Semiannual Remedy Selection Progress Report

for Compliance with the Coal Combustion Residuals (CCR) Rule

Valmont Station

Public Service Company of Colorado

July 30, 2022

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Certification

Semiannual Remedy Selection Progress Report for Valmont 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.

30-JUL-2022

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Colorado PE License 0053467
License renewal date October 31, 2023

1.0 Introduction

Valmont Station located in Boulder County, Colorado is owned and operated by Public Service Company of Colorado (PSCo), an Xcel Energy Company (**Figure 1**). Valmont Station has three CCR units subject to the U.S. Environmental Protection Agency's (EPA's) Coal Combustion Residuals (CCR) Rule specified in 40 CFR 257: the ash landfill and two former incised bottom ash impoundments. These CCR units have triggered assessment of corrective measures and therefore are the subject of this update on remedy selection. The bottom ash impoundments were physically closed by removal of CCR in 2018, with ongoing groundwater monitoring. The landfill is substantially closed; one cell is in an interim closed condition in anticipation of receiving additional waste. A fourth CCR unit at Valmont, the former ash settling pond, was clean closed pursuant to 40 CFR 257.102(c) and the Closure Certification was published in May 2022.

In accordance with the CCR Rule, PSCo initiated groundwater monitoring in the certified network around the CCR units in 2015. In October 2018, PSCo first reported that concentrations of Appendix IV constituents in monitoring wells at the landfill and at the bottom ash impoundments were observed at statistically significant levels (SSLs) above Groundwater Protection Standards (GPS) (HDR, 2018; HDR, 2019a). Subsequently, PSCo drilled additional wells, completed additional hydrogeologic investigation, and completed the *Conceptual Site Model and Assessment of Corrective Measures* Report (ACM Report) in June 2019 and posted to PSCo's public website (HDR, 2019b). Since the ACM Report, a phased program of feasibility level testing and evaluation has been diligently implemented to support remedy selection and progress updates have been made on a semiannual basis.

The purpose of this report is to provide an update describing progress in the first half of 2022 toward selecting a remedy for corrective action at the Valmont ash landfill and bottom ash impoundments, as required by 40 CFR 257.97(a) of the CCR Rule.

