South Railroad Project Antidegradation Alternative Analysis and Socioeconomic Impacts

National Pollutant Discharge Elimination System Draft Permit (NV0024267)

Prepared for

Gold Standard Ventures (US) Inc.
Elko, Nevada

Prepared by

LOUGHLIN
WATER ASSOCIATES LLC
a Geo-Logic Company

3100 Pinebrook Road, Suite 1100
Park City, Utah 84098
www.LoughlinWater.com

August 18, 2026

Report Preparation

Prepared for:

Equinox Gold Corp.
Gold Standard Ventures (US) Inc.
2320 Last Chance Road
Elko, NV, 89801

Prepared by:

Rachael Peavler, P.G., PMP, Principal Hydrogeologist

Reviewed by:

Stan Smith, P.G., Senior Hydrogeologist and Geochemist

George Fennemore, Ph.D., Permitting Specialist

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Executive Summary

Gold Standard Ventures (US) Inc. (GSV), a wholly owned subsidiary of Equinox Gold Corp., has applied for a National Pollutant Discharge Elimination System (NPDES) permit for the South Railroad Project (the Project), a proposed open-pit gold mine in Elko County, Nevada. Mining the Dark Star pits below the groundwater table will require dewatering to maintain safe operating conditions. Water that cannot be reused by the Project would be treated and discharged through Outfall 001 to an unnamed tributary of Dixie Creek.

Because the proposed discharge would be new to waters of the State, the Nevada Division of Environmental Protection Bureau of Water Pollution Control (NDEP-BWPC) must evaluate it under Nevada's antidegradation requirements. NDEP's draft permit evaluation identified arsenic, antimony, iron, manganese, thallium, fluoride, and sulfate as potential constituents of concern. The proposed coagulation-assisted filtration system is expected to effectively treat arsenic and other metals but would not substantially reduce sulfate or fluoride.

This report evaluates practicable alternatives for avoiding or minimizing potential receiving-water quality effects while meeting the Project's dewatering and operational requirements.

The alternatives considered included:

- Supplemental water-treatment technologies;
- Alternative discharge locations and mixing approaches;
- Rapid infiltration basins;
- Increased operational reuse;
- Seasonal or controlled discharge;
- Land application; and
- A no-discharge alternative.

Alternatives relying on downstream dilution, rapid infiltration, seasonal storage, land application, operational reuse alone, or no discharge were eliminated because they could not reliably manage the anticipated dewatering volume, consistently achieve water-quality objectives, or function as practical standalone solutions under site-specific hydrologic, operational, and permitting conditions.

Four treatment alternatives were evaluated in detail:

1. The proposed coagulation-assisted filtration system;
2. Partial-stream reverse osmosis;
3. Partial-stream ion exchange; and
4. Barite precipitation.

Each alternative was evaluated for treatment performance, environmental effects, cost, operational complexity, safety, residual-waste management, permitting and schedule risk, and consistency with Project objectives.

Reverse osmosis and ion exchange could further reduce sulfate, but would generate concentrated brine requiring disposal or evaporation, increase energy use and operational complexity, create long-term waste-management obligations, and add substantial capital and recurring costs. Barite precipitation would also reduce sulfate but could increase chloride and total dissolved solids, require residual barium control, and add reagent-handling and solids-management requirements.

These supplemental systems would therefore create substantial environmental, operational, and economic tradeoffs for a relatively limited improvement in water quality. Groundwater sulfate concentrations are only modestly above the draft Tier 2/RMHQ-based permit limit and remain well below the next most restrictive standard established to protect designated beneficial uses.

<u>Based on the multiple accounts analysis, the proposed coagulation-assisted filtration system is the preferred alternative.</u> It would reliably treat the metals of concern while avoiding the concentrated waste streams, long-term disposal requirements, increased environmental footprint, and substantial costs associated with supplemental sulfate treatment. Overall, it provides the best balance of water-quality protection, technical feasibility, economic achievability, operational safety, permitting certainty, and consistency with Project objectives.

The South Railroad Project is expected to provide substantial employment, income, tax revenue, and mineral-production benefits to Elko County and Nevada. Approval of the proposed discharge, subject to appropriate permit limits and treatment requirements, would allow these benefits to be realized while protecting applicable water-quality standards and designated beneficial uses.

1. Introduction

Gold Standard Ventures (US) Inc. (GSV), a wholly owned subsidiary of Equinox Gold Corp., has applied for a National Pollutant Discharge Elimination System (NPDES) permit in support of the South Railroad Mine Project (Project), a proposed open-pit gold mining operation located in Elko County, Nevada, approximately 17 miles south of Carlin and 25 miles southwest of Elko (Figure 1).

To facilitate mining below the existing groundwater table, GSV proposes to dewater the mine area and discharge excess groundwater to an unnamed tributary of Dixie Creek through Outfall 001 (Figure 2). The NPDES application, submitted to the Nevada Division of Environmental Protection Bureau of Water Pollution Control (NDEP-BWPC) in September 2026, requested authorization to discharge excess dewatering water following treatment using a coagulation-assisted filtration system consisting of chemical precipitation, ultrafiltration, pH adjustment, and cooling. The NPDES application was supported by studies and design documents describing Project hydrogeology, source water quality, receiving-water conditions, and the proposed water treatment system.

Because the proposed discharge represents a new point source discharge to waters of the State, the Project is subject to Nevada's antidegradation review requirements. As part of that review, NDEP-BWPC developed draft permit limits for Tier 1 and Tier 2 parameters based on applicable water quality standards or interim baseline values (IBVs), which are calculated as the 95th percentile of the available receiving-water dataset. The regulatory framework, data, statistical analysis, and results that contributed to the draft permit limits are presented in further detail in Section 2 of this report.

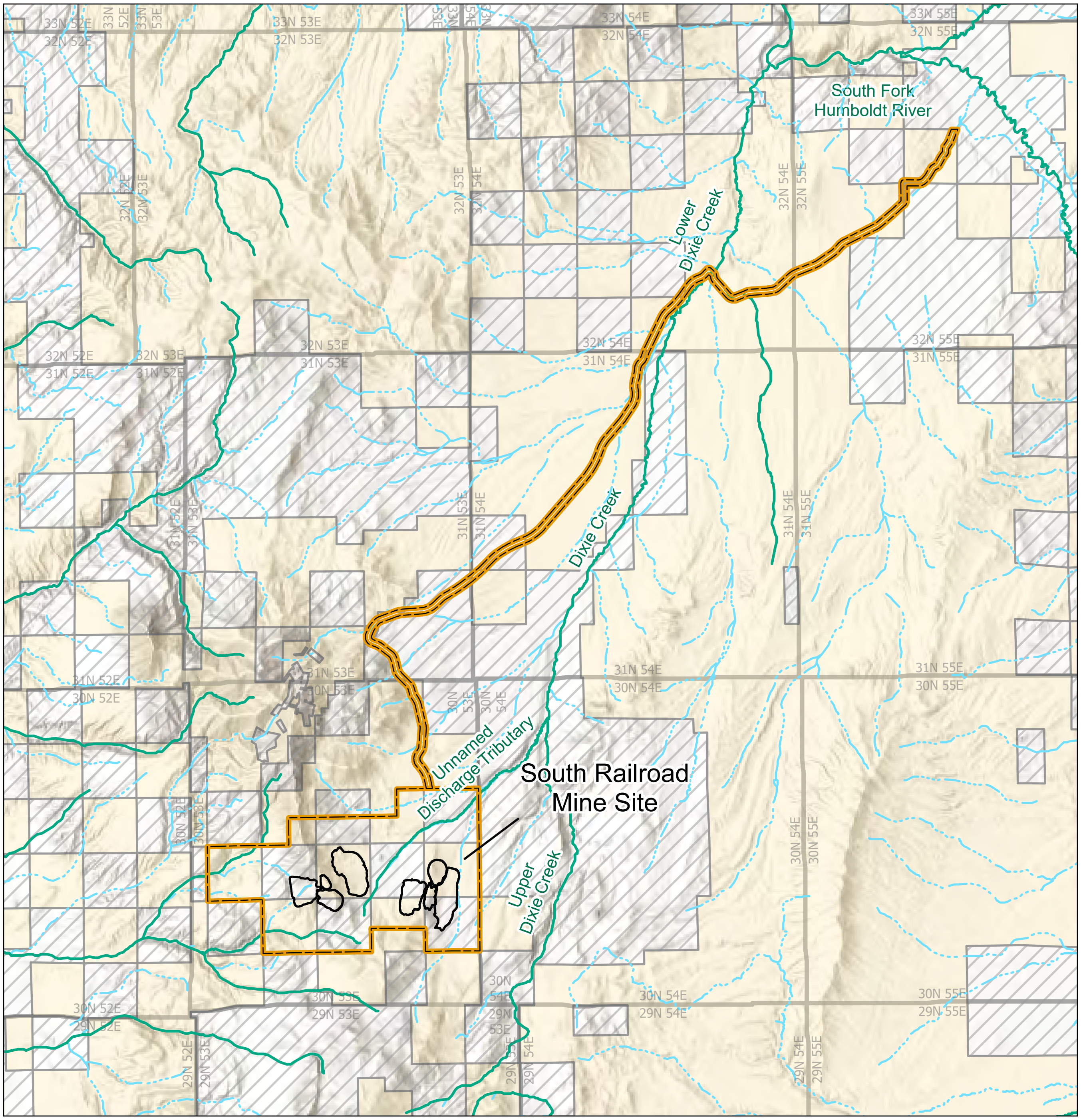
The draft permit limits are the primary driver for this alternatives analysis. Several of the draft permit limits, particularly for dissolved constituents that are not substantially reduced by the proposed coagulation-assisted filtration treatment system, may require substantial treatment design modifications or supplemental treatment technologies. As a result, a range of treatment and discharge-management alternatives was identified for evaluation in accordance with Nevada's antidegradation requirements as presented in Section 3 of this report.

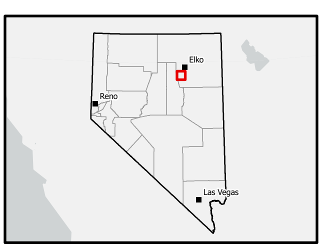
The alternatives analysis presented in Section 4 of this report is intended to provide a transparent, objective, and defensible evaluation of the identified alternatives. The analysis is not intended to presume that an alternative treatment technology or discharge-management approach is preferable to the proposed Project configuration. Rather, the evaluation is structured to systematically compare the proposed coagulation-assisted filtration treatment system and identified alternatives using a consistent set of considerations to determine whether a technologically feasible and economically achievable alternative exists that would avoid or reduce degradation of receiving-water quality while meeting Project objectives.

To support a transparent and repeatable comparison of alternatives, the evaluation framework incorporates principles of multiple accounts analysis (MAA). MAA is a structured decision-making approach commonly used to compare alternatives across multiple disciplines using clearly defined evaluation criteria. The approach provides a documented basis for evaluating tradeoffs among alternatives and identifying preferred options while minimizing subjective bias.

The analysis begins with a fatal-flaw screening to identify alternatives that cannot reasonably satisfy Project requirements or regulatory objectives. Alternatives that pass the screening are then evaluated using a consistent framework that considers technical, environmental, economic, and social factors. The results of that evaluation are used to compare alternatives and identify a preferred alternative. This approach ensures that all viable alternatives, including the proposed coagulation-assisted filtration treatment system, are evaluated using the same criteria and decision framework.

This report presents the alternatives analysis for the proposed discharge from the Project. The analysis is intended to support NDEP-BWPC and State Environmental Commission (SEC) review under Nevada’s antidegradation requirements and to provide a transparent record of the basis used to evaluate alternatives and identify the preferred approach for management of excess dewatering water.





Legend

- Project Boundary
- Conceptual Mine Facilities
- Public Land
- Private Land
- Named NHD Streams
- Unnamed NHD Streams

0 7,500 15,000 Feet

(At original document size of 8.5x11)
1 inch = 15,000 Feet

N

Stantec

Project Location
T30N, R53E
Elko County, NV

Prepared by IMH on 8/28/2025
TR by HE on 8/28/2025
IR by SS on 8/28/2025

Client/Project
203724511
Gold Standard Ventures (US) Inc.
South Railroad Project
NPDES Permit Application

Figure No.
1

Title
Site Overview

Notes
1.Coordinate System: NAD 1927 UTM Zone 11N
2. Data Sources: Stantec Inc. and Gold Standard Ventures (US) Inc.
3. Background:Esri, NASA, NGA, USGS, Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

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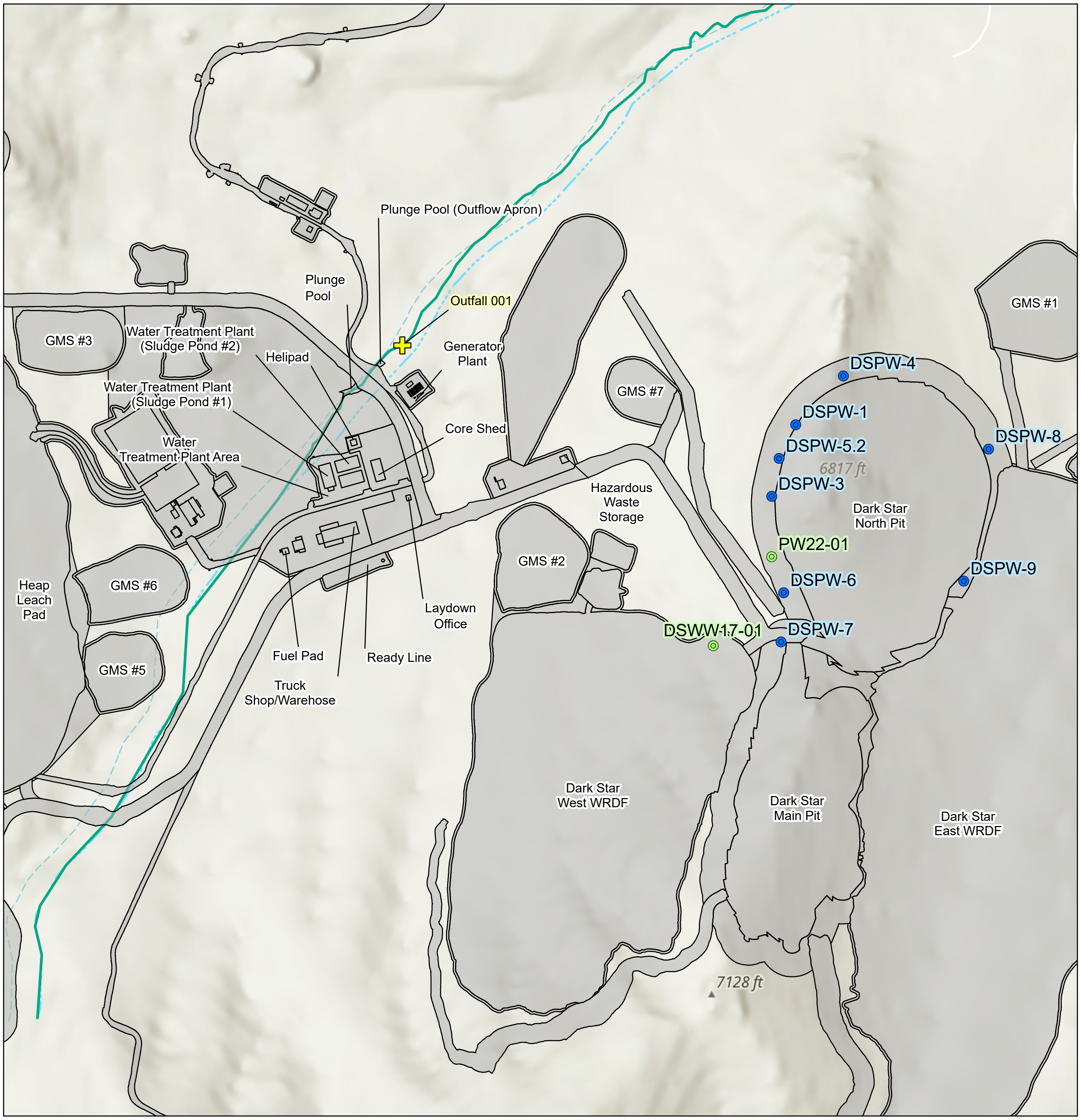

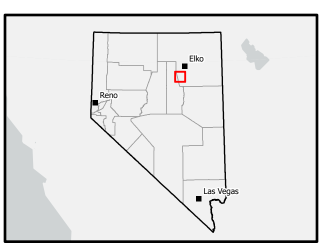

Notes
1. Coordinate System: NAD 1927 UTM Zone 11N
2. Data Sources: Stantec Inc. and Gold Standard Ventures (US) Inc.
3. Background: Esri, NASA, NGA, USGS, FEMA, Sources: Esri, TomTom, Garmin, FAO, NOAA, USGS, © OpenStreetMap contributors, and the GIS User Community

Legend
- Project Boundary
- Conceptual Mine Facilities
- Discharge Point
- Unnamed NHD Streams
- Named NHD Streams
- Existing Water Supply Well Locations
- Proposed Water Supply Well Locations

0 650 1,300 Feet
(At original document size of 8.5x11)
1 inch = 1,300 Feet

N

Stantec

Project Location
T30N, R53E
Elko County, NV

Prepared by IMH on 8/28/2025
TR by HE on 8/28/2025
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Client/Project
203724511
Gold Standard Ventures (US) Inc.
South Railroad Project
NPDES Permit Application

Figure No.
2

Title
Proposed Outfall Location

1.1 Project Summary

The Project is in the Piñon Range at elevations ranging from 6,600 to 7,100 feet above mean sea level. The Project involves the extraction of mined material, including heap leach ore and waste rock, using conventional open pit mining methods such as drilling, blasting, loading, and hauling. A total of four pits is proposed: Pinion North, Pinion Main, Dark Star North, and Dark Star Main. Ore will be transported to crushing, conveying, and stacking facilities or directly to the heap leach pad (HLP) as run-of-mine (ROM) material. Ore will be stacked on the HLP and leached with a weak cyanide solution. The resulting pregnant leach solution will be processed through an adsorption-desorption-recovery (ADR) plant, and the final doré product will be shipped off site for refining.

1.2 Project Discharge Basis

The Project discharge basis reflects the dewatering rates, operational water demands, and proposed treatment approach presented in the NPDES application. These elements define the volume of excess groundwater requiring management and provide the project-specific context for evaluating alternatives to the proposed discharge.

1.2.1 Dewatering Rates and Discharge Timing

The NPDES permit application requested authorization to discharge excess dewatering water for up to five years based on the modeled timing and magnitude of groundwater inflows to the Dark Star pits. Dewatering would be accomplished using wells in the Dark Star area drilled to approximately 1,000 feet below ground surface. Aquifer testing and numerical groundwater modeling indicate that up to nine wells could be required. During the first four years of dewatering, projected withdrawal rates range from approximately 2,089 to 2,235 gallons per minute (gpm). For permitting purposes, the application requested an average daily discharge rate of 2,300 gpm and a maximum daily discharge rate of 2,400 gpm. The draft NPDES permit establishes corresponding flow limitations for Outfall 001 of 3.31 million gallons per day (MGD) as a 30-day average and 3.46 MGD as a daily maximum.

The timing and rate of discharge are important to this alternatives analysis because excess dewatering water would be generated based on mine water-management needs, while receiving-water flow in the unnamed tributary and Dixie Creek varies seasonally and can be limited during low-flow periods. Alternatives that rely on timing discharge to coincide with higher receiving-water flows, reducing discharge volume through operational reuse, or receiving-water dilution must therefore be evaluated in relation to both projected dewatering rates and receiving-water hydrology.

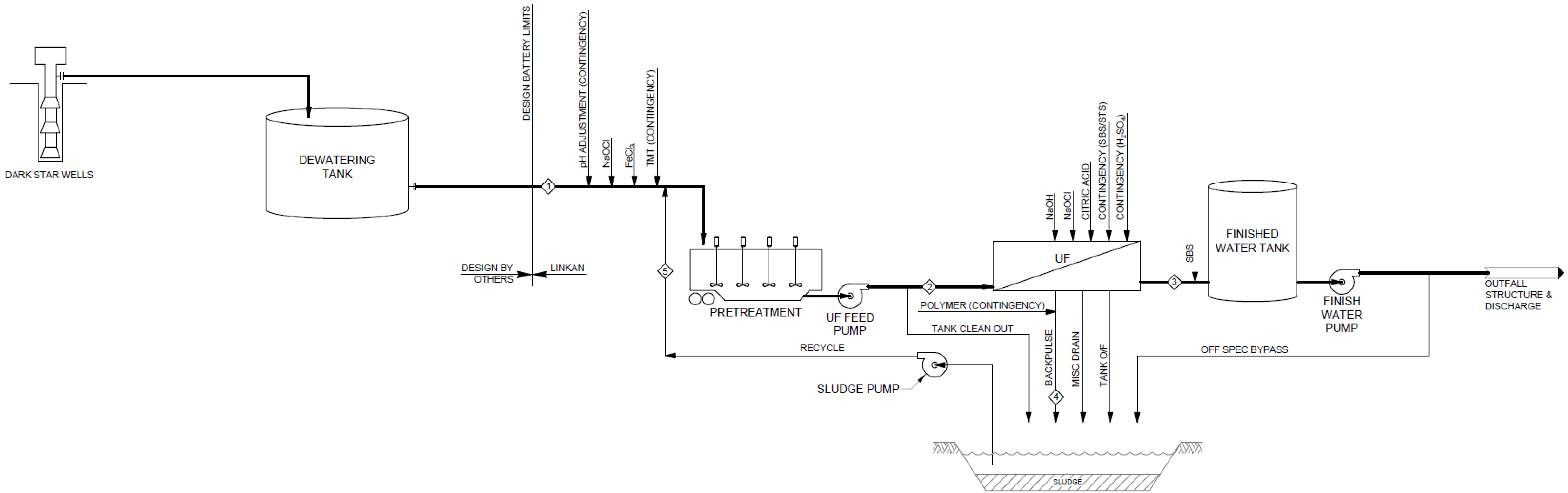
1.2.2 Proposed Base Treatment: Coagulation-Assisted Filtration

The proposed base treatment system is a coagulation-assisted filtration process developed from bench-scale testing completed by Linkan in 2020 and further described in the *South Railroad Mine Water Treatment Plant* design package (Linkan, 2025). Coagulation-assisted filtration was selected for the NPDES application because it demonstrated effective removal of metals and suspended solids while avoiding the liquid brine waste stream, larger footprint, and greater operational complexity associated with membrane-based treatment alternatives evaluated at that time.

The proposed coagulation-assisted filtration process flow diagram is shown in Figure 3. The treatment train includes sodium hypochlorite addition for oxidation, ferric chloride addition for coagulation, reaction tanks for mixing and contact time, ultrafiltration to remove suspended solids and precipitated metals, pH adjustment, residual chlorine neutralization using a reducing agent such as sodium bisulfite or sodium thiosulfate, and evaporative cooling prior to discharge. The system also includes contingency chemical addition, including TMT-15 for selected trace metals if needed. Following treatment via the coagulation-assisted filtration process, treated water would be cooled, as required, using evaporation towers to lower the temperature to or below 20 degrees Celsius (°C).

Residual solids and backwash streams from the treatment system would be routed to lined sludge ponds, where solids would settle and clarified water would be recycled to the front of the treatment system for reprocessing. The design package also includes containment features for process fluids and chemicals, including secondary containment for bulk chemical tanks, containment for tote chemicals, and a lined process area connected to the sludge ponds.

For purposes of this alternatives analysis, coagulation-assisted filtration is retained as the proposed base case treatment system against which other alternatives are compared. Coagulation-assisted filtration is primarily intended to remove arsenic, antimony, iron, manganese, suspended solids, and selected trace metals. Supplemental treatment alternatives are evaluated because several draft permit limits apply to dissolved constituents, including sulfate, total dissolved solids (TDS), and fluoride, that are not expected to be substantially reduced by coagulation-assisted filtration.



MASS BALANCE

DESIGN

STREAM TAG	1	2	3	4	5
PROCESS PARAMETERS	INLET	UF FEED (with 10% XR)	UF FILTRATE	UF BACKPULSE (ASBW)	RECYCLE
DESIGN FLOW (INSTANTANEOUS), GPM	1,705	1,984	1,705	528	99
DESIGN FLOW, GPD	2,455,200	2,857,418	2,455,200	142,453	142,453
TOTAL SUSPENDED SOLIDS, MG/L	10	9	-	379	10
TOTAL SUSPENDED SOLIDS, DRY LB/DAY	204	204	-	204	12
SERVICE FACTOR, HR/DAY	24.0	22.8		1.20	24.0

MAX

STREAM TAG	1	2	3	4	5
PROCESS PARAMETERS	INLET	UF FEED (with 10% XR)	UF FILTRATE	UF BACKPULSE (ASBW)	RECYCLE
DESIGN FLOW (INSTANTANEOUS), GPM	2,400	2,793	2,400	528	139
DESIGN FLOW, GPD	3,456,000	4,022,172	3,456,000	200,520	200,520
TOTAL SUSPENDED SOLIDS, MG/L	10	9	-	379	10
TOTAL SUSPENDED SOLIDS, KG/DAY	288	288	-	288	17
SERVICE FACTOR (HR/DAY)	24.0	22.25		1.75	24.0

Figure 3. Proposed Coagulation-Assisted Filtration Process Flow Diagram

2. Existing Conditions

Existing conditions were characterized through a combination of surface water quality, flow, and groundwater monitoring from 2018 through 2024, with emphasis on the unnamed tributary to Dixie Creek and Dixie Creek as receiving-water conditions and groundwater as the source proposed for discharge. Data were used to characterize baseline water quality conditions, develop IBVs, determine tier levels, and establish pollutants of concern.

