Location Restriction Criteria - Certification Report

Public Service Company of Colorado – Cherokee Station
CCR Impoundments

Denver, Colorado
October 2018

Prepared For:
Public Service Company of Colorado
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Contents ........................................................................................................................................ i

LIST OF ABBREVIATIONS AND ACRONYMS ........................................................................... iii

Qualified Professional Engineer Certification ........................................................................ iv

1 Introduction ................................................................................................................................... 1
  1.1 General Information ................................................................................................................... 1
  1.2 Type of Facility ........................................................................................................................ 1

2 Location Restrictions .................................................................................................................. 1
  2.1 Placement Above The Uppermost Aquifer 40 CFR §257.60 ................................................... 1
  2.2 Wetlands 40 CFR §257.61 ....................................................................................................... 2
  2.3 Fault Areas 40 CFR §257.62 ................................................................................................. 3
  2.4 Seismic Impact Zones 40 CFR §257.63 .................................................................................. 5
  2.5 Unstable Areas 40 CFR §257.64 ............................................................................................ 6

3 Summary ...................................................................................................................................... 7

4 References ................................................................................................................................... 8

List of Figures

Figure 1 – Cherokee Station Location Map

Figure 2 – Cherokee Station Layout and Monitoring Wells Location Map

Figure 3 – Wetland Inventory Map

Figure 4 – USGS Topographic Quadrangle Map

Figure 5 – Geology Map

Figure 6 – Earthquake and Fault Map

Figure 7 – USGS Quaternary Faults Map

Attachments

Attachment A – PGA Calculation

Attachment B – Monitoring Well Logs

Attachment C – CCR Impoundments Plan and Sections
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LIST OF ABBREVIATIONS AND ACRONYMS

AMSL  Above Mean Sea Level
CCR  Coal Combustion Residuals
CDPHE  Colorado Department of Public Health and Environment
CFR  Code of Federal Regulations
CGS  Colorado Geological Survey
EDOP  Engineering Design and Operations Plan
EPA  U.S. Environmental Protection Agency
HDPE  High Density Polyethylene
NEHRP National Earthquake Hazards Reduction Program
PGA  Peak Ground Acceleration
PSCo  Public Service Company of Colorado
RCRA  Resource Conservation and Recovery Act
USGS  United States Geological Survey
Qualified Professional Engineer Certification

I hereby certify, as a Professional Engineer in the State of Colorado, that the information in this document was assembled under my direct supervisory control. This report is not intended or represented to be suitable for reuse by PSCo or others without specific verification or adaptation by the Engineer.

I hereby certify, as a Professional Engineer in the State of Colorado, that the information contained in this report has been prepared in accordance with the requirements of 40 CFR §257. I further certify that a satisfactory demonstration of the requirements of 40 CFR Sections §257.60, §257.61, §257.62, §257.63 and §257.64 have been made.

SIGNATURE:

Matthew M Rohr, PE
Colorado Licensed Professional Engineer No. 0053467
My license renewal date is October 31, 2019
1 Introduction

This Location Restriction Certification report has been prepared for the existing CCR impoundments located at the Public Service Company of Colorado (PSCo) - Cherokee Station (Site). This report conforms to 40 CFR Part 257. This report was prepared to address the federal CCR regulations for disposal of ash under subtitle D of the Resource Conservation and Recovery Act (RCRA). The final rule was published in the Federal Register, Volume 80 Number 74 on April 17, 2015, and became effective on October 19, 2015.

1.1 General Information

Figure 1 shows the Cherokee Station in Section 11 of Township 3 South, Range 68 West of the 6th Principle Meridian in Adams County, Colorado. The land-surface elevations range from approximately 5,190 feet above mean sea level (AMSL) at the southwestern corner of the Site to approximately 5,130 feet AMSL at the northeastern corner. Figure 2, Cherokee Station Layout shows the various facilities and infrastructure located at the Cherokee Station.

1.2 Type of Facility

Cherokee Station currently has three incised impoundments that were used for storage of CCR: the West, Center, and East impoundments (Figure 2). All three CCR impoundments were constructed in 1957, have depths of approximately 20 feet, and do not have engineered low-permeability liners. The detailed geometry of each impoundment is provided in Attachment C. All three of the impoundments ceased receiving CCR and non-CCR wastes in 2018 and are being closed in fall 2018, with all CCR planned to be removed by the end of 2018. The closure of these CCR impoundments consists of removing all waste in accordance with “closure by removal of CCR” under 257.102(c). Closure will also meet the requirements of Section 9 of Colorado Department of Public Health and Environment’s (CDPHE) Solid Waste Regulations (6-CCR 1007-2, Part 1).

2 Location Restrictions

40 CFR §257.60-64 applies to new CCR landfills, existing and new CCR surface impoundments, and all lateral expansions of CCR units.

