Groundwater Remedial Design/Remedial Action Work Plan

Plant Site

Colstrip Steam Electric Station, Colstrip, Montana

Prepared by

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TABLE OF CONTENTS

ABBREVIATIONS AND ACRONYMS iv

1. INTRODUCTION ................................................................................................... 1
   1.1 Purpose ........................................................................................................... 1
   1.2 Scope .............................................................................................................. 1
      1.2.1 Remedial Design Objectives .............................................................. 2
      1.2.2 Overview of Remedial Design Process .............................................. 3
   1.3 Work Plan Organization ................................................................................. 3

2. BACKGROUND ..................................................................................................... 4
   2.1 Facility Location ............................................................................................. 4
   2.2 Plant Site Description ..................................................................................... 4
   2.3 Process Wastewater Ponds ............................................................................. 5
   2.4 Wastewater Facility Closure Plan .................................................................. 5

3. REMEDIAL ACTION OBJECTIVES AND PREFERRED REMEDY ................. 7
   3.1 Summary of Remedial Action Objectives ...................................................... 7
      3.1.1 Cleanup Criteria ................................................................................. 7
      3.1.2 Point of Compliance ............................................................................ 7
      3.1.3 Source Control ................................................................................... 8
      3.1.4 Migration Management ....................................................................... 8
      3.1.5 Institutional Controls ......................................................................... 8
   3.2 Description of Preferred Remedy ................................................................... 8

4. BASIS OF DESIGN .............................................................................................. 10
   4.1 Geotechnical Evaluations ............................................................................. 10
      4.1.1 Brine Concentrator Solids Disposal Area ......................................... 10
      4.1.2 Units 1 & 2 A Pond and Units 1 & 2 Bottom Ash Clearwell .......... 11
   4.2 Ash Dewatering Pipe for Units 1 & 2 A Pond Design .................................... 11
   4.3 Vertical and Horizontal Capture Well Design ............................................. 12
   4.4 Injection System Pilot Test Design .............................................................. 13
   4.5 Injection System Design ............................................................................... 16
      4.5.1 Injection Water .................................................................................... 17
      4.5.2 Injection System Operation ............................................................... 18
   4.6 Vertical Injection Well Design ..................................................................... 18
      4.6.1 Permitting for Injection Wells ............................................................. 18
4.6.2 Injection Well Conceptual Design .............................................. 19
4.6.3 Injection Well Installation ......................................................... 20
4.6.4 Injection Well Registration ......................................................... 21
4.6.5 Injection Well Operation .......................................................... 22
4.7 Preliminary Scoping of MNA Data Needs and Demonstrations .......... 22
4.8 Preliminary Scoping of PRB Feasibility Test Data Needs and Demonstrations 22
4.9 Units 1 & 2 North and South C Ponds Soil Sampling Plan ................. 23
4.10 Former Units 1 & 2 Bottom Ash Ponds Soil Sampling Plan .............. 23
4.11 Assessment of Emergency Preparedness Procedures and Health and Safety Plan 24
4.12 Approach to Monitoring Plan Update ............................................. 24
4.13 Development of Institutional Controls ......................................... 25

5. SCHEDULE ......................................................................................... 26

6. CERTIFICATION .................................................................................. 28

7. REFERENCES ....................................................................................... 29

Appendix A  Tables

Table 2-1  List of Wastewater Facilities
Table 3-1 Cleanup Criteria for Groundwater Constituents
Table 4-1 Analytical Results for Injection Water
Table 4-2 Predicted Injection Rates for Injection Wells
Table 8-1 Remedy Implementation Schedule

Appendix B  Sheets

1. Groundwater Remedial Design/Remedial Action Work Plan – Cover Sheet
2. Existing Groundwater Capture System Layout
3. Upgraded Groundwater Capture System Layout
4. Units 1&2 A Pond – Ash Dewatering Trench and Horizontal Capture Well Profile
5. Former Brine Ponds – Horizontal Capture Well Profile
6. Injection Well Locations
7. Injection System Piping Layout
8. Injection System Process Flow Diagram
9. Injection Water Treatment and Distribution System Piping & Instrument Diagram
10. Injection System Tank T-01 Piping & Instrumentation Diagram
11. Injection System Tank T-02 Piping & Instrumentation Diagram
12. Injection System Tank T-03 Piping & Instrumentation Diagram
13. Injection System Tank T-04 Piping & Instrumentation Diagram
14. General Design of Injection Wells

Appendix C  Calculations

   C-1  Horizontal Capture Well Design
   C-2  Injection Water Treatment Equipment Sizing
   C-3  Injection System Hydraulic Calculations
   C-4  Injection Water Compatibility Evaluation

Appendix D  Geotechnical Evaluation of Brine Concentrator Solids Disposal Area

Appendix E  Ash Dewatering Pipe for Units 1 & 2 A Pond Design

   E-1  Dewatering Pipe Design and Selection
   E-2  Filter Design and Material Selection

Appendix F  Injection Pilot Test Work Plan

Appendix G  USEPA Fact Sheet: Class V – Injection Well Information for Aquifer Remediation Systems

Appendix H  MNA Approach

Appendix I  Soil Sampling Plans

   I-1  Soil Sampling Plan – Units 1 & 2 North and South C Ponds
   I-2  Soil Sampling Plan - Former Units 1 & 2 Bottom Ash Ponds
# ABBREVIATIONS AND ACRONYMS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>AOC</td>
<td>Administrative Order on Consent</td>
</tr>
<tr>
<td>ARM</td>
<td>Administrative Rules of Montana</td>
</tr>
<tr>
<td>BCSDA</td>
<td>Brine Concentrator Solids Disposal Area</td>
</tr>
<tr>
<td>BSL</td>
<td>Background Screening Level</td>
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<tr>
<td>CCR</td>
<td>Coal Combustion Residuals</td>
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<tr>
<td>CCRA</td>
<td>Cleanup Criteria and Risk Assessment</td>
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<tr>
<td>CFR</td>
<td>Code of Federal Regulations</td>
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<tr>
<td>CGWA</td>
<td>Controlled Groundwater Area</td>
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<tr>
<td>COI</td>
<td>Constituent of Interest</td>
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<tr>
<td>CO2</td>
<td>Carbon Dioxide</td>
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<tr>
<td>CSES</td>
<td>Colstrip Steam Electric Station</td>
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<tr>
<td>DEQ-7</td>
<td>MDEQ Circular DEQ-7</td>
</tr>
<tr>
<td>EHP</td>
<td>Effluent Holding Pond</td>
</tr>
<tr>
<td>gpm</td>
<td>gallons per minute</td>
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<tr>
<td>GWIC</td>
<td>Groundwater Information Center</td>
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<tr>
<td>HCL</td>
<td>Hydrochloric Acid</td>
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<tr>
<td>HDPE</td>
<td>High Density Polyethylene</td>
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<tr>
<td>HW</td>
<td>Horizontal Capture Well</td>
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<tr>
<td>IW</td>
<td>Injection Well</td>
</tr>
<tr>
<td>Kv</td>
<td>Vertical Hydraulic Conductivity</td>
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<tr>
<td>Kh</td>
<td>Horizontal Hydraulic Conductivity</td>
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<tr>
<td>MBMG</td>
<td>Montana Bureau of Mines and Geology</td>
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<tr>
<td>MCA</td>
<td>Montana Code Annotated</td>
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<tr>
<td>MCL</td>
<td>Maximum Contaminant Level</td>
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<tr>
<td>MDEQ</td>
<td>Montana Department of Environmental Quality</td>
</tr>
<tr>
<td>MNA</td>
<td>Monitored Natural Attenuation</td>
</tr>
<tr>
<td>MW</td>
<td>Megawatt</td>
</tr>
<tr>
<td>O&amp;M</td>
<td>Operation and Maintenance</td>
</tr>
<tr>
<td>POC</td>
<td>Point of Compliance</td>
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<tr>
<td>PRB</td>
<td>Permeable Reactive Barrier</td>
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<tr>
<td>RA</td>
<td>Remedial Action</td>
</tr>
<tr>
<td>RAO</td>
<td>Remedial Action Objective</td>
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<tr>
<td>RCRA</td>
<td>Resource Conservation and Recovery Act</td>
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<tr>
<td>RD</td>
<td>Remedial Design</td>
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<tr>
<td>RSL</td>
<td>Risk Screening Level</td>
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<tr>
<td>SOEP</td>
<td>Stage I Evaporation Pond</td>
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<tr>
<td>STEP</td>
<td>Stage II Evaporation Pond</td>
</tr>
<tr>
<td>TSS</td>
<td>Total Suspended Solids</td>
</tr>
<tr>
<td>UIC</td>
<td>Underground Injection Control</td>
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USEPA  U.S. Environmental Protection Agency
USDW  Underground Source of Drinking Water
VSEP  Vibratory Shear-Enhanced Process
WRMP  Water Resources Monitoring Plan (Talen, 2015)
1. INTRODUCTION

