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Memo

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From:	Dan Mackie Gregory Fagerlund	**Project No:**	1CT022.001.410
Cc:	Tom Sharp, SRK Mark Liskowich, SRK	**Date:**	October 31, 2014
Subject:	Hope Bay Project: Madrid Advanced Exploration Project: Underground Inflow Estimates		

1 Introduction and Scope

This memo summarizes updated inflow estimates and inflow water quality for the Madrid Advanced Exploration Project. The project consists of bulk samples at Madrid North and Madrid South.

The Madrid North underground bulk sample area is within the Naartok deposit. It has been determined this bulk sample will be within permafrost. As such, ground water inflows are not an issue and will not be discussed below.

The Madrid South underground bulk sample is within the Patch14 and Wolverine deposits. The mining areas are not expected to be completely within permafrost, thus groundwater inflows are possible. This memo presents estimates of groundwater inflow for use with overall mine water management planning, not engineering design.

The scope includes updating inflow estimates based on the current mine plans and existing data. No new data has been collected specifically for this work, but existing data from Madrid South (and across the entire Hope Bay belt) suggests that bedrock is generally competent and inflows to relatively small mine openings should not be excessive. The modeling approach does not attempt to provide rigorous calibration or incorporate a detailed mine plan; an approximation of the major mine openings are used to test the influence of different assumptions about bedrock hydraulic conductivity on inflow. The groundwater flow system around these mine openings is constrained by the more regional concepts for how groundwater moves in permafrost environments and results are sufficient for the purpose of water management planning.

Figure 1 shows the locations of the Madrid South bulk sample areas relative to Patch and Wolverine lakes.

