POWER CLEANUP JOBS STUDY
REMEDIATION ALTERNATIVES ANALYSIS

PREPARED FOR:
NORTHERN PLAINS RESOURCE COUNCIL

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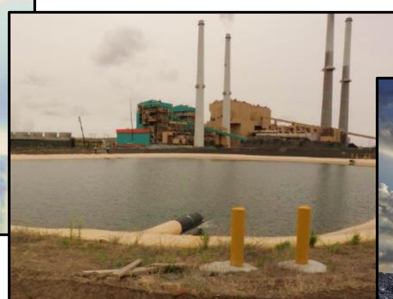


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1. Introduction

1.1 Background

This report provides an analysis of remediation alternatives for the Colstrip Steam Electrical Station Plant Site, and the resulting costs and jobs created by each environmental cleanup plan. Our objective is to identify and provide cost estimates for alternatives that will enhance the environmental outcome and employ local community members as service providers in the remediation process. This report was prepared by KirK Engineering & Natural Resources, Inc. (Kirk ENR) and Apex Engineering PLLC (Apex), both Montana environmental engineering companies. KirK ENR provided the overall environmental and remediation alternative development, while Apex evaluated groundwater contamination and water treatment options. KirK ENR and Apex prepared this report under contract to Northern Plains Resources Council. Northern Plains is a grassroots conservation and family agriculture group that organizes Montanans to protect our water quality, family farms and ranches, and unique quality of life. Since its inception, Northern Plains has advocated for protection of land and water resources, which are the foundation of ranching and agricultural interests in the Colstrip area.

The Colstrip Plant is co-owned by Talen Montana, LLC, PacifiCorp, Puget Sound Energy, Inc., Portland General Electric Company, Avista Corporation, and NorthWestern Corporation. Talen is the current manager of the Plant, having taken over operations from PPL Montana in 2015. Units 1&2 of the Colstrip Plant, which have operated since 1975, are required by a court settlement related to air quality to shut down no later than the end of 2022. Units 3&4, which have operated since 1983, are slated to operate with modifications to their coal ash management for what is expected to be additional decades.

Coal combustion residuals (CCR) produced over the years from Units 1&2 and 3&4 are contained in large surface impoundments at two CCR pond areas located near the Plant, referred to as: 1) the Unit 1&2 Stage I Evaporation Pond and Stage II Evaporation Pond, and 2) the Unit 3&4 Effluent Holding Pond. CCR ponds and bottom ash dewatering areas are also located at the Colstrip Plant. Each of these three sites, which we refer to as the SOEP-STEP Site, EHP Site, and Plant Site, are shown in Figure 1.1-1. In addition to coal ash ponds, each site also has water management ponds which store water from the Colstrip Plant's coal ash slurry process and from the contaminated groundwater capture system.

The ponds at all three sites have leaked CCR leachate and decant water for decades, with seepage contaminating local aquifers and creeks. Colstrip Plant management has constructed an elaborate system of wells and trenches to capture contaminated groundwater and pump it back into the plant water circuit, with the water treated to improve its quality to that required in the various plant operations. Colstrip Plant management has also upgraded the coal ash slurry system and pond liners to reduce seepage of CCR contaminants to groundwater.

The steps taken to reduce contaminant release from the ponds to the environment have generally prevented further spread of contamination but have not been effective in restoring water quality to meet standards in aquifers underlying and near the SOEP-STEP, EHP, and Plant Sites. Another limitation with the steps taken so far to control the spread of contaminated groundwater is if the capture system were shut down, contamination would resume spreading in groundwater and area creeks. Talen is in the process of submitting cleanup proposals for the three sites for approval with the State of Montana Department of Environmental Quality (DEQ). Talen's cleanup proposals generally rely on a combination of reducing water inventories in the ponds, pond closure by capping with engineered infiltration barrier caps, and groundwater flushing, capture, and treatment.

This report evaluates Talen's cleanup proposal and the jobs it would create. We also present and compare two alternative remedy proposals which would provide additional benefits, clean up contaminated areas faster, and create additional jobs in the cleanup effort. Our alternative remedies were developed with two main goals: 1) address and remediate the current groundwater contamination problem; and 2) provide a more permanent remedy, which eliminates to the extent possible the potential for long-term leaching or seepage from CCR and other waste stored at the Colstrip Plant.

The report is divided into sections as follows:

- Section 1 provides this introduction, describes the assumptions we have made in our cleanup alternative analysis, provides the data sources used, explains the limitations of this analysis, and provides a description of the regulatory framework (laws, regulations, and court settlements) which provide the cleanup guidelines.
- Section 2 provides a Site Characterization Summary and Environmental Risk Assessment, which summarizes the site data used in our alternatives and summarizes a hydrogeologic and environmental risk assessment undertaken to inform our remedy evaluation process.
- Section 3 presents the Screening of Remediation Technologies, a summary of all remediation/cleanup technologies considered.
- Section 4 presents the Cleanup Alternatives. This section describes Talen's preliminary plans and the two alternative cleanup proposals we have developed.
- Section 5 presents the Comparison of Cleanup Alternatives. This compares the environmental cleanup efficacy, cost, and number and type of jobs created in the cleanup effort for Talen's plan and the alternatives.

1.2 Data Sources and Assumptions

KirK ENR and Apex prepared this analysis using publicly available documents which were prepared by Talen and PPL Montana to comply with either the Administrative Order on Consent (AOC) or Federal CCR Rule (see section 1.3 for a discussion of these regulations). These publicly available documents are the source for our understanding of the site. We do not work for the Colstrip Plant owners or operators, and we did not have access to information, data, and site modeling not contained in the public documents. We have made assumptions to accomplish a number of calculations and to produce estimates in our analysis; these assumptions are noted in the sections of this report which describe those calculations and estimates.

Our sources of information are described in the sections below. Information sources for our understanding of site characterization and site data are presented in the first section. Information sources used to outline Talen's remediation and closure plan are described in the second section. The third section describes our sources for Talen's cost estimate and implementation schedule.

Site Characterization

The following site characterization reports, prepared by Talen and PPL Montana, form the basis of our understanding of the site and were used in our assessment of site conditions:

AOC documents:

Colstrip Steam Electric Station: Administrative Order on Consent: Units 1 & 2 Stage I and II Evaporation Ponds Site Report (Hydrometrics 2016).

Colstrip Steam Electric Station: Administrative Order on Consent: Plant Site Report (Hydrometrics 2015).

Colstrip Steam Electric Station Administrative Order on Consent: Units 3 & 4 Effluent Holding Pond (EHP) Site Report (Hydrometrics 2016).

Federal CCR Rule documents:

History of Construction Report (Geosyntec 2016)

2017 Surface Impoundment Annual Inspection Report (Jorgensen Geotechnical 2018)

2017 Annual Groundwater Monitoring and Corrective Action Report (Hydrometrics 2018)

Other Talen documents:

Talen's Master Plan Summary Report Update (Geosyntec 2016) also provided site characterization data and other information on the site.

Talen's Remediation and Closure Plan

This analysis also uses numerous assumptions in comparing cleanup plans because a site-wide cleanup plan has not been finalized or approved by DEQ. Talen is currently formulating groundwater remedy and pond closure plans, with the plans being written separately for each of the three areas: SOEP-STEP Site, EHP Site, and Plant Site. As of the November 2018 date of our analysis, DEQ has approved only the Plant Site Remedy Evaluation Report and has not approved any of the three pond/surface impoundment Closure Plans. At the SOEP-STEP Site, Talen is expected to make significant changes and improvements to its proposed groundwater contamination remedy, in a revised Remedy Evaluation Report. For the purposes of our analysis and comparison, we assume Talen's plans are those proposed in the current plans, which have been submitted to DEQ and which are publicly available as of September 2018.

Our comparison uses Talen's proposed cleanup plan from the following AOC documents:

SOEP-STEP Site: *Colstrip Wastewater Facility Closure Plan: Units 1 & 2 Stage I & II Evaporation Pond Site (Geosyntec 2018) and Remedy Evaluation Report: Units 1 & 2 Stage I and II Evaporation Ponds (Geosyntec 2018).*

EHP Site: *Colstrip Wastewater Facility Closure Plan: Units 3 & 4 Effluent Holding Pond Site (Geosyntec 2018).* Talen has not released a Remedy Evaluation Report for the EHP Site; therefore, we do not know their proposed plan for groundwater remediation at the EHP. For simplicity and because Talen has not provided cost estimates for additional groundwater remediation systems at the EHP, we assume that Talen's proposal will be to continue to operate the contaminated groundwater capture and treat system at the EHP; costs for this are provided in Talen's *Master Plan Summary Report Update (Geosyntec 2016).* We also assume Talen does not plan to pump the EHP underdrain to dewater the EHP ponds because that system is not currently in use.

Plant Site: *Colstrip Wastewater Facility Closure Plan: Plant Site (Geosyntec 2018) and Revised Remedy Evaluation Report: Plant Site (Geosyntec 2017).* It is not clear what Talen's plan is for the Units 1&2 and 3&4 Bottom Ash Clearwells, which hold bottom ash decant water. The Closure Plan indicates the clearwells will be filled with CCR and capped, but the *Written Closure Plan per Requirement on 40 CFR §257.102 for Existing Impoundments* does not include the clearwells. Given this uncertainty, we assume the clearwells will be dewatered, closed, and reclaimed.

Talen has also produced separate closure plans and post-closure O&M plans to comply with the Federal CCR Rule. These are the *Written Closure Plan per Requirement on 40 CFR §257.102 for Existing Impoundments and for J Cell (Geosyntec 2016)* and *Written Post-Closure Plan per Requirement on 40 CFR §257.104 for Existing Impoundments and for J Cell (Geosyntec 2016).* These CCR Rule Closure Plans outline the same proposal as the AOC Closure Plan but in a different format compliant with the federal rule, and were consulted in our analysis.

Talen's Cost Estimate and Implementation Schedule

To evaluate the total cost of Talen's proposed plan we use closure and remedy costs provided by Talen in the SOEP-STEP and Plant Site Remedy Evaluation Reports and EHP Closure Plans (documents referenced in the previous section).

