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Project Memorandum

To:	**KGHM Ajax Mining Inc.**	**Doc No.:**	**BGC-005**
Attention:	**Nettie Ore**	**cc:**	
From:	**Cassandra Koenig**	**Date:**	**April 14, 2016**
Subject:	**Ajax Project EA/EIS – Responses to Information Requests COK-SLR635, 636, FLNRO-017, -035, -036, -037, -038, SSN-347**		
Project No.:	**1125011-05**		

1.0 INTRODUCTION

The Ajax Project Environmental Assessment Certificate Application/Environmental Impact Statement (Application/EIS) was issued in September 2015 (KAM 2015). Initial comments, and permit information requirements (IRs) were provided to KAM on February 22, 2016 by the City of Kamloops (COK) and the Ministry of Forests, Lands & Natural Resource Operations (FLNRO) following a review of the Application and supporting documents. Comments from the Stk'emlupsemc Te Secwepemc Nation (SSN) were provided to KAM on March 3, 2016.

This memorandum documents responses for the following IRs: COK-SLR635, COK-SLR636, FLNRO-017, FLNRO-035, FLNRO-036, FLNRO-037, FLNRO-038 and SSN-347.

2.0 PERMIT INFORMATION REQUIREMENT RESPONSES

2.1. Information Requirement Issue ID # COK-SLR635 and COK-SLR636

"The extent of areas serviced by the municipal water supply within the RSA is shown on Drawing 02 [City of Kamloops, 2013a]" (Appendix 6.6-A(1), Section 9.0 Groundwater Budget). All that is shown is the City limits, much of the southern area inside the City limits near the mine development are not developed and therefore not irrigated. This comment or Drawing 2 need revision

and:

Ditto and all subsequent references to DWG 02 showing the extent of municipal water supply and therefore areas of irrigation

Response:

The extents of the Kamloops municipal water supply service (within the RSA) provided in Drawing 02 of Appendix 6.6-A of the project's Application/EIS were originally obtained from the City of Kamloops Sustainable Development Plan - Information Package on Water document, (http://www.city.kamloops.bc.ca/sustainable/pdfs/SKP-WaterBackground.pdf). In

response to this comment, the water system extents were verified by contacting City of Kamloops GIS manager Adam Chadwick (via email correspondence on March 22, 2016), who provided the most recent extents in the administrative dataset on Kamloops' Open Data Downloads site (www.kamloops.ca/maps). The water system extents for the City of Kamloops were accessed March 23, 2016, and are the same as presented on Drawing 02 of Appendix 6.6-A of the Application/EIS. Therefore, no revision to Drawing 02 is required.

2.2. Information Requirement Issue ID # FLNRO-017

The Cooper Jacob analyses are difficult to inspect visually due to very large Y-axis scale, relative to drawdown, resulting in a horizontal line. Typically data for this analysis is plotted such that the line is sloped across the page and the majority of the y-axis spread is populated with data. Please present these analyses in a conventionally accepted form.

Response:

Agreed, the spread of the y-axis presented for the Cooper-Jacob analyses (i.e., BGC14-PW01, BGC13-021 and DH14-057 in Appendix 6.6-C of the Application/EIS) made visual inspection of the results difficult. The y-axis for the three Cooper-Jacob analyses has been modified such that the majority of the spread is populated with data. Modified plots are attached in Appendix A of this memorandum.

2.3. Information Requirement Issue ID # FLNRO-035

KAX-14-128S aquifer test solutions. The test data show 10 or less cm of displacement in a well with a static water column height >5 m. Therefore recovery does not fall within the recommended range (0.2-0.4 of normalized head). Two early time and two late time analyses are run. FLNRO is concerned the potential errors and/or poor quality of this and other test(s) may result in poor data inputs into the numerical model and other proposed monitoring or assessments relying on this data. Please comment.

Response:

The Hvorslev (1951) method of analysis was used to interpret recovery test data obtained from the rising head (RH) and falling head (FH) tests performed on well KAX-14-128S. Because the test data from KAX-14-128S exhibited a concave upward appearance (indicative of storage in the formation) when plotted in semi-log space (Appendix 6.6-B of the Application/EIS) and with the well screened through fluvial and glaciofluvial sands (upper portion of well screen) and lacustrine deposits (lower portion of well screen)[1], the recovery responses were considered in two different ways.

The first approach (used to analyze KAX-14-128S FH Test 1 and RH Test 2) fixed the straight line solution to pass through the known initial displacement at $t = 0$ (i.e., through the early-

[1] KAX-14-128S overburden drill log is available in Appendix 6.6-A of the project's Application/EIS.

time portion of the response, or where normalized head = 1). The hydraulic conductivity (K) results using this method were applied to the formation in the upper portion of the well screen (fluvial and glaciofluvial sands). The second approach, which was used to reinterpret the test data (and labelled KAX-14-128S FH Test 1a and RH Test 2a in Appendix 6.6-B of the Application/EIS), fit a straight line through the late time response, interpreted to be representative of the response and hydraulic conductivity estimate of the lacustrine deposits in the lower portion of the well screen. Estimates of hydraulic conductivity interpreted from both types of analyses were presented in Table 6 (Appendix 6.6-B) of the Application/ EIS.

A third approach, mentioned by FLNRO in this information requirement, matches the straight-line solution to the 0.2-0.4 range of normalized head[2]. This approach was not considered applicable for this case given the change in lithology across KAX-14-128S's screen interval and the range of normalized head for the data (0.5 - 1.0).

It is recognized that the estimates of hydraulic conductivity from the analysis of FH and RH tests in KAX-14-128S (and other monitoring wells) must be used with caution, since recovery data from these tests is dominated by conditions close to the well, with responses potentially affected by drilling method, well construction and well condition (e.g., not adequately developed, partly or fully plugged well screen). Note that to minimize the potential for skin effects, well development for KAX-14-128S was carried out in a rigorous manner (refer to methodology in Appendix 6.6-B of the Application/EIS). However, while physicochemical stability criteria was met, the turbidity criteria was not met as a result excessive amounts of silt within the well[3]. The silt levels will have more of an impact to the analysis of water quality in KAX-14-128S, such that interpretation of dissolved and total metal concentrations was carried out with caution.

From the FH and RH tests in KAX-14-128S, the best fit value of K for the glaciofluvial sands was 2×10^{-6} m/s, while the best fit value of K in the lacustrine deposits was 1×10^{-7} m/s. The former value fell within the range of previously compiled estimates for similar materials in the project area; K values for glaciofluvial sands in the Ajax South wells (i.e., south of Jacko Lake) range from 1×10^{-6} to 6×10^{-6} m/s with a geomean of 3×10^{-6} m/s (Appendix 6.6-A and Appendix 6.6-B of the Application/EIS). No previous K values for the lacustrine deposits were available in the area, however the K value of 1×10^{-7} m/s is considered acceptable for lacustrine deposits based on standard values for these types of materials (Freeze and Cheery 1979).

Hydrogeologic parameter results from the RH and FH tests from KAX-14-128S (and other monitoring wells) were considered in combination with a number of different sources of information (e.g., mapped regional surficial geology (Fulton 1975), local geologic mapping by

[2] Butler (1998) recommends matching Hvorslev (1951) within 0.15 - 0.25 of normalized head
[3] In general, surging of an interval within a well screen for the purpose of well development is considered complete once physicochemical parameters are stable and turbidity values are less than 250 NTU.

Keystone (2008) and Knight Piésold (2014a), soil descriptions, material types) to develop the hydrostratigraphic units of the numerical groundwater flow model (Appendix 6.6-D of the Application/EIS).

2.4. Information Requirement Issue ID # FLNRO-036

BGC14-008D RH Test 1 aquifer test solution. Displacement is shown to be slightly greater than static water column height.