2.1 Placement Above The Uppermost Aquifer 40 CFR §257.60

The 40 CFR §257.60 places restrictions on locating the base of a CCR landfill or surface impoundment within 5 feet of the uppermost aquifer. It states the following:

“New CCR landfills, existing and new CCR surface impoundments, and all lateral expansions of CCR units must not be constructed with a base that is located no less than 1.52 meters (5 feet)
above the upper limit of the uppermost aquifer, or must demonstrate that there will not be an intermittent, recurring, or sustained hydraulic connection between any portion of the base of the CCR unit and the uppermost aquifer due to normal fluctuations in groundwater elevations (including the seasonal high water table).”

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). The static groundwater level is shallow, measured between 5 and 25 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).

Based upon original impoundment drawings, the bottoms of the three impoundments are at an elevation of approximately 5,119 feet as shown on the plan view and cross sections in Attachment C. The water table elevation in wells immediately around the three impoundments determined from well surveys and depth to water measurements collected between 2015 and 2017 ranges from 5,110 to 5,127 feet elevation (HDR, 2018). The base of the CCR impoundments does not meet the requirement in 257.60 to be greater than 5 feet above the upper limit of the uppermost aquifer beneath the impoundment.

2.2 Wetlands 40 CFR §257.61

The 40 CFR §257.61 places restrictions on locating CCR landfills and surface impoundments in areas designated as wetlands. It states the following:

“New CCR landfills, existing and new CCR surface impoundments, and all lateral expansions of CCR units must not be located in wetlands, as defined in §232.2 of this chapter, unless the owner or operator demonstrates by the dates specified in paragraph (c) of this section that the CCR unit meets the requirements of paragraphs (a)(1) through (5) of this section.”

Definition of Wetlands

The CFR Regulations (40 CFR §232.2) defines wetlands and other waters of the U.S. as:

- All waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide.
- All interstate waters including interstate wetlands.
- All other waters such as intrastate lakes, rivers, streams (including intermittent streams), mudflats, sandflats, wetlands, sloughs, prairie potholes, wet meadows, playa lakes, or natural ponds, the use, degradation or destruction of which could affect interstate or foreign commerce including any such waters:
  - Which are, or could be, used by interstate or foreign travelers for recreational or other purposes; or
From which fish or shellfish are, or could be, taken and sold in interstate or foreign commerce; or
Which are used, or could be used, for industrial purposes by industries in interstate commerce.

- All impoundments of waters otherwise defined as waters of the U.S. under the definition.
- Tributaries of waters of the U.S. identified above.
- The territorial seas.
- Wetlands adjacent to waters (other than waters that are themselves wetlands) identified in the paragraphs above. The term “adjacent” means bordering, contiguous, or neighboring. Wetlands separated from other waters of the U.S. by human-made dikes or barriers, natural river berms, beach dunes, and the like are “adjacent wetlands.

Wetlands can be waters of the U.S. and are defined by 40 CFR §232.2 (3)(iv) as areas that are inundated or saturated by surface or ground water at a frequency and duration sufficient to support—and that under normal circumstances do support—a prevalence of vegetation typically adapted for life in saturated soil conditions. Wetlands generally include swamps, marshes, bogs, and similar areas.

No wetlands or other waters of the U.S. were identified within the project study area. The National Wetlands Inventory map incorrectly identified the three CCR impoundments as freshwater emergent wetlands. Currently, the area consists of one open water (the West Impoundment) with little to no riparian or wetland vegetation. The Center and East impoundments are currently dewatered for the purpose of removing all CCR in accordance with 257.102(c). These impoundments were inspected prior to commencement of dewatering and found to contain little to no riparian or wetland vegetation. The three CCR impoundments located in the project study area are isolated from the nearby South Platte River, therefore are not considered waters of the United States. Topographic, National Hydrology Dataset, and National Wetlands Inventory maps within and near the project study area are provided in Figure 3.

Based on the site reconnaissance, the existing CCR impoundments are not located within any known wetlands.

2.3 Fault Areas 40 CFR §257.62

The 40 CFR §257.62 places restrictions on locating CCR landfills and surface impoundments in close proximity to active fault areas. It states the following:

“New CCR landfills, existing and new CCR surface impoundments, and all lateral expansions of CCR units must not be located within 60 meters (200 feet) of the outermost damage zone of a fault that has had displacement in Holocene time unless the owner or operator demonstrates by the dates specified in paragraph (c) of this section that an alternative setback distance of less than 60 meters (200 feet) will prevent the damage to the structural integrity of the CCR unit.”
The Holocene time period is defined in the CCR Rule (40 CFR § 257.53, 2015) as the most recent epoch of the Quaternary period, extending from the end of the Pleistocene Epoch, at 11,700 years before present, and continues to present.

The proximity of the Cherokee Station to faults that have been active in Holocene time was investigated through research conducted for identifying such fault zones. The results of this research document the absence of Holocene time fault zones within 200 feet from the Cherokee Station and the three CCR impoundments.

