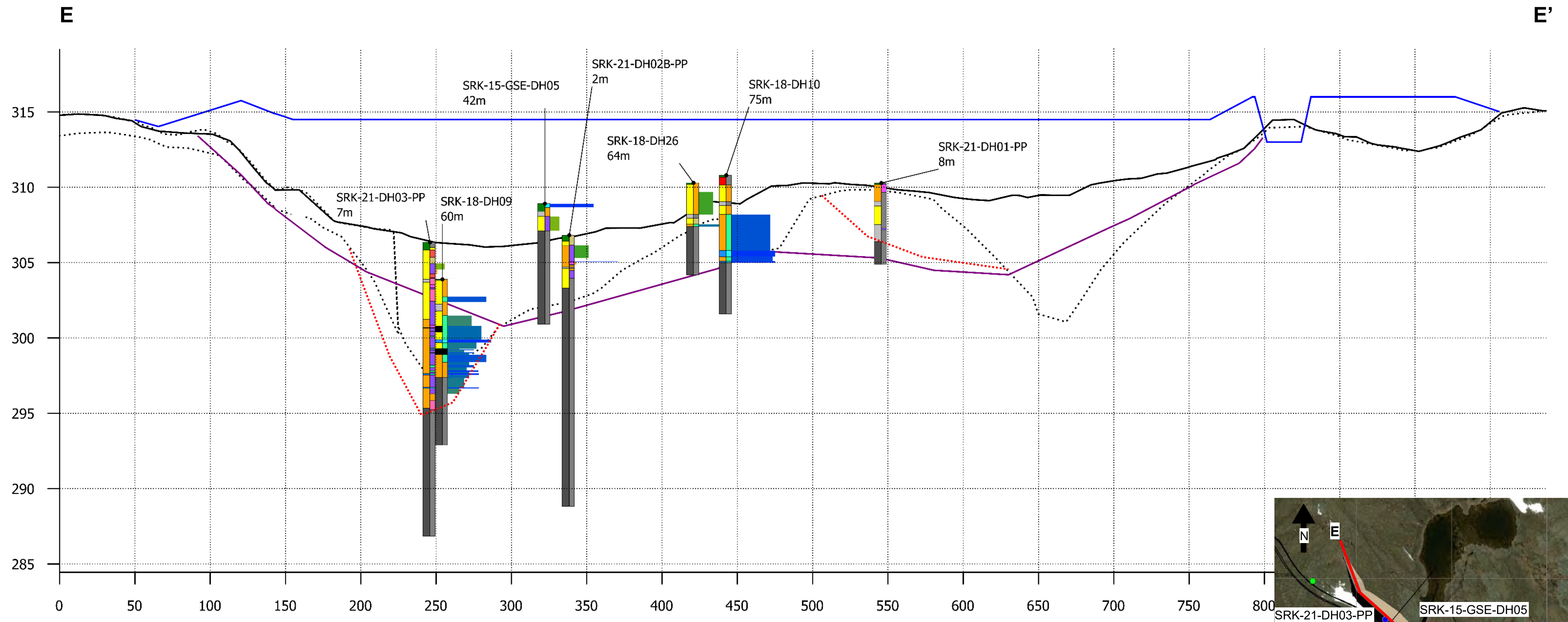
Job No: 1CS020.020
Filename: BackRiver_SubsurfaceModel_Figures.pptx

Back River Project

Primary Pond Dam
Subsurface Model Overview

**Section D-D'**
**Interpreted Subsurface Stratigraphy**

Date: Nov 2022
Approved: JBK
Figure: **D.2**



## Section E-E'

## Legend

**Primary Material Type - Left Side of the Stick Log**

| | | | |
|---|---|---|---|
| ■ Bedrock | 🟥 Gravel | ■ No Recovery | 🟨 Sand |
| ■ Boulder/Cobbles | 🟦 Ice | 🟩 Organics | 🟧 Silt |

**Ground Ice Type - Middle of the Stick Log**

| | | | |
|---|---|---|---|
| ■ Ice | ■ Nbn | ■ Uf | ■ Vs |
| ■ Ice w/ Soil | 🟨 Nf | 🟥 Vc | ■ Vx |
| 🟧 Nbe | ■ No Recovery | ■ Vr | |

**Excess Ground Ice Content (%) - Right Side of the Stick Log**

0 25 50 75 100

**Surfaces**

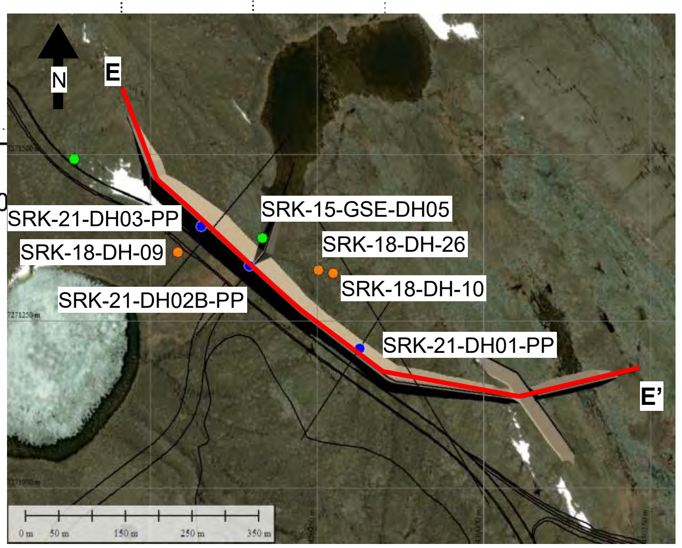
| | | |
|---|---|---|
| Ground Surface - From Sabina | Goose AWR | Proposed Primary Pond Dam Shell |
| Bedrock Surface - from Sabina | Proposed Primary Pond Dam Key Trench | Estimated Bedrock Surface Based on 2021 Drilling |

Note: Excess ice content is determined by visual estimations in the field

### Ground Ice Type Description

Uf: Unfrozen
Nf: Poorly Bonded
Nbn: Well Bonded - No Excess Ice
Nbe: Well Bonded - Excess Ice
ICE: Ice without soil inclusions
ICE w/ soil: Ice with soil inclusions

Vx: Individual Ice Inclusions
Vc: Ice Coatings on Particles
Vr: Randomly Oriented Ice Formations
Vs: Stratified Ice Formations



**Location**

| | |
|---|---|
| E: | 429456, 7271600 |
| E': | 430231, 7271178 |

Scale: 1:2,700
Vertical exaggeration: 10x
0m 100m

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GOLD & SILVER CORP.

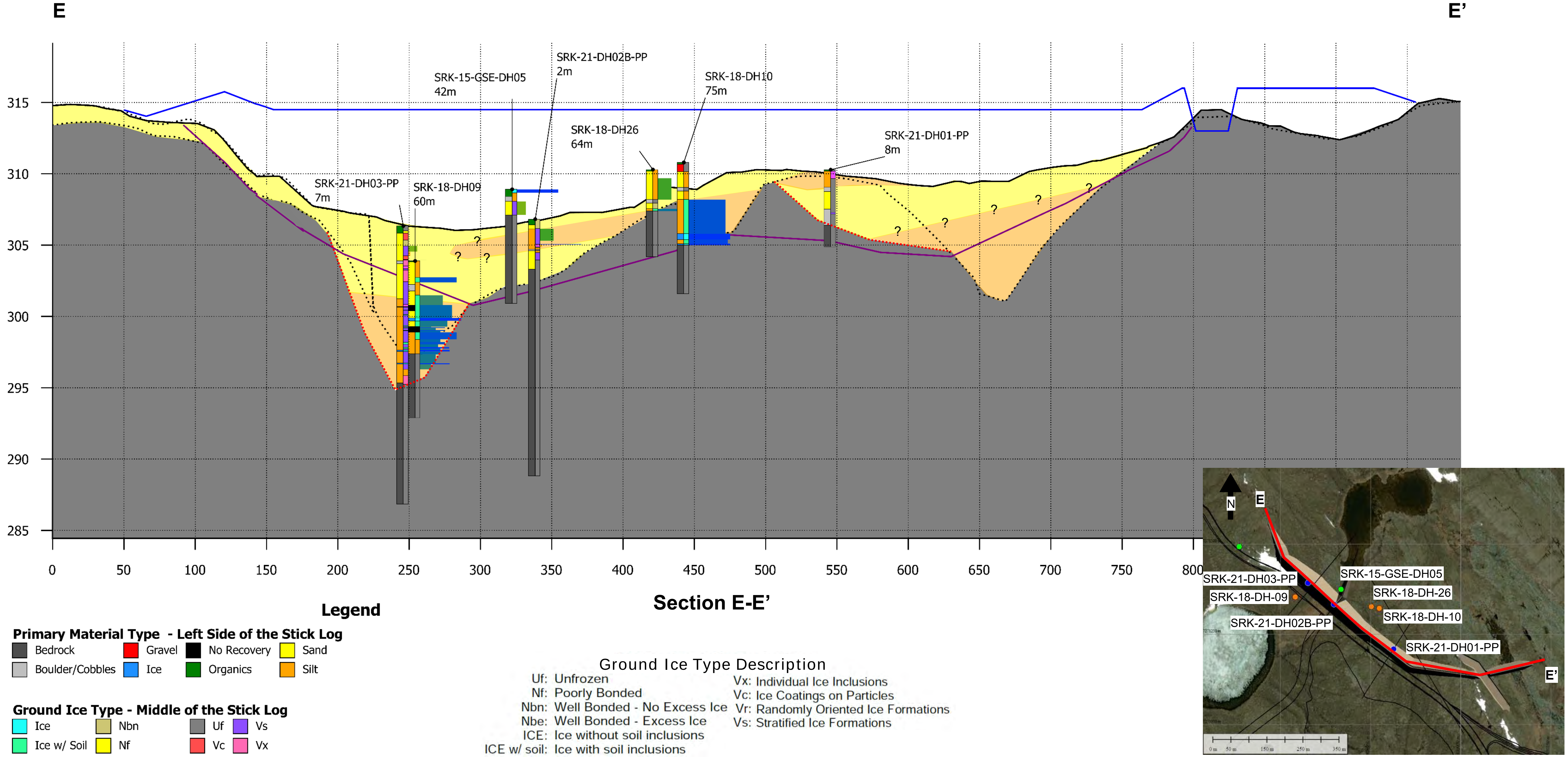
Job No: 1CS020.020
Filename: BackRiver_SubsurfaceModel_Figures.pptx

Back River Project

Primary Pond Dam
Subsurface Model Overview

**Section E-E'**
**Stick Logs**

Date: Nov 2022
Approved: JBK
Figure: **E.1**



## Section E-E'

## Legend

**Primary Material Type - Left Side of the Stick Log**

⬛ Bedrock
⬜ Boulder/Cobbles
🟥 Gravel
🟦 Ice
⬛ No Recovery
🟩 Organics
🟨 Sand
🟧 Silt

**Ground Ice Type - Middle of the Stick Log**

🟦 Ice
🟩 Ice w/ Soil
🟧 Nbe
🟫 Nbn
🟨 Nf
⬛ No Recovery
⬜ Uf
🟥 Vc
🟪 Vr
🟪 Vs
🟪 Vx

**Excess Ground Ice Content (%) - Right Side of the Stick Log**

0 25 50 75 100

**Surfaces**

Ground Surface - From Sabina
Bedrock Surface - from Sabina
Goose AWR
Proposed Primary Pond Dam Key Trench
Proposed Primary Pond Dam Shell
Estimated Bedrock Surface Based on 2021 Drilling
--?--? Layer interpretation with greatest uncertainly or extrapolation with limited data

Note: Excess ice content is determined by visual estimations in the field

### Ground Ice Type Description

| | |
|---|---|
| Uf: | Unfrozen |
| Nf: | Poorly Bonded |
| Nbn: | Well Bonded - No Excess Ice |
| Nbe: | Well Bonded - Excess Ice |
| ICE: | Ice without soil inclusions |
| ICE w/ soil: | Ice with soil inclusions |
| Vx: | Individual Ice Inclusions |
| Vc: | Ice Coatings on Particles |
| Vr: | Randomly Oriented Ice Formations |
| Vs: | Stratified Ice Formations |

**Location**

| | |
|---|---|
| E: | 429456, 7271600 |
| E': | 430231, 7271178 |

Scale: 1:2,700
Vertical exaggeration: 10x
0m 100m

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Sabina GOLD & SILVER CORP.

Primary Pond Dam
Subsurface Model Overview
**Section E-E'**
**Interpreted Subsurface Stratigraphy**

Job No: 1CS020.020
Filename: BackRiver_SubsurfaceModel_Figures.pptx

Back River Project

Date: Nov 2022
Approved: JBK
Figure: E.2

# Attachment 2 Drillhole Logs

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PROJECT: Back River
CLIENT: Sabina Gold & Silver Corp

HOLE ID: **SRK-15-GSE-DH04**
LOCATION: Kitikmeot, Nunavut
PROJECT NO: 1CS020.009
DRILLING CONTRACTOR: Major Drilling
DRILLING TYPE & CORE DIA: Diamond Drilling, HQ
LOGGED BY: SA
BORING DATE: 10-Apr-15 To 10-Apr-15
FACILITY: Primary CW Collection Pond Diversion

SABINA HOLE ID: **15GGT065**
*Page:* 1 of 1
COORDINATES: 429386.2 E 7271492.8 N
DATUM: UTM Zone 13
GROUND ELEV (m): 308.38
AZIMUTH: 0
DIP: -90
EOH ELEV. (m): 299.88
TOTAL DEPTH (m): 8.5

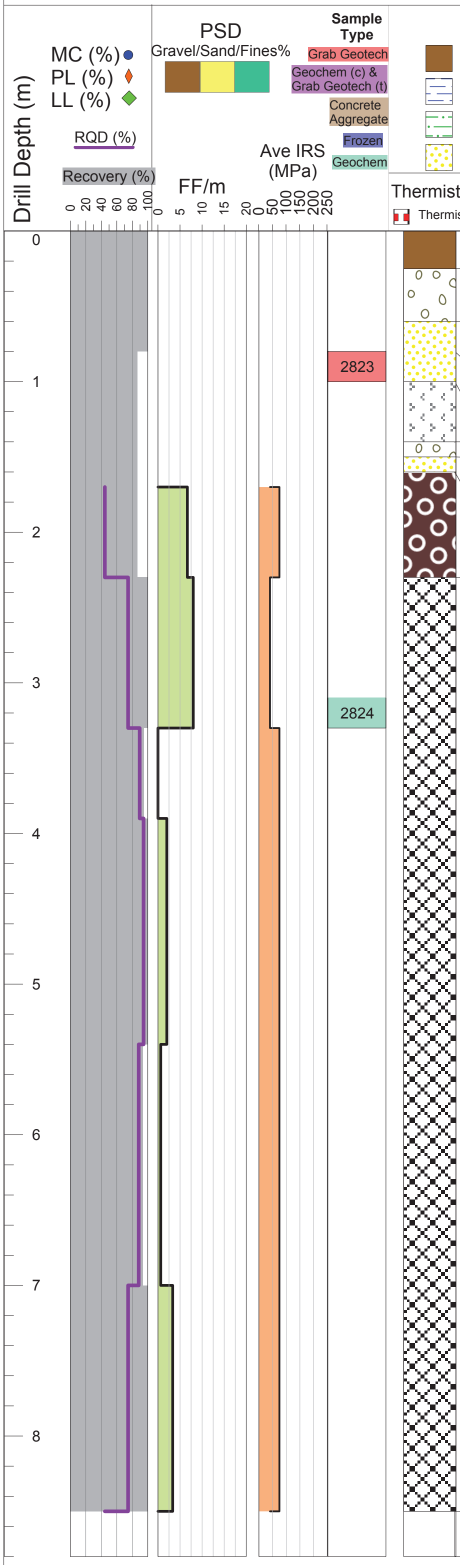
## Lithological Symbol

| | | | | | |
|---|---|---|---|---|---|
| ▨ | ORGANICS | ▨ | GRAVEL | ▨ | RUBBLE ZONE |
| ▨ | CLAY | ▨ | COBBLE | ▨ | SNOW |
| ▨ | SILT | ▨ | BOULDER | ▨ | ICE |
| ▨ | SAND | ▨ | BEDROCK | ▨ | LAKE |

## Ice Description

Nf: No visible ice, Poorly Bonded
Nbn: No visible ice, Well Bonded - No Excess Ice
Nbe: No visible ice, Well Bonded - Excess Ice

Vx: Individual Ice Inclusions
Vc: Ice Coatings on Particles
Vr: Random or Irregularly Oriented Ice Formations
Vs: Stratified / Distinctly Oriented Ice Formations



Thermistor ID:
Thermistor Bead

| Soil Description | Additional Comments |
|---|---|
| ORGANICS, dark brown to black | |
| COBBLE, some gravel, trace sand, dark brown (10YR2/2), gap graded, wet, sub-angular, non-plastic, non-cohesive, oxidized | |
| Silty SAND, some gravel, dark grey (10YR4/1), well graded, wet, sub-angular, non-plastic, non-cohesive | |
| SAND and SILT, trace gravel, grey (2.5YR/5/1), well graded, wet, sub-rounded, non-plastic, non-cohesive | |
| ICE | |
| COBBLE | |
| SAND and SILT, trace gravel, grey (2.5YR/5/1), well graded, wet, sub-rounded, non-plastic, non-cohesive | |
| BOULDER | |
| BEDROCK: Greywacke, dark grey | |

| Ice Description | |
|---|---|
| Nf | No visible ice |
| Nbn | |
| Vr | 10% excess water |
| Ice | Ice and soil - about 10% soil |
| Vr | 10% excess water |

Drill Depth (m)
0
1
2
3
4
5
6
7
8

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PROJECT: Back River
CLIENT: Sabina Gold & Silver Corp

HOLE ID: **SRK-15-GSE-DH05**
LOCATION: Kitikmeot, Nunavut
PROJECT NO: 1CS020.009
DRILLING CONTRACTOR: Major Drilling
DRILLING TYPE & CORE DIA: Diamond Drilling, HQ
LOGGED BY: KK
BORING DATE: 10-Apr-15 To 10-Apr-15
FACILITY: Primary CW Collection Pond Diversion

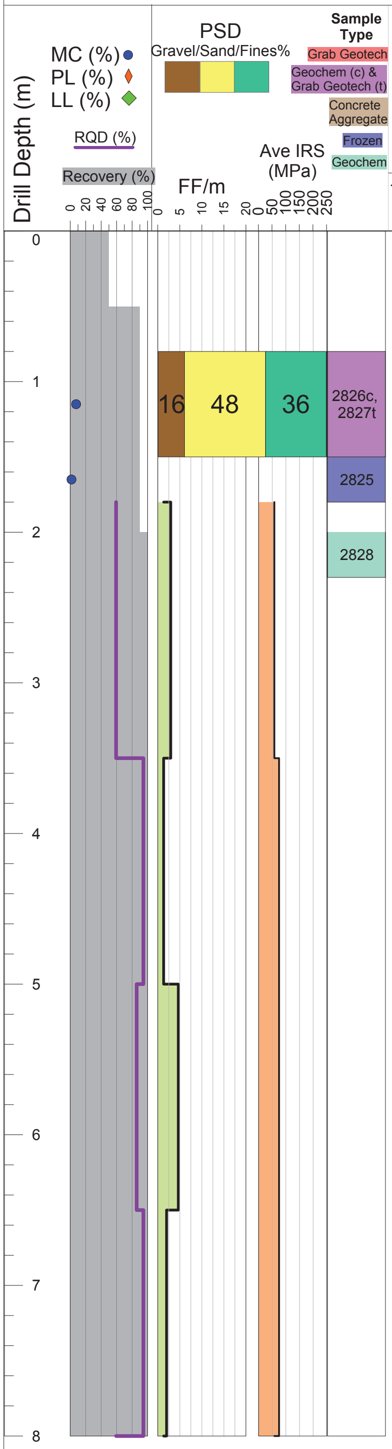
SABINA HOLE ID: **15GGT066**
*Page:* 1 of 1
COORDINATES: 429668.8 E 7271373.4 N
DATUM: UTM Zone 13
GROUND ELEV (m): 308.91
AZIMUTH: 0
DIP: -90
EOH ELEV. (m): 300.91
TOTAL DEPTH (m): 8

## Lithological Symbol

| | | |
|---|---|---|
| ORGANICS | GRAVEL | RUBBLE ZONE |
| CLAY | COBBLE | SNOW |
| SILT | BOULDER | ICE |
| SAND | BEDROCK | LAKE |

## Ice Description

| | |
|---|---|
| Nf: | No visible ice, Poorly Bonded |
| Nbn: | No visible ice, Well Bonded - No Excess Ice |
| Nbe: | No visible ice, Well Bonded - Excess Ice |
| Vx: | Individual Ice Inclusions |
| Vc: | Ice Coatings on Particles |
| Vr: | Random or Irregularly Oriented Ice Formations |
| Vs: | Stratified / Distinctly Oriented Ice Formations |



Thermistor ID:
Thermistor Bead

| Soil Description | Additional Comments | | |
|---|---|---|---|
| SNOW | | | |
| ORGANICS , dark brown (7.5YR2.5/1) | | | |
| COBBLE, some organics, angular | Organics found between two pieces of cobbles. About 15% organics by volume. The top piece of boulder is broken into cobbly pieces from drilling process. | Nbe | |
| SAND, some silt, some gravel, light brown (2.5YR4/2), well graded, angular, non-plastic, non-cohesive, slow-dilatancy, thinly bedded (>0.5cm), sharp contact | Gravel pieces oriented parallel to bedding. Sand and ice bedding throughout. Ice content/thickness increases with depth. 10mm of ice and 20mm of ice found above and below cobble at 1.25m. | Vs | Stratified ice embedded in sand layers oriented at 10 degrees. Ice thickness increases gradually from 1mm to 8mm. Ice has soil inclusion. Overall ice content increases from approx. 20% to 40% with depth. |
| COBBLE | | | |
| SAND, some silt, trace gravel, light brown (2.5YR4/2), well graded, angular, non-plastic, non-cohesive, slow-dilatancy, thinly bedded (>0.5cm), sharp contact | | | |
| BEDROCK: Greywacke, medium grey | | | |

Drill Depth (m)

HOLE ID: **SRK-15-GSE-DH06**
LOCATION: Kitikmeot, Nunavut
PROJECT NO: 1CS020.009
DRILLING CONTRACTOR: Major Drilling
DRILLING TYPE & CORE DIA: Diamond Drilling, HQ
LOGGED BY: SA
BORING DATE: 3-Apr-15 To 3-Apr-15
FACILITY: Umwelt Waste Rock Pile

SABINA HOLE ID: **15GGT042**
*Page:* 1 of 1
COORDINATES: 430360.6 E 7271108.2 N
DATUM: UTM Zone 13
GROUND ELEV (m): 318.12
AZIMUTH: 0
DIP: -90
EOH ELEV. (m): 311.92
TOTAL DEPTH (m): 6.2

PROJECT: Back River
CLIENT: Sabina Gold & Silver Corp

Drill Depth (m)

MC (%) ●
PL (%) ♦
LL (%) ◆
RQD (%)
Recovery (%)
0 20 40 60 80 100

PSD
Gravel/Sand/Fines%

FF/m
0 5 10 15 20

Ave IRS (MPa)
0 50 100 150 200 250

Sample Type
Grab Geotech
Geochem (c) & Grab Geotech (t)
Concrete Aggregate
Frozen
Geochem

## Lithological Symbol

| | | |
|---|---|---|
| ORGANICS | GRAVEL | RUBBLE ZONE |
| CLAY | COBBLE | SNOW |
| SILT | BOULDER | ICE |
| SAND | BEDROCK | LAKE |

Thermistor ID:
Thermistor Bead

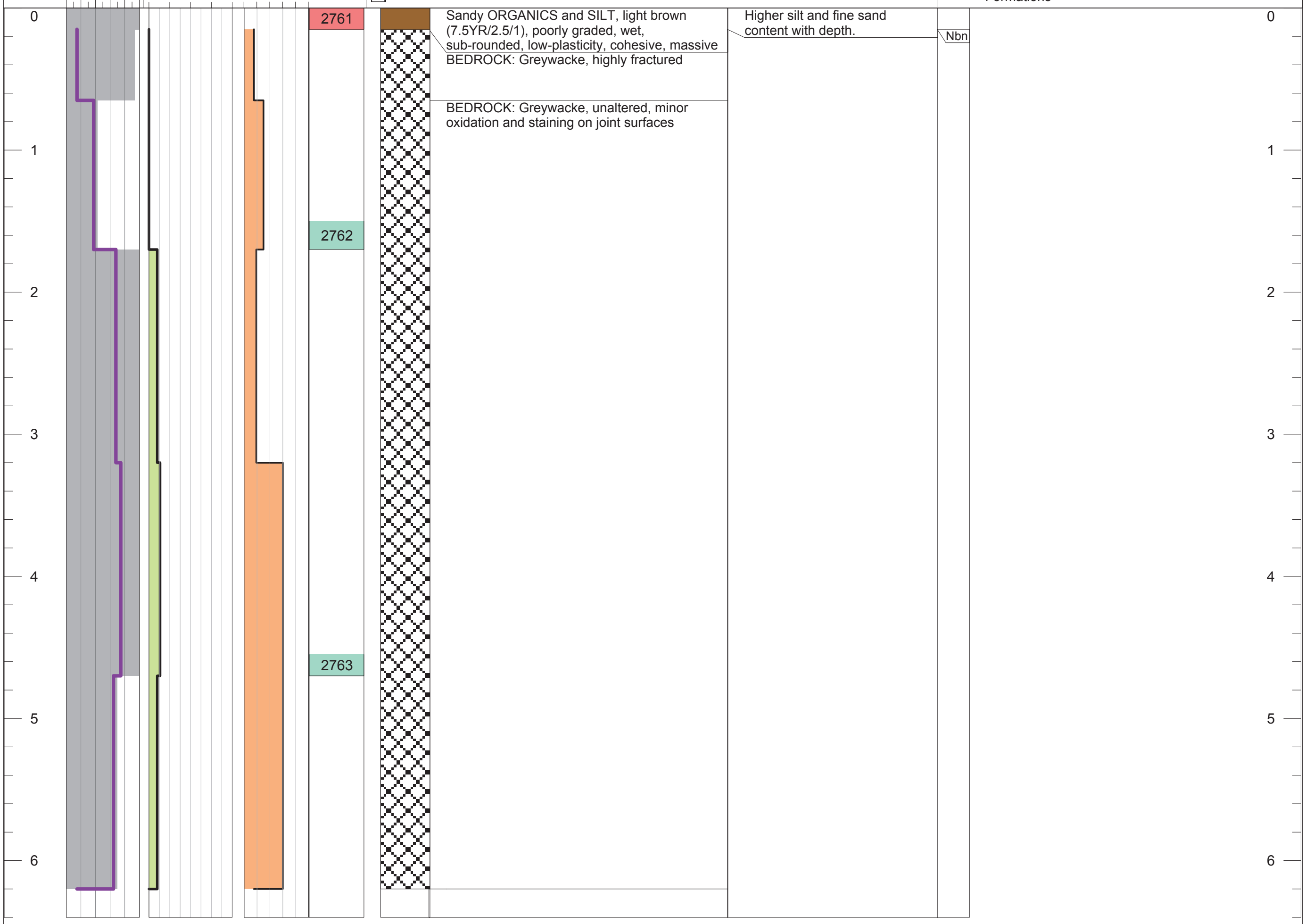
**Soil Description**

**Additional Comments**

## Ice Description

| | |
|---|---|
| Nf: | No visible ice, Poorly Bonded |
| Nbn: | No visible ice, Well Bonded - No Excess Ice |
| Nbe: | No visible ice, Well Bonded - Excess Ice |
| Vx: | Individual Ice Inclusions |
| Vc: | Ice Coatings on Particles |
| Vr: | Random or Irregularly Oriented Ice Formations |
| Vs: | Stratified / Distinctly Oriented Ice Formations |

Drill Depth (m)



Sandy ORGANICS and SILT, light brown (7.5YR/2.5/1), poorly graded, wet, sub-rounded, low-plasticity, cohesive, massive

BEDROCK: Greywacke, highly fractured

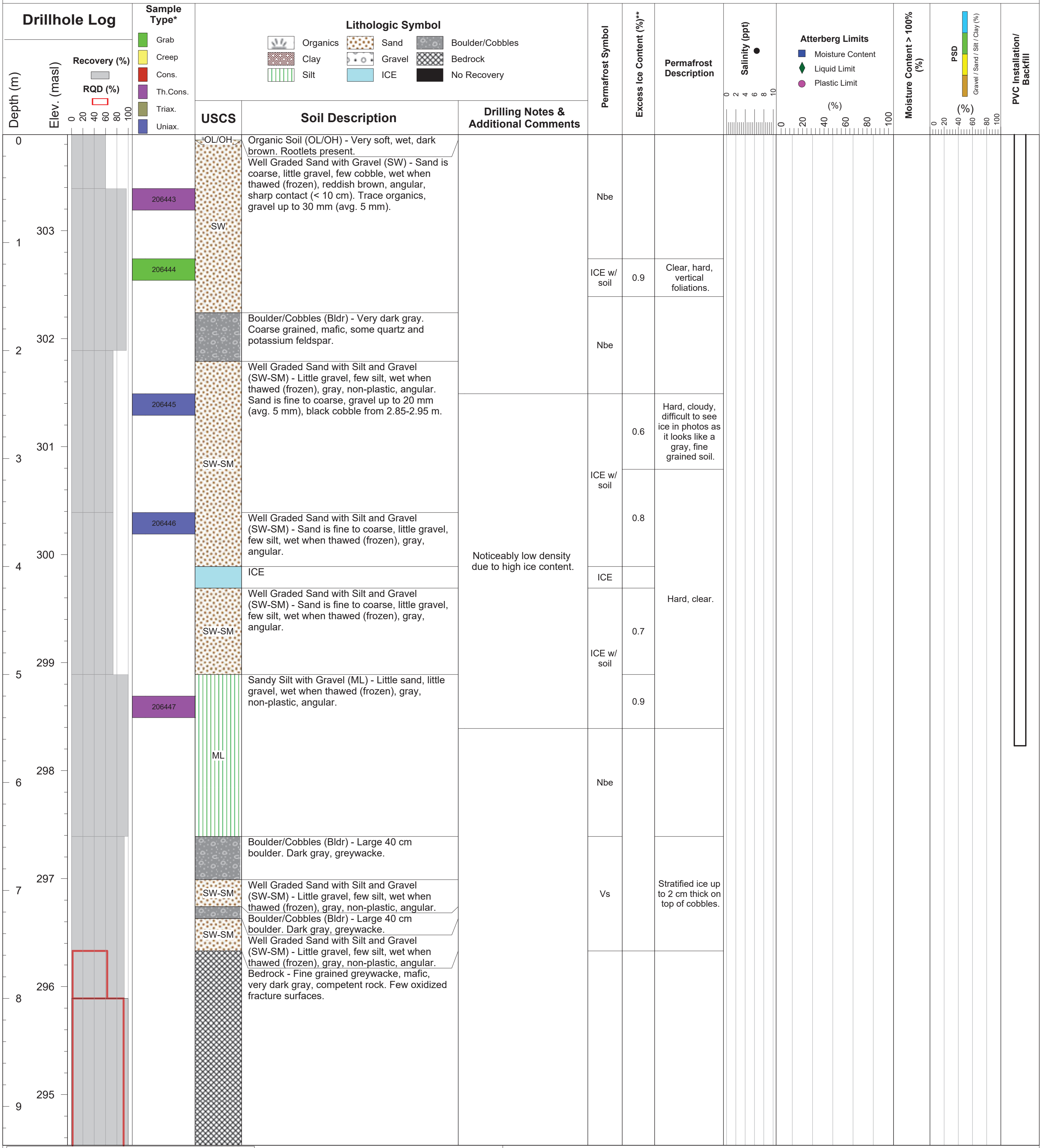
BEDROCK: Greywacke, unaltered, minor oxidation and staining on joint surfaces

Higher silt and fine sand content with depth.

**PROJECT:** 2018 Geotechnical Investigation
**CLIENT:** Sabina Gold & Silver Corp

| | | | |
|---|---|---|---|
| **DRILLHOLE ID:** | SRK-18-DH09 (18GGT40) | **DRILLING DATE:** | 26-Mar-18 **TO:** 26-Mar-18 |
| **LOCATION:** | PRIMARY POND HAUL ROAD DAM | **COORDINATES:** | 429,542 E 7,271,352 N |
| **PROJECT NO:** | 1CS020.016 | **DATUM:** | UTM Projection NAD83 Zone 13 |
| **DRILL TYPE:** | Diamond Drill | **GROUND ELEV. (masl):** | 303.89 |
| **CORE DIA (mm):** | 63.5 | **AZIMUTH:** | 0 **DIP:** -90 |
| **CONTRACTOR:** | Major Drilling Group International | **TOTAL DEPTH (m):** | 11.00 |
| **LOGGED BY:** | M. Stephenson | **WATER LEVEL (masl):** | - |

## Drillhole Log



| USCS | Soil Description |
|---|---|
| OL/OH | Organic Soil (OL/OH) - Very soft, wet, dark brown. Rootlets present. |
| SW | Well Graded Sand with Gravel (SW) - Sand is coarse, little gravel, few cobble, wet when thawed (frozen), reddish brown, angular, sharp contact (< 10 cm). Trace organics, gravel up to 30 mm (avg. 5 mm). |
| | Boulder/Cobbles (Bldr) - Very dark gray. Coarse grained, mafic, some quartz and potassium feldspar. |
| SW-SM | Well Graded Sand with Silt and Gravel (SW-SM) - Little gravel, few silt, wet when thawed (frozen), gray, non-plastic, angular. Sand is fine to coarse, gravel up to 20 mm (avg. 5 mm), black cobble from 2.85-2.95 m. |
| | Well Graded Sand with Silt and Gravel (SW-SM) - Sand is fine to coarse, little gravel, few silt, wet when thawed (frozen), gray, angular. |
| | ICE |
| SW-SM | Well Graded Sand with Silt and Gravel (SW-SM) - Sand is fine to coarse, little gravel, few silt, wet when thawed (frozen), gray, angular. |
| ML | Sandy Silt with Gravel (ML) - Little sand, little gravel, wet when thawed (frozen), gray, non-plastic, angular. |
| | Boulder/Cobbles (Bldr) - Large 40 cm boulder. Dark gray, greywacke. |
| SW-SM | Well Graded Sand with Silt and Gravel (SW-SM) - Little gravel, few silt, wet when thawed (frozen), gray, non-plastic, angular. |
| | Boulder/Cobbles (Bldr) - Large 40 cm boulder. Dark gray, greywacke. |
| SW-SM | Well Graded Sand with Silt and Gravel (SW-SM) - Little gravel, few silt, wet when thawed (frozen), gray, non-plastic, angular. |
| | Bedrock - Fine grained greywacke, mafic, very dark gray, competent rock. Few oxidized fracture surfaces. |

**Drilling Notes & Additional Comments**

Noticeably low density due to high ice content.

| Permafrost Symbol | Excess Ice Content (%)** | Permafrost Description |
|---|---|---|
| Nbe | | |
| ICE w/ soil | 0.9 | Clear, hard, vertical foliations. |
| Nbe | | |
| ICE w/ soil | 0.6 | Hard, cloudy, difficult to see ice in photos as it looks like a gray, fine grained soil. |
| | 0.8 | Hard, clear. |
| ICE | | |
| ICE w/ soil | 0.7 | |
| | 0.9 | |
| Nbe | | |
| Vs | | Stratified ice up to 2 cm thick on top of cobbles. |

### Permafrost Description

| | | | |
|---|---|---|---|
| Uf: | Unfrozen | Vx: | Individual Ice Inclusions |
| Nf: | Poorly Bonded | Vc: | Ice Coatings on Particles |
| Nbn: | Well Bonded - No Excess Ice | Vr: | Randomly Oriented Ice Formations |
| Nbe: | Well Bonded - Excess Ice | Vs: | Stratified Ice Formations |
| ICE: | Ice without soil inclusions | UN: | Unknown, due to melting or no recovery |
| ICE w/ soil: | Ice with soil inclusions | | |

**Excess ice content determined by visual estimation in the field

* Cons.: Consolidation Test
Triax.: Triaxial Compression Test
Uniax.: Uniaxial Compression Test

### PVC Installation Details

▩ Bentonite Chips ☐ 2" PVC

**PROJECT:** 2018 Geotechnical Investigation
**CLIENT:** Sabina Gold & Silver Corp

**DRILLHOLE ID:** SRK-18-DH09 (18GGT40)
**LOCATION:** PRIMARY POND HAUL ROAD DAM
**PROJECT NO:** 1CS020.016
**DRILL TYPE:** Diamond Drill
**CORE DIA (mm):** 63.5
**CONTRACTOR:** Major Drilling Group International
**LOGGED BY:** M. Stephenson

**DRILLING DATE:** 26-Mar-18 **TO:** 26-Mar-18
**COORDINATES:** 429,542 E 7,271,352 N
**DATUM:** UTM Projection NAD83 Zone 13
**GROUND ELEV. (masl):** 303.89
**AZIMUTH:** 0 **DIP:** -90
**TOTAL DEPTH (m):** 11.00
**WATER LEVEL (masl):** -

## Drillhole Log

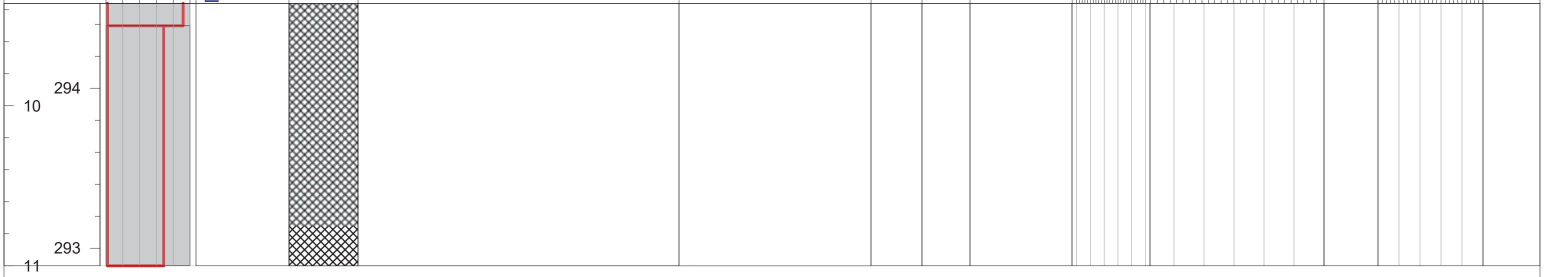
Depth (m) | Elev. (masl) | Recovery (%) | RQD (%) | 0 20 40 60 80 100

**Sample Type***
- 🟩 Grab
- 🟨 Creep
- 🟥 Cons.
- 🟪 Th.Cons.
- 🟫 Triax.
- 🟦 Uniax.

**Lithologic Symbol**

| | | |
|---|---|---|
| Organics | Sand | Boulder/Cobbles |
| Clay | Gravel | Bedrock |
| Silt | ICE | No Recovery |

**USCS** | **Soil Description** | **Drilling Notes & Additional Comments** | **Permafrost Symbol** | **Excess Ice Content (%)**** | **Permafrost Description** | **Salinity (ppt)** ● 0 2 4 6 8 10 | **Atterberg Limits** ■ Moisture Content ◆ Liquid Limit ● Plastic Limit (%) 0 20 40 60 80 100 | **Moisture Content > 100% (%)** | **PSD** Gravel / Sand / Silt / Clay (%) 0 20 40 60 80 100 | **PVC Installation/ Backfill**



**Permafrost Description**

| | | | |
|---|---|---|---|
| Uf: | Unfrozen | Vx: | Individual Ice Inclusions |
| Nf: | Poorly Bonded | Vc: | Ice Coatings on Particles |
| Nbn: | Well Bonded - No Excess Ice | Vr: | Randomly Oriented Ice Formations |
| Nbe: | Well Bonded - Excess Ice | Vs: | Stratified Ice Formations |
| ICE: | Ice without soil inclusions | UN: | Unknown, due to melting or no recovery |
| ICE w/ soil: | Ice with soil inclusions | | |

**Excess ice content determined by visual estimation in the field

* Cons.: Consolidation Test
Triax.: Triaxial Compression Test
Uniax.: Uniaxial Compression Test

**PVC Installation Details**

▩ Bentonite Chips ☐ 2" PVC

**PROJECT:** 2018 Geotechnical Investigation
**CLIENT:** Sabina Gold & Silver Corp

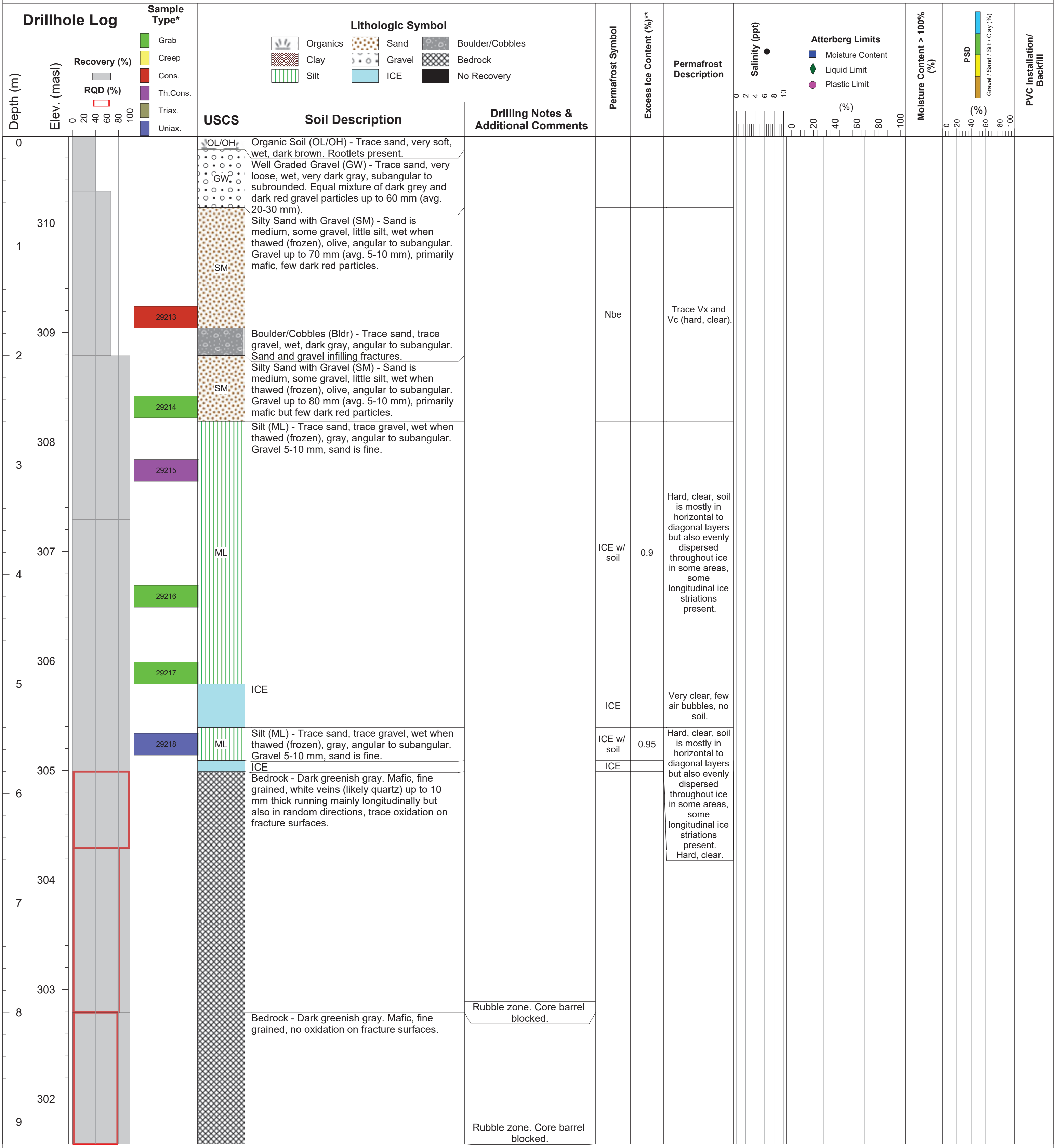
**DRILLHOLE ID:** SRK-18-DH10 (18GGT49)
**LOCATION:** PRIMARY POND HAUL ROAD DAM
**PROJECT NO:** 1CS020.016
**DRILL TYPE:** Diamond Drill
**CORE DIA (mm):** 63.5
**CONTRACTOR:** Major Drilling Group International
**LOGGED BY:** M. Stephenson

**DRILLING DATE:** 06-Apr-18 **TO:** 06-Apr-18
**COORDINATES:** 429,775 E 7,271,321 N
**DATUM:** UTM Projection NAD83 Zone 13
**GROUND ELEV. (masl):** 310.79
**AZIMUTH:** 0 **DIP:** -90
**TOTAL DEPTH (m):** 9.20
**WATER LEVEL (masl):** -

## Drillhole Log

**Sample Type***
- 🟩 Grab
- 🟨 Creep
- 🟥 Cons.
- 🟪 Th.Cons.
- Triax.
- 🟦 Uniax.

**Lithologic Symbol**
- Organics
- Clay
- Silt
- Sand
- Gravel
- ICE
- Boulder/Cobbles
- Bedrock
- ■ No Recovery



| USCS | Soil Description | Drilling Notes & Additional Comments | Permafrost Symbol | Excess Ice Content (%)** | Permafrost Description |
|---|---|---|---|---|---|
| OL/OH | Organic Soil (OL/OH) - Trace sand, very soft, wet, dark brown. Rootlets present. | | | | |
| GW | Well Graded Gravel (GW) - Trace sand, very loose, wet, very dark gray, subangular to subrounded. Equal mixture of dark grey and dark red gravel particles up to 60 mm (avg. 20-30 mm). | | | | |
| SM | Silty Sand with Gravel (SM) - Sand is medium, some gravel, little silt, wet when thawed (frozen), olive, angular to subangular. Gravel up to 70 mm (avg. 5-10 mm), primarily mafic, few dark red particles. | | Nbe | | Trace Vx and Vc (hard, clear). |
| | Boulder/Cobbles (Bldr) - Trace sand, trace gravel, wet, dark gray, angular to subangular. Sand and gravel infilling fractures. | | | | |
| SM | Silty Sand with Gravel (SM) - Sand is medium, some gravel, little silt, wet when thawed (frozen), olive, angular to subangular. Gravel up to 80 mm (avg. 5-10 mm), primarily mafic but few dark red particles. | | | | |
| ML | Silt (ML) - Trace sand, trace gravel, wet when thawed (frozen), gray, angular to subangular. Gravel 5-10 mm, sand is fine. | | ICE w/ soil | 0.9 | Hard, clear, soil is mostly in horizontal to diagonal layers but also evenly dispersed throughout ice in some areas, some longitudinal ice striations present. |
| | ICE | | ICE | | Very clear, few air bubbles, no soil. |
| ML | Silt (ML) - Trace sand, trace gravel, wet when thawed (frozen), gray, angular to subangular. Gravel 5-10 mm, sand is fine. | | ICE w/ soil | 0.95 | Hard, clear, soil is mostly in horizontal to diagonal layers but also evenly dispersed throughout ice in some areas, some longitudinal ice striations present. |
| | ICE | | ICE | | Hard, clear. |
| | Bedrock - Dark greenish gray. Mafic, fine grained, white veins (likely quartz) up to 10 mm thick running mainly longitudinally but also in random directions, trace oxidation on fracture surfaces. | Rubble zone. Core barrel blocked. | | | |
| | Bedrock - Dark greenish gray. Mafic, fine grained, no oxidation on fracture surfaces. | Rubble zone. Core barrel blocked. | | | |

**Permafrost Description**

| | | | |
|---|---|---|---|
| Uf: | Unfrozen | Vx: | Individual Ice Inclusions |
| Nf: | Poorly Bonded | Vc: | Ice Coatings on Particles |
| Nbn: | Well Bonded - No Excess Ice | Vr: | Randomly Oriented Ice Formations |
| Nbe: | Well Bonded - Excess Ice | Vs: | Stratified Ice Formations |
| ICE: | Ice without soil inclusions | UN: | Unknown, due to melting or no recovery |
| ICE w/ soil: | Ice with soil inclusions | | |

**Excess ice content determined by visual estimation in the field

* Cons.: Consolidation Test
Triax.: Triaxial Compression Test
Uniax.: Uniaxial Compression Test

**PVC Installation Details**

▩ Bentonite Chips ☐ 2" PVC

**PROJECT:** 2018 Geotechnical Investigation
**CLIENT:** Sabina Gold & Silver Corp

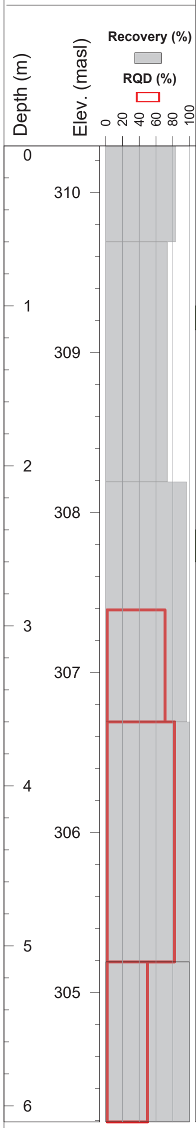
**DRILLHOLE ID:** SRK-18-DH26 (18GGT50)
**LOCATION:** PRIMARY POND HAUL ROAD DAM
**PROJECT NO:** 1CS020.016
**DRILL TYPE:** Diamond Drill
**CORE DIA (mm):** 63.5
**CONTRACTOR:** Major Drilling Group International
**LOGGED BY:** M. Stephenson/S. Sam

**DRILLING DATE:** 06-Apr-18 **TO:** 06-Apr-18
**COORDINATES:** 429,753 E 7,271,326 N
**DATUM:** UTM Projection NAD83 Zone 13
**GROUND ELEV. (masl):** 310.29
**AZIMUTH:** 0 **DIP:** -90
**TOTAL DEPTH (m):** 6.10
**WATER LEVEL (masl):** -

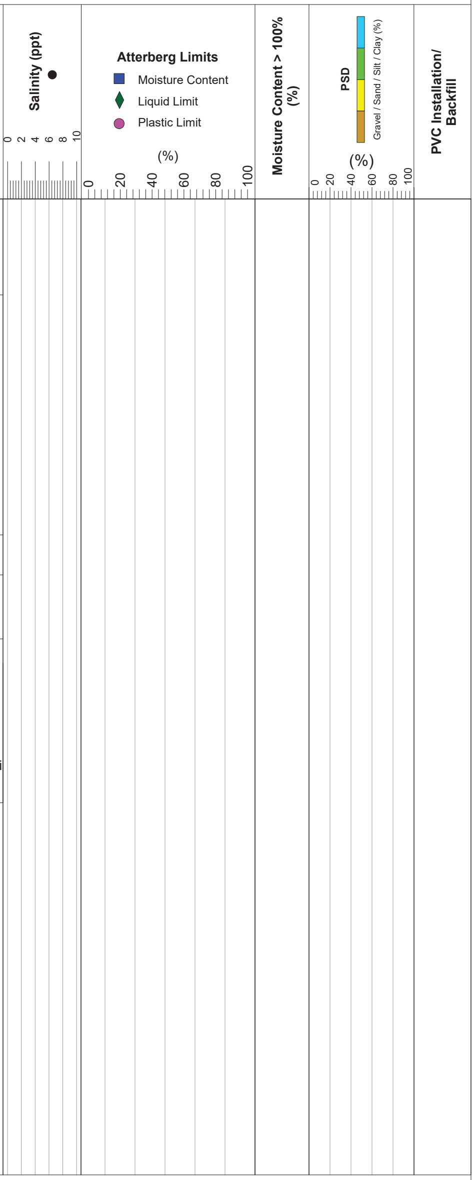
## Drillhole Log

**Sample Type***
- 🟩 Grab
- 🟨 Creep
- 🟥 Cons.
- 🟪 Th.Cons.
- ▨ Triax.
- 🟦 Uniax.

**Lithologic Symbol**
- ▨ Organics
- ▨ Clay
- ▨ Silt
- ▨ Sand
- ▨ Gravel
- ▨ ICE
- ▨ Boulder/Cobbles
- ▨ Bedrock
- ■ No Recovery



| Sample Type* | USCS | Soil Description | Drilling Notes & Additional Comments | Permafrost Symbol | Excess Ice Content (%)** | Permafrost Description |
|---|---|---|---|---|---|---|
| | OL/OH | Organic Soil (OL/OH) - Wet when thawed (frozen), dark brown. Rootlets. | | Nbe | | |
| 29219 | SW | Well Graded Sand with Gravel (SW) - Sand is medium to coarse, little organics, little gravel, wet when thawed (frozen), very dark grayish brown, subangular. Gravel up to 20 mm (avg. 5-10 mm).<br>Becomes: Little cobble. | | | 0.4 | 10% Vs, 10% Vc, 10% Vr (hard, clear). |
| | | Boulder/Cobbles (Bldr) - Coarse, very dark gray. | | | | |
| 29220 | SW-SM | Well Graded Sand with Silt (SW-SM) - Sand is medium to coarse, some gravel, wet when thawed (frozen), gray. | | Nbn | | |
| | ML | Silt (ML) - Trace sand, trace gravel, wet when thawed (frozen), dark gray. | | ICE w/ soil | 0.75 | Hard, clear, soil is mostly as horizontal to diagonal layers but also evenly dispersed throughout, some vertical/longitudinal ice striations. |
| | | Bedrock - Dark greenish gray greywacke. Mafic, massive, fine grained, horizontal and vertical quartz veins 0.05-0.30m long, quartz content increases with depth. | | | | |



**Permafrost Description**

| | | | |
|---|---|---|---|
| Uf: | Unfrozen | Vx: | Individual Ice Inclusions |
| Nf: | Poorly Bonded | Vc: | Ice Coatings on Particles |
| Nbn: | Well Bonded - No Excess Ice | Vr: | Randomly Oriented Ice Formations |
| Nbe: | Well Bonded - Excess Ice | Vs: | Stratified Ice Formations |
| ICE: | Ice without soil inclusions | UN: | Unknown, due to melting or no recovery |
| ICE w/ soil: | Ice with soil inclusions | | |

**Excess ice content determined by visual estimation in the field

* Cons.: Consolidation Test
Triax.: Triaxial Compression Test
Uniax.: Uniaxial Compression Test

**PVC Installation Details**

▨ Bentonite Chips ☐ 2" PVC

srk consulting

Sabina GOLD & SILVER CORP

PROJECT: 2021 Geotechnical Drilling
CLIENT: Sabina Gold & Silver Corp

DRILLHOLE ID: SRK-21-DH01-PP
LOCATION: Primary Pond Dam
PROJECT NO: 1CS020.021
DRILL TYPE: Diamond Drill
CORE DIA (mm): 63.5
CONTRACTOR: Major Drilling Group International
LOGGED BY: JU/JBK

DRILLING DATE: 13-Apr-21 TO: 14-Apr-21
COORDINATES: 429,814 E 7,271,208 N
DATUM: UTM Projection NAD83 Zone 13
GROUND ELEV. (masl): 310.3
AZIMUTH: 0 DIP: -90
TOTAL DEPTH (m): 5.40
DEPTH TO BEDROCK (m): 3.90
WATER LEVEL (masl): -

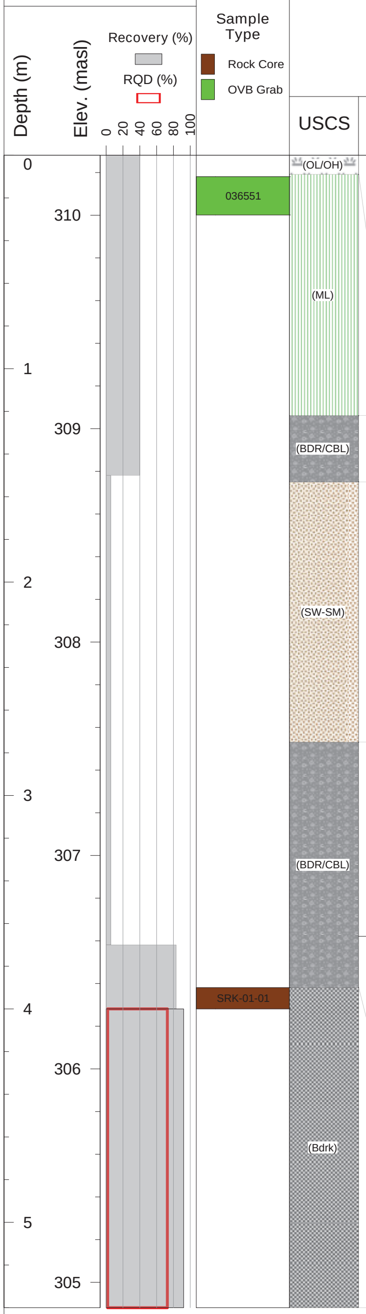
## Drillhole Log

Lithologic Symbol

| | | | | | |
|---|---|---|---|---|---|
| ▨ | Organics | ▨ | Sand | ▨ | Boulder/Cobbles |
| ▨ | Clay | ▨ | Gravel | ▨ | Bedrock |
| ▨ | Silt | 🟦 | ICE | ■ | No Recovery |

Sample Type: 🟫 Rock Core 🟩 OVB Grab

Recovery (%) ▭ RQD (%) 🟥



| USCS | Soil Description | Drilling Notes & Additional Comments | Permafrost Symbol | Excess Ice Content (%)* | Permafrost Description |
|---|---|---|---|---|---|
| (OL/OH) | Organic Soil (OL/OH) - Medium, little silt, few gravel, frozen, wet when thawed (frozen), dusky red, noncohesive, angular to subangular, well graded, gradual (>10 cm). Frozen, ice/snow layers throughout the interval. Top tundra matt. Organics and silt ric | | Vr | 0.1 | Randomly oriented formations, mostly horizontal. |
| (ML) | Sandy Silt (ML) - Fine, some sand, trace gravel, frozen, wet when thawed (frozen), brown, low plasticity, subangular, well graded, gradual (>10 cm). 5cm (2') fat clay lence at ~1 mbgs. | Core run was retrieved at 0.9 m due to thawed material coming out from the collar. | | | |
| (BDR/CBL) | Boulder/Cobbles (BDR/CBL) - Dark greenish gray. Outside of core looks washed / impacted by water from drilling. | | | | |
| (SW-SM) | Well Graded Sand with Silt and Gravel (SW-SM) - Sand is medium, some gravel, little, frozen, wet when thawed (frozen), pinkish gray, subangular to subrounded, well graded, massive, gradual (>10 cm). Sand rich unit. Very poor recovery. Inferring some of th | | | | |
| (BDR/CBL) | Boulder/Cobbles (BDR/CBL) - Some sand, little gravel, very dense, gray, subangular to subrounded, well graded. Recovered cobbles and rocks are of various colours (reddish, black, cloudy white). Poor recovery and short split due to loose drill rod connecti | Drill rod froze in hole. Adjusted brine concentration (more CaCl), reamed out, then continued drilling. Ice rich soil plugged the drill bit end.<br>Lots of drill chatter and rod bounding. Variable and inconsistent. Following this drilling started to get 'smoother' again. | Vs | Unable to estimate | Ice lence / ice formation. Hard to know exact start and finish as portion of run washed away from drilling in sandier unit above. |
| (BDR/CBL) | Boulder/Cobbles (BDR/CBL) - Some sand, very dark gray. Various coloured larger rock fragments. Just before the top of potential weathered bedrock. Portion of the sample is washed out. Measurements are approximate. Some sand is recovered. Assumed sand was | Driller pulled out the core barrel with the tube in it. Tried pulling it out, did not work. Removed the whole drilling barrel/rod from the hole, removed the drill bit and pushed out the tube. Suspected reason for tube getting stuck is sand clog up between | | | |
| (Bdrk) | Bedrock (Bdrk) - Dark greenish gray. Only have one run into rock then had to end hole. Assumed this is bedrock. Consistent rock unit. Unable to drill another run without mobilizing casing and driving casing from top of hole. | | | | |
| | | End of Hole (EOH) at 5.4 m. Hole terminated due to drill bit getting stuck in the hole. | | | |

Salinity (ppt) ● 0 2 4 6 8 10

Atterberg Limits
■ Moisture Content
◆ Liquid Limit
● Plastic Limit
(%) 0 20 40 60 80 100

Moisture Content > 100% (%)

PSD Gravel / Sand / Silt / Clay (%) 0 20 40 60 80 100

PVC Installation/ Backfill

### Permafrost Description

Uf: Unfrozen
Nf: Poorly Bonded
Nbn: Well Bonded - No Excess Ice
Nbe: Well Bonded - Excess Ice
ICE: Ice without soil inclusions
ICE w/ soil: Ice with soil inclusions
Vx: Individual Ice Inclusions
Vc: Ice Coatings on Particles
Vr: Randomly Oriented Ice Formations
Vs: Stratified Ice Formations
UN: Unknown, due to melting or no recovery

*Excess ice content determined by visual estimation in the field

### PVC Installation Details

▨ Bentonite Chips ▭ 2" PVC

srk consulting

Sabina GOLD & SILVER CORP

PROJECT: 2021 Geotechnical Drilling
CLIENT: Sabina Gold & Silver Corp

DRILLHOLE ID: SRK-21-DH02A-PP
LOCATION: Primary Pond Dam
PROJECT NO: 1CS020.021
DRILL TYPE: Diamond Drill
CORE DIA (mm): 63.5
CONTRACTOR: Major Drilling Group International
LOGGED BY: JBK

DRILLING DATE: 14-Apr-21 TO: 14-Apr-21
COORDINATES: 429,649 E 7,271,332 N
DATUM: UTM Projection NAD83 Zone 13
GROUND ELEV. (masl): 306.8
AZIMUTH: 0 DIP: -90
TOTAL DEPTH (m): 1.50
DEPTH TO BEDROCK (m): -
WATER LEVEL (masl): -

## Drillhole Log

Recovery (%) ▨ RQD (%) ☐

Sample Type: 🟫 Rock Core 🟩 OVB Grab

Lithologic Symbol: Organics, Sand, Boulder/Cobbles, Clay, Gravel, Bedrock, Silt, ICE, No Recovery

Atterberg Limits: ■ Moisture Content ◆ Liquid Limit ● Plastic Limit

PSD: Gravel / Sand / Silt / Clay (%)

| Depth (m) | Elev. (masl) | Sample Type | USCS | Soil Description | Drilling Notes & Additional Comments | Permafrost Symbol | Excess Ice Content (%)* | Permafrost Description |
|---|---|---|---|---|---|---|---|---|
| 0 | | | (OL/OH) | Organic Soil (OL/OH) - Medium, few silt, trace sand, frozen, wet when thawed (frozen), brown. Top tundra matt. Very fibrous. Frozen. Rich brown colour. | | Nbn | 0.05 | Well bonded frozen tundra (organics and organic rich soil). |
| | | 036552 | (SM) | Silty Sand (SM) - Sand is fine, some silt, few gravel, frozen, wet when thawed (frozen), grayish brown, slow dilatancy, non-plastic, cohesive, subangular to subrounded, well graded, massive, gradual (>10 cm). Fines around some of the outside portion of co | | Nbe | 0.1 | Well bonded with a little bit of excess ice. |
| | 306 | | (SW) | Well Graded Sand with Gravel (SW) - Sand is medium, little gravel, trace silt, frozen, wet when thawed (frozen), reddish brown, no dilatancy, non-plastic, noncohesive, subangular to subrounded, well graded, massive, sharp (< 10 cm). | | Vs | 0.15 | Some stratified / distinct ice layers through section. Clear ice lence form 0.8 to 0.83 m. |
| 1 | | | (BDR/CBL) | Boulder/Cobbles (BDR/CBL) - Dark greenish gray. Cobble with one joint in it. From surrounding bedrock, looks like similar rock unit to surrounding outcrops. Dark, fine grained. | | | | |
| | | 036553 | (SM) | Silty Sand with Gravel (SM) - Sand is fine, little silt, few gravel, frozen, wet when thawed (frozen), gray, slow dilatancy, non-plastic, noncohesive, subangular to subrounded, well graded, massive, gradual (>10 cm). Ice in core. more ice around lower por | Ice rich zone. End of core looks like ice rich soil washed out.<br>End of Hole (EOH) at 1.5 m. Hole terminated due to drill rods getting stuck in hole. Sand grabbing bit. Bit broke off from rods. Drill in same / similar area. Move hole forward to east by ~0.4m and restart hole. | Vr | 0.2 | Ice coatings to notable ice and random irregular oriented ice formations. |

Salinity (ppt) ● 0 2 4 6 8 10

Atterberg Limits (%) 0 20 40 60 80 100

Moisture Content > 100% (%)

PSD (%) 0 20 40 60 80 100

PVC Installation/ Backfill

### Permafrost Description

Uf: Unfrozen
Nf: Poorly Bonded
Nbn: Well Bonded - No Excess Ice
Nbe: Well Bonded - Excess Ice
ICE: Ice without soil inclusions
ICE w/ soil: Ice with soil inclusions
Vx: Individual Ice Inclusions
Vc: Ice Coatings on Particles
Vr: Randomly Oriented Ice Formations
Vs: Stratified Ice Formations
UN: Unknown, due to melting or no recovery
*Excess ice content determined by visual estimation in the field

### PVC Installation Details

▨ Bentonite Chips ☐ 2" PVC

srk consulting

Sabina GOLD & SILVER CORP

PROJECT: 2021 Geotechnical Drilling
CLIENT: Sabina Gold & Silver Corp

DRILLHOLE ID: SRK-21-DH02B-PP
LOCATION: Primary Pond Dam
PROJECT NO: 1CS020.021
DRILL TYPE: Diamond Drill
CORE DIA (mm): 63.5
CONTRACTOR: Major Drilling Group International
LOGGED BY: JU/JBK

DRILLING DATE: 14-Apr-21 TO: 15-Apr-21
COORDINATES: 429,649 E 7,271,332 N
DATUM: UTM Projection NAD83 Zone 13
GROUND ELEV. (masl): 306.8
AZIMUTH: 0 DIP: -90
TOTAL DEPTH (m): 18.00
DEPTH TO BEDROCK (m): 3.50
WATER LEVEL (masl): -

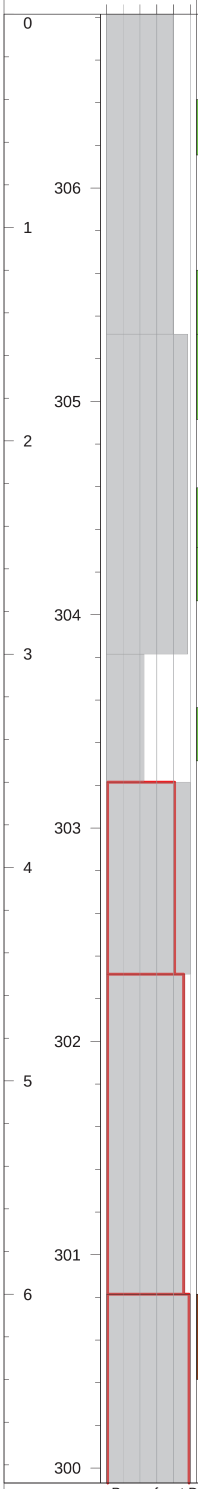
## Drillhole Log

Recovery (%) ▨
RQD (%) 🟥

Sample Type: 🟫 Rock Core, 🟩 OVB Grab

Lithologic Symbol: Organics, Sand, Boulder/Cobbles, Clay, Gravel, Bedrock, Silt, ICE, ■ No Recovery

Columns: Depth (m) | Elev. (masl) | Recovery (%) / RQD (%) | Sample Type | USCS | Soil Description | Drilling Notes & Additional Comments | Permafrost Symbol | Excess Ice Content (%)* | Permafrost Description | Salinity (ppt) ● | Atterberg Limits (%): Moisture Content, Liquid Limit, Plastic Limit | Moisture Content > 100% (%) | PSD (%) Gravel / Sand / Silt / Clay (%) | PVC Installation/ Backfill



| USCS | Soil Description |
|---|---|
| (OL/OH) | Organic Soil (OL/OH) - Medium, few silt, trace sand, frozen, wet when thawed (frozen), brown. Top tundra matt. Very fibrous. Frozen. Rich brown colour. |
| (SM) | Silty Sand with Gravel (SM) - Sand is medium, some silt, little gravel, frozen, wet when thawed (frozen), grayish brown, slow dilatancy, non-plastic, cohesive, subangular, well graded, massive, sharp (< 10 cm). Sharp transition from organic layer. Less sh |
| (ML) | Sandy Silt with Gravel (ML) - Fine, little sand, little gravel, frozen, wet when thawed (frozen), dark olive gray, angular to subangular, well graded, thickly bedded, gradual (>10 cm). Little cobbles along the layer. 5cm cobble at 1.95-2m. Recovered core |
| (BDR/CBL) | Boulder/Cobbles (BDR/CBL) - Very dark gray. Fine grained rock. |
| (SM) | Silty Sand (SM) - Sand is fine, some silt, frozen, wet when thawed (frozen), dark olive gray, subangular to subrounded, well graded, bedded, sharp (< 10 cm). |
| | Becomes: Some gravel, little cobble, gray. Significantly more gravel and cobbles. Transition in ~ 5 cm. |
| | Becomes: Very loose, wet. Top 35 cm is washed out. |
| | Weathered Bedrock (Bdrk) - Some gravel, very dark gray. Crushed up on the top. Orange (oxidation) staining from 3.6 to 3.8 m (close to vertical fracture (80 to 85 degrees from horizontal)). |
| | Bedrock (Bdrk) - Very dark gray. Orange (oxidation) staining at 4.2m (close to horizontal fractures). Fracture likely 2-3cm wide or filled with fines. |
| | Bedrock (Bdrk) - Very dark gray. More frequent and larger oxidised fractures than the run above. |
| | Bedrock (Bdrk) - Very dark gray. |

Sample Type: 036554, 036555, 036556, 036557, 036558, 036559 (OVB Grab); SRK-02B-01 (Rock Core)

Drilling Notes & Additional Comments:

Water on top of the sample. Likely the drilling brine.

The run was continuous with signs of small washout. Driller noted that the snow of top of ground was completely removed under the dill bit. Drilling started once snow was cleated to the ground surface.

Recovered the core at 7.2 due to difficulties with drilling. Drilled the 7.2-7.5 separately. Oxidised fractures from 6.4 to 7 m.

| Permafrost Symbol | Excess Ice Content (%)* | Permafrost Description |
|---|---|---|
| Nbn | | |
| Vs | 0.4 | Mainly stratified, some irregularly oriented formations. |
| | 0.1 | |
| Ice | 1 | Clear, colourless. |
| Vr | 0.15 | |
| | | |
| Nbe | | Cobble between 1.95 and 2m. |
| | | |
| Nbe | | Boulder between 2.1 and 2.22m. |
| Vs | 0.08 | Some boulders (up to 5 cm in the interval). |

### Permafrost Description

Uf: Unfrozen
Nf: Poorly Bonded
Nbn: Well Bonded - No Excess Ice
Nbe: Well Bonded - Excess Ice
ICE: Ice without soil inclusions
ICE w/ soil: Ice with soil inclusions
Vx: Individual Ice Inclusions
Vc: Ice Coatings on Particles
Vr: Randomly Oriented Ice Formations
Vs: Stratified Ice Formations
UN: Unknown, due to melting or no recovery

*Excess ice content determined by visual estimation in the field

### PVC Installation Details

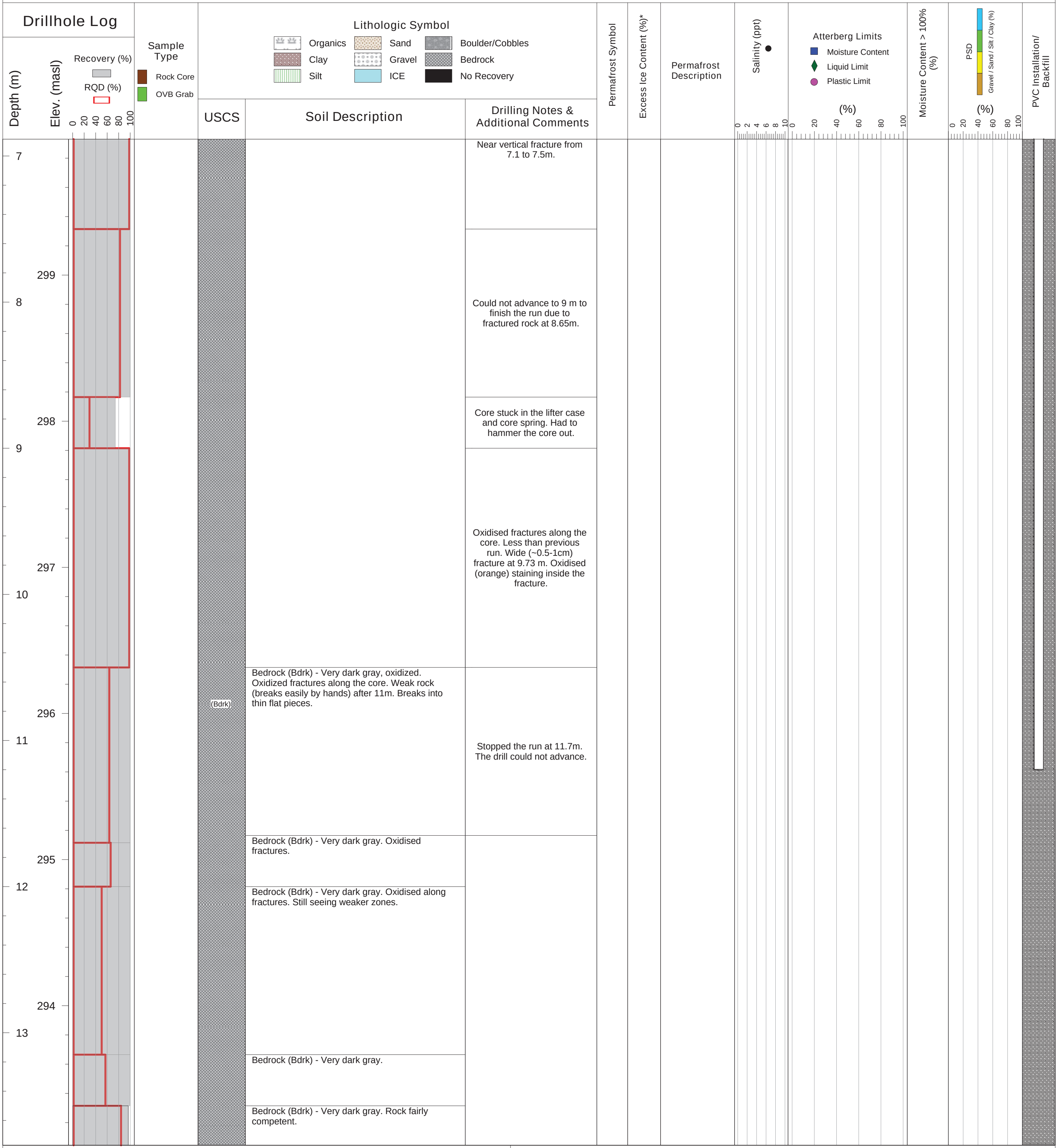
▨ Bentonite Chips ☐ 2" PVC

PROJECT: 2021 Geotechnical Drilling
CLIENT: Sabina Gold & Silver Corp

DRILLHOLE ID: SRK-21-DH02B-PP
LOCATION: Primary Pond Dam
PROJECT NO: 1CS020.021
DRILL TYPE: Diamond Drill
CORE DIA (mm): 63.5
CONTRACTOR: Major Drilling Group International
LOGGED BY: JU/JBK

DRILLING DATE: 14-Apr-21 TO: 15-Apr-21
COORDINATES: 429,649 E 7,271,332 N
DATUM: UTM Projection NAD83 Zone 13
GROUND ELEV. (masl): 306.8
AZIMUTH: 0 DIP: -90
TOTAL DEPTH (m): 18.00
DEPTH TO BEDROCK (m): 3.50
WATER LEVEL (masl): -

## Drillhole Log



Near vertical fracture from 7.1 to 7.5m.

Could not advance to 9 m to finish the run due to fractured rock at 8.65m.

Core stuck in the lifter case and core spring. Had to hammer the core out.

Oxidised fractures along the core. Less than previous run. Wide (~0.5-1cm) fracture at 9.73 m. Oxidised (orange) staining inside the fracture.

Bedrock (Bdrk) - Very dark gray, oxidized. Oxidized fractures along the core. Weak rock (breaks easily by hands) after 11m. Breaks into thin flat pieces.

Stopped the run at 11.7m. The drill could not advance.

Bedrock (Bdrk) - Very dark gray. Oxidised fractures.

Bedrock (Bdrk) - Very dark gray. Oxidised along fractures. Still seeing weaker zones.

Bedrock (Bdrk) - Very dark gray.

Bedrock (Bdrk) - Very dark gray. Rock fairly competent.

Permafrost Description

Uf: Unfrozen
Nf: Poorly Bonded
Nbn: Well Bonded - No Excess Ice
Nbe: Well Bonded - Excess Ice
ICE: Ice without soil inclusions
ICE w/ soil: Ice with soil inclusions
Vx: Individual Ice Inclusions
Vc: Ice Coatings on Particles
Vr: Randomly Oriented Ice Formations
Vs: Stratified Ice Formations
UN: Unknown, due to melting or no recovery

*Excess ice content determined by visual estimation in the field

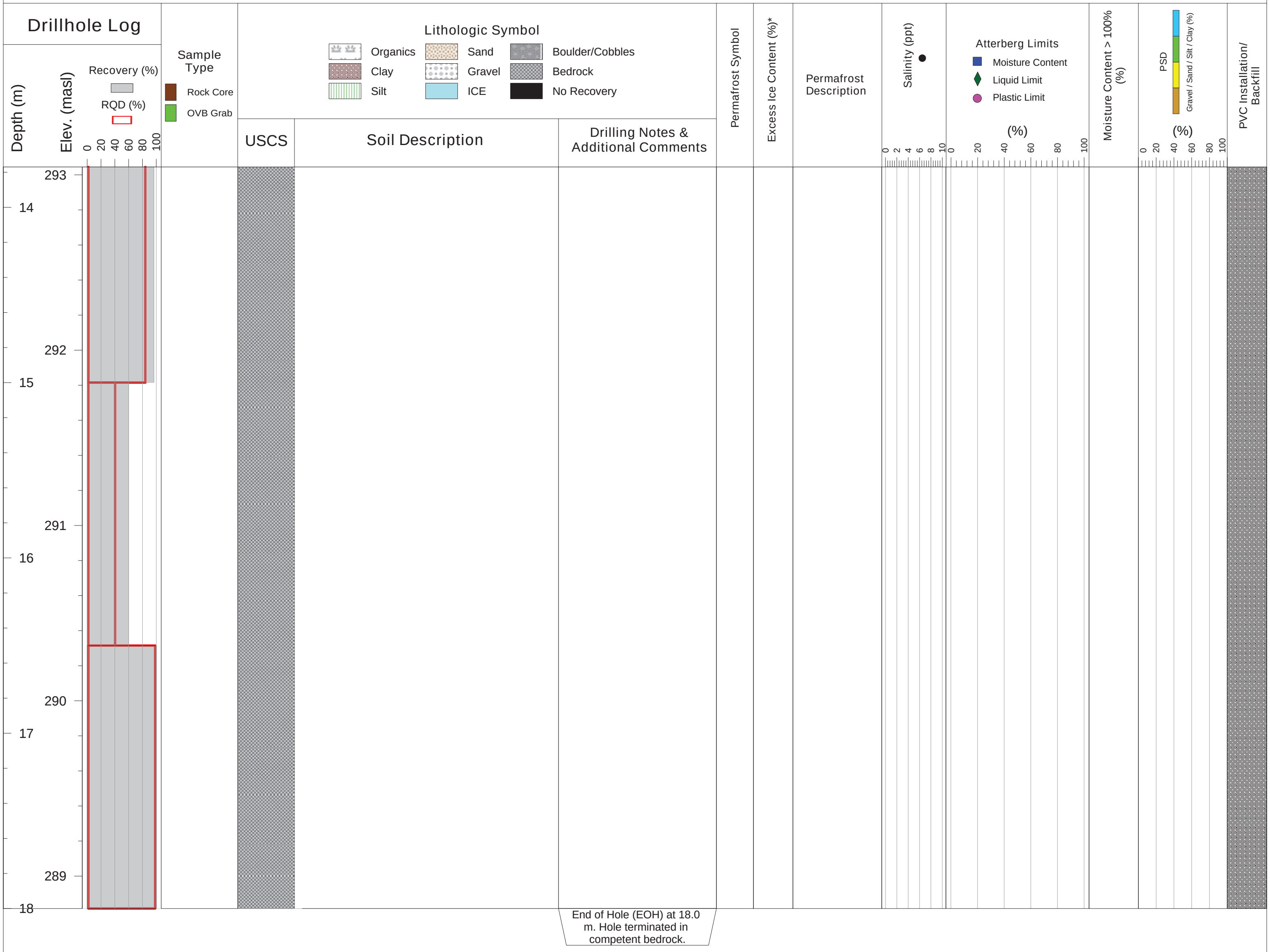
PVC Installation Details

▨ Bentonite Chips ☐ 2" PVC

PROJECT: 2021 Geotechnical Drilling
CLIENT: Sabina Gold & Silver Corp

DRILLHOLE ID: SRK-21-DH02B-PP
LOCATION: Primary Pond Dam
PROJECT NO: 1CS020.021
DRILL TYPE: Diamond Drill
CORE DIA (mm): 63.5
CONTRACTOR: Major Drilling Group International
LOGGED BY: JU/JBK

DRILLING DATE: 14-Apr-21 TO: 15-Apr-21
COORDINATES: 429,649 E 7,271,332 N
DATUM: UTM Projection NAD83 Zone 13
GROUND ELEV. (masl): 306.8
AZIMUTH: 0 DIP: -90
TOTAL DEPTH (m): 18.00
DEPTH TO BEDROCK (m): 3.50
WATER LEVEL (masl): -



End of Hole (EOH) at 18.0 m. Hole terminated in competent bedrock.

Permafrost Description

Uf: Unfrozen
Nf: Poorly Bonded
Nbn: Well Bonded - No Excess Ice
Nbe: Well Bonded - Excess Ice
ICE: Ice without soil inclusions
ICE w/ soil: Ice with soil inclusions

Vx: Individual Ice Inclusions
Vc: Ice Coatings on Particles
Vr: Randomly Oriented Ice Formations
Vs: Stratified Ice Formations
UN: Unknown, due to melting or no recovery

*Excess ice content determined by visual estimation in the field

PVC Installation Details

▩ Bentonite Chips ☐ 2" PVC

srk consulting

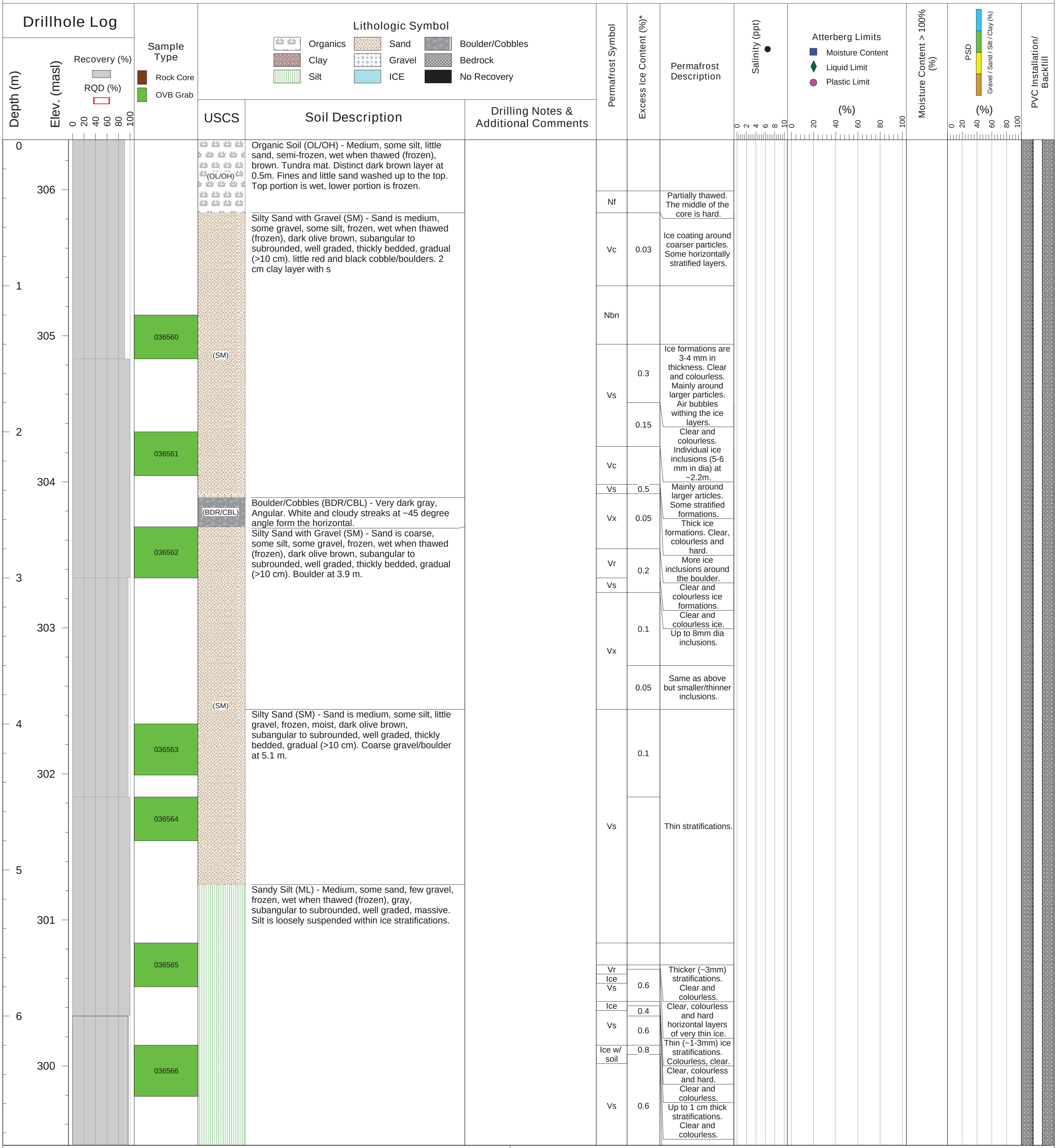
Sabina GOLD & SILVER CORP

PROJECT: 2021 Geotechnical Drilling
CLIENT: Sabina Gold & Silver Corp

DRILLHOLE ID: SRK-21-DH03-PP
LOCATION: Primary Pond Dam
PROJECT NO: 1CS020.021
DRILL TYPE: Diamond Drill
CORE DIA (mm): 63.5
CONTRACTOR: Major Drilling Group International
LOGGED BY: JU/JBK

DRILLING DATE: 16-Apr-21 TO: 16-Apr-21
COORDINATES: 429,577 E 7,271,392 N
DATUM: UTM Projection NAD83 Zone 13
GROUND ELEV. (masl): 306.3
AZIMUTH: 0 DIP: -90
TOTAL DEPTH (m): 19.50
DEPTH TO BEDROCK (m): 11.10
WATER LEVEL (masl): -

## Drillhole Log



| USCS | Soil Description |
|---|---|
| (OL/OH) | Organic Soil (OL/OH) - Medium, some silt, little sand, semi-frozen, wet when thawed (frozen), brown. Tundra mat. Distinct dark brown layer at 0.5m. Fines and little sand washed up to the top. Top portion is wet, lower portion is frozen. |
| (SM) | Silty Sand with Gravel (SM) - Sand is medium, some gravel, some silt, frozen, wet when thawed (frozen), dark olive brown, subangular to subrounded, well graded, thickly bedded, gradual (>10 cm). little red and black cobble/boulders. 2 cm clay layer with s |
| (BDR/CBL) | Boulder/Cobbles (BDR/CBL) - Very dark gray, Angular. White and cloudy streaks at ~45 degree angle form the horizontal. |
| (SM) | Silty Sand with Gravel (SM) - Sand is coarse, some silt, some gravel, frozen, wet when thawed (frozen), dark olive brown, subangular to subrounded, well graded, thickly bedded, gradual (>10 cm). Boulder at 3.9 m. |
| | Silty Sand (SM) - Sand is medium, some silt, little gravel, frozen, moist, dark olive brown, subangular to subrounded, well graded, thickly bedded, gradual (>10 cm). Coarse gravel/boulder at 5.1 m. |
| | Sandy Silt (ML) - Medium, some sand, few gravel, frozen, wet when thawed (frozen), gray, subangular to subrounded, well graded, massive. Silt is loosely suspended within ice stratifications. |

| Permafrost Symbol | Excess Ice Content (%)* | Permafrost Description |
|---|---|---|
| Nf | | Partially thawed. The middle of the core is hard. |
| Vc | 0.03 | Ice coating around coarser particles. Some horizontally stratified layers. |
| Nbn | | |
| Vs | 0.3 | Ice formations are 3-4 mm in thickness. Clear and colourless. Mainly around larger particles. Air bubbles withing the ice layers. |
| | 0.15 | Clear and colourless. Individual ice inclusions (5-6 mm in dia) at ~2.2m. |
| Vc | | Mainly around larger articles. Some stratified formations. |
| Vs | 0.5 | Thick ice formations. Clear, colourless and hard. |
| Vx | 0.05 | More ice inclusions around the boulder. |
| Vr | 0.2 | Clear and colourless ice formations. |
| Vs | | Clear and colourless ice. |
| Vx | 0.1 | Up to 8mm dia inclusions. |
| | 0.05 | Same as above but smaller/thinner inclusions. |
| Vs | 0.1 | Thin stratifications. |
| | | |
| Vr<br>Ice<br>Vs | 0.6 | Thicker (~3mm) stratifications. Clear and colourless. |
| Ice | | Clear, colourless and hard horizontal layers of very thin ice. |
| | 0.4 | |
| Vs | 0.6 | Thin (~1-3mm) ice stratifications. Colourless, clear. |
| Ice w/ soil | 0.8 | Clear, colourless and hard. |
| Vs | 0.6 | Clear and colourless.<br>Up to 1 cm thick stratifications. Clear and colourless. |

Permafrost Description

| | | | |
|---|---|---|---|
| Uf: | Unfrozen | Vx: | Individual Ice Inclusions |
| Nf: | Poorly Bonded | Vc: | Ice Coatings on Particles |
| Nbn: | Well Bonded - No Excess Ice | Vr: | Randomly Oriented Ice Formations |
| Nbe: | Well Bonded - Excess Ice | Vs: | Stratified Ice Formations |
| ICE: | Ice without soil inclusions | UN: | Unknown, due to melting or no recovery |
| ICE w/ soil: | Ice with soil inclusions | | |

*Excess ice content determined by visual estimation in the field

PVC Installation Details

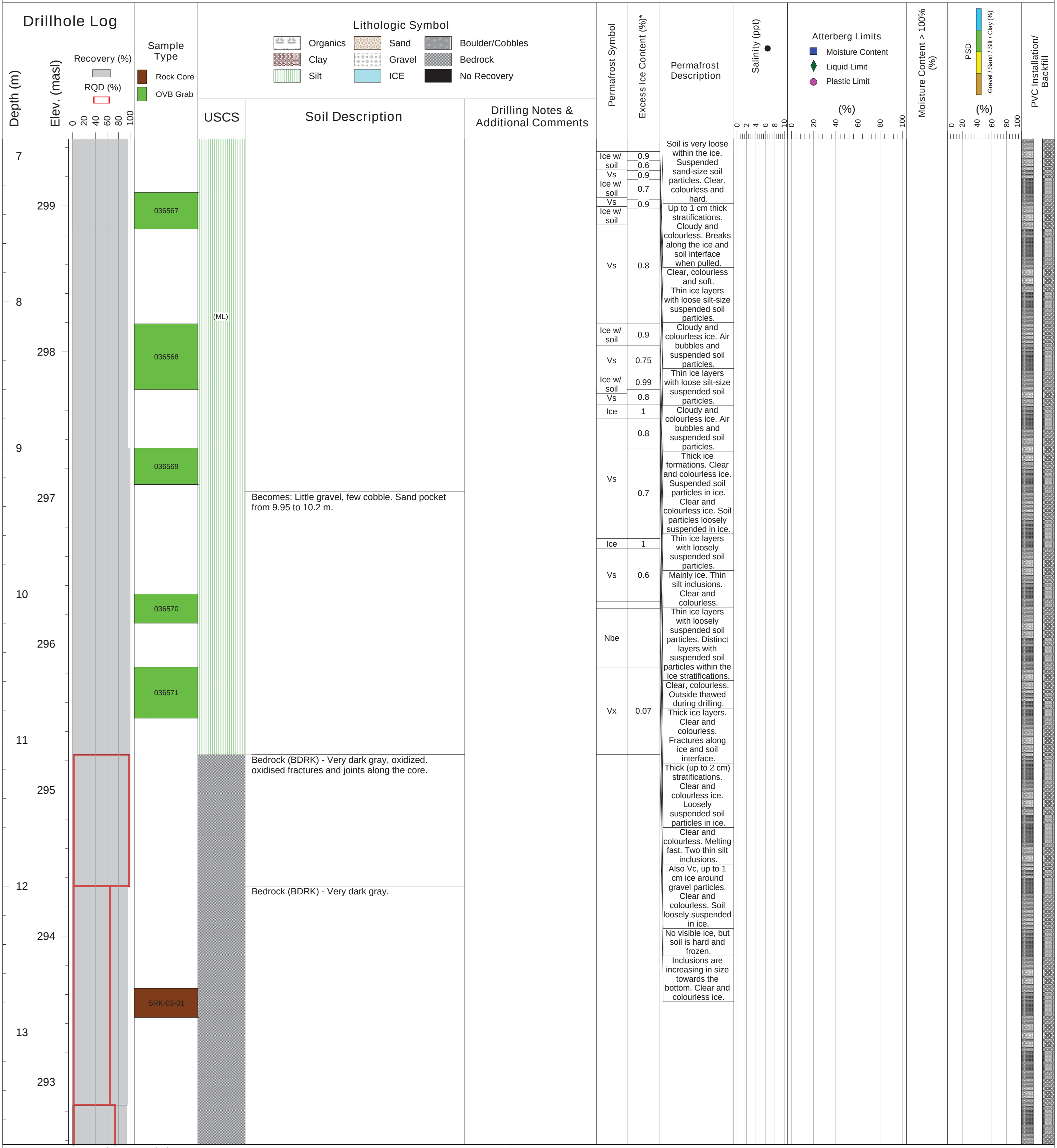
▨ Bentonite Chips ☐ 2" PVC

PROJECT: 2021 Geotechnical Drilling
CLIENT: Sabina Gold & Silver Corp

DRILLHOLE ID: SRK-21-DH03-PP
LOCATION: Primary Pond Dam
PROJECT NO: 1CS020.021
DRILL TYPE: Diamond Drill
CORE DIA (mm): 63.5
CONTRACTOR: Major Drilling Group International
LOGGED BY: JU/JBK

DRILLING DATE: 16-Apr-21 TO: 16-Apr-21
COORDINATES: 429,577 E 7,271,392 N
DATUM: UTM Projection NAD83 Zone 13
GROUND ELEV. (masl): 306.3
AZIMUTH: 0 DIP: -90
TOTAL DEPTH (m): 19.50
DEPTH TO BEDROCK (m): 11.10
WATER LEVEL (masl): -

## Drillhole Log



Soil Description:

Becomes: Little gravel, few cobble. Sand pocket from 9.95 to 10.2 m.

Bedrock (BDRK) - Very dark gray, oxidized. oxidised fractures and joints along the core.

Bedrock (BDRK) - Very dark gray.

| Permafrost Symbol | Excess Ice Content (%)* |
|---|---|
| Ice w/ soil | 0.9 |
| | 0.6 |
| Vs | 0.9 |
| Ice w/ soil | 0.7 |
| Vs | 0.9 |
| Ice w/ soil | |
| Vs | 0.8 |
| Ice w/ soil | 0.9 |
| Vs | 0.75 |
| Ice w/ soil | 0.99 |
| Vs | 0.8 |
| Ice | 1 |
| Vs | 0.8 |
| | 0.7 |
| Ice | 1 |
| Vs | 0.6 |
| Nbe | |
| Vx | 0.07 |

Permafrost Description:

- Soil is very loose within the ice. Suspended sand-size soil particles. Clear, colourless and hard.
- Up to 1 cm thick stratifications. Cloudy and colourless. Breaks along the ice and soil interface when pulled.
- Clear, colourless and soft.
- Thin ice layers with loose silt-size suspended soil particles.
- Cloudy and colourless ice. Air bubbles and suspended soil particles.
- Thin ice layers with loose silt-size suspended soil particles.
- Cloudy and colourless ice. Air bubbles and suspended soil particles.
- Thick ice formations. Clear and colourless ice. Suspended soil particles in ice.
- Clear and colourless ice. Soil particles loosely suspended in ice.
- Thin ice layers with loosely suspended soil particles.
- Mainly ice. Thin silt inclusions. Clear and colourless.
- Thin ice layers with loosely suspended soil particles. Distinct layers with suspended soil particles within the ice stratifications.
- Clear, colourless. Outside thawed during drilling.
- Thick ice layers. Clear and colourless. Fractures along ice and soil interface.
- Thick (up to 2 cm) stratifications. Clear and colourless ice. Loosely suspended soil particles in ice.
- Clear and colourless. Melting fast. Two thin silt inclusions.
- Also Vc, up to 1 cm ice around gravel particles. Clear and colourless. Soil loosely suspended in ice.
- No visible ice, but soil is hard and frozen.
- Inclusions are increasing in size towards the bottom. Clear and colourless ice.

### Permafrost Description

Uf: Unfrozen
Nf: Poorly Bonded
Nbn: Well Bonded - No Excess Ice
Nbe: Well Bonded - Excess Ice
ICE: Ice without soil inclusions
ICE w/ soil: Ice with soil inclusions

Vx: Individual Ice Inclusions
Vc: Ice Coatings on Particles
Vr: Randomly Oriented Ice Formations
Vs: Stratified Ice Formations
UN: Unknown, due to melting or no recovery

*Excess ice content determined by visual estimation in the field

### PVC Installation Details

▨ Bentonite Chips ☐ 2" PVC

**srk consulting**

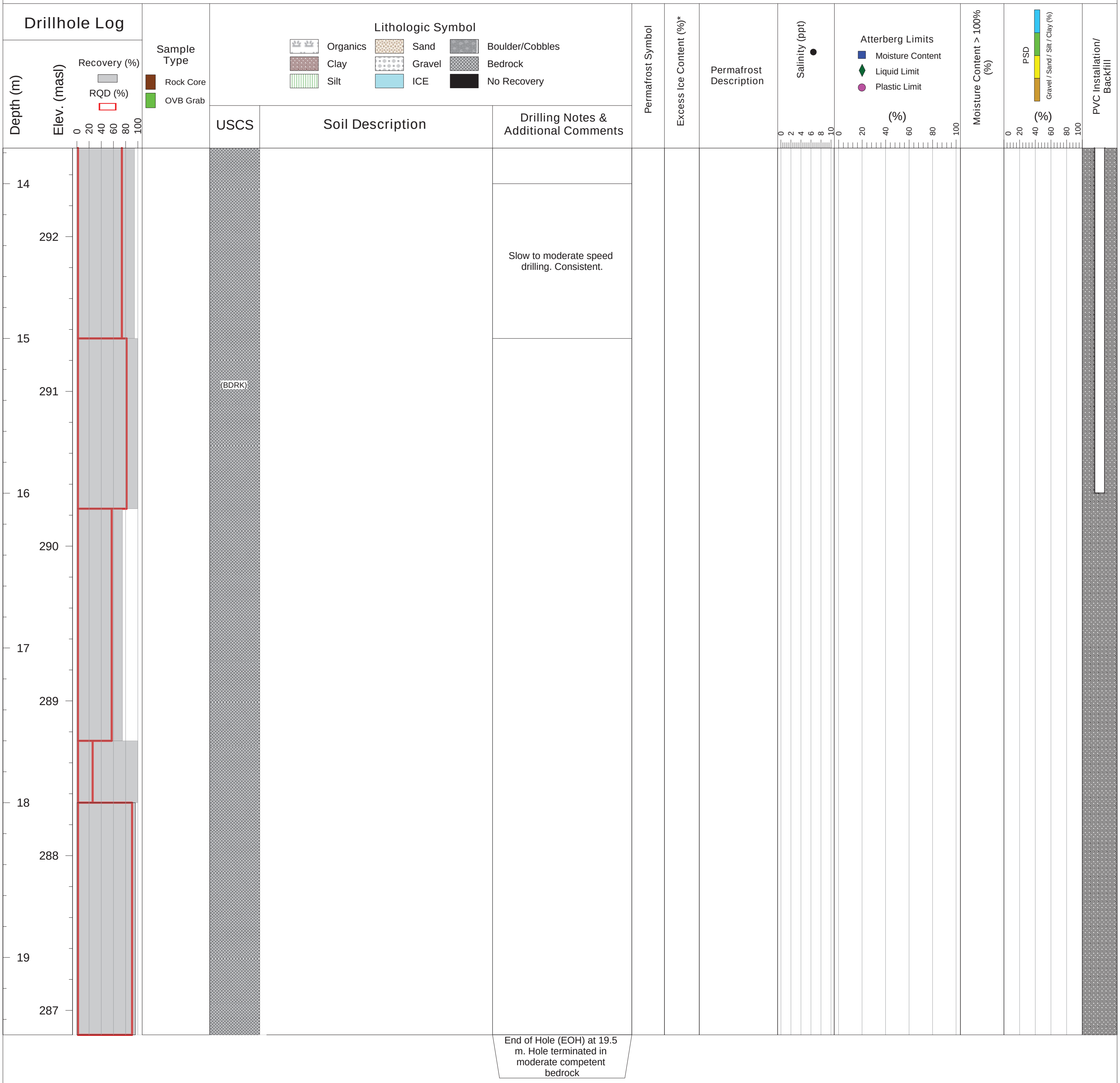
**Sabina**

PROJECT: 2021 Geotechnical Drilling
CLIENT: Sabina Gold & Silver Corp

DRILLHOLE ID: SRK-21-DH03-PP
LOCATION: Primary Pond Dam
PROJECT NO: 1CS020.021
DRILL TYPE: Diamond Drill
CORE DIA (mm): 63.5
CONTRACTOR: Major Drilling Group International
LOGGED BY: JU/JBK

DRILLING DATE: 16-Apr-21 TO: 16-Apr-21
COORDINATES: 429,577 E 7,271,392 N
DATUM: UTM Projection NAD83 Zone 13
GROUND ELEV. (masl): 306.3
AZIMUTH: 0 DIP: -90
TOTAL DEPTH (m): 19.50
DEPTH TO BEDROCK (m): 11.10
WATER LEVEL (masl): -

## Drillhole Log



Slow to moderate speed drilling. Consistent.

End of Hole (EOH) at 19.5 m. Hole terminated in moderate competent bedrock

**Permafrost Description**

Uf: Unfrozen
Nf: Poorly Bonded
Nbn: Well Bonded - No Excess Ice
Nbe: Well Bonded - Excess Ice
ICE: Ice without soil inclusions
ICE w/ soil: Ice with soil inclusions

Vx: Individual Ice Inclusions
Vc: Ice Coatings on Particles
Vr: Randomly Oriented Ice Formations
Vs: Stratified Ice Formations
UN: Unknown, due to melting or no recovery

*Excess ice content determined by visual estimation in the field

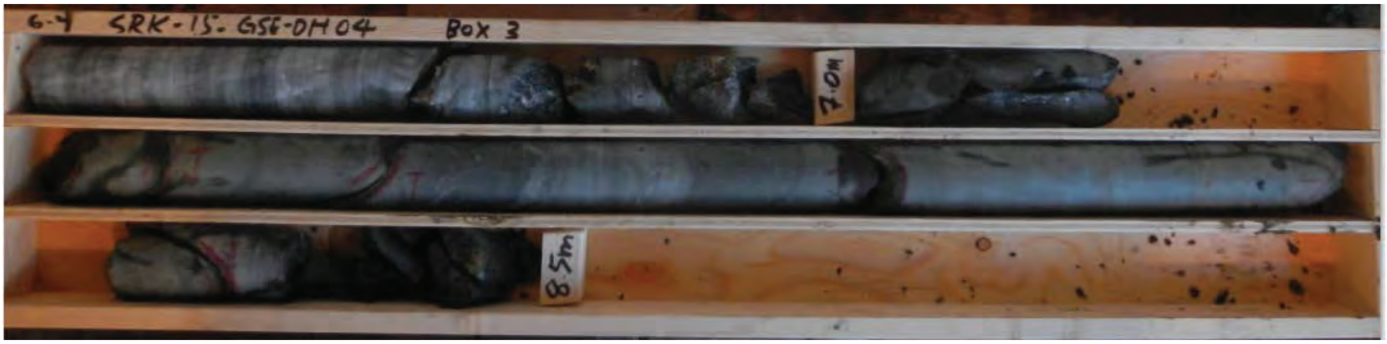
**PVC Installation Details**

▨ Bentonite Chips ☐ 2" PVC

# Attachment 3 Core Box Photos

SRK-15-GSE-DH04: 0 – 3.3m

SRK-15-GSE-DH04: 3.3 – 6.4m



SRK-15-GSE-DH04:6.4 – 8.5m

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2015 Overburden Geotechnical Investigation Program

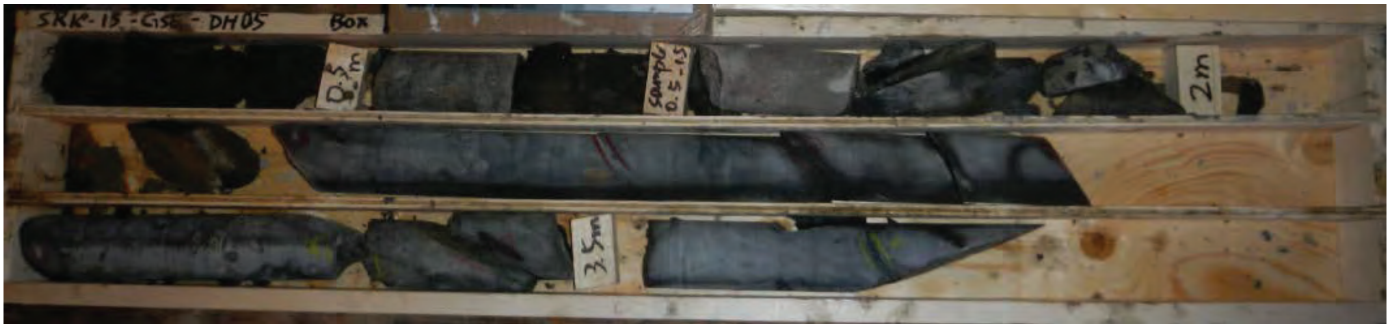
**SRK-15-GSE-DH04**

**Core Box Photo Log**

Job No: 1CS020.009
Filename: BackRiver_Corephotos_DH02-06.pptx

Back River Project

| Date: | Reviewed: | Figure: |
|---|---|---|
| October 2015 | EH | **DH04 - 1** |



SRK-15-GSE-DH05: 0 – 3.75m

SRK-15-GSE-DH05: 3.75 – 6.5m

SRK-15-GSE-DH05:6.45– 8m

2015 Overburden Geotechnical Investigation Program

**SRK-15-GSE-DH05**

**Core Box Photo Log**

Job No: 1CS020.009

Filename: BackRiver_Corephotos_DH02-06.pptx

Back River Project

| Date: | Reviewed: | Figure: |
|---|---|---|
| October 2015 | EH | **DH05 - 1** |

SRK-15-GSE-DH06: 0 – 3.74m

SRK-15-GSE-DH06: 3.74 – 6.2m

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2015 Overburden Geotechnical Investigation Program

**SRK-15-GSE-DH06**

**Core Box Photo Log**

Job No: 1CS020.009
Filename: BackRiver_Corephotos_DH02-06.pptx

Back River Project

Date: October 2015
Reviewed: EH
Figure: **DH06 - 1**

**Photo 26. SRK-18-DH09 (18GGT40)**

**Photo 27. SRK-18-DH09 (18GGT40) 0.0–4.2 m, box 1, 2018-03-26**

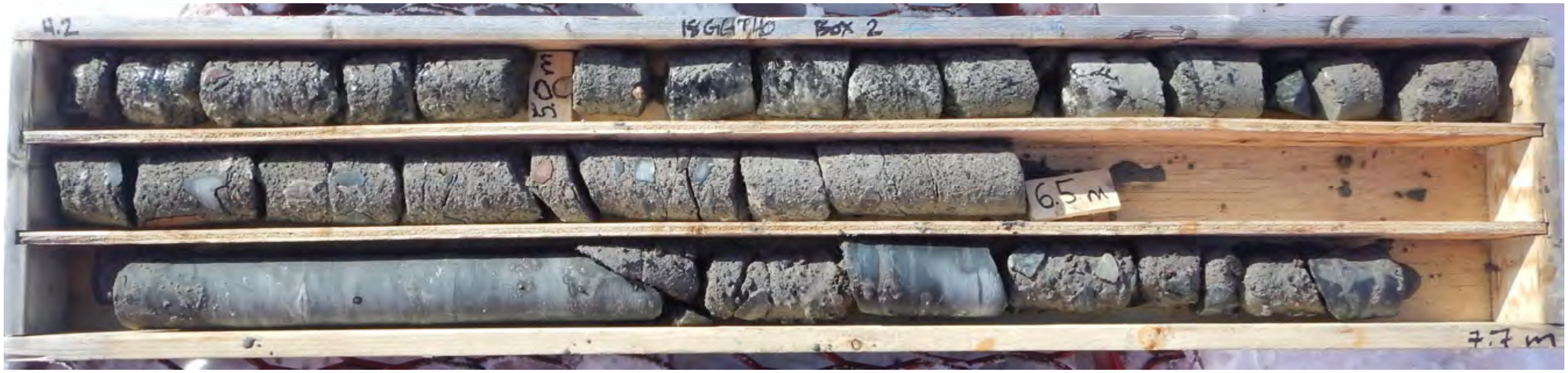

**Photo 28. SRK-18-DH09 (18GGT40) 4.2–7.7 m, box 2, 2018-03-26**

**Photo 29. SRK-18-DH09 (18GGT40) 0.0–11.0 m, box 1-3, 2018-03-26**

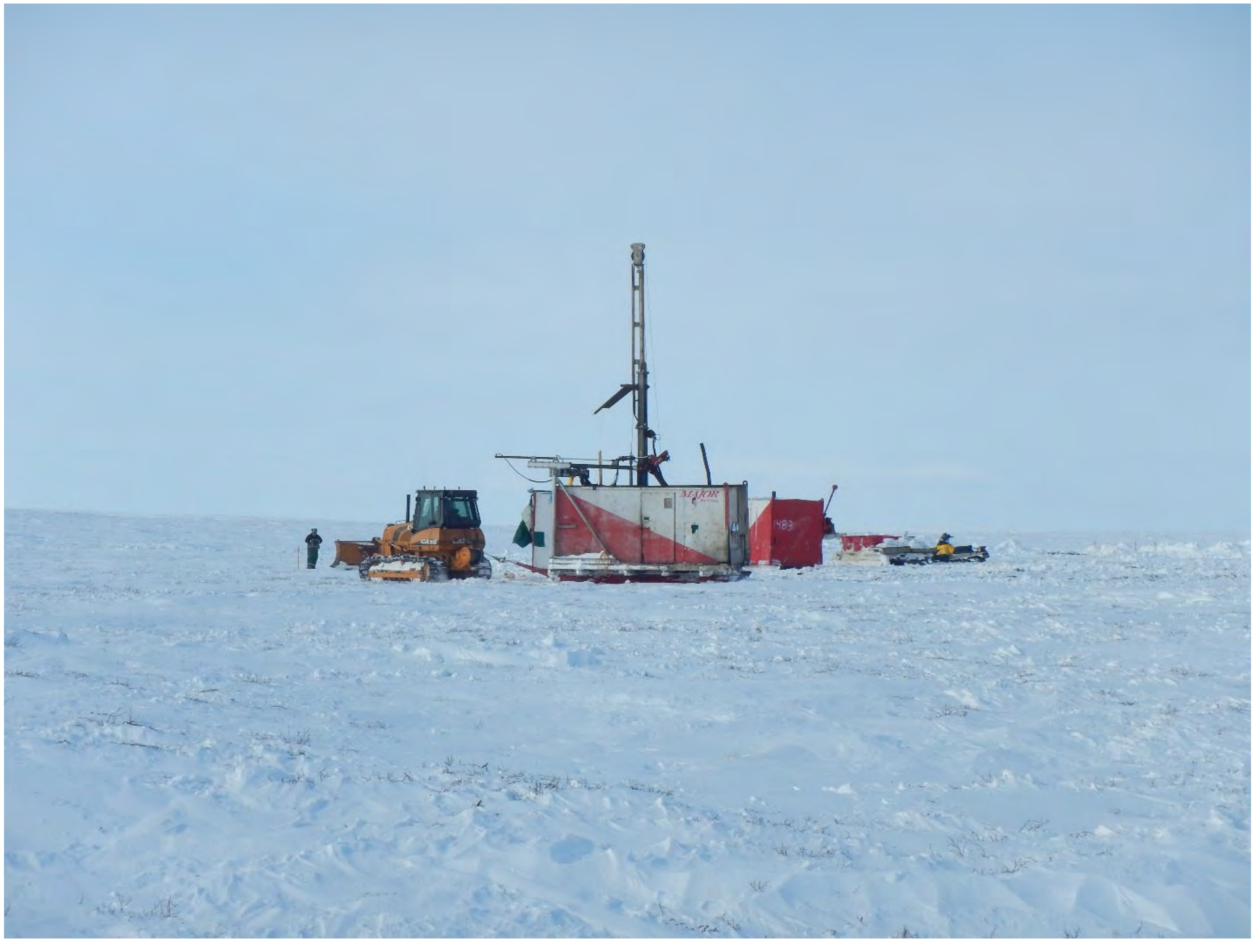

**Photo 30. SRK-18-DH10 (18GGT49)**

**Photo 31. SRK-18-DH10 (18GGT49) 0.0–9.2 m, box 1-3, 2018-04-06**

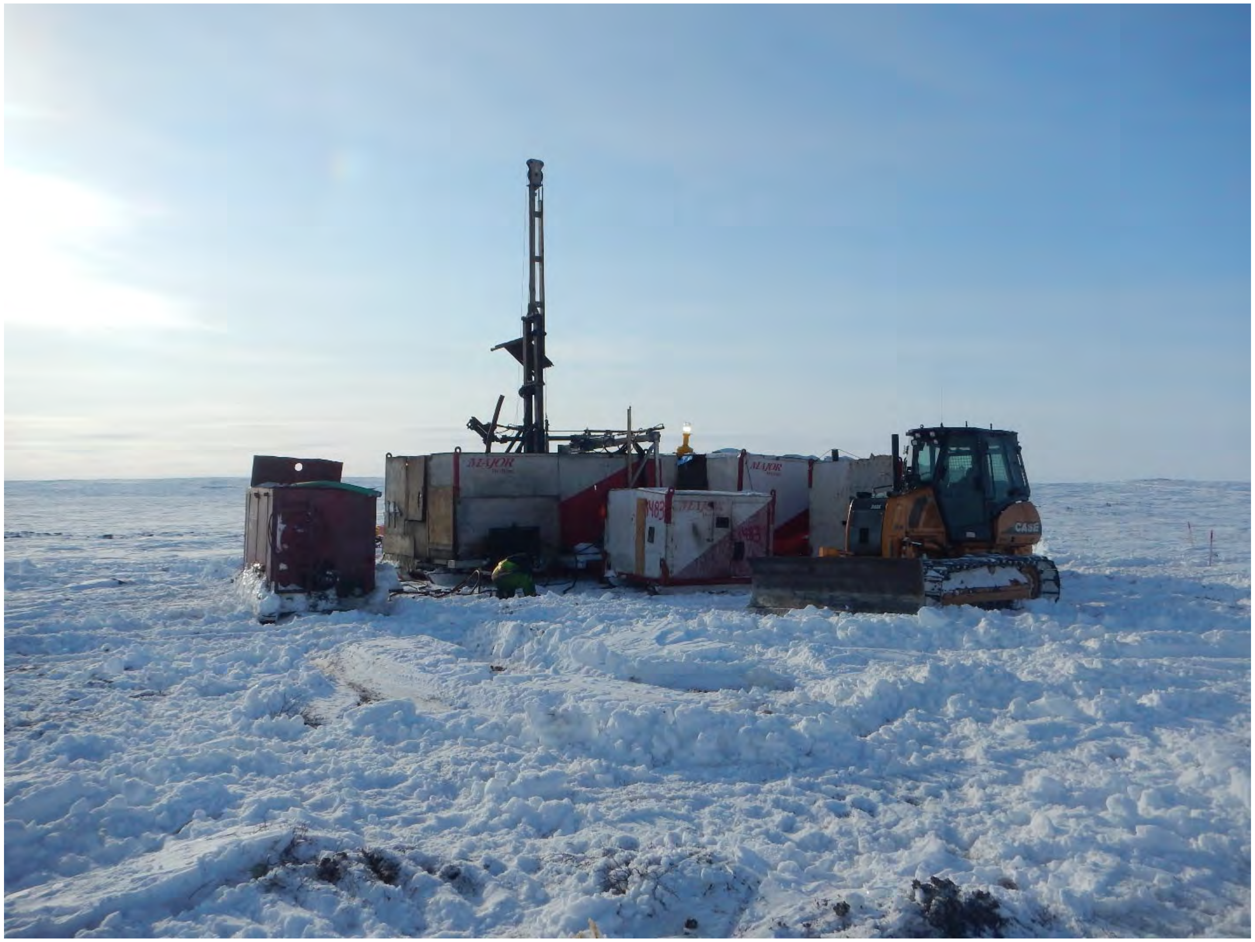

**Photo 74. SRK-18-DH26 (18GGT50)**

**Photo 75. SRK-18-DH26 (18GGT50) 0.0–2.8 m, box 1, 2018-04-06**

SRK-21-DH01-PP, 0.0-5.4 m, box 1 of 1

2021 Geotechnical Drilling Program

**Core Box Photos**
**SRK-21-DH01-PP**
**Sheet 1 of 1**

Job No: 1CS020.021

Filename: AppC2_CoreBoxPhotos.pptx

Back River Project

| Date: | Approved: | Figure: |
|---|---|---|
| June 2021 | JBK | **C2.1** |

SRK-21-DH02A-PP, 0.0-1.5 m, box 1 of 1

2021 Geotechnical Drilling Program

**Core Box Photos**
**SRK-21-DH02A-PP**
**Sheet 1 of 1**

Job No: 1CS020.021
Filename: AppC2_CoreBoxPhotos.pptx

Back River Project

Date: June 2021
Approved: JBK
Figure: **C2.2**

SRK-21-DH02B-PP, 0.0-3.75 m, box 1 of 6

SRK-21-DH02B-PP, 3.75-6.9 m, box 2 of 6

SRK-21-DH02B-PP, 6.9-9.6 m, box 3 of 6

2021 Geotechnical Drilling Program

**Core Box Photos**
**SRK-21-DH02B-PP**
**Sheet 1 of 2**

Job No: 1CS020.021
Filename: AppC2_CoreBoxPhotos.pptx

Back River Project

| Date: | Approved: | Figure: |
|---|---|---|
| June 2021 | JBK | C2.3 |

SRK-21-DH02B-PP, 9.6-12.6 m, box 4 of 6

SRK-21-DH02B-PP, 12.6-16.1 m, box 5 of 6

SRK-21-DH02B-PP, 16.1-18.0 m, box 6 of 6

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2021 Geotechnical Drilling Program

**Core Box Photos**
**SRK-21-DH02B-PP**
**Sheet 2 of 2**

Job No: 1CS020.021
Filename: AppC2_CoreBoxPhotos.pptx

Back River Project

Date: June 2021
Approved: JBK
Figure: **C2.4**

SRK-21-DH03-PP, 0.0-3.4 m, box 1 of 6

SRK-21-DH03-PP, 3.4-6.55 m, box 2 of 6

SRK-21-DH03-PP, 6.55-9.85 m, box 3 of 6

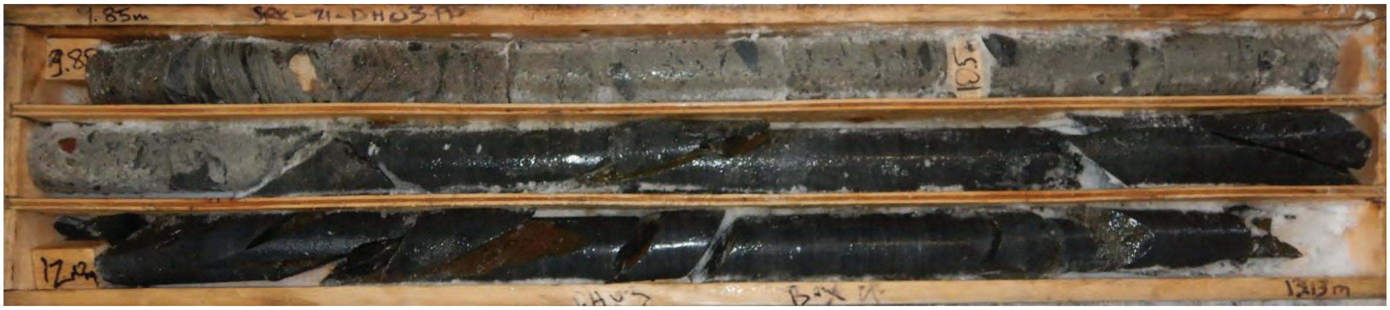
2021 Geotechnical Drilling Program

**Core Box Photos**
**SRK-21-DH03-PP**
**Sheet 1 of 2**

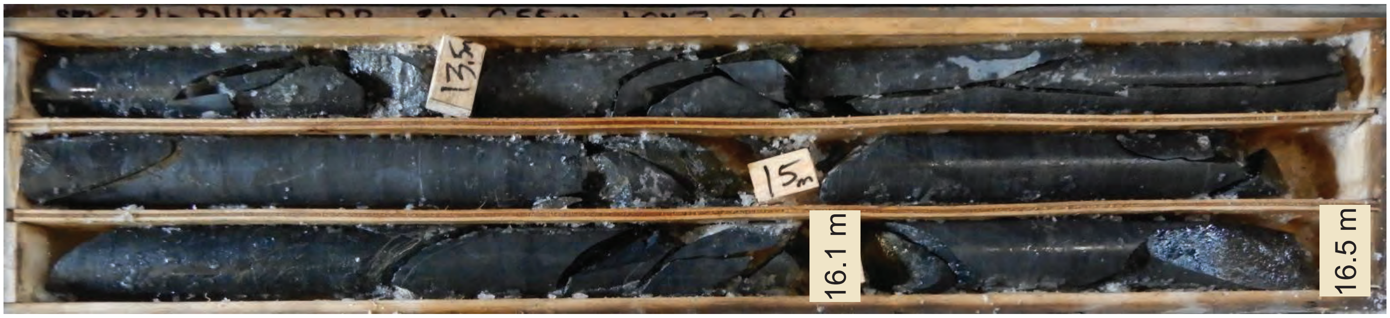
Job No: 1CS020.021
Filename: AppC2_CoreBoxPhotos.pptx

Back River Project

Date: June 2021
Approved: JBK
Figure: **C2.5**



SRK-21-DH03-PP, 9.85-13.13 m, box 4 of 6



SRK-21-DH03-PP, 13.13-16.5 m, box 5 of 6

SRK-21-DH03-PP, 16.5-19.5 m, box 6 of 6

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2021 Geotechnical Drilling Program

**Core Box Photos**
**SRK-21-DH03-PP**
**Sheet 2 of 2**

Job No: 1CS020.021
Filename: AppC2_CoreBoxPhotos.pptx

Back River Project

Date: June 2021
Approved: JBK
Figure: **C2.6**

# ATTACHMENT 2

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vancouver@srk.com
www.srk.com

FINAL DRAFT

# Back River: Updated Feasibility Study – Hydrology Update

July 16, 2021

| | |
|---|---|
| **To** | Project File |
| **From** | Samantha Barnes, SRK Consulting |
| **Cc** | John Kurylo, SRK Consulting |
| **Subject** | Back River – Updated Feasibility Study Hydrology Update Memo |
| **Client** | Sabina Gold and Silver Corp. |
| **Project** | 1CS020.020 |

## 1 Introduction

SRK Consulting (Canada) Inc. was retained by Sabina Gold and Silver Corp. (Sabina) to confirm the design of water management infrastructure around the Goose Property in support of an updated Feasibility Study for the Back River Project (Project). Critical inputs to the water management designs include an understanding of extreme snowmelt and rainfall rates as well as associated peak flows and peak inflow volumes. A review of available meteorological and hydrologic data was prepared to refine the extreme event analyses for infrastructure design.

As part of the review, refinements to the following meteorological and hydrologic parameters were prepared:

- Mean annual precipitation (MAP) and annual precipitation for wet and dry years.
- Extreme precipitation, ranging from the 2 through 200-year return periods for durations including the 5-minute event through 72-hour event.
- Probable maximum precipitation (PMP) in 24 hours.
- Mean annual runoff (MAR) and annual runoff for wet and dry years.
- Peak flows, including snowmelt contributions.
- Climate change implications to precipitation, air temperature and wind speed.

Recommendations for future monitoring and model calibration in advance of detailed engineering are provided in the conclusions section of this memo.

## 1.1 Previous Studies

The baseline meteorological program for the Property was initiated by Golder Associates Ltd in 2004. In 2008, Rescan Environmental Services Ltd. (ERM) took over the monitoring program for the Property. The most recent published meteorology report published by ERM contains a summary of the baseline meteorology from 2004 to 2014 (Rescan 2014a). Additional meteorological data from 2014 through 2020 were provided in Excel spreadsheet format, including daily precipitation and daily maximum, minimum and average temperature data from the local meteorological stations.

The Property's hydrology baseline program was initiated by ERM in 2010 which included the installation of two hydrometric stations. The program was expanded in 2012 to include a total of 12 stations to represent baseline hydrological conditions for the Goose and George properties. A number of baseline hydrology reports have been produced by ERM (Rescan 2012a, Rescan 2012b and Rescan 2014b) with the most recent being the Back River 2014 Hydrology Baseline Report (Rescan 2014c). In-stream flow measurements were provided in Excel spreadsheet format from 2017 through 2020, however no continuous flow records were available at the time of this study.

A hydrometeorological report was produced by Knight Piésold in 2013 to support the pre-feasibility design of the Property. The report incorporated data collected on site and regional data collected by government agencies to calculate long-term estimates for the Property (Knight Piésold 2013).

Sabina also published a Draft Environmental Impact Statement (DEIS) report (Rescan 2013) providing a summary of regional trends and existing baseline data. However, hydrologic estimates for the Property and mean annual precipitation, runoff, and evaporation were not provided.

SRK completed a hydrology review for the Feasibility Study (FS) of the Property (SRK 2015a), and an updated analysis in support of the Final Environmental Impact Statement (FEIS) later in 2015 (SRK 2015b). The following summaries build on results presented in 2015 using recent data, where applicable.

# 2 Precipitation Analysis

## 2.1 Supporting Precipitation Datasets

Regional precipitation data were obtained from Environment Climate Change Canada (ECCC) via the weathercan R package (LaZerte et al. 2018). Figure 2-1 displays all stations within a 500km radius of the Property.

### 2.1.1 Site Specific Precipitation Records

Site-specific meteorological monitoring for the Property began in August 2004 by Golder Associates with the installation of two 3 m-high stations at the Goose and George exploration camps. ERM subsequently took over the monitoring in 2008. At the time, the stations were unable to measure precipitation as snowfall. The two initially installed stations were upgraded to 10 m-high stations with the capability of measuring total precipitation (rain and snow) in March 2012. In 2012 a third station was commissioned at the Marine Laydown Area (MLA), approximately 50 km north of the Goose Property. Photos 2-1,2-2 and, 2-3 present images of each the George, Goose and MLA stations respectively (Rescan 2013).

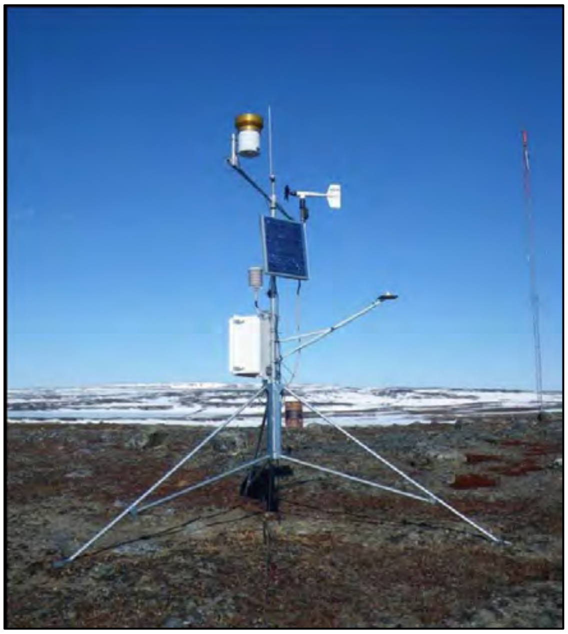


**Photo 2-1: George Meteorological Station (May 25, 2011)**
Note: The station was upgraded to a 10 m tower in 2012

**Photo 2-2: Goose Meteorological Station (June 16, 2012)**

**Photo 2-3: MLA Meteorological Station (June 28, 2010)**

All meteorological stations are equipped with gauges to monitor air temperature, precipitation as rainfall and snowfall, solar radiation, wind speed, and wind direction. However, the available records do not present winter precipitation measurements, with continuous 0 mm readings between November and April. SRK expects that the winter measurements are not currently being reported or have been removed for quality control purposes. As a result, there are no years in the historical records with continuous year-round precipitation measurements on-site.

