Hayden Station, Denver, Colorado

Groundwater Monitoring System Certification

for Compliance with the Coal Combustion Residuals (CCR) Rule

Hayden Station

Xcel Energy

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Table of Abbreviations and Acronyms

Abbreviation	Definition
ADF	Ash Disposal Facility
cm/sec	centimeters per second
CCR	Coal Combustion Residuals
EPA	U.S. Environmental Protection Agency
ft/ft	feet per foot

Certification

Groundwater Monitoring System for Compliance with the Coal Combustion Residuals Rule

Public Service Company of Colorado, an Xcel Energy Company

Hayden Station, Routt County, Colorado

I hereby certify that the groundwater monitoring system at Hayden Station is designed to meet the performance standard in Sections 257.91(a)(1) and (2) of the Federal Coal Combustion Residuals Rule, and that the groundwater monitoring system has been designed and constructed to ensure that the groundwater monitoring will meet this performance standard for the CCR unit located at Hayden Station.

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License Renewal Date October 31, 2019

1.0 Introduction

The U.S. Environmental Protection Agency's (EPA's) final Coal Combustion Residuals (CCR) Rule establishes a comprehensive set of requirements for the management and disposal of CCRs (or coal ash) in landfills and surface impoundments by electric utilities. Hayden Generating Station (Hayden Station) in Routt County, Colorado (**Figure 1**) has an ash disposal facility (ADF) subject to the CCR Rule (**Figure 2**).

This document supports compliance with the CCR Rule by demonstrating that the groundwater monitoring system at Hayden Station meets the requirements outlined in Section § 257.91 of the Rule. Specifically, this document satisfies requirements outlined in Section § 257.91 of the Rule, which states:

- Section § 257.91(f): *'The owner or operator must obtain a certification from a qualified professional engineer stating that the groundwater monitoring system has been designed and constructed to meet requirements of this section* [§257.91]. *If the groundwater monitoring system includes the minimum number of monitoring wells specified in paragraph (c)(1) of this section* [Section § 257.91], *the certification must document the basis supporting this determination*.'

Table 1 summarizes components required by groundwater monitoring systems, per the CCR Rule and the professional engineer's certification of compliance with these requirements. The remainder of this document provides information to support certification for the single unit groundwater monitoring system for the ash disposal facility at Hayden Station.

Table 1. Summary of 40 CFR Section § 257.91 Groundwater Monitoring System Requirements and Site-Specific Compliance

Groundwater Monitoring System Requirements	Compliance with Requirement
(a) *Performance standard.* The owner or operator of a CCR unit must install a groundwater monitoring system that consists of a sufficient number of wells, installed at appropriate locations and depths, to yield groundwater samples from the uppermost aquifer that: (1) Accurately represent the quality of background groundwater that has not been affected by leakage from a CCR unit. A determination of background quality may include sampling of wells that are not hydraulically upgradient of the CCR management area where: (i) Hydrogeologic conditions do not allow the owner or operator of the CCR unit to determine what wells are hydraulically upgradient; or (ii) Sampling at other wells will provide an indication of background groundwater quality that is as representative or more representative than that provided by the upgradient wells; and (2) Accurately represent the quality of groundwater passing the waste boundary of the CCR unit. The downgradient monitoring system must be installed at the waste boundary that ensures detection of groundwater contamination in the uppermost aquifer. All potential contaminant pathways must be monitored.	**Yes.** The direction of groundwater flow has been determined at the site; the groundwater monitoring system includes the minimum number of wells at appropriate locations and depths to yield groundwater samples necessary to meet performance standards (a)(1) and (a)(2). See Sections 3 and 4.