Response:

The static water column height originally reported for BGC14-008D RH Test 1 (of 6.927 m, Appendix 6.6-B of the Application/EIS) is an error and should be 7.737 m. This error did not affect the result of the RH test in BGC14-008D, and the estimate of hydraulic conductivity remains as reported in Appendix 6.6-B (i.e., 1.0×10^{-9} m/s).

2.5. Information Requirement Issue ID # FLNRO-037

BGC14-001D aquifer test analysis. Test displacement (<1 m) is very small relative to the >13 m static height and the first response record is >10 seconds into the test. FLNRO is concerned the potential errors and/or poor quality of the test(s) may result in poor data inputs into the numerical model and other proposed monitoring or assessments relying on this data. Please comment.

Response:

The initial FH Test 1 displacement (of 0.507 m) and the initial RH Test 2 displacement (of 0.708 m) provided satisfactory recovery data in well BGC14-001D to estimate hydraulic conductivity in the vicinity of the well. According to Butler (1998), in moderate or lower permeability formations (i.e., hydraulic conductivity $<2 \times 10^{-4}$ m/s), an initial displacement of 0.3 to 0.9 m should produce a reasonable signal-to-noise ratio.

Water level records are available from the initiation of both RH and FH tests ($t = 0$) for BGC14-001D. The first response record is greater than 10 seconds into the test on the normalized head versus time plots as a result of the 'auto axis' function in AQTESOLV version 4.5 (HydroSOLVE 2007) used to generate the outputs. The x-axis has been modified to reflect all RH and FH response data. Updated plots for the BGC14-001D FH Test 1 and BGC14-001D RH Test 2 are attached to this memorandum as Appendix B.

2.6. Information Requirement Issue ID # FLNRO-038

BGC14-015S RH TEST 1 aquifer test analysis: The first recovery response shown is more than 1000 seconds into the test. The density of data presented suggest a datalogger was used. Please present an analysis of the entire test. Also please verify the result's impact, if any, on inputs into other aspects of the groundwater quality and quantity assessments.

Response:

Yes, a datalogger was used to record water levels in BGC14-015S during the RH slug test; the full record is presented in Figure 2-1. Analysis of the full test record is not recommended, which will be discussed in the paragraphs below.

As indicated in Section 4.3 of Appendix 6.6-B, single RH hydraulic tests were conducted in a number of wells (including BGC14-015S), due to long water level recovery times. This involved manually bailing between 9.5 and 95 L (2.5 and 25 USG) of water from the PVC well casings before deploying the datalogger to monitor well recovery. As such, water was removed from BGC14-015S in a non-instantaneous manner.

There are three common approaches for estimation of the initial displacement (H_0) and test start time (t_0) from slug test response data that are impacted by non-instantaneous slug introduction. The first approach, used to analyze the RH test in BGC14-015S, is to ignore the early-time portions of the record and assume that t_0 and H_0 occur when bailing stops (i.e., "D" on Figure 2-1, or approximately 10 minutes from the true start of the test). This is called the Translation Method after Pandit and Miner (1986).

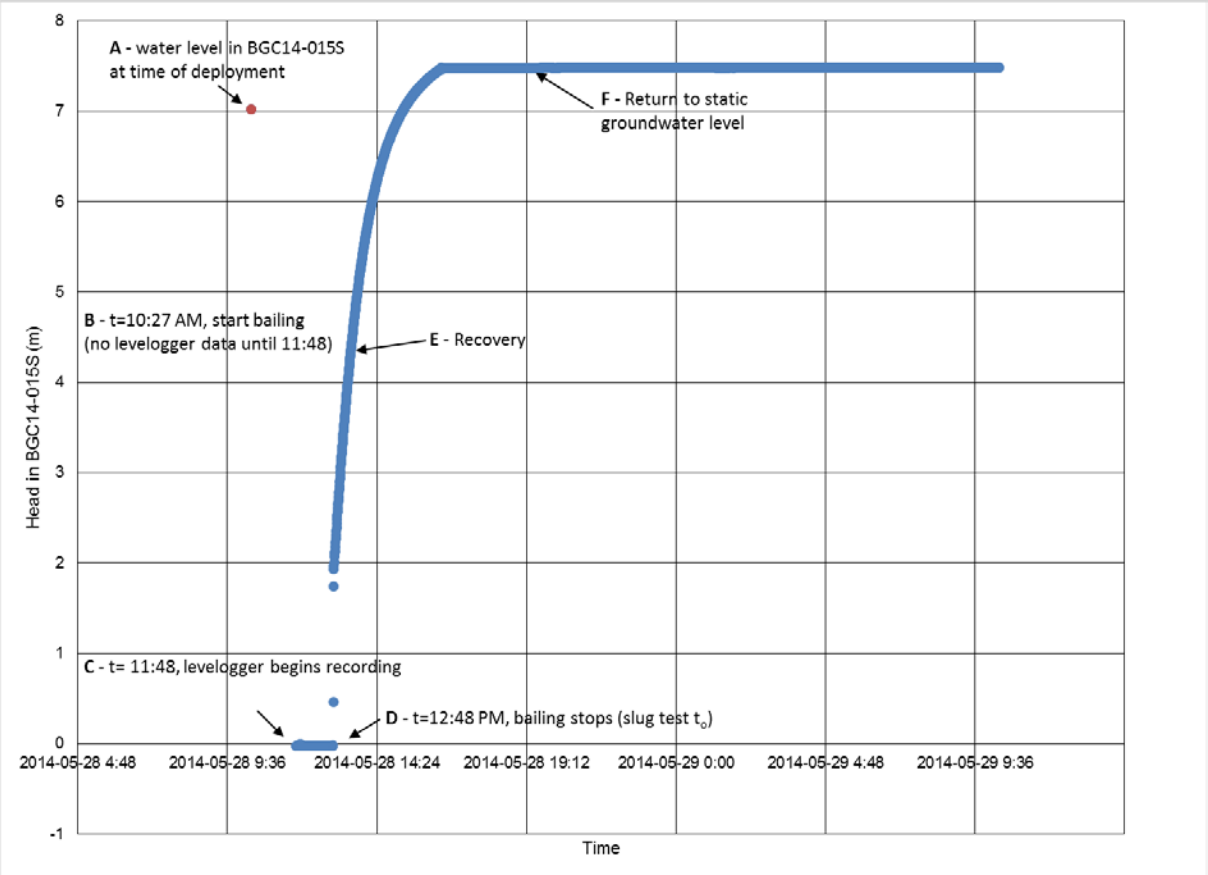

Figure 2-1. Slug test in BGC14-015S.

Alternative approaches to analysis involve using the *expected* initial displacement (H_0^*) and the actual time at which the slug introduction began (t_i), and ignoring the early-time portions of the

dataset. A third approach is to use H_0 and t_i, but once again ignore the early-time portions of the record (Butler 1998).

As discussed in the response to Information Requirement Issue ID # FLNRO-035, the primary objective of a slug test is to provide insight into the characteristics of the formation of the tested well. BGC14-015S is screened within glaciofluvial sands and gravels, and the best-fit value of hydraulic conductivity (K) of 1.3 x 10^{-6} m/s fell within the range of previously compiled estimates for similar materials in the project area; K values for glaciofluvial sands in the Ajax South wells (i.e., south of Jacko Lake) ranged from 1 x 10^{-6} to 6 x 10^{-6} m/s with a geomean of 3 x 10^{-6} m/s (Appendix 6.6-A and Appendix 6.6-B of the Application/EIS).

2.7. Information Requirement Issue ID # SSN-347

Appendix 6.6-C p113 to 122 and Appendix 6.6-A p618. Time – drawdown/log derivative drawdown plots do not have legend. Please revise.

