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Memorandum

To: Brad Thrall, Alexco Resource Corp.

From: Leia Fougere and Fred Marinelli, Alexco Environmental Group Inc.

Date: 27 September 2017

Re: Bermingham Mine Groundwater Evaluation

1 INTRODUCTION

Alexco Resource Corp. (Alexco) plans to advance the development of the Bermingham deposit towards production, and an understanding of the groundwater flow regime and an estimation of the groundwater inflow rates is necessary for water management design.

This memo presents: (1) groundwater information collected during the field program, (2) analysis of data to characterize the rock mass hydrologic properties, and (3) a general dewatering estimate to support the planning and permitting of the proposed mine. The proposed Bermingham Mine would produce approximately 220,000 tonnes of ore over a 6 year mine life. The mine would extend from approximately 170 meters below ground surface to an ultimate depth of 340 meters. Figure 1-1 shows the Bermingham life-of-mine plan and the ultimate extent and depth of the Bermingham mine in relation to the surface topography.

Borehole drilling has been completed to aid in the assessment of the groundwater inflow rates into the Bermingham mine. During October 2016, two test boreholes (KAR16-020 and KAR16-021) were drilled into bedrock to investigate groundwater conditions within the vicinity of the Bermingham deposit. The overall objectives of the drilling program were to evaluate and estimate groundwater inflows into the mine, with emphasis on the decline. Discharge flow rates were monitored during air-rotary drilling and airlift pumping/recovery tests were performed in the open holes to evaluate the hydraulic conductivity of the rock mass.

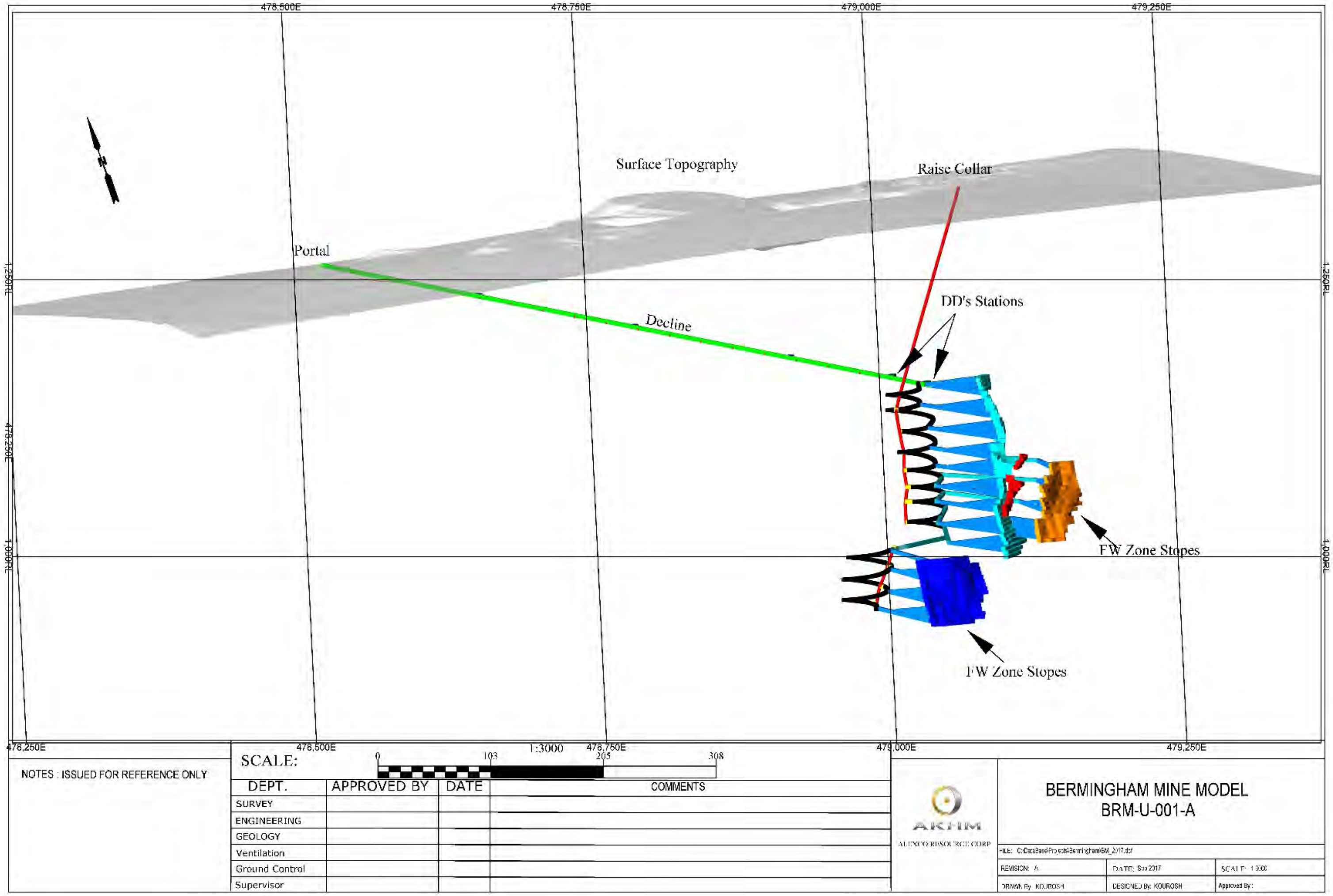


Figure 1-1 Bermingham Life-of-Mine Plan

1.1 PROJECT BACKGROUND AND PROPOSED DEVELOP PLAN

The Bermingham deposit is in close proximity to the historical Bermingham mine (underground and open pit) on the upper northwest slopes of Galena Hill. The Bermingham deposit comprises a westerly Etta Zone and a fault separated larger easterly Arctic Zone. Recent surface exploration work (2015 – 2017) has focused on the northeasterly extension of the Arctic Zone where several structurally controlled sets of subparallel moderately to steeply southeast dipping veins, including the Bermingham, Bermingham Footwall, and Bear veins, that splay and rejoin in a manner controlled by the host rock stratigraphy. A westerly and shallower dipping conjugate vein set (West Dipper vein) is also present. All vein sets in the northeasterly Arctic Zone are closely associated and connected either laterally or vertically within the wider Bermingham vein-fault structural corridor that is silver enriched over a 660 m strike length. The mineralization extends from 90 m to 160 m below surface to a depth of approximately 370 m where veining remains open.

Within the Bermingham area, the bedrock geology is generally quartzite and graphitic schist, with lenses of sericite schist and greenstone. The groundwater flow direction is generally northwest towards the valley bottom, sequentially passing through the historic Bermingham, Ruby, and No Cash Mines.

2 DRILLING AND TESTING

2.1 GENERAL FIELD METHODS

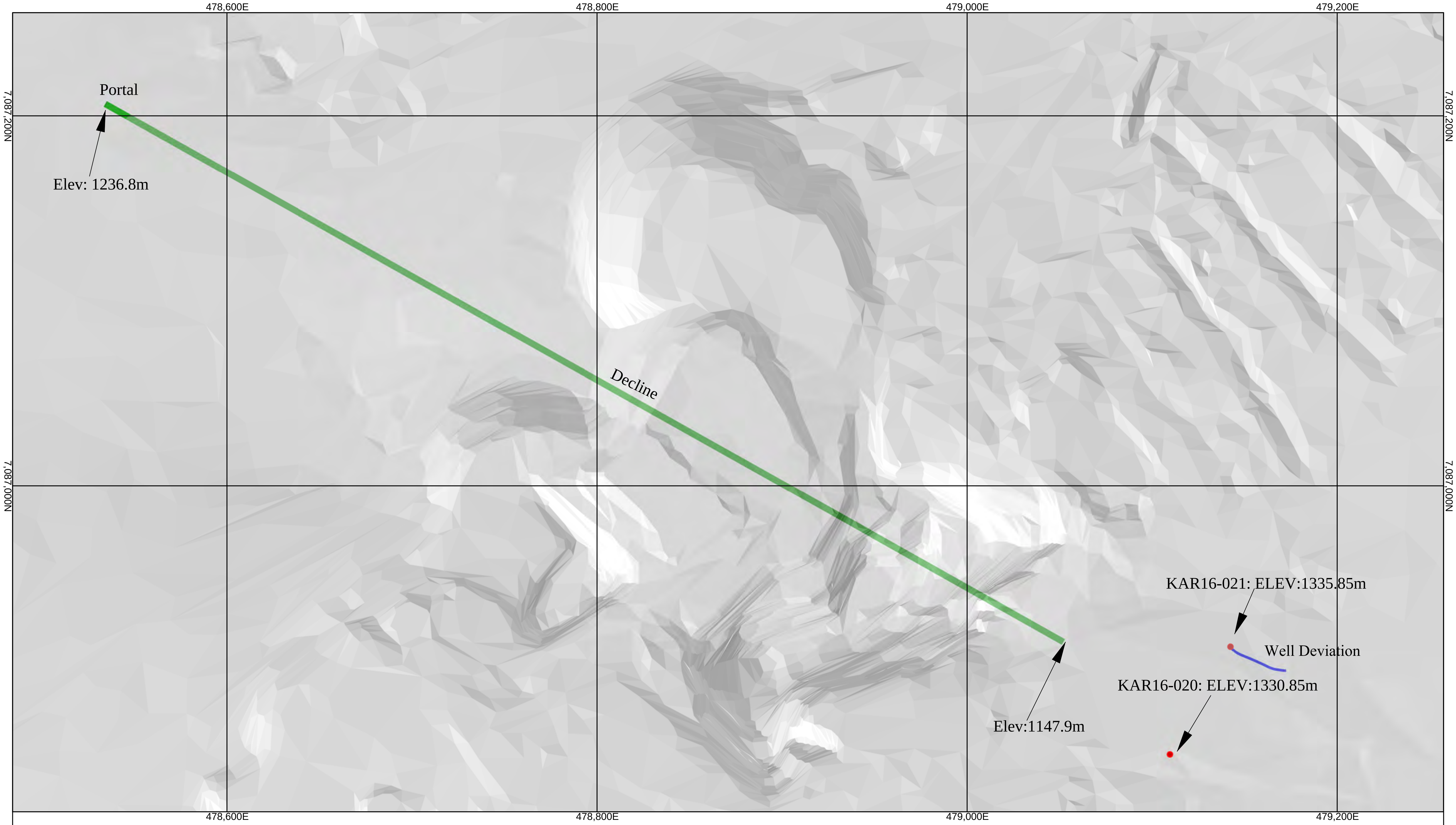
Drilling and testing of the two boreholes was performed between October 19th and October 27th 2016 by Midnight Sun Drilling Company using a truck-mounted air rotary drill rig. The borehole locations were determined based on historical mine maps and subsurface geologic mapping interpreted from mineral exploration coreholes drilled by Alexco. The locations of the two test holes (KAR16-020 and KAR16-021) are shown on Figure 2-1 and Figure 2-2.