Figure 1. Valmont Station Vicinity Map

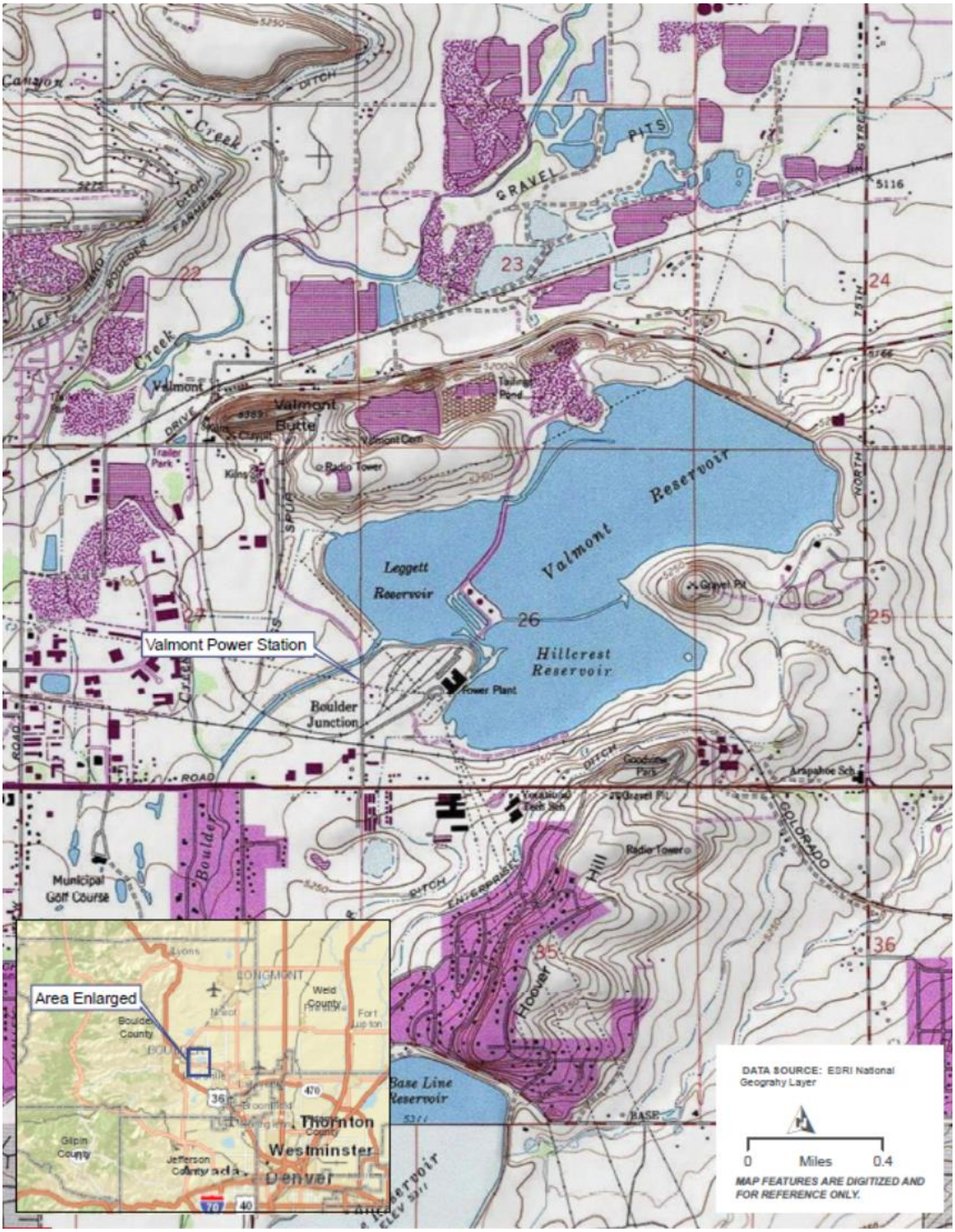
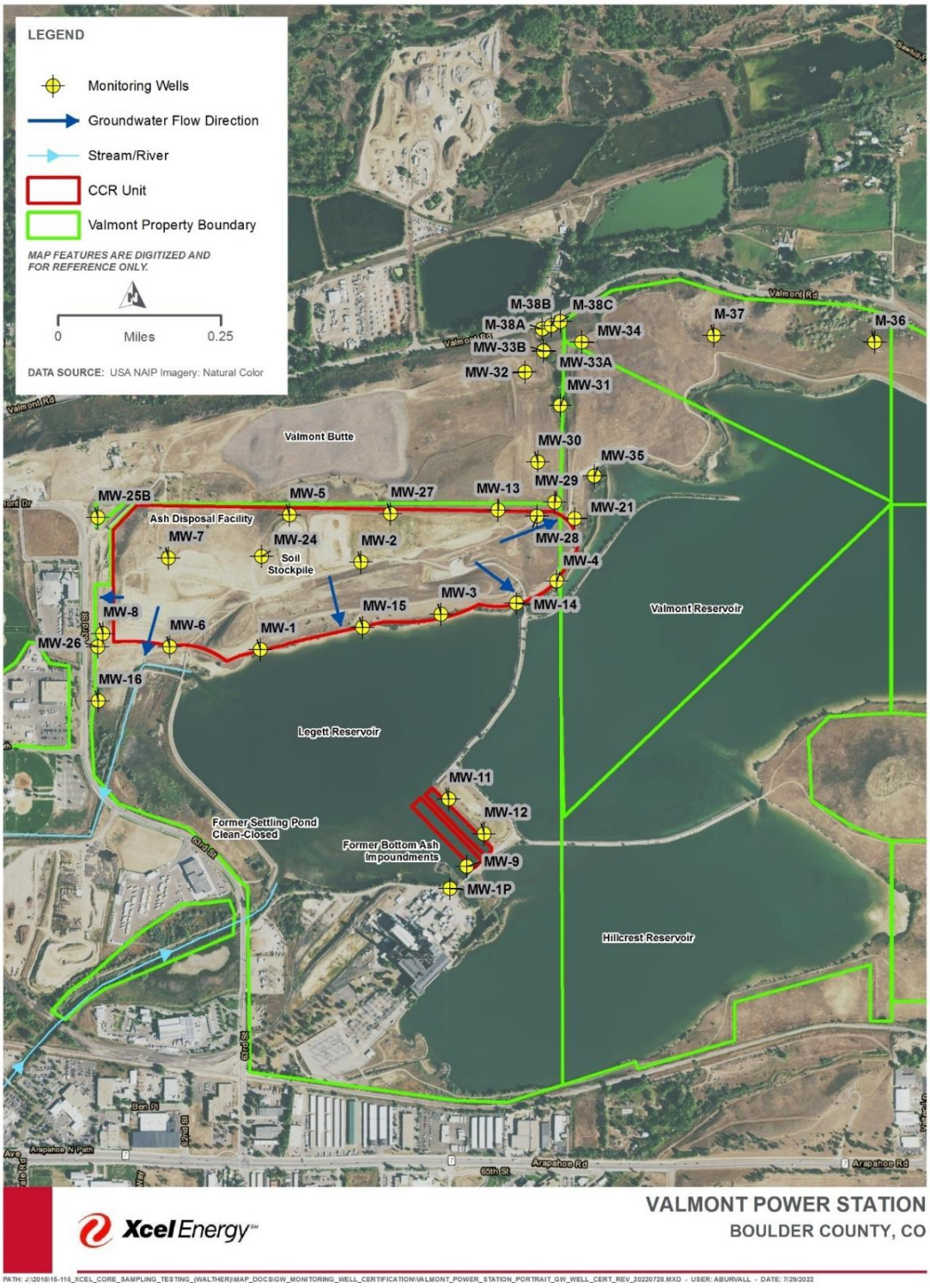