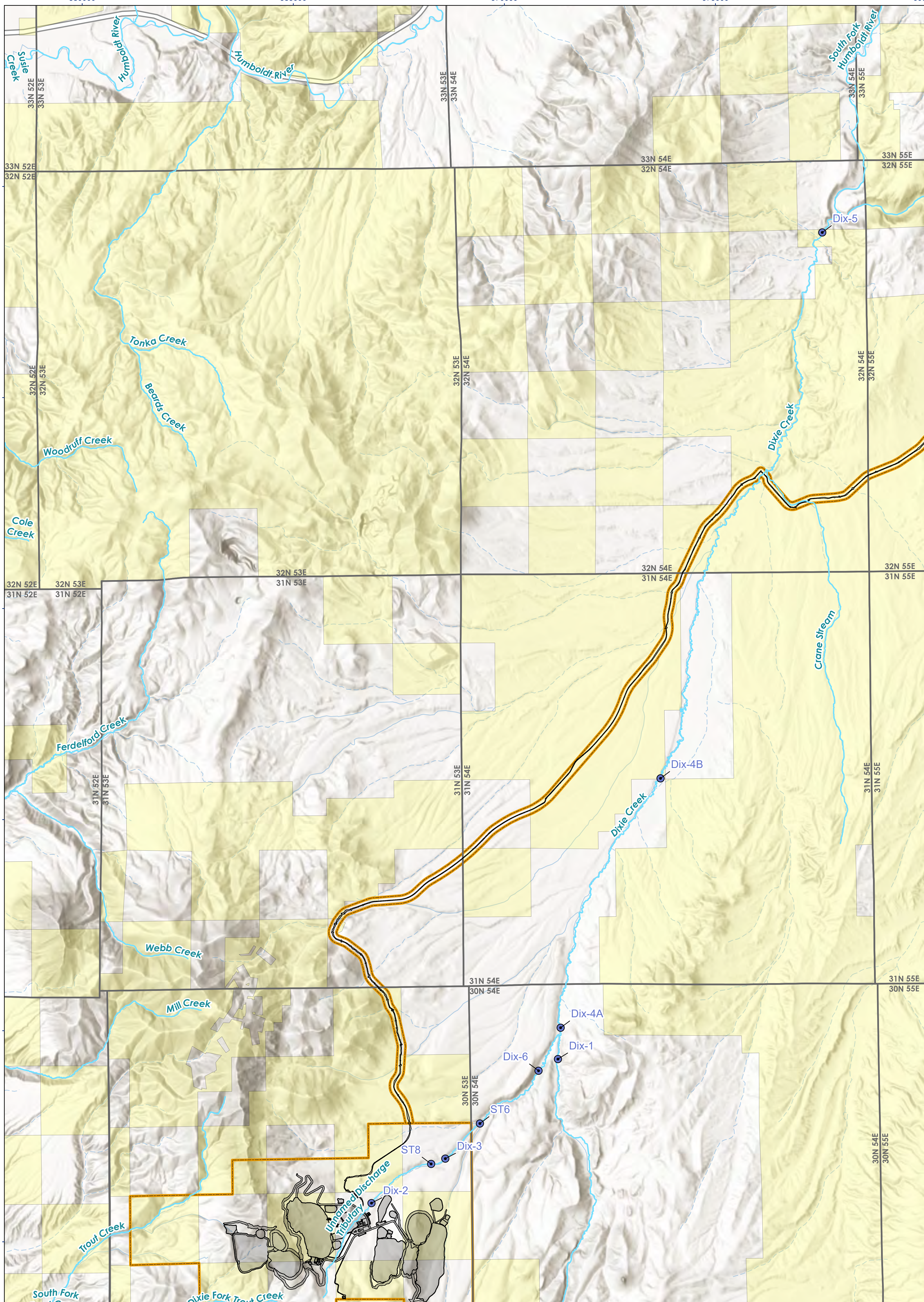
2.1 Hydrologic Setting

The proposed discharge would occur in the upper portion of an unnamed tributary to Dixie Creek, upstream of the reach where perennial flow is established. The receiving-water setting, including the proposed outfall, unnamed tributary, Dixie Creek, and downstream South Fork Humboldt River, is shown on Figure 4.

Project-specific monitoring has been conducted to characterize flow and water quality conditions in the unnamed tributary and Dixie Creek, including periodic flow measurements and water quality sampling, and continuous stage and temperature monitoring at selected locations. The surface-water monitoring network and key hydrologic features, including the proposed outfall, Dix-2, Dix-3, SP4, and the approximate transition from intermittent to perennial flow, are shown on Figure 4.

The unnamed tributary and Dixie Creek are characterized by strong seasonal variability. The upper unnamed tributary near the proposed outfall is dry during baseflow conditions and carries water only in response to spring runoff and storm events. Perennial flow begins downstream where groundwater discharges to the channel near monitoring location SP4. Downstream of this groundwater-discharge area, baseflow is sustained by groundwater inputs from springs, seeps, and gaining conditions until between monitoring station Dix-4A and Dix-4B, where Dixie Creek transitions to a losing reach with intermittent flow reaching South Fork Humboldt River. Data from Dixie Creek monitoring show a seasonal pattern of higher flows during spring runoff followed by lower groundwater-supported baseflow conditions, as shown on Figure 5. The observed flow conditions provide context for evaluating the proposed discharge and the alternatives considered in this analysis.

This hydrologic conceptual model is important for interpreting both flow and water quality conditions. Because perennial flow is largely supported by groundwater discharge during baseflow conditions, water quality in Dixie Creek and the unnamed tributary reflects the chemistry of groundwater discharging to the surface. Monitoring results are consistent with this conceptual model, showing that groundwater source water and receiving-water samples have generally similar major ion and trace-constituent chemistry, as discussed further in Section 2.3.1.2.



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Legend

Surface Water Monitoring Locations

- Stream Monitoring
- Proposed Mine Facilities
- Mine Permit Area
- BLM Land

N

1:90,000

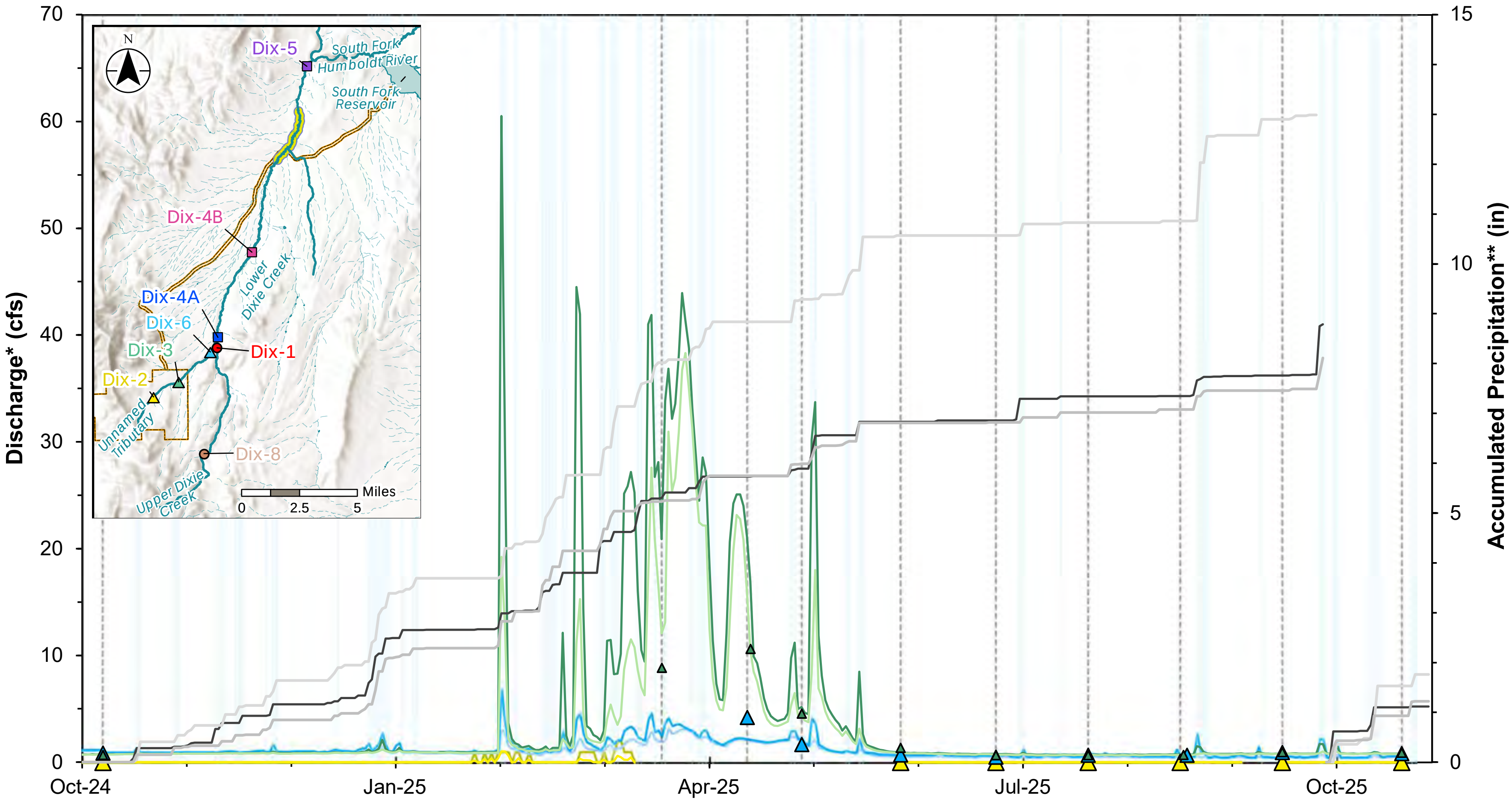
0 4,700 9,400 Feet

Gold Standard Ventures (US) Inc.
South Railroad Project

T30N, R53E Elko County, NV
NAD 1983 UTM Zone 11N

DRAWN BY: SS	1ST REVIEW: SS	2ND REVIEW: RP
DATE: 7/31/2026	PROJECT NO: 182924526	

Figure 4
Dixie Creek Monitoring Locations



Legend:

- Spring Creek Precip. Accumulation**
- Elko Regional Airport Precip. Accumulation**
- Pine Valley Precip. Accumulation**
- Date with Precip >0.1 inch**
- Monitoring Visit
- Dix-2 Max. Daily Discharge*†
- Dix-2 Avg. Daily Discharge*†
- Dix-2 Manual Discharge Meas.*†
- Dix-3 Max. Daily Discharge*
- Dix-3 Avg. Daily Discharge*
- Dix-3 Manual Discharge Meas.*
- Dix-6 Max. Daily Discharge*
- Dix-6 Avg. Daily Discharge*
- Dix-6 Manual Discharge Meas.*

Notes:

*Discharge measurements estimated from pressure transducer data and provide an estimate only.

† No data collected at Dix-2 between March 12 - May 30, 2025 and from Sep 7-18, 2025 due to datalogger battery failure.

**Climate Data Source: (NCEI-NOAA, 2023; NOAA, 2025)

PINE VALLEY CARLIN 20S, NV US USC00266242; Elevation: 5176 ft. Latitude: 40.4369° N Longitude: -116.1190° W

ELKO REGIONAL AIRPORT, NV US USW00024121; Elevation: 5030 ft. Latitude: 40.8288° N Longitude: -115.7886° W

SPRING CREEK 1.3 NNE, NV US US1NVEL0025; Elevation: 5498 ft. Latitude: 40.7552° N Longitude: -115.584° W

Stantec

Gold Standard Ventures (US) Inc.

2025 Dixie Creek Monitoring Report

DRAWN BY: NS	PROJECT: Dixie Creek Baseline Monitoring
1ST REVIEW: SS	PROJECT NO: 203724511
2ND REVIEW: RP	DATE: 01/27/2026

Figure 5

Dixie Creek Seasonal Patterns

2.2 Receiving Water (Dixie Creek and Unnamed Tributary)

This section summarizes applicable water quality standards, beneficial uses, and baseline water quality conditions for the unnamed tributary and Dixie Creek. The discussion provides the regulatory and monitoring context for evaluating the proposed discharge and the alternatives identified in Section 3.

2.2.1 Applicable Water Quality Standards and Beneficial Uses

Applicable water quality standards for the unnamed tributary to Dixie Creek and downstream receiving waters are established by NDEP pursuant to the Clean Water Act and Nevada Administrative Code (NAC). This section summarizes those standards, designated beneficial uses, existing impairment listings and total maximum daily loads (TMDLs), and the antidegradation tier determinations applied in the draft NPDES permit.

2.2.1.1 Water Quality Standards, Beneficial Uses, and TMDLs

Dixie Creek is a tributary to the South Fork Humboldt River; therefore, applicable water quality standards for the unnamed tributary and Dixie Creek are based on the standards established for the South Fork Humboldt River and its tributaries in NAC 445A.1466. These standards identify designated beneficial uses and establish criteria intended to protect those uses. For toxic materials such as metals, applicable water quality standards are defined in NAC 445A.1236.

The designated beneficial uses applicable to the South Fork Humboldt River and its tributaries include municipal or domestic supply, irrigation, watering of livestock, propagation of aquatic life, recreation involving contact with the water, recreation not involving contact with the water, and industrial supply.

Dixie Creek has also been evaluated under Sections 303(d), 305(b), and 314 of the Clean Water Act. In 2006, Dixie Creek was identified as impaired due to elevated temperature, and NDEP subsequently conducted a temperature TMDL assessment for Dixie Creek (NDEP, 2010). Because the elevated temperatures were not attributed to point source discharges, the TMDL emphasized riparian condition and vegetative shading rather than numeric wasteload allocations. Following approval of the TMDL, the temperature impairment was delisted for Dixie Creek (NDEP, 2013). Ongoing stream monitoring shows that stream temperatures remain seasonally elevated above the standard of 20°C. The Draft Nevada 2024 Water Quality Integrated Report (NDEP, 2025) identifies Dixie Creek as impaired for total phosphorus and E.

coli for the 2017–2022 assessment period, resulting in non-attainment of standards for the aquatic life and recreation involving water contact beneficial uses.

2.2.1.2 *Antidegradation Tier Determinations*

Nevada's antidegradation framework assigns protection levels on a parameter-by-parameter basis relative to the applicable water quality standards in NAC 445A.1466 for Dixie Creek as a tributary to the South Fork Humboldt River. In NDEP-BWPC's initial antidegradation review, the IBV (95th percentile of the available receiving-water dataset) is used as the interim representation of existing receiving-water quality when there is not yet enough long-term monitoring data to establish full baseline water quality. A Tier 1 level of protection applies where baseline water quality or an IBV is not better than the applicable water quality standard, while a Tier 2 level of protection applies where baseline water quality or an IBV is better than the applicable water quality standard. Where NDEP-BWPC establishes a requirement to maintain existing higher water quality (RMHQ), the RMHQ represents the antidegradation-based water quality level for Tier 2 parameters. Tier 2.5 and Tier 3 levels of protection also exist under Nevada's antidegradation framework but are not applicable to the proposed discharge or this alternatives analysis.

For the South Railroad Project, NDEP-BWPC used available receiving-water data from the unnamed tributary and Dixie Creek to assign antidegradation tiers on a parameter-specific basis. NDEP-BWPC used IBVs to support draft permit development. Consistent with NDEP-BWPC's antidegradation permit writer guidance, Tier 2 values are not established below 10 percent of the most restrictive applicable water quality standard. Tier 1 and Tier 2 determinations provide the regulatory basis for the draft permit limits and identify where proposed discharge quality may need to be evaluated against existing higher water quality.

2.2.2 Baseline Water Quality

Water quality field parameters and water samples have been collected in support of the Project since 2018. Quarterly surface-water monitoring has been conducted at numerous sites across the Project area, including three locations along the unnamed discharge tributary: ST2, ST6, and ST8. A synoptic survey of water quality and flow along Dixie Creek and the unnamed tributary was conducted in November 2021 (Stantec, 2024a). In spring 2022, nine additional locations were established for ongoing flow and water quality monitoring (Stantec, 2022). Monitoring locations along the unnamed discharge tributary best represent baseline conditions of the receiving waters, with Dix-2 and Dix-3 being the two most relevant locations for the proposed discharge.

2.2.2.1 *Summary of Monitoring Results*

The Dix-2 monitoring location is immediately downstream of the proposed discharge location and was visited 21 times between spring 2022 and fall 2024. During these visits, water was present on nine occasions, with the site becoming dry in early summer. The Dix-3 sample location is downstream of Dix-2 and has perennial flow, which is fed by a spring (monitoring site SP4) located immediately upstream of Dix-3. Stream stage and water temperature are collected every 15 minutes at Dix-2 and Dix-3 through a transducer with datalogger. Field parameters have included temperature, pH, dissolved oxygen, specific conductance, oxidation-reduction potential, and turbidity. Select field parameters are summarized in Table 1. Laboratory analyses of water samples have included the NDEP Profile III list, which includes general chemistry, total metals, nutrients, TDS, and total suspended solids (TSS). Summary statistics of the results are provided in Appendix A. Analytical data, monitoring-location figures, coordinates, field parameters, and flow data were transmitted to NDEP-BWPC by email on August 12 and September 4, 2025.

Table 1. Field Parameter Measurements

Parameter	Dix-2 Range of Measurements	Dix-3 Range of Measurements
Temperature (°C)	0.01–21.6	2.1–24.4
Dissolved Oxygen (mg/L)	3–8.3	1.9–9.1
pH (s.u.)	6.9–8.3	7.8–8.5
Flowrate (gpm)	0–421	9.23–1,812

2.2.2.2 *Interim Baseline Values*

NDEP-BWPC used water quality data collected from the unnamed tributary to Dixie Creek and Dixie Creek to development of IBVs (Table 2). These values are used as the basis for selected draft discharge limits.

2.2.2.3 *Tier Levels and Draft Permit Limits*

Using the receiving-water dataset, applicable water quality standards, and the IBVs described above, NDEP-BWPC assigned antidegradation tiers on a parameter-specific basis for the draft NPDES permit. Table 2 lists each parameter with an assigned Tier 1 or Tier 2 designation and its associated draft permit limit. For Tier 2 parameters, the table also provides the IBV and the next most restrictive water quality standard for reference.

Table 2. Baseline Receiving Water Quality

Parameter	Units	No. Samples	Min.	Median	95th Perc.	Max.	Most Restrictive WQS	Draft Permit Tier	Draft Permit Value
Antimony	µg/L	54	1.25	1.25	1.25	1.25	146	Tier 2	14.6
Arsenic	µg/L	54	2.5	24	37.7	48	50	Tier 2	37.7
Barium	µg/L	54	98	170	251.5	690	2000	Tier 2	251.5
Beryllium	µg/L	54	0.5	0.5	0.5	1	4	Tier 2	0.5
Boron	µg/L	54	50	50	50	100	750	Tier 2	75
Cadmium	µg/L	54	0.5	0.5	0.5	1	5	Tier 2	0.5
Cadmium, Dissolved	µg/L	38	0.50	0.50	0.50	4.70	2.99	Tier 2	0.50
Chromium, (total)	µg/L	54	2.5	2.5	2.5	16	100	Tier 2	10
Copper	µg/L	54	20	20	20	40	200	Tier 2	20
Copper, Dissolved	µg/L	38	20	20	20	20	22	Tier 2	20
Fluoride	µg/L	92	150	150	360	500	1000	Tier 2	360
Iron	µg/L	54	50	250	1650	13000	1000	Tier 1	1000
Lead	µg/L	54	1.25	1.25	1.7575	12	50	Tier 2	5
Lead, Dissolved	µg/L	38	1.25	1.25	1.25	1.25	116	Tier 2	11.6
Manganese	µg/L	54	5	30	155	820	200	Tier 2	155
Mercury	µg/L	54	0.225	0.225	0.225	0.225	2	Tier 2	0.225
Mercury, Dissolved	µg/L	38	0.05	0.225	0.225	0.225	1.4	Tier 2	0.225
Molybdenum	µg/L	54	10	10	10	20	6160	Tier 2	616
Nickel	µg/L	54	15	15	15	30	13.4	Tier 1	13.4
Nickel, Dissolved	µg/L	38	15	15	15	15	743	Tier 2	74.3
Selenium	µg/L	54	2.5	2.5	2.5	2.5	3.9	Tier 2	2.5

Parameter	Units	No. Samples	Min.	Median	95th Perc.	Max.	Most Restrictive WQS	Draft Permit Tier	Draft Permit Value
Silver, Dissolved	µg/L	38	2.5	2.5	2.5	2.5	0.0715	Tier 1	0.071514281
Thallium	µg/L	54	0.5	0.5	0.5	0.5	13	Tier 2	1.3
Zinc	µg/L	54	10	10	13.5	52	2000	Tier 2	200
Zinc, Dissolved	µg/L	38	10	10	26.2	90	186	Tier 2	26.2
Chloride	mg/L	92	0.5	4	6.935	9.7	860	Tier 2	86
Dissolved Oxygen	mg/L	83	0.01	7.5	9.769	10.77	6	Tier 1	6
Nitrate	mg/L	92	0.01	0.05	0.0725	0.34	10	Tier 2	1
Nitrite	mg/L	35	0.005	0.005	0.0493	0.14	0.06	Tier 2	0.0493
Phosphorus, (total)	mg/L	54	0.25	0.25	0.25	0.56	0.1	Tier 1	0.1
Sulfate	mg/L	92	0.75	22.5	30.45	38	250	Tier 2	30.45
Total Alkalinity	mg/L	92	45	140	170	210	>20	Tier 2	>72.65
TDS	mg/L	92	64	185	234.5	310	500	Tier 2	234.5
TSS	mg/L	52	5	5	31	300	25	Tier 1	25
Turbidity	NTU	51	0.75	8.9	221.5	431	10	Tier 1	10
Ammonia (total)	µg/L	29	0.025	0.05	0.05	0.072	1.46	Tier 2	0.145
E. coli	MPN/100mL	27	5	97	681.4	1100	410	Tier 1	410
Fecal Coliform	MPN/100mL	32	3	86.5	603.5	3500	1000	Tier 2	603.5
Color	PCU	26	5	15	43.75	80	75	Tier 2	43.75
pH	s.u.	90	6.18	8.22	8.7055	9	6.5	Tier 2	7.22–8.71
Temperature	°C	98	0.4	17.5	26.2	29.4	20	Tier 1	20

Statistics calculated using non-detect values at half the detection limit. Non-detect values are shown at half the detection limit

2.3 Untreated Source Water (Groundwater)

Untreated source water for the proposed discharge is represented by groundwater samples collected from existing wells DSWW17-01 and PW22-01 in the Dark Star area. These wells are similar in depth and hydrogeologic setting to the planned dewatering wells and provide the best available dataset for characterizing groundwater that would be extracted during mine dewatering. This section summarizes groundwater source-water quality and identifies constituents that may require treatment or further evaluation for purposes of the draft NPDES permit and alternatives analysis.

2.3.1 Baseline Water Quality

Well DSWW17-01 was installed in 2017 and has been sampled 13 times between 2018 and 2025. Well PW22-01 was installed in 2023 and has been sampled 5 times between 2023 and 2025. During groundwater sampling, water quality field parameters are measured and samples typically collected for NDEP Profile I constituents. Select samples have also been collected for other parameters including additional nutrients, volatile organic compounds, total coliform, total organic carbon (TOC), and total metals.

2.3.1.1 Summary of Monitoring Results

Groundwater quality in DSWW17-01 and PW22-01 is generally similar. Median TDS concentration is 160 milligrams per liter (mg/L), and major-ion chemistry is dominated by calcium and bicarbonate.

Select trace metals have been detected in DSWW17-01 and PW22-01, as summarized in Table 3. Table 3 also lists the most restrictive water quality standard for each constituent, as applicable to the South Fork Humboldt River and its tributaries (NAC 445A.1466 and NAC 445A.1236). Arsenic concentrations exceed the water quality standard, whereas concentrations of all other summarized constituents were non-detect and/or below the most restrictive applicable standard.

One sample had detections for weak acid dissociable (WAD) cyanide at 0.069 mg/L. It was collected from DSWW17-01 on October 30, 2023. The same sample was analyzed for total cyanide, which came back as non-detect at <0.015 mg/L. WAD cyanide is a component of total cyanide and therefore should not exceed the total cyanide value, indicating an inconsistent result. All other WAD cyanide results from both wells were non-detect at less than 0.01 mg/L.

The Project area has no history of cyanide usage and therefore this single detection of WAD cyanide has been interpreted as anomalous.

Except for one TOC sample, there were no detections for any organic-demanding compounds. Only a few samples were collected, but these parameters were not expected to be present in the deep groundwater. Well PW22-01 had one TOC detection of 1.4 mg/L in a sample collected on August 4, 2023; the result for a subsequent sample collected on November 6, 2023 was <1.0 mg/L.

During sampling events, field parameters were measured at well DSWW17-01 and PW22-01. Groundwater temperatures range from 16.3 to 23 °C, dissolved oxygen ranged from 0.04 to 6.9 mg/L, and pH ranged from 6.6 to 8.6 standard units (s.u.).

Table 3. Water Quality Summary for Groundwater Source

Parameter	Units	Most Restrictive WQS	Min.	Median.	Max.	RPA
Antimony	ug/L	146	<2.5	3.8	9	19.92
Arsenic	ug/L	50	14	63	100	147.54
Barium	ug/L	2000	14	75.5	120	194.06
Beryllium	ug/L	4	<1	<1	<1	< 0.50
Cadmium*	ug/L	0.41	<1	<1	<2	< 1.00
Chromium, Total	ug/L	100	<5	<5	<10	< 5.00
Copper*	ug/L	14.9	<40	<40	<80	< 40.00
Iron	ug/L	1000	<100	270	720	1660.49
Lead*	ug/L	6.4	<1	1.25	<5	3.79
Manganese	ug/L	200	21	26.5	98	220.22
Mercury	ug/L	0.91	<0.1	0.225	<0.6	< 0.30
Nickel	ug/L	13.4	<30	<30	<30	< 15.00
Selenium	ug/L	3.9	<5	<5	<10	< 5.00
Silver*	ug/L	9.7	<5	<5	<10	< 5.00
Thallium	ug/L	13	<1	<1	<2	2.93
Zinc*	ug/L	190	<20	<20	<40	86.87
Ammonia, Total (as N)**	mg/L	1.46	<0.5	<0.5	<0.5	< 0.25
Boron	ug/L	750	<100	<100	<100	< 50.00
Chloride	mg/L	--	2.2	3.65	3.8	4.82
Fluoride	ug/L	1000	<300	<300	<300	905.37
Nitrate, Total (as N)	mg/L	--	<0.15	<0.15	<0.15	< 0.08
Nitrogen, Total (as N)	mg/L	--	<0.5	<0.5	<0.5	< 0.25
Phosphorus, Total (as P)	mg/L	--	<0.5	<0.5	<0.5	< 0.25
Sulfate	mg/L	250	26	32	37	40.80
Total Dissolved Solids	mg/L	500	150	160	180	199.08
Total Trihalomethanes	ug/L	100	<2	<2	<2	< 1.00

*Listed water quality standard is hardness dependent, as calculated using equations in NAC 445A.1236 and assumes a hardness of172.58 mg/L as $CaCO_3$

**Listed water quality standard is pH dependent, using the equation specific to Acute Water Quality Criteria for Total Ammonia for Freshwater Aquatic Life in NAC 445A.118, and assumed pH of 8.7

2.3.1.2 Comparison to Receiving Waters

The similarity between groundwater source-water chemistry and receiving-water chemistry is illustrated by comparison of the 95th percentile values for the groundwater and receiving-water datasets on Figure 6. The figure plots the groundwater source-water value for each analyte against the corresponding receiving-water value, with the 1:1 line representing equal concentrations in groundwater and receiving water. Most analytes plot near the 1:1 line and within one order of magnitude, indicating that the groundwater proposed for discharge and receiving-water samples have similar chemistry.