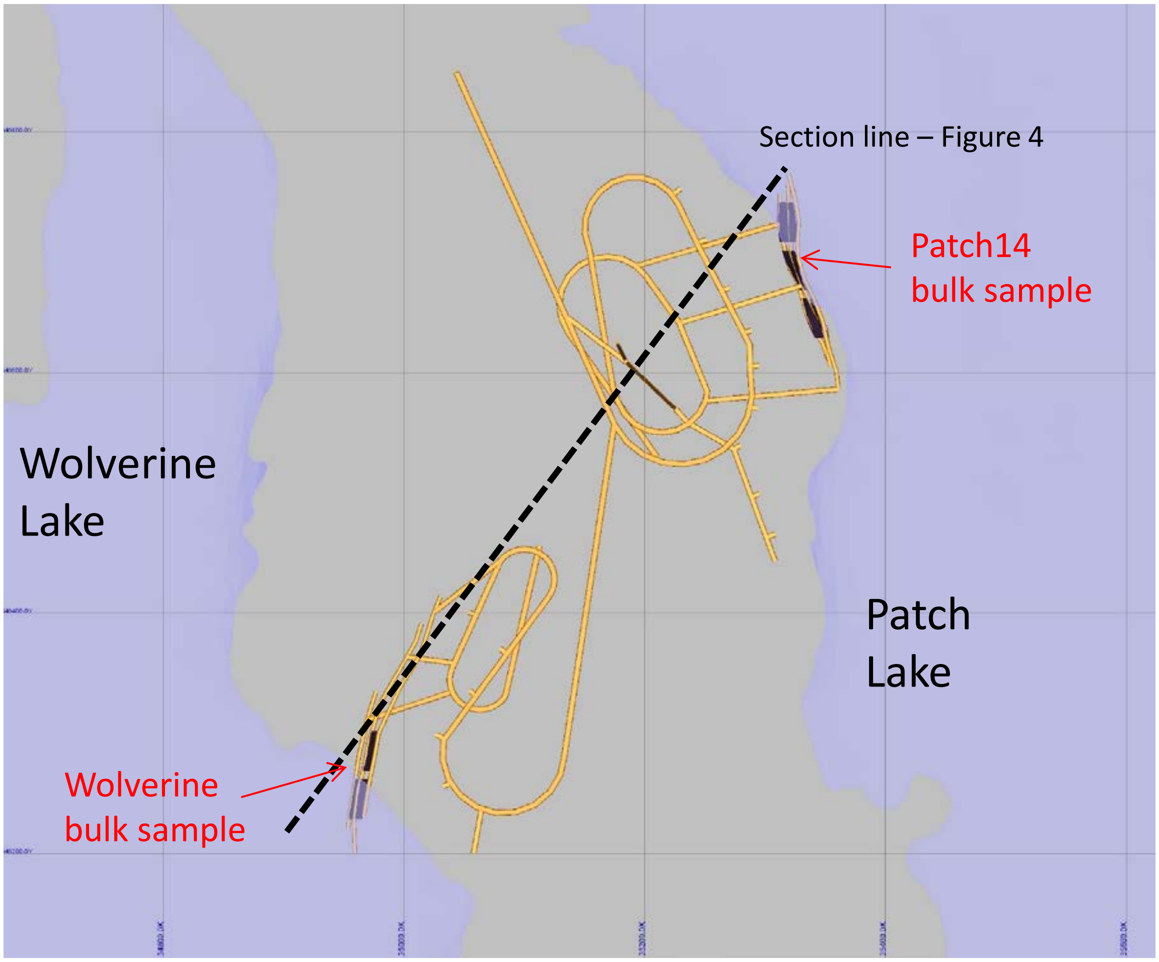

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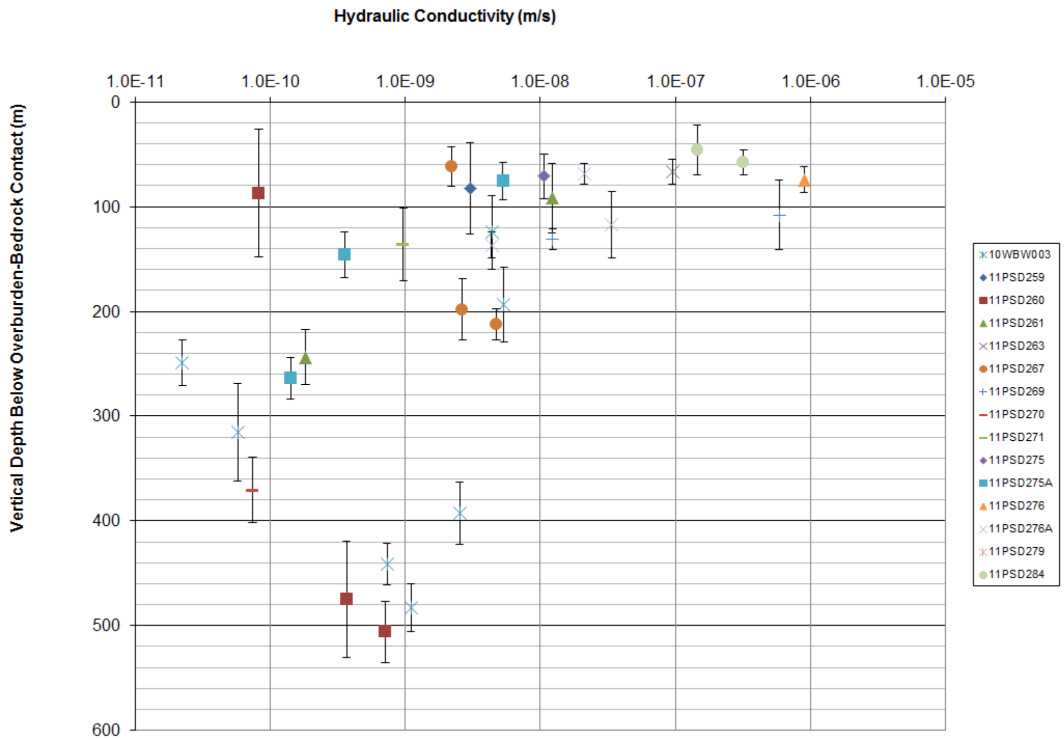
Figure 1: Map of Bulk Sample Locations Relative to Lakes

2 Available Data for Madrid South

2.1 Hydraulic Conductivity

Hydraulic conductivity (K) for the Madrid South area was collected during the 2010 and 2011 field seasons. The hydraulic conductivity (K) was measured through down-hole injection tests during drilling. Figure 3 shows all available data for Madrid South. Figure 4 presents average K by lithologic unit.