Figure 2. Valmont Station — CCR Units



2.0 Background

In accordance with the CCR Rule, PSCo initiated background groundwater monitoring around the landfill in 2015, conducted detection monitoring at the landfill in 2017, and initiated assessment monitoring in 2018. As described in the October 10, 2018 memorandum Groundwater Protection Standards and Determination of SSLs per 257.95(g), GPS were established for each detected Appendix IV constituent of interest (COI) and concentrations of arsenic, lithium and selenium were identified at SSLs above the GPS in several downgradient landfill monitoring wells (HDR, 2018; HDR, 2019a). Therefore, PSCo completed the *Conceptual Site Model* and *Assessment of Corrective Measures Report* ('ACM Report') on June 6, 2019 in accordance with CCR Rule 257.96 (HDR, 2019b). A groundwater flow and transport model was developed for the landfill in 2019 to support characterization of the nature and extent of the release per 257.95(g)(1) and to be used to simulate the effectiveness of alternative remedies identified in the assessment of corrective measures report in addressing groundwater impacts from the landfill. The original model has undergone a significant update to expand the model boundaries and to incorporate additional data generated from the phased drilling program that has been implemented as part of the release characterization investigation. The original groundwater model is described in the ACM Report and the updated model will be described as part of future reports where it is used to describe site conditions and evaluate the release and potential remedies.

For the two former bottom ash impoundments, detection monitoring in 2017 identified SSIs and assessment monitoring was initiated in 2018. In accordance with CCR Rule 257.95(h), GPS were established for each detected Appendix IV COI as documented in the October 10, 2018 memorandum Groundwater Protection Standards and Determination of SSLs per 257.95(g) (HDR, 2018; HDR, 2019a) and downgradient wells were found to have concentrations of cobalt and molybdenum at SSLs above the GPS. Closure of the two CCR impoundments was initiated in April 2018 under Colorado Department of Public Health and Environment (CDPHE) Regulations Pertaining to Solid Waste Sites and Facilities, 6 CCR 1007-2 Part 1 (State Solid Waste Regulations) prior to determining that there were any SSLs and the need for development of the Assessment of Corrective Measures. Removal of CCR, and all areas affected by releases of CCR was completed in September 2018 per State Solid Waste Regulations and 40 CFR 257.102(c) ('closure by removal') and approved by CDPHE, thus effectively implementing source control corrective action. Completion of CCR removal was certified by a Professional Engineer, and when final closure is completed, including meeting the GPS in groundwater per 40 CFR 257.98(c), this documentation will be included in the remedy completion report. All groundwater monitoring at the impoundments since September 2018 reflects post source removal conditions, and recent events reflect declining concentrations in most wells.

