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Centennial Pit Backfilling Mine Plan Modification for the Lisbon Valley Copper Mine, San Juan County, Utah

Location: Sections 25, 36, T. 30 S, R. 25 E

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1 PURPOSE AND NEED

1.1 Introduction

This Environmental Assessment (EA) has been prepared to disclose and analyze the environmental consequences of an operator-requested proposed mine plan modification to allow the backfilling of a pit at the operator's copper mine located in the Lisbon Valley area in San Juan County, Utah. The operator, Lisbon Valley Mining Company LLC (LVMC), proposes to backfill the Penny Pit and Keystone Pit areas of the Centennial Pit with a best-engineering estimate in the range of up to 75 M tons. Due to the opportunistic nature of backfilling, an exact estimate is difficult to constrain, but LVMC commits to backfilling any final pit to an elevation 10 feet above the pre-mine groundwater elevation.

The EA is a site-specific analysis of potential impacts that could result with the implementation of a proposed action or alternatives to the proposed action. The EA assists the BLM in project planning and ensuring compliance with the National Environmental Policy Act (NEPA), and in making a determination as to whether any "significant" impacts could result from the analyzed actions. "Significance" is defined by NEPA and is found in regulation 40 CFR 1508.27. An EA provides evidence for determining whether to prepare an Environmental Impact Statement (EIS) or a statement of "Finding of No Significant Impact" (FONSI). If the decision maker determines that this project has "significant" impacts following the analysis in the EA, then an EIS would be prepared for the project. If the agency decision-maker determines that the selected alternative would result in a FONSI, a Decision Record (DR) may be signed for the EA approving the selected alternative, whether the proposed action or another alternative. A DR, including a FONSI statement, documents the reasons why implementation of the selected alternative would not result in "significant" environmental impacts (effects) beyond those already addressed in Moab Resource Management Plan (October, 31, 2008).

1.2 Background

The Lisbon Valley Copper Mine is located about 15 miles south of La Sal, Utah in a geographic area called Lisbon Valley (Map 1, Appendix D). The mine was authorized through analysis of a final environmental impact statement (EIS) in 1997, a Record of Decision in 1998, and began operations under the approved mine plan in 2005. The mining operation was authorized to disturb up to 1,104 acres. LVMC proposes a modification to its existing mine plan where characterized waste rock would be used for backfill in the Centennial Pit. The characterization process is designed to determine the acid-forming potential of the waste rock, followed by additional simulations of an updated groundwater model to determine fate and transport of dissolved constituents. Only waste rock with the least potential to form acidic leachate would be authorized to be placed as backfill in the Centennial Pit.

The Lisbon Valley Copper Mine has been operating under an approved mine plan since May 2005. The environmental effects of the copper mine were initially analyzed in a final environmental impact statement (FEIS) titled "*Final Environmental Impact Statement Lisbon Valley Copper Project*," and dated February 1997. Four alternatives to the proposed action were analyzed in the FEIS: the No Action Alternative, the Open Pit Backfilling Alternative, the Facility Layout Alternative, and the Waste Rock Selective Handling Alternative. The Record of Decision for this EIS was signed on March 26, 1997, selecting the Waste Rock Selective Handling Alternative. Because the current proposed action concerns backfilling and relies on data an analysis contained in the 1997 EIS, a summary of the open-pit backfilling alternative evaluated in the 1997 EIS is presented as Table A-1 of Appendix A.

The 1997 decision was appealed to the Interior Board of Land Appeals (IBLA) (National Wildlife Federation et al., 1998) and in February 1999 the BLM published a Notice of Final Decision[1]. All decisions made in the Record of Decision (ROD) for the EIS remain in effect for this proposal.

The 1998 IBLA appeal raised several issues. Principally germane to the present environmental assessment is the assertion of the appellants that the BLM failed to consider the alternative of backfilling the pits with only non-acid-generating rock. The appellants further cite information contained in the ROD which highlight benefits of backfilling the pits, such as improved visual resources, an additional 231 acres returned to post-mining uses for wildlife and livestock, and enhanced public safety, and state that, despite those benefits, BLM rejected backfilling principally because of the threat of acid run off. The appellants assert that this is a viable option because the mine operator would be required by the BLM to separate out acid-generating rock from the non-acid-generating rock.

In response, BLM responded that the FEIS did consider a partial backfilling option in which the material would most likely come from the nonacid generating waste rock in the waste dumps but that BLM rejected backfilling regardless of whether it was done with non-acid-generating material or a combination of waste rock types. BLM provided five reasons in its ROD for rejecting either partial or complete backfilling. The first of those reasons, which directly speaks to the present proposed action was:

> "There would be water quality impacts from backfilling the pits with material from the waste dumps, due to the chemical makeup of the waste rock backfill material, particularly the acid generating material. With the tremendous increase in surface area exposed in the rubblized backfill material, chemical reactions between this material and groundwater could present a host of unquantifiable adverse impacts to the down-gradient aquifers, resulting from chemical interactions of groundwater and waste rock."

In its 1998 decision (National Wildlife et al. 1998), the Board agreed with the appellants that the record did not support BLM's rejection of the Open Pit Backfilling Alternative in the ROD based

[1] Federal Register Volume 64, No. 25, pp. 6112-6113[2]
http://www.blm.gov/ut/st/en/prog/grazing/utah_guidelines_for.html

on its concern for impacts on water quality from acid generating material. The board's reasoning is summarized as follows:

- The FEIS is inconsistent with BLM's concern with "particularly the acid generating material. Static acid/base accounting (ABA) tests are used as a screening technique to determine whether sample material has the potential to generate or consume acid. The test results also indicate that the majority of the waste rock to be produced from the GTO, Centennial, and Sentinel pits is acid-neutralizing and an analysis indicated that the volume of acid-generating waste rock is less than 10% of the total waste rock to be generated. Therefore, the waste rock and exposed pit wall rock are anticipated to be overall net acid-neutralizing.

- With respect to the FEIS discussion of the environmental impacts on geochemistry of partial or complete backfilling. The overall impacts of partial or complete backfilling are described as positive, although the FEIS does state that regardless of the geochemical characteristics of the backfilled material, its rubblized nature would make it "easier to leach soluble constituents from these materials, especially as water levels fluctuated." However, impacts to hydrology predicted by the results of static testing of waste rock samples indicate that only approximately 10 percent of the waste rock would be capable of producing acidic solutions. Because the remainder of the waste rock has a net acid-neutralizing capacity, it is expected that leaching of aluminum and iron would be minimal.

- The FEIS states further that under alkaline conditions leaching of sulfates and some oxyanions could occur. While BLM's concern regarding impacts from alkaline conditions may be legitimate, those concerns are not so well stated anywhere in the ROD or the FEIS as to serve as the principal basis for complete rejection of the alternative,

Accordingly, IBLA's 1998 appeal decision set aside the ROD to the extent concerning the above and remanded the case to BLM for reconsideration of the backfilling alternative.

The 1998 IBLA decision directed the BLM to conduct an analysis of the available data. The analyses were summarized in a memorandum from the Moab Field Office to the Utah State Director dated January 25th, 1999. This memorandum reiterated the concerns expressed in the FEIS and ROD of potential alkaline conditions in the post-mining pit lake could cause mobilization of metal oxyanions in backfill material and potentially result in contamination of the underlying aquifer.

The 1999 Notice of Final Decision further notes that as reflected in the FEIS and ROD, the BLM retained the authority to further analyze backfilling if the results of required life-of-the-mine waste rock sampling and hydrologic testing reveals additional adverse impacts not foreseen or predicted in the EIS, and/or indicates that the potential impact of metal oxyanion mobilization and transport associated with backfilling is overestimated.

With respect to the foregoing, LVMV's Proposed Action is intended to address the above concerns and provide the results of additional testing as design features of their mine plan revision.

The Federal Land Policy and Management Act of 1976 (FLPMA) and regulations at 43 CFR Subpart 3809 mandate that operations authorized by the mining laws are conducted in a manner that will prevent unnecessary or undue degradation of public lands. Accordingly, the BLM's primary purpose for considering the Proposed Action is to evaluate all operations authorized by the mining laws in the context of its requirement to prevent unnecessary and undue degradation of Federal lands and resources. To accomplish its primary purpose, BLM must ensure that operations meet the performance standards outlined at 43 CFR 3809.420.

LVMC's purpose for the Proposed Action is to realize potential operational benefits, including:

- Reduced haul truck miles, thereby reducing fuel costs and haul truck emissions;
- Increased safety to haul truck operators;
- Reduced dust generation;
- Reduced need for water consumption for dust suppression;
- Reduced haul truck air emissions;
- Reduction of waste dump volumes and pit depth, thereby reducing visual impacts; and
- Reduction in the total acres of surface disturbance, thereby reducing costs associated with reclamation.

The need for the LVMC action is reflected in BLM surface management regulations where an operator must submit a modification and receive BLM's approval before making changes to the operations described in the approved Plan of Operations (e.g., 43 CFR 3809.431).

1.3 Need for the Proposed Action

As required by Federal regulations at 43 CFR 3809.430, LVMC has filed a mine plan modification to its existing mining plan of operations (mine plan) that allows Lisbon Valley to mine copper The mine plan modification as submitted to BLM is provided in Appendix B of this EA. The BLM's underlying need is to respond to the applicant's proposals to modify its current mining plan of operations under the authority of the Mining Law of 1872, as amended.

1.4 Purpose(s) of the Proposed Action

The BLM's purpose in evaluating the mine plan modification is to prevent unnecessary or undue degradation of BLM lands in accordance with the Federal Land Policy and Management Act (FLPMA) of 1976 and pursuant to the Code of Federal Regulations at 43 CFR 3809.420.

1.5 Conformance with BLM Land Use Plan(s)

The Proposed Action has been determined to be in conformance with the terms and conditions of the Moab Resource Management Plan (RMP), which was approved by the Record of Decision on October 31, 2008. The Proposed Action is in conformance with the Minerals Decision 6 (MIN-6) of the RMP:

"*Existing operations will continue to be subject to the stipulations developed for the notice of the plan of operations. The BLM will evaluate all operations authorized by the mining laws in the context of its requirement to prevent unnecessary and undue degradation of the Federal lands and resources. Consistent with the rights afforded claimants under the mining laws, operations conducted after this RMP will be required to conform to the surface disturbing stipulations developed in this RMP* " (BLM, 2008a: p. 73).

1.6 Relationship to Statutes, Regulations, or Other Plans

Mining operations are subject to a wide range of Federal, State, and local requirements. Many of these require permits, approvals or consultations before the mining operations commence, whereas others mandate the submission of various documents, or establish specific prohibitions or standards.

The Proposed Action would be subject to the following laws, regulations, and policies where applicable:

- **National Environmental Policy Act of 1969 (PL 91-190; 42 USC 4321); 40 CFR Parts 1500-1508 CEQ implementation of NEPA; BLM Handbook H-1790-1; U.S. Department of the Interior Department Manual 516, Environmental Quality:** Evaluation of impacts to environmental resources that may result from a proposed action prior to its implementation.

- **Federal Land Policy and Management Act of 1976, Section 201(a) (PL 94-579; 43 USC 1701 et seq.):** Management of federal lands under principles of multiple use and sustained yield while protecting environmental resources.

- **Surface Management Regulations (43 CFR 3809):** Regulations implementing FLPMA as it pertains to provisions of the General Mining Act of 1872 (30 USC 22 et seq.) that among other things, gave miners the right to stake mining claims for exploration, development and extraction of valuable minerals on federal lands The surface management regulations revised the manner in which the surface of a mining claim can be used, set standards for surface disturbance, and developed authorization levels based on the exploration or mining techniques used and the amount and degree of surface disturbance.

- **Endangered Species Act of 1973 (PL 93 205; 16 1531 et seq.):** The purpose of the ESA is to protect and recover imperiled native plant and animal species and the ecosystems upon which they depend.

- **National Historic Preservation Act (NHPA) of 1966 (PL 89-665; 16 U.S.C. 470 et seq.):** The purpose of the NHPA is to preserve historical and archaeological sites in the United States of America. The act created the National Register of Historic Places, the list of National Historic Landmarks, and the State Historic Preservation Offices.

- **Clean Air Act (CAA) of 1963 (PL 88-206; 77 Stat. 392):** CAA is a United States federal law designed to control air pollution on a national level. It requires the United States Environmental Protection Agency (USEPA) to develop and enforce regulations to protect the public from airborne contaminants known to be hazardous to human health.

- **Clean Water Act (CWA) of 1972 (PL 92-500, 86 Stat. 816):** The primary federal law in the United States governing water pollution. The purpose of the CWA is to restore and maintain the chemical, physical, and biological integrity of the nation's waters by preventing point and nonpoint pollution sources, providing assistance to publicly owned treatment works for the improvement of wastewater treatment, and maintaining the integrity of wetlands.

- **Migratory Bird Treaty Act (MBTA) of 1918 (16 USC 707 et seq.):** One of the first federal environmental laws, the MBTA protects migratory birds between the United States and several foreign countries party to the treaty. The law makes it illegal to pursue, hunt, take, capture, kill or sell birds listed as "migratory birds" by the United States Fish and Wildlife Service.

- **Standards for Rangeland Health (43 CFR 4180; 43 USC 1901) and Guidelines for Grazing management for BLM Lands in Utah[2]:** The objectives of these regulations and legislation is carry out the intent of the Taylor Grazing Act of 1934 (PL 73-482), as amended and supplemented, the Federal Land Policy and Management Act of 1976, and the Public Rangelands Improvement Act of 1978 (43 USC 1901) in order to manage, maintain and improve the condition of the public rangelands so that they become as productive as feasible for all rangeland values in accordance with management objectives and the land use planning process.

- **BLM Special Status Species (BLM Manual 6840):** Provides for the conservation of BLM special status species and the ecosystems upon which they depend on BLM-administered lands. BLM special status species are: (1) species listed or proposed for listing under the ESA, and (2) species requiring special management consideration to promote their conservation and reduce the likelihood and need for future listing under the ESA, which are designated as Bureau sensitive by the State Director(s). All Federal candidate species, proposed species, and delisted species in the 5 years following delisting will be conserved as Bureau sensitive species.

The San Juan County Master Plan (San Juan County, 2008) lists several policies related to the management of the public lands. Policies are stated recognizing the roles of FLPMA and NEPA in the management of public lands, and for supporting multiple uses. The plan supports responsible natural resource use and development, including growth and development in San Juan County. The plan also covers San Juan County's policies on public lands, public land use and development and public access. The Proposed Action would be consistent with the goals and objectives of the San Juan County Master Plan.

[2] http://www.blm.gov/ut/st/en/prog/grazing/utah_guidelines_for.html

In addition to BLM regulations, the mine plan modification must comply with the State of Utah, Division of Oil Gas and Mining (UDOGM) requirements for mining activities.