Arithmetic mean is provided for average K data because it is considered more appropriate than geometric mean for fractured rock environments. The wide range of K values for a given lithology is typical of the fractured rock environment at Hope Bay. K values are influenced by the presence or absence of discrete, relatively narrow fractures that have higher K than the unfractured bedrock. It is not apparent during drilling what fractures may control water flow (and K), and as a result, the “bulk K” determined by testing over even moderate scale testing intervals (e.g., 25 m) can vary by orders of magnitude.



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Notes:

1) Data presented by drill hole.
2) All PSD drill holes are from Madrid South area.
3) 10WBW003 is from the specific Patch 14 area.
4) Error bars indicate the test zone.

Figure 2. Hydraulic Conductivity vs Depth

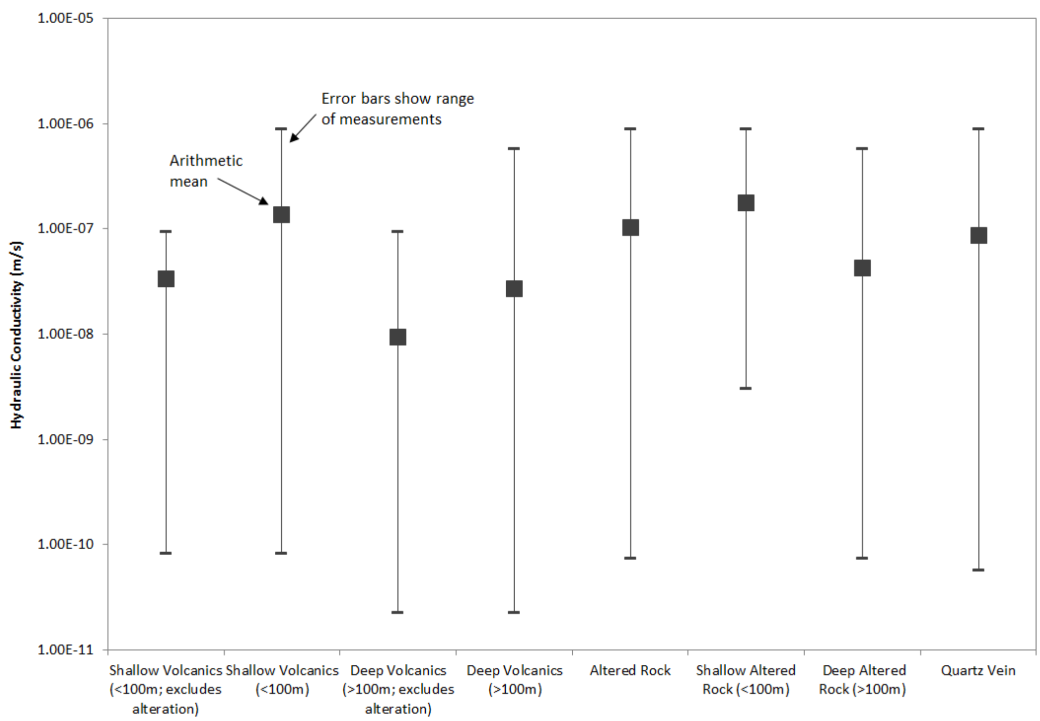

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Figure 3. Hydraulic Conductivity by Lithology

2.2 Permafrost

There are a number of deep thermistor strings in place across the Hope Bay belt that provide information on the likely depth of permafrost, including one string at Patch14 that was installed during the summer of 2014. Data from the Patch14 thermistor string was not available for this work. Estimates of the permafrost distribution were developed based on thermal data from the Doris, Madrid North and Boston areas of the Hope Bay Belt and the analytical model of Andersland and Ladanyi (2004).

