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State of Utah

Underground Injection Control Program

Aquifer Exemption Request

Submitted to the

U.S. Environmental Protection Agency Region 8

Prepared by the State of Utah,
Department of Environmental Quality,
Division of Water Quality

December 1, 2021

Table of Contents

LIST OF FIGURES

LIST OF TABLES

KEY ACRONYMS AND DEFINITIONS

ADEQ	Arizona Department of Environmental Quality
AE	Aquifer Exemption
amsl	above mean sea level
AOR	Area of Review
Aquifer	a saturated bed, formation, or group of formations that yields water in sufficient quantity to be economically useful (Driscoll, 1986)
BC Aquifer	Burro Canyon Aquifer
BLM	Bureau of Land Management
Director	Utah UIC Director
Division	Division of Water Quality
DWQ	Division of Water Quality
EPA	U.S. Environmental Protection Agency
FW	footwall block, the block of rock on the lower side of a fault plane
gpm	gallons per minute
injection interval	within a well, the injection interval refers to the specific range of depths below the ground surface at which fluids will be injected into the aquifer; within the injection interval, well casing screens or perforated casing allows fluids to enter the permeable rock formation; above the injection interval, a solid casing is used

	for the well and forms a barrier between the well and the surrounding rock or aquifer
ISR	in-situ recovery
LLV	lower Lisbon Valley
LVMC	Lisbon Valley Mining Company, LLC
MCL	maximum contaminant levels
N Aquifer	Entrada, Navajo, Kayenta, and Wingate Formations, sandstone aquifers
National Instrument 43-101	National Instrument 43-101 is a national instrument for the *Standards of Disclosure for Mineral Projects* within Canada. The Instrument is a codified set of rules and guidelines for reporting and displaying information related to mineral properties owned by, or explored by, companies which report these results on stock exchanges within Canada.
mg/L	milligrams per liter
Perched water	unconfined groundwater separated from an underlying main body of groundwater by an unsaturated zone (Driscoll, 1986); in some cases it may be confined by low permeability formations above and below the perched water
Permit	Utah Division of Water Quality Class III Area Permit, Underground Injection Control (UIC) Program, UIC Permit Number: UTU-37-AP-5D5F693
SDWA	Safe Drinking Water Act
SLB&M	Salt Lake Base and Meridian
TDS	total dissolved solids
UAC	Utah Administrative Code
UIC	Underground Injection Control
USDW	underground sources of drinking water

INTRODUCTION

The Lisbon Valley Mining Company, LLC (LVMC), has submitted a permit application (LVMC, 2019) to the Utah Division of Water Quality (DWQ or Division) for work in the lower Lisbon Valley (LLV), Utah. LVMC is proposing to use a portion of the Burro Canyon (BC) Aquifer in the LLV in San Juan County, Utah, for in-situ recovery (ISR) of copper. The Director has prepared an Underground Injection Control, Class III Permit (UTU-37-AP-5D5F693), hereafter referred to as the Permit (DWQ, 2020) based on LVMC's permit application.

This Aquifer Exemption (AE) request is part of the Permit. This document provides background information and the basis for the Director's decision to request that the U.S. Environmental Protection Agency (EPA) approve an AE for a portion of the BC Aquifer. The basis of the AE request includes selected material and data contained in LVMC's Technical Report (LVMC 2020) submitted with the permit application (LVMC, 2019), but the Technical Report, in its entirety, is not the permit or part of the permit (DWQ 2020). The Director required LVMC to include the Technical Report as part of its application for the permit to provide information relevant to the Director's review of the application and to use when writing the Permit and this AE request. The Technical Report was provided to the public in response to a request from the public, but it is not part of this public notice package because the Technical Report itself in its entirety is not part of the Permit (DWQ 2020) or this AE request. Moreover, LVMC revised and updated the Technical Report during the permit review process in response to requests from the Director for more information and for modifications to the proposed plan and AE request. The Draft Permit (DWQ 2020) is the legal regulatory document that defines all permit conditions. The objective of the Director's review of LVMC's application and Technical Report is not to edit, critique, and finalize those documents, but rather to use those documents to prepare the Permit and this AE request, which is subject to public notice comment under UIC regulations (40 CFR §§ 124.10, 124.11, 124.12, and 124.17 as incorporated in Utah Administrative Code [UAC] R317-7-1). Specific information from the Technical Report used to support this AE request is cited, quoted, or reproduced in this AE request.

Under Part III, Section E.1 of the Permit (DWQ 2020), an AE and an approved Aquifer Restoration Plan are required prior to commencement of ISR wellfield construction and operations by LVMC in the LLV. LVMC provided justification for the AE in its permit application (LVMC 2019), and information in that application and Technical Report (LVMC, 2020) is used to support this AE request.

Aquifer to Be Exempted: A portion of the BC Aquifer as described herein.

Exemption Criteria: The portion of the BC Aquifer proposed for exemption qualifies under 40 CFR § 146.4 because it is not currently serving as a source of drinking water and cannot serve as a potential future source of drinking water because LVMC has demonstrated that it contains minerals that are expected to be commercially producible.

Primacy Agency: State of Utah, Department of Environmental Quality, Division of Water Quality, under Section 1422 of the Safe Drinking Water Act (SDWA) and the Utah Underground Injection Control (UIC) Rules in UAC R317-7. The Utah Bureau of Water Pollution Control, now the Utah Division of Water Quality, received primacy from EPA on February 10, 1983, according to 40 CFR §§ 145 and 147 to administer the program in Utah under section 1422 of the SDWA for Class I, III, IV, and V wells (the Utah 1422 UIC Program). All Utah UIC regulations are enforced by the Division under the authority of the Director of DWQ who is also the designated Utah UIC Director (Director).

Date of AE Request: November 2021

SUBSTANTIAL OR NON-SUBSTANTIAL APPROVAL: NON-SUBSTANTIAL

Under 40 CFR § 144.7(b)(3) and § 145.32, this AE request to EPA is a state program revision and requires EPA to determine whether approval of the AE request is a major or minor (i.e., substantial or non-substantial) amendment to Utah's UIC Program. The Director believes this AE decision is minor, or non-substantial, because it is associated with the issuance of a site-specific UIC Class III permit action, not a statewide programmatic change or a revision with implications for the national UIC program. The basis for characterizing this AE as a minor, non-substantial program revision is also consistent with the corresponding state program revision process detailed in EPA Guidance #34: *Guidance for Review and Approval of State Underground Injection Control (UIC) Programs and Revisions to Approved State Programs* (EPA, 2000). Guidance #34 explains that determining whether a program revision is substantial or non-substantial is done on a case-by-case basis and, with the exception of AEs associated with certain Class I wells or exemptions not related to action on a permit, AE requests are typically treated as non-substantial program revisions. While this is the first Class III AE in the state of Utah, there are several Class II AEs in the state.

Current Operator: Lisbon Valley Mining Company, LLC (LVMC)

Well/Project Name: Lisbon Valley In-Situ Copper Recovery Project

Well/Project Permit Number: Permit No. UTU-37-AP-5D5F693

Well/Project Location: All of Sections 4, 5, 6, 7, 8, 9, 10, 11, 14, 15, 16, and 17 of Township 31 South, Range 26 East, Salt Lake Base and Meridian (SLB&M). All of Sections 31 and 32 of Township 30 South, Range 26 East, SLB&M. All of Section 36 of Township 30 South, Range 25 East, SLB&M. All of Section 1 of Township 31 South, Range 25 East, SLB&M.

County: San Juan

State: Utah

Well Class /Type: Class III in-situ copper recovery

DESCRIPTION OF THE PROPOSED COPPER RECOVERY PROCESS

BACKGROUND

LVMC currently operates an existing open pit and heap leach copper mine in southeastern San Juan County, Utah, about 20 miles north-northeast of Monticello and east of U.S. Route 191 (Figure 1). The current Lisbon Valley mine has been using open pit and heap leaching methods for 13 years. The mine has recovered approximately 65%–75% of available copper using these methods, which are used throughout the copper industry.

Additional copper resources in the LLV are currently uneconomical to develop using open pit mining methods. Therefore, LVMC proposes to extend the life of the Lisbon Valley mine by adopting ISR technology. ISR methods involve injecting lixiviant (which is defined and explained below in the In-Situ Recovery Process section) into injection wells (classified by the Director as Class III injection wells). LVMC's proposal requires a Class III Area Permit from the UIC Director (Permit, DWQ 2020). LVMC requested this AE as part of its application for a UIC permit (LVMC, 2019). This AE request is part of the Permit, and the Director is submitting this AE request to the EPA for approval.

Figure 1 shows the Permit Area boundary in dark green and the Area of Review (AOR) considered by the Director in its permit application review in light green. Under UAC R317-7-1, the AOR extends 2 miles from the circumscribed Permit Area for an area permit.

LVMC has identified three ore bodies with commercial grades of copper suitable for ISR. Figure 2 shows the LVMC Permit Area and the Lone Wolf, GTO, and Flying Diamond deposits where ISR wellfields are proposed. Other areas with potential copper resources within the Permit Area, as indicated in Appendix D of LVMC's Technical Report (LVMC 2020: Appendix D), may also be amenable to ISR. Other copper resources that may exist in LLV outside of the area considered in the Permit cannot be developed by ISR under UIC regulations unless the Permit is revised at a future date or a separate permit is applied for and approved.

