Hayden Station, Routt County, Colorado

Monitoring Well Installation Report

for Compliance with the Coal Combustion Residuals (CCR) Rule

Hayden Station

Xcel Energy

July 21, 2016

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Table of Abbreviations and Acronyms

Abbreviation	Definition
AMSL	above mean sea level
bgs	below ground surface
BTOC	below top of casing
CCR	Coal Combustion Residuals
cm/sec	centimeter per second
HP Geotech	Hepworth-Pawlak Geotechnical, Inc.
µS/cm	microsiemens per centimeter
NTU	nephelometric turbidity unit
PSCo	Public Service Company of Colorado
TOC	top of casing
USCS	Unified Soil Classification System

1.0 Introduction

The purpose of this Monitoring Well Installation Report is to document details pertaining to the drilling, construction, and development of four groundwater monitoring wells installed at the Xcel Energy Hayden Generating Station (Hayden Station) in Routt 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). Hayden Station has one ash landfill 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 oversee the installation of the four groundwater monitoring wells at Hayden Station. HDR retained Hepworth-Pawlak Geotechnical, Inc. (HP Geotech) to provide on-site drilling services, while HDR provided field monitoring 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 investigations have been completed at Hayden Station, as documented in reports identified and summarized in the Monitoring Well Installation Plan for Hayden Station (HDR, 2015a). Soils in the immediate vicinity of the ash landfill are silty clay to clay colluvium underlain by shale bedrock of the Lewis Shale Formation. The Lewis Shale Formation is several hundred feet thick in the area and is recognized as an aquiclude (Xcel, 2001) that inhibits vertical movement of water.

The ash landfill is located on a west-sloping hillslope that drains west to Sage Creek (**Figure 2**). The top of the ridgeline (east side of the landfill) forms a drainage divide between Grassy Creek and Sage Creek. The bedrock surface slopes down to the west/northwest towards Sage Creek (Walsh, 2013). Sage Creek and Grassy Creek, tributaries of the Yampa River, flow to the north.

Regionally, a water table does not exist in the Lewis Shale formation (Robson and Stewart, 1990). To the west of the ash landfill, the uppermost aquifer is the alluvium deposited along the Sage Creek valley. Based on the prior investigations, groundwater is not anticipated at the landfill except in the northwest area near County Road 27. Where groundwater is present, it is presumed to flow west towards Sage Creek. Groundwater in the alluvium of the Sage Creek valley bottom flows to the north.

The four new monitoring wells installed at Hayden (MW-5, -6, -7, -8) 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 report (HDR, 2015b). The four new monitoring wells are shown on **Figure 2**.

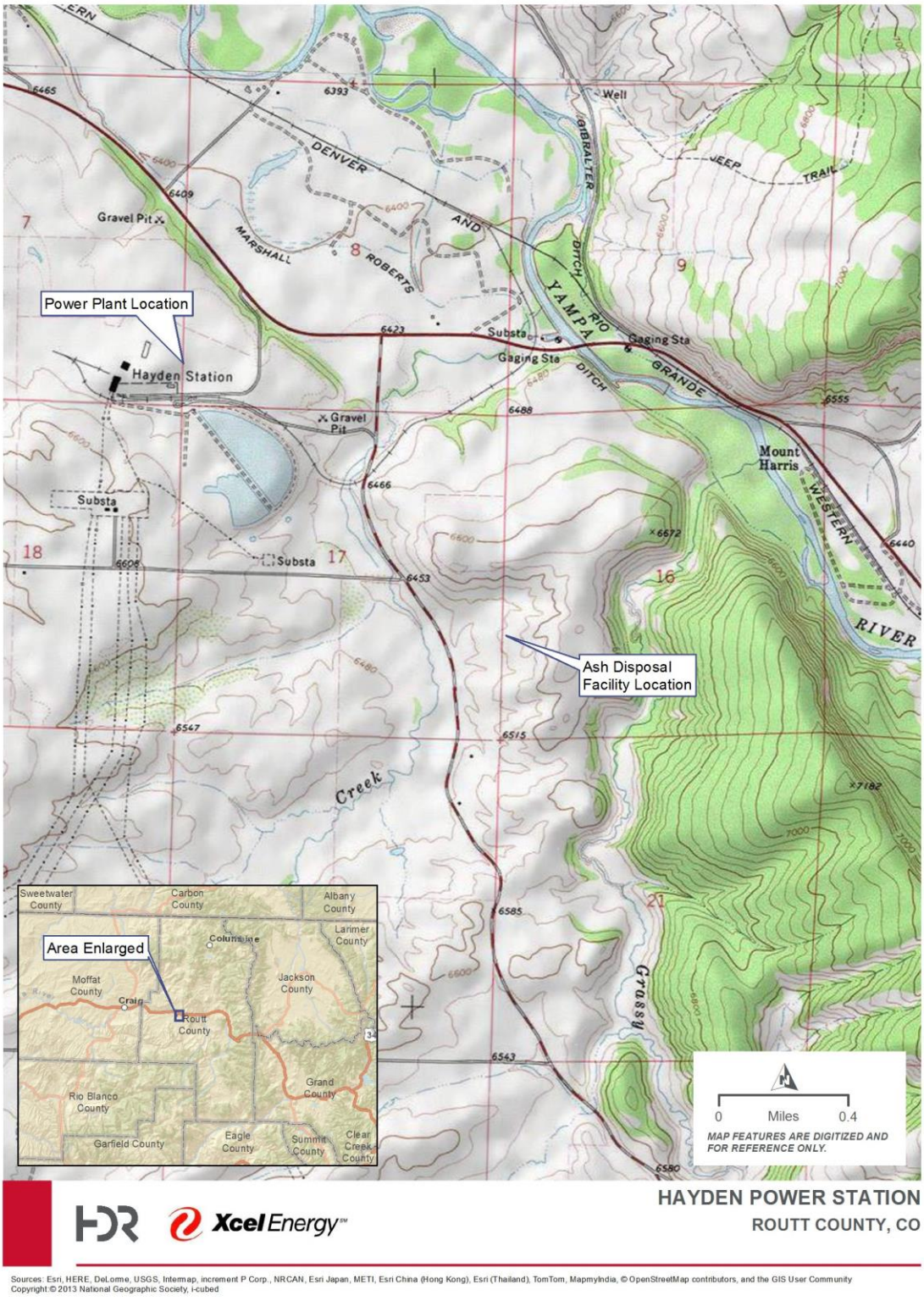

Figure 1. Vicinity Map for Hayden Station

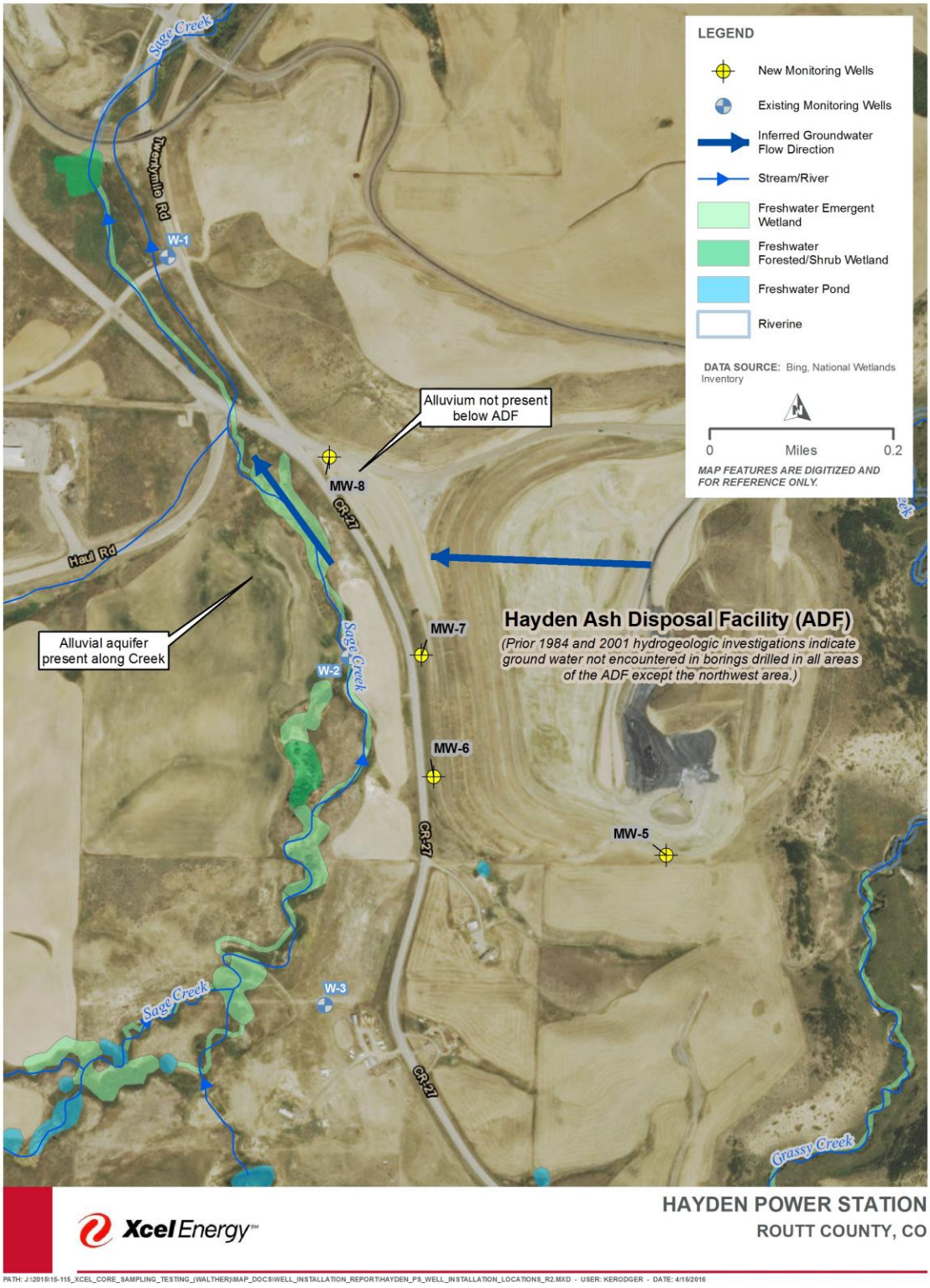

Figure 2. Well Location Map, Hayden

3.0 Field and Laboratory Methods

3.1 Borehole Drilling

The boreholes for each well were drilled by HP Geotech using a hollow stem auger drilling method on November 3 and 4, 2015. Utility locations were identified prior to beginning drilling operations. However, to verify the absence of any buried utilities, the driller advanced soil borings from the ground surface by using a pot-holing technique to a minimum depth of 8 feet prior to drilling. The borehole was then advanced using the hollow stem auger drilling equipment with a CME-55 drill rig. The nominal borehole diameter was 8 inches to accommodate construction of 2-inch diameter wells.

Well screen depth was targeted for placement above the Lewis Shale bedrock. Therefore, as described in the Monitoring Well Installation Plan (HDR, 2015a), all boreholes were drilled to the top of the Lewis Shale or to a depth of at least 10 feet below the water table, whichever was shallower. This resulted in boreholes with total depths ranging from 20.75 to 36 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 from each well was collected within the well screen depth interval and submitted to a lab for hydraulic properties analysis, as described in **Section 3.2**. 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 the existing on-site ash landfill. Drilling equipment was decontaminated with potable water before moving to the next borehole.