Response:

The well test analysis plots from Appendix 6.6-C have been modified and now include a legend. Revised plots are presented in Appendix A of this memorandum.

3.0 CLOSURE

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Yours sincerely,

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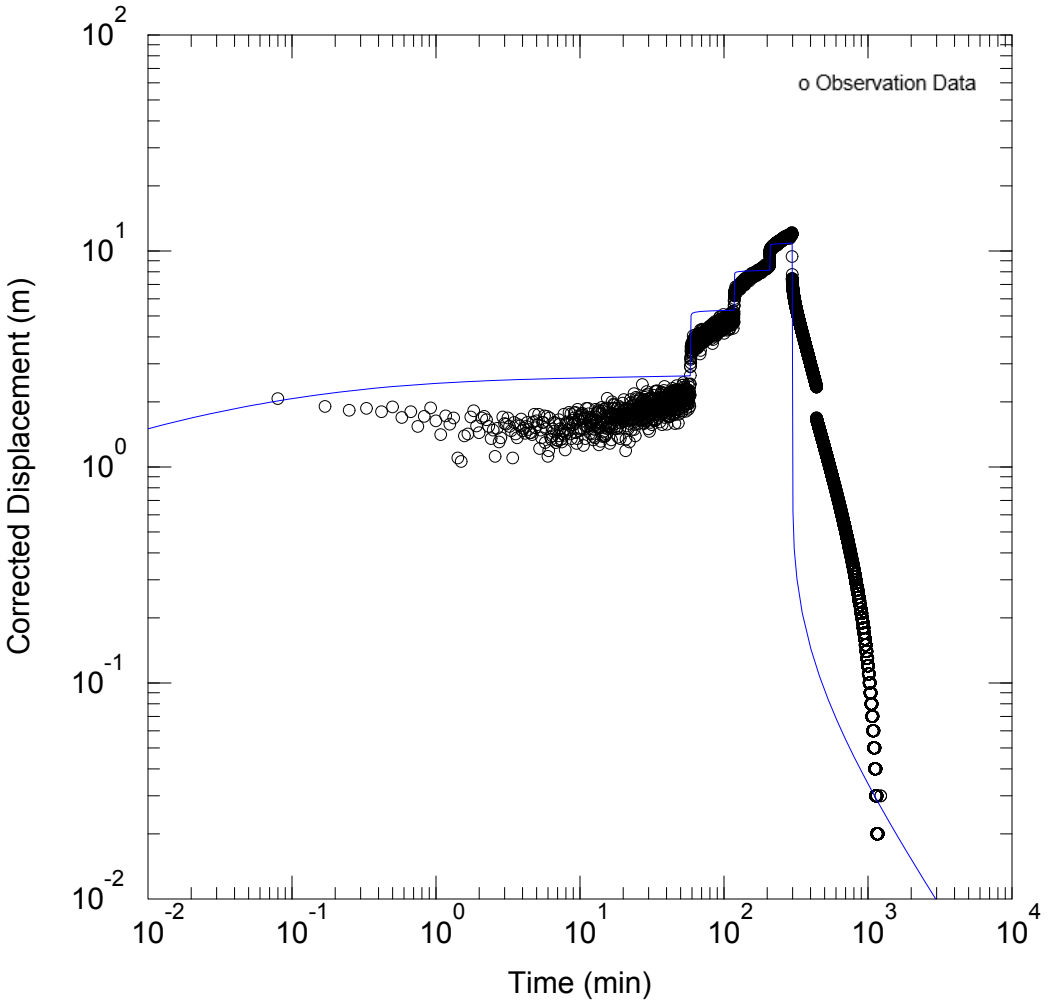
APPENDIX A
REVISED DISPLACEMENT VERSUS TIME PLOTS FROM THE PETERSON CREEK AQUIFER PUMPING TESTS
(Information Requirement Issue ID # FLNRO-017 and SSN-347)

A-1. Step Test in BGC14-PW01, Plot Update in Response to SSN-347



WELL TEST ANALYSIS

Data Set: N:\...\Step Test_Theis.aqt
Date: 03/24/16 Time: 15:13:53

PROJECT INFORMATION

Company: BGC Engineering Inc.
Client: KGHM Ajax Mining Inc.
Project: 1125007-08
Location: Kamloops
Test Well: BGC14-PW01

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
BGC14-PW01	687482	5609457

Observation Wells

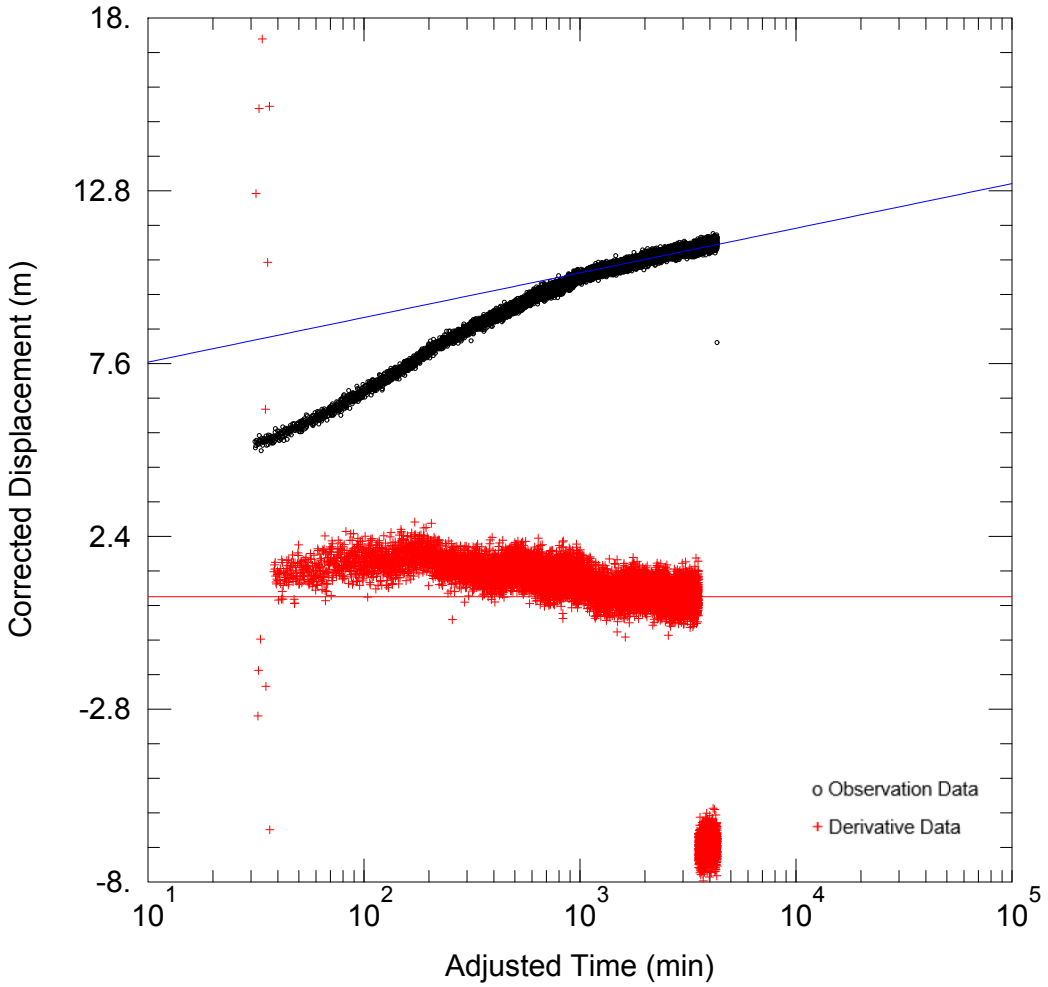
Well Name	X (m)	Y (m)
○ BGC14-PW01	687482	5609457