Table 1. Summary of 40 CFR Section § 257.91 Groundwater Monitoring System Requirements and Site-Specific Compliance	
Groundwater Monitoring System Requirements	**Compliance with Requirement**
(b) The number, spacing, and depths of monitoring systems shall be determined based upon site-specific technical information that must include thorough characterization of: (1) Aquifer thickness, groundwater flow rate, groundwater flow direction including seasonal and temporal fluctuations in groundwater flow; and (2) Saturated and unsaturated geologic units and fill materials overlying the uppermost aquifer, materials comprising the uppermost aquifer, and materials comprising the confining unit defining the lower boundary of the uppermost aquifer, including, but not limited to, thicknesses, stratigraphy, lithology, hydraulic conductivities, porosities and effective porosities.	**Yes.** The monitoring system was designed based on results of technical, site-specific data, including (b)(1) and (b)(2). See Sections 3 and 4.
(c) The groundwater monitoring system must include the minimum number of monitoring wells necessary to meet the performance standards specified in paragraph (a) of this section, based on the site-specific information specified in paragraph (b) of this section. The groundwater monitoring system must contain: (1) A minimum of one upgradient and three downgradient monitoring wells; and (2) Additional monitoring wells as necessary to accurately represent the quality of background groundwater that has not been affected by leakage from the CCR unit and the quality of groundwater passing the waste boundary of the CCR unit.	**Yes.** One well upgradient of the landfill and three downgradient wells were installed at the landfill waste boundary, and were completed in colluvium. However, the upgradient well in the colluvium is consistently dry. With no background water quality available in the colluvium, a well network (upgradient and three downgradient wells) in the alluvial aquifer located immediately downgradient of the landfill/colluvium is utilized for the landfill monitoring system. See Section 4.
(d) The owner or operator of multiple CCR units may install a multiunit groundwater monitoring system instead of separate groundwater monitoring systems for each CCR unit. (1) The multiunit groundwater monitoring system must be equally as capable of detecting monitored constituents at the waste boundary of the CCR unit as the individual groundwater monitoring system specified in paragraphs (a) through (c) of this section for each CCR unit based on the following factors:(i) Number, spacing, and orientation of each CCR unit; (ii) Hydrogeologic setting; (iii) Site history; and (iv) Engineering design of the CCR unit. (2) If the owner or operator elects to install a multiunit groundwater monitoring system, and if the multiunit system includes at least one existing unlined CCR surface impoundment as determined by §257.71(a), and if at any time after October 19, 2015 the owner or operator determines in any sampling event that the concentrations of one or more constituents listed in appendix IV to this part are detected at statistically significant levels above the groundwater protection standard established under §257.95(h) for the multiunit system, then all unlined CCR surface impoundments comprising the multiunit groundwater monitoring system are subject to the closure requirements under §257.101(a) to retrofit or close.	**Not Applicable**

Table 1. Summary of 40 CFR Section § 257.91 Groundwater Monitoring System Requirements and Site-Specific Compliance	
Groundwater Monitoring System Requirements	**Compliance with Requirement**
(e) Monitoring wells must be cased in a manner that maintains the integrity of the monitoring well borehole. This casing must be screened or perforated and packed with gravel or sand, where necessary, to enable collection of groundwater samples. The annular space (*i.e.,* the space between the borehole and well casing) above the sampling depth must be sealed to prevent contamination of samples and the groundwater. (1) The owner or operator of the CCR unit must document and include in the operating record the design, installation, development, and decommissioning of any monitoring wells, piezometers and other measurement, sampling, and analytical devices. The qualified professional engineer must be given access to this documentation when completing the groundwater monitoring system certification required under paragraph (f) of this section. (2) The monitoring wells, piezometers, and other measurement, sampling, and analytical devices must be operated and maintained so that they perform to the design specifications throughout the life of the monitoring program.	**Yes.** Well design meets requirements (e). See Section 4. Groundwater monitoring system will be operated and maintained per (e)(2).
(f) The owner or operator must obtain a certification from a qualified professional engineer stating that the groundwater monitoring system has been designed and constructed to meet the requirements of this section. If the groundwater monitoring system includes the minimum number of monitoring wells specified in paragraph (c)(1) of this section, the certification must document the basis supporting this determination.	**Yes.** System designed and constructed to meet the requirements of Section §257.91. Technical information to support certification and number of wells, per (c)(1). See Sections 2.0, 3.0 and 4.0.