Table 2-1 (Rescan 2014) presents metadata information for the Goose, George and MLA climate stations at the Property, and Table 2-2 presents monthly summaries of collected precipitation data.

**Table 2-1: Back River Property Climate Station Metadata**

| Station | Record Length | Latitude | Longitude | Elevation (masl.) |
|---|---|---|---|---|
| Goose Station | 2006 – 2020 | 65.54 | -106.41 | 277 |
| George Station | 2006 – 2013 | 65.92 | -107.45 | 355 |
| MLA Station | 2012 - 2020 | 66.65 | -107.69 | 11 |

Source: \\srk.ad\dfs\na\van\01_SITES\Back River\1CS020.020_Water_Management_FS_Update\Hydrology_Review\Analysis\Precip_AnnualCompiled_rev5_02102021.xlsx

Note:

2004 to 2005 data is not reported as this data was not used by ERM to describe baseline conditions (Rescan 2014).

**Table 2-2: Collected Monthly Precipitation at the Back River Property in mm/month**

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Goose Station** | | | | | | | | | | | | |
| 2006 | | | | | | 1.6 | | | | | | |
| 2007 | | | | | | R | R | R | R | | | |
| 2008 | | | | | | 21.0 | 1.9 | 71.3 | 35.4 | | | |
| 2009 | | | | | | 21.4 | 27.3 | 25.4 | 37.2 | | | |
| 2010 | | | | | | | | | | | | |
| 2011 | | | | | | 13.4 | 21.1 | 53.7 | 65.2 | | | |
| 2012 | | | 2.6 | 5.1 | 10.2 | 16.1 | 20.7 | 32.4 | 28.1 | 2.6 | 7.9 | 5.0 |
| 2013 | | | 27.2 | | 1.8 | 31.8 | 23.0 | 33.9 | | | | |
| 2014 | | | | | | 37.2 | 29.9 | 164.2 | 41.3 | 0.3 | | |
| 2015 | | | | | | | | | | | | |
| 2016 | | | | | | | | | | | | |
| 2017 | | | | 0.3 | 11.9 | 15.5 | 85.7 | 59.3 | 49.7 | 0.9 | | |
| 2018 | | | | | | 7.0 | 41.8 | 108.9 | 25.9 | 0.6 | | |
| 2019 | | | | | 9.0 | | | | | | | |
| 2020 | | | | | 9.0 | 3.2 | 0.1 | | | | | |

| Year | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **George Station** | | | | | | | | | | | | |
| 2007 | | | | | | R | R | R | R | | | |
| 2008 | | | | | | 49.7 | 29.9 | 102.6 | 29.6 | | | |
| 2009 | | | | | | 16.6 | 24.0 | 40.5 | 34.6 | | | |
| 2010 | | | | | | | | | | | | |
| 2011 | | | | | | 14.2 | 20.6 | 70.3 | 46.6 | | | |
| 2012 | | | 2.8 | 5.9 | 3.3 | 13.4 | 24.1 | 42.7 | 29.5 | 3.4 | 6.9 | |
| 2013 | | | 27.2 | | 1.8 | 31.8 | 23.0 | 33.9 | | | | |
| **MLA Station** | | | | | | | | | | | | |
| 2012 | | | | | | | 8.0 | 58.5 | 46.1 | 3.6 | | |
| 2013 | | | | 0.2 | 12.3 | 50.8 | 50.2 | 30.9 | 36.7 | 8.6 | | |
| 2014 | | | | 0.4 | 24.7 | 10.4 | 41.9 | 48.9 | 46.7 | 0.3 | | |
| 2015 | | | | 0.3 | 10.1 | 32.2 | 95.3 | 33.2 | 26.2 | 0.7 | | |
| 2016 | | | | | 2.8 | 56.5 | 55.8 | 28.9 | 45.2 | 0.1 | | |
| 2017 | | | 0.5 | | 11.3 | 36.0 | 34.1 | 52.8 | 24.5 | 2.1 | | |
| 2018 | | | | 0.3 | 3.5 | 42.3 | 21.5 | 62.6 | 4.6 | | | |
| 2019 | | | 0.8 | 1.1 | 8.7 | 42.6 | 93.2 | 85.2 | 21.6 | 5.8 | | |
| 2020 | | | | | 1.3 | 13.9 | 91.0 | | | | | |

Source: \\srk.ad\dfs\na\van\01_SITES\Back River\1CS020.020_Water_Management_FS_Update\Hydrology_Review\Analysis\Precip_AnnualCompiled_rev5_02102021.xlsx

Note:

The date presented in this table provides a summary of total precipitation. Empty cells illustrate that precipitation data were not recorded or were removed for quality control purposes. This includes winter months which, in recent years, frequently reported 0 mm of precipitation from November through April

R: monthly information removed based on limited representativity

2004 to 2005 data is not reported as this data was not used by ERM to describe baseline conditions (Rescan 2014).

### 2.1.2 Regional Climate Stations

Due to the unavailability of precipitation measurements in winter months, the analysis of Project precipitation relies on regional characterization. Precipitation data was downloaded from the Environment and Climate Change Canada database (LaZerte et al. 2018). All stations within 550 km of the Project were downloaded and reviewed. Station details are summarized in Table A1-1**.** The analysis provided in subsequent sections considers stations with a length of record greater than 10 years, as listed in Table 2-5. Note that the Ekati A station was also included, despite having a shorter period of record, due to its more recent record availability and its geographic location being inland from the Arctic Ocean, similar to the Back River Property. Figure 2-1 presents the geographic locations of selected stations with respect to the Project.

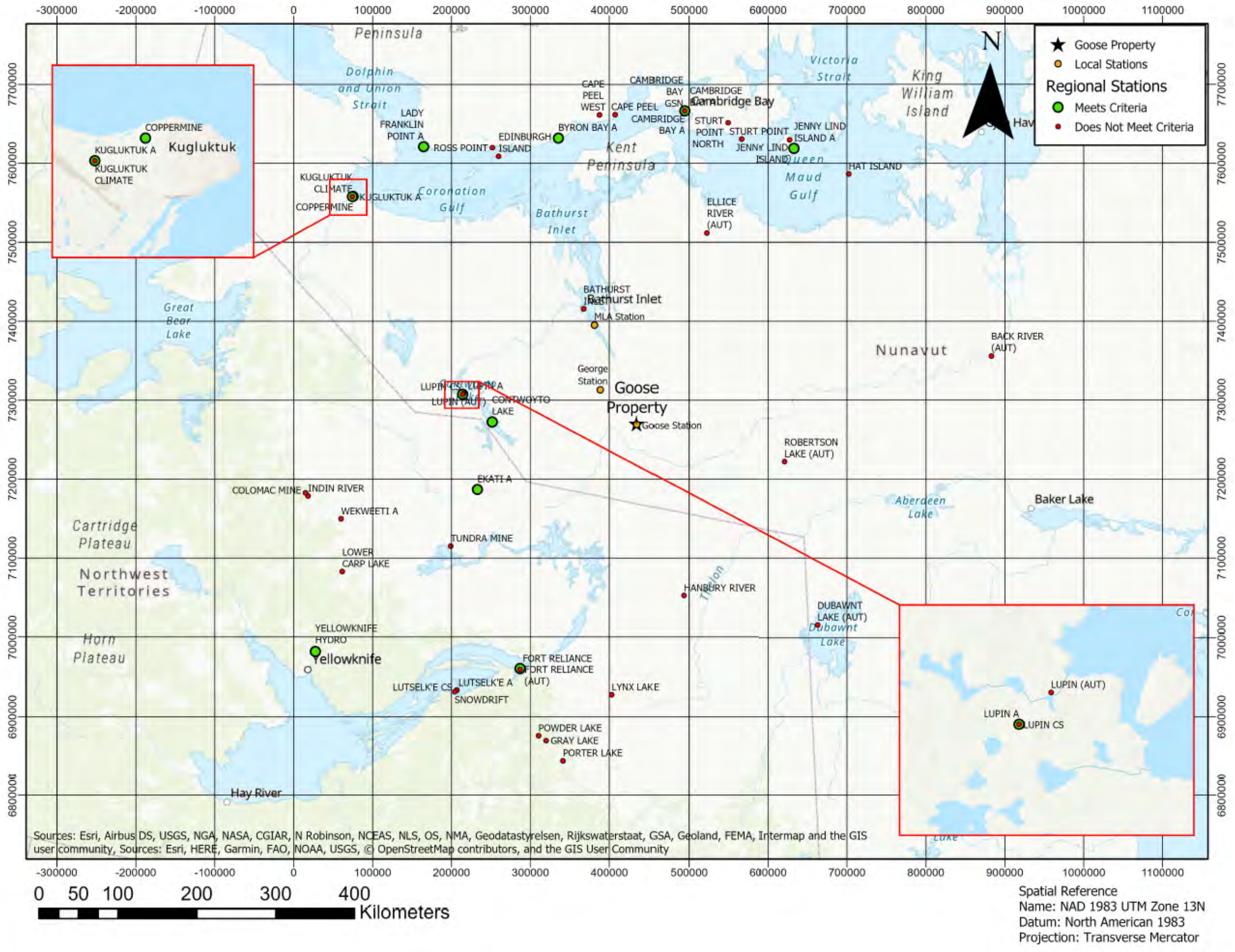
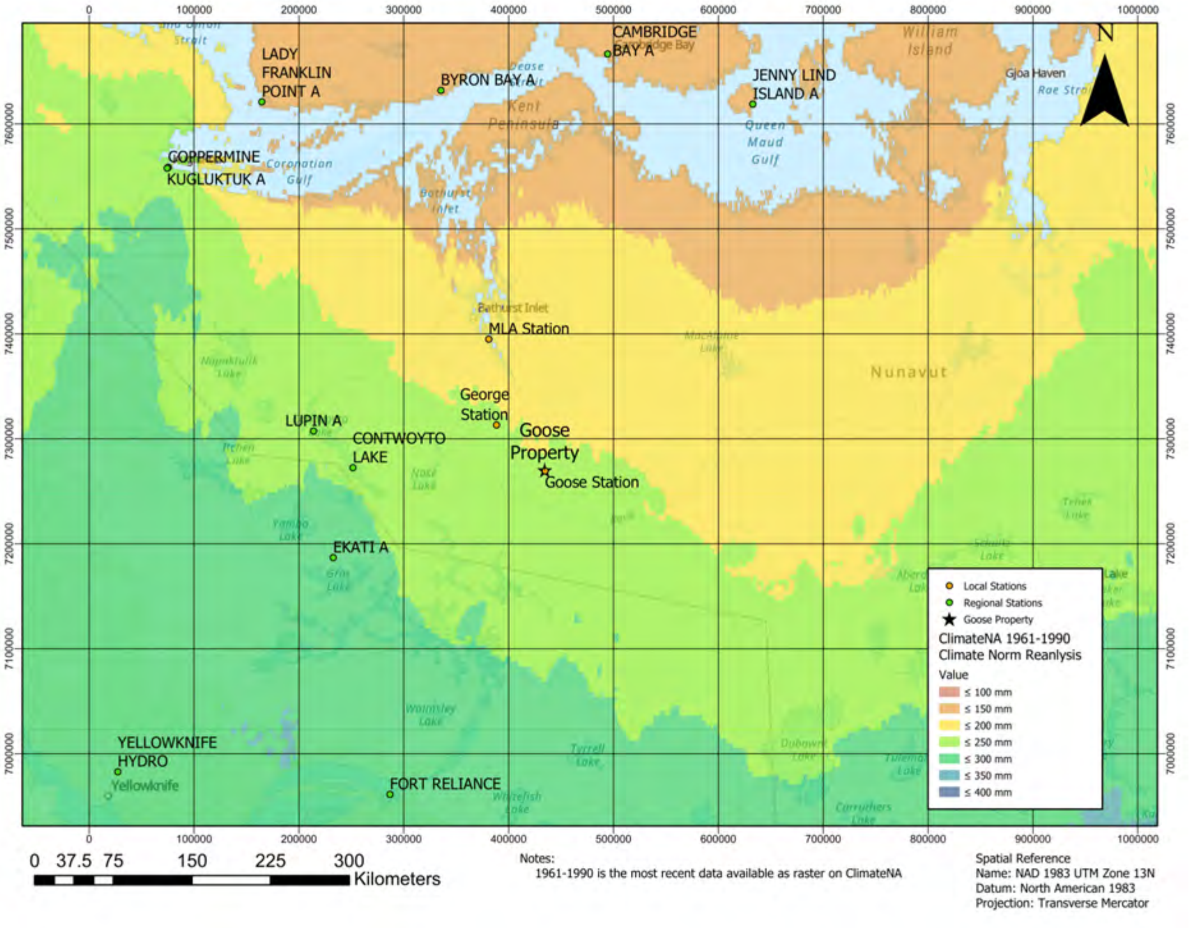


**Figure 2-1: Regional Meteorological Stations**

Source: \\srk.ad\dfs\na\van\ 01_SITES\Back River\1CS020.020_Water_Management_FS_Update\!040_AutoCAD\!GIS\!Final\regional_met.ppkx

ClimateNA was used to assess the regional context of mean annual precipitation and validate the use of a regional regression. ClimateNA downscales PRISM 1971-2000 gridded monthly climate normal data to scale-free locations (Wang Et al. 2016). Figure 2-2 presents the most recent; 1961-1990, downscaled climate norms available as a raster on the ClimateNA website and the selected regional stations. The data obtained from ClimateNA were not used directly in the following analysis but show a general decrease in annual precipitation in proximity to the coast.

The Goose and George properties would be expected to have a similar mean annual precipitation value as other land-locked stations, however the MLA may experience reduced precipitation rates. For the purpose of Feasibility designs, it was assumed that the precipitation estimated for Goose area is applicable to both George and the MLA.



Notes:
1961-1990 is the most recent data available as raster on ClimateNA

Spatial Reference
Name: NAD 1983 UTM Zone 13N
Datum: North American 1983
Projection: Transverse Mercator

**Figure 2-2: Regional Map of Mean Annual Precipitation using Gridded ClimateNA dataset for 1961-1990**

Source path: \\srk.ad\dfs\na\van\ 01_SITES\Back River\1CS020.020_Water_Management_FS_Update\!040_AutoCAD\!GIS\!Final\BR_ClimateNA_Reanalysis.ppkx

**Table 2-3: Regional Climate Station Summary**

| Station Name | Station ID | Lat. | Lon. | Distance from Project (km) | Elevation (m) | Data Availability | Length of Record[1] | MAP (mm) |
|---|---|---|---|---|---|---|---|---|
| Contwoyto Lake | 1639 | 65.48 | -110.37 | 183 | 451 | 1959-1981 | 21 | 249 |
| Lupin A | 1671 | 65.76 | -111.25 | 223 | 490 | 1982-2006 | 24 | 301 |
| Fort Reliance | 1652 | 62.72 | -109.17 | 344 | 166 | 1949-1990 | 39 | 260 |
| Fort Reliance AUT | 8935 | 62.71 | -109.17 | 344.7 | 168 | 1994-2020 | 16 | 363 |
| Coppermine | 1640 | 67.83 | -115.12 | 456 | 9 | 1933-1977 | 42 | 228 |
| Kugluktuk A | 1641 | 67.82 | -115.14 | 460 | 23. | 1978-2020 | 30 | 244 |
| Ekati A[2] | 27240 | 64.7 | -110.61 | 219 | 468 | 1999-2015 | 7 | 291 |

Source: \\srk.ad\dfs\na\van\01_SITES\Back River\1CS020.020_Water_Management_FS_Update\Hydrology_Review\Analysis\Precip_AnnualCompiled_rev5_02102021.xlsx

Notes:

[1] Years with more than 300 days of data available.

[2] Station has a length of record less than 10 years but has been included due to proximity to the Project and similar geographic location.

[3] MAP = mean annual precipitation

Regional stations which recorded concurrent monitoring periods as the site-specific stations include Ekati A, Kugluktuk A, and Fort Reliance (AUT). To verify the accuracy of the data recorded by the local stations, monthly precipitation from local and regional stations were compared. Figure 2-3 displays time total monthly precipitation for two years when multiple stations have data available (2012 and 2017). Results demonstrate that the three local stations were not accurately recording snow as precipitation as the data collected was significantly below the regional data during January – May and October – December.

To investigate the precipitation tendencies throughout the remainder of the year, Table 2-4 presents the total precipitation recorded between June – September for the regional and local stations with concurrent data. Figure 2-4 and Figure 2-5 display regressions using ordinary least squares line of best fit between the local and regional stations, for Goose and George respectively. Regressions with a coefficient of determination ($r^2$) less than 0.3 were considered insignificant and screened out. The MLA station did not display any significant regressions between the regional stations. Each point in the regressions represents one month of recorded precipitation with the cumulative monthly precipitation from each local station on the y-axes, and the cumulative monthly precipitation for each overlapping regional station on the x-axes.

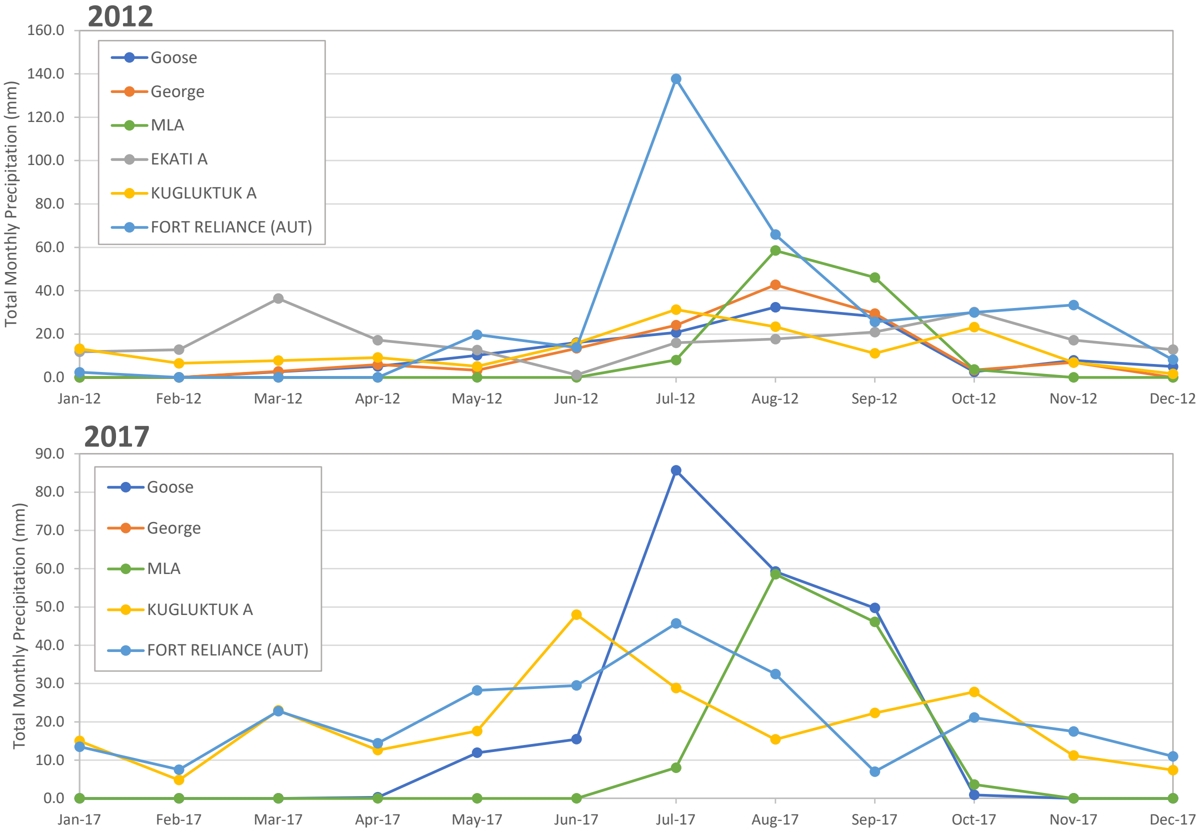


**Figure 2-3: Local and Regional Monthly Precipitation [mm] for Select Years of Overlapping Data**

Source: \\srk.ad\dfs\na\van\01_SITES\Back River\1CS020.020_Water_Management_FS_Update\Hydrology_Review\Analysis\Precip_AnnualCompiled_rev5_02102021.xlsx

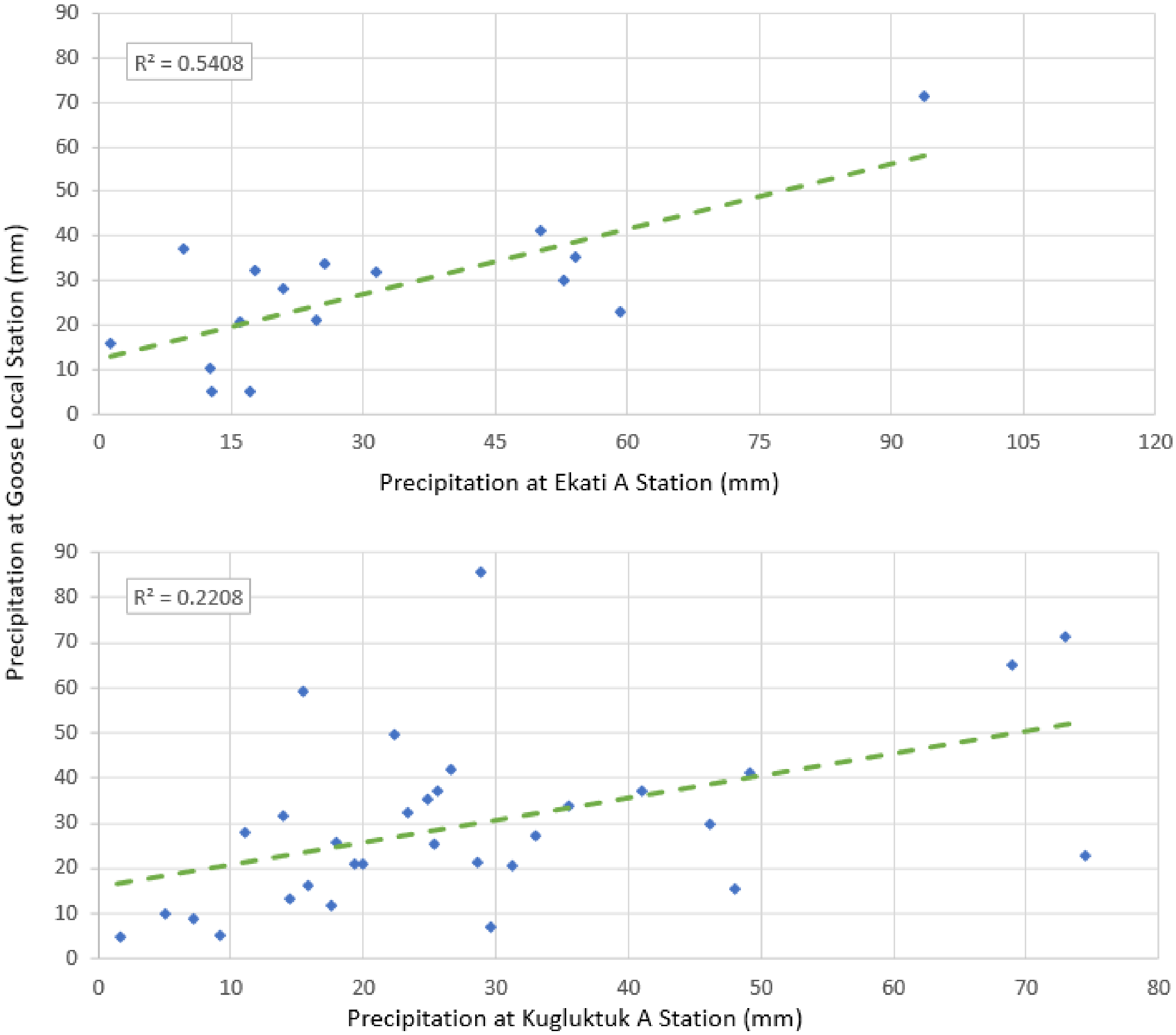


**Figure 2-4: Goose Station Regional Regressions for Monthly Precipitation [mm]**

Source: \\srk.ad\dfs\na\van\01_SITES\Back River\1CS020.020_Water_Management_FS_Update\Hydrology_Review\Analysis\
Precip_AnnualCompiled_rev5_02102021.xlsx

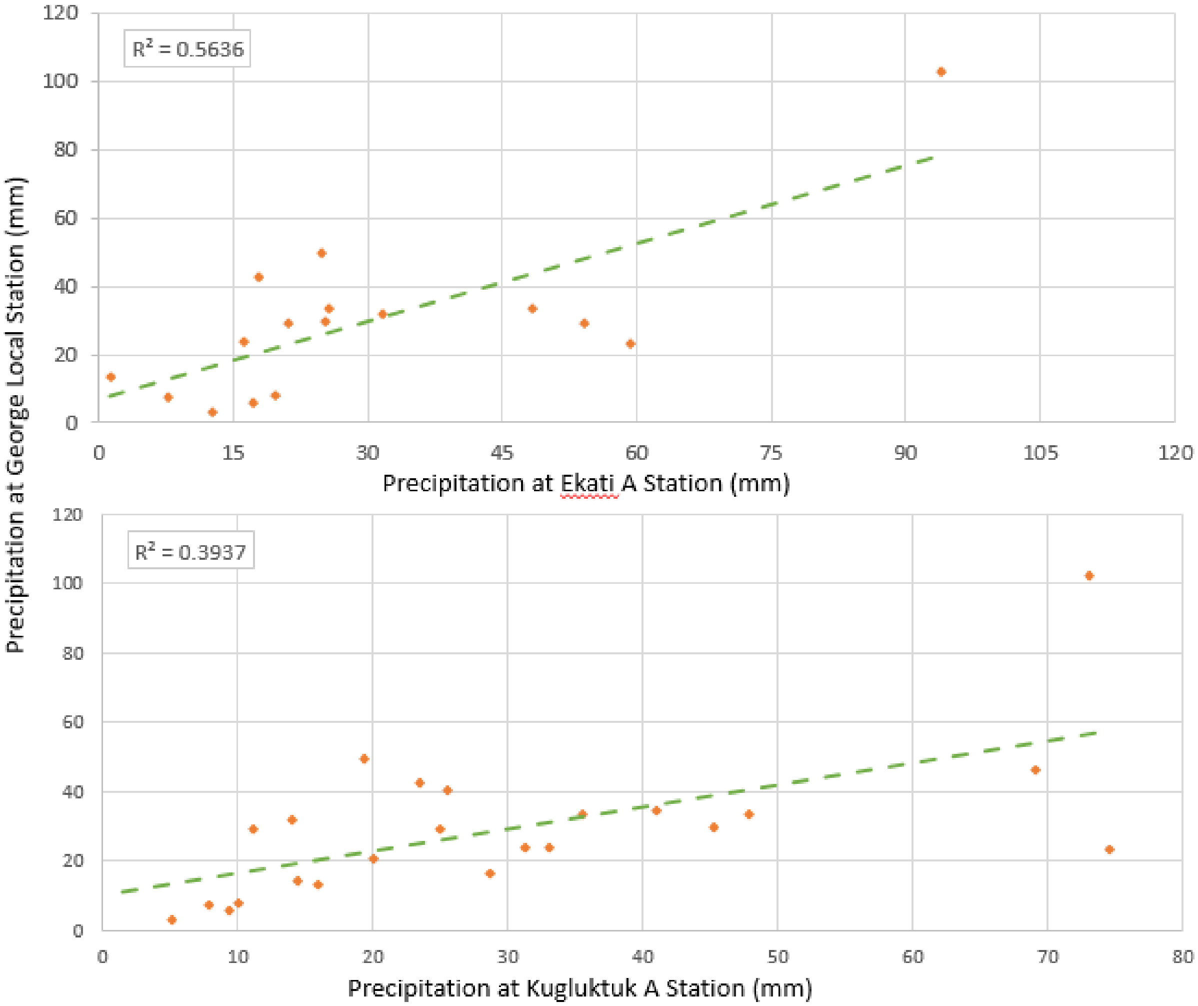


**Figure 2-5: George Station Regional Regressions for Monthly Precipitation [mm]**

Source: \\srk.ad\dfs\na\van\01_SITES\Back River\1CS020.020_Water_Management_FS_Update\Hydrology_Review\Analysis\Precip_AnnualCompiled_rev5_02102021.xlsx

Despite variation in the geographic locations of regional and local stations, a similar relationship between monthly precipitation would be expected. Ekati A station presents the strongest relationship between local stations at Goose and George; however, the strength of this regression is dependent on one higher precipitation value, which suggests the overall regression is weak. The quality of data recorded at the local stations is variable. This may be caused by, but is not limited to:

- High winds interfering with the collection of precipitation
- Inadequate gauges
- Improper data management

Recommendations on data collection at the local meteorological stations are presented in Section 5.2.

**Table 2-4 Regional and Local Total Precipitation between June and September**

| | Local Stations | | | Regional Stations | | |
|---|---|---|---|---|---|---|
| **Year** | **Goose** | **George** | **MLA** | **Kugluktuk A** | **Ekati A** | **Fort Reliance AUT** |
| 2006 | | | | 102 | 212 | 162 |
| 2007 | | | | 254 | 123 | 88 |
| 2008 | 130 | 212 | | 162 | 198 | |
| 2009 | 111 | 116 | | 128 | | 74 |
| 2010 | | | | 141 | | 93 |
| 2011 | 153 | 152 | 113 | 205 | | 175 |
| 2012 | 97 | 110 | 169 | 82 | 56 | |
| 2013 | 89 | 89 | 148 | 174 | 146 | 190 |
| 2014 | 273 | | 187 | 139 | 140 | 113 |
| 2015 | | | 186 | 192 | 161 | 153 |
| 2016 | | | 147 | 179 | | 179 |
| 2017 | 210 | | 131 | 115 | | 115 |
| 2018 | 184 | | 243 | 120 | | 162 |
| 2019 | | | 105 | 128 | | 138 |
| 2020 | | | 172 | 93 | | 59 |

Source: \\srk.ad\dfs\na\van\01_SITES\Back River\1CS020.020_Water_Management_FS_Update\Hydrology_Review\Analysis\Precip_AnnualCompiled_rev5_02102021.xlsx

Note:

Empty cells illustrate that data was removed for quality control purposes.

Since the winter precipitation measurements at the site-specific stations contain gaps, a regression analysis for mean annual precipitation using the regional stations was developed to estimate the expected annual precipitation for the Project.

The mean annual precipitation (MAP) of the regional stations was calculated with the following filters applied:

- Years must have a minimum of 300 days with information.
- Each month must not exceed a maximum of 5 days with missing information.

Ekati A was included in this analysis due to its close proximity to site and similar elevation to the Project, despite only having 7 years of complete precipitation records. Figure 2-6 displays the linear regression between station elevation and the MAP, which presented a regression coefficient of 0.61. Applying the regression to the Project's average elevation of 315 masl., the uncorrected MAP was calculated to be 266 mm.

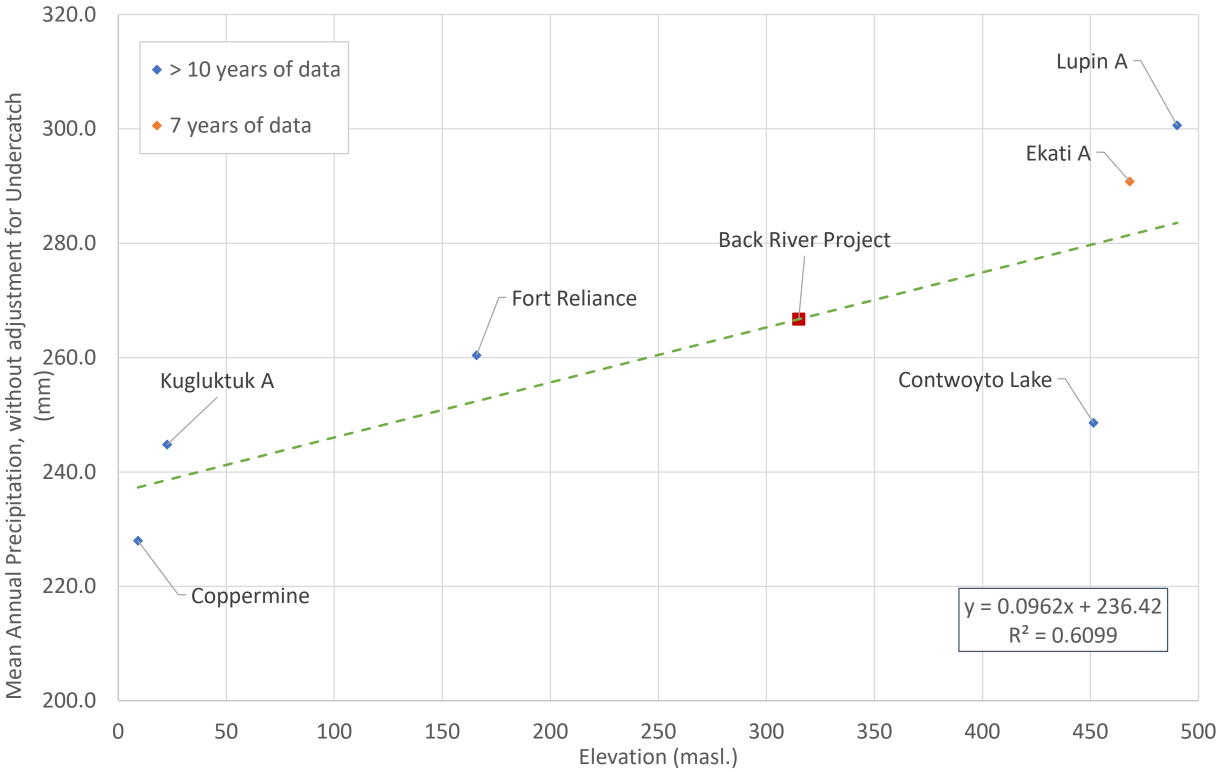


**Figure 2-6: Regional Regression of Mean Annual Precipitation without Adjustment for Undercatch and Elevation**

Source: \\srk.ad\dfs\na\van\01_SITES\Back River\1CS020.020_Water_Management_FS_Update\Hydrology_Review\Analysis\Precip_AnnualCompiled_rev5_02102021.xlsx

Monthly precipitation distribution for the Project was calculated using the average distribution from the selected regional stations, similar to previous studies (SRK 2015a).

Precipitation measurements in the Arctic are affected by systematic errors mainly caused by wind-induced undercatch, wetting losses, and evaporation losses. The combined effect of these measurement errors result in an underestimation of actual precipitation (Mekis and Vincent 2011). The magnitude of the undercatch losses vary by type of precipitation (rain, mixed, and snow) where precipitation in the form of snow is commonly greatest.

In the 2015 SRK report, an undercatch adjustment analysis was completed using the Lupin, Cambridge, Yellowknife and Baker Lake regional stations, which have published adjusted precipitation datasets with undercatch (Environment Canada). Monthly undercatch correction factors were calculated using the uncorrected and corrected records at each station, and the average correction factors were applied to the Project. Table 2-5 presents the monthly average undercatch correction factors (SRK 2015a), the updated monthly average precipitation distribution from selected regional stations, and the corrected monthly precipitation estimates for the Project. The MAP after undercatch correction was determined to be 427 mm with an annual undercatch factor of 1.61.

**Table 2-5: Back River Property Monthly and Annual Precipitation with Undercatch**

| Month | Undercatch Adjustment Factor | Precipitation Distribution (%) | Adjusted Precipitation (mm) |
|---|---|---|---|
| January | 2.23 | 4.7% | 27.9 |
| February | 2.09 | 4.2% | 23.3 |
| March | 1.93 | 5.9% | 30.3 |
| April | 1.75 | 6.2% | 28.9 |
| May | 1.76 | 6.4% | 30.0 |
| June | 1.57 | 9.8% | 40.9 |
| July | 1.30 | 12.5% | 43.2 |
| August | 1.31 | 18.2% | 63.4 |
| September | 1.38 | 11.4% | 41.8 |
| October | 1.58 | 9.7% | 40.8 |
| November | 1.84 | 6.3% | 30.8 |
| December | 2.04 | 4.8% | 26.0 |
| Annual | 1.61 | 100% | 427.4 |

Source: \\srk.ad\dfs\na\van\01_SITES\Back River\1CS020.020_Water_Management_FS_Update\Hydrology_Review\Analysis\Precip_AnnualCompiled_rev5_02102021.xlsx

Notes:

A factor of 1.61 was evaluated based on the ratio between the precipitation depth evaluated using monthly undercatch adjustment factors (427.4 mm) and the precipitation depth using the regional regression analysis (266 mm).

A frequency analysis was performed using the annual precipitation records for each of the selected regional stations with a minimum of 10 years of complete data. For each return period result in the frequency analysis, the average annual precipitation was calculated from the selected stations. The mean annual precipitation was calculated to be 266 mm.

Since the annual precipitation values in the frequency analyses did not include undercatch corrections, the annual correction factor of 1.61 calculated from SRK (2015) was applied to all return period results. Table 2-6 presents the unadjusted and undercatch-adjusted annual precipitation results for the Project for each return period. The undercatch-adjusted MAP for the Project is 427 mm.

**Table 2-6: Unadjusted and Adjusted Annual Precipitation Results for the Project based on Annual Undercatch Factor of 1.61**

| Hydrological Condition | Return Period (years) | Unadjusted Annual Precipitation[1] (mm) | Undercatch Adjusted Annual Precipitation[2] (mm) |
|---|---|---|---|
| Wet | 200 | 406 | 653 |
| | 100 | 391 | 628 |
| | 50 | 374 | 601 |
| | 20 | 349 | 561 |
| | 10 | 328 | 527 |
| | 5 | 303 | 486 |
| MAP | | 266 | 427 |
| Dry | 5 | 212 | 341 |
| | 10 | 191 | 306 |
| | 20 | 173 | 278 |
| | 50 | 154 | 247 |
| | 100 | 141 | 227 |
| | 200 | 130 | 209 |

Source: \\srk.ad\dfs\na\van\01_SITES\Back River\1CS020.020_Water_Management_FS_Update\Hydrology_Review\Analysis\Precip_AnnualCompiled_rev5_02102021.xlsx

Notes:

[1] An adjustment factor of 1.006 was applied to the annual precipitation depths from regional stations to correct for the site conditions.

[2] An undercatch factor of 1.61 was applied to account for undercatch errors and precipitation measurements.

## 2.2 Short-Duration Precipitation Events

Daily maximum and rolling sum 72-hour precipitation events were calculated for each of the selected regional stations using complete years, where complete years carry the same criteria as described in Section 2.1.2. Daily and three-day rolling sum maximum precipitation data for each year were corrected to 24-hour data and 72-hour data with correction factors equal to 1.13 and 1.04, respectively (Hershfield 1961). Using the best fit selected for each dataset, a frequency analysis was performed to extrapolate the 24-hour and 72-hour rainfall depths for a range of return periods. There was no strong regression between magnitude of storm events and the station characteristics, including latitude, longitude or elevation.

Figure 2-7 presents the precipitation depth-frequency curves for each of the selected stations, with frequency estimates ranging from 1 in 2-year to the 1 in 200-year event. The maximum 24-hour and 72-hour depths were selected for each return period to be applied at the Project. In the case of 24-hour events, the maximum events were dominated by Byron Bay and Kugluktuk A stations, and in the case of the 72-hour events, the maximum is consistently at Kuglugktuk A station.

Shorter duration events, from the 5-minute storm to the 12-hour storm, were generated using the depth-duration-frequency relationships from the IDF-CC web-based tool.

For durations less than 24-hours, the depth-duration-frequency curve data from the coordinates of the Project were obtained and modified to account for the 24-hour results calculated above. Depth-duration-frequency data for the Project location were obtained using the IDF_CC Tool (Version 3) (ICLR 2018) for return periods ranging from 2 to 100-years. Frequency and duration factors were calculated based on the 24-hour precipitation depths from the IDF-CC dataset and were applied to the Project 24-hour depths described above.

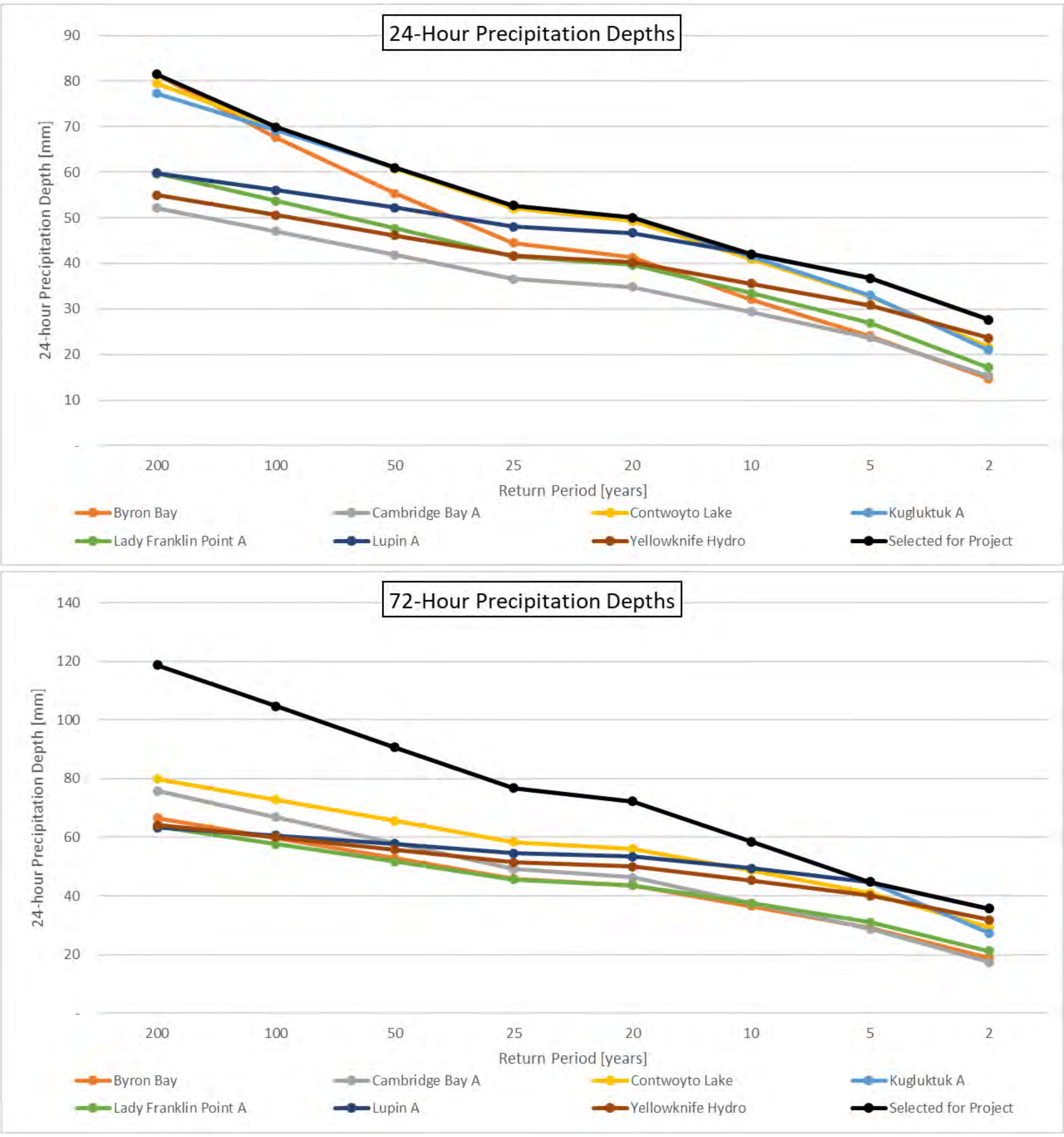


**Figure 2-7: 24-hour and 72-hour Regional Extreme Precipitation Curves for a Range of Return Periods**

Source path: \\srk.ad\dfs\na\van\01_SITES\Back River\1CS020.020_Water_Management_FS_Update\Hydrology_Review\Analysis\Precip_AnnualCompiled_rev5_02102021.xlsx

Table 2-7 summarizes the baseline depth-duration-frequency curve for the Project, where the orange highlighted rows are based on frequency analyses from regional stations and the grey highlighted rows are estimated using frequency and duration factors from the IDF-CC dataset. Duration factors were extrapolated for the 200-year event.

**Table 2-7: Project Baseline Precipitation-Duration-Frequency Curve**

| Storm Duration | | Precipitation Depth (mm) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Return Period (years) | | | | | | |
| **min** | **hours** | 2 | 5 | 10 | 25 | 50 | 100 | 200 |
| 5 | 0.08 | 3.0 | 4.3 | 5.3 | 6.3 | 6.7 | 7.9 | 9.3 |
| 10 | 0.17 | 4.7 | 6.6 | 8.2 | 9.9 | 10.4 | 12.3 | 14.5 |
| 15 | 0.25 | 5.4 | 7.7 | 9.5 | 11.5 | 12.1 | 14.3 | 16.9 |
| 30 | 0.5 | 6.0 | 8.5 | 10.5 | 12.6 | 13.3 | 15.8 | 18.6 |
| 60 | 1 | 6.4 | 9.1 | 11.3 | 13.5 | 14.3 | 16.9 | 19.9 |
| 120 | 2 | 9.0 | 12.7 | 15.8 | 18.9 | 20.0 | 23.7 | 27.8 |
| 360 | 6 | 14.9 | 21.2 | 26.2 | 31.5 | 33.2 | 39.4 | 46.4 |
| 720 | 12 | 18.5 | 26.3 | 32.5 | 39.1 | 41.2 | 48.8 | 57.5 |
| 1440 | 24 | 29.5 | 36.7 | 42.0 | 50.0 | 52.7 | 61.0 | 69.9 |
| 4320 | 72 | 36.5 | 43.5 | 56.7 | 70.1 | 74.5 | 88.0 | 101.6 |

Source: \\srk.ad\dfs\na\van\01_SITES\Back River\1CS020.020_Water_Management_FS_Update\Hydrology_Review\Analysis\BackRiver_IDF_Update_rev04_02102021.xlsm

## 2.3 Probable Maximum Precipitation Event

The 24-hour PMP for each regional station was calculated using the Hershfield method (WMO 2009) (Table 2-8). The greatest PMP estimate from regional stations was calculated to be 285.1 mm and was selected for application to the Project. Climate change was not considered in the estimation of the PMP. Additional characterization of climate change effects to the PMP are recommended in detailed engineering.

**Table 2-8 Regional PMP Values**

| Station | PMP (mm) |
|---|---|
| BYRON BAY A | 152 |
| CAMBRIDGE BAY A | 156 |
| CONTWOYTO LAKE | 214 |
| COPPERMINE | 208 |
| FORT RELIANCE | 180 |
| JENNY LIND ISLAND A | 192 |
| KUGLUKTUK A | 213 |
| LADY FRANKLIN POINT A | 280 |
| LUPIN A | **285** |
| YELLOWKNIFE HYDRO | 179 |

Source: \\srk.ad\dfs\na\van\01_SITES\Back River\1CS020.020_Water_Management_FS_Update\Hydrology_Review\Analysis\Precip_AnnualCompiled_rev5_02102021.xlsx

# 3 Streamflow Analysis

Annual runoff occurs primarily during spring freshet and is derived from the snowpack. The presence of permafrost in the watershed limits groundwater flows into streams resulting in low to zero flows during winter months for small watersheds in the Project area.

Snowmelt is typically the main driver behind regional peak flow events, based on tendencies observed in the historical hydrograph records for regional hydrometric stations. Therefore, characterization of snowmelt rates is an important input for modeling peak flows and volumes. The following sections include a review of available hydrometric data from regional and local sources, as well as the methodology for extreme event flow estimation.

## 3.1 Supporting Datasets

Regional hydrometric data were obtained from the Water Survey of Canada (WSC) for each station within a 300km radius of the Project. Figure 3-1 displays the location of each station and their respective catchment area. Local hydrometric data were obtained from the ERM baseline study completed in 2013. Figure 3-2 displays the stations and catchments applicable to the Goose Property (Rescan 2013).

### 3.1.1 Site Specific Hydrometric Records

Baseline hydrometric data was collected by ERM between 2010 and 2014 and 2017 through 2020. Continuous flow records from 2017 through 2020 were not available at the time of this study, and therefore the runoff analyses remain unchanged from the SRK Hydrology reporting (SRK 2015a). Table 3-1 provides a summary of the hydrometric stations installed in the Property area.

**Table 3-1: Summary of Hydrometric Stations in the Local Study Area**

| Station ID | Description | Latitude (degrees) | Longitude (degrees) | Drainage Area (km$^2$) | Monitoring Years |
|---|---|---|---|---|---|
| GL-H1 | Giraffe Lake Inflow | 65.558 | -106.543 | 18.0 | 2010-2013 |
| GL-H2 | Llama Lake Outflow | 65.545 | -106.453 | 1.7 | 2010-2013 |
| GL-H3 | Goose Lake Inflow | 65.635 | -106.388 | 1.8 | 2011-2013 |
| PL-H1 | Propeller Lake Outflow | 65.564 | -106.408 | 204.6 | 2011-2014 |
| PL-H2 | Propeller Lake Inflow | 65.560 | -106.457 | 101.6 | 2011-2014 |
| GI-H1 | Giraffe Lake Outflow | 65.541 | -106.470 | 27.4 | 2011-2013 |
| EL-H1 | Echo Drainage Outflow | 65.543 | -106.423 | 1.4 | 2011-2013 |
| WL-H1 | Wolf Drainage Outflow | 65.438 | -106.238 | 32.7 | 2011-2013 |
| REFB-H1 | Reference B Lake Outflow | 65.531 | -106.535 | 5.3 | 2011-2013 |
| BL-H1 | Big Lake Inflow | 65.501 | -106.641 | 3.6 | 2012 |

| Station ID | Description | Latitude (degrees) | Longitude (degrees) | Drainage Area ($km^2$) | Monitoring Years |
|---|---|---|---|---|---|
| BL-H2 | Swan Lake Outflow | 65.498 | -106.654 | 160.0 | 2012, 2014 |
| BL-H3 | Moby Lake Outflow | 65.573 | -106.494 | 21.4 | 2012 |
| TIA-H1 | Tailings Impoundment Outflow | 65.550 | -106.534 | 5.0 | 2013 |
| UM-H1 | Umwelt Lake Outflow | 65.585 | -106.494 | 4.1 | 2013 |
| WP-H1 | Wasp Lake Outflow | 65.542 | -106.414 | 17.6 | 2013 |
| WR-H1 | WRSA B Outflow | 65.887 | -107.400 | 2.7 | 2013 |
| KL-H1 | Komatic Lake Inflow | 65.933 | -107.491 | 24.2 | 2012-2013 |
| KL-H2 | George Lake Outflow | 65.850 | -107.316 | 9.6 | 2012-2013 |
| LG-H1 | Long Lake Outflow | 65.922 | -107.479 | 271.1 | 2013 |
| LY-H1 | Lytle Lake Outflow | 65.912 | -107.454 | 10.6 | 2013 |
| SL-H1 | Sleigh Lake Outflow | 65.899 | -107.503 | 13.0 | 2013 |
| MC-H1 | McCoy Lake Outflow | 65.892 | -107.522 | 10.8 | 2013 |
| MC-H2 | McCoy Lake Outflow | 65.830 | -107.505 | 15.8 | 2013 |
| REFQ-H1 | Reference Q Lake | 66.124 | -107.292 | 14.7 | 2013 |
| REFC-H1 | Reference C Lake | 65.558 | -106.543 | 9.5 | 2012 |

Source: Rescan 2013

Note: Lake level stations were not included in the analysis.

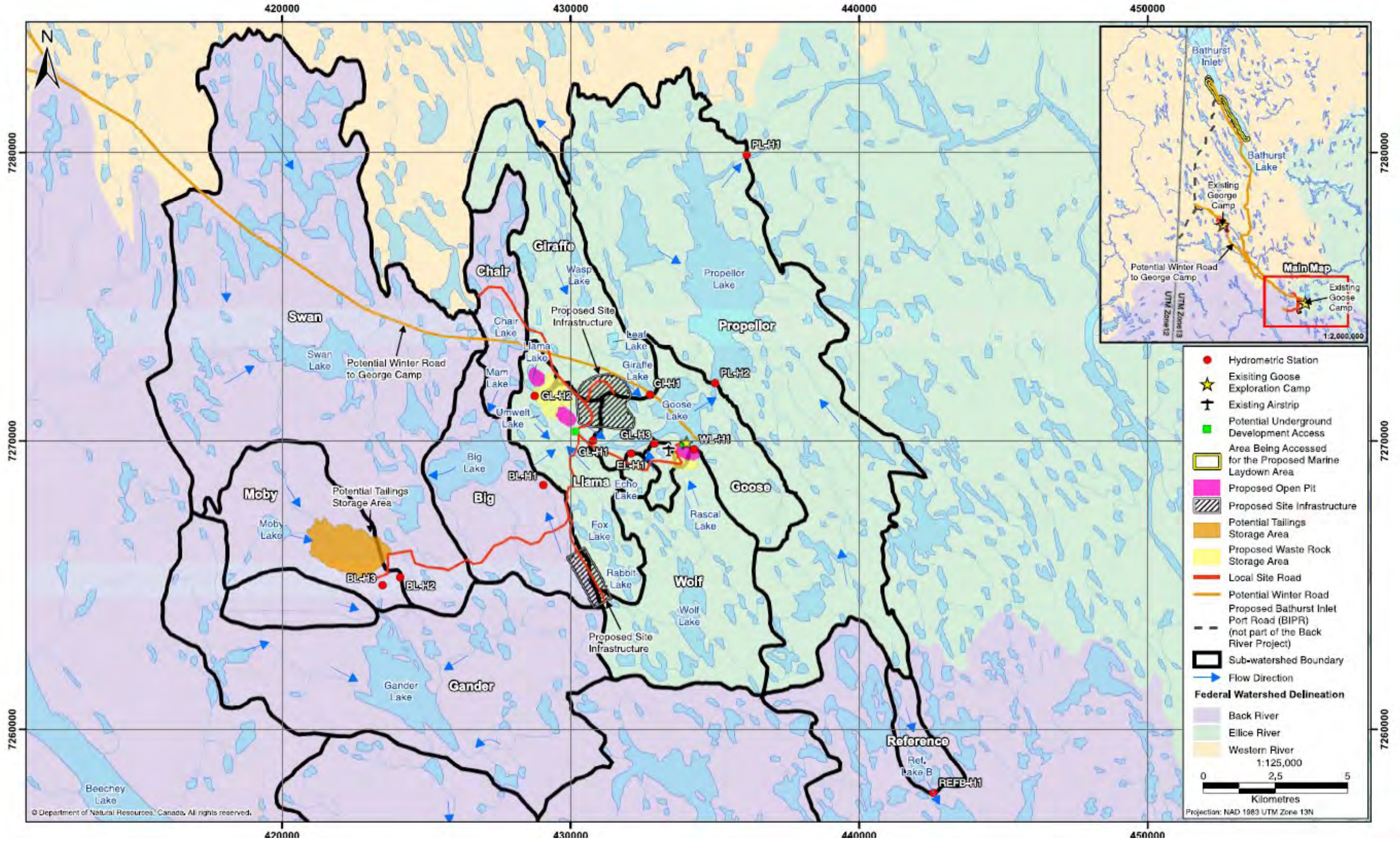


**Figure 3-1: Local Hydrometric Stations (Rescan 2013)**

Source: Rescan 2013

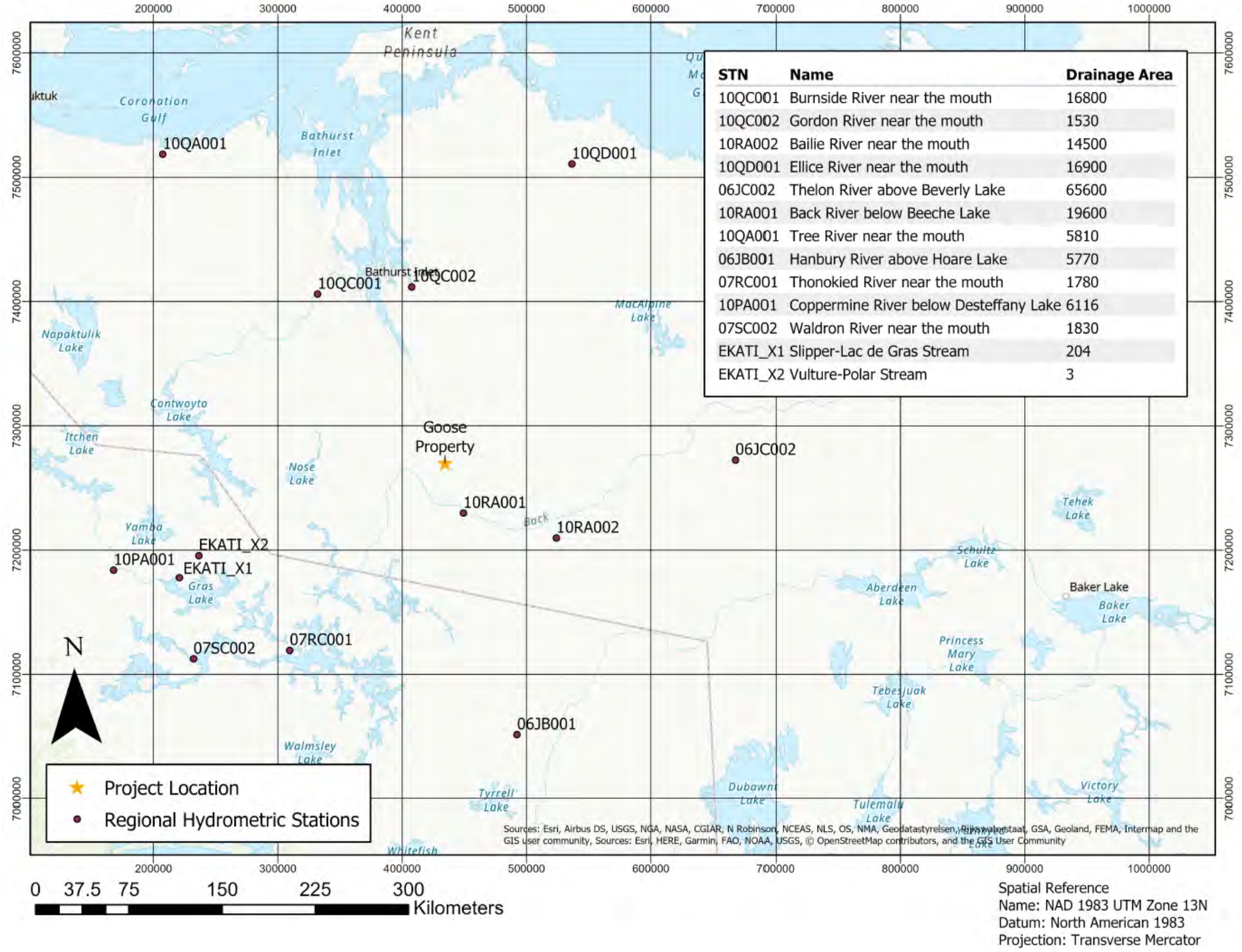
The hydrometric networks were operated through the open water season, typically from end of May through beginning of October. Continuous water level data were collected at each streamflow station along with manual discharge measurements, developing stage-discharge equations and ultimately annual hydrographs. Hydrographs from stations show a snowmelt-driven high flow during spring freshet, during late May and early June. Post-freshet, the hydrographs exhibit a falling limb, with little to no flow through the summer months and a second rainfall-generated peak in late August or early September. Daily data on site is only available during the open water season as all hydrometric stations are demobilized during the winter months. Prior to annual remobilization, rising limbs of the hydrographs were estimated by ERM (Rescan 2012a, 2012b, 2014b and 2014c).

In consultation with ERM it was agreed that the hydrometric station downstream of Goose Lake (PL-H2) and Propeller Lake (PL-H1) would be most representative for use in evaluating the MAR for the Property.

Local site hydrology is of great interest to evaluate available water on site for mining operations and for the water balance model calibration. However, given that there is currently only four years of incomplete data available, a regional analysis was conducted to determine regional hydrological trends and establish extreme event statistics.

### 3.1.2 Regional Hydrometric Datasets

Regional daily hydrometric data for 11 stations were obtained from the WSC within an approximate 300 km radius surrounding the Goose Property (EC 2015). The selected regional stations exhibit similar runoff distributions where the majority of runoff occurs during freshet in June, followed by a continuous decline during the summer months, and a slight rise in September, followed once more by a decline to near zero flow during the winter. Summaries of the 11 stations are provided in Attachment 1, Table A1-2.



| STN | Name | Drainage Area |
|---|---|---|
| 10QC001 | Burnside River near the mouth | 16800 |
| 10QC002 | Gordon River near the mouth | 1530 |
| 10RA002 | Bailie River near the mouth | 14500 |
| 10QD001 | Ellice River near the mouth | 16900 |
| 06JC002 | Thelon River above Beverly Lake | 65600 |
| 10RA001 | Back River below Beeche Lake | 19600 |
| 10QA001 | Tree River near the mouth | 5810 |
| 06JB001 | Hanbury River above Hoare Lake | 5770 |
| 07RC001 | Thonokied River near the mouth | 1780 |
| 10PA001 | Coppermine River below Desteffany Lake | 6116 |
| 07SC002 | Waldron River near the mouth | 1830 |
| EKATI_X1 | Slipper-Lac de Gras Stream | 204 |
| EKATI_X2 | Vulture-Polar Stream | 3 |

**Figure 3-2: Regional Hydrometric Station Map**

Source path: \\srk.ad\dfs\na\van\ 01_SITES\Back River\1CS020.020_Water_Management_FS_Update\!040_AutoCAD\!GIS\!Final\Hydromet_Regional.ppkx

## 3.2 Annual Runoff

The MAR was calculated from each regional station, and is presented in Attachment 1, Table A1-2. Table 3-2 provides a summary of these long-term MAR estimates using three different methods. Method 1, which simply consists of the average MAR for all 11 regional stations, which presents a result of 178 mm. From this dataset, MAR is typically greater than 150 mm. Method 2 and 3 consist of applying PL-H2 and PL-H1 correlations respectively to the long-term Bailie River flows (SRK 2015a). The MAR for the Property was selected to be 149 mm (average of Method 2 and Method 3).

**Table 3-2 Mean Annual Runoff Estimates**

| Method | Description | Runoff Estimate (mm) | |
|---|---|---|---|
| | | June to September | Annual |
| 1 | Regional Average (11 stations) | 146 | 178 |
| 2 | Estimated PL-H2 | 130 | 154 |
| 3 | Estimated PL-H1 | 125 | 143 |
| Property (Average of Methods 2,3) | | 134 | 149 |

Source: SRK 2015a

Table 3-3 provides a summary of the average annual runoff distribution for a MAR of 149 mm, based on the average distribution from regional stations. For a typical hydrological year, freshet occurs in June, recedes during the summer months and streams experience higher flows in later summer to early fall. The average monthly runoff for the Project was calculated by multiplying the monthly distribution by the selected MAR of 149 mm.

**Table 3-3 Monthly Average Flows for the Project**

| Month | % Runoff Distribution | Average Monthly Runoff (mm) |
|---|---|---|
| January | 0.0% | 0.0 |
| February | 0.0% | 0.0 |
| March | 0.0% | 0.0 |
| April | 0.0% | 0.0 |
| May | 4.0% | 5.9 |
| June | 50.5% | 75.3 |
| July | 19.0% | 28.3 |
| August | 8.7% | 12.9 |
| September | 11.9% | 17.8 |
| October | 5.5% | 8.2 |
| November | 0.4% | 0.6 |
| December | 0.0% | 0.0 |
| Annual | 100.0% | 149.0 |

Source: SRK 2015a

A frequency analysis was conducted to the correlated long-term Bailie River station to evaluate the MAR and frequency distribution between wet and dry years. The results are presented in Table 3-4 and are based on the normal probabilistic distribution which was found to provide the best-fit to the data.

**Table 3-4 Annual Frequency Analysis**

| Hydrological Condition | Return Period (years) | Annual Runoff (mm) |
|---|---|---|
| Wet | 200 | 269 |
| | 100 | 258 |
| | 50 | 245 |
| | 20 | 227 |
| | 10 | 210 |
| | 5 | 190 |
| Mean Annual Runoff (MAR) | | 149 |
| Dry | 5 | 112 |
| | 10 | 92 |
| | 20 | 75 |
| | 50 | 56 |
| | 100 | 44 |
| | 200 | 32 |

Source: SRK 2015a

## 3.3 Peak Flows

### 3.3.1 Regional Analysis for Peak Flows

An analysis of regional peak flows was completed as part of the 2015 FEIS (SRK 2015b). A frequency analysis was conducted to fit a probability distribution to the peak flow data for each regional hydrometric station. The catchment areas for site infrastructure are orders of magnitude smaller than those for the regional hydrometric stations presented in Table A1-2. Peak flow magnitudes and response times for these smaller catchment areas are expected to vary from those of larger catchments.

To assess the peak flows for the site infrastructure catchments, data from the regional hydrometric stations were complimented by data from two gauges at the Ekati project. The Ekati gauges are located closer to the site than most of the regional stations, and presented smaller watershed areas similar in magnitude to the site infrastructure catchment areas. Table 3-5 presents a summary of these two gauging stations and the results of the frequency analysis conducted by ERM (2013).

**Table 3-5: Estimated Instantaneous Peak Flows from Ekati Project (ERM 2013)**

| Parameter | Slipper-Lac de Gras Stream | Vulture-Polar Stream |
|---|---|---|
| Latitude (deg) | 67.74 | 64.606 |
| Longitude (deg) | -104.548 | -104.863 |
| Drainage Area (km$^2$) | 204 | 2.7 |
| Period of Record | 1995-2011 | 1995-2011 |
| Distance from Goose Site (km) | 259 | 129 |
| 2-year Flood (m$^3$/s/km$^2$) | 0.06 | 0.22 |
| 5-year Flood (m$^3$/s/km$^2$) | 0.14 | 0.44 |
| 10-year Flood (m$^3$/s/km$^2$) | 0.20 | 0.56 |
| 20-year Flood (m$^3$/s/km$^2$) | 0.26 | 0.70 |
| 50-year Flood (m$^3$/s/km$^2$) | 0.35 | 0.89 |
| 100-year Flood (m$^3$/s/km$^2$) | 0.43 | 1.00 |
| 200-year Flood (m$^3$/s/km$^2$) | 0.50 | 1.11 |

Source: SRK 2015a

Figure 3-3 presents the results of the frequency analyses for regional peak flows, along with the peak flows presented in Table 3-5. The peak flows for the 10-year, 50-year and 100-year return period events are plotted against the associated drainage areas, and a regression line of best fit is presented in Figure 3-4.

The results show a conservative representation of the peak flows for gauges in watersheds greater than 200 km$^2$ in size. For smaller watersheds, the predicted peak flows tend to be smaller than the observed values. This phenomenon was presented in every return period from 2 to 200 years.

To account for the potentially higher peak flow response of the smaller catchments and match the estimates for the Ekati gauges, a rainfall-runoff model was developed. The Soil Conservation Services (SCS) methodology was selected, which allows for an adjustment to rainfall depth due to climate change and adjustments for land use in the curve number (CN).

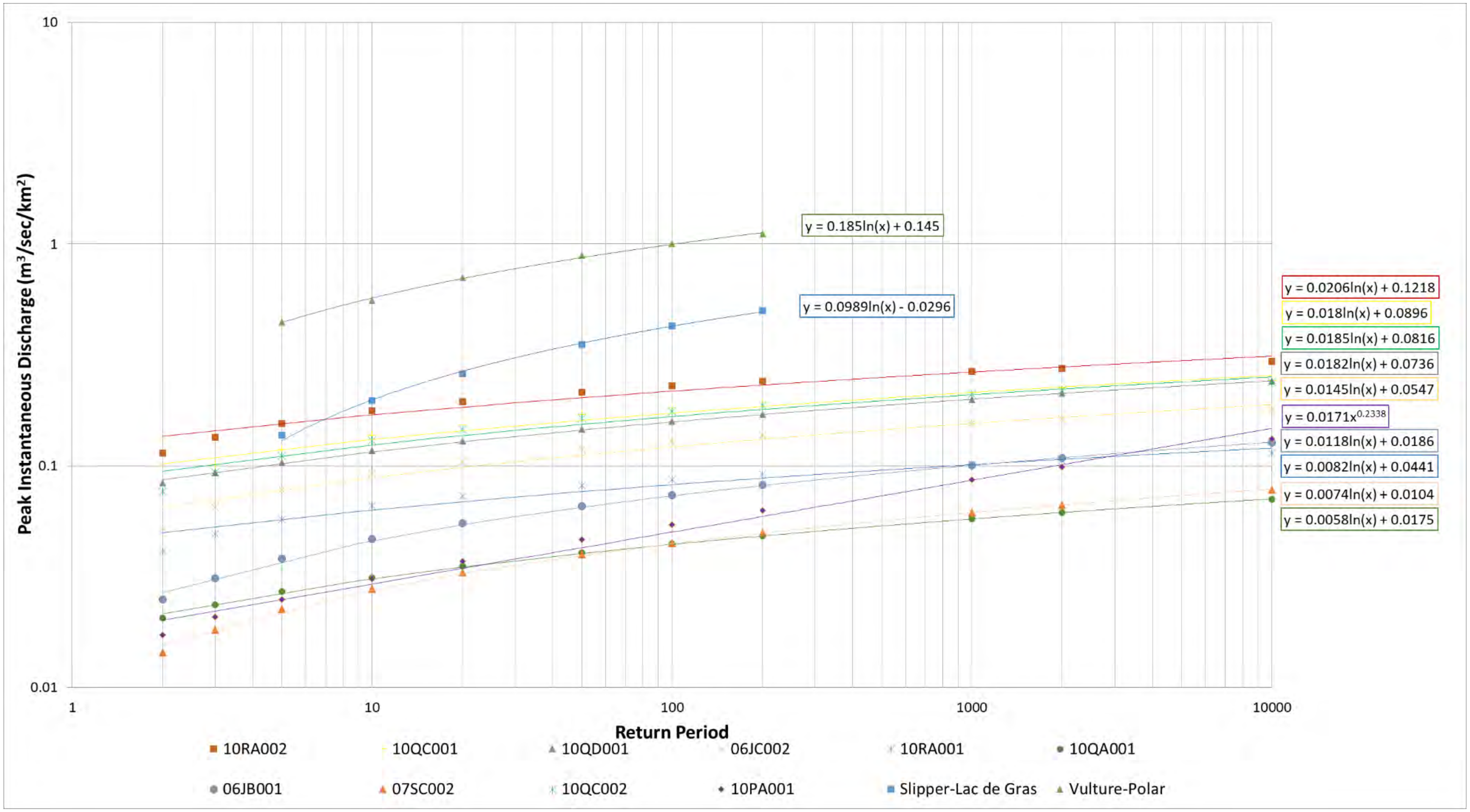


**Figure 3-3: Regional Peak Instantaneous Floods for a range of Return Periods**

Source: \\srk.ad\dfs\na\van\01_SITES\Back River\1CS020.020_Water_Management_FS_Update\Hydrology_Review\Analysis\ Precip_AnnualCompiled_rev5_02102021.xlsx

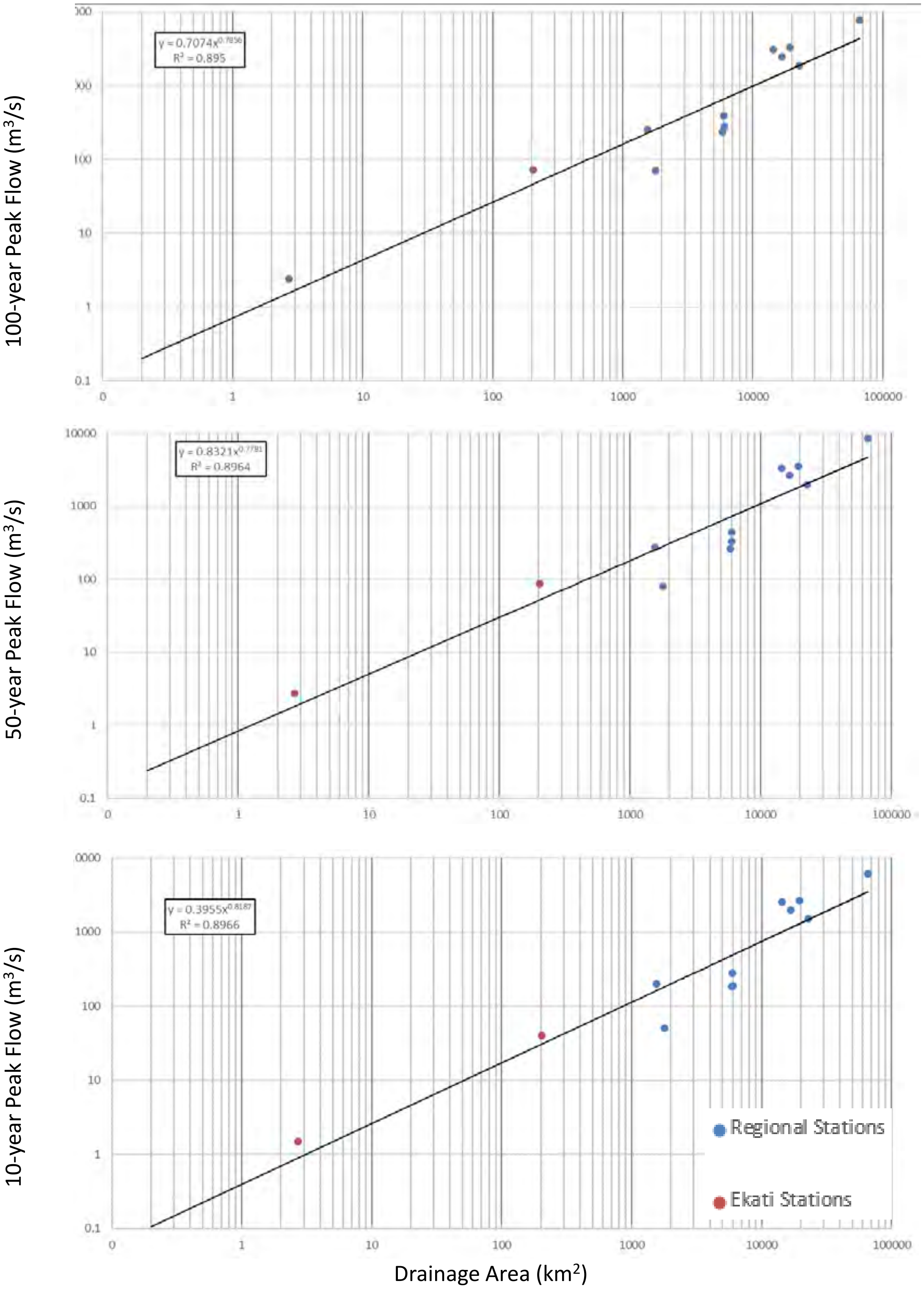


**Figure 3-4: Regression of Instantaneous Peak Flows and Drainage Area [km$^2$]**

Source: Z:\01_SITES\Back River\1CS020.008_FEIS\700_Water_Mgt_System_Update\Water Balance\Analysis\Hydrology\FEIS_Peak Flow Analysis_Rev04_SPB.xlsx

### 3.3.2 Precipitation-Based Peak Flow Model

To improve the peak flow estimation for smaller watersheds (less than 200 km²), the SCS Method was used. The CN is based on factors such as the hydrologic soil group, cover type, and hydrologic conditions. To estimate an appropriate CN for the Property, a hydrological model was generated in HEC-HMS (2013), where the CN was defined following an iterative process using the regional results from the Index Flood Method and the two Ekati gauges.

Input to the HEC-HMS model for each catchment includes response time, catchment area, and CN. The Clark Unit hydrograph (USDA 1986) was selected to estimate the transformation for the hydrograph. The catchments for each gauging station were delineated in Global Mapper™ software, as well as, catchment characteristics calculations, including average slope gradient and maximum flow path length (Blue Marble 2015). The time of concentration (TOC) for each catchment were estimated using the Watt and Chow method.

The HEC-HMS calibration was developed for each of the Ekati stations, resulting in an associated CN for each return period. Curve number results for each station were similar for corresponding return periods. Table 3-5 presents the maximum CN result for each Ekati station for the 10, 20, 50 and 100-year return period event. Decreasing CN with increasing storm size is an observed hydrological behaviour, where results below represent a standard behaviour output with a near-constant CN for higher return periods (Hawkins, 1993).

**Table 3-5 Calibrated SCS Curve Numbers for the Different Return Periods**

| Return Period | SCS Curve Number |
|---|---|
| 100 | 67 |
| 50 | 67 |
| 20 | 66 |
| 10 | 70 |

Source: \\Srk.ad\dfs\na\van\Projects\01_SITES\Back River\1CS020.020_Water_Management_FS_Update\Hydrology_Review\Design\BackRiver_WaterMgmt_rev03.xlsm

For the purpose of estimating peak flows for natural catchments at the Property, the SCS Method with the associated CN for the different return periods in Table 3-5 was implemented using the project-specific rainfall dataset. It should be emphasized that these CN values applied to natural catchment include snowmelt contribution. For mine site catchments, the SCS Method may need to incorporate adjusted CN values for each type of infrastructure, extreme rainfall depths and snowmelt flows.

### 3.3.3 Snowmelt Contribution Assumptions

Seasonal floods for the area are snowmelt driven and typically occur in June, therefore the peak flows were assumed to occur as a result of a snowmelt-driven hydrograph.

Snowmelt depths were developed in SRK (2015a) based on a daily water balance model using expressions from the US Army Corps of Engineers Snow Hydrology report (USACE 1956) and 30 years of daily meteorological data from Modern-Era Retrospective Re-analysis for Research and

Applications (Rienecker et al., 2011). The model used precipitation and temperature to predict snowpack and the potential snowmelt on a daily basis.

The maximum daily snowmelt was calculated for each year, which produced an average maximum daily snowmelt of 28 mm/day. Snowmelt depth was multiplied by the Property catchment areas to generate snowmelt baseflow, using a sinusoidal distribution over a 24-hour period. This rate was added to the incremental precipitation depths using the alternating block method and the depth-duration-frequency table rainfall results, creating a rain-on-snow precipitation hyetograph as input to the HEC-HMS model.

# 4 Climate Change

A climate change analysis was completed for the Project in 2015 following SRK's Standardized Procedure for Clime Change Integration into Engineering Design (SRK 2015c). Through the procedure's screening process, it was determined that the Feasibility Designs should consider climate change on the following parameters:

- Air Temperature
- Precipitation
- Wind Speed

The following sections summarize the climate change estimates prepared in 2015, with updated estimates related to the depth-duration-frequency data for extreme events. The climate analysis is segmented in 30 year periods with a context assigned to each timeline. 2011-2040 shall be used to represent the 2020's, 2041-2070 shall be used to represent the 2050's and 2071-2100 shall be used to represent the 2080's.

## 4.1 Long Term Temperature Trends

Table 4-1 shows that in accordance with climate change models the mean annual temperature will increase about 5.3ºC over the next century. The average predicted increase is 2.0ºC, 3.7ºC and 5.3ºC for the 2020s, 2050s and 2080s, respectively. This will increase annual mean temperatures to approximately -8.6ºC, -6.9ºC and -5.3ºC, respectively.

**Table 4-1 Mean Annual Air Temperature**

| Timeline | Context | Mean Annual Value (˚C) | Change with Respect to Baseline (˚C) | Change [%][1] |
|---|---|---|---|---|
| 1979 – 2005 | Baseline | -10.6 | - | - |
| 2011 – 2040 | 2020s | -8.6 | 2.0 | 0.75% |
| 2041 – 2070 | 2050s | -6.9 | 3.7 | 1.40% |
| 2071 – 2100 | 2080s | -5.3 | 5.3 | 2.00% |

Source: SRK 2015b

Notes:

[1] Change with respect to kelvin degrees

## 4.2 Long Term Precipitation Trends

In accordance with climate change models, the annual precipitation is predicted to increase by 6%, 11% and 16% for the 2020s, 2050s and 2080s, respectively.

**Table 4-2 Total Precipitation**

| Timeline | Context | Change with Respect to Baseline [%] |
|---|---|---|
| 1979 – 2005 | Baseline | - |
| 2011 – 2040 | 2020s | 6.00% |
| 2041 – 2070 | 2050s | 11.0% |
| 2071 – 2100 | 2080s | 16.0% |

Source: SRK 2015b

## 4.3 Rain on Snow Events Trend

There is no clear trend for the maximum daily snowmelt in an average year as seen in Table 4-3. As a result, there is no trend for an increasing or decreasing trend associated with rain on snow events.

**Table 4-3 Maximum Daily Snowmelt in Average Year**

| Timeline | Maximum Daily Snowmelt in an Average Year (mm) |
|---|---|
| 1979 – 2005 (Baseline) | 32 |
| 2020's | 24 |
| 2050's | 28 |
| 2080's | 27 |

Source: SRK 2015b

## 4.4 Short-Duration Precipitation Events with Climate Change

The effects of climate change were incorporated by adjusting the IDF curve presented in Section 2.2. For each return period and duration, a rate of change over baseline was calculated from data obtained from the IDF-CC tool (ICLR 2018). The IDF-CC tool allows the user to select the desired representative concentration pathway (RCP) and apply Pacific Climate Impacts Consortium (PCIC) bias correction methods to climate change data generated from a multi-model ensemble. RCP's are used in climate modeling to describe emissions scenarios based on future population size, lifestyle, energy use, land use, and policy (IPCC 2016).

The 5th assessment report released by the intergovernmental panel on climate change (IPCC) recognizes four representative RCPs: 2.6, 4.5, 6.0 and 8.5. These scenarios provide a range of future outcomes. RCP 2.6 describes a future where emissions are stringently mitigated. RCPs 4.5 and 6.0 represent middle ground scenarios in which mitigations are progressively established and primarily differ based on the rate at which emissions are reduced (Senses 2020). RCP 8.5 represents a future where greenhouse gas emissions continue to increase rapidly. For this analysis, RCP 8.5 was selected to generate a conservative precipitation duration frequency curve.

The rate of change ranged from 17% for 2-year storms to 24% for 100-year storms. Table 4-4 presents the adjusted IDF curve. Climate change effects were extrapolated to the 72-hour duration event based on a logarithmic line of best fit from durations ranging from 5-minute to 24-hours.

**Table 4-4: Project Climate Change Precipitation-Duration-Frequency Curve**

| **Storm Duration** | | **Precipitation (mm)** | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | **Return Period (years)** | | | | | | |
| min | hours | 2 | 5 | 10 | 25 | 50 | 100 | 200 |
| 5 | 0.08 | 3.5 | 5.2 | 6.4 | 7.7 | 8.1 | 9.6 | 11.6 |
| 10 | 0.17 | 5.5 | 8.2 | 10.1 | 12.0 | 12.6 | 15.0 | 18.0 |
| 15 | 0.25 | 6.4 | 9.5 | 11.7 | 13.9 | 14.6 | 17.5 | 21.0 |
| 30 | 0.5 | 7.0 | 10.5 | 12.9 | 15.4 | 16.1 | 19.3 | 23.1 |
| 60 | 1 | 7.5 | 11.2 | 13.8 | 16.4 | 17.2 | 20.6 | 24.7 |
| 120 | 2 | 10.5 | 15.7 | 19.3 | 23.0 | 24.1 | 28.9 | 34.6 |
| 360 | 6 | 17.5 | 26.1 | 32.1 | 38.3 | 40.2 | 48.1 | 57.7 |
| 720 | 12 | 21.7 | 32.3 | 39.9 | 47.5 | 49.8 | 59.6 | 71.5 |
| 1440 | 24 | 34.6 | 45.1 | 51.5 | 60.8 | 63.8 | 74.5 | 87.0 |
| 4320 | 72 | 42.9 | 53.4 | 69.5 | 85.2 | 90.1 | 107.4 | 126.4 |

Source: \\srk.ad\dfs\na\van\01_SITES\Back River\1CS020.020_Water_Management_FS_Update\Hydrology_Review\Analysis\BackRiver_IDF_Update_rev04_02102021.xlsm

## 4.5 Wind Speed Trends

Mean annual windspeed is predicted to increase by 4.5% over the next century as described in Table 4-5.

**Table 4-5 Mean Annual Windspeeds**

| **Timeline** | **Context** | **Mean Annual Value (m/s)** | **Change with Respect to Baseline (m/s)** | **Change with Respect to Baseline [%]** |
|---|---|---|---|---|
| 1979 – 2005 | Baseline | 4.83 | - | - |
| 2011 – 2040 | 2020s | 4.90 | 0.07 | 1.50% |
| 2041 – 2070 | 2050s | 4.96 | 0.13 | 2.70% |
| 2071 – 2100 | 2080s | 5.05 | 0.22 | 4.50% |

Source: SRK 2015b

# 5 Summary

Key findings of this memo are listed below.

### Precipitation:

1. Regional analysis was applied to determine a mean annual precipitation of 412 mm.
2. This value includes an annual undercatch adjustment factor of 1.61 to account for snow loss due to wind.
3. The 24-hour and 72-hour duration 100-year precipitation depths with climate change are 74.5 mm and 107.4 mm, respectively.
4. PMP is estimated as 285 mm and it was assumed this value will not change due to climate change.

### Streamflow:

1. Regional analysis was applied to determine an MAR of 149 mm.
2. Peak flow events from regional and local datasets suggest a snowmelt-driven annual peak flow. A CN value was calibrated using regional datasets and determined to be between 67 and 69 depending on the event return period for a 24-hour event
3. Rainfall from the climate change-adjusted depth-duration-frequency table along with maximum expected snowmelt can be incorporated into a hydrologic model to calculate Project-specific peak flows.

### Climate Change:

Mean air temperature, precipitation and windspeed are expected to change over the lifespan of this project. The change relative to the baseline scenario summarized below:

| Timeline | Change with Respect to Baseline [%] | | |
|---|---|---|---|
| | Air Temperature[1] | Precipitation | Wind Speed |
| 2011 – 2040 | 0.75% | 6.00% | 1.50% |
| 2041 – 2070 | 1.40% | 11.0% | 2.70% |
| 2071 – 2100 | 2.00% | 16.0% | 4.50% |

Additionally, the rate of change ranged from 17% for 2-year storms to 24% for 100-year storms.

---

[1] Change with respect to kelvin degrees

## 5.2 Recommendation and Limitations

The current hydrologic analysis is predominantly developed using regional datasets. Local climate monitoring does not capture snow, snowpack measurements and streamflow monitoring may not fully capture the spring freshet magnitudes. Additional monitoring within the Project area is recommended to validate site-specific precipitation estimates, runoff rates and peak flows.

SRK recommends that the local meteorological stations be upgraded to include year-round precipitation measurements, with appropriate equipment to capture snowpack depth and snow water equivalent. Once year-round precipitation records are available, the local record should be augmented and extended using the regional datasets or climatic gridded models, and appropriate updates to the climate statistics as-needed. Local wind speed data could also be used to validate undercatch assumptions for precipitation.

Consideration of climate change effects to the PMP may be required if water management infrastructure is required in closure for high-risk infrastructure. Current modeling is based on the historical PMP which should be re-evaluated at Detailed Engineering.

Streamflow monitoring on-site should continue, including validation of previously developed rating curves with manual discharge measurements and surveys of creek cross-section geometry. Re-installation of hydrometric stations should be targeted prior to onset of snowmelt in order to capture the freshet peak flows. A continuous rainfall-runoff model is recommended, calibrated against the continuous local hydrometric / snowpack data, which could also be used to validate the peak flow modeling and CN selection.

Hydrologic variables presented herein are appropriate for Feasibility-level designs and costing, but should be reviewed and validated with additional site data in advance of Detailed Engineering.

## Attachments:

| | |
|---|---|
| Attachment 1 | Additional Tables |

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

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# Attachment 1 Additional Tables

Table A1-1: Regional Climate Stations

Table A1-2: Regional Hydrometric Stations

**Table A1-1 Regional Climate Stations**

| Station Name | Station Identifier | Latitude | Longitude | Distance from Project (km) | Elevation (m) | Period of Record | Years with Information * |
|---|---|---|---|---|---|---|---|
| BATHURST INLET | 1628 | 66.83 | -108.02 | 158.9 | 13.4 | 1958-2019 | 3 |
| BATHURST INLET | 50657 | 66.84 | -108.01 | 159.7 | 5 | 1958-2019 | 3 |
| CONTWOYTO LAKE | 1639 | 65.48 | -110.37 | 182.9 | 451.4 | 1959-1981 | 21 |
| ROBERTSON LAKE (AUT) | 7337 | 65.1 | -102.43 | 192.8 | 243.7 | 1997-2006 | 1 |
| EKATI A | 27240 | 64.7 | -110.61 | 218.8 | 468.2 | 1999-2015 | 7 |
| LUPIN (AUT) | 8941 | 65.77 | -111.23 | 222.4 | 499.6 | 1993-1995 | 0 |
| LUPIN A | 1671 | 65.76 | -111.25 | 223.3 | 490.1 | 1982-2006 | 24 |
| LUPIN CS | 27376 | 65.76 | -111.25 | 223.3 | 488 | 2018-2019 | 1 |
| HANBURY RIVER | 10897 | 63.6 | -105.13 | 227.1 | 317.4 | 1995-2015 | 1 |
| ELLICE RIVER (AUT) | 10895 | 67.72 | -104.47 | 255.8 | 42 | 1996 | 0 |
| TUNDRA MINE | 1701 | 64.03 | -111.17 | 282.9 | 470.9 | 1965 | 0 |
| DUBAWNT LAKE (AUT) | 10802 | 63.23 | -101.76 | 343.3 | 237.4 | 1999-2000 | 0 |
| FORT RELIANCE | 1652 | 62.72 | -109.17 | 343.7 | 165.8 | 1949-1990 | 39 |
| FORT RELIANCE (AUT) | 8935 | 62.71 | -109.17 | 344.7 | 167.6 | 2003-2020 | 5 |
| LYNX LAKE | 1672 | 62.47 | -106.88 | 345.2 | 1183 | 1990-1993 | 0 |
| BYRON BAY A | 1785 | 68.75 | -109.07 | 373.8 | 92.1 | 1958-1992 | 32 |
| EDINBURGH ISLAND | 10831 | 68.49 | -110.88 | 380.0 | 193.8 | 1992-1993 | 0 |
| STURT POINT | 1725 | 68.78 | -103.35 | 382.8 | 19.5 | 1961-1962 | 1 |
| CAPE PEEL | 1634 | 69.05 | -107.32 | 391.1 | 58.5 | 1959-1962 | 0 |
| CAPE PEEL WEST | 10828 | 69.04 | -107.82 | 392.7 | 165.3 | 1993-2020 | 0 |
| ROSS POINT | 1692 | 68.58 | -111.1 | 393.3 | 148.7 | 1959-1962 | 2 |
| WEKWEETI A | 50721 | 64.19 | -114.08 | 393.6 | 368.2 | 2019-2020 | 1 |
| STURT POINT NORTH | 10832 | 68.97 | -103.77 | 397.0 | 106 | 1992-1993 | 0 |
| CAMBRIDGE BAY A | 1786 | 69.11 | -105.14 | 399.7 | 31.09 | 1940-2019 | 61 |
| CAMBRIDGE BAY A | 53512 | 69.11 | -105.14 | 399.7 | 31.1 | 1940-2019 | 61 |

| Station Name | Station Identifier | Latitude | Longitude | Distance from Project (km) | Elevation (m) | Period of Record | Years with Information * |
|---|---|---|---|---|---|---|---|
| CAMBRIDGE BAY A | 54139 | 69.11 | -105.14 | 399.7 | 31.1 | 1940-2019 | 61 |
| CAMBRIDGE BAY GSN | 32233 | 69.11 | -105.14 | 399.7 | 18.69 | 2003-2020 | 5 |
| JENNY LIND ISLAND A | 1717 | 68.65 | -101.73 | 400.0 | 18.3 | 1959-1991 | 27 |
| JENNY LIND ISLAND | 10829 | 68.75 | -101.85 | 406.9 | 78.5 | 1992-1993 | 0 |
| LUTSELK'E A | 27797 | 62.42 | -110.68 | 407.2 | 178.6 | 2000-2010 | 6 |
| LUTSELK'E A | 53508 | 62.42 | -110.68 | 407.2 | 178.6 | 2000-2010 | 6 |
| LUTSELK'E CS | 29451 | 62.42 | -110.69 | 407.5 | 178.9 | 2001-2007 | 3 |
| SNOWDRIFT | 1695 | 62.4 | -110.73 | 410.4 | 176.8 | 1973 | 1 |
| HAT ISLAND | 1716 | 68.32 | -100.09 | 413.6 | 36.1 | 1959-1962 | 4 |
| POWDER LAKE | 10931 | 61.97 | -108.62 | 414.6 | 485 | 1994-2003 | 0 |
| GRAY LAKE | 10929 | 61.92 | -108.43 | 417.7 | 451.1 | 1994-2001 | 0 |
| LOWER CARP LAKE | 27610 | 63.6 | -113.86 | 417.7 | 373.4 | 1999-2003 | 1 |
| INDIN RIVER | 10757 | 64.39 | -115.02 | 426.1 | 304.7 | 1994-2002 | 0 |
| COLOMAC MINE | 1638 | 64.42 | -115.1 | 428.5 | 327.1 | 1990 | 0 |
| PORTER LAKE | 1689 | 61.7 | -108 | 437.3 | 364.8 | 1975 | 0 |
| LADY FRANKLIN POINT A | 1675 | 68.5 | -113.22 | 441.4 | 15.9 | 1959-1992 | 20 |
| BACK RIVER (AUT) | 10723 | 66.09 | -96.51 | 456.4 | 61 | 1994-2004 | 0 |
| COPPERMINE | 1640 | 67.83 | -115.12 | 459.5 | 9.1 | 1933-1977 | 42 |
| KUGLUKTUK A | 1641 | 67.82 | -115.14 | 459.7 | 22.6 | 1978-2020 | 30 |
| KUGLUKTUK A | 53335 | 67.82 | -115.14 | 459.7 | 22.6 | 1978-2020 | 30 |
| KUGLUKTUK A | 54158 | 67.82 | -115.14 | 459.7 | 22.6 | 1978-2020 | 30 |
| KUGLUKTUK CLIMATE | 43003 | 67.82 | -115.14 | 459.7 | 22.6 | 2005-2020 | 3 |
| YELLOWKNIFE HYDRO | 1707 | 62.67 | -114.25 | 498.7 | 159.4 | 1943-1996 | 34 |

Notes:

* Years with more than 300 days of data available.

**Table A1-2 Regional Hydrometric Stations**

| Station ID | Station Name | Drainage Area (km$^2$) | Percent Lake Cover (%) | Average Catchment Elevation (m) | MAR (mm) | Monitoring Years (complete years) |
|---|---|---|---|---|---|---|
| 10QC001 | Burnside River near the mouth | 16,800 | 14% | 458 | 252 | 1976 – 2013 (27) |
| 10QC002 | Gordon River near the mouth | 1,530 | 14% | 262 | 195 | 1977 – 1994 (11) |
| 10RA002 | Bailie River near the mouth | 14,500 | 15% | 337 | 164 | 1978 – 2011 (25) |
| 10QD001 | Ellice River near the mouth | 16,900 | 15% | 244 | 157 | 1971 – 2013 (32) |
| 06JC002 | Thelon River above Beverly Lake | 65,600 | 18% | Not Available | 151 | 1970 – 2013 (36) |
| 10RA001 | Back River below Beeche Lake | 19,600 | 21% | 402 | 175 | 1978 – 2013 (29) |
| 10QA001 | Tree River near the mouth | 5,810 | 25% | 409 | 192 | 1968 – 2013 (31) |
| 06JB001 | Hanbury River above Hoare Lake | 5,770 | 25% | 380 | 156 | 1971 – 2013 (17) |
| 07RC001 | Thonokied River near the mouth | 1,780 | 27% | 427 | 190 | 1980 – 1990 (5) |
| 10PA001 | Coppermine River below Desteffany Lake | 6,116 | 29% | 442 | 144 | 1994 – 2013 (12) |
| 07SC002 | Waldron River near the mouth | 1,830 | 58% | 421 | 114 | 1979 – 2013 (19) |

# ATTACHMENT 3

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# Technical Memo

November 29, 2022

| | |
|---|---|
| **To** | Project File |
| **From** | Christopher Stevens, PhD |
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| **Subject** | Primary Pond Dam – Thermal Modeling Overview |
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## 1 Introduction

SRK Consulting (Canada) Inc. was retained by Sabina Gold & Silver Corp. (Sabina) to predict thermal performance of the Primary Pond Dam (the Dam) at the Back River Project located in Nunavut. The Primary Pond Dam will be operated as a water retention dam with a 10-year design life.

The dam will be constructed primarily of rock fill placed directly on the existing tundra surface, with exception of the excavated key trench. The dam will rely on an impermeable HDPE liner incorporated in the dam fill and keyed into the permafrost foundation to achieve the required water retention properties. It is imperative that the liner remain frozen to the permafrost foundation to maintain containment. Stability of the structure is also reliant on maintaining an adequately frozen permafrost foundation over areas with ice-rich overburden soil.

This memo summarises the approach, methods, assumptions, and results of numerical thermal modeling to support design of the Primary Pond Dam. Background information on dams constructed on permafrost is provided along with the potential impact of water seepage (Sections 2 and 3), followed by summary of permafrost and foundation at the Primary Pond Dam (Section 4), ground thermal modeling methods (Section 5), and model results, including design modification to reduce uncertainty in thermal performance (Section 6).

### 1.1 Objectives

The modeling objectives were to determine:

- If the design key trench depth with passive thermosyphons is adequate to maintain a frozen connection with the HDPE liner and frozen overburden foundation.

- Evaluate the overall thermal performance based on ground temperature of the fill and foundation over the design life.

The foundation was considered to be frozen if colder than -2°C, which represents a conservative freezing point depression for the average overburden pore water salinity measured from samples collected at the Goose Property (see Section 4.2).

# 2 Dams Constructed on Permafrost

## 2.1 Typical Designs

Water and tailings dams founded on ice-rich permafrost can be divided into two broad categories; frozen core dam and frozen foundation dams (Miller et al. 2013; Holubec et al. 2003). The dams typically include an impermeable liner that is incorporated into a key trench and backfilled with geochemically suitable quarry rock (Figure 1). In some cases, locally derived overburden soil may be suitable for construction material.

Frozen core dams are designed to include a frozen, ice-saturated core to achieve the required water retention properties and to provide a large thermal mass to accommodate heat from the impounded water (Figure 1). An impermeable liner (GCL or HDPE liner) is typically installed along the upstream side of the frozen core to provide secondary water-retaining capability and acts as a preventative measure should cracks develop in the core from thermal expansion or creep deformation. The core material is placed in unfrozen lifts near the material's saturation and allowed to freeze during construction to ice-saturate the pore space and reduce the potential of water seepage through the core. Modern-day frozen core dams include passive thermosyphons that allow for annual heat extraction from the core (see Section 2.3 for description of thermosyphons).

In contrast to frozen core dams are frozen foundation dams that typically contain tailings solids and rely on a liner keyed into the frozen permafrost foundation to achieve containment (Figure 1). The thermal design is based on passive heat transfer with the atmosphere and includes sufficient thermal cover of dam fill to limit warming and thaw of the foundation. The deposition of low permeability tailings from the upstream face of the dam contributes to development a subaerial beach to further limit the potential for water seepage and to promote heat loss from the foundation over time. A frozen foundation dam typically does not include passive thermosyphons for extract heat from the ground.

The Primary Pond Dam would be classified as a frozen foundation water retention dam.

## 2.2 Heat Transfer

It is generally accepted that thermal conduction accounts for a notable portion of the heat transfer in natural soils (Johansen 1975). Modeling thermal performance of water and tailings embankments in permafrost environments is typically based on thermal conduction without direct consideration of non-conductive heat transfer in the model. However, there are circumstances where non-conductive heat transfer may represent a significant influence on thermal performance of the dam. Non-conductive heat transfer may include mass transport of heat from air movement through air-filled inter-connected rock pore space or movement of water (water seepage). An additional influence on heat transfer exists where thermosyphons are installed and operated as part of the design.

Heat transfer of significance to thermal performance of dams constructed on permafrost include:

- Atmosphere to exposed rock fill that causes a greater seasonal input of heat to the ground when compared to undisturbed vegetated tundra.
- Impounded water against the upstream face of the dam that has a large thermal mass and allows for heat gain to the foundation, and consequently limits winter heat loss along some regions of the dam.
- Water seepage, if present, that causes advection of heat and more rapid ground warming when compared to heat transfer from thermal conduction alone.
- Natural air convection within areas of air-filled rock that would seasonally increase heat loss, if adequate physical and thermal conditions exist. Forced convection from wind may also occur in the presence of rock with a relatively high air permeability.
- Seasonal heat extraction from thermosyphons, if present, which is controlled by the unit capacity and efficiency to extract heat from the ground.

Heat transfer from the above-mentioned act to modify the ground thermal regime and are therefore considerations in thermal design of the structure.

## 2.3 Passive Thermosyphons

Passive thermosyphons are commonly installed during construction of water retention dams and consist of pressurized sealed pipes that are charged with a two-phase working gas (fluid) that vaporizes and condenses to move heat without the need of a mechanical pump. A typical passive thermosyphon consists of an evaporator pipe buried in the ground and radiator exposed at the surface. The radiator section is manufactured with fins attached to the radiator pipe to enhance heat transfer with the atmosphere.

Heat is extracted from the ground when the air temperature at the radiator is colder than the ground temperature adjacent to the evaporator pipe. The pressurized working fluid lowers the pressure-boiling point within the pipe which causes the fluid to change phase to a gas under the temperature differential. The gas rises to the surface end of the pipe where it cools and condenses back to a liquid. The gas-liquid phase change releases the energy (heat) previously extracted from the ground at the evaporator. The condensed fluid flows under gravity back to the bottom of the evaporator pipe, and this phase change process repeats until the air temperature becomes warmer than the ground temperature.

# 3 Water Seepage

Water seepage is an important consideration for dams with frozen components due to the potential for transport of heat (energy) from water movement that contributes to rapid ground warming and thaw.

## 3.1 Advection of Heat

Non-conductive heat transfer from water can be considered to either be free convection (natural convection) that is driven by temperature or chemical variation in fluid density and forced convection (advection) that occurs due to fluid pressure gradients. The advection of heat from flowing water is known to cause relatively rapid warming and thawing of permafrost. Advective heat transport has also been shown to be a highly efficient process to transmit heat and melt ice-filled rock fractures (Hasler et al. 2011).

The relatively rapid melting of ice from flowing water is due, in part, to the high efficiency of convective heat exchange between moving water and ice. Shur (1977) evaluated natural convection and concluded that the heat exchange between ice and non-flowing water depended on the water temperature, from 100 to 300 W $m^{-2}$ °C. In contrast, the heat exchange for flowing water is reported to be from 1,000 W $m^{-2}$ °C (Are 1980) to 3000 W $m^{-2}$ °C) (Pekhovich and Shatalina 1970). This demonstrates the relative potential for rapid ground thaw from water flow due to the advection of heat.

## 3.2 Thermal Erosion

Thermal erosion is a process involving heat advection and is caused by the combined thermal and hydraulic action of moving water. Rapid drainage of ponds and lakes from thermal erosion have been document in areas of undisturbed terrain (Mackay 1981, 1988, 1997; Marsh and Neumann 2001). Common thermal erosion features include subsurface conduits, sinkholes, erosional surface gullies. The process is not limited to is not limited to warm permafrost settings and has been observed to rapidly take place over large areas of cold (-15 °C) permafrost (Fortier et al. 2007).

## 3.3 Potential Seepage Pathways

There are three main pathways for water seepage to consider which include:

- Seepage through the rockfill.
  - Movement of water through the rock fill from compromised HDPE liner integrity.
- Seepage at the foundation surface beneath the rock fill.
  - Movement of water at the rock fill – tundra surface beneath the HDPE liner.
- Seepage in the subsurface foundation.
  - Movement of water within the foundation soil either through existing unfrozen taliks or post-construction thaw; including thermal erosion in the presence of massive ground ice.

# 4 Primary Pond Dam

## 4.1 Permafrost

The Goose Property is located with the zone of continuous permafrost. The has undergone multiple glaciations during the Quaternary period, resulting in the striated landscape and overburden materials characteristic of a post-glacial environment with glacial till and drumlines being the most dominant geomorphic deposits at the Goose property.

Permafrost temperature has been measured to range from -4.7°C to -7.5°C at the Goose Property, with an average of -6.3°C. The seasonally thawed active layer ranges from approximately 1 to 4 m below ground surface (bgs), with the greatest active layer depths occurring in areas with thin soil veneers above bedrock (SRK 2015a; 2015b). Depth to the base of permafrost is estimated to range from 490 to 570 meters below ground surface (mbgs) using the 0°C isotherm, with a reported geothermal gradient of 0.013 to 0.014°C/m (SRK 2015b).

## 4.2 Foundation

The Primary Pond Dam will extend across exposed bedrock, bedrock with thin overburden, and several depressions in the bedrock surface with thick overburden soil (Figure 2). Three geotechnical investigations have been conducted with the drilling and sampling of nine drillholes near the planned footprint of the dam (Figure 2). Additional in-fill drilling and percolation hole tests are planned for November 2022.

Drillholes completed prior to November 2022 near the Primary Pond Dam, as primary material type and visible ground ice content is shown in Figure 3. The foundation is characterized by relatively thin organics (<10 cm) that are typically underlain by coarse-grained sand and gravel with intervals of boulders, followed by silt commonly above the top of bedrock. Soil pore water salinity has been determined from laboratory testing to average 23 ppt. The average pore water freezing point depression is calculated to be -1.4°C. Visible ground ice more than 60% by volume has been observed to occur within the overburden soil.

Frozen ice-bonded permafrost is expected to be continuous beneath the foundation of the dam based on current drillholes, and findings of geotechnical investigation completed at other locations within the property. The exception would be the seasonally thawed active layer that freezes back each winter and a creek thaw bulb (closed talik) that occurs near Station 0+325. Drillholes completed near the creek have confirmed continuously frozen soil at the time of investigation, such as drillhole SRK-15-GSE-05 and SRK-21-DH02B-PP. Additional drillhole during percolation testing of the foundation will be used to confirm the thaw bulb extent.

# 5 Methods

## 5.1 Approach

Ground thermal modeling has been used to evaluate thermal performance of the structure over the design life of the structure. A series of two-dimensional (2D) models were constructed in GeoStudio 2021.4 (v. 11.3.1.23726), TEMP/W finite element program, developed by Geoslope International Ltd. The models consider two-dimension heat flow based on thermal conduction with phase change of water and ice. Non-conductive heat transfer was not considered in the model, such as the advection of heat from water seepage.

## 5.2 Model Sections

The models were developed in TEMP/W using a simplified geometry of critical dam sections:

- Thick fill section to be constructed over thaw-sensitive ice-rich permafrost soil at Station 0+200.
- Thin fill section to be constructed over thaw-sensitive ice-rich permafrost soil at Station 0+600.

Figure 2 shows the critical section locations along the dam alignment. The model domain for each station is shown in Figures 4 through 6. The model geometry for Station 0+200 was modified to improve thermal performance of the dam by moving the key trench toward the centerline of the dam in this area. The comparison between the initial and modified model domain for Station 0+200 is shown in Figures 4 and 5, respectively.

## 5.3 Model Inputs

### 5.3.1 Material Properties

Four materials were defined in the thermal model: ROQ rock, ROQ saturated rock, natural overburden silty sand, and bedrock (Table 1). The thermal properties for the ROQ rock have a material porosity of 0.3 and saturation of 30% (SRK 2015b). ROQ saturated rock assumes an equivalent porosity with complete saturation of the material due to this interaction in the model with water located on the upstream side of the HDPE liner. The properties for bedrock were taken from previous work completed by SRK at the Goose Property (SRK 2015c).

The thermal properties for silty sand were based on average soil properties and porewater salinity measured from samples collected at the Goose Property and estimated in accordance with Cote and Konrad (2005). The freezing point depression of -1.4°C and modification to the unfrozen water content curve was estimated for an average in situ porewater salinity of 23 parts per thousand (ppt) in accordance with Banin and Anderson (1974).

**Table 1: Material Thermal Properties**

| Material | Porosity | Degree of Saturation | Thermal Conductivity, (kJ/day/m/°C) | | Volumetric Heat Capacity, (kJ/m$^3$/°C) | |
|---|---|---|---|---|---|---|
| | | | Frozen | Unfrozen | Frozen | Unfrozen |
| ROQ Rock | 0.30 | 0.30 | 147 | 144 | 1,766 | 2,161 |
| ROQ Saturated | 0.30 | 1.00 | 264 | 178 | 1,988 | 2,601 |
| Silty Sand[1] | 0.36 | 0.66 | 217 | 177 | 1,948 | 2,444 |
| Bedrock | 0.05 | 0.05 | 346 | 350 | 2,110 | 2,120 |

Notes:
1. Estimated unfrozen water content curve applied to material property within model
2. Freezing point depression based on porewater salinity of 23 parts per thousand (ppt)
3. Latent heat of fusion for ice 334 kJ/kg

### 5.3.2 Climate Boundary Condition

A surface energy balance (SEB) heat flux boundary was applied to the uppermost surface of the model, with exception of the upstream boundary that relied on a water temperature boundary (see Section 5.3.4). The SEB flux boundary estimates the energy from the atmosphere that is available at the ground surface and utilized through several processes, such as evapotranspiration, sublimation, and measurable changes in air and ground surface temperature.

Energy received at the surface must be used to warm or cool the air above the ground surface (sensible heat flux), evaporate water (latent heat flux), or warm or cool the ground (ground heat flux):

$$(q_{ns} - q_{nl}) = q_h + q_l + q_g \qquad \text{Equation 1}$$

where:

$q_{ns}$ is the net solar shortwave radiation (MJ m$^{-2}$ d$^{-1}$)
$q_{nl}$ is the net terrestrial longwave radiation (MJ m$^{-2}$ d$^{-1}$)
$q_h$ is the sensible heat flux (MJ m$^{-2}$ d$^{-1}$)
$q_l$ is the latent heat flux (MJ m$^{-2}$ d$^{-1}$)
$q_g$ is the ground heat flux (MJ m$^{-2}$ d$^{-1}$)

The ground heat flux is expressed as:

$$q_g = (q_{ns} - q_{nl}) - q_h - q_l \qquad \text{Equation 2}$$

The energy flux throughout the defined period of snow cover $q_{snow}$ is expressed as:

$$q_{snow} = q_g = (q_{ns} - q_{nl}) - q_h - q_l \qquad \text{Equation 3}$$

It is assumed in the model that snow does not have the capacity to store energy.

The average monthly climate parameters applied to the SEB boundary for contemporary climate conditions is shown in Table 2. Energy transported by water (rainfall or snow meltwater) infiltration through the ground was not accounted for in the models. Non-convective heat transfer from water seepage was not considered in the models.

Table 2: Monthly Average Climate Parameters for Goose Meteorological Station

| Month | Air Temperature (°C) | Relative Humidity (%) | Windspeed (m/s) | Snow Depth (m) | Solar Radiation (W/m$^2$) |
|---|---|---|---|---|---|
| January | -28.9 | 75.7 | 5.5 | 0.24 | 6 |
| February | -28.9 | 73.5 | 6.9 | 0.27 | 38 |
| March | -26.0 | 76.2 | 7.4 | 0.30 | 111 |
| April | -16.4 | 80.7 | 6.6 | 0.34 | 211 |
| May | -5.4 | 85.4 | 6.5 | 0.10 | 275 |
| June | 6.4 | 76.6 | 6.4 | 0.00 | 272 |
| July | 12.6 | 72.7 | 7.2 | 0.00 | 221 |
| August | 10.1 | 80.3 | 6.8 | 0.00 | 141 |
| September | 2.6 | 84.3 | 6.9 | 0.00 | 86 |
| October | -6.6 | 90 | 6.8 | 0.07 | 40 |
| November | -19.8 | 82 | 6 | 0.16 | 10 |
| December | -25.8 | 79.4 | 6.2 | 0.20 | 2 |

Notes:

1. Climate parameters measured at Goose Station between August of 2004 and September 2020
2. Snow depth based on regional measurements confirmed to be reasonable with verification model

### 5.3.3 Water Boundary Condition

A water temperature boundary is applied to the upstream face of the dam to the full supply level to account thermal influence of the impounded water. The temperature boundary is applied as a step function using the average monthly water temperature measured at Llama Lake, located at the Goose Property, for the months of April and August (Rescan 2011) (Table 3). Water temperature is assumed to be at 0°C from December to the end of March beneath floating ice and forecasted for the remaining months. The water temperature is consistent with measurements reported for water bodies located in the Canadian Arctic (Burn 2005). The average annual water temperature calculated from the monthly values was +5.5°C.

**Table 3: Water Temperature Values**

| Month | Average Water Temperature (°C) |
|---|---|
| Jan. | 0 |
| Feb. | 0 |
| Mar. | 0 |
| April | 2.5 |
| May | 5.6 |
| June | 8.8 |
| July | 11.9 |
| Aug. | 15 |
| Sept. | 11.3 |
| Oct. | 7.5 |
| Nov. | 3.8 |
| Dec. | 0 |
| Average | **5.5** |

### 5.3.4 Thermosyphon

Passive thermosyphons were considered in some of the model scenarios as a convective boundary using a relation between heat transfer to windspeed and evaporator slope angles. Haynes and Zarling (1988) determined for a thermosyphon with 6.5 m$^2$ radiator and a horizontal evaporator, heat transfer conductance $\left[\frac{Q}{\triangle T}\right]_{6.5}$ is expressed by:

$$\left[\frac{Q}{\triangle T}\right]_{6.5} = 8.7 + 12.29 \cdot V_w^{0.83}$$ Equation 4

The overall conductance at various wind speeds was described by the empirically derived equation:

$$C = A + B({V_w}^n) \cdot A^s$$ Equation 5

Heat conductance for difference size radiators can be determined by multiplying by the ratio of the radiator surface area to the reference area of 6.5 m$^2$. The heat transfer $H_c$ is calculated as:

$$H_c = \frac{C}{2\pi r l}$$ Equation 6

where

$V_w$ is the wind speed in m s$^{-1}$
$r$ is the evaporator pipe radius in meters
$l$ is the evaporator pipe length in meters
$A, B, n$ are coefficients derived from laboratory tests
$A_s$ is the surface area of the evaporator

The thermosyphon radiator surface area used in the thermal analysis is based on double 19.5 $m^2$ radiator with a total surface are of 39 $m^2$ per evaporator pipe. The evaporator pipes are assumed to be approximately 0.1 m in diameter with an overall length of 250 m. The $A, B, n$ coefficients are based on a 3-degree sloped evaporator pipe with the value 3.02, 4.99 and 0.3, respectively.

An average winter windspeed of 6.7 m/s is based on Goose Meteorological Station measurements made between months of October and April. Wind direction over this period of the year is predominately from the west and south.

### 5.3.5 Initial Conditions

Initial ground temperature for permafrost was set to -6.3°C which is representative of shallow permafrost temperatures at the Goose Property (SRK 2015b). Dam construction will take place in the winter and the initial ROQ rock is assumed to be -2°C at the time of placement. Based on our experience, ROQ rock placed in the winter will thermally adjust to the ambient air temperature at the time of placement. It has been assumed that dam construction can be completed in one winter with material placement prior to the ambient air temperature rising above -2°C.

The sides of the model space were set to zero flux with the lower boundary set to a constant flux 4.84 kJ/day/$m^2$ which was calculated from the local geothermal gradient (0.014°C/m) and the thermal conductivity of the bedrock.

## 5.4 Model Scenarios

Two model scenarios for Station 0+200 and 0+600 are presented in this memorandum:

- Operation of the dam with water at FSL for the first 3 years; and
- Operation of the dam with water at FSL for 10 years.

Model sensitivities are also presented to improve thermal performance and reduce uncertainty related to the potential for water seepage:

- Addition of thermosyphons with evaporator pipes installed in the key trench;
- Placement of fill material immediately upstream of the dam following winter construction; and
- Post-construction installation of thermosyphons installed beneath the upstream fill.

# 6 Results

## 6.1 Verification Model

A one-dimensional model was developed to verify that the model can reasonably predicted site ground temperature using the surface boundary and material properties described in Section 5.3. The verification model was based on generalized ground stratigraphy for monitoring site GAS-GT13-01 (Figure 7).

The predicted temperature has good agreement with the measured values that effectively capture the minimum and maximum annual ground temperature (Figure 8). The active layer is slightly overestimated in the model when compared with measured ground temperature which represents a conservative condition in the context of dam performance. General agreement of the verification model with measured ground temperature indicates that the input parameters adequately reflect site conditions and can provide reasonable prediction of ground temperature.

## 6.2 Primary Pond Dam

The Primary Pond Dam thermal models are used to evaluate conditions that may impact water retention and foundation stability beneath and immediately surrounding the structure. The overall thermal behaviour of the dam on the foundation is used to evaluate potential impacts caused by thawing of ice-rich permafrost soils. The frozen or thawed state of the foundation beneath the upstream portion of dam fill is also used to evaluate development of a potential seepage pathways beneath the dam. In addition, the modeled key trench temperature is used to evaluate whether the liner remains frozen to the underlying foundation to maintain water containment.

### 6.2.1 Stations 0+200

The primary pond dam was initially modeled with water maintained at the FSL for the 10-year design life. Figure 9 shows the modeled key trench temperature for Station 0+200 with the initial key trench position and a modified key trench position. The initial key trench is closer to the impounded water and upstream dam face when compared to the modified key trench position that has been shifted 8 m toward the centerline.

The maximum annual temperature with the initial key trench position is warmer than -2°C within the first three years of operation and exceeds the freezing point depression by model year 5 (Figure 9). The predicted thermal performance is improved with the modified key trench position. Based on these findings, the initial design of Station 0+200 can be expected to have poor thermal performance with increased risk of thaw at the key trench liner tie-in that could result in a loss in containment. Thermal performance is improved with modification of the key trench position due to increased distance from the upstream water and increased ROQ fill over the key trench. The updated geometry with modified key trench position is therefore advanced as the base case model used for all subsequent thermal analysis.

Figure 10 shows the modeled temperatures under conditions where the dam is operated with water at the FSL for a period of either 3 or 10 years. The model results indicate a typical frozen core of the dam from model year 2 and 10. The upstream thaw expands beneath the bottom of the pond and upstream toe of the dam under conditions where water is maintained at the FSL for 10 years (Figure 10).

Figure 11 shows the key trench temperature for both scenarios. As expected, the increase in key trench temperature is controlled by the duration of time water is impounded against the upstream face of the dam. The maximum annual key trench temperature is predicted to up to -2.9°C under the scenario of water at the FSL for the full 10-year period. The predicted temperature in the key trench is colder (maximum annual temperature of -3.6°C) under conditions where water is maintained at the FSL for the first 3 years and maintained empty at the upstream toe for the remaining seven years.

### 6.2.2 Station 0+600

The modeled temperature for Station 0+600 with water maintained at the FSL for a period of either 3 or 10 years is shown in Figure 12. The corresponding key trench temperature is shown in Figure 13. Greater seasonal heat transfer in the key trench is predicted for Station 0+600 when compared to conditions modeled for Station 0+200. The increase in seasonal heat transfer is due to the relatively smaller fill section at Station 0+600.

The key trench temperature is predicted to increase (warm) with time due to thermal forcing from the impounded water of the 10-year period. For the model with water maintained at the FSL for three years, the key trench temperature is expected to initially warm from the impounded water and then gradually cool for the remaining seven years when the pond is operated empty at the upstream toe. It is assumed that the water level is maintained at a lower elevation over remaining seven years of the design life. The freezing point depression is not exceeded for both cases, assuming no seepage of water occurs (Figure 13).

### 6.2.3 Bedrock Foundation

Models for Station 0+200 and 0+600 with a completely bedrock foundation was prepared to evaluate whether the liner tie-in would remain frozen over the design life. Bedrock has a higher thermal conductivity and lower latent heat energy requirements to freeze and thaw in-situ water which allows for more rapid changes in sensible heat compared to a soil. Ground warming is predicted to be greater over the design life assuming water is maintained at the full supply level for 10 years compared with a foundation with soil underlain by bedrock. The liner tie-in with key trench is predicted to remain frozen assuming no seepage of water (Figure 14). For Station 0+200 and 0+600, the maximum key trench temperature is predicted to be -2.0°C and -1.8°C over the 10-year period, respectively. Construction fill and bedding material placed at the liner tie-in can be expected to freeze and thaw near 0°C.

## 6.3 Options to Improve Performance

The Primary Pond Dam is a water retention dam with variable foundation conditions that include areas of ice-rich permafrost soils. The relatively high ground ice content is a risk to stability of the structure under conditions of foundation thaw that lead to thaw-settlement (i.e., the change in soil volume from thaw and melt of ground ice, followed by material consolidation). If the foundation was to significantly thaw, the pore water pressure at the thawing front would be expected to be elevated depending on the rate of thaw and drainage of the water.

There is also a potential for thermal erosion in the foundation under conditions where water seepage and advection of heat occurs. The impounded water would form a hydraulic head and supply of water under which seepage could occur; either through the dam fill if liner integrity is compromised, through the foundation contact with coarse rock fill, or through relatively deeper pathways in the foundation. As mentioned in Section 3, seepage of water can be initiated through frozen soils and ground ice and lead to rapid ground thaw.

The following options are evaluated to improve thermal performance of the dam and reduce the risk of water seepage:

- Thermosyphons with evaporator pipes installed along the key trench are evaluated as an option to increase heat loss from a portion of the key trench constructed on ice-rich permafrost soils.
- Upstream placement of fill material to form a thermal buffer and increase potential seepage pathways.
- Post-construction installation of thermosyphons with evaporator pipes installed laterally along the upstream toe of the dam to mitigate potential water seepage, should it occur.

### 6.3.1 Thermosyphons with Key Trench Evaporator Pipes

Thermal performance of the dam with thermosyphons installed in the key trench was evaluated for Stations 0+200 and 0+600. The thermosyphon units consist of 39 $m^2$ radiators with four 250 m long evaporator pipes installed at the key trench base during construction of the dam (see Figures 5 and 6). The thermosyphon surface radiators are assumed to be located on the downstream side of the dam, such that the structure does not block the wind and impact advection of heat from the exposed radiators.

The thermosyphons are observed to be active in the model during the winter, as indicated by heat loss and ground cooling within the key trench (Figures 15 and 17). The maximum annual key trench temperature for Station 0+200 operated at FSL for 3 years is between -6.0°C and -7.1°C over the design life (Figure 16). With water maintained at the FSL for 10 years, the key trench temperature is between -6.0°C and -5.3°C. These key trench temperatures are notably colder than model scenarios without thermosyphons in the key trench (Figure 16). The addition of thermosyphons for Station 0+600 is predicted to similarly improve thermal performance of the dam including colder key trench temperature to maintain frozen condition of the liner key trench tie-in (Figure 17 and 18). The findings indicate thermosyphons installed at the key trench base would reduce uncertainty with maintaining a frozen foundation and the initiation of seepage over the design life of the structure.

### 6.3.2 Upstream Fill Material

An additional model for Station 0+200 was prepared with sand fill material placed immediately upstream of the dam. The fill material is prescribed in the model to be continuous with dam crest and extend 30 m from upstream of the toe. The sand fill is assumed to be placed in the early summer with an initial material temperature of +4.0°C. The model is run without thermosyphons to isolate the potential thermal benefit of the upstream fill material on thermal performance.

The model applies the same surface energy balance boundary conditions as the exposed rock shell of the dam. It is therefore assumed that the sand fill would be subaerially exposed during operation and not covered with water. The material would likely become saturated to the phreatic surface of the pond water. Heat laterally transported through the sand fill from the rise and fall of water levels is not accounted for in the model.

Figure 19 shows the modeled ground temperature at four locations for Station 0+200. Three of the reported temperatures are located at the foundation surface and the fourth within the key trench. The predicted key trench temperature at Position 4 decrease from a maximum annual value of -4.0°C to -4.9°C at the end of 10 years. The key trench temperature with sand fill placed upstream of the dam is significantly colder when compared to model predictions with water impounded at FSL for 10 years (see Figure 11).

Figure 19 also shows more immediate freezeback and colder ground temperature at the rock fill - foundation contact (Positions 1 through 3). The upstream ROQ rock contact with the foundation is predicted to be frozen for most of the design life and more favorable to reducing the potential for seepage pathways and to improve stability of the structure. These conditions are in contrast with model scenarios without placement of upstream sand fill which indicate progressive upstream thaw.

The improved thermal performance of the dam is due to removal of heat from water otherwise impounded against the upstream dam shell. The upstream fill material would be expected to reduce the potential for foundation thaw beneath the upstream region of the dam that could result in development of seepage pathways, and allow for colder key trench temperature to maintain the frozen liner tie-in.

### 6.3.3 Thermosyphons Installed at Upstream Toe

Thermosyphons laterally installed along the upstream toe was explored as potential mitigation options to address potential water seepage. This option has assumed upstream fill material has been placed and mitigation is required at a future date. The model is based on thermosyphon units consist of 39 $m^2$ radiators with four 250 m long evaporator pipes installed along the upstream toe of the dam within a key trench excavated 2 m into the foundation. The key trench and overlying upstream fill material are unfrozen at the start of the model.

Figure 20 shows the late summer ground temperature distribution for the model scenario with lateral thermosyphons installed upstream of the dam toe. The model results indicate ground cooling occurs between the first winter following installation and model year 10. Heat extraction from the upstream evaporator pipes result in progressive cooling over the first four years (Figure 20). Seepage is not considered in the model and would been to be evaluated in the future using actual water seepage conditions, should it occur. In some cases, vertically installed thermosyphons may be more efficient to develop a freeze barrier to cut-off water seepage. Active ground freeze may temporarily be needed to shut-down water movement before converting the units to passive thermosyphons which maintain the frozen cut-off barrier.

# 7 Conclusions

The Primary Pond Dam will be constructed as a water retention structure that extends across both bedrock and ice-rich overburden soil. The dam will rely on an impermeable HDPE liner incorporated in the dam fill and keyed into frozen permafrost soils. It is imperative that the liner remain frozen to the permafrost foundation to maintain the required water retention function and stability of the dam. The top of bedrock is sufficiently deep across two sections of the dam alignment, making it impractical to extend the key trench to bedrock along the entire alignment.

Primary Pond Dam thermal modeling to inform design has assumed one season of winter construction and water at the FSL for the first three years. For the remaining seven years of the design life, the model assumes water is maintained at a lower elevation and is not impounded against the upstream face of the dam. A sensitivity model with water at the FSL for 10 years was used to evaluate a longer than expected period of water impoundment against the dam. Thermal performance of the dam may not be achieved under operating conditions that are different from the model inputs and scenarios included in this analysis.

At Station 0+200, the key trench temperature without thermosyphons and the initial key trench position was expected to exceed the thawing point of the overburden soil. Thermal performance was improved with modification of the key trench position toward the dam centerline. The modification increases the distance of the trench from the upstream water heat source and consequently increased ROQ fill over the key trench. Colder key trench temperatures below the materials thawing point are predicted for Station 0+200 with the modified key trench position.

At Station 0+600, a frozen core of the dam and foundation are maintained with water at the FSL for either 3 or 10 years. The key trench temperature is also predicted to be below the freezing point for the design life of the structure, assuming no water seepage. The current key trench position for Station 0+600 is adequate and therefore no modification was considered in this analysis.

The model results confirm that modification of the key trench position toward the centerline will provide additional thermal protection beneath the dam fill at the HDPE line tie-in. This change improves thermal performance of the dam from the initial configuration at Station 0+200 and reduces, but does not eliminate, the risk of water seepage beyond the liner tie-in at the key trench. The modified key trench should be advance with the final design of the Primary Pond Dam.

Several thermal design options exist to reduce uncertainty related to water seepage. The two options evaluated include installation of thermosyphon evaporator pipes within the key trench during construction, and post-construction placement of upstream fill material. The use of thermosyphons will provide additional winter heat extraction from the dam foundation. The additional cooling capacity reduces the risk of water movement beyond the key trench liner tie-in.

Placement of upstream fill material was independently evaluated as an option to provide additional thermal protection over the upstream foundation and increase length potential seepage pathways. The model predicts the ROQ rock contact with the foundation will be frozen for most of the design life. The upstream fill material provides more favorable conditions to limit development of the potential for seepage pathways and to also improve stability of the structure by reducing foundation thaw.

A proactive approach to improve thermal performance of the dam can be adopted into the design. The addition of thermosyphons into the key trench may provide additional challenges with the already short winter construction schedule, while upstream fill material placement can take place immediately following winter construction of the dam. In-fill percolation drillhole tests will provide additional information on foundation conditions that will support Sabina's decision for implementation of these modifications to the base case design.

Options to thermally mitigate water seepage exist although not fully explored in this memorandum. Lateral or vertically installed passive thermosyphons are a potential option. Temporary active freezing may be needed to initially establish a freeze barrier, depending on the timing, location, and discharge of water forming the seepage zone. The cut-off of seepage using the freeze barrier would need to be based on actual site conditions that require mitigation.