SOLUTION

Aquifer Model: Unconfined
Solution Method: Theis

T = 0.01453 m^2/sec
S = 0.01
Kz/Kr = 1.
b = 53.13 m

A-2. BGC14-PW01 Plot Update in Response to FLNRO-035



WELL TEST ANALYSIS

Data Set: N:\...\BGC14-PW01_CJ.aqt
Date: 04/12/16 Time: 16:26:19

PROJECT INFORMATION

Company: BGC Engineering Inc.
Client: KGHM Ajax Mining Inc.
Project: 1125007-08
Location: Kamloops
Test Well: BGC14-PW01

AQUIFER DATA

Saturated Thickness: 53.13 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
BGC14-PW01	687482	5609457

Observation Wells

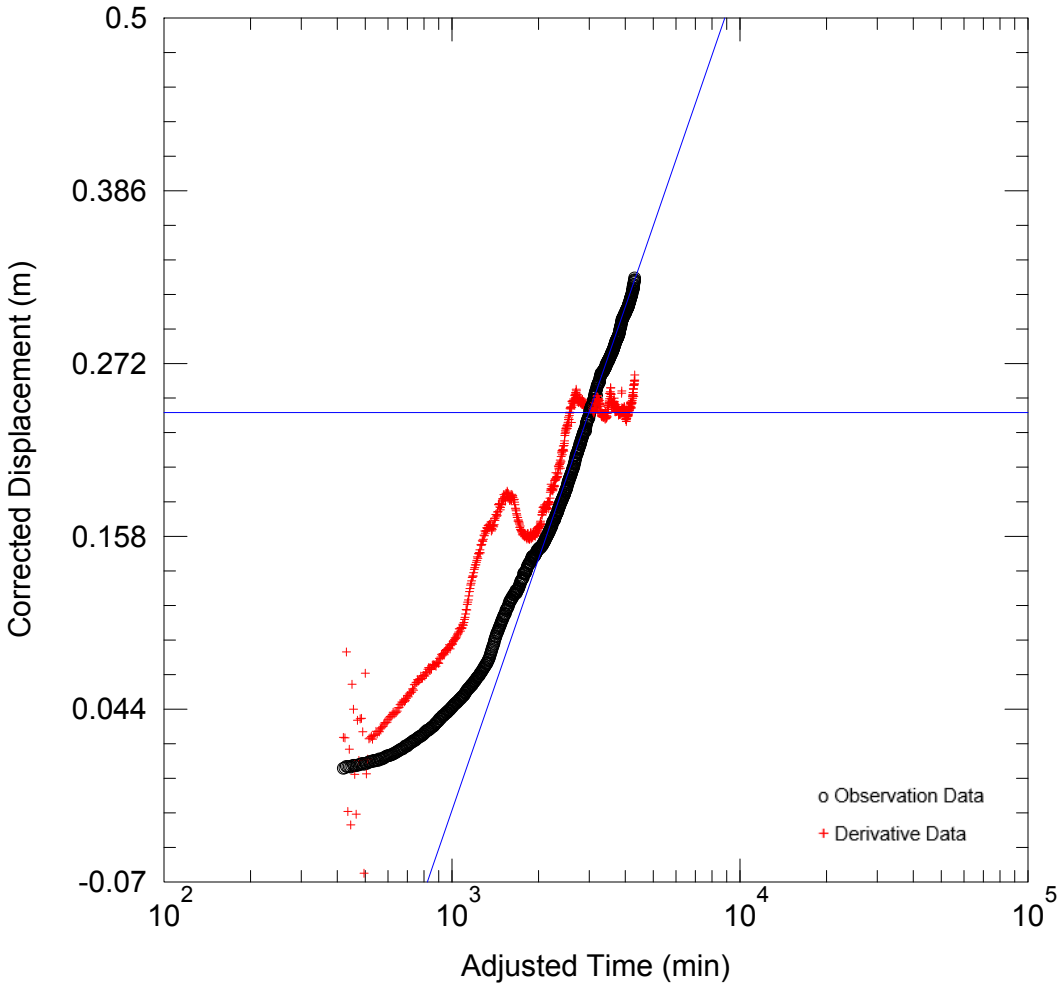
Well Name	X (m)	Y (m)
◦ BGC14-PW01	687482	5609457

SOLUTION

Aquifer Model: Unconfined Solution Method: Cooper-Jacob

T = 0.00216 m^2/sec S = 0.0005764

A-3. BGC13-021 Plot Update in Response to FLNRO-035



WELL TEST ANALYSIS

Data Set: N:\...\BGC13-021_CJ.aqt
Date: 03/24/16 Time: 14:40:42

PROJECT INFORMATION

Company: BGC Engineering Inc.
Client: KGHM Ajax Mining Inc.
Project: 1125007-08
Location: Kamloops
Test Well: BGC14-PW01

AQUIFER DATA

Saturated Thickness: 53.13 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
BGC14-PW01	687482	5609457

Observation Wells

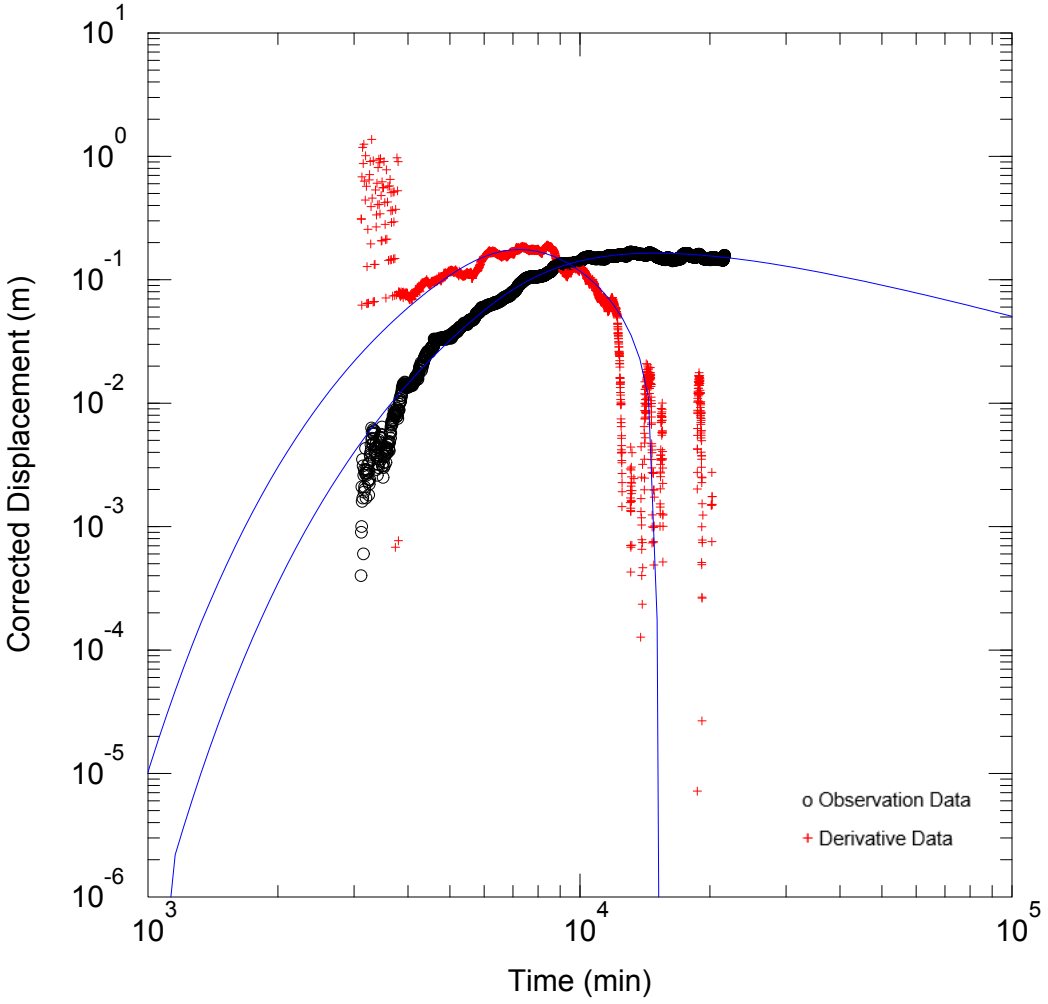
Well Name	X (m)	Y (m)
○ BGC13-021	687756	5609524