3.0 Evaluation of Potential Remedies

3.1 Landfill

Since the last semiannual selection of remedy update in January 2022, semi-annual assessment monitoring was completed in May 2022 and substantive progress has been made to evaluate feasibility of the remedies identified in the ACM Report, including:

- further define the contaminant plume by drilling and sampling additional wells,
- update the conceptual site model with data obtained in the drilling program
- evaluate potential exposure of nearby populations and receptors,
- continued discussions with adjacent landowners and private well sampling,
- engineering design of the ash removal (source control),
- progress towards agreement for ash removal for beneficial reuse, and
- continued feasibility evaluation of permeable reactive barrier (PRB) to treat groundwater.

Several new wells have been installed on both PSCo's property and the adjacent property owner to the north of the landfill (Valmont Butte) to further define the contaminant plume and to provide lithologic and groundwater data for groundwater flow model expansion. In addition to assessment monitoring, multiple groundwater sampling events have been conducted to help characterize the nature and extent of the release, including sampling private wells north of the Valmont Station and Valmont Butte properties. The engineering and geochemical feasibility study has continued with new bench-scale treatability results for use in evaluating a permeable reactive barrier (PRB) as a remedy. Additionally, PSCo is working towards entering an agreement for the source removal and beneficial reuse of CCR from multiple cells of the landfill.

3.1.1 Nature and Extent Characterization Progress

Quarterly sampling of the eight new landfill monitoring wells installed in September 2021 was initiated in 2022 to further characterize the extent of SSLs. This includes the 6 wells located north of Valmont's property boundary on the adjacent Valmont Butte property owned by the City of Boulder, and the 2 wells located within the PSCo property boundary immediately east of the Valmont Butte property.

In addition to sampling the eight nature and extent characterization wells installed in 2021, 5 new wells were installed in 2022 to further characterize conditions downgradient of the landfill. Two monitoring wells were installed in April 2022, wells MW-36 and MW-37 (**Figure 2**). These wells were installed northeast of the landfill on PSCo's property to help further characterize groundwater flow direction in this area of the groundwater flow model and evaluate groundwater flow coming from Valmont reservoir located to the south.

Three wells were installed in June 2022 on the Valmont Butte property: MW-38A, MW-38B, and MW-38C. Because the groundwater flow direction from the northeastern portion of the landfill is

to the north from the landfill, these wells were installed as far north as possible on the Valmont Butte property to monitor concentrations of constituents of concern (COCs) as close as possible to private properties north of Valmont Road and determine if GPS exceedances were bounded in this direction. They were installed adjacent to each other and at different depths to evaluate the groundwater quality variability with depth. One well was screened in the uppermost groundwater in the weathered shale (29 feet below ground surface (bgs)), and two wells were screened at different depths in the deeper, consolidated shale (65 and 200 feet bgs) to evaluate the potential for vertical migration of COCs. Originally, these wells were planned to be located north of Valmont Road to attempt to bound the extent of the GPS exceedances further downgradient. However, PSCo was unable to obtain agreement from the owner of that property and is in discussions with the owner of the next property to the north about installing one to two wells to delineate the northernmost extent of GPS exceedances.

Each of the existing and new well locations are shown in **Figure 2**. All 5 of the wells installed in 2022 are being sampled on a quarterly basis. Samples from the 3 wells on the Valmont Butte property are being analyzed for the three COCs (arsenic, lithium, and selenium) and select general water quality parameters. Samples from the 2 wells on PSCo property are being analyzed for all Appendix III and IV constituents. The data collected from 2021 and 2022 wells is being incorporated into the groundwater flow and transport model update and used to further evaluate alternative remedy scenarios discussed below.

3.1.2 Groundwater Model Progress

A groundwater flow and transport model was initially developed for the landfill in Spring 2019 to support the corrective measures assessment. The objectives of the modeling are to simulate groundwater flow and COC concentrations to help delineate the likely extent of GPS exceedances, and to evaluate the effectiveness of each potential corrective measure to reduce groundwater concentrations over time with the goal of selecting the best remedy or combination of measures for implementation. For each corrective measure alternative simulated, the model is used to evaluate:

- concentrations of COCs over time, transport directions and potential for movement offsite; and
- the time required for each alternative to “complete the remedy” (per 257.96(c)(2)).

