STATE OF COLORADO

Eschberger - DNR, Amy <amy.eschberger@state.co.us>

CLL Application For Permit Amendment No. 6 - M1977300

Arnold, Daniel J. <Daniel.Arnold@denverwater.org> Wed, Sep 15, 2021 at 2:08 PM
To: "Eschberger - DNR, Amy (amy.eschberger@state.co.us)" <amy.eschberger@state.co.us>, "Cunningham - DNR, Michael (michaela.cunningham@state.co.us)" <michaela.cunningham@state.co.us>, Jeff Fugate <Jeff.Fugate@coag.gov>, "Means - DNR, Russ" <russ.means@state.co.us>
Cc: "Witheridge, Alison" <Alison.Witheridge@denverwater.org>, Emmy Apostol <eapostol@geosyntec.com>, Jason Kerstiens <JKerstiens@geosyntec.com>, "Poncelet, Nicole" <Nicole.Poncelet@denverwater.org>, Sharon Israel <sisrael@arvada.org>, Evan Valencia <evalencia@ensero.com>, CLL- Jim Harrington <jim@coloradolegacy.land>

Attached, please find Denver Water's comments in response to CLL's application for permit amendment no. 6. If you have any questions regarding the attached, please feel free to contact me.

I would appreciate it if you could please confirm receipt.

Thank you

Daniel J. Arnold | Attorney | Office of General Counsel
Denver Water | t: 303-628-6469 | e: daniel.arnold@denverwater.org
denverwater.org | denverwater.org/TAP

DENVER WATER

5 attachments

DW Attach C - Reclamation Costs Memo.pdf
195K

DW Attach B - Mine Pool Stabilization Memo.pdf
2943K

DW Attach A - CSM Memo.pdf
4361K

Recommendation Summary Table v2.pdf
126K

20210915 Final M1977300 AM-06 DW Public Comment Letter.pdf
204K

DENVER WATER

1600 West 12th Ave
Denver, CO 80204-3412
303.628.6000
denverwater.org

Sent Via Email

September 15, 2021

Amy Eschberger
Division of Reclamation, Mining and Safety
Colorado Dept. of Natural Resources
1313 Sherman Street, Room 215
Denver, Colorado 80203

Re: Schwartzwalder Mine – File No. M-1977-300, Colorado Legacy Land, LLC – Amendment Application (Amendment 6)

Dear Ms. Eschberger:

Denver Water is submitting its written comments in response to the Application Amendment 6 for mine permit M-1977-300 ("Amendment 6") submitted by Colorado Legacy Land LLC ("CLL") concerning the Schwartzwalder Mine in Golden, Colorado. For the reasons discussed below and in the three enclosed technical memoranda, the Division of Reclamation, Mining and Safety ("DRMS") should deem Amendment 6 deficient and require CLL to supplement with additional information. Denver Water further requests that DRMS increase CLL's financial warranty due to the inability of CLL to stabilize the mine pool chemistry with its current method of operation.

On June 23, 2021, CLL submitted an application to its 112d Designated Mining Reclamation Permit with the Colorado Mine Land Reclamation Board ("MLRB") under the provisions of the Colorado Mined Land Reclamation Act. CLL proposes to reclaim the affected land to wildlife habitat. In addition, CLL submitted a report prepared by Ensero Solutions US, Inc. dated June 2021 ("Amendment 6 Report") apparently intended to satisfy conditions number 2 and 3 of the DRMS revised approval of the transfer of permit and succession of operator ("SO-01") letter dated February 20, 2018. As set forth in SO-01, conditions number 2 and 3 require CLL to:

> 2. …amend Permit No. M-1977-300, pursuant to Rules 1.1(6) and 1.10, affirming the permanent cessation of mining activities, provide a conceptual site model, provide a plan addressing the physical and chemical stabilization of the mine pool and specifically addressing the concentrations of dissolved uranium and other constituents as required under the conditions of the permit, and updating the reclamation and environmental protection plans (the "Amendment"). …
>
> 3. Subsequent to the Division's review and approval of the permit Amendment described above, CLL may further modify the permit through the Technical Revision or Amendment process, addressing the long term cost of operating of the water treatment plant and managing the mine pool. The Division anticipates such demonstration will be based on three consecutive years of data which verify the

physical and chemical stabilization of the mine pool. Upon such demonstration CLL may request a reduction in financial warranty in accordance with Rules and Regulations for that portion of the financial warranty attributable to the water treatment and management of the mine pool.

Denver Water retained Geosyntec Consultants to review and evaluate the Amendment 6 Report and to prepare three technical memoranda evaluating CLL's: 1) conceptual site model; 2) claim that the data demonstrate the physical and chemical stabilization of the mine pool; and 3) long-term cost of operating the water treatment plant and managing the mine pool. The conclusions set forth in the three technical memoranda are summarized below:

1) CLL's Conceptual Site Model is Deficient:
A conceptual site model ("CSM") for a site as complex as the Schwartzwalder Mine is a critical component for understanding current and future reclamation activities including long-term water treatment decisions. The CSM fails to satisfy the most basic requirements of the ASTM Standard applicable to the development of a conceptual site model; nor does it satisfy EPA's guidance for conceptual site models, and at best represents an initial first step toward development of a CSM. The CSM, which does not appear to have been modified or updated since 2018, should follow EPA and ASTM standard guidance for developing conceptual site models, including that "a model should be refined and revised through the site investigation process".[1] The CSM has multiple data gaps as acknowledged by CLL in Appendix 1. These data gaps have not been addressed, nor has CLL provided all supporting data as is required under SO-1. In addition, CLL's proposed CSM fails to consider the full potential range of natural and operational conditions and is an insufficient basis for development of reclamation and water quality strategies.

   A summary of recommended updates to the CSM are presented in a technical memorandum enclosed as Attachment A to this letter.

2) CLL has failed to Stabilize the Mine Pool:
Attachment B to Amendment 6 provides a plan addressing the physical and chemical stabilization of the mine pool, specifically addressing the concentrations of dissolved uranium and other constituents as required under the conditions of the permit. Denver Water does not agree that three consecutive years of data verifying the physical and chemical stabilization of the mine pool has been provided in Amendment 6. Demonstration of the inward gradient supporting physical stability relies upon only two wells, one of which only has three data points. CLL also claims that only six months of operation is needed to maintain the mine pool at 150 feet below the Steve Level Adit, however there is only one full year of data that supports this claim.

   CLL also excludes significant data needed to confirm concentration trends regarding physical and/or chemical stabilization of the mine pool. Specifically:

[1] ASTM Standard E1689, 1995 (2014), "Standard Guide for Developing Conceptual Site Models for Contaminated Sites," ASTM International, West Conshohocken, PA, 2014, DOI: 10.1520/E1689-95R14 , www.astm.org.; United States Environmental Protection Agency, 2011. "Effective Use of the Project Life Cycle Conceptual Site Model," Office of Solid Waste and Emergency Response. EPA 542-F-11-011, July.

a) Concentration trends for samples taken from the mine pool do not demonstrate its chemical stability. Although in-situ treatment often helps to decrease uranium concentrations on a temporary basis, the upward trend of uranium concentrations appears to resume after each treatment. Furthermore, in a troubling sign, there was not a significant decrease in uranium concentrations after the most recent in situ treatment.
b) Amendment 6 reveals several concerns with respect to data collection, analysis, and planning, including CLL's exclusion of data, errors in data presentation, faulty monitoring equipment, and need for contingency planning.
c) A long-term plan for reclamation of the mine pool is not clearly presented, which raises the question of whether CLL will pump from the pool and treat extracted water indefinitely.

A summary of recommended updates to the analysis for evaluating chemical and physical stabilization are presented in a technical memorandum enclosed as Attachment B to this letter.

3) <u>The long-term operational costs to minimize harm to the prevailing hydrologic balance and avoid unauthorized discharges should be reevaluated:</u>
Amendment 6 provides a plan addressing the long-term cost of operating the water treatment plant and managing the mine pool, based on a minimum of three consecutive years of data which verify the physical and chemical stabilization of the mine pool. Denver Water does not agree with the long-term operation and maintenance costs presented in Exhibit L, for the reasons stated in Denver Water's objection to the Surety Reduction request dated January 2021. It is premature to draw any conclusions about the long-term viability of CLL's treatment approach based upon the limited amount of data that are available. In addition, the long-term operation and maintenance costs for the water treatment plant presented in Exhibit L are not adequate to provide financial assurance for a reclamation strategy in the absence of a schedule for completion.

In addition to the issues raised in the enclosed technical memoranda, Denver Water has several other concerns that should be considered and addressed by CLL. The reclamation plan presented in Exhibit E of Amendment 6 does not meet the requirements of the Mineral Rules and Regulations of the MLRB for Hard Rock, Metal, and Designated Mining Operations (2 CCR 407-1). Unlike previous amendments, there is no description of the type of reclamation proposed for the affected lands (for example the Black Forest Mine area or the North Waste Rock Pile upland area), or a closure plan for mine entrances and portals, or time estimates as to the duration of these reclamation activities. No justification or description of the alluvial valley excavation, environmental monitoring, mine opening closures, or backfilling is provided in the reclamation plan.

The environmental protection plan ("EPP") was not updated in Amendment 6 as required by condition number 2 of the SO-1. Denver Water's concern with the reclamation of the Schwartzwalder Mine and the future impacts to the watershed also includes long-term management of evolving environmental conditions including climate change and wildfires. Climate change and wildfires pose a natural threat to conditions at the Schwartzwalder Mine. For example, after the 2013 floods, the underground workings were inaccessible, and the floods impacted in-situ treatment conditions. More frequent and intense flooding is expected in the future due to climate change. In addition, wildfires in Colorado have posed significant threats to tree and shrub coverage that are necessary to help control flow from large rain events. This could impact infiltration into the mine and waste rock pile stability if a wildfire occurred in the area. Denver Water recommends the EPP be updated to include strategies for management and mitigation of these pending environmental conditions.

Denver Water recognizes that CLL has successfully completed several reclamation tasks related to surface conditions at the mine site. However, to date CLL has not addressed the management of the mine pool and its potential to impact downstream drinking water resources in the future and does not establish a viable reclamation plan for minimizing disturbances to the prevailing hydrologic balance of the affected land and the surrounding area and to the quality and quantity of water in surface and groundwater system.

For these reasons, Denver Water objects to Amendment 6 pursuant to Hard Rock/Metal Mining Rule 1.4.9(1) and requests party status to any hearing that is set before the MLRB concerning Amendment 6 and reserves its right to withdraw this objection if Denver Water's comments are adequately addressed by CLL. For your convenience, a table with Denver Water's specific comments and recommendations is enclosed as Table 1.

In closing, I want to thank you for your consideration of our comments. If you have any questions regarding Denver Water's comments set forth in this letter or the enclosed technical memoranda, please feel free to contact me.

Sincerely,

Daniel J. Arnold
Attorney
Denver Water

Enclosures:

- Attachment A: CSM Technical Memorandum
- Attachment B: Mine Pool Stabilization Technical Memorandum
- Attachment C: Operational Costs Technical Memorandum
- Table 1: Recommendation Summary Table

Geosyntec consultants

Denver Water Comments

Attachment A

5670 Greenwood Plaza Blvd
Suite 540
Greenwood Village, CO
PH 303-790-1340
www.geosyntec.com

Technical Memorandum

Date: September 14, 2021

To: Nicole Poncelet, Denver Water Director of Water Quality & Treatment Team

From: Emmy Apostol, David Adilman, and Jennifer Nyman, Geosyntec

Subject: Schwartzwalder Mine Amendment 6 Comments – Conceptual Site Model

CC: Jason Kerstiens, Geosyntec

Figures: Figure 1 – Cross Section of Potential Migration Pathways from Mine Pool; Figure 2 – Estimate of Bedrock Mine Pool Pumping Capture Zone; Attachment A – *Use of the Project Life Cycle Conceptual Site Model*, EPA Guidance; Attachment B – CLL Cross-Sectional View of Groundwater Conditions

---

INTRODUCTION

Denver Water retained Geosyntec Consultants, Inc. to review and evaluate Colorado Legacy Land, LLC's (CLL) application for Amendment 6 to the Division of Reclamation, Mining and Safety (DRMS) mine permit M-1977-300. The purpose of Amendment 6 is to satisfy the conditions of the revised Succession of Operations (SO-1) approval letter dated February 20, 2018, which include providing a conceptual site model (CSM), a plan addressing the physical and chemical stabilization of the mine pool (specifically addressing the concentrations of dissolved uranium and other constituents), an updated Reclamation Plan, and an updated Environment Protection Plan (EPP). This Technical Memorandum specifically addresses the CSM provided in Appendix 1 and described in the Reclamation Plan in Amendment 6.

APPENDIX 1 – PRELIMINARY CONCEPTUAL SITE MODEL

The CSM submitted by CLL consists of a set of slides prepared in 2018 and labeled as "Preliminary". These slides are an insufficient basis for reclamation planning and monitoring; the

CSM should describe the potential movement of contaminants over the full potential range of natural and operational conditions and provide a picture of current site conditions. The SO letter indicated the CSM is to include all underlying assumptions and data; CLL has not included these.

Furthermore, the CSM slides include three pages of data gaps, referred to as "Data Issues" to be addressed. These include:

- More accurate stream flow measurements to evaluate gaining/losing reaches with more confidence.
- Evaluation of future flood impacts on waste dumps and other facilities.
- Additional evaluation of the Illinois Fault Zone, as it may be a significant connection between the mine area and Ralston Creek.
- More robust infiltration/GW recharge evaluation.
- More robust mine inflow analysis (in progress).
- Continued evaluation of seasonality effects on mine inflows.
- Continued evaluation of mine area capture zone and recharge area.
- Ongoing evaluation of contamination (mine, alluvium, bedrock, soils):
    - Surficial deposits (e.g., waste rock)
    - Soil/surface contamination from mining
    - Stored mass in alluvium (e.g., sorbed or labile phases like salts)
    - Mine pool connection to Ralston Creek and alluvium
    - Natural source from mineralized bedrock and secondary deposits in alluvium
- Uncertainty in upgradient (background) groundwater concentrations of uranium (i.e., MW-11).

Based on quarterly data submittals and Amendment 6, CLL has begun addressing some of these data issues, such as stream flow measurements and more robust flow analysis. However, the CSM does not indicate the status of these data gaps. The CSM should be updated to include data and analysis that has been collected in an effort to address these data issues. CLL should also provide a schedule for addressing any data issues that have not been addressed so far.

Denver Water and Geosyntec acknowledge that CLL has accomplished several reclamation tasks, and appreciates its work to date. ASTM guidance states that "the model should be refined and revised throughout the site investigation process."[1] The work performed over the last three years by CLL provides data for informing decisions on reclamation efforts and costs at the site. Geosyntec recommends that the preliminary CSM provided in 2018 be revised to include data collected over the last three years.

---

[1] ASTM Standard E1689, 1995 (2014), "Standard Guide for Developing Conceptual Site Models for Contaminated Sites," ASTM International, West Conshohocken, PA, 2014, DOI: 10.1520/E1689-95R14 , www.astm.org.

The current set of slides provided as Appendix 1 Conceptual Site Model are titled "Schwartzwalder Preliminary Conceptual Model". Guidance published by the USEPA, *Effective Use of the Project Life Cycle Conceptual Site Model* (provided as Attachment A), defines six stages of the project life cycle CSM: 1) Preliminary CSM Stage; 2) Baseline CSM Stage; 3) Characterization CSM stage; 4) Design CSM Stage; 5) Remediation/Mitigation CSM Stage; and 6) Post Remedy CSM Stage. The "Preliminary CSM Stage" is described as the "project milestone or deliverable based on existing data; developed prior to systematic planning to provide fundamental basis for planning effort." The Baseline CSM stage is described as "the project milestone or deliverable used to document stakeholder consensus/divergence, identify data gaps, uncertainties, and needs; an outcome of systematic planning."

Based on these definitions, it is our opinion that the current CSM is at the Baseline CSM stage. Data gaps, uncertainties, and needs are provided in the current version of the CSM. Therefore, we recommend that the CSM be updated and revised to meet the criteria of the Remediation/Mitigation CSM Stage. A more detailed diagram and description depicting geologic, hydrogeologic, chemical information, and fate and transport processes, in support of remedy design, are recommended to assist key stakeholders such as Denver Water in understanding complex site information and to increase confidence that solutions are developed "to ensure protectiveness, effectively manage resources, and limit the environmental footprint of site cleanup activities."[2] Examples of more detailed diagrams and depictions are provided on the fact sheet.

In addition, Geosyntec recommends the preliminary CSM include more detailed descriptions of work performed by Cotter Corporation prior to 2018 provided in the Environmental Protection Plan (EPP). Some specific examples of modifications include:

- On slide 6, average annual precipitation and infiltration is based on data from 1978 – 2005. Substantial shifts in weather have occurred over the last 20 years. Update the data to include recent years.
- CLL describes that the brine from reverse osmosis treatment of the "mine pool" water "remains isolated in the deep workings because of inward hydraulic gradients and density stratification." (slide 11). This claim however contradicts CLL's stated results of the tracer test which claims that the "mine pool is fully mixed". Provide a discussion on the effect of injecting the reverse osmosis (RO) concentrate back into the mine pool.
- Update slide 15 to represent current conditions of sump system due to impacts from alluvium excavation.