3.2 Soil Samples - Geotechnical Analysis

Soils were logged from the cutting returns during drilling and classified based on the USCS. During drilling, one undisturbed soil sample was obtained from each borehole at a depth coinciding with 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 each well) were submitted to HP Geotech for 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 and results are provided in **Appendix B**.

3.3 Well Construction

Once the target drilling depth was reached at each borehole, the 2-inch diameter, Schedule 40 PVC casing and well screen (0.010-inch slots) were assembled and lowered into each borehole. Approximately 10 feet of screen was installed in each of the four new wells.

After PVC casing and screen placement in the borehole, the sand filter pack and the bentonite seal was 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 1 to 3 feet above the well screen. An annular seal of medium bentonite chips was placed to (a minimum of) 7 feet above the top of the filter pack and hydrated in lifts throughout placement, while the remaining drill casing was removed from the borehole using the hydraulic jacks.

An annular surface seal consisting of neat cement was installed from the top of the bentonite to the surface. All wells were finished with a 2-foot-by-2-foot concrete pad using Quickrete fast setting concrete, extending to a depth of approximately 1 to 2 feet below grade. Each well included between 3 and 4 feet of PVC stick-up. Two bollards were installed at MW-8; bollards were not installed at the other three new wells as they were deemed unnecessary. 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 using a submersible pump. This method involves moving the submersible pump 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 by removing the purge water and fine sediments from the well using a pump. Purge water was placed into drums and/or buckets and disposed of at the ash landfill. MW-5 was found to be dry; therefore, well development was not attempted.

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. Field parameters were recorded approximately every 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 consecutive readings where temperatures are within 1°C, pH readings are within 0.2 standard units, conductivity is within 10 percent, and turbidity values are 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. All non-dedicated down-well equipment used during development was decontaminated. Well development is further discussed in **Section 4.4.**

3.5 Well Survey

Surveying of the monitoring wells was performed by Joy Surveying Company (JSC, INC.), a professional surveying company, 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 MW-6, MW-7, and MW-8 to obtain estimates of hydraulic conductivity for the shallow unconfined aquifer. Slug tests were not performed at MW-5 because the well was dry.

A 1.5-inch diameter by 3-foot long watertight slug was used. Given a 2-inch diameter well, an expected slug displacement of 1.69 feet is estimated for the slug. A transducer was suspended on a communications cable near the bottom of the well, and water level measurements were recorded 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:

MW-6: One slug-in and one slug-out test were performed on December 6, 2015. The depth to water in the well was 14.88 feet below top of casing. With a well screen interval of 14.7-24.7 feet bgs and a casing stick-up of 3.94 feet, the well screen is fully submerged with the top of the screen 3.76 feet below the water table.

MW-7: One slug-in and one slug-out test were performed on December 7, 2015. The depth to water in the well was 15.61 feet below top of casing. With a well screen interval of 18.5-28.5 feet bgs and a casing stick-up of 3.44 feet, the well screen is fully submerged with the top of the screen 6.33 feet below the water table.

MW-8: One slug-in and one slug-out test were performed on December 7, 2015. The depth to water in the well was 21.28 feet below top of casing. With a well screen interval of 25.4-35.4 feet bgs and a casing stick-up of 3.72 feet, the well screen is fully submerged with the top of the screen 7.84 feet below the water table.

Slug test data were downloaded from the Rugged Reader at the end of each working day and saved locally to a laptop.

3.7 Decontamination of Field Equipment

Field instrumentation (such as interface probes or water quality meters) and all non-dedicated down-well equipment used during slug testing 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 consisted primarily of silt and sandy silt with gravels. The water table was encountered at three of the four borings; soil cuttings were dry and water was not encountered at MW-5. Shale was encountered at approximately 10 feet in MW-5 and 24 feet in MW-6, which based on regional geology was identified as the top of the Lewis Shale formation. A hard silt was encountered at 24 feet bgs in MW-7 and 34 feet bgs in MW-8; however this silt was not logged at the shale bedrock.

Sandy silt (with some gravel) was the primary soil encountered in the vadose zone at MW-5. Sandy silt was logged from just below the ground surface to approximately 10 feet, at which point silt was encountered. Screen placement was based upon the shallow depth to bedrock.

Sediment collected from MW-6 was wet at approximately 19 feet bgs during drilling. Shale bedrock was encountered at approximately 24 feet bgs at MW-6. Well screen was placed 10 feet above the bedrock contact.

Silt was the primary soil encountered throughout the MW-7 borehole, encountering silt at 24 feet bgs. Soil cuttings were logged as wet at approximately 19 feet bgs. Well screen was placed ten feet below where water was encountered during drilling.

Sandy silt, silt with gravel, and a layer of clay were logged from soil cuttings from just below the ground surface to approximately 36 feet bgs at MW-8. The clay layer was encountered approximately 5.5 feet bgs, followed by silt (with gravel). Soil cuttings were logged as wet at approximately 24 feet bgs. Well screen was placed ten feet below where water was encountered during drilling.

4.2 Soil Samples – Geotechnical Analysis

The undisturbed soil samples collected from the well screen depth interval of each borehole were analyzed for grain size and porosity by HP Geotech, and are summarized in **Table 1**. The soil laboratory results are presented in **Appendix B**.

Laboratory results show the wells are screened in sandy silt, with porosities between 32 and 38 percent, which is consistent with the sandy silt material noted in the boring logs.

Table 1. Summary of Geotechnical Testing Results

Well I.D.	Sample Depth (feet bgs)	Gradation			Porosity (%)	Moisture Content (%)
		Gravel (%)	Sand (%)	Silt and Clay (%)		
MW-5	14	0	5	95	37.6	17.2
MW-6	19	0	17	83	33.4	12.1
MW-7	24	0	12	88	32.0	13.4
MW-8	29	0	8	92	37.4	20.9

Note:
BGS = below ground surface

4.3 Well Construction

A diagram for each well that documents well construction is provided in **Appendix C**. Approximately 10 feet of screen was installed in each well. The screen was placed from approximately 10 to 20 feet bgs at MW-5 because shale was encountered at 10 feet bgs; 14.67 to 24.67 feet bgs at MW-6 because shale was encountered at 24 feet bgs; 18.5 to 28.5 feet bgs at MW-7 because the cuttings were wet at 19 feet bgs; and 25.4 to 35.4 feet bgs at MW-8 because the cuttings were wet at 24 feet bgs. At MW-5, the water table was not encountered; the Lewis Shale formation was encountered at approximately 10 feet bgs. Total well depths ranged from 20 to 35.4 feet bgs. Well construction details for all four wells are summarized in **Table 2**. State well construction permits are included in **Appendix D**.

Table 2. Well Construction Details for Groundwater Monitoring Wells MW-5, MW-6, MW-7, and MW-8 at Hayden Station, 2015

Well ID	Northing (State Plane, NAD 1983 UTM Zone 13 N meters)	Easting (State Plane, NAD 1983 UTM Zone 13 N meters)	Elevation TOC (feet AMSL)	Well Total Depth (feet bgs)	Depth of Screen Interval (feet bgs)	Well Stickup (feet)	Casing Type	Depth to Water (feet BTOC)	Static Water Level (feet elevation)
MW-5	316882.80	4482224.55	6617.17	20.75	10.75-20.75	3.89	2-inch PVC	dry	dry
MW-6	316475.59	4482362.27	6476.71	24.67	14.67-24.67	3.94	2-inch PVC	14.88	6461.83
MW-7	316453.67	4482574.97	6475.00	28.5	18.5-28.5	3.44	2-inch PVC	15.66	6459.34
MW-8	316292.54	4482922.16	6465.77	35.4	25.4-35.4	3.72	2-inch PVC	21.33	6444.44

Notes:
TOC = top of casing
BTOC = below top of casing
BGS = below ground surface
AMSL = above mean sea level

4.4 Well Development

Two wells, MW-6 and MW-7, were developed within one day while MW-8 was developed over several days, due primarily to high turbidity readings and relatively slow recharge rates. Well MW-5 remained dry; therefore, development did not take place.

On November 12, 2015, water quality field parameters stabilized at MW-6 after approximately 200 gallons of water had been removed. Development of MW-7 was completed on November 13, 2015, after removing approximately 260 gallons of water. On November 13, 2015, approximately 65 gallons of water were removed from MW-8; however, field parameters did not stabilize. Development of MW-8 resumed on December 3, 2015 and was conducted for 3 additional consecutive days. After a total of approximately 192.5 gallons of water had been removed, field parameters stabilized and development of MW-8 was complete on December 6, 2015.

Table 3. Field Water Quality After Well Development: MW-6, MW-7, MW-8, Hayden Station, 2015

Well I.D.	Conductivity (µS/cm)	pH	Temperature (degrees Celsius)	Turbidity (NTU)
MW-6	5304	8.44	11.0	9.7
MW-7	5357	9.00	11.0	5.2
MW-8	9189	7.04	11.5	9.6

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

4.5 Well Survey

Survey coordinates and elevations are provided in **Table 2**.

4.6 Groundwater Level Measurement and Aquifer (Slug) Testing

All slug-in and slug-out tests were analyzed using the Bouwer and Rice (1976) slug test solution for unconfined aquifers, and implemented using Aqtesolv® v4.5. All well screens were below the water table (i.e., fully submerged) during the slug testing; therefore no effective casing radius correction was applied to account for drainage to and from the filter pack. The aquifer at MW-6 was represented with a saturated thickness of 13.06 feet. Because the bedrock contact was not definitively encountered during drilling MW-7 and MW-8, the depth to bedrock is uncertain and therefore the saturated thickness of the aquifer was assumed to be 30 feet for aquifer test analyses. 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 4. In some tests the initial displacement did not reasonably match the expected displacement of 1.69 feet. Due to the discrepancy, the early ‘noisy’ data were not fitted during the analysis. Plots of the analyses are included in Appendix E. The geometric mean of the hydraulic conductivity calculated at MW-6, MW-7, and MW-8 is 6.84 x 10-4 centimeters per second (cm/sec). This value corresponds with the textbook range for silt to silty sand (Freeze and Cherry, 1979), which generally agrees with the silt formation noted in the boring logs at each location.

Table 4. Slug Testing Results for MW-6, MW-7, and MW-8			
Well	**Test Name**	**Initial Displacement (feet)**	**Hydraulic Conductivity (cm/sec)**
MW-6	Slug In	2.58	8.66E-04
MW-6	Slug Out	1.25	7.65E-04
MW-7	Slug In	1.80	2.47E-03
MW-7	Slug Out	2.02	2.65E-03
MW-8	Slug In	1.75	1.33E-04
MW-8	Slug Out	1.59	1.28E-04
		Geometric Mean	**6.48E-04**

5.0 References

Bouwer, H. and R.C. Rice, 1976. A slug test method for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells, Water Resources Research, vol. 12, no. 3, pp. 423-428.

Dagan, G., 1978. A note on packer, slug, and recovery tests in unconfined aquifers, Water Resources Research, vol. 14, no. 5. pp. 929-934.

Freeze, R.A. and J.A. Cherry, 1979. Groundwater, Prentice-Hall, Inc., Englewood Cliffs, NJ.

HDR, 2015a. Monitoring Well Installation Plan for Compliance with the Coal Combustion Residuals (CCR) Rule, Xcel Energy Hayden Station. November 30, 2015.

HDR, 2015b. Groundwater Monitoring System Certification for Compliance with the Coal Combustion Residuals (CCR) Rule, Xcel Energy, Hayden Station. April 15, 2015.

