Groundwater Monitoring System Certification

for Compliance with the Coal Combustion Residuals (CCR) Rule

Cherokee Station

Xcel Energy

April 26, 2016

Cherokee Station, Denver, Colorado

CERTIFICATION

Groundwater Monitoring System for Compliance
with the Coal Combustion Residuals Rule
Public Service Company of Colorado, an Xcel Energy Company
Cherokee Station, Denver, Colorado

I hereby certify that the groundwater monitoring system at Cherokee Station is designed to meet the performance standard in Sections 257.91(a)(1) and (2) of the Federal Coal Combustion Residuals (CCR) Rule, and that the groundwater monitoring system has been designed and constructed to ensure that the groundwater monitoring will meet this performance standard for all active CCR units. Cherokee Station is owned by the Public Service Company of Colorado (PSCo), an Xcel Energy Company, and is located in Denver, Colorado.

I am duly licensed Professional Engineer under the laws of the State of Colorado.

Gokhan Inci, PE (Colorado PE 0048172) April 18, 2016

My license renewal date is October 31, 2017

Table of Contents

List of Tables

List of Figures

Table of Abbreviations and Acronyms

Abbreviation	Definition
cm/sec	centimeters per second
CCR	Coal Combustion Residuals
EPA	U.S. Environmental Protection Agency
ft/ft	feet per foot
TSS	Total Suspended Solids

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 CCR (or coal ash) in landfills and surface impoundments by electric utilities. Cherokee Station, located in Denver, Colorado (**Figure 1**), has three incised impoundments subject to the CCR Rule: the West, Center, and East bottom ash impoundments (**Figure 2**).

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

- Section § 257.91(f): *'The owner or operation 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 multiunit groundwater monitoring system for the three CCR units (impoundments) at Cherokee 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.
(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.

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

Groundwater Monitoring System Requirements	Compliance with Requirement
(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 upgradient and three downgradient wells that meet the performance standards are being monitored in compliance with the CCR Rule. 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.	**Yes.** A multiunit system capable of detecting monitored constituents per (d)(1) was installed. See Sections 2 and 4. The 3 CCR impoundments are unlined. Requirements per (d)(2) will be followed.
(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.