This conclusion is supported by a review of project reports and published literature that included:

**Regional Topographic and Geologic Maps and Hydrogeologic Study**

Topographically, the Cherokee Station is located on a broadly rolling terrain area northeast of the intersection of interstate highways I-70 and I-25 along the west bank of the South Platte River as shown by the *U.S. Geological Survey, 2017* map (Figure 4). Elevations vary from a high of approximately 5,190 feet AMSL at the southwestern corner of the Station to a low of approximately 5,130 feet AMSL at the northeastern corner. Geologically, the Station resides in alluvium materials. As shown in the *Lindvall, 1980* map (Figure 5), these range from relatively recent (Post-Piney Creek Alluvium) materials near the active channel to older deposits (e.g., Piney Creek Alluvium and Broadway Alluvium) at depth and preserved on terraces overlooking the river. The alluvial deposits consist largely of coarse sands and gravels, with local cobbles as well as lenses of clays and silty sands. Underlying the alluvial deposits, is bedrock of the Paleocene and Upper Cretaceous Denver Formation. It consists largely of claystones, mudstones, and sandstones interbedded with scattered lenticular conglomerates. The Denver Formation also crops out along a thin band from the southwestern corner of the site to the northeastern corner of the site. West of the Denver Formation outcrop, the Slocum Alluvium is present at the surface. Except for the early Paleocene lava flows in the upper part of the Denver formation (Van Horn, 1957), evidence of later geologic activity in the region has not been identified.

**Maps and Reports by the Colorado Geological Survey (CGS), and the United States Geological Survey (USGS) relative to faulting in the area.**

Using information from a variety of sources, the Colorado Geological Survey compiled information on nearly 100 potentially hazardous faults in Colorado that ruptured the earth’s surface during the past 2 million years (*Widmann et al., 1998*). These faults are shown as wide lines on the map in Figure 6. Faults with evidence of movement during the past 130,000 years are often considered active faults. These faults are shown in red on Figure 6. Similar information further dividing the Quaternary faults into late, latest, middle and latest Quaternary, is depicted by the interactive Quaternary Fault and Fold Database released by the *U.S. Geological Survey and Colorado Geological Survey, 2006*. In addition to identifying well-constrained or inferred locations of faults, this interactive database also provides information, such as geologic setting, fault orientation, fault type, sense of movement, slip rate, recurrence interval, and the time of the most recent surface-faulting event, on faults and associated folds that are believed to be sources of earthquakes greater than magnitude 6 (M>6). These faults are shown as color-coded lines on the map in Figure 7, with the latest
Quaternary (<15,000 years) being denoted by orange. The closest documented latest Quaternary active fault to the site is the Williams Fork Mountains fault, which is located approximately 68 miles to the northwest. Nevertheless, review of available geologic and fault maps does not indicate the presence of active or potentially active faults in the proximity of the Cherokee Station that have been active in Holocene or previous time (epoch).

2.4 Seismic Impact Zones 40 CFR §257.63

The 40 CFR §257.63 places restrictions on locating CCR landfills and surface impoundments in seismic impacted zones. It states the following:

“New CCR landfills, existing and new CCR surface impoundments, and all lateral expansions of CCR units must not be located in seismic impacted zones unless the owner or operator demonstrates by the dates specified in paragraph (c) of this section that all structural components including liners, leachate collection and removal systems, and surface water control systems, are designed to resist the maximum horizontal acceleration in lithified earth material for site.”

The Federal Register Volume 80 No. 74 defines a seismic impact zone as the following:

“A Seismic impact zone means an area having a 2% or greater probability that the maximum expected horizontal acceleration, expressed as a percentage of earth’s gravitational pull (g), will exceed 0.10 g in 50 years.”

The U.S. Geological Survey (USGS) Earthquake Hazards Program interactive website was used to determine the earthquake hazard for the Site. The 2009 National Earthquake Hazards Reduction Program (NEHRP) seismic design maps indicated a mapped peak ground acceleration of 0.091 g for the Station area on rock (seismic site classification B). Using the shear wave velocity test results from the June 2011 Kumar & Associates Geotechnical Engineering Study, Cherokee Station Steam Generating Plant report, a best estimate site shear wave velocity of 1,250 ft/s in the top 100 feet was used for this evaluation (Attachment A). The aforementioned shear wave velocity corresponds to a seismic site classification C (very dense soil and soft rock). Using the default seismic site classification adjustment factor of 1.2 for seismic site classification C results in a design peak ground acceleration of 0.109 g.

Based on the subsurface information and seismic hazard spectral response maps, the peak ground acceleration at the Site exceeds the threshold value of 0.10 g in 50 years; indicating the site is located in a seismic impact zone. This would require that “…the owner or operator demonstrate that all structural components including liners, leachate collection and removal systems, and surface water control systems are designed to resist the maximum horizontal acceleration in lithified earth material for site.” However, these impoundments do not contain liners or leachate collection and removal systems. Also, these impoundments are fully incised, and therefore do not contain any type of earthen or manmade dam structure that could impound surface water, and potentially fail during a seismic event. Due to the lack of structural components defined by the CCR rule, and the incised geometry of the impoundments, these impoundments do not need
to “…demonstrate that they are designed to resist the maximum horizontal acceleration in lithified earth material for site.”