This pattern is evident for major ions and general water quality parameters such as sulfate, TDS, alkalinity, chloride, hardness-related constituents, and pH, and is consistent with the groundwater-supported baseflow conceptual model described in Section 2.1. Arsenic is naturally present in the groundwater source water and remains a key treatment driver because concentrations exceed applicable water quality standards, while sulfate and fluoride are important to this alternatives analysis because draft permit limits (see Section 2.2.2.3) are close to existing groundwater and receiving-water concentrations. Overall, the comparison supports the interpretation that proposed discharge source water is similar to the groundwater-supported receiving-water system.

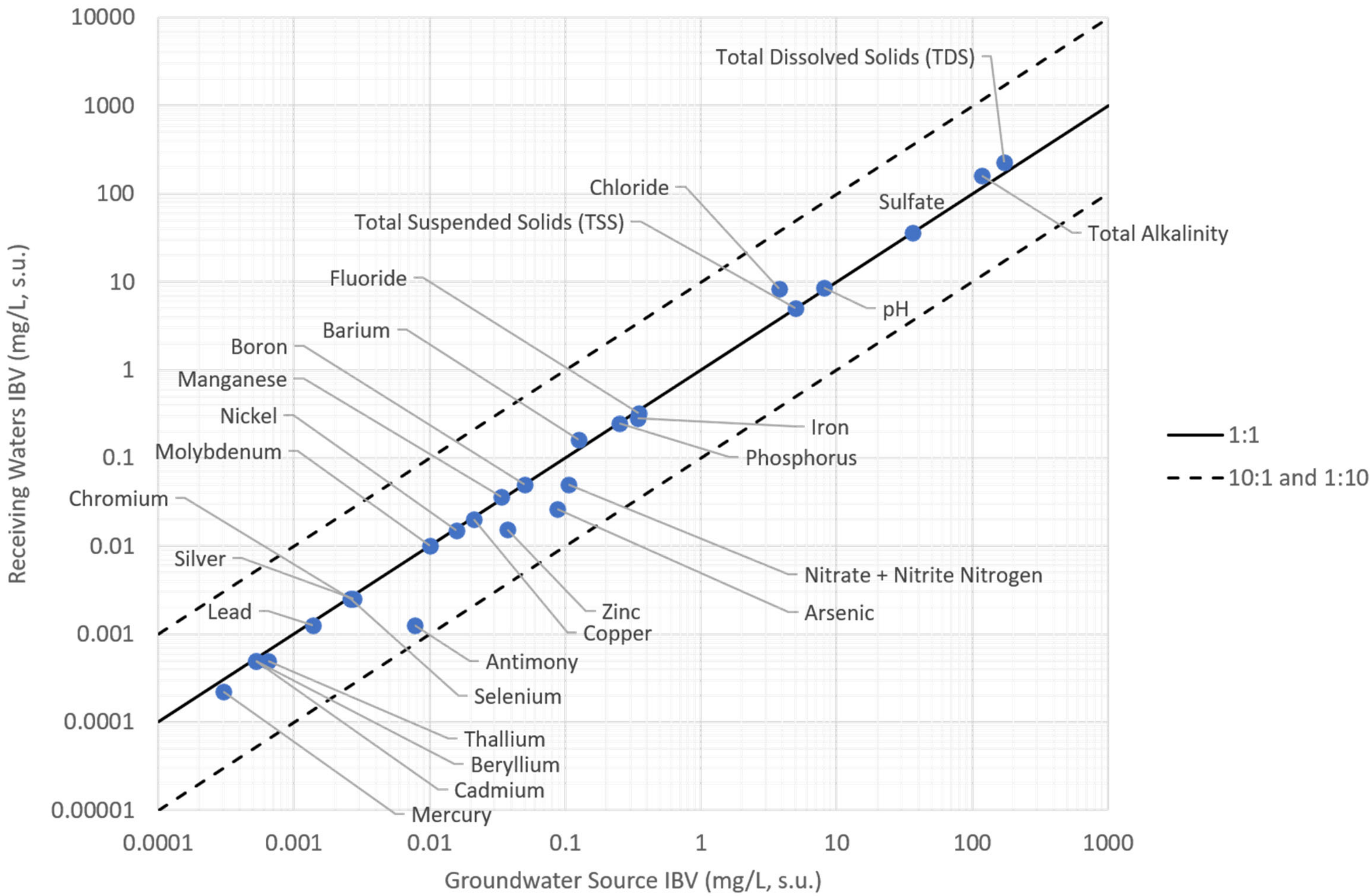


Figure 6. Comparison of Groundwater Source to Receiving Waters Interim Baseline Values (95th percentiles)

2.3.2 Identification of Potential Pollutants of Concern

Groundwater proposed for discharge was evaluated during development of the draft NPDES permit to identify constituents that may require effluent limitations, treatment, or further evaluation. NDEP-BWPC performed a reasonable potential analysis (RPA) to estimate conservative upper-end untreated source-water concentrations (Table 3). The RPA used the U.S. Environmental Protection Agency (EPA) *Technical Support Document for Water Quality-Based Toxics Control* (U.S. EPA, 1991) method for statistically calculating the projected maximum effluent concentration. This method uses the 99 percent probability basis and 99 percent confidence interval presented in Table 3-1 of the Technical Support Document. Constituents with no detections in groundwater were excluded from the RPA.

The results from the RPA were compared to applicable water quality standards, as well as Nevada antidegradation requirements for Tier 2 parameters, to identify whether a parameter could have reasonable potential to cause or contribute to exceedances of applicable criteria. Constituents identified through this process are listed in Table 4 and are considered potential pollutants of concern for purposes of this alternatives analysis.

Iron was identified based on reasonable potential relative to the chronic aquatic life criterion, while antimony, arsenic, manganese, thallium, fluoride, and sulfate were identified based on RMHQ criteria associated with Tier 2 antidegradation protection.

For sulfate, the pollutant-of-concern determination is driven by the Tier 2/RMHQ-based draft permit limit rather than exceedance of the next most restrictive beneficial-use standard. The technical implications of the relatively small sulfate reduction required to meet the draft permit limit are evaluated in Section 4.2.1.

Table 4. Pollutants of Concern

Parameter	Units	No. of Samples	Count ND	Min. Meas.	Median Meras.	Max. Meas.	Most Restrictive WQS	Draft Permit Limit	Min Basis	RPA
Antimony, Total Recoverable	µg/L	22	7	<2.5	3.8	9	146	14.6	Tier 2/ RMHQ	19.92
Arsenic, Total Recoverable	µg/L	21	0	14	63	100	50	37.7	Tier 2/ RMHQ	147.54
Iron, Total Recoverable	µg/L	22	4	<100	270	720	1,000	1,000	Chronic Aquatic Life	1660.49
Manganese, Total Recoverable	µg/L	22	0	21	26.5	98	200	155	Tier 2/ RMHQ	220.22
Thallium, Total Recoverable	µg/L	21	16	<1	<1	<2	13	1.3	Tier 2/ RMHQ	2.93
Fluoride	µg/L	10	9	<300	<300	<300	1,000	360	Tier 2/ RMHQ	905.37
Sulfate	mg/L	21	0	26	32	37	250	30.45	Tier 2/ RMHQ	40.80

ND = non-detect

2.3.3 Potential Nitrogen Species Variability

Nitrogen species, including nitrate, nitrite, and ammonia, have not been detected in samples collected from DSWW17-01 and PW22-01. These results indicate that nitrogen species are not currently present at concentrations that would be expected to drive treatment requirements under baseline groundwater conditions.

However, concentrations of nitrogen species could potentially increase slightly during mine operations due to contact between dewatering water and blasting-related residuals from ammonium nitrate-based explosives. Although the proposed discharge is intended to consist of treated dewatering groundwater rather than mine contact water, future operational variability could result in nitrogen species being present at concentrations above current non-detect values.

This potential variability is relevant because the draft permit includes low effluent limits for nitrogen species relative to the existing non-detect source-water dataset and relative to the next most restrictive beneficial-use standards in NAC 445A.1466 (and NAC 445A.118 for ammonia). The draft permit limits for nitrate, nitrite, and ammonia are 1.0 mg/L as N, 0.0493 mg/L as N, and 0.146 mg/L as N, respectively, compared to the applicable NAC standards of 10 mg/L as N for nitrate, 0.06 mg/L as N for nitrite, and 1.46 mg/L as N for ammonia. Accordingly, nitrogen species are not a primary baseline groundwater-quality concern, but they are carried forward as a treatment and operational consideration in the alternatives analysis because future operational variability could result in concentrations above current non-detect values.

3. Alternatives Identification

This section identifies the practicable alternatives evaluated to avoid or minimize potential degradation of receiving water quality associated with the proposed discharge, particularly regarding controls on the dissolved sulfate concentrations, which would not reliably meet the anticipated permit limit using the proposed technology.

The alternatives identified in this section were selected to address the categories identified in Nevada’s antidegradation review requirements, including alternative treatment technologies, alternative discharge locations, alternative processes that would improve discharge quality, seasonal or controlled discharge, and an alternative that would not result in discharge. The alternatives are presented here as descriptive concepts only. The relative feasibility, advantages, limitations, costs, and environmental tradeoffs of these alternatives are evaluated in Section 4.

3.1 Alternative Treatment Technologies

Alternative treatment technologies were identified to evaluate whether additional or modified treatment processes could further reduce concentrations of constituents that may exceed draft permit limits. The alternatives considered in this category focus primarily on supplemental treatment for dissolved ions, including sulfate, TDS, and fluoride, that are not substantially removed by the proposed coagulation-assisted filtration process. A more detailed description of the alternative treatment technologies is provided in the *South Railroad Sulfate Treatment Alternative Analysis* in Appendix B (Linkan Engineering, 2026).

3.1.1 Partial-Stream Reverse Osmosis

Partial-stream reverse osmosis would involve diverting a portion of the coagulation-assisted filtration effluent through reverse osmosis treatment prior to recombining the treated stream (permeate) with the remainder of the coagulation-assisted filtration effluent. Reverse osmosis processes are pressure-driven membrane processes that remove dissolved ions by separating a lower-dissolved-solids permeate from a concentrated reject stream. Under this alternative, the membrane system would be sized to treat only the portion of flow necessary to reduce target constituents in the blended effluent, rather than treating the full discharge volume. Alkalinity removed through reverse osmosis would be replaced to meet permit requirements.

3.1.2 Partial-Stream Ion Exchange

Partial-stream ion exchange would use selective resin media to remove dissolved constituents from a portion of the discharge stream. In this process, target ions in the water are exchanged with ions held on the resin surface. The treated portion of the stream would then be blended with the remaining discharge to achieve the desired effluent quality. Ion exchange can be configured for dissolved ions such as sulfate and selected metals or metalloids, depending on resin selection, source-water chemistry, and competing ions present in the water.

3.1.3 Barite Precipitation

Barite precipitation would involve addition of a barium-bearing reagent to promote formation of barite, a relatively insoluble barium sulfate mineral. Under this alternative, sulfate would be reduced by chemical precipitation rather than by membrane separation or ion exchange. The process would require reagent addition, solids separation, and management of precipitated solids. Barite precipitation was identified as a potential treatment alternative because it directly targets sulfate, which is one of the principal constituents driving the alternatives analysis.

3.2 Alternative Discharge Location / Mixing

An alternative discharge location was identified to evaluate whether moving the discharge downstream to a perennial reach, or establishing a downstream point of compliance, could provide dilution and mixing prior to permit compliance evaluation. The purpose of relocating the discharge or compliance point would be to evaluate whether available receiving-water flow could provide meaningful mixing for constituents such as sulfate.

Under this alternative, treated water would either be conveyed to a downstream reach where perennial flow is present or evaluated using a downstream compliance point intended to account for mixing with receiving water. The unnamed tributary is dry or seasonally intermittent near the proposed outfall during portions of the year, while perennial flow begins downstream of SP4 (Figure 4) where groundwater discharge contributes to the channel. Relocating the discharge point or compliance point would therefore be evaluated in relation to the amount of perennial baseflow, seasonal runoff, and resulting dilution available downstream of the proposed outfall.

3.3 Alternative Processes: Improve Discharge

Alternative processes that would improve discharge quality include approaches that would reduce the volume of water requiring surface-water discharge or manage dewatering water through a pathway other than direct discharge to the unnamed tributary. These alternatives include use of rapid infiltration basins (RIBs) and additional reuse of dewatering water within mining operations.

3.3.1 Rapid Infiltration Basins

RIBs would route excess dewatering water to constructed basins where water would infiltrate into the subsurface and recharge groundwater rather than being discharged to surface water. RIBs were considered both within the Dixie Creek subbasin, where dewatering would occur, and in the adjacent Pine Valley basin. The Dixie Creek subbasin concept would seek to return water to the same hydrographic basin from which it was produced. The Pine Valley concept would consider potentially more favorable alluvial materials west of the Project area but would require conveyance outside the Dixie Creek subbasin and evaluation of associated water-rights and permitting considerations.

3.3.2 Reuse in Mining Operations

Reuse in mining operations would involve maximizing use of extracted groundwater for operational demands before any excess water is treated and discharged. Potential uses include dust suppression, heap leach make-up water, fire-water supply, construction water, and other operational needs. This alternative would reduce the volume of water requiring discharge to the extent that dewatering production coincides with on-site consumptive demand and available storage.

3.4 Seasonal or Controlled Discharge

Seasonal or controlled discharge alternatives would manage the timing, rate, or location of discharge to reduce the potential for degradation during periods when receiving-water flows are limited. These alternatives include controlled discharge during higher-flow periods and land application where discharge to surface water could be seasonally reduced or avoided.

3.4.1 Seasonal or Controlled Discharge During Higher-Flow Periods

Seasonal or controlled discharge during higher-flow periods would involve limiting discharge to periods when receiving-water flow is greater, such as during spring runoff or other periods of increased streamflow. The objective of this alternative would be to reduce discharge during low-flow periods when the volume of treated dewatering water could be large relative to natural receiving-water flow. Implementation would require sufficient storage, operational flexibility, and water-management capacity to temporarily retain dewatering water when discharge is curtailed.

3.4.2 Land Application

Land application would involve routing dewatering water to suitable land areas for irrigation or other controlled application to land rather than continuous discharge to surface water. This alternative could seasonally reduce or avoid discharge to the unnamed tributary where land, crop demand, soil conditions, and water quality are suitable for application. Because land application is dependent on seasonal demand and available application area, it would need to be considered in conjunction with storage or another discharge-management approach for periods when application is not practicable.

3.5 No Discharge Alternative

The no discharge alternative would eliminate discharge to the unnamed tributary of Dixie Creek. This alternative would require modifying the mine plan to avoid mining below the groundwater table. Although this approach would eliminate the need for dewatering and discharge of excess groundwater, it would substantially constrain ore recovery and would not meet the Project's mining objectives.

4. Analysis of Alternatives

This section evaluates the alternatives identified in Section 3 using the staged evaluation framework introduced in Section 1. The first stage, presented in Section 4.1, screens all identified alternatives for fatal flaws related to technical feasibility. Alternatives with fatal flaws are not advanced for detailed evaluation.

Alternatives that pass the fatal-flaw screening are evaluated further using an MAA framework. For this alternatives analysis, the retained alternatives are compared using accounts that reflect technical performance, environmental tradeoffs, economics, and social considerations. Each account includes qualitative or quantitative metrics that allow alternatives to be compared consistently.

The retained alternatives are not evaluated solely based on their ability to reduce individual constituent concentrations. Rather, each alternative is evaluated based on whether it provides a meaningful water quality benefit when considered alongside implementation feasibility, residuals or waste generation, energy use, cost, operational complexity, environmental impacts, permitting risk, and consistency with Project objectives. This approach allows the alternatives to be ranked transparently and supports identification of a preferred alternative in Section 4.2.5.

4.1 Technical Feasibility Screening

The technical feasibility screening evaluated whether each alternative could reasonably function as a practicable approach for managing the proposed discharge or improving discharge quality. Screening criteria included the ability to manage projected dewatering flow rates, achieve the intended water quality objective, operate reliably under site-specific hydrologic and climatic conditions, be implemented within the Project schedule, be permitted and operated within known regulatory constraints, and provide either a standalone discharge-management alternative or a technically viable treatment alternative. Alternatives that did not satisfy these minimum criteria were considered to have fatal flaws and were not advanced for detailed MAA.

4.1.1 Initial Technical Feasibility Screening

The results of the initial technical feasibility screening are summarized in Table 5.

Table 5. Initial Technical Feasibility Screening of Alternatives

Alternative	Fatal Flaw Category	Technical Feasibility Screening Result	Advance to MAA?
Proposed coagulation-assisted filtration	None identified	Technically feasible as the proposed base treatment system	Yes
Partial-stream RO	None identified at screening level	Potentially feasible as supplemental treatment	Yes
Partial-stream ion exchange	None identified at screening level	Potentially feasible as supplemental treatment	Yes
Barite precipitation	None identified at screening level	Potentially feasible as supplemental treatment	Yes
Downstream perennial reach/ mixing concept	Insufficient and variable assimilative capacity	Not technically reliable as a compliance strategy	No
Rapid infiltration basins	Hydrogeologic and implementation uncertainty	Demonstrated to be unreliable for full projected flows.	No
Reuse in mining operations	Insufficient demand relative to dewatering supply	Useful as a partial water-management measure, but not a standalone alternative	No
Seasonal or controlled discharge	Storage and operational constraints	Not feasible as a standalone discharge-management strategy	No
Land application	Capacity, seasonality, and land-area constraints	Not feasible as a standalone alternative	No
No discharge alternative	No practicable complete water-management pathway	Not feasible based on projected dewatering volumes	No

Alternatives retained for further evaluation include the proposed coagulation-assisted filtration treatment system and the three supplemental treatment technologies: partial-stream reverse osmosis, partial-stream ion exchange, and barite precipitation. The remaining alternatives were not advanced because they contain one or more fatal flaws that prevent them from serving as practicable alternatives to the proposed discharge.

4.1.2 Alternatives Eliminated from Further Evaluation

The alternatives eliminated from further evaluation are organized below by the alternative categories identified in Section 3. Each was excluded from consideration because it contains one or more fatal flaws that prevent it from serving as a practicable standalone alternative to the proposed discharge.

4.1.2.1 Alternative Discharge Location/Mixing

This alternative was eliminated based on the reliability of available downstream assimilative capacity under baseflow conditions. Although perennial flow is present downstream of the proposed outfall, the alternative would rely on receiving-water dilution rather than additional pollutant reduction.

Monitoring data for Dixie Creek indicate that streamflow varies seasonally and spatially, and that baseflows in Dixie Creek can be low relative to the proposed year-round discharge. An average daily discharge of 2,300 gpm and a maximum daily discharge of 2,400 gpm was requested in the NPDES application. Available Dixie Creek monitoring data show that measured flows can be substantially lower than the projected discharge during portions of the year. For example, in a typical year, flows measured at Dix-2 ranged from 0 to 421 gpm, and flows measured at Dix-3 ranged from approximately 9 to 1,812 gpm (Stantec, 2026). As a result, the proposed discharge would often equal or exceed available receiving-water flow.

A screening-level mixing calculation prepared for sulfate further illustrates the limitation of relying on downstream dilution. The calculation indicates that under non-runoff baseflow conditions, receiving-water flow would need to comprise approximately 70 percent or more of the mixed flow to reduce sulfate below the draft permit limit of 30.45 mg/L. Stated another way, the proposed discharge would need to represent no more than about 30 percent of the combined flow for dilution alone to meet the draft sulfate limit. Because the requested daily discharge limit is 2,300 gpm and measured baseflows in the unnamed tributary and Dixie Creek are commonly lower than the discharge rate, this level of dilution would not be reliably available outside spring runoff conditions.

Because the discharge volume would frequently be large relative to natural baseflow, this alternative would not provide a reliable or consistent means of achieving water quality objectives. Compliance would remain dependent on variable hydrologic conditions rather than treatment performance. Therefore, the downstream perennial reach / mixing concept was not advanced for further evaluation.

4.1.2.2 Alternative Processes to Improve Discharge: Rapid Infiltration Basins

This alternative was removed based on whether site hydrogeologic conditions could support reliable, large-scale infiltration of projected dewatering flows. The RIB viability assessment considered potential locations in both the Dixie Creek subbasin and adjacent Pine Valley basin, which raised distinct technical and permitting constraints (Stantec, 2023).

The site-specific RIB viability assessment identified fatal technical and permitting limitations for both concepts. Within the Dixie Creek subbasin, multiple field investigations, including trenching, percolation testing, geophysical surveys, and construction of an unsuccessful test RIB, did not identify locations with the combination of deep groundwater, coarse-grained alluvium, and sustained infiltration rates needed for reliable long-term RIB operation. Although some localized percolation tests produced higher short-term infiltration rates, field-scale performance was constrained by shallow groundwater or perched saturated zones, fine-grained alluvial materials, and declining infiltration performance. These conditions are inconsistent with the success factors for large-scale RIB operations, particularly for a system that would need to manage dewatering flows on the order of approximately 2,300 gpm.

The assessment concluded that no locations characterized within the Dixie Creek subbasin would be expected to support successful RIB operation for disposal of excess dewatering water, primarily because the alluvium is derived from weathered volcanic lithologies that produce relatively fine-grained, low-permeability sediments. Potentially coarser alluvial materials west of the Project area occur in the Pine Valley hydrographic basin; however, using those areas would require conveyance outside the basin where groundwater is produced and would constitute an interbasin transfer of groundwater. That approach would add substantial infrastructure, water-rights, and permitting uncertainty and would not satisfy the objective of returning dewatering water to the same hydrographic basin. Based on the lack of demonstrated infiltration capacity in Dixie Creek, the interbasin transfer concerns associated with Pine Valley, and the need for continuous reliable management of full dewatering flows, RIBs were determined to have fatal flaws and were not advanced for further evaluation.

4.1.2.3 Alternative Processes to Improve Discharge: Reuse in Mining Operations

This alternative was screened based on whether operational water demands could consume the projected dewatering volume. Reuse will be incorporated into Project water management to the extent practicable and is already reflected in the site-wide water balance. The water balance model indicates that total mine makeup water demand over the operating period is approximately 6,400 acre-feet, including approximately 2,150 acre-feet for heap leach facility makeup water and approximately 3,350 acre-feet for dust suppression. By comparison, estimated groundwater produced by dewatering is approximately 19,300 acre-feet, of which approximately 6,390 acre-feet would offset mine makeup water requirements and approximately 12,910 acre-feet would still require management through the mine water treatment plant and discharge (Stantec, 2024b). These results demonstrate that operational reuse is an important component of Project water management, but mine water demands are variable and subject to seasonal weather conditions and ultimately are not sufficient to consume the full dewatering volume. Therefore, reuse cannot reliably eliminate the need for discharge or otherwise manage all excess dewatering water as a standalone alternative. For this reason, reuse was not advanced as a separate alternative for detailed evaluation.

4.1.2.4 Seasonal or Controlled Discharge: Higher-Flow Periods

This alternative was eliminated based on whether adequate receiving-water flow would be available frequently enough to support discharge without requiring impracticable storage. Dixie Creek monitoring data and the screening-level sulfate mixing calculation indicate that adequate dilution would likely be available only during a short spring runoff window, estimated at approximately 4 to 6 weeks per year under the conditions evaluated (Stantec, 2026). At the proposed average discharge rate of approximately 2,300 gpm, equivalent to approximately 3.31 MGD or 10.2 acre-feet per day, curtailing discharge for the remaining approximately 46 to 48 weeks per year would require storage on the order of 3,300 to 3,400 acre-feet, assuming no offset from additional reuse or reduced dewatering production. This storage requirement is far beyond the scale of the Project's planned operational water-management ponds and would introduce substantial design, permitting, land-disturbance, safety, and operational constraints. Because mine dewatering must occur as needed to maintain safe and dry mining conditions regardless of receiving-water flow, seasonal or controlled discharge does not provide a practicable standalone discharge-management strategy and was not advanced for further evaluation.

4.1.2.5 Seasonal or Controlled Discharge: Land Application

This alternative was removed based on whether land application could reliably manage continuous dewatering flows as a standalone discharge-management method. Although land application could theoretically reduce surface-water discharge during the irrigation season, it is not a practicable standalone alternative for the Project. The projected dewatering volume is large relative to typical seasonal irrigation demand and would require a dedicated land-application area, conveyance infrastructure, storage during non-irrigation periods, and confirmation that soils, crop demand, water quality, agronomic loading rates, and land access are suitable. The Project is located at relatively high elevation, where freezing conditions, snowpack, and limited growing-season demand would further constrain year-round application. As a result, land application would not provide a reliable means of managing continuous dewatering flows and was not advanced for further evaluation as a standalone alternative.

4.1.2.6 No Discharge Alternative

This alternative was eliminated based on whether all excess dewatering water could be managed without any surface-water discharge. Under this alternative, all dewatering water would need to be consumed, stored, infiltrated, evaporated, or otherwise managed without discharge to surface water. Because mine dewatering is required to support safe mining below the groundwater table, and because projected dewatering volumes exceed the practical capacity of reuse, storage, infiltration, evaporation, or land application alternatives, no practicable complete water-management pathway has been identified that would avoid discharge entirely. Therefore, the no discharge alternative was not advanced for further evaluation.

4.1.3 Alternatives Advanced for Detailed Evaluation

Four treatment-based alternatives were retained for detailed evaluation: the proposed coagulation-assisted filtration system, partial-stream reverse osmosis, partial-stream ion exchange, and barite precipitation. These alternatives were advanced because each could be implemented within the proposed discharge-management framework and no fatal flaw was identified at the technical feasibility screening level.

The retained alternatives differ in treatment mechanism, constituents targeted, residuals generated, operational complexity, implementation requirements, and cost. Section 4.2 evaluates these differences using the MAA framework to support ranking and identification of a preferred alternative.

4.2 Multiple Accounts Analysis

To support the detailed evaluation of retained treatment alternatives, Linkan Engineering developed conceptual-level designs and planning-level evaluations for supplemental treatment technologies that could be integrated with the proposed coagulation-assisted filtration system, including reverse osmosis, ion exchange, and barite precipitation (Linkan, 2026). Linkan's conceptual designs, process assumptions, flow balances, waste-management requirements, and planning-level cost estimates provide the technical basis for the MAA. The detailed MAA matrix, including account weights, subaccount weights, scoring assumptions, and final scores, is provided in Appendix C.