The comparison we make to Talen's cost estimate is only for those items which are part of final closure and remedy. We do not compare costs incurred which are part of normal plant operation. For instance, where Talen proposes to close existing CCR cells and build a new overfill cell on top, in order to comply with the current regulations, we assume that cost is part of normal plant operations. Similarly, where Talen proposes to construct a new Capture Well Treatment System Solids Disposal Area, we assume that is part of normal plant operations because it is required to continue using the existing capture system.

Talen's *Master Plan Summary Report Update (Geosyntec 2016)* provides an implementation schedule for Talen's water treatment construction and closure plans for some ponds. That schedule was used for allocating Talen's closure and remedy costs to a given year, with the exception that both design and construction dates were both allocated to the same year to be consistent with our cost analysis. Groundwater remedy costs and closure dates for ponds not included in the Master Plan Summary schedule were scheduled by year according to the dates given in the SOEP-STEP Remedy Evaluation Report or were assumed based on Units 1&2 and Units 3&4 closure dates for the Plant and EHP Sites. A closure date of 2040 is assumed for Units 3&4 based on the Master Plan Summary. Cost and job analyses were performed out to 2069 to match Talen's Master Plan Summary schedule which assumes Units 3&4 close in 2040 and includes 30 years of O&M.

1.3 Limitations of this Analysis

The limitations of our analysis are related to both the data and information available to us and the scope of our analysis. The data and information available are described in section 1.2. The scope of our analysis is to summarize cleanup, remediation, and closure alternatives, compare cleanup efficacy of the alternatives, and provide a cost estimate and jobs analysis for each alternative. Our analysis includes a review of remediation technologies available for controlling CCR contamination and groundwater remediation like that existing at the Colstrip Plant, and makes recommendations for technologies which should be further evaluated or pilot-tested for use at Colstrip.

This report was prepared by professional engineers, licensed in Montana; however, this report is not a Preliminary Engineering Report or Engineering Design Document. Further feasibility study, pilot tests, and engineering is required to determine how the proposed alternatives could be implemented. The scope of this analysis also does not identify exact volumes of contaminants or perform a detailed evaluation of coordinating remediation with continued plant operations; the costs and jobs number are therefore an estimate.

1.4 Regulatory Framework for Colstrip Cleanup

The cleanup process at Colstrip is guided by a complex set of laws, regulations, and court-approved settlements. This regulatory framework defines the criteria and water quality standards which must be met for cleanup at the Colstrip Plant but also defines how CCR must be handled and disposed. This regulatory framework is summarized here to explain how it affects Talen's remediation and closure plan, and the proposed alternatives.

Montana Regulations

The Montana Water Quality Act and Montana Major Facility Siting Act are the state-based regulatory framework guiding the operation and cleanup of the Colstrip Plant and coal ash pond sites. Administrative Rules of Montana promulgated under that state Water Quality Act include 17.30.1006 CLASSIFICATIONS, BENEFICIAL USES, AND SPECIFIC STANDARDS FOR GROUND WATERS. Under state regulations, Colstrip groundwater is Class III, which means the water has generally high total dissolved solids/salinity. ARM 17.30.1006 requires Class III waters of the shallowest aquifer in Colstrip to be maintained so that the waters are at least marginally suitable for: irrigation of some salt-tolerant crops; some commercial and industrial purposes; drinking water for some livestock and wildlife; and drinking, culinary, and food processing purposes.

On August 3, 2012, PPL Montana and the Montana Department of Environmental Quality (DEQ) entered into an Administrative Order on Consent (AOC) to address environmental impacts from the coal ash ponds and other wastes at the Colstrip Plant. The AOC is an enforcement action taken by DEQ under the Montana Water Quality Act and the Major Facility Siting Act to address groundwater contamination at the Colstrip Plant. PPL Montana transferred its ownership to Talen Energy in 2015 and Talen is responsible for fulfilling the requirements of the AOC.

The AOC leads to the cleanup criteria, which the groundwater remedy is required to meet. Talen's remediation proposal for the SOEP-STEP Site does not meet the cleanup criteria, which is one reason the plan was not approved by DEQ and is currently being revised by Talen. Our proposed alternatives are designed to enhance groundwater remediation timeframes and to protect groundwater from long-term leaching of coal ash, thereby meeting the AOC cleanup criteria faster and more permanently.

The AOC also requires Talen to prepare Site Characterization Reports, Remedy Evaluation Reports, and Facility Closure Plans for the SOEP-STEP, EHP, and Plant Sites. Talen's groundwater remedy plans are contained in the Remedy Evaluation Reports and its facility closure plans are contained in the Closure Plans. These reports and plans provide the basis for our understanding of Talen's cleanup plan and comparison to the proposed alternatives, described further in section 1.2. Although the AOC requires remediation, it is not prescriptive regarding how remediation should occur; the chosen cleanup plan is left for Talen to propose and DEQ to approve, if it meets the cleanup criteria and other AOC requirements. The cleanup plan must also meet the prescriptive criteria of the Federal CCR Rule where applicable, described further below.

The AOC requirements are further described in documents produced by Talen and DEQ available at the DEQ website: http://deq.mt.gov/DEQAdmin/mfs/ColstripSteamElectricStation

Consent Decree Related to AOC Litigation

In Fall 2012, two lawsuits were filed by the Montana Environmental Information Center (MEIC) and Earthjustice against the DEQ pertaining to the AOC. MEIC and Earthjustice contended that the AOC as originally signed and being implemented was an improper enforcement action, and violates Montanans' constitutional right to a clean and healthful environment. PPL Montana intervened, and the case was transferred to Montana state court. The parties entered into settlement discussions and lodged a consent decree in state court in September 2016. Talen agreed to retirement of Units 1&2 and transition to a dry disposal system for CCR from Units 3&4 no later than July 1, 2022. The closure date for Units 1&2 and conversion to dry CCR storage for Units 3&4 is included in both Talen's proposal, and in our analysis and proposed alternatives.

Federal Regulations

Federal CCR Rule

Cleanup and coal ash management at the Colstrip Plant are regulated by the Federal CCR Rule, which is officially titled 'Standards for the Disposal of Coal Combustion Residuals in Landfills and Surface Impoundments.' The Federal CCR Rule regulates CCR disposal as nonhazardous waste similar to municipal waste. The rule was promulgated under the governing statute of the Resource Conservation and Recovery Act (RCRA), the primary federal law regulating solid waste disposal. The rule is published in Code of Federal Regulations (CFR) Title 40 Part 257, Subpart D.

The rule is intended to address risks from coal ash disposal, such as leaking of contaminants into groundwater, blowing of contaminants into the air as dust, and catastrophic failure of coal ash containment structures. The rule establishes technical design, operations and maintenance (O&M), closure, and post-closure care requirements for CCR surface impoundments and landfills. The rule requires groundwater monitoring; that data has been used in our analysis. The rule also establishes corrective action requirements for any related leakage and groundwater contamination.

The Federal CCR Rule was first issued in 2015 and has been in flux since. The current presidential administration has made changes to the rule to ease implementation costs to the coal industry. Perhaps more significantly, on August 21, 2018 in the court case Utilities Solid Waste Activities Group (USWAG) v. EPA, the 4th U.S. Circuit Court of Appeals ruled that parts of the original CCR Rule were too lenient and not in compliance with RCRA. The court remanded the CCR Rule back to EPA to devise changes consistent with the court decision. Given uncertainties in the actual requirements of the Federal CCR Rule going forward, for our analysis we assume the Federal CCR Rule as published in September 2018 regulates CCR disposal.

The Federal CCR Rule does not apply the same requirements to all ponds and impoundments at Colstrip. New impoundments and landfills are required to have the highest level of design and construction standards; existing ponds which are in use are not required to be retrofitted to meet the new standards but may be required to close if they are impacting groundwater. Other ponds at Colstrip which were properly closed prior to the October 19, 2015 effective date of the rule are not covered by the rule and are therefore subject to Montana regulations and the AOC. The Federal Rule does apply to CCR which is excavated and moved to a new repository, as proposed in our alternatives.

Consent Decree Related to New Source Review/Prevention of Significant Deterioration

The Sierra Club and MEIC filed a lawsuit in federal district court in 2013, alleging that the Colstrip Plant had violated the Federal Clean Air Act by undertaking major repairs without a permit that would have required installation of best available pollution control technology. The parties entered into a consent decree on July 2016 in which Unit 1&2 owners agreed to close that unit no later than July 1, 2022 and to meet more stringent SO_2 and NO_x limits for Units 1&2 until closure. This closure date for Units 1&2 is included in both Talen's proposal, and in our analysis and proposed alternatives.

2. Site Characterization Summary and Environmental Risk Assessment

The site characterization summary in section 2.1 describes the most relevant information on the coal ash ponds and waste-containing areas, which we used in developing remedy alternatives and cost estimates. Section 2.2 presents an assessment of hydrogeologic conditions and pond construction; both are factors which were weighed in evaluating the remedy alternatives. Together, the information in these sections provides the basis for which ponds and waste areas were chosen for additional remedy in the proposed alternatives.

2.1 Site Characterization Summary

PPL Montana and Talen have prepared detailed site characterization reports. These reports include groundwater contaminant modeling and remedy evaluation reports, which include predictive groundwater modeling to show the results of their proposed plan (documents listed in section 1.2). The documents also describe the history of construction and current status of the coal ash ponds, groundwater contamination, past groundwater contaminant response actions, and plant operations such as water management practices which may affect release of contaminants from CCR. Talen's reports are the foundation of our understanding of site conditions and contaminant extent, but will not be summarized in detail here due to their length and complexity.

The AOC divides the Colstrip Plant and waste ponds into three areas for remediation planning; these are the SOEP-STEP, EHP, and Plant Sites. Each site contains ponds which are used for CCR and/or water storage. There are currently 40 unique ponds and waste storage areas, spread over the three sites, although this number is somewhat arbitrary because several CCR or water storage cells may be referred to as one pond.

