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Project Memorandum

To:	**KGHM Ajax Mining Inc.**	**Doc. No.:**	**BGC-030**
Attention:	**Todd Goodsell**	**cc:**	
From:	**Cassandra Koenig, Trevor Crozier**	**Date:**	**April 25, 2017**
Subject:	**Ajax Project EA/EIS – Response to GW Solutions (2017)**		
Project No.:	**1125011**		

1.0 INTRODUCTION

An *Application for an Environmental Assessment Certificate/Environmental Impact Statement for a Comprehensive Study* (the Application/EIS) was issued in January 2016 (KAM, 2016) for the Ajax Project (the Project). The Application/EIS is currently in the review phase, during which the Environmental Assessment Office (EAO) reviews all available information and seeks input from Aboriginal groups, all levels of government and the public to identify potential environmental impacts of the Project. The review phase includes two rounds of public comments (i.e., Round 1 and Round 2), followed by the preparation of an Assessment Report by EAO (the Assessment Report). The Assessment Report documents the results of the review phase and is used by BC Provincial Ministers to aid their decision about whether to approve the Project for construction (EAO, 2016).

Round 2 comments and commenter Information Requirements (IRs) related to groundwater quantity were provided to the Proponent, KGHM Ajax Mining Inc. (KAM), by Dr. Gilles Wendling of GW Solutions (the Reviewer) on behalf of the Stk'emlupsemc Te Secwepemc Nation (SSN) in a memorandum entitled "Review of the KGHM Response to Ajax Project Application/EIS Panel Report Dated 7 November 2016 and KGHM Responses to Round 2 Information Request from SSN Dated 13 December 2017" (GW Solutions, 2017).

BGC Engineering Inc. (BGC) prepared this memorandum on behalf of KAM to respond specifically to the opinions presented in GW Solutions (2017); the IR issues are presented in italics followed by the responses in the sections below.

2.0 INFORMATION REQUIREMENT RESPONSES

2.1. GW Solutions' Comments on KAM's Response to Pumping Test Interpretation

2.1.1. Comment Summary

GW Solutions suggested the dual porosity approach in its first review of the pumping test relying solely on the graph provided by KGHM (see Figure 1a). After receiving the raw data for this pumping test, GW Solutions clearly highlighted (Figure 1b) that the behavior of this aquifer is governed by the presence of a conductive fault as shown by the typical slope of 0.25 in the log-derivative curve. In addition, the delayed signature of the bilinear flow indicates that the fault is *not physically and directly connected to the well (i.e., the pumped well does not go through the fault); but instead, it is a major drain close to the well. The recharge boundary would likely be located along the axis of this fault. GW Solutions wants to emphasize that this interpretation is based on actual data, which is more reliable than a model. Moreover, after receiving local geological information on fracture location, this conclusion is well supported. Figure 5 (residual drawdown in monitoring wells as function of t/t') provided by KAM shows that the recovery of drawdown after pumping test does not compensate ideally, and it has been interpreted by KGHM as an aquifer of limited extent (i.e., the presence of barrier boundaries), giving the general reference of Driscoll (1986). GW Solutions believes that the interpretation given by Driscoll (1986) and adopted by KGHM is too general and that other interpretations can explain the fact that the water level does not return to where it was at the beginning of the pumping test after 7 days of recovery. A possible interpretation is that the rate of recharge from the lake is less than the recovery rate in the wells. This recharge rate might be increased with the creation of the open pit. The fact that the recharge from the lake is significant or not is subjective.*

As for water quality, the samples from Jacko lake, the pumping well BGC10-PW01, and the monitoring well KAX13-005 were taken at different time periods (Jacko Lake in 2012, BGC10-PW01 in 2011 and KAX13-005 in 2012). Therefore, the Piper plot analysis is not rigorous enough to draw solid conclusions. Then, the fact that pH and Electrical conductivity did not show a change over the 7-day pumping test in 2014 is not sufficient to support the absence of hydraulic connection because the change in water quality may take several days to happen after the water level stabilized. The pumping test is not long enough to draw a definitive conclusion. GW Solutions recommends more rigorous work on water quality, such as recording real-time physico-chemical parameters in the pumping well as well as in selected monitoring wells between Jacko Lake and the pumping well during a long-term pumping test. These wells could be KAX-13-005 and also KAX-14-114 which is close to the southern arm of Jacko Lake where GW Solutions suspects the hydraulic connection and where drawdown (approximately 10 cm) has been observed (see interpretation of pumping test combined with lithological information).

2.1.2. Response

The assertion by GW Solutions that pumping test responses indicate that "*the behavior of <u>this aquifer</u> [emphasis added] is governed by the presence of a conductive fault"* is not supported by geologic data or the majority of the observed responses to pumping from BGC10-PW01 during the 2011 pumping test. Of note, no significant, hydraulically conductive faults have been mapped or interpreted in the area between the proposed pit and Jacko Lake. The limitations on use of these conceptual cross sections were explained in a previous memorandum addressed to the Reviewer (i.e., 1213_MKAM_BGC-023).

In response to the Reviewer's concern regarding the duration of the pumping test, KAM has previously committed to conducting a longer-term (i.e., 28-day) pumping test near Jacko Lake. Real-time physico-chemical parameters would be monitored in the BGC10-PW01 (i.e., the pumping well) and in selected monitoring wells between Jacko Lake and BGC10-PW01 during this longer-term pumping test. Physico-chemical parameters would be monitored in KAX-14-114 during the test, but it is not possible to do so at KAX-13-005 due to the nature of the installation (i.e., KAX-13-005 was completed as a fully-grouted nest of vibrating wire piezometers (VWPs) and can only be monitored for groundwater elevation). Please refer to 041317_KAM_BGC Response to the Ministry of Forests, Lands and Natural Resource Operations' (FLNRO) David Thomson for a conceptual discussion of the field program contemplated for this longer test.

The hydrogeologic investigations carried out to date were completed to a high level of detail and the groundwater flow modeling assessment completed for the Ajax Project was robust when submitted with the Application/EIS. This was clearly demonstrated in the Application/EIS and in subsequent supplementary memoranda prepared during the Project review (see below). Numerous additional simulations have been completed to consider specific concerns raised by reviewers and regulators. The conditions and scenarios evaluated to date are considered sufficient to bracket the range of potential effects of the Project on the groundwater system, and have identified areas for additional work to further reduce uncertainty at the next phase of the Project (i.e., permitting) consistent with good practice and the regulatory review process. The Reviewer is referred to the following supplementary memoranda for discussions on the use of the groundwater flow model to identify and bracket uncertainty associated with groundwater quantity near the Project:

- 0706_KAM_ELFZ_Model_BGC-002
- 0415_KAM_Model_Calibration_BGC-004
- 0530_KAM_Jacko_Model_BGC-006
- 0414_KAM_JL_Ptest_BGC-012,
- BGC-021_Round_2_Groundwater_20161124 0706_KAM_BGC-17
- 1213_KAM_BGC-022_FLNRO
- 1213_KAM_BGC-023_SSN
- 1214_KAM_BGC_Response_to_EAO_and_FLNRO.

The Reviewer has expressed concern regarding the interpretation of drawdown responses to pumping at BGC10-PW01, and has provided alternate opinions about the behavior of the groundwater system related to bilinear flow and recharge boundary conditions along an assumed drain feature. BGC has responded to these opinions in Sections 2.1.2.1 and 2.2.2.2, respectively, and has used actual data to show that the Reviewer's interpretation is not supported by observation.

