Semiannual Progress Report Selection of Remedy

for Compliance with the Coal Combustion Residuals (CCR) Rule

Pawnee Station

Public Service Company of Colorado

July 31, 2023

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Certification

Semiannual Remedy Selection Progress Report for Pawnee Station

I hereby certify to the best of my knowledge that this Semiannual Remedy Selection Progress Report is designed to meet the performance standard in 40 CFR Part 257 of the Federal Coal Combustion Residuals (CCR) Rule.

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

Matthew Rohr, PE
Colorado PE License 0053467
License renewal date October 31, 2023
Signed July 31, 2023

1.0 Introduction

Pawnee Station, located in Brush, Colorado is owned and operated by Public Service Company of Colorado (PSCo), an Xcel Energy Company (**Figure 1**). Pawnee Station has four Coal Combustion Residuals (CCR) units subject to the U.S. Environmental Protection Agency's (EPA's) CCR Rule specified in 40 CFR 257: The North Landfill, the East Landfill, the former Bottom Ash Storage Pond (BASP), and the former Ash Water Recovery Pond (AWRP) (**Figure 2).** Only the North Landfill and the former BASP and AWRP have triggered assessment of corrective measures. The AWRP and BASP ceased receiving CCR prior to October 19, 2015 and therefore met the definition of Inactive CCR Surface Impoundments that first became subject to the groundwater monitoring requirements under the Direct Final Rule effective October 4, 2016 (Extension Rule). The two impoundments were physically closed by removal of all CCR in March and April 2017, with ongoing groundwater monitoring.

In January 2019, PSCo first reported that concentrations of one Appendix IV constituent, lithium, in monitoring wells at the North Landfill were observed at statistically significant levels (SSLs) above Groundwater Protection Standards (GPS) (HDR, 2019a). Subsequently, PSCo completed the *Conceptual Site Model and Assessment of Corrective Measures (ACM) Report* in August 2019 and posted to PSCo's public website (HDR, 2019b). In May 2020, PSCo first reported that concentrations of lithium in monitoring wells at the former BASP and AWRP were observed at statistically significant levels (SSLs) above Groundwater Protection Standards (GPS) (HDR, 2020b). In August 2020, PSCo initiated the Assessment of Corrective Measures for the former BASP and former AWRP, and PSCo completed the *Conceptual Site Model and Assessment of Corrective Measures (ACM) Report* in January 2021 and posted to PSCo's public website (HDR, 2021a). The North Landfill and the BASP and AWRP are the subject of this update on remedy selection.

The purpose of this technical memorandum is to provide an update describing progress toward selecting a remedy for corrective action at the Pawnee North Landfill, former BASP and former AWRP, per the requirements specified in 40 CFR 257.97(a) of the CCR Rule.