Table 2.1-1 provides a summary of each pond and waste area including construction history including liner type, function, sizing, contents, and Talen's closure plan. Figures 2.1-1, 2.1-2, and 2.1-3 show the SOEP-STEP, EHP, and Plant Sites, respectively.

There are two general categories of pond: 1) CCR-containing ponds (formally called surface impoundments in the Federal CCR Rule) which contain a mixture of CCR and slurry water, and 2) water management ponds. The water management ponds store CCR decant water, process water used in plant operations (e.g., cooling, emission control), stormwater, and captured contaminated groundwater. Decant water is currently produced by the paste plant, which converts the coal ash slurry into a lower water content paste; paste plant decant water is stored in the "clearwell" ponds.

Information provided in Table 2.1-1 provides the basis for the volumes and acreage of CCR and other contaminated media, for which we developed cost estimates for remediation and permanent storage. Contaminant volumes were obtained from the *Written Closure Plan per Requirement on 40 CFR §257.102 Existing Impoundments and J Cell (Geosyntec Consultants 2016)* where provided, or were estimated from pond design drawings or other available information as summarized under the column header "CCR volume source" in Table 2.1-1. Pond areas requiring a cap were either obtained from the AOC site characterization documents (listed in section 1.2) or were calculated from aerial photography using a geographic information system (GIS). The other information in Table 2.1-1 was obtained from the site characterization reports and closure plans.

For a number of years, the plant operators have been transitioning water management ponds which store contaminated CCR decant water or contaminated groundwater into new double-lined ponds with leachate collection. Storing this water in double-lined ponds effectively reduces potential for the water to leak directly into groundwater or saturate and leach CCR stored in the ponds. The STEP Old Clearwell and Plant Site Units 1&2 Cooling Tower Blowdown Pond - Pond C (North and South ponds) are the only ponds which currently contains CCR process water or captured contaminated groundwater that are not double-lined with leachate collection. Replacing these remaining single-lined or unlined ponds that store CCR process water or captured groundwater with new ponds which are double-lined with leachate collection would improve groundwater quality.

The 21 existing CCR ponds and waste cells are the focus of our cleanup alternative analysis. These solid waste-containing ponds and waste cells require a permanent remedy solution which will protect people, stock animals, and the environment in perpetuity. The water management ponds will be drained by the time of plant closure because Talen proposes to reuse this water in plant operations or treat it. When Units 1&2 and Units 3&4 shut down, Talen proposes to use the current double-lined water management ponds to store captured contaminated groundwater or for stormwater management, and to close and reclaim the single-lined and unlined water management ponds. Talen's closure plan for the water management ponds is protective and we incorporate it without modification in our alternatives.

The 21 solid waste-containing ponds and cells were further characterized using available information to evaluate potential remedies, and to understand the limitation on removal or other remedial activities. In addition to volumes, information compiled includes the bottom elevation, maximum fill elevation, approximate depth of fill, current water elevation, saturated thickness, saturated volume of CCR, and pore water volume. These additional data are provided in Table 2.1-2 and were used in our remedy analysis and cost estimates.

2.2 Hydrogeologic and Environmental Risk Assessment

In order to inform our proposed remedy alternatives, we built upon the analysis provided in Talen's Site Characterization reports to specifically evaluate three factors we consider to be critical criteria for evaluating pond closure and groundwater remedy alternatives: 1) construction of existing ponds and impoundments, and types of liners present; 2) a hydrogeologic assessment of each pond and its separation from groundwater; and 3) dam condition and hazard. Our goal in assessing these three factors was to illuminate problem areas so that solutions could be proposed in the remedy alternatives. This is further described in the next sections.

Pond Construction

The major consideration in pond construction is presence and type of liner system, and presence of a leachate collection system. Pond liners, where present, reduce or eliminate seepage of CCR leachate to groundwater. Leachate collection systems serve several purposes, including collecting leachate before it reaches groundwater, allowing monitoring of seepage and liner integrity, and allowing for CCR in the pond to drain and be collected without impacting groundwater.

SOEP-STEP Pond Construction

The SOEP pond was partially lined with clay, a liner which does not prevent CCR in this pond from being saturated with groundwater. There is also no leachate collection system at SOEP. A groundwater capture system has been installed at this pond, but this system only serves to limit the spread of contamination and requires perpetual O&M.

The STEP A Cell, E Cell, and Old Clearwell have older single-layer HDPE liners and do not have leachate collection. The HDPE liners at these ponds have had integrity issues over their lifespan and are relatively leaky compared to newer liner standards, which include double liners and leachate collection. The Old Clearwell is still used for storage of CCR slurry water, which presents a risk given the liner design. Notably, the Old Clearwell is the only pond which does not have a double liner and leachate collection, and which is used for process water storage or contaminated groundwater storage, at any of the three areas (SOEP-STEP, EHP, or Plant Sites).

The STEP Cell B/New Clearwell and D Cell both have a modern double-reinforced polypropylene (RPP) geomembrane liner with leachate collection.

EHP Pond Construction

The EHP Pond bottom soil was treated with compacted bentonite in places considered to be more permeable and is unlined. The EHP contains numerous overfill cells where new CCR cells or water management cells are built on top of existing CCR, which are unlined. These overfill cells are single- or double-lined with synthetic liners and leachate collection. Some have underliner leachate collection on top of dried and graded CCR paste, which is a less-effective barrier to leachate seepage compared to a double liner. The presence of overfill cell liners at the EHP is beneficial for reducing seepage from new CCR cells or from water management ponds, but the underlying CCR remains to slowly drain over time and is not protected should groundwater levels remain elevated into the EHP pond bottom.

An underdrain system was constructed at the bottom of the EHP above the bentonite-soil mixture and designed to help dewater the pond in the future. Scant details are provided on the construction or location of the underdrain other than it consists of 6-inch slotted corrugated polyethylene pipe. Talen reports in Appendix A of the EHP Site Characterization Report (Hydrometrics 2016) that the underdrain is not currently in use, but it is not clear why it is not used. Evidently, in late 2013 and early 2014, Hydrometrics pump-tested the underdrain and several wells within the EHP pond area for several months to evaluate dewatering potential. The pump test showed that the underdrain could sustain a flow of 187 gpm. Well 1003R, completed in clinker, sustained 440 gpm for six days and showed the potential to dewater the clinker within the cutoff wall rapidly. If the underdrain and existing wells within the EHP can be used to dewater the CCR within the ponds and reduce future seepage, it would have positive benefits for the groundwater remediation timeframe.

Plant Site Pond Construction

The ponds and solid waste cells at the Plant Site run the full gamut of construction, with scant details on the construction of the older ponds. Table 2.1-1 provides liner and leachate collection details. The current CCR-containing bottom ash ponds and Units 1&2 Flyash A Pond do not have synthetic liners or leachate collection but do have clay liners, which are anticipated to be relative leaky compared to geomembrane liners. The Units 1&2 Flyash B Pond, which is currently used for water management but will be used for CCR storage in the future, has a double liner with leachate collection. The Units 1&2 Flyash B Pond is constructed in contact with the water table and the leachate collection system captures groundwater, which presents a problem for long-term leachate collection. The Units 3&4 Bottom Ash Pond Clearwell is clay-lined while the Units 1&2 Bottom Ash Clearwell is double-lined with leachate collection.

Hydrogeologic Assessment

Our hydrogeologic assessment looked at the three areas where CCR is stored (the SOEP-STEP, EHP, and Plant Sites) and evaluated the hydraulic connection between the ponds and groundwater. We used existing data provided in the site characterization documents and other existing data provided in well logs and field studies performed by the Montana Bureau of Mines and Geology. We developed an Excel worksheet for each of the three areas which compares groundwater levels in wells adjacent to and below the existing CCR storage ponds to pond bottom elevations (this worksheet is included as Table 2.1-3).

SOEP-STEP Hydrogeologic Assessment

The groundwater level comparison shows that the SOEP contains CCR saturated with groundwater to a depth of at least 19 ft. The SOEP is unlined, and the CCR contact with groundwater presents both a current and long-term hazard for groundwater quality. Both the impoundment dam at the SOEP and STEP ponds and the construction of Castle Rock Lake appear to have increased groundwater levels underneath the SOEP and STEP because the dams back up the regional groundwater flow and raise water levels. The water balance discussion in the groundwater modeling report, Appendix A of the SOEP-STEP Site Characterization Report (Hydrometrics 2016), indicates that seepage from the STEP ponds is only 3% of the inflow into the local groundwater system. The water balance indicates that if the STEP is capped and eventually all free water drains from the ponds, that the impact on groundwater levels will be minimal.

We were unable to find in a publicly available report where the current or future groundwater levels in the ponds have been modeled in reference to the CCR. Our professional judgment is that the groundwater levels in this area will remain elevated long-term, leading to continued leaching of contaminants from CCR. Because of this, the SOEP CCR is targeted for additional remedy in our proposed alternatives. The available information also suggests that any modeling which is performed to evaluate long-term effects of proposed groundwater remedies in this area should include the saturated SOEP CCR as a permanent source of contaminants, unless the contaminants are removed or somehow attenuated. Our understanding of the modeling performed to date suggests that the models could be improved to better predict the long-term leaching of CCR in contact with groundwater.

The STEP pond has similar issues with elevated groundwater levels at A Cell, E Cell, and Old Clearwell, although the potential depth at which CCR would remain saturated with groundwater appears to be less than the SOEP. The STEP D Cell has adequate separation from groundwater. The STEP ponds which are in contact with groundwater have older single-layer plastic HDPE liners, which would be expected to limit leaching of CCR by groundwater if the liners are intact; however, the type of liners present do not allow monitoring for leaks. Long-term contact of groundwater with the liners will serve to keep CCR in the ponds saturated into the future because the cells will not drain completely on their own. This, combined with the age of the liners and lack of leak detection, presents a long-term risk to groundwater quality in this area. Due to these concerns, the STEP A Cell, E Cell, and Old Clearwell are targeted for additional remedy in our proposed alternatives.