Lisbon Valley Copper Mine operates under a Plan of Operations that was authorized in a Record of Decision dated March 26, 1997. This EA is tiered to the analyses contained in the *Final Environmental Impact Statement, Lisbon Valley Copper Project*, dated February 1997.

1.7 Identification of Issues

The public was notified of the proposed project on November 7, 2013 when the action was posted on BLM's Electronic Notification Bulletin Board (ENBB). The ENBB included the project description, and a statement of the BLM's intent to prepare an EA. A draft of the Proposed Action was formally scoped through a press release and was published as a legal notice in the San Juan Record that appeared in the San Juan Record on April 15, 2014. The scoping period began on April 9, 2014 and ended on May 12, 4014. Only one comment was received. The comment contained general content and did not raise issues that required analysis in the EA.

As part of internal scoping, BLM resource specialists in the Moab Field Office reviewed the Proposed Action to identify issues that would require evaluation in the NEPA process. This evaluation of issues may lead to identification of design or operational elements to avoid, minimize, or mitigate impacts. Elements can then be incorporated into the Proposed Action, mitigation measures, or addressed in alternatives to the Proposed Action.

Internal scoping within the BLM was conducted between March 4th and March 27th, 2015, and consisted of a review of the Proposed Action and discussion of resource issues of concern by an interdisciplinary resource team (ID Team). Internal scoping identified the following issue to carry forward for analysis in the EA: Water Resources.

The issues identified by the ID Team are included in the Interdisciplinary Team Checklist (Appendix C). The checklist includes a summary of the potential resources and issues that may be encountered in the project area and categorizes those issues: resources that are not present in the project area (i.e. NP); resources that would not be impacted by the Proposed Action (i.e. NI); and resources that may be impacted (PI) and must be analyzed in detail in the EA.

The issue statement for the resource carried forward for analysis is:

1.7.1 Water Resources/Groundwater

- How would the waste rock used as back fill impact groundwater?

1.8 Issues Considered but Eliminated from Further Analysis

No issues were raised during formal scoping of the Proposed Action. Refer to the ID Team checklist in Appendix C for resources considered but eliminated from further analysis.

1.9 Summary

This chapter has presented the purpose and need of the proposed project, as well as the relevant issues, i.e., those previously uncharacterized elements of the human environment that could be affected by the implementation of the proposed project. In order to meet the purpose and need of the proposed project in a way that resolves the issues, the BLM has considered and/or developed a range of action alternatives. These alternatives are presented in Chapter 2. The potential environmental impacts or consequences resulting from the implementation of each alternative considered in detail are analyzed in Chapter 4 for the identified issue.

2 DESCRIPTION OF ALTERNATIVES, INCLUDING PROPOSED ACTION

2.1 Introduction

Three alternatives are carried forward for analysis in this EA: Alternative A, which is the proposed action (i.e., LVMC's proposed mine plan modification), Alternative B, Complete Backfill, and Alternative C, the no-action alternative, which is required by CEQ regulations (40 CFR 1502.14). Alternative A presents LVMC's proposed modification to the existing mine plan, where mine waste rock would be placed as backfill to the Centennial Pit. Alternative A is presented in Section 2.2. Alternative B is the Complete Backfill alternative would modify the exiting plan by completely backfilling the Centennial Pit and is presented in Section 2.3. Alternative C is the alternative of no action and presented in Section 2.4. This alternative describes what would likely happen in the event that the proposed action did not take place. The no-action alternative is provided as a baseline comparison to the Proposed Action and other action alternatives.

No other alternatives were considered, because no other alternatives were identified through internal or external scoping. This analysis is narrowly focused on analyzing only the groundwater impact issues that were not addressed in the FEIS prepared for the original Plan of Operations.

2.2 Alternative A – Proposed Action

2.2.1 Summary of Current Mining Operations

LVMC mines sandstone-hosted copper ore using conventional open pit mining methods. Copper ore is mined from the mineralized portions of the Cretaceous-age Dakota and Burro Canyon Formations. The ore is drilled and then blasted to the described fragmentation from 20-ft benches. The ore is loaded and transported to heap leach pads using conventional front-end loaders and haul trucks. Waste rock is hauled to waste dumps using the same methods and equipment. Waste rock is hauled from the three pits to three above ground waste dumps.

LVMC contracts its drilling and blasting. The drilling contractors utilize a fleet of conventional 10-in rotary drills. The blast contractor utilizes an ammonium nitrate/fuel oil (AN/FO) explosive. Blasthole depth is 20 feet and drill holes are spaced 15 to 20 feet depending on rock hardness. The blast schedule is every other day during daylight hours.

2.2.2 Proposed Mine Plan Modification

The Lisbon Valley Mining Company (LVMC) proposes an operator-requested modification to the current approved Plan of Operations (POO). Specifically, this modification proposes to partially backfill (reclaim) the Centennial Pit as part of final reclamation (Figure 1) of this pit. The proposed mine plan modification as submitted to BLM by LVMC is included as Appendix C to this EA.

The backfilling sequence will mirror the sequence of mining phases of the Centennial Pit, except only waste rock from Bed 14 and 15 (Burro Canyon Formation) will be used as backfill. The remainder of the waste will be deposited in above-ground waste dumps per current waste rock

management protocols. All waste is dumped in 20-foot lifts, whether on the dumps or when backfilling the pit. The lifts are compacted as a function of the haul truck (100-ton) traffic.

The Centennial Pit is mined in phases that would allow the backfilling process to occur within the larger (planned) pit boundaries. The backfilling process would begin by incrementally identifying areas within the Centennial Pit that have been mined to planned limits (generally final pit walls) or geologic/mineralization boundaries (pit floors). Because backfilling has the potential to permanently condemn future economic mining where employed, an assessment was made that provides a reasonable degree of certainty that future economic loss of the ore body would be minimized.

The Centennial Pit is divided lengthwise into two lobes, separated by a topographic "ridge." The elongated lobe on the southwest side is known as the Penny Phase, while the lobe on the northeast side is referred to as the Keystone Phase. The Penny Phase was excavated first, followed later by the Keystone Phase. Both have been mined to a final elevation of 6,020 feet amsl. These phases are shown on Maps 1 and 2 (Appendix A).

The initial target area for backfilling will be in the Penny Phase area of the Centennial pit. Following Penny, portions of the Keystone Phase immediately north of the Penny would become additional backfill targets. Beyond these two phases the envisioned sequence becomes less clear as future mining sequences could change depending on the-economic and operational conditions. Up to 75M tons of waste rock are proposed to backfill the phases within the Centennial Pit, to a maximum elevation of 6,400 feet amsl. This would be a maximum, the volume of backfill material placed into the pit could be less, but the end volume placed at a grade of 6,200 feet or higher amsl to cover the Burro Canyon Formation exposed in the pit walls. Appendix E presents the modeling report for the various scenarios proposed for pit backfill.

As a general rule, backfill progression will follow pit development along successive pushbacks of the pit walls to final mining limits. This would be accomplished by establishing an access to the target area in the form of either an in-pit haul route or a haul-back route along the pit perimeter. In the case of an in-pit haul, ramps would be constructed within the pit to allow haul traffic to access different elevations. In the haul-back scenario, the trucks would exit the pit, travel around the rim on the surface and then dump over the rim into the target area. Backfilling would then proceed in the target area to predefined limits that would be established from the aforementioned assessment. When backfilling operations are completed in a target area, the process would repeat itself until all backfilling opportunities are exhausted, resulting in the final configuration.

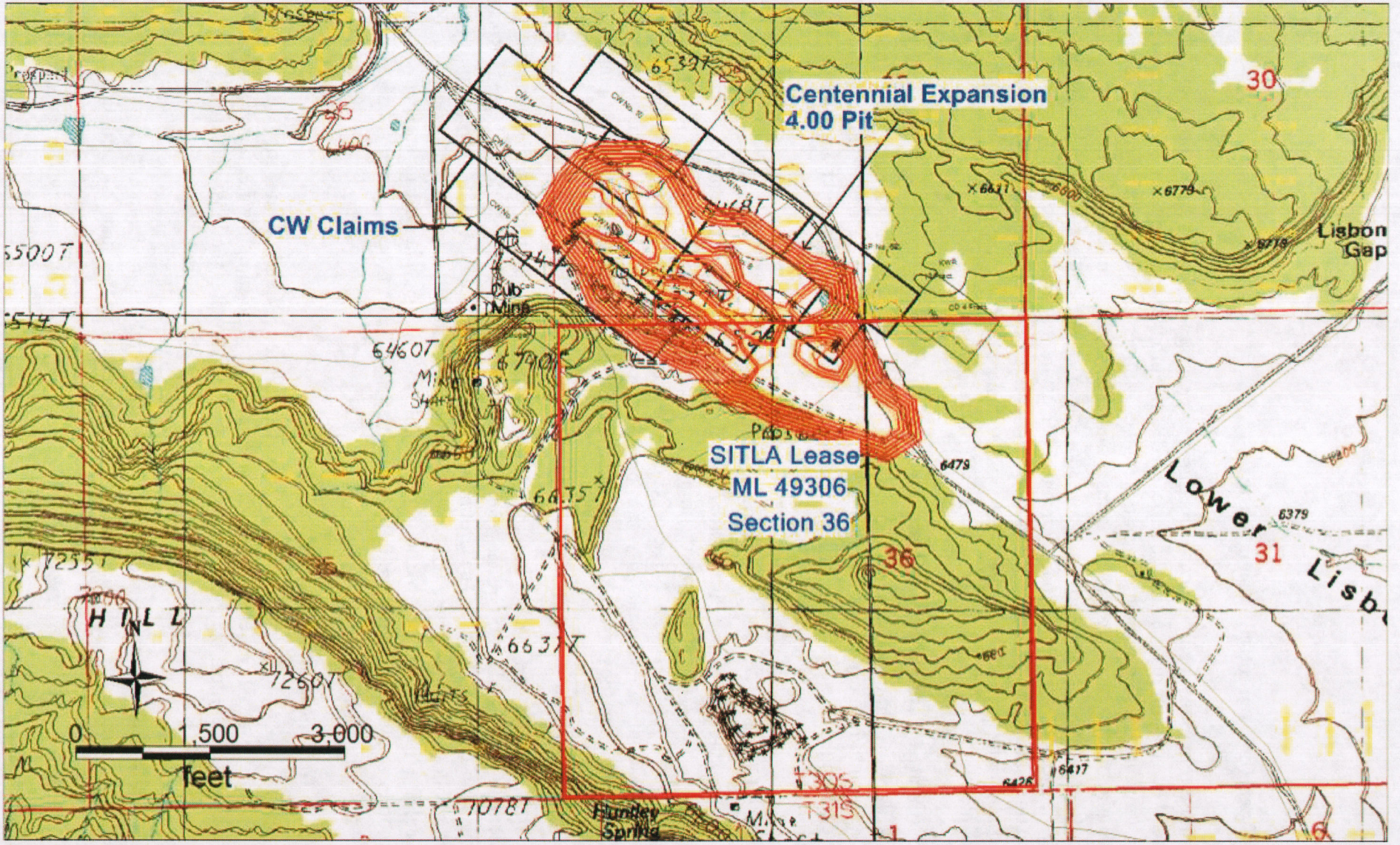


Figure 1. Site Location Showing the Footprint of the Centennial Pit.

2.2.3 Operator-Committed Design Features

Design features are those specific means, measures or practices that make up the proposed action and alternatives. Design features may be specified at the project design phase. Design features, especially those that would reduce or eliminate adverse effects, may also be specified after the initial formulation of alternatives, as the impact analysis is being conducted. In this situation, design features may be added to the proposed action or alternatives. Standard operating procedures, stipulations, and best management practices are usually considered design features. Design features are not considered mitigation. In some cases, a proposed action with design features appropriately crafted to address potential significant effects may not require mitigation and consequently the analysis may arrive at a FONSI.

2.2.3.1 Estimated Annual Acreage/Tonnage of Backfill

Since backfilling would occur within the previously-mined pit, the waste tonnage would not be added to waste dumps located outside the pit. The area needed for future waste dumps would be reduced accordingly. Based on the current mine schedule and fleet capacity, approximately 7 million tons per year would be backfilled.

2.2.3.2 Rock Characterization and Handling Plan

As stated earlier, the Centennial Pit would be backfilled with waste rock obtained from beds 14 Bed 15 of the Burro Canyon Formation mined in accordance with the approved waste rock management plan (LVMC, 2005). No acid-generating waste rock would be placed within the pit backfill. It would all be encapsulated within non-acid generating waste rock in the waste rock piles on the surface, per the current Plan of Operations and the waste rock management plan.

2.2.3.3 Monitoring Plan

LVMC would monitor the backfilling project in accordance with the Utah Department of Environmental Quality (UDEQ) Groundwater Discharge Permit (UDEQ 2015) and Waste Rock Monitoring Plan (LVMC 2005). The groundwater monitoring would extend to a period of at least 5 years following mine closure (BLM 1997c). Groundwater monitoring wells are shown on Maps 1 and 2 (Appendix D). An additional monitoring well is planned to supplement the existing monitoring wells in the Burro Canyon (BC) aquifer. This proposed well (MW15-16) is included on Maps 1 and 2.

2.2.3.3.1 Groundwater Monitoring

The groundwater-monitoring program for the Lisbon Valley Mine includes routine monitoring of water level elevations and water quality. The sampling frequency, sampling methods, and analytical suite are summarized in the following sections, and are subject to annual review.

Water levels would be measured quarterly during operations in 12 monitoring wells and piezometers and these measurements would be presented in the quarterly sampling reports submitted to UDEQ, DOGM and BLM. The wells to be measured are tabulated in Table A-2 of Appendix A. Water levels in active pumping wells and observation piezometers

located near the pits are measured approximately monthly for operational purposes, and the data are presented in the Hydrogeologic Update Report submitted annually to BLM, DOGM and UDEQ. Water levels would be measured in accordance with the standard operating procedures. Time-contiguous water level data would be collected to the extent possible.

2.2.3.3.2 Groundwater Quality Sampling Frequency

Water quality would be sampled routinely in monitoring wells and water supply wells at the Lisbon Valley Mine. The list of wells to be sampled for water quality would be reviewed on an annual basis, as described in in the Sampling and Analysis Plan (SAP) (LVMC, 2012).

2.2.3.3.3 Groundwater Quality Parameters to Be Monitored.

The list of parameters to be analyzed in groundwater was developed during the 1994 – 1996 timeframe and was revised in 2006 based on over ten years of analytical results of groundwater obtained from monitoring wells. The Comprehensive Analytical Suite for groundwater monitoring at the Lisbon Valley Mine is provided in Table A-3 of Appendix A. Analytical parameters that are consistently below detection limits would be evaluated and potentially omitted from quarterly or annual sampling. A limited analytical suite may be developed and customized on per monitoring well to achieve greater efficiency. Elements such as uranium, copper, and nickel, which all occur in the ore body, would not be eliminated from sampling.