Regards,
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Christopher Stevens, PhD
Associate – Senior Consultant
Permafrost and Arctic Infrastructure

And reviewed by

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John Kurylo, MSc, PEng
Principal Consultant
Geotechnical, Civil

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

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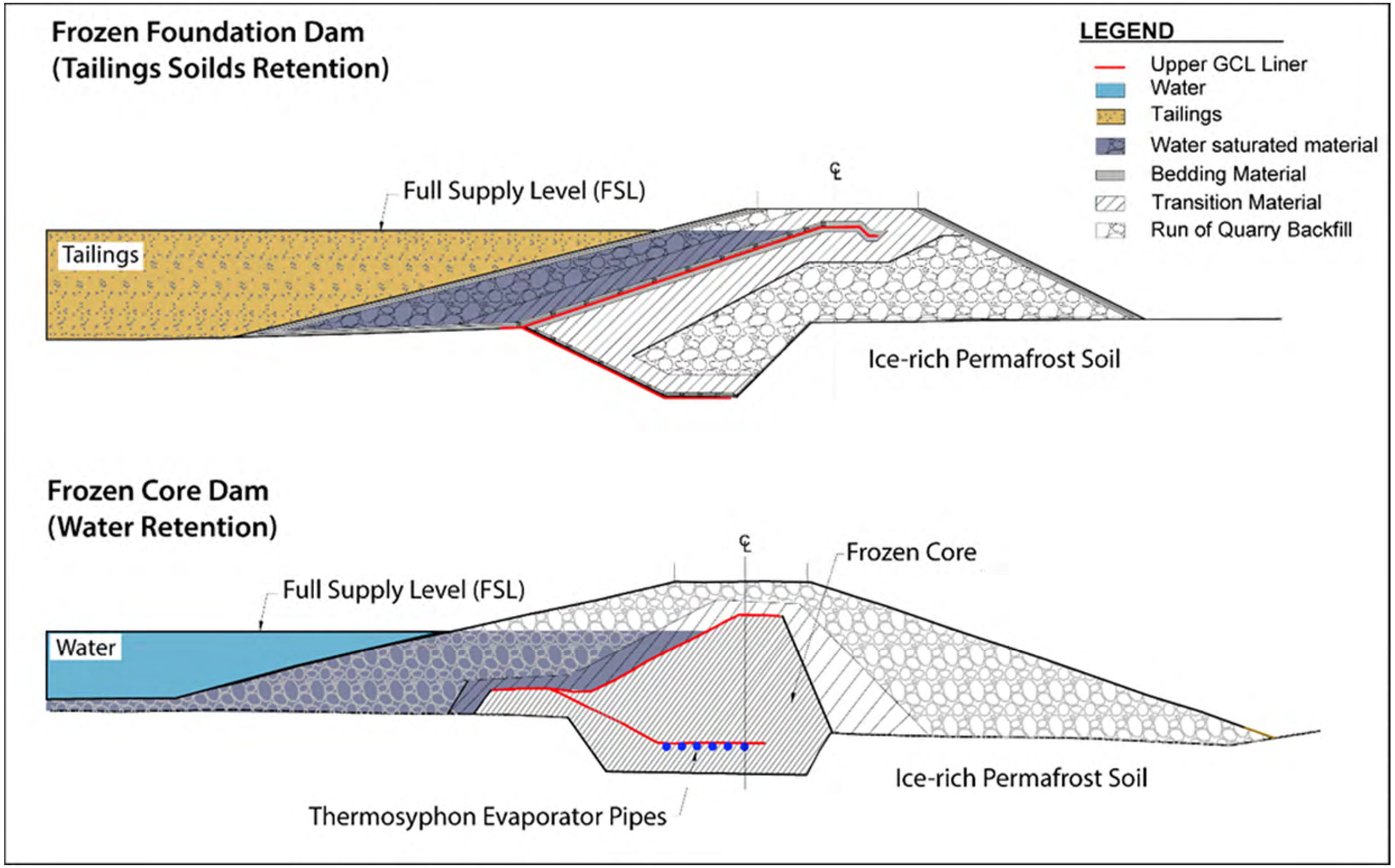
# Attachment 1 Figures



Notes:

1. Typical frozen foundation and frozen core designs used for dams constructed on permafrost from Stevens et al. 2020.

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**Frozen Foundation and Frozen Core Designs**

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Date: Nov 2022
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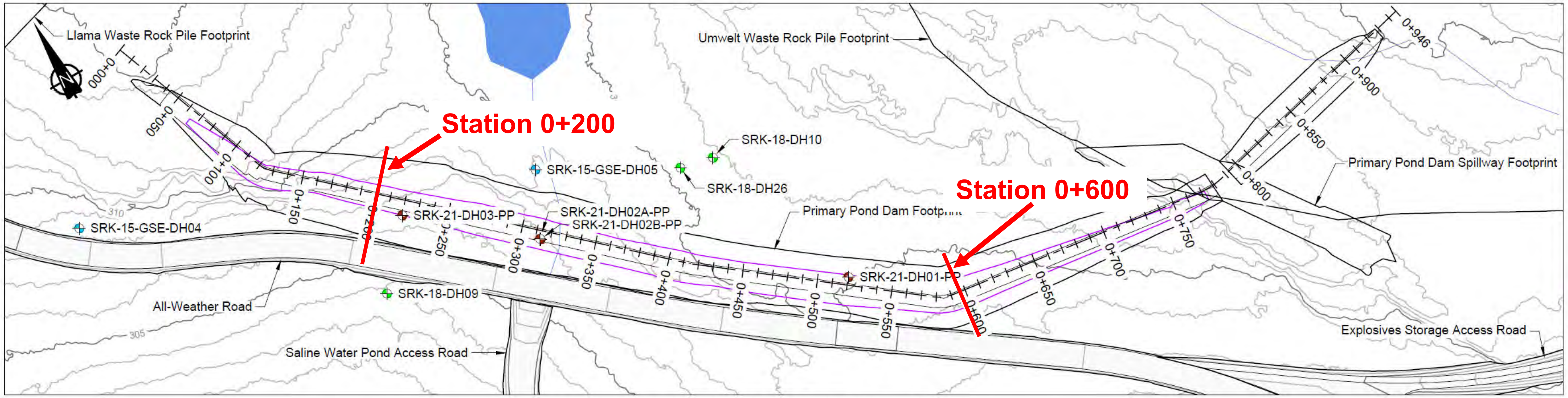
Figure: 1



**Primary Pond Dam Final Configuration Plan**

0m 30 60 90 120

**LEGEND**

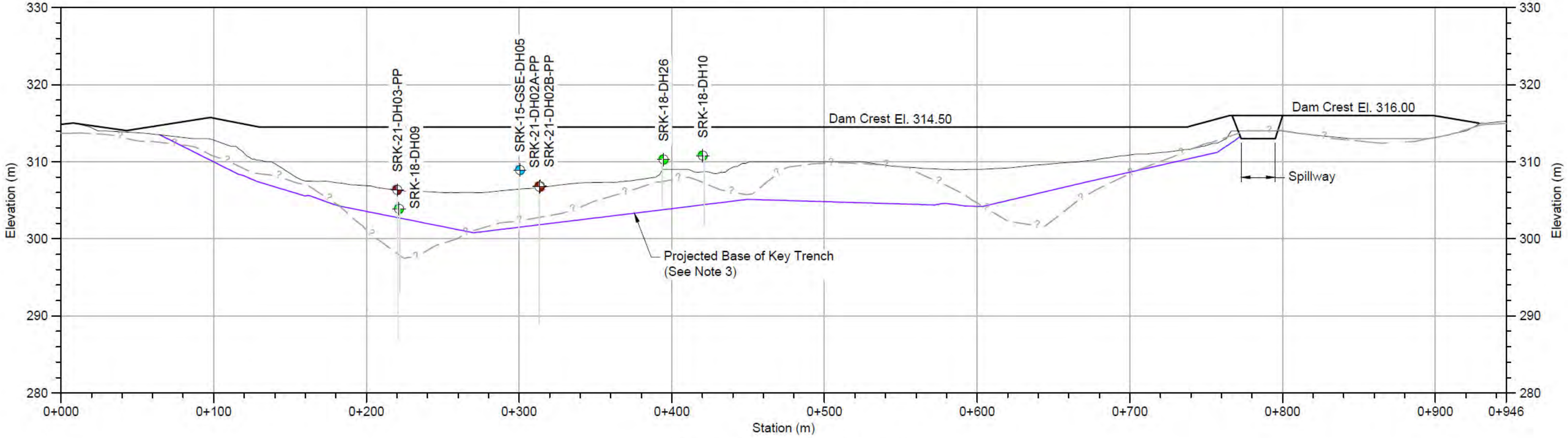
- ⊕ 2015 Boreholes
- ⊕ 2018 Boreholes
- ⊕ 2021 Boreholes
- Contours
- Design Surface
- Excavation
- Existing Ground
- Inferred Bedrock
- Waterbody
- ☐ Other Design Infrastructure
- ☐ Primary Pond Design Infrastructure
- ☐ Primary Pond Design Key Trench

**NOTES**

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Base of key trench on this profile is based on a section down the centerline of the dam crest. Note that the key trench centerline and the dam crest centerline do not share the exact same alignment and overall the chainages vary in any given location (between the key trench and dam crest shown in these drawings) in the range of ±5m.

**REFERENCES**

NAD83 UTM Zone 13.



**Primary Pond Dam Centerline Profile**

0m 6 12 18 24 Vertical

0m 30 60 90 120 Horizontal

Notes:

1. Planning stage layout of Primary Pond Dam – August 25, 2022
2. Location of modeled sections shown with solid red line at Stations 0+200 and 0+600
3. Drillholes completed in 2015, 2018, and 2021

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**Primary Pond Dam Layout and Drillhole Locations**

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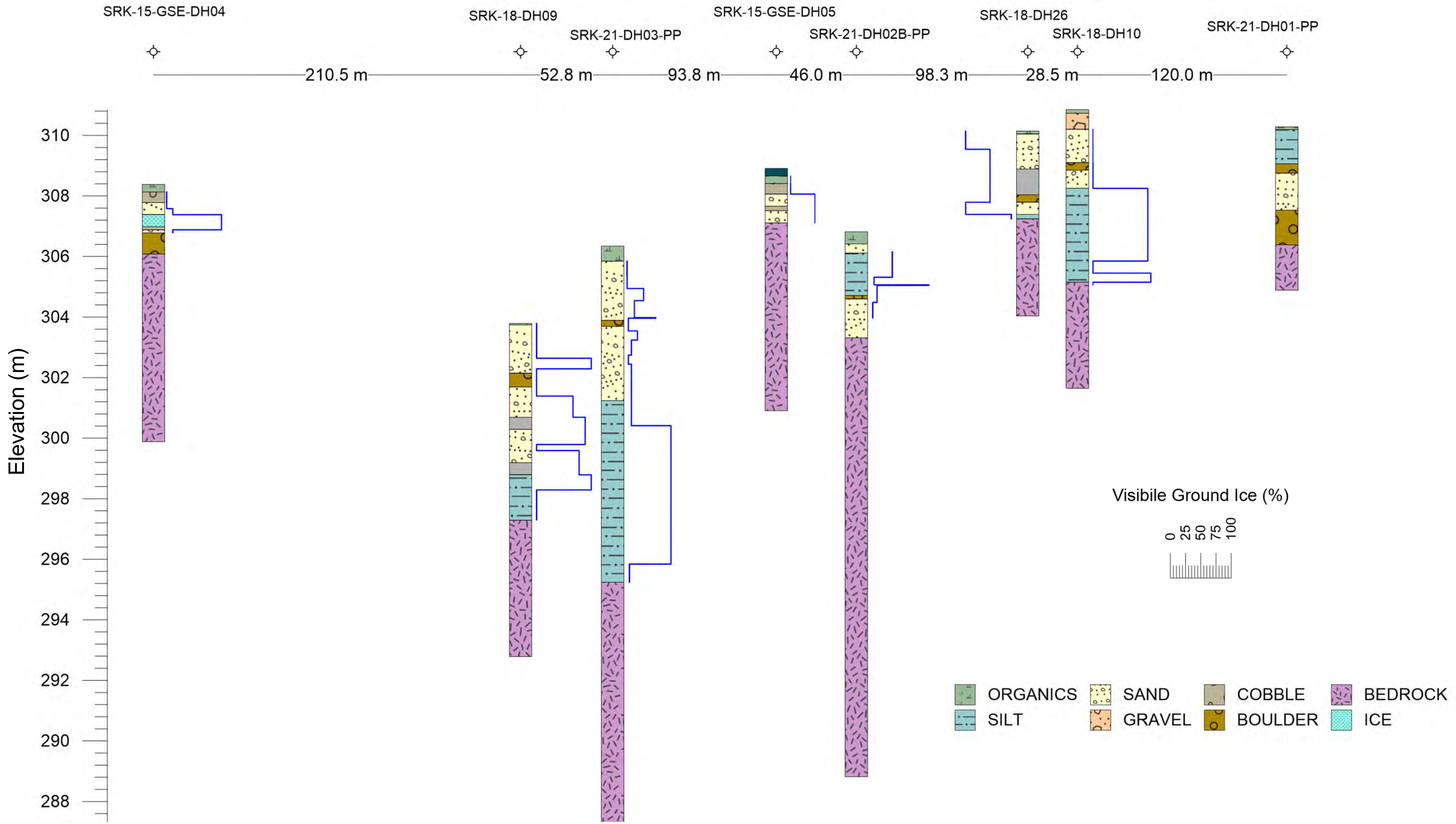
Figure: 2



Notes:

1. Primary material type and visible ground ice for drillholes near the Primary Pond Dam footprint
2. Ground ice content based on visual estimate at time of core recovery

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**Primary Material Type and Visible Ground Ice**

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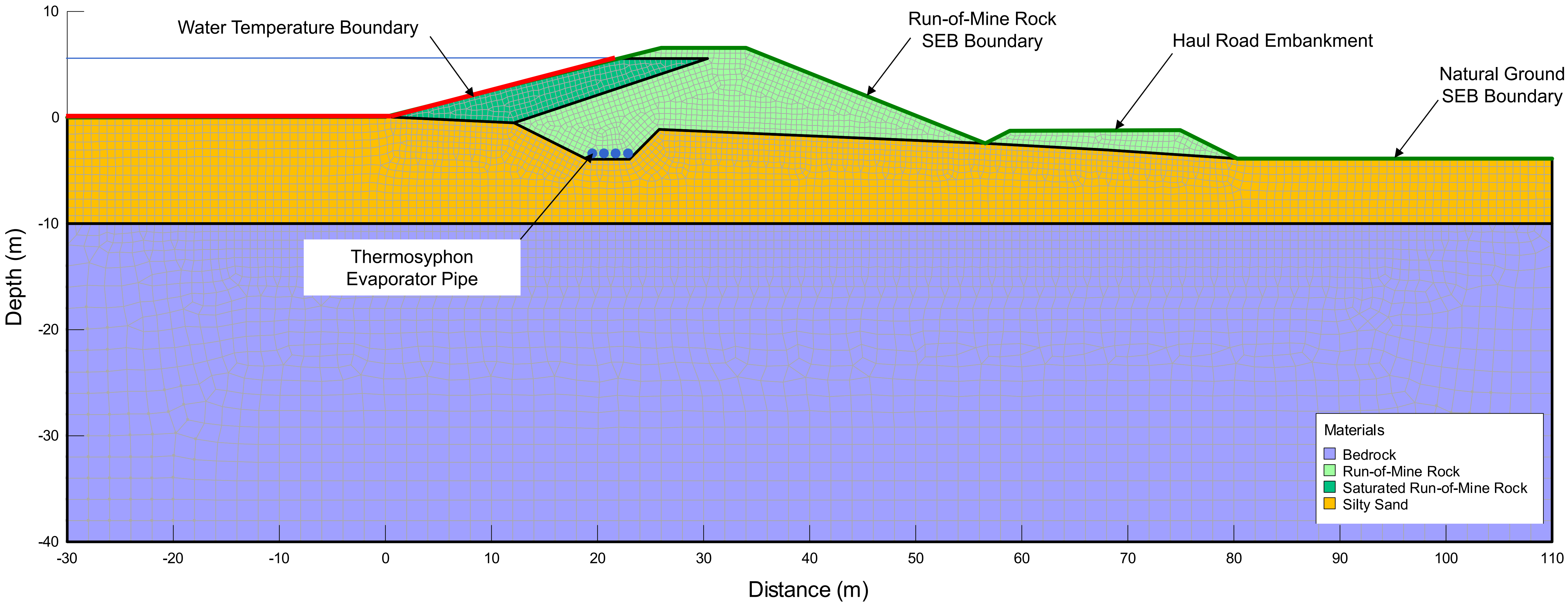
| Date: | Approved: | Figure: |
|---|---|---|
| Nov 2022 | CWS | 3 |

## Station 0+200



Notes:

1. Model domain for Station 0+200 with initial key trench position
2. Thermosyphons only included in specific model scenarios

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**Station 0+200 – Modeled Domain (Initial)**

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Filename: BackRiverPrimaryPondThermalModeling.pptx

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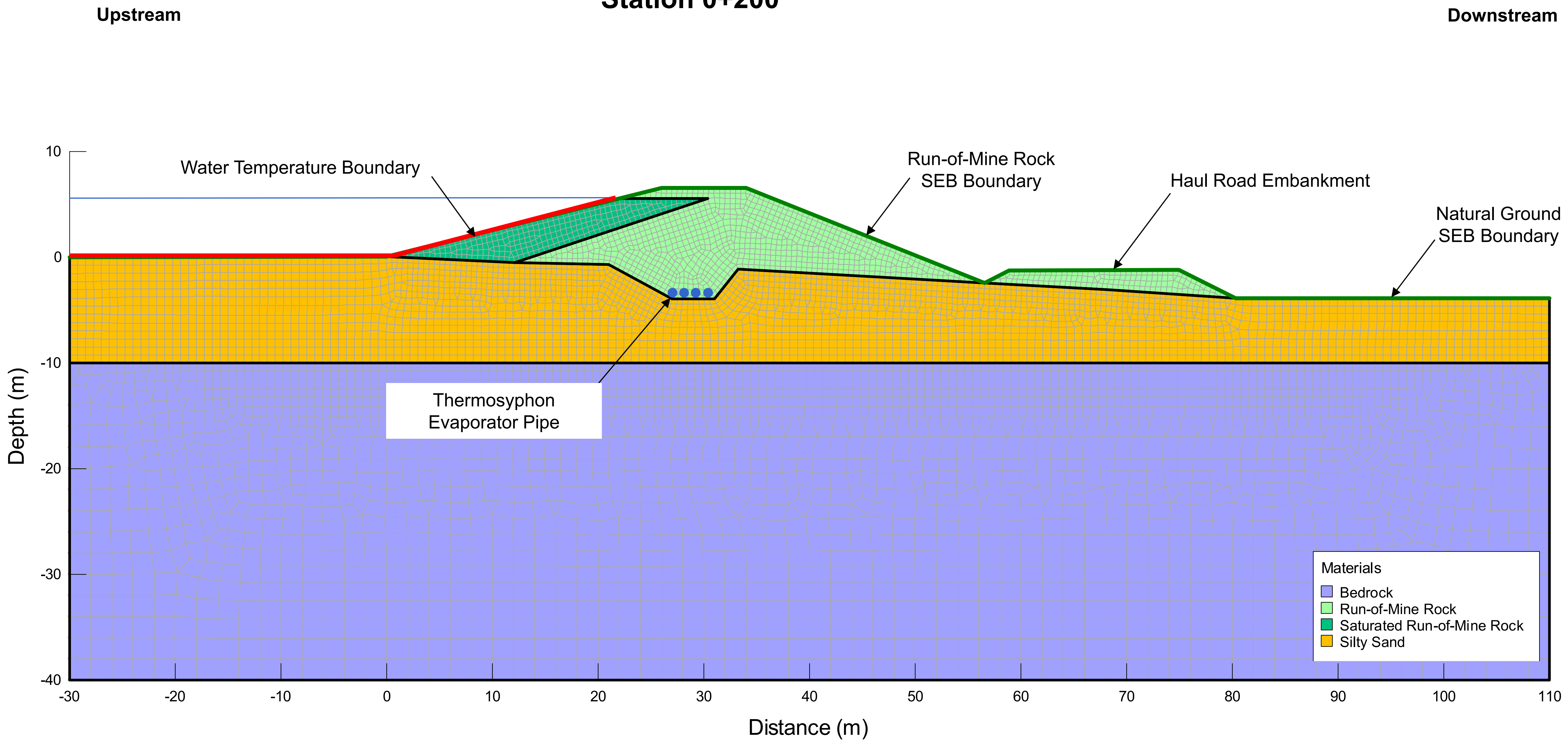
Figure: 4

# Station 0+200



Notes:

1. Model domain for Station 0+200 with modified key trench position
2. Thermosyphons only included in specific model scenarios

Job No: 1CS020.020
Filename: BackRiverPrimaryPondThermalModeling.pptx

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**Station 0+200 – Modeled Domain (Modified)**

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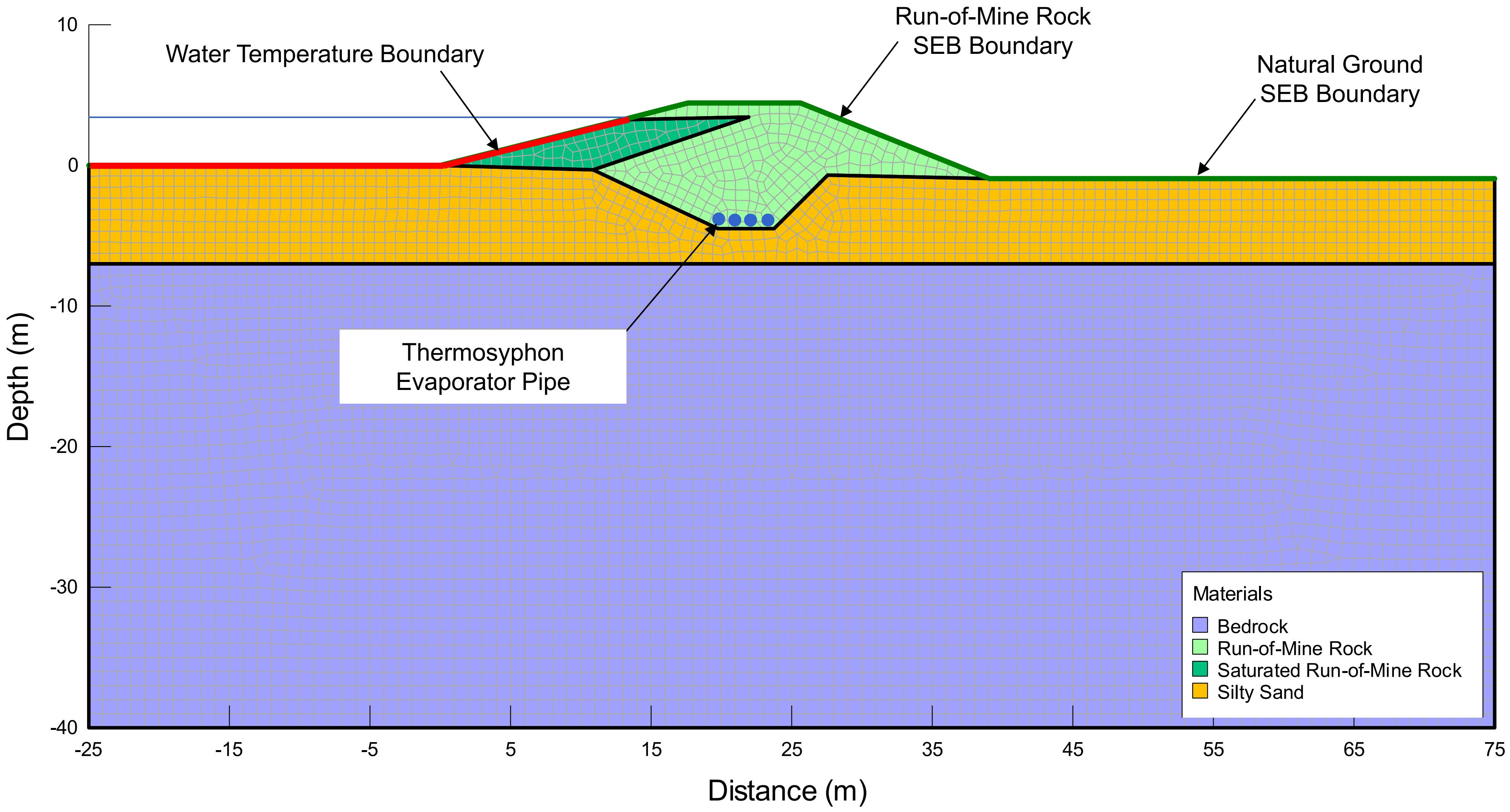
Figure: 5

# Station 0+600



Notes:
1. Model domain for Station 0+600
2. Thermosyphons only included in specific model scenarios

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**Station 0+600 – Modeled Domain**

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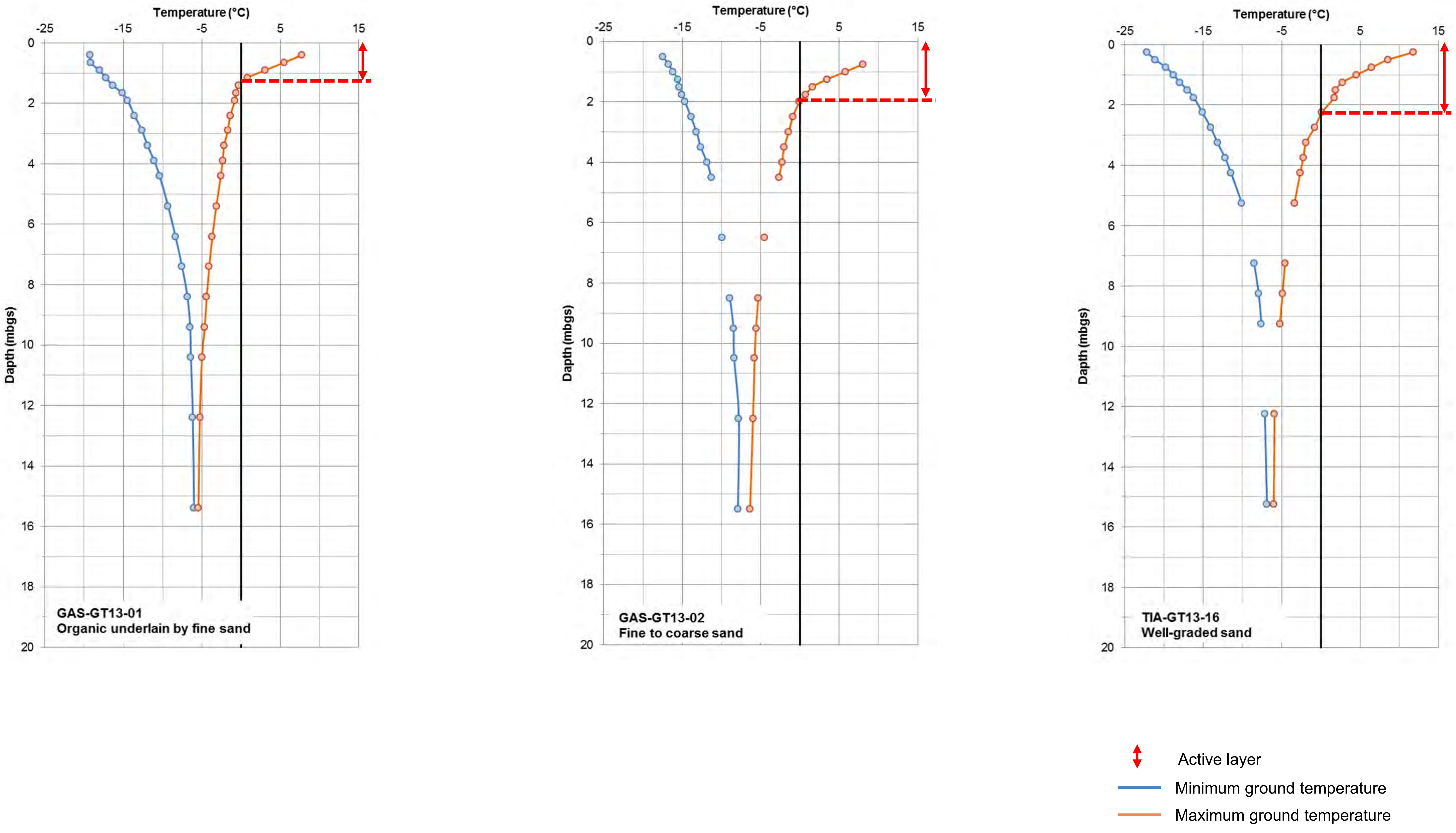
Figure: 6



Notes:

1. Ground temperatures represent minimum and maximum annual values for sites with sand overburden
2. Depth expressed as meters below ground surface (mbgs)

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**Measured Ground Temperature for Sites with Sand Overburden Soil**

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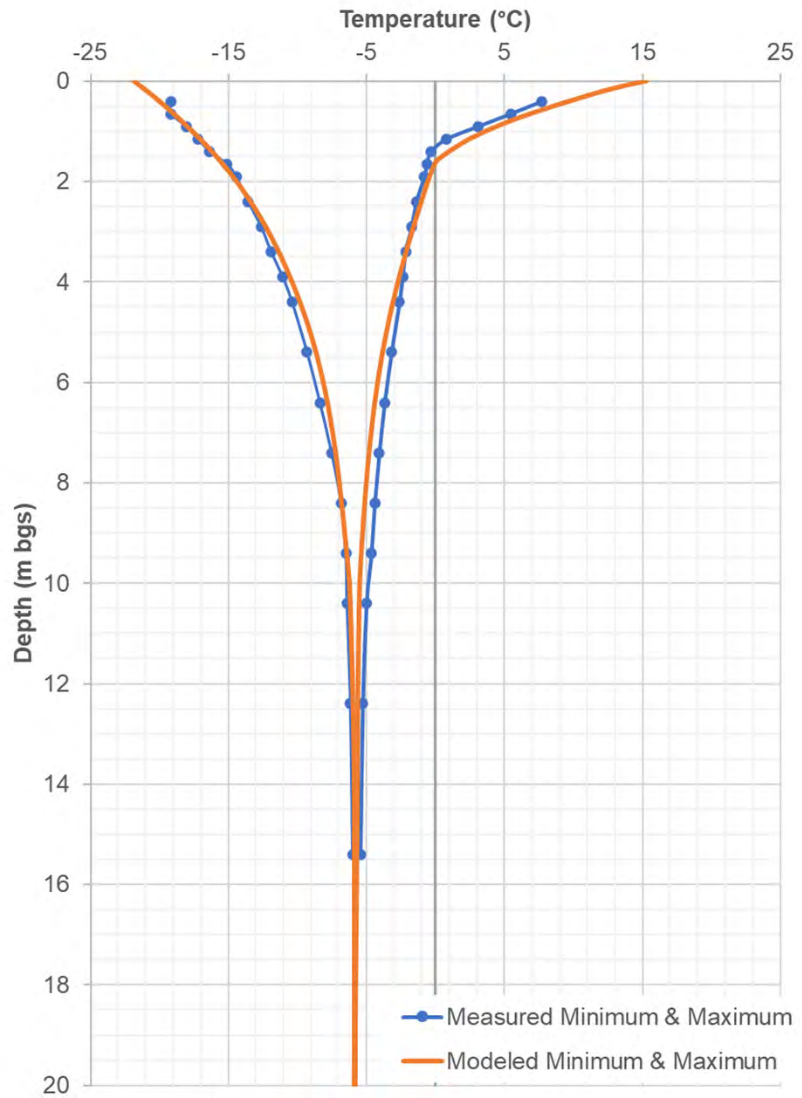
Figure: 7

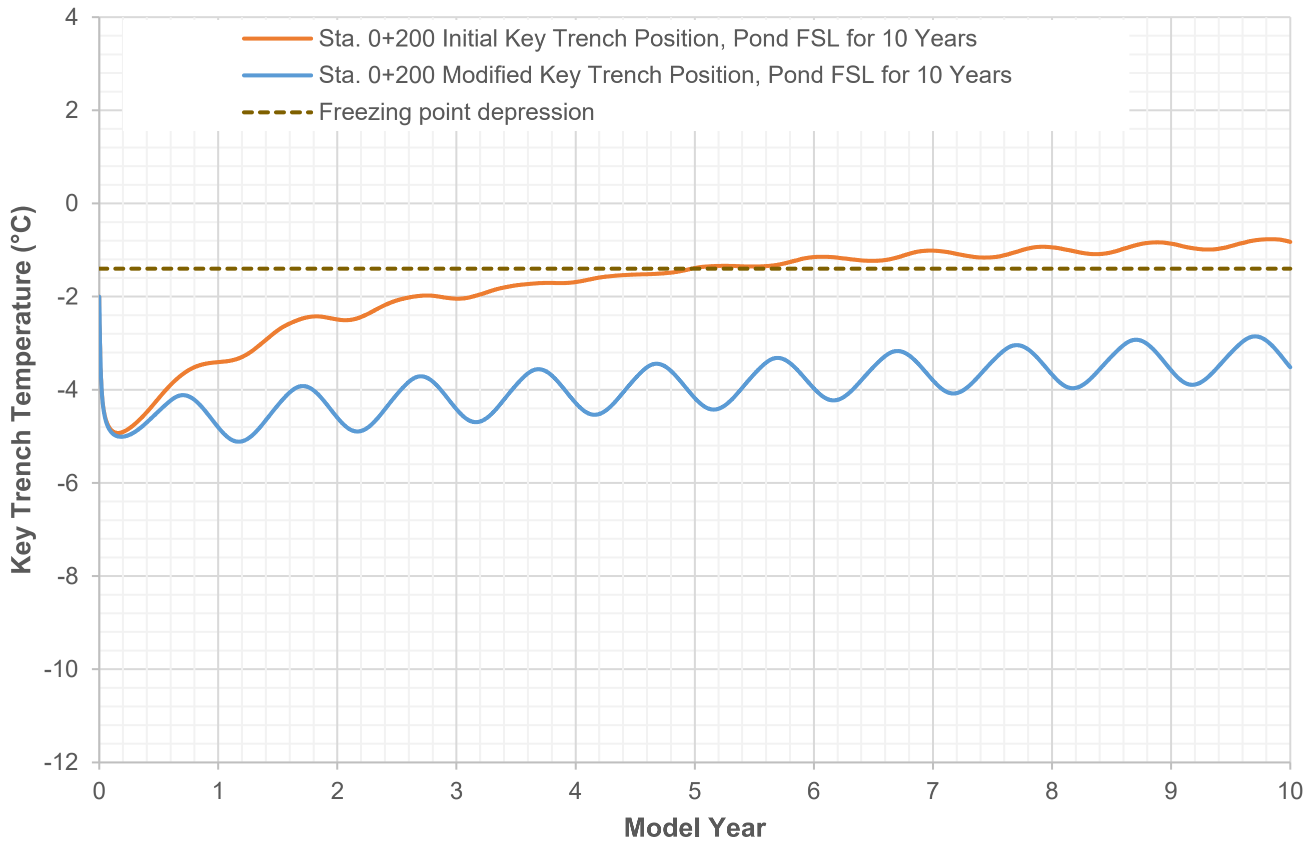


Notes:

1. Verification model annual minimum and maximum ground temperature compared to equivalent measurements made at site GAS-GT13-01

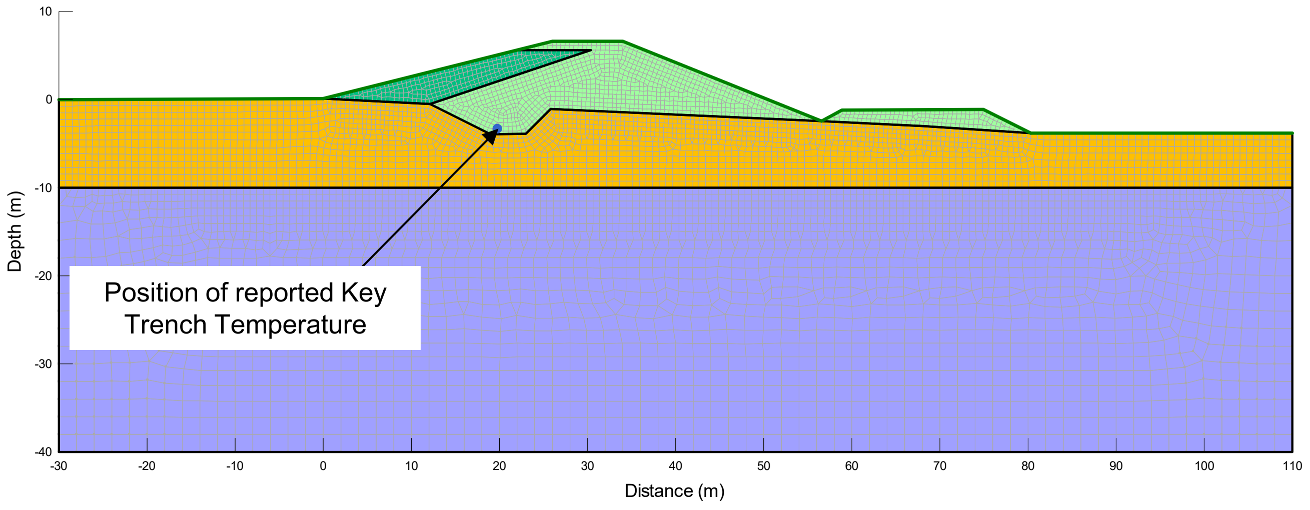
| | | |
|---|---|---|
| srk consulting | Sabina GOLD & SILVER CORP | Primary Pond Dam Thermal Modeling |
| | | **Verification Model Comparison with Measured Ground Temperature** |
| Job No: 1CS020.020<br>Filename: BackRiverPrimaryPondThermalModeling.pptx | BACK RIVER PROJECT | Date: Nov 2022 &#124; Approved: CWS &#124; Figure: 8 |

**Key Trench Temperature – Initial vs. Modified Key Trench Position**

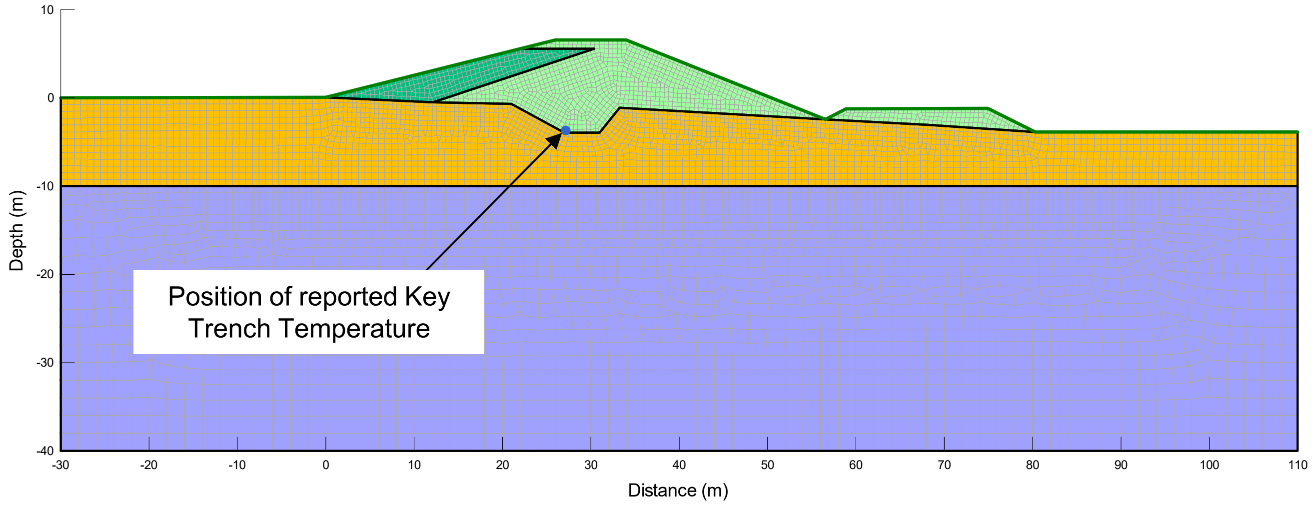


**Upstream** **Downstream**

**Initial Key Trench Position**



**Modified Key Trench Position**



Notes:

1. Model results for Station (Sta.) 0+200, pond water level at full supply level for 10 years
2. Key trench moved 8 m in downstream direction for model with “Modified Key Trench Position”
3. Model results without thermosyphons

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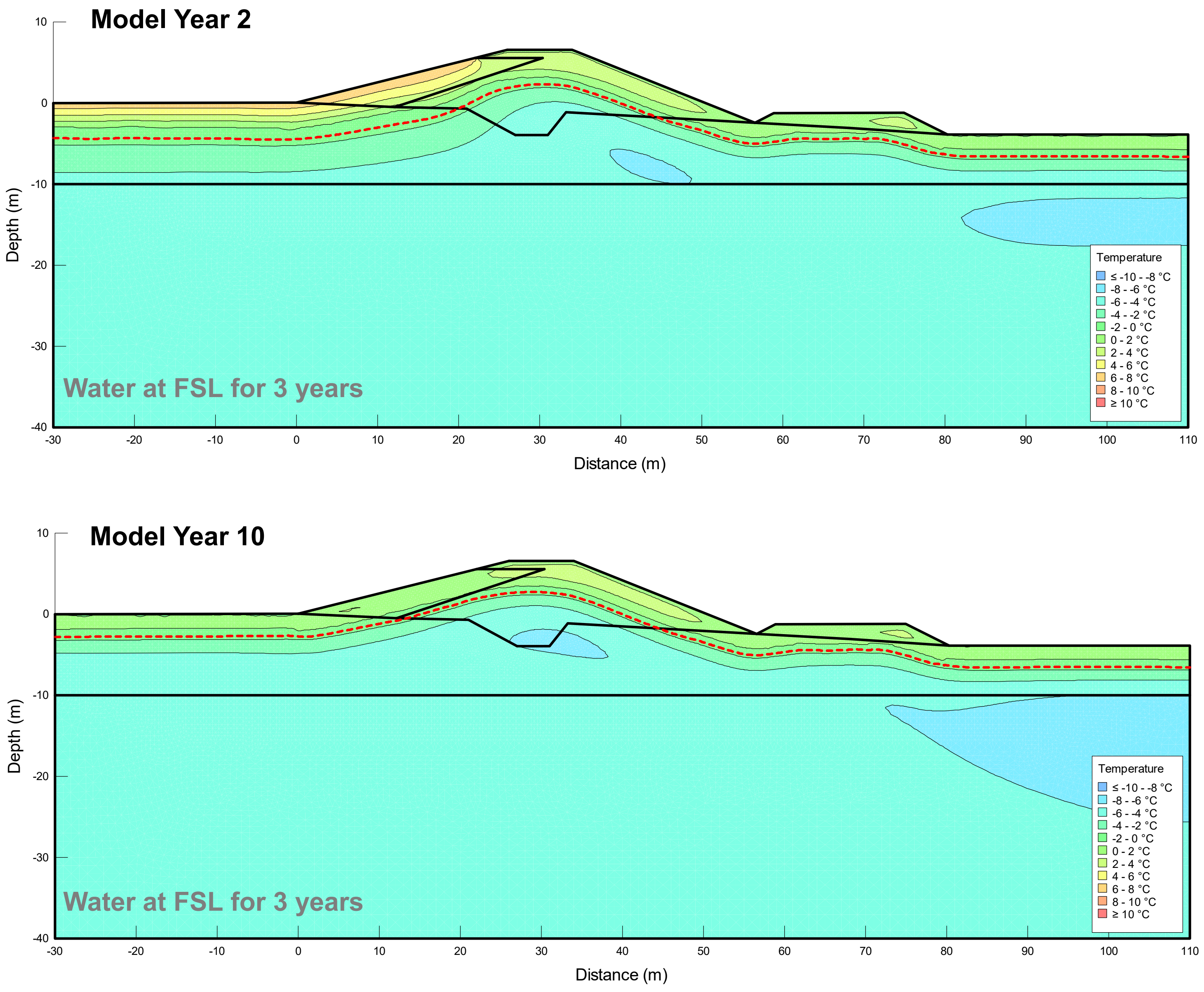
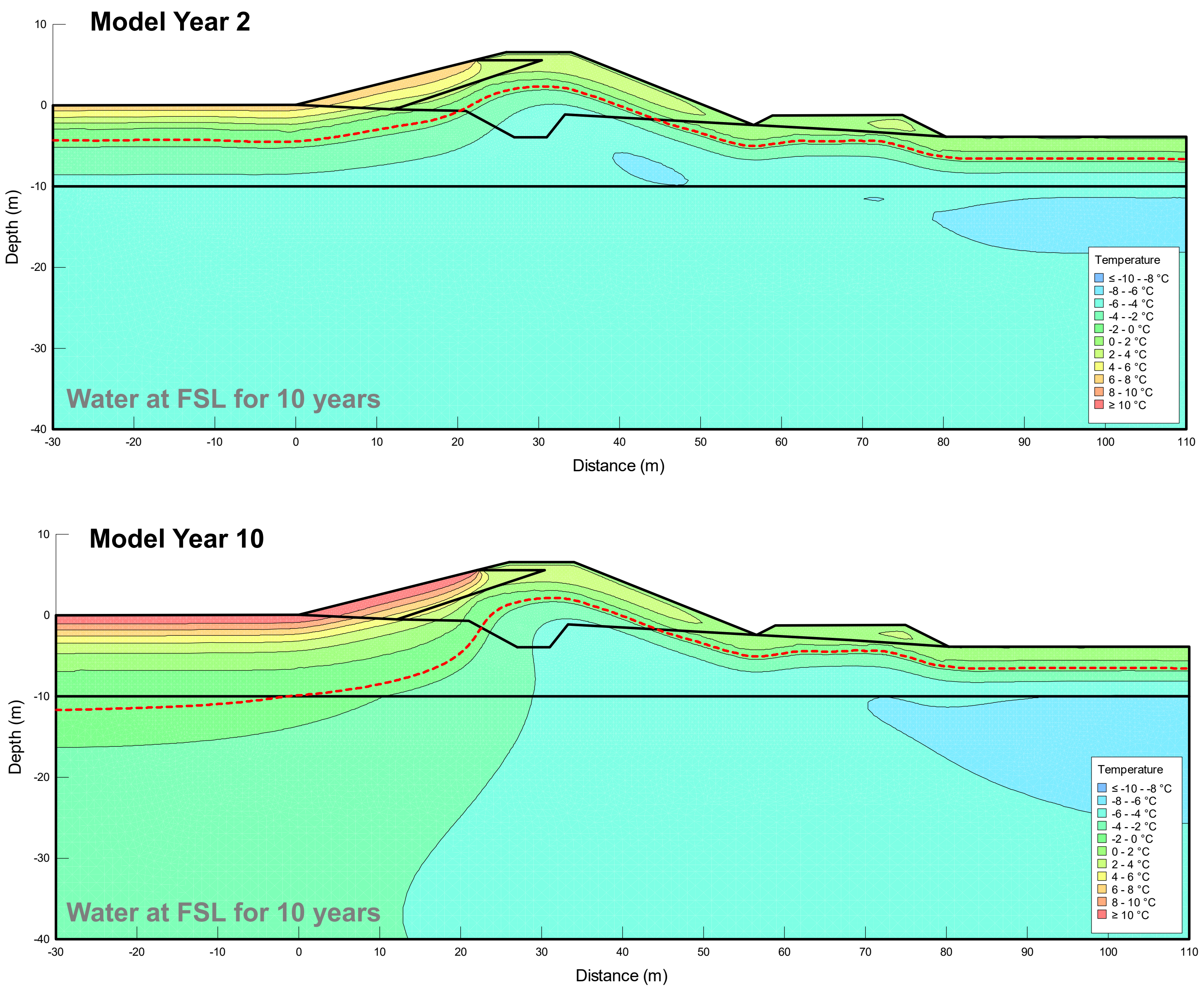
**Station 0+200 – Initial vs. Modified Key Trench Position**

Date: Nov 2022
Approved: CWS
Figure: 9

## Station 0+200 with Water at FSL for 3 years



## Station 0+200 with Water at FSL for 10 years



Temperature

- 🟦 ≤ -10 - -8 °C
- 🟦 -8 - -6 °C
- 🟦 -6 - -4 °C
- 🟩 -4 - -2 °C
- 🟩 -2 - 0 °C
- 🟩 0 - 2 °C
- 🟩 2 - 4 °C
- 🟨 4 - 6 °C
- 🟧 6 - 8 °C
- 🟧 8 - 10 °C
- 🟥 ≥ 10 °C

Notes:

1. Model results for Station (Sta.) 0+200
2. Pond water level at full supply level for 3 and10 years
3. Red dashed line indicated -1.4°C porewater freezing point depression
4. Initial rock fill temperature -2.0°C
5. Model results without thermosyphons

Primary Pond Dam Thermal Modeling

**Station 0+200 – Water at FSL**
**for 3 and 10 years**

Job No: 1CS020.020
Filename: BackRiverPrimaryPondThermalModeling.pptx

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Date: Nov 2022
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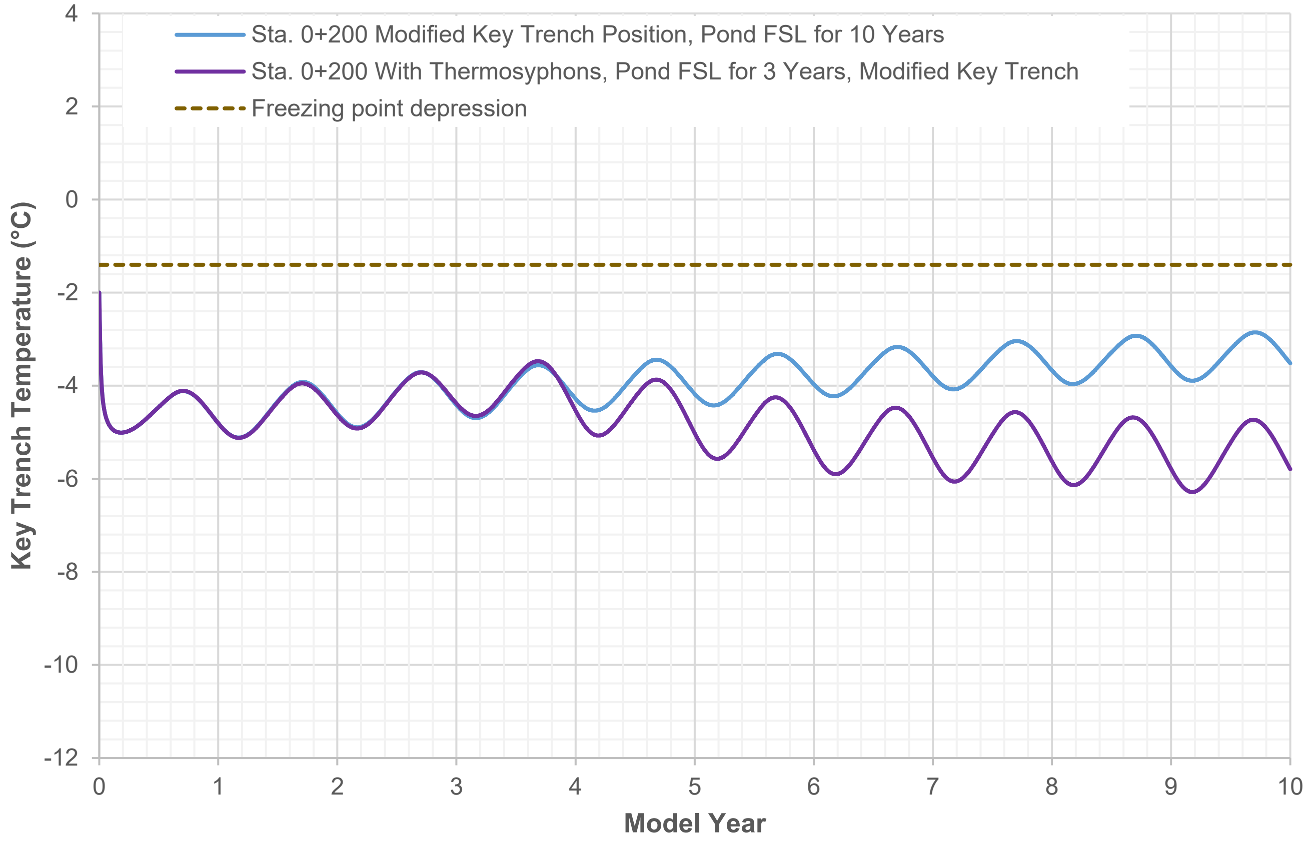
Figure: 10

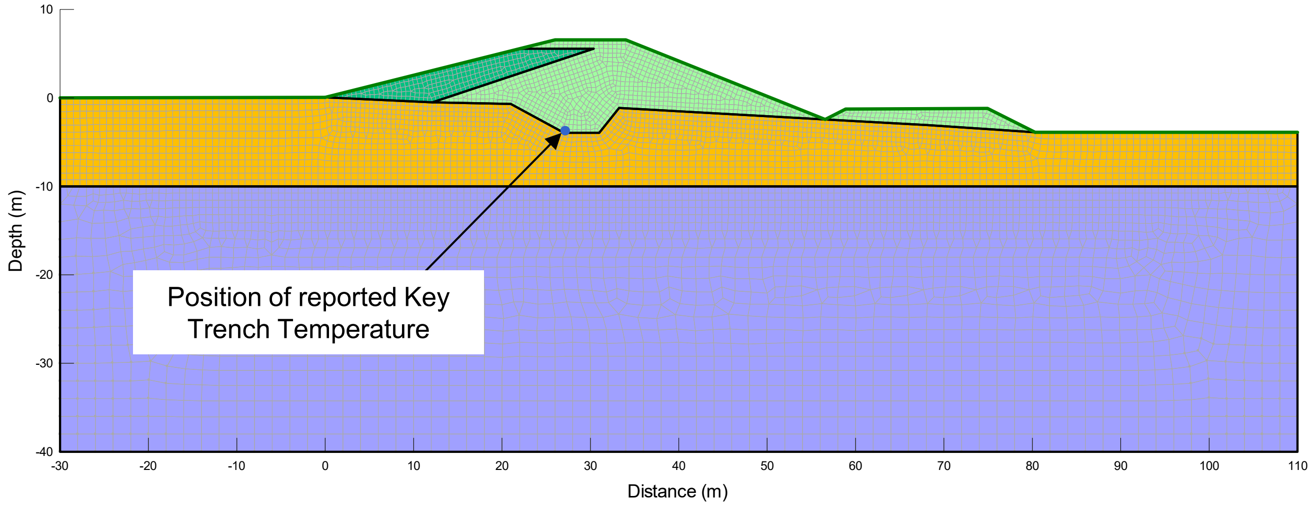
## Key Trench Temperature – Initial vs. Modified Key Trench Position



**Upstream**

**Downstream**

## Modified Key Trench Position



Notes:

1. Model results for Station (Sta.) 0+200, pond water level at full supply level for either 3 or 10 years
2. Key trench moved 8 m in downstream direction for model with “Modified Key Trench Position”
3. Model results without thermosyphons installed in the key trench

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**Station 0+200 – Water at FSL for 3 and 10 years**

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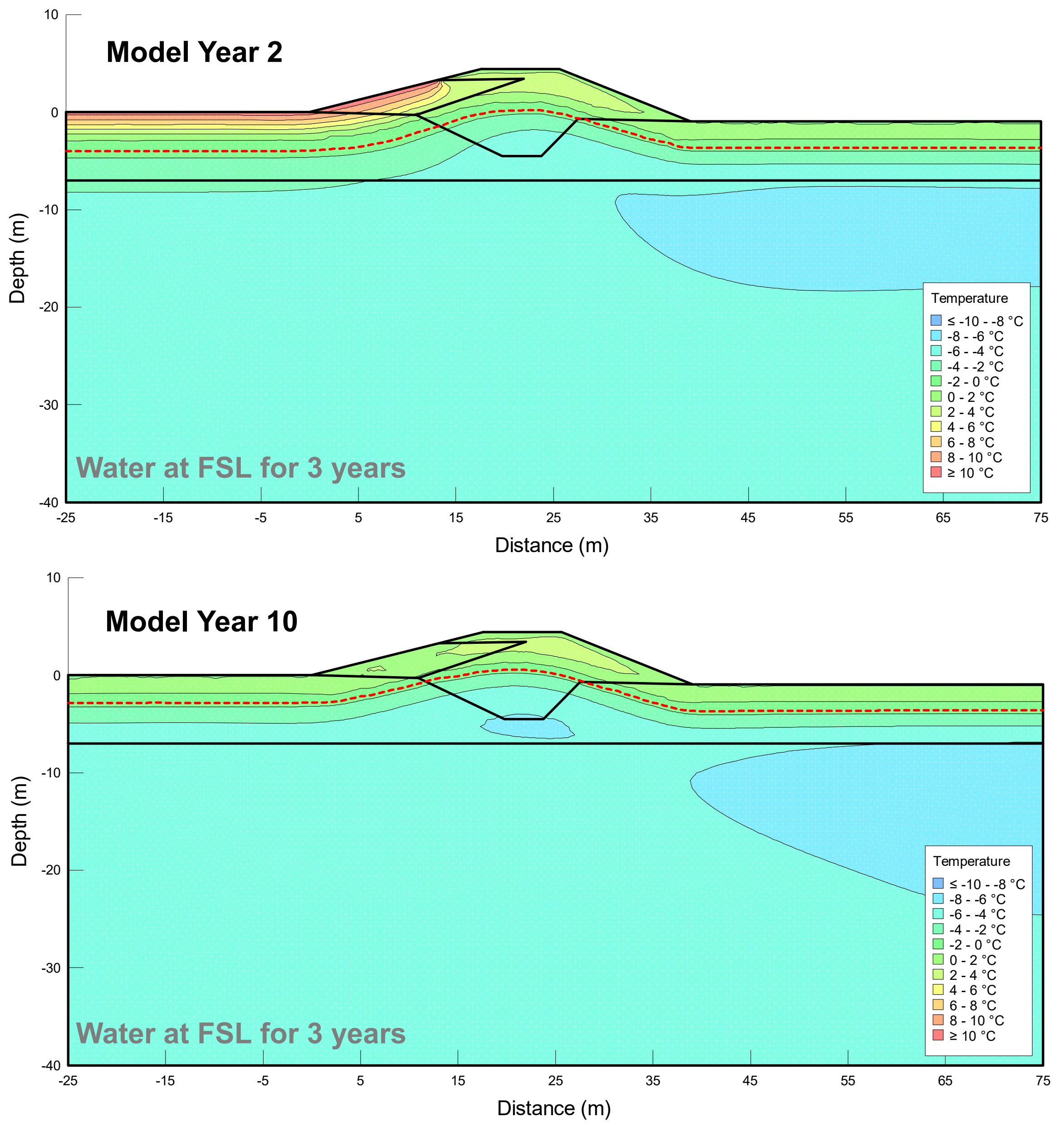
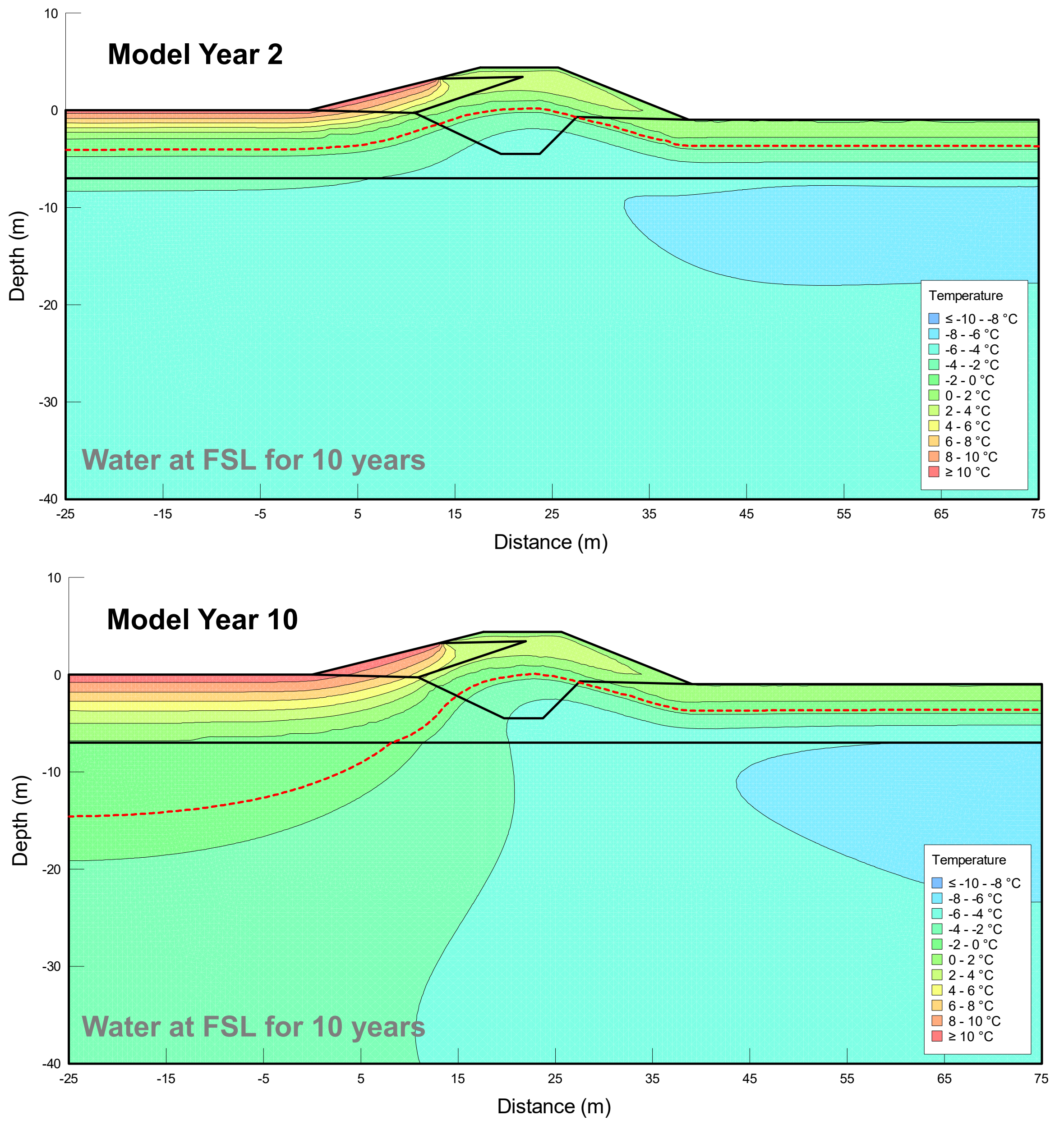
Figure: 11

## Station 0+600 with Water at FSL for 3 years



## Station 0+600 with Water at FSL for 10 years



Temperature

- 🟦 ≤ -10 - -8 °C
- 🟦 -8 - -6 °C
- 🟩 -6 - -4 °C
- 🟩 -4 - -2 °C
- 🟩 -2 - 0 °C
- 🟩 0 - 2 °C
- 🟩 2 - 4 °C
- 🟨 4 - 6 °C
- 🟧 6 - 8 °C
- 🟧 8 - 10 °C
- 🟥 ≥ 10 °C

Notes:
1. Model results for Station (Sta.) 0+600
2. Pond water level at full supply level for either 3 or 10 years
3. Red dashed line indicated -1.4°C porewater freezing point depression
4. Initial rock fill temperature -2.0°C
5. Model results without thermosyphons

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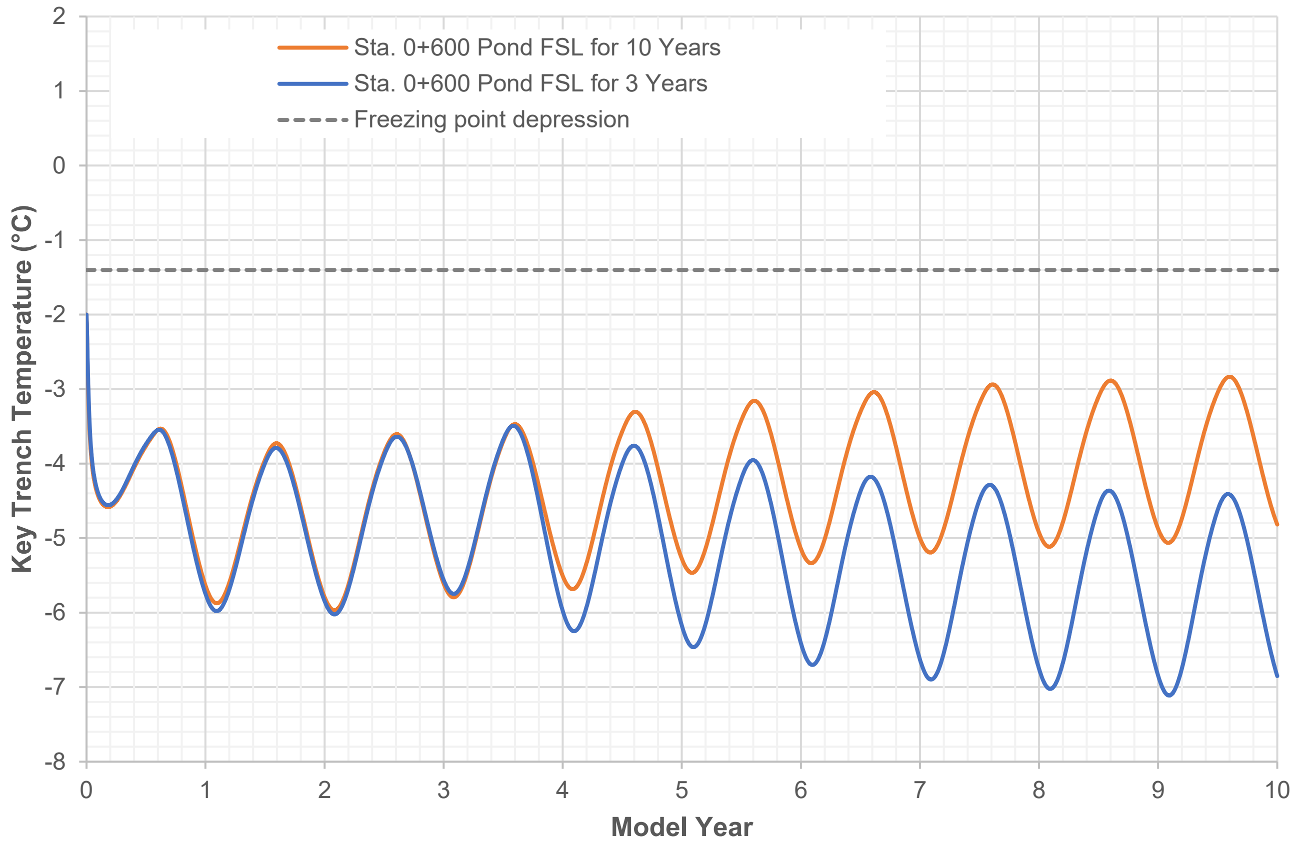
Primary Pond Dam Thermal Modeling

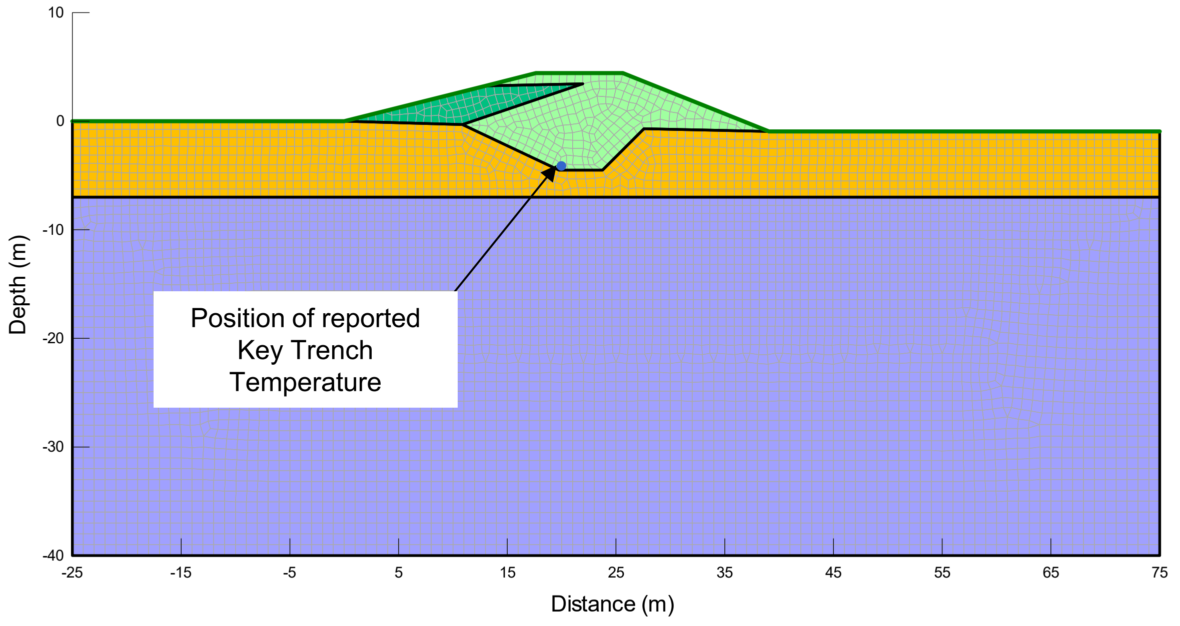
**Station 0+600 – Water at FSL**
**for 3 and 10 years**

Date: Nov 2022
Approved: CWS
Figure: 12

## Key Trench Temperature with Water FSL Maintained for 3 and 10 years



## Station 0+200



Notes:

1. Model results for Station (Sta.) 0+200, pond water level at full supply level for 10 years
2. Key trench moved 8 m in downstream direction for model with “Modified Key Trench Position”
3. Model results without thermosyphons

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Primary Pond Dam Thermal Modeling

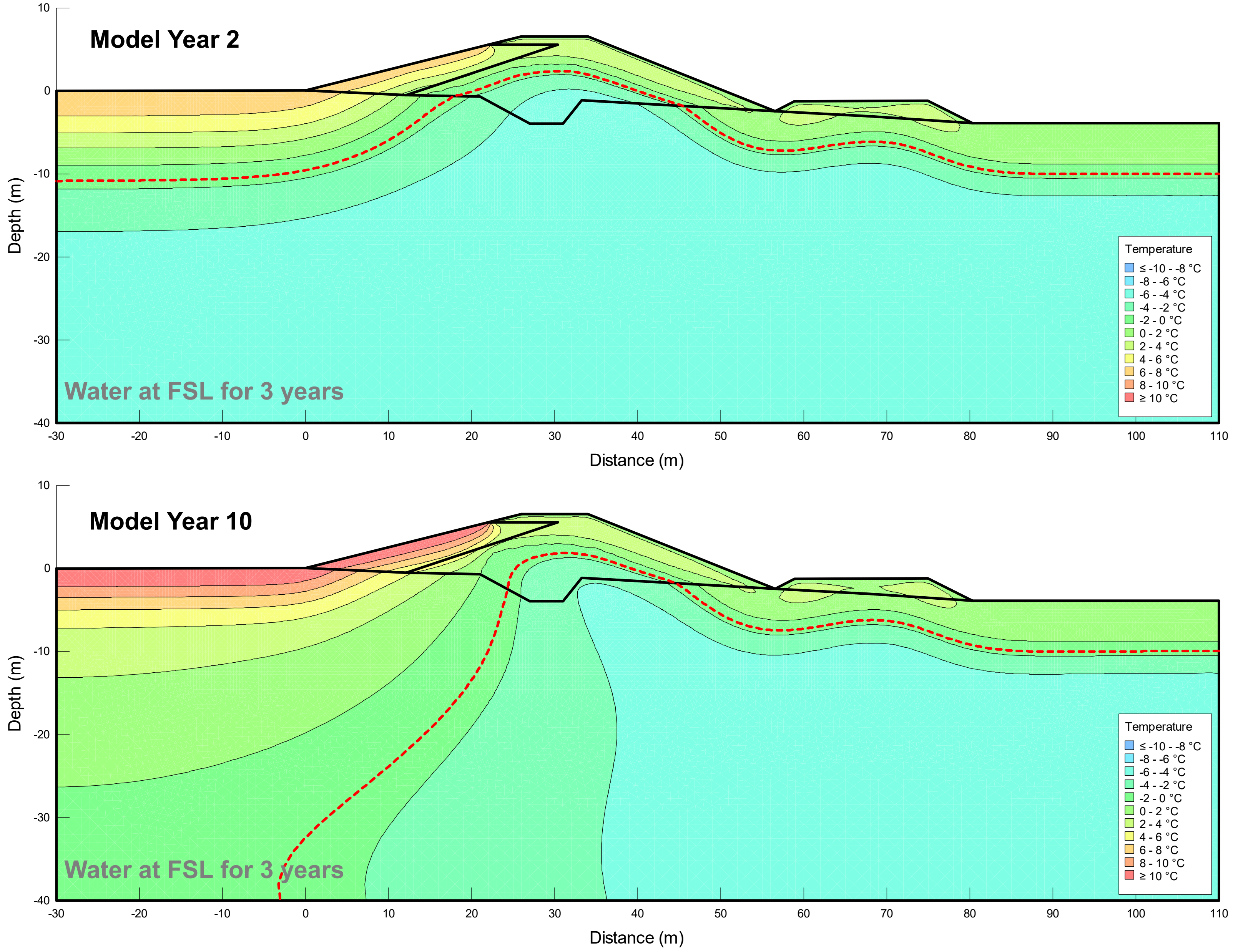
**Station 0+600 – Water at FSL for 3 and 10 years**

Date: Nov 2022

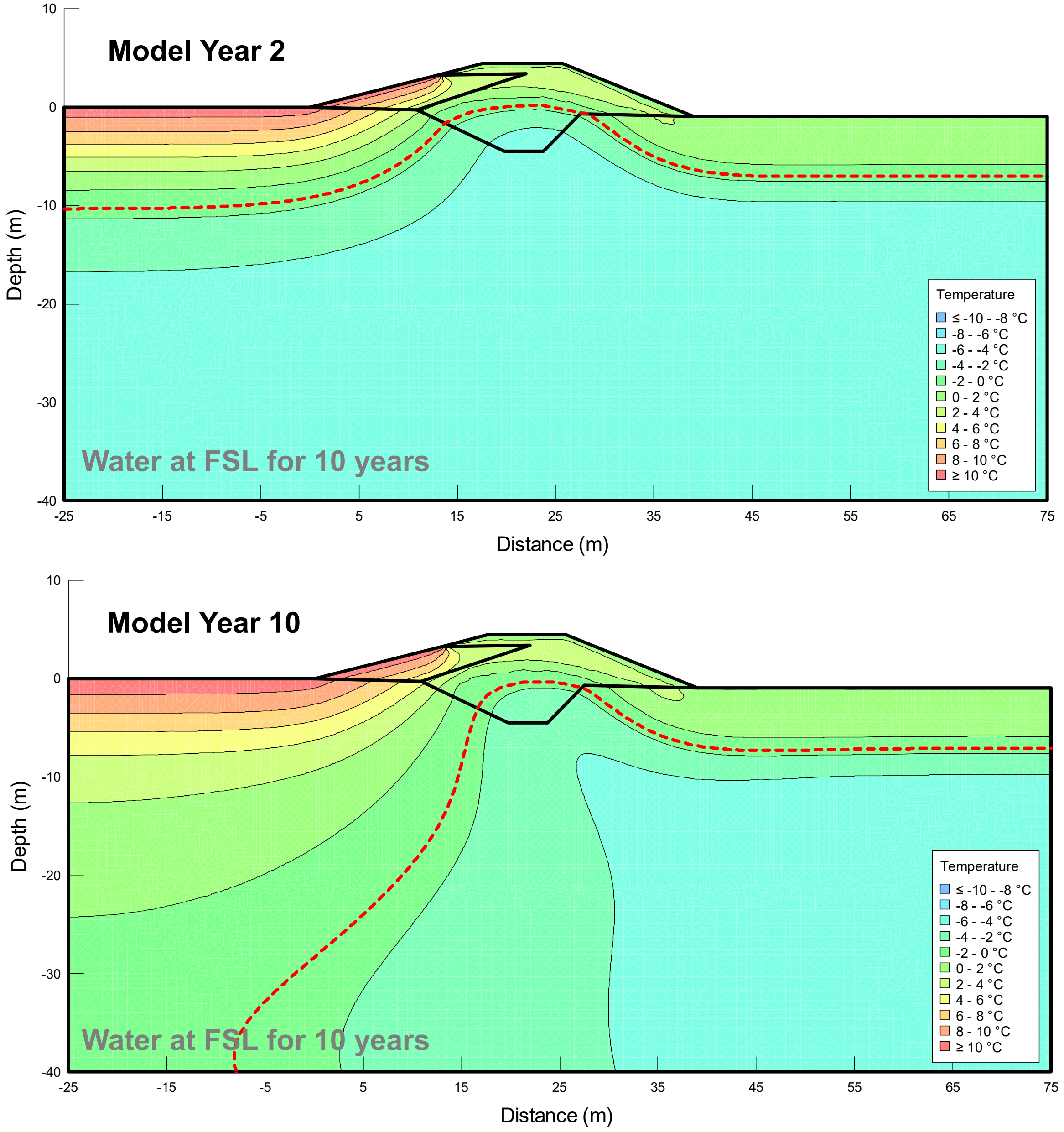
Approved: CWS

Figure: 13

Station 0+200 with Bedrock Foundation, Water at FSL for 10 years



Station 0+600 with Bedrock Foundation, Water at FSL for 10 years



Temperature
- 🟦 ≤ -10 - -8 °C
- 🟦 -8 - -6 °C
- 🟦 -6 - -4 °C
- 🟩 -4 - -2 °C
- 🟩 -2 - 0 °C
- 🟩 0 - 2 °C
- 🟨 2 - 4 °C
- 🟨 4 - 6 °C
- 🟧 6 - 8 °C
- 🟧 8 - 10 °C
- 🟥 ≥ 10 °C

Notes:
1. Model results for Station (Sta.) 0+200 and 0+600
2. Pond water level at full supply level for 10 years
3. Red dashed line indicated -1.4°C porewater freezing point depression
4. Initial rock fill temperature -2.0°C
5. Model results without thermosyphons

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Primary Pond Dam Thermal Modeling

**Station 0+200 & 0+600 with Bedrock Foundation**

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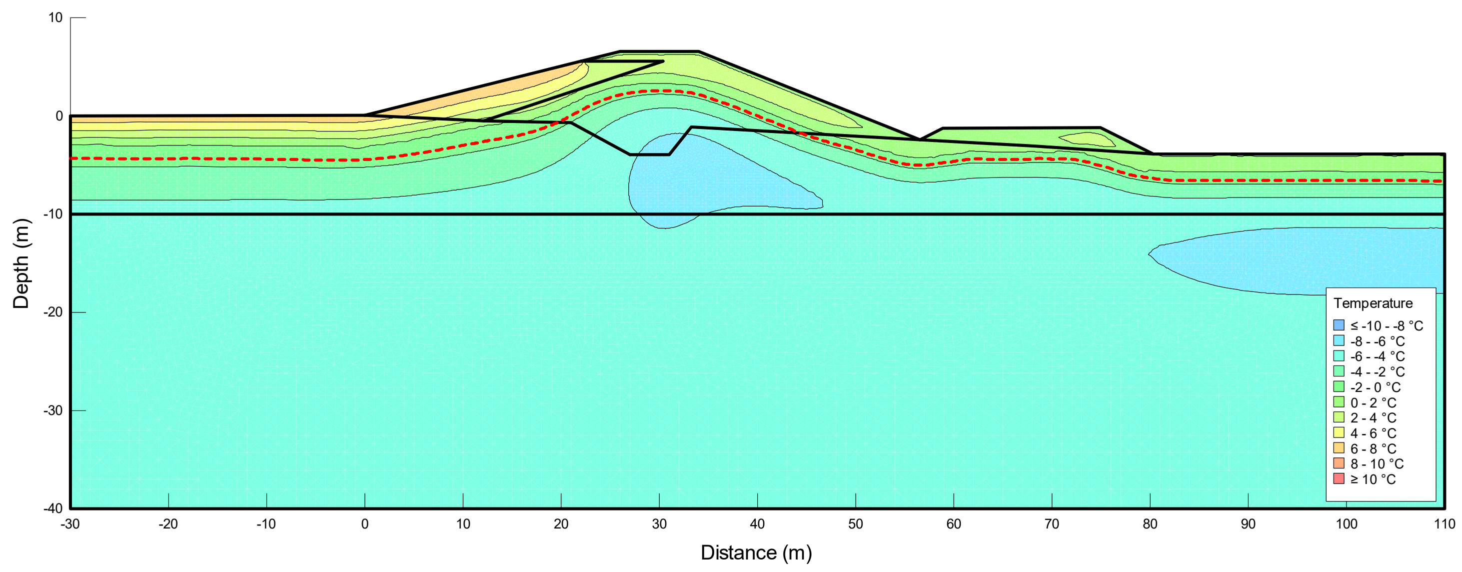
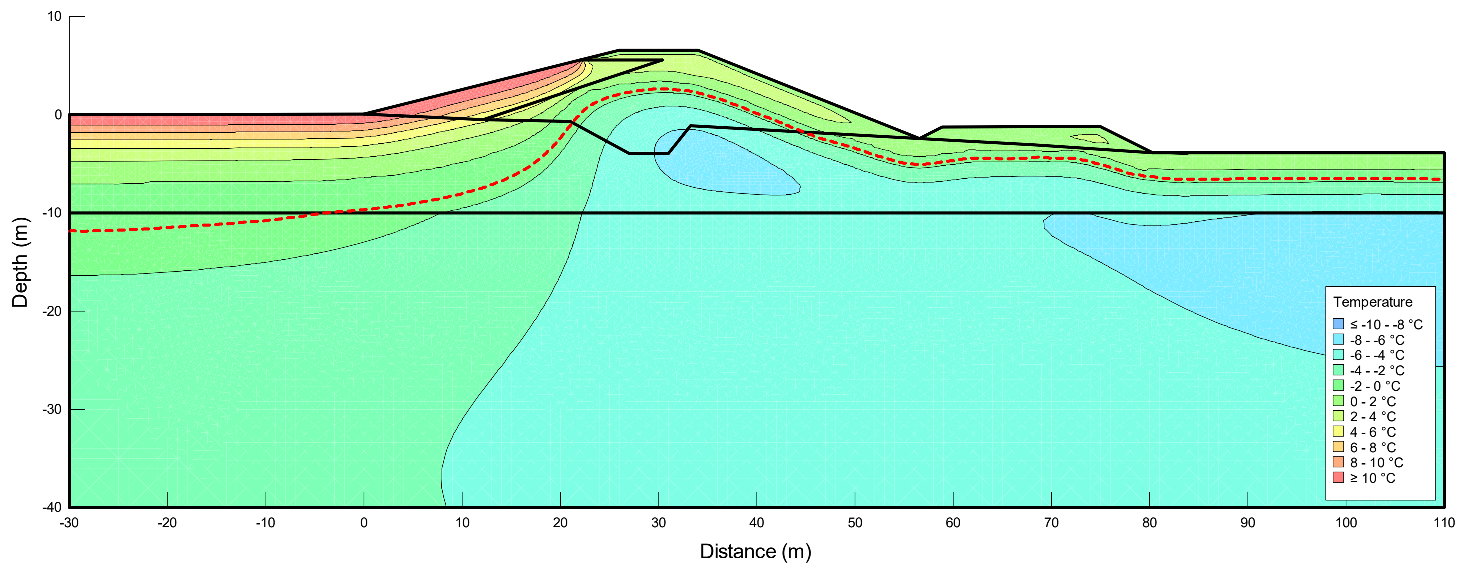
Date: Nov 2022
Approved: CWS
Figure: 14

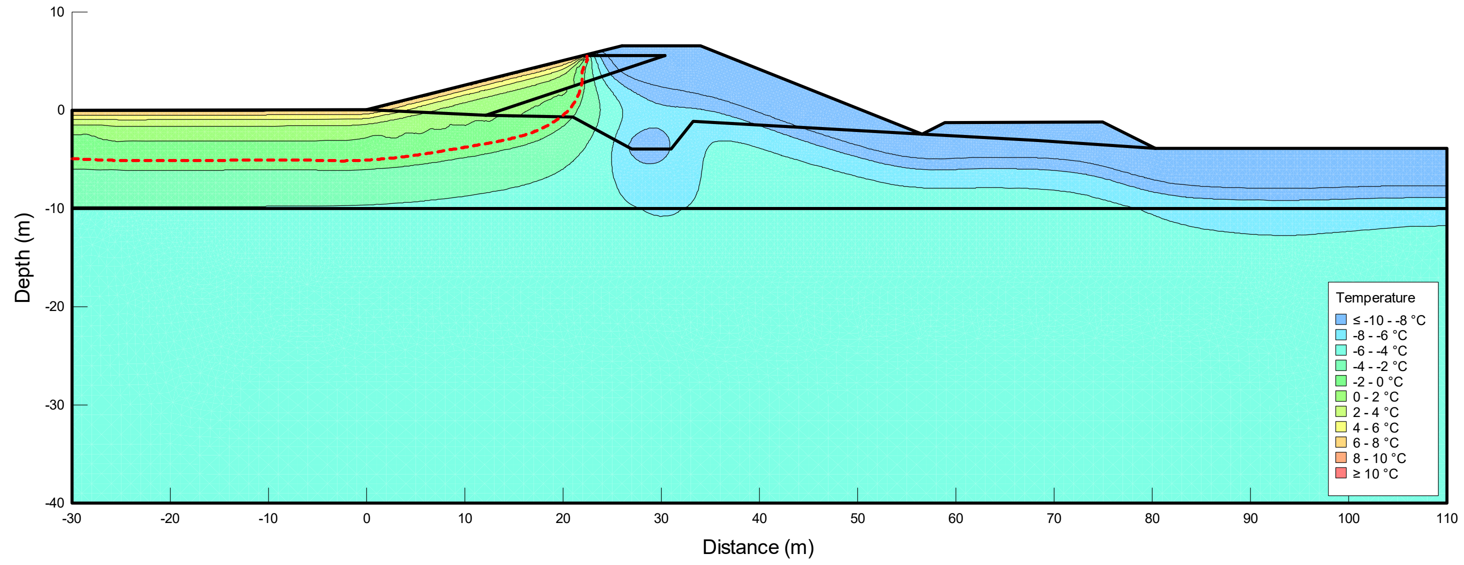
## Station 0+200 – Model Year 2
## Late Summer



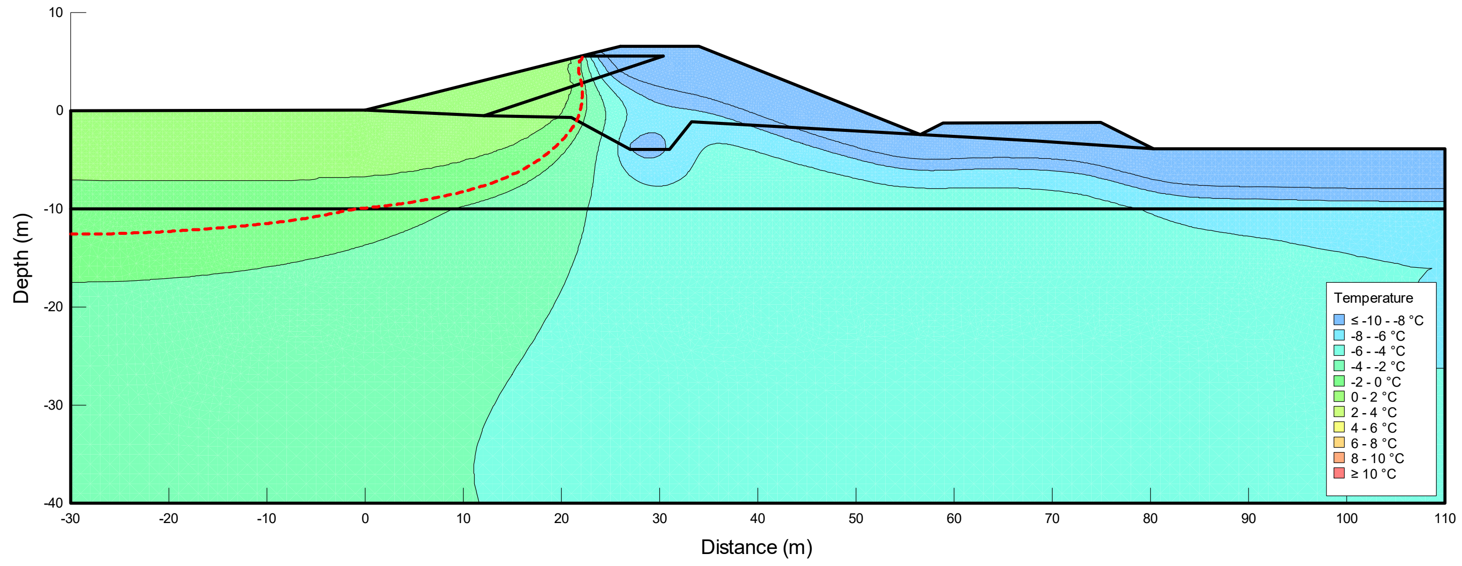
## Station 0+200 – Model Year 10
## Late Summer



## Station 0+200 – Model Year 2
## Late Winter



## Station 0+200 – Model Year 10
## Late Winter



Temperature

- 🟦 ≤ -10 - -8 °C
- 🟦 -8 - -6 °C
- 🟦 -6 - -4 °C
- 🟩 -4 - -2 °C
- 🟩 -2 - 0 °C
- 🟩 0 - 2 °C
- 🟩 2 - 4 °C
- 🟨 4 - 6 °C
- 🟧 6 - 8 °C
- 🟧 8 - 10 °C
- 🟥 ≥ 10 °C

Notes:

1. Pond operated at full supply level (FSL) for 10 years
2. Thermosyphons radiators 39 m$^2$, four evaporator pipes, pipe length 250 m
3. Late summer defined as mid-September and late winter at the end of March

Job No: 1CS020.020
Filename: BackRiverPrimaryPondThermalModeling.pptx

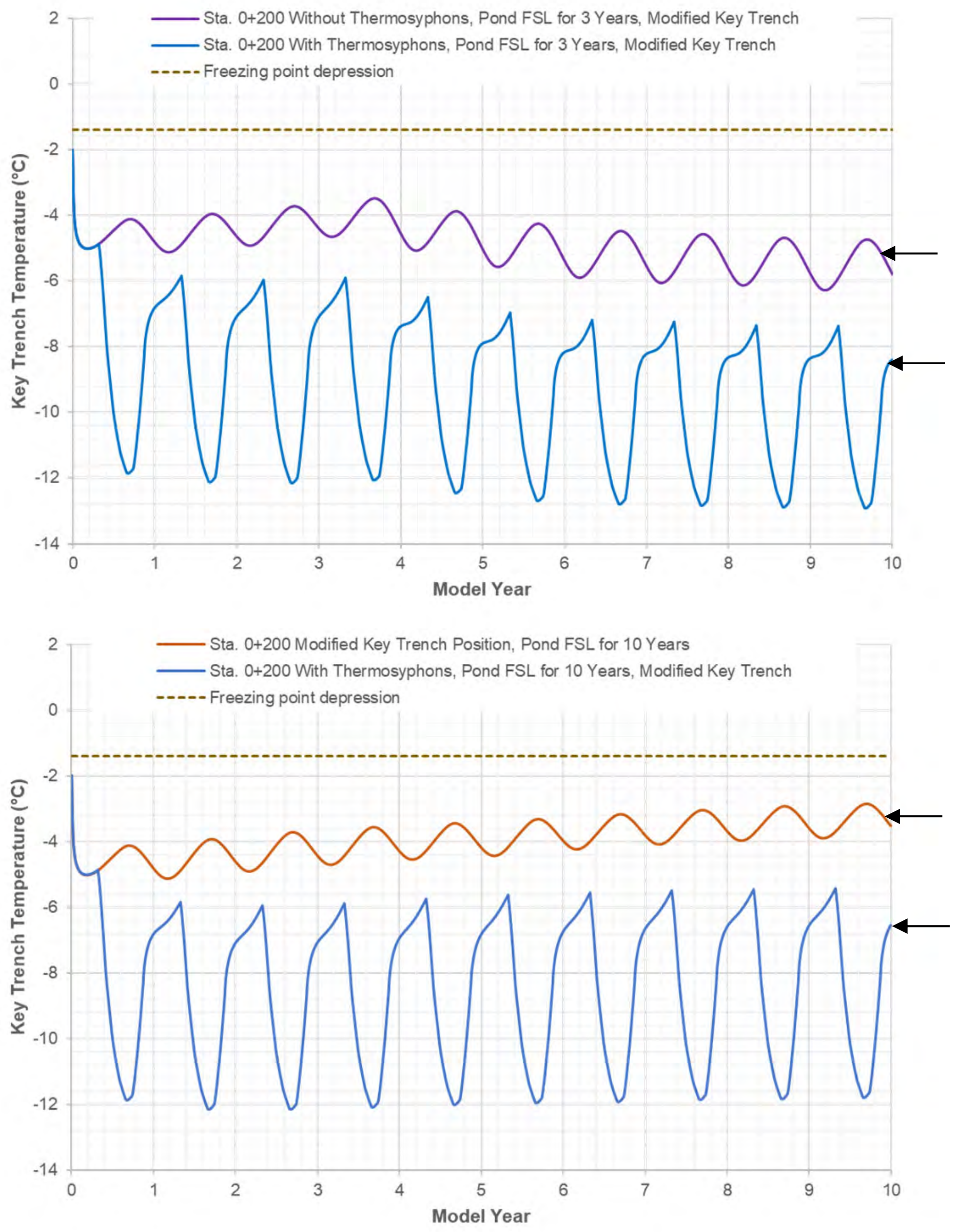
BACK RIVER PROJECT

Primary Pond Dam Thermal Modeling

**Station 0+200 – Thermosyphons with Key Trench Evaporator Pipes**

Date: Nov 2022
Approved: CWS
Figure: 15

## Key Trench Temperature



Pond at FSL for first 3 years, without thermosyphons

Pond at FSL for first 3 years, with thermosyphons

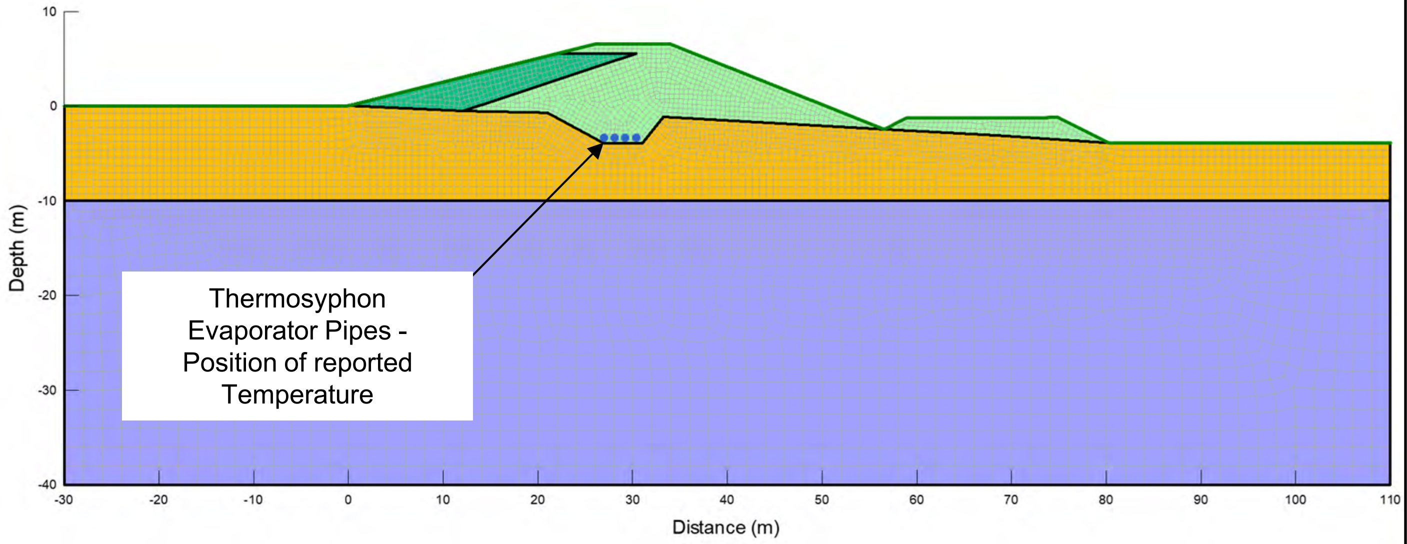
Pond at FSL for first 10 years, without thermosyphons

Pond at FSL for first 10 years, with thermosyphons

**Upstream**

**Downstream**

### Modified Key Trench Position



Notes:

1. Thermosyphon evaporator pipes installed during construction
2. Thermosyphon based on four units with radiators size of 39m$^2$, evaporator pipe length 250 m.

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Primary Pond Dam Thermal Modeling

**Station 0+200 – Key Trench Temperature with Thermosyphons**

Job No: 1CS020.020

Filename: BackRiverPrimaryPondThermalModeling.pptx

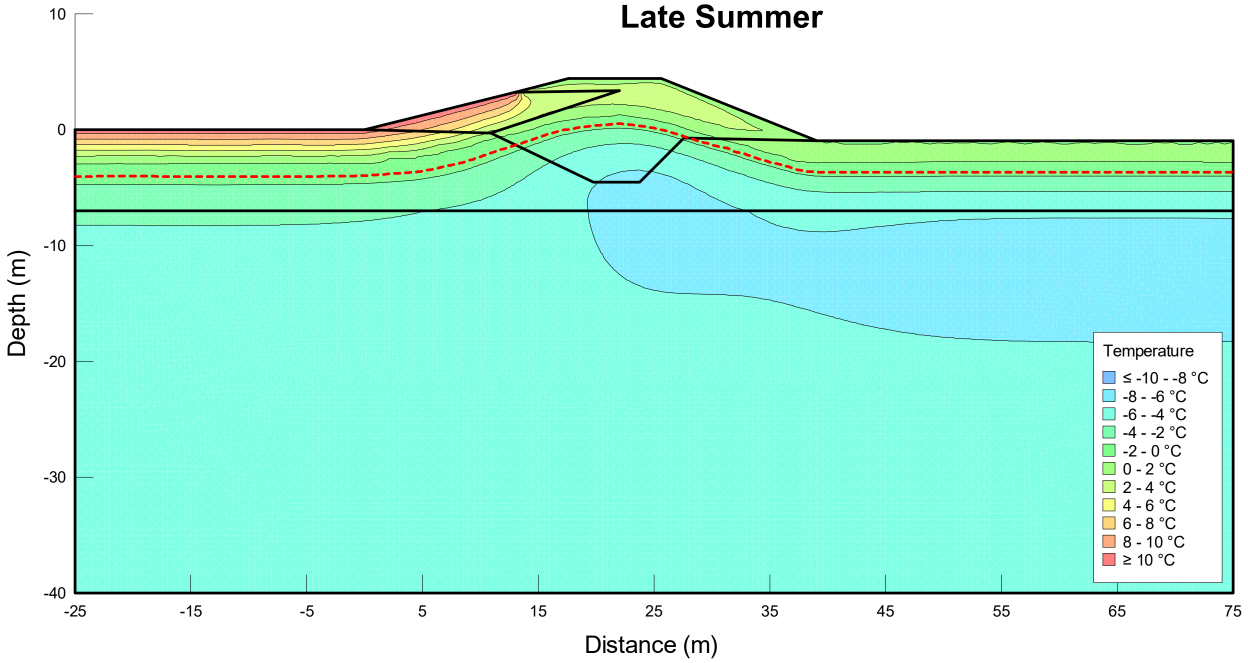
BACK RIVER PROJECT

Date: Nov 2022

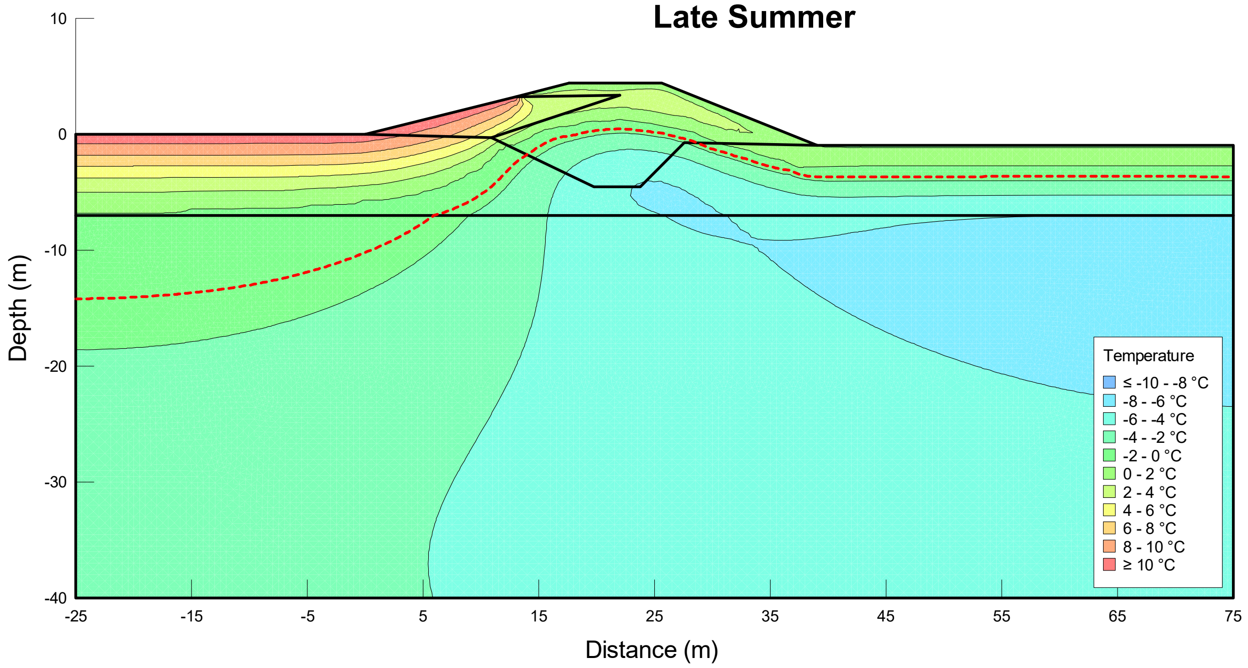
Approved: CWS

Figure: 16

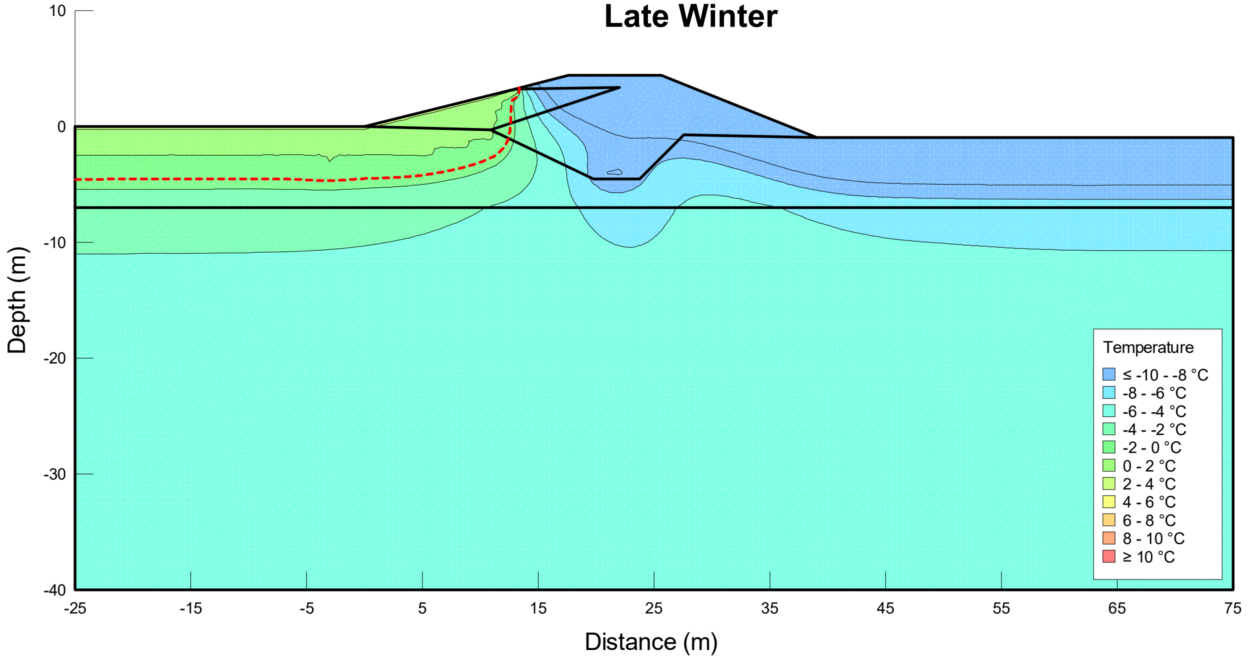
## Station 0+600 – Model Year 2
## Late Summer



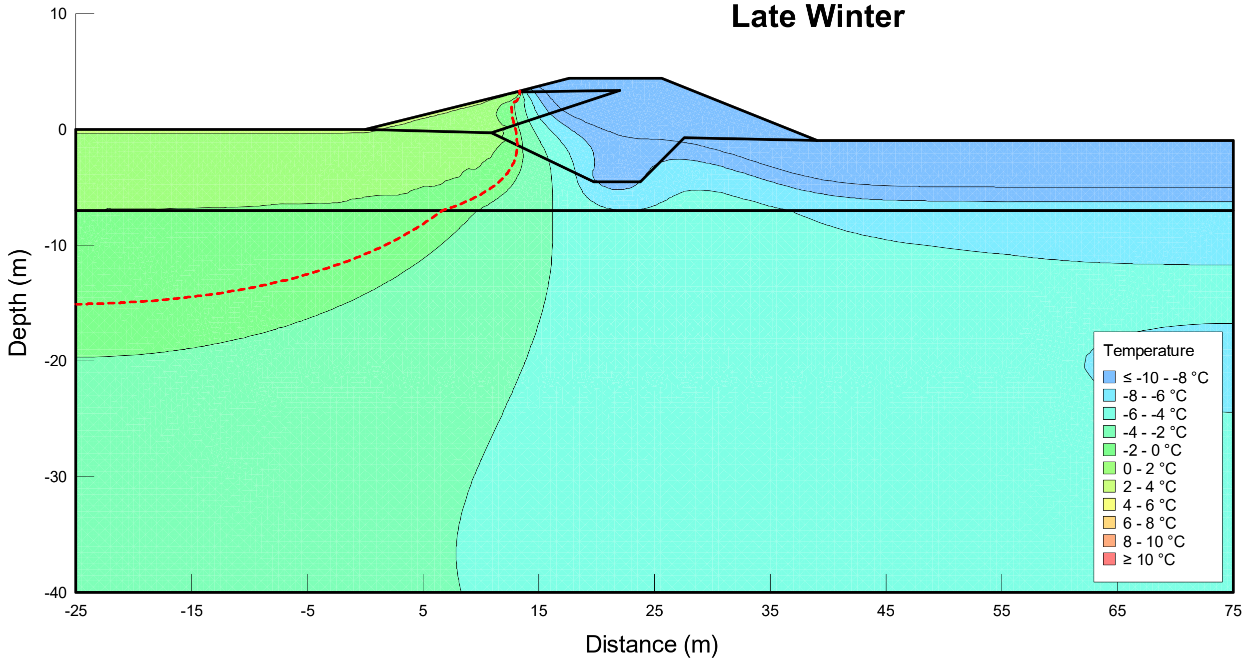
## Station 0+600 – Model Year 10
## Late Summer



## Station 0+600 – Model Year 2
## Late Winter



## Station 0+600 – Model Year 10
## Late Winter



Temperature

🟦 ≤ -10 - -8 °C
🟦 -8 - -6 °C
🟦 -6 - -4 °C
🟩 -4 - -2 °C
🟩 -2 - 0 °C
🟩 0 - 2 °C
🟩 2 - 4 °C
🟨 4 - 6 °C
🟧 6 - 8 °C
🟧 8 - 10 °C
🟥 ≥ 10 °C

Notes:

1. Pond operated at full supply level (FSL) for 10 years
2. Thermosyphons radiators 39 m$^2$, four evaporator pipes, pipe length 250 m
3. Late summer defined as mid-September and late winter at the end of March

Job No: 1CS020.020
Filename: BackRiverPrimaryPondThermalModeling.pptx

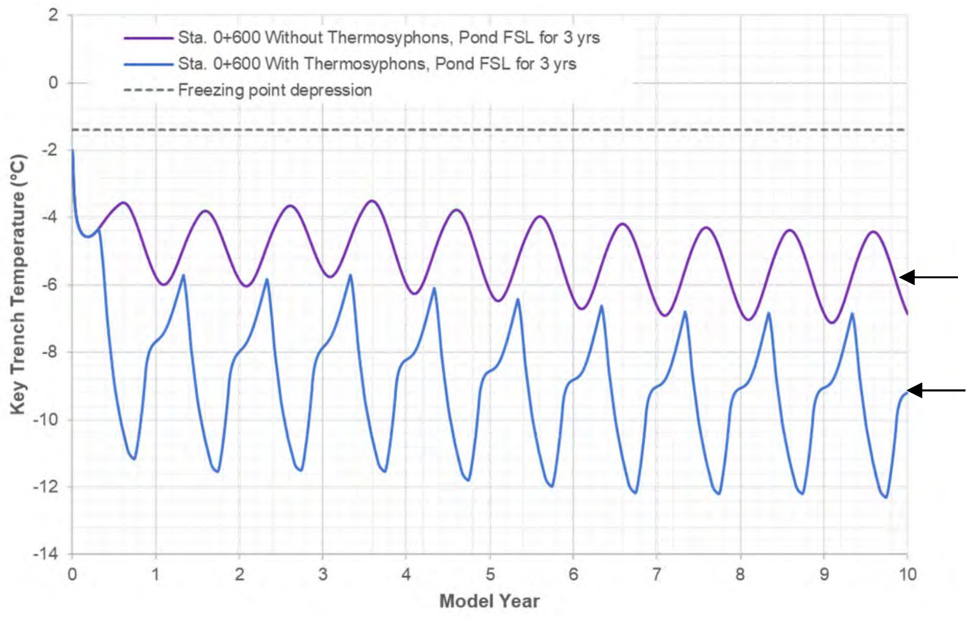
BACK RIVER PROJECT

Primary Pond Dam Thermal Modeling

**Station 0+600 – Thermosyphons with Key Trench Evaporator Pipes**

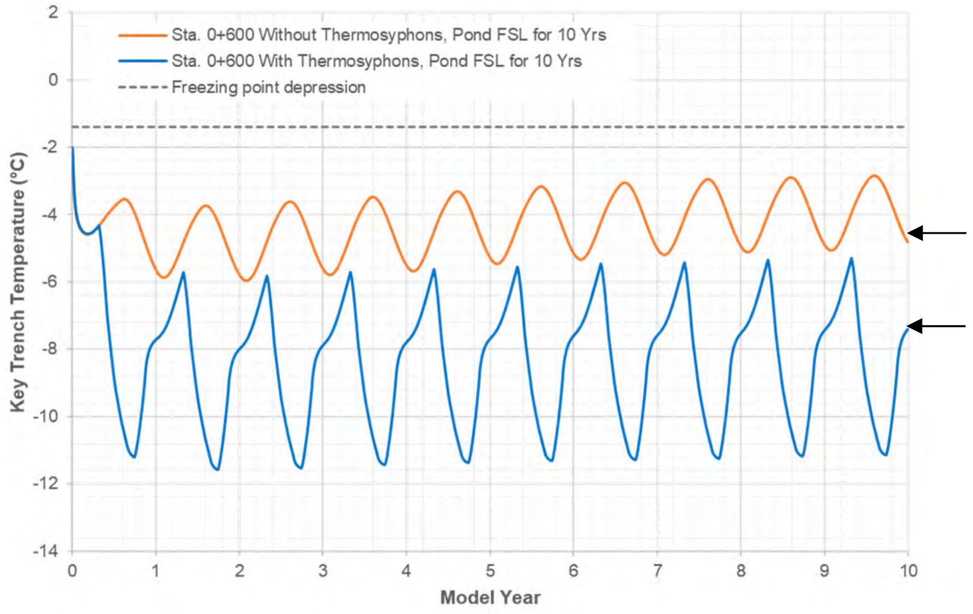
Date: Nov 2022
Approved: CWS
Figure: 17

## Key Trench Temperature



Pond at FSL for first 3 years, without thermosyphons

Pond at FSL for first 3 years, with thermosyphons



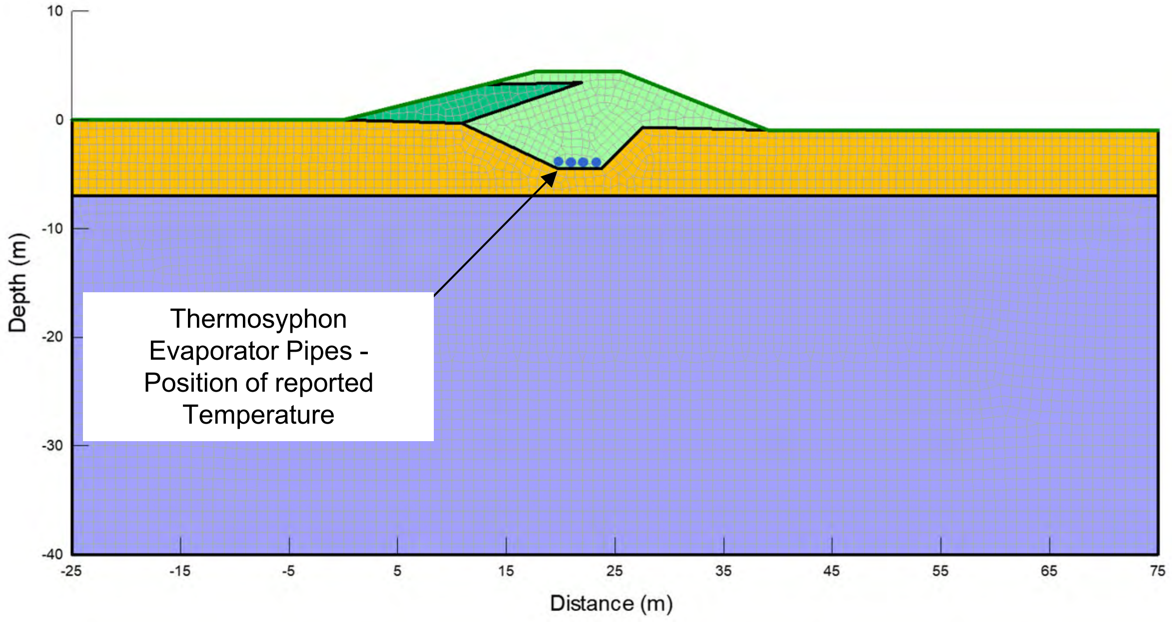
Pond at FSL for first 10 years, without thermosyphons

Pond at FSL for first 10 years, with thermosyphons

**Upstream**

**Downstream**

## Modified Key Trench Position

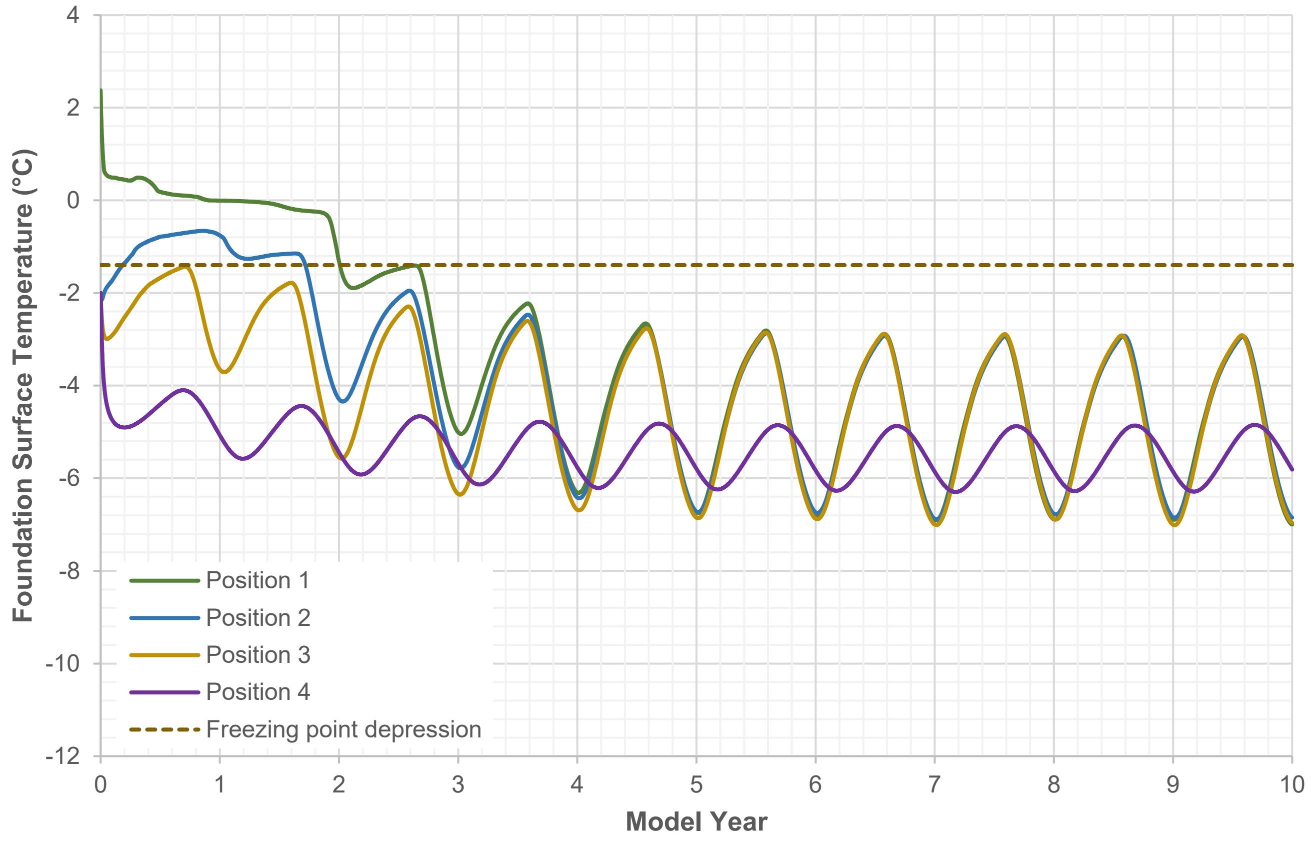


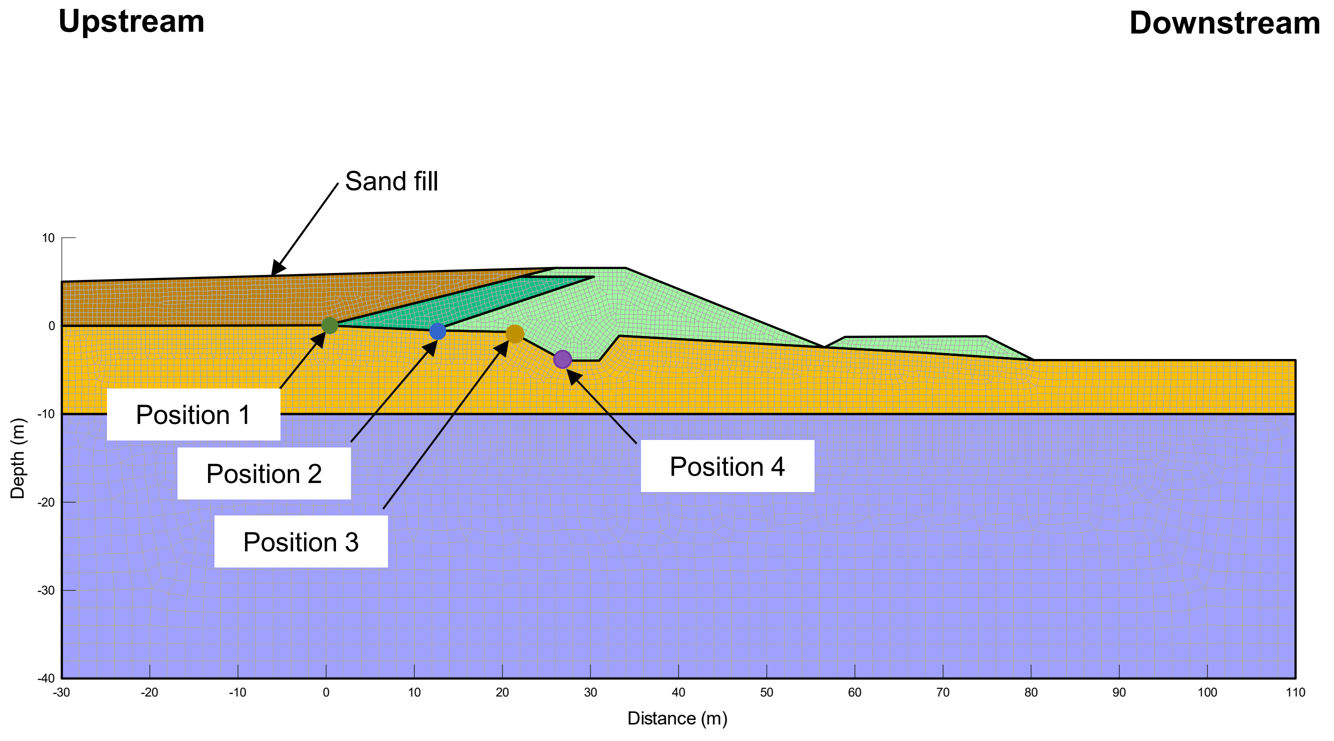
Thermosyphon Evaporator Pipes - Position of reported Temperature

Notes:

1. Thermosyphon based on four units with radiators size of 39m$^2$, evaporator pipe length 250 m.
2. Thermosyphon evaporator pipes installed during construction

| | | |
|---|---|---|
| srk consulting | Sabina GOLD & SILVER CORP | Primary Pond Dam Thermal Modeling |
| | | **Station 0+600 – Key Trench Temperature with Thermosyphons** |
| Job No: 1CS020.020<br>Filename: BackRiverPrimaryPondThermalModeling.pptx | BACK RIVER PROJECT | Date: Nov 2022<br>Approved: CWS<br>Figure: 18 |





Notes:

1. Sand fill placed immediately upstream of dam
2. Ground temperature reported for four locations at the foundation surface (Positions 1 through 4)

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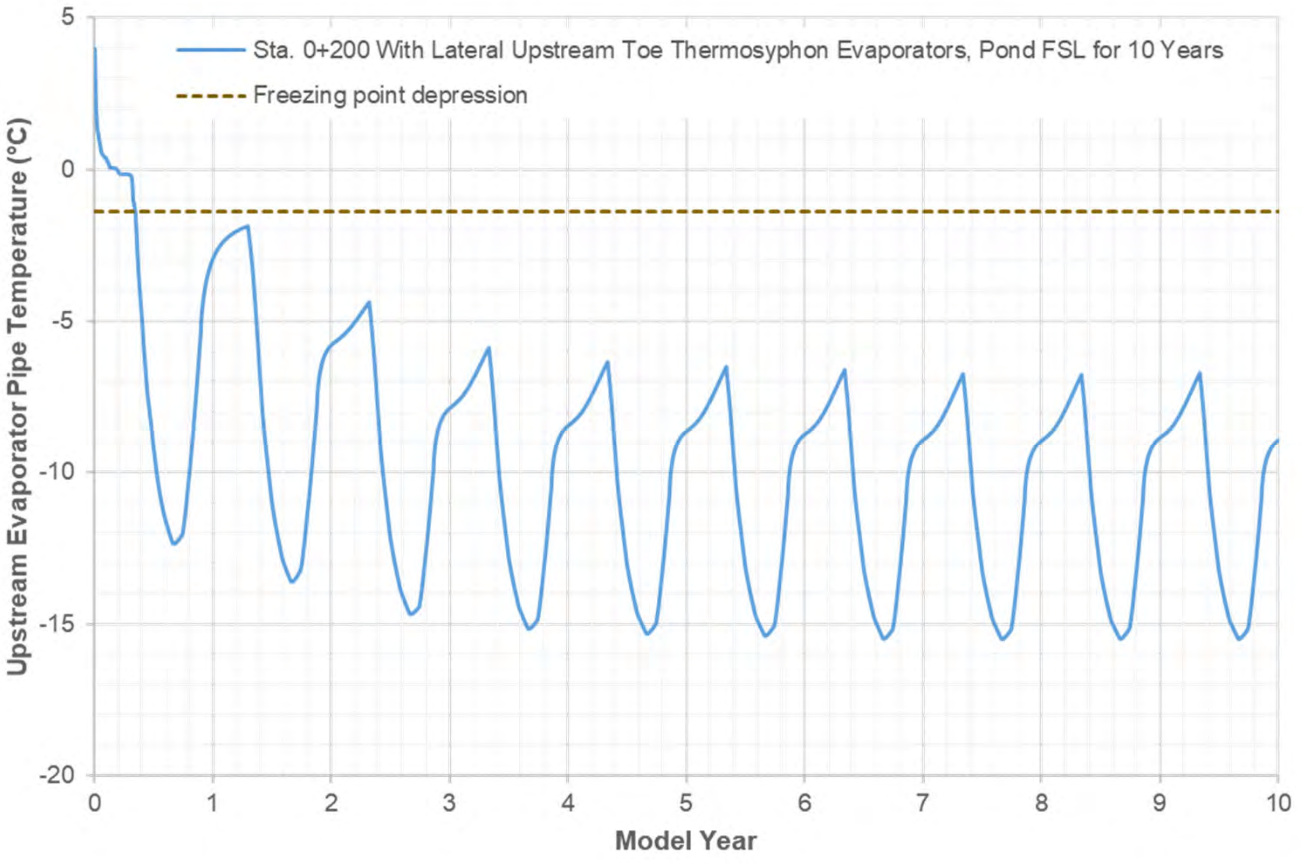
Job No: 1CS020.020
Filename: BackRiverPrimaryPondThermalModeling.pptx

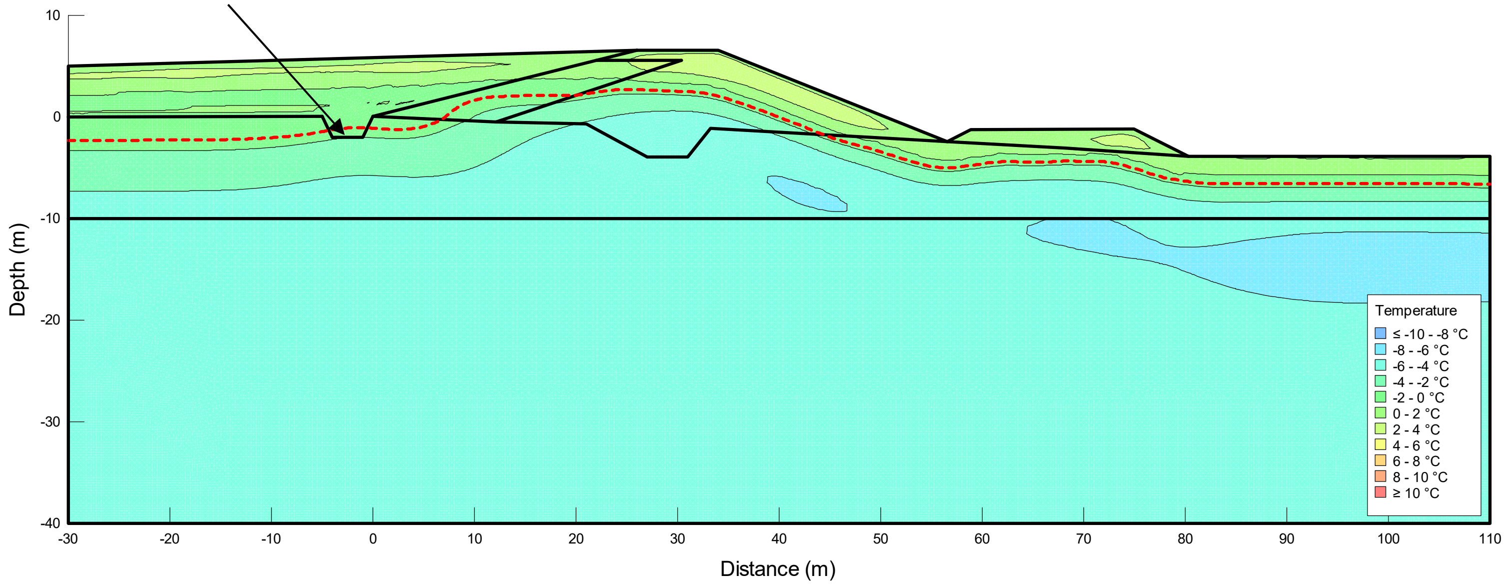
BACK RIVER PROJECT

Primary Pond Dam Thermal Modeling

**Station 0+200 –**
**Upstream Fill Placement**

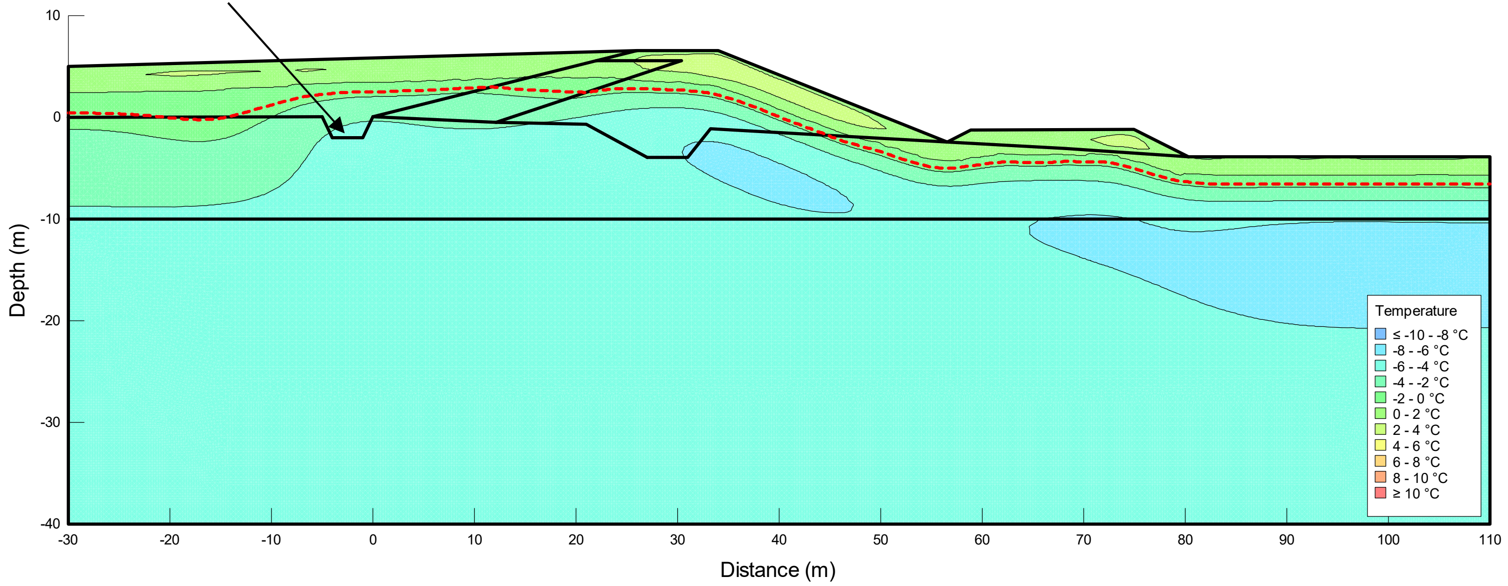
Date: Nov 2022
Approved: CWS
Figure: **19**





Location of thermosyphon evaporator pipes

**Station 0+200 – Model Year 2**



Location of thermosyphon evaporator pipes

**Station 0+200 – Model Year 10**

Notes:

1. Sand fill placed immediately upstream of dam with installation of thermosyphons upstream of dam toe
2. Thermosyphons radiators 39 m$^2$, four evaporator pipes, pipe length 250 m
3. Model does not include thermosyphon evaporator pipes within the dam key trench

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Primary Pond Dam Thermal Modeling

**Station 0+200 – Thermosyphons Installed Upstream**

Job No: 1CS020.020
Filename: BackRiverPrimaryPondThermalModeling.pptx

BACK RIVER PROJECT

Date: Nov 2022
Approved: CWS
Figure: **20**

# ATTACHMENT 4

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www.srk.com

**FINAL DRAFT**

# Memo

| | | | |
|---|---|---|---|
| **To** | File | **Project** | CAPR000396 |
| **From** | Anna Timchenko | **Reg. No.** | EGBC 1003655 |
| **Cc** | John Kurylo, Jasur Umarov | **Date** | November 29, 2022 |
| **Client** | Sabina Gold and Silver Corp. | | |

**Subject** Back River –Water Management Infrastructure Design
Primary Pond – Slope Stability Analysis

---

# 1 Introduction

## 1.1 Scope

SRK Consulting (Canada) Inc. (SRK) was retained by Sabina Gold and Silver Corp. (Sabina) to complete a geotechnical stability analysis of Primary Pond Dam, in support of its detailed design.

