Monitoring Well Installation Report

For Compliance with the Coal Combustion Residuals (CCR) Rule

Pawnee Station

Xcel Energy

February 1, 2016

Rev 1: December 28, 2018
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<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>AMSL</td>
<td>above mean sea level</td>
</tr>
<tr>
<td>BGS</td>
<td>below ground surface</td>
</tr>
<tr>
<td>BTOC</td>
<td>below top of casing</td>
</tr>
<tr>
<td>CCR</td>
<td>Coal Combustion Residuals</td>
</tr>
<tr>
<td>cm/sec</td>
<td>centimeter per second</td>
</tr>
<tr>
<td>HP Geotech</td>
<td>Hepworth-Pawlak Geotechnical, Inc.</td>
</tr>
<tr>
<td>µS/cm</td>
<td>microsiemens per centimeter</td>
</tr>
<tr>
<td>NTU</td>
<td>nephelometric turbidity unit</td>
</tr>
<tr>
<td>PSCo</td>
<td>Public Service Company of Colorado</td>
</tr>
<tr>
<td>TOC</td>
<td>top of casing</td>
</tr>
<tr>
<td>USCS</td>
<td>Unified Soil Classification System</td>
</tr>
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</table>
1.0 Introduction

The purpose of this Monitoring Well Installation Report is to document details pertaining to the drilling, construction, and development of eleven groundwater monitoring wells installed at the Xcel Energy Pawnee Generating Station (Pawnee Station) in Morgan County, Colorado (Figure 1). The groundwater monitoring system is intended to support compliance with the U.S. Environmental Protection Agency’s final Coal Combustion Residuals (CCR) Rule (40 CFR Parts 257 and 261). Pawnee Station has an existing CCR landfill unit (North Landfill) subject to the CCR Rule, as well as a new CCR landfill (East Landfill). The East Landfill was constructed in 2018 and is scheduled to begin operations in 2019. There are also two former CCR Impoundments (Ash Water Recovery Pond and Bottom Ash Storage Pond) that are subject to the CCR Rule. The drilling and well installation was performed in accordance with the State of Colorado Water Well Construction Rules (2 Code of Colorado Regulations 402-2).

HDR was contracted to locate, design, permit and oversee the installation of groundwater monitoring wells at Pawnee Station. HDR retained Hepworth-Pawlak Geotechnical, Inc. (HP Geotech) and Site Services Drilling, LLC to provide on-site drilling services, while HDR provided oversight of the drilling, well installation, and development. All on-site personnel completed the site-specific safety training. Additionally, daily safety briefs were conducted by the on-site project team prior to commencing work. The training and safety briefs were documented in accordance with the PSCo CCR Rule Compliance Health & Safety Plan.

2.0 Background Information

Prior hydrogeologic and geotechnical investigations have been conducted at Pawnee as documented in reports identified and summarized in the Pawnee Monitoring Well Installation Plan (HDR, 2015). Dune sand deposits are present at both the existing North Landfill and East Landfill, which overlie a sandy silt (referred to in other reports as fine-grained residual soil) and Pierre Shale Formation bedrock. Groundwater is generally found at the bedrock and sandy silt contact. Dune sands in the CCR landfill areas overlay the residual soil and generally do not contain water; however, perched water-table conditions can be present in localized areas underlain by low-permeability material (PSCo, 2015).

Regional groundwater flow is generally to the northeast across the site towards the South Platte River; however, a bedrock high, trending northwest to southeast, is present beneath the North CCR landfill area, resulting in an eastern radial flow away from both of the landfill sites on the eastern side (PSCo, 2015; shown in Figure 2).

The eleven new monitoring wells installed at Pawnee Station (PNMW-13, -14, -15, -16, -17, -18, -19, -20, -21, -22, and -23; shown in Figure 2) were sited based on monitoring requirements in the CCR Rule, facility design, and existing hydrogeologic data for the vicinity, as described in the Groundwater Monitoring System Certification (HDR, 2018). Wells PNMW-13, -14, -15, and -16 were installed to monitor the North Landfill; wells PNMW-17, -18, -19, and -20 were installed to monitor the former Ash Water Recovery Pond; and PNMW-17, -21, -22, and -23 were installed to monitor the East Landfill and the former Bottom Ash Storage Pond. The East Landfill was constructed in the footprint of the former Bottom Ash Storage Pond which had all waste removed and was closed in 2017.
Figure 1. Vicinity Map for Pawnee Station
Figure 2. Well Location Map, Pawnee Station
3.0 Field and Laboratory Methods

3.1 Borehole Drilling

The boreholes for wells PNMW-13 and PNMW-14 were drilled by HP Geotech using a hollow stem auger drilling method between November 16 and 18, 2015. The boreholes for wells PNMW-15 through PNMW-23 were drilled by Site Services Drilling, LLC using a hollow stem auger method between January 23 and February 8, 2017. Utility locations were identified prior to beginning drilling operations. However, to ensure the absence of any buried utilities, the driller advanced soil borings from the ground surface to a depth of approximately 8 feet using a pot-holing technique prior to drilling. The borehole was then advanced using the hollow stem auger drilling method with a CME-55 drill rig. The nominal borehole diameter was 6 inches to accommodate construction of 2-inch diameter wells.

Similar to the previously constructed groundwater monitoring wells on site\(^1\), screen depth was targeted for placement above the Pierre Shale bedrock, including weathered bedrock, within the dune deposits and silt layers between the dune sands and the weathered bedrock. All well screens were placed at and below the water table and to represent both the dune sand and residual soil above the weathered bedrock. This resulted in boreholes with total depths of approximately 50 and 70 feet below ground surface (bgs), as further described in Section 4.3.

An HDR geologist was present during drilling operations to collect samples and log the subsurface material, in addition to overseeing site safety and proper well construction. Soil samples from boreholes were collected in plastic bags and logged every 5 feet by the field geologist during drilling to document lithologic soil characteristics. The geologist visually classified soil type, consistency/relative density, color, and water content in accordance with the Unified Soil Classification System (USCS) as well as grain size, mineralogy, sorting, rounding, hardness, and matrix/clast support, among other textural properties. Samples were placed in sample bags labeled with the borehole identification and depth interval. One undisturbed soil sample was collected within the well screen depth interval from PNMW-13, and -14 and submitted to a lab for hydraulic properties analysis, as described below in Section 3.2. It was determined that the screened interval for the wells was characterized through the testing of those wells and additional laboratory analysis is not necessary. Boring logs for each borehole are provided in Appendix A.

Soil cuttings, fluids, and potholing slurry generated during drilling were transported to and disposed of at an existing on-site evaporation pond. Drilling equipment was decontaminated with potable water before moving to the next bore hole.

\[^1\] The existing wells on site are screened above the Pierre Shale bedrock. The screened intervals at these existing wells capture the higher of either the residual soil/dune sand contact or the residual soil/weathered bedrock, up to the maximum historic groundwater elevation. This screening interval intercepts potential seepage from the landfill through either the dune sand or transition zone bedrock (PSCo, 2015). This approach has worked well for the groundwater monitoring program conducted on the site and wells for this project were therefore similarly constructed.
3.2 Soil Samples – Geotechnical Analysis

Soils were logged from the cutting returns during November 2015 drilling and classified based on the USCS. During drilling, one undisturbed soil sample was obtained from each borehole at a depth coinciding with the interval of the well screen depth. An 18-inch long California Modified Style Split-Spoon Sampler was used to collect the undisturbed core of sediment. The undisturbed soil samples (one from PNMW-13 and -14) were submitted to HP Geotech for geotechnical analysis of the following parameters:

- Grain-size: Sieve and Hydrometer (ASTM D421/422)
- Total Porosity (SW9100)
- Bulk Density (ASTM D2937)
- Moisture Content (ASTM D2216)
- Specific Gravity (ASTM D854)

Analysis was completed in accordance with the method for grain-size analysis using sieve and hydrometer described in ASTM D421/422 (ASTM D421-85, 1998 and ASTM D422-63, 2007). Chain of custody documentation is provided in Appendix B.

Soils were logged from the cutting returns during February 2017 drilling and classified based on the USCS. During drilling, soil samples were obtained from the boreholes at PNMW-21 and -22 for geotechnical properties to assist in design of the East Landfill. A brass liner was used to collect undisturbed cores of sediment and other samples were bagged for analysis. The following soil samples were submitted to Advanced Terra Testing for geotechnical analysis of the parameters in Table 1.

Table 1. February 2017 Geotechnical Soil Samples

<table>
<thead>
<tr>
<th>Boring</th>
<th>Sample Depth below ground surface</th>
<th>Lithologic Material</th>
<th>Laboratory Analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNMW-21 (also referred to as TB-4)</td>
<td>60-62 feet (just below screened interval 30-60)</td>
<td>Weathered Shale</td>
<td>Permeability (ASTM D5084 Method D)</td>
</tr>
<tr>
<td>PNMW-22 (also referred to as TB-5)</td>
<td>49-51 feet (in screened interval)</td>
<td>Sandy Silt</td>
<td>Grain size (ASTM D6913)</td>
</tr>
</tbody>
</table>
3.3  Well Construction

Once the target drilling depth was reached at each location, 2-inch diameter, Schedule 40 PVC casing and well screens (0.010-inch slots) were assembled and lowered into each borehole. Approximately 30 feet of screen was installed at PNMW-13, -14, -15, -16, -17, -18, -19, -20, -21, -22, and -23.

After PVC casing and screen placement in the borehole, the filter pack sand and the bentonite pellet seal were placed via gravity feed from the surface into the annular space. The filter pack consisted of 10-20 (sieve size) washed silica sand emplaced from the bottom of the hole to approximately 5 feet above the well screen. An annular seal of bentonite pellets was placed to 5 feet above the top of the filter pack and hydrated for 12 hours after placement. HP Geotech and Site Services Drilling, LLC then used a tremie pipe to place bentonite grout above the bentonite seal to within approximately 2 feet of the surface.

An annular surface seal consisting of neat cement was installed from the top of the bentonite grout to the surface. All wells were finished with a 2-foot-by-2-foot concrete pad. Each well included between 2 and 4 feet of PVC stick-up. Bollards were installed at all wells except PNMW-13 and -14 where they were not deemed necessary due to well locations. Each well was secured with a protective steel casing and lock. Well construction is further described in Section 4.3.

3.4  Well Development

Wells were developed over several days to improve hydraulic connectivity in the area immediately surrounding the well and remove any fluids introduced during drilling. Well development involves removing as much of the introduced drilling fluids, cuttings, and particulates from within and adjacent to the well as possible. Development did not begin until at least 12 hours after the wells had been grouted to ensure grout had sufficiently set.

Wells were developed by surge blocking and pumping. This method involves moving a surge block up and down the well screen and casing which alternately forces water in and out of the screen, loosens sediment, and draws fine-grained materials into the well, then removing the purge water and fine sediment from the well using a pump.

The duration of development; initial water level; well depth; method; and field parameter measurements of pH, specific conductance, temperature, and turbidity were recorded on the development record for each well. The amount of purge water removed from each well was estimated in the field. Field parameters were recorded approximately every five (5) minutes of discharge and checked more often for wells with slow recharge. Well development continued until field parameters stabilized. Stabilized field parameters were defined as three (3) consecutive readings where temperatures were within 1°C, pH readings were within 0.2 standard units, and conductivity within 10 percent, and turbidity values were less than 10 nephelometric turbidity units (NTU). The field manager was notified when field parameters stabilized, and development ceased when the water was visually free of suspended solids. Purge water was placed into drums and/or buckets and disposed of in an on-site evaporation pond. The wells took considerable time to develop, between four (4) and six (6) days. All non-dedicated down-well equipment used during development was decontaminated between wells.
3.5 Well Survey

Surveying of the monitoring wells was performed by a professional land surveyor (PLS), Edward-James Surveying, Inc. after well completion. The surveyor recorded elevations of the top of PVC casing (point at notch on the north side of the casing top) and ground surface using a level loop. The northing and easting coordinates of the wells were also surveyed.

3.6 Groundwater Level Measurement and Aquifer (Slug) Testing

HDR performed slug tests on monitoring wells PNMW-13, and PNMW-14 on December 9, 2015; and PNMW-15-23 in February and March 2017 to obtain estimates of hydraulic conductivity for the shallow unconfined aquifer. A 1.5-inch diameter by 2.7-foot long watertight slug was used. Given a 2-inch diameter well, an expected slug displacement of 1.52 feet is estimated for the slug. A transducer was suspended on a communications cable near the bottom of the well, and recorded water level measurements at 1-second intervals. Both slug-in and slug-out tests were performed. Slug-in tests were completed by dropping the slug into the water column as quickly as possible, and measuring the falling water level that followed. Slug-out tests were completed after each slug-in test by removing the slug from the water column as quickly as possible and measuring the rising water level that followed. Well-specific testing details are summarized below:

- PNMW-13: One slug-in and one slug-out test were performed on December 9, 2015. The depth to water in the well was 42.68 feet below top of casing. With a well screen interval of 20−50 feet below ground surface and a casing stick-up of 3.89 feet, 18.7 feet of the well screen was exposed to the vadose zone.

- PNMW-14: One slug-in and one slug-out test were performed on December 9, 2015. The depth to water in the well was 59.32 feet below top of casing. With a well screen interval of 40−70 feet below ground surface and a casing stick-up of 4.00 feet, 15.3 feet of the well screen was exposed to the vadose zone.

- PNMW-15: One slug-in and two slug-out tests were performed on February 27, 2017. The depth to water in the well was 28.9 feet below top of casing. With a well screen interval of 25−55 feet below ground surface and a casing stick-up of 2.18 feet, 1.7 feet of the well screen was exposed to the vadose zone.

- PNMW-17: Two slug-in and two slug-out tests were performed on February 27, 2017. The depth to water in the well was 8.93 feet below top of casing. With a well screen interval of 5−35 feet below ground surface and a casing stick-up of 2.23 feet, 1.7 feet of the well screen was exposed to the vadose zone.

- PNMW-18: One slug-in and one slug-out test were performed on February 28, 2017. The depth to water in the well was 30.36 feet below top of casing. With a well screen interval of 20−50 feet below ground surface and a casing stick-up of 2.35 feet, 8.01 feet of the well screen was exposed to the vadose zone.

- PNMW-19: One slug-in and one slug-out test were performed on February 28, 2017. The depth to water in the well was 31 feet below top of casing. With a well screen interval of 23−53 feet below ground surface and a casing stick-up of 2.17 feet, 5.83 feet of the well screen was exposed to the vadose zone.
• PNMW-20: One slug-in and two slug-out tests were performed on March 6, 2017. Depth to water was 29.11 feet below top of casing. With a well screen interval of 21.2–51.2 feet below the ground surface and a casing stick-up of 2.15 feet, 5.76 feet of the well screen was exposed to the vadose zone. All three slug tests in PNMW-20 had initial displacements significantly less than the expected displacement of 1.52 feet, and for this reason the estimated conductivity at PNMW-20 should be viewed as less reliable.

• PNMW-21: Two slug-in and two slug-out tests were performed on March 6, 2017. Depth to water was 39.25 feet below top of casing. With a well screen interval of 30.7 to 60.7 feet below the ground surface and a casing stick-up of 2.35 feet, 6.2 feet of the well screen was exposed to the vadose zone.

• PNMW-22: Two slug-in and two slug-out tests were performed on March 6, 2017. Depth to water was 41.32 feet below top of casing. With a well screen interval of 30 to 60 feet below the ground surface and a casing stick-up of 2.59 feet, 8.7 feet of the well screen was exposed to the vadose zone.