The model was originally used in 2019 and 2020 to help identify potential plume migration, and the model predictions are what lead to the installation of additional wells at the landfill property boundary and nature and extent wells on the Valmont Butte property. However, the modeling process is iterative, and given that the simulated plume was close to the model boundary at that time, it was determined that a model expansion was necessary to simulate conditions further downgradient. The model has been significantly updated in 2021 and 2022 to expand the model boundaries and incorporate additional offsite data including the Valmont Butte property and within the Boulder Creek alluvial valley.

Two landfill ash characterization studies were completed between June and August 2021, consisting of 31 borings within the ash. The purpose was to collect ash samples for the ash removal component, obtain ash pore water samples, evaluate to what extent saturated conditions are present within the landfill, and refine the landfill bottom elevations. The lithology from these borings was included in the update made to the geologic model to better reflect the landfill ash limits and the underlying native materials. The limited observed moist ash in borings is resulting in fewer and thinner areas of saturated ash area in the updated model. Of the 31 borings drilling into the ash, only 6 borings encountered wet ash:

- 1 boring in central landfill area (referred to as Cell A) installed a temporary well to evaluate moisture, it went dry after initial pumping and did not recharge, appearing to be associated with rain into the boring/casing.
- 2 borings in central and easternmost landfill area (referred to as Cell A and Cell B) installed a temporary well to evaluate moisture, slow recharge and ash pore water was sampled. The native material below the moist ash was “moist to dry” lean clay and therefore the saturated ash is considered perched and not connected to the water table.
- 2 borings in the northern most landfill area (referred to as Cell D) had native material below the moist ash which was “moist to dry” lean clay and therefore the saturated ash is considered perched and not connected to the water table.
- 1 boring in the south/central landfill area (referred to as Cell A) was saturated, with saturated native conditions below the ash, and elevations appear to potentially match the potentiometric surface and therefore a limited area is simulated in the model as below the water table.

With the installation of new monitoring wells north of the landfill and private well water level and water quality data in 2021 and 2022, the model was updated, and recalibration is underway to match the new data. The model has been successfully calibrated to hydraulic head measurements, and the work to calibrate the transport model is in progress. Once the current calibration is complete, the model will be used to simulate the effectiveness of the proposed ash removal and other potential remedy alternatives like the permeable reactive barrier, including prediction of the time to achieve compliance with the GPS.

3.1.3 Source Removal

PSCo has made significant progress in its negotiations with a vendor to remove the majority of the ash from the landfill (source removal) for encapsulated beneficial reuse in concrete and expects to execute an agreement by end of the year. This would result in removal of the majority of the CCR from the landfill. The ash located in the northernmost area (referred to as Cells D and E) would remain in place and a final cover system will be designed and installed in accordance with 40 CFR 257.102(d) of the CCR Rule. PSCo has developed an engineered design plan for phased ash removal which will be submitted to the State for approval under solid waste regulations. Once the agreement for beneficial reuse is finalized, the planning and permitting process will continue and construction schedules will be developed. Currently, PSCo expects ash removal work to begin in middle to late 2023 pending permit approvals.

As discussed in the ACM Report, landfill ash removal is anticipated to result in a significant decrease of COC concentrations in groundwater over time. The excavation process for this remedy is now anticipated to take 10 to 12 years, focusing initial excavation on the areas that appear responsible for the off-site transport of COCs in groundwater. Additional groundwater modeling scenarios will be used to evaluate the short- and long-term effectiveness of the source removal, in combination with the PRB.

3.1.4 PRB Potential Remedy Progress

PSCo advanced work on the engineering and geochemical feasibility study developed in 2021 to evaluate the PRB as a potential remedy to address groundwater conditions at the landfill. PSCo developed a PRB study designed to evaluate the feasibility of a PRB via conventional trench, injection wells, or funnel and gate in a limited area of the landfill boundary where groundwater concentrations exceeded GPS. The study uses a phased approach designed to evaluate geochemical bench testing of reagents with site-specific substrate and groundwater followed by the geotechnical characteristics of the substrate for hydraulic and construction feasibility.