The objectives of this memorandum are to:

- Complete a stability analysis (static, pseudo-static and rapid drain down) for the Primary Pond Dam considering the latest proposed dam geometry of selected critical cross-sections;
- Complete sensitivity analysis on liner properties to determine its implications on the proposed design configuration; and
- Undertake additional sensitivity scenarios considering variable water levels (expected during operation of the facility).

## 1.2 Background

Primary Pond Dam is one of the proposed water management infrastructures at the Goose Property of Back River Project. The Project is located in the territory of Nunavut, 160 km south of the Bathurst Inlet and is comprised of two distinct active sites: Goose Property and the Marine Laydown Area (MLA). The MLA is located approximately 80 km north of the George Advanced Exploration Property, which in turn is located 50 km north of the Goose Property.

Primary Pond Dam is designed as a water retaining structure with an active water pond for the duration of mine operations. The initial approximately three years of operation the Primary Pond will have a higher water level. Following this the water level of the pond is expected to be notably reduced (water typically not against the dam slope and mostly in the area where the existing natural pond, Round Pond, exists). Water retention will be provided by means of installing an HDPE liner tied into the foundation permafrost (SRK 2022), creating a frozen foundation structure. Over the majority of the mine life the Primary Pond will be used more as a surge pond for contact water (associated with the Umwelt Waste Rock Storage Area (WRSA) and south portion of Llama WRSA, both located on the upstream of the facility). In the initial years of pre-development and operations the Primary Pond will be used to assist with lake dewatering (to assist with sediment and Total Suspended Solids management if / as needed) and will assist with the initial mill start up (water in Primary Pond to be used until sufficient volume in the pits is established for reclaim). Water retention will be provided by means of installing an HDPE geomembrane liner tied into the foundation permafrost and bedrock (SRK 2022), creating a frozen foundation structure.

# 2 Slope Stability Analysis

## 2.1 Geometry

The Primary Pond Dam is designed to have crest elevation of 314.5 masl, with a maximum height of 9 m. Downstream and und upstream slopes of the dam will have slopes of 2.5H:1V and 4H:1V slopes, respectively. The dam will be built using engineered rockfill.

A wide key trench will be excavated min 2-5m into the foundation, with upstream and downstream slopes of 2.0H:1.0V and 1.0H:1.0V, respectively. The key trench will then be backfilled with compacted ROQ rock, which also will form the bulk of the dam structure. The HDPE liner will extend from the base of the key trench, along the upstream slope of the key trench excavation, before sweeping back along the upstream face of the dam at a slope of 3.0H:1.0V, as shown in Appendix A, Figure 2. The liner will be protected with a 0.3 m bedding layer and a 1 m thick layer of transition fill on either side.

Four cross-sections were selected for slope stability analysis to represent key sections of the dam (UP-PP-102) (Section A, Section B, Section C, and Section D (Appendix A, Figure 4). The modeled cross-sections are shown in Appendix A (Figure 5).

## 2.2 Method of Analysis

Two-dimensional (2D) stability analyses on the representative cross-sections (Appendix A, Figures 4 and 5) were performed using the slope stability software Slide2, Version 9.020 (Rocscience Inc., 2021). The factor of safety (FOS) was determined using static limit equilibrium analysis that satisfies all three equations of equilibrium (force equilibrium in horizontal and vertical directions and moment equilibrium condition). The limit equilibrium analysis used the Spenser and GLE/Morgenstern-Price method of slices. Slip surface searches (typically auto-locate) utilized the Cuckoo Search method and were completed for each model section to ensure the models' lowest and most representative FOS were identified. To examine FOS for both shallow and deep slip surfaces, minimum failure depths were set at 0.5 m, 1.0 m, and 1.5 m.

The stability analysis models were run under both static and pseudo-static conditions. Both upstream and downstream stability of the water management infrastructure elements were examined.

## 2.3 Factor of Safety Criteria

The required factor of safety ($FOS_{MIN}$) for Primary Pond Dam in accordance with CDA (2019a) are summarized in Table 1.

**Table 1: Minimum Required Factors of Safety**[1]

| Assessment Type | Loading Condition/ Assessment Method | Minimum FOS ($FOS_{MIN}$) | Applicable Slope |
|---|---|---|---|
| Static | During or at the end of construction | >1.3<br>depending on risks assessed during construction | Typically, downstream |
| Static | During operation[2] | 1.5 | Downstream and upstream |
| Static | Long-term (steady-state seepage, normal reservoir level)[3] | 1.5 | Downstream and upstream |
| Static | Rapid Drawdown | 1.2 to 1.3 | Upstream |
| Seismic | Pseudo-Static | 1.0 | Downstream and upstream |

Notes:

[1] This table is summarized from Tables 3-4 and 3-5 of CDA (2019a)

[2] Taken from the draft version of the revised Factor of Safety Guideline CDA (2019b)

[3] The long-term loading condition refers to steady-state seepage conditions for normal operation water levels. However, it still applies to Construction, Operation, and Transition Phases (i.e., the long-term loading condition does not imply that the analysis applies to the site abandonment phase).

## 2.4 Seismicity

The CDA (2019a) provide recommended minimum seismic design criteria based on the hazard classification assigned to the structure. Assuming a High hazard classification for all water management infrastructure elements, the CDA (2019a) specifies the design earthquake with an annual exceedance probability (AEP) of 1/2,475-year event for the construction and operations.

Site-specific seismic parameters for the Primary Pond Dam were obtained from the 2020 National Building Code of Canada seismic hazard calculator (NBCC 2022) which provides ground accelerations and probability of occurrences. Table 2 provides seismic hazard values obtained based on the 2020 National Building Code of Canada. Horizontal seismic coefficients used in the slope stability calculations are presented in Table 3. Appendix B presents the methodology for determining horizontal and vertical seismic parameters to be used in pseudo-static slope stability calculations of Primary Pond Dam.

**Table 2: Seismic Hazard Values for Primary Pond Dam Location**[1, 2]

| Probability (% in 50 Years) | Sa(0.2) [g] | Sa(0.5) [g] | Sa(1.0) [g] | Sa(2.0) [g] | Sa(5.0) [g] | Sa(10.0) [g] | PGA [g] |
|---|---|---|---|---|---|---|---|
| 2 | 0.104 | 0.0969 | 0.0517 | 0.0215 | 0.00457 | 0.00141 | 0.0616 |

| Probability (% in 50 Years) | Sa(0.2) [g] | Sa(0.5) [g] | Sa(1.0) [g] | Sa(2.0) [g] | Sa(5.0) [g] | Sa(10.0) [g] | PGA [g] |
|---|---|---|---|---|---|---|---|
| 5 | 0.0555 | 0.0531 | 0.0276 | 0.0109 | 0.00215 | 0.000663 | 0.0312 |
| 10 | 0.0322 | 0.031 | 0.0154 | 0.00572 | 0.00103 | 0.00031 | 0.0173 |

Notes:

[1] NBCC 2022b

[2] All values are presented for Site Class D (Table 4.1.8.4.A. Site Classification for Seismic Site Response)

**Table 3: Horizontal Seismic Coefficient**

| Section | Embankment Height (m) | Horizontal Seismic Coefficient (g) [1,2] | | |
|---|---|---|---|---|
| | | Site Class B[3] | Site Class C[3] | Site Class D[3] |
| (0+240) | 9 | 0.0208 | 0.0217 | 0.0282 |
| B | 7.8 | 0.0220 | 0.0229 | 0.0298 |
| C | 5.3 | 0.0244 | 0.0254 | 0.0331 |
| A | 2.6 | 0.0270 | 0.0282 | 0.0366 |

Notes:

[1] Horizontal seismic coefficient was obtained based on the FHWA 2011 recommendations

[2] Vertical seismic coefficient assumed to be zero (see Appendix B).

[3] All values are presented for three different site classes: B, C, and D. The reference values that were taken for the stability runs are for site class D.

## 2.5 Material Properties

Material properties for the analysis were based on the site-wide geotechnical design properties (SRK 2019), Goose Property – 2018 Overburden Investigation (SRK 2018), and SRK's engineering judgment. The geotechnical material parameters selected for the stability analysis are summarised in Table 4.

Geotechnical design parameters used for the stability runs are summarized in Table 4. The material properties were based on the site-wide geotechnical design properties (SRK 2017, SRK 2019a) as well as SRK's engineering judgment.

The HDPE-geotextile interface was found to be the most critical plane in the upstream stability analyses. Based on published data (Stark *et al*., 1996, Bacas *et al*., 2015, and Howell and Kirsten, 2016) a peak friction angle of 28 degrees was assigned to the interface between a 1.5-mm-thick textured HDPE and a nonwoven geotextile made of needle-punched monofilaments with a mass per unit area of at least 500 g/m$^2$.

Since Primary Pond Dam will be lined with HDPE and base case scenarios were assessed with a liner system assigned an angle shear of resistance of 28 degrees. Additional sensitivity analyses were also performed assuming reduced angle shear of resistance up to 18 degrees.

**Table 4: Summary of Geotechnical Model Parameters**

| Geotechnical Unit | Unit Weight, γ (kN/m³) | Cohesion, c (kPa) | Friction Angle, φ (°) | Strength Type |
|---|---|---|---|---|
| Silty Sand Foundation (Unfrozen) | 19 | 0 | 32 | Mohr-Coulomb |
| Silty Sand Foundation (Frozen) | 19 | 40 | 32 | Mohr-Coulomb |
| HDPE Liner | 10 | 0 | 28 | Mohr-Coulomb |
| Bedrock | 18 | | | Infinite Strength |
| Bedding Material | 18 | 0 | 36 | Mohr-Coulomb |
| Transition Material | 18 | 0 | 36 | Mohr-Coulomb |
| ROQ (Thawed, Unconsolidated) | 20 | 0 | 38 | Mohr-Coulomb |

## 2.6 Modelled Scenarios

Stability analysis models were compiled to evaluate both the upstream and downstream sides of Primary Pond Dam.

Figure 5 in Appendix A presents the cross-sections assuming checking the Upstream and Downstream slopes of the dam, respectively. Four model runs were set up with three conditions for the sand layer: frozen, thawed 2.0 m-layer, and thawed overburden (potential talik zone).

Table 5 provides a summary of the slope stability runs for the Base Cases.

**Table 5: Assessment Scenarios**

| Model Number | Model Case | Assessed Slope | Analysis Type | Model Description |
|---|---|---|---|---|
| 1 | Base case | Upstream | Static | Deterministic, limit equilibrium analysis, with the water level at +313m. HDPE Liner is modeled as a Weak Layer. |
| 2 | Base case | Downstream | Static | Deterministic, limit equilibrium analysis with the water level at +313m. |
| 3 | Base Case | Upstream | Pseudo-Static | Same as Model 1, but pseudo-static analysis type |
| 4 | Base Case | Downstream | Pseudo-Static | Same as Model 2, but with pseudo-static analysis type |
| 5[1] | Sensitivity Case | Upstream | Static | Same as Model 2, but without Goose All-Weather Road and ROQ backfill on the downstream toe |
| 6[1] | Sensitivity Case | Upstream | Static | Same as Model 1, but the angle of shear resistance of the liner is reduced to 25º |
| 7[1] | Sensitivity Case | Upstream | Static | Same as Model 1, but the angle of shear resistance of the liner is reduced to 22º |
| 8[1] | Sensitivity Case | Upstream | Static | Same as Model 1, but the angle of shear resistance of the liner is reduced to 18º |

| | | | | |
|---|---|---|---|---|
| 9[1,2] | Sensitivity Case | Upstream | Rapid Drawdown | Deterministic, limit equilibrium analysis assuming rapid drawdown. |
| 10[1] | Sensitivity Case | Upstream | No Free Water Level | Deterministic, limit equilibrium analysis assuming no free water level from upstream. |

Notes:

[1] Slope stability simulation was performed only for cross-section Sta (0+240).

[2] Assumed full rapid drawdown, undrained behavior of the material modeled using $\overline{B}$=1

# 3 Results

A summary of limit equilibrium analysis runs is provided in the sub-sections below with detailed results in Figures 8–20 in Appendix A.

The calculated FOS for Primary Pond Dam base scenarios described in Section 2.5 are presented in Table 6.

**Table 6: Summary of Base and Sensitivity Cases Results**

| Model Number | Cross-section / Station | Assessed Slope | Analysis Type[4] | FOS[1, 2] | | | | | | | | | $FOS_{MIN}$[5] | Fig.[6] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Frozen Foundation Condition | | | Thawed Foundation Condition | | | Thawed Active Layer Condition | | | | |
| | | | | 0.5 m[3] | 1.0 m[3] | 1.5 m[3] | 0.5 m[3] | 1.0 m[3] | 1.5 m[3] | 0.5 m[3] | 1.0 m[3] | 1.5 m[3] | | |
| 1 | A/ Sta (0+115) | Upstream | Static | 3.0 | 3.1 | 3.2 | 2.3 | 2.4 | 2.4 | - | - | - | 1.5 | 8 |
| 1 | B/ Sta (0+160) | Upstream | Static | 2.7 | 2.6 | 2.6 | 2.4 | 2.4 | 2.4 | - | - | - | 1.5 | 9 |
| 1 | -/ Sta (0+240) | Upstream | Static | 2.9 | 2.9 | 2.9 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 1.5 | 10 |
| 1 | C/ Sta (0+630) | Upstream | Static | 2.7 | 2.7 | 2.7 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 1.5 | 11 |
| 2 | A/ Sta (0+115) | Downstream | Static | 2.0 | 2.1 | 2.4 | 1.8 | 1.8 | 1.8 | 1.8 | 1.7 | 1.8 | 1.5 | 16 |
| 2 | B/ Sta (0+160) | Downstream | Static | 1.9 | 2.0 | 2.0 | 1.9 | 2.0 | 1.9 | - | - | - | 1.5 | 17 |
| 2 | -/ Sta (0+240) | Downstream | Static | 2.0 | 2.0 | 2.0 | 1.9 | 2.0 | 2.0 | 1.9 | 2.0 | 2.0 | 1.5 | 18 |
| 2 | C/ Sta (0+630) | Downstream | Static | 2.0 | 2.0 | 2.1 | 18 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.5 | 19 |
| 3 | A/ Sta (0+115) | Upstream | Pseudo-Static | 2.6 | 2.7 | 2.8 | 2.1 | 2.1 | 2.1 | - | - | - | 1.1 | 8 |
| 3 | B/ Sta (0+160) | Upstream | Pseudo-Static | 2.3 | 2.2 | 2.2 | 2.0 | 2.0 | 2.0 | - | - | - | 1.1 | 9 |
| 3 | -/ Sta (0+240) | Upstream | Pseudo-Static | 2.4 | 2.4 | 2.4 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 1.1 | 10 |
| 3 | C/ Sta (0+630) | Upstream | Pseudo-Static | 2.3 | 2.3 | 2.3 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 1.1 | 11 |
| 4 | A/ Sta (0+115) | Downstream | Pseudo-Static | 1.8 | 2.0 | 2.2 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.1 | 16 |

| Model Number | Cross-section / Station | Assessed Slope | Analysis Type[4] | FOS[1, 2] | | | | | | | | | $\text{FOS}_{\text{MIN}}$[5] | Fig.[6] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Frozen Foundation Condition | | | Thawed Foundation Condition | | | Thawed Active Layer Condition | | | | |
| | | | | 0.5 m[3] | 1.0 m[3] | 1.5 m[3] | 0.5 m[3] | 1.0 m[3] | 1.5 m[3] | 0.5 m[3] | 1.0 m[3] | 1.5 m[3] | | |
| 4 | B/ Sta (0+160) | Downstream | Pseudo-Static | 1.8 | 1.8 | 1.9 | 1.8 | 1.8 | 2.0 | - | - | - | 1.1 | 17 |
| 4 | -/ Sta (0+240) | Downstream | Pseudo-Static | 1.8 | 1.8 | 1.9 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.1 | 18 |
| 4 | C/ Sta (0+630) | Downstream | Pseudo-Static | 1.8 | 1.8 | 1.9 | 1.8 | 1.8 | 2.0 | 1.8 | 1.8 | 1.9 | 1.1 | 19 |
| 5[7] | -/ Sta (0+240) | Downstream | Static | 1.9 | 2.0 | 2.0 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.5 | 20 |
| 6[7] | -/ Sta (0+240) | Upstream | Static | 2.9 | 2.9 | 2.8 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 1.5 | 14 |
| 7[7] | -/ Sta (0+240) | Upstream | Static | 2.8 | 2.8 | 2.9 | 2.8 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 1.5 | 14 |
| 8[7] | -/ Sta (0+240) | Upstream | Static | 2.7 | 2.7 | 2.8 | 2.7 | 2.7 | 2.6 | 2.7 | 2.7 | 2.7 | 1.5 | 14 |
| 9[7] | -/ Sta (0+240) | Upstream | Static | 2.9 | 2.9 | 2.9 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 2.0 | 1.2 to 1.3 | 13 |
| 10[7] | -/ Sta (0+240) | Upstream | Static | 2.9 | 2.9 | 2.9 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 2.4 | 1.5 | 12 |

Notes:

[1] Calculated Factor of Safety

[2] Red numbers indicate values below the Minimum FOS

[3] Minimum failure depth

[4] For the Model Description refer to Table 5

[5] Minimum FOS (see Section 2.3)

[6] Refer to Appendix A

[7] Sensitivity runs are highlighted

# 4 Conclusions and Recommendations

1. The Primary Pond Dam meets all the required minimum slope stability FOS as prescribed by the CDA (2019a). The required factors of safety of 1.5 for Static conditions and 1.1 for Pseudo-Static conditions were exceeded for all analyses conducted for the studied dam.
2. All results presented herein were performed using the Spenser search method, but the stability runs were also performed using the GLE/Morgenstern-Price approach. The obtained results are similar for both methods.
3. Majority of the analyses performed on the upstream slopes indicate that the liner and bedding material interface will likely be the most critical failure path. However, with a liner peak friction angle of 18 degrees (worst scenario out of 28, 25, 22, and 18 degrees), the FOS will still be above recommended 1.5. For frozen foundation conditions, the failure plane did not pass along the liner interface and resulted in the highest FOS on the upstream side.
4. The full rapid drawdown case was studied for the upstream slope. The slope stability results showed that minimum FOS for the cases with frozen overburden foundation increases.

## Attachments:

| | |
|---|---|
| Appendix A | Primary Pond Dam Stability Analysis Summary |
| Appendix B | Horizontal Seismic Parameters |
| Appendix C | Primary Pond Dam Stability Run |

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# Appendix A Primary Pond Dam Stability Analysis Summary

# Appendix B Horizontal Seismic Parameters

# 1 Introduction

Appendix B presents the methodology for determining horizontal and vertical seismic parameters to be used in pseudo-static slope stability calculations of Primary Pond Dam. The parameter values presented herein are site-specific and should not be applied to sites not meeting the criteria described

# 2 Seismic Parameter Calculations

## 2.1 Site Ground Motions

Ground motions for the Site were obtained from the 2020 National Building Code of Canada seismic hazard calculator (NBCC 2022b), using coordinates from the center of the plant site: 65.542°N and -106.427°E. These can be seen in Table 2.1.

**Table 2.1: Site Class D ground motions for an event with 2% probability of exceedance in 50 years**

| Spectral Period (s) or Peak Parameters | Seismic Values (g) |
|---|---|
| 0.2 | 0.104 |
| 0.5 | 0.0969 |
| 1.0 | 0.0517 |
| 2.0 | 0.0215 |
| PGA | 0.0616 |

Source: NBCC 2022

The ground motions provided by the seismic hazard calculator are for soils classified as Site Class D: Stiff soil. Table 2.2 presents all site classes and the properties used to define the different classes.

**Table 2.2: Site Classification for Seismic Site Response**

| Site Class | Ground Profile Name | Average Properties top 30 m | | |
|---|---|---|---|---|
| | | Average Shear Wave Velocity, $\overline{V}_s$(m/s) | Average Standard Penetration Resistance, $\overline{N}_{60}$ | Soil Undrained Shear Strength, $s_u$ |
| A | Hard Rock[2] | $\overline{V}_{s30} > 1500$ | N/A | N/A |
| B | Rock[2] | $760 < \overline{V}_{s30} \leq 1500$ | N/A | N/A |
| C | Very Dense Soil and Soft Rock | $360 < \overline{V}_{s30} \leq 760$ | $\overline{N}_{60} > 50$ | $s_u$ > 100 kPa |

| Site Class | Ground Profile Name | Average Properties top 30 m | | |
|---|---|---|---|---|
| | | **Average Shear Wave Velocity, $\bar{V}_s$(m/s)** | **Average Standard Penetration Resistance, $\bar{N}_{60}$** | **Soil Undrained Shear Strength, $s_u$** |
| D | Stiff Soil | $180 < \bar{V}_{s30} \le 360$ | $15 < \bar{N}_{60} \le 50$ | 50 kPa < $s_u$ ≤ 100 kPa |
| E | Soft Soil | $140 < \bar{V}_{s30} < 180$ | $10 < \bar{N}_{60}$<15 | 40 kPa < $s_u$ < 50 kPa |
| | | Any soil with more than 3 m of soil with the following characteristics:<br>1. Plasticity Index: PI > 20<br>2. Moisture content: w ≥ 40%<br>3. Undrained shear strength: $s_u$ < 25 kPa | | |
| F[1] | Other Soils | $\bar{V}_{s30} \le 140$ | $\bar{N}_{60} < 10$ | $s_u$ ≤ 40kPa |
| | | Other Soils include:<br>1. Liquefiable soils, quick and highly sensitive clays, collapsible weakly cemented soils, and other soils susceptible to failure or collapse under seismic loading.<br>2. Peat and/or highly organic clays greater than 3 m thickness<br>3. Highly plastic clays (PI>75) more than 8 m thick<br>4. Soft to medium stiff clays more than 30 m thick | | |

Source: Adapted from National Building Code of Canada 2020 Table 4.1.8.4.-B (NRCC 2022a)

Notes:

[1] Site-specific evaluation is required.

[2] Site Classes A and B are not to be used if there are more than 3 m of softer materials between the rock and the underside of the footing or mat foundations. If more than 3 m of softer materials exist, the Site Class is determined based on the average properties of the softer materials.

The conversion factor for spectral periods less than or equal to 0.2 s was used to convert the peak ground acceleration (PGA) ground motion to the different site classes.

## 2.2 Horizontal Seismic Parameters

The horizontal seismic parameters were calculated using the Limit Equilibrium Pseudo-Static Stability Analysis method presented in Section 6.2.2 of the LRFD Seismic Analysis and Design of Transportation Geotechnical Features and Structural Foundations, Reference Manual (FHWA 2011).

This analysis determines the horizontal seismic coefficient by reducing the site-adjusted PGA based on slope height and allowable deformation. The method assumes an allowable deformation of 1 to 2 inches (25 to 51 mm) for a seismic factor of safety of 1.1.

As the horizontal seismic parameter is dependent on both slope height and soil properties, it was calculated separately for each cross-section location. The parameter values are discussed in the section below.

## 2.3 Vertical Seismic Parameters

For most earthquakes the horizontal acceleration component is much greater than the vertical acceleration component; therefore, the vertical seismic coefficient is commonly assumed to be zero (Seed and Whitman 1970; FHWA 2011).

However, if a vertical seismic coefficient is specified, a common rule of thumb is that the vertical seismic coefficient is approximately two-thirds of the horizontal seismic coefficient (FHWA 2011, CGS 2006).

# 3 Results

## 3.1 Horizontal Seismic Coefficient

Table 3.1 presents the horizontal seismic coefficient for various embankment heights, assuming non-liquefiable soil. It is assumed that the vertical seismic coefficient at these sites would be zero.

**Table 3.1: Horizontal Seismic Coefficients Assuming Non-liquefiable Soils**

| Embankment Height (m) | Horizontal Seismic Coefficient (g)[1] |
|---|---|
| 2.6 | 0.0366 |
| 5.3 | 0.0331 |
| 7.8 | 0.0298 |
| 9 | 0.0282 |

Notes:

[1] Calculated horizontal seismic coefficient

## 3.2 Primary Pond Dam

Due to the layer of sand (2-9 m thick) underneath the dam the site was determined to be Site Class D. However, a sensitivity analysis was performed to determine the seismic coefficient if the Site Class were B or C. Table 3.2 presents the horizontal seismic coefficient for various wall heights.

**Table 3.2: Horizontal Seismic Coefficients for Primary Pond Dam Sections.**

| Section | Embankment Height (m) | Horizontal Seismic Coefficient (g) | | |
|---|---|---|---|---|
| | | Site Class B | Site Class C | Site Class D[1] |
| A | 2.6 | 0.0270 | 0.0282 | 0.0366 |
| B | 7.8 | 0.0220 | 0.0229 | 0.0298 |
| C | 5.3 | 0.0244 | 0.0254 | 0.0331 |
| Sta (0+240) | 9 | 0.0208 | 0.0217 | 0.0282 |

Notes:

[1] Primary Pond Dan is assumed to be Site Class D.

# 4 References

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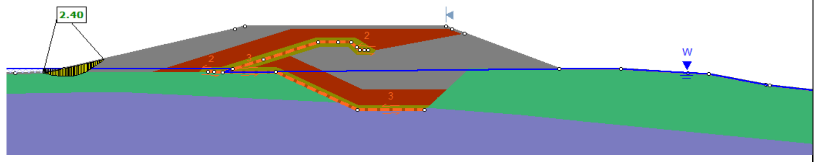
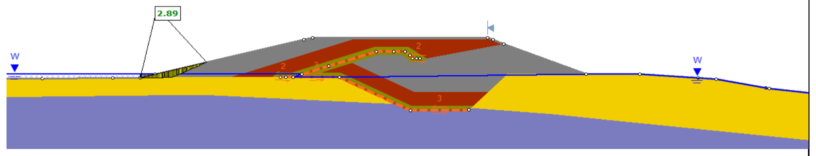
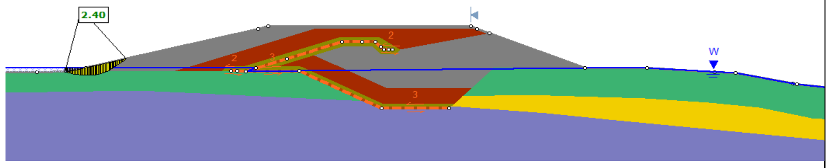
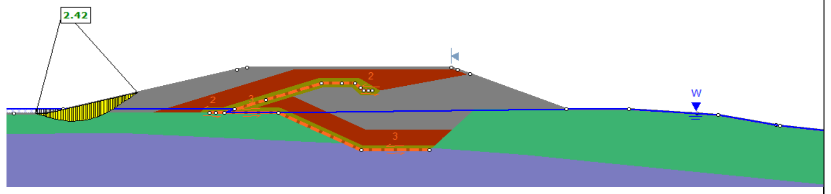
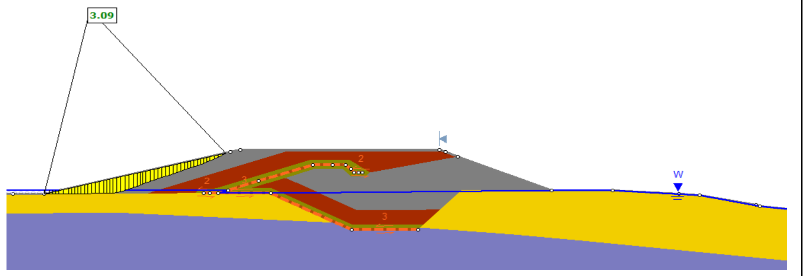
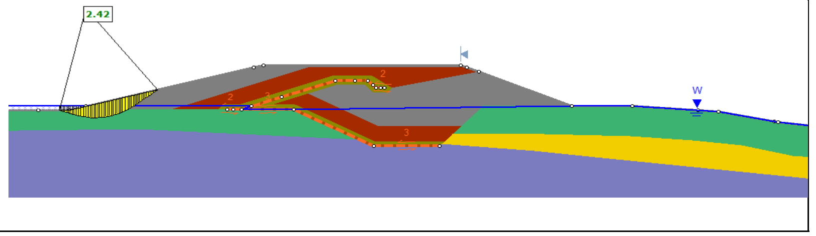
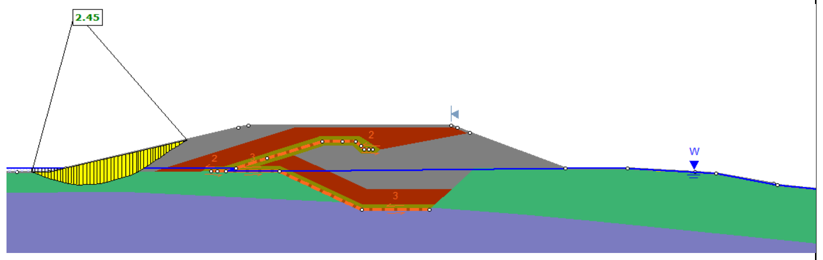
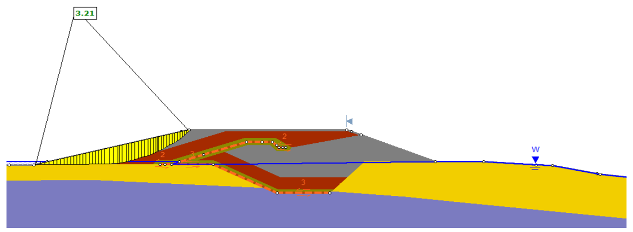
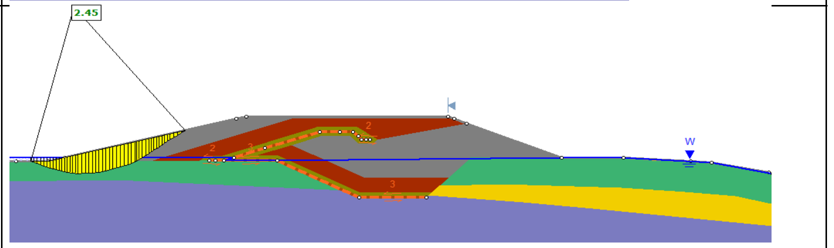
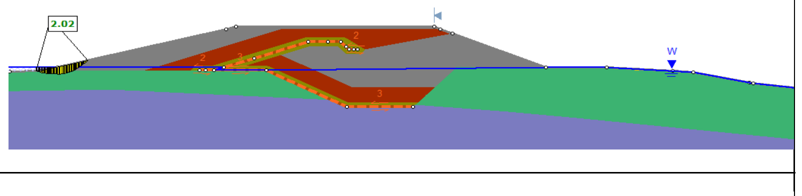
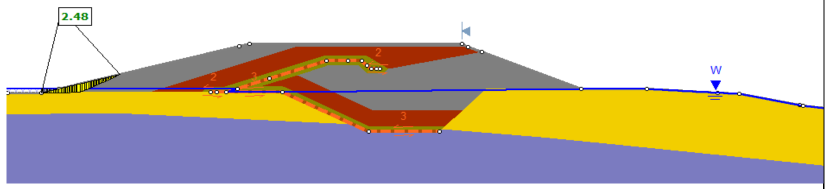
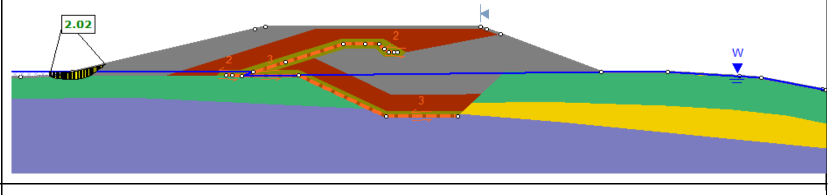
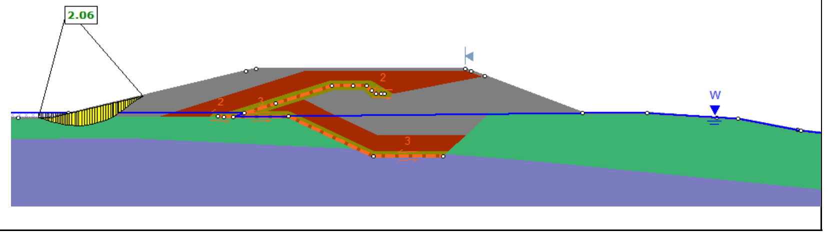
# Appendix C Primary Pond Dam Stability Run

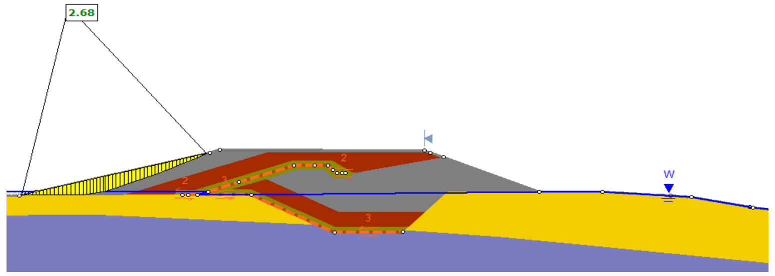
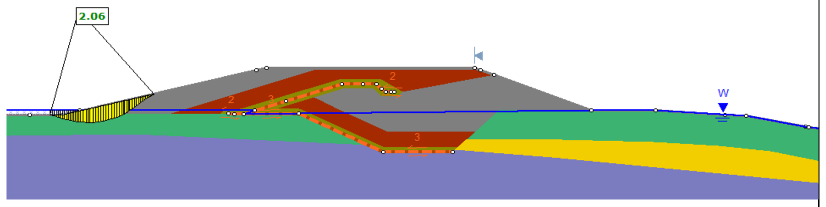
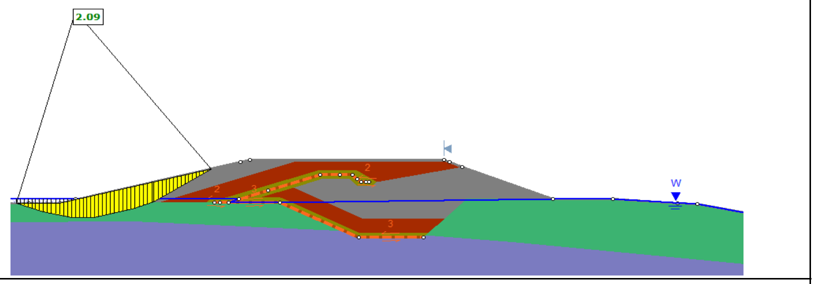
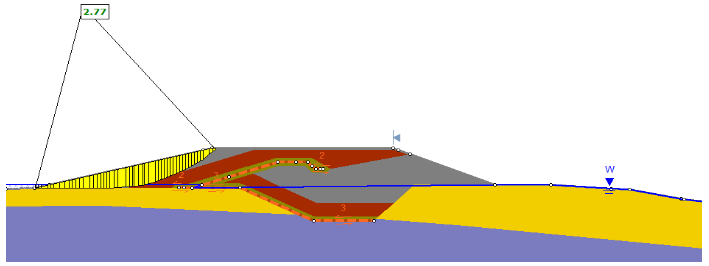
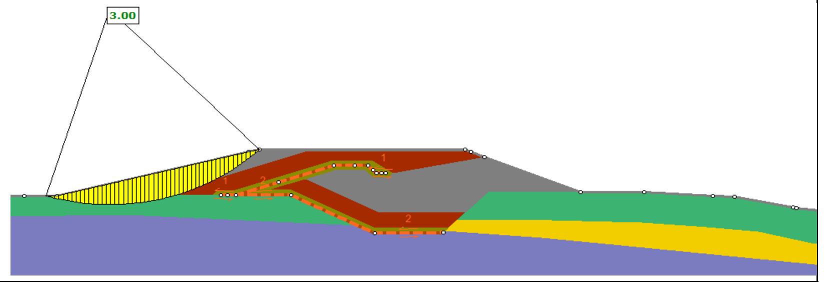
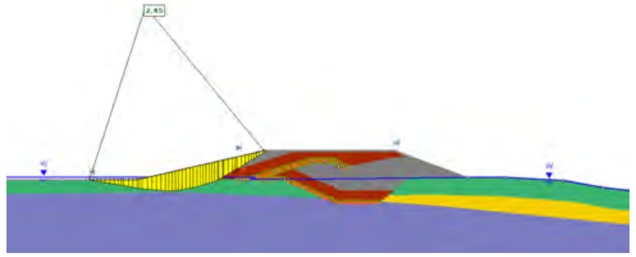
## Results (Base Case Runs)

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimun FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **1.01** | **Section A<br>(0+115)** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.40 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **1.02** | **Section A<br>(0+115)** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.89 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| **1.03** | **Section A<br>(0+115)** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.40 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |
| **1.04** | **Section A<br>(0+115)** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.42 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 1.0m. Thawed Overburden |  |
| **1.05** | **Section A<br>(0+115)** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 3.09 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 1.0m. Frozen Overburden |  |
| **1.06** | **Section A<br>(0+115)** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.42 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 1.0m. Thawed layer thickness is h=2m |  |

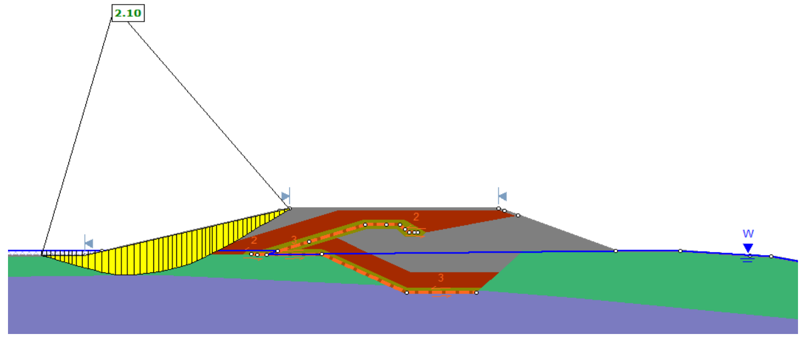
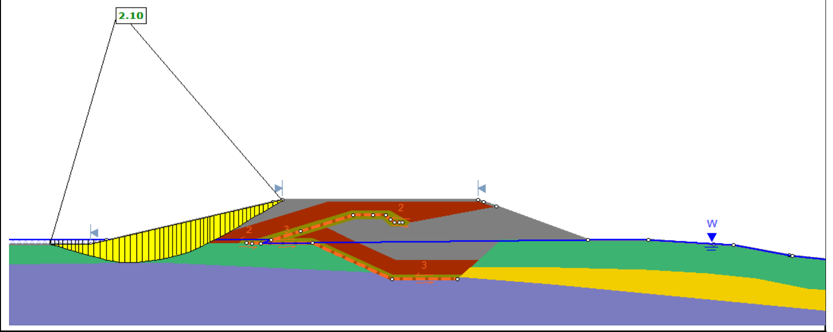
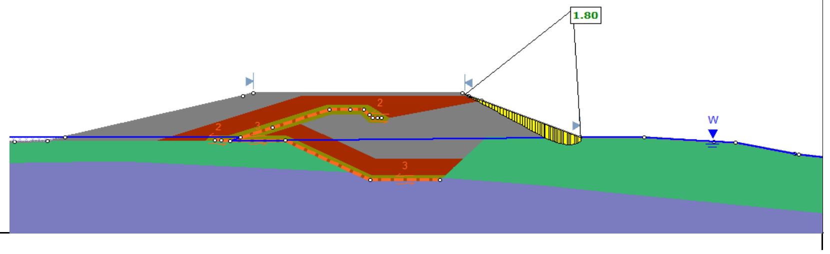
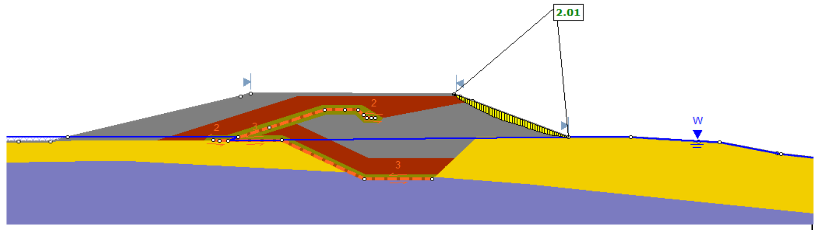
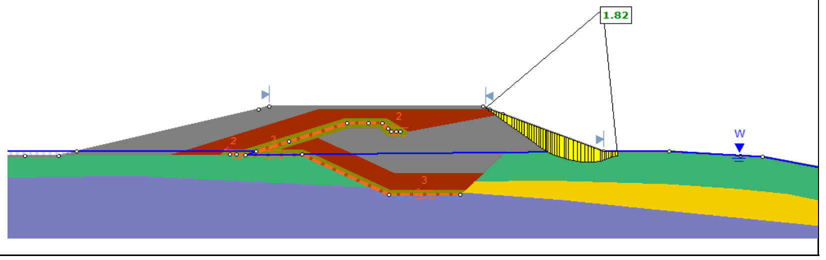
## Results (Base Case Runs)

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimun FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **1.07** | **Section A<br>(0+115)** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.45 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **1.08** | **Section A<br>(0+115)** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 3.21 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |
| **1.09** | **Section A<br>(0+115)** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.45 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |
| **1.10** | **Section A<br>(0+115)** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | Yes ($k_x$=0.0366) | 2.02 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **1.11** | **Section A<br>(0+115)** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | Yes ($k_x$=0.0366) | 2.48 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Frozen overburden. |  |
| **1.12** | **Section A<br>(0+115)** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | Yes ($k_x$=0.0366) | 2.02 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |
| **1.13** | **Section A<br>(0+115)** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | Yes ($k_x$=0.0366) | 2.07 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 1m. Thawed Overburden |  |

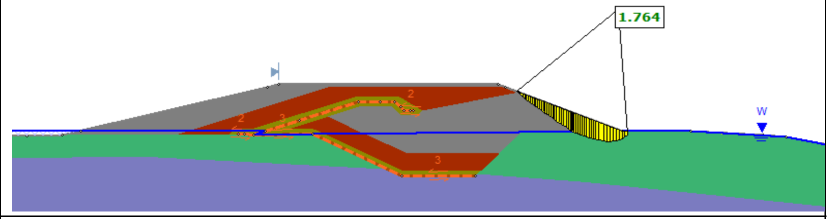
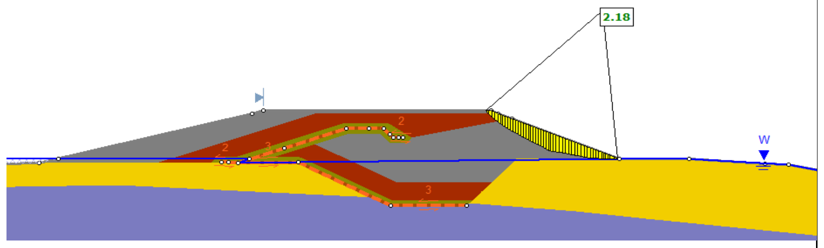
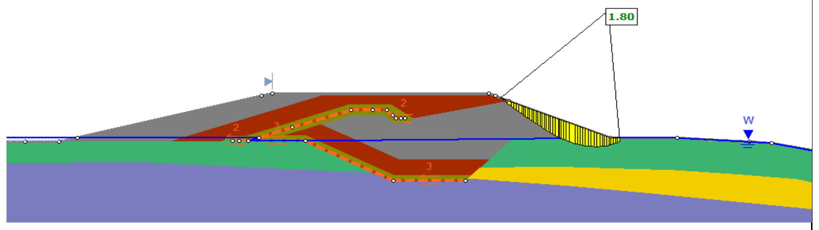
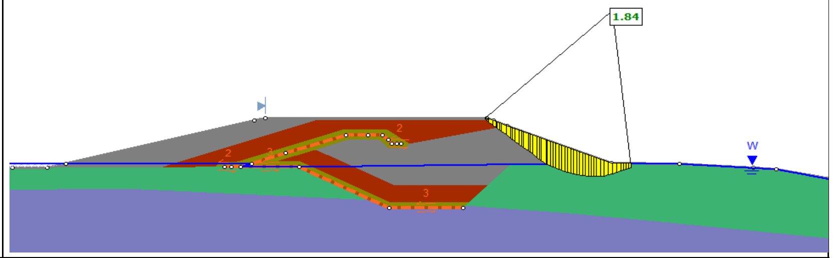
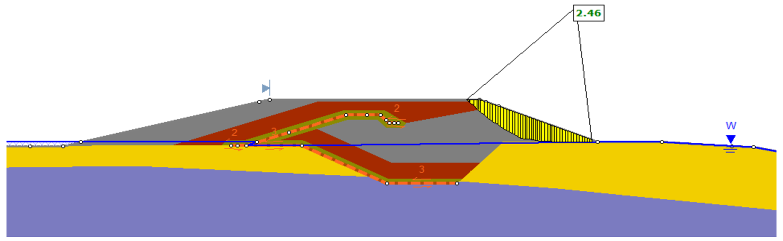
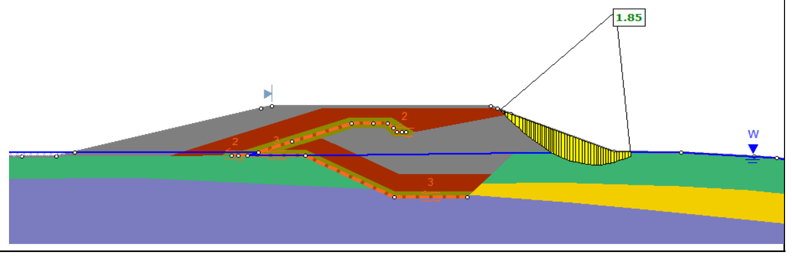
## Results (Base Case Runs)

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimun FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **1.14** | **Section A (0+115)** | **3**<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water level | Yes ($k_x$=0.0366) | 2.68 | Slip surface search from right to left (upstream). Embankment H=2.950m. The minimum depth of the slip surface is 1m. Frozen Overburden |  |
| **1.15** | **Section A (0+115)** | **3**<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water level | Yes ($k_x$=0.0366) | 2.09 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 1.0m. Thawed layer thickness is h=2m |  |
| **1.16** | **Section A (0+115)** | **3**<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water level | Yes ($k_x$=0.0366) | 2.09 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **1.17** | **Section A (0+115)** | **1**<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water level | Yes ($k_x$=0.0366) | 2.77 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |
| **1.18** | **Section A (0+115)** | **4**<br>Base Case (Entry & Exit) | Slide 9.0 | Spencer | Water level | Yes ($k_x$=0.0366) | 3.00 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |
| **1.19** | **Section A (0+115)** | **4**<br>Base Case (Entry & Exit) | Slide 9.0 | Spencer | Water level | No | 2.45 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |

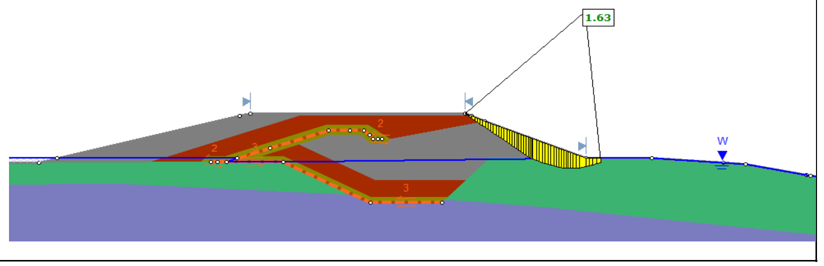
**Results (Base Case Runs)**

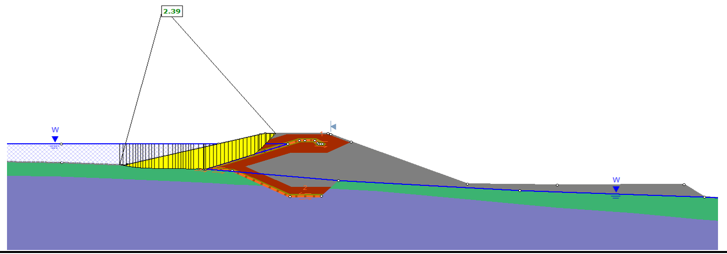
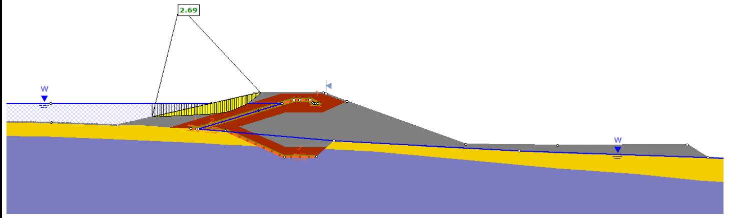
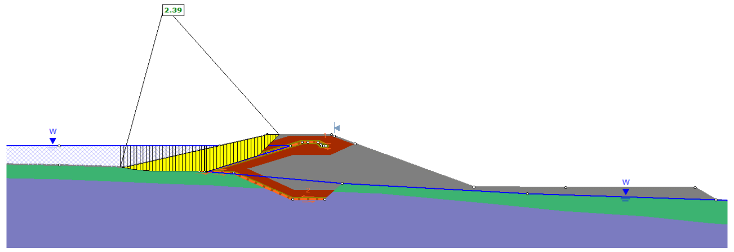
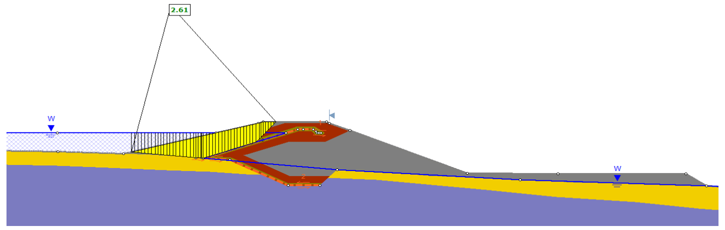
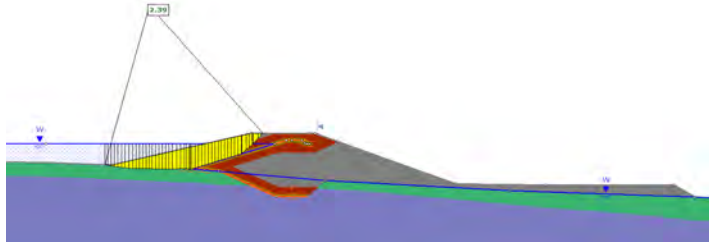
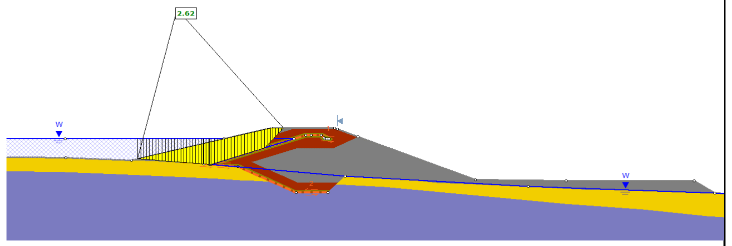
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimun FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **1.20** | **Section A<br>(0+115)** | **4**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water level | Yes ($k_x$=0.0366) | 2.10 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Thawed overburden. |  |
| **1.21** | | **4**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water level | Yes ($k_x$=0.0366) | 2.10 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |
| **1.22** | **Section A<br>(0+115)** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 1.80 | Slip surface search from left to right (downstream). Embankment H=2.7m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **1.23** | **Section A<br>(0+115)** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.01 | Slip surface search from left to right (downstream). Embankment H=2.7m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| **1.24** | **Section A<br>(0+115)** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 1.82 | Slip surface search from left to right (downstream). Embankment H=2.7m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |

## Results (Base Case Runs)

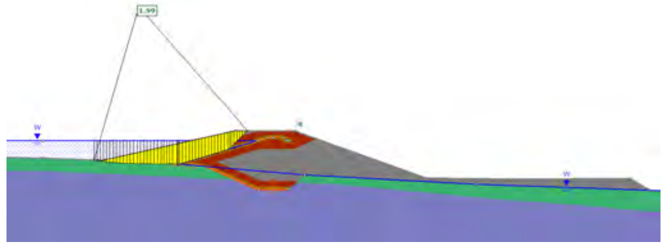
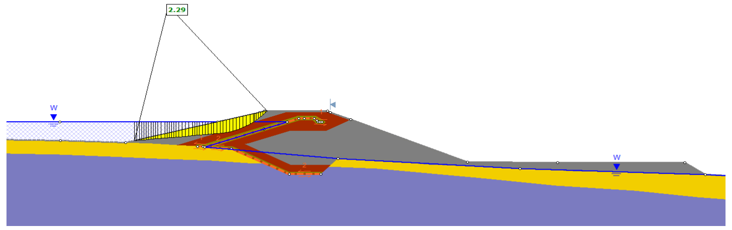
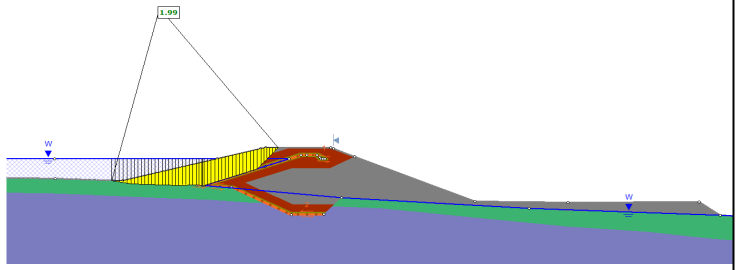
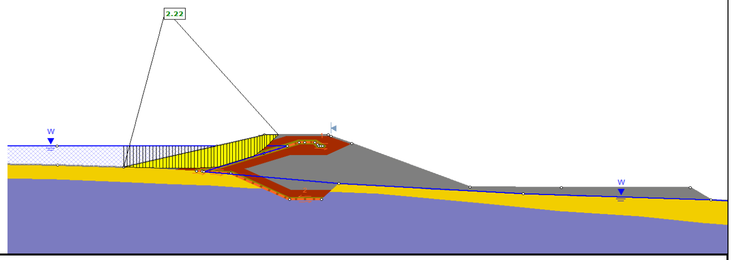
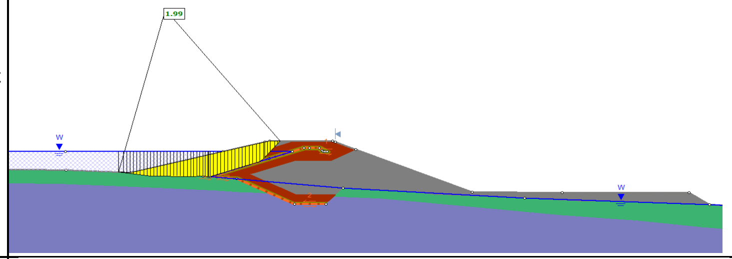
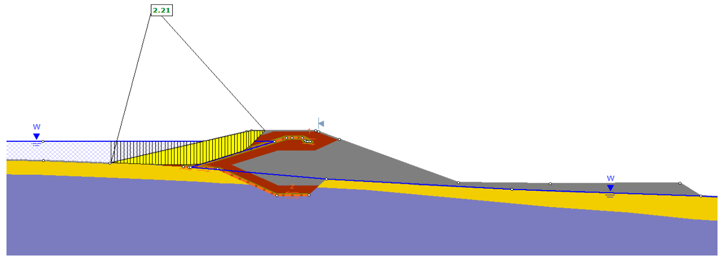
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimun FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **1.25** | **Section A (0+115)** | **2** Base Case (Auto Locate) | Slide 9.0 | Spencer | Water level | No | 1.76 | Slip surface search from left to right (downstream). Embankment H=2.7m. The minimum depth of the slip surface is 1.0m. Thawed Overburden |  |
| **1.26** | **Section A (0+115)** | **2** Base Case (Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.18 | Slip surface search from left to right (downstream). Embankment H=2.696m. The minimum depth of the slip surface is 1.0m. Frozen Overburden |  |
| **1.27** | **Section A (0+115)** | **2** Base Case (Auto Locate) | Slide 9.0 | Spencer | Water level | No | 1.80 | Slip surface search from left to right (downstream). Embankment H=2.7m. The minimum depth of the slip surface is 1m. Thawed layer thickness is h=2m |  |
| **1.28** | **Section A (0+115)** | **2** Base Case (Auto Locate) | Slide 9.0 | Spencer | Water level | No | 1.84 | Slip surface search from left to right (downstream). Embankment H=2.7m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **1.29** | **Section A (0+115)** | **2** Base Case (Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.46 | Slip surface search from left to right (downstream). Embankment H=2.7m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |
| **1.30** | **Section A (0+115)** | **2** Base Case (Auto Locate) | Slide 9.0 | Spencer | Water level | No | 1.85 | Slip surface search from left to right (downstream). Embankment H=2.7m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |

## Results (Base Case Runs)

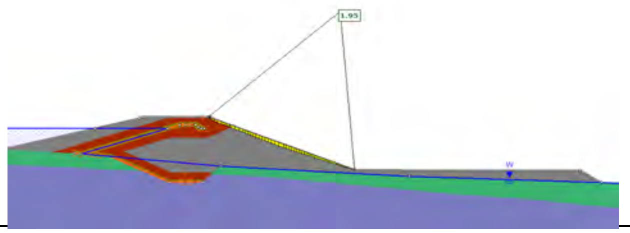
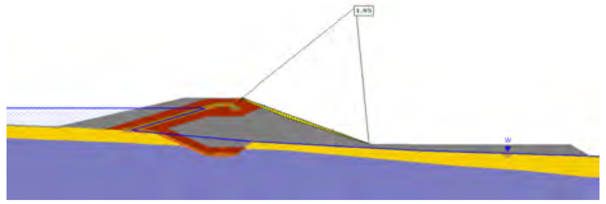
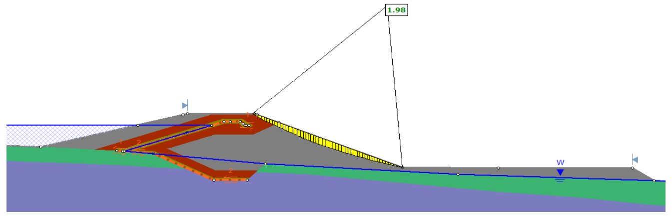
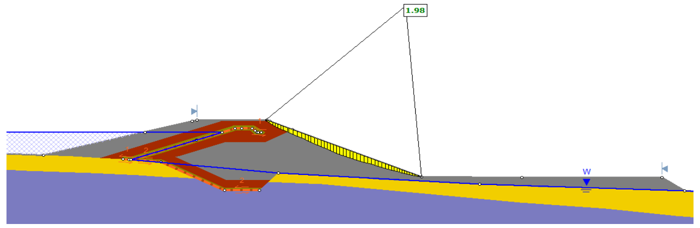
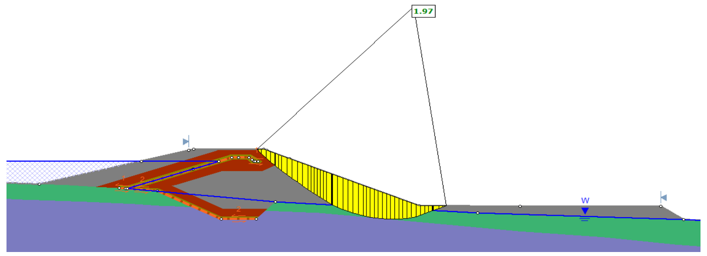
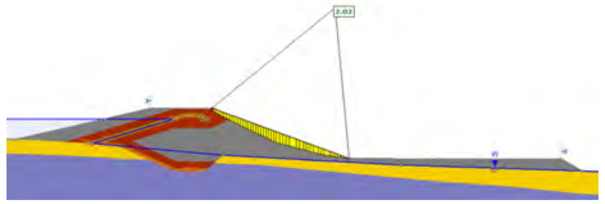
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimun FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **1.31** | **Section A (0+115)** | **1**<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water level | Yes ($k_x$=0.0366) | 1.63 | Slip surface search from left to right (downstream). Embankment H=2.7m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimun FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **2.01** | **0+160** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.39 | Slip surface search from right to left (upstream). Embankment H=4.424m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **2.02** | **0+160** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=4.424m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| **2.03** | **0+160** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.39 | Slip surface search from right to left (upstream). Embankment H=4.424m. The minimum depth of the slip surface is 1m. Thawed Overburden |  |
| **2.04** | **0+160** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.61 | Slip surface search from right to left (upstream). Embankment H=4.424m. The minimum depth of the slip surface is 1m. Frozen Overburden |  |
| **2.05** | **0+160** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.39 | Slip surface search from right to left (upstream). Embankment H=4.424m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **2.06** | **0+160** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.62 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |

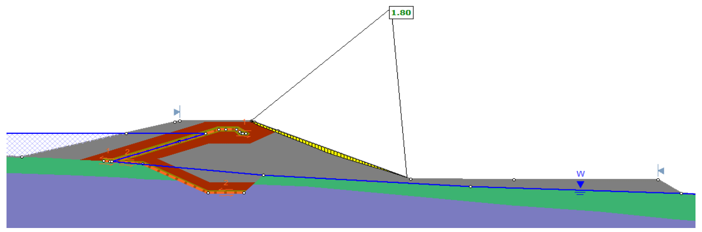
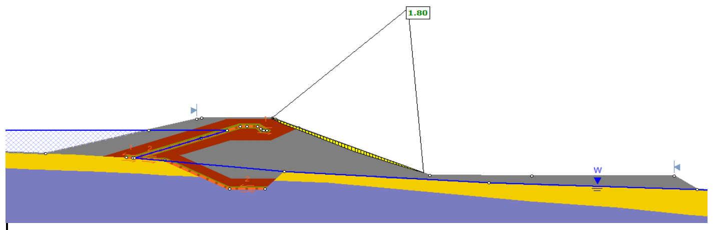
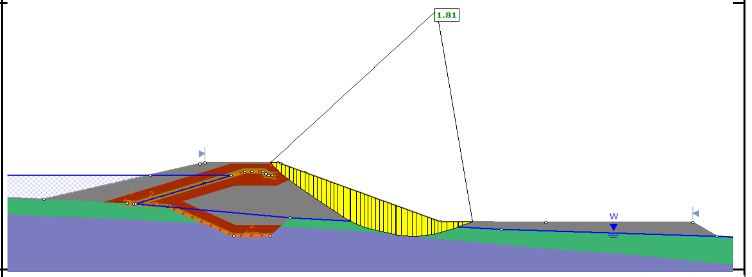
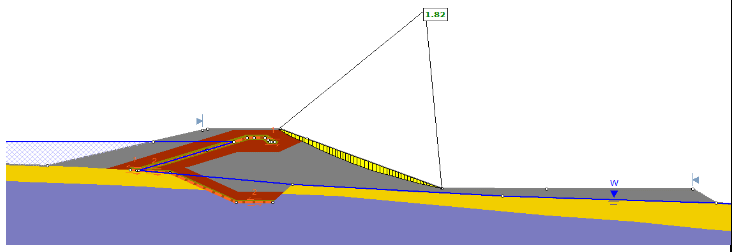
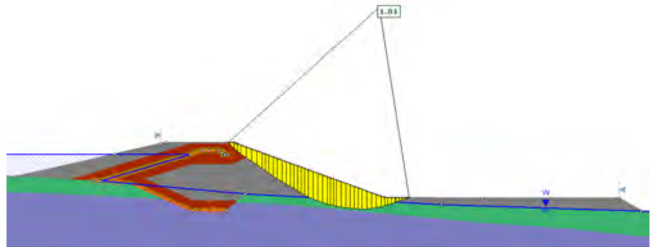
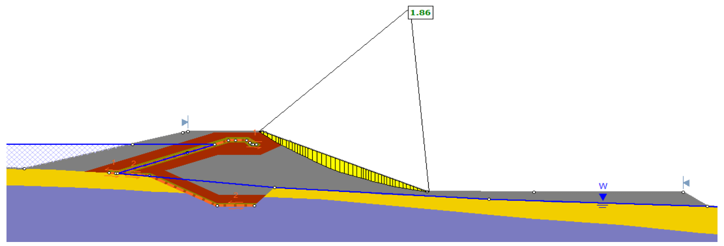
## Results (At Closure Runs)

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimun FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **2.07** | **0+160** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0298) | 1.99 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **2.08** | **0+160** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0298) | 2.29 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| **2.09** | **0+160** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0298) | 1.99 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 1m. Thawed Overburden |  |
| **2.10** | **0+160** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0298) | 2.22 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 1m. Frozen Overburden |  |
| **2.11** | **0+160** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0298) | 1.99 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **2.12** | **0+160** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0298) | 2.21 | Slip surface search from right to left (upstream). Embankment H=4.5mThe minimum depth of the slip surface is 1.5m. Frozen Overburden |  |

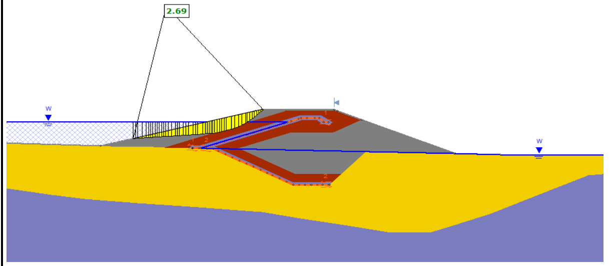
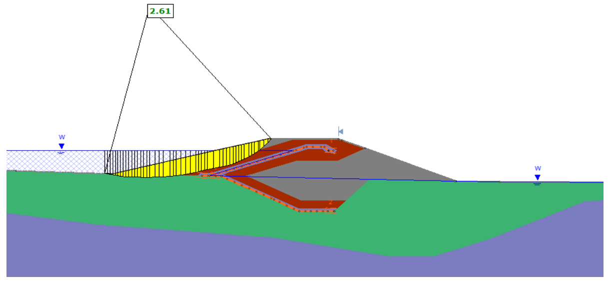
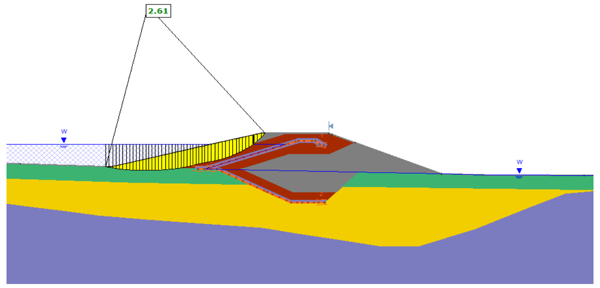
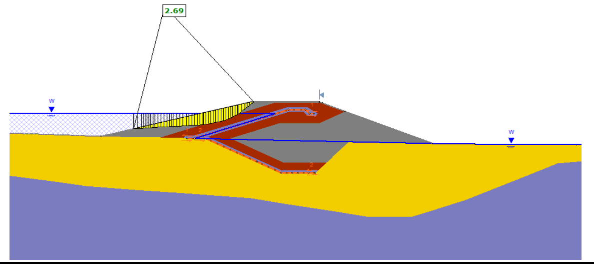
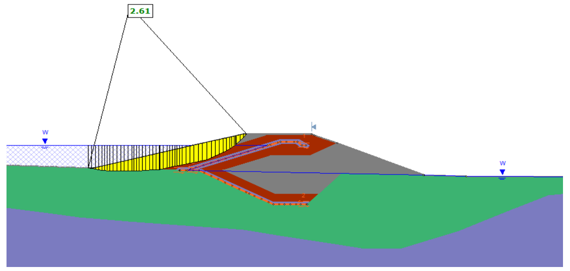
## Results (At Closure Runs)

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimun FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **2.13** | **0+160** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.95 | Slip surface search from left to right (downstream). Embankment H=7.2m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **2.14** | **0+160** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.95 | Slip surface search from left to right (downstream). Embankment H=7.2m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| **2.15** | **0+160** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.1 | Spencer | Water Level | No | 1.98 | Slip surface search from left to right (downstream). Embankment H=7.2m. The minimum depth of the slip surface is 1.0m. Thawed Overburden |  |
| **2.16** | **0+160** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.1 | Spencer | Water Level | No | 1.98 | Slip surface search from left to right (downstream). Embankment H=7.147m. The minimum depth of the slip surface is 1.0m. Frozen Overburden |  |
| **2.17** | **0+160** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.97 | Slip surface search from left to right (downstream). Embankment H=7.147m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **2.18** | **0+160** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.02 | Slip surface search from left to right (downstream). Embankment H=7.2m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |

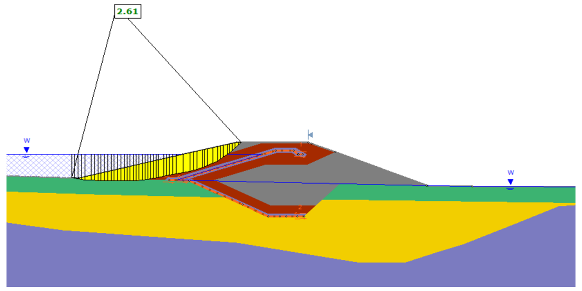
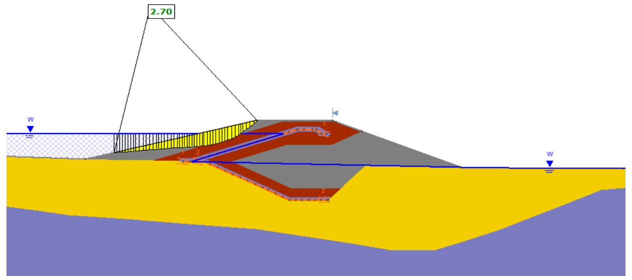
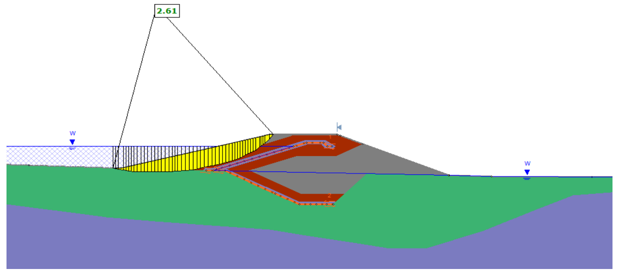
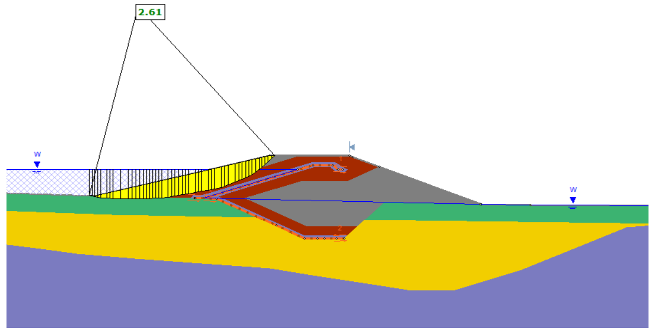
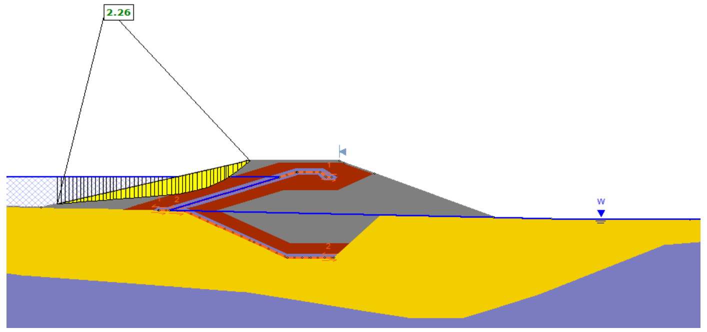
## Results (At Closure Runs)

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimun FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| 2.19 | 0+160 | 4<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0298) | 1.80 | Slip surface search from left to right (downstream). Embankment H=7.2m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| 2.20 | 0+160 | 4<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0298) | 2.80 | Slip surface search from left to right (downstream). Embankment H=7.2m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| 2.21 | 0+160 | 4<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0298) | 2.81 | Slip surface search from left to right (downstream). Embankment H=7.2m. The minimum depth of the slip surface is 1.0m. Thawed Overburden |  |
| 2.22 | 0+160 | 4<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0298) | 2.82 | Slip surface search from left to right (downstream). Embankment H=7.2m. The minimum depth of the slip surface is 1.0m. Frozen Overburden |  |
| 2.23 | 0+160 | 4<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0298) | 1.81 | Slip surface search from left to right (downstream). Embankment H=7.2m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| 2.24 | 0+160 | 4<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0298) | 1.86 | Slip surface search from left to right (downstream). Embankment H=7.2m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |

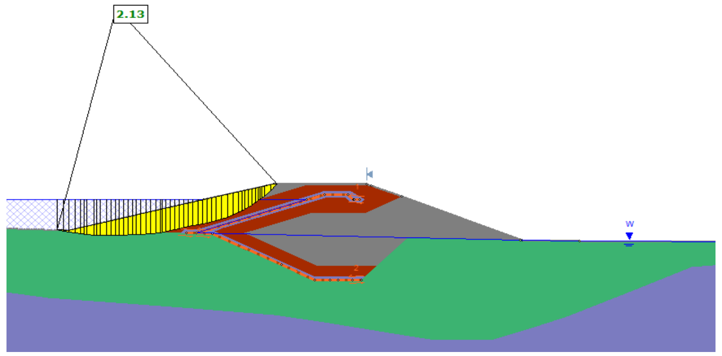
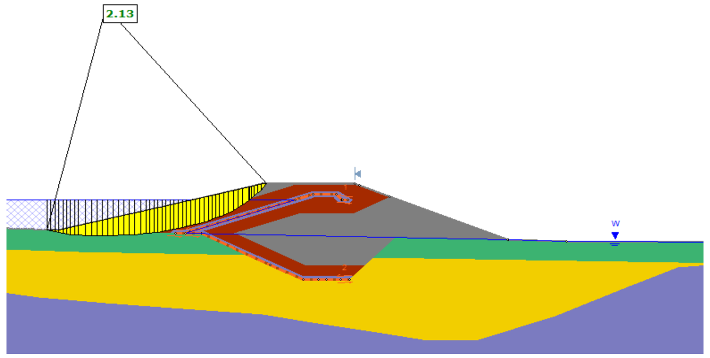
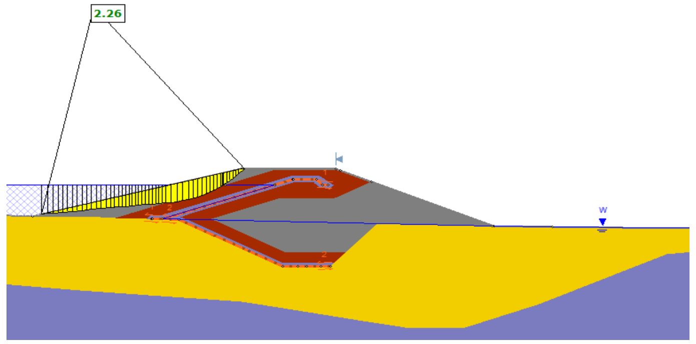
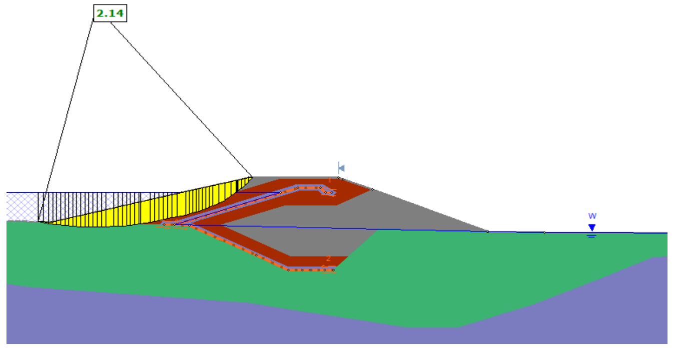
## Results (Shear Strength Reduction Runs)

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **3.01** | **0+630** | **1**<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| **3.02** | **0+630** | **1**<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.61 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **3.03** | **0+630** | **1**<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.61 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |
| **3.04** | **0+630** | **1**<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=4.387m. The minimum depth of the slip surface is 1.0 m. Frozen Overburden |  |
| **3.05** | **0+630** | **1**<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.61 | Slip surface search from right to left (upstream). Embankment H=4.387m. The minimum depth of the slip surface is 1.0 m. Thawed Overburden |  |

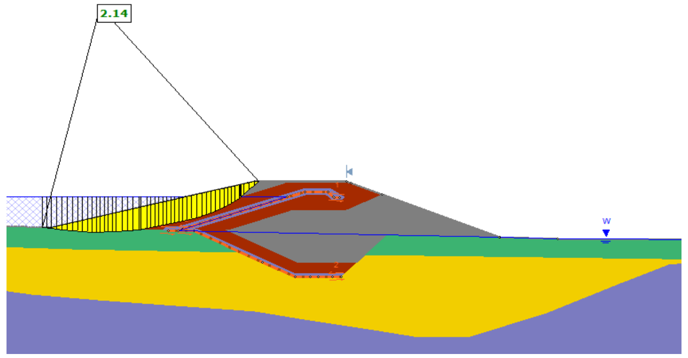
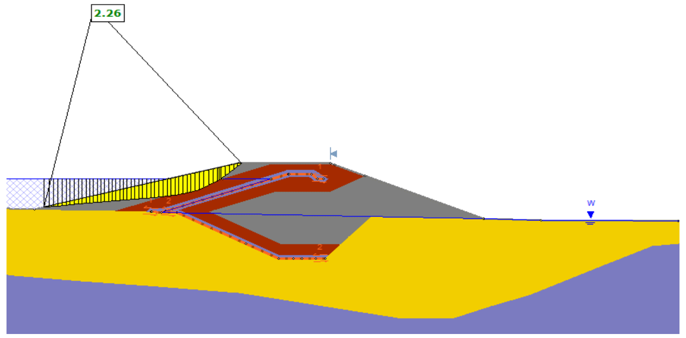
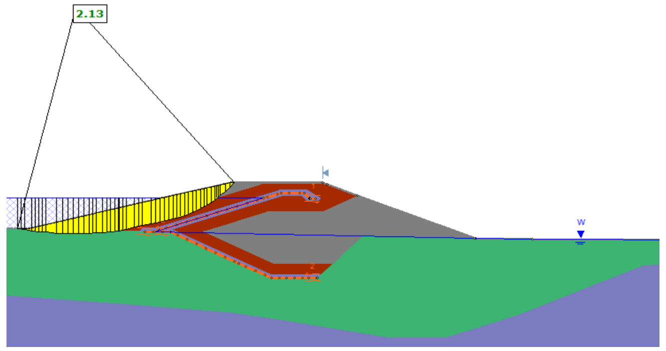
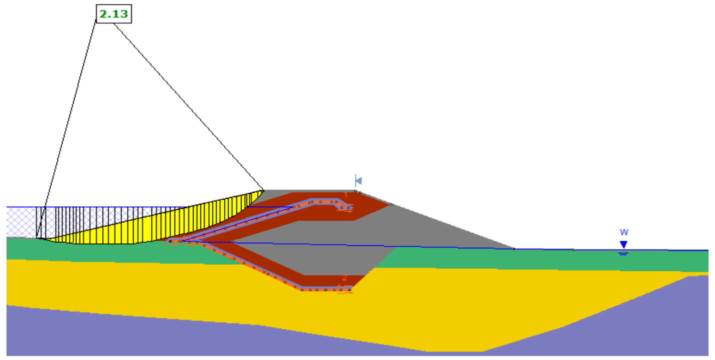
## Results (Shear Strength Reduction Runs)

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **3.06** | **0+630** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.61 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 1.0 m. Thawed layer thickness is h=2m |  |
| **3.07** | **0+630** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.70 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 1.5 m. Frozen Overburden |  |
| **3.08** | **0+630** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.61 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 1.5 m. Thawed Overburden |  |
| **3.09** | **0+630** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.61 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 1.5 m. Thawed layer thickness is h=2m |  |
| **3.10** | **0+630** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 2.26 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |

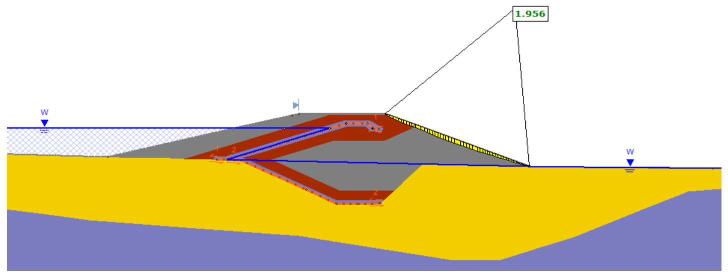
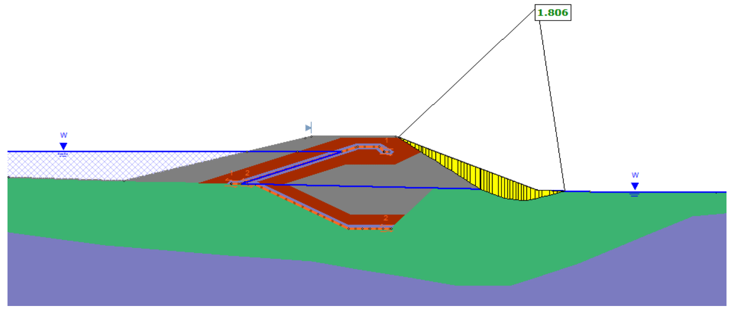
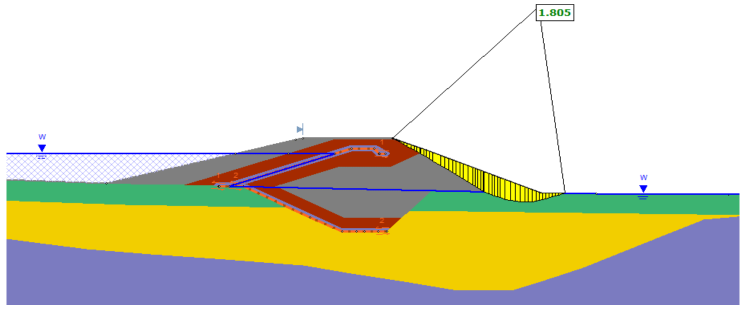
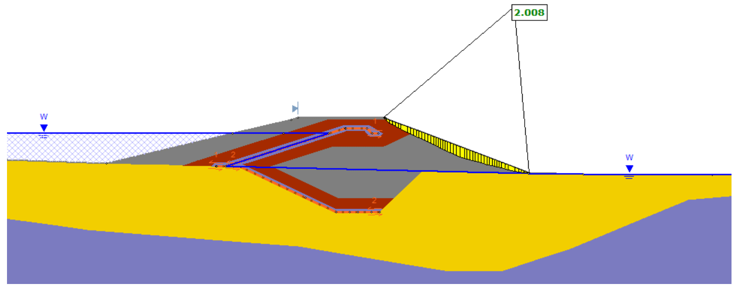
## Results (Shear Strength Reduction Runs)

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **3.11** | **0+630** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 2.13 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **3.12** | **0+630** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 2.13 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |
| **3.13** | **0+630** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 2.26 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 1.0 m. Frozen Overburden |  |
| **3.14** | **0+630** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 2.14 | Slip surface search from right to left (upstream). Embankment H=4.387m. The minimum depth of the slip surface is 1.0 m. Thawed Overburden |  |

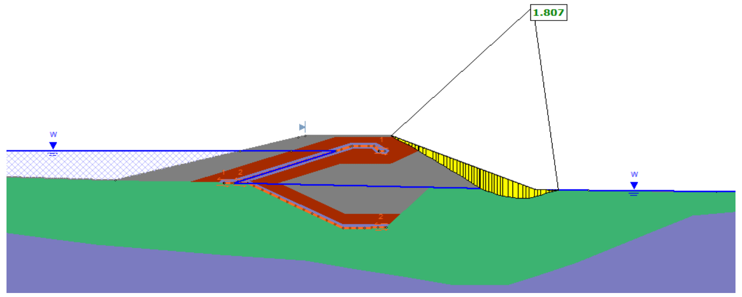
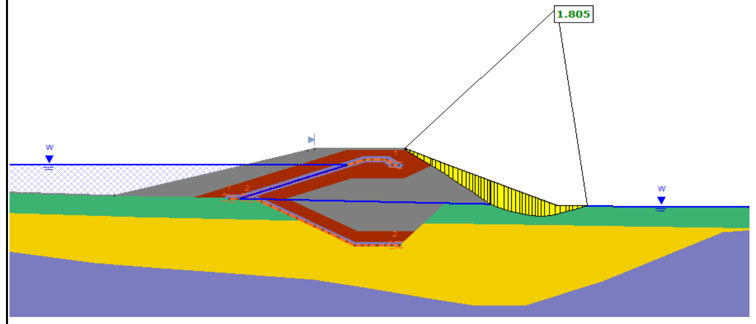
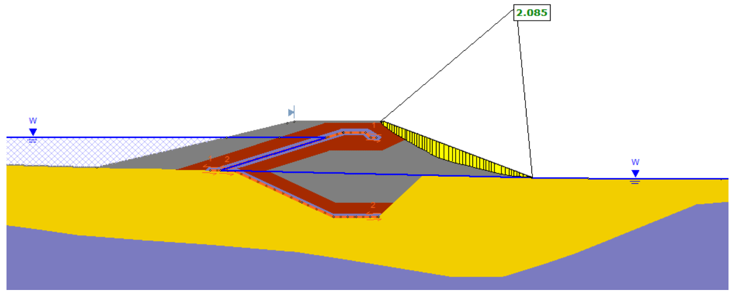
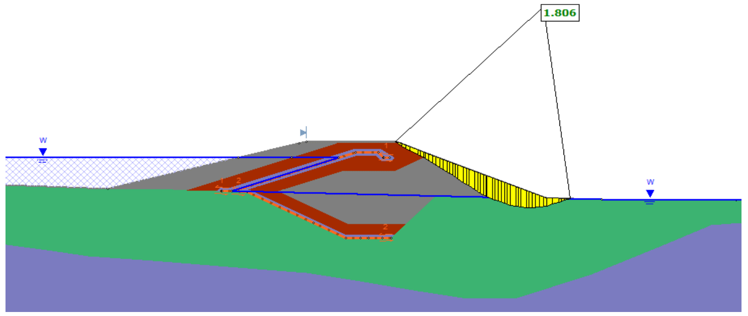
## Results (Shear Strength Reduction Runs)

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **3.15** | **0+630** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 2.14 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 1.0 m. Thawed layer thickness is h=2m |  |
| **3.16** | **0+630** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 2.26 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 1.5 m. Frozen Overburden |  |
| **3.17** | **0+630** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 2.13 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 1.5 m. Thawed Overburden |  |
| **3.18** | **0+630** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 2.13 | Slip surface search from right to left (upstream). Embankment H=4.5m. The minimum depth of the slip surface is 1.5 m. Thawed layer thickness is h=2m |  |

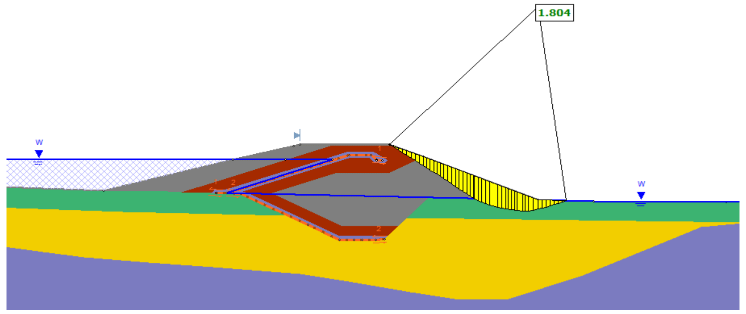
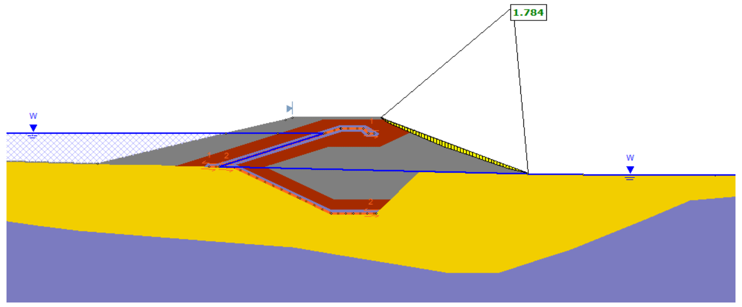
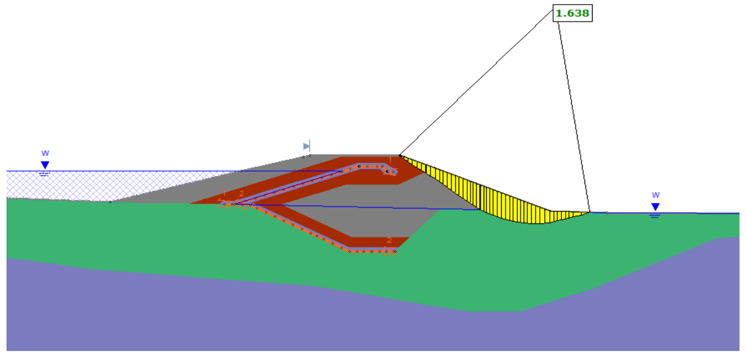
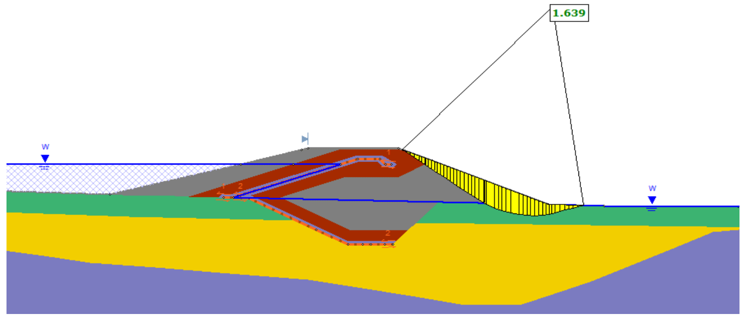
## Results (Shear Strength Reduction Runs)

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments |
|---|---|---|---|---|---|---|---|---|
| **3.19** | **0+630** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.96 | Slip surface search from left to right (downstream). Embankment H=5.3m. The minimum depth of the slip surface is 0.5m. Frozen Overburden  |
| **3.20** | **0+630** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.81 | Slip surface search from left to right (downstream). Embankment H=5.298m. The minimum depth of the slip surface is 0.5m. Thawed Overburden  |
| **3.21** | **0+630** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.81 | Slip surface search from left to right (downstream). Embankment H=5.298m. The minimum depth of the slip surface is 0.5 m. Thawed layer thickness is h=2m  |
| **3.22** | **0+630** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.01 | Slip surface search from left to right (downstream). Embankment H=5.298m. The minimum depth of the slip surface is 1.0m. Frozen Overburden  |

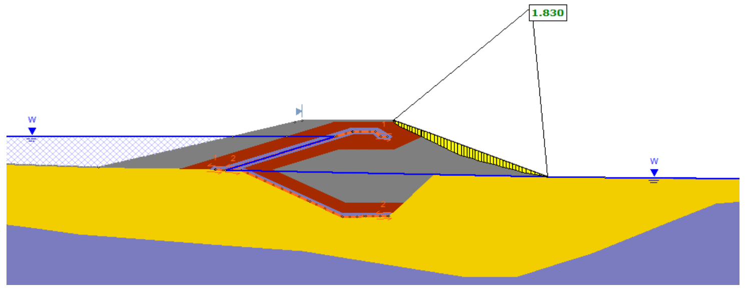
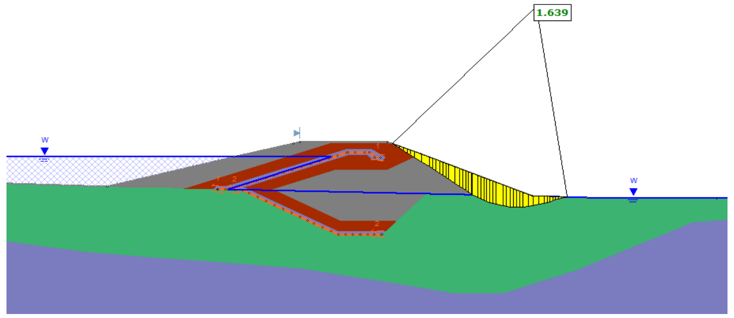
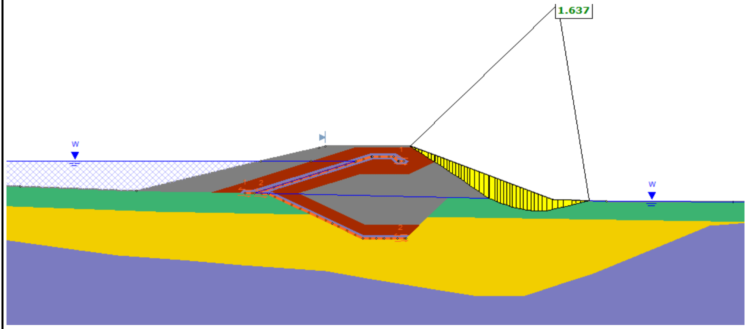
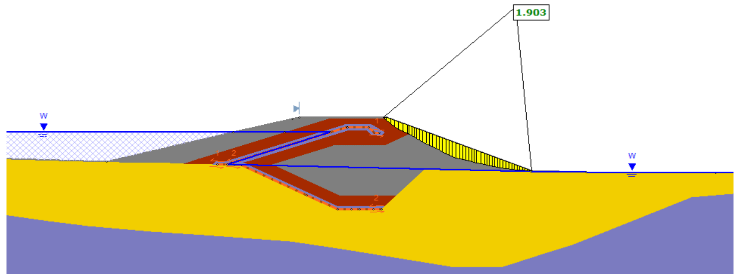
## Results (Shear Strength Reduction Runs)

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments |
|---|---|---|---|---|---|---|---|---|
| 3.23 | 0+630 | 2<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.81 | Slip surface search from left to right (downstream). Embankment H=53m. The minimum depth of the slip surface is 1.0m. Thawed Overburden  |
| 3.24 | 0+630 | 2<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.81 | Slip surface search from left to right (downstream). Embankment H=5.3m. The minimum depth of the slip surface is 1.0 m. Thawed layer thickness is h=2m  |
| 3.25 | 0+630 | 2<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.09 | Slip surface search from left to right (downstream). Embankment H=5.3m. The minimum depth of the slip surface is 1.5m. Frozen Overburden  |
| 3.26 | 0+630 | 2<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.81 | Slip surface search from left to right (downstream). Embankment H=5.3m. The minimum depth of the slip surface is 1.5m. Thawed Overburden  |

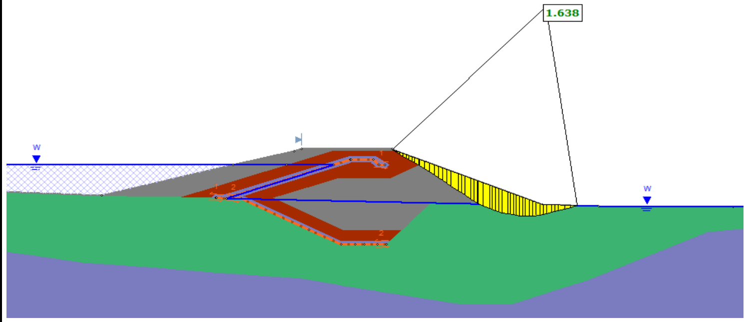
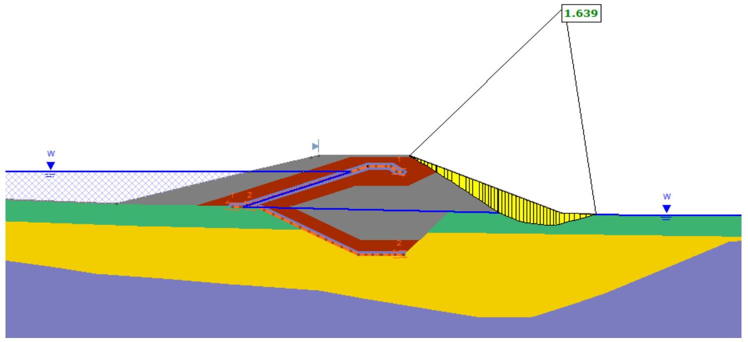
## Results (Shear Strength Reduction Runs)

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments |
|---|---|---|---|---|---|---|---|---|
| 3.27 | 0+630 | 2<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.80 | Slip surface search from left to right (downstream). Embankment H=5.3m. The minimum depth of the slip surface is 1.5 m. Thawed layer thickness is h=2m  |
| 3.28 | 0+630 | 4<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 1.78 | Slip surface search from left to right (downstream). Embankment H=5.3m. The minimum depth of the slip surface is 0.5m. Frozen Overburden  |
| 3.29 | 0+630 | 4<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 1.64 | Slip surface search from left to right (downstream). Embankment H=5.298m. The minimum depth of the slip surface is 0.5m. Thawed Overburden  |
| 3.30 | 0+630 | 4<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 1.64 | Slip surface search from left to right (downstream). Embankment H=5.298m. The minimum depth of the slip surface is 0.5 m. Thawed layer thickness is h=2m  |

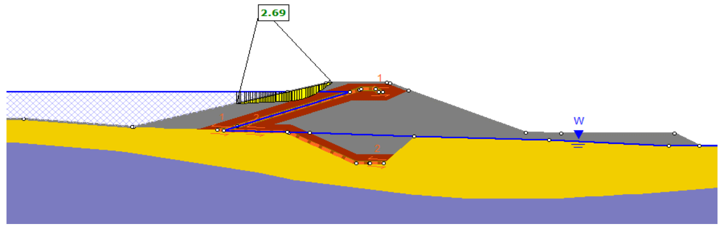
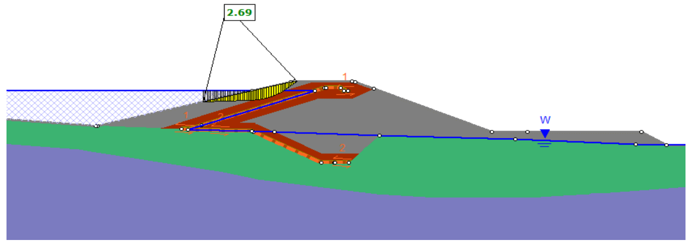
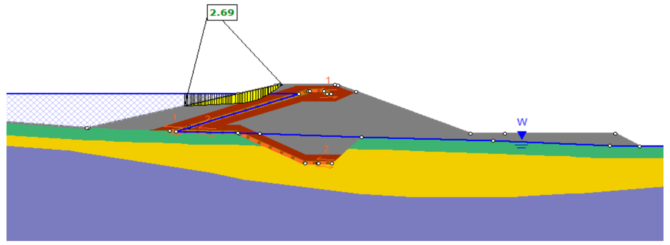
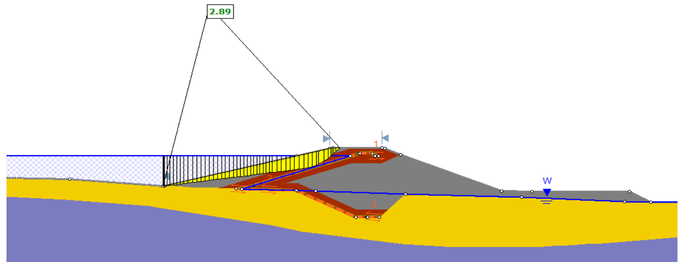
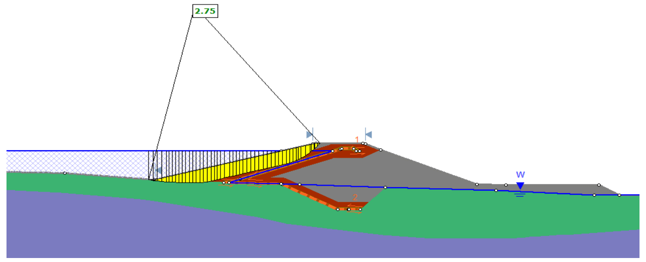
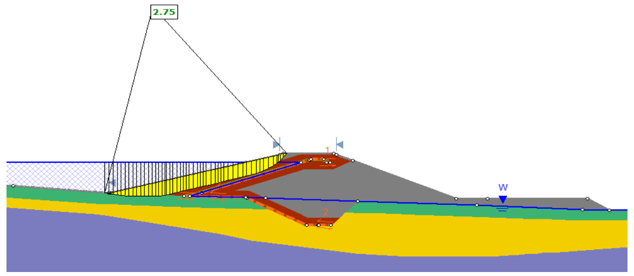
## Results (Shear Strength Reduction Runs)

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments |
|---|---|---|---|---|---|---|---|---|
| 3.31 | 0+630 | **4**<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 1.83 | Slip surface search from left to right (downstream). Embankment H=5.3m. The minimum depth of the slip surface is 1.0m. Frozen Overburden  |
| 3.32 | 0+630 | **4**<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 1.64 | Slip surface search from left to right (downstream). Embankment H=5.3m. The minimum depth of the slip surface is 1.0m. Thawed Overburden  |
| 3.33 | 0+630 | **4**<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 1.64 | Slip surface search from left to right (downstream). Embankment H=5.298m. The minimum depth of the slip surface is 1.0 m. Thawed layer thickness is h=2m  |
| 3.34 | 0+630 | **4**<br>Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 1.90 | Slip surface search from left to right (downstream). Embankment H=5.298m. The minimum depth of the slip surface is 1.5m. Frozen Overburden  |

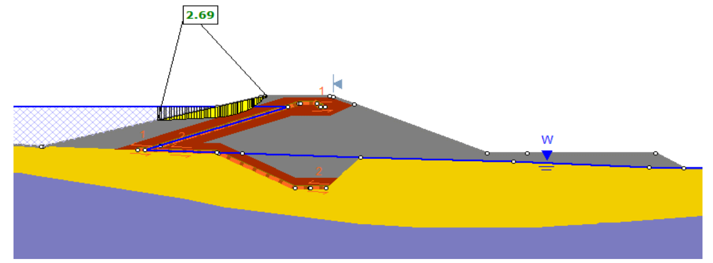
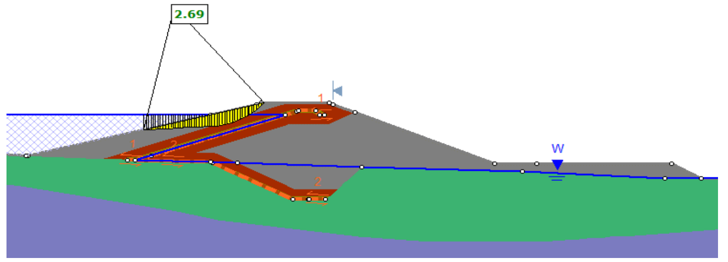
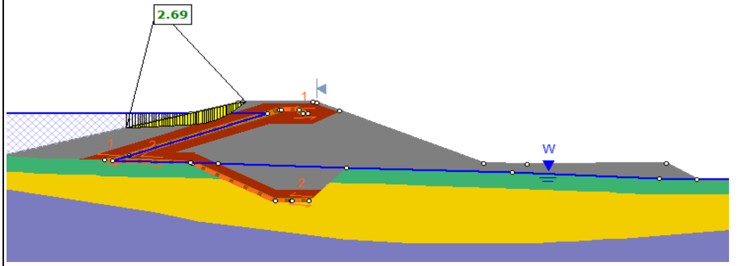
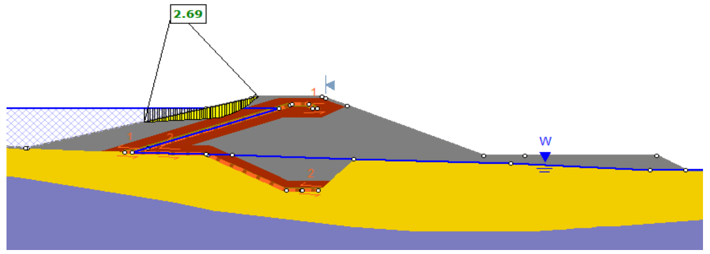
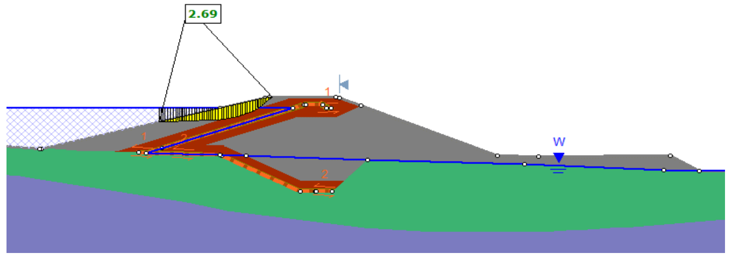
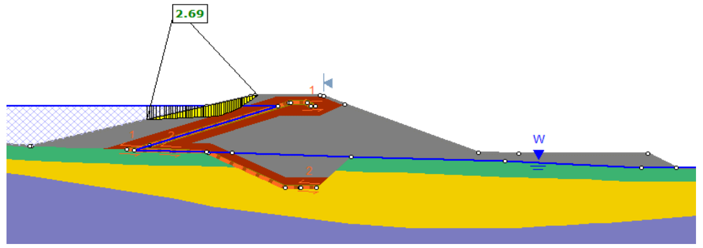
## Results (Shear Strength Reduction Runs)

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **3.35** | **0+630** | **4**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 1.64 | Slip surface search from left to right (downstream). Embankment H=5.3m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **3.36** | **0+630** | **4**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0331) | 1.64 | Slip surface search from left to right (downstream). Embankment H=5.3m. The minimum depth of the slip surface is 1.5 m. Thawed layer thickness is h=2m |  |

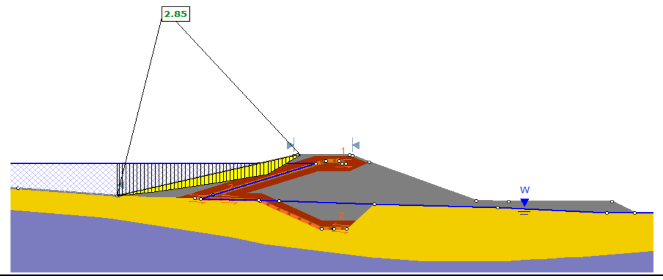
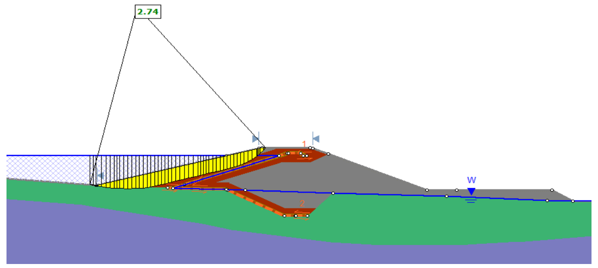
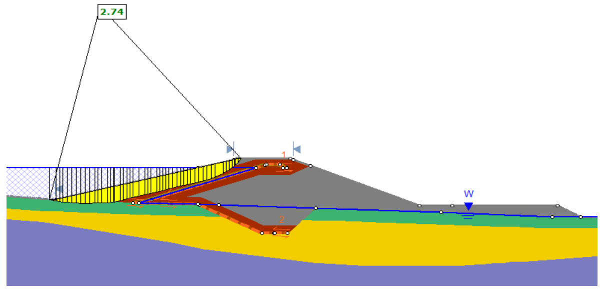
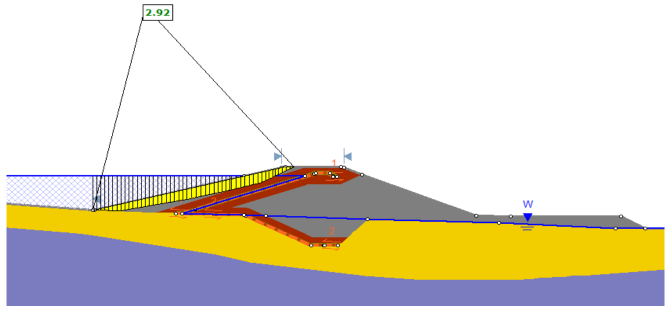
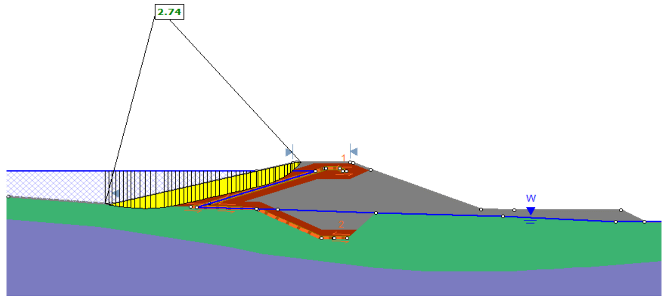
## Results (Shear Strength Reduction Runs)

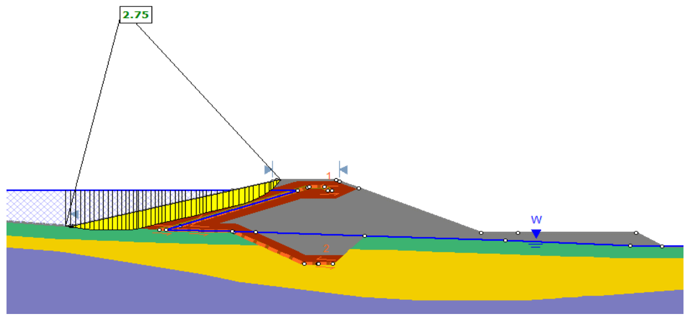
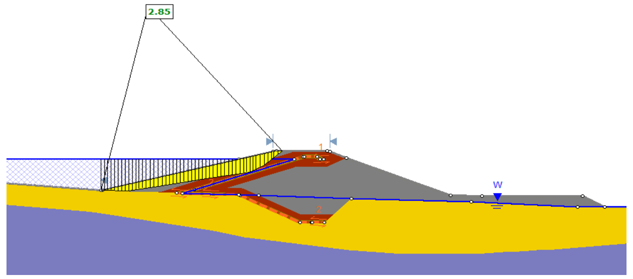
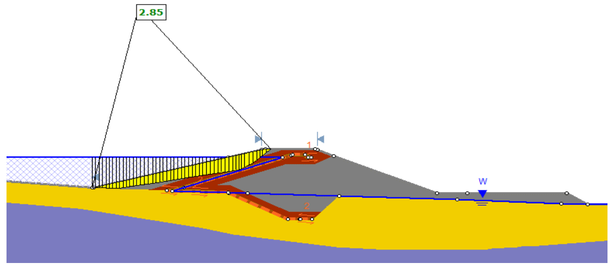
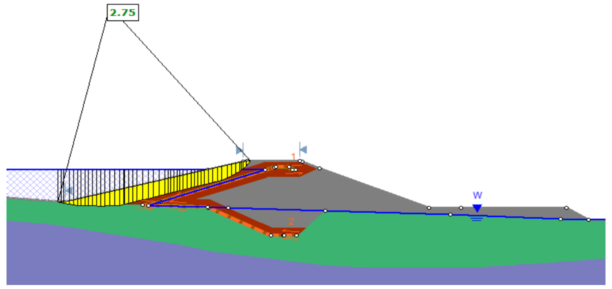
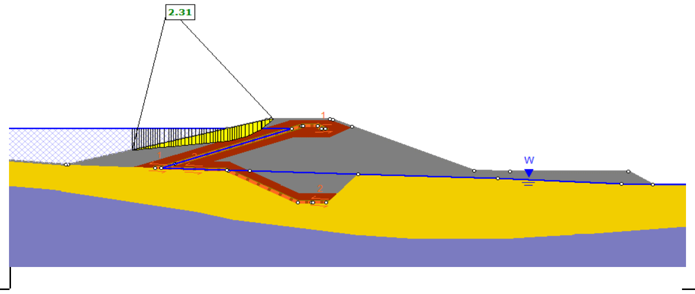
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum F)S | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| 4.01 | 0+240 | 1<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| 4.02 | 0+240 | 1<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| 4.03 | 0+240 | 1<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |
| 4.04 | 0+240 | 1<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.89 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| 4.05 | 0+240 | 1<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| 4.06 | 0+240 | 1<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |

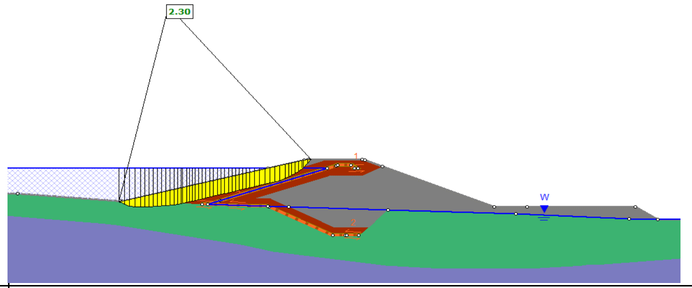
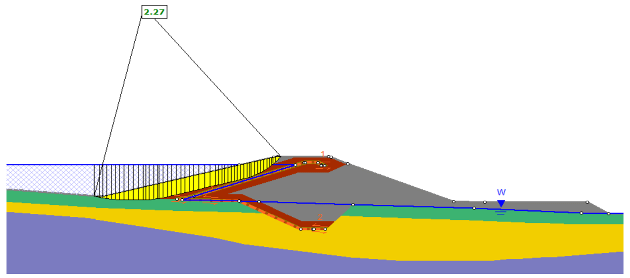
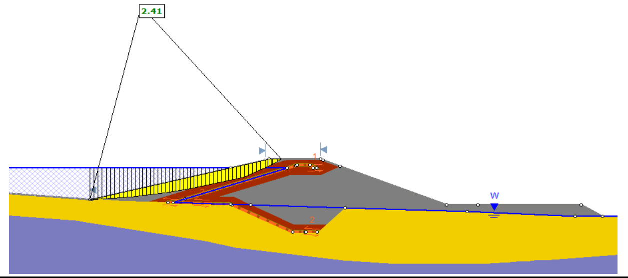
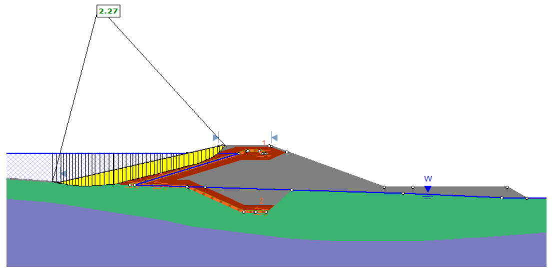
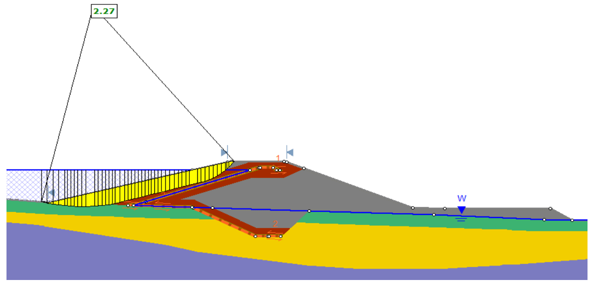
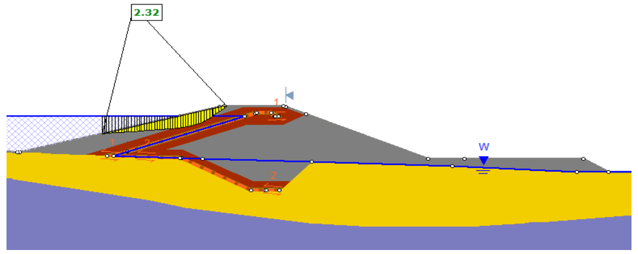
## Results (Shear Strength Reduction Runs)

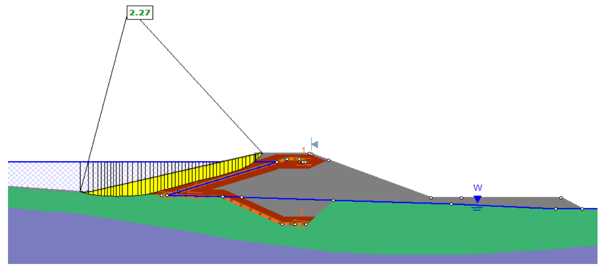
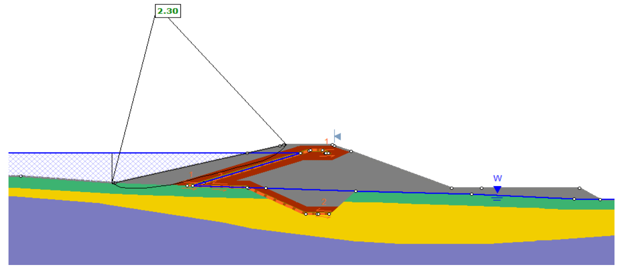
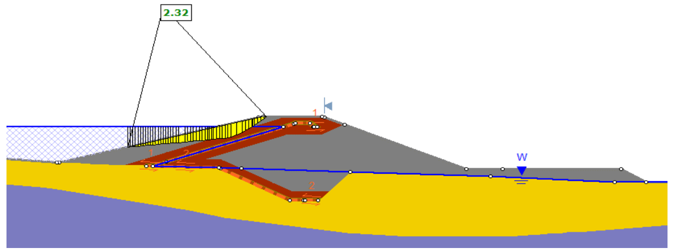
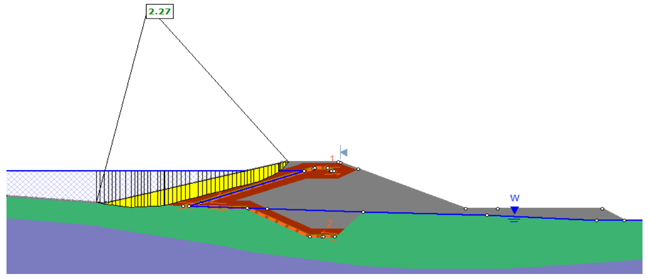
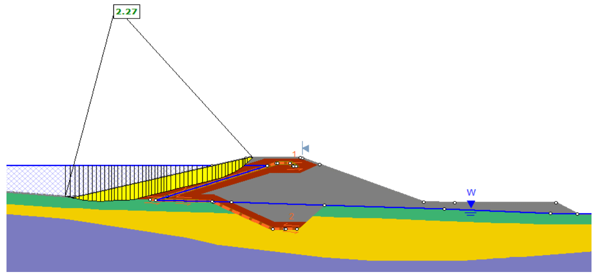
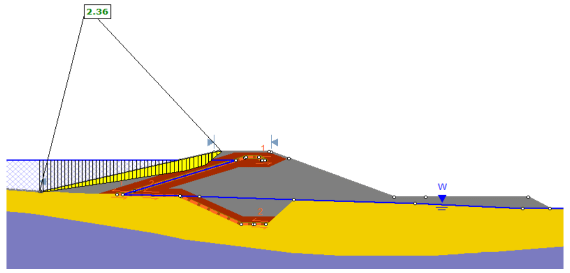
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum F)S | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| 4.07 | 0+240 | 1 Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.0m. Frozen Overburden |  |
| 4.08 | 0+240 | 1 Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.0m. Thawed Overburden |  |
| 4.09 | 0+240 | 1 Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.0m. Thawed layer thickness is h=2m |  |
| 4.10 | 0+240 | 1 Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |
| 4.11 | 0+240 | 1 Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| 4.12 | 0+240 | 1 Base Case (Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |

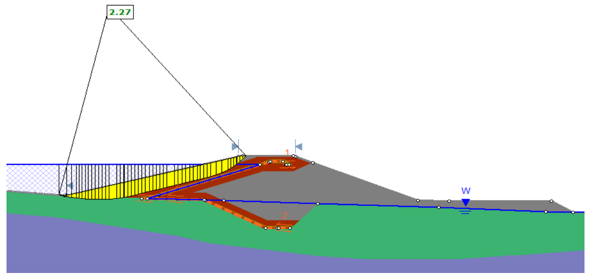
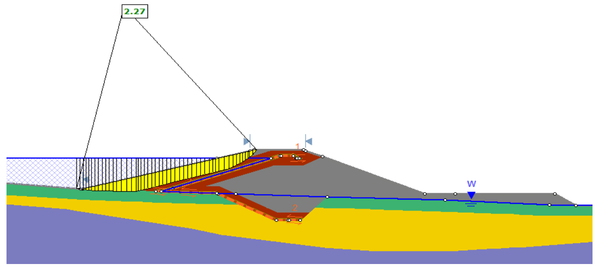
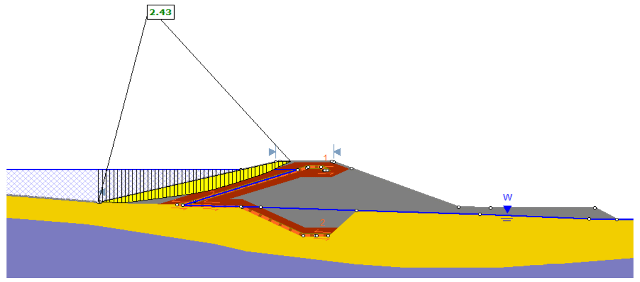
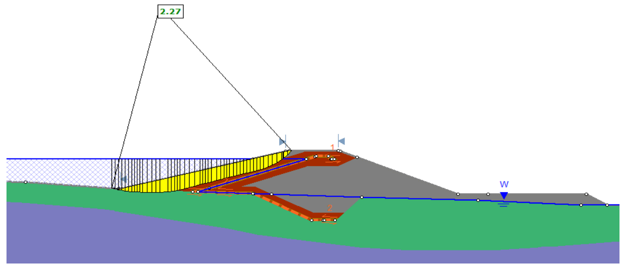
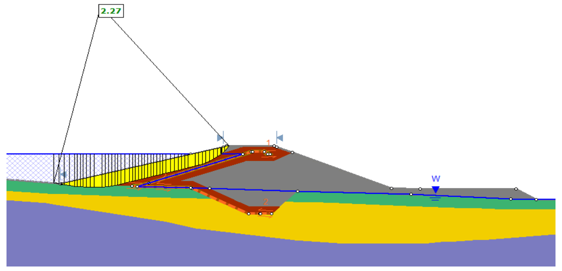
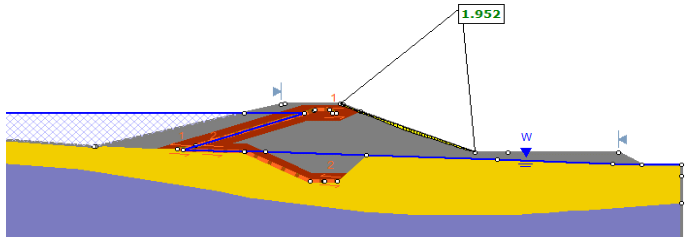
## Results (Shear Strength Reduction Runs)

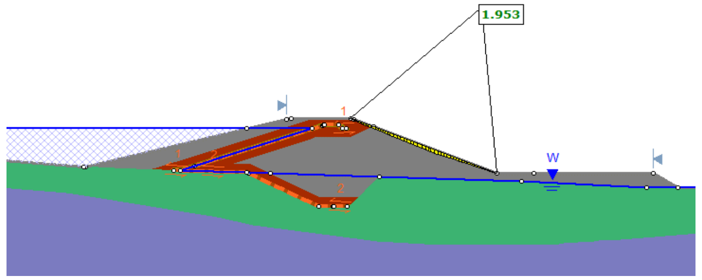
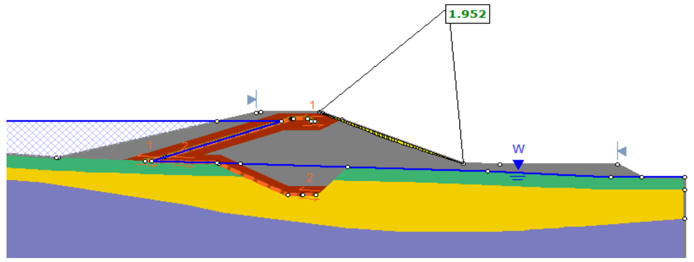
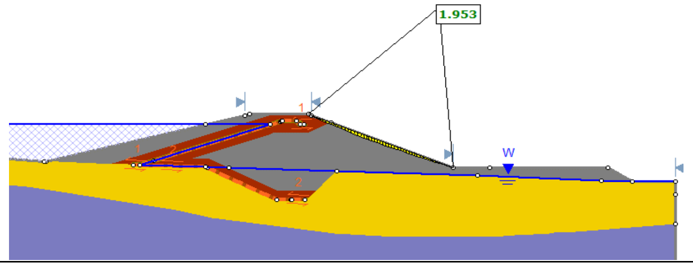
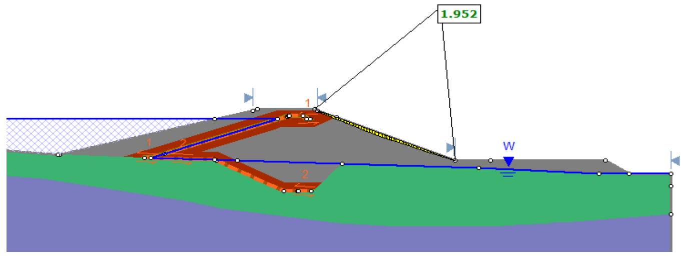
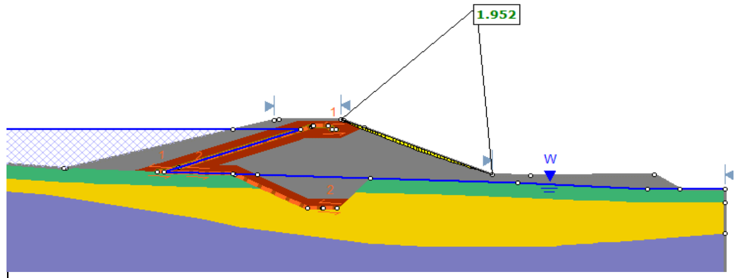
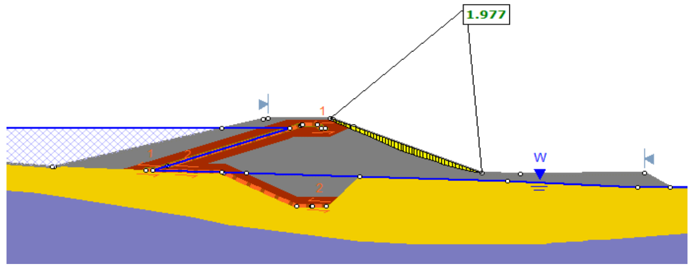
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum F)S | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **4.13** | **0+240** | **1**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.85 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |
| **4.14** | **0+240** | **1**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.74 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **4.15** | **0+240** | **1**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.74 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |
| **4.16** | **0+240** | **1**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.92 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Frozen Overburden |  |
| **4.17** | **0+240** | **1**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.74 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Thawed Overburden |  |

