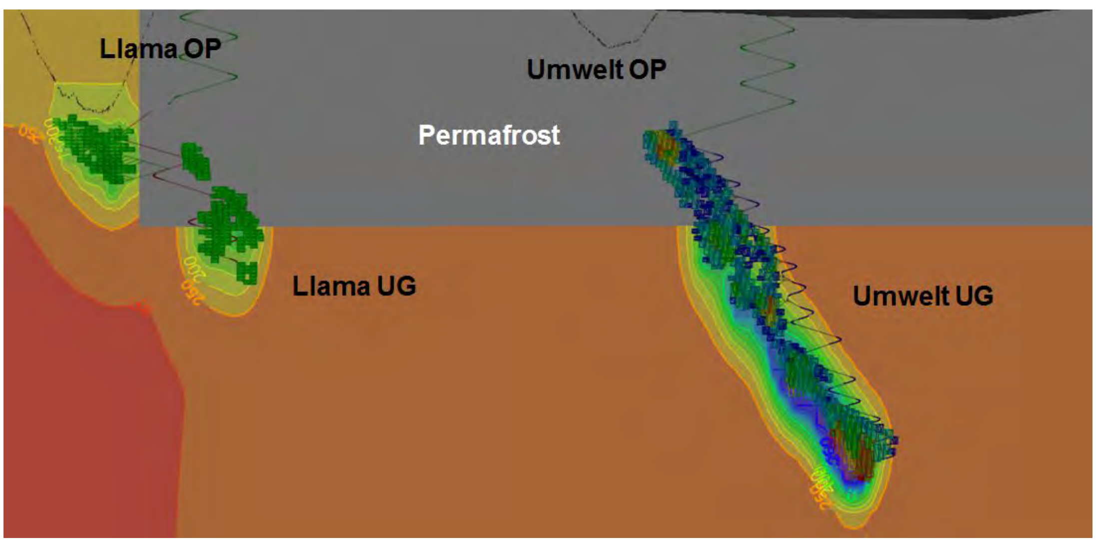
Hydrogeological Characterization and Modeling of the Proposed Back River Project

Prepared for

Sabina Gold & Silver Corporation



Prepared by

SRK Consulting (Canada) Inc.
1CS020.008
October 2015

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Executive Summary

The Back River Project (the Project) is a proposed open pit and underground gold mining project located 80 km south of Bathurst Inlet in the West Kitikmeot region of Nunavut. Mining will be completed using both open pit and underground methods at the Goose Property, which includes four main deposits: Umwelt, Llama, Goose Main, and Echo.

The Property is located in the continuous permafrost region of Canada. Although permafrost is pervasive and may extend to depths in excess of 400 metres below ground surface (mbgs), some of the underground mines will extend below the permafrost. Furthermore, both open pit and underground mining will occur underneath, or in close proximity to, large lakes associated with bodies of unfrozen ground which occur in permafrost areas due to local anomalies in thermal, hydrological, hydrogeological, or hydrochemical conditions, known as taliks. As a result, groundwater inflows to the mines are expected.

SRK Consulting (Canada) Inc. (SRK) reviewed all of the available local historic baseline data as well as regional data that supported the characterization of the hydrogeological regime. SRK is confident that the local and regional data provides an adequate basis to characterize the groundwater flow system at the Property.

The Property is situated in the Canadian Shield, composed of Precambrian-aged metamorphic rock of sedimentary, volcanic, and plutonic origin. The rock quality of the rock mass units is classified as fair to good. The hydraulic conductivity (K) of the fractured rock is generally low with a geometric mean of $3x10^{-9}$ metres per second (m/s) and an arithmetic mean of $3x10^{-7}$ m/s, based on the testing conducted to date. The only discernible trend in K is an apparent decrease with increasing depth, and particularly below about 220 m depth; there is no obvious correlation with lithology or structural features (i.e. major faults that could act as a flow conduit or flow barrier in taliks and beneath the permafrost).

The groundwater sampled at the Property is estimated to be more saline than sea water, based on samples collected between 515 m and 622 m depth with total dissolved solids (TDS) content of 66,000 to 73,000 mg/L measured in two boreholes with calcium chloride and sodium chloride as the dominant salts and salinity increasing with depth. This chemistry and elevated salinity, increasing with depth, is commonly observed in permafrost environments. Concentrations of arsenic, boron, iron, and zinc are naturally enriched and noted to be above the CCME (2013) guidelines for the protection of freshwater aquatic life.

The distribution of permafrost is well constrained by available data (e.g. ground temperature measurements from thermistors, piezometric pressure from vibrating wire piezometers, lake bathymetry, and groundwater salinity) and suggest that the -2°C temperature isotherm should be used to delineate the base of the permafrost. The -2°C isotherm depth is estimated to be about 320 to 350 mbgs (-30 metres above sea level (masl) to -60 masl). The locations of potential open (through) taliks, or unfrozen zones which extend fully through the permafrost and usually associated with surface water bodies, was mapped for the Project area. Lakes are expected to support an open talik if they are deeper than 1.3 m and with a smaller width dimension greater than 200 m. However, these analyses do not account for transient conditions (i.e. if a talik is

degrading, developing or in equilibrium) that can impact talik configuration, thermal influence of adjacent lakes, spatial variability in ground surface temperature, or complex water bathymetry.

While much of the proposed mining area will be frozen, some pits and underground areas will encounter unfrozen ground. Analyses suggest unfrozen conditions could occur where the Llama open pit mine intercepts the Llama Lake and the open talik associated with this lake. Portions of the Umwelt, Llama, and Goose Main underground mines are also expected to be within unfrozen zones at depth.

A three-dimensional numerical groundwater model was developed to estimate the quantity and quality of groundwater flow into the mine workings at the Goose Property. The model simulates the progressive excavation of the open pit and underground mines according to the mine plan. When a mine is in contact with areas of unfrozen pore water, groundwater flow and its dissolved constituents, report to the mine water management system. The lakes estimated to support open taliks represent natural entry or exit points of groundwater (i.e. recharge or discharge areas); their elevation and their spatial distribution define the regional direction of flow.

The numerical model incorporates assumptions based on available data. The base of the permafrost is simplified and represented as a -30 masl horizontal surface, which corresponds to the maximum elevation of permafrost based on -2°C isotherm assumption, with open talik zones extending from this horizon up through to surface. The bedrock is simulated as an equivalent porous media and K progressively decreasing with increasing depth. The use of a fracture network model was not justified for a model of this scale and scope. No faults were included in this model because there currently has been no significant relationship established between K and the presence of geologic structures. In terms of salinity, a vertical profile was assigned to the groundwater with a Total Dissolved Solids (TDS) increasing with depth, based on local and regional groundwater quality data.

The model predicts the yearly average inflows and TDS levels of groundwater reporting to the Llama open pit mine, as well as Llama, Umwelt, and Goose Main underground mines. Results from the numerical groundwater model indicate that total groundwater inflows requiring management for the Goose Property will reach a peak of about 830 m^3/day in Year 3 of Operations. More than half of the mine inflows are predicted to come from Umwelt underground, with very minor inflows predicted to occur at Goose Main underground. These will be supplemented by meltwater and surface runoff at the Llama open pit. Actual groundwater pumped volumes may be somewhat less, due to the effects of turbulent flow losses in small-aperture fractures adjacent to the mine workings, the removal of some inflow water through evaporation, and removal with waste rock and ore.

At the end of mining, maximum estimated groundwater TDS concentrations at the Umwelt underground are expected to be 60,200 mg/L. Estimated TDS concentrations for other parts of the Goose Property are lower; 22,350 mg/L at the Llama underground, 12,000 mg/L at the Llama open pit, and 34,360 mg/L at the Goose Main underground. Groundwater is anticipated to be calcium-sodium-chloride-dominant. Peak salt loading is expected to occur in Year 5, with an estimated yearly average of 35 tonnes of salt per day. The great majority of salt loading is estimated to come from Umwelt underground.

These estimates are all subject to a degree of uncertainty, and represent best estimates only. Sensitivity analyses show inflows are sensitive to assumptions for K, faults and permafrost; inflow quality is sensitive to the assumed baseline TDS profile with depth. The salt loading will be reducing according to the amount of water removed with waste rock and ore.

However, based on a regional review of mine inflows, these estimates appear to be reasonable, barring the existence of significantly permeable structures that, as yet, remain undetected. This information serves as input to the site wide water and load balance model to support the Final Environmental Impact Statement (FEIS) for the Project. The site wide water and load balance model is documented in SRK report “Water and Load Balance of the Back River Property” (2015a).

Table of Contents

List of Figures

List of Tables

Appendices

1 Introduction

1.1 Background

The Back River Project (the Project) is a proposed open pit and underground gold mining project located 160 km south of Bathurst Inlet in the West Kitikmeot region of Nunavut, approximately 520 km northeast of Yellowknife (Figure 1). The Project is located in the continuous permafrost region of Canada, in an area where permafrost typically extends to depths of 400 to 500 metres below ground surface (mbgs).

Mine development is proposed at the Goose Property. Mining will consist of multiple concurrent open pit and underground mines. Although permafrost is pervasive, some of the underground mines will extend below the base of the permafrost. Furthermore, both open pit and underground mining will occur underneath or in close proximity to an open, or through, talik associated with a large lake. As a result, groundwater inflows to the mines are expected.

Water quality sampling has confirmed that the groundwater quality is high in Total Dissolved Solids (TDS) and as a result direct discharge to the environment is unlikely, requiring a rigorous groundwater and/or surface water management plan.

This report presents the results of hydrogeological modeling completed by SRK Consulting (Canada) Inc. (SRK) to estimate the potential quantity and quality of groundwater flow into mining areas during active mining. This information serves as input to the site-wide water and load balance model to support the Final Environmental Impact Statement (FEIS) for the Project. The site wide water and load balance model is documented in SRK report “Water and Load Balance of the Back River Property” (2015a).

1.2 Scope of Work

Although it is generally understood that groundwater flow does not occur in permafrost, the presence of taliks, that usually lie underneath lakes and rivers which do not completely freeze in winter, and where groundwater is unfrozen and flow can occur, makes for challenging hydrogeological analysis. Baseline hydrogeological characterization has been carried out at the Project; however, to allow for a complete understanding of the hydrogeological regime, further interpretation and extrapolation of the available data was required. This report documents the methodology and ultimate outcome of this further analysis, which included rigorous thermal analysis to help define the extent of permafrost and the presence and extent of lake taliks where groundwater flow may be expected.

A conceptual model for groundwater flow on the Goose Property is presented and was used to develop a numerical model that allows for estimation of groundwater flow and quality conditions both during Operation and Post-Closure periods. This report focuses on the Operations period. The results of these simulations are presented in a way that provides information for design of suitable mine dewatering systems, and for use in the site wide water and load balance.

1.3 Report Layout

Section 2 of this report lists all of the site characterization studies relevant to groundwater that have been carried out at the Project site and provides the framework for understanding the hydrogeological regime. Section 3 describes the proposed mine plan. The evaluation of the site-specific hydrogeological regime is presented in Section 4. This includes in-depth evaluation of the available data coupled with comparisons to regional groundwater quality. The conceptual model is described in Section 5. The methodology used to construct, calibrate and run simulations with, the groundwater numerical model, the choice of numerical code, and the model setup is defined in Section 6. The results of the numerical modeling are presented in Section 7.

2 Baseline and Field Investigation Data Sources

SRK has reviewed all of the historic baseline data that supported the characterization of the hydrogeological regime. The following sections provide a summary of the documents reviewed by SRK and used for building the hydrogeological conceptual model. The site monitoring location maps compiled by Knight Piésold Ltd. have been included in Appendix A to help the reader identify monitoring locations referred to in this document.

In 1995, 2003, and 2005, reviews and analyses of the structural geology were conducted. The analyses included geological mapping, outcrop examination, compilation, re-interpretation of existing data (i.e. geophysical and mapped surface geological data, past reports, and memos), and structural analysis of core.

Baseline studies have been carried out since 2008. In 2008, hydrology and meteorology baseline data collection was initiated on a limited scale at the Property. No baseline studies were conducted in 2009, with the exception of the continued operation of the meteorology station located near the existing Goose exploration camp. Comprehensive environmental baseline studies were carried out between 2010 and 2015. During this period, the studies that supported understanding of the groundwater system included structural geology, hydrology, meteorology, lake and pond bathymetry, hydraulic testing of bedrock, installations of thermistors, installation of a multilevel groundwater (Westbay) monitoring well, and sampling for groundwater quality. All of these studies are described in detail in the documents listed below:

- Peter D Lewis, Structural Evaluation: Goose Lake Property, March 1995.
- W.A. Barclay, Structural Analysis of Selected Drill Core (DDH 02G0-29 & 02G0-30) from the Goose Lake Deposit, Nunavut, including Reviews of Previous Petrographic and Structural Studies, Jan. 10, 2003.
- RGS, Structural Geological Assessment of the Back River Project, Nunavut, Northern Canada, August 2005.
- Rescan, The Back River Project – Draft Environmental Impact Statement, Prepared for Sabina Gold and Silver Corporation, December 2013.
  - Main Report, Vol. 5: Terrestrial Environment.
  - Main Report, Vol. 6: Freshwater Environment.
  - Appendix V4-3A: 2006 to 2012 Meteorological Baseline Report.
  - Appendix V4-3B: Climate Change Prediction – Model Variation.
  - Appendix V5-2A: 2010 Thermistor Data Summary (Goose property) Memorandum Report.
  - Appendix V5-2B: 2012 Thermistor Data Summary (goose property) Memorandum Report.

- Appendix V5-2C: 2012-2013 Thermistor String Records Obtained at the Hackett River Project.
- Appendix V6-2A: Analytical Results of the Umwelt Westbay Groundwater Sampling Program.
- Appendix V6-2B: Completion Report, Westbay System Monitoring Well: 13-GSE-319.
- Appendix V6-2C: 2012 Geotechnical and Hydrogeological Drilling Program Factual Data Report.
- Appendix V6-2D: 2013 Geomechanical and Hydrogeological Site Investigation.
- Appendix V6-3D: Back River Project: Bathymetric Surveys of Lakes in the Goose and George Property Areas.

- Knight Piésold Ltd. Re: Back River: Groundwater Mine Inflow Estimates. Letter October 8, 2013.
- Knight Piésold Ltd. Back River 2013 Geotechnical Site Investigation Program Summary. Prepared for Sabina Gold & Silver Corporation. November 2013.
- Rescan, Back River Project, Sub-permafrost Groundwater Quality Baseline Report. February 2014, November 2014 and June 2015.
- Rescan. Back River Project: Cumulative Permafrost Baseline Data Report (2007 to May 2014). June 2014.

Other relevant regional baseline data have also been collected over the past ten years through the various proposed mineral development and infrastructure projects. Such projects include the Doris North project, the Hackett River project, the High Lake project, the Kiggavik project, the Lupin project, the Meadowbank Gold project, and the Meliadine project. Data from these regional studies (i.e. permafrost extent and depths, groundwater quality and flow) are also relevant to the Property.

SRK is confident that local data combined with regional data provides an adequate basis to characterize the groundwater flow system at the Goose Property. However, uncertainty will always exist at the local scale. Groundwater data are difficult to collect in areas of continuous permafrost; therefore, the database remains limited. SRK cannot rule out potential influences to groundwater flow from unidentified localized networks of fractures and regional high flow conduits or low flow barriers (e.g. major faults, diabase dykes). The existing database provides a good constraint on overall spatial distribution of permafrost, but local variations in groundwater quality could cause some heterogeneity; furthermore, the transience in the thermal regime of taliks beneath lakes (i.e. if a talik is degrading, developing, or in equilibrium) cannot be estimated.

3 Mine Plan

The Goose Property includes four main deposits that contain predominantly structurally-controlled gold mineralization: Umwelt, Llama, Goose Main, and Echo (Figure 2).

The mine plan consists of four open pits and four underground mine operations:

- The four proposed open pit mines include Umwelt, Llama, Goose Main, and Echo pits. Open pit mining will be carried out by conventional truck/shovel methods. The pit development is planned to a maximum depth of about 150 m, which is equivalent to a minimum elevation of pit development at 130 metres above sea level (masl).
- The four underground mines include Umwelt, Llama, Goose Main and Echo undergrounds. At Umwelt, underground mine operations will be carried out by post pillar cut and fill (i.e. a selective mining method where orebody extraction progresses up-dip in alternating cutting and filling cycles). Llama and Goose Main will be mined by drift and fill. Longhole stoping will be used at Echo. The underground development is planned to a maximum depth of about 650 m, which is equivalent to a minimum elevation of underground development at -355 masl.

The mining schedule is defined as Construction in Years -2 and -1, and Operations in Years 1 to 10. Mining will begin with open pits. The open pit mining is supplemented by underground mining production at Llama, starting in Year 1, Umwelt, in Year 2, Goose Main in Year 5, and Echo in Year 6.

The footprint of the Llama open pit mine overlies Llama Lake. Llama Lake will be dewatered prior to mining operations in order to isolate the mine workings from direct interaction with the lake.

4 Hydrogeological Conditions

4.1 Geology

The Property is situated in the central-eastern portion of the Slave Structural Province of Nunavut Territory and forms part of the Canadian Shield. The Slave Geologic Province is predominantly comprised of metamorphosed 2.73 to 2.63 Ga greenstone and turbidite sequences and 2.72 to 2.58 Ga plutonic rocks underlain by older gneiss and granitoids. Volcanic-turbidite series rocks are widespread and consist of large areas of turbidites flanked by narrow volcanic belts. Iron formations are locally abundant in the volcanic-turbidite series and host most of the stratabound gold deposits.

The Goose Property geology is shown in Figure 3. The general topography of the area consists largely of rolling lowland plains shaped by thick ice sheets during the Pleistocene glaciation. Elevation ranges between 270 and 350 masl. The Goose Property is underlain by folded Beechey Lake turbiditic meta-sediments, including subordinate oxide and silicate banded iron formation. This sequence is cut by felsic and gabbroic dykes. From oldest to youngest, the sequence is composed of lower greywacke, lower iron formation, middle mudstone, upper iron formation, and upper sediments. At the Goose Property, gold mineralization tends to be hosted in the lower greywacke; at the Goose Main Deposit, mineralization is also associated with the lower iron formation unit.

Overburden materials are characteristic of a post-glacial environment. Morainal sediments are dominant, covering nearly half the landscape. Other sediments commonly found include glaciofluvial, organic, and marine sediments (primarily in proximity to Bathurst Inlet). Overburden thicknesses vary from 1 m (e.g., outcropping weathered bedrock in highlands) to 37 m, and are generally thicker at topographic lows.

4.2 Structural Geology

Gold mineralization is mainly located along shear zones associated with tightly folded and structurally complex banded iron formation horizons that provide favourable chemical and structural traps. The folding generally trends to the northwest and Table 1 summarizes information on the Goose Property mineralization. The Goose Main, Umwelt, and Llama deposits are associated with anticlinal structures that have been structurally thickened and disrupted, and cut by axial planar felsic dykes, which apparently trace the fluid pathways and are related to mineralization. The Echo deposit is associated with gentle folding cross cut by a planer felsic dyke; mineralization is spatially associated with the felsic dyke.

Table 1: Goose Property Mineralization Summary by Deposit (Tetra Tech, 2013e)

Deposit	Folded	Trend of Fold Axes (º)	Plunge of Fold Axes (º)	Dip of Fold Axial Plane (º)	Dip	Strike Length (m)	Average Length Down Dip(m)	Mean True Thickness (m)
Goose Main	Yes	105	15	70	W	650	480	15
Llama	Yes	145	20	75	E	1,080	220	12
Umwelt	Yes	135	26	50	E	1,530	240	15

In general, the rock quality of the various rock mass units is classified as fair to good. Zones within the mudstone unit and major structures, such as faults and shears, have reduced rock quality that ranges from poor to fair. Evidence of faulting has been observed. Two main fault orientations have been identified, a) sub-parallel to the ore bodies (northwest-southeast to north-south) and steeply dipping, and b) perpendicular to the ore bodies (northeast-southwest) and steeply dipping. At Goose Main, faulting has offset the limbs of the anticline. Brittle structures (e.g., faults) have also been identified through core and air photo interpretation, striking to the north and northwest, and associated with the folding (2013a, Appendix V6-2C). Brittle structures tend to dip steeply, at 50° from horizontal to near-vertical.