Groundwater quality data from Hope Bay (and within the broader Canadian Shield in general) indicate elevated total dissolved solids (TDS) can occur at depth and at relatively shallow depths within taliks (refer to section 2.3). The elevated TDS can depress the temperature at which water actually freezes, creating “cryopegs” or areas where temperature is less than 0 degrees Celsius but water is not frozen. The influence of TDS distribution with depth, and the possibility of freezing point depression, has been considered as part of hydrogeological assessments for other mines in the north (e.g., Meliadine, Meadowbank, Diavik). At Hope Bay, potential freezing point depression was estimated based on water quality data collected from the Doris Central Westbay monitoring well using the following equation:

$$\Delta T = i \times K_f \times m$$

$\Delta T = change\ in\ freezing\ point\ from\ 0\ degrees\ Celsius$

i = numberof i) ions in a molecule or ii) molecular compounds

K_f = freezing point depression constant for water (-1.858 C kg/mol)

$m = molality$

Results suggest a freezing point between about -1 and -2 degree Celsius. Since the water quality at Madrid South is not well constrained, a -2 degree freezing point is assumed.

Figure 4 presents a cross section through the Madrid South Advanced Exploration Bulk Sample showing the -2 degree Celsius isotherm based on results of previous Patch14 thermal modeling (SRK 2010). Permafrost was assumed to start at the shoreline.

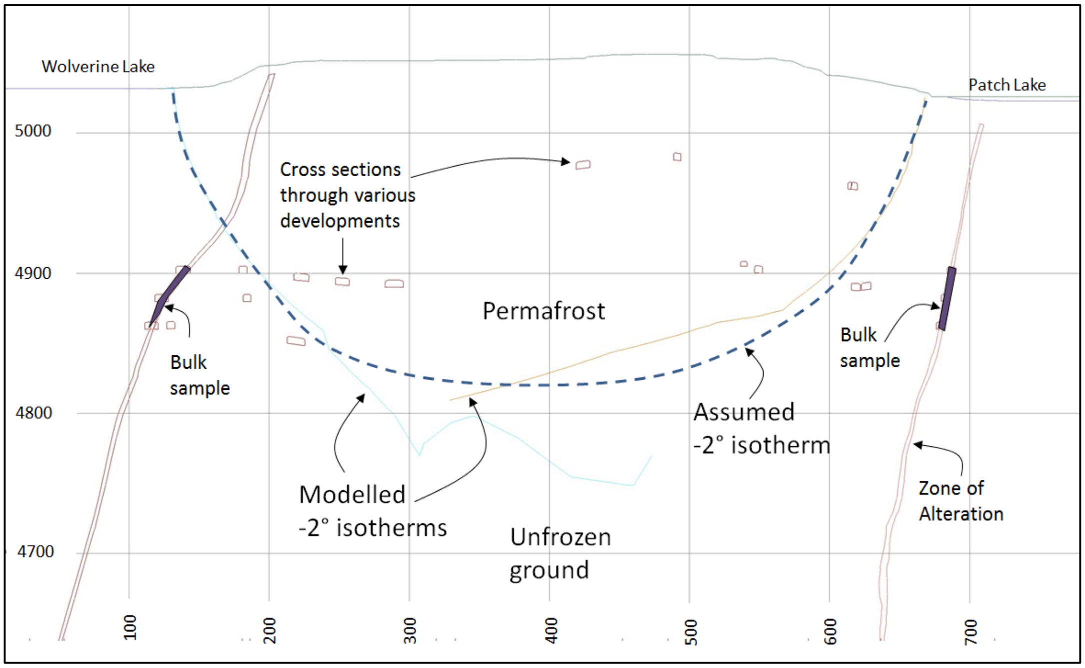

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Figure 4. Cross Section of Bulk Sample areas and -2° Isotherm.

Looking at the map view in Figure 2, a portion of both the Patch14 and Wolverine deposits may be below land and not below the lakebed. In general, a larger portion of the development occuring below land can be assumed to be in permafrost, but the stope areas for the bulk sample are within unfrozen ground.

For Patch14, the deposit is very close to the lake edge and Patch Lake is not particularly deep (about 2 to 3 meters deep to a couple of hundred meters offshore). Under these conditions the lake may freeze to the bottom during winter such that permafrost actually extends under the lake.

2.3 Water Quality

There is no groundwater quality data available for the Madrid South Advanced Exploration Bulk Sample.