• PNMW-23: Two slug-in and two slug-out tests were performed on March 6, 2017. Depth to water was 47.51 feet below top of casing. With a well screen interval of 30 to 61.3 feet below the ground surface and a casing stick-up of 2.24 feet, 14.8 feet of the well screen was exposed to the vadose zone.

3.7 Decontamination of Field Equipment

Field instrumentation (such as interface probes or water quality meters) was decontaminated between sample locations by rinsing with an Alconox/distilled water solution followed by a potable water rinse and a final rinse with deionized water.

4.0 Field and Laboratory Results

4.1 Borehole Drilling

Boring logs for each borehole are provided in Appendix A. Soil cuttings from the borehole samples, which consisted primarily of fine to medium grained sand and silty sand, were dry at the wells from the ground surface to approximately 30 to 35 feet. Weathered shale was encountered at approximately 45 to 50 feet. This was presumed to be the top of the Pierre Shale formation. Lean clay was encountered in PNMW-19 at 45 feet.

4.2 Soil Samples – Geotechnical Analysis

The soil samples collected from some of the boreholes were analyzed for grain size and porosity in PNMW-13 and -14, for permeability of the weathered bedrock below the screened interval in PNMW-21, and for grain size in the screened interval in PNMW-22. Results are summarized in Table 1. The soils laboratory results are presented in Appendix B.

Laboratory results show the wells are screened in sandy silt, with porosities between 32 and 40 percent, which is consistent with the silty sand material noted in the drilling logs.
Table 2. Summary of Geotechnical Testing Results

<table>
<thead>
<tr>
<th>Well I.D.</th>
<th>Sample Depth (ft BGS)</th>
<th>Gradation</th>
<th>Total Porosity (%)</th>
<th>Permeability (cm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNMW-13</td>
<td>34</td>
<td>0</td>
<td>38</td>
<td>62</td>
</tr>
<tr>
<td>PNMW-14</td>
<td>69</td>
<td>0</td>
<td>31</td>
<td>69</td>
</tr>
<tr>
<td>PNMW-21</td>
<td>61</td>
<td>NM</td>
<td>NM</td>
<td>NM</td>
</tr>
<tr>
<td></td>
<td>(weathered bedrock below screen interval)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PNMW-22</td>
<td>50</td>
<td>0</td>
<td>13</td>
<td>87</td>
</tr>
</tbody>
</table>

Note: NM = Not measured; BGS = below ground surface

4.3 Well Construction

A diagram for each well documenting well construction is provided in Appendix C. Approximately 30 feet of screen was installed in each well. The screen was placed above the Pierre Shale formation. Well construction details for all wells are summarized in Table 2. State well construction permits are included in Appendix D.
### Table 3. Well Construction Details for Groundwater Monitoring Wells at Pawnee Station

<table>
<thead>
<tr>
<th>Well I.D.</th>
<th>Northing (State Plane, NAD 1983 UTM Zone 13 N meters)</th>
<th>Easting (State Plane, NAD 1983 UTM Zone 13 N meters)</th>
<th>Elevation TOC (feet AMSL)</th>
<th>Well Total Depth (feet BGS)</th>
<th>Depth of Screen Interval (feet BGS)</th>
<th>Well Stickup (feet)</th>
<th>Casing Type</th>
<th>Depth to Water (feet BTOC)</th>
<th>Static Water Level (feet AMSL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNMW-13</td>
<td>611555.4201</td>
<td>4451735.628</td>
<td>4378.11</td>
<td>50</td>
<td>20–50</td>
<td>3.90</td>
<td>2-inch Sch. 40 PVC</td>
<td>42.78</td>
<td>4335.33</td>
</tr>
<tr>
<td>PNMW-14</td>
<td>611555.2833</td>
<td>4451488.609</td>
<td>4376.96</td>
<td>70</td>
<td>40–70</td>
<td>4.00</td>
<td>2-inch Sch. 40 PVC</td>
<td>59.34</td>
<td>4317.62</td>
</tr>
<tr>
<td>PNMW-15</td>
<td>612108.6655</td>
<td>4451975.9531</td>
<td>4341.57</td>
<td>55</td>
<td>25–55</td>
<td>2.18</td>
<td>2-inch Sch. 40 PVC</td>
<td>28.9</td>
<td>4312.67</td>
</tr>
<tr>
<td>PNMW-16</td>
<td>612130.9766</td>
<td>4452060.4886</td>
<td>4322.73</td>
<td>35</td>
<td>5–35</td>
<td>2.45</td>
<td>2-inch Sch. 40 PVC</td>
<td>15.59</td>
<td>4307.14</td>
</tr>
<tr>
<td>PNMW-17</td>
<td>612548.5390</td>
<td>4452006.0495</td>
<td>4314.78</td>
<td>35</td>
<td>5–35</td>
<td>2.23</td>
<td>2-inch Sch. 40 PVC</td>
<td>8.93</td>
<td>4305.85</td>
</tr>
<tr>
<td>PNMW-18</td>
<td>612658.3353</td>
<td>4452085.1461</td>
<td>4331.21</td>
<td>50</td>
<td>20–55</td>
<td>2.35</td>
<td>2-inch Sch. 40 PVC</td>
<td>30.36</td>
<td>4300.85</td>
</tr>
<tr>
<td>PNMW-19</td>
<td>612660.9447</td>
<td>4452044.6224</td>
<td>4330.82</td>
<td>53</td>
<td>23–53</td>
<td>2.17</td>
<td>2-inch Sch. 40 PVC</td>
<td>31</td>
<td>4299.82</td>
</tr>
<tr>
<td>PNMW-20</td>
<td>612657.8838</td>
<td>4451971.2478</td>
<td>4330.83</td>
<td>50</td>
<td>20–50</td>
<td>2.15</td>
<td>2-inch Sch. 40 PVC</td>
<td>29.11</td>
<td>4301.72</td>
</tr>
<tr>
<td>PNMW-21</td>
<td>612828.8799</td>
<td>4451939.3059</td>
<td>4331.06</td>
<td>60</td>
<td>30–60</td>
<td>2.35</td>
<td>2-inch Sch. 40 PVC</td>
<td>39.29</td>
<td>4291.81</td>
</tr>
<tr>
<td>PNMW-22</td>
<td>612830.1897</td>
<td>4451823.4324</td>
<td>4331.05</td>
<td>60</td>
<td>30–60</td>
<td>2.59</td>
<td>2-inch Sch. 40 PVC</td>
<td>41.32</td>
<td>4289.73</td>
</tr>
<tr>
<td>PNMW-23</td>
<td>612830.8628</td>
<td>4451655.4639</td>
<td>4331.48</td>
<td>60</td>
<td>30–60</td>
<td>2.24</td>
<td>2-inch Sch. 40 PVC</td>
<td>47.50</td>
<td>4283.97</td>
</tr>
</tbody>
</table>

**Notes:**
- TOC = top of casing
- BTOC = below top of casing
- BGS = below ground surface
- AMSL = above mean sea level
### 4.4 Well Development

Wells PNMW-13 and -14 were developed over several weeks (November 19 through December 7, 2015). Development was considered relatively difficult for both wells, due primarily to high turbidity readings and relatively slow recharge rates. On December 7, 2015 the field parameters stabilized at PNMW-13 after 64 gallons of water had been removed. Development of PNMW-14 was completed on December 4, 2015 after 127 gallons of water had been removed. Water quality parameters measured in the field after development are noted in Table 4.

Wells PNMW-15, -16, -17, -18, -19, -20 -21, -22, and -23 were developed after installation (between January 23 and February 9, 2017). Development was time consuming due to high turbidity readings and relatively slow recharge rates. Water quality parameters measured in the field after development are noted in Table 4.

#### Table 4. Field Water Quality After Well Development

<table>
<thead>
<tr>
<th>Well I.D.</th>
<th>Conductivity (µS/cm)</th>
<th>pH</th>
<th>Temperature (degrees C)</th>
<th>Turbidity (NTU)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNMW-13</td>
<td>583</td>
<td>7.61</td>
<td>14.1</td>
<td>9.4</td>
</tr>
<tr>
<td>PNMW-14</td>
<td>377.3</td>
<td>7.78</td>
<td>14.3</td>
<td>3.0</td>
</tr>
<tr>
<td>PNMW-15</td>
<td>2568</td>
<td>7.18</td>
<td>14.5</td>
<td>3.5</td>
</tr>
<tr>
<td>PNMW-16</td>
<td>1097</td>
<td>7.44</td>
<td>14.7</td>
<td>2.2</td>
</tr>
<tr>
<td>PNMW-17</td>
<td>1480</td>
<td>7.63</td>
<td>12.3</td>
<td>3.2</td>
</tr>
<tr>
<td>PNMW-18</td>
<td>1215</td>
<td>7.63</td>
<td>15.9</td>
<td>4.4</td>
</tr>
<tr>
<td>PNMW-19</td>
<td>471.2</td>
<td>7.66</td>
<td>15.9</td>
<td>4.8</td>
</tr>
<tr>
<td>PNMW-20</td>
<td>3430</td>
<td>7.31</td>
<td>16.5</td>
<td>4.0</td>
</tr>
<tr>
<td>PNMW-21</td>
<td>4305</td>
<td>7.35</td>
<td>18.0</td>
<td>91.3</td>
</tr>
<tr>
<td>PNMW-22</td>
<td>564</td>
<td>7.66</td>
<td>13.9</td>
<td>3.9</td>
</tr>
<tr>
<td>PNMW-23</td>
<td>2005</td>
<td>7.49</td>
<td>12.9</td>
<td>4.2</td>
</tr>
</tbody>
</table>

Notes:  
µS/cm = microsiemens per centimeter  
NTU = nephelometric turbidity unit

### 4.5 Well Survey

Survey coordinates and elevations are provided in Table 3.

### 4.6 Groundwater Level Measurement and Aquifer (Slug) Testing

All slug-in and slug-out tests were analyzed using the Dagan (1978) slug test solution for unconfined aquifers, and implemented using Aqtesolv® v4.5. Each well screen intersected the water table (i.e., was partially submerged) during the slug testing. An effective casing radius correction was applied using Aqtesolv® to account for drainage to and from the filter pack. For this correction, a well radius of 0.25 ft was used and an equipment radius of 0.005 ft was specified for the transducer cable for the December 2015 tests, an equipment radius of 0.01 ft was specified for the transducer cable for the March 2017 tests. The aquifer at each location was represented with the following estimates of saturated thickness: 11.22 feet (PNMW-13), 14.68 feet (PNMW-14), 28.28 (PNMW-15), 28.3
(PNMW-17), 21.99 feet (PNMW-18), 17 feet (PNMW-19), 17.64 feet (P-20), 23.8 (PNMW-21), 21.27 (PNMW-22), 16.03 (PNMW-23). An anisotropy ratio of 1 (unitless) was assigned to the aquifer at each well location.

Initial displacement created by the slug, and hydraulic conductivity results for the slug testing are shown in Table 5. With exception of two tests, the initial displacement was less than the expected displacement of 1.52 feet; it is suspected that this is due either to filter pack effects or to the transducer not recording quickly enough to read the initial displacement at the moment it reached maximum. Plots of the analyses are included in Appendix E. The geometric mean of the hydraulic conductivity calculated at PNMW-13, and PNMW-14 is $4.32 \times 10^{-3}$ cm/sec. This value corresponds with the textbook range of $10^{-5}$ to $10^{-1}$ cm/sec for silty sand by Freeze and Cherry (1979), which generally agrees with the range of formation materials noted in the boring logs (medium silty sand at PNMW-13, and fine silty sand at PNMW-14). The geometric mean of the hydraulic conductivity calculated from the slug tests at PNMW-15, -16, -17, -21, -22, -23 is $4.27 \times 10^{-4}$. The geometric mean of the hydraulic conductivity calculated from the slug tests at PNMW-18, -19, -20 is $3.31 \times 10^{-4}$ cm/sec. This value also corresponds with the textbook range of $10^{-5}$ to $10^{-1}$ cm/sec for silty sand by Freeze and Cherry (1979), and generally agrees with the formation materials noted in the boring logs (silt and silt with sand at PNMW-15, silt with sand at PNMW-17, silty fine sand at PNMW-18, fine sand and sandy silt at PNMW-19, silt and sand at PNMW-20, silt at PNMW-21, fine sand and silt at PNMW-22, and medium to coarse sand and silt at PNMW-23).

Table 5. Slug Testing Results

<table>
<thead>
<tr>
<th>Well</th>
<th>Test Name</th>
<th>Initial Displacement (ft)</th>
<th>Hydraulic Conductivity (cm/sec)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PNMW-13</td>
<td>Slug In</td>
<td>0.99</td>
<td>3.45E-03</td>
</tr>
<tr>
<td>PNMW-13</td>
<td>Slug Out</td>
<td>1.26</td>
<td>5.90E-03</td>
</tr>
<tr>
<td>PNMW-14</td>
<td>Slug In</td>
<td>1.22</td>
<td>2.06E-02</td>
</tr>
<tr>
<td>PNMW-14</td>
<td>Slug Out</td>
<td>1.47</td>
<td>8.33E-04</td>
</tr>
<tr>
<td>PNMW-15</td>
<td>Slug In</td>
<td>1.70</td>
<td>5.93E-04</td>
</tr>
<tr>
<td>PNMW-15</td>
<td>Slug Out</td>
<td>1.30</td>
<td>2.28E-03</td>
</tr>
<tr>
<td>PNMW-15</td>
<td>Slug Out (2nd Test)</td>
<td>1.30</td>
<td>8.83E-04</td>
</tr>
<tr>
<td>PNMW-17</td>
<td>Slug In (2nd Test)</td>
<td>1.72</td>
<td>1.78E-04</td>
</tr>
<tr>
<td>PNMW-17</td>
<td>Slug Out</td>
<td>1.09</td>
<td>4.81E-04</td>
</tr>
<tr>
<td>PNMW-17</td>
<td>Slug Out (2nd Test)</td>
<td>1.40</td>
<td>3.69E-04</td>
</tr>
<tr>
<td>PNMW-18</td>
<td>Slug In</td>
<td>1.17</td>
<td>3.47E-04</td>
</tr>
<tr>
<td>PNMW-18</td>
<td>Slug In (2nd Test)</td>
<td>1.14</td>
<td>2.11E-04</td>
</tr>
<tr>
<td>PNMW-18</td>
<td>Slug Out</td>
<td>1.35</td>
<td>1.41E-03</td>
</tr>
<tr>
<td>PNMW-18</td>
<td>Slug Out (2nd Test)</td>
<td>1.24</td>
<td>7.99E-04</td>
</tr>
<tr>
<td>PNMW-19</td>
<td>Slug In (2nd Test)</td>
<td>1.34</td>
<td>1.47E-04</td>
</tr>
<tr>
<td>PNMW-19</td>
<td>Slug In</td>
<td>0.79</td>
<td>1.00E-04</td>
</tr>
<tr>
<td>PNMW-19</td>
<td>Slug Out (2nd Test)</td>
<td>1.40</td>
<td>3.12E-04</td>
</tr>
<tr>
<td>PNMW-19</td>
<td>Slug Out</td>
<td>1.09</td>
<td>4.39E-04</td>
</tr>
<tr>
<td>PNMW-20</td>
<td>Slug In</td>
<td>0.51</td>
<td>3.12E-03</td>
</tr>
<tr>
<td>Well</td>
<td>Test Type</td>
<td>Level</td>
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<td>------------------</td>
<td>-------</td>
<td>--------</td>
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<td>PNMW-20</td>
<td>Slug Out</td>
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<td>1.13E-03</td>
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<td>PNMW-20</td>
<td>Slug Out (2nd test)</td>
<td>0.62</td>
<td>5.75E-03</td>
</tr>
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<td>PNMW-21</td>
<td>Slug In</td>
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<td>3.12E-04</td>
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<td>PNMW-21</td>
<td>Slug In (2nd test)</td>
<td>1.04</td>
<td>2.55E-04</td>
</tr>
<tr>
<td>PNMW-21</td>
<td>Slug Out</td>
<td>0.91</td>
<td>8.90E-05</td>
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<tr>
<td>PNMW-21</td>
<td>Slug Out (2nd test)</td>
<td>0.89</td>
<td>4.58E-04</td>
</tr>
<tr>
<td>PNMW-22</td>
<td>Slug In</td>
<td>1.07</td>
<td>7.90E-05</td>
</tr>
<tr>
<td>PNMW-22</td>
<td>Slug Out</td>
<td>1.43</td>
<td>1.79E-04</td>
</tr>
<tr>
<td>PNMW-22</td>
<td>Slug Out (2nd test)</td>
<td>1.23</td>
<td>2.94E-04</td>
</tr>
<tr>
<td>PNMW-23</td>
<td>Slug In</td>
<td>0.84</td>
<td>5.31E-05</td>
</tr>
<tr>
<td>PNMW-23</td>
<td>Slug Out (2nd test)</td>
<td>1.17</td>
<td>3.25E-04</td>
</tr>
<tr>
<td>PNMW-23</td>
<td>Slug In (2nd Test)</td>
<td>0.79</td>
<td>6.33E-05</td>
</tr>
<tr>
<td>PNMW-23</td>
<td>Slug Out</td>
<td>1.38</td>
<td>1.46E-04</td>
</tr>
<tr>
<td></td>
<td>Geometric Mean:</td>
<td></td>
<td>4.27E-04</td>
</tr>
</tbody>
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**5.0 References**