2.5 Unstable Areas 40 CFR §257.64

The 40 CFR §257.64 places restrictions on locating CCR landfills and surface impoundments in unstable areas. It states the following:

“An existing or new CCR landfill, existing or new CCR surface impoundment, or any lateral expansion of a CCR unit must not be located in an unstable area unless the owner or operator demonstrates by the dates specified in paragraph (d) of this section that recognized and generally accepted good engineering practices have been incorporated into the design of the CCR unit to ensure that the integrity of the structural components of the CCR unit will not be disrupted. The owner or operator must consider all of the following factors, at a minimum, when determining whether an area is unstable (1) on-site or local soil conditions that may result in significant differential settling; (2) On-site or local geological or geomorphologic features; and (3) On-site or local human-made features or events (both surface and subsurface).”

Based on the available geotechnical explorations performed at the site, the subsurface soils encountered in the vicinity of these impoundments generally consist of alluvium to the top of sandstone or claystone bedrock. The alluvium is generally described as medium to very dense sand with variable gravel and occasional silty sand zones. Monitoring well borings performed near the impoundments are included in Attachment B. Three out of the four monitoring well borings taken around the impoundments shows bedrock at or near the base of the impoundment at approximate elevation of 5,119 feet. One of the borings taken near the southeast corner of the East Ash Pond (MW-10) shows approximately 18 feet of alluvial sand on top of the bedrock at the base of the East Impoundment which is likely to be medium to very dense based on the descriptions provided in other nearby borings on-site at this same elevation. Soft or compressible soils were not noted in any of the monitoring well borings in the vicinity of the three impoundments.

Based on our evaluation of the geotechnical investigations and cross sections of the impoundments, these impoundments are not located in an unstable area.
3 Summary

The Cherokee Station CCR impoundments (East, Center and West Ash Impoundments) meet and/or exceed the following location restriction requirements required for existing impoundments detailed in 40 CFR Part 257:

- **40 CFR §257.61** – Wetlands
- **40 CFR §257.62** – Fault Areas
- **40 CFR §257.63** – Seismic Impact Zones
- **40 CFR §257.64** – Unstable Areas

However, it cannot be demonstrated that the Cherokee Station CCR impoundments meet the following location restriction requirements:

- **40 CFR §257.60** – Upper Most Aquifer

As a result of not meeting the requirements of §257.60, Cherokee Station is required to cease placing additional CCR and non-CCR waste streams in the CCR impoundments and close the impoundments in accordance with §257.102 within 6 months of making this determination. Prior to this determination, PSCo had ceased placing waste streams within the CCR impoundments and had commenced closure of those impoundments by removal of CCR in accordance with 257.102(c).
4 References

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Figure 1. Cherokee Station Location Map
Figure 2. Cherokee Station Layout and Monitoring Wells Location Map
Figure 3. Wetland Inventory Map
Figure 4. USGS Topographic Quadrangle Map
Figure 5. Geology Map
COLORADO'S EARTHQUAKE and FAULT MAP
Showing Locations of Historical Earthquakes and Known or Suspected Geologically Young Faults

EARTHQUAKE EPICENTERS
Instrumentally located epicsenters (~1962 to 2006) Size of dot indicates magnitude.
- 5.5
- 4.4
- 3.9

Approximate location of pre-instrumental earthquake epicsenters (~1867 to 1961). Square size indicates the maximum Modified Mercalli intensity for the earthquake (see back of map for intensity scale).

> VII > IV
> VI > III
> V

1882 Earthquake; magnitude estimated at 6.6 +/- 0.6 (Spence and others, 1996)

QUATERNARY FAULTS
Geologically young faults that displace sediments or rocks deposited during the Quaternary Period (approximately past 2 million years).
- Known or suspected fault displacement of late Quaternary deposits (approximately past 130,000 years).
- Known or suspected fault displacement of middle to early Quaternary deposits (approximately past 130,000 to 2 million years old).

Temporary Seismic Stations - Indicates seismographs temporarily operated by the U.S. Geological Survey as part of the Advanced National Seismic System.

Cities and Towns

DATA SOURCES
Earthquake epicenters:
- US: Widmann and others, 1998
- CAN: Panfelt and others, 2002

Faults:
- Widmann and others, 1998
- Colorado Geological Survey
- US: Widmann and others, 2000

The data are from the U.S. Geological Survey's National Seismic Network.

Scale 1:1,150,000

Figure 6. Earthquake and Fault Map
Figure 7. USGS Quaternary Faults Map
Attachment A
PGA Calculation
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**Design Maps Summary Report**

**User-Specified Input**

**Report Title**  6198 FRANKLIN ST DENVER CO  
(which utilizes USGS hazard data available in 2008)  
**Site Coordinates**  39.80993°N, 104.96862°W  
**Site Soil Classification**  Site Class C – “Very Dense Soil and Soft Rock”  
**Risk Category**  1/II/III

**USGS-Provided Output**

\[
\begin{align*}
S_s &= 0.179 \text{ g} & S_{m5} &= 0.215 \text{ g} & S_{ds} &= 0.143 \text{ g} \\
S_1 &= 0.058 \text{ g} & S_{m1} &= 0.098 \text{ g} & S_{d1} &= 0.066 \text{ g}
\end{align*}
\]

For information on how the \( S_s \) and \( S_1 \) values above have been calculated from probabilistic (risk-targeted) and deterministic ground motions in the direction of maximum horizontal response, please [view the detailed report](https://prod01-earthquake.cr.usgs.gov/designmaps/us/summary.php?template=minimal&latitude=39.8099366472387&longitude=-104.968624255871...).