Groundwater quality for this area is assumed based on data from Doris and Boston areas. Both areas have saline groundwater at relatively shallow depths in the respective taliks. There is no reason to believe these areas are any different than the Madrid South Bulk Sample. Table 1 presents data from Doris Central that can be used as the assumption for Madrid South Advanced Exploration Bulk Sample groundwater quality.

Table 1. 75th Percentile of Selected Parameters for Hope Bay Waters at Doris Central

		Doris Central		
Parameters	**Units**	**10WBW001 Zone 1 (548 m)**	**10WBW001 Zone 6 (246 m)**	**10WBW001 Zone 10 (63 m)**
pH		7.67	7.65	7.57
TDS	mg/L	44900	37550	38550
Alkalinity	mg/L	2.18	71.6	115
Bicarbonate	mg/L	9.98	56.5	115
Ammonia	mg/L	0.0625	3.44	4.05
Chloride	mg/L	19000	19050	19350
Sulphate	mg/L	976	2025	1853
Calcium	mg/L	4920	1540	1730
Sodium	mg/L	7200	9093	9100
Potassium	mg/L	39	232	258
Magnesium	mg/L	69.5	1480	1310
Dissolved Metals				
Aluminum	mg/L	0.005	0.005	0.005
Arsenic	mg/L	0.002	0.0043	0.002
Cadmium	mg/L	0.00012	0.00007	0.00011
Chromium	mg/L	0.0005	0.0005	0.005
Cobalt	mg/L	0.000059	0.00027	0.00015
Copper	mg/L	0.00083	0.0005	0.0005
Iron	mg/L	0.056	4.5	6.3
Lead	mg/L	0.0003	0.0003	0.0003
Manganese	mg/L	0.73	2.1	1.9
Mercury	mg/L	0.00005	0.00005	0.00005
Molybdenum	mg/L	0.011	0.034	0.013
Nickel	mg/L	0.0016	0.0010	0.00067
Selenium	mg/L	0.002	0.002	0.002
Zinc	mg/L	0.137	0.228	0.0659

Source: \\van-svr0\Projects\01_SITES\Hope.Bay\1CT022.001_2014 Hope Bay Ongoing Support\310_Response to Information Requests\Groundwater Quality 2011

3 Inflow Estimates

Previous estimates for inflows to the Patch14 deposit were developed based on scaling of results from the Doris Central area. When these previous Patch14 estimates were initially completed, there was little K data on which to base any calculations, thus specific modeling was not justified.

Inflow estimates for the Madrid South Advance Exploration Bulk Sample have been updated taking into consideration K data collected since completion of initial results and portions of the bulk sample areas (Patch 14 and Wolverine deposits) that are within the talik zones (as modeled). Revised estimates have been made using a 3D groundwater model.

3.1 3D Numerical Modeling

For the numerical model, the 3D geometry of the Madrid South Advanced Exploration Bulk Sample and the -2 degree Celsius isotherm previously discussed were incorporated into model design. Patch and Wolverine lakes are assigned constant head boundary conditions and the model sides are no flow boundaries. The model is essentially a box with groundwater flow driven by lake levels; this is consistent with the overall hydrogeological conceptual model for the region.

Because the hydraulic conductivity of any given unit is not precisely known, multiple scenarios were assessed. The scenarios represent a reasonable set of hydraulic conductivity distributions that could occur, and provide a range of potential inflows. Table 2 summarizes results.

Further details on the 3D model are provided in Section 4.

Table 2. Inflow Estimates (m^3/d).

Scenario	Best Case	Best Judgement	High Inflow Case 1	High Inflow Case 2
	K of deep volcanic rock = 1x10-10 m/s	K is observed mean for each rock formation	Worst Case K is maximum observed for each rock formation	Reasonable Case K for for deep volcanic or altered rock is maximum observed
Patch14 Deposit	11	60	672	300
Wolverine Deposit	5	35	401	200
Total Inflow	16	95	1073	500

Sources: “case_list&Inflows.xlsx”`

The results from the 3D groundwater model are consistent with previous calculation.

The Best Case scenario demonstrates that inflows to the Patch 14 and Wolverine deposits may not be an issue for the project if K of deep volcanic rock remains low.