Structural features in the bedrock, such as the northwest-southeast trending faults commonly found at the Goose Property, could act as preferential groundwater flow pathways and/or as a barrier to flow in taliks and beneath the permafrost. The current data does not allow concluding which faults could be conduits or barriers, if either.

4.3 Hydraulic Properties of the Fractured Rock

The hydraulic conductivity (K) values for the unfrozen ground are based on field values collected from packer-based hydraulic tests and slug tests in the Westbay multilevel monitoring well by SRK in 2012 and 2015 (Rescan 2013a, SRK 2015b), Knight Piésold in 2013 (2013c), and Rescan in 2015 (2015c). The dataset includes 72 successful tests in 47 drillholes.

On average, K values are generally low, ranging between $1x10^{-11}$ and $6x10^{-6}$ m/s, with a geometric mean of $3x10^{-9}$ m/s and arithmetic mean[1] of $3.3x10^{-7}$ m/s, and highly variable, ranging over four orders of magnitude for elevations above about 170 masl and three orders of magnitude below 170 masl. Based on the data collected, the spatial distribution of K values does not show any particular pattern and there is no obvious correlation with lithology. Figure 4 illustrates the K distribution per lithology. The only discernible trend is the progressive decrease in K with increasing depth. This is a reasonable relationship considering that fractures tend to close with depths. This relationship has been observed at many mine sites in northern Canada (i.e. Kiggavik and Hope Bay).

[1] The choice of either geometric mean or arithmetic mean to represent the appropriate “average” K depends largely on the nature of the rock type – geometric mean values are frequently used for rock without preferred layering (bedding, gneissosity or schistosity), or where these are highly variable (Beale and Read, 2014e). It is also subject to the orientation of the drill hole or well tested.

Figure 5 illustrates the K distribution as a function of elevation. For the groundwater modeling, the purple line represents the relationship assumed for the “base case” scenario. Frozen ground is assumed to be completely impermeable.

Currently there has been no relationship established between K and lithology. Between the 150 and 250 masl elevation range, drillholes 12GSE206, 13GSE279, and 13GSE261B report higher K values (around $1x10^{-8}$ m/s) compared to other tests at the same depths. The presence of a fault in 12GSE206 likely explains the higher K. Structural and geotechnical data do not clarify the cause for the other drillholes. While only one structure has been identified to promote high K, the presence of such features cannot be completely ruled out and it is recognized that the K dataset is relatively limited for a site of this scale and geologic complexity.

Bedrock storativity (or specific storage) and specific yield are parameters that influence the depressurization and drainability of rock, respectively. There are no-site specific measurements of these parameters. A storativity value of $1x10^{-4}$ m^{-1} and a specific yield value of 0.001 are assumed based on scientific literature (B.B.S Singhal, R.P.Gupta, 2010) and on regional experience.

The potential for a connection between a shallow aquifer in the overburden units and the deeper bedrock groundwater system will be localized to taliks associated with lakes. Away from lakes, permafrost exists at relatively shallow depths and acts as a barrier between these shallow depths and the deeper groundwater system; shallow aquifers are also usually poorly developed in these areas. The infiltration of water from lakes to the deeper groundwater system will be affected by the hydraulic properties of sediments found on the lake bottom. Finer grained materials (e.g., clay) will have a lower hydraulic conductivity than coarse grained materials (e.g., sand), and thus allow less infiltration. The percentage of clay and silt in these lake bottom sediments will have a significant effect on hydraulic conductivity. Layered lake bottom sediments will have a lower vertical hydraulic conductivity (K_v) than horizontal hydraulic conductivity (K_h), further impeding downward flow.

A summary of grain size analyses from lake bottom sediments is provided in the FEIS (2013a, Volume 6, Section 5.1). For the 130 Goose Property samples, average clay content is 9.0%. A K value of $1x10^{-8}$ m/s is assumed for these materials based on testing of similar materials at Hope Bay.

4.4 Groundwater Quality

4.4.1 Regional Sub-Permafrost Groundwater Quality Data

Rescan (2014a, Section 2.4) compiled the published groundwater quality data collected in deep and sub-permafrost areas in Canada’s North since the 1980’s. The dataset includes samples from several mine sites across Canada, e.g. Kiggavik, Meliadine, and Lupin. SRK added data from the Doris Central Deposit at Hope Bay. The distribution of TDS concentrations with depth in Figure 6 shows that brackish to hypersaline water is commonly observed in permafrost environments and salinity (TDS) generally increases with depth. Concentrations on the scale of tens of grams per litre have been measured at depths of 500 mbgs, beneath continuous permafrost.

Calcium and chloride tend to dominate as the major ions at depth, together with elevated concentrations of sodium, bromide, and magnesium. Sulphate and bicarbonate concentrations are not elevated with respect to near-surface conditions. Sodium is often a dominant cation at shallower depths.

4.4.2 Back River Sub-Permafrost Groundwater Quality Data

Sub-permafrost groundwater quality data at the Project was acquired using a Westbay groundwater multilevel monitoring system, which was installed adjacent to the Umwelt deposit at the Goose Property. The Westbay well (13-GSE-319) is 782 m long (748 m deep) which includes five sampling zones located at depths ranging from 515 to 669 mbgs. Westbay Zones 3 and 5 (respectively 622 and 515 mbgs) were purged and sampled. Detailed descriptions of methods and results pertaining to design, installation, purging, and sampling of the Westbay system are provided in the three Rescan reports, “Back River Project - Sub-permafrost Groundwater Quality Baseline Report” dated February 2014 (2014a), November 2014 (2014c), and June 2015 (2015c).

The interpretation of the groundwater quality results from the Westbay well was confounded because the drill hole was completed in an area of thick permafrost, requiring the use of a concentrated calcium chloride drilling brine to avoid freezing during drilling. Final samples collected in 2013 from Zones 3 and 5 were estimated to contain 90% in-situ groundwater and 10% drilling brine (Rescan, 2014a). In the 2014 samples, concentrations of lithium, potassium, chloride, calcium, and bromide increased, indicating a rebound in the proportion of drilling brine in the samples. Rescan estimated that the proportion of drilling brine was 30% in Zone 3 and 50% in Zone 5. The 2015 samples indicated the proportion of drilling brine remained at 30% in Zone 3, and slightly increased to 55% in in Zone 5. SRK’s evaluation of the available data indicates that this estimate is likely slightly high but reasonable. Because the 2014 and 2015 samples reported more drilling brine than in 2013 and as a result carried more uncertainty about unimpacted groundwater quality, SRK used the 2013 data (Rescan, 2014a) to characterize the baseline groundwater quality and for the purpose of the site wide water and load balance model. Using the 2013 samples is also conservative because a lower proportion of drilling brine in the sample means that unimpacted groundwater has higher TDS.

The sampled groundwater is estimated to be more saline than sea water (TDS of 66,000 to 76,000 mg/L) with calcium chloride and sodium chloride as the dominant salts, and salinity increasing with depth. The estimated salinities are similar to those reported for other sites situated in continuous permafrost environments (e.g. Meliadine and Hope Bay). Estimated concentrations of arsenic (0.010 to 0.026 mg/L), boron (3 to 4 mg/L), iron (1.1 to 8 mg/L), and zinc (0.30 to 0.76 mg/L) are noted due to their naturally enriched concentrations relative to CCME (2013) guidelines for the protection of freshwater aquatic life (2014a).

SRK compared the chemical signature of the groundwater corrected for 10% drilling brine (from 2013) to drilling brine, typical sea water, and samples from other sites located in permafrost environments. The samples from others sites included publically available data for the Miramar

Con Mine near Yellowknife monitored between 1980 and 1996 at all underground sites with significant groundwater flow (Kuchling, Chorley, Zawadzki, 2000a) and data from Hope Bay in Nunavut. The water quality data are plotted as Figure 7, Figure 8, and Figure 9. The data from the Con Mine demonstrates that the Property's hydrogeochemistry is consistent with other calcium-chloride brines in the Canadian Shield. The drilling brine and seawater are chemically distinct.

Table 2 provides the groundwater quality results at the Property.

Table 2: Estimated Groundwater Quality Parameters from the Umwelt Westbay Sub-permafrost Monitoring System (Rescan, 2014a)

Analyte [D]	Unit	CCME FWAL Guideline [P]	Sample Zone 3 620 mbgs		Sample Zone 5 515 mbgs	
			Raw Data (2013)	Corrected for 10% Brine	Raw Data (2013)	Corrected for 10% Brine
pH	-	6.5 - 9.0	6.92	-	8.01	-
Total Dissolved Solids	mg/L	-	82,900	76,611	73,400	66,056
Hardness	mg/L as $CaCO_3$	-	52,400	45,167	51,900	44,611
Anions and Nutrients						
Total Alkalinity [B]	mg/L as $CaCo_3$	-	10.7	12	16.2	20
Ammonia - Total	mg/L as N	0.017 – 190 [S]	0.477	0.137	0.591	0.264
Bromide	mg/L	-	584	523	618	561
Chloride	mg/L	120	50,300	46,439	45,400	40,994
Fluoride	mg/L	0.12 [F]	0.70	0.64	0.57	0.50
Nitrate	mg/L	13	<0.5	<0.5	<0.5	<0.5
Nitrite	mg/L	0.06	<0.1 [N]	<0.1 [N]	<0.1 [N]	<0.1 [N]
Orthophosphate - Dissolved	mg/L as P	-	0.041	0.042	0.077	0.082
Phosphorus - Total	-	-	0.176	0.187	0.237	0.255
Sulfate	mg/L	-	<50	<50	<50	<50
Major Cations and Dissolved Metals						
Aluminum	mg/L	0.1 [G]	<0.1	0.08	<0.1	0.08
Antimony	mg/L	-	<0.005	<0.005	<0.005	<0.005
Arsenic	mg/L	0.005	0.0075	0.0069	0.0080	0.0074
Barium	mg/L	-	8.68	9.37	2.82	2.86
Beryllium	mg/L	-	<0.005	<0.005	<0.005	<0.005
Bismuth	mg/L	-	<0.05	<0.05	<0.05	<0.05
Boron	mg/L	1.5	4.08	3.26	5.30	4.62
Cadmium	mg/L	Zone 3 = 0.007 Zone 5 = 0.005 [H]	<0.001	<0.001	<0.001	<0.001
Calcium	mg/L	-	19,300	16,222	19,500	16,444
Chromium	mg/L	0.001 to 0.0089 [J]	<0.01 [N]	0.0062	<0.01 [N]	0.0062
Cobalt	mg/L	-	<0.01	<0.01	<0.01	<0.01
Copper	mg/L	Zone 3 = 2.3 ; Zone 5 = 1.9 [K]	<0.02	0.008	<0.02	0.008
Iron	mg/L	0.3	6.16	6.73	0.89	0.88
Lead	mg/L	Zone 3 = 8 ; Zone 5 = 6 [L]	<0.005	<0.005	<0.005	<0.005
Lithium	mg/L	-	8.09	5.0	11.8	9.1
Magnesium	mg/L	-	1,040	1,151	801	885
Manganese	mg/L	-	3.24	3.54	2.03	2.19
Mercury	mg/L	-	<0.00001	<0.00001	<0.00001	<0.00001
Molybdenum	mg/L	0.073	0.056	0.025	0.0873	0.060
Nickel	mg/L	Zone 3 = 10 ; Zone 5 = 9 [M]	0.011	0.011	0.011	0.011
Potassium	mg/L	-	370	202	446	287
Selenium	mg/L	0.001	<0.01 [N]	<0.01 [N]	<0.01 [N]	<0.01 [N]
Silicon	mg/L	-	<1	<1	<1	<1
Silver	mg/L	0.0001	<0.001 [N]	<0.001 [N]	<0.001 [N]	<0.001 [N]
Sodium	mg/L	-	7,180	7,870	5,200	5,670
Strontium	mg/L	-	399	360	338	292
Thallium	mg/L	0.0008	<0.005 [N]	<0.005 [N]	<0.005 [N]	<0.005 [N]
Tin	mg/L	-	<0.01	<0.01	<0.01	<0.01
Titanium	mg/L	-	<0.20	<0.20	<0.20	<0.2
Uranium	mg/L	0.015	<0.001	<0.001	<0.001	<0.001
Vanadium	mg/L	-	<0.05	<0.05	<0.05	<0.05
Zinc	mg/L	0.03	0.35	0.37	0.24	0.24

Notes:
A Indexing parameters used to estimate groundwater concentrations from samples containing residual drilling brine.
B Determined from field titration measurements.
C Determined from field measurements using calibrated electronic probe.
D Values determined based on laboratory tests (methods and results documented in Appendix V6-2C) unless specified otherwise.
E Laboratory analysis indicated concentration below detection limit for sample with lowest drilling fluid proportion.
F Interim Guideline.
G Aluminum guideline concentration 0.005 mg/L if pH < 6.5 and 0.10 mg/L if pH > 6.5.
H Cadmium guideline 100.86[log10(hardness)]-3.2 µg/L.
J Chromium Hexavalent 0.001 mg/L and Chromium Trivalent 0.0089 mg/L.
K Copper guideline concentration = $e^{0.8545[\ln(hardness)]-1.465 * 0.2}$ µg/L.
L Lead guideline concentration = $e^{1.273[\ln(hardness)]-4.705}$ µg/L.
M Nickel guideline concentration = $e^{0.76[\ln(hardness)]+1.06}$ µg/L.
N Detection limits exceeds CCME guideline.
P Published in CCME 2013 as guidelines for the protection of freshwater aquatic life. Guidelines for all metals except aluminium and iron are intended for total concentrations.
Q Range is within precision of estimate.
R Calculated lower limit of range is a negative concentration: rounded to zero.
S Total ammonia guideline pH and temperature dependent.

4.5 Permafrost Extent

The Property is situated within the zone of continuous permafrost, as delineated in a database compiled by the Geological Survey of Canada (NRCan, 2002).

Based on site ground temperature, a geothermal gradient of 0.013 to 0.014°C/m has been observed in the deeper extents of the permafrost and at depths up to 700 mbgs, equivalent to -400 masl. The basal depth of the permafrost, assuming a 0°C isotherm, and without consideration of groundwater TDS, would be estimated to range from -190 to -260 masl, which is approximately 490 to 570 mbgs (2013a).

4.5.1 Freezing Point Depression

Freezing point depression is a phenomenon by which water in porous materials does not freeze at 0°C. There are two main mechanisms that contribute to lowering the freezing point below zero. First, capillary forces in porous material develop surface tensions between water, ice, and soil particles and this tension must be overcome by reducing the temperature in order to change phase. Secondly, dissolved ions in the pore-water, such as the addition of salts, can also reduce the freezing point.

At the Project, the influence of capillary forces within the fractured rock has not been studied; however, the water quality data collected at the Goose Property indicate the presence of saline connate water. To refine the estimation of the freezing point temperature at the site, SRK looked at both local and regional data.

The site groundwater quality samples collected from the Westbay well serves as the primary basis for estimating the freezing point temperature at depth. The results of the groundwater quality are provided in Section 4.4. SRK corrected the measured concentrations of the main cations and anions to address the influence of drilling brine still present in the groundwater samples.

The water quality results show that over 90% of the TDS is due to dissolved calcium, sodium, and chloride (92% for Zone 3, and 95% for Zone 5). It is therefore reasonable to estimate a freezing point temperature based on properties of a $CaCl_2$ or NaCl aqueous solution that has the same concentrations as measured at the Property. Properties for aqueous solutions of various types and mass weight are available in the CRC handbook of Chemistry and Physics (Haynes, 2012b). The analysis concluded that the anticipated freezing point temperature was approximately -4.4°C for Zone 3 (using 7.1% by weight TDS for a solution of NaCl), and approximately -3.7°C for Zone 5 (6.2% by weight TDS for a solution of NaCl). The freezing point temperatures derived from $CaCl_2$ solution (-2.9 and -3.6°C, respectively) were less conservative than for NaCl.

The estimated freezing temperature however cannot apply to the full depth profile because TDS is anticipated to vary with depth. TDS in the deep fractured rock is not homogeneous and generally observed to increase with depth. This is shown in Figure 6 which compiles TDS data published by Frape and Fritz (1987) as well as other mining projects located in the Canadian North (Diavik, Hope Bay, Lupin, Meadowbank, and Meliadine). To account for TDS variations, SRK developed a relationship that correlates the estimated freezing point temperature for the Project's groundwater samples and the estimated vertical TDS profile. The Property's TDS vertical profile was defined by the slope of Frape and Fritz (1987) profile and by the Back River water quality data, both shown on Figure 6. The final relationship between the freezing point temperature and depth is shown in Figure 10. The curve shows how TDS concentrations may influence the distribution of freezing temperature points with depths. It also suggests that it is not appropriate to use the 0ºC isotherm to determine the basal depth of the cryopeg (i.e. the basal portion of the permafrost, in which freezing is prevented by freezing-point depression due to the dissolved-solids content of the pore water). Ground temperature data are needed to support a conclusion on what freezing temperature should be used to define the basal cryopeg.

The data from within the Westbay well and from certain vibrating wire piezometers (VWP) are useful in that regard. At the Goose Property, the VWPs in drill holes 13-GESE-284 and 13-GSE-288 reported piezometric levels above the ground surface (Rescan, 2013a). Knight Piésold (2013a, Appendix V6-2D) interpreted these data as a build-up of pressure indicating that the sensors had frozen and that the VWPs were installed in permafrost, an interpretation which was also supported by temperature profiles from the thermistors. SRK reviewed the VWP data downloaded in 2014 and confirmed that the measurements in 2014 were consistent with the initial Knight Piésold interpretations.

It is concluded from Figure 10 that the -2°C isotherm may more accurately delineate the limit of frozen ground due to the presence of dissolved solids. The depth of the -2°C isotherm is estimated to be about 320 to 350 mbgs, which corresponds to an elevation of -30 masl to -60 masl respectively.

4.5.2 Lake Taliks

By definition, a talik is “a layer or body of unfrozen ground occurring in a permafrost area due to local anomalies in thermal, hydrological, hydrogeological or hydrochemical conditions”. Lakes or other waterbodies cause local departure in terrestrial ground temperature as a result of surface climate and microclimatic effects. The mean water bottom temperature, lake half-width (or radius), and the surrounding terrestrial ground thermal regime are key variables that influence talik configuration and extent.

In this report, references are made to both closed and open taliks; a closed talik is an unfrozen zone beneath a water body that is enclosed at the base and the surrounding sides by permafrost; and an open talik is an unfrozen zone beneath a water body that penetrates the permafrost completely and may connect suprapermafrost (i.e. the layer of ground above permafrost) and subpermafrost (i.e. the non-frozen ground below the permafrost) groundwater.

Mapping of Potential Open Taliks

The locations of open taliks are important for understanding groundwater flow processes. For modeling purposes, to avoid the potential influence of boundary conditions, SRK mapped the potential locations of open taliks over an area about 4 km distance from any Project mine footprint. The methodology for identifying potential open taliks for areas included in the groundwater models is based on the site geothermal gradient, and the depth and shape of the water body because lakes must be sufficient in depth and size to create an insulating layer. The depth and shape criteria for identifying potential open taliks are given below.