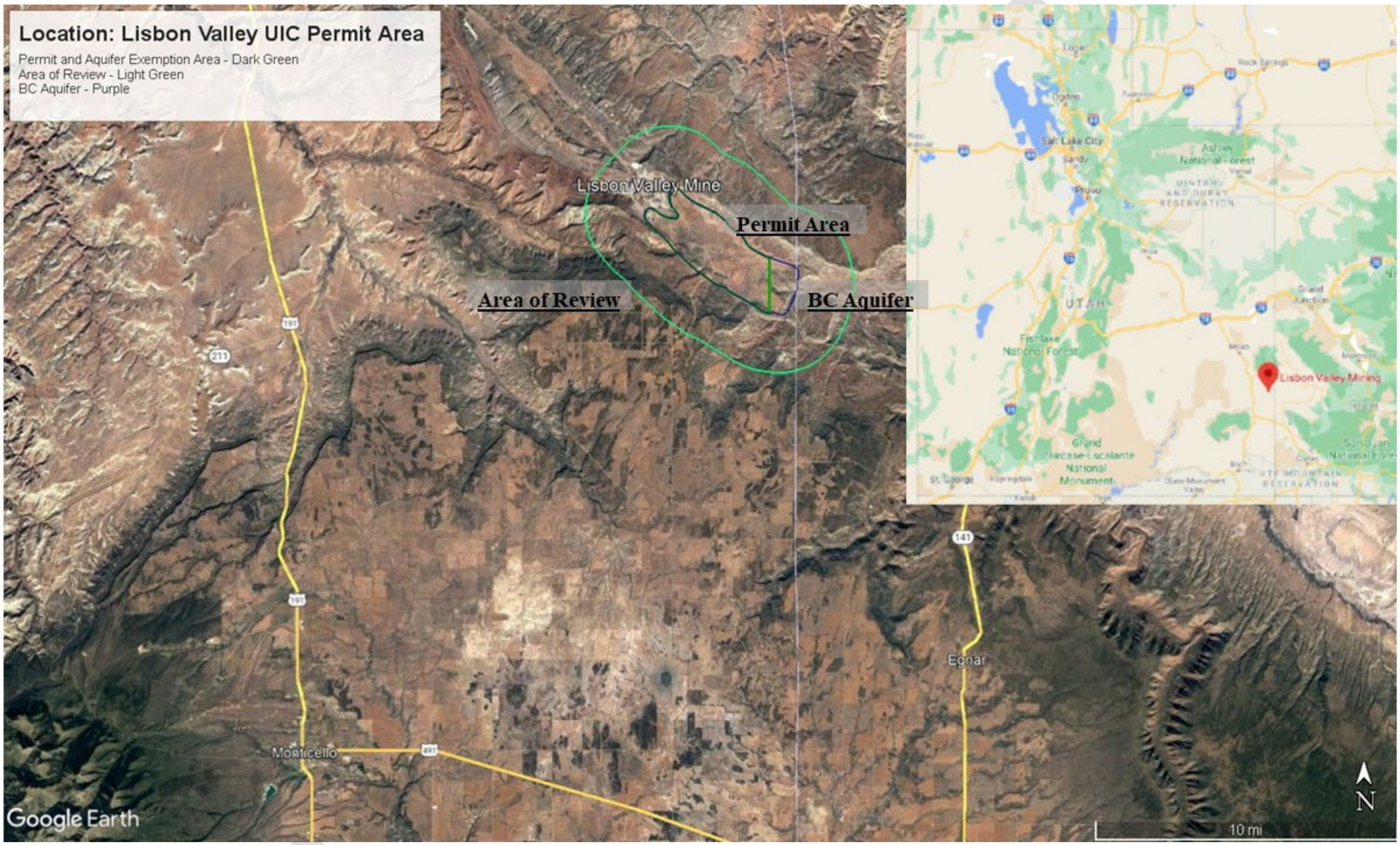

Figure 1. Location of the Lisbon Valley Mining Company proposed Permit Area and Aquifer Exemption Area, Area of Review, and BC Aquifer.

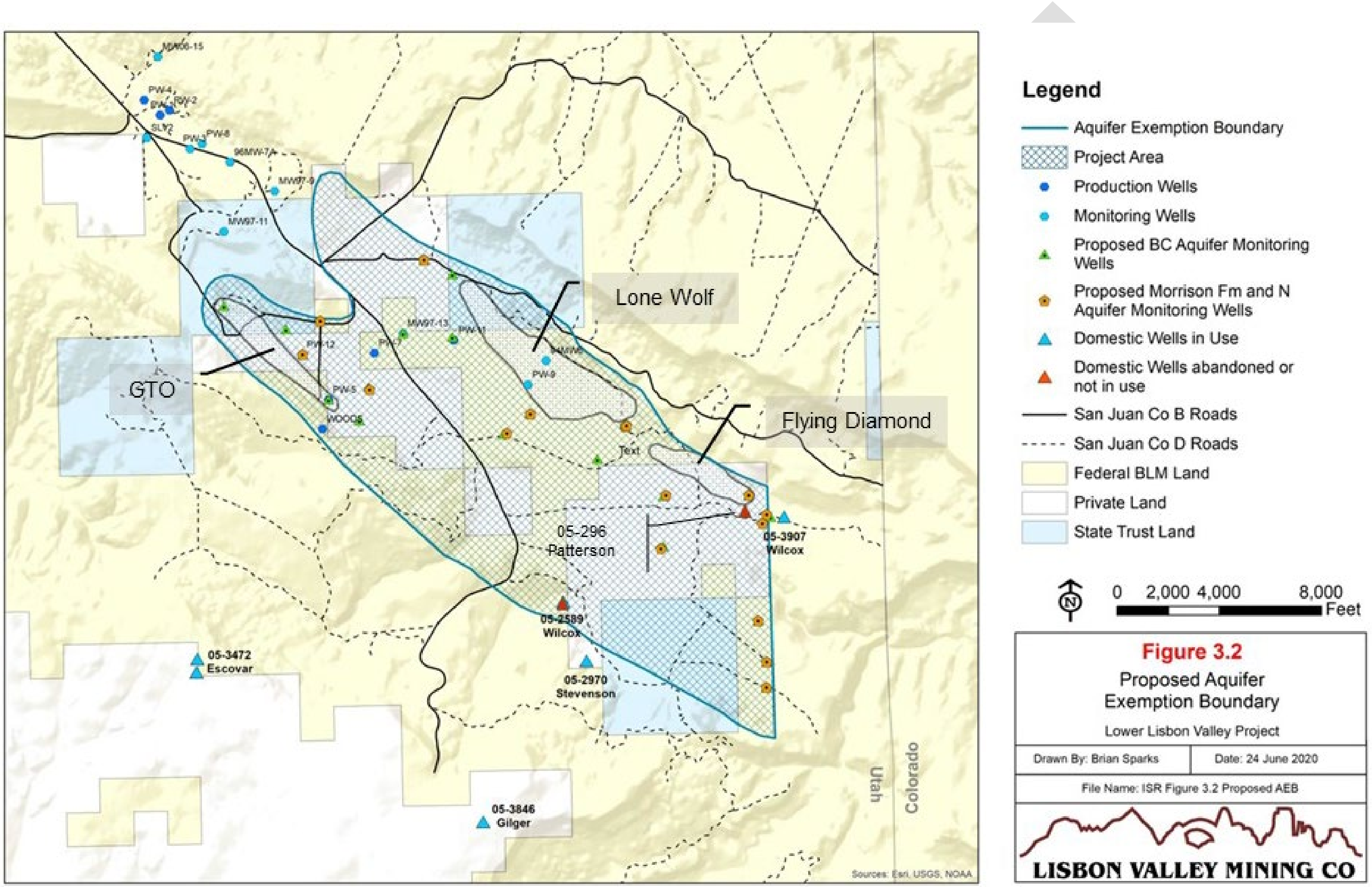

Figure 2. Proposed Aquifer Exemption boundary, Project Area, existing water production and monitoring wells associated with current open pit mining, proposed point of compliance monitoring wells for the Permit, and GTO, Lone Wolf, and Flying Diamond copper deposits that are targets for ISR. Adapted from the Lisbon Valley Mining Company Technical Report (LVMC 2020: Figure 3.2).

PROPOSED INJECTION, PRODUCTION, AND MONITORING WELLS

LVMC proposes to construct and operate up to approximately 2,650 Class III ISR injection wells to continue extraction of copper from ore in the LLV within mineralized zones of a portion of the BC Aquifer, which includes the Dakota and Burro Canyon Formations. These formations exist generally between 200 and 900 feet below the ground's surface in the LLV, east of the current mining operation.

Figure 3 shows the proposed typical arrangement of injection wells, production wells, and monitoring wells. Each ISR wellfield will have a perimeter ring of monitoring wells around the wellfield as shown in Figure 3.

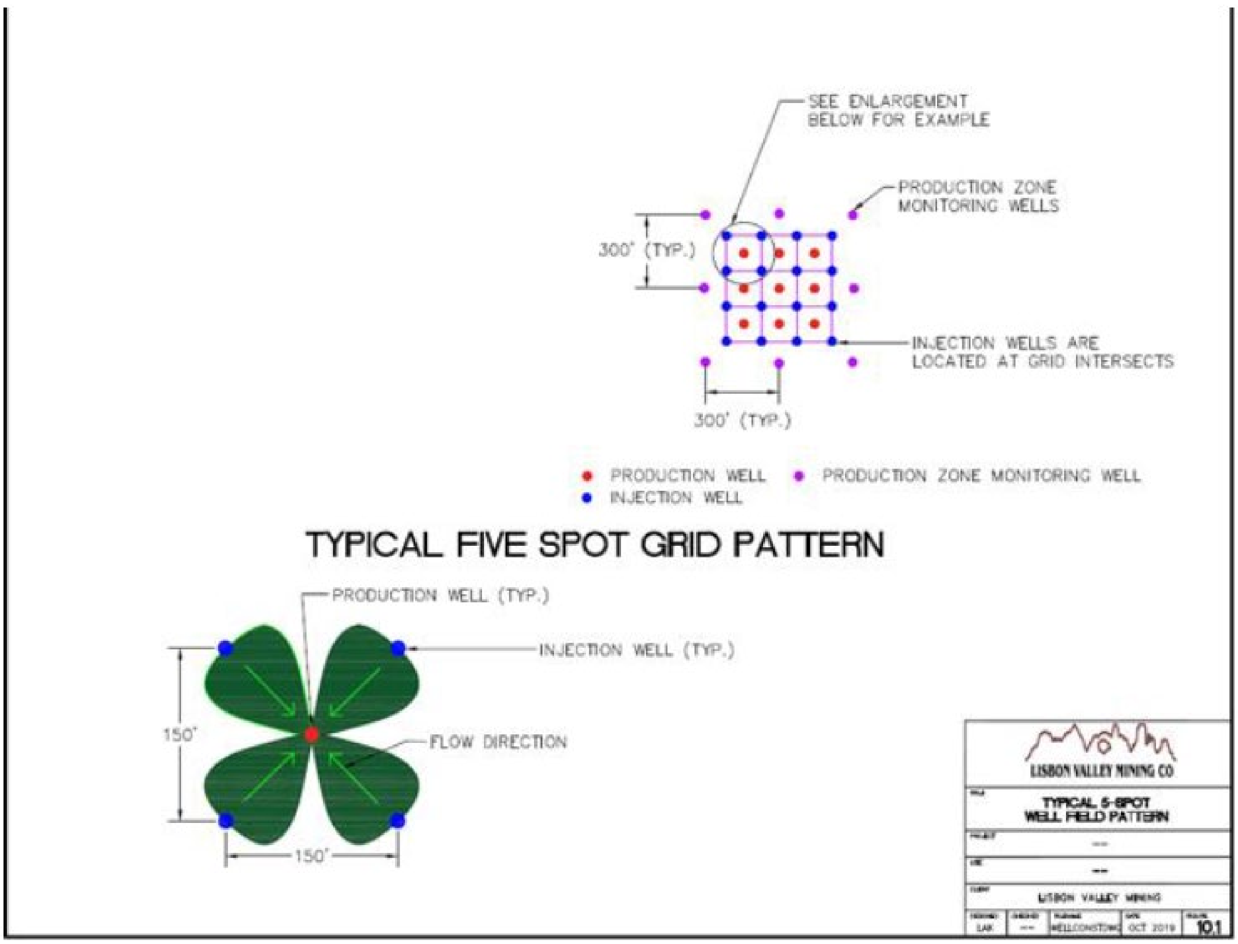

Figure 3. Spacing between perimeter monitoring wells will be no greater than 300 feet or close enough to ensure no undetected excursions at the nearest injection well. Reproduced from the Lisbon Valley Mining Company Technical Report (LVMC 2020: Figure 11.4); also reproduced in Permit Attachment E.

Each perimeter ring of monitoring wells will be located about 150 feet from the injection and production wells. Perimeter monitoring wells will be spaced approximately every 300 feet along the perimeter of the wellfield. LVMC anticipates the construction of up to approximately 200 Class III injection wells and production wells per year over the expected 20 years of ISR operations. Approximately 200 to 700 ISR wells will be operational at any given time during the project The total rate of flow of lixiviant (which is defined below in the In-Situ Recovery Process section) that will be recirculated in the ISR wellfields ranges from approximately 5,000 to 20,000 gallons per minute (gpm).