Penetrated geological units were identified based on information from nearby exploration coreholes and rock chips collected from the cyclone as the drilling advanced. The rock types included schist, quartzite, and highly fractured rock and gauge within fault zones. Vibrations of the drill rig also helped to identify the locations of highly fractured and broken up rock. Geologic logs for the two test holes are provided in Attachment A.

Both test holes were drilled using the air rotary method with a pneumatic hammer drill bit. For this drilling method, any groundwater in the hole was continuously airlifted to ground surface and discharged through the cyclone. After encountering groundwater, drilling was interrupted approximately every two drill rods (12.2 m) and the airlift flow rate was measured. The flow rate measurements were done by discontinuing makeup water injection and blowing the hole with compressed air (airlift pumping) until the cyclone discharge rate was visually stable. Then several flow rate measurements were made at the cyclone using a stopwatch to record the number of seconds to fill a 20-liter bucket. The flow rate measurement was repeated 3 to 5 times at each depth depending on the consistency of the measured values.

A borehole deviation survey was performed in KAR16-021 borehole after drilling and the survey values (inclination and azimuth) are provided on the borehole logs in Attachment A. The downhole survey was not completed in borehole KAR16-020 as there was a post-drilling blockage in the borehole at approximately 43 m. The deviation in KAR16-021 is shown graphically on Figure 2-1 (plan view) and in the section view on Figure 2-2. As shown, there was significant deviation from vertical in the lower portion of KAR16-021.

After each hole was drilled, one or two airlift pumping tests were performed by first lowering a Solinst, Inc. Levelogger (pressure transducer plus dataloger) down the hole via wireline. Then the drill rods were lowered to a depth of 9 to 25 m above the Levelogger. After allowing time for the water level to stabilize, airlift pumping was initiated and discharge flow rates were measured on a regular basis using the bucket and stopwatch method discussed above. After a period of sustained pumping, the airlift was discontinued and time was allowed for water-level recovery in the borehole. The rods were then removed, the Levelogger retrieved, and time-pressure data were downloaded into a laptop computer for subsequent processing.



NOTES :

DATE	ISSUE / REVISION	REV	DRW	APP

COMMENTS

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AKHM

ALEXCO RESOURCE CORP

BERMINGHAM DEWATERING MEMO

FIGURE 2-1
BERMINGHAM - PLAN VIEW

FILE: C:\DataBase\Projects\Bermingham\BM_water_table.dcf

REVISION:

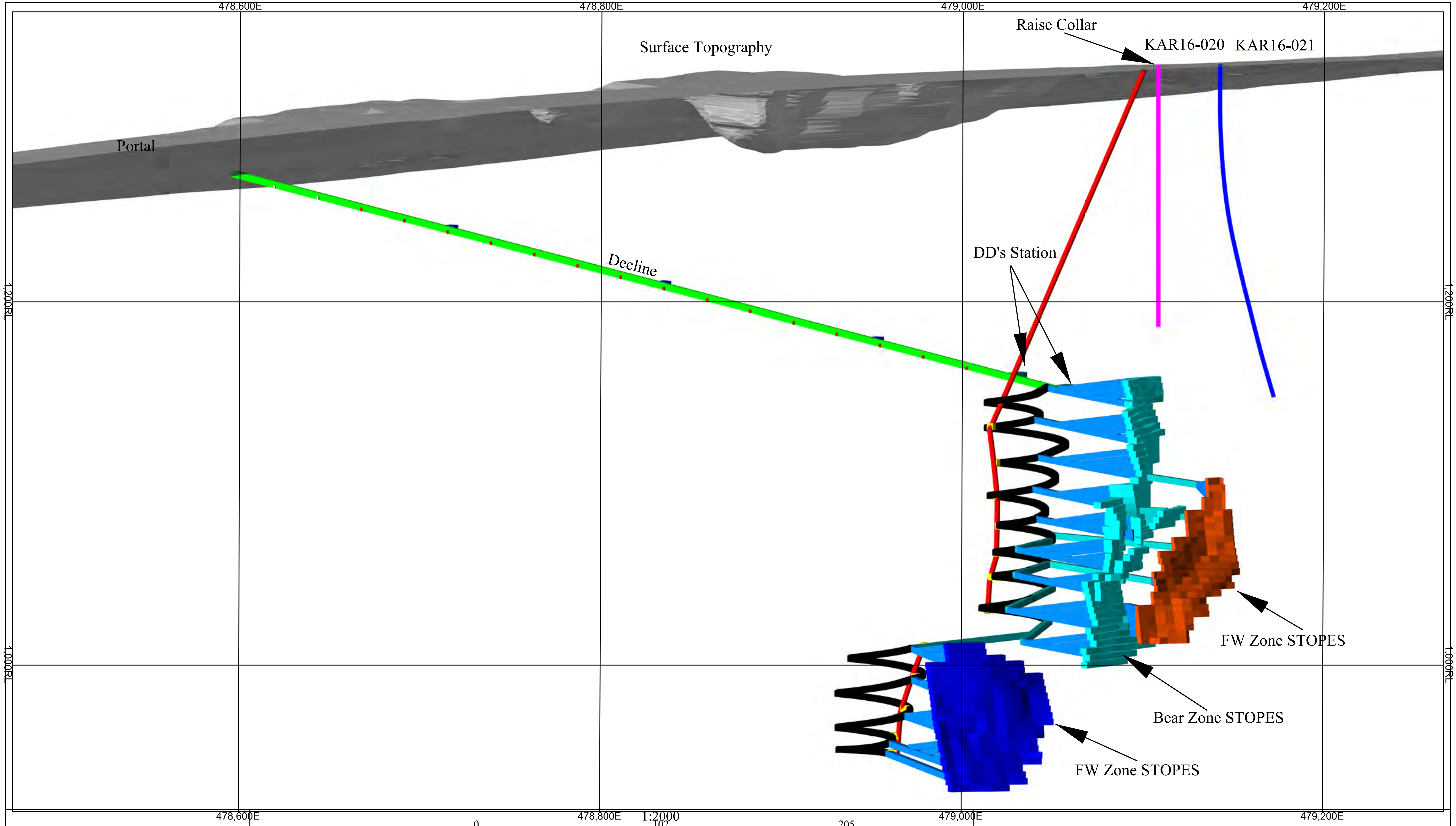
DATE: MAR 2017

SCALE: 1:2000

DRAWN By:

DESIGNED By:

REVIEWED By :



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NOTES : ISSUED FOR REFERNCE ONLY
Borehole deviation not measured
in KAR16-20

DEPT.	APPROVED BY	DATE	COMMENTS
SURVEY			
ENGINEERING			
GEOLOGY			
Ventilation			
Ground Control			
Supervisor			

AKHM
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Bermingham Proposed Mine-Section view
Fig 2-2

FILE: C:\DataBase\Projects\Bermingham\BM_water_table.dcf

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2.2 BOREHOLE KAR16-020

After setting a 6-inch steel surface casing to a depth of 2.4 m below ground, KAR16-020 was started on October 19th, 2016 using a 6-inch pneumatic hammer drill bit. Noticeable groundwater was encountered at a depth of about 43 m. The average airlift discharge rates obtained at each depth (while drilling was interrupted) are presented in Table 2-1 below.

Table 2-1 Average airlift flow rates measured while drilling borehole KAR16-020

Drilled Depth (m)	Average Flow Rate (L/s)	Comments
54.9	0.28	Quartzite, rumbly, water flowing out of TOC
67.1	0.31	Sericite schist
79.2	0.30	Graphitic schist
91.4	0.32	Sericite schist
97.5	0.94	Quartzite, rumbly, fault
103.6	0.67	Greenstone
115.8	1.05	Quartzite
128.0	1.20	Quartzite
134.1	1.94	Quartzite, cross-fault

As shown in Table 2-1, there was a progressive increase in discharge rate as the borehole was deepened.

At the end-of-shift on October 20th, the borehole had advanced to 134.1 m with significant caving between 128.0 and 134.1 m. The cave zone was interpreted to be a cross-fault containing highly fractured rock. The following morning, the borehole had filled with debris up to a depth of 121.9 m. The bottom of the hole was re-drilled and advanced to a depth of 140.2 m. At this depth, a decision was made to discontinue drilling and the drill string was removed from the hole. While tripping out the drill rods, additional airlift discharge tests were performed and these are summarized in Table 2-2.

Table 2-2 Airlift flow rates measured while pulling rods from KAR16-020

Bottom of Rod Depth (m)	Average Flow Rate (L/s)
121.9	2.01
106.7	2.41
91.4	2.17
76.2	2.45
61.0	1.24
42.7	0.12
24.4	0.05

On the morning of October 22nd, an attempt was made to lower the rods in the hole, but the string hung up at a depth of about 42.7 m below ground surface. It is believed that the rods landed on a "bridge" and the borehole beneath the bridge may have been open or filled with very coarse material that would not restrict upward flow during airlift pumping. To perform the airlift pumping test, a Levelogger was positioned at a depth of 42.1 m and the rods were lowered to 33.5 m below ground. With this configuration, the airlift pumping test was conducted between 09:40 am and 11:10 am, followed by recovery to 1:25 pm. Discharge rates measured during the airlift pumping test are provided in Table 2-3 below.

Table 2-3 KAR16-020 airlift flow rates during pumping test

Time	Flow Rate (L/s)
10:30 am	0.24
10:41 am	0.25
10:52 am	0.25
11:04 am	0.25

As observed in Table 2-3, the airlift discharge rate was essentially constant during the pumping test.

2.3 BOREHOLE KAR16-021

The second borehole location was chosen to be near the original location yet avoid the cross-fault that had been encountered in KAR16-020. After setting 8-inch steel surface casing to a depth of 4.9 m, the drilling of KAR16-021 began on October 22nd using an 8-inch pneumatic hammer drill bit. The hole was advanced to a depth 128 m at which point a geologic structure was encountered. Increased caving was experienced with continued drilling. At a depth of 146+ m, the drill string was removed and 6-inch steel casing was lowered to 146.6 m and pushed into the bottom of the hole without placement of grout. The borehole was then advanced using a 6-inch bit. When drilling continued, there was a sharp drop in the airlift flow rate indicating that a reasonably good seal had been established at the bottom of the 6-inch casing. A decision was made to terminate the borehole at 189 m below ground because its depth had reached the maximum depth of the proposed decline and therefore fulfilled the primary drilling objective. As shown on Figure 2-1 and Figure 2-2, KAR16-021 deviated from vertical and did not intersect any of the vein targets.

Beginning at depth of 48.8 m, drilling was generally interrupted every two rods (12.2 m) and airlift discharge rates were measured. These data are summarized in Table 2-4.