Lake Depth Criteria:

Taliks can be expected below lakes with depths greater than two-thirds of the maximum thickness of ice forming annually on their surface (Mackay 1992). At the Property, maximum waterbody ice depths are typically 2 m thick. It is therefore assumed that open talik can occur for lakes with depths greater than 1.3 m (Rescan, 2013a). Shallow waterbodies (< 1.5 m) freeze to the bottom (Rescan, 2013a).

Lake Shape Criteria:

Thermal models documented by Mackay (1962), Smith (1976), and Burn (2002a) were developed for use at study sites in the Canadian Arctic and have been used for talik characterization at other proposed mine projects located in the continuous permafrost region of mainland Nunavut, including the Meliadine (Golder, 2013d), Kiggavik (Areva, 2011a), High Lake (Wolfden, 2006), Doris North (SRK, 2005c), and Meadowbank (Cumberland, 2005b) projects. Using these thermal models with data collected at the Property, Rescan (2013a) interpreted that:

- Round ponds and lakes with widths up to 175 m (e.g., Echo Lake, Lytle Lake) are interpreted to overlie closed taliks up to 50 m deep.
- Elongated waterbodies with the smaller width dimensions up to 150 m (e.g., Gander Pond), round waterbodies with widths up to 120 m (e.g., Mam Lake), and those with extensive shallow terraces (e.g., Rabbit Lake) are interpreted to overlie closed taliks ranging 50 to 100 m deep.
- Larger lakes tend to have elongated shapes, and have been predicted to overlie open taliks where the smaller lake width dimension exceeds 200 m.

These criteria were further refined based on a -2ºC freezing temperature and conclusions from thermal modeling described in Section 4.5.2. The final mapping is shown in Figure 11. It must be noted that paleo-climate variability was not considered but could influence the distribution of open taliks. Lunardini (1995b) showed temperature at depths up to 600 mbgs can be influenced by the surface temperatures as far into the past as 100,000 years. Other influences, such as changes in water or ground temperature or lake geometry would induce transience in the thermal regime, were also not considered.

Thermal Modeling

Thermal modeling was carried out to refine the assessment of potential open taliks in areas where mining is planned, as well as to provide further definition regarding the differences between the 0°C and -2°C isotherms related to these taliks. Two modeling methods were used: an analytical steady-state thermal model based on conductive heat flow; and a two-dimensional (2D) finite element steady-state thermal model.

The 2D numerical modeling was carried out using the finite element code SVHeat version 6.0 (SoilVision Systems 2004). The model inputs are summarized in Table 3. The details of the analyses, analytical modeling results, and 2D finite element results are presented in Appendix B.

Table 3: Thermal Modeling Inputs to Assess the Presence of Taliks

Parameter	Value (Base Case)	Value (Sensitivity Analysis)
Mean annual ground surface temperature (MAGST)	-6°C	-5°C to -7°C
Mean annual lake-bottom temperature (Tb)	4.5°C	3.5°C to 5.5°C
Geothermal heat flux (G)	0.014°C m^{-1}	n/a
Water body half width (lake width divided by two)	5 to 150 m	n/a
Unfrozen greywacke thermal conductivity	346 kJ m^{-1} day^{-1} $°C^{-1}$	n/a
Frozen greywacke thermal conductivity	350 kJ m^{-1} day^{-1} $°C^{-1}$	n/a
Unfrozen greywacke volumetric heat capacity	2120 kJ m^{-3} $°C^{-1}$	n/a
Frozen greywacke volumetric heat capacity	2110 kJ m^{-3} $°C^{-1}$	n/a

Figure 12 and Figure 13 show the half-width thickness predictions for each isotherm. Modeling suggests that for base case conditions, an open talik based on the 0°C isotherm will develop for a water body with half-widths greater than 100 m. This reduces to 50 m for the -2°C isotherm. The finite element model showed a more conservative result, suggesting that a water body half width greater than 92 m may have an open talik developed for the 0°C isotherm. The sensitivity analysis also demonstrates that changing the MAGST by 1°C results in a change in the half width distance of about 30 m; changing the Tb by 1°C has less of an effect, with only a 10 m change of the half width. The model estimates do not account for the thermal influence of adjacent lakes, spatial variability in ground surface temperature, or complex water bathymetry.

The open taliks mapped in Figure 11 were defined based on the predicted 100 m half width for a 0°C isotherm. To be consistent with the previous conclusion to use a freezing point temperature of -2°C (Section 4.5.1), mapping could have used a half width of 50 m. SRK did not update the open talik maps because the influence of this assumption was deemed to have no impact on predictions of mine inflow and TDS load, as explained below:

- None of the small lakes (i.e. between 50 and 100 m half width) overlap or are close to a mining area; and
- Bathymetries of most small lakes are not known. Many of them are likely shallow, with depths less than 1.5 m, and therefore not likely to support open taliks.

4.6 Mine Interactions with Unfrozen Ground

The analyses of baseline ground temperatures, mapping of potential open taliks, and thermal modeling suggest frozen conditions exist for most of the pits, with an exception of where the Llama open pit mine intercepts Llama Lake. The thermal modeling, supported by baseline ground temperature data confirms that the Umwelt, Goose Main, and Echo open pits do not intercept taliks. The Llama open pit overlaps the footprint of Llama Lake, which is expected to have an open (through) talik.

The Umwelt, Llama, and Goose Main underground mines will intercept unfrozen bedrock at depth, but the Echo underground mine is completely within permafrost.

5 Hydrogeological Modeling Approach

5.1 Conceptual Groundwater Model

SRK reviewed the conceptual groundwater model completed by Rescan (Rescan 2013a) and deemed the approach reasonable and considered, and confirmed that no significant changes were justified for the purposes of this assessment. The conceptual model is summarized below and illustrated in Figure 14.

The permafrost is essentially impermeable. Two groundwater flow regimes are present in the unfrozen material (overburden or bedrock):

1. Shallow flows in the active layer and talik zones; and
2. Deep flows via open taliks beneath lakes of substantial size and depth.

The interception of shallow, active layer flow by the proposed pits is considered insignificant for this study because the active layer is not particularly thick (less than 2 m), unfrozen only during the summer months, pore water volumes are small, and the water quality is not saline. Furthermore, such flow could be diverted from the pit during operation using diversion structures if deemed necessary.

Where open taliks exist beneath lakes (e.g. Llama Lake), some minor groundwater flow is expected from higher elevation lakes towards lower elevation lakes and travel through fractured bedrock.

When a mine is in contact with areas of unfrozen pore water, groundwater flow and dissolved constituents report to the mine water management system. The lakes theorized to support open taliks represent natural entry or exit points of groundwater (i.e. recharge or discharge areas); their elevation and their spatial distribution define the regional direction of flow.

It is not well understood how lithology and geological structures influence the hydraulic properties of the regional groundwater system. Measurements and analyses to date have not identified correlations between lithological units and hydraulic conductivities. It is likely that structural features in the bedrock, if they exist, could induce preferential pathways (high flow conduit) and, together with dykes promote compartmentalisation (hydraulic barrier).

5.2 Numerical Groundwater Model

5.2.1 Software and Model Type

A three-dimensional numerical saturated groundwater model of the Property was completed using the modeling software FEFLOW v6.2 (P9) (DHI, July 2015). FEFLOW is a professional software package for modeling fluid flow and transport of dissolved constituents and/or heat transport processes in the subsurface. This program is used extensively for mining groundwater projects around the world.

The model is defined with flow for saturated media only within an unconfined or confined aquifer. FEFLOW switches automatically to confined assumptions where appropriate.

The model was run in steady-state mode to define current conditions and in transient mode to predict mine inflows.

The soil and bedrock is simulated as an equivalent porous media. The use of a fracture network model was not justified for a model of this scale and scope. No faults were included in this model because there currently has been only limited characterization of K and the presence of geologic structures. Groundwater salinity was incorporated into the model.

5.2.2 Model Domain

Figure 15 shows the model domain (area included in the model). The model domain is about 180 km^2. It was delineated based on the distribution of potential open taliks and the respective lake elevations to reproduce the estimated regional groundwater flow direction (aligned similarly to surface water catchment areas). It encompasses the Llama, Umwelt, Echo, and Goose Main deposits. The mines are all located at a distance of about 4 km from the external edges and 350 m minimum from the bottom of the model to avoid numerical influences from the boundaries.

5.2.3 Model Mesh

The finite element mesh has 54,433 elements per layer. The mesh is coarsest in areas outside of the mine footprint and away from potential open taliks (average dimensions of element about 250 x 250 m), and finest close to and at the mines (average dimensions of elements about 10 m x 10 m).

The model is built with 34 layers, ranging in elevation from 341 masl to -500 masl. Layer thicknesses vary: 1 m for the first two top layers, 25 m maximum thickness down to layer 32, 50 m for layer 33 and 100 m for layer 34.

Figure 16 presents an oblique view of the 3D Goose Property groundwater model.

5.2.4 Model Parameters

The material properties of the model are defined as follows:

- Hydraulic conductivity is constant within a given layer, with the distribution of K values for the unfrozen ground a function of elevation, as shown in Figure 4, and “stepped” between layers. Figure 5, Section 4.3 shows the vertical K distribution with depths (purple curve) used in the base case groundwater model. Given that the modelled K distribution with depth generally exceeds the geometric mean, and generally coincides with the arithmetic mean below 170 masl, the distribution is considered to be conservative[2]. The sensitivity of the model to higher K in the upper section of the rock are tested with an hypothetical scenario in Section 6.3 using the orange curve in Figure 5;

[2] In this case of sub-vertically dipping metasedimentary rocks tested by vertical and sub-vertical drillholes, a value intermediate to geometric and arithmetic means is considered to be valid overall to represent “average” K.

- Permafrost is impermeable, and represented in FEFLOW with inactive elements. The base of permafrost is modelled at -30 masl;
- Where potential open taliks have been mapped (as per Section 4.5.2), the model simulates flow for the full depth between lake bottom and the sub-permafrost groundwater system;
- There are no closed taliks represented in the model. Groundwater inflows from closed taliks are expected to be minor;
- There are no high K nor low K faults included in the base case model. The sensitivity of the model to potential faults are tested with an hypothetical scenario in Section 6.3;
- Sediments at the bottom of the lakes are assumed to be 1 m thick and have a K of $1x10^{-8}$ m/s;
- The mass transport model assumes an effective porosity for the fractured rock of 0.1%, a longitudinal dispersivity of 30 m and transverse dispersivity of 10 m. These were estimated based on literature values for fractured rock from “Applied Hydrogeology of Fractured Rocks” (Singhal and Gupta, 2010). Groundwater density does not vary in the model; and
- A vertical profile was assigned to the groundwater with TDS increasing with depth, “stepped” by layer. Initial TDS concentrations are assigned through the model domain according to the TDS-depth relationship presented in Figure 6.

5.2.5 Boundary Conditions

The boundary conditions are defined as followed:

- The interpreted extent of permafrost is modelled as inactive elements from surface to -30 masl, which corresponds to the minimum elevation of permafrost based on the -2°C isotherm assumption.
- Top layer:
  - Lakes assumed to be supporting taliks are represented by constant heads and constant mass concentration (constant TDS = 40 mg/L) conditions. Lake elevations used in the models are indicated in Figure 11;
  - If a lake is drained, a phreatic (unconfined) water table is simulated where the lake formerly existed; and
  - There is no recharge from infiltration of precipitation due to permafrost conditions.
- Other layers:
  - Pit slopes and underground stopes are represented as seepage face conditions where permafrost doesn’t exist. Seepage face conditions allow water to exit the model (flow into pits or underground areas) but water cannot enter the groundwater system. These conditions are activated sequentially over time according to the mine production plan (PowerPoint “High-Level Mine Plan Review Back River 2014 Feasibility Study”, August 5, 2014) – details are presented in the next section.
- Bottom layer:
  - The base of the model is a no flow boundary condition and has a condition of constant mass concentration of 228,210 mg/L, based on the TDS-depth relationship shown in Figure 6.

5.2.6 Model Calibration

Since there is little data to calibrate the regional piezometric surface for current conditions, and the piezometric surface is essentially represented by lake elevations, there was no attempt at calibration. The uncertainty with respect to model parameter values was addressed through uncertainty analysis via testing a plausible range of parameter values.

5.2.7 Model Simulations

The numerical groundwater model simulates the progressive excavation of the open pit and underground mines according to a time step function based on the planned mining schedule. Each mine area is activated in sequence according to the mine production plan. Each mine area progressively "turns on", with seepage faces activated, during an active mining period with a progressive increase in depth or development area based on the timeframe of mining and "turns off", with seepage faces inactivated, when not being mined, with the assumption being that dewatering will be undertaken coincident with mining only. A simplified version of the mine schedule incorporated in the models is presented in Table 4. The progression was implemented on a monthly time step whereas the table shows only yearly progression. The table also indicates which areas are within frozen or unfrozen ground and changes in bottom elevation of mine over one year.

Table 4: Mine Schedule Applied to Model Boundary Conditions

Mine Name	Element	*-1*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
		Table values correspond the bottom elevation (masl) of a mine element at end of year										
Umwelt UG	Decline		75	-150	-350	-350	-350	-350	-350	-350	-350	-350
	Stope			75	75	-350	-350	-350	-350	-350	-350	-350
Llama UG	Decline	0	-75	-75	-75	-75						
	Stope		0	-75	-75	-75						
Llama OP	Pit		250	200	150							
Goose Main UG	Decline					0	0	0	-100	-100	-100	
	Stope						0	0	-100	-100	-100	

Source: BackRiver_Modeling_Assumptions_v2.xlsx

Notes: A cell with dark grey shade signifies mine is progressing in frozen ground (base permafrost is at -30 masl).
A cell with blue shade signifies mine is progressing in unfrozen ground.

The Umwelt decline is estimated to intersect the base of the permafrost at Q2 of Year 2. The Goose Main decline is estimated to intersect the base of the permafrost at Q4 of Year 6. Once declines intersect unfrozen ground, both the Umwelt Underground and Goose Main mines are allowed to receive inflows.

5.2.8 Model Sensitivity and Uncertainty Analysis

Multiple hypothetical scenarios were conducted to assess the sensitivity of model predictions to K values, the potential presence of fault conduits, lake sediment K, and permafrost distribution.

6 Modeling Results

6.1 Current Conditions

Figure 17 shows the predictions of hydraulic head for current (pre-mining) conditions at the Goose Property, based on the steady-state modeling. TDS concentration in unfrozen ground is increasing with depths as shown in vertical profile in Figure 6.

6.2 Goose Life-of-Mine Inflows and Inflow Quality

At the Goose Property, the mines that may capture groundwater inflows are the Llama Pit, Llama underground, Umwelt underground, and the Goose Main underground. The Llama Pit and Llama underground partially intersect the open talik supported by Llama Lake; this lake will be dewatered prior to the start of mining operations. The Llama, Umwelt, and Goose Main undergrounds partially intersect the sub-permafrost groundwater system.

Table 5 and Figure 18 present the predicted yearly average inflows for the Goose Property. Figure 19 shows a 2D cross-section of hydraulic head distribution across the Llama open pit, Llama underground, and the Umwelt underground. Table 6 and Figure 20 present the predicted yearly average concentrations of TDS associated with groundwater inflows to the mines.

Table 5: Predicted Yearly Inflow for the Goose Property

	Flow in m³/d				
Year No.	**Q_{ug} Umwelt**	**Q_{ug} Llama**	**Q_{op} Llama**	**Q_{ug} Goose Main**	**Q Total**
-2	0	0	0	0	0
-1	0	168	0	0	168
1	0	334	120	0	454
2	89	350	76	0	515
3	543	264	19	0	826
4	440	185	0	0	625
5	596	0	0	0	596
6	498	0	0	21	519
7	405	0	0	85	490
8	359	0	0	77	436
9	329	0	0	16	345
10	156	0	0	0	156

Source: BackRiver _FEIS_6a3_upd3_Base_Case_20150904.xlsx

Notes: Q = Flow rate, ug = underground, op = open pit.
Year No. = Year number, Negative numbers correspond to pre-production years and positive numbers to production years.

Reflooding of open pit or underground mine are not simulated.

* The maximum peak inflow is predicted at Year 3 with an average of 1,120 m³/day for the Q3 period and 830 m³/day for the Year 3 period.

Table 6: Predicted Yearly TDS Concentrations in Groundwater Inflows for the Goose Property

	TDS concentrations in mg/L				
Year No.	**C $_{ug}$ Umwelt**	**C $_{ug}$ Llama**	**C $_{op}$ Llama**	**C $_{ug}$ Goose Main**	**C Total**
-2	0	0	0	0	0
-1	0	15’533	0	0	15,533
1	0	17’128	8,758	0	14,915
2	32,157	21’004	10,888	0	20,795
3	40,901	21’911	12,000	0	33,262
4	49,820	22’344	0	0	41,706
5	58,826	0	0	0	58,826
6	57,571	0	0	29,021	56,413
7	58,198	0	0	31,467	53,556
8	58,919	0	0	33,017	54,339
9	59,681	0	0	34,360	58,511
10	60,224	0	0	0	60,224

Source: BackRiver _FEIS_6a3_upd3_Base_Case_20150904.xlsx

Note: C = Concentration, ug = underground, op = open pit.

Year No. = Year number, Negative numbers correspond to pre-production years and positive numbers to production years.

Reflooding of open pit or underground mine are not simulated.

C Total = Total concentrations when all mine inflows are combined.

Predicted mine inflows are modest for the following reasons:

- Only Llama Pit is interpreted to have a local connection to an open talik zone, and the lake above it will be drained prior to mining; and
- Sub-permafrost K is low, hence hydraulic connection to nearby open talik zones is limited.

More than half of the mine inflows are predicted to occur at the Umwelt underground. Very minor inflows are predicted at Goose Main underground.

Peak salt loading is expected to occur in Year 5, with an estimated yearly average of 35 tonnes of salt per day. The great majority of salt loading is estimated to come from Umwelt underground.

The Llama open pit groundwater flows will be supplemented by meltwater and surface runoff flows in late spring and summer months, which will dilute TDS levels.

An additional phenomenon which is not typically considered in numerical models is the potential for non-Darcian, or turbulent flow. With flow focused on small-aperture fractures of varying roughness and planarity and very high hydraulic gradients associated with pit and underground working dewatering, significant hydraulic losses can occur, hence *actual* groundwater inflows will be lesser than those predicted by a numerical model which simulates only Darcian, or, laminar flow (Dudgeon, 1985).

Pumped groundwater volumes are likely to be lesser still, as *pumped* groundwater volumes will be somewhat less than the *inflow* volumes, due to evaporative and sublimative losses, notably those losses associated with heated underground air, and water and ice removed with broken rock. The amount of water which leaves the mining operations via these modes can be significant where inflow rates are low, such as is predicted at the Property.

6.3 Mine Inflow Data Review

SRK researched groundwater inflow measurements reported by closed or operating mines located in continuous permafrost environments to benchmark the inflow predictions estimated for the Project. The available public data were often limited. No information was found for closed mines such as Polaris, Nanisivik, and Rankin Inlet. SRK obtained useful public information on measured mine inflows as well as predicted inflow and TDS concentrations for three operating mines located in the Northwest Territories: Diavik, Ekati, and Snap Lake (Itasca, 2013f, Golder, 2014d).