Figure 1. Pawnee Station Vicinity Map

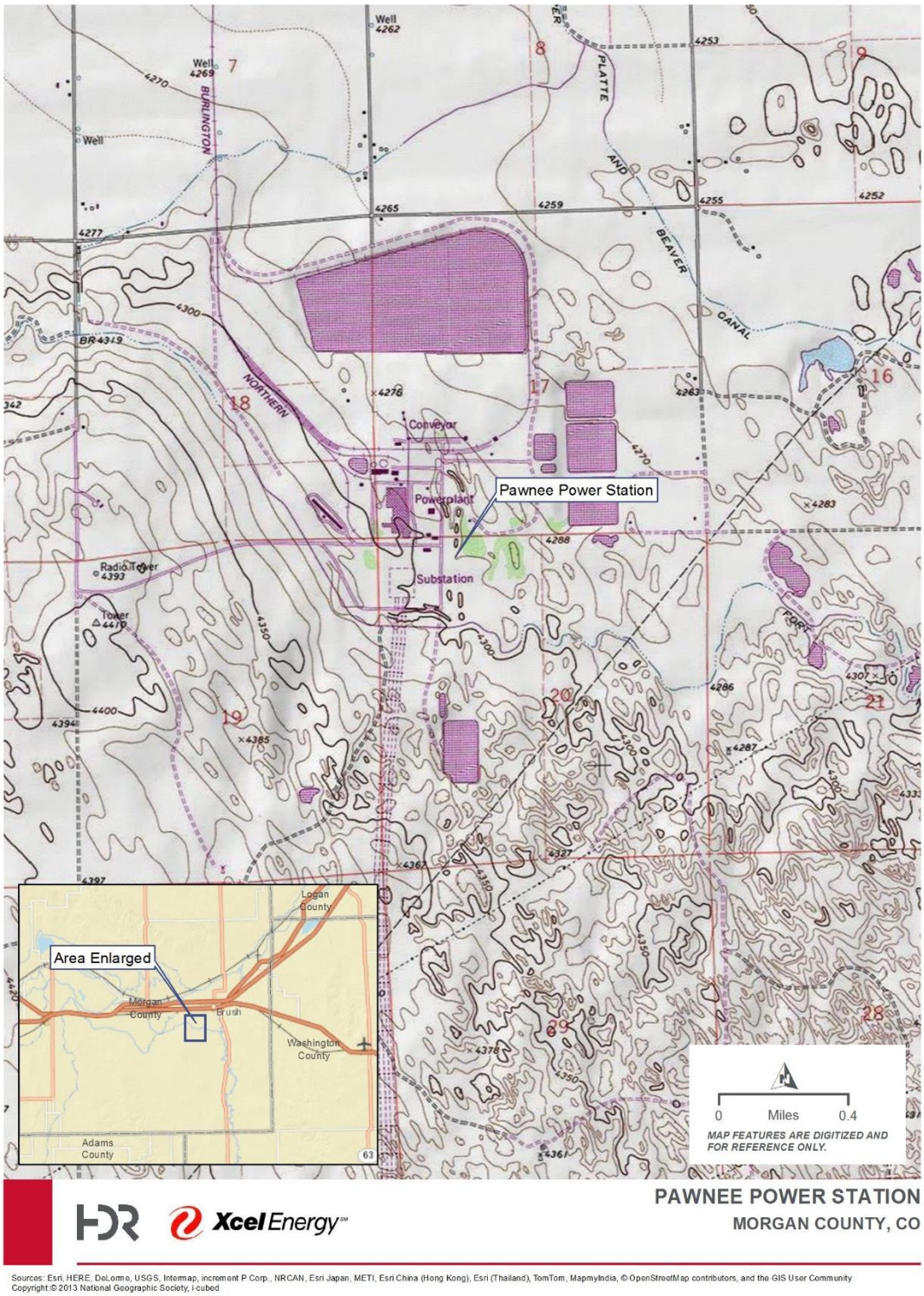
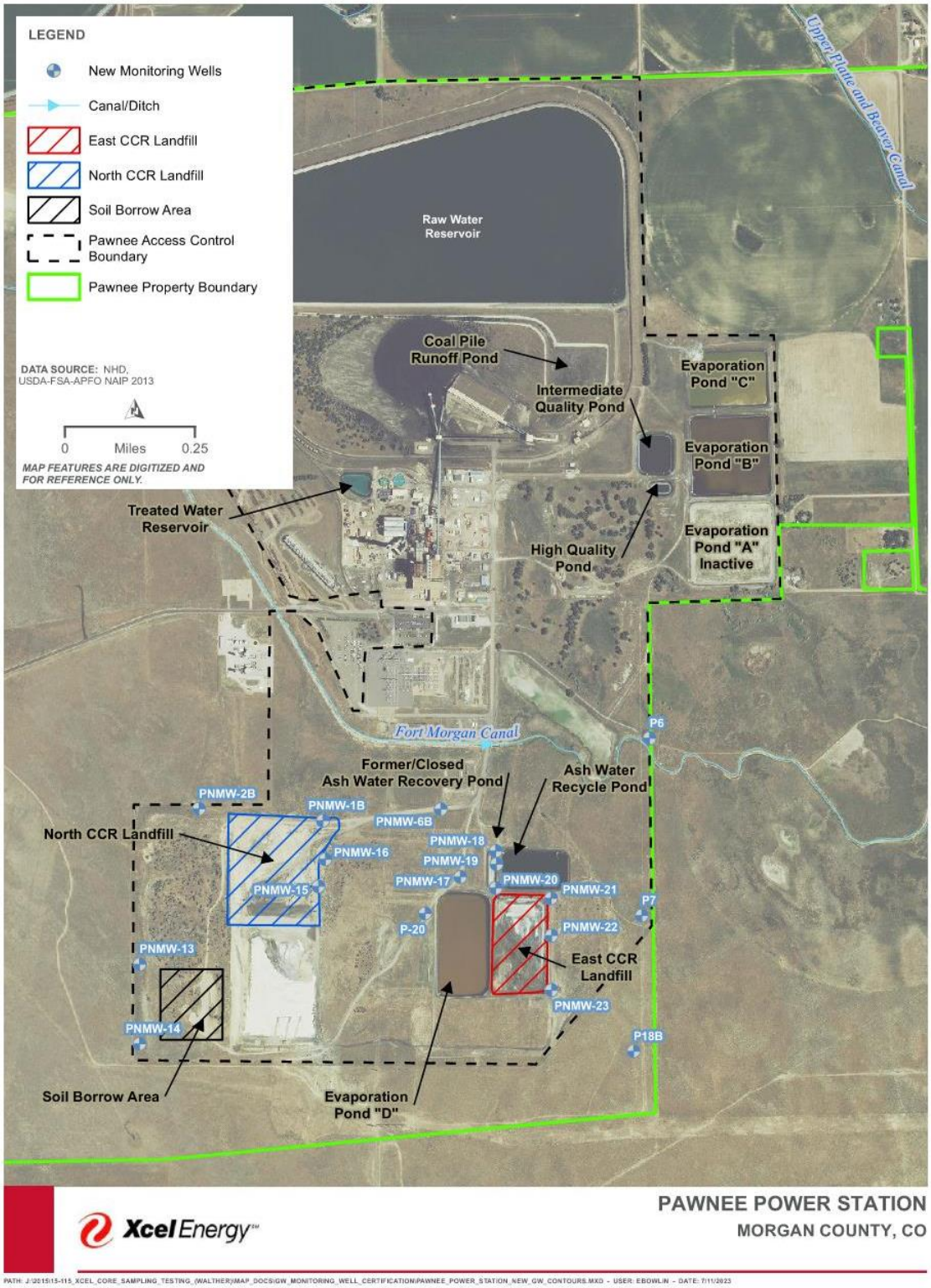