1.1 Purpose

This Remedial Design/Remedial Action (RD/RA) Work Plan (30% Remedial Design Package) has been prepared by Geosyntec Consultants, Inc. (Geosyntec) on behalf of Talen Montana, LLC (Talen) pursuant to Article VI.D of the “Administrative Order on Consent Regarding Impacts Related to Wastewater Facilities Comprising the Closed-Loop System at Colstrip Steam Electric Station, Colstrip Montana” (AOC) (MDEQ, 2012). The AOC was entered between PPL Montana, LLC and the Montana Department of Environmental Quality (MDEQ or the Department) in August 2012. PPL Montana, LLC transferred ownership of their share of the Colstrip Steam Electric Station (CSES) to Talen in June 2015, and Talen now operates the facility. The AOC for CSES applies to three areas:

1. Areas at and downgradient of the main plant site (Plant Site); 
2. Areas at and downgradient of Units 1&2 Stage I and Stage II evaporation ponds northwest of the main plant site (Units 1&2 SOEP/STEP area); and 
3. Areas at and downgradient of Units 3&4 effluent holding ponds southeast of the main plant site (Units 3&4 EHP area).

The location of the Plant Site is shown on Sheet 1. Article VI.D of the AOC requires a RD/RA Work Plan be developed for the remedies selected for each of the three areas (or sites). This Plan demonstrates the manner in which the design and implementation of the preferred remedy for groundwater impacts at the Plant Site will be conducted. Separate RD/RA Work Plans will be developed to address the remedies for the Units 1&2 SOEP/STEP area and Units 3&4 EHP area following remedy approval.

1.2 Scope

In September 2018, Geosyntec prepared a Facility Closure Plan for the Plant Site pursuant to Article IX of the AOC. The Facility Closure Plan includes the closure (capping) or reclamation of several process wastewater ponds at the Plant Site, and the planned shutdown of Generating Units 1 and 2 by July 2022. MDEQ conditionally approved the Facility Closure Plan for the Plant Site on 3 December 2018, and it was resubmitted to MDEQ on 15 February 2019 with minor revisions (Geosyntec, 2019).

In August 2018, Geosyntec submitted the Revised Plant Site Remedy Evaluation Report (Geosyntec, 2018b) to MDEQ pursuant to Article VI.C of the AOC. On 30 October 2018, MDEQ issued a letter to Talen approving the Revised Plant Site Remedy Evaluation Report, including approval of the selected remedy for the Plant Site. The selected remedy for the Plant Site includes implementing the planned pond upgrades/closures identified in the Facility Closure Plan, implementing injection with clean water from the Surge Pond and increasing
groundwater capture. The planned pond upgrades/closures will be implemented at the Plant Site in accordance with schedule provided in the Facility Closure Plan and are not addressed herein. Handling of captured groundwater will include storage for re-use at Units 3 & 4, evaporation, or treatment for re-use or discharge (being designed by others and also not addressed herein).

1.2.1 Remedial Design Objectives

In accordance with Article VI.D.1 of the AOC, this RD/RA Work Plan includes the following components:

a) Narrative description and preliminary (30 percent) design of the selected remedy;

b) Description of compliance monitoring and confirmatory soil sampling;

c) Description of emergency preparedness procedures;

d) Health and safety plan;

e) Engineering certification of the remediation design;

f) A timetable for implementing the remedy;

g) A statement that applicable health and safety regulations will be met during implementation of the remediation proposal;

h) A description of how short-term disturbances during implementation of the remediation proposal will be minimized and reclaimed;

i) Identification of Permits under 75-20-401, Montana Code Annotated (MCA), necessary to conduct the proposed remedies;

j) A commitment to provide an Annual Progress Report if implementation of the remedy exceeds one (1) year and periodic status reports as requested by MDEQ;

k) Anticipated Operation and Maintenance requirements;

l) A commitment to obtain approval from MDEQ for major deviations from the approved work plan to the extent feasible and appropriate; and

m) Such other information as appropriate based on conditions unique to the site.

This RD/RA Work Plan comprises a 30 percent design package for remedy components that are not already included in the Facility Closure Plan for the Plant Site.
1.2.2 Overview of Remedial Design Process

Several items discussed in this RD/RA Work Plan are critical path pre-requisites to finalizing the remedial design. Following completion of the Injection System Pilot Test Work Plan (Appendix F) in the spring and summer of 2019, Geosyntec on behalf of Talen will finalize design of the remedial components and prepare a Final Remedial Design Package. The Final Remedial Design Package will include design sheets, calculations, construction quality assurance/quality control plan, and Operation and Maintenance (O&M) Plan.

Following approval of this RD/RA Work Plan by MDEQ, Talen will obtain approval from MDEQ for major deviations from the approved work plan to the extent feasible and appropriate in accordance with Article VI.D of the AOC. In addition, Talen will provide annual progress reports during remedy implementation and periodic status reports as requested by MDEQ.

1.3 Work Plan Organization

This work plan describes the approach for the design and implementation of the preferred remedy that addresses identified impacts to groundwater at the Plant Site. Background information is provided in Section 2. The Remedial Action Objectives (RAOs) and a description of the preferred remedy are presented in Section 3. The basis of design for the preferred remedy is provided in Section 4. The schedule for completion of the work and contents of the remedial design are discussed in Section 5. Engineering certification of the 30 percent remedial design is provided in Section 6. References are listed in Section 7. Supporting information is provided in appendices that follow the text.
2. BACKGROUND

2.1 Facility Location

The CSES is a coal-fired steam electric generating facility partially owned and operated by Talen. The Site is located near the City of Colstrip, which lies within Rosebud County in south central Montana, approximately 90 miles east of Billings, Montana. The CSES is located at 580 Willow Avenue, Colstrip, Montana 59323.

2.2 Plant Site Description

The CSES consists of four operating coal-fired electric generating units. Generating Units 1 and 2 are 333 megawatts (MW) each and have been operating since 1975. Generating Units 3 and 4 are 805 MW each and have been operating since 1983 and 1986, respectively. Generating Units 1 and 2 are scheduled to be shut down no later than 1 July 2022, while Generating Units 3 and 4 will continue to operate. The CSES is co-owned by Talen; PacifiCorp; Puget Sound Energy, Inc.; Portland General Electric Company; Avista Corporation; and NorthWestern Corporation. Talen is responsible for operating the CSES (Talen, 2015).

The CSES uses a closed-loop process water/scrubber system. Raw water for use in the CSES closed loop process is piped from the Yellowstone River to Castle Rock Lake (a.k.a., the Surge Pond) via a 29-mile long pipeline. From the Surge Pond, water is piped to holding tanks at the Plant Site for use in the boilers, cooling towers and scrubber systems for Generating Units 1 through 4. Slurries of flyash from the scrubber system are transported to two paste plants, which remove water from the slurry and create a paste that is deposited in disposal ponds at the Units 1 & 2 SOEP/STEP and the Units 3 & 4 EHP. Clearwater from the paste plants at the Units 1 & 2 SOEP/STEP and Units 3 & 4 EHP is recirculated back to the Plant Site for reuse in the scrubbers. Bottom ash dewatered at the Plant Site, and then transported to the Units 3 & 4 EHP for disposal. Clearwater from the bottom ash dewatering ponds is conveyed back to the Units 1 through 4 bottom ash systems for reuse. In 2018, the Units 3 & 4 Bottom Ash ponds were removed from service and the new Units 3 & 4 Bottom Ash Dewatering System was constructed to dewater bottom ash from Generating Units 3 and 4.

As discussed in Section 2.5.2 of the Revised Plant Site Remedy Evaluation Report, groundwater flow patterns within the hydrostratigraphic units in the Plant Site area are a function of geology, areas of recharge and discharge, ground surface topography, pond seepage, and groundwater capture. Hydraulic conductivity values of hydrostratigraphic units measured in the Plant Site area are highly variable. Coarse (basal) alluvium and localized areas of coarse fragmented spoils (typically near the base of old mine cuts) have the highest hydraulic conductivity while fine alluvium, spoils and bedrock units typically have lower values.

Groundwater at and downgradient of certain process wastewater ponds contain concentrations of indicator parameters, such as boron and sulfate, that are higher than background concentrations. As such, some current and former process wastewater ponds have been
identified as potential sources of higher concentrations of these indicator parameters detected in groundwater.