Robson, S.G. and Stewart, Michael, 1990. Geohydrologic Evaluation of the Upper Part of the Mesaverde Group, Northwestern Colorado. U.S. Geological Survey Water-Resources Investigations Report 90-4020.

Walsh Environmental Scientists and Engineers (Walsh), November 2013. Hayden Station Coal Ash Disposal Facility Engineering and Design and Operation Plan. Xcel Energy, Hayden, Colorado.

Xcel Energy, 2001. Hayden Ash Disposal Facility Environmental Monitoring System (EMS) Work Plan, August 23, 2001. Xcel Energy.

Xcel Energy, 2001. Hayden Station Coal Ash Disposal Facility Environmental Monitoring System (EMS) Installation Report, November 27, 2001. Xcel Energy.

Xcel Energy, 2014. Hayden Station Ash Disposal Ground Water Monitoring, Fall, 2014, December 23, 2014. Xcel Energy.

Appendix A

Borehole Logs

Boring Log

Project Name	Project No.	Drilling Company
Xcel CCR	266180	HP Geotech

Boring No.	Location	Drilling Rig Type and Drilling Method
MW-5	Hayden Station	CME-55 Hollow Stem Auger (8-inch diameter borehole)

Sample No.	Blow Count	Depth (feet)	Description (USCS)	Remarks
1' below ground surface (bgs)	N/A		10YR 4/3; Silt w/Sand (ML); nonplastic, noncohesive; dry	Potholed to 8' on 11/2/2015
5' bgs	N/A	5	10YR 4/3; Silt w/Sand (ML), some gravel; nonplastic, noncohesive; dry	
9' bgs	10-10-18 (SS)	10	10YR 4/2; Silt (ML); very stiff, nonplastic; noncohesive; dry Bedrock (Shale); flakey and friable	Alluvium encountered at 8' bgs Fe staining; calcite deposit on bottom
14' bgs	50/12" (Cal)	15	As above but slightly moist	Iron oxide present 14-14.5' bgs. Calcite depoits. Cal sample MW-5 14' bgs submitted for geotech analysis
19' bgs 21' bgs	50/4" (SS) 50/8" (Cal)	20	As above	Flakey, friable shale; calcite deposits
		25		
		30		

Total Depth (feet)	Water Level (feet)		Logged By:	Drilled/Sampled By:
	After Drilling:	Hours After:	Date Started:	Date Completed:
20.75	Dry	24	11/3/2015	11/3/2015

Nick Hanrahan

Brent McDaniel

Boring Log

Project Name	Project No.	Drilling Company
Xcel CCR	266180	HP Geotech

Boring No.	Location	Drilling Rig Type and Drilling Method
MW-6	Hayden Station	CME-55 Hollow Stem Auger (8-inch diameter borehole)

Sample No.	Blow Count	Depth (feet)	Description (USCS)	Remarks
1' below ground surface (bgs)	N/A		10YR 4/3; Silty Sand (ML) with Gravel; nonplastic; noncohesive; dry	Potholed to 8' on 11/2/2015
5' bgs	N/A	5	As above but moist, likely due to potholing	
10' bgs	50/10" (Cal)	10	10YR 4/1; Silt (ML); hard; nonplastic; noncohesive; slightly laminated; flakey; dry	some iron oxide observed
11' bgs	50/5" (SS)			
14' bgs	50/4" (SS)	15	As above	
MW-6 19' bgs	50/6" (Cal)	20	As above but wet	Calcite deposits. Cal sample MW-6 at 19' bgs submitted for geotechnical analysis. Water level during drilled was 19.3' bgs
7	50/3" (Cal)	25	Gley 1 4/1; Silt (ML); hard; nonplastic; shale bedrock; noncohesive, laminated, friable; moist	

Total Depth (feet)	Water Level (feet)		Logged By:	Drilled/Sampled By:
	After Drilling:	Hours After:	Nick Hanrahan	Brent McDaniel
25	10.75	24	Date Started: 11/3/2015	Date Completed: 11/3/2015

Boring Log

Project Name	Project No.	Drilling Company
Xcel CCR	266180	HP Geotech

Boring No.	Location	Drilling Rig Type and Drilling Method
MW-7	Hayden Station	CME-55 Hollow Stem Auger (8-inch diameter borehole)

Sample No.	Blow Count	Depth (feet)	Description (USCS)	Remarks
1' below ground surface (bgs)	N/A		10YR 4/3; Silt (ML); nonplastic; noncohesive; dry	Potholed to 8' on 11/2/2015
5' bgs	N/A	5	As above but moist, likely due to potholing	
9' bgs	50/7" (SS)	10	7.5YR 4/2; Silt (ML); hard; nonplastic; noncohesive; laminated; dry	Fe staining
14' bgs	50/7" (SS)	15	As above, but with noticeable calcite crystals	Fe staining
15' bgs	50/8" (Cal)			
19' bgs	50/7" (Cal)	20	As above, but wet	Fe staining
				Driller using water, unable to get an accurate water level on 11/3/2015
MW-7 24' bgs	50/5" (Cal)	25	Gley 1 4/N; Silt (ML); hard; nonplastic; noncohesive; laminated; wet	Cal sample MW-7 at 24' bgs submitted for geotechnical analysis.
29' bgs	50/4" (SS)	30	Gley 1 4/N; Silt (ML); hard; nonplastic; noncohesive; laminated; wet	small calcite crystals visible

Total Depth (feet)	Water Level (feet)		Logged By:	Drilled/Sampled By:
	After Drilling:	Hours After:	Date Started:	Date Completed:
30	11.45	24	11/3/2015	11/3/2015

Nick Hanrahan

Brent McDaniel

Boring Log

Project Name	Project No.	Drilling Company
Xcel CCR	266180	HP Geotech

Boring No.	Location	Drilling Rig Type and Drilling Method
MW-8	Hayden Station	CME-55 Hollow Stem Auger (8-inch diameter borehole)

Sample No.	Blow Count	Depth (feet)	Description (USCS)	Remarks
1' below ground surface (bgs)	N/A		10YR 5/4; Sandy Silt (ML) w/ Gravel; nonplastic; noncohesive; dry	Potholed to 8' on 11/2/2015
5.5' bgs	N/A	5	10YR 4/2; Lean Clay (CL); medium plasticity; cohesive; dry to moist	
9' bgs	5-4-7 (SS)	10	Brown 10YR 5/3; Silt (ML); some gravel; stiff; low plasticity, cohesive; massive; moist	Weathered calcite crystals
14' bgs	3-4-5 (SS)	15	As above	Fe staining and calcite visible
19' bgs	3-4-5 (SS)	20	As above	Fe staining and calcite visible
24' bgs	5-5-6 (SS)	25	Dark yellowish brown 10YR 4/4; Silt (ML); some gravel; stiff; low plasticity, cohesive; massive; moist to wet	
MW-8 29' bgs	5-6 (Cal)	30	As above	Fe staining. Cal sample MW-8 29' bgs submitted for geotechnical analysis
34' bgs 35' bgs	50/6" (SS) 50/10" (Cal)*	35	Very dark gray 10YR 3/1; Silt (ML); hard; nonplastic; noncohesive; laminated to thinly bedded; moist *Sample at 35' bgs's blow count affected by previous SS	Fe staining

Total Depth (feet)	Water Level (feet)		Logged By:	Drilled/Sampled By:
	After Drilling:	Hours After:	Date Started:	Date Completed:
35	17.4	24	11/4/2015	11/4/2015

Nick Hanrahan

Brent McDaniel

Appendix B

Geotechnical Soil Testing Results and Chain of Custody Records

Hepworth-Pawlak Geotechnical, Inc.
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December 14, 2015

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

215333B
Anna.Lundin@HDRinc.com

Subject: Laboratory Tests Results – Xcel Coal Combustion Residuals Rule Compliance Project, Hayden 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 1-4 and Table 1.

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

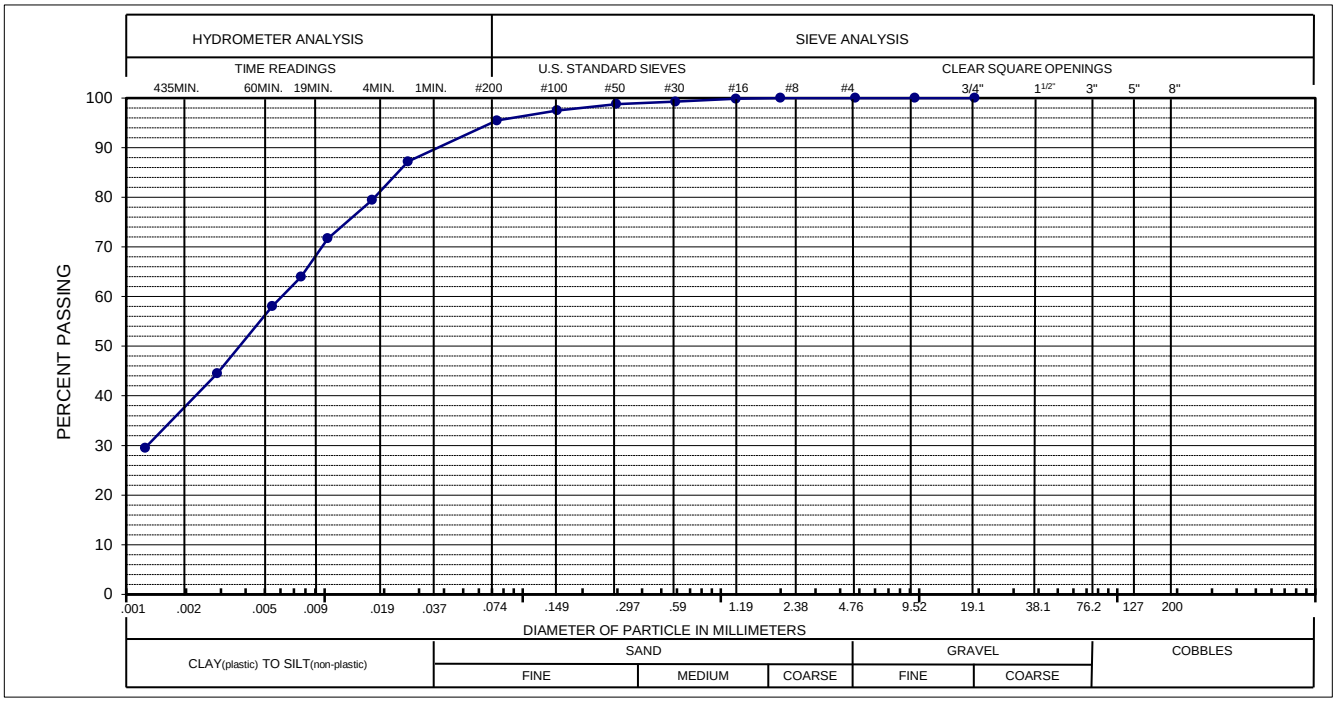
Sincerely,

HEPWORTH-PAWLAK GEOTECHNICAL, Inc.

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

Reviewed by: Arben Kalaveshi, P.E.