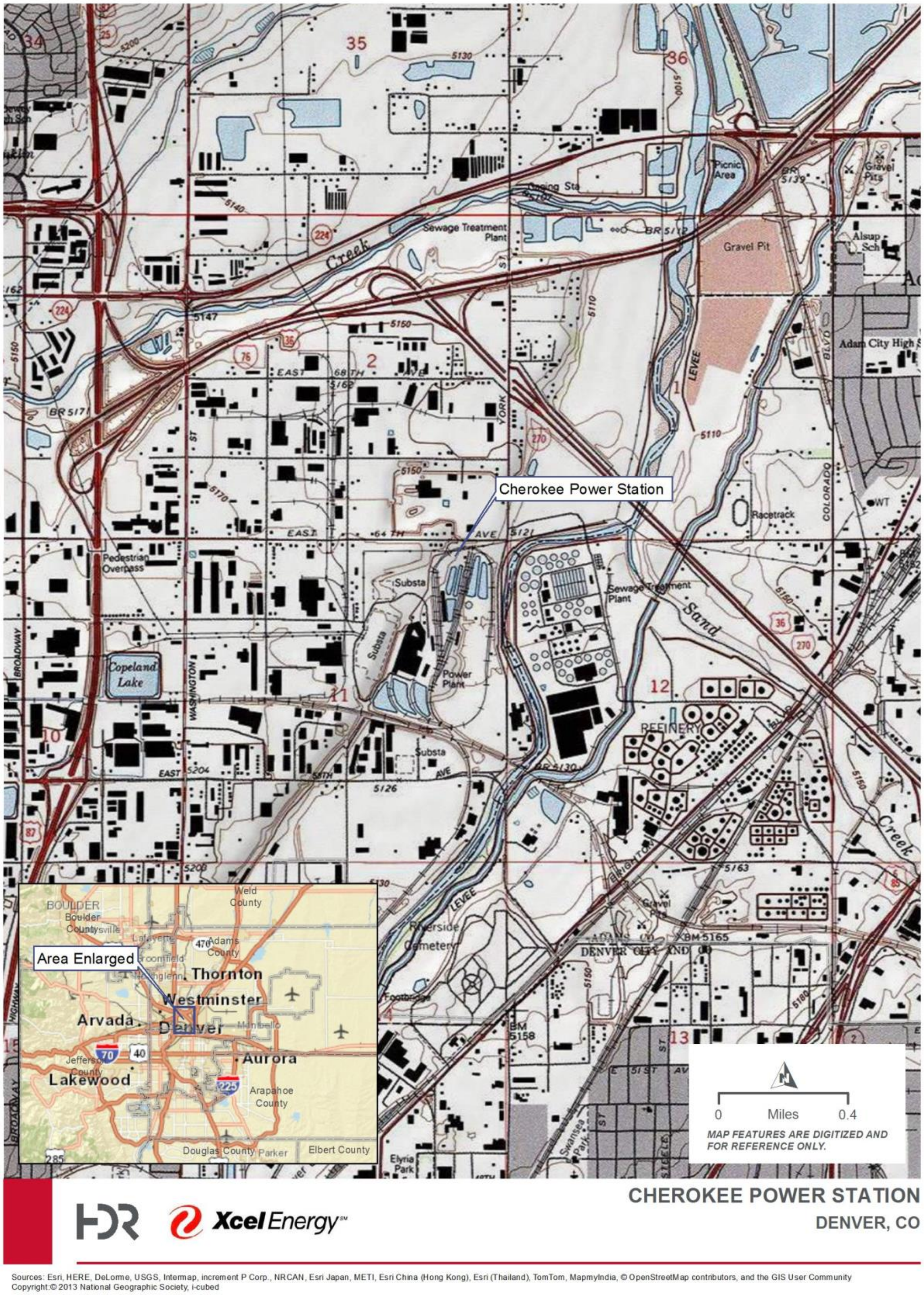

Figure 1. Vicinity Map for Cherokee Station

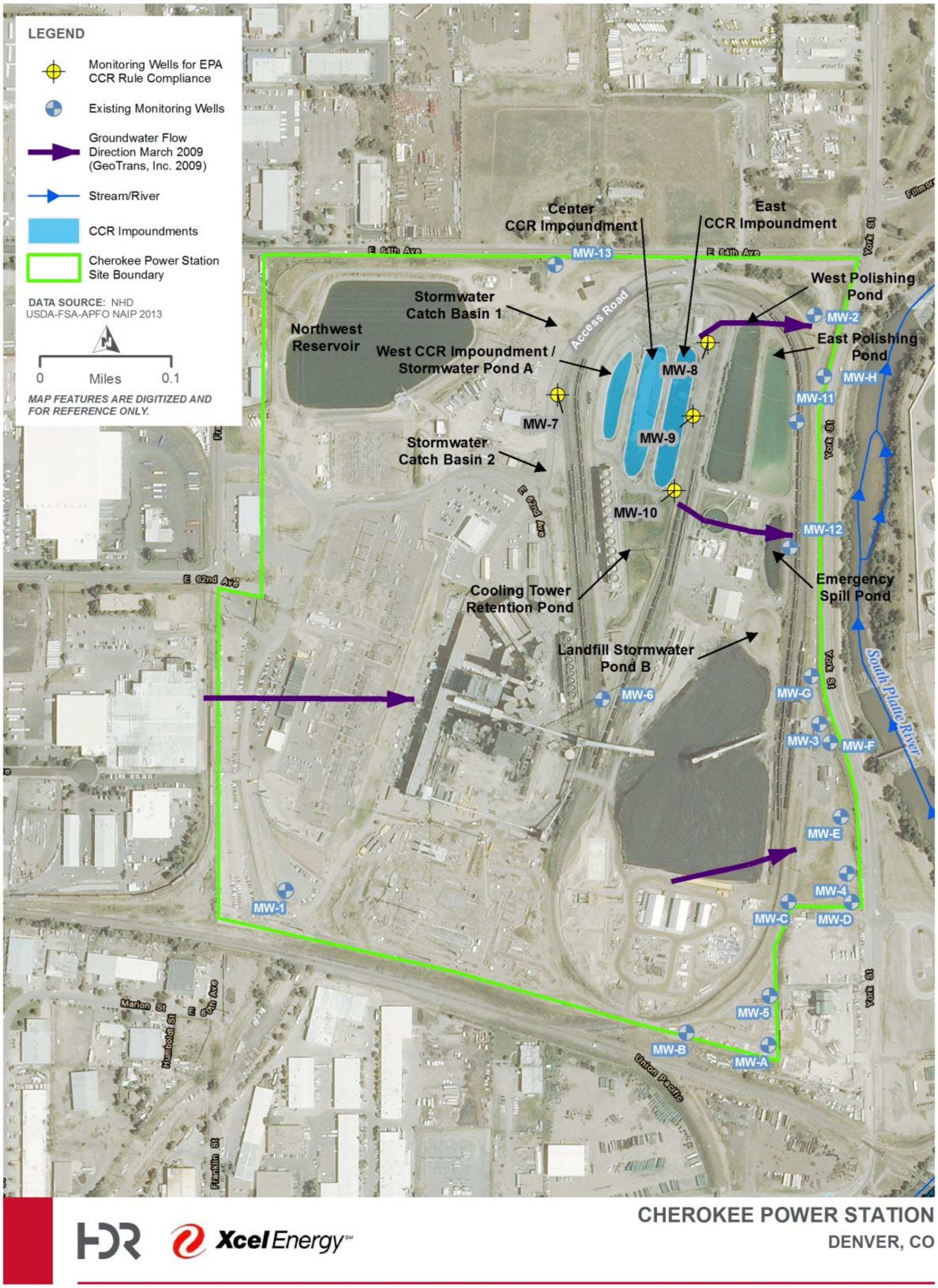

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Figure 2. Cherokee Station – CCR Units and Monitoring Well Location Map

2.0 Facility Description

Cherokee 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. Cherokee Station uses and returns water to the Platte River, and the plant has strict standards for all water discharged back in to the river. Cherokee Station began operating in 1957 (Unit 1). Unit 2 went into service in 1959 and Unit 3 and Unit 4 in the 1960s. Cherokee Station is undergoing a complete makeover as part of the Colorado Clean Air – Clean Jobs Act (HB 10-1365) signed on April 19, 2010. As a result, Units 1 and 2 have been retired. The plan also involves adding a new combined cycle facility, rated at approximately 530 megawatts and converting Unit 4 from coal to natural gas at the end of 2017. Unit 3 will be retired shortly after the new combined cycle facility comes on line.

Cherokee Station currently has three incised impoundments that are used for storage of CCR: the West, Center, and East impoundments (**Figure 2**). All three CCR impoundments do not contain engineered low-permeability liners. Bottom ash is currently sluiced to the Center and the East CCR impoundments. Fly ash is handled dry and collected in on-site silos. Both bottom ash and fly ash are hauled off-site to facilities permitted for either beneficial use or disposal. The sections that follow provide a brief description of the three CCR impoundments.