EHP Hydrogeologic Assessment

All cells at the EHP Site, with the exception of A cell, are currently saturated and hydraulically connected to groundwater. The EHP Site was constructed with a bentonite-amended concrete cutoff wall (cutoff wall) around the perimeter of the entire EHP to limit horizontal seepage. The bottom of the EHP is not lined. The effect of 35 years of seepage from the EHP cells has been to raise groundwater levels in the area such that the ponds are hydraulically connected to groundwater.

At the EHP Site, CCR saturation appears to be mostly a function of historic and continuing seepage from the ponds. The water balance discussion in the groundwater modeling report, Appendix A of the EHP Site Characterization Report (Hydrometrics 2016), states that seepage from the EHP is the greatest source of recharge to groundwater in the area, comprising 34-53% of all recharge in recent decades. Given the water balance, we expect that when the ponds are completely dewatered, and seepage eliminated, the EHP will no longer be hydraulically connected to groundwater. The existing groundwater models should be used to test this, and predict groundwater levels in the post-closure period to ensure the ponds can be dewatered such that CCR is no longer in contact with groundwater. Monitoring wells installed within the EHP complex would also be useful to monitor water levels long-term to ensure the ponds are dewatered and groundwater does not keep CCR saturated within the ponds.

Plant Site Hydrogeologic Assessment

The Units 1&2 A Pond and B Pond at the Plant Site are currently in contact with groundwater. The A Pond is partially lined with clay and leaky. The B Pond is double-lined with a leachate collection system. The leachate collection system partially collects groundwater due to high groundwater levels under the pond. Separation of the Units 1&2 Bottom Ash Pond from groundwater could not be determined because the pond bottom elevation is not provided in any of the documents available. Given that the adjacent Units 1&2 Bottom Ash Clearwell is in contact with groundwater, we assume that the Units 1&2 Bottom Ash Pond does not have adequate separation from groundwater. The prospect for continued saturation of CCR by groundwater in these ponds presents a long-term risk to groundwater; these ponds are targeted for additional remedy to address this risk.

Units 3&4 Bottom Ash Pond has adequate separation from groundwater.

Dam Hazard Assessment

Lewis Burton, PE reviewed the two most recent (2009 and 2014) dam inspection reports for the pond and impoundments at the SOEP-STEP, EHP, and Plant Sites. The review was performed to identify any potential significant hazards with the ponds which would warrant mitigation or removal of the pond.

Conclusions of the dam safety review are that as long as the site operator continues to follow normal maintenance and monitoring activities as recommended in the reports, and continues to have regular inspections by a professional engineer, the dams and dikes will be in adequately maintained and in conformance with State of Montana high-hazard dam safety criteria, which are fairly conservative. As long as design intent, sizing, etc. are not modified, the dams should not require significant work other than normal maintenance and monitoring. While the dams are not required to meet State of Montana high-hazard dam safety criteria, PPL Montana and Talen have chosen to do what is needed to have the dams comply with these criteria. The inspections were performed as five-year dam safety inspections.

The inspection reports we reviewed are:

> *Final Coal Ash Impoundment – Specific Site Assessment Report PPL Montana Colstrip Power Plant (GEI Consultants 2009)*

2014 Engineer's Inspection A/B Pond Complex Dike (Hydrometrics 2014)

2014 Periodic Engineer's Inspection Units 1&2 Stage II Evaporation Pond (STEP) Main Dam (Hydrometrics 2014)

2014 Periodic Engineer's Inspection Units 3&4 Effluent Holding Pond Main and Saddle Dams (Hydrometrics 2014)

The 2009 inspection reviewed nearly every aspect of the dams and provided several recommendations, primarily related to seepage issues. The conclusion was that the dams were in "fair" condition, meaning that they met all significant dam safety criteria even though some issues need to be addressed.

The 2014 inspection summarizes all previous reports and work completed on the dams, as well as completing a new field inspection and several follow-up hydraulics and other studies. The reports suggest that all concerns previously identified by GEI or others had been addressed. There were still some monitoring needs with some seepage areas and other issues that were recommended. The recommendations in the reports were normal maintenance and monitoring recommendations expected with any high-hazard dam. It was concluded that the dams do conform to State of Montana high-hazard dam safety criteria and in fact, are probably somewhat conservative in their hydraulic design.

3. Remediation Technologies

3.1 Screening and Summary of Remediation Technologies

We reviewed available remediation technologies which are potentially applicable to CCR pond source control, contaminated groundwater cleanup, and water treatment at the Colstrip Plant. Table 3.1-1 describes the various remediation options which were considered and evaluated. The table provides a qualitative description of the likely effectiveness, implementability, and cost of each option as well as whether the option was retained for use in the proposed alternatives.

Talen also performed a screening of remediation technologies in their Remedy Evaluation Reports for the Units 1&2 SOEP-STEP Site and Plant Site. We do not repeat the screening for every technology considered by Talen; any technologies which did not appear to have merit we did not re-evaluate. However, we do bring several technologies back into consideration for the proposed alternatives, namely CCR excavation and removal to new repository and pond dewatering.

3.2 Remediation Technologies Retained for Cleanup Alternatives

This section summarizes the remediation technologies which are retained from the screening process and used in the alternative remedies which are outlined in section 4 and 5.

Contaminant Source Control Technology Options

The contaminant source control technologies which are retained for the alternative remedy are discrete *in situ* solidification and stabilization (ISS) and CCR excavation and removal to new repository.

Discrete in situ solidification and stabilization

ISS can be thought of as cementing the CCR into a solid, a process which physically and hydraulically encapsulates the ashes and reduces the mobility of the contaminants in fly ashes because of the reduced surface area and low permeability. Additives can be mixed in with the cementing agent to chemically stabilize the contaminants in the ash. A conceptual picture of ISS application to a coal ash impoundment is shown in Figure 3.2-1.

Pilot tests would be conducted on Colstrip CCR prior to treatment to determine which additives are used. The Federal CCR Rule requires the regulated active disposal ponds to be closed and free water removed: "free liquids must be eliminated by removing liquid wastes or solidifying the remaining wastes and waste residues" (§ 257.102 (d)(2)(i). Dewatering and solidifying the waste using ISS therefore addresses this for those ponds where the Federal CCR Rule applies.

Discrete ISS applies this process to the bottom and sides of the CCR, which provides the same protection from groundwater leaching as an entirely solidified mass, while reducing costs of the treatment application because less cement and additives are needed, and labor and equipment costs are lower. Where ISS is included in Alternative 1, it is specifically discrete ISS which is proposed and cost estimated.

The application of ISS to CCR impoundments is relatively new, in part due to the fact that CCR was not federally regulated until 2015 and a lack of state regulation allowed for CCR to be dammed in large impoundments which both leached contaminants to groundwater and were the subject of dam failures and coal ash releases to land and waterways. Since the federal regulations were enacted in 2015, the coal ash remediation industry is currently ramping up both technological innovation and availability of treatment methods. Coal ash remediation with ISS has been evaluated and described in the coal generating industry literature (Silar et al. 2015; Lear 2017; Wittenberg et al. 2013). Studies have also evaluated the effectiveness of ISS to reduce coal ash leachability (Bowders et al., 1990; Hartuti et al. 2017). Ideal coal ash leaching studies are still being developed but available studies show that stabilized fly ash has greatly decreased leachability over time, after initial flushing of the surface of the encapsulated material. Pilot studies would be performed on Colstrip CCR to determine the best formulation of the ISS cement and to evaluate leachability.

ISS treatment will entail dewatering of the ponds, although one benefit is some dewatering water can be used in the cementing process, leaving less water which requires water treatment. After ISS is completed the encapsulated pond is left fully dewatered and capped with an impermeable cover so that the CCR is stored dry.

The scale of ISS we propose is larger than anything done to date for coal ash. ISS technology has been used to treat other types of waste for decades but only a few lab-based studies and pilot studies have been reported for CCR; we believe this is mainly due to the recent regulatory motivators to treat coal ash at all. A medium scale example of ISS for CCR is Geo-Solutions completing a fly ash material stabilization project at the W.F. Wyman Station operated by Central Maine Power Company in Yarmouth, Maine. The project solidified 30,000 cubic yards of fly ash. Future planned ISS applications for CCR include the Lansing Generating Station in Lansing Iowa in 2021, according to their written closure plan (Issued 2/12/2018).

Several U.S. companies list ISS of CCR materials under their services, such as:

- NorthStar
- Great Lakes Environmental & Infrastructure
- Silar Services, Inc and OBG, Inc.

An engineering feasibility study will be needed to identify vendors, perform pilot studies on Colstrip CCR, and outline other details of the remedy.

CCR excavation and removal to new repository

Excavation and removal has been used extensively on large volumes of fly ash, in part because of large catastrophic releases which have occurred in recent years where impoundments have failed, requiring cleanup of enormous quantities of ash from land and waterways. The Duke Energy Dan River spill in North Carolina and Tennessee Valley Authority Kingston Fossil Plant in Tennessee spill are notable examples.

Excavation and removal requires dewatering of the CCR because saturated fly ash is liquefiable and construction equipment cannot access a pond until the deeply saturated ash is dry enough for safe construction access (Landry 2015; Heyman et al. 2017). Once free pore water is removed from the CCR it is easily loaded by heavy equipment buckets because the CCR undergoes a transformation from runny and liquefiable to cohesive as the water content is lowered by dewatering. Excavation and transport also require keeping the CCR damp enough to mitigate dust blowing, as required by the Federal CCR Rule.

The removed CCR is proposed to be hauled by truck to new landfill repositories located as close to the existing pond as possible. We ruled out slurrying and piping the CCR to the new repositories because we do not believe that introducing large volumes of water to the CCR will be economical given the considerations on water storage and treatment costs for the slurry water which would be required to be removed prior to disposal at the new landfill.

