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Project Memorandum

To:	**KGHM Ajax Mining Inc.**	**Doc. No.:**	**BGC-006**
Attention:	**Nettie Ore**	**cc:**	
From:	**Cassandra Koenig**	**Date:**	**May 30, 2016**
Subject:	**Ajax Project EA/EIS – Responses to Information Requests COK-SLR568 and ECCC-001**		
Project No.:	**1125011**		

1.0 INTRODUCTION

The *Ajax Project Environmental Assessment Certificate Application / Environmental Impact Statement for a Comprehensive Study* was issued in January 2016 (KAM, 2016). Comments and Information Requirements (IRs) were provided to KGHM Ajax Mining Inc. (KAM) on February 22, 2016 by the City of Kamloops (COK), Environment and Climate Change Canada (ECCC), and Stk'emlupsemc Te Secwepemc Nation (SSN) following a review of the Application and supporting documents.

Several IRs were received that pertained to the prediction of seepage losses from Jacko Lake as a result of Project development. Further questions and comments were raised at the Water and Fish sub-Working Group Meeting hosted in Kamloops, BC on April 6, 2016. This memorandum documents responses to questions/comments raised at this meeting, as well as for the following IRs: COK-SLR568 and ECCC-001. Additional IRs with questions/comments related to Jacko Lake seepage include SSN-328 and SSN-329. Proponent responses to these IRs can be found in 0414_KAM_JL_Ptest_BGC-012.

2.0 PERMIT INFORMATION REQUIREMENT RESPONSES

2.1. Information Request Summary

2.1.1. COK-SLR568

The following comment was provided in COK-SLR568:

- *Concern that predictions of the groundwater flow and subsurface hydraulic connection between Jacko Lake and the mine pit may be more than predicted and therefore underestimate the potential effects of mine dewatering on the lake and the volume of groundwater flowing to the pit from the lake. See MEMO NUMBER - SLR017.*

Further questions and comments contained in memo number SLR017 are summarized below:

- *The potential effect on Jacko Lake has been investigated, and specific impact assessment made. It is a stated important undertaking to ensure that Jacko Lake is not adversely affected by this undertaking. The proponent has undertaken field drilling and testing to examine this issue. The groundwater flow model has been used to predict impacts. Our review has considered the documented information and how it was used in the model, and we are concerned that the predictions have not been conservative in nature and that the effect[s] on Jacko Lake have been understated.*
- *The new pit will be 435 m deep, as opposed to the current pit which is about 50 m deep, and thus the driving head from the lake to the pit will be far greater than before. Since it will also be much closer, then the horizontal gradients will also be very high. For these reasons, it is prudent to examine the analyses which suggest the leakage will be minimal.*
- *The lake was recently raised by 4 m with the construction of four dams. The nature of the new sides to the lake should be investigated to see if they share the same blanket of low permeability materials.*
- *Consideration should be given [to] re-examining the sensitivity analysis in this area [i.e. between Jacko Lake and the open pit], to see what would happen if a higher K were actually present in this area on the basis of geologic distribution.*
- *We note that the modelling has assumed a fixed head in Jacko Lake (Section 5.5.1 of the KCB report). Whereas this maximizes projected losses from the lake, it does not account for potential draining of the lake. Lake inflow and outflow appears to be 25 L/s coming from the catchment area, and then discharged to Peterson Creek at the dam overflow. If the groundwater losses exceed 25 L/s, then the lake level will deplete. This should be considered when examining the more permeable scenario discussed above.*
- *It appears that the modelling uses the low end of the range of possible [bedrock] hydraulic conductivity and thus may under-predict [Jacko Lake seepage] losses in the direction of the pit. Should the bedrock bulk hydraulic conductivity value be higher by an order of magnitude, which may reasonably be inferred from the measured values, would this mean ten times the loss, say 15 L/s?*

2.1.2. ECCC-001

- *There are a number of vertical and sub-vertical faults within the proposed project area and weak rock formations within the western sector of the Ajax pit.*
- *Assess the potential for groundwater seepage from Jacko Lake to the proposed Ajax pit via sub-vertical fault structures present in the western sector of the pit. What hydraulic conductivities and volumes are probable?*
- *Should it be determined that groundwater seepage may occur, provide mitigation measures to reduce potential impacts to groundwater and surface water quality.*

2.2. Information Requirement Response

Development of the proposed Ajax Project (the Project) will include expansion of the existing open pits located immediately east of Jacko Lake (Figure 01). As mining progresses, a dam will be required within the northeast arm of the lake to allow development of the proposed open pit while maintaining the current average water level of about 892 masl. Note that COK-SLR568 incorrectly states that the lake was recently raised by 4 m with the construction of four dams. The reviewer is referred to Supplementary Memorandum “0706_KAM_Fish Compensation Plan” for Jacko Lake dam design information.

Pit lakes are present within the existing open pits with water levels of about 837 masl and 875 masl (Application/EIS Appendix 6.6-A). The existing pit lakes are interpreted to be approximately 15 m to 50 m below an estimated pre-disturbance groundwater elevation of about 890 masl after more than 20 years post-mining.

The Proponent developed a groundwater flow model using 3-D MODFLOW-SURFACT (Hydrogeologic Inc., 1996) that incorporated prevailing hydrostratigraphic conditions across the study area. The model was used to evaluate potential Project effects on the physical groundwater system (see Section 2.0; Application/EIS Appendix 6.6-D) and surface water resources such as Jacko Lake during operation of the mine and following the post-closure period.

Several IRs and questions/comments posed at the sub-Working Group Meeting have been received by the Proponent pertaining to the prediction of seepage losses from Jacko Lake as a result of Project development. In general, these questions and comments have focused on three main topics, including:

- Geologic and Hydrogeologic Data: What data is available to characterize the distribution, thickness, and hydraulic conductivity of materials controlling Jacko Lake seepage?
- Groundwater Flow Model: How has the available geologic and hydrogeologic dataset been represented within the groundwater flow model? Was the dataset used to inform sensitivity analyses conducted to put conservative brackets on estimated seepage losses from Jacko Lake?
- Mitigation: What monitoring and mitigation measures will be implemented by the Proponent to reduce potential impacts to Jacko Lake and surrounding surface water and groundwater quality?