The MAA compares the retained alternatives across weighted accounts and subaccounts selected to reflect the purpose of the antidegradation alternatives analysis (Table 6). Environmental tradeoffs were weighted most heavily because the review focuses on avoiding or reducing degradation while considering cumulative water quality effects and other environmental impacts. Technical and social considerations were also weighted heavily because a practicable alternative must be reliable, implementable, permittable, safe, and compatible with Project objectives. Economic considerations were weighted slightly less but remain important because alternatives must also be economically achievable. Subaccounts were scored on a scale of 1 to 5, where higher scores indicate a more favorable outcome relative to the other retained alternatives.

Table 6. Summary of MAA Framework

Account	Weight	Purpose	Scored Subaccounts
Technical	25%	Evaluate treatment performance, reliability, implementability, and operational requirements.	Metals removal, sulfate/fluoride/nitrogen removal, operational complexity, waste type, technology maturity, and equipment lead time.
Environmental	30%	Evaluate water-quality benefit and secondary environmental tradeoffs.	Net improvement in water quality, energy consumption, waste volume and resources required for disposal, and on-site land use.
Economic	20%	Evaluate relative capital and operating costs.	Capital cost and operating cost.
Social	25%	Evaluate permitting, schedule, transportation, and safety considerations relevant to implementation.	Permits required, schedule risk to net positive socioeconomic benefits, traffic and community perception/safety impacts, and operator safety.

Sections 4.2.1 through 4.2.4 summarize the scoring results and major tradeoffs for each account. Section 4.2.5 presents the overall ranking and preferred alternative based on the MAA results.

4.2.1 Technical Performance

The technical account evaluates whether each retained alternative can reliably achieve the intended treatment objective while remaining implementable within the proposed discharge-management framework. Scored technical subaccounts include metals removal, sulfate/fluoride/ nitrogen removal, operational complexity, waste type, technology maturity, and equipment lead time (Appendix C). Because sulfate is one of the principal constituents driving the supplemental treatment evaluation, the technical performance discussion focuses on whether each retained alternative can reasonably achieve the required sulfate reduction while maintaining overall treatment reliability, managing operational risk and complexity, and supporting the Project's water-management and implementation objectives.

Table 7 summarizes the technical subaccounts, weights, and rationale used to develop the technical account score.

The magnitude of sulfate reduction required should be considered in context. The highest sulfate concentration measured in representative groundwater source-water samples is 37 mg/L, compared to the draft sulfate permit limit of 30.45 mg/L and an RPA value of 40.80 mg/L. The next most restrictive applicable water quality standard for sulfate is 250 mg/L, which is substantially higher than these concentrations. Measured groundwater sulfate concentrations are only modestly above the draft permit limit and remain substantially below both the applicable beneficial-use standard. Linkan projected that sulfate in the ultrafiltration filtrate could increase to approximately 67 mg/L due to treatment chemical additions, still far below the beneficial-use standard (Linkan, 2026). As a result, the technical question is not whether sulfate can be reduced in theory, but whether the reduction needed to meet the draft sulfate limit justifies the additional treatment complexity, residuals management, and operational risk associated with supplemental sulfate/ TDS treatment.

The proposed coagulation-assisted filtration system scored strongly in the technical account because it is a mature and proven treatment approach for arsenic, thallium, suspended solids, and selected trace metals. These constituents include those requiring the greatest metals removal under the draft permit evaluation. Coagulation-assisted filtration is not expected to substantially remove sulfate or TDS, which is why it received a low sulfate-removal score. However, because the required sulfate reduction is relatively small and the process provides robust metals treatment with lower operational complexity than the supplemental alternatives, it remains technically strong as the base treatment system.

Table 7. Technical Account Subaccount Weighting Rationale

Subaccount	Weight	Rationale for Weight
Metals removal	5	Weighted highest because groundwater source water contains metals, particularly arsenic, at concentrations above the most restrictive applicable water quality standards, and metals treatment is required regardless of whether supplemental sulfate treatment is implemented. Arsenic represents the highest required metals removal in the MAA, at approximately 53%.
Sulfate removal	3	Weighted moderately because sulfate is a key driver for supplemental treatment evaluation, but measured source-water concentrations are only slightly above the Tier 2/RMHQ-based draft permit limit and more than 200 mg/L below the next most restrictive beneficial use standard.
Operational complexity	4	Weighted highly because process complexity directly affects treatment reliability, staffing, maintenance, treatment capacity, and risk of noncompliance.
Waste type	3	Weighted moderately because residuals and waste type affect manageability, handling requirements, operational risk, and compatibility with existing Project waste-management systems; however, overall waste volume is evaluated separately in the environmental account and is the more important waste-related differentiator.
Technology maturity	2	Weighted moderately because proven technologies reduce implementation risk, but maturity alone does not determine whether an alternative is preferred.
Equipment lead time	4	Weighted highly because procurement and construction schedule can affect Project implementation, permit compliance timing, and the ability to realize Project benefits.

Partial-stream reverse osmosis scored high for sulfate removal because membrane treatment can reduce dissolved ions and Linkan's conceptual design targets a blended sulfate concentration of approximately 20 mg/L. However, achieving that reduction would require a major supplemental membrane system, significant energy demand, pretreatment controls, pH adjustment, antiscalant addition, membrane protection, periodic cleaning, brine management, and alkalinity replacement. Linkan assumed treatment of approximately 70 percent of the ultrafiltration filtrate through reverse osmosis to meet the sulfate target while blending the remaining 30 percent with permeate. Although technically capable of removing sulfate, the added system complexity and brine-management requirements reduce the overall technical score relative to the base treatment system (Linkan, 2026).

Partial-stream ion exchange also scored well for sulfate removal because sulfate-selective resin can reduce sulfate concentrations in the treated stream. Linkan's conceptual design assumes treatment of approximately 78 percent of the flow through ion exchange, with the remainder bypassed and blended to achieve the target sulfate concentration. However, ion exchange introduces operational complexity associated with resin loading, regeneration scheduling, lead-lag vessel operation, brine makeup, and management of spent regeneration brine. The process also exchanges sulfate for chloride, leaving limited compliance margin for chloride in the blended effluent. These constraints reduce the technical score even though sulfate removal is technically achievable (Linkan, 2026).

Barite precipitation directly targets sulfate through formation of barium sulfate solids, but Linkan identified important technical limitations. Achieving the draft sulfate limit would require precise chemical dosing and solids separation while simultaneously maintaining compliance with residual barium, chloride, TDS, and pH limits. Barite precipitation is also less effective as a supplemental sulfate strategy because it would occur upstream of the coagulation-assisted filtration system and would not remove sulfate subsequently added by treatment chemicals such as sulfuric acid and sodium bisulfite. Barium chloride dosing would add chloride and TDS, and Linkan concluded that projected treated-water TDS would exceed the draft TDS limit. Alternative barium reagents were also considered but were limited by low solubility, pH effects, and increased risk associated with unreacted barium in solids. As a result, barite precipitation scored lowest in the technical account among the retained treatment alternatives (Linkan, 2026).

Table 8 summarizes the key technical strengths, key technical limitations, and technical account score for each retained alternative.

Overall, the technical account results show that supplemental sulfate treatment is technically achievable using reverse osmosis and ion exchange, but only through addition of complex treatment and waste-management systems to address a relatively small sulfate reduction. Coagulation-assisted filtration does not provide substantial sulfate removal, but it remains the strongest technical option overall because it uses mature, proven treatment processes for metals and suspended solids, addresses the constituents requiring the greatest metals removal, and avoids the operational complexity and secondary compliance risks introduced by the supplemental alternatives.

Table 8. Summary of Technical Account Results

Alternative	Key Technical Strength	Key Technical Limitation	Technical Score
Coagulation-assisted filtration	Proven metals and suspended solids treatment; lower operational complexity	Limited sulfate/TDS removal	4.24
Partial-stream reverse osmosis	Strong sulfate/TDS removal capability	Membrane complexity, brine management, and alkalinity replacement	3.67
Partial-stream ion exchange	Sulfate removal with lower waste volume than reverse osmosis	Regeneration complexity, chloride compliance margin, and brine management	3.38
Barite precipitation	Direct sulfate precipitation	TDS/chloride addition, residual barium control, and hazardous reagent handling	2.95

4.2.2 Environmental Tradeoffs

Nevada's antidegradation permit writer guidance recognizes that alternatives should be evaluated based on cumulative water-quality effects and environmental tradeoffs, not solely on whether they reduce one parameter of concern. An alternative that provides the greatest reduction for sulfate or TDS may not be preferred if it creates larger impacts to other water-quality parameters, groundwater, air quality, waste management, energy consumption, chemical use, wildlife, or other environmental media. For this reason, the environmental account evaluates both the potential receiving-water benefit and the secondary impacts associated with implementing each retained alternative.

The environmental account includes four scored subaccounts: net improvement in water quality, energy consumption, waste volume and resources required for disposal, and onsite land use. These subaccounts were selected because they capture the principal environmental tradeoffs among the retained alternatives: whether additional treatment meaningfully improves discharge quality, whether it transfers impacts to waste streams or offsite disposal, whether it increases energy demand and associated air emissions, and whether it requires additional land disturbance.

Table 9 summarizes the environmental subaccounts, weights, and rationale used to develop the Environmental account score.

Table 9. Environmental Account Subaccount Weighting Rationale

Subaccount	Weight	Rationale for Weight
Net improvement in water quality	5	Weighted highest because water-quality benefit is the primary environmental objective of the antidegradation alternatives analysis.
Energy consumption	4	Weighted highly because increased energy demand affects fuel use, air emissions, and the long-term environmental footprint of treatment.
Waste volume and resources required for disposal	5	Weighted highest because the retained alternatives differ substantially in brine, sludge, or other waste generation and associated long-term disposal obligations, affecting land use, greenhouse gas emissions for haulage, consumption of liner materials for ponds, air quality, wildlife, etc..
Onsite land use	2	Weighted lower because treatment-plant footprint differences are smaller than waste-management and energy-related impacts, although land disturbance remains relevant.

The proposed coagulation-assisted filtration system provides treatment for arsenic, thallium, suspended solids, and selected trace metals while minimizing secondary environmental impacts. Residual solids and backwash streams would be managed through the proposed sludge-management system, and clarified water would be recycled through the treatment process. Because this alternative does not require a separate brine-management system, large evaporation pond, off-site liquid-waste hauling program, or major additional land disturbance, it scored highest in the environmental account despite providing limited sulfate and TDS removal.

Partial-stream reverse osmosis provides the greatest reduction in sulfate and TDS, but it also produces the largest secondary waste stream. Linkan estimated that reverse osmosis treatment would generate approximately 240,000 gallons per day of concentrated brine, or about 90 million gallons per year, requiring long-term waste management. If hauled off site, the brine would require approximately 53 to 77 tanker loads per day; if managed through evaporation, the required evaporation pond would be approximately 270 acres and would store an estimated 3,572 acre-feet of liquid. Reverse osmosis would also increase energy demand by approximately 50 percent while reducing the alkalinity and hardness in the discharge water. Low hardness and alkalinity can result in elevated uptake of toxic heavy metals by aquatic life and reduce buffering capacity to resist pH changes in downstream receiving waters. While the blended effluent hardness is projected to be 37 mg/L as $CaCO_3$ on average and generally sufficient to protect the downstream aquatic ecosystem (typically 40–50 mg/L as $CaCO_3$ is targeted to protect aquatic life), the alkalinity is projected to be 42 mg/L as $CaCO_3$; the draft discharge permit requires a minimum alkalinity of 72.65 mg/L as $CaCO_3$. These secondary impacts substantially reduce the environmental benefit of the additional sulfate and TDS removal (Linkan, 2026).

Partial-stream ion exchange generates less liquid waste than reverse osmosis but still creates a long-term concentrated waste stream. Linkan estimated that ion exchange would generate approximately 24,000 gallons per day of spent regeneration brine, or about 9 million gallons per year, with off-site hauling requiring approximately 5 to 8 truckloads per day and 15 – 30 acres of storage depending on the design of the facility. Ion exchange also transfers part of the water-quality concern from sulfate to chloride because sulfate removal occurs through exchange with chloride. Linkan estimated that the blended effluent would have only about 1 mg/L of compliance margin relative to the draft chloride limit, leaving little operational flexibility. As a result, ion exchange provides sulfate reduction but introduces waste-disposal, transportation, and secondary water-quality constraints (Linkan, 2026).

Barite precipitation directly targets sulfate but introduces important secondary environmental concerns. Linkan concluded that barium chloride dosing would increase chloride and TDS concentrations, with projected treated-water TDS of approximately 291 mg/L compared to the draft TDS limit of 234.5 mg/L. The process would also require precise control of residual barium to meet the draft barium limit and would involve handling large quantities of barium-bearing reagent and waste. Linkan estimated annual barium chloride demand of approximately 1,000,000 pounds and barite sludge generation of approximately 850,000 pounds per year. These factors create additional chemical-handling, waste-management, and water-quality risks that limit the environmental benefit of the sulfate removal (Linkan, 2026).

Table 10 summarizes the primary water-quality benefit, key environmental tradeoffs, and environmental account score for each retained alternative.

Based on these considerations, the proposed coagulation-assisted filtration system received the highest environmental account score because it avoids brine hauling/evaporation, minimizes energy consumption, and minimizes land-disturbance impacts associated with supplemental sulfate/TDS treatment. Ion exchange scored higher than reverse osmosis and barite precipitation because it provides sulfate reduction with lower waste volume and energy demand than reverse osmosis and avoids the residual barium-control issues associated with barite precipitation. However, ion exchange still introduces regeneration brine disposal and chloride compliance constraints. Overall, the environmental account results indicate that the incremental water-quality benefit of supplemental sulfate/TDS treatment must be weighed against substantial secondary environmental impacts.

Table 10. Summary of Environmental Account Results

Alternative	Primary Water-Quality Benefit	Key Environmental Tradeoffs	Environmental Score
Coagulation-assisted filtration	Metals and suspended solids removal	Limited sulfate/TDS removal, but minimal secondary impacts and no separate brine-management system	4.69
Partial-stream reverse osmosis	Greatest sulfate/TDS reduction	Large brine volume, hauling or evaporation requirements, energy demand, alkalinity replacement, and potential land disturbance	2.75
Partial-stream ion exchange	Sulfate reduction	Regeneration brine, chloride addition, hauling/disposal requirements, and limited chloride compliance margin	3.69
Barite precipitation	Sulfate precipitation	TDS/chloride increase, residual barium-control risk, barium reagent handling, and sludge generation	3.38

4.2.3 Economic Evaluation

The economic account evaluates the relative capital and operating costs associated with each retained alternative. Scored economic subaccounts include capital cost and operating cost. Conceptual cost estimates were developed to a planning level appropriate for alternatives comparison and are intended to support relative ranking rather than final design or budgeting. For supplemental treatment alternatives, the economic evaluation focuses on incremental costs beyond the proposed coagulation-assisted filtration system, including major equipment, chemical consumption, power demand, residuals or waste management, and off-site disposal or hauling requirements.

Table 11 summarizes the economic subaccounts, weights, and rationale used to develop the economic account score.

The proposed coagulation-assisted filtration system represents the base treatment case for the economic evaluation. Linkan's conceptual cost estimate focused on reverse osmosis as the representative membrane treatment alternative; therefore, the economic scores for the membrane alternative are based on reverse osmosis cost and waste-management assumptions. Based on Linkan's conceptual estimates and the MAA assumptions, reverse osmosis would add approximately $14 million in capital cost, ion exchange would add approximately $14 million in capital cost, and barite precipitation would add approximately $9 million in capital cost beyond the base treatment system. These estimates are conceptual and include contingency to account for unknowns associated with the current level of design.

Table 11. Economic Account Subaccount Weighting Rationale

Subaccount	Weight	Rationale for Weight
Capital cost	3	Weighted moderately because supplemental infrastructure costs are important but represent one-time expenditures and are based on conceptual planning-level estimates.
Operating cost	5	Weighted highest because annual treatment, power, chemical, waste-management, and hauling costs would continue throughout the discharge period and represent the largest economic differentiator among alternatives.

Operating costs are the primary economic differentiator among the supplemental alternatives. Reverse osmosis would generate the highest annual operating cost, estimated at approximately $30 million per year beyond the base case, primarily due to the large brine volume and assumed off-site hauling requirements. Ion exchange has a lower estimated annual operating cost, approximately $3 million per year beyond the base case, but would still add substantial recurring costs for chemical use, regeneration waste management, hauling, monitoring, and operational support. The MAA uses a planning-level operating-cost assumption of approximately $3 million per year for barite precipitation to reflect reagent use, solids handling, waste management, and operational support. Linkan separately estimated annual barium chloride chemical costs of approximately $700,000, excluding shipping, storage, handling, hazardous chemical management, and additional solids-management costs.

Table 12 summarizes the approximate incremental costs and economic account score for each retained alternative.

The economic account results indicate that supplemental sulfate/TDS treatment would substantially increase both capital and operating costs relative to the proposed base treatment system. Although reverse osmosis and ion exchange can reduce sulfate concentrations, the required supplemental infrastructure and long-term waste-management obligations result in economic scores well below the base case. Reverse osmosis is the least favorable economically due to the large recurring brine-hauling cost. Ion exchange and barite precipitation have lower estimated operating costs than reverse osmosis but still require substantial incremental investment and recurring waste-management costs. These costs are important to the MAA because the incremental sulfate reduction is driven by Tier 2/RMHQ-based draft permit limits rather than concentrations approaching the next most restrictive beneficial-use standard.

Table 12. Summary of Economic Account Results

Alternative	Approximate Supplemental CAPEX	Approximate Annual OPEX	Key Cost Driver	Economic Score
Coagulation-assisted filtration	Base case	$2.4M/year	Proposed base treatment system	5.00
Partial-stream reverse osmosis	Base case +$14M	Base case +$30M/year	Brine hauling, membrane system, power, chemicals	1.00
Partial-stream ion exchange	Base case +$14M	Base case +$3M/year	Regeneration brine hauling/disposal and resin system	1.00
Barite precipitation	Base case +$9M	Base case +$3M/year	Reagent use, solids handling, waste management	1.38

4.2.4 Social Considerations

The social account evaluates implementation considerations that could affect Project delivery, community impacts, worker safety, and realization of the Project’s socioeconomic benefits. Scored social subaccounts include permits required, schedule risk to net positive socioeconomic benefits, traffic and community perception/safety impacts, and operator safety. These subaccounts were selected because the retained alternatives differ in permitting complexity, implementation schedule, transportation requirements, and operational safety risks.

Table 13 summarizes the social subaccounts, weights, and rationale used to develop the social account score.

Table 13. Social Account Subaccount Weighting Rationale

Subaccount	Weight	Rationale for Weight
Permits required	4	Weighted highly because additional permits can affect implementation certainty, regulatory schedule, and the ability to construct and operate supplemental treatment and waste-management systems.
Schedule risk to net positive socioeconomic benefits	3	Weighted moderately because delays could affect the timing of employment, public revenue, and other Project benefits, but schedule risk is partly captured through permitting and equipment lead-time considerations.
Traffic and community perception/safety impacts	5	Weighted highest because offsite waste hauling can create recurring heavy-truck traffic, community concerns, roadway safety risks, and air-emissions impacts.
Operator safety	5	Weighted highest because chemical handling, high-pressure systems, brine management, and hazardous materials can materially affect worker safety and day-to-day operational risk.

The proposed coagulation-assisted filtration system scored highest in the social account because it would not introduce the same level of additional permitting, off-site waste hauling, or operational safety complexity as the supplemental treatment alternatives. The system involves conventional chemical pretreatment and ultrafiltration with engineered containment and on-site residuals management, and the MAA assumes fewer than one truck trip per day associated with waste management.

Reverse osmosis scored lowest in the social account. Although it can reduce sulfate and TDS concentrations, it would require a major supplemental treatment and brine-management system, likely additional disturbance beyond that evaluated in NEPA, and potentially additional air and dam-safety permitting. If brine is hauled off site, the MAA assumes at least 50 truck trips per day for waste disposal, creating substantial traffic, community perception, roadway safety, and air-emissions concerns. Reverse osmosis also introduces high-pressure equipment, additional chemicals, and increased operational noise and complexity, all of which increase operator safety considerations.

Ion exchange scored higher than reverse osmosis because it would generate substantially less liquid waste and require fewer off-site hauling trips. However, it would still require additional permitting, long lead time for design and fabrication of pressure vessels, management of concentrated regeneration brine, and approximately 5 to 8 truck trips per day for waste disposal, plus delivery of treatment chemicals. These requirements create moderate schedule, traffic, and operational risks.

Barite precipitation scored below ion exchange because it would require handling large quantities of barium-bearing reagent and managing barite solids. The MAA identifies raw barium material handling as an operator-safety concern, and Linkan estimated approximately 1,000,000 pounds per year of barium chloride demand and approximately 850,000 pounds per year of barite sludge generation. Although traffic impacts would be lower than reverse osmosis, barite precipitation would still require chemical deliveries, solids management, and additional operational controls to manage hazardous-material and worker-safety risks.

Table 14 summarizes the key social and permitting considerations and social account score for each retained alternative.

Table 14. Summary of Social Account Results

Alternative	Key Social/Permitting Consideration	Social Score
Coagulation-assisted filtration	Fewest additional permitting, traffic, and operator-safety impacts	4.71
Partial-stream reverse osmosis	High brine-hauling demand, added permitting/schedule risk, high-pressure system	2.00
Partial-stream ion exchange	Moderate brine hauling, regeneration brine management, additional permitting/schedule risk	3.29
Barite precipitation	Barium reagent handling, solids management, chemical delivery and worker-safety concerns	3.00

The social account results show that the supplemental alternatives introduce implementation and community-impact considerations that are not present to the same degree under the proposed base treatment system. Reverse osmosis is the least favorable socially due to the magnitude of off-site brine hauling, additional permitting, and operator-safety considerations. Ion exchange reduces the hauling burden relative to reverse osmosis but still requires long-term brine management, additional truck traffic, and schedule risk. Barite precipitation avoids brine hauling at the same scale as reverse osmosis but introduces hazardous reagent handling and solids-management concerns. These considerations are important because alternatives that are technically capable of reducing sulfate may still be less practicable if they delay Project implementation, increase community impacts, or introduce material safety risks.

4.2.5 Ranking and Preferred Alternative

The MAA results were used to rank the retained alternatives based on the weighted technical, environmental, economic, and social account scores. The overall scores reflect the combined effect of treatment performance, secondary environmental tradeoffs, cost, implementation risk, and social considerations. The detailed MAA scoring table is provided in Appendix C, and the overall ranking is summarized on Figure 7 and Figure 8.

Figure 7 presents the overall MAA score for each retained alternative. The proposed coagulation-assisted filtration system received the highest overall score, followed by partial-stream ion exchange, barite precipitation, and partial-stream reverse osmosis.

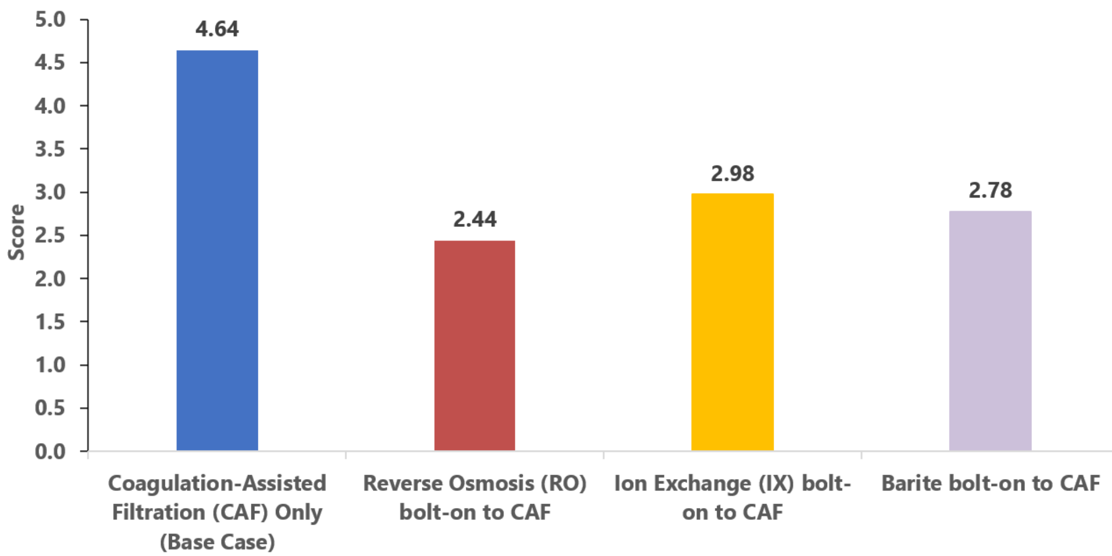
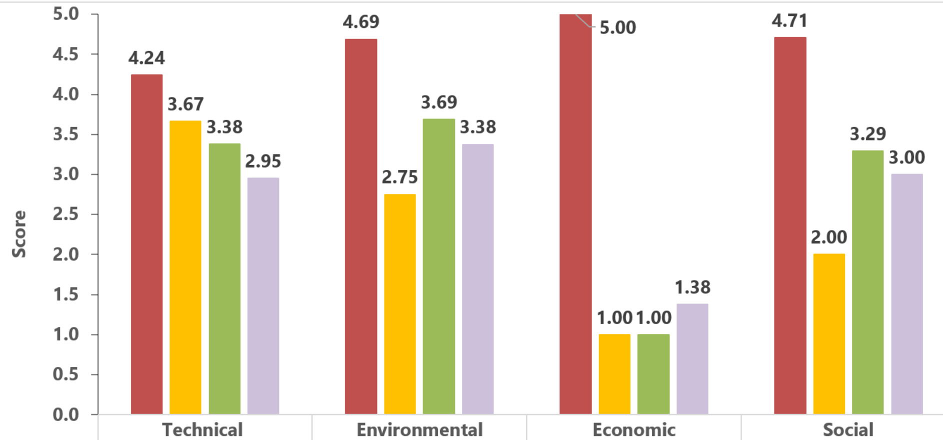


Figure 7. Overall MAA Score by Retained Alternatives

The proposed coagulation-assisted filtration system ranked highest because it provides reliable treatment for metals and suspended solids while avoiding the major secondary impacts associated with supplemental sulfate/TDS treatment. Although reverse osmosis and ion exchange are capable of reducing sulfate concentrations, their incremental water-quality benefit is offset by increased treatment complexity, brine generation, offsite waste management, energy use, traffic, permitting risk, and recurring operating costs. Barite precipitation directly targets sulfate but scored lower due to TDS/chloride addition, residual barium-control risk, reagent handling, and solids-management concerns.

Figure 8 presents the account-level MAA scores for the retained alternatives. The account-level results show that coagulation-assisted filtration scores highest across the accounts, while the supplemental alternatives score lower because their sulfate-removal benefit is accompanied by substantial technical, environmental, economic, or social tradeoffs.