According to the AOC Site Report for the Plant Site (Hydrometrics, 2015), the first documented release of process wastewater from ponds at the CSES occurred at the Plant Site in 1980. The release was the result of a tear in the liner of the former Brine Pond D3. Beginning in 1982, capture wells were installed at the CSES to return impacted groundwater to the process wastewater ponds. Since installation, numerous additions have been made to the capture systems to mitigate migration of seepage from process wastewater ponds. The existing groundwater capture system as of March 2019 is shown on Sheet 2.

Overall, groundwater quality has improved in the Plant Site area as a result of action taken to mitigate process pond impacts to groundwater, especially in spoils and interburden in the former Brine Ponds area, and alluvium downgradient of Units 1 & 2 Bottom Ash Clearwell. The improvement is a result of groundwater capture system operation and changes in water management. In 2017, concentrations of constituents, such as boron and sulfate, above cleanup criteria in alluvial groundwater extended westward from east of the Units 1 & 2 B Pond to groundwater capture wells completed in alluvium along East Fork Armells Creek. Small isolated areas of groundwater constituents, such as boron and sulfate, above cleanup criteria were also present in alluvium west of East Fork Armells Creek between well OT-7 and the City of Colstrip Sewage Lagoons.

2.3 Process Wastewater Ponds

The CSES is a zero-discharge facility, which means there is no direct discharge of process wastewater or stormwater from the Plant Site. The Plant Site uses a variety of ponds to manage wastewater from the steam electric power generating process. Plant Site ponds are also used to store captured groundwater and stormwater runoff for re-use. The historic and current wastewater facilities at the Plant Site, including ponds, are summarized in Table 2-1, and the pond locations are shown on Sheet 2. Details of the construction history of some of the individual ponds (i.e. CCR units) can be found in the “Colstrip Steam Electric Station History of Construction” prepared by Geosyntec (Geosyntec, 2016).

2.4 Wastewater Facility Closure Plan

In July 2017, Geosyntec prepared a Facility Closure Plan that addresses the AOC Article IX requirements for the Plant Site including:

1. provisions for control, minimization, or elimination, to the extent necessary to protect human health and the environment, of post-closure escape of Constituents of Interest (COIs) to the environment;

2. proposed actions to inform and obtain input from the community consistent with AOC Article V – Public Participation; and
3. cost estimates for closure and post-closure care.

The Facility Closure Plan was conditionally approved by MDEQ in December 2018 and was revised in February 2019 by Geosyntec (Geosyntec, 2019) in response to comments received from MDEQ, and to reflect the planned shutdown of Units 1 and 2 no later than 1 July 2022. The Facility Closure Plan includes the closure (capping) or reclamation of several ponds at the Plant Site. Closure of all coal combustion residual (CCR) units will occur in compliance with the criteria for closure set forth in 40 CFR 257.102.
3. REMEDIAL ACTION OBJECTIVES AND PREFERRED REMEDY

3.1 Summary of Remedial Action Objectives

This section presents the Remedial Action Objectives (RAOs) for the Plant Site.

3.1.1 Cleanup Criteria

The AOC embraces a risk-based remediation approach for the wastewater systems at the CSES. The AOC states “…the Department and [Talen] have concluded that a comprehensive, risk-based approach incorporating all tools and requirements applicable under Montana’s generally applicable environmental laws, including adaptive management practices available thereunder, is needed to address groundwater contamination and seepage.”

The Revised Cleanup Criteria and Risk Assessment (CCRA) Report was conditionally approved by MDEQ on 27 November 2018 and re-submitted to MDEQ on 20 December 2018 with minor changes. The Revised CCRA Report evaluated “parameters found in soil, groundwater or surface water that (1) result from Site operations and the wastewater facilities and (2) exceed background or unaffected reference areas concentrations” to identify COIs and cleanup criteria under the AOC. There were no COIs identified for soil, sediment or surface water at the Plant Site. Therefore, there are no cleanup criteria for soil, sediment or surface water (Marietta Canty, LLC, 2018).

The Revised CCRA Report identified COIs and cleanup criteria for groundwater at the Plant Site (Marietta Canty, LLC, 2018). The cleanup criteria are based on the following criteria prioritized in the order they are listed: (i) Montana Circular DEQ-7standards; (ii) United States Environmental Protection Agency (USEPA) tapwater risk screening levels (RSLs); and (iii) ecological (livestock) risk. In accordance with Article IV.G. of the AOC, no cleanup criterion may be more stringent than the background or unaffected reference area concentrations. During a February 2017 meeting, MDEQ approved using the BSLs that had been developed at the time the remedy evaluation was initiated (Neptune, 2016) for the Plant Site. The cleanup criteria for groundwater at the Plant Site are presented in Table 3-1.

The preferred remedy is intended to achieve the cleanup criteria for the COIs presented in the Revised CCRA Report. The Revised CCRA Report provides cleanup criteria for each COI in alluvium, spoils, clinker, coal-related, and Sub-McKay groundwater. As requested by MDEQ, the preferred remedy will also address the regulated substances identified in the AOC. The BSLs are one of the multiple lines of evidence that will be used to assess the effectiveness of the preferred remedy in addressing regulated substances that do not have cleanup criteria.

3.1.2 Point of Compliance

The edge of the ponds is considered as the point of compliance (POC) for remedy implementation as directed by MDEQ. Select transects representing interim milestones will be used as a metric for assessing remedial progress. The transects were developed based on the
RCRA Subtitle D POC, which is 150 meters from the edge of the pond or the Talen property boundary, whichever is closer.

3.1.3 Source Control

The RAOs for Source Control Components of the preferred remedy are to:

“control future release of COIs to the groundwater to the extent necessary to achieve the cleanup levels at the downgradient point of compliance in a reasonable period of time.”

Seepage from former and operating process wastewater ponds at the Plant Site has been the main source of constituents to groundwater. The existing underdrains and sumps in Units 1 & 2 B Pond, Units 1 & 2 Bottom Ash Clearwell, and former Brine Pond D4 provide a degree of source control by intercepting seepage and reducing the flux of groundwater constituents to downgradient (distal) areas. Source Control Components of the preferred remedy are intended to significantly reduce future seepage from several process wastewater ponds.

3.1.4 Migration Management

The RAOs for Migration Management Components of the preferred remedy are to:

“Prevent potential current and future exposure of human and ecological receptors to COIs at concentrations greater than cleanup criteria in groundwater beyond the point of compliance, and in surface water in East Fork Armells Creek, and to restore water quality to Cleanup Criteria or background, whichever is greater, in a reasonable period of time.”

The Migration Management Components of the preferred remedy are intended to significantly decrease the effects of long-term seepage and achieve cleanup criteria at the POC of affected groundwater to acceptable levels and within reasonable timeframes.

3.1.5 Institutional Controls

Existing or new institutional controls including city ordinances, deed restrictions, easements, reservations, covenants, controlled groundwater areas, or zoning restrictions may be implemented at the Plant Site and/or off-site to contribute to controlling potential exposure to groundwater constituents until such time that the remedy has achieved the cleanup criteria. Permissions from land owners in areas where groundwater may be impacted, and/or governmental bodies with jurisdiction in those areas, would be needed to implement institutional controls. The RAO for institutional controls is to alert potential receptors to the presence of groundwater constituents and to reduce or eliminate potential exposure.

3.2 Description of Preferred Remedy

According to the Revised Remedy Evaluation Report (Geosyntec, 2018b) Alternative 4 is the preferred remedy for the Plant Site because it addresses constituents with a broad range of
mobility in groundwater, within target timeframes. The preferred remedy includes additional aggressive source control technologies beyond the pond closure systems consisting of: (i) in situ flushing with clean water via new vertical injection wells; (ii) increased groundwater capture in the injection zones using new horizontal wells to control potential spreading of contamination by the injection operations; and (iii) ash dewatering in former Units 1 & 2 A Pond. The total capture system pumping rate would exceed the total injection rate by an estimated 94 to 136 gallons per minute (gpm), which suggest that the in situ flushing system would not simply dilute impacted groundwater. Figures ES-1 and ES-2 of Geosyntec (2018b) show conceptually how the water would be injected and then captured. Based on the modeling results (Figures 6.35 – 6.38, Appendix D1 through D7 of Geosyntec, 2018b), the western line of injection wells along the west side of former Units 1 & 2 A Pond would push a small portion of the boron plume westward into coarse grained alluvium; however, that portion of the plume would be captured by three wells (78A, 199A, and 43S). The need for additional monitoring wells in this area to verify that injection and capture rates are adequately balanced will be evaluated during the injection pilot test. The preferred remedy includes pilot testing to evaluate the potential for the presence of preferential pathways in proposed injection zones. Installation of additional monitoring wells will be determined based on actual monitoring data and performance evaluations after full-scale injection system startup.