Additional ponds at the facility include emergency spill, stormwater, polishing, and cooling water ponds. These units do not hold CCR, and therefore are not considered CCR units, in compliance with the CCR Rule:

> *"CCR surface impoundments do not include units generally referred to as cooling water ponds, process water ponds, wastewater treatment ponds, storm water holding ponds, or aeration ponds. These units are not designed to hold an accumulation of CCR, and in fact, do not generally contain significant amounts of CCR."*

2.1 West CCR Impoundment/Stormwater Pond A

The West CCR Impoundment/Stormwater Pond A was initially constructed in 1957 and modified in 2012. The original dimensions were approximately 20 feet deep, 455 feet long, and 90 feet wide, with a surface area of approximately 0.94 acre (Tetra Tech, 2013). The West CCR impoundment is unlined. Historically, it received influent water from sluiced bottom ash as well as other sources. In 2012, it was converted for use as a stormwater pond and currently receives only stormwater from the northwest portion of the site and emergency overflow from the Northwest Reservoir (TetraTech, 2013). Prior to the 2012 modification, some but not all of the ash from this impoundment was removed.

During the 2012 modification, the side slopes were re-graded and covered with clean fill; and clean fill was placed on the pond bottom to bring it up to the current depth of about 9 feet. Inlets to the pond were armored with riprap to prevent erosion of the side slopes. Outflow is routed into the lift station and through the wastewater treatment process. The impoundment volume is approximately 6.8 acre-feet. After the 2017 fuel conversion from coal to gas, this pond will be closed.