We completed a screening level siting analysis for the new landfill repositories to evaluate whether the material could be stored on-site and to assist in estimating trucking costs; this is described in section 4.1. Our analysis assumes the CCR landfills will be constructed on site, land currently listed as owned by PPL Montana in Montana Department of Revenue Records. The siting analysis also avoids trucking the CCR on public streets given the very large quantity of material to be removed, public safety concerns, as well as damage which would occur to roads from the heavy equipment. The new landfills would be built to Federal CCR Rule requirements, which include double liners with leachate collection, a minimum of 5-foot separation from groundwater, and impermeable caps.

Health and Safety Considerations

Both ISS and excavation construction will be required to use special protective measures and it is anticipated that a minimum of Level C personal protective equipment (PPE) will be needed for those workers in contact with CCR. Level C also requires medical monitoring of the construction work force. A Sitewide Health and Safety Plan will need to be developed by Talen, which is outside the scope of our analysis. Additional costs for construction worker protection and dust control are considered in our cost estimate, described in section 5.

Groundwater Contamination Technology Options

The groundwater remediation technologies retained in the remediation technologies screening are: 1) Groundwater capture and treatment, 2) *In situ* flushing with clean water, and 3) Enhanced dewatering of CCR stored in ponds.

An extensive groundwater capture treatment system currently operates at all three sites at the Colstrip Plant. The capture system has been effective at preventing the further spread of contamination but has not been effective in restoring water quality to meet standards in aquifers, in part because CCR pond contaminant source areas are still leaking. Talen proposes an enhanced capture and treatment system as part of their remedy. Our alternatives incorporate Talen’s plan for enhanced capture and treatment as outlined by Talen. The actual enhanced capture system design will have to be tailored to the specifics of the final remedy if it includes additional source area remedy. This can be done using groundwater contaminant and flow modeling. That work is outside the scope of our analysis; therefore, we incorporate Talen’s proposed groundwater capture and treatment costs as proposed.

Talen also proposes *in situ* flushing with clean water to speed the groundwater cleanup timeframe so that AOC cleanup criteria are met for a larger portion of the aquifer within 30 years. Our alternatives incorporate Talen’s plan for *in situ* flushing. The actual *in situ* flushing system design will have to be tailored to the specifics of the final remedy for source area remedy using groundwater contaminant and flow modeling. That work is outside the scope of our analysis; therefore, we incorporate Talen’s proposed *in situ* flushing costs as proposed.

Talen does not propose enhanced dewatering of CCR ponds in the Remedy Evaluation Reports for the SOEP-STEP or Plant Sites. A Remedy Evaluation Report has not been released for the EHP Site and it is unknown if Talen will propose to use the existing underdrain or new wells to dewater the ponds. For our proposed alternatives, we selectively apply enhanced dewatering to specific CCR ponds to limit future seepage of contaminants to groundwater and to speed the groundwater cleanup timeframe. We also propose using the EHP underdrain to dewater the EHP cells. We also propose using capture wells around the perimeter of the EHP, to dewater the underlying geology, to remove contaminated seepage and help ensure dry storage of CCR in the capped in place ponds.

Water Treatment Technology Options

The three water treatment options retained for further consideration are reverse osmosis (RO), enhanced solar evaporation, and a brine concentrator and crystallizer (BCC). RO is a robust technology that will remove most impurities from water; it has high removal efficiencies for sulfate and boron, the primary contaminants of concern at the Colstrip site. RO does require removal of total suspended solids (TSS) prior to treatment but groundwater typically has low TSS concentrations. The main disadvantage of RO is generation of a concentrated brine, but this is addressed in the Talen plan by including a BCC in the treatment system. BCC is a technology that is similar in robustness to RO, in that it can treat nearly any quality of water.

Enhanced solar evaporation has the potential for lower costs and simpler operation than the combination of RO and BCC. It could be used as a stand-alone technology, or could also replace just the BCC by treating RO brine. Enhanced solar evaporation is also very robust in that it can treat nearly any quality of water. Treating the brine through either BCC or enhanced solar evaporation will eliminate its long-term storage as a liquid at the site.

The existing water treatment system used at the plant for industrial water reuse utilizes RO. The existing system does not have the capacity for treating either the additional groundwater captured in the proposed remedies or water from dewatering in the ponds proposed in the alternatives. The Talen plan will treat the additional groundwater captured, and our alternatives will treat the additional groundwater plus the water from dewatering of CCR ponds by building new treatment capacity.

4. Cleanup Alternatives

This section summarizes the differences in the remedy components for Talen's proposed plan and each alternative. Section 5 presents a comparison of the costs and jobs created by Talen's proposal and each alternative. Our alternatives were developed to further address the deficiencies with current pond and waste repository construction, described in section 2.2. The proposed alternatives are also designed to meet the regulatory framework which is described in section 1.4. Further background information and rationale for the remediation technologies prescribed in each alternative are discussed in section 3.2.

The objective of our cleanup alternatives is to provide remedy options that will enhance the environmental outcome and employ local community members as service providers in the remediation process. The alternative remedies were developed with two main goals: 1) address and remediate the current groundwater contamination problem; and 2) provide a more permanent remedy, which eliminates to the extent possible the potential for long-term leaching or seepage from CCR and other waste stored at the Colstrip Plant.

The contaminant source control and groundwater contamination alternatives are combined into two alternatives. Section 4.1 describes the specifics of the contaminant source control measures prescribed for each of the two alternatives. Section 4.2 describes the specific groundwater remedy measures. Water treatment options are independent of contaminant source control and groundwater remedy components of the cleanup, because water treatment will be required regardless of the chosen remedy and final closure plan. Water treatment options are presented as four separate alternatives in section 4.3 below. The efficacy, cost, and jobs created by each alternative are discussed in section 5.

4.1 Contaminant Source Control

Talen's Proposed Plan

Talen proposes a cap-in-place remedy for most of the CCR ponds and contaminated waste; excavation and removal is limited to the Former Units 1&2 Bottom Ash Ponds, located at the Plant Site. Type IV cover systems (caps with 18-inches of vegetated soil, drainage control, and an impermeable synthetic liner) would be installed on all ponds and cells which are currently or in the future used for CCR disposal. Some of the existing water management ponds would be drained of process water and used for future storm water management or captured groundwater storage.

Table 4.1-1 summarizes Talen's plan and the two alternatives. Table 4.1-2 compares the specific remedy and closure plans for each of the CCR and contaminated solid waste areas. Table 4.1-3 compares specific closure plans for each of the ponds which do not contain CCR (clearwells, water management ponds, stormwater ponds, drain pits, etc.).

Alternative 1

Alternative 1 focuses on a combination of discrete *in situ* solidification and stabilization (ISS) and excavation and removal of CCR to new repositories to address risk of contaminant leaching from the ponds which are considered the greatest long-term risk to groundwater (see table 4.1-1). Where we refer to ISS for Alternative 1 in all instances it is discrete ISS (discussed in section 3.2) which is proposed and cost-estimated.

Table 4.1-2 compares the specific remedy for each of the CCR and contaminated solid waste areas. The 21 existing CCR ponds and waste cells are the focus of our cleanup alternative analysis; the rationale for the proposed remedy is summarized in the last column of Table 4.1-2 and described in detail in section 2.1.

For the remaining ponds which do not and are not planned to hold CCR, our alternative proposal closely follows Talen's plan (Table 4.1-3). The exception under both alternative 1 and 2, is the Units 1&2 Cooling Tower Blowdown Ponds at the Plant Site will be converted to water storage ponds to store the large quantity of water anticipated from dewatering of the CCR ponds. CCR dewatering is required prior to application of ISS or removal and where not performed for these actions "enhanced CCR dewatering" is proposed at ponds which hold saturated CCR to eliminate the source of seepage sooner.

In alternative 1, excavation is proposed for the SOEP and smaller waste areas at the Plant Site. Where excavated CCR and other contaminated media (residual brine waste and contaminated soil) would be removed to new landfill repositories constructed to Federal CCR Rule standards, greatly reducing potential for long-term leaching to groundwater and improving leak monitoring capability by use of composite liners with leachate collection. The proposed location of these new repositories is discussed in the section below, *Siting Analysis for New Landfill Repositories*.

Discrete ISS is proposed for the ponds at the STEP and Plant Site where separation from groundwater is inadequate and long-term leaching of CCR is a risk. Even where ponds have a liner, such as the STEP A Cell, the approximate 100-year lifespan of a liner is problematic considering contact with groundwater. ISS encapsulates CCR, thereby reducing leaching of CCR from any pore water remaining in the ponds and also reducing the potential for long-term leaching by groundwater where the ponds are in contact with groundwater.

Type IV cover systems (caps with 18-inches of vegetated soil, drainage control, and an impermeable synthetic liner) would be installed on all ponds treated with ISS to eliminate future infiltration of precipitation and storm water. Caps are not required where CCR is removed because the excavation would be cleaned of contaminated material and reclaimed with appropriate vegetation. Type IV cover systems are included for the new CCR repositories.

Excavation of the SOEP in Alternative 1, while leaving the STEP ponds encapsulated with ISS and capped, leaves a large reclaimed basin behind the SOEP Main Dam. For Alternative 1, we propose a stormwater collection basin with pump is constructed at the bottom of the basin, in front of the SOEP main dam, to keep this basin dry and not lead to further CCR saturation issues at the STEP.

Alternative 2

Alternative 2 focuses on excavation and removal of CCR to new repositories to address risk of contaminant leaching from the ponds which are considered the greatest long-term risk to groundwater. Table 4.1-1 summarizes the differences in Talen's plan and Alternative 2.

Table 4.1-2 compares the specific remedy for each of the CCR and contaminated solid waste areas. The 21 existing CCR ponds and waste cells are the focus of our cleanup alternative analysis; the rationale for the proposed remedy is summarized in the last column of Table 4.1-2 and described in detail in section 2.1.

For the remaining ponds which do not and are not planned to hold CCR, our alternative proposal closely follows Talen's plan (Table 4.1-3). The exception under both alternative 1 and 2, is the Units 1&2 Cooling Tower Blowdown Ponds at the Plant Site will be converted to water storage ponds to store the large quantity of water anticipated from dewatering of the CCR ponds. CCR dewatering is required prior to application of ISS or removal and where not performed for these actions, “enhanced CCR dewatering” is proposed at ponds which hold saturated CCR to eliminate the source of seepage sooner.