2.2.3.4 Waste Rock Management Plan

The current Waste Management Plan (LVMC 2005) is designed to characterize rock as it is mined and determine whether it comprises ore for further processing, or waste rock to be disposed to surface dumps or used in the proposed partial backfilling operations.

Waste rock that has acid-generating potential would be segregated by trained personnel and placed in appropriate, designated areas in accordance with the approved LVMC Waste Rock Management Plan (LVMC 2005).

2.2.3.5 Interim Management Plan

Temporary and seasonal closures are not planned. In the event that the possibility of an unplanned closure is anticipated, an interim management plan would be developed for review by the BLM. Such a plan would address securing access to the mine area, safeguarding the public, wildlife, and livestock from possible injury on mine property, and protecting the environment from releases of toxic or hazardous materials.

Interim management outside the pit area is provided by surface water diversion in accordance with the Utah Department of Environmental Quality Division of Water Quality (UDWQ)-approved LVMC Stormwater Pollution Prevention Plan (SWPPP) (LVMC 2013b) Stormwater discharges from construction activities such as clearing, grading, excavating, and stockpiling, that disturb one or more acres, (or smaller sites that are part of a larger common plan of development) are regulated under the National Pollutant Discharge Elimination System (NPDES) stormwater program. Operators obtain a permit under the NPDES program that details requirements such as compliance with effluent limits and the development of the SWPPP.

2.2.3.6 Reclamation Plan

If the Proposed Action is approved, the reclamation plan would continue as currently approved with the exception that a mixture of rock from beds 14 and 15 of the Burro Canyon Formation would be used to partially backfill the Centennial Pit. By doing so, backfilling would partially reclaim the pit and reduce the amount of reclamation required for the above-ground dumps. Backfilling the Centennial Pit would reduce the overall size of the pit, the elevation of high walls and slopes, and the degree of surface area available for ponding as these features are partially buried with waste rock. The proposed backfilled area would be capable of re-vegetation and would be re-seeded from the air with a BLM-approved seed mix to reduce the potential for erosion of the reclaimed area and return the proposed backfilled area to a future condition capable of providing productive habitat for wildlife or forage for livestock.

2.2.3.6.1 Erosion Control

There is no requirement to control erosion or runoff (meteoric water run on) in the interior of the open pit. However, the same is reduced as a result of backfilling due to the concomitant reduction of pit surface area. Outside the pit, surface runoff is diverted around the pit in accordance with the approved Storm Water Pollution Prevention Plan SWPPP (LVMC 2013b). A 3-foot minimum height berm is planned for post mine closure around the pit. This berm is shown in Maps 1 and 2, along with the current storm water diversion channels. LVMC is currently permitted to leave the pit open. Backfilling the pit would serve to buttress the walls and would provide additional stability relative to the final height. Stability is increased by additional backfill.

2.2.3.6.2 Economic, Environmental, and Safety Factors

- *Economic Factors.* Pit backfilling would reduce haul costs $0.3/ton relative to mean distance hauls to LVMC permitted above-ground dumps.

- *Environmental Factors.* LVMC abides by a fugitive dust control plan for control of all dust sources associated with the Lisbon Valley open pit copper mine. This plan contains sufficient controls to prevent an increase in PM 10 emissions. Dust emissions increase as a function of haul distance. The haul distance is reduced by backfilling relative to the pit rather than to waste dumps. Accordingly, fuel use, and related emissions are reduced. The groundwater used for dust control is reduced accordingly.

- *Safety Factors.* Pit backfilling would reduce haul distance. The backfilled pit would not contain a pit pool, thereby reducing entrapment hazards to unauthorized human access, wildlife, and livestock. Post-closure fencing and berms would be constructed in accordance with Mitigation and Monitoring Plan (BLM 1997c) to deter unauthorized access, and prevent access by wildlife and livestock

2.2.3.6.3 Habitat Rehabilitation

The proposed backfilled pit would have potential for re-vegetation in contrast to an open pit that would contain a pit pool (WP Resource Consulting, Inc. 2012). Loss of wildlife habitat would be reduced by a function of the backfilled area.

2.2.3.6.4 Isolation, Removal, and/or Control of Acid-forming, Toxic, or Deleterious Materials

Acid-forming waste is encapsulated in the dumps in accordance with the waste rock management plan (Lisbon Valley Mining Co 2013). Based on analytical results none of the waste is considered toxic deleterious (LVMC, 2013a).

2.2.3.6.5 Post-closure Management

LVMC would manage the pit after closure with fencing, berms, and re-seeding signage in accordance with the Mitigation & Monitoring Plan (BLM, 1997c). This would include surface water management in accordance with the SWPPP and long term groundwater monitoring in accordance with the reclamation bond.

2.2.3.6.6 Sedimentation of Surface Water

There are no natural surface water bodies or streams within ½ mile of the Centennial Pit. Additionally, excess sedimentation cannot occur from inside the pit because it is a closed internally-drained basin. Sedimentation outside the pit is managed by surface water diversion and retention. These features are shown on Maps 1 and 2.

2.2.3.6.7 Acreage Disturbance

An estimate of the relationship of reclaimed disturbance to the volume of proposed backfilling accomplished is presented in Figure 2. The permitted Centennial Pit boundary is 176 acres. This disturbance would be reduced and partially reclaimed by backfilling. The area of backfill is dependent on actual volume of backfill material disposed to the pit.

2.2.3.6.8 Anticipated Productive Post-mining Use of the Land

The backfilled waste is suitable for re-vegetation. It would be aerially re-seeded with a BLM-approved seed mix prior to closure.

2.2.3.6.9 Proposed Reclamation Schedule

The reclamation schedule is dependent on mine life. The current estimate of mine life is 5-to-10 years. Backfilling (reclamation) is constrained only by the phases of the mining, which provide the backfilling opportunity. More mining phases would increase backfilling opportunities and resultant volume of backfill material available. A reduction in the number of mining phases diminishes opportunities and therefore the volume of backfill material available.

2.2.3.6.10 Proposed Post-mining Topography

Post-mining topography is shown in Maps 1 and 2. The proposed backfill surface would be level to enhance evaporation.

2.2.3.6.11 Slope Stability

No backfilled slopes are proposed, except for ramps into and out of the pit that would provide ingress and egress. The proposed grade of the access ramps would be less than 10 percent.

2.2.3.6.12 Concurrent Reclamation

Concurrent reclamation is achieved as a function of the backfill sequence. As one phase of the pit is completed, it is backfilled by the next phase, and so on until the final backfill elevation is

achieved. Final grading and re-seeding occurs at that point in the sequence. Concurrent reclamation is intrinsic to the backfilling sequences.

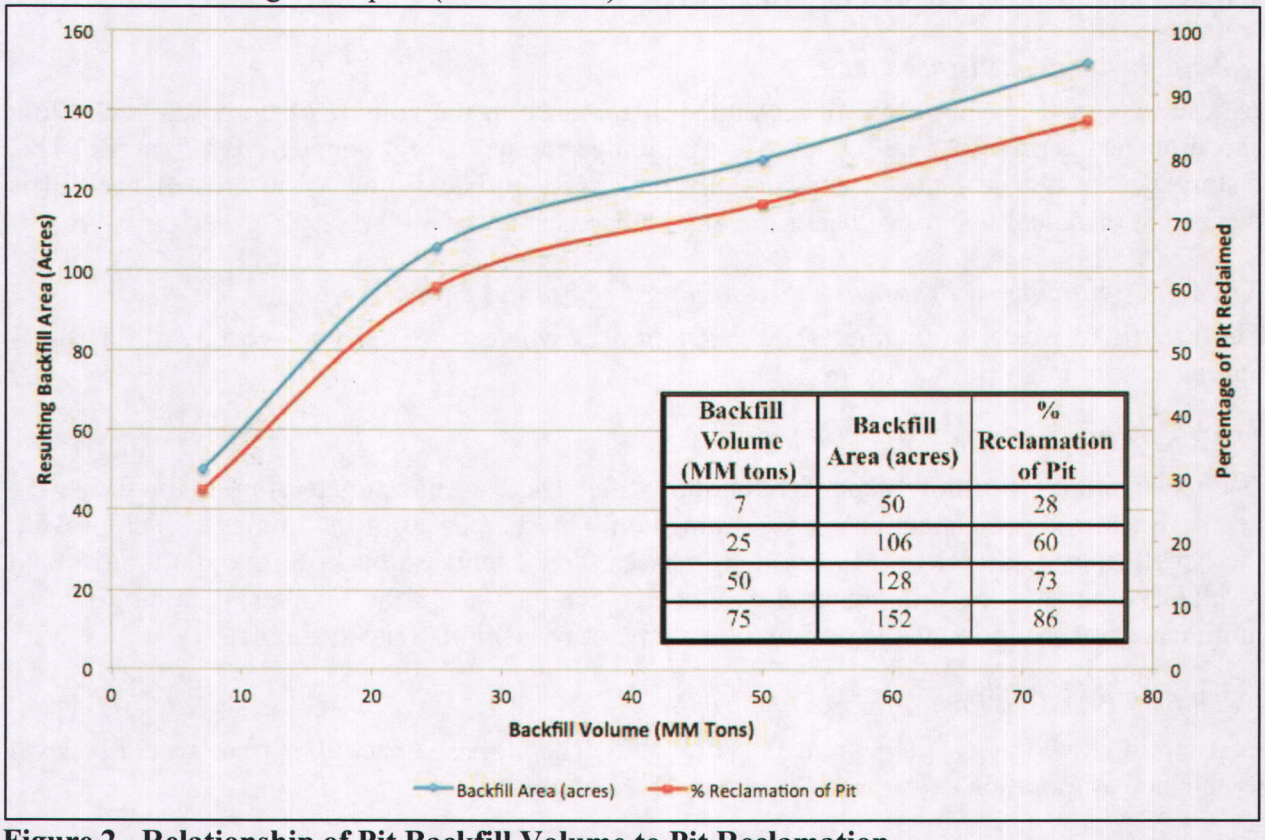
2.2.3.6.13 Effect on Future Mining

The reclamation would not condemn future mining in the area. Additional deposits below the pit are too deep to mine by open-pit methods. The area would remain available for in-situ leach recovery or underground mining methods.

2.2.3.7 Quality Assurance Plans

2.2.3.7.1 Ore Grade Quality Assurance

LVMC analyzes all of the blast holes, surveys and demarks ore/waste boundaries, and creates detailed geologic maps of the all pits as part of its grade control process. These processes are described in the Ore Grade Quality Assurance Plan (LVMC 2008). This plan provides the quality assurance necessary to identify waste to dumps and waste for backfill in accordance with the waste rock management plan (LVMC 2005).



Backfill Volume (MM tons)	Backfill Area (acres)	% Reclamation of Pit
7	50	28
25	106	60
50	128	73
75	152	86

Figure 2. Relationship of Pit Backfill Volume to Pit Reclamation.

2.2.3.8 Pit Backfill Monitoring

LVMC would monitor the backfilling project in accordance with Groundwater Discharge Permit No. UGW370005. This monitoring would extend to a period of 5 years following mine closure.

2.3 Alternative B: Complete Backfill

Alternative B is the Complete Backfill Alternative. Under this alternative, the mined pit would be completely backfilled at the cessation of mining operations. Design, implementation, management, and monitoring would be the same as partial backfilling. Such action would substantially reduce visual impacts, would lessen the threat to long-term public health and safety from the 300-600 foot open pit, would return an additional 231 acres to post-mining uses for wildlife and livestock forage, and would reduce the size of the remaining waste dumps considerably. This alternative was also identified as a potential solution to eliminate impacts from any ponding of water in the post-mining pit that could pose a threat to water quality. This alternative would also render any future recovery of remaining lower grade copper resources unrecoverable under current mining practices. Advancements in in-situ leaching technology may provide the opportunity to recover lower grade material at depth but additional amenability testing would need to be conducted.

2.4 Alternative C: No Action

Alternative C is the No-action alternative where the proposed mine plan modification would not be authorized. The No-action alternative means that the LVMC would continue operations as identified in its current POO. Waste rock would not be used to backfill the Centennial Pit and all backfill would continue to be placed on the ground surface in surface waste dumps. The No-action alternative serves as the baseline for the analysis contained in this EA. It is critical to the understanding of the No-action alternative that if implemented, environmental consequences would still occur because the existing environment is not static. The No-action alternative as expressed in this EA was the selected alternative under the 1997 FEIS (BLM 1997a) and its effects were described in that document. Under the No-action alternative, the Lisbon Valley Copper Mine mining operations would continue as permitted under the 1997 FEIS.

Waste rock would continue to be selectively handled and placed in surface waste dumps and encapsulated within waste rock that is acid-neutralizing, which would lessen the long-term potential for acid-bearing leachates to emanate from the waste dumps and impact watersheds, vegetation and wildlife. Overburden and waste rock would be contained in three waste dumps, encompassing 394 acres. At the completion of mining, waste dumps would be reclaimed in place by grading them to approved slopes, covering them with appropriate soils, and reseeding with a BLM-approved seed mix. As determined in the 1997 FEIS, the opportunity to reduce impacts to topography (i.e., visual resources), return more area to vegetative cover and further enhance public safety (in comparison to the other alternatives not selected at that time) is reduced under the implementation of surface dumps.

Surface disturbance would still occur as originally permitted under the 1997 FEIS, which allows for the disturbance of 1,103 acres over the life of the mine. Vegetative reclamation would occur on 872 acres with the ultimate long-term loss of 231 acres associated with the open pit left after mining.

The mined-out Centennial pit would still be left open and un-reclaimed, with the likelihood of a pit lake forming. A 3-foot berm would be constructed around the mined pit within 50 feet of the pit edge, designed to drain surface water runoff away from the pit and discourage access. In the

case of pit lakes forming, groundwater impacts to adjacent and lower groundwater aquifers could occur due to (1) evapoconcentration of solutes (e.g., metal oxyanions such as antimony, arsenic, cadmium, copper, molybdenum, selenium, uranium, and zinc), (2) high TDS, and (3) high pH levels. In addition, wildlife (principally water fowl) would be attracted to and therefore exposed to any pit lake that would form. Long-term testing of post-mining pit lake water would be required under the No-action alternative.

With the Centennial pit left open and un-reclaimed, there exists the possibility that at some point in the future where a significant price increases in copper occur, the possibility of recovery of lower grade copper reserves would not be foreclosed. Therefore, leaving mine pits open and un-reclaimed preserves this possibility of mining lower grade resource with conventional surface mining techniques.

Groundwater depletion would occur as a result of water used for mining operations. The 1997 FEIS estimated that 22% of the shallow Burro Canyon aquifer water supply would be depleted and up to a 6% depletion of the deeper Entrada/Navajo aquifer would occur. After the cessation of mining, groundwater would slowly recharge over many years. However, under the No-action alternative, because of the existence of open mine pits which intersect the upper aquifer, the levels of groundwater in the upper aquifer would never return to levels which existed prior to mining. The 1997 FEIS estimated that groundwater levels in the upper aquifer would be permanently lowered by 60 to 100 feet. However, long-term lowering of groundwater levels in the deeper Entrada/Navajo aquifer was not expected.