	Technical	Environmental	Economic	Social
Coagulation-Assisted Filtration (CAF) Only (Base Case)	4.24	4.69	5.00	4.71
Reverse Osmosis (RO) bolt-on to CAF	3.67	2.75	1.00	2.00
Ion Exchange (IX) bolt-on to CAF	3.38	3.69	1.00	3.29
Barite bolt-on to CAF	2.95	3.38	1.38	3.00

Figure 8. MAA Account Scores by Retained Alternative

Based on the MAA results, the proposed coagulation-assisted filtration treatment system is identified as the preferred alternative for the Project. The preferred alternative provides reliable metals and suspended-solids treatment, is technically implementable, avoids the large secondary waste streams and long-term off-site disposal obligations associated with supplemental sulfate/TDS treatment, and provides the best overall balance of technical feasibility, environmental tradeoffs, economic achievability, social considerations, and consistency with Project objectives. The MAA supports the conclusion that the incremental water-quality benefit of supplemental sulfate/TDS treatment is outweighed by the associated technical, environmental, economic, and social tradeoffs.

As a sensitivity analysis, the economic evaluation weighting was reduced to 10% and all other categories were set at 30% weight. Using this weighting, coagulation-assisted filtration remains the preferred alternative with a score of 4.59, followed by ion exchange at 3.21 and no changes to the ranking of alternatives. This sensitivity analysis shows that costs are not a significant driver in the MAA results.

5. Project Social and Economic Importance

The South Railroad Project is expected to provide substantial social and economic benefits to Elko County and the State of Nevada. Construction of the Project is expected to support approximately 600 direct jobs, and operations are expected to employ approximately 313 people. These direct employment opportunities would generate an estimated $62 million in direct income and would also support additional indirect and induced economic activity through local contractors, vendors, equipment suppliers, transportation providers, fuel suppliers, maintenance services, and other regional businesses.

The Project would also generate demand for local and regional housing, public services, and supporting infrastructure. During construction, non-local labor is expected to create demand for up to 682 housing units, while operations are expected to create demand for up to 197 housing units. This activity would contribute to increased school enrollment and increased demand for supporting community services, including law enforcement, health care, and other public services. Although these demands require planning and coordination, they also reflect the broader economic activity and population-supporting role of the Project within Elko County.

In addition to employment and income benefits, the Project would provide fiscal contributions to Elko County and the State of Nevada. These contributions are expected to include sales and use taxes, ad valorem property taxes, net proceeds of minerals taxes, and business taxes distributed to Elko County. These revenues would support local government services, public infrastructure, schools, emergency response, and other community needs.

The social and economic benefits of the Project are directly tied to the ability to safely and efficiently mine below the groundwater table in the Dark Star pits. Mine dewatering is required to maintain safe working conditions, support pit access and slope stability, and allow recovery of the mineral resource. Excess dewatering water that cannot be reused in mine operations must therefore be treated and managed through the NPDES permit framework. As described in this alternatives analysis, the proposed coagulation-assisted filtration system provides the base treatment approach for metals and suspended solids, while the analysis of alternatives demonstrates that additional discharge-management or supplemental sulfate/TDS treatment alternatives would introduce substantial technical, environmental, economic, and social tradeoffs.

If the SEC determines that degradation of existing higher water quality for one or more Tier 2 parameters may occur, the Project's social and economic importance provides context for evaluating whether such degradation is justified under Nevada's antidegradation requirements. Approval of the proposed discharge, subject to appropriate permit limits and treatment requirements, would support realization of the Project's employment, income, tax revenue, and mineral-production benefits while maintaining protection of applicable water quality standards and designated beneficial uses.

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Appendix A

Monitoring Results

LOUGHLIN
WATER ASSOCIATES LLC
a Geo-Logic Company

Parameter	Units	WQS: Aquatic Life	WQS: Most Restrictive	NPDES Draft Permit	Antideg. Tier	Statistic	Dix-2	Dix-3	Dix-6	ST2	ST6	ST8
Sample Count, Dissolved	-	-	-	-	-	-	**0**	**0**	**0**	**6**	**19**	**19**
Sample Count, Total	-	-	-	-	-	-	**9**	**21**	**23**	**0**	**0**	**1**
Hardness, Total*	mg/L CaCO3	-	-	-	-	Minimum	35	83	73	-	-	159
						Median	66	162	152	-	-	159
						Maximum	99	176	176	-	-	159
Hardness, Dissolved*	mg/L CaCO3	-	-	-	-	Minimum	-	-	-	35	67	92
						Median	-	-	-	51	150	146
						Maximum	-	-	-	73	177	173
Total Alkalinity	mg/L as CaCO3	≥20	≥20	≥72.65	Tier 2	Minimum	45	90	48	32	78	98
						Median	74	150	150	65.5	140	140
						Maximum	100	180	190	94	210	160
Bicarbonate (HCO3)	mg/L as CaCO3	--	--	--	--	Minimum	45	90	48	32	78	98
						Median	74	150	140	65.5	130	140
						Maximum	100	180	180	94	200	160
Carbonate (CO3)	mg/L as CaCO3	--	--	--	--	Minimum	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
						Median	<1.0	<1.0	4.9	<1.0	1.5	<1.0
						Maximum	<1.0	22	30	<1.0	27	<1.0
Hydroxide (OH)	mg/L as CaCO3	--	--	--	--	Minimum	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
						Median	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
						Maximum	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
Aluminum	mg/L	--	--	--	--	Minimum	<0.050	<0.050	<0.050	-	-	0.66
						Median	0.31	0.22	0.29	-	-	0.66
						Maximum	1.6	5.2	19	-	-	0.66
Aluminum, Dissolved	mg/L	--	--	--	--	Minimum	-	-	-	<0.050	<0.045	<0.045
						Median	-	-	-	0.071	<0.050	<0.050
						Maximum	-	-	-	2.1	0.41	0.66
Antimony	mg/L	--	0.146	0.0146	Tier 2	Minimum	<0.0025	<0.0025	<0.0025	-	-	<0.0025
						Median	<0.0025	<0.0025	<0.0025	-	-	<0.0025
						Maximum	<0.0025	<0.0025	<0.0025	-	-	<0.0025
Antimony, Dissolved	mg/L	--	0.146	--	--	Minimum	-	-	-	<0.0025	<0.0025	<0.0025
						Median	-	-	-	<0.0025	<0.0025	<0.0025
						Maximum	-	-	-	<0.0025	<0.0025	<0.0025
Arsenic	mg/L	0.15	0.05	0.0377	Tier 2	Minimum	<0.0050	0.014	0.008	-	-	0.025
						Median	<0.0050	0.028	0.022	-	-	0.025
						Maximum	0.0067	0.048	0.037	-	-	0.025
Arsenic, Dissolved	mg/L	0.15	0.05	--	--	Minimum	-	-	-	<0.0050	0.011	0.013
						Median	-	-	-	<0.0050	0.023	0.019
						Maximum	-	-	-	0.006	0.030	0.040

Parameter	Units	WQS: Aquatic Life	WQS: Most Restrictive	NPDES Draft Permit	Antideg. Tier	Statistic	Dix-2	Dix-3	Dix-6	ST2	ST6	ST8
Barium	mg/L	--	2	0.2515	Tier 2	Minimum	0.1	0.12	0.098	-	-	0.22
						Median	0.16	0.17	0.17	-	-	0.22
						Maximum	0.22	0.36	0.69	-	-	0.22
Barium, Dissolved	mg/L	--	2	--	--	Minimum	-	-	-	0.082	0.038	0.1
						Median	-	-	-	0.12	0.14	0.14
						Maximum	-	-	-	0.17	0.19	0.18
Beryllium	mg/L	--	0	0	Tier 1	Minimum	<0.0010	<0.0010	<0.0010	-	-	<0.0010
						Median	<0.0010	<0.0010	<0.0010	-	-	<0.0010
						Maximum	<0.0010	<0.0010	<0.0020	-	-	<0.0010
Beryllium, Dissolved	mg/L	--	0	--	--	Minimum	-	-	-	<0.0010	<0.0010	<0.0010
						Median	-	-	-	<0.0010	<0.0010	<0.0010
						Maximum	-	-	-	<0.0010	<0.0010	<0.0010
Cadmium	mg/L	hardness dependent	hardness dependent	0.00036	Tier 2	Minimum	<0.0010	<0.0010	<0.0010	-	-	<0.0010
						Median	<0.0010	<0.0010	<0.0010	-	-	<0.0010
						Maximum	<0.0010	<0.0020	<0.0020	-	-	<0.0010
Cadmium, Dissolved	mg/L	hardness dependent	hardness dependent	0.00036	Tier 2	Minimum	-	-	-	<0.0010	<0.0010	<0.0010
						Median	-	-	-	<0.0010	<0.0010	<0.0010
						Maximum	-	-	-	<0.0010	<0.0010	0.0047
Calcium	mg/L	--	--	--	--	Minimum	9.3	21	18	-	-	39
						Median	18	40	38	-	-	39
						Maximum	27	44	44	-	-	39
Calcium, Dissolved	mg/L	--	--	--	--	Minimum	-	-	-	8.9	17	24
						Median	-	-	-	14	37	37
						Maximum	-	-	-	20	43	43
Chloride	mg/L	230	230	86	Tier 2	Minimum	2.2	<1.0	2.6	2.7	<5.0	2
						Median	4.9	3.1	5.3	4.5	<5.0	3.4
						Maximum	7.1	4.7	9.4	5.7	9.7	8.6
Chromium	mg/L	--	0.1	0.01	Tier 2	Minimum	<0.005	<0.005	<0.005	-	-	<0.005
						Median	<0.005	<0.005	<0.005	-	-	<0.005
						Maximum	<0.005	<0.005	0.016	-	-	<0.005
Chromium, Dissolved	mg/L	--	0.1	--	--	Minimum	-	-	-	<0.005	<0.005	<0.005
						Median	-	-	-	<0.005	<0.005	<0.005
						Maximum	-	-	-	<0.005	<0.005	<0.005
Copper	mg/L	hardness dependent	hardness dependent	0.01428	Tier 2	Minimum	<0.04	<0.04	<0.04	-	-	<0.04
						Median	<0.04	<0.04	<0.04	-	-	<0.04
						Maximum	<0.04	<0.04	<0.08	-	-	<0.04
Copper, Dissolved	mg/L	hardness dependent	hardness dependent	0.01428	Tier 2	Minimum	-	-	-	<0.04	<0.04	<0.04
						Median	-	-	-	<0.04	<0.04	<0.04
						Maximum	-	-	-	<0.04	<0.04	<0.04

Parameter	Units	WQS: Aquatic Life	WQS: Most Restrictive	NPDES Draft Permit	Antideg. Tier	Statistic	Dix-2	Dix-3	Dix-6	ST2	ST6	ST8
Fluoride	mg/L	--	1	0.36	Tier 2	Minimum	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
						Median	<0.3	<0.3	<0.3	<0.3	<0.3	<0.3
						Maximum	<0.3	0.4	0.38	<0.3	<1.0	0.41
Iron	mg/L	1	1	1	Tier 1	Minimum	<0.10	<0.10	<0.10	-	-	0.52
						Median	0.22	0.23	0.28	-	-	0.52
						Maximum	1	3.9	13	-	-	0.52
Iron, Dissolved	mg/L	1	1	--	--	Minimum	-	-	-	<0.10	<0.10	<0.10
						Median	-	-	-	0.11	<0.10	<0.10
						Maximum	-	-	-	1.2	1.3	0.36
Lead	mg/L	hardness dependent	hardness dependent	0.00453	Tier 2	Minimum	<0.0025	<0.0025	<0.0025	-	-	<0.0025
						Median	<0.0025	<0.0025	<0.0025	-	-	<0.0025
						Maximum	<0.0025	0.0038	0.012	-	-	<0.0025
Lead, Dissolved	mg/L	hardness dependent	hardness dependent	0.00453	Tier 2	Minimum	-	-	-	<0.0025	<0.0025	<0.0025
						Median	-	-	-	<0.0025	<0.0025	<0.0025
						Maximum	-	-	-	<0.0025	<0.0025	<0.0025
Magnesium	mg/L	--	--	--	--	Minimum	2.9	7.4	6.9	-	-	15
						Median	5.2	15	14	-	-	15
						Maximum	7.8	16	16	-	-	15
Magnesium, Dissolved	mg/L	--	--	--	--	Minimum	-	-	-	3	5.9	7.9
						Median	-	-	-	4	14	13
						Maximum	-	-	-	5.7	17	16
Manganese	mg/L	--	0.2	0.155	Tier 2	Minimum	<0.010	0.015	0.021	-	-	0.07
						Median	0.025	0.03	0.031	-	-	0.07
						Maximum	0.045	0.46	0.82	-	-	0.07
Manganese, Dissolved	mg/L	--	0.2	0.155	Tier 2	Minimum	-	-	-	<0.010	<0.010	<0.010
						Median	-	-	-	<0.010	<0.010	0.021
						Maximum	-	-	-	0.015	0.087	0.05
Mercury	mg/L	0.00077	0.00077	0.000225	Tier 2	Minimum	<0.0005	<0.0005	<0.0005	-	-	<0.0005
						Median	<0.0005	<0.0005	<0.0005	-	-	<0.0005
						Maximum	<0.0005	<0.0005	<0.0005	-	-	<0.0005
Mercury, Dissolved	mg/L	0.00077	0.00077	0.000225	Tier 2	Minimum	-	-	-	<0.0005	<0.0001	<0.0001
						Median	-	-	-	<0.0005	<0.0005	<0.0005
						Maximum	-	-	-	<0.0005	<0.0005	<0.0005
Molybdenum	mg/L	1.65	1.65	0.616	Tier 2	Minimum	<0.02	<0.02	<0.02	-	-	<0.02
						Median	<0.02	<0.02	<0.02	-	-	<0.02
						Maximum	<0.02	<0.02	<0.04	-	-	<0.02
Nickel	mg/L	hardness dependent	0.0134	0.0134	Tier 1	Minimum	<0.03	<0.03	<0.03	-	-	<0.03
						Median	<0.03	<0.03	<0.03	-	-	<0.03
						Maximum	<0.03	<0.03	<0.06	-	-	<0.03

Parameter	Units	WQS: Aquatic Life	WQS: Most Restrictive	NPDES Draft Permit	Antideg. Tier	Statistic	Dix-2	Dix-3	Dix-6	ST2	ST6	ST8
Nitrate + Nitrite Nitrogen	mg/L	--	--	--	--	Minimum	<0.0	<0.0	<0.0	<0.1	<0.1	<0.1
						Median	<0.1	0.1	<0.1	<0.1	<0.1	<0.1
						Maximum	<0.1	<0.5	<0.5	0.13	<0.1	<0.1
Total Nitrogen	mg/L	--	10	--	--	Minimum	<0.4	<0.4	<0.4	<0.5	<0.5	<0.5
						Median	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
						Maximum	1.1	<0.9	2.4	0.74	1.2	<0.5
Total Kjeldahl Nitrogen	mg/L	--	--	--	--	Minimum	<0.4	<0.4	<0.4	<0.4	<0.4	<0.4
						Median	0.41	<0.4	<0.4	<0.4	<0.4	<0.4
						Maximum	1.1	0.57	2.2	0.61	1.2	0.42
pH	s.u.	6.5-9.0	6.5-9.0	7.2-8.7	--	Minimum	6.41	6.74	6.80	7.10	6.93	7.58
						Median	7.61	8.27	8.34	7.77	8.31	8.10
						Maximum	7.98	8.55	8.77	8.00	8.59	8.25
Potassium	mg/L	--	--	--	--	Minimum	1.5	1.2	1.6	-	-	2.2
						Median	2.1	1.8	2.7	-	-	2.2
						Maximum	3	4.3	5.7	-	-	2.2
Potassium, Dissolved	mg/L	--	--	--	--	Minimum	-	-	-	1.5	1.3	1
						Median	-	-	-	1.75	2	1.8
						Maximum	-	-	-	2.7	3.2	4
Phosphorus	mg/L	0.1	0.1	0.1	Tier 1	Minimum	<0.5	<0.5	<0.5	-	-	<0.5
						Median	<0.5	<0.5	<0.5	-	-	<0.5
						Maximum	<0.5	<0.5	<1.0	-	-	<0.5
Selenium	mg/L	0.05	0.02	0.0025	Tier 2	Minimum	<0.0050	<0.0050	<0.0050	-	-	<0.0050
						Median	<0.0050	<0.0050	<0.0050	-	-	<0.0050
						Maximum	<0.0050	<0.0050	<0.0050	-	-	<0.0050
Selenium, Dissolved	mg/L	0.05	0.02	--	--	Minimum	-	-	-	<0.0050	<0.0050	<0.0050
						Median	-	-	-	<0.0050	<0.0050	<0.0050
						Maximum	-	-	-	<0.0050	<0.0050	<0.0050
Silver	mg/L	0.0000715	0.0000715	0.0000715	Tier 1	Minimum	-	-	-	-	-	-
						Median	-	-	-	-	-	-
						Maximum	-	-	-	-	-	-
Silver, Dissolved	mg/L	0.0000715	0.0000715	0.0000715	Tier 1	Minimum	-	-	-	<0.0050	<0.0050	<0.0050
						Median	-	-	-	<0.0050	<0.0050	<0.0050
						Maximum	-	-	-	<0.0050	<0.0050	<0.0050
Sodium	mg/L	--	--	--	--	Minimum	6.9	7.4	8.7	-	-	8.1
						Median	11	8.9	11	-	-	8.1
						Maximum	15	10	14	-	-	8.1
Sodium, Dissolved	mg/L	--	--	--	--	Minimum	-	-	-	6.4	6.4	5.4
						Median	-	-	-	8.75	9.5	7.7
						Maximum	-	-	-	12	15	13

Parameter	Units	WQS: Aquatic Life	WQS: Most Restrictive	NPDES Draft Permit	Antideg. Tier	Statistic	Dix-2	Dix-3	Dix-6	ST2	ST6	ST8
Sulfate	mg/L	--	250	30.45	Tier 2	Minimum	5.5	<2	6.3	4.7	10	15
						Median	15	23	20	8.2	25	26
						Maximum	18	28	30	12	38	37
Thallium	mg/L	--	0.013	0.0013	Tier 2	Minimum	<0.0010	<0.0010	<0.0010	-	-	<0.0010
						Median	<0.0010	<0.0010	<0.0010	-	-	<0.0010
						Maximum	<0.0010	<0.0010	<0.0010	-	-	<0.0010
Thallium, Dissolved	mg/L	--	0.013	--	--	Minimum	-	-	-	<0.0010	<0.0010	<0.0010
						Median	-	-	-	<0.0010	<0.0010	<0.0010
						Maximum	-	-	-	<0.0010	<0.0010	<0.0010
Uranium	mg/L	--	--	--	--	Minimum	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
						Median	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
						Maximum	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Zinc	mg/L	hardness dependent	hardness dependent	0.18758	Tier 2	Minimum	<0.02	<0.02	<0.02	-	-	<0.02
						Median	<0.02	<0.02	<0.02	-	-	<0.02
						Maximum	<0.02	0.021	0.052	-	-	<0.02
Zinc, Dissolved	mg/L	hardness dependent	hardness dependent	0.0262	Tier 2	Minimum	-	-	-	<0.02	<0.02	<0.02
						Median	-	-	-	<0.02	<0.02	<0.02
						Maximum	-	-	-	<0.02	0.033	0.09
WAD Cyanide	mg/L	--	--	--	--	Minimum	-	-	-	<0.01	<0.01	<0.01
						Median	-	-	-	<0.01	<0.01	<0.01
						Maximum	-	-	-	0.099	<0.01	<0.01
Total Dissolved Solids (TDS)	mg/L	--	500	234.5	Tier 2	Minimum	64	130	110	63	100	130
						Median	99	190	200	112	190	185
						Maximum	170	310	240	190	260	230
Total Suspended Solids (TSS)	mg/L	25	25	25	Tier 1	Minimum	<10	<10	<10	-	-	15
						Median	<10	<10	<10	-	-	15
						Maximum	17	36	300	-	-	15

Highlighted values exceed NDPES draft permit values

The following analytes have standards for South Fork Humboldt River under NAC 445A.1236, but have not been analyzed in any samples: Chromium VI, Chromium III, and Fecal Coliform

All of the VOCs and SVOCs analyzed for drinking water in PW21-01, DSWW17-01, and PW22-01 were non-detect. Unfortunately, there was no overlap between the list of organic toxins applicable under NAC 445A.1236, and the constituents analyzed for drinking water. For full list, see separate Sheet !OrganicAnalytes

Appendix B

Linkan Engineering Sulfate Treatment Alternative Analysis

LOUGHLIN WATER ASSOCIATES LLC
a Geo-Logic Company

South Railroad Sulfate Treatment

Alternatives Analysis

Doc. No.: 26US0328_1152-Rev. 1

Date: July 29, 2026

Prepared for:

Orla Mining

Prepared by:

Linkan
2720 Ruby Vista Drive
Suite 101
Elko, NV 89801
775.777.8003

EXECUTIVE SUMMARY

Orla Mining is developing the South Railroad Mine Water Treatment Plant (WTP) to comply with draft National Pollutant Discharge Elimination System (NPDES) discharge requirements. The existing Coagulation-Assisted-Filtration (CAF) process was designed to remove arsenic, thallium, and other metals to meet Nevada Profile 1 discharge standards. However, draft antidegradation-based discharge limits for sulfate and total dissolved solids (TDS) would require supplemental treatment beyond the scope of the original WTP design. This report evaluates the technical feasibility, environmental impacts, socioeconomic impacts, and conceptual costs associated with treatment technologies capable of meeting the proposed sulfate and TDS limits.

The preliminary evaluation found that modifications to the existing chemical treatment process could not achieve compliance with the proposed sulfate and TDS limits without creating additional water quality, operational, or environmental concerns. Three supplemental treatment alternatives—barite precipitation, reverse osmosis (RO), and ion exchange (IX)—were therefore evaluated. Barite precipitation was eliminated because chloride addition associated with barium dosing increases treated-water TDS above the proposed discharge limit. In addition, reliable simultaneous compliance with sulfate and residual barium limits is not considered achievable under full-scale operating conditions.

Both RO and IX were determined to be technically capable of reducing sulfate concentrations to meet the proposed discharge limit. However, achieving this incremental improvement in effluent quality would require construction and operation of a major treatment and waste-management system. RO would generate approximately 90 million gallons of concentrated brine annually, require up to 77 tanker loads per day for off-site disposal, and incur estimated operating costs of approximately $30 million per year. IX would reduce waste generation substantially relative to RO but would still generate approximately 9 million gallons of regeneration brine annually, require long-term off-site waste disposal, and introduce chloride as a secondary compliance constraint with an estimated compliance margin of only 1 mg/L.

The evaluation demonstrates that while additional sulfate treatment is technically achievable, it transfers environmental impacts from the receiving water to increased energy consumption, chemical use, waste generation, transportation, land disturbance, and air emissions, while substantially increasing capital and operating costs. These impacts are disproportionate to the incremental reduction in sulfate concentration required by the draft antidegradation-based discharge limits.

If supplemental sulfate treatment is ultimately required, ion exchange represents the more practical alternative because it achieves the required sulfate reduction with substantially lower waste generation, energy consumption, operating cost, and implementation complexity than reverse osmosis. However, based on the findings of this evaluation, Linkan recommends that Orla continue pursuing a variance from the draft antidegradation-based sulfate and TDS limits, as the incremental water-quality benefit of additional treatment is outweighed by the associated technical, environmental, and socioeconomic impacts.

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ACRONYMS & ABBREVIATIONS

BOD	Biochemical oxygen demand
CAF	coagulation-assisted-filtration
CCRO	closed-circuit reverse osmosis
CIP	clean-in-place
COC	constituents of concern
gals	gallons
gpm	gallons per minute
IFC	Issued for Construction
IX	ion exchange
lbs	pounds
mg/L	milligrams per liter
MGD	millions of gallons per day
MWh	megawatt-hour
NDEP	Nevada Division of Environmental Protection
NPDES	National Pollutant Discharge Elimination System
OH&P	overhead and profit
PFD	process flow diagram
RO	reverse osmosis
SBS	sodium bisulfite
SWOT	strengths, weaknesses, opportunities, threats analysis
TDS	total dissolved solids
TMT	trimercapto-s-triazine trisodium salt
UIC	underground injection control
UF	ultrafiltration
WTP	water treatment plant

1.0 INTRODUCTION

Linkan Engineering (Linkan) has prepared this report for Orla Mining (Orla) to evaluate alternative treatment processes for the South Railroad Mine Water Treatment Plant (WTP). Following the development of draft National Pollutant Discharge Elimination System (NPDES) permit requirements, including anti-degradation criteria, supplemental treatment processes are required beyond the scope of the original WTP design. Of particular interest to this study, are sulfate and total dissolved solids (TDS).

Linkan evaluated three treatment alternatives—barite precipitation, reverse osmosis (RO), and ion exchange—for the removal of sulfate and TDS to meet the proposed draft discharge limits. Each alternative was developed to a level sufficient to support feasibility analysis; key evaluation criteria include technical, environmental, economic, and social impacts of the proposed system modifications.

1.1. Existing Water Treatment Design

Previously, Linkan completed the Issued for Construction (IFC) design package for the South Railroad Mine Water Treatment Plant (25US0190_S.Railroad_IFC_REV0). The original design was developed assuming water discharges would be required to meet the Nevada Division of Environmental Protection (NDEP) Profile 1 discharge requirements.

In the designed treatment process, groundwater is pumped initially to a Dewatering Tank to buffer variability in flows and feed water chemistry. From the Dewatering Tank, water is conveyed via gravity to the treatment system where chemical dosing systems provide sulfuric acid for pH adjustment, sodium hypochlorite for oxidation, ferric chloride for coagulation, and trimercapto-s-triazine trisodium salt (TMT) for heavy metal precipitation. Following chemical dosing, chemically pretreated water is conveyed to two mixed frac-style Reaction Tanks in parallel providing a minimum of 15 minutes of retention time for chemical reactions to occur.

Effluent from the Reaction Tanks is pumped to the ultrafiltration (UF) system for suspended solids removal. UF filtrate is dosed with sodium bisulfite (SBS) to quench residual oxidant then collected in a Finished Water Tank prior to discharge. Backwash water, membrane cleaning solutions, and tank cleanout waste are directed to sludge holding ponds. Water recovered from the sludge holding ponds is recycled to the Reaction Tanks to maximize water recovery and minimize wastewater generation.

This treatment process, also commonly referred to as Coagulation-Assisted-Filtration (CAF), is the state-of-the-art for removing arsenic, antimony, and heavy metals. Linkan has deployed CAF multiple times to achieve Profile 1 discharge limits at mine sites in Nevada. The process flow diagram from the IFC design package is included in **Appendix A** for reference.