---

[2] United States Environmental Protection Agency, 2011. "Effective Use of the Project Life Cycle Conceptual Site Model," Office of Solid Waste and Emergency Response. EPA 542-F-11-011, July.

- On slide 16, CLL describes mass loading to Ralston Creek from the alluvium. CLL has performed significant work to mitigate this mass loading. Provide the data supporting a reduction in mass loading to the creek due to the alluvium excavation work.
- Slides 18 and 19 discuss groundwater in the alluvium and bedrock. This section should be updated to include 1) subsurface flows through bedrock and alluvium groundwater; 2) existing data on inward hydraulic gradients; 3) the cross-section diagrams provided in the quarterly deliverables describing the groundwater flow paths. Also, data should continue to be collected on inward hydraulic gradients prior to approval, including the installation of an additional groundwater well, downgradient of the mine pool.
- Annotate slide 22 with arrows to show inflow into the mine. Provide supporting data in the CSM for estimations of inflow to the mine. Update the CSM to include a contingency of increased inflow to the mine as a result of climate change impacts in the future.
- Update slide 26 with current mine pool pumping conditions. Describe operations on receiving brine from the WTP and its potential impact to mine pool chemical stabilization.
- Update slide 27 to provide more detail on in-situ treatment including a description of previous treatments, plan for brine when it is not acting as an amended slurry for treatment, and other data collected since 2018 representing the progress of in-situ treatment.
- Update slides 29 and 30 with current groundwater monitoring wells and their data. Annotate which wells are dry. Provide a diagram describing underground workings with groundwater wells to demonstrate their purpose in the groundwater network.

AMENDMENT 6 CONCEPTUAL CONSIDERATIONS

Statements from the Amendment 6 Reclamation Plan have been excerpted (in ***bold italics***) and are followed by Geosyntec's observations and recommendations (in plain text).

> ***Historical sources, e.g., waste rock dumps and alluvial waste rock fill, have contributed to mass loading of Ralston Creek, with uranium and metals, and affected the alluvial groundwater.***

A CSM should identify and characterize all of the sources, according to ASTM and EPA standard guidance. Although the waste rock dumps, alluvial waste rock fill, and alluvial groundwater were identified and characterized, based on documented historical discharges from the mine pool to Ralston Creek, the mine pool is also considered a historical source. We recognize that the mine pool is addressed in the next bullet of the conceptual consideration; details are lacking on the identification and characterization of the mine pool as a potential source and potential migration pathways. The established regulatory limit of 150 feet (ft) below the Steve Level, approved by DRMS during the Amendment 4 Adequacy Review process, lowers the mine pool to an elevation of approximately 63 ft below Ralston Creek in the permit area to prevent flow from the mine pool towards the creek.

Although theoretically this mitigates the direct migration pathway between the mine pool and the surface water, the CSM does not characterize other potential migration pathways through bedrock groundwater or faults and fractures such as the Illinois Fault. The Illinois Fault was also identified as a data gap in the preliminary conceptual model on slide 34 "data issues – hydrology", which states "additional evaluation of the Illinois Fault Zone, as it may be a significant connection between the mine area and Ralston Creek". In addition, the ASTM *Standard Guide for Developing Conceptual Site Models* also provides specific recommendations for updates to the CSM such as stating that "sources should be located accurately on site maps" and "the potential for both current and future releases and migration of the contaminants along the complete pathways should be determined." Specific recommendations for updates to the diagrams and description in the CSM should be made, including:

- Provide a definition of the three-dimensional extent of the mine pool and characterization of the mine pool as a potential source (or historical source) of contaminants to Ralston Creek.
- Provide two figures/diagrams showing the extents of the uranium plume within the mine workings on a plan view and cross-sectional view. Examples of the design stage CSM depicting the extents of plume boundaries is provided in the EPA guidance, *Use of the Project Life Cycle Conceptual Site Model,* provided as **Attachment A**.
- Provide two figure/diagrams depicting the delineation of potential migration pathways from the mine pool through bedrock groundwater, and other fractures or faults such as the Illinois Fault Zone. An example of a cross-section is shown in **Figure 1**.
    - Include subsurface flow rates, fractures, and/or other preferred flow paths as indicated in the ASTM *Standard Guide for Developing Conceptual Site Models.*
- Include the cross-sectional view of groundwater conditions in the mine pool compared to MW-15 as provided in the Q4 2020 and Q1 2021 reports and provided as **Attachment B**.
    - This diagram should continue to be updated as data is collected.
- Prepare two figures in plan view depicting the potentiometric surface of groundwater at different pumping conditions in the mine pool (e.g. at 150 ft below Steve Level Adit and at 325 ft below Steve Level Adit), similar to **Figure 2**, to demonstrate that 150 ft below the Steve Level Adit is adequate for maintaining an inward hydraulic gradient from Ralston Creek to the mine pool.
    - Add an additional groundwater monitoring well downgradient of the mine pool to refine the potentiometric surface. A recommended location is also depicted on Figure 2.

Maintaining the mine pool below the regulatory limit (150-feet below the Steve Level) has led to (i) establishing a hydraulic gradient away from Ralston Creek in the permit area…

Geosyntec recognizes that hydraulic gradients are provided in E.5.1 Physical Stabilization of the Mine Pool Demonstration which help support this claim under pumping conditions. However, the data also suggests that the hydraulic gradient away from Ralston Creek is stronger at lower levels below Steve Level Adit. This is another example of data that were collected and should be included in the CSM. This hydraulic (and therefore contaminant) gradient assumes that pumping in the mine pool will continue in perpetuity; however, this assumption is not stated in the preliminary CSM, conceptual considerations, or within the reclamation plan. Therefore, according to ASTM Standard Guide Section 6.5 Identifying Migration Pathways, if pumping does not continue in perpetuity future releases and migration of the contaminants along all complete potential pathways should be modeled.

Furthermore, as stated in the memo addressing physical and chemical stabilization of the mine pool, data presented are insufficient to assert that an inward bedrock groundwater gradient has been established for all areas of the uranium plume in bedrock groundwater. CLL uses only two bedrock monitoring wells, one of which only has three data points dating to Q2 2020, and both of which are essentially cross-gradient.

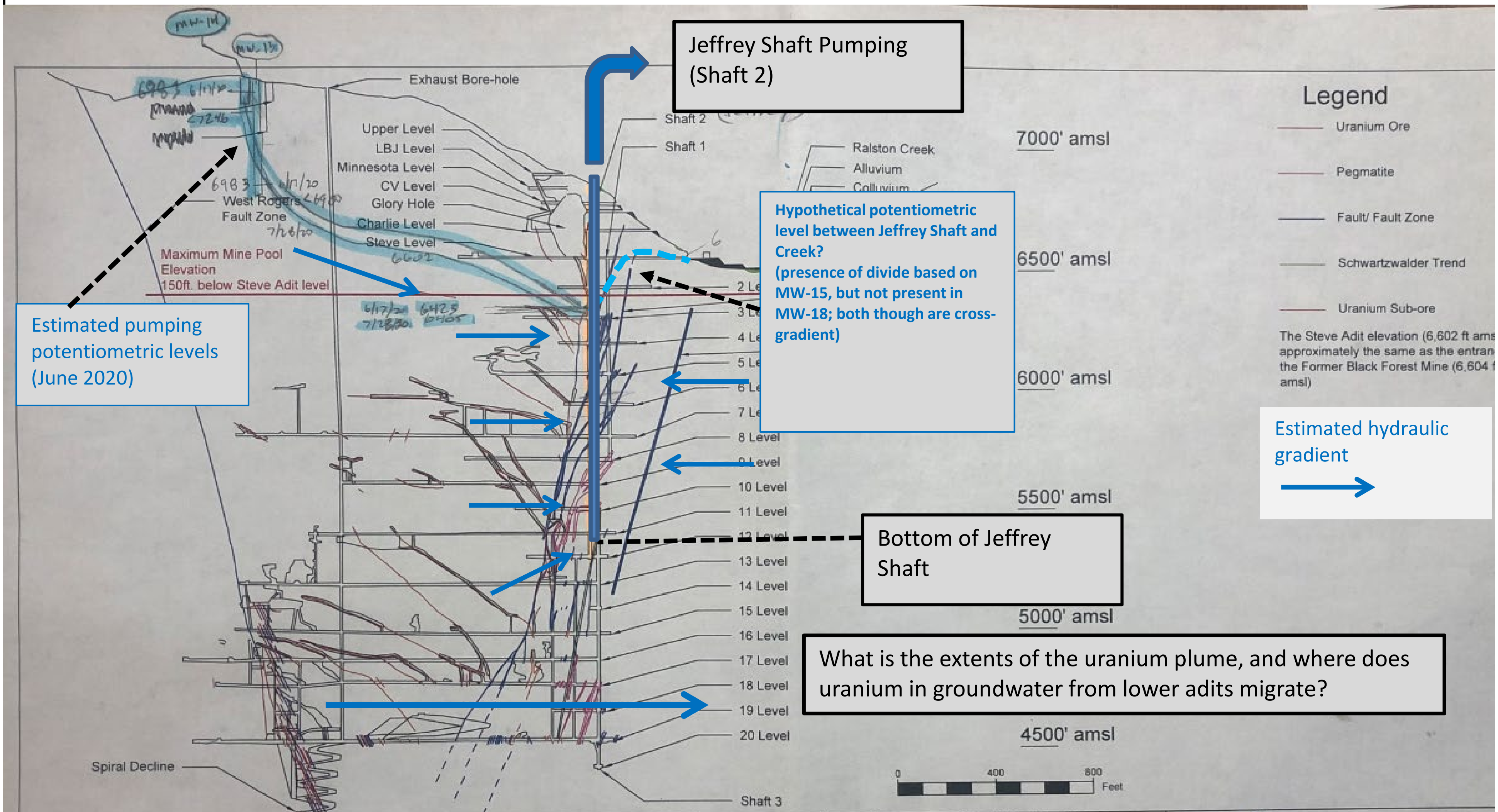
In addition, Figure 2 depicts an estimate of the bedrock mine pool pumping capture zone based on the bedrock groundwater elevations. Since CLL has described the pumping capture zone as anisotropic, additional bedrock groundwater elevations and more bedrock groundwater wells (particularly within the permit boundary immediately east/northeast of the mine pool pump and southwest of Ralston Creek) would be necessary to demonstrate an inward groundwater gradient towards the mine pool.

> ***Alluvial waste rock: As described above, a by-pass pipeline prevents Ralston Creek from interacting with the contaminated alluvial valley soil. Similarly, alluvial groundwater in the permit area is captured by a main sump system and sent back into the mine. These engineering controls shall be removed once the onsite source is addressed.***

The by-pass pipeline and the main sump system are key engineered controls that prevent uranium loading from the alluvium into Ralston Creek. Although most of the alluvium has been removed during reclamation, it is still unclear from the preliminary CSM and limited data on the hydraulic gradients that there won't be a future hydraulic connection between high uranium concentrations in the bedrock and Ralston Creek or from remaining alluvium to Ralston Creek. The by-pass and sump system should not be removed until the data analysis demonstrate there will be no present or future contamination of this area from the mine pool, particularly through bedrock discharge, or other sources.

* * *

FIGURES



Cross Section of Potential Migration Pathways from Mine Pool

Schwartzwalder Mine, CO

Geosyntec consultants

Lakewood, CO | August 2021

Figure 1

Legend

- Monitoring Location
- Bedrock Monitoring Location
- Dewatering Pump Location
- Ralston Creek
- Ravine
- Outline of Pumping Capture Zone
- Potential Bedrock Groundwater Migration Outside of Pumping Capture Zone
- Approximate Footprint of Mine Workings
- Approximate Permitted Boundary
- Bedrock Potentiometric Contours - 06/17/2020

Water Level Data - 06/17/2020

Uranium Concentration in Bedrock Groundwater (µg/L)
(MW) - 07/09/2020
(Mine Pool) - 08/06/2020

Notes:
1. Capture zone delineated in yellow should be considered very approximate as it was estimated from only 4 data points.
2. Data from Colorado Legacy Land – Application Amendment 5, Mine Permit M-1977-300, Schwartzwalder Mine, Golden, Colorado, August 2020.

0 500 Feet

Estimate of Bedrock Mine Pool Pumping Capture Zone

Schwartzwalder Mine, CO

Geosyntec consultants

Acton, Massachusetts | March 2021

Figure 2

Q:\GISProjects\DE0350_DenverWater\MXD\MW_Locations_v2.mxd 3/24/2021 12:09:51 AM

ATTACHMENT A - *Use of the Project Life Cycle Conceptual Site Model*, EPA Guidance

United States
Environmental Protection Agency

Office of Solid Waste and
Emergency Response (5102G)

EPA 542-F-11-011
July 2011

Environmental Cleanup Best Management Practices: Effective Use of the Project Life Cycle Conceptual Site Model

Office of Superfund Remediation and Technology Innovation

Quick Reference Fact Sheet

The U.S. Environmental Protection Agency (EPA) supports the use of best management practices (BMPs)* as a mechanism for maximizing technical effectiveness and resource efficiency in the execution of site assessment and cleanup projects. This fact sheet is the first in a series of documents that address conceptual site models (CSMs). A more comprehensive document is planned that will detail techniques to develop and maintain an accurate CSM as a primary planning and decision making tool used to identify and manage site uncertainty that can inhibit effective project decision making. This fact sheet summarizes how environmental practitioners can use CSMs to achieve, communicate, and maintain stakeholder consensus on site understanding, while satisfying the technical and quality objectives required for each stage of a cleanup project's life cycle. The focus is on defining stages and products of CSMs along with potential applications of CSMs at various stages of a project life cycle. Content herein is presented in a Superfund Program context; however, to the extent practical, text has been written to maximize applicability in other programs and regulatory frameworks. Other agencies and programs may find these concepts useful and environmental cleanup practitioners are encouraged to explore the utility and integration of a project life cycle CSM within their own program requirements and deliverable schedules.

* Best Management Practices (BMPs) are, in general, methods or techniques found to be the most effective and practical means in achieving an objective while optimizing the use of resources. BMPs, such as those described herein, however, are not programmatic requirements.

Purpose and Audience

The Conceptual Site Model (CSM) is an iterative, 'living representation' of a site that summarizes and helps project teams visualize and understand available information. This fact sheet demonstrates the utility of using the CSM to assist Superfund project teams, hazardous waste site cleanup managers, and decision makers throughout the life cycle stages of investigation and cleanup. It also encourages the creation and revision of a CSM as a primary project planning and management tool.

The ability to efficiently access and interpret data is essential to guiding project teams through the entire cleanup process, from project planning to site completion. Development and evolution of a CSM can address the unique needs of each stage in a project's life cycle, and provide a valuable tool for successful environmental cleanup. The level of effort necessary to develop specific CSM components should correlate with the level of site maturity, site complexity, and the magnitude of the characterization and cleanup challenges project teams face.

The CSM uses a concise combination of written and graphical work products to portray both known and hypothesized site information. At more mature sites, this information is often contained in a variety of reports, data sets, and electronic or hard copy formats where the construction and use of a CSM synthesizes multiple independent data sets and maximizes the value of historical information. A range of tools, from simplified renderings to more complex visualization tools, are used to capture and communicate existing information and focus future data collection to fill data gaps and reduce key site uncertainties. The CSM serves as the framework for incorporating new data as it becomes available during characterization and remediation. A detailed, up-to-date, and accurate CSM can be very beneficial in supporting decisions related to key project elements, such as cumulative risk, remedy selection, remedy implementation, site completion, and site reuse.

Effective use of the CSM is also a critical BMP that facilitates technical team decision making while supporting stakeholder communication and consensus building. By facilitating efficient real-time evaluation of data, CSM elements provide a platform to inform decision makers in a manner that can help limit the number of field mobilizations necessary to characterize a site, minimize the need to re-characterize a site late in a project's life cycle, and optimize elements of remedy implementation. A comprehensive CSM synthesizes chemical data with geologic, hydrogeologic, and other site information to enhance a project team's ability to develop solutions to ensure protectiveness, effectively manage resources, and limit the environmental footprint of site cleanup activities.

Conceptual Site Model Life Cycle

The life cycle of a CSM mirrors the common progression of the environmental cleanup process where available information is used, or new information acquired, to support a change in focus for a project. The focus of a CSM may shift from characterization towards remedial technology evaluation and selection, and later, remedy optimization. As a project progresses, decisions, data needs, and personnel shift as well to meet the needs of a particular stage of a project and the associated technical requirements.

Figure 1 shows the relationship of the CSM life cycle stages to various environmental regulatory programs and the applicability of other BMPs such as comprehensive systematic planning, use of dynamic work strategies, and real-time measurement technologies. Note that CSMs become increasingly quantitative and decreasingly conceptual in nature as data are collected, data gaps filled, and CSM elements that help depict site data mature.