3 AFFECTED ENVIRONMENT

3.1 Introduction

This chapter presents the potentially affected existing environment (i.e., the physical, biological, social, and economic values and resources) of the impact area as identified in the Interdisciplinary Team Checklist presented in Appendix C of this environmental assessment. This chapter provides the baseline for comparison of impacts/consequences described in Chapter 4.

The Affected Environment as described in the 1997 FEIS (BLM, 1997a) is incorporated by reference into this document, and will not be repeated in detail this environmental assessment.

Internal scoping identified groundwater as the remaining element of the Affected Environment that requires analysis in this environmental assessment. Because the current conditions of the other elements of the Affected Environment, and any past, present or future actions relevant to the current status of these other resources, are adequately described 1997 FEIS (BLM 1997a), this environmental assessment shall focus only on the groundwater resource as the issue of interest and only briefly discuss other elements of the Affected Environment to orient the reader and place the groundwater resource in the proper context for analysis.

3.2 General Setting

3.2.1 Site Description

The Lisbon Valley Copper Mine is located in Lisbon Valley, in San Juan County, Utah, approximately 18 miles southeast of La Sal, Utah, in San Juan County, Sections 25, 26, and 36 of Township 45 North Range 25 East. The mine consists of a total of 1,104 acres, including federal (547 acres), state (273 acres), and privately owned land (256 acres).

The Lisbon Valley Copper Mine lies within the Lisbon Prong-Salt Anticline physiographic subprovince of the Colorado Plateau (Stokes, 1986). The Southern Rocky Mountains and Basin and Range physiographic provinces flank the Colorado Plateau Province on the east and west, respectively (Stokes, 1986). Lisbon Valley was formed when the anticline collapsed because of the dissolution of the underlying salts in the Paradox Formation. (Woodward-Clyde 1983:132). Lisbon Valley is a broad, flat-bottomed valley approximately one mile wide and four miles long. The valley is bounded in some areas by steep walled mesas and ridges, which rise 500 to 700 feet above the valley floor. These mesas are dissected by canyons that generally drain away from the Lisbon Valley. Elevations in the area range from approximately 5,600 to 6,200 ft. above mean sea level (amsl).

The vegetation in the mine area ranges from pinon-juniper forests on the cliffs to sagebrush, grassland and rangeland in the valley. Annual average precipitation and free water surface evaporation rates are 15.05 and 48.03 inches per year, respectively. These rates are consistent with those used in past and recent pit modeling by Whetstone (2009; 2010). The highest percentage of the annual precipitation occurs during July, August, September, and October in the form of high intensity, short duration thunderstorms. The temperatures vary and average in the

upper teens during the winter months and the mid-80s in the summer months (Western Regional Climate Center website).

Historical uses in the area are livestock grazing and copper and uranium mining.

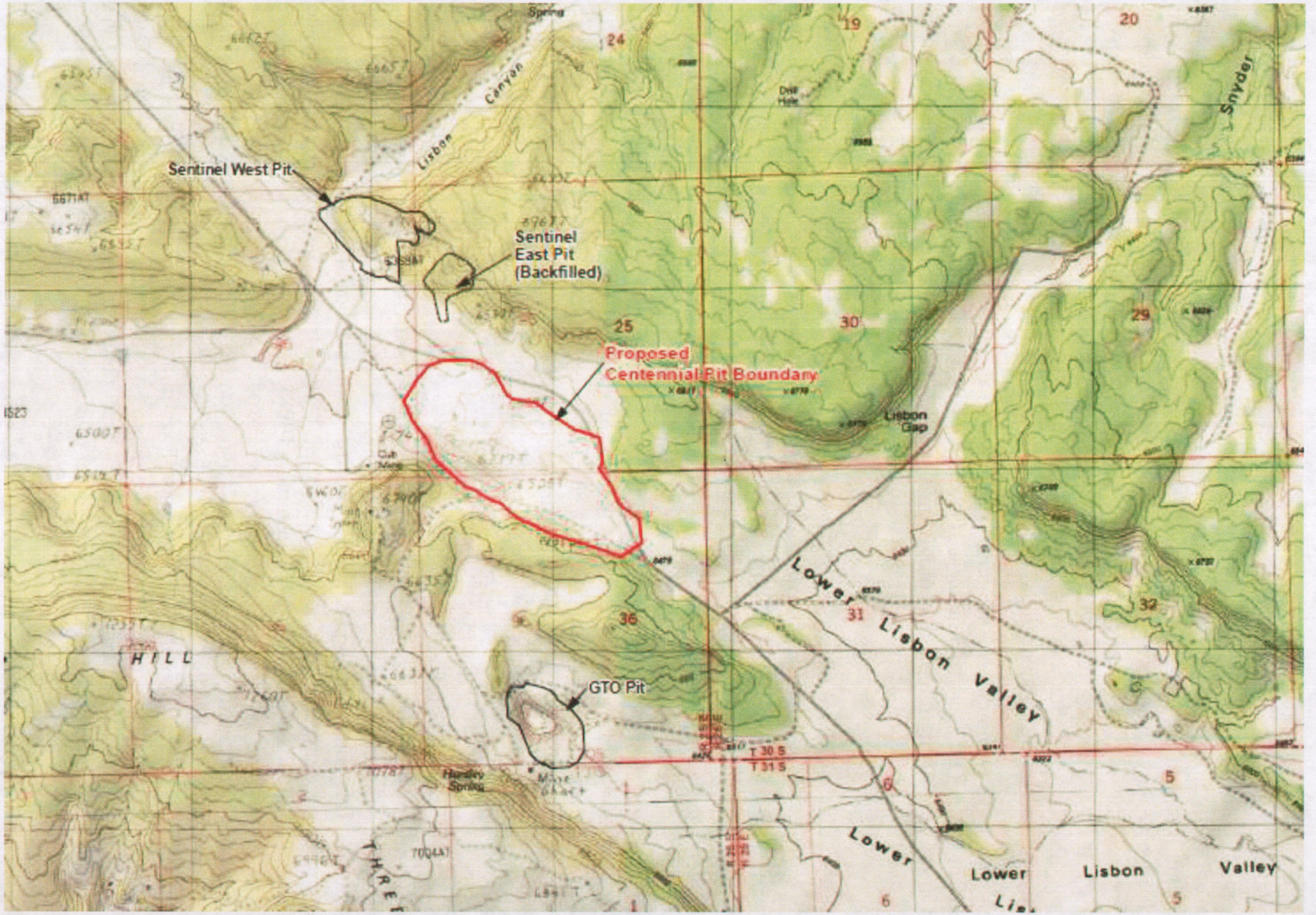


Figure 3. Locations of Existing Pits at the LVMC Mine Site.

3.2.2 Water Resources/Groundwater

The geologic structure of the mine vicinity is dominated by two features: the doubly-plunging Lisbon Valley Anticline, trending N45°W, parallel to the Lisbon Valley Fault Zone and the Lisbon Valley Fault Zone which trends long the crest of the Lisbon Valley Anticline for a distance of approximately 20 miles in a northwesterly direction. The fault zone contains multiple fault traces of varying thickness and displacement. A dominant fault trace, referred to as the Lisbon Valley Fault, was mapped by Weir et al. (1961). Maximum stratigraphic displacement along the fault zone apparently ranges between 4,000 and 5,000 feet (down-dropped on the east) as reported by various workers (Weir and Puffett 1960; Huber 1981). Ascending mineral-rich fluids moving along high-angle faults of the Lisbon Valley Fault Zone are the mechanism for the ore deposit emplacement.

The Centennial pit is bound on the southwest and northeast by faults with large vertical displacement at the fault on the southwest side of the pit. These faults limit the extent of the aquifers in the area of the mine. A geologic cross-section through the Centennial Pit, showing the faults and mineralized zones is presented in the 2014 Revised Backfill Evaluation Report (see Figure 7, Arcadis 2014).

Groundwater at the LVM principally occurs in two aquifers, the Burro Canyon aquifer and the N Aquifer. A local zone of saturated alluvium also exists in a "collapse zone" between the Sentinel and Centennial pits. The depth to water in the alluvium ranges between 60 and 80 feet bgs as measured in wells 98R3, PW-1, PW-1A, and SLV-2.

At the Centennial Pit area, the Burro Canyon aquifer is underlain by the Brushy Basin Member (Brushy Basin) of the Morrison Formation, which consists of low-permeability shale, mudstone, and minor siltstone. The Morrison Formation is in turn underlain by sandstones and siltstones of the middle Jurassic-age Entrada Sandstone, the early Jurassic-age Navajo sandstones, the early Jurassic-age Kayenta Formation, and the Wingate Sandstone of late Triassic to early Jurassic age. The saturated portions of these rock units are collectively referred to as the N-aquifer (BLM 1997a). The Burro Canyon aquifer, Morrison Formation, and N-aquifer are described in more detail below.

3.2.2.1 Burro Canyon Aquifer

Besides the aforementioned localized occurrence of saturated alluvium between the Sentinel and Centennial pits, the Burro Canyon aquifer is the shallowest aquifer system in the vicinity of the Centennial Pit. This aquifer is perched on the Brushy Basin member of the Morrison Formation due to a graben structure, and limited in lateral extent by the Brushy Basin member subsurface topography and by faults (Adrian Brown Consultants 1998).

In the vicinity of the Centennial Pit, the Burro Canyon aquifer is laterally bounded on all sides, towards the south by the Lisbon Valley Fault, and towards the north by faults which raise the Burro Canyon Formation above the ambient water level in the Lisbon Valley Floor. The areal extent of the aquifer is shown by the pink line in Figure 5. No appreciable lateral groundwater flows into the aquifer, with recharge occurring from direct precipitation over the footprint of the Burro Canyon Formation. The net primary direction of groundwater flow through the Burro

Canyon is conceptualized to be downward through into discontinuous fracture and limited formation permeability in the underlying Morrison Formation.

The Burro Canyon aquifer is dewatered to allow current open pit mining operations to occur as the leakance below the Morrison is negligible. Prior to commencement of mining, the top of the ambient aquifer generally ranged from about 250 to 300 feet bgs east of the Lisbon Valley Fault in the area of the mine pits, and current water levels range from 350 to 450 feet bgs. The lower portion of the Burro Canyon (Bed 15) is the principal water-bearing zone in the Burro Canyon aquifer augmented in some places by relatively thin (10-30 feet) layers of permeable material in the upper Brushy basin member of the Morrison Formation. The pre-mining Burro Canyon aquifer ranges in thickness from about 10 to 180 feet (Adrian Brown Consultants, 1998). The Burro Canyon aquifer is not present beneath the leach pad area west of the Lisbon Valley Fault due to erosion on the up-thrown side of the fault.

In the vicinity of the Centennial Pit, pre-mining static depths to groundwater ranged from 151 to 325 feet below ground surface (bgs), which corresponds to elevations ranging from 6,160 to 6,302 feet amsl (BLM 1997a). Aquifer stress (pumping) tests conducted at wells 95R1, SLV-3, PW-3, PW-4, PW-5, and PW-6 indicate that the hydraulic conductivity of the Burro Canyon aquifer ranges from approximately 1×10^{-5} centimeters per second (cm/s) to 5×10^{-3} cm/s (Whetstone 2006).

The Burro Canyon aquifer groundwater is calcium-sulfate type water that is neutral to alkaline (pH ranging from 6.5 to 8.3). Burro Canyon groundwater has high total dissolved solids (TDS), averaging 2,142 milligrams per liter (mg/L) and high sulfate, averaging of 1,111 mg/L and the aquifer is classified as Class III Limited Use Groundwater due to natural exceedances of Utah Groundwater Quality Standards for uranium, gross alpha, and gross beta (UDEQ 2015). Site-specific Burro Canyon aquifer water chemistry is available for 34 samples from SLV-1A, 29 samples from SLV-3, 27 samples from MW-2A, and 38 samples from MW96-7A (see Figure 5 for well locations).

Summary statistics from the updated Backfill Evaluation Report (Arcadis 2014) for Burro Canyon aquifer water chemistry are presented in Table A-4 of Appendix A.

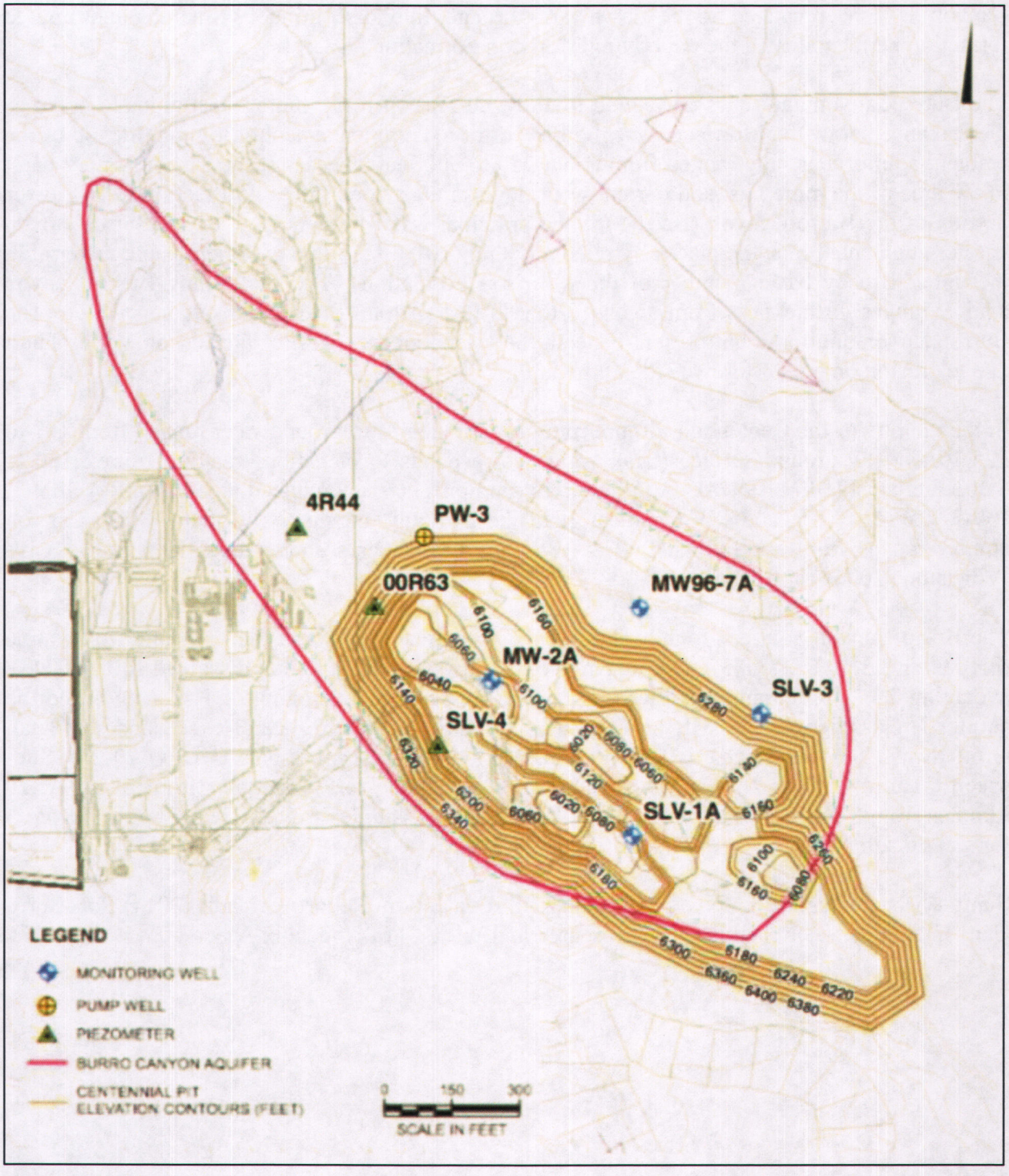


Figure 4. Proposed Ultimate Centennial Pit Footprint and Well Locations.