In-Situ Recovery Process

If approved, this AE request would allow the injection of sulfuric acid lixiviant into the copper-bearing portions of the BC Aquifer. Injecting this solution will facilitate ISR of copper by solubilization of copper currently suspended in the copper-bearing mineral deposits within the BC Aquifer.

The ISR process involves the injection of lixiviant into a water body that contains copper ore deposits. For this project, lixiviant will consist of groundwater to which sulfuric acid and oxygen have been added. The lixiviant will be pumped into the copper-bearing portions of the BC Aquifer through the injection wells. When the lixiviant displaces groundwater in the aquifer, it will dissolve the copper within the solid matrix of the aquifer. The chemistry of copper sulfide oxidation and dissolution is characterized by the reaction:

$$\mathbf{Cu_2S + 10Fe^{3+} + 15SO_4^{\ 2-} + 4H_2O = 2Cu^{2+} + 10\ Fe^{2+} + 12SO_4^{\ 2-} + 4H_2SO_4}$$

LVMC will employ an iron-based lixiviant because chalcocite (Cu_2S) is the primary form of copper in the Lisbon Valley deposits. Ferric iron will be the key leaching agent for copper ISR at the LVMC. Air or oxygen may be injected with the lixiviant to increase the amount of ferric iron in the leaching lixiviant. The lixiviant will increase total iron and ferric iron levels in the groundwater from baseline water concentrations by lowering the pH and adding dissolved air or oxygen.

Production wells will pump the copper-bearing lixiviant out of the ground. The copper-bearing lixiviant will then flow via pipeline from the wellfield to the solvent extraction plant. At the plant, gravity will be used to separate the lixiviant into copper-laden organic material and aqueous material. The insoluble organic extraction liquid will be mixed with a leach solution, and then a sulfuric acid solution will be used to extract the copper from the organic material. The copper sulfate solution will then be sent to an electrowinning facility where copper will be plated onto cathodes from the solution. The copper cathodes will be stripped to produce copper plates for commercial sale on the market. The barren lixiviant will be pumped from the solvent extraction plant back to the ISR wellfield where sulfuric acid and oxygen will be added before the solution is injected back into the copper deposits through the wellfield injection wells.

INJECTATE (LIXIVIANT) CHARACTERISTICS

The Class III Area Permit allows the following types of fluids to be injected into the Class III injection wells:

1. During the ISR process, the injection fluid is limited to ISR lixiviant consisting of SXEW raffinate (sulfuric acid solution with dissolved solids similar to current heap leach solutions) with ferric iron and oxygen added. Per the Permit, Part III, Section M, other chemicals, grout, and fresh groundwater may be injected for the purposes of facilitating the movement of or containing leach solutions and protecting domestic and livestock watering wells based on the Director's order(s) and approval(s).
2. During the groundwater restoration phase, the injectate will be limited to recycled spent leach solution and clean groundwater extracted from the post-ISR wellfields. Per the Area Permit, Part III, Section M, neutralizing agents and other chemicals may be injected for the purposes of enhancing groundwater restoration based on the Director's order(s) and approval(s).

DESCRIPTION OF THE LAND USE, GEOLOGY, AND WATER QUALITY IN THE PERMIT AREA

Land Use in the Permit Area

Two residences are within the Permit Area: a ranch and a seasonal bed and breakfast commercial operation. Seven people reside permanently within the Permit Area. An additional two residences are located outside the Permit Area in the AOR.

Land ownership within the AOR is roughly 80% Bureau of Land Management (BLM) (24,338 acres), 12% private (3,587 acres), and 8% State of Utah (2,552 acres). Hence, development in the area is highly restricted by the predominance of Federal jurisdiction.

The predominant land uses within the Project Area are mining and ranching. Most of the land surface serves as grazing land for cattle. Some of the land is used for recreational activities—primarily off-road motorsports and hunting. However, ISR is compatible with multiple land uses, and operations can be conducted with little impact on existing activities.

Geological Structure of the Burro Canyon Aquifer

LVMC is seeking an AE for a portion of the BC Aquifer, which includes the saturated portions of the Dakota and Burro Canyon Formations (Figure 4). The BC Aquifer is generally between 200 and 900 feet below the ground's surface in the LLV. Appendix D of the LVMC Technical Report (LVMC, 2020: Appendix D), which was submitted with LVMC's permit application, describes the perched water within the BC Aquifer as being vertically and laterally confined by the geological structure of the LLV. The geological structure is a large graben, which is a large block of land between two faults that has dropped down relative to the surrounding area. The major confining formations of the BC and the N Aquifers are illustrated in Figure 5. The N Aquifer is a sandstone aquifer in the Entrada, Navajo, Kayenta, and Wingate Formations. The N Aquifer is not artesian in the LLV, and pumping is required to bring water to the surface.

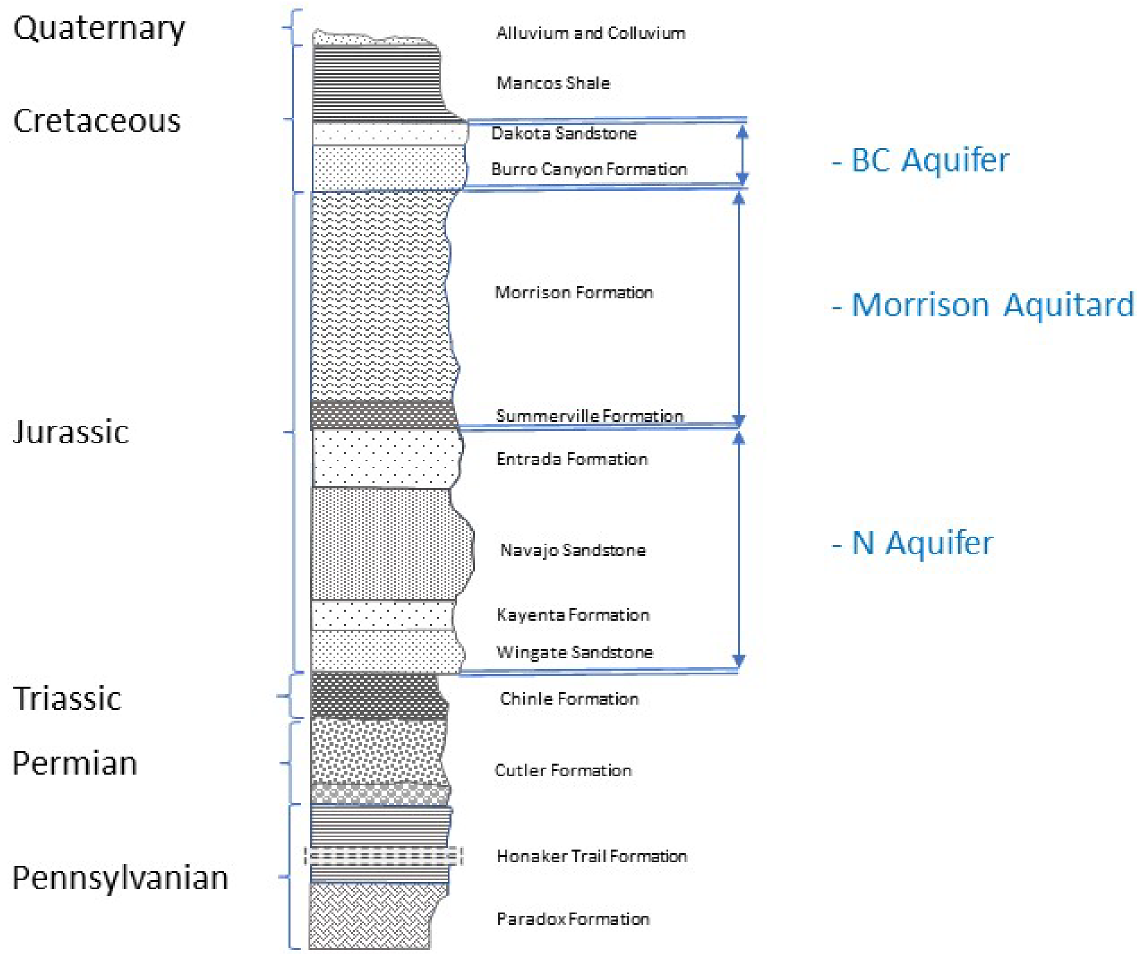

Figure 4. Stratigraphic column of the BC Aquifer, the major confining zone (the Morrison Aquitard), and the N Aquifer. Adapted from the Lisbon Valley Mining Company Technical Report (LVMC, 2020: Figure 3.12).

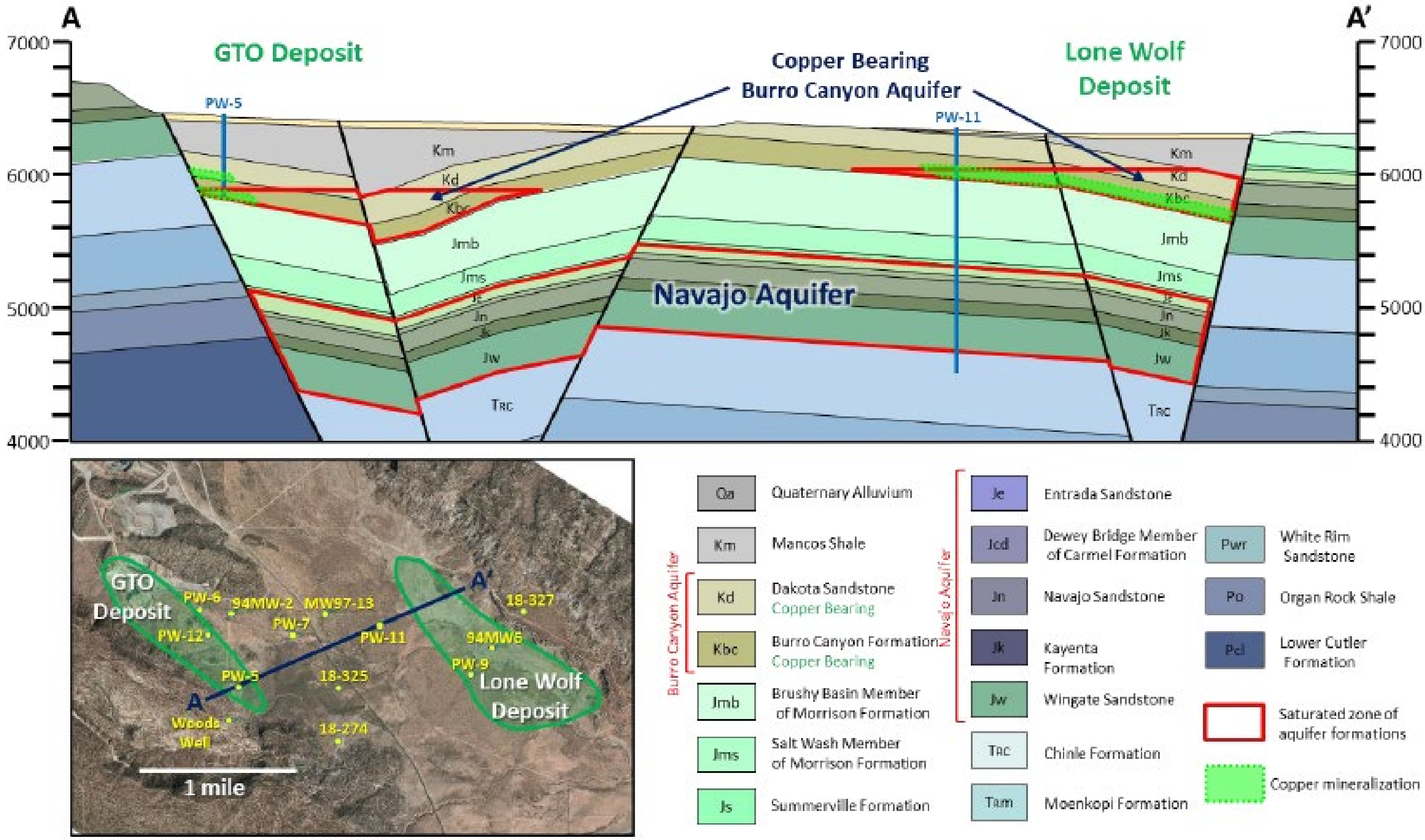

Figure 5. Southwest to northeast cross section A–A' of the GTO and Lone Wolf Deposits in the lower Lisbon Valley. The schematic shows the Burro Canyon Aquifer, the major confining formations (Morrison and Mancos Aquitards), and the N Aquifer. Reproduced from the Lisbon Valley Mining Company Technical Report (LVMC, 2020: Figure 3.23).

