# Final

# Deep South Expansion Project Supplemental Environmental Report – Geology and Minerals

**Prepared in Support of:**
**File Number: NVN-067575 (16-1A)**
**DOI-BLM-NV-B010-2016-0052 EIS**


Bureau of Land Management
Battle Mountain District Office
Mount Lewis Field Office
50 Bastian Road
Battle Mountain, NV 89820


**2019**

**COOPERATING AGENCIES:**
U.S. Environmental Protection Agency
U.S. Fish and Wildlife Service
Nevada Department of Wildlife
Lander County and Eureka County

BLM MOUNT LEWIS FIELD OFFICE

***BLM Mission Statement***

The Bureau of Land Management's mission is to sustain the health, diversity, and productivity of public lands for the use and enjoyment of present and future generations.

Prepared in Support of: DOI-BLM-NV-B010-2016-0052 EIS

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# Acronyms and Abbreviations

| | |
|---|---|
| AMEC | AMEC Earth and Environmental, Inc. |
| amsl | above mean sea level |
| BCI | Barrick Cortez Inc. |
| BEA | Bank Enabling Agreement |
| BLM | Bureau of Land Management |
| CESA | cumulative effects study area |
| CFR | Code of Federal Regulations |
| CGM | Cortez Gold Mines |
| EIS | environmental impact statement |
| Geomega | Geomega Inc. |
| HC/CUEP | Horse Canyon/Cortez Unified Exploration Project |
| InSAR | Interferometric Synthetic Aperture Radar |
| NAC | Nevada Administrative Code |
| NDEP | Nevada Division of Environmental Protection |
| NEPA | National Environmental Policy Act |
| NRS | Nevada Revised Statute |
| PCRI | properties of cultural and religious importance |
| Piteau | Piteau Associates |
| PPV | peak particle velocity |
| RFFA | reasonably foreseeable future action |
| RIB | rapid infiltration basin |
| ROW | right-of-way |
| SEIS | supplemental environmental impact statement |
| SRK | SRK Consulting, (U.S.) Inc. |
| tpd | tons per day |
| tpy | tons per year |
| USBM | U.S. Bureau of Mines |
| USGS | U.S. Geological Survey |

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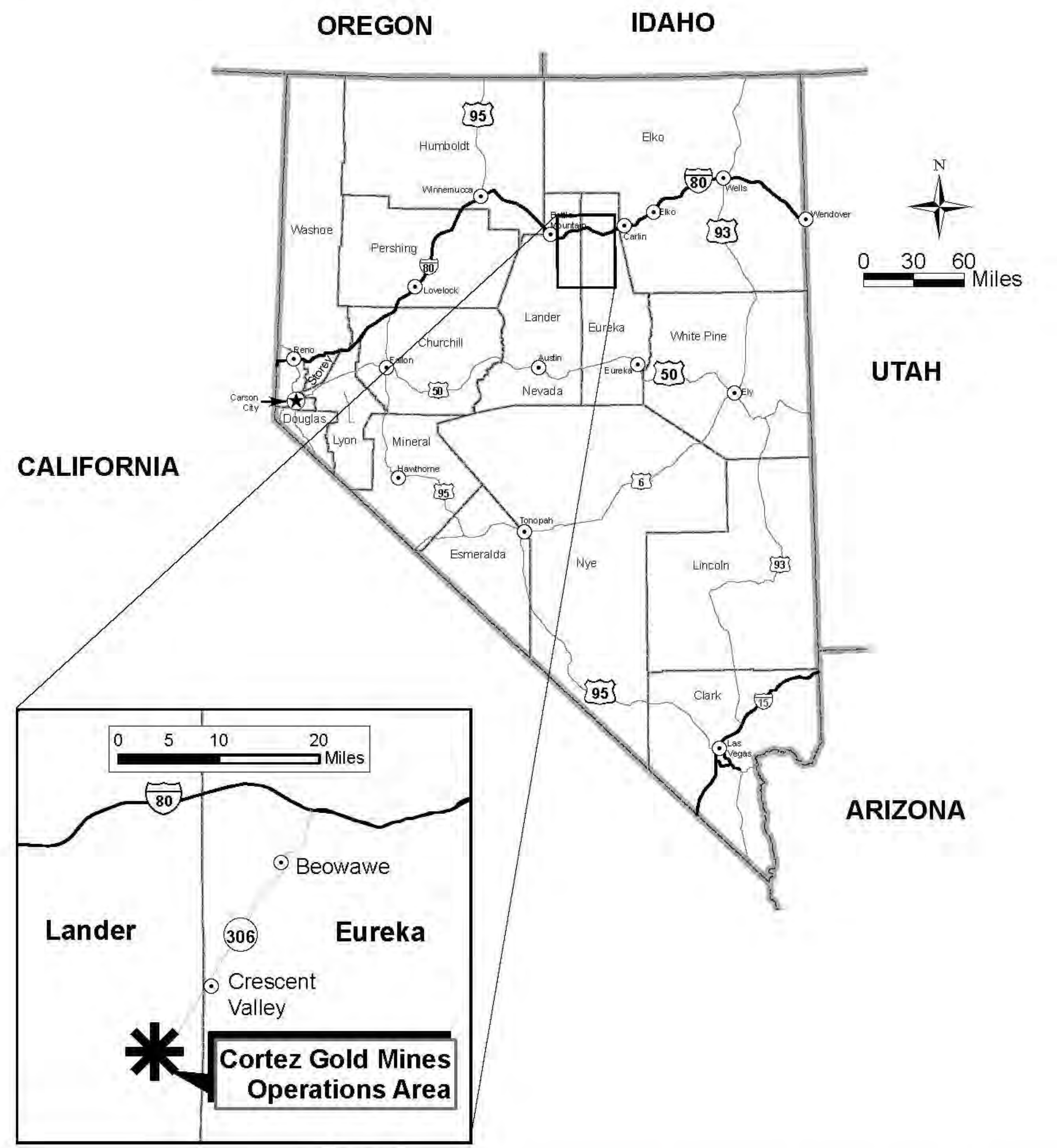
# 1.0 Introduction

Barrick Cortez Inc. (BCI), as manager of the Cortez Joint Venture, proposes modifications to BCI's existing gold mining and processing operations within the Cortez Gold Mines (CGM) Operations Area, which is located approximately 24 miles south of Beowawe in Lander and Eureka counties, Nevada (**Figure 1-1**). On March 30, 2016, BCI submitted the Barrick Cortez Inc. (NVN-067575 (16-1A)) Deep South Expansion Project Amendment to Plan of Operations and Reclamation Permit Application #0093, which describes the proposed modifications, to the Bureau of Land Management (BLM) Battle Mountain District, Mount Lewis Field Office in compliance with 43 Code of Federal Regulations (CFR) Subpart 3809 and 3715. A revised plan amendment was submitted October 6, 2016 (BCI 2016).

The proposed modifications would result in new surface disturbance on private land owned by BCI and public lands administered by the BLM. The proposed mining activities on public and private lands are subject to review and approval by the BLM pursuant to the Federal Land Policy and Management Act of 1976 as amended, and the BLM's surface management regulations (43 CFR Subpart 3809). The BLM's review and approval of a mine plan of operations under the surface management regulations constitute a federal action that is subject to the National Environmental Policy Act of 1969 (NEPA). The BLM has determined that the project constitutes a major federal action and has determined that an environmental impact statement (EIS) must be prepared to fulfill NEPA requirements. The BLM is serving as the lead agency for preparing the Deep South Expansion Project EIS in compliance with all applicable regulations and guidance. The U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, Nevada Department of Wildlife, and Lander and Eureka counties are serving as cooperating agencies for preparation and review of the EIS.

The EIS development is supported by supplemental environmental reports. This supplemental environmental report describes the potentially affected environment and the environmental consequences (direct, indirect, and cumulative) of implementing the Proposed Action or the alternatives, identifies monitoring and mitigation measures, as needed, and identifies the residual adverse effects for geology and minerals.

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**Deep South Expansion Project EIS**

Figure 1-1

Project Vicinity

# 2.0 Alternatives Including the Proposed Action

## 2.1 Introduction

This chapter summarizes the elements of the Proposed Action and other alternatives (including the No Action Alternative), and the past and present actions, as well as reasonably foreseeable future actions (RFFAs), considered in the cumulative impact analysis.

## 2.2 Existing Facilities

Existing BCI mining and processing facilities are located in four mine complexes (Pipeline, Gold Acres, Cortez, and Cortez Hills) within the current CGM Operations Area boundary (**Figure 2-1**). The majority of the existing facilities would be used in support of the Proposed Action. Changes to existing facilities are summarized below.

## 2.3 Proposed Action

### 2.3.1 Project Overview

BCI's proposed Deep South Expansion Project (Proposed Action) would include modifications to existing facilities in the four existing mine complexes, construction of new facilities, modifications to overall operations, and expansion of the CGM Operations Area boundary (**Figures 2-2** and **2-3**). The proposed modifications and expansions are summarized below.

Pipeline Complex:

- Deepen the existing Crossroads Pit (southeast portion of the Pipeline Pit Complex) by 200 feet and layback portions of the current Pipeline, Crossroads, and Gap pit walls.
- Reconfigure the currently authorized backfill in the Pipeline and Gap pit portions of the Pipeline Pit Complex per one of three proposed backfill scenarios (**Figures 2-4**, **2-5**, and **2-6**), depending on the economic conditions at the time of mining.
- Modify the existing Pipeline/South Pipeline Waste Rock Facility.
- Expand the existing oxide ore stockpile.

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| Number | Facility | Number | Facility |
|---|---|---|---|
| 1 | Gold Acres Pit | 15 | Cortez Mill #1 |
| 2 | Gold Acres North Waste Rock Facility | 16 | Cortez Pit and Ada 52 Pit |
| 3 | Gold Acres East Waste Rock Facility | 17 | Cortez East Waste Rock Facility |
| 4 | Gold Acres South Waste Rock Facility | 18 | Ada 52 Top Waste Rock Facility |
| 5 | Pipeline Pit Complex | 19 | F-Canyon Waste Rock Facility |
| 6 | Pipeline Mill | 20 | Cortez Waste Rock Facility |
| 7 | Pipeline Heap Leach Facility | 21 | F-Canyon Pit |
| 8 | Pipeline Tailings Facility | 22 | Conveyor Corridor |
| 9 | Pipeline/South Pipeline Waste Rock Facility | 23 | Canyon Waste Rock Facility |
| | | 24 | Conveyor Crusher/Ore Stockpiles |
| 10 | Pipeline South Area Heap Leach Facility | 25 | North Waste Rock Facility |
| 11 | Gap Waste Rock Facility | 26 | Cortez Hills Pit |
| 12 | Airport Gravel Pit | 27 | South Waste Rock Facility |
| 13 | Cortez Tailings Impoundment | 28 | Grass Valley Heap Leach Facility |
| 14 | Cortez Heap Leach Facility | 29 | Grass Valley Borrow Area |

**Note:** Existing Crescent Valley RIBs are located northeast of the CGM Operations Area boundary as shown in **Figure 2-3**.