Table 2-4 Average airlift flow rates measured while drilling borehole KAR16-021

Depth (m)	Average Flow Rate (L/s)	Comments
48.8	0.30	Mostly sericite schist
61.0	0.88	Quartzite + quartz
73.2	0.49	Sericite schist + quartz
85.3	0.49	Graphitic schist, lots of material flushing out even after aerating for several minutes
97.5	1.02	Quartzite, less material
115.8	1.47	Quartzite, rusty color, weathered, water clearing up
122.5	1.77	Quartzite, rusty, lots of material
134.1	2.08	Quartzite, rusty, lots of material; open hole to this depth
152.4	0.19	Quartzite, fairly clear water; hole cased to 146.6 m below ground
164.6	0.42	Quartzite and schist
170.7	0.33	Quartzite + quartz
176.8	0.56	Quartzite, some graphitic schist
182.9	0.67	Quartzite
189.0	0.68	Quartzite and schist

Note that the decrease in discharge rate below 134.1 m was due to placement of the steel casing that effectively sealed off the upper portion of the borehole.

Two airlift pumping tests were conducted on October 26th. The Levelogger was initially lowered to a depth of 145.7 m and the rods to 121.9 m. The first period of airlift pumping (Test A) lasted from 3:28 pm to 5:25 pm, with flow rates summarized in Table 2-5.

Table 2-5 KAR16-021 airlift flow rates during first pumping test (Test A)

Time	Flow Rate (L/s)
3:35 pm	0.38
3:46 pm	0.33
3:57 pm	0.30
4:07 pm	0.27
4:20 pm	0.26
4:36 pm	0.25
4:46 pm	0.25
5:03 pm	0.25
5:14 pm	0.24
5:23 pm	0.24

Groundwater was allowed to recover until 8:00 pm, and then both the Levelogger and rods were raised to higher positions in the borehole (Levelogger at depth of about 121.3 m and bottom of rods at 97.5 m). The second period of airlift pumping (Test B) lasted from 8:29 pm to 9:02 pm, and the associated flowrates are summarized in Table 2-6.

Table 2-6 KAR16-021 airlift flow rates during second pumping test (Test B)

Time	Flow Rate (L/s)
8:37 pm	0.15
8:43 pm	0.08
8:52 pm	0.07
9:01 pm	0.06

After the second pumping period, groundwater recovery was monitored overnight and the Levelogger and rods were removed from the hole the following morning.

3 DATA ANALYSIS

Drilling discharge rates and airlift pumping tests were used to evaluate hydraulic conductivity and rock mass heterogeneity with regard to hydraulic properties. These characteristics are important in estimating the groundwater inflow rates for the proposed mine.

3.1 DRILLING DISCHARGE RATES

Based on the information in Table 2-1 and Table 2-2, Figure 3-1 is a plot of drilling discharge rate versus depth for borehole KAR16-020. The relatively small change in flow rate over the depth interval of 25 to 90 m suggests lower permeability rock. The distinct increase in flow at about 130 m indicates a more permeable zone that correlates with intersection of the cross-fault. As expected, the airlift flow rates measured during rod removal are higher because the full length of the final borehole (depth of 140 m) provides flow, which was not the case during drilling.

Figure 3-2 is a similar plot for borehole KAR16-021. To estimate how the plot might look in the absence of casing, the flows measured below the casing (that is, below 140 m) are corrected by adding the measured flow rate in the deepest part of the borehole before casing was installed (2.1 liters per second). With the corrected data points, the plot shows a generally uniform increase in flow rate with depth, suggesting relatively uniform rock hydraulic conductivity.

Figure 3-3 combines the data from both boreholes into a single plot. While there is some scatter, the flow rate versus depth trends for both boreholes are similar, suggesting that the hydraulic characteristics of rock at both drilling locations are similar.

Drilling discharge analysis provides evidence that at large scale, the rock mass is relatively homogeneous with regard to hydraulic conductivity, both laterally and vertically. While increased hydraulic conductivity may exist in the cross faults, it is not to a degree that fault zones completely dominate the groundwater hydraulics. This is consistent with mining experience within the Keno Hill District, which has shown that cross-faults tend to be the more water-bearing rock structures. Note that the boreholes did not penetrate the vein targets, so was no direct measurement of hydraulic properties in these structures. However, experience within the Keno Hill Silver District suggests that while the ore veins may have higher hydraulic conductivity than adjacent rock, the relative increase is not extreme.

During air-rotary drilling, discharge rates from a borehole can be higher than the inflow rates observed during subsequent tunneling into the same rock. Inflows to dewatered wells and excavations tend to decrease over time as factures depressurize and dewater. Because drilling represents a rapid “excavation” in the rock mass, there is not sufficient time for the downward trending flows to reach a steady-state. Tunneling is a much longer process that allows time for the decreasing flows to reach a final (lower) inflow rate.

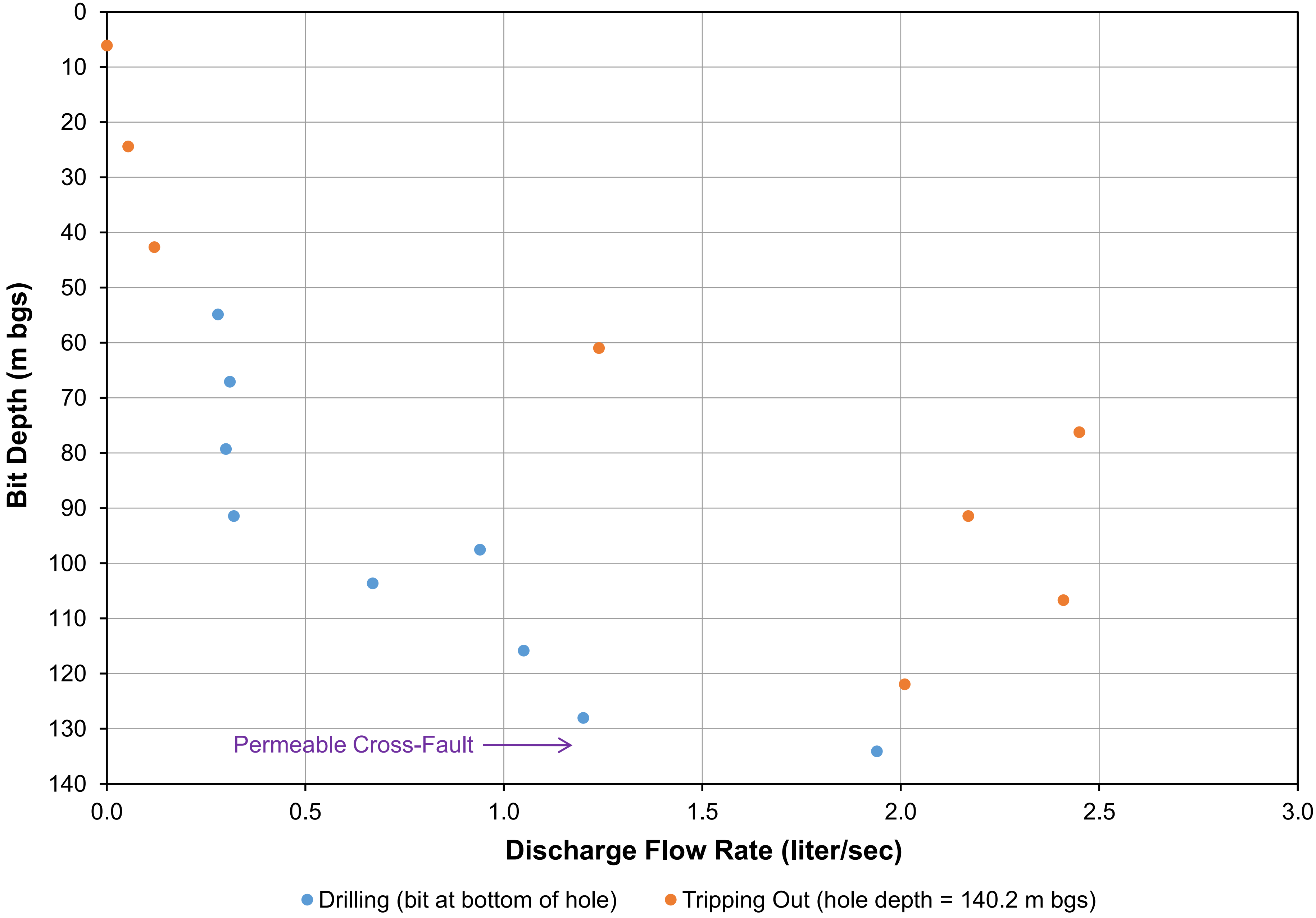

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FIGURE 3-1

KAR16-020 DISCHARGE DURING AIR HAMMER DRILLING

DECEMBER 2016

D:\Project\AllProjects\ALEX-05-01\gis\mxd\Overview_Maps\SiteSpecific\Bermingham\Memo_2016\Figure 3

