2013 Field Hydrogeology Report
Pogo Mine
Delta Junction, Alaska

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1 Introduction

Field investigations were conducted to characterize the hydrogeologic system at the Pogo site and to provide the data needed to construct, advance and improve the groundwater flow model in support of permitting the East Deep Expansion of the mine. The investigations were carried out during the field seasons of 2012 and 2013.

The 2012 field program provided water level data and values for hydraulic conductivity within Liese Ridge, the diorite dike and the immediate area of the East Deep expansion. In addition, the 2012 program included installation and testing of two wells to quantify the direction of flow between the bedrock and Goodpaster Alluvium, testing of the existing exploration water supply wells, and attempts to collect hydraulic data from exploration coreholes being drilled underground by Pogo. The data collected in 2012 formed the basis for developing a preliminary groundwater flow model. That preliminary model, described in detail in the model report (SRK, 2013), required additional data to simulate mine inflows and potential future impacts to surface and groundwater resources to an acceptable level of confidence. The purpose of the flow model is to predict groundwater inflow, estimate potential dewatering requirements, and support the permitting of the East Deep Expansion.

To extend the results of the previous year's field program, the field program for 2013 collected hydrogeologic information specifically needed to fill gaps in information critical to conduct a transient calibration and refine the predictive simulations of the model.

The field program began early June 2013 and continued until late September when the onset of freezing weather terminated the field season. It involved the following activities:

- Seven coreholes were drilled underground specifically to target structures of hydrogeologic interest. The holes were each fitted with a mechanical packer (Margo Plugs) and a valved shut-in assembly to accommodate a data logging pressure transducer (hereafter called PT). Each of the underground coreholes was hydraulically tested, sampled; and
- Six surface exploration coreholes were tested and temporary or permanent wells were installed; each was subsequently tested.

This report documents the field work conducted during the 2013 field season.

The Hydrogeological Study Area for Pogo, defined by the boundaries of the groundwater numerical flow model, is shown on Figure 1. The approach taken by SRK relative to both the surface and underground drillholes was to integrate hydrogeological data collection with surface and underground exploratory drilling being conducted by Pogo as part of their exploration of the East Deep deposit. A groundwater flow model requires data that characterize the flow of groundwater through the geologic materials associated with the deposit and surrounding country rock. Given the relatively low and uniform hydraulic conductivity of the bulk country rock, discontinuities in the rock capable of conveying larger volumes of water were the focus of the testing work. Specifically, the margins of the diorite intrusive, the veins of the East Deep deposit, and a number of faults suspected of producing large discrete inflows were tested where exploration drillholes provided the opportunity for interception.
2 Field Program

2.1 Surface Exploration Drillholes

SRK planned and directed the installation of piezometers in six surface drillholes. Five of the six were in holes drilled as part of the Pogo geology exploration program. One hole was drilled explicitly as a hydrogeology characterization hole. The holes for hydrogeological study were selected to provide the additional data needed to strengthen the understanding of the groundwater flow system and fill the gaps in that understanding that were identified during development of the preliminary groundwater flow model. Piezometers were installed in six surface drillholes (13-H3, ED_K 13-562, ED_K 13-597, EDW_C 13-695, SP_C 13-651, SP_G 13-758). The locations of the piezometers are presented on Figure 2. Specific objectives to the 2013 field program were to:

- Characterize the behavior of groundwater near the margin of the diorite dike in the North Zone on the flank of Liese Ridge (holes 13-562, 13-597, and 13-695);
- Establish groundwater monitoring points along Pogo Ridge above the existing Liese workings, and generating water levels for 1) comparison to pre-mining water levels and 2) future monitoring of trends over time (holes 13-H3, 13-651, and 13-758); and
- Provide additional water level data and hydraulic conductivity values in support of the groundwater flow model (all holes).

2.1.1 Installation of Piezometers

All surface holes were drilled as HQ-size (2.98-inch diameter hole) coreholes with HW size (3.93-inch inside diameter) surface casing. The holes telescoped to an NQ size with depth, although the piezometers were installed into the upper portions of the exploration holes, within the HQ diameter. The piezometers in the deep angled holes have no bottom plugs. The bottoms of the installations were left open to allow monitoring of water levels should levels drop significantly in the future. As shown in the schematic diagram on Figure 3, the piezometers were constructed of flush-threaded two-inch, Schedule 80 PVC. The piezometer strings were inserted by the drill crew immediately after a hole was terminated at Total Depth. The string consisted of approximately 100 feet of blank casing and 7 feet of an annular seal assembly. The assembly consisted of a cement basket with two Benseal sleeves immediately above the basket. Photos of the seal assembly are presented in Appendix A. Screened intervals were limited to 30 feet in the angled holes. Piezometers in the two shorter vertical holes (13-H3 and 13-758) were constructed with longer screened sections. The screens were alternated with blank casing to increase the strength of the piezometer string while maintaining a long open interval. Details of piezometer construction are presented in Table 1.
2.1.2 Hydraulic Testing of Piezometers

Falling head slug tests were conducted in four of the piezometers (13-H3, 13-562, 13-695, and 13-651). The tests were performed with a pressure transducer installed into the piezometer. A pre-test water level was recorded, and then 5 gallons of water were poured into the piezometer. The water was poured as quickly as possible to induce an essentially instantaneous rise in water level. Water level recovery was recorded by the transducer at a one-minute frequency. The pressure transducers were downloaded and the interval for readings lengthened for long-term monitoring.

The slug tests were analyzed using the Hvorslev method. Test data and analytical plots for the surface core holes are presented in Appendix B. Values for hydraulic conductivity calculated from the test data are provided in Table 2. The analyses yielded values for hydraulic conductivity with a geometric mean of 1.4x10^{-3} ft/day, a maximum value of 4.910^{-2} ft/day, and minimum of 1.4x10^{-4} ft/day. These results are similar to the mean and range in values obtained during the 2012 field program, and within the range of all bedrock tests conducted at the Pogo site.
Table 1: Summary of Surface Drillholes and Piezometer Installations