(Modified after Arcadis, 2014)

3.2.2.2 Morrison Formation

The Morrison Formation acts as a confining unit which perches groundwater in the overlying Burro Canyon aquifer and impedes the downward flow of water. At water well PW-7, strong downward vertical hydraulic gradients were observed during drilling, and a temporary well completed in the lower Salt Wash Morrison Formation yielded very little water.

The upper member of the Morrison Formation is the Brushy Basin, which is regionally comprised of a mudstone that is rich in volcanic ash and typically forms an aquitard (BLM 1997a). Based on the lithology data obtained during the drilling of monitoring well MW96-7B, approximately 390 feet of shale, mudstone, and minor siltstone of the Morrison Formation occur between the Burro Canyon aquifer and underlying Entrada Sandstone, which in turn was encountered at a depth of 810 feet bgs. The underlying Navajo Sandstone was encountered at 985 feet while the Summerville Formation, normally occurring between the Morrison Formation and the Entrada Sandstone was absent at this well location.

The ambient depth to water in well MW96-7B was 906 feet bgs, suggesting that the lower portion of the Entrada Formation is also water bearing (BLM 1997a). Previous modeling by Whetstone (2009; 2010) used a thickness of 460 feet to simulate the aquitard between the Burro Canyon aquifer and N-aquifer. This thickness was based on drilling and water level data for on-site wells.

3.2.2.3 N Aquifer

The N aquifer lies below the Morrison and Summerville Formations, which together perform as a confining layer between the overlying Burro Canyon aquifer and the underlying N aquifer (see Figure 5). The N aquifer is composed of several sandstones in the vicinity of the mine area (listed in order of increasing depth): the Entrada Formation, the Navajo Sandstone, the Kayenta Formation, and the Wingate Sandstone. The combined thickness of the formations comprising the N aquifer is on the order of 700 feet and may approach a maximum total thickness of 1,200 feet in the vicinity of LVM. The Entrada Formation is present in the subsurface east of the Lisbon Valley Fault at a depth of approximately 810 feet bgs, while the Navajo sandstone is present at a depth of approximately 985 feet bgs near the Centennial Pit.

Beneath the mine site, the N aquifer is bounded by faults. Due to fault gouge and vertical displacement, these faults act as barriers to groundwater flow. Due to erosion of the up-thrown block, the N aquifer is not present west of the Lisbon Valley Fault in the vicinity of the heap leach pad. Four wells were completed in the N aquifer within the vicinity of the Centennial Pit including MW96-7B, MW97-9, MW97-11, and PW-8 (Figure 5). Water level elevations measured in MW96-7B, MW97-9, and PW-8, located on the northeast side of the Lisbon Valley Fault, are similar, about 5,539 feet amsl. The water level at M97-11, located on the up-thrown side of the Lisbon Valley Fault, is approximately 200 feet higher than the aforementioned wells.

While the N aquifer is considered an important groundwater resource in the mine area, the overall hydraulic conductivity is very low. The large combined thickness of the Entrada, Navajo and Wingate sandstones translates to an overall medium to high value of transmissivity (i.e., a measure of an aquifer to transmit water horizontally through its entire bed thickness).

N-aquifer water chemistry is available based on analysis of 22 samples from MW96-7B, 19 samples from MW97-9 and 18 samples from MW97-11. The N-aquifer is sodium-bicarbonate type water that is neutral to alkaline (pH ranging from 6.9 to 9.1). The average TDS of the N aquifer is 584 mg/L, compared to 2,142 mg/L for the Burro Canyon aquifer. Major ion concentrations vary between the two aquifers, most notably calcium, magnesium, and sulfate concentrations are approximately an order of magnitude lower in the N aquifer than in the Burro Canyon aquifer. Additionally, total uranium concentrations are lower in the N-aquifer, with an average concentration of 0.005 mg/L, compared to an average concentration of 0.092 mg/L in the Burro Canyon aquifer.

Summary statistics for water chemistry data obtained from the N aquifer are presented in Table A-4 of Appendix A.

3.2.2.4 Groundwater Flow

The regional flow of groundwater in the principal N aquifer is generally to the east toward the Dolores River (Freethey and Cordy 1991). Locally, geologic structures in the vicinity of the mine (e.g., faults on the southwest and northeast sides of the valley) effectively compartmentalize groundwater flow in the Dakota, Burro Canyon, and Entrada/Navajo aquifer from the surrounding regional aquifers (Adrian Brown Consultants 1998). Displacement along faults has juxtaposed units of differing hydrologic conductivity, interrupting local groundwater flow patterns. Extensive faulting in Lisbon valley and McIntyre Canyon likely interrupts the local flow pattern between the mine area and the Delores River.

Local groundwater gradients are aligned with the prevailing local structural grain exhibited by Lisbon Valley (northwest – southeast), trending southeast toward the Delores River. No springs are documented in McIntyre Canyon from the mine area to the Delores River, suggesting that the Burro Canyon, Morrison, Entrada, Navajo rock units do not host significant groundwater flow in this area.

The directions of groundwater flow in the Burro Canyon aquifer and N-aquifer have been determined through an extensive network of pumping wells, monitoring wells, and exploration drill holes. The drilling programs encountered dry holes beyond the boundaries of the Burro Canyon aquifer and determined that the Burro Canyon aquifer is laterally bounded on all sides. No appreciable lateral groundwater flows into the aquifer, and recharge occurs from direct precipitation over the footprint of the Burro Canyon Formation. The primary direction of groundwater flow in the Burro Canyon aquifer is downward, evident by a strong vertical gradient, with flow through both fracture and formation permeability toward the underlying Morrison Formation (Adrian Brown Consultants 1998; Whetstone, 2006).

The Burro Canyon aquifer system in the Lisbon Valley is considered a closed system, with all recharge moving downward to the Morrison Formation. The Morrison Formation forms a confining layer between the Burro Canyon and the N-aquifer. The thickness of the Morrison Formation was determined from drill holes and is 390 feet thick at monitoring well MW96-7, located north of the pit. The vertical gradient through the Morrison was calculated to be 0.0002 ft/day (7.056×10^{-8} cm/s). The vertical gradient was consistent in both steady state and transient

calibrations. Hydraulic Conductivity values were obtained from steady state calibration and compared with field observations recorded from 5 wells; SLV-3, MW96-7A, PW-3, OOR63, and 4R44. The transient model was compared to 5 years of monitoring data from monitoring well MW96-7A and historical data from dewatering wells SLV-3 and PW-2. This rate fits within the range for hydrogeological barriers of 1.4×10^{-6} to 9.4×10^{-10} cm/s as defined in the EPA Groundwater Rule Source Assessment Guidance Manual (EPA, 2008).

A downward vertical gradient also exist in the N-aquifer and, to the extent possible, water will move downward through the N-aquifer. However, the horizontal permeability of the N-aquifer is higher than the vertical permeability of the confining units below, and groundwater can more easily move laterally except where open fractures exist (Whetstone, 2010). Regional groundwater flow in the N-aquifer is generally east toward the Dolores River (Freethey and Cordy 1991); however, because the complex geologic structure in Lisbon Valley isolates the N-aquifer, the groundwater gradient follows the northwest-to- southeast trending valley, with flow in a northeast direction and toward Lisbon Canyon.

3.2.3 Precipitation, Evaporation, and Runoff

Annual average precipitation and free water surface evaporation rates are 15.05 and 48.03 inches per year (inches/year), respectively. These rates are consistent with those used in previous pit modeling by Whetstone (2009; 2010).

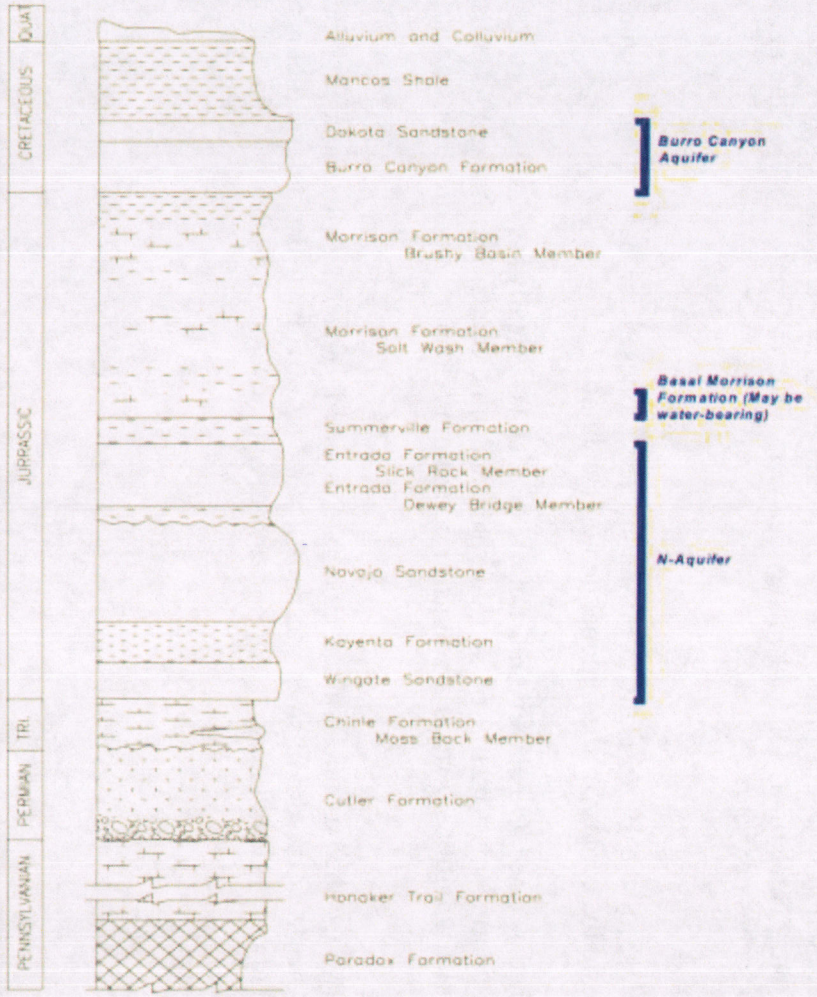
Catchment area runoff into the pit would be limited by a berm which would be constructed around the pit rim at closure. It is assumed that the area inside the berm and pit rim is 176 acres. Within this area, precipitation would fall directly on the pit bottom and on the pit walls. A portion of the precipitation that falls on the pit walls would infiltrate the walls before it reaches the bottom of the pit. Total runoff of 0.74 inches per year is approximately 5% of the annual precipitation of 15 inches per year.

3.2.4 Waste Rock

Only Beds 14 and 15 of the Burro Canyon Formation are proposed for backfilling. Figure 6 presents these beds in the context of the regional geologic column.

Bed 14 is generally described as a clayey limestone. The rock is typically very poorly sorted and sand grains are supported by a matrix of detrital shale and lime mud. Detrital grains consist predominately of quartz with very small amounts of potassium feldspar. Apatite grains occur in very small quantities.

Bed 15 is generally described as fine-grained moderately-sorted sandstone with rounded to sub-rounded grains. Quartz is the dominant grain constituent while feldspar and feldspathoids are present in very small quantities. Intergranular porosity is well developed, indicative of a "clean" sandstone aquifer.



Bed Numbering System for the Lisbon Valley Mine

Unit Number	Formation	Lithology	Thickness (ft)	Copper Mineralization
1	Quaternary	red and yellow sand and silt, aeolian or alluvial	0-40	None
2	Mancos	black to brownish-green shale with local gypsum	0-70 in drillholes	sporadic, low-grade
3	Dakota	buff to white sandstone, may have shale at base	15-20	
4	Dakota	buff to white sandstone, minor gray shale	15-20	local economic grades
5	Dakota	buff sandstone, fine- to medium-grained	15-20	local economic grades at base
6	Dakota	coal, grades into carbonaceous shale	20-May	minor, at top
7	Dakota	light gray shale, may grade into sandstone	20-Oct	None
8	Dakota	coal, similar to #6 but shaley or sandy with pyrite balls	20-May	low-grade
9	Dakota	light gray shale, grading into fine-grained sandstone as #10	10-May	None
10	Dakota	sandstone with local mudstone, similar to #9	0-15	local economic grades
11	Dakota	white or buff sandstone, 1-10% shale or organics, similar to #11 when white	Feb-35	major ore host, GTO & Centennial
12	Dakota	greenish shale and sandstone, often pyritic	20-May	locally minor
13	Dakota	white, buff or orange sandstone, poorly-cemented, similar to #11	20-50	major ore host, GTO & Centennial
14	Burro Canyon	varicolored shale, may grade into cherty limestone or conglomerate	70-120	
15	Burro Canyon	pure white quartzose sandstone, local shale intercalations	90-150	major ore host in Sentinel Pit
16	Burro Canyon	transition from #15 to #16; not always logged separately	30-Oct	none
17	Morrison	red or white shale, some red sandstone	10+	minor
none	Morrison	mainly shale and sandstone, some limestone and conglomerate	600-800	minor
none	pre-Morrison	other Jurassic, Triassic, Permian, and Pennsylvanian sandstones, shales, etc.	several thousand	minor except possibly Cutler Fm.

Source: Pincock, Allen & Holt (2005)

Figure 5. Stratigraphic Column Showing Burro Canyon and N Aquifers at Lisbon Valley Mine (After Arcadis 2014).

4 ENVIRONMENTAL IMPACTS

4.1 Introduction

As stated earlier, the EA is focused on groundwater impacts. Because the Affected Environment includes only the groundwater resource, it follows that the discussion of environmental impacts is limited to groundwater.