2.1.2.1. Bilinear Flow

GW Solutions has presented the opinion that the behavior of "the aquifer" (i.e., the groundwater flow system within bedrock near Jacko Lake) is governed by the presence of a conductive fault as shown by the typical slope of 0.25 in the log-derivative curve of late time data for one well, which is not identified in the Reviewer's comment (GW Solutions, 2017; Figure 1b). BGC has assumed for this response that the drawdown response and derivative shown are for the pumped well, BGC10-PW01 during the Klohn Crippen Berger (KCB) 2014 pumping test (KCB 2015).

While the 0.25 slope of the derivative curve is frequently indicative of a condition called "bilinear flow", GW Solutions fails to point out that bilinear flow occurs primarily in wells with low conductivity hydraulic fractures (http://petrowiki.org/Diagnostic_plots Plots published by Society of Petroleum Engineers (SPE)). Bilinear flow in a conductive feature affecting a pumping well will more commonly be evident from a 0.25 slope diagnosed in the early time response of the pumping well (http://www.aqtesolv.com/pumping-tests/derivative-analysis.htm), and not at the later time response data noted by GW Solutions. GW Solutions explains the delay by inferring that this "major drain" feature is not physically and directly connected to the pumped well. A slope of 0.25 at later time might be used to interpret the presence of a compressible aquitard overlying a confined leaky confined aquifer or a channel aquifer (http://www.aqtesolv.com/pumping-tests/derivative-analysis.htm). A positive slope at late time may also simply indicate that drawdown in the aquifer is continuing in a pseudo-steady state condition (i.e. the groundwater level is being drawn down, and no boundaries have influenced the rate of drawdown).

The GW Solutions hypothesis that a "major drain" feature governs the behavior of the aquifer is not supported by other data that must be considered before this conclusion can be drawn. Specifically, if a major drain feature were present and governing the behavior of the aquifer, then similar responses (i.e., a 0.25 slope to the derivative) would be observed at other locations used to monitor responses to pumping at BGC10-PW01. To investigate the GW Solutions hypothesis, BGC reviewed the data from the pumping test conducted at BGC10-PW01 in 2011 (BGC 2011)[1]. BGC confirms that during the 2011 test, this condition (i.e., a 0.25 slope to the derivative) was not present in any of the other wells and observations points where drawdown responses were observed (Appendix A). Since this behavior was not observed in any of the locations monitored in the BGC (2011) pumping test, it is unlikely that the response examined by GW Solutions in the pumped well in the KCB (2014) pumping test indicates the presence of a conductive fracture that governs behavior of the aquifer. A local scale, discrete fracture may exist near the pumped well, but the lack of similar responses in the other monitored locations confirms that this feature does not govern behavior of the aquifer. Furthermore, the drawdown response (and therefore the derivative response) noted by GW Solutions in the KCB (2014) pumping test was likely affected by other factors such as adjustments to pumping rate. This is discussed further in Section 2.1.2.2.

[1] The KCB (2015) interpretation was not reviewed in this assessment because reduced data files were not available to BGC. It is however valid to use the BGC (2011) results to respond to the Reviewer's concern since BGC10-PW01 was used as the test well in both the KCB (2015) and BGC (2011) studies, and results of the BGC(2011) test were confirmed in KCB (2014). Test duration in both studies was comparable, with the BGC (2011 test being slightly longer (i.e., 11,303 minutes compared to 10,080 minutes).

2.1.2.2. Boundary Condition Interpretation

GW Solutions interprets that a levelling of the drawdown curve in BGC10-PW01 at late time and a negative slope to the derivative indicates a recharge boundary was reached, and expresses the concern that this recharge may be supplied by Jacko Lake along an assumed drain feature. However, GW Solutions fails to point out that data collected at a pumping well data can be quite “noisy” (i.e. unexplained variation across data) in response to many factors either acting independently or cumulatively (e.g., turbulent flow across the well screen or towards the pump intake, the adjustments needed to maintain a constant discharge rate and to maintain adequate submergence of the pump in the well to prevent overheating or running the pump dry).

Adjustments to pumping rate can affect both the well drawdown response and the slope of the derivative curve. BGC has not reviewed the KCB (2015) pumping data in detail to evaluate if this was a possible explanation for the slope change during the 2014 pumping test[2] but did review the drawdown and pumping rate records for the BGC (2011) test. The following points present the logic and evidence against the presence of a recharge boundary noted from this review:

- The BGC (2011) test was conducted for 11,303 minutes at an average pumping rate of 8.5 US gpm compared to the pumping rate of between 8.5 to 10 US gpm for a duration of 10,080 minutes by KCB (KCB 2015, BGC 2011). Drawdown in BGC10-PW01 (i.e., the pumping well) was approximately 158 m at its greatest, inducing a steep gradient driving groundwater flow towards the well.
- The BGC (2011) test was conducted at an average pumping rate of 8.5 US gpm. The target and initial pumping rate was 10 US gpm. The initial pumping rate declined as the drawdown in BGC10-PW01 increased (a typical condition during all pumping tests that requires constant supervision and adjustment of the discharge valve to maintain as near to constant a pumping rate as possible). Due to the significant drawdown in BGC10-PW01 (~158 m), and in spite of valve adjustments, declines in pumping rate from 10 US gpm, to 9.4 US gpm (at t ~ 2,243 minutes) to 8.7 US gpm (at t~ 4,160 minutes) occurred[3]. In spite of this decline, at t ~ 7,523 minutes BGC decreased the pumping rate to 7 US gpm for the balance of the test (until 11,303 minutes) due to an observed increase in the rate of drawdown in the pumping well that risked damaging the test pump. This change in pumping rate initiated recovery of water level in the well on the order of 25 m (and is clearly evident in the pumping response and derivative signals in the pumped well). Of interest, is that the slope of the drawdown curve becomes flat and the slope of the derivative curve

[2] The KCB (2015) test reports a pumping rate between 8.5 and 10 gpm, from which it can be inferred that modest changes to pumping rate occurred over the duration of the test in response to the significant increase in total dynamic head that occurs in this well during testing (i.e., pumping efficiency declines as the pump must work harder to lift the water an increasing distance to surface).

[3] Complete list of pumping rate Q vs time t as applied in Figure 1 Neuman-Witherspoon solution is provided in Appendix A.