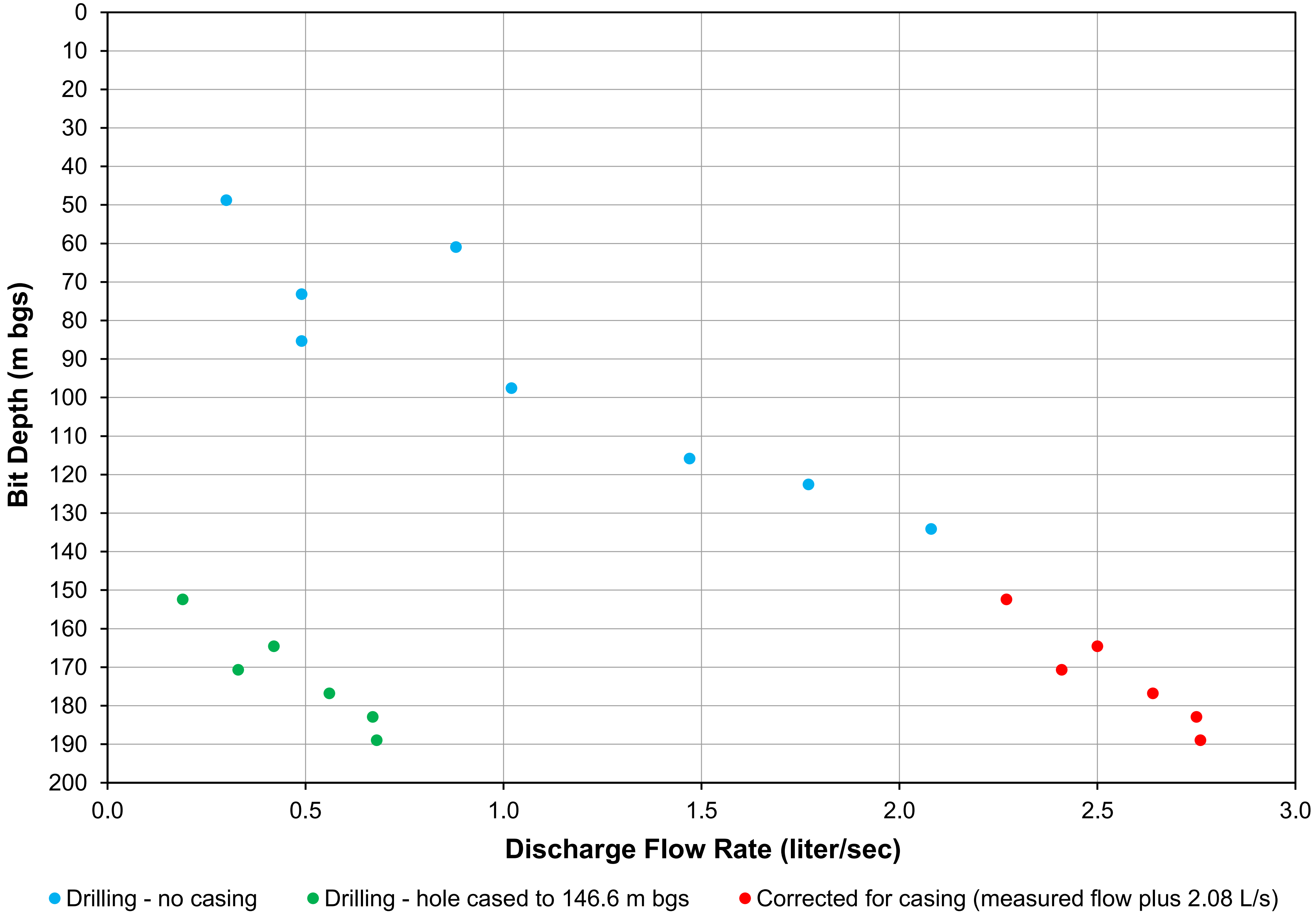

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FIGURE 3-2

KAR16-021 DISCHARGE DURING AIR HAMMER DRILLING

DECEMBER 2016

D:\Project\AllProjects\ALEX-05-01\gis\mxd\Overview_Maps\SiteSpecific\Bermingham\Memo_2016\Figure 4

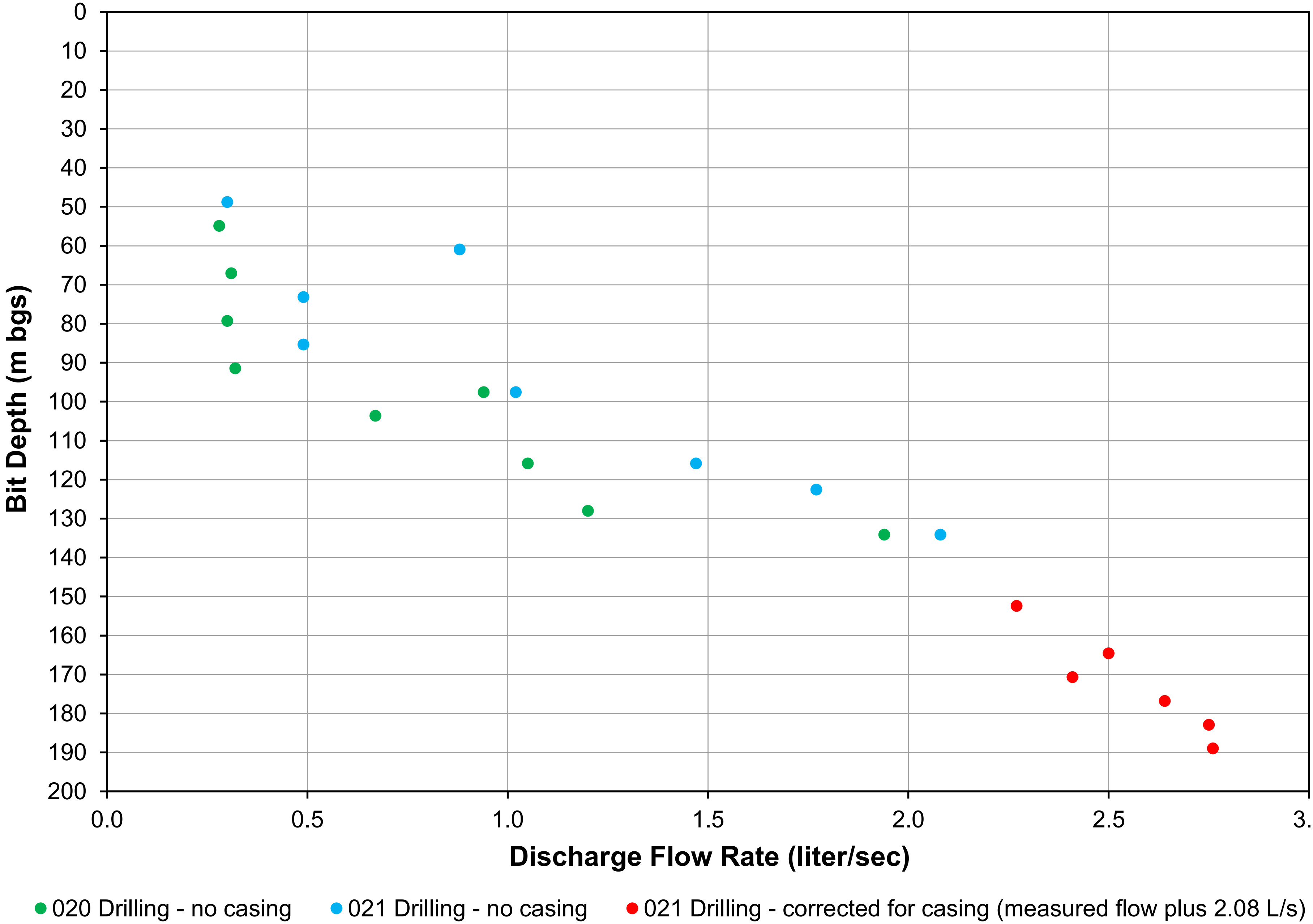

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FIGURE 3-3

DISCHARGE DURING AIR HAMMER DRILLING
FOR COMBINED BOREHOLES

DECEMBER 2016

D:\Project\AllProjects\ALEX-05-01\gis\mxd\Overview_Maps\SiteSpecific\Bermingham\Memo_2016\Figure 5

3.2 PUMPING TESTS

The airlift pumping tests were evaluated using the Theis recovery method for analysis of transient residual drawdowns measured during the recovery period after pumping was terminated. The data plots, equations, inputs, and results associated with the pumping tests are provided in Attachment B. The general results are summarized in Table 3-1 below.

Table 3-1 Results of airlift pumping tests

Well/Test (a)	Theis Recovery Transmissivity (m²/day)	Best-Estimate Transmissivity (b) (m²/day)	Length of Test Interval (c) (m)	Best-Estimate Hydraulic Conductivity (d) (cm/s)
KAR16-020	0.546	0.546	127.8	4.94×10^{-6}
KAR16-021 first pumping test	0.129	0.137	42.2	3.74×10^{-6}
KAR16-021 second pumping test	(e)			
KAR16-021 combined tests	0.144 (f)			

(a) KAR16-021 had one pumping/recovery test immediately followed by a second pumping/recovery test
(b) For KAR16-021, the average of two test results
(c) Length of borehole providing groundwater flow into well
(d) Best estimate transmissivity divided by the test interval length and converted to cm/s
(e) Not analyzed, affected by recovery of first pumping test
(f) Based on residual drawdowns measured during second (long) recovery period

The best-estimate hydraulic conductivities for the two boreholes are similar, providing further evidence that the rock mass is relatively homogeneous with regard to hydraulic properties. The average of the two values is 4.3×10^{-6} cm/s, and this is taken as the best-estimate of the large-scale (bulk) hydraulic conductivity for rock within the mine area.

4 GROUNDWATER INFLOW ESTIMATE

Groundwater inflow estimates for the mine were performed using a steady-state equation for radial flow towards a vertical groundwater sink. Figure 4-1 shows the estimated inflow (dewatering) flow rates versus depth of mining. The equations and inputs used to estimate the inflow rates are provided on the figure. The first curve on the figure is the estimated inflow rate to a water well using a shape factor (F) of 5.8, which is considered reasonable for an ideal well. The mine factor (M) multiplies the well inflow rate to arrive at a reasonable inflow rate for excavated mine workings. Based on professional judgment and previous experience, the mine factor typically is in the range of 2.5 to 4. Based on these values, the estimated inflow rate when the decline reaches its maximum depth of 175 m ranges from 110 to 180 cubic meters per day (cmd), or 1.3 to 2.1 liters per second (lps). For the fully developed mine, with an ultimate depth of 370 m, the estimated inflow rate ranges from 600 to 960 cmd (6.9 to 11.1 lps).

For relatively uniform fractured rock, the bulk hydraulic conductivity typically decreases at greater depths. Under these conditions, it is considered that at the maximum mining depth of 370 m, the actual mine inflow rate may tend towards the curve defined by M = 2.5, which predicts a maximum mine inflow rate of 600 cmd (6.9 lps). However, some historical mines in the Keno District have intersected permeable structures that caused relatively high inflows that did not diminish over time. For this situation, it is considered that the mine inflow rate might be characterized by the M = 4 curve, which computes a maximum mine inflow rate 960 cmd (11.1 lps).

As the decline is advanced and subsequent underground workings are excavated, mine dewatering rates will be closely monitored to evaluate if the inflows are consistent with the trends shown on Figure 6. If the observed dewatering rates differ from the Figure 4-1 predictions, the inflow analysis will be modified to provide better inflow estimates as the mine is deepened. In addition, pilot holes will be drilled into areas of future excavations to identify bedrock structures that could provide enhanced inflows. If significant, the structures will be allowed to depressurize via the pilot holes prior to actual excavation, which should reduce the mine inflows when the structures are penetrated by open excavations.