The “Best Judgement” case is thought to be a reasonable indication of average inflow conditions that could be observed.

High Inflow Case 1 represents the maximum inflows that may occur if K of the volcanic and altered rock were characterized by the maximum K values reported from observations. This scenario represents extreme conditions that are highly unlikely to occur.

High Inflow Case 2 represents inflows that could occur if K of the deep volcanic rock and alteration zone are represented by the maximum K values observed. This high flow scenario is considered more plausible than Case 1.

For the purposes of water management design it is recommended that results of Case 2 be used. The results from Case 2 represent a reasonable design basis for average inflow *when working in talik areas*.

4 3D Groundwater Model

4.1 Model Geometry

The model domain covers an area of 870,000 m^2. The limit of the domain was defined according to the spatial extent and water elevations of Patch and Wolverine Lakes as well as consideration for potential groundwater flow directions between taliks.

The finite element mesh has 1,831,260 elements with average element dimensions varying gradationally depending on what model elements represent. The mesh is largest in areas outside of the underground developments (average dimensions of about 10 m x 10 m), and smallest at the stopes (average dimensions of about 2 m x 2 m).

The layer thickess is 20 m for the ground surface to 200 m depth and 20 m from 20 m to 400 m depth.

4.2 Model Boundary Conditions

The Patch and Wolverine Lakes are assigned with a constant head node and respectively assigned with head values of 34 m mean annual sea level (masl) and 25 m masl. The stopes are assigned with seepage conditions.

4.3 Model K Values

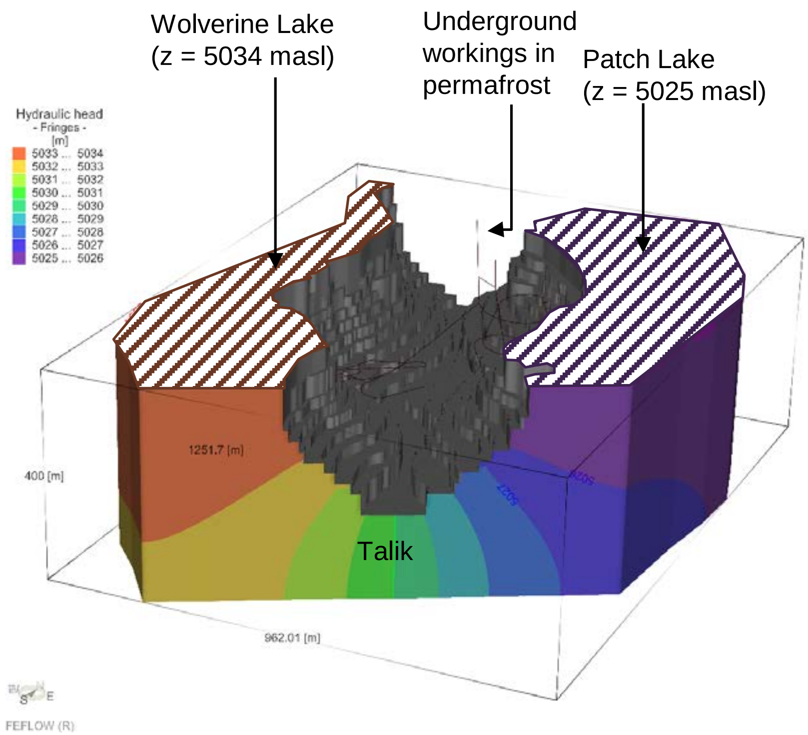
There are four distinct rock formation represented in the Groundwater Model. K for each formation are compiled in Table 3. The spatial distribution of these formations were defined from the Gemcom model.

All simulations were run at steady state; therefore, storage properties are not defined.

Table 3. Hydraulic Conductivity Values.