SOLUTION

Aquifer Model: Unconfined Solution Method: Cooper-Jacob

T = 0.005258 m^2/sec S = 0.009798

A-4. BGC13-022 Plot Update in Response to SSN-347



WELL TEST ANALYSIS

Data Set: N:\...\BGC13-022_Theis.aqt
Date: 03/24/16 Time: 14:42:49

PROJECT INFORMATION

Company: BGC Engineering Inc.
Client: KGHM Ajax Mining Inc.
Project: 1125007-08
Location: Kamloops
Test Well: BGC14-PW01

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
BGC14-PW01	687482	5609457

Observation Wells

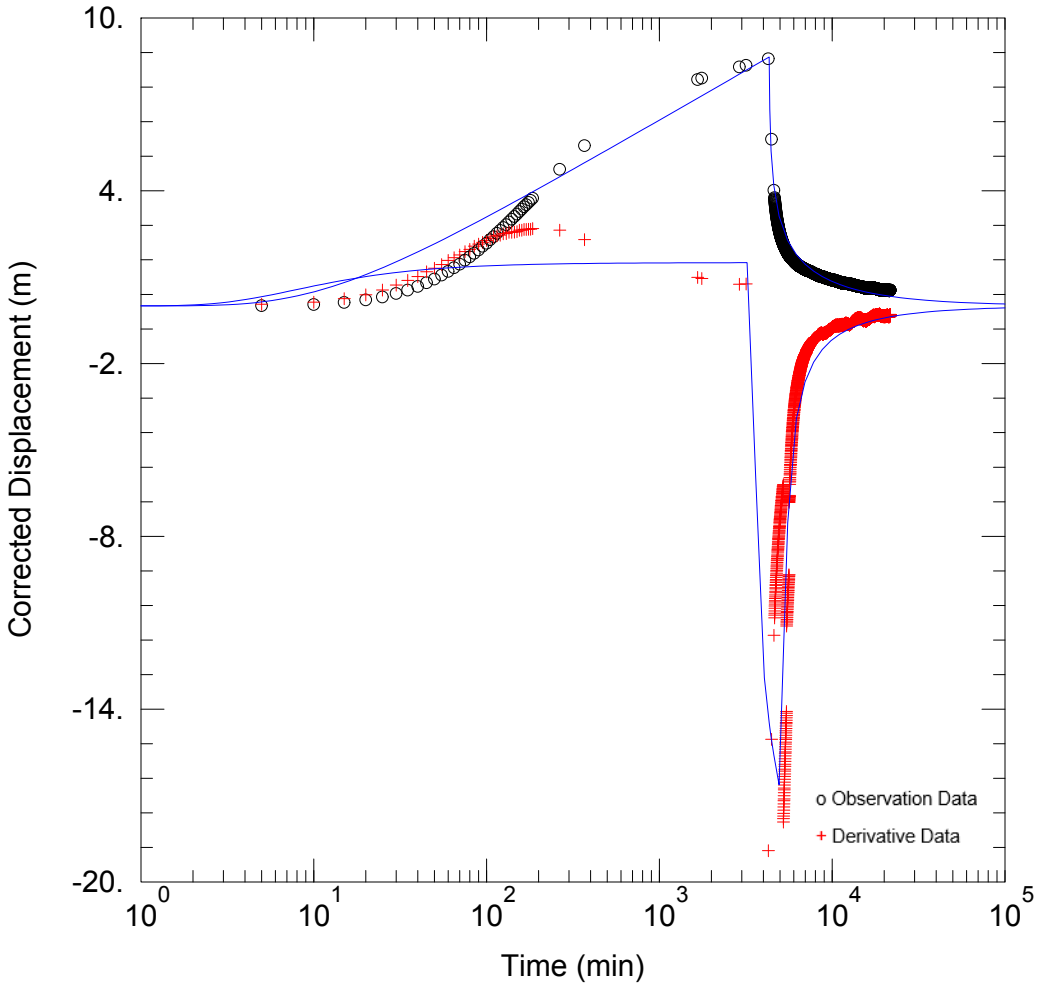
Well Name	X (m)	Y (m)
○ BGC13-022	687168	5609516

SOLUTION

Aquifer Model: Unconfined
Solution Method: Theis

T = 0.0009683 m^2/sec
S = 0.0285
Kz/Kr = 1.
b = 53.13 m

A-5. BGC14-004 Plot Adjustment in Response to SSN-347



WELL TEST ANALYSIS

Data Set: N:\...\BGC14-004_Theis.aqt
Date: 03/24/16 Time: 15:02:29

PROJECT INFORMATION

Company: BGC Engineering Inc.
Client: KGHM Ajax Mining Inc.
Project: 1125007-08
Location: Kamloops
Test Well: BGC14-PW01

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
BGC14-PW01	687482	5609457

Observation Wells

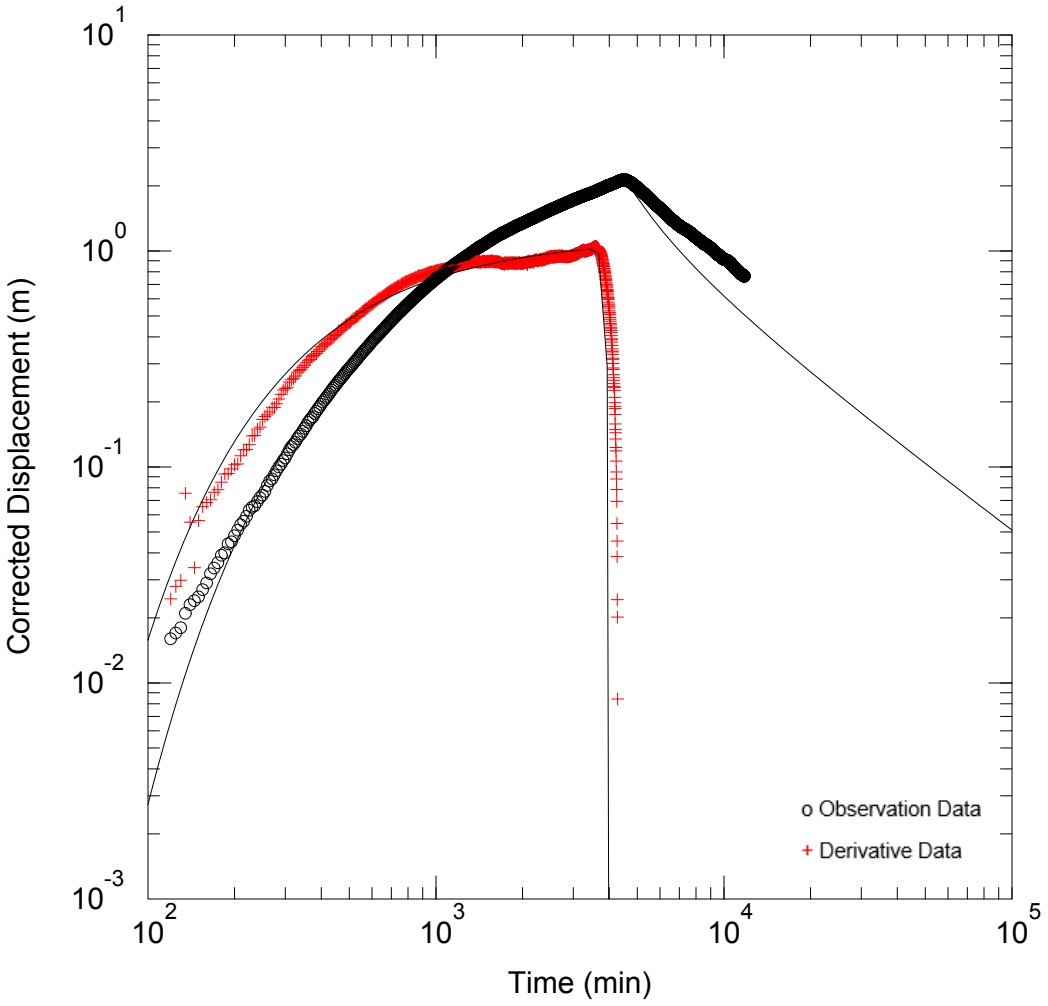
Well Name	X (m)	Y (m)
○ BGC14-004	687746	5609526