In order to address these questions, this memorandum summarizes:

- Geologic and hydrogeologic data available within the vicinity of Jacko Lake and the proposed open pit,
- Groundwater flow model results contained within the Application/EIS,
- Results of further simulations conducted since submission of the Application/EIS,

- Monitoring and mitigation plans
- General conclusions and proposed path forward.

The following sections draw upon information contained within Appendix 6.6-A and Appendix 6.6-D of the Application/EIS as well as within 0414_KAM_JL_Ptest_BGC-12.

Geologic Data

Drilling investigations in support of design and environmental assessment of the Project were not permitted within the footprint of Jacko Lake due to concerns raised by the SSN. Therefore, lake bathymetry and the distribution of materials underlying the lake were evaluated using geophysical methods (Appendix A; Application/EIS Appendix 6.6-A) and results from investigations (Klohn Leonoff, 1988) conducted within the current footprint of the lake, but prior to the last lake level raise completed as part of habitat mitigation for the historical mining in the Project area. Results of this study indicated that Jacko Lake ranges in depth from about 24 m at its center to 2 – 3 m within its northeast and southeast arms. Most of the lake's volume is contained within its central portion as the lakebed drops off rapidly from the shoreline and western margin of the northeast and southeast arms. The lake morphometry generally conforms to the bedrock surface which features a depression (i.e., elevation of about 850 masl) at the center of the lake. Within the central portion of Jacko Lake, glacial till overlies the bedrock surface with general thickness of 2 m to 6 m (0 m to 9 m range). The till is in turn overlain by lakebed sediments primarily comprised of fine-grained clay and silt successions with typical thickness of 8 m to 12 m (0 m to 18 m range) resulting in a minimum of about 10 m of sediment overlying the bedrock. Within the northeast arm of Jacko Lake, 4 m thick clayey silt lake bed sediments overlying glacial till were observed in a test pit prior to the lake being raised to its current level. No information is currently available to characterize sediments within the southeast arm.

Geologic mapping within the Project area indicates that overburden in the vicinity of Jacko Lake and the open pit is comprised primarily of glacial till, along with glaciofluvial and fluvial deposits, and more recently modified anthropogenic deposits (i.e., during historic mining; Drawings 06 and 07, Application/EIS Appendix 6.6-A). Available subsurface information consists of geologic observations derived from 18 boreholes along with several test pits and hand auger locations (Drawing 03 and Appendix A, Application/EIS Appendix 6.6-A) distributed across the area between Jacko Lake and the open pit. These observations indicate the following general characteristics:

- The overburden consists primarily of sandy to silty clay till.
- Discontinuous sand and gravel layers of variable thickness (i.e., less than 1 m to greater than 11 m) are interspersed within the till and are prevalent within the mapped area of glaciofluvial/fluvial deposits.
- Near-surface (i.e., less than 1 m) deposits adjacent to the current shoreline of Jacko Lake are primarily composed of silty to clayey materials (Appendix A; Application/EIS Appendix

6.6-A). Geologic information below this depth is unavailable due to site investigation restrictions.

The surficial deposits typically vary from 10 m to about 40 m between Jacko Lake and the existing pits (Figure 4, Application/EIS Appendix 6.6-A); although along the lake's southeastern arm consistently thicker deposits of about 40 m have been encountered.

Bedrock underlying the glacial till consists of rocks from the Nicola Group Volcanics, Iron Mask Batholith (Sugarloaf Diorite, Sugarloaf Volcanic Hybrid, and Iron Mask Hybrid units), and picrite (Drawings 04, 05, and 08; Application/EIS Appendix 6.6-A). The Edith Lake Fault Zone (ELFZ; Drawing 04, Application/EIS Appendix 6.6-A) has been mapped to extend from Wallander Lake to Edith Lake in a northwest to southeasterly direction within the Nicola Group Volcanics and underlies the western edge of Jacko Lake. Faults and shear zones encountered during drilling between Jacko Lake and the open pit have generally been closed and/or infilled with clay or gouge. No discrete open faults were encountered during recent drilling programs between Jacko Lake and the open pit (Appendix A; Application/EIS Appendix 6.6-A).

Hydrogeologic Data

Results of hydrogeologic testing (i.e., air lift, slug, packer, and pumping tests) conducted between Jacko Lake and the open pit have generally indicated low hydraulic conductivity within both the overburden and bedrock. Within the vicinity of Jacko Lake and the open pit (i.e., area shown in Figure 01), 142 quantitative estimates of hydraulic conductivity (i.e., slug, packer, and pumping tests) have been obtained from tests conducted in piezometers, monitoring wells, open boreholes, and test pits. Nineteen of these hydraulic conductivity tests were obtained from surficial materials (Table 01 and Figure 02) with the remaining 123 obtained from within the bedrock (Table 01 and Figure 03). The test results from the vicinity of Jacko Lake and the open pit indicate similar hydraulic conductivity ranges for each material as compared to the larger Project area and regional study area for both surficial deposits and bedrock (Tables 01 and 02).

Within the bedrock, the geometric mean hydraulic conductivity (i.e., $2x10^{-8}$ m/s; Table 01) from point-scale tests (i.e., slug and packer tests) was similar to ranges estimated from pumping test results (i.e., 1.7×10^{-8} m/s to 4.1×10^{-8} m/s; BGC, 2011). The close agreement of the geometric mean hydraulic conductivity from point-scale test results with the larger-scale, best-fit estimates of hydraulic conductivity obtained from the pumping test interpretation provide good confidence in the characterization of the bulk permeability of the fractured rock mass in this area of the Project. Furthermore, characterization of the hydraulic conductivity of faulted and sheared rock along with contacts between rock units was a specific focus of the investigations within the pit area. Compilation of packer and slug testing results evaluating hydraulic conductivity of these features demonstrates that with the exception of test results in one borehole investigating the ELFZ, the distribution of hydraulic conductivity with depth for faults, shears and material contacts is consistent with the larger data population (Figure 04).