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum F)S | Comments |
|---|---|---|---|---|---|---|---|---|
| **4.18** | **0+240** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Thawed layer thickness is h=2m  |
| **4.19** | **0+240** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.85 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 2.5m. Thawed Overburden  |
| **4.20** | **0+240** | **1**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.85 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 2.5m. Thawed layer thickness is h=2m  |
| **4.21** | **0+240** | **1**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 2.5m. Frozen Overburden  |
| **4.22** | **0+240** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.31 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Frozen Overburden  |

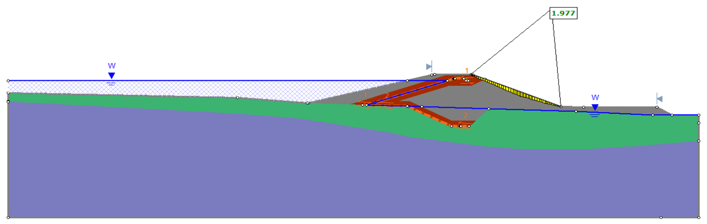
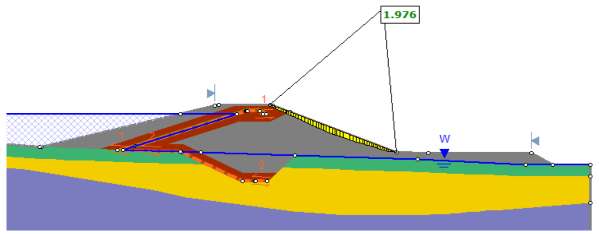
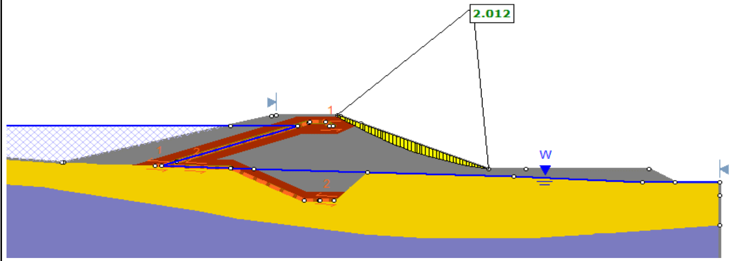
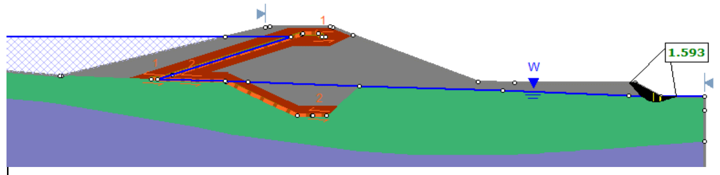
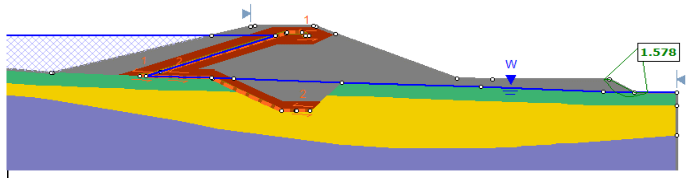
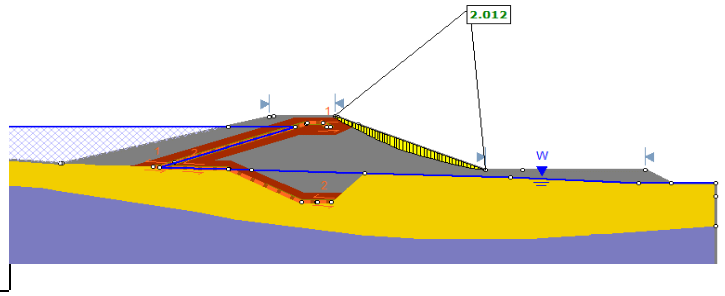
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum F)S | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| 4.23 | 0+240 | 3<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.30 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| 4.24 | 0+240 | 1<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.27 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |
| 4.25 | 0+240 | 1<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.41 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| 4.26 | 0+240 | 3<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.27 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| 4.27 | 0+240 | 3<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.27 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |
| 4.28 | 0+240 | 3<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.32 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.0m. Frozen Overburden |  |

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum F)S | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| 4.29 | 0+240 | 3<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.27 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.0m. Thawed Overburden |  |
| 4.30 | 0+240 | 3<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.30 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.0m. Thawed layer thickness is h=2m |  |
| 4.31 | 0+240 | 3<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.32 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |
| 4.32 | 0+240 | 3<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.27 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| 4.33 | 0+240 | 3<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.27 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |
| 4.34 | 0+240 | 3<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.36 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |

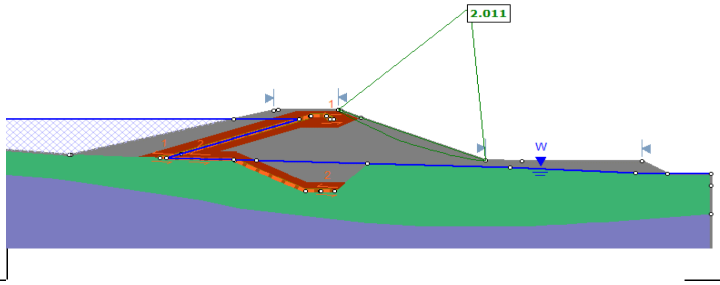
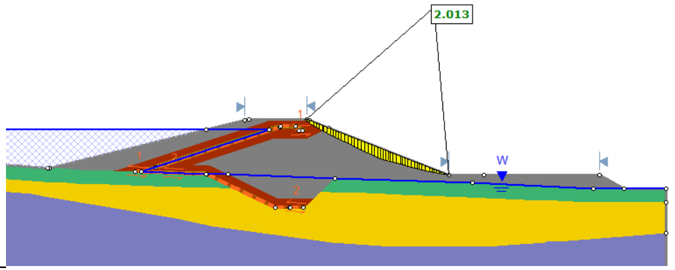
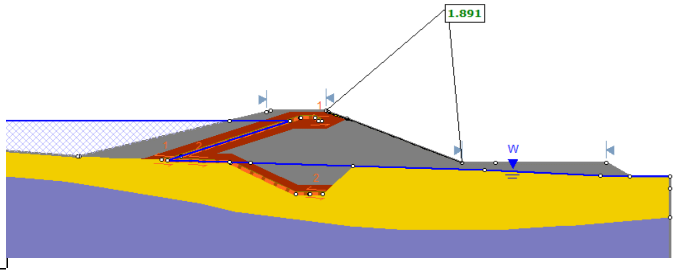
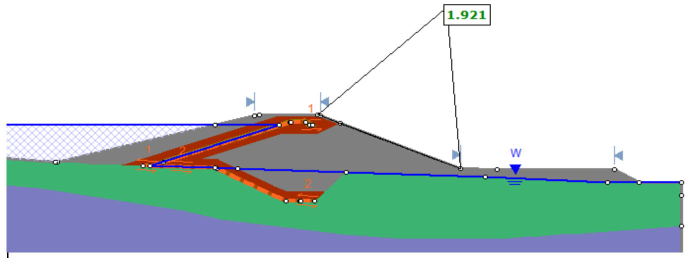
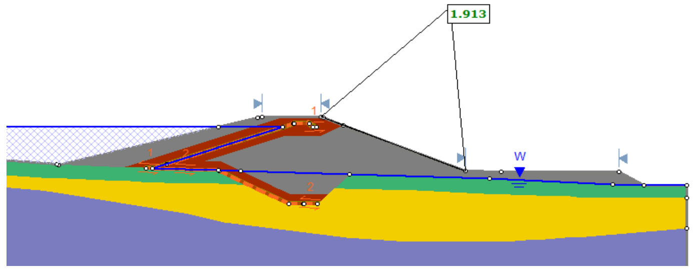
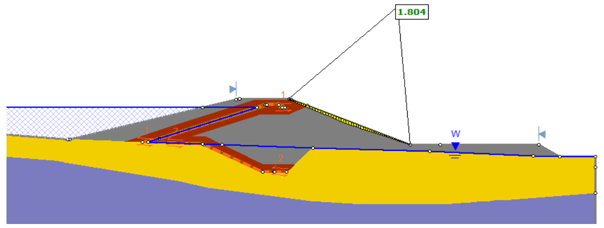
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum F)S | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **4.35** | **0+240** | **3**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.27 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **4.36** | **0+240** | **3**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.27 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |
| **4.37** | **0+240** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.43 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Frozen Overburden |  |
| **4.38** | **0+240** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.27 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Thawed Overburden |  |
| **4.39** | **0+240** | **3**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 2.27 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Thawed layer thickness is h=2m |  |
| **4.40** | **0+240** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.95 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum F)S | Comments |
|---|---|---|---|---|---|---|---|---|
| **4.41** | **0+240** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.95 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 0.5m. Thawed Overburden  |
| **4.42** | **0+240** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.95 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m  |
| **4.43** | **0+240** | **2**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 1.95 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 0.5m. Frozen Overburden  |
| **4.44** | **0+240** | **2**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 1.95 | Slip surface search from left to right (downstream). Embankment H=7.823m. The minimum depth of the slip surface is 0.5m. Thawed Overburden  |
| **4.45** | **0+240** | **2**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 1.95 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m  |
| **4.46** | **0+240** | **2**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.98 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 1.0m. Frozen Overburden  |

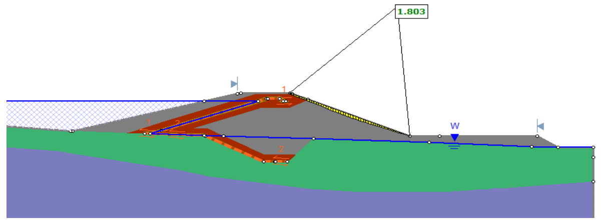
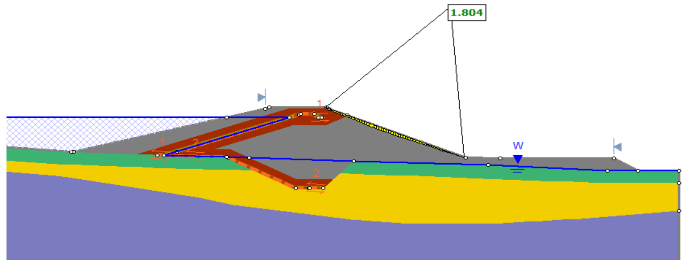
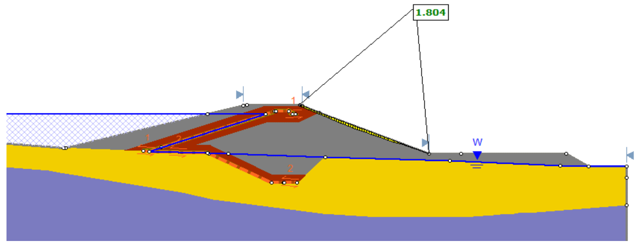
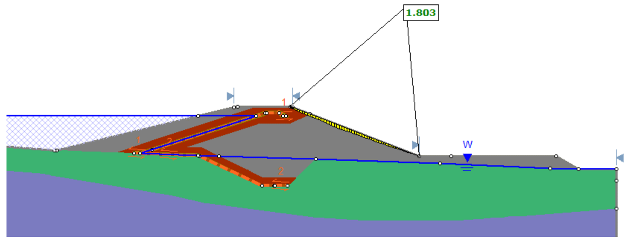
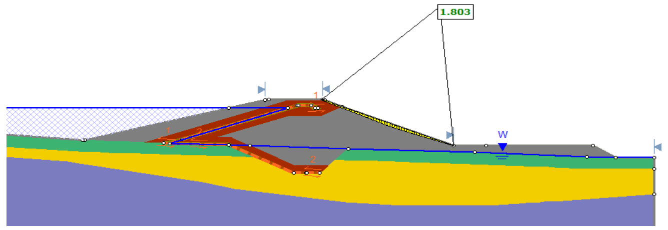
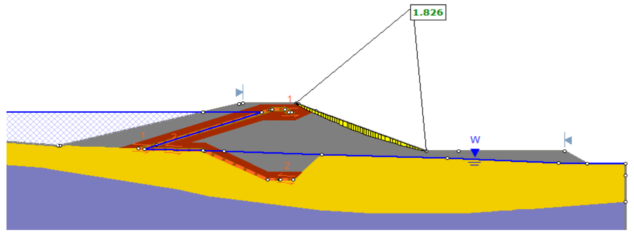
## Results (Shear Strength Reduction Runs)

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum F)S | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| 4.47 | 0+240 | 2<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.98 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 1.0m. Thawed Overburden |  |
| 4.48 | 0+240 | 2<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.98 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 1.0m. Thawed layer thickness is h=2m |  |
| 4.49 | 0+240 | 2<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.01 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |
| 4.50 | 0+240 | 2<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.59 | Slip surface search from left to right (downstream). Embankment H=2m (only All-Weather Road embankment). The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| 4.51 | 0+240 | 2<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.58 | Slip surface search from left to right (downstream). Embankment H=2m (only All-Weather Road embankment). The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |
| 4.52 | 0+240 | 2<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.01 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |

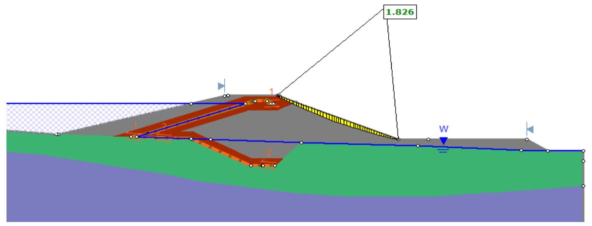
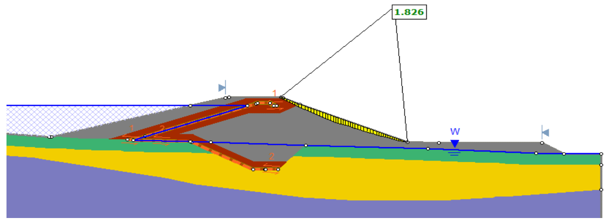
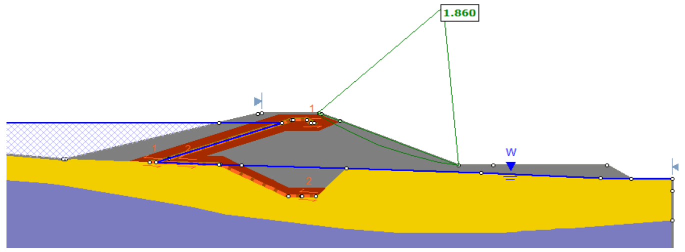
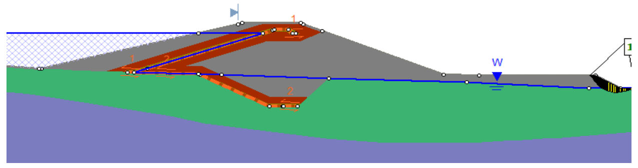
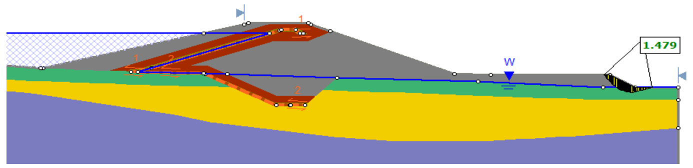
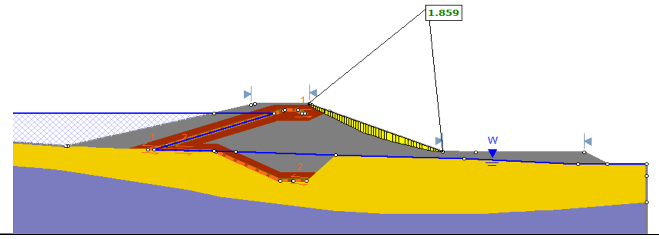
## Results (Shear Strength Reduction Runs)

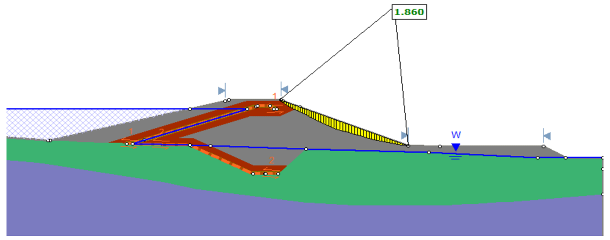
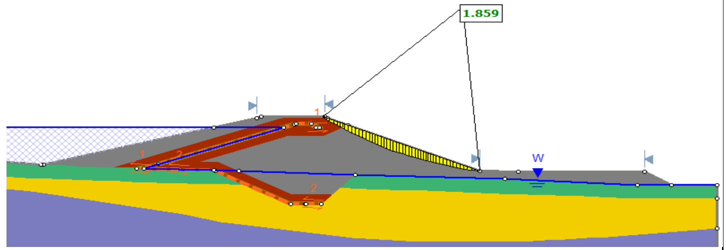
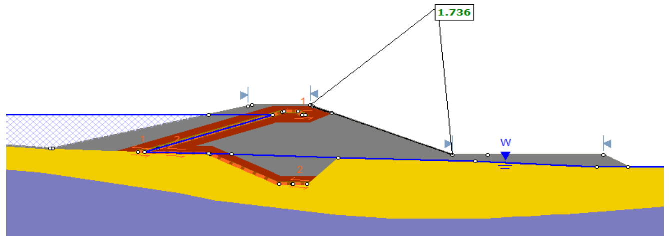
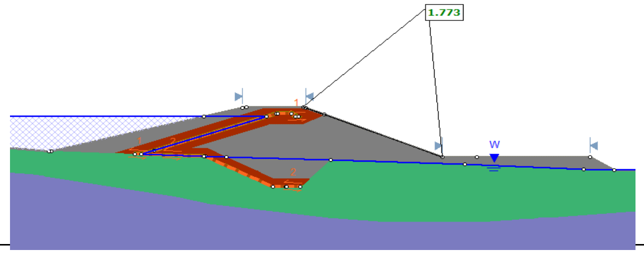
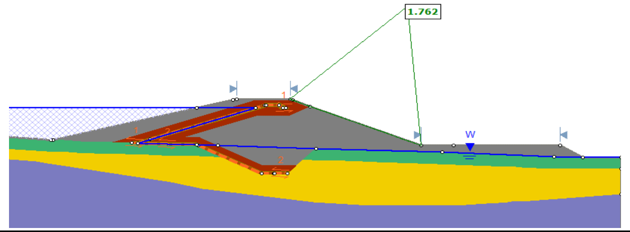
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum F)S | Comments |
|---|---|---|---|---|---|---|---|---|
| 4.53 | 0+240 | 2<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.01 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 1.5m. Thawed Overburden  |
| 4.54 | 0+240 | 2<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.01 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m  |
| 4.55 | 0+240 | 2<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 1.89 | Slip surface search from left to right (downstream). Embankment H=8m. No minimum depth of the slip surface is specified. Frozen Overburden  |
| 4.56 | 0+240 | 2<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.92 | Slip surface search from left to right (downstream). Embankment H=8m. No minimum depth of the slip surface is specified. Thawed Overburden  |
| 4.57 | 0+240 | 2<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 1.91 | Slip surface search from left to right (downstream). Embankment H=8m. No minimum depth of the slip surface is specified. Thawed layer thickness is h=2m  |
| 4.58 | 0+240 | 4<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.80 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 0.5m. Frozen Overburden  |

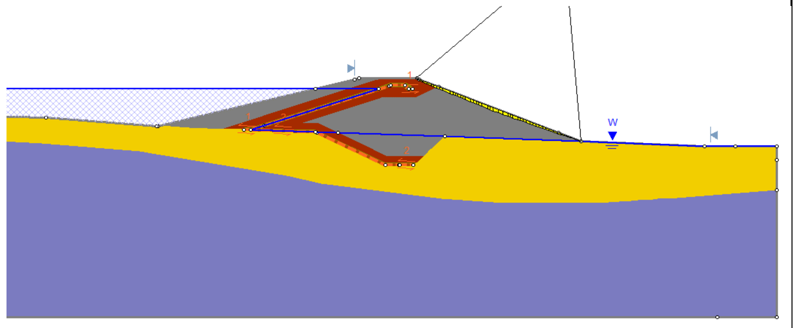
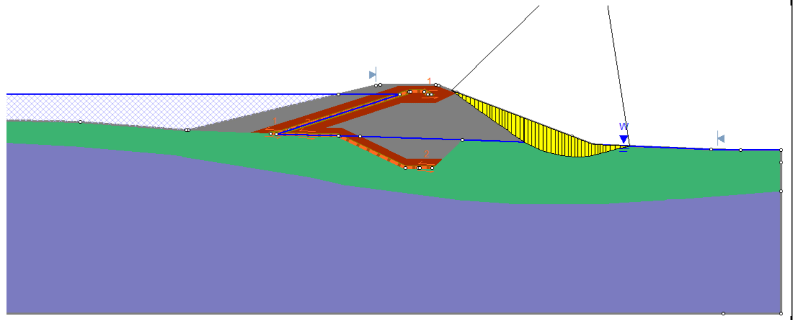
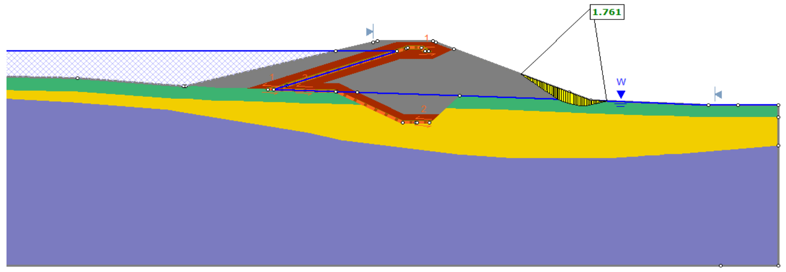
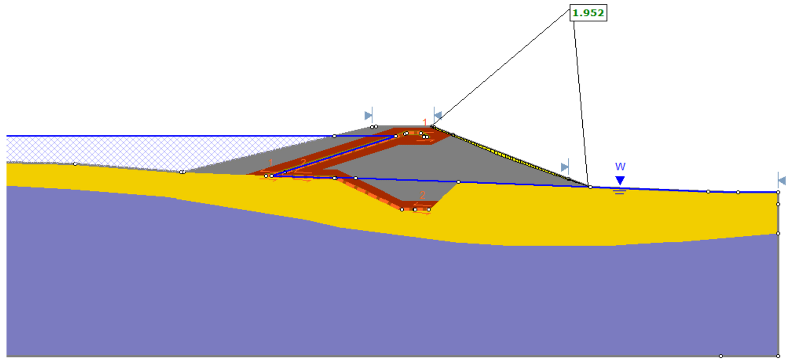
## Results (Shear Strength Reduction Runs)

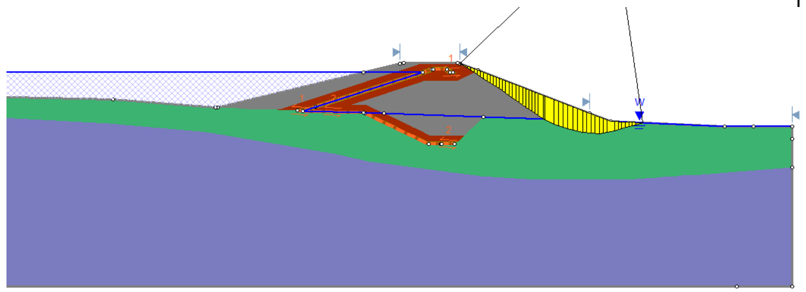
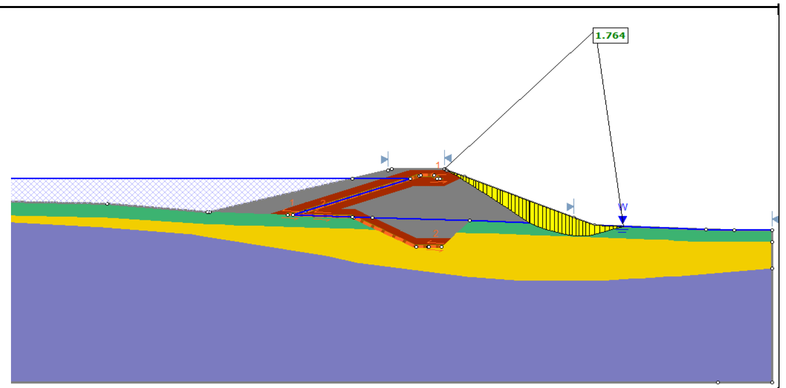
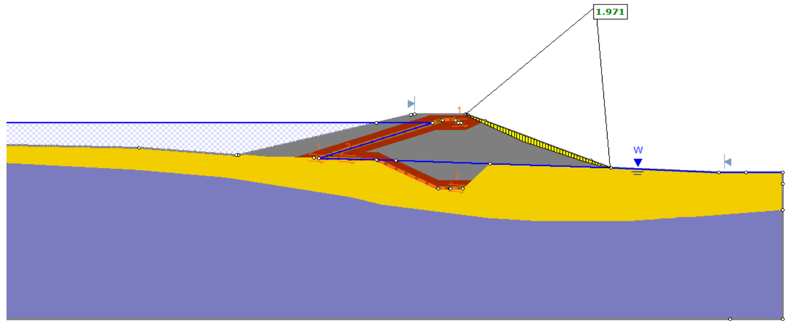
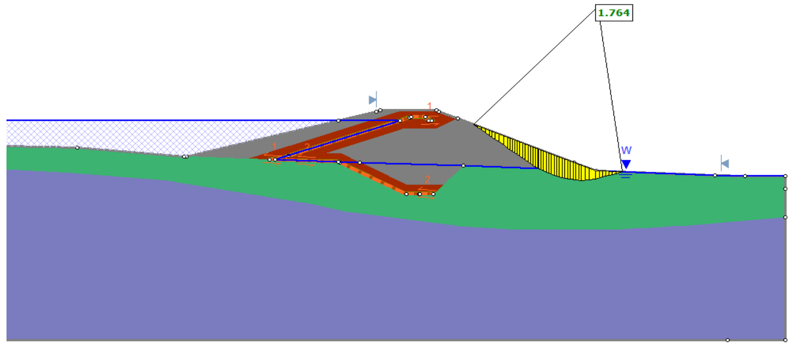
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum F)S | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **4.59** | **0+240** | **4**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.80 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **4.60** | **0+240** | **4**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.80 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |
| **4.61** | **0+240** | **4**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.80 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| **4.62** | **0+240** | **4**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.80 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **4.63** | **0+240** | **4**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.80 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |
| **4.64** | **0+240** | **4**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.83 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 1.0m. Frozen Overburden |  |

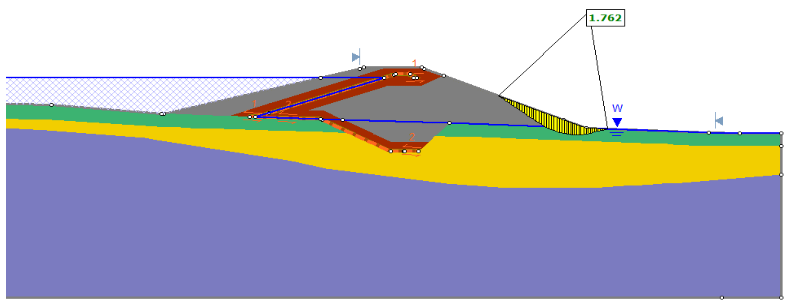
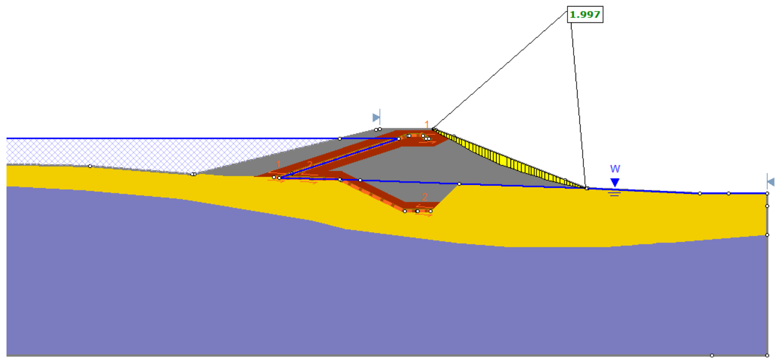
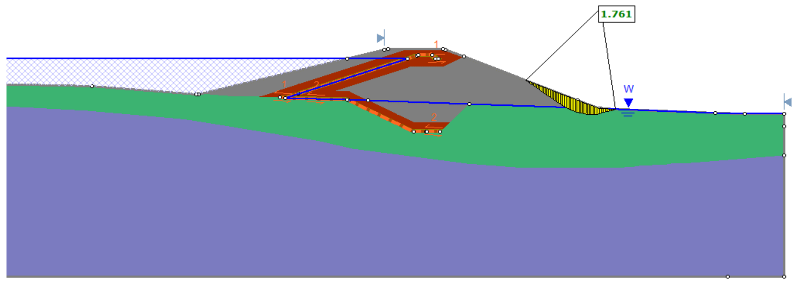
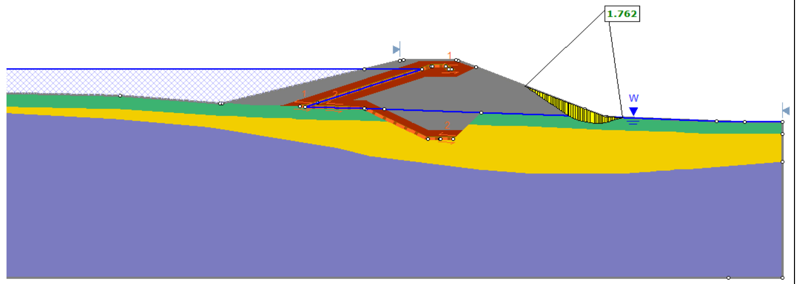
## Results (Shear Strength Reduction Runs)

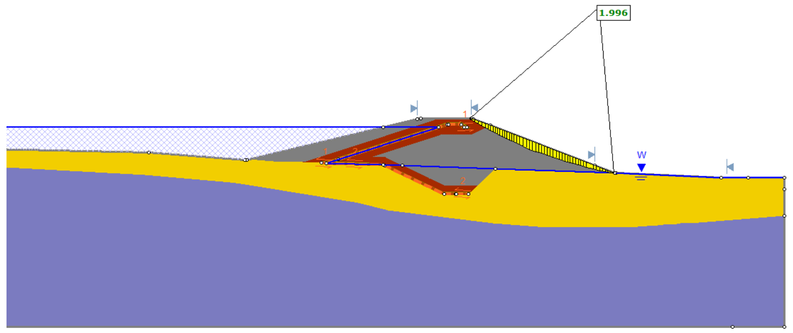
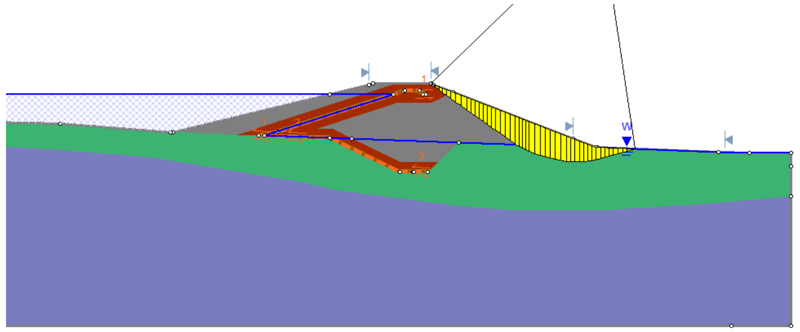
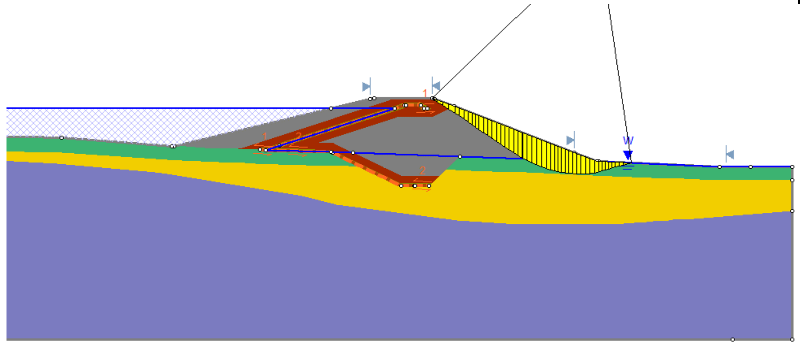
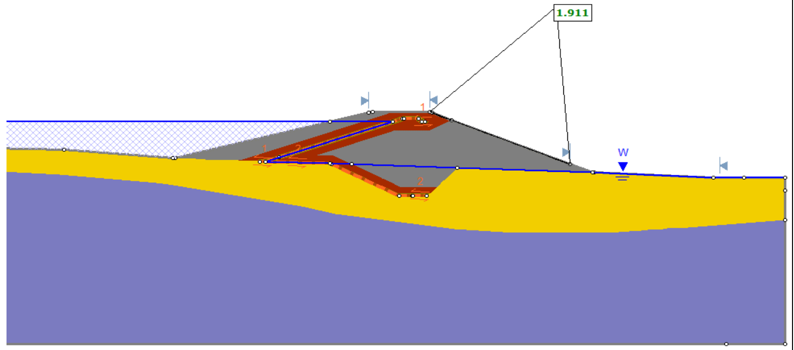
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum F)S | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| 4.65 | 0+240 | 4<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.83 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 1.0m. Thawed Overburden |  |
| 4.66 | 0+240 | 4<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.83 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 1.0m. Thawed layer thickness is h=2m |  |
| 4.67 | 0+240 | 4<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.86 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |
| 4.68 | 0+240 | 4<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.48 | Slip surface search from left to right (downstream). Embankment H=2m (only All-Weather Road embankment). The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| 4.69 | 0+240 | 4<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.48 | Slip surface search from left to right (downstream). Embankment H=2m (only All-Weather Road embankment). The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |
| 4.70 | 0+240 | 4<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.86 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |

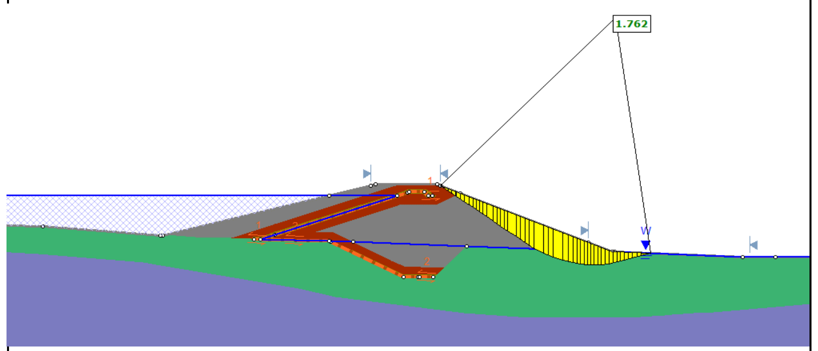
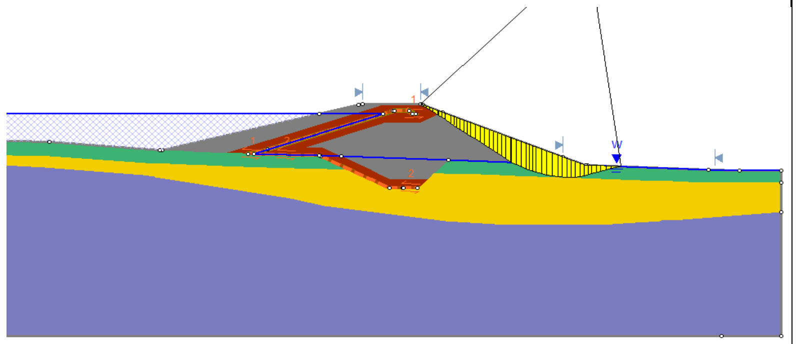
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum F)S | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **4.71** | **0+240** | **4**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.86 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **4.72** | **0+240** | **4**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.86 | Slip surface search from left to right (downstream). Embankment H=8m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |
| **4.73** | **0+240** | **1**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.74 | Slip surface search from left to right (downstream). Embankment H=8m. No minimum depth of the slip surface is specified. Frozen Overburden |  |
| **4.74** | **0+240** | **1**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.77 | Slip surface search from left to right (downstream). Embankment H=8m. No minimum depth of the slip surface is specified. Thawed Overburden |  |
| **4.75** | **0+240** | **4**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | Yes ($k_x$=0.0282) | 1.76 | Slip surface search from left to right (downstream). Embankment H=8m. No minimum depth of the slip surface is specified. Thawed layer thickness is h=2m |  |

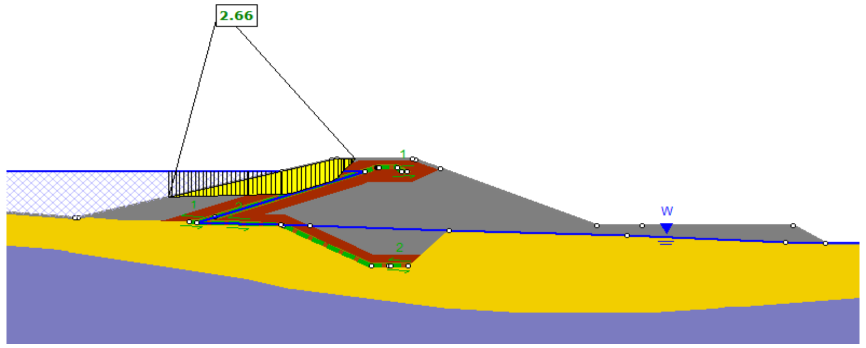
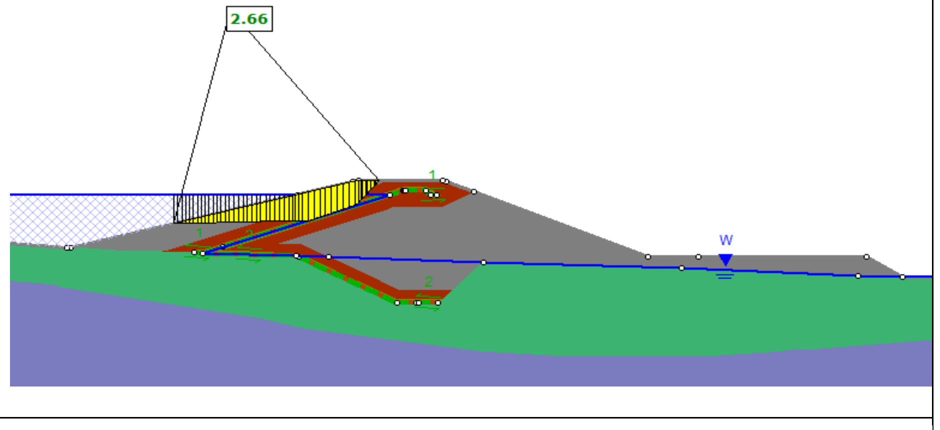
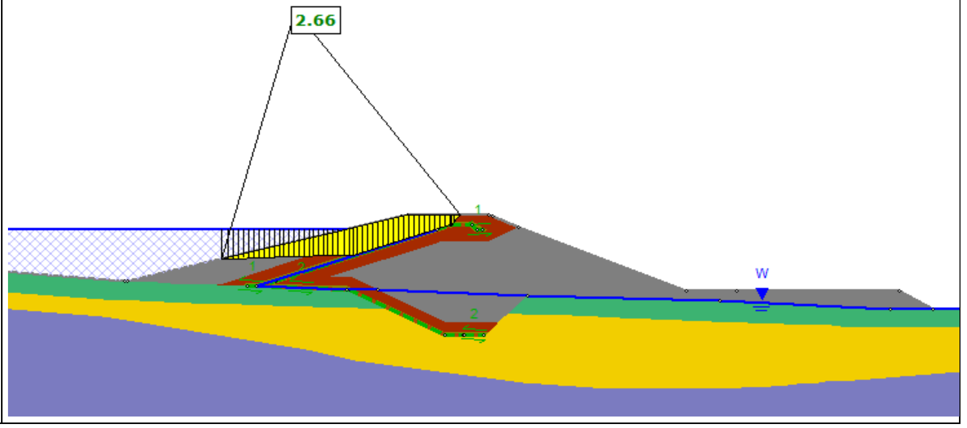
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Minimum FOS | Comments |
|---|---|---|---|---|---|---|---|
| **5.01** | **0+240** | **5**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | 1.95 | Slip surface search from left to right (downstream). Embankment H=9m. The minimum depth of the slip surface is 0.5m. Frozen Overburden  |
| **5.02** | **0+240** | **5**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | 1.76 | Slip surface search from left to right (downstream). Embankment H=9m. The minimum depth of the slip surface is 0.5m. Thawed Overburden  |
| **5.03** | **0+240** | **5**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | 1.76 | Slip surface search from left to right (downstream). Embankment H=9m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m  |
| **5.04** | **0+240** | **5**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | 1.95 | Slip surface search from left to right (downstream). Embankment H=9m. The minimum depth of the slip surface is 0.5m. Frozen Overburden  |

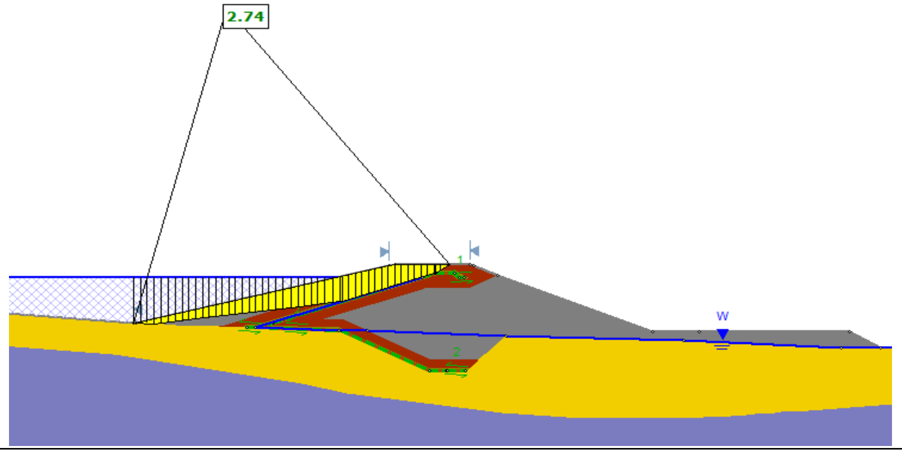
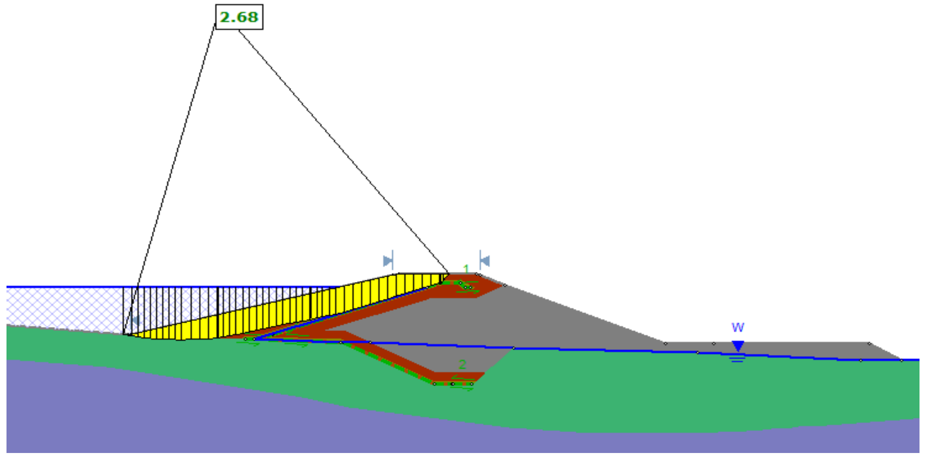
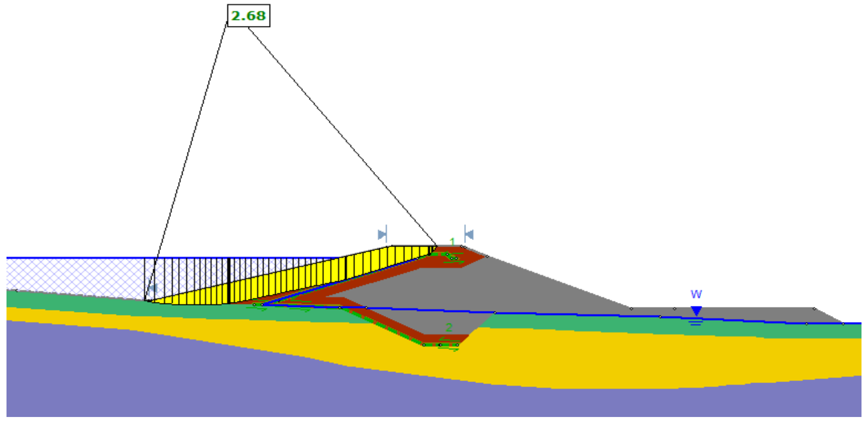
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|
| **5.05** | **0+240** | **5**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | 1.76 | Slip surface search from left to right (downstream). Embankment H=9m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **5.06** | **0+240** | **5**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | 1.76 | Slip surface search from left to right (downstream). Embankment H=9m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |
| **5.07** | **0+240** | **5**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | 1.97 | Slip surface search from left to right (downstream). Embankment H=9m. The minimum depth of the slip surface is 1.0m. Frozen Overburden |  |
| **5.08** | **0+240** | **5**<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | 1.76 | Slip surface search from left to right (downstream). Embankment H=9m. The minimum depth of the slip surface is 1.0m. Thawed Overburden |  |

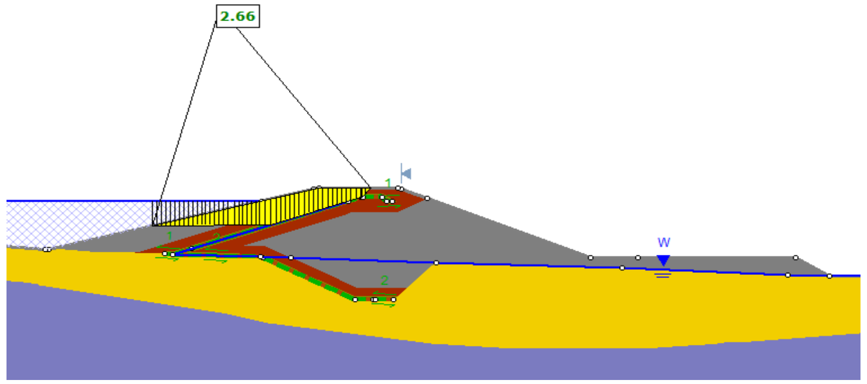
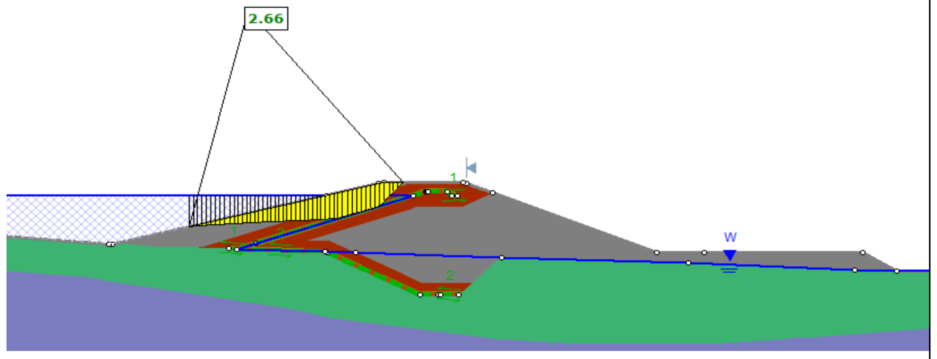
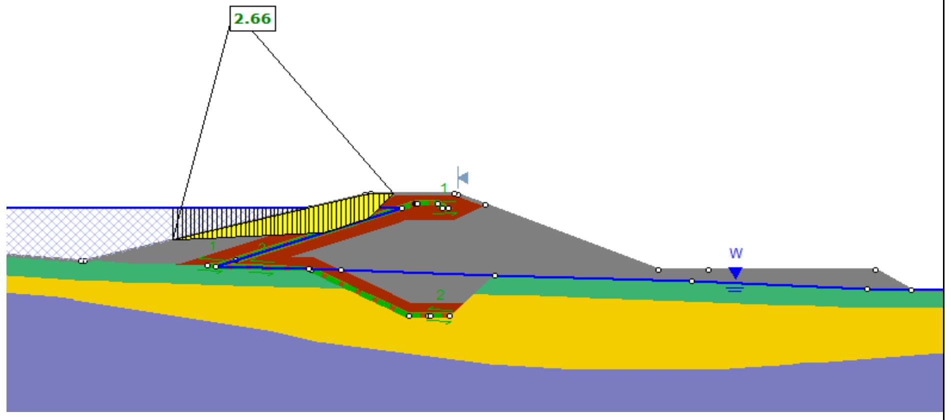
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|
| 5.09 | 0+240 | 5<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | 1.76 | Slip surface search from left to right (downstream). Embankment H=9m. The minimum depth of the slip surface is 1.0m. Thawed layer thickness is h=2m |  |
| 5.10 | 0+240 | 5<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | 2.00 | Slip surface search from left to right (downstream). Embankment H=9m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |
| 5.11 | 0+240 | 5<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | 1.76 | Slip surface search from left to right (downstream). Embankment H=9m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| 5.12 | 0+240 | 5<br>Base Case<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | 1.76 | Slip surface search from left to right (downstream). Embankment H=9m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |

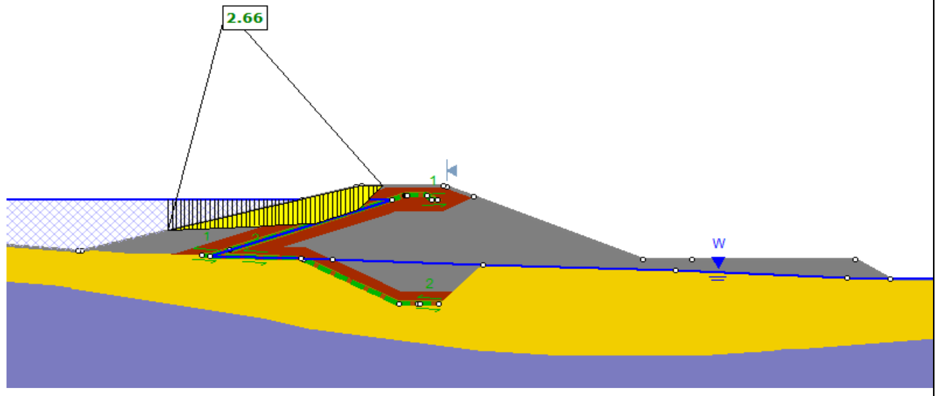
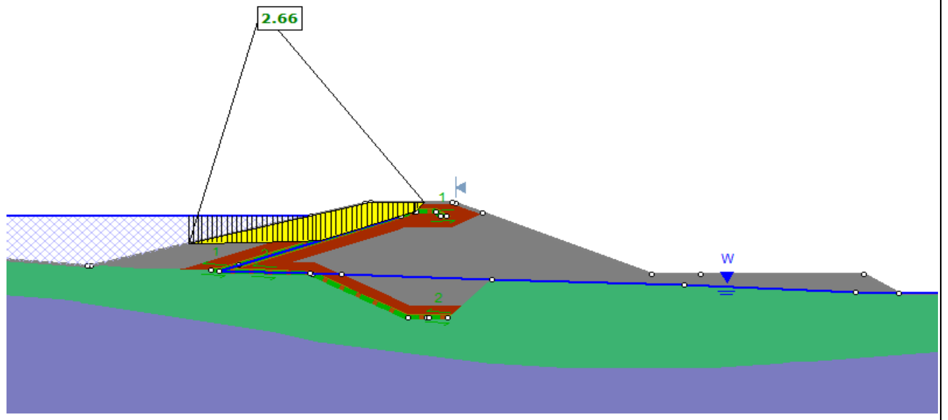
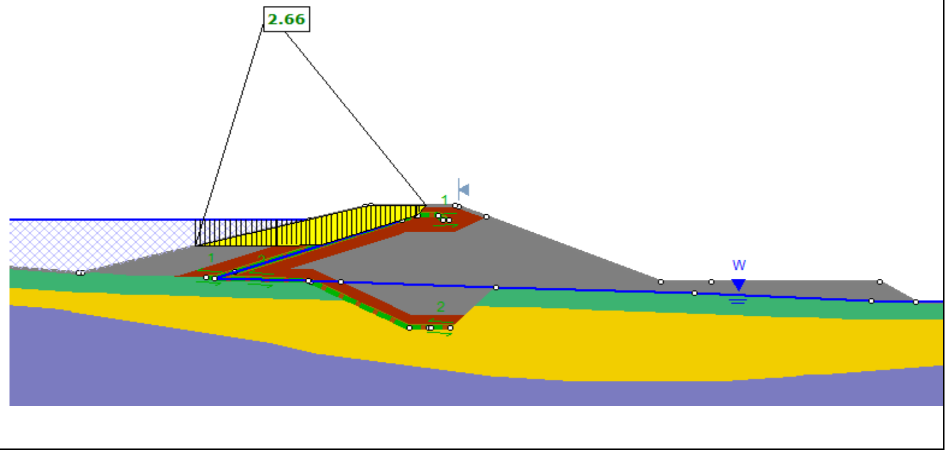
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|
| **5.13** | **0+240** | **5**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | 2.00 | Slip surface search from left to right (downstream). Embankment H=9m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |
| **5.14** | **0+240** | **5**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | 1.76 | Slip surface search from left to right (downstream). Embankment H=9m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **5.15** | **0+240** | **5**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | 1.76 | Slip surface search from left to right (downstream). Embankment H=9m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |
| **5.16** | **0+240** | **5**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | 1.91 | Slip surface search from left to right (downstream). Embankment H=9m. No minimum depth of the slip surface is specified. Frozen Overburden |  |

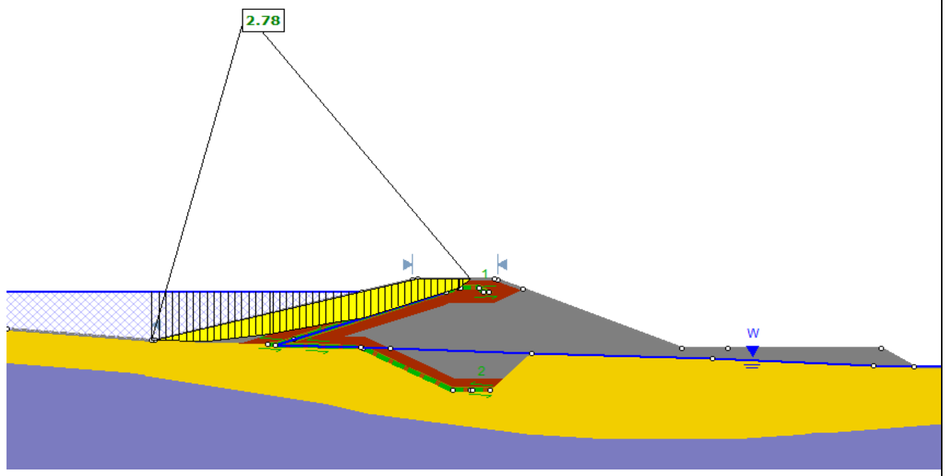
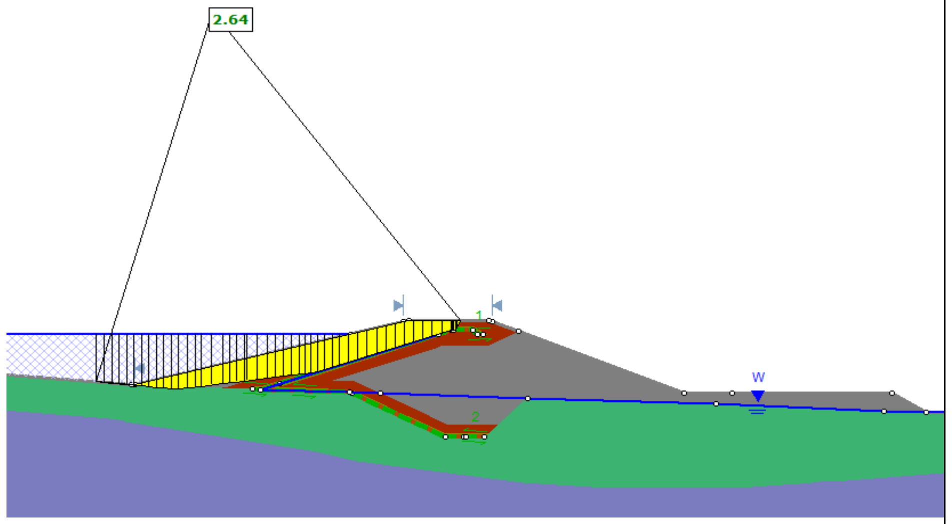
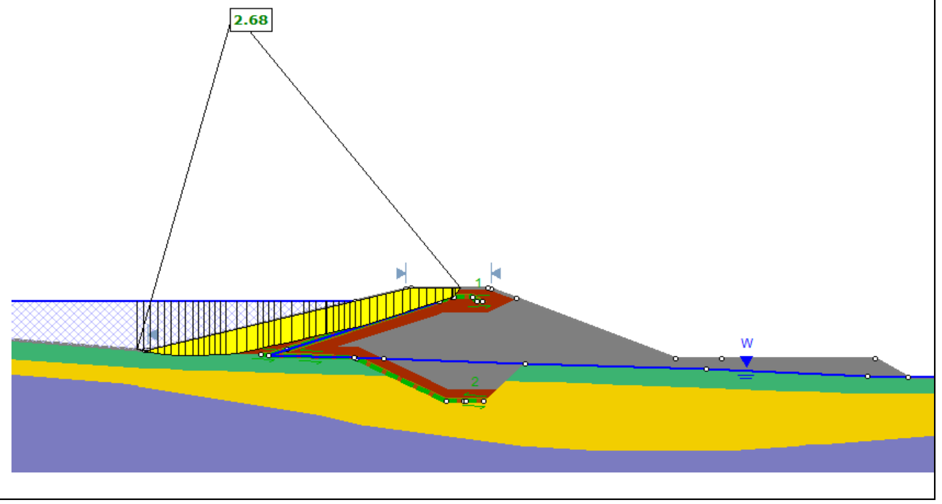
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Minimum FOS | Comments |
|---|---|---|---|---|---|---|---|
| 5.17 | 0+240 | **5**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | 1.76 | Slip surface search from left to right (downstream). Embankment H=9m. No minimum depth of the slip surface is specified. Thawed Overburden  |
| 5.18 | 0+240 | **5**<br>Base Case<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | 1.76 | Slip surface search from left to right (downstream). Embankment H=9m. No minimum depth of the slip surface is specified. Thawed layer thickness is h=2m  |

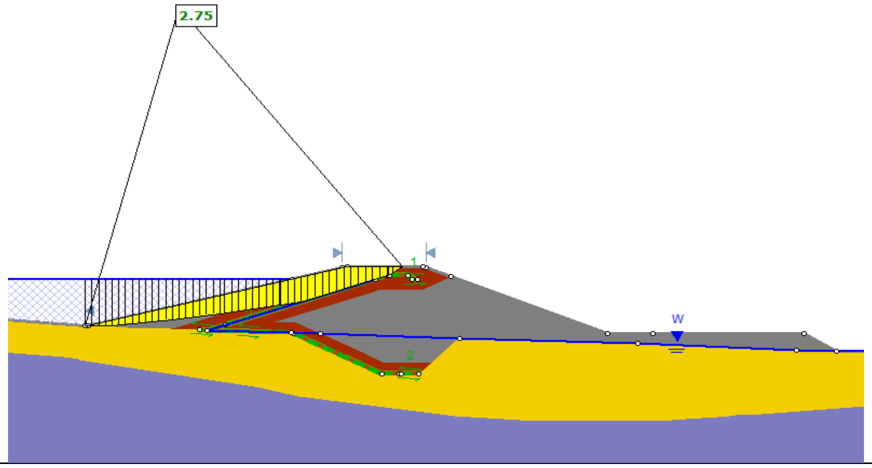
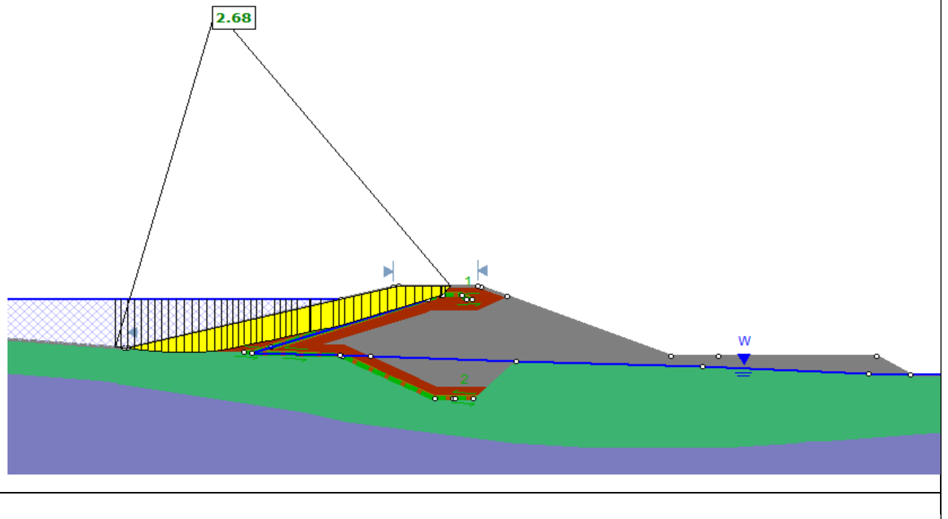
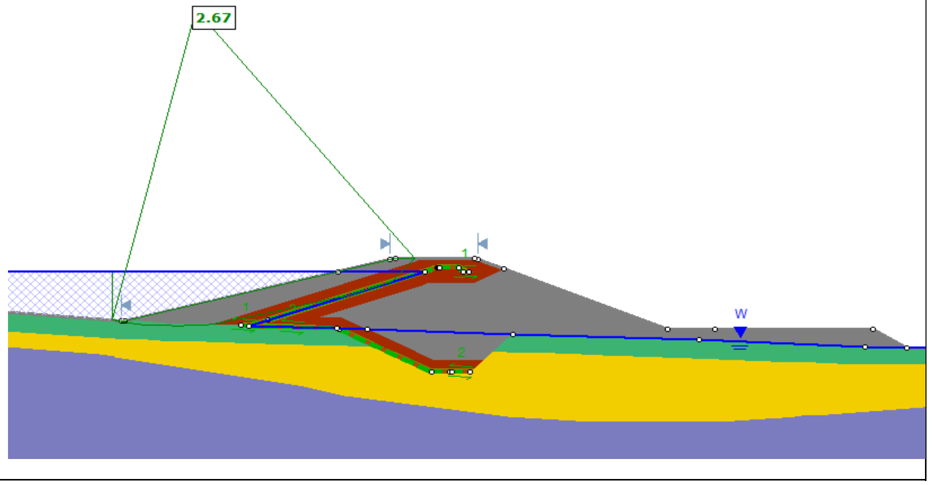
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **8.01** | **0+240** | **8**<br>HDPE Liner<br>φ=18°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.66 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Frozen Overburden. |  |
| **8.02** | **0+240** | **8**<br>HDPE Liner<br>φ=18°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.66 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **8.03** | **0+240** | **8**<br>HDPE Liner<br>φ=18°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.66 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |

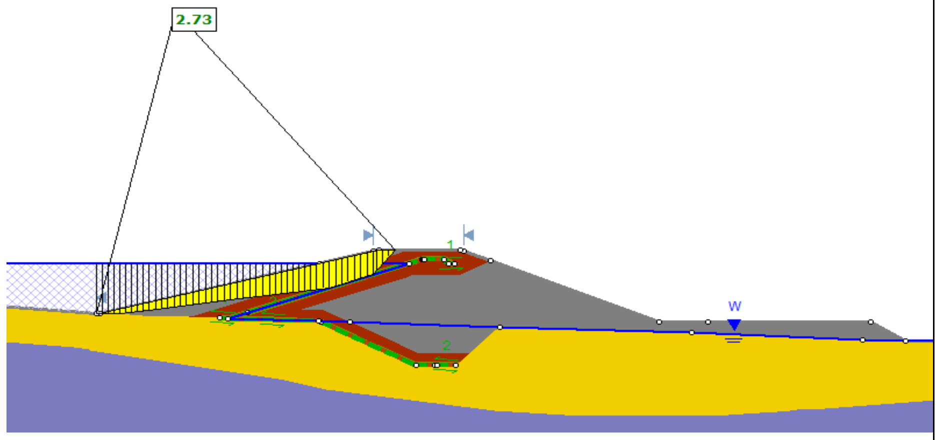
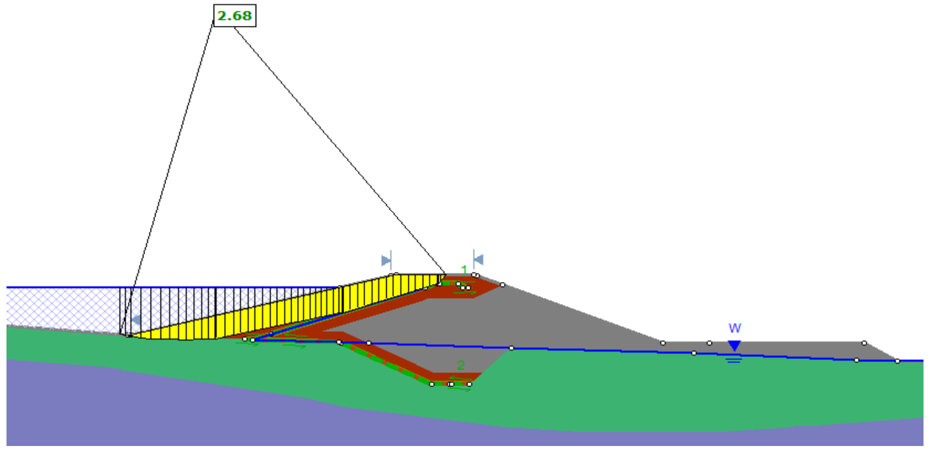
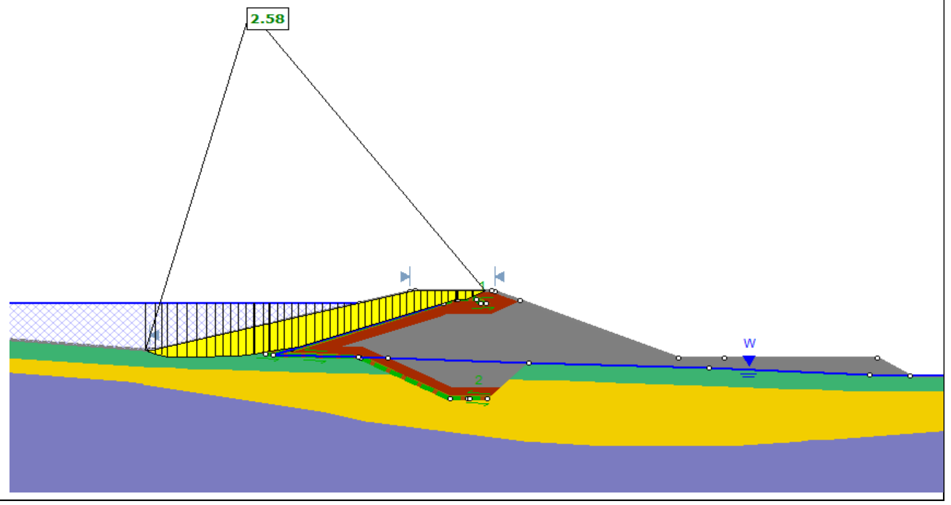
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **8.04** | **0+240** | **8**<br>HDPE Liner<br>φ=18°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.74 | Slip surface search from right to left (upstream). Embankment H=6.899m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| **8.05** | **0+240** | **8**<br>HDPE Liner<br>φ=18°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.68 | Slip surface search from right to left (upstream). Embankment H=6.899m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **8.06** | **0+240** | **8**<br>HDPE Liner<br>φ=18°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.68 | Slip surface search from right to left (upstream). Embankment H=6.899m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |

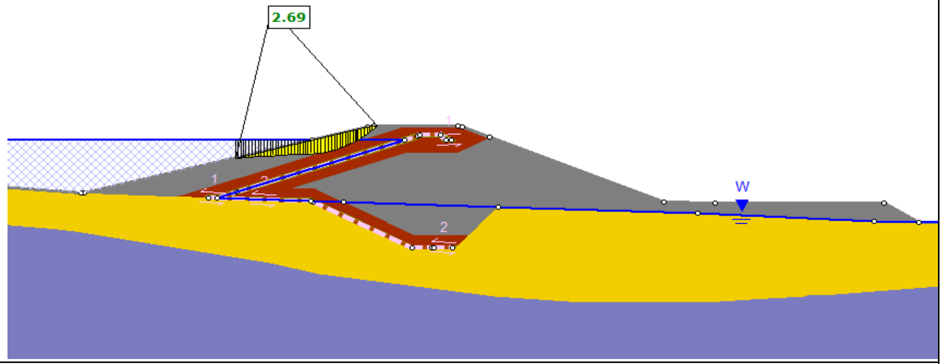
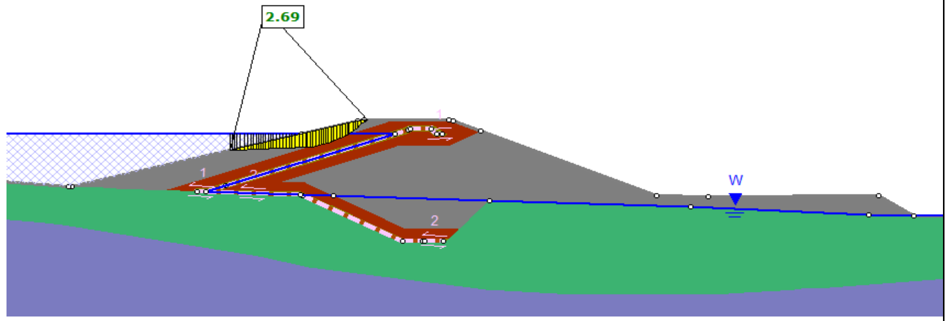
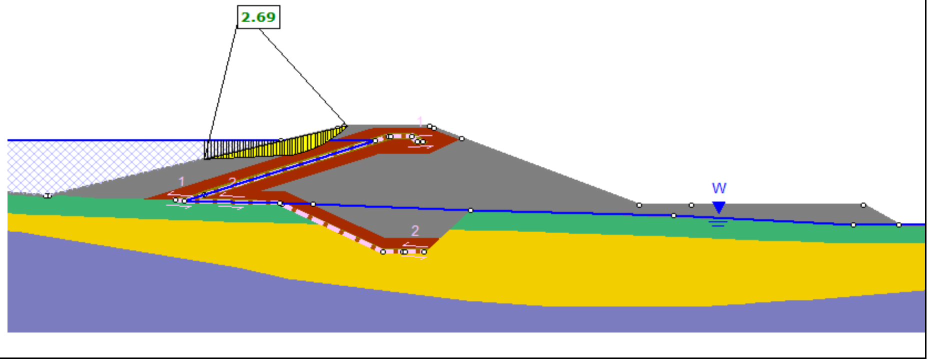
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **8.07** | **0+240** | **8**<br>HDPE Liner<br>φ=18°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.66 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.0m. Frozen Overburden |  |
| **8.08** | **0+240** | **8**<br>HDPE Liner<br>φ=18°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.66 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.0m. Thawed Overburden |  |
| **8.09** | **0+240** | **8**<br>HDPE Liner<br>φ=18°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.66 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.0m. Thawed layer thickness is h=2m |  |

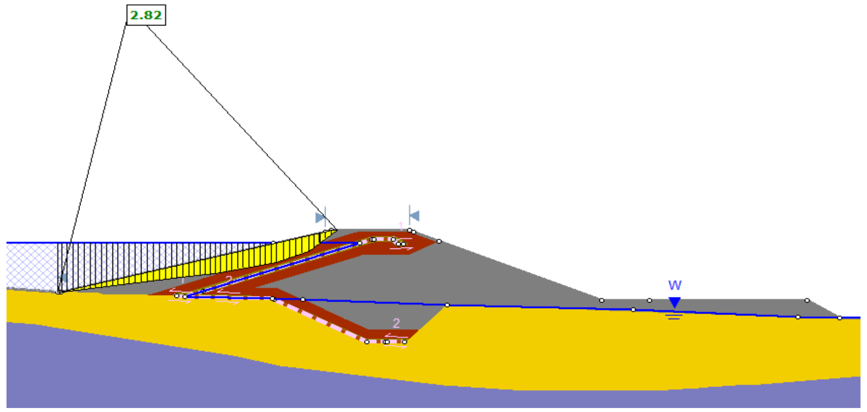
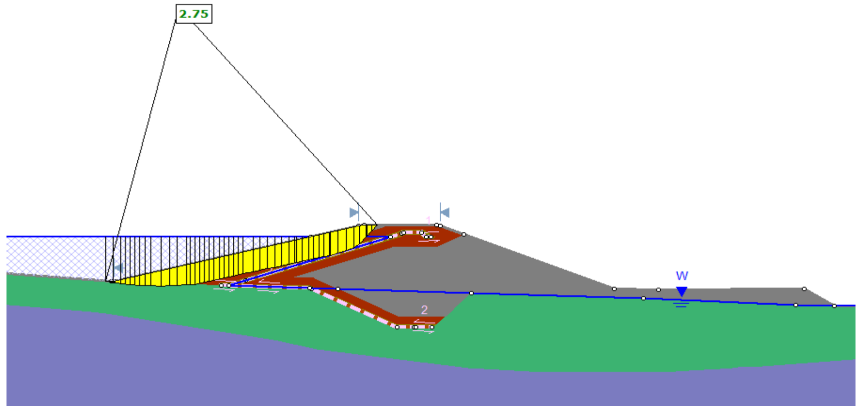
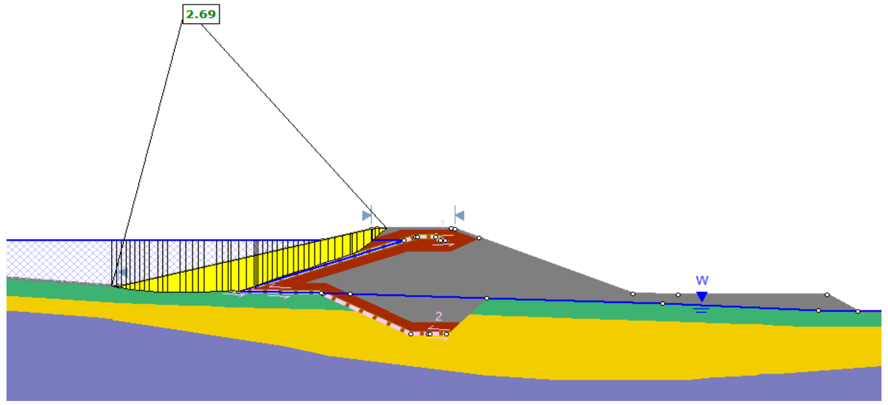
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **8.10** | **0+240** | **8**<br>HDPE Liner<br>φ=18°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.66 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |
| **8.11** | **0+240** | **8**<br>HDPE Liner<br>φ=18°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.66 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **8.12** | **0+240** | **8**<br>HDPE Liner<br>φ=18°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.66 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |

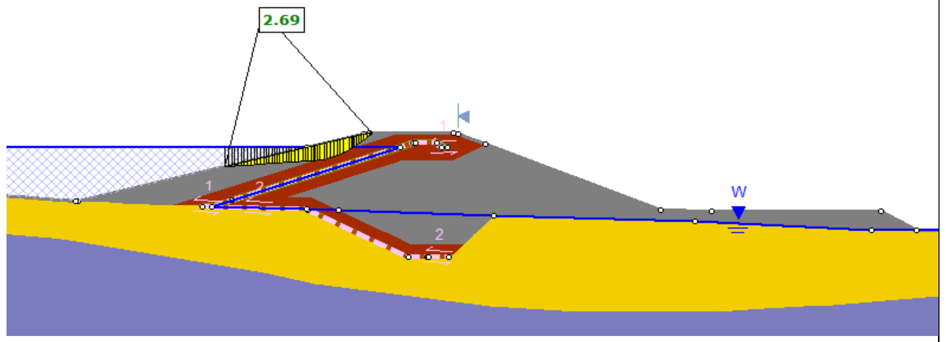
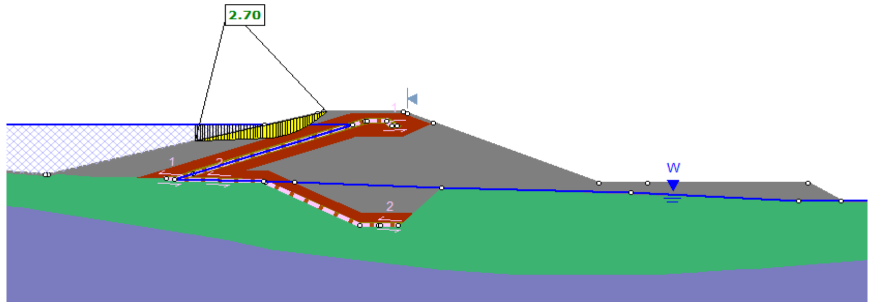
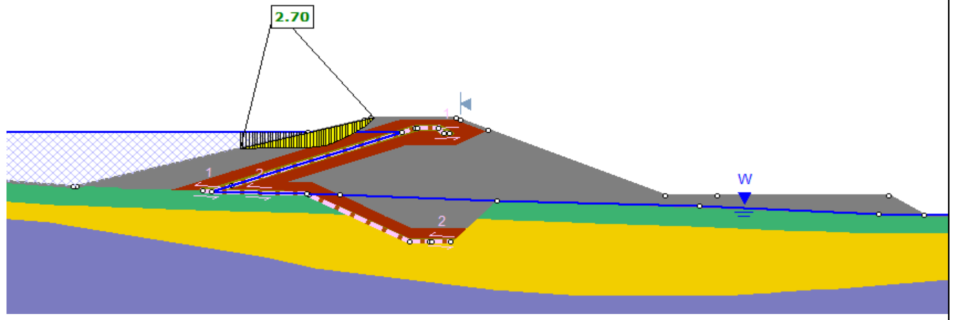
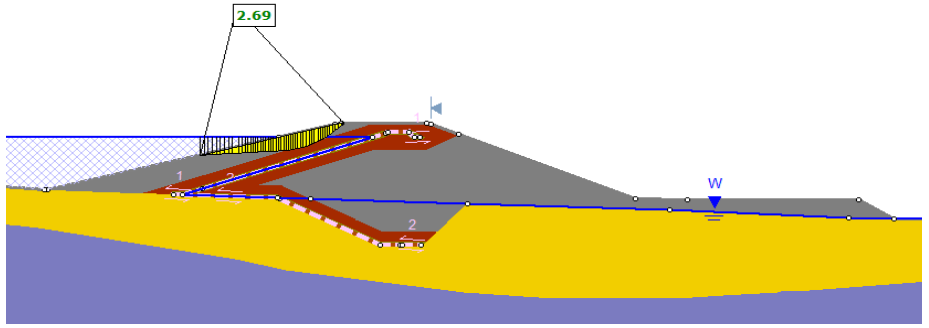
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **8.13** | **0+240** | **8**<br>HDPE Liner<br>φ=18°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.78 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |
| **8.14** | **0+240** | **8**<br>HDPE Liner<br>φ=18°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.64 | Slip surface search from right to left (upstream). Embankment H=6.899m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **8.15** | **0+240** | **8**<br>HDPE Liner<br>φ=18°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.68 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |

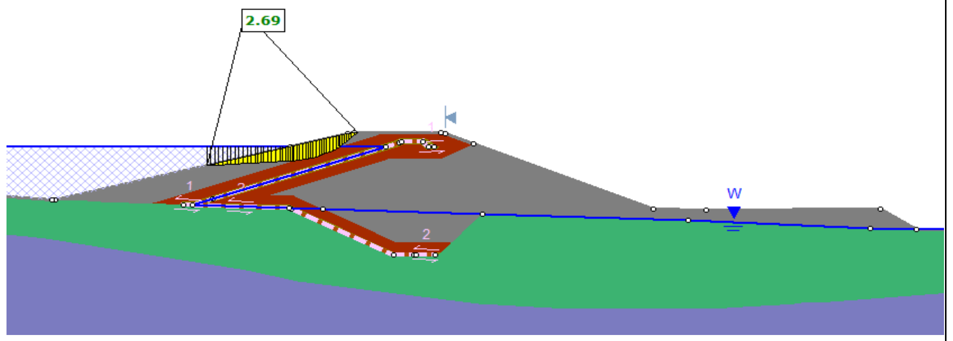
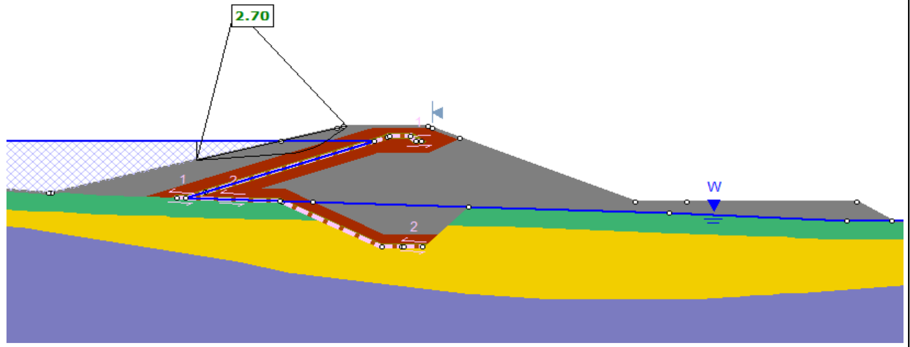
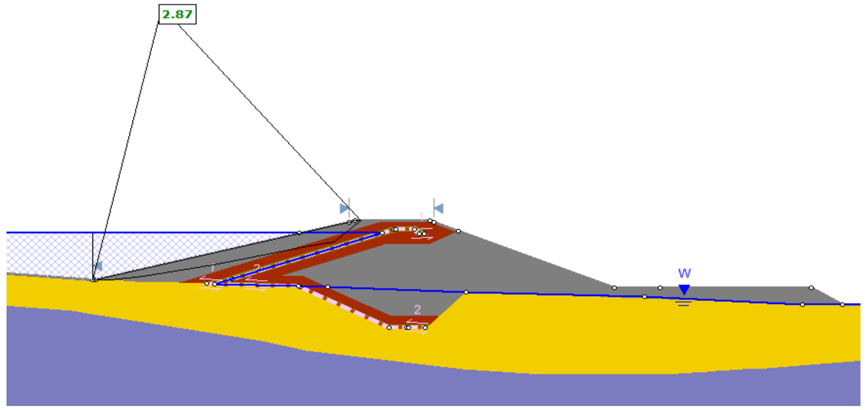
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| 8.16 | 0+240 | **8**<br>HDPE Liner<br>φ=18°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Frozen Overburden |  |
| 8.17 | 0+240 | **8**<br>HDPE Liner<br>φ=18°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.68 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Thawed Overburden |  |
| 8.18 | 0+240 | 8<br>HDPE Liner<br>φ=18°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.67 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified.  Thawed layer thickness is h=2m |  |

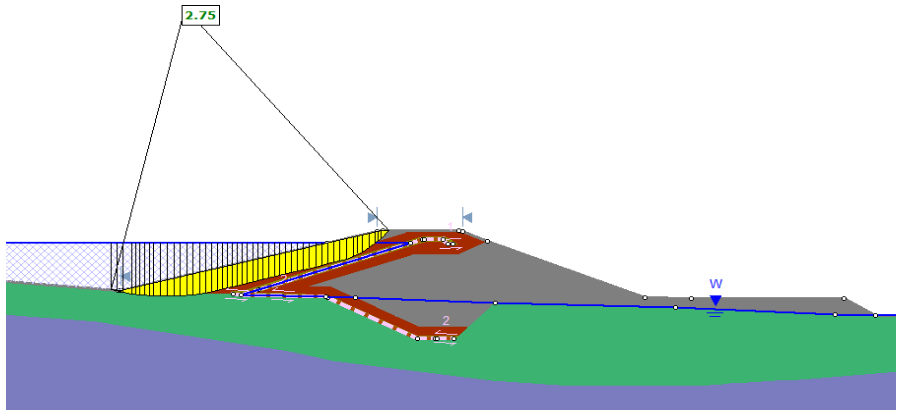
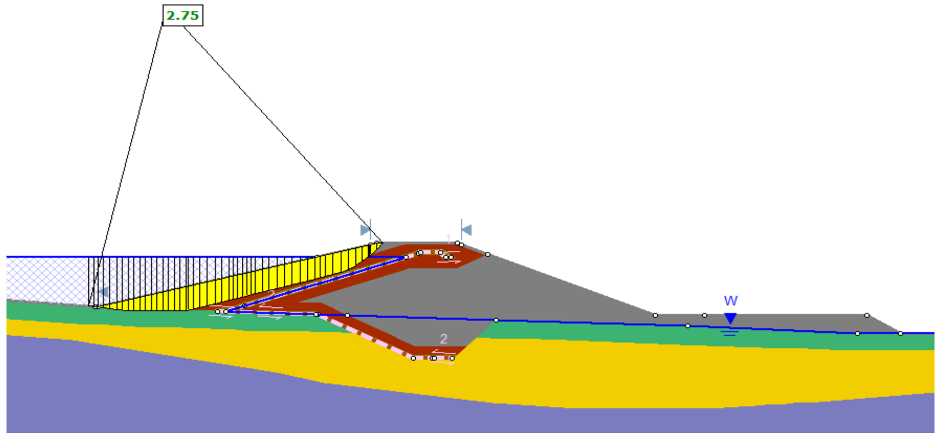
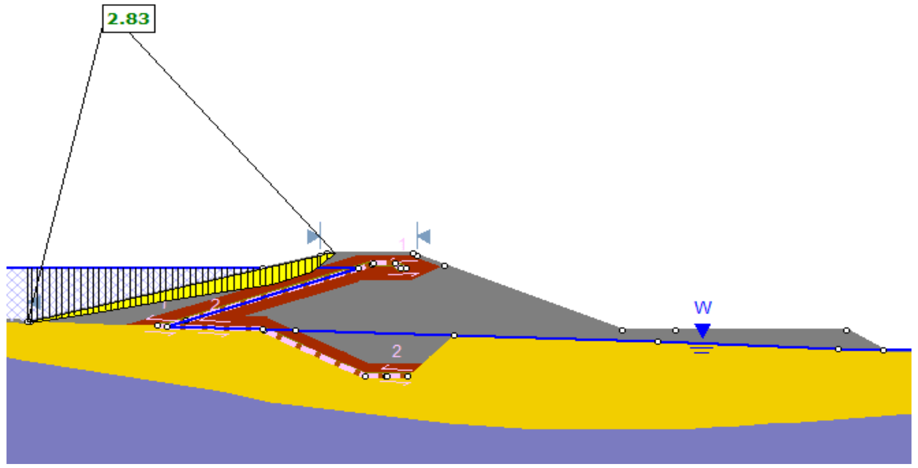
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **8.19** | **0+240** | 8<br>HDPE Liner<br>φ=18°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.73 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 2.5m. Frozen foundation |  |
| **8.20** | **0+240** | 8<br>HDPE Liner<br>φ=18°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.68 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 2.5m. Thawed foundation |  |
| **8.21** | **0+240** | 8<br>HDPE Liner<br>φ=18°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.58 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 2.5m. Thawed layer thickness is h=2m |  |

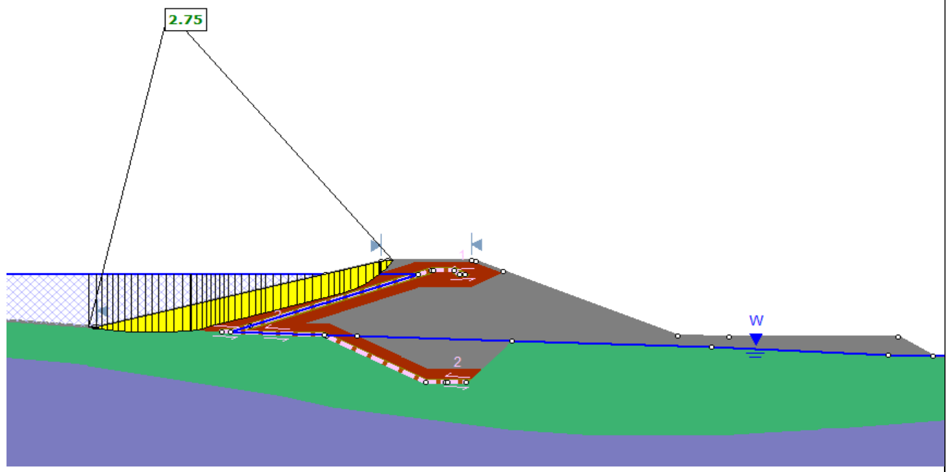
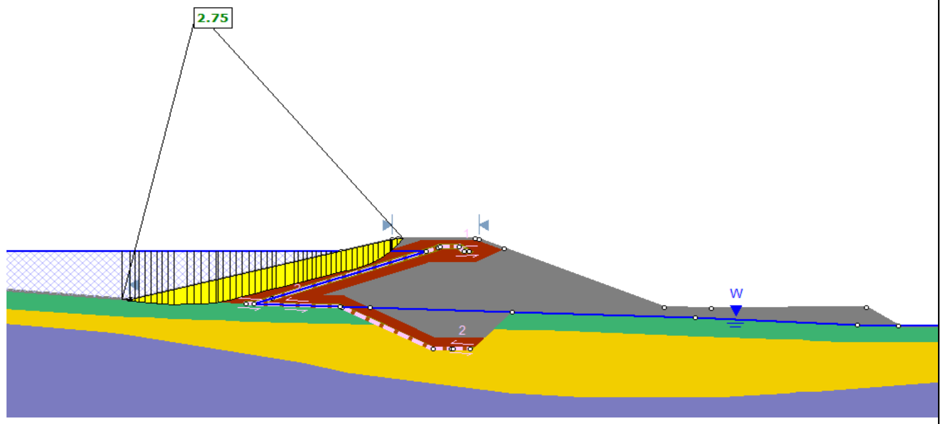
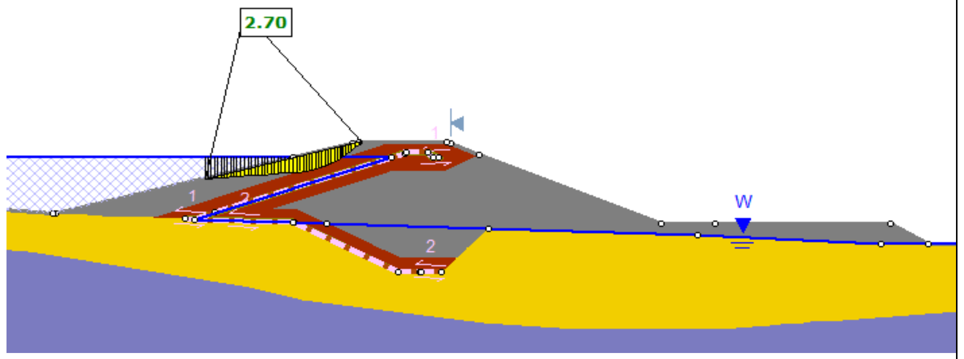
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **7.01** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip is surface is 0.5m. Frozen Overburden. |  |
| **7.02** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **7.03** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |

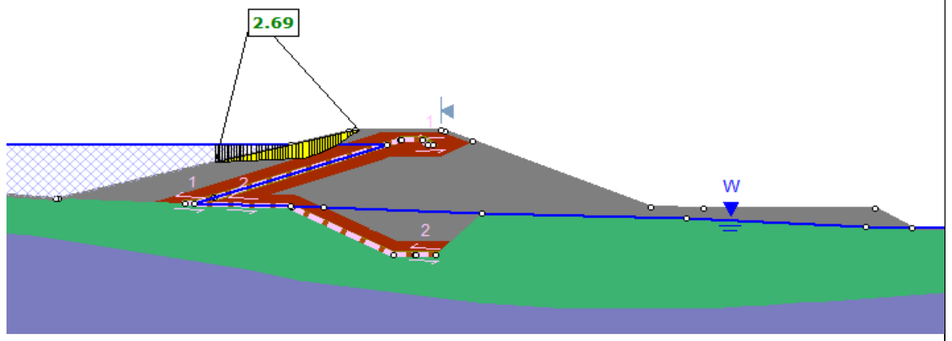
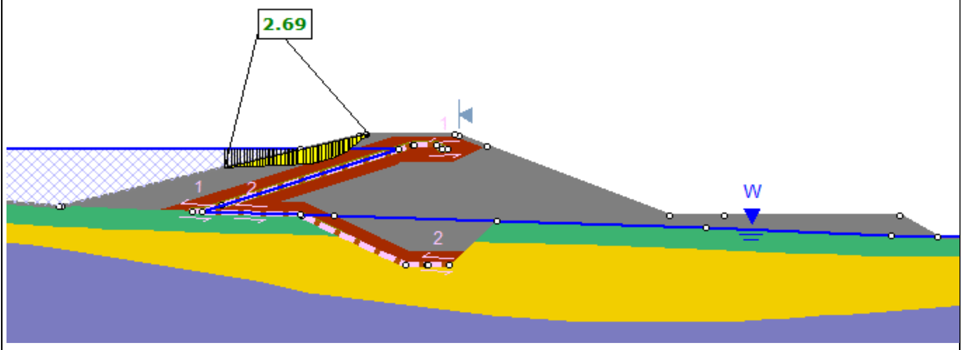
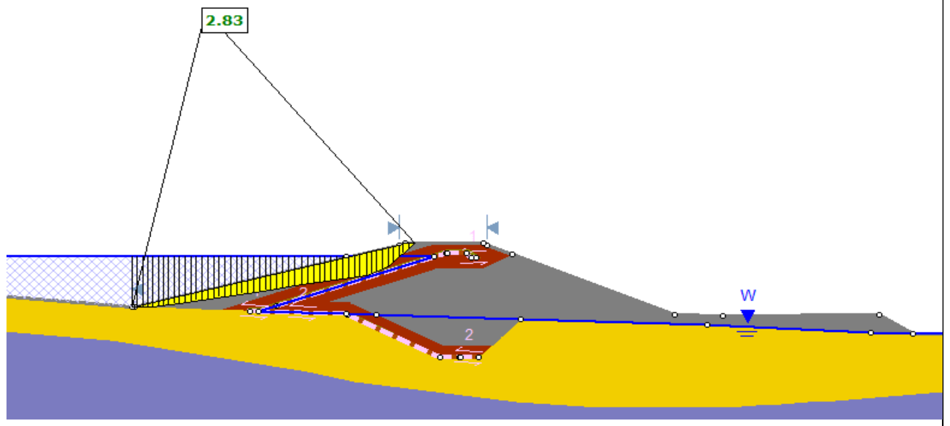
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **7.04** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.82 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| **7.05** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **7.06** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |

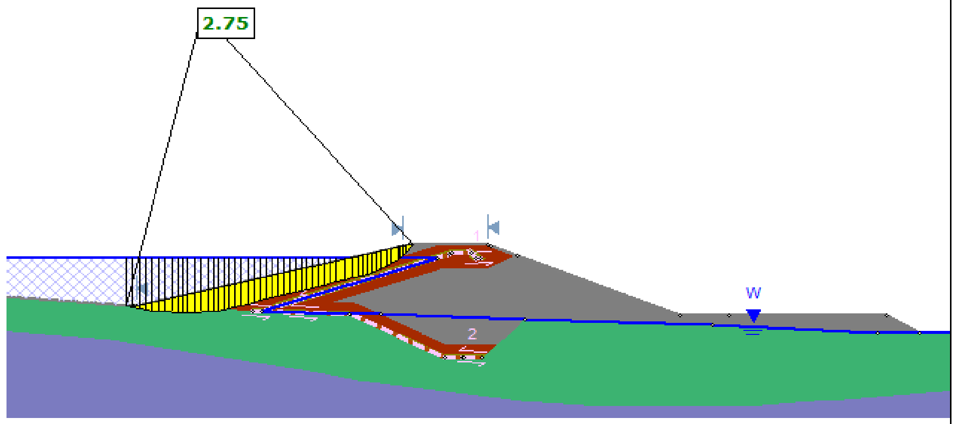
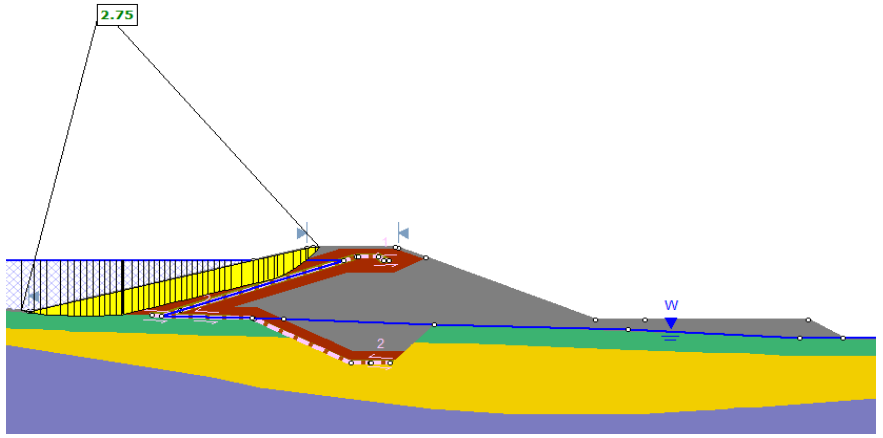
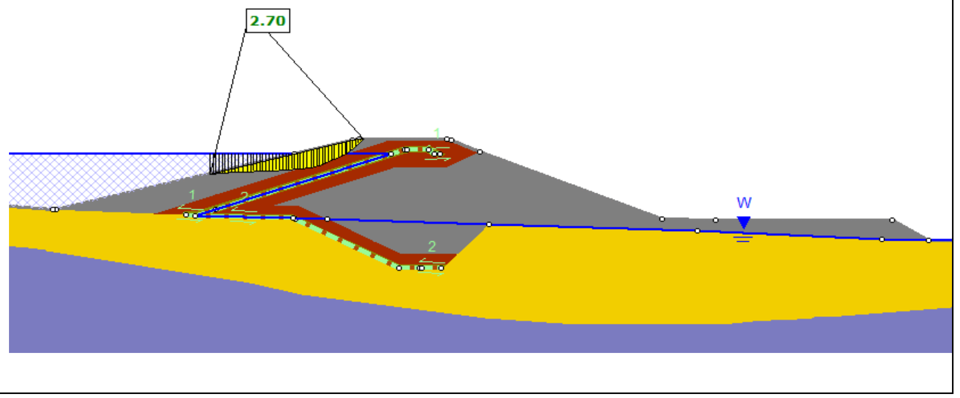
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **7.07** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.0m. Frozen Overburden |  |
| **7.08** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.70 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.0m. Thawed Overburden |  |
| **7.09** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.70 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.0m. Thawed layer thickness is h=2m |  |
| **7.10** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |

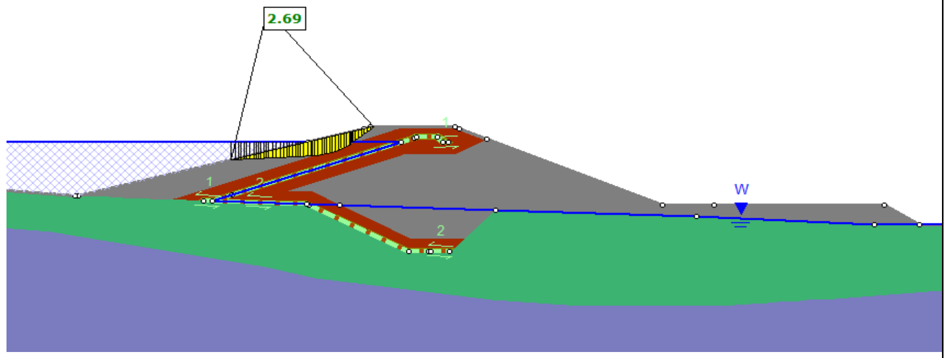
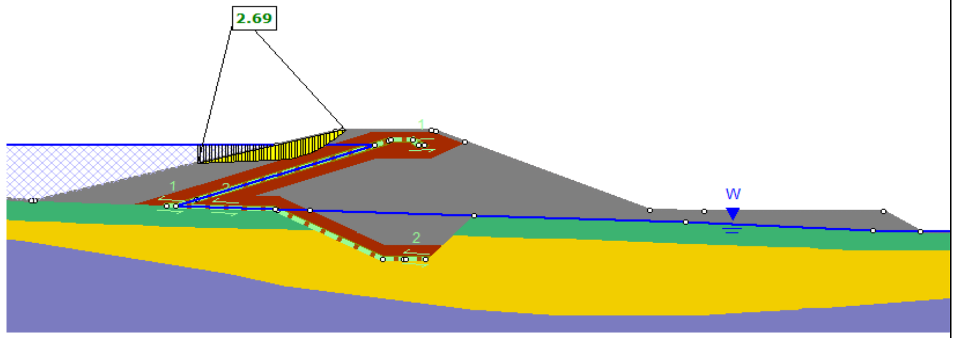
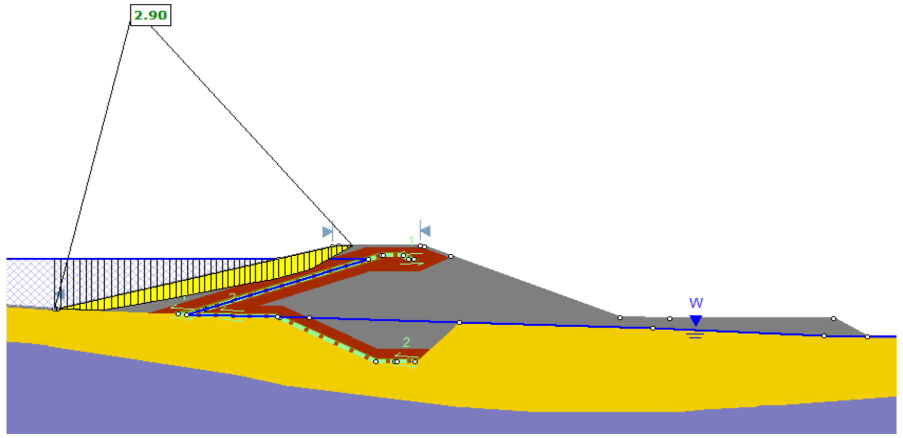
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **7.11** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **7.12** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.70 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |
| **7.13** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.87 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |

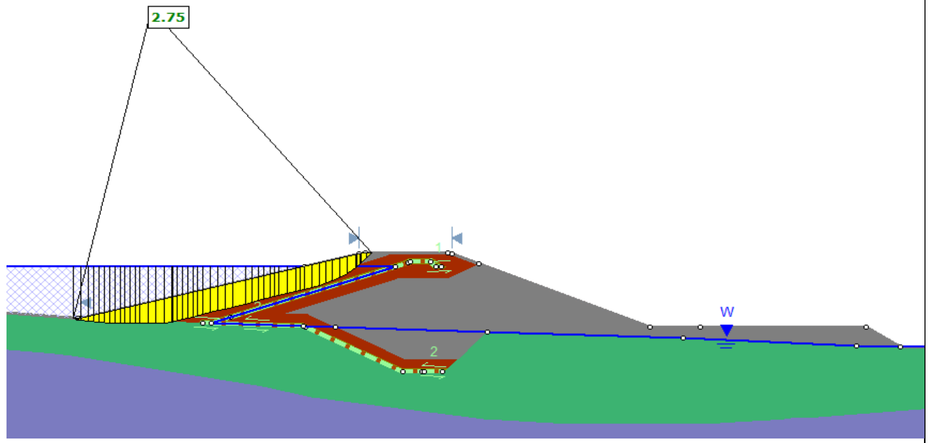
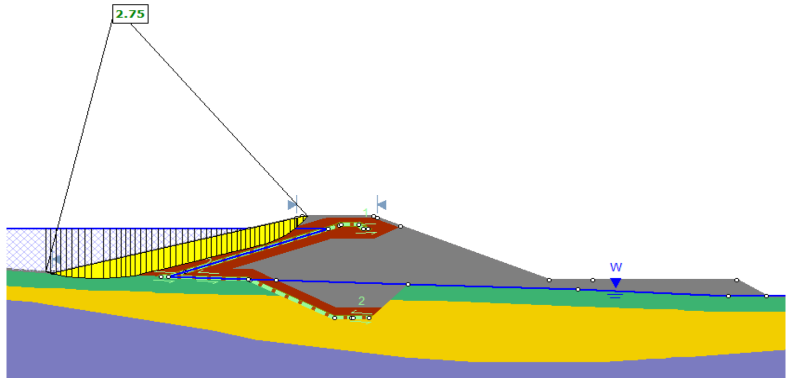
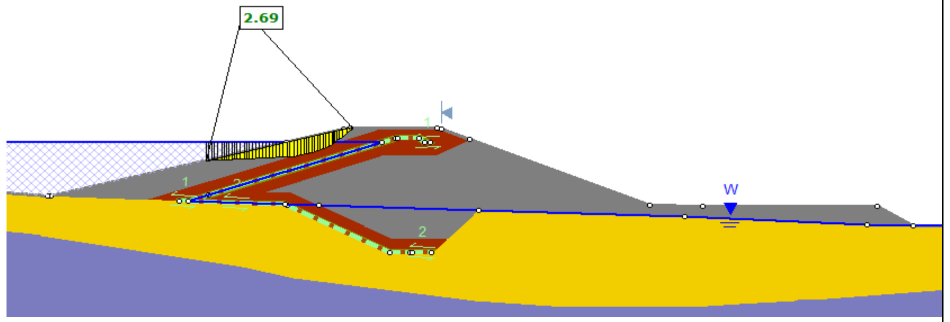
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **7.14** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **7.15** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |
| **7.16** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.83 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Frozen Overburden |  |

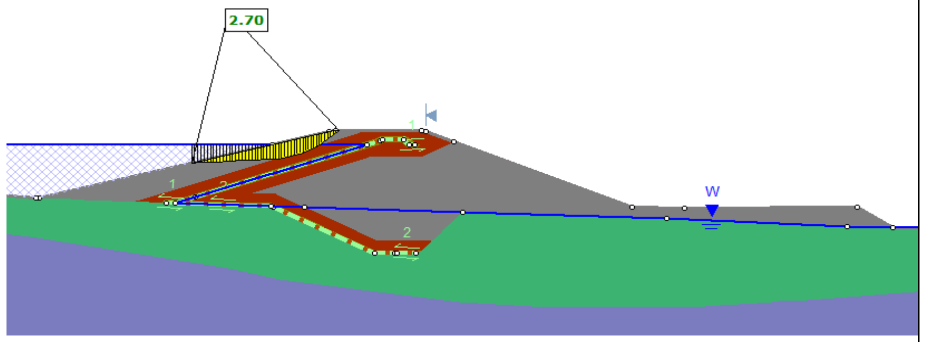
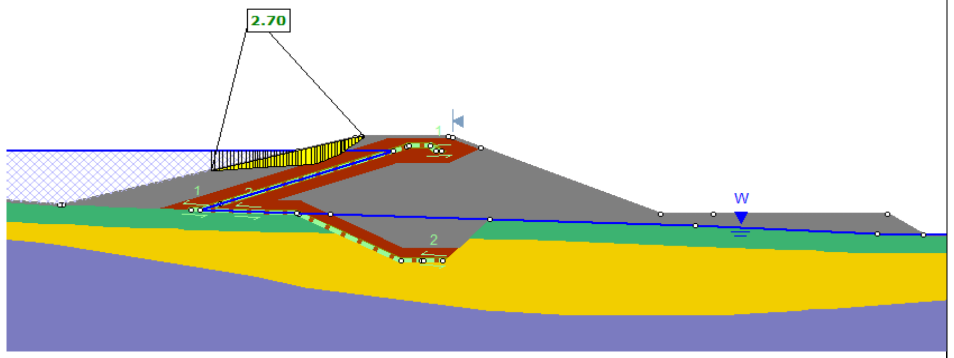
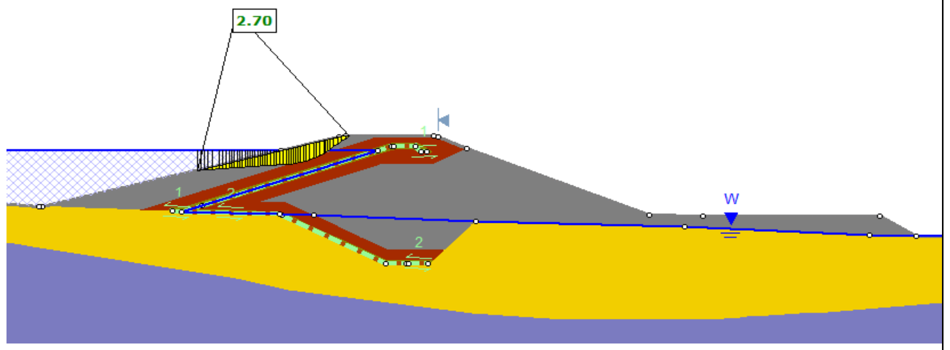
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| 7.17 | 0+240 | **7**<br>HDPE Liner<br>φ=22°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Thawed Overburden |  |
| 7.18 | 0+240 | **7**<br>HDPE Liner<br>φ=22°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Thawed layer thickness is h=2m |  |
| 7.19 | 0+240 | **7**<br>HDPE Liner<br>φ=22°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.70 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Frozen Overburden. |  |

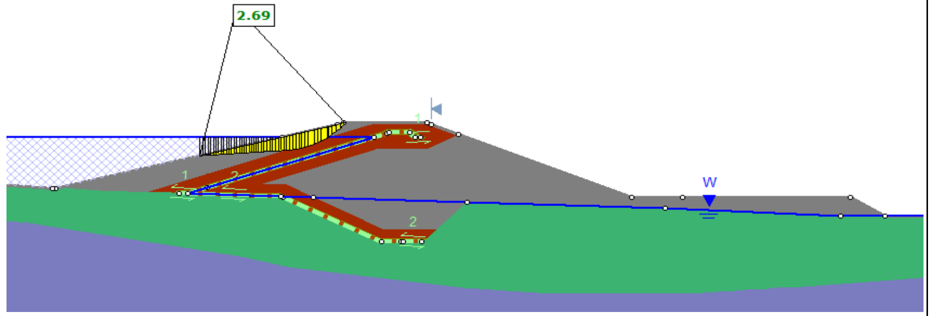
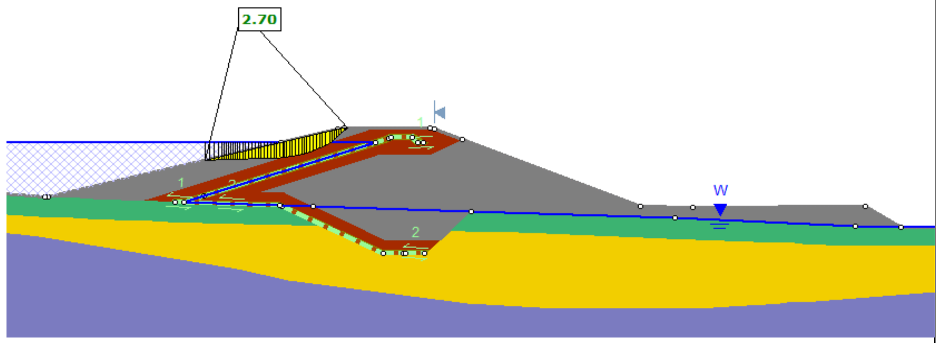
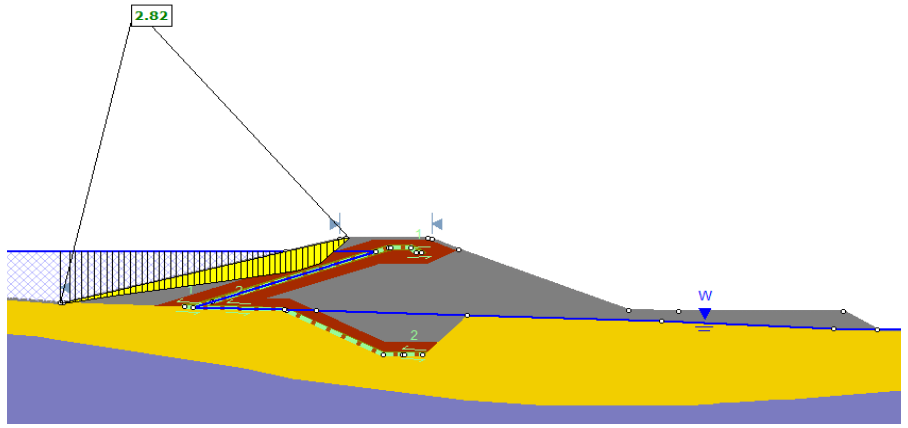
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **7.20** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Thawed overburden. |  |
| **7.21** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Thawed layer thickness is h=2m. |  |
| **7.22** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.83 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 2.5m Frozen overburden. |  |

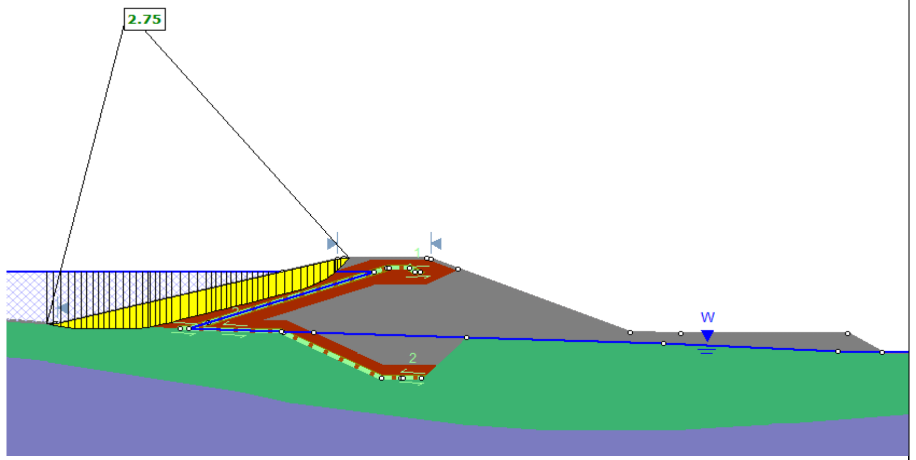
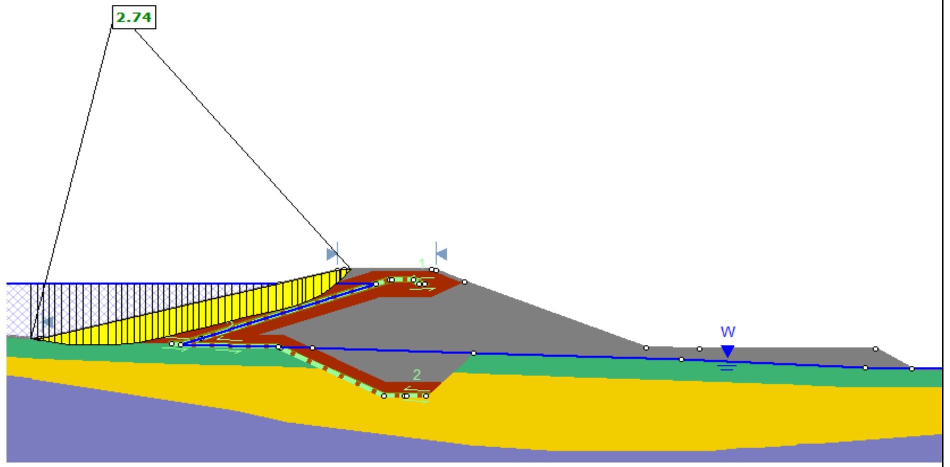
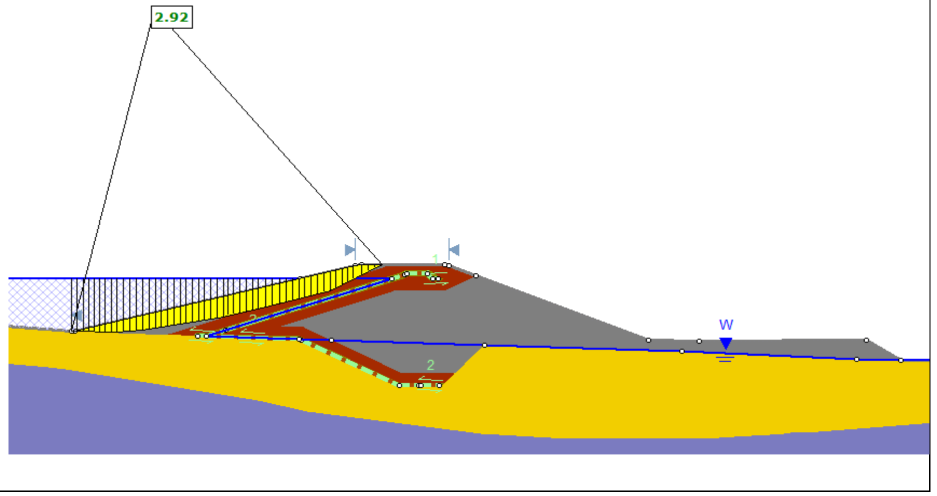
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **7.23** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 2.5m  Thawed overburden. |  |
| **7.24** | **0+240** | **7**<br>HDPE Liner<br>φ=22°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 2.5m  Thawed layer thickness is h=2m |  |
| **6.01** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.70 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Frozen Overburden. |  |

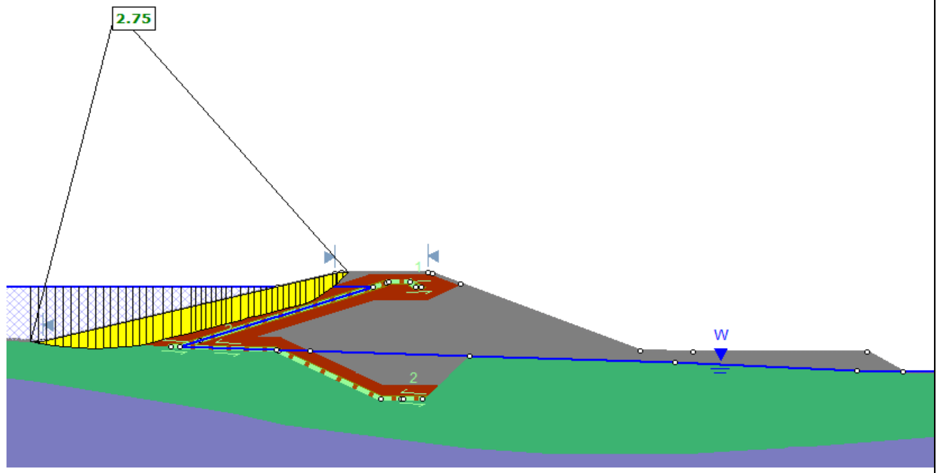
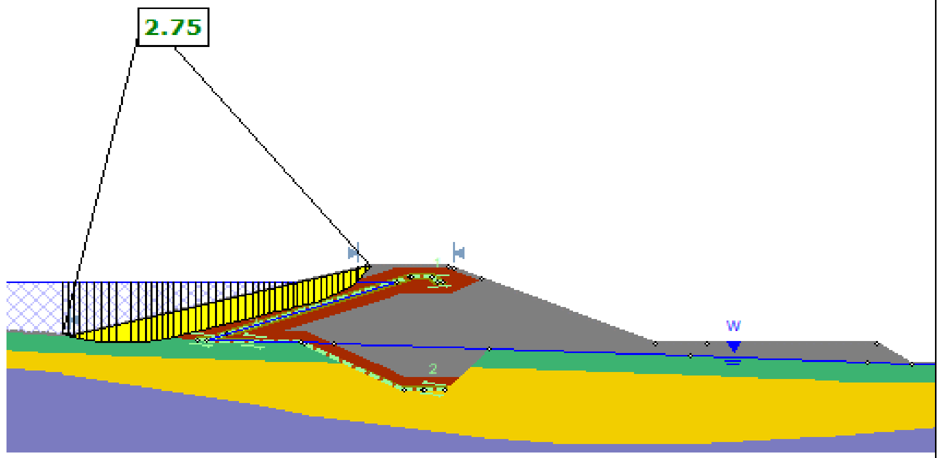
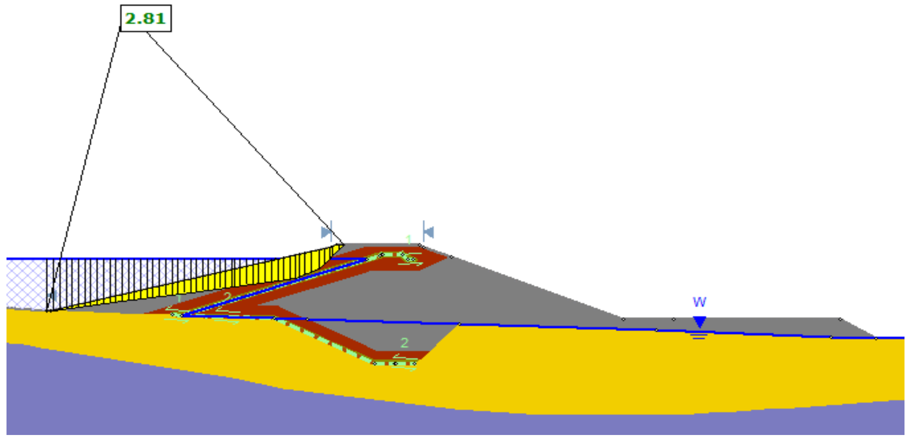
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **6.02** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **6.03** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |
| **6.04** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.90 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |

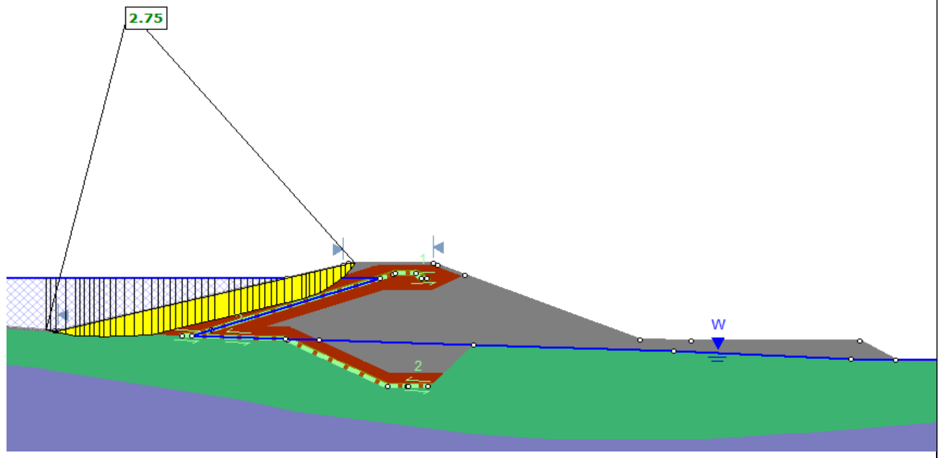
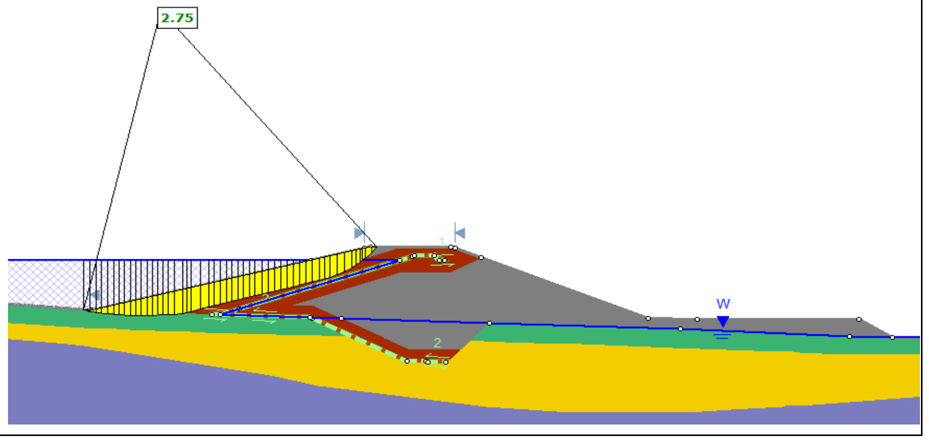
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **6.05** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **6.06** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |
| **6.07** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.0m. Frozen Overburden |  |

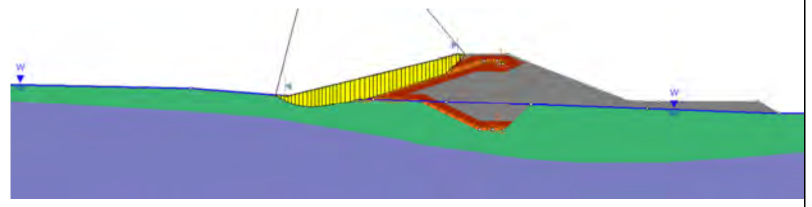
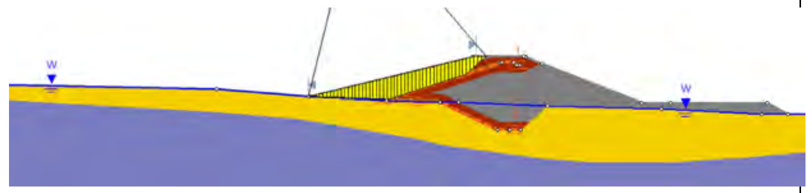
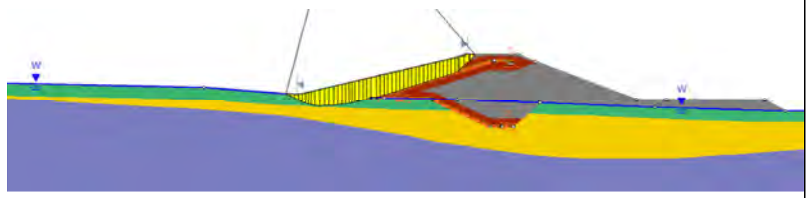
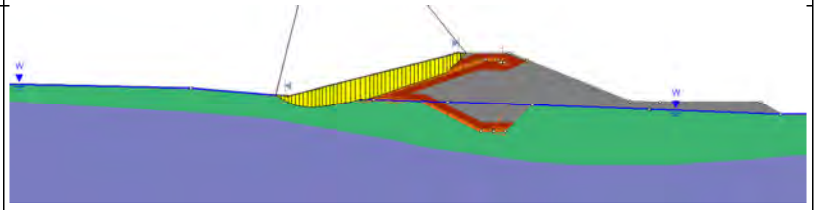
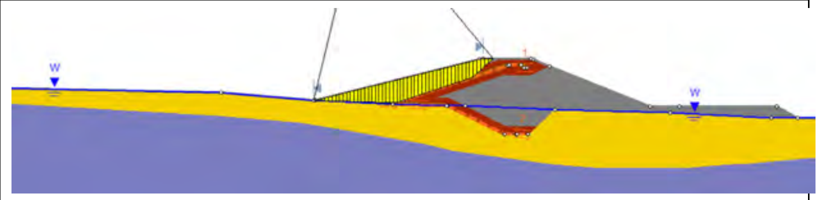
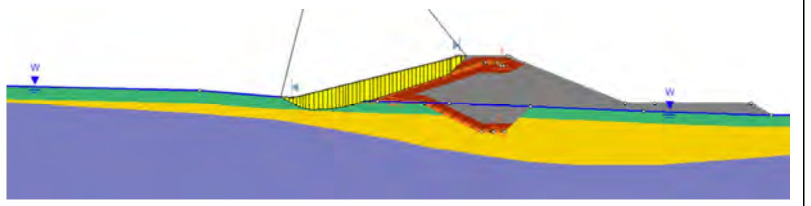
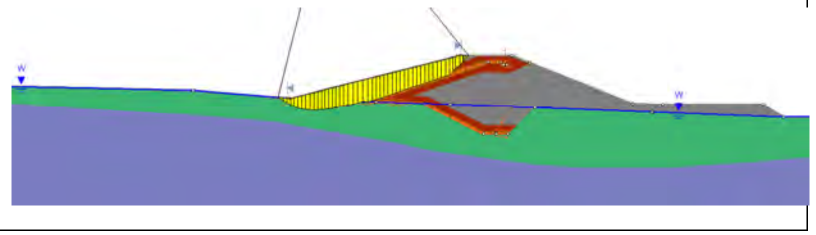
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **6.08** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.70 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.0m. Thawed Overburden |  |
| **6.09** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.70 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.0m. Thawed layer thickness is h=2m |  |
| **6.10** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.70 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |

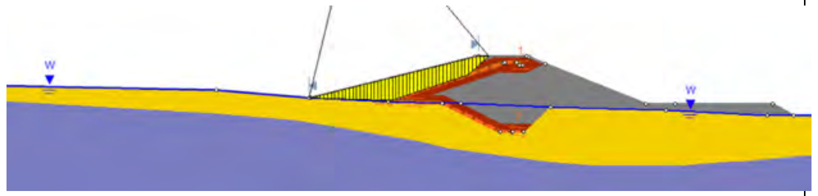
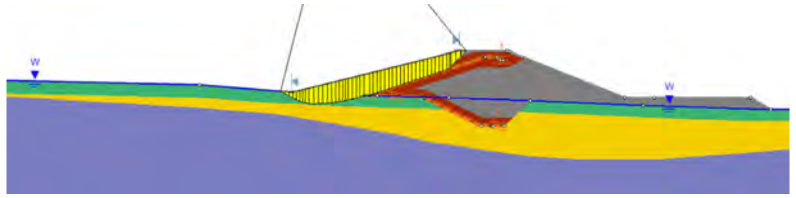
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **6.11** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.69 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **6.12** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Auto Locate) | Slide 9.0 | Spencer | Water Level | No | 2.70 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |
| **6.13** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.82 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |

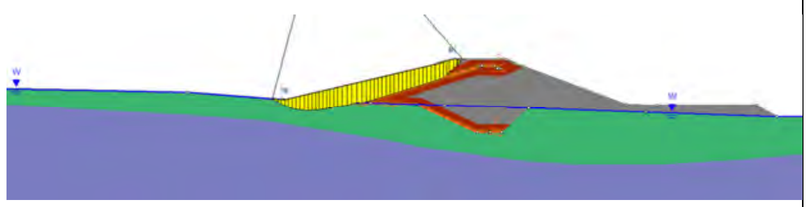
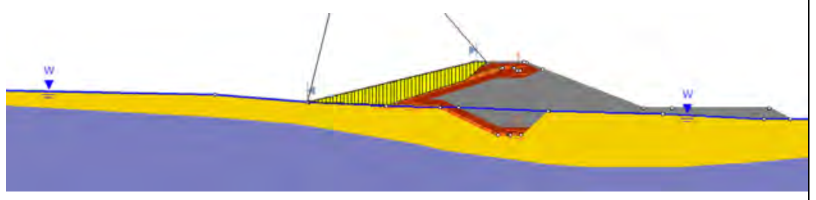
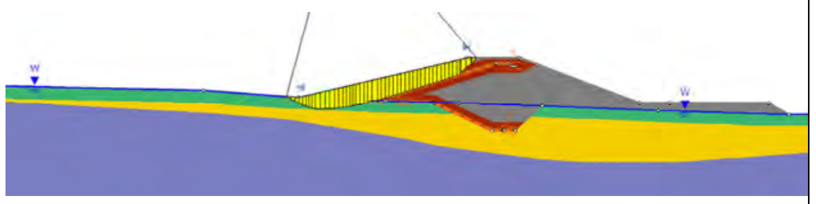
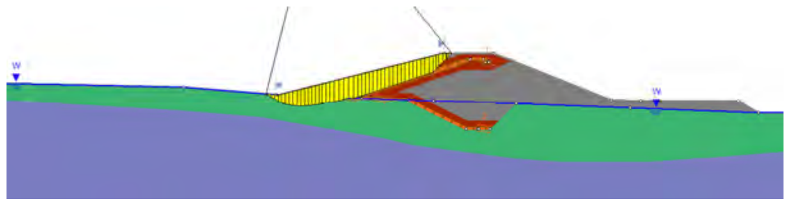
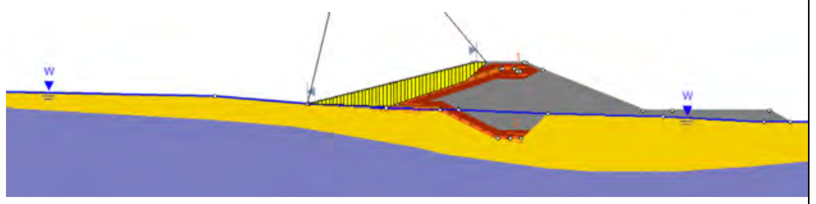
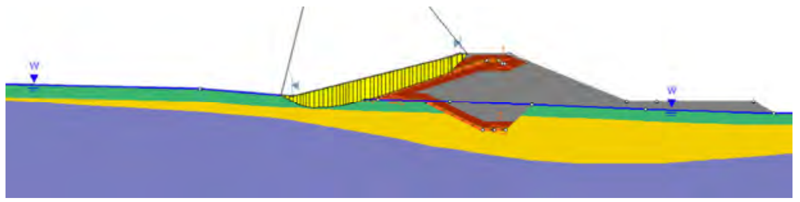
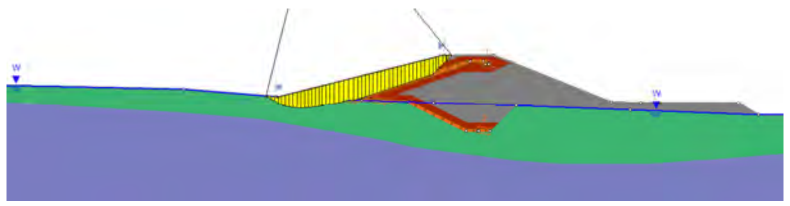
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **6.14** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |
| **6.15** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.74 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |
| **6.16** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.92 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Frozen Overburden |  |

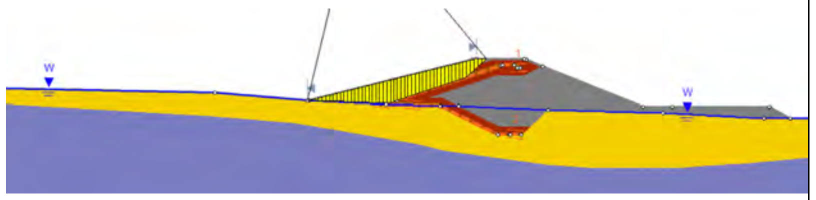
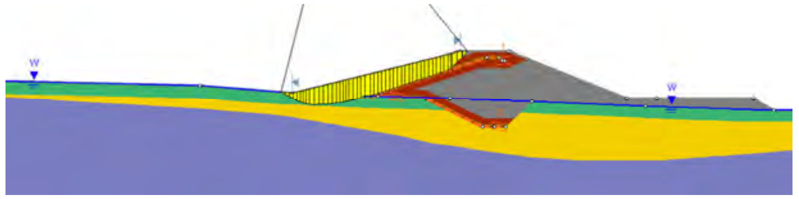
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **6.17** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Thawed Overburden |  |
| **6.18** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. No minimum depth of the slip surface is specified. Thawed layer thickness is h=2m |  |
| **6.19** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.81 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 2.5m. Frozen foundation |  |

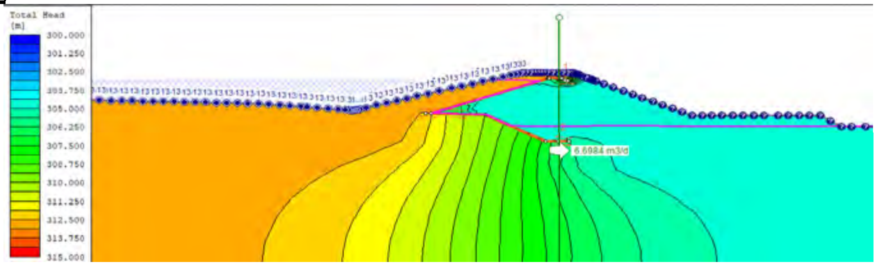
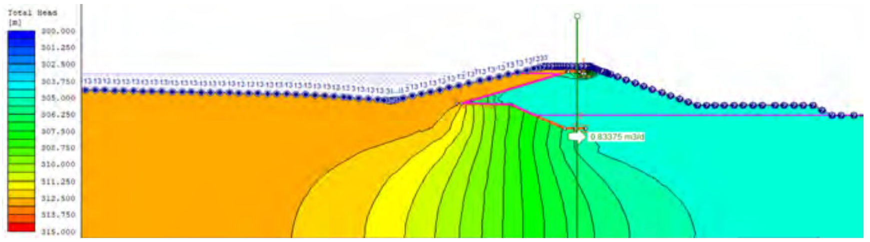
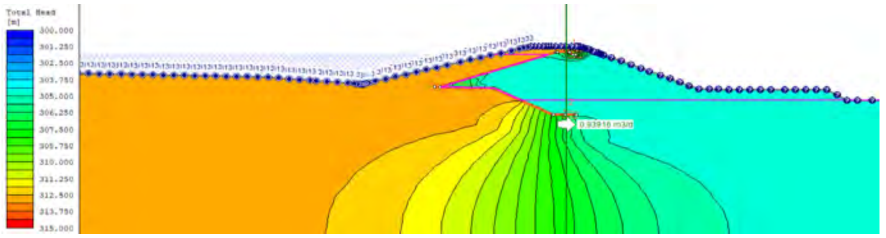
| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimum FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **6.20** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 2.5m. Thawed foundation |  |
| **6.21** | **0+240** | **6**<br>HDPE Liner<br>φ=25°<br>(Entry & Exit) | Slide 9.0 | Spencer | Water Level | No | 2.75 | Slip surface search from right to left (upstream). Embankment H=7m. The minimum depth of the slip surface is 2.5m. Thawed layer thickness is h=2m |  |

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimun FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **7.01** | **Section (0+240)** | **9**<br>**Rapid Drawdown (Auto Locate)** | Slide 9.0 | Spencer | Water level | No | 2.04 | Slip surface search from right to left (upstream). Embankment H=7.0m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **7.02** | **Section (0+240)** | **9**<br>Rapid Drawdown (Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.92 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| **7.03** | **Section (0+240)** | **9**<br>**Rapid Drawdown (Auto Locate)** | Slide 9.0 | Spencer | Water level | No | 2.04 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |
| **7.01** | **Section (0+240)** | **9**<br>**Rapid Drawdown (Auto Locate)** | Slide 9.0 | Spencer | Water level | No | 2.04 | Slip surface search from right to left (upstream). Embankment H=7.0m. The minimum depth of the slip surface is 1m. Thawed Overburden |  |
| **7.02** | **Section (0+240)** | **9**<br>Rapid Drawdown (Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.90 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 1m. Frozen Overburden |  |
| **7.03** | **Section (0+240)** | **9**<br>**Rapid Drawdown (Auto Locate)** | Slide 9.0 | Spencer | Water level | No | 2.04 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 1m. Thawed layer thickness is h=2m |  |
| **7.01** | **Section (0+240)** | **9**<br>**Rapid Drawdown (Auto Locate)** | Slide 9.0 | Spencer | Water level | No | 2.04 | Slip surface search from right to left (upstream). Embankment H=7.0m. The minimum depth of the slip surface is 1.5m. Thawed Overburden |  |

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimun FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **7.02** | **Section (0+240)** | **9**<br>Rapid<br>Drawdown<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.91 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 1.5m. Frozen Overburden |  |
| **7.03** | **Section (0+240)** | **9**<br>**Rapid**<br>**Drawdown**<br>**(Auto Locate)** | Slide 9.0 | Spencer | Water level | No | 2.04 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 1.5m. Thawed layer thickness is h=2m |  |

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimun FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **10.01** | **Section (0+240)** | **10**<br>No free water level<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.42 | Slip surface search from right to left (upstream). Embankment H=7.0m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **10.02** | **Section (0+240)** | **10**<br>No free water level<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.91 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| **10.03** | **Section (0+240)** | **10**<br>No free water level<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.42 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |
| **10.04** | **Section (0+240)** | **10**<br>No free water level<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.41 | Slip surface search from right to left (upstream). Embankment H=7.0m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |
| **10.05** | **Section (0+240)** | **10**<br>No free water level<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.91 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| **10.06** | **Section (0+240)** | **10**<br>No free water level<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.42 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |
| **10.07** | **Section (0+240)** | **10**<br>No free water level<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.41 | Slip surface search from right to left (upstream). Embankment H=7.0m. The minimum depth of the slip surface is 0.5m. Thawed Overburden |  |

| Run | Section | Case | Software Used | Limit Equilibrium Method | Water/Pwp Conditions | Seismic | Minimun FOS | Comments | |
|---|---|---|---|---|---|---|---|---|---|
| **10.08** | **Section (0+240)** | **10**<br>No free water level<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.91 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Frozen Overburden |  |
| **10.09** | **Section (0+240)** | **10**<br>No free water level<br>(Auto Locate) | Slide 9.0 | Spencer | Water level | No | 2.42 | Slip surface search from right to left (upstream). Embankment H=3.0m. The minimum depth of the slip surface is 0.5m. Thawed layer thickness is h=2m |  |

| Run | Section | Case | Software Used | Water/Pwp Conditions | Leakage rate, m³/s | Leakage rate, m³/d | Comments | |
|---|---|---|---|---|---|---|---|---|
| **11.01** | **Section (0+240)** | **11<br>Seepage analysis** | Slide 9.0 | From Slide's Finite Element Groundwater Calculator | 8.04E-05 | 6.7 | Embankment H=7.0m. Thawed overburden. With HDPE Liner (Hydraulic conductivity k=5e-10 m/s). Total head contours are shown in the screenshot. |  |
| **11.02** | **Section (0+240)** | **11<br>Seepage analysis** | Slide 9.0 | From Slide's Finite Element Groundwater Calculator | 9.96E-06 | 0.83 | Embankment H=7.0m. Frozen overburden. With HDPE Liner (Hydraulic conductivity k=5e-10 m/s). Total head contours are shown in the screenshot. |  |
| **11.03** | **Section (0+240)** | **11<br>Seepage analysis** | Slide 9.0 | From Slide's Finite Element Groundwater Calculator | 1.12E-05 | 0.93 | Embankment H=7.0m. Thawed layer h=2m. With HDPE Liner (Hydraulic conductivity k=5e-10 m/s). Total head contours are shown in the screenshot. |  |

| Geotechnical Domain | Unit Weight (kN/m$^3$) | Cohesion C' (kPa) | Phi φ' | Hydraulic conductivity, k (m/s) | Comments |
|---|---|---|---|---|---|
| Bedrock | 18 | 0 | 35 | 5.7x10$^{-11}$ | |
| Overburden soil material (Sand/Silt foundation, frozen) | 19 | 40 | 32 | 4.5x10$^{-7}$ | |
| Overburden soil material (Sand/Silt foundation, thawed) | 19 | 0 | 32 | 5x10$^{-5}$ | |
| Bedding Material | 18 | 0 | 36 | 1x10$^{-5}$ | Parameters for sensitivity analysis: k=1x10$^{-7}$, k=1x10$^{-9}$ |
| Transition Material | 18 | 0 | 36 | 1x10$^{-5}$ | |
| ROQ (Thawed, Unconsolidated) | 20 | 0 | 38 | 2x10$^{-1}$ | Parameters for sensitivity analysis: k=1x10$^{-2}$, k=1x10$^{-3}$ |
| HDPE Liner | 10 | 0 | 28 | 5x10$^{-10}$ | Parameters for sensitivity analysis: j= 18°, 22°, 25° |

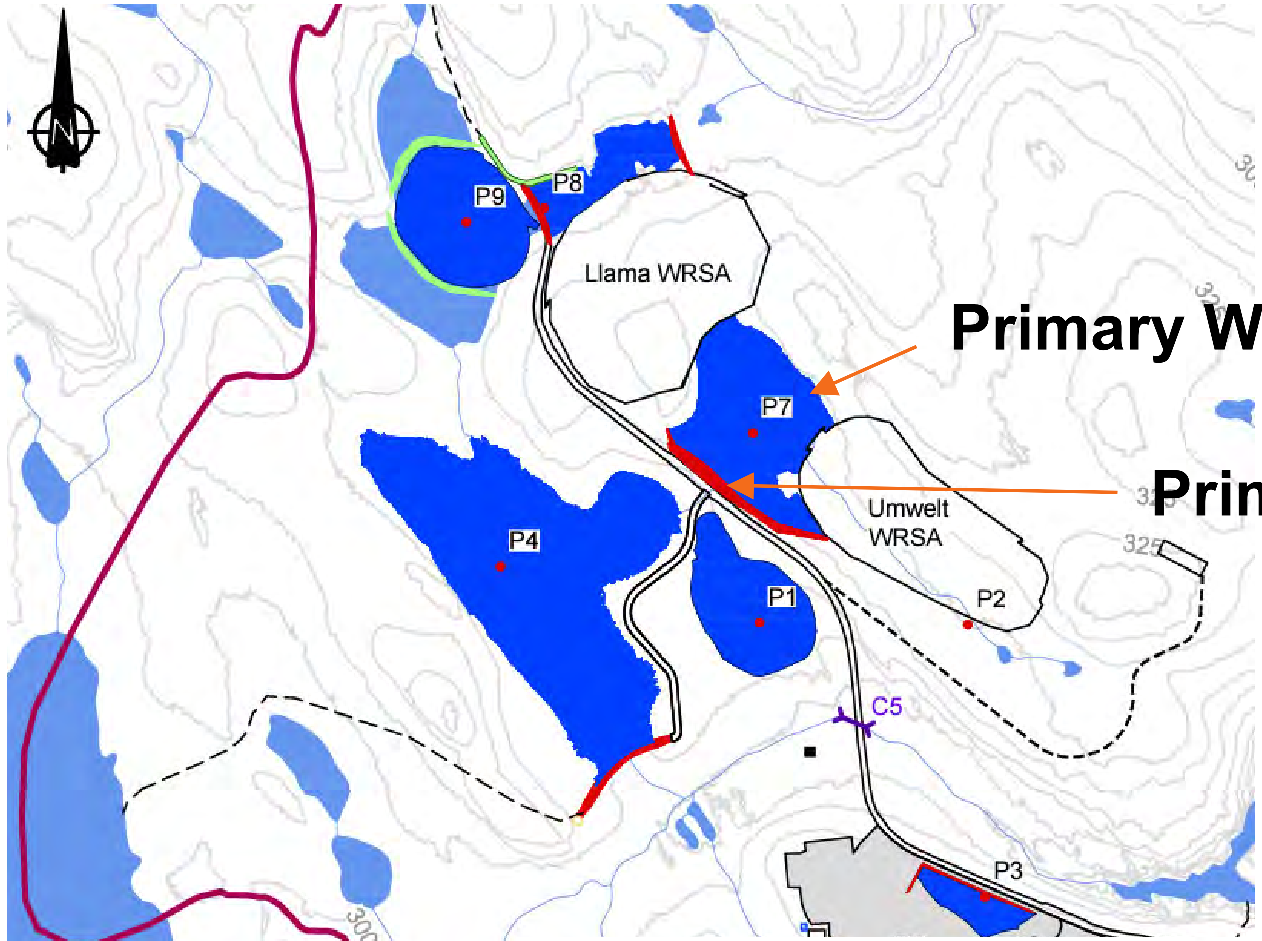
**Material properties are based on:**

SRK Consulting (Canada) Inc. 2019. Back River Property Geotechnical Design Parameters – Revision 0. For Comment. Report prepared for Sabina Gold & Silver. July 2019.