Among the three mine projects, the Ekati mine has the most similarities with the Project. The Ekati mine is an open pit and underground operating diamond mine, started in 1997. Permafrost is estimated to extend down to 320 to 485 mbgs. Dewatering data exists for six operations at four sites at Ekati: the Panda and the Koala open pits and underground mines, the Fox pit mine and the Misery pit mine. All these mines are situated in open taliks but, unlike the Snap Lake or the Diavik project, there are no diked off portion of the lake beds. The respective lakes were dewatered prior to mining, alike what is proposed at the Goose Property. At Ekati, the hydrostratigraphic units related to the rock mass differ from the units found at the Project, although in terms of hydraulics, the competent country rock is considered to be relatively similar to the rock mass at the Property in terms of average hydraulic conductivity. The competent granitic country rock, which comprises a majority of the rock domain, is described as generally low, between $1x10^{-9}$ and $1x10^{-7}$ m/s and decreasing with depth. The Ekati project (as well as Snap Lake and Diavik) is also characterized by Enhanced Permeability Zones (EPZs), which are zones of greater fracturing and good hydraulic connectivity, related to structures such as faults, found to be present at operating diamond mine in crystalline rock of the Canadian Shield. Hydraulic conductivity of the EPZs ranges between $1x10^{-6}$ and $1x10^{-5}$ m/s, across variable widths (transmissivity between about $8x10^{-5}$ and $1x10^{-3}$ m^2/s). At the Diavik project, which borders the large Lac du Gras, an EPZ was found during mining to be the source of substantial groundwater inflow. Such zones have not been identified at the Property, which also does not border a large water body, as at Diavik.

All three projects, Diavik, Ekati, and Snap Lake, are characterized by high salinity, with groundwater TDS more or less corresponding to the Frape & Fritz (1987) profile shown in Figure 6. TDS concentrations at depth at these projects are significantly lower than the groundwater samples collected at similar depths at the Property.

At the Ekati project, in 2012, an annual total average mine water inflow of approximately 1,200 m^3/day was reported to the Panda and Koala underground mines, and 1,000 m^3/day to the Fox pit. During mining of the Misery pit, minor groundwater inflows were reported; in 2010, pit inflow was observed to range between 200 and 300 m^3/day and was interpreted to originate primarily from the active zone. The measured inflows were within the bounds of the groundwater numerical model predictions completed in 2005 and 2006. The predictions ranged between 1,000 and 1,700 m^3/day for the Panda and Koala underground mines, and 400 and 4,300 m^3/day for the Fox pit mine.

At the Snap Lake project, a measured inflow to the workings of approximately 50,000 m^3/day was reported in 2015. With the use of real underground flow measurements for calibration, the most recent numerical models, built after 2011, predicted the same magnitude of inflow as measured in year 2015, and future peak inflow of about 60,000 m^3/d for the year 2017. Earlier numerical model versions (2001, 2002) underestimated the inflows, with a predicted peak inflows between 24,000 and 34,000 m^3/day for the year 2018, about half of the flow observed in 2015. The major differences between the early and late inflow predictions at Snap Lake are linked to updated field data and modifications to the mine plan. New findings changed the permafrost depth assumption, the characterisation of hydrogeological units and their properties, the characterisation of structural features, and the calibration leakage factors associated with underground tunnels.

At the Diavik project, a combined flow between 3,300 and 6,600 m^3/day was reported to the underground mine labelled A154/A418, in 2009 and 2010. Alike the Snap Lake project, several groundwater models were completed and updated prior to and after mining operations started. Because the mine plans and objective of those models changed, it is difficult to compare the predictions with the mine inflow measured in 2009 and 2010. However, it is possible to state that the incorporation of the EPZ identified during mining and calibration with data collected during mining provided accurate predictions of groundwater inflows and quality.

The benchmarking results do demonstrate that in all likelihood the Back River inflow range should be significantly lower than those observed at Snap Lake and Diavik due to the significant physical differences in the setting. The significantly higher magnitude of inflows, observed and predicted, at Snap Lake and Diavik are linked to the connection with the lakes at their surface via the EPZs. These features have not been observed at the Property to date; however, the significance of the EPZ connecting the Diavik working to Lac du Gras was not fully understood until mining commenced. From practical perspective, further data collection at the Property may never be enough to reduce of the uncertainty associated with EPZs given the spatial extent of the problem; the only real proof of concept being actually intercepting the features as part of mining. In addition, the fact that groundwater inflows at the Property will originate from four different mines, provides ample opportunity to learn and adjust as mining progresses, which is consistent with what has happened at the benchmarked sites.

6.4 Model Sensitivity and Uncertainty Analysis

6.4.1 Context

The results of the sensitivity runs were analyzed by comparing the results to the Base Case model predictions presented in Section 6.2. The base case model uses SRK's best estimate of the hydrogeological parameters. The model is based on the assumption that, on the scale modelled, flow within the fractured bedrock media will approximate flow through an equivalent porous media. In fact, much of the mine area is likely to have no inflow, with areas of inflow constrained to discrete, bedding-controlled or structurally affected areas.

6.4.2 Hydraulic Conductivity

The Base Case model hydraulic conductivity profile was determined from the geometric mean and arithmetic mean of testing results calculated over depth intervals. The K distribution used in the base case is considered to be reasonably conservative, i.e. K varies between the geomean and arithmetic mean of the K measurements. The Base Case model assumes that the top 100 m of the rock mass matches the geometric mean, while in the deeper rock mass; model assumes a K profile based on the higher K measurements, values close to the arithmetic mean, as well as a trend of decreasing K with depth.

A more conservative run was undertaken with K distribution based on the arithmetic mean of the site measurements between ground surface and 170 masl, as shown by the orange curve in Figure 5.

As expected, the inflow results are sensitive to assumptions for K. However, model predictions using the most conservative K profiles indicate that inflows and TDS concentrations at Umwelt underground, Llama underground, and Goose Main underground are insensitive to a change of hydraulic conductivity in the upper section of the rock mass because they are being developed at depths below the area of interest. Only the inflows predicted for the Llama open pit are sensitive to a change of hydraulic conductivity at these depth intervals. The sensitivity model predicts an increase of inflow of about +220 % in the Llama open pit at Year 1, associated with the increase of K by about an order of magnitude over the upper 200 m of the model. This leads ultimately into an increase to the total inflow (all mines combined) of +55% at Year 1.

In terms of TDS, the effects on the model predictions are tied to the inflow augmentation predicted at Llama open pit and the relatively lower salinity concentration at shallow depth compared to deep groundwater. The sensitivity model predicts a reduction of the total TDS concentration (all mines combined) ranging between -11% and -1%.

6.4.3 Potential Influence of Faults

No fault zones were included in the Base Case model. Although evidence of faulting has been observed, the current data set does not permit an adequate evaluation of the hydraulic characteristics of significant structures on the Property. Only one test, in drillhole 12GSE206, was identified to be associated with a fault and a higher K measurement (relative to other tests completed at the same depths interval).

To assess the potential influence of faults, a hypothetical model scenario considered all the major faults identified on Figure 3 behaving as potential conduits relative to the rock mass. Faults were assumed to be vertical, intersecting the full rock mass, and characterized by a thickness of 5 m and a hydraulic conductivity of $2x10^{-7}$ m/s, even though the highest K value associated with a fault was measured at $2x10^{-8}$ m/s in drillhole 12GSE206.

The sensitivity model predictions show no effect on the Goose underground inflows, even though a fault is mapped at close proximity, at about 60 m. The Umwelt underground inflows are increased by +15% to +56% during the mine life. The Llama underground inflows are increased by +32% to +72%. The Llama open pit inflows are decreased by -53% because the Llama underground lowered the heads above the mine, prior to the start of excavation. In terms of total inflow (all mines combined), the inflow augmentation ranges between +18 to +72%. For TDS concentration, the effects on the model predictions are tied to capture of lower salinity groundwater from shallow depth via the faults. The sensitivity model predicts a reduction of the total TDS concentration (all mines combined) ranging between -1% and -14% between Year --1 and 2, followed by an augmentation of +1% to +20% between Year 3 and 10.

6.4.4 Lake Sediments

The Base Case model assumes the lake sediments are 1 m thick and have a K of $1x10^{-8}$ m/s. The sensitivity model assumes lake sediments are absent. The lakes are in direct contact with the rock mass. Groundwater flow is not restricted from the overlying lakes.

To assess the potential influence of the lake sediments, a hypothetical model scenario considered that sediments had the same hydraulic properties as the top of bedrock ($4x10^{-8}$ m/s).

The sensitivity model predictions indicate that inflows and TDS concentrations are relatively insensitive to the presence of lake sediments.

6.4.5 Distribution of Permafrost

The distribution of permafrost is reasonably understood, but the exact 3D distribution of frozen vs. unfrozen ground is not known. Shifting of the assumed boundary between frozen and unfrozen ground does change inflow rates. If the mines intersects more unfrozen bedrock, potential inflow will increase and inversely. The same applies for the presence of open or closed taliks.

6.5 Limitations of the Groundwater Model

The following limitations should be considered when interpreting or using model results:

- The model has been constructed based on available data, but actual conditions may vary locally, due to local variations in K, water quality or ground temperature (permafrost distribution).
- Actual pumped ground water volumes are likely to be lesser than predicted mine inflows, due to water removed by evaporation, and sublimation with ore and waste rock. The percentage that leaves via these pathways could be significant if inflows are relatively low.

- Faults that act as significant flow conduits or flow barriers, in taliks and beneath the permafrost, could be present and not identified to date.
- The results do not account for transient thermal conditions that can impact talik configuration, thermal influence of adjacent lakes, spatial variability in ground surface temperature, or complex water bathymetry.
- Estimates of inflow water quality do not consider the influence of direct precipitation or runoff into lake areas, which could lower TDS observed in mining areas (for those areas that intersect lake footprints at ground surface). Inflow TDS estimates are considered conservative but appropriate for water management planning.

7 Conclusions

A 3D numerical groundwater model has been developed based on available data to estimate groundwater inflow rates and inflow TDS to individual mining areas on the Goose Property. The model is based on a conceptual model developed on the basis of previous hydrogeological and thermal investigations. The extent of permafrost has been undertaken through consideration of ground temperature and groundwater total dissolved solids (TDS) and pressure data, and includes the interpreted extents of open taliks, or unfrozen zones. Groundwater quality measurements from the site have been used with regional data to develop pre-mine TDS distributions in the model. The model simulates mine development in a step-wise fashion according to the mine plan. The inflow volumes and water quality results presented here have been used as input into the site wide water and load balance model to assess water management strategies. The findings are as follows:

- Total groundwater inflows for the Goose Property will reach a maximum of about 830 m^3/day in Year 3 of Operations, with more than half expected to occur at Umwelt underground. Actual groundwater pumped volumes may be somewhat less, due to the effects of turbulent flow in small-aperture fractures losses adjacent to the mine workings and the removal of some inflows water through evaporation and removal with waste rock and ore. The predicted inflows appear to be consistent with the investigations to date and with analogous operations elsewhere in the Arctic, notably Ekati. Inflows could be significantly greater if permeable geologic structures intersect mine workings in open talik zones or sub-permafrost groundwater.
- Maximum estimated TDS concentrations are predicted to occur at the Umwelt underground at the end of mining in Year 10. Estimated TDS concentrations for other areas of the Goose Property are relatively lower and maximum values do not necessarily occur at the end of mining in each area. Peak salt loading is expected to occur in Year 5, with an estimated 35 tonnes of salt per day. Through the mine life, the great majority of salt loading is expected to occur from Umwelt underground. Groundwater is anticipated to be calcium-sodium-chloride-dominant. These estimates are all subject to a degree of uncertainty, and represent best estimates only. The salt loading will be reducing accord to the amount of water removed with waste rock and ore. The predicted groundwater chemistry and TDS values are consistent with data obtained from other operations in permafrost regions of Canada.
- Sensitivity analyses show inflows are sensitive to assumptions for K, faults and permafrost; inflow quality is sensitive to the assumed baseline TDS profile with depth.

This report, “Hydrogeological Characterization and Modeling of the Proposed Back River Property”, was prepared by SRK Consulting (Canada) Inc.

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All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted professional engineering and environmental practices.

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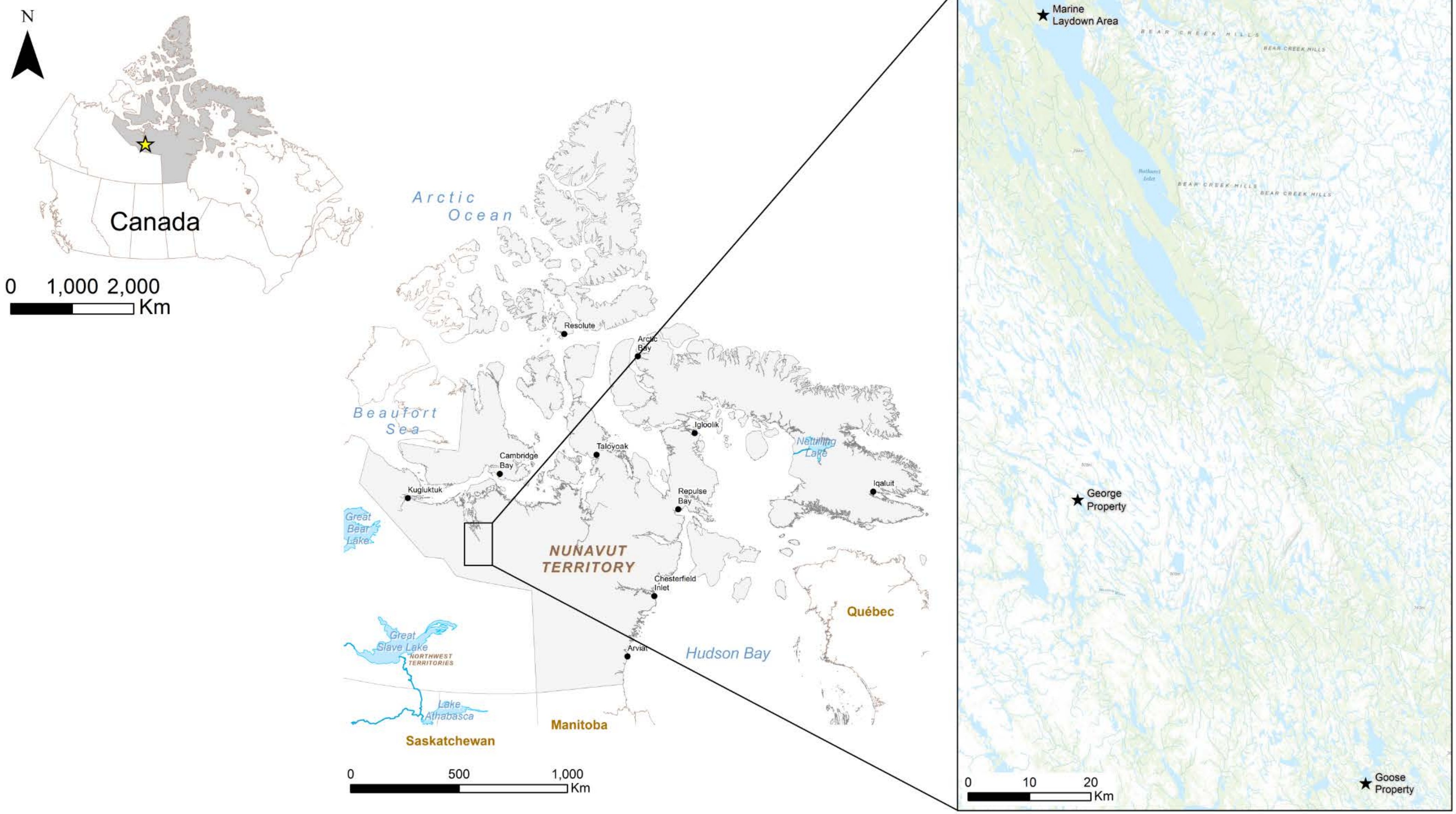
Figures



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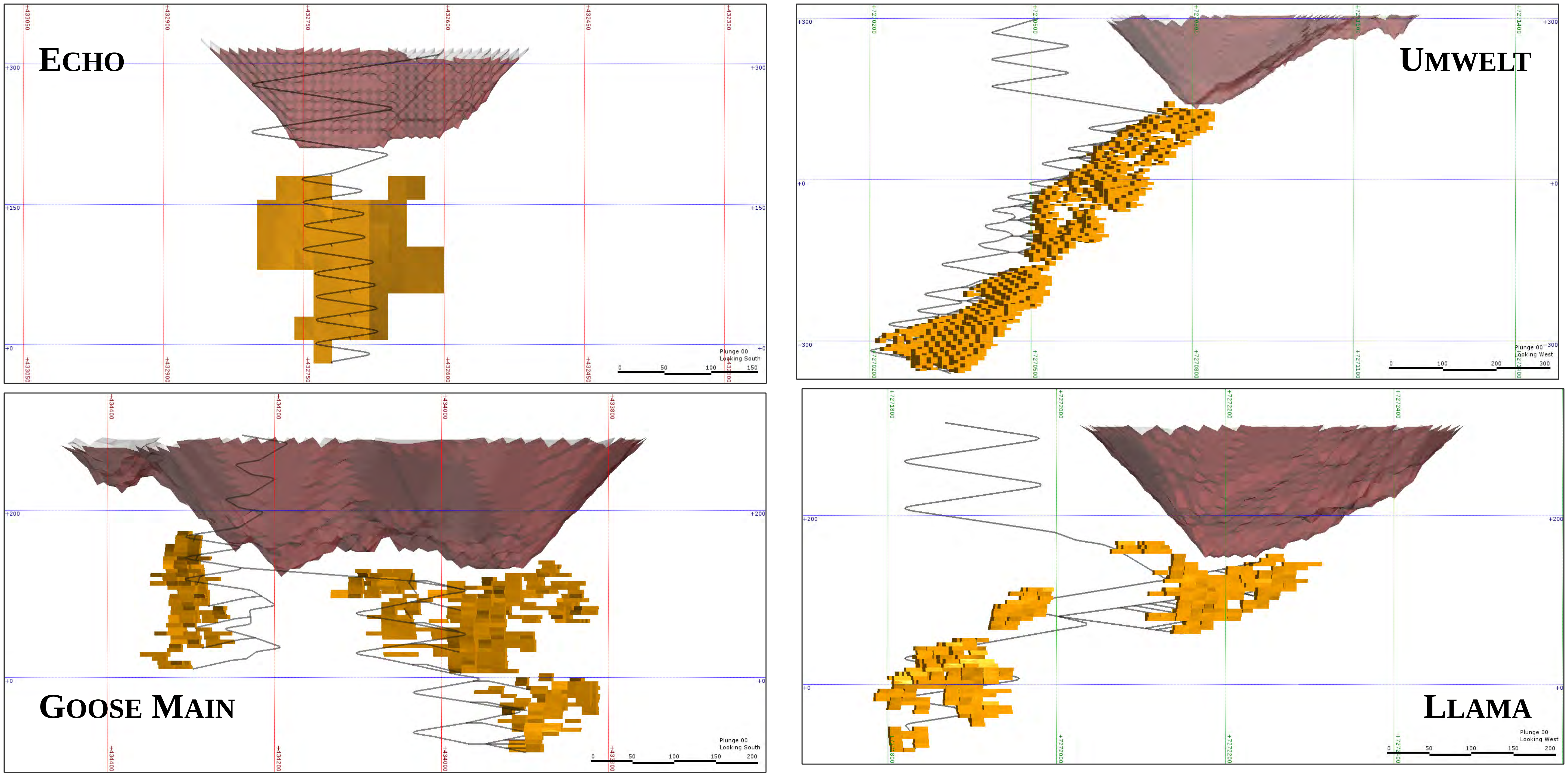
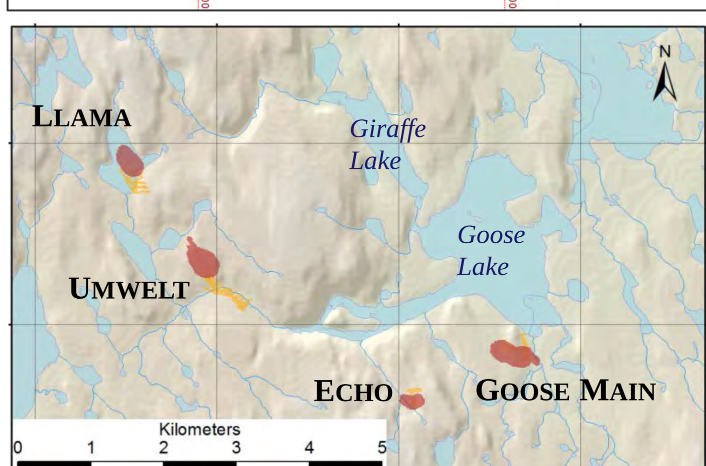
Coordinate System: NAD 1983 UTM Zone 13N