215333B (Hayden) xmittal.doc



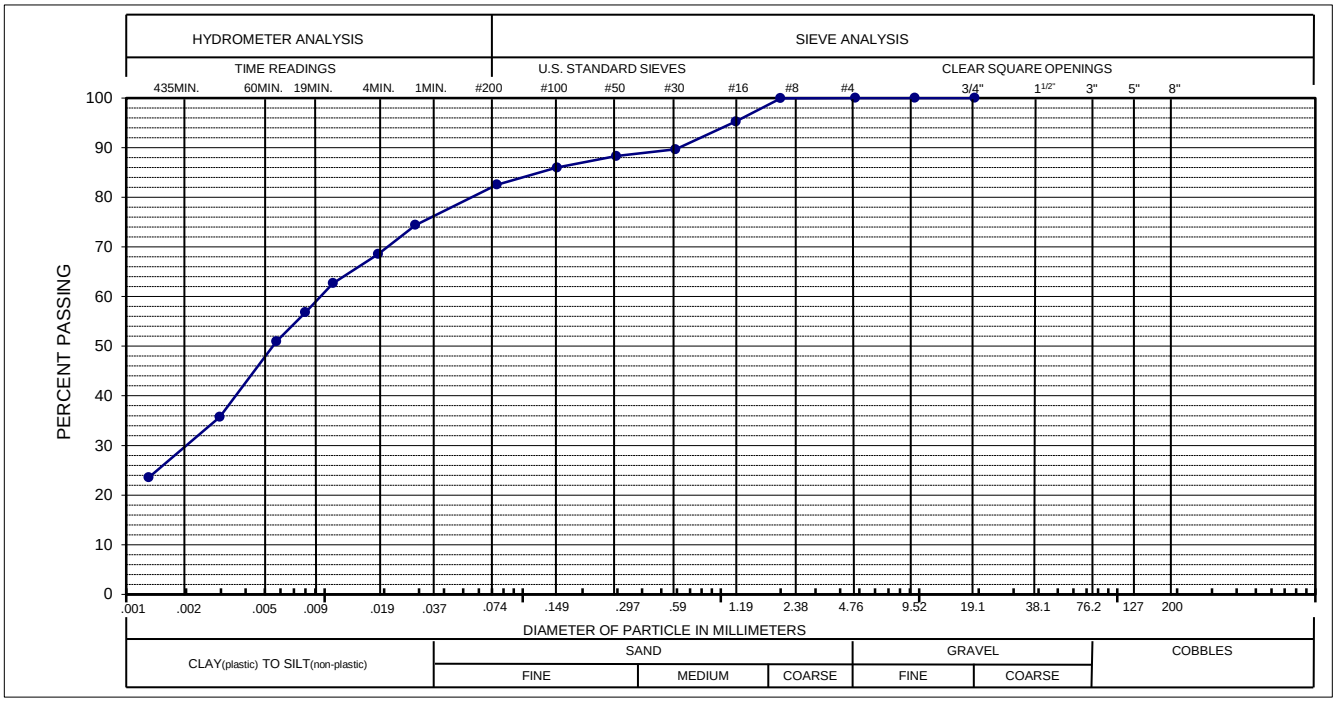
GRAVEL: 0% SAND: 5% SILT / CLAY: 95%

BORING : MW5 Specific Gravity: 2.88

DEPTH : 14 feet Porosity : 37.6%

Sieve Size / Particle Diameter	Percent Passing
(1")	100
(3/4")	100
(1/2")	100
(3/8")	100
(#4)	100
(#10)	100
(#16)	100
(#30)	99
(#50)	99
(#100)	97
(#200)	95
0.0264	87
0.0174	79
0.0104	72
0.0076	64
0.0054	58
0.0029	44
0.0012	29

215333B	HEPWORTH-PAWLAK GEOTECHNICAL, INC.	HDR HAYDEN HYDROMETER AND SIEVE ANALYSIS	FIG. 1



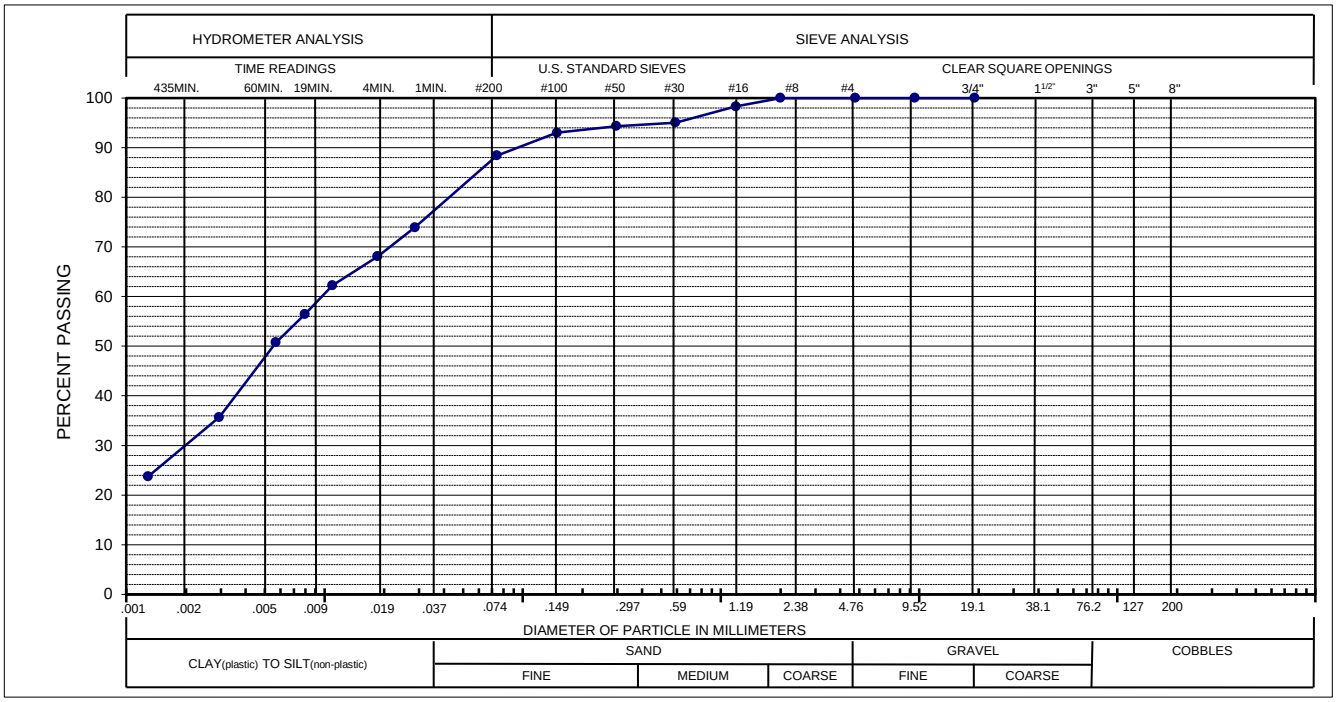
GRAVEL: 0% SAND: 17% SILT / CLAY: 83%

BORING : MW6 Specific Gravity = 2.80

DEPTH : 19 feet Porosity : 33.4%

Sieve Size / Particle Diameter	Percent Passing
(1")	100
(3/4")	100
(1/2")	100
(3/8")	100
(#4)	100
(#10)	100
(#16)	95
(#30)	90
(#50)	88
(#100)	86
(#200)	83
0.0287	74
0.0187	69
0.0110	63
0.0080	57
0.0057	51
0.0030	36
0.0013	24

215333B	HEPWORTH-PAWLAK GEOTECHNICAL, INC.	HDR HAYDEN HYDROMETER AND SIEVE ANALYSIS	FIG. 2



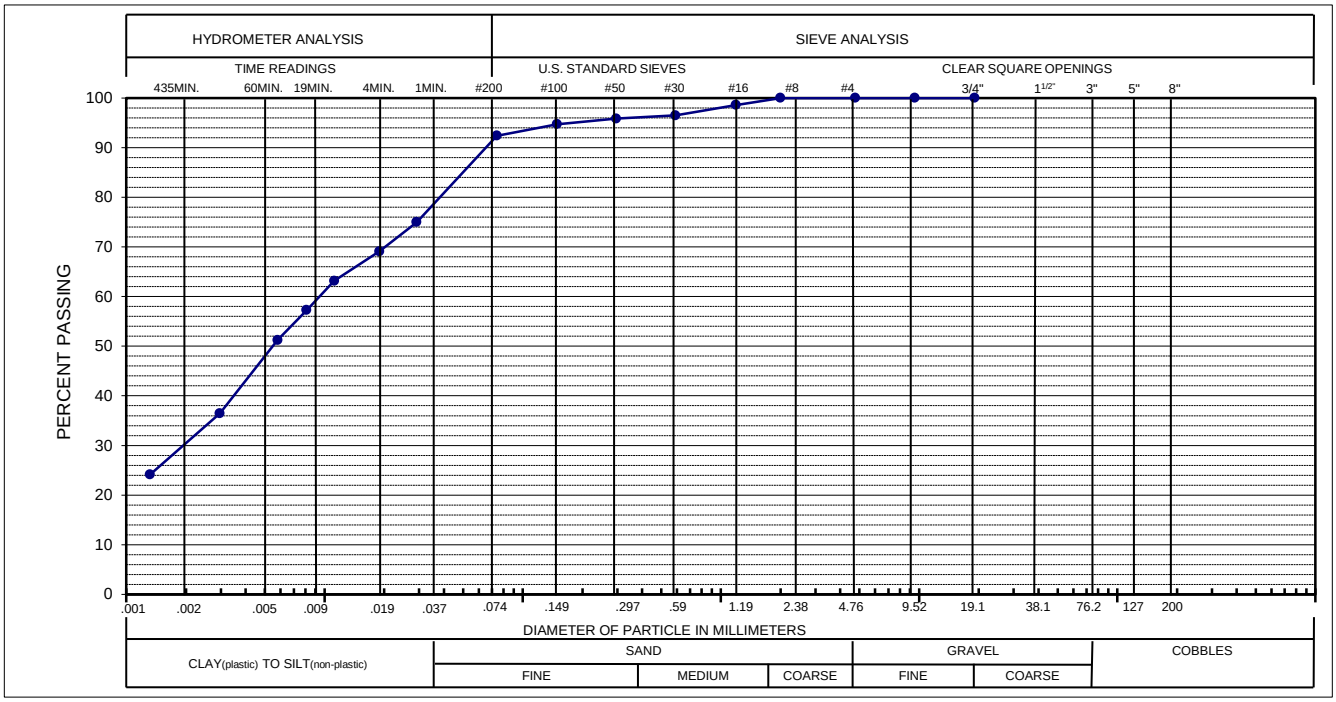
GRAVEL: 0% SAND: 12% SILT / CLAY: 88%

BORING : MW7 Specific Gravity = 2.82

DEPTH : 24 feet Porosity : 32.0%

Sieve Size / Particle Diameter	Percent Passing
(1")	100
(3/4")	100
(1/2")	100
(3/8")	100
(#4)	100
(#10)	100
(#16)	98
(#30)	95
(#50)	94
(#100)	93
(#200)	88
0.0286	74
0.0185	68
0.0110	62
0.0080	56
0.0057	51
0.0029	36
0.0013	24

215333B	HEPWORTH-PAWLAK GEOTECHNICAL, INC.	HDR HAYDEN HYDROMETER AND SIEVE ANALYSIS	FIG. 3



GRAVEL: 0% SAND: 8% SILT / CLAY: 92%

BORING : MW8 Specific Gravity = 2.75

DEPTH : 29 feet Porosity : 37.4%

Sieve Size / Particle Diameter	Percent Passing
(1")	100
(3/4")	100
(1/2")	100
(3/8")	100
(#4)	100
(#10)	100
(#16)	99
(#30)	96
(#50)	96
(#100)	95
(#200)	92
0.0291	75
0.0189	69
0.0112	63
0.0081	57
0.0058	51
0.0030	36
0.0013	24

215333B	HEPWORTH-PAWLAK GEOTECHNICAL, INC.	HDR HAYDEN HYDROMETER AND SIEVE ANALYSIS	FIG. 4

HEPWORTH-PAWLAK GEOTECHNICAL, INC.