# Back River – Primary Pond Dam

## Slope Stability Analysis Runs (2022 Overview)

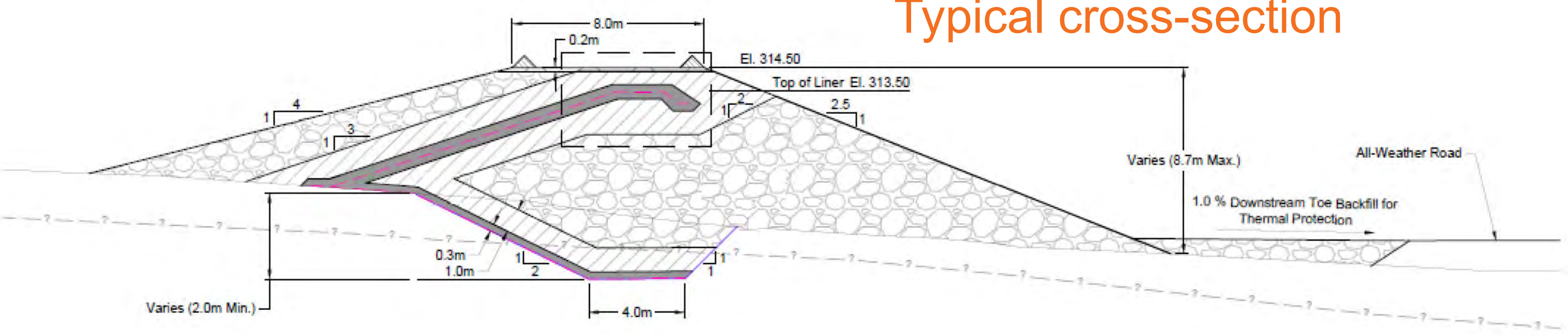
# Projecting Location



**Primary WD Pond**

**Primary Dam**

Typical cross-section

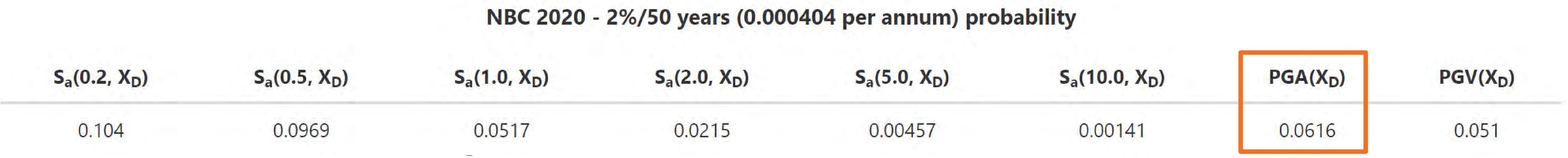


LEGEND

| | |
|---|---|
| ▭ | Contours |
| — | Design Surface |
| — | Excavation |
| — | Existing Ground |
| – – | HDPE Liner System |
| – – | Non-woven Geotextile |
| –·– | Inferred Bedrock |
| — | Waterbody |
| ▭ | Other Design Infrastructure |
| ▨ | Primary Pond Design Infrastructure |
| ▨ | Run of Quarry |
| ▨ | Surfacing |

# Seismicity

2020 National Building Code of Canada Seismic Hazard Tool (nrcan.gc.ca)



**NBC 2020 - 2%/50 years (0.000404 per annum) probability**

| $S_a(0.2, X_D)$ | $S_a(0.5, X_D)$ | $S_a(1.0, X_D)$ | $S_a(2.0, X_D)$ | $S_a(5.0, X_D)$ | $S_a(10.0, X_D)$ | $PGA(X_D)$ | $PGV(X_D)$ |
|---|---|---|---|---|---|---|---|
| 0.104 | 0.0969 | 0.0517 | 0.0215 | 0.00457 | 0.00141 | 0.0616 | 0.051 |

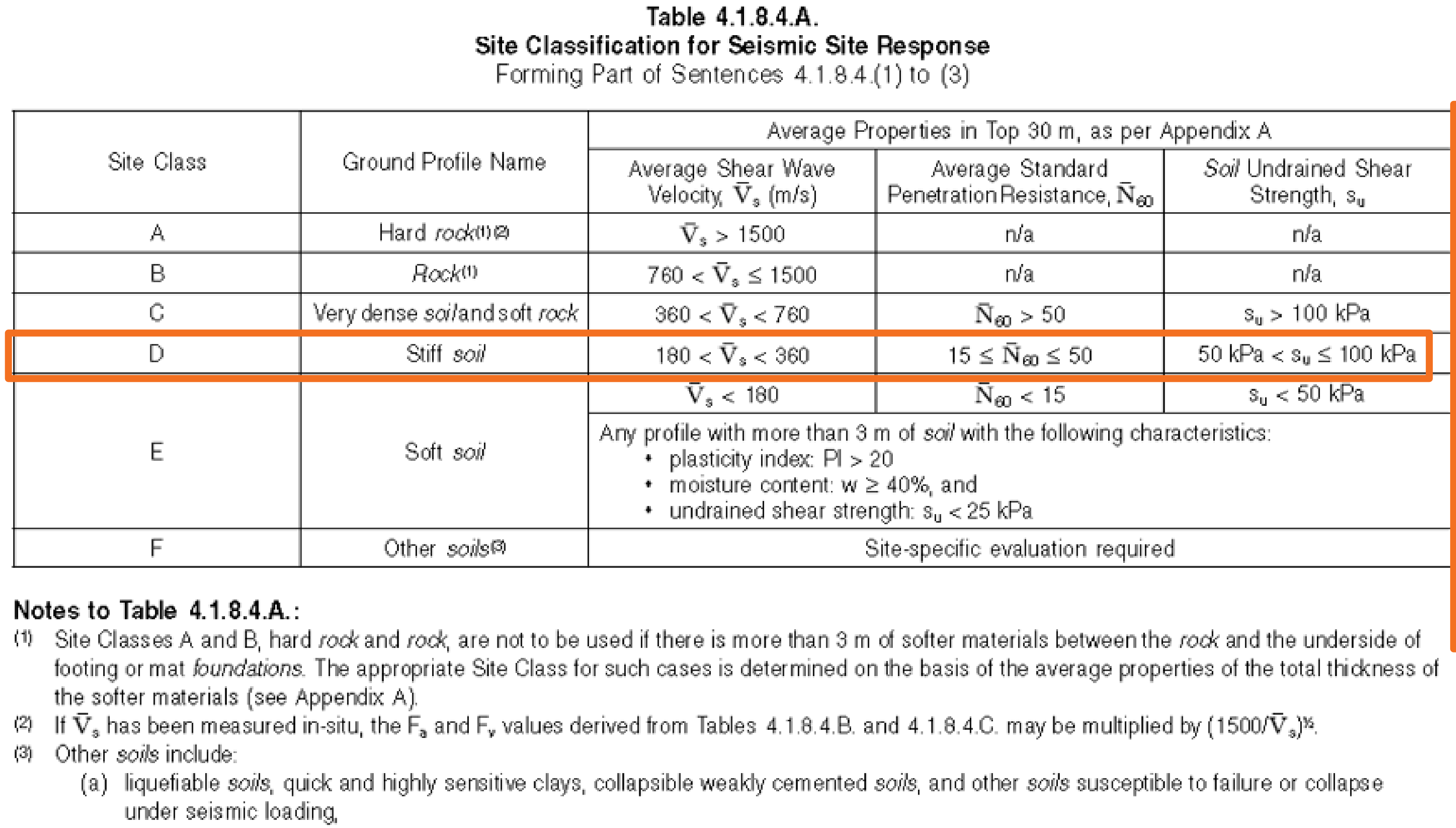


**Table 4.1.8.4.A.**
**Site Classification for Seismic Site Response**
Forming Part of Sentences 4.1.8.4.(1) to (3)

| Site Class | Ground Profile Name | Average Properties in Top 30 m, as per Appendix A | | |
|---|---|---|---|---|
| | | Average Shear Wave Velocity, $\bar{V}_s$ (m/s) | Average Standard Penetration Resistance, $\bar{N}_{60}$ | *Soil* Undrained Shear Strength, $s_u$ |
| A | Hard *rock*(1)(2) | $\bar{V}_s > 1500$ | n/a | n/a |
| B | *Rock*(1) | $760 < \bar{V}_s \leq 1500$ | n/a | n/a |
| C | Very dense *soil* and soft *rock* | $360 < \bar{V}_s < 760$ | $\bar{N}_{60} > 50$ | $s_u > 100$ kPa |
| D | Stiff *soil* | $180 < \bar{V}_s < 360$ | $15 \leq \bar{N}_{60} \leq 50$ | $50 \text{ kPa} < s_u \leq 100$ kPa |
| E | Soft *soil* | $\bar{V}_s < 180$ | $\bar{N}_{60} < 15$ | $s_u < 50$ kPa |
| | | Any profile with more than 3 m of *soil* with the following characteristics:<br>• plasticity index: PI > 20<br>• moisture content: w ≥ 40%, and<br>• undrained shear strength: $s_u < 25$ kPa | | |
| F | Other *soils*(3) | Site-specific evaluation required | | |

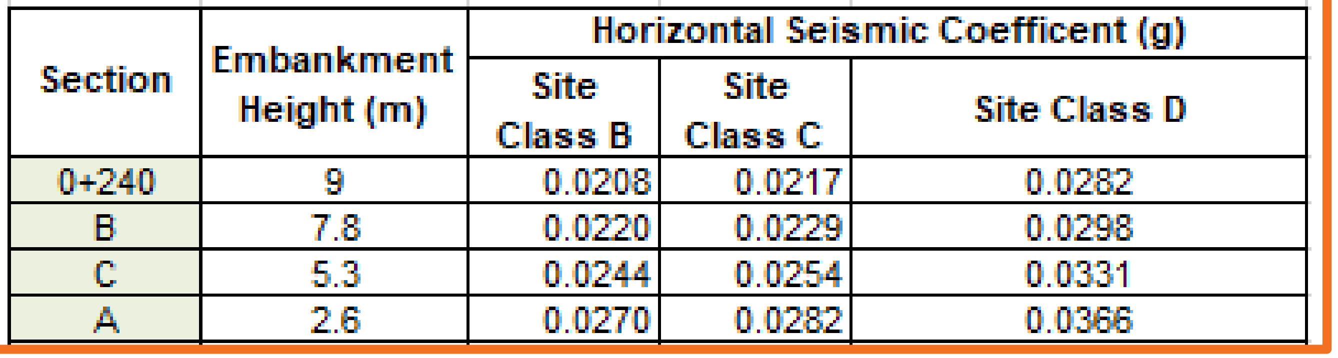
**Notes to Table 4.1.8.4.A.:**

(1) Site Classes A and B, hard *rock* and *rock*, are not to be used if there is more than 3 m of softer materials between the *rock* and the underside of footing or mat *foundations*. The appropriate Site Class for such cases is determined on the basis of the average properties of the total thickness of the softer materials (see Appendix A).

(2) If $\bar{V}_s$ has been measured in-situ, the $F_a$ and $F_v$ values derived from Tables 4.1.8.4.B. and 4.1.8.4.C. may be multiplied by $(1500/\bar{V}_s)^{½}$.

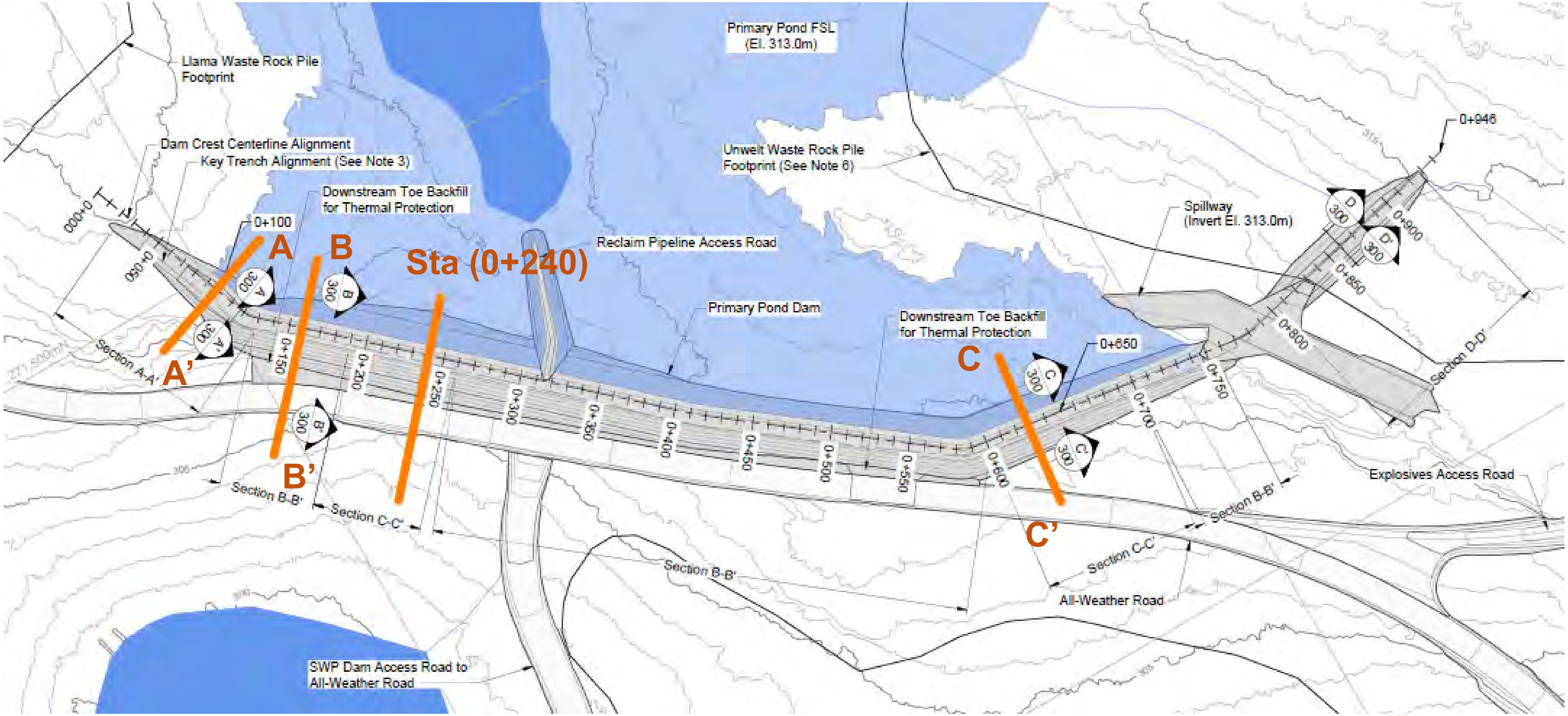
(3) Other *soils* include:
   (a) liquefiable *soils*, quick and highly sensitive clays, collapsible weakly cemented *soils*, and other *soils* susceptible to failure or collapse under seismic loading,

Site-Specific Horizontal Seismic Coefficient used in the slope stability runs (FHWA 2011)



| Section | Embankment Height (m) | Horizontal Seismic Coefficent (g) | | |
|---|---|---|---|---|
| | | Site Class B | Site Class C | Site Class D |
| 0+240 | 9 | 0.0208 | 0.0217 | 0.0282 |
| B | 7.8 | 0.0220 | 0.0229 | 0.0298 |
| C | 5.3 | 0.0244 | 0.0254 | 0.0331 |
| A | 2.6 | 0.0270 | 0.0282 | 0.0366 |

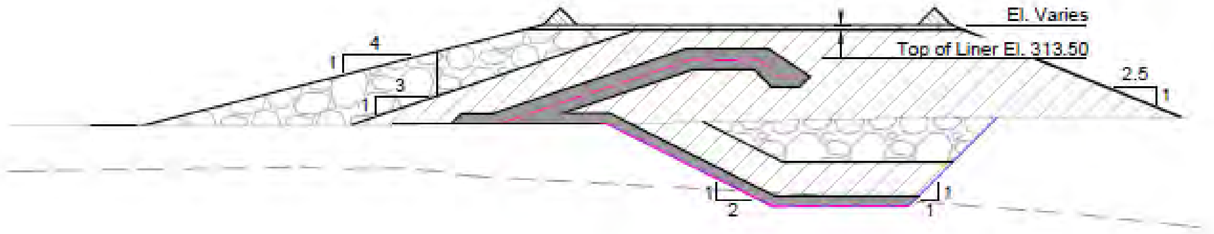
# Plan View



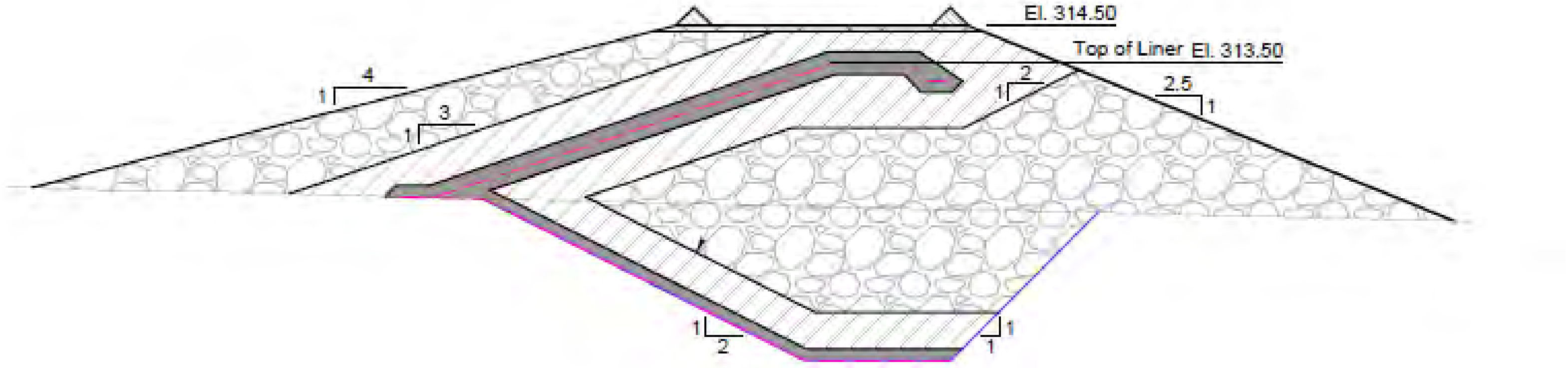
srk consulting

# Sections to be checked

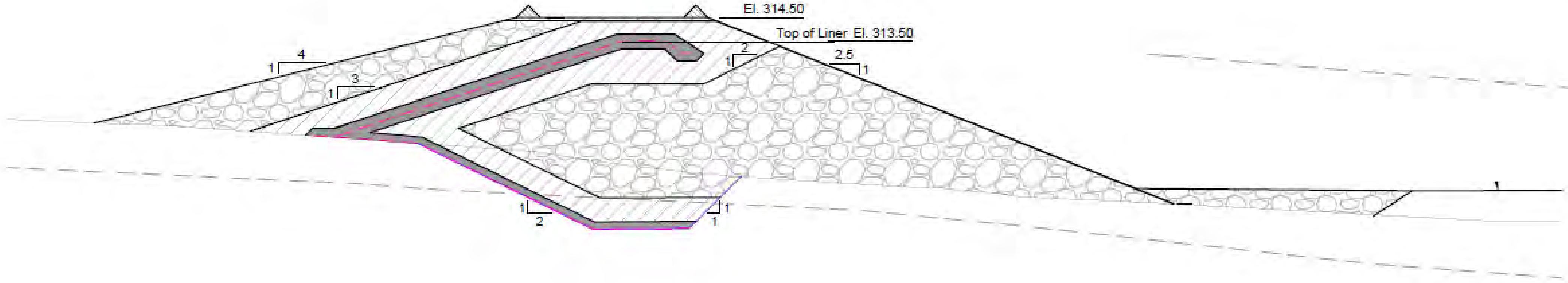
Section A (Sta. 0+115)



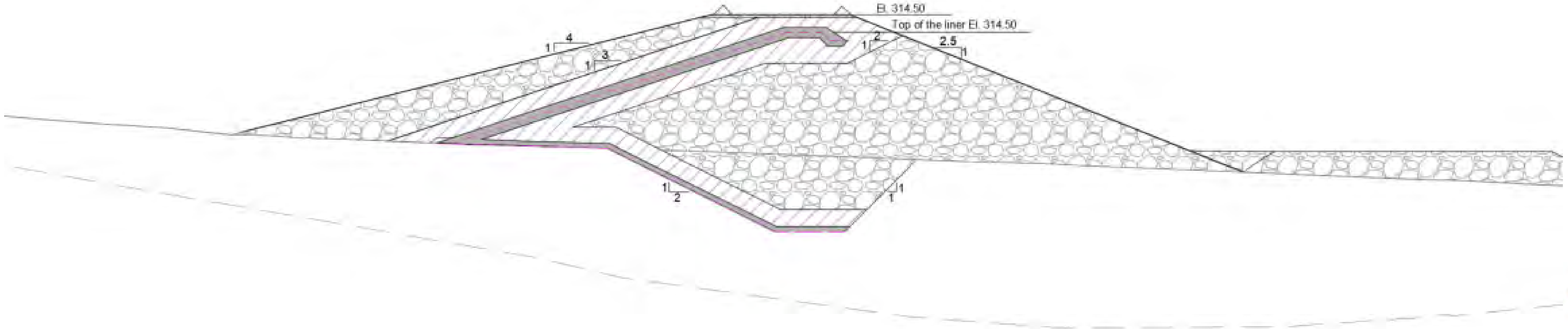
Section C (Sta. 0+630)



Section B (Sta. 0+160)



Section (Sta. 0+240)



# Material Properties

| Material Name | Color | Unit Weight (kN/m3) | Strength Type | Cohesion (kPa) | Phi (deg) | Allow Sliding | Water Surface | Hu Type | Hu |
|---|---|---|---|---|---|---|---|---|---|
| Sand Foundation (Frozen) | 🟨 | 19 | Mohr-Coulomb | 40 | 32 |  | Water Surface | Custom | 1 |
| Sand Foundation (Thawed) | 🟩 | 19 | Mohr-Coulomb | 0 | 32 |  | Water Surface | Custom | 1 |
| HDPE Liner (28 deg) | 🟧 | 10 | Mohr-Coulomb | 0 | 28 |  | Water Surface | Custom | 1 |
| Bedrock | 🟪 | 18 | Infinite strength |  |  | Yes | Water Surface | Custom | 0 |
| Bedding Material | 🟫 | 18 | Mohr-Coulomb | 0 | 36 |  | Water Surface | Custom | 1 |
| Transitional Materia | 🟥 | 18 | Mohr-Coulomb | 0 | 36 |  | Water Surface | Custom | 1 |
| ROQ (Thawed, Unconsolidated) | ⬛ | 20 | Mohr-Coulomb | 0 | 38 |  | Water Surface | Custom | 1 |

References:

1. Goose Property - 2015 Overburden Geotechnical Investigation Program (SRK, December 2015)
2. Water Management Infrastructure – Updated Feasibility Study - Stability Analyses – Draft (SRK, May 2020)
3. Laboratory test results (Tetra Tech, 2019)

Name of Method: Spencer and GLE/M-P
Search method: Non-circular Cuckoo search
Min. failure depth for stability analysis: 0.5, 1.0, and 2.0 m

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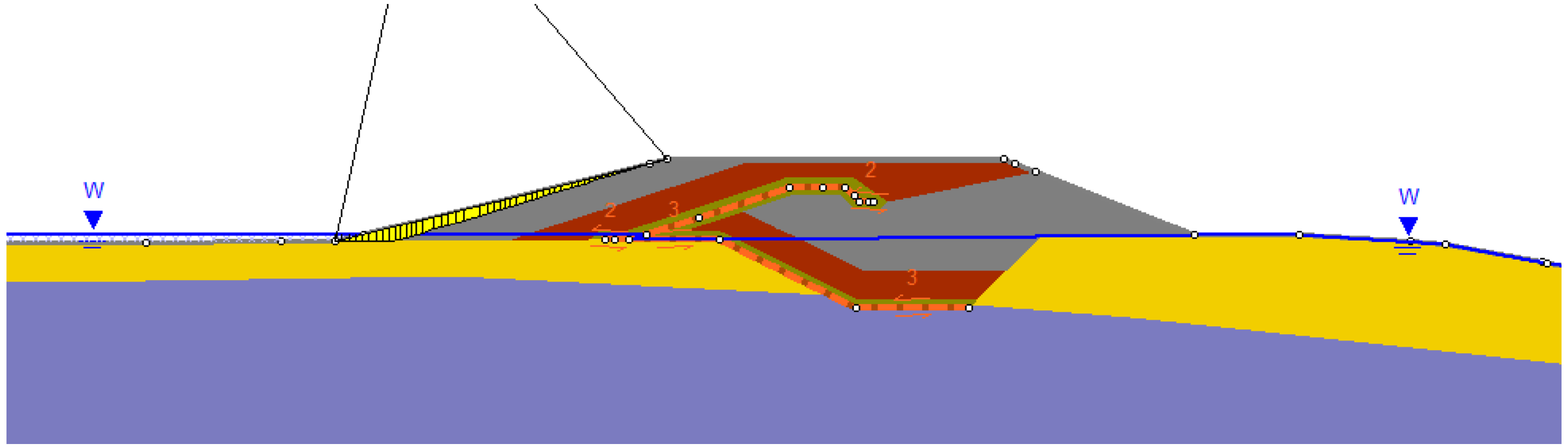
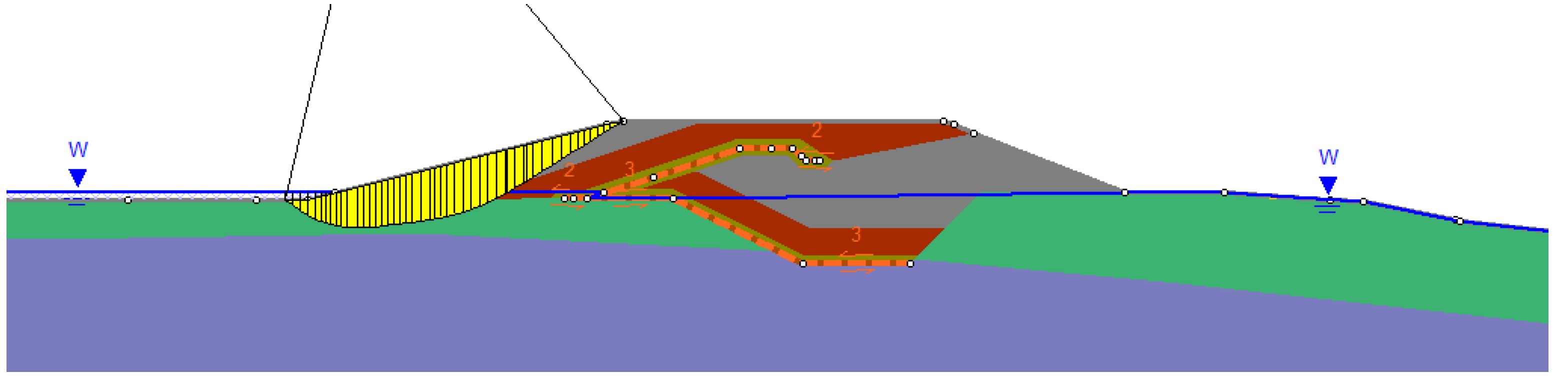
# **Upstream Stability Summary** (Base Case Scenario)

| Cross-section / Station | Assessed Slope | Analysis Type | FOS | | | | | | | | | $\text{FoS}_{\text{MIN}}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Frozen Foundation Condition | | | Thawed Foundation Condition | | | Thawed Active Layer Condition | | | |
| | | | 0.5 m | 1.0 m | 1.5 m | 0.5 m | 1.0 m | 1.5 m | 0.5 m | 1.0 m | 1.5 m | |
| A/ Sta (0+115) | Upstream | Static | 3.0 | 3.1 | 3.2 | 2.3 | 2.4 | 2.4 | - | - | - | 1.5 |
| B/ Sta (0+160) | Upstream | Static | 2.7 | 2.6 | 2.6 | 2.4 | 2.4 | 2.4 | - | - | - | 1.5 |
| -/ Sta (0+240) | Upstream | Static | 2.9 | 2.9 | 2.9 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 2.7 | 1.5 |
| C/ Sta (0+630) | Upstream | Static | 2.7 | 2.7 | 2.7 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 2.6 | 1.5 |
| A/ Sta (0+115) | Upstream | Pseudo-Static | 2.6 | 2.7 | 2.8 | 2.1 | 2.1 | 2.1 | - | - | - | 1.1 |
| B/ Sta (0+160) | Upstream | Pseudo-Static | 2.3 | 2.2 | 2.2 | 2.0 | 2.0 | 2.0 | - | - | - | 1.1 |
| -/ Sta (0+240) | Upstream | Pseudo-Static | 2.4 | 2.4 | 2.4 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 2.3 | 1.1 |
| C/ Sta (0+630) | Upstream | Pseudo-Static | 2.3 | 2.3 | 2.3 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 2.1 | 1.1 |

# Upstream Stability – Base Case – Section A



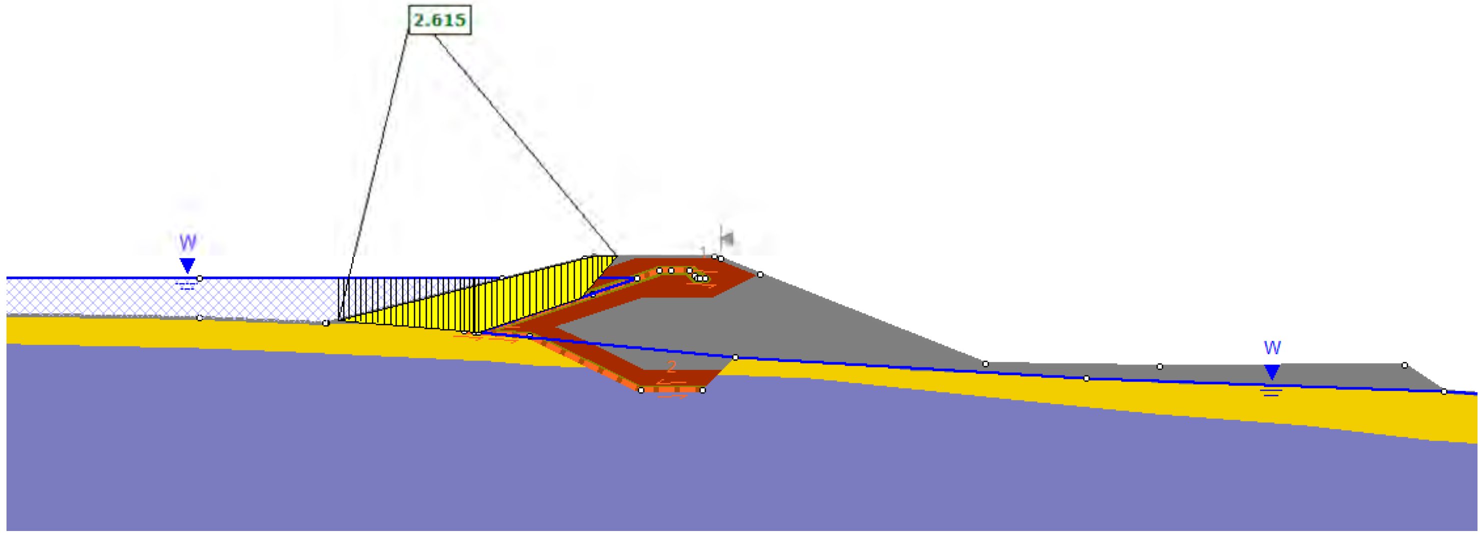
Frozen Foundation



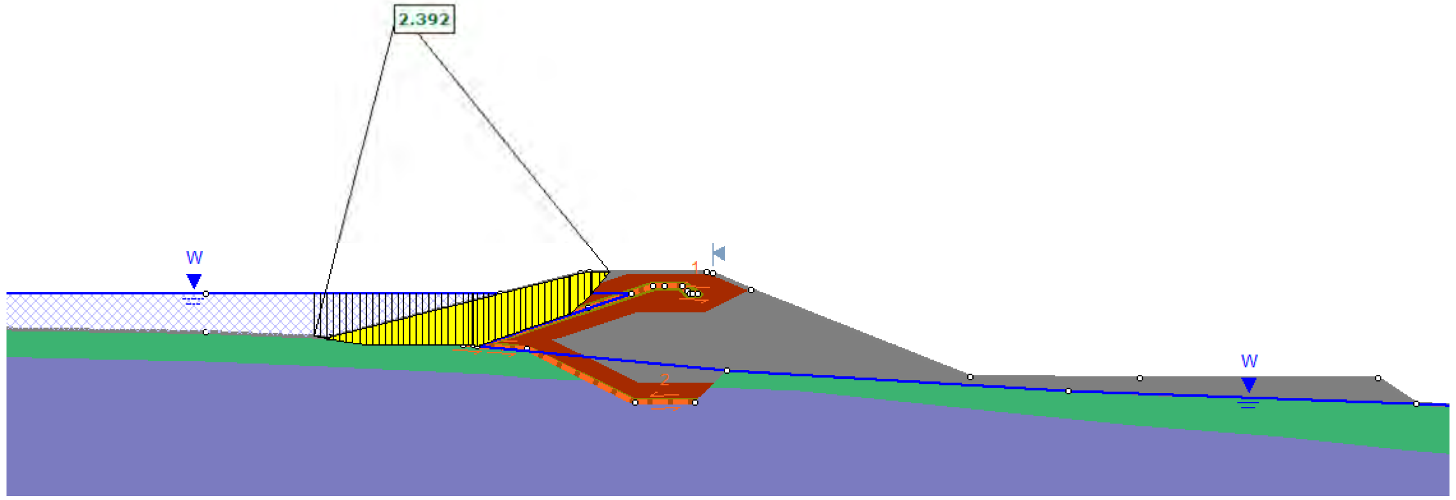
Completely Thawed Foundation

| Thaw Depth (m) | Min slip surface depth | 0 | 2 | To BR |
|---|---|---|---|---|
| FOS (Static) | 0.5 | 3.00 | - | 2.32 |
| FOS (Pseudo-Static) | 0.5 | 2.58 | - | 2.10 |
| FOS (Static) | 1.0 | 3.10 | - | 2.45 |
| FOS (Pseudo-Static) | 1.0 | 2.68 | - | 2.10 |
| FOS (Static) | 1.5 | 3.21 | - | 2.45 |
| FOS (Pseudo-Static) | 1.5 | 2.79 | - | 2.10 |

# Upstream Stability – Base Case – Section B



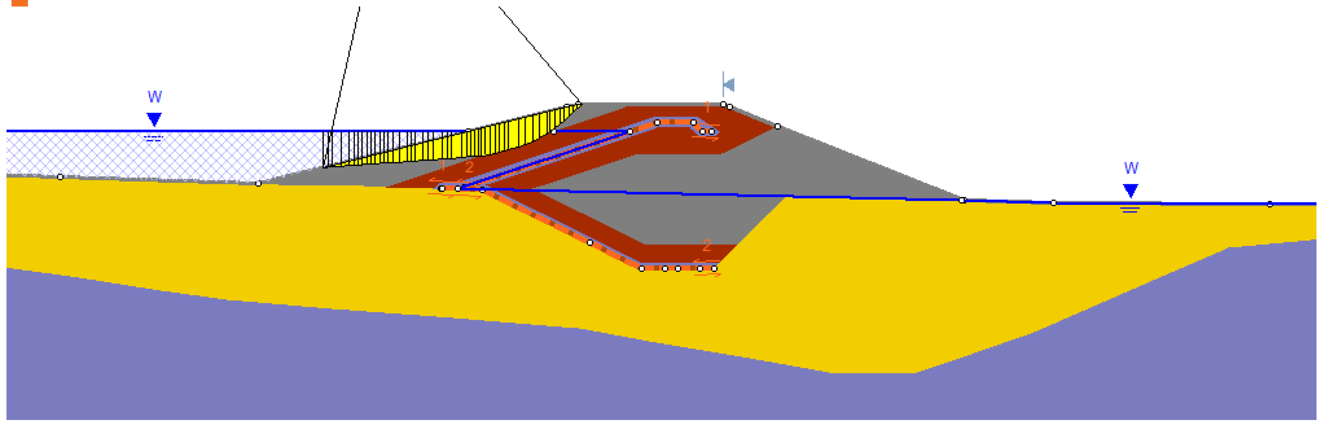
Frozen Foundation



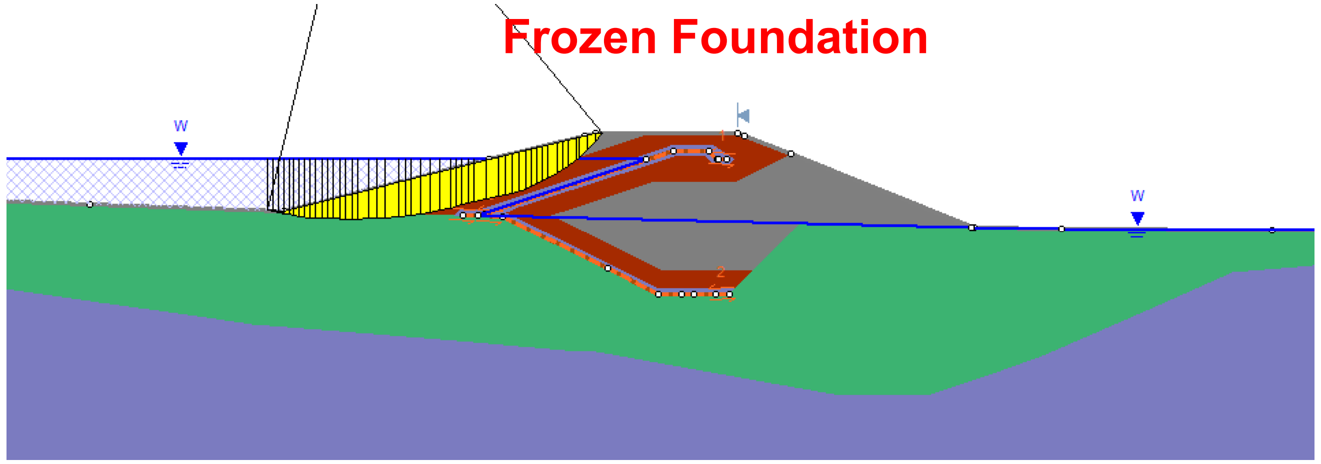
Completely Thawed Foundation

| Thaw Depth (m) | Min slip surface depth | 0 | 2 | To BR |
|---|---|---|---|---|
| FOS (Static) | 0.5 | 2.69 | - | 2.39 |
| FOS (Pseudo-Static) | 0.5 | 2.29 | - | 1.99 |
| FOS (Static) | 1.0 | 2.61 | - | 2.39 |
| FOS (Pseudo-Static) | 1.0 | 2.22 | - | 1.99 |
| FOS (Static) | 1.5 | 2.61 | - | 2.39 |
| FOS (Pseudo-Static) | 1.5 | 2.21 | - | 1.99 |

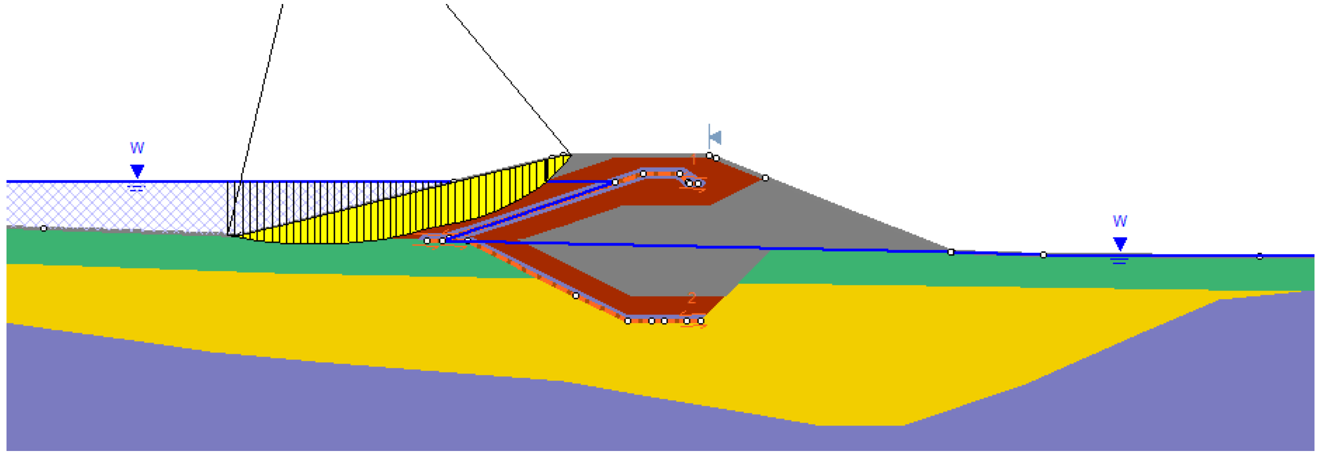
# Upstream Stability – Base Case – Section C



Frozen Foundation



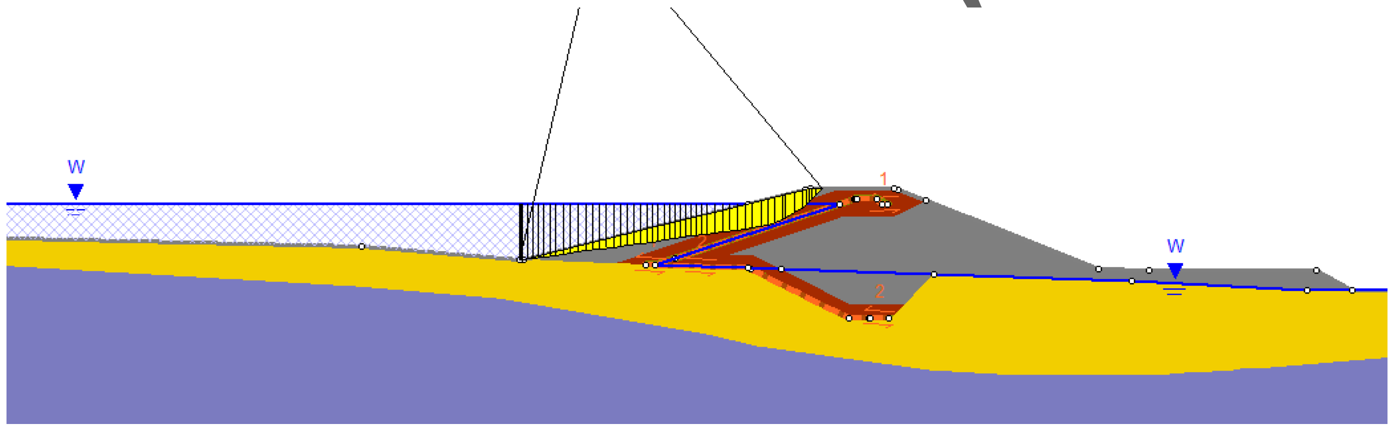
Completely Thawed Foundation



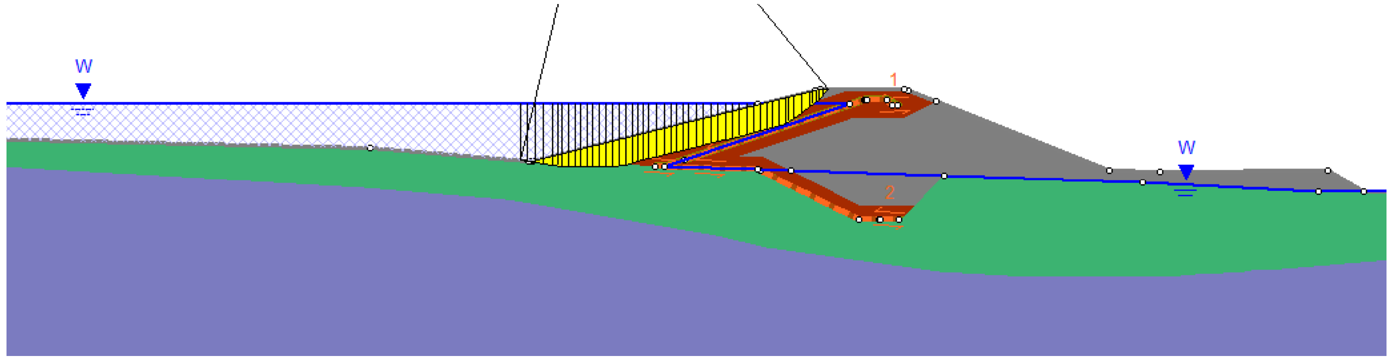
2 m Thawed Foundation

| Thaw Depth (m) | Min slip surface depth | 0 | 2 | To BR |
|---|---|---|---|---|
| FOS (Static) | 0.5 | 2.69 | 2.61 | 2.61 |
| FOS (Pseudo-Static) | 0.5 | 2.26 | 2.13 | 2.13 |
| FOS (Static) | 1.0 | 2.69 | 2.61 | 2.60 |
| FOS (Pseudo-Static) | 1.0 | 2.26 | 2.14 | 2.14 |
| FOS (Static) | 1.5 | 2.69 | 2.61 | 2.61 |
| FOS (Pseudo-Static) | 1.5 | 2.26 | 2.14 | 2.14 |

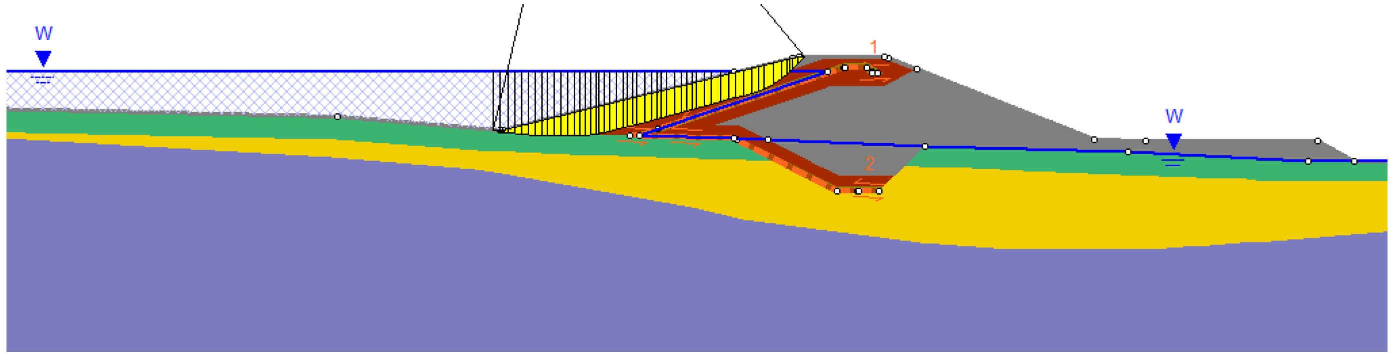
# Upstream Stability – Base Case – Section Sta(0+240m)



Frozen Foundation



Completely Thawed Foundation



2 m Thawed Foundation

| Thaw Depth (m) | Min slip surface depth | 0 | 2 | To BR |
|---|---|---|---|---|
| FOS (Static) | 0.5 | 2.89 | 2.74 | 2.75 |
| FOS (Pseudo-Static) | 0.5 | 2.41 | 2.27 | 2.27 |
| FOS (Static) | 1.0 | 2.87 | 2.74 | 2.74 |
| FOS (Pseudo-Static) | 1.0 | 2.43 | 2.27 | 2.27 |
| FOS (Static) | 1.5 | 2.85 | 2.74 | 2.74 |
| FOS (Pseudo-Static) | 1.5 | 2.36 | 2.28 | 2.27 |

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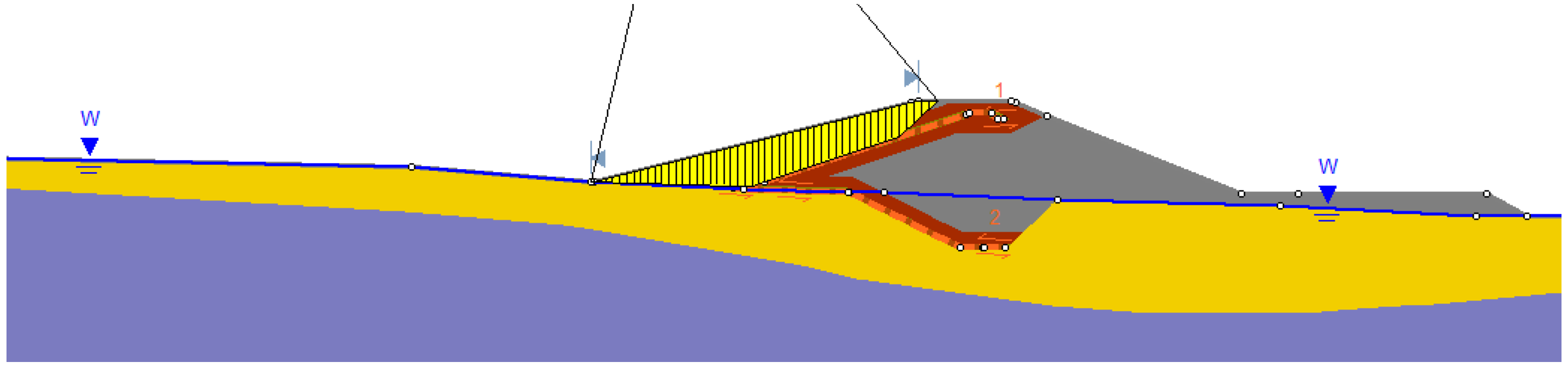
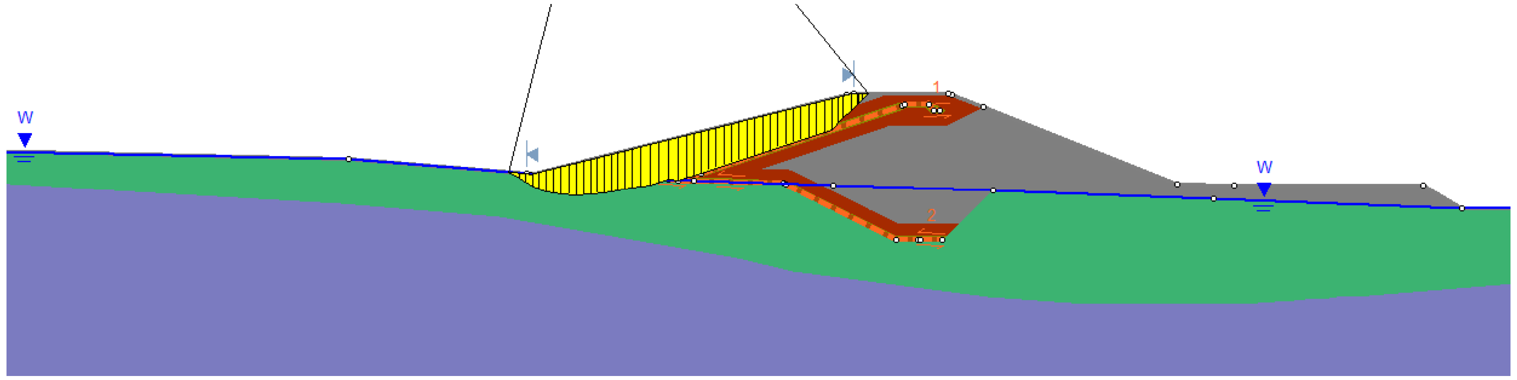
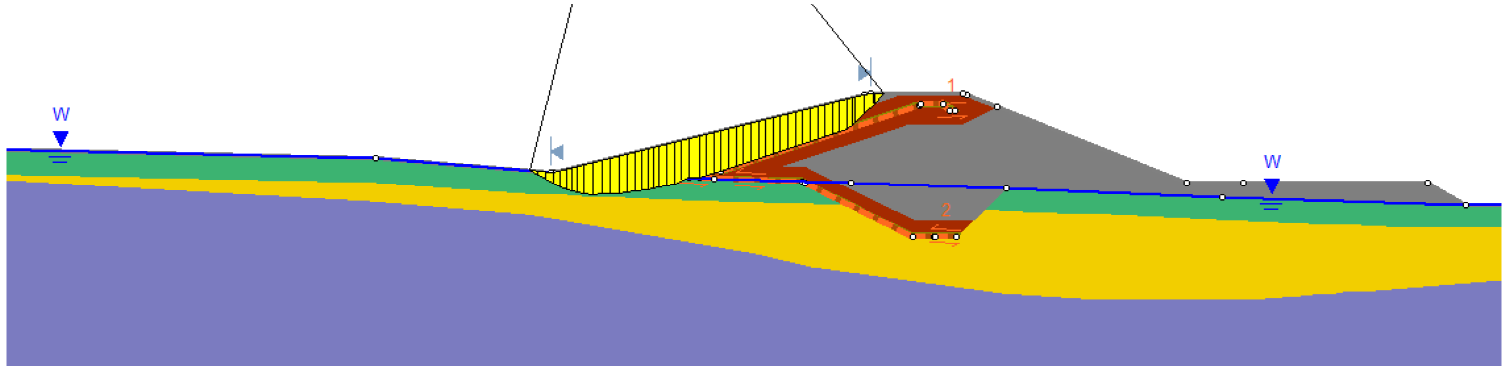
# Upstream Stability – No Free Water Level – Section (0+240m)



Frozen Foundation



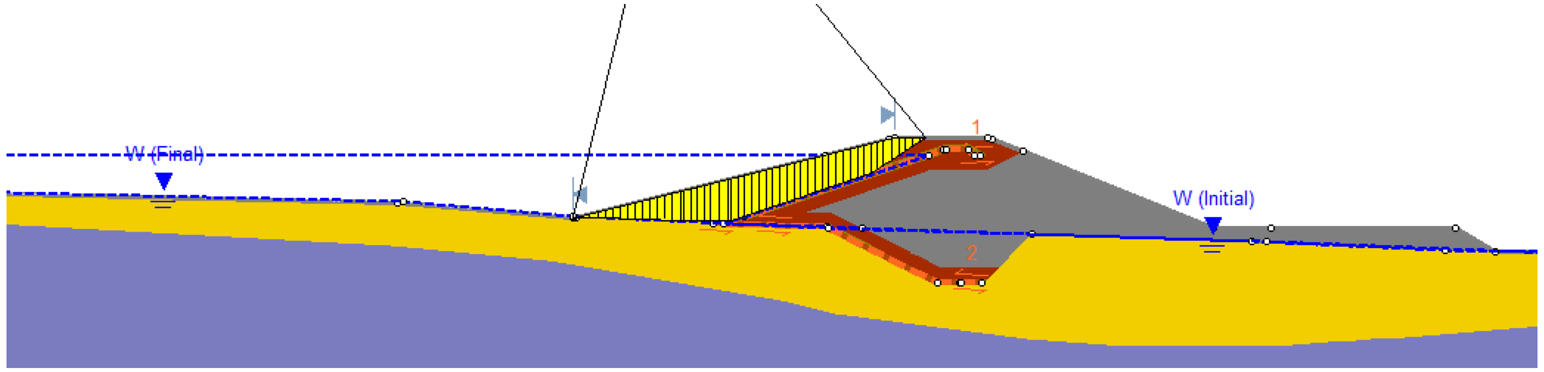
Completely Thawed Foundation



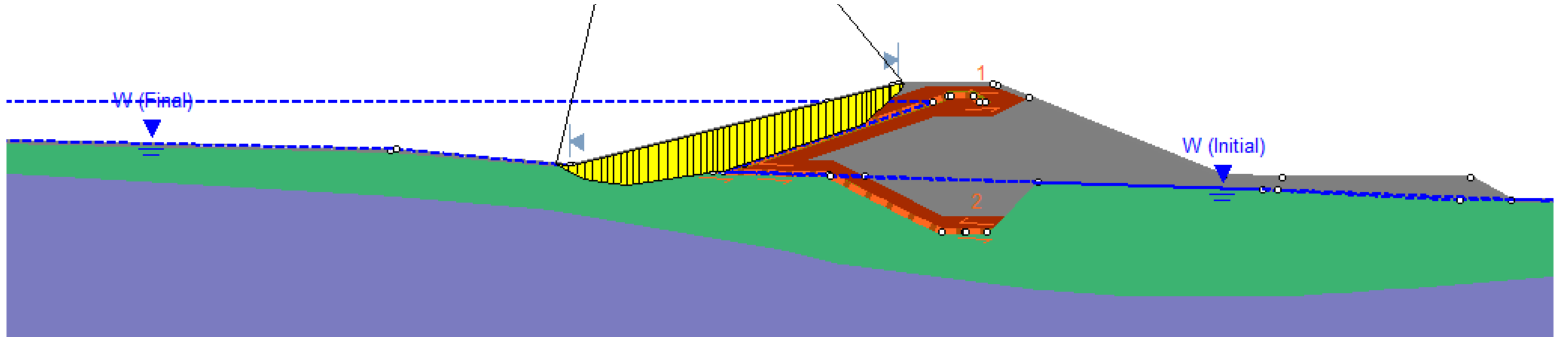
2 m Thawed Foundation

| Thaw Depth (m) | Min slip surface depth | 0 | 2 | To BR |
|---|---|---|---|---|
| FOS (Static) | 0.5 | 2.91 | 2.42 | 2.42 |
| FOS (Static) | 1.0 | 2.91 | 2.41 | 2.42 |
| FOS (Static) | 1.5 | 2.91 | 2.41 | 2.42 |

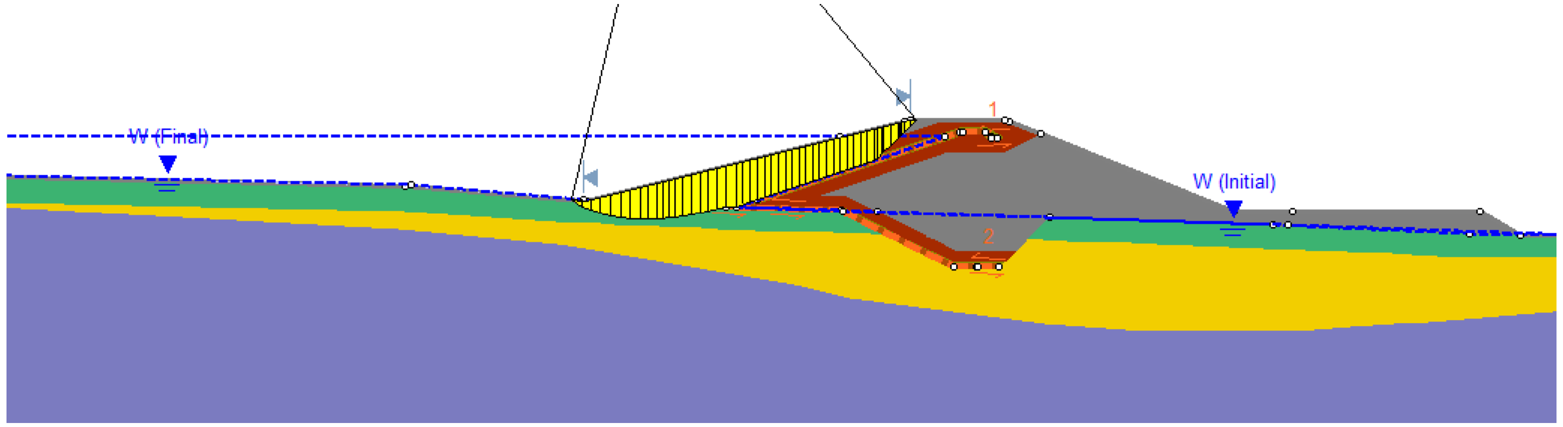
# Upstream Stability – Rapid Drawdown – Section (0+240m)



**Frozen Foundation**



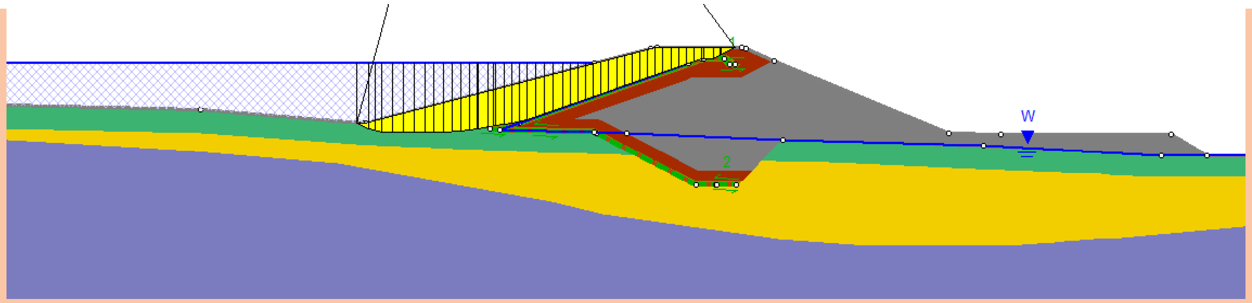
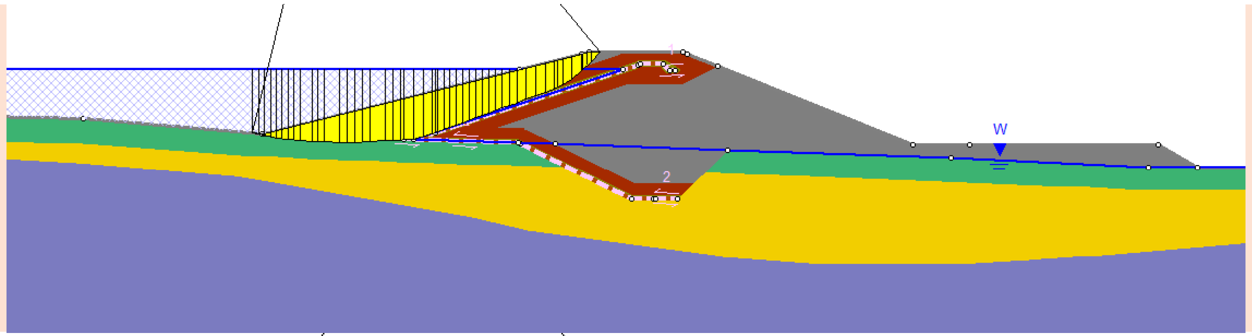
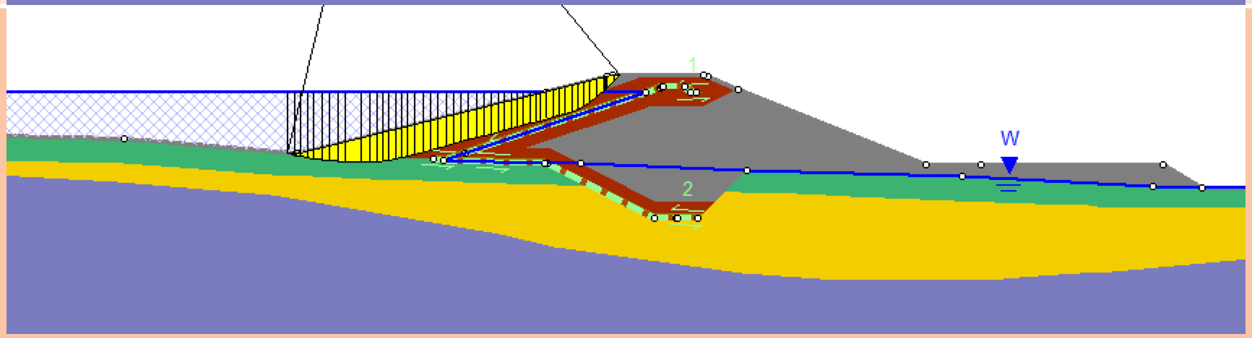
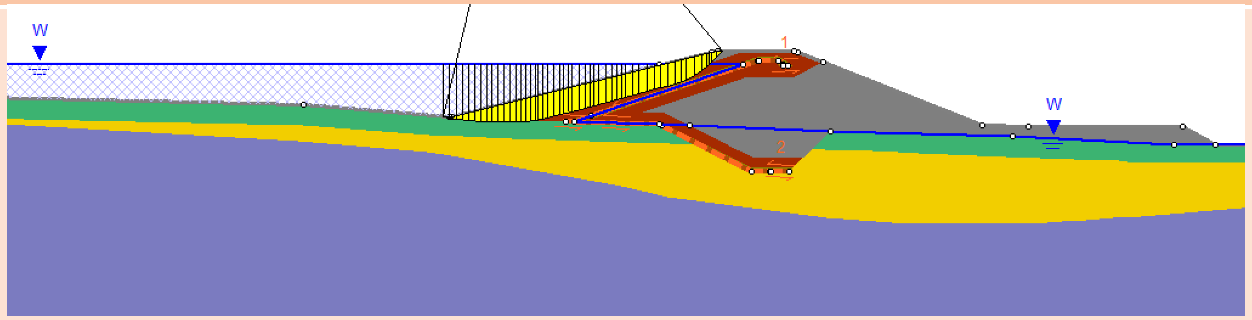
**Completely Thawed Foundation**



**2 m Thawed Foundation**

| Thaw Depth (m) | Min slip surface depth | 0 | 2 | To BR |
|---|---|---|---|---|
| FOS (Static) | 0.5 | 2.92 | 2.04 | 2.04 |
| FOS (Static) | 1.0 | 2.90 | 2.04 | 2.04 |
| FOS (Static) | 1.5 | 2.91 | 2.04 | 2.04 |

# HDPE Liner Sensitivity Analysis

| HDPE | φ, (°) | FOS | |
|---|---|---|---|
| HDPE Liner (18) | 18 | 2.58 |  |
| HDPE Liner (22) | 22 | 2.68 |  |
| HDPE Liner (25) | 25 | 2.75 |  |
| HDPE Liner (28)<br>Base Case | 28 | 2.75 |  |

**References**

a. Bacas M.B., Canizal J., and Konietzky H. 2015. Shear Strength Behaviour of Geotextile/ Geomembrane interfaces. Journal of Rock Mechanics and Geotechnical Engineering. Volume 6, Issue 6, December 2015: 638-645.

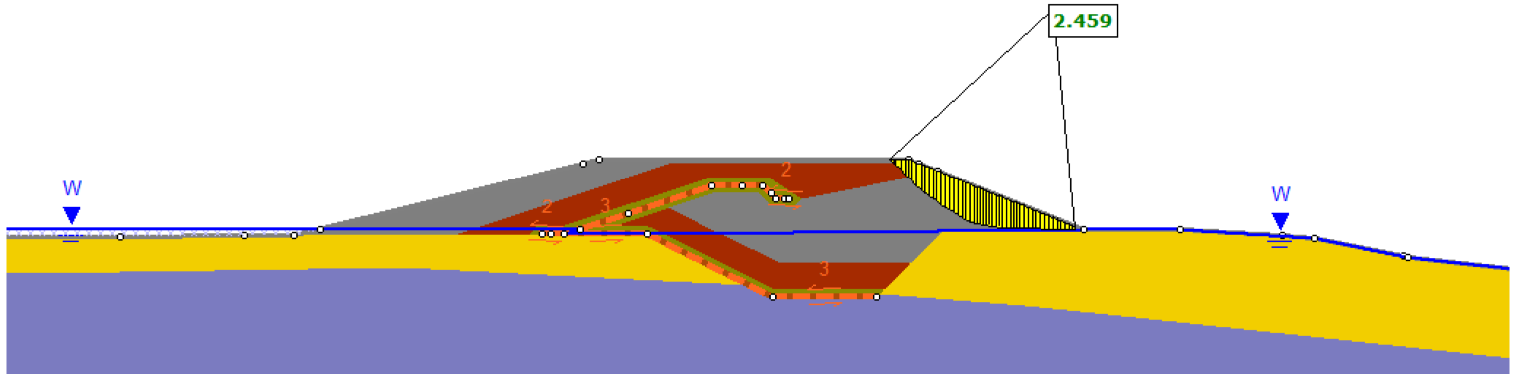
b. Stark et al. 1996. HDPE Geomembrane/Geotextile Interface Shear Strength. Journal of Geotechnical Engineering, Vol. 122, No3.

c. Howell G.C., and Kirsten A.H. 2016. Inference Shear: Towards understanding the significance in Geotechnical Structures. First South African Geotechnical Conference. 2016

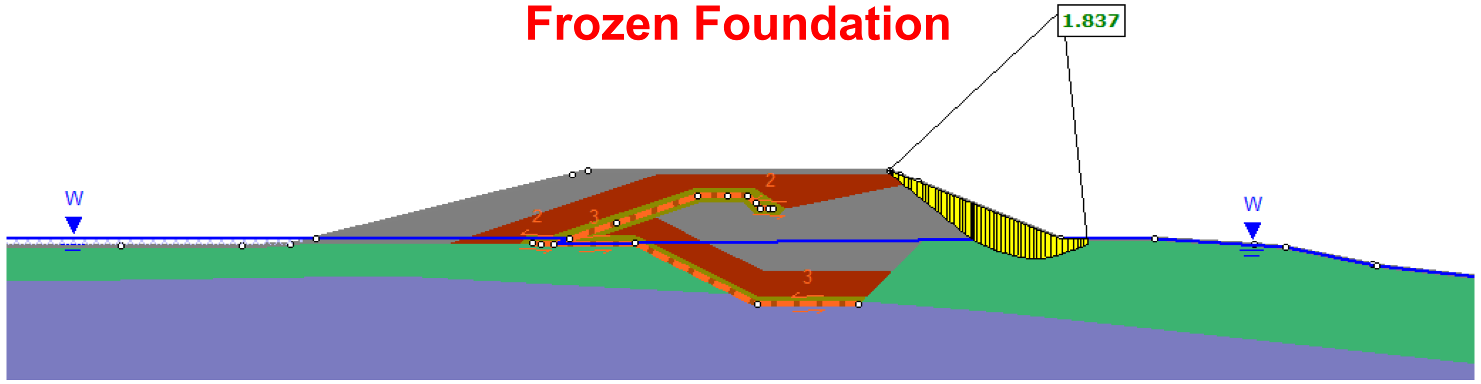
# Downstream Stability Summary (Base Case Scenario)

| Cross-section / Station | Assessed Slope | Analysis Type | FOS | | | | | | | | | $\text{FoS}_{\text{MIN}}$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Frozen Foundation Condition | | | Thawed Foundation Condition | | | Thawed Active Layer Condition | | | |
| | | | 0.5 m | 1.0 m | 1.5 m | 0.5 m | 1.0 m | 1.5 m | 0.5 m | 1.0 m | 1.5 m | |
| A/ Sta (0+115) | Downstream | Static | 2.0 | 2.1 | 2.4 | 1.8 | 1.8 | 1.8 | 1.8 | 1.7 | 1.8 | 1.5 |
| B/ Sta (0+160) | Downstream | Static | 1.9 | 2.0 | 2.0 | 1.9 | 2.0 | 1.9 | - | - | - | 1.5 |
| -/ Sta (0+240) | Downstream | Static | 2.0 | 2.0 | 2.0 | 1.9 | 2.0 | 2.0 | 1.9 | 2.0 | 2.0 | 1.5 |
| C/ Sta (0+630) | Downstream | Static | 2.0 | 2.0 | 2.1 | 18 | 1.8 | 1.8 | 1.8 | 1.8 | 1.8 | 1.5 |
| A/ Sta (0+115) | Downstream | Pseudo-Static | 1.8 | 2.0 | 2.2 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.1 |
| B/ Sta (0+160) | Downstream | Pseudo-Static | 1.8 | 1.8 | 1.9 | 1.8 | 1.8 | 2.0 | - | - | - | 1.1 |
| -/ Sta (0+240) | Downstream | Pseudo-Static | 1.8 | 1.8 | 1.9 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.6 | 1.1 |
| C/ Sta (0+630) | Downstream | Pseudo-Static | 1.8 | 1.8 | 1.9 | 1.8 | 1.8 | 2.0 | 1.8 | 1.8 | 1.9 | 1.1 |

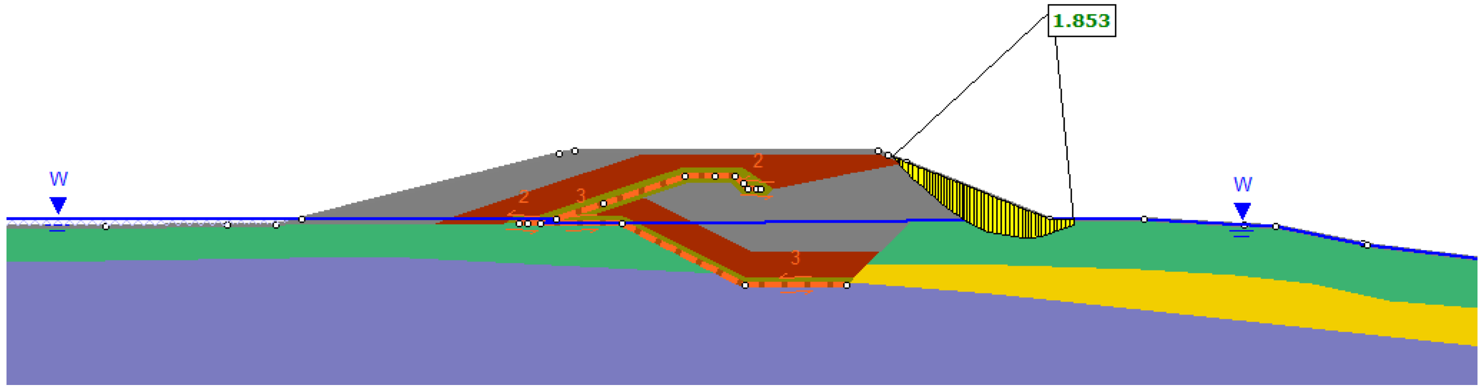
# Downstream Stability – Base Case – Section A



Frozen Foundation



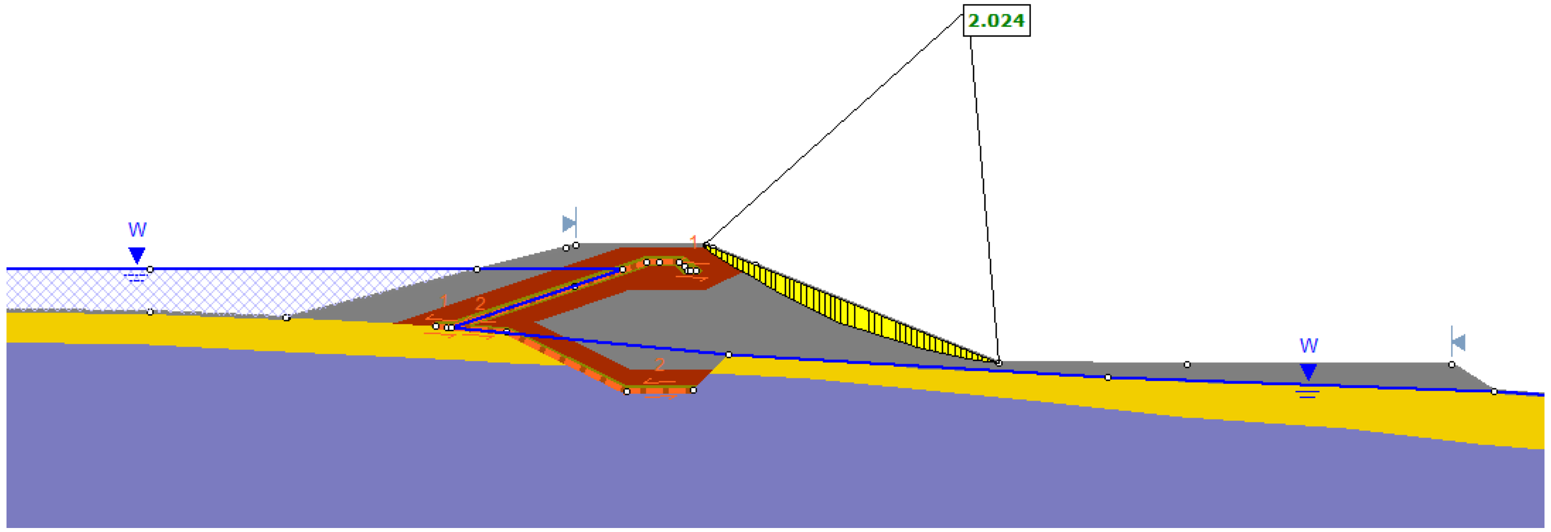
Completely Thawed Foundation



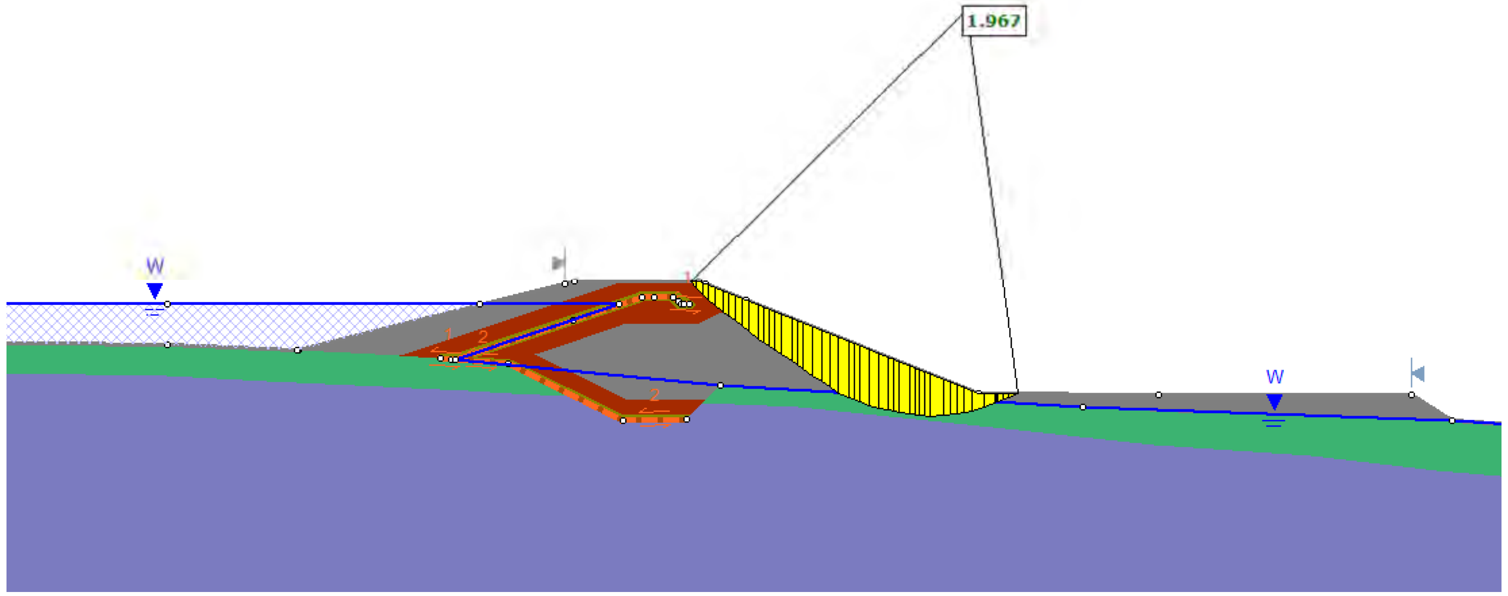
2 m Thawed Foundation

| Thaw Depth (m) | Min slip surface depth | 0 | 2 | To BR |
|---|---|---|---|---|
| FOS (Static) | 0.5 | 2.01 | 1.80 | 1.82 |
| FOS (Pseudo-Static) | 0.5 | 1.82 | 1.61 | 1.63 |
| FOS (Static) | 1.0 | 2.18 | 1.80 | 1.76 |
| FOS (Pseudo-Static) | 1.0 | 1.97 | 1.62 | 1.61 |
| FOS (Static) | 1.5 | 2.46 | 1.85 | 1.84 |
| FOS (Pseudo-Static) | 1.5 | 2.22 | 1.65 | 1.66 |

# Downstream Stability – Base Case – Section B



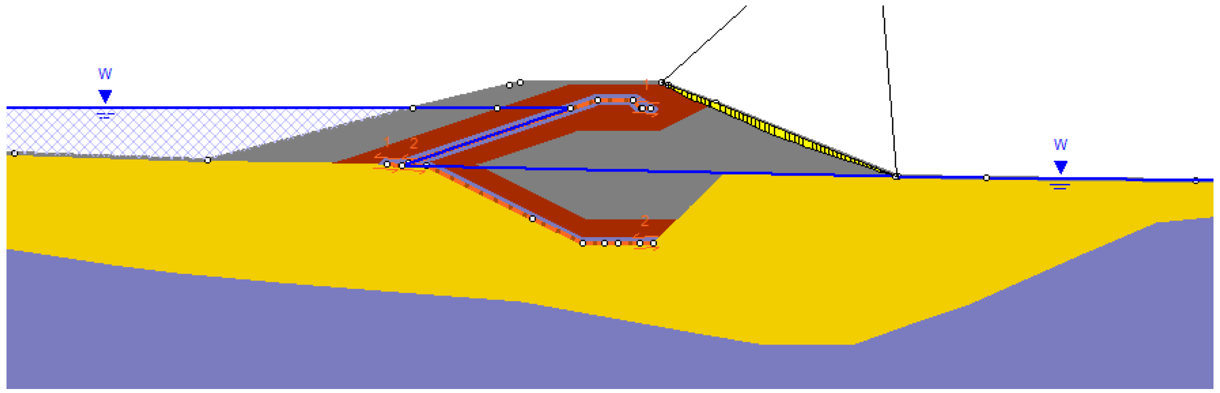
Frozen Foundation



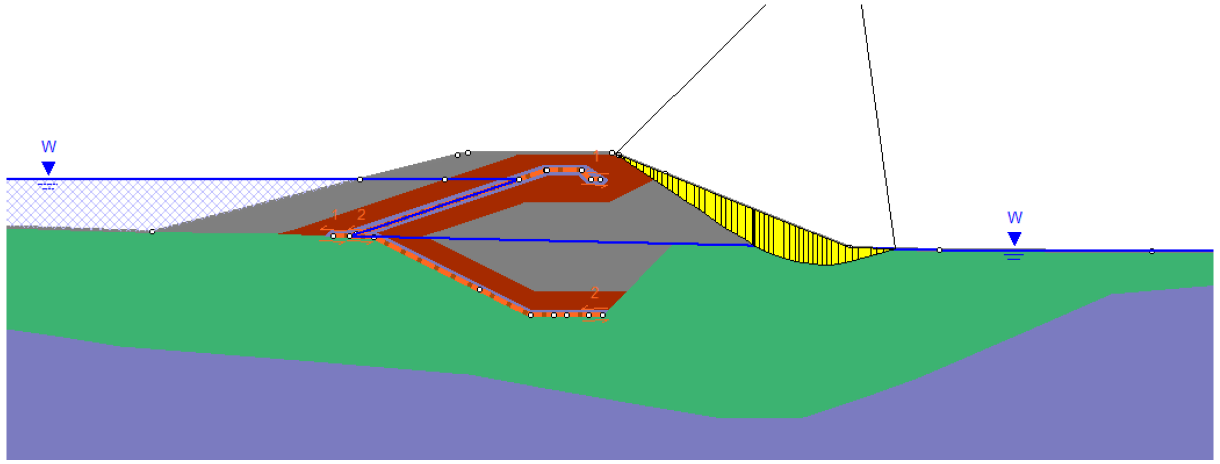
Completely Thawed Foundation

| Thaw Depth (m) | Min slip surface depth | 0 | 2 | To BR |
|---|---|---|---|---|
| FOS (Static) | 0.5 | 1.95 | - | 1.95 |
| FOS (Pseudo-Static) | 0.5 | 1.80 | - | 1.80 |
| FOS (Static) | 1.0 | 1.98 | - | 1.98 |
| FOS (Pseudo-Static) | 1.0 | 1.82 | - | 1.81 |
| FOS (Static) | 1.5 | 2.02 | - | 1.97 |
| FOS (Pseudo-Static) | 1.5 | 1.86 | - | 1.81 |

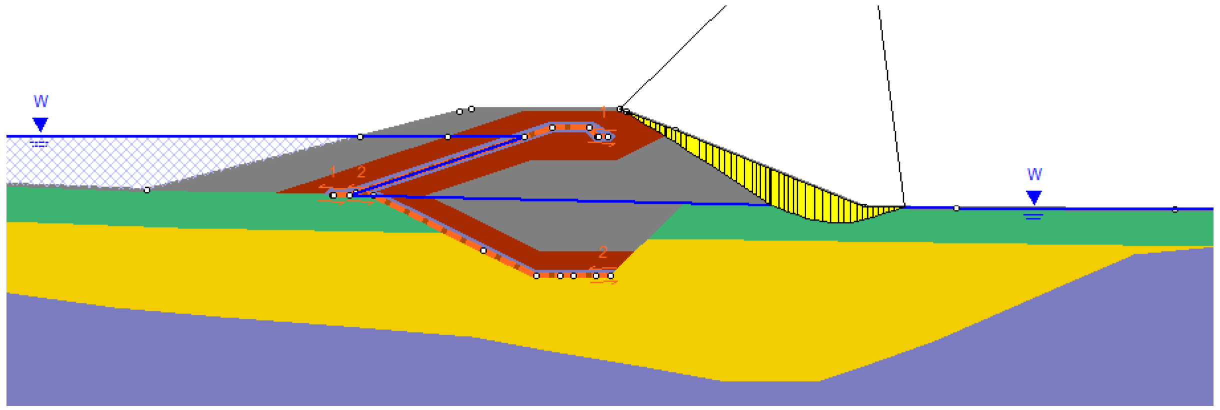
# Downstream Stability – Base Case – Section C



Frozen Foundation



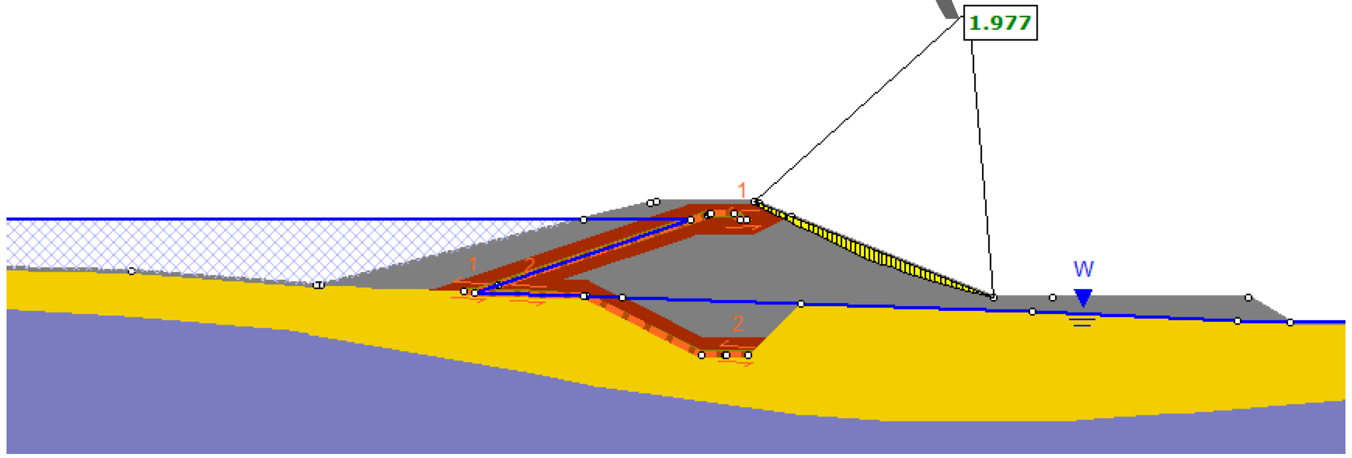
Completely Thawed Foundation



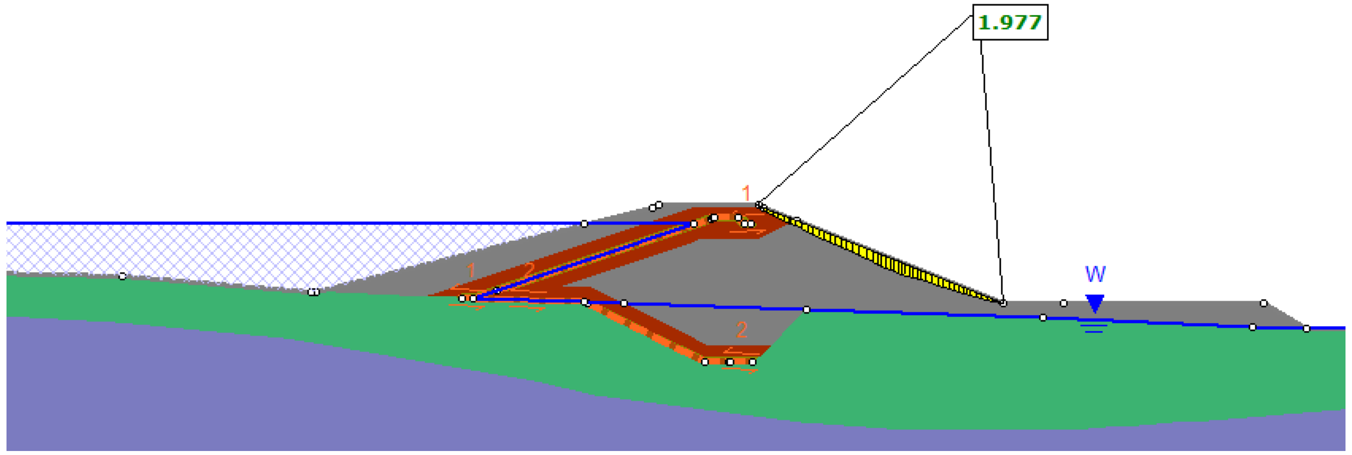
2 m Thawed Foundation

| Thaw Depth (m) | Min slip surface depth | 0 | 2 | To BR |
|---|---|---|---|---|
| FOS (Static) | 0.5 | 1.96 | 1.81 | 1.81 |
| FOS (Pseudo-Static) | 0.5 | 1.78 | 1.64 | 1.64 |
| FOS (Static) | 1.0 | 2.01 | 1.81 | 1.81 |
| FOS (Pseudo-Static) | 1.0 | 1.83 | 1.64 | 1.64 |
| FOS (Static) | 1.5 | 2.09 | 1.80 | 1.81 |
| FOS (Pseudo-Static) | 1.5 | 1.90 | 1.64 | 1.64 |

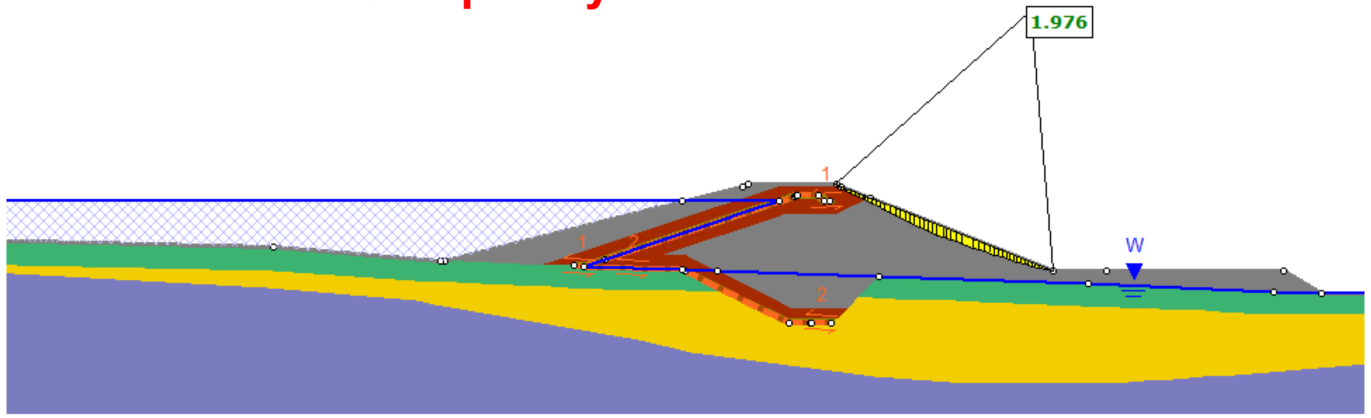
# Downstream Stability – Base Case – Section Sta(0+240m)



Frozen Foundation



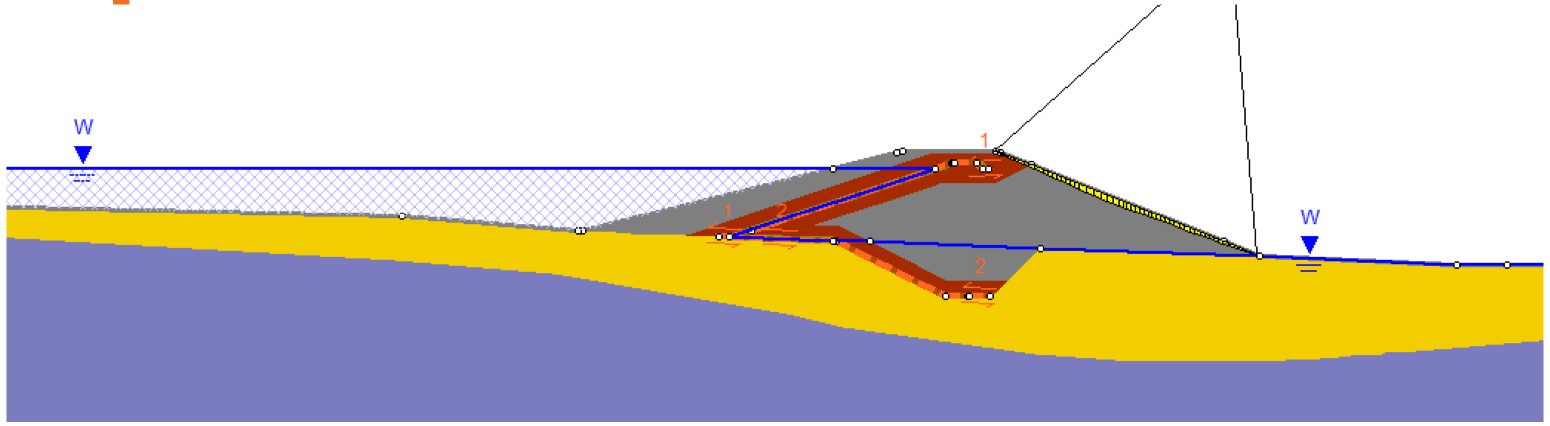
Completely Thawed Foundation



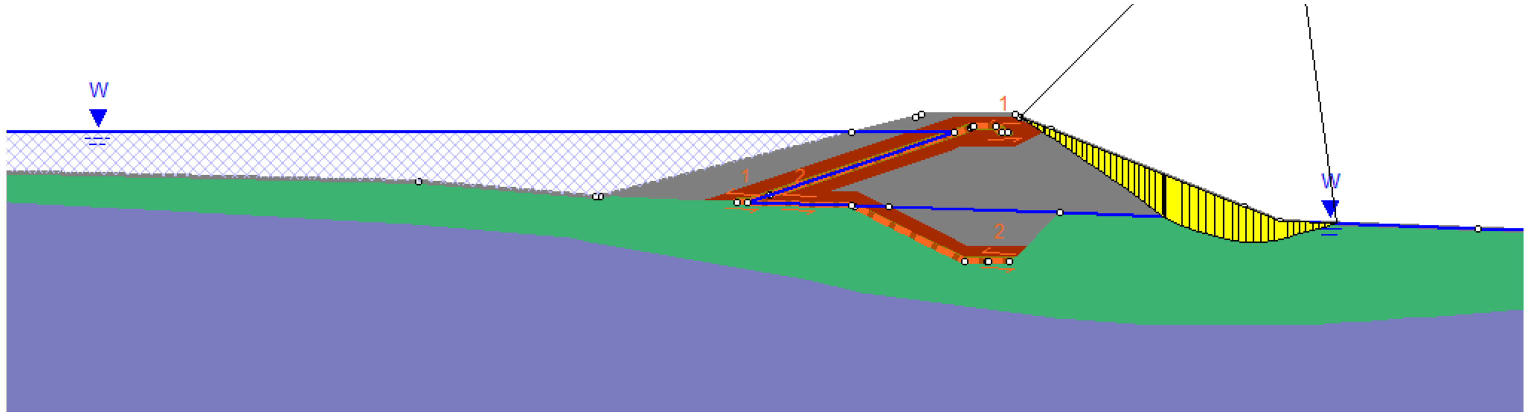
2 m Thawed Foundation

| Thaw Depth (m) | Min slip surface depth | 0 | 2 | To BR |
|---|---|---|---|---|
| FOS (Static) | 0.5 | 1.95 | 1.95 | 1.95 |
| FOS (Pseudo-Static) | 0.5 | 1.80 | 1.80 | 1.80 |
| FOS (Static) | 1.0 | 2.01 | 2.01 | 2.01 |
| FOS (Pseudo-Static) | 1.0 | 1.82 | 1.82 | 1.82 |
| FOS (Static) | 1.5 | 1.98 | 1.98 | 1.98 |
| FOS (Pseudo-Static) | 1.5 | 1.86 | 1.86 | 1.86 |

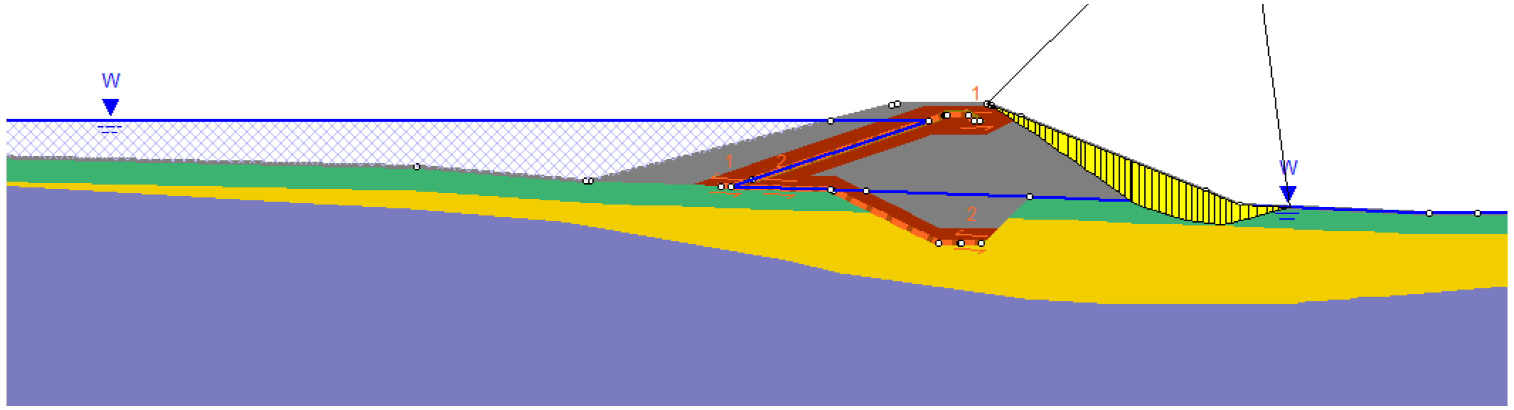
# Downstream Stability – No All-Weather Road – Section (0+240m)



Frozen Foundation



Completely Thawed Foundation



2 m Thawed Foundation

| Thaw Depth (m) | Min slip surface depth | 0 | 2 | To BR |
|---|---|---|---|---|
| FOS (Static) | 0.5 | 1.95 | 1.76 | 1.76 |
| FOS (Static) | 1.0 | 1.97 | 1.76 | 1.76 |
| FOS (Static) | 1.5 | 2.00 | 1.76 | 1.76 |

# ATTACHMENT 5

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www.srk.com

**DRAFT**

# Memo

| | | | |
|---|---|---|---|
| **To** | John Kurylo | **Project** | CAPR000396 |
| **From** | Anna TImchenko | **Reg. No.** | EGBC 1003655 |
| **Cc** | Jasur Umarov | **Date** | November 29, 2022 |
| **Client** | Sabina Gold & Silver Corp. | | |

**Subject** Primary Pond Dam – Investigation of Liner Seepage

## 1 Introduction

SRK Consulting (Canada) Inc. has been contracted by Sabina Gold & Silver Corp. to design the surface water management for the Back River Project (Project). As part of the Project's surface water management, dams and berms are required to divert or hold both contact water and non-contact water. The property is located in the territory of Nunavut, 160 km south of the Bathurst Inlet and approximately 50 km south of Advanced Exploration Property.

One of the elements of the water management infrastructure at the Goose Property is the Primary Pond Dam which is designed to be located about 0.5 km southeast of the Llama open pit. The Dam consists primarily of a lined dam that is keyed into permafrost (frozen sand foundation) or tied directly into bedrock. The proposed dam will be operated for the duration of the mine operations. The Dam design encompasses a relatively low-profile structure with a maximum crest height of about 8 m, and a length of about 900 m constructed primarily of run-of-quarry (ROQ) rock fill. The Dam slopes will be 3.0H:1.0V on the upstream side and 2.5H:1.0V on the downstream, with a crest width of 8 m. A wide key trench will be excavated min 2-4 m into the foundation, with upstream and downstream slopes of 2.0H:1.0V and 1.0H:1.0V, respectively. The key trench will then be backfilled with compacted ROQ rock, which also will form the bulk of the dam structure. An impermeable liner (HDPE) will be incorporated into the structure of the dam.

A dam seepage assessment was performed under the assumption that permafrost will prevent seepage through the foundation and that the impermeable liner will remain keyed into permafrost for the duration of the Project. This memo documents the assumptions and the results of the analysis.

## 2 Foundation Condition

The Project site is located in cold continuous permafrost, with an active layer that seasonally thaws to a depth of between 1.0 and 2.4 m. The typical depth of the active layer is 1.5 m (SRK 2015a and SRK 2019), but for the seepage rate assessment, the depth of the active layer was assumed to be 2.0 m.

Therefore, there is no groundwater table, and any surficial seepage from ponds is limited to seasonal flow within the active layer. The Primary Pond area ground profile consists of variable overburden overlying competent bedrock. Typically, based on drill holes completed in the proposed containment dam areas, bedrock is about 3–15 m below ground (SRK 2015b, SRK 2018, SRK 2021).

# 3 Material Hydraulic Properties

Hydraulic properties adopted for the foundation, and dam materials seepage assessment are presented in this memorandum (SRK 2019). Table 1 summarizes these properties of the Primary Pond Dam.

**Table 1: Primary Pond Dam Hydraulic Properties**

| Geotechnical Domain | Moist Unit Weight ($kN/m^3$) | Hydraulic Conductivity (m/s) |
|---|---|---|
| Bedrock | 18 | $1.6x10^{-8}$ |
| Overburden soil material (Sand/Silt foundation, frozen) | 19 | $4.5x10^{-7}$ |
| Overburden soil material (Sand/Silt foundation, thawed) | 19 | $5x10^{-5}$ |
| Bedding Material | 18 | $1x10^{-5}$ |
| Transition Material | 18 | $1x10^{-5}$ |
| ROQ (Thawed, Unconsolidated) | 20 | $2x10^{-1}$ |
| HDPE Liner | 10 | $5x10^{-10}$ |

Sources: SRK Consulting (Canada) Inc. 2019. Back River Property Geotechnical Design Parameters – Revision 0. For Comment. Report prepared for Sabina Gold & Silver. July 2019.

# 4 Seepage Rate Assessment

## 4.1 General

The Primary Pond Dam will be constructed of ROQ rock fill and crushed gravel materials. These materials have a range of hydraulic conductivities that precludes their normal use for water retention purposes. Therefore, the water retention capacity of the dam relies on the performance of the impermeable liner incorporated within the dam fill.

Different approaches to the seepage calculations were implemented:

- Seepage analysis using Slide’s FEM GW calculator (assumed tree states of the overburden foundation: thawed overburden; frozen overburden, and thawed layer 2 m thick).
- Empirical estimation of the leakage rate through geomembrane holes (assumed 1 hole of d=2, 5, and 10 mm).

- Empirical estimation of the leakage rate through pinholes (assumed 1 pinhole of d=0.3, 0.5, and 0.8 mm).

## 4.2 Seepage Analysis Using Slide's FEM GW Calculator

### 4.2.1 Methodology

Seepage analysis was carried out using the commercial Rocscience Slide2 (Built 9.024) (Rocscience Inc., 2022). software package. All seepage values were generated using the Steady State Groundwater Finite Element Analysis method in Slide2. The water levels were applied at elevation +313 m on the upstream side, and relevant ground condition cases were also applied.

The modeling code does not handle very thin units like the HDPE liner (60 mils) used in the Primary Pond Dam. For this reason, the modeled HDPE liner was expanded to a 0.3 m thick layer with an equivalent hydraulic conductivity that would mimic the performance of the HDPE geomembrane.

### 4.2.2 Model Setup

For the dam, a single typical cross-section was analyzed. This critical section was conservatively assumed to be the zone where the foundation overburden soils were at their maximum thickness, and the structure was at its maximum height. Figure 5 in Attachment 1 presents the typical cross-section of the Primary Pond Dam.

The Primary Pond Dam seepage analysis was carried out for three scenarios: partially thawed foundation conditions (2 m-thick layer), fully thawed foundation conditions, and frozen foundation conditions. Thermal modeling at the Goose Property has confirmed that fully thawed foundation conditions are not likely to occur (SRK 2015c); however, the analysis includes a conservative case (fully thawed overburden) demonstrating the system's sensitivity.

### 4.2.3 Results

The resultant seepage through the Primary Pond Dam is presented in Table 2. The expected maximum seepage rate through the structure during the operational phase would be 6.7 $m^3$/day/1m. This assumes fully thawed conditions which are not expected.

Two additional cases were modeled to demonstrate the system sensitivity (Table 2). These cases assume the fully frozen foundation and thawed 2m-thick layer. For all modeled cases, the free water table is located at elevation 313 m.

**Table 2: Primary Pond Dam Seepage Assessment Results**

| Primary Pond Dam Seepage Condition | Upstream Water Level (masl) | Seepage Rate ($m^3$/day/1m) | Total Volume ($m^3$/day/650m[1]) |
|---|---|---|---|
| Thawed foundation | 313 | 6.7 | 4355 |
| Partially thawed foundation (2 m-thick layer) | 313 | 0.93 | 605 |
| Frozen foundation | 313 | 0.83 | 540 |

Notes:

[1] The designed length of the Primary Pond Dam is 750m, but the total seepage volume was calculated based on the typical 2D cross-section of the dam; therefore, the Dam's length of 650m was assumed.

## 4.3 Assessment Methods for the Leakage Rate Estimation

Two empirical methods were used to estimate the increase in equivalent infiltration due to liner imperfections. These methods assume that the rate of seepage through a liner due to the liner's permeability is negligible, compared to the rate of seepage through defects in the liner (Giroud and Bonaparte 1989). Therefore, only seepage through defects is considered. The assessment is based on the use of an HDPE liner, which was deemed to be the most suitable based on a preliminary evaluation of technical and economic considerations.

### 4.3.1 Input Parameters

The empirical model requires the following input parameters:

- The contact condition between the liner and the bedding material below the liner;
- The installation quality (number of defects per unit surface area);
- The total surface area of the liner;
- The thickness and hydraulic conductivity of the bedding material;
- Total hydraulic head on top of the liner; and
- The shape and size of the defects.

The following input values were utilized in the leakage rate calculations:

- Good contact condition between the liner and the bedding material was assumed, meaning that the installation would contain few wrinkles.
- Three different installation qualities (excellent, fair, and poor) were analyzed. The frequency of the defects was set at one per every 10 m, one per 20 m, and one defect per 60 m of liner for the excellent, fair, and poor installation qualities, respectively.
- The total surface area of the liner that was utilized in the model was 13,360 $m^2$ (the liner surface area was above grade, outside of the key trench). The thickness of the liner is 60 mils.

- The average hydraulic head of 6 m was determined by calculating the average value of the hydraulic head every 10 m along the centerline of the dam, assuming the pond elevation at full supply level (Elev. 313 m).
- The imperfections were simulated as having circular and square shapes that could be caused during liner manufacturing (circular pinholes) or during installation (square rips), respectively. It was considered that appropriate quality control would prevent infinitely long linear defects (substandard seams).

### 4.3.2 Leakage Due to Defects in the Liner

Two deterministic methods were utilized for the leakage rate calculation through the defects in the liner: leakage due to pinholes and due to holes (Giroud and Bonaparte 1989).

#### Leakage Due to Pinholes

According to Giroud and Bonaparte (1989) pinholes can be defined as openings having a dimension (such as diameter or size) significantly smaller than the geomembrane thickness. For leakage calculation purposes, pinholes can be considered as pipes and, therefore, the following equation can be used:

$$Q = \pi \rho g h_w d^4 / (128 \eta T_g) \qquad (1)$$

where:

$Q$ = leakage rate through a pinhole ($m^3/s$);

$h_w$ = liquid depth on top of the geomembrane (m); assumed the average depth of 6 m;

$T_g$= thickness of the geomembrane (m). For the Primary Pond Dam construction will be used the HDPE liner of 60mils, $T_g$=1.5 mm;

*d* = pinhole diameter (m); for both circular and square shape diameter of a pinhole, assumed to be 0.3, 0.5, and 0.8 mm.

$\rho$ and $\eta$ = density ($kg/m^3$) and dynamic viscosity of the liquid (kg/(m·s)), respectively; and *g* = acceleration due to gravity ($m/s^2$). For water at 20°C, $\rho$= 1000 $kg/m^3$ and $\eta$ = $10^{-3}$ kg/(m s).

The results are presented in the figure.

#### Leakage Due to Holes

According to Giroud and Bonaparte (1989) pinholes can be defined as openings having a dimension (e.g. diameter) about as large as, or larger than, the geomembrane thickness

$$Q = C_B a \sqrt{2 g h_w} \qquad (2)$$

where:

$Q$ = leakage rate through a liner hole (m$^3$/s);
$a$ = hole area (m$^2$); the area was checked for both circular and square hole shapes. The first hole ('small hole' with a size of 2 mm) has an area of (3.14·10$^{-6}$) m$^2$, the second hole ('intermediate hole' with a size of 5 mm) has an area of (1.93·10$^{-5}$) m$^2$, and the third hole ('large hole' with a size of 10 mm) has an area of (7.85·10$^{-5}$) m$^2$.

g = acceleration due to gravity (m/s$^2$); g=9.8 m/s$^2$

$h_w$ = liquid depth on top of the geomembrane (m), assumed the average depth of. $h_w$=6m

$C_B$ is a dimensionless coefficient, valid for any Newtonian fluid, and is related to the shape of the edges of the aperture; for sharp edges, $C_B = 0.6$.

### 4.3.3 Summary Results

The defect sizes, along with the corresponding defect surface areas, are summarized in Table 3.

**Table 3: Defect Sizes and Areas**

| Type of Defects | Defect Geometry | Installation Quality Condition | Total Defects (for the Entire Dam) [1] | Defect Dimension (m)[1] | Area of Defect (m$^2$) |
|---|---|---|---|---|---|
| Hole | Circular | Excellent | 4 | 0.002 (diameter) | 3.14·10$^{-6}$ |
| | | Fair | 34 | 0.005 (diameter) | 1.96·10$^{-5}$ |
| | | Poor | 136 | 0.01 (diameter) | 7.86·10$^{-5}$ |
| | Square | Excellent | 4 | 0.002x0.002 | 4·10$^{-6}$ |
| | | Fair | 34 | 0.005x0.005 | 2.5·10$^{-5}$ |
| | | Poor | 136 | 0.01x0.01 | 0.0001 |
| Pinhole | Circular | Excellent | 4 | 0.0003 (diameter) | 7.07·10$^{-8}$ |
| | | Fair | 34 | 0.0005 (diameter) | 1.96·10$^{-7}$ |
| | | Poor | 136 | 0.0008 (diameter) | 5.02·10$^{-7}$ |
| | Square | Excellent | 4 | 0.0003x0.0003 | 9·10$^{-8}$ |
| | | Fair | 34 | 0.0005x0.0005 | 2.5·10$^{-7}$ |
| | | Poor | 136 | 0.0008x0.0008 | 6.4·10$^{-7}$ |

Notes:

[1] Additional sizes and areas of the defects, as well as the total defect number, can be found in Appendix 1, Figures 8 and 9.

