Appendix A

Revised Section 3.4, Water Resources and Geochemistry

3.4 Water Resources and Geochemistry

3.4.1 Affected Environment

3.4.1.1 Hydrologic Setting

The proposed project is located within the Humboldt River basin in north-central Nevada. The proposed project area is composed of the area encompassed by the Plan of Operations (PoO) boundary, the Bootstrap Haul Road, power connection yard, secondary access road entrance, and the power transmission line corridor that occurs outside the project PoO boundary. These features are indicated in **Figure 2-2**. The Humboldt River flows westward within a closed basin that terminates at the Humboldt Sink south of Lovelock. The entire Humboldt River basin covers an area of nearly 17,000 square miles.

The proposed project is located within the Boulder Creek watershed within the Boulder Flat Hydrographic Area 61 (**Figure 3.4-1**). The headwaters of Boulder Creek are in the Tuscarora Mountains located east of the proposed project. The hydrologic study area for direct and indirect impacts to water resources consists of the project area and the upper Boulder Creek watershed including tributaries that join Boulder Creek upgradient of Rodeo Creek (approximately 0.25 mile upgradient of Boulder Valley Monitoring Plan (BVMP) monitoring station BC-A located in **Figure 3.4-2**). ***Due to the footprint of the proposed West Waste Rock Disposal Facility (WRDF), the study area for direct and indirect project impacts also extends into 275 acres of the Antelope Creek watershed in the northwest portion of the PoO boundary. No direct or indirect project impacts would occur upstream of BVMP monitoring station ANT-1 (Figure 3.4-3). Downstream of the proposed project area, Antelope Creek monitoring has been conducted at stations ANT-2 and ANT-3 (Figure 3.4-3) for a number of years (Barrick Goldstrike Mines Inc. [BGMI] 2010). Station ANT-2 reflects water from both Antelope Creek and Little Antelope Creek; the latter drains the watershed around the proposed Hollister Project. Therefore, the study area boundary for direct and indirect effects from the proposed Arturo Mine project is upstream of ANT-2, reflecting the sub-watershed where drainage from the project area could contribute to Antelope Creek. This is further discussed in Section 3.4.2.***

This comprises a ***study*** area of approximately ***39*** square miles (approximately ***24,960*** acres). Elevations in the study area range from approximately 6,100 feet above mean sea level (amsl) along the watershed divide, to approximately 5,200 feet amsl along Boulder Creek (**Figure 3.4-2**).

The Cumulative Effects Study Area (CESA) for water resources encompasses six designated hydrographic basins and approximately 2,105 square miles. These six hydrographic basins are listed in **Table 3.4-1** and shown in **Figure 3.4-1**. All six basins drain southward to the Humboldt River. The CESA is bounded by the Tuscarora Mountains on the north, the Adobe Range and the Independence Mountains on the east, and the Humboldt River on the south. The western boundaries of the Willow Creek and Rock Creek groundwater basins form the western boundary of the CESA. Elevations within this CESA range from 8,800 feet amsl in the Tuscarora Mountains to 4,500 feet amsl along the Humboldt River. The CESA for water resources in this Environmental Impact Statement (EIS) is identical to the CESA analyzed in the Cumulative Impact Analysis of Dewatering and Water Management Operations for the Betze Project, South Operations Area Project Amendment, and Leeville Project (Bureau of Land Management [BLM] 2000b), Betze Project Draft Supplemental EIS (BLM 2000c), Betze Pit Expansion Project Draft Supplemental EIS (BLM 2008b), Leeville Project Final Supplemental EIS (BLM 2010b), and South Operations Area Project Amendment Cumulative Effects Final Supplemental EIS (BLM 2010a).

Table 3.4-1 Hydrographic Basins Within the CESA for Water Resources

Nevada Designated Hydrographic Basins	Basin Number	Approximate Land Area (square miles)
Susie Creek Area	50	220
Maggie Creek Area	51	410
Marys Creek Area	52	60
Boulder Flat	61	560
Rock Creek Valley	62	450
Willow Creek Valley	63	405

Sources: Maurer et al. 1996; Nevada Division of Water Resources (NDWR) 2010a.

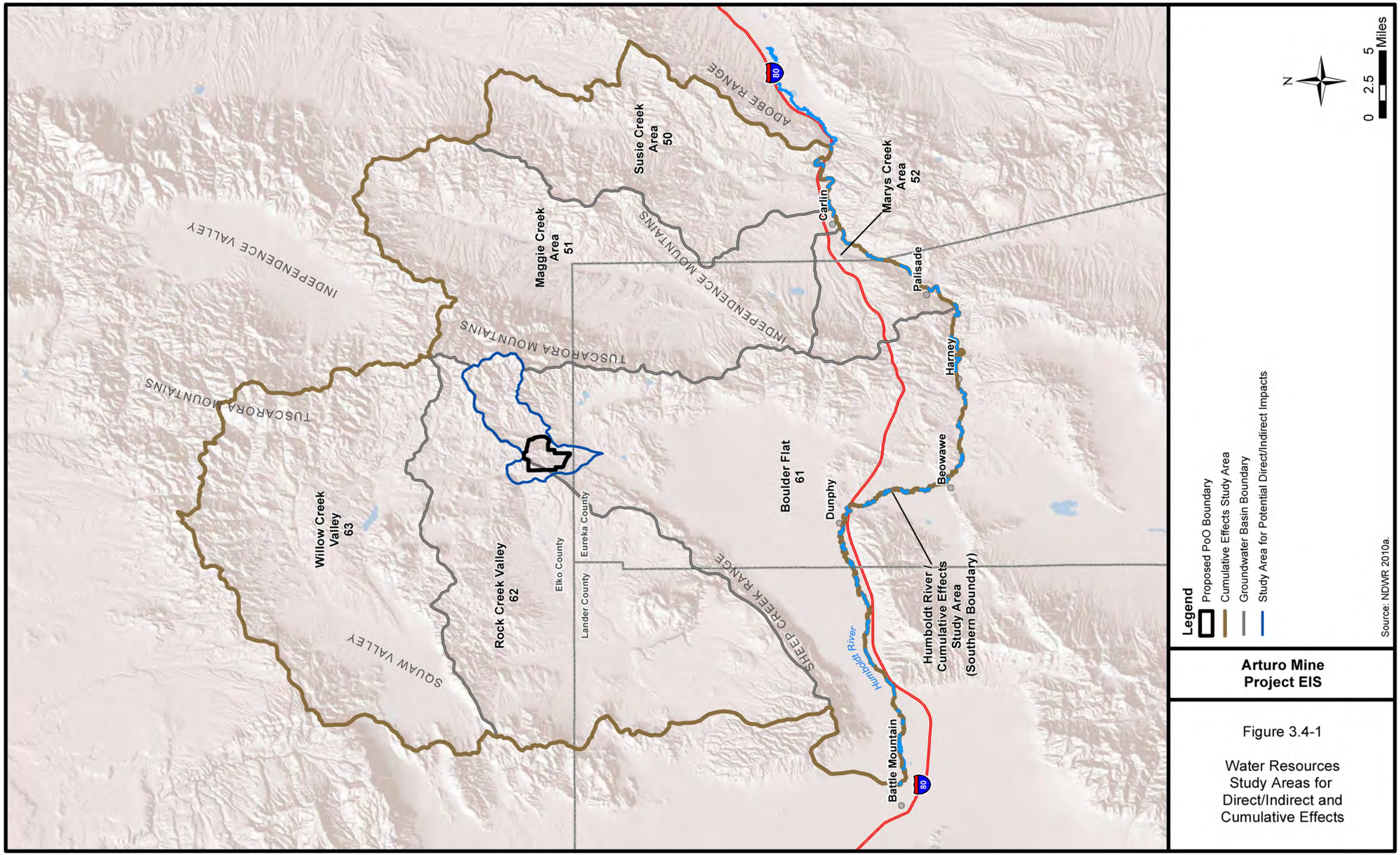
Regionally, the average annual precipitation varies, but it generally increases with elevation. Most of the precipitation falls during winter and spring. Historically, total annual precipitation generally has ranged from 14 to 20 inches at higher elevations in the Tuscarora Mountains to less than 10 inches at lower elevations on Boulder Flat (U.S. Department of Agriculture-Natural Resources Conservation Service 1998). In the study area, the average annual precipitation is approximately 10.7 inches (SRK Consulting [U.S.], Inc. [SRK] 2010a). The months of July, August, and September are relatively dry, and most precipitation occurs during November through March. The average annual lake evaporation is approximately 44.6 inches (SRK 2010a), far exceeding precipitation amounts. Most rainfall and snowmelt is removed by evapotranspiration; the remainder recharges groundwater.

3.4.1.2 Surface Water Resources

This section describes surface water resources from the standpoint of water quantity, water quality, and related features such as stream channels, diversions, ponds, and springs. It also describes water features for subsequent assessment of potential impacts to water quantity and quality. Habitat features, ecological relationships, and other biological or terrestrial considerations have been included by reference, but are assessed in detail in other sections of the EIS.

Streams and Ponds

The study area is dominated by unnamed, relatively steep, ephemeral channels that drain towards Boulder Creek. Boulder Creek is located immediately east of the proposed PoO boundary (**Figure 2-2**). Investigators mapped eight ephemeral stream channels within the study area, including three segments that no longer reach Boulder Creek (JBR Environmental Consultants, Inc. [JBR] 2009). Typical streambed slopes within the study area range from 1 to 5 percent (approximately 50 to 260 feet/mile) (Cedar Creek Associates, Inc. [Cedar Creek] 2009). The channel beds are generally less than 2 feet wide, and the depths are shallow, typically 2 inches or less (JBR 2009) indicating low flow rates. The channel substrates are usually gravelly but can be composed of coarser cobbles where larger flows have occurred. Field investigations indicate that annual vegetation similar to the adjacent plant community is common within the ephemeral channels, indicating that flows in these streams typically occur before most of the growing season (JBR 2009).



Arturo Mine Project EIS

Figure 3.4-1

Water Resources Study Areas for Direct/Indirect and Cumulative Effects

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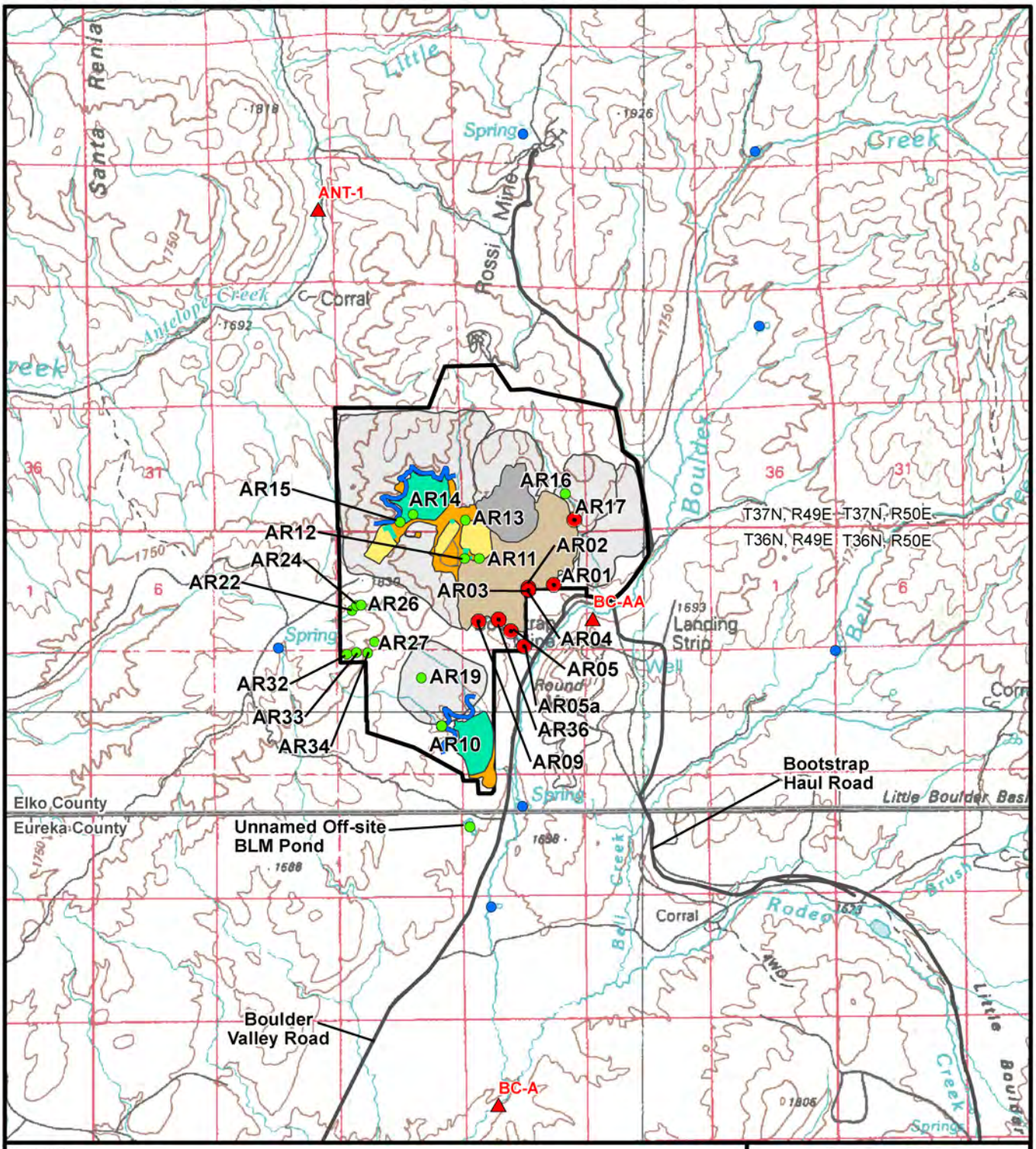
2014



Legend

- Proposed PoO Boundary
- Proposed Facilities Footprint
- Stream Monitoring Stations: BC-AA, BC-A, and ANT-1
- Feature Possibly Affected By Existing Mine Drainage
- Seep, Catchment, or Sample Location
- Spring

Existing Facilities

- Ancillary
- Heap Leach Pad Facilities
- Open Pit
- Waste Rock Disposal Facility
- Tailings Disposal Facility
- Existing Stormwater Diversions

N

0 0.5 1 Miles

Note: Sample Location ANT-1A located off figure, approximately 5 miles north of proposed project.
Refer to **Figure 2-3** for waterbody impoundment locations.
Source: BLM 2012; Cedar Creek Associates 2009.

Arturo Mine Project EIS

Figure 3.4-2

Water Features in and Near the Study Area

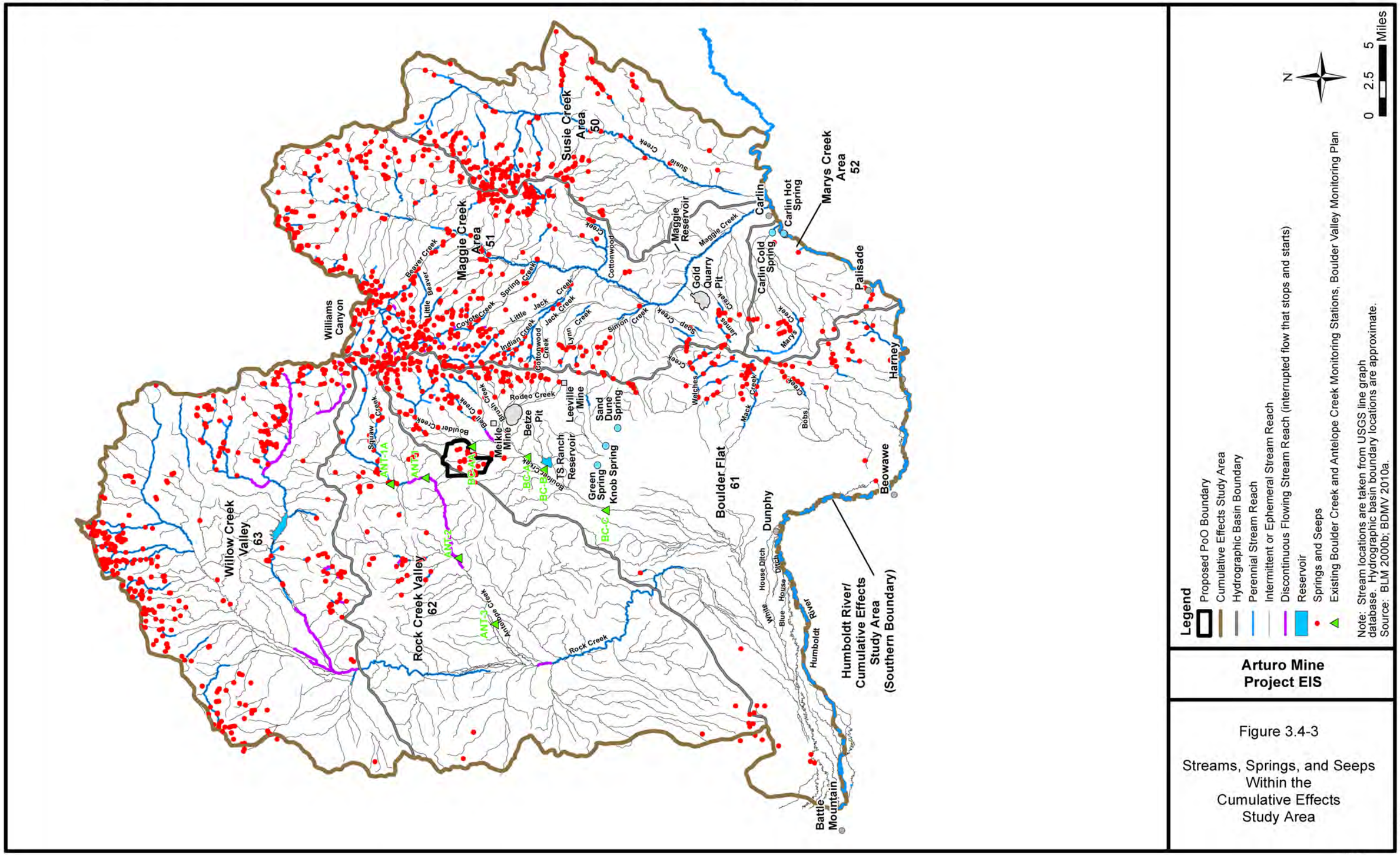


Figure 3.4-3

Streams, Springs, and Seeps Within the Cumulative Effects Study Area

The BVMP was approved by regulatory agencies and implemented by Barrick in 1990. The program monitors wells, springs, and streams in Boulder Valley and nearby watersheds. As part of the BVMP, f*lows* in Boulder Creek near the study area are monitored monthly in the northwest quarter of the southwest quarter, Section 2, Township 36 North, Range 49 East (BC-AA) (Barrick Dee Mining Venture [BDMV] 2010e). Recent discharges range from dry in late February 2010, up to 12,640 gallons per minute (gpm) (28.2 cubic feet per second) in late May 2009. The maximum recorded recent flow in Boulder Creek adjacent to the proposed PoO boundary was 37,221 gpm (82.9 cubic feet per second) in late April 2006 (BDMV 2010e). The stream is typically dry from late June or July until March.

Based on a review of aerial photography and existing data, three small impoundments that are used for runoff and sediment control or stock watering exist within the study area. The largest of these is approximately 2 acres in size encompassing locations AR36 and AR09, which was built in 1964 by the BLM as a detention pond to reduce sedimentation in Boulder Creek resulting from wildfires. An additional impoundment (including sample site AR05) is located downgradient within the PoO boundary. The upper impoundment (including sample sites AR09 and AR36) receives direct surface runoff from the existing Dee project components as well as ***naturally occurring flow that has been routed*** through a limestone-lined ***French*** drain ***that was placed during construction of the existing WRDF***. The lower impoundment was originally created as a temporary stock watering feature. Both of these ponds seep, allowing the formation of wetlands. As discussed above, the upgradient 2-acre pond was originally constructed as a detention pond, which means this impoundment was designed and constructed to leak and temporarily hold a minimal amount of water. This impoundment was modified by the Dee Gold Mining Company over time. Wetland features and ecology are discussed in Section 3.14, Vegetation, Including Riparian Zones and Wetlands.

The third impoundment noted in **Figure 2-3** (without a reference number) is ***an unnamed BLM*** detention pond located outside the project area in Section 15, Township 36 North, Range 49 East. It receives ***supplemental*** runoff ***diverted*** from the ***watershed upstream of*** Tailings Disposal Facility No. 2 (TD2)**.** This impoundment was originally constructed by the BLM in 1964 to reduce sedimentation in Boulder Creek from wildfires that occurred then. ***It is not owned by BDMV, or located in the TD2 drainage. Based on inspection of several historical aerial photographs taken in different years and field surveys conducted by SRK and Cedar Creek Associates, the TD2 facility does not seep or create downstream wetland features.***

Springs and Seeps

On-site investigations have identified 22 seeps and associated features within the study area that contain free surface water or are associated with wet soils (Cedar Creek 2009; SRK 2010b). An additional detention pond (AR36) was constructed in 1964 and was added to the sampling program in 2009. These features are listed in **Table 3.4-2**. Several of these are apparently associated with historic sediment and runoff control features, while others are at or near the toes of the existing WRDF (Cedar Creek 2009). The locations of known seeps and springs in the study area are indicated in **Figure 3.4-2**. Water quality data have been retrieved at or near the free-water features, but no flow monitoring is known to exist at the sites. Based on site visit records, flows are either non-existent or small and seasonal (Cedar Creek 2009; JBR 2009). Additional discussion of biological or ecological resources occurring at the springs and seeps is presented in Section 3.14, Vegetation, Including Riparian Zones and Wetlands, or in Section 3.17, Wildlife and Aquatic Biological Resources.

A number of other springs are known to be located near the proposed PoO boundary, either within the study area or nearby in the CESA (**Figure 3.4-2**). Based on United States Geological Survey (USGS) topographic maps, the closest springs to the proposed PoO boundary are unnamed features located:

- In the southwest quarter, Section 13, Township 37 North, Range 49 East;
- In the southeast quarter, Section 15, Township 37 North, Range 49 East;

- In the northeast quarter, Section 25, Township 37 North, Range 49 East;
- Near the south quarter corner, Section 5, Township 36 North, Range 49 East;
- In the northwest quarter, Section 15, Township 36 North, Range 49 East;
- In the northwest quarter, Section 22, Township 36 North, Range 49 East; and
- At the southwest corner, Section 6, Township 36 North, Range 48 East.

These nearby water features are depicted in **Figure 3.4-2** along with the seeps and other features listed in **Table 3.4-2**. No recent flow or water quality data are known to exist for these nearby locations. Other springs are identified upstream of the proposed PoO boundary in the headwaters of Boulder Creek watershed, as indicated in **Figure 3.4-3**.

Table 3.4-2 Seeps and Other Features Within the Study Area

Inventory Number	Feature Type	Related Existing Facility
AR01	Seep wetland, occasional open water	**Yes**
AR02	Probable seep	**Yes**
AR03	Seep	**Yes**
AR04	Seep	**Yes**
AR05 and 05a	Drainage bottom wetlands and pond, open water	**Yes**
AR09	Sampling location on upstream end of BLM detention pond; wetland, spring and open water	**Yes**
AR10	Seep or catchment	**No**
AR11	Mostly dry mine constructed basin	**No**
AR12	Mostly dry mine-excavated area	**No**
AR13	Seep or catchment	**No**
AR14	Remnant constructed collection pond	**No**
AR15	Remnant constructed collection pond	**No**
AR16	Seep and marginal wetlands	**No**
AR17	Drainage bottom wetland	**Yes**
AR19	Seep	**No**
AR22	Seep or catchment	**No**
AR24	Seep or catchment	**No**
AR26	Seep or catchment	**No**
AR27	Seep wetland	**No**
AR32	Seep or catchment	**No**
AR33	Seep or catchment	**No**
AR34	Seep or catchment	**No**
AR36	Sampling location on downgradient end of BLM detention pond; open water	**Yes**

Source: Cedar Creek 2009.

Streams, springs, and seeps within the CESA are shown in **Figure 3.4-3**. Based on ***BVMP*** flow monitoring data, Boulder Creek is intermittent in its upper reaches to the east of the proposed PoO boundary (BGMI 2010). Downgradient along the channel toward Rodeo Creek, evapotranspiration and seepage losses into the stream alluvium reduce the flow duration in Boulder Creek to ephemeral conditions (BLM 2008b, 2000c, 1991a). Downgradient in Boulder Valley (also known as "Boulder Flat"), these temporary channel flows are routed into a series of agricultural diversions in combination with Rock Creek flows (JBR 2009). Boulder Creek is ephemeral on the valley surface of Boulder Flat. Boulder Creek has no hydrologic connectivity with Rock Creek ditch or the Humboldt River as discussed below in Waters of the United States. ***BVMP monitoring locations along Boulder Creek and Antelope Creek are depicted on Figure 3.4-3.***

East of the Tuscarora Mountains, major tributaries to the Humboldt River include Maggie Creek, Marys Creek, and Susie Creek (**Figure 3.4-3**). These drainages have been extensively investigated by Maurer et al. (1996), the USGS (Prudic et al. 2006), and others. Maggie Creek and Susie Creek are dominantly perennial streams (BLM 2008b). West of the Tuscarora Mountains, Rock Creek is the major tributary to the Humboldt River within the CESA. That channel traverses the southwestern portion of Boulder Valley before joining the river near the town of Battle Mountain (**Figure 3.4-3**). Further detail about flows in Boulder Valley and other streams in the CESA was provided in previous National Environmental Policy Act (NEPA) documents (BLM 2008b, 2000b,c, 1991a).