2.0 DESIGN BASIS

The following represents the design basis utilized for this study. Linkan has assumed the existing design will remain in place but that additional unit operations will be required to accommodate the draft discharge limits, specifically with respect to sulfate and TDS.

2.1. Water Chemistry and Draft Discharge Limits

The maximum water quality data collected from representative dewatering wells in the mineralized Darkstar (DSWW17-01) and Pinion (PW22-01) zones represent the design basis for raw feed water quality to the water treatment plant. Using the maximum instead of the average water quality data is good practice to ensure the design meets continual compliance. With that raw feed water quality and anticipated maximum chemical doses to be utilized in the water treatment process, UF filtrate water quality has been projected. Both data sets are presented alongside the draft discharge limits in **Table 2-1**.

Constituents such as arsenic and thallium that can be removed with the existing water treatment process design utilizing CAF have been assumed to be equivalent to the draft discharge limit in the UF filtrate. Note that due to the chemical additions throughout the process, sulfate, TDS, and chloride concentrations will increase in the UF filtrate relative to the feed.

Table 2-1: Raw Feed and UF Filtrate Water Chemistry Relative to the Draft Discharge Permit Limits

Parameter	Units	Raw Feed	UF Filtrate Projected[1]	Draft Limit
Total Alkalinity	mg/L as $CaCO_3$	140	140	≥72.65
Antimony	mg/L	0.009	0.009	0.0146
Arsenic	mg/L	0.081	0.0377	0.0377
Barium	mg/L	0.14	0.14	0.2515
Beryllium	mg/L	<0.0010	<0.0010	0
Boron	mg/L	No Data	No Data	0.075
Cadmium	mg/L	<0.0010	0.00036	0.00036
Cadmium, Dissolved	mg/L	<0.0020	0.00036	0.00036
Chloride	mg/L	9.8	47	86
Chromium	mg/L	<0.005	<0.005	0.01
Copper	mg/L	<0.04	0.01428	0.01428
Copper, Dissolved	mg/L	<0.08	0.01428	0.01428
Fluoride[2]	mg/L	< 0.3	0.36	0.36
Iron	mg/L	0.72	0.72	1
Lead	mg/L	<0.0025	<0.0025	0.00453
Lead, Dissolved	mg/L	<0.0050	<0.0050	0.00453
Manganese	mg/L	0.098	0.098	0.155
Manganese, Dissolved	mg/L	0.087	0.087	0.155
Mercury	mg/L	<0.0006	0.000225	0.000225
Mercury, Dissolved	mg/L	<0.0005	0.000225	0.000225
Molybdenum	mg/L	<0.02	<0.02	0.616
Nickel	mg/L	<0.03	0.0134	0.0134
Nitrate + Nitrite Nitrogen	mg/L	<0.2	<0.2	1
pH	s.u.	8.26	8.26	7.2-8.7
Phosphorus, Total as P	mg/L	<0.5	0.1	0.1
Selenium	mg/L	<0.0050	0.0025	0.0025
Silver, Dissolved	mg/L	<0.0100	0.0000715	0.0000715
Sulfate	mg/L	37	67	30.45
Thallium	mg/L	0.0016	0.0013	0.0013
Zinc	mg/L	0.039	0.039	0.18758
Zinc, Dissolved	mg/L	<0.04	0.0262	0.0262
Total Dissolved Solids (TDS)	mg/L	180	264	234.5
Total Suspended Solids (TSS)	mg/L	<10	<10	25
NOTES:				

1 - Note that for those constituents that are either above the draft discharge limit in the raw feed and the treatment system is designed to remove (arsenic, cadmium, copper, mercury, nickel, silver, thallium, and zinc) or those constituents that the detection limits in the raw feed were lower than the draft discharge limit (phosphorus and selenium), Linkan has assumed the UF filtrate concentration is equal to the draft discharge limit. This provides a conservative treatment basis for unit operations downstream of UF.

2 - The fluoride concentration in the feed water data set is consistently < 0.3. As Linkan understands, a single value of 0.38 mg/L was measured. Linkan assumes this maximum value measured in the raw feed, 0.38 mg/L, is a statistical outlier and has therefore set the fluoride concentration in the UF filtrate to the draft discharge limit to represent a conservative treatment basis for unit operations downstream of UF.

2.2. Constituents of Concern

Constituents of concern (COCs) are parameters that require treatment to achieve draft discharge limits (**Table 2-2**). The following summarizes the COCs and the assumptions used in the evaluation of the treatment alternatives presented in this report.

Table 2-2: Constituents of Concern

Parameter	Raw Feed [mg/L][1,2,3]	UF Filtrate [mg/L]	Discharge Limit [mg/L]
Primary Constituents of Concern			
Arsenic	0.081	< 0.0377	0.0377
Thallium	0.0016	< 0.0013	0.0013
Sulfate	37	67	30.45
Total Dissolved Solids (TDS)	180	264	234.5
Secondary Constituents of Concern			
Chloride	9.8	47	86
Iron	0.72	< 0.72	1
pH	8.26	6-8.26	7.2-8.7

NOTES:

1 - Several constituents were analyzed with detection limits that were insufficient to determine whether targeted treatment is required to achieve compliance with the draft permit limits. These constituents include beryllium, cadmium, copper, lead, mercury, nickel, phosphorus, selenium, silver, and zinc. For the purposes of this evaluation, these constituents are assumed to comply with the proposed draft permit limits.

2 - Although current groundwater concentrations of nitrate and TSS are below the proposed permit limits, it is anticipated that blasting and mining activities may increase concentrations during operation. It is assumed that these constituents will be managed through source control measures rather than by the downstream WTP.

3 - Groundwater monitoring well DSWW17-01 reported an average fluoride concentration of less than 0.3 mg/L, with a single measured concentration of 0.38 mg/L, exceeding the proposed permit limit. The existing WTP design is not capable of reliably treating elevated fluoride concentrations. Because only one sample exceeded the proposed limit, this analysis assumes the result is not representative of long-term water quality and fluoride removal is not required in the treatment system.

Arsenic, thallium, sulfate, and TDS are the primary constituents of concern. While the existing treatment system design utilizing CAF can remove arsenic and thallium effectively, sulfate or TDS removal were not considered in that design. Sulfate and TDS removal represent the principal design drivers for the treatment alternatives evaluated in this report.

The chemistry utilized in the treatment system, including sulfuric acid (H_2SO_4), sodium hypochlorite (NaOCl), ferric chloride ($FeCl_3$), TMT ($Na_3N_3S_3C_3$), sodium bisulfite ($NaHSO_3$), and sodium hydroxide (NaOH) may also affect sulfate, chloride, iron, pH, and TDS concentrations. Accordingly, chloride, iron, and pH are considered secondary constituents of concern as chemical dosing will be constrained by their respective draft discharge limits.

2.3. Flow Rates

The existing water treatment plant design flow balance serves as the design basis for this study (**Table 2-3**). The maximum case is considered here as any additional unit operations must produce compliant effluent in all scenarios.

Table 2-3: Existing Water Treatment Design Flow Balance

Stream Description	Raw Feed	UF Feed (with recycle)	UF Filtrate	UF Backwash	Recycle
Design Flow (Instantaneous), GPM	2,400	2,793	2,400	528	139
Design Flow, GPD	3,456,000	4,022,172	3,456,000	200,520	200,520

3.0 ASSUMPTIONS AND LIMITATIONS

- Note, that mine impacted waters in the Carlin Trend have exhibited variable concentrations of silica. For example, the silica concentration in TSF3 at the Goldstrike Mine was 61.2 mg/L in 2023 and the silica concentration in the 5/6 East Tailings Impoundment at the Gold Quarry Mine was 7 mg/L in 2026. Silica has the potential to limit RO recovery or increase the fouling rate of ion exchange media; in either case, elevated silica concentrations have the potential to increase waste generation and operational complexity for either process. Silica data is not available in the dewatering well data set; thus, the effect of silica on treatment system performance has been neglected for the purposes of this study.
- Operating costs associated with power consumption were estimated assuming $0.08 per kWh.
- Brine hauling costs were estimated from 2025 national average truck carrier charges for mined commodities. Prices were escalated to 2026 utilizing the producer price index for general freight trucking, long-distance truckload from the US Bureau of Labor Statistics via FRED. Hauling costs represent transportation only and do not include any treatment, processing, or disposal fees charged by the receiving facility. Brine hauling estimates assume that brine will be transported to the Clean Harbors treatment facility located in Aragonite, Utah, requiring an estimated 420-mile roundtrip haul distance from the project site. Further investigation is needed to confirm this facility has the capacity to accept large amounts of brine and what additional costs associated with brine treatment may be incurred.
- For constituents that are either above the draft discharge limit in the raw feed and the treatment system is designed to remove (arsenic, cadmium, copper, mercury, nickel, silver, thallium, and zinc), or those constituents that the detection limits in the raw feed were lower than the draft discharge limit (phosphorus and selenium), Linkan has assumed the UF filtrate concentration is equal to the draft discharge limit. This provides a conservative treatment basis for unit operations downstream of UF.
- All alternatives assessed in this study require inclusion of the existing water treatment system design to ensure reliable operations performance and compliant effluent. As such, costing, including capital and operating costs, of any equipment or unit operation included in the existing design is not included in this study.

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4.0 CHEMICAL ALTERNATIVES

Compliance concerns associated with sulfate could be mitigated with chemical substitutions. For example, sulfuric acid (H_2SO_4) could be replaced with hydrochloric acid (HCl) and/or sodium bisulfite ($NaHSO_3$ which forms sulfate after reacting with residual oxidant) could be replaced with ascorbic acid ($C_6H_8O_6$) or sodium ascorbate ($C_6H_7NaO_6$). However, these substitutions are limited in practicality for the following reasons:

- Replacing the anticipated 15 mg/L maximum dose of sulfuric acid (H_2SO_4) with hydrochloric acid (HCl) would require a theoretical dose of 11.5 mg/L of HCl as it is a stronger acid. Replacing the anticipated 15 mg/L maximum dose of sodium bisulfite ($NaHSO_3$) with sodium ascorbate ($C_6H_7NaO_6$) would require a theoretical dose of approximately 30 mg/L as it is a weaker reducing agent. Both chemical substitutions are anticipated to increase TDS by 15 mg/L, which results in a UF filtrate TDS of 250 mg/L, above the draft discharge limit of 234.5 mg/L. Achieving sulfate compliance via chemical substitution alone is not technically feasible as the TDS criteria would still be exceeded.
- Substituting hydrochloric acid for sulfuric acid comes with safety concerns. Hydrochloric acid is approximately 30,000 times more volatile than sulfuric acid based on vapor pressures at ambient conditions. Acid mist and acid fumes represent occupational health risks. Because the system is located outdoors and subject to changes in ambient conditions, HCl mist/vapor production would be uncontrolled and subject to environmental conditions. In addition, excess acid fumes represent structural risk to the water treatment plant equipment due to corrosion.
- While sodium bisulfite reacts rapidly and is readily controlled, an organic-based reducing agent such as ascorbic acid or sodium ascorbate reacts more slowly and forms residual organic byproduct species. Residual organic byproducts in the process effluent increases biological oxygen demand (BOD), risking health of the downstream aquatic community as excess BOD may rapidly deplete dissolved oxygen and/or promote an environment for bacterial and/or algae growth.

Due to these concerns, chemical substitution is not a feasible alternative to achieve the draft permit limits for sulfate and TDS concurrently.

5.0 BARITE PRECIPITATION

In a theoretical barite precipitation process, groundwater is directed from the Dewatering Tank to Barite Reaction Tanks where barium chloride ($BaCl_2$) is added to precipitate sulfate as barium sulfate ($BaSO_4$), or barite. Following barite precipitation, barite solids would be removed via clarification and the treatment process would continue as designed.

Barite precipitation was evaluated as a potential sulfate treatment process, however, this alternative was determined to be infeasible for the reasons presented below.

<u>Chloride and TDS Addition</u>

Barium chloride (dihydrate) is approximately 30% chloride by mass, thus, for each gram of barium chloride added, 0.3 grams of chloride are added to the water as well. The theoretical stoichiometric barium chloride demand (as barium chloride dihydrate) is 93 mg/L; the associated chloride addition is estimated to be 27 mg/L. With the various chemical additions in the treatment process expected to add up to 37 mg/L of chloride, and a maximum chloride concentration measured in the dewatering wells of

10 mg/L, the maximum estimated chloride in the treatment system effluent is 74 mg/L. With a draft chloride discharge limit of 86 mg/L, this leaves very little room for error. Furthermore, actual barium demand is expected to exceed the theoretical stoichiometric demand due to the lack of ideal reaction conditions in an actual process.

Most importantly, the chloride addition associated with barium chloride is expected to increase the treatment system effluent TDS to 291 mg/L. With a draft TDS discharge limit of 234.5 mg/L, this renders barium chloride dosing technically infeasible.

While alternatives to barium chloride exist, such as barium hydroxide or barium carbonate, their low solubility and effect on pH render them technically infeasible as well. Sludges from barium hydroxide or barium carbonate tend to contain higher concentrations of unreacted raw product due to their low solubilities; therefore, these sludges are more hazardous as excess undissolved raw barium products are leachable under acidic conditions and pose elevated environmental risks of barium contamination. Likewise, the high pH associated with both alkaline barium materials would require acid addition to ensure compliant effluent pH. Acid additions would result in noncompliant concentrations of sulfate (with sulfuric acid addition) or chloride (with hydrochloric acid addition) and ultimately increase TDS above the draft discharge limit.

<u>Operational Complexity</u>

Sulfate will be added to the process via sulfuric acid and sodium bisulfite; thus, to consistently achieve the proposed sulfate discharge limit, complete sulfate removal would be necessary in the barite precipitation step. This would necessitate dosing excess barium chloride to ensure complete precipitation under varying operating conditions. Excessive barium chloride poses the following risks:

- The existing WTP utilizes trimercapto-s-triazine trisodium salt (TMT) for heavy metal removal. The presence of excess dissolved barium would interfere with downstream heavy metal removal and increase TMT consumption.
- The draft NPDES permit includes a discharge limit of 0.2515 mg/L for barium. Achieving complete sulfate removal while simultaneously maintaining residual barium below this limit would require extremely precise chemical dosing and real-time process control. Given normal process variability and analytical limitations, reliably maintaining compliance would present a significant operational challenge that is likely impossible to achieve in practice.

<u>Hazardous Material Handling</u>

Barium salts, whether barium chloride, barium hydroxide, or barium carbonate, are considered hazardous materials that represent occupational health risks (29 CFR 1910.1200) and environmental risks (40 CFR 261.24) and thus require dedicated unloading, storage, and handling facilities. Increased chemical inventory and handling frequency would increase operational complexity and risk for worker exposure and accidental chemical releases.

Annual barium chloride demand equates to approximately 1,000,000 pounds. Such a large consumption would require approximately 25–50 bulk truck deliveries to the site per year. The resulting increase in heavy truck traffic would contribute to transportation-related costs, roadway use, and logistical impacts associated with chemical delivery and storage both onsite and in the local communities. Excessive handling and transfer of raw barium materials also increases exposure risk to the local communities, onsite staff, and the environment.

The process would also generate approximately 850,000 lbs of barite sludge per year. Handling this quantity of solids would require additional sludge management equipment and associated infrastructure to avoid environmental and occupational health risks.

Cost Implications

Based on the design flow and sulfate concentration, annual barium chloride dihydrate consumption is estimated to result in approximately $700,000 per year in chemical operating costs, excluding shipping, storage, handling, and hazardous chemical management costs. The increased solids loading would require significant capital costs, including a bulk silo storage system, chemical makedown and dosing system, an additional reaction tank, clarifier(s), and sludge management system(s) to mitigate fouling in the UF system. Estimated capital cost associated with barite precipitation are on the order of $9M installed.

Conclusion

Based on the inability to reliably achieve TDS compliance and the substantial operational, environmental, and economic disadvantages discussed above, barite precipitation was not considered further.

6.0 REVERSE OSMOSIS

Reverse osmosis (RO) is a separation technology that utilizes a semipermeable membrane to separate dissolved species from water by applying a pressure that exceeds the osmotic pressure gradient between the feed and clean water streams. RO was evaluated as a potential sulfate and TDS treatment process and is discussed in detail in the following subsections.

6.1. Process Description

RO is a complex system that requires pretreatment and proper membrane selection to optimize treatment capabilities. The existing water treatment plant design represents a robust physical pretreatment for RO, where chemical oxidation and UF ensure iron, manganese, and fine colloidal materials are removed from the process stream prior to RO treatment (**Figure 6-1**). A conceptual site layout updated to include the theoretical RO treatment process is included in **Appendix B**. It should be noted that RO is not technically viable as a standalone treatment process; chemical pretreatment followed by microfiltration or ultrafiltration is always required prior to RO.

In the theoretical RO treatment process, UF filtrate is dosed with sodium bisulfite (SBS) to neutralize residual oxidant that could damage the RO membranes or risk downstream aquatic life. The stream is split, with a portion of the UF filtrate bypassing the RO to the Finished Water Tank and the remaining UF filtrate being conveyed to the RO Feed Tanks. Sulfuric acid is added to lower RO feed pH prior to the RO Feed Tanks, minimizing the scaling potential for calcium carbonate ($CaCO_3$). Antiscalant is added prior to the RO skids to mitigate scaling of RO membranes and maintain long-term system recovery.

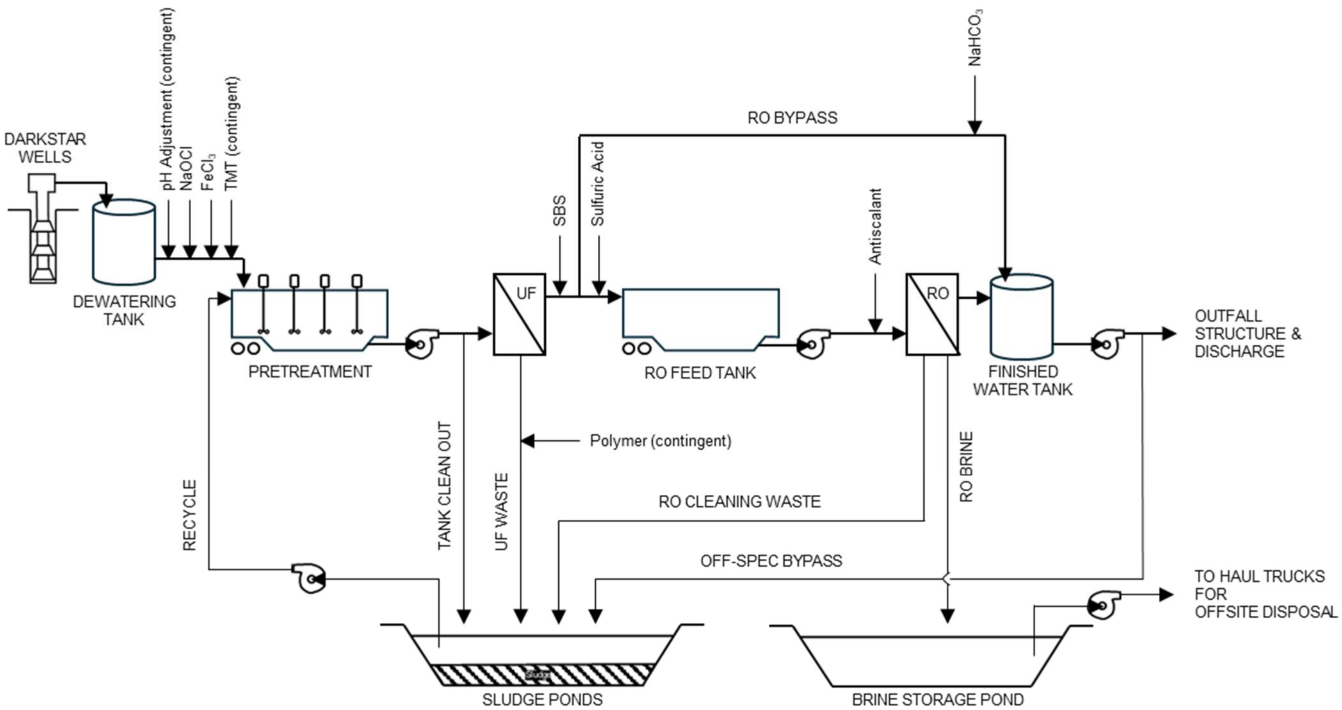

Figure 6-1: RO Process Flow Diagram

In the RO skids, the feed stream is separated into a low-TDS permeate stream and a concentrated brine stream. Due to the relatively mild water chemistry in the RO feed, the RO system operates at 90% recovery on average, meaning 90% of the water fed to the RO skids is recovered as clean water, or permeate, while the remaining 10% of feed water and most of the dissolved solids are concentrated as brine. To achieve such a recovery, the RO skids are configured as closed-circuit reverse osmosis (CCRO) systems; CCRO utilizes a semi-batch sequence to achieve a target recovery while automatically maintaining membrane cross-velocity requirements and minimizing system footprint.

RO permeate and UF filtrate blend together in the Finished Water Tank prior to discharge. As dissolved gases readily pass through the RO membranes (carbon dioxide), the RO permeate pH is projected to be 4.9 and void of alkalinity. As the UF filtrate and RO permeate are blended, sodium bicarbonate ($NaHCO_3$) is added to ensure the blended pH and alkalinity are within the draft discharge limits of 7.2-8.7 and ≥ 72.65 mg/L as $CaCO_3$, respectively.

The RO concentrate, or brine, is conveyed to a Brine Storage Pond. For this report, this pond had been sized to provide 5 days of storage volume which would allow flexibility in removing brine waste off site. Further brine treatment options are discussed in depth later.

UF and RO membranes require periodic cleaning to restore membrane performance. During these cleaning events, individual UF or RO systems are removed from service and cleaned using a high pH then low pH membrane cleaning solution. Cleaning waste is routed to the existing sludge ponds, where it is diluted, neutralized, then recycled to the Reaction Tanks.

6.2. Effluent Water Quality and Blending Requirements

RO modeling predicts a sulfate concentration of 0.38 mg/L in the permeate stream. Following upstream chemical additions, UF filtrate will contain up to 67 mg/L of sulfate (**Table 2-1**). Given a draft permit limit of 30.45 mg/L of sulfate, RO permeate and UF filtrate blending has been assumed to minimize equipment costs, footprint, waste production, and electrical demands associated with RO while reliably achieving the draft discharge limit.

To provide safety margin within the RO system design, the target sulfate concentration following blending of UF filtrate and RO permeate was set at 20 mg/L. Given these sulfate concentrations, the system is designed such that 70% of the UF filtrate is treated via RO while the remaining 30% of the UF filtrate is bypassed to the Finished Water Tank. The system flow balance is summarized in **Table 6-1**.

Table 6-1: RO Design Flows

PROCESS PARAMETERS	PLANT FEED	UF FILTRATE	RO BYPASS	RO FEED	RO PERMEATE	RO CONCENTRATE	RO CIP WASTE	FINISHED WATER
DESIGN FLOW (INSTANTANEOUS), GPM	2,400	2,546	764	1,708	1,537	171	-	2301
DESIGN FLOW (DAILY AVERAGE), GPM	2,400	2,400	720	1,680	1,512	168	0.4	2232
DESIGN FLOW, MGD	3.46	3.46	1.04	2.42	2.18	0.24	0.00	3.21

6.2.1. *Secondary Water Quality Impacts*

RO membranes reduce concentrations of dissolved minerals, including hardness and alkalinity. Low hardness and alkalinity can result in elevated uptake of toxic heavy metals by aquatic life and reduce buffering capacity to resist pH changes in downstream receiving waters. While the blended effluent hardness is projected to be 37 mg/L as $CaCO_3$ on average and generally sufficient to protect the downstream aquatic ecosystem (typically 40-50 mg/L as $CaCO_3$ is targeted to protect aquatic life), the alkalinity is projected to be 42 mg/L as $CaCO_3$; the draft discharge permit requires a minimum alkalinity of 72.65 mg/L as $CaCO_3$.

The blended effluent alkalinity is therefore dosed with sodium bicarbonate ($NaHCO_3$) to increase the effluent alkalinity above 72.65 mg/L as $CaCO_3$. As alkalinity is added to the blended effluent stream, the TDS will increase, from approximately 90 mg/L to approximately 140 mg/L on average, due to the dissolved solids added back into the effluent stream.

6.2.2. *Waste Generation and Handling*

Due to mineral solubility limitations associated with the dissolved species in the feed water, only 90% of the RO feed water can be recovered as clean water, or permeate. The remaining 10% of the RO feed water is a concentrated brine – the brine flow amounts to approximately 170 gpm, or 240,000 gallons per day.

Reverse osmosis brine is particularly difficult to treat; this brine specifically is saturated with respect to gypsum ($CaSO_4*2H_2O$), calcium carbonate ($CaCO_3$), barium sulfate ($BaSO_4$), calcium phosphate [$Ca_3(PO_4)_2$], and calcium fluoride (CaF_2). In addition, the brine contains elevated TDS (~4,700 mg/L) composed primarily of sodium (~775 mg/L), magnesium (~150 mg/L), calcium (~450 mg/L), bicarbonate (~1,600 mg/L), sulfate (~650 mg/L), and chloride (~1,000 mg/L).

Several brine management options were considered in this study to assess feasibility:

- Surface Application
- Deep Well Disposal
- Evaporation
- Active Treatment
- Hauling

Surface Application

Surface application of brine, whether for infiltration or irrigation, is not a common approach utilized in Nevada. Brine is noncompliant water, exceeding both the draft permit and Nevada Profile 1 discharge standards. Surface application of brine risks contamination of surface waters and groundwater due to infiltration. This approach was deemed infeasible due to the associated environmental risk.

Deep Well Disposal

Deep well injection of RO brine is regulated by NDEP. Injection of industrial waste falls under the jurisdiction of the NDEP's Underground Injection Control (UIC) Permit program; as a Class 5 well receiving industrial waste, the NDEP has categorized this as a high risk to groundwater contamination due to alkalinity and sulfate (among other constituents) which are characteristic of the brine that would be generated from the theoretical RO treatment system.

We estimate that this brine disposal route would require a substantial hydrogeological modeling campaign, test well development, and rigorous regulatory review process. Even if a formation could be identified that could receive this RO brine and be permitted without significant risk of groundwater degradation, we estimate that the well would be authorized for use in 12-24 months, which represents a significant risk to the project timeline.

Due to the environmental risks associated with deep well injection, Linkan assumes this brine disposal strategy will not be feasible and deep well injection was not considered further in this study.