In Alternative 2, excavation and removal is proposed for the SOEP, STEP (with exception of D Cell), and all CCR ponds and waste areas at the Plant Site. Excavated CCR and other contaminated media (residual brine waste and contaminated soil) will be removed to new landfill repositories constructed to Federal CCR Rule standards, greatly reducing potential for long-term leaching to groundwater and improving leak monitoring capability by use of composite liners with leachate collection. The proposed location of these new repositories is discussed in the next section, *Siting Analysis for New Landfill Repositories*.

Siting Analysis for New Landfill Repositories

We sited locations and provided preliminary designs for new landfill repositories to accommodate CCR materials proposed for excavation from existing ponds in both alternatives. Our siting analysis assumes the CCR landfills will be constructed on-site, land currently listed as owned by PPL Montana in Montana Department of Revenue records. The siting analysis also avoids trucking the CCR on public streets given the very large quantity of material to be removed, public safety concerns, as well as damage which would occur to roads from the heavy equipment. The new landfills would be built to Federal CCR Rule requirements, which include double liners with leachate collection, a minimum of 5-foot separation from groundwater, and impermeable caps. Groundwater depth were evaluated for all of the property using depths reported on well logs and in Montana Bureau of Mines and Geology studies. The suitability of the proposed areas from a geotechnical and hydrogeological perspective would need to be confirmed through a subsurface exploration and geotechnical testing program.

The approximate design of each new landfill repository includes 3:1 slopes (in-slope and out-slope) constructed berms with a depth and area that exceeds the required excavation volume to account for swelling of materials, although our plan dewaters the CCR material to minimize swelling. The new landfill repositories were designed using Carlson Civil Software. We designed each repository with a depth and location that does not interfere with current or future groundwater levels. Each new repository is proposed to be excavated, have berms constructed, have lining and leachate collection systems installed, filled with CCR material, and capped with Type IV caps to comply with the Federal CCR rule.

We designed two new landfill repositories for each alternative, one located northwest of the SOEP/STEP site and one located east of the existing cooling tower blowdown ponds. Both chosen locations allow for easy access by trucks once roads are constructed. We have included the costs and jobs from construction, depositing of CCR material, capping, annual operation and maintenance, and specifications of the new landfill repositories within our cost and jobs analysis contained in Section 5.2. Figure 4.1-1 and 4.1-2 provides the general layout and location of the proposed landfill repositories at the SOEP/STEP and Plant Site, respectively.

4.2 Groundwater Contamination Remedy

Talen’s Proposed Plan

Talen’s plan for groundwater remediation includes long-term operation of the contaminated groundwater capture and treatment system, until 2050 at SOEP-STEP Site and 2049 at the Plant Site. In addition, Talen’s plan for the SOEP-STEP and Plant Site includes additional capture wells and *in situ* flushing of specific areas with clean water to improve and hasten the recovery of contaminants in groundwater. The *in situ* flushing is necessary to speed the groundwater cleanup, because the low flow nature of the aquifers does not lend to rapid natural flushing.

Talen's plan is to allow all ponds at the SOEP-STEP Site and at the Plant Site, with the exception of Units 1&2 Flyash A Pond, to drain slowly by gravity over time. Talen proposes to dewater the Units 1&2 Flyash A Pond if determined feasible; a dewatering pilot project work plan has been prepared by Talen's consultant. Talen has not published estimated times for the other ponds to fully drain by gravity. Talen's capture well network operates outside of the ponds in the native geology. In doing so, the existing capture system essentially waits for seepage to reach groundwater before it is captured.

Talen's proposed groundwater remedy for the EHP Site is unknown because the Remedy Evaluation Report has not been released; given available information, we assume that Talen's plan for groundwater remediation at the EHP site is to continue to operate the capture system. It is unknown if Talen will propose to use the EHP underdrain which was designed to dewater the EHP. Talen has pump-tested the underdrain in recent years and states in the EHP Site Report (Hydrometrics 2016) that data obtained from the underdrain can be used to evaluate when more aggressive dewatering inside of the cutoff wall will be most beneficial. It is also not clear why the underdrain has not been used extensively already. For the purposes of comparison, we assume that a large-scale dewatering effort will not be proposed for the EHP.

Alternative 1 & 2

Alternative 1 & 2 both have the same groundwater remedy. Table 4.1-1 summarizes the differences in Talen's plan and the alternatives. In Alternatives 1 & 2, Talen's proposal for capture and treat and *in situ* flushing would be carried out as described above. *In situ* flushing is required to flush contaminants from the low-flow aquifers in the area; the amount and location of flushing will need to be fine-tuned, using groundwater modeling, to the proposed alternative source control and CCR dewatering described next.

Alternatives 1 & 2 also includes capture of pond CCR pore water within the ponds using new extraction wells and the EHP underdrain; we refer to this as "active dewatering" where it is performed prior to ISS treatment or excavation or "enhanced CCR dewatering" where it is performed on CCR which will be capped in place to limit the amount of future seepage. Active dewatering is necessary to accomplish excavation safely and to install ISS without impounding the existing CCR leachate in the ponds (essentially creating a bathtub). Dewatering times and ISS or excavation schedules take into account the CCR pore water volumes of each pond, provided in Table 2.1-2, as well as treatment and storage capacity.

The proposed active dewatering and enhanced CCR dewatering would involve installation of extraction wells within the STEP and Plant Site ponds above any liners or the pond bottom. At the EHP Site dewatering will use the existing underdrain combined with perimeter wells located in the native rock below the pond bottom. The proposed enhanced dewatering wells will help to eliminate CCR leachate seepage, which is the pathway of contaminant transport from CCR to groundwater, in a shorter time. At the STEP and Plant Site ponds which are treated with ISS in Alternative 1, monitoring wells which can be converted to capture wells would be installed after the ISS treatment. These monitoring wells would provide a long-term monitoring and capture system for CCR leachate that can be used to check that infiltration is not occurring through the cap, resaturating CCR and causing long-term risks to groundwater. This provides a secondary method for monitoring to ensure cover system caps are operating correctly (the primary method being visual observations at the surface, which Talen proposes). If a problem with the caps did occur and leachate was to accumulate on the pond bottoms post-closure, the enhanced dewatering system provides an in-place solution to remove and treat contaminated water prior to contaminating groundwater.

In both Alternatives 1 & 2, the Units 1&2 Cooling Tower Blowdown Ponds (North Pond and South Pond) at the Plant Site will be converted to water storage ponds to store the large quantity of water anticipated from dewatering. We assume that the existing return pipeline from the SOEP-STEP Site and EHP Site can be used to economically plumb the dewatering systems at these remote locations to the new storage pond with a new pipeline connection at the Plant Site. Ideally these ponds will be sized to also accommodate the CCR decant water that is currently stored at the STEP Old Clearwell, which is leaky because it does not have a double liner with leachate collection, to reduce seepage at the STEP site.

4.3 Water Treatment Options

Four treatment options were developed as alternatives to the plan submitted by Talen Energy. All four groundwater treatment alternatives use a new enhanced evaporation technology developed by a start-up company called Solar Multiple (SM). Two of the four alternatives also include the reverse osmosis (RO) system proposed by Talen. The SM technology increases natural evaporation rates, which are already substantial during most of the year in the Colstrip area, by a factor of 5-40 times. The SM system could ultimately generate a wet concentrated brine or relatively dry solids. The Brine Concentrator/Crystallizer (BCC) proposed by Talen, or a similar system, could potentially be used to generate dry solids from this wet brine. However, costs for the BCC were not included in the alternatives because we believed this treatment step would not be necessary.

Basis for Groundwater Treatment

The same basis for groundwater treatment was used to compare Talen's plan to the four alternatives. For the Plant Site, it was assumed the total current captured groundwater flow rate is 424 gallons per minute (gpm)[1]. After shutdown of Units 1&2, it was assumed the pumpback rate would increase by 98 gpm to a total of 522 gpm[2].

For the SOEP-STEP Site, the current captured groundwater flow rate was assumed to be 183 gpm[3]. After shutdown, it was assumed the pumpback rate would increase by 9 gpm to 192 gpm[4].

For the EHP site, it was assumed the current captured groundwater flow rate is 241 gpm[5]. As of this writing, the Remedy Evaluation Report for the EHP Site was not available but it was assumed that the future pumpback rate would increase similarly to 281 gpm.

Therefore, the total future groundwater pumpback flow rate for the Plant Site, the SOEP-STEP Site and the EHP Site is 995 gpm (522 + 192 + 281) or approximately 1,000 gpm. It was assumed that all of this captured groundwater would require some type of treatment, and the same level of treatment.

It was assumed the groundwater pumpback rate would remain at the current level of 848 gpm through 2022, with the flow rate increasing to 1,000 gpm through 2048. Beginning in 2049, nearly 30 years after shutdown of Units 1&2, groundwater from the Plant Site and the SOEP-STEP Site is predicted to no longer require treatment. The pumpback rate of groundwater to be treated would then be only 281 gpm.

To be consistent with Talen's Master Plan Summary Update, groundwater treatment costs were calculated through 2069. After 2048, most of the costs are incurred at the EHP Site.

Pond Dewatering

Alternative 2 for source control proposes to dewater up to 16 ponds on-site beginning in 2020. The dewatering flow rate would be about 450 gpm for the years 2020-2027, 160 gpm for 2028-2029 and essentially zero after that. Water treatment equipment with a capacity of 450 gpm, with the same relative costs as the CWTS, would be added to the process. A difference from the Talen plan is that the four alternatives would treat this water in addition to captured groundwater.

Talen Energy Groundwater Treatment Plan

Talen's groundwater treatment plan and associated costs was compiled from three sources[1,3,6]. In addition, costs in Table 7-6 of the Plant Site Remedy Evaluation Report referred to both the 2017 Annual Plan and the 5-Year Plan.