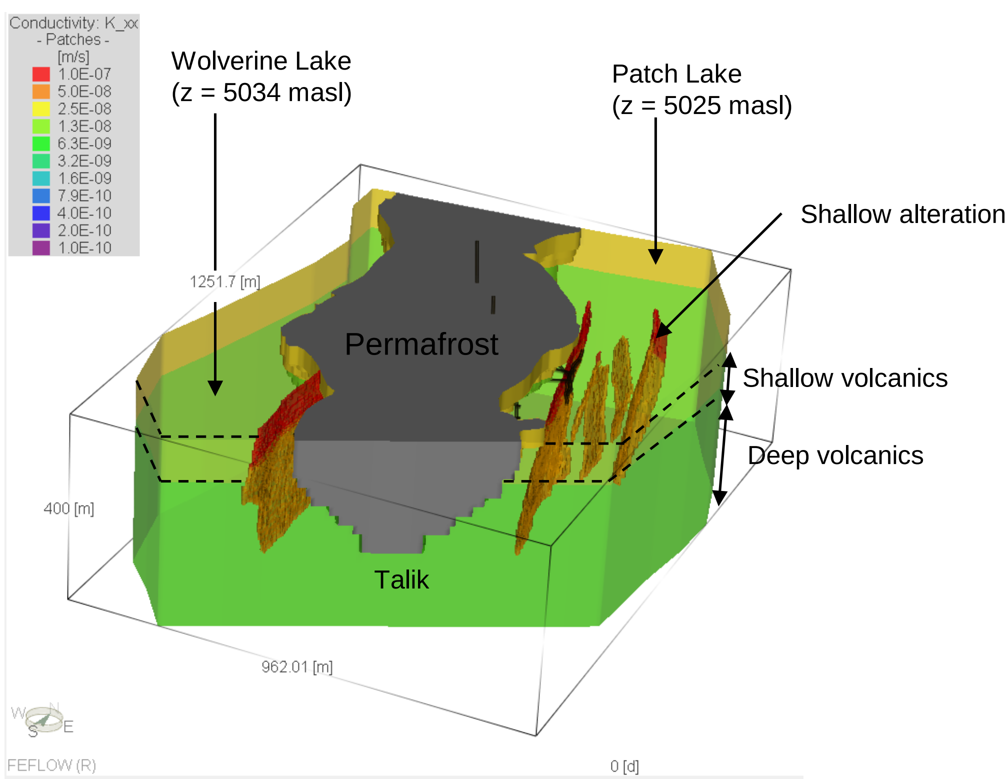
Material	K_{min}	Selected	K_{max}
Shallow Volcanics	$1x10^{-10}$	$3x10^{-08}$	$1x10^{-07}$
Deep Volcanics	$1x10^{-10}$	$9x10^{-09}$	$1x10^{-07}$
Shallow altered	$1x10^{-09}$	$1x10^{-07}$	$1x10^{-06}$
Deep altered	$1x10^{-10}$	$7x10^{-08}$	$1x10^{-06}$

4.4 Model Screenshots



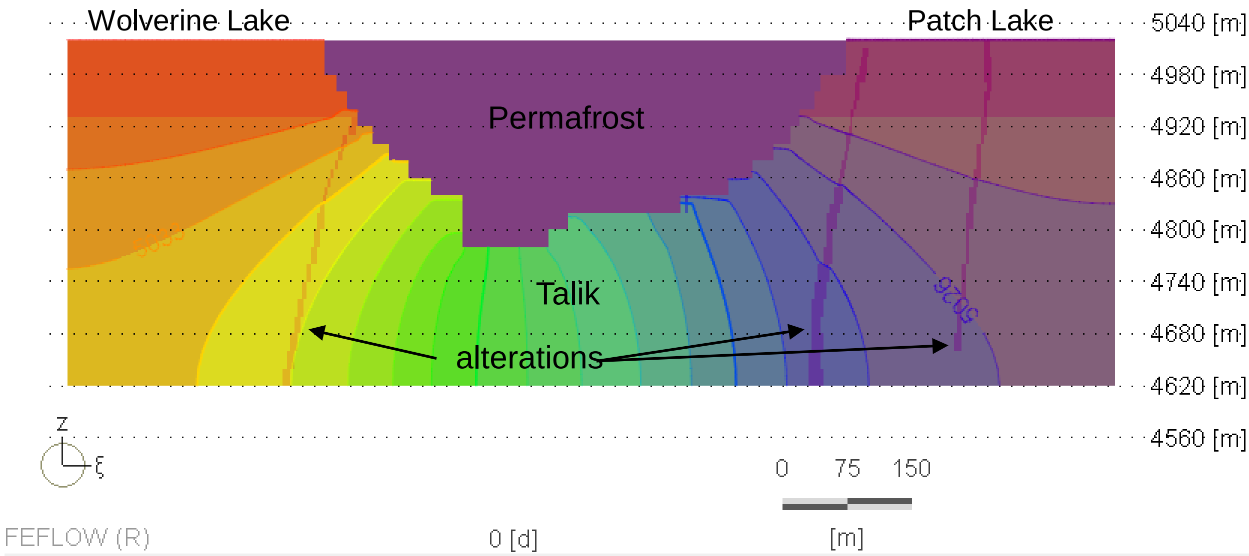
Note: Elevation in mine grid coordinates.