The project life cycle CSM presented in this technical bulletin and summarized in the adjacent text box consists of six stages. These are not six different CSMs; rather, they are representations of the CSM as it is evolved through defined states of maturity and purposes over a project's life cycle. Whether early or late in the project life cycle, development of the preliminary and baseline CSMs necessitates an initial compilation, synthesis, and presentation of the CSM to the technical team and stakeholders to facilitate systematic planning. Regardless of where in the assessment and cleanup process a particular site resides these earliest CSM versions can potentially serve as milestone deliverables. These early stage versions take advantage of text, figures, tables, and potentially electronic 3-D data visualizations to compile, interpret, and present the CSM. Project teams are encouraged to consider existing schedules and scope of programmatic deliverables to integrate these CSM components early in the systematic planning process. Project teams can initiate development of a project life cycle CSM at any stage of an active project to serve as a tool to help facilitate site decision making. The phase of a project and the adequacy of the existing CSM or project data will indicate what stage of the CSM life cycle is most appropriate.

Simple drawings and concepts are commonly used to communicate early project stage CSMs. As the level of information and complexity increases, the ability of a CSM to capture and synthesize new data in support of decision making can be significantly improved through the use of visualization platforms, appropriate data management strategies, and decision support tools.[1] These tools and strategies enable the CSM to be revised as more site information is collected and adapted to support the changing decision making needs of a project.

Six Stages of the Project Life Cycle CSM

Key Points in the Development of a CSM

(1) **Preliminary CSM Stage** – Project milestone or deliverable based on existing data; developed prior to systematic planning to provide fundamental basis for planning effort.

(2) **Baseline CSM Stage** – Project milestone or deliverable used to document stakeholder consensus/divergence, identify data gaps, uncertainties, and needs; an outcome of systematic planning.

Key Points in the Evolution and Refinement of a CSM

(3) **Characterization CSM Stage** – Iterative improvement of CSM as new data become available during investigation efforts; supports technology selection and remedy decision making.

(4) **Design CSM Stage** – Iterative improvement of CSM during design of the remedy; supports development of remedy design basis and technical detail.

(5) **Remediation / Mitigation CSM Stage** – Iterative improvement of CSM during remedy implementation; supports remedy implementation and optimization efforts, provides documentation for attainment of cleanup objectives.

(6) **Post Remedy CSM Stage** – Comprehensive site physical, chemical, geologic, and hydrogeologic information of CSM supports reuse planning; documents institutional controls and waste left on site; and other key site attributes.

General Environmental Cleanup Steps	CSM Life Cycle	Best Management Practices: SPP	Best Management Practices: DWS/ RTMT	CERCLA - Superfund	RCRA	Brownfields	UST	VCUP Varies by State	IRP/ERP	MMRP
SITE ASSESSMENT	Conceptual Preliminary CSM Baseline CSM			Preliminary Assessment (PA) Site Inspection (SI) National Priorities List (NPL) No Further Remedial Action Planned (NFRAP)	Facility Assessment (RFA)	Phase I Environmental Site Assessment (ESA)	Initial Site Characterization Initial Response	PA SI	PA SI	PA SI MR Site Prioritization Protocol (MRSPP)
SITE INVESTIGATION AND ALTERNATIVES EVALUATION	Characterization CSM Stage			Remedial Investigation/ Feasibility Study (RI/FS) Removal Actions - Emergency/ Time Critical/Non-Time-Critical	Facility Investigation (RFI) Corrective Measures Study (CMS)	Phase II ESA	SI Corrective Action Plan (CAP)	RI/FS	RI/FS NFRAP	RI/FS
REMEDY SELECTION	Design CSM Stage			Proposed Plan Record of Decision (ROD)	Statement of Basis (SB) Final Decision and Response to Comments	Remedial Action Plan (RAP)	Cleanup Selection	ROD	Proposed Plan ROD	Remedy Selection
REMEDY IMPLEMENTATION	Remediation/ Mitigation CSM Stage			Remedial Design (RD) Remedial Action (RA) – Interim and Final	Corrective Measure Implementation (CMI)	Cleanup and Development	Corrective Action - Low-impact site cleanup - Risk-based remediation - Generic remedies - Soil matrix cleanup	RD RA	RD RA – Interim and Final Remedy in Place (RIP)	RD Time Critical Removal Action (TCRA) RA RIP
POST-CONSTRUCTION ACTIVITIES	Post-Remedy CSM Stage			Operational & Functional Period Operation & Maintenance (O&M) Long term monitoring (LTM) Optimization Long Term Response Action (Fund-lead groundwater/surface water restoration)	O&M On-site inspections and oversight	Property Management Long-term O&M Redevelopment Activities (Private- and Public-led)	LTM	O&M LTM	Shakedown period Operating Properly and Successfully O&M LTM	Shakedown period Long Term Management
SITE COMPLETION	Quantitative			Construction Complete (CC) Preliminary or Final Close Out Report (PCOR/FCOR) Site Completion - FCOR Site Deletion O&M as appropriate	Certification of Completion Corrective Action Complete with Controls or without Controls	CC Property Management	No Further Action (NFA)	CC	Response Complete (RC) NFA	RC NFA

Abbreviations:

SPP = Systematic Project Planning
DWS = Dynamic Work Strategies
RTMT = Real Time Measurement Technologies

CERCLA = Comprehensive Environmental Response, Compensation and Liability Act
RCRA = Resource Conservation and Recovery Act

UST = Underground Storage Tanks
VCUP = Voluntarily Clean Up Programs

IRP/ERP = Installation Restoration Program/ Environmental Restoration Program
MMRP = Military Munitions Response Program

Figure 1. Crosswalk of Regulatory Program Stages and CSM Life Cycle Phases. Use of terminology from regulatory frameworks is not intended to supplement any specific programmatic requirements or guidance; however, use of CSM components in a flexible and comprehensive framework can facilitate site decision making during the entire site-cleanup process, irrespective of the environmental program driving site cleanup. Using SPP, evolving the CSM, and leveraging DWS and RTMT at each key project stage can improve project efficiency and effectiveness.

Note: The width and gradation of the blue arrows demonstrating BMPs indicate the relative level of effort applied and the resulting impact and value of performing the BMPs at the indicated project stages.

Where key stakeholders change, particularly project managers, regulatory personnel, and contractors, consistent use of a project life cycle CSM serves to document and maintain the "state of knowledge" about a site. Similarly, review of historical iterations of the project life cycle CSM provides context for new team members to understand previous site decisions and can facilitate effective transition of supporting data sets, data management strategies, and visualization platforms.

Preliminary CSM

EPA requires that a systematic planning process be employed to plan all environmental data operations.[2] The Preliminary CSM, therefore, can act as a starting point for compiling and synthesizing existing information to support building stakeholder consensus, identifying data gaps and uncertainties, and determining subsequent data needs.

The Preliminary CSM provides a comprehensive overview of the site, based on available site-related documents, with information relevant to the identified problems. Interviews with site owners and other stakeholders, historical or regional geologic/hydrogeologic information, and third-party information such as historical aerial photographs, electronic environmental databases, property tax maps, and Sanborn Maps are also considered. The evaluation and synthesis of this information forms the basis for developing and presenting the Preliminary CSM to systematic planning participants.

Figure 2 shows a pathway network receptor diagram, which is commonly used as a CSM to support risk assessment. A project life cycle CSM includes this information, and to support investigation, design, and remedy implementation project phases, it also includes other elements, such as known and suspected contaminants of potential concern (COPCs), locations of probable source areas, the mechanisms and timing of historical and potential releases, affected environmental media, contaminant distribution data, potential migration pathways, and potential receptors.

Visual elements of a Preliminary CSM can range from simple sketches, to basic two-dimensional (2-D) graphics such as maps and cross sections, to more advanced three-dimensional (3-D) visualizations. The complexity of the CSM at this stage depends on the volume and state of data (electronic or hard copy) along with any prior CSM component development.

Baseline CSM

A critical strategic output of a systematic planning effort, the Baseline CSM is an improved, more informative version of the Preliminary CSM used to

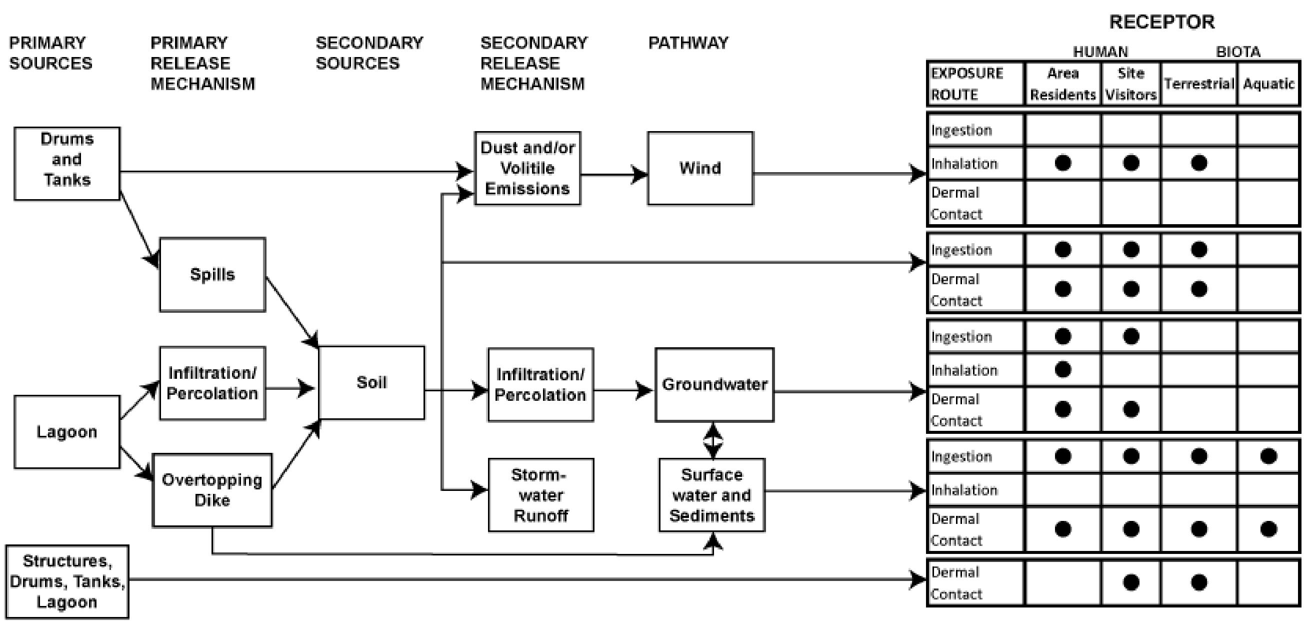


Figure 2. Example Pathway Receptor Network Diagram. Commonly referred to as a CSM, the pathway receptor network diagram is an important element of the project life cycle CSM, used to ensure the incorporation of human and ecological exposure information in project planning and implementation.

help identify data gaps and information needed to meet key project objectives. The Baseline CSM documents stakeholder consensus (or divergence) on known site conditions; uncertainty hypotheses; data gaps, needs, and collection plans; and potential remedial challenges. Armed with this knowledge, project teams can leverage the Baseline CSM to identify needs for data types, density, quality objectives, and quality indicators such as precision and accuracy.

At this point in the project planning process, the project team can also consider the need for collaborative data to support hypotheses testing and uncertainty reduction, risk assessment, technology evaluation and selection, and design for the most-probable remedial technologies. The scale and distribution of data gaps identified provides the basis for designing a dynamic work strategy and subsequent data collection efforts. The need to perform a demonstration of methods applicability[3] to understand site and matrix specific analytical performance or optimize sampling strategies, is generally identified at this stage of the planning process.

A 2-D diagram used to depict the Preliminary CSM for the Cache La Poudre River Site[4] project in Colorado is shown in Figure 3. The diagram and supporting CSM components effectively facilitated an agreement between the project team to follow separate, but related, paths to address questions posed by stakeholder groups with differing views of site conditions and processes. During systematic planning, the project team did not reach consensus on a single Baseline CSM; however, the team agreed to use divergent CSM viewpoints to identify all data and information needs necessary to resolve to one CSM version and facilitate key project decision making.

Characterization CSM Stage

Using the Baseline CSM as its starting point, the Characterization CSM is used to efficiently capture and synthesize data generated during site characterization efforts. This CSM is updated continually at an agreed upon frequency or in relation to key data collection efforts. When used effectively, the Characterization CSM helps to identify and manage stakeholder uncertainty associated with

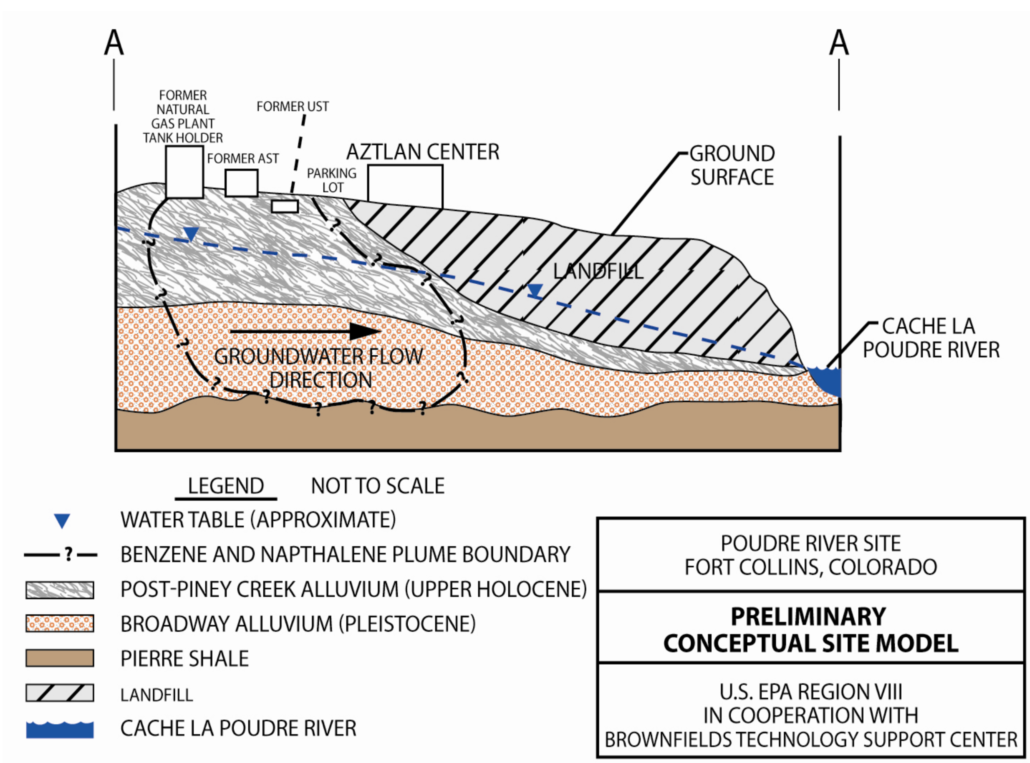


Figure 3. Preliminary CSM Representation. This Preliminary CSM summarizes general site information, including primary site attributes, geologic stratigraphy, groundwater potentiometric surface and flow direction, groundwater-surface water relationship, and presumed extent of soil and groundwater contamination. This representation of a CSM can be an effective method of communicating site conditions to a diverse audience in an easy-to-understand format.

principle study questions like the nature and extent of contamination, or identification of key geologic/hydrogeologic features controlling fate and transport processes.

Characterization CSM components capture and synthesize data that can be used to support estimates of cumulative risk and identification of immediate risks to human health and the environment. The Characterization CSM integrates key geologic, hydrogeologic, and chemical data that can also be used to support an effective screening of remedial alternatives.

Figure 4 is a representation of the Characterization CSM developed for the Poudre River Site project. The CSM indicated that site contaminant type, sources, and migration pathways were significantly more complex than originally understood, affecting the goals of subsequent characterization efforts. At this stage of the project, the use of collaborative data sets, comprised of field- and fixed-based laboratory analyses, improved risk characterization and facilitated collection of remedy design data during site characterization efforts.

Characterization efforts are becoming more comprehensive because of the availability of field-based, high-density data collection methods. These high-resolution tools effectively mature the CSM more quickly, particularly when data management strategies (such as use of electronic data deliverables and relational databases) are employed in conjunction with 3-D visualization platforms.

More than any other CSM life cycle stage, the use of real-time technologies for dynamic data collection efforts requires the Characterization CSM to be flexible and easily modified in 'real-time.' This need is driven by the fact that the nature and extent of contamination and related cumulative risks typically are not yet well defined at this stage, thus the evolution of significant site knowledge tends to occur rapidly as characterization data are collected. The tools used to frame, document, or depict the CSM must therefore be capable of quickly and efficiently capturing high-density data streams and translating those data streams into predetermined formats.