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**Deep South Expansion Project EIS**

Figure 2-1

Existing Mine Facilities

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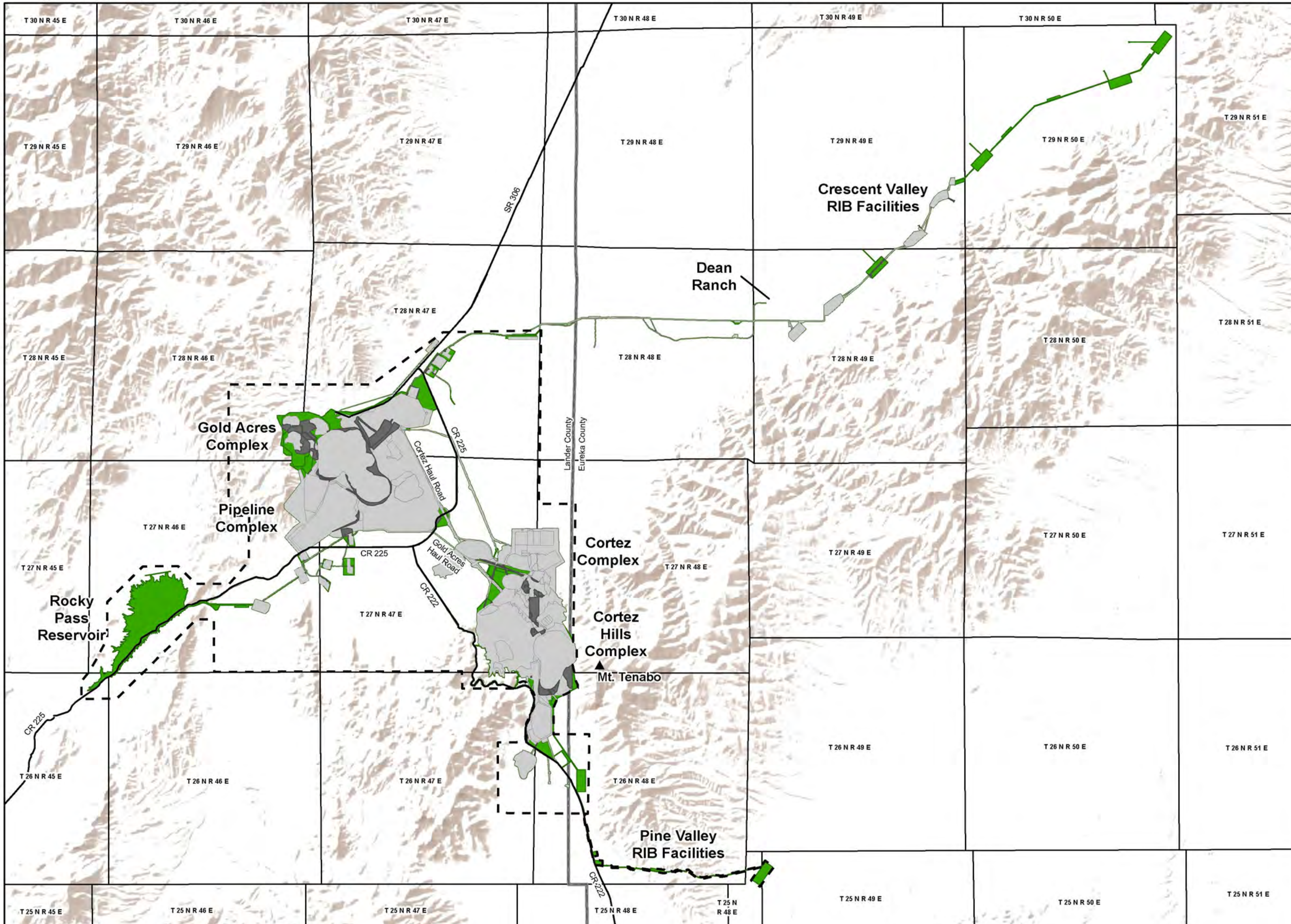


**Notes:** See **Figure 2-4** for additional detail relative to proposed modifications at the mine complexes. RIBs and associated infrastructure northeast of the CGM Operations Area are on private land.

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**Deep South Expansion Project EIS**

Figure 2-2

Proposed Action

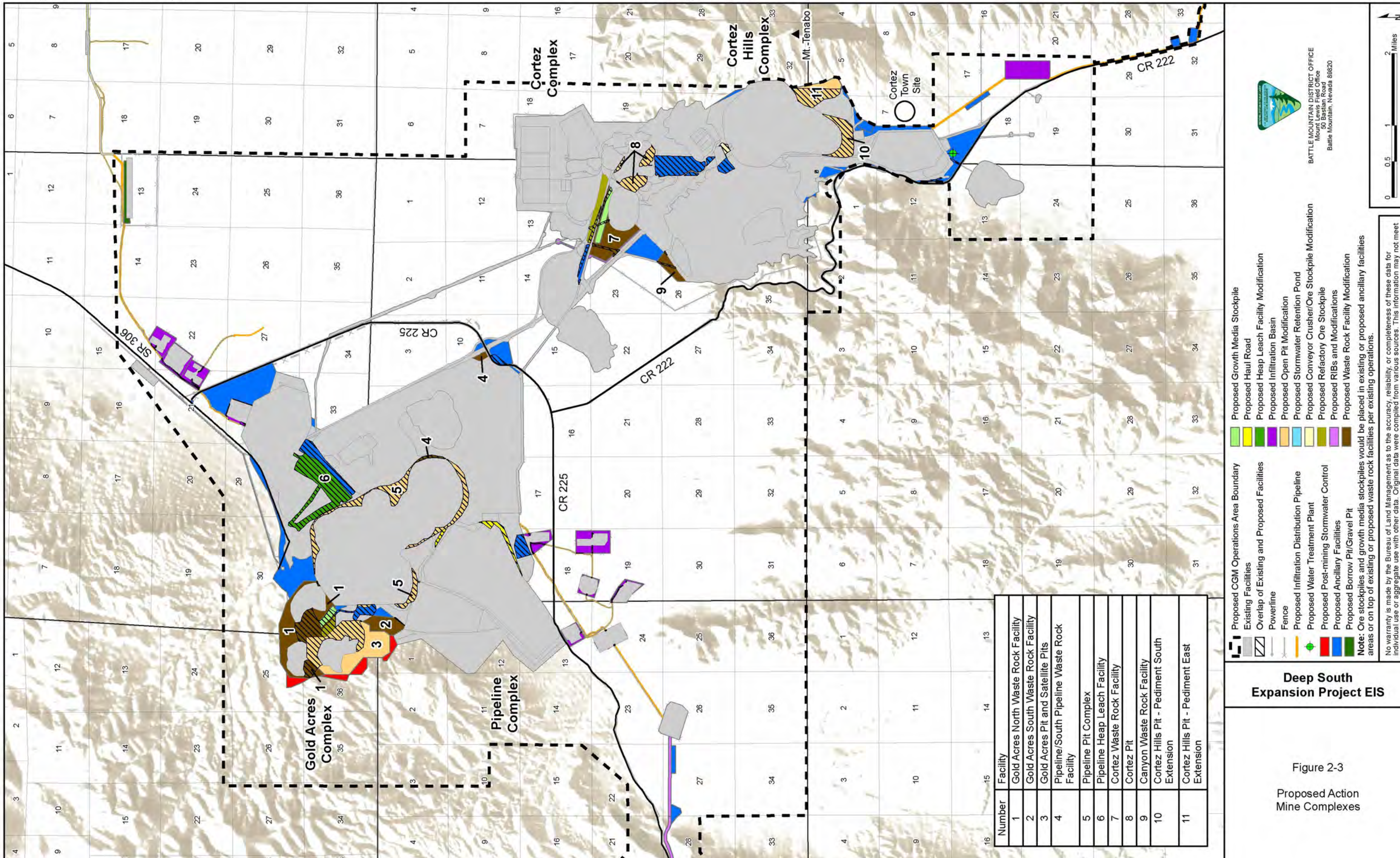
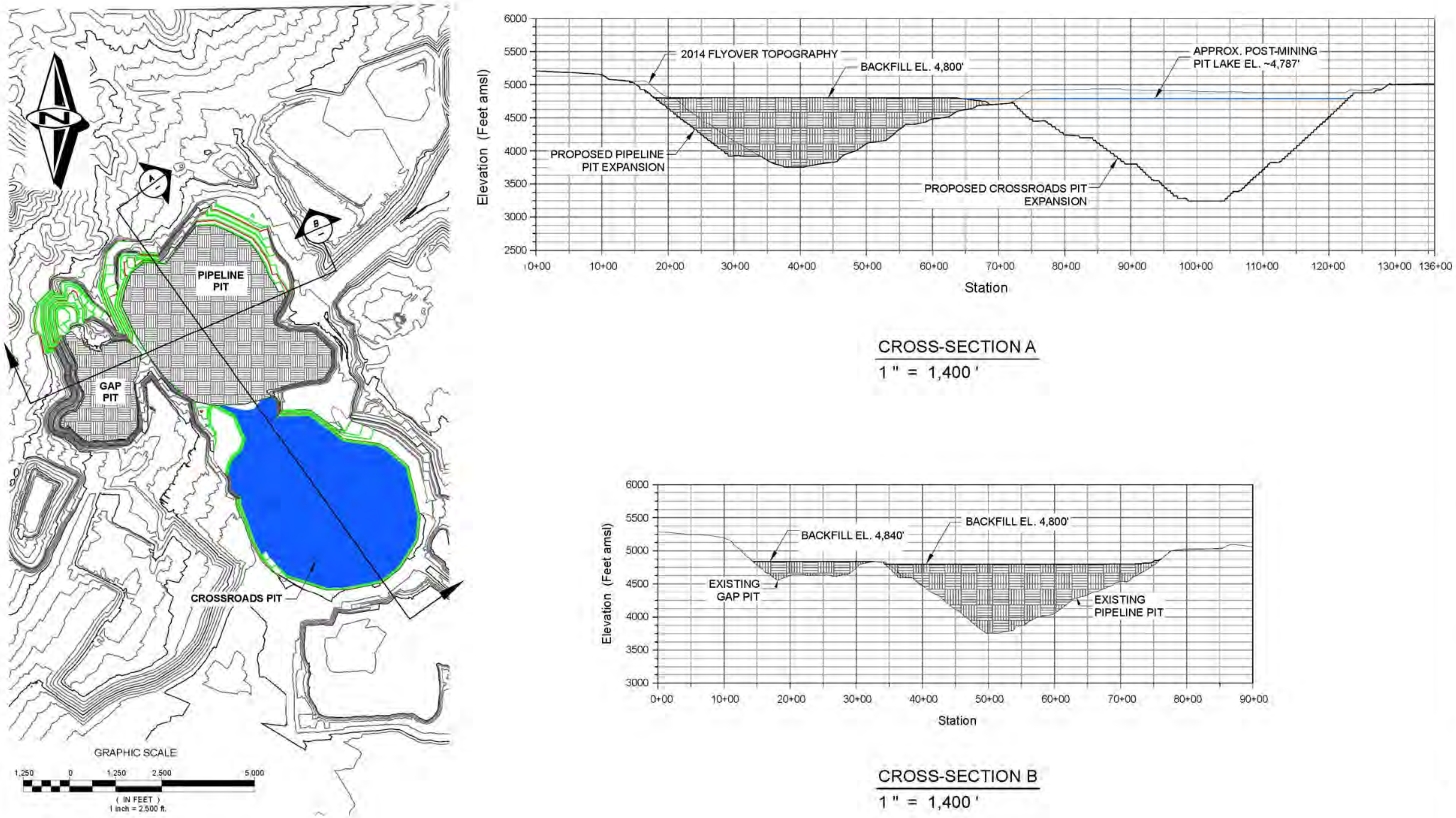