Appendix A

Borehole Logs
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Blow Count</th>
<th>Depth (feet)</th>
<th>Description (USCS)</th>
<th>Elevation (feet)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/A</td>
<td>5</td>
<td>Brown 10YR 4/3; Fine-medium SAND (SP); Dry</td>
<td></td>
<td>Pothole to 8 ft</td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
<td>5</td>
<td>Light yellow brown 2.5Y 6/4; Fine-medium SAND (SP); Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>2-2-3</td>
<td>10</td>
<td>Yellow brown 10YR 5/4; ; Fine-medium SAND (SP); Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>3-3-5</td>
<td>15</td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>7-14-12</td>
<td>20</td>
<td>Light yellow-brown 10YR 6/4; Fine-medium SAND (SP); Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>8-15-19 (SS)</td>
<td>25</td>
<td>Light yellow-brown 2.5YR 6/4; Fine SAND (SP); Dry</td>
<td></td>
<td>SS=Splitt spoon sampler</td>
</tr>
<tr>
<td>7</td>
<td>13-15-13</td>
<td>30</td>
<td>Light yellow-brown 2.5YR 6/4; Medium SAND (SP); Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MW-13: 34' bgs</td>
<td>12-20-2</td>
<td>35</td>
<td>Light olive brown 2.5Y 5/3; Fine-medium SAND (SP); Dry</td>
<td></td>
<td>Soil sample submitted for geotech analysis</td>
</tr>
<tr>
<td>9</td>
<td>50/11&quot;</td>
<td>40</td>
<td>Light olive brown 2.5Y 5/3; Fine-medium SAND (SP); Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>50/9&quot;</td>
<td>45</td>
<td>Light olive brown 2.5Y 5/3; Silty SAND (SM); Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>5/4&quot;</td>
<td>50</td>
<td>Light olive brown 7.5Y 5/3; Fine SAND (SP) and Shale; Dry</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Depth (feet): 50
Water Level (feet): After Drilling: -- Hours After: --
Logged/Sampled By: Matthew Keaveney Drilled By: HP Geotech
Date Started: 11/18/2015 Date Completed: 11/18/2015
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Blow Count</th>
<th>Depth (feet)</th>
<th>Description (USCS)</th>
<th>Elevation (feet)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/A</td>
<td></td>
<td>Brown 10YR 4/3; Fine Silty SAND (SM); Dry</td>
<td></td>
<td>Pothole to 8 ft</td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
<td></td>
<td>Brown 10YR 4/3; Fine SAND (SP); Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4-6-6 (SS)</td>
<td>10</td>
<td>Light yellowish brown 2.5Y 6/4; Fine SAND (SP); Dry</td>
<td></td>
<td>SS=SPLIT spoon sampler</td>
</tr>
<tr>
<td>4</td>
<td>5-8-8 (SS)</td>
<td></td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>9-12-13 (SS)</td>
<td>20</td>
<td>Yellowish brown 10YR 5/6; Fine-medium Silty SAND (SM); Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>50/10&quot;</td>
<td></td>
<td>Light yellowish brown 2.5Y 6/3; Fine SAND (SP); Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>50/11&quot;</td>
<td>30</td>
<td>Light yellowish brown 2.5Y 6/4; Very fine SAND (SP); Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>50/11&quot;</td>
<td></td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>10-15-18(SS)</td>
<td>40</td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>10-14-15(SS)</td>
<td>40</td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>8-14-17 (SS)</td>
<td>50</td>
<td>Light yellowish brown 10YR 6/4; Very fine SAND (SP); Dry</td>
<td></td>
<td>Moist</td>
</tr>
<tr>
<td>12</td>
<td>9-13-13 (SS)</td>
<td></td>
<td>Light olive brown 2.5Y 5/4; Very fine SAND (SP); Moist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>5-9-12 (SS)</td>
<td>60</td>
<td>Light olive brown 2.5Y 5/4; Silty SAND (SM); Wet</td>
<td></td>
<td>Wet</td>
</tr>
<tr>
<td>14</td>
<td>5-7-10 (SS)</td>
<td></td>
<td>As above</td>
<td></td>
<td></td>
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<tr>
<td>MW-14: 69° bgs</td>
<td>50/9&quot;</td>
<td>70</td>
<td>Light olive brown 2.5Y 5/4; Silty SAND (SP) with trace SHALE; Wet</td>
<td></td>
<td>Undisturbed sample submitted for geotech analysis</td>
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</tbody>
</table>

Total Depth (feet): 70

Water Level (feet): After Drilling: 59.00

Logged/Sampled By: Matthew Keaveney

Drilled By: HP Geotech

Date Started: 11/18/2015

Date Completed: 11/18/2015
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Blow Count</th>
<th>Depth (feet)</th>
<th>Description (USCS)</th>
<th>Elevation (feet)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td>Pothole to 8 ft</td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4-9-13 (SS)</td>
<td>10</td>
<td>Very pale brown 10YR 7/4; Medium-fine SAND (SM); Dry</td>
<td></td>
<td>SS=SPLIT SPOON SAMPLER</td>
</tr>
<tr>
<td>4</td>
<td>19-28-39 (SS)</td>
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<td>Light gray 10Y 7/1; SILT with Sand (ML); Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>50/6&quot;</td>
<td>20</td>
<td>As above</td>
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<td></td>
</tr>
<tr>
<td>6</td>
<td>13-23-38 (SS)</td>
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<td>As above</td>
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<tr>
<td>7</td>
<td>18-26-43 (SS)</td>
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<td>Dark gray Gley 1 4/N; SILT; Dry</td>
<td></td>
<td>Likely weathered shale and limestone</td>
</tr>
<tr>
<td>8</td>
<td>50/4&quot;</td>
<td></td>
<td>Brownish yellow 10YR 6/6; SILT with Sand (ML); Moist</td>
<td></td>
<td>Likely weathered shale and limestone</td>
</tr>
<tr>
<td>9</td>
<td>50/5&quot;</td>
<td>40</td>
<td>As above</td>
<td></td>
<td>Likely weathered shale and limestone</td>
</tr>
<tr>
<td>10</td>
<td>50/5&quot;</td>
<td></td>
<td>As above</td>
<td></td>
<td>Likely weathered shale and limestone</td>
</tr>
<tr>
<td>11</td>
<td>50/6&quot;</td>
<td>50</td>
<td>Dark gray Gley 1 4/N; SILT (ML); Moist</td>
<td></td>
<td>Likely weathered shale and limestone</td>
</tr>
<tr>
<td></td>
<td>50/9&quot;</td>
<td></td>
<td>As above</td>
<td></td>
<td>Weathered shale</td>
</tr>
</tbody>
</table>

**Logged/Sampled By:**
N. Hanrahan

**Drilled By:**
Site Services Drilling, LLC

<table>
<thead>
<tr>
<th>Total Depth (feet)</th>
<th>Water Level (feet below top of casing)</th>
<th>Logged/Sampled By</th>
<th>Drilled By</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>After Drilling: 28.90</td>
<td>N. Hanrahan</td>
<td>Site Services Drilling, LLC</td>
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<tr>
<td></td>
<td>Hours After: +48</td>
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<td></td>
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<tr>
<td></td>
<td>Date Started: 1/26/2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Date Completed: 1/27/2017</td>
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<td></td>
</tr>
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## Boring Log

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<th>Blow Count</th>
<th>Depth (feet)</th>
<th>Description (USCS)</th>
<th>Elevation (feet)</th>
<th>Remarks</th>
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<tbody>
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<td>N/A</td>
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<td></td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>22-34-38 (SS)</td>
<td>10</td>
<td>Light gray 10VR 7/2; SILT (ML); Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>50/6&quot;</td>
<td>15</td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>50/6&quot;</td>
<td>20</td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>50/4&quot;</td>
<td>25</td>
<td>Light gray 10VR 7/2; SILT with Sand (ML); Dry</td>
<td></td>
<td>SS=S; split spoon sampler</td>
</tr>
<tr>
<td>7</td>
<td>50/6&quot;</td>
<td>30</td>
<td>As above</td>
<td></td>
<td></td>
</tr>
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</table>

### Total Depth (feet)
- **35**

### Water Level (feet below top of casing)
- **15.59**

### Logged/Sampled By:
- N. Hannahan

### Drilled By:
- Site Services Drilling, LLC

### After Drilling:
- 1/25/2017

### Date Completed:
- 1/26/2017
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Blow Count</th>
<th>Depth (feet)</th>
<th>Description (USCS)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/A</td>
<td></td>
<td></td>
<td>Pothole to 8 ft</td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>22-34-38 (SS)</td>
<td>10</td>
<td>Light gray 10YR 7/2; SILT (ML); Dry</td>
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</tr>
<tr>
<td>4</td>
<td>50/6</td>
<td>15</td>
<td>As above</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>50/6</td>
<td>20</td>
<td>As above</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>50/4</td>
<td>25</td>
<td>Light gray 10YR 7/2; SILT with Sand (ML); Dry</td>
<td>SS=Split spoon sampler weathered bedrock</td>
</tr>
<tr>
<td>7</td>
<td>50/6</td>
<td>30</td>
<td>As above</td>
<td></td>
</tr>
</tbody>
</table>

**Total Depth (feet):** 37

**Water Level (feet below top of casing):**
- After Drilling: 8.93
- Hours After: +48

**Logged/Sampled By:** N. Hanrahan
**Drilled By:** Site Services Drilling, LLC
**Date Started:** 1/25/2017
**Date Completed:** 1/25/2017
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Blow Count</th>
<th>Depth (feet)</th>
<th>Description (USCS)</th>
<th>Elevation (feet)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td>Pothole to 8 ft</td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>5-7-8 (SS)</td>
<td>10</td>
<td>Light yellowish brown 10YR 6/4; Fine SAND (SP); Moist</td>
<td></td>
<td>SS=Split spoon sampler</td>
</tr>
<tr>
<td>4</td>
<td>4-4-6 (SS)</td>
<td></td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>5-5-2 (SS)</td>
<td>20</td>
<td>Light yellowish brown 10YR 6/4; Fine SAND (SP); Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>18-22-33 (SS)</td>
<td>30</td>
<td>Light gray; 10YR 7/2; Medium SAND (SP); Dry</td>
<td></td>
<td>SS=Split spoon sampler</td>
</tr>
<tr>
<td>7</td>
<td>14-21-28 (SS)</td>
<td>30</td>
<td>Light yellowish brown 2.5Y 6/4; Silty SAND (SM); Moist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td>40</td>
<td>Olive yellow 2.5Y 6/4; Silty Fine SAND (SM); Moist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>28-33-50 (SS)</td>
<td>50</td>
<td>As above</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Total Depth (feet): 55
Water Level (feet below top of casing): After Drilling: 30.36, Hours After: +48
Logged/Sampled By: N. Hanrahan
Drilled By: Site Services Drilling, LLC
Date Started: 1/26/2017
Date Completed: 1/27/2017
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Blow Count</th>
<th>Depth (feet)</th>
<th>Description (USCS)</th>
<th>Elevation (feet)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td>Pothole to 8 ft</td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>8-8-5 (SS)</td>
<td>10</td>
<td>Brownish yellow 10YR 6/6; Poorly graded fine medium SAND; Dry</td>
<td>SS=Split spoon sampler</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>8-11-11 (SS)</td>
<td>20</td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>13-18-14 (SS)</td>
<td>30</td>
<td>Brownish yellow 10 YR 6/6; Fine SAND (SW); Dry</td>
<td>SS=Split spoon sampler</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>19-25-36 (SS)</td>
<td>30</td>
<td>Brownish yellow 10 YR 6/4; Sandy SILT (ML); Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>32-59-5 (SS)</td>
<td></td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>30/5&quot;</td>
<td>40</td>
<td>As above; Wet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>50/5&quot;</td>
<td>46</td>
<td>As above</td>
<td></td>
<td>Light olive brown 2.5Y 5/6; Lean CLAY (CL); Wet</td>
</tr>
<tr>
<td>11</td>
<td>50/6&quot;</td>
<td>50</td>
<td>As above</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Depth (feet)**: 53.5  
**Water Level (feet below top of casing)**: 31.00  
**Logged/Sampled By**: N. Hanrahan  
**Drilled By**: Site Services Drilling, LLC  
**Date Started**: 1/23/2017  
**Date Completed**: 1/23/2017
## Boring Log

**Project Name**: Xcel CCR  
**Project No.**: 266180-006  
**Drilling Company**: Site Services Drilling, LLC

**Boring No.**: PNMW-20  
**Location**: Pawnee Station  
**Drilling Rig Type and Drilling Method**: CME-55, Hollow Stem Auger (6-inch diameter)