JOB NO. 215333B

PROJECT: HDR HAYDEN

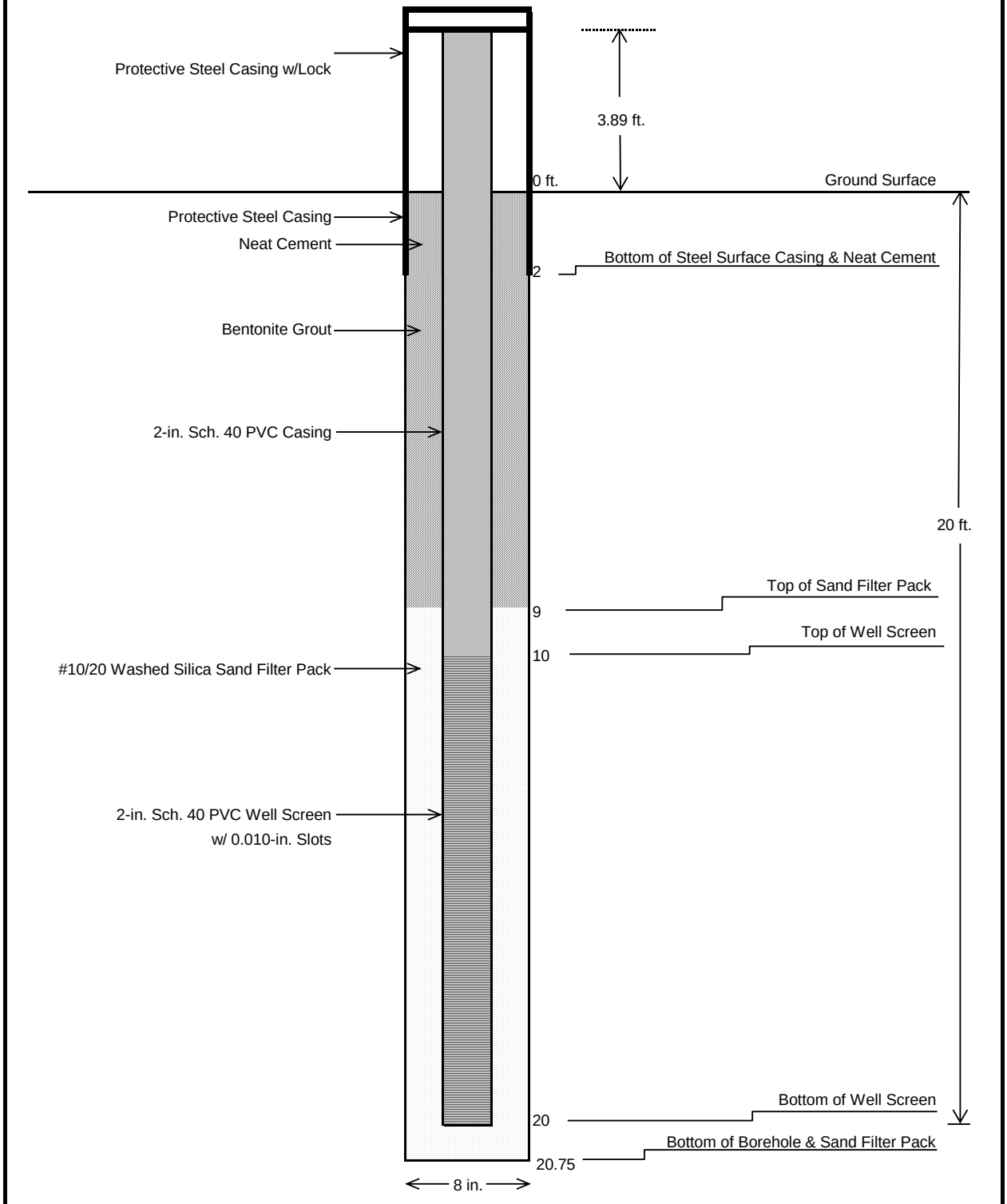
TABLE 1

SUMMARY OF LABORATORY TEST RESULTS

SAMPLE LOCATION		NATURAL MOISTURE CONTENT (%)	NATURAL DRY UNIT WEIGHT (PCF)	GRADATION			SPECIFIC GRAVITY	POROSITY (%)
BORING	DEPTH (feet)			GRAVEL (%)	SAND (%)	SILT & CLAY (%)		
MW5	14	17.2	112	0	5	95	2.88	37.6
MW6	19	12.1	116	0	17	83	2.80	33.4
MW7	24	13.4	119	0	12	88	2.82	32.0
MW8	29	20.9	107	0	8	92	2.75	37.40

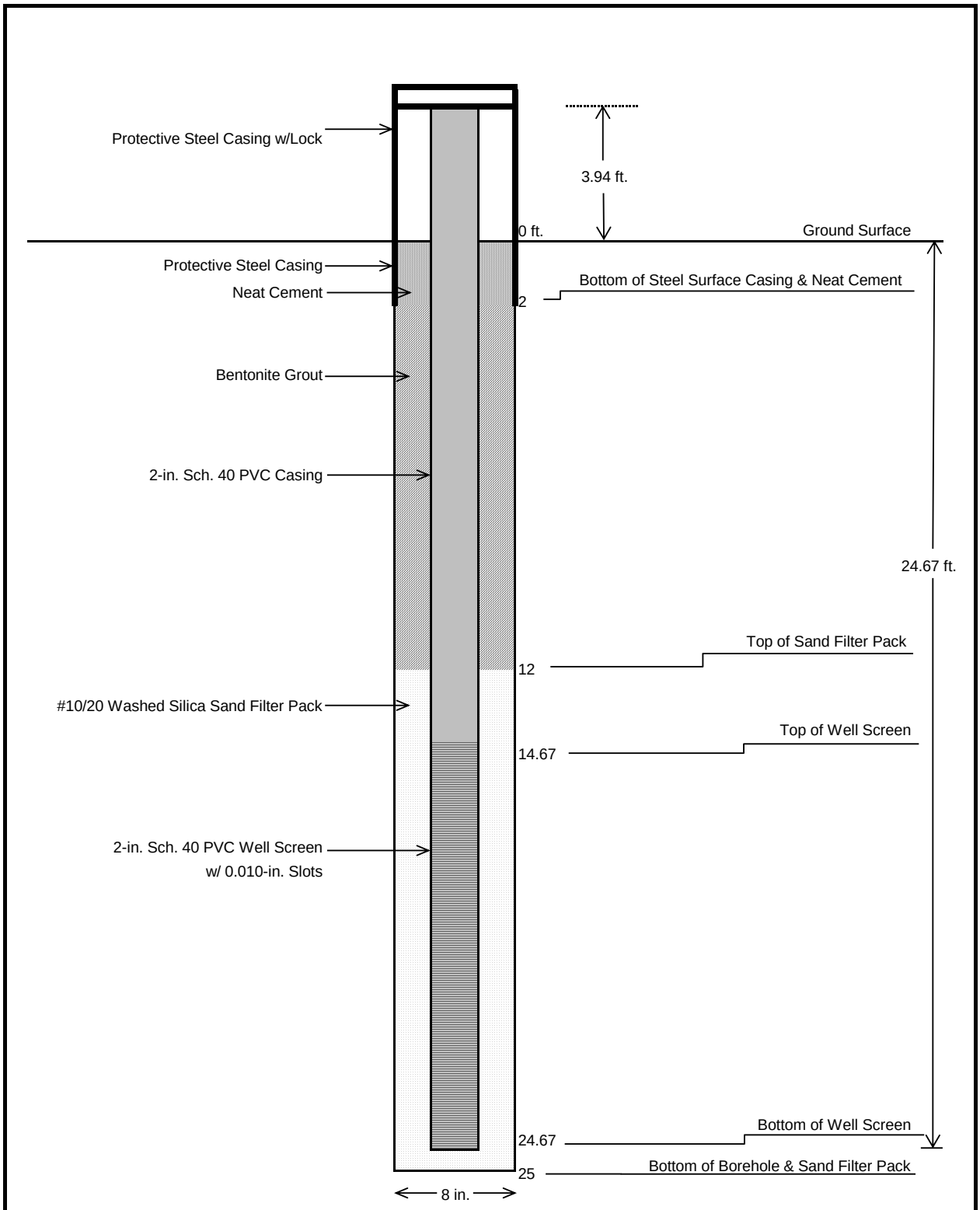
Appendix C

Well Construction Diagrams



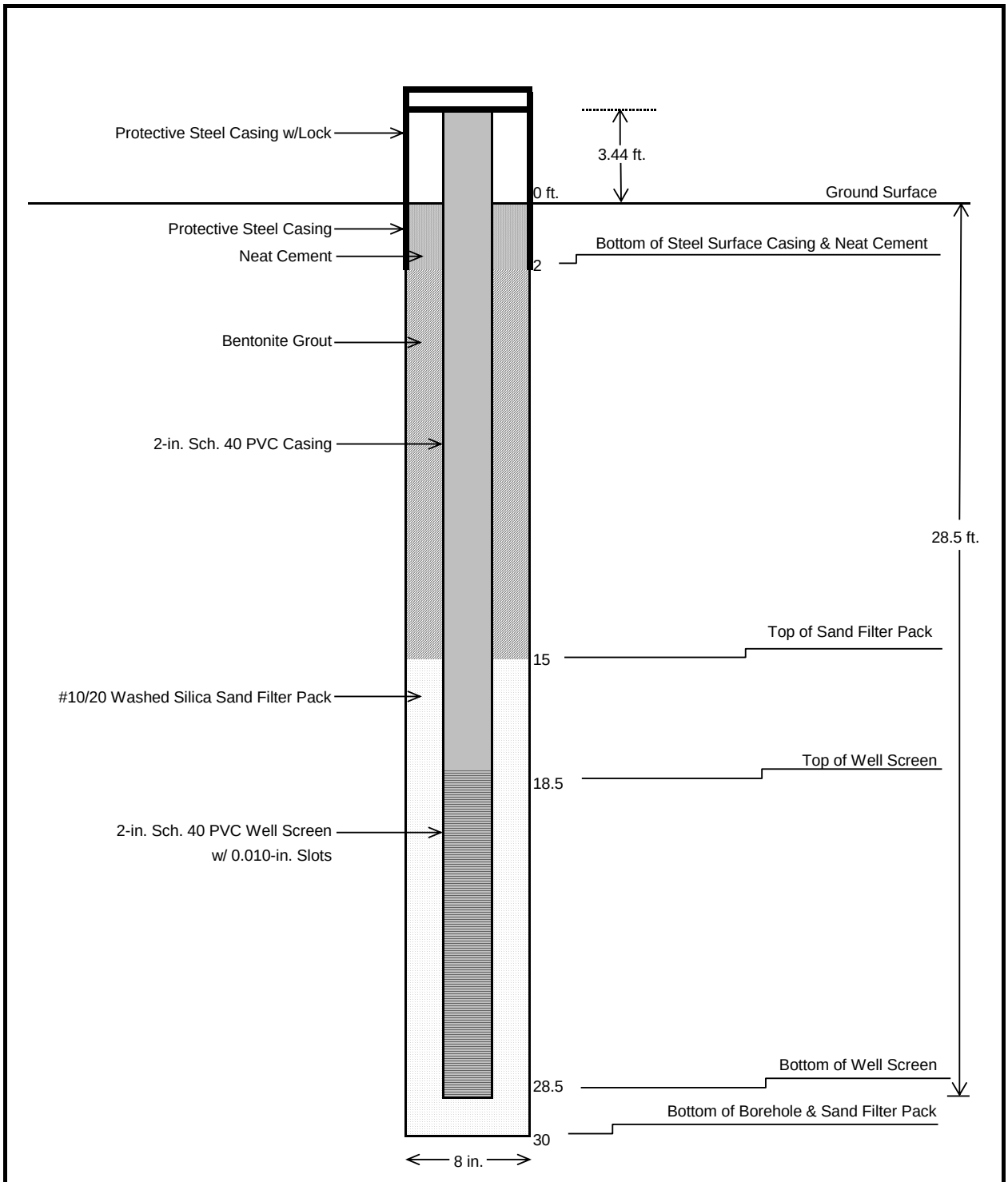
Constructed: 11/03/2015
Drilled By: HP Geotech
PVC Casing EL: 6617.17 ft amsl
Water EL: DRY (December 2015)