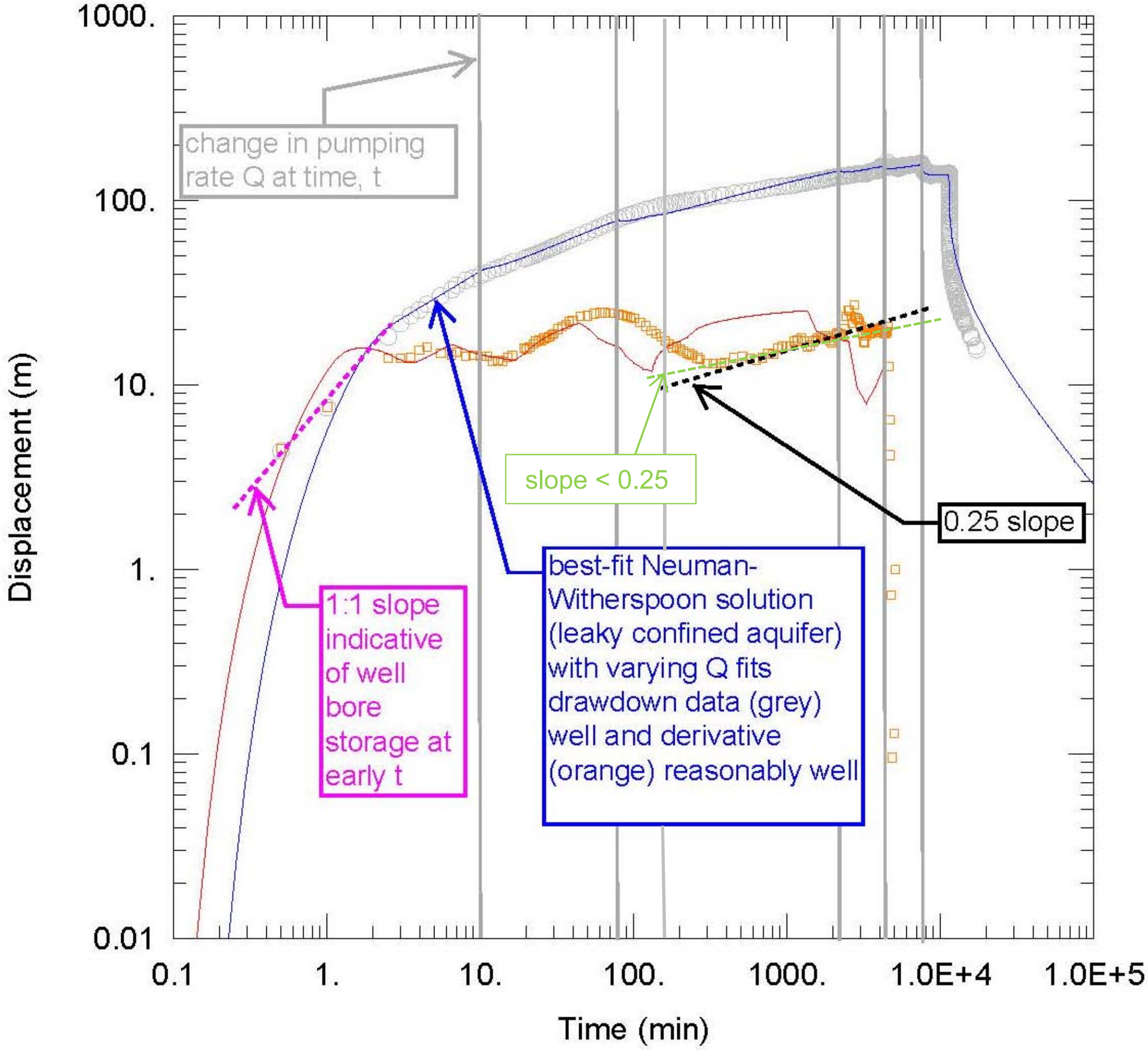
becomes negative at this point in the pumping well record (Figure 1). Consistent with the GW Solutions technical commentary, this indicates recharge to the well, but in response to a pumping rate change and not in response to the intersection of a recharge boundary.

- If a significant recharge boundary was encountered, then flattening of the drawdown curve at other locations close to the pumped well would be expected. Additionally, the position of an observation point relative to the recharge feature and BGC10-PW01 would provide diagnostic information about the location of the feature; that is, an observation point would see a recharge response earlier than BGC10-PW01 if closer to the feature, and later than BGC10-PW01 if further away. Observation data from the nested vibrating wire piezometers (VWPs) in BGC10-MWA and MWB are well situated to consider a recharge signal from Jacko Lake to the pumping well. Near flat (“0 slope”) derivatives are seen for most of these signals indicating infinite acting aquifer conditions are present. Slightly negative slopes may be due to the slight decline in pumping rates with increasing test duration noted above, or slow drainage from overlying rock (i.e. an incompressible layer above the aquifer) or overburden (compressible or incompressible aquitard depending on material type) and/or adjacent fractured rock. Flattening of the drawdown curve does not occur in any of the six VWPs installed at BGC10-MWA and BGC10-MWB until after the pumping rate was decreased to 7,523 minutes (Appendix A).
- Perhaps the most compelling evidence speaking against the presence of a major drain feature governing the behavior of the aquifer is the length of time required for the groundwater levels to recover to pre-test conditions. The BGC (2011) test was conducted in January 2011 during freezing conditions. Recharge from snow melt would likely be limited until temperatures climb above freezing so recovery of water levels would have to come from surrounding groundwater (i.e., re-levelling of the groundwater in response to the depressed water level around the well) or from the adjacent lakes in the West-West and East-West pits, or from Jacko Lake. If a significant, conductive feature were present and directly connected to Jcko Lake, then recovery would occur quickly (i.e., at least equal to the rate of drawdown). However, as of February 24, 2011, approximately one month after the BGC pumping test was shut down, groundwater level recovery in the six VWPs within BGC10-MWA and MWB ranged between 70% and 93% of pre-test conditions indicating low hydraulic conductivity surrounding well and a lack of significant recharge to the groundwater system (i.e., the water groundwater level in the test area of influence was pumped down during a period of 11, 303 minutes, but after turning off the pump and greater than 40,000 minutes had not returned to pre-test levels demonstrating that the rate of recharge from all of the area surrounding the test (including the pit lakes, Jacko Lake and the surrounding aquifer) in total was less than the pumping rate (i.e. less than the average pumping rate of 8.5 US gpm used for the test).

GW Solutions presents this very argument when it explains that the lack of immediate recovery could be explained by other factors when it states “*that the rate of recharge from the lake is less than the recovery rate in the wells*.” This would have to mean that materials of lower hydraulic conductivity than the rock immediately surrounding the pumping well and observation point boreholes (geomean K of 10^{-7} to 10^{-8} m/s depending on rock type) were present and influencing groundwater flow in the area. In addition to the pumping test responses at observation points other than the pumped well, actual data that support the existence of lower hydraulic conductivity materials in this area include:

- the till and lake bed sediments interpreted in Jacko Lake from the geophysics assessment,
- the 48 discrete interval hydraulic packer tests completed by KCB in drill holes KAX-14-107, 108, 114, 121, 124, 128 130 (KCB 2015) with hydraulic conductivity values ranging from 10^{-7} m/s to less than 10^{-9} m/s.
- the fine grained sediments present in the Klohn Leonoff logs for holes drilled into the Southeast and Northeast arms of Jacko Lake in the late 80's prior to the lake level increase into this area (Klohn Leonoff, 1988).

All of these data are consistent with and support the conceptual hydrogeologic model developed for the Application/EIS, which does not include a "major drain" feature immediately connected to Jacko Lake.



2.2. Figure 1. Pumping Test Interpretation for BGC10-PW01.

Notes:

1. Neuman Witherspoon solution for drawdown in a leaky confined aquifer with partial penetrating well and varying pumping rate. GW Solutions' comments on KAM's Response to Discussion of Incorporation of Pumping Test Data to Numerical Model
2. Complete list of pumping rate Q vs time t as applied in Figure 1 Neuman-Witherspoon solution is provided in Appendix A.
3. The degree and method of derivative smoothing can also influence the slope of the best fit line to the derivative. For example in Figure 1 above, the best fit line to the derivative from t = 300 minutes to t~4160 minutes for the Bourdet factor of 2 smoothing of the derivatives is less than 0.25.

2.2.1. Comment Summary

Based on the results of the calibration presented in Section 5.4.6 and Appendix B of the Numerical Groundwater Flow Model Report, the transient correlation coefficient (0.934) was only calculated *based on the simulated drawdown at the end of pumping test not for the whole stress period during pumping test. Furthermore, the trend of simulated drawdown is comparable with observed drawdown only in the pumped well and the closest monitoring wells. As a result, the transient model could not simulate the drawdown trend in the rest of monitoring wells. Moreover, the BC MOE (2012) does not suggest that a correlation coefficient of 0.95 or greater indicates that a model is well calibrated. BC MOE (2012) indicates that "in hydrogeological modelling, a model is considered calibrated when the correlation coefficient is at least 0.95". Therefore, GW Solutions notes that the model does not appear to be well calibrated.*

2.2.2. Response

It should be noted that calibration of the groundwater model to the 2011 pumping test only represents one out of three datasets considered in the calibration process. It is therefore not appropriate to assess the quality of the model calibration based solely on the fit to the 2011 pumping test data.