Once contamination and related risks have been adequately defined, projects typically shift focus to the collection of physical and chemical data needed to

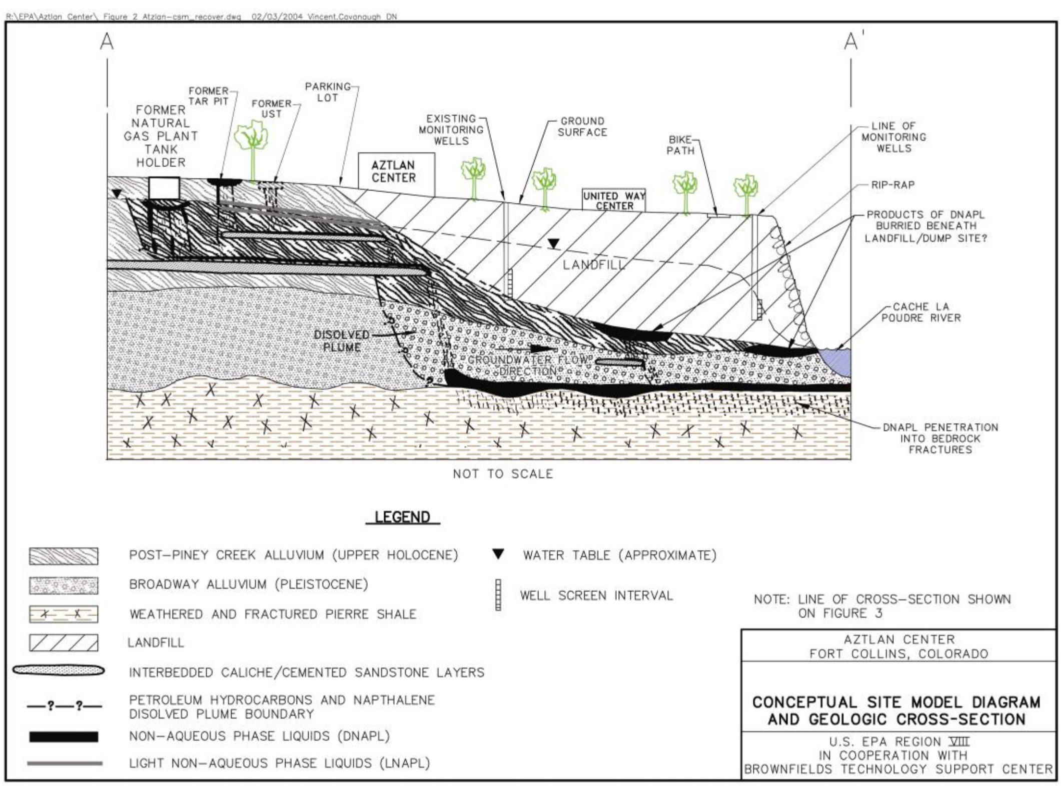


Figure 4. 2-D Component of Characterization CSM. The Characterization CSM serves as a repository for the integration of site attributes with field observation and measurement data. Depictions of integrated data guide investigation efforts and support technology selection and remedy decision-making.

support technology selection and remedy design. These data may be of a different focus or density scale than characterization efforts aimed solely at delineation. For example, additional physical property testing of the matrix or refinement of treatment zones, source zones, residual phase, and dissolved plume components is used support feasibility studies and future design considerations. Information from these efforts can be incorporated into the Characterization CSM and used for subsequent decision-making.

Collection, evaluation, and synthesis of data used to refine the Characterization CSM also supports the development of key remedial project support documents such as the Record of Decision (ROD) or intermediate decisions such as the need for implementation of an interim remedy.

Design CSM Stage

CSM elements are used in the design stage to help identify additional information requirements and synthesize data supporting the implementation of a selected remedy. The Design CSM directly supports the design basis for implementation of both pilot and full-scale remedies at a site. Physical property data, geologic and hydrogeologic conditions, or contaminant concentrations and distribution may need to be refined to optimize remedy design. For example, elements of the Design CSM might be used to plan and incorporate the results of hydraulic conductivity profiling or geochemical parameters testing to support the design of an *in situ* treatment strategy. Geologic and hydrogeologic Design CSM components support evaluation of important design considerations such as radius of influence, tracer tests, or aquifer geochemical characteristics like pH, oxidation/reduction potential, and dissolved oxygen.

For performance-based projects, the Design CSM can support development of metrics for system installation and performance. The Design CSM typically can be developed using the same data management and 3-D tools as those used during the characterization effort. Elements of the Design CSM such as concentration ranges, mass estimates, location, and spatial dimensions of source materials can be used to help establish initial benchmarks, as well as short-, medium-, and long-term metrics, to measure and evaluate remedy/system performance. This capability has direct application to support documentation and data analysis for Five Year Review, remediation optimization efforts, or both.

For project managers, elements of the Design CSM can be used to develop supporting documentation for solicitation of final design and construction contracts.

Figure 5 depicts elements of the Design CSM developed for the Cache La Poudre River Site project.

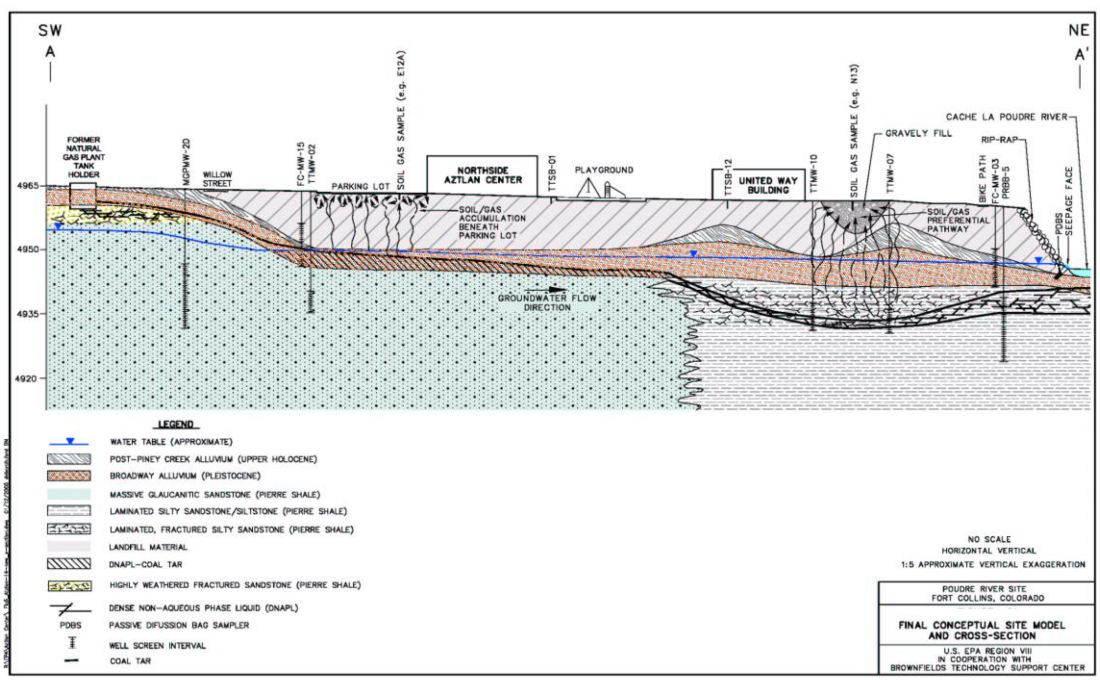


Figure 5. 2-D Component of Design CSM. The Design CSM captures key design considerations, such as site attributes; geologic, hydrogeologic, and chemical information; and fate and transport processes, in support of remedy design.

CSM Case Study: NASA Ames Research Center / Naval Air Station Moffett Field

NASA and the U.S. Navy (USN) undertook a joint effort at their adjacent installations in Mountain View, California, to inhibit the migration of a trichloroethene (TCE) groundwater contamination plume from NASA property onto the adjacent USN facility. The project involved designing an air sparging/soil vapor extraction (AS/SVE) system across a buried sedimentary paleochannel to intercept the plume and limit the spread of contamination. A Remediation/Mitigation CSM was used to visualize real-time field data to verify site geology, optimize the remedy design, and ensure its successful implementation.

Initial characterization was completed using cone penetrometer testing (CPT) and 3-D visualization to identify optimized sampling locations to verify the adequacy of remedy design. CPT data were used collaboratively with soil cores and air sparging test results to optimize air sparging well construction. Core recoveries were poor because of the consistency of sands within the paleochannel, making the CPT data essential to the proper design of the sparging system.

The project team verified the CPT data to optimize the AS/SVE systems design in real-time. Data were introduced into 3-D visualization software, and images of subsurface lithology developed from CPT data at locations where air sparging wells were also installed. The 3-D visualizations, such as Figure 6, provided the basis for optimizing the air sparging system through reduction in well point quantities and provided assurance that the remedy would accomplish project goals.

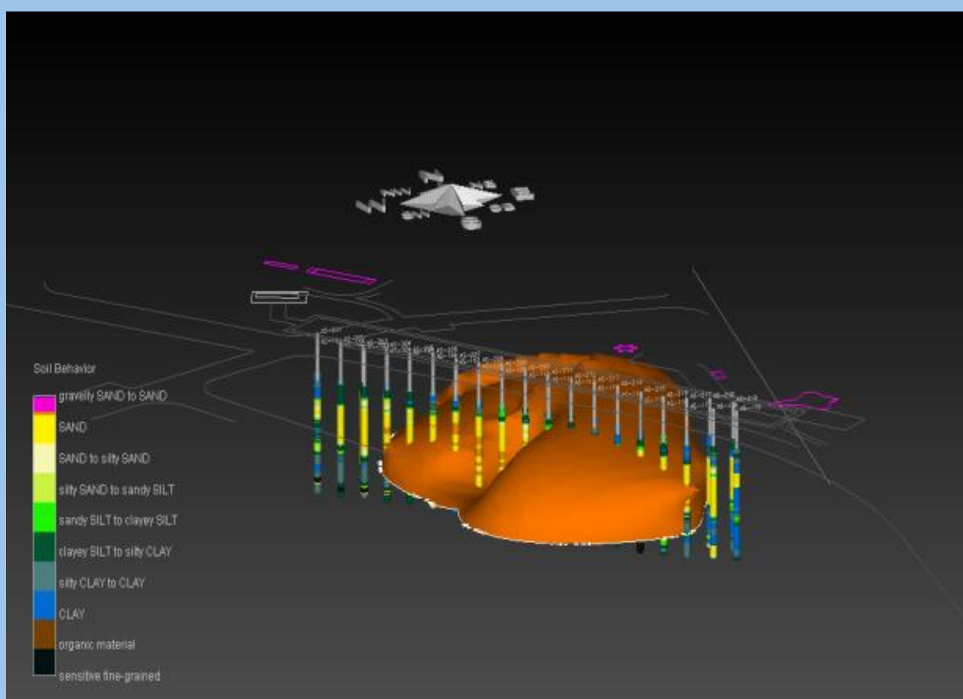


Figure 6. 3-D Visualization Component of Remediation/Mitigation CSM. The Remediation/Mitigation CSM enhances a project team's ability to evaluate and modify remedial designs during implementation to minimize resources and maximize remedy effectiveness.

Data from 1-foot sparging screened intervals were correlated with geologic logs and CPT data to identify the specific design modifications needed. The data were also used to optimize the long-term monitoring program for groundwater. Project results confirmed that using a real-time evolving CSM to manage and visualize collaborative data enabled the cost-effective development of a sound design basis, design, and successful remedy implementation.

The updated CSM includes new information on water levels, well locations, soil gas, and a critical dense non-aqueous phase liquid (DNAPL) migration pathway identified in fractured bedrock. Using the Design CSM as a guide, remedial efforts were targeted to address a variety of site concerns. Elements included: defining spatial dimensions for source areas to aid hydraulic isolation; identification of DNAPL migration pathways and river discharge locations to design a sheet pile wall barrier and hydraulic control system to limit DNAPL migration to the Poudre River; and supporting the design of vapor intrusion mitigation systems at some site buildings.

Remediation/Mitigation CSM Stage

The Remediation/Mitigation Stage CSM can be used to guide remediation/mitigation efforts, such as:

(1) Directing and documenting excavation activities;
(2) Managing phased remediation programs;
(3) Managing remediation at separate operable units or subunits of a site;
(4) Responding to changed conditions encountered in the field; and
(5) Optimizing *in situ* and *ex situ* treatment remedy implementation

This stage also includes operation and maintenance (O&M), and long-term monitoring activities. Continuous updating of the CSM during this stage can be used to maintain stakeholder consensus, identify potential challenges as remediation/mitigation progresses, and support future remediation optimization efforts.

The same CSM platform and data management system employed during the previous CSM stages typically can be used as the basis for the Remediation/Mitigation CSM. Consistent platform use may help project teams realize significant cost savings during remediation/mitigation. For example, efforts could be limited to minor modifications to data fields or the addition of new software for system evaluations.

The Remediation/Mitigation CSM also can be used to assess performance metrics to help ensure that remedies are operating according to design or other project parameters. For example, information about changing concentrations in a monitoring well can be indicative of source depletion, rebound, or other important processes effecting assessment of remedy performance. Similar to the Design CSM, the Remediation/Mitigation CSM can be used to refine further the scale of design to ensure remediation approaches are sized appropriately to limit costly over- or under-designed systems. The higher resolution areas of the CSM also serve to identify focus areas of sites that may warrant special design considerations, such as source zones, NAPL areas, dissolved phase contamination, and residual contamination. When the Remediation/Mitigation CSM is updated as a remedy is implemented or optimized, system design specifications and operating protocols can be modified in real-time to adapt to small-scale variations in site conditions.

As a remedy begins to achieve performance goals such as cleanup or action levels, components of the Remediation/Mitigations CSM can be used to support documentation of site completion activities, including issuance of the final close-out report and site deletion under the CERCLA program; or certifying completion or making a No Further Action determination under other regulatory programs.

Post Remedy CSM Stage

While use of the CSM in the Remediation/Mitigation stage can help project teams document the attainment of remediation goals, the utility of a life cycle CSM does not end here. The Post Remedy CSM provides integrated and synthesized information that can assist project teams with a variety of documentation and redevelopment planning needs. When the Remediation/Mitigation CSM is appropriately and fully evolved throughout the performance of a remedial action project, its end state will generally serve as a Post Remedy CSM.

Applications of the Post Remedy CSM can help:

(1) Provide a basis for using statistical methods to programmatically evaluate remedy effectiveness and performance for sites meeting cleanup goals;

(2) Document and leverage identified best management and technical practices associated with a remedy success;

(3) Document site remediation activities including locations, dimensions, and concentrations of waste left on site; institutional/engineering controls; and other important remedy features; and

(4) Facilitate reuse planning by providing detailed understanding of geologic/hydrogeologic site conditions and key site physical or chemical features.

Figures 7a and 7b are 'during and after' photographs of the investigation and river restoration effort at the Poudre River Site, which served as components of the Post Remedy CSM, visually documenting the completed site remediation and restoration effort.

Summary

The project life cycle CSM is a versatile and powerful tool than can be used to support project and site decisions unique to each stage of a cleanup project. A CSM developed and maintained on a single platform is highly effective at integrating new information into existing data sets. This enables project teams to understand the significance of new data in the context of existing site understanding. Environmental cleanup practitioners can use CSMs to achieve, communicate, and maintain stakeholder consensus on site understanding, while satisfying the technical and quality objectives required to perform the project successfully.

This fact sheet highlights CSM life cycle stages and provides examples of how CSM components can be leveraged to answer principal study questions and address key site challenges. From documenting and spatially defining the nature and extent of contamination and providing key system design and optimization parameters, to facilitating reuse planning, the project life cycle CSM provides a platform to capture, synthesize, and readily use important site data and information.

Figure 7a. Poudre River Site Restoration Effort. Photographs of active restoration efforts can be shared with stakeholders, general public, and media to demonstrate activities being conducted at sites.

References

Direct References

[1] Decision support tools are interactive software tools used by decisions makers to help answer questions, solve problems, and support or refute conclusions. For examples of available tools, visit www.frtr.gov/decisionsupport/index.htm

[2] EPA Requirements for Quality Assurance Project Plans, EPA QA/R5 March 2001, page 2. EPA/240/B-01/003. www.epa.gov/quality/qs-docs/r5-final.pdf

[3] Information on addressing site uncertainty, developing DWS, and demonstrating methods applicability can be found in the following resource: U.S. EPA. 2008. *Demonstrations of Method Applicability under a Triad Approach for Site Assessment and Cleanup — Technology Bulletin*; August. www.clu-in.org/download/char/demonstrations_of_methods_applicability.pdf

[4] A full case study of the Cache La Poudre River Site project can be accessed at: *Innovations in Site Characterization Case Study: The Role of a Conceptual Site Model for Expedited Site Characterization Using the Triad Approach at the Poudre River Site, Fort Collins, Colorado.* www.cluin.org/download/char/poudre_river_case_study.pdf

Select EPA Superfund References Pertaining to CSMs

"The CSM is a three-dimensional "picture" of site conditions that illustrates contaminant distributions, release mechanisms, exposure pathways and migration routes, and potential receptors. The CSM documents current site conditions and is supported by maps, cross

Figures 7b. Poudre River Site Post-Restoration. Photographs of the site after completion of restoration efforts serve as partial documentation of this phase of remedy completion.

sections, and site diagrams that illustrate human and environmental exposure through contaminant release and migration to potential receptors. Developing an accurate CSM is critical to the proper implementation of the Soil Screening Guidance." (Section 2.1, p. 5)

Soil Screening Guidance: User's Guide, July 1996, Publication 9355.4-23 (EPA 540-R-96-018). www.epa.gov/superfund/resources/soil/ssg496.pdf

"Analyses of the data collected should focus on the development or refinement of the conceptual site model by presenting and analyzing data on source characteristics, the nature and extent of contamination, the contaminated transport pathways and fate, and the effects on human health and the environment" (Ref 7, p. 3-19).