Only circular and square defects were considered for each model that was analyzed. For each analysis, the three quality installations that were previously discussed were considered. Assuming a constant head of 6 m, seepage rates were obtained, as shown in Table 4.

**Table 4: Leakage Rate Estimations**

| Number of Defects per Hectare | Leakage Rate, $m^3$/day | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Hole | | | | | | Pinholes | | | | | |
| | Square | | | Circular | | | Square | | | Circular | | |
| | 2 mm | 5 mm | 10 mm | 2 mm | 5 mm | 10 mm | 0.3 mm | 0.5 mm | 0.8 mm | 0.3 mm | 0.5 mm | 0.8 mm |
| 102 | 305 | 1907 | 7627 | 240 | 1497 | 5990 | 116 | 897 | 5881 | 91 | 705 | 4619 |
| 46 | 137 | 854 | 3415 | 107 | 671 | 2682 | 52 | 402 | 2634 | 41 | 316 | 2068 |
| 25 | 77 | 484 | 1936 | 61 | 380 | 1520 | 30 | 228 | 1493 | 23 | 176 | 1172 |
| 16 | 50 | 312 | 1248 | 39 | 245 | 980 | 19 | 147 | 962 | 15 | 115 | 756 |
| 12 | 35 | 218 | 873 | 27 | 171 | 686 | 13 | 103 | 673 | 10 | 81 | 529 |
| 8 | 26 | 162 | 646 | 20 | 127 | 507 | 10 | 76 | 498 | 8 | 60 | 391 |
| 7 | 20 | 125 | 498 | 16 | 98 | 491 | 8 | 59 | 384 | 6 | 46 | 302 |
| 3 | 9 | 57 | 228 | 7 | 45 | 179 | 3 | 27 | 176 | 3 | 21 | 138 |

As shown in Table 4, the potential leakage through the liner due to its defects (although unexpected) could be managed by the pump-back system, even in case of poor installation conditions. It should also be noted that poor installation condition is a very conservative assumption. According to numerous case studies analyzed in (Rowe 2012), the typical number of defects in the geomembrane is 3-12 holes/ha, and the average radius of the hole is <6mm. Based on practical experience, numerous examples of HDPE liners are also used successfully in water-retaining applications under similar conditions.

## Attachments:

| | |
|---|---|
| Attachment 1 | Back River – Primary Pond Dam  Seepage Analysis |

# References

Giroud J. P. and Bonaparte R. 1989. Leakage through Liners Constructed with Geomembrane. Part I. Geomembrane Liners. Geotextiles and Geomembranes 8 (1989) pp. 27-67

SRK Consulting (Canada) Inc., 2015a. Hydrogeological Characterization and Modeling of the Proposed Back River Property. Prepared for Sabina Gold & Silver Corp. 1CS020.006. April 2015.

SRK Consulting (Canada) Inc., 2015b. Goose Property - 2015 Overburden Geotechnical Investigation Program. Prepared for Sabina Gold & Silver Corp. 1CS020.009. December 2015.

SRK Consulting (Canada) Inc., 2015c. Technical Memorandum. Back River Project: Goose Property Talik Thermal Modeling. Prepared for Sabina Gold & Silver Corp. 1CS020.008. September 2015.

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SRK Consulting (Canada) Inc. 2019. Back River Property Geotechnical Design Parameters – Revision 0. For Comment. Report prepared for Sabina Gold & Silver. July 2019.

SRK Consulting (Canada) Inc. 2021. 2021 Back River/ Goose Geotech Drilling Program. Daily Reports. 1CS020.020

Rocscience Inc. 2022. Slide2 Built 9.024

Rowe K. 2012. Short- and long-term leakage through composite liners. The 7th Arthur Casagrande Lecture. Can. Geotech. J. Vol. 49, 2012, pp.141-169.

# Attachment 1 Back River – Primary Pond Dam Seepage Analysis

# Back River – Primary Pond Dam

## Seepage Analysis

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# Introduction

Different approaches to the seepage calculations were implemented:

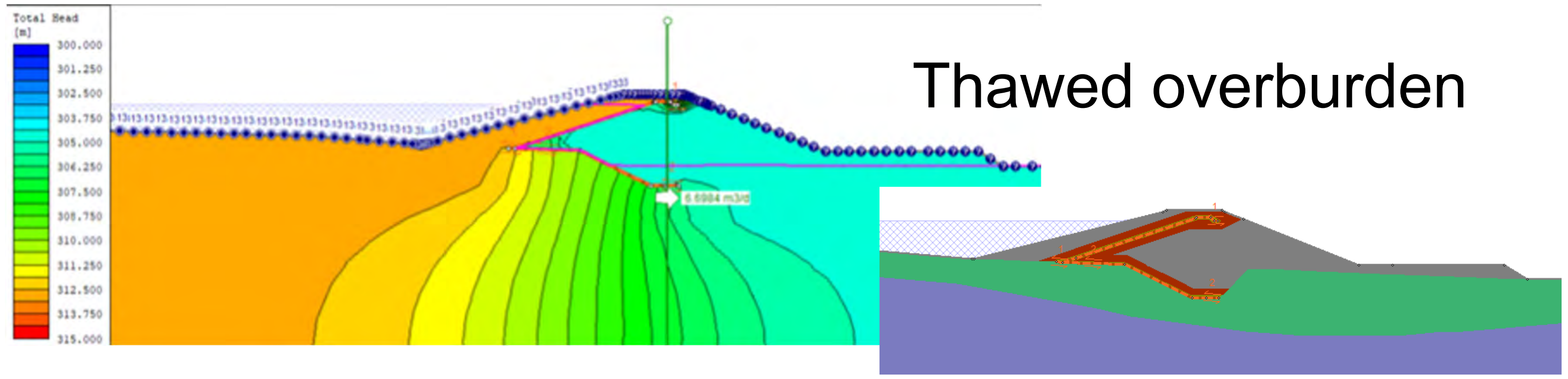
- Seepage analysis using Slide’s FEM GW calculator (Thawed overburden; Frozen overburden, and thawed layer 2m thick)
- Leakage rate through geomembrane holes (assumed 1 hole of d=0.5mm every 10m of the liner)*
- Leakage rate through pinholes (assumed 1 pinhole of d=0.3mm every 10 m of the liner)*

**References**

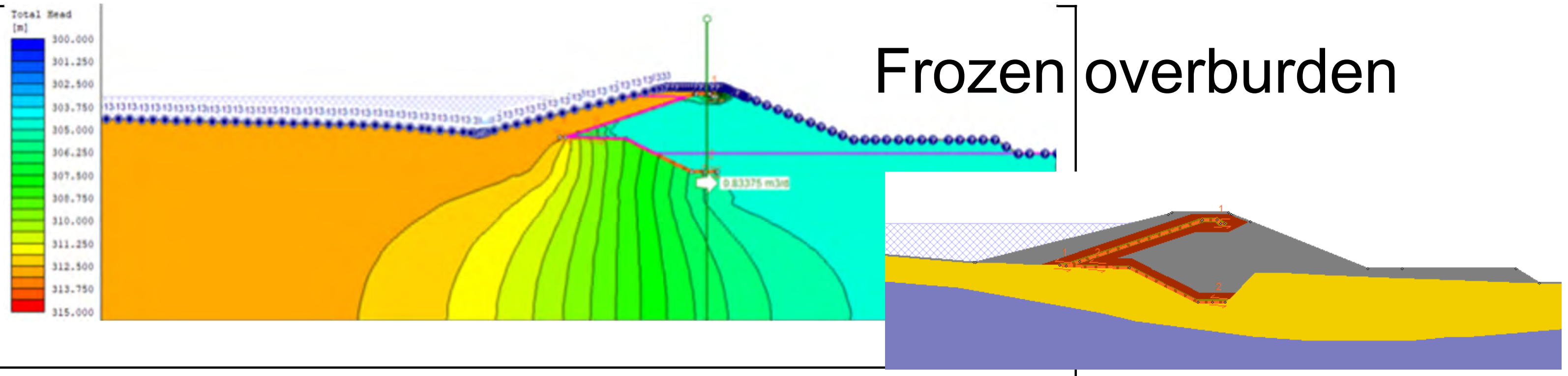
*) J. P. Giroud & R. Bonaparte (1989). Leakage through Liners Constructed with Geomembrane= Part I. Geomembrane Liners. *Geotextiles and Geomembranes 8 (1989)* p. 27-67

# Seepage analysis (Slide's FEM GW calculator)

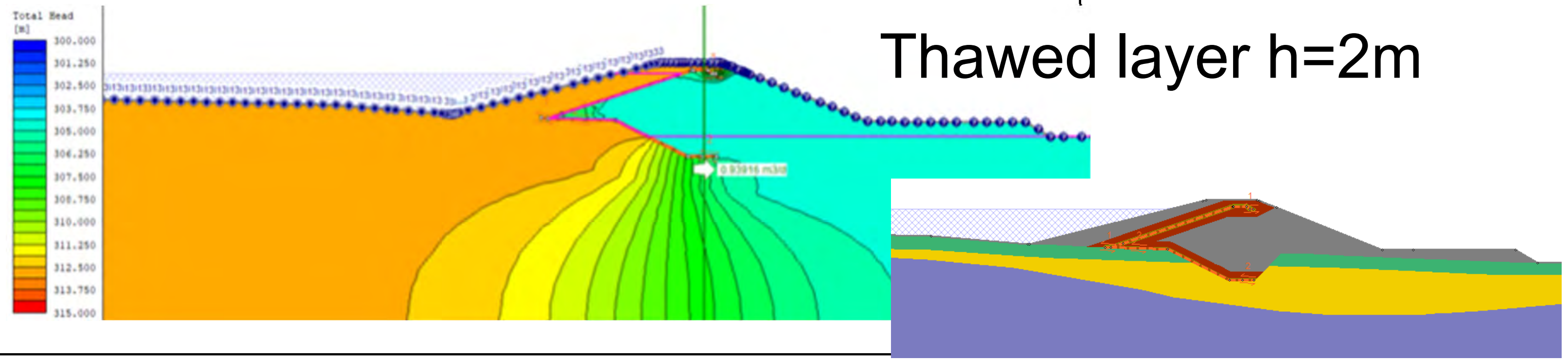
| Water/Pwp Conditions | Leakage rate, m³/s | Leakage rate, m³/d | Comments |
|---|---|---|---|
| From Slide's Finite Element Groundwater Calculator | 8.04E-05 | 6.7 | Embankment H=7.0m. Thawed overburden. With HDPE Liner (Hydraulic conductivity k=5e-10 m/s). Total head contours are shown in the screenshot. |
| From Slide's Finite Element Groundwater Calculator | 9.96E-06 | 0.83 | Embankment H=7.0m. Frozen overburden. With HDPE Liner (Hydraulic conductivity k=5e-10 m/s). Total head contours are shown in the screenshot. |
| From Slide's Finite Element Groundwater Calculator | 1.12E-05 | 0.93 | Embankment H=7.0m. Thawed layer h=2m. With HDPE Liner (Hydraulic conductivity k=5e-10 m/s). Total head contours are shown in the screenshot. |



Thawed overburden



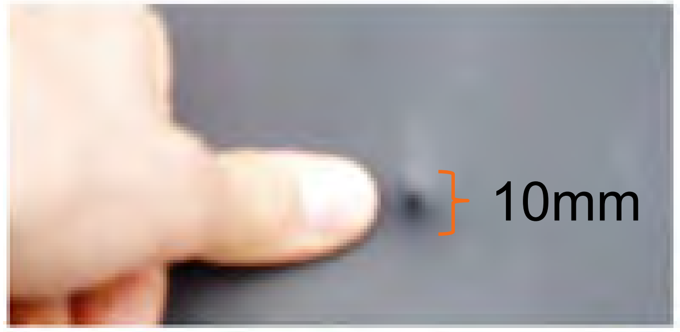
Frozen overburden



Thawed layer h=2m

# Typical Size of the Hole

Typical size of the holes in the liner



(ref.: based on the SRK Consulting experience)

Typical shape of the holes in the liner

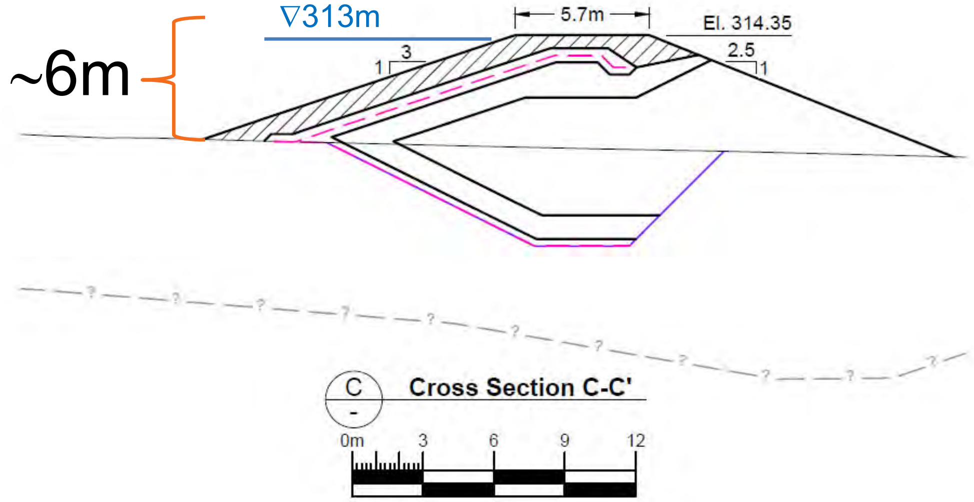
during liner
manufacturing
(circular pinholes)

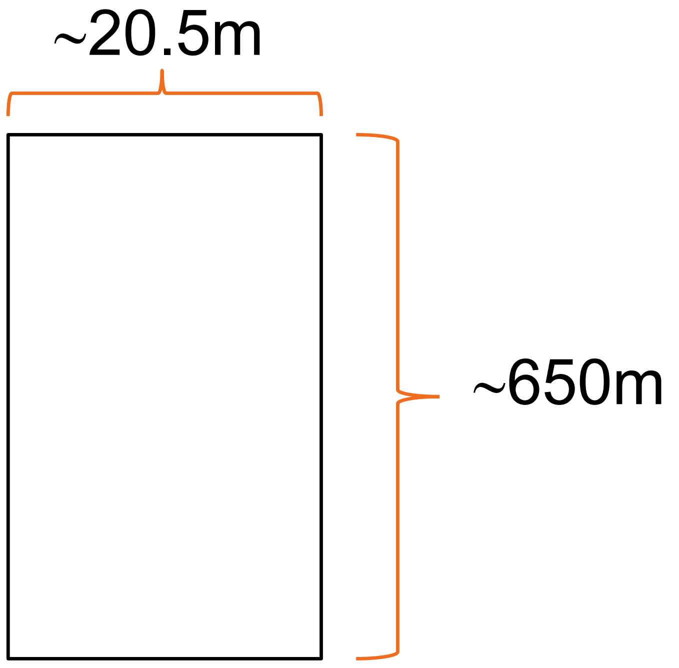
during installation
(square rips)

<u>Holes can be due to the following:</u>

- Defective seaming;
- Failure of the geomembrane due to poor design;
- Damage to the geomembrane during the placement of overlying;
- Puncturing of geomembranes by coarsely crushed stones in the support or cover material;
- Damage to geomembranes as a result of excessive stresses caused by equipment traffic during the construction process, etc.

# Leakage Through the Liner (input parameters)





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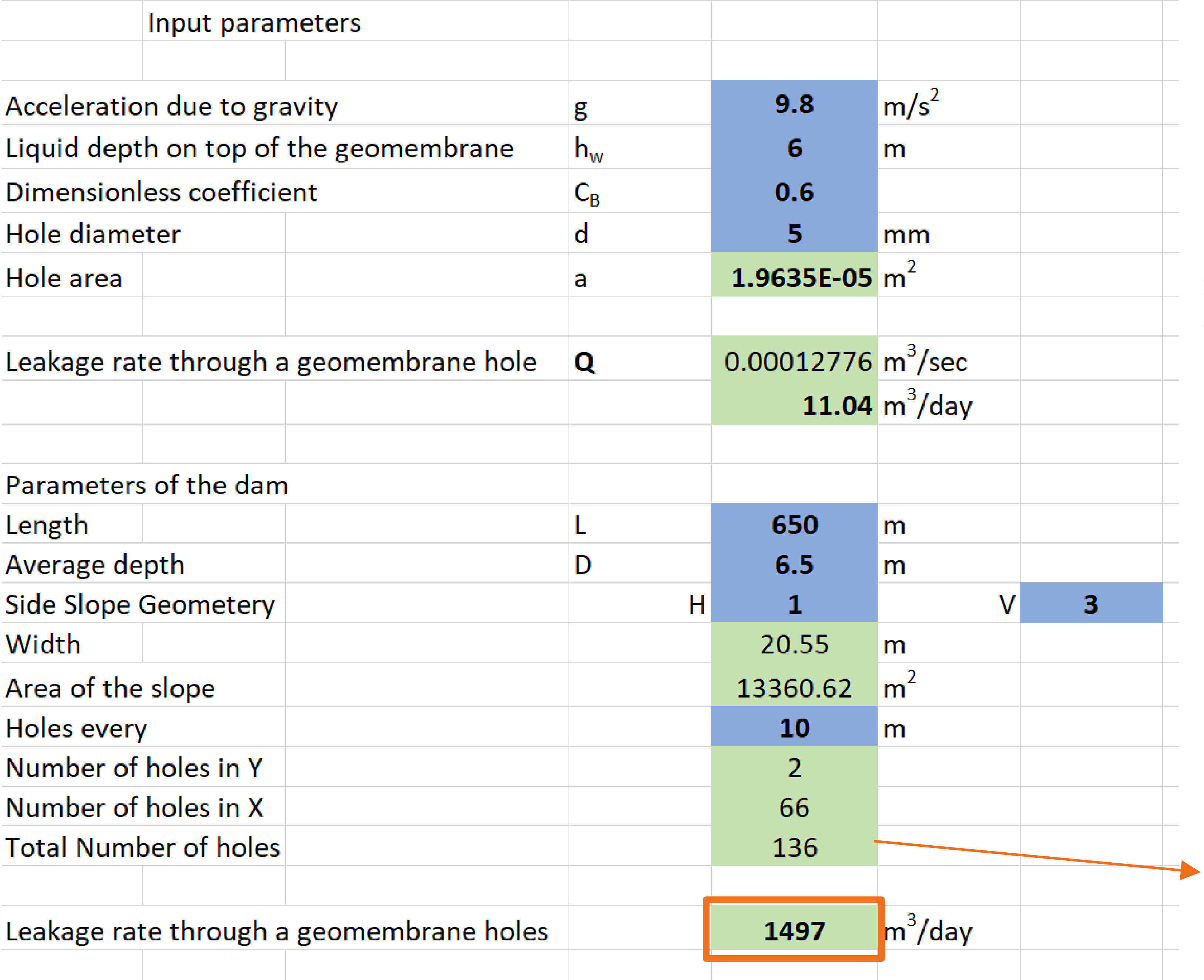
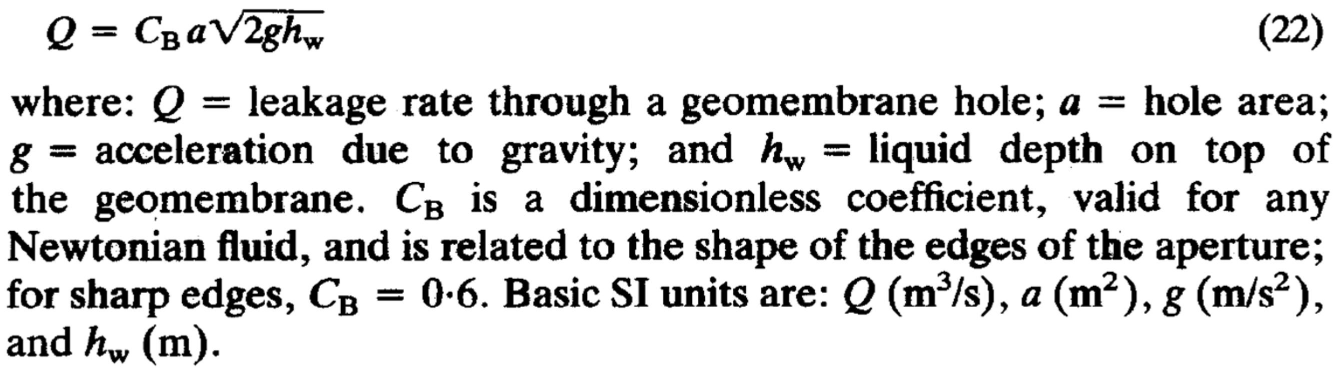
# Leakage rate through geomembrane holes*



| | | | | | |
|---|---|---|---|---|---|
| Input parameters | | | | | |
| | | | | | |
| Acceleration due to gravity | g | **9.8** | $m/s^2$ | | |
| Liquid depth on top of the geomembrane | $h_w$ | **6** | m | | |
| Dimensionless coefficient | $C_B$ | **0.6** | | | |
| Hole diameter | d | **5** | mm | | |
| Hole area | a | **1.9635E-05** | $m^2$ | | |
| | | | | | |
| Leakage rate through a geomembrane hole | **Q** | 0.00012776 | $m^3$/sec | | |
| | | **11.04** | $m^3$/day | | |
| | | | | | |
| Parameters of the dam | | | | | |
| Length | L | **650** | m | | |
| Average depth | D | **6.5** | m | | |
| Side Slope Geometery | H | **1** | | V | **3** |
| Width | | 20.55 | m | | |
| Area of the slope | | 13360.62 | $m^2$ | | |
| Holes every | | **10** | m | | |
| Number of holes in Y | | 2 | | | |
| Number of holes in X | | 66 | | | |
| Total Number of holes | | 136 | | | |
| | | | | | |
| Leakage rate through a geomembrane holes | | **1497** | $m^3$/day | | |

*) J. P. Giroud & R. Bonaparte (1989) Leakage through Liners Constructed with Geomembrane= Part I. Geomembrane Liners. *Geotextiles and Geomembranes 8 (1989)* p. 27-67

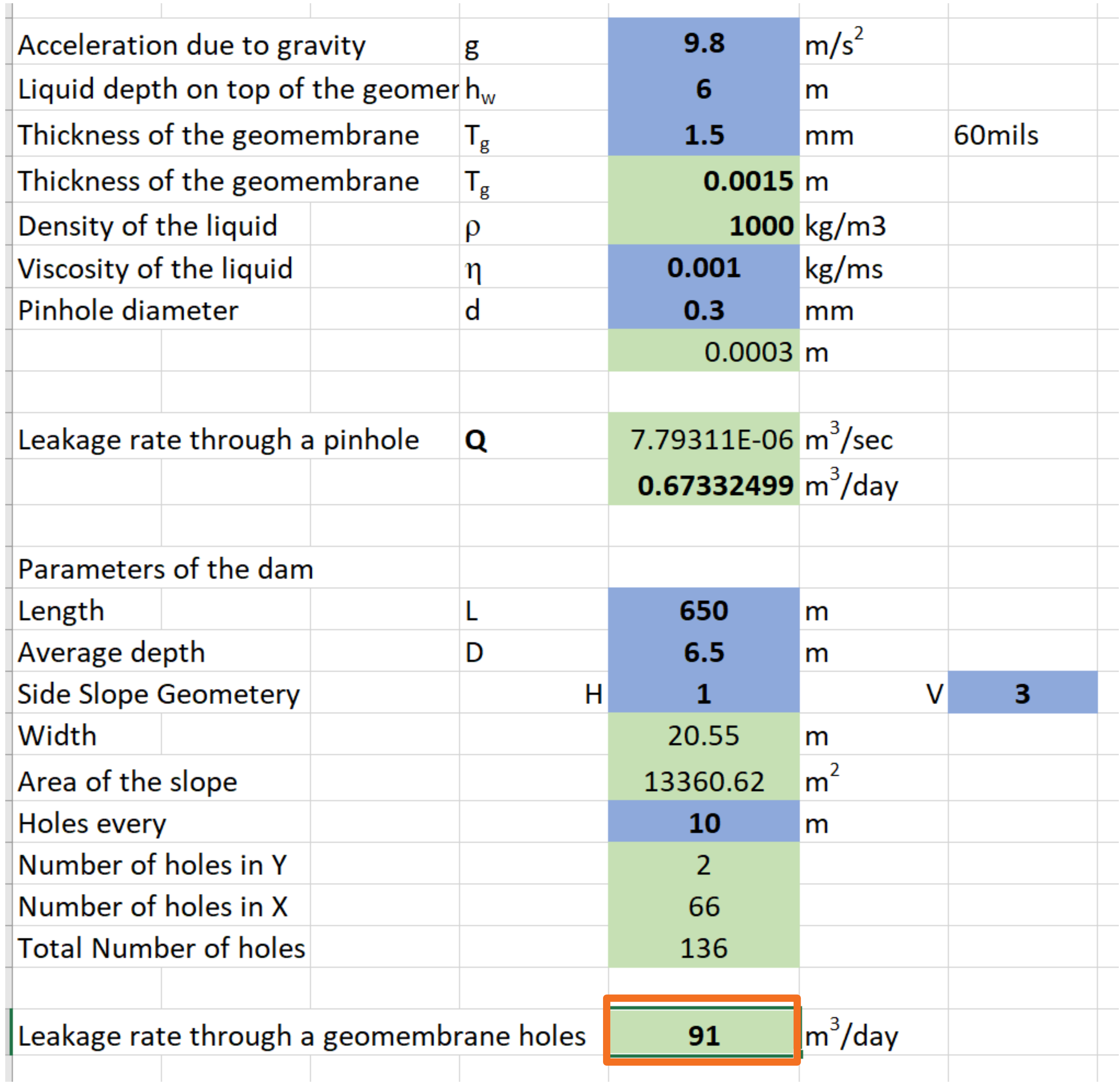


$$Q = C_B a \sqrt{2 g h_w} \qquad (22)$$

where: $Q$ = leakage rate through a geomembrane hole; $a$ = hole area; $g$ = acceleration due to gravity; and $h_w$ = liquid depth on top of the geomembrane. $C_B$ is a dimensionless coefficient, valid for any Newtonian fluid, and is related to the shape of the edges of the aperture; for sharp edges, $C_B = 0{\cdot}6$. Basic SI units are: $Q$ ($m^3/s$), $a$ ($m^2$), $g$ ($m/s^2$), and $h_w$ (m).

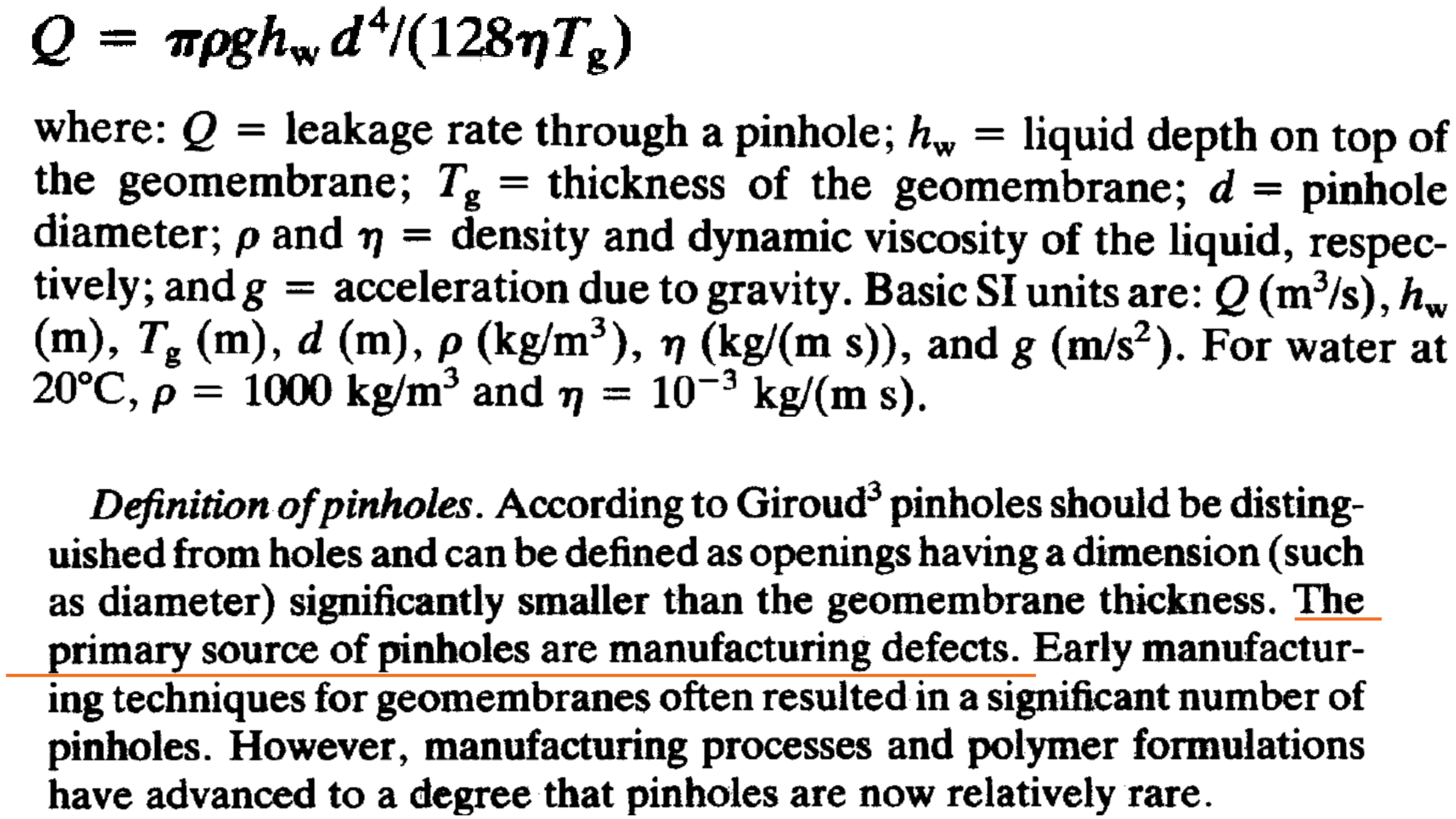
**Note:** K.Rowe (2012) assumes max 5 holes per hectare for the leakage rate calculations, so maybe we need to decrease the number of holes?

# Leakage rate through pinholes*



| | | | | |
|---|---|---|---|---|
| Acceleration due to gravity | g | 9.8 | m/s$^2$ | |
| Liquid depth on top of the geomer | $h_w$ | 6 | m | |
| Thickness of the geomembrane | $T_g$ | 1.5 | mm | 60mils |
| Thickness of the geomembrane | $T_g$ | 0.0015 | m | |
| Density of the liquid | ρ | 1000 | kg/m3 | |
| Viscosity of the liquid | η | 0.001 | kg/ms | |
| Pinhole diameter | d | 0.3 | mm | |
| | | 0.0003 | m | |
| | | | | |
| Leakage rate through a pinhole | **Q** | 7.79311E-06 | m$^3$/sec | |
| | | 0.67332499 | m$^3$/day | |
| | | | | |
| Parameters of the dam | | | | |
| Length | L | 650 | m | |
| Average depth | D | 6.5 | m | |
| Side Slope Geometery | H | 1 | V | 3 |
| Width | | 20.55 | m | |
| Area of the slope | | 13360.62 | m$^2$ | |
| Holes every | | 10 | m | |
| Number of holes in Y | | 2 | | |
| Number of holes in X | | 66 | | |
| Total Number of holes | | 136 | | |
| | | | | |
| Leakage rate through a geomembrane holes | | 91 | m$^3$/day | |

*) J. P. Giroud & R. Bonaparte (1989) Leakage through Liners Constructed with Geomembrane= Part I. Geomembrane Liners. *Geotextiles and Geomembranes 8 (1989)* p. 27-67



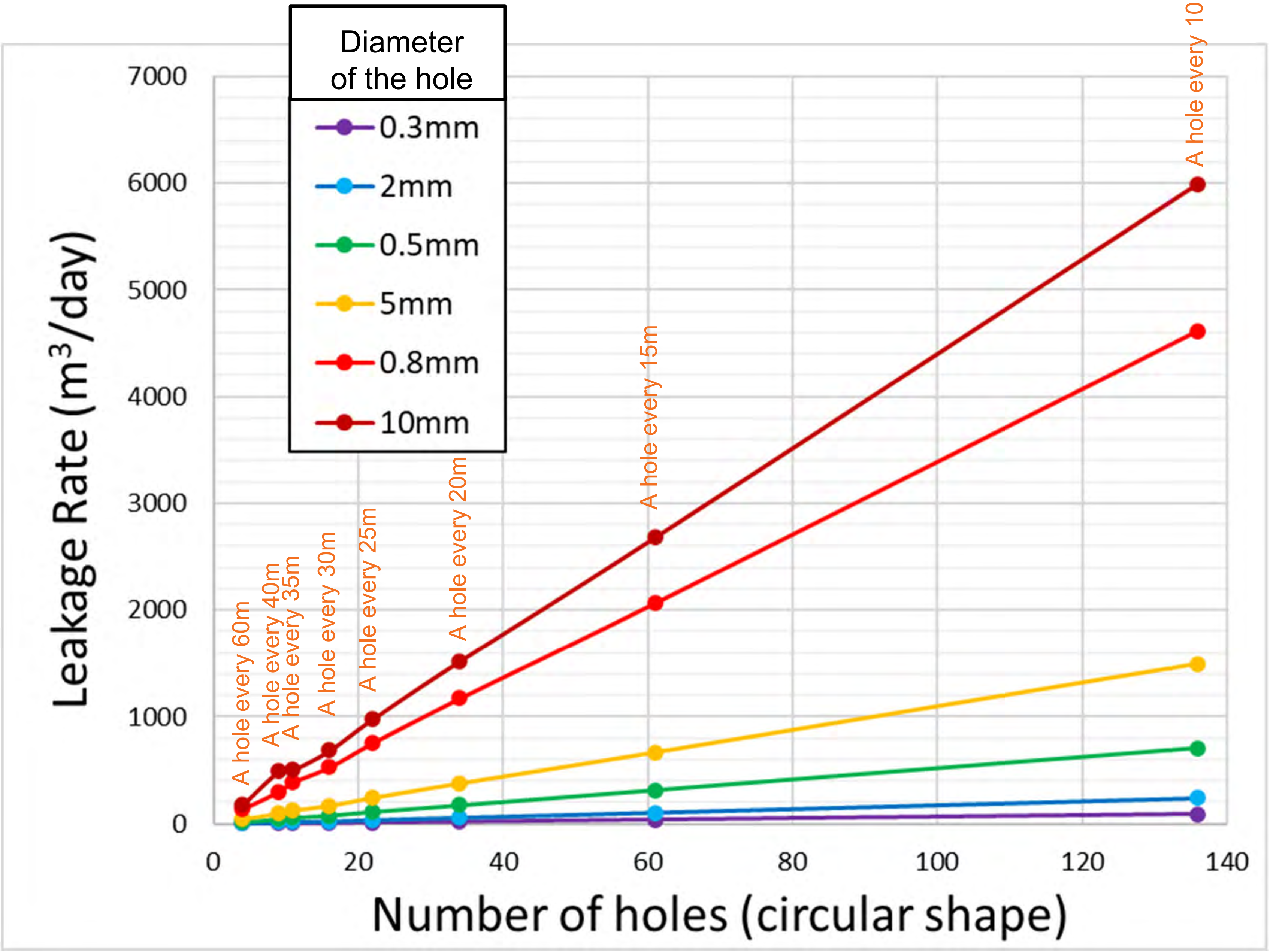
$$Q = \pi \rho g h_w d^4/(128 \eta T_g)$$

where: $Q$ = leakage rate through a pinhole; $h_w$ = liquid depth on top of the geomembrane; $T_g$ = thickness of the geomembrane; $d$ = pinhole diameter; $\rho$ and $\eta$ = density and dynamic viscosity of the liquid, respectively; and $g$ = acceleration due to gravity. Basic SI units are: $Q$ (m$^3$/s), $h_w$ (m), $T_g$ (m), $d$ (m), $\rho$ (kg/m$^3$), $\eta$ (kg/(m s)), and $g$ (m/s$^2$). For water at 20°C, $\rho = 1000$ kg/m$^3$ and $\eta = 10^{-3}$ kg/(m s).

*Definition of pinholes*. According to Giroud[3] pinholes should be distinguished from holes and can be defined as openings having a dimension (such as diameter) significantly smaller than the geomembrane thickness. The primary source of pinholes are manufacturing defects. Early manufacturing techniques for geomembranes often resulted in a significant number of pinholes. However, manufacturing processes and polymer formulations have advanced to a degree that pinholes are now relatively rare.

# Sensitivity analysis
# Leakage rate vs. # of holes in the liner

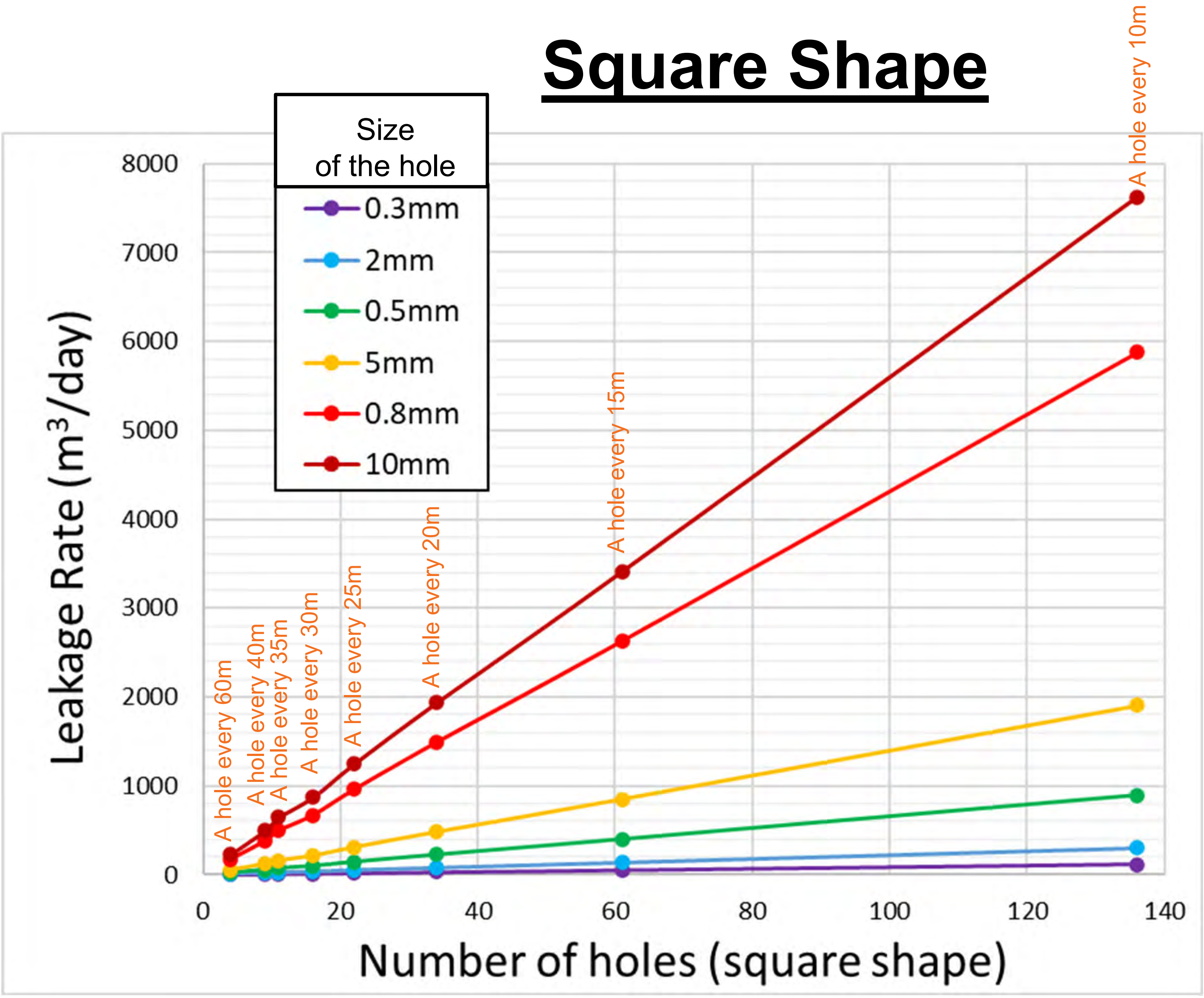
## Circular Shape



| A hole every … m | Number of holes per 1 hectare |
|---|---|
| 10 | 102 |
| 15 | 46 |
| 20 | 25 |
| 25 | 16 |
| 30 | 12 |
| 35 | 8 |
| 40 | 7 |
| 60 | 3 |

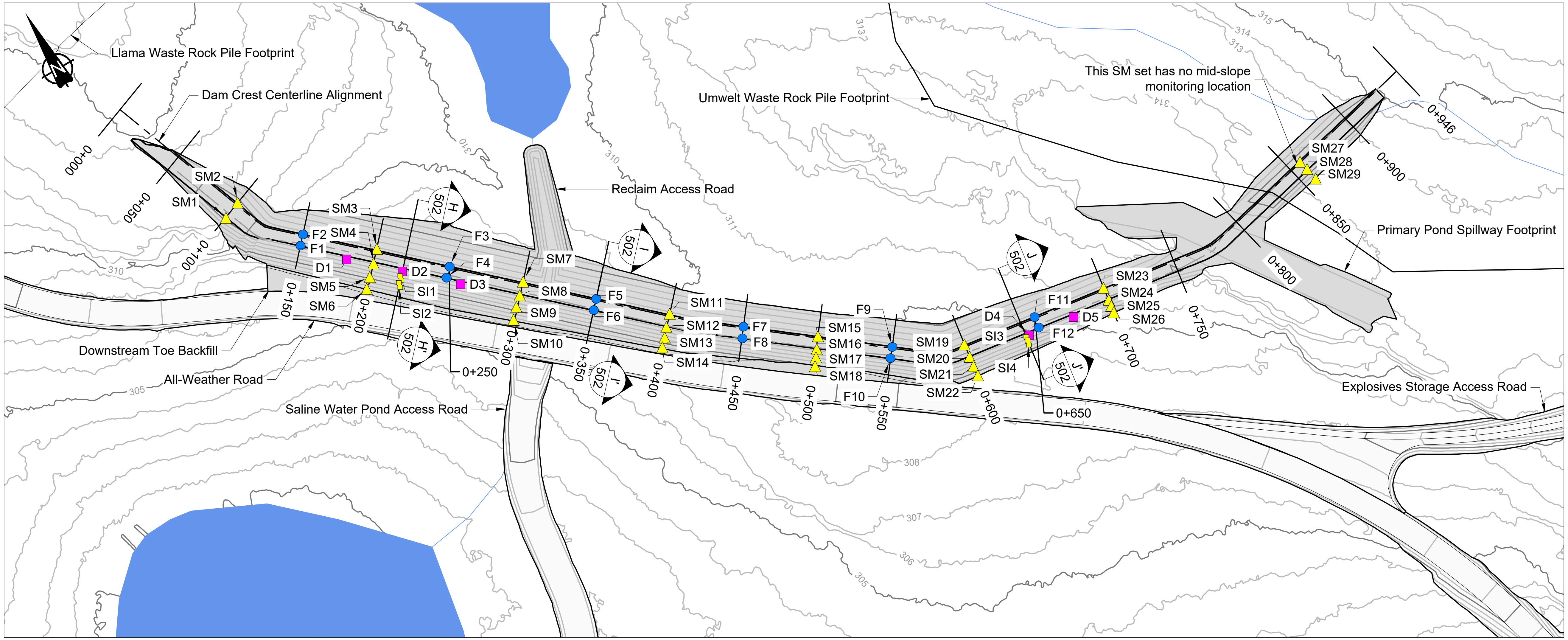
# Sensitivity analysis
# Leakage rate vs. # of holes in the liner

## Square Shape



| A hole every … m | Number of holes per 1 hectare |
|---|---|
| 10 | 102 |
| 15 | 46 |
| 20 | 25 |
| 25 | 16 |
| 30 | 12 |
| 35 | 8 |
| 40 | 7 |
| 60 | 3 |

# ATTACHMENT 6



## Primary Pond Dam Plan

## LEGEND

| | |
|---|---|
| ● | Fixed Survey Monitoring Point |
| △ | Surficial Survey Monitoring Point |
| ■ | Deep Monitoring Point |
| ▯ | Slope Inclinometers |
| ═ | Contours |
| ─ | Monitoring Section |
| ─ | Waterbody |
| ☐ | Other Design Infrastructure |
| ▨ | Primary Pond Design Infrastructure |

## NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

## REFERENCES

NAD83 UTM Zone 13.

### Surficial Survey Monitoring Points

| Identify | Easting | Northing |
|---|---|---|
| SM1 | 429493.6 | 7271483 |
| SM2 | 429505.4 | 7271487 |
| SM3 | 429570.2 | 7271414 |
| SM4 | 429563.6 | 7271407 |
| SM5 | 429556.8 | 7271400 |
| SM6 | 429551.1 | 7271395 |
| SM7 | 429643.8 | 7271347 |
| SM8 | 429637.3 | 7271340 |
| SM9 | 429631.4 | 7271334 |
| SM10 | 429625.5 | 7271328 |
| SM11 | 429717.6 | 7271279 |
| SM12 | 429711.3 | 7271273 |
| SM13 | 429706.8 | 7271267 |
| SM14 | 429702.2 | 7271262 |
| SM15 | 429795.7 | 7271217 |
| SM16 | 429790.6 | 7271210 |
| SM17 | 429787.5 | 7271206 |
| SM18 | 429784.1 | 7271201 |
| SM19 | 429877.3 | 7271164 |
| SM20 | 429876.4 | 7271155 |
| SM21 | 429875.5 | 7271148 |
| SM22 | 429874.9 | 7271141 |
| SM23 | 429976.6 | 7271150 |
| SM24 | 429975.6 | 7271141 |
| SM25 | 429975 | 7271137 |
| SM26 | 429974.4 | 7271132 |
| SM27 | 430131.8 | 7271157 |
| SM28 | 430133.6 | 7271151 |
| SM29 | 430135.3 | 7271142 |

0m 30 60 90 120

### Deep Survey Monitoring Points

| Identify | Easting | Northing |
|---|---|---|
| D1 | 429549.4 | 7271418 |
| D2 | 429577.5 | 7271393 |
| D3 | 429606.8 | 7271366 |
| D4 | 429917.7 | 7271147 |
| D5 | 429949.6 | 7271143 |

### Slope Inclinometer Monitoring Points

| Identify | Easting | Northing |
|---|---|---|
| SI1 | 429574.6 | 7271390 |
| SI2 | 429571.5 | 7271386 |
| SI3 | 429915.5 | 7271146 |
| SI4 | 429915.1 | 7271144 |

### Fixed Survey Monitoring Points

| Identify | Easting | Northing |
|---|---|---|
| F1 | 429527.3 | 7271442 |
| F2 | 429532.5 | 7271447 |
| F3 | 429606.3 | 7271380 |
| F4 | 429600.8 | 7271374 |
| F5 | 429680.2 | 7271312 |
| F6 | 429675 | 7271307 |
| F7 | 429755.8 | 7271247 |
| F8 | 429751.3 | 7271241 |
| F9 | 429835 | 7271186 |
| F10 | 429830.2 | 7271180 |
| F11 | 429926.9 | 7271156 |
| F12 | 429925.9 | 7271149 |

| DRAWING NO. | DRAWING TITLE | NO. | DESCRIPTION | CHK'D | APP'D | DATE | NO. | DESCRIPTION | CHK'D | APP'D | DATE |
|---|---|---|---|---|---|---|---|---|---|---|---|
| - - | - - | - - | - - | - - | - - | - - | A | Issued for Permit | JD/AT | JBK | 2022/09/02 |

REFERENCE DRAWINGS

REVISIONS

Original Drawings Signed and Stamped

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DESIGN: JU/JBK
DRAWN: SGE
REVIEWED: JU/CS/AT
CHECKED: JD/AT/VB
APPROVED: JBK
DATE: 2022/09/02
FILE NAME: 1CS020.020 - UM-PP-Instrum plans.dwg

Sabina

Back River

SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond

DRAWING TITLE:
Primary Pond Dam
Instrumentation Plan

DRAWING NO.: UM-PP-500
REVISION NO.: A

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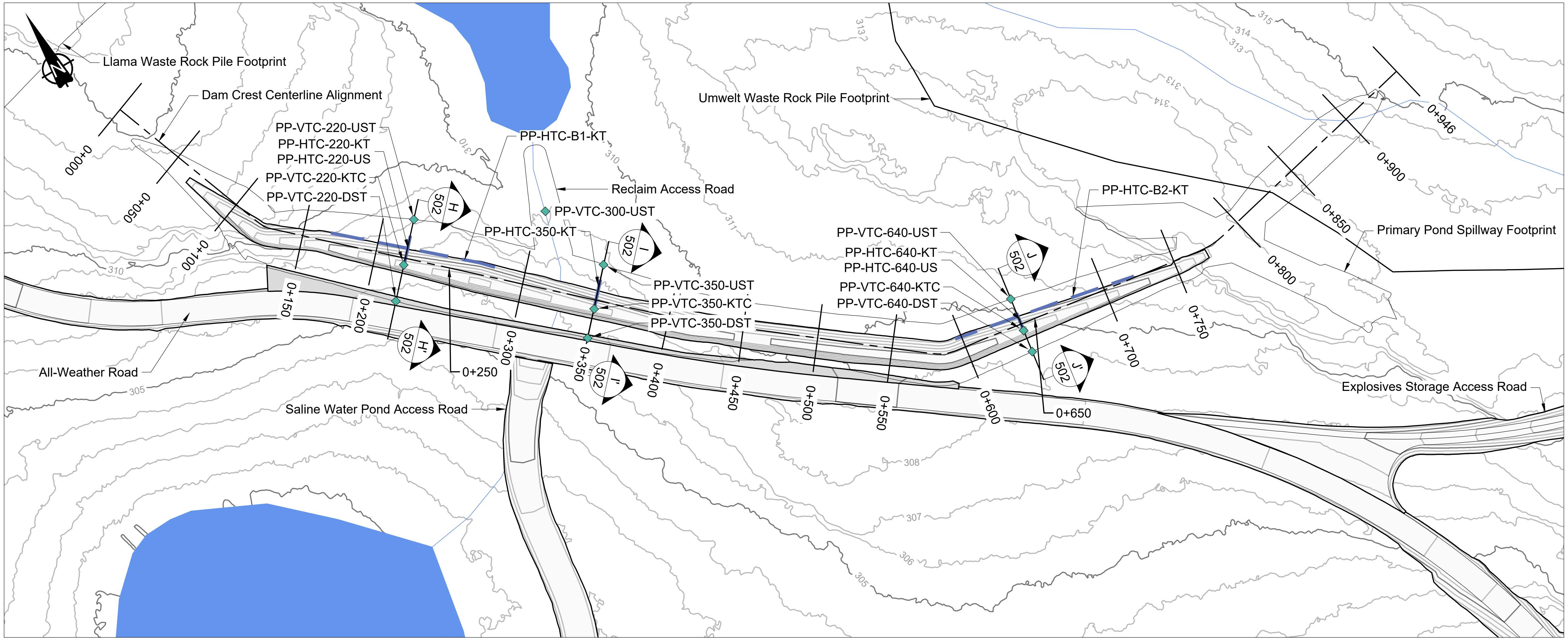

## Primary Pond Dam Plan

### LEGEND

| | |
|---|---|
| ◆ | Vertical Ground Temperature Cable |
| — — | Horizontal Ground Temperature Cable |
| — | Contours |
| — | Monitoring Section |
| — | Waterbody |
| ☐ | Other Design Infrastructure |
| ▨ | Primary Pond Design Infrastructure |

### NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

### REFERENCES

NAD83 UTM Zone 13.

### Vertical Ground Cable Locations

| Identify | Easting | Northing |
|---|---|---|
| PP-VTC-220-DST | 429563.9 | 7271378 |
| PP-VTC-220-KTC | 429580.5 | 7271396 |
| PP-VTC-220-UST | 429601.4 | 7271419 |
| PP-VTC-300-UST | 429680 | 7271380 |
| PP-VTC-350-DST | 429662.2 | 7271293 |
| PP-VTC-350-KTC | 429675.7 | 7271307 |
| PP-VTC-350-UST | 429695.8 | 7271330 |
| PP-VTC-640-DST | 429914.3 | 7271137 |
| PP-VTC-640-KTC | 429916.2 | 7271152 |
| PP-VTC-640-UST | 429919.3 | 7271174 |

0m 30 60 90 120

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

REVISIONS

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|---|---|---|
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| CHECKED: JD/AT/VB | APPROVED: JBK | DATE: 2022/09/02 |

FILE NAME: 1CS020.020 - UM-PP-Instrum plans.dwg

Sabina GOLD & SILVER CORP

Back River

SRK JOB NO.: 1CS020.020

REG. NO.: EGBC 1003655

Primary Pond

DRAWING TITLE:
Primary Pond Dam
Horizontal and Vertical GTC Layout

DRAWING NO.: UM-PP-501

REVISION NO.: A

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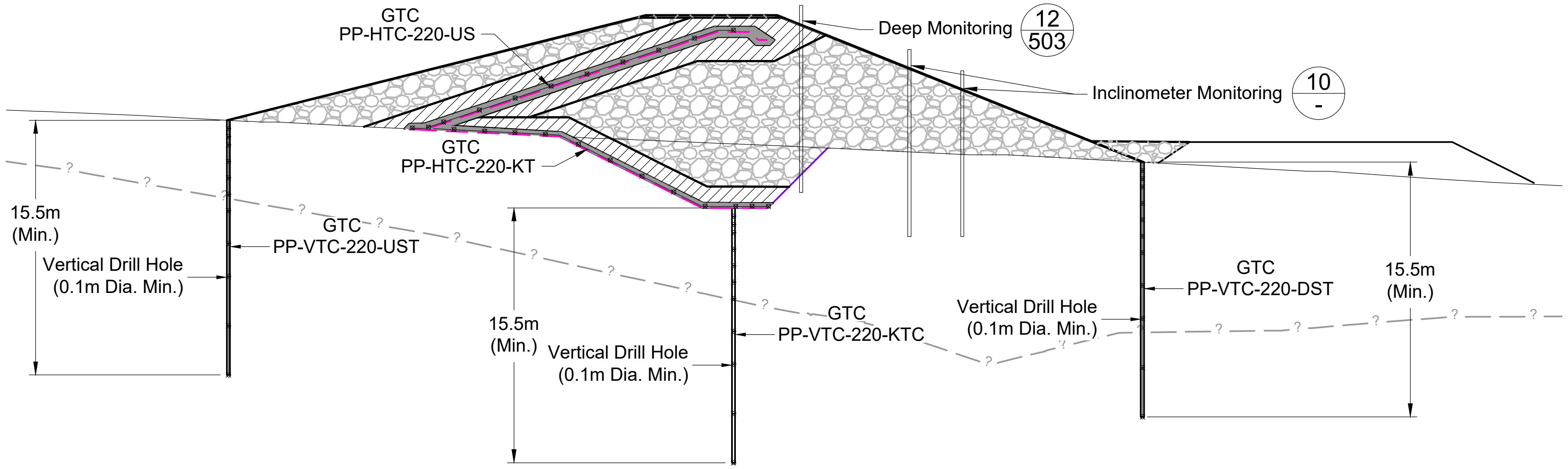
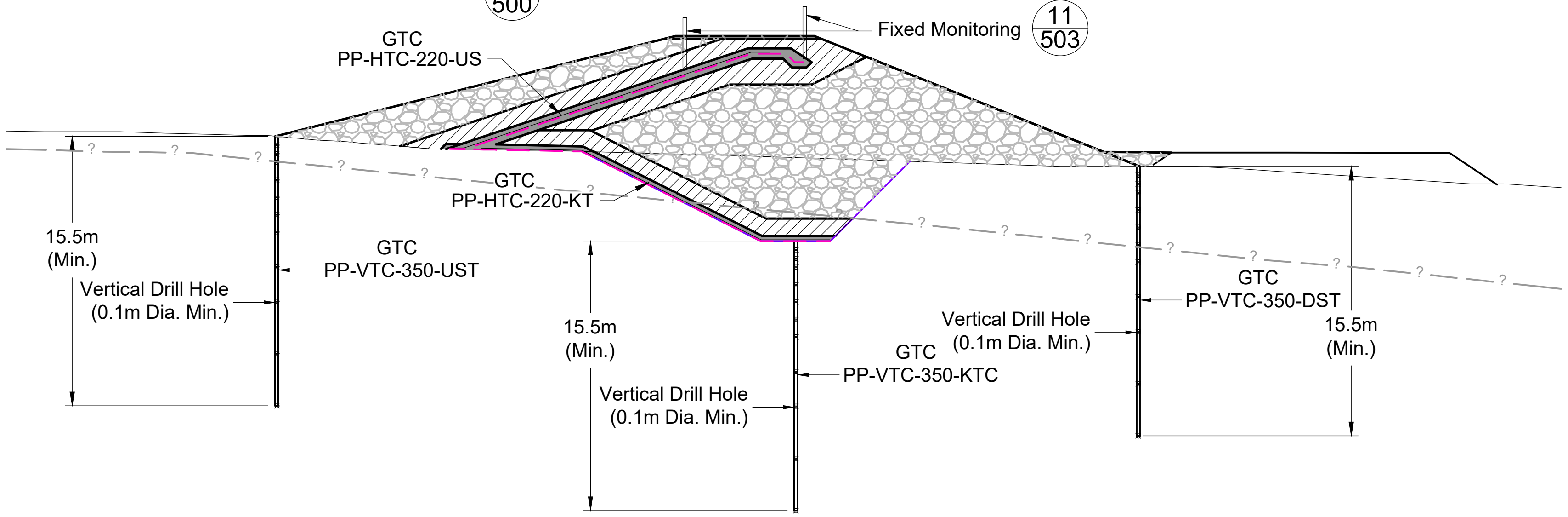
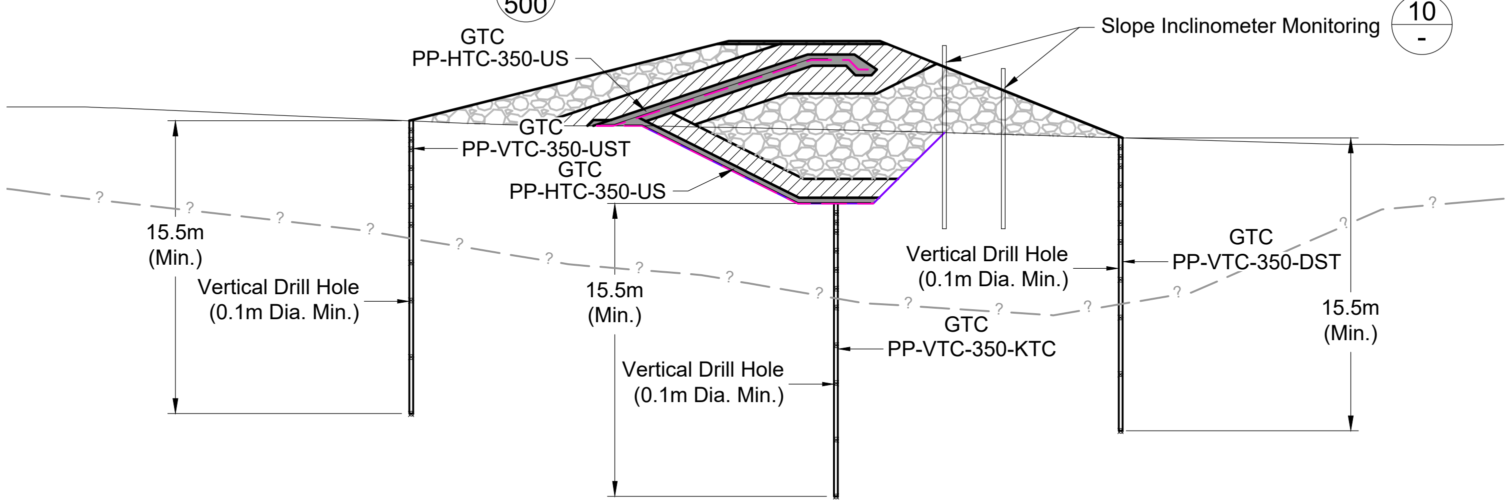


H
500
**Ground Temperature Cable at Station 0+220**



I
500
**Ground Temperature Cable at Station 0+350**



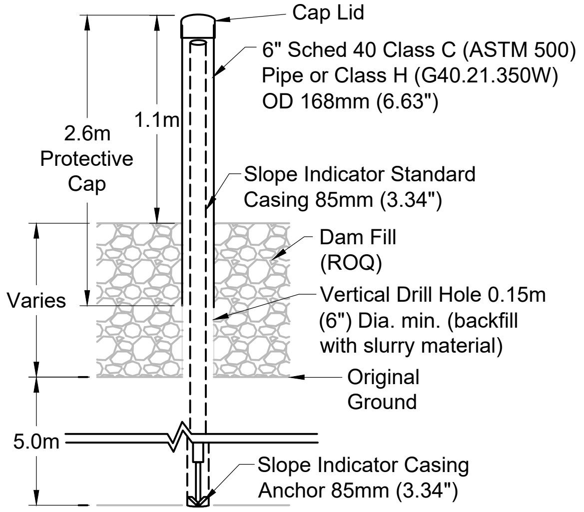
J
500
**Ground Temperature Cable at Station 0+640**

**LEGEND**

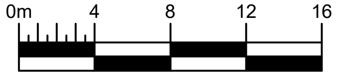
- — Design Surface
- — Excavation
- — Existing Ground
- – – ? – Inferred Bedrock
- – – HDPE Liner
- ▬ Bedding
- ▭ Run of Quarry
- ☒ Surfacing
- ▨ Transition Material

**NOTES**

1. All units are in meters unless otherwise specified.
2. Bead spacing is as follows:
   -Vertical Cables (below ground surface): 0.5, 1.0, 1.5, 2.5, 3.5, 4.5, 5.5, 7.5, 9.5, 12.5, 15.5
   -Horizontal cables : at 0, 1, 2, then every 2 m after until the end of cable.
3. GTC = Ground Temperature Table



10
-
**Inclinometer Installation Detail**
Not To Scale



| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| - - | - - | - - | - - | - - | - - | - - | A | Issued for Permit | JD/AT | JBK | 2022/09/02 |
| DRAWING NO. | DRAWING TITLE | NO. | DESCRIPTION | CHK'D | APP'D | DATE | NO. | DESCRIPTION | CHK'D | APP'D | DATE |
| REFERENCE DRAWINGS | | REVISIONS | | | | | | | | | |

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CHECKED: JD/AT/VB
APPROVED: JBK
DATE: 2022/09/02
FILE NAME: 1CS020.020 - UM-PP-Instrum plans.dwg

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GOLD & SILVER CORP

Back River

SRK JOB NO.: 1CS020.020
REG. NO.:

Primary Pond
DRAWING TITLE:
Primary Pond Dam
Instrumentation Details
DRAWING NO.: UM-PP-502
REVISION NO.: A

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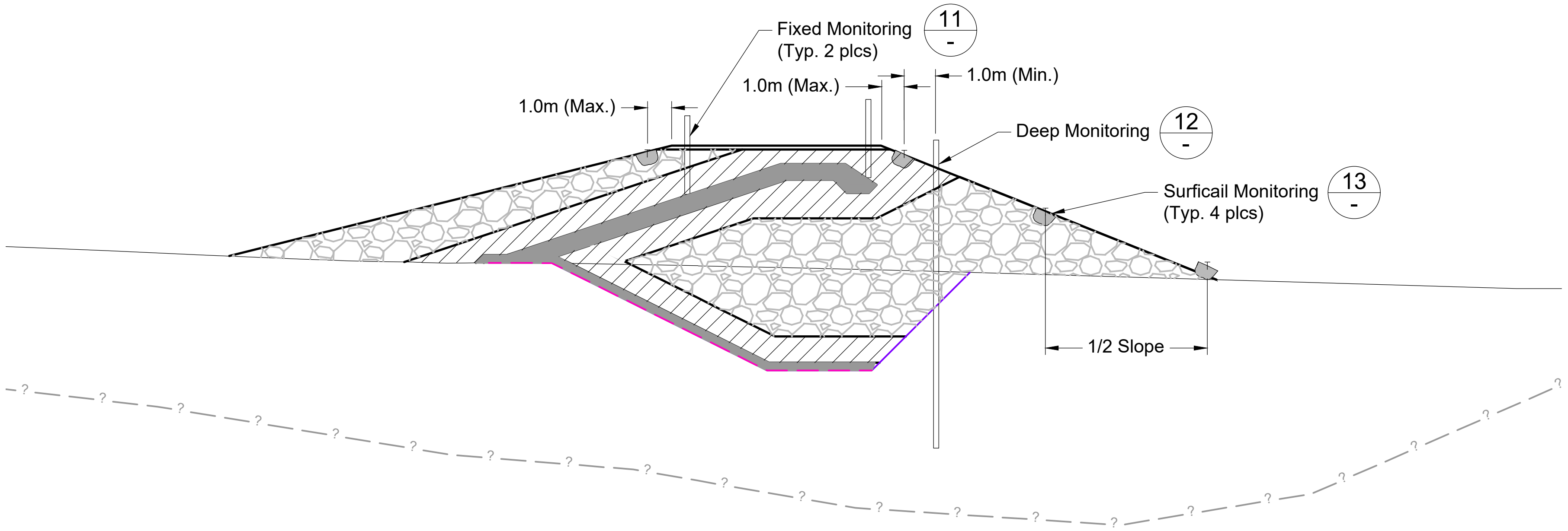
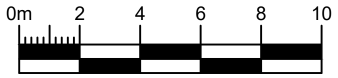


## Typical Survey Monitoring Pin Locations

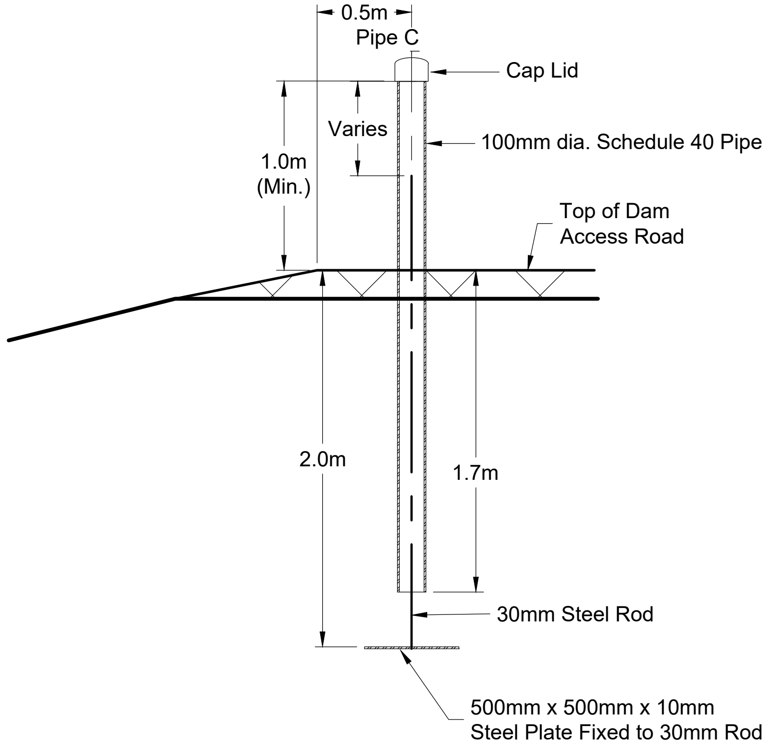


**LEGEND**

| | |
|---|---|
| — | Design Surface |
| — | Excavation |
| — | Existing Ground |
| – – ? – | Inferred Bedrock |
| – – | HDPE Liner |
| ■ | Bedding |
| ▭ | Run of Quarry |
| ☒ | Surfacing |
| ▨ | Transition Material |

**NOTES**

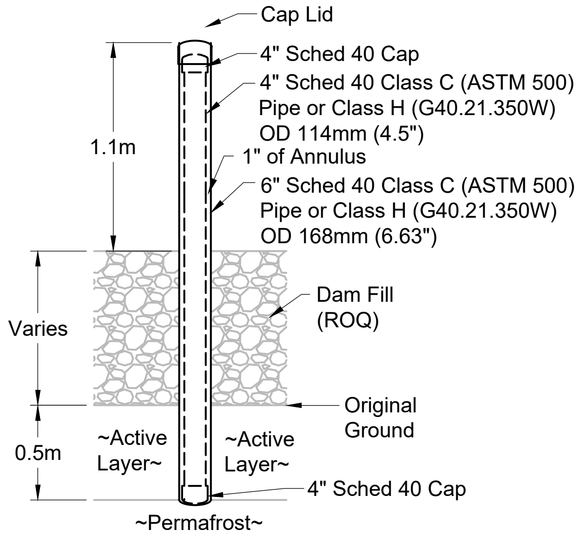
1. All units are in meters unless otherwise specified.



11
-

## Fixed Survey Monitoring Point Detail

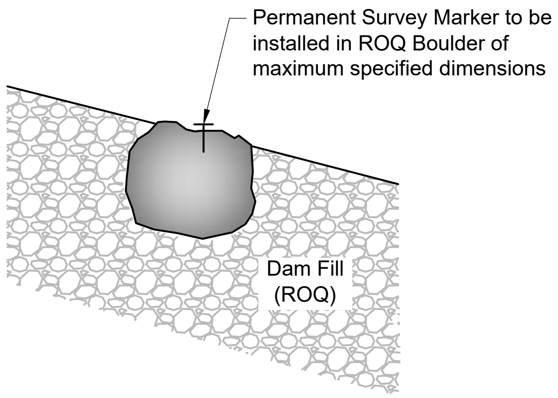
Not To Scale



12
-

## Deep Settlement Point Installation Detail

Not To Scale



13
-

## Surficial Survey Point Installation Detail

Not To Scale

| DRAWING NO. | DRAWING TITLE |
|---|---|
| - - | - - |

REFERENCE DRAWINGS

| NO. | DESCRIPTION | CHK'D | APP'D | DATE | NO. | DESCRIPTION | CHK'D | APP'D | DATE |
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| CHECKED: JD/AT/VB | APPROVED: JBK | DATE: 2022/09/02 |

FILE NAME: 1CS020.020 - UM-PP-Instrum plans.dwg

Sabina
GOLD & SILVER CORP

Back River

SRK JOB NO.: 1CS020.020

REG. NO.:

Primary Pond

DRAWING TITLE:
Primary Pond Dam
Instrumentation Details

DRAWING NO.: UM-PP-503

REVISION NO.: A

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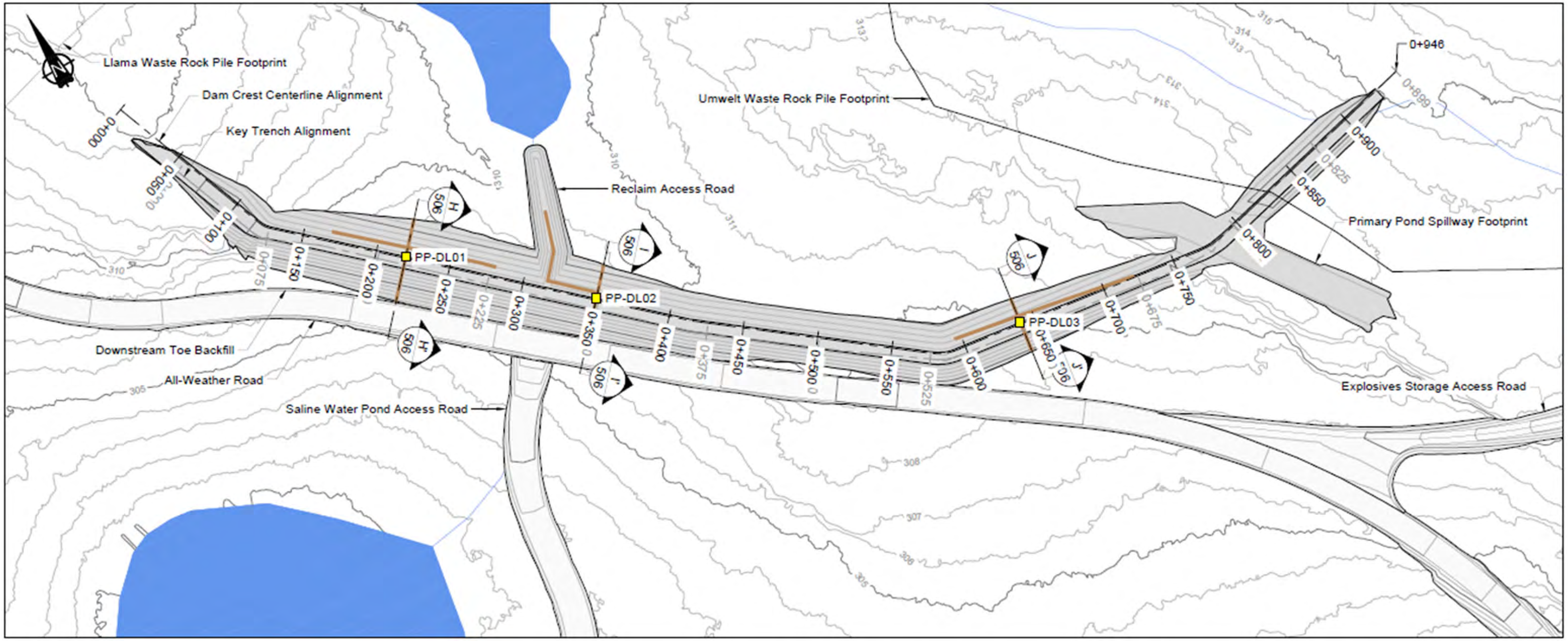


Primary Pond Dam Plan

| | |
|---|---|
| 🟨 | Data Logger Location |
| ━ | Cable Trench |
| ═ | Contours |
| ─ | Monitoring Section |
| ─ | Waterbody |
| ☐ | Other Design Infrastructure |
| ▨ | Primary Pond Design Infrastructure |

**LEGEND**

**NOTES**

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Ground Temperature Cable backfilled cable trenches to be excavated through final dam shell – See drawing UM-PP-506

**REFERENCES**

NAD83 UTM Zone 13.

**Data Logger Location Points**

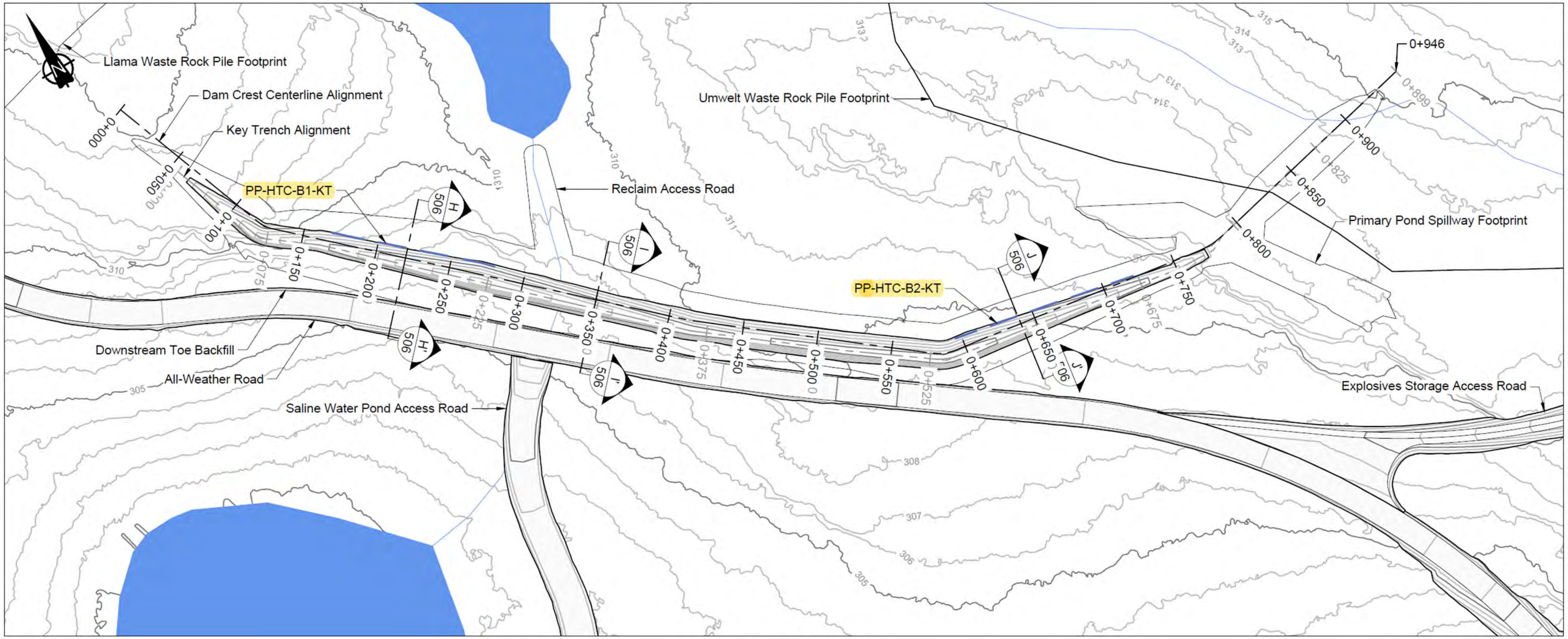
| Identify | Easting | Northing |
|---|---|---|
| PP-DL01 | 429584.4298 | 7271400.33 |
| PP-DL02 | 429680.4355 | 7271312.7 |
| PP-DL03 | 429917.1034 | 7271157.81 |

Primary Pond

DRAWING TITLE:

Primary Pond Dam
Backfill Cable Trenches

504 - Working Draft – To be updated and added into main drawing package after information from supplier confirmed



**Primary Pond Dam Plan**

**LEGEND**

| | |
|---|---|
| – – | Horizontal Ground Temperature Cabl |
| — | Contours |
| — | Monitoring Section |
| — | Waterbody |
| ☐ | Other Design Infrastructure |
| ▨ | Primary Pond Design Infrastructure |

**NOTES**

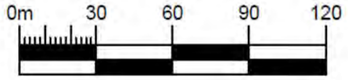
1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Bead spacing is 5.0m for upstream base / toe of the key trench horizontal ground temperature cable.

**REFERENCES**

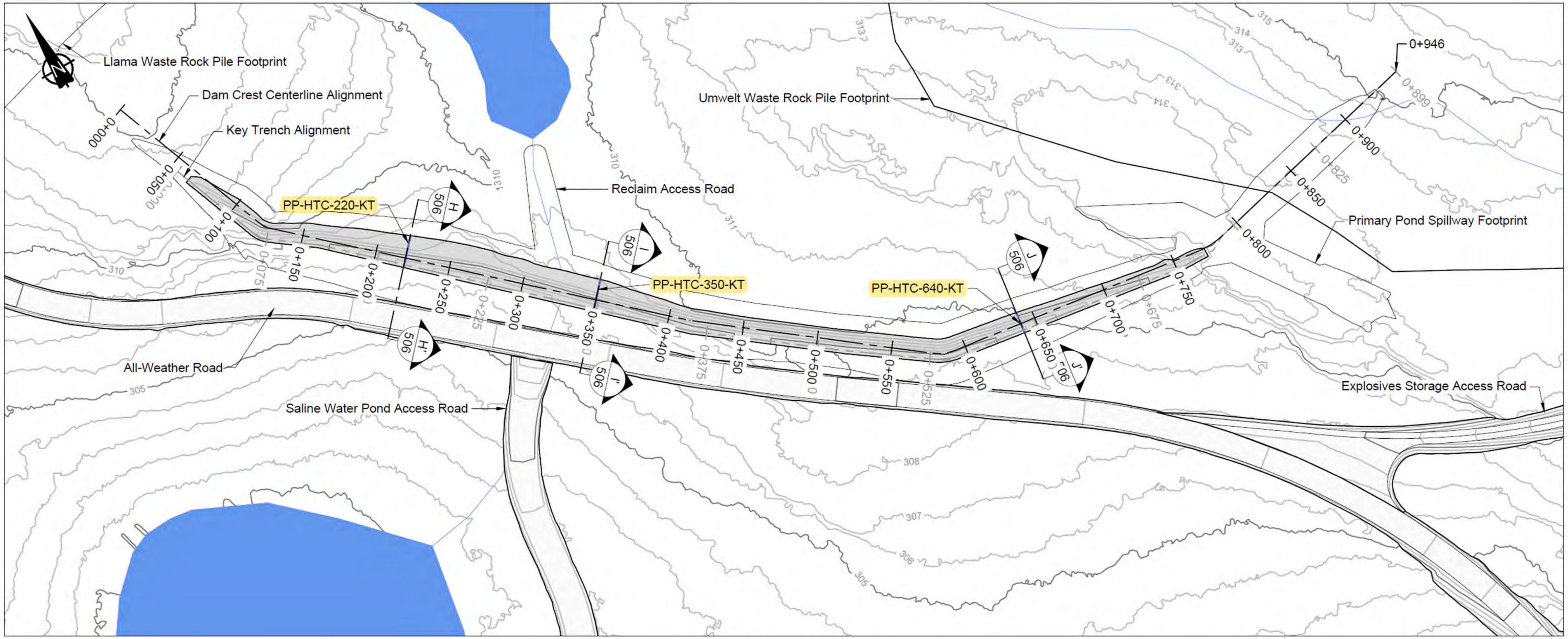
NAD83 UTM Zone 13.

Primary Pond

DRAWING TITLE:
Primary Pond Dam
Horizontal GTC Key Trench
Upstream Base / Toe Layout



504 - Working Draft – To be updated and added into main drawing package after information from supplier confirmed



**Primary Pond Dam Plan**

**LEGEND**

- Horizontal Ground Temperature Cabl
- Contours
- Monitoring Section
- Waterbody
- ☐ Other Design Infrastructure
- ▨ Primary Pond Design Infrastructure

**NOTES**

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

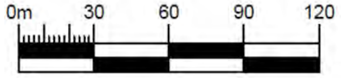
**REFERENCES**

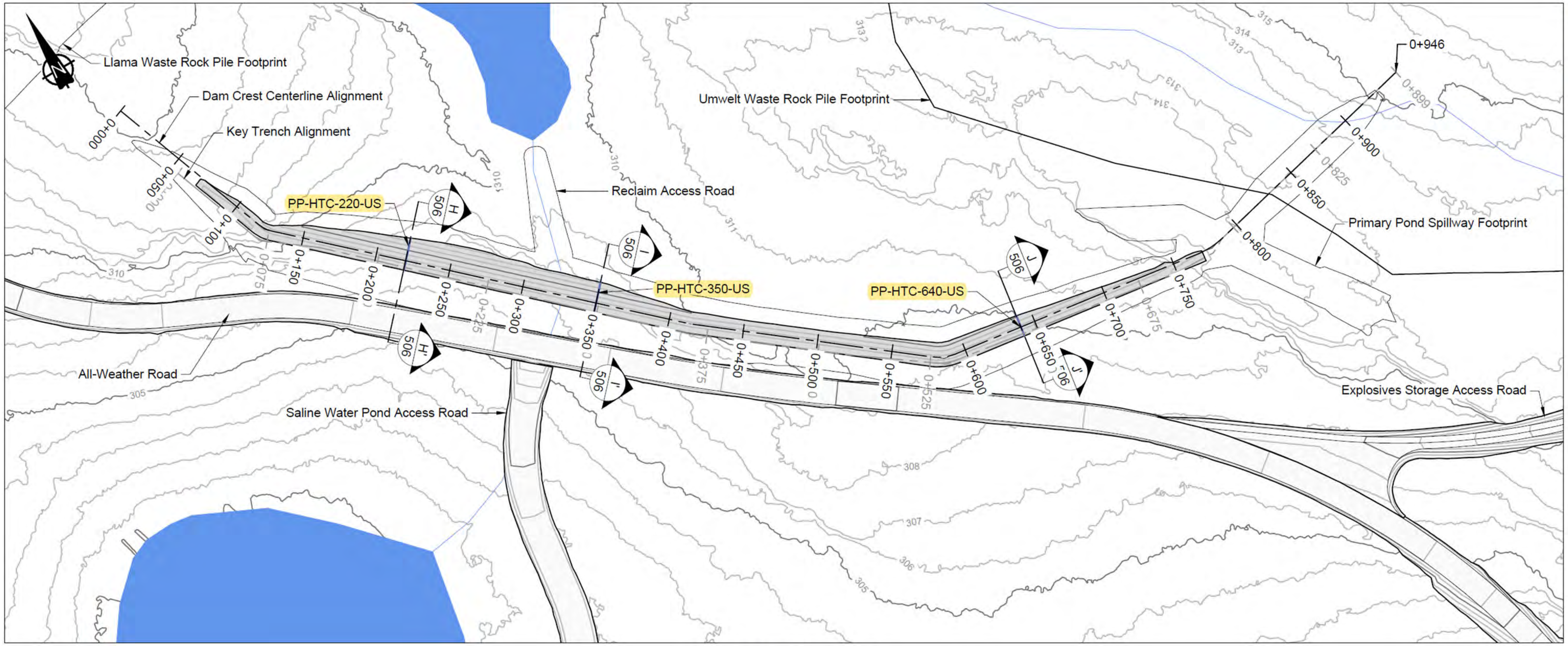
NAD83 UTM Zone 13.

Primary Pond

DRAWING TITLE: Primary Pond Dam
Horizontal GTC Key Trench
Upstream Slope Layout

504 - Working Draft – To be updated and added into main drawing package after information from supplier confirmed





Primary Pond Dam Plan

**LEGEND**

Horizontal Ground Temperature Cable
Contours
Monitoring Section
Waterbody
Other Design Infrastructure
Primary Pond Design Infrastructure

**NOTES**

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

**REFERENCES**

NAD83 UTM Zone 13.

Primary Pond

DRAWING TITLE: Primary Pond Dam
Horizontal GTC Dam Liner
Upstream Slope Layout

504 - Working Draft – To be updated and added into main drawing package after information from supplier confirmed

0m 30 60 90 120

# *Additional Details*

# Beaded Stream Specification Sheets

(GTC and Dataloggers)

# DIGITAL TEMPERATURE CABLE (DTC)

## FULLY CUSTOM TEMPERATURE READINGS

SCAN FOR MORE

Increase the ease of obtaining temperature for your environmental or infrastructure operations with the Digital Temperature Cable from **beaded**stream.

Questions? Email us at contact@beadedstream.com or call 844-488-4880

beadedstream

# DIGITAL TEMPERATURE CABLE

## SPECIFICATIONS

| | |
|---|---|
| **Custom Length** | Up to 750 m (2460 ft) (call if your application is longer) |
| **Custom Sensor Options** | Up to 125 sensors (call if your application is more)<br>Made to order sensor placements. Unlimited spacing options<br>Standard minimum spacing 10 cm (4 in)<br>Closer spacing available (please inquire) |
| **Sensor Range** | -55°C to +125°C (-67°F to +257°F) |
| **Sensor Accuracy** | ±0.1°C from -10°C to 30°C (14°F to 86°F) |
| **Sensor Resolution** | ±0.063°C |
| **Outer Jacket & Node Construction** | Low-temperature flexibility polyurethane jacket<br>Optional armored feature for proven resistance to wildlife<br>UV stabilized. Cut and abrasion resistant<br>IP68 |
| **Colors** | High-vis yellow (standard), white (optional), or gray (armored) |
| **DTC Diameter** | Sensor cable = 7.0 mm (0.28-inch)<br>Sensor nodes = 11.0 mm (0.44-inch)<br>DTC diameter does not change with the number of sensors |
| **Tensile Load Member** | 250 lb (113.4 kg) tensile strength with straight-laid aramid fibers built-in |
| **Termination Options** | 3-pin field XLR series<br>3 bare leads for terminal blocks (e.g. 3rd party data loggers) |

**beadedstream**

**7810 King Street**
**Anchorage, AK 99518**

**844.488.4880**

contact@beadedstream.com
beadedstream.com

beadedstream

# ¾” PEX CABLE SHIELDING

## Advanced Cable Protection Options

SCAN FOR MORE

Our most commonly used shielding, PEX provides a flexible and workable layer around our DTCs, enhancing abrasion and crush resistance and providing the capacity to direct-bury. Adapter fittings allow transitions to bare cable lead, HDPE*, or directly into panel boxes.

*HDPE and stainless steel conduit options also available

Questions? Email us at contact@beadedstream.com or call 844-488-4880

beadedstream

# ¾ PEX
# CABLE SHIELDING

## SPECIFICATIONS

| | |
|---|---|
| Installation | Ready to install. Suitable for direct burial |
| Nominal Diameter | ¾” (0.953cm) |
| Average OD | 0.875”(2.22cm) ± 0.004”(0.01cm) |
| Wall Thickness | 0.875 ± 0.004” (.247 cm) |
| Weight | 0.10 lb/ft (0.149kg/m) |
| Degree of cross-linking | 70-79% |
| Thermal Conductivity | 0.24 BTU/(hr ft °F) (0.41 W/(m°K)) |
| Linear Expansion | 9.33 X10^-4 in/(ft°F) @ 68° F |
| Working Range | -40° F to 200° F (-40° C to 93° C) |

**beadedstream**

**7810 King Street**
**Anchorage, AK 99518**

**844.488.4880**

contact@beadedstream.com
beadedstream.com

beadedstream

# D605 DATA LOGGER

## NEXT GENERATION DIRECT-TO-ORBIT CONNECTIVITY

SCAN FOR MORE

### Log your data without logging the miles.

Tried and true in the most extreme conditions of Alaska, the **beaded**stream D605 Data Logger is purpose-built for remote deployments and reliable performance

- Remotely access real-time data from anywhere in the world
- Indefinite power from the best-in-class solar cell
- Seamlessly connect with our iOS app through bluetooth

Questions? Email us at contact@beadedstream.com or call 844-488-4880

beadedstream

# D605
# DATA LOGGER

## SPECIFICATIONS

| | |
|---|---|
| **Communications** | • Bluetooth 5.0 wireless interface<br>• Compatible with *Capture*, **beaded**stream's iOS app |
| **Worldwide Telemetry** | • Embedded two-way satellite transceiver and Iridium antenna<br>• 100% pole-to-pole worldwide coverage. integrated 1575.42 MHz GPS antenna |
| **Ports** | • 4 plug and play Digital Temperature Cable (DTC) ports connect up to 500 sensors<br>• One additional custom-ordered port for the Sonic Range Sensor |
| **Battery / Power** | • No plug-in required.<br>• Rechargeable 6V 5.5Ah sealed lead-acid battery<br>• 6+ months without solar recharge (transmitting daily), survives northern winters |
| **Integrated Solar** | • 3 W integrated single-crystal silicon solar cell; works even in partial shading<br>• Full battery recharge with 5 days of sunlight |
| **Data Storage** | • Capacity for over 10 million samples<br>• 20+ years on-board data integrity<br>• 32 MB non-volatile flash data storage expandable to 1 GB |
| **Software / Hardware** | • Over the Air (OTA) software updates<br>• Built in self-diagnostics and logger health monitoring<br>• Open architecture for integrating most sensors and IoT technologies<br>• Built-in magnetic switch is immune to dust, dirt, mud and water.<br>• Used for advanced settings only for the D605 |
| **Operating Range** | • -40° C to +60° C (-40° F to +140° F)<br>• Fully NEMA Type 4X/IP68 |
| **Mounting** | • Easy to mount with built-in features for pivot arm, hose clamps, and/or Unistrut |
| **Weight and Dimension** | • 2.3 kg (5.1 lbs) (without mount)<br>• 15.5 cm x 15.5  cm x 9.0 cm (6.1" x 6.1"x 3.5") |

**beaded**stream

**7810 King Street**
**Anchorage, AK 99518**

**844.488.4880**

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beadedstream.com

# ATTACHMENT 7

Sabina
GOLD & SILVER CORP.

# Engineering Drawings for the Primary Pond Dam, Back River Project, Nunavut, Canada

| Drawing Number | Drawing Title | Issue | Date | Revision |
|---|---|---|---|---|
| UM-PP-100 | Project Location General Arrangement | Issued for Permit | 2022/09/02 | A |
| UM-PP-101 | General Arrangement (Orthophoto) | Issued for Permit | 2022/09/02 | A |
| UM-PP-102 | General Arrangement | Issued for Permit | 2022/09/02 | A |
| UM-PP-103 | Existing Foundation Investigation Plan View | Issued for Permit | 2022/09/02 | A |
| UM-PP-104 | Proposed Percolation Drillhole/Testing Locations | Issued for Permit | 2022/09/02 | A |
| UM-PP-200 | Primary Pond Dam Key Trench Plan and Profile | Issued for Permit | 2022/09/02 | A |
| UM-PP-201 | Primary Pond Dam Key Trench Liner Placement Plan and Sections | Issued for Permit | 2022/09/02 | A |
| UM-PP-202 | Primary Pond Dam Key Trench Bedding Plan and Sections | Issued for Permit | 2022/09/02 | A |
| UM-PP-203 | Primary Pond Dam Key Trench Transition Plan and Sections | Issued for Permit | 2022/09/02 | A |
| UM-PP-204 | Primary Pond Dam Downstream ROQ Plan and Sections | Issued for Permit | 2022/09/02 | A |
| UM-PP-205 | Primary Pond Dam Downstream Transition Plan and Sections | Issued for Permit | 2022/09/02 | A |
| UM-PP-206 | Primary Pond Dam Downstream Liner and Bedding Plan and Sections | Issued for Permit | 2022/09/02 | A |
| UM-PP-207 | Primary Pond Dam Overliner Transition Plan and Sections | Issued for Permit | 2022/09/02 | A |
| UM-PP-208 | Primary Pond Dam Cover Plan and Sections | Issued for Permit | 2022/09/02 | A |
| UM-PP-209 | Primary Pond Dam Final Configuration Plan and Profile | Issued for Permit | 2022/09/02 | A |
| UM-PP-210 | Primary Pond Dam Spillway Plan and Profile | Issued for Permit | 2022/09/02 | A |
| UM-PP-211 | Primary Pond Dam Reclaim Road Plan and Profile | Issued for Permit | 2022/09/02 | A |
| UM-PP-300 | Typical Dam Cross Sections | Issued for Permit | 2022/09/02 | A |
| UM-PP-301 | Typical Spillway and Reclaim Road Cross Sections | Issued for Permit | 2022/09/02 | A |
| UM-PP-400 | Details | Issued for Permit | 2022/09/02 | A |
| UM-PP-401 | Details | Issued for Permit | 2022/09/02 | A |
| UM-PP-500 | Primary Pond Dam Instrumentation Plan | Issued for Permit | 2022/09/02 | A |
| UM-PP-501 | Primary Pond Dam Horizontal and Veritcal GTC Layout | Issued for Permit | 2022/09/02 | A |
| UM-PP-502 | Primary Pond Dam Instrumentation Details | Issued for Permit | 2022/09/02 | A |
| UM-PP-503 | Primary Pond Dam Instrumentation Details | Issued for Permit | 2022/09/02 | A |

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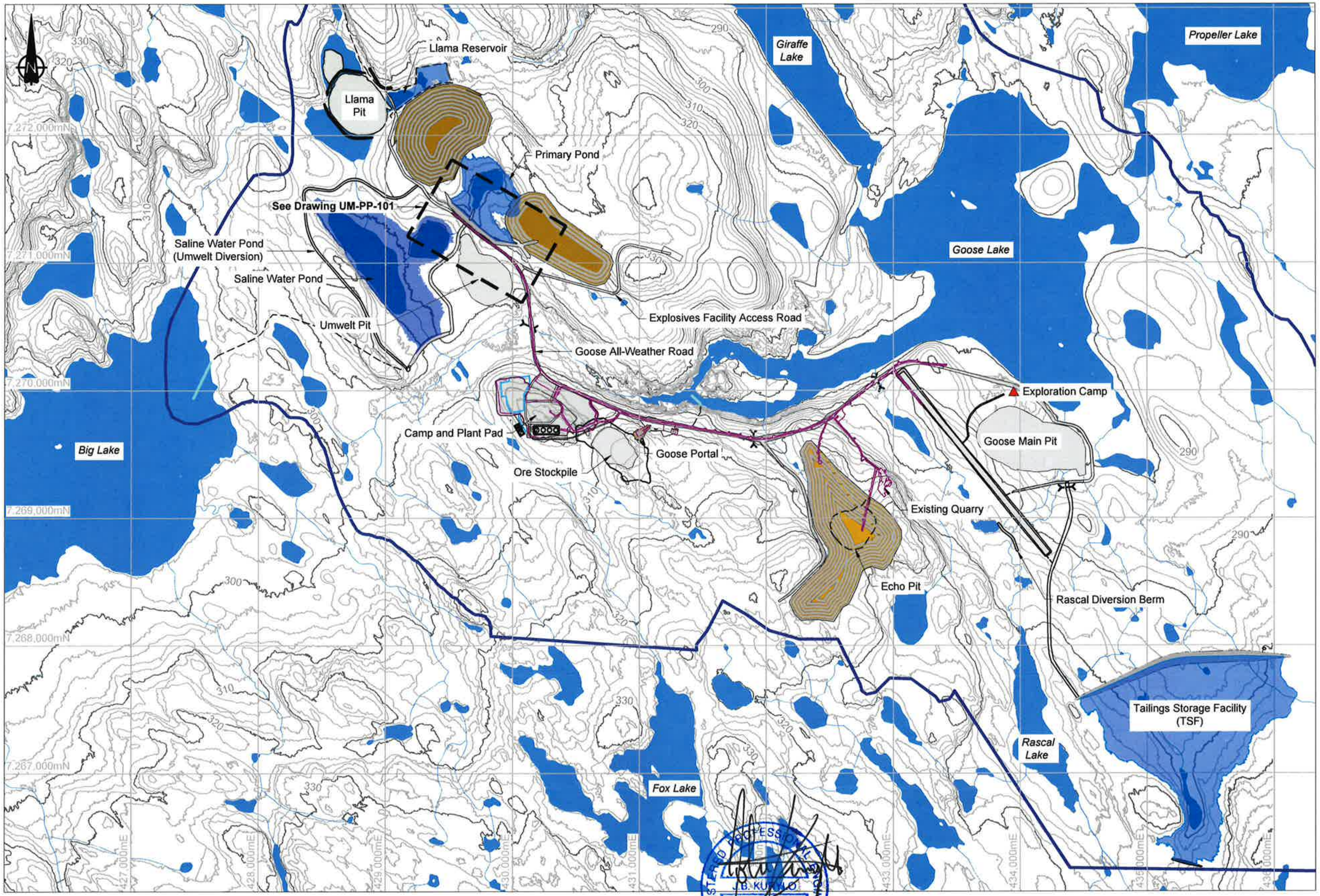

**LEGEND**

- ⟩—⟨ Crossing Location
- – – Pipeline Access
- — Water Intake Pipeline
- — As-built Infrastructure (2021)
- ▭ Design Infrastructure
- ▬ Design Stockpile Location
- ▭ Project Boundary

**NOTES**

1. Contours are shown at 2.0m intervals.
2. All units are in meters unless otherwise specified.

**REFERENCES**

NAD83 UTM Zone 13.

0m 300 600 900 1200

| DRAWING NO. | DRAWING TITLE |
|---|---|
| REFERENCE DRAWINGS | |

| NO. | DESCRIPTION | CHK'D | APP'D | DATE | NO. | DESCRIPTION | CHK'D | APP'D | DATE |
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Back River

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Primary Pond

DRAWING TITLE:
Project Location
General Arrangement

DRAWING NO.: UM-PP-100
REVISION NO.: A

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## LEGEND

| | |
|---|---|
| ═ | Contours |
| ─ | Waterbody |
| ▭ | Other Design Infrastructure |
| ▨ | Primary Pond Design Infrastructure |

## NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Base of key trench on this profile is based on a section down the centerline of the dam crest. Note that the key trench centerline and the dam crest centerline do not share the exact same alignment and overall the chainages vary in any given location (between the key trench and dam crest shown in these drawings) in the range of ±5m offset, ±50m station chainage.
4. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
5. All drawings should be read in conjunction with the latest technical specifications document ('Technical Specifications - Earthworks and Geotechnical Engineering - Back River Gold Project, Nunavut Canada - Issue for Construction' prepared by SRK) . The on site engineer representative should be consulted to determine what the latest revision of the technical specifications is.
6. Unwelt Waste Rock Pile to be modified in the future and will be outside of the Primary Pond Dam Spillway footprint.

## REFERENCES

NAD83 UTM Zone 13.
Orthophoto provided by Client, July 2013.

0m 30 60 90 120

| DRAWING NO. | DRAWING TITLE |
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REG. NO.: EGBC 1003655

Primary Pond
DRAWING TITLE: General Arrangement (Orthophoto)
DRAWING NO. UM-PP-101
REVISION NO. A

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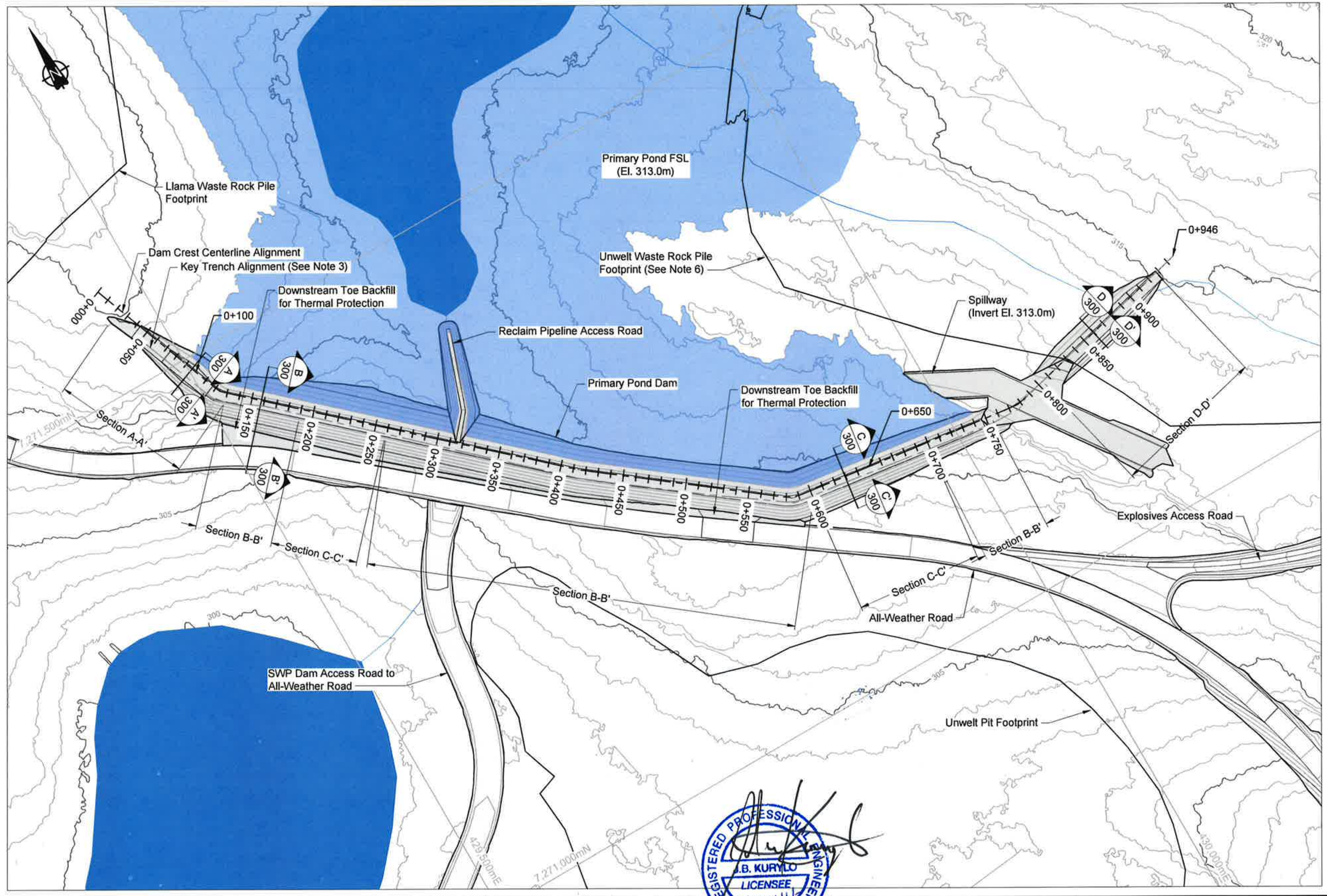


**LEGEND**

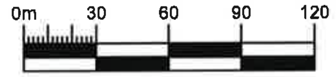
| | |
|---|---|
| ═ | Contours |
| ─ | Waterbody |
| ▭ | Other Design Infrastructure |
| ▨ | Primary Pond Design Infrastructure |

**NOTES**

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Base of key trench on this profile is based on a section down the centerline of the dam crest. Note that the key trench centerline and the dam crest centerline do not share the exact same alignment and overall the chainages vary in any given location (between the key trench and dam crest shown in these drawings) in the range of ±5m offset, ±50m station chainage.
4. All drawings are scaled appropriately for B-size construction drawings. These drawings can therefore be plotted at double size to fit D-Size. Scales may not be correct if these drawings are reproduced and presented in any other format.
5. All drawings should be read in conjunction with the latest technical specifications document ('Technical Specifications - Earthworks and Geotechnical Engineering - Back River Gold Project, Nunavut Canada - Issue for Construction' prepared by SRK) . The on site engineer representative should be consulted to determine what the latest revision of the technical specifications is.
6. Umwelt Waste Rock Pile to be modified in the future and will be outside of the Primary Pond Dam Spillway footprint.

**REFERENCES**

NAD83 UTM Zone 13.



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Back River

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REG. NO.: EGBC 1003655

Primary Pond

DRAWING TITLE:
General Arrangement

DRAWING NO.: UM-PP-102
REVISION NO.: A

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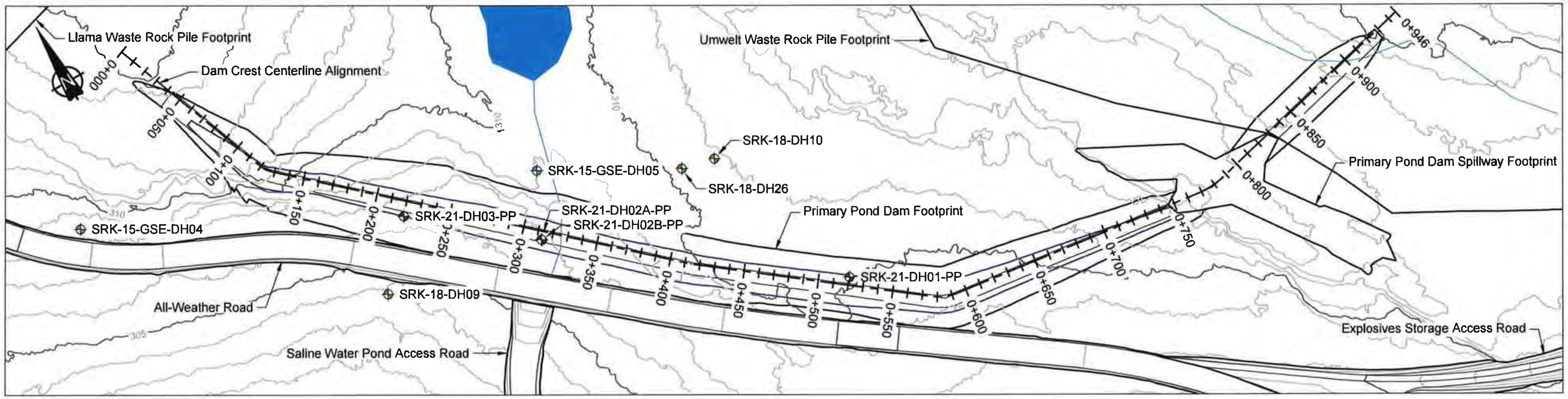
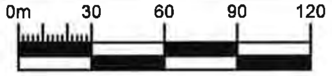
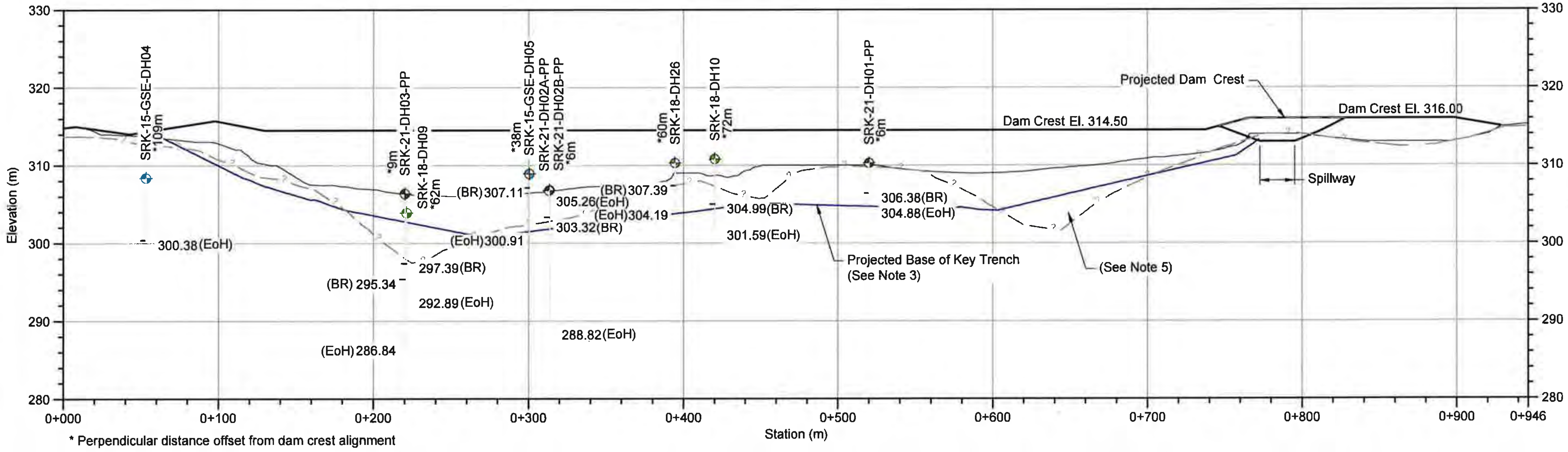


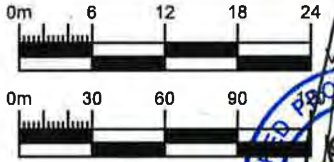
## Primary Pond Dam Final Configuration Plan





* Perpendicular distance offset from dam crest alignment

## Primary Pond Dam Crest Profile



**LEGEND**

| | |
|---|---|
| ⊕ | 2015 Boreholes |
| ⊕ | 2018 Boreholes |
| ⊕ | 2021 Boreholes |
| — | Contours |
| — | Design Surface |
| — | Excavation |
| — | Existing Ground |
| – – | Inferred Bedrock |
| — | Waterbody |
| ☐ | Other Design Infrastructure |
| ☐ | Primary Pond Design Infrastructure |
| ☐ | Primary Pond Design Key Trench |

**NOTES**

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Base of key trench on this profile is based on a section down the centerline of the dam crest. Note that the key trench centerline and the dam crest centerline do not share the exact same alignment and overall the chainages vary in any given location (between the key trench and dam crest shown in these drawings) in the range of ±5 offset, ±50 station chainage.
4. Inferred Bedrock surface provided by Client.
5. Secondary deeper overburden area supported by exploration drill hole and the geomorphological interpretations that show the drillholes SRK-18-DH26 and SRK-18-DH10 could be considered more in a SSE projection towards the dam. This area is one of the main target of the percolation testing. As outlined on drawing UM-PP-104 there is a tighter drill hole spacing proposed for this area to help gather additional information before construction.

**REFERENCES**

NAD83 UTM Zone 13.

| DRAWING NO. | DRAWING TITLE |
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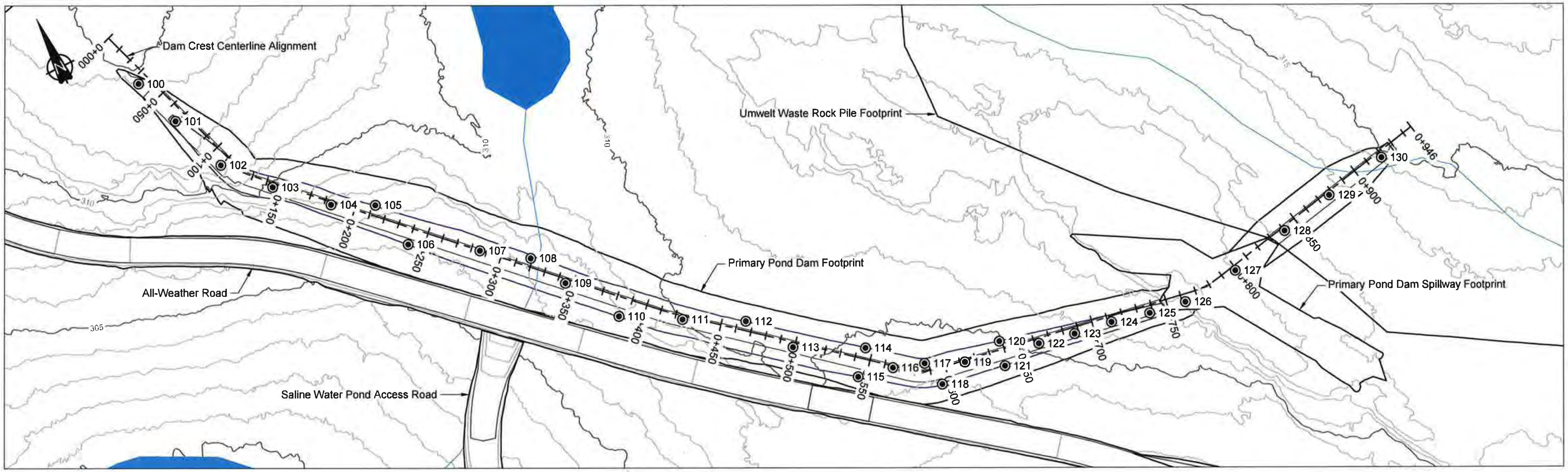
Back River

SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

DRAWING TITLE: Primary Pond
Existing Foundation Investigation
Plan View

DRAWING NO.: UM-PP-103
REVISION NO.: A



### Proposed Percolation Hole Locations

| Description | Easting | Northing |
|---|---|---|
| 100 | 429474 | 7271545 |
| 101 | 429486 | 7271513 |
| 102 | 429501 | 7271475 |
| 103 | 429526 | 7271448 |
| 104 | 429556 | 7271422 |
| 105 | 429582 | 7271410 |
| 106 | 429591 | 7271378 |
| 107 | 429632 | 7271355 |
| 108 | 429660 | 7271337 |
| 109 | 429674 | 7271313 |
| 110 | 429697 | 7271279 |
| 111 | 429734 | 7271260 |
| 112 | 429771 | 7271242 |
| 113 | 429792 | 7271214 |
| 114 | 429835 | 7271194 |

| Description | Easting | Northing |
|---|---|---|
| 115 | 429823 | 7271179 |
| 116 | 429846 | 7271175 |
| 117 | 429866 | 7271169 |
| 118 | 429871 | 7271152 |
| 119 | 429890 | 7271159 |
| 120 | 429916 | 7271162 |
| 121 | 429913 | 7271146 |
| 122 | 429939 | 7271150 |
| 123 | 429963 | 7271146 |
| 124 | 429988 | 7271143 |
| 125 | 430013 | 7271138 |
| 126 | 430037 | 7271135 |
| 127 | 430075 | 7271140 |
| 128 | 430115 | 7271150 |
| 129 | 430151 | 7271159 |
| 130 | 430192 | 7271167 |

### NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. It is suggested that an air-track drill (quarry drill) be used to complete the percolation testing.
4. Percolation holes to be advanced a minimum 2.0m into bedrock.
5. Percolation test boreholes should be a minimum of 4-6 inches (100-150mm) in diameter.
6. Air-track drill cuttings should be sampled every 0.5m for the upper (top) 4.0m below ground surface (bgs), and every 1m thereafter to a depth of 10.0mbgs. Material returned from a depth greater than 10mbgs should be sampled every 2.0m. Photographs should be taken of the collected samples in the field.
7. Observations of massive ground ice and crushed ice cuttings should be logged and sampled based on occurrence.
8. Collected samples should be double bagged, tied, and labeled at the time of field collection. All samples should be maintained in a frozen state until processed by the receiving laboratory to preserve moisture content.
9. Once all percolation test locations are drilled the testing will be completed on site as directed by the Engineer.

### LEGEND

| | |
|---|---|
| ◉ | Percolation Drillhole/Testing Location |
| — | Contours |
| — | Waterbody |
| ▭ | Other Design Infrastructure |
| ▭ | Primary Pond Design Infrastructure |
| ▭ | Primary Pond Key Trench Surface |

### REFERENCES

NAD83 UTM Zone 13.

0m 20 40 60 80 100

| DRAWING NO. | DRAWING TITLE |
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REG. NO.: EGBC 1003655

Primary Pond
DRAWING TITLE: Proposed Percolation Drillhole/Testing Locations Plan

DRAWING NO. UM-PP-104
REVISION NO. A

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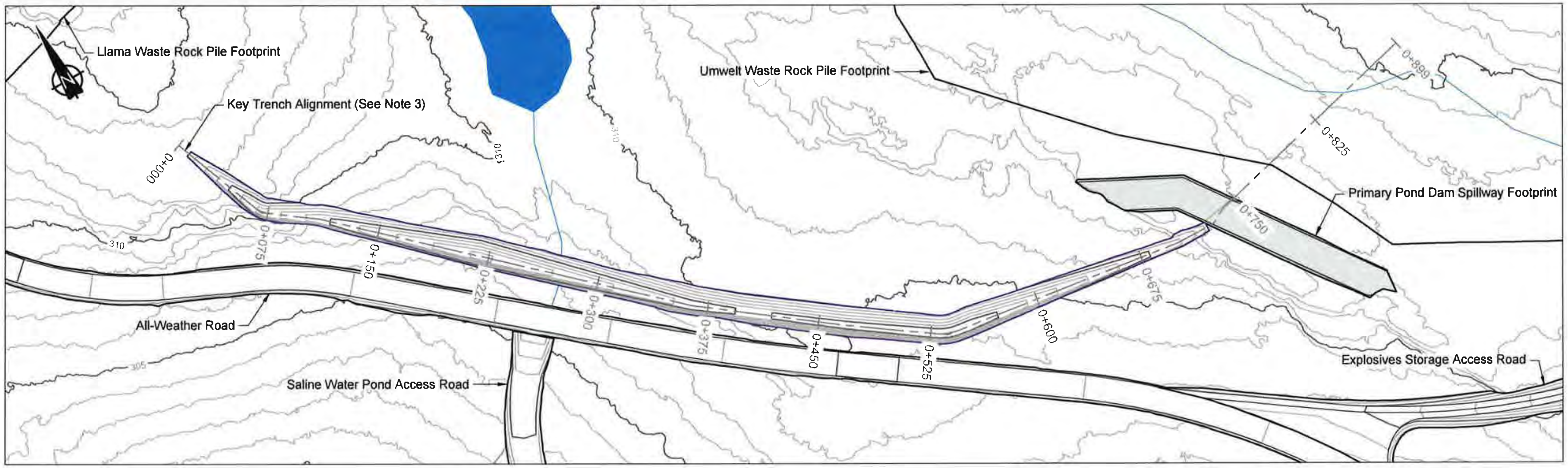
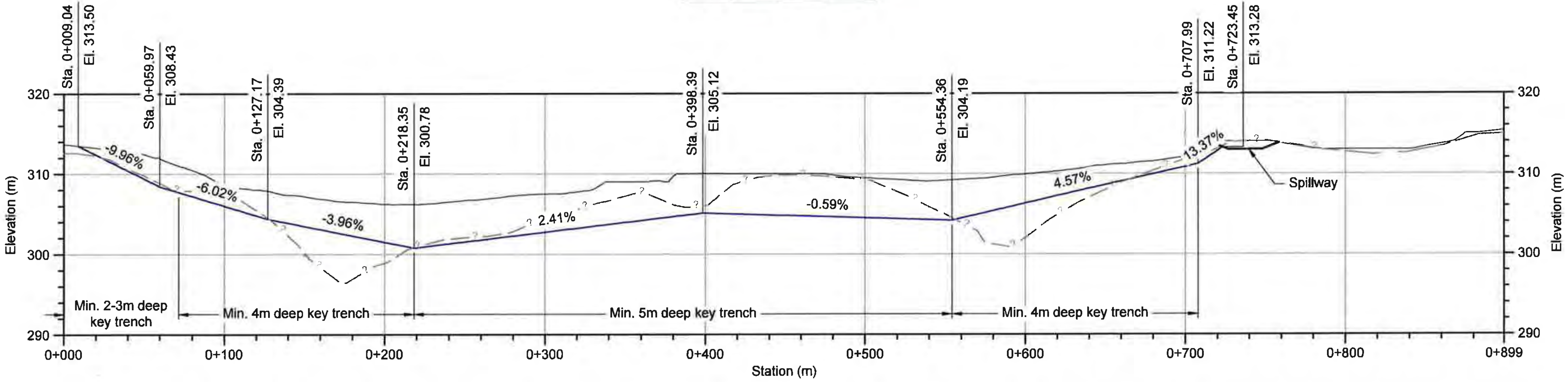


## Primary Pond Dam Key Trench Plan

0m 30 60 90 120



## Primary Pond Dam Key Trench Centerline Profile

0m 6 12 18 24
Vertical

0m 30 60 90 120
Horizontal

**LEGEND**

| | |
|---|---|
| — | Contours |
| — | Design Surface |
| — | Excavation |
| — | Existing Ground |
| - - | Inferred Bedrock |
| — | Waterbody |
| ☐ | Design Key Trench |
| ☐ | Other Design Infrastructure |
| ▨ | Primary Pond Design Infrastructure |

**NOTES**

1. Contours are shown at 1.0m intervals.
2. All units are in meters unless otherwise specified.
3. Alignment and profile shown correspond to the centerline of the key trench.
4. The final key trench extent and depth will be determined in the field by the Engineer. Minimum excavation depth in overburden is 4.0m, unless massive ice, hypersaline soil or bedrock encountered. The Engineer will inspect all excavations and approve the foundation conditions.
5. If any area of the key trench is over-blasted or over-excavated then the extra excavation will need to be backfilled in thin lifts (see 'Technical Specifications') until the key trench design lines and grades are reached.
6. Overblasting and/or overexcavation of the key trench beyond the design lines (as presented on this figure) should be avoided if at all possible. Extra care should be taken during the key trench excavation to ensure that the excavation can result as close to the design lines as possible. Excavation beyond the key trench design lines may require that the overall Primary Pond dam footprint be enlarged to provide the necessary thermal coverage and to uphold design requirements.

**REFERENCES**

NAD83 UTM Zone 13.

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Back River

SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond

DRAWING TITLE:
Primary Pond Dam
Key Trench Plan and Profile

DRAWING NO.: UM-PP-200
REVISION NO.: A

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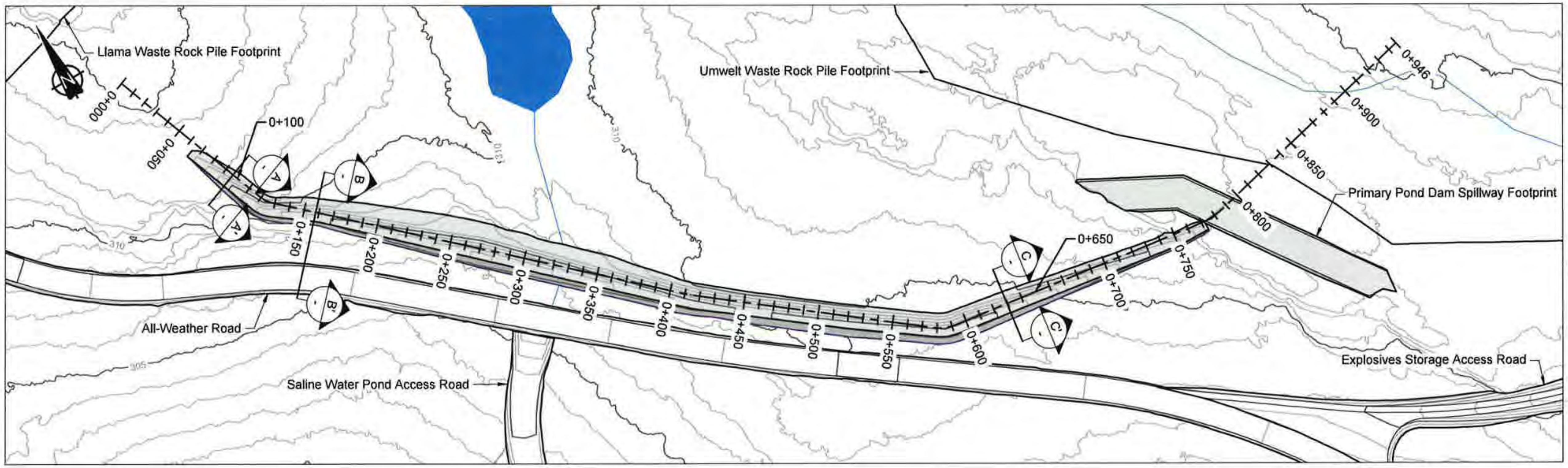
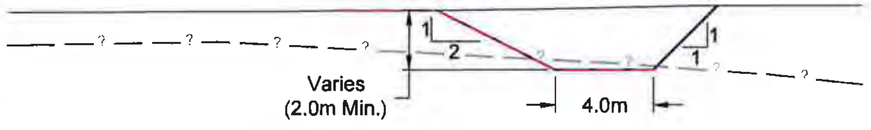


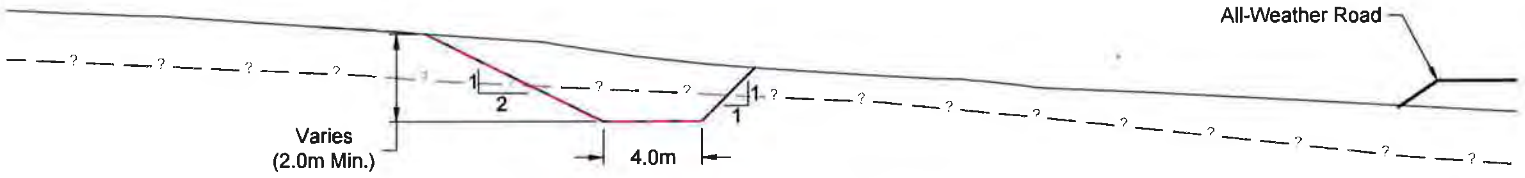
## Key Trench Liner Plan

0m 30 60 90 120



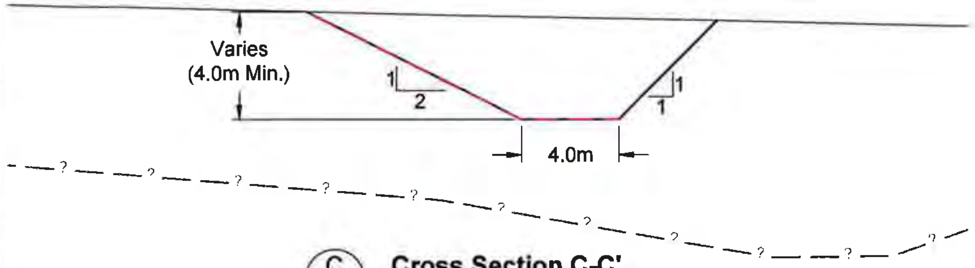
**A Cross Section A-A'**

0m 3 6 9 12



**B Cross Section B-B'**

0m 3 6 9 12



**C Cross Section C-C'**

0m 3 6 9 12

### LEGEND

| | |
|---|---|
| ⋯ | Contours |
| — | Design Surface |
| — | Excavation |
| — | Existing Ground |
| – – | HDPE Liner System |
| – – | Inferred Bedrock |
| — | Waterbody |
| ☐ | Design Key Trench |
| ☐ | Other Design Infrastructure |
| ▨ | Primary Pond Design Infrastructure |

### NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Alignment and profile shown correspond to centerline of Primary Pond Dam.
4. The upstream slope of the key trench excavation need to be scraped and smoothed to prepare a suitable subbase for the HDPE liner as determined by field Engineer. If any voids larger than 0.15m or undulation exist then they will need to be smoothed as shown in Details 7 and 9, depending on surface (overburden or bedrock).
5. Non-woven geotextile shall be placed on both sides of HDPE liner, unless otherwise approved /directed by the Engineer.
6. The subgrade surface must be free of vegetation, sharp-edged rocks, stones, sticks, construction debris, and other foreign material that could contact the HDPE liner. Furthermore, all protrusions extending more than 12 mm from the subgrade surface shall either be removed, crushed, or pushed into the surface with a smooth-drum compactor.
7. Liner should not be placed over massive ice or standing water (both need to be removed prior to placement).
8. Liner panels shall have a minimum overlap of 15cm for fusion (hot shoe) welding or according to manufacturer's specifications. upslope panels shall overlap downslope to provide a shingle effect for drainage.
9. At the locations where bedrock is encountered in the key trench then these areas will be required to be ripped down to competent bedrock or scrapped smooth.
10. Depth of key trench and bedrock intersection estimated (see UM-PP-200 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines, until competent bedrock is encountered, or as directed by Engineer.
11. The HDPE liner system will consist of a HDPE liner that is sandwiched between two 12 oz nonwoven geotextiles.

### REFERENCES

NAD83 UTM Zone 13.