Figure 2-3
Proposed Action
Mine Complexes

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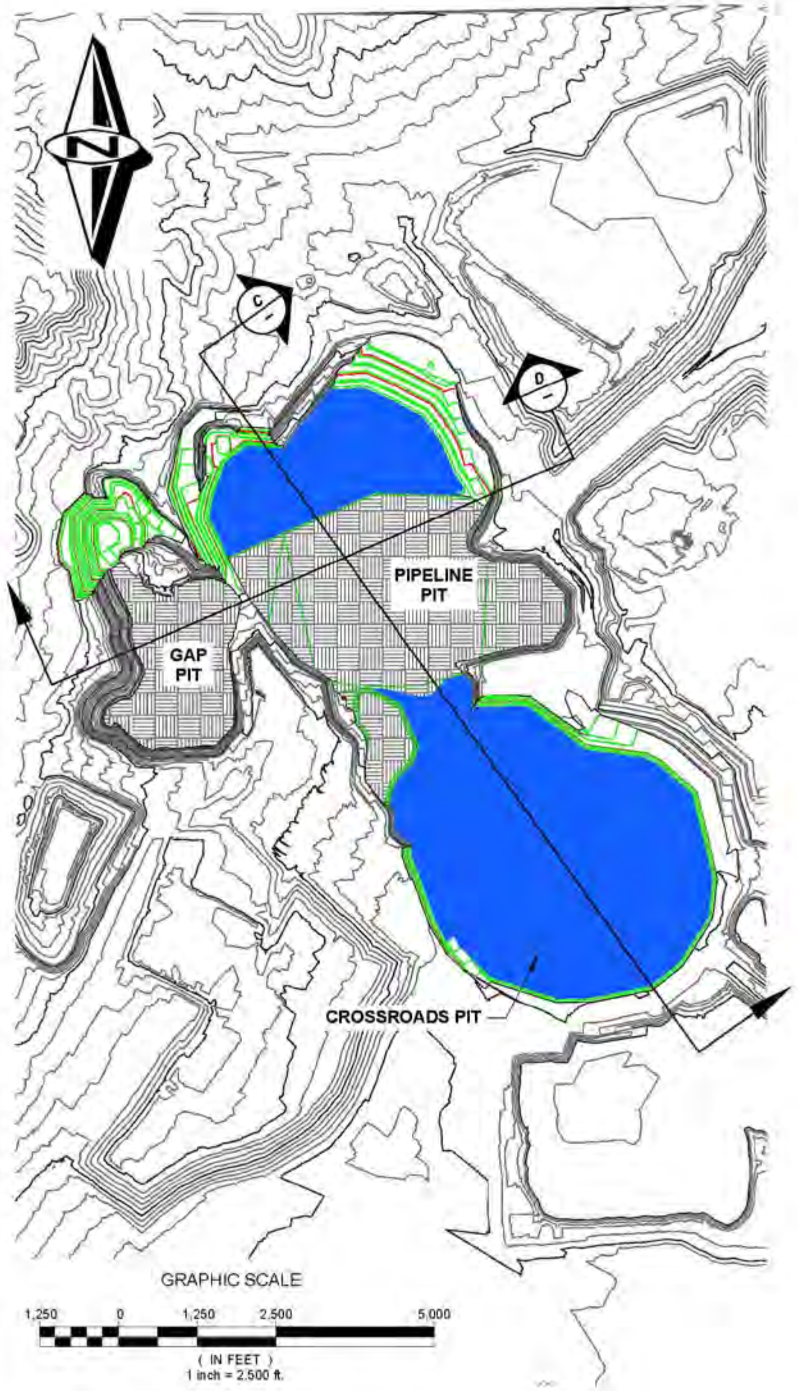
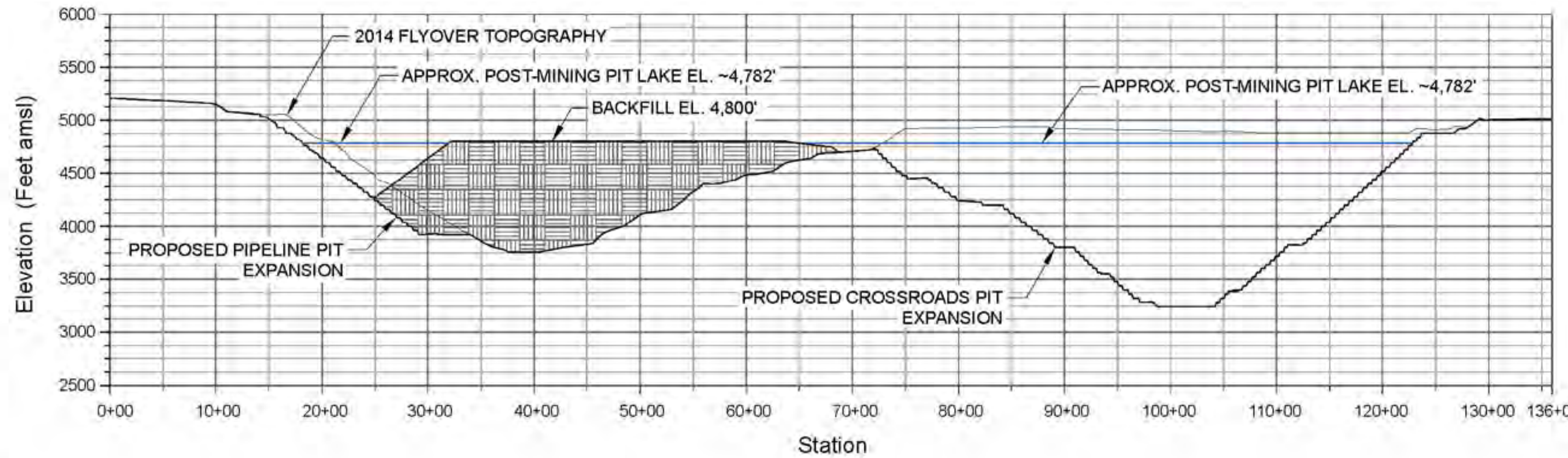
**Deep South Expansion Project EIS**

Figure 2-4

Pipeline Pit Complex
Backfill Scenario 1

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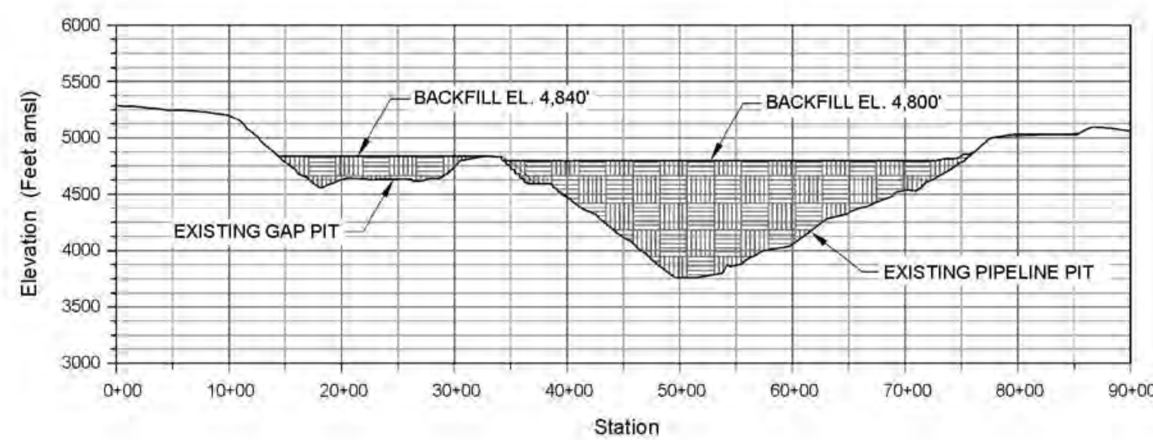


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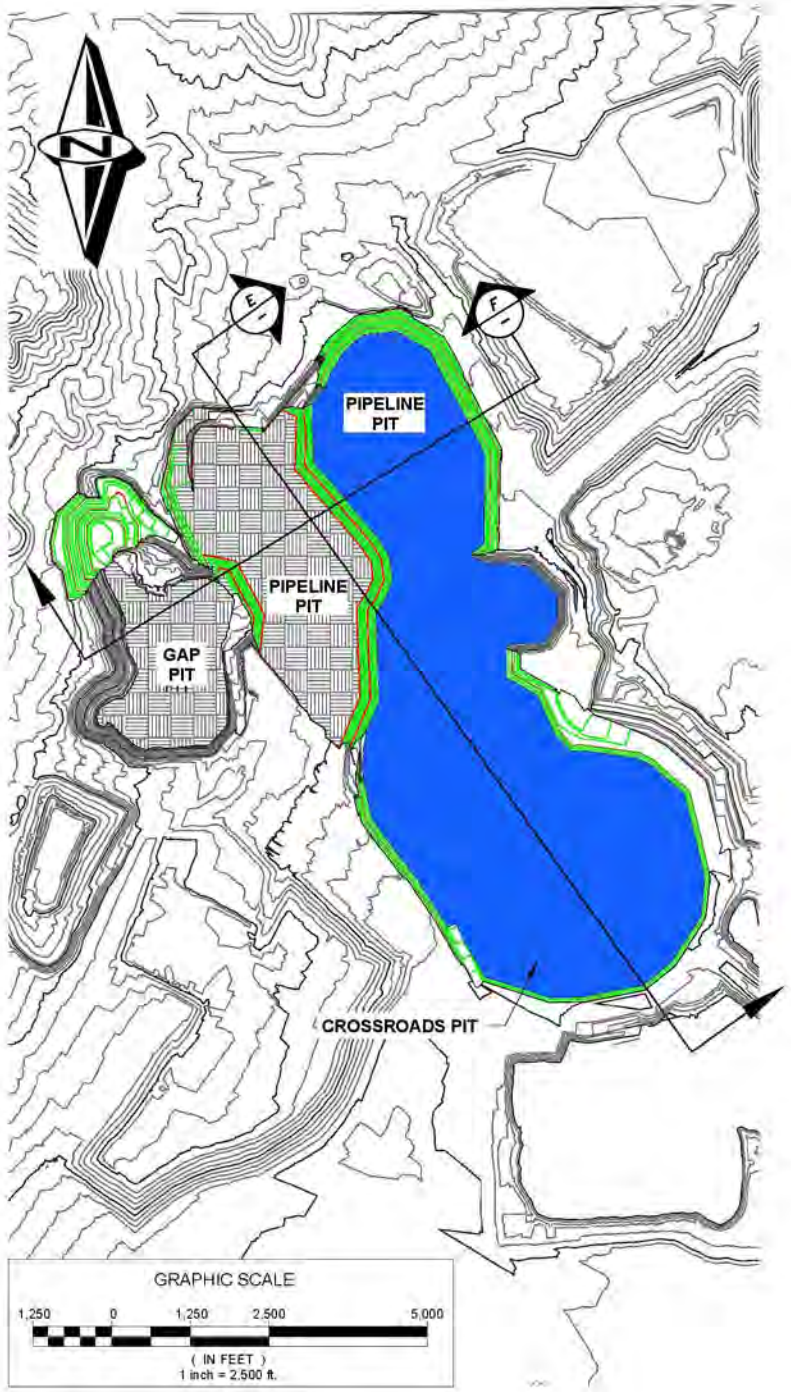
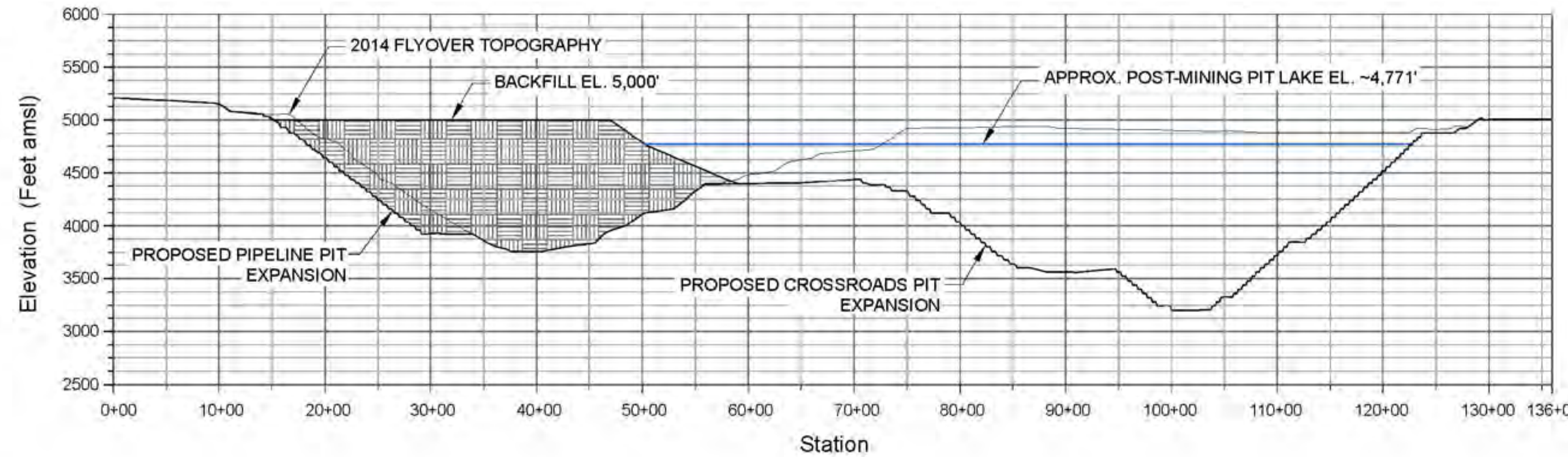
Figure 2-5

Pipeline Pit Complex
Backfill Scenario 2

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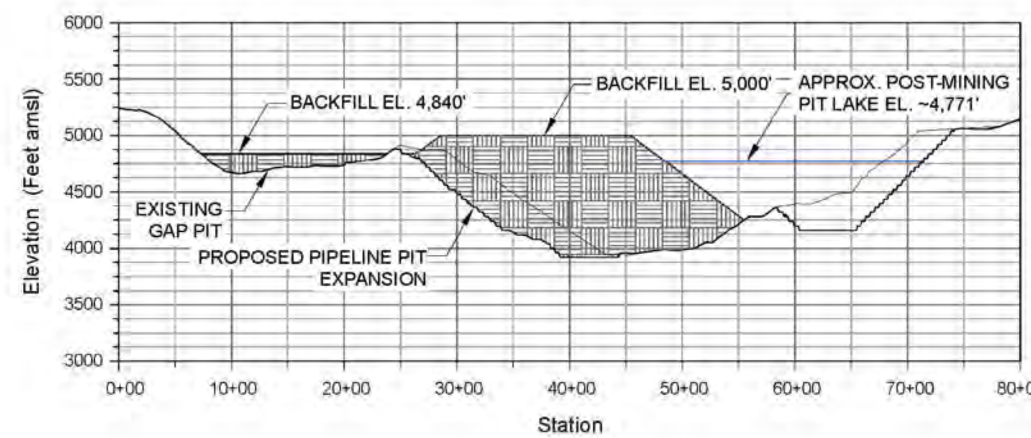


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Figure 2-6

Pipeline Pit Complex
Backfill Scenario 3

Gold Acres Complex:

- Expand and deepen the existing Gold Acres Pit and develop three satellite pits (Alta, Bellweather, and Pasture) (**Figure 2-7**).
- Expand the existing Gold Acres South Waste Rock Facility and combine the existing Gold Acres North and Gold Acres East waste rock facilities into one facility (Gold Acres North Waste Rock Facility).
- Construct a new Class III-waivered landfill and close the existing landfill.
- Construct a new refractory ore stockpile and a new growth media stockpile.
- Construct or install additional ancillary support facilities (e.g., mine operations office, septic system, fuel skid, water pipeline, power infrastructure).