Figure 2. Pawnee Station—CCR Units



2.0 Background

In accordance with the CCR Rule, PSCo initiated background groundwater monitoring at the North Landfill in 2015, conducted detection monitoring at the landfill in 2017, and initiated assessment monitoring in 2018. As described in the *Groundwater Protection Standards and Determination of SSLs per 257.95(g)*, downgradient wells at the landfill were first found to have concentrations of lithium at SSLs above the GPS in several downgradient landfill monitoring wells in January 2019 (HDR, 2019a). Therefore, PSCo completed the *North Landfill Conceptual Site Model and Assessment of Corrective Measures Report* ('ACM Report') on August 30, 2019, in accordance with CCR Rule 257.96 (HDR, 2019b). A groundwater flow and transport model was developed for the North Landfill in 2019 to support characterization of the nature and extent of the release per 257.95(g)(1) and to support the corrective measures assessment. The groundwater model is described in the ACM Report. The status of the North Landfill groundwater monitoring program remains in assessment monitoring and assessment of corrective measures as of July 2023. Waste boundary wells at the North Landfill have low-level concentration exceedances of lithium above the GPS. Concentration exceedances do not extend to wells PNMW-17 or P-20; therefore the lithium exceedance in groundwater downgradient of the North Landfill is limited in extent to close to the landfill units with no risk of offsite migration.

Removal of CCR and all areas affected by releases of CCR was completed at the BASP in March 2017 and at the AWRP in April 2017 per 40 CFR 257.102(c) ('closure by removal') and the early closure provision in 40 CFR 257.100(b). In accordance with the CCR Rule and Extension Rule, PSCo initiated background groundwater monitoring at the BASP in 2017 and AWRP in 2018. Detection monitoring was conducted in 2019 for both ponds and PSCo has been performing assessment monitoring at the AWRP and BASP since 2019. As described in the Groundwater Protection Standards and Determination of SSLs per 257.95(g), downgradient wells at the AWRP and BASP were first found to have concentrations of lithium at SSLs above the GPS in May 2020 (HDR, 2020b) in one downgradient AWRP monitoring well and two downgradient BASP wells. The ACM Report was completed for the AWRP and the BASP and was published on the CCR website January 27, 2021 (HDR, 2021a). The status of the AWRP and BASP groundwater monitoring programs remains in assessment monitoring and assessment of corrective measures as of July 2023. Only wells PNMW-20, PNMW-21, and PNMW-22 have very low-level concentration exceedances of lithium above the GPS. Concentration exceedances do not extend to the property boundary wells; therefore, the lithium exceedance in groundwater downgradient of the former AWRP and former BASP is limited in extent to close to those CCR units with little to no risk of offsite migration.