<table>
<thead>
<tr>
<th>Drillhole Name</th>
<th>Drill Pad</th>
<th>Purpose</th>
<th>Easting</th>
<th>Northing</th>
<th>Collar Elevation (ft. amsl)</th>
<th>Azimuth</th>
<th>Dip</th>
<th>Total Hole Depth (ft.)</th>
<th>Installed Piezo Depth (ft.)</th>
<th>Depth of Cement Basket (ft.)</th>
<th>Screen Interval (ft.)</th>
<th>Bottom Cap?</th>
</tr>
</thead>
<tbody>
<tr>
<td>13-H3</td>
<td>2013_H3</td>
<td>Water level above Liese workings</td>
<td>1812235</td>
<td>3820041</td>
<td>2,520</td>
<td>--</td>
<td>-90</td>
<td>718</td>
<td>718</td>
<td>151</td>
<td>multiple (1)</td>
<td>Y</td>
</tr>
<tr>
<td>13-562</td>
<td>ED_K</td>
<td>Diorite Contact</td>
<td>1813342</td>
<td>3822625</td>
<td>2,166</td>
<td>277</td>
<td>-82</td>
<td>2,800</td>
<td>350</td>
<td>109</td>
<td>320-350</td>
<td>N</td>
</tr>
<tr>
<td>13-597</td>
<td>ED_K</td>
<td>Diorite Contact</td>
<td>1813342</td>
<td>3822625</td>
<td>2,166</td>
<td>29</td>
<td>-85</td>
<td>3,300</td>
<td>350</td>
<td>109</td>
<td>320-350</td>
<td>N</td>
</tr>
<tr>
<td>13-695</td>
<td>EDW_C</td>
<td>North Zone Area</td>
<td>1812922</td>
<td>3823509</td>
<td>2,192</td>
<td>192</td>
<td>-81</td>
<td>2,758</td>
<td>359</td>
<td>109</td>
<td>329-359</td>
<td>N</td>
</tr>
<tr>
<td>13-651</td>
<td>SP_C</td>
<td>Current Water Level</td>
<td>1813573</td>
<td>3818867</td>
<td>2,578</td>
<td>80</td>
<td>-71</td>
<td>2,006</td>
<td>309</td>
<td>109</td>
<td>None</td>
<td>N</td>
</tr>
<tr>
<td>13-758</td>
<td>SP_G</td>
<td>Water level near Liese workings</td>
<td>1813951</td>
<td>3819365</td>
<td>2,685</td>
<td>--</td>
<td>-90</td>
<td>959</td>
<td>681</td>
<td>111</td>
<td>multiple (2)</td>
<td>Y</td>
</tr>
</tbody>
</table>

Notes:
(1) Screen alternates with blank casing from 151 ft to 718 ft at a ratio of 30 ft of screen to 20 ft of blank. Total of 320 feet of screen.
(2) Screen alternates with blank casing from 111 ft to 681 ft at a ratio of 10 ft of screen to 10 ft of blank. Total of 280 feet of screen.

Table 2: Summary of Surface Drillholes and Results of Hydraulic Tests

<table>
<thead>
<tr>
<th>Drill Pad</th>
<th>Hole ID</th>
<th>Coordinates</th>
<th>Start of Long-Term Monitoring</th>
<th>Date of Hydraulic Test</th>
<th>Collar Elevation (ft. amsl)</th>
<th>Total Length (ft.)</th>
<th>Total Depth (ft.)</th>
<th>Azimuth (deg.)</th>
<th>Inclination (deg.)</th>
<th>Measured Static WL (ft. depth)</th>
<th>Static WL Elevation (ft. amsl)</th>
<th>Hydraulic Conductivity (ft/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2013_H3</td>
<td>13-H3</td>
<td>1812235 3820041</td>
<td>7/27/2013</td>
<td>7/30/2013</td>
<td>2,520</td>
<td>718</td>
<td>718</td>
<td>0</td>
<td>-90</td>
<td>141</td>
<td>2,379</td>
<td>4.90E-02</td>
</tr>
<tr>
<td>ED_K</td>
<td>13-562</td>
<td>1813342 3822625</td>
<td>8/6/2013</td>
<td>8/6/2013</td>
<td>2,166</td>
<td>2,800</td>
<td>2,773</td>
<td>277</td>
<td>-82</td>
<td>240</td>
<td>1,928</td>
<td>7.10E-04</td>
</tr>
<tr>
<td>EDW_C</td>
<td>13-695</td>
<td>1812922 3823509</td>
<td>8/6/2013</td>
<td>8/6/2013</td>
<td>2,192</td>
<td>3,000</td>
<td>2,963</td>
<td>192</td>
<td>-81</td>
<td>232</td>
<td>1,963</td>
<td>1.40E-04</td>
</tr>
<tr>
<td>SP_C</td>
<td>13-651</td>
<td>1813573 3818867</td>
<td>7/27/2013</td>
<td>7/19/2013</td>
<td>2,578</td>
<td>1,880</td>
<td>1,778</td>
<td>80</td>
<td>-71</td>
<td>117</td>
<td>2,467</td>
<td>7.50E-04</td>
</tr>
</tbody>
</table>

Note:
All tests were conducted as falling head slug tests
2.1.3 Potentiometric Data from Piezometers

Dedicated pressure transducers were installed in five of the piezometers for the purpose of long-term monitoring of groundwater levels. One of the six piezometers (13-597 at drill pad ED_K) was plugged at 114 feet in depth and was not fitted with a pressure transducer. From the presence of bentonite on the water level probe, it appears that the bentonite seal is plugging the piezometer casing. Piezometer 13-597 is located on the same drill pad as but with a different azimuth than 13-562. Because of the plug, no potentiometric elevation data can be collected from 13-597.

Long-term monitoring of the 2013 piezometers began in late July and early August, 2013 (Table 2). Data collection has continued to date, and will continue in the piezometers installed in 2012 and 2013. A time-plot of the groundwater elevation data from both sets of piezometers is presented on Figure 4. The short traces for the water elevations in the 2013 piezometers are a result of trimming the data to show only the static levels and do not include the variations in level at the time of the installation of the pressure transducers and subsequent hydraulic testing.

The water levels in the piezometers generally show a seasonal increase during the summer, thought to be a result of increased infiltration to groundwater after the spring melt.

2.2 Underground Coreholes

The underground core holes were drilled to intersect and hydraulically test specific features of hydrogeologic interest. The targets were identified as a result of the uncertainties borne out by the initial numerical modeling effort. One key uncertainty in the preliminary model is described here: larger inflows to the workings occurred at faults or at the contact with the diorite intrusive, yet testing from the previous 2012 field program showed only slightly higher values for hydraulic conductivity than the surrounding country rock. Based on previous results, it was not clear if the faults and diorite contacts acted as consistent and pervasive conduits for groundwater flow, or if the larger inflows were confined to isolated areas in within those features. To resolve this issue, SRK and the Pogo Geology department identified locations where those features could be intersected with relatively short, near horizontal, core holes. The features that are known or suspected to be in places that produce the larger inflows to the workings are:

- The margin of the diorite intrusive (contact with country rock);
- N1, and N2 faults;
- The D3_3 fault package that includes the Liese and Graphite faults; and
- Intersections of the diorite contact with the various faults.