Cortez Hills Complex:

- Expand existing underground operations by increasing the depth of mining by 1,300 feet and construct additional surface support facilities for underground operations.
- Extend the Pediment portion (southern portion) of the existing Cortez Hills Pit to create the Pediment East and Pediment South extensions.
- Potentially backfill the Cortez Hills Pit with approximately 63 million tons of waste rock (**Figure 2-8**).
- Modify the existing Canyon Waste Rock Facility.
- Construct a new water treatment plant and associated facilities.
- Construct a new refractory ore/oxide ore stockpile and a new growth media stockpile.

Cortez Complex:

- Expand and deepen the existing Cortez Pit by approximately 200 feet.
- Backfill the northern portion of the Cortez Pit and the existing Ada 52 Pit with approximately 3 million tons of waste rock (**Figure 2-9**).
- Expand the existing Cortez Waste Rock Facility and re-route the power infrastructure.
- Construct or install additional ancillary support facilities (e.g., mine operations office, septic system, fuel skids, water pipeline, power infrastructure).

Water Management:

- Continue dewatering to accommodate mining to lower elevations in the Pipeline and Cortez Hills complexes, with the maximum dewatering rate remaining below the currently authorized rate of 36,100 gallons per minute.
- Construct additional rapid infiltration basins (RIBs) and associated infrastructure in Grass Valley, Pine Valley, and on private land outside of the CGM Operations Area in Crescent Valley.
- Convert the two existing Grass Valley production wells to injection wells, and construct up to four additional injection wells in Grass Valley, to re-inject treated dewatering water into the aquifer.
- Construct the proposed Rocky Pass Reservoir and associated infrastructure, if needed, and realign a segment of County Road 225 to provide public access around the reservoir.

- Construct stormwater controls, as necessary.

General Site-wide Changes:

- Expand the CGM Operations Area boundary from the current 58,093 acres to 62,372 acres to include the proposed Pediment East extension of the Cortez Hills Pit, the Pine Valley RIBs and associated infrastructure, and the Rocky Pass Reservoir and associated infrastructure.
- Increase the off-site refractory ore shipment to the existing Goldstrike Mill (**Figure 2-10**) for processing from the currently authorized rate of 1.2 million tons per year (tpy) to 2.5 million tpy. The additional ore would extend processing at the Goldstrike Mill by approximately 3 years.
- Increase the backhaul of oxide ore from the Arturo Mine through the Goldstrike Mine to the Pipeline Complex (**Figure 2-10**) for processing at the existing Pipeline Mill or heap leach facility from the currently authorized rate of 600,000 tpy to 2.5 million tpy. No associated change in the current mill throughput rate, increase in the existing Pipeline Tailings Impoundment, or expansion of the existing Pipeline South Area Heap Leach Facility would be required to accommodate the processing of Arturo Mine oxide ore.
- Modify the site-wide surface mining rate from the currently authorized 580,000 tons per day (tpd) to a maximum of 600,000 tpd.

In addition to incorporation of the modifications outlined above, BCI proposes to modify the plan boundaries for BCI's two existing exploration projects (Horse Canyon/Cortez Unified Exploration Project [HC/CUEP] [NVN-66621] and West Pine Valley Exploration Project [NVN-077213]) to eliminate overlap with portions of the expanded CGM Operations Area boundary.

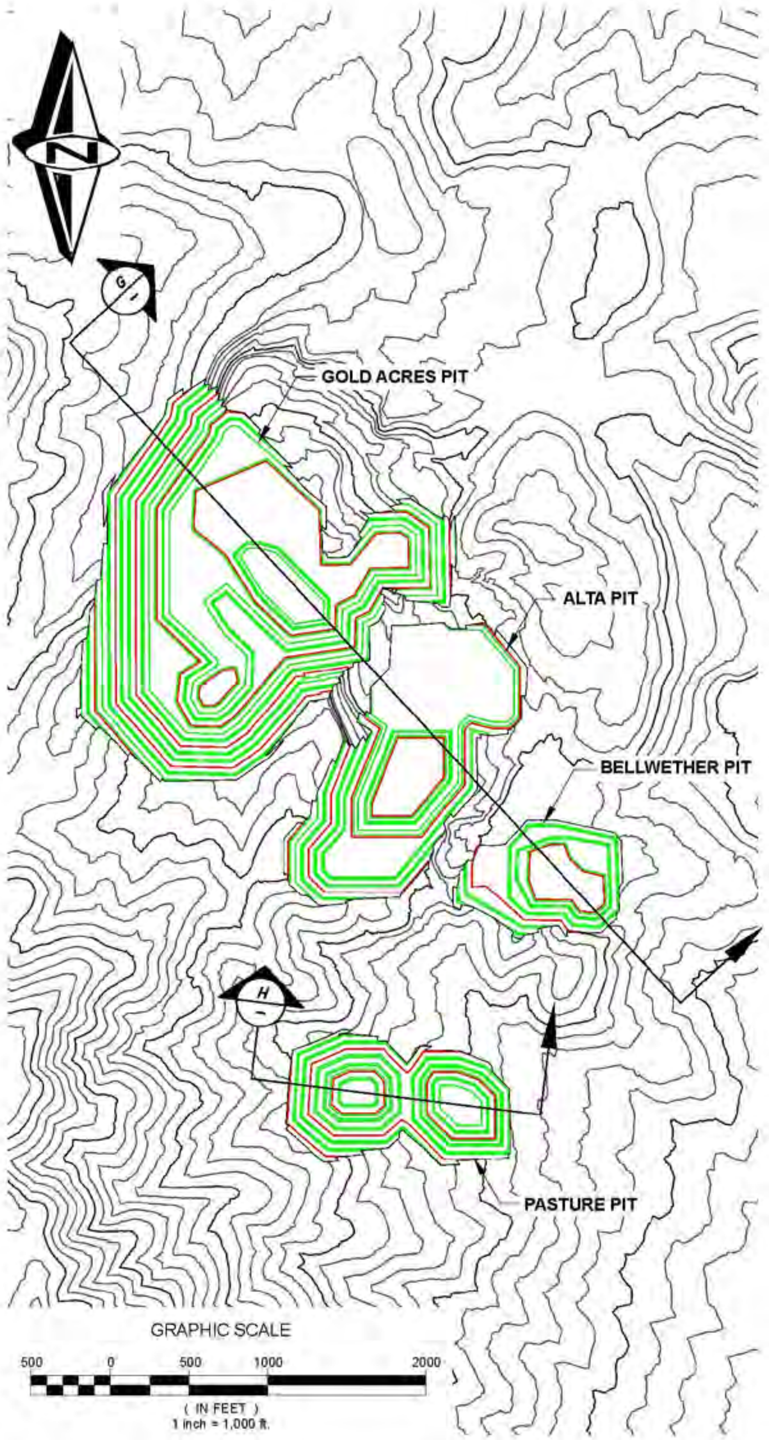
The Proposed Action would result in a total proposed new surface disturbance of 4,380 acres, including 3,846 acres within the CGM Operations Area and 534 acres outside of the CGM Operations Area on private land owned by BCI. Approximately 2,779 acres of the total proposed new disturbance would be on BLM-administered public lands. The currently authorized and proposed new surface disturbance, as well as reallocation of use of currently authorized disturbance, at the site is summarized in **Table 2-1**.

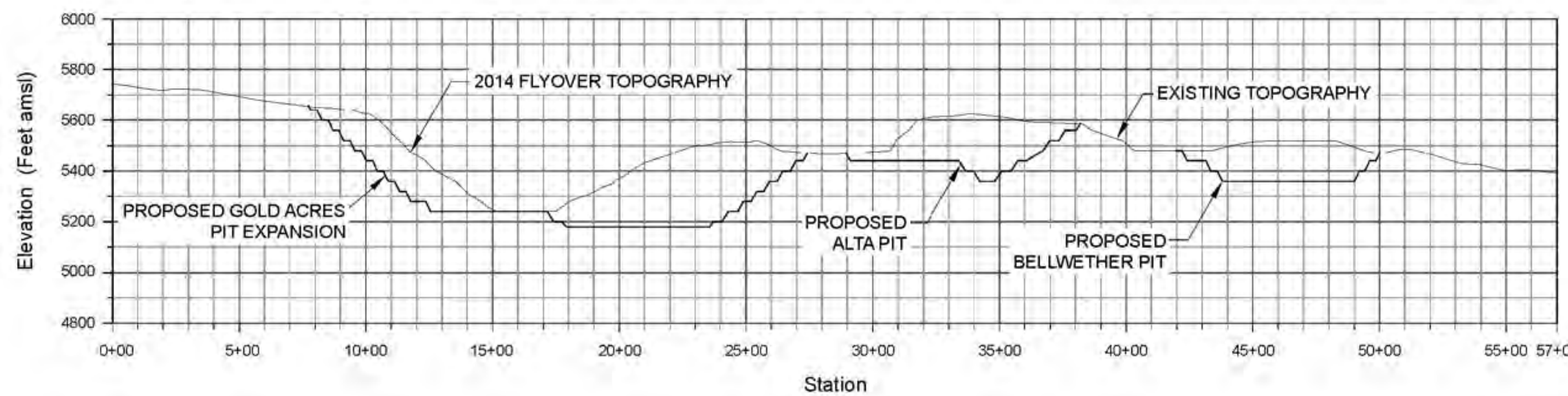
No increase in BCI's current work force (1,250 workers) would be required for the Proposed Action. It is anticipated that a contractor work force of approximately 350 workers also would be on site throughout the life of the project for construction of facilities and for other site preparation activities. Approximately 155 workers would be required for the final 3 years of ongoing ore processing, closure, and reclamation. The total BCI operations work force payroll/benefits is estimated to be approximately $628.8 million. The average annual contractor costs would be approximately $13.5 million.

If approved, the Deep South Expansion Project would extend the life of the mine by approximately 12 years, followed by approximately 3 years for site closure and final reclamation.

### 2.3.2 Dewatering and Water Management

Dewatering currently is and would continue at the Pipeline and Cortez Hills complexes. No additional dewatering would be required to facilitate mining of the Cortez Pit. No dewatering would be required for the proposed expansion of the Gold Acres Pit or development of the Gold Acres satellite pits. The dewatering rate for the Deep South Expansion Project would remain below the currently authorized maximum rate of 36,100 gallons per minute.

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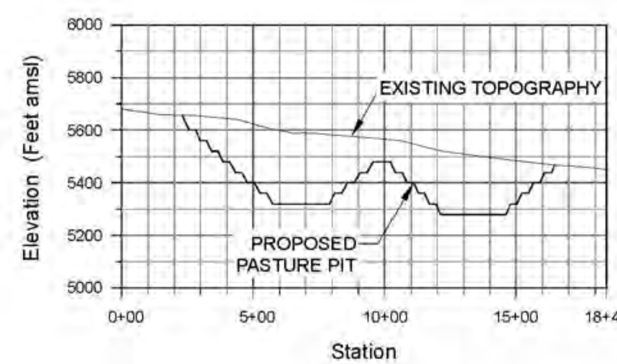