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Blow Count</th>
<th>Depth (feet)</th>
<th>Description (USCS)</th>
<th>Elevation (feet)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td>Pothole to 8 ft</td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>16-21-26 (SS)</td>
<td>10</td>
<td>Reddish yellow 7.5 YR 6/6; Fine to medium SAND (SP); Dry</td>
<td></td>
<td>SS=Split spoon sampler</td>
</tr>
<tr>
<td>4</td>
<td>10-11-12 (SS)</td>
<td>10</td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>8-12-19 (SS)</td>
<td>20</td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>10-13-20 (SS)</td>
<td>30</td>
<td>Light yellowish brown 2.5Y 6/4; SILT (ML) with sand; Dry</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>10-13-20 (SS)</td>
<td>40</td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>50/5&quot;</td>
<td>40</td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>50/6&quot;</td>
<td>50</td>
<td>As above; Moist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>50/6&quot;</td>
<td>50</td>
<td>Light gray 2.5Y 7/2; SILT and fine SAND (ML-SP); weathered bedrock</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>50/6&quot;</td>
<td>50</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Depth (feet)</th>
<th>Water Level (feet below top of casing)</th>
<th>Logged/Sampled By</th>
<th>Drilled By</th>
</tr>
</thead>
<tbody>
<tr>
<td>50.5</td>
<td>After Drilling: 29.11 Hours After: +48</td>
<td>N. Hanrahan</td>
<td>Site Services Drilling, LLC</td>
</tr>
<tr>
<td></td>
<td>Date Started: 1/24/2017 Date Completed: 1/24/2017</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample No.</td>
<td>Blow Count</td>
<td>Depth (feet)</td>
<td>Description (USCS)</td>
</tr>
<tr>
<td>------------</td>
<td>------------</td>
<td>--------------</td>
<td>-----------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>1</td>
<td>N/A</td>
<td></td>
<td>Brown 10YR 4/3; Fine Silty SAND (SM); Dry</td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
<td></td>
<td>Brown 10YR 4/3; Fine SAND (SP); Dry</td>
</tr>
<tr>
<td>3</td>
<td>21-23-35 (SS)</td>
<td>10</td>
<td>Light yellowish brown 10 YR 6/4; Fine to medium SAND (SP); Dry</td>
</tr>
<tr>
<td>4</td>
<td>5-7-10 (SS)</td>
<td></td>
<td>As above</td>
</tr>
<tr>
<td>5</td>
<td>9-10-11 (SS)</td>
<td>20</td>
<td>As above</td>
</tr>
<tr>
<td>6</td>
<td>12-14-17 (SS)</td>
<td></td>
<td>As above</td>
</tr>
<tr>
<td>7</td>
<td>11-12-20 (SS)</td>
<td>30</td>
<td>As above</td>
</tr>
<tr>
<td>8</td>
<td>19-22-24 (SS)</td>
<td></td>
<td>As above</td>
</tr>
<tr>
<td>9</td>
<td>12-20-29 (SS)</td>
<td>40</td>
<td>Brownish gray 2.5Y 6/2; SILT (ML) with sand; M</td>
</tr>
<tr>
<td>10</td>
<td>50/3&quot;</td>
<td></td>
<td>As above</td>
</tr>
<tr>
<td>11</td>
<td>50/6&quot;</td>
<td>50</td>
<td>As above</td>
</tr>
<tr>
<td>12</td>
<td>50/6&quot;</td>
<td></td>
<td>Light brownish gray 2.5Y 6/2; SILT (ML); Moist</td>
</tr>
<tr>
<td>13</td>
<td>50/3&quot;</td>
<td>60</td>
<td>Dark gray Gley 1 4/N; SILT (ML); Moist</td>
</tr>
</tbody>
</table>

**Total Depth (feet):** 60  
**Water Level (feet below top of casing):** 39.25  
**Logged/Sampled By:** N. Hanrahan  
**Drilled By:** Site Services Drilling, LLC  
**Date Started:** 1/30/2017  
**Date Completed:** 1/30/2017
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Blow Count</th>
<th>Depth (feet)</th>
<th>Description (USCS)</th>
<th>Elevation (feet)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4-6-6 (SS)</td>
<td>10</td>
<td>Light yellowish brown 10 YR 6/4; Poorly graded sand (SP); Moist</td>
<td></td>
<td>SS=SPLIT spoon sampler</td>
</tr>
<tr>
<td>4</td>
<td>5-8-8 (SS)</td>
<td></td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>9-12-13 (SS)</td>
<td>20</td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>50/10&quot;</td>
<td></td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>50/11&quot;</td>
<td>30</td>
<td>Pale yellow 2.5Y 7/3; Poorly graded fine SAND (SP); Moist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>50/11&quot;</td>
<td></td>
<td>As above; heavy FE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>10-15-18(SS)</td>
<td>40</td>
<td>Light gray 5Y 7/2; Si</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>10-14-15(SS)</td>
<td></td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>8-14-17 (SS)</td>
<td>50</td>
<td>Light gray 5 Y 7/2; SILT (ML); Moist</td>
<td></td>
<td>Some weathered shale</td>
</tr>
<tr>
<td>12</td>
<td>9-13-13 (SS)</td>
<td></td>
<td>As above</td>
<td></td>
<td>Moist</td>
</tr>
<tr>
<td>13</td>
<td>5-9-12 (SS)</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>5-7-10 (SS)</td>
<td>70</td>
<td>Light gray 5Y 7/2; SILT (ML); Moist</td>
<td></td>
<td>Laminated weathered shale</td>
</tr>
<tr>
<td>PNMW-22: 70' bgs</td>
<td>50/9&quot;</td>
<td>70</td>
<td>Dark gray Gley 1 4/N; SHALE BEDROCK; Wet</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total Depth (feet)</th>
<th>Water Level (feet below top of casing)</th>
<th>Logged/Sampled By:</th>
<th>Drilled By:</th>
</tr>
</thead>
<tbody>
<tr>
<td>71</td>
<td>41.32 After Drilling: +48</td>
<td>N. Hanrahan</td>
<td>Site Services Drilling, LLC</td>
</tr>
<tr>
<td></td>
<td>Date Started: 2/8/2017</td>
<td></td>
<td>Date Completed: 2/8/2017</td>
</tr>
</tbody>
</table>

---
# Boring Log

**Project Name:** Xcel CCR  
**Project No.:** 266180-006  
**Drilling Company:** Site Services Drilling, LLC

**Boring No.:** TB-6/PNMW-23  
**Location:** Pawnee Station  
**Drilling Rig Type and Drilling Method:** CME-55, Hollow Stem Auger (6-inch diameter)

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Blow Count</th>
<th>Depth (feet)</th>
<th>Description (USCS)</th>
<th>Elevation (feet)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/A</td>
<td>10</td>
<td>Light yellowish brown 10 YR 6/4; Medium SAND (SP)</td>
<td></td>
<td>Pothole to 8 ft</td>
</tr>
<tr>
<td>2</td>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>4-5-5 (SS)</td>
<td>10</td>
<td>Light yellowish brown 10 YR 6/4; Medium SAND (SP)</td>
<td></td>
<td>SS=S Split spoon sampler</td>
</tr>
<tr>
<td>4</td>
<td>9-14-7 (SS)</td>
<td>20</td>
<td>As above</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>18-26-30 (SS)</td>
<td>30</td>
<td>As above; some Fe staining</td>
<td></td>
<td>Notable preferential flow pathway</td>
</tr>
<tr>
<td>6</td>
<td>23-30-30 (SS)</td>
<td>40</td>
<td>Light yellowish brown 10YR 6/4; Silty SAND (SM)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>14-17-16 (SS)</td>
<td>50</td>
<td>Thinnly bedded, Fe staining</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>20-34-24 (SS)</td>
<td>60</td>
<td>Gray Gley1 6/N; SILT (ML); Moist</td>
<td></td>
<td>Weathered shale</td>
</tr>
<tr>
<td>9</td>
<td>50/5&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>50/4&quot;</td>
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</tr>
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<td>50/4&quot;</td>
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</tr>
<tr>
<td>12</td>
<td>50/4&quot;</td>
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<td></td>
</tr>
<tr>
<td>13</td>
<td>50/4&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Logged/Sampled By:** N. Hanraran  
**Drilled By:** Site Services Drilling, LLC

**Total Depth (feet):** 61  
**Water Level (feet below top of casing):** 47.51  
**After Drilling:** +48  
**Date Started:** 1/31/2017  
**Date Completed:** 1/31/2017
Appendix B
Well Construction Diagrams
Constructed: 11/18/2015
Drilled By: HP Geotech
PVC Casing EL: 4378.11 ft amsl
Water EL: 4335.33 ft amsl (December 2015)
Monitoring Well Construction Diagram
PNMW-14
Pawnee Station
Xcel Energy

- Protective Steel Casing w/Lock
- Protective Steel Casing
- Bentonite Grout
- 2-in. Sch. 40 PVC Casing
- Bentonite Pellet Seal
- 2-in. Sch. 40 PVC Well Screen w/ 0.010-in. Slots
- #10/20 Washed Silica Sand Filter Pack

Constructed: 11/16/2015
Drilled By: HP Geotech
PVC Casing EL: 4376.96 ft amsl
Water EL: 4317.62 ft amsl (December 2015)
Monitoring Well Construction Diagram
PNMW-16
Pawnee Station
Xcel Energy

Constructed: 1/26/2017
Drilled By: Site Services Drilling, LLC
PVC Casing EL: 4322.73 ft amsl
Water EL: 4307.14 ft amsl (February 2017)
Monitoring Well Construction Diagram
PNMW-17
Pawnee Station
Xcel Energy

Constructed: 1/26/2017
Drilled By: Site Services Drilling, LLC
PVC Casing EL: 4314.78 ft amsl
Water EL: 4305.85 ft amsl (February 2017)
Monitoring Well Construction Diagram
PNMW-18
Pawnee Station
Xcel Energy

Constructed: 1/19/2017
Drilled By: Site Services Drilling, LLC
PVC Casing EL: 4331.21 ft amsl
Water EL: 4300.85 ft amsl (Feb 2017)
Constructed: 1/23/2017
Drilled By: Site Services Drilling, LLC
PVC Casing EL: 4330.82 ft amsl
Water EL: 4299.82 ft amsl (February 2017)
December 14, 2015

Anna Lundin
HDR
1670 Broadway, Suite 3400
Denver, CO 80202

Subject: Laboratory Tests Results – Xcel Coal Combustion Residuals Rule Compliance Project, Pawnee Power Station.

Dear Ms. Lundin:

This letter presents the results of laboratory tests performed on samples submitted for the subject project. The test results are presented on the attached Figures 1-3 and Table 1.

If there are any questions, please feel free to contact us.

Sincerely,

HEPWoRTH-PAWLAK GEOTECHNICAL, Inc.

Cuong Vu, Ph.D., P.E.

Reviewed by: Arben Kalaveshi, P.E.

215333B (Pawnee) xmittal.doc
GRAVEL: 0%  SAND: 34%  SILT / CLAY: 66%
BORING: MW12  Specific Gravity: 2.83
DEPTH: 44 feet  Porosity: 39.5%

<table>
<thead>
<tr>
<th>Sieve Size / Particle Diameter</th>
<th>Percent Passing</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1&quot;)</td>
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<tr>
<td>(3/4&quot;)</td>
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</tr>
<tr>
<td>(1/2&quot;)</td>
<td>100</td>
</tr>
<tr>
<td>(3/8&quot;)</td>
<td>100</td>
</tr>
<tr>
<td>(#4)</td>
<td>100</td>
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<td>(#10)</td>
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</tr>
<tr>
<td>(#16)</td>
<td>100</td>
</tr>
<tr>
<td>(#40)</td>
<td>100</td>
</tr>
<tr>
<td>(#50)</td>
<td>100</td>
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<tr>
<td>(#100)</td>
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<td>0.0030</td>
<td>28</td>
</tr>
<tr>
<td>0.0013</td>
<td>20</td>
</tr>
</tbody>
</table>
GRAVEL: 0%  
SAND: 38%  
SILT / CLAY: 62%

BORING: MW13  
DEPTH: 34 feet  
Specific Gravity: 2.72  
Porosity: 31.7%

### Sieve Size / Particle Diameter and Percent Passing

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GRAVEL: 0%  SAND: 31%  SILT / CLAY: 69%
BORING: MW14  Specific Gravity: 2.81
DEPTH: 69 feet  Porosity: 39.7%

### Sieve Size / Particle Diameter vs. Percent Passing

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PERMEABILITY TEST - BACK PRESSURE SATURATED - FLOW PUMP METHOD
ASTM D5084 Method D

CLIENT: HDR
JOB NO.: 2279-11

PROJECT: Xcel Pawnee
PROJECT NO.: --
BORING NO.: TB-3
DEPTH: 42-44'
SAMPLE NO.: --
LOCATION: --
SAMPLE TYPE: Liner

MOISTURE / DENSITY DATA

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<th>BEFORE TEST</th>
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<td>Wt. Soil + Moisture - (g)</td>
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<td>Dry Density - (pcf)</td>
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| Init. Diameter - (in) | 1.938 |
| Init. Area - (sq in) | 2.950 |
| Init. Height - (in) | 3.049 |
| Vol. Bef. Consol. - (cu ft) | 0.00520 |
| Vol. After Consol. - (cu ft) | 0.00502 |
| Porosity - (%) | 40.41 |

FLOW PUMP CALCULATIONS

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Data entry by: KR
Date: 03/27/2017
Checked by: CAL
Date: 03/28/2017

File Name: 2279_11_HarvardFlowPump-Perm-ASTMD5084-R3_0.xls
### PERMEABILITY TEST - BACK PRESSURE SATURATED - FLOW PUMP METHOD

**ASTM D5084 Method D**

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### SATURATION DATA

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<tr>
<td>360</td>
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- **Initial Height - (in):** 3.049
- **Height Change - (in):** 0.054
- **Ht. After Cons. - (in):** 2.985
- **Initial Area - (sq in):** 2.950
- **Area After Cons. - sq in:** 2.905
- **Init. Vol. - (cc):** 147.41
- **Vol. Change - (cc):** 19.50
- **Cell Exp. - (cc):** 14.21
- **Net Change - (cc):** 5.29
- **Cons. Vol. - (cc):** 142.12
### PERMEABILITY TEST - BACK PRESSURE SATURATED - FLOW PUMP METHOD

**ASTM D5084 Method D**

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#### MOISTURE / DENSITY DATA

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<td>Wt. Dry Soil &amp; Pan - (g)</td>
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<td>Dry Density - (pcf)</td>
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| Init. Diameter - (in) | 1.918 |
| Init. Area - (sq in) | 2.889 |
| Init. Height - (in) | 3.044 |
| Vol. Bef. Consol. - (cu ft) | 0.00509 |
| Vol. After Consol. - (cu ft) | 0.00490 |
| Porosity - (%) | 40.08 |

#### FLOW PUMP CALCULATIONS

| Pump Setting (gear number) | 12 |
| Percentage of Pump Setting | 100 |
| Q - (cc/s) | 2.30E-05 |
| Height - (in) | 2.966 |
| Diameter - (in) | 1.907 |
| Pressure - (psi) | 4.010 |
| Area after consol. - (sq cm) | 18.422 |
| Gradient | 37.424 |
| Permeability k - (cm/s) | 3.3E-08 |
| Permeability k - (m/s) | 3.3E-10 |
| Back Pressure - (psi) | 66.0 |
| Cell Pressure - (psi) | 119.1 |
| Ave. Effective Stress - (psi) | 49.095 |
| Average temperature degree - (°C) | 22.2 |

Data entry by: CAL  
Checked by: MAN  
Date: 03/30/2017  
Date: 3/1/17  

FileName: 2279_11_HarvardFlowPump-Perm-ASTMD-5084-R3_1.xls  
Page 1 of 3
### SATURATION DATA

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<tr>
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<td>-11.75</td>
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Initial Height (in) 3.044 Initial Vol. (cc) 144.15
Height Change (in) 0.078 Vol. Change (cc) 23.90
Ht. After Cons. (in) 2.966 Cell Exp. (cc) 18.56
Initial Area (sq in) 2.889 Net Change (cc) 5.34
Area After Cons. (sq in) 2.855 Cons. Vol. (cc) 138.81
CONSOLIDATION DATA
MW-21,--,59-61'

VOLUME DEFLECTION - (cc)

SQUARE ROOT OF TIME IN MINUTES

0.00
0.25
0.5
1
2
4
9
10
30
60
120
240
360

0 2 4 6 8 10 12 14 16 18 20

FileName: 2279_11_HarvardFlowPump-Perm-ASTMD-5084-R3_1.xls
# PERMEABILITY TEST - BACK PRESSURE SATURATED - FLOW PUMP METHOD