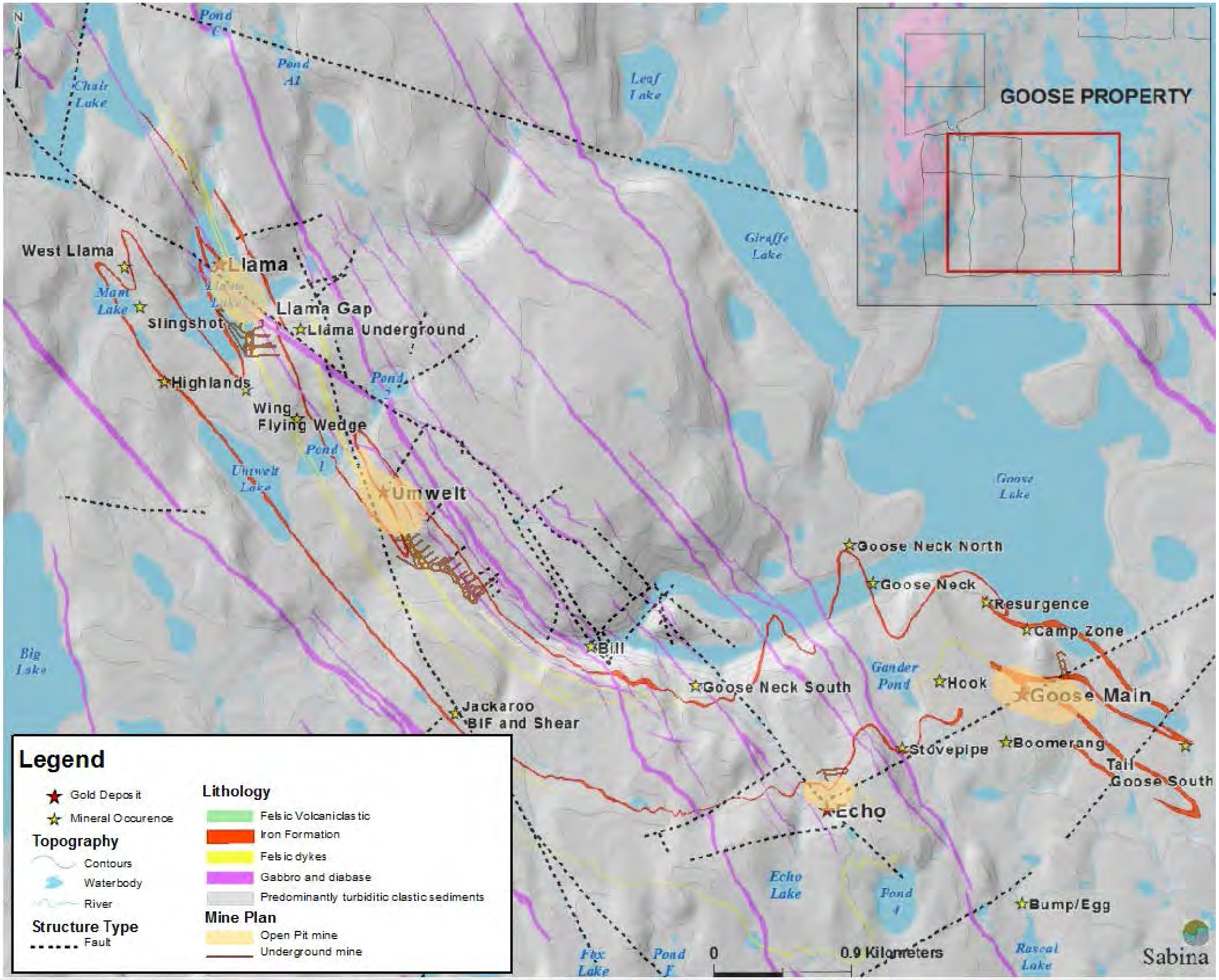
srk consulting	Sabina GOLD & SILVER CORP.	Hydrogeological Characterization and Modeling **Site Location Plan**		
Job No: 1CS020.008 Filename: Figures.pptx	Back River Project	Date: September 2015	Approved: SPB	Figure: 1





Red solid = pit shell
Orange solid = Underground stope
Dark grey line = Underground tunnel
All vertical references are in meter above sea level

srk consulting	Sabina GOLD & SILVER CORP.	Hydrogeological Characterization and Modeling
		Mine Plans at Goose Property
Job No: 1CS020.008 Filename: BackRiver_LandFigs_11x17_1CS020.008_rev01	Back River Project	Date: Sep. 2015 · Approved: GF · Figure: 2



Source: Tetra Tech, Report, Mineral Resource Update for the Back River Gold Property, Nunavut, Canada Figure 7.3

srk consulting	Sabina GOLD & SILVER CORP.	Hydrogeological Characterization and Modeling
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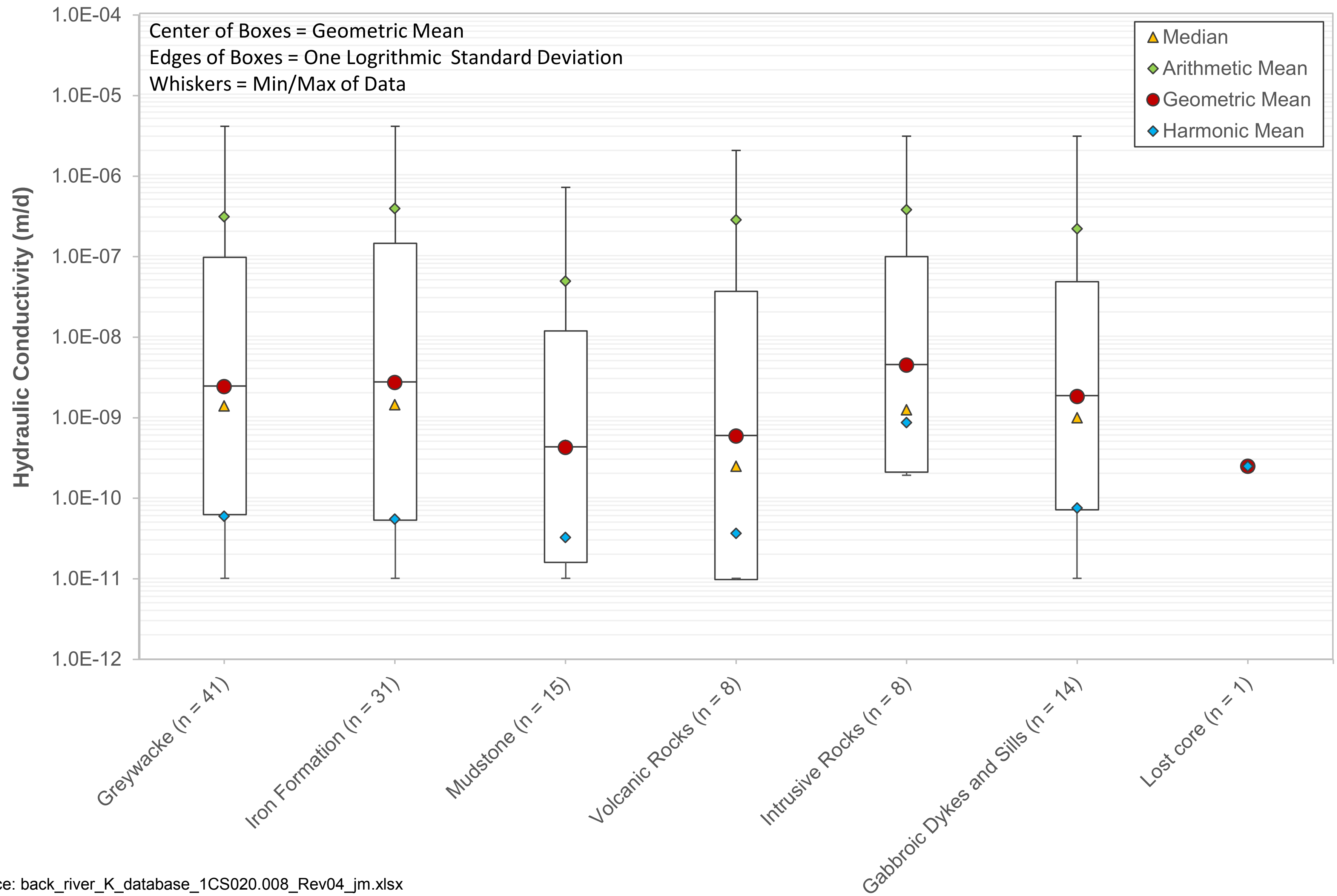

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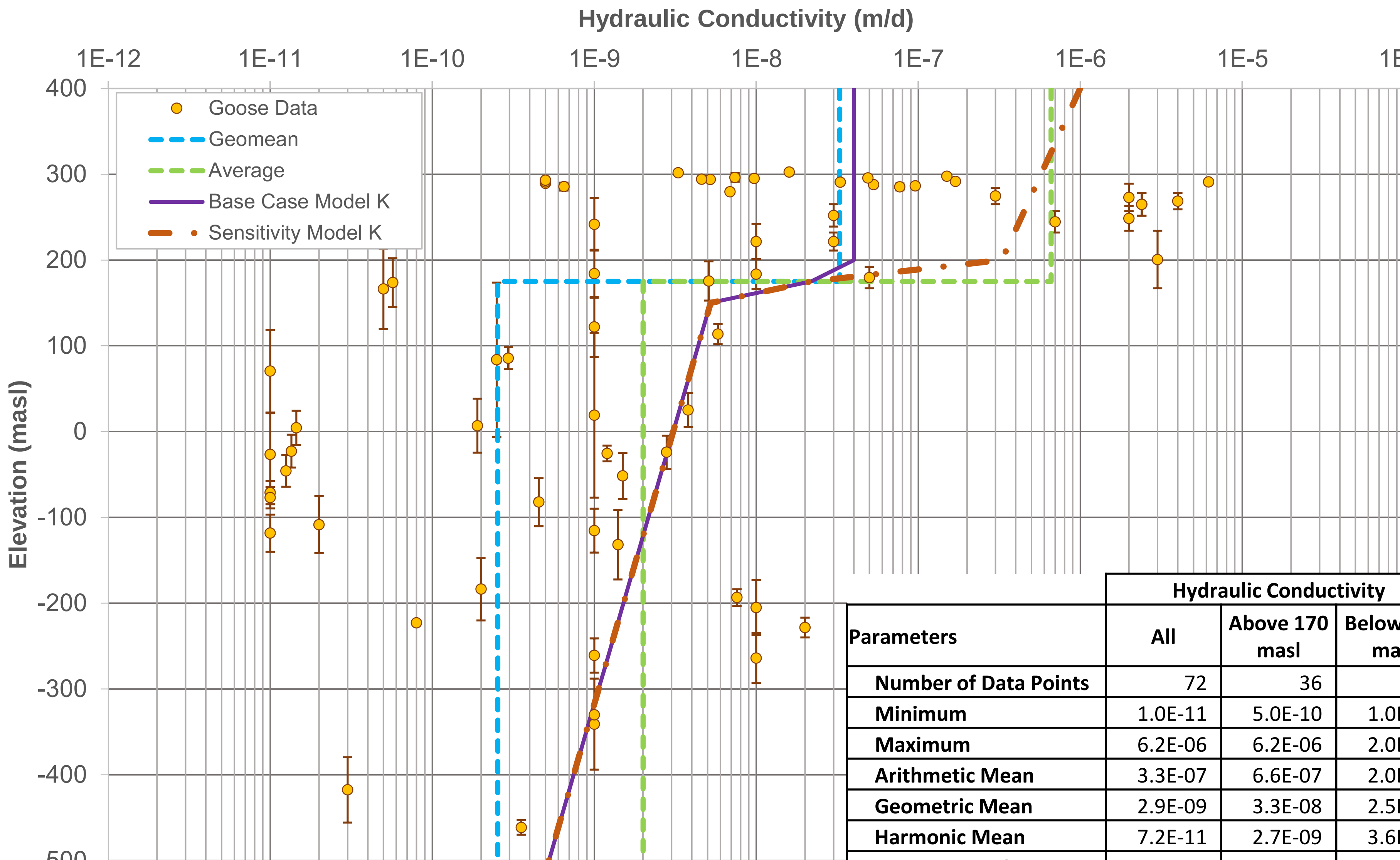
srk consulting	Sabina GOLD & SILVER CORP.	Hydrogeological Characterization and Modeling
		Hydraulic Conductivity Versus Lithology
Job No: 1CS020.008 Filename: BackRiver_LandFigs_8x11_1CS020.008_rev01	Back River Project	Date: Sep. 2015 / Approved: GF / Figure: 4



Parameters	Hydraulic Conductivity All	Hydraulic Conductivity Above 170 masl	Hydraulic Conductivity Below 170 masl
Number of Data Points	72	36	36
Minimum	1.0E-11	5.0E-10	1.0E-11
Maximum	6.2E-06	6.2E-06	2.0E-08
Arithmetic Mean	3.3E-07	6.6E-07	2.0E-09
Geometric Mean	2.9E-09	3.3E-08	2.5E-10
Harmonic Mean	7.2E-11	2.7E-09	3.6E-11
Log-Norm. Std. Dev.	1.57	1.27	1.06
Geometric COV	1718%	630%	346%

Source: BackRiver_Modeling_Assumptions.xlsx

Note:

COV — Coefficient of Variation

Log.Norm. Std. Dev — LOG normalized standard deviation

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Job No: 1CS020.008

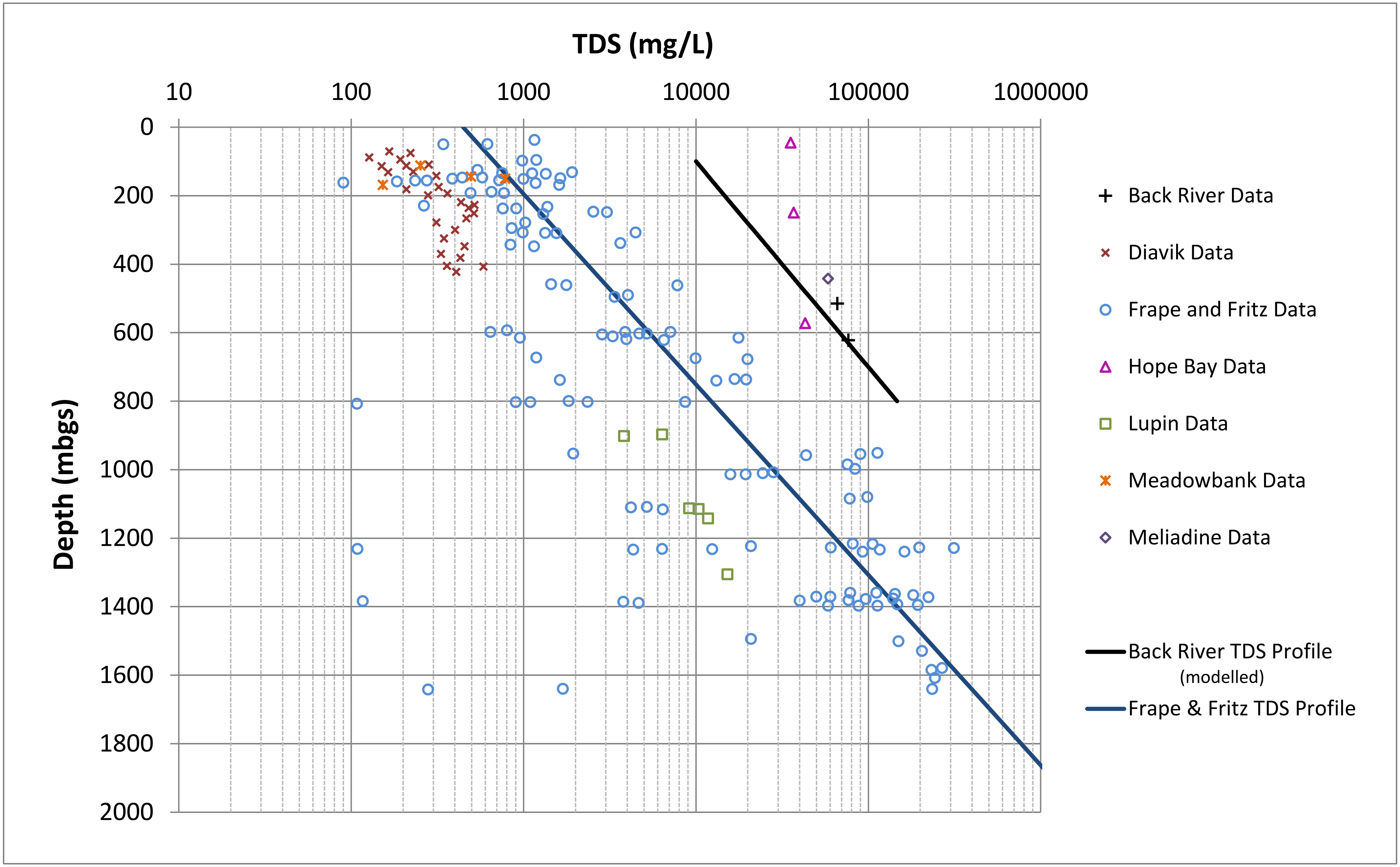
Filename: BackRiver_LandFigs_8x11_1CS020.008_rev01

Back River Project

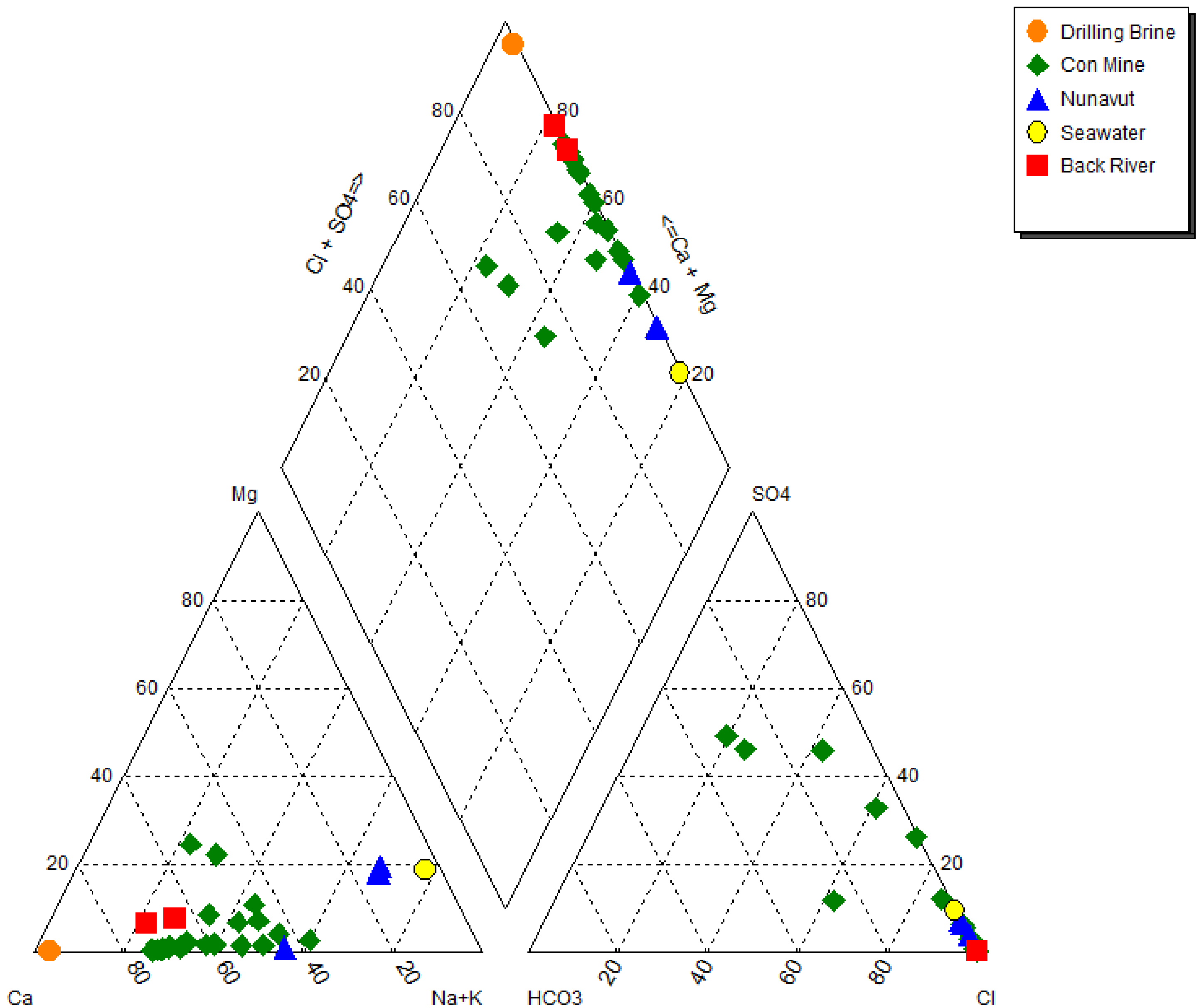
Hydrogeological Characterization and Modeling