Figure 5: 3D View of the Groundwater Model Showing Hydraulic Head (m).



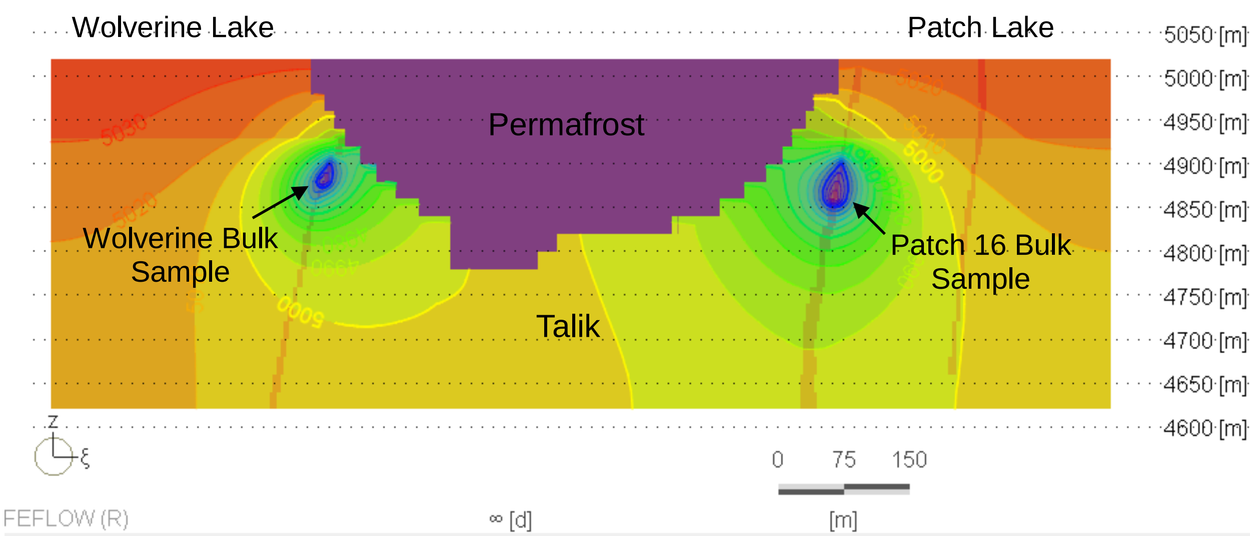
Note: Elevation in mine grid coordinates.

Figure 6: 3D view of the Groundwater Model Showing Conductivity (K m/s)



Note: Elevation in mine grid coordinates.

Figure 7: Cross Section Across the Stopes Showing the Distribution of Hydraulic Head at Time = 0



Note: Elevation in mine grid coordinates.

Figure 8: Cross Section Across the Stopes Showing the Distribution of Hydraulic Head after Bulk Samples are Extracted at time = ∞

5 References

Andersland and Ladanyi, 2004. Frozen Ground Engineering, Second Edition. ASCE Press and John Wiley & Sons. 363p.

SRK Consulting (Canada) Inc., 2010. Possible Permafrost Conditions at Patch14. Technical Memorandum prepared for Newmont Mining Corporation., Project Number: 1CH008.013. December 1, 2010.