The LLV graben's large down-dropped structure causes groundwater in the Dakota-Burro Canyon Formations (the BC Aquifer) to be confined to those geological strata. The BC Aquifer is vertically confined by the underlying Morrison Formation and overlying Mancos Shale, both of which are unsaturated aquitards. The BC Aquifer is laterally sealed by fine-grained fault gouge on the major northeast and southwest fault sections and by the relative elevations of surrounding geologic structures.

The LLV is part of the Colorado Plateau and includes thick sedimentary stratigraphic sequences (see Figure 4) that are regionally horizontal and relatively continuous (Williams et al., 2014). However, local warping, faulting, salt doming, salt dissolution, and the collapse of overlying beds within the Paradox Formation have caused the bedded sequences to become offset. The LLV was created by normal faulting on the northeast and southwest flanks of the valley along the LoneWolf/Flying Diamond and Lisbon Valley faults, respectively. Hence, in the LLV, the BC and N Aquifers are contained within a closed basin isolated by the regional geologic anticlinal structure within a graben bounded by faults with low hydraulic conductivity owing to the occurrence of fine-grained fault gouge material (LVMC, 2020: Appendix M).

The BC Aquifer within the LLV is perched water, which means it is separated from a lower body of regional groundwater (i.e., the N Aquifer) by an unsaturated zone (Driscoll, 1986) and does not contribute to the regional groundwater system (i.e., it does not flow to the Dolores or Colorado Rivers). The N Aquifer groundwater in the LLV flows east to the Dolores River rather than west to the Colorado River, which is where the regional groundwater system flows (Avery, 1986). The N Aquifer is a much greater source of regional groundwater for southeastern Utah than the BC Aquifer (Avery, 1986).

The central part of the LLV graben is largely unsaturated where the Mancos shale has been eroded and the Burro Canyon and Dakota Formations are at ground surface or have been partly eroded owing to greater down dropping of these formations at the fault-bounded edges of the graben where the copper resources occur (see Figure 5).

Groundwater elevations range from 5,900–6,200 feet above mean sea level (amsl). Elevations have no overall regional or lateral gradient because the BC Aquifer is bounded on all sides and is segmented by block faulting within the graben. These hydrogeologic conditions exist across the entire LLV.

CONFINING ZONE(S)

Table 1 lists the major confining zones and their minimum and maximum thicknesses at wellfield locations beneath the Permit Area. The thickness values for the upper and lower confining zones for the BC Aquifer (the subject of this AE request) are based on cross sections and logs from drill holes located throughout the Permit Area. These overlying and underlying confining zones comprise shale and silty shale horizons.

Table 1. Major Confining Zones of the BC Aquifer in Lower Lisbon Valley

Injection Interval	Confining Zone Formation Name	Minimum Thickness (feet)	Maximum Thickness (feet)
GTO (Section A–A')	Upper Confining Zone: Mancos Shale	150	600
	Lower Confining Zone: Morrison Formation	350	600
Lone Wolf (Section B–B')	Upper Confining Zone: Mancos Shale	0	225
	Lower Confining Zone: Morrison Formation	450	600
Flying Diamond (Section C–C')	Upper Confining Zone: Mancos Shale	0	200
	Lower Confining Zone: Morrison Formation	600	800

Cross sections A through E from the LVMC Technical Report (LVMC, 2020: Figures 3.16–3.20) show the BC Aquifer is discontinuous, segmented by faults, and locally confined vertically and horizontally as perched groundwater. The lack of continuity within the BC Aquifer is also supported by the highly variable groundwater chemistry, given the relatively small size of the aquifer. For example, the oxygen isotope $\delta^{18}O$ ratios range from −10.2‰ to −16.5‰ and are relatively evenly distributed across that range. This is a remarkably wide range for such a small-volume and partially confined aquifer hosted by relatively homogeneous sedimentary formations. This range spans the known range of the combined surface and groundwater values in the region (LVMC, 2020: Appendix C). In contrast, the N aquifer $\delta^{18}O$ values are below the range for the BC Aquifer and vary by only about 1‰.

The isotopic data and other geochemical indicators show that the perched water in the BC Aquifer is actually composed of separate perched water zones that have very limited lateral connections among blocks via unsaturated pore connections with the N Aquifer. Hence, groundwater production from individual wells is limited to the yield from individual blocks of the BC Aquifer within the compartmentalized BC Aquifer volume.

Block faulting has compartmentalized the BC Aquifer laterally. Each wellfield will have operational vertical confining units as described in Table 1. The upper confining unit is the Mancos Shale Formation, and the lower confining unit is the Morrison Formation. In some locations the Mancos Shale (the upper confining unit) may not be present because it has been eroded in the central part of the LLV. The Morrison Formation separates the BC Aquifer from the N Aquifer, as shown in Figure 5. The formation testing required under Part III, Section D.7, and Attachment D of the Class III Area Permit (DWQ, 2020) will verify whether these local confining units are sufficient to direct the injected lixiviant to flow through the ore deposit in the intended injection, flow, and production pattern shown in Figure 3.

Depth and Thickness of the Burro Canyon and N Aquifers

In the Permit Area, the geologic strata dip variably across and along the axis of the LLV graben structure because of the normal block faulting within the graben. Therefore, the depth to the top and bottom of the BC and N Aquifers varies across the Permit Area. The local normal faulting within the LLV graben results in down-dropped blocks, which causes the depth to the top of the Dakota and BC Formations to vary locally (Table 2). The average thickness of the BC Aquifer does not vary substantially and is approximately 370 feet. Table 2 presents an approximate average depth of the BC and N Aquifer units in the Permit Area based on cross sections A through E presented in Figure 3.15 of the LVMC Technical Report (LVMC, 2020: 53) and shown in Figures 3.16 through 3.20 of the LVMC Technical Report (LVMC, 2020: 54–58).

Table 2. Depth Below Ground Surface and Thickness of the BC and N Aquifers

Cross Section	BC Aquifer Maximum and Minimum Depth and Thickness			N Aquifer Maximum and Minimum Depth and Thickness		
	Max. Depth (feet)	Min. Depth (feet)	Thickness (feet)	Max. Depth (feet)	Min. Depth (feet)	Thickness (feet)
A–A'	500	0	350	1300	450	700
B–B'	375	0	500	1400	400	900
C–C'	200	0	400	1000	900	750
D–D'	300	0	300	1400	1000	700
E–E'	50	0	300	950	800	600

Source: Data from the Lisbon Valley Mining Company Technical Report (LVMC, 2020: 53–58, Figures 3.15–3.20).

The thickness of the BC Aquifer formation is relatively constant (with an average of approximately 370 feet) across the Permit Area. Portions of the BC Aquifer are confined along the bounding faults by low-permeability Mancos Shale (see Figure 5, which is a typical northeast–southwest cross section of the LLV).

Water Quality—Total Dissolved Solids

The Director evaluated the groundwater quality of the BC Aquifer within the proposed AE volume, which is the portion of the BC Aquifer within the AE boundary, with respect to drinking water quality for potential future use. A summary of analytical results from the BC Aquifer groundwater samples are included in

Table 12.4 of the LVMC Technical Report (LVMC, 2020: 155) submitted with the LVMC Permit Application (LVMC, 2019).

In the BC Aquifer, total dissolved solids (TDS) concentrations range from 542 to 5,340 milligrams per liter (mg/L) with a mean TDS of 986 mg/L (median = 1,010 mg/L). These measurements are based on 101 samples. The concentrations of other contaminants, including uranium and radioactivity, in some groundwater samples exceeded maximum contaminant levels (MCLs).

Because of the characteristics described above, BC Aquifer groundwater from some wells would necessarily require treatment by reverse osmosis, electrocoagulation, or other appropriate water treatment technology to decrease TDS, iron, manganese, and sulfate concentration below the secondary drinking water standards before it is palatable for human consumption. In addition, some BC Aquifer groundwater has high radium and gross alpha and uranium concentrations above MCLs. Radon risk is also high in the Lisbon Valley area (Black, 1993). While the BC Aquifer groundwater is treatable using best available technologies, the cost to make this relatively small and localized groundwater resource suitable for human consumption will be relatively high depending upon its location within the LLV.

In the N Aquifer, TDS ranges from 260 to 1,440 mg/L with a mean TDS of 605 mg/L (median = 540 mg/L) based on 129 samples. The TDS and other groundwater quality analyses are provided in Table 12.4 of the LVMC Technical Report (LVMC, 2020: 155) submitted with the LVMC permit application (LVMC, 2019). The concentrations of other contaminants, including uranium and radioactivity, in some groundwater samples exceeded MCLs.

PERMIT AREA FOR THIS AQUIFER EXEMPTION

The Permit Area for this AE is approximately 4,803 acres and is depicted in Figure 1 and Figure 2 of this document. The proposed Permit Area for this AE includes the location of commercially producible copper ore from the GTO, Lone Wolf, and Flying Diamond ore deposits plus a buffer zone beyond the perimeter monitoring well ring for each wellfield. The Permit Area encompasses other exploration areas of interest as well.

While the wellfield monitoring perimeter ring is located about 150 feet from the boundary of the wellfield, the horizontal extent of the proposed Permit Area includes all likely Class III ISR wellfield areas and the permit area monitoring well rings will be located approximately 1,000 feet from the wellfields.

BASIS FOR DECISION

REGULATORY CRITERIA UNDER WHICH THE EXEMPTION IS REQUESTED

Regulations in 40 CFR § 146.4(a) require that a request for an AE demonstrate that the aquifer does not currently serve as a source of drinking water.