**MCE\(_R\) Spectrum**

![MCE\(_R\) Spectrum](image)

**Design Response Spectrum**

![Design Response Spectrum](image)

For \( PGA_{m1}, T_{c}, C_{RF} \) and \( C_{d1} \) values, please [view the detailed report](https://prod01-earthquake.cr.usgs.gov/designmaps/us/summary.php?template=minimal&latitude=39.8099366472387&longitude=-104.968624255871...).

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Although this information is a product of the U.S. Geological Survey, we provide no warranty, expressed or implied, as to the accuracy of the data contained therein. This tool is not a substitute for technical subject-matter knowledge.
Section 11.4.2 — Site Class

The authority having jurisdiction (not the USGS), site-specific geotechnical data, and/or the default has classified the site as Site Class C, based on the site soil properties in accordance with Chapter 20.

<table>
<thead>
<tr>
<th>Site Class</th>
<th>$\bar{v}_s$</th>
<th>$\bar{N}$ or $\bar{N}_{eh}$</th>
<th>$\bar{s}_s$</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. Hard Rock</td>
<td>&gt;5,000 ft/s</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>B. Rock</td>
<td>2,500 to 5,000 ft/s</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>C. Very dense soil and soft rock</td>
<td>1,200 to 2,500 ft/s</td>
<td>&gt;50</td>
<td>&gt;2,000 psf</td>
</tr>
<tr>
<td>D. Stiff Soil</td>
<td>600 to 1,200 ft/s</td>
<td>15 to 50</td>
<td>1,000 to 2,000 psf</td>
</tr>
<tr>
<td>E. Soft clay soil</td>
<td>&lt;600 ft/s</td>
<td>&lt;15</td>
<td>&lt;1,000 psf</td>
</tr>
</tbody>
</table>

Any profile with more than 10 ft of soil having the characteristics:
- Plasticity index $PI > 20$,
- Moisture content $w \geq 40\%$, and
- Undrained shear strength $\bar{s}_s < 500$ psf

F. Soils requiring site response analysis in accordance with Section 21.1

See Section 20.3.1

For SI: 1 ft/s = 0.3048 m/s 1 lb/ft$^2$ = 0.0479 kN/m$^2$

Section 11.4.3 — Site Coefficients, Risk Coefficients, and Risk–Targeted Maximum Considered Earthquake (MCE) Spectral Response Acceleration Parameters

Equation (11.4–1):

$$C_{RKS}S_{SLH} = 0.907 \times 0.198 = 0.179 \text{ g}$$

Equation (11.4–2):

$$S_{SD} = 1.500 \text{ g}$$

$$S_s \equiv \text{"Lesser of values from Equations (11.4–1) and (11.4–2)"} = 0.179 \text{ g}$$

Equation (11.4–3):

$$C_{R1}S_{1ULH} = 0.897 \times 0.064 = 0.058 \text{ g}$$

Equation (11.4–4):

$$S_{1D} = 0.600 \text{ g}$$

$$S_1 \equiv \text{"Lesser of values from Equations (11.4–3) and (11.4–4)"} = 0.058 \text{ g}$$
Section 11.8.3 — Additional Geotechnical Investigation Report Requirements for Seismic Design Categories D through F

Table 11.8–1: Site Coefficient \( F_{PGA} \)

<table>
<thead>
<tr>
<th>Site Class</th>
<th>Mapped MCE Geometric Mean Peak Ground Acceleration, PGA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>PGA ≤ 0.10</td>
</tr>
<tr>
<td>A</td>
<td>0.8</td>
</tr>
<tr>
<td>B</td>
<td>1.0</td>
</tr>
<tr>
<td>C</td>
<td>1.2</td>
</tr>
<tr>
<td>D</td>
<td>1.6</td>
</tr>
<tr>
<td>E</td>
<td>2.5</td>
</tr>
<tr>
<td>F</td>
<td></td>
</tr>
</tbody>
</table>

Note: Use straight-line interpolation for intermediate values of PGA

For Site Class = C and PGA = 0.091 g, \( F_{PGA} = 1.200 \)

Mapped PGA: \( PGA = 0.091 \) g

Equation (11.8–1): \( PGA_m = F_{PGA} \times PGA = 1.200 \times 0.091 = 0.109 \) g
Figure 2 – Generalized site map showing approximate locations and orientation of ReMi survey lines (shown in red). Lines are not drawn to scale.
Step 3: Shear wave velocity modeling - The ReMi method interactively forward-models the normal-mode dispersion data picked from the p-f images with a code adapted from Saito (1979, 1988) in 1992 by Yuchua Zeng. This code produces results identical to those of the forward-modeling codes used by Iwata et al. (1998), and by Xia et al. (1999) within their inversion procedure. The modeling iterates on phase velocity at each period (or frequency) and reports when a solution has been found within the iteration parameters. This analysis approach and the propagation properties of surface waves allows velocity reversals (low shear-wave velocity layers at depth) to be modeled successfully.