A groundwater model was developed in 2019 to create a digital representation of the groundwater flow system to predict groundwater movement and constituent fate and transport. The model is a critical tool in evaluating the nature and extent of constituent concentrations and the effectiveness of the identified potential remedies for the North Landfill. The preliminary model simulations predict that there is groundwater flow with concentrations of lithium above the GPS moving eastward from the North Landfill waste boundary; however, in very small mass

fluxes. The extent of the lithium exceedance in groundwater is well within the plant boundary, there is currently no offsite transport of any constituents of concern (COCs) at the site, nor does the groundwater flow model simulate offsite migration in the future. Numerous simulations of the groundwater flow and transport model have been run to predict groundwater movement and constituent transport under the alternative corrective measures described in the ACM, including:

- Monitored natural attenuation (MNA)
- Permeable Reactive Barrier
- Partial ash removal
- Complete ash removal
- Slurry wall
- Partial In-situ solidification

Each predictive simulation predicts that the extent of lithium in groundwater attributed to the North Landfill is well within the Pawnee Station property and does not (and will not in the future) extend as far as the former BASP or AWRP.

3.0 Evaluation of Potential Remedies

3.1 North Landfill

Since the last semiannual selection of remedy update in January 2023, one round of groundwater sampling for assessment monitoring has been completed, and progress has been made to evaluate potential remedies, as well as initiate landfill closure.

3.1.1 Permeable Reactive Barrier Remedy

PSCo assessed the engineering and geochemical feasibility of a Permeable Reactive Barrier (PRB) as a potential remedy at the Pawnee Station. PSCo previously developed a PRB feasibility study design to evaluate the feasibility of a PRB via conventional trench, via injection wells, and via funnel and gate. The study used a phased approach designed to evaluate geochemical bench testing of reagents with site-specific groundwater, followed by the evaluation of the geotechnical characteristics of site-specific substrate for hydraulic and construction feasibility. PSCo completed a similar remedy evaluation at the Valmont Station CCR landfill, and the results of that work are used in the evaluation of a PRB as a potential remedy for Pawnee Station.

PSCo initiated a bench testing program using samples from the Valmont Station to evaluate the geochemical feasibility of treating COCs via reagent alternatives. The first and second phases of testing completed in 2021 focused on reductive precipitation and adsorption as a treatment mechanism and were not successful at reducing COC concentrations below the GPS. The third phase of testing completed in 2022 focused on adsorptive polishing of the treated groundwater from the second phase of testing and indicated significant reductions in the targeted metal concentrations using biochar. Due to the impracticability of a two-step PRB, a fourth phase of

testing completed in late 2022 focused on adsorption using biochar without initial reductive precipitation and adsorption.

The intention of the bench test program was to evaluate if geochemical treatment using targeted reagents (or other mechanisms) could be effective in reducing COC concentrations. Three phases of bench-scale laboratory testing were conducted using groundwater and sediment samples collected in 2021 for Phases I and II and groundwater samples collected in 2022 for Phase III. The first phase of testing focused on reductive precipitation and adsorption as a treatability mechanism. Four microcosm reagent treatments were tested and found to be largely ineffective. A second round of testing was then conducted using modified conditions employing adsorptive polishing with biochar and activated carbon. Adsorptive polishing with biochar yielded results that indicated significant reduction in some targeted metal concentrations but was unable to reduce all COC concentrations below GPS. A third round of testing was conducted employing only adsorptive polishing with biochar without initial reductive precipitation and adsorption. Groundwater samples from Valmont Station and Pawnee Station were submitted for phase four testing which focused on testing different biochar reagents. The testing yielded results that indicate initial reductions of boron; however, the ability of the biochar to remove boron declined considerably over the course of the testing. The biochar treatments had little to no impact on lithium.

This testing that was performed in 2022 was last reported by the bench test laboratory December 20, 2022. Early 2023 was used to complete the final review of the PRB bench test results and compile the technical memorandum, *Summary of PRB Evaluation Bench Testing Results*. Based on the geochemical bench-scale testing, a PRB no longer appears to be an effective groundwater remedy. Based on the testing, HDR does not recommend additional evaluation of a PRB as a potential remedy for groundwater cleanup at Pawnee due to the inability of the tested reagents to reduce lithium below GPS. However, the results of these geochemical bench scale tests can be utilized when exploring other ex-situ remedy options.