Hydraulic Conductivity Versus Elevation

Date: Sep. 2015 | Approved: GF | Figure: 5



srk consulting	Sabina GOLD & SILVER CORP.	Hydrogeological Characterization and Modeling
		TDS versus Depth
Job No: 1CS020.008 Filename: BackRiver_LandFigs_8x11_1CS020.008_rev01	Back River Project	Date: Sep. 2015 / Approved: GF / Figure: 6



Note:
Back River quality is represented by the samples collected in 2013, corrected from drilling brine

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Hydrogeological Characterization and Modeling

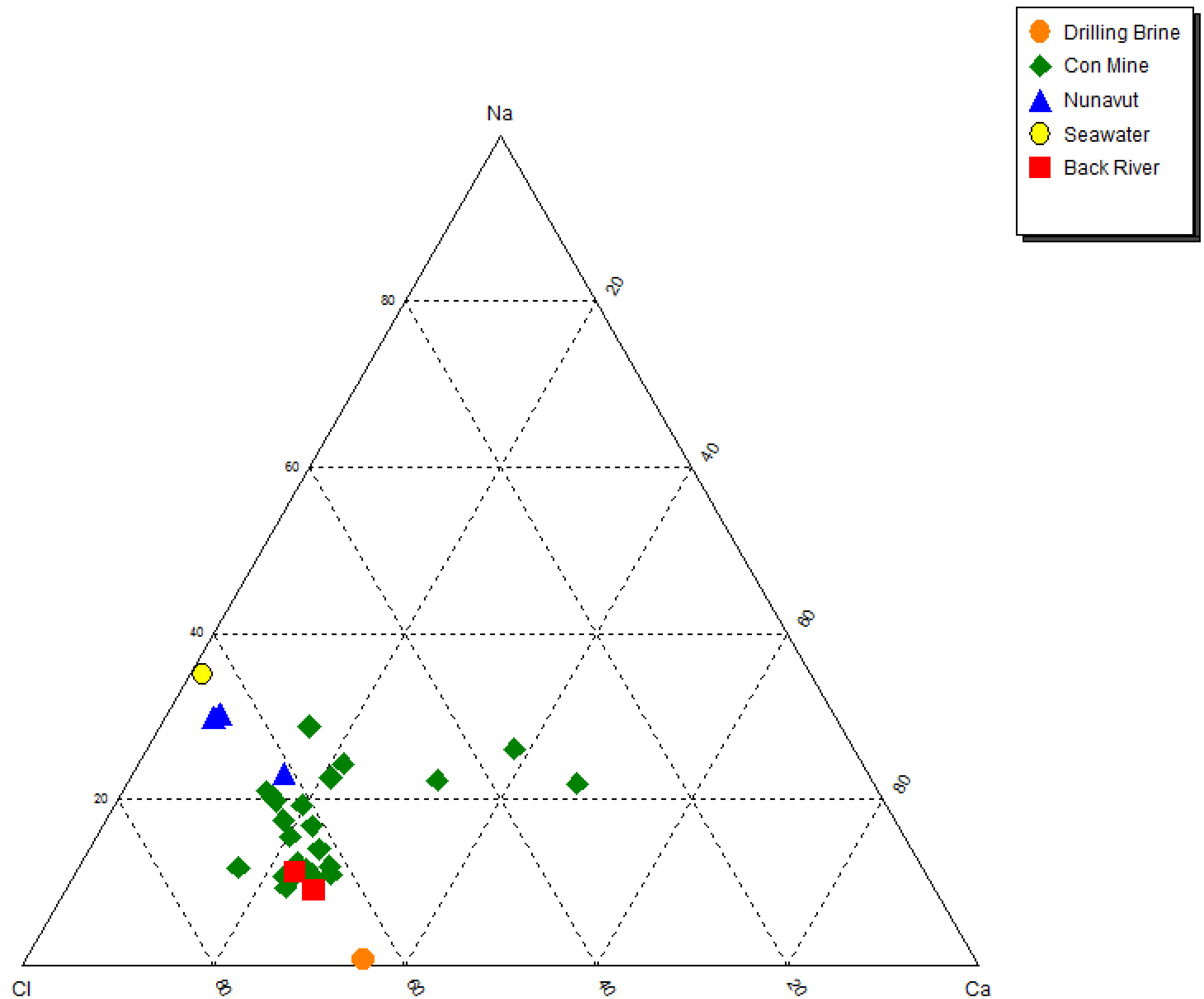
Piper Plot
Regional Hydrogeochemistry

Job No: 1CS020.008
Filename: BackRiver_LandFigs_8x11_1CS020.008_rev01

Back River Project

Date: Sep. 2015
Approved: GF
Figure: 7

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.008_FS_Study\Task 7100_Water_Treatment\Brine Hydrogeochemistry Memo 20141031\Figures\Figure1PiperPlotrev2.PNG



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Job No: 1CS020.008
Filename: BackRiver_LandFigs_8x11_1CS020.008_rev01

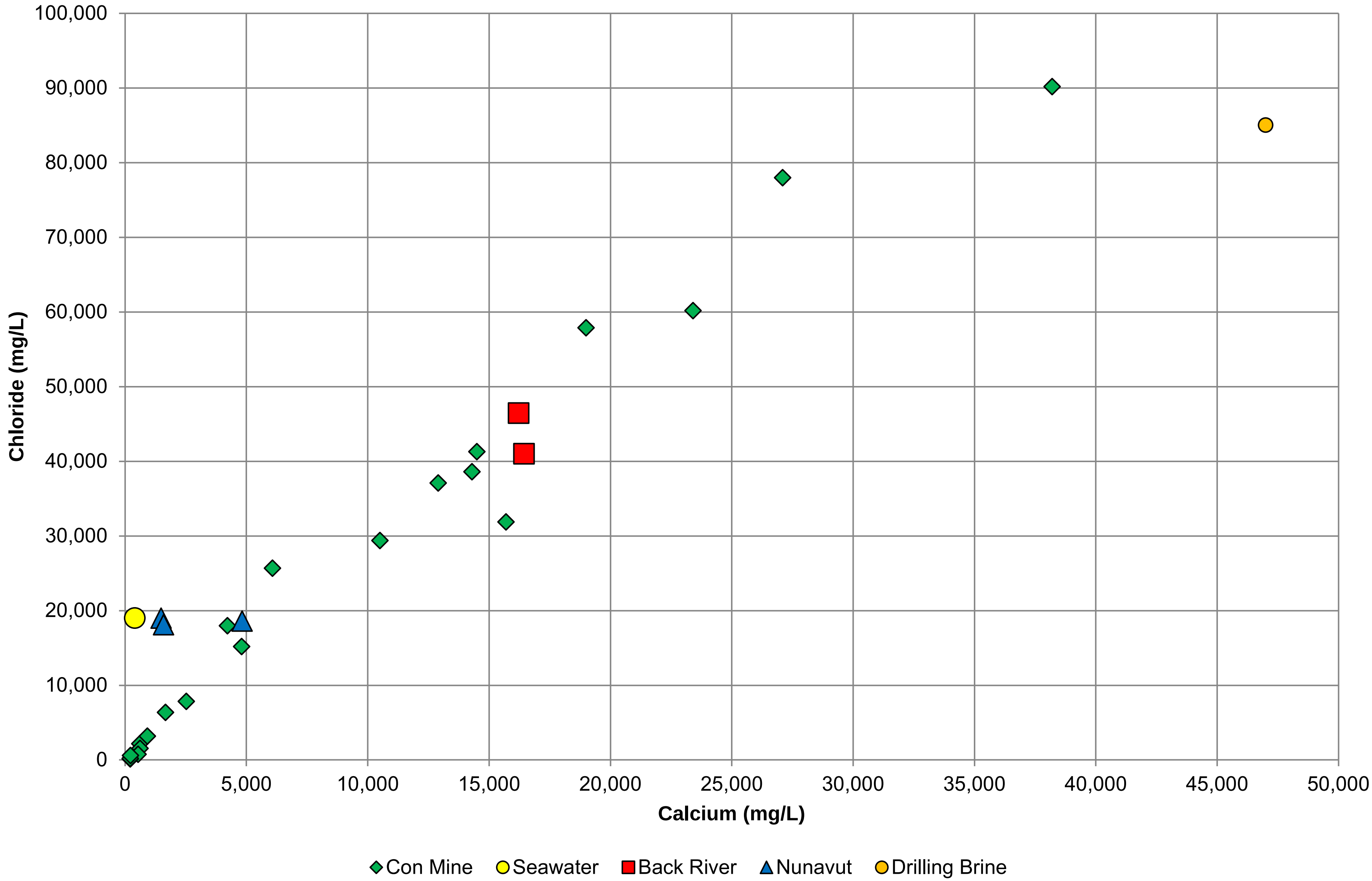
Back River Project

Hydrogeological Characterization and Modeling

Calcium-Sodium-Chloride Ternary Plot

Date:	Approved:	Figure:
Sep. 2015	GF	8

Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.008_FS_Study\Task 7100_Water_Treatment\Brine Hydrogeochemistry Memo 20141031\Figures\Figure2TernaryPlotrev2.PNG



Note:
Back River quality is represented by the samples collected in 2013, corrected from drilling brine

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Job No: 1CS020.008
Filename: BackRiver_LandFigs_8x11_1CS020.008_rev01

Back River Project

Hydrogeological Characterization and Modeling

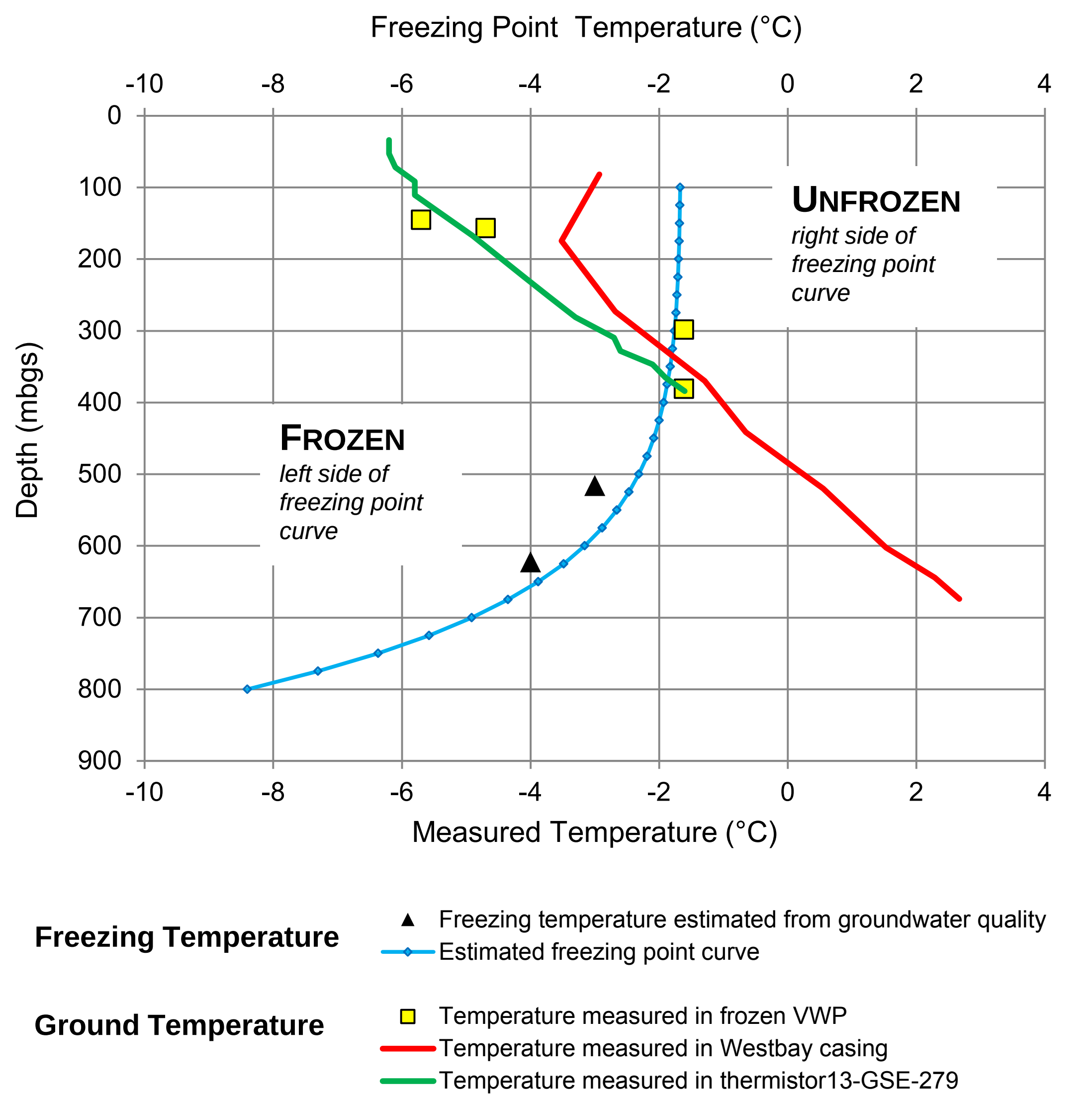
Relationship Between Calcium and Chloride Concentrations

Date: Sep. 2015
Approved: GF
Figure: 9

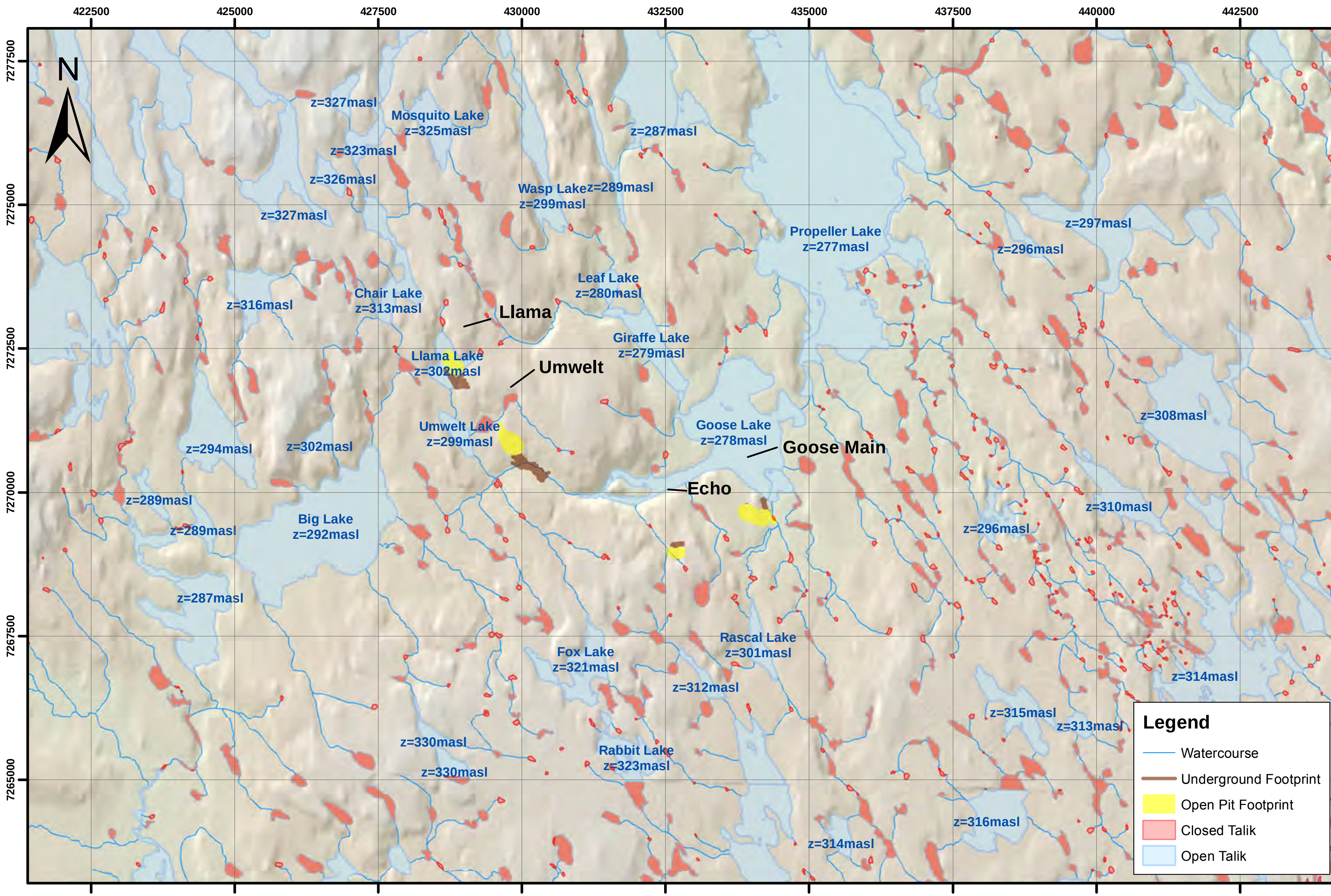
Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.008_FS_Study\Task 7100_Water_Treatment\Brine Hydrogeochemistry Memo 20141031\Data Analysis\WestbayGWAnalysis_1CS020-006_rev01_lmc_trs.xlsx

Tabulated Results: Groundwater TDS

Depth (mbgs)	TDS (mg/L)	TDS (wt%)	Freezing Point (°C)
100	10,000	1.0%	-1.67
125	11,007	1.1%	-1.68
150	12,115	1.2%	-1.68
175	13,335	1.3%	-1.69
200	14,678	1.4%	-1.69
225	16,156	1.6%	-1.71
250	17,783	1.7%	-1.72
275	19,573	1.9%	-1.74
300	21,544	2.1%	-1.76
325	23,714	2.3%	-1.79
350	26,102	2.5%	-1.83
375	28,730	2.8%	-1.87
400	31,623	3.1%	-1.93
425	34,807	3.4%	-2.00
450	38,312	3.7%	-2.08
475	42,170	4.0%	-2.19
500	46,416	4.4%	-2.31
525	51,090	4.9%	-2.47
550	56,234	5.3%	-2.66
575	61,897	5.8%	-2.88
600	68,129	6.4%	-3.16
625	74,989	7.0%	-3.48
650	82,540	7.6%	-3.88
675	90,852	8.3%	-4.35
700	100,000	9.1%	-4.91
725	110,069	9.9%	-5.58
750	121,153	10.8%	-6.37
775	133,352	11.8%	-7.31
800	146,780	12.8%	-8.41



srk consulting	Sabina GOLD & SILVER CORP.	Hydrogeological Characterization and Modeling
		Freezing Point Temperature Curve
Job No: 1CS020.008 Filename: BackRiver_LandFigs_8x11_1CS020.008_rev01	Back River Project	Date: Sep. 2015 / Approved: GF / Figure: 10