Monitoring Well Construction Diagram
MW-5
Hayden Station
Xcel Energy



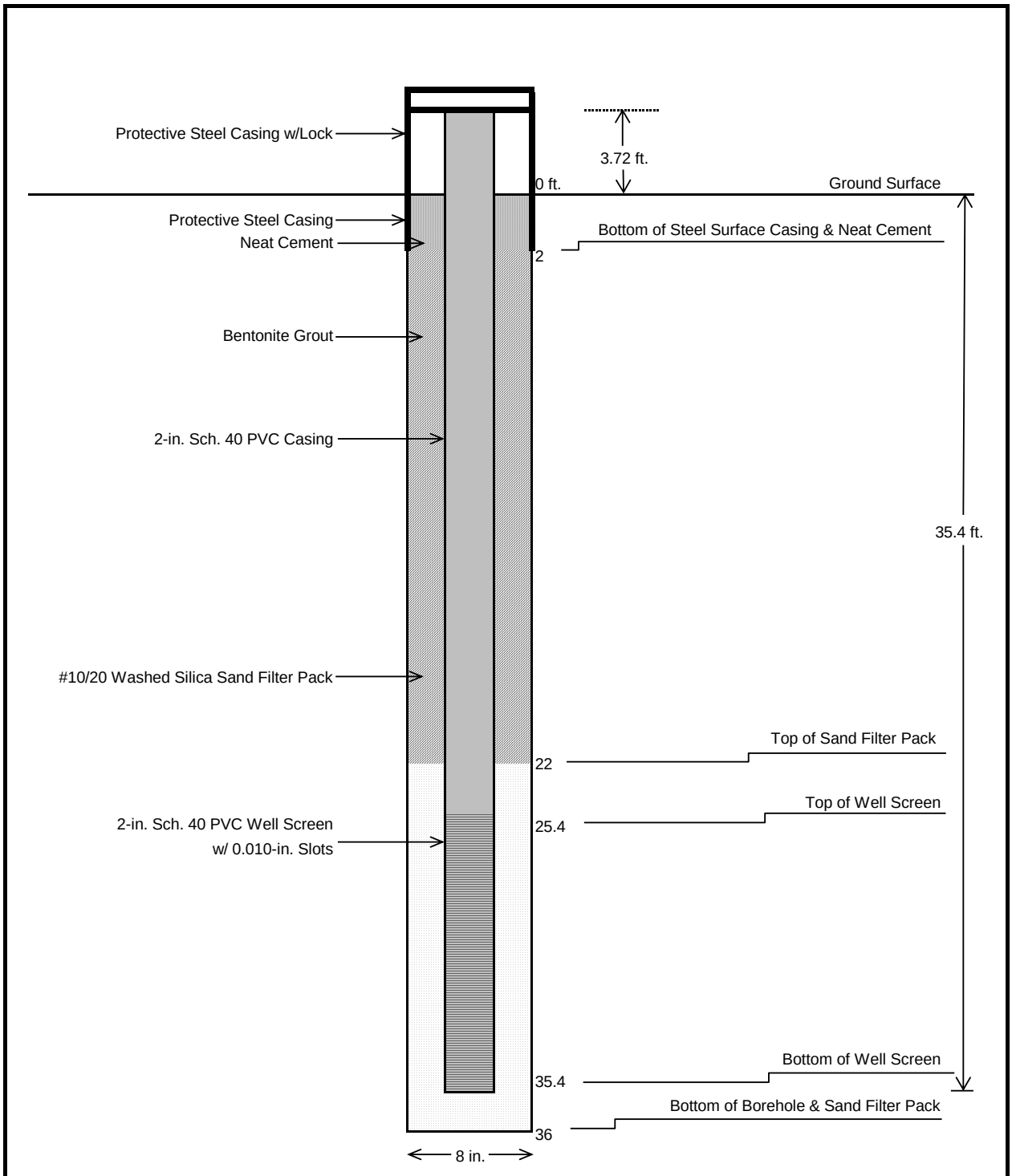
Constructed:	**11/03/2015**
Drilled By:	**HP Geotech**
PVC Casing EL:	**6476.71 ft amsl**
Water EL:	**6461.83 ft amsl (December 2015)**

Monitoring Well Construction Diagram
MW-6
Hayden Station
Xcel Energy



Constructed:	**11/03/2015**
Drilled By:	**HP Geotech**
PVC Casing EL:	**6675.00 ft amsl**
Water EL:	**6459.34 ft amsl (December 2015)**

Monitoring Well Construction Diagram
MW-7
Hayden Station
Xcel Energy



Constructed:	**11/04/2015**
Drilled By:	**HP Geotech**
PVC Casing EL:	**6465.77 ft amsl**
Water EL:	**6444.44 ft amsl (December 2015)**

Monitoring Well Construction Diagram
MW-8
Hayden Station
Xcel Energy

Appendix D

State-Issued Well Permits

Form No. GWS-25

OFFICE OF THE STATE ENGINEER
COLORADO DIVISION OF WATER RESOURCES

818 Centennial Bldg., 1313 Sherman St., Denver, Colorado 80203
(303) 866-3581

EXST

WELL PERMIT NUMBER 299819 - -

DIV. 6 WD 57 DES. BASIN MD

APPLICANT

PUBLIC SERVICE COMPANY OF COLORADO
13125 US 40
HAYDEN, CO 81639-

(303) 571-7340

APPROVED WELL LOCATION
ROUTT COUNTY
NE 1/4 SE 1/4 Section 17
Township 6 N Range 87 W Sixth P.M.

DISTANCES FROM SECTION LINES
1363 Ft. from South Section Line
778 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)(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 MW-7.
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.)

Ar 1-5-16

APPROVED
AOT

[signature]
State Engineer

[signature]
By

Receipt No. 3672797C DATE ISSUED 01-05-2016 EXPIRATION DATE N/A

Form No.
GWS-25

OFFICE OF THE STATE ENGINEER
COLORADO DIVISION OF WATER RESOURCES

818 Centennial Bldg., 1313 Sherman St., Denver, Colorado 80203
(303) 866-3581

EXST

WELL PERMIT NUMBER 299818 - - -
DIV. 6 WD 57 DES. BASIN MD

APPLICANT

PUBLIC SERVICE COMPANY OF COLORADO
13125 US 40
HAYDEN, CO 81639-

(303) 571-7340

APPROVED WELL LOCATION
ROUTT COUNTY
SW 1/4 SW 1/4 Section 16
Township 6 N Range 87 W Sixth P.M.

DISTANCES FROM SECTION LINES
50 Ft. from South Section Line
731 Ft. from West 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)(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 MW-5.
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.)

AT 1-5-16

APPROVED
AOT

Dick Wolfe
State Engineer

By

Receipt No. 3672797A DATE ISSUED 01-05-2016 EXPIRATION DATE N/A

Form No.
GWS-25

OFFICE OF THE STATE ENGINEER
COLORADO DIVISION OF WATER RESOURCES

818 Centennial Bldg., 1313 Sherman St., Denver, Colorado 80203
(303) 866-3581

EXST

WELL PERMIT NUMBER 299817 - - -
DIV. 6 WD 57 DES. BASIN MD

APPLICANT

PUBLIC SERVICE COMPANY OF COLORADO
13125 US 40
HAYDEN, CO 81639-

(303) 571-7340

APPROVED WELL LOCATION
ROUTT COUNTY
SE 1/4 SE 1/4 Section 17
Township 6 N Range 87 W Sixth P.M.

DISTANCES FROM SECTION LINES
498 Ft. from South Section Line
615 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)(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-54577, and known as MW-6.
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.)

AT 1-5-16

APPROVED
AOT

Dick Wolfe
State Engineer

By Alex Todd

Receipt No. 3672797B DATE ISSUED 01-05-2016 EXPIRATION DATE N/A

Form No.
GWS-25

OFFICE OF THE STATE ENGINEER
COLORADO DIVISION OF WATER RESOURCES

818 Centennial Bldg., 1313 Sherman St., Denver, Colorado 80203
(303) 866-3581

EXST

WELL PERMIT NUMBER 299820 - - -
DIV. 6 WD 57 DES. BASIN MD

APPLICANT

PUBLIC SERVICE COMPANY OF COLORADO
13125 US 40
HAYDEN, CO 81639-

(303) 571-7340

APPROVED WELL LOCATION
ROUTT COUNTY
NE 1/4 SE 1/4 Section 17
Township 6 N Range 87 W Sixth P.M.

DISTANCES FROM SECTION LINES
2319 Ft. from South Section Line
1262 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)(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 MW-8.
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.)