Results / Interpretations
ReMi Vs100’ shear-wave velocity results are presented on Figures 3 through 6. The Vs100’ profiles represent a one-dimensional (1D) seismic sounding centered at the middle of each ReMi array. Thus, about halfway along each line would be the representative location of the 1D Vs data, if we were comparing results from a downhole or crosshole seismic test, for example. Locations for the ReMi lines were chosen based on the safety of the area and orientation with respect to possible noise sources. Lines 1 and 2 were placed on the West and East side of the coal pile, respectively. Noise from trains and nearby drilling allowed for acceptable data acquisition. The orientation of Line 3, perpendicular to the power plant, received high levels of energy traveling down the line. This environment also allowed for acceptable data acquisition.

Contrarily, the location of Line 4 did not receive adequate source energy, resulting in unacceptable data. Consequently, a location for a substitute line (Line 5) was approved by the site safety manager and data was acquired. The surface wave energy for Line 5 was much more favorable, resulting in acceptable data. As described in the previous section, ReMi data are derived by averaging the ambient noise across the geophone array and as such represent the bulk properties of the soil and/or rock beneath the array. Vs100’ results from ReMi surveys have been shown in to be within 10-15% of Vs data obtained via crosshole or downhole testing, and can typically determine the depth to competent layers or bedrock also to within 10 to 15 percent.

ReMi data obtained at this site indicate: Line 1 Vs100’ = 1210 ft/s (feet/second), Line 2 Vs100’ = 1199 ft/s, Line 3 Vs100’ = 1285 ft/s, and Line 5 Vs100’ = 1307 ft/s. The average Vs100’ value for all ReMi lines is Vs100’ = 1250 ft/s at the Cherokee Power Plant project site in Denver. As previously discussed, the data acquired from Line 4 were unacceptable and will not be included in the results. Vs100’ values for Lines 1, 2, 3 and 5 correlate to within 5% of the average. The Vs100’ values listed here, presented on Figures 3, 4, 5, and 6, and in Tables 1-4 were computed in order to be used with Table 1613.5.2 of IBC 2006, or equivalent. Velocity values and layer thicknesses derived by the ReMi forward modeling process are also presented on Figures 3, 4, 5, and 6, and in Tables 1-4. Aside from Line 4, the quality of data at the Cherokee Power Plant project site in Denver site was good, and the models correlate well with each other and borehole data.

Based on the ReMi seismic results, unaltered bedrock is interpreted to be approximately 55-80 feet beneath the lines. The interpreted depth to bedrock is based on Vs values greater than or equal to 1,800 ft/s. All models show a sudden increase in Vs around this depth, and the general trend in the models correlate with each other.
### Table 1 - Line 1 ReMi Data

<table>
<thead>
<tr>
<th>Depth, ft</th>
<th>Vs, ft/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>641.0</td>
</tr>
<tr>
<td>5.0</td>
<td>641.0</td>
</tr>
<tr>
<td>5.0</td>
<td>806.0</td>
</tr>
<tr>
<td>17.0</td>
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<td>17.0</td>
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</tr>
<tr>
<td>31.5</td>
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<tr>
<td>31.5</td>
<td>1108.0</td>
</tr>
<tr>
<td>54.0</td>
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<tr>
<td>54.0</td>
<td>1968.0</td>
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<tr>
<td>100.0</td>
<td>1968.0</td>
</tr>
</tbody>
</table>

**Line 1 Vs100' = 1210 ft/s**

### Table 2 - Line 2 ReMi Data

<table>
<thead>
<tr>
<th>Depth, ft</th>
<th>Vs, ft/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>641.0</td>
</tr>
<tr>
<td>7.5</td>
<td>641.0</td>
</tr>
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<td>7.5</td>
<td>875.0</td>
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<tr>
<td>19.0</td>
<td>875.0</td>
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<tr>
<td>19.0</td>
<td>960.0</td>
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<td>35.5</td>
<td>960.0</td>
</tr>
<tr>
<td>35.5</td>
<td>1172.0</td>
</tr>
<tr>
<td>60.5</td>
<td>1172.0</td>
</tr>
<tr>
<td>60.5</td>
<td>1973.0</td>
</tr>
<tr>
<td>100.0</td>
<td>1973.0</td>
</tr>
</tbody>
</table>

**Line 2 Vs100' = 1199 ft/s**

### Table 3 - Line 3 ReMi Data

<table>
<thead>
<tr>
<th>Depth, ft</th>
<th>Vs, ft/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>732.0</td>
</tr>
<tr>
<td>7.5</td>
<td>732.0</td>
</tr>
<tr>
<td>7.5</td>
<td>1172.0</td>
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<tr>
<td>23.0</td>
<td>1172.0</td>
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<tr>
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<td>1230.0</td>
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<td>35.0</td>
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<td>35.0</td>
<td>1294.0</td>
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<td>82.0</td>
<td>2079.0</td>
</tr>
<tr>
<td>100.0</td>
<td>2079.0</td>
</tr>
</tbody>
</table>