Upon that determination, PSCo began evaluating alternative corrective measures in conjunction with the most effective corrective measure, source removal. PSCo has initiated ash removal from the North Landfill, described further below. While the low permeability of the weathered shale can be a limitation to groundwater extraction, it does not rule it out at Pawnee and that alternative remains the most effective and timely remedy alternative for treating lithium in groundwater. PSCo is currently focused on the planning and site-specific data collection to support investigating an extraction and treatment system for the North Landfill lithium plume.

3.1.2 Groundwater Extraction and Treatment and MNA Potential Remedy Progress

Between January and June 2023, a remedial investigation work plan was developed to support design of an extraction and treatment system and selection of MNA as part of overall remedy selection. The work plan included the following for the extraction and treatment system:

- Aquifer testing procedures to evaluate potential pumping rates and capture zones
    - Extraction well siting and design, monitoring well siting and design.

- A pump test will be performed at one location within the plume area in the vicinity of existing monitoring well PNMW-16. Step drawdown and a 24-hour constant rate tests are planned from pumping the weathered shale and drawdown and recovery will be measured and analyzed. Purge water from the pump tests will be contained in 55-gallon drums or totes temporarily stored onsite and eventually disposed offsite.
- Coordination with drilling companies.

As MNA is anticipated to potentially be a component of the remediation strategy at the site the work plan also included data collection to assess potential performance and reliability of MNA. Soil property data and additional groundwater monitoring parameters are needed to identify attenuation mechanisms at the site, the capacity for attenuation, and to support estimating the time required to achieve remediation objectives. The work plan included the following for the MNA study:

- Sediment sampling procedures
  - A minimum of eight borings will be drilled to collect core (sediment) samples.
  - Samples will be analyzed for contaminant concentrations in aquifer solids (COCs include boron, chloride, lithium, selenium, sulfate). Mineralogy of the weathered shale will be identified (clay mineralogy, Fe-Mn-Al oxides, carbonate minerals, sulfides), as well as cation exchange capacity (CEC). Batch attenuation testing for COCs will be completed at a laboratory, which include chemical extractions to determine probable range of partition coefficient values (K_d) that suggest attenuation is taking place.
  - Coordination with drilling companies.
- Groundwater sampling and analysis procedures specific to MNA evaluation.

The EPA's tiered approach to MNA requires that information is collected as necessary to identify attenuation mechanisms at the site, the capacity for attenuation, and the estimated time to achieve corrective action objectives. Demonstrating attenuation mechanisms and capacity can be time consuming and take up to 24 months, especially given offsite access limitations.

The drilling for both the pump test and the MNA sample collection is planned to be completed by early fall 2023, primarily constrained by driller availability. Following data collection, the pump test analysis will advance the groundwater extraction design, and the sediment chemical characterization, mineralogy, and attenuation testing will advance the evaluation of MNA.

3.1.3 Source Removal

During 2022, PSCo developed a plan that was approved by the state to remove ash from the North Landfill for use in solidifying non-CCR waste generated at Pawnee prior to placement in the East Landfill. Source removal activities began in February 2023. Approximately 11,500 cubic yards of CCR material has been removed from the North Landfill for final placement in the East Landfill. The project anticipates removing all CCR from the North Landfill and placing it for final disposal in the East Landfill and is anticipated to take approximately five years. The East Landfill has sufficient capacity to receive both the CCR and the non-CCR waste from this project. PSCo

is in progress for developing the engineering design to implement source removal as part of its remedy; however, ash removal from the North Landfill has already begun under an interim approval by the state as part of the non-CCR waste solidification project.

3.2 AWRP and BASP

3.2.1 Source Control Measures Undertaken

Closure by removal of CCR and all areas affected by releases of CCR at the former BASP and AWRP was completed in March and April 2017, respectively, effectively implementing source control corrective action. Completion of CCR removal was certified by a Professional Engineer as documented in the August 2017 CCR Removal Certification report, which has been posted to the CCR website (Xcel, 2017). Since all CCR and impacted material has been completely removed from the former ponds, all groundwater monitoring occurring after April 2017 at these units reflect post-CCR removal conditions. PSCo has continued to conduct assessment monitoring at the former impoundments since source removal in 2017.