4.2 +Alternative A – Proposed Action

Partial Backfill Alternative was previously considered in the Lisbon Valley FEIS (February, 1997) but was not selected in the Record of Decision (March 26, 1997). The following lists the reasons why this alternative was not selected and the new information that supports the backfilling of only one of the pits.

Reason 1: *"The analysis indicates under both backfill scenarios, that there would be water quality impacts from backfilling the pits with material from the waste dumps; due to the chemical makeup of the waste rock backfill material, particularly the acid generating material. With the tremendous increase in surface area exposed in the rubblized backfill material, chemical reactions between this material and the groundwater could present a host of unquantifiable adverse impacts to the down gradient aquifers, resulting from chemical interactions of groundwater and the waste rock."*

Updated Information: When the FEIS was written, the geologic and groundwater information focused on the shallow aquifers. Further characterization and refinement to the groundwater model includes confining layers that provide a level of protections to the deeper N-aquifer. Quarterly monitoring reports were submitted from 1999 through 2004, summarizing the groundwater data that was generated during that period. Whetstone prepared the hydrogeologic updates after mining began in 2005 (Whetstone 2006b, 2007, 2009, 2010). The hydrogeologic evaluations included a pit water balance to predict filling rates in the open pit and a geochemical mass balance to predict TDS concentrations in the pit lake. The water balance model estimates flow annually and accounts for runoff into the pit, precipitation, groundwater discharge from the Burro Canyon aquifer into the open pit, vertical leakage to the N-aquifer, and evaporation. The evaporation from the pits and the limited recharge of the aquifer will not allow the Burro Canyon aquifer to reach the pre-mining water elevation.

Reason 1: *"The analysis indicates under both backfill scenarios, that there would be water quality impacts from backfilling the pits with material from the waste dumps; due to the chemical makeup of the waste rock backfill material, particularly the acid generating material. With the tremendous increase in surface area exposed in the rubblized backfill material, chemical reactions between this material and the groundwater could present a host of unquantifiable adverse impacts to the down gradient aquifers, resulting from chemical interactions of groundwater and the waste rock."*

Updated Information: Faults located in and along the margins of the Lisbon Valley and the cause the water-bearing units to occur as isolated blocks. Groundwater levels are not expected to fully recover in the Burro Canyon aquifer due to evaporation from limited recharge area and the discontinuity of the isolated blocks. Post-mining capping and re-vegetation of the partially backfilled pit would reduce groundwater-surface water interaction. The groundwater model predicted no pit

lake would form because the net evaporation acting upon the design pit area (6.9 acres at the pit bottom elevation of 6,020 feet amsl, Table 1) is greater than total inflow rates to the pit (groundwater seepage into the pit, precipitation, and runoff from the pit walls). A sensitivity analysis of the model was conducted by increasing the runoff to the pit lake by 10%. For this simulation, a pit lake was predicted to form in the Centennial Pit, with an approximate water depth of 40 ft.

Reason 2: *"A secondary problem associated with backfilling is the decision to select the Waste Rock Selective Handling Alternative to mitigate potential for post-mining acid rock drainage. Under this alternative, the acid generating waste rock mined from the pits will be selectively place in the waste dumps to encapsulate the acid generating material within acid neutralizing material. The intent is to encapsulate this material such that there will be no long-term acid leachates emanating from the waste dumps. By requiring a backfill of material from the waste dumps into the pits, the engineered placement and isolation of acid generating material in the dumps would be jeopardized and foregone. "*

Updated Information: Waste rock is routinely characterized in accordance with the Waste Rock Sampling Plan (LVM,2005). Additional testing was performed to further characterize waste rock, reported by Arcadis, 2014. Updated waste rock characterization included the leachate quality and acid-generating potential. Leachate quality associated with the backfill material was assessed using several different testing methods. Test methods included:

- Acid-base Accounting (ABA) testing was conducted for the 1997 FEIS (BLM 1997a), the operational characterization program (2005 through 2013), and for the column testing program in 2014 (Arcadis 2014).
- Static water leach testing of bed 14 and bed 15 material including single-pass and multiple-pass MWMP testing (Arcadis, 2014).
- Saturated column testing of bed 14 and bed 15 materials to provide additional characterization data was conducted at the request of the agencies and described in the Updated Centennial Pit Backfill Evaluation Report (Arcadis 2014).
- Bed 14 waste rock was also earlier subjected to SPLP testing as part of the 1997 FEIS (BLM 1997a).

Backfill material is not expected to generate problematic groundwater chemistry. The proposed action utilizes a mix of at least 75% Bed 14 material from the Burro Canyon Formation and 25%, maximum, Bed 15 material. The placement and isolation of waste rock with acid generating potential would be preserved when backfilling the Centennial Pit.

Reason 3: *"From the stand point of visual impact reduction, the analysis indicates that even with backfilling, there will still be surface dumps present because of the swell factor of rock once it is taken from the ground and rubblized."*

Updated Information: Lisbon Valley is rated a Class IV under the BLM's Visual Classification Rating system, which is the lowest rating, therefore visual impacts are not critical (145 IBLA 348).

Reason 4: *"With post-mining pit berming, fencing and signing, public safety issues will be minimized. The analysis indicated no known instances of public safety problems associated with the unbermed, unfenced and unsigned pits that have existed on the site for the past 20 years. "*

Updated Information: Though there have been no known instances of public safety problems associated with the unbermed, unfenced Centennial Pit, backfilling the pit will remove the potential hazards the pit poses.

Reason 5: *"Not requiring backfilling of the pits also involves a conservation of resources issue. Requiring the pits to be backfilled will render future recovery of lower grade copper ore remaining in the pits at the end of mining infeasible from an economic standpoint. Summo will mine copper reserves to an "economic limit", determined by mining costs, grade of copper and the price of copper. However, when they have reached this limit, there will still likely be lower grade copper ore remaining in the pits. Its grade would be uneconomical for recovery by Summo (now Lisbon Valley Mining Company) at prices and technology projected at this time."*

Updated Information: Lisbon Valley Mining Company has determined that the mineralization in the Centennial Pit is limited to the Burro Canyon Formation. The current mining depths intercept the lower extent of the mineralization therefore backfilling would not limit access to mineralized zones at depth. Furthermore, by reducing the area of the dumps, the lateral extent of the pits would remain available for exploration and expansion of lower grade resources. In-situ leaching processes have also been developed that allow for the recovery otherwise uneconomic resources at depth. In-situ leaching would allow mineral recovery in for un-mined and under backfilled surface areas.

IBLA Remand: In May 2007 the National Wildlife Federation et al, filed an appeal to the Interior Board of Land Appeals (Board) (97-339). On September 23, 1998, the Board (145 IBLA 348) based on their de novo review of the ROD affirmed it in part and set aside and remanded in part to allow the BLM to reconsider the backfilling alternative. The stay imposed by the Board's June 16, 1997 Order was lifted. Summo was granted the right to proceed with the Lisbon Valley Copper Project.

In the IBLA decision (145 IBLA 348), the Board concluded that the record did not support the BLM's rejection of the Open Pit Backfilling Alternative in the ROD based on concerns for impacts on water quality from acid generating material. The Board further recognized that while concerns regarding impacts from alkaline conditions may be legitimate, those concerns were not sufficiently stated in the ROD of the FFEIS, so as to serve complete rejection of the alternative (145 IBLA at 374). The Board remanded that portion of the ROD and directed the BLM to reconsider the backfill alternative.

Using the data they had at the time, the BLM conducted the analysis directed by the Board and summarized in a memorandum dated January 25, 1999, from the Moab Field Office to the Utah State Director. While the FEIS and ROD contained analyses of multiple complex geochemical and geohydrologic technical issues, the re-analysis of data summarized in this memorandum confirmed the BLM's concerns expressed in the FEIS and ROD that potential alkaline conditions

in the post-mining pit lakes could mobilize and transport metal oxyanions from mine waste material utilized as pit backfill material into underlying groundwater at the mine site. The data indicated that such mobilization and transport has a significant likelihood of adversely impacting groundwater quality and violating acceptable water quality standards.

4.3 Alternative B – Complete Backfill

Complete backfill was also previously considered. The complete backfill alternative addresses issues the same as the proposed action alternative. In addition, the complete backfill would prohibit runoff into the remaining pit and a pit lake would not be able to form due to the topography. Though there have been no known instances of public safety problems associated with the unbermed, unfenced Centennial Pit, complete backfilling of the pit will remove the potential hazards the pit poses.

4.4 Alternative C-No Action

The no action alternative results in a pit lake. Models used water balance to predict filling rates in the open pit and a mass balance to predict constituent concentrations in the pit lake. The 2009 hydrogeologic update (Whetstone 2010), predicted an approximate water elevation of 6,120 feet for the pit lake, which is 40 feet above the bottom of the previous pit design (6,080 feet). The pit was projected to fill with precipitation and runoff at a rate faster than the aquifer recharges after mining ceases. Therefore, in the initial 42 years, meteoric water entering the open pit recharges the aquifer. After 42 years, the model indicated that the shallow aquifer had sufficiently recharged to overcome evaporation, and the Burro Canyon aquifer discharges to the open pit (Whetstone 2010). However, the 2009 model (Whetstone 2010) was conducted using different final pit dimensions than those current in use in updated groundwater modeling report (Arcadis, 2014). Table 2 provides a comparison of the pit dimensions used in the 2009 hydrogeologic update and the updated dimensions used in the updated backfilling evaluation report (Arcadis 2014).Geochemical mass balance modeling of TDS in the 2009 model (Whetstone 2010) predicted that in the initial 42 years after mining, water accumulating in the pit is of higher quality than the Burro Canyon aquifer and therefore does not negatively impact the Burro Canyon aquifer. After 42 years, the model predicted that the higher TDS water from the Burro Canyon aquifer would flow into the pit.

Evapoconcentration of the surface water from the pit and inflow of groundwater from the Burro Canyon resulted in increasing TDS concentrations until the pit water reached a solubility-controlled limit, assumed to be a TDS concentration of 3,000 mg/L. As water in the pit increased in TDS, small concentration increases were predicted for the N-Aquifer due to leakage from the bottom of the pit.

Previous modeling predicted that the TDS concentration of the N-aquifer below the Centennial Pit would increase to 724 mg/L from 683 mg/L, which is a 6% percent in TDS from pre-mining conditions (Whetstone 2010).

Table 1. Comparison of Pit Design Dimensions Used in Modeling.

	Current Open Pit Design		Backfill Scenario 1 (4.6 Million Tons)		Previous Pit Design *	
Elevation (ft amsl)	Area (acres)	Volume (acre-ft)	Area (acres)	Volume (acre-ft)	Area (acres)	Volume (acre-ft)
6,020	8.4	0	6.9	0	--	--
6,040	9.5	179	7.8	147	--	--
6,060	17	380	13.6	311	--	--
6,080	25.2	736	19.5	596	1	0
6,100	44.3	1271	27.8	1002	3.4	45
6,120	53.6	2183	37.6	1591	4.3	122
6,140	69.4	3307	50.6	2398	10.7	272
6,160	75.6	4727	55.8	3451	18.4	563
6,180	103.4	6265	83.6	4606	30.1	1047
6,400 (Top of Pit)	176.3	--	176.3	--	165	--

NOTES:

Source: Whetstone (2010)

Backfill Scenarios 2, 3, and 4 include the Keystone and Penny Phases, with top-of-backfill elevations of 6200, 6260, and 6320 feet amsl.

4.5 Cumulative Impacts Analysis

4.5.1 Introduction

Cumulative effects are those effects which may occur when other past, present, and reasonably foreseeable future actions are considered in light of incremental impacts resulting from the action under analysis. When viewed collectively, any number of relatively minor actions taking place over a period time, regardless of what agency, business, person, etc. undertook such action, can result in cumulative impacts. Cumulative effects result from the spatial (geographic) and temporal (time) crowding of environmental perturbations (CEQ, 1997).

Because of the narrow scope of this EA, only cumulative effects on the groundwater resource will be considered. Such an analysis focuses on multiple actions (past, present, or reasonably foreseeable) that could affect the quality of the groundwater resource.

4.5.2 Cumulative Impact Area

4.5.3 Water Resources/Groundwater

The cumulative impact area for groundwater resources is the area shown in Map 4 in Appendix D. This area incorporates the following hydrologic code 12 units: Lisbon Canyon, Island-Coyote Wash, Upper McIntyre Canyon, Lower McIntyre Canyon and Horse Range Spring. These hydrologic units (watersheds) were selected because they are adjacent the LVM area and drain toward the Dolores River. Hydrologic units (watersheds) are used as surrogates for local groundwater systems when detailed information delineating regional groundwater flow and groundwater divides is not available. Local groundwater systems are often controlled or parallel by the surface expression of drainage (see Map Appendix D). Overall surface flow is toward the

Dolores River and based on the geologic structure, groundwater would move in a similar direction. Downward migration of groundwater from the LVM is expected to be extremely slow. The Morrison Formation, comprised of 390 feet of shale and mudstone, forms a confining layer above the N-aquifer. The rate of downward migration is approximately 0.0002 ft/yr, based on the rates identified in the groundwater model. If any cumulative degradation of groundwater from the LVM were to occur it would be diluted by the influx of water from other sources within the Upper and Lower McIntyre Canyon hydrologic units (BLM 1997a).

The cumulative impact area is about 99,833.42 acres in size. The timeframe for the impact analysis is the life of the mine plus eight years for a total of 18 years.

4.3.3.2 Past and Present Actions

Past and present actions within the cumulative impact area are uranium mining and exploration, copper mining, and oil and gas development and water development. Though no uranium mines are documented with the BLM or appear on the 1:24,000 USGS quadrangle maps within the cumulative impact area, based on geologic maps, the Morrison Formation where most uranium mining occurred in the area outcrops in McIntyre Canyon in Colorado and along the base of Pine Ridge in the Island-Coyote Hydrologic Unit. An assumption is made that some small scale mining took place in the 1950's in these areas. Based on experience with other mines in the Morrison Formation within Southeastern Utah, these mines were likely to have been dry. Uranium exploration probably occurred within the cumulative impact area between the mid-1950s to late 1970s. The BLM does not know if groundwater was encountered during these drilling activities. However, during the uranium exploration drilling that was conducted in 2007 and 2008, northwest of LVM within the Lisbon Canyon and Upper McIntyre Hydrologic Units, no groundwater was encountered during drilling operations.

The Blackbird copper mine (precursor to the LVM), operated on an intermittent basis beginning in the 1950s and ending in the early 1970s. Copper exploration in the area has occurred intermittently from the 1950s to the present. Copper mining in the area resulted in numerous small mines and prospects which all have some degree of potential environmental impact from sediment transport and the leaching of waste dumps. However, none of these small historical operations are known to intersect the water table and for that reason have a low probability of groundwater impact.