Guidance for Conducting Remedial Investigation and Feasibility Studies Under CERCLA. October 1988. OSWER Directive No. 9355.3-01. www.epa.gov/superfund/policy/remedy/pdfs/540g-89004-s.pdf

"A conceptual site model is a useful tool for selecting sampling locations. It helps ensure that sources, pathways, and receptors throughout the site have been considered before sampling locations are chosen. The conceptual model assists the Site Manager in evaluating the interaction of different site features. Risk assessors use conceptual models to help plan for risk assessment activities. Frequently, a conceptual model is created as a site map (see Figure 1) or it may be developed as a flow diagram which describes potential migration of contaminants to site receptors."

Superfund Program Representative Sampling Guidance, OSWER Directive 9360.4-10 (EPA 540-R-95-141). www.epa.gov/tio/download/char/sf_rep_samp_guid_soil.pdf

"The site conceptual model synthesizes data acquired from historical research, site characterization, and remediation system operation. The conceptual model, like any theory or hypothesis, is a dynamic tool that should be tested and refined throughout the life of the project. As illustrated in Figure 5, the model should evolve in stages as information is gathered during the various phases of site remediation. This iterative process allows data collection efforts to be designed so that key model hypotheses may be tested and revised to reflect new information." (Section 4.4.3, p. 13)

"Conceptual Model Provides Basis for:

- *Early Action/Removal of Near Surface Materials*
- *Site Characterization Studies (RI/FS, RFI)*
- *Removal of Subsurface Sources*
- *Pilot Studies*
- *Interim Ground-Water Actions*
- *Evaluation of Restoration Potential (or TI)*
- *Full-Scale Treatment System Design and Implementation*
- *Performance Monitoring and Evaluations*
- *Enhancement or Augmentation of Remediation System, if Required*
- *Future Evaluation of TI, if Required"*

(Figure 5. Evolution of the Site Conceptual Model)

Guidance for Evaluating the Technical Impracticability of the Ground-Water Restoration, September 1993, publication 9234.2-25 www.clu-in.org/download/contaminantfocus/dnapl/Policy_and_Guidance/TI_guidance.pdf

"*In addition to the items discussed in more detail below, it is important to keep in mind that remedial action costs are influenced, in general, by the quality of the conceptual site model (CSM), which is a three-dimensional 'picture' of site conditions that illustrates contaminant distributions, release mechanisms, exposure pathways and migration routes, and potential receptors… It is initially developed during the scoping phase of the RI/FS, and modified as additional information becomes available. Careful evaluation of site risks, incorporating reasonable assumptions about exposure scenarios and expected future land use, and the definition of principle threat waste generally warranting treatment, help to prevent implementation of costly remediation programs that may not be warranted."* (Section 1, p. 2)

The Role of Cost in the Superfund Remedy Selection Process, Quick Reference Fact Sheet. Publication 9200.3-23FS (EPA 540-F-96-018). September 1996. www.epa.gov/superfund/policy/cost_dir/cost_dir.pdf

Additional CSM References:

Improving Sampling, Analysis, and Data Management for Site Investigation and Cleanup (EPA 542-F-04-001a) April 2004. www.triadcentral.org/ref/ref/documents/2004triadfactsheeta.pdf

Triad Issue Paper: Using Geophysical Tools to Develop the Conceptual Site Model (EPA 542-F-08-007). December 2008. www.brownfieldstsc.org/pdfs/Geophysics Issue Paper FINAL Dec 3 20081.pdf

Innovations in Site Characterization, Streamlining Cleanup at Vapor Intrusion and Product Removal Sites Using the Triad Approach: Hartford Plume Site, Hartford, Illinois. (EPA 542-R-10-006). September 2010. www.brownfieldstsc.org/pdfs/Hartford Case Study FINAL 9-30-10.pdf

Streamlining Site Cleanup in New York City (EPA 542-R-10-005) August 2010. www.brownfieldstsc.org/pdfs/Streamlining_Site_Cleanup_in_NYC_Final.pdf

Best Management Practices: Use of Systematic Project Planning Under a Triad Approach for Site Assessment and Cleanup (EPA-542-F-10-010). September 2010. www.clu-in.org/download/char/epa-542-f-10-010.pdf

Improving Decision Quality: Making The Case For Adopting Next-Generation Site Characterization Practices (EPA-542-F-03-012). 2003. http://nepis.epa.gov

Additional Resources:

Triad Resource Center Web site (www.triadcentral.org)

Contaminated Site Clean-Up Information Network Web site (www.cluin.org)

The Brownfields and Land Revitalization Technology Support Center (www.brownfieldstsc.org)

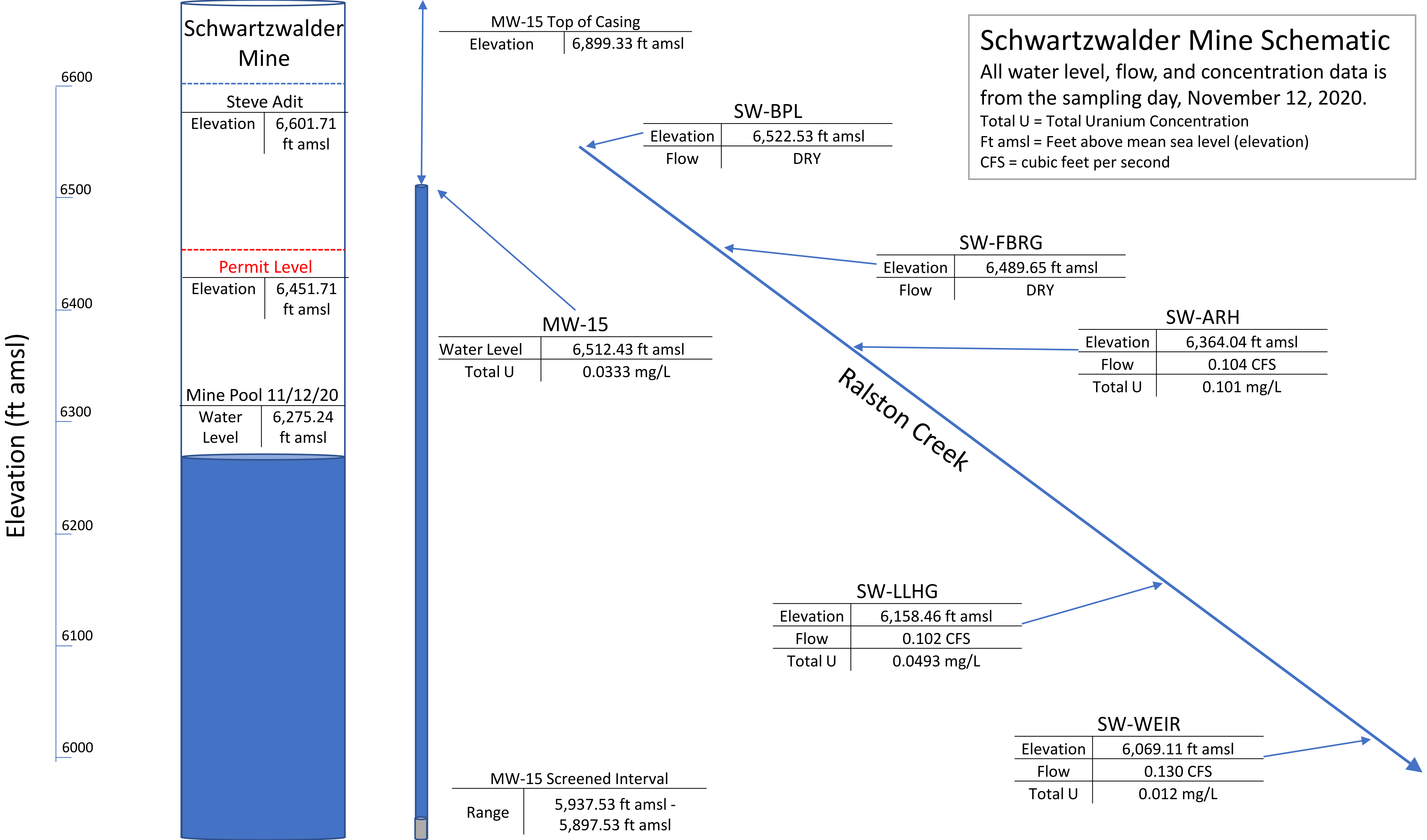
EPA Superfund (www.epa.gov/superfund)

For technical inquiries regarding this document, contact:

Stephen Dyment, EPA OSWER/OSRTI
dyment.stephen@epa.gov or 703.603.9903

Michael Adam, EPA OSWER/OSRTI
adam.michael@epa.gov or 703.603.9915

ATTACHMENT B - CLL Cross-Sectional View of Groundwater Conditions


Schwartzwalder Mine Schematic
All water level, flow, and concentration data is from the sampling day, November 12, 2020.
Total U = Total Uranium Concentration
Ft amsl = Feet above mean sea level (elevation)
CFS = cubic feet per second
Elevation (ft amsl)
6600
6500
6400
6300
6200
6100
6000
Schwartzwalder Mine
Steve Adit
Elevation 6,601.71 ft amsl
Permit Level
Elevation 6,451.71 ft amsl
Mine Pool 11/12/20
Water Level 6,275.24 ft amsl
MW-15 Top of Casing
Elevation 6,899.33 ft amsl
MW-15
Water Level 6,512.43 ft amsl
Total U 0.0333 mg/L
MW-15 Screened Interval
Range 5,937.53 ft amsl - 5,897.53 ft amsl
SW-BPL
Elevation 6,522.53 ft amsl
Flow DRY
SW-FBRG
Elevation 6,489.65 ft amsl
Flow DRY
SW-ARH
Elevation 6,364.04 ft amsl
Flow 0.104 CFS
Total U 0.101 mg/L
Ralston Creek
SW-LLHG
Elevation 6,158.46 ft amsl
Flow 0.102 CFS
Total U 0.0493 mg/L
SW-WEIR
Elevation 6,069.11 ft amsl
Flow 0.130 CFS
Total U 0.012 mg/L

Geosyntec consultants

5670 Greenwood Plaza Blvd
Suite 540
Greenwood Village, CO
PH 303-790-1340
www.geosyntec.com

Denver Water Comments

Attachment B

Technical Memorandum

Date: September 14, 2021

To: Nicole Poncelet, Denver Water Director of Water Quality & Treatment Team

From: Sarah Walker, Emmy Apostol, David Adilman, and Jennifer Nyman Geosyntec

Subject: Schwartzwalder Mine Amendment 6 Comments – Physical and Chemical Stabilization of the Mine Pool

CC: Jason Kerstiens, Geosyntec

Attachments: Figure 1 – Estimate of Bedrock Mine Pool Pumping Capture Zone; Figure 2 – Mine Pool Uranium Concentrations; Table 1 – Mann Kendall Trend Analysis of the Mine Pool; Attachment A – Outlier Test

---

INTRODUCTION

Denver Water retained Geosyntec Consultants, Inc. to review and evaluate Colorado Legacy Land, LLC's (CLL) application for Amendment 6 to the Division of Reclamation, Mining and Safety (DRMS) mine permit M-1977-300. The purpose of Amendment 6 is to satisfy the conditions of the revised Succession of Operations (SO-1) approval letter dated February 20, 2018, which include providing a conceptual site model (CSM), a plan addressing the physical and chemical stabilization of the mine pool (specifically addressing the concentrations of dissolved uranium and other constituents), an updated Reclamation Plan, and an updated Environment Protection Plan (EPP).

Based upon its review of Amendment 6, Geosyntec has the following overall observations on the chemical and physical condition of the Mine Pool:

- The characterization and monitoring of the hydraulic gradient around the mine pool are insufficient to demonstrate capture and physical stabilization.

- Concentration trends for samples taken from the mine pool do not demonstrate its chemical stability. Although in-situ treatment often helps to decrease uranium concentrations on a temporary basis, the upward trend of uranium concentrations appears to resume after each treatment, and uranium concentrations did not decline after the most recent in situ treatment.
- Amendment 6 reveals several concerns with respect to data collection, analysis, and planning, including CLL's exclusion of data, errors in data presentation, faulty monitoring equipment, and need for contingency planning.
- A long-term plan for reclamation of the mine pool is not clearly presented, which raises the question of whether CLL will pump from the pool and treat extracted water indefinitely.

Statements from the Amendment 6 Reclamation Plan have been excerpted (in ***bold italics***) and are followed by Geosyntec's observations and recommendations (in plain text).

PHYSICAL STABILIZATION

1. Mine Pool Water Level Demonstration

> **E.5.1. Physical Stabilization of the Mine Pool Demonstration.** ***In October 2020, a team [Ensero Solutions] entered the mine to verify the mine pool elevation and calibrate the transducer used to measure the mine pool elevation. The team noticed that the mine pool had been dewatered to 22 feet lower than the elevation of the transducer, which caused inaccurate measurements to be recorded.***

The established regulatory limit of 150 feet (ft) below the Steve Level was approved by DRMS during the Amendment 4 Adequacy Review process in lieu of a limit of 500 ft below the Steve Level. This shallower limit minimizes the oxidation of uranium in the mine workings and lowers the mine pool to an elevation of approximately 63 ft below Ralston Creek in the permit area to prevent flow from the mine pool towards the creek.

CLL describes how in October 2020, the transducer measuring water levels in the mine pool was recording inaccurate measurements by 22 ft, and that the problem was only discovered after a team entered the mine to verify the mine pool elevation. The fact that mine pool levels are monitored by a single transducer that is infrequently inspected and calibrated calls into question the accuracy of this data and demonstrates the risk of using a single instrument reading to make decisions for dewatering operations. Geosyntec recommends that CLL submit a monitoring contingency plan describing the pump and transducer inspection and maintenance procedures and schedule. Geosyntec also recommends the installation of a secondary backup transducer to confirm mine pool water levels and to maintain monitoring continuity in the event of a malfunction.

2. Groundwater Gradients

> **E.5.1. Physical Stabilization of the Mine Pool Demonstration.** ***Maintaining the mine pool elevation below the regulatory limit (150-feet below the Steve Level) has established a hydraulic gradient inward toward the mine pool and away from Ralston Creek. A summary of the observed quarterly groundwater elevations in bedrock wells MW-15 and MW-18 with respect to the mine pool elevation is presented in Table E-1.***

CLL does not provide sufficient data to assert that an inward bedrock groundwater gradient has been established. CLL uses only two bedrock monitoring wells, one of which only has three data points dating back to Q2 2020. This does not demonstrate physical stabilization of the mine pool for the last three consecutive years, as required by the SO-1 approval letter. This is an important condition when considering the conditions for updated reclamation costs.

Furthermore, Table E-1, which shows groundwater elevations in the mine pool, MW-15, and MW-18, contains multiple errors. The column headings "Groundwater Elevation (ft btoc)" is mis-named and should be labeled as depths to groundwater. The groundwater elevations in feet above mean sea level (ft amsl) for MW-18 in Q2 2020 and Q3 2020 are identical, despite different depths to water measured from below top of casing. Based on the well casing elevations surveyed in July 2020, the groundwater elevation in Q3 2020 should be 6,414.58 ft amsl. The elevation in Q1 2021 should be 6,361.88 ft amsl. These correspond to MW-18 head values of 10.79 ft in Q3 2020 and 16.78 ft in Q1 2021 compared to the mine pool, which are significantly lower than those listed in the table E-1.

TABLE E-1. OBSERVED GROUNDWATER GRADIENTS

Quarterly Sampling Memo/Data Source	Sampling Date	Daily Average Mine Pool Elevation		MW-15				MW-18			
		(feet below Steve Adit)	(ft amsl)	Groundwater Elevation (ft btoc)	Groundwater Elevation (ft amsl)	Head in Well Compared to Mine Pool (ft)	Gradient Toward Mine Pool (ft/ft)	Groundwater Elevation (ft btoc)	Groundwater Elevation (ft amsl)	Head in Well Compared to Mine Pool (ft)	Gradient Toward Mine Pool (ft/ft)
Q1 2019	N/A			No access, winter conditions				Dry			
Q2 2019				No data transducer malfunction				Dry			
Q3 2019	9/25/2019	191.62	6,410.38					159.70	6,417.18	6.80	0.020
Q4 2019	10/23/2019	187.84	6,414.16	No access, winter conditions				153.60	6,423.28	9.12	0.026
Q1 2020	3/4/2020	192.84	6,409.16					162.77	6,414.11	4.95	0.014
Q2 2020	6/4/2020	158.71	6,443.29	N/A				124.70	6,452.18	8.89	0.026
	6/17/2020	178.05	6,423.95	373.40	6,525.93	101.98	0.098	N/A			
Q3 2020	7/29/2020	198.21	6,403.79	336.10	6,563.23	159.44	0.153	162.30	6,452.18	48.39	0.139
Q4 2020	11/12/2020	326.76	6,275.24	386.90	6,512.43	237.19	0.228	Dry			
Q1 2021	1/29/2021	256.61	6,345.10	Dry				215.00	6,414.58	69.48	0.200

Although there are a limited number of bedrock monitoring wells which can be used to draft potentiometric contours, an estimate of the mine pool pumping capture zone based on the existing bedrock groundwater elevation (potentiometric) data is shown in **Figure 1**. Capture zone estimates are typically drawn in plan view and cross-section to fully illustrate the area in which inward hydraulic gradients exist due to pumping. Although CLL has demonstrated inward gradients based on two wells cross-gradient to the pumping area (MW-15, MW-18), they have not illustrated the capture zone relative to the mine workings or permit boundary. In Section E.5.1 (p. 15) CLL describes the pumping capture zone as anisotropic but has not depicted the capture zone they are referring to.