3.2.2 Progress Towards Remedy Selection

The Assessment of Corrective Measures (ACM) was completed for the AWRP and the BASP and was published on the CCR website January 27, 2021. PSCo anticipates that the remedy will be comprised of source removal (complete) and is conducting feasibility evaluation of MNA as an additional component. The reduction of hydraulic loading and recharge of the aquifer that result from pond closure and cleanout are expected to gradually change groundwater redox conditions and the physical removal of CCR is expected to improve groundwater quality.

Assessment monitoring indicates that concentrations of lithium above the GPS have been consistently observed in two downgradient wells for the former BASP, PNMW-21 and PNMW-22 and one downgradient well, PNMW-20, at the former AWRP. Well P-20, a former State program monitoring well, has been identified as an additional background monitoring well for these two units, which in conjunction with the current background well PNMW-17, more completely reflects background conditions of lithium relative to the footprints of the former BASP and AWRP. Once eight background sample events have been completed for P-20, background threshold values (BTVs) will be recalculated.

At the former BASP, lithium concentrations at both wells PNMW-21 and PNMW-22 in May 2023 went down since November 2022. Concentrations at PNMW-22 are below GPS in May 2023. Background well PNMW-17 had a higher concentration of lithium in November 2022 than the background value, and along with higher concentrations at background well P-20, indicate that when the background value recalculation that is pending later this year is completed, concentrations at the former BASP may no longer exceed GPS.

At the former AWRP, lithium concentrations at PNMW-20 in May 2023 went up just slightly since November 2022, but have generally plateaued since ash removal, indicating the need for the background recalculation and evaluation. Background well PNMW-17 had a higher concentration of lithium in November 2022 than the background value, and along with higher concentrations at background well P-20.

PSCo will continue assessment monitoring at the former impoundments to evaluate concentration trends and whether natural attenuation, in combination with the previous source removal, is an effective remedy to address groundwater conditions. Based upon the limited extent of lithium exceedances which are well within the Pawnee Station property, interim measures (per 40 CFR 257.98(a)(3)) are not considered to be necessary at this time.

4.0 Next Steps

The following activities are anticipated to be completed or initiated in the next 6-month period for the landfill but are subject to change based upon the iterative nature of the process, uncertainty about the results of each step, and interim findings. PSCo continues to proceed through the process of further evaluating potential remedies, consistent with best practices and professional judgment and in the meantime, lithium exceedances which are well within the Pawnee Station property and interim measures are not considered to be necessary at this time.

- Engineering design and permitting of source removal at the North Landfill
- Ash removal from the North Landfill with disposal at the East Landfill will continue.
- Continued evaluation of MNA as a remedy to address groundwater conditions at the former impoundments. The observed plateau in lithium concentrations may reflect greater variability in background concentrations, which is being evaluated by inclusion of new background well P-20.
- Continue semi-annual groundwater assessment monitoring for all CCR units.
- In accordance with 257.97(a), PSCo will complete semi-annual progress reporting.

5.0 References

HDR, 2019a. Pawnee Station North CCR Landfill Groundwater Protection Standards and Determination of SSLs per 257.95(g). January 2, 2019.

HDR, 2019b. Conceptual Site Model and Assessment of Corrective Measures - Compliance with the Coal Combustion Residuals Rule Pawnee Station North Landfill. August 30, 2019.

HDR, 2020a. Annual Groundwater Monitoring and Corrective Action Annual Report and Semi-Annual Remedy Selection and Design Progress Report - Compliance with the Coal Combustion Residuals Rule. January 31, 2020.

HDR, 2020b. Pawnee Station Ash Water Recovery Pond and Bottom Ash Storage Pond Groundwater Protection Standards and Determination of SSLs per 257.95(g). May 8, 2020.

HDR, 2021a. Conceptual Site Model and Assessment of Corrective Measures - Compliance with the Coal Combustion Residuals Rule Pawnee Station Ash Water Recovery Pond and Bottom Ash Storage Pond. January 27, 2021.

HDR, 2021b. Annual Groundwater Monitoring and Corrective Action Annual Report and Semi-Annual Remedy Selection and Design Progress Report - Compliance with the Coal Combustion Residuals Rule. January 31, 2021.

Xcel Energy, 2017. Pawnee Station – Inactive Pond Waste Removal Certification. Letter to Colorado Department of Public Health and Environment, August 9, 2017.