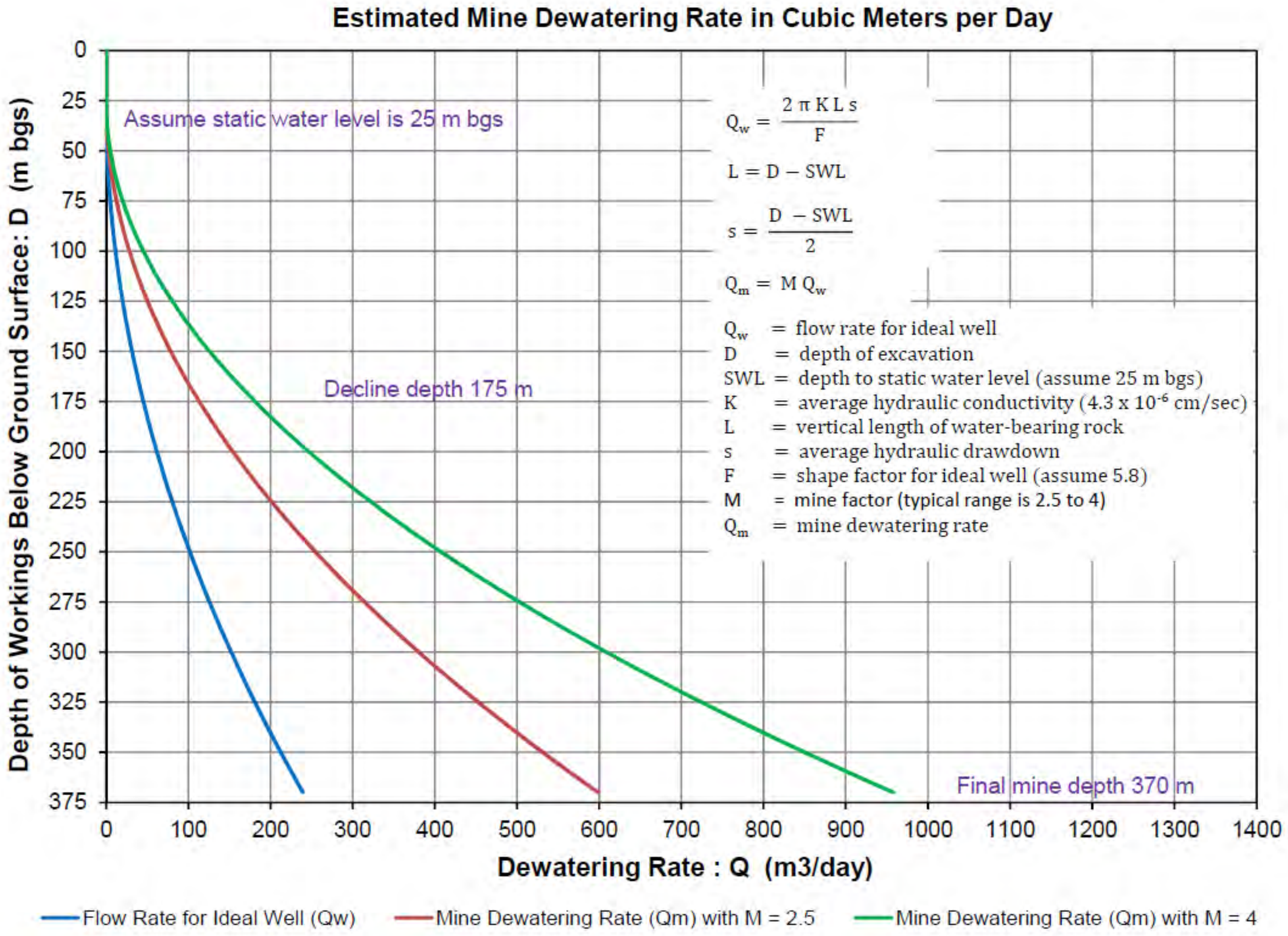


Figure 4-1 Groundwater Inflow (Dewatering) Rate versus Mine Depth

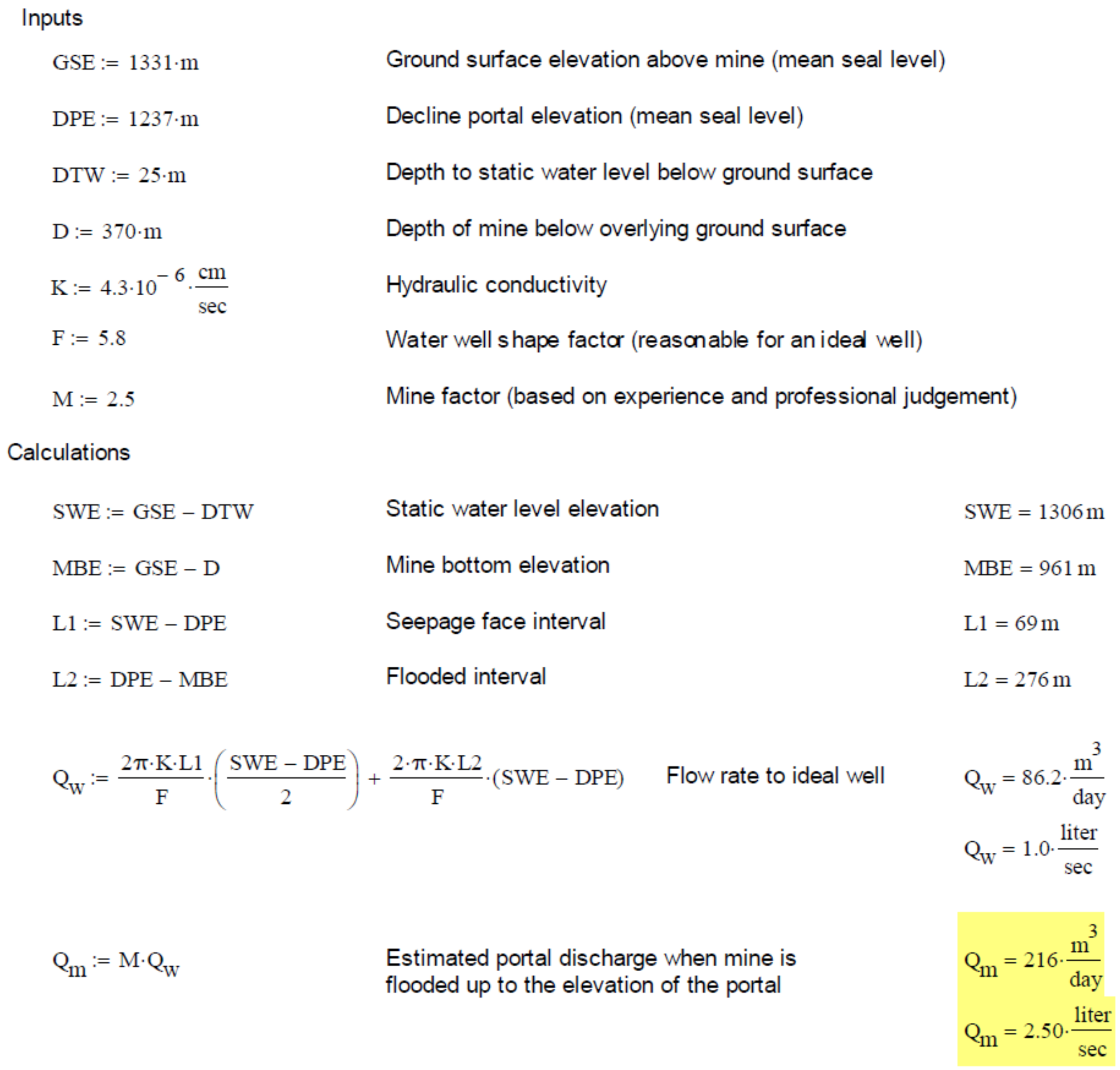
5 LONG-TERM PORTAL DISCHARGE ESTIMATE

An estimate of the expected discharge from the portal during closure was calculated using an equation to estimate the flow rate of an ideal well multiplied by a factor to account for the mine conditions.

Similar to the dewatering estimates described above, the mine factor (M) used was 2.5, which was based professional judgment and previous experience. The hydraulic conductivity used in this calculation was 4.3 x 10^{-6} cm/s, which is the average of the two pumping tests previously described in this memo. This calculation is sensitive to the assumed hydraulic conductivity. The value used in the calculation is considered to be the best-estimate of the large-scale (bulk) hydraulic conductivity for rock within the mine area.

Given these assumptions, the estimated portal discharge rate during closure is 216 cmd (2.5 lps). This calculation, along with input values, is summarized in Table 5-1.

Table 5-1 Estimated long-term discharge rate from the Bermingham decline portal after the mine floods



Inputs

$GSE := 1331 \cdot m$	Ground surface elevation above mine (mean seal level)
$DPE := 1237 \cdot m$	Decline portal elevation (mean seal level)
$DTW := 25 \cdot m$	Depth to static water level below ground surface
$D := 370 \cdot m$	Depth of mine below overlying ground surface
$K := 4.3 \cdot 10^{-6} \cdot \frac{cm}{sec}$	Hydraulic conductivity
$F := 5.8$	Water well shape factor (reasonable for an ideal well)
$M := 2.5$	Mine factor (based on experience and professional judgement)

Calculations

$SWE := GSE - DTW$	Static water level elevation	$SWE = 1306\,m$
$MBE := GSE - D$	Mine bottom elevation	$MBE = 961\,m$
$L1 := SWE - DPE$	Seepage face interval	$L1 = 69\,m$
$L2 := DPE - MBE$	Flooded interval	$L2 = 276\,m$
$Q_w := \frac{2\pi \cdot K \cdot L1}{F} \cdot \left(\frac{SWE - DPE}{2}\right) + \frac{2 \cdot \pi \cdot K \cdot L2}{F} \cdot (SWE - DPE)$	Flow rate to ideal well	$Q_w = 86.2 \cdot \frac{m^3}{day}$ $Q_w = 1.0 \cdot \frac{liter}{sec}$
$Q_m := M \cdot Q_w$	Estimated portal discharge when mine is flooded up to the elevation of the portal	$Q_m = 216 \cdot \frac{m^3}{day}$ $Q_m = 2.50 \cdot \frac{liter}{sec}$

6 REFERENCES

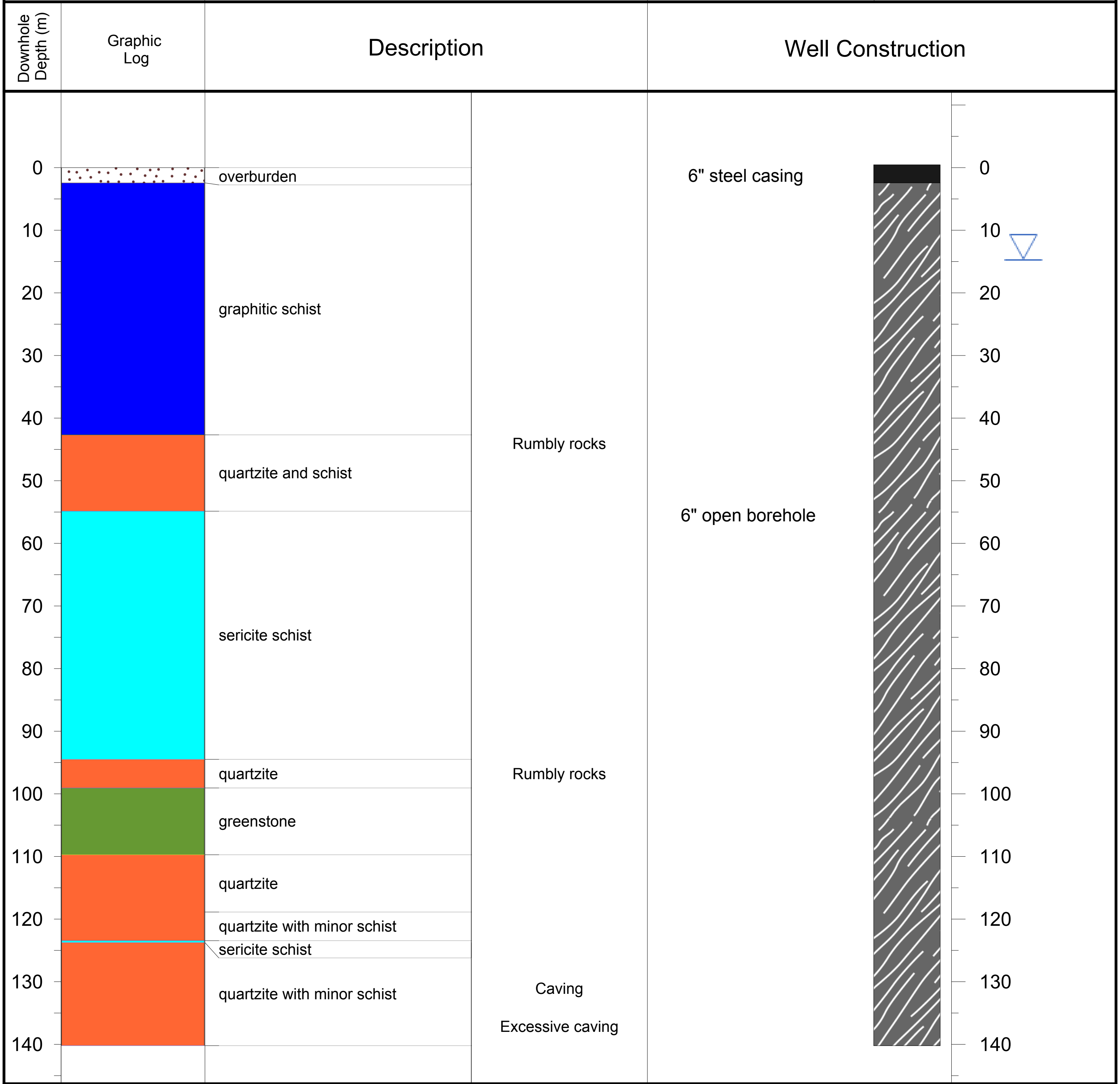
Alexco Environmental Group Inc. (2016). *2016 Keno Hill Silver District Hydrogeology Characterization Report. Water Use License QZ12-057*. Prepared for Elsa Reclamation & Development Company Ltd.