Groundwater Flow Model

The groundwater flow model developed by the Proponent incorporated geologic and hydrogeologic data from within the vicinity of Jacko Lake and the open pit as well as from the regional study area (Application/EIS Appendices 6.6-A and 6.6-D). Hydrostratigraphic units were defined within the model based on available geologic mapping, subsurface information (e.g., borehole data), and KAM's 3D geology model (i.e., within the proposed open pit area).

Memo number SLR017 specifically points to Appendix K (K-1, Application/EIS Appendix 6.6-A), containing a regional interpretation of the extent of glaciofluvial deposits and suggests that the mapped glaciofluvial deposits may not have been conservatively represented within the model as a continuous, high permeability (i.e., "…as high as 10^{-5} m/s") hydrostratigraphic unit. It should be noted that memo number SLR017 fails to note the more discontinuous nature of these deposits when mapped at a finer scale as also presented on the following page of Appendix K (K-2, Application/EIS Appendix 6.6-A).

However, to clarify, within the numerical groundwater flow model these glaciofluvial deposits were represented as a continuous (Figure 02 below; Figure 08, Application/EIS Appendix 6.6-D), higher hydraulic conductivity (i.e., 1.4×10^{-5} m/s; Table 02 below; Table 01, Application/EIS Appendix 6.6-D) hydrostratigraphic unit as constrained by available borehole data. Furthermore, all surficial deposits overlying the bedrock were assumed to be uniform with depth (Section 5.2.1, Application/EIS Appendix 6.6-D). As a result, the thickness of coarse materials within the mapped extent of these glaciofluvial/fluvial deposits between Jacko Lake and the open pit was likely over-estimated as thick sequences of dense silty to clayey glacial till have generally been found to be interspersed (Appendix A, Application/EIS Appendix 6.6-A). In this respect, the numerical groundwater flow evaluation of seepage from Jacko Lake to the proposed open pit via these sediments is considered to be reasonable and conservative.

The groundwater flow model was calibrated using a combination of manual and automated techniques using steady-state (i.e., no change in groundwater storage) and transient (i.e., incorporates groundwater storage inflow/outflows) scenarios (Section 5.4, Application/EIS Appendix 6.6-D). During this process, the hydraulic conductivity of hydrostratigraphic units was permitted to vary across measured ranges (see Table 05, Application/EIS Appendix 6.6-D; see also memo 0415_KAM_Model_Calibration_BGC-004 for further discussion).

The model was calibrated to hydraulic head observations at 418 locations for the steady-state scenario. Of these monitoring points, 126 were located within the Project area in the general vicinity of Jacko Lake and the open pit. Calibration statistics computed for both the overall model and the Project area were well within recommended tolerances (i.e., NRMS <10%, correlation coefficient >0.95; BCMoE, 2012) suggesting a good calibration was achieved. As noted by the reviewer, the calibrated hydraulic conductivity of several hydrostratigraphic units (e.g., Nicola Group Volcanics) was less than estimated mean values. However, the calibrated hydraulic conductivity dataset is generally consistent with other groundwater models developed within the regional study area (e.g., Aberdeen [Golder, 2008]; Afton [Piteau, 2006]). In addition, chosen test intervals and monitoring well locations may have been biased towards more conductive (i.e., higher hydraulic conductivity) zones to facilitate testing methodologies and allow equilibration of monitoring wells/test intervals. Therefore, the Proponent believes the calibrated hydraulic conductivity values to be reasonable, as the overall bulk hydraulic conductivity of the bedrock units is likely on the lower end of available measurements.

The model was also calibrated to the 2011 pumping test conducted in bedrock between Jacko Lake and the proposed open pit. In general, the model was able to capture the magnitude and timing of drawdown for many observations (Appendix B, Application/EIS Appendix 6.6-D). Some discrepancy was present at several locations reflecting a combination of the local-scale bedrock heterogeneity as well as limitations in the resolution of KAM's 3D geologic model (i.e., 50 m resolution).

The calibrated groundwater flow model was used to provide estimates of groundwater discharge to and seepage from Jacko Lake under existing conditions, throughout mining operations and closure, and into the post-closure period. Results of these base case simulations along with parameter sensitivity simulations that were conducted (see Section 8.3 and Appendix E; Application/EIS Appendix 6.6-D) predict that net seepage losses from Jacko Lake (i.e., seepage losses minus groundwater discharge from adjacent glacial materials) will increase from (see also Table 04):

- Existing Conditions: Less than -0.01 L/s (i.e., net discharge conditions; -0.7 L/s to 0.1 L/s range)
- End of Mine Operations (i.e., Year 23): 1.5 L/s (0.7 L/s to 3.2 L/s range)
- Post-Closure (500 masl pit lake): 1.5 L/s (0.7 L/s to 3.2 L/s range)

Net surface water inflow to Jacko Lake (including lake evaporation losses) is estimated to be about 40 L/s (Section 8.7.3.4 and Appendix 6.4-C of the Application/EIS); therefore, the lake is expected to remain an overall gaining system through all phases of the Project.

To further investigate the influence of hydraulic conductivity assigned within the calibrated base case model on predictions of seepage losses from Jacko Lake, the following additional sensitivity simulations were performed:

- Case 1: The conductance of general head boundary cells used to represent Jacko Lake was increased by an order of magnitude (i.e., the base case vertical lake bed hydraulic conductivity was increased from 1×10^{-8} m/s to 1×10^{-7} m/s).
- Case 2: The hydraulic conductivity of surficial deposits between Jacko Lake and the open pit (i.e., glaciofluvial/fluvial sands and gravels and glacial till) was increased to equal or exceed third quartile values from all available measurements (Figure 20, Application/EIS Appendix 6.6-D). The hydraulic conductivity of anthropogenic materials was also increased by half an order of magnitude within this scenario.
- Case 3: The hydraulic conductivity of all of the bedrock hydrostratigraphic units between Jacko Lake and the open pit (i.e., Nicola Volanics, Sugarloaf Diorite, Iron Mask Hybrid, and picrite) was increased to measured geometric mean values. The hydraulic

conductivity of undifferentiated shallow/outcropping bedrock was also increased by half an order of magnitude within this scenario.