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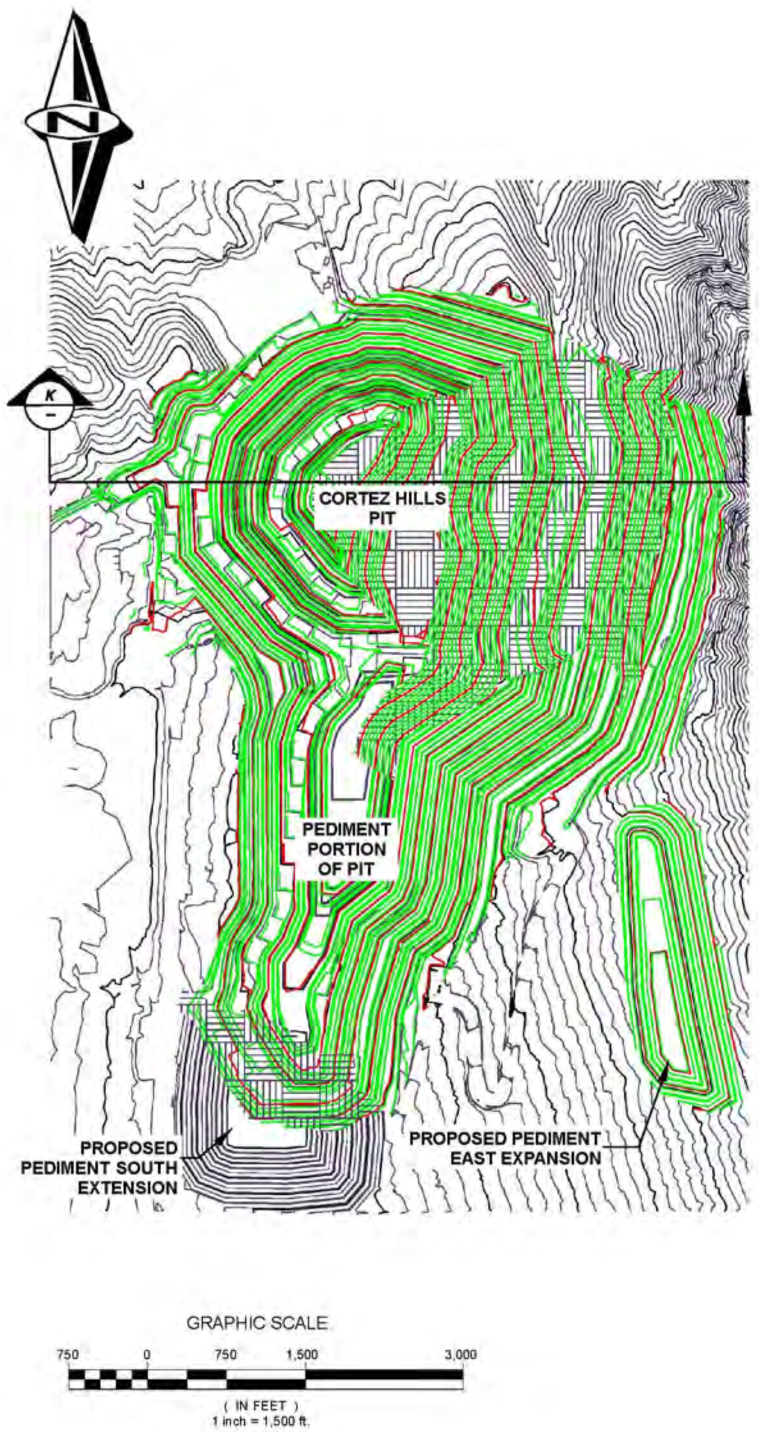
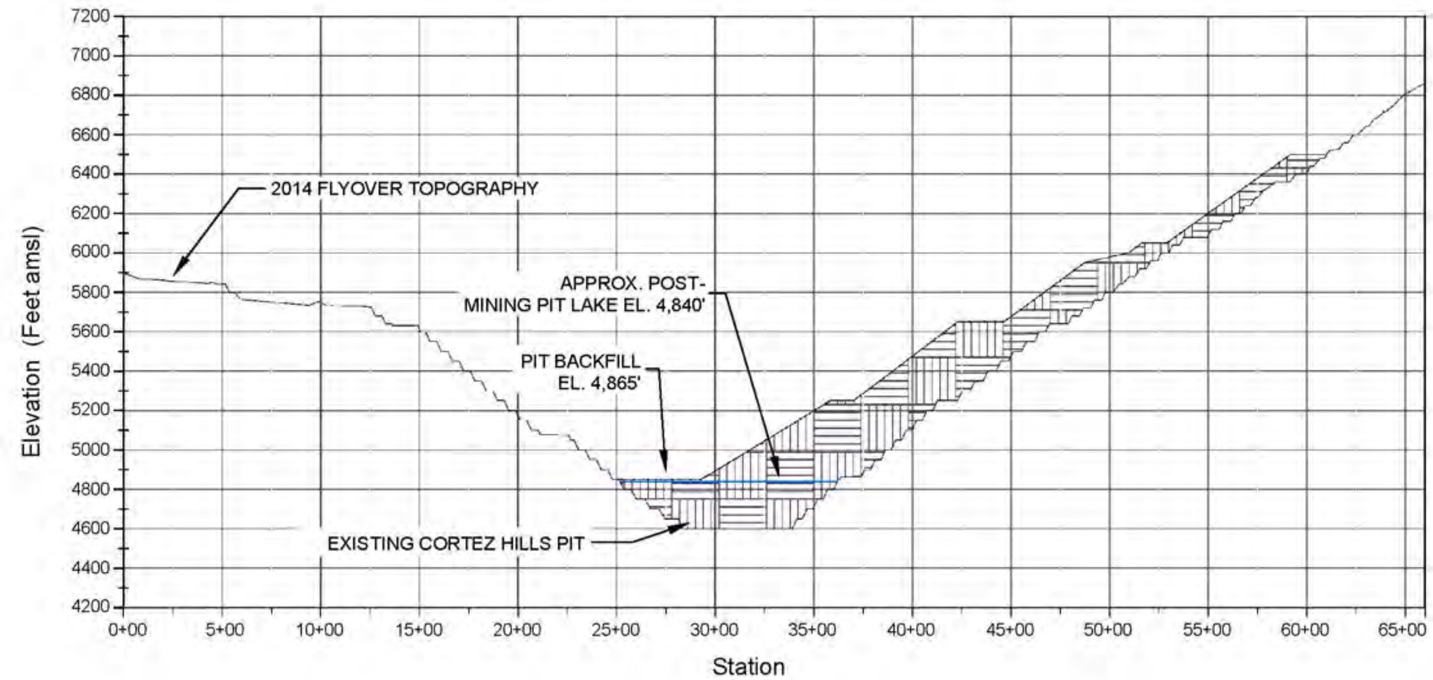
Figure 2-7

Gold Acres Pit and Satellite Pits

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**Note:** Waste rock temporarily may be stored in the Pediment South extension and if not utilized for Cortez Hill Pit backfill would be reclaimed in place.

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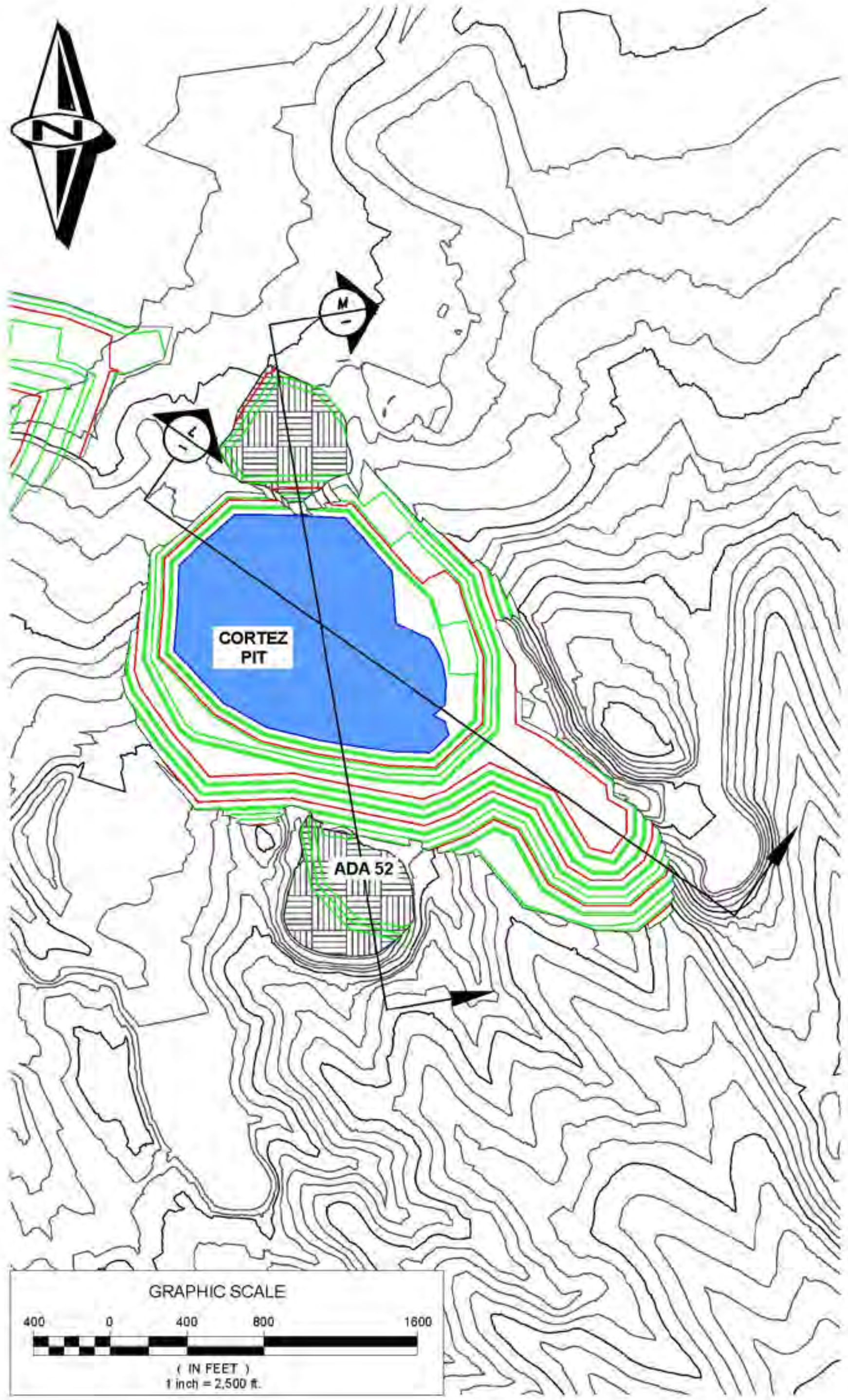
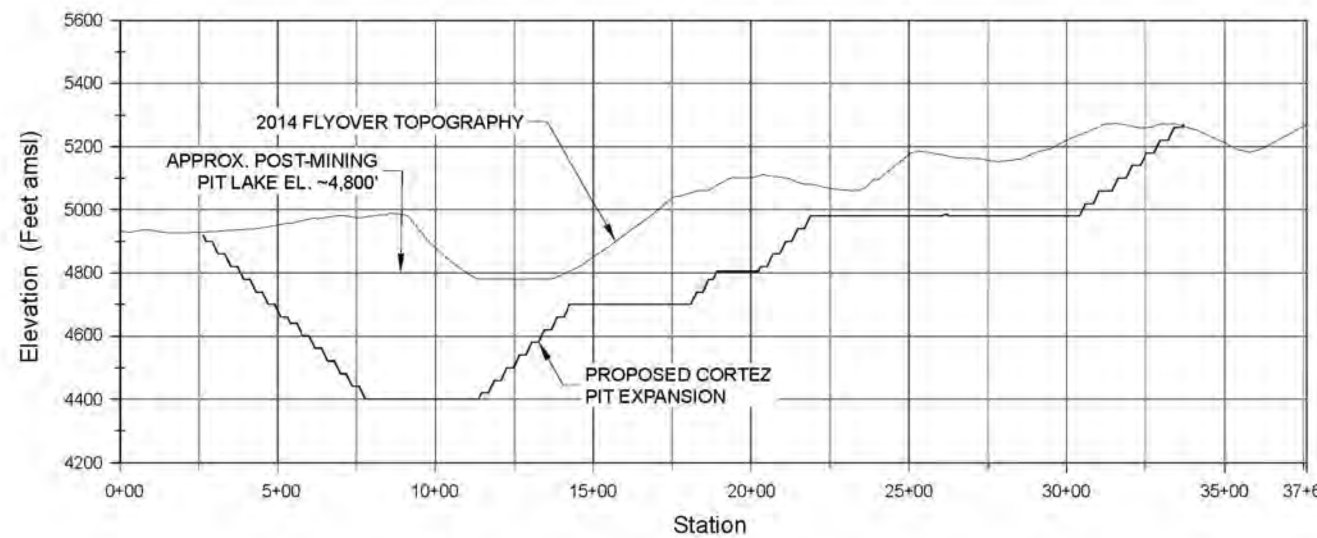
Figure 2-8