Kilometers

0 1 2 3 4 5

1:90,000

NOTES:
1. Topographical information from geobase server, Natural Resources Canada (NRCan).
2. Watercourse, waterbody, and island information from CanVec, NRCan.
3. Coordinate System: NAD 1983 UTM Zone 13N
Projection: Transverse Mercator
Datum: North American 1983

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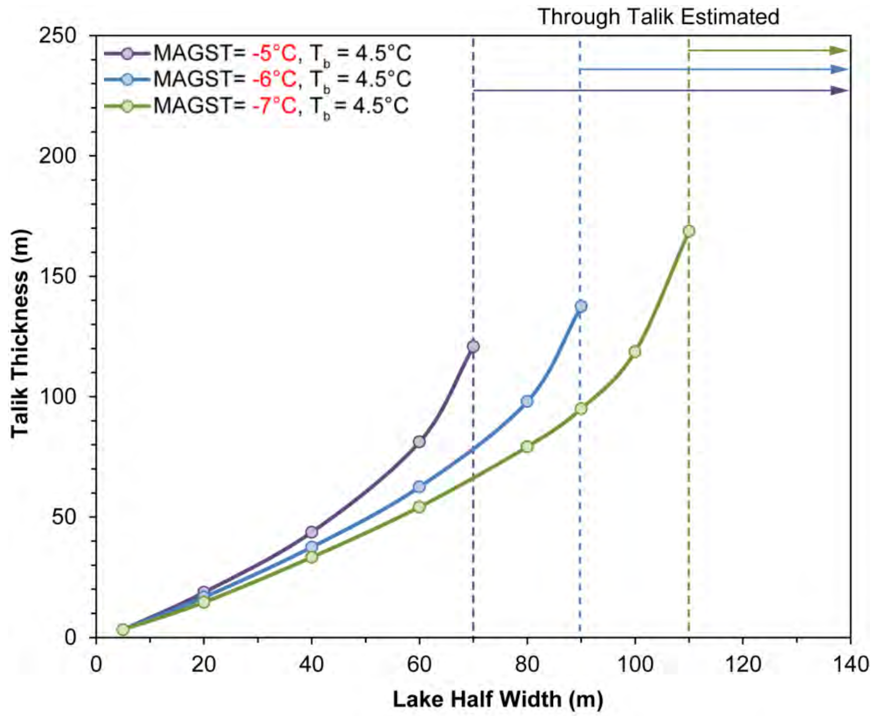
Job No: 1CS020.008

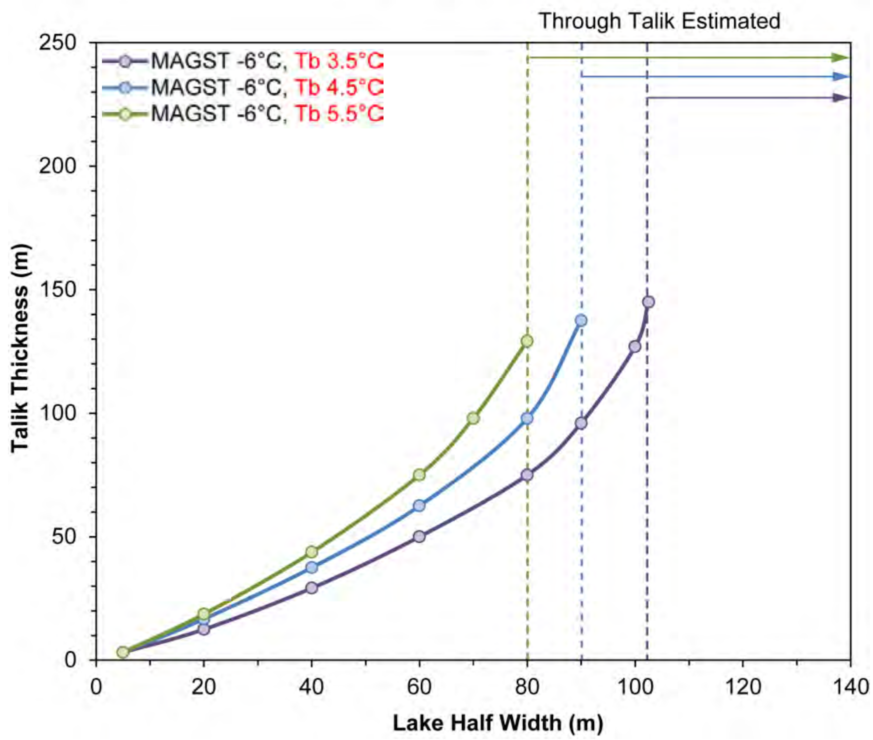
Filename: Figure_1_GW_Memo_Goose

Back River Project

Potential Taliks in the Goose Property

Date: Sep. 2015 | Approved: GF | Figure: 11

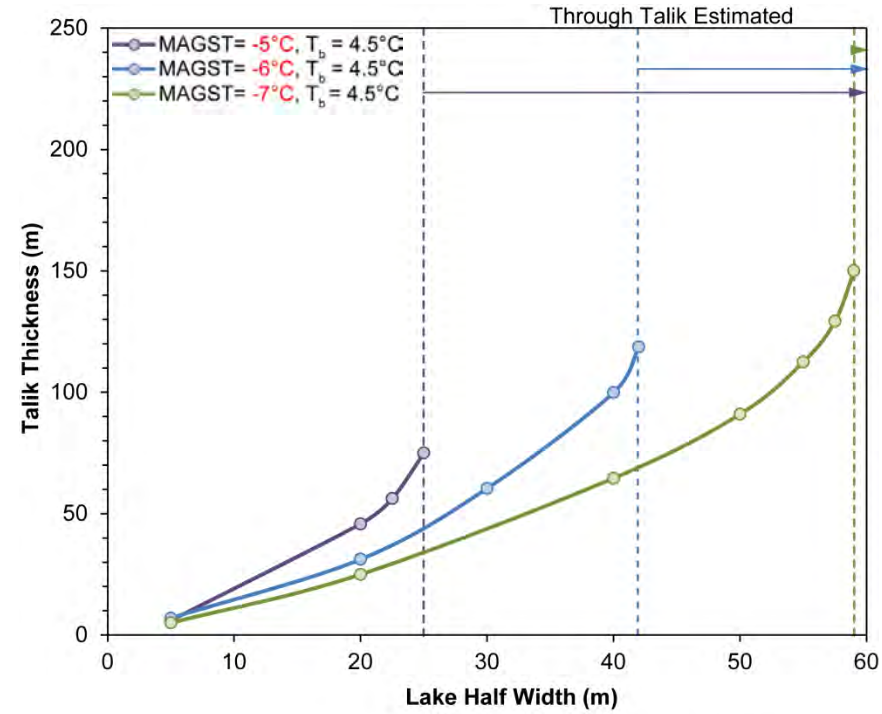


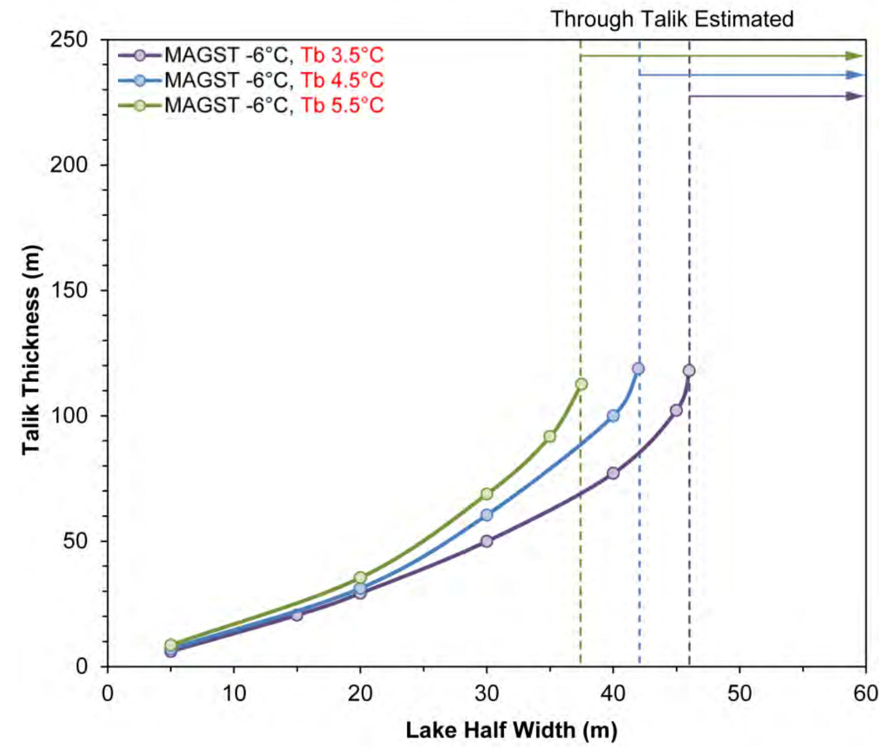


Notes:

1. Talik thickness based on steady state thermal model and 0°C isotherm
2. Mean annual ground surface temperature (MAGST)
3. Mean annual lake bottom temperature (T_b)
4. Lake width is 2 x lake half width
5. Geothermal gradient, 0.014°C/m
6. Dashed line indicates the approximate minimum lake half width to sustain an closed talik. Open talik (through talik) conditions are estimated for lakes with a great half width.

srk consulting	Sabina GOLD & SILVER CORP.	Hydrogeological Characterization and Modeling — **Lake Talik Thickness Based on 0°C Isotherm**
Job No: 1CS020.008 Filename: Fig_SteadyState2DModel.pptx	Back River Project	Date: Sep. 2015 / Approved: cws / Figure: 12





Notes:

1. Talik thickness based on a 2D steady state thermal model and -2°C isotherm
2. Mean annual ground surface temperature (MAGST)
3. Mean annual lake bottom temperature (T_b)
4. Lake width is 2 x lake half width
5. Geothermal gradient, 0.014°C/m
6. Dashed line indicates the approximate minimum lake half width to sustain an closed talik. Open talik (through talik) conditions are estimated for lakes with a great half width.

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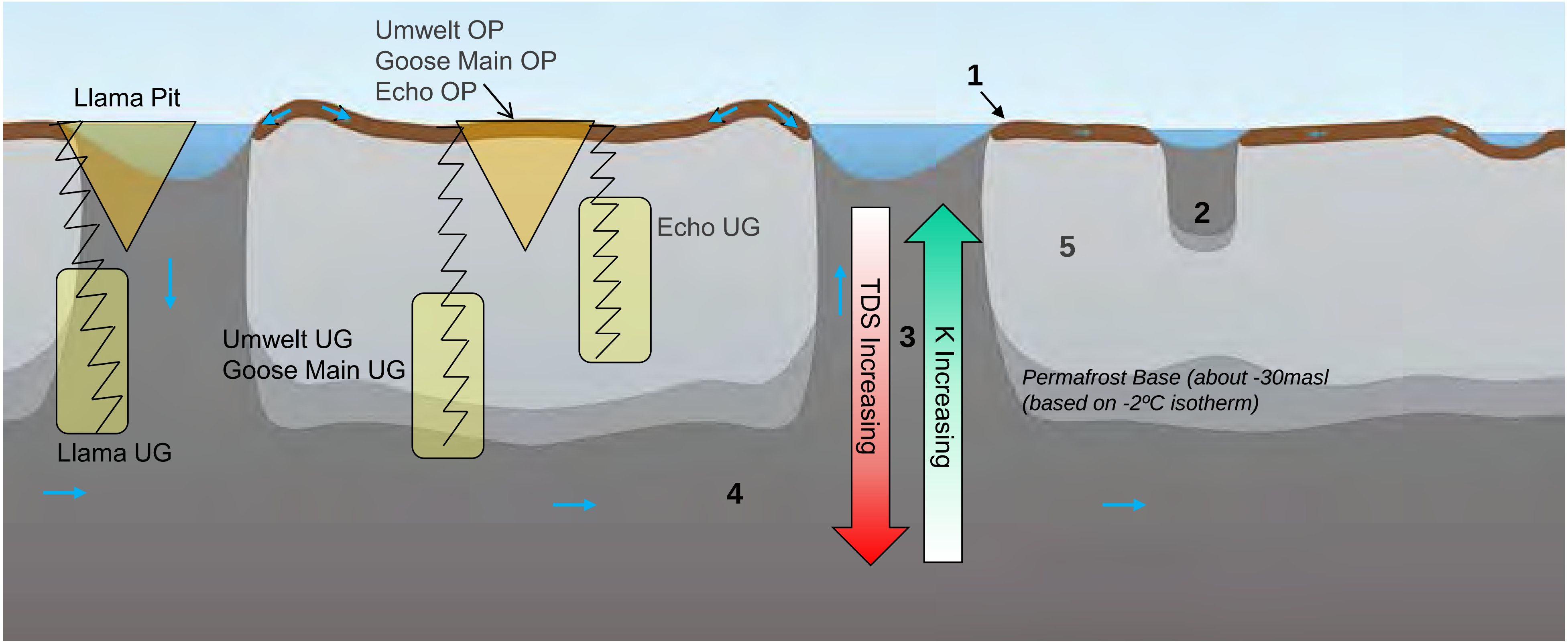
		Lake Talik Thickness Based on -2°C Isotherm
Job No: 1CS020.008	Back River Project	Date: Sep. 2015
Filename: SteadyState2DModel_-2Ccombined_plot.ai		Approved: cws
		Figure: 13



PERMAFROST COMPONENTS:

1 – Active layer.
2 – Closed talik caused by mid-size lake, pond or stream.
3 – Open talik caused by large lake or river.
4 – Sub-permafrost.
5 – Permafrost.

GROUNDWATER FLOW REGIMES

1 – Seasonally flowing[1]
2 – Flowing, not connected to sub-permafrost.
3 – Flowing, connected to sub-permafrost.
4 – Flowing, connected to open taliks.
5 – No flow.

[1]The interception of active layer flow by the pits is considered insignificant because it is not particularly thick, only fluid during the summer months, volumes are small, and the water quality is not saline.

LEGEND

Open Pit
Decline
Underground
Groundwater Flow Direction

Note:
OP – Open Pit
UG - Underground

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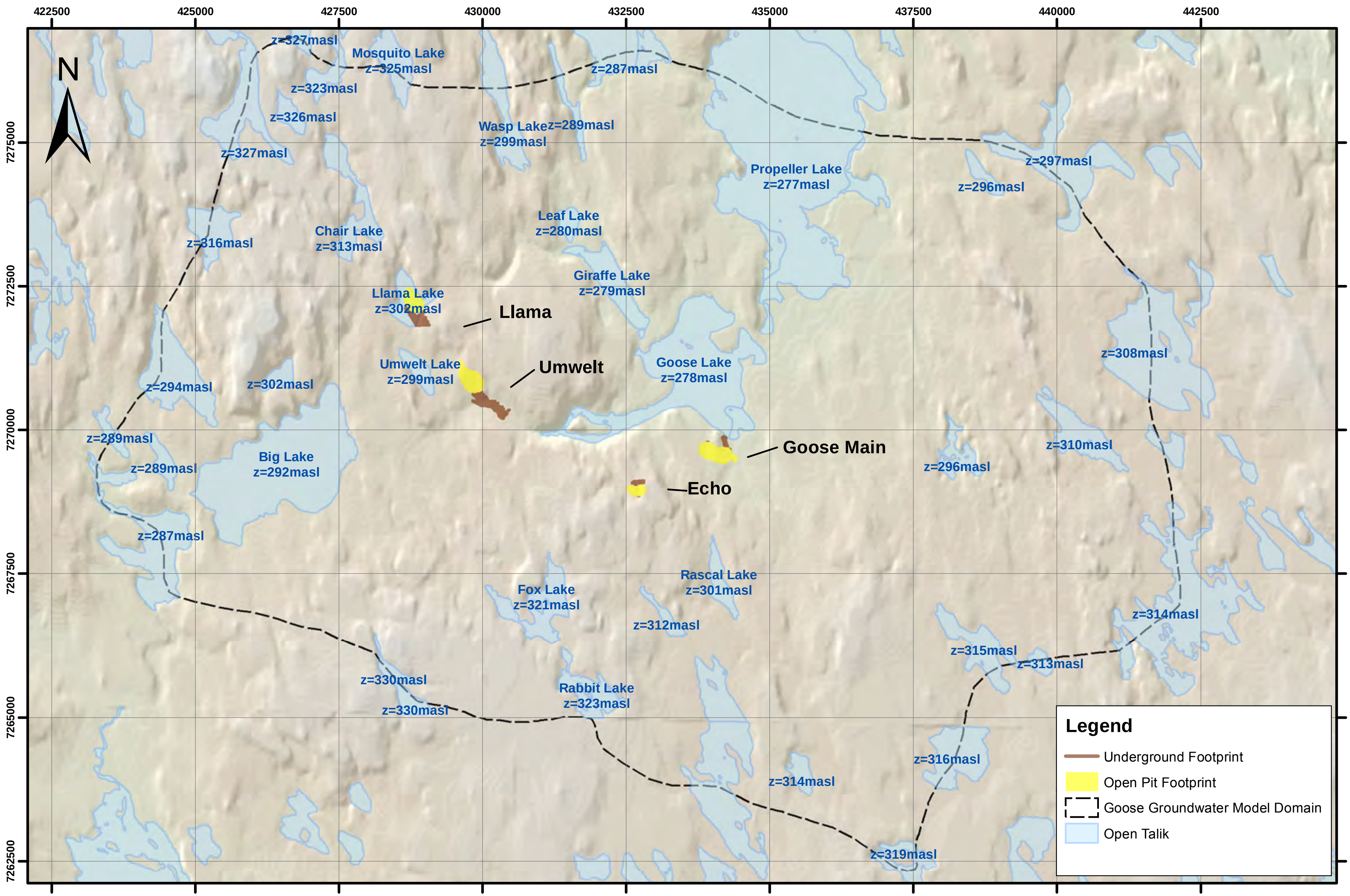
Conceptual Groundwater Model

Job No: 1CS020.008
Filename: BackRiver_LandFigs_8x11_1CS020.008_rev01

Back River Project

Date: Sep. 2015 | Approved: GF | Figure: 14



Kilometers

0 1 2 3 4 5

1:90,000

NOTES:
1. Topographical information from geobase server, Natural Resources Canada (NRCan).
2. Watercourse, waterbody, and island information from CanVec, NRCan.
3. Coordinate System: NAD 1983 UTM Zone 13N
Projection: Transverse Mercator
Datum: North American 1983

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Job No: 1CS020.008
Filename: Fig_Goose_GWM_Domain