- Case 4: The high hydraulic conductivity sensitivity case (i.e., hydraulic conductivity of all materials increased by a factor of five) described in the Application/EIS (Section 8.3, Application/EIS Appendix 6.6-D) was modified to include the same factor of 5 increase in conductance of general head boundary cells used to represent Jacko Lake (i.e., assumed a vertical lake bed hydraulic conductivity of $5x10^{-8}$ m/s).

Hydraulic conductivity values specified in each sensitivity case along with those used in the base case scenario are summarized in Table 02. For each case, simulations were conducted for pre-mining and post-closure conditions to assess the respective influence on model calibration and post-closure seepage losses from Jacko Lake.

Results of the pre-mining simulations indicate that the increased Jacko Lake conductance (Case 1) and hydraulic conductivity of Project area surficial materials (Case 2) has limited influence on the overall model calibration as similar statistics were obtained for each scenario (Table 03). In contrast, simulation results indicate that the model is sensitive to increases in both Project area bedrock hydraulic conductivity (Case 3) and the overall hydraulic conductivity of the system (Case 4). The magnitude of hydraulic head residuals was generally increased for both cases (i.e., greater difference between observed and simulated), with groundwater levels generally under-estimated. Furthermore, in both cases the correlation coefficient for observation points within the Project area is reduced to below or near the recommended minimum of 0.95 (Table 03) indicating that the observed hydrogeologic system is not as well represented by these scenarios.

Results of the post-closure simulations indicate that simulated Jacko Lake seepage losses are sensitive to specified hydraulic conductivities. Predicted net seepage at post-closure (Table 04) for the additional sensitivity cases ranges from 2.4 L/s (Case 2) to 7.6 L/s (Case 4) relative to the base case estimate of 1.5 L/s, with the majority of seepage (i.e., 40% to 80%) predicted to occur along the southeast arm of the lake in the area closest to the open pit. However, despite the predicted seepage losses from Jacko Lake to the open pit, the lake itself is still expected to remain an overall gaining system through all phases of the Project due to surface water inflows (Section 8.7.3.4 and Appendix 6.4-C of the Application/EIS). This is true for all sensitivity scenarios considered both here and within the Application/EIS.

Monitoring and Mitigation

KAM is committed to monitoring groundwater surface water quantity and quality in the Project area. A surface water and groundwater monitoring and management plan (SWGMMP) and site water management plan (WMP) were developed for the Application/EIS (see Chapter 11). The SWGMMP and WMP will be updated as part of the Mines Act and Environmental Management Act (MA/EMA) permitting process and will be designed based around predictions made for the Effects Assessments for the Project.

Evaluation of the predicted flows versus actual conditions encountered will be accomplished through monitoring. Under the currently proposed SWGMMP, groundwater levels and quality will be monitored near the western sector of the Ajax pit at KAX-14-107, -108, -114 and -128 (Table 11.24-1, Application/EIS), and surface water levels and quality will be monitored at PC08, PC10 and JACL-D/M/S (Table 11.23-1, Application/EIS). These measurements will be in addition to geotechnical monitoring of pit slope groundwater levels and open pit dewatering rates.

Seepage of water from Jacko Lake to the pit is not anticipated to have an effect on the water quality of Jacko Lake or Peterson Creek as any water collected in the pit will be pumped back to the lined Central Collection Pond for use in the mine process during operations, or will be allowed to contribute to pit lake formation at closure and into post closure. Nevertheless, water quality mitigation measures, if deemed necessary based on monitoring results, would be designed in accordance with the actual conditions encountered during mining. Adaptive management is also included in the SWGMMP, allowing sampling locations and frequency to be altered, if necessary, to suit conditions encountered at any stage of mining. If measures are needed to mitigate the seepage of water from Jacko Lake to the pit, conventional mitigation strategies that might be considered include:

- Implementation of bentonite, cement-bentonite or soil-cement-bentonite slurry cutoff walls, sheet pile cutoff walls, lining portions of Jacko Lake and/or interception wells to control shallow seepage in unconsolidated materials.
- Grouting, or installation of horizontal drains or interception wells within the rock mass.

From a water quantity perspective, the predicted reduction in groundwater discharge to Jacko Lake and increase in seepage loss to the open pit will be mitigated by implementation of the Water Management Plan.

3.0 CONCLUSIONS AND PROPOSED PATH FORWARD

A groundwater flow model was developed by the Proponent based on available geologic and hydrogeologic data and calibrated to measured groundwater levels for both steady-state and transient scenarios. Tabulated calibration statistics were well within recommended tolerances across both the regional and Project study areas indicating a good calibration was achieved. The calibrated groundwater flow model was used to evaluate potential Project effects on the physical groundwater system within the Project area and the surrounding region. This evaluation included the assessment of seepage from Jacko Lake, which has been the focus of several IRs received by the Proponent.

To address questions/comments contained within these IRs, this memo has provided a summary of:

- Available geologic and hydrogeologic data within the Jacko Lake and open pit area,
- How the information was incorporated into the groundwater flow model,
- The range in predicted net seepage losses from Jacko Lake for the base case and sensitivity scenarios (i.e., including additional scenarios conducted as part of this memo),

- Proposed monitoring and mitigation plans within the Jacko Lake and open pit area.

Further questions/comments and Proponent responses in related IRs (i.e., SSN-328 and SSN-329) can be found within 0414_KAM_JL_Ptest_BGC-012.

Results of the Proponent's groundwater flow model indicate that net groundwater seepage from Jacko Lake is predicted to increase from -0.01 L/s (i.e., net discharge from adjacent glacial materials; -0.7 L/s to 0.3 L/s range) under existing conditions to 1.5 L/s (0.6 L/s to 7.6 L/s range) in post-closure. However, despite the predicted increase in seepage, Jacko Lake is expected to remain an overall gaining system through all phases of the Project due to surface water inflows (i.e., net surface water inflow including evaporation losses of about 40 L/s; Application/EIS Appendix 6.4-C). This is true for all sensitivity scenarios considered both here and within the Application/EIS.