SOLUTION

Aquifer Model: Unconfined
Solution Method: Theis

T = 0.0008377 m^2/sec
S = 2.099E-5
Kz/Kr = 1.
b = 53.13 m

A-6. BGC14-005 Plot Update in Response to SSN-347



WELL TEST ANALYSIS

Data Set: N:\...\BGC14-005_Theis DD.aqt
Date: 03/24/16 Time: 15:03:48

PROJECT INFORMATION

Company: BGC Engineering Inc.
Client: KGHM Ajax Mining Inc.
Project: 1125007-08
Location: Kamloops
Test Well: BGC14-PW01

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
BGC14-PW01	687482	5609457

Observation Wells

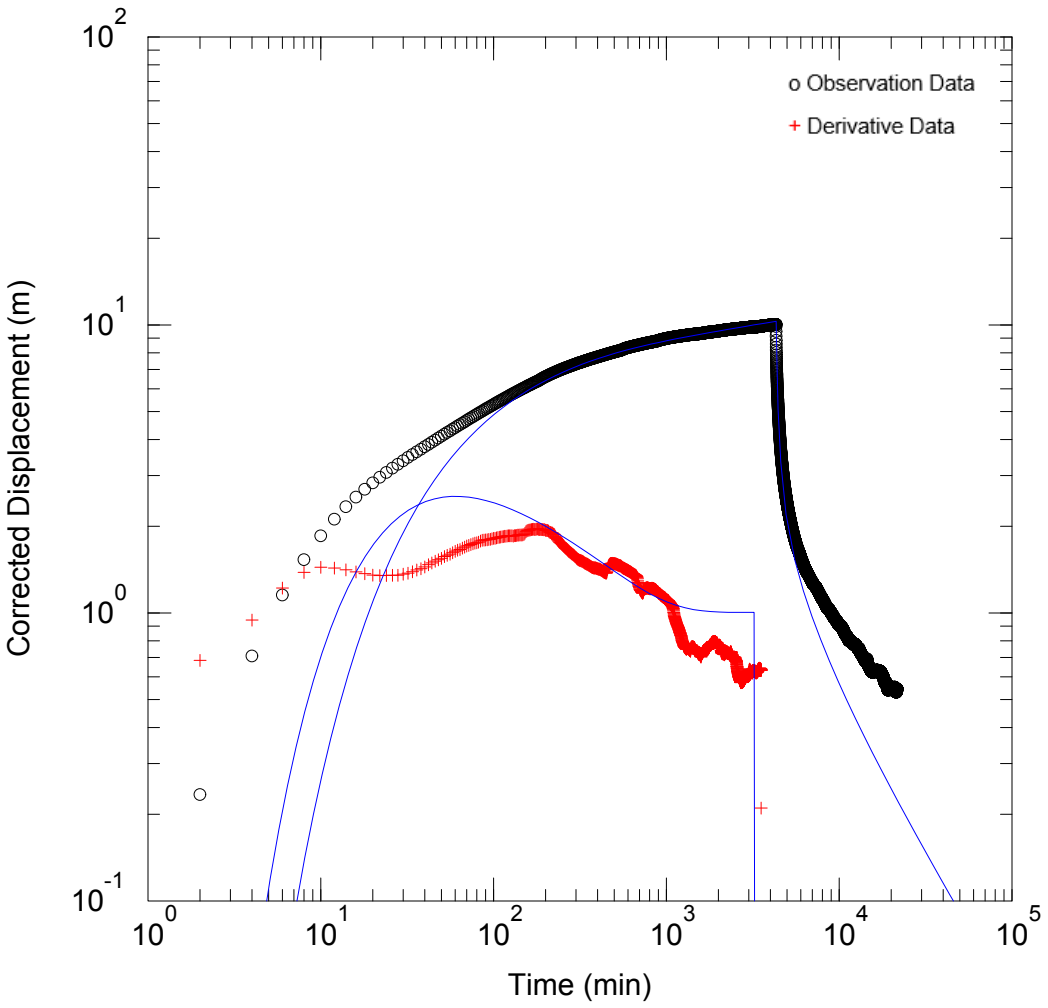
Well Name	X (m)	Y (m)
○ BGC14-005	687161	5609519

SOLUTION

Aquifer Model: Unconfined
Solution Method: Theis

T = 0.001087 m^2/sec
S = 0.001071
Kz/Kr = 1.
b = 53.13 m

A-7. BGC14-018 Plot Update in Response to SSN-347



WELL TEST ANALYSIS

Data Set: N:\...\BGC14-018_Theis.aqt
Date: 03/24/16 Time: 14:47:04

PROJECT INFORMATION

Company: BGC Engineering Inc.
Client: KGHM Ajax Mining Inc.
Project: 1125007-08
Location: Kamloops
Test Well: BGC14-PW01