Existing cutouts or muckbays in the areas of interest were identified. Using the Vulcan model (which SRK uploaded to Leap Frog), the collar locations, azimuth, and inclinations were selected that provided relatively short drill lengths to intersect the target features. Holes ranged between 202 and 600 feet in length. All holes were drilled into ribs within the cutouts or bays and are secluded from day to day underground traffic and mining activities. Table 3 summarizes the corehole locations and alignments while Figure 5 shows the locations of the holes.
Table 3: Summary of Underground Drillholes

<table>
<thead>
<tr>
<th>Drillhole Name</th>
<th>Target</th>
<th>Easting</th>
<th>Northing</th>
<th>Collar Elevation (ft. amsl)</th>
<th>Azimuth (deg.)</th>
<th>Inclination (deg.)</th>
<th>Static Pressure (psi)</th>
<th>Total Length (ft)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13Hydro-01</td>
<td>Diorite Contact, N2 Fault</td>
<td>1815297</td>
<td>3821248</td>
<td>1,215</td>
<td>76.4</td>
<td>21</td>
<td>80</td>
<td>464</td>
</tr>
<tr>
<td>13Hydro-02</td>
<td>N1 Fault</td>
<td>1812596</td>
<td>3821217</td>
<td>1,090</td>
<td>33</td>
<td>23</td>
<td>100</td>
<td>500</td>
</tr>
<tr>
<td>13Hydro-03</td>
<td>Diorite Contact</td>
<td>1814608</td>
<td>3821731</td>
<td>887</td>
<td>260</td>
<td>30</td>
<td>65</td>
<td>218</td>
</tr>
<tr>
<td>13Hydro-04</td>
<td>N2 Fault</td>
<td>1815296</td>
<td>3821254</td>
<td>1,217</td>
<td>48.4</td>
<td>15</td>
<td>265</td>
<td>425</td>
</tr>
<tr>
<td>13Hydro-05</td>
<td>Diorite Contact/Faults</td>
<td>1815302</td>
<td>3821243</td>
<td>1,218</td>
<td>129</td>
<td>31</td>
<td>230</td>
<td>600</td>
</tr>
<tr>
<td>13Hydro-06A</td>
<td>D3_3/Diorite Contact</td>
<td>1812199</td>
<td>3822644</td>
<td>1,067</td>
<td>225</td>
<td>27</td>
<td>95</td>
<td>202</td>
</tr>
<tr>
<td>13Hydro-06B</td>
<td>D3_3 Fault</td>
<td>1812207</td>
<td>3822663</td>
<td>1,062</td>
<td>86.4</td>
<td>18.4</td>
<td>120</td>
<td>453</td>
</tr>
</tbody>
</table>

Once the holes were completed Margot Plugs were installed. The plugs were equipped with a ball valve and a pressure transducer reading port. The ball valve maintained the static hydraulic pressure, keeping the hole sealed and allowing the pressure transducer to collect data at a rate of one reading per minute. The Margot plug was left in place, and the pressure transducer recorded pressures, allowing the drill rig to pivot and continue drilling desired targets. The hydrostatic pressure data that were collected are presented on Figure 6.

Flow and shut-in testing was conducted on the finished holes. A test consisted of a flow period of 60 to 90 minutes, followed by recovery of hydrostatic pressure once the valve was closed. The pressure transducer automated the collection of pressure data. Flow data (gpm) was collected by timing the discharge to fill a five gallon bucket. Photos of the instrument installations are provided in Appendix A.

The test data enabled calculation of hydraulic conductivity by applying the Theis recovery solution. The results of the analyses are presented in Table 4. Analytical plots of the test data, and the calculations, are shown in Appendix B-2.
**Table 4: Summary of the Results of Hydraulic Tests**

<table>
<thead>
<tr>
<th>Underground Drillhole</th>
<th>Coordinates</th>
<th>Collar Elev. (ft. amsl)</th>
<th>Type of Test</th>
<th>Test No.</th>
<th>Flow Rate (gpm)</th>
<th>Transmissivity (ft²/day)</th>
<th>Hydraulic Conductivity (ft/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>13Hydro-01</td>
<td>1815297 3821248</td>
<td>1,215</td>
<td>Shut-In</td>
<td>1</td>
<td>0.5</td>
<td>0.026</td>
<td>5.60E-05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Shut-In</td>
<td>2</td>
<td>1.2</td>
<td>0.37</td>
<td>8.10E-04</td>
</tr>
<tr>
<td>13Hydro-02</td>
<td>1812596 3821217</td>
<td>1,090</td>
<td>Shut-In</td>
<td>1</td>
<td>3.1</td>
<td>0.26</td>
<td>5.20E-04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Shut-In</td>
<td>2</td>
<td>1.0</td>
<td>0.57</td>
<td>1.10E-03</td>
</tr>
<tr>
<td>13Hydro-03</td>
<td>1814608 3821731</td>
<td>887</td>
<td>Shut-In</td>
<td>1</td>
<td>2.4</td>
<td>3.66</td>
<td>1.70E-02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Shut-In</td>
<td>2</td>
<td>0.7</td>
<td>0.73</td>
<td>3.30E-03</td>
</tr>
<tr>
<td>13Hydro-04</td>
<td>1815296 3821254</td>
<td>1,217</td>
<td>Shut-In</td>
<td>1</td>
<td>2.5</td>
<td>0.29</td>
<td>6.90E-04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Shut-In</td>
<td>2</td>
<td>0.9</td>
<td>1.11</td>
<td>2.60E-03</td>
</tr>
<tr>
<td>13Hydro-05</td>
<td>1815302 3821243</td>
<td>1,218</td>
<td>Shut-In</td>
<td>1</td>
<td>0.4</td>
<td>0.014</td>
<td>2.30E-05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Shut-In</td>
<td>2</td>
<td>1.2</td>
<td>0.14</td>
<td>2.40E-04</td>
</tr>
<tr>
<td>13Hydro-06A</td>
<td>1812199 3822644</td>
<td>1,067</td>
<td>Shut-In</td>
<td>1</td>
<td>3.3</td>
<td>3.89</td>
<td>1.90E-02</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Shut-In</td>
<td>2</td>
<td>1.2</td>
<td>12.54</td>
<td>6.20E-02</td>
</tr>
<tr>
<td>13Hydro-06B</td>
<td>1812207 3822663</td>
<td>1,062</td>
<td>Shut-In</td>
<td>1</td>
<td>6.4</td>
<td>0.57</td>
<td>1.30E-03</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Shut-In</td>
<td>2</td>
<td>1.4</td>
<td>1.29</td>
<td>2.80E-03</td>
</tr>
</tbody>
</table>

Geometric Mean: 1.3E-03
Minimum: 2.3E-05
Maximum: 6.2E-02

The values calculated for hydraulic conductivity ranged between 2x10⁻⁵ and 6x10⁻² ft/day, with a geometric mean value of 1x10⁻³ ft/day. These values are within the general range of values for the rock mass at any location in the mine, based on the compiled results from previous testing. The conclusion reached from the testing of the coreholes within the features in the workings thought to be most conductive of water, is that the fault and diorite features are not consistently or pervasively conductive. Rather, the high spot-inflows encountered in the workings are a result of specific locations where the features are particularly conductive due to the structural geology proximal to those locations. For example, the Graphite and Liese faults have produced some of the larger point-flows, but they do not have enhanced conductivity over large distances.