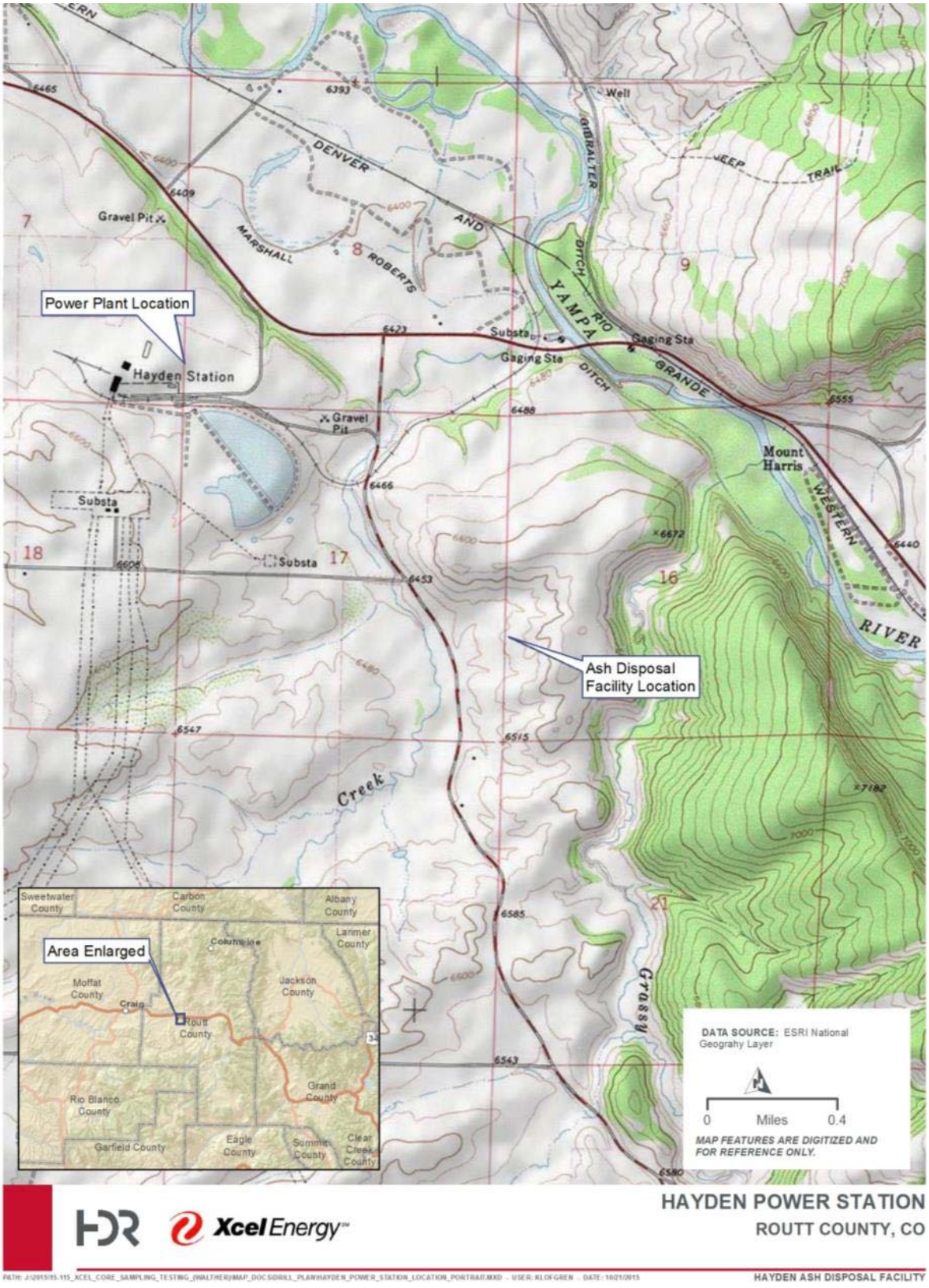

Figure 1. Vicinity Map for Hayden Station

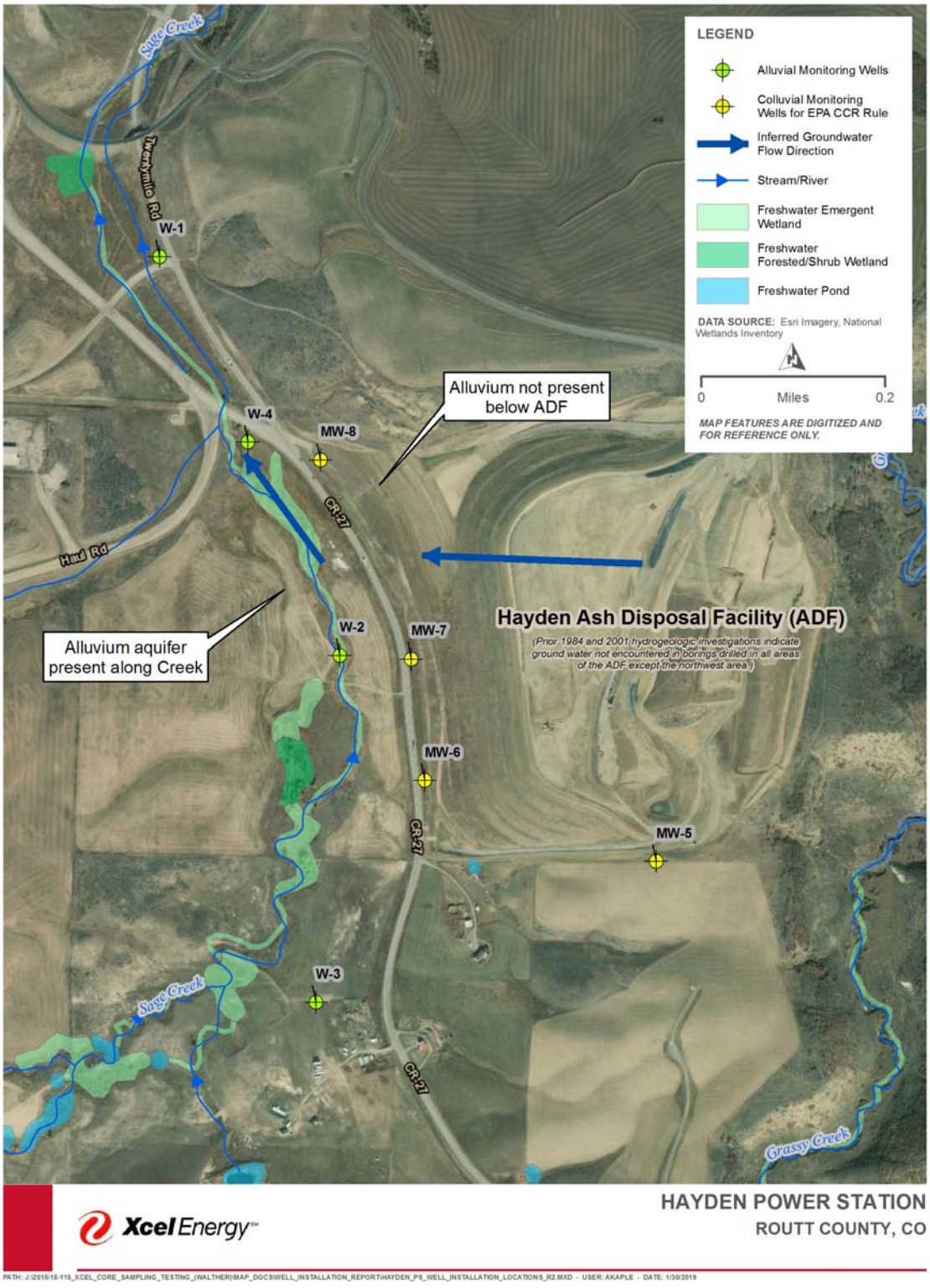

Figure 2. Hayden Station – CCR Unit and Monitoring Well Location Map

2.0 Facility Description

The Hayden Station is a joint venture facility owned by the Public Service Company of Colorado (PSCo), PacifiCorp, and the Salt River Project. PSCo is a wholly owned subsidiary of Xcel Energy. Hayden Station is a coal-fired, steam turbine electric generating station; the fuel source for the existing coal-fired units is sub-bituminous, low-sulfur coal supplied by several mines in western Colorado. Hayden Station uses water from the Yampa River and discharges no water offsite. Hayden Station began operating in 1965 (Unit 1), with the addition of Unit 2 in 1976. All CCR generated at the Station is stored in an Ash Disposal Facility (ADF), which is characterized as a landfill. The ADF is the only CCR unit at Hayden Generating Station.

The ADF is located on Routt County Road 27 approximately 1 mile south of Colorado Highway 40 in Routt County, Colorado (**Figure 2)**. The wastes accepted at the ADF consist of coal ash, air emission control byproducts, water intake silt, excavation soils, and coal impurities. The area inside the permitted boundary