2.2 Center CCR Impoundment

The Center CCR Impoundment was constructed in 1957 and is unlined. It has a depth of approximately 20 feet. It is approximately 520 feet long and 80 feet wide, with a surface area of approximately 0.48 acre (Tetra Tech, 2013). The Center CCR Impoundment's primary influent water source is sluiced bottom ash from Unit 3 and Unit 4, but it also receives other influent sources (yard sumps, micro/nano filtration backwash, boiler seal water, and clarifier underflow). Effluent water is routed into the lift station and through the wastewater treatment process. After the 2017 fuel conversion from coal to gas, this pond will be closed.

2.3 East CCR Impoundment

The East CCR Impoundment was constructed in 1957 and is unlined. It has a depth of approximately 20 feet. It is approximately 580 feet long and 90 feet wide, with a surface area of approximately 1.14 acres (Tetra Tech, 2013). Sluiced bottom ash is the primary source of water influent into the East CCR Impoundment, although other influent sources (yard sumps, micro/nano filtration backwash, boiler seal water, and clarifier underflow) also contribute to the East Impoundment. Effluent water is routed into the lift station and through the wastewater treatment process. After the 2017 fuel conversion from coal to gas, this pond will be closed.

3.0 Site Hydrogeology/Geology

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

- March 2009 Groundwater/Surface-Ponds Data Evaluation (GeoTrans, Inc., 2009)
- Surface Water Impoundment Infiltration Characterization Analysis (GeoTrans, Inc., 2010)
- Inventory and Preliminary Classification Report, Waste Impoundments (Tetra Tech, 2013)

The uppermost aquifer under Cherokee Station is the alluvial aquifer associated with the nearby South Platte River and is present across the site. Groundwater under the facility flows east, perpendicular to the South Platte River, where it ultimately discharges to the river (GeoTrans, Inc., 2009). A total of 14 existing monitoring wells (MW-1 to MW-6 and MW-A to MW-H) are located throughout the facility. The static groundwater level is shallow, measured between 7 and 20 feet below the top of monitoring well casings in 2009 by GeoTrans, Inc. (2009). The alluvial aquifer is between 8 and 38 feet thick, mostly sandy, in the area of the impoundments and is underlain by the low permeability claystone deposits of the Denver Formation that inhibits vertical downward flow to the deeper, regional Arapahoe Aquifer (GeoTrans, Inc. 2009). The Denver Formation is over 70 feet thick in this area (CDH, 1993).

The hydraulic gradient under the western half of the facility is approximately 0.017 feet per foot (ft/ft); however, the hydraulic gradient between the CCR impoundments and the eastern property boundary is about 0.39 ft/ft (GeoTrans, Inc., 2009). The permeability of the alluvial aquifer is unknown; however, GeoTrans, Inc. (2009) assumed horizontal hydraulic conductivity of $1x10^{-3}$ centimeters per second (cm/sec) for alluvial deposits based on a hydraulic conductivity value of $5x10^{-3}$ cm/sec that was established for similar alluvial deposits approximately 2 miles from this site. GeoTrans, Inc. (2009) calculated groundwater velocities across the site is expected to be approximately 90 to 200 feet per year.

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. Section 257.9 of the Rule states that the operator: *"…may install a multiunit groundwater monitoring system instead of separate groundwater monitoring systems for each CCR unit."* 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 sited for CCR compliance to serve as one upgradient and three downgradient monitoring wells **(Figure 2)**. Site Services, LLC drilled four monitoring wells at Cherokee in November 2015.

<u>Upgradient Monitoring Well</u>

The upgradient well (MW-7) is located west of the three CCR units, on the west side of the railroad tracks (**Figure 2**). The flow of groundwater is eastward, perpendicular to the length of the impoundments, such that the MW-7 well location on the west side of the West Impoundment is upgradient of all three of the impoundments (GeoTrans, Inc., 2009). Thus, water quality from the MW-7 location will accurately represent the quality of background groundwater that has not been affected by leakage from the CCR unit. In the event that MW-7 is determined to be impacted by groundwater mounding such that it does not represent background water quality, MW-13 will be used as the background well for CCR monitoring.

<u>Downgradient Monitoring Wells</u>

The flow of groundwater is perpendicular to the length of the impoundments, such that installation of downgradient monitoring wells to the east of the East Impoundment will monitor potential impacts to groundwater from all three CCR units. There is inadequate access for drilling between the impoundments; therefore, a multi-unit monitoring network, consisting of three wells, was installed along the boundary of the furthest downgradient impoundment (east side of the East Impoundment).