As discussed in 0415_KAM_Model_Calibration, the model was calibrated iteratively for the Application/EIS using the following datasets:

1. Average annual groundwater elevations (steady-state)
2. Average fluctuations in seasonal groundwater elevations (transient)
3. Pumping test results from a test conducted in bedrock near Jacko Lake (transient).

Iterative calibration of numerical groundwater models to numerous datasets is an effective way to improve the fit between simulated and target values (Anderson, Woessner and Hunt 2015), and this process was followed using the above-noted data sets to develop the calibrated groundwater flow model for the Application/EIS. In addition, the calibrated model was able to reproduce observed groundwater flow directions and vertical hydraulic gradients (i.e., magnitude and directions) at the majority of well pairs reasonably well.

It should be noted that the steady-state calibration to average annual groundwater elevations (i.e., #1 above) considered 432 observations across the model domain and achieved a correlation coefficient of 0.995 (i.e., an acceptable guideline as per BC MOE (2012)), with an overall mean error of -4.8 m (0.6% of the observed range), and a normalized root mean square error (NRMSE) of 2.4%. An NRMSE of 10% is generally suggested as a guideline for the difference between simulated and measured target values (NBLM 2006). Of these measurements, 126 were taken from monitoring locations installed in the immediate Project area. The correlation coefficient for these data was 0.981, the overall mean error was -2.1m and the NRMSE was 3.5%.

The calibration process resulted in adjustments to hydraulic conductivity (K) and specific storage (Ss) and specific yield (Sy) of the modelled units. The two transient calibrations are more appropriately considered to represent benchmarking steps for the calibrated steady-state model, whereby storage parameters (i.e., Ss and Sy) were refined to simulate general trends in groundwater levels over time in response to seasonal and/or pumping stresses. In general, the model captured the magnitude and timing of water level fluctuations 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). This is not indicative of global poor calibration, but suggests an area of local refinement that could be completed in the future to support detailed design of specific Project infrastructure (e.g., the design of water management facilities such as seepage collection ponds).

Additional model development and refinement will be undertaken during permitting and at detailed design to support such assessments before any mining occurs. The model will be recalibrated using the results of field investigations planned to be completed as a condition(s) of the EA (See 041317_KAM_BGC Response to FLNRO David Thomson).

2.3. GW Solutions' comments on KAM's Response to Discussion of Flow System Conceptualization

2.3.1. Comment Summary

Hydrogeology is a science that is evolving rapidly and hydrogeologists have to rely on the most advanced methods and knowledge to adequately assess subsurface conditions. This is particularly the case when projects are large in size, complex, and their potential negative impacts can be significant and not reversible. Therefore, comparing the tool used in previous applications to set the standard does not apply.

GW Solutions understands that the conceptualization of the groundwater flow system was done using an equivalent porous medium. We believe that it is important to conceptualize the site for what it is: A fractured bedrock system. Existing and characterized fractures in the bedrock have to be modelled as different hydrostratigraphical zones with high hydraulic conductivity.

GW Solutions considers that postponing any update of the model, including the integration of the 2014 results, to further phases of the application and detailed engineering is not acceptable. An adequate understanding of the groundwater regime and a defendable assessment of the risks of negatively impacting Jacko Lake are some of SSN's top priorities.

2.3.2. Response

We agree with the Reviewer that existing fractures could be modelled as separate hydrostratigraphic units if the existing configuration in 3D is known and the scale-dependent hydraulic conductivity of these features has been or will be assessed. However, as noted above, the hydrogeologic and geologic site investigations and modelling (geologic and hydrogeologic) completed to date have not identified the presence of conductive faults or other high hydraulic conductivity bedrock features between Jacko Lake and the pits. In addition, as demonstrated by the responses of the observation points to the BGC pumping test, there is limited evidence to suggest the presence of a major drain or conductive feature governing the aquifer behavior in this area. As such, detailed modelling work suggested by the Reviewer is not warranted at this time.

However, it is proposed that the existing structural model could be reviewed and incorporated into a sensitivity simulation at the next stage of the project. This simulation could be used to inform monitoring and, depending upon results, refine or define targets for additional investigation or design work to develop triggers or preferred mitigation measures to be implemented if conditions encountered during Construction and/or Operations warrant. It is noted that the hydraulic conductivity of individual fractures would not necessarily be simulated using a high hydraulic conductivity. The hydraulic conductivity of fractures assigned in the model would need to be representative of observed field conditions (i.e., to be guided by hydraulic test data and calibrated to groundwater levels in the vicinity of any such structural features).

It is acknowledged that the potential risks of negatively impacting Jacko Lake is a priority for the SSN; this is also a top priority for KAM. However, a detailed understanding of the groundwater flow regime has been developed for the Application/EIS. In addition, the potential impacts to the groundwater flow regime due to the Project, including Jacko Lake, have been bracketed through numerous sensitivity studies completed as part of the Application/EIS, and documented in supplementary response memoranda prepared to date during the review process (See 041317_KAM_BGC Response to FLNRO David Thomson).

It is reasonable that updates to the groundwater model proposed in supplementary response memoranda to date should be completed as a EA Certificate Condition for the Project. The proposed modelling would be completed prior to any mining.

2.4. GW Solutions' Comments on KAM's Response to Discussion of ELFZ Hydraulic Conductivity and Water Levels

2.4.1. Comment Summary

KAM accepted that more monitoring points would be required to properly assess the hydrogeological behavior of the fault BEFORE any proposed mining. GW Solutions stresses that the role played by major fractured zones, including the ELFZ, needs to be assessed at this present stage of the application. It should not be part of the conditions of the EA Certificate nor a task to be completed in the early phases of the project construction. As stated above, an adequate understanding of the groundwater regime and a defendable assessment of the risks of negatively impacting Jacko Lake are some of SSN's top priorities.

2.4.2. Response

As stated above, the potential risk of negatively impacting Jacko Lake is also a top priority for KAM. However, a defensible understanding of the groundwater flow regime was developed for the Application/EIS.

BGC agrees with the Reviewer that additional work to update the understanding of hydrogeology for the site should be completed before any proposed mining (i.e., prior to construction). KAM has committed to completing work that will inform and update the conceptual hydrogeologic model for the site, including:

- An update to the Surface Water and Groundwater Monitoring and Management Plan (SWGMMP). This would include drilling and installation of new wells in targeted areas of concern.
- Data reviews from monitoring under the updated SWGMMP.
- Pumping tests around Jacko Lake.
- A pumping test around the ELFZ.
- Integration of the data from the updated SWGMMP, pumping tests at Jacko Lake and the ELFZ into the groundwater model, and recalibration of the model to these new data where and as needed.
- Predictive simulations with the updated groundwater flow model, and further updates of the SWGMMP if needed (e.g., if the updated model identifies new areas of concern for groundwater quantity).

As discussed in 1213_KAM_BGC-023_SSN, this work would be completed at the Permitting/Detailed Engineering phases of the Project, prior to any construction or proposed mining. Further details on proposed work scope and schedule is provided in 041317_KAM_BGC Response to FLNRO David Thomson.

2.5. GW Solutions' Comments on KAM's Response to Discussion of Evaluation of Potential Effects of Climate Change on Surface and Groundwater

2.5.1. Comment Summary

Based on the Numerical Flow Model Report provided in the Application, the model was calibrated to transient groundwater elevations at monitoring wells in the Mine Site with several years of seasonal data. Detailed climate data for the Mine Site were not available for the full groundwater monitoring period when transient model calibration was completed. Therefore, the transient climate dataset reflected average climate conditions rather than the specific conditions for a particular year.

GW Solutions believes that the model was not adequately developed/calibrated for transient state, when we compare observed values and simulated values. The insensitivity of the model to increased evapotranspiration (Climate change effect) likely results from considering the average seasonal conditions when developing the model.