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
BGC14-PW01	687482	5609457

Observation Wells

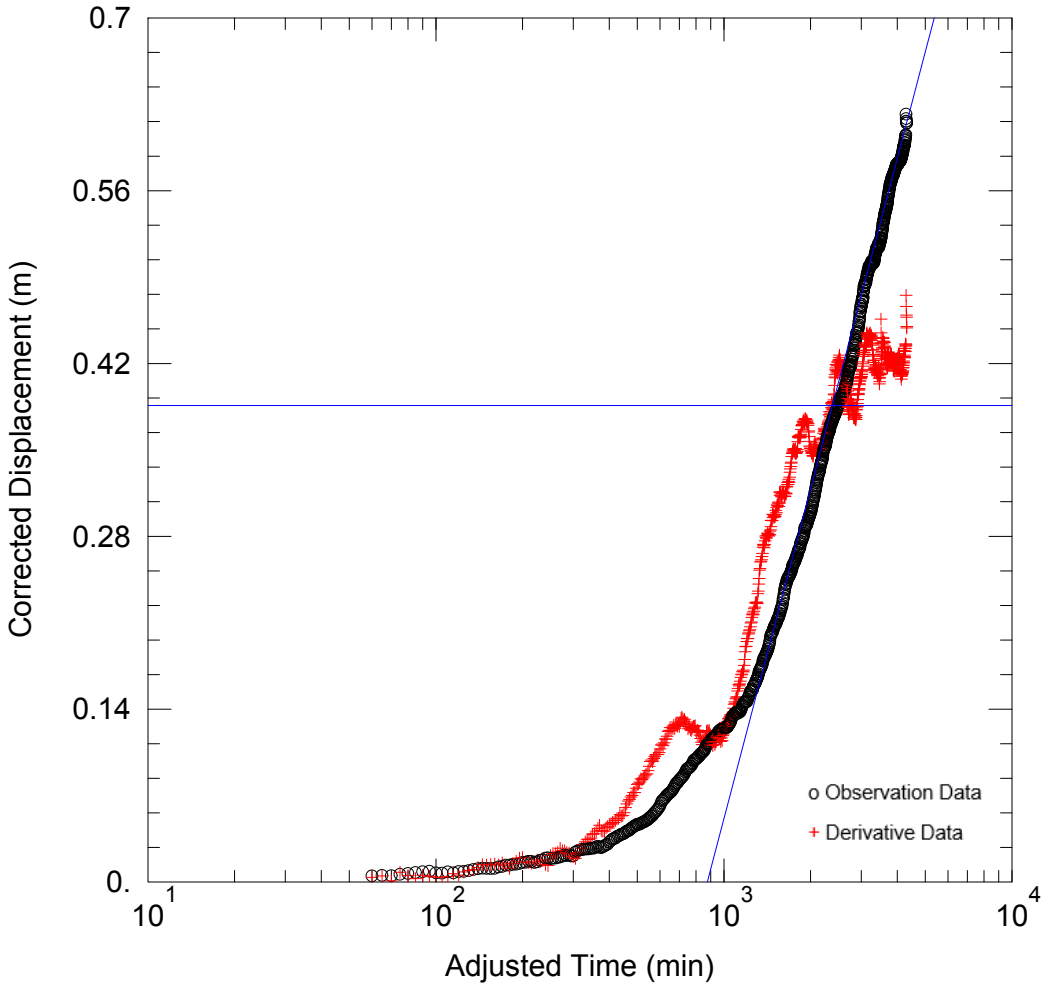
Well Name	X (m)	Y (m)
○ BGC14-018	687489	5609453

SOLUTION

Aquifer Model: Unconfined
Solution Method: Theis

T = 0.001247 m^2/sec
S = 0.08977
Kz/Kr = 1.
b = 53.13 m

A-8. DH14-057 Plot Update in Response to FLNRO-035



WELL TEST ANALYSIS

Data Set: N:\...\DH14-057_CJ.aqt
Date: 03/24/16 Time: 14:53:52

PROJECT INFORMATION

Company: BGC Engineering Inc.
Client: KGHM Ajax Mining Inc.
Project: 1125007-08
Location: Kamloops
Test Well: BGC14-PW01

AQUIFER DATA

Saturated Thickness: 53.13 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
BGC14-PW01	687482	5609457

Observation Wells

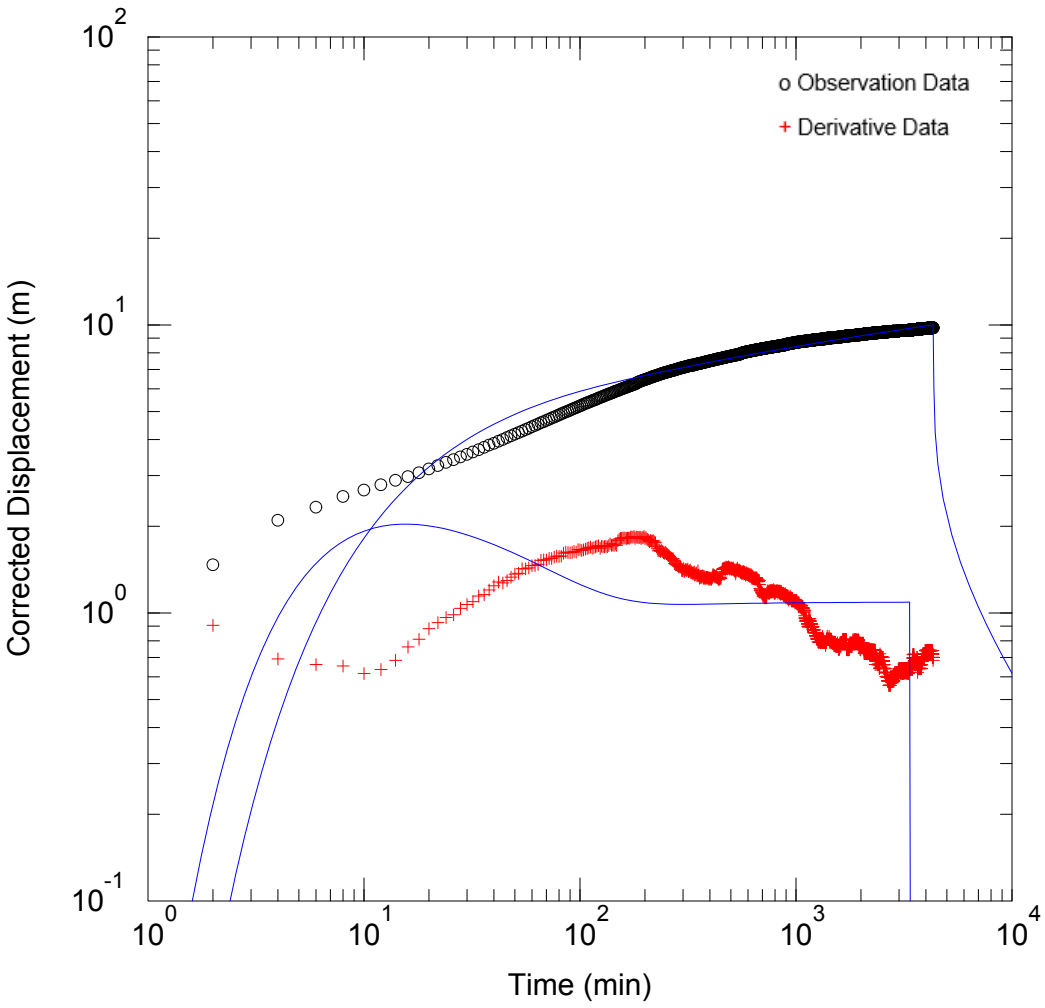
Well Name	X (m)	Y (m)
○ DH14-057	687035	5609442

SOLUTION

Aquifer Model: Unconfined Solution Method: Cooper-Jacob

T = 0.003265 m^2/sec S = 0.001926

A-9. MW11-10D Plot Update in Response to SSN-347



WELL TEST ANALYSIS

Data Set: N:\...\MW11-10D_theis.aqt
Date: 03/24/16 Time: 14:48:44

PROJECT INFORMATION

Company: BGC Engineering Inc.
Client: KGHM Ajax Mining Inc.
Project: 1125007-08
Location: Kamloops
Test Well: BGC14-PW01