Ongoing monitoring of groundwater and surface water will continue to provide additional information regarding the connectivity of the lake and the open pit throughout all stages of mining. Through this process, the Proponent's groundwater flow model will be iteratively updated as new information is collected.

4.0 CLOSURE

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Yours sincerely,

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REFERENCES

B.C. Ministry of Environment (BCMoE), 2012. Guidelines for Groundwater Modelling to Assess Impacts of Proposed Natural Resource Development Activities. Prepared by: Christoph Wels, Daniel Mackie, and Jacek Scibek. Submitted to BCMoE April 2012, Report No. 194001.

BGC, 2011. Ajax Project Feasibility Study – Prototype Dewatering Well and Pumping Test. Report prepared by BGC Engineering Inc. for Abacus Mining and Exploration Corporation, dated September 10, 2011, Doc. No.: 0712-003-M01-2011.

Golder, 2008. Hydrogeological Investigation (1998 – 2000) Aberdeen Area, Kamloops, BC. Report prepared by Golder Associates Ltd. for the City of Kamloops, dated September 25, 2008.

Hydrogeologic Inc., 1996. MODFLOW-SURFACT Software (Version 3.0) Overview: Installation, Registration and Running Procedures. Herndon, Virginia, 548 p.

KAM. 2016. *Ajax Project: Environmental Assessment Certificate Application / Environmental Impact Statement for a Comprehensive Study.* Assembled for KGHM Ajax Mining Inc. by ERM Consultants Canada Ltd.: Vancouver, British Columbia.

Klohn Leonoff, 1988. AJAX Mine Project Hydrogeology Study. Report prepared by Klohn Leonoff Consulting Engineers for the Afton Operating Corporation, dated May 11, 1988.

Piteau, 2006. Permit Level Hydrogeological Assessment for Tailings Storage Facility and Block Cave, New Afton Copper-Gold Project, Kamloops, B.C.. Report prepared by Piteau Associates Engineering Ltd. for New Gold Inc. and Hatch Associates, dated November 2006, Project No.: 2807

Table 01. Summary of hydraulic conductivity data from vicinity of Jacko Lake and the open pit.

Class	Geology	Hydraulic Conductivity (m/s)			Number of Tests
		Minimum	Maximum	Geometric Mean	
Surficial Materials	Glaciofluvial/Fluvial Sands and Gravels	1.3E-06	2.0E-05	4.7E-06	6
	Glacial Till	9.0E-08	1.0E-05	3.6E-07	13
	All Surficial Materials	**9.0E-08**	**2.0E-05**	**8.1E-07**	**19**
Bedrock	Undivided Bedrock	1.5E-08	1.9E-07	3.3E-08	9
	Iron Mask Hybrid	2.0E-10	5.0E-07	1.1E-08	24
	Nicola Group Volcanics and Sediments	3.0E-10	4.1E-06	1.7E-08	37
	Sugarloaf Diorite	4.6E-09	1.0E-06	2.6E-08	13
	Picrite	4.0E-10	3.3E-06	3.9E-08	40
	All Bedrock	**2.0E-10**	**4.1E-06**	**2.2E-08**	**123**

Notes:

a) Data summarized from area shown within Figures 01 to 03.

Table 02. Summary of specified hydraulic conductivity within additional sensitivity simulations relative to base case simulation and regional data geometric mean.

Hydrostratigraphic Unit	Hydraulic Conductivity (m/s)					
	Base Case	Case 1[c]	Case 2[c]	Case 3[c]	Case 4 [a,c]	Geometric Mean [a]
Jacko Lake Lake Bed	1.0E-08	1.0E-07	1.0E-08	1.0E-08	5.0E-08	- [b]
Fluvial/Glaciofluvial Sands and Gravels	1.4E-05	1.4E-05	4.0E-05	1.4E-05	6.9E-05	1.0E-05
Glacial Till	1.7E-07	1.7E-07	5.0E-07	1.7E-07	8.5E-07	1.0E-07
Anthropogenic Materials	5.0E-07	5.0E-07	1.0E-06	5.0E-07	2.5E-06	1.0E-05
Bedrock Outcrop/Shallow	5.8E-08	5.8E-08	5.8E-08	1.0E-07	2.9E-07	-
Nicola Volcanics (Regional)	3.2E-09	3.2E-09	3.2E-09	2.0E-08	1.6E-08	2.0E-08
Iron Mask Hybrid (Regional)	1.5E-09	1.5E-09	1.5E-09	5.0E-08	7.5E-09	5.0E-08
Nicola Volcanics (Project Area)	1.0E-09	1.0E-09	1.0E-09	2.0E-08	5.2E-09	2.0E-08
Picrite (Project Area)	1.0E-09	1.0E-09	1.0E-09	4.0E-08	5.2E-09	4.0E-08
Sugarloaf Diorite (Project Area)	2.6E-08	2.6E-08	2.6E-08	4.0E-08	1.3E-07	2.0E-08
Sugarloaf Volcanic Hybrid (Project Area)	1.8E-08	1.8E-08	1.8E-08	4.0E-08	8.8E-08	2.0E-08
Iron mask hybrid (Project Area)	1.0E-09	1.0E-09	1.0E-09	5.0E-08	5.2E-09	5.0E-08

Notes:

a) Geometric mean hydraulic conductivity based on all available data within the regional study area.

b) No data currently available due to site investigation restrictions.

c) Additional sensitivity cases summarized within this memo.

Table 03. Calibration statistics for base case and additional sensitivity cases.