Flood Hydrology

No regulatory floodplain (Flood Hazard Zone A) delineations have been made by the Federal Emergency Management Agency (FEMA) in the study area or nearby along Boulder Creek (FEMA 2010). The nearest FEMA Zone A delineation on Boulder Creek is located approximately 1 mile south of the Elko-Eureka county line, downgradient of a point approximately 1.2 miles north of Rodeo Creek. From a geomorphic perspective, narrow floodplain deposits or low-lying areas that would be inundated from a large precipitation or snowmelt event occur along all of the ephemeral streams in the proposed project area. Inundated channel areas probably would be on the order of 10 feet wide at most locations (Cedar Creek 2009; JBR 2009) depending on the size of a particular runoff event. The 100-year, 24-hour point precipitation for the study area is 2.60 inches (SRK 2010a).

Waters of the United States

Field investigations to evaluate the potential jurisdictional status of ephemeral channels and wetlands within the proposed project area were performed by JBR in late summer of 2009 ***and in early summer 2013***. All isolated waterbody features that are solely contained in the proposed project area were mapped, as well as features that have a potential tributary connection to Boulder Creek (JBR 2009) ***and Antelope Creek (JBR 2013)***.

The JBR survey documented that the Ordinary High Water Mark associated with Boulder Creek ceases to exist 17.4 stream miles downgradient of the proposed project area (at a location 6.7 miles upgradient of the Rock Creek Ditch) (JBR 2009). The distance from the Rock Creek Ditch to the Humboldt River is approximately 25 miles. Because Boulder Creek lacks a regular or frequent direct connection with the Humboldt River, tributaries of Boulder Creek (and, correspondingly, any associated wetlands) present within the proposed project area were determined to be isolated (JBR 2009). In addition to the lack of any direct channel connection between the proposed project area and downgradient waters, there are no interstate commerce uses for Boulder Creek or for any channel or wetland located within the proposed project area (JBR 2009). The investigation concluded that Boulder Creek, its tributaries, and all waterbody features found in the proposed project area are not subject to federal jurisdiction, and thus not regulated, under Section 404 of the Clean Water Act (JBR 2009). The United States Army Corp of Engineers (USACE) formally concurred with this conclusion in a letter dated August 13, 2010 (USACE 2010).

JBR conducted a survey for jurisdictional waters on the 275-acre portion of the proposed project area that drains towards Antelope Creek in the Rock Creek watershed in June 2013. The field investigation found no Waters of the United States in the survey area (JBR 2013). The survey report was submitted to BLM and the USACE. BDMV would not disturb drainage features in the Antelope Creek watershed until the USACE has concurred with the JBR findings that the area does not contain potentially jurisdiction streams or wetlands that would be subject to regulation pursuant to Section 404 of the Clean Water Act. BDMV would comply with applicable Clean Water Act Section requirements in the case where the USACE did not concur with the JBR survey findings.

Existing Mining Water Management Facilities in the Project Area

As described in Chapters 1.0 and 2.0, a number of mine-water control and process-water management features currently exist within the proposed project area. Existing and authorized disturbance in the proposed project area is depicted in **Figures 2-1** ***and 3.4-2***. Process-water management features for the heap leach facilities, mill, and solution processing facilities have been reclaimed (***SRK 2012***).

Current features include runoff collection and sedimentation impoundments (described above under *Streams and Ponds*), as well as two tailings disposal facilities under various stages of reclamation. The footprint for Tailings Disposal Facility No. 1 (TD1) occupies approximately 87 acres, and the permitted footprint for TD2 occupies approximately 83 acres (***SRK 2012***). The TD1 embankment face has been reduced to a flatter angle for reclamation except where the road to the water tank exists on the dam (Telesto Nevada 2004). TD1 and TD2 have been reclaimed and vegetation has been established. Diversion ditches designed for the 100-year, 24-hour runoff event are in place to divert water around these features ***in accordance with Nevada Division of Environmental Protection (NDEP) and BLM guidance*****.**

Watersheds

The regional hydrologic setting is described in Section 3.4.1.1, Hydrologic Setting. This watershed discussion examines general runoff conditions over large drainage areas from a hydrologic perspective.

Influences on runoff and sedimentation include snowmelt and rainfall, topography and soil characteristics, vegetation conditions, drainage controls and conservation practices. On a regional basis, overland flow originates from snowmelt or rainfall on hillslopes and more gently sloping alluvial fans and valley floors. Infiltration and porosity are typically greater on the lower depositional features, and runoff is sometimes completely absorbed downslope before reaching a stream channel.

Other land surface influences, such as grazing, fire, mining and exploration activities, and roads, also affect runoff conditions within the study area and CESA. While grazing is the most extensive land use activity within the CESA, rangeland fires are very common. Approximately 59 percent of the water resources CESA, including some of the project study area, has been burned by wildfire (**Figure 3.2-3**). Much of the CESA has been burned by wildfire more than once since 1985. The primary areas where fire has not recently occurred include most of Boulder Flat, and lower elevations in the southwestern part of Rock Creek Valley, and Squaw Valley.

In the CESA, which occupies approximately 2,105 square miles (approximately 1.35 million acres), ongoing disturbance from mines and exploration activities occupies approximately 35,344 acres (approximately 55.2 square miles). This is approximately 2.6 percent of the land area within the water resources CESA. Additional surface disturbance from roads, pipelines, and transmission lines also exists within the CESA.

3.4.1.3 Groundwater Resources

Recharge, storage, and movement of groundwater is dependent in part on the geologic conditions and topography of a site. The general stratigraphic and structural framework throughout the hydrologic study area and the proposed project area are described in Section 3.3, Geology and Minerals. For the purpose of characterizing the groundwater conditions in the area, the geologic formations have been grouped into six hydrostratigraphic units. The general physical characteristics of these units are presented in **Table 3.4-3**.

Table 3.4-3 Summary of Hydrostratigraphic Unit Properties

Hydrostratigraphic Unit	Reported Yields (gpm)	Estimated Hydraulic Conductivity (feet per day)	Estimated Transmissivity (square feet per day)	Estimated Specific Yield (no units)
Younger Basin Fill	Up to 3,600 in Boulder Valley[2]	1 - 100[2]	4,500[1] - 13,400[2]	0.15 - 0.252[2]
Older Basin Fill	<100 - 1,000[1]	0.05 - 5[2]	20 - 14,000[2]	0.01 - 0.10[2]
Intrusive Rocks	Generally <100[2]	0.01 - 1[2]	NA	NA
Volcanic Rocks	Up to 5,800 in Boulder Valley[2]	0.5 - 200[2]	300 - 100,000[2]	0.0007 - 0.07[2]
Marine Clastic Rocks	10 - 600[2,3]	0.01 - 0.5[2]	30 - 800[2]	0.0001 - 0.004[2]
Marine Carbonate Rocks	500 - 5,000[2]	0.1 - 100[2]	13 - 300,000[2]	0.0002 - 0.03[2]

[1] Source: Maurer et al. 1996.
[2] Source: McDonald Morrissey Associates, Inc. (MMA) 1998, 1996a,b.
[3] Where highly fractured, may yield more than 600 gpm.

NA – No data available.

These six hydrostratigraphic units include two distinct types of materials: fractured rock (carbonate, siliceous, intrusive, volcanic, and bedrock), and unconsolidated to poorly consolidated sediments (alluvial and basin fill deposits). In the bedrock units, recharge, storage, flow, and discharge of groundwater primarily are controlled by the secondary features (i.e., fractures, faults, and solution cavities) that enhance the porosity and permeability of the rock. In the unconsolidated to poorly consolidated sediment, the groundwater is stored and transmitted through interconnected pores within the sediments.

Hydrogeologic Units

The six hydrostratigraphic units and their hydrogeologic characteristics are discussed below.

Marine Carbonate Rocks

The Paleozoic marine carbonate rocks consist of limestone and dolomite and lesser amounts of shale, sandstone, and quartzite that are part of the lower plate. These rocks are mainly Cambrian to Devonian in age but locally also include Pennsylvanian/Permian carbonate rocks. These rocks are part of the Carbonate Rock Aquifer Province, a major bedrock carbonate aquifer system that covers extensive areas in eastern Nevada (Prudic et al. 1995). Regional maps infer that the northwestern boundary of the Carbonate Rock Aquifer Province is located near the proposed project area (Prudic et al. 1995). Carbonate rocks appear at the surface in the Tuscarora Mountains south of the Betze-Post Pit and in bedrock outcrops in the Maggie Creek and Susie Creek basins. Carbonate rocks are believed to underlie the younger units and the marine clastic rocks (beneath the Roberts Mountain Thrust) in areas within the carbonate rock province. In areas of carbonate rock outcrop, the overlying clastic rocks and younger volcanics are thought to have been removed by erosion (MMA 1996a).

The marine carbonate rocks have low primary permeability. However, where they are faulted or fractured coupled with dissolution, their transmissive properties greatly increase. Secondary permeability can raise the hydraulic conductivity of the marine carbonate rocks approximately 100 feet per day and result in a transmissivity as high as 300,000 square feet per day. The specific yield for these rocks ranges from 0.0002 to 0.03. Yields from wells range from 500 to as much as 5,000 gpm due to secondary permeability.

Marine Clastic Rocks

The Paleozoic marine clastic rocks consist of interbedded shale, siltstone, chert, quartzite, and limestone. Marine clastic rocks are believed to underlie the alluvium and volcanic rocks in most of the study area, and they form the upper plate of the Roberts Mountain Thrust. These clastic rocks are exposed in the Tuscarora Mountains, Independence Range, and Adobe Range (**Figure 3.3-2**). They have been extensively thrusted and eroded, and estimates of their thickness range from 50 to 5,000 feet. These rocks are fine-grained and have low hydraulic conductivity with most reported values ranging from 0.01 to 0.5 feet per day (MMA 1996a), but local faulting, fracturing, and solution widening can increase secondary permeability (Maurer et al. 1996). Transmissivity ranges from 30 to 800 square feet per day, and the specific yield ranges from 0.0001 to 0.004. Well yields are low and in the range of 10 to 600 gpm.

Intrusive Rocks

Tertiary through Jurassic intrusive rocks are a minor component of the rock types in the study area and consist mostly of granodiorite, quartz monzonite, monzonite, and diorite. The intrusive rocks tend to form relatively impermeable boundaries or impediments to groundwater flow. Reasonable estimates of hydraulic conductivity are 0.01 to 1 feet per day, and wells generally yield less than 10 gpm (MMA 1996a). Wells completed in the intrusive rocks may yield small quantities of water near some faults (Maurer et al. 1996).

Volcanic Rocks

The volcanic rocks consist of Tertiary through Jurassic aged rocks that include a wide range of igneous rock types: rhyolitic to basaltic lava flows, welded and nonwelded ash-fall tuffs, flow breccia, and tuffaceous sedimentary rocks. The volcanics occur throughout the area with most of the exposures in the western, northern, and south-central portions of the CESA. This wide range of rock types results in highly variable hydraulic parameters. The welded tuff, basalt, and andesite generally have low transmissive properties, while the rhyolite, particularly where fractured, is more transmissive. Estimates of hydraulic conductivity range from 0.01 to 200 feet per day, with transmissivity ranging from 300 to as much as 100,000 square feet per day. The specific yield has been estimated to range from 0.0007 to 0.07 in the case of the Boulder Valley rhyolite. Yields to wells can be up to 5,800 gpm.

Older Basin-fill Deposits

The older basin fill deposits (including the Carlin Formation) are Pliocene to Miocene age and are primarily composed of poorly consolidated shale, claystone, mudstone, siltstone, sandstone, conglomerate, freshwater limestone, tuff and lava flow (Maurer et al. 1996; Plume 1995). These deposits accumulated in basins that developed in the earliest stages of extensional faulting. In the upper Maggie Creek basin, these deposits are estimated to be up to 6,000 feet thick. In Susie Creek and lower Maggie Creek basins, the deposits are generally less than 2,000 feet thick (Hydrologic Consultants, Inc. 1999). Wells completed in the Carlin Formation have reported yields ranging from less than 100 to 1,000 gpm. In the Maggie Creek area, hydraulic conductivity ranges from 1 to 7 feet per day and transmissivity from 780 to 9,800 square feet per day (Maurer et al. 1996). In the northern part of Boulder Flat, transmissivity is estimated to range from 70 to 300 square feet per day. Locally, the fine-grained beds act as an aquitard producing confined groundwater conditions in the underlying rocks (BLM 1991a). The estimated specific yield is in the range of 0.01 to 0.10.

Younger Basin-fill Deposits

The Quaternary alluvium contains a wide range of materials: sandy clay, silty sand, gravelly sand, and sandy gravel. The thickness and lateral extent of this material also is highly variable. In higher elevation mountain areas, the alluvium occurs as discontinuous to continuous strands of unconsolidated material covering or partially covering bedrock along the floor of the valley or ravine. Alluvium in higher elevation areas generally is less than a few tens of feet thick. In broad basin areas, such as Boulder Flat, and to a lesser extent in the Maggie Creek and Susie Creek basins, the alluvium occurs as sequences of unconsolidated to poorly consolidated material up to 1,000 feet thick (MMA 1996a). Overall, the alluvium is generally coarser-grained in the mountains and finer-grained in the basins, and it becomes finer toward the center of the basin. The alluvium also is characterized by significant lateral and vertical stratigraphic variation with clay typically occurring as thinly bedded lenses. The alluvium generally is presumed to be an unconfined aquifer; however, semi-confined conditions may exist locally where less permeable fine-grained units inhibit vertical flow. Well yields can range up to 3,600 gpm in Boulder Valley, with hydraulic conductivities ranging from 1 to 100 feet per day, transmissivity ranging from 4,500 to 13,400 square feet per day, and a specific yield estimated to range from 0.15 to 0.25.

Hydrostructural Units

Faults can serve as pathways for groundwater flow or act as barriers to flow, depending on the nature of the brecciation along the fault and the permeability of units juxtaposed by the faulting. Fractures, bedding planes, and cavities in bedrock units often allow for local flow of groundwater and create increased permeability over a defined area. Long-term monitoring of water level changes in the vicinity of the BGMI facility has resulted in the recognition of three major fault zones that impede groundwater flow across the fault zone: Boulder Narrows Fault, Siphon Fault, and Post Fault. Other faults with the potential to influence groundwater flow and groundwater dewatering are the Little Boulder Basin Fault, the Tuscarora Fault on the east side of the Tuscarora Mountains, and the Gold Quarry Fault. The influence of these structures on the groundwater flow system generally is characterized by a noticeable change in gradient and water levels on either side of the faults. These hydrostructural features are described in the Betze Project, Draft Supplemental EIS (BLM 2000c) and Betze Pit Expansion Project, Draft Supplemental EIS (BLM 2008b).

Groundwater Levels

BGMI has monitored water levels in the regional aquifer system in the Boulder Valley, Rock Creek, and Willow Creek hydrographic basins since 1991 as a condition of their water rights permits. This monitoring system includes several wells located within and near the vicinity of the proposed project area (**Figure 3.4-4**). The water level contours indicate that the regional groundwater elevations range from approximately 5,200 feet at the northeastern corner to approximately 3,576 feet in the southeastern portion of the proposed project area. The water level contours also infer that hydraulic gradient for the regional groundwater aquifer system slopes steeply from north to south in the northern portion of the proposed project area, and west to east along the western portion of the proposed project area. In contrast, the water level elevations in the southeastern portion of the proposed project area are essentially flat and equivalent to the water levels at the Betze-Post Pit located approximately 3.9 miles south of the proposed project boundary.

Figure 3.4-5 shows the change in groundwater elevation (i.e., drawdown) since dewatering at the BGMI facility was initiated in 1990. Mine dewatering for the Betze Pit was initiated in 1990 and continued through 2010. The target dewatering elevation for the Betze/Post Pit of 3,576 feet amsl was reached in 2000 (John Shomaker & Associates, Inc. [JSA] 2010a). Since that time, the mine dewatering operations have continued to maintain water levels at the approximate 3,576 elevation. Mine dewatering activities at the BGMI facility have resulted in lowering the groundwater levels approximately 1,700 feet within an approximately 2.5-mile-wide northwest-trending zone that extends from the Betze-Post Pit to near the center of the proposed project area. Groundwater pumping for mine dewatering at the BGMI facility is

projected to continue until the end of 2021, and additional pumping for mine reclamation and mine processing activities would continue through 2034 (JSA 2010b).

Water Quality Standards

Waters of the State of Nevada are defined in Nevada Revised Statutes Chapter 445, Section 445.191 and include, but are not limited to: 1) all streams, lakes, ponds, impounding reservoirs, marshes, water courses, waterways, wells, springs, irrigation systems, and drainage systems; and 2) all bodies of accumulations of water, surface and underground, natural or artificial.

Water quality standards for state waters have been established by the State of Nevada under Nevada Administrative Code (NAC) 445A.117 through 445A.128. NAC 445A.453 establishes primary water quality standards, and NAC 445A.455 establishes secondary standards for water quality. General Nevada water quality standards are summarized in **Table 3.4-4**. Primary standards are based on the potential use of groundwater for drinking water and are established to protect human health; the secondary standards are for aesthetic qualities. These standards also are referred to as Maximum Contaminant Levels (MCLs). Because groundwater downgradient of the project has the potential to be used for drinking water, the Nevada drinking water standards would apply to mine-related activities that affect groundwater (NAC 445.424).

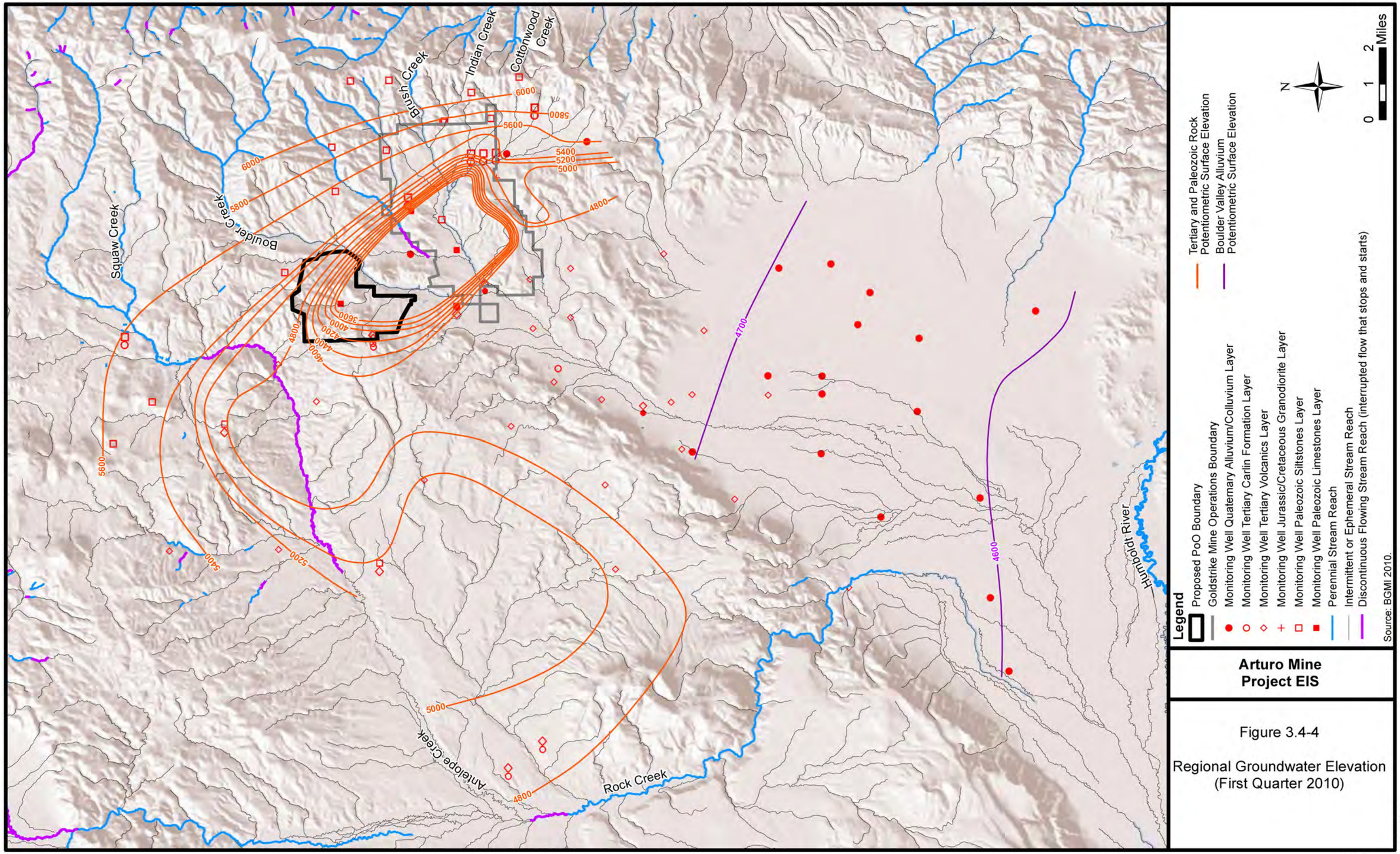
Surface water quality standards indicated in **Table 3.4-5** represent more specific values for streams designated as Class C waters by the state of Nevada. Designated Class C surface waters, such as Rock Creek, have stream standards identified by the state in NAC 445A.121 and 122, NAC 445A.126, and NAC 445A.144. Because of the questionable drainage continuity in lower Boulder Flat, it is currently unknown if Class C standards apply to Boulder Creek and its tributaries within the project area. The standards indicated in **Table 3.4-5** are included simply for reference and as a basis for discussion.

Surface Water Quality

Surface water sampling has been conducted in the proposed project area since the second quarter of 2008 (SRK 2010b), and on Boulder Creek at Sites BC-AA and BC-A nearby since March 1993 (BGMI 2010; BDMV 2010e). On-site sampling efforts were conducted at seep, spring, and pond sites shown in **Figure 3.4-2**. Sampling results are summarized in **Table 3.4-5**. Based in **Table 3.4-5,** most of the water quality constituents analyzed in the samples have levels within the reference Class C water quality standards.

The surface water quality results (Table 3.4-5) reflect standard USEPA analytical methods and the NDEP Profiles I and II orientation required for the state Water Pollution Control Permit and subsequent monitoring programs for mining projects. The analyses were conducted by an NDEP-approved analytical laboratory (SVL Analytical of Kellogg, Idaho). The Method Reporting Limits (MRLs), as indicated by the "less-than" symbol (<) in Table 3.4-5, relate to the NDEP Profile I and Profile II reference values. While some MRLs presented on Table 3.4-5 may be greater than the most stringent Class C stream standard, they are well within the NDEP Profile I and II reference values, which form the monitoring basis for the NDEP Water Pollution Control Permit and BLM NEPA analysis according to interagency agreements. NDEP Profile I and II reference values are currently the Nevada Drinking Water Standards indicated in Table 3.4-4.

Monitoring records indicate that at most of the sites, for most of the time, sufficient free water did not exist to allow sample retrieval (SRK 2010b). Due to moisture conditions, samples were intermittently obtained at Sites AR05, AR17, AR27, and AR34. At Sites AR09 and AR36 (**Table 3.4-5** and **Figure 3.4-2**) samples consistently were retrieved and analyzed.