Regulations in 40 CFR § 146.4(b)(1) require that the portion of the aquifer proposed for the AE (in this case, the portion of the BC Aquifer) cannot now and will not in the future serve as a source of drinking water because of the following characteristics:

> *It is mineral, hydrocarbon, or geothermal energy producing, or can be demonstrated by a permit applicant as part of a permit application for a Class II or III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible. 40 CFR § 146.4(b)(1)*

Regulation 40 CFR § 144.7(c)(1) requires a UIC Class III Permit Application that "necessitates an aquifer exemption under 40 CFR §146.4(b)(1) to furnish the data necessary to demonstrate that the aquifer is expected to be mineral or hydrocarbon producing. Information contained in the mining plan for the proposed project, such as a map and general description of the mining zone, general information on the mineralogy and geochemistry of the mining zone, analysis of the amenability of the mining zone to the proposed mining method, and a timetable of planned development of the mining zone" shall be considered by the UIC Director.

These regulatory requirements are addressed in the subsequent subsections of this document.

ASSESSMENT OF THE BC AQUIFER AS A SOURCE OF DRINKING WATER

A Portion of the BC Aquifer Is Not an Underground Source of Drinking Water (USDW)

UIC regulations in 40 CFR § 144.3 define an underground source of drinking water (USDW) as an aquifer or its portion:

(a) (1) Which supplies any public water system; or

    (2) Which contains a sufficient quantity of groundwater to supply a public water system; and

        (i) Currently supplies drinking water for human consumption; or

        (ii) Contains fewer than 10,000 mg/L total dissolved solids; and

(b) Which is not an exempted aquifer.

The portion of the BC Aquifer requested for use by LVMC does not qualify as a USDW because it does not currently supply any public water system and does not contain a sufficient quantity of water to supply a public water system. The BC Aquifer is a perched water system and is laterally and vertically confined from regional aquifer systems and USDWs. Perched water is of little importance for municipal water supplies (Goetz, 2010). Moreover, the confinement restricts groundwater recharge, and local recharge is limited owing to low rainfall (15.5 inches) and high rates of evaporation (38.8 inches) as summarized in the LVMC Technical Report, 2020 (LVMC, 2020: Appendix J). Groundwater age data presented in the LVMC Technical Report (LVMC, 2020: Table 3.4 and Appendix C) shows that the BC Aquifer groundwater has an average residence time between 3,300 and 11,000 years despite being exposed at the ground surface in some parts of the LLV. The long residence times indicate that the rate of recharge to the BC Aquifer is very low. Using a conservative (i.e. with respect to higher recharge estimates) residence time of 5,000 years, the rate of recharge can be calculated using the equation:

Recharge = Volume / Residence Time

Using a continuous BC Aquifer volume beneath the proposed Permit Area based on an average area of 220 million square feet (5,000 acres), an average saturated thickness of 370 feet, and a porosity of 25 percent, the calculated rate of BC Aquifer groundwater recharge is approximately 58 gpm. However, approximately half of the BC Aquifer area is either unsaturated or partially saturated (see Figure 5) because the entire BC Aquifer thickness is only fully saturated below an elevation of 6,200 feet amsl (LVMC, 2020: Appendix D). Hence, if it is assumed that half of the aquifer is only half saturated, then the average rate of BC Aquifer recharge is only about 43.5 gpm. The regional BC Aquifer recharge in southeastern Utah is estimated to be about 24,200 gpm (Avery, 1986), which means that the proportional amount of BC Aquifer recharge in LLV is only about 0.2 percent of the total.

The estimated rate of recharge within the BC Aquifer in the LLV (43.5 gpm) is about three times greater than the minimum criteria for a public water system (approximately 15 gpm). However, it is likely that the present rate of groundwater recharge in the LLV is much lower than it was in the Pleistocene. The oldest age of BC Aquifer groundwater is approximately 11,000 years. This was determined by C^{14} age dating (LVMC, 2020: Appendix C). Approximately 11,000 years ago, at the end of the Pleistocene and during the last period of alpine glaciation, the climate was much cooler and wetter than it is today. The Pleistocene climate would have resulted in greater rates of infiltration and groundwater recharge. Hence, the present-day rate of recharge is likely much lower than the average recharge calculated on the basis of the past 11,000 years.

Tritium concentration in BC Aquifer groundwater samples is near or below the method detection limit (LVMC, 2020: Appendix C). Very low levels of tritium indicate little or no modern recharge, which is consistent with the semi-arid climate of southeastern Utah. In addition, given the groundwater withdrawals from the BC Aquifer by LVMC, local ranchers, and future mining operations, the actual amount of groundwater in the BC Aquifer available for sustainable supply to public water systems in the future is limited.

The BC Aquifer does not serve as a regional source of drinking water because of its separation from the regional system by the LLV graben. Section 4.1 of the LVMC Technical Report (LVMC, 2020: 92) documents that the boundary of the Permit Area/AE Area is 14 miles from the nearest public drinking water well.

Moreover, because most of the land is government owned, it is unlikely that the population in the area can increase to a size that would require a centralized public water system. In addition, owing to the low rate of recharge, high rate of mining use, and partial saturation (perched water), it is unlikely that the remaining BC Aquifer groundwater within the AE boundary can or will be used in the future to supply drinking water.

Private and Public Wells Within the Permit Area / Aquifer Exemption Boundary

The boundary of an aquifer exemption contains the portion of the aquifer that may be affected by the injection activity (EPA, 2019). Figure 2 shows that no domestic drinking water wells inside the Permit Area / AE boundary are currently in use. Two abandoned wells are within the Permit Area:

- The very shallow Patterson 05-296 livestock watering well (total depth of 60 feet) is recorded as a dry hole that is out of use. It is in the alluvial wash of an arroyo, not the BC Aquifer. The Patterson well draws from an isolated, perched water source within Quaternary alluvium. That source is not considered an active aquifer because it has limited water availability and is only recharged by infrequent precipitation (LVMC, 2020: Appendix J).

- The Wilcox domestic well 05-2589 that draws from the BC Aquifer is recorded as abandoned.

The technical analysis demonstrated that water within the Permit Area / AE boundary is not a current source of drinking water for any existing wells. Within the Permit Area no domestic or livestock watering wells draw from the N Aquifer because of how deep the aquifer is within the Permit Area.

Private and Public Wells Outside the Permit Area / Aquifer Exemption Boundary

When considering the capture zone for a well, it is possible that water within the Permit Area / AE boundary could serve as a current source of drinking water for wells outside the Permit Area / AE boundary. To identify any such instances, the Director looked for wells within the AOR , which extends 2 miles beyond the Permit Area / AE boundary per UAC R317-7-1.1B and R317-7-1.2B. The AOR area is greater than the minimum 0.25-mile buffer zone from the Permit Area boundary discussed in EPA

Guidance #34 (EPA, 2000). A complete inventory of wells within the AOR is included in Part C of the LVMC Technical Report (LVMC, 2020: Part C).

Figure 2, Figure 6, and Figure 7 show the locations of the two domestic drinking water wells located within the AOR but outside the Permit Area that are being used, or have been used, for drinking water:

- The Wilcox well 05-3907 is relatively shallow (151 feet) and extends only into the Dakota Formation, which is the uppermost part of the BC Aquifer (see Figure 2, Figure 4, Figure 6, and Figure 7). This well is located outside of the portion of the BC Aquifer included in the AE request—this AE request does **not** include the Dakota Formation from which the Wilcox well draws its water.

- The Stevenson well 05-2970 is located near the Permit Area / AE boundary on the southeast side of the Lisbon Valley Fault just outside the Permit Area and proposed AE boundary. Well logs show that it draws from the N Aquifer and is upgradient of the Permit Area / AE boundary and is separated from the Permit Area by the Lisbon Valley Fault on the footwall block side (see Figure 2, Figure 4, Figure 6, and Figure 7).

Well records are provided by the Utah Department of Natural Resources, Division of Water Rights (https://waterrights.utah.gov/wrinfo/query.asp).

Water for the City of Monticello, which is approximately 20 miles southwest of the Permit Area / AE boundary (see Figure 1), is supplied from municipal wells drawing from the N Aquifer. Furthermore, the city's water supply is hydrologically isolated from the LLV by the Lisbon Valley Fault (see Figure 6). The town of La Sal is approximately 13 miles upgradient of the LLV and is also hydrologically isolated from the LLV by the Lone Wolf / Flying Diamond Fault. The town of Egnar is located in the state of Colorado and is cross gradient from the regional groundwater flow system (Avery, 1986) and is similarly hydrologically isolated from the LLV because the BC Aquifer pinches out to the southeast (see Figure 6).

Hydrologists have determined that the occurrences of Dakota, Burro Canyon, and Navajo Formations in the Lisbon Valley down-dropped graben are separate from the regional aquifer system (Avery, 1986) that is used by La Sal, Monticello, and other towns in San Juan County (see Figure 1). Hence, groundwater withdrawals in Lisbon Valley for mining, stock watering, and irrigation will not affect water levels in wells located near La Sal or Monticello.

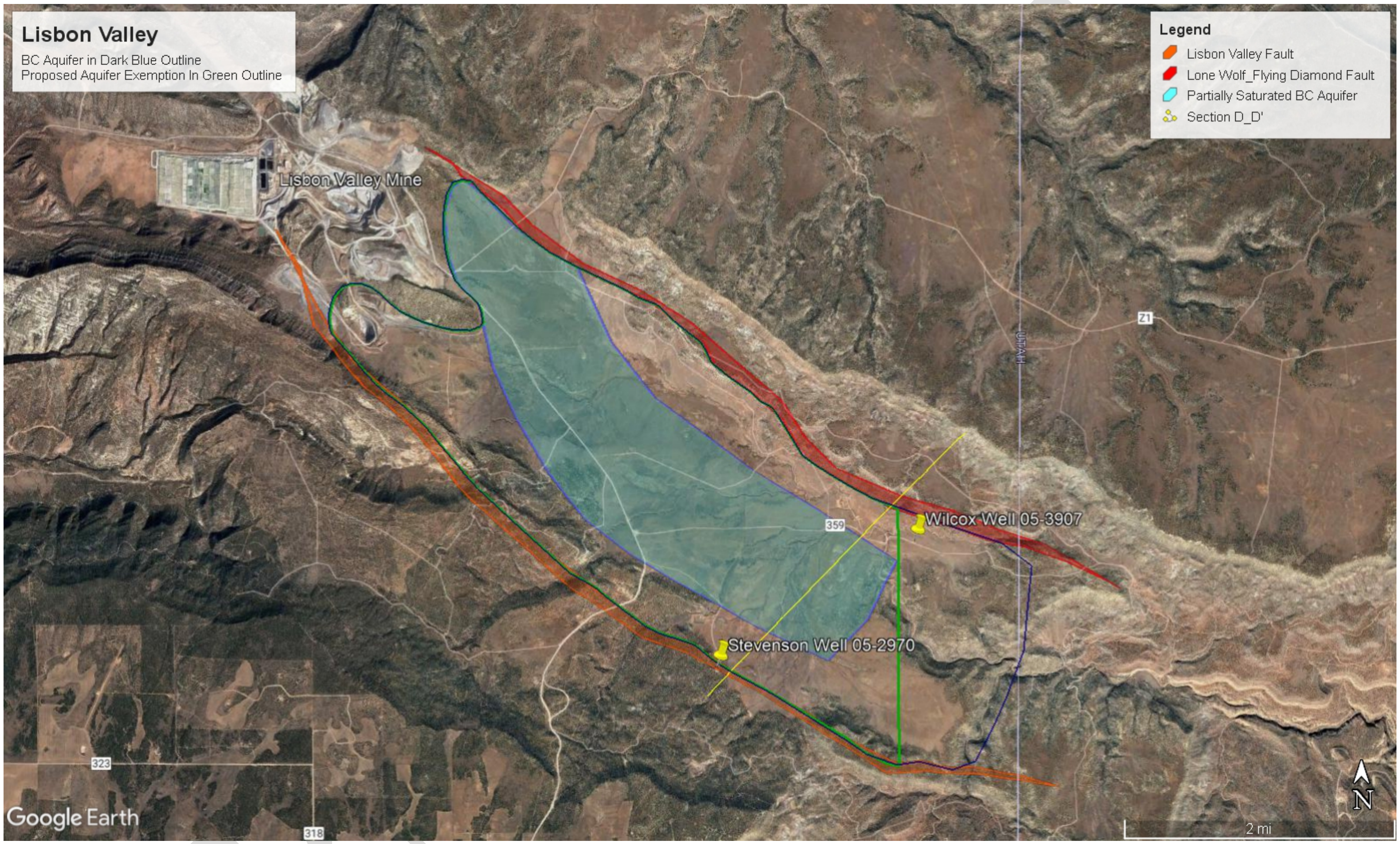

Figure 6. The BC Aquifer, Aquifer Exemption area, hydrologic features of interest in the lower Lisbon Valley, and two wells in the AOR but outside the Permit Area.