### 2.3 Water Quality Samples

Samples were collected by SRK or the Pogo Environmental department from all the underground coreholes. The samples were prepared and shipped using standard methods for environmental compliance used by Pogo Environmental. The samples were analyzed for Pogo’s compliance suite 12g, and the results input into Pogo’s EDMS database.

Water quality sample results are presented in **Table 5**. The results are compared in the tables to standards for drinking water quality, aquatic life for fresh water (chronic), and for permitted discharge effluent limits (Outfall 001). The samples contained few concentrations above the discharge limits for metals. Review of the site environmental database (EDMS) indicates that high concentrations are common from underground and monitoring wells when initially sampled after drilling. Later sample results in the database show a trend of lower concentrations with time, perhaps due to disturbance and grinding of rock materials by drilling. Cuttings remaining in the drillholes are initially oxidized during drilling and flushing and yield the elevated concentrations of metals. Decreasing concentrations might be expected from subsequent periodic samples.
### Table 5: Water Quality Results of Samples Collected from Underground Drillholes

<p>| Site Name | Ground Water Drinking Water Quality Standard | Aquatic Life for Fresh Water - Chronic | Effluent Limits (Mon. Avg) | 9/8/2013 | 8/20/2013 | 8/20/2013 | 8/19/2013 | 8/19/2013 | 8/19/2013 | 8/19/2013 | 8/19/2013 | 8/20/2013 | 8/20/2013 |
|-----------|------------------------------------------|------------------------------------------|-----------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| Sample Date|                                          |                                          |                             |         |         |         |         |         |         |         |         |         |         |         |
| Alkalinity, Total | (Total) mg/L | 20000 | 310 | 220 | 160 | 140 | 140 | 260 | 120 | 190 | 120 |        |        |
| Antimony | (Dissolved) ug/L | 0.78 | 0.0511 | 1.89 | 0.613 | 98.3 | 0.101 | 0.245 | 117 | 2.72 |        |        |        |        |
| Antimony | (Total) ug/L | 0.77 | -0.44 | 1.96 | 0.602 | 97.6 | -0.44 | -0.44 | 118 | 2.72 |        |        |        |        |
| Arsenic | (Dissolved) ug/L | 4.7 | 455 | 314 | 125 | 69.1 | 963 | 520 | 42.7 | 4.78 |        |        |        |        |
| Arsenic | (Total) ug/L | 7.84 | 564 | 366 | 124 | 67.4 | 1160 | 598 | 44.7 | 5.46 |        |        |        |        |
| Cadmium | (Dissolved) ug/L | 0.969787 | 0.2 | -0.045 | -0.045 | -0.045 | -0.045 | -0.045 | 0.217 | -0.045 |        |        |        |        |
| Cadmium | (Total) ug/L | -0.066 | -0.66 | -0.66 | -0.066 | -0.66 | -0.66 | 0.0778 | -0.066 |        |        |        |        |
| Calcium | (Dissolved) mg/L | 100 | 95 | 73 | 36 | 36 | 72 | 69 | 120 | 55 |        |        |        |        |
| Calcium | (Total) mg/L | 84 | 97 | 62 | 35 | 38 | 79 | 72 | 120 | 59 |        |        |        |        |
| Carbonate | mg/L | -1.2 | -1.2 | -1.2 | -1.2 | -1.2 | -1.2 | -1.2 | -1.2 | -1.2 |        |        |        |        |
| Chloride | mg/L | 230000 | 0.919 | 0.899 | 0.395 | 2.36 | 1.42 | 0.261 | 0.58 | 9.01 | 1.22 |        |        |        |
| Chromium | (Dissolved) ug/L | 0.244 | 0.0925 | -0.049 | -0.049 | 0.0491 | 0.11 | -0.049 | 0.295 | -0.049 |        |        |        |        |
| Chromium | (Total) ug/L | 100 | -0.2 | -2 | -2 | -0.2 | -2 | -0.2 | 0.583 | -0.2 |        |        |        |        |
| Copper | (Dissolved) ug/L | 0.619 | 0.549 | 1.1 | 1.12 | 1.41 | 0.198 | 0.814 | 1.56 | 1.16 |        |        |        |        |
| Copper | (Total) ug/L | 2.2 | 0.345 | -0.76 | -0.76 | 0.517 | 0.548 | -0.76 | -0.76 | 1.11 | 0.603 |        |        |        |
| Cyanide, Weak Acid Dissociable | ug/L | -1.2 | -1.2 | -1.2 | 1.8 | -1.2 | -1.2 | -1.2 | -1.2 | 5.8 | -1.2 |        |        |        |
| Fluoride | mg/L | 4000 | 1.25 | 0.107 | 0.157 | 0.779 | 0.188 | 0.251 | 0.135 | 0.253 | 0.745 |        |        |        |
| Hardness, Total | mg/L | 2800 | 93 | 270 | 140 | 110 | 74 | 56 | 120 | 49 |        |        |        |        |
| Iron | (Dissolved) ug/L | 350 | 310 | -14 | -14 | -14 | -14 | -14 | 110 | -14 |        |        |        |        |
| Iron | (Total) ug/L | 1000 | 580 | 1300 | 240 | 91 | 39 | 1300 | 240 | 310 | 72 |        |        |        |
| Lead | (Dissolved) ug/L | -0.03 | -0.03 | -0.03 | 0.0488 | 0.138 | -0.03 | 0.032 | 0.361 | 0.0423 |        |        |        |        |
| Lead | (Total) ug/L | 0.5 | -0.073 | -0.73 | -0.73 | -0.073 | 0.22 | -0.73 | -0.73 | 0.692 | 0.218 |        |        |        |
| Magnesium | (Dissolved) mg/L | 75 | 57 | 22 | 13 | 5.7 | 48 | 26 | 79 | 26 |        |        |        |        |
| Magnesium | (Total) mg/L | 73 | 56 | 26 | 14 | 6.2 | 49 | 24 | 71 | 25 |        |        |        |        |
| Manganese | (Dissolved) ug/L | 6.33 | 58.1 | 54.5 | 32.2 | 28 | 39.6 | 59.1 | 94.2 | 34.2 |        |        |        |        |
| Manganese | (Total) ug/L | 5.78 | 57 | 54.9 | 31 | 26.4 | 40.3 | 58.6 | 93.1 | 33.6 |        |        |        |        |
| Mercury | (Dissolved) ug/L | 2 | 0.77 | -0.00014 | 0.000248 | 0.000532 | 0.000341 | 0.000188 | -0.00014 |        |        |        |        |        |
| Nickel | (Dissolved) ug/L | 173.347 | 4.61 | 6.07 | 4.74 | 3.13 | 7.29 | 3.75 | 4.95 | 9.73 | 12.2 |        |        |        |</p>
<table>
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<tr>
<th>Ground Water</th>
<th>Drinking Water Quality Standard</th>
<th>Aquatic Life for Fresh Water - Chronic Effluent Limits (Mon, Avg)</th>
<th>UG Corehole 001</th>
<th>UG Corehole 12U201</th>
<th>UG Corehole 13HYDRO-01</th>
<th>UG Corehole 13HYDRO-02</th>
<th>UG Corehole 13HYDRO-03</th>
<th>UG Corehole 13HYDRO-04</th>
<th>UG Corehole 13HYDRO-05</th>
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<td>2.72</td>
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<td>Nitrate-Nitrite as Nitrogen</td>
<td>mg/L</td>
<td>10000</td>
<td>0.016</td>
<td>-0.015</td>
<td>0.084</td>
<td>0.017</td>
<td>0.549</td>
<td>0.119</td>
<td>0.02</td>
<td>26.8</td>
<td>-0.015</td>
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<tr>
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<td>mg/L</td>
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<td>-0.028</td>
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<td>645</td>
<td>620</td>
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</table>