To fully define the shape and magnitude of an anisotropic capture zone, additional bedrock groundwater well locations from which to gauge groundwater elevations (particularly within the permit boundary between the mine pool and Ralston Creek) are necessary to demonstrate the area of inward groundwater gradients towards the mine pool. Lastly, although the groundwater level in the mine pool is lower than the surface water elevation at the adjacent Ralston Creek, there are no bedrock groundwater elevations between the pumping area and the creek to illustrate that this inward gradient is continuous from the creek to the mine pool. Figure 1 depicts a recommended location for installation of an additional bedrock groundwater monitoring well located between the mine pool and Ralston Creek. The purpose of this location is to confirm the hypothesis of inward gradients in bedrock groundwater from Ralston Creek to the mine pool. The current data suggests that the inward gradient towards the mine pool would be increased by lowering the mine pool more than 150 ft below Steve Level Adit. More data should be collected to confirm the inward gradient particularly when the mine pool is close to 150 ft below Steve Level Adit and when it is at its deepest (approximately 325 ft below Steve Level Adit). Data would help define the capture zone at these levels and, in particular, provide critical data in the months where the mine pool is close to 150 ft below Steve Level Adit.

3. Tracer Test Review

> **Appendix 2. Tracer Test. Tracer Test Conclusions*. Therefore, it is more likely that the tracers dispersed within a large volume of mine water, perhaps the entire mine. The addition of sump water to the mine pool as previously discussed may have also contributed to the dilution/dispersion of the tracers. Regardless of the reason why only a small fraction of the tracers was not observed in recycle/mixing system, it appears the mine pool has been sufficiently mixed, and the water quality samples are representative of the mine pool.***

Geosyntec acknowledges CLL's effort to demonstrate mixing conditions in the Mine Pool; however, the data do not prove CLL's conclusions of the tracer test that the mine pool is fully mixed. The water in the mine pool (i.e., the various levels of saturated laterals) may not be thoroughly mixed; the tracer may have transported downward. The bulk of the 25 pounds of injected rhodamine tracer (with a density 30% greater than water[1]), may have sunk to the bottom of Shaft #2 (~2,000 ft deep) and may not have been accessible by pumping from the Jeffrey Shaft

---

1 https://www.penergetic.com/fileadmin/user_upload/www.penergetic.com/downloads/SDS/EN_PKD_SDS_Molasses_penergetic-p_180712.pdf

(1,100 ft deep). The data does not support a clear understanding of how much actual mixing of an injected carbon source is occurring within the greater mine pool.

> **Appendix 2. Tracer Test. Tracer Test Conclusions. *Finally, on the basis of the no tracer leaving the mine, the mine is a hydrogeologic sink, e.g., mine pool water is not exiting the mine.***

The basis of CLL's conclusion that no mine pool water is leaving the mine is that no tracer was detected in the treated water discharged to Ralston Creek and that the level in the mine pool was always below 150 ft below the Steve Level. These observations do not prove that no tracer left the mine. Additional sampling and analysis of tracer dyes in bedrock and alluvial groundwater and surface water from Ralston Creek would provide more informative data with which to evaluate this question.

CHEMICAL STABILIZATION

1. Injection of RO Concentrate into Mine Pool

> **E.1. Conceptual Consideration. *The mine pool is pumped to a water treatment plant (WTP), treated, clean water is discharged to Ralston Creek, and reject brine is sent back to the mine.***

In Amendment 6, CLL offers no discussion on the effect of injecting the reverse osmosis (RO) concentrate (reject brine) back into the mine pool. The addition of concentrated brine into the mine pool system may have major implications for the geochemical behavior of uranium and other constituents of concern targeted in the in-situ treatment (i.e., its effect on redox conditions, its effect on the sulfate-reducing bacteria [SRB] population, speciation, and solubility). It is also not clear that CLL is taking measures to understand how the RO concentrate is altering the redox conditions of the mine pool or to control the amount of dissolved oxygen present in the RO concentrate. Geosyntec recommends that CLL demonstrate that the addition of RO concentrate to the mine pool will not negatively impact the on-going in-situ treatment of the mine pool.

Based on Amendment 4 Adequacy Review Comment Responses from the Cotter Corporation (dated March 8, 2013), the RO concentrate is mixed with barium chloride to cause the precipitation of gypsum (calcium sulfate) and barite (barium sulfate) and blended with sugar syrups to further increase the solution density. The sugar syrups also provide another carbon source for the SRB, which create the reducing environment necessary for uranium reduction and immobilization. This information is a critical component of the in-situ uranium bioremediation process and should be included in Exhibit E. These details are also missing from the Reclamation Costs tables in Exhibit L.

As explained in the Amendment 4 Adequacy Review Comment Responses, the intent of increasing the density of the RO concentrate is so that the "backfill slurry" sinks to the bottom of the mine pool. In the Amendment 4 Adequacy Review Comment Responses, Cotter Corporation describes a contingency plan in case the backfill slurry does not behave as predicted: "if the Slurry does not sink, there will be a conductivity increase in the in-situ monitoring troll suspended at depth in the mine pool that will be detectible as the fluid begins to mix with the mine pool". In the event of a 20 percent increase in conductivity, the slurry injection point will be lowered deeper into the mine pool, and the injection rate will be decreased by 25 percent. CLL does not provide any information on specifications or the location of the monitoring troll nor how conductivity is used to assess the distribution of the RO concentrate within the mine pool. Below is a portion of Table E-2, which shows a comparison of mine pool data from before and after in-situ treatment. The mean values for conductivity and pH fall outside of the minimum and maximum range of these constituents. This is obviously an error but suggests that CLL has not carefully reviewed the data from the mine pool used to inform their injection strategy. Many of the means calculated in this table are not statistically possible given the data range.

Figure E-2 (Schwartzwalder Mine In-Situ Treatment Injection Locations) illustrates the backfill slurry as entering and filling lateral shafts connected to Shaft 1 and Shaft 2. These shafts are presumably the Jeffrey Shaft and #2 Shaft as described in the Tracer Test (Appendix 2). CLL does not provide injection volumes or the density of the slurry/iron sulfide precipitates; however, if the volume of backfill slurry represented in the figure is approximately correct, then it appears as though there would be a risk of filling underground shafts with the slurry and/or with iron sulfide precipitate. If this occurs, there may be unintended hydraulic effects, potentially redirecting groundwater towards Ralston Creek, which should be evaluated and discussed.

TABLE E-2: COMPARISON OF SCHWARTZWALDER MINE POOL CONCENTRATIONS PRE-2017 AND POST-2017

Variable	Units	Number of Samples	Number of Non-Detects	Percent of Non-Detects	Minimum	Maximum	Mean[1]	Median[1]	Standard Deviation	Pre-2017 Sample Data – Mean[2]
		March 2018 to September 2020 Mine Pool Sample Data								
General Parameters										
Bicarbonate as CaCO3	mg/L	18	0	0%	491	950	360	843	136	374
Calcium	mg/L	19	0	0%	153	352	144	316	54	299
Chloride	mg/L	32	0	0%	8	54.7	34	43	8.92	31
Conductivity Field	µS/cm	7	0	0%	2680	5131	634	3250	839	3319
Oxidation Reduction Potential	mv	4	0	0%	-136	147	-5.81	-119	118	193
pH Field	s.u.	8	0	0%	6.82	7.59	1.50	7.39	0.21	7.19
Phosphorus	mg/L	19	3	8%	0.03	0.7	0.09	0.17	0.15	0.15
Potassium	mg/L	19	0	0%	15	31.7	13	27	4.56	17.2
Sodium	mg/L	19	0	0%	139	284	111	225	40	197
Sulfate	mg/L	32	0	0%	408	1790	1091	1395	285	1725
TDS - Total Dissolved Solids	mg/L	22	0	0%	960	3390	1581	2955	534	2917
Temperature	Deg C	7	0	0%	7.8	21.2	2.93	17.2	3.83	17.2
Dissolved Metals										
Aluminum	mg/L	19	18	46%	0.17	0.17	0.021	0.03	0.03	0.15
Antimony	mg/L	19	18	46%	0.0012	0.0012	0.0019	0.0004	0.01	0.014
Copper	mg/L	19	19	49%	0	0	0.0041	0.01	0.00	0.01
Iron	mg/L	32	0	0%	0.09	10.7	2.98	3.12	2.89	0.02
Lead	mg/L	16	16	41%	0	0	0.00016	0.0001	0.00	0.0003
Magnesium	mg/L	19	0	0%	112	280	112	239	46	224
Manganese	mg/L	32	0	0%	0.252	1	0.604	0.733	0.12	2.05
Mercury	mg/L	9	9	23%	0	0	2.3E-05	0.0001	0.00	0.00036
Molybdenum	mg/L	32	0	0%	0.0371	1.4	0.450	0.54	0.37	1.85
Silver	mg/L	19	19	49%	0	0	0.00073	0.0001	0.00	0.0034
Thallium	mg/L	19	18	46%	0.0003	0.0003	0.00023	0.0001	0.00	0.0249
Uranium	mg/L	32	0	0%	3.95	16	9.39	12	2.55	41

Notes:

[1] Mean and median statistics calculated using one-half the detection limit.

[2] Mean values from Table 37 in Whetstone Associates, Inc. Schwartzwalder Mine Hydrologic Evaluation of Mine Closure and Reclamation. (2007) November 7, which were calculated from results of mine pool samples collected from June 2000 to July 2007.

Deg C - Degrees Celsius
µS/cm - microSiemens per centimeter
mg/L - Milligrams per liter
mv - Millivolts
pCi/l - picoCuries per liter
s.u. - Standard unit

Finally, Exhibit E is titled "Reclamation Plan." CLL, however, does not provide an operational plan for the injection of RO concentrate into the mine pool. Geosyntec recommends CLL specify such a plan, including the parameters within which the injection will occur and the monitoring to assess the effect of the injection.

2. Treatment Efficacy and Risk of Uranium Remobilization

> **E.5.2.3. In-Situ Treatment Results.** ***As shown on Figure E-3, there was not a significant decrease in uranium concentrations after the 2020 in-situ treatment as was seen in the previous in-situ treatments.***

The observation that the uranium concentrations following the 2020 treatment did not significantly decrease raises concerns about the continued efficacy of the in-situ treatment of uranium and other constituents of concern in the mine pool. CLL offers three possible explanations for why this might be the case:

1. The natural population of SRB is at a "steady-state" condition and no longer reducing the sulfate that enters the mine pool;
2. Based on similar uranium concentrations in 2018 and 2020, there may be a "rate-limiting factor" in generating required reducing conditions for uranium reduction and uraninite precipitation; and
3. The introduction of oxygenated water into the mine pool from the sump interfered with the creation of a reducing environment.

Other than identifying these reasons for why the latest in-situ treatment was not successful, CLL offers no solutions or changes to their current treatment strategy to resolve these issues. Each of these explanations suggests that continued carbon-dosing and in-situ treatment may no longer be effective in controlling uranium concentrations in the mine pool. These issues also demonstrate that the mine pool may not be chemically stable and may not achieve chemical stabilization without the constant maintenance of reducing conditions. CLL also provides no mechanism for why uranium and molybdenum concentrations have rebounded after every dosing event where data are available.

Geosyntec recommends the following:

1. The injection of the RO concentrate into the mine pool may be introducing excess oxidants into the system. That may preclude the creation of a sufficiently reducing environment conducive to the reduction of U(VI) to U(IV). Analytical data for and volumes of the RO concentrate are not provided. Disposing of the concentrate elsewhere could mitigate this problem. Geosyntec recommends characterizing the volume and oxidants in the RO concentrate.
2. CLL collect additional groundwater data to understand the volume of groundwater that flows into the mine pool and its chemical composition. Understanding the composition of the volume of captured groundwater would inform the overall geochemical understanding of the mine pool system and the influence of groundwater on uranium concentrations.
3. CLL must develop a better understanding of the factors influencing uranium concentrations during in-situ treatment. The purpose of in-situ treatment is to reduce uranium and accumulate reduced, precipitating uranium in the mine pool. This reduced uranium functions as a new source of uranium independent from the uranium present in the ore material within the mine workings. The introduction of oxidants such as oxygenated water can reverse the reduction reaction and remobilize this uranium back into groundwater. Without year-round pumping control and water treatment capabilities, CLLs risks the influx of oxygenated water back into the mine. A plan to develop a better

understanding of the factors influencing uranium concentrations during in-situ treatment should be developed.

3. Elevated Uranium Concentrations in 2017

E.5.2.3. In-Situ Treatment Results. ***A red circle is shown on Figures E-3 and E-4 to signify suspect data in the months preceding the 2017 in-situ treatment. These data are suspect because in the nearly 10 years of data shown on these figures, uranium concentrations have not exceeded 25 mg/L and molybdenum concentrations have not exceeded 2 mg/L, with the possible exception on one sampling event in November 2017.***

Geosyntec does not agree that the "suspect data" shown on Figures E-3 and E-4 are statistical outliers and questions the plausibility of a labelling error of 10 samples over multiple sampling events. Geosyntec performed a statistical analysis of the available sample data for total uranium collected from the mine pool between July 2013 and July 2020 using ProUCL. Based on Rosner's Outlier Test at a 5% significance level, one potential outlier was identified. The potential outlier was removed from the data set and the test was re-run until no potential outliers were identified. The results from this exercise, provided in Attachment A, indicate that there are three potential outliers in the data set and not 10. This is the type of analysis that Geosyntec would recommend for supporting claims such as "suspect data". CLL attributes these elevated uranium concentrations to "a mix-up in the labelling of these samples [or] the samples were collected from the wrong sample port". The mislabeling of 10 samples over multiple sampling events seems unlikely. If it did occur or if incorrect sampling procedures were used (i.e., using the wrong sample port), Geosyntec recommends a reconsideration of quality assurance/quality control (QA/QC) procedures.

Further, CLL concedes that "a definitive explanation is not available" for the elevated uranium concentrations preceding the 2017 treatment; however, they do not consider the operational changes that occurred during this time in their explanation for data increases. Based on our understanding of the site the RO water treatment plant was turned on in January of 2016. Therefore, it was around this time period that operators also began injecting RO concentrate back into the mine. This substantial increase in concentrations compared to historical data could also be the result of introducing a new source of uranium into the mine pool.

4. Concentration Trends

Uranium

E.5.2.4. Chemical Stabilization of the Mine Pool Conclusion. ***The concentrations and linear regressions for uranium and molybdenum over three consecutive years are shown***

> ***on Figure E-5. The uranium concentrations (dissolved and total) have maintained an average of approximately 12 mg/L with a slight positive slope.***

Uranium concentrations in the mine pool have been increasing since 2018. This trend is not consistent with chemical stabilization and does not suggest that stabilization can be achieved without intervention. Uranium concentrations in the mine pool have been increasing since the onset of in-situ treatment in 2013 as shown in **Figure 2**. A Mann-Kendall statistical analysis was also performed for the same period (2018-2020) and is provided in **Table 1**. Dissolved uranium is classified as probably increasing, and both total and dissolved molybdenum are classified as increasing. The strength of a Mann-Kendall trend test over a linear regression (as used in Amendment 6) is that Mann-Kendall can find trends even when the data are not linear. Linear regressions are only appropriate if the data are normally distributed; a Mann-Kendall test is a non-parametric test, meaning that no distribution assumptions are required. Furthermore, an increasing linear regression trend is demonstrated when evaluating data between 2012 and 2020.

Lastly, CLL has not collected uranium concentration data in the mine pool when the pump is shut off and when uranium concentrations might increase. As described above, the established regulatory limit of 150 ft below the Steve Level was approved by DRMS during the Amendment 4 Adequacy Review process in lieu of a limit of 500 ft below the Steve Level. One reason presented in favor of this shallower limit was to minimize the oxidation of uranium in the mine workings that could occur from exposure of rock wall faces in the mine. The current operational strategy presented in Amendment 6 pumps the mine pool as far as 326 ft below the Steve Level Adit. This strategy exposes 200 ft of rock wall face in the mine workings that may cause a re-oxidation of uranium to occur; therefore, the cyclic nature of the operating strategy may not allow chemical stabilization to occur in the mine pool. As described above, multiple potential reasons exist for why uranium concentrations in the mine pool may not continue to decrease. For operational control, at a minimum, monthly sampling of the mine pool for uranium and other indicator parameters such as total organic carbon, oxidation-reduction potential, and dissolved oxygen is recommended.