Squaw Creek
Boulder Creek
Bush Creek
Indian Creek
Cottonwood Creek
Antelope Creek
Rock Creek
Humboldt River
6000
5800
5600
5400
5200
5000
4800
4600
4400
4200
4000
3600
4700
Legend
Proposed PoO Boundary
Goldstrike Mine Operations Boundary
Monitoring Well Quaternary Alluvium/Colluvium Layer
Monitoring Well Tertiary Carlin Formation Layer
Monitoring Well Tertiary Volcanics Layer
Monitoring Well Jurassic/Cretaceous Granodiorite Layer
Monitoring Well Paleozoic Siltstones Layer
Monitoring Well Paleozoic Limestones Layer
Perennial Stream Reach
Intermittent or Ephemeral Stream Reach
Discontinuous Flowing Stream Reach (interrupted flow that stops and starts)
Tertiary and Paleozoic Rock Potentiometric Surface Elevation
Boulder Valley Alluvium Potentiometric Surface Elevation
Source: BGMI 2010.
N
0 1 2 Miles
Arturo Mine Project EIS
Figure 3.4-4
Regional Groundwater Elevation (First Quarter 2010)
05/25/2012
2014

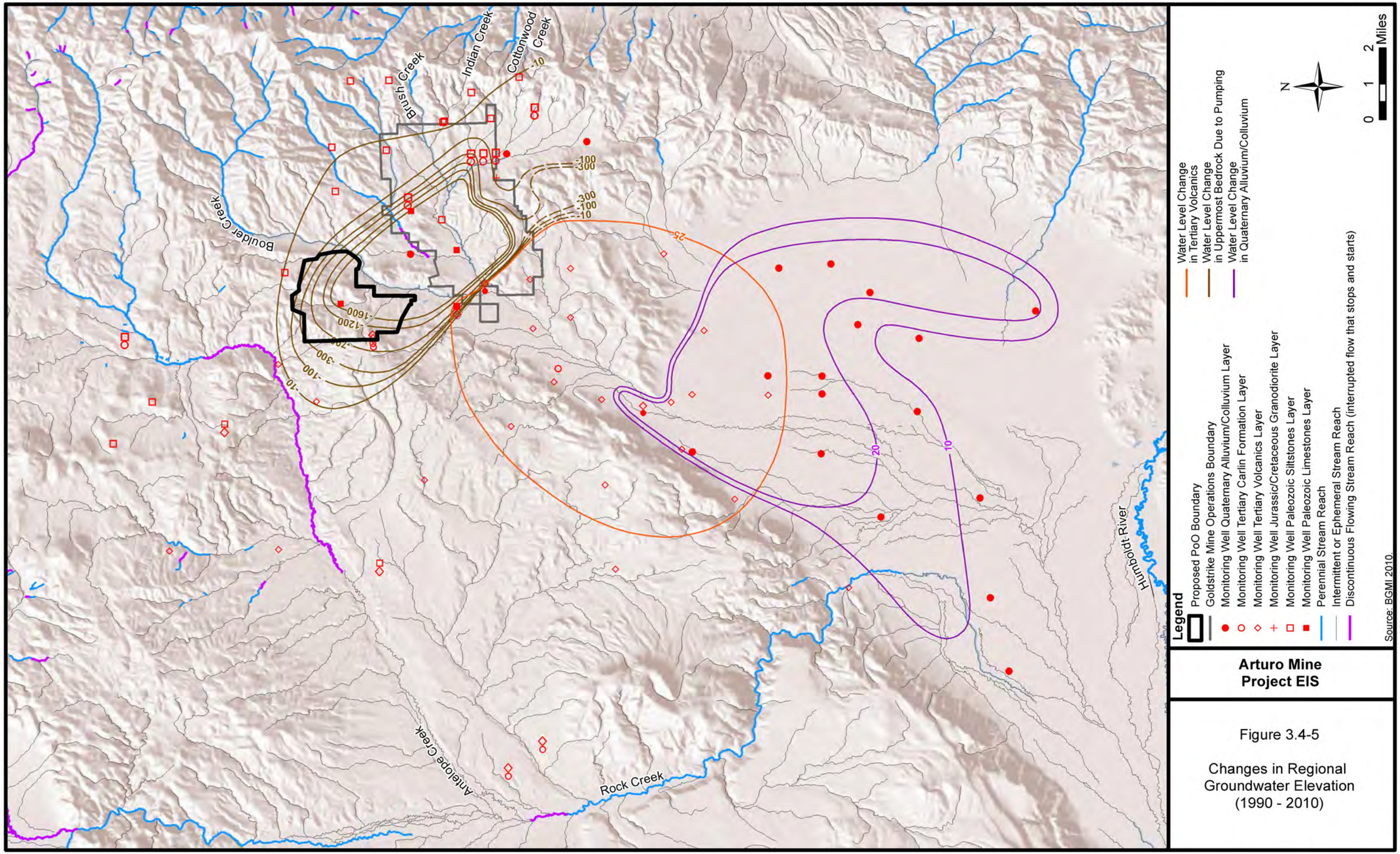

Brush Creek
Indian Creek
Cottonwood Creek
Boulder Creek
Antelope Creek
Rock Creek
Humboldt River
-10
-100
-300
-1200
-1600
25
20
10
Legend
Proposed PoO Boundary
Goldstrike Mine Operations Boundary
Monitoring Well Quaternary Alluvium/Colluvium Layer
Monitoring Well Tertiary Carlin Formation Layer
Monitoring Well Tertiary Volcanics Layer
Monitoring Well Jurassic/Cretaceous Granodiorite Layer
Monitoring Well Paleozoic Siltstones Layer
Monitoring Well Paleozoic Limestones Layer
Perennial Stream Reach
Intermittent or Ephemeral Stream Reach
Discontinuous Flowing Stream Reach (interrupted flow that stops and starts)
Water Level Change in Tertiary Volcanics
Water Level Change in Uppermost Bedrock Due to Pumping
Water Level Change in Quaternary Alluvium/Colluvium
N
0 1 2 Miles
Source: BGMI 2010.
Arturo Mine Project EIS
Figure 3.4-5
Changes in Regional Groundwater Elevation (1990 - 2010)
05/24/2012
2014

Table 3.4-4 General Nevada Water Quality Standards

Constituent (mg/l)[1]	Groundwater		Surface Water			
	Nevada Drinking Water Standards		Municipal or Domestic Supply	Nevada Agriculture		Aquatic Life
	Primary MCL[2]	Secondary MCL[2]		Irrigation	Livestock Watering	
Physical Properties						
Dissolved Oxygen	--	--	Aerobic	--	Aerobic	5.0
Color (color units)	--	15[3]	75	--	--	--
Total Dissolved Solids (TDS) (at 180°C)	--	500[4]; 1,000[3]	500[4]; 1,000[3]	--	3,000	--
Turbidity (NTU)	--	--	--	--	--	--
Inorganic Nonmetals						
Ammonia (unionized) (Total NH_3 as N)	--	--	0.5	--	--	--
Chloride	--	250[4]; 400[3]	250[4]; 400[3]	--	1,500	--
Cyanide (as CN)	0.2	--	0.2	--	--	--
Fluoride	4.0	2.0[4]	--	1.0	2.0	0.0052[5]
Nitrate (as N)	10	--	10	--	100	--
Nitrite (as N)	1.0	--	1.0	--	10	--
pH (standard units)	--	6.5-8.5[3]	5.0-9.0	4.5-9.0	6.5-9.0	6.5-9.0
Sulfate	--	250[4]; 500[3]	250[4]; 500[3]	--	--	--
Metals[6]/Elements						
Aluminum	--	0.05[3]-0.2[4]	---	--	--	--
Antimony	0.006	--	0.006	--	--	--
Arsenic (total)	0.01	--	0.01	0.10	0.20	0.18[5,7]
Barium	2.0	--	2.0	--	--	--
Beryllium	0.004	--	--	0.10	--	--
Boron	--	--	--	0.75	5.0	--
Cadmium	0.005	--	0.005	0.01	0.05	0.0006[5,8]
Chromium (total)	0.1	--	0.1	0.10	1.0	0.015[5,8]
Copper	1.3[9]	1.0[3]	--	0.20	0.50	0.0065[5,8]
Iron	--	0.3[4]; 0.6[3]	--	5.0	--	1.0
Lead	0.015[9]	--	0.05	5.0	0.10	0.0004[5,8]
Magnesium	--	125[4]; 150[3]	--	--	--	--
Manganese	--	0.05[4]; 0.1[3]	--	0.2	--	--
Mercury	0.002	--	0.002	--	0.01	0.00012[5]

Table 3.4-4 General Nevada Water Quality Standards

Constituent (mg/l)[1]	Groundwater		Surface Water			
	Nevada Drinking Water Standards		Municipal or Domestic Supply	Nevada Agriculture		Aquatic Life
	Primary MCL[2]	Secondary MCL[2]		Irrigation	Livestock Watering	
Nickel	0.1	--	0.134	0.20	--	0.087[5,8]
Selenium	0.05	--	0.05	0.02	0.05	0.005[5]
Silver	--	0.1[3]	--	--	--	0.0014[5,8]
Thallium	0.002	--	0.013	--	--	--
Zinc	--	5.0[4]	--	2.0	25	0.584[5,8]

[1] Units are milligrams per liter (mg/l) unless otherwise noted.

[2] MCL = Maximum contaminant level. Federal primary standards that existed as of July 1, 2009, are incorporated by reference in NAC 445A.4525.

[3] Nevada secondary MCLs.

[4] Federal secondary MCLs.

[5] 96-hour average.

[6] The standards for metals **and metalloids** are expressed as total recoverable unless otherwise noted.

[7] Standard for arsenic (III); trivalent (reduced) inorganic form of arsenic, which occurs as a water soluble form.

[8] Standard is dependent on site-specific hardness; displayed value is based on a hardness of 60 mg/l as calcium carbonate. (See NAC 445A.144 for equations.)

[9] Value is action level for treatment technique for lead and copper.

Sources: 40 Code of Federal Regulations (CFR) 141.51; 40 CFR 143.3; NAC 445A.119, 445A.144, 445A.453, and 445A.455.

TDS concentrations were outside the Class C stream standards at Site AR09. This site is located at the toe of the existing WRDF, on the upgradient side of where water flows into a constructed pond. Investigators indicate it is likely that water at Site AR09 is partially from meteoric sources and also from a previously-existing water source, as indicated by the observed perennial flow (SRK 2010b). Cedar Creek (2009) suggests the water at Site AR09 is spring flow or mine drainage.

The occurrence of low levels of weak acid dissociable (WAD) cyanide in water chemistry at AR-09 may suggest a historical process source for some of the seepage. However, the WAD cyanide concentrations are low (geometric mean of 0.029 mg/l; arithmetic mean of 0.033 mg/l), and well within NDEP Profile I and II reference values. In addition, no WAD cyanide concentrations were reported for samples analyzed at AR-36 or AR-05 immediately downgradient.

TDS concentrations were outside the Class C Stream standards at Site AR17. This sampling location is above the Carlin Formation, and also is in a drainage bottom at the toe of the existing WRDF (Cedar Creek 2009; SRK 2010b). Free water or moist soil was observed at Site AR17 during each sampling event. The elevated TDS concentrations at this location may be due to the generally stagnant conditions.

TDS concentrations and pH were outside the Class C Stream standards at Site AR36. This location is next to the earthen dam on the opposite (downgradient) side of the 2-acre detention pond from Site AR09. ***The TDS concentrations at AR-36 are somewhat less than those at AR-09; conditions at AR-36 are affected by seasonal runoff. Rather than evapoconcentration, the higher pH values at AR-36 are likely due to algal accumulations, which remove aqueous CO_2. A corresponding decline in calcium and total alkalinity is reflected in the data. Substantial algae growth at the BLM***

pond is evident in historical aerial photography, and the elevated pH values do not occur downstream.

Off-site water quality data are available for Boulder Creek and Antelope Creek as indicated in **Table 3.4-5**. For pH and TDS, ***historical*** sampling data from the BVMP ***during the time of active mining in the area*** indicate that constituent concentrations in Boulder Creek upgradient and downgradient of the project area were well within the reference Class C receiving water quality standards (BGMI 2010). Site BC-AA is located on Boulder Creek immediately upgradient of the ephemeral channel on which Site AR17 is located (**Figures 3.4-2** ***and 3.4-3***). Water quality from BC-AA for these constituents was well within the reference Class C water quality standards during the same sampling period as the project baseline samples.

BVMP Site BC-A is located on Boulder Creek approximately 2.5 miles downgradient of the project area. Similar to the upstream data, the water quality at Site BC-A was well within the reference Class C water quality standards during the same sampling period as the project baseline samples. On upper Antelope Creek, water quality from Site ANT-1 was well within the reference Class C water quality standards for the constituents of interest. This site is upgradient of any potential project effects, and indicates that background water quality is within reference stream standards.

Data from these sites on Boulder and Antelope creeks indicate that, although TDS and/or pH levels were elevated in the project area, off-site conditions for these constituents were not elevated above the reference Class C water quality standards. On-site baseline exceedences at AR09, AR17, and AR36 do not appear to have generated concentrations above the Class C reference values in Boulder Creek. This may result from a combination of factors, including the impounded nature of the AR09 and AR36 locations, limited flow durations in the project-area tributaries, seepage into channel beds, and dilution from other tributaries to Boulder Creek.

Groundwater Quality

Groundwater quality in the region is based on sampling conducted for the original Betze Project EIS (BLM 1991a,b) and from 61 wells sampled as part of the Betze-Screamer Pit Lake Study (Radian International and Baker Consultants 1997). In addition, 36 regional wells were selected to characterize the groundwater in the Boulder Valley alluvium and Tertiary volcanics (BLM 2000b,c). The Betze Pit Expansion Project, Draft Supplemental EIS Appendix B, (BLM 2008b) presents the general groundwater chemistry for the major hydrostratigraphic units in the region.

There are three main hydrostratigraphic units that occur within the proposed project area and are exposed in the existing open pit and that would be exposed in the proposed pit expansion: 1) marine carbonate rocks; 2) marine clastic rocks; and 3) older basin fill deposits (i.e., Carlin Formation). The marine carbonate rocks contain a strong calcium-bicarbonate water type that is relatively low in sodium and sulfate; average TDS are approximately 566 mg/l, and average pH is around 6.7 standard units. The marine clastic rocks in the region primarily contain calcium-magnesium-bicarbonate water with elevated sulfate and silica. The average TDS in this water are approximately 305 mg/l, and pH is approximately 7.6 standard units. The older basin fill contains a calcium-bicarbonate water with silica and sulfate; average TDS are approximately 478 mg/l, and average pH is approximately 7.4 standard units.

3.4.1.4 Rock Geochemistry

Mining operations bring mineralized rocks from depth, where they are geochemically stable, to the surface, where they are exposed to air and water and are subject to weathering reactions. Sulfide minerals, in particular, undergo oxidation reactions resulting in acid sulfate and metal-bearing solutions that could potentially affect surface and groundwater resources. The potential of mined rock to affect contact water within the proposed project area is assessed in two principal ways: by determining acid rock drainage risk and metal leaching risk (***Schafer 2013***).

A series of standard geochemical tests were conducted with rock material from the proposed open-pit mine expansion area, the future and existing mine pit surface areas, and existing WRDF to evaluate the potential for future releases of metals and other solutes. These tests include acid-base accounting, static testing, net-acid generation (NAG), pH tests, kinetic testing (humidity cells), and meteoric water mobility procedures (MWMP). Two hundred twenty-five waste rock samples were tested. **Table 3.4-6** shows the number of samples per each waste rock type.

Waste Rock Characterization

The proposed project would generate approximately 600 million tons of waste rock material that would be placed in the West WRDF and East WRDF. The waste rock material generated during mining consists of the following:

- Carlin Formation (***38.0*** percent of the projected waste rock tonnage), which is composed of unmineralized silt and clay. It has no potential for acid generation.
- Vinini Formation (***39.3*** percent of the waste rock tonnage), which consists of interbedded siltstones and cherts. The Vinini is generally oxidized throughout the proposed project area. Vinini rocks are siliceous, have a low acid neutralizing potential (ANP), and have variable but generally low levels of sulfide sulfur. A small fraction of Vinini rocks may have the ability to form acidic conditions upon weathering, and silicic portions of the Vinini may release metals at neutral pH levels.
- Rodeo Creek Unit (***15.2*** percent of the waste rock tonnage), which is a siltstone containing approximately 8 percent carbonate minerals. Approximately 44 percent of the Rodeo Creek unit materials are oxidized and 56 percent are unoxidized. The abundance of sulfur varies according to the oxidation status. Oxidized rock generally has no detectable sulfide sulfur (except rarely near transition zones). Unoxidized rock averaged 0.9 percent total sulfur in available test work, but only a minority of these samples (9 of 23, or 39 percent) (***Schafer 2013***) had more acid generation potential (AGP) than ANP. Overall, sulfide-containing Rodeo Creek material comprises approximately 11 percent of the waste rock. Approximately 25 percent of the sulfide Rodeo Creek unit is acid-generating, while 75 percent is expected to remain neutral (***Schafer 2013***).
- Bootstrap limestone (***2.0*** percent of waste rock). Based on the analytical results, approximately ***44*** percent of the Bootstrap limestone material contains sulfide; however, the calcite in the limestone makes acid generation unlikely.

Acid-base Accounting Tests

Acid-base accounting (static testing) is based on determinations of the AGP, which is a function of the amount of sulfide minerals in a rock, and the ANP, which is a function of the amount of carbonate minerals in a rock. The ANP and AGP are expressed in terms of kilograms of calcium carbonate per ton of sample (kg/t). The difference between the ANP and AGP is the net-neutralizing potential (NNP).

For purposes of assessing acid rock drainage risk, rocks within the proposed project area were assumed to be potentially acid generating (PAG) if the NNP was less than 0, and pyritic sulfur exceeded 0.1 percent. Sulfide values below 0.1 percent rarely result in acid generation (***Schafer 2013***). Fifteen of the 225 samples tested were PAG according to the above criteria. (**Table 3.4-6**).

Table 3.4-5 Water Quality Summary for Sampled Surface Drainage Locations within and near the Project Area[1]

Constituent [2]	Stream Standard Reference[3]	Site AR05	Site AR09	Site AR17	Site AR27	Site AR34	Site AR36	Site BC-AA	Site BC-A	*Site ANT-1*	*Site ANT-2*
Aluminum		<0.080	<0.080	<0.080	3.39	1.58	<0.080 – 0.14	0.85 – 0.859	0.727 – 3.89	*2.96*	*<0.08*
Antimony		0.00572	0.0149 – 0.0229	0.0196 -0.0286	<0.00300	<0.00300	0.0136	<0.003	<0.003	*<0.003*	*<0.003*
Arsenic	0.1 (I)	0.0241	0.0508 – 0.0805	0.0178 – 0.0728	<0.00300	<0.00300	0.0595 – 0.0763	<0.003	0.00396 – 0.00418	*<0.003*	*0.00583*
Barium		0.0116	0.0421 – 0.105	0.175 – 0.83	0.0674	0.0841	0.0083 – 0.0981	0.0765 – 0.126	0.1990 – 0.346	*0.0637*	*0.0958*
Beryllium	0.1 (I)	<0.00200	<0.00200	<0.00200	<0.00200	<0.00200	<0.00200	<0.002	<0.002	*<0.002*	*<0.002*
Boron	0.75 (I)	0.27	0.198 – 0.283	0.119 – 0.144	<0.074	0.09	0.297 – 0.375	<0.04 – 0.041	<0.04 – 0.04	*0.056*	*0.176*
Cadmium[4]	0.0006 (A)	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.002	<0.002	*<0.002*	*<0.002*
Chloride		85	80.8 – 136	48.8 – 79.3	2.27	5.65	142 – 156	2.45 – 3.54	3.68 – 3.86	*8.66*	*21.7*
Chromium (total)	0.1 (I)	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.006	<0.006	*<0.006*	*<0.006*
Copper[4]	0.0065 (A)	<0.010	<0.010 – 0.011	<0.010	<0.010	<0.010	<0.010	<0.01	<0.01 – 0.01	*<0.01*	*<0.01*
Fluoride	1 (I)	0.891	0.829 – **1.13**	0.712 – 0.822	0.159	0.139	0.831 – 0.974	0.131 – 0.158	0.186	*0.268*	*0.321*
Iron[4]	1 (A)	<0.060	<0.060	<0.060	**2.03**	0.857	<0.060 – 0.097	0.453 – 0.512	0.458 – 2.78	*1.8*	*<0.06*
Lead[4]	0.0004 (A)	<0.00300	<0.00300	<0.00300	<0.00300	<0.00300	<0.00300	<0.003	<0.003	*<0.003*	*<0.003*
Manganese	0.2 (I)	0.138	<0.0040 – 0.0197	0.0045 – 0.0158	0.0196	0.0102	<0.0040 – 0.0051	0.0134 – 0.016	0.008 – 0.101	*0.0495*	*0.188*
Mercury[4]	0.00077 (A)	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.0002	<0.0002	*<0.0002*	*<0.0002*
Nickel[4]	0.087 (A)	<0.010	<0.010 – 0.0221	<0.010	<0.010	<0.010	<0.010	0.01	<0.01	*<0.01*	*<0.01*
Nitrate + Nitrite, Total (as N)		1.38	15.0 – 38.6	14.7 – 42.7	0.0789	0.0996	0.32 – 8.08	<0.02 – <0.25	<0.05 – <0.25	*0.117*	*0.0538*
pH (S.U.)	6.5 – 9.0	8.18	8.09 – *8.52*	8.07 – 8.74	7.45	7.62	**9.03 – 9.67**	7.95 – 8.13	7.81 – 8.1	*7.76*	***9.04***
Selenium[4]	0.005 (A)	<0.040	<0.040	<0.040	<0.040	<0.040	<0.040	<0.003	<0.003	*<0.003*	*<0.003*
Silver		<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.005	<0.005	*<0.005*	*<0.005*
Sulfate		157	139 – 186	59.6 – 80.6	9.92	17.8	239 – 262	16.2 – 22.2	181.1 – 31.5	*25.3*	*150*
Thallium		<0.00100	<0.00100	<0.00100	<0.00100	<0.00100	<0.00100	<0.001	<0.001	*<0.001*	*<0.001*
Total Dissolved Solids	≤500 milligrams per liter (mg/l) or 1/3 above that characteristic of natural conditions (whichever is less)	**580**	**560 – 961**	**510 – 650**	182	195	**747 – 862**	151 – 160	136 – 167	*178*	*394*
WAD Cyanide		<0.0100	0.0198 – 0.0702	no data	no data	no data	<0.0100				
Zinc[4]	0.584 (A)	<0.0100	<0.0100	<0.0100	0.0105	<0.0100	<0.0100	<0.01	<0.01 – 0.0331	*0.0236*	*<0.01*

[1] Where more than one sample was analyzed, the range of results is indicated. *The less than symbol (<) indicates the laboratory method reporting limits (MRL) as discussed in the text.*

[2] Units are milligrams per liter unless otherwise indicated. *Values for metals and metalloids are total recoverable concentrations.* Bold values exceed reference standards.

[3] For reference only. Indicates the most stringent Class C surface water standard for either irrigation (I), livestock watering (L), or aquatic life (A) in milligrams per liter. The *intermittent and* ephemeral reaches of Boulder Creek are not used for municipal/domestic supply. Standards for metals are expressed as total recoverable.

[4] 96-hour average; some are hardness based, where displayed value assumes a hardness of 60 mg/l as $CaCO_3$. Actual hardness (and the resulting stream standard) may differ.

Source: BGMI 2010; SRK 2010b.

Table 3.4-6 Acid-based Accounting Test Results Summary for Waste Rock to be Placed in the WRDFs

Rock Type	Number of Samples	NNP (kg/t)	AGP (kg/t)	ANP (kg/t)	ANP/AGP Ratio	NAG/pH (s.u.)[1]	Paste pH (s.u.)	PAG (%)
Carlin Formation	19	6.7	0.3	7.1	24	7.4	7.8	0
Vinini Formation	102	40.9	1.0	42.0	42	6.6	8.2	3.9
Bootstrap Oxide	13	560.8	0.7	561.5	802	8.0	8.2	0
Bootstrap Sulfide	17	869.8	0.3	870.1	2,900	8.1	8.6	0
Rodeo Creek Oxide	27	140.7	2.6	143.3	55	7.4	8.2	0
Rodeo Creek Sulfide	47	96.2	24.4	120.6	5	6.5	7.7	23.4
Expansion Area (average value)		**154.2**	**6.0**	**160.2**	**27**	**6.9**	**8.1**	***3.5***[2]

[1] s.u. - standard unit

[2] ***Overall percentage of PAG based on abundance of each rock type from block modeling multiplied by proportion of PAG from acid-base accounting tests (Schafer 2013).***

Source: Schafer 2011a; ***SRK 2012***.

The ratio of ANP to AGP can also be used to access the acid generation potential. If the ratio of the neutralization potential is 1:1(or less), the material is more likely to generate acid; whereas, if the ratio is 3:1 (or greater), the material is unlikely to generate acid (U.S. Environmental Protection Agency [USEPA] 1994). The average ANP/AGP ratio for all of the rock units tested ranged from 5:1 to 2,900:1. The average ANP of all samples tested was 160.2 kg/t, while the average AGP was 6.0 kg/t, for an average NNP of 154.2 kg/t **(Table 3.4-6b)** and an ANP/AGP ratio of approximately 27:1 (***Schafer 2013***).

The NAG pH testing consists of the addition of hydrogen peroxide, a strong oxidant, to a sample to accelerate the reaction of sulfides. If the acidity liberated through sulfide oxidation is not neutralized, the resultant acidic pH indicates a PAG sample. Twenty of the 225 NAG pH tests were PAG, including 15 of 47 Rodeo Creek sulfide samples and 5 of 102 Vinini samples. NAG test results are shown in **Table 3.4-6**.

Kinetic Testing

Kinetic testing, consisting of humidity cell testing, is designed to represent maximum rates of acid generation and metals released from rocks caused by intense weathering. The information obtained from these tests is used in geochemical modeling to represent the rate of solute release from pit rock into pit lakes and to evaluate waste rock for disposal alternatives.

Humidity cell tests were conducted for 52 weeks on six samples that varied in NNP from -31 to +943 kg/t. Samples tested in humidity cells represented rocks most likely to react and form acid, being selected mostly from unoxidized (sulfide) zones that had elevated pyritic sulfur levels. ***The samples selected for testing included three samples of the Rodeo Creek unit; two samples of Vinini Formation, and one sample of the Bootstrap limestone. One*** **of the six samples** ***(sample 3, Rodeo Creek sulfide)*** became strongly acidic over the period of testing. Acid generation was accompanied by high concentrations of trace metals. The samples that did not become acidic showed low concentrations of trace metals ***(Schafer 2013)***.

Table 3.4-6b 52-Week Humidity Cell Test Results

Humidity Cell	Rock Type	NNP	NAG pH	Average pH Last 5 weeks	Net Alkalinity Last 5 weeks
1	Rodeo Creek sulfide	50.3	7.8	6.89	9.42
2	Bootstrap sulfide	943	8.2	7.70	12.79
3	Rodeo Creek sulfide	-31.5	2.5	2.14	-785.55
4	Rodeo Creek sulfide	-30.7	2.7	6.15	2.39
5	Vinni Formation	5.1	4.4	6.02	-0.48
6	Vinni Formation	5.4	5.2	5.97	0.90

Source: Schafer 2013.

Constituent mobility potential tests were conducted on Carlin and Vinni Formation materials to assess the potential mobility from the solids by contact with meteoric water (McClelland Laboratories, Inc. 2010). These tests were conducted for a duration of 10 weeks in 7-day cycles. In brief, the testing method consisted of placing composites of crushed rock material (~3/8 inch or less) in columns and applying deionized water to the top of the column at a constant rate for 5 days and then allowing the column to free drain for 2 days. Each week, the pH, EC, and acidity and alkalinity of effluent was analyzed. The effluent collected at the end of weeks 2, 4, 6, 8, and 10 were submitted for laboratory analysis to evaluate the pH and release of metals within the effluent. The results indicate that the pH of the effluent over the 10 week duration of the test was neutral ranging from pH 7.44 to 8.31. These tests indicate that the composite samples of Carlin and Vinini Formation materials did not generate acid or release elevated concentrations of metals.