of the ADF consists of approximately 154 acres of which approximately 136 acres is used for ash disposal and approximately 18 acres for stormwater control structures, access roads, and borrow area (Walsh Environmental Scientists and Engineers, 2013). The landfill does not have an engineered liner, but is underlain by the Lewis Shale formation, which acts as an aquitard and confining layer. The Lewis Shale can be as thick as 1900 feet; however, at the Hayden site it is likely between 100 and 200 feet thick (Robson and Stewart, 1990).

3.0 Site Hydrogeology/Geology

Prior hydrogeologic investigations have been conducted at Hayden Station as documented in the following reports and summarized in the text below:

- Eight borings and monitoring wells (HD-1 to HD-8) were first installed on the site in 1984. The logs for these borings are presented in the 2001 report by Xcel (Xcel, 2001).
- The 2001 Environmental Monitoring System Installation Report documents installation of three new monitoring wells (W-1 to W-3) to the west of the landfill along Sage Creek and two soil borings on the landfill (to characterize landfill waste types) and groundwater quality monitoring (Xcel, 2001).
- A 2014 Ground Water Monitoring report describes the results of groundwater monitoring at the three monitoring wells located west of the landfill (Xcel, 2014).
- The 2013 Engineering Design and Operation Plan describes the physical characteristics of the ADF and landfill closure design plans (Walsh, 2013).

The ash landfill is located on a west-facing hillslope that drains to Sage Creek (**Figure 2**). The top of the slope is the east side of the landfill which forms a drainage divide between Grassy Creek and Sage Creek. Sage Creek and Grassy Creek flow to the north.

The prior hydrogeologic investigation conducted in 1984 (former wells HD-1 to HD-8) reported that the soil underlying the landfill is colluvium consisting of silty clay or clay to a depth of 9 to 24 feet, which is underlain by shale bedrock of the Lewis Shale Formation (Walsh, 2001). The Lewis Shale Formation surface slopes down to the west/northwest towards Sage Creek (Walsh,

2001). 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 landfill wells described in Walsh (2001) were dry with the exception of HD-1 to the northwest near County Road 27, which was wet at the top of bedrock at about 24 feet below grade and had a measured water level elevation of 6,434.7 feet amsl in October 2001. The wells were completed to a depth of 15 to 25 feet. Wells HD-1 to HD-8 have been abandoned.