Note: Values that exceed effluent limits are bolded and shaded.
HYDROGEOLOGICAL STUDY

LOCATIONS OF 2013 SURFACE PIEZOMETERS AND UNDERGROUND TEST HOLES

POGO UNDERGROUND MINE IN ALASKA


DATE: MAR. 2014
APPROVED: LC
FIGURE: 2
REV/WORK NO.: A
SCHEMATIC OF SURFACE PIEZOMETER CONSTRUCTION

POGO UNDERGROUND MINE IN ALASKA


HYDROGEOLOGICAL STUDY

**POGO UNDERGROUND MINE IN ALASKA**

- **100 ft Blank 2" Sched. 80 PVC, Flush-Threaded**
- **Benseal Grout + 2 Benseal Sleeves (6ft long)**
- **Cement Basket (3ft long). Bottom of Basket Set at 109 feet**
- **389 ft total**
- **30 ft Machine-cut 20-Slot Screen. Sched. 80 PVC, Flush-Threaded**
- **Open Corehole**
- **Colluvium & Weathered Bedrock**
- **Fresh Bedrock**
- **Static Water Level Below Cement Basket**
- **HW Casing as Surface Cover, Fitted with Locking Cap**

**FIGURE:**

- **DATE:** MAR. 2014
- **APPROVED:** LC
- **FIGURE:** 3
- **REVISION NO.:** A
- **SRK JOB NO.:** 147900.002
- **FILE NAME:** 147900.020.Rev.A.Figure.3.Schematic.Piezometer.Construction.2014-03-20.dwg

**srk consulting**

**SUMITOMO METAL MINING CO., LTD.**
Hydrogeological Study

Pogo Underground
Mine in Alaska

Potentiometric Elevations from Instrumented Surface Piezometers
LOCATIONS OF UNDERGROUND HYDRAULIC TEST HOLES

POGO UNDERGROUND MINE IN ALASKA

DATE: MAR. 2014
APPROVED: LC
FIGURE: 5
REVISION NO: A
POTENTIOMETRIC ELEVATIONS FROM INSTRUMENTED UNDERGROUND CORE HOLES

**HYDROGEOLOGICAL STUDY**

**POGO UNDERGROUND MINE IN ALASKA**

**DATE:** MAR. 2014

**APPROVED:** LC

**FIGURE:** 6

**REV./ED.:** A

---

The graph shows the groundwater elevation (ft. amsl) from May 2013 to September 2013. The elevations are measured from the top of the core holes. The colors represent different core holes as indicated in the legend:

- Blue: 13Hydro-01
- Blue: 13Hydro-02
- Red: 13Hydro-03
- Green: 13Hydro-04
- Purple: 13Hydro-05
- Cyan: 13Hydro-06A
- Orange: 13Hydro-06B
- Gray: 13U283

The graph indicates fluctuations in elevation over time, with some core holes showing a steady increase while others show more variability.
3 Conclusions

The 2013 field program advanced the understanding of the mechanisms of the groundwater flow system that control inflow to the underground workings. The data obtained and the analysis conducted resolved some of the uncertainties identified during the development and calibration of the preliminary numerical groundwater flow model.

The results of hydraulic testing of piezometers further supported the conclusion presented in the 2012 field report (SRK, 2013) that the saturated bedrock of Liese Ridge in the area of the East Deep expansion are on the average no more permeable than those of Pogo Ridge and the current mine. However, more discrete large inflows were encountered as workings encroached and intersected the margins of the diorite intrusive and East Deep area. These inflows, shown to be of larger rate and higher pressure than had been previously encountered in the older Liese mine workings, occur to date as isolated discrete points of inflow, rather than extensive structural features that consistently drain across a large area.

Though the 2013 field program sought to locate and test pervasive hydraulic features, testing confirmed the results from the previous year's field program. That is, no particularly large permeabilities were encountered in the underground or surface drillholes. The two order of magnitude range in values is similar to the range in values calculated from testing in 2012. Further, the range is similar to the range exhibited by the saturated bedrock to the extensive testing conducted by prior investigations (Golder, 1998). The relatively high potentiometric surface in Pogo and Liese Ridges serves to confirm that (to date) there has been no large persistent drainage feature that cannot be effectively plugged by the ongoing grouting program.

The 2013 field program provides the information needed to evaluate the hydraulic behavior of those features and to more reliably simulate them with the groundwater flow model.

The numerical groundwater flow model was calibrated to steady-state conditions, which provides an estimate of groundwater flow conditions in the study area prior to mining. Mine-induced influences include the effect dewatering of the mine has on the groundwater system within Pogo and Liese ridges, and the degree to which drainage of the local discrete flow features has on the flow system at a site-wide scale. The effects of these transient influences were evaluated so that the numerical model can be defended during the agency review process. The data that were collected in 2013 were necessary to complete the transient calibration and to provide more robust predictions of inflow to the planned East Deep workings by:

- Documenting the change in the elevation of the water table in Pogo Ridge since mining commenced. This was done during the 2013 field program by installing a groundwater well into Pogo Ridge above the current workings; and
- Evaluating the drainage rates and hydraulic conductivities of the more significant discrete features of inflow in the flow system.
4 References Cited


5  Date and Signature Page

Signed on this 1st Day of April, 2014.