The intention of the bench test program is to evaluate if geochemical treatment using targeted reagents (or other mechanisms) can be effective in reducing COC concentrations. Three phases of bench-scale laboratory testing have been conducted thus far using the groundwater and sediment samples collected in 2021 and a summary of these can be found in **Table 1**. The first phase of testing completed in 2021 focused on reductive precipitation and adsorption as a treatability mechanism. Four microcosm reagent treatments were tested but it was determined that the site soil used in the reaction vessels for testing was creating interference by contributing extremely high total dissolved solids (TDS) into solution. The laboratory advised to use clean sand instead as the turbulent mixing conditions were creating artificially high TDS that was not representative of field-conditions.

In early 2022, a second phase of testing was conducted using the modified testing procedure (clean sand), with the same reagents. The results showed a substantial reduction for selenium, though still above the GPS, but the treatment had no impact on lithium. Since reductive precipitation and adsorption was proving to be insufficient as a standalone method to effectively treat all COCs, a third phase of treatment was completed in 2022 employing adsorptive polishing with biochar and activated carbon. The polishing phase was meant to be supplemental to the previous phase, and thus the treated groundwater from Phase II was used as the input for Phase III.

Adsorptive polishing with biochar (Phase III) yielded results that indicated significant reduction in the targeted metal concentrations, including lithium. Activated carbon was also shown to be effective, but less so than biochar. The biochar treatment reduced soluble lithium by approximately 73% from 278 µg/L to 77 µg/L. Both adsorbents reduced soluble boron and selenium concentrations by more the 98%. The concentration of arsenic in the sample collected from MW-28 was an order of magnitude below the GPS value and remained at that level post-

treatment. While the bench-scale testing up to this point has shown that the groundwater can be treated geochemically under bench-scale laboratory conditions, the next phase of testing (Phase IV) will be intended to evaluate if and/or how the reagents/biochar could be practically implemented in the field.

Additional geochemical treatability testing to estimate adsorption and biofouling rates of the biochar material will be conducted in the second half of 2022 to complete the evaluation of whether biochar will be feasible for use in a PRB. The adsorption testing will provide data required to size the PRB trench or to determine if targeted injections may be possible. Biofouling rates should provide information for how often the media would need to be replaced or recharged. Additionally, testing will be done to determine biochar can provide the same level of reductions in COCs in groundwater without pairing with reductive precipitation.

Core samples of newly drilled wells have also been collected for geotechnical testing pending the additional geochemical treatability bench-scale testing. If these results indicate biochar can be an effective media in PRB, to further determine if a PRB is a viable remedy, an in-depth hydrogeologic and geological/geotechnical feasibility investigation will be used to evaluate which PRB installation method would best work at this site (conventional trench, injection wells, or funnel and gate).

The geological and geotechnical investigation would include several new borings in the desired location for the PRB to collect samples to be sent to a geotechnical laboratory for testing in addition to the core samples previously collected. Data obtained during the geological and geotechnical investigation will be used to evaluate depth to bedrock, competency of bedrock to anchor a PRB, and efficacy of unconsolidated material to propagate PRB amendments. Additionally, some of these borings could be converted to monitoring wells to facilitate periodic groundwater sample collection and water level measurements along the length of the planned PRB. Data obtained during the hydrogeologic investigation would be used to supplement groundwater quality data obtained from existing monitoring wells to further refine the location, depth, and length of the PRB, or as well as any required hydraulic mechanism, such as a gate.

Table 1. PRB Potential Remedy Progress

Timeframe	Progress Steps	Results
2021 Quarter 3	Site-specific samples collected	Geochemical treatability study initiated
2021 Quarter 4	Results from Phase I	Revise testing conditions
2022 Quarter 1	Results from Phase II	Not effective for all COCs
2022 Quarter 2	Results from Phase III + Geotechnical samples collected from newly drilled wells	Phase III – results demonstrated effectiveness of biochar polishing
2022 Quarter 3	Results from Phase IV	TBD
2022 Quarter 4	Geological/geotechnical feasibility study initiated	TBD