Meteoric Water Mobility Procedure Testing

MWMP testing simulates conditions under which infiltrating precipitation (rainwater and snowmelt) may leach constituents present in the waste rock. MWMP tests were conducted on 89 samples, including 40 samples of Rodeo Creek (24 sulfide), 14 samples of Bootstrap (6 sulfide), 33 samples of Vinini, and 2 samples of Carlin. The vast majority of project samples would be expected to have solution with high pH and low metals, but a small fraction of the higher sulfide Rodeo Creek samples may develop low to moderate pH and moderate to high metals (***Schafer 2013***).

The MWMP tests also reflected the typical Carlin Trend geochemical signature of elevated arsenic, antimony, and mercury with alkaline samples ranging from 0.002 to 0.2 mg/l soluble arsenic and antimony. Antimony levels generally were equal to arsenic, which is uncommon. More commonly, arsenic is more abundant in solution than antimony by a factor of 3 to 10. Most samples had no detectable mercury (<0.0002 mg/l), but a few Rodeo Creek samples had mercury from 0.001 to 0.008 mg/l.

In addition to information presented for numerous samples in Appendix A of the PoO, MWMP constituent analyses are available from the project area for representative material samples from the Carlin Formation, the Vinini Formation, Rodeo Creek waste rock materials, and surface soils (McClelland Laboratories 2010). These sample results are summarized in **Table 3.4-7**

Table 3.4-7 Meteoric Water Mobility Results for Representative Material Sources

Constituent [1]	Nevada Drinking Water Standards [2]	Carlin	Vinini	Rodeo Cr Sulfide, PAG [7]	Rodeo Cr Sulfide, Non-PAG	Rodeo Creek Oxide	Surface Soil
Aluminum	0.05[4] – 0.2[5]	1.84	0.141	<0.080	<0.080	<0.080	0.297
Antimony	0.006	<0.0030	0.00492	1.67	0.0231	0.00421	<0.0030
Arsenic	0.01	0.00806	0.0138	0.0243	0.0151	0.00569	0.0268
Barium	2.0	0.0998	0.0814	0.0183	0.0508	0.0333	0.106
Beryllium	--	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020	<0.0020
Boron	--	0.079	0.111	0.167	0.087	0.153	0.207
Cadmium	0.005	<0.0020	<0.0020	0.0026	<0.0020	<0.0020	<0.0020
Calcium	--	19.4	28.6	371	67.6	109	42.7
Chloride	250[3], 400[4]	--	--	--	--	--	--
Chromium (total)	0.1	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060	<0.0060
Copper	1.3[6], 1.0[5]	<0.010	0.011	<0.010	<0.010	<0.010	<0.010
Fluoride	2.0[4], 4.0[5]	--	--	--	--	--	--
Iron	0.3[4], 0.6[5]	0.683	<0.060	<0.060	<0.060	<0.060	0.111
Lead	0.015[6]	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
Magnesium	125[4], 150[5]	3.74	6.94	39.2	38.6	43.2	10.6
Manganese	0.05[4], 0.1[5]	0.0178	0.0114	4.25	0.0419	0.0231	<0.0040
Mercury	0.002	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020	<0.00020
Molybdenum	--	0.0252	0.0662	0.784	1.26	0.204	0.0221
Nickel	0.1	<0.010	<0.010	0.286	0.014	<0.010	<0.010
Nitrate N	10	<2.00	<2.00	<2.00	<2.00	<2.00	<2.00
pH, Extraction Fluid	--	5.61	5.61	5.61	5.61	5.61	5.61
pH, Leachate	6.5 – 8.5[3]	8.00	8.09	7.74	8.26	8.03	8.17
Potassium	--	--	--	--	--	--	--
Selenium	0.05	<0.0030	0.0221	0.240	0.143	0.0266	0.00488
Silver	0.1[5]	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Sodium	--	37.4	20.4	11.1	35.5	46.1	103
Thallium	0.002	<0.0010	<0.0010	0.00206	<0.0010	<0.0010	<0.0010
TDS	500[4], 1,000[5]	230	190	1700	580	800	520
Vanadium	--	0.0091	0.0079	<0.0050	0.0063	<0.0050	0.0359
Zinc	5.0[5]	<0.010	<0.010	0.0933	<0.010	<0.010	<0.010

[1] Values in milligrams per liter, except for pH in standard units.
[2] Nevada primary MCLs unless otherwise noted.
[3] Source: Appendix B, BLM 2008b.
[4] Federal secondary MCLs.
[5] Nevada secondary MCLs.
[6] Value is action level for treatment technique for lead and copper.
[7] Potentially Acid Generating
Source: McCelland Laboratories, Inc. 2010.

As reported in **Table 3.4-7**, many of the MWMP analyses for constituents of interest have concentrations below their reporting limits. These constituents include beryllium, cadmium, chromium, most copper analyses, lead, mercury, silver, and most thallium and zinc results. Thallium results in the Rodeo Creek PAG material are borderline to the primary MCL for drinking water. TDS values in MWMP analyses exceed the secondary MCL for drinking water in Rodeo Creek materials. Barium, leachate pH, zinc, and most other results are well within Nevada water quality standards (**Table 3.4-4**).

As mentioned above, some constituents of primary interest in the region include antimony, arsenic, and mercury. Antimony concentrations are elevated in MWMP results for the Rodeo Creek sulfide materials. Arsenic MWMP values in several materials are elevated above the primary MCL for drinking water, but are within surface water standards (**Table 3.4-4**). Mercury concentrations are all below reporting limits in the samples reported above in MWMP analyses. Selenium concentrations also are of interest to surface water uses. Selenium concentrations exceed the MCL for drinking water in the Rodeo Creek sulfide materials, and exceed aquatic life standards in the Vinini and Rodeo Creek materials. Potential impacts to water quality are summarized in Section 3.4.2, Environmental Consequences.

Existing Waste Rock Material

The historic Dee Mine operated from 1984 to 2000, resulting in the placement of waste rock in the existing WRDF of which a portion would be incorporated into the proposed pit expansion area. The previously placed waste rock was mostly oxidized, which is confirmed by test results from 44 samples collected during the life of the mine. All samples had NNP values greater than 0, and only 8 samples had AGP greater than 5 kg/t. The average NNP of historic samples was 187 kg/t, while the average AGP was 2.6 kg/t (***Schafer 2013***).

Pit Wall Rock Characterization

Rocks exposed in the existing Dee open pit and would be exposed in the proposed pit expansion include a thick wedge of Carlin Formation, oxidized Vinini Formation, and oxidized and unoxidized Rodeo Creek and Bootstrap Formation rocks (**Table 3.4-8**).

Table 3.4-8 Average NNP of Rock Materials Exposed in the Pit Walls in the Existing and Proposed Open Pit

Rock Type	Existing Dee OpenPit			Proposed Pit Expansion		
	Pit Surface (%)	PAG (%)	Average NNP (kg/t)	Pit Surface (%)	PAG (%)	Average NNP (kg/t)
Old Dump Fill - Mostly Vinini	10.60	0.00	39.3	2.00	0.00	39.3
Carlin Formation	18.20	0.00	19.1	28.20	0.00	19.1
Vinini Formation - Oxide	35.20	3.9	39.3	30.80	3.90	39.3
Rodeo Creek - Oxide	20.70	0.00	129.8	10.30	0.00	129.3
Rodeo Creek - Sulfide	1.60	23.40	-	16.10	23.40	-
Bootstrap Oxide	7.70	0.00	591.2	5.60	0.00	591.2
Bootstrap Sulfide	5.90	0.00	857.7	6.90	0.00	857.7
Total	**100.00**	**1.80**	**145.9**	**100.00**	**5.00**	**137.2**

Source: Schafer 2012a.

The Carlin Formation comprises approximately 18.2 percent of the existing Dee open pit surface and 28.2 percent of the future pit surface. The Carlin Formation postdates mineralization and ore deposition and as a result does not contain sulfides or significant amounts of sulfur, and is geochemically inert (***Schafer 2012a***).

The Vinini Formation accounts for 35.2 percent of the rock exposed in the existing Dee open pit surface and 30.8 percent of the proposed pit surface. Backfilled waste rock (mostly Vinini material) also covers 10.6 percent of the existing pit and 2.0 percent of the proposed pit surface. A small fraction (less than 4 percent) of Vinini rocks may have the ability to form acidic conditions upon weathering, and silicic portions of the Vinini may release metals at neutral pH levels.

The Rodeo Creek unit accounts for most of the remaining pit surface area. It is a siltstone containing approximately 8 percent carbonate. Its geochemical behavior depends on whether or not it has been oxidized. Oxidized Rodeo Creek material contains very little sulfide sulfur and is not potentially acid generating. Oxidized Rodeo Creek material accounts for 20.7 percent of the existing exposed pit surface and 10.3 percent of the proposed pit expansion surface. Unoxidized Rodeo Creek material contains an average of 0.9 percent sulfide sulfur. Twenty-four percent (24 percent) of the unoxidized Rodeo Creek samples had more AGP than ANP. Unoxidized Rodeo Creek material is exposed in 1.6 percent of the existing pit surface and would be exposed in 16.1 percent of the proposed open-pit expansion. Unoxidized Rodeo Creek Unit rocks exposed in the pits is potentially acid-generating material.

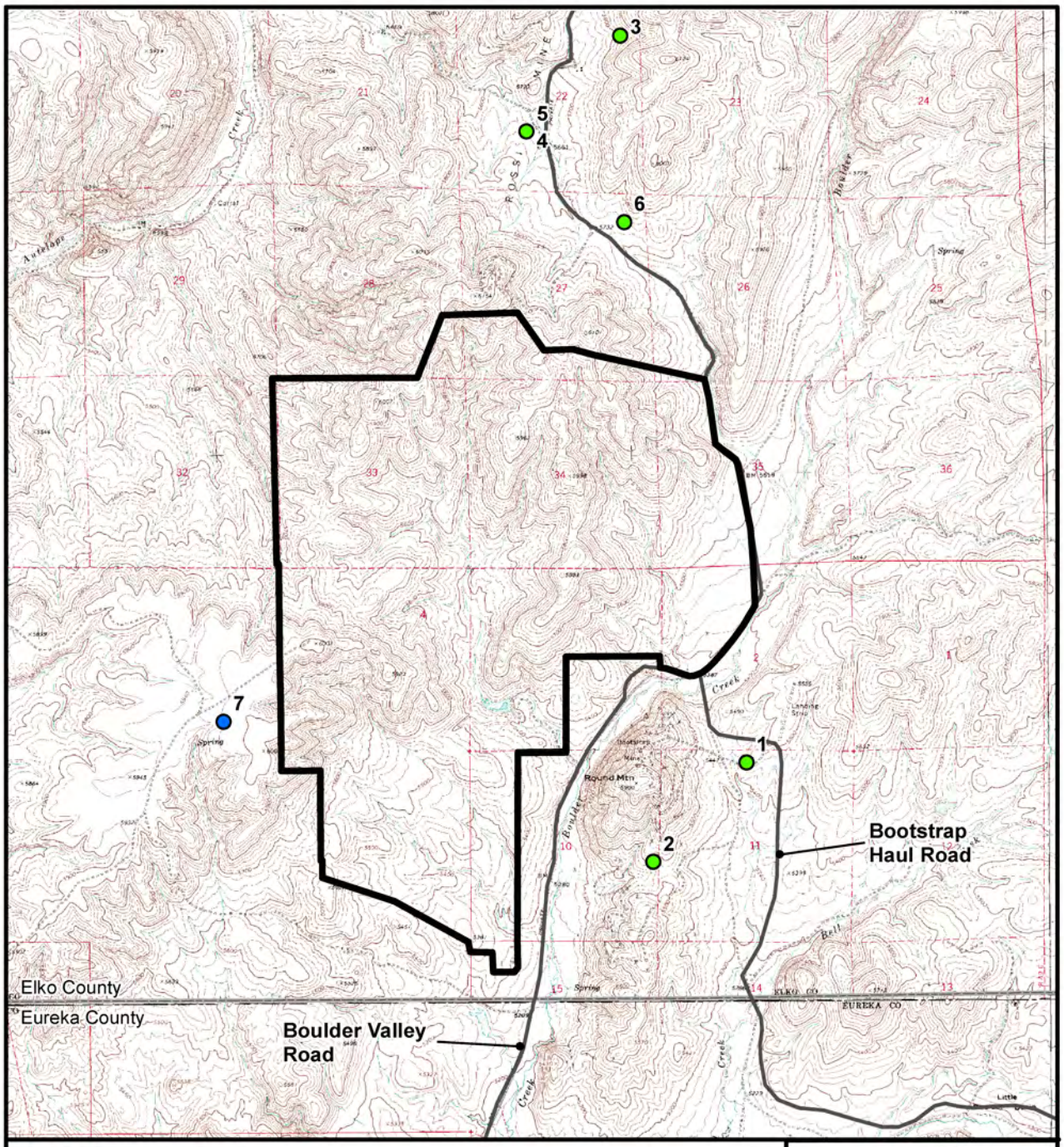
The last rock type in the existing Dee open pit is the Bootstrap limestone, which also is the primary ore host. The Bootstrap accounts for 13.6 percent of the rock exposed in the current Dee highwall and 12.5 percent of the future pit surface.

3.4.1.5 Water Rights

An inventory of active water rights in the region surrounding the proposed project was used to identify the location and status of water rights within potentially affected areas. The inventory was based on water rights records on file with the NDWR. The inventory identified all active water rights located within the vicinity of the proposed project. For the purpose of the EIS analysis, all groundwater rights owned by BGMI and Cordex Exploration Company that historically conducted exploration activities at the project site, were excluded from this summary. The locations of the points of diversion for the identified water rights in the project vicinity are shown in **Figure 3.4-6**; the owners, beneficial use, and annual duty for each water right are summarized in **Table 3.4-9**. Based on the NDWR database, there are a total of seven active water rights in the inventoried area, which includes one surface water right and six groundwater rights. The only identified surface water right is a spring used for stock watering. No public reserve water rights under the 1926 Executive Order, Public Water Reserve No. 107 were identified in the database within the inventoried area. All other water rights are groundwater rights used for mining.

3.4.2 Environmental Consequences

The primary issues related to water resources include: 1) impacts to groundwater and surface water quality from the construction, operation, and closure of heap leach facilities, waste rock storage facilities, and other mining and processing facilities; 2) impacts from flooding, erosion, and sedimentation associated with mine construction, operation, or closure activities; and 3) impacts related to the water quality of the post-mining pit lakes.



Legend

- Proposed PoO Boundary
- Surface Water Right
- Groundwater Right

Note: Excludes water rights owned by BGMI or Cordex Exploration Co. (listed for the Dee Mining Project).

Source: NDWR 2010b.

N

0 0.25 0.5 Miles

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Figure 3.4-6

Active Water Rights Located in the Vicinity of the Study Area

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Table 3.4-9 Active Water Rights Located in the Vicinity of the Proposed Project

Map ID	Application	Certificate	Status	Source	Type of Use	Annual Duty (afy)[1]	Owner of Record
1	17233	5729	Certificate	Underground	Mining-Milling	0.0	Newmont Gold Company
2	26728	9940	Certificate	Underground	Mining-Milling	199.5	Newmont Gold Company
3	42931	15356	Certificate	Underground	Mining-Milling	724.0	Baroid Division
4	61410	15359	Certificate	Underground	Mining-Milling	565.0	Baroid Drilling Fluids, Inc.
5	62578		Permit	Underground	Mining-Milling	1,448.0	Meridian Gold Company
6	62579		Permit	Underground	Mining-Milling	1,448.0	Meridian Gold Company
7	V06236		Vested	Spring	Stock Watering	0.0	26 Ranch Inc. (Spg #5)

[1] acre feet per year (afy).

Source: NDWR 2010b.

3.4.2.1 Proposed Action

Water Quantity Impacts

Impacts to Streams, Springs, Impoundments, and Seeps

No perennial stream reaches are located within the study area, as described previously in Section 3.4.1.2, Surface Water Resources. Under the proposed project, no impacts to perennial streams would occur. Short reaches of unnamed ephemeral stream channels would be removed by proposed project components. These mostly occur in the northeastern part of the proposed project area where the proposed pit expansion and the East WRDF would be located, and the south central part of the proposed project area where Heap Leach Pad No. 12 and associated processing facilities would be located. At the proposed East WRDF, a small ephemeral watershed occupying approximately 360 acres would be affected. Additional ephemeral drainage headwaters would be covered in Section 33 by the West WRDF. The watershed area that would be disturbed by the West WRDF in the northwest corner of the proposed project area, which occupies approximately 240 acres in its undisturbed condition, and contributes only ephemeral flow to Antelope Creek, a tributary of Rock Creek. In the south, the ephemeral drainage is already controlled by existing storm water diversions.

For all of these drainages, runoff from contributing upgradient watersheds would be diverted around the proposed components or contained as described in Chapter 2.0 of the proposed PoO (***SRK 2012***). Accepted engineering practices, including diversion ditches, sediment traps, small containment structures, or other Best Management Practices (BMPs) would be implemented to comply with Nevada storm water management practices for the mining industry.

Based on the lack of perennial stream reaches, the relatively small ephemeral drainages involved, and the proposed storm water management approach, direct impacts to stream flows in Boulder Creek would be of minimal consequence and local in nature.

Drainage Area Considerations

The hydrologic study area occupies approximately 47,360 acres (74 square miles). At monitoring location BC-AA (**Figure 3.4-2**), the upper Boulder Creek watershed area is approximately 17,537 acres (27.4 square miles). Further downstream at monitoring location BC-A, the Boulder Creek watershed area is approximately 47,913 acres (approximately 75 square miles). The removal or re-routing of basin areas for the proposed project would affect the contributing watershed area of upper Boulder Creek. Under existing conditions, approximately 513 acres of disturbance do not drain to the watershed. This acreage includes existing project components such as heap leach pads, tailings disposal facilities, the open pit, and associated isolated drainages. Under the Proposed Action, approximately 1,626 acres of contributing watershed area would be removed from the upper Boulder Creek drainage in the post-mining topographic configuration. This would be an increase in restricted drainage of approximately 1,113 acres from the existing condition in upper Boulder Creek. Overall, the Proposed Action would restrict watershed contributions from approximately 3.4 percent of the approximately 47,360-acre hydrologic study area. Restricted drainage from the Proposed Action would represent approximately 0.45 percent of the 560 square miles of watershed in Boulder Flat (Hydrographic Basin 61).

In the Antelope Creek watershed (which is part of the Rock Creek Valley hydrographic basin 62), approximately 292 acres of the proposed West WRDF would drain to small ephemeral tributaries. These channels run a distance of about one to 1.5 miles from the proposed WRDF footprint to Antelope Creek itself. In addition to the western slopes of the West WRDF, this acreage estimate assumes that a portion of the WRDF would drain westward to the Antelope Creek watershed during high runoff events. At its mouth at the connection with Rock Creek, the overall Antelope Creek watershed occupies approximately 144.4 square miles (92,416 acres), or about one-third of the Rock Creek Valley hydrographic basin. The watershed area affected by the proposed WRDF would represent approximately 0.3 percent of the Antelope Creek drainage and about 0.1 percent of the Rock Creek Valley Hydrographic Basin.

The areas that would be affected by the Proposed Action are drained in the project area by ephemeral streams. The impacts of drainage modifications on flow quantities in Boulder Creek or Antelope Creek would probably not be measurable.

The existing impoundments in the proposed project area described in Section 3.4.1.2, Surface Water Resources, and shown in **Figure 2-3** would not be removed by the proposed project. Direct disturbance to these features by the proposed project footprint would be avoided. Potential water quality impacts to these features are discussed below in the water quality assessment. Upgradient watershed areas that contribute to the ponds would be disturbed primarily by the southern part of the West WRDF and ancillary features on the north side of proposed Heap Leach Pad No. 12. Topographic modifications and storm water control features would reduce the contributing watershed area for the upgradient small pond. This temporarily may reduce the amount of runoff stored in that pond (or routed to the lower pond) until recontouring and reclamation are completed as proposed. Water would still collect in both ponds, since the West WRDF would be reclaimed as the proposed project proceeds, and some existing contributing drainage area would not be incrementally disturbed. However, the extent of open water habitat and fringing wetlands may be somewhat reduced. No springs would be removed by the proposed project. Seeps and non-jurisdictional wetlands would be incrementally removed either by burial under proposed project components or by removal of water sources adjacent to the proposed pit expansion. The seeps and springs identified within the proposed project area and nearby locations are indicated in **Figure 3.4-2**. Based on inventories (Cedar Creek 2009) and comparison of the existing and authorized disturbance footprint to the proposed project (**Figure 3.4-2**), the following 12 seep features would be incrementally removed:

- AR01, AR02, AR03, and AR04 are seeps in the middle of Section 3, Township 36 North, Range 49 East, that would be removed or drained by the proposed open pit expansion.

- AR10, AR11, AR12, AR13, AR14, and AR15 are seeps or catchments (such as remnant collection ponds or basins constructed during mining operations) that would be buried or otherwise removed by construction of the West WRDF or Heap Leach Number 12.
- AR17 and AR19 are, respectively, a drainage bottom wetland with open water and a seep area dominated by crested wheatgrass (Cedar Creek 2009).

These impacts would minimally affect surface water or groundwater resources, and would primarily involve habitat effects.

Potential impacts to floodplains and flood hydrology from the proposed project would be minimal. No federally delineated flood hazard zones have been identified within the proposed project area, and drainageways consist of narrow ephemerals. Storm water drainage ditches and small catchments would be constructed to manage runoff according to the NDEP and BLM requirements.

Impacts to Water Rights

Potential impacts to the water rights identified in **Table 3.4-9** are not anticipated. There are no surface water rights identified within the proposed project area. The proposed project is not expected to result in measurable effects to water levels in the regional aquifer associated with the groundwater rights.

Impacts to Water Levels

As described in Section 3.4.1.3, Groundwater Resources, the depth to groundwater beneath the study area is controlled by dewatering at the BGMI facility. Mine dewatering activities at the BGMI facility have resulted in lowering the groundwater levels approximately 1,700 feet within an approximately 2.5-mile-wide, northwest-trending zone that extends from the Betze/Post Pit to near the center of the proposed project area (**Figure 3.4-5**). Therefore, mine dewatering would not be required for the proposed project, except as necessary to control localized perched groundwater that may be encountered in the Carlin Formation during open-pit mining. Water captured during open-pit mining would be used on site for dust suppression, processing, or evaporated.

The estimated average water requirement for the proposed project is 1,120 afy (700 gpm). This water would be supplied by pumping groundwater from existing or new wells. The most likely target for the groundwater development would be the carbonate aquifer. The current maintenance pumping rate at the BGMI facility to sustain water levels at the 3,576-foot amsl level is approximately 15,000 gpm. The pumping rate required to maintain the drawdown varies within a few hundred gpm from quarter to quarter but has remained relatively constant over the past several years. (For example, in the fourth quarter of 2009 the average pumping rate was 15, 310 gpm; and in the first quarter of 2010 the average pumping rate was 15,880 gpm [BGMI 2010]). Considering the extremely high transmissivity of the carbonate aquifer (JSA 2010a) and flat hydraulic gradient between the Betze Pit to the proposed project area, pumping required for the proposed project from the carbonate aquifer likely would be offset by an equivalent reduction in pumping from the same aquifer at the BGMI facility. Consequently, pumping required for the proposed project is unlikely to result in additional drawdown in the carbonate aquifer over that which was previously predicted and analyzed for the BGMI facility (BLM 2008b, 2000c).

After dewatering ceases at the BMGI facility, the groundwater levels in the carbonate aquifer would rise above the bottom of the proposed open pit and result in the development of three separate pit lakes in the West, South, and East Pits. The estimated timeframe for development and predicted water quality of the pit lakes is discussed in the “Water Quality Impacts” section below.

Water Quality Impacts

Pit Lake Water Quality Evaluation

Pit Lake Development Predictions

The BGMI regional hydrologic model was used to predict the rate of recovery and water balance and pit lake development for the final open-pit configuration. As part of the modeling process, the previous model was updated and refined to more accurately represent the hydrogeologic conditions in the proposed pit expansion area. Model updates included: 1) refining the model grid spacing; 2) increasing the number of model layers from four to six; 3) incorporating new information or improving the model representation of field conditions; and 4) recalibration, as described in JSA (2010a).

The proposed pit expansion would expand the existing pit to include three lobes incorporated into the overall open-pit boundary that, for discussion purposes, are referred to as the North Pit, South Pit, and East Pit. Dewatering at the BGMI facility is predicted to end in 2021, after which regional groundwater levels gradually would rise. When the water table rises above the bottom of the pit, the pit would begin to fill, and three separate permanent pit lakes would form. Prior to that time, direct precipitation and runoff from the pit walls, combined with discharge from localized perched zones containing groundwater that are intercepted by the pit walls, could result in the development of a shallow lake up to several feet deep that would be either perennial, seasonal, or ephemeral, depending on the infiltration rates through the pit bottom (JSA 2010b).