The aggressive source control effects of in situ flushing, increased capture, and ash dewatering under the preferred remedy combined with the planned pond upgrades/closures should reduce constituent mass exceeding cleanup criteria and achieve cleanup criteria for highly and moderately mobile constituents by 2049. Due to in situ flushing through unsaturated zones containing residual boron mass, boron plumes should not re-emerge in the preferred remedy. As a result, distal areas more than 500 feet from the source areas would attain cleanup criteria for boron and more mobile constituents in the first approximately 20 years of operation (Figure ES-3 of Geosyntec, 2018b).

Under the preferred remedy, both boron and sulfate are expected to meet the cleanup criteria at the POC by 2049 (the target year for shutting down the injection/capture system). The estimated mass of boron and sulfate exceeding the cleanup criteria in groundwater at the Plant Site would decrease by approximately 97% and 100%, respectively, with the remaining mass occurring beneath former ponds. The mass of manganese and lithium would also be reduced.
4. BASIS OF DESIGN

4.1 Geotechnical Evaluations

4.1.1 Brine Concentrator Solids Disposal Area

A new Brine Concentrator Solids Disposal Area (BCSDA) was constructed in 2018 over the former Brine Ponds D1 – D4 area. The remedy includes the planned installation of twelve new vertical clean water injection wells and one new horizontal groundwater capture well in spoils beneath the BCSDA in 2019. As shown on Sheet 3, three of the new vertical injection wells are planned near the perimeter of the BCSDA and a portion of the new horizontal capture well will extend beneath the BCSDA. It is estimated the new injection/capture system would operate until 2049.

The geotechnical evaluation provided in Appendix D was conducted to assess the possible effects of the planned injection/capture system on the integrity of the geosynthetic liner for the BCSDA. The computer program SLIDE®, Version 6.0 (Rocscience, 2012) was used to assist in the analysis. SLIDE® is a 2D slope stability program for evaluating the factor of safety of circular failure surfaces in soils. The following was concluded from the results of the geotechnical evaluation of the BCSDA:

- The hydraulic conductivities of the spoils would affect the groundwater elevation due to injection operation.

- The calibrated model Kh provided in NewFields (2015), and the Kh estimated from the vertical-to-horizontal hydraulic conductivity anisotropy ratio were used in the SLIDE simulations.

- Laboratory data in Appendix D indicates that the vertical hydraulic conductivity (Kv) of the spoils can be very low (0.004 ft/day), while the horizontal hydraulic conductivity can be high (Kh/Kv = 1,300). Therefore, it would take time (e.g., 30 years) for the groundwater table to rise near the injection well due to the increased injection head and associated upward vertical hydraulic gradient. The water injected deeper in the spoils below the groundwater table would not flow to the upper layers although the groundwater table would rise near the injection well due to the increased injection head and associated upward vertical hydraulic gradient. In other words, the water injected deeper below the groundwater table would mainly flow horizontally. SLIDE simulations using different injection depths demonstrate that injection intervals should be set as low as possible in the spoils to avoid the water table from rising within five feet of the liner.

- The horizontal hydraulic conductivity (Kh) of the spoils was estimated. Sensitivity analysis using different Kh indicates that the injection response is sensitive to the injection pressure and not the injection volume. The final groundwater elevation would
also be affected by the length of the injection operation (e.g., 30 years used in the analysis). The results indicate that no uplifting of the liner or slope instability would occur for Kh between 0.04 ft/day and 5.21 ft/day. Note the groundwater elevation is within 5 ft below the liner for the following SLIDE simulations by the end of 30 years’ injection: Case 2.1 near the vertical capture well (injection interval = 3,255 to 3,238 ft-msl, Kh = 5.21 ft/day), and Case 2.2 near the injection well (injection interval 3,255 to 3,238 ft-msl, Kh = 0.4 ft/day).

- Soil erosion (i.e., piping) is not likely to occur. The spoils beneath the BCSDA, may be subject to suffusion. The filter surrounding the capture well limits localized suffusion (if occurring) to further develop. Therefore, effect of the injection/capture system on the integrity of the liner system is insignificant and the settlement analysis is not needed. However, it is recommended that captured groundwater be routinely examined.

Due to the planned injection and capture in the spoils below the geosynthetic liner for up to 30 years, soil erosion in the foundation might take place. Erosion-induced voids in the foundation may further result in liner settlement, threatening the integrity of the liner system. The design report for the BCSDA (Geosyntec, 2018a), indicates that the maximum calculated strain of the liner system is 0.7 percent, which is an order of magnitude less than the long-term allowable strain of high-density polyethylene (HDPE) geomembrane in the liner system.

The analysis presented in Appendix D only evaluates the injection wells to the south of the BCSDA. The conclusions are drawn based on the available data and the assumptions as discussed in the analysis. When the injection pilot test results are available, the analysis should be re-evaluated if the actual design and the inputs vary considerably from the assumptions discussed in Appendix D.

4.1.2 Units 1 & 2 A Pond and Units 1 & 2 Bottom Ash Clearwell

Additional geotechnical analysis will be conducted prior to preparing the final remedial design package to evaluate the effects of injection on the liner in Units 1-4 Sediment Retention Pond, and the stability of the existing embankment along the west and north sides of Units 1 & 2 Bottom Ash Clearwell and west side former Units 1 & 2 A Pond.

4.2 Ash Dewatering Pipe for Units 1 & 2 A Pond Design

The closure of former Units 1 & 2 A Pond is scheduled for 2019. A geosynthetic final cover system was designed in 2018. According to the seepage analysis “Liquid Seepage Rate Update” performed for the Plant Site dated 16 June 2017, a dewatering system installed in former Units 1 & 2 A Pond would reduce the volume of seepage into the groundwater (estimated 526,000 cubic feet liquid in the former Units 1 & 2 A Pond ash to be extracted) by 2026. It is assumed that no additional dewatering would be necessary since former Units 1 & 2 A Pond will be capped in 2019, which is expected to mitigate recharge to the pond through precipitation.
Hydrometrics, Inc. (Hydrometrics) submitted a Dewatering Work Plan to MDEQ in June 2017. The Dewatering Work Plan included installing wells and piezometers in former Units 1 & 2 A Pond to confirm the water levels and hydraulic properties assumed for the ash in the analysis. Data from the work plan implementation were used to evaluate the feasibility and efficacy of dewatering the ash in former Units 1 & 2 A Pond. Based on the available data from the seepage analysis and implementation of the dewatering work plan, the ash dewatering pipe is planned to be installed as part of the capping of former Units 1 & 2 A Pond in 2019.

The design for the ash dewatering pipe was completed in January 2019 and are incorporated into the cap design for former Units 1 & 2 A Pond. The proposed design of the dewatering system includes construction of a 2-feet-wide trench backfilled with ASTM C33 sand and installation of a dewatering pipe 12 inches above the bottom of the trench. Based on the analysis discussed in Appendix E-1, a 6-inch nominal diameter, SDR 11, HDPE pipe will meet the design requirements for the horizontal dewatering pipe placed in the trench. The slot width is specified to be 0.025 ± 0.01 inch (acceptable 0.045 in maximum). As the design pumping rate is 5 gpm, the discharge pipe shall be 1.0 inch in diameter, yielding a design flow velocity of 2.04 ft/s (> 2.0 ft/s). The design pump power is 0.5 horsepower. A cross section showing the alignment for the dewatering pipe is shown in Sheet 4. The basis of design for the slotted pipe, including: (i) pipe size, (ii) slot with, (iii) flow capacity, and (iv) pipe strength is provided in Appendix E-1.

The new ash dewatering pipe in former Units 1 & 2 A Pond will connect to a new 2-inch underground capture pipeline north of the Units 1 & 2 Bottom Ash Clearwell that will convey captured groundwater to an existing 3-inch underground capture pipeline that discharges into Units 1 & 2 B Pond.

4.3 Vertical and Horizontal Capture Well Design

The remedy includes increasing the pumping rate at five existing vertical capture wells (1D, 5M, 55D, 113M, and 115M) by either redeveloping, stimulating or replacing the wells. In addition, the remedy includes adding the two new horizontal capture wells (HW), and three new vertical capture wells (CW4, CW11, and CW12) in the vicinity of the former Units 1 & 2 A Pond and former Brine Ponds D1-D4 to enhance hydraulic control during in-situ flushing activities. The basis of design for the new horizontal capture wells including pipe selection, slot width, pipe flow capacity, design pump rate, and pump head are provided in Appendix C-1.