Cortez Hills Pit Backfill

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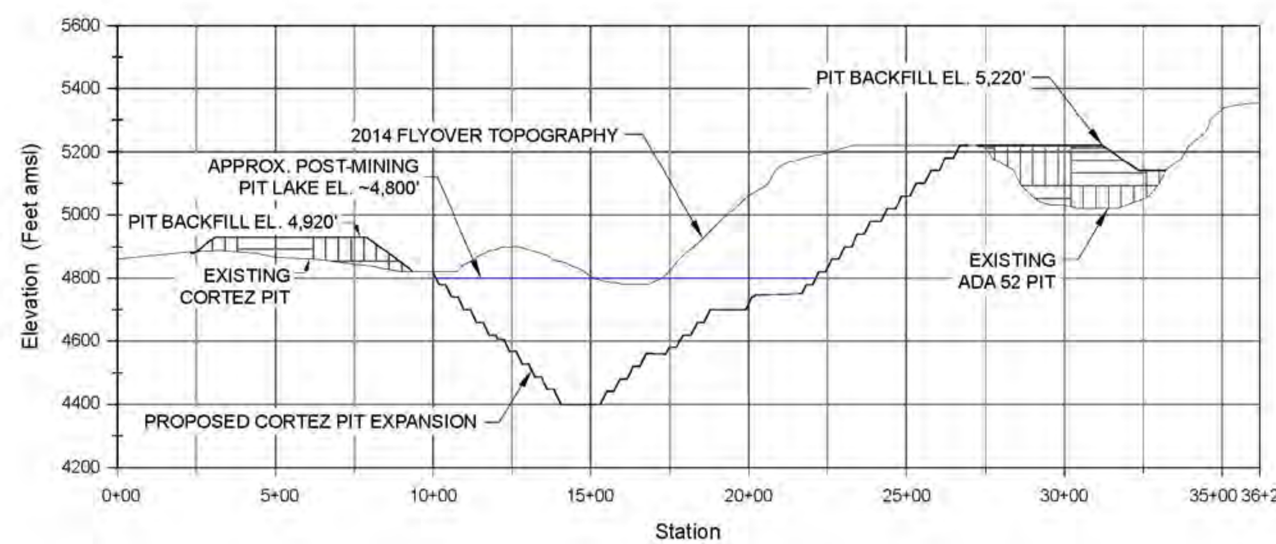


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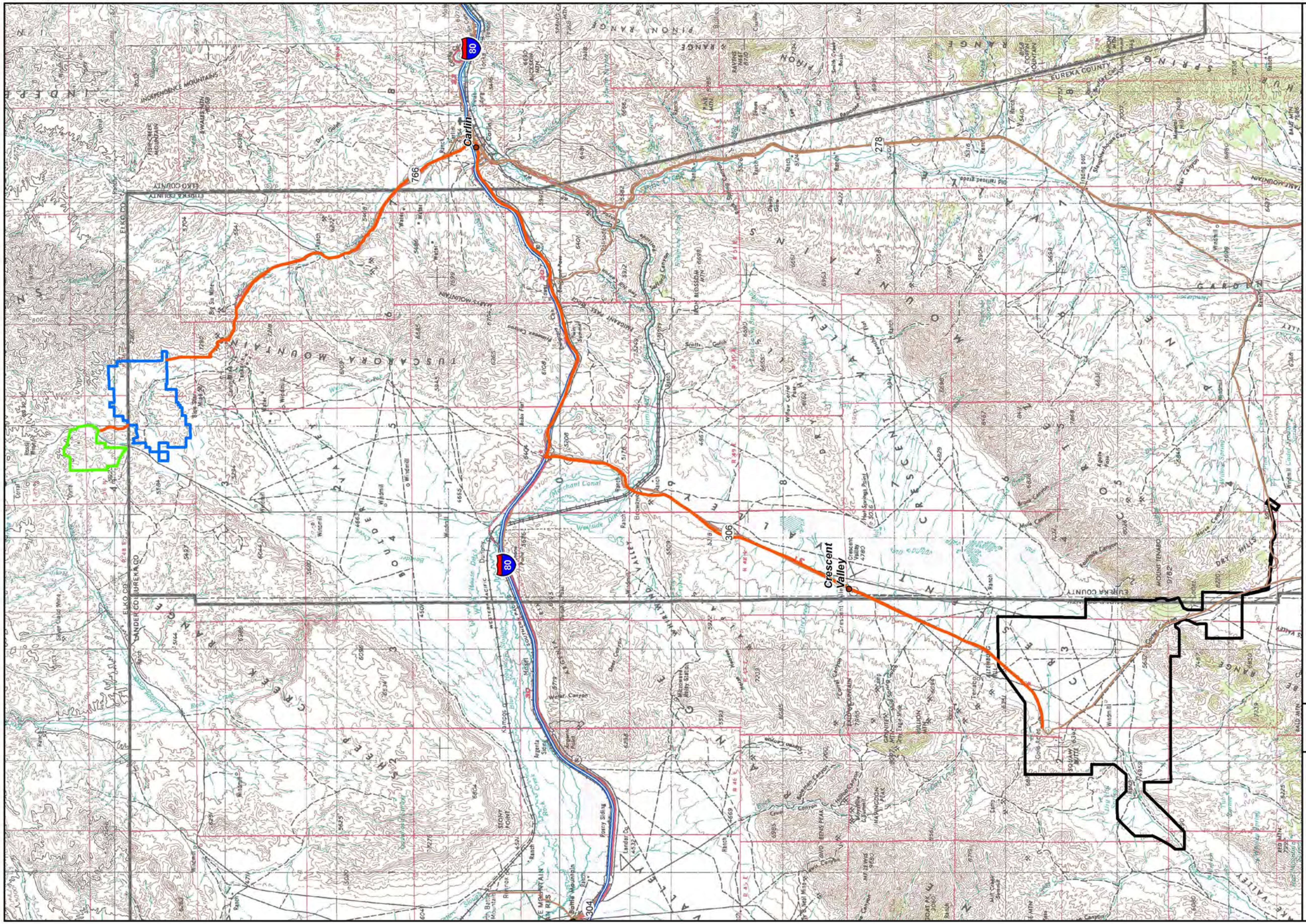
Figure 2-9

Cortez Pit and Ada 52 Pit Backfill




Proposed CGM Operations Area Boundary
Goldstrike Mine Operations Boundary
Arturo Mine Operations Boundary
Ore Transportation Route

**Note:** No change in the currently authorized ore transportation route is proposed.

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Figure 2-10

Ore Transportation Route

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**Table 2-1 Currently Authorized Disturbance and Proposed New Disturbance under the Proposed Action**

| Mine Complex | Facility | No Action Alternative Total Authorized Disturbance by Facility (acres) | Proposed Action | | |
|---|---|---|---|---|---|
| | | | Proposed Total Disturbance by Facility (acres) | Proposed Reallocation of Use of Currently Authorized Disturbance (sum total acres) | Proposed New Surface Disturbance by Facility (acres) |
| Open Pits | | 2,752 | 3,411 | 474 | 185 |
| Underground Operations | | 0[1] | 0[1] | 0[1] | 0[1] |
| Waste Rock Facilities | | 5,393 | 5,685 | -105 | 397 |
| Heap Leach Facilities and Process Areas | | 1,933 | 2,049 | 116 | 0 |
| Tailings Impoundments | | 1,416 | 1,208 | -208 | 0 |
| Ancillary Support Facilities | | 4,111 | 4,696 | -336 | 921 |
| Water Management Facilities | | 704 | 3,057 | 10 | 2,343 |
| Exploration | | 391 | 391 | 0 | 0 |
| **Total Acres within CGM Operations Area[2]** | | **16,700** | **20,498** | **-48[3]** | **3,846** |
| **Proposed New Disturbance Outside CGM Operations Area[4]** | | | | | **534** |
| **Total Proposed New Disturbance** | | | | | **4,380** |

[1] Disturbance associated with surface infrastructure for underground mining is accounted for in other currently authorized or proposed disturbance footprints.

[2] Differences are due to rounding.

[3] Reflects reallocation of undisturbed land that previously was authorized for disturbance.

[4] Reflects surface disturbance associated with proposed RIBs and associated infrastructure northeast of the CGM Operations Area in Crescent Valley.

Prior to disposal through infiltration in the RIBs, irrigation use, or temporary storage in the reservoir, the dewatering water would be treated in the existing Pipeline water treatment facility or proposed Cortez Hills water treatment facility to reduce naturally occurring arsenic concentrations to meet Nevada Profile I reference values (Nevada Administrative Code [NAC] 445A).

### 2.3.3 Applicant-committed Environmental Protection Measures

BCI's committed environmental protection measures for operations in the CGM Operations Area are identified in the Barrick Cortez Inc. (NVN-067575 (16-1A)) Deep South Expansion Project Amendment to Plan of Operations and Reclamation Permit Application #0093 (BCI 2016). These measures currently are, and would continue to be, implemented as standard operating procedures to mitigate potential impacts to environmental and human resources. The measures specific to geology are presented below.

#### 2.3.3.1 Geology

- Geotechnical monitoring, consisting of geologic structure mapping, groundwater monitoring, and slope stability analyses, would be conducted during active mining to assist in optimizing the final pit designs. Slope movement monitoring also would be initiated to evaluate the safety of the open pit high walls. In addition, operational procedures for controlling blasting and bench scaling would facilitate mining with stable pit walls.

- BCI has implemented management, monitoring, and mitigation measures to address possible future fissuring in the Pipeline Complex area. These measures are described in the Pipeline/South Pipeline Pit Expansion Project Final Supplemental EIS (SEIS) (BLM 2004). These protective measures, which would continue as part of the Proposed Action, include integration of the following components:
  - Stormwater diversion ditch to intercept and route surface water runoff away from the fissure area;
  - Dewatering pipeline instrumentation and pressure monitoring;
  - Intercept trench east of the existing Pipeline/South Pipeline Heap Leach Facility and west of the main fissure complex;
  - Backfilling of existing open fissure gullies;
  - Protective berms and surface grades to exclude water from the fissure field;
  - Alluvial waste rock dikes to provide containment and channelization in the event of a dewatering line break;
  - Monitoring of subsidence rates and horizontal strain; and
  - The step back area would be fenced with four-strand range fence at mine closure.

## 2.3.4 Reclamation

Principal land uses in the project vicinity include mineral exploration and development, livestock grazing, wildlife habitat, and dispersed recreation. Following closure and final reclamation, the CGM Operations Area would support the multiple land uses of livestock grazing, wildlife habitat, and recreation. Other land uses that may be conducted concurrent with operations and following site closure may include irrigated pasture and alfalfa (or other crop) production on private land parcels within the CGM Operations Area.

The proposed Reclamation Plan for the Deep South Expansion Project is summarized below.

### 2.3.4.1 Reclamation Overview

With the exception of pit highwalls, ramps, and floors; post-reclamation stormwater control features; rerouted county roads (e.g., County Road 225); and roads selected by BLM for post-mining use, all of the surface disturbance associated with the mine components would be reclaimed. Concurrent reclamation would be conducted to the extent practical to accelerate revegetation of disturbance areas. All sediment and erosion control measures and revegetated areas would be inspected periodically to ensure long-term erosion control and successful reclamation.

### 2.3.4.2 Growth Media

Growth media replacement depths for the existing heap leach pads and tailings impoundments would be at least 18 inches and 12 inches, respectively. All other mine facilities (with the exception of the open pits) would be covered to a depth of at least 6 inches. Approximately 1.2 million cubic yards of growth media would be required to reclaim Proposed Action facilities. Approximately 1.6 million cubic yards of suitable growth media would be salvage, with up to approximately 190 million tons of alluvium/colluvium also available for reclamation use. The proposed growth media placement depths would be reviewed in coordination with the BLM and the Nevada Division of Environmental Protection (NDEP) for specification in the final closure plan for the project.

#### 2.3.4.3 Seeding, Planting, and Noxious Weed Control

Seeding would be conducted using the seed mixes that originally were developed by the BLM (BLM 2008a,b), as presented in the Barrick Cortez Inc. (NVN-067575 (16-1A)) Deep South Expansion Project Amendment to Plan of Operations and Reclamation Permit Application #0093 (BCI 2016 – Tables 3-2 and 3-3). The seed mixes were based on the species' effectiveness in providing erosion protection, the ability to grow within the constraints of the low annual precipitation experienced in the region, species suitability for site aspect, and the site elevation and soil type (BLM 2008a). In addition to seeding the waste rock facilities, BCI would evaluate planting of singleleaf pinyon seedlings in suitable areas as part of the reclamation program.

BCI's Noxious Weed Control Plan (SRK Consulting, (U.S.) Inc. [SRK] 2014) would continue to be implemented at the site as a property-wide program.

#### 2.3.4.4 Facility Reclamation

Facility reclamation is discussed in detail in the Barrick Cortez Inc. (NVN-067575 (16-1A)) Deep South Expansion Project Amendment to Plan of Operations and Reclamation Permit Application #0093 (BCI 2016) and summarized below.