To the west of the ash landfill, the uppermost aquifer is within the alluvium deposited along the Sage Creek valley. Monitoring wells W-1, W-2, and W-3 were drilled to a depth of 15 to 20 feet in 2001 and encountered layers of sand and gravel alternating with finer-grained layers of sand, silt and clay. Groundwater was encountered from 5 to 10 feet below grade (Xcel, 2001). However, these wells were not located at the waste boundary per 257.91(a)(2), so were not included in the original groundwater monitoring system.

Groundwater encountered west of the ADF, along CR-27, will partially infiltrate into the bedrock on a limited basis, but will primarily flow within the colluvium above the bedrock contact and ultimately discharge to Sage Creek. Groundwater in the alluvium present in the Sage Creek valley bottom flows to the north.

4.0 Monitoring Wells

The CCR Rule requires, at a minimum, one upgradient and three downgradient monitoring wells per CCR unit to be completed in the uppermost aquifer. In addition, the CCR Rule states that downgradient monitoring wells should be installed to: *"accurately represent the quality of groundwater passing the waste boundary of the CCR unit. The downgradient monitoring system must be installed at the waste boundary that ensures detection of groundwater contamination in the uppermost aquifer."*

Based on the CCR requirements, hydrogeological data, and site visits, four wells were originally sited for CCR compliance to serve as one upgradient and three downgradient monitoring wells at the waste boundary **(Figure 2)**. Hepworth-Pawlak Geotechnical, Inc. (HP Geotech) drilled four monitoring wells at Hayden in November 2015.

Upgradient Monitoring Well

The original upgradient well (MW-5) is located to the southeast of the ash landfill (**Figure 2**). This location is upgradient from the landfill and also upgradient from an existing stormwater pond. This location did not encounter groundwater during drilling.

Downgradient Monitoring Wells

The potential flow of groundwater is perpendicular to the length of the ADF. Therefore downgradient monitoring wells to evaluate potential impacts to groundwater from the ADF are located to the west of the ADF, at the waste boundary.

All three original downgradient wells (MW-6, 7 and 8, see **Figure 2**) are located immediately west of the ADF, and east of CR-27. The three downgradient wells are spaced along the length of the ADF at the waste boundary of the CCR unit to ensure the water quality from these three locations will

detect constituents from the CCR unit, if present. All three downgradient wells are completed below the water table.

These original four monitoring wells (MW-5 through MW-8) were completed in the colluvium that underlies the landfill and above the Lewis bedrock shale. The upgradient colluvial monitoring well MW-5 has continued to be dry since program implementation and comparison of upgradient and downgradient groundwater chemistry in the colluvial wells has not been possible.

The colluvium under the landfill discharges to the adjacent alluvial aquifer of Sage Creek. Based on the site hydrogeology and westerly sloping bedrock surface, impacts to groundwater in colluvium under the landfill should be observable in the alluvial aquifer downgradient of the landfill waste boundary. Therefore, existing monitoring wells in the adjacent alluvial aquifer (W-1, W-2, W-3, and W-4) are being added to the monitoring system for the landfill to supplement the colluvial monitoring wells (**Figure 2**). These four wells are screened in the alluvial aquifer west of the waste boundary (**Figure 2**). One upgradient well (W-3) is located southwest of the landfill to represent background water quality conditions that have not been impacted by the CCR unit. Three downgradient wells (W-1, W-2, and W-4) are located west and northwest of the landfill waste boundary, and are capable of detecting impacts in groundwater that passes the waste boundary in compliance with the CCR Rule, (**Figure 2**).

4.1 Well Construction

All CCR monitoring wells were drilled by a licensed well driller using a nominal 6-inch diameter hollow-stem auger drilling method. Groundwater in the colluvium below the landfill will primarily flow within the colluvium above the bedrock contact (where MW-5 through MW-8 are located), infiltrate into the bedrock on a very limited basis, and ultimately discharge to Sage Creek alluvial aquifer where wells W-1 through W-4 are located. Therefore wells MW-5 through MW-8 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. Colluvial monitoring well screens in the three downgradient wells are located immediately above the bedrock to capture water in the uppermost water bearing unit at the waste boundary that could be impacted by the landfill. Colluvial well depths range from 20.75 to 36 feet below ground surface (bgs).