Captured groundwater from the three new vertical capture wells will be conveyed to the VSEP for treatment via a new 2-inch underground capture pipeline constructed northeast of the Units 1-4 Sediment Retention Pond. The new horizontal capture well beneath Units 1 & 2 A Pond will connect to a new 2-inch underground capture pipeline north of the Units 1 & 2 Bottom Ash Clearwell that will convey captured groundwater to an existing 3-inch underground capture pipeline that discharges into Units 1 & 2 B Pond. Captured groundwater from the new horizontal capture well beneath the former Brine Ponds D1-D4 will flow into a new 3-inch SDR-11 HDPE underground capture pipeline that connects into a new 3-inch SDR-11HDPE
underground capture pipeline installed in place of the existing 2-inch underground capture pipeline near capture well 111SP. From capture well 111SP, the captured groundwater will be conveyed into the existing 3-inch underground capture pipeline near capture well 19SP that discharges into Units 1 & 2 B Pond. The upgraded groundwater capture system is shown on Sheet 3, and profiles of the new horizontal capture wells beneath the Units 1 & 2 A Pond and former Brine Ponds D1-D4 are shown in Sheets 4 and 5, respectively.

4.4 Injection System Pilot Test Design

The remedial design includes injection pilot testing to address design data gaps for the design of the in-situ flushing component of the selected remedy. The Injection Pilot Test Work Plan, provided in Appendix F, describes the pre-field activities, injection pilot test permitting, and injection pilot testing operations that will be conducted at the Plant Site to achieve the following objectives:

- Evaluate injection flow rates predicted in the groundwater flow model;
- Evaluate required injection pressures to achieve desired flow rates; and
- Evaluate areas of influence and possible preferential flow paths in the pilot test injection zones.

Pre-field activities will be conducted prior to installation and development of the new pilot test monitoring and injection wells at the Plant Site. Those activities include preparing and submitting the injection well information USEPA Region 8 requires for Class V injection wells for aquifer remediation systems. USEPA Region 8 will review the information and evaluate the impact the injection wells will have on the local hydrogeologic system, potential for underground source of drinking water (USDW) contamination, and whether a permit will be required for this operation, rather than a rule authorization. In addition, Talen’s existing health and safety plan for the site will be reviewed and supplemental addenda will be prepared, as necessary, to address health and safety precautions for the field activities to be completed during implementation of this Injection Pilot Test Work Plan.

After obtaining necessary approvals for the pilot injection system of the injection permit, and reviewing and updating, as necessary, the site’s health and safety plan, installation and development of the new monitoring and injection wells will begin.

The pilot test will be conducted at three (3) new vertical pilot test injection wells targeting three (3) different stratigraphic horizons for the in-situ flushing system. It will include one (1) injection well screened in alluvium northwest of former Units 1&2 A Pond (injection well IW-4A), one (1) injection well screened in McKay Coal west of former Units 1&2 A Pond (injection well IW-37M), and one (1) injection well screened in spoils beneath the former Brine Ponds D1-D4 (injection well IW-47SP). Anticipated drilling depths and planned screen intervals for the pilot test injection wells are presented in Table 2-1 of Appendix F. The target
hydrogeological interval and depth of each new injection well were initially estimated based on the groundwater modeling results (NewFields, 2019). The well locations were then adjusted based on access limitations due to the physical features of the site shown on the topographical survey, and the well depths were adjusted based on the lithology shown on the borehole logs provided for nearby monitoring wells.

The injection water for the injection pilot test will be obtained from the Surge Pond via the Units 1&2 Clarifier Building, which currently receives raw water from the Surge Pond, and pumped into three temporary tanks. Each temporary water tank will be staged next to a pilot injection well and will serve as the reservoir for the injection test. Table 4-1 presents the analytical results of the planned injection water collected from the Units 1&2 Clarifier Building on 27 September 2018. USEPA Maximum Contaminant Levels (MCLs), MDEQ Circular DEQ-7, USEPA tapwater RSLs and the site background screening levels (BSLs) (Neptune and Company, 2016) were added for comparison. No exceedances were identified.

NewFields (2019) conducted groundwater modeling using the existing MDEQ-approved groundwater flow model to simulate groundwater flow and constituent transport in the vicinity of the three (3) planned injection wells during the injection pilot test. Based on the fate and transport modeling results and the anticipated lithology at each pilot injection zone, eight (8) new monitoring wells and sixteen (16) existing monitoring and capture wells will be used to monitor changes in groundwater elevations and specific conductance concentrations during the injection pilot tests. Anticipated drilling depths and planned screen intervals for the twenty-four (24) pilot test monitoring wells are presented in Table 2-2 of Appendix F. The new monitoring wells that will be installed for the injection pilot tests are as follows:

- Two (2) new monitoring wells will be installed in alluvium 25 feet north (IW4-A-N) and 25 feet south (IW4-A-S) of injection well IW-4A, and one (1) new monitoring well will be installed in alluvium 75 feet east of injection well IW-4A (IW4-A-E);

- Two (2) new paired monitoring wells will be installed in alluvium (IW37-A-N-S) and McKay Coal (IW37-M-N-D) 25 feet north of injection well IW-37M, and one (1) new monitoring well will be installed in McKay Coal (IW37-M-S) 25 feet south of injection well IW-37M; and

- Two (2) new monitoring wells will be installed in spoils 25 feet west and 25 feet south of injection well IW-47SP.

The existing monitoring and capture wells that will be monitored during the injection pilot tests are as follows:

- Alluvial capture well SRP-5 and alluvial monitoring well 50S, which are located approximately 50 feet southwest and 60 feet southwest, respectively, of injection well IW-4A;
• Sub-McKay bedrock capture well 56D and 55D, which are located approximately 75 feet southwest and 300 feet northwest, respectively, of injection well IW-4A;

• Alluvial monitoring wells 148A-CCR and AB20S, which are located approximately 125 feet northwest and 200 feet east, respectively, of injection well IW-4A;

• Alluvial capture well SRP-7, which is located approximately 50 feet northwest of injection well IW-37M;

• Alluvial monitoring well AB4-S and McKay Coal capture well 58M, which are located approximately 50 feet southwest of injection well IW-37M;

• McKay Coal capture wells 115M and 169M, which are located approximately 150 feet northwest and 150 feet southwest, respectively, of injection well IW-37M;

• McKay Coal monitoring well 58M-P, which is located approximately 250 feet southwest of injection well IW-37M;

• Spoils capture well 175SP and monitoring well 180SP, which are located approximately 25 feet northeast and 200 feet west, respectively, of injection well IW-47SP; and

• Spoils capture wells 4S-2 and 19SP, which are located approximately 250 feet east and 300 feet north, respectively, of injection well IW-47SP.

The Injection Pilot Test Work Plan, provided in Appendix F, also discusses the procedures for installation of monitoring and injection wells, well registration requirements of the Montana Bureau of Mines and Geology (MBMG), and the injection pilot test system configuration.

When pre-field activities are complete, and the injection pilot test systems have been installed, the field injection pilot tests will commence. The injection test will be initiated by pumping water into each injection well at the injection flow rates predicted by the existing MDEQ-approved groundwater flow model for the Plant Site (Table 2-4 of Appendix F). When the target injection rate is achieved, the injection rate will be maintained for at least seven (7) days to allow injected water to migrate to the nearby monitoring wells.

Initially during the injection tests, manual readings of injection rates and injection pressures at the pilot injection wells will be recorded hourly during field testing. Once constant injection rates and injection pressures are achieved, manual readings will be reduced to once every two to four hours for the remaining duration of the tests. The cumulative volume of water injected at each injection well will be calculated daily.

According to modeling results for the pilot injection test provided in NewFields (2019), a response in water levels and change in boron and sulfate concentrations is expected to be detected almost instantaneously after initiating the injections east of the Units 1 & 2 A Pond in
McKay Coal, and as early as two days after initiating the injections in observation points located in unconsolidated deposits (alluvium and spoils) 25 feet from the injection well. Therefore, transducers capable of datalogging water levels and specific conductance will be installed in at least three (3) monitoring wells for each pilot injection well. Past data have shown a very good correlation between specific conductance and sulfate concentrations in groundwater at the Plant Site.

Water levels and specific conductance will also be measured manually in these wells (in case of datalogger failure) and in the other pilot test monitoring wells every two to four hours during the pilot tests using a hand-held meter. Water levels will also be measured at capture wells through the existing stilling tubes.