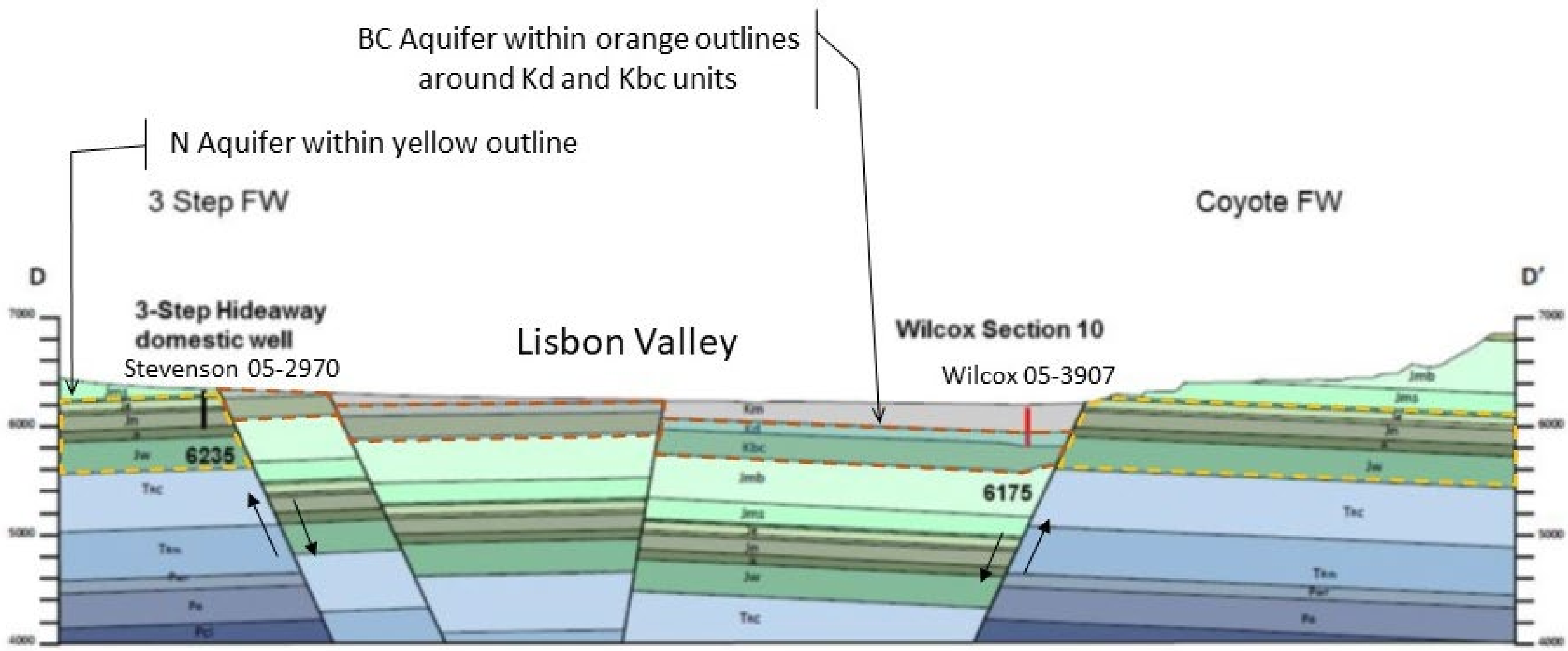

Figure 7. Cross section D–D' (see Figure 6) showing the total depths of the Stevenson well 05-2970 (3-Step Hideaway domestic well) and the Wilcox well 05-3907 (Wilcox Section 10 projected from outside the AE onto D-D') with respect to the lower Lisbon Valley graben faults and footwall blocks (FW). The Stevenson well is outside the Aquifer Exemption boundary. The Wilcox well penetrates the Dakota Formation at the top of the BC Aquifer just outside the Aquifer Exemption boundary on the southeast (see Figure 2 and legend in Figure 5). Adapted from the Lisbon Valley Mining Company Technical Report (LVMC 2020: Figure 3-26).

MINING PLAN

Commercial Producibility

The commercial producibility of acid-soluble copper from the Lower Lisbon Valley Project is demonstrated by (1) current heap leach and SXEW operations, (2) the long period of copper exploration and mine development in the area, and (3) the fact that the BC Aquifer host rock formation supports the commercial potential for copper ISR. The LVMC Technical Report (LVMC, 2020) discloses the existence of abandoned uranium mines in the AOR, and exploration for and production of uranium has occurred throughout Lisbon Valley for several decades (Chenoweth, 2006). In addition, oil and natural gas wells tap resources in the Paradox Formation in Lisbon Valley. Exploration for lithium brines is also occurring in Lisbon Valley. Hence, Lisbon Valley is a well-known mineral district for copper and other mineral resources that could be produced by drilling and well production operations that may require UIC permits.

LVMC is a private mining company and not subject to public financial and technical feasibility disclosure requirements like National Instrument 43-101. The commercial producibility of the Project is demonstrated by the extensive exploration and academic research on the Lisbon Valley Mineral District (Weir and Puffett, 1981; Hitzman et al., 2005; Hahn and Thorson, 2006; and Person et al., 2019) that has been conducted recently. These studies indicate the technical and economic feasibility of copper recovery by ISR methods within the Permit Area. The combined exploration database indicates that the existing copper resources total approximately 800 million pounds of copper suitable for ISR contained in three deposits along the northwest-to-southeast-trending Lisbon Valley mineral district (Krahulec, 2006) within the Permit Area. Additional exploration by LVMC has indicated commercial copper resource potential and is documented in information submitted with the LVMC Technical Report (LVMC, 2020: Appendix D). In addition, LVMC currently operates an SXEW plant that will be used for copper cathode production by processing of ISR pregnant leach solutions. Hence the investment risk in an ISR wellfield is very low as capital expenditures for plant construction costs are low but some plant upgrades and modifications may be necessary in the future.

Demonstration of Amenability of Mining Method

Two commercial copper ISR projects have been approved by the EPA for AEs and are operating in Arizona: the Florence (EPA, 2016) and Gunnison (EPA, 2018) copper projects. Both of these operations are UIC facilities permitted by EPA Region 9. The Dewy-Burdock uranium ISR project in South Dakota is located within the Inyan Kara aquifers, which are similar to the BC Aquifer in that the Morrison Formation is the bottom confining unit within that project area (EPA, 2020).

The lixiviant will consist of groundwater pumped from the production zone and fortified with dilute sulfuric acid and oxygen. The effectiveness of this type of lixiviant is demonstrated by leach amenability studies conducted on core samples collected within the Project Area using standard industry column testing as well as pressurized vessel testing that have demonstrated commercial copper recovery. All test work has been performed by the Company in its laboratory, and additional confirmatory third-party laboratory test work is planned. LVMC has extensive experience leaching target mineralogy in its existing open-pit heap-leach operations, which have been in operation since 2006, and which use comparable leaching metallurgy and chemistry. Furthermore, the necessary processing plant and infrastructure is already owned and operated by the Company.

Hydraulic properties of the BC Aquifer have been determined through pumping tests as described in Sections 7.2 and 7.3 of the LVMC Technical Report (LVMC, 2020: 101–105). The measurement of water levels in observation wells completed in the pumped aquifers confirmed that during all three pump tests a cone of depression formed in the pumped aquifer (LVMC, 2020: Appendix D). The development of a cone of depression verifies that hydraulic control of injection fluids (i.e., lixiviant) can be maintained within the BC Aquifer. Table D in the Groundwater Assessment section of Appendix D of the Technical Report summarizes the best estimates of hydraulic conductivity determined from these tests (LVMC, 2020: Appendix D). The average hydraulic conductivity of the BC Aquifer is approximately 2.6×10^{-4} cm/second. This hydraulic conductivity is within the range for fine or silty sandstone and the minimum hydraulic conductivity necessary for ISR without matrix modification (Bartlett, 1998). The hydraulic properties of each well will be determined prior to operations as required in the Area Permit, Part III, Section E.2 (DWQ 2020). The aquifers are saturated in the target ore bodies, which are well suited for ISR operations.

Geochemistry and Mineralogy of the Mining Zone

The copper deposits are hosted by the clastic sedimentary rocks of the Burro Canyon and Dakota Formation as shown in Figure 5. Copper minerals are finely disseminated within the interstices of the coarse- and medium-grained sandstone units, and less common occurrences are in lenses and nodules along fractures, are around organic matter, or replace calcareous nodules or concretions, primarily within sandstone units. Extensive calcite-bearing layers have been mapped in the BC Aquifer exposures in mine pit walls at the LVMC open pit cuts (Barton et al., 2021), which may increase acid consumption, which is negative for ISR economics but positive for leach solution containment and neutralization of residual leach solution during groundwater restoration. The fine dissemination of copper mineralization in the host sandstone is ideal for ISR, which utilizes the sandstone's permeability to access fine copper mineralization with lixiviant for recovery.

The copper deposits are divided into oxide and sulfide mineralogical zones:

- Oxide/Sulfide Interface—The oxide/sulfide interface is approximately 0–250 feet below the surface, although it varies according to lithology and permeability of the individual host beds. Oxide minerals primarily include malachite, azurite, tenorite, cuprite, and other unidentified oxidized copper minerals.

- Sulfide Zone—The sulfide zone consists mainly of chalcocite or djurleite, with minor amounts of bornite and chalcopyrite on the fringes of the deposits. Chalcocite is fine-grained and "sooty" near the oxide/sulfide interface, where it might be secondary (supergene) in origin. Chalcocite disseminated in the BC Formation at depths greater than 250 feet is crystalline and steely and is primary (hypogene) in origin. Native copper is found only rarely at the oxide/sulfide interface at depth and is secondary in origin.