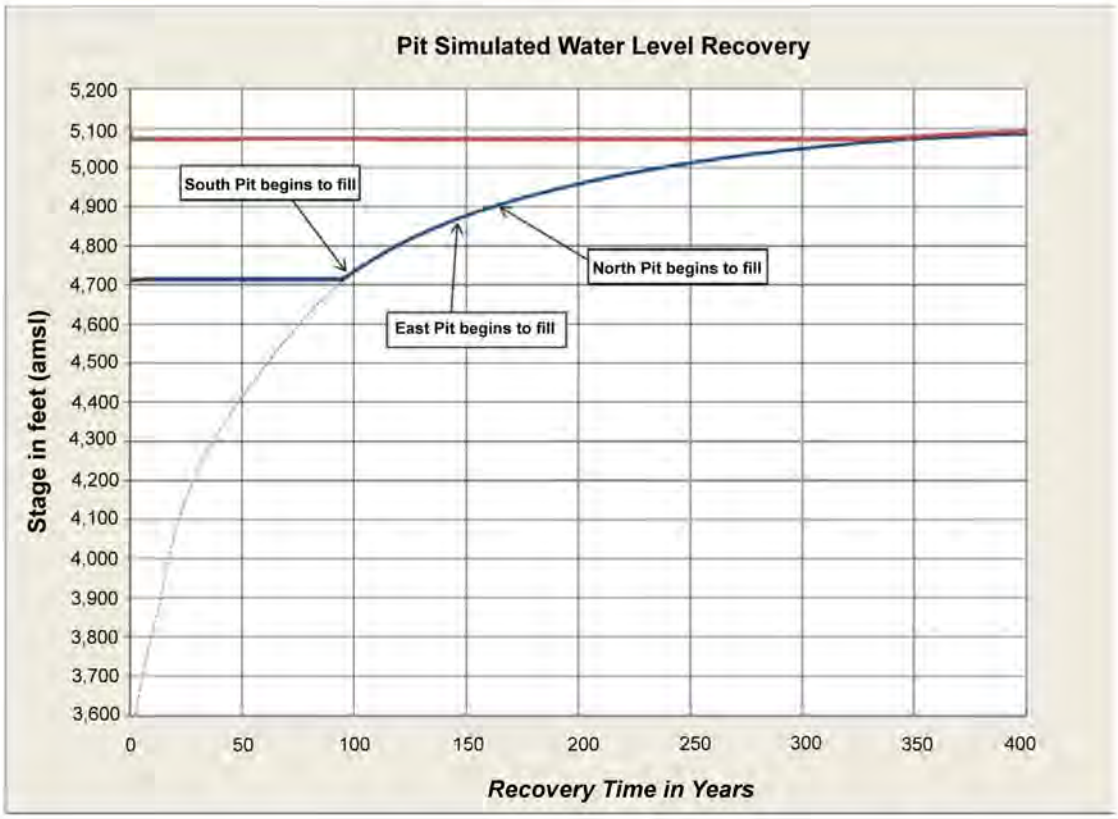
The elevation of the water surface in the pit lake over time and the final water level is dependent primarily on the water level recovery in the carbonate aquifer. Because of the high transmissivity of the carbonate aquifer, and the hydraulic interconnection between the three pit lakes, the water levels in each of the pit lakes are predicted to be the same. The model-simulated recovery of groundwater levels and development of the pit lakes is shown in **Figure 3.4-7**. The South Pit would begin to form first after approximately 100 years, followed by the East Pit at Year 150, and finally the North Pit at Year 170. Water levels in all three pits would then rise at the same rate (determined by the recovery curve for the carbonate aquifer) until a steady state was reached, after approximately 400 years. The final pit lake area is illustrated in **Figure 3.4-8**; predicted surface area, volume, and depth from each of the pit lakes are summarized in **Table 3.4-10**.

Table 3.4-10 Predicted Pit Lake Development Summary for the Proposed Action and Alternatives

Alternative[1]	Pit Lake Location	Lake Surface Area (acre)	Lake Volume (acre-feet)	Lake Surface Elevation (feet amsl)	Pit Floor Elevation (deepest) (feet amsl)	Maximum Depth (feet)	Groundwater Outflow at 400 years (Yes/No) (afy)
Proposed Action	South Pit	41.9	5,411	5,093	4,730	363	No
Proposed Action	East Pit	27.3	2,281	5,093	4,910	183	No
Proposed Action	North Pit	19.9	2,478	5,093	4,890	203	No
Total		**89.1**	**10,170**				
Partial Pit Backfill Alternative	North Pit	19.9	2,663	5,093	4,890	203	No
No Action Alternative	Dee Open Pit	0.6	6.5	5,093	5,053	40	Yes

[1] Predicted pit lake development for the Single WRDF Alternative would be the same as the Proposed Action.

Source: JSA 2011, 2010b,c; Schafer 2012a, 2011d; SRK 2012.



Legend

- Regional Aquifer Water Level
- Proposed Arturo Pit
- Existing Dee Pit

Source: Schafer 2012a.

Dee Arturo Expansion Project

Figure 3.4-7

Comparison of Predicted Rate of Filling for the Existing Dee Pit and the Proposed Arturo Pit

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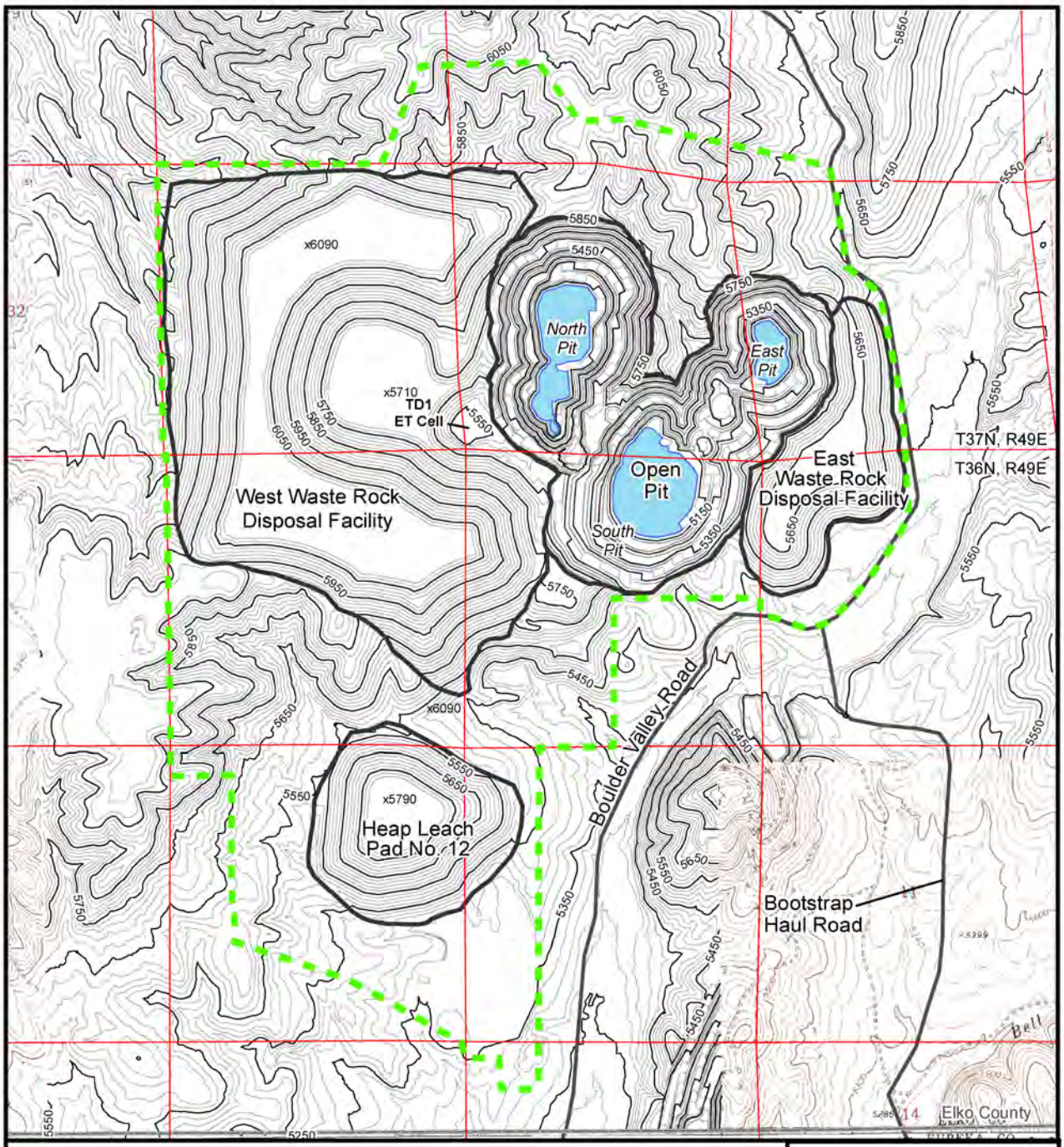

Legend

- Proposed PoO Boundary
- Proposed Facilities
- Predicted Pit Lake Surface 400 Years After BGMI Dewatering Ceases (approximately 5,093 feet amsl)

Note: 20-foot contour interval.
Contours do not reflect WRDF setback distance from open pit or reclamation topography design software.
Source: Schafer 2012a.

N

0 0.25 0.5 Miles

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Figure 3.4-8

Post-mining Pit Lakes Proposed Action

8/21/2012

The model predicts that during the early stages of recovery, local water tables would develop in the Carlin and Vinini formations that represent perched groundwater systems above the carbonate aquifer system. During the first 110 years, runoff and groundwater inflow from perched aquifer zones intercepted in the pit would be discharged primarily as groundwater infiltration to the carbonate aquifer. Between approximately 110 and 200 years, the amount of pit water discharged gradually would be reduced as the lake volume and surface area increase and the amount of water lost through evaporation increases. After approximately 200 years of recovery, the pit lakes are expected to behave as a strong sink (i.e., hydrologic capture zone where there is groundwater inflow that is lost to evaporation but no outflow to the groundwater system) (JSA 2010b).

Pit Lake Geochemical Modeling Methodology

A hydrochemical evaluation of pit lake water quality was performed for the proposed project (Schafer 2012a). In this evaluation, water quality in the pit was estimated from modeling that included the following inputs and reactions: 1) the quality and quantity of groundwater inflow and outflow; 2) pyrite oxidation rates in exposed wall rock; 3) chemical releases from oxidized wall rock and waste rock; 4) aqueous geochemical reactions in the pit lakes; 5) evaporation from the pit lake surfaces; 6) direct precipitation into the pit lakes; 7) runoff from pit walls; and 8) exchange of carbon dioxide between the pit lakes and the atmosphere.

The following paragraphs provide a brief summary of the major inputs and assumptions used in the modeling. Additional details and supporting information are provided in the pit lake geochemistry modeling report for the proposed project (Schafer 2012a).

Pit lake water quality was modeled on the assumption that water compositions would be determined by the proportions of three types of water entering the pit:

- Precipitation;
- Runoff that flows across the weathered highwall; and
- Groundwater that flows through the submerged portion of the weathered highwall.

The compositions of both runoff and groundwater input would vary with time as different rock types are exposed/submerged in the pit walls. Groundwater inputs from different aquifers would vary as a result of water level changes. The three pits are very similar but, because their geometries and predicted wall rock compositions are not identical, each was modeled separately.

Precipitation. Average annual precipitation amounts were based on long-term records from the Elko Airport supplemented by monitoring at the BGMI facility over the past 18 years. A value of 10 inches per year was used in the modeling.

Pit Wall Geochemistry. The rocks exposed in the pit highwall play an important role in determining pit lake water quality. The amount of chemical load that may be rinsed from the highwall is closely related to the acid generation potential of the rock. The majority of the rock in the highwall is either oxidized or contains abundant carbonate minerals or both. Consequently, the average NNP of exposed highwall rock in the existing and proposed pit is 146 kg/t and 137 kg/t, respectively (**Table 3.4-8**). Overall, 1.8 percent of the existing pit walls and 5 percent of the proposed pit surface contains rock that would be considered PAG based on NNP values less than 0 kg/t (Schafer 2012a).

Runoff from Pit Walls. The pit walls would consist of four stratigraphic units, the Carlin Formation, the Vinini Formation, the Rodeo Creek Unit, and the Bootstrap Limestone described in Section 3.3.1.4, Site Geology and Mineralization. Runoff would result from both meteoric water input and groundwater discharge above the level of the contemporaneous pit lake. Runoff compositions from each lithology in

the exposed wall rock were estimated from a series of experiments: rinsing experiments on fresh and weathered rocks, humidity cell tests, and meteoric water mobility tests (Schafer 2012a).

Groundwater Inflow. The inflow of groundwater from each aquifer to each pit over time was estimated using the calibrated regional hydrologic model described previously. Water is derived from three aquifers: the Carlin Aquifer, the Vinini Aquifer, and the carbonate aquifer. In the long-term, the carbonate aquifer would be the dominant source of water to all three pits.

Geochemical Modeling. After the inputs to the lakes had been calculated, the geochemical evolution of the resulting lake was calculated using the geochemical computer program PHREEQC (Parkhurst and Appelo 1999). PHREEQC can perform various calculations, including chemical equilibrium with selected solid phases, equilibration with an atmosphere, equilibration at operator-selected redox levels, and evaporation. The output from PHREEQC provides predictions of the chemical composition of water after chemical equilibration (and other specified reactions) has taken place.

During the early stages of pit filling, most of the water flowing into the pit lakes would come from highwall runoff with lesser amounts of groundwater from the Carlin and Vinini aquifers. Until groundwater levels reach the base of the pits, virtually all water that enters the pits would infiltrate out of the bottom of the pits into the carbonate aquifer.

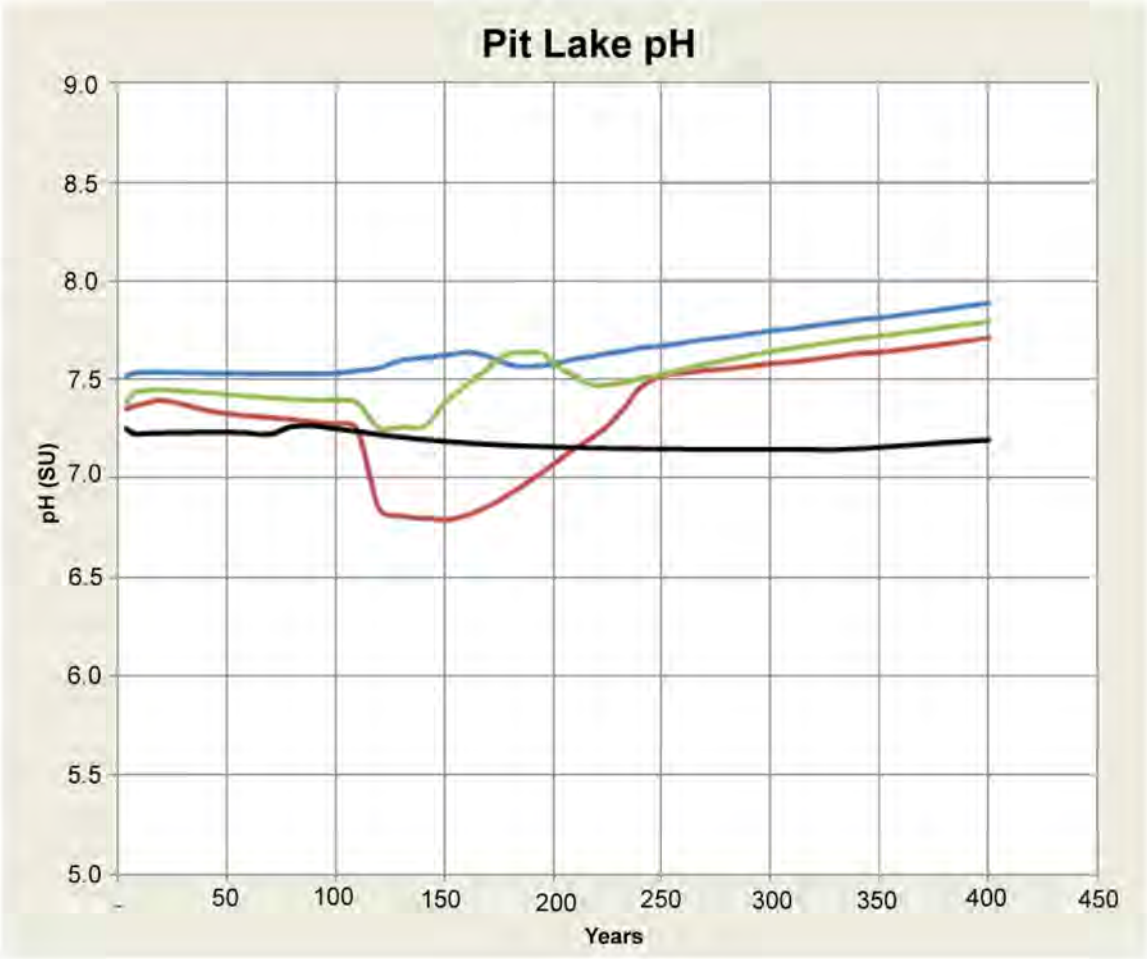
Pit Water Infiltration to Groundwater

Water that accumulates in the pits during the first approximately 150 to 200 years of recovery, and does not evaporate, is predicted to infiltrate into the floor of the pit and discharge into the carbonate aquifer system (JSA 2010b). The estimated rate of infiltration is approximately 75 afy (50 gpm) at the initial stage of recovery, increases to approximately 150 afy (90 gpm) by Year 100, and then gradually declines to zero when the permanent pit lakes form as a result of inflow from the carbonate aquifer after 200 years.

The composition of the infiltrating water was predicted by the same procedure based on PHREEQC as was used for the final pit lakes. The pit water captured in the South, East, and North Pit lakes would have an initial pH of approximately 7.3 to 7.5 and a TDS of 600 to 900 mg/l (**Figures 3.4-9** and **3.4-10**, respectively). The TDS is predicted to gradually decrease as the highwall is rinsed by meteoric water. A sharp increase in the TDS concentrations would occur when inflow from the carbonate aquifer begins.

This results from a renewed influx of soluble salts as weathered carbonate rock is rinsed by flow from the carbonate aquifer.

Nevada regulations address the post-mining pit lakes and provide that pit lakes must not have the potential to degrade groundwaters of the State or adversely affect the health of human, terrestrial, or avian life (NAC 445A.429[3]). The predicted water chemistry of the infiltrated pit water is summarized in **Table 3.4-11**. This predicted water quality also represents the quality of any shallow ponding that may occur in the pit prior to permanent pit lake development. Predicted concentrations of antimony, arsenic, nickel, and selenium in the infiltration water from one or more of the pit lake areas would exceed the primary Nevada water quality standards for drinking water. In addition, the predicted manganese concentrations, and TDS ***concentrations*** from one or more of the pit lake areas would exceed the Nevada secondary drinking water standards. The minimum, maximum, and average concentrations in the carbonate aquifer also are listed for comparison in **Table 3.4-11**. ***Of these constituents with exceedances of primary or secondary water quality standards t***he predicted average concentrations of ***arsenic, selenium, manganese, and TDS*** over the infiltration period also would exceed the average background water quality for the carbonate aquifer in the region. However, the range of concentrations of antimony and arsenic predicted for the proposed pit are within the range of concentrations that naturally exist in the carbonate aquifer. The maximum predicted concentration of selenium (0.084 mg/l), and manganese (0.306) would be greater than the maximum concentrations reported for the carbonate aquifer.



Legend
- South Pit
- North Pit
- East Pit
- Existing Pit

Source: Schafer 2012a.

Dee Arturo Expansion Project

Figure 3.4-9

Predicted Trends in pH for the South, North, and East Pit Lakes (Proposed Action) and Existing Pit (No Action)

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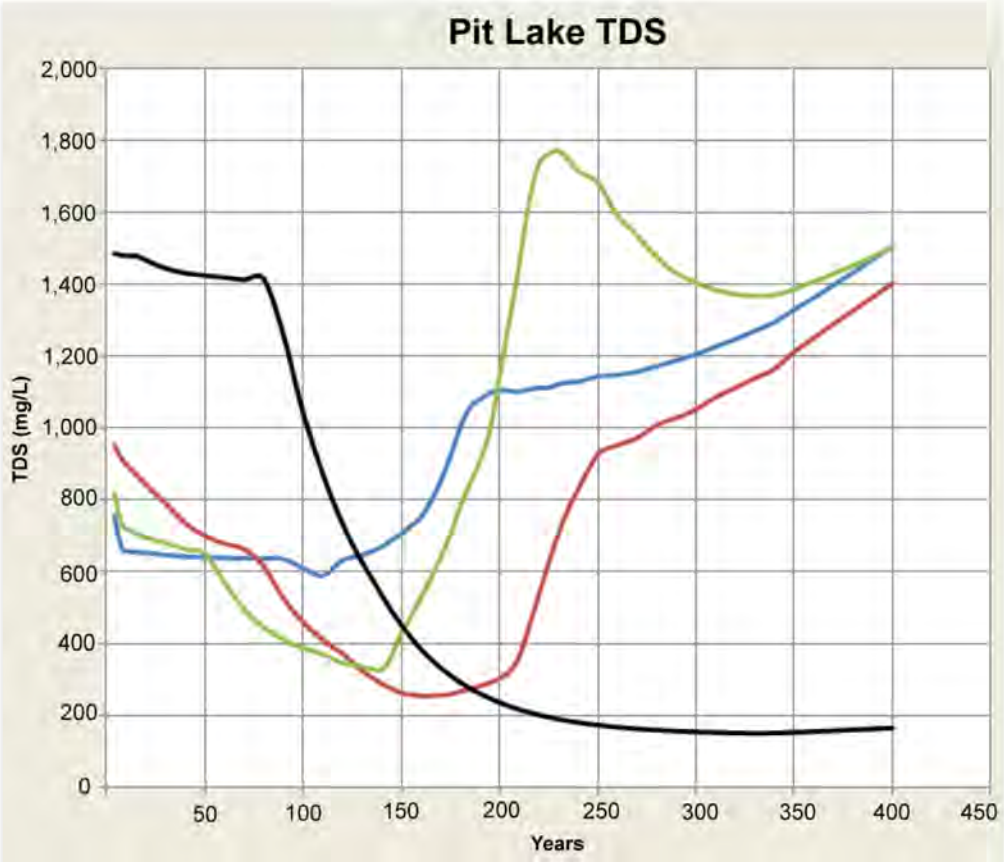

Legend
- South Pit
- North Pit
- East Pit
- Existing Pit

Source: Schafer 2012a.

Dee Arturo Expansion Project

Figure 3.4-10

Predicted Trends in TDS for the South, North, and East Pit Lakes (Proposed Action) and Existing Pit (No Action)

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Table 3.4-11 Predicted Water Quality of Outflow from the Pits Prior to Permanent Development of Pit Lakes

Constituent (mg/l)[1]	Nevada Drinking Water Standards[2]	No Action Pit			Proposed Project Pit			Carbonate Aquifer[7]		
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Aluminum	0.054[3] – 0.2[4]	<0.004	<0.005	<0.004	<0.005	<0.018	<0.004			
Antimony	0.006	**0.036**	**0.042**	**0.038**	**0.019**	**0.041**	**0.021**	**0.022**	**0.050**	**0.035**
Arsenic (total)	0.01	0.010	**0.097**	**0.029**	**0.024**	**0.088**	**0.059**	0.008	**0.451**	**0.021**
Barium	2.0	0.032	0.110	0.075	0.049	0.085	0.061			
Boron	--	0.0	0.5	0.1	0.0	0.2	0.1	0.600	0.847	0.767
Cadmium	0.005	<0.002	<0.006	<0.003	<0.002	<0.003	<0.002			
Calcium	--	128.2	397.2	209.8	152	229	182.7	39	109	88.9
Chloride	250[3], 400[4]	3.8	15.3	5.3	4.3	17.6	13.9	3.0	19	14.9
Chromium (total)	0.1	<0.001	<0.001	<0.001	<0.001	<0.007	<0.001			
Copper	1.3[5], 1.0[4]	0.001	0.012	0.004	0.008	0.018	0.010			
Fluoride	2.0[3], 4.0[4]	0.9	1.9	0.9	1.0	1.9	1.1	0.6	1.6	1.3
Iron	0.3[3], 0.6[4]	0.001	0.001	0.001	0.004	0.001	0.005	0.030	14.7	0.308
Lead	0.015[5]	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.012	0.007
Magnesium	125[3], 150[4]	8.9	78.3	30.6	18.0	45.2	33.1	19.0	32.0	21.9
Manganese	0.05[3], 0.1[4]	0.034	**0.724**	**0.098**	**0.053**	**0.306**	**0.094**	0.007	**0.092**	0.013
Mercury	0.002	< 0.0007	< 0.0008	< 0.0007	< 0.0003	< 0.0006	< 0.0004	0.001	0.00222	0.0007
Nickel	0.1	0.069	**0.285**	**0.104**	0.046	**0.137**	0.065			
Nitrate (as N)	10	0.1	0.3	0.1	0.4	0.8	0.5			
pH (standard units)	6.5 – 8.5[4]	6.85	6.99	6.94	6.93	6.98	6.96	5.1	8	6.7
Potassium	--	5.3	16.1	6.5	6.5	10.4	7.3	6.6	25	20.9
Selenium	0.05	0.005	**0.207**	0.022	0.009	**0.084**	0.021	0.002	0.004	0.004

Table 3.4-11 Predicted Water Quality of Outflow from the Pits Prior to Permanent Development of Pit Lakes

Constituent (mg/l)[1]	Nevada Drinking Water Standards[2]	No Action Pit			Proposed Project Pit			Carbonate Aquifer[7]		
		Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Silver	0.1[4]	<0.001	<0.001	<0.001	<0.001	<0.002	<0.001			
Sodium	--	8.9	59.4	13.6	152.0	229.0	182.7	21.0	85.5	73.9
Sulfate	250[3], 500[4]	36.7	**897.9**	308.0	137.5	410.6	260.9	48	160	77.0
Thallium	0.002	0.000	0.014	0.001	0.0005	0.006	0.001	<0.001	<0.001	<0.001
Bicarbonate	--	407.9	488.9	461.4	457.0	501.0	475.9	195	582	414.5
TDS[6]	500[3], 1,000[4]	***603***	***1,961***	***1,043***	***802***	***1,287***	***1,024***	310	672	566.2
Zinc	5.0[4]	0.040	1.749	0.501	0.625	01.969	0.769			0.017

[1] Units are mg/l unless otherwise noted.

[2] Nevada primary MCLs unless otherwise noted.

[3] Federal secondary MCLs.

[4] Nevada secondary MCLs.

[5] Value is action level for treatment technique for lead and copper.