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
BGC14-PW01	687482	5609457

Observation Wells

Well Name	X (m)	Y (m)
○ MW11-10D	687493	5609464

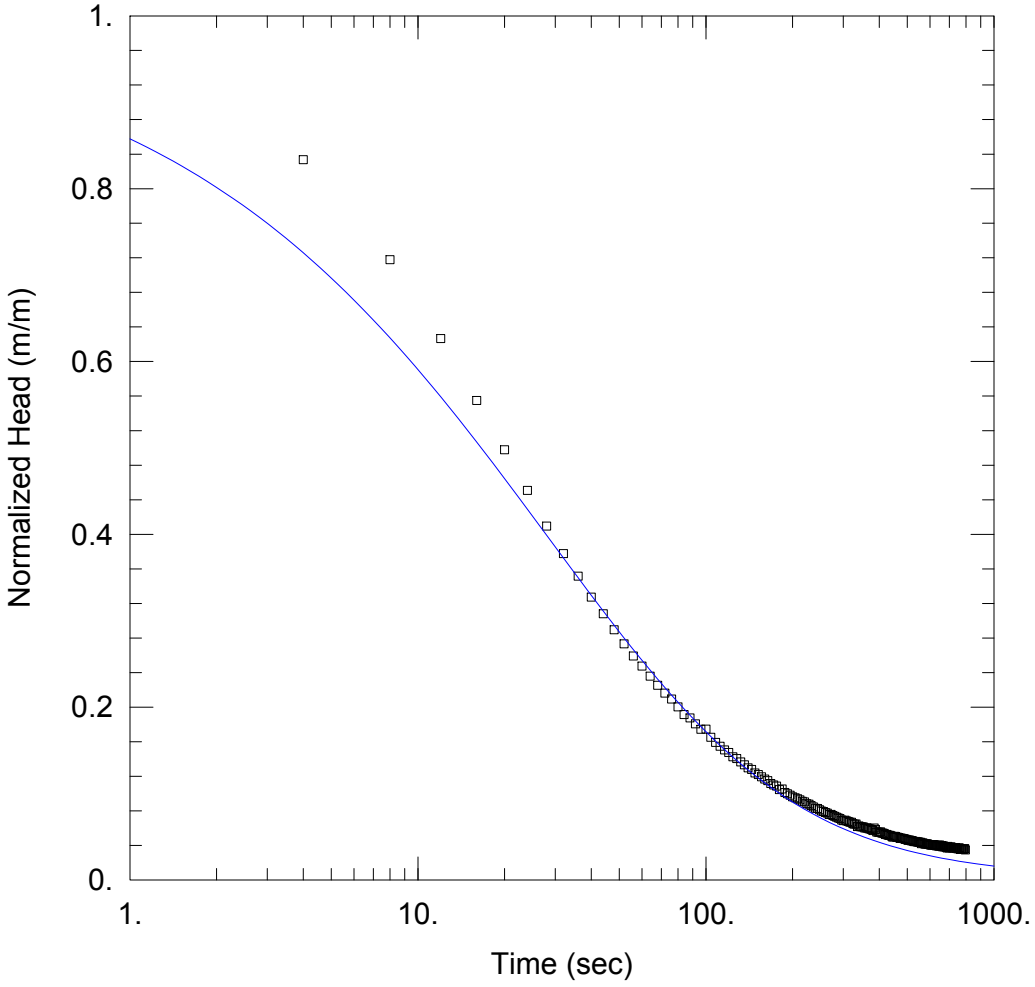
SOLUTION

Aquifer Model: Unconfined
Solution Method: Theis

T = 0.001154 m^2/sec
S = 0.01139
Kz/Kr = 1.
b = 53.13 m

APPENDIX B
REVISED DISPLACMENT VERSUS TIME PLOTS FOR THE AJAX SOUTH GROUNDWATER AND SURFACE WATER SITE (Information Requirement Issue ID # FLNRO-037)

B-1. BGC14-001D Plot Update in Response to FLNRO-037



BGC14-001D FH TEST 1

PROJECT INFORMATION

Company: BGC Engineering Inc.
Client: KJHM Ajax Mining Inc.
Location: Ajax
Test Well: BGC14-001D
Test Date: 04-Apr-2014

AQUIFER DATA

Saturated Thickness: 13.27 m

WELL DATA (BGC14-001D)

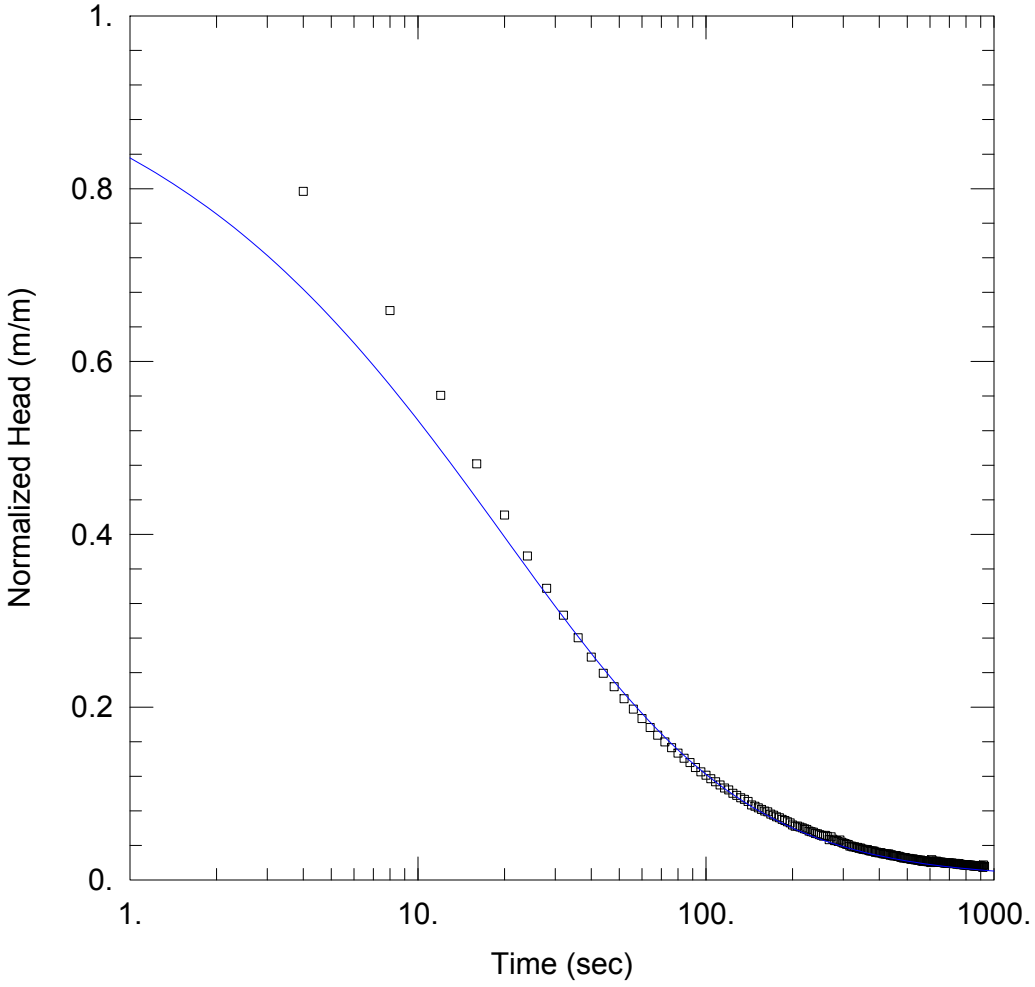
Initial Displacement: 0.5071 m
Total Well Penetration Depth: 13.27 m
Casing Radius: 0.0254 m
Static Water Column Height: 13.27 m
Screen Length: 6.1 m
Well Radius: 0.0762 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 1.699E-6 m/sec
Kz/Kr = 1.
Ss = 0.004603 m^{-1}

B-2. BGC14-001D Plot Update in Response to FLNRO-037



BGC14-001D RH TEST 2

PROJECT INFORMATION

Company: BGC Engineering Inc.
Client: KJHM Ajax Mining Inc.
Location: Ajax
Test Well: BGC14-001D
Test Date: 04-Apr-2014

AQUIFER DATA

Saturated Thickness: 13.27 m

WELL DATA (BGC14-001D)

Initial Displacement: 0.7084 m
Total Well Penetration Depth: 13.27 m
Casing Radius: 0.0254 m
Static Water Column Height: 13.27 m
Screen Length: 6.1 m
Well Radius: 0.0762 m

SOLUTION

Aquifer Model: Unconfined
Solution Method: KGS Model

Kr = 2.577E-6 m/sec
Kz/Kr = 1.
Ss = 0.003965 m^{-1}