**ASTM D5084 Method D**

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## MOISTURE / DENSITY DATA

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<td>Init. Height - (in)</td>
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<tr>
<td>Vol. Bef. Consol. - (cu ft)</td>
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## FLOW PUMP CALCULATIONS

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<tbody>
<tr>
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<tr>
<td>Q - (cc/s)</td>
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<tr>
<td>Height - (in)</td>
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Data entry by: CAL
Date: 3/31/2017
Checked by: DPA
Date: 4/5/17
PERMEABILITY TEST - BACK PRESSURE SATURATED - FLOW PUMP METHOD
ASTM D5084 Method D

CLIENT: HDR
JOB NO: 2279-11

PROJECT NO. Xcel Pawnee
BORING NO. TP-7
DEPTH 19-21'
SAMPLE NO. --
LOCATION --
SAMPLE TYPE liner

TEST STARTED 3/16/2017 By: CAL
TEST FINISHED 3/30/2017 By: CAL

CELL NUMBER 11P
PERMEANT Tap Water
CONF. PRES. - (psf) 2175

SATURATION DATA

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Initial Height (in) 3.025
Height Change (in) 0.003
Ht. After Cons. (in) 3.022
Initial Area (sq in) 2.904
Area After Cons. (sq in) 2.847
Init. Vol. (cc) 144.00
Vol. Change (cc) 15.40
Cell Exp. (cc) 12.41
Net Change (cc) 2.99
Cons. Vol. (cc) 141.01
PERMEABILITY TEST - BACK PRESSURE SATURATED - FLOW PUMP METHOD

ASTM D5084 Method D

CLIENT: Xcel Pawnee
PROJECT NO.: TP-8
BORING NO.: 19-21'
DEPTH: 9P
SAMPLE NO.: --
LOCATION: Tap Water
SAMPLE TYPE: liner

MOISTURE / DENSITY DATA

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<td>Wt. Wet Soil &amp; Pan - (g)</td>
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<td>Wt. Dry Soil &amp; Pan - (g)</td>
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<td>Wt. Lost Moisture - (g)</td>
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<td>Wt. of Pan Only - (g)</td>
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<tr>
<td>Wt. of Dry Soil - (g)</td>
<td>233.70</td>
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<tr>
<td>Moisture Content - (%)</td>
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<td>Wet Density - (pcf)</td>
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<td>Dry Density - (pcf)</td>
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<table>
<thead>
<tr>
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<tbody>
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<td>Init. Diameter - (in)</td>
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<tr>
<td>Init. Area - (sq in)</td>
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<td>Init. Height - (in)</td>
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<tr>
<td>Vol. Bef. Consol. - (cu ft)</td>
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<tr>
<td>Vol. After Consol. - (cu ft)</td>
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<td>Porosity - (%)</td>
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FLOW PUMP CALCULATIONS

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<tr>
<td>Percentage of Pump Setting</td>
<td>100</td>
</tr>
<tr>
<td>Q - (cc/s)</td>
<td>1.09E-01</td>
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<td>Height - (in)</td>
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<td>Diameter - (in)</td>
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<tr>
<td>Back Pressure - (psi)</td>
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<td>Cell Pressure - (psi)</td>
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<td>Ave. Effective Stress - (psi)</td>
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<td>Average temperature degree - (°C)</td>
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Data entry by: CAL
Date: 03/31/2017
Checked by: DPM
Date: 4/5/17
# PERMEABILITY TEST - BACK PRESSURE SATURATED - FLOW PUMP METHOD

**ASTM D5084 Method D**

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<td>--</td>
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<td>BORING NO.</td>
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## SATURATION DATA

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## CONSOLIDATION DATA

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<tr>
<td>360</td>
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<td>-2.00</td>
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Initial Height - (in) 3.037
Height Change - (in) 0.016
Ht. After Cons. - (in) 3.021
Initial Area - (sq in) 2.929
Area After Cons. - sq in 2.974

Init. Vol. - (cc) 145.77
Vol. Change - (cc) 15.10
Cell Exp. - (cc) 16.59
Net Change - (cc) -1.49
Cons. Vol. - (cc) 147.27

CONSOLIDATION DATA
TP-8-,--19-21'

VOLUME DEFLECTION - (cc)

SQUARE ROOT OF TIME IN MINUTES

Time in Minutes

FileName: 2279_11_HarvardFlowPump-Perm-ASTMD-5084-R3_3.xls
Particle Size Distribution (Gradation) of Soil Using Sieve Analysis
ASTM D 6913

Client: HDR
Job Number: 2279-11
Project: Xcel Pawnee
Location: --
Project Number: --

Boring Number: TB-8
Depth: 10-56'
Sample Number: --
Sampled Date: --
(+ ) Wash Date: 03/06/2017
(- ) Wash Date: 03/08/2017
Sampled By: --
Technician: CKP
Technician: SKS

Grain Size Data

Hygroscopic Moisture of Fines
Weight of Wet Soil & Pan (g): 1078.70
Weight of Dry Soil & Pan (g): 1066.14
Weight of Water (g): 12.56
Weight of Pan (g): 843.27
Weight of Dry Soil (g): 222.87
Moisture (%): 5.6

Total Wet Weight of Sample (g): 15,727.28
Total Dry Weight of Sample (g): 14,888.41
Calculated Weight Plus #200 (g): 11,209.63
Moisture of Total Sample (%): 5.6
Percent Retained #200 Sieve (%): 75.3

Plus Split Data
Original Weight of +#4 (g): 3.28
Calculated Weight of +#4 (g): 3.23

Minus Split Data
Original Weight of -#4 (g): 15,724.00
Calculated Dry Weight of -#4 (g): 14,885.18

235.43g split out of -#4 material.

<table>
<thead>
<tr>
<th>Sieve Number</th>
<th>Sieve Size (mm)</th>
<th>Weight of Retained Soil &amp; Pan (g)</th>
<th>Weight of Pan (g)</th>
<th>Weight of Retained Soil (g)</th>
<th>Calculated Weight of Retained Soil (g)</th>
<th>Percent Passing by Weight (%)</th>
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<td>1.5”</td>
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Data Entered By: CKP
Date: 3/10/2017
File Name: 2279_11_grainSize-ASTM-C33-D1140-D6319-D2487-R6_0.xls

Checked By: [signature]
Date: [signature date]
Appendix D
State Well Permits
WELL PERMIT NUMBER 299821
DIV. 1 WD 1 DES. BASIN MD

APPLICANT
PUBLIC SERVICE COMPANY OF COLORADO
14940 CR 24
BRUSH, CO 80723-
(303) 571-7340

PERMIT TO USE AN EXISTING WELL

ISSUANCE OF THIS PERMIT DOES NOT CONFER A WATER RIGHT

CONDITIONS OF APPROVAL

1) This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of this permit does not ensure that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.

2) The construction of this well shall be in compliance with the Water Well Construction Rules 2 CCR 402-2, unless approval of a variance has been granted by the State Board of Examiners of Water Well Construction and Pump Installation Contractors in accordance with Rule 18.

3) Approved pursuant to CRS 37-92-602(3)(b)(I) for uses as described in CRS 37-92-602(1)(f). Use of this well is limited to monitoring water levels and/or water quality sampling.

4) Approved for the use of an existing well known as PNMW-12.

5) This well must be equipped with a locking cap or seal to prevent well contamination or possible hazards as an open well. The well must be kept capped and locked at all times except during sampling or measuring.

6) Records of water level measurements and water quality analyses shall be maintained by the well owner and submitted to the Division of Water Resources upon request.

7) Upon conclusion of the monitoring program the well owner shall plug this well in accordance with Rule 16 of the Water Well Construction Rules. A Well Abandonment Report must be completed and submitted to the Division of Water Resources within 60 days of plugging.

8) The owner shall mark the well in a conspicuous place with the well permit number and name of aquifer as appropriate, and shall take necessary means and precautions to preserve these markings.

9) This well must have been constructed by or under the supervision of a licensed well driller or other authorized individual according to the Water Well Construction Rules.

10) This well must be located not more than 200 feet from the location specified on this permit.

NOTE: Issuance of this permit does not guarantee that this well can be converted to a production well under a future permit. Additionally, pursuant to Rule 14.2 of the Water Well Construction Rules (2 CCR 402-2), monitoring holes constructed pursuant to a monitoring hole notice shall not be converted to a production well. (Upon obtaining a permit from the State Engineer, a monitoring hole may be converted to a monitoring well, recovery well for remediation of the aquifer, or a dewatering system for dewatering the aquifer.)

NOTICE: This permit has been approved subject to the following changes: The UTM coordinate values provided with the permit application were not used and the well location was determined from the PLSS coordinates provided. In addition MH-54630 was not referenced on this permit since it is not located in the SE 1/4 of the SE 1/4 of Sec 19, Twp 3N, Rng 56W. You are hereby notified that you have the right to appeal the issuance of this permit, by filing a written request with this office within sixty (60) days of the date of issuance, pursuant to the State Administrative Procedures Act. (See Section 24-4-104 through 106, C.R.S.)

APPROVED
DG2

State Engineer

DATE ISSUED 01-05-2016

EXPIRATION DATE N/A

Receipt No. 3672804A

By

N/A
OFFICE OF THE STATE ENGINEER
COLORADO DIVISION OF WATER RESOURCES
818 Centennial Bldg., 1313 Sherman St, Denver, Colorado 80203
(303) 866-3581

WELL PERMIT NUMBER 299822
DIV. 1 WD 1 DES. BASIN MD

APPLICANT
PUBLIC SERVICE COMPANY OF COLORADO
14940 CR 24
BRUSH, CO 80723-

(303) 571-7340

APPROVED WELL LOCATION
MORGAN COUNTY
NE 1/4 SW 1/4 Section 19
Township 3 N Range 56 W Sixth P.M.

DISTANCES FROM SECTION LINES
2230 Ft. from South Section Line
2722 Ft. from East Section Line

UTM COORDINATES (Meters, Zone:13,NAD83)
Easting: Northing:

PERMIT TO USE AN EXISTING WELL

ISSUANCE OF THIS PERMIT DOES NOT CONFER A WATER RIGHT

CONDITIONS OF APPROVAL

1) This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of this permit does not ensure that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.

2) The construction of this well shall be in compliance with the Water Well Construction Rules 2 CCR 402-2, unless approval of a variance has been granted by the State Board of Examiners of Water Well Construction and Pump Installation Contractors in accordance with Rule 18.

3) Approved pursuant to CRS 37-92-602(3)(b)(f) for uses as described in CRS 37-92-602(1)(f). Use of this well is limited to monitoring water levels and/or water quality sampling.

4) Approved for the use of an existing well known as PNMW-13.

5) This well must be equipped with a locking cap or seal to prevent well contamination or possible hazards as an open well. The well must be kept capped and locked at all times except during sampling or measuring.

6) Records of water level measurements and water quality analyses shall be maintained by the well owner and submitted to the Division of Water Resources upon request.

7) Upon conclusion of the monitoring program the well owner shall plug this well in accordance with Rule 16 of the Water Well Construction Rules. A Well Abandonment Report must be completed and submitted to the Division of Water Resources within 60 days of plugging.

8) The owner shall mark the well in a conspicuous place with the well permit number and name of aquifer as appropriate, and shall take necessary means and precautions to preserve these markings.

9) This well must have been constructed by or under the supervision of a licensed well driller or other authorized individual according to the Water Well Construction Rules.

10) This well must be located not more than 200 feet from the location specified on this permit.

NOTE: Issuance of this permit does not guarantee that this well can be converted to a production well under a future permit. Additionally, pursuant to Rule 14.2 of the Water Well Construction Rules (2 CCR 402-2), monitoring holes constructed pursuant to a monitoring hole notice shall not be converted to a production well. (Upon obtaining a permit from the State Engineer, a monitoring hole may be converted to a monitoring well, recovery well for remediation of the aquifer, or a dewatering system for dewatering the aquifer.)

NOTICE: This permit has been approved subject to the following changes: The UTM coordinate values provided with the permit application were not used and the well location was determined from the PLSS coordinates provided. In addition MH-54630 was not referenced on this permit since it is not located in the NE 1/4 of the SW 1/4 of Sec 19, Twp 3N, Rng 56W. You are hereby notified that you have the right to appeal the issuance of this permit, by filing a written request with this office within sixty (60) days of the date of issuance, pursuant to the State Administrative Procedures Act. (See Section 24-4-104 through 106, C.R.S.)

APPROVED
DG2

State Engineer

Receipt No. 3672804B DATE ISSUED 01-05-2016

By EXPIRATION DATE N/A
OFFICE OF THE STATE ENGINEER
COLORADO DIVISION OF WATER RESOURCES
818 Centennial Bldg., 1313 Sherman St., Denver, Colorado 80203
(303) 866-3581

WELL PERMIT NUMBER 299823
DIV. 1 WD 1 DES. BASIN MD

APPLICANT
PUBLIC SERVICE COMPANY OF COLORADO
14940 CR 24
BRUSH, CO 80723-
(303) 571-7340

PERMIT TO USE AN EXISTING WELL

ISSUANCE OF THIS PERMIT DOES NOT CONFER A WATER RIGHT
CONDITIONS OF APPROVAL

1) This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of this permit does not ensure that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.

2) The construction of this well shall be in compliance with the Water Well Construction Rules 2 CCR 402-2, unless approval of a variance has been granted by the State Board of Examiners of Water Well Construction and Pump Installation Contractors in accordance with Rule 18.

3) Approved pursuant to CRS 37-92-602(3)(b)(i) for uses as described in CRS 37-92-602(1)(f). Use of this well is limited to monitoring water levels and/or water quality sampling.

4) Approved for the use of an existing well acknowledged for construction under monitoring hole notice MH-54630, and known as PNMW-14.

5) This well must be equipped with a locking cap or seal to prevent well contamination or possible hazards as an open well. The well must be kept capped and locked at all times except during sampling or measuring.

6) Records of water level measurements and water quality analyses shall be maintained by the well owner and submitted to the Division of Water Resources upon request.

7) Upon conclusion of the monitoring program the well owner shall plug this well in accordance with Rule 16 of the Water Well Construction Rules. A Well Abandonment Report must be completed and submitted to the Division of Water Resources within 60 days of plugging.

8) The owner shall mark the well in a conspicuous place with the well permit number and name of aquifer as appropriate, and shall take necessary means and precautions to preserve these markings.

9) This well must have been constructed by or under the supervision of a licensed well driller or other authorized individual according to the Water Well Construction Rules.

10) This well must be located not more than 200 feet from the location specified on this permit.

NOTE: Issuance of this permit does not guarantee that this well can be converted to a production well under a future permit. Additionally, pursuant to Rule 14.2 of the Water Well Construction Rules (2 CCR 402-2), monitoring holes constructed pursuant to a monitoring hole notice shall not be converted to a production well. (Upon obtaining a permit from the State Engineer, a monitoring hole may be converted to a monitoring well, recovery well for remediation of the aquifer, or a dewatering system for dewatering the aquifer.)

NOTICE: This permit has been approved subject to the following changes: The distances from section lines were calculated from UTM coordinate values provided with the permit application. You are hereby notified that you have the right to appeal the issuance of this permit, by filing a written request with this office within sixty (60) days of the date of issuance, pursuant to the State Administrative Procedures Act. (See Section 24-4-104 through 106, C.R.S.)

APPROVED
DG2
State Engineer

Receipt No. 3672804C DATE ISSUED 01-05-2016

By EXPIRATION DATE N/A
ORIGINAL PERMIT APPLICANT(S)
PUBLIC SERVICE COMPANY OF COLORADO

APPROVED WELL LOCATION
Water Division: 1  Water District: 1
Designated Basin: N/A
Management District: N/A
County: MORGAN
Parcel Name: N/A

SE 1/4 NE 1/4 Section 19 Township 3.0 N Range 56.0 W Sixth P.M.