In summary, substantive progress has been made in 2021 and 2022 on evaluation of the PRB as an effective remedy to address groundwater impacts, including eliminating geochemical methods that proved ineffective or insufficient and identifying and testing additional geochemical treatment methods. PSCo anticipates that the additional work planned in the second half of 2022 should advance the PRB evaluation to the point where the advanced hydrogeologic and geotechnical feasibility stage of evaluation can be initiated, potentially in 2023, followed by the conceptual design phase. Design considerations will include the use of the groundwater flow model to simulate effectiveness and timeliness of the PRB in achieving compliance with GPS over a short- and long-term period. Impacts from source removal over time and the delineated plume extents, which are still being characterized, will need to be accounted for in this full-scale site analysis. If the PRB remedy is selected, design engineering will begin, followed by construction which would be no more than a few years and depends on the PRB configuration or injection method chosen to best accommodate site-specific conditions.

3.2 Bottom Ash Impoundments

As discussed in the ACM Report, concentrations of CCR constituents that exceeded GPS (cobalt and molybdenum) are relatively low at the impoundment monitoring wells. The area that was once the former impoundments prior to closure by removal of all CCR has now been submerged by Leggett Reservoir. Closure by CCR removal, completed in 2018, was the most significant corrective action that could be taken to mitigate impacts to groundwater. As discussed in the ACM Report, based on the impoundment site characteristics and constraints, source removal in combination with monitored natural attenuation may be the most appropriate alternative to address groundwater conditions at this site surrounded by the reservoirs. Monitored attenuation is a recognized approach for attainment of groundwater protection standards, especially where the source has been removed, provided it can meet the remedy criteria, particularly timeliness.

PSCo continues assessment monitoring at the former impoundments to evaluate concentration trends of these constituents of concern (COC) since source removal was completed in 2018. The groundwater chemistry from 2019 through the first half of 2022 has shown decreasing concentrations of molybdenum in all three downgradient wells and concentrations of molybdenum are now well below the GPS concentration in all wells. The groundwater chemistry from 2019 through the first half of 2022 has also shown decreasing concentrations in cobalt in two of the three downgradient wells. Only one downgradient well has cobalt concentrations that have not appeared to consistently decrease.

By continuing to track the trends observed since 2019 through ongoing assessment monitoring, PSCo will evaluate the potential for groundwater around the impoundments to meet clean closure criteria in groundwater or if additional measures should be further considered.

4.0 Next Steps

PSCo continues to proceed diligently through the process of further evaluating potential remedies, consistent with best practices and professional judgment.

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:

- Expansion of the groundwater monitoring network and sampling to delineate the contaminant plume.
- Groundwater flow and transport model expansion calibration and simulation of corrective measures scenarios.
- Continue progress towards finalizing agreement to initiate ash removal for beneficial use as a source removal component of the landfill remedy.
- Evaluation of the next phase of PRB feasibility study bench test results at the landfill for effectiveness of reagent treatment of lithium, selenium, and arsenic in groundwater. If the findings of the bench testing show a PRB utilizing biochar to be a viable groundwater treatment, PSCo will move into the next stages of the feasibility study:
    - Geotechnical feasibility to evaluate whether or not the hydraulic properties will be conducive to groundwater flow through the PRB and evaluate construction feasibility for the PRB alternatives.
    - Update the groundwater flow and transport model predictive simulations associated with the PRB remedy to reflect measured treatment effectiveness.
- Continue semi-annual groundwater assessment monitoring at each CCR unit.
- Continued evaluation of COC concentrations relative to GPS and background and general trends.
- In accordance with 257.97(a), PSCo will complete semiannual progress reporting to document additional work completed towards remedy selection and design.

The following activities are anticipated to be completed or initiated in the next 6-month period for the bottom ash impoundments, but are subject to change based upon the iterative nature of the process, uncertainty about the results of each step, and interim findings:

- Continued semiannual groundwater assessment monitoring.
- Continued evaluation of COC concentrations relative to GPS and background and general trends.

5.0 References

HDR, 2018. Groundwater Protection Standards and Determination of SSLs per 257.95(g). October 10, 2018.

HDR, 2019a. Groundwater Protection Standards and Determination of SSLs per 257.95(g) Revision 1. June 7, 2019.

HDR, 2019b. Conceptual Site Model and Assessment of Corrective Measures - Compliance with the Coal Combustion Residuals Rule Valmont Station. June 6, 2019.

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