Prepared by

Larry Cope, Principal Consultant, Hydrogeologist

Reviewed by

Paul Williams, Principal Consultant, Hydrogeologist

All data used as source material plus the text, tables, figures, and attachments of this document have been reviewed and prepared in accordance with generally accepted industry practices.
Disclaimer

The opinions expressed in this Report have been based on the information supplied to SRK Consulting (U.S.), Inc. (SRK) by Sumitomo Metal Mining Pogo LLC (Pogo). These opinions are provided in response to a specific request from Pogo to do so, and are subject to the contractual terms between SRK and Pogo. SRK has exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them. Opinions presented in this report apply to the site conditions and features as they existed at the time of SRK’s investigations, and those reasonably foreseeable. These opinions do not necessarily apply to conditions and features that may arise after the date of this Report.

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Appendix A: Surface Corehole Photos
A-1: Piezometer Installation
Installation of piezometer showing 2-inch PVC tubing and cement basket with Benseal sleeves
Surface Completion Piezometer ED-K 13-695
Mixing EZMud polymer grout for seal in cement basket and around benseal sleeves
A-2: Hydraulic Testing
UG 13Hydro-01, 13Hydro-04 and 13Hydro-05.

Note reflective tape on datalogger cables and discharge hoses. Signage at all installation protect equipment from inadvertent place in muck at those locations.
Note water discharging from hose during purging prior to collecting water quality sample.
UG 13Hydro-06A
(on right side of drift)

and

UG 13Hydro-6B
(on left side)
Appendix B:
Hydraulic Test Plots and Analyses
Appendix B-1:
Falling Head Slug Tests in Surface Parameters
FIGURE B-1
Overview of Test Data
Surface Drillhole 13-H3
Hvorslev Equation:

\[ K = \frac{r^2 \ln \left( \frac{L}{R} \right)}{2LT_o} \]

Where:
- \( K \) = Estimate of Hydraulic Conductivity (ft/d)
- \( r \) = Radius of Well Casing (ft)
- \( R \) = Radius of Well Screen (ft)
- \( L \) = Length of Test Interval (ft)
- \( T_o \) = Time for Water Level to Fall 37% of Initial Change (days)

\[ K = \frac{(0.129')^2 \ln(569'/0.158')}{2(569')(0.00243')} \]

\[ K = 4.9 \times 10^{-2} \text{ ft/d} \]
FIGURE B-3
Overview of Test Data
Surface Drillhole 13-562

Raw Data

PROJECT NO. 147900.02
DATE October, 2013
VERSION 1.0
Depth of Test Interval: 238 – 2,773 ft (TD)

Thickness of Test Interval: 2,535 ft

Recovery Duration: 23 mins

Hvorslev Equation:

\[ K = \frac{r^2 \ln \left( \frac{L}{R} \right)}{2L \rho \Delta} \]

Where:
- \( K \) = Estimate of Hydraulic Conductivity (ft/d)
- \( r \) = Radius of Well Casing (ft)
- \( R \) = Radius of Well Screen (ft)
- \( L \) = Length of Test Interval (ft)
- \( \Delta \) = Time for Water Level to Fall 37% of Initial Change (days)

\[ K = \frac{(0.129')^2 \ln(2,535'/0.158')} {2(2,535')(0.045)} \]

\[ K = 7.1 \times 10^{-4} \text{ ft/d} \]
Hvorslev Equation:

\[ K = \frac{r^2 \ln\left(\frac{L}{R}\right)}{2L \tau_{0}} \]

Where:
- \( K \) = Estimate of Hydraulic Conductivity (ft/d)
- \( r \) = Radius of Well Casing (ft)
- \( R \) = Radius of Well Screen (ft)
- \( L \) = Length of Test Interval (ft)
- \( \tau_{0} \) = Time for Water Level to Fall 37% of Initial Change (days)

\[ K = \left(0.129\right)^2 \ln\left(\frac{2,734'}{0.158'}\right) \frac{2(2,734')}{(0.218)} \]

\[ K = 1.4 \times 10^{-4} \text{ ft/d} \]

Depth of Test Interval:
229 – 2,963 ft (TD)

Thickness of Test Interval: 2,734 ft

Recovery Duration: 13.9 hours
FIGURE B-7
Overview of Test Data
Surface Drillhole 13-651
Hvorslev Equation:

\[ K = \frac{r^2 \ln \left( \frac{L}{R} \right)}{2LT_o} \]

Where:
- \( K \) = Estimate of Hydraulic Conductivity (ft/d)
- \( r \) = Radius of Well Casing (ft)
- \( R \) = Radius of Well Screen (ft)
- \( L \) = Length of Test Interval (ft)
- \( T_o \) = Time for Water Level to Fall 37% of Initial Change (days)

\[ K = \left( \frac{0.129'}{2} \right)^3 \ln \left( \frac{1,667'}{0.158'} \right) \div \left( \frac{1,667'}{0.062'} \right) \]

\[ K = 7.5 \times 10^{-4} \text{ ft/d} \]
Appendix B-2:
Flow and Shut-In Recovery Tests
in Underground Drillholes
Raw Data

![Graph showing raw data over time with two tests marked as Test #1 and Test #2. The x-axis represents the 2013 date from July 1 to September 30, and the y-axis represents the height of water above the transducer in feet (ft).]

FIGURE B-9
Overview of Test Data
Underground Drillhole 13Hydro-01
Theis Recovery Analysis

Theis Equation:

\[ T = \frac{2.3 \ Q}{4\pi \Delta s} \]

Where:
- \( T \) = Transmissivity (ft\(^2\)/d)
- \( Q \) = Pumping Rate (ft\(^3\)/d)
- \( \Delta s \) = Drawdown per Log Cycle (ft)

\[ T = \frac{2.3 \ (92.4)}{4\pi(650)} = 0.026 \text{ ft}^2/\text{d} \]

\[ K = \frac{T}{b} \]

Where:
- \( K \) = Estimate for Hydraulic Conductivity (ft/d)
- \( b \) = Test Interval Length (ft)

\[ K = \frac{(0.026)}{(464)} = 5.6 \times 10^{-5} \text{ ft/d} \]

\[ T = 0.026 \text{ ft}^2/\text{d} \]

\[ K = 5.6 \times 10^{-5} \text{ ft/d} \]
Theis Equation:

\[ T = \frac{2.3 \cdot Q}{4\pi \Delta s} \]

Where:
- \( T \) = Transmissivity (ft²/d)
- \( Q \) = Pumping Rate (ft³/d)
- \( \Delta s \) = Drawdown per Log Cycle (ft)

\[ T = \frac{2.3 \cdot 225.2}{4\pi(110)} = 0.37 \text{ ft}^2/\text{d} \]

\[ K = \frac{T}{b} \]