**Line 3 Vs100' = 1285 ft/s**

### Table 4 - Line 5 ReMi Data

<table>
<thead>
<tr>
<th>Depth, ft</th>
<th>Vs, ft/s</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>748.0</td>
</tr>
<tr>
<td>7.5</td>
<td>748.0</td>
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<tr>
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<td>23.0</td>
<td>1264.0</td>
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<tr>
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<td>81.0</td>
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<tr>
<td>81.0</td>
<td>2069.0</td>
</tr>
<tr>
<td>100.0</td>
<td>2069.0</td>
</tr>
</tbody>
</table>

**Line 5 Vs100' = 1307 ft/s**
*Shear-Wave Velocity, ft/s*

**Cherokee Powerplant Building Project - Line 1: Vs Profile**

Vs100\(^{\prime}\) = 1210 ft/s

Figure 3.
Shear-Wave Velocity, ft/s

Vs100' = 1199 ft/s

Cherokee Powerplant Building Project - Line 2: Vs Profile

Figure 4.
Shear-Wave Velocity, ft/s

Cherokee Powerplant Building Project - Line 3: Vs Profile

Figure 5.
Shear-Wave Velocity, ft/s

Figure 6.

 Cherokee Powerplant Building Project - Line 5: Vs Profile

Vs100' = 1307 ft/s
Attachment B

Monitoring Well Logs
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# Table 2. Well Construction Details for New Groundwater Monitoring Wells Cherokee Station, 2015

<table>
<thead>
<tr>
<th>Well</th>
<th>Northing</th>
<th>Easting</th>
<th>Elevation TOC (feet)</th>
<th>Well Total Depth (feet bgs)</th>
<th>Depth of Screen Interval (feet bgs)</th>
<th>Well Stickup (feet)</th>
<th>Casing Type</th>
<th>Depth to Water (feet BTOC)</th>
<th>Static Water Level (feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW-7</td>
<td>503100.25399</td>
<td>4406795.9759</td>
<td>5153.86</td>
<td>11.59</td>
<td>6.6-11.6</td>
<td>1.16</td>
<td>2-inch Sch. 40 PVC</td>
<td>5.5</td>
<td>5148.36</td>
</tr>
<tr>
<td>MW-8</td>
<td>503284.39859</td>
<td>4406859.9822</td>
<td>5140.64</td>
<td>12.67</td>
<td>7.7-12.7</td>
<td>1.25</td>
<td>2-inch Sch. 40 PVC</td>
<td>8.3</td>
<td>5132.34</td>
</tr>
<tr>
<td>MW-9</td>
<td>503266.2015</td>
<td>4406770.1456</td>
<td>5141.26</td>
<td>23.18</td>
<td>13.2-23.2</td>
<td>1.57</td>
<td>2-inch Sch. 40 PVC</td>
<td>19.06</td>
<td>5122.20</td>
</tr>
<tr>
<td>MW-10</td>
<td>503243.54239</td>
<td>4406678.6084</td>
<td>5140.88</td>
<td>38.61</td>
<td>28.6-38.6</td>
<td>1.59</td>
<td>2-inch Sch. 40 PVC</td>
<td>25.41</td>
<td>5115.47</td>
</tr>
<tr>
<td>MW-13</td>
<td>503100.2539</td>
<td>4406795.9759</td>
<td>5174.497</td>
<td>32.75</td>
<td>22.8-32.8</td>
<td>2.05</td>
<td>2-inch Sch. 40 PVC</td>
<td>31.24</td>
<td>5143.257</td>
</tr>
</tbody>
</table>

Notes: TOC = top of casing; bgs = below ground surface; BTOC = below top of casing; Depth to water measured December 2015
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Blow Count</th>
<th>Depth (feet)</th>
<th>Description (USCS)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>MW-7 0-6' bgs</td>
<td>Not recorded</td>
<td></td>
<td>Gray 10YR 6/1; Clayey Silt (ML), dense weathered bedrock; friable; wet</td>
<td>Collected Sample MW-7 0-6' bgs submitted for geotechnical analysis</td>
</tr>
<tr>
<td>8-8.5' bgs</td>
<td>Not recorded</td>
<td></td>
<td>Gray 10YR 6/1; Clayey Silt (ML), dense weathered bedrock; friable; wet</td>
<td>Depth to water ~6' bgs</td>
</tr>
<tr>
<td>12.5-13' bgs</td>
<td>Not recorded</td>
<td></td>
<td>Gray 10YR 6/1; Clayey Silt (ML), dense weathered bedrock; friable; wet; Iron mineralization</td>
<td></td>
</tr>
</tbody>
</table>