Copper sulfide minerals may have precipitated by reduction reactions owing to natural organic material in the ore deposit. The oxide mineralization was likely created by fluctuation of the water table and unsaturated conditions at the top of the ore zone and oxidation of primary copper sulfide minerals.

Project Timetable

The proposed timetable for project development is shown in Figure 8. LVMC anticipates that the LLV copper ore deposits will be commercially produced by ISR for approximately 20 years.

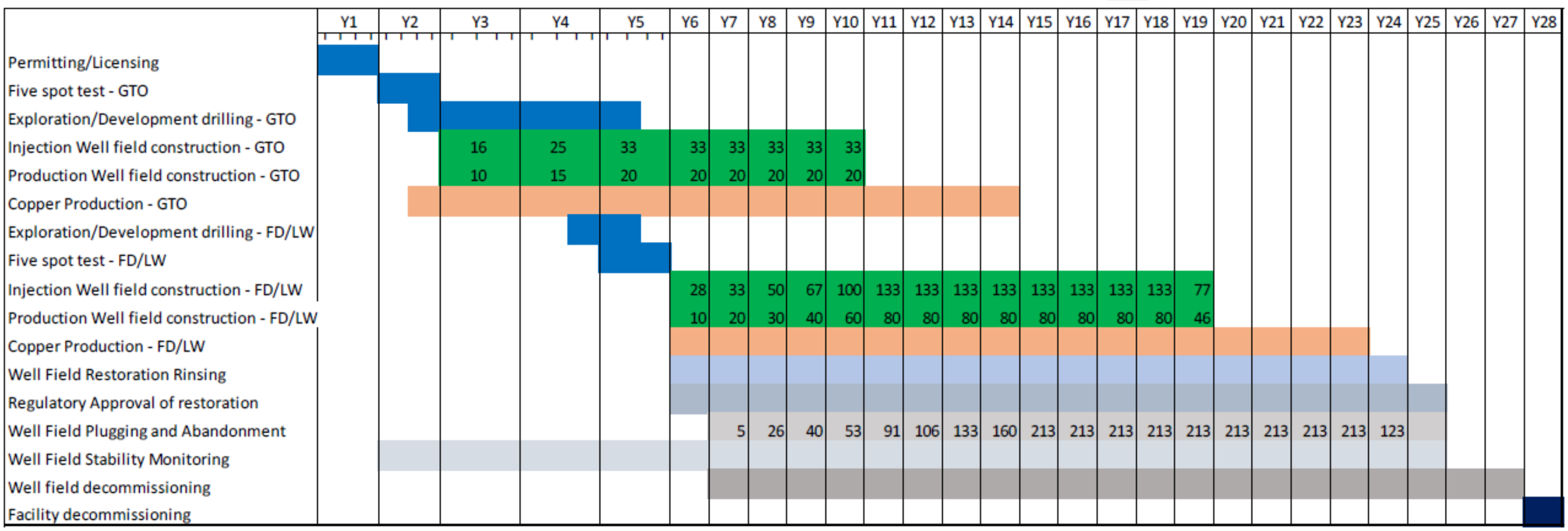

Figure 8. Lisbon Valley Mining Company's timetable for project development.
Reproduced from Figure 11.8 of the Lisbon Valley Mining Company Technical Report (LVMC, 2020: 141).

OTHER CONSIDERATIONS

NATURAL ATTENUATION

While not discussed in LVMC's Technical Report, natural attenuation will provide additional confinement of leach solutions in the ISR wellfield. The ore and formation contain natural carbonate mineralization and organic matter that will reverse the leaching reaction and neutralize leach solutions at the boundary of the wellfield(s) according to the generalized reaction:

$$\mathbf{2Cu^{2+} + Fe^{2+} + 3SO_4^{2-} + H_2SO_4 + CaCO_3 + CH_2O = Cu_2S + FeS_2 + CaSO_4 \cdot (2H_2O) + 2CO_2 + 5O_2}$$

The presence of abundant calcite (calcium carbonate) in the BC Aquifer host formations is described in the LVMC Technical Report (LVMC, 2020) and in Barton et al. (2021).

DEMONSTRATION THAT THE INJECTION ZONE FLUIDS WILL REMAIN WITHIN THE AQUIFER EXEMPTION AREA

EPA Guidance #34 states that if the exemption pertains to only a portion of an aquifer, a demonstration must be made that the waste will remain in the exempted portion (EPA, 2000). Such a demonstration should consider, among other factors, the pressure in the injection zone, the waste volume, and injected waste characteristics (i.e., specific gravity, persistence, etc.) throughout the life of the facility. Given the nature of the ISR operation, waste fluids are not being injected into the exempted portion of the aquifer. The concern in the case of the ISR operation is whether contaminants from ISR activities will cross the AE boundary laterally or migrate vertically into USDWs. A number of factors, including Class III Area Permit requirements, led the Director to the conclusion that adjacent USDWs will not be impacted by ISR contaminants crossing the AE boundary laterally or migrating vertically.

The Class III Area Permit includes the following requirements:

- Injection interval confining zones will be evaluated during pre-ISR operation wellfield pump tests for their capacity to contain injection interval fluid vertically within the approved injection interval per Permit conditions in Part III, Section E, and cited attachments (DWQ, 2020).

- LVMC must demonstrate the ability of the confining zones to contain injection interval fluids before the Director will issue an authorization to commence injection per Permit conditions in Part III, Section E, and cited attachments (DWQ, 2020).

- LVMC must demonstrate the ability of the monitoring network to detect any movement of injection interval fluids out of the approved injection interval before the Director will issue an authorization to commence injection per Permit conditions in Part III, Section G, and cited attachments (DWQ, 2020).

- Hydraulic control of the wellfield must be maintained by ensuring that the volume of lixiviant injected into the periphery of the wellfield is less than the amount of groundwater and lixiviant that is withdrawn from the production wells. Hydraulic control will be verified by continuous monitoring of injection rate and volume and the measurement of water levels in the wellfield perimeter monitoring well ring to verify a cone of depression per Permit conditions in Part III, Sections F and G, and cited attachments (DWQ, 2020). This is also consistent with Arizona Mining—BADCT Guidance for copper ISR (ADEQ, 2004).

- The extensive monitoring well network will verify both lateral and vertical containment of injection interval fluids. If any injection interval fluids begin to migrate out of the approved injection interval, the water level measurements in the monitoring well network will provide early detection to allow LVMC to implement timely corrective response actions to reverse the migration per Permit conditions in Part III, Sections C, G, and H, and cited attachments (DWQ, 2020).

- The requirements to demonstrate initial mechanical integrity for all injection, production, and monitoring wells and ongoing mechanical integrity tests for injection wells will prevent vertical migration of injection interval fluids through confining zones per Permit conditions in Part III, Sections G and I, and cited attachments (DWQ, 2020).

- Part III, Sections E, G, and J (and cited attachments), of the Permit requires LVMC to develop a groundwater restoration plan for each wellfield that includes monitoring to evaluate the long-term stability of restored ISR contaminant concentrations to ensure that no ISR contaminants cross the AE boundary (DWQ, 2020).

Vertical Confinement

Throughout most of the ore zones in the LLV, the BC Aquifer is bounded above by shale units of the Mancos Shale, which serve as the uppermost confining zone for ISR operations. However, the Mancos Shale pinches out in the center of the LLV owing to block faulting and erosion within the Lisbon Valley graben (see Table 2). Well drilling records and a shallow downward gradient within the BC Aquifer indicate that the BC Aquifer is perched water on top of the Morrison Formation. The hydraulic conductivity of the Morrison Formation Brushy Basin Member reported in the LVMC Technical Report (LVMC 2020, Section 3.8.2, p. 61) is 1.27×10^{-8} to 5×10^{-9} cm/second. The 400-foot thickness of the Morrison Formation and the unsaturated conditions below the perched BC Aquifer result in a high degree of confinement. Fracture flow under unsaturated conditions is also low.

Distinct water chemistries for the BC and N Aquifer groundwaters presented in the LVMC Technical Report (LVMC, 2020: Appendix C) indicate that minimal communication is occurring between the BC and N Aquifers. Major ion chemistry indicates that the BC and N Aquifers have distinct geochemical signatures. Groundwater in the BC Aquifer is a Ca-Mg-SO_4-type water, and N Aquifer wells generally plot as an Na-HCO_3-type water. In addition, BC Aquifer wells, on average, had higher concentrations of ore-forming trace and base metal elements, such as cobalt, copper, iron, manganese, and uranium, than the N Aquifer wells.

Other chemical lines of evidence presented int the LVMC Technical Report (LVMC, 2020: Appendix C) include isotopic analyses, such as stable isotopes of water ($\delta^{18}O$ and δD), stable isotopes of dissolved carbon and sulfur ($\delta^{13}C$-DIC, $\delta^{34}S$-SO_4, and $\delta^{18}O$-SO_4), and $^{87}Sr/^{86}Sr$ ratios. All such evidence indicates that the BC and N Aquifers have distinct water compositions. Based on radiogenic carbon analysis, the water in the BC Aquifer has an age range of 3,300 to 11,000 years BP, while the water in the N Aquifer has an age range of 15,000 to 36,000 years BP (LVMC, 2020: Appendix C, Table 5). This also indicates a lack of connection between the BC and N Aquifers.

The depth to the top of the BC Aquifer (the Dakota Formation or Burro Canyon Formation, depending on erosion) ranges from approximately 0 feet where the Dakota and Burro Canyon Formations crop out in the central and southeastern part of the LLV to approximately 500 feet below the ground surface near the bounding faults of the LLV graben where the Mancos Formation occurs as a confining layer on top of the BC Aquifer. The Mancos Shale is considered a barrier to recharge wherever it is present. Based on various down-well methods (e.g., packer tests, bailer recovery tests, etc.) conducted around the region, hydraulic conductivity of the BC Aquifer ranges from 1.59×10^{-7} to 2.72×10^{-6} cm/second (LVMC, 2020: Appendix C). The saturated hydraulic conductivity of the Dakota Sandstone and Burro Canyon Formations ranges from 10^{-2} to 10^{-4} cm/second.

The Morrison Formation Brushy Basin Member is composed of gray and red-brown bentonitic mudstone. It is a regional confining unit with vertical saturated hydraulic conductivities ranging from about 1×10^{-8} to 5×10^{-9} cm/second (LVMC, 2020: Section 3.8.2, p. 61). However, the unsaturated hydraulic conductivity is lower, depending upon moisture content. The Brushy Basin member is approximately 400 feet thick in the Permit Area. It separates the BC and N Aquifers vertically by approximately 600 feet and creates a BC to N Aquifer head contrast ranging from 500 to 650 feet. The vertical head contrast is shown on Figures 3-26 and 3-27 of the Lisbon Valley Technical Report (LVMC, 2020: 67, 69), underscoring the robust perching characteristics of the Morrison Formation.