Evaporation

Evaporation of the RO brine would require a significant evaporation pond. Assuming 170 gpm of brine is produced on average, annual precipitation of 12 inches, and annual evaporation of 51 inches, the evaporation pond would encompass approximately 270 acres without any assumed redundancy or contingency for major precipitation events.

From an environmental perspective, this represents a substantial risk. With over 270 acres of additional disturbance footprint, wildlife habitat disturbances would substantially increase at the project site. The RO brine is naturally high in TDS, alkalinity, and sulfate; as water is evaporated, these concentrations will increase over time. High TDS, alkalinity, and sulfate pose risks to local wildlife, particularly avian species migrating over the area.

Relative to the Nevada Division of Water Resources Dam Safety Program's jurisdiction, this evaporation pond would exceed the 20 acre-feet of stored liquid with an estimated 3,572 acre-feet of stored volume. Thus, this brine disposal pathway would require additional permitting efforts; combined with design and construction, an evaporation pond of this size represents a significant risk to project timeline.

Due to the mountainous landscape surrounding the project site, constructing a level evaporation pond with such a footprint would be an extremely difficult task. Based on recent pond construction cost estimates in the State of Nevada, the estimated capital cost for a single 270-acre evaporation pond is approximately $30M installed.

While reducing pond footprint is possible by introducing enhanced mechanical evaporation, the environmental risk associated with land disturbance is traded for increased air quality concerns, wildlife and local vegetation exposure, and substantial power requirements. For these reasons, evaporative brine disposal was not considered feasible for the purposes of this study.

Active Treatment

As thermal evaporation and crystallization are so capitally expensive and energy intensive, it is most cost-effective to first reduce the brine volume as much as possible via a second iteration of RO. Typically, an RO brine can be desaturated by chemically precipitating the inorganic species limiting the recovery of the RO system; in this instance, the RO system is limited by barium sulfate scaling.

Barium sulfate is saturated in the RO brine; as such, conceptual modeling indicates that with antiscalant oxidation and enough residence time, barium sulfate may precipitate. After antiscalant destruction and precipitation, the RO brine would be processed by an additional iteration of UF and an additional iteration of CCRO. Preliminary modeling indicates that a second iteration of reverse osmosis could achieve 90% recovery if pH were reduced to approximately 5 in the RO feed.

The second iteration RO brine could be treated via thermal evaporator/crystallizer to achieve zero liquid discharge, producing clean distillate for discharge and salt crystals for disposal. Solid waste from the crystallization process would amount to roughly 3.5M pounds of dry material annually, or nearly 9M pounds as 40% cake. Removal of these potentially hazardous materials would require at least 220 truckloads annually.

The theoretical Active Brine Treatment route to RO brine disposal is accompanied by negative impacts on the local communities and environment. The estimated energy demand associated with the proposed Active Brine Treatment System is 3-8 MWh/day, doubling the power demand of the water treatment system. Operating such a system on generator power results in a significant increase in combustion byproduct emissions, air quality concerns, and significant fuel consumption. Hauling of generator fuel, additional chemicals, and solid wastes only increases environmental risk. For these reasons, active treatment of the RO brine was not considered further.

Hauling

Due to the sheer volume of brine generated from the treatment process, the estimated trucking demand would require 53-77 truckloads per day depending on payload capacity. The resulting increase in heavy traffic would impact local communities, impact air quality, and be exorbitantly expensive. While this brine management strategy represents elevated risk to the local communities and environment, relative to the other options, it is the lowest risk. For that reason, this brine management strategy has been developed in the following sections.

6.3. Estimated Capital Costs

A Class 5 capital cost estimate was developed for the theoretical RO treatment process. This estimate includes equipment costs of mobile trailer units, pumps, waste ponds, tanks, instrumentation, piping, generators, electrical, other miscellaneous items needed. These estimates were calculated to include the cost of installation (15%), shipping, tax (7.1%), 15% overhead and profit (OH&P), and a general contingency (40%) to reflect the cost uncertainties at the current level of project development.

Table 6-2: Estimated Capital Costs for RO Treatment

Item	Quantity	Unit	Unit Rate	Installed Cost
Mobile CCRO Trailer	3	Each	$ 1,883,800	$ 5,651,400
RO Membranes	576	Each	$ 700	$ 403,200
Finish Water Tank	1	Each	$ 144,300	$ 144,300
Finish Water Pump Skid	1	Each	$ 303,800	$ 303,800
Antiscalant Storage Container (heated/insulated)	1	Each	$ 53,200	$ 53,200
Instrumentation	1	Lot	$ 113,900	$ 113,900
Control Valves	1	Lot	$ 53,200	$ 53,200
Piping	1	Lot	$ 144,100	$ 144,100
Bicarbonate System (building, tanks, mixers, pumps)	1	Lot	$ 192,200	$ 192,200
Waste Pond	1	Each	$ 460,300	$ 460,300
Generator	3	Each	$ 612,200	$ 1,836,600
Electrical	1	Lot	$ 211,400	$ 211,400
Ancillary Equipment	1	Lot	$ 76,000	$ 76,000
			DIRECT COSTS SUBTOTAL	**$ 9,643,600**
			Contingency	**40%**
				$ 3,857,440
			TOTAL CAPEX ESTIMATE	**$ 13,501,040**

The RO equipment is the primary cost driver for the theoretical RO treatment process.

6.4. Estimated Operating Costs

A Class 5 operating cost estimate was developed based on estimated chemical and power consumption for the theoretical RO treatment process. These estimates are based on the average flows found in **Table 6-1**. The results are summarized in **Table 6-3** and **Table 6-4**.

6.4.1. *Chemical Costs*

Table 6-3: Estimated Chemical Costs for RO Treatment

Chemical	Dose	Daily Consumption	Monthly Consumption [gal]	Monthly Consumption [lb]	Average Monthly Cost
Antiscalant	5 mg/L	11 gal	327 gal	3,653 wet-lb	$ 8,296
Sulfuric Acid	82 mg/L	135 gal	4,105 gal	63,000 wet-lb	$ 16,422
RO Clean P192	1-2 wt%	4 lbs	-	122 lb	$ 962
RO Clean P903	1-2 wt%	13 lbs	-	395 lb	$ 2,775
RO Clean L811	1-2 wt%	6 gal	182 gal	-	$ 9,053
Sodium Bicarbonate	52 mg/L	1,438 gal	-	43,736 lb	$ 43,526
				Total	**$ 81,035**

The largest chemical cost associated with RO operation is sodium bicarbonate, estimated at approximately $43,500 per month. The high cost is driven by the large dose requirement and continuous consumption rate necessary to meet water quality objectives.

Antiscalant is required to minimize membrane scaling, while sulfuric acid is used for pH adjustment to improve membrane performance. Periodic membrane clean-in-place (CIP) will require RO Clean P192, P903, and L811 chemicals to remove accumulated inorganic and organic foulants and maintain membrane permeability.

Overall, chemical costs represent a significant operational consideration for the RO alternative at an estimated cost of nearly $1M annually.

6.4.2. *Brine Hauling*

The estimated RO brine production rate is approximately 240,000 gallons per day. A hauling cost of $0.33 per gallon was assumed based on anticipated transportation requirements, including truck mobilization, distance, loading, transportation, and delivery costs. This results in a total monthly cost to transport brine off-site of roughly $2,400,000. Annually brine hauling costs are estimated to be approximately $29M.

6.4.3. *Power Costs*

Table 6-4: Estimated Power Costs for RO Treatment

Equipment	Quantity	HP	Amp	Voltage	KVA	KW	Avg Load	Average Monthly Cost
Mobile RO Unit	3	-	400	460.0	957	766	85%	$ 38,025
Finish Water Pump	2	20	27	460.0	44	36	90%	$ 1,892
Bicarb Dosing Pumps	2	1	1.8	460.0	3	3	95%	$ 167
Bicarb Mixers	2	5	7.6	460.0	13	11	95%	$ 608
							Total	**$40,692**

The primary contributor to power costs is the mobile RO units, which use large amounts of power due to the various pumps (low pressure, high pressure, circulation, and CIP) they utilize.

6.5. Operational Philosophy

Compared to conventional treatment processes, RO introduces additional operational complexity associated with membrane protection, routine maintenance, and process optimization. RO membranes are susceptible to scaling, fouling, and oxidative damage; therefore, proper pretreatment, chemical dosing, and membrane protection strategies are critical. Residual oxidants must be neutralized prior to treatment, while antiscalant dosing and pH adjustment must be controlled to minimize scaling. A bypass around the RO system may be required during upset conditions or periods of off-specification feed water to prevent irreversible membrane damage.

Periodic clean-in-place (CIP) procedures and permeate flushing cycles are required to maintain membrane performance and minimize fouling during operation. These maintenance activities temporarily reduce treatment availability and increase chemical consumption and wastewater generation. Additionally, maintaining accurate recovery setpoints is necessary to balance water recovery with membrane longevity. Operating at excessive recovery can accelerate scaling and reduce membrane life, while lower recovery increases concentrate generation and reduces system efficiency. Continuous monitoring and adjustment of operating parameters are required to maintain reliable RO performance.

7.0 ION EXCHANGE

Ion exchange (IX) utilizes a sulfate-selective strong-base anion exchange resin technology to remove sulfate from the feed water by exchanging sulfate ions for chloride ions. The process reduces sulfate concentrations but requires periodic resin regeneration, generating a high concentration liquid waste stream that must be managed to reduce environmental risk.

7.1. Process Description

Like the theoretical RO system, IX is a complex system that requires pretreatment and proper resin selection to optimize treatment capabilities. The existing water treatment plant design represents a robust physical pretreatment for IX, where chemical oxidation and UF ensure iron, manganese, and fine colloidal materials are removed from the process stream prior to IX treatment (**Figure 7-1**). A conceptual site layout updated to include the theoretical IX treatment process is included in **Appendix C**.

In a theoretical IX treatment process, UF filtrate is split, with a portion of the UF filtrate bypassing the IX to the Finished Water Tank and the remaining UF filtrate being conveyed to the IX Feed Tanks. From the IX Feed Tank, water is pumped through multiple ion exchange vessels containing strong base anion exchange resin. As water passes through the resin beds, sulfate ions are exchanged for chloride ions, thereby reducing the sulfate concentration of the treated water.

Vessels are arranged in a lead-lag configuration, with the lead vessels performing the sulfate removal process and the lag vessels (in series following the lead vessels) polishing any residual sulfate leaking from the lead vessels to ensure compliance is achieved continuously. This arrangement is necessary as continuous in-line sulfate monitoring instrumentation is neither readily available nor reliable enough to depend on for discharge compliance. The IX system is configured with multiple vessels to provide operational flexibility and continuous treatment. Individual vessels may be removed from service for regeneration while the remaining vessels continue to treat the design flow. The treated effluent is collected in the Finished Water Tank prior to discharge.

As sulfate loads onto the resin, its ion exchange capacity decreases and periodic regeneration is required to restore treatment performance. Regeneration consists of a backwash cycle to remove accumulated solids and reclassify the media bed followed by the introduction of a concentrated sodium chloride (NaCl) waste brine, which displaces the adsorbed sulfate ions and restores the resin's exchange capacity. The spent waste regeneration solution is collected in a brine storage pond for subsequent off-site disposal or additional treatment.

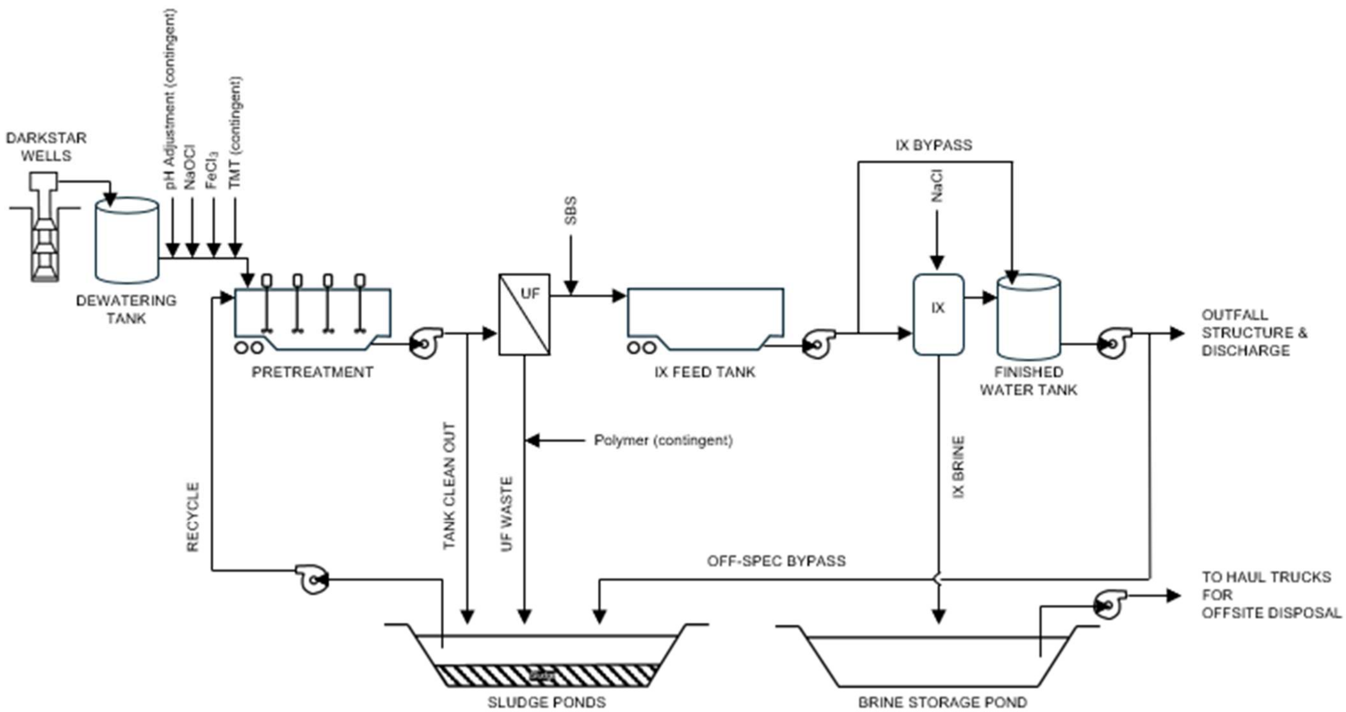

Figure 7-1: Ion Exchange Process Flow Diagram

7.2. Effluent Water Quality and Blending Requirements

Frequent regeneration reduces system availability and increases operating costs, while excessive sulfate breakthrough increases the size and cost of the IX system necessary to achieve discharge compliance. Based on this tradeoff, a maximum IX effluent sulfate concentration of 20 mg/L was selected as the regeneration target. Using this design basis, a blend ratio of approximately 78% IX effluent and 22% UF filtrate is necessary to maintain the target sulfate concentration in the final treatment process effluent while minimizing the size, cost, footprint, and power consumption associated with the IX system (**Table 7-1**).

Table 7-1: Ion Exchange Design Flows

PROCESS PARAMETERS	PLANT FEED	IX BYPASS	IX FEED	IX EFFLUENT	IX REGEN WASTE	FINISHED WATER
DESIGN FLOW (INSTANTANEOUS), GPM	2,400	560	1,882	1,882	202	2,442
DESIGN FLOW (DAILY AVERAGE), GPM	2,400	528	1,872	1,741	17	2,269
DESIGN FLOW, MGD	3.46	0.76	2.70	2.51	0.03	2.51

7.2.1. *Secondary Water Quality Impacts*

In this theoretical IX process, every mole of sulfate removed results in two moles of chloride being added to the IX effluent. The estimated increase in chloride concentration due to the exchange process is 50 mg/L. Upstream chemical additions, such as sodium hypochlorite and ferric chloride, also contribute to the overall chloride loading of the treatment system – the estimated increase in chloride concentration due to chemical addition is 37 mg/L. With a maximum of 10 mg/L of chloride in the raw feed water, the estimated chloride concentration after blending is 85 mg/L. With a draft discharge limit of 86 mg/L of chloride, this leaves no room for chemical dose tuning and represents a risk to discharge compliance.

7.2.2. *Waste Generation and Handling*

Regeneration of the ion exchange resin generates liquid waste that cannot be recycled to the process feed as the concentration of sodium chloride at approximately 100,000 mg/L represents significant risks to the treatment equipment (due to corrosion) and an increase in chloride in the process effluent. The regeneration waste equates to approximately 17 gpm, or 24,000 gallons per day.

Several regeneration waste management strategies were considered in this study to assess feasibility:

Surface Application

Like the argument for RO brine, surface application of spent IX regeneration brine, whether for infiltration or irrigation, was deemed infeasible due to the associated environmental risk.

Deep Well Disposal

Like RO brine, deep well disposal of spent IX regeneration brine was deemed infeasible due to the associated environmental risks.

Evaporation

Evaporation of the spent IX regeneration brine would require a significant evaporation pond. Assuming 17 gpm of brine is produced on average, annual precipitation of 12 inches, and annual evaporation of 51 inches, the evaporation pond would encompass approximately 24 acres without any assumed redundancy or contingency for major precipitation events.

While this evaporation pond represents a smaller footprint relative to the planned South Railroad site, the additional footprint still introduces additional wildlife habitat disturbances and poses risks to local wildlife, particularly avian species migrating over the area. Sodium chloride concentrations would be expected to approach 26%, or approximately 260,000 mg/L in the evaporation pond, which represents a severe toxicity threat to any wildlife that may potentially come into contact with the water.

Relative to the Nevada Division of Water Resources Dam Safety Program's jurisdiction, this evaporation pond would exceed the 20 acre-feet of stored liquid with an estimated 332 acre-feet of stored volume. Thus, this brine disposal pathway would require additional permitting efforts; combined with design and construction, an evaporation pond of this size represents a significant risk to project timeline. In addition, the evaporation pond represents an additional significant expenditure; the estimated capital cost for a single 24-acre evaporation pond is approximately $9M installed.

While reducing pond footprint is possible by introducing enhanced mechanical evaporation, the environmental risk associated with land disturbance is traded for increased air quality concerns, wildlife and local vegetation exposure, and substantial power requirements. For these reasons, evaporative brine disposal was not considered feasible for the purposes of this study.

<u>Active Treatment</u>

At nearly 100,000 mg/L of TDS, the only feasible approach for active treatment of the spent IX regeneration brine is thermal evaporation and crystallization. In a thermal treatment process, such a high TDS elevates the boiling point and substantially increases the power required to evaporate the water. Due to this boiling point elevation, the energy demand is estimated to be similar to the RO brine treatment process discussed previously, 7-9 MWh/day. Note that even with the spent IX regeneration brine flow rate being one-tenth of the RO brine flow rate, the estimated power consumption is nearly the same due to the boiling point elevation incurred by the high TDS.

In addition, 3,700 dry-tons of contaminated sodium chloride and sulfate-laden crystals would be produced annually. Due to the corrosive nature and material handling risks, hauling these materials would pose a threat to the local communities and environment and represent a significant operating cost.

Operating such a system on generator power results in a significant increase in combustion byproduct emissions, air quality concerns, and fuel consumption. Hauling of generator fuel, raw sodium chloride, and crystalline wastes only increases environmental risk. For these reasons, active treatment of the spent IX regeneration brine was not considered further.

<u>Hauling</u>

Due to the elevated TDS, the spent IX regeneration brine is much denser and the estimated haul capacity with a typical tanker truck would range from 3,000 gallons to 4,000 gallons per load. This is substantially lower than the typical 5,000-to 6,500-gallon capacity of common tanker vehicles. As a result, the hauling of the spent IX regeneration brine would require 5-8 trucks per day depending on payload capacity. The resulting increase in heavy traffic would impact local communities, impact air quality, and be exorbitantly expensive.

While this brine management strategy represents risk to the local communities and environment, relative to the other options, it is the lowest risk. For that reason, this brine management strategy has been developed in the following sections.

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7.3. Estimated Capital Costs

A Class 5 CAPEX estimate was developed for the theoretical IX treatment process (**Table 7-2**). This estimate includes equipment costs for skidded IX vessels, pumps, tanks, instrumentation, piping, electrical, a building to house and winterize equipment, and other miscellaneous items needed. These estimates were calculated to include the cost of installation (15%), shipping, tax (7.1%) 15% overhead and profit (OH&P), and a general contingency (40%) to reflect the cost uncertainties at the current level of project development.

Table 7-2: Estimated Capital Costs for IX Treatment System

Item	Quantity	Unit	Unit Rate	Installed Cost
IX Vessels (Duplex Skids)	6	Each	$ 827,000	$ 4,962,000
IX Resin	2830	ft^3	$ 300	$ 849,000
Finish Water Tank	1	Each	$ 106,300	$ 106,300
Finish Water Pump Skid	1	Each	$ 303,800	$ 303,800
Brine Makedown System	1	Each	$ 387,400	$ 387,400
Brine Pump	4	Each	$ 38,000	$ 152,000
Backwash Pump	2	Each	$ 38,000	$ 76,000
Sprung Structure	1	Each	$ 1,455,500	$ 1,455,500
Instrumentation	1	Lot	$ 135,500	$ 135,500
Control Valves	1	Lot	$ 60,800	$ 60,800
Piping	1	Lot	$ 165,700	$ 165,700
Waste Pond	1	Each	$ 198,000	$ 198,000
Generator	1	Each	$ 612,200	$ 612,200
Electrical	1	Lot	$ 110,500	$ 110,500
Ancillary Equipment	1	Lot	$ 76,000	$ 76,000
			DIRECT COSTS SUBTOTAL	**$ 9,650,700**
			Contingency	**40%**
				$ 3,860,280
			TOTAL CAPEX ESTIMATE	**$ 13,510,980**

The IX vessels are the primary cost driver for the theoretical IX treatment process.

7.4. Estimated Operating Costs

A Class 5 operating cost estimate was developed based on estimated chemical and power consumption for the theoretical IX treatment process. These estimates are based on the average flows found in **Table 7-1**. The results are summarized in **Table 7-3** and **Table 7-4**.

7.4.1. *Chemical Costs*

Table 7-3: Estimated Chemical Costs for IX Treatment

Chemical	Daily Consumption	Monthly Consumption [lb]	Monthly Consumption [ton]	Average Monthly Cost
NaCl	3,135 dry lb	95,604 dry lb	48 dry ton	$ 11,913
			Total	**$ 11,913**

Chemical costs for the theoretical IX treatment system consist solely of NaCl, used to make up the regeneration brine solution. Overall, chemical costs represent an additional $143,000 for the project annually.

7.4.2. *Brine Hauling*

The estimated spent IX regeneration brine production rate is 24,000 gallons per day. A hauling cost of $0.33 per gallon was assumed based on anticipated transportation requirements, including truck mobilization, distance, loading, transportation, and delivery costs. This results in a total monthly cost to transport brine offsite of roughly $240,800. Annually brine hauling costs are estimated to be approximately $2.9M.

7.4.3. *Power Costs*

Table 7-4: Estimated Power Costs for IX Treatment

Equipment	Quantity	HP	Amp	Voltage	KVA	KW	Avg Load	Average Monthly Cost
Brine Pump	2	5	7.6	460.0	13	11	25%	$ 158
Backwash Pump	3	20	27	460.0	65	52	25%	$ 758
Finish Water Pump	2	20	27	460.0	44	36	90%	$ 1,892
							Total	**$2,808**

The primary contributor to power costs is the Finished Water Pump. Relative to the theoretical RO treatment process, the power consumption is low as the pressure drop through the media is low relative to the pressure drop through an RO membrane.

7.5. Operational Philosophy

The IX system introduces significant operational complexity associated with resin management, regeneration scheduling, and maintaining consistent effluent quality. As the strong-base anion exchange resin becomes loaded with sulfate, the vessel performance gradually decreases, requiring operators to balance regeneration frequency with sulfate breakthrough risk. Regenerating vessels too frequently increases chemical consumption, wastewater generation, and operational costs, while delaying regeneration may result in elevated sulfate concentrations that challenge permit compliance.

Multiple IX vessels provide operational flexibility by allowing individual vessels to be removed from service for regeneration while maintaining treatment capacity. However, operation requires coordination of vessel sequencing, brine makeup, brine regeneration cycles, backwashing, and monitoring of key water quality parameters. A scenario in which multiple vessels require regeneration simultaneously could easily be encountered; this risks noncompliant discharge as sulfate breaks through the redundant “lag” vessels so rapidly (~3.4 days). Additionally, the introduction of chloride during the ion exchange process requires ongoing monitoring to ensure chloride concentrations remain within proposed discharge limits; proper wasting and rinsing of spent IX regeneration brine must always be ensured. Effective operation of the IX system depends on maintaining optimized regeneration intervals while balancing treatment performance, chemical usage, and discharge compliance.

8.0 COMPARATIVE ASSESSMENT

The following sections present a comparative assessment of the theoretical RO and IX treatment alternatives.

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8.1. Cost Comparison

A Class 5 capital cost estimate was developed for both the RO and IX treatment alternatives. As summarized in **Table 8-1**, the estimated installed capital costs are virtually the same; given the expected accuracy range associated with a Class 5 estimate, this difference is not considered significant.

Table 8-1: RO vs IX Treatment Cost Analysis

Cost Item	RO Treatment	IX Treatment
CAPEX[1]	$ 14,000,000	$ 14,000,000
Annual OPEX	$ 30,000,000	$ 3,000,000
NOTES: 1 – Includes 40% contingency to reflect the cost uncertainties associated with the current level of project development.		

The operating costs of the two alternatives, however, differ substantially. The RO treatment system is estimated to be approximately 10 times more expensive operationally on an annual basis. The higher operating cost associated with RO is primarily attributable to the 10-times higher brine production rate and associated hauling costs. Accordingly, operating cost rather than capital investment represents the primary economic differentiator between the two treatment alternatives.

8.2. Evaluation Matrix

Linkan has supported the development of an evaluation matrix in support of the broader report. See the broader report for evaluation details and alternatives ranking.

9.0 CONCLUSIONS

The existing South Railroad Mine Water Treatment Plant was designed to meet Nevada Profile 1 discharge requirements through coagulation-assisted filtration for the removal of arsenic, thallium, and other metals. The existing process was not designed to remove sulfate or general dissolved solids. Based on the projected effects of the required treatment chemicals, the existing WTP is expected to produce UF filtrate containing a maximum of 67 mg/L sulfate and 264 mg/L total dissolved solids (TDS).

The draft antidegradation-based discharge limits would require sulfate and TDS concentrations of no more than 30.45 mg/L and 234.5 mg/L, respectively. Consequently, additional treatment infrastructure would be required to address relatively low concentrations of dissolved constituents remaining after the originally designed treatment process. Three supplemental treatment alternatives—barite precipitation, reverse osmosis (RO), and ion exchange (IX)—were evaluated to determine whether the additional water-quality improvement could be achieved without disproportionate technical, environmental, economic, or socioeconomic effects.