Other Constituents

> **E.5.2.4 Chemical Stabilization of the Mine Pool Conclusion.** ***A comparison of historical mean concentrations to current mean concentrations indicates an overall decrease in concentrations with the exception of a limited number of increases, specifically arsenic, chloride, and iron, while most of the constituent concentrations have decreased.***

In addition to uranium and molybdenum, the Mann-Kendall analysis shows increasing concentration trends for iron and radium (**Table 1**). No trend was identified for arsenic, and total manganese is classified as stable. Stable or decreasing trends would support demonstration of chemical stability of the mine pool; increasing trends indicate instability that could impact treatment operations and protectiveness of Ralston Creek.

5. Environmental Monitoring Requirements for Surface Water, Groundwater, and the Mine Pool – Total Carbon

Exhibit U. Designated Mining Operation Environmental Protection Plan.

CLL incorrectly references the environmental monitoring requirements for surface water, groundwater, and the mine pool, and, more importantly, does not include total carbon as a required analyte. Amendment 6 states that the EPP, which outlines the monitoring requirements for surface water, groundwater, and the mine pool, is presented in Technical Revision 23, Attachment B and was updated in Amendment 5. This is inaccurate. Technical Revision 23 addresses the Disposal of Alluvial Fill Source Term Materials, and Attachment B is entitled *Appendix E-3 from the 1983 Mine Permit Amendment: Schwartzwalder Mine Waste Rock Pile Stability* (dated December 28, 2015). The EPP (Exhibit U) was also not updated in Amendment 5, which references the same Technical Revision 23 Attachment. Analytes for quarterly surface water and groundwater sampling are listed in table E-4 of Exhibit E in Amendment 5 (as approved during Technical Revision 27).

In a letter from DRMS to Denver Water dated April 10, 2013, DRMS informed Denver Water that the Cotter Corporation will monitor for total carbon (which includes organic carbon as well as carbon bound in carbon dioxide and bicarbonate). This is intended to be an indicator of the biological in-situ treatment process. Currently, CLL does not monitor for total carbon or organic carbon. No data are presented in Amendment 6 or elsewhere showing how much organic carbon is present in the mine pool during and after in-situ treatment. It is unclear how the amount of carbon added to the mine pool during treatment is determined without this information. Geosyntec recommends updating the EPP in Exhibit U (which is a requirement of the Succession of Operations) and adding total carbon to the list of mine pool analytes.

6. Operational Strategy and Stabilization Criteria

E.5.4 Water Treatment Plant Operating Strategy. ***During the period in which the WTP is shut down, in-situ treatment of the mine pool shall be conducted, as needed, to maintain chemical stabilization. The criteria for in-situ treatment of the mine pool shall be when the mean annual concentration of dissolved uranium indicates an increasing trend as compared to the prior year.***

If CLL is to use mean annual uranium concentrations for determining when treatment will be conducted, Geosyntec recommends CLL collect data year-round including when the mine pool pump is shut off and the WTP is not operating. More information on the in-situ treatment operations and criteria is also recommended. Using a mean annual concentration could result in a delay of six months to a year between in-situ treatment and increasing concentrations measured in the pool. CLL also does not identify a contingency plan in the event the prescribed treatment is no longer effective, as appeared to be the case in 2020. A contingency plan should be developed and presented.

CLL also does not describe how the RO concentrate will be handled and stored in between in-situ treatment events. It is Geosyntec's understanding that the RO concentrate is continuously injected into the mine pool. However, it is unclear if the RO concentrate is always injected as "backfill slurry" containing barium chloride and sugars during treatment.

* * *

FIGURES

Legend

- Monitoring Location
- Bedrock Monitoring Location
- Dewatering Pump Location
- Ralston Creek
- Ravine
- Outline of Pumping Capture Zone
- Potential Bedrock Groundwater Migration Outside of Pumping Capture Zone
- Approximate Footprint of Mine Workings
- Approximate Permitted Boundary
- Bedrock Potentiometric Contours - 06/17/2020

Water Level Data - 06/17/2020

Uranium Concentration in Bedrock Groundwater (µg/L)
(MW) - 07/09/2020
(Mine Pool) - 08/06/2020

Notes:
1. Capture zone delineated in yellow should be considered very approximate as it was estimated from only 4 data points.
2. Data from Colorado Legacy Land – Application Amendment 5, Mine Permit M-1977-300, Schwartzwalder Mine, Golden, Colorado, August 2020.

0 500 Feet

Estimate of Bedrock Mine Pool Pumping Capture Zone

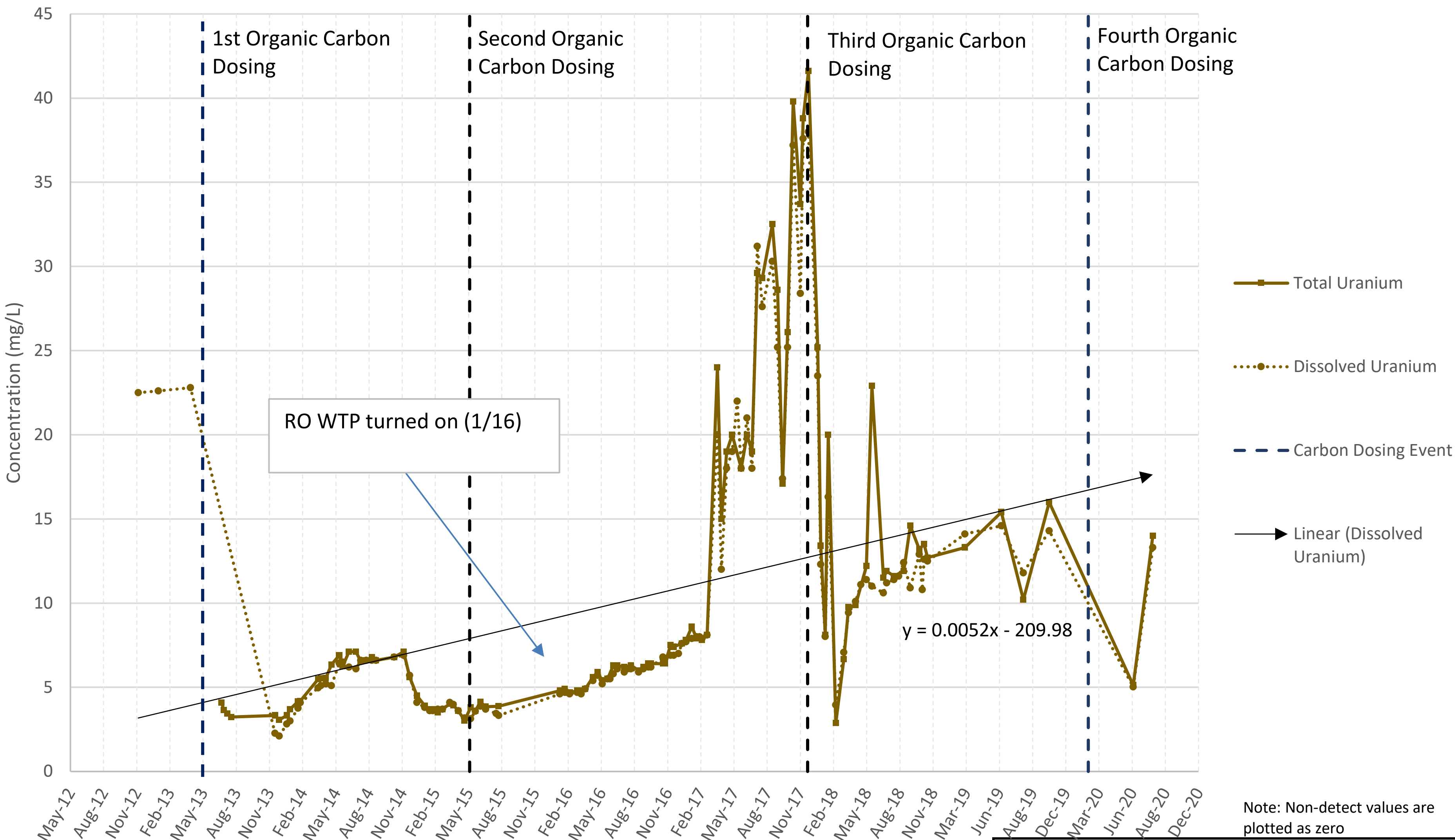
Schwartzwalder Mine, CO

Geosyntec consultants

Acton, Massachusetts | March 2021

Figure 1

Q:\GISProjects\DE0350_DenverWater\MXD\MW_Locations_v2.mxd 3/24/2021 12:09:51 AM



Note: Non-detect values are plotted as zero

Note:
1. Total and dissolved uranium concentrations in the mine pool since the beginning of carbon dosing (in-situ treatment).
2. Acronyms: mg/L = milligrams per liter; WTP = water treatment plant

Mine Pool Uranium Concentrations Schwartzwalder Mine, CO		**Figure**
Geosyntec consultants		**2**
Lakewood, CO	August 2021	

https://geosyntec-my.sharepoint.com/personal/eapostol_geosyntec_com/Documents/Denver Water/AM-06 Deliverables/Chem stab memo figures, appendix, attachments/[Figure 2 Mine Pool U Concentrations.xlsx]

TABLE

Table 1
Mann Kendall Trend Analysis of the Mine Pool
Amendment 6 Comments - Physical and Chemical Stabilization of the Mine Pool

Location	Analyte	N	Detection Frequency (%)	Mann-Kendall (S)	COV	Probability	Confidence in Trend	Concentration Trend	Previous Trend
Raw Feed	Arsenic D	15	100	19	0.549	0.372	0.628	No Trend	Probably Increasing
Raw Feed	Arsenic T	14	86	10	0.558	0.622	0.378	No Trend	No Trend
Raw Feed	Iron D	15	100	44	0.717	0.03313	0.967	Increasing	Increasing
Raw Feed	Iron T	15	100	49	0.302	0.017531	0.98	Increasing	Increasing
Raw Feed	Manganese D	15	100	11	0.0656	0.618	0.382	No Trend	No Trend
Raw Feed	Manganese T	15	100	-13	0.0470	0.548	0.4520	Stable	No Trend
Raw Feed	Molybdenum D	14	100	48	0.329	0.009970	0.99	Increasing	Increasing
Raw Feed	Molybdenum T	13	100	43	0.363	0.010	0.9897	Increasing	Increasing
Raw Feed	Radium-226 D	7	100	1	0.276	0.500	0.500	No Trend	No Trend
Raw Feed	Radium-226 T	13	100	30	0.357	0.076	0.924	Probably Increasing	Increasing
Raw Feed	Radium-226; Radium-228 T	13	100	32	0.355	0.056	0.944	Probably Increasing	Increasing
Raw Feed	Radium-228 T	13	100	21	0.592	0.222	0.778	No Trend	No Trend
Raw Feed	Uranium D	15	100	37	0.1923	0.075	0.925	Probably Increasing	Increasing
Raw Feed	Uranium T	13	100	17	0.2202	0.328	0.672	No Trend	Probably Increasing

Notes:

COV - coefficient of variation calculated as the ratio of sample standard deviation to the sample mean.

Confidence in Trend is calculated as 1-Probability.

Mann-Kendall (S) = Mann-Kendall test statistic.

N = sample size.

NA = not analyzed due to < 50% detection frequency.

Probability = the probability of observing a Mann-Kendall test statistic as extreme as the one actually observed.

-- = not calculated due to < 50% detection frequency.

For sample sizes n ≤10, exact probability were obtained from Table A-12b (EPA, 2009).

ATTACHMENT A – OUTLIER TEST

	A	B	C	D	E	F	G	H	I
1					**Outlier Tests for Selected Uncensored Variables**				
2				**User Selected Options**					
3	Date/Time of Computation			ProUCL 5.18/20/2021 2:48:37 PM					
4				From File	WorkSheet.xls				
5				Full Precision	OFF				
6									
7									
8				**Rosner's Outlier Test for C0**					
9									
10									
11			**Mean**	**10.31**					
12			**Standard Deviation**	**8.709**					
13			**Number of data**	**109**					
14			**Number of suspected outliers**	**1**					
15									
16				Potential	Obs.	Test	Critical	Critical	
17	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)	
18	1	10.31	8.669	41.6	85	3.609	3.405	3.775	
19									
20	For 5% Significance Level, there is 1 Potential Outlier								
21	Potential outliers is: 41.6								
22									
23	For 1% Significance Level, there is no Potential Outlier								
24									

	A	B	C	D	E	F	G	H	I
1					**Outlier Tests for Selected Uncensored Variables**				
2				**User Selected Options**					
3	Date/Time of Computation			ProUCL 5.18/20/2021 2:52:12 PM					
4				From File	WorkSheet.xls				
5				Full Precision	OFF				
6									
7									
8				**Rosner's Outlier Test for C1**					
9									
10									
11			**Mean**	**10.02**					
12			**Standard Deviation**	**8.205**					
13			**Number of data**	**108**					
14			**Number of suspected outliers**	**1**					
15									
16				Potential	Obs.	Test	Critical	Critical	
17	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)	
18	1	10.02	8.167	39.8	82	3.646	3.402	3.772	
19									
20	For 5% Significance Level, there is 1 Potential Outlier								
21	Potential outliers is: 39.8								
22									
23	For 1% Significance Level, there is no Potential Outlier								
24									

	A	B	C	D	E	F	G	H	I
1					**Outlier Tests for Selected Uncensored Variables**				
2				**User Selected Options**					
3	Date/Time of Computation			ProUCL 5.18/20/2021 2:52:52 PM					
4				From File	WorkSheet.xls				
5				Full Precision	OFF				
6									
7									
8				**Rosner's Outlier Test for C2**					
9									
10									
11			**Mean**	**9.746**					
12			**Standard Deviation**	**7.715**					
13			**Number of data**	**107**					
14			**Number of suspected outliers**	**1**					
15									
16				Potential	Obs.	Test	Critical	Critical	
17	#	Mean	sd	outlier	Number	value	value (5%)	value (1%)	
18	1	9.746	7.679	38.8	83	3.784	3.4	3.77	
19									
20	For 5% Significance Level, there is 1 Potential Outlier								
21	Potential outliers is: 38.8								
22									
23	For 1% Significance Level, there is 1 Potential Outlier								
24	Potential outliers is: 38.8								
25									

Outlier Tests for Selected Uncensored Variables

User Selected Options	
Date/Time of Computation	ProUCL 5.18/20/2021 2:53:14 PM
From File	WorkSheet.xls
Full Precision	OFF

Rosner's Outlier Test for C3

Mean	9.472
Standard Deviation	7.209
Number of data	106
Number of suspected outliers	1

#	Mean	sd	Potential outlier	Obs. Number	Test value	Critical value (5%)	Critical value (1%)
1	9.472	7.175	33.7	82	3.377	3.397	3.767

For 5% Significance Level, there is no Potential Outlier

For 1% Significance Level, there is no Potential Outlier

Geosyntec consultants

5670 Greenwood Plaza Blvd
Suite 540
Greenwood Village, CO
PH 303-790-1340
www.geosyntec.com

Denver Water Comments

Attachment C

Technical Memorandum

Date:	September 14, 2021
To:	Nicole Poncelet, Denver Water Director of Water Quality and Treatment Team
From:	Emmy Apostol and Jonathan Gillen, P.E. (CO) - Geosyntec
Subject:	Schwartzwalder Mine Amendment 6 Comments – Water Treatment Plant Operational Costs
CC:	Jason Kerstiens, P.E. (CO) - Geosyntec

INTRODUCTION

Denver Water retained Geosyntec Consultants, Inc. (Geosyntec) to review and evaluate the Colorado Legacy Land, LLC (CLL) application for an amendment (Amendment 6) to the Division of Reclamation, Mining and Safety (DRMS) mine permit number M-1977-300. Permit M-1977-300 was issued by DRMS for the Schwartzwalder Mine, located in Golden, Colorado, and CLL is the current operator of the mine.

CLL indicates in the application that the purpose of Amendment 6 is to satisfy the conditions of the Succession of Operations letter dated February 20, 2018 and to "provide a conceptual site model, a plan addressing the physical and chemical stabilization of the mine pool, specifically addressing the concentrations of dissolved uranium and other constituents as required under the conditions of the permit, and updated reclamation and environmental protection plans. Provide a plan addressing the long-term cost of operating the water treatment plant and managing the mine pool, based on a minimum of 3 consecutive years of data which verify the physical and chemical stabilization of the mine pool."

This technical memorandum presents a summary of Geosyntec's comments on the amendment application, and specific comments regarding 1) requirements of the Hard Rock/Metal Mining

Rules (the Rules)[1], and 2) CLL schedule for long-term water treatment plan (WTP) operation and the chemical and physical stabilization of the mine pool.

SUMMARY OF AMENDMENT APPLICATION COMMENTS

Based on the information provided in Amendment 6, 20-years of operational costs will be inadequate to provide financial assurance for a reclamation strategy with no completion schedule. Actual operational costs associated with three years of operational data demonstrating the reclamation strategy to operate the WTP for six months per year with in-situ treatment needs to be provided for review.