UTM COORDINATES (Meters, Zone:13, NAD83)
Easting: 612109.0 Northing: 4451976.0

PERMIT TO USE AN EXISTING WELL

ISSUANCE OF THIS PERMIT DOES NOT CONFER A WATER RIGHT

CONDITIONS OF APPROVAL

1) This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of this permit does not ensure that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.

2) The construction of this well shall be in compliance with the Water Well Construction Rules 2 CCR 402-2, unless approval of a variance has been granted by the State Board of Examiners of Water Well Construction and Pump Installation Contractors in accordance with Rule 18.

3) Approved pursuant to CRS 37-92-602(3)(b)(I) for uses as described in CRS 37-92-602(1)(f). Use of this well is limited to monitoring water levels and/or water quality sampling.

4) Approved for the use of an existing well known as PNMW-15.

5) This well must be equipped with a locking cap or seal to prevent well contamination or possible hazards as an open well. The well must be kept capped and locked at all times except during sampling or measuring.

6) Records of water level measurements and water quality analyses shall be maintained by the well owner and submitted to the Division of Water Resources upon request.

7) Upon conclusion of the monitoring program the well owner shall plug this well in accordance with Rule 16 of the Water Well Construction Rules. A Well Abandonment Report must be completed and submitted to the Division of Water Resources within 60 days of plugging.

8) The owner shall mark the well in a conspicuous location with the well permit number and name of aquifer as appropriate, and shall take necessary means and precautions to preserve these markings.

9) This well must have been constructed by or under the supervision of a licensed well driller or other authorized individual according to the Water Well Construction Rules.

10) This well must be located not more than 200 feet from the location specified on this permit.

NOTE: Issuance of this permit does not guarantee that this well can be converted to a production well under a future permit. Additionally, pursuant to Rule 14.2 of the Water Well Construction Rules (2 CCR 402-2), monitoring holes constructed pursuant to a monitoring hole notice shall not be converted to a production well. (Upon obtaining a permit from the State Engineer, a monitoring hole may be converted to a monitoring well, recovery well for remediation of the aquifer, or a dewatering system for dewatering the aquifer.)

NOTICE: This permit has been approved subject to the following changes: MH-56328 was not referenced on this permit since it is located in the NE 1/4 of the NE 1/4 of Sec 19, Twp 3 N, Rng 56 W. You are hereby notified that you have the right to appeal the issuance of this permit, by filing a written request with this office within sixty (60) days of the date of issuance, pursuant to the State Administrative Procedures Act. (See Section 24-4-104 through 106, C.R.S.)

Debra Gonzales
Issued By DEBRA GONZALES

Date Issued: 8/15/2017
Expiration Date: N/A

For questions about this permit call 303.866.3581 or go to www.water.state.co.us

Page 1 of 1
PERMIT TO USE AN EXISTING WELL

ISSUANCE OF THIS PERMIT DOES NOT CONFER A WATER RIGHT
CONDITIONS OF APPROVAL

1) This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of this permit does not ensure that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.

2) The construction of this well shall be in compliance with the Water Well Construction Rules 2 CCR 402-2, unless approval of a variance has been granted by the State Board of Examiners of Water Well Construction and Pump Installation Contractors in accordance with Rule 18.

3) Approved pursuant to CRS 37-92-602(3)(b)(I) for uses as described in CRS 37-92-602(1)(f). Use of this well is limited to monitoring water levels and/or water quality sampling.

4) Approved for the use of an existing well acknowledged for construction under monitoring hole notice MH-56329, and known as PNMW-16.

5) This well must be equipped with a locking cap or seal to prevent well contamination or possible hazards as an open well. The well must be kept capped and locked at all times except during sampling or measuring.

6) Records of water level measurements and water quality analyses shall be maintained by the well owner and submitted to the Division of Water Resources upon request.

7) Upon conclusion of the monitoring program the well owner shall plug this well in accordance with Rule 16 of the Water Well Construction Rules. A Well Abandonment Report must be completed and submitted to the Division of Water Resources within 60 days of plugging.

8) The owner shall mark the well in a conspicuous location with the well permit number and name of aquifer as appropriate, and shall take necessary means and precautions to preserve these markings.

9) This well must have been constructed by or under the supervision of a licensed well driller or other authorized individual according to the Water Well Construction Rules.

10) This well must be located not more than 200 feet from the location specified on this permit.

NOTE: Issuance of this permit does not guarantee that this well can be converted to a production well under a future permit. Additionally, pursuant to Rule 14.2 of the Water Well Construction Rules (2 CCR 402-2), monitoring holes constructed pursuant to a monitoring hole notice shall not be converted to a production well. (Upon obtaining a permit from the State Engineer, a monitoring hole may be converted to a monitoring well, recovery well for remediation of the aquifer, or a dewatering system for dewatering the aquifer.)

DEBRA GONZALES
Issued By

Date Issued: 8/15/2017
Expiration Date: N/A
ISSUANCE OF THIS PERMIT DOES NOT CONFER A WATER RIGHT

CONDITIONS OF APPROVAL

1) This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of this permit does not ensure that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.

2) The construction of this well shall be in compliance with the Water Well Construction Rules 2 CCR 402-2, unless approval of a variance has been granted by the State Board of Examiners of Water Well Construction and Pump Installation Contractors in accordance with Rule 18.

3) Approved pursuant to CRS 37-92-602(3)(b)(I) for uses as described in CRS 37-92-602(1)(f). Use of this well is limited to monitoring water levels and/or water quality sampling.

4) Approved for the use of an existing well acknowledged for construction under monitoring hole notice MH-56330, and known as PNMW-17.

5) This well must be equipped with a locking cap or seal to prevent well contamination or possible hazards as an open well. The well must be kept capped and locked at all times except during sampling or measuring.

6) Records of water level measurements and water quality analyses shall be maintained by the well owner and submitted to the Division of Water Resources upon request.

7) Upon conclusion of the monitoring program the well owner shall plug this well in accordance with Rule 16 of the Water Well Construction Rules. A Well Abandonment Report must be completed and submitted to the Division of Water Resources within 60 days of plugging.

8) The owner shall mark the well in a conspicuous location with the well permit number and name of aquifer as appropriate, and shall take necessary means and precautions to preserve these markings.

9) This well must have been constructed by or under the supervision of a licensed well driller or other authorized individual according to the Water Well Construction Rules.

10) This well must be located not more than 200 feet from the location specified on this permit.

NOTE: Issuance of this permit does not guarantee that this well can be converted to a production well under a future permit. Additionally, pursuant to Rule 14.2 of the Water Well Construction Rules (2 CCR 402-2), monitoring holes constructed pursuant to a monitoring hole notice shall not be converted to a production well. (Upon obtaining a permit from the State Engineer, a monitoring hole may be converted to a monitoring well, recovery well for remediation of the aquifer, or a dewatering system for dewatering the aquifer.)
**ORIGINAL PERMIT APPLICANT(S)**
PUBLIC SERVICE COMPANY OF COLORADO

**APPROVED WELL LOCATION**

- Water Division: 1
- Water District: 1
- Designated Basin: N/A
- Management District: N/A
- County: MORGAN
- Parcel Name: N/A

SW 1/4 NW 1/4 Section 20 Township 3.0 N Range 56.0 W Sixth P.M.

**UTM COORDINATES (Meters, Zone:13, NAD83)**
- Easting: 612658.0
- Northing: 4452085.0

**PERMIT TO USE AN EXISTING WELL**

**ISSUANCE OF THIS PERMIT DOES NOT CONFER A WATER RIGHT**

1) This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of this permit does not ensure that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.

2) The construction of this well shall be in compliance with the Water Well Construction Rules 2 CCR 402-2, unless approval of a variance has been granted by the State Board of Examiners of Water Well Construction and Pump Installation Contractors in accordance with Rule 18.

3) Approved pursuant to CRS 37-92-602(3)(b)(I) for uses as described in CRS 37-92-602(1)(f). Use of this well is limited to monitoring water levels and/or water quality sampling.

4) Approved for the use of an existing well acknowledged for construction under monitoring hole notice MH-56331, and known as PN MW-18.

5) This well must be equipped with a locking cap or seal to prevent well contamination or possible hazards as an open well. The well must be kept capped and locked at all times except during sampling or measuring.

6) Records of water level measurements and water quality analyses shall be maintained by the well owner and submitted to the Division of Water Resources upon request.

7) Upon conclusion of the monitoring program the well owner shall plug this well in accordance with Rule 16 of the Water Well Construction Rules. A Well Abandonment Report must be completed and submitted to the Division of Water Resources within 60 days of plugging.

8) The owner shall mark the well in a conspicuous location with the well permit number and name of aquifer as appropriate, and shall take necessary means and precautions to preserve these markings.

9) This well must have been constructed by or under the supervision of a licensed well driller or other authorized individual according to the Water Well Construction Rules.

10) This well must be located not more than 200 feet from the location specified on this permit.

**NOTE:** Issuance of this permit does not guarantee that this well can be converted to a production well under a future permit. Additionally, pursuant to Rule 14.2 of the Water Well Construction Rules (2 CCR 402-2), monitoring holes constructed pursuant to a monitoring hole notice shall not be converted to a production well. (Upon obtaining a permit from the State Engineer, a monitoring hole may be converted to a monitoring well, recovery well for remediation of the aquifer, or a dewatering system for dewatering the aquifer.)

**NOTICE:** This permit has been approved subject to the following changes: The quarter/quarter, quarter, Section, Township, Range and P.M. were determined from UTM coordinate values provided with the permit application. You are hereby notified that you have the right to appeal the issuance of this permit, by filing a written request with this office within sixty (60) days of the date of issuance, pursuant to the State Administrative Procedures Act. (See Section 24-4-104 through 106, C.R.S.)

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**Issued By:** DEBRA GONZALES

**Date Issued:** 8/15/2017

**Expiration Date:** N/A
ORIGINAL PERMIT APPLICANT(S)  
PUBLIC SERVICE COMPANY OF COLORADO

APPROVED WELL LOCATION
Water Division: 1  Water District: 1  
Designated Basin: N/A  
Management District: N/A  
County: MORGAN  
Parcel Name: N/A

SW 1/4 NW 1/4 Section 20 Township 3.0 N Range 56.0 W Sixth P.M.

UTM COORDINATES (Meters, Zone:13, NAD83)
Easting: 612661.0  Northing: 4452045.0

PERMIT TO USE AN EXISTING WELL

ISSUANCE OF THIS PERMIT DOES NOT CONFER A WATER RIGHT

CONDITIONS OF APPROVAL

1) This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of this permit does not ensure that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.

2) The construction of this well shall be in compliance with the Water Well Construction Rules 2 CCR 402-2, unless approval of a variance has been granted by the State Board of Examiners of Water Well Construction and Pump Installation Contractors in accordance with Rule 18.

3) Approved pursuant to CRS 37-92-602(3)(b)(I) for uses as described in CRS 37-92-602(1)(f). Use of this well is limited to monitoring water levels and/or water quality sampling.

4) Approved for the use of an existing well known as PNMW-19.

5) This well must be equipped with a locking cap or seal to prevent well contamination or possible hazards as an open well. The well must be kept capped and locked at all times except during sampling or measuring.

6) Records of water level measurements and water quality analyses shall be maintained by the well owner and submitted to the Division of Water Resources upon request.

7) Upon conclusion of the monitoring program the well owner shall plug this well in accordance with Rule 16 of the Water Well Construction Rules. A Well Abandonment Report must be completed and submitted to the Division of Water Resources within 60 days of plugging.

8) The owner shall mark the well in a conspicuous location with the well permit number and name of aquifer as appropriate, and shall take necessary means and precautions to preserve these markings.

9) This well must have been constructed by or under the supervision of a licensed well driller or other authorized individual according to the Water Well Construction Rules.

10) This well must be located not more than 200 feet from the location specified on this permit.

NOTE: Issuance of this permit does not guarantee that this well can be converted to a production well under a future permit. Additionally, pursuant to Rule 14.2 of the Water Well Construction Rules (2 CCR 402-2), monitoring holes constructed pursuant to a monitoring hole notice shall not be converted to a production well. (Upon obtaining a permit from the State Engineer, a monitoring hole may be converted to a monitoring well, recovery well for remediation of the aquifer, or a dewatering system for dewatering the aquifer.)

NOTICE: This permit has been approved subject to the following changes: MH-56330 was not referenced on this permit since it is located in the NW 1/4 of the SW 1/4 of Sec 20, Twp 3 N, Rng 56 W. You are hereby notified that you have the right to appeal the issuance of this permit, by filing a written request with this office within sixty (60) days of the date of issuance, pursuant to the State Administrative Procedures Act. (See Section 24-4-104 through 106, C.R.S.)

Date Issued: 8/15/2017  
Expiration Date: N/A

Issued By: DEBRA GONZALES
**ORIGINAL PERMIT APPLICANT(S)**
PUBLIC SERVICE COMPANY OF COLORADO

**APPROVED WELL LOCATION**

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<td>N/A</td>
</tr>
</tbody>
</table>

NW 1/4 SW 1/4 Section 20 Township 3.0 N Range 56.0 W Sixth P.M.

**UTM COORDINATES (Meters, Zone: 13, NAD83)**

- Easting: 612658.0
- Northing: 4451971.0

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**PERMIT TO USE AN EXISTING WELL**

**ISSUANCE OF THIS PERMIT DOES NOT CONFER A WATER RIGHT**

**CONDITIONS OF APPROVAL**

1) This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of this permit does not ensure that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.

2) The construction of this well shall be in compliance with the Water Well Construction Rules 2 CCR 402-2, unless approval of a variance has been granted by the State Board of Examiners of Water Well Construction and Pump Installation Contractors in accordance with Rule 18.

3) Approved pursuant to CRS 37-92-602(3)(b)(I) for uses as described in CRS 37-92-602(1)(f). Use of this well is limited to monitoring water levels and/or water quality sampling.

4) Approved for the use of an existing well acknowledged for construction under monitoring hole notice MH-56330, and known as PNMW-20.

5) This well must be equipped with a locking cap or seal to prevent well contamination or possible hazards as an open well. The well must be kept capped and locked at all times except during sampling or measuring.

6) Records of water level measurements and water quality analyses shall be maintained by the well owner and submitted to the Division of Water Resources upon request.

7) Upon conclusion of the monitoring program the well owner shall plug this well in accordance with Rule 16 of the Water Well Construction Rules. A Well Abandonment Report must be completed and submitted to the Division of Water Resources within 60 days of plugging.

8) The owner shall mark the well in a conspicuous location with the well permit number and name of aquifer as appropriate, and shall take necessary means and precautions to preserve these markings.

9) This well must have been constructed by or under the supervision of a licensed well driller or other authorized individual according to the Water Well Construction Rules.

10) This well must be located not more than 200 feet from the location specified on this permit.

**NOTE:** Issuance of this permit does not guarantee that this well can be converted to a production well under a future permit. Additionally, pursuant to Rule 14.2 of the Water Well Construction Rules (2 CCR 402-2), monitoring holes constructed pursuant to a monitoring hole notice shall not be converted to a production well. (Upon obtaining a permit from the State Engineer, a monitoring hole may be converted to a monitoring well, recovery well for remediation of the aquifer, or a dewatering system for dewatering the aquifer.)