Total Depth (feet): 13

Water Level (feet): 5.13

Logged By: Justin Bills

Drilled/Sampled By: Josh Eckhoff

Date Started: 11/9/2015

Date Completed: 11/9/2015
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Blow Count</th>
<th>Depth (feet)</th>
<th>Description (USCS)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.5-9' bgs</td>
<td>Not recorded</td>
<td>5</td>
<td>Brown 7.5YR 5/4; Coarse Silty Sand (SM), well sorted with Gravel &gt; 1&quot;; wet</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MW-8 12'4&quot;-12'8&quot; bgs</td>
<td>Not recorded</td>
<td>15</td>
<td>Gray 10YR 6/1; Clayey Silt (ML), bedrock; friable</td>
<td>Sample MW-8 12'4&quot;-12'8&quot; submitted for geotechnical analysis</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>25</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>30</td>
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<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>45</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Total Depth (feet):** 13.92  
**Water Level (feet):** 9.5  
**Logged By:** Justin Bills  
**Drilled/Sampled By:** Josh Eckhoff  
**Date Started:** 11/9/2015  
**Date Completed:** 11/9/2015
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Blow Count</th>
<th>Depth (feet)</th>
<th>Description (USCS)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>8' bgs</td>
<td>Not recorded</td>
<td>5</td>
<td>Ash, loose, dry</td>
<td></td>
</tr>
<tr>
<td>8.5-9' bgs</td>
<td>Not recorded</td>
<td>10</td>
<td>Dark brown 10YR 4/3; Fine Silty Sand (SM), poorly sorted, medium dense; moist</td>
<td>Depth to water ~10' bgs</td>
</tr>
<tr>
<td>13-13.5' bgs</td>
<td>Not recorded</td>
<td>15</td>
<td>Dark brown 10YR 4/3; Fine Silty Sand (SM), poorly sorted, medium dense; wet at 10' bgs</td>
<td></td>
</tr>
<tr>
<td>18-18.5' bgs</td>
<td></td>
<td>20</td>
<td>Dark brown 10YR 4/3; Silty Sand (SM), well sorted with Gravel &lt;1&quot;; wet</td>
<td></td>
</tr>
<tr>
<td>MW-9 19'10&quot;-20'2&quot; bgs</td>
<td></td>
<td>25</td>
<td>Yellowish brown 10YR 5/4; Clayey Silt (ML); wet</td>
<td>Sample MW-9 19'10&quot;-20'2&quot; bgs submitted for geotechnical analysis</td>
</tr>
<tr>
<td>21-21.5' bgs</td>
<td></td>
<td>30</td>
<td>Silt; Grayish blue weathered bedrock; wet</td>
<td></td>
</tr>
<tr>
<td>22' bgs</td>
<td></td>
<td>35</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23.18</td>
<td></td>
<td>40</td>
<td></td>
<td></td>
</tr>
<tr>
<td>23.18</td>
<td></td>
<td>45</td>
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<tr>
<td>23.18</td>
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<td>50</td>
<td></td>
<td></td>
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</table>

**Total Depth (feet):** 23.18  
**Water Level (feet):** 20.6

**Logged By:** Justin Bills  
**Drilled/Sampled By:** Josh Eckhoff

**Date Started:** 11/9/2015  
**Date Completed:** 11/9/2015
## Boring Log

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Blow Count</th>
<th>Depth (feet)</th>
<th>Description (USCS)</th>
<th>Remarks</th>
</tr>
</thead>
<tbody>
<tr>
<td>8-8.5' bgs</td>
<td>Not recorded</td>
<td>5</td>
<td>Yellowish brown 10YR 5/4; Fine Sand (SM) with trace Gravel &lt;1&quot;; moist</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>10</td>
<td>Brown 10YR 5/3; Very Fine Sand (SP), poorly sorted; moist</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Not recorded</td>
<td>15</td>
<td>Brown 10YR 5/3; Medium Silty Sand (SP); moist</td>
<td></td>
</tr>
<tr>
<td>MW-10 20'4&quot;-20'8&quot; bgs</td>
<td></td>
<td>20</td>
<td>Brown 10YR 5/3; Clayey Sand, well sorted with Gravel &gt;1&quot;; Sample MW-10 20'4&quot;-20'8&quot; bgs submitted for geotechnical analysis</td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>Light brown 7.5YR 6/4; Coarse Sand (SW); well sorted; wet</td>
<td>25</td>
<td>Depth to water ~26' bgs</td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>As above</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35</td>
<td>Light yellowish brown 10YR6/4; Silt (ML); stiff; moist</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>Silt (ML); blue gray bedrock; moist</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Project Details

- **Project Name:** Xcel CCR
- **Project No.:** 266180-006
- **Drilling Company:** Site Services Drilling, LLC
- **Location:** Cherokee Station
- **Drilling Rig Type and Drilling Method:** CME-75 Hollow Stem Auger

### Logged By:
- Justin Bills

### Drilled/Sampled By:
- Josh Eckhoff

### After Drilling:
- 27.6

### Total Depth (feet):
- 38.61

### Water Level (feet):
- 27.6

### Hours After:
- Not recorded

### Date Started:
- 11/10/2015

### Date Completed:
- 11/10/2015
Attachment C

CCR Impoundments Plan and Sections
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