Part III, Sections B and E, of the Permit requires investigation of the confining zone for each wellfield through formation testing and reporting before the Director will authorize any injection activities. If a confining zone breach is caused by an improperly plugged historic exploratory borehole or a well causes a pathway through a confining zone, the Permit requires LVMC to take corrective action (see DWQ 2020: Part III.C and Attachment C) to prevent the breach from resulting in the vertical migration of injection interval fluids out of the injection interval. Exploration records from the Utah Department of Natural Resources, Division of Oil Gas and Mining, indicate that most of the exploration activity has occurred in the BC Aquifer zones, but some limited deeper drilling has likely occurred outside the bounding faults of the LLV graben where uranium mineralization is present in the Chinle Formation below the N Aquifer (see Figure 4). Hence, these boreholes into the Three-Step footwall block (see Figures 6 and 7) are separated from the AE volume and BC Aquifer by low hydraulic conductivity fault gouge. In addition, hydraulic head is higher on the footwall block side such that any groundwater seepage through the fault would flow towards Lisbon Valley and not towards the N Aquifer.

To verify that no wellfield fluids migrate vertically out of the approved injection interval, monitoring wells will be completed within each wellfield in the overlying and underlying hydrogeologic units above and below the ISR injection interval. Hydraulic control will be verified by continuous monitoring of injection rate and volume and the measurement of water levels in the wellfield perimeter monitoring well ring (see Figure 3). Furthermore, the Permit and AE will require LVMC to verify containment per Permit conditions in Part III, Sections F and G, and cited attachments (DWQ, 2020). Even though the Morrison Formation is a thick and impermeable confining zone, the Permit requires monitoring of the aquifer underlying the Morrison Formation during wellfield operation and restoration. In addition, the Permit requires observation wells below the Morrison Formation in the N Aquifer to be monitored to verify the containment of the Morrison Formation as a confining zone in the AE volume. These wells will be monitored during wellfield operation, after ISR groundwater restoration, and after restoration monitoring to detect any potential vertical migration of ISR solutions out of the approved injection interval. The Director may require additional overlying or underlying monitoring wells beyond the network shown in Figure 2 to detect potential vertical excursions in areas where the integrity of a confining zone is in question. If any injection interval fluids begin to migrate out of the approved injection interval, the water level measurements in the monitoring well network will provide early detection to allow LVMC to implement timely corrective response actions to reverse the migration per Permit conditions in Part III, Sections C, G, and H, and cited attachments (DWQ, 2020). The Permit requires LVMC to demonstrate mechanical integrity for all wells installed, including injection, production, and monitoring wells, to ensure that the cement-filled annulus between the well casing and drillhole wall does not contain any channels that could potentially allow migration of injection interval fluids out of the injection interval through confining zones.

Lateral Confinement

The portion of the BC Aquifer included in this AE is bounded by the Lone Wolf/Flying Diamond Fault and extensions on the northeast and the Lisbon Valley Fault and extensions on the southwest that formed the LLV graben. Fault gouge analyses conducted under Dr. Krantz at the University of Arizona are summarized in the LVMC Technical Report (LVMC, 2020). These analyses concluded that the bounding graben faults have very low hydraulic conductivity and laterally confine the BC Aquifer in the Permit Area. It is noted that copper mineralization is also limited within the Permit Area by these faults, which may have formed a structural trap for the mineralized fluids that formed the deposit (Krahulec, 2006).

In addition, cross sections A through E from the LVMC Technical Report (LVMC, 2020: Figures 3.16–3.20) show the BC Aquifer is discontinuous and segmented and confinement of perched water is local. Hence, the BC Aquifer in the AE volume is likely discontinuous. As summarized in the LVMC Technical Report, previous work completed at LVMC indicates that lateral flow in the BC Aquifer is influenced by geologic structures (i.e., faults; LVMC, 2020: Figures 3.24), which prevent flow and compartmentalize the BC Aquifer into many disconnected blocks. These blocks will be managed individually or as wellfield segments. In addition, the Permit requires LVMC to demonstrate and maintain hydraulic control of injection fluids during the copper recovery process and post-ISR groundwater restoration. To accomplish this, the wellfield pumping rate in the perimeter pumping wells must exceed the injection rate and result in a net extraction of injection interval fluids and groundwater that flows towards the wellfield (DWQ 2020: Part III, Section F). Continuous monitoring of injection and production flow rates and volume is required for each wellfield to verify that these conditions are being met (DWQ, 2020: Part III, Section G).

The net extraction of injection interval fluids and groundwater creates a cone of depression within each wellfield indicating that an inward hydraulic gradient is pulling groundwater into the wellfield. The measurement of water levels in observation wells during the pump tests performed by LVMC demonstrate that a cone of depression formed in the pumped aquifer during the pump tests (LVMC, 2020: Appendix D). The presence of a cone of depression verifies that hydraulic control of injection interval fluids can be maintained within the BC Aquifer. The required monitoring of water levels in the wellfield perimeter monitoring well ring will verify whether the cone of depression is being maintained during wellfield operations and post-ISR groundwater restoration (DWQ, 2020: Part III, Section G).

Monitoring Requirements

A combination of monitoring and response actions required during the operational, the post-ISR groundwater restoration, and the post-restoration phases will ensure that any effects from the ISR operations will remain within the exempted portion of the aquifer. Monitoring wells will be installed in and around each wellfield, up- and down-gradient, and in overlying and underlying aquifers to detect the potential migration of ISR solutions away from the approved injection interval.

The Permit operating conditions in Part III, Section F, and Attachment E, require LVMC to maintain hydraulic control of injection interval fluids within each wellfield at all times to prevent horizontal movement of lixiviant out of the wellfield and include a rigorous monitoring program to verify hydraulic control (DWQ, 2020: Part III, Section G, and Attachment F).

Baseline water quality parameters for the BC and N Aquifers are stated in Table 3. Analytical results of groundwater samples collected from the overlying and underlying monitoring wells required in the Permit may provide additional baseline water quality data from which the compliance limits for the overlying and underlying aquifers may be revised if new data indicates that the baseline concentrations in Table 3 are statistically different with the acquisition of additional data (DWQ, 2020; Part II Section D.6.a.1.ii).

Table 3. BC and N Aquifer Baseline Water Quality (mean values from Table 12.4 of LVMC, 2020)

Major Ions and Water Quality Indicator Parameters	Units	BC Aquifer, Mean	N Aquifer, Mean
Alkalinity dissolved, as CaCO3 equivalents	milligrams per liter	144	259
Alkalinity, as CaCO3 equivalents	milligrams per liter	282.6	265.3
Bicarbonate, as CaCO3 equivalents	milligrams per liter	279	261
Carbonate, as CaCO3 equivalents	milligrams per liter	5	3
Hydroxide, as CaCO3 equivalents	milligrams per liter	3	2
Hardness	milligrams per liter	433	219
Calcium	milligrams per liter	103	53.3
Magnesium	milligrams per liter	42.4	20.6
Potassium	milligrams per liter	9.5	7.2
Sodium	milligrams per liter	146	121
Chloride	milligrams per liter	23	64
Fluoride	milligrams per liter	0.5	0.6
Silica	milligrams per liter	10.9	14.4
Sulfate	milligrams per liter	463	150
Sodium Absorption Ratio	percent	1.70	3.66
Total Dissloved Solids	milligrams per liter	986	605
Total Suspended Solids	milligrams per liter	832	509
pH		7.8	7.8
Electrical Conductivity	micro seimens per centimeter	1358	951
Nutrients			
Phosphorous total, as P equivalents	milligrams per liter	0.03	0.33
Nitrate dissolved, as N equivalents	milligrams per liter	0.16	0.07
Nitrite dissolved, as N equivalents	milligrams per liter	0.01	0.01
Ammonium	milligrams per liter	0.24	0.15
Dissolved Metals			
Aluminum	milligrams per liter	0.06	0.05
Antimony	milligrams per liter	0.0014	0.0024
Arsenic	milligrams per liter	0.0035	0.0091
Barium	milligrams per liter	0.034	0.151
Beryllium	milligrams per liter	0.0004	0.0004
Cadmium	milligrams per liter	0.0076	0.0005
Chromium	milligrams per liter	0.0015	0.0046
Copper	milligrams per liter	0.01	0.01
Iron	milligrams per liter	1.37	0.85
Lead	milligrams per liter	0.0019	0.0018
Manganese	milligrams per liter	0.153	0.349
Mercury	milligrams per liter	0.0002	0.0002
Molybdenum	milligrams per liter	0.04	0.08
Nickel	milligrams per liter	0.01	0.44
Selenium	milligrams per liter	0.002	0.002
Silver	milligrams per liter	0.01772	0.01191
Strontium	milligrams per liter	3.13	2.93
Thallium	milligrams per liter	0.0005	0.0006
Uranium,	milligrams per liter	0.0395	0.0113
Vanadium	milligrams per liter	0.007	0.007
Zinc	milligrams per liter	0.15	0.50
Radiological			
Gross Alpha total	picocuries per liter	73	24
Gross Beta total	picocuries per liter	63	34
Radium 226 total	picocuries per liter	7	1
Radium 228 total	picocuries per liter	3	2
Thorium 228 total	picocuries per liter	1	0
Thorium 230 total	picocuries per liter	3	1
Throrium 232 total	picocuries per liter	1	0

DECISION

LVMC provided mineral exploration information to the Director to support the conclusion that the proposed Permit Area / AE Area within the BC Aquifer cannot now and will not in the future serve as a source of drinking water. Furthermore, the dominance of Federal land ownership in the LLV and the combined legal, technical, and economic challenges to the development of wells capable of producing enough water to sustainably supply public water systems from the proposed AE volume support the Director's determination that the BC Aquifer is not a USDW.

The Director reviewed the information provided by LVMC and has concluded that the portion of the BC Aquifer proposed for exemption does not currently serve as a source of drinking water. Based on the information reviewed, the Director has determined that the following regulatory criterion has been met:

> ***40 CFR § 146.4(a)*** *It does not currently serve as a source of drinking water.*

LVMC demonstrated in the Class III permit application for the copper ISR operation that the portion of the aquifer proposed for exemption contains minerals in a quantity and location that is expected to be commercially producible.

The portion of the BC Aquifer proposed for the AE cannot now and will not in the future serve as a source of drinking water because of the following characteristics:

> ***40 CFR § 146.4(b)(1)*** *It is mineral, hydrocarbon, or geothermal energy producing, or can be demonstrated by a permit applicant as part of a permit application for a Class II or III operation to contain minerals or hydrocarbons that considering their quantity and location are expected to be commercially producible.*

The Director's findings indicate that this portion of the BC Aquifer may be exempted as a source of underground drinking water based on UAC R317-7-4 and following the procedures and requirements outlined in 40 CFR § 144.7 and 40 CFR § 146.4. The exemption is subject to approval by the EPA UIC Program Administrator following public notice and comment per 40 CFR § 144.7(b)(3).

CONCLUSION

The Director requests this exemption pursuant to Aquifer Exemption criteria in 40 CFR § 144.7 and 40 CFR § 146.4 and based on strong evidence for natural containment as well as operational containment systems required in the Permit (DWQ, 2020). Based on review of the information LVMC provided, the Director finds that exemption criteria in 40 CFR § 146.4(a) and § 146.4(b)(1) have been met. Therefore, the Director is seeking EPA approval of the AE request as a minor/non-substantial program revision for the AE area and volume depicted in Figure 2.

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Erica Brown Gaddis, Ph.D. Date
Director, Water Quality Division

DWQ-2021-030502

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