- Open Pits: Post-mining safety barriers (e.g., berms, fencing, or other appropriate barriers) would be installed peripherally to the crest of each pit, with pit ramps barricaded in a similar manner to prevent entrance. Pit lakes would form in the bottom of some pits after dewatering activities cease (i.e., portions of the Pipeline Pit Complex and Cortez Pit). Other pits would be completely or partially backfilled with waste rock material.
- Underground Mine: Closure procedures would include: 1) construction of water-tight dams in select portions of the declines to re-establish pre-mining hydrologic conditions; 2) removal and salvage or disposal in an approved waste disposal facility of underground and surface piping, pumps, and equipment; 3) abandonment of surface dewatering wells and boreholes in accordance with applicable rules and regulations; 4) disposal of remaining fuels, lubricants, and explosives at a licensed off-site facility; and 5) installation of and earthen plug (minimum 30 feet long) in each decline to prevent access.
- Waste Rock Facilities: Concurrent reclamation would be conducted to the extent possible using an interim reclamation seed mix ((Barrick Cortez Inc. (NVN-067575 (16-1A)) Deep South Expansion Project Amendment to Plan of Operations and Reclamation Permit Application #0093 [BCI 2016] – Table 3-1). Lifts would be regraded to an overall average 2.5H:1V slope, growth media distributed to a depth of approximately 6 inches, areas reseeded, and erosion controls and storm diversions installed. Portions of pit backfill areas that would be above the projected groundwater table would be reclaimed in a manner similar to out-of-pit waste rock facilities.
- Existing Heap Leach Facilities: A Final Plan for Permanent Closure detailing proposed closure technology (e.g., evaporation cells or evapotranspiration cells), management requirements for long-term effluent discharge, and closure would be developed 2 years prior to project closure pursuant to the requirements of the NDEP (NAC 445A.430 through 445.447) at the time of closure. An ecological risk assessment evaluating

potential sodium (and other constituent) accumulation in the soils of the evaporation and evapotranspiration cells would be included.

- Existing Tailings Impoundment: A Final Plan for Permanent Closure would be developed 2 years prior to project closure for submittal to BLM and NDEP. The plan would include tailings closure specifications, including draindown management, which would be similar to that for the heap leach facilities.
- RIBs: The RIBs would be backfilled to grade and revegetated at closure. A detailed closure plan would be prepared at least 2 years prior to the anticipated closure date (NAC 445A.447) for submittal to BLM and NDEP. The closure plan would conform to the water pollution control regulations in effect at the time of closure.
- Rocky Pass Reservoir: Water remaining in the reservoir would be pumped back to the Pipeline Pit. The material from the earthen embankment would be removed and placed in the impoundment footprint from where it was borrowed during construction. The pipelines and other equipment would be removed and properly disposed or reused at another Barrick site. The entire reservoir footprint would be scarified and seeded.
- Roads: Some access roads would be maintained to provide access to monitoring sites following the completion of mining. As determined by BLM, any roads on public lands determined to be suitable for public access or which continue to provide public access consistent with pre-mining conditions would not be reclaimed. County roads also would be retained. Roads that potentially would support alternate land uses, as would be determined in coordination with agencies, local governments, and tribes, also may be retained. All other haul, access, and exploration roads would be recontoured and reclaimed.
- Buildings and Ancillary Facilities: Disposition of buildings and ancillary facilities would be conducted as described in the the Barrick Cortez Inc. (NVN-067575 (16-1A)) Deep South Expansion Project Amendment to Plan of Operations and Reclamation Permit Application #0093 (BCI 2016). BCI would work with agencies, local governments, and tribes to evaluate alternative land uses that could provide long-term socioeconomic benefits from the mine infrastructure.
- Drill Holes and Water Wells: All drill holes and water wells subject to Nevada Division of Water Resources regulations would be abandoned in accordance with applicable rules and regulations (NAC 534.425 through 534.428). Boreholes would be sealed to prevent cross contamination between aquifers, and the required shallow seal would be placed to prevent contamination by surface access.
- Monitoring Wells: Monitoring wells around the heap leach facilities would be maintained until BCI is released from post-mining groundwater monitoring requirements by the NDEP. These wells then would be plugged and abandoned according to the requirements of the Nevada State Engineer.

#### 2.3.4.5 Post-reclamation Monitoring and Maintenance

Following mine closure, BCI would conduct maintenance, site inspections, and any other necessary monitoring for the period of reclamation responsibility. Post-mining groundwater quality would be monitored according to the requirements established by NDEP, with the goal of demonstrating non-degradation to waters of the state. Monitoring of revegetation success would be conducted annually for a minimum of 3 years or until the revegetation standards have been met, as determined by the jurisdictional agencies. In addition, noxious weed monitoring and control would be implemented for a period of 5 years. Post-mining monitoring and maintenance is provided for in BCI’s long-term contingency fund (BCI 2016).

## 2.4 Alternatives to the Proposed Action

Two alternatives to the Proposed Action were carried forward for analysis of impacts and are summarized below.

### 2.4.1 Gold Acres Pit Partial Backfill Alternative

Project development, operation, and reclamation under the Gold Acres Pit Partial Backfill Alternative would be the same as under the Proposed Action, with the following exceptions.

- Expansion of the existing Gold Acres Pit would be completed prior to development of the proposed satellite pits (Alta, Bellwether, and Pasture), with the waste rock from the satellite pits (30 million tons) placed as backfill in the Gold Acres Pit (**Figures 2-11** and **2-12**).
- Placement of backfill in the Gold Acres Pit would result in a 72-acre reduction in the proposed new disturbance for the Gold Acres North Waste Rock Facility (**Table 2-2**).

### 2.4.2 No Action Alternative

Under the No Action Alternative, the existing mining and processing operations in the CGM Operations Area, the current off-site transport of refractory ore to the Goldstrike Mill for processing, the backhaul of Arturo Mine oxide ore to the Pipeline Complex for processing, and site reclamation would continue under the terms of current permits and approvals as authorized by the BLM and State of Nevada. Existing facilities in the four mine complexes in the CGM Operations Area and the authorized disturbance are shown in **Figure 2-1** and presented in **Table 2-1**. The facilities and ongoing operations are summarized below.

Mine Facilities:

- Open pit mining at the Pipeline Pit Complex and the Cortez Hills and Cortez pits would continue. Any additional mining at the Gold Acres Pit would be conducted in accordance with existing permit criteria.
- Underground mining at the Cortez Hills Complex would continue, with mining conducted to the 3,800-foot elevation.
- The following out-of-pit waste rock facilities would continue to be used: Pipeline/South Pipeline Waste Rock Facility, Gap Waste Rock Facility, Canyon Waste Rock Facility, North Waste Rock Facility, South Waste Rock Facility, and Cortez Waste Rock Facility.
- Waste rock mined in the Pipeline Pit Complex alternately may be placed in the currently authorized backfill areas in the northeast and northwest portions of the pit complex (i.e., Pipeline Pit and Gap Pit, respectively).
- The following heap leach facilities would continue to be used: Pipeline South Area Heap Leach Facility, the heap leach portion of the Pipeline Heap Leach/Tailings Facility, and the Grass Valley Heap Leach Facility.
- The Pipeline Mill would continue to be used, and tailings would continue to be deposited at the tailings portion of the Pipeline Heap Leach/Tailings Facility.
- Existing ancillary facilities would continue to be used.

Water Management:

- Mine dewatering and disposal would continue through the completion of mining (early 2023). Dewatering water would be consumed, piped to the existing RIBs in Crescent Valley for infiltration, or piped to the Dean Ranch for seasonal irrigation purposes as currently authorized. Dewatering water would be treated at the Pipeline water treatment plant prior to disposal.

General Site-wide Operations:

- Refractory ore would continue to be trucked off-site at a rate of up to 1.2 million tpy for processing at the Goldstrike Mill, with shipments and processing continuing through 2023.
- Arturo Mine oxide ore would continue to be backhauled at a rate up to 600,000 tpy to the Pipeline Complex for mill and heap leach processing through 2023.

Approximately 1,250 workers currently are employed by BCI for open-pit and underground mining, heap leach and mill processing, and reclamation activities in the CGM Operations Area, with an on-site contractor work force of approximately 350 workers. Operations are anticipated to continue through approximately 2023. Approximately 155 workers would be required for the final 3 years (through 2026) of ongoing ore processing, decommissioning, and final reclamation. The average annual operations work force payroll for the remainder of the currently authorized project would be approximately $406 million.

#### 2.4.2.1 Environmental Protection Measures

BCI's committed environmental protection measures for operations in the CGM Operations Area, as well as additional BLM-stipulated mitigation measures, were identified in the associated NEPA documents (BLM 2015a, 2014a, 2011a, 2008a) and decision documents (BLM 2015b, 2014b, 2011b, 2008b). These measures would continue to be implemented as standard operating procedures to mitigate potential impacts to environmental and human resources.

#### 2.4.2.2 Reclamation

Existing facilities would be closed and reclaimed in accordance with the currently approved reclamation plan, current permits, and applicable federal and state site closure and reclamation requirements. Final closure and reclamation of the mine site are discussed in previous NEPA documents (BLM 2015a, 2014a, 2008a) and generally would follow the procedures in Section 2.3.4, Reclamation. Post-mining pit lakes would develop in the Crossroads Pit and southern portion of the Gap Pit portions of the Pipeline Pit Complex, the Cortez Hills Pit, and the Cortez Pit as discussed in the Cortez Hills Expansion Project Final EIS (BLM 2008a).

#### 2.4.2.3 Monitoring

Under the No Action Alternative, monitoring would continue as described in the approved plans and the comprehensive Cortez Integrated Monitoring Plan (BLM 2011a, 2008a).

### 2.5 Past, Present, and Reasonably Foreseeable Future Actions

The past and present actions, as well as the RFFAs, for the cumulative impact analysis are summarized below in **Table 2-3**, and the distribution of the primary surface-disturbing actions shown in **Figure 2-13**.