4.5 Injection System Design

It is assumed that the tie-in for the injection system for the Plant Site will be in the existing water supply line from the Surge Pond in the Units 1&2 Clarifier Building. New pumps and conveyance piping are planned to transport injection water through a multimedia filter and then into four tanks located northeast of the Units 1-4 Sediment Retention Pond, northwest and north of the Units 1 & 2 Bottom Ash Clearwell, and north of the BCSDA. The conveyance piping will be placed under ground and will be rated to an anticipated injection pressure plus 25 percent. Piping and instrumentation diagrams for the four tanks are provided as Sheets 10 through 13. Inline pumps will be used to pump the clean water to a network of 54 injection wells in the following five target injection zones near/beneath a source area (pond).

1. Unconsolidated deposits (alluvium) west of former Units 1 & 2 A Pond;
2. Unconsolidated deposits (alluvium) east of former Units 1 & 2 A Pond;
3. McKay Coal west of former Units 1 & 2 A Pond;
4. McKay coal east of former Units 1 & 2 A Pond; and
5. Spoils in a former mine cut (buried trench) by former Brine Ponds D1 – D4.

The injected water is intended to increase the flux of groundwater constituents beneath the former ponds to the upgraded capture system and achieve more aggressive cleanup timeframes.

The flow into the wells will be controlled via manual valves at each well. The pumps will be sized to deliver the maximum flow for the wells they are feeding, at a pressure sufficient to maintain distribution of those flows to the wells. Preliminary hydraulic calculations for the injection system, including pump capacities and pipe sizes, are provided in Appendix C-3. The preliminary pump capacities are conservative in that it is unlikely that all equalization tanks will require filling at once at the maximum flow rate. The pipe diameters were selected assuming that the maximum flow rates for all injection wells in the former Units 1&2 A Pond area were injecting at 4 gpm, and all injection wells in the former Brine Ponds D1-D4 area were injecting at 6 gpm. The hydraulic calculations for the injection system will be updated as part of the final remedial design package to include feed pressure at the tie-in point, final tank
locations and elevations, required delivery pressure at the injection wells, and actual head losses due to piping transitions and fittings.

Based on the equipment sizing calculations for the injection system, provided in Appendix C-2, four 3-ft diameter self-backwashing multimedia filters will be needed for the planned average and maximum injection flow rates. The average carbon dioxide (CO₂) delivery requirement for each of the six injection distribution lines ranges from 12 lb/day to 64 lb/day. The CO₂ storage requirement for each of the six injection distribution lines ranges from 0.5 to 2.9 tons for quarterly filling of the tanks. The maximum CO₂ feed rate for each of the six injection distribution lines ranges from 19 to 86 lb/day.

The pressures required to overcome the hydrostatic pressures in the screened portion of each injection well will be determined based on the results of the injection pilot study but should not exceed 65 psi. Control of flow to the individual injection wells will be achieved using a control panel and automated valves.

The process flow diagram, and injection system distribution system piping layout including pumps, tanks, lift stations, and multimedia filters are shown on Sheets 7 and 8.

### 4.5.1 Injection Water

The remedy includes pumping and conveyance of clean water to the injection well network for in-situ flushing. The injection system is planned to tap into the existing water supply line from the Surge Pond to the Units 1&2 Clarifier Building at the Plant Site. As discussed in Section 4.4, no exceedances of the USEPA MCLs, MDEQ Circular DEQ-7, USEPA tapwater RSLs, and the site BSLs were identified in the sample of proposed injection water collected from the Units 1&2 Clarifier Building on 27 September 2018.

While Table 4-1 shows total suspended solids (TSS) concentrations in the planned injection water sample were low (4 mg/L), TSS can be variable in surface water sources like the Surge Pond. Therefore, a multimedia filtration system will be included in the injection system in case TSS removal is needed.

The injection water compatibility evaluation provided in Appendix C-4, was conducted to simulate the effect of mixing injection water with groundwater from within the alluvium, spoils, and McKay coal units on mineral saturation; and evaluate the effect of pre-treatment of injection water with carbon dioxide on mineral saturation during mixing. While mixing injection water with groundwater is not expected to increase mineral saturation, calcite is expected to be over-saturated in both the groundwater and the injection water. Therefore, some scaling of the wells or the surrounding formation is possible. Equipment for controlling pH is included in the design to lower injection water pH using CO₂. The evaluation described in Appendix C-4 indicates that a modest pH decrease to 6.5 standard units should result in undersaturated calcite conditions in the injection water.
The planned injection water is slightly basic, with a pH of 8.7 (Table 4-1), while groundwater underlying the Plant Site has a neutral pH. According to Goldberg (1997), boron does not undergo oxidation-reduction reactions, and sorption tends to occur at higher pH values. As such, lowering the injection water pH would likely enhance in-situ flushing of boron and other less mobile constituents in groundwater. Additional modeling will be conducted in preparation for the full-scale injection system design to evaluate the effect of lowering injection water pH using CO₂ or hydrochloric acid (HCl) on pH and calcite saturation, as well as the performance of flushing boron and other less mobile constituents. However, CO₂ and HCl injection are not included in the pilot injection test because the injections are not long enough to assess the performance of mobility enhancement measures. Instead, the pilot injection test is designed to confirm predicted flow rates from the groundwater flow model; evaluate required injection pressures to achieve desired flow rates; and evaluate possible preferential flow paths in injection test areas. The injection water treatment and distribution system piping and instrument diagram for the full-scale injection system is provided as Sheet 9.

4.5.2 Injection System Operation

The injection system will begin operating in 2019 after the capture system upgrades discussed in Sections 4.2 and 4.3 have been implemented, the injection system and vertical injection wells have been installed, and well registration requirements have been met. The injection system is planned to operate until 2049.

Every one to five years during its operational lifetime, the performance and progress of the injection/capture system will be re-evaluated. If monitoring data in a given area show constituents are approaching the cleanup criteria or demonstrate natural attenuation has the capacity to achieve the cleanup criteria, the injection/capture wells in that area would be evaluated as to whether there is much benefit to their continued operation.

4.6 Vertical Injection Well Design

As discussed in Section 4.5, the remedial design includes the addition of 54 new vertical injection wells (IW-1A to IW-54M) in the vicinity of the former Units 1 & 2 A Pond and former Brine Ponds D1-D4 to deliver water for in situ flushing. The following sections discuss the permitting required to install the new injection wells, as well as the conceptual design, installation procedure, registration requirements, and operational criteria for the injection wells.

4.6.1 Permitting for Injection Wells

According to 40 Code of Federal Regulations (C.F.R.) Section (§) 144.83, Montana is a “Direct Implementation” state, which means that injection wells, other than for oil and gas related purposes, are administered by USEPA through the Region 8 Administrator for the Underground Injection Control (UIC) program. The injection wells proposed for the in situ flushing system and the injection pilot test will fall into the definition of Class V wells that inject non-hazardous fluids into or above underground sources of drinking water. USEPA established minimum requirements for Class V wells to prevent them from contaminating USDWs.
According to the Revised CCRA Report (Marietta Canty, LLC, 2018) for the Plant Site, groundwater at the Plant Site is a typical Class III water in that specific conductance in unimpacted groundwater for all units was greater than 2,500 µmhos/cm (equivalent to microSiemens/cm) ranging from 4,130 to 4,900 µmhos/cm. As stated in Administrative Rules of Montana (ARM) 17.30.1006, the quality of Class III groundwater must be maintained so that these waters are at least marginally suitable for drinking and other specified beneficial uses. Therefore, the water at the Plant Site qualifies as an USDW and must be protected for drinking water use. As discussed in **Section 4.4, Table 4-1** shows that the proposed injection water meets the MCLs established by the USEPA in 40 CFR 143.3.

Prior to construction of the planned injection wells, Geosyntec will prepare and submit the injection well information USEPA Region 8 requires for Class V injection wells for aquifer remediation systems. USEPA Region 8 will review the information and evaluate the impact the injection wells will have on the local hydrogeologic system, potential for USDW contamination, and whether a permit will be required for this operation, rather than a rule authorization. The fact sheet describing the injection well information required by USEPA Region 8 for Class V injection wells for aquifer remediation systems are provided in **Appendix G**. According to Talen, there are no domestic wells present within 100 feet of the pilot test injection wells or in the Plant Site area. No new private wells are anticipated to be constructed in the Plant Site. The injection water is of higher quality than groundwater in the injection zone.

After the injection wells have been completed, the licensed well constructor is required to prepare and submit a well report form, including a log of borehole lithology and well completion, for each well drilled in accordance with ARM 36.21.809 (1). The well log report (Form No. 603) will be filed within 60 days of completion of the well with the Ground Water Information Center (GWIC) of the MBMG. The constructor will also provide copies of each well log, within 60 days of completion of the well to the well owner (Talen).