For the Plant Site, Talen's plan through 2022 is to treat about 250 gpm through the Vibratory Shear Enhanced Processing (VSEP) system, which is a type of reverse osmosis (RO) process and return the remaining groundwater (also about 250 gpm) back to Units 1&2 for use as scrubber water[1]. Starting in 2023, after Units 1&2 shut down, all Plant Site captured groundwater would be treated through the new Capture Well Treatment System (CWTS) and the new Brine Concentrator/Crystallizer (BCC). Talen currently envisions the CWTS to be another VSEP or similar RO system.

At the SOEP-STEP Site, it was assumed that all 183 gpm of captured groundwater would be used as scrubber water through 2022[3]. For treatment that would begin in 2023, Talen is currently evaluating whether groundwater can be used directly in the Units 3&4 scrubbers, or whether it will require treatment prior to reuse. It was assumed this treatment would use the CWTS and BCC.

At the EHP Site, all captured groundwater is currently treated through a VSEP unit. It was assumed that RO permeate is used as cooling tower makeup and that RO brine goes to the STEP pond. Beginning in 2023, it was assumed that groundwater will be treated through the CWTS and BCC rather than through the existing VSEP unit.

Alternative 1

Alternative 1 would treat all captured groundwater and dewatering water from the site through the Solar Multiple technology, using only solar panels as the source for heating air. It was assumed that all this water could be treated at a central location, although since this is a modular technology, capital and operating costs would be the same even if several treatment systems were required (e.g., one each at the Plant Site, SOEP-STEP Site and EHP Site). All water is evaporated, so treated water is not available for beneficial use, which may or may not be a detriment. An advantage would be that a Montana Pollutant Discharge Elimination System (MPDES) permit would probably not be required after complete site closure.

Alternative 2

This alternative would use the Solar Multiple system after treating all captured groundwater and dewatering water through the new CWTS, which will be an RO system. An RO recovery rate of 70 percent was assumed, which means the Solar Multiple system would treat 300 gpm while the groundwater pumpback rate is 1,000 gpm. Permeate from the CWTS (700 gpm during most years) would be available for beneficial uses such as scrubber water or cooling tower makeup.

Alternative 3

Alternatives 3 and 4 assume that enough waste heat is available from Units 3&4 to provide an evaporation air temperature of 140 degrees F until 2043, when 3&4 shut down. Heat from solar panels would augment this waste heat until 2043, then serve as the only heat source for enhanced evaporation after 2043. Only half as many evaporation modules would be installed as for Alternatives 1 and 2, so capital and operating costs are reduced by about 50 percent.

Alternative 3 is comparable to Alternative 1, but with lower capital and operating costs.

Alternative 4

This alternative includes waste heat from the steam plant for evaporation, after treating groundwater and dewatering water through the CWTS. It is comparable to Alternative 2 but with lower costs. Alternative 4 would have the lowest capital cost of any of the alternatives considered.

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4.4 Monitoring

We do not develop alternative monitoring plans for comparison to Talen's plan. We assume in all alternatives that the monitoring costs and job requirements are the same as Talen's proposal, a reasonable assumption given the exact details of the monitoring plans will differ and be tailored to the final remedy, but the annual costs should be similar.

5. Comparison of Alternatives

5.1 Cleanup Efficacy Comparison

Contaminant source control

Table 5.1-1 provides a pond-by-pond comparison of cleanup efficacy for Talen's proposal and Alternatives 1 & 2. The total volume of CCR and contaminated media (brine and contaminated soils) present at each of the three AOC sites (SOEP-STEP, EHP, and Plant Sites) and the volume which would be treated by Talen's plan and the two alternative remedies is presented in table 5.1-2.

In summary, Talen's cap-in-place proposal eliminates seepage of contaminated CCR leachate caused by future infiltration of precipitation but does not protect groundwater from leaching where ponds are expected to be in contact with groundwater in perpetuity.

The proposed alternatives are focused on providing long-term (perpetual) protection of groundwater. The AOC requires that the Closure Plan must provide for each site "control, minimization or elimination, to the extent necessary to protect human health and the environment, of post-closure escape of COIs *(contaminants of interest)* to the environment" (emphasis added). Remedies which leave CCR in perpetual contact with groundwater do not meet this criteria. One apparent side effect of the design of the SOEP and STEP main dams is that by sealing the dams into bedrock, the dams have backed up groundwater flow and elevated groundwater levels so that they are now above the pond bottoms. The construction of Castle Rock Lake has also raised groundwater levels in that area.

Synthetic liners such as those used at the STEP ponds will eventually break down; this is why current CCR regulatory criteria requires a 5-foot separation from groundwater. Buried synthetic liner lifespan varies significantly depending on a number of factors, including synthetic type, synthetic stabilizer and antioxidant additives, thickness, temperature, chemical conditions, and tensile stresses. Few details are available on the older liners at the STEP Site, other than they are single-layer HDPE. Generally, the lifespan of HDPE is from 100 years to over 400 years for plastic which is buried at cooler temperatures (Koerner et al. 2005; Rowe and Sangam 2002). It is difficult to predict with accuracy the current condition of the liners or the tensile stresses causes by CCR settling against the liner subgrade, both of which may cause liner deterioration. For these reasons, the alternatives provide a better long-term remedy for CCR which does not have adequate separation from groundwater, through either *in situ* solidification and stabilization (ISS) or excavation and removal of CCR to new landfills which meet current regulatory criteria.

Alternatives 1 also include installation of monitoring wells at the STEP ponds, which will provide post-closure monitoring and capture capability for CCR leachate; this monitoring would check that infiltration into the ponds post-closure is not resaturating the CCR above the ISS-encapsulated layer and causing long-term risks to groundwater. This provides a secondary method for monitoring to ensure cover system caps are operating correctly (the primary method being visual observations at the surface). If a problem with the caps did occur and leachate was to accumulate in the ponds post-closure, the monitoring well system would provide an in-place solution to remove and treat contaminated water prior to it becoming seepage to groundwater.

Groundwater remediation

Much of the groundwater remedy is the same for Talen's proposal and the two alternatives: all incorporate Talen's plan for continued capture and treatment of contaminated groundwater and *in situ* flushing (injection using wells) with clean water to speed groundwater quality recovery.

The plans differ significantly on the control of the source of groundwater contamination which is CCR leaching and seepage. Talen's plan is to allow the STEP to slowly drain, as the existing pond pore water (CCR leachate) slowly seeps to groundwater. Even with the capture and *in situ* flushing, Talen's proposal does not meet cleanup criteria within 30-years at all areas of the STEP Site. Talen's plan for the EHP is unknown because the Remedy Evaluation Report has not been released. We assume for comparison that they will not propose enhanced dewatering of the EHP but will continue capture and treatment at the EHP.

Alternatives 1 & 2 both propose significant dewatering of CCR pore water and treatment of that water. The dewatering is either performed in conjunction with ISS or CCR removal ("Active dewatering") or for reducing future seepage from CCR capped in place and speeding groundwater remediation timeframes ("Enhanced dewatering"). The proposed dewatering will remove the source of groundwater contamination faster, speeding up groundwater remediation timeframes. The proposed dewatering is also expected to reduce the length of time capture and treatment systems will need to operate and may reduce the amount of *in situ* flushing required which would both offset some of the dewatering costs. Calculating the exact changes in capture and treat and flushing timeframes requires modeling and is outside the scope of this analysis.

Alternatives 1 & 2 will both construct new water storage capacity at the Plant Site, by retrofitting the Units 1&2 Cooling Tower Blowdown Ponds with double liners and leachate collection. This extra capacity may allow CCR decant water which is currently stored in the relatively leaky Old Clearwell at STEP to be stored instead in a modern lined impoundment. The STEP Old Clearwell is one of the remaining contaminated water storage ponds which has not been upgraded to a double liner with leachate collection. This change would be expected to have positive water quality impacts for the STEP Site.

At the EHP site, the plant operators are currently creating stacked cells so that the old cells can be considered closed. Our interpretation is that dewatering needs to accompany closure to comply with Federal CCR rule § 257.102 (d)(2)(i) which states, "Free liquids must be eliminated by removing liquid wastes or solidifying the remaining wastes and waste residues." Free liquids mean liquids that readily separate from the solid portion of a waste under ambient temperature and pressure (§ 257.53 Definitions). Therefore, the proposed alternatives provide better compliance with this regulation.

Table 5.1-3 provides a comparison of the volume of pond pore water dewatered and treated for each alternative. Functionally, there is overlap in the dewatering volumes whether the dewatering is performed prior to CCR removal and ISS treatment or for enhanced CCR dewatering. Therefore, it is the total dewatering volume in Table 5.1-3 which should be compared.

Limitations of this comparison

Our professional judgment is that either the treatment of CCR ponds with ISS or removal by excavation both of which are combined with CCR dewatering, will reduce pond seepage, reduce CCR leaching, and speed up groundwater remediation timeframes faster than Talen's proposal. Modeling the groundwater cleanup timeframe of our proposed alternatives is outside the scope of our analysis but would be required to evaluate cleanup timeframes. Modeling is also required to determine how Talen's proposed *in situ* flushing of groundwater, an element of their cleanup proposal designed to speed groundwater remediation, would be needed given the additional remedy proposed in the alternatives. Talen can perform this modeling relatively easily by adapting their existing groundwater models.

We assume there would be a water treatment cost savings for Alternatives 1 & 2 because the significant dewatering which occurs and reduction in pond seepage will likely reduce the amount of time that the capture and treatment systems would need to be operated. This is because it may be less expensive to treat the smaller, more concentrated volume of dewatering leachate than it is to wait for that to seep to groundwater and be captured. Again, this would need to be modeled to predict water treatment lifespan.

Water Treatment

Water treatment is assumed to be equally as effective regardless of the alternative. All of the water treatment alternatives, including Talen's proposal, are capable of either treating contaminated water to meet a discharge standard or evaporating the water so that it does not require discharge. Discharge standards are those limits required to be met before the water is returned to state waterways, such as would be required in a Montana Pollutant Discharge Elimination System (MPDES) permit.