2.5.2. Response

As noted in Section 2.2.2, the numerical groundwater flow model was calibrated iteratively for the Application/EIS using several datasets, including average annual water levels (steady-state), seasonal water levels (transient) and water levels measured during the 2011 pumping test (transient). The primary measure of calibration was to the steady-state dataset as it included the largest number of observations and covered the greatest area near the Project. The two transient calibrations were conducted as benchmarking steps to the calibrated steady-state model to refine storage parameters (i.e., Ss and Sy). Please see Section 2.2.2 for further detail on the adequacy of the steady-state calibration.

As discussed in Appendix 6.6-A, of the Application/EIS, and also in 0415_KAM_Model_Calibration_BGC-004, seasonal changes in groundwater elevations do not result in significant changes to the direction or magnitude of groundwater flow. This is because of the strong influence topography has on groundwater flow directions near the Project (i.e., the regional water table is a subdued replica of topography and seasonal groundwater fluctuations range from about 0.1 m to 4 m on an annual basis). The topographic influence on groundwater levels currently overwhelms the influence of seasonal fluctuations near the Project. Since this effect would be further intensified with the mine infrastructure (i.e., development of strong hydraulic gradients towards the open pit), better match to seasonal groundwater levels in a transient calibration would not change the conclusions of the Application/EIS.

It should also be noted that temporal differences between observed and simulated water level trends may be due to factors other than climatic conditions that were not simulated in the model. This could include undocumented pumping and surface water diversions related to agricultural land uses, fluctuations in surface water elevations in the ungauged ponds, pumping and drilling activities near the Project, etc. However, the model provides a good overall representation of the existing hydrogeologic system with respect to groundwater levels and seasonal trends (Section 5.4, Appendix 6.6-D of the Application/EIS).

With regards to the Reviewer's concern about the sensitivity of modelled evapotranspiration (ET), the simulated hydrogeologic regime was insensitive to ET because the water table is below rooting depths (i.e., extinction depth of 5.5 m) throughout the majority of the model. Despite specifying an increase in potential evapotranspiration of 50%, only a 2% increase in actual evapotranspiration is predicted for both pre-mining and post-closure. Thus, calibration statistics are predicted to be unchanged from the base case scenario, and little difference in groundwater flow paths is expected (0415_KAM_Model_Calibration_BGC-004).

Additional predictive simulations could be carried out by varying inter-annual climate, potentially resulting in greater increases in actual ET during wetter seasons or periods, if water levels are predicted to rise closer to the ground surface. However, this would likely only be the case near water bodies and depressions where groundwater levels are relatively shallow, and most of the modelled area is unlikely to be affected.

It is emphasized that such an exercise would not represent revision to the calibration and would be strictly a predictive assessment. Furthermore, this is unlikely to change groundwater flow patterns or effects of the Project presented in the Application/EIS.

3.0 CLOSURE

BGC Engineering Inc. (BGC) prepared this document for the account of KGHM Ajax Mining Inc. The material in it reflects the judgment of BGC staff in light of the information available to BGC at the time of document preparation. Any use which a third party makes of this document or any reliance on decisions to be based on it is the responsibility of such third parties. BGC accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this document.

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Yours sincerely,

BGC ENGINEERING INC.
per:

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CK/TC/vg/ht

Attachments: Appendix A

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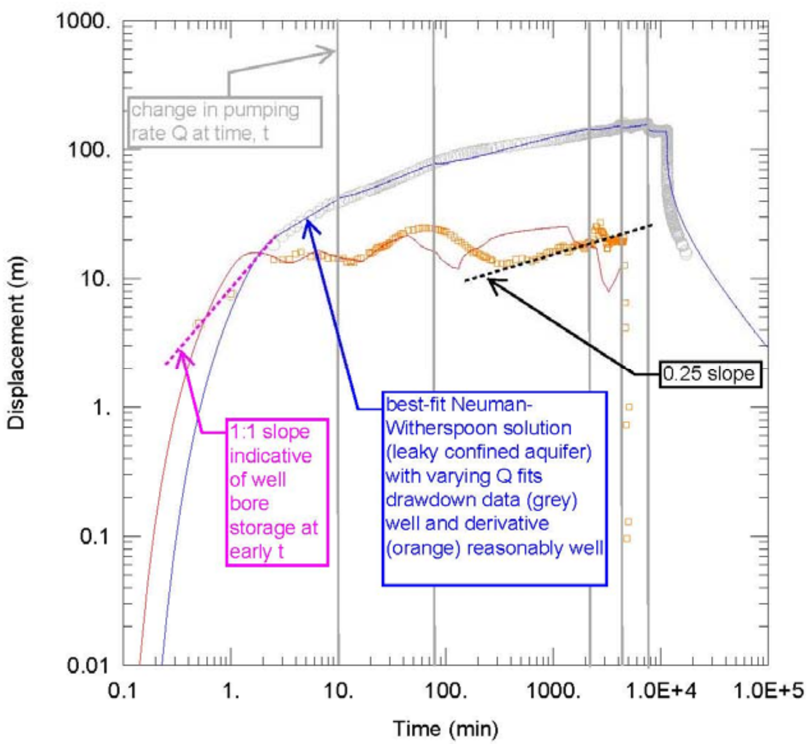
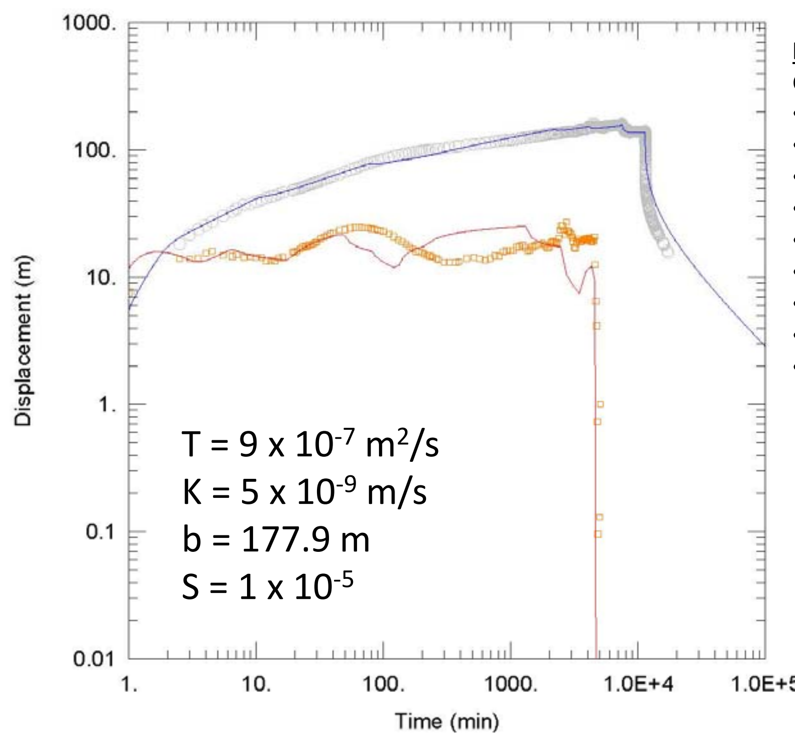
Appendix A

Drawdown and derivative responses for observation wells and pumping well monitored during 2011 Pumping test (BGC 2011)

BGC10-PW01 – Neuman-Witherspoon solution* for leaky confined aquifer





<u>In this Appendix</u>:

Changes to Q occur at:

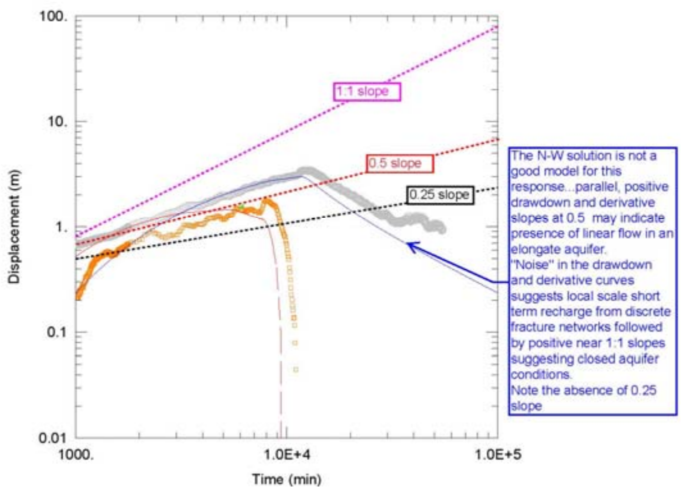
- t = 0 mins Q = 30 gpm
- t ~ 1.5 mins Q = 15 gpm
- t ~ 10 mins Q = 12 gpm
- t ~ 78.5 mins Q = 10.5 gpm
- t ~ 133.5 mins Q = 10 gpm
- t ~ 2,243 mins Q = 9.4 gpm
- t ~ 4160 mins Q = 8.7 gpm
- t ~ 7,523 mins Q = 7 gpm
- t = 11,303.5 mins Q = 0 gpm

Drawdown data point
Derivative point
Best-fit solution* to drawdown data
Simulated derivative

* All solutions as implemented in Aqtesolv Pro Ver 4.5

MWB-075 – Best-fit Neuman-Witherspoon, Gringarten-Witherspoon and Neuman Solutions

MWB-075 is a vibrating wire piezometer (VWP) tip located at a depth of 75 m below grade and a radial distance of 39 m from the pumping well and is situated between the pumped well and Jacko Lake. Note the absence of the 0.25 slope. Best-fit solution of the three is the Neuman Solution for response to pumping in an unconfined aquifer.



<u>Neuman-Witherspoon</u>

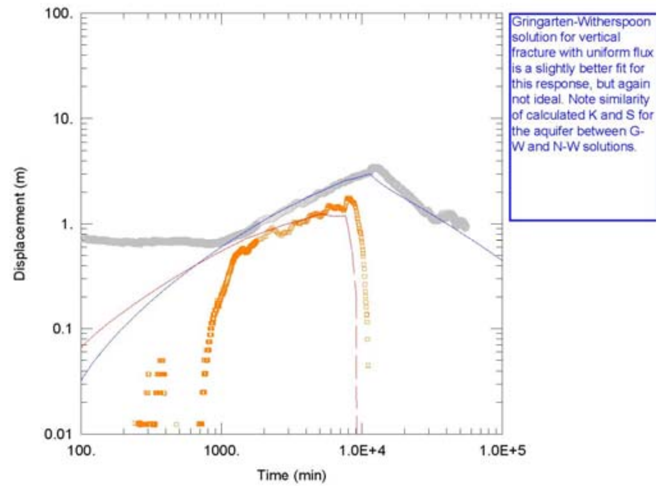
T = 3 x 10^{-5} m^2/s

K = 2 x 10^{-7} m/s

b = 177.9 m

S = 0.004

Leaky Confined Aquifer solution



<u>Gringarten-Witherspoon*</u>

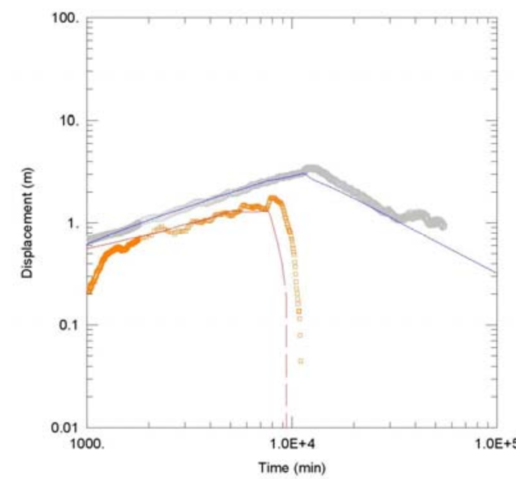
T = 2 x 10^{-5} m^2/s

K = 1 x 10^{-7} m/s

b = 177.9 m

S = 0.005

* Fractured Rock solution with vertical fracture



<u>Neuman</u>

T = 2 x 10^{-5} m^2/s

K = 9 x 10^{-8} m/s

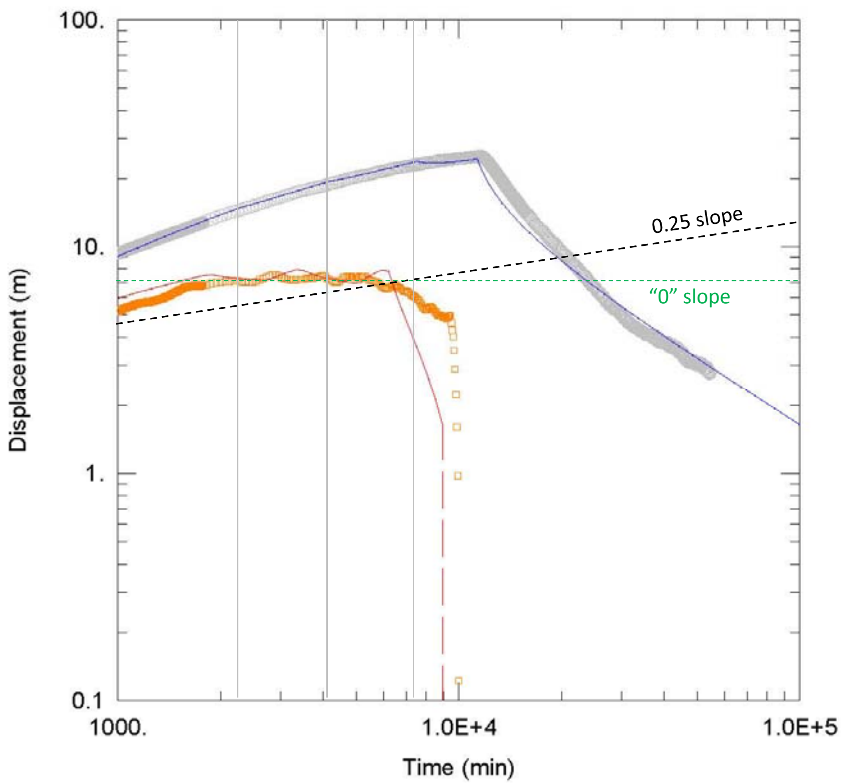
b = 177.9 m

S = 0.0014

Sy = 0.005

Unconfined Aquifer

MWB-125 Neuman-Witherspoon best-fit solution



- MWB-125 is a VWP at 125 m depth, located 39 m radial distance from BGC10-PW01
- There is no 0.25 slope evident in the derivative plot
- "0" slope to the derivative dominates the recorded responses and defines time during which the response indicates "infinite acting aquifer" properties.
- Changes in drawdown slope and derivative slope occur in response to changes in pumping rate, most notable in drawdown at t ~ 7,523 mins