SRK Consulting Inc. (2014). *Updated Preliminary Economic Assessment for the Keno Hill Silver District Project – Phase 2, Yukon, Canada.* Report Prepared for Alexco Resource Corp.

ATTACHMENT A

BOREHOLE LOGS

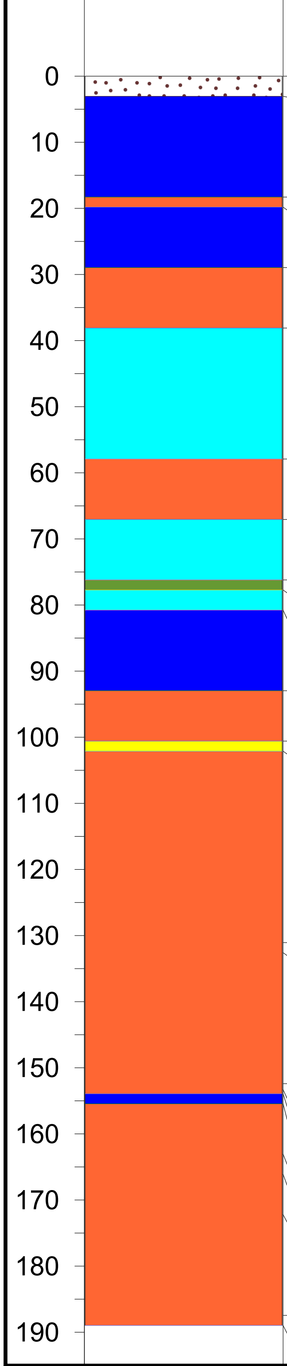
	PROJECT: **Bermingham Hydrogeological Testing and Permitting**	BORING ID: **KAR16-020**	
	LOCATION: **Bermingham, Keno Hill, Yukon**	WELL ID: **KAR16-020**	
	DRILLING CONTRACTOR: **Alexco Environmental Group**	NORTHING: **7086854.92**	EASTING: **479109.73**
	DRILLING EQUIPMENT: **Midnight Sun Drilling Inc.**	GROUND SURFACE ELEV. (masl): **1335.85**	TOC ELEVATION (m ags): **1**
	DRILLING METHOD: **Truck Mounted Sandvik Marlin M5 Air Rotary**	TOTAL DEPTH (m): **145.34**	WATER DEPTH (m bgs): **12.3**
LOGGED BY: **E Roy**	SAMPLING METHOD: **Cyclone**	DATE STARTED: **October 19, 2016**	DATE COMPLETED: **October 22, 2016**



NOTES: Borehole abbandonned at 460 ft due to excessive caving. Azimuth 0°, Dip -90°.

PROJECT: **Bermingham Hydrogeological Testing and Permitting**		BORING ID: **KAR16-021**	
LOCATION: **Bermingham, Keno Hill, Yukon**		WELL ID: **KAR16-021**	
DRILLING CONTRACTOR: **Alexco Environmental Group**		NORTHING: **7086913.11**	EASTING: **479142.39**
DRILLING EQUIPMENT: **Midnight Sun Drilling Inc.**		GROUND SURFACE ELEV. (masl): **1330.85**	TOC ELEVATION (m ags): **1.03**
DRILLING METHOD: **Truck Mounted Sandvik Marlin M5 Air Rotary**		TOTAL DEPTH (m): **187.7**	WATER DEPTH (m bgs): **69.86**
LOGGED BY: **E Roy**	SAMPLING METHOD: **Cyclone**	DATE STARTED: **October 22, 2016**	DATE COMPLETED: **October 26, 2016**

Downhole Depth (m)	Graphic Log	Description	Well Construction



Overburden
graphitic schist
quartzite and schist
graphitic schist
quartzite with minor schist
75% sericite schist, 20% quartzite, 5% graphitic schist, alternate layers
quartzite
sericite schist with minor quartzite
greenstone
sericite schist with minor quartzite
graphitic schist
quartzite
fault
quartzite
quartzite and schist
quartzite
siderite, galena and quartzite
quartzite
graphitic schist
quartzite
quartzite and schist
quartzite, abundant quartz
quartzite
quartzite and graphitic schist

Very wet

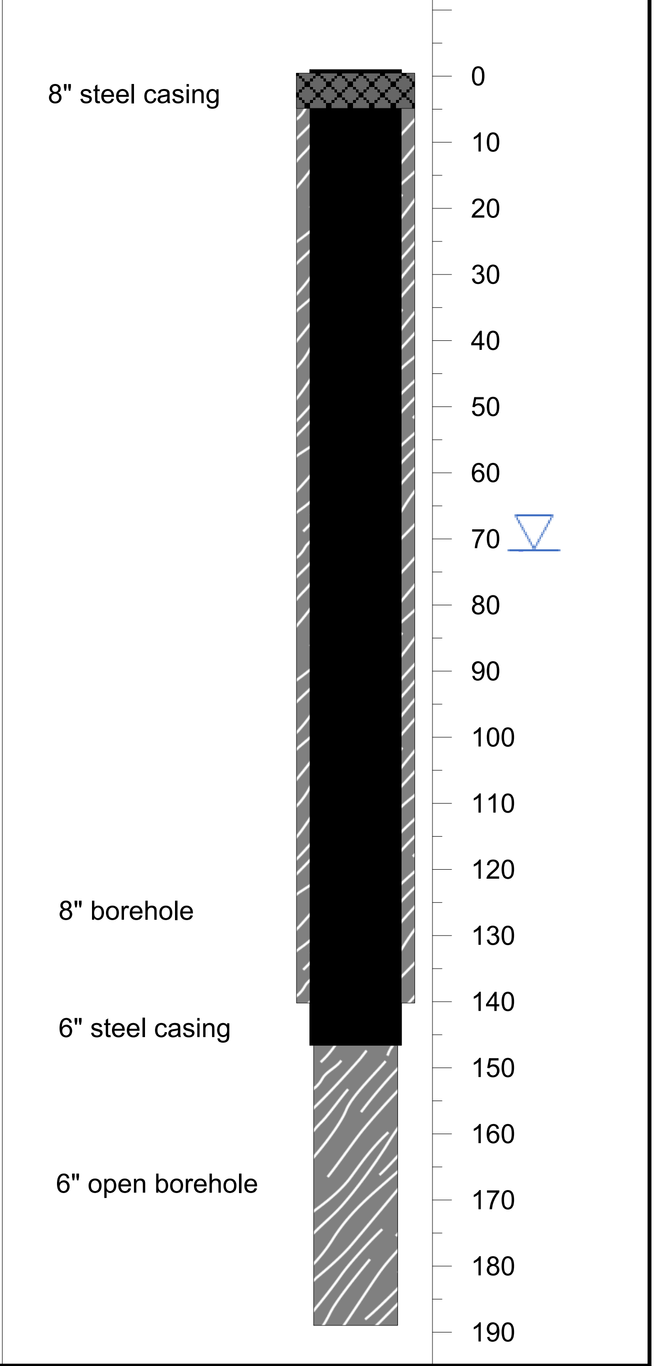
Bigger rocks

No return

Oxidized

Caving

Azimuth	Dip
296.34	-89.52
256.82	-89.37
192.47	-89.22
150.32	-87.56
133.29	-86.37
129.12	-84.89
131.1	-83.18
128.26	-81.4
120.8	-80.09
113.38	-78.25
112.11	-76.3
112.23	-75.64
113.75	-74.93
114.36	-74.01
114.94	-73.85
116.81	-73.77
109.11	-74.17
98.49	-73.59
82.94	-72.7



NOTES: Drilled with 8" bit to 480 ft. 6" casing lowered to 481 ft. Drilled with 6" hammer bit to 620 ft, left open.

ATTACHMENT B

PUMPING TEST DATA AND ANALYSES

This attachment contains the data plots, equations, and inputs used to compute the transmissivity and average hydraulic conductivity from airlift pumping tests conducted in KAR16-020 and KAR16-021. The calculations for these hydraulic parameters are documented in Table B1.

Table B1 Bermingham Pumping Test Results

Well Information									Theis Recovery Analysis			Best-Estimate Values	
ID	Borehole diameter D cm	Approx static water level m bgs	Bottom of well casing m bgs	Casing nominal diameter cm	Bottom of borehole m bgs	Bottom of airline m bgs	Airline submergence (c) m	Test interval length (a) L m	Change in residual drawdown per log cycle Δs_{10} m	Average pumping rate Q L/sec	Transmissivity T m^2/day	Best-estimate transmissivity T m^2/day	Average hydraulic conductivity K cm/sec
020	15.24	12.4	no casing	no casing	140.2	33.5	21.1	127.8	7.25	0.25	0.546	0.546	4.94E-06
021 Test A	15.24	73.4	146.6	15.2	189.0	121.9	48.5	42.4	31.8	0.26	0.129	0.137	3.74E-06
021 Test B	15.24	73.4	146.6	15.2	189.0	97.5	24.1	42.4	(b)	(b)	(b)		
021 Combined Tests A&B (d)	15.24	73.4	146.6	15.2	189.0	two settings	two settings	42.4	10.75	0.098	0.144		

Overall Average --> 4.3E-06

(a) If no casing installed, test interval is from static water level to bottom of borehole. If casing installed, test interval length is from bottom of casing to bottom of borehole.