5.2 Cost and Job Comparison

Costs are incurred and jobs created by Talen's plan and Alternative 1 & 2 for the capital investment in pond closure and groundwater remedy. Costs are incurred and jobs are also created by operations and maintenance (O&M) of the pond closure caps and leachate collection systems, O&M of the water treatment system, and the water quality monitoring which is required to ensure the remedy is working. The total annual cost and jobs for each alternative are compared in Figures 5.2-1 and 5.2-2. In these figures, it is assumed that Water Treatment Alternative 2 is used with both Alternatives 1 & 2 for Source Control and Groundwater Remediation.

These figures show the average number of annual full time employment (FTE) jobs created over a 5-year period. The 5-year period window was chosen because the actual project construction schedule is not known at this time. Additionally, costs and jobs for each particular remedy component are assigned to a single year in the analysis and tables in section 5.2.1; this is not intended to suggest that these activities will only take one year and the 5-year window helps to show a more likely progression of costs and jobs created for the duration of the period.

The cost and job analyses were developed separately for the source control and groundwater remedy, water treatment, and groundwater monitoring. These cost and jobs analyses are presented in the next three sections.

5.2.1 Source Control and Groundwater Remediation

We conducted a cost and job analysis for our proposed alternatives and Talen's cleanup proposals to examine the cost and job potential for cleanup, dewatering, and post-closure operation and maintenance (O&M) at each of the facilities. Cost and jobs for our proposed alternatives were developed on a per-unit basis, meaning costs are directly proportional to the area of a proposed cap, volume of CCR removed or encapsulated, or number of dewatering wells installed, etc.

Cost Impact

Talen's costs for each remedy were extracted from the Remedy Evaluation Reports for the SOEP-STEP and Plant Sites and the Closure Plan for the EHP Site (see section 1.2 for more details). Table 5.2-1 provides a cost comparison between our alternatives and Talen's plan. All costs shown in this section are represented in 2018 dollars. Cost and job analyses were performed out to 2069 to match Talen's Master Plan Summary schedule, which assumes Units 3&4 closes in 2040 and includes cost for 30 years of O&M. Differences in total capital cost between each of our alternatives primarily stem from differences in cost between the ISS and excavation methods. However, the excavation in Alternative 2 requires less post-closure care since fewer ponds require capping and closure, and more material is allocated to one or two landfill repositories. Table 5.2-2 and Table 5.2-3 provide the methodology, equations, references, and assumptions for how costs were developed for each of our alternatives.

Our cost analysis included developing a cost schedule which illustrates capital and O&M expenditures over time for each alternative which can be compared to Talen's schedule. We compiled the cost and timeline data from Talen's reports (see section 1.2), and combined the design and capital costs to show total expenditures for each year as shown in Table 5.2-4. The same was done for our Alternative 1 and Alternative 2 costs, which are shown in Table 5.2-5 and Table 5.2-6, respectively. Cost schedules can be used to compare costs between remedy schedules over time. Similar to Talen's cost timelines contained in the Remedy Evaluation Reports, it was assumed that each construction activity will be completed in a single year. This assumption simplifies the timeline, calculations for determining cost each year, and jobs analysis. In the case where our remedy is identical to Talen's remedy, the costs are unchanged.

Jobs Impact

In addition to conducting a cost analysis of our alternatives in comparison to Talen's alternatives, we also conducted a jobs analysis to determine the number of jobs available during construction, dewatering, and post-closure O&M activities. Similar to the development of costs for our remedy alternatives, the number of jobs were determined on a per-unit area or volume basis based on production rates of equipment, other references such as contractor quotes of production rates, and assumptions. Annual O&M jobs were determined on a cost-basis by calculating the number of jobs based on a median salary of a particular job position with additional inflation to account for taxes, benefits, space, and materials to better represent a full-time position. Jobs are denoted as Full-Time Employee, or FTE, which represents the number of jobs per position per year. Table 5.2-7 shows the comparison of construction, dewatering, and annual O&M jobs between Talen's plan and our alternatives. A small difference in jobs is expected between our two alternatives, while the difference in comparison to Talen's plan is significant due to the scope of our proposed cleanup strategies.

The calculations, assumptions, and references for how jobs were determined for Talen's plan, Alternative 1, and Alternative 2 are contained in Tables 5.2-8, 5.2-9, and 5.2-10, respectively. The types of jobs fall under the categories of skilled labor, unskilled labor, and professional. The specific jobs and associated number of jobs for each category are listed in the tables and are limited to the scope of our analysis. A specific list of jobs and roles would generally be developed during the design phase of the remediation, but our analysis provides a representative comparison between the number of jobs for our alternatives and Talen's plan.

Similar to the cost schedules developed and described above, we created job schedules based on the same timelines to illustrate the estimated number of jobs available between the alternatives and Talen's plan. Tables 5.2-11, 5.2-12, and 5.2-13 provide job schedules for Talen's plan, Alternative 1, and Alternative 2, respectively. Table 5.2-14 provides a list of references used in the cost and jobs analysis. Our cost and jobs analysis demonstrate that even though the alternatives outlined in this study significantly increase the cost of cleanup, excavation and ISS can provide a significant number of additional jobs as well as reduce the environmental impact of CCR in comparison to Talen's closure and post-closure plan.

5.2.2 Water Treatment

Cost Impact

Capital and operating costs for each alternative are shown relative to the Talen plan in Figure 5.2.2-1. Alternative 1 has a higher capital cost than the Talen plan but Alternatives 2-4 all have lower capital costs. Alternative 3 has by far the lowest operation and maintenance (O&M) cost, with capital costs lower than all but Alternative 4. Even with the availability of waste heat, Alternative 4 has a relatively high O&M cost because of the high cost of treating 1,000 gpm through the CWTS system, similar to Alternative 2. The cost advantage of using waste heat is reduced in Alternative 4 because of using the CWTS, the Solar Multiple system would treat only 30% of the water treated in Alternative 3.

If waste heat is available, and if all the assumptions are correct, Alternative 3 is the most cost-effective treatment option. If waste heat is not available, Alternative 2 is the most cost-effective treatment option. Both of these alternatives have a lower total cost (capital plus O&M costs) than the Talen plan, even though they have the extra burden of treating a substantial volume of dewatering water from the ponds for ten years.

Jobs Impact

For O&M, it is estimated that the Solar Multiple system would require one water treatment operator/technician for every 15 evaporation modules. Estimated numbers of water treatment jobs are shown in Figure 5.2.2-1 and Table 5.2.2-1. These are the average number of jobs for the period 2020-2069, with the labor requirement decreasing over time.

We did not attempt to estimate the number of construction jobs provided by equipment installation for the Talen plan or for any of the alternatives. This equipment would include the CWTS, BCC, an expanded CWTS to treat dewatering water, and the Solar Multiple system. We assumed that the capital cost would be a lump sum paid to a contractor, which would supply its own laborers.

Our projections show that all four alternatives would create fewer water treatment jobs than the Talen plan. For the Talen plan, it was assumed that:

1) O&M costs are those shown in Table 5.2.3-2;
2) 30% of the total O&M cost is due to labor; and
3) The total wage rate for a water treatment operator at Colstrip, including benefits, is $46/hr. This is based on the 2018 U.S. Department of Labor service contract rate for the area, which was doubled to include benefits. A Davis-Bacon wage rate was not used because Davis-Bacon does not include a plant operator classification. A common method used by water treatment contractors to estimate costs is to apply a multiplier to a service contract rate for water treatment operators, as we have done.

Assumption #2 is probably the most tenuous assumption among these. We assume Talen has a breakdown of its estimated O&M costs but we do not have access to this information. If we were to assume that only 20% of the total O&M cost is due to labor (with the remainder due to chemicals, power, parts, etc.), the average number of jobs for the Talen plan would decrease from 7.9 to 5.3. This would also slightly decrease the number of jobs for Alternatives 2 and 4, but the number of jobs for Alternatives 1, 2 and 4 would then be comparable to the Talen plan.

The principal advantages of the proposed water treatment alternatives are that they would:

1. Provide treatment of dewatering water from the ponds;
2. Accomplish this at equal or lower cost than the Talen plan, which does not include dewatering;
3. Possibly not require an MPDES permit, depending on which alternative is chosen.

However, the alternatives would not provide more water treatment jobs than the Talen plan. One component of the lower cost is that fewer water treatment operators/technicians would probably be required. The alternatives accomplish a similar or better effect on groundwater quality at lower cost, i.e., less labor.

Yearly breakdowns of costs and estimated number of jobs are shown in Tables 5.2.2-2 through 5.2.2-6 for the Talen plan and Alternatives 1-4. In addition, Table 5.2.2-7 shows an estimated cost breakdown for the CWTS and BCC treatment systems, which was necessary to estimate the CWTS costs for Alternatives 2 and 4. Groundwater flow rates for each treatment alternative by year are shown in Table 5.2.2-8.

5.2.3 Groundwater Monitoring

Cost and Jobs Impact

Groundwater monitoring costs and the number of jobs were estimated from information supplied by Talen. We assume in all alternatives that the monitoring costs and job requirements are the same, a reasonable assumption given the exact details of the monitoring plans will differ and be tailored to the final remedy, but the annual costs should be similar. Annual costs were available for the Plant Site Report (Geosyntec 2017), and the Master Plan Summary for the SOEP-STEP Site and EHP Site (Geosyntec 2016). It was assumed that 60% of these monitoring costs are due to labor, with the remainder for laboratory analysis and other expenses. This cost breakdown is shown in Table 5.2.3-1 along with the estimated number of jobs.

It was assumed that the total wage rate for an environmental technician at Colstrip, including benefits, is $36/hr, from the Department of Labor service contract rate. Similar to plant operators, an environmental technician Davis-Bacon job classification is not available. For the period 2020-2069, an average of about four jobs would be available for groundwater monitoring (Table 5.2.3-1).

Cost summary tables for groundwater treatment and monitoring are shown in Tables 5.2.3-2 through 5.2.3-6 for the Talen plan and Alternatives 1-4.

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