Calibration Statistics		Base Case	Sensitivity Cases [b]			
			Case 1	Case 2	Case 3	Case 4
Regional Calibration Statistics	Residual Mean (m)	-4.8	-4.8	-3.9	-0.1	7.2
	Absolute Residual Mean (m)	11.1	11.1	11.2	13.7	15.7
	RMS Error (m) [a]	18.1	18.1	18.1	20.8	24.6
	No. of Observations	431	431	431	431	431
	Observations Range (m)	747.7	747.7	747.7	747.7	747.7
	Normalized RMS Error (%)	2.4	2.4	2.4	2.8	3.3
	Correlation Coefficient	0.995	0.995	0.995	0.993	0.991
Local Calibration Statistics	Residual Mean (m)	-2.2	-2.2	-1.4	3.0	4.2
	Absolute Residual Mean (m)	5.9	5.9	6.0	9.8	8.8
	RMS Error (m) [a]	8.8	8.8	8.8	14.4	13.5
	No. of Observations	139	139	139	139	139
	Observations Range (m)	250.0	250.0	250.0	250.0	250.0
	Normalized RMS Error (%)	3.5	3.5	3.5	5.8	5.4
	Correlation Coefficient	0.978	0.978	0.977	0.945	0.951

Notes:

a) RMS = root mean square.

b) Additional sensitivity cases summarized within this memo.

Table 04. Summary of predicted net seepage from Jacko Lake for the base case and additional sensitivity cases.

Scenario	Predevelopment (L/s)			Post-Closure (L/s)		
	Seepage	Groundwater Discharge	Net Seepage [a]	Seepage	Groundwater Discharge	Net Seepage [a]
Base Case	0.2	0.2	-0.01	1.6	0.1	1.5
Case 1	0.2	0.2	0.05	4.4	0.1	4.3
Case 2	0.3	0.2	0.1	2.5	0.1	2.4
Case 3	0.0	0.7	-0.7	4.1	0.1	4.0
Case 4	0.9	0.6	0.3	8.0	0.4	7.6
EA/EIS High K [c]	0.6	0.5	0.1	3.4	0.3	3.2
EA/EIS Low K [c]	0.06	0.07	-0.02	0.7	0.05	0.7

Notes:

a) Net seepage = seepage minus groundwater discharge.

b) Additional sensitivity cases summarized within this memo.

c) K = hydraulic conductivity.

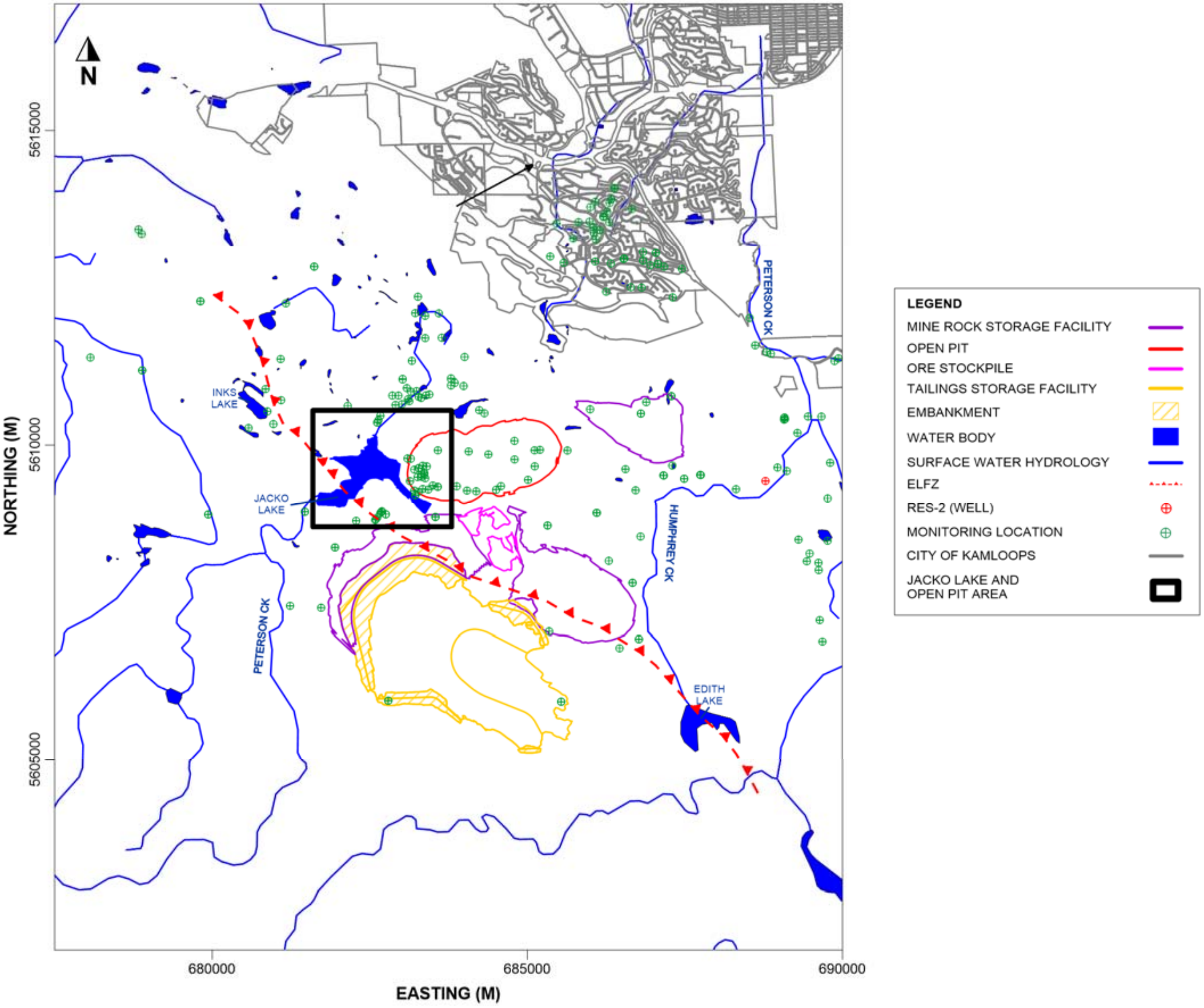


Figure 01. Project area layout and monitoring wells.