Ap 1-5-16

APPROVED
AOT

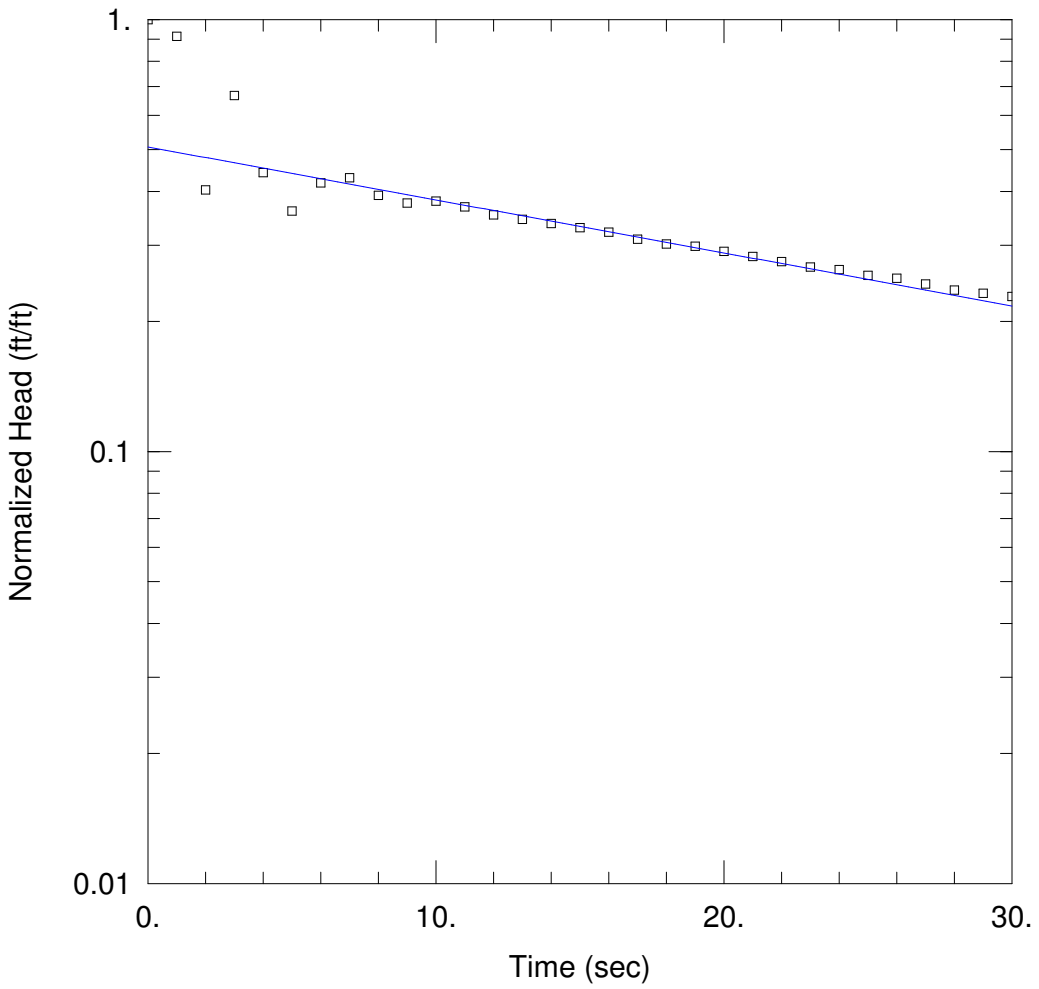
State Engineer

By

Receipt No. 3672797D DATE ISSUED 01-05-2016 EXPIRATION DATE N/A

Appendix E

Slug Testing Plots and Analytical Results



MW-6 SLUG IN

Data Set: P:\...\Hayden_MW-6_Slug_In_BouwerRice.aqt
Date: 01/18/16 Time: 12:13:52

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Project: 266180
Location: Hayden Station
Test Well: MW-6
Test Date: 12/6/2015

AQUIFER DATA

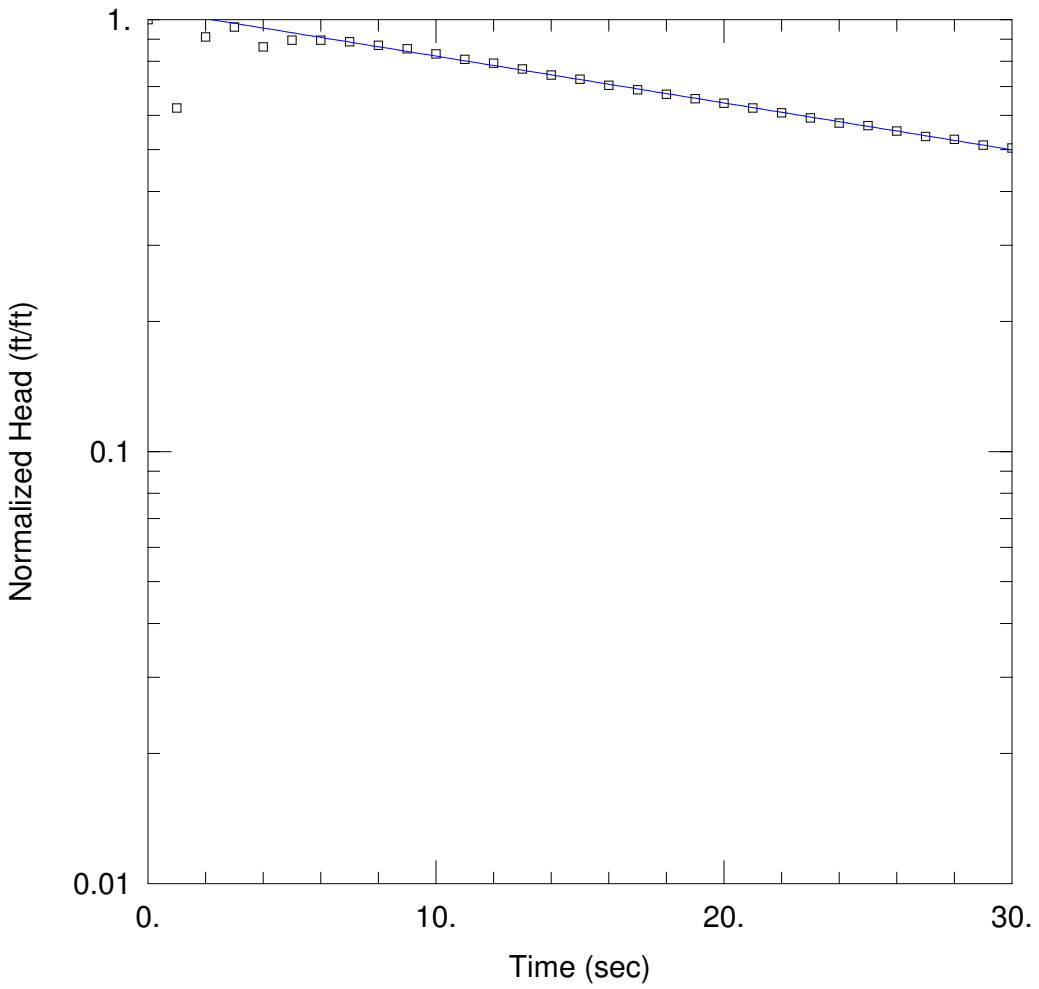
Saturated Thickness: 13.06 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-6)

Initial Displacement: 2.58 ft
Total Well Penetration Depth: 13.06 ft
Casing Radius: 0.083 ft
Static Water Column Height: 13.06 ft
Screen Length: 9.3 ft
Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.0008661 cm/sec
y0 = 1.308 ft



MW-6 SLUG OUT

Data Set: P:\...\Hayden_MW-6_Slug_Out_BouwerRice.aqt
Date: 01/18/16 Time: 12:14:19

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Project: 266180
Location: Hayden Station
Test Well: MW-6
Test Date: 12/6/2015

AQUIFER DATA

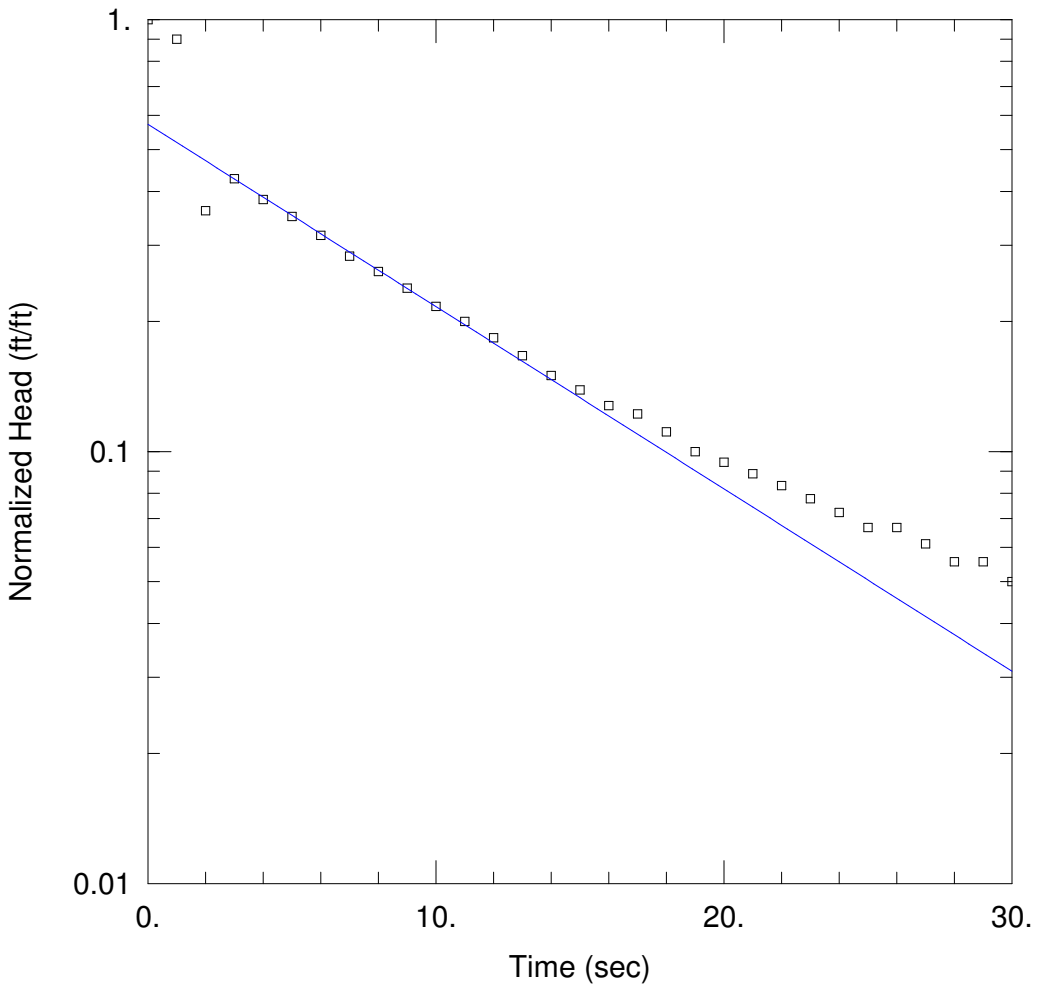
Saturated Thickness: 13.06 ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-6)

Initial Displacement: 1.25 ft
Total Well Penetration Depth: 13.06 ft
Casing Radius: 0.083 ft
Static Water Column Height: 13.06 ft
Screen Length: 9.3 ft
Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.0007654 cm/sec
y0 = 1.32 ft



MW-7 SLUG IN

Data Set: P:\...\Hayden_MW-7_Slug_In_BouwerRice.aqt
Date: 01/18/16 Time: 12:14:40

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Project: 266180
Location: Hayden Station
Test Well: MW-7
Test Date: 12/7/2015