Some subsurface water is encountered during drilling in perched water zones within the valley fill and in water zones where the drilling penetrates the Burro Canyon Formation where it occurs below the ground surface. Drill holes through aquifers have to meet State cementing requirement to seal off the aquifer.

Past oil and gas operations include drilling and production of oil and gas wells which continues to this day. Oil and gas drilling operations are required to protect groundwater resources through casing and cementing the water bearing zones. Hydraulic fracturing is rarely used due to the geologic structure in the area. Oil and gas drilling within the cumulative impact area occurs along the northeastern limb of the Lisbon Valley Anticline, where water flow is toward the northeast, east and southeast away from the central part of Lisbon Valley. Twenty-one oil and

gas wells have been drilled within the cumulative impact area. Of these, 13 have been plugged and abandoned, 3 have been shut in and 5 are producing. Drilling operations for oil and gas are required to case water bearing zones to protect groundwater resources.

Each existing well represents a potential source of contamination to groundwater resources. There is no information available which suggests that contamination has occurred. Continued development of well-field technology and the use of best management practices in well completion and abandonment should address the majority of potential effects. Because completion zones are deep, generally over 7,000 feet deep, the likelihood of contamination of shallow groundwater of suitable quality for use is low. In any case, as additional wells are plugged and abandoned, and the mechanical integrity of casing and cement used for plugged degrades with age, the potential for impacts to groundwater could increase into the future to some (unknown) degree.

Present actions within the cumulative impact area include the LVM and water uses. The LVM began operations in 2004. Water pools in the bottom of two of the three open pits at the mine. Most of this water is from precipitation and melting snow and tends to evaporate quickly creating damp areas in the bottoms of the pits.

There are 263 water rights actions located within the cumulative impact area. These actions include water wells for domestic and livestock use and a majority of which are used for production water at the LVM (Division of Water Rights, 2015). The water rights access different water zones and aquifers. Production and monitoring wells at the LVM are completed in the either the Burro Canyon or the Navajo aquifers. A majority (239) of these water right actions have lapsed water rights or have been rejected and were mainly related to mining. Of the remaining 25 water rights, 23 are for production water and monitoring wells for the LVM, two of the water rights are owned by the BLM and are in unnamed drainages; one located southeast of the mine and one on Pine Ridge. Two of the water rights are for water wells located southeast of the LVM.

One of the water wells located southeast of the mine is 60-feet deep and used for livestock. The other water well completed at a depth of 284 feet in sandstone. It is used for livestock and domestic use and irrigation.

4.3.3.3 Reasonably Foreseeable Action Scenario

Reasonably foreseeable actions within the cumulative impact area are oil and gas development copper exploration and the proposed action.

Currently there are two authorized Applications to Drill (APDs) for oil and gas within the cumulative impact area. The Reasonably Foreseeable Development (RFD) Scenario for Oil and Gas (BLM, 2005) assessed oil and gas development in greater Lisbon Valley. The RFD projected an average of 2 to 4 wells drilled annually in the Lisbon Valley area over 15 years, or approximately 30 to 60 wells. The projection includes the Big Indian Valley and its western flanks and Lisbon and its eastern and western flanks. The western flanks of Big Indian Valley, Big Indian Valley and the western flanks of Lisbon Valley area have experienced more interest in drilling due to favorable drilling results. Six oil and gas wells have been drilled in Lisbon

Valley proper and all have been plugged and abandoned which indicates unfavorable conditions for these resources to occur within the core of the Lisbon Valley anticline. Though the RFD assumed that there would be an average of 1-2 wells drilled annually in the greater Lisbon Valley area for a total of 15 to 30 wells over the next 15 years, it is not likely that this drill projection would include the valley itself. Maybe 1 to 2 wells in Lisbon Valley within the next 15 years could be assumed, but it is doubtful that the rate would be more than this. Estimated surface disturbance for two wells assuming road and pad construction to be 30 acres. Three approved APDs are located within the cumulative impact area and are located to the northwest of the LVM. Two are within the Lisbon Canyon Hydrologic Unit and one within the Upper McIntyre Hydrologic Unit portions of the cumulative impact area (see Map in Appendix D).

As was stated under past and present actions, any future well represents a potential source of contamination to groundwater resources. There is no information available which suggests that contamination has occurred in the past.

LVM has an authorized Mining Plan of Operations for Exploration within the Upper McIntyre Canyon portion of the cumulative Impact Area. The authorized mine plan proposes to drill 150 exploration drill holes with a maximum depth of 600 feet. These exploration drill holes could encounter groundwater during drilling in isolated perched water zones within the valley fill and in water zones where the drilling penetrates the Burro Canyon Formation where it occurs below the ground surface. Drilling into/or through an aquifer has to meet State cementing requirement to seal off the aquifer.

4.3.3.4 Cumulative Impact Analysis

Alternative A – Proposed Action

The cumulative impacts to groundwater within the cumulative impact area are expected to be small to negligible. The Centennial Pit would be backfilled to a grade of 6,200 feet or higher amsl to cover the Burro Canyon Formation exposed in the pit walls. This would prevent any groundwater from the Burro Canyon from collecting in the bottom of the pit. Backfilling of the pit would also prevent the development of a pit pool that would otherwise develop if the pit were left open.

The pit backfill is not likely to reach a saturated condition that would lead to leaching and migration of oxyanions into the N-aquifer. If this were to occur, testing has shown that the elements of concern would reach equilibrium. The estimated conductivity to the Morrison Formation confining layer is 0.0002 ft/day which is very slow and not expected to degrade the Navajo aquifer beyond acceptable limits. Those acceptable limits are….

As described in Chapter 3, the Burro Canyon aquifer system in the Lisbon Valley is considered a closed system. Regional groundwater flow in the N-aquifer is generally east toward the Dolores River (Freethey and Cordy 1991); however, because the complex geologic structure in Lisbon Valley isolates the N-aquifer, the groundwater gradient follows the northwest-to-southeast trending valley, with flow in a northeast direction and toward Lisbon Canyon. For these reasons, the impacts from backfilling the Centennial Pit would be localized to the mine site and would not add to the impacts of oil and gas exploration and development and other groundwater uses in the

area. The two water wells located southeast of the mine are shallow and seem to be completed in water zones that have no connection to the aquifer systems that underlie the mine.

Alternative B- Complete Backfill

Under the Complete Backfill alternative the effects would be similar to those described for the proposed action. The additional thickness and capping of a complete backfill would add further protection to groundwater resources. Additional material would exclude runoff from pit walls reducing potential for surface water accumulation. This would also have reduced impacts to topography through reducing the size of the waste dumps and filling the open pits. The analysis indicated positive impacts from a complete backfill to visual resources, more area returned to vegetative cover, and reduced risk to public safety.

Alternative C -No Action

Under the No Action alternative the effects would be the same as those described in the FEIS. Water, mainly from precipitation would accumulate in the bottom of the Centennial pit. The analysis in the FEIS predicted the post-mining final pit floor, in the Centennial pit, would expose the shallow aquifer (Burro Canyon) and the Entrada Sandstone. A post-mining pit lake of between 1 and 84 feet deep is predicted to form. Pit lake water could move into and out of the shallow aquifer and the Entrada/Navajo aquifer (FEIS, 1997:4-25). Since the natural quality of shallow aquifer water exceeds state standards for agricultural uses no post-mining beneficial use of this water is expected. In addition, evapoconcentration of pit lake water could further degrade water quality with increased concentrations of Total Dissolved Solids (TDS), sulfate, and metal oxyanions. The pit lake water would not be available for any potential future beneficial uses. (FEIS, 1997:ES-6).

Approximately 0.3 percent of the pit lake volume would seep into the underlying Morrison Formation per year and eventually mix with the N Aquifer; however, the water is not expected to impact the N Aquifer due to changes in redox conditions in the Morrison Formation and dilution with the N Aquifer. However, due to faulting in the area, any degradation would occur within proximity of the mine site and would not add to the impacts of oil and gas impacts of oil and gas exploration and development and other groundwater uses in the area.

5 CONSULTATION AND COORDINATION

5.1 Introduction

The issue identification section of Chapter 1 identifies those issues analyzed in detail in Chapter 4. The ID Team Checklist provides the rationale for issues that were considered but not analyzed further. The issues were identified through the public and agency involvement process described in sections 5.2 and 5.3 below.

5.2 Persons, Groups, and Agencies Consulted:

Table 2. List of all Persons, Agencies and Organizations Consulted for Purposes of this EA.

Name	Purpose & Authorities for Consultation or Coordination	Findings & Conclusions
Utah Department of Environmental Quality, Groundwater Protection Section (Keith Eagan)	The State of Utah holds primacy over groundwater. The Utah Code, Title 19, Chapter 5 and groundwater protection. Review of testing and procedures to ensure no unnecessary or undue degradation of the groundwater resource.	Backfilling is the preferred method for protection of the groundwater resource in the Centennial Pit. The Utah Department of Environmental Quality is working with LVM to develop a long-term monitoring and closure plans for the backfilled area.
United States Geological Survey (David Naftz and Tom Marston)	Review Waste Rock Analyses Plans and provides Technical Assistance for the Department of the Interior	There was lack of concurrence with regard to the waste rocks testing on bed 15. The USGS was not prepared to support the findings of the laboratory. The USGS supported the backfilling of the Centennial Pit with limitations restricting the ratio of bed 15 materials to 25% of the total backfill.
Utah Division of Oil, Gas, and Mining (UDOGM) (Dana Dean, Peter Brinton, and Mike Bradley)	The Utah Division of Oil, Gas, and Mining primary function is permitting and inspection/enforcement procedures to ensure proper mine operation and the reclamation of affected lands.	Backfilling is the preferred method of non-acid generating waste rock handling and long term closure in the Centennial Pit. UDOGM preferred complete backfill but accepted an elevation of 10 feet higher than the Burro Canyon.
Utah Division of State History, State Historic Preservation Office (SHPO)	SHPO provides guidance to agencies and governments who are affected by the Historic Preservation Act.	SHPO was not consulted with regard to backfilling. The site was assessed and consultation conducted as part of the FEIS**36 CFR 800 Subpart B-The section 106 Process** **§ 800.3 Initiation of the section 106 process.** (a) (1) *No potential to cause effects*. If the undertaking is a type of activity that

Name	Purpose & Authorities for Consultation or Coordination	Findings & Conclusions
		does not have the potential to cause effects on historic properties, assuming such historic properties were present, the agency official has no further obligations under section 106 or this part. ***BLM Handbook 8110 – Guidelines for Identifying Cultural Resources."*** We can waive conducting an inventory .23 B. Survey Not Required. 2. Human activity within the last 50 years has created a new land surface to such an extent as to eradicate locatable traces of cultural properties. 6. The nature of the proposed action is such that no impact can be expected on significant cultural resources. **Actions Not Normally Requiring Inventory** **Minerals** 14. Approving minor modifications to or minor variances from activities described in an approved underground or surface mine plan that does not affect historic properties.

5.3 Summary of Public Participation

5.3.1 Response to Public Comment

Public input regarding the Proposed Action was solicited through a scoping and public review process through a press release and was published as a legal notice that appeared in the San Juan Record on April 15, 2014. The scoping period began on April 9, 2014 and ended on May 12, 2014.

The 30 day public comment period was from July 31, 2015 to August 30, 2015. The BLM received five comment emails. Four of the respondents were in favor of complete backfill of the Centennial Pit. One commenter questioned the validity of the tests and the competency of the consultants conducting the tests. And another commented on photographic content of the EA and

format and pointed out an error message that appeared in the EA. The error message was fixed in the EA. None of the other comments that were received required changes to the EA.

Though not reflected in the public responses to the Proposed Action, past experience with mining-related projects has shown that certain groups and members of the public are generally opposed to mining and that these projects can be contentious. Therefore, based on the comments received from the public and the analyses in the EA, we have determined that the effects of the Proposed Action on the quality of the human environment are not considered "highly controversial" because there is not a substantial dispute as to its size, nature, or effect.

5.4 Lists of Preparers

Table 3. List of BLM Preparers

Name	Title	Responsible for the Following Section(s) of this Document
David Pals	Geologist	Project lead, content of EA
Lisa Bryant	Asst. Field Manager	Document Review
Rebecca Doolittle	NEPA Planner	Document Review

Table 4. Non-BLM Preparers

Name	Title	Responsible for the Following Section(s) of this Document
Jon F. Kaminsky	Principal, Mesa Hydro-Logic LLC	Entire Document

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6.1 Glossary of Terms

Term	Definition
Alkaline	Term used to describe pH conditions greater than 7 (basic). Not to be confused with the term "alkalinity."
Allochems	A term used to describe the recognizable grains in carbonate rocks. Any fragment from around 0.5 mm upwards in size may be considered an allochem.
Alluvium	Loose, unconsolidated soil or sediments, which has been eroded, reshaped by water in some form, and deposited in a non-marine setting.
Aquifer	A geologic formation(s) that is water bearing. A geological formation or structure that stores and/or transmits water, such as to wells and springs. Use of the term is usually restricted to those water-bearing formations capable of yielding water in sufficient quantity to constitute a usable supply for people's uses.
Aquitard	A water-saturated sediment or rock whose permeability is so low it cannot transmit any useful amount of water.
Arkosic	Modifier terms for a sedimentary rock containing a significant quantity of feldspar minerals
Authigenic	A term applied to minerals formed in the place of occurrence.
Azurite	A copper-bearing mineral, commonly found in the oxidized zone of copper deposits with the chemical formula $Cu_3(CO_3)_2(OH)_2$
Bicarbonate	One of the so-called major dissolved constituents in groundwater, with a formula od HCO_3^-. Bicarbonate, along with carbonate, are major contributors to a water's alkalinity, which is a measure of the water's ability to neutralize or "buffer" acids.
Brine	Salt water generally containing greater than 5 percent dissolved salts.
$CaCO_3$	Calcium carbonate, a mineral
Flouroapatite	A phosphate mineral with the formula $Ca_5(PO_4)_3F$ (calcium fluorophosphate).
Carbonate	In chemistry, a carbonate is a salt of carbonic acid, characterized by the presence of the carbonate ion, CO_3^{2-}. Carbonate is a source of alkalinity in water. In geology and mineralogy, the term "carbonate" can refer both to carbonate minerals and carbonate rock
Colluvium	Unconsolidated sediments that have been deposited at the base of hillslopes by either rainwash, sheetwash, slow continuous downslope creep, or a variable combination of these processes
Facies	A distinctive rock unit that forms under certain conditions of sedimentation, reflecting a particular process or environment

Term	Definition
Feldspathoids	The feldspathoids are a group of tectosilicate minerals which resemble feldspars but have a different structure and much lower silica content. They occur in rare and unusual types of igneous rocks
Ferrosilite	Iron-rich end member of the pyroxene silicate mineral series with a formula of FeSiO3, commonly found in igneous and metamorphic rocks
Hydraulic conductivity	The rate at which water can flow through a rock or sediment under a unit hydraulic gradient.
Hydroxide	Hydroxide is a common dissolved constituent in water, and contributes to a water's alkalinity.
Illite	A non-expanding, clay-sized, micaceous mineral, a variable chemical composition.
Illuviated	The deposition in an underlying soil layer of colloids, soluble salts, and mineral particles leached out of an overlying soil layer.
Kaolinite	A clay mineral, part of the group of industrial minerals, with the chemical composition $Al_2Si_2O_5(OH)_4$.
Lazurite	A feldspathoid is a mineral containing sulfate, sulfur and chloride is a member of the sodalite mineral group.
Meteoric	Meteoric water is the water derived from precipitation (snow and rain).
No Action Alternative	Under NEPA analysis, the no-action alternative would mean that the proposed action would not take place and the resulting environmental effects from taking no action would be compared to the effects of permitting the proposed activity or an another alternative activity to move forward.
Pedoliths	The soil layer at or near land surface
pH	The negative log of the activity of the hydrogen ion in an aqueous solution. Solutions with a pH less than 7 are said to be acidic and solutions with a pH greater than 7 are basic or alkaline. Pure water has a pH of 7.
Pyrite	Iron sulfide (FeS), a metallic mineral
Saline	Salt water generally containing between 3 and 5 percent dissolved salts as in seawater generally speaking.
Smectite	A group of soft clay minerals that includes montmorillonite, a clay with variable chemical composition, and variable water content that increases greatly in volume when it absorbs water.
Transmissivity	Transmissivity is a measure of how much water can be transmitted horizontally through a certain thickness of rock or sediment, such as to a pumping well
Uranium6+	Uranium ion representing the uranium (VI) oxidation state and is known to form compounds such as uranyl carbonate,

Term	Definition
	uranyl chloride and uranyl sulfate.