The water table was encountered at the four alluvial borings in W-1 through W-4 and well screens were placed approximately ten feet below the water table in the alluvial aquifer to capture water in the uppermost water bearing unit that could be impacted by the landfill (**Table 2**). All monitoring wells are 2-inch diameter, Schedule 40 PVC casing and screen with 0.010-inch screen slots.

Table 2. Monitoring Well Construction											
Well I.D.	**Easting**	**Northing**	**Elevation TOC (ft)**	**Well Total Depth (ft bgs)**	**Screen Interval (ft bgs)**	**Well Stickup (ft)**	**Well Type**	**Static WL (ft TOC) November 2015**	**Well Permit Number**	**Approximate Depth Shale if encountered (ft bgs)**	**Well Location Relative to Landfill**
	NAD 1983 UTM Zone 13N, Meter										
MW-5	316881.2113	4482210.262	6617.17	20.75	10.75-20.75	3.89	2-inch PVC	dry	299818	14	Upgradient (colluvial)
MW-6	316475.5933	4482351.157	6476.71	25.00	14.67-24.67	3.94	2-inch PVC	14.88	299817	20	Downgradient (colluvial)
MW-7	316452.08	4482565.443	6475.00	30.00	18.5-28.5	3.44	2-inch PVC	15.66	299819	Not Encountered	Downgradient (colluvial)
MW-8	316292.5404	4482914.221	6465.77	36.00	25.4-35.4	3.72	2-inch PVC	21.33	299820	33	Downgradient (colluvial)
W-1	316010.2902	4483272.838	6439.78	20.00	5.0-20.0	2.58	2-inch PVC	12.17*	40083	Not Encountered	Downgradient (alluvial)
W-2	316326.4809	4482571.379	6448.19	18.4	8.4-18.4	2.49	2-inch PVC	6.71*	40084	Not Encountered	Downgradient (alluvial)
W-3	316284.6864	4481962.36	6460.88	16.3	6.3-16.3	2.58	2-inch PVC	9.38*	40085	Not Encountered	Upgradient (alluvial)
W-4	316165.5838	4482945.665	6450.69	20.00	10.0-20.0	2.80	2-inch PVC	6.82*	56532	Not Encountered	Downgradient (alluvial)

bgs = below ground surface
TOC = top of casing
*October 2017

5.0 Groundwater Quality Sampling

5.1 Schedule

In accordance with CCR Rule 257.94, eight rounds of background sampling were completed in the original colluvial wells (MW-5, MW-6, MW-7, and MW-8), where water was present, on a quarterly frequency before October 17, 2017. After completion of background sampling, semi-annual detection monitoring was initiated in 2018. Samples were analyzed for Appendix III COIs (Table 1). Detection monitoring in MW-6, MW-7, and MW-8 will continue, as long is water is present in these wells. However, since MW-5 has been continuously dry, it is not possible to develop background water quality data in the upgradient colluvial well. Therefore, four alluvial wells (W-1, W-2, W-3 and W-4) were added to the monitoring system in 2018, to supplement the original colluvial well system. As discussed in Section 4, the upgradient alluvial well represents background water quality conditions that have not been impacted by the CCR unit, and the three downgradient alluvial wells (W-1, W-2, and W-4) are capable of detecting impacts in groundwater that passes the waste boundary in compliance with the CCR Rule.

As stipulated in the CCR Rule, eight rounds of background groundwater sampling were completed in 2018 in the alluvial monitoring wells west of the landfill. Sampling was conducted on a monthly frequency, between April and November 2018. Samples were collected from the alluvial monitoring wells (W-1, W-2, W-3, and W-4). Samples were analyzed for Appendix III and IV COIs plus total suspended solids (TSS) (**Table 1**). Detection monitoring will be initiated in the alluvial wells in 2019.