AQUIFER DATA

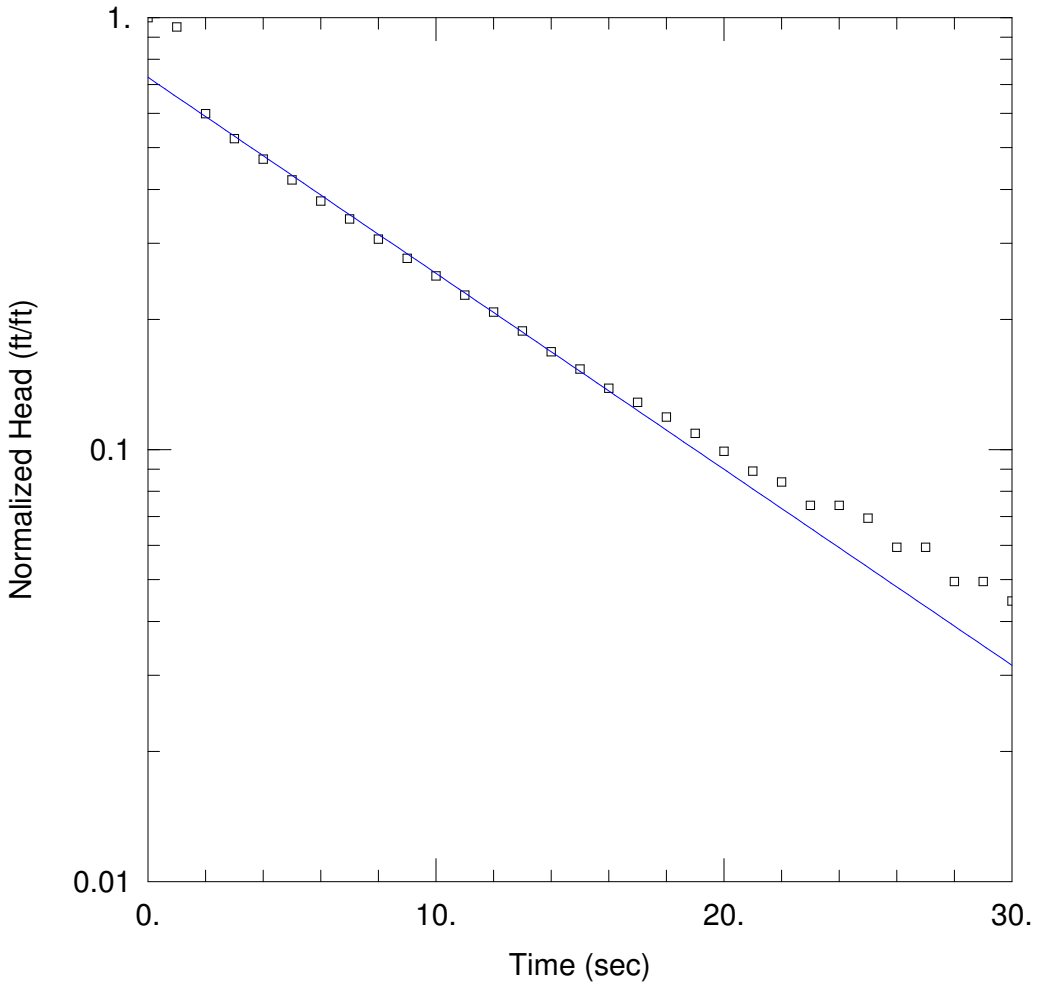
Saturated Thickness: 30. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-7)

Initial Displacement: 1.8 ft
Total Well Penetration Depth: 16.33 ft
Casing Radius: 0.083 ft
Static Water Column Height: 18.83 ft
Screen Length: 10. ft
Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.002468 cm/sec
y0 = 1.03 ft



MW-7 SLUG OUT

Data Set: P:\...\Hayden_MW-7_Slug_Out_BouwerRice.aqt
Date: 01/18/16 Time: 12:15:02

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Project: 266180
Location: Hayden Station
Test Well: MW-7
Test Date: 12/7/2015

AQUIFER DATA

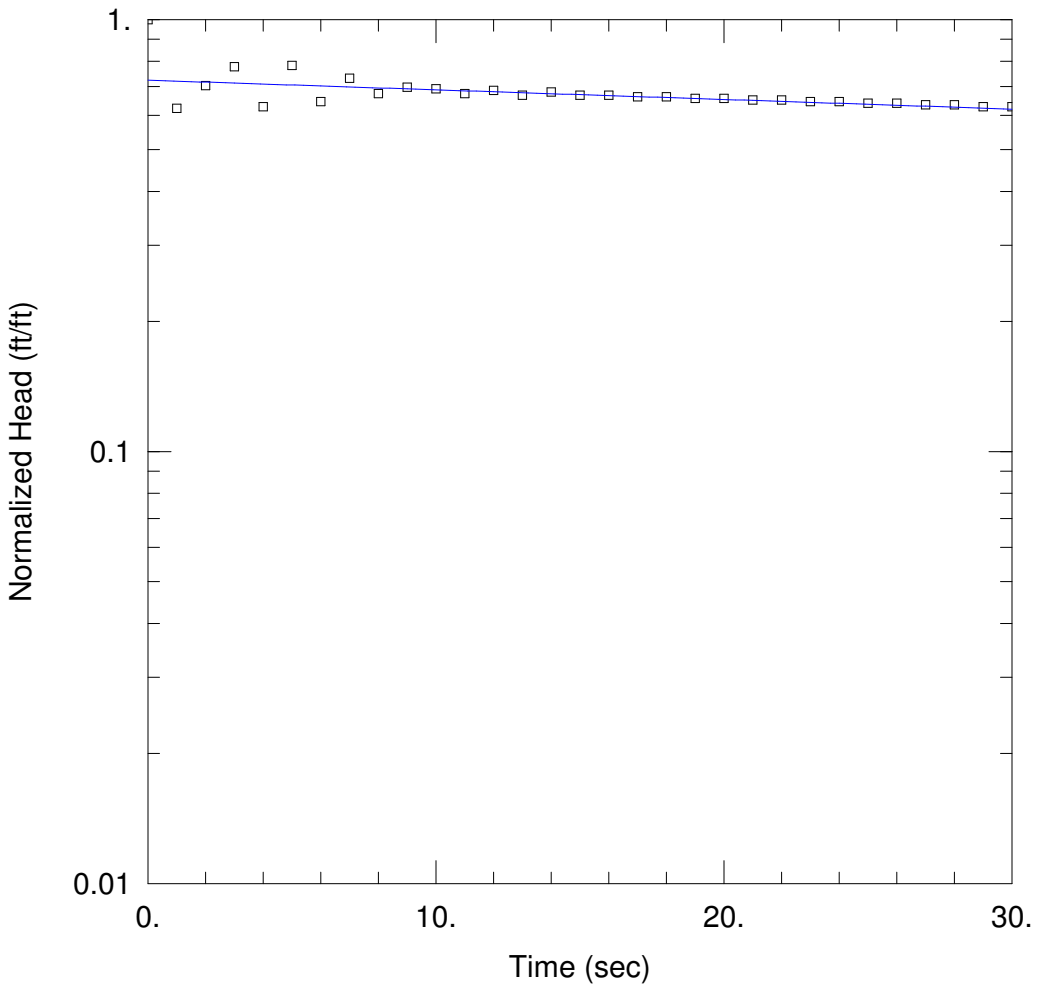
Saturated Thickness: 30. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-7)

Initial Displacement: 2.02 ft
Total Well Penetration Depth: 16.33 ft
Casing Radius: 0.083 ft
Static Water Column Height: 18.83 ft
Screen Length: 10. ft
Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.002653 cm/sec
y0 = 1.468 ft



MW-8 SLUG IN

Data Set: P:\...\Hayden_MW-8_Slug_In_BouwerRice.aqt
Date: 01/18/16 Time: 12:15:26

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Project: 266180
Location: Hayden Station
Test Well: MW-8
Test Date: 12/7/2015

AQUIFER DATA

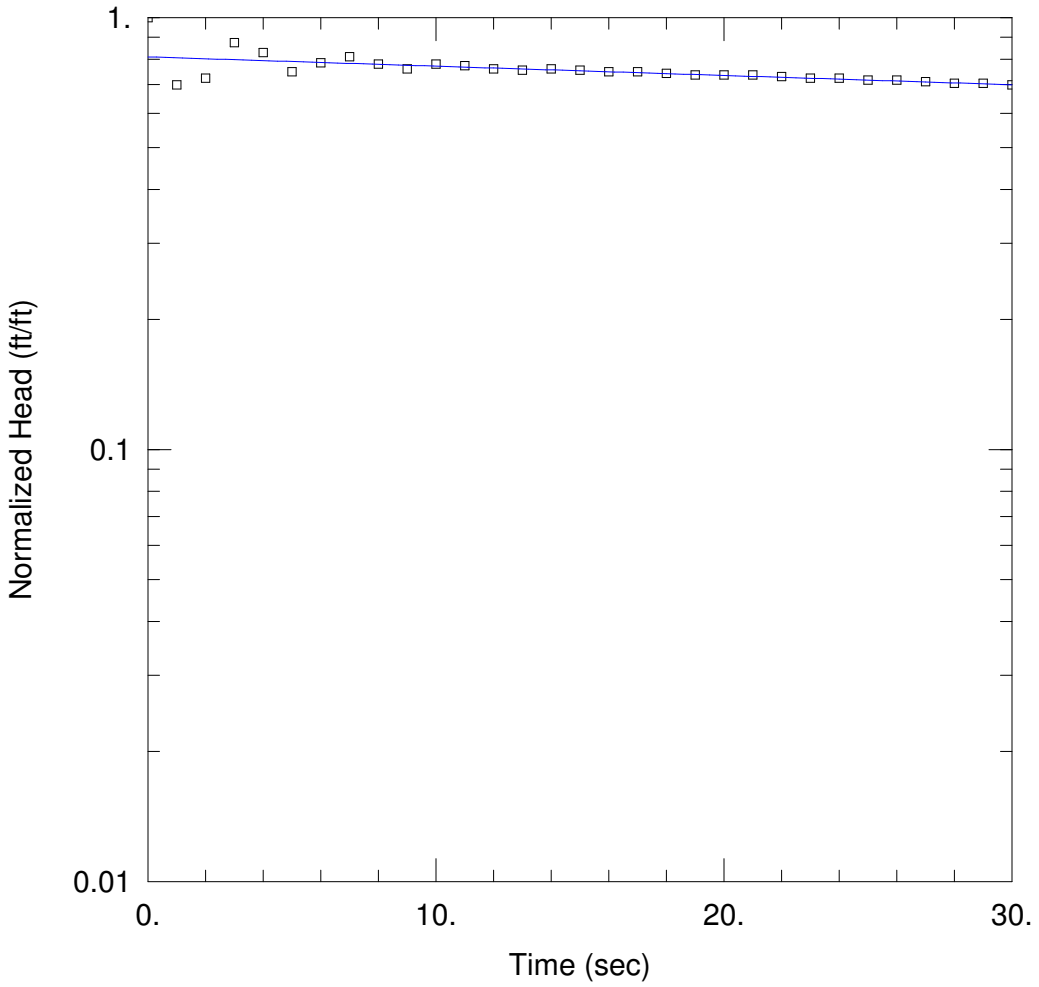
Saturated Thickness: 30. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-8)

Initial Displacement: 1.75 ft
Total Well Penetration Depth: 17.84 ft
Casing Radius: 0.083 ft
Static Water Column Height: 18.44 ft
Screen Length: 10. ft
Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.000133 cm/sec
y0 = 1.266 ft



MW-8 SLUG OUT

Data Set: P:\...\Hayden_MW-8_Slug_Out_BouwerRice.aqt
Date: 01/18/16 Time: 12:16:12

PROJECT INFORMATION

Company: HDR
Client: Xcel Energy
Project: 266180
Location: Hayden Station
Test Well: MW-8
Test Date: 12/7/2015

AQUIFER DATA

Saturated Thickness: 30. ft
Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (MW-8)

Initial Displacement: 1.59 ft
Total Well Penetration Depth: 17.84 ft
Casing Radius: 0.083 ft
Static Water Column Height: 18.44 ft
Screen Length: 10. ft
Well Radius: 0.33 ft

SOLUTION

Aquifer Model: Unconfined
Solution Method: Bouwer-Rice
K = 0.0001282 cm/sec
y0 = 1.289 ft