---

**Issued By** DEBRA GONZALES

**Date Issued:** 8/15/2017

**Expiration Date:** 8/15/2019
WELL PERMIT NUMBER 306578-
RECEIPT NUMBER 3680794G

ORIGINIAL PERMIT APPLICANT(S)
PUBLIC SERVICE COMPANY OF COLORADO

APPROVED WELL LOCATION
Water Division: 1 Water District: 1
Designated Basin: N/A
Management District: N/A
County: MORGAN
Parcel Name: N/A

NE 1/4 SW 1/4 Section 20 Township 3.0 N Range 56.0 W Sixth P.M.

UTM COORDINATES (Meters, Zone:13, NAD83)
Easting: 612829.0 Northing: 4451939.0

PERMIT TO USE AN EXISTING WELL

ISSUANCE OF THIS PERMIT DOES NOT CONFER A WATER RIGHT
CONDITIONS OF APPROVAL

1) This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of this permit does not ensure that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.

2) The construction of this well shall be in compliance with the Water Well Construction Rules 2 CCR 402-2, unless approval of a variance has been granted by the State Board of Examiners of Water Well Construction and Pump Installation Contractors in accordance with Rule 18.

3) Approved pursuant to CRS 37-92-602(3)(b)(I) for uses as described in CRS 37-92-602(1)(f). Use of this well is limited to monitoring water levels and/or water quality sampling.

4) Approved for the use of an existing well acknowledged for construction under monitoring hole notice MH-56332, and known as PNMW-21.

5) This well must be equipped with a locking cap or seal to prevent well contamination or possible hazards as an open well. The well must be kept capped and locked at all times except during sampling or measuring.

6) Records of water level measurements and water quality analyses shall be maintained by the well owner and submitted to the Division of Water Resources upon request.

7) Upon conclusion of the monitoring program the well owner shall plug this well in accordance with Rule 16 of the Water Well Construction Rules. A Well Abandonment Report must be completed and submitted to the Division of Water Resources within 60 days of plugging.

8) The owner shall mark the well in a conspicuous location with the well permit number and name of aquifer as appropriate, and shall take necessary means and precautions to preserve these markings.

9) This well must have been constructed by or under the supervision of a licensed well driller or other authorized individual according to the Water Well Construction Rules.

10) This well must be located not more than 200 feet from the location specified on this permit.

NOTE: Issuance of this permit does not guarantee that this well can be converted to a production well under a future permit. Additionally, pursuant to Rule 14.2 of the Water Well Construction Rules (2 CCR 402-2), monitoring holes constructed pursuant to a monitoring hole notice shall not be converted to a production well. (Upon obtaining a permit from the State Engineer, a monitoring hole may be converted to a monitoring well, recovery well for remediation of the aquifer, or a dewatering system for dewatering the aquifer.)

Issued By DEBRA GONZALES

Date Issued: 8/15/2017
Expiration Date: N/A

For questions about this permit call 303.866.3581 or go to www.water.state.co.us

Page 1 of 1
Printed 08-18-2017 For questions about this permit call 303.866.3581 or go to www.water.state.co.us Page 1 of 1

ORIGINAlle PERMIT APPLICANT(S)  APPROVED WELL LOCATION
PUBLIC SERVICE COMPANY OF COLORADO  Water Division: 1  Water District: 1
Designated Basin: N/A  Management District: N/A
County: MORGAN  Parcel Name: N/A

NE 1/4 SW 1/4 Section 20 Township 3.0 N Range 56.0 W Sixth P.M.

UTM COORDINATES (Meters, Zone:13, NAD83)
Easting: 612830.0  Northing: 4451823.0

PERMIT TO USE AN EXISTING WELL

ISSUANCE OF THIS PERMIT DOES NOT CONFER A WATER RIGHT
CONDITIONS OF APPROVAL

1) This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of this permit does not ensure that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.

2) The construction of this well shall be in compliance with the Water Well Construction Rules 2 CCR 402-2, unless approval of a variance has been granted by the State Board of Examiners of Water Well Construction and Pump Installation Contractors in accordance with Rule 18.

3) Approved pursuant to CRS 37-92-602(3)(b)(I) for uses as described in CRS 37-92-602(1)(f). Use of this well is limited to monitoring water levels and/or water quality sampling.

4) Approved for the use of an existing well acknowledged for construction under monitoring hole notice MH-56332, and known as PNMW-22.

5) This well must be equipped with a locking cap or seal to prevent well contamination or possible hazards as an open well. The well must be kept capped and locked at all times except during sampling or measuring.

6) Records of water level measurements and water quality analyses shall be maintained by the well owner and submitted to the Division of Water Resources upon request.

7) Upon conclusion of the monitoring program the well owner shall plug this well in accordance with Rule 16 of the Water Well Construction Rules. A Well Abandonment Report must be completed and submitted to the Division of Water Resources within 60 days of plugging.

8) The owner shall mark the well in a conspicuous location with the well permit number and name of aquifer as appropriate, and shall take necessary means and precautions to preserve these markings.

9) This well must have been constructed by or under the supervision of a licensed well driller or other authorized individual according to the Water Well Construction Rules.

10) This well must be located not more than 200 feet from the location specified on this permit.

NOTE: Issuance of this permit does not guarantee that this well can be converted to a production well under a future permit. Additionally, pursuant to Rule 14.2 of the Water Well Construction Rules (2 CCR 402-2), monitoring holes constructed pursuant to a monitoring hole notice shall not be converted to a production well. (Upon obtaining a permit from the State Engineer, a monitoring hole may be converted to a monitoring well, recovery well for remediation of the aquifer, or a dewatering system for dewatering the aquifer.)

Date Issued: 8/15/2017  Expiration Date: N/A

Issued By  DEBRA GONZALES
PERMIT TO USE AN EXISTING WELL

ISSUANCE OF THIS PERMIT DOES NOT CONFER A WATER RIGHT

CONDITIONS OF APPROVAL

1) This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of this permit does not ensure that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.

2) The construction of this well shall be in compliance with the Water Well Construction Rules 2 CCR 402-2, unless approval of a variance has been granted by the State Board of Examiners of Water Well Construction and Pump Installation Contractors in accordance with Rule 18.

3) Approved pursuant to CRS 37-92-602(3)(b)(I) for uses as described in CRS 37-92-602(1)(f). Use of this well is limited to monitoring water levels and/or water quality sampling.

4) Approved for the use of an existing well acknowledged for construction under monitoring hole notice MH-56332, and known as PNMW-23.

5) This well must be equipped with a locking cap or seal to prevent well contamination or possible hazards as an open well. The well must be kept capped and locked at all times except during sampling or measuring.

6) Records of water level measurements and water quality analyses shall be maintained by the well owner and submitted to the Division of Water Resources upon request.

7) Upon conclusion of the monitoring program the well owner shall plug this well in accordance with Rule 16 of the Water Well Construction Rules. A Well Abandonment Report must be completed and submitted to the Division of Water Resources within 60 days of plugging.

8) The owner shall mark the well in a conspicuous location with the well permit number and name of aquifer as appropriate, and shall take necessary means and precautions to preserve these markings.

9) This well must have been constructed by or under the supervision of a licensed well driller or other authorized individual according to the Water Well Construction Rules.

10) This well must be located not more than 200 feet from the location specified on this permit.

NOTE: Issuance of this permit does not guarantee that this well can be converted to a production well under a future permit. Additionally, pursuant to Rule 14.2 of the Water Well Construction Rules (2 CCR 402-2), monitoring holes constructed pursuant to a monitoring hole notice shall not be converted to a production well. (Upon obtaining a permit from the State Engineer, a monitoring hole may be converted to a monitoring well, recovery well for remediation of the aquifer, or a dewatering system for dewatering the aquifer.)

Issued By DEBRA GONZALES

Date Issued: 8/15/2017
Expiration Date: N/A
Appendix E
Slug Test Analyses
### PROJECT INFORMATION

- **Company:** HDR  
- **Client:** Xcel Energy  
- **Project:** 266180  
- **Location:** Pawnee Station  
- **Test Well:** PNMW-13  
- **Test Date:** 12/9/2015

### AQUIFER DATA

- **Saturated Thickness:** 11.22 ft  
- **Anisotropy Ratio (Kz/Kr):** 1.

### WELL DATA (PNMW-13)

- **Initial Displacement:** 0.99 ft  
- **Total Well Penetration Depth:** 11.22 ft  
- **Casing Radius:** 0.083 ft  
- **Static Water Column Height:** 11.22 ft  
- **Screen Length:** 11.22 ft  
- **Well Radius:** 0.25 ft  
- **Gravel Pack Porosity:** 0.3

### SOLUTION

- **Aquifer Model:** Unconfined  
- **Solution Method:** Dagan  
- **K:** 0.003451 cm/sec  
- **y0:** 0.4755 ft
PNMW-13 SLUG OUT

Data Set: P:\...\Pawnee_PNMW-13_Slug_Out_Dagan.aqt
Date: 02/01/16  Time: 14:36:00

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Project: 266180
Location: Pawnee Station
Test Well: PNMW-13
Test Date: 12/9/2015

AQUIFER DATA

Saturated Thickness: 11.22 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (PNMW-13)

Initial Displacement: 1.26 ft
Total Well Penetration Depth: 11.22 ft
Casing Radius: 0.083 ft
Static Water Column Height: 11.22 ft
Screen Length: 11.22 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.005901 cm/sec
y0 = 1.251 ft
PNMW-14 SLUG IN
Data Set: P:\..\Pawnee_PNMW-14_Slug_In_Dagan.aqt
Date: 02/01/16
Time: 14:36:47

PROJECT INFORMATION
Company: HDR
Client: Xcel Energy
Project: 266180
Location: Pawnee Station
Test Well: PNMW-14
Test Date: 12/9/2015

AQUIFER DATA
Saturated Thickness: 14.68 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (PNMW-14)
Initial Displacement: 1.22 ft
Total Well Penetration Depth: 14.68 ft
Casing Radius: 0.083 ft
Static Water Column Height: 14.68 ft
Screen Length: 14.68 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION
Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.02059 cm/sec
y0 = 0.2426 ft
**PROJECT INFORMATION**

Company: HDR  
Client: Xcel Energy  
Project: 266180  
Location: Pawnee Station  
Test Well: PNMW-14  
Test Date: 12/9/2015

**AQUIFER DATA**

Saturated Thickness: 14.68 ft  
Anisotropy Ratio (Kz/Kr): 1

**WELL DATA (PNMW-14)**

Initial Displacement: 1.47 ft  
Total Well Penetration Depth: 14.68 ft  
Casing Radius: 0.083 ft  
Static Water Column Height: 14.68 ft  
Screen Length: 14.68 ft  
Well Radius: 0.25 ft  
Gravel Pack Porosity: 0.3

**SOLUTION**

Aquifer Model: Unconfined  
Solution Method: Dagan  
K = 0.000833 cm/sec  
y0 = 1.485 ft
Data Set:  
Date: 04/10/17  
Time: 13:04:06

PROJECT INFORMATION  
Company: HDR  
Client: Xcel Energy  
Location: Pawnee Station  
Test Well: MW-15

AQUIFER DATA  
Saturated Thickness: 28.28 ft  
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-15)  
Initial Displacement: 1.697 ft  
Total Well Penetration Depth: 30 ft  
Casing Radius: 0.083 ft  
Static Water Column Height: 28.28 ft  
Screen Length: 30 ft  
Well Radius: 0.25 ft

SOLUTION  
Aquifer Model: Unconfined  
Solution Method: Dagan  
$K = 0.0005934 \text{ cm/sec}$  
$y_0 = 0.3961 \text{ ft}$
Data Set:
Date: 04/10/17
Time: 13:35:23

PROJECT INFORMATION
Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-15

AQUIFER DATA
Saturated Thickness: 28.28 ft
Anisotropy Ratio (Kz/Kr): 1

WELL DATA (MW-15)
Initial Displacement: 1.296 ft
Total Well Penetration Depth: 28.28 ft
Casing Radius: 0.083 ft
Static Water Column Height: 28.28 ft
Screen Length: 28.28 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION
Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.002275 cm/sec
y0 = 0.5979 ft
**PROJECT INFORMATION**

Company: HDR  
Client: Xcel Energy  
Location: Pawnee Station  
Test Well: MW-15

**AQUIFER DATA**

Saturated Thickness: 28.28 ft  
Anisotropy Ratio (Kz/Kr): 1.

**WELL DATA (MW-15)**

Initial Displacement: 1.302 ft  
Total Well Penetration Depth: 28.28 ft  
Casing Radius: 0.083 ft  
Static Water Column Height: 28.28 ft  
Screen Length: 28.28 ft  
Well Radius: 0.25 ft  
Gravel Pack Porosity: 0.3

**SOLUTION**

Aquifer Model: Unconfined  
Solution Method: Dagan  

\[ K = 0.0008826 \text{ cm/sec} \]  
\[ y_0 = 0.4183 \text{ ft} \]
MW-17 (SLUG IN - 2ND TEST)
Data Set: C:\...\MW-17_slugin2_847.aqt
Date: 04/10/17 Time: 14:48:04

PROJECT INFORMATION
Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-17

AQUIFER DATA
Saturated Thickness: 28.3 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-17)
Initial Displacement: 1.717 ft
Total Well Penetration Depth: 28.3 ft
Casing Radius: 0.083 ft
Static Water Column Height: 28.3 ft
Screen Length: 28.3 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION
Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.0001783 cm/sec
y0 = 0.2923 ft
MW-17 (SLUG OUT- 2ND TEST)
Data Set: C:\..\MW17-slugout2-213.aqt
Date: 04/10/17  Time: 15:18:12

PROJECT INFORMATION
Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-17

AQUIFER DATA
Saturated Thickness: 28.3 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-17)
Initial Displacement: 1.397 ft
Total Well Penetration Depth: 28.3 ft
Casing Radius: 0.083 ft
Static Water Column Height: 28.3 ft
Screen Length: 28.3 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION
Aquifer Model: Unconfined
Solution Method: Dagan
$K = 0.0003688$ cm/sec
$y_0 = 0.2822$ ft
MW-17 (SLUG OUT)

Data Set: C:\MW17-slugout-412.aqt
Date: 04/10/17
Time: 15:10:16

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-17

AQUIFER DATA

Saturated Thickness: 28.3 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-17)

Initial Displacement: 1.086 ft
Total Well Penetration Depth: 28.3 ft
Casing Radius: 0.083 ft
Static Water Column Height: 28.3 ft
Screen Length: 28.3 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.000481 cm/sec
y0 = 0.2565 ft
**MW-17 (SLUG IN)**

Data Set: C:\...\MW17_slugin_465.aqt
Date: 04/10/17
Time: 14:32:56

**PROJECT INFORMATION**

Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-17

**AQUIFER DATA**

Saturated Thickness: 28.3 ft
Anisotropy Ratio (Kz/Kr): 1.