[6] For the No Action and Proposed Action pit lakes; the TDS is dominated by calcium and bicarbonate ions, whose high concentrations are an artifact of the very high partial pressure of carbon dioxide determined for the carbonate aquifer. If atmospheric carbon dioxide levels are applied, the resulting average TDS values are less than 500 mg/l (Schafer 2012a).

[7] Source for carbonate aquifer data: BLM 2008b, Table B-2.

Note: Bold values exceed Nevada Drinking Water Standards.

Source: Schafer 2012a.

The movement of infiltration from the open pit was evaluated using the regional groundwater flow model described previously. Specifically, particle tracking was used to identify the likely flow paths that would occur over time from the infiltrating water (JSA 2010d). The results indicate that flow infiltrating in the pit area at Year zero would travel south toward the Betze Pit. Later flow (released at 50, 100 years, and 150 years after the start of recovery) would travel toward the west.

Attenuation batch testing and numerical modeling were conducted to assess the potential fate and transport of key metals and TDS that may infiltrate through the pit floors into bedrock prior to development of permanent pit lakes controlled by recovery of the regional carbonate aquifer. The Bootstrap Formation would be exposed in the floor of the proposed pits and would be the receptor of flow that infiltrates from the pit prior to pit lake development. Minerals within the Bootstrap Formation may absorb or precipitate dissolved constituents within the solutions that infiltrate the pit floor. Samples of rock core taken from the Bootstrap Formation were selected to represent materials that would be exposed in the pit floor. These samples were then tested to evaluate the sorption capacity for the six metals of concern (arsenic, antimony, manganese, nickel, selenium and thallium). Although some of the isotherms are not well constrained, the experiments do show strong adsorption of the elements of interest, which indicates that migration would be limited. Overall, the results of the batch testing indicate that the Bootstrap Formation has the capacity to absorb and precipitate constituents of concern and inhibit migration (Geomega 2011; Schafer 2012b, 2011b)

Solute transport modeling was conducted to simulate sorption along potential flow paths between the pit bottom and the groundwater aquifer. For simplicity, water infiltrating the pit flow was assumed to connect with the deeper aquifer system with no retention time or attenuation in the vadoze zone. The analysis was conservative since it did not account for dilution or dispersion that would occur as the pit infiltrate entered the groundwater flow system. Separate model simulations were conducted for each constituent of concern. The results of the modeling indicate that the elevated metals concentrations would not be detected further than 20 to 50 meters (70 to 170 feet) from the margin of the pit. TDS of water infiltrating from the pits would be less than 500 mg/l ***(at atmospheric conditions)***, but would increase in the deeper aquifer due to calcite dissolution. If the deep groundwater were pumped to the surface for use, its TDS would again drop below 500 mg/l under atmospheric conditions due to off-gassing and calcite precipitation. (Schafer 2011b). Because elevated metals concentrations are not expected to affect groundwater quality outside the footprint of the pits, infiltration from the pits is not ***expected*** to adversely affect the ***water quality in the downgradient*** carbonate aquifer.

Pit Water Quality Predictions

As described previously, permanent pit lakes are predicted to develop in the South, East, and North Pits at 100, 150, and 170 years, respectively, when inflow from the carbonate aquifer enters the pit areas. The pH predictions shown in **Figure 3.4-9** indicate that the lakes would be near neutral (pH 6.8 to 8). This new source of inflow (i.e., the carbonate aquifer) would result in the rinsing of soluble salts in the weathered carbonate and would result in a sharp increase in TDS (**Figure 3.4-10**). Once permanent pit lakes form, groundwater outflow would cease and evapoconcentration would result in a gradual increase in TDS, reaching TDS levels of 1,400 to 1,500 mg/l at the end of the simulation period. In the longer term (beyond 400 years), the salinity of the pit lakes steadily would increase in response to evaporation. Groundwater would continue to flow into the pits to replace water lost by evaporation, and the solutes in the water (other than those lost by precipitation of carbonate) would accumulate.

Water in the South, North, and East pit lakes would be calcium-sulfate type water initially and would transition to calcium-bicarbonate water as highwall rinsing progresses and then sodium-bicarbonate water after approximately 300 years due to evaporation and precipitation of calcium carbonate.

The behavior of several trace elements, and hydrous ferric oxide, is sensitive to redox conditions in the water. It was assumed in the modeling that the pit lake waters would remain oxidizing. A review of pit lakes that are analogous to the pit lakes that would develop under the Proposed Action (Schafer 2012a)

indicates that the pit lakes are likely to turn over seasonally: once or more each year. It is, therefore, realistic to assume that the waters would remain oxidizing at all depths.

The long-term (400-year) predicted pit lake water chemistry for the Proposed Action is summarized in **Table 3.4-12**. Although the pit lakes are not intended to be used as a drinking water source for human consumption, **Table 3.4-12** includes the current Nevada Drinking Water Standards as a reference. The pit lake water has predicted constituent concentrations that exceeded the Nevada primary water quality standards for antimony and arsenic. The predicted concentrations of fluoride, manganese, sulfate, and TDS also exceed the Nevada secondary drinking water standards. These pit lakes are predicted to eventually behave as groundwater sinks. As a result, it is anticipated that in the long term (after approximately 200 years), these lakes would not affect the water quality of downgradient aquifers. The potential risk to wildlife associated with exposure to the pit lakes is addressed in Section 3.17, Wildlife and Aquatic Biological Resources.

Waste Rock Disposal Facilities

The geochemical testing data for waste rock material is summarized in Section 3.4.1.4, Rock Geochemistry. Exploration drilling data and geochemical testing results were entered into a geologic block model to estimate the waste materials and mass of PAG waste rock generated during mining (**Table 3.4-13**). The modeling indicates that approximately 3.5 percent of the total waste rock tonnage may be acid generating. A large fraction of the waste rock tonnage (46 percent) would be from the Carlin Formation, the oxidized Bootstrap, and oxidized Rodeo Creek material, which are non acid-generating. The next largest group of waste rock material (39 percent) is Vinini Formation, which has a small percentage (3.9 percent) of material that may generate acid. The Rodeo Creek sulfide material comprises approximately 8.5 percent of the total waste rock material, and approximately 23 percent of the Rodeo Creek sulfide bearing material is potentially acid-generating.

The metals leaching risk of rocks is closely related to the solution pH. Samples that generated acidic conditions (<5.5) in MWMP tests or humidity cell tests had moderate to high levels of base metals while near-neutral samples had mostly low base metal levels. Some rock samples contained elevated levels of arsenic and antimony, but rarely mercury. Although soluble levels of oxyanions are often elevated at alkaline pH levels, the majority of these elements are retained in solid phase. In materials containing oxidized iron, an important mechanism that reduces the mobility of these metals is sorption on iron oxyhydroxides. Consequently, although small pockets of mineralized rock within the WRDFs may generate higher levels of soluble metals, arsenic and antimony would tend to become sorbed by adjacent rock masses as interstitial water from these zones migrates (Schafer ***2013***).

Table 3.4-12 Model-predicted Pit Lake Water Chemistry at Year 400

Constituent (mg/l)[1]	Nevada Drinking Water Standards[2]	No Action Pit Lake	Proposed Action Pit Lakes			Partial Backfill (North Pit Lake)
			South	North	East	
Aluminum	0.05[3] – 0.2[4]	0.004	0.009	0.007	0.006	0.007
Antimony	0.006	**0.041**	**0.099**	**0.14**	**0.104**	**0.085**
Arsenic (total)	0.01	**0.037**	0.009	0.0005	0.003	**0.011**
Barium	2.0	0.110	0.042	0.038	0.038	0.039
Boron	--	0.03	1.7	1.8	1.7	
Cadmium	0.005	0.003	0.001	0.001	0.001	0.001
Calcium	--	18	30	68	48	82
Chloride	250[3], 400[4]	4	79	50	68	38
Chromium (total)	0.1	<0.001	<0.001	<0.001	<0.001	0.0014
Copper	1.3[5], 1.0[4]	0.001	0.031	0.021	0.026	0.020
Fluoride	2.0[3], 4.0[4]	1.0	**4.3**	**5.0**	**4.5**	3.7
Iron	0.3[3], 0.6[4]	< 0.001	< 0.001	< 0.001	< 0.001	<0.001
Lead	0.015[5]	<0.0001	0.0004	<0.0001	<0.0001	0.0002
Magnesium	125[3], 150[4]	10	117	106	116	92
Manganese	0.05[3], 0.1[4]	0.04	**0.20**	**0.30**	**0.28**	**0.25**
Mercury	0.002	< 0.001	< 0.003	< 0.004	< 0.003	0.002
Nickel	0.1	0.07	0.13	0.25	0.20	0.23
Nitrate (as N)	10	0.1	2.3	1.5	2.3	1.4
pH (standard units)	6.5 – 8.5[4]	7.20	7.89	7.71	7.80	7.67
Potassium	--	6	62	69	63	50
Selenium	0.05	0.006	0.023	0.036	0.032	0.032
Silver	0.1[4]	<0.001	<0.005	<0.0016	<0.005	0.004
Sodium	--	10	245	211	230	156
Sulfate	250[3], 500[4]	39	**548**	**603**	**624**	**562**
Thallium	0.002	0.0003	<0.002	<0.002	<0.002	0.002
Bicarbonate	--	69	347	235	282	210
TDS	500[3], 1000[4]	157	1428	1343	1432	1190
Zinc	5.0[4]	0.04	0.19	0.43	0.29	0.768

[1] Units are mg/l unless otherwise noted.
[2] Nevada primary MCLs unless otherwise noted.
[3] Federal secondary MCLs.
[4] Nevada secondary MCLs.
[5] Value is action level for treatment technique for lead and copper.
Note: Bold values exceed Nevada drinking water standards.
Source: Schafer 2012a, 2011c.

Table 3.4-13 Estimated Waste Rock Generated by Proposed Action Mining

Waste Material Type	Estimated Tons	Percent of Total Waste Rock	Estimated Tons of PAG	Percent PAG
Fill	33,300,000	5.5	0	0
Carlin	228,200,000	38.0	0	0
Vinini	235,800,000	39.3	9,196,200	3.9
Rodeo Creek Oxide	40,400,000	6.7	0	0
Rodeo Creek Sulfide	50,900,000	8.5	11,910,600	23.4
Bootstrap Oxide	6,505,000	1.1	0	0
Bootstrap Sulfide	5,207,000	0.9	0	0
Total Waste	**600,312,000**	**100.0**	**21,106,800**	**3.5**

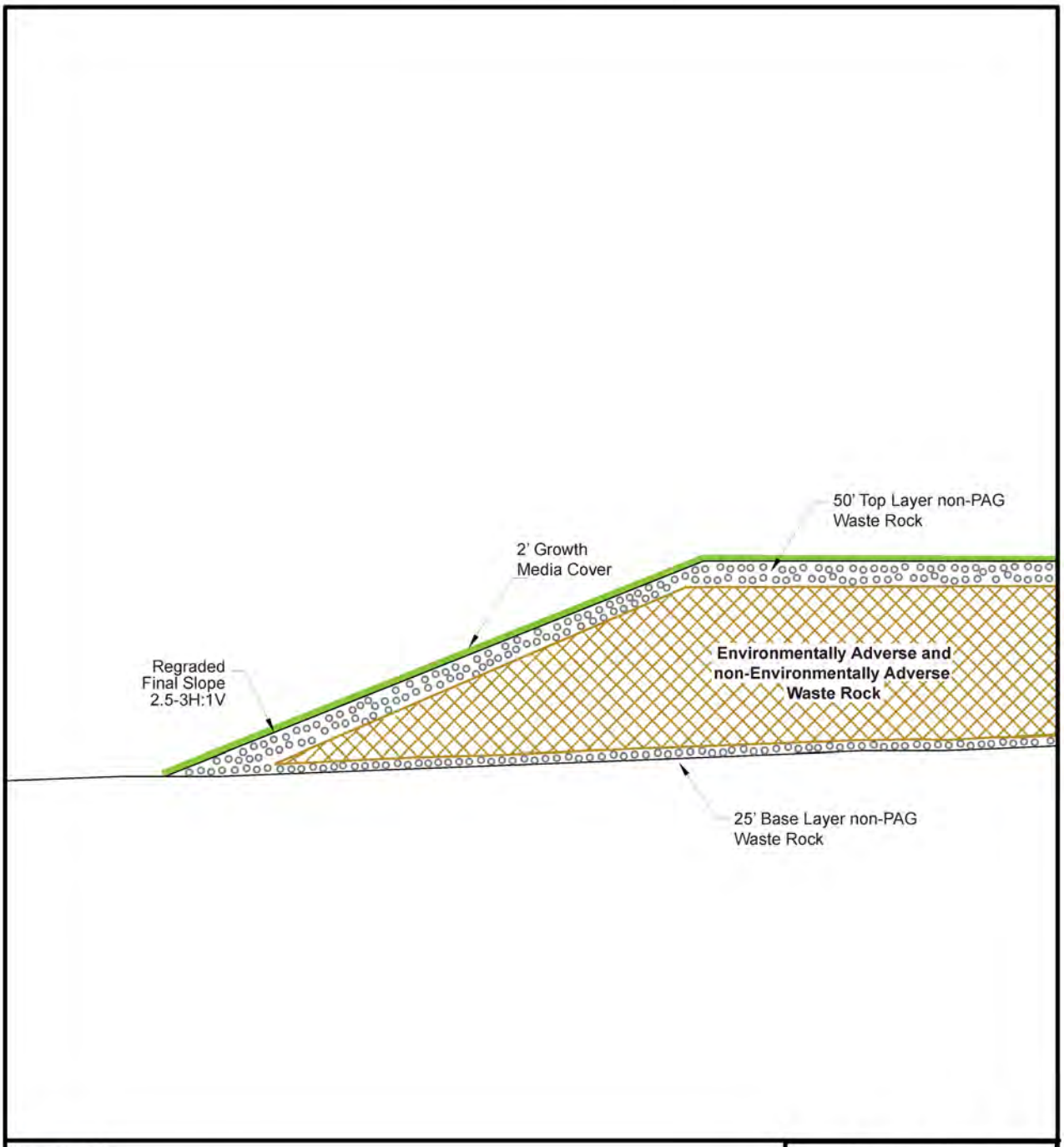
Source: Schafer 2013.

The strategy for handling waste rock material is presented in the Waste Rock Management Plan prepared by Schafer for the PoO (***Schafer 2013***). Waste rock would be placed into an expanded footprint of the West WRDF and a new East WRDF (Section 2.3.3, Waste Rock Disposal Facilities). A conceptual diagram of the environmental protection measures incorporated into the design of the WRDFs shown in **Figure 3.4-11**. Construction, operation and management, and closure and reclamation of the facilities would include BMPs for storm water management and erosion control (Section 2.3.9.7, Water Resource Protection).

Waste rock units classified as “environmentally adverse” contain rock with the potential to become acidic, leach metals, or both. Environmentally adverse rock would account for an estimated ***9*** percent of the material placed in the WRDFs (***Schafer 2013***). Under the proposed waste rock handling plan, this material would be identified during mining and managed during development of the WRDFs. Environmentally adverse waste rock would be intermixed with oxidized waste rock and not segregated. This intermixed waste rock material would be underlain and covered by a shell of waste rock classified as oxidized (i.e., non-PAG). The minimum thickness of the oxidized (non-PAG) shell would be 25 feet at the base of the facility, and 50 feet along the sides and top of the final reclaimed facility (***Schafer 2013***). The perimeter shell would ensure that migrating water contacting acid forming rock in the interior of the facility also would encounter acid neutralizing rock in the perimeter shell before exiting the facility.

Acid-base accounting tests results for waste rock materials to be placed in the WRDFs are presented in **Table 3.4-6**. A ratio of ANP/AGP of 3:1 (or greater) generally indicates that the material is unlikely to generate acid (USEPA 1994). The ANP/AGP of 3:1 criteria is sometimes used as a criteria for material used to encapsulate PAG waste rock. The average ANP/AGP ratio for all of the rock units tested ranged from 5:1 to 2,900:1. The average ANP of all samples tested was 160.2 kg/t, while the average AGP was 6.0 kg/t, for an average NNP of 154.2 kg/t and an ANP/AGP ratio of approximately 27:1 (***Schafer 2013***). Based on these results it is anticipated that the average ANP/AGP ratio for the non PAG shell would exceed the ANP/AGP 3:1 criteria.

The WRDFs are sited and designed to minimize the risk of impact to waters of the State. During operations, little if any flux of meteoric water is expected to occur within the WRDFs because of the dry nature of rock when it is initially placed and the dry climate at the site. Reclaimed landforms would promote long-term geomorphic stability. Additionally, closure practices have been recently implemented



Legend

- Mixed Waste Rock
- Non-Potentially Acid Generating (non-PAG) Waste Rock
- Growth Media Cover

Source: BDMV 2012.

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Figure 3.4-11

WRDF Schematic Cross-section Showing Encapsulation of Environmentally Adverse Waste Rock

at the BGMI facility that reduce or eliminate infiltration of water and oxygen (Zhan et al. 2006); these closure practices would be applied to the proposed project. This design, involves shaping the facility to a geomorphically stable configuration ***and*** placing a soil cover composed of Carlin and/or topsoil material**.** ***This cover material has been shown to have a*** high water holding capacity***, is suitable for establishing*** perennial vegetation**,** ***which acts to reduce net infiltration and*** meet post-mining land use objectives.

Relationship to Adjacent Surface Water and Groundwater

The existing WRDF is within the headwaters of a small ephemeral tributary to upper Boulder Creek. The WRDF was constructed with a French drain to conduct any flows that occurred in the facility foundation. Small flows from the French drain are collected in a small pond (the BLM detention pond at AR36 and AR09 in **Figure 3.4-2**) that would not be covered by the waste rock material. Water quality data for this feature is reported in **Table 3.4-5** for Sites AR09 and AR36. During operations, storm water from the proposed WRDFs would be managed under a general permit issued by NDEP. Sediment releases would be minimized or eliminated using a variety of best management practices (Section 2.3.6.9, Storm Water Management Facilities).

The seep at AR-09 and the BLM pond have been in place for approximately 25 years and are represented by AR-36 (Figure 3.4-2) data. As such, they are part of the existing baseline conditions. Flow from the seep would be reduced by reclamation practices that would cover the existing waste rock pile and create a vegetative cover. The BLM pond would continue to be an evaporative feature as it has been historically, with saline flats at the upstream end. While current conditions are anticipated to continue into the future, ongoing monitoring and any needed responses implemented through agency interactions would address water quality in the AR-09/AR-36 system as necessary.

After mining cessation, the WRDFs would be covered with growth media. After reclaimed vegetation becomes established and drainage systems stabilize, any surface runoff (expected to be an infrequent occurrence based on climatic conditions, predictive modeling, and observation) is expected to be suitable for release to waters of the State without storm water controls. The vegetated slopes and channel network would minimize sediment movement.

Groundwater is located in carbonate rock, at a depth of more than 1,000 feet beneath the WRDF. Groundwater also occurs as discontinuous or localized perched systems in the Carlin Formation deposits and Paleozoic clastic units.

Water Movement During Mine Operations

While the net infiltration of water through a cover dictates the amount of meteoric water that may contact waste rock in the long term, the water content of waste rock also is an important short-term factor affecting potential water movement within the dump. Rock material contains little water when mined because it has an inherently low porosity and has been desaturated by mine dewatering. When rock is blasted, mined, hauled, and placed, its void space and porosity increases from a few percent to 30 percent or more. Rock initially placed in the WRDFs would have approximately 2 to 3 percent volumetric water content. The equilibrium water content of waste rock (the field capacity) is expected to range from 5 to 8 percent volumetric water content in coarse rock (***Schafer 2013***). Therefore, rock material would need to absorb from 2 to 6 percent water before appreciable water movement would occur. Consequently, during and immediately after operations, the waste rock would absorb any percolation of meteoric water until the field capacity is reached and noticeable drainage occurs. Toe seepage may be observed during the operational phase due to the potential preferential flow, snowmelt infiltration, and surface water runoff from the sloped area.

Water Movement in the Post-closure Period

The reclamation plan proposed for the West and East WRDFs specifies the amount and type of plant growth media to be placed over the graded facility, the slope angles to be achieved, and the seed mix to be used. Evaporation and transpiration by vegetation extracts water from near-surface layers, predominantly during warmer periods, leaving a moisture-depleted plant root zone by fall, which can store water. Available information indicates that a vegetated evapotranspiration cover (consisting of topsoil or Carlin material) can reduce infiltration of meteoric water to pre-mining levels that occur naturally (***Schafer 2013***).

The proposed operational waste rock management plan and cover design are critical elements in achieving satisfactory long-term environmental performance. The net alkaline character of waste rock, the relatively small volume of acid-generating material, and the selective handling program would further help protect waters of the State. The waste rock classification, segregation, and selective placement program are designed to reduce the occurrence of acid rock drainage and migration of soluble metals, and to prevent releases of surface runoff, ***and minimize the potential for acid generation or metals mobilization***. The reclamation and closure approach for the facility is to grade and cover waste rock to prevent contact between waste rock and surface runoff, to minimize seepage and infiltration of water, and to reduce the diffusive flux of oxygen into the facility after closure of the facility. Minimization of net infiltration into the WRDFs through use of ***evapotranspiration (ET)*** covers would provide an effective means of ***minimizing*** migration of interstitial water from the facility**.**

The final ET cover is projected to reduce the net infiltration rate to approximately 1 to 2 percent of annual precipitation (BDMV 2013). Using an estimated average annual precipitation rate of 10.7 inches for the project site, and an assumed long term net infiltration rate ranging from 1 to 2 percent of the average annual precipitation, the estimated long term (i.e. postclosure) range of flow from the West WRDF is 6.2 to 12.2 gpm; and from the East WRDF is 1.0 to 2.1 gpm. This long-term seepage from the WRDFs is not expected to impact the downgradient groundwater quality because of the site geochemical conditions as described in the WRMP (Schafer 2013) and summarized below:

- ***Excess of alkalinity in both the waste rock material stored in the WRDFs, and in the unconsolidated sediments and bedrock beneath the facilities that is available to neutralize acidity generated locally by pockets of mineralized rock material stored in the facilities;***
- ***Elevated concentrations of soluble metals (such as iron, aluminum, copper, cadmium and lead) will tend to precipitate in secondary minerals predicted to form under neutral to alkaline pH conditions along the flow path that commonly occur in carbonate rich rocks;***
- ***The bedrock materials beneath the WRDFs are oxidized, and iron is relatively abundant in virtually all rocks in the project area (Schafer 2013). Therefore, arsenic, antimony and mercury released into solution are likely to be immobilized by sorption onto iron oxyhydroxides minerals that occur along the flow path.***

In addition, the groundwater elevation is currently over 1,000 feet beneath the surface footprint of the WRDFs as a result of extensive mine dewatering operations at the BGMI. After dewatering ceases, the groundwater elevation will eventually rebound to an elevation that will still be situated several hundred feet beneath the facility footprints. The low flow rates combined with the depth to groundwater indicates that 1) any seepage leaving the facility would experience relatively long travel times through the unsaturated zone prior to reaching groundwater, and 2) the long travel time would provide ample time for completion of slow neutralization and attenuation processes (Schafer 2013).

For these reasons, seepage from the WRDFs is not expected to result in a measurable change in downgradient groundwater quality that would exceed water quality standards for the anticipated beneficial uses (such as a potential source of drinking water).

Ore Stockpiles

The ore stockpiles would be designed and constructed to prevent potential degradation to surface or groundwater resources in accordance with Nevada mining regulations and in accordance with the NDEP water pollution control permit. The facilities would include an engineered liner system and a protective rock cover placed over the liner to prevent damage during ore dumping or excavation activities. Therefore, ore stockpiling activities are not expected to result in impacts to surface or groundwater resources.

Heap Leach and Other Process Facilities

Impacts to surface water quality from the heap leach and other process-related facilities would occur: 1) if process fluids, fuels, solvents, or other liquids were released to surface waters in sufficient quantities to exceed water quality standards or degrade beneficial uses; and 2) if runoff, erosion, or sedimentation were accelerated to a degree that degraded surface water flows or features.

Construction and Operation. Since the proposed project would be designed and operated as a zero-discharge facility in accordance with NDEP mining regulations, impacts from process fluids would be unlikely under anticipated construction and operating conditions. The heap leach and ancillary facilities would be constructed with geomembrane liners, lined ditches, and monitored leak detection/collection systems in compliance with NDEP design requirements. Plant facilities, storm water diversions, and solution and storm water event ponds also would be designed in accordance with regulations and interagency agreements. Compliance with interagency closure and reclamation requirements, including monitoring, would minimize the potential for long-term effects on surface water quality after cessation of proposed project operations. Based on these project commitments, no impacts to surface water quality are anticipated from process components under anticipated construction and operating conditions. Ore processing at the BGMI facility would be conducted under currently permitted authorizations. As a result no additional impacts to surface water quality are anticipated from ore processing at the existing BGMI process facilities.

Closure and Post Closure. The proposed strategy for reclamation and closure of the proposed heap leach pad is described in Section 2.3.8. In summary, the heap leach pad would be regraded to a slope of 3:1 and covered with a minimum of 24 inches of soil material derived from the Carlin Formation that would support vegetation. The cover material and vegetation would limit infiltration of water into the reclaimed facility by storing the infiltration water in the cover and removing moisture in the soil through evaporation and plant transpiration processes.

An important issue for closure of the heap leach facility is the management of effluent during draindown of the facility after mineral processing ceases and any residual flow that may occur in the post closure period. The performance of the existing heap leach pads was used to estimate the long-term infiltration rates from historic heap leach facilities that were previously reclaimed at the Dee Mine (Leach Pads No. 1-9, 10 and 11) and the AA Leach Pad at the nearby BGMI (BDMV 2013). The cover thickness, cover source material, and estimated net infiltration rate as a percentage of annual precipitation for each of these reclaimed leach pads is summarized in Table 3.4-13b.