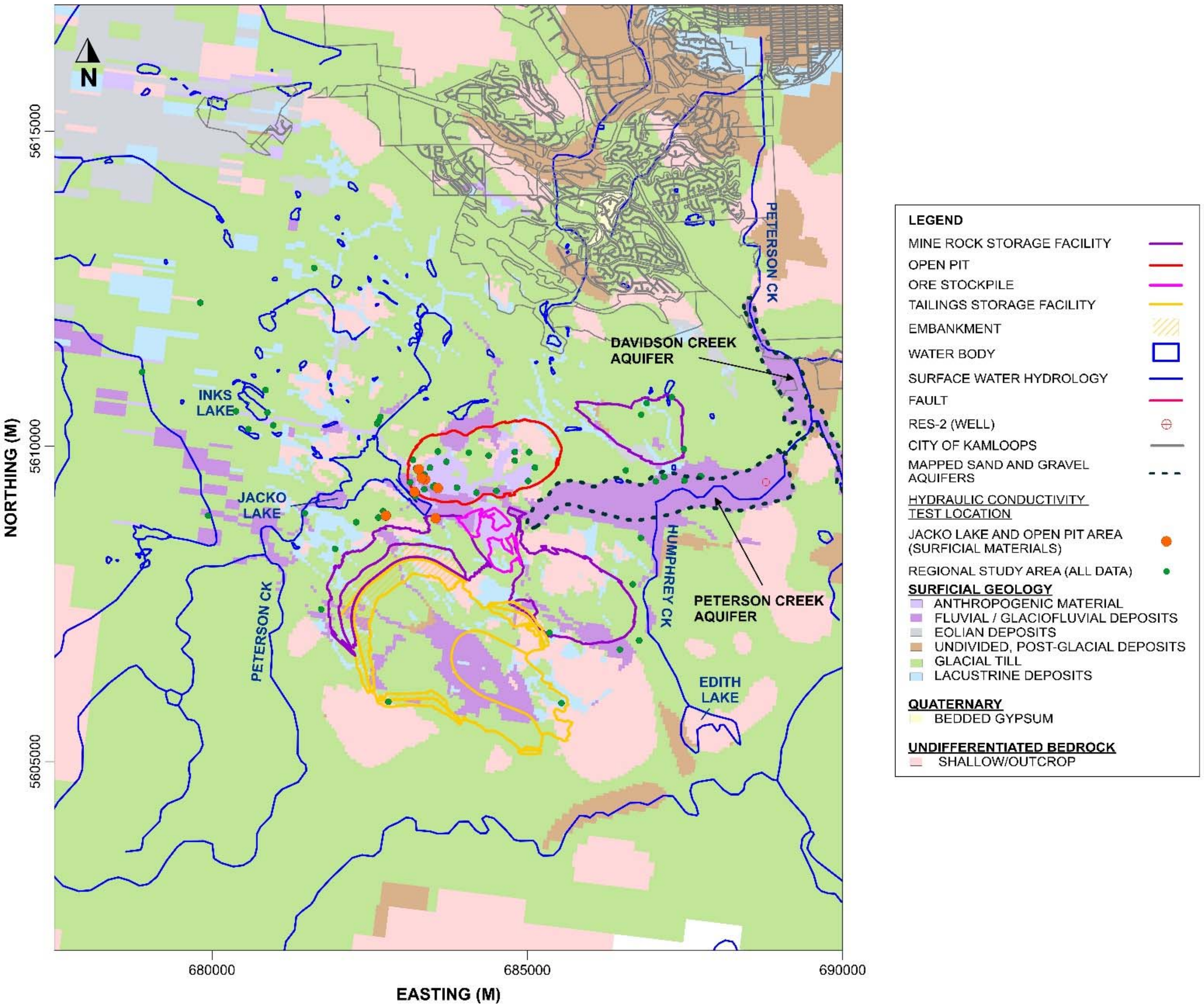


Figure 02. Surficial materials: Hydraulic conductivity test locations and distribution within model layer 1.