(b) Not analyzed; affected by recovery of previous test

(c) Vertical distance from static water level to bottom of airline

(d) For 021 combined tests A&B, the total flow period of 339.5 min (t_{pAB}) had two separate pumping periods
The first pumping period had a duration of 117.5 min (T_{pa}) and discharge flow rate of 0.26 L/sec (Q_a)
The second pumping period had a duration of 36.0 min (T_{pb}) and a discharge flow rate of 0.08 L/sec (Q_b)
The time-weighted average pumping rate was computed using the following equation

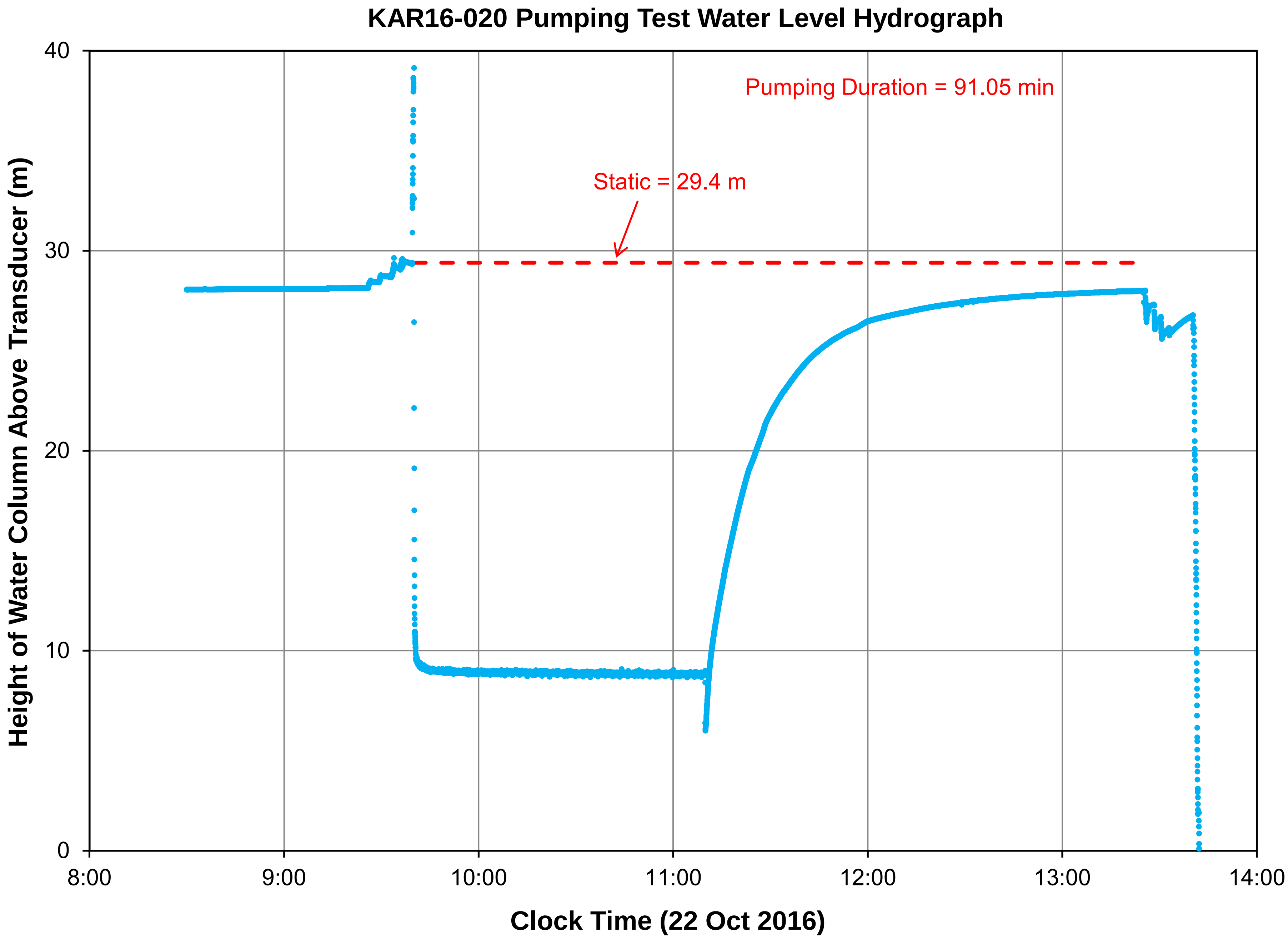
$$\boxed{Q_{AB} = \frac{t_{pA}\, Q_A + t_{pB}\, Q_B}{t_{pAB}}}$$

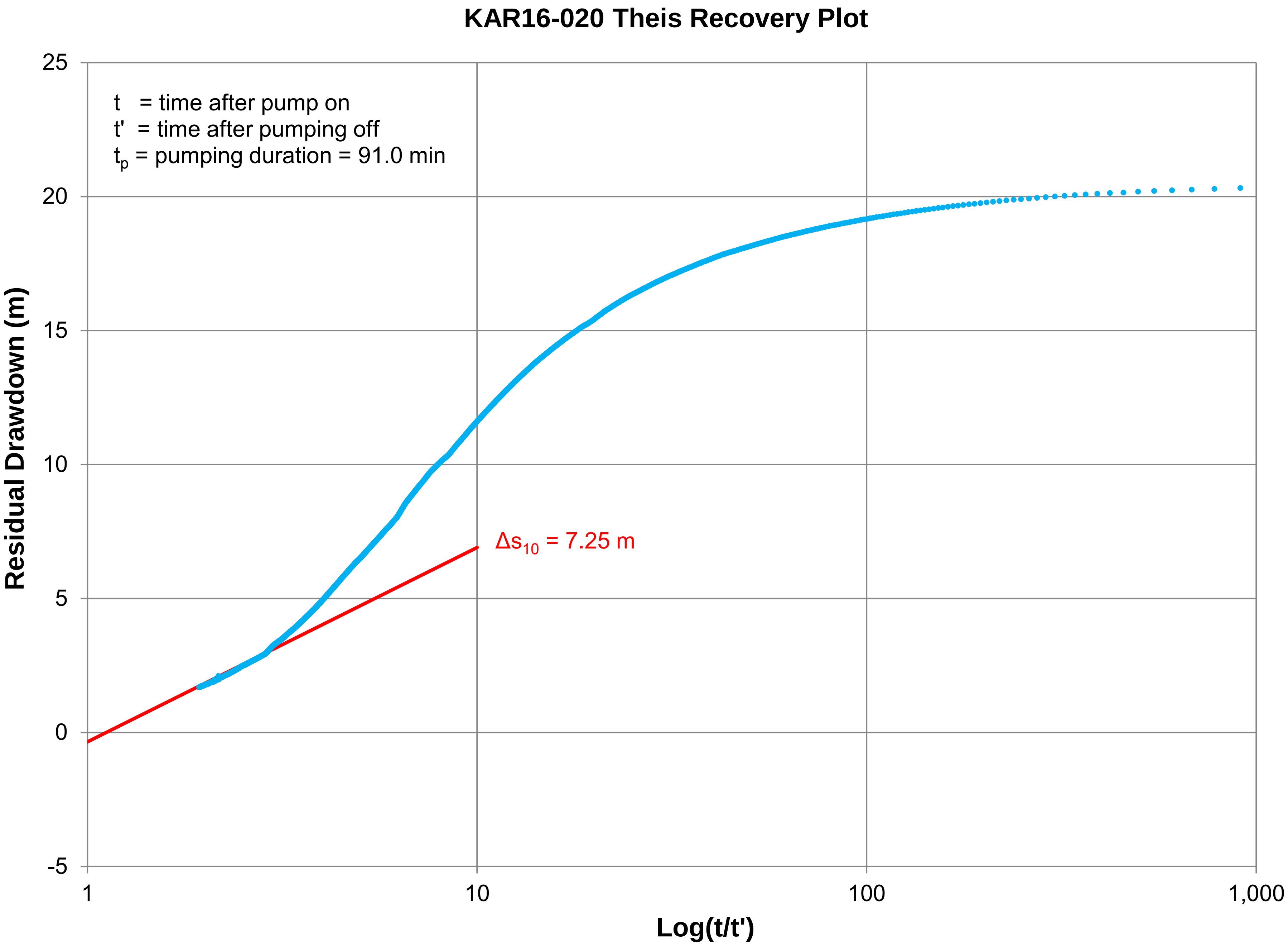
Theis Recovery Analysis

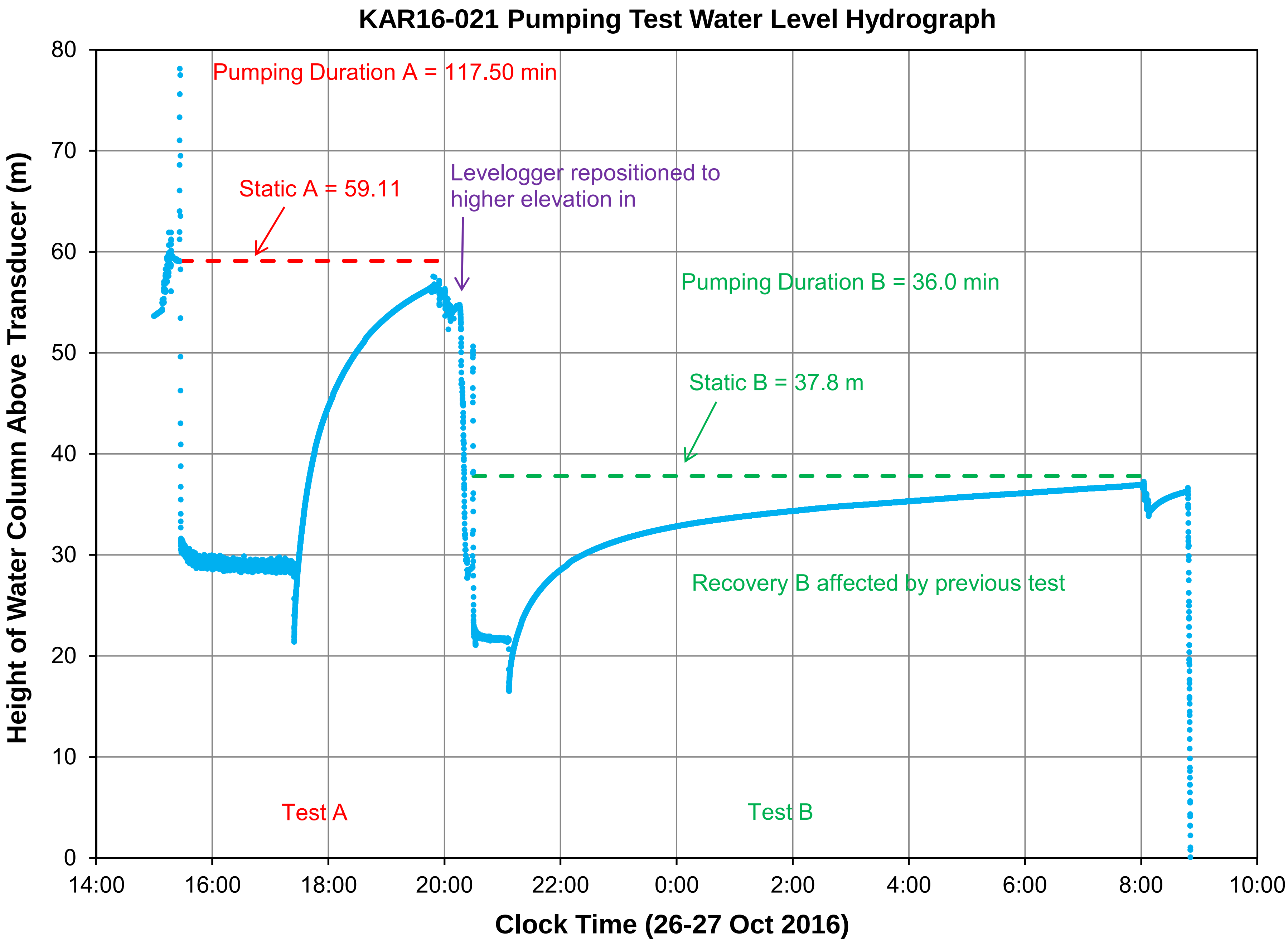
$$\boxed{T = \frac{2.303\, Q}{4\, \pi\ \Delta s_{10}}}$$