Table 3.4-13b Historic Heap Leach Pad Infiltration Rate Estimates

Heap Leach Pad (Project)	***Cover Thickness (feet)***	***Cover Source Material***	***Estimated Net Infiltration Rate (% Annual Precipitation)[1]***
Heap Leach Pad No.1-9 (Dee Mine)	***1-10***	***Carlin Formation***	***2%***
Heap Leach Pad No. 10 (Dee Mine)	***1***	***Carlin Formation***	
Heap Leach Pad No. 11 (Dee Mine)	***1-2*** ***5***	***Carlin Formation*** ***Vinini Chert***	
AA Leach Pad BGMI	***4***	***Carlin Formation***	***0.63%***

[1]BDMV 2013

The Heap Leach Draindown Estimator (HLDE) spreadsheet model was calibrated to the estimated combined draindown flow rates from the Dee Mine Heap Leach Pads No. 1 to 11. The calibrated model used an assumed infiltration rate of 2 percent of the annual precipitation to simulate the observed flow from the Dee Mine Heap Leach Pads No. 1-11. Flow data from the BGMI AA Leach Pad indicates that the net infiltration through the reclaimed leach pad is approximately 0.63 percent of annual precipitation (BDMV 2013). The results of the spreadsheet modeling for the Dee Mine leach pads, and monitoring data for the BGMI AA Leach Pad substantiate the use of long term infiltration rates ranging from 0.6 to 2 percent of annual precipitation to estimate infiltration through similarly designed heap leach facilities.

The HLDE model was used to estimate the long-term flow rates from the proposed Heap Leach Pad No. 12. The calculation method, input parameter values, and results are presented in the spreadsheet model (BDMV 2013). The results of the analysis estimate average flow rates after 10, 20, and 30 years of draindown are 6.74 gpm, 4.56 gpm and 3.61 gpm, respectively for the proposed heap leach pad. These rates are based on an assumed infiltration rate of 1 percent of annual precipitation for the covered reclaimed facilities.

Water quality data for the Dee Mine heap leach pads No. 10 and 11 for the period of January 2006 and January 2011 is summarized in BDMV 2013. This water quality data set indicates that effluent from the leach pads has a pH ranging between 7 and 9; and TDS concentrations ranging between approximately 1000 to 3000 mg/l, with elevated sulfate concentrations. Nitrate is strongly elevated in the heap effluent resulting from the fact that nitrate is a decomposition product of cyanide oxidation. Detectible WAD cyanide also occurs in most samples of the effluent. Arsenic concentration in the effluent generally ranges from 0.1 to 0.2 mg/l, which is within the range of concentrations observed within the regional carbonate aquifer. These water data provides an indication of the likely range in concentrations that would be anticipated for the leachate generated during the closure period from the proposed Heap Leach Pad No. 12.

As described in Section 2.3.8.6, at closure, one or both of the storm water event ponds (and the process ponds, if necessary) would be converted to a long-term, post-closure fluid management facility consisting of ET-cells or evaporation basins. Prior to construction, a detailed engineering design would be submitted as part of the final closure plan for review by the NDEP and BLM prior to construction. The conceptual plan for the ET-cells or evaporation basins would include

leaving the pond liners in place and protected with a 2-foot over liner layer of earthen material and installing the required fluid distribution piping. The ponds would be backfilled with alluvial material to eliminate standing water (to prevent potential exposure to wildlife). It is anticipated the use of ET-cell or evaporation basin technologies would result in no discharge requiring treatment. Actual results would be monitored during the post-closure period and alternative use or treatment of the fluids would be developed if required. A final closure plan would be prepared and submitted to NDEP and BLM to provide for any detailed adjustments to the preliminary heap leach pad design to ensure adequate fluid management as required by regulations (NAC 445A.430 through 445A.447) and described in Section 2.3.8. The proposed conceptual design of the ET cells and evaporation basins and procedures for management of leachate generated from the proposed heap leach pad facility in the closure and post-closure period would prevent the solution from infiltrating to the groundwater system or impacting surface water resources. Therefore, closure of the heap leach facility is not expected to impact water resources.

Storm Water Management

Storm water would be managed under the proposed project in accordance with the Nevada General Storm Water Permit NVR300000 and the site Storm Water Pollution Prevention Plan (SWPPP). BMPs would be applied to route or control runoff and would reduce potential impacts from accelerated erosion and sedimentation. Storm water BMPs are discussed in Chapter 2.0, Section 2.3.6.9, Storm Water Management Facilities. Accepted engineering practices would be used to design and apply storm water controls such as diversion ditches, sediment traps, rock and gravel covers, or other applications. Concurrent reclamation and long-term reclamation practices (Chapter 2.0) would help reduce erosion and sedimentation from proposed project components.

Although potential impacts would be avoided or reduced under anticipated construction and operating conditions by compliance with agency programs and proposed measures, extreme weather events may create bypass conditions or unforeseen impacts. Severe (high intensity) storms, rapid snowmelt, or rain-on-snow events have the potential to damage operating or reclaimed project components. This has been known to occur at other mining sites in the region (BLM 2008b). Resulting adverse effects may include degradation of waters of the State and delays in successful restoration of post-mining land uses.

Both WRDFs have comparatively small upgradient catchment areas. This would reduce the need for designed diversion structures along their upgradient perimeters. Similar conditions would exist at the proposed pit. Small storm water control basins would be constructed upgradient of these components. Approximately 80 acres would drain to the basin near the proposed pit in Section 34. Approximately 160 acres would drain to the easternmost constructed storm water basin at the West WRDF in Section 27, and approximately 40 acres would drain to the constructed basin in the southeast corner of Section 28. Given the upgradient locations, proposed waste rock management plan (***Schafer 2013***), and proposed evapotranspiration cover on the WRDFs, acid rock drainage accumulation is not likely to occur at these locations. Meteoric water and run-on would seasonally accumulate in the storm water basins. Evaporation of that water may elevate the concentrations of TDS and other constituents, notably arsenic, which was identified in MWMP test results described previously in Section 3.4.1.4, Rock Geochemistry, and in Appendix A of the PoO. While such water would be isolated within the small, immediate watersheds, adverse water quality conditions may occur on a seasonal basis.

<u>Haul Road Improvements</u>

As stated in the SWPPP, road surfaces would be sloped gently toward ditches running the length of the roads. These ditches would have stabilized cut-outs or culverts and energy dissipation features to distribute storm water flows and reduce flow velocities. Storm water routed from roads would ultimately lead to sediment basins (as needed), open pits, or natural drainages.

As described in Chapter 2.0, Section 2.3.5.2, Bootstrap Haul Road, the Bootstrap Haul Road currently crosses Boulder Creek and Bell Creek via an earth-fill roadway that incorporates a series of culverts.

Under the Proposed Action, the culverts would be extended to accommodate additional road width. Accelerated erosion, sedimentation, and runoff water quality would be controlled by storm water BMPs used along the road as discussed in Chapter 2, Section 2.3.6.9, Storm Water Management Facilities, and in Appendix D of the Plan of Operations ("Stormwater Pollution Prevention Plan and Stormwater Monitoring Plan").

Water or approved dust suppressants such as magnesium chloride, calcium chloride, or lignin-sulfate would be used to minimize fugitive dust on the road. Dust suppressants would be sprayed in a manner that only moistens the road surface and minimizes run-off into adjacent areas. Dust suppressants would only be applied within the bermed road area. Similar to the existing road drainage features, the widened Bootstrap Haul Road would employ culvert crossings and berms, ditches and ditch outlets, relief culverts, armoring and energy dissipation, and other erosion control practices to control runoff and sedimentation from the road surface.

On the basis of these provisions, incremental water quality impacts to Boulder or Bell creeks are not anticipated to be noticeable from the Bootstrap Haul Road modification and maintenance.

3.4.2.2 Single Waste Rock Disposal Facility Alternative

Under the Single WRDF Alternative, the East WRDF would not be constructed. The Single WRDF alternative would eliminate direct impacts to a small ephemeral watershed area of approximately 197 acres that is tributary to Boulder Creek that would be located within the footprint of the East WRDF under the Proposed Action. As a result, any potential for seepage, or runoff, erosion and sedimentation impacts to Boulder Creek associated with the East WRDF would be avoided under this alternative.

Changes in contributing watershed areas under the Single WRDF Alternative would be similar to those described for the Proposed Action. The watershed area affected by the Single WRDF would represent approximately 0.3 percent of the Antelope Creek drainage and about 0.1 percent of the Rock Creek Valley (Hydrographic Basin 62). The absence of the East WRDF would allow runoff contributions from approximately 54 additional acres in the upper Boulder Creek watershed in comparison to the Proposed Action. Under existing conditions, approximately 513 acres of disturbance do not drain to the watershed. Under the Single WRDF Alternative, surface runoff from approximately 1,572 acres within the project area would be restricted from draining to upper Boulder Creek. These ephemeral headwater areas would comprise approximately 3.3 percent of the hydrologic study area, and approximately 0.44 percent of the Boulder Flat hydrographic basin.

Potential impacts to floodplains and flood hydrology from the Single WRDF Alternative would be minimal and similar to the Proposed Action. No federally delineated flood hazard zones have been identified within the proposed project area, and drainageways consist of narrow ephemeral streams.

The strategy for handling waste rock material is presented in the waste rock management plan submitted to BLM with the proposed PoO (***Schafer 2013***). A conceptual diagram of the environmental protection measures incorporated into the design of the West WRDF is shown in **Figure 3.4-11**. Since the geochemical characterization of the waste rock material, environmental protection measures incorporated into the design of the West WRDF, and closure and reclamation practices would be the same as the Proposed Action, the potential impacts to surface and groundwater would be similar to those previously described under the Proposed Action.

Storm water drainage ditches and small catchments would be constructed to manage runoff according to NDEP and BLM requirements. Meteoric water and run-on seasonally would accumulate in the storm water basins. Evaporation of that water may elevate the concentrations of TDS and other constituents, as discussed under the Proposed Action. Potential impacts associated with storm water basins would be similar to those under the Proposed Action for the West WRDF; potential impacts from the storm water basins on the East WRDF would be eliminated.

Impacts to springs, seeps, and ponds under this alternative would be the same as those described for the Proposed Action. All other project components in the Single WRDF Alternative are the same as those in the Proposed Action (including the open pit, heap leach facility, haul roads, process ponds, and ancillary facilities). Therefore, potential impacts to watershed areas and to streams, springs, and seeps and water rights associated with these project components would be the same as described under the Proposed Action.

3.4.2.3 Partial Pit Backfill Alternative

Under this alternative, impacts to surface water quantity and quality would be similar to those described for the Proposed Action. No perennial stream reaches would be disturbed, since none are located within the project area. Short reaches of unnamed ephemeral stream channels would be removed by project components. Similar to the Proposed Action, no springs would be removed, but seeps and/or wetlands would be removed as disturbance increases. Compliance with interagency requirements, including monitoring, would minimize the potential for long-term effects on surface water quality. Potential impacts from access roads and Heap Leach Pad No. 12 would be the same as those described for the Proposed Action.

Under the Partial Pit Backfill Alternative, the length of slopes on the West WRDF would be reduced and the area of the flatter crest surface would expand in comparison to the Proposed Action and the Single WRDF Alternative (see **Figure 2-18**). This would further reduce the potential for runoff and sedimentation from sideslopes at the West WRDF, but substantial surface water impacts from these source areas are not anticipated in general. Surface infiltration into the West WRDF would increase in comparison to the Proposed Action and the Single WRDF Alternative. The operational waste rock management plan would be the same as that implemented under the Proposed Action, however. Selective handling of waste rock, and the development of a vegetated soil cover over the waste rock, would still provide effective controls on the migration of interstitial water from the facility. This approach would avoid or reduce the potential impacts to waters of the state.

Under this alternative, the volume of East WRDF would be expanded in comparison to the Proposed Action, with corresponding substantial increases in slope lengths along the aspects draining to Boulder Creek. Under the Partial Pit Backfill Alternative, the expanded east-facing slopes would generally range from 1,500 to 2,000 feet long (see **Figure 2-18**). Although geomorphic drainage designs and storm water controls would be implemented, the potential for erosion, sedimentation, and related run off impacts to upper Boulder Creek would increase under the Partial Pit Backfill Alternative in comparison to the Proposed Action.

Changes in contributing watershed areas under the Partial Pit Backfill Alternative would be similar to those described for the Proposed Action. The watershed area affected by the West WRDF would represent approximately 0.3 percent of the Antelope Creek drainage and about 0.1 percent of the Rock Creek Valley (Hydrographic Basin 62). On the east side of the project area, the backfill configuration and the East WRDF would allow runoff contributions from approximately 145 additional acres in the upper Boulder Creek watershed when compared to the Proposed Action. Under existing conditions, approximately 513 acres of disturbance do not drain to the watershed. Under the Partial Pit Backfill Alternative, surface runoff from approximately 1,481 acres within the project area would be restricted from draining to upper Boulder Creek. These ephemeral headwater areas would comprise approximately 3.1 percent of the hydrologic study area, and approximately 0.41 percent of the Boulder Flat hydrographic basin.

<u>Pit Lake Development</u>

The same methodology described for the proposed project in Section 3.4.2.1, Proposed Action, was used to evaluate the pit lake development and geochemistry of the Partial Pit Backfill Alternative. The regional groundwater flow model was used to predict the development of the pit lake (JSA 2011). In contrast to the Proposed Action, the groundwater flow model simulations indicate that a single pit lake

would eventually develop in the North Pit (**Figure 3.4-12**). The placement of backfill within the south and east pit areas would preclude pit lake development within these areas.

The estimated surface area, volume and depth of the pit lake after full recovery are summarized in **Table 3.4-10**. The predicted lake development in the North Pit area is essentially the same as previously described for the North Pit area under the Proposed Action. However, due to the elimination of the pit lakes in the South and East Pits, the total area of final pit lakes would reduce from an estimated 89.1 acres under the Proposed Action, to 19.1 acres under the Partial Pit Backfill Alternative.

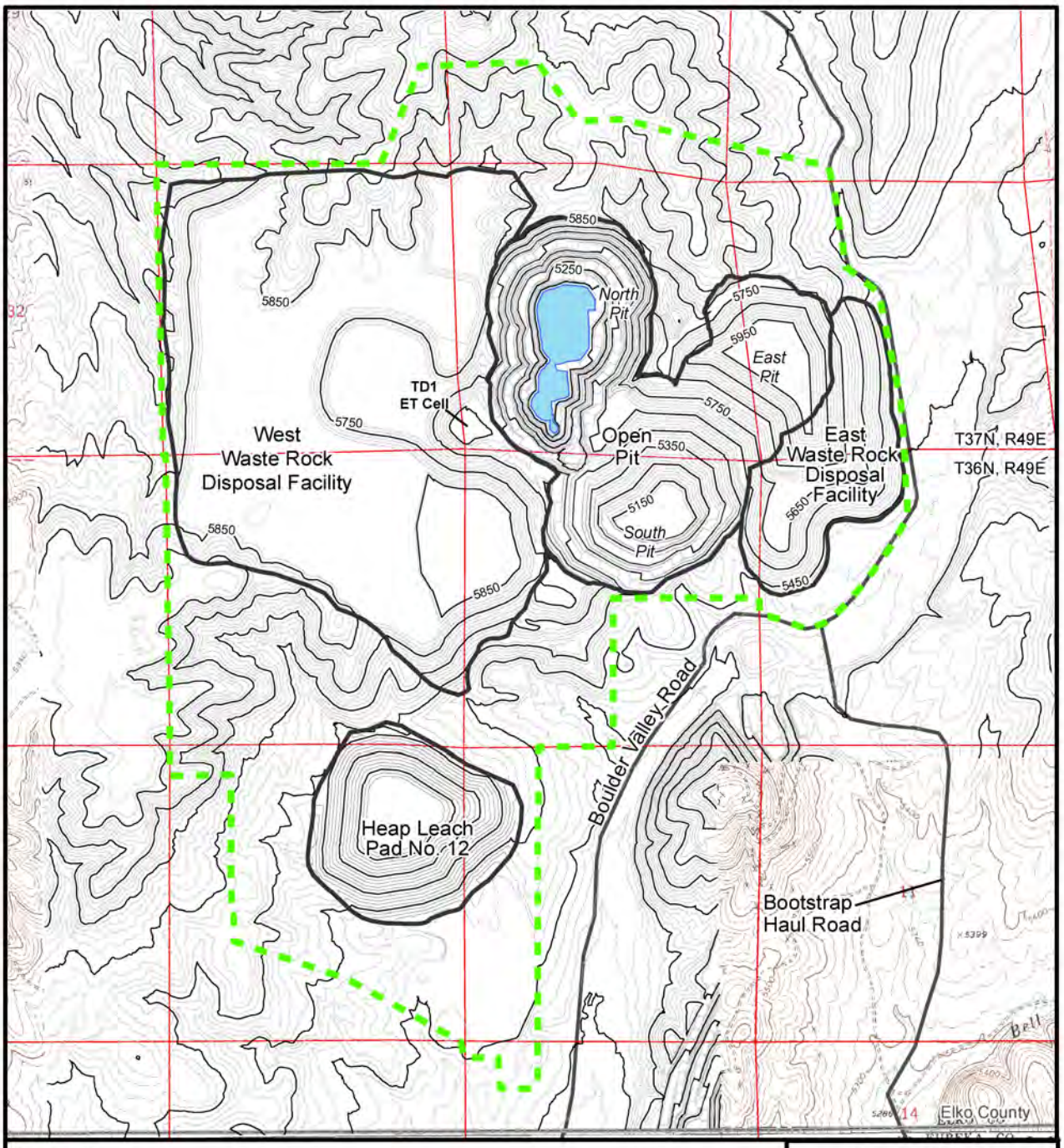
The lake would develop after the elevation of the recovering water levels in the carbonate aquifer reach the bottom of the existing pit at about 140 years after dewatering ceases. As with the Proposed Action, the North Pit lake would approach steady state conditions at approximately 400 years after cessation of pumping (JSA 2011). As with the Proposed Action, prior to development of the permanent pit lake (from Year zero to approximately 140 years after dewatering ceases) it is possible that a shallow pond up to a few feet deep could form from the collection of runoff and groundwater inflow from local or perched aquifers. This shallow pond may be perennial, seasonal, or ephemeral (JSA 2010c). Any water ponded in the pit would be perched above the carbonate aquifer system until the rebounding water levels in the pit intersect the pit shell.

Water that accumulates in the pits during the first approximately 140 years of recovery, and does not evaporate, is predicted to infiltrate into the floor of the pit and recharge into the carbonate aquifer system (JSA 2010c). The predicted water quality for water that would infiltrate into the pit floor during the initial 140 years of recovery is summarized in **Table 3.4-14**. This predicted water quality also represents the quality of any shallow ponding that may occur in the pit prior to permanent pit lake development. Predicted concentrations of antimony, arsenic, nickel, and selenium in the infiltration water from one or more of the pit lake areas would exceed the primary Nevada water quality standards for drinking water. In addition, the predicted manganese, sulfate concentrations, and TDS from one or more of the pit lake areas would exceed the Nevada secondary drinking water standards. Overall, the predicted water quality for the North Pit is similar to the predicted water quality for the North Pit predicted under the Proposed Action. Therefore, potential effects to groundwater associated with this infiltration would be similar to those for the Proposed Action. However, the overall quantity of groundwater recharge from the pits during this period would be less than the Proposed Action.

Solute transport modeling results indicate that the elevated metals concentrations would not be detected outside the footprint of the pit (Schafer 2011c,d). TDS of water infiltrating from the pits would be less than 500 mg/l, but would increase in the deeper aquifer due to calcite dissolution. If the deep groundwater were pumped to the surface for use, its TDS would again drop below 500 mg/l under atmospheric conditions due to off-gassing and calcite precipitation (Schafer 2012b, 2011b). Because elevated metals concentrations are not expected to affect groundwater quality outside the footprint of the pits, infiltration from the North Pit under this alternative is not likely to adversely affect the water quality in the carbonate aquifer.

Pit Lake Water Quality

The long-term (400-year) predicted pit lake water chemistry for the Partial Backfill Alternative is summarized in **Table 3.4-12**. The predicted water quality for the North Pit lake is essentially the same as reported previously for the North Pit Lake under the Proposed Action. Therefore, impacts associated with this North Pit lake are the same as described under the Proposed Action.



Legend

- Proposed PoO Boundary
- Proposed Facilities
- Predicted Pit Lake Surface 400 Years After BGMI Dewatering Ceases (approximately 5,093 feet amsl)

Note: 20-foot contour interval.
Contours do not reflect WRDF setback distance from open pit or reclamation topography design software.
Source: Schafer 2012a.

N

0 0.25 0.5 Miles

Arturo Mine Project EIS

Figure 3.4-12

Post-mining Pit Lake Partial Pit Backfill Alternative

8/21/2012

Table 3.4-14 Predicted Water Quality of Outflow from the Pit Prior to Permanent Development of a Permanent Pit Lake: Partial Pit Backfill Alternative

Constituent (mg/l)[1]	Applicable Nevada Drinking Water Standards[2]	Partial Backfill Alternative		
		Minimum	Maximum	Average
Aluminum	0.05[3] – 0.2[4]	<0.004	<0.008	<0.006
Antimony	0.006	**0.021**	**0.039**	**0.028**
Arsenic (total)	0.01	**0.034**	**0.113**	**0.070**
Barium	2.0	0.041	0.084	0.06
Boron	--	0.1	0.3	0.3
Cadmium	0.005	<0.002	<0.004	<0.003
Calcium	--	155.3	277.8	198.4
Chloride	250[3]; 400[4]	3.2	14.7	7.4
Chromium (total)	0.1	<0.0002	<0.0002	<0.0002
Copper	1.3[5]; 1.0[4]	0.008	0.012	0.01
Fluoride	2.0[3]; 4.0[4]	1.0	1.7	1.2
Iron	0.3[3]; 0.6[4]	0.000	0.001	0.001
Lead	0.015[5]	<0.001	<0.001	<0.001
Magnesium	125[3]; 150[4]	17.1	53.4	30.2
Manganese	0.05[3]; 0.1[4]	0.057	**0.419**	**0.135**
Mercury	0.002	< 0.0003	< 0.0005	< 0.0004
Nickel	0.1	0.055	**0.175**	0.099
Nitrate (as N)	10	0.1	0.5	0.3
pH (standard units)	6.5 – 8.5[4]	6.90	6.97	6.94
Potassium	--	5.7	11.6	7.2
Selenium	0.05	0.011	**0.118**	0.033
Silver	0.1[4]	<0.001	<0.002	<0.001
Sodium	--	8.5	43.6	18.3
Sulfate	250[3]; 500[4]	139.0	**539.2**	277.3
Thallium	0.002	0.000	0.008	0.002
Bicarbonate	--	446	488.7	470.7
TDS	500[3]; 1,000[4]	780	**1,437**	**1,015**
Zinc	5.0[4]	0.79	1.95	1.25

[1] Units are mg/l unless otherwise noted.
[2] Nevada primary MCLs unless otherwise noted.
[3] Federal secondary MCLs.
[4] Nevada secondary MCLs.
[5] Value is action level for treatment technique for lead and copper.
Note: Bold values exceed Nevada Drinking Water Standards.
Source: Schafer 2011c.

Groundwater Flow Through Backfilled Pits

As with the proposed WRDFs, the waste rock backfilled into the South and East Pits would be graded to a geomorphically stable configuration and then covered with soil material composed of Carlin and/or topsoil that incorporates high water holding capacity and establishment of perennial vegetation. The reclamation is designed to eliminate contact between the waste rock and runoff; minimize infiltration through the waste rock; and reduce the flux of oxygen into the facility. The reclamation and waste rock ET cover would result in a reduction in the total amount of infiltration through the pits compared to the Proposed Action (Schafer 2011c).

In the post-mining period, groundwater levels in the carbonate aquifer will eventually rise above the buried floor of the pit and flood a portion of the backfilled waste rock material placed in the pit. The numerical groundwater flow predictions indicate that groundwater would initially encounter the backfilled waste rock at approximately 100 years after mine dewatering ceases at the BGMI facility. By approximately year 140 (after mine dewatering ceases) the groundwater flow gradient from the backfilled waste in the pits is towards the North Pit. Groundwater that comes into contact with the waste rock is expected to have a neutral pH, elevated TDS and metals concentrations similar to the water quality estimated to infiltrate the floor of the pit prior to pit lake development described above. However, development of the hydraulic sink in the North Pit is expected to essentially capture the groundwater that has interacted with the waste rock. As a result, the chemical load contained in water contacting backfilled waste rock in the South and East Pits is expected to be drawn into the pit lake that develops in the North Pit (Schafer 2011c). The contribution of this chemical load is not expected to substantially change the predicted water quality of the pit lake because of the similarity between the anticipated chemistry of the water contacting the waste rock and the predicted pit lake water quality and the relatively small proportion of ground water that would flow through the waste rock prior to reaching the North Pit (Schafer 2011c).

3.4.2.4 No Action Alternative

Under the No Action Alternative, the proposed project would not be developed and the related potential impacts to water resources would not occur. Continuation of mining activities associated with the Storm Underground Mine, completion of closure and reclamation activities associated with existing disturbance, and ongoing mineral exploration activities within the study area would be conducted under existing authorizations. No additional ground-disturbing activities beyond those currently authorized would occur at the mine site.

<u>Water Quantity Impacts</u>

Impacts to Water Levels

After dewatering ceases at the BGMI facility, the groundwater levels in the carbonate aquifer would eventually rise above the bottom of the pit and result in the development of a pit lake. The development and predicted water quality of the pit lakes is discussed under the “Pit Lake Water Quality” section below.