### 4.6.2 Injection Well Conceptual Design

The locations of the 54 new injection wells estimated from groundwater modeling (NewFields, 2018) are shown on **Sheet 6**. The injection wells will be constructed with 2-inch diameter, Schedule 40 flush-threaded steel riser pipe and 2-inch diameter stainless steel wire-wound screen (0.020-inch slot). A filter pack, consisting of 10/20 silica sand, will be placed along the entire screened interval to at least two (2) feet above the top of the screen.

A bentonite annular seal will be placed to two (2) feet above the filter pack. Neat Type V (sulfate-resistant) cement grout annular seal will be placed by tremie or pumping above the bentonite seal to the ground surface. An 8-inch diameter, black steel surface casing equipped with a protective steel locking cover will extend above the grade 18 to 24 inches.

A general design of the injection wells that will be installed at the Plant Site is illustrated in **Sheet 14**. Construction details of the planned injection wells, including ground surface elevation, unit screened, depth to water, and screen depths and elevations, will be determined.
after completion injection pilot testing. The planned screen depths and elevations for the
injection wells were estimated from groundwater modeling provided in NewFields (2019) and
confirmed by injection pilot testing. The actual screen depths and elevations may be adjusted
in the field based on observations during drilling.

4.6.3 Injection Well Installation

Locations of the planned injection wells (shown on Sheet 6) will be marked with paint, flags
or stakes prior to commencement of intrusive ground activities. Montana 811 will be notified
at least 48 hours in advance to identify the location of public underground utilities. A private
utility locator will be retained to evaluate the presence of subsurface utilities at each proposed
location identified by an on-site geologist or engineer.

The planned injection wells will be drilled and installed by a licensed monitoring well
constructor according to Montana Board of Water Well Contractors standards, as noted in ARM
36.21.8. The work flow and materials described herein for new well installation are based on
the typical work flow and materials used for monitoring well installation and development at
the CSES, which is provided in the Water Resources Monitoring Plan (WRMP; Talen, 2015).

The well boreholes will be advanced either hollow stem auger or sonic drilling method to
planned screen intervals, which will be determined based on groundwater modeling and the
results of the injection system pilot tests. According to the WRMP (Talen, 2015), hollow-stem
auger and sonic methods have been successful in advancing other boreholes installed to similar
depths and geologic units at the Plant Site. The actual screen intervals are subject to change
based on the field observations of lithology and groundwater levels.

After reaching the total depth in each borehole, the injection well will be constructed through
the hollow stem auger or sonic casing. Drilling fluids are not planned to be used unless
necessary, but if used, the volume of drilling fluid lost will be recorded. Consistent with the
WRMP (Talen, 2015), cuttings from the borings will be logged for lithology, including texture,
color, relative moisture, and origin (alluvium, colluvium, bedrock, etc.) by a geologist or
engineer.

Injection wells will be constructed with 2-inch diameter, Schedule 40 flush-threaded steel riser
pipe and 2-inch diameter stainless steel wire-wound screen (0.020-inch slot). Although,
Schedule 40 PVC would likely provide sufficient unconfined burst strength for the relatively
low injection pressures at lower material cost, Schedule 40 steel will be more durable for long
term well maintenance, thus reducing the likelihood of replacement. The injection wells are
planned to be in operation for 30 years.

Generally, water wells should be constructed with sufficient open area within the well screen
so that the calculated entrance velocity will not exceed 0.1 foot per second during pumping
(Driscoll, 1986). For injection wells, the entrance velocity is the velocity injection water enters
the screened unit through the well screen. At high entrance velocities, there is an increased
potential for mineral fouling and corrosion to occur within the well screen as a result of high friction loss and turbulent flow. Prior to finalizing the remedial design, the entrance velocities for the injection wells will be estimated by dividing the desired injection rates (specified in Table 4-2) by the surface areas of the openings in the screen (0.020-inch slot) to ensure they are less than the generally accepted maximum entrance velocity discussed in Driscoll (1986).

Following completion, injection wells will be developed by surging and pumping. Surging involves flushing the filter pack of fine sediment to reduce disruption to the filter pack and screen. Prior to surging and pumping, the total depth of the well will be measured. Sustainable pumping rates will be logged during surging. Following surging, the well will be pumped or bailed to remove sediment drawn in by the surging process until suspended sediment is reduced to acceptable levels (see below). Bailing involves repeatedly removing water from the well with a bailer (with check valve) until the well has been adequately purged. A well is considered fully developed when all of the following criteria are met:

- the well water is clear to the unaided eye (based on observations of water clarity through a clear glass jar or white bucket);
- the sediment thickness remaining in the well is less than one percent of the screen length; and
- the total volume of water removed from the well equals or exceeds five times the standing water volume in the well (including the well screen and casing plus saturated annulus, assuming 30 percent porosity) plus the volume of drilling fluid lost.

Field groundwater quality parameters (specific conductance, pH, temperature) will be measured and recorded during development.

All non-dedicated downhole equipment will be rinsed prior to use in each well. If there is not enough water in the well to adequately rinse the equipment prior to use in each well, it must be decontaminated with deionized water.

After installation, the locations and elevations of the new injection and monitoring wells will be surveyed by a licensed professional land surveyor. Wells at the CSES are typically measured to the top of the PVC casing or steel protective casing.

### 4.6.4 Injection Well Registration

After completion of installation of the planned injection wells, the well constructor will prepare and submit a well report, including a log of borehole lithology and well completion, for each well installed at the site. The well log reports will be filed within 60 days of completion of the well with the GWIC of the MBMG and provide copies of each well log to Talen.
4.6.5 Injection Well Operation

Table 4-2 provides the planned injection strata, average injection flow rate for the 54 new injection wells estimated from groundwater modeling provided in NewFields (2019). The planned injection flow rates and pressures may be adjusted based on the results of the injection pilot tests, and further adjusted in the field based on observations during drilling. Hydrostatic heads and pressures will be estimated based on nearby well logs and the results of the injection pilot tests prior to installation. The injection system is planned to operate until 2049.

As discussed in Section 4.5.2, the performance and progress of the injection/capture system will be routinely re-evaluated during its operational timeframe, and injection/capture wells may be shut down earlier than 2049 in a given area if monitoring data show constituents are approaching the cleanup criteria or demonstrate natural attenuation has the capacity to achieve the cleanup criteria.

4.7 Preliminary Scoping of MNA Data Needs and Demonstrations

The preferred remedy includes a monitored natural attenuation (MNA) component to address some of the less mobile constituents (i.e., cobalt, lithium, manganese, molybdenum, and selenium), if any, remaining after the capture system is shut down in 2049. The desktop assessment of MNA (Appendix H) was conducted to assess the potential for MNA to address the less mobile constituents in groundwater at the Plant Site. The assessment includes evaluation of groundwater concentrations in source area and downgradient wells to assess the degree to which less mobile constituents in groundwater have migrated downgradient, as well as surface complexation adsorption modeling to evaluate sorption potential of aquifer grains. The adsorption modeling was conducted using the Geochemists Work Bench® SpecE8 program.

The results of the MNA assessment, indicate that less mobile constituents have not migrated downgradient from the ponds to a significant degree, and the preferred remedy for the Plant Site groundwater will likely achieve cleanup criteria for all the constituents when the system is shut down in 2049 and further evaluation of the MNA component is not necessary. Although additional evaluation of MNA is not needed at this time, it is still retained as a contingency to the selected remedy.

4.8 Preliminary Scoping of PRB Feasibility Test Data Needs and Demonstrations

As discussed in the previous section, the desktop assessment of MNA provided in Appendix H demonstrated that less mobile constituents have not migrated downgradient from the ponds to a significant degree and MNA will sufficiently address constituents remaining after the capture system is shut down. Therefore, a permeable reactive barrier (PRB) will not likely be needed at the Plant Site. Although additional evaluation of PRB is not needed at this time, it is still retained as a contingency to the selected remedy.
4.9 Units 1 & 2 North and South C Ponds Soil Sampling Plan

The Units 1 & 2 North and South C Ponds Soil Sampling Plan, provided in Appendix I-1, was prepared in accordance with the Revised Remedy Evaluation Report (Geosyntec, 2018b) to investigate the clay liner and underlying soils beneath the Units 1 & 2 North and South C Ponds (referred to herein as the North and South C Ponds) after they are dewatered. The area of North and South C Ponds is the planned location of the new Groundwater Capture Storage Pond at the Plant Site. The new Groundwater Capture Storage Pond is planned to store excess captured groundwater from the Plant Site and the Units 1 & 2 SOEP/STEP area until it can be treated, reused in the Units 3 & 4 scrubbers, evaporated or discharged. Due to the expedited schedule for construction, sampling was conducted in early 2019 prior to complete dewatering and results are pending. The purpose of Units 1 & 2 North and South C Ponds Soil Sampling Plan is to:

1. evaluate if the clay liner material beneath the North and South C Ponds can be used as fill without restrictions or if it has to be disposed of as a source of COIs due to leaching to groundwater or to prevent direct contact; and

2. evaluate if soils beneath those liners could be ongoing sources of COIs leaching to groundwater and should be removed and disposed of before constructing the new Groundwater Capture Storage Pond.