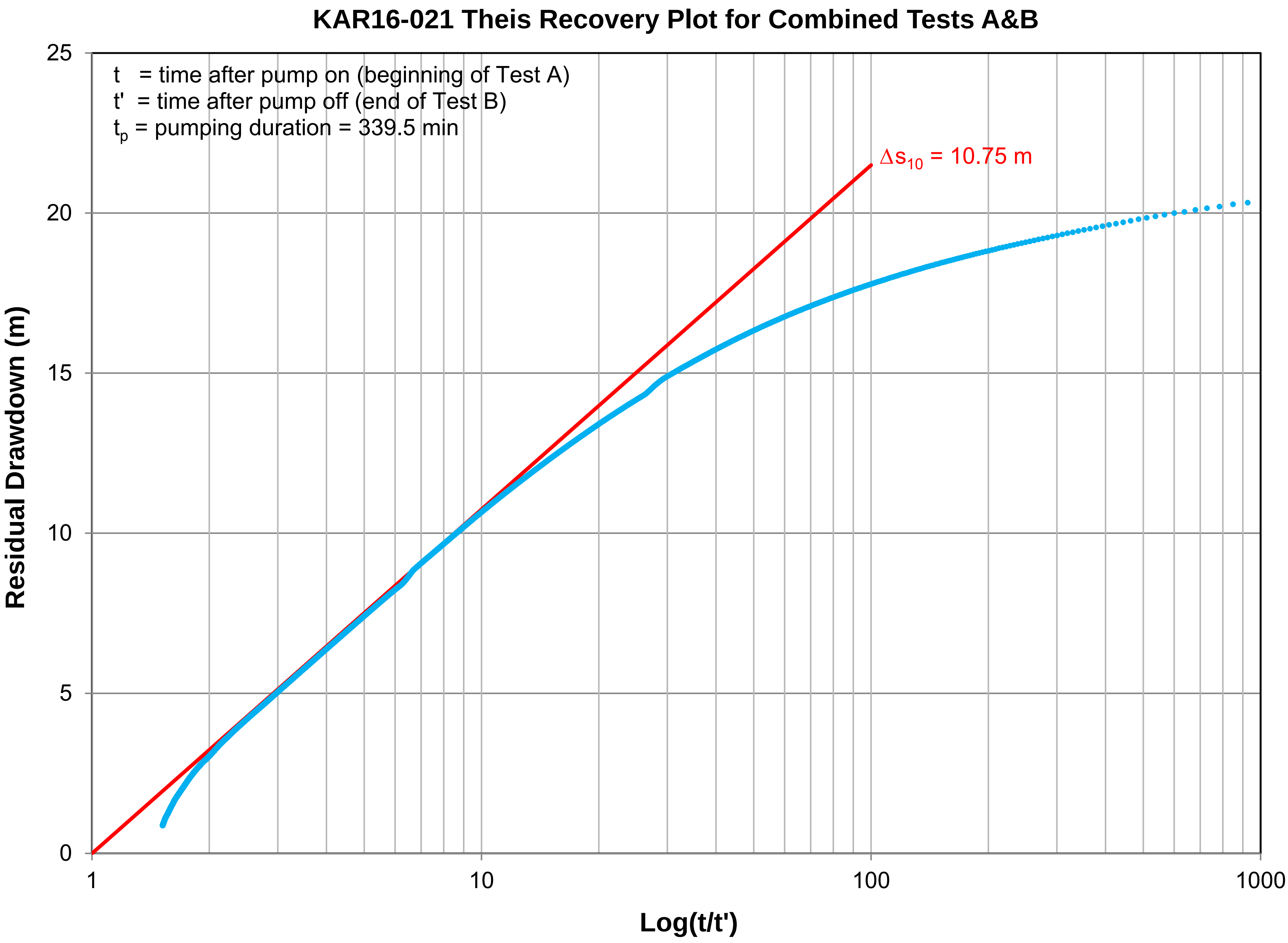
Average Hydraulic Conductivity

$$\boxed{K = \frac{T}{L}}$$

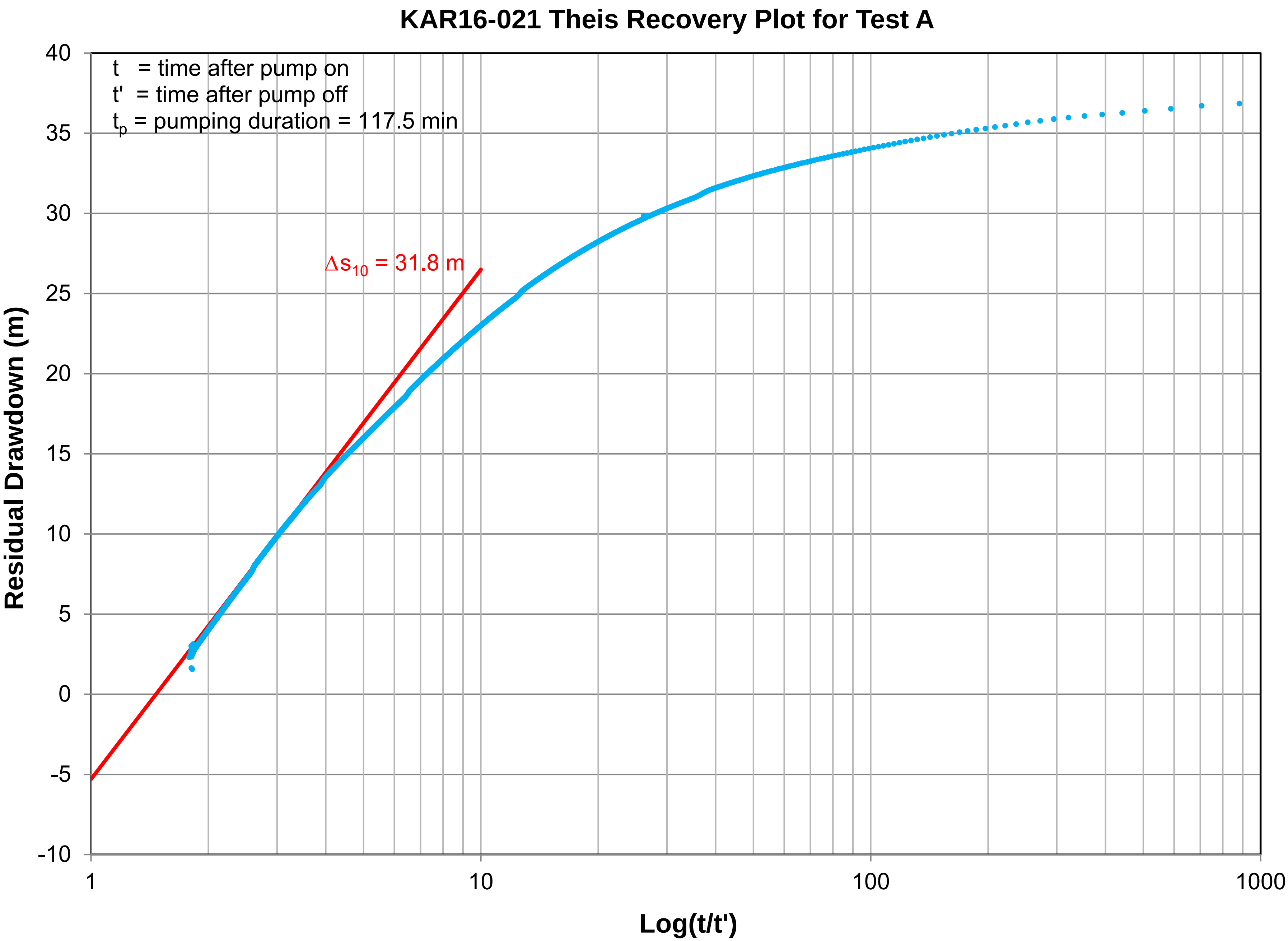

KAR16-020 Pumping Test Water Level Hydrograph
Pumping Duration = 91.05 min
Static = 29.4 m
Height of Water Column Above Transducer (m)
0
10
20
30
40
8:00
9:00
10:00
11:00
12:00
13:00
14:00
Clock Time (22 Oct 2016)


KAR16-020 Theis Recovery Plot
t = time after pump on
t' = time after pumping off
t_p = pumping duration = 91.0 min
Δs_{10} = 7.25 m
Residual Drawdown (m)
25
20
15
10
5
0
-5
1
10
100
1,000
Log(t/t')


KAR16-021 Pumping Test Water Level Hydrograph
Height of Water Column Above Transducer (m)
80
70
60
50
40
30
20
10
0
Clock Time (26-27 Oct 2016)
14:00
16:00
18:00
20:00
22:00
0:00
2:00
4:00
6:00
8:00
10:00
Pumping Duration A = 117.50 min
Static A = 59.11
Levelogger repositioned to
higher elevation in
Pumping Duration B = 36.0 min
Static B = 37.8 m
Recovery B affected by previous test
Test A
Test B



KAR16-021 Theis Recovery Plot for Combined Tests A&B


KAR16-021 Theis Recovery Plot for Test A
t = time after pump on
t' = time after pump off
t_p = pumping duration = 117.5 min
Δs10 = 31.8 m
Residual Drawdown (m)
40
35
30
25
20
15
10
5
0
-5
-10
1
10
100
1000
Log(t/t')