Where:
- \( K \) = Estimate for Hydraulic Conductivity (ft/d)
- \( b \) = Test Interval Length (ft)

\[ K = \frac{0.37}{464} = 8.1 \times 10^{-4} \text{ ft/d} \]

\[ T = 0.37 \text{ ft}^2/\text{d} \]

\[ K = 8.1 \times 10^{-4} \text{ ft/d} \]
Depth of Test Interval:  
0 – 500 ft (TD)

Flow Duration: 136 mins
Recovery Duration: 13.2 days

Flow Rate (Q) = 3.05 gpm
Flow Rate (Q) = 587.1 ft³/d

Theis Equation:

\[ T = \frac{2.3 \times Q}{4\pi \Delta s} \]

Where:
- \( T \) = Transmissivity (ft²/d)
- \( Q \) = Pumping Rate (ft³/d)
- \( \Delta(s) \) = Drawdown per Log Cycle (ft)

\[ T = \frac{2.3 \times (587.1)}{4\pi (410)} = 0.26 \text{ ft}^2/\text{d} \]

\[ K = \frac{T}{b} \]

Where:
- \( K \) = Estimate for Hydraulic Conductivity (ft/d)
- \( b \) = Test Interval Length (ft)

\[ K = \frac{(0.26)}{(500)} = 5.2 \times 10^{-4} \text{ ft/d} \]

\[ T = 0.26 \text{ ft}^2/\text{d} \]
\[ K = 5.2 \times 10^{-4} \text{ ft/d} \]
Depth of Test Interval: 0 – 500 ft (TD)

Flow Duration: 30.2 hours
Recovery Duration: 21.1 days

Flow Rate (Q) = 0.97 gpm
Flow Rate (Q) = 186.7 ft³/d

Theis Equation:

\[ T = \frac{2.3 \, Q}{4\pi \Delta s} \]

Where:
- \( T \) = Transmissivity (ft²/d)
- \( Q \) = Pumping Rate (ft³/d)
- \( \Delta s \) = Drawdown per Log Cycle (ft)

\[ T = \frac{2.3 \, (186.7)}{4\pi (60)} = 0.57 \, \text{ft}^2/\text{d} \]

\[ K = \frac{T}{b} \]

Where:
- \( K \) = Estimate for Hydraulic Conductivity (ft/d)
- \( b \) = Test Interval Length (ft)

\[ K = \frac{(0.57)}{(500)} = 1.1 \times 10^{-3} \, \text{ft/d} \]

\[ T = 0.57 \, \text{ft}^2/\text{d} \]
\[ K = 1.1 \times 10^{-3} \, \text{ft/d} \]
Overview of Test Data
Underground Drillhole 13Hydro-03
Theis Recovery Analysis

Theis Equation:

\[ T = \frac{2.3 Q}{4\pi \Delta s} \]

Where:
- \( T \) = Transmissivity (ft\(^2\)/d)
- \( Q \) = Pumping Rate (ft\(^3\)/d)
- \( \Delta s \) = Drawdown per Log Cycle (ft)

\[ T = \frac{2.3 \times 460.1}{4\pi \times 23} = 3.66 \text{ ft}^2/\text{d} \]

\[ K = \frac{T}{b} \]

Where:
- \( K \) = Estimate for Hydraulic Conductivity (ft/d)
- \( b \) = Test Interval Length (ft)

\[ K = \frac{(3.66)}{218} = 1.7 \times 10^{-2} \text{ ft/d} \]

\[ T = 3.66 \text{ ft}^2/\text{d} \]

\[ K = 1.7 \times 10^{-2} \text{ ft/d} \]

Depth of Test Interval:
0 – 218 ft (TD)

Flow Duration: 125 mins
Recovery Duration: 4.5 days

Flow Rate (Q) = 2.39 gpm
Flow Rate (Q) = 460.1 ft\(^3\)/d

FIGURE B-16
Shut-In Test
Underground Drillhole Hydro-03 Test No.1
Theis Equation:

\[ T = \frac{2.3 \, Q}{4\pi \Delta s} \]

Where:
- \( T \) = Transmissivity (ft\(^2\)/d)
- \( Q \) = Pumping Rate (ft\(^3\)/d)
- \( \Delta s \) = Drawdown per Log Cycle (ft)

\[ T = \frac{2.3 \times (127.1)}{4\pi (32)} = 0.73 \text{ ft}^2/\text{d} \]

\[ K = \frac{T}{b} \]

Where:
- \( K \) = Estimate for Hydraulic Conductivity (ft/d)
- \( b \) = Test Interval Length (ft)

\[ K = \frac{0.73}{(218)} = 3.3 \times 10^{-3} \text{ ft/d} \]

\[ T = 0.73 \text{ ft}^2/\text{d} \]

\[ K = 3.3 \times 10^{-3} \text{ ft/d} \]
Theis Recovery Analysis

Theis Equation:

\[ T = \frac{2.3 Q}{4\pi \Delta s} \]

Where:

- \( T \) = Transmissivity (ft\(^2\)/d)
- \( Q \) = Pumping Rate (ft\(^3\)/d)
- \( \Delta s \) = Drawdown per Log Cycle (ft)

\[ T = \frac{2.3 \times 481.3}{4\pi \times 300} = 0.29 \text{ ft}^2/\text{d} \]

\[ K = \frac{T}{b} \]

Where:

- \( K \) = Estimate for Hydraulic Conductivity (ft/d)
- \( b \) = Test Interval Length (ft)

\[ K = \frac{0.29}{425} = 6.9 \times 10^{-4} \text{ ft/d} \]

\[ T = 0.29 \text{ ft}^2/\text{d} \]
\[ K = 6.9 \times 10^{-4} \text{ ft/d} \]
Theis Recovery Analysis

Theis Equation:

\[ T = \frac{2.3 \, Q}{4\pi \Delta s} \]

Where:
- \( T \) = Transmissivity (ft\(^2\)/d)
- \( Q \) = Pumping Rate (ft\(^3\)/d)
- \( \Delta s \) = Drawdown per Log Cycle (ft)

\[ T = \frac{2.3 \, (163.6)}{4\pi (27)} = 1.11 \, \text{ft}^2/\text{d} \]

\[ K = \frac{T}{b} \]

Where:
- \( K \) = Estimate for Hydraulic Conductivity (ft/d)
- \( b \) = Test Interval Length (ft)

\[ K = \frac{(1.11)}{(425)} = 2.6 \times 10^{-3} \, \text{ft/d} \]

\[ T = 1.11 \, \text{ft}^2/\text{d} \]

\[ K = 2.6 \times 10^{-3} \, \text{ft/d} \]

Depth of Test Interval: 0 – 425 ft (TD)

Flow Duration: 30.5 hours
Recovery Duration: 3.6 days

Flow Rate (Q) = 0.85 gpm
Flow Rate (Q) = 163.6 ft\(^3\)/d

FIGURE B-20
Shut-In Test
Underground Drillhole Hydro-04 Test No.2
Overview of Test Data
Underground Drillhole 13Hydro-05
FIGURE B-22
Shut-In Test
Underground Drillhole Hydro-05 Test No.1