<u>Neuman-Witherspoon</u>

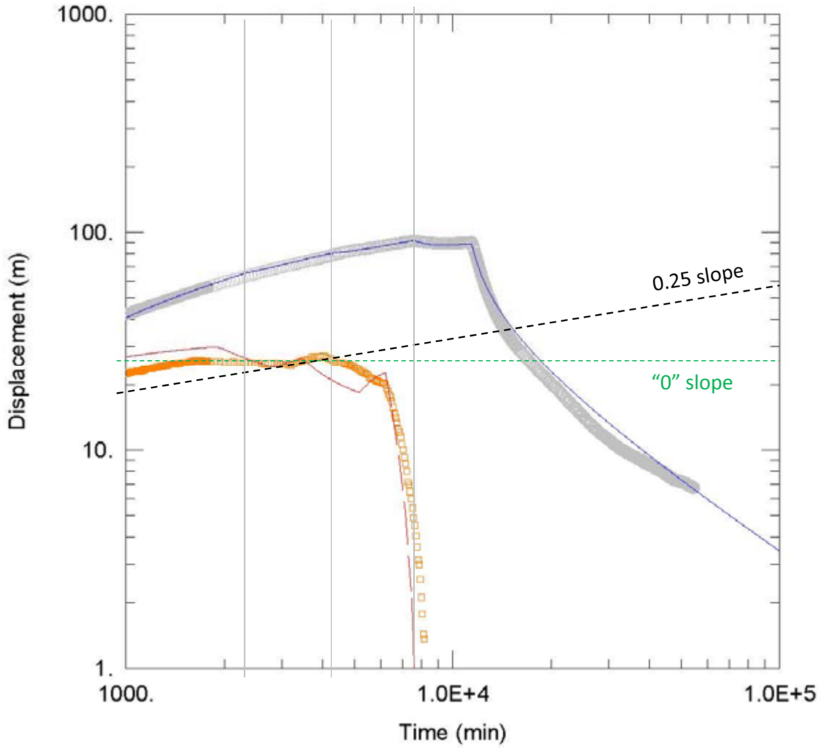
$T = 1 \times 10^{-6}\ m^2/s$

$K = 7 \times 10^{-9}\ m/s$

b = 177.9 m

$S = 1.0 \times 10^{-6}$

MWB-175 Neuman-Witherspoon best-fit solution



- MWB-175 is a VWP at 175 m depth located 39 m radial distance from BGC10-PW01
- There is no 0.25 slope evident in the derivative plot
- "0" slope to the derivative dominates the recorded responses and defines time during which the response indicates "infinite acting aquifer" properties.
- Changes in drawdown slope and derivative slope occur in response to changes in pumping rate, most notable in drawdown at t ~ 7,523 mins.

<u>Neuman-Witherspoon</u>

$T = 2 \times 10^{-6}\ m^2/s$

$K = 8 \times 10^{-9}\ m/s$

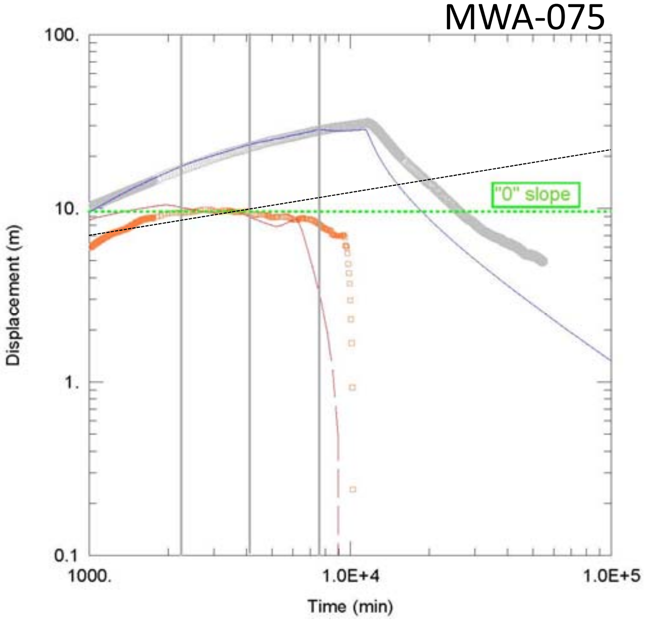
$b = 177.9\ m$

$S = 1.0 \times 10^{-6}$

MWA-075, 125 and 175 Best-fit Neuman-Witherspoon solutions

MWA-075 is a VWP located at 75 m below grade a radial distance of 25 m from BGC10-PW01 and proximate to, but further away from Jacko Lake than MWB. MWA-125 and MWA-175 are VWP tips located at the same radial distance but at 125 and 175 m below grade, respectively