Geosyntec provides the following overall comments:

- The Reclamation Plan (Exhibit E) is not written as a plan for reclamation activities, rather it summarizes activities that have been performed. Amendment 6 should incorporate the previously submitted plan material from Amendment 4 and be modified as needed based on the additional data collected. Due to this significant deficiency, it is impossible to compare Exhibit L costs to the current reclamation activities specifically related to the mine pool.
- The Reclamation Plan (Exhibit E) presented in Amendment 6 does not include a schedule for completion of reclamation and WTP operations. The duration for operating the WTP and performing in-situ treatments needs to be updated based on the data and information presented in Exhibit E.
- The Reclamation Costs (Exhibit L) does not sufficiently describe the basis used for durations and quantities for specific reclamation activities. For example, how was the cost for WTP decommissioning established, and why are there conflicting statements regarding the initial bonding periods (i.e., 10 and 20 years)?
- Based on the current data presented, there is no clear end date to cease pumping; therefore, no costs should be released for the "completion of 3 years of operation". Current reclamation estimates are insufficient to cover WTP operations and mine pool treatments if DRMS has to complete reclamation due to forfeiture.
- Three consecutive years of data are not provided to indicate physical or chemical stabilization in the mine pool; therefore, it is recommended that the "Denver Water Contingency", included in the original bond calculation, remain in the cost estimate. The

---

[1] Division of Reclamation, Mining and Safety, 2019. *Mineral Rules and Regulations of the Colorado Mined Land Reclamation Board for Hard Rock, Metal, and Designated Mining Operations*, effective July 15, 2019.

viability and operational costs should be demonstrated using the proposed operational strategy (operate the WTP for six months per year and continue in-situ treatments). In addition, the costs for

HARD ROCK/METAL MINING RULES

Geosyntec excerpted statements from the Hard Rock/Metal Mining Rule (in *italics*) and provided specific comments and recommendations on Amendment 6 (in plain text) as they relate to the Rules.

DRMS Hard Rock/Metal Mining Rule 3.1 states:

3.1.5 (11) Reclamation Measures – Materials Handling: No unauthorized release of pollutants to groundwater shall occur from any materials mined, handled, or disposed of within the permit area.

The current regulatory limit for water elevations within the mine pool is set at 150 feet below Steve Level Adit to achieve compliance with this rule and not allow a pollutant release. Based on the current reclamation plan, it appears that pumping will need to occur indefinitely; otherwise the pool will rise and discharge to groundwater and surface water.

3.1.7 (8) Groundwater – Specific Requirements: Release of Reclamation Liability: An operator shall demonstrate… that reclamation has been achieved so that existing and reasonably potential future uses of groundwater are protected.

It is unclear how long the remediation will occur and if decommissioning a WTP will affect the ability of the reclamation activities to protect future groundwater uses. The Reclamation Plan should be clarified to indicate the specific remaining reclamation/remediation activities, the corresponding schedule for those activities, and how those activities will protect against future releases. Based on the information provided, it is not clear whether the results obtained from monitoring current remediation efforts are indicative of expected results, or whether remediation activities or activity durations need to be changed or updated.

Furthermore, Amendment 4 indicated that in-situ treatment would achieve concentrations closer to 2.9 milligrams per liter (mg/L) to approach concentrations more comparable to background concentrations in the area; however, the concentrations currently present in the pool are around 14 mg/L. If the mine pool was ever allowed to rise past the regulatory limit, concentrations would need to be decreased to mitigate the potential for a pollutant release.

4.2.1 (4) Financial Warranty Liability Amount – Adequacy of Financial Warranties: The amount of the Financial Warranty shall be sufficient to assure the completion of reclamation of affected lands if the Office has to complete such reclamation due to forfeiture.

As previously described, the schedule for reclamation activities is unclear. For example, it is unclear how long the WTP will be required to operate. Based on the current information, it appears that WTP operation may be an indefinite requirement. Similarly, there may need to be additional financial assurance for updates to the plan affecting the duration and frequency of in-situ treatments.

Although indefinitely cannot be quantified in a reclamation cost, and as inferred by Rule 6.4.5, it is recommended that the reclamation costs (Exhibit L) be based on the confirmation of actual stages of reclamation, not based on the simple duration for which reclamation activities (or a simple portion of these reclamation activities) have been undertaken. For example, reclamation costs for operating the treatment plant could be reduced when the mine pool no longer poses a risk to future water resources. Based on available data, this requires a confirmed reduction in concentrations measured in the mine pool to below limit standards.

In addition, calculations for yearly costs are incorrect; Cotter Corporation, the previous owner/operator, estimated that maintenance for in-situ treatment would cost $85,000 for 2 years ($42,500 per year); however, Exhibit L estimates that in-situ treatment will only cost $139,760 over 7 years ($19,966 per year). Lastly, the assumptions for in-situ treatment indicate that CLL anticipates 5 additional injections before 2021 in reference to notes under "Mine Pool Sampling", but only 4 under the notes for chemical injections.

Furthermore, there is no statement or basis for the cost to demolish the water treatment plant ($30,000). This number should include module disposal costs and account for the radionuclides that will require special disposal.

As presented in Amendment 6, high concentrations of uranium are currently being measured in the mine pool[2], the observed trends indicate uranium concentrations are increasing over time between treatments (Figure E-3 in Amendment 6), and the recent data

[2] Total uranium measured at 14 mg/L on July 28, 2020.

indicate less effective results after in-situ treatment. For these reasons, a larger estimation of costs for in-situ treatment should be made by increasing the number of treatments needed over the time period and/or increasing the time period to achieve consistent target concentrations in the mine pool.

DRMS Hard Rock/Metal Mining Rule 6.4.5 Exhibit E – Reclamation Plan requires:

A description of how the Reclamation Plan will be implemented to meet each applicable requirement of Rule 3.1

The current reclamation plan in Amendment 6 appears to update information previously provided in Amendments 4 and 5. It describes the proposed reclamation approach of operating the WTP six months per year in combination with in-situ treatments, but it is unclear whether the cyclical decreases and subsequent increases in both mine water elevations and concentrations of uranium and molybdenum, shown in Figures E-1 and E-3 of Amendment 6, have leveled out. There is no demonstration that stabilization has definitively occurred, and no projected treatment timeline to allow for this to occur. Furthermore, there is no plan or schedule presented to address the long-term cost of operating the WTP.

It is recommended that Amendment 6 be updated to provide a plan to operate the WTP, including a schedule and specific milestones for the completion of operational activities. If the WTP is to continue to operate indefinitely, the plan should also incorporate the capital costs associated with replacement of the WTP based on a 20-year life span for a reverse osmosis plant to provide financial assurance for the full service-life of the WTP. Ultimately this plan should be used to address the "long-term costs" associated with the WTP.

A plan or schedule indicating how and when reclamation will be implemented. Such plan or schedule shall not be tied to any specific date but shall be tied to implementation or completion of different stages.

The current Reclamation Plan (Exhibit E) (in Amendment 6 and in the previous) describes the plan for different stages of remediation activities, however there is no description of how these stages individually achieve one or more of the reclamation conditions required by Rule 3.1. It appears CLL is seeking a release of financial warranty based on the time rather than achieving a condition required by Rule 3.1.

There is no discussion of an updated schedule for remaining work or anticipated durations of the remaining work. The only reference to durations for the remaining work appears to be in notes provided in Exhibit L which reference conflicting schedule durations such as 20 years for operation of the WTP, and 10 years for other aspects of the reclamation (such as in-situ treatment). It is not clear how these estimates were derived. If a reduction in time and/or money is being sought, the existing information does not support a conclusion that the "reclamation activities" will achieve a condition consistent with Rule 3.1 at the end of the reclamation period (which is not well defined).

MINE POOL CHEMICAL AND PHYSICAL STABILIZATION

Amendment 6 presents a reclamation plan that is "based on a minimum of 3 consecutive years of data which verify the physical and chemical stabilization of the mine pool". The cyclic nature of the operating strategy does not support stable conditions in the mine pool and therefore the costs for operating the WTP only six months out of the year may not be enough to support physical and chemical stabilization of the mine pool. Specific comments and recommendations for verifying the physical and chemical stabilization of the mine pool are, provided in Tech Memo# [3]. Comments on the timeframe for demonstrating physical and chemical stabilization are provided below:

- Physical stabilization – only one year of data are provided to indicate an inward hydraulic gradient is achieved under pumping conditions. In addition, physical stabilization under the proposed plan to operate the treatment plant six months of the year is only supported by one year of data, which were not updated to include the timeframe during the submittal of Amendment 6. In addition, the data include some potentially concerning assumptions such as the transducer recalibration and projecting the data trends over the final months. The previous two years of data support that the plant could be turned off for approximately four months (12/20/2019 – 4/18/2020) and two months (3/22/2019 – 5/15/2019). It is recommended that at least three years of data be provided demonstrating physical stabilization of the mine pool with the WTP turned off for the full six-month period, without data concerns or major issues. It is also requested that the real costs to operate the WTP under this plan be provided to support the Exhibit L Reclamation Costs.
- Chemical stabilization – Concentration trends for water samples collected from the mine pool do not demonstrate its chemical stability. Although in-situ treatment often helps to decrease uranium concentrations on a temporary basis, the upward trend of uranium concentrations appears to resume after each treatment, and uranium concentrations did not decline after the most recent in situ treatment. It is recommended that at least three years

[3] Geosyntec, 2021. *Schwartzwalder Mine Amendment 6 Comments – Physical and Chemical Stabilization of the Mine Pool*, August 23.

of data be provided that do not indicate increasing trends but rather indicate statistically significant stable concentration trends in the mine pool prior to approving a decrease in reclamation costs for in-situ treatment.

* * *

Table 1
Recommendation Summary Table
Amendment 6 Comments

Item Number	Topic	General Comment	Comment Detail	Recommended Action Item
1	CSM	Conceptual Site Model (CSM) is "preliminary" and does not include recent data (2018 - present).	The CSM provided with Amendment 6 is described as "preliminary" and has not been updated since 2018. Denver Water .and Geosyntec acknowledge that CLL has accomplished several reclamation tasks and collected additional data in this period, which will impact the CSM	Incorporate data collected and work performed since 2018 into the CSM.
2	CSM	The CSM contains a list of data gaps without a plan for addressing data gaps.	The CSM includes three pages of "data issues" to be addressed. CLL does not indicate the status of the data gaps or a plan for how they will be addressed.	Develop and present a plan to address the data gaps outlined in the CSM, especially with regard to the characterization and monitoring of the hydraulic gradient around the mine pool.
3	CSM	The CSM provided in Appendix 1 of Amendment 6 is more characteristic of the *Baseline CSM Stage* as described by USEPA guidance[1]. Based on the Reclamation Plan in Exhibit E, the CSM should be updated and revised to meet the criteria of the *Remediation/Mitigation CSM Stage* .	According to USEPA guidance, a more detailed diagram and description depicting geologic, hydrogeologic, chemical information, and fate and transport processes, in support of remedy design are necessary to assist key stakeholders (including Denver Water) in understanding complex site information. A CSM should also identify and characterize all contaminant sources, including the mine pool and potential migration pathways through faults/fractures (such as the Illinois Fault) or bedrock groundwater. A more robust CSM will also increase confidence that the Reclamation Plan will ensure protectiveness of the environment, effectively manage resources, and limit the environmental footprint of site cleanup activities[1].	Update and revise the CSM to USEPA's Remediation/Mitigation CSM Stage and the ASTM Standard for Developing Conceptual Site Models[2]. See specific recommendations in CSM memo.
4	CSM	More data is necessary to demonstrate the established regulatory limit of 150 feet below Steve Level Adit.	The established regulatory limit of 150 feet below Steve Level Adit was approved by DRMS during the Amendment 4 Adequacy Review process in lieu of a limit of 500 ft below the Steve Level. The technical basis for this was that the shallower limit minimizes the oxidation of uranium in the mine workings and lowers the mine pool to an elevation of approximately 63 ft below Ralston Creek in the permit area to prevent flow from the mine pool towards the creek. Data provided on hydraulic gradients indicates that a lower level would establish a stronger hydraulic gradient to ensure protection of Ralston Creek. The data also indicates that oxidation of uranium may be occuring during the cyclical nature of the oeprating strategy.	Install a bedrock groundwater monitoring well downgradient of the mine pool. Collect additional data on hydraulic gradients at different mine water levels and develop potentiometric surface diagrams at different levels. Collect data on uranium concentrations and oxidizing conditions through indicator paratmeters such as dissolved oxygen, oxidation reduction potential, and total organic carbon, in the mine pool on a monthly basis including when the mine pool is refilling.
5	Physical Stabilization of the Mine Pool	Water levels in the mine pool are measured by a single transducer. The transducer and pump in the mine pool are infrequently inspected and calibrated.	In the Reclamation Plan, CLL describes an event where the transducer measuring mine pool levels was recording inaccurate readings, which was only verified by a team physically entering the mine. Reliance on a single measurement from a single piece of equipment to make decisions for dewater operations is inherently risky.	Submit a monitoring contingency plan describing inspection and maintenance procedures for the mine pool pump and transducer. Install a secondary backup transducer to confirm water level readings and in case of a malfunction of the primary transducer.
6	Physical Stabilization of the Mine Pool	CLL does not provide sufficient data to assert that physical stabilization of the mine pool has occurred.	CLL uses only two bedrock monitoring wells, one of which only has three data points dating back to Q2 2020. This does not demonstrate physical stabilization of the mine pool for the last three consecutive years, as required by the SO-1 approval letter.	Continue collecting bedrock groundwater data. Consider installation of additional bedrock wells to further refine CSM.
7	Chemical Stabilization of the Mine Pool	CLL has not described the effect of injecting the reverse osmosis (RO) concentrate from the water treatment plant (WTP) back into the mine pool.	The addition of concentrated brine to the mine pool may significantly affect the geochemical behavior of uranium and other constituents of concern. It is unclear how the brine affects in-situ treatment performance.	Demonstrate that the addition of RO concentrate to the mine pool will not negatively impact on-going in-situ treatment.
8	Chemical Stabilization of the Mine Pool	RO concentrate mixed with various additives is used during in-situ treatment to increase solution density and deliver carbon to the mine pool.	This information is a critical component of the in-situ uranium bioremediation process and should be included in Exhibit E as well as the reclamation cost tables in Exhibit L.	Provide additional operational details for the generation and injection of backfill slurry.
9	Chemical Stabilization of the Mine Pool	Uranium concentrations did not significantly decrease after the 2020 in-situ treatment event.	Other than identifying speculative reasons for why the latest in-situ treatment was not successful, CLL offers no solutions or changes to their current treatment strategy to resolve these issues. Geosyntec provides recommendations for additional sampling and characterization of mine pool constituents to better understand factors influencing uranium concentrations.	Develop and present a plan to characterize the factors influence uranium concentrations during in-situ treatment. See specific recommendations in Mine Pool Stabilization memo. A contingency should also be developed and presented in the event that in-situ treatments are no longer effective.
10	Chemical Stabilization of the Mine Pool	CLL identifies a possible labelling error as an explanation for elevated uranium concentrations in the months preceding the 2017 in-situ treatment.	It is unlikely that 10 samples collected over multiple sampling events were incorrectly labeled. If this is the case, sampling quality assurance/quality control (QA/QC) procedures need to be evaluated and reconsidered.	Develop a QA/QC plan and sampling plan to collect high quality data reliably.
11	Tracer Test	Data do not prove CLL's conclusions of the tracer test that the mine pool is fully mixed.	The water in the mine pool (i.e., the various levels of saturated laterals) may not be thoroughly mixed; the tracer may have transported downward. The bulk of the 25 pounds of injected rhodamine tracer (with a density 30% greater than water0F), may have sunk to the bottom of Shaft #2 (~2,000 ft deep) and may not have been accessible by pumping from the Jeffrey Shaft (1,100 ft deep).	Additional sampling and analysis of tracer dyes in bedrock and alluvial groundwater and surface water from Ralston Creek would provide more informative data indicating that no mine pool water is leaving the mine.
12	Updated Environmental Protection Plan (EPP)	CLL does not monitor for total carbon or organic carbon.	No data are presented in Amendment 6 or elsewhere showing how much organic carbon is present in the mine pool, and it is unclear how the amount of carbon added during in-situ treatment is determined.	Explain how carbon dosing volumes are determined during in-situ treatment. Update the EPP in Exhibit U to include total carbon to the list of mine pool analytes.
13	Reclamation Costs	The Reclamation Plan (Exhibit E) is not written as a plan for reclamation activities, rather it summarizes those activities that have been performed.	It is difficult to compare Exhibit L Reclamation Costs with the current reclamation activities specifically related to the mine pool. The Reclamation Plan also does not include a schedule for completion of reclamation and WTP operations nor does CLL sufficiently describe the bases used for durations and quantities for specific reclamation activities.	Incorporate previously submitted material from Amendment 4 in the Reclamation Costs and modify as needed based on WTP operational costs and other data that have been collected. Provide description and justification for all assumptions used for costing.
14	Reclamation Costs	Based on the current data presented, there is no clear end date to cease pumping. CLL has also not established that the mine pool is physically or chemically stable.	Because there is no timeline to cease pumping, no costs should be released for the "completion of 3 years of operation". Geosyntec does not believe that the current reclamation costs are enough to cover WTP operations and mine pool treatments if the Division has to complete reclamation due to forfeiture.	Develop a long-term plan for operation of the mine pool pump and water treatment plant in the Reclamation Plan and establish a clear reclamation schedule and timeline