**REFERENCE DRAWINGS**

| DRAWING NO. | DRAWING TITLE |
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Sabina
GOLD & SILVER CORP

Back River

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| DESIGN: JU/JBK | DRAWN: SGE/SL | REVIEWED: JU/CS/AT |
| CHECKED: JD/AT/VB | APPROVED: JBK | DATE: 2022/09/02 |

FILE NAME: 1CS020.020 - UM-PP-KT-Liner.dwg

SRK JOB NO.: 1CS020.020

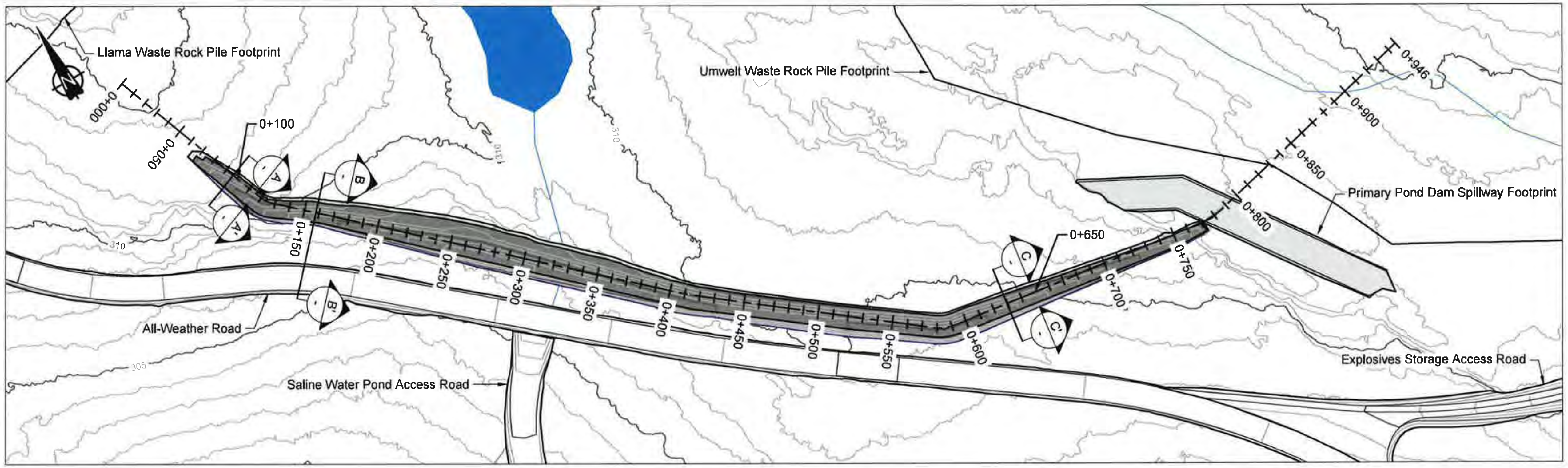
REG. NO.: EGBC 1003655

Primary Pond

DRAWING TITLE:
Primary Pond Dam
Key Trench Liner Plan
and Sections

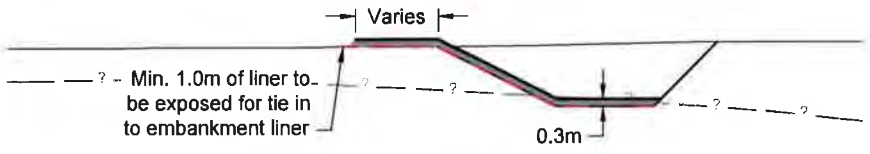
DRAWING NO.: UM-PP-201

REVISION NO.: A



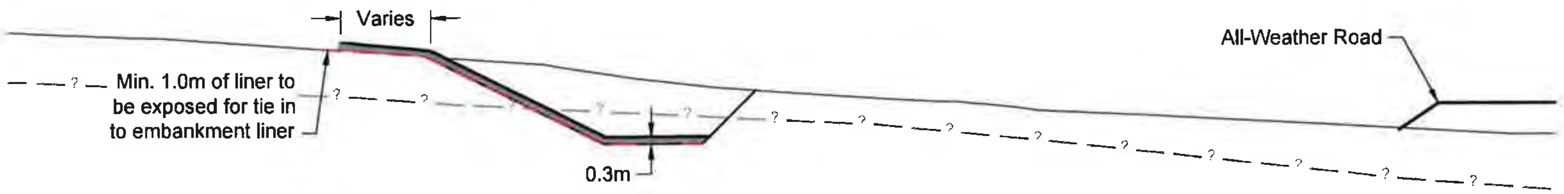
## Key Trench Bedding Plan

0m 30 60 90 120



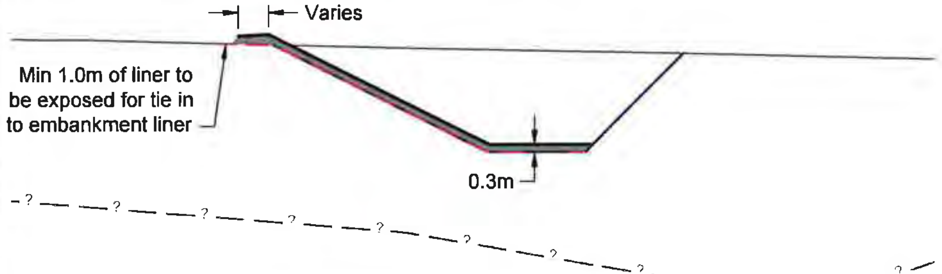
### A Cross Section A-A'

0m 3 6 9 12



### B Cross Section B-B'

0m 3 6 9 12



### C Cross Section C-C'

0m 3 6 9 12

## LEGEND

| | |
|---|---|
| — | Contours |
| — | Design Surface |
| — | Excavation |
| — | Existing Ground |
| – – | HDPE Liner System |
| – – | Inferred Bedrock |
| — | Waterbody |
| ▨ | Bedding |
| ☐ | Design Key Trench |
| ☐ | Other Design Infrastructure |
| ☐ | Primary Pond Design Infrastructure |

## NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Alignment and profile shown correspond to centerline of Primary Pond Dam.
4. Bedding layer to be placed in 0.15m lifts.
5. The subsurface below the liner should be free of protrusions or any sharp / angular cobbles or larger size material. See the Technical Specifications document for more details ('Technical Specifications - Earthworks and Geotechnical Engineering - Back River Gold Project, Nunavut Canada - Issue for Construction' prepared by SRK).
6. Bedding material cover shall be placed over the HDPE using construction equipment that minimizes stresses on the liner. Unless otherwise approved /directed by the Engineer a minimum thickness of 600mm or greater is required to be placed over any areas where heavy equipment will be trafficking over the liner. Thickness requirement are related to equipment type. For light equipment (which will have to be directly approved by the Engineer), as an absolute minimum a thickness of 300mm of cover must be maintained between light tracked equipment (e.g. skid-steer or 30 excavator) tracks/tires, and the liner at all times during the covering process.
7. Soil cover should be placed in a manner that prevents the soil from entering/disturbing the liner overlap zones.
8. Depth of key trench and bedrock intersection estimated (see UM-PP-200 for additional details). Actual depth to bedrock may vary in field. Key trench excavation should progress to the design lines, until competent bedrock is encountered, or as directed by Engineer.

## REFERENCES

NAD83 UTM Zone 13.

| DRAWING NO. | DRAWING TITLE |
|---|---|
| -- | -- |

REFERENCE DRAWINGS

| NO. | DESCRIPTION | CHK'D | APP'D | DATE | NO. | DESCRIPTION | CHK'D | APP'D | DATE |
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Back River

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| REVIEWED: JU/CS/AT | CHECKED: JD/AT/VB |
| APPROVED: JBK | DATE: 2022/09/02 |

FILE NAME: 1CS020.020 - UM-PP-KT-bedding.dwg

SRK JOB NO.: 1CS020.020

REG. NO.: EGBC 1003655

Primary Pond

DRAWING TITLE: Primary Pond Dam
Key Trench Bedding Plan
and Sections

DRAWING NO. UM-PP-202

REVISION NO. A

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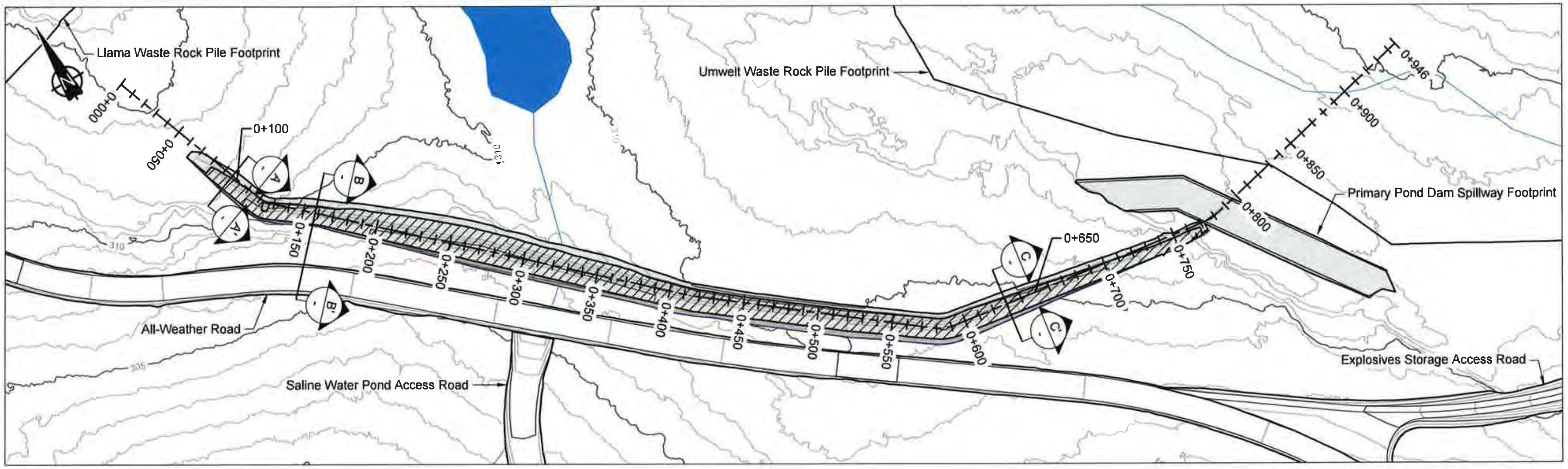


## LEGEND

| | |
|---|---|
| ▭ | Contours |
| — | Design Surface |
| — | Excavation |
| — | Existing Ground |
| – – | HDPE Liner System |
| – – | Inferred Bedrock |
| — | Waterbody |
| ▭ | Design Key Trench |
| ▭ | Other Design Infrastructure |
| ▭ | Primary Pond Design Infrastructure |
| ▨ | Transition Material |

## NOTES

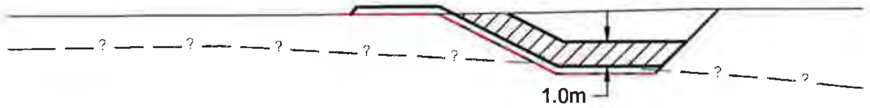
1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Alignment and profile shown correspond to centerline of Primary Pond Dam.

## REFERENCES

NAD83 UTM Zone 13.

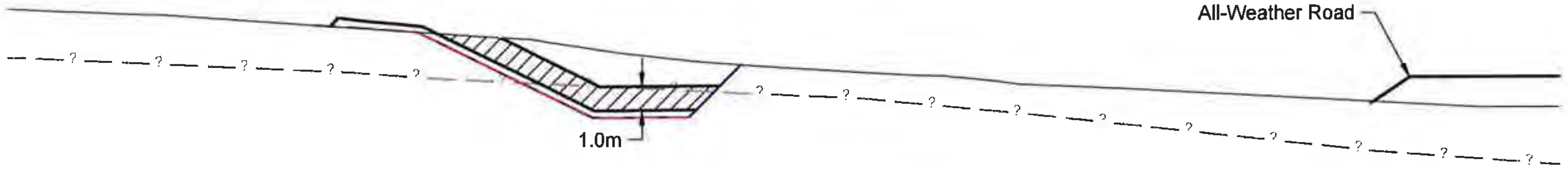
**Key Trench Transition Plan**

0m 30 60 90 120



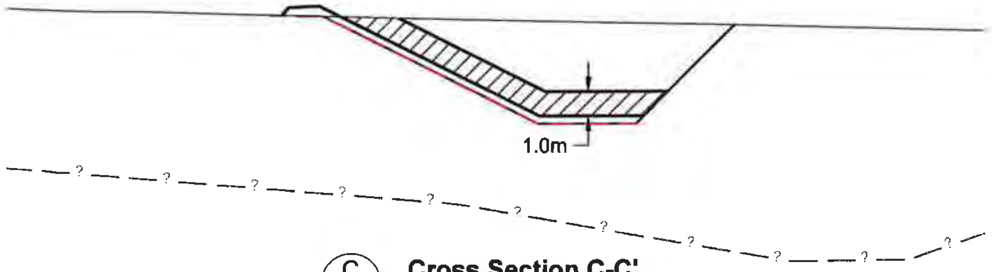
**A Cross Section A-A'**

0m 3 6 9 12



**B Cross Section B-B'**

0m 3 6 9 12



**C Cross Section C-C'**

0m 3 6 9 12

| DRAWING NO. | DRAWING TITLE | NO. | DESCRIPTION | CHK'D | APP'D | DATE | NO. | DESCRIPTION | CHK'D | APP'D | DATE |
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DATE: 2022/09/02
FILE NAME: 1CS020.020 - UM-PP-KT-trans.dwg

Sabina
GOLD & SILVER CORP.

Back River

SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond

DRAWING TITLE: Primary Pond Dam
Key Trench Transition Plan
and Sections

DRAWING NO. UM-PP-203
REVISION NO. A

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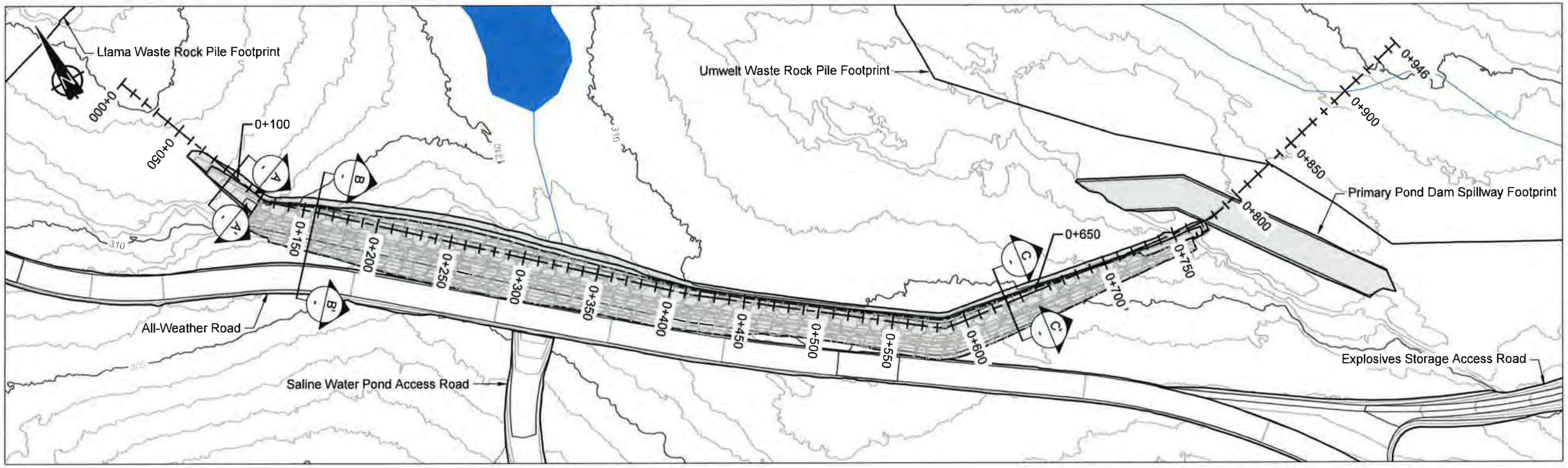


## Downstream ROQ Plan

0m 30 60 90 120

**LEGEND**

| | |
|---|---|
| — | Contours |
| — | Design Surface |
| — | Excavation |
| — | Existing Ground |
| – – | HDPE Liner System |
| – – | Inferred Bedrock |
| — | Waterbody |
| ☐ | Design Key Trench |
| ☐ | Other Design Infrastructure |
| ▨ | Primary Pond Design Infrastructure |
| ▨ | Run of Quarry |

**NOTES**

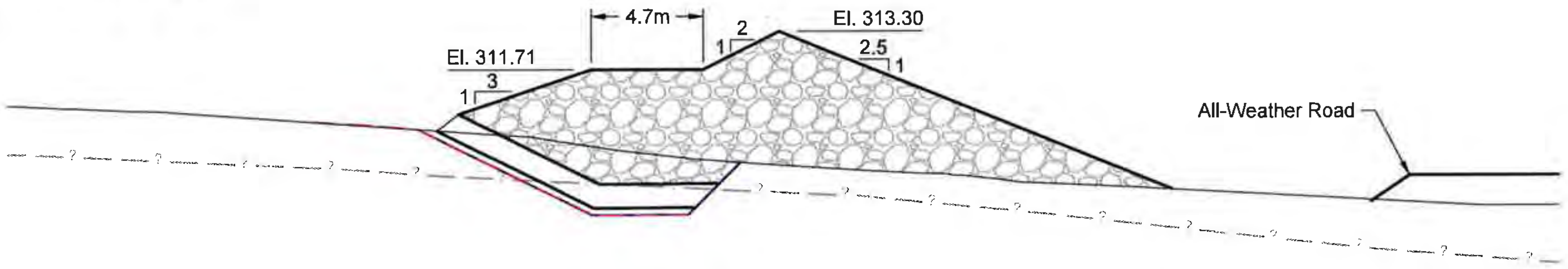
1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

**REFERENCES**

NAD83 UTM Zone 13.

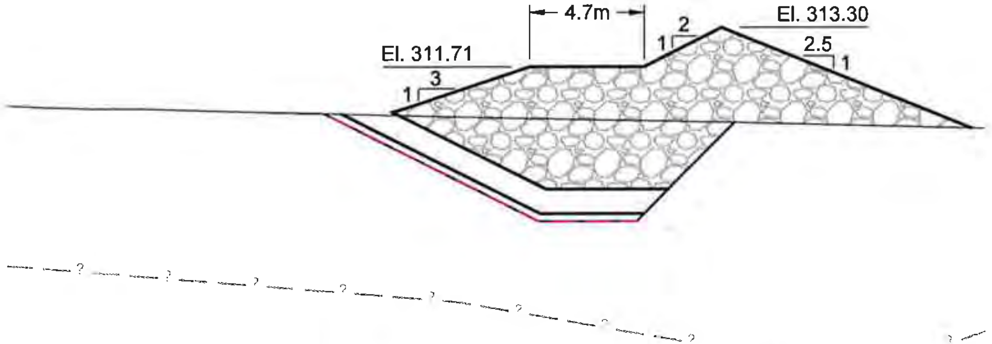
## A Cross Section A-A'

0m 3 6 9 12



## B Cross Section B-B'

0m 3 6 9 12



## C Cross Section C-C'

0m 3 6 9 12

| DRAWING NO. | DRAWING TITLE |
|---|---|
| -- | -- |

REFERENCE DRAWINGS

| NO. | DESCRIPTION | CHK'D | APP'D | DATE | NO. | DESCRIPTION | CHK'D | APP'D | DATE |
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APPROVED: JBK
DATE: 2022/09/02
FILE NAME: 1CS020.020 - UM-PP-Dam-ROQ.dwg

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GOLD & SILVER CORP

Back River

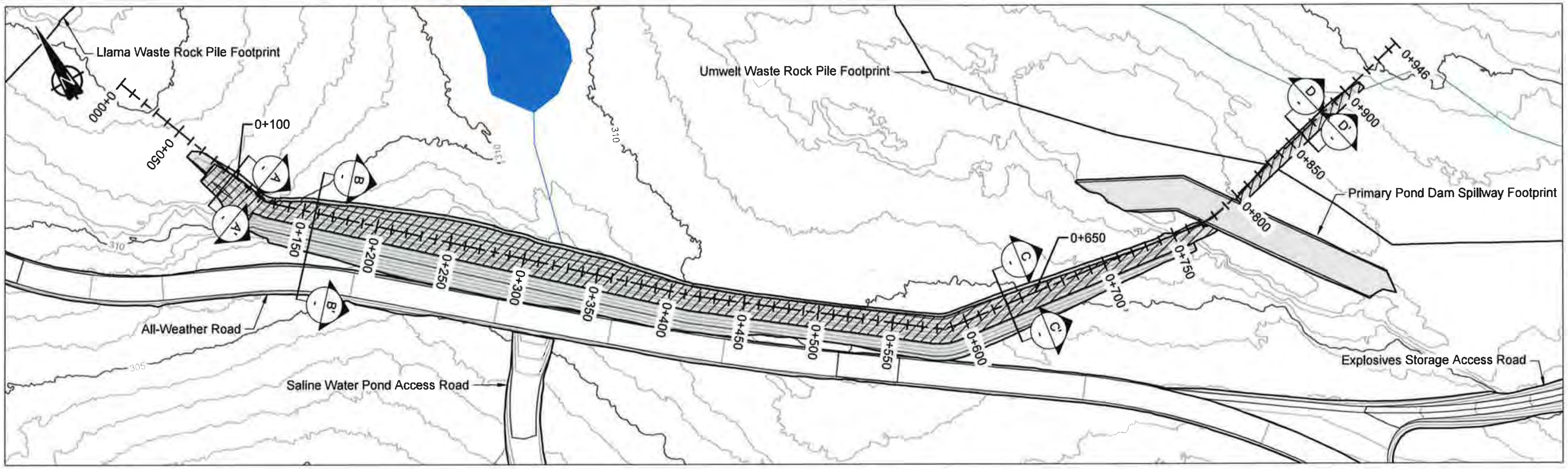
SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond

DRAWING TITLE: Primary Pond Dam Downstream ROQ Plan and Sections

DRAWING NO. UM-PP-204

REVISION NO. A



## Downstream Transition Plan

0m 30 60 90 120

## LEGEND

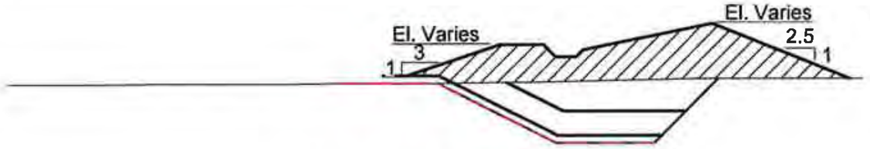
| | |
|---|---|
| ═ | Contours |
| — | Design Surface |
| — | Excavation |
| — | Existing Ground |
| – – | HDPE Liner System |
| – – | Inferred Bedrock |
| — | Waterbody |
| ☐ | Other Design Infrastructure |
| ▨ | Primary Pond Design Infrastructure |
| ▨ | Transition Material |

## NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Alignment and profile shown correspond to centerline of Primary Pond Dam.

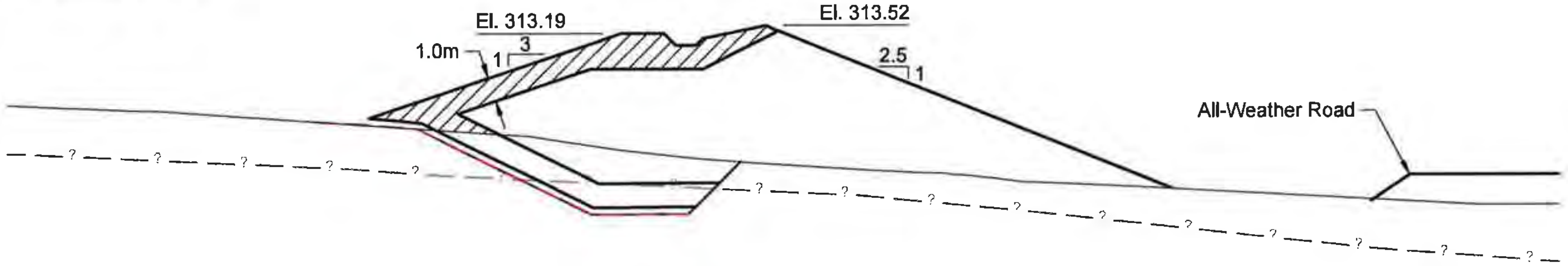
## REFERENCES

NAD83 UTM Zone 13.



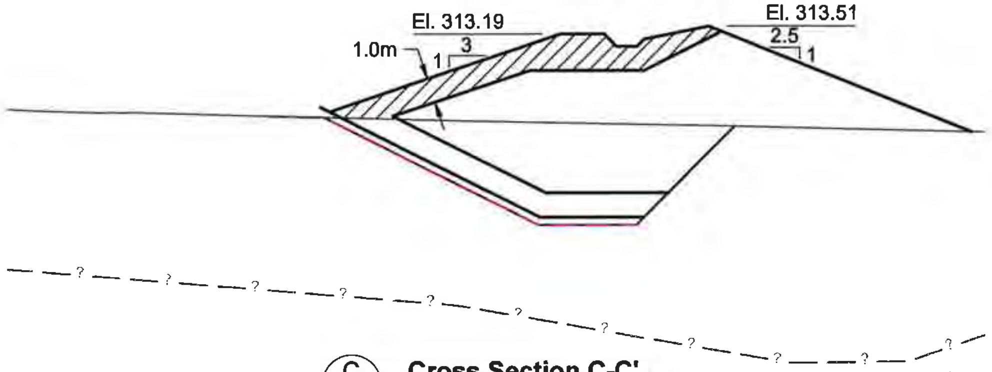
### Cross Section A-A'

0m 3 6 9 12



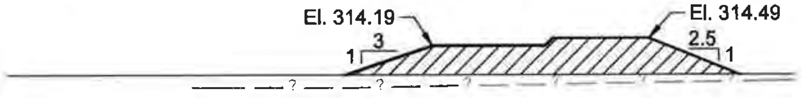
### Cross Section B-B'

0m 3 6 9 12



### Cross Section C-C'

0m 3 6 9 12



### Cross Section D-D'

0m 3 6 9 12

**REFERENCE DRAWINGS**

| DRAWING NO. | DRAWING TITLE |
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Back River

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| CHECKED: JD/AT/VB | APPROVED: JBK | DATE: 2022/09/02 |

FILE NAME: 1CS020.020 - UM-PP-Dam-Trans.dwg
SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond
DRAWING TITLE: Primary Pond Dam
Downstream Transition
Plan and Sections
DRAWING NO. UM-PP-205
REVISION NO. A

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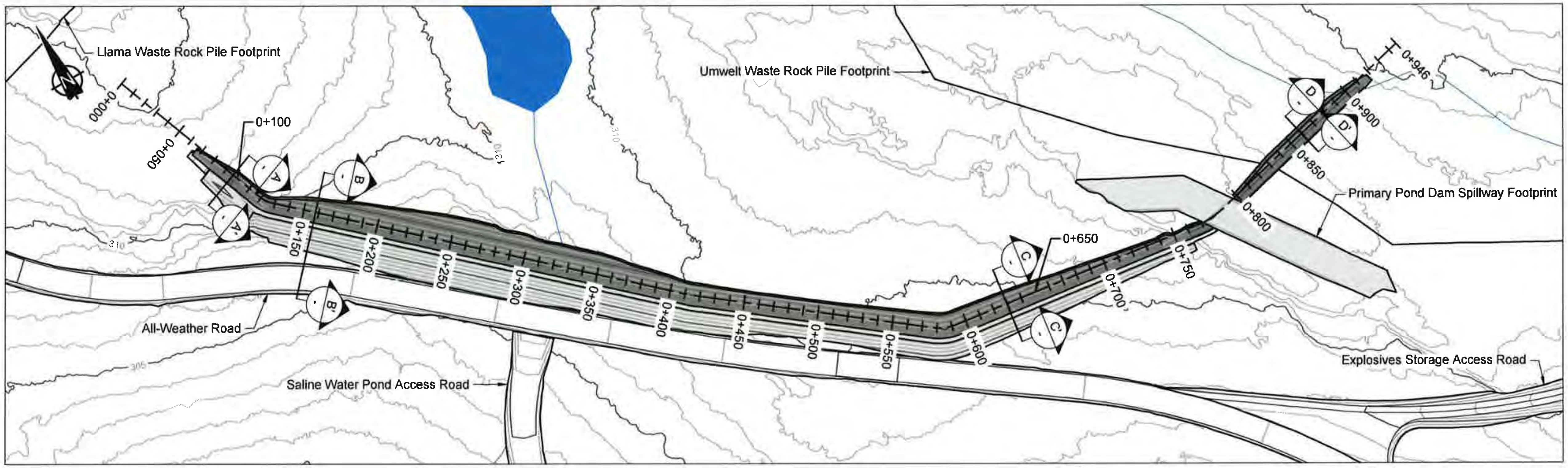
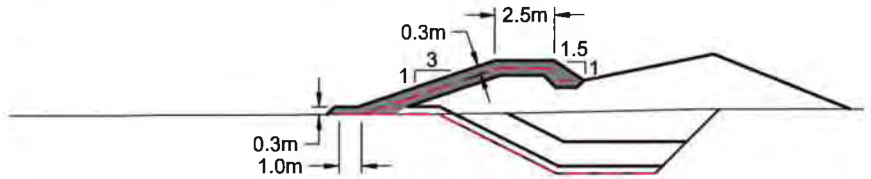


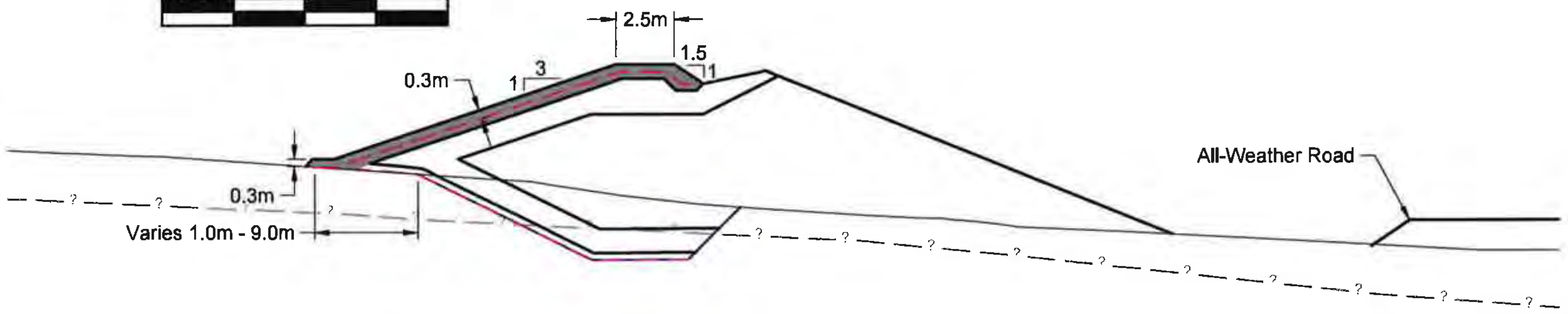
## Downstream Bedding Plan

0m 30 60 90 120



**A** - **Cross Section A-A'**

0m 3 6 9 12



**B** - **Cross Section B-B'**

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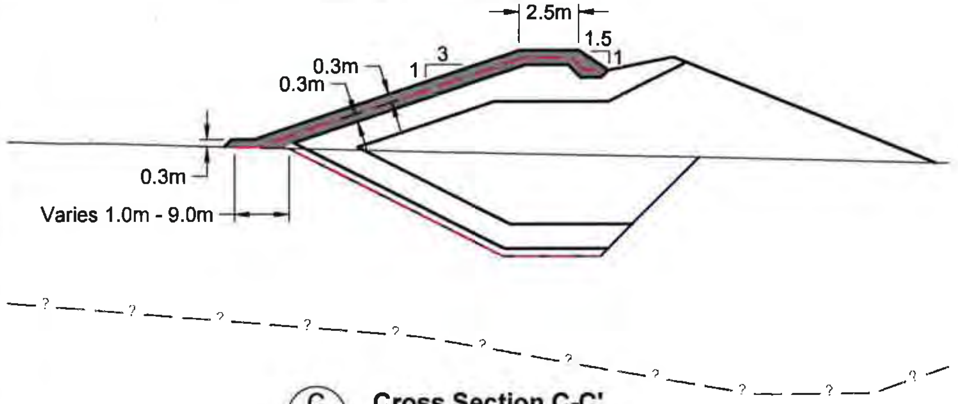
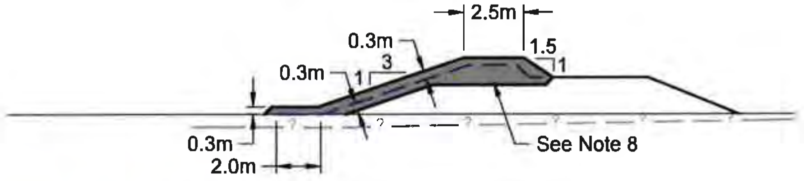


**C** - **Cross Section C-C'**

0m 3 6 9 12



**D** - **Cross Section D-D'**

0m 3 6 9 12

## LEGEND

- Contours
- Design Surface
- Excavation
- Existing Ground
- HDPE Liner System
- Non-woven Geotextile
- Inferred Bedrock
- Waterbody
- ▇ Bedding
- ☐ Other Design Infrastructure
- ▨ Primary Pond Design Infrastructure

## NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Alignment and profile shown correspond to centerline of Primary Pond Dam.
4. Bedding layer to be placed in 0.15m lifts and compacted before liner placement.
5. The subsurface below the liner should be free of protrusions or any sharp / angular cobbles or larger size material. See the Technical Specifications document for more details ('Technical Specifications - Earthworks and Geotechnical Engineering - Back River Gold Project, Nunavut Canada - Issue for Construction' prepared by SRK).
6. Bedding material cover shall be placed over the HDPE using construction equipment that minimizes stresses on the liner. Unless otherwise approved /directed by the Engineer a minimum thickness of 600mm or greater is required to be placed over any areas where heavy equipment will be trafficking over the liner. Thickness requirement are related to equipment type. For light equipment which will have to be directly approved by the Engineer), as an absolute minimum a thickness of 300mm of cover must be maintained between light tracked equipment (e.g. skid-steer or 30 excavator) tracks/tires, and the liner at all times during the covering process.
7. Soil cover should be placed in a manner that prevents the soil from entering/disturbing the liner overlap zones.
8. The bedding (crush) material is required below the geotextile but from chainage 0+800 to 0+920 some of the crush material below the top (horizontal) liner segment may be able to be optimized in the field (i.e more ROQ used and less crush to optimize quantities if / as needed). This small 'field fit' to be done in consultation with the site engineer.

## REFERENCES

NAD83 UTM Zone 13.

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|---|---|
| DRAWING NO. | DRAWING TITLE |

REFERENCE DRAWINGS

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DATE: 2022/09/02
FILE NAME: 1CS020.020 - UM-PP-Dam-Bedding.dwg

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GOLD & SILVER CORP

Back River

SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond

DRAWING TITLE: Primary Pond Dam Downstream Liner and Bedding Plan and Sections

DRAWING NO. UM-PP-206
REVISION NO. A

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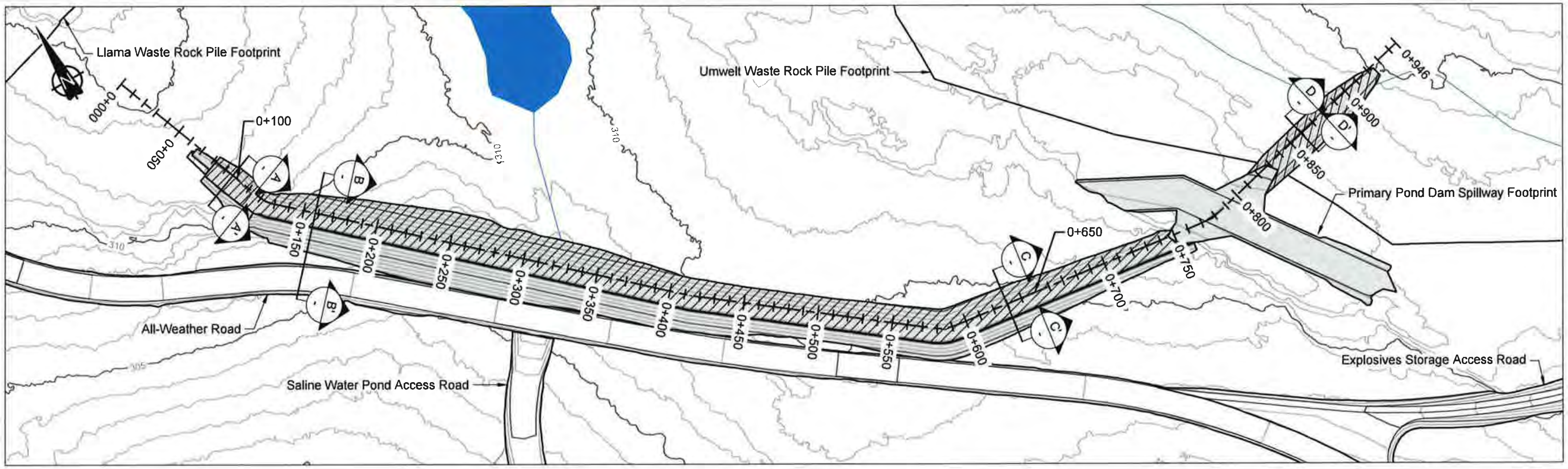


## Overliner Transition Plan

0m 30 60 90 120

## LEGEND

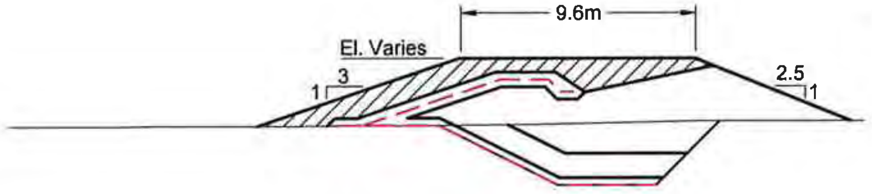
| | |
|---|---|
| — | Contours |
| — | Design Surface |
| — | Excavation |
| — | Existing Ground |
| – – | HDPE Liner System |
| – – | Non-woven Geotextile |
| – · – | Inferred Bedrock |
| — | Waterbody |
| ☐ | Other Design Infrastructure |
| ▭ | Primary Pond Design Infrastructure |
| ▨ | Transition Material |

## NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Alignment and profile shown correspond to centerline of Primary Pond Dam.

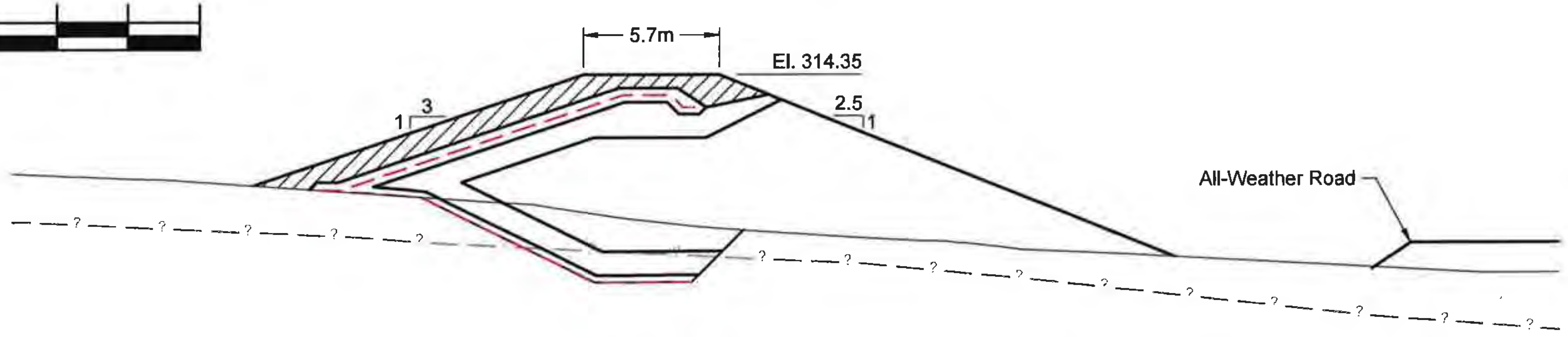
## REFERENCES

NAD83 UTM Zone 13.



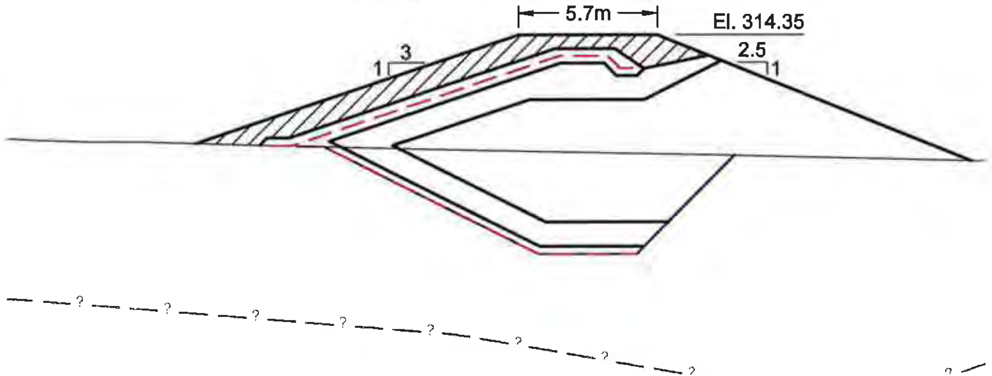
## Cross Section A-A'

0m 3 6 9 12



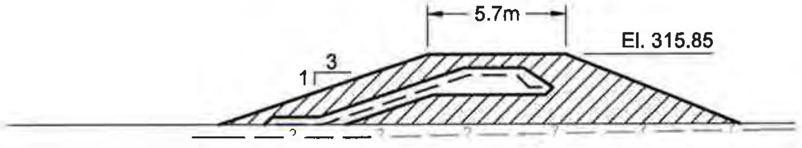
## Cross Section B-B'

0m 3 6 9 12



## Cross Section C-C'

0m 3 6 9 12



## Cross Section D-D'

0m 3 6 9 12

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| CHECKED: JD/AT/VB | APPROVED: JBK | DATE: 2022/09/02 |

FILE NAME: 1CS020.020 - UM-PP-Dam-OL Trans.dwg

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GOLD & SILVER CORP.

Back River

SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond

DRAWING TITLE:
Primary Pond Dam
Overliner Transition
Plan and Sections

DRAWING NO.
UM-PP-207

REVISION NO.
A

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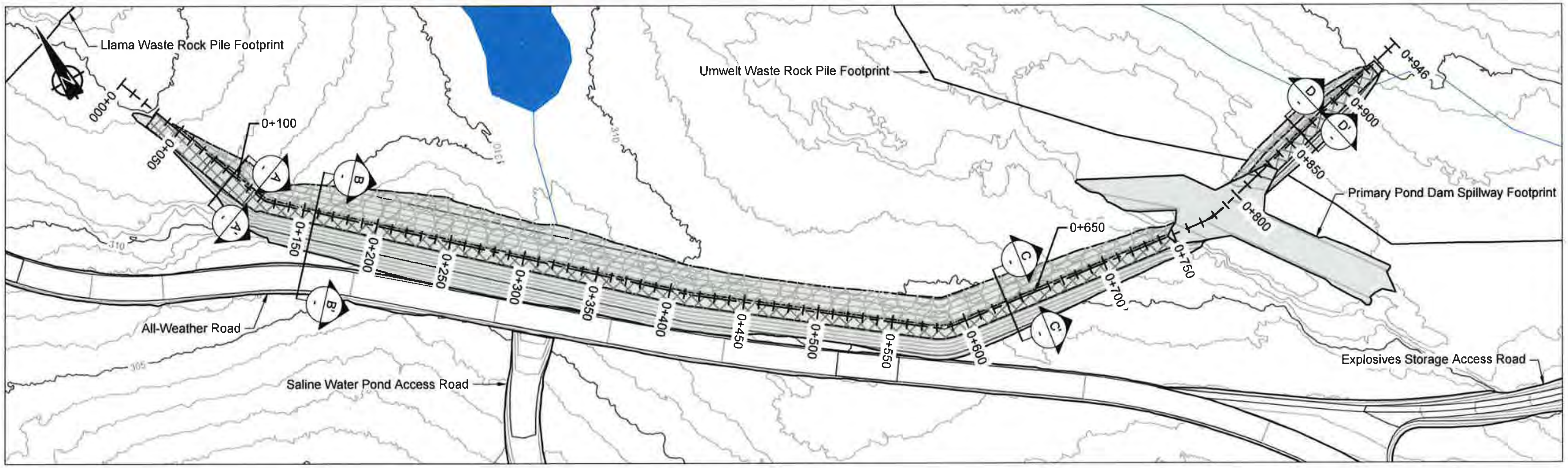


## Overliner ROQ and Cover Plan

0m 30 60 90 120

**LEGEND**

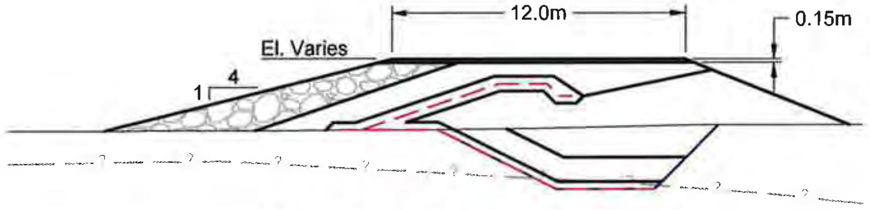
- Contours
- Design Surface
- Excavation
- Existing Ground
- HDPE Liner System
- Non-woven Geotextile
- Inferred Bedrock
- Waterbody
- Other Design Infrastructure
- Primary Pond Design Infrastructure
- Run of Quarry
- Surfacing

**NOTES**

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Alignment and profile shown correspond to centerline of Primary Pond Dam.
4. The outside upstream dam ROQ should be sloped at 4H:1V or shallower.

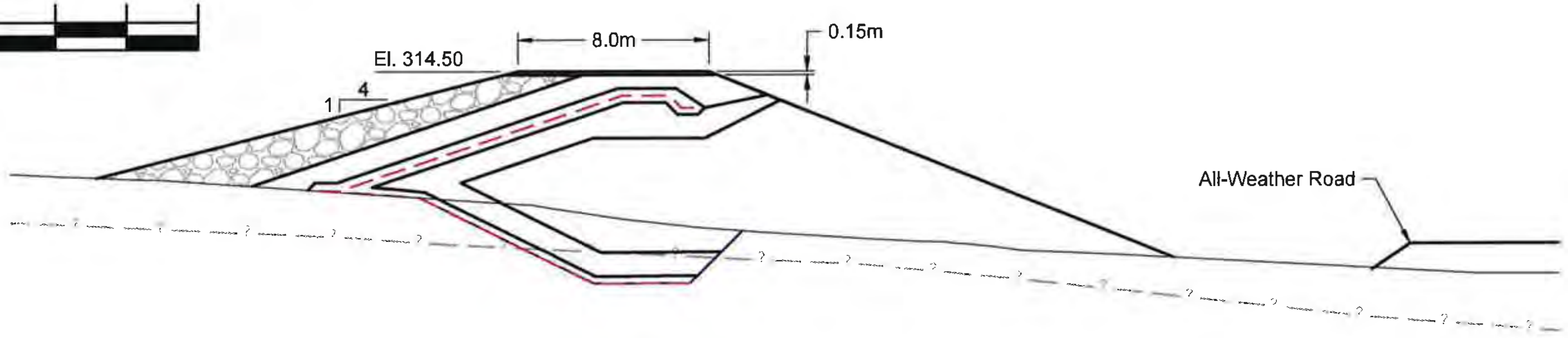
**REFERENCES**

NAD83 UTM Zone 13.



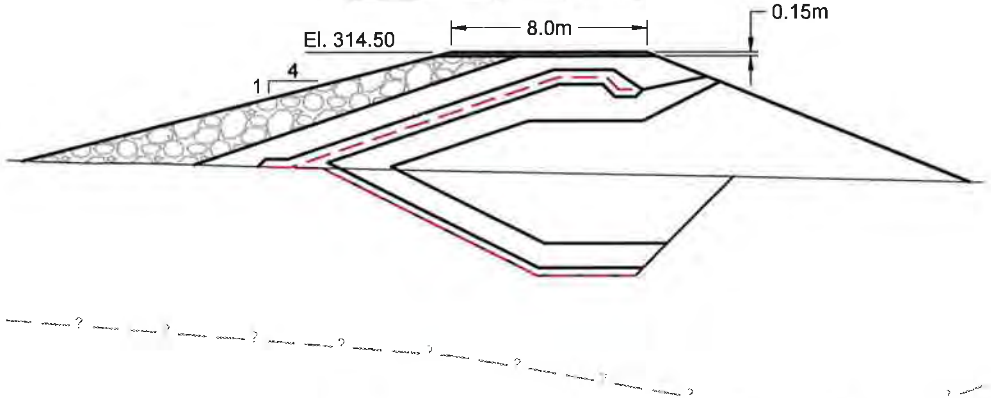
A
-
**Cross Section A-A'**

0m 3 6 9 12



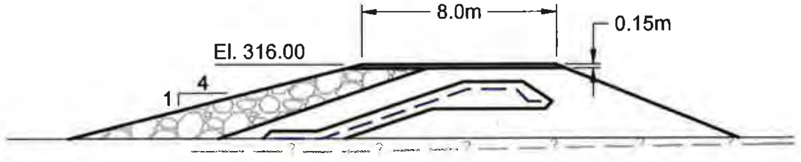
B
-
**Cross Section B-B'**

0m 3 6 9 12



C
-
**Cross Section C-C'**

0m 3 6 9 12



D
-
**Cross Section D-D'**

0m 3 6 9 12

| DRAWING NO. | DRAWING TITLE |
|---|---|
| -- | -- |

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FILE NAME: 1CS020.020 - UM-PP-Dam-OL ROQ.dwg

Sabina
GOLD & SILVER CORP

Back River

SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond

DRAWING TITLE: Primary Pond Dam
Cover
Plan and Sections

DRAWING NO. UM-PP-208
REVISION NO. A

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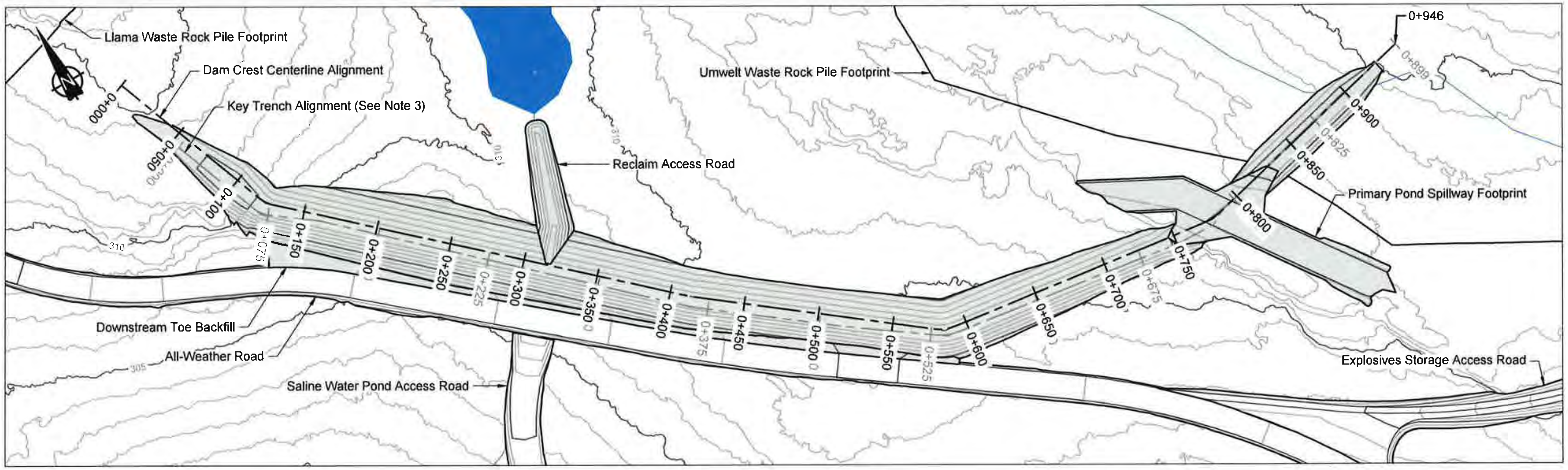
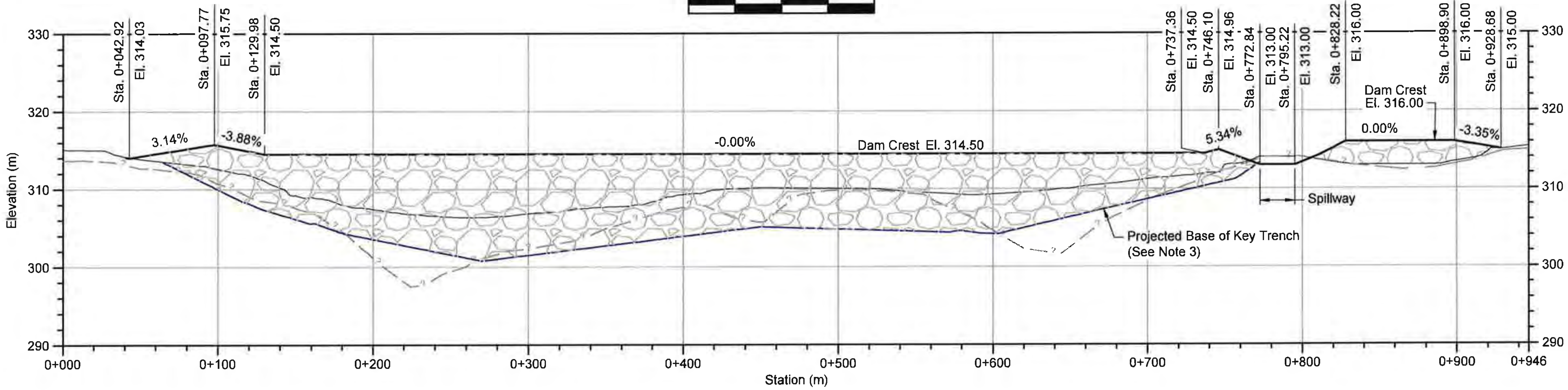


## Primary Pond Dam Final Configuration Plan



## Primary Pond Dam Centerline Profile

## LEGEND

| | |
|---|---|
| ═ | Contours |
| ― | Design Surface |
| ― | Excavation |
| ― | Existing Ground |
| – – | Inferred Bedrock |
| ― | Waterbody |
| ☐ | Other Design Infrastructure |
| ▨ | Primary Pond Design Infrastructure |
| ▨ | Run of Quarry |

## NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Base of key trench on this profile is based on a section down the centerline of the dam crest. Note that the key trench centerline and the dam crest centerline do not share the exact same alignment and overall the chainages vary in any given location (between the key trench and dam crest shown in these drawings) in the range of ±5m offset, ±50 chainage station.
4. Volumes presented based on neat-lines only and are approximate. These include no over-excavation or over-blasting allowance of the key trench.

## REFERENCES

NAD83 UTM Zone 13.

## MATERIAL LIST AND NEAT LINE QUANTITY

| | |
|---|---|
| Overall Excavation: | 34,900m$^3$ |
| Bedrock Excavation: | 12,100m$^3$ |
| ROQ Fill: | 88,600m$^3$ |
| Transition Fill: | 37,000m$^3$ |
| Bedding Fill: | 10,800m$^3$ |
| Surfacing Fill: | 1,300m$^3$ |
| Geotextile: | 48,500m$^2$ |
| Liner: | 23,700m$^2$ |

All quantities presented are to neat-lines and do not allow / account for bulking, compaction, overlaps or material losses.

**REFERENCE DRAWINGS**

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FILE NAME: 1CS020.020 - UM-PP-Final Config.dwg

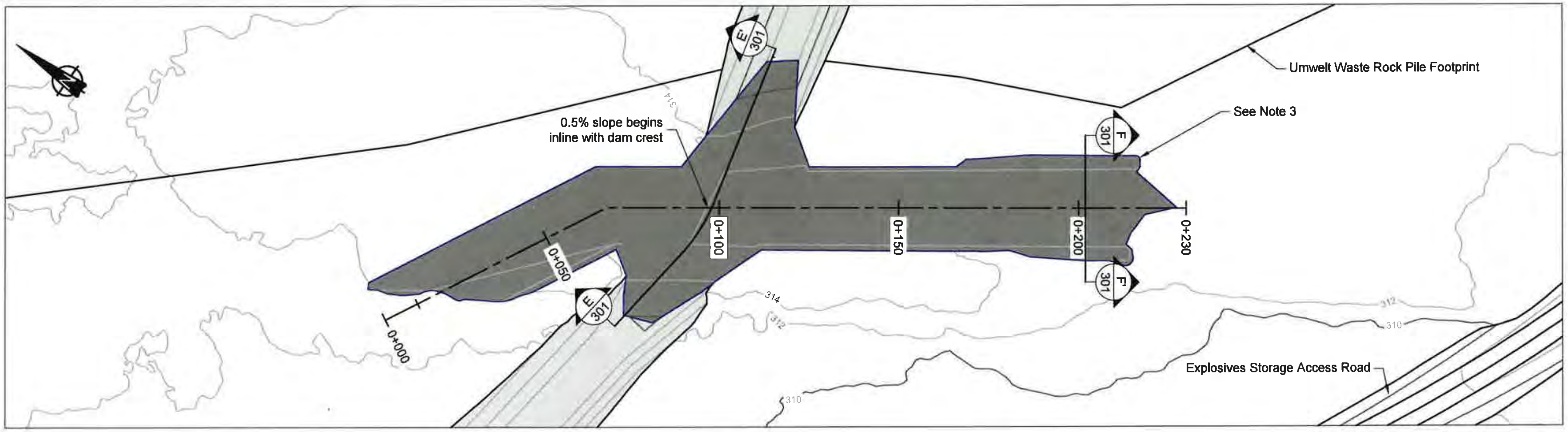
Sabina
Back River

SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond

DRAWING TITLE: Primary Pond Dam Final Configuration Plan and Profile

DRAWING NO.: UM-PP-209
REVISION NO.: A



## Spillway Plan

0m 10 20 30 40 50

**LEGEND**

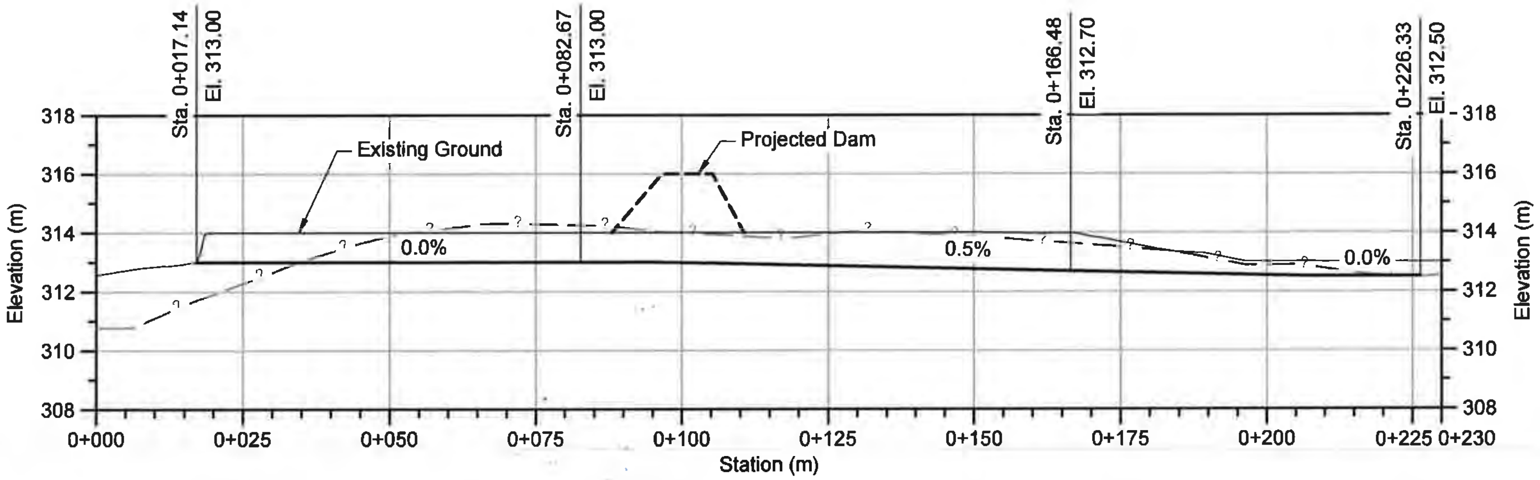
| | |
|---|---|
| — — · — | Inferred Bedrock |
| ═ | Contours |
| ── | Design Surface |
| ─ | Existing Ground |
| ☐ | Other Design Infrastructure |
| ■ | Primary Pond Design Spillway |
| ▨ | Primary Pond Design Infrastructure |

**NOTES**

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.
3. Berm required if cut depth is less than 1.0m.

**REFERENCES**

NAD83 UTM Zone 13.



## Spillway Profile

0m 2 4 6 8 10 Veritcal

0m 10 20 30 40 50 Horizontal

| DRAWING NO. | DRAWING TITLE |
|---|---|
| -- | -- |

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FILE NAME: 1CS020.020 - UM-PP-Spillway.dwg

Sabina
GOLD & SILVER CORP.

Back River

SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond

DRAWING TITLE:
Primary Pond Dam
Spillway Plan and Profile

DRAWING NO.: UM-PP-210
REVISION NO.: A

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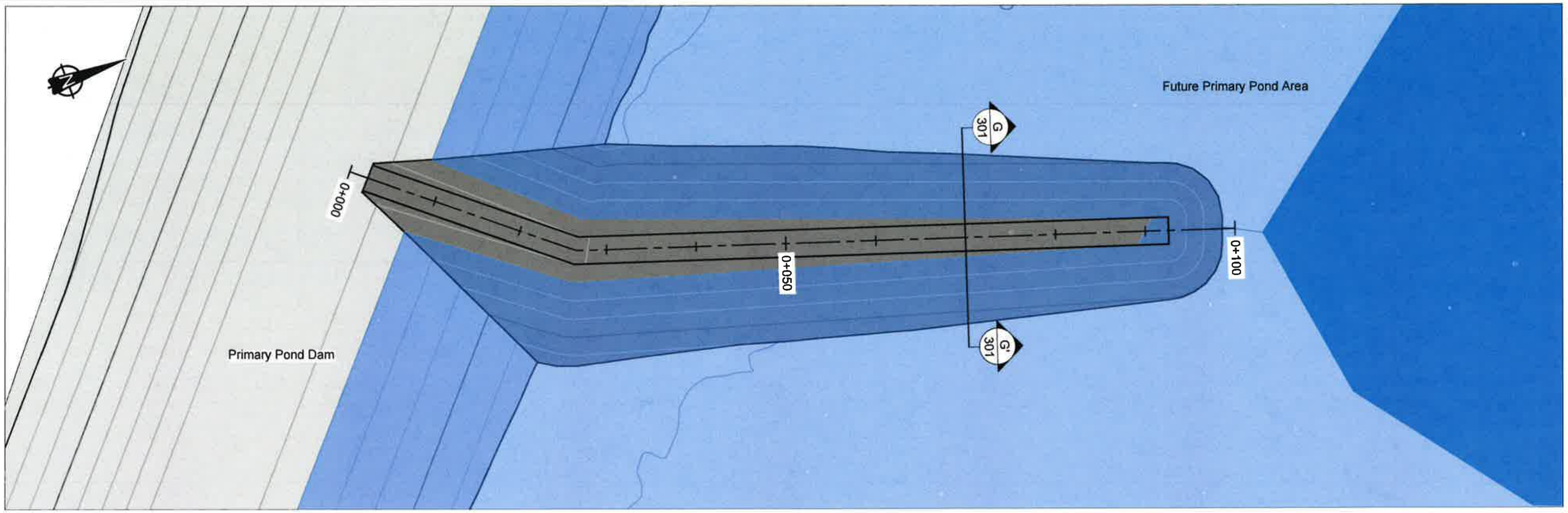


## LEGEND

| | |
|---|---|
| ═ | Contours |
| ━ | Design Surface |
| ─ | Existing Ground |
| - - | Inferred Bedrock |
| ─ | Waterbody |
| ☐ | Other Design Infrastructure |
| ■ | Primary Pond Reclaim Road Design |
| ▨ | Primary Pond Design Infrastructure |
| ▨ | Run of Quarry |

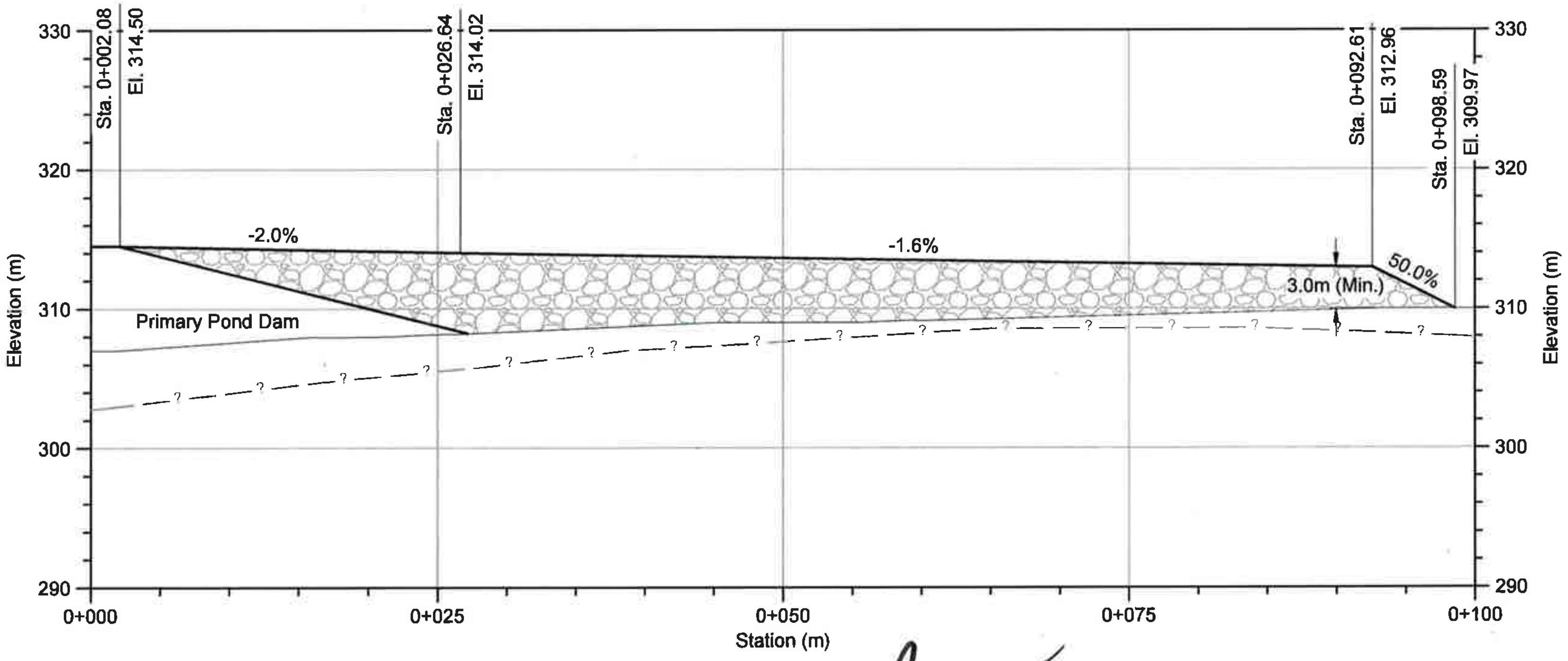
## NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

## REFERENCES

NAD83 UTM Zone 13.

Reclaim Road Plan



Reclaim Road Centerline Profile

0m 5 10 15 20

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
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FILE NAME: 1CS020.020 - UM-PP-Reclaim Road.dwg

Sabina
GOLD & SILVER CORP.
Back River
SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond
DRAWING TITLE: Primary Pond Dam
Reclaim Road
Plan and Profile
DRAWING NO. UM-PP-211
REVISION NO. A

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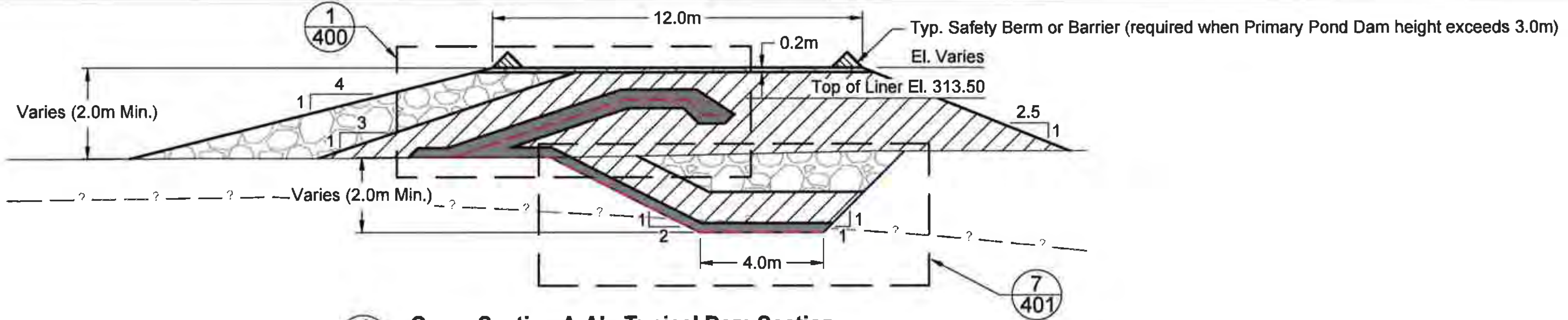
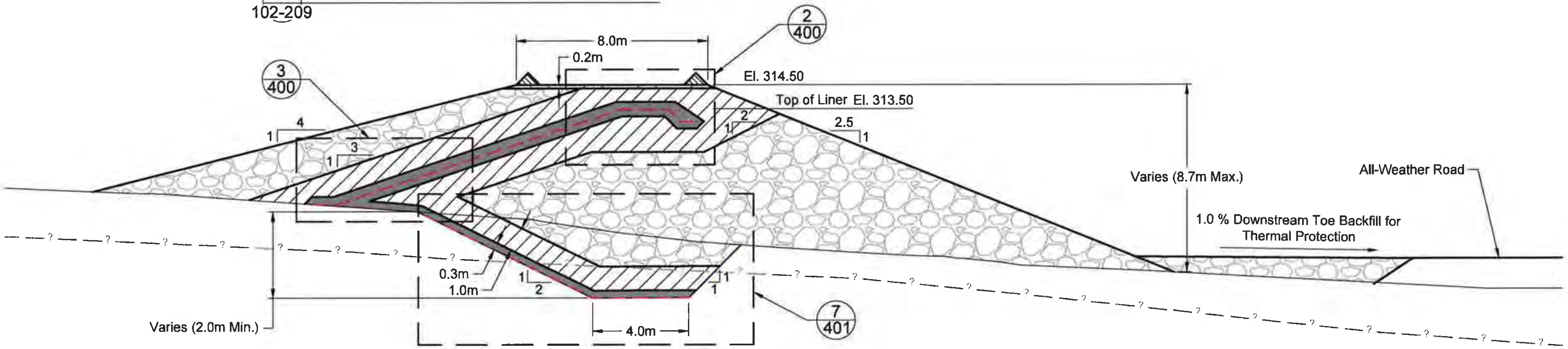
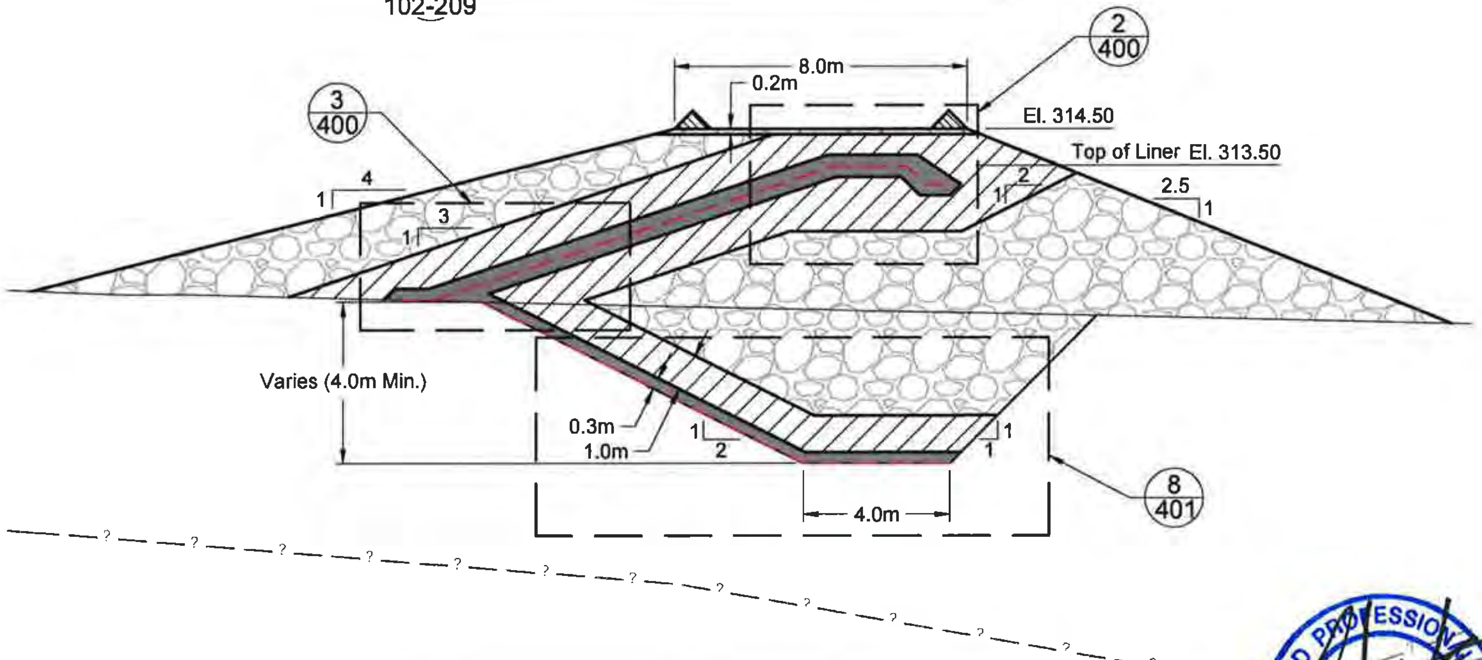


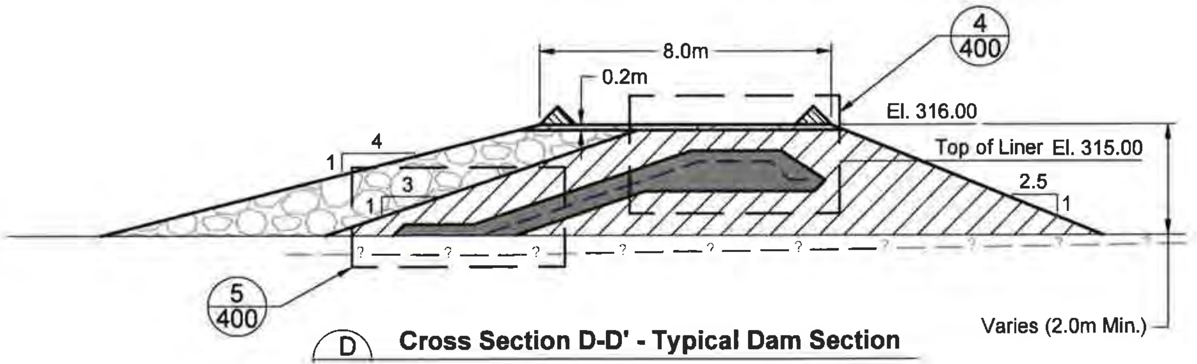
A 102-209 **Cross Section A-A' - Typical Dam Section**



B 102-209 **Cross Section B-B' - Typical Dam Section**



C 102-209 **Cross Section C-C' - Typical Dam Section**



D 102-209 **Cross Section D-D' - Typical Dam Section**

**LEGEND**

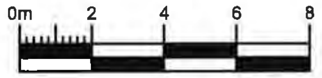
- ― Design Surface
- ― Excavation
- ― Existing Ground
- – · – Inferred Bedrock
- – – HDPE Liner
- – – Non-woven Geotextile
- ▬ Bedding
- ▭ Run of Quarry
- ☒ Surfacing
- ▨ Transition Material

**NOTES**

1. All units are in meters unless otherwise specified.

**SECTION LOCATION**

| Dam Crest Centerline Alignment Station (m) | | Section |
|---|---|---|
| Start | End | |
| 0+020 | 0+130 | A-A' |
| 0+130 | 0+190 | B-B' |
| 0+190 | 0+260 | C-C' |
| 0+260 | 0+600 | B-B' |
| 0+600 | 0+700 | C-C' |
| 0+700 | 0+770 | B-B' |
| 0+800 | 0+920 | D-D' |



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DATE: 2022/09/02
FILE NAME: 1CS020.020 - UM-PP-Dam-Typ Sect.dwg

Sabina
GOLD & SILVER CORP.

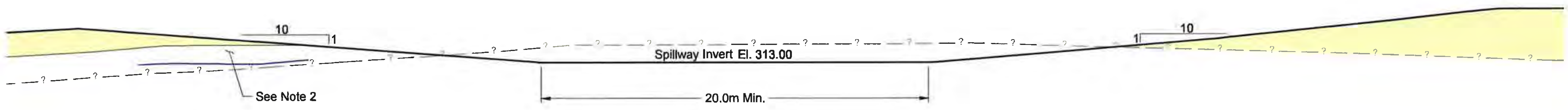
Back River

SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond

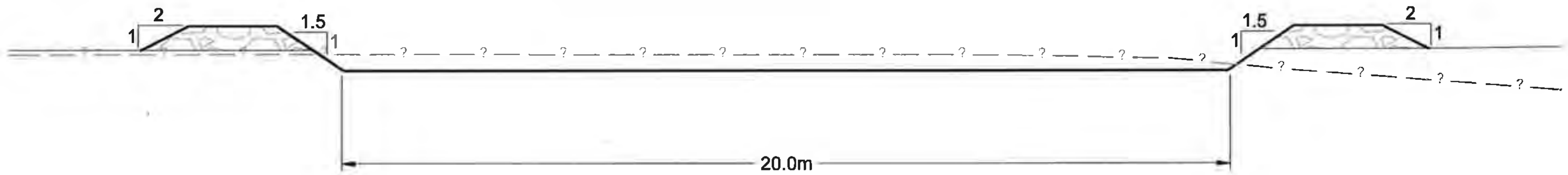
DRAWING TITLE:
Typical Dam Cross Sections

DRAWING NO.: UM-PP-300
REVISION NO.: A



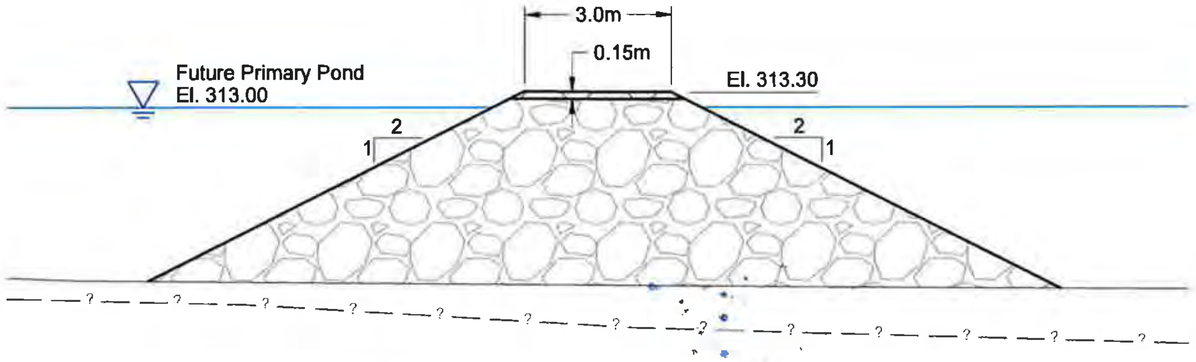
**E 210 Spillway - Section Through Access**

0m 2 4 6 8 10



**F 210 Spillway - Typical Section**

0m 1 2 3 4 5 6



**G 211 Reclaim Road - Typical Section**

0m 1 2 3 4 5 6

**LEGEND**

| | |
|---|---|
| — | Design Surface |
| — | Excavation |
| — | Existing Ground |
| – – ? – | Inferred Bedrock |
| 🟨 | Fill Material |
| ▨ | Run of Quarry |
| ☒ | Surfacing |

**NOTES**

1. All units are in meters unless otherwise specified.
2. The transition between the overburden to bedrock cut to be 'field fit' with the approval of the site engineer to ensure that adequate (approx. 2m) of thermal protection is maintained over any exposed overburden or disturbed tundra.

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FILE NAME: 1CS020.020 - UM-PP-Dam-Typ Sect.dwg

Sabina GOLD & SILVER CORP.

Back River

SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond

DRAWING TITLE:
Typical Spillway and Reclaim Road Cross Sections

DRAWING NO.: UM-PP-301
REVISION NO.: A

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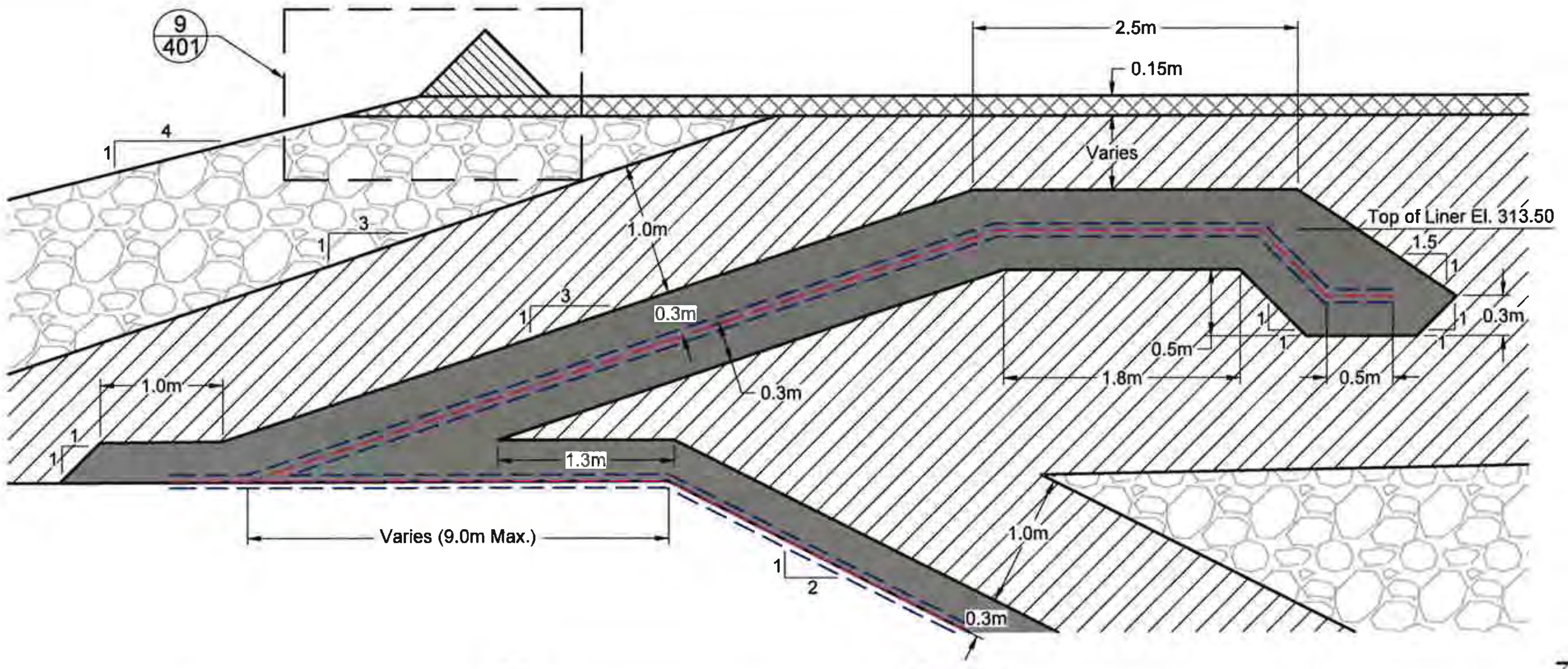


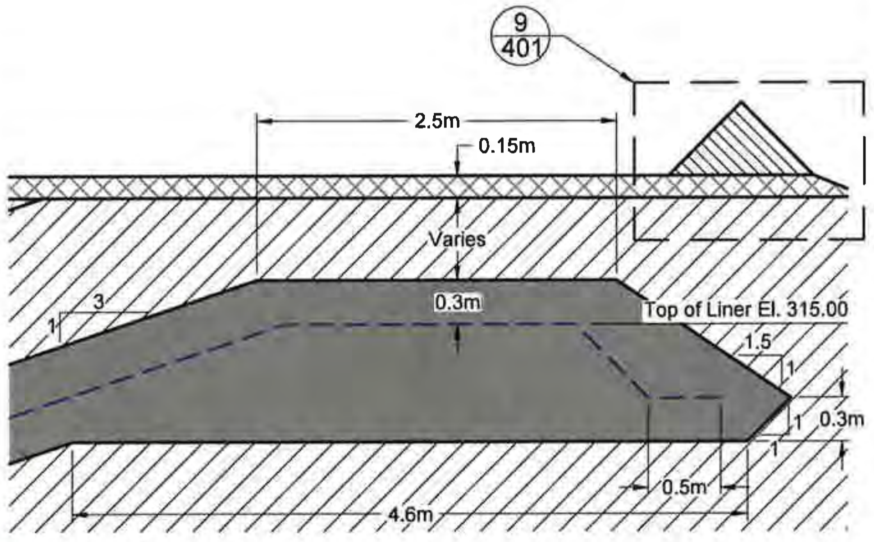
1
300
**Detail 1 - Section A-A' Liner and Bedding Placement**

**LEGEND**

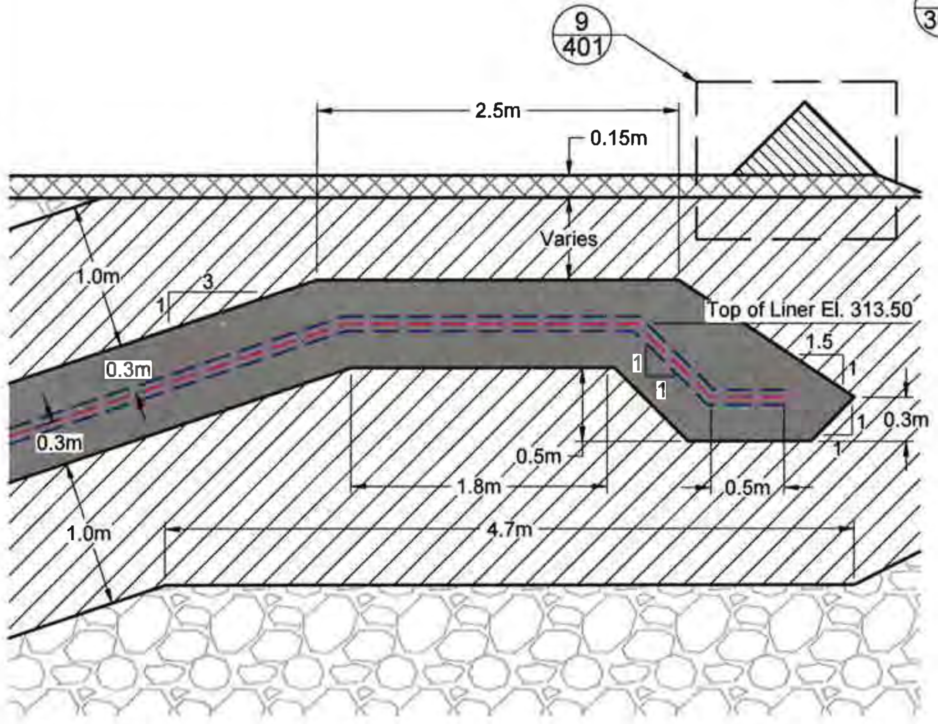
| | |
|---|---|
| — | Design Surface |
| — — | HDPE Liner |
| — — | Non-woven Geotextile |
| ▬ | Bedding |
| ▭ | Run of Quarry |
| ⊠ | Surfacing |
| ▨ | Transition Material |

**NOTES**

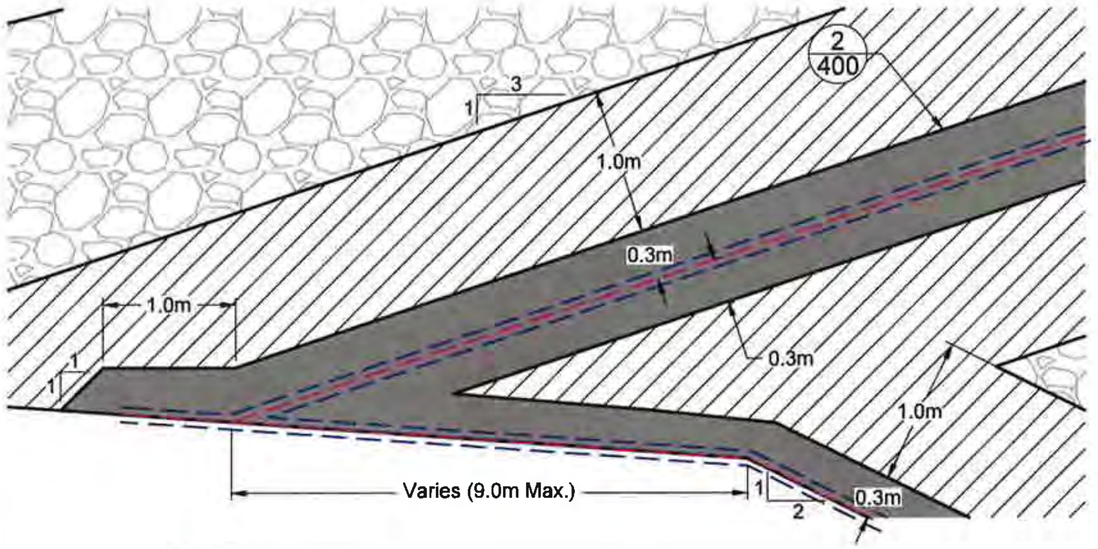
1. All units are in meters unless otherwise specified.



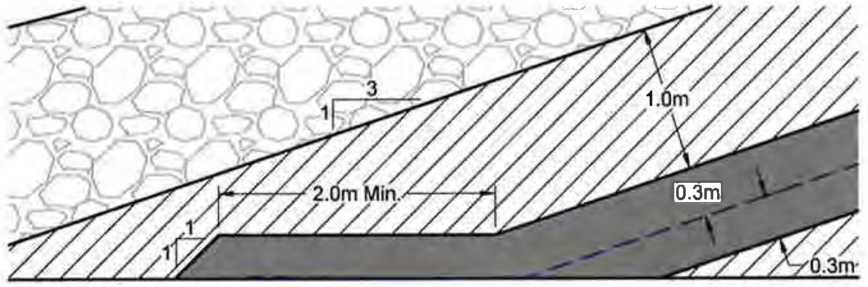
4
300
**Detail 4 - Section D-D' Crest Geotextile and Bedding Placement**



2
300,400
**Detail 2 - Section B-B' and C-C' Crest Liner and Bedding Placement**



3
300
**Detail 3 - Section B-B' and C-C' Toe Liner Overlap**



5
300
**Detail 5 - Section D-D' and C-C' Toe Geotextile Placement**

0m 0.5 1.0 1.5 2.0

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FILE NAME: 1CS020.020 - UM-PP-Dam-Typ Sect dwg

Sabina
GOLD & SILVER CORP.

Back River

SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond
DRAWING TITLE:
Details

DRAWING NO.
UM-PP-400

REVISION NO.
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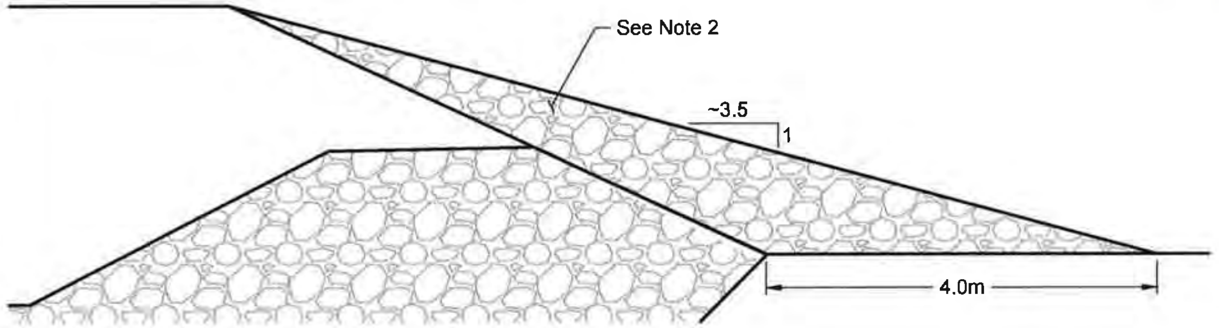
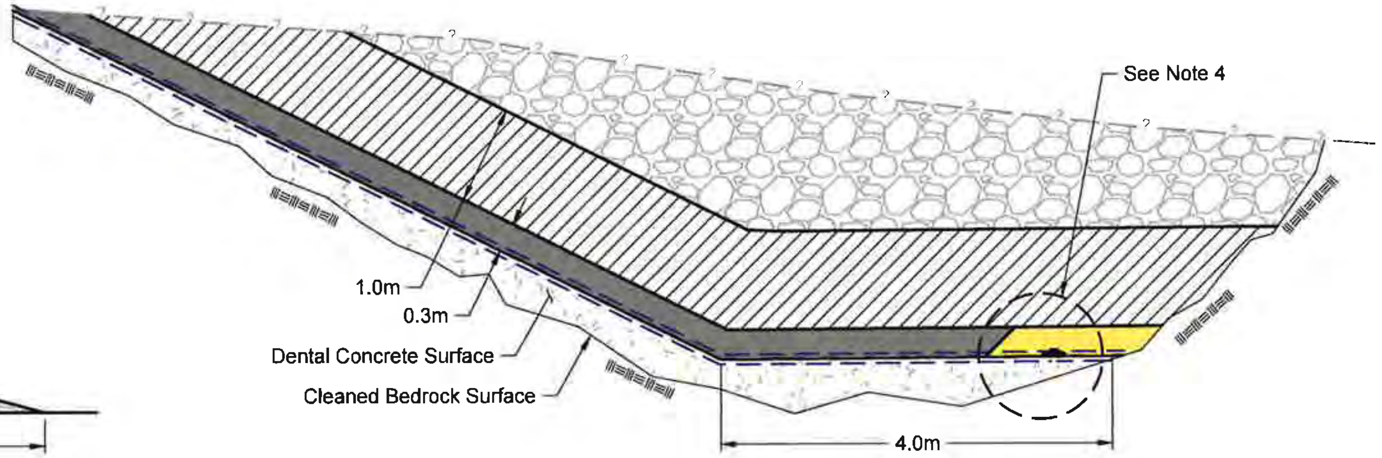


### 6/300 Detail 6 - Contingency ROQ Thermal Barrier

0m 1 2 3 4



### 7/300 Detail 7 - Downstream Liner to Bedrock Tie-in Seepage Cut Off - Plan

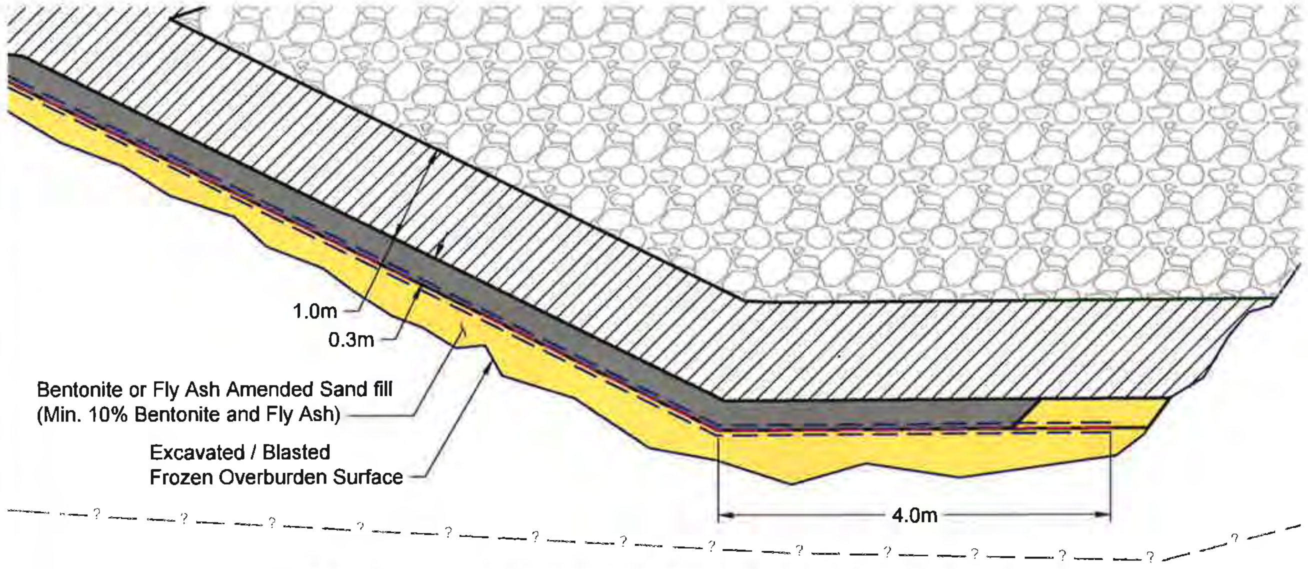
0m 1 2 3 4

**LEGEND**

- — Design Surface
- — Excavation
- – – HDPE Liner
- – – Inferred Bedrock
- – – Non-woven Geotextile
- ▬ Cleaned Bedrock
- ■ Bedding
- 🟨 Bentonite / Fly Ash Sand Fill
- ☐ Concrete
- ☐ Run of Quarry
- ☒ Surfacing
- ▨ Stainless Steel
- ▨ Transition Material

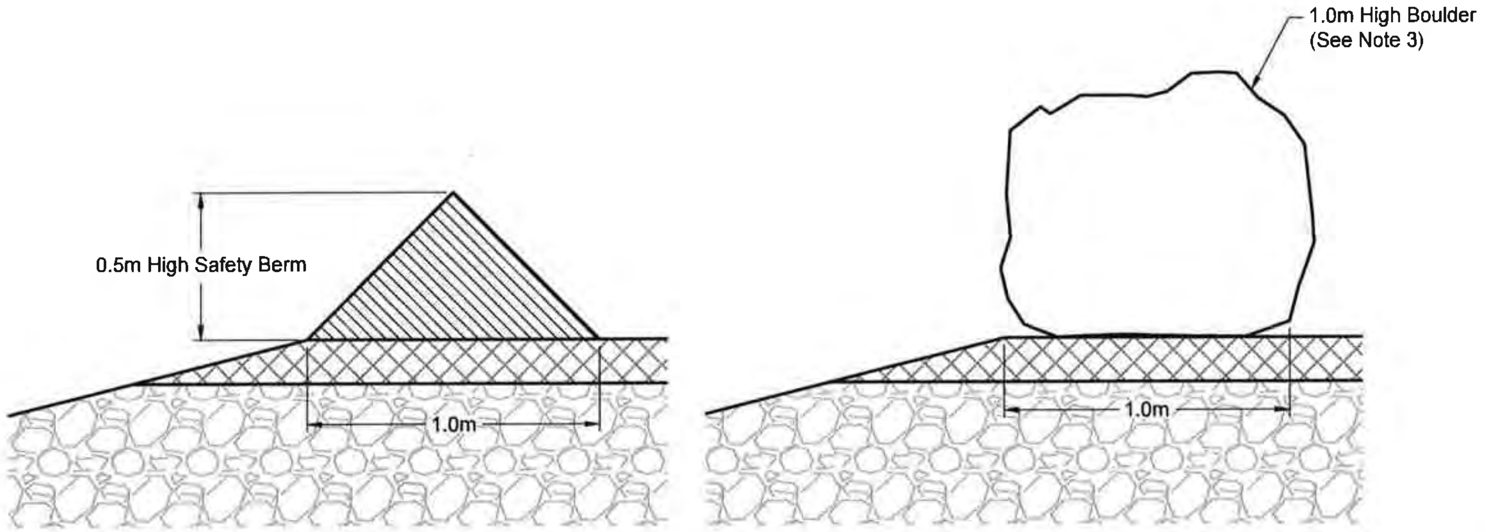
**NOTES**

1. All units are in meters unless otherwise specified.
2. If the key trench is over-blasted or over-excavated, beyond the new design lines presented for the downstream toe of the outside dam shell, then additional ROQ material will be required to be placed in and above the backfill key trench.
3. Barrier required when Primary Pond Dam height exceeds 3.0m.
4. For the bedrock sections at liner anchor, bolt or water stop to be placed to create a better seal between the bedrock and the liner at the back / downstream side of the key trench.



### 8/300 Detail 8 - Downstream Liner to Overburden Tie-in - Plan

0m 1 2 3 4



### 9/400 Detail 9 - Typical Safety Berm or Barrier Options

0m 0.25 0.5 0.75 1.0

| DRAWING NO. | DRAWING TITLE |
|---|---|
| -- | -- |

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DATE: 2022/09/02
FILE NAME: 1CS020.020 - UM-PP-Dam-Typ Sect.dwg

Sabina
GOLD & SILVER CORP.

Back River

SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond
DRAWING TITLE:
Details

DRAWING NO.: UM-PP-401
REVISION NO.: A

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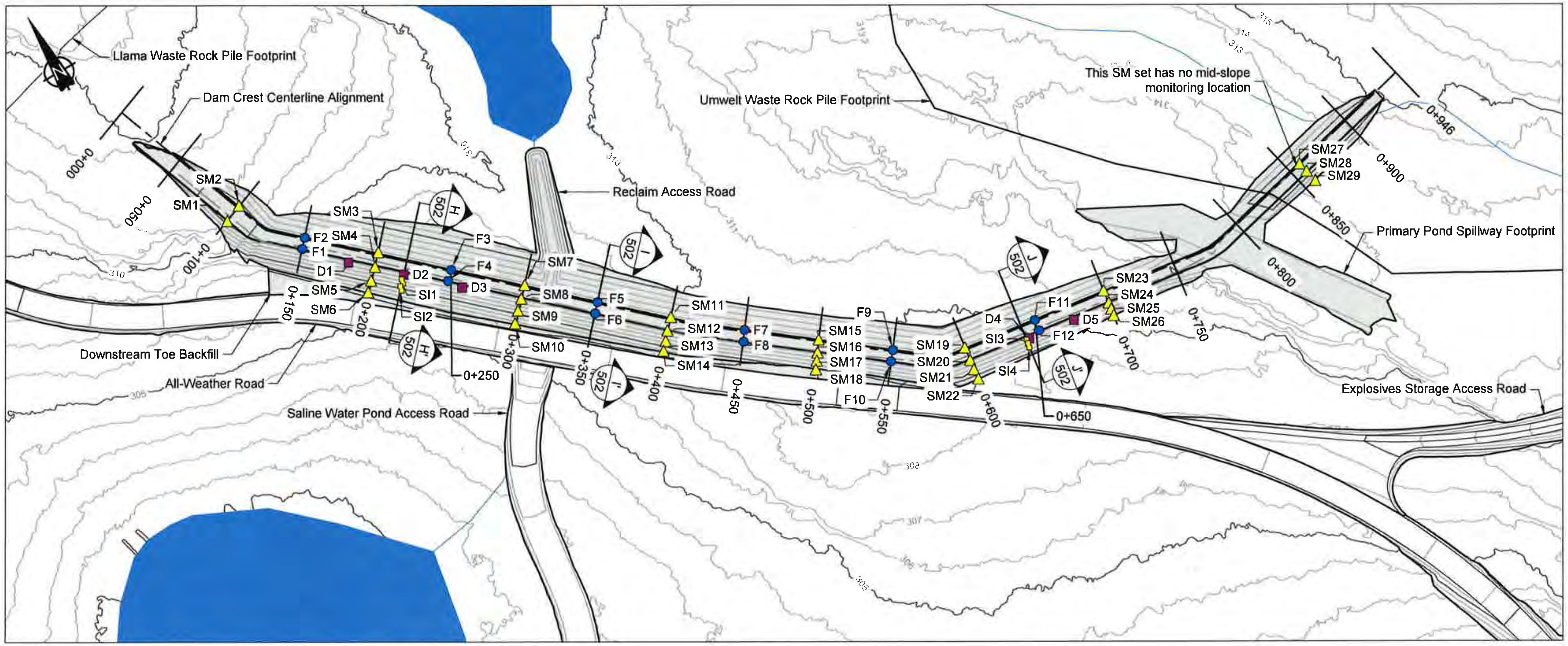

## Primary Pond Dam Plan

### LEGEND

| | |
|---|---|
| ● | Fixed Survey Monitoring Point |
| △ | Surficial Survey Monitoring Point |
| ■ | Deep Monitoring Point |
| ▯ | Slope Inclinometers |
| ═ | Contours |
| ─ | Monitoring Section |
| ─ | Waterbody |
| ▭ | Other Design Infrastructure |
| ▨ | Primary Pond Design Infrastructure |

### NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

### REFERENCES

NAD83 UTM Zone 13.

### Surficial Survey Monitoring Points

| Identify | Easting | Northing |
|---|---|---|
| SM1 | 429493.6 | 7271483 |
| SM2 | 429505.4 | 7271487 |
| SM3 | 429570.2 | 7271414 |
| SM4 | 429563.6 | 7271407 |
| SM5 | 429556.8 | 7271400 |
| SM6 | 429551.1 | 7271395 |
| SM7 | 429643.8 | 7271347 |
| SM8 | 429637.3 | 7271340 |
| SM9 | 429631.4 | 7271334 |
| SM10 | 429625.5 | 7271328 |
| SM11 | 429717.6 | 7271279 |
| SM12 | 429711.3 | 7271273 |
| SM13 | 429706.8 | 7271267 |
| SM14 | 429702.2 | 7271262 |
| SM15 | 429795.7 | 7271217 |
| SM16 | 429790.6 | 7271210 |
| SM17 | 429787.5 | 7271206 |
| SM18 | 429784.1 | 7271201 |
| SM19 | 429877.3 | 7271164 |
| SM20 | 429876.4 | 7271155 |
| SM21 | 429875.5 | 7271148 |
| SM22 | 429874.9 | 7271141 |
| SM23 | 429976.6 | 7271150 |
| SM24 | 429975.6 | 7271141 |
| SM25 | 429975 | 7271137 |
| SM26 | 429974.4 | 7271132 |
| SM27 | 430131.8 | 7271157 |
| SM28 | 430133.6 | 7271151 |
| SM29 | 430135.3 | 7271142 |

0m 30 60 90 120

### Deep Survey Monitoring Points

| Identify | Easting | Northing |
|---|---|---|
| D1 | 429549.4 | 7271418 |
| D2 | 429577.5 | 7271393 |
| D3 | 429606.8 | 7271366 |
| D4 | 429917.7 | 7271147 |
| D5 | 429949.6 | 7271143 |

### Slope Inclinometer Monitoring Points

| Identify | Easting | Northing |
|---|---|---|
| SI1 | 429574.6 | 7271390 |
| SI2 | 429571.5 | 7271386 |
| SI3 | 429915.5 | 7271146 |
| SI4 | 429915.1 | 7271144 |

### Fixed Survey Monitoring Points

| Identify | Easting | Northing |
|---|---|---|
| F1 | 429527.3 | 7271442 |
| F2 | 429532.5 | 7271447 |
| F3 | 429606.3 | 7271380 |
| F4 | 429600.8 | 7271374 |
| F5 | 429680.2 | 7271312 |
| F6 | 429675 | 7271307 |
| F7 | 429755.8 | 7271247 |
| F8 | 429751.3 | 7271241 |
| F9 | 429835 | 7271186 |
| F10 | 429830.2 | 7271180 |
| F11 | 429926.9 | 7271156 |
| F12 | 429925.9 | 7271149 |

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Sabina
GOLD & SILVER CORP

Back River

SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond

DRAWING TITLE:
Primary Pond Dam
Instrumentation Plan

DRAWING NO.: UM-PP-500
REVISION NO.: A

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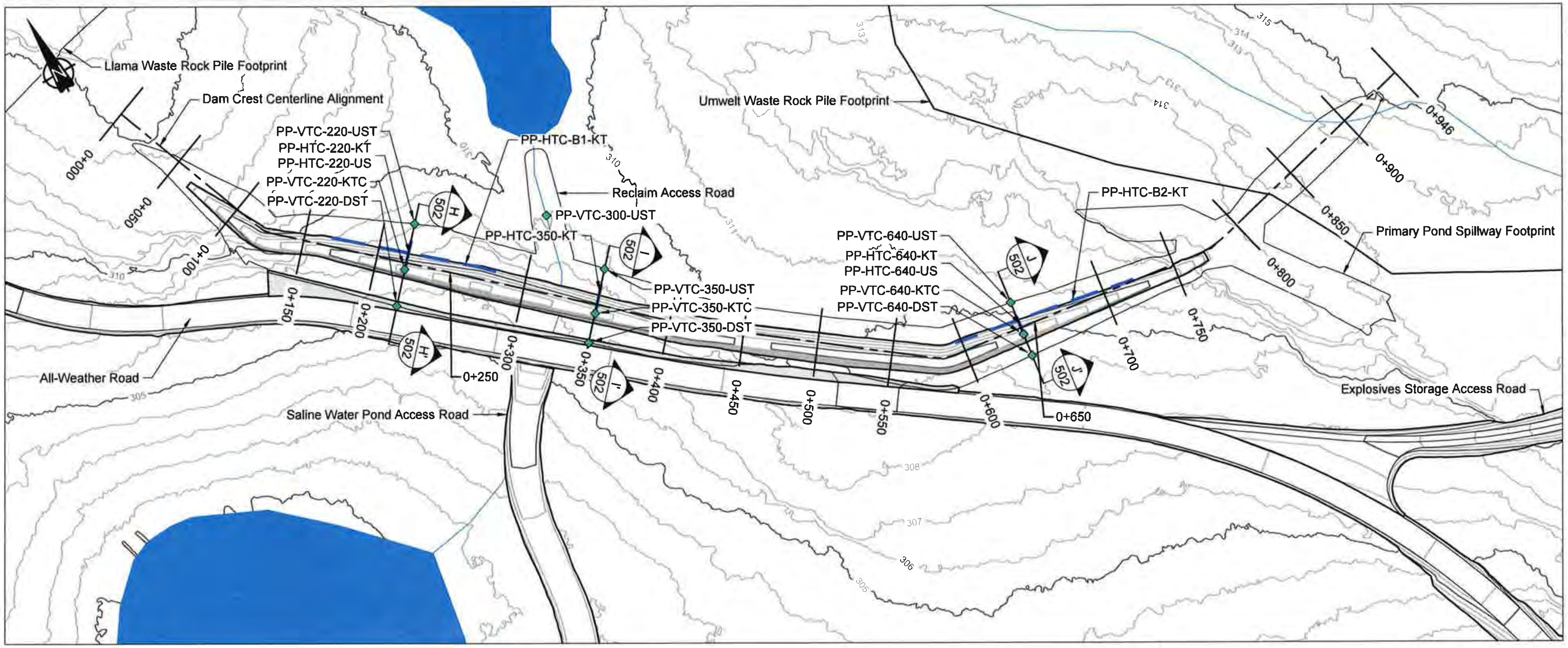

## Primary Pond Dam Plan

### LEGEND

| | |
|---|---|
| ◆ | Vertical Ground Temperature Cable |
| – – | Horizontal Ground Temperature Cable |
| — | Contours |
| — | Monitoring Section |
| — | Waterbody |
| ☐ | Other Design Infrastructure |
| ▨ | Primary Pond Design Infrastructure |

### NOTES

1. Contours are shown at 1.0 m intervals.
2. All units are in meters unless otherwise specified.

### REFERENCES

NAD83 UTM Zone 13.

### Vertical Ground Cable Locations

| Identify | Easting | Northing |
|---|---|---|
| PP-VTC-220-DST | 429563.9 | 7271378 |
| PP-VTC-220-KTC | 429580.5 | 7271396 |
| PP-VTC-220-UST | 429601.4 | 7271419 |
| PP-VTC-300-UST | 429680 | 7271380 |
| PP-VTC-350-DST | 429662.2 | 7271293 |
| PP-VTC-350-KTC | 429675.7 | 7271307 |
| PP-VTC-350-UST | 429695.8 | 7271330 |
| PP-VTC-640-DST | 429914.3 | 7271137 |
| PP-VTC-640-KTC | 429916.2 | 7271152 |
| PP-VTC-640-UST | 429919.3 | 7271174 |

0m 30 60 90 120

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GOLD & SILVER CORP

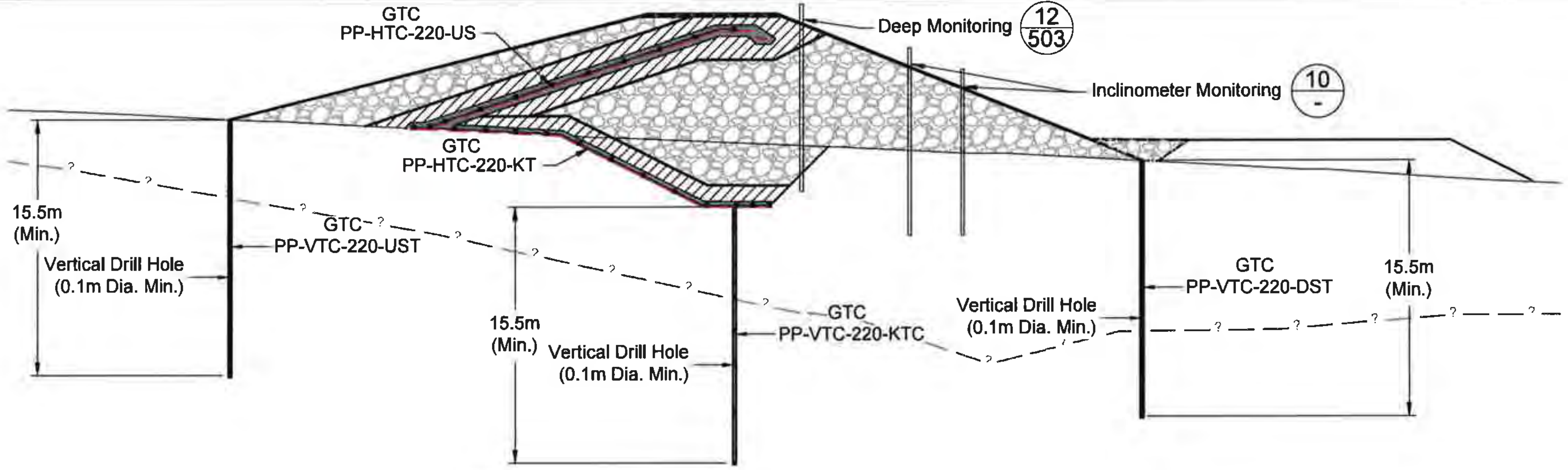
Back River

SRK JOB NO.: 1CS020.020
REG. NO.: EGBC 1003655

Primary Pond

DRAWING TITLE:
Primary Pond Dam
Horizontal and Vertical GTC Layout

DRAWING NO.: UM-PP-501
REVISION NO.: A



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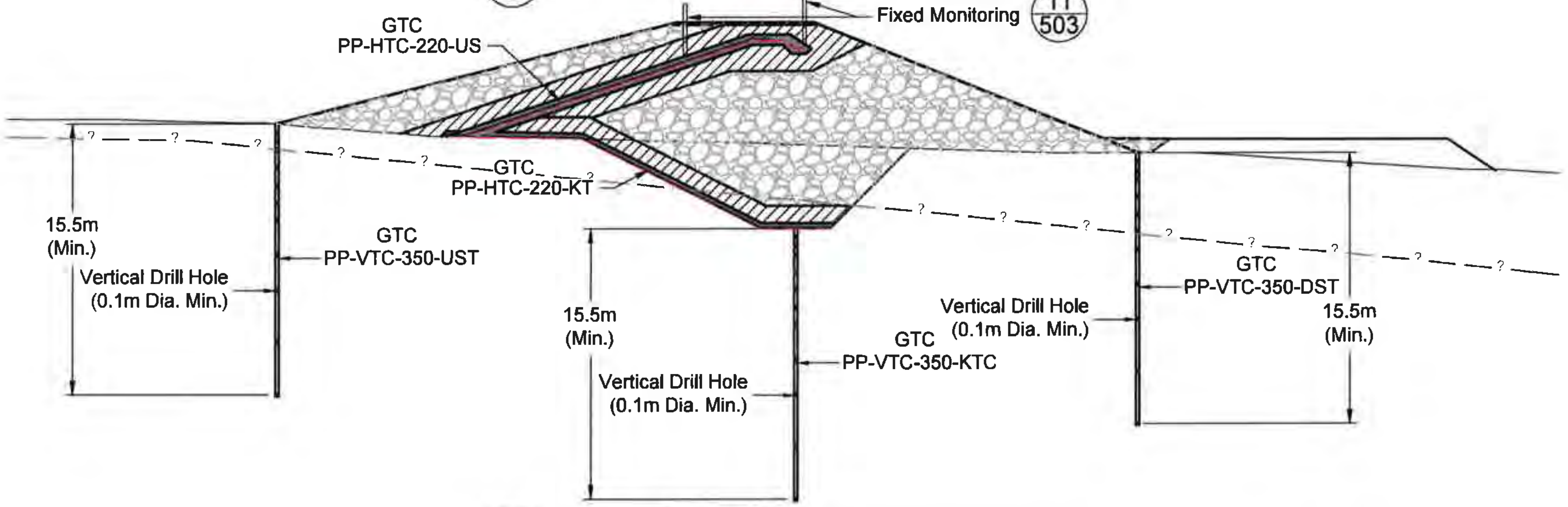
## Ground Temperature Cable at Station 0+220



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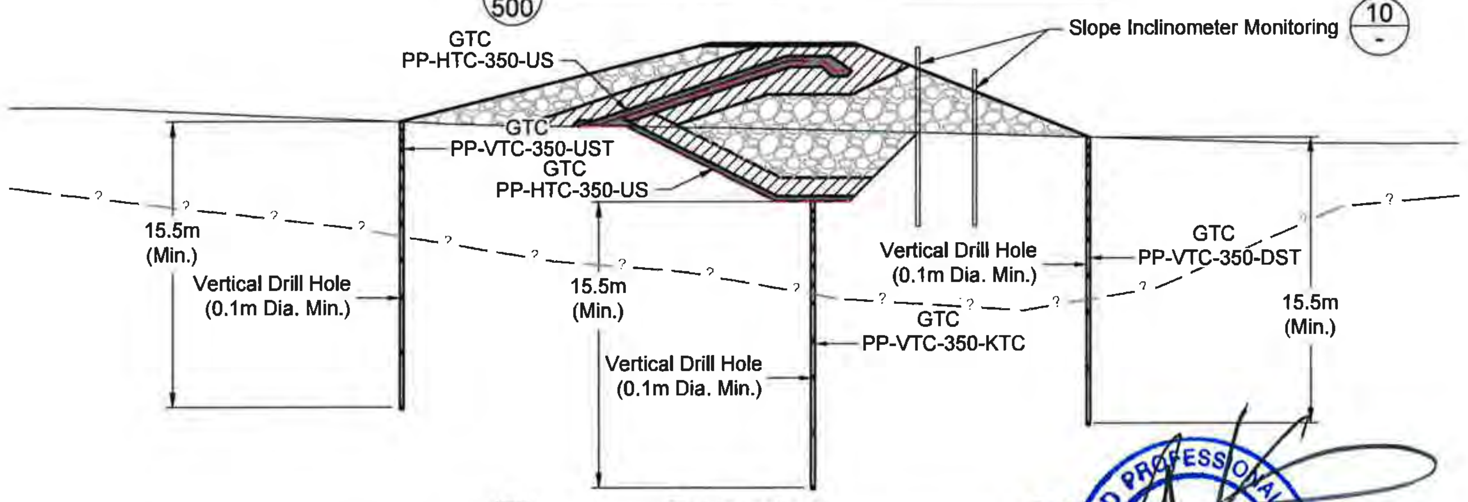
## Ground Temperature Cable at Station 0+350



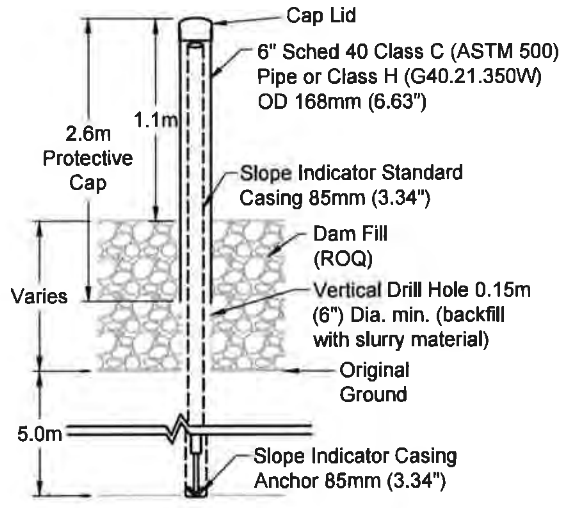
J
500
## Ground Temperature Cable at Station 0+64[illegible]

### LEGEND

| | |
|---|---|
| — | Design Surface |
| — | Excavation |
| — | Existing Ground |
| - - ? - - | Inferred Bedrock |
| - - - | HDPE Liner |
| ▬ | Bedding |
| ▭ | Run of Quarry |
| ☒ | Surfacing |
| ▨ | Transition Material |

### NOTES

1. All units are in meters unless otherwise specified.
2. Bead spacing is as follows:
   -Vertical Cables (below ground surface): 0.5, 1.0, 1.5, 2.5, 3.5, 4.5, 5.5, 7.5, 9.5, 12.5, 15.5
   -Horizontal cables : at 0, 1, 2, then every 2 m after until the end of cable.
3. GTC = Ground Temperature Table



10
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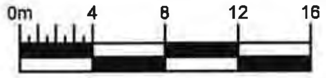
## Inclinometer Installation Detail

Not To Scale



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Back River

SRK JOB NO.: 1CS020.020
REG. NO.:

Primary Pond

DRAWING TITLE:
Primary Pond Dam
Instrumentation Details

DRAWING NO.: UM-PP-502
REVISION NO.: A

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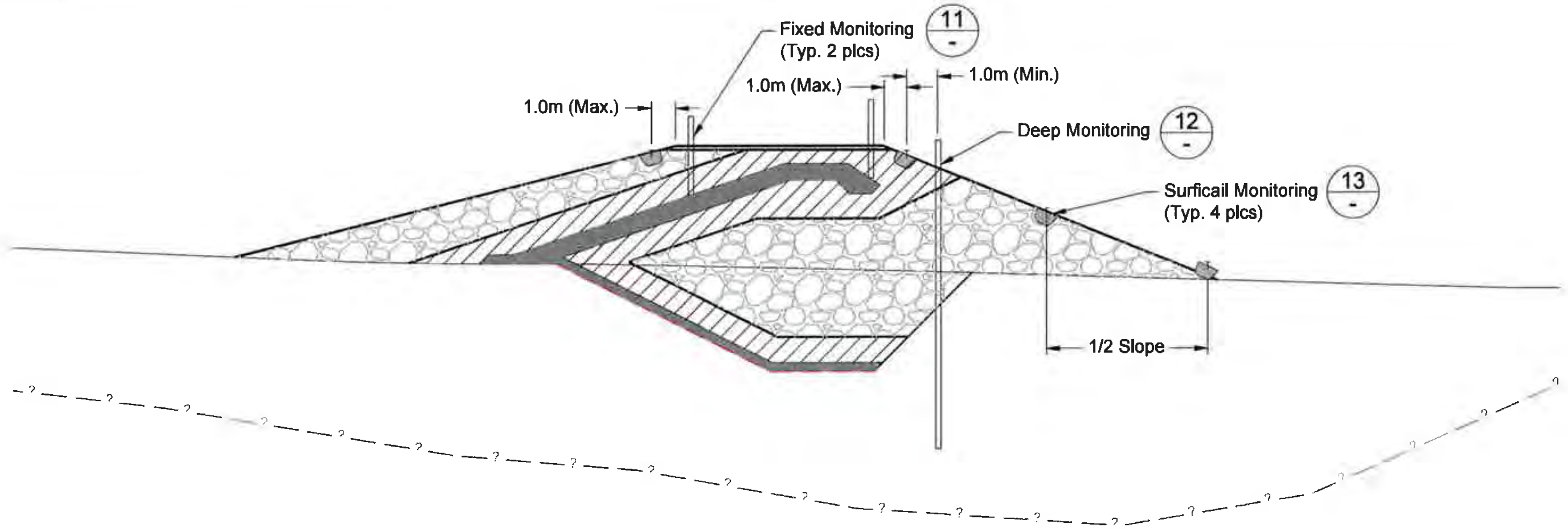


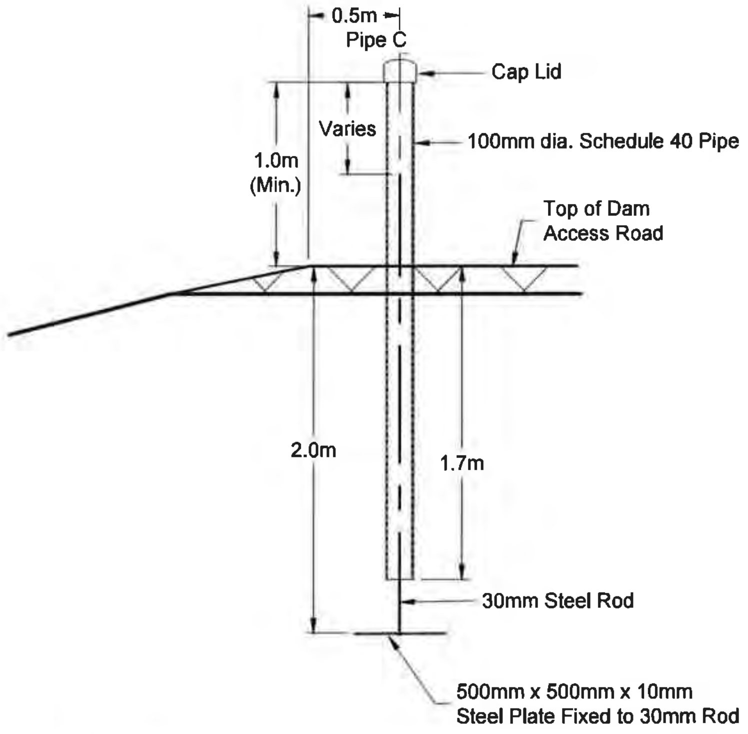
## Typical Survey Monitoring Pin Locations

**LEGEND**

- ─── Design Surface
- ─── Excavation
- ─── Existing Ground
- ─ ─ · ─ Inferred Bedrock
- ─ ─ HDPE Liner
- ■ Bedding
- ▭ Run of Quarry
- ☒ Surfacing
- ▨ Transition Material

**NOTES**

1. All units are in meters unless otherwise specified.



11
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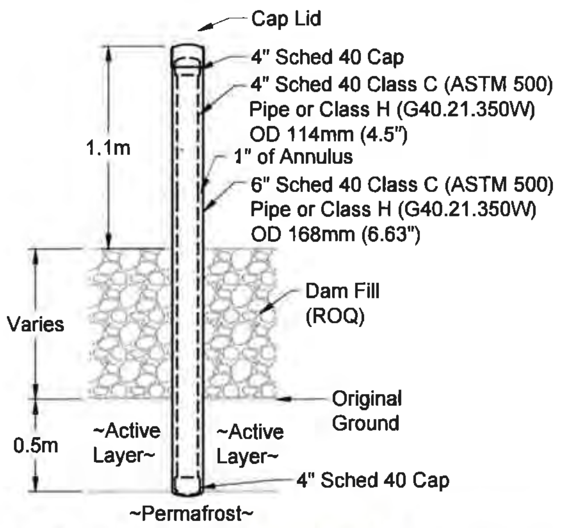
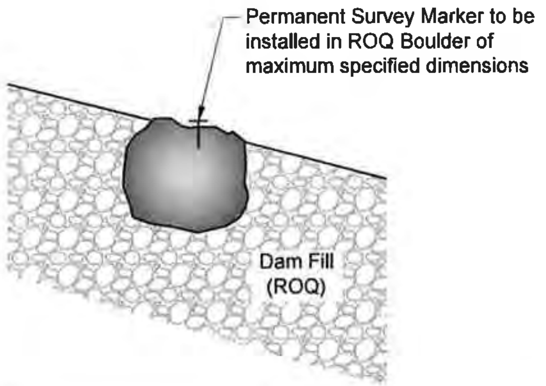
### Fixed Survey Monitoring Point Detail
Not To Scale



12
-
### Deep Settlement Point Installation Detail
Not To Scale



13
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### Surficial Survey Point Installation Detail
Not To Scale

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Back River

SRK JOB NO.: 1CS020.020
REG. NO.:

Primary Pond

DRAWING TITLE:
Primary Pond Dam
Instrumentation Details

DRAWING NO.: UM-PP-503
REVISION NO.: A