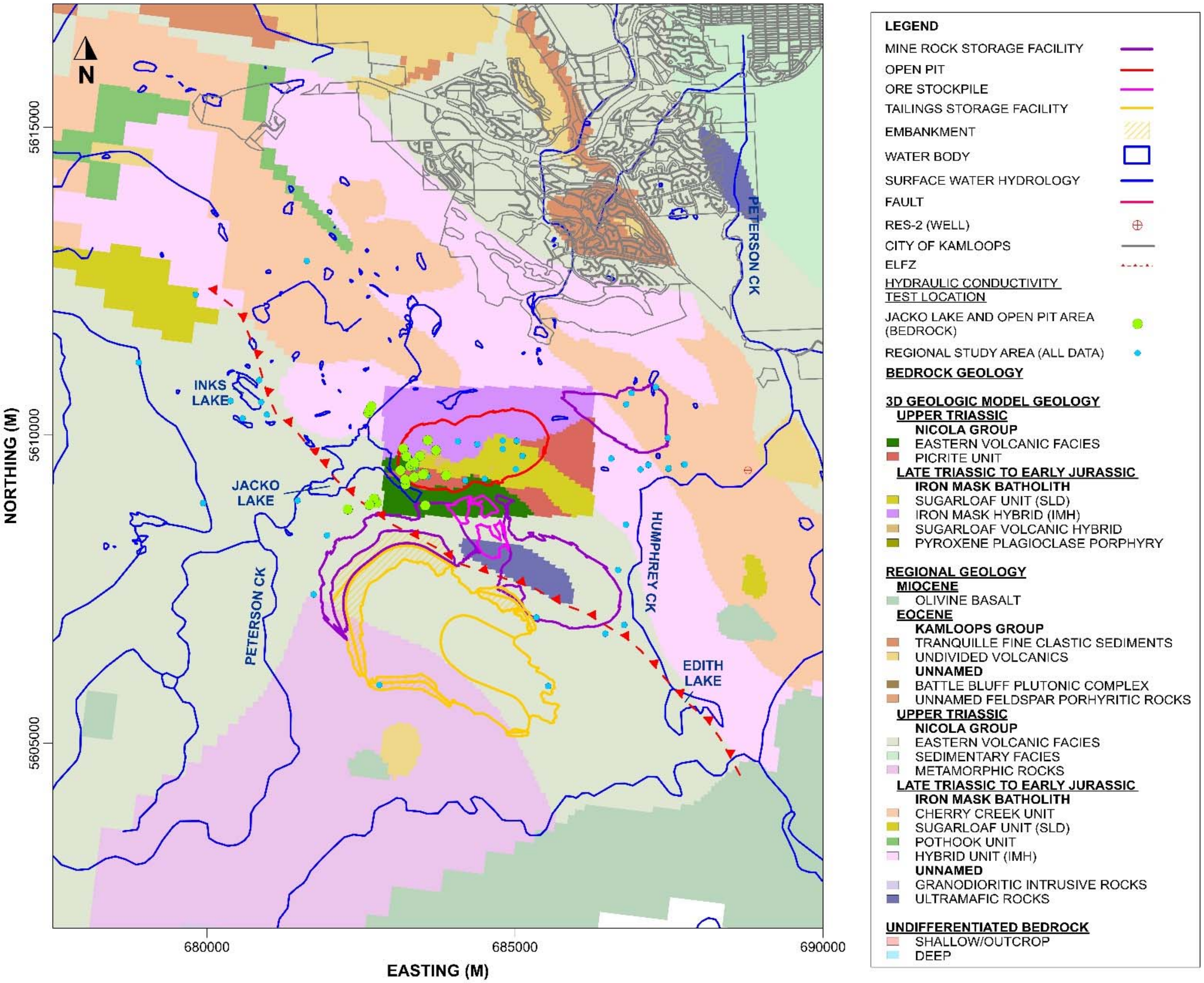
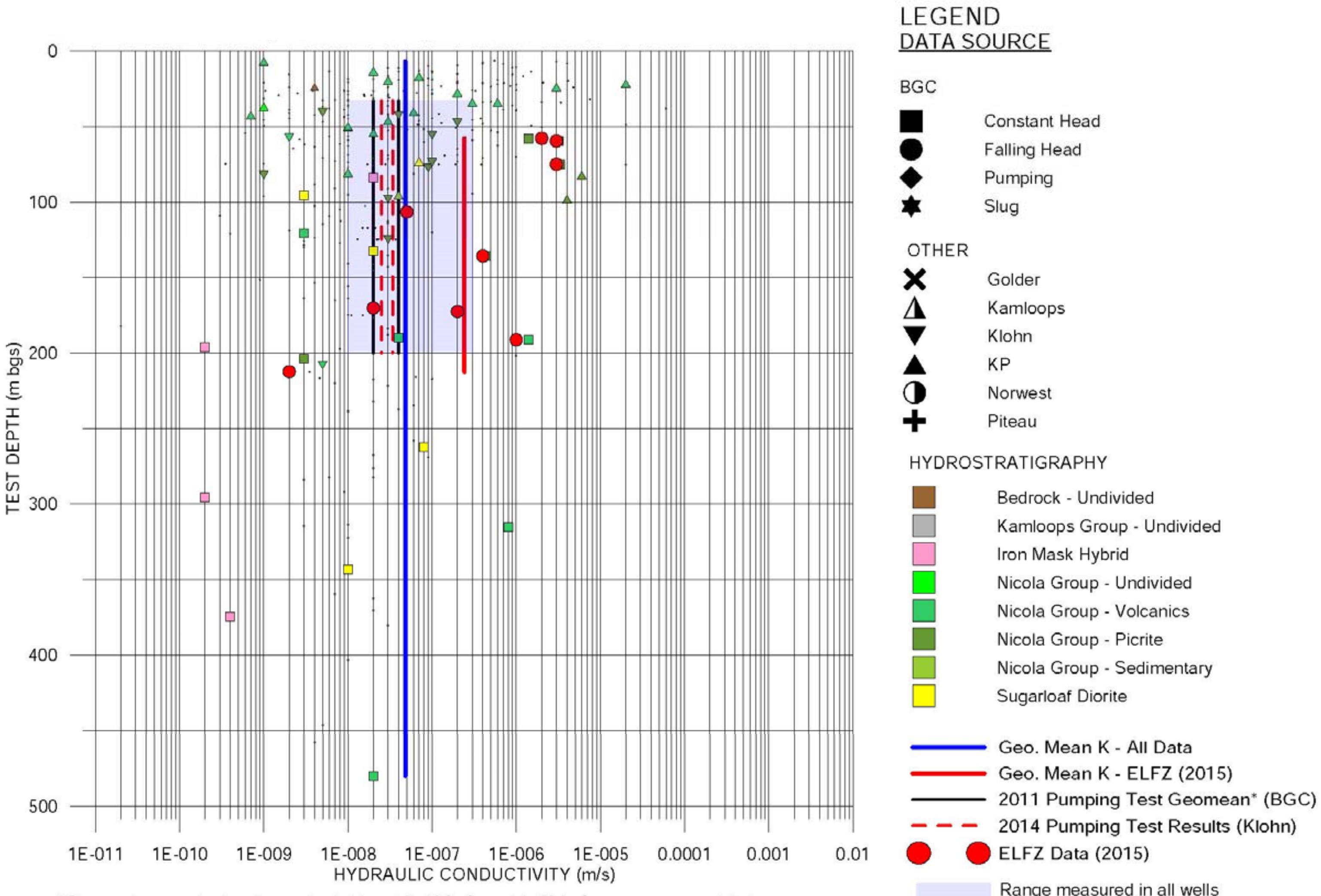


Figure 03. Bedrock: Hydraulic conductivity tests locations and distribution within model layer 5.



*Geometric mean hydraulic conductivities of 2×10^{-8}m/s and 4×10^{-8}m/s were measured during recovery testing and drawdown testing respectively

Figure 04. Hydraulic conductivity (K) of faults versus depth.