The analysis demonstrates that achieving the draft antidegradation-based sulfate limit would require significant modification to the existing WTP. Substantive design and a lengthy permit process would be needed further delaying mining and processing. It would require construction and perpetual operation of a second major treatment and waste-management system.

Barite precipitation was determined to be technically infeasible because chloride addition associated with barium chloride dosing increases the projected treated-water TDS concentration to approximately 291 mg/L, well above the draft discharge limit, while reliable simultaneous compliance with the proposed residual barium limit is unlikely to be achievable under full-scale operating conditions.

RO and IX are technically capable of reducing the projected sulfate concentration from approximately 67 mg/L to a design target of 20 mg/L. However, technical capability alone does not establish that the additional treatment is environmentally preferable or socioeconomically reasonable. The additional sulfate reduction would be obtained through significant transfers of environmental impact:

- RO would generate approximately 90 million gallons of brine annually and require as many as 77 tanker loads per day. Waste hauling and trucking of additional chemicals would greatly increase exposure risk to the site employees and local environment. Likewise, elevated heavy traffic would greatly increase air emissions.
- RO increases the energy demand of the treatment system by over 50%. This would necessitate significant fuel hauling and consumption and would greatly increase combustion byproduct air emissions to the local environment.
- RO requires continuous alkalinity replacement via sodium bicarbonate. The net benefit of TDS removal is reduced as sodium bicarbonate contributes additional TDS into the system effluent following sulfate removal.
- IX would generate approximately 9 million gallons of concentrated regeneration waste annually. Similar to RO, waste hauling increases exposure risk and air emissions to the local jurisdictions.
- IX replaces sulfate with chloride rather than simply removing dissolved mass. IX is projected to operate with only 1 mg/L of chloride compliance margin - the compliance constraint is transferred from sulfate to chloride. The benefit of sulfate removal is negated by chloride exchange into the process effluent.
- Annual operating costs are estimated at approximately $30 million for RO and $3 million for IX. Supplemental capital costs are approximately $14 million for either RO or IX. These substantial cost increases and associated project delays represent real risk to the net socioeconomic benefit of the project; delays reduce job availability in the short term and significant capital allocation may reduce the ability to commence planned community development activities.

Both alternatives would depend on long-term availability of an off-site facility capable of accepting millions of gallons of concentrated waste annually. Alternatives to off-site waste disposal would result in substantial land disturbance, energy use, air emissions, solid-waste generation, or additional regulatory and schedule risk.

The treatment alternatives would therefore reduce sulfate in the final effluent but would not eliminate environmental impacts. Rather, they would transfer and, in several respects, amplify those impacts through increased energy consumption, chemical use, waste generation, land disturbance, transportation, air emissions, and long-term disposal obligations.

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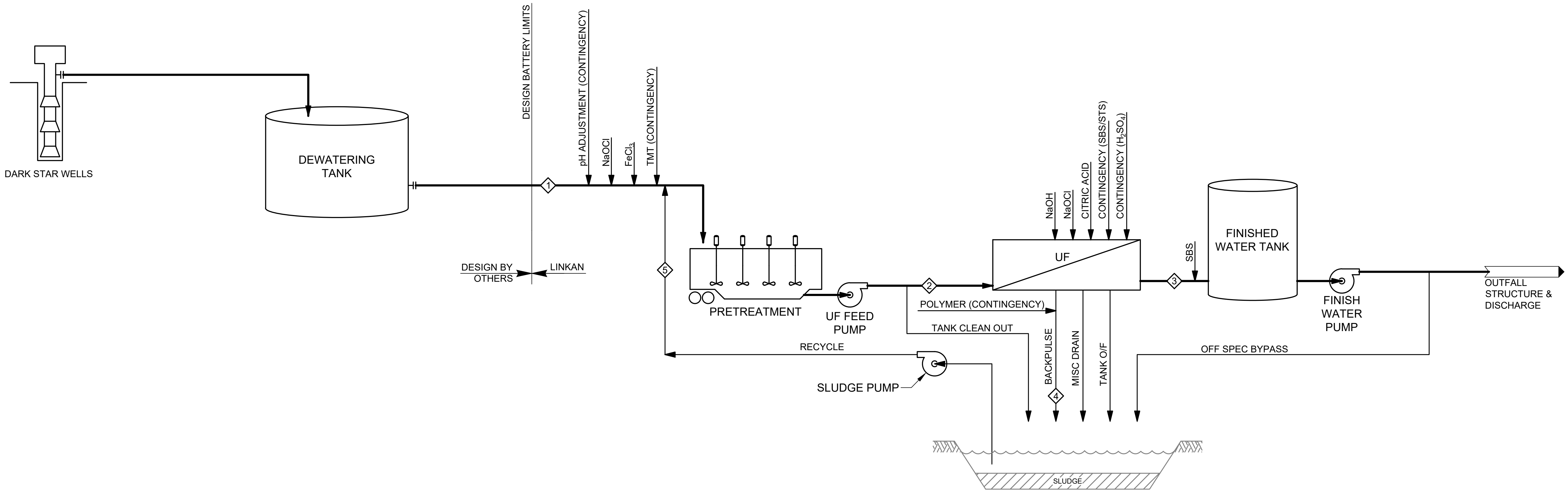
APPENDIX A

PROCESS FLOW DIAGRAM FROM PERVIOUS IFC DESIGN



MASS BALANCE

DESIGN

STREAM TAG	1	2	3	4	5
PROCESS PARAMETERS	INLET	UF FEED (with 10% XR)	UF FILTRATE	UF BACKPULSE (ASBW)	RECYCLE
DESIGN FLOW (INSTANTANEOUS), GPM	1,705	1,984	1,705	528	99
DESIGN FLOW, GPD	2,455,200	2,857,418	2,455,200	142,453	142,453
TOTAL SUSPENDED SOLIDS, MG/L	10	9	-	379	10
TOTAL SUSPENDED SOLIDS, DRY LB/DAY	204	204	-	204	12
SERVICE FACTOR, HR/DAY	24.0	22.8		1.20	24.0

MAX

STREAM TAG	1	2	3	4	5
PROCESS PARAMETERS	INLET	UF FEED (with 10% XR)	UF FILTRATE	UF BACKPULSE (ASBW)	RECYCLE
DESIGN FLOW (INSTANTANEOUS), GPM	2,400	2,793	2,400	528	139
DESIGN FLOW, GPD	3,456,000	4,022,172	3,456,000	200,520	200,520
TOTAL SUSPENDED SOLIDS, MG/L	10	9	-	379	10
TOTAL SUSPENDED SOLIDS, KG/DAY	288	288	-	288	17
SERVICE FACTOR (HR/DAY)	24.0	22.25		1.75	24.0

PROFESSIONAL ENGINEER - STATE OF NEVADA
JASON MICHAEL WHEELER
Exp: 06/30/2026
CIVIL
No. 026066
09/10/2025

Linkan ENGINEERING
2720 Ruby Vista Dr. Suite 101
Elko, NV 89801
775-777-8003

REV.	DESCRIPTION	DATE	BY	CHECK	APPR
0	ISSUED FOR CONSTRUCTION	09/10/2025	JLB	ERN	JMW

TITLE: PROCESS FLOW DIAGRAM

PROJECT: GOLD STANDARD VENTURES SOUTH RAILROAD MINE SITE WATER TREATMENT PLANT

PROJECT NO.: 25US0190

DATE: APRIL 19, 2024

SCALE: N.T.S.

SHEET NO.: G-100

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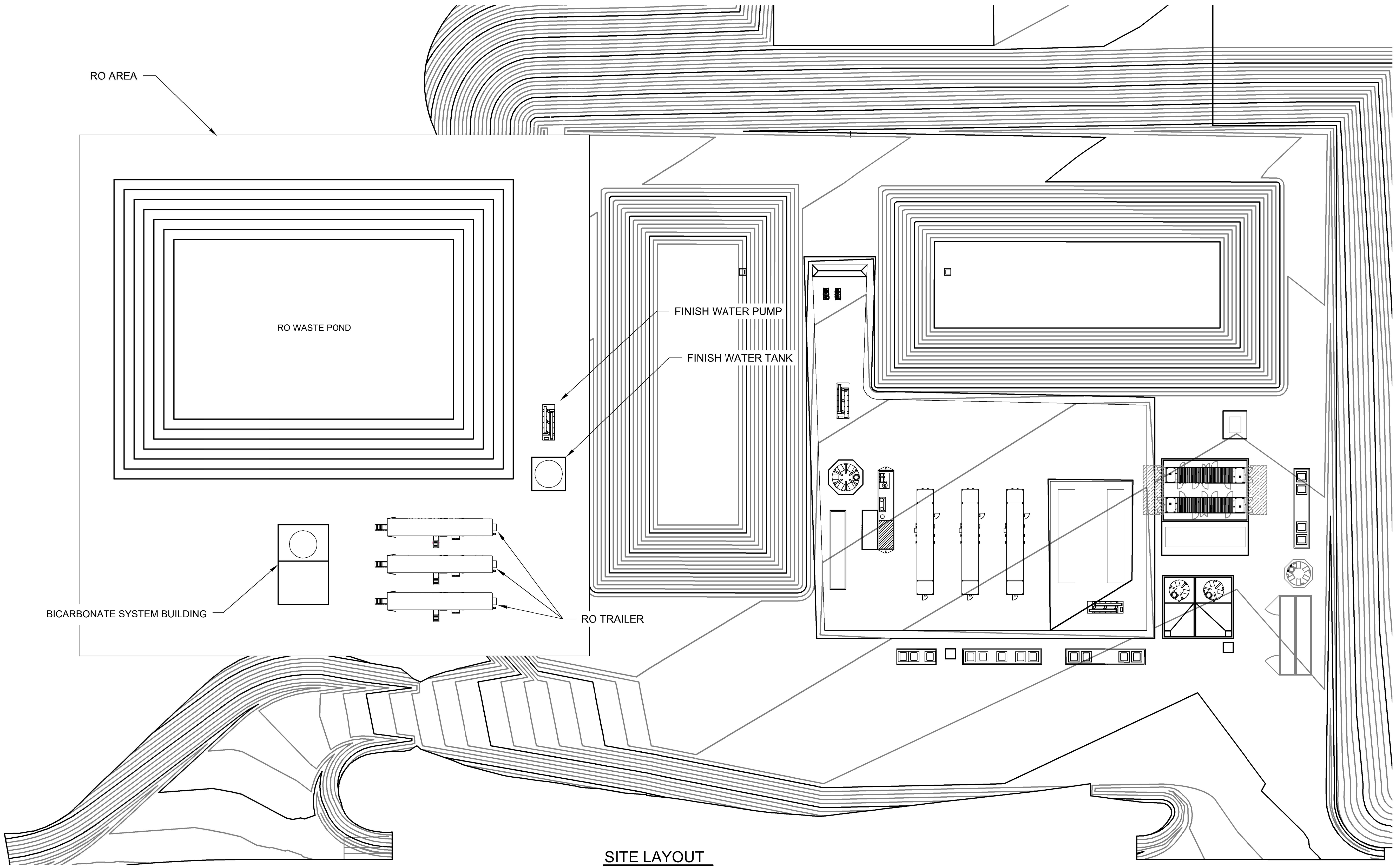
APPENDIX B

CONCEPTUAL SITE LAYOUT FOR THEORETICAL RO PROCESS



SITE LAYOUT

SCALE: 1"=50'-0"

REV.	REVISION DESCRIPTION	DATE	BY	CHECK	APPR
X	PRELIMINARY	XX/XX/XX	XXX	XXX	XXX

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FIGURE A

TITLE:
GOLD STANDARD VENTURES
SOUTH RAILROAD WTP - REVERSE OSMOSIS ADDITION

PROJECT:
26US0328

7/13/2026 10:10 AM ---- FIGURE A – RO LAYOUT.dwg

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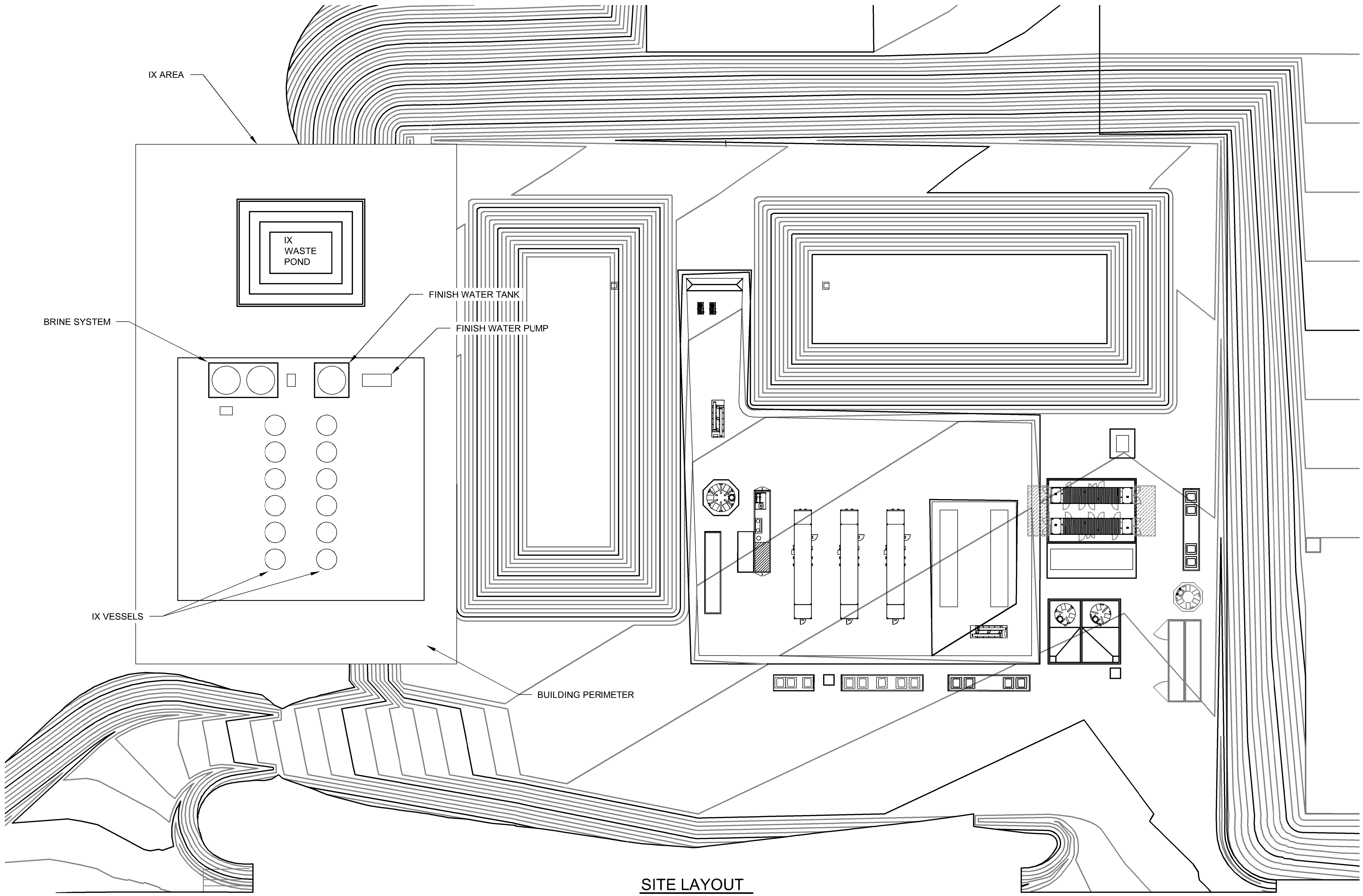
APPENDIX C

CONCEPTUAL SITE LAYOUT FOR THE THEORETICAL IX PROCESS



SITE LAYOUT

SCALE: 1"=50'-0"

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REV.	REVISION DESCRIPTION	DATE	BY	CHECK	APPR
X	PRELIMINARY	XX/XX/XX	XXX	XXX	XXX

FIGURE B

TITLE:
GOLD STADARD VENTURES
SOUTH RAILROAD WTP - ION EXCHANGE ADDITION (OPTION 1)

PROJECT:
26US0328

Appendix C

MAA Matrix

LOUGHLIN
WATER ASSOCIATES LLC
a Geo-Logic Company

Multiple Accounts Analysis
South Railroad Project
Antidegradation Alternative Analysis
National Pollutant Discharge Elimination System Draft Permit (NV0024267)

ACCOUNT	Wt (%)	SUB-ACCOUNT	Wt (1 to 5)	Comments	Metrics	Coagulation-Assisted Filtration (CAF) Only (Base Case)		Reverse Osmosis (RO) bolt-on to CAF		Ion Exchange (IX) bolt-on to CAF		Barite bolt-on to CAF	
						Notes	Score	Notes	Score	Notes	Score	Notes	Score
Technical	25%	Metals removal	5	Based on the reasonable potential analysis (RPA), treatment of antimony, arsenic, iron, manganese, and thallium could be required. Based on maximum measured metals from samples to date, exceedances of draft permit levels have occurred for arsenic and thallium, and arsenic also exceeds the next most restrictive water quality standard. Scoring is based on constituent requiring the highest percentage of removal, which is arsenic.	1=<20% 2=20-30% 3=30-40% 4=40-50% 5=>50%	CAF can achieve high metals removal when combined with proper chemistry and fine filtration. For arsenic and thallium, oxidation and ferric coprecipitation followed by ultrafiltration will supply necessary removals.	5	CAF pretreatment prior to RO provides necessary removals.	5	CAF pretreatment prior to Ion Exchange provides necessary removals.	5	CAF following Barite precipitation provides necessary removals.	5
		Sulfate, fluoride, nitrogen species removal	3	While groundwater may exceed the draft permit limit of 30.45 mg/L, the median measured concentration in representative groundwater samples to date is less than 2 mg/L above the draft permit level and over 200 mg/L lower than the next most restrictive standard of 250 mg/L. While fluoride shows up as a potential pollutant of concern, the measured concentrations were nearly all non-detect. Similarly, nitrogen species were not detected in groundwater. The relative impact to receiving water quality due to these negligible reductions in anions is, therefore, given a moderate weight.	1=<10% 2=10-20% 3=30-60% 4=60-90% 5=>90%	Not designed for sulfate removal. Maximum sulfate concentration following CAF (due to sulfuric acid and sodium bisulfite addition) is anticipated to be 67 mg/L. Has the potential to remove some fluoride and ammonia.	1	Near complete sulfate, fluoride, and nitrogen species removal achievable downstream of CAF.	5	Sulfate removal downstream of CAF. Removal is variable depending on resin capacity. Negligible removal of fluoride or nitrogen species.	3	Sulfate removal prior to CAF, thus, sulfate addition due to chemical addition (sulfuric acid and sodium bisulfite) is unaffected. Negligible removal of fluoride or nitrogen species.	3
		Operational Complexity	4	The number of unit operations, level of automation, and required operator diligence are considered here to determine operational complexity. Risks are associated with system performance, including risk to treatment system capacity or discharge compliance.	1=high operational complexity/ risk 3=moderate operational complexity/ risk 5=low operational complexity/ risk	Two primary unit operations (chemical pretreatment & UF); highly automated.	5	Four primary unit operations (chemical pretreatment, UF, RO, and alkalinity addition). RO requires frequent modeling and membrane cleaning to maintain performance.	3	Three primary unit operations (chemical pretreatment, UF, and IX). Requires diligent regeneration cycles every ~3.4 days; risk to compliance and capacity should regeneration maintenance cycles be interrupted.	2	Three primary unit operations (barite precip, chemical pretreatment, UF). Risk for sulfate, chloride, barium, and metals exceedances if dosing is not properly tuned.	1
		Waste type	3	While waste type is of importance because it impacts the ability to manage materials onsite, it carries less importance than the magnitude of the waste. Thus, waste type was given a moderate weight.	1=offsite management 3=mixed 5=manageable onsite	Non-hazardous sludge is managed onsite and liquid waste is recycled back into the system, thus not accumulating. Solid waste is deposited on the heap leach pad.	5	Cleaning wastes managed onsite. RO produces 170 gpm of high salinity / saturated brine that cannot be managed onsite.	1	Produces 17 gpm of high salinity / corrosive NaCl brine that cannot be managed onsite.	1	Barite sludge poses occupational risk and environmental risk due to potential contamination concerns.	2
		Technology maturity	2	Low technology maturity can add additional risk to commissioning and operations but in most cases can be overcome with additional O&M and controls, thus given a moderate weight.	1=pilot 3=proven 5=standard	Standard for arsenic/thallium removal in Nevada groundwater treatment.	5	Mature technology for sulfate removal.	5	Mature technology for sulfate removal.	5	Proven and demonstrated, but not the industry standard for sulfate removal.	3
		Equipment lead time	4	Discharge will be required within 9 months of the start of construction - disruptions due to extended equipment lead time could have a significant impact on the overall project.	1=>24 months 3=12-18 months 5=<6 months		4		3		4		3
					Technical Account Score		4.24		3.67		3.38		2.95
Environmental	30%	Net improvement in water quality	5	In addition to metals, various treatment technologies affect ion constituents due to chemical addition, and in turn alkalinity. Weighted highly as improvements to discharge water quality is the purpose of the treatment.	1=none 3=moderate 5=high	Effective metal removals. Adds sulfate, chloride, and TDS. Sulfate is predicted to exceed draft limit by up to 37 mg/L and TDS by up to 30 mg/L based on available sample data for source water; however both will be significantly below the most restrictive water quality standard established by NAC 445A.1236 and NAC 445A.1466.	4	Strips required hardness and alkalinity which requires additional treatment. Hardness after blending would be 37 mg/L as $CaCO_3$, which is lower than it would be with CAF. Assumed 37 mg/L as $CaCO_3$ is sufficient to protect aquatic life but it is on the threshold. Alkalinity addition is required to meet draft discharge limits. Alkalinity addition increases effluent TDS.	5	Adds chloride and TDS. Chloride would be right at permit limit and TDS would remain below. Zero room for error.	4	TDS is predicted to exceed draft permit limit by 57 mg/L. Risk of overdosing barium as well, with a draft permit level of 0.2515 mg/L.	3
		Operational energy consumption	4	Based on maximum power rating in kilowatts from load list. Moderate to high weight as energy consumption affects overall environmental footprint through increased demand as well as air quality effects.	1=>2500 kW 3=1750-2000 kW 5=1500 kW or less (base case)	1500 kW	5	2320 kW	2	1600 kW	4	1600 kW	4
		Waste volume/ resources required for disposal	5	Weighted high as the potential environmental impact associated with waste management can be tremendous, affecting land use, greenhouse gas emissions for haulage, consumption of liner materials for ponds, air quality, wildlife, etc.	1=very high 3=moderate 5=minimal	Limited waste with all onsite disposal	5	240,000 gallons per day. Storage/evaporation would require an estimated 150-300 acres depending on design of facility. > 50 truckloads per day required for disposal.	1	24,000 gallons per day. Storage/evaporation would require an estimated 15-30 acres depending on design of facility. > 5 truckloads per day for disposal.	3	850,000 pounds of barite waste produced per year, estimated to 14,000 gallons per day. Annual storage would require an estimated 15-30 acres depending on design of facility.	3
		Onsite land use	2	Weighted relatively low assuming no onsite management of additional waste byproducts beyond what is anticipated under the base case. Additional footprint would be required for alternative treatment technologies but do not have a significant impact on the environment.	1=≥300% of base case 3=≥150% of base case 5=base case	Footprint of treatment facility is approximately 3 acres with no additional land use required.	5	Footprint of treatment facility is approximately 5 acres.	3	Footprint of treatment facility is approximately 4 acres.	4	Footprint of treatment facility is approximately 4 acres.	4
					Environmental Account Score		4.69		2.75		3.69		3.38
Economic	20%	CAPEX	3		1=≥150% of base case 2=≥130-<150% of base case 3=≥115-<130% of base case 4=>100-<115% of base case 5=base case	~US$20M	5	+ ~US$14M on top of base case	1	+ ~US$14M on top of base case	1	+ ~US$9M on top of base case	2
		OPEX	5	Assuming maximum load running 24 hours per day	1=≥200% of base case 2=≥150-<200% of base case 3=≥120-<150% of base case 4=>100-<120% of base case 5=base case	~US$2.4M annually	5	+ ~US$30M annually on top of base case assuming haulage of waste	1	+ ~US$3M annually on top of base case assuming hauling of waste	1	+ ~US$3M annually on top of base case assuming hauling of waste	1
					Economic Account Score		5.00		1.00		1.00		1.38
Social	25%	Permits required	4	Federal and State permitting has been an important focus of the South Railroad Project for more than 5 years. Significant progress and communication has occurred with agencies throughout. Changes to permits, or new permits, would have a major impact on the schedule and likely knock on affects to permits that are nearly complete.	1=new permits required 2=new permits likely 3=new permits possible 4=new permits unlikely 5=none required	Impacts from land use and emmisions have been included in ongoing federal and State permitting efforts.	5	Would require additional disturbance area beyond what has been analyzed in NEPA and would likely require an additional air permit associated with the power consumption and haulage. May also require an additional dam permit associated with the waste holding pond.	2	Would require additional disturbance area beyond what has been analyzed in NEPA and may require an additional air permit associated with the power consumption and haulage.	3	Would require additional disturbance area beyond what has been analyzed in NEPA and may require an additional air permit associated with the power consumption and haulage.	3
		Schedule risk to net positive socioeconomic benefits of project	3	This schedule risk includes design efforts, equipment lead times, and permitting requirements. Changes to the schedule would have major socioeconomic impacts to contractors.	1=>2 year delay 2=1 to 2 years 3=6 months to 1 year 4=up to 6 months 5=no delay	Permitted and equipment currently in fabrication.	5	Likely the most permitting efforts required and longest equipment lead time for containerized RO systems.	2	Long lead time for design and fabrication of ASME pressure vessels and additional permitting requirements.	3		3
		Traffic (community perception and safety impacts)	5	Assumes offsite storage of waste. Traffic through the nearby town of Lucky Strike has been a point of discussion. Increasing traffic for haulage of waste material is unlikely to be viewed favorably and would increase safety risks.	1>50 trips/day 3=10-20 trips/day 5=<1 per day	<1 trip per day	5	50 trips a day for waste at a minimum.	1	5-8 trips just for waste plus delivery of chemicals for treatment	3	5-8 trips just for waste plus delivery of chemicals for treatment	3
		Operator safety	5	Operator safety is weighted highly as safety is always a number one priority.	1=high risk 3=moderate 5=low	Relatively simple operation with engineered controls to minimize safety risks.	4	Higher pressure, more chemicals, louder than CAF.	3	Similar to CAF	4	Raw barium material handling - OSHA regulated material	3
					Social Account Score		4.71		2.00		3.29		3.00
Combined MAA score							4.64		2.44		2.98		2.78