6.2 Acronyms Used in This Document

Acronym	Definition
ABA	Acid-base accounting, an analytical procedure that provides values to help assess the acid-producing and acid neutralizing potential of overburden (waste) rock prior to mining.
AGP	Acid-generating-potential, the amount of acid that can be generated by weathering of minerals in a rock without considering the acid neutralizing potential, a term commonly used in acid-base accounting.
AGR	Acid-generation rate, the rate at which a specific rock can generate acidic water, a term commonly used in acid-base accounting.
amsl	Above mean sea level, referring to elevation.
AN/FO	Ammonium Nitrate/Fuel Oil, a blasting agent, commonly used in mining and usually composed of a mixture of ammonium nitrate and #2 diesel fuel oil.
ANP	Acid-Neutralizing Potential, the amount of acid that can be consumed by minerals in a rock or soil, a term commonly used in acid-base accounting.
ASTM	American Society for Testing and Materials, a not-for-profit organization that provides a forum for the development and publication of international voluntary consensus standards for materials, products, systems and services.
bbls.	Barrels, a unit of volume, commonly used by the oil and gas industry, and equal to 42 gallons.
BC	Burro Canyon Formation
BEE	Best engineering estimate
bgs	Below ground surface
BLM	Bureau of Land Management, an agency of the U.S. Department of Interior that that administers more than 247.3 million acres of public lands in the United States under a mandate of multiple-use.
CAA	Clean Air Act, a U.S. federal law designed to control air pollution on a national level.
CEA	Cumulative Effects Area, refers to the area in which cumulative effects are considered when performing a NEPA analysis.
CEQ	Council of Environmental Quality, a division of the Executive Office of the President that coordinates federal environmental efforts in the United States and works closely with agencies and other White House offices in the development of environmental and energy policies and initiatives.
CFR	Code of Federal Regulations
cm	Abbreviation for centimeter, a unit of length and equal to 1/100 of a

Acronym	Definition
	meter.
CWA	Clean Water Act, The primary federal law in the United States governing water pollution.
DO	Dissolved oxygen
DR	Decision Record, a NEPA document, synonymous with Record of Decision (ROD).
EA	Environmental Assessment, is a document required by NEPA for certain federal actions when the certainty of impacts to the environment are not known, or when such impacts are not expected to occur". If analysis under an EA determines that environmental impacts are indeed significant, an EIS generally is prepared as the follow up document used for the federal decision-making.
EIS	Environmental Impact Statement, is a document required by NEPA for certain federal actions "significantly affecting the quality of the human environment". An EIS is a tool for federal decision making.
ENBB	Electronic NEPA Bulletin Board, an on-line database federal agencies use to post NEPA documents for public notification purposed.
EPA	Environmental Protection Agency. A U.S. government agency.
ESA	Endangered Species Act, U.S. federal law designed to protect and recover imperiled native plant and animal species and the ecosystems upon which they depend.
et seq.	Latin phrase, abbreviation for *et sequentes*, meaning "and the following." Commonly used in technical and legal documents,
FEIS	Final Environmental Impact Statement.
FLPMA	Federal Land Policy and Management Act, a United States federal law that governs the way in which the public lands administered by the BLM are managed. The law was enacted in 1976 by the 94th Congress and is found in the United States Code under Title 43.
FONSI	Finding of Non-Significant Impact, a document issued when environmental analysis during the EA process determines that a project will have no significant impacts on the quality of the environment. A FONSI typically allows the preparing agency to proceed with decision-making without having to complete an EIS.
GIS	Geographic information system, a system designed to capture, store, manipulate, analyze, manage, and present all types of spatial or geographical data.
gpm	Gallons per minute, a volumetric flow rate, typically used in the water well industry.
IBLA	Interior Board of Land Appeals, an appellate review body that exercises the delegated authority of the Secretary of the Interior to issue final decisions for the Department of the Interior.
ICDD	The International Centre for Diffraction Data, a non-profit scientific organization dedicated to collecting, editing, publishing, and distributing powder diffraction data for the identification of crystalline

Acronym	Definition
	materials.
ICP-AES	Inductively coupled plasma atomic emission spectroscopy, an analytical technique used for the detection of trace metals.
ICP-MS	Inductively coupled plasma mass spectrometry, a type of mass spectrometry analytical technique which is capable of detecting metals and several non-metals at low .concentrations
ID	Inter-disciplinary.
IDT	Inter-disciplinary team, a group of specialists involved in environmental analysis, commonly for the purpose of fulfilling NEPA obligations.
kt	Abbreviation for kiloton, a unit of mass equal to 1,000 metric tons.
L	Abbreviation for liter, a unit of volume in the metric system
LLC	Limited Liability Company, a legal form of a company that provides limited liability to its owners in many jurisdictions.
LVM	Lisbon Valley Mine
LVMC	Lisbon Valley Mining Company
M	Abbreviation for a million, a quantity of 1,000,000.
MBTA	Migratory Bird Treaty Act, a U.S. federal environmental law enacted to protect migratory birds between the United States and several foreign countries party to the treaty
mg	Abbreviation for milligram, a unit of mass in the metric system equal to 1/1000 of a gram or one millionth of a kilogram.
MLA	Mineral Leasing Act, a 1920 United States federal law that governs the way in which certain mineral deposits (e.g., coal, phosphate, oil, gas, sodium, etc.) on federally-owned lands are administered. The MLA has been extensively amended over the years since first passing.
MODFLOW	Modular Three-Dimensional Finite-Difference Ground-Water Flow Model, a finite-difference flow numerical model, which is a computer code that solves the groundwater flow equation. Produced by the United States Geological Survey, the program is used by hydrogeologists to simulate the flow of groundwater through aquifers numerical modeling.
MT	Abbreviation for a million tons, a unit of weight.
MWMP	Meteoric Water Mobility Extraction Procedure, a test method for the percolation of meteoric water through a column of mine rock to determine the potential for dissolution and mobility of certain constituents contained in the rock.
NHPA	National Historic Preservation Act, a U.S. federal law enacted for the purpose of preserving historical and archaeological sites in the United States of America.
NEPA	National Environmental Policy Act, a U.S. federal environmental law that established a U.S. national policy promoting the enhancement of the environment. Additionally, it established the President's Council on Environmental Quality (CEQ).
NI	Not impacted. Used to indicate whether a specific resource would not be impacted by the proposed action under NEPA analysis.

Acronym	Definition
NNP	Net neutralization potential, the difference between the acid neutralization potential and acid generation potential, a term commonly used in acid-base accounting.
NP	Not present. Used to indicate whether a specific resource is present in the area under NEPA analysis.
NPDES	National Pollutant Discharge Elimination System, a permit program under the Clean Water Act which controls water pollution by regulating point sources that discharge pollutants into waters of the United States.
NPR	Neutralization potential ratio, a term commonly used in acid-base accounting to describe whether material is non-acid generating by dividing the value for ANP by the value of AGP.
NRCS	Natural Resource Conservation Service, an agency of the U.S. Department of Agriculture that provides technical assistance to farmers and other private landowners and managers.
ORP	Oxidation-reduction potential, a term used to describe the equilibrium of ions in a solution under test, and is the measure of the tendency of a chemical species to acquire electrons and thereby be reduced.
PAG	Potentially acid-generating, a term commonly used in acid-base accounting to describe material which has the potential to generate acidic leachate when in contact with water.
PI	Potentially impacted. Used to indicate whether a specific resource is potentially impact by the proposed action under NEPA analysis.
PL	Public law, refers to the actual act enacted by congress. The citation for each enacting and amending act includes the public law or chapter number, division, title, and section numbers (if any), the date of enactment, and the Statutes at Large volume and page number.
PM10	Particulate matter with a diameter of less than 10 micro-meters. A term used in air quality analysis to represent respirable pollutants in the air.
POO	Plan of operations, a document describing a mining operation that among other things, contains information at a sufficient level of detail for the agency (e.g., BLM) to determine whether or not the POO prevents unnecessary or undue degradation. The format and content for a BLM POO is described at 43 CFR 3809.401 Surface Management Regulations.
PVC	Polyvinyl chloride, a widely produced synthetic plastic polymer, commonly used by the construction industry for piping/plumbing applications.
PV	Pore volume. The volume of non-solid space contained in a certain volume of rock, commonly filled with either air or water. Often taken to refer to the amount of water required to completely flush through a certain amount of permeable rock.
PV0.5	One-half of a pore volume, or half the calculated volume of water required to completely flush through a certain volume of permeable rock.

Acronym	Definition
PV1	One pore volume, or the calculated volume water required to completely flush through a certain volume of permeable rock
PV2	Two pore volumes, or the calculated volume water required to completely flush twice through a certain volume of permeable rock.
PV3	Three pore volumes, or the calculated volume water required to completely flush thrice through a certain volume of permeable rock.
QA	Quality Assurance, the maintenance of a desired level of quality in a service or product, especially by means of attention to every stage of the process of delivery or production.
QC	Quality Control, the observation techniques and activities used to fulfill requirements for quality.
R	Range, a term used in the U.S. public land survey system used to denote a distance of east or west from a principal meridian, nominally in units of six miles.
RCRA	Resource Conservation and Recovery Act, enacted in 1976, is the principal federal law in the United States governing the disposal of solid waste and hazardous waste.
RMP	Resource Management Plan, a land use decision-making document that provides guidance for Bureau of Land Management decisions in a designated area. The plan is created through an open public process, utilizing the input from those who have an interest in these public lands, and the surrounding communities.
ROD	Record of Decision, the formal decision document of the U.S. government which is recorded for the public, commonly, but not limited to NEPA decisions.
s	Abbreviation for second, one 1/60 of a minute.
SAP	Sampling and Analysis Plan, a document prepared to describe the environmental sampling protocols, quality assurance and quality control used when obtaining samples to characterize certain aspects of the environment.
SITLA	School and Institutional Trust Lands Administration, At the time of statehood, Congress granted parcels of land to Utah from which revenue could be generated to support state institutions, including public schools, hospitals, teaching colleges, and universities.
SPLP	Synthetic Precipitation Leaching Procedure, a U.S. EPA SW-846 test method that can be used with soil samples from a contaminated site to estimate the site-specific adsorption-desorption potential of a contaminant that may impact ground water.
SURFACT	A proprietary groundwater flow and transport numerical modeling computer code, produced by Hydrogeologic, Inc., based on the USGS code MODFLOW with added enhancements consisting of sub-surface (SURF) modules and analysis of contaminant transport (ACT) modules.
SWPPP	Storm Water Pollution Prevention Plan, a plan required by the U.S. EPA in order to issue a National Pollutant Discharge Elimination

Acronym	Definition
	Permit.
T	Township, a term used in the U.S. public land survey system used either to denote a distance north or south from a referenced baseline, nominally in units of six miles, or as a synonym for survey township, a square parcel of land containing 36 square miles.
t	Abbreviation for ton, a unit of weight or mass.
TDS	Total dissolved solids, a measure of the combined content of all inorganic and organic substances contained in a liquid in molecular, ionized or micro-granular (colloidal sol) suspended form in water.
UAC	Utah Administrative Code, the effective rules issued by agencies of the state of Utah.
UDEQ	Utah Department of Environmental Quality, State of Utah agency which implements State and federal environmental laws and work with individuals, community groups, and businesses to protect the quality of our air, land and water
UDOGM	Utah Division of Oil, Gas and Mining, UDNR agency whose mission is to regulate the exploration and development of coal, oil and gas, and other minerals.
UDNR	Utah Department of Natural Resources, a State of Utah agency whose mission is to manage and protect the State's natural resources. UDNR is composed of seven agencies: State Parks & Recreation; Oil Gas & Mining; Wildlife Resources; Water Rights; Water Resources; Forestry, Fire and State Lands; and Geological Survey.
UDWQ	Utah Division of Water Quality, agency of the UDEQ, whose mission is to protect surface and groundwater quality to allow beneficial uses and to protect public health.
UDWR	Utah Division of Water Resources, an agency of the UDNR, with the mission to plan, conserve, develop and protect Utah's water resources.
USC	United States Code, a consolidation and codification by subject matter of the general and permanent laws of the United States. It is prepared by the Office of the Law Revision Counsel of the United States House of Representatives.
USDA	U.S. Department of Agriculture, U.S. federal executive department responsible for developing and executing federal government policy on farming, agriculture, forestry, and food.
USFS	United States Forest Service, an agency of the U.S. Department of Agriculture that administers the nation's 154 national forests and 20 national grasslands.
USGS	United States Geological Survey, a scientific agency of the United States Government, under the Department of Interior, it studies the landscape of the United States, its natural resources, and the natural hazards that threaten it. The organization has four major science disciplines, concerning biology, geography, geology, and hydrology. The USGS is a fact-finding research organization with no regulatory

Acronym	Definition
	responsibility.
WBD	Watershed boundary dataset, a term used to describe the framework used by various agencies define the areal extent of surface water drainage to a point, accounting for all land and surface areas. The WBD is commonly available as a GIS dataset from the NRCS or USGS.
XRD	X-ray powder diffraction, a rapid analytical technique primarily used for identification of a crystalline material and can provide information on unit cell dimensions. The analyzed material is finely ground, homogenized, and average bulk composition is determined.