Theis Recovery Analysis

Depth of Test Interval:
0 – 600 ft (TD)

Flow Duration: 91 mins
Recovery Duration: 7.8 days

Flow Rate (Q) = 0.36 gpm
Flow Rate (Q) = 69.3 ft³/d

Theis Equation:

\[ T = \frac{2.3 \times Q}{4\pi \Delta s} \]

Where:
- \( T \) = Transmissivity (ft²/d)
- \( Q \) = Pumping Rate (ft³/d)
- \( \Delta s \) = Drawdown per Log Cycle (ft)

\[ T = \frac{2.3 \times 69.3}{4\pi \times 920} = 0.014 \text{ ft²/d} \]

\[ K = \frac{T}{b} \]

Where:
- \( K \) = Estimate for Hydraulic Conductivity (ft/d)
- \( b \) = Test Interval Length (ft)

\[ K = \frac{0.014}{600} = 2.3 \times 10^{-5} \text{ ft/d} \]

\[ T = 0.014 \text{ ft²/d} \]
\[ K = 2.3 \times 10^{-5} \text{ ft/d} \]
Theis Equation:

\[ T = \frac{2.3 \, Q}{4\pi \Delta s} \]

Where:

- \( T \) = Transmissivity (ft²/d)
- \( Q \) = Pumping Rate (ft³/d)
- \( \Delta s \) = Drawdown per Log Cycle (ft)

\[ T = \frac{2.3 \, (221.4)}{4\pi (285)} = 0.14 \, \text{ft}^2/\text{d} \]

\[ K = \frac{T}{b} \]

Where:

- \( K \) = Estimate for Hydraulic Conductivity (ft/d)
- \( b \) = Test Interval Length (ft)

\[ K = \frac{(0.14)}{600} = 2.4 \times 10^{-4} \, \text{ft/d} \]

\[ T = 0.14 \, \text{ft}^2/\text{d} \]

\[ K = 2.4 \times 10^{-4} \, \text{ft/d} \]
Raw Data

Overview of Test Data
Underground Drillhole 13Hydro-06A
Theis Recovery Analysis

Theis Equation:

\[ T = \frac{2.3 \times Q}{4\pi \Delta s} \]

Where:
- \( T \) = Transmissivity (ft\(^2\)/d)
- \( Q \) = Pumping Rate (ft\(^3\)/d)
- \( \Delta s \) = Drawdown per Log Cycle (ft)

\[ T = \frac{2.3 \times 637.2}{4\pi \times 30} = 3.89 \text{ ft}^2/\text{d} \]

\[ K = \frac{T}{b} \]

Where:
- \( K \) = Estimate for Hydraulic Conductivity (ft/d)
- \( b \) = Test Interval Length (ft)

\[ K = \frac{(3.89)}{202} = 1.9 \times 10^{-2} \text{ ft/d} \]

\[ T = 3.89 \text{ ft}^2/\text{d} \]

\[ K = 1.9 \times 10^{-2} \text{ ft/d} \]

Depth of Test Interval:
0 – 202 ft (TD)

Flow Duration: 106 mins
Recovery Duration: 4.9 days

Flow Rate (Q) = 3.31 gpm
Flow Rate (Q) = 637.2 ft\(^3\)/d

FIGURE B-25
Shut-In Test
Underground Drillhole Hydro-06A Test No.1
Theis Recovery Analysis

Theis Equation:

\[ T = \frac{2.3 \cdot Q}{4\pi \cdot \Delta s} \]

Where:
- \( T \) = Transmissivity (ft\(^2\)/d)
- \( Q \) = Pumping Rate (ft\(^3\)/d)
- \( \Delta s \) = Drawdown per Log Cycle (ft)

\[ T = \frac{2.3 \cdot (232.9)}{4\pi \cdot (3.4)} = 12.54 \text{ ft}^2/\text{d} \]

\[ K = \frac{T}{b} \]

Where:
- \( K \) = Estimate for Hydraulic Conductivity (ft/d)
- \( b \) = Test Interval Length (ft)

\[ K = \frac{(12.54)}{(202)} = 6.2 \times 10^{-2} \text{ ft/d} \]

\[ T = 12.54 \text{ ft}^2/\text{d} \]
\[ K = 6.2 \times 10^{-2} \text{ ft/d} \]

Depth of Test Interval:
- 0 – 202 ft (TD)

Flow Duration: 29.8 hours
Recovery Duration: 26.5 hours

Flow Rate (Q) = 1.21 gpm
Flow Rate (Q) = 232.9 ft\(^3\)/d

FIGURE B-26
Shut-In Test
Underground Drillhole Hydro-06A Test No.2
Raw Data

Underground Drillhole 13Hydro-06B

Leaking collar plug repaired

Test #1

Test #2

2013 Date

Height of Water Above Transducer (ft)
Theis Equation:

\[ T = \frac{2.3 \, Q}{4\pi \Delta s} \]

Where:
- \( T \) = Transmissivity (ft²/d)
- \( Q \) = Pumping Rate (ft³/d)
- \( \Delta s \) = Drawdown per Log Cycle (ft)

\[ T = \frac{2.3 \times 1237.8}{4\pi \times 400} = 0.57 \, \text{ft}^2/\text{d} \]

\[ K = \frac{T}{b} \]

Where:
- \( K \) = Estimate for Hydraulic Conductivity (ft/d)
- \( b \) = Test Interval Length (ft)

\[ K = \frac{0.57}{453} = 1.3 \times 10^{-3} \, \text{ft}/\text{d} \]

\[ T = 0.57 \, \text{ft}^2/\text{d} \]

\[ K = 1.3 \times 10^{-3} \, \text{ft}/\text{d} \]
Theis Recovery Analysis

Theis Equation:

\[ T = \frac{2.3}{\pi} \frac{Q}{\Delta s} \]

Where:
- \( T \) = Transmissivity (ft²/d)
- \( Q \) = Pumping Rate (ft³/d)
- \( \Delta s \) = Drawdown per Log Cycle (ft)

\[ T = \frac{2.3 \times 259.9}{4\pi \times 37} = 1.29 \text{ ft}^2/\text{d} \]

\[ K = \frac{T}{b} \]

Where:
- \( K \) = Estimate for Hydraulic Conductivity (ft/d)
- \( b \) = Test Interval Length (ft)

\[ K = \frac{(1.29)}{(453)} = 2.8 \times 10^{-3} \text{ ft/d} \]

\[ T = 1.29 \text{ ft}^2/\text{d} \]

\[ K = 2.8 \times 10^{-3} \text{ ft/d} \]