Impacts to Streams, Springs, and Seeps and Water Rights

Under the No Action Alternative, no impacts to perennial streams, springs, seeps would occur. In addition, impacts to the water rights identified in **Table 3.4-9** are not anticipated.

<u>Pit Lake Development</u>

Under the No Action Alternative, the existing Dee open pit would remain in its present configuration. The same methodology described for the proposed project in Section 3.4.2.1, Proposed Action, was used to evaluate the pit lake development and geochemistry of the No Action Alternative. The regional groundwater flow model was used to predict the development of the pit lake, as described in JSA (2010c). The flow modeling predicts that a shallow pond up to a few feet deep would initially form

from the collection of runoff and groundwater inflow from local or perched aquifers. This shallow pond may be perennial, seasonal, or ephemeral (JSA 2010c). Any water ponded in the pit would be perched above the carbonate aquifer system during an estimated 330 years of recovery. The elevation of the recovering water levels in the carbonate aquifer is predicted to reach the bottom of the existing pit at about 330 years after dewatering ceases. At this time, flow from the carbonate aquifer into the pit would result in the development of a permanent pit lake. The pit lake would approach steady state conditions at approximately 400 years after cessation of pumping.

The final pit lake area under the No Action Alternative is illustrated in **Figure 3.4-13**; predicted surface area, volume, and depth of the pit lake are summarized in **Table 3.4-10**. Under this scenario, a single (small) pit lake would develop with a surface area of approximately 0.6 acre. An estimated 95 percent of the net inflow to the pit lake (8.6 gpm) would come from highwall runoff and the remainder from direct rainfall. Most of the water in the existing Dee open pit (approximately 80 percent) would infiltrate into the carbonate aquifer, and the remainder would evaporate.

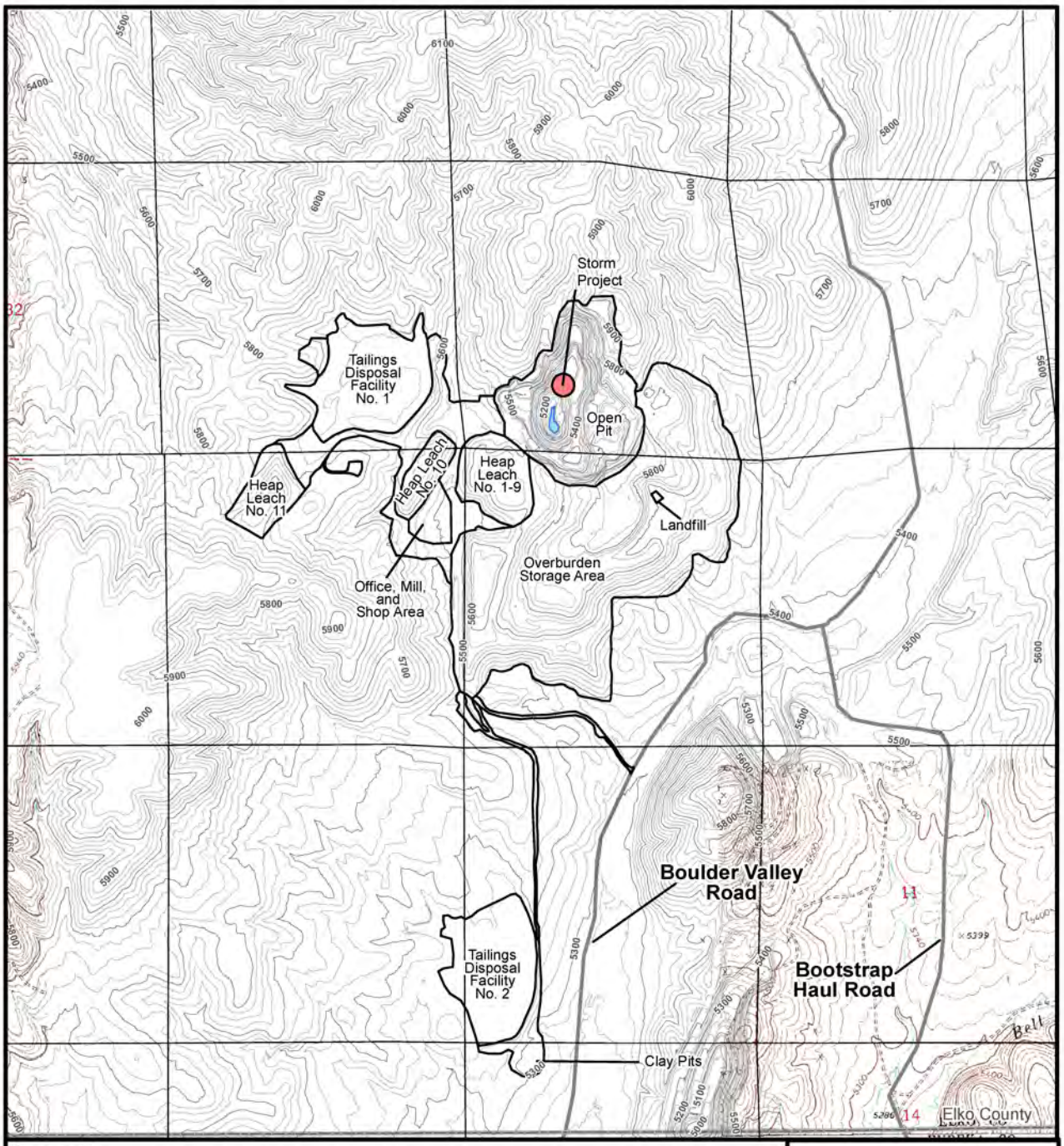
Rocks exposed in the existing Dee open pit include the Carlin Formation; oxidized Vinini Formation; and oxidized and unoxidized Rodeo Creek and Bootstrap Formation (**Table 3.4-8**). The rocks exposed in the existing pit surface have an average NNP of 146 kilogram per liter with 1.8 percent of the exposed rock classified as PAG.

Pit Water Infiltrating to Groundwater

Prior to development of the permanent pit lake, most of the precipitation and runoff into the pit would infiltrate into the floor of the pit and eventually contribute to flow in the carbonate aquifer. The estimated average infiltration rate during this period is 12 afy (7.5 gpm).

The predicted water chemistry of the infiltrated pit water is summarized in **Table 3.4-11**. The predicted concentrations of arsenic, nickel, and selenium in the infiltration water exceed the primary Nevada water quality standards for drinking water. In addition, the predicted maximum and average concentration of manganese, and maximum concentration of sulfate and TDS, exceed the Nevada secondary drinking water standards. The predicted average concentrations of antimony and arsenic over the infiltration period are similar to the average background water quality for the regional carbonate aquifer, while the concentrations of selenium and manganese are greater than background concentration in the carbonate aquifer.

As described for the Proposed Action, attenuation batch testing and numerical modeling were conducted to assess the potential fate and transport of key metals and TDS that may infiltrate from the pit floors prior to development of a permanent pit lake controlled by recovery of the regional carbonate aquifer. Results of the batch testing indicate that the bedrock in the floor of the pit has the capacity to absorb and precipitate constituents of concern and inhibit migration (Geomega 2011; Schafer 2011b). Solute transport modeling conducted to simulate sorption along potential flow paths between the pit bottom and the groundwater aquifer indicate that the elevated metals concentrations would not be detected outside the footprint area of the pit. TDS of water infiltrating from the pits would be less than 500 mg/l, but would increase in the deeper aquifer due to calcite dissolution. If the deep groundwater were pumped to the surface for use, its TDS would again drop below 500 mg/l under atmospheric conditions due to off-gassing and calcite precipitation (Schafer 2011b). Because elevated metals concentrations are not expected to affect groundwater quality outside the footprint of the pits infiltration from the pits is not likely to adversely affect the carbonate aquifer.



Legend

- Existing Facilities
- Predicted Pit Lake Surface 400 Years After BGMI Dewatering Ceases (approximately 5,093 feet amsl)

N

0 0.25 0.5 Miles

Source: Schafer 2012a.

Arturo Mine Project EIS

Figure 3.4-13

Post-mining Pit Lake No Action

8/21/2012

Pit Lake Water Quality

Accumulated water in the existing pit (No Action Alternative) is predicted to have a near neutral pH, as shown in **Figure 3.4-9** over the entire 400-year simulation period. The initial TDS is predicted to be approximately 1,400 mg/l, and gradually decrease over time as the highwall is rinsed by meteoric water, eventually dropping to approximately 100 mg/l after 300 years (**Figure 3.4-10**). Water would be calcium-sulfate type water initially but would transition to calcium-bicarbonate water as highwall rinsing progresses.

The predicted pit lake water chemistry for the existing pit after 400 years is summarized in **Table 3.4-12**. The predicted pit lake water constituent concentrations exceed the Nevada water quality standards for antimony and arsenic. Unlike the proposed project pit lake, the No Action pit lake is not predicted to behave as a groundwater sink. At 400 years, the pit lake is predicted to have outflow to the carbonate aquifer system at a rate of approximately 10 afy (6 gpm). Although the predicted concentrations of arsenic (0.037 mg/l) and antimony (0.041 mg/l) exceed the Nevada drinking water standards, these predicted concentrations are similar to the average concentrations for antimony (0.035 mg/l), and arsenic (0.021 mg/l) that occur in the carbonate aquifer, and are within the range of concentration (antimony 0.022 to 0.055 mg/l; arsenic 0.008 to 0.451 mg/l) in the carbonate aquifer. Therefore, pit lake outflow is not expected to adversely affect the water quality of the downgradient aquifer system. The potential risk to wildlife associated with exposure to the pit lakes is addressed in Section 3.17, Wildlife and Aquatic Biological Resources.

Surface Water Quality

Under the No Action Alternative, there would be no direct or indirect incremental impacts to surface water quality.

3.4.3 Cumulative Impacts

The CESA for water resources is defined in Section 3.4.1, Affected Environment, and is shown in **Figure 3.4-1**. The past, present, and reasonably foreseeable future actions (RFFAs) are discussed in Section 3.2, Past, Present, and Reasonably Foreseeable Future Actions. RFFAs from mining activities are identified in **Table 3.2-1**; their locations are shown in **Figures 3.2-1** and **3.2-2**.

3.4.3.1 Proposed Action

Surface Water Resources

Cumulative effects on surface water resources result from mine dewatering and discharge, runoff or seepage from mine components, from removal of surface water features within project footprints, from road or pipeline construction and maintenance, or from wildfire and livestock grazing.

Surface Water Quantity and Quality Effects from Mining

Mining projects within the CESA include those depicted north of the Humboldt River in **Figure 3.2-2**. Approximately 31,360 acres of past and present surface disturbance for mining and exploration actions are located in the water resources CESA. This represents approximately 2.3 percent of the 2,105 square mile CESA. Approval of the Proposed Action would add approximately 2,774 acres of disturbance within the CESA for a total of 34,134 acres, a 9 percent increase over the total past, present, and RFFAs within the CESA. Including this additional acreage, mining and exploration disturbance in the CESA would represent approximately 2.5 percent of the land area.

Major streams in the CESA include the Humboldt River; Rock Creek and its tributaries including Willow Creek, Antelope Creek, and Boulder Creek; Marys Creek; Maggie Creek; and Susie Creek (**Figure 3.4-3**). Perennial or discontinuously flowing stream reaches along these waterbodies would not be adversely affected by direct or cumulative impacts from the Proposed Action.

Runoff from small ephemeral tributaries would be reduced in the upper Boulder Creek drainage and elsewhere, due to expanding mine disturbance in the CESA. The Proposed Action would reduce contributing watershed acreage in the Boulder Creek drainage by approximately 1,626 acres. This reduction would represent approximately 0.45 percent of the 560 square miles of watershed in Boulder Flat (Hydrographic Basin 61), and approximately 0.12 percent of the CESA. In the Antelope Creek drainage, runoff from the Proposed Action would affect approximately 0.3 percent of that drainage, and about 0.1 percent of the Rock Creek Valley hydrographic basin.

The major effect of these reduced contributing areas would include a slight reduction of ephemeral flows from snowmelt and rainfall runoff in the CESA. These flows mostly occur in spring. Smaller flow rates and/or shorter flow durations may allow sediment build-up in affected tributary channels, and would reduce shallow groundwater availability in nearby alluvial deposits. Reduced recharge and soil moisture may adversely affect riparian systems. In parts of some streams such as Boulder Creek, lower Maggie Creek, lower Marys Creek, lower Susie Creek, and Antelope Creek, flow reductions could occur from mine-induced groundwater drawdown (BLM 2000b). Within the CESA, reduced ephemeral surface flow contributions would add to these impacts.

The Proposed Action would create disturbance in the Antelope Creek watershed in the northwestern part of the project area, within the Rock Creek Valley Hydrographic Basin. Runoff and seepage from the West WRDF would contribute to flow in small ephemeral tributaries of Antelope Creek. Direct flow impacts to Antelope Creek would be small, possibly unnoticeable, and would generate minor cumulative flow impacts on Antelope Creek.

Stream flows in Boulder Creek are ephemeral on Boulder Flat, and are generally removed from the channel by seepage and evapotranspiration. As discussed above in Section 3.4.1.2, Surface Water Resources, since there is no hydrologic connection of the Boulder Creek to the Rock Creek ditch or the Humboldt River there would be no cumulative surface water impacts from the proposed project.

In addition to these streamflow considerations, the Proposed Action would generate cumulative impacts to the overall number of springs and seeps. As described in previous NEPA documents (BLM 2008b, 2000b), approximately 130 springs and seeps were identified in the early 1990s in the Boulder, Bell, Brush, and Rodeo Creek drainages near the BGMI facility. Approximately 280 additional springs and 210 additional seeps were identified in the Willow Creek, Rock Creek, and Antelope Creek drainages. In the region around Newmont's Gold Quarry operations, 200 springs and seeps were identified. These features, identified from the earlier fieldwork and recent project-specific surveys, also are indicated in **Figure 3.4-3**.

Cumulative impacts to springs and seeps would occur within the CESA, since removal of these features would result from the Proposed Action. These impacts would add to existing and future impacts on springs and seeps, as described in other NEPA documents (BLM 2010a,b, 2008b, 2007a, 2000b). There are 67 identified spring sites located within the maximum extent of the 10-foot drawdown contour predicted by BGMI groundwater modeling (BLM 2003a). Flows from at least two of these springs that occur downstream along Boulder Creek have already ceased (AATA International 2006). These springs are the southernmost two indicated in **Figure 3.4-2**. Based on the analysis conducted in 2000, a total of 182 springs could be potentially impacted by mine dewatering in the Carlin Trend (BLM 2000b). However, recent assessments suggest that fewer springs/seeps could potentially be affected in the CESA overall (BLM 2010a,b, 2007a). In any case, the removal of springs and seeps during the Proposed Action would be an incremental addition to these impacts. Barrick and Newmont have existing obligations to mitigate mine dewatering effects on springs at selected locations in the CESA.

Cumulative surface water quality impacts could result from runoff and seepage from mining and exploration project components within the CESA. In general, these potential sources include leach pads, tailing ponds, mills and other process buildings, shops and warehouses, process fluid ditches and ponds, ore stockpiles, waste rock disposal facilities, drill pads and pits, and roads. The severity and extent of

these impacts would be reduced or mitigated by project design and construction, and by compliance with regulatory programs and associated permit stipulations. Examples of such controls include ditches, pipelines and containment features to manage runoff and process fluids; storm water pollution prevention programs; and spill prevention and response programs. With the exception of Newmont's Ivanhoe Open Pit Mine Project, water monitoring stations within the CESA have not reported elevated concentrations of metals or acid rock drainage (BLM 2010a,b). At Newmont's Ivanhoe Open Pit Mine Project, mine drainage issues are being addressed through waste rock stockpile treatments and a constructed wetland. In general, cumulative long-term mining impacts to surface water quality would be reduced by waste rock management, compliance with closure and reclamation permits and related agreements, and by the implementation of monitoring and mitigation measures.

Surface water quality impacts could result in the CESA from incidental spills, from intensive storms overwhelming control features and creating bypasses, and by erosion and sedimentation events at mining sites (e.g., ditch or slope failures). These isolated occurrences would affect surface water quality in their immediate locales. Operator and agency responses, in the form of containment and mitigation, would limit the extent and severity of these incidental impacts.

Pit lakes that ultimately form at Gold Quarry, Betze/Post, Arturo, and other sites in the CESA are not anticipated to discharge to surface waters. They are expected to be "sinks," where water is lost to evaporation (BLM 2008b). Based on modeling at the Betze-Post Pit, predicted concentrations of TDS, sulfate, flouride, arsenic, cadmium, nickel, and antimony are anticipated to exceed Nevada drinking water standards (BLM 2008b). The pH of Betze-Post pit lake water is anticipated to be near neutral in the long term, but there is a potential that it may be acidic in the short term (BLM 2008b). The long-term pit lake water quality under the Proposed Action would also exceed drinking water standards for several constituents. It should be noted, however, that based on restricted access, wildlife support is anticipated to be the only beneficial use of pit lake waters in the CESA. The potential cumulative risk to wildlife from exposure to pit lakes is addressed in Section 3.17, Wildlife and Aquatic Biological Resources.

Effects from Other Watershed Conditions

Other sources of surface water impacts in the CESA include existing conditions from grazing, irrigated croplands, wildland fires, and road construction and maintenance. These also contribute to existing surface water conditions of surface water flow and quality.

Grazing has been the most extensive historic land use in the CESA, and this is expected to continue. Surface water impacts from grazing are both beneficial and adverse. The contributions and impacts of grazing have long been debated (e.g., Elko County Nevada 2010; Northeastern Nevada Stewardship Group, Inc. 2003; Resource Concepts 2001; West 1983). In summary, both beneficial and adverse effects from grazing are widespread in the CESA. Among others, these effects include additional herbaceous growth and diversity, livestock trampling in riparian areas, and reduced overall vegetative cover.

Irrigated agricultural lands occupy a small portion of the CESA (Section 3.19, Land Use and Access). Impacts to surface water include flow diversions from streams and springs, consumptive use by crops, and increased concentrations of TDS and agricultural chemicals in irrigation return flows.

Wildfires in the CESA also have increased erosion and sedimentation, with attendant increases in turbidity and concentrations of suspended solids, dissolved solids, and temperature in area streams and ponds. Fire extent in the CESA is depicted in **Figure 3.2-3**. Most of the CESA has been burned, sometimes repeatedly, since the year 2000. From a watershed viewpoint, the most significant effect of these wildland fires is the loss of vegetation cover, which can lead to adverse changes in hillslope hydrologic function through decreased infiltration, increased runoff, and reduced soil quality (Pierson et al. 2011, 2003). These conditions then lead to increased flooding, accelerated erosion, increased turbidity and sedimentation and increased nutrient loading in surface water (National Wildfire

Coordinating Group 2001). Other effects of fire, and the potential for fire in the watersheds, are discussed in the vegetation and range management sections of the EIS.

Other disturbances in the CESA include the Ruby Pipeline, roads, and transmission lines. The Ruby Pipeline, a recently constructed natural gas pipeline, crosses about 28 miles of the Willow Creek Valley watershed. Assuming a disturbed width of 115 feet, approximately 390 acres were disturbed by the pipeline in the CESA. BMPs for backfilling, topsoil handling, revegetation, and erosion control would avoid or reduce runoff and erosion impacts from the proposed pipeline in the CESA.

The road network is extensive in the CESA. Potential cumulative impacts to runoff, erosion, and sedimentation are similar to those described for direct impacts. These existing effects include restricted drainage at road crossings of streams, modified drainage patterns, concentrated flow conditions that may accelerate erosion and sedimentation, sediment yielded from road maintenance, and water quality impacts from treatment chemicals (e.g., magnesium chloride) carried to nearby streams or riparian areas. These impacts affect streams such as Boulder Creek, Antelope Creek, Rock Creek, Willow Creek, Maggie Creek, Marys Creek, Susie Creek, and their tributaries. Generally the severity of these impacts diminishes with distance and increasing watershed area away from roads.

Groundwater Resources

The cumulative effects to water resources resulting from historic, present, and projected future dewatering activities for mines in the CESA were evaluated in detail in the CIA report for dewatering and water operations (BLM 2000b) and in the Betze Project, Draft Supplemental EIS (BLM 2000c). These impact evaluations used a calibrated numerical model to simulate the combined or cumulative hydrologic effects associated with dewatering and water management activities at existing and proposed mines.

Newmont Nevada Energy Investment, LLC (NNEI) operates the TS Power Plant in Boulder Valley. The power plant is a 242 MW coal-fired steam-turbine electric generation facility that commenced commercial power generation in June 2008. The design water requirement for the plant is approximately 2,400 gpm (the average water use since startup has averaged 1,400 gpm). The water required for the power plant is supplied from a primary production well located approximately 2 miles north of the plant site and two backup wells located closer to the plant. NNEI holds water rights to support TS Power Plant that allow a withdrawal rate of up to 5,565 gpm. The wells withdraw water from the alluvial basin fill aquifer in Boulder Valley. Depth to groundwater near the TS Power Plant varies from approximately 10 to 30 feet below surface. The alluvial water supply wells for the TS Power Plant operate outside of the area that is affected by drawdown associated with mine dewatering activities in the Carlin Trend. Therefore, water withdrawal for the TS Power Plant is unlikely to contribute to the cumulative drawdown associated with mine dewatering activities. Groundwater quality is acceptable for cooling water, which is the largest water use at TS Power Plant. NNEI maintains a potable water treatment system for arsenic removal and disinfection. Additionally, a reverse osmosis system with an associated ion exchange demineralizing circuit operated to produce boiler water (Laybourn 2012). Wastewater for the facility is discharged to four double-lined evaporation ponds managed in accordance to NDEP discharge permit requirements (NDWR 2011). Because the lined evaporative ponds are permitted as a zero-discharge facility, the TS Power Plant operation is not expected to impact surface or groundwater quality.

Expansion and deepening of the pit area would result in the development of three pit lakes, as discussed in Section 3.4.2.1, Proposed Action. The recently refined and recalibrated groundwater flow model (JSA 2010a) was used to evaluate the cumulative long-term effects of the pit lakes on the predicted maximum extent of drawdown. Specifically, this modeling evaluated the maximum extent of the 10-foot drawdown contour irrespective of time, as used in the earlier cumulative assessments. Cumulative results were generated for the No Action and Proposed Action pit lake scenarios. Comparison of the cumulative 10-foot drawdown for the No Action and Proposed Action scenarios indicated that the results are visually identical. The proposed project does not substantially change the predicted regional

drawdown pattern because the pit lakes would be a minor influence on the regional groundwater flow system (JSA 2010a).

As described under the proposed project (Section 3.4.2.1, Proposed Action), water accumulated in the pit would infiltrate to the carbonate aquifer during the first 200 years after dewatering ceases. After that time, the pit would behave as a sink with no outflow to groundwater. The estimated average infiltration rate over this period would range up to 90 gpm (total from all three pit areas). The predicted average concentrations of the water quality constituents over the infiltration period are predicted to exceed the background water quality for the carbonate aquifer, and exceed some Nevada drinking water standards. However, the results of solute transport modeling indicate that elevated metals concentrations are not expected to affect groundwater quality outside the footprint of the pits, as summarized in Section 3.4.2.1, Proposed Action. Therefore, the Proposed Action is unlikely to contribute to cumulative impacts to groundwater quality.

3.4.3.2 Single Waste Rock Disposal Facility Alternative

Surface Water Resources

Cumulative impacts to surface water quantity and quality would be the same as those described for the Proposed Action.

Groundwater Resources

Potential cumulative impacts to groundwater resources under the Single WRDF Alternative would be essentially the same as those described for the Proposed Action.

3.4.3.3 Partial Backfill Alternative

Surface Water Resources

Cumulative impacts to surface water quantity and quality would be the same as those described for the Proposed Action.

Groundwater Resources

Potential cumulative impacts to groundwater resources under the Single WRDF Alternative would be essentially the same as those described for the Proposed Action.

3.4.3.4 No Action Alternative

Surface Water Resources

Under the No Action Alternative, no additional cumulative effects to surface water resources would occur. Cumulative effects to surface water quantity and quality would approximate those identified in previous NEPA assessments for the CESA (BLM 2010a,b, 2008b, 2007a, 2000b,c).

Groundwater Resources

After pit dewatering at the BGMI facility ceases the groundwater elevation in the carbonate aquifer would gradually rebound and eventually intercept the pit shell and form a permanent pit lake. The results of groundwater modeling indicate that this permanent pit lake would begin to develop 330 years after mining ceases. Prior to this time, water captured in the pit that does not evaporate would infiltrate into the carbonate aquifer. The estimated average infiltration rate during the first 330 years of water level recovery is 12 afy (7.5 gpm). The predicted average concentrations of the water quality constituents over the infiltration period are predicted to exceed the background water quality for the carbonate aquifer, and exceed some Nevada drinking water standards. Solute transport modeling indicates that elevated metals concentrations are not expected to affect groundwater quality outside the footprint of the pits. Therefore,

the No Action is unlikely to contribute to cumulative impacts to groundwater quality. Other cumulative impacts to groundwater resources would be the same as described under the Proposed Action.

3.4.4 Potential Monitoring and Mitigation Measures

Monitoring and mitigation measures for water resources and geochemistry are provided in the Final EIS, Appendix B, Monitoring and Mitigation Plan. These measures would apply to both the Proposed Action and the Single WRDF Alternative.

3.4.5 Residual Impacts

No residual impacts are anticipated for surface water resources. The existing streams are ephemeral and the contributing watershed areas are comparatively small and/or already disturbed. Control of process fluids and storm water would be required and monitored according to state and federal permits. The predicted infiltration of water from the pits that exceed some Nevada drinking water standards under both the Proposed Action and No Action alternatives is considered an unavoidable residual adverse impact to the local water quality of the carbonate aquifer.