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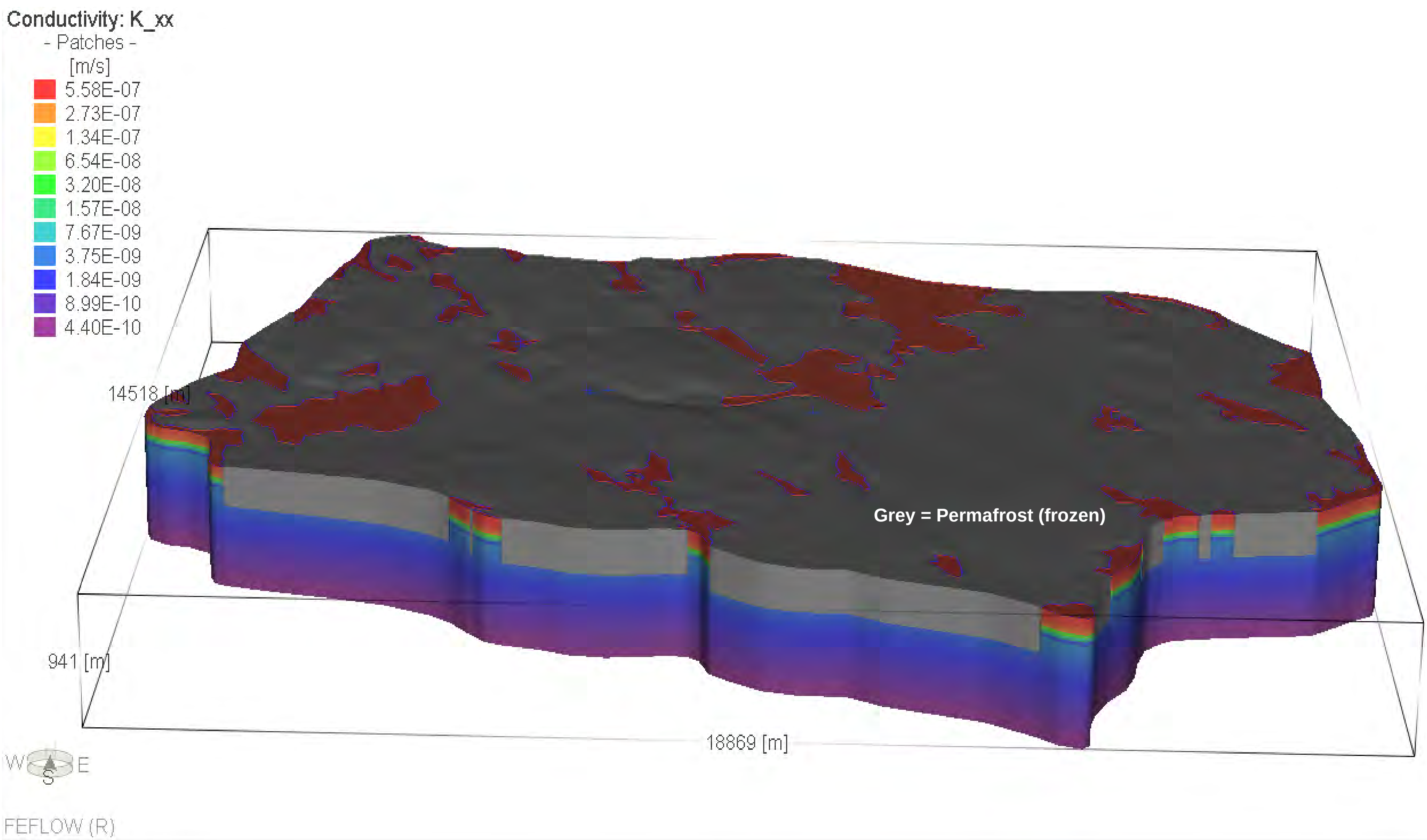
Goose Model Domain

Date: Sep. 2015

Approved: GF

Figure: 15



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Hydrogeological Characterization and Modeling

Goose Groundwater Model in 3D View

Job No: 1CS020.008

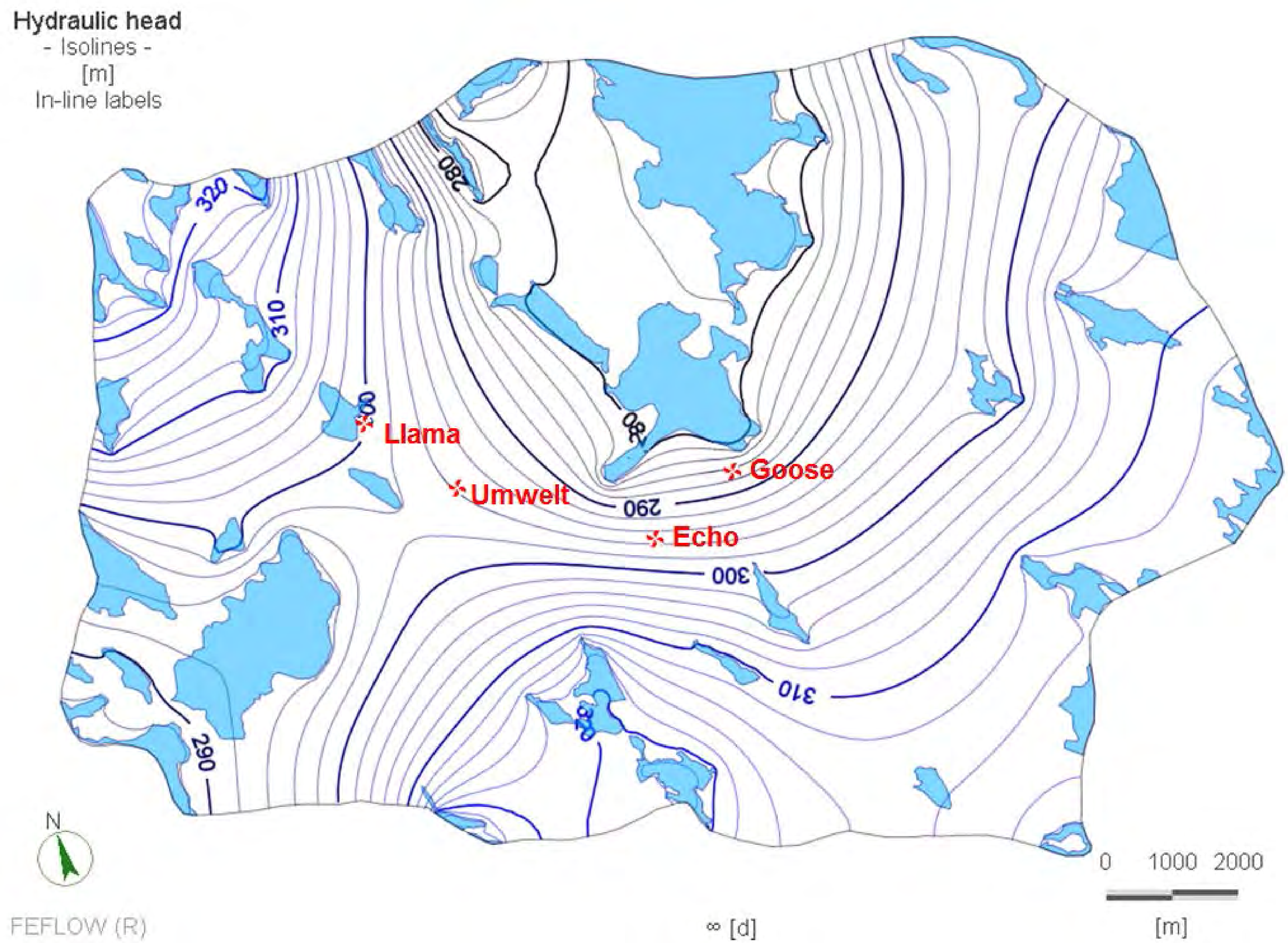
Filename: BackRiver_LandFigs_8x11_1CS020.008_rev01

Back River Project

Date: Sep. 2015

Approved: GF

Figure: 16



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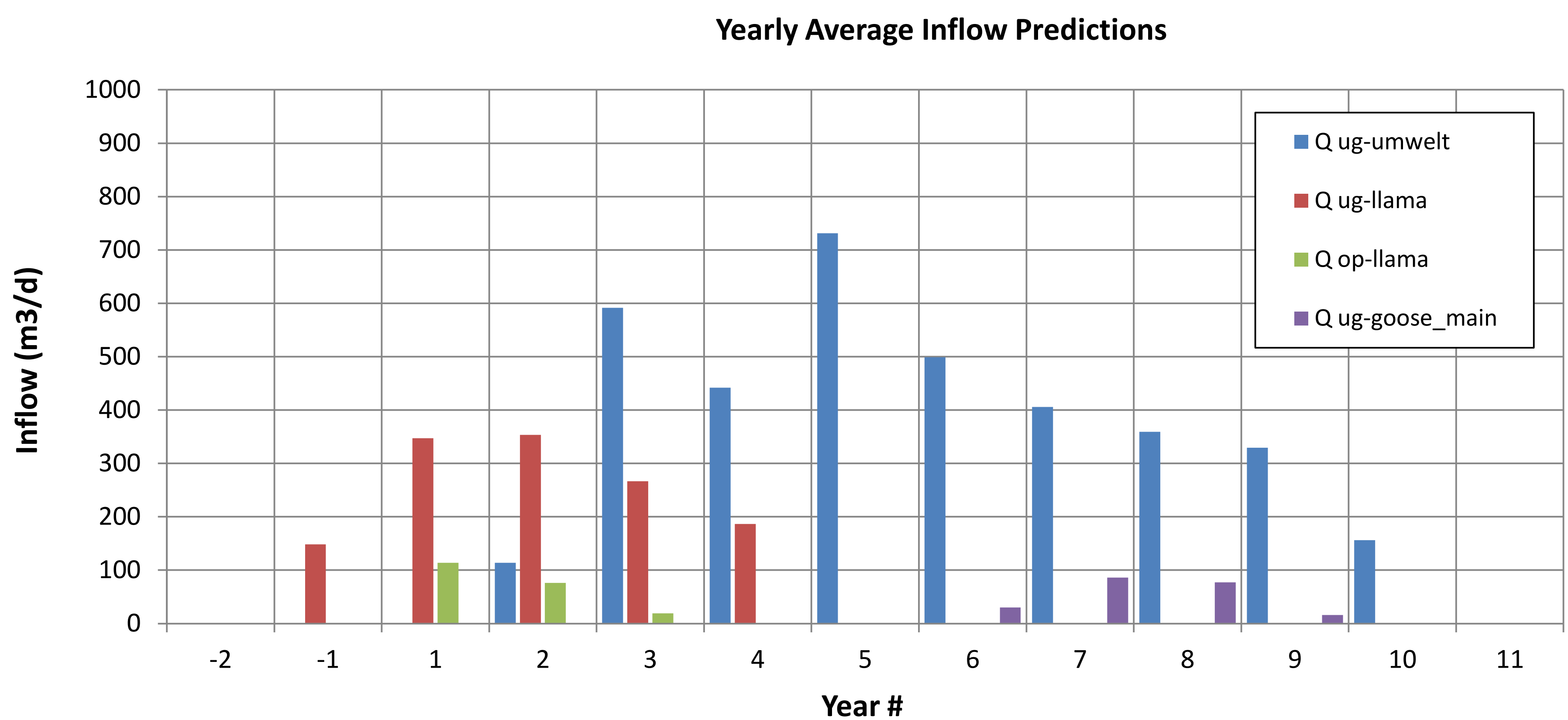
Hydrogeological Characterization and Modeling

Simulated Hydraulic Head at Goose Property for Current Conditions

Job No: 1CS020.008
Filename: BackRiver_LandFigs_8x11_1CS020.008_rev01

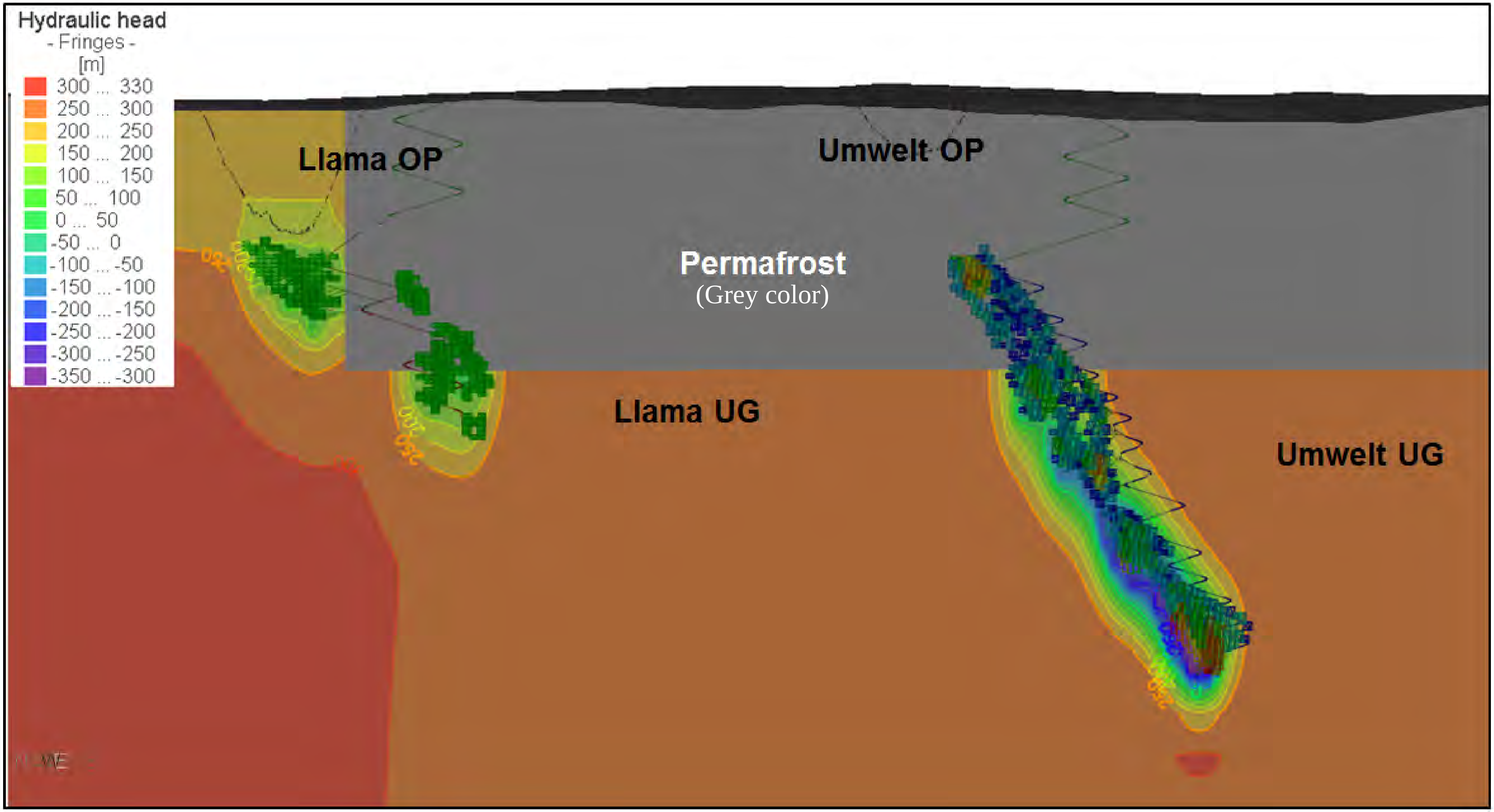
Back River Project

Date:	Approved:	Figure:
Sep. 2015	GF	**17**



Source: \\VAN-SVR0\Projects\01_SITES\Back River\1CS020.008_FEIS\!020_Project_Data\010_SRK\GW_Model\Feflow

srk consulting	Sabina GOLD & SILVER CORP.	Hydrogeological Characterization and Modeling
		Predicted Yearly Inflow for the Goose
Job No: 1CS020.008 Filename: BackRiver_LandFigs_8x11_1CS020.008_rev01	Back River Project	Date: Sep. 2015 / Approved: GF / Figure: **18**



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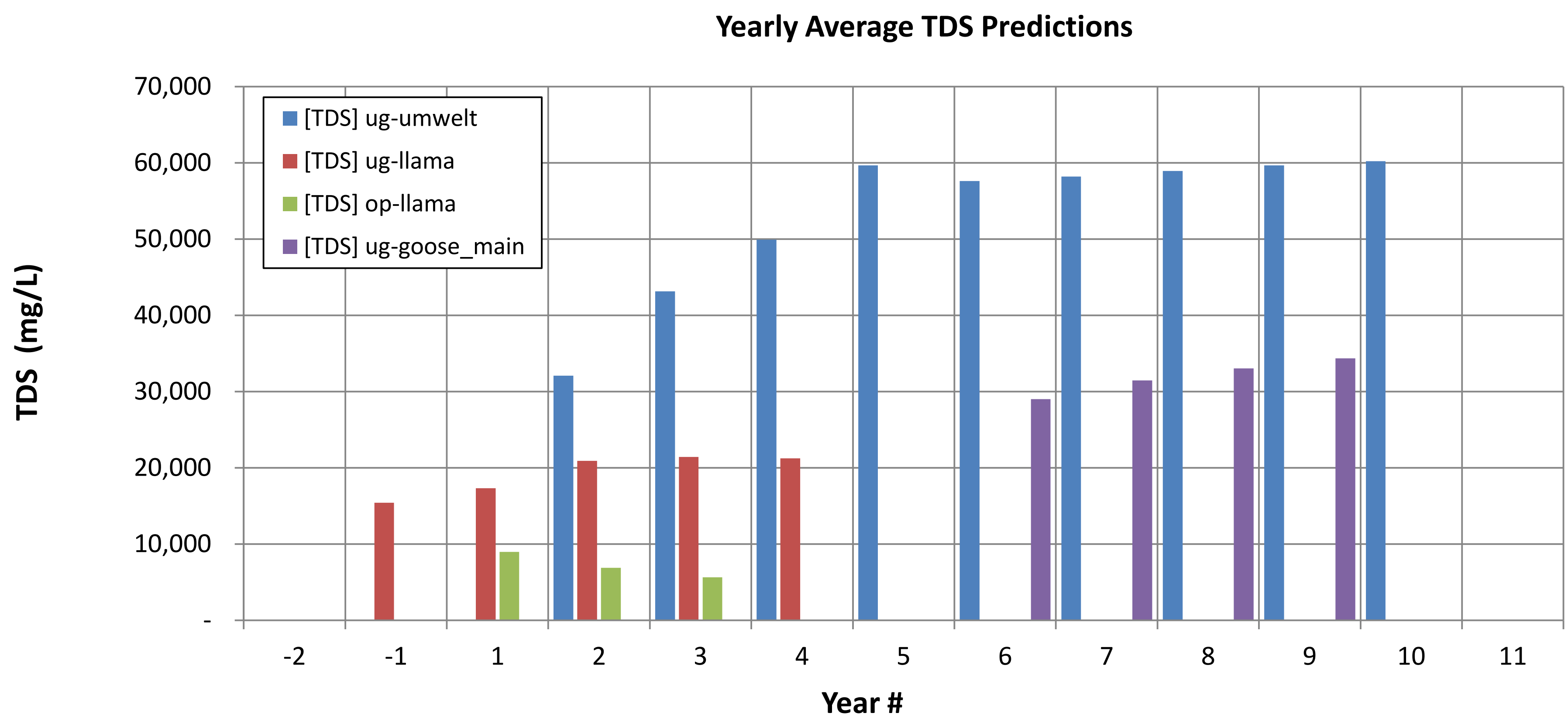
srk consulting	Sabina GOLD & SILVER CORP.	Hydrogeological Characterization and Modeling
		Section Across Llama Pit, Llama Underground and Umwelt Underground, End of Year 3
Job No: 1CS020.008 Filename: BackRiver_LandFigs_8x11_1CS020.008_rev01	Back River Project	Date: Sep. 2015 | Approved: GF | Figure: 19



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srk consulting	Sabina GOLD & SILVER CORP.	Hydrogeological Characterization and Modeling
		Predicted Yearly Average TDS for the Goose Property
Job No: 1CS020.008 Filename: BackRiver_LandFigs_8x11_1CS020.008_rev01	Back River Project	Date: Sep. 2015 · Approved: GF · Figure: **20**

Appendix A: Site Monitoring Map (Knight Piésold, 2013b)