The soil sampling plan includes criteria for determining if the soils beneath North and South C Ponds could act as sources of constituents to groundwater above cleanup criteria, and criteria to assess the suitability of the clay liner from beneath North and South C Ponds for reuse as fill at the Plant Site. It also identifies where composite soil samples of the clay liner and underlying soils beneath North and South C Ponds were collected. Lastly, the plan describes the decontamination procedure for field equipment, and quality assurance/quality control criteria for soil sampling and laboratory analysis.

4.10 Former Units 1 & 2 Bottom Ash Ponds Soil Sampling Plan

The former Units 1 & 2 Bottom Ash Ponds Soil Sampling Plan, provided in Appendix I-2, was prepared in accordance with the Revised Remedy Evaluation Report (Geosyntec, 2018b) to investigate the clay liner and underlying soils beneath the former Units 1 & 2 Bottom Ash Ponds. The former Units 1 & 2 Bottom Ash Ponds contained a clay liner and began operating in 1980. During operation, those ponds were used to dewater bottom ash and collect clear water. The ponds were removed from operation in 1988 and closed in place by filling with bottom ash. In 2016, most of the bottom ash was excavated and stockpiled next to Units 3&4 Bottom Ash Ponds to be used as fill for capping Units 3 & 4 Bottom Ash Ponds. According to the Revised Remedy Evaluation Report (Geosyntec, 2018b), the remaining bottom ash in the former Units 1&2 Bottom Ash Ponds is planned to be excavated and used as fill for capping ponds.

The purpose of the Former Units 1 & 2 Bottom Ash Ponds Soil Sampling Plan is to:
1. evaluate if the clay liner material beneath the former Units 1 & 2 Bottom Ash Ponds can be left in place or if it has to be removed and disposed of as a source of COIs due to leaching to groundwater before backfilling the excavation; and

2. if the clay liner material has to be removed and disposed of, evaluate if the underlying soils could be an additional ongoing source of COIs due to leaching to groundwater and should also be removed and disposed of before backfilling the excavation.

The soil sampling plan includes criteria for determining if the clay liner and underlying soils in the former Units 1 & 2 Bottom Ash Ponds could act as sources of constituents to groundwater above cleanup criteria, and if removed, criteria to assess the suitability of the clay liner from the former Units 1 & 2 Bottom Ash Ponds for reuse as fill at the Plant Site. It also identifies where composite soil samples of the clay liner and underlying soils beneath the former Units 1 & 2 Bottom Ash Ponds are planned to be collected. Lastly, the plan describes the decontamination procedure for field equipment, and quality assurance/quality control criteria for soil sampling and laboratory analysis.

4.11 Assessment of Emergency Preparedness Procedures and Health and Safety Plan

Talen’s existing emergency preparedness procedures and health and safety plan for the site will be reviewed and addenda will be prepared, as necessary, to supplement the plans during RD/RA Work Plan implementation. The Final Remedial Design Package will discuss how the existing, or addendums to, emergency preparedness procedures and health and safety plan will meet applicable health and safety regulations during implementation of the remedy.

4.12 Approach to Monitoring Plan Update

In the Revised Plant Site Remedy Evaluation Report, Talen committed to provide groundwater monitoring activities over a 34-year timeframe (from 2019 to 2053), as well as system performance evaluations for the injection and capture system. The system performance evaluations would be conducted after the first year of operation, bi-annually in the third and fifth years of operation, and then every five years thereafter until the capture system is shut down.

Talen’s existing WRMP (Talen, 2015) and Coal Combustion Residuals Rule Comprehensive Groundwater Monitoring Plan (GWMP; Hydrometrics, 2018) for the site will be reviewed and addenda will be prepared, as necessary, to include groundwater monitoring activities over a 34-year timeframe (from 2019 to 2053) and system performance evaluations at regular intervals during the operational lifetime of the injection/capture system. Continued groundwater monitoring will be used to demonstrate that groundwater constituents are attenuating naturally. The injection/capture system performance evaluations will be used to monitor performance and progress, and if necessary, to make adjustments.
4.13 Development of Institutional Controls

In the Revised Plant Site Remedy Evaluation Report, Talen committed to consider implementing institutional controls to restrict and/or control the use of impacted groundwater in uncontrolled access areas until the cleanup criteria are achieved. Institutional controls may also be considered to restrict and/or control the use of impacted groundwater, if any, remaining in the operations area within the fence after 2049 (or after the injection/capture system is shut off). One institutional control being considered may take the form of a controlled groundwater area (CGWA). Prior to finalizing the Final Remedial Design Package, Talen will evaluate if and where institutional controls may be needed at the Plant Site until the cleanup criteria are achieved and/or after 2049.
5. SCHEDULE

Table 8-1 provides a proposed schedule for implementation of remedy. The following remedy components have been or will be implemented:

- Construction of the planned pond upgrades/closures was initiated in 2016, and are scheduled to be completed in 2023;
- Construction of the new BCSDA was constructed in 2018 and will be ready for use in 2019;
- The pumping rate of existing vertical capture well 98M was increased in 2018 and is planned to continue pumping until 2049;
- If possible, the pumping rates of existing vertical capture wells 1D, 55D, 5M, 113M, and 115M will be increased in 2019 and would continue pumping until 2049;
- As discussed in Section 4.1, a geotechnical evaluation was completed in 2019 that assessed the possible effects of the planned injection/capture system on the integrity of the geosynthetic liner for the BCSDA;
- North and South C Ponds were dewatered in 2018;
- As discussed in Section 4.9, the soils beneath the liners in North and South C Ponds were sampled in 2019 before construction of the new Groundwater Capture Storage Pond;
- Construction of the new Groundwater Capture Storage Pond in 2019;
- A treatment system is planned to treat or evaporate captured groundwater from the Plant Site and the SOEP/STEP areas from 2023 to 2049;
- As discussed in Section 4.4, an injection system pilot test will be conducted for approximately seven (7) days in the spring of 2019, following installation of new injection wells (IW-4A, IW-37M, and IW-47SP) and monitoring wells (IW4-A-N, IW4-A-S, IW4-A-E, IW37-A-N-S, IW37-M-N-D, IW37-M-S, IW47-SP-S, and IW47-SP-W);
- As discussed in Sections 4.3 through 4.6, installation and operation of new injection wells (IW-1A to IW-54M), vertical capture wells (CW4, CW11, and CW12), and horizontal wells (in the vicinity of former Units 1 & 2 A Pond and former Brine Ponds D1-D4) are planned to begin in 2019, and will operate until 2049;
• As discussed in Section 4.2, installation and operation of a horizontal dewatering pipe in the ash of former Units 1 & 2 A Pond are planned to begin in 2019 and continue until 2026; and

• As discussed in Section 4.10, the clay liner and underlying soils beneath former Units 1 & 2 Bottom Ash Ponds are planned to be sampled after the remaining bottom ash is excavated.
6. CERTIFICATION

Civil Engineer’s Certification: Civil/Water Resources (General)

I, David L. Richardson, a registered Professional Engineer in the State of Montana (License No. 38740PE), certify that the Groundwater Remedial Design/Remedial Action Work Plan for the Plant Site at the Colstrip Steam Electric Station in Colstrip, Montana fulfills the minimum requirements of a Remedial Design/Remedial Action Work Plan pursuant to Article VI.D.1 of the “Administrative Order on Consent Regarding Impacts Related to Wastewater Facilities Comprising the Closed-Loop System at Colstrip Steam Electric Station, Colstrip Montana”.

Geosyntec Consultants

______________________
David L. Richardson, P.E.
Montana P.E. License No. 38740PE

Civil Engineer’s Certification: Process (Injection)

I, Todd D. DeJournett, a registered Professional Engineer in the State of Montana (License No. 60136PE), certify that the Groundwater Remedial Design/Remedial Action Work Plan for the Plant Site at the Colstrip Steam Electric Station in Colstrip, Montana fulfills the minimum requirements of a Remedial Design/Remedial Action Work Plan pursuant to Article VI.D.1 of the “Administrative Order on Consent Regarding Impacts Related to Wastewater Facilities Comprising the Closed-Loop System at Colstrip Steam Electric Station, Colstrip Montana”.

Geosyntec Consultants

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Todd D. DeJournett, P.E.
Montana P.E. License No. 60136PE
7. REFERENCES