MWA-075



<u>Neuman-Witherspoon</u>

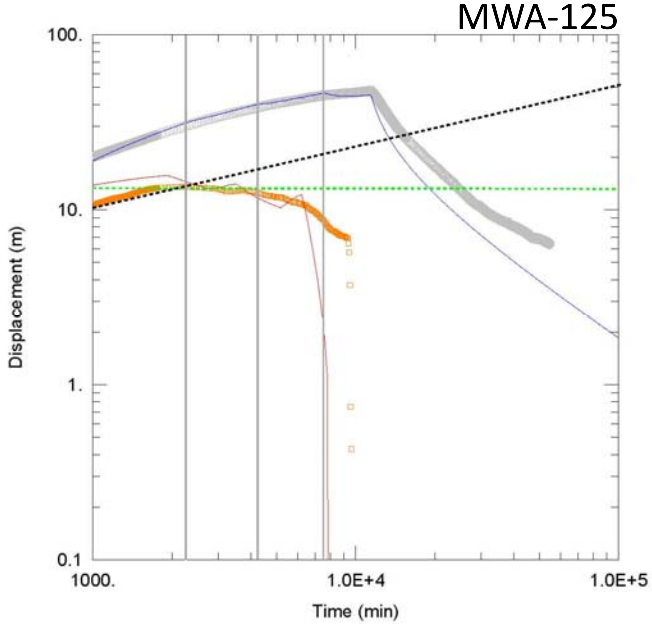
$T = 4 \times 10^{-6}\ m^2/s$

$K = 2 \times 10^{-8}\ m/s$

$b = 177.9\ m$

$S = 0.0006$

MWA-125



<u>Neuman-Witherspoon</u>

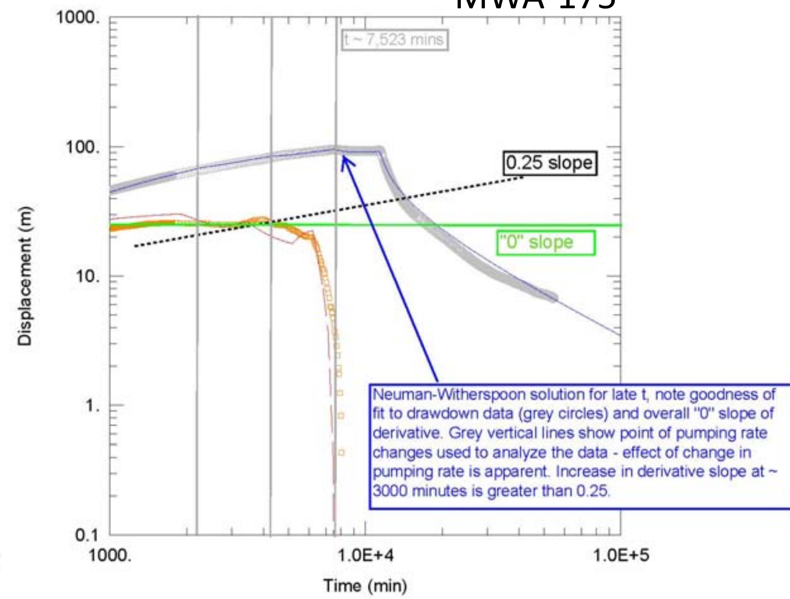
$T = 3 \times 10^{-6}\ m^2/s$

$K = 2 \times 10^{-8}\ m/s$

$b = 177.9\ m$

$S = 0.0002$

MWA-175



<u>Neuman-Witherspoon</u>

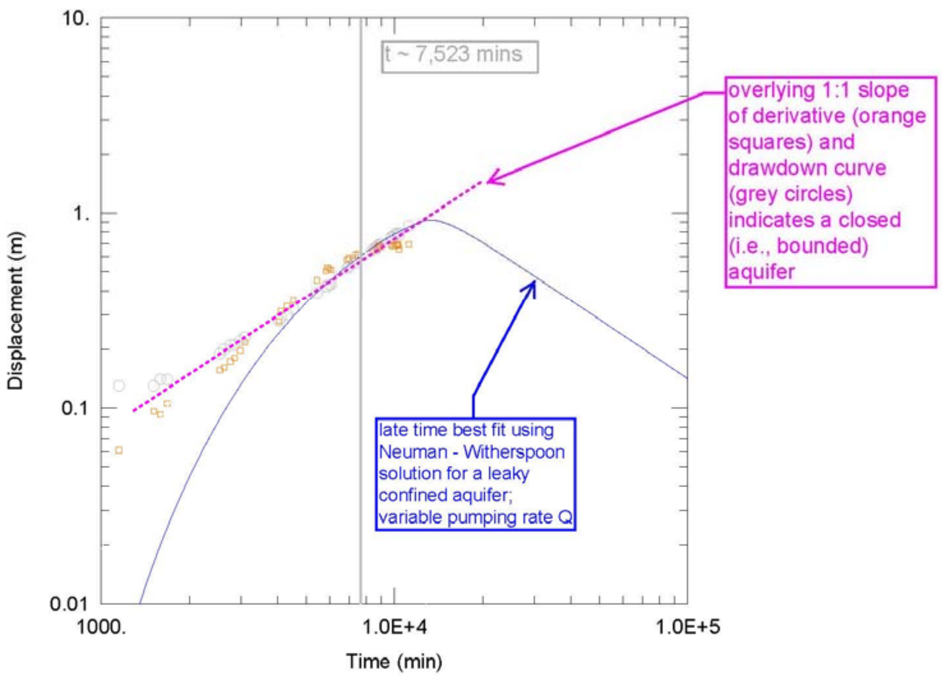
$T = 1.5 \times 10^{-6}\ m^2/s$

$K = 8 \times 10^{-9}\ m/s$

$b = 177.9\ m$

$S = 0.0001$

AW09-104



<u>Neuman-Witherspoon</u>

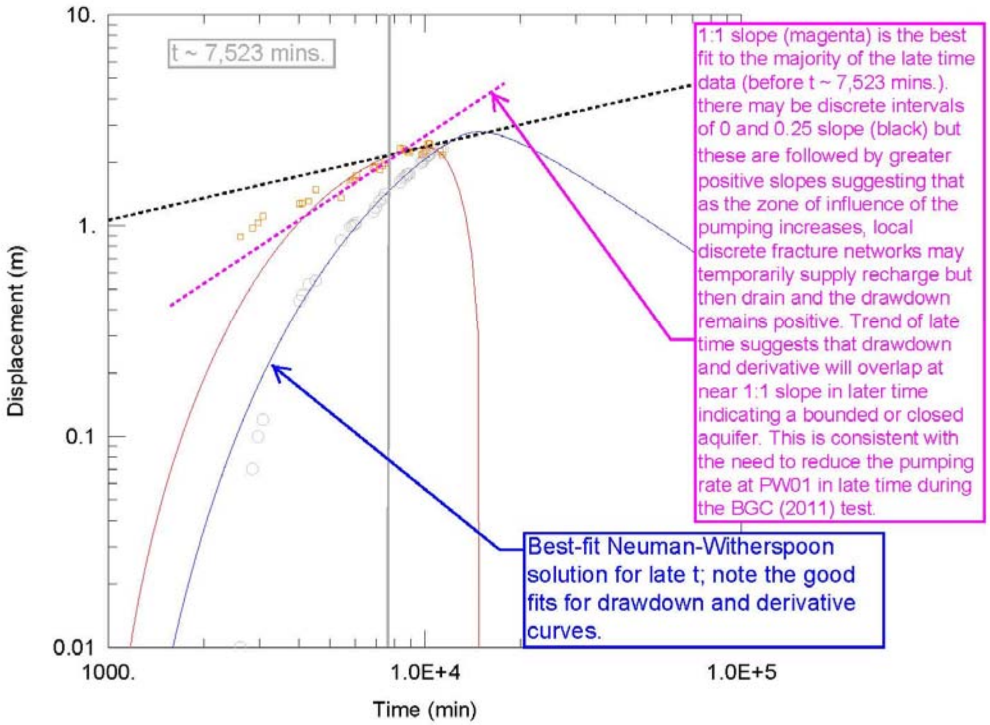
T = 9×10^{-6} m^2/s

K = 5×10^{-8} m/s

b = 177.9 m

S = 7×10^{-5}

AW09103S



<u>Neuman-Witherspoon</u>

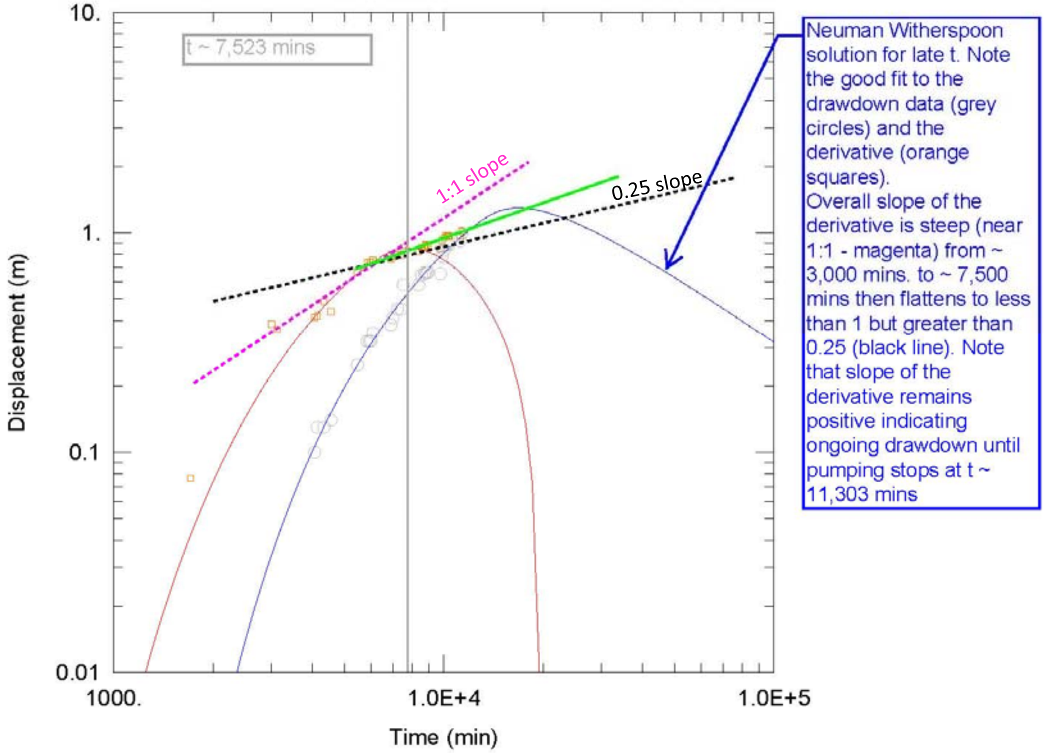
$T = 5 \times 10^{-6}\ m^2/s$

$K = 3 \times 10^{-8}\ m/s$

$b = 177.9\ m$

$S = 0.0002$

AJGW02



<u>Neuman-Witherspoon</u>

$T = 3 \times 10^{-6}$ m^2/s

$K = 2 \times 10^{-8}$ m/s

b = 177.9 m

S = 0.0004