The expanded groundwater monitoring system continues to meet the requirements of 257.91. Three colluvial wells located at the waste boundary will continue to be sampled for detection monitoring constituents in Appendix III. However, since the upgradient colluvial well continues to be dry, it is not possible to compare the downgradient wells to upgradient colluvial water quality. Therefore, four alluvial wells have been added to the monitoring system. The upgradient alluvial well represents background water quality conditions that have not been impacted by the CCR unit. The three downgradient alluvial wells are capable of detecting impacts in groundwater that passes the waste boundary, and results can be statistically evaluated and compared to the background water quality in the upgradient alluvial well.

Samples are collected following the protocol in the Xcel Energy Groundwater Sample Collection Standard Operating Procedure (HDR, 2015c). Groundwater quality sampling is conducted in all upgradient and downgradient monitoring wells unless wells are dry. In accordance with the CCR Rule, groundwater samples are not field filtered. The field parameters of turbidity, pH, and temperature are measured using a YSI Professional Plus (or an equivalent) portable water quality instrument that has been calibrated prior to use.

5.2 Analytical testing

Analytical testing of groundwater samples are performed by TestAmerica or other EPA certified laboratory. Samples were analyzed for the parameters shown on **Table 3**, which include all of the parameters in Appendices III and IV of Part 257 for the initial eight background sample events, plus Total Suspended Solids (TSS). For detection monitoring, the constituents listed in Appendix III will be analyzed. Subsequent sampling events will be analyzed for the constituents listed in

Appendix III or IV as appropriate, based upon the results of previous sampling and statistical evaluation of results. For quality control, one field duplicate sample and one field equipment blank sample will be collected for each sample event. The laboratory will analyze matrix spike/matrix spike duplicates at a rate of 5 percent, per laboratory quality control standards.

Table 3. Groundwater Quality Parameters
Appendix III Constituents for Detection Monitoring
Boron
Calcium
Chloride
Fluoride
pH
Sulfate
Total Dissolved Solids (TDS)
Appendix IV Constituents for Assessment Monitoring
Antimony
Arsenic
Barium
Beryllium
Cadmium
Chromium
Cobalt
Fluoride
Lead
Lithium
Mercury
Molybdenum
Selenium
Thallium
Radium 226 and 228 combined
Additional Parameters
Total Suspended Solids (TSS)

6.0 Reporting

The CCR Rule 297.90(e) identifies the reporting requirements for the groundwater monitoring program for the CCR units. The annual reporting documents will be developed no later than January 31, 2018 and annually thereafter. The annual reports will be placed in the Hayden operating record. The data validation, verification, and statistical methods used to analyze each specified constituent in each monitoring well is described in a separate Data Management and Statistical Procedures Plan. Since the upgradient colluvial well (MW-5) does not produce water, it is not possible to conduct a statistical evaluation of results from the downgradient colluvial wells (MW-6, MW-7, and MW-8) to

MW-5. It is also not appropriate to compare colluvial water quality to alluvial water quality. Therefore, detection monitoring results from the three downgradient colluvial wells will continue to be reported, but not statistically evaluated; in essence they will function as sentinel wells. The alluvial wells will be used to statistically compare downgradient wells to upgradient background water quality.

Annual reports will summarize key monitoring actions completed, describe any problems encountered, discuss actions to resolve the problems, and project key activities for the upcoming year. For CCR compliance, Xcel Energy will file the report in the facility operating records.

Xcel will comply with the CCR Rule recordkeeping requirements specified in § 257.105(h), notification requirements specified in § 257.106(h), and internet requirements specified in § 257.107(h).

7.0 References

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

HDR, 2015b. Monitoring Well Installation Report for Compliance with the Coal Combustion Residuals (CCR) Rule, Xcel Energy Hayden Station. January 25, 2016.

HDR, 2015c. Groundwater Sample Collection Standard Operating Procedure for Compliance with the Coal Combustion Residuals (CCR) Rule, Xcel Energy.

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