All three downgradient wells (MW-8, 9, and 10; see **Figure 2**) were installed immediately east of the East Impoundment, and west of the access road and rail spur that separate the CCR units from other down gradient non-CCR impoundments. The three downgradient wells are spaced approximately equidistant from one another along the length of the impoundment. Each downgradient well is located 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.

4.1 Well Construction

The boreholes for each well were drilled by a licensed well driller. All wells were drilled to a depth of 10 feet below the water table, or to the top of the claystone Denver Formation, whichever was shallower. The placement of the monitoring wells screens just above the bedrock was designed for capturing water in the uppermost aquifer, which is the alluvial aquifer, which could be impacted by the CCR impoundments. Alluvial groundwater above the bedrock will partially infiltrate into the bedrock on a limited basis, but will primarily flow within the alluvium above the bedrock and discharge to the South Platte River. Therefore, screens were designed to capture the uppermost alluvial groundwater.

Each well was constructed with 2-inch diameter, Schedule 40 PVC casing and screen with 0.010-inch screen slots. Design of monitoring wells commonly includes screens that are 10 feet long. However, at wells MW-7 and MW-8, 5-foot screens were installed due to encountering the claystone bedrock at 8 and 12 feet below ground surface, respectively. At wells MW-7, MW-8, MW-9, and MW-10, bedrock was encountered during drilling and the bottom of the well screen was set just below the bottom of the bedrock contact. In these wells the entire screen may not be saturated. A 10-20 washed silica sand was used for the filter pack and placed approximately 5 feet above the well screen. An annular seal of coated bentonite pellets was placed from the top of the filter pack to the surface and hydrated after placement. Monitoring wells were developed and surveyed by a licensed professional surveyor after construction.

Table 2. Monitoring Well Construction

Well I.D.	Northing	Easting	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 of Denver Formation (claystone) if encountered (ft bgs)
	(State Plane, NAD 83, feet)									
MW-7	1174504.066	3150639.147	5153.86	8.00	3.00-8.00	1.16	2-inch PVC	5.14	299988	8.0
MW-8	1174717.548	3151242.333	5140.64	13.92	8.92-13.92	1.25	2-inch PVC	9.50	299989	12.0
MW-9	1174422.363	3151184.273	5141.26	24.75	14.75-24.75	1.57	2-inch PVC	20.62	299990	22.0
MW-10	1174121.514	3151111.600	5140.88	40.21	30.21-40.21	1.59	2-inch PVC	27.62	299991	38.0
MW-13	1175028.413	3150625.296	5174.50	32.00	12.00-32.00	2.05	2-inch PVC	27.75	299993	31.00

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

5.0 Groundwater Quality Sampling

5.1 Schedule

Sampling is conducted at a frequency compliant with CCR Part 257.94. Eight rounds of upgradient and downgradient monitoring well sampling will be completed before October 17, 2017. These samples will represent background water quality. Groundwater sampling will be conducted quarterly between fourth quarter 2015 and third quarter 2017. After eight rounds of sampling to establish background water quality, semi-annual (twice per year) groundwater detection monitoring will be initiated. Groundwater quality sampling will be conducted in all upgradient and downgradient monitoring wells unless wells are dry. Samples will be collected using a low-flow sampling method. In accordance with the CCR Rule, groundwater samples will not be field filtered. The field parameters of turbidity, pH, and temperature will be 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 will be performed by TestAmerica or other EPA certified laboratory. Samples will be 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 subsequent events, it is anticipated the parameters listed in Appendix III will be analyzed, unless assessment monitoring is required. 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

Table 3. Groundwater Quality Parameters
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 Cherokee operating record. The data validation, verification, and statistical methods used to analyze each specified constituent in each monitoring well is described in a separate Statistical Methods Certification document.

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

Colorado Department of Health (CDH), 1993. Record of Decision ASARCO Globe Plant Site. Denver, Colorado. February 18, 1993.

GeoTrans, Inc., 2009. Letter to Christine Johnston, Xcel Energy. Groundwater/Surface-Ponds Data Evaluation, Cherokee Station, Denver, Colorado. March 2009.

GeoTrans, Inc., 2010. Letter to Christine Johnston, Xcel Energy. Surface Water Impoundment Infiltration Characterization Analysis, Cherokee Station, Denver, Colorado. September 2010.

Tetra Tech, 2013. Inventory and Preliminary Classification Report, Waste Impoundments, Cherokee Station, Denver, Colorado. March 29, 2013.