**WELL DATA (MW-17)**

Initial Displacement: 1.613 ft
Total Well Penetration Depth: 28.3 ft
Casing Radius: 0.083 ft
Static Water Column Height: 28.3 ft
Screen Length: 28.3 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

**SOLUTION**

Aquifer Model: Unconfined
Solution Method: Dagan

\[ K = 0.0002614 \text{ cm/sec} \]
\[ y_0 = 0.1807 \text{ ft} \]
MW-18 (SLUG IN - 2ND TEST)

Data Set: C:\...\MW18-Slugln2-843.aqt
Date: 04/10/17            Time: 19:49:33

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-18

AQUIFER DATA

Saturated Thickness: 21.99 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-18)

Initial Displacement: 1.136 ft
Total Well Penetration Depth: 21.99 ft
Casing Radius: 0.083 ft
Static Water Column Height: 21.99 ft
Screen Length: 21.99 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan

\[ K = 0.0002107 \text{ cm/sec} \]
\[ y_0 = 0.2552 \text{ ft} \]
<table>
<thead>
<tr>
<th>MW-18 (SLUG IN)</th>
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<tbody>
<tr>
<td>Data Set:</td>
</tr>
<tr>
<td>Date: 04/10/17</td>
</tr>
<tr>
<td>Time: 19:38:06</td>
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</tbody>
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<table>
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<th>PROJECT INFORMATION</th>
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<tr>
<td>Client: Xcel Energy</td>
</tr>
<tr>
<td>Location: Pawnee Station</td>
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<tr>
<td>Test Well: MW-18</td>
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<table>
<thead>
<tr>
<th>AQUIFER DATA</th>
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</thead>
<tbody>
<tr>
<td>Saturated Thickness: 21.99 ft</td>
</tr>
<tr>
<td>Anisotropy Ratio (Kz/Kr): 1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WELL DATA (MW-18)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial Displacement: 1.169 ft</td>
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<tr>
<td>Total Well Penetration Depth: 21.99 ft</td>
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<tr>
<td>Casing Radius: 0.08 ft</td>
</tr>
<tr>
<td>Screen Length: 21.99 ft</td>
</tr>
<tr>
<td>Static Water Column Height: 21.99 ft</td>
</tr>
<tr>
<td>Well Radius: 0.25 ft</td>
</tr>
<tr>
<td>Gravel Pack Porosity: 0.3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SOLUTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aquifer Model: Unconfined</td>
</tr>
<tr>
<td>Solution Method: Dagan</td>
</tr>
<tr>
<td>$K = 0.0003473 \text{ cm/sec}$</td>
</tr>
<tr>
<td>$y_0 = 0.2667 \text{ ft}$</td>
</tr>
</tbody>
</table>
### MW-18 (SLUG OUT - 2ND TEST)

Data Set: `C:\...\MW18-SlugOut2-648.aqt`
Date: **04/10/17**
Time: **20:13:36**

### PROJECT INFORMATION

Company: **HDR**  
Client: **Xcel Energy**  
Location: **Pawnee Station**  
Test Well: **MW-18**

### AQUIFER DATA

- Saturated Thickness: **21.99 ft**  
- Anisotropy Ratio (Kz/Kr): **1.**

### WELL DATA (MW-18)

- Initial Displacement: **1.24 ft**  
- Total Well Penetration Depth: **21.99 ft**  
- Casing Radius: **0.083 ft**  
- Static Water Column Height: **21.99 ft**  
- Screen Length: **21.99 ft**  
- Well Radius: **0.25 ft**  
- Gravel Pack Porosity: **0.3**

### SOLUTION

- Aquifer Model: **Unconfined**  
- Solution Method: **Dagan**  
- \( K = 0.0007989 \text{ cm/sec} \)  
- \( y_0 = 0.314 \text{ ft} \)
## MW-18 (SLUG IN)

Data Set: C:\\...\\MW18-SlugOut-131.aqt  
Date: 04/10/17  
Time: 20:06:34

## PROJECT INFORMATION

- **Company:** HDR  
- **Client:** Xcel Energy  
- **Location:** Pawnee Station  
- **Test Well:** MW-18

## AQUIFER DATA

- **Saturated Thickness:** 21.99 ft  
- **Anisotropy Ratio (Kz/Kr):** 1

## WELL DATA (MW-18)

- **Initial Displacement:** 1.351 ft  
- **Total Well Penetration Depth:** 21.99 ft  
- **Casing Radius:** 0.083 ft  
- **Static Water Column Height:** 21.99 ft  
- **Screen Length:** 21.99 ft  
- **Well Radius:** 0.25 ft  
- **Gravel Pack Porosity:** 0.3

## SOLUTION

- **Aquifer Model:** Unconfined  
- **Solution Method:** Dagan  
- **K:** 0.00141 cm/sec  
- **y0:** 0.3738 ft
MW-19 (SLUG OUT)
Data Set: C:\...\MW19_slugout-480.aqt
Date: 04/10/17
Time: 15:51:55

PROJECT INFORMATION
Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-19

AQUIFER DATA
Saturated Thickness: 24.17 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-19)
Initial Displacement: 1.339 ft
Total Well Penetration Depth: 24.17 ft
Casing Radius: 0.083 ft
Static Water Column Height: 24.17 ft
Screen Length: 24.17 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION
Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.000147 cm/sec
y0 = 0.2574 ft
Data Set: C:\...\MW19_SlugIn_066.aqt
Date: 04/10/17

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-19

AQUIFER DATA

Saturated Thickness: 24.17 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-19)

Initial Displacement: 0.7897 ft
Total Well Penetration Depth: 24.17 ft
Casing Radius: 0.083 ft
Static Water Column Height: 24.17 ft
Screen Length: 24.17 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.0001004 cm/sec
y0 = 0.2806 ft
**PROJECT INFORMATION**

Company: HDR  
Client: Xcel Energy  
Location: Pawnee Station  
Test Well: MW-19

**AQUIFER DATA**

Saturated Thickness: 24.17 ft  
Anisotropy Ratio (Kz/Kr): 1.

**WELL DATA (MW-19)**

- Initial Displacement: 1.087 ft  
- Total Well Penetration Depth: 24.17 ft  
- Casing Radius: 0.083 ft  
- Static Water Column Height: 24.17 ft  
- Screen Length: 24.17 ft  
- Well Radius: 0.25 ft  
- Gravel Pack Porosity: 0.3

**SOLUTION**

- Aquifer Model: Unconfined  
- Solution Method: Dagan  
- \[ K = 0.0004388 \text{ cm/sec} \]  
- \[ y_0 = 0.3161 \text{ ft} \]
MW-19 (SLUG OUT - 2ND TEST)

Data Set: C:\\\MW19-slugout2-619.aqt
Date: 04/10/17 Time: 16:12:02

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-19

AQUIFER DATA

Saturated Thickness: 24.17 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-19)

Initial Displacement: 1.399 ft
Total Well Penetration Depth: 24.17 ft
Casing Radius: 0.083 ft
Static Water Column Height: 24.17 ft
Screen Length: 24.17 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.0003122 cm/sec
y0 = 0.3083 ft
WELL TEST ANALYSIS

Data Set: C:\WorkProjects\XcelEnergy\SlugTests\SlugTestData\Analysed\MW-20_in\MW-20_in.aqt
Date: 03/30/17  Time: 10:08:12

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-20 (in)
Test Date: 3/6/17

AQUIFER DATA


WELL DATA (MW-20 (in))

Initial Displacement: 0.5054 ft  Static Water Column Height: 24.24 ft
Total Well Penetration Depth: 24.24 ft  Screen Length: 24.24 ft
Casing Radius: 0.083 ft  Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined  Solution Method: Dagan
K = 0.003115 cm/sec  y0 = 0.229 ft
WELL TEST ANALYSIS

Data Set: C:\...\MW20_out2.aqt
Date: 03/30/17
Time: 14:53:51

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-20 (Out - 2nd test)
Test Date: 3/6/17

AQUIFER DATA

Saturated Thickness: 24.24 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-20 (Out - 2nd test))

Initial Displacement: 0.6233 ft
Total Well Penetration Depth: 24.24 ft
Casing Radius: 0.083 ft
Static Water Column Height: 24.24 ft
Screen Length: 24.24 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan

\[ K = 0.0005751 \text{ cm/sec} \]
\[ y_0 = 0.1182 \text{ ft} \]
WELL TEST ANALYSIS

Data Set: C:\WorkProjects\XcelEnergy\SlugTests\SlugTestData\Analysed\MW-20_out\MW-20-out.aqt
Date: 03/30/17  Time: 09:33:29

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-20 (Out)
Test Date: 3/6/17

AQUIFER DATA


WELL DATA (MW-20 (Out))

Initial Displacement: 0.8531 ft  Static Water Column Height: 24.24 ft
Total Well Penetration Depth: 24.24 ft  Screen Length: 24.24 ft
Casing Radius: 0.083 ft  Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined  Solution Method: Dagan
K = 0.001133 cm/sec  y0 = 0.1231 ft
WELL TEST ANALYSIS
Data Set: C:\WorkProjects\XcelEnergy\SlugTests\SlugTestData\Analysed\MW-21\MW_21_in.aqt
Date: 03/29/17
Time: 13:37:18

PROJECT INFORMATION
Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-21 (in)
Test Date: 3/6/17

AQUIFER DATA
Saturated Thickness: 23.8 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-21)
Initial Displacement: 1.003 ft
Total Well Penetration Depth: 23.8 ft
Casing Radius: 0.083 ft
Static Water Column Height: 23.8 ft
Screen Length: 23.8 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION
Aquifer Model: Unconfined
\( K = 0.0003122 \text{ cm/sec} \)
Solution Method: Dagan
\( y_0 = 0.2083 \text{ ft} \)
WELL TEST ANALYSIS
Data Set: C:\WorkProjects\XcelEnergy\SlugTests\SlugTestData\Analysed\MW-21in_2\MW21_in2ndtest.aqt
Date: 03/30/17
Time: 10:37:08

PROJECT INFORMATION
Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-21 (In - 2nd Test)
Test Date: 3/6/17

AQUIFER DATA
Saturated Thickness: 23.8 ft
Anisotropy Ratio (Kz/Kr): 1

WELL DATA (MW - 21 (In - 2nd Test))
Initial Displacement: 1.042 ft
Total Well Penetration Depth: 23.8 ft
Casing Radius: 0.083 ft
Static Water Column Height: 23.8 ft
Screen Length: 23.8 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION
Aquifer Model: Unconfined
Solution Method: Dagan

\[ K = 0.0002546 \text{ cm/sec} \]
\[ y_0 = 0.1864 \text{ ft} \]
WELL TEST ANALYSIS

Data Set:
Date: 03/30/17
Time: 08:52:06

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-21 (Out)
Test Date: 3/6/17

AQUIFER DATA

Saturated Thickness: 23.8 ft
Anisotropy Ratio (Kz/Kr): 1

WELL DATA (MW-21 (Out))

Initial Displacement: 0.9134 ft
Total Well Penetration Depth: 23.8 ft
Casing Radius: 0.083 ft
Static Water Column Height: 23.8 ft
Screen Length: 23.8 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
K = 8.903E-5 cm/sec
Solution Method: Dagan
y0 = 0.3196 ft
WELL TEST ANALYSIS

Data Set: C:\...\MW-21_out2.aqt
Date: 03/30/17
Time: 15:02:34

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-21 (Out - 2nd test)
Test Date: 3/6/17

AQUIFER DATA

Saturated Thickness: 23.8 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-21 (Out - 2nd Test))

Initial Displacement: 0.8883 ft
Static Water Column Height: 23.8 ft
Total Well Penetration Depth: 23.8 ft
Screen Length: 23.8 ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.0004582 cm/sec
y0 = 0.1606 ft
WELL TEST ANALYSIS

Data Set: C:\WorkProjects\XcelEnergy\SlugTests\SlugTestData\Analysed\MW-22-in\MW-22_in_1.aqt
Date: 03/29/17

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-22 (in)
Test Date: 3/6/17

AQUIFER DATA

Saturated Thickness: 21.27 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-22 (In))

Initial Displacement: 1.074 ft
Total Well Penetration Depth: 21.27 ft
Casing Radius: 0.083 ft
Static Water Column Height: 21.27 ft
Screen Length: 21.27 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan
K = 7.904E-5 cm/sec
y0 = 0.3108 ft
WELL TEST ANALYSIS
Data Set: C:\...\MW-22in2ndtest.aqt
Date: 03/30/17
Time: 15:11:45

PROJECT INFORMATION
Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-22 (In - 2nd test)
Test Date: 3/6/17

AQUIFER DATA
Saturated Thickness: 21.27 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-22 (In - 2nd Test))
Initial Displacement: 1.002 ft
Static Water Column Height: 21.27 ft
Total Well Penetration Depth: 21.27 ft
Screen Length: 21.27 ft
Casing Radius: 0.083 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION
Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.0001722 cm/sec
y0 = 0.3575 ft
WELL TEST ANALYSIS
Data Set: C:\WorkProjects\XcelEnergy\SlugTests\SlugTestData\Analysed\MW-22_out\MW-22_out.aqt
Date: 03/30/17
Time: 08:30:18

PROJECT INFORMATION
Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-22 (Out)
Test Date: 3/6/17

AQUIFER DATA
Saturated Thickness: 21.27 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-22)
Initial Displacement: 1.427 ft
Total Well Penetration Depth: 21.27 ft
Casing Radius: 0.083 ft
Static Water Column Height: 21.27 ft
Screen Length: 21.27 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION
Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.0001788 cm/sec
y0 = 0.3416 ft
WELL TEST ANALYSIS

Data Set: C:\...\MW22-out2nd.aqt
Date: 03/31/17
Time: 11:16:36

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-22 (Out - 2nd test)
Test Date: 3/6/17

AQUIFER DATA

Saturated Thickness: 21.27 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-22 (Out - 2nd Test))

Initial Displacement: 1.235 ft
Total Well Penetration Depth: 21.27 ft
Casing Radius: 0.083 ft
Static Water Column Height: 21.27 ft
Screen Length: 21.27 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan

K = 0.0002939 cm/sec
y0 = 0.3704 ft
WELL TEST ANALYSIS

Data Set:
Date: 03/29/17
Time: 14:26:19

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-23 (in)
Test Date: 3/6/17

AQUIFER DATA

Saturated Thickness: 16.03 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-23)

Initial Displacement: 0.8432 ft
Total Well Penetration Depth: 16.03 ft
Casing Radius: 0.083 ft
Static Water Column Height: 16.03 ft
Screen Length: 16.03 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan
K = 5.307E-5 cm/sec
y0 = 0.3224 ft
WELL TEST ANALYSIS

Data Set: C:\...\MW-23in2ndtest.aqt
Date: 03/31/17
Time: 11:48:54

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-23 (In - 2nd test)
Test Date: 3/6/17

AQUIFER DATA

Saturated Thickness: 16.03 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-23 (In - 2nd test))

Initial Displacement: 0.7931 ft
Total Well Penetration Depth: 16.03 ft
Casing Radius: 0.083 ft
Static Water Column Height: 16.03 ft
Screen Length: 16.03 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan

K = 6.326E-5 cm/sec
y0 = 0.347 ft
WELL TEST ANALYSIS

Data Set: C:\WorkProjects\XcelEnergy\SlugTests\SlugTestData\Analysed\M-23-out\MW-23-out.aqt
Date: 03/29/17
Time: 18:52:07

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-23 (Out)
Test Date: 3/6/17

AQUIFER DATA

Saturated Thickness: 16.03 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-23 (Out))

Initial Displacement: 1.378 ft
Total Well Penetration Depth: 16.03 ft
Casing Radius: 0.083 ft
Static Water Column Height: 16.03 ft
Screen Length: 16.03 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan
K = 0.0001462 cm/sec
y0 = 0.3371 ft
WELL TEST ANALYSIS

Data Set: C:\...\MW23out_2ndtest.aqt
Date: 03/30/17
Time: 11:12:26

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Location: Pawnee Station
Test Well: MW-23 (Out - 2nd test)
Test Date: 3/6/17

AQUIFER DATA

Saturated Thickness: 16.03 ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-23 (Out - 2nd test))

Initial Displacement: 1.171 ft
Total Well Penetration Depth: 16.03 ft
Casing Radius: 0.083 ft
Screen Length: 16.03 ft
Well Radius: 0.25 ft
Gravel Pack Porosity: 0.3

SOLUTION

Aquifer Model: Unconfined
Solution Method: Dagan

K = 0.0003249 cm/sec
y0 = 0.38 ft