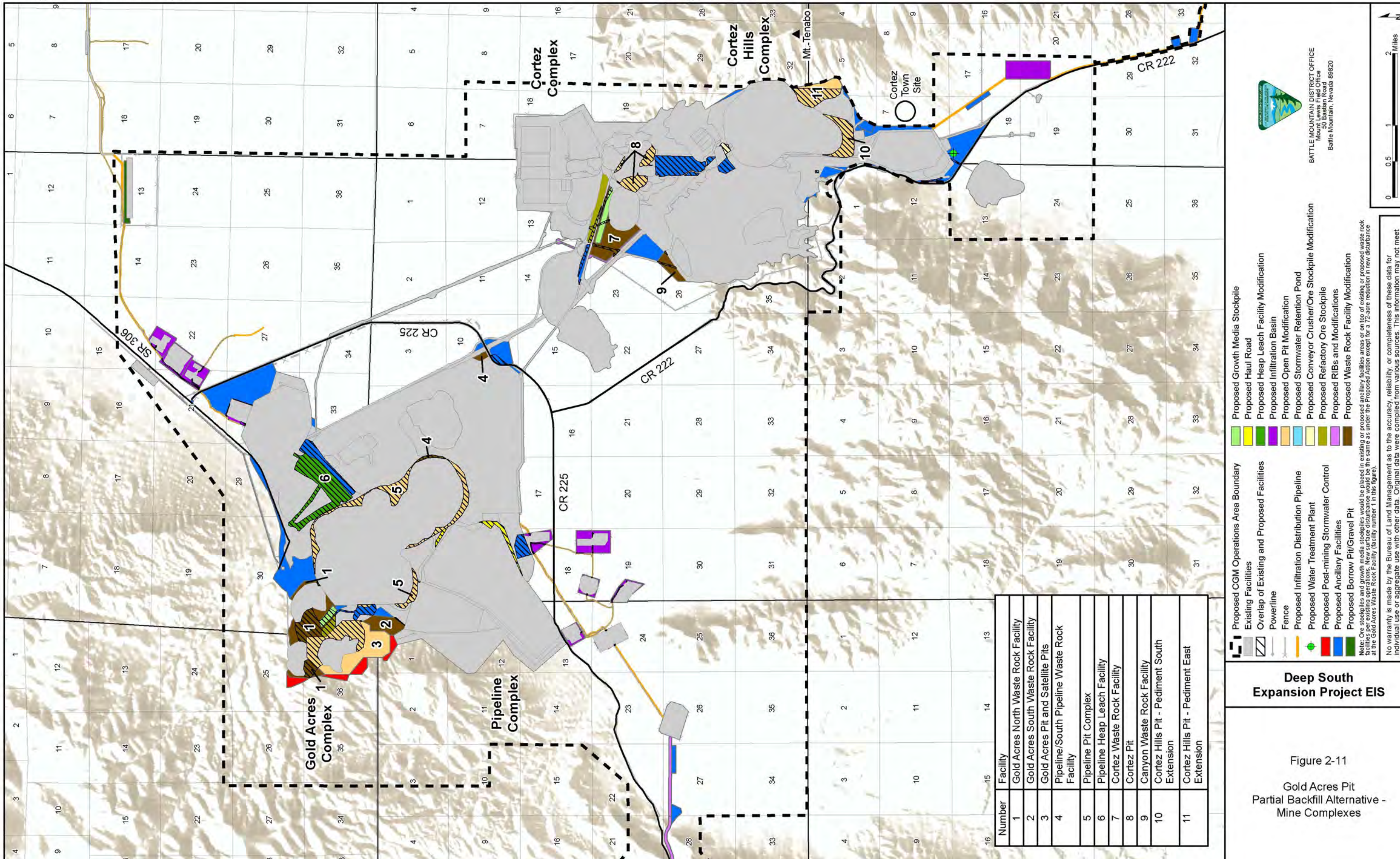
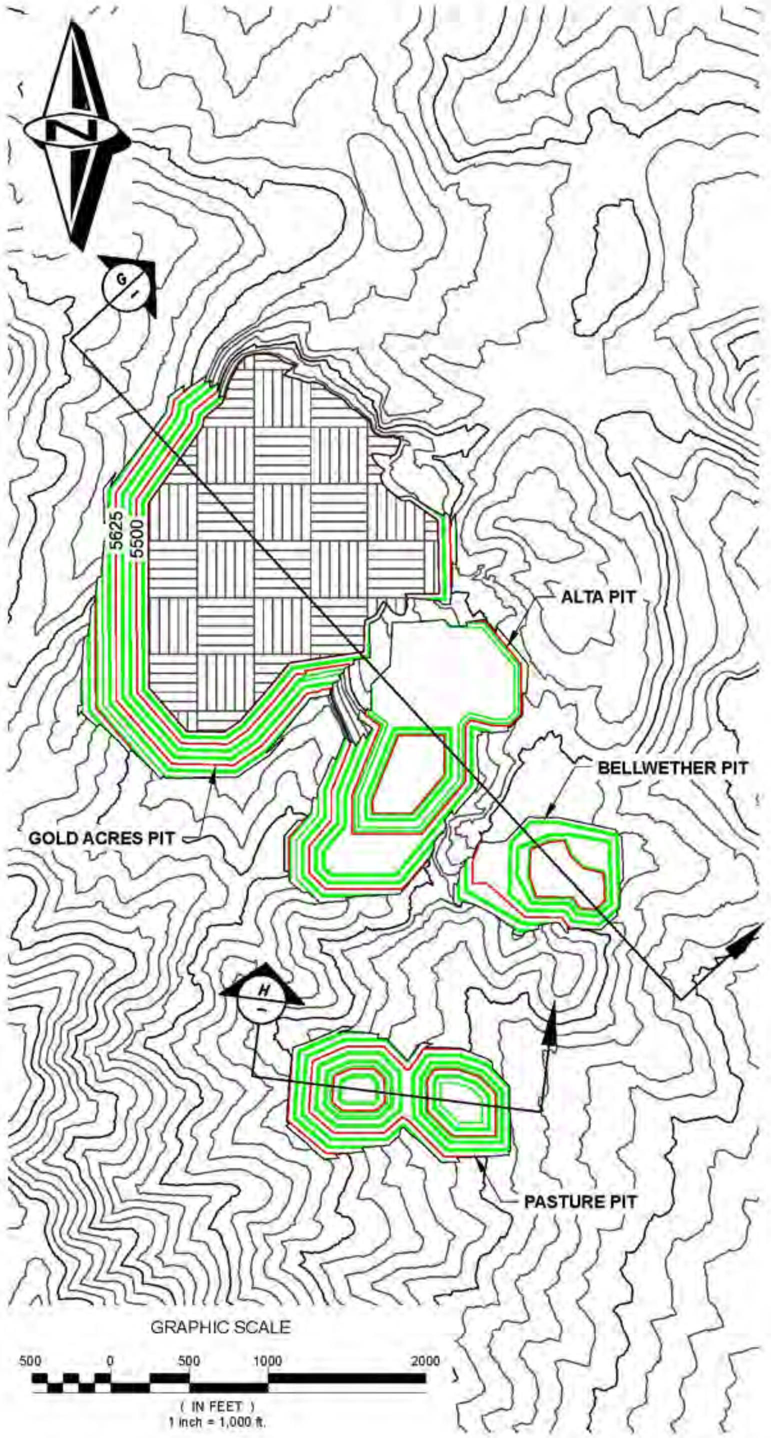
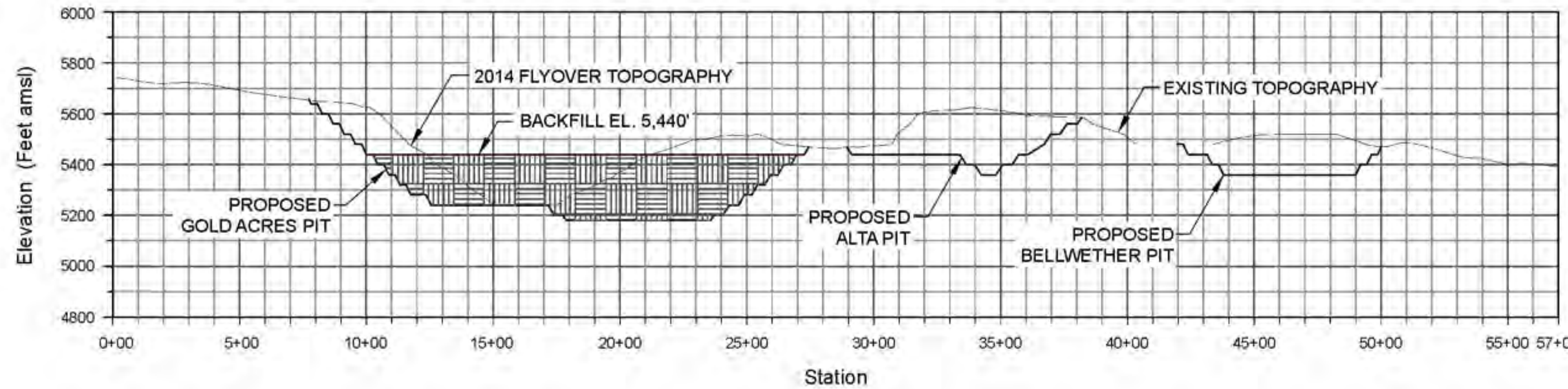



Figure 2-11

Gold Acres Pit
Partial Backfill Alternative -
Mine Complexes

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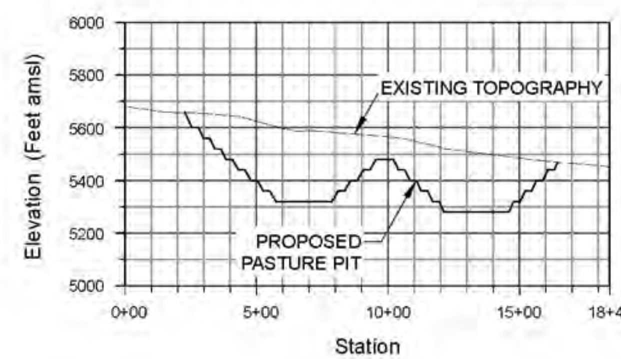


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BATTLE MOUNTAIN DISTRICT OFFICE
Mount Lewis Field Office
50 Bastian Road
Battle Mountain, Nevada 89820



**Deep South Expansion Project EIS**

Figure 2-12

Gold Acres Pit Partial Backfill

## Table 2-2 Currently Authorized Disturbance and Proposed New Disturbance under the Gold Acres Pit Partial Backfill Alternative

| Mine Complex | Facility | No Action Alternative Total Authorized Disturbance by Facility (acres) | Gold Acres Pit Partial Backfill Alternative | | |
|---|---|---|---|---|---|
| | | | Proposed Total Disturbance by Facility (acres) | Proposed Reallocation of Use of Currently Authorized Disturbance (sum total acres) | Proposed New Surface Disturbance by Facility (acres) |
| Open Pits | | 2,752 | 3,411 | 474 | 185 |
| Underground Operations | | 0[1] | 0[1] | 0[1] | 0[1] |
| Waste Rock Facilities | | 5,393 | 5,597 | -121 | 325 |
| Heap Leach Facilities | | 1,933 | 2,049 | 116 | 0 |
| Tailings Impoundment | | 1,416 | 1,208 | -208 | 0 |
| Ancillary Support Facilities | | 4,111 | 4,696 | -336 | 921 |
| Water Management Facilities | | | | | |
| Water Management Facilities | | 704 | 3,057 | 10 | 2,343 |
| Exploration | | 391 | 391 | 0 | 0 |
| **Total Acres within CGM Operations Area[2]** | | **16,700** | **20,410** | **-64[3]** | **3,774** |
| **Proposed New Disturbance Outside CGM Operations Area[4]** | | | | | **534** |
| **Total Proposed New Disturbance** | | | | | **4,308** |

[1] Disturbance associated with surface infrastructure for underground mining is accounted for in other currently authorized or proposed disturbance footprints.

[2] Differences are due to rounding.

[3] Reflects reallocation of undisturbed land that previously was authorized for disturbance.

[4] Reflects surface disturbance associated with proposed RIBs and associated infrastructure northeast of the CGM Operations Area in Crescent Valley.

## Table 2-3 Surface Disturbance Associated with Past and Present Actions and RFFAs

| Action | Past and Present Approved Disturbance (acres) | RFFA Projected Disturbance (acres) | Total Approved/ Projected Disturbance (acres) |
|---|---|---|---|
| **Mining Projects** | | | |
| Black Rock Canyon Mine | 117 | 0 | 117 |
| Clipper Mine | 400 | 0 | 400 |
| BCI Buckhorn Mine | 820 | 0 | 820 |
| BCI CGM Operations Area | 16,700 | 0 | 16,700 |
| BCI Goldrush Project[1] | 0 | ***1,102*** | ***1,102*** |
| BCI Horse Canyon Mine | ***425*** | 0 | ***425*** |
| BCI Mill Canyon | 18 | 0 | 18 |

## Table 2-3 Surface Disturbance Associated with Past and Present Actions and RFFAs

| Action | Past and Present Approved Disturbance (acres) | RFFA Projected Disturbance (acres) | Total Approved/ Projected Disturbance (acres) |
|---|---|---|---|
| Cortez Silver Mining District[2] | 92 | 0 | 92 |
| Elder Creek Mine | 143 | 0 | 143 |
| Fire Creek Mine | 285 | 5 | 290 |
| Fox Mine | 4 | 0 | 4 |
| Greystone Mine | 242 | 0 | 242 |
| Grey Eagle Project | 5 | 0 | 5 |
| Hot Springs Sulfur Mine | 5 | 0 | 5 |
| May Mine | 1 | 0 | 1 |
| Mud Spring Gulch | 10 | 0 | 10 |
| South Silicified Project | 31 | 0 | 31 |
| Utah Mine and Camp | 6 | 0 | 6 |
| Other Mining Projects[3] | 97 | 210 | 307 |
| **Subtotal** | **19,*401*** | **1,*317*** | **20,*718*** |
| **Exploration** | | | |
| Notices BLM-Battle Mountain District Office: 118 expired, 8 pending, and 30 authorized[4] | 265 | 0 | 265 |
| Plans (7) BLM-Battle Mountain District Office[4] | 306 | 0 | 306 |
| Notices (10) BLM-Ely Field Office[4] | 50 | 0 | 50 |
| BCI HC/CUEP[5] | 549 | 0 | 549 |
| BCI West Pine Valley | 150 | 0 | 150 |
| BCI Hilltop Exploration/Mine | 92 | 0 | 92 |
| BCI Pipeline/South Pipeline/Gold Acres Exploration Project | 50 | 0 | 50 |
| BCI Robertson Project | 12 | 0 | 12 |
| BCI Robertson Exploration Project[6] | 294 | 0 | 294 |
| Dean Mine | 67 | 0 | 67 |
| Mud Springs | 0 | 10 | 10 |
| Mill Canyon Exploration | 250 | 0 | 250 |
| South Roberts | 0 | 3 | 3 |
| Toiyabe Project | 40 | 0 | 40 |
| Uhalde Lease | 100 | 0 | 100 |
| Other Mining Exploration[7] | 32 | 1,564 | 1,596 |
| **Subtotal** | **2,257** | **1,577** | **3,834** |

## Table 2-3 Surface Disturbance Associated with Past and Present Actions and RFFAs

| Action | Past and Present Approved Disturbance (acres) | RFFA Projected Disturbance (acres) | Total Approved/ Projected Disturbance (acres) |
|---|---|---|---|
| **Utilities/Community** | | | |
| State Route 306 and Roads in Northern Crescent Valley (100 feet wide) | 422 | 0 | 422 |
| Gravel Roads in Crescent Valley and Northern Carico Lake Valley (50 feet wide) | 1,558 | 0 | 1,558 |
| Dirt Roads in Crescent Valley and Northern Carico Lake Valley (30 feet wide) | 776 | 0 | 776 |
| Power lines in Crescent Valley (60 feet wide) | 364 | 0 | 364 |
| Wells Rural Electric Cooperative power line for potential future Goldrush Project | 0 | ***150*** | ***150*** |
| BCI Fiber Optic Cable (20 feet wide)[8] | 53 | 0 | 53 |
| BCI Jeremy's Knob Communications Tower and Right-of-Way (ROW)[9] | 0.5 | 0 | 0.5 |
| Towns of Crescent Valley and Beowawe[10] | 900 | 0 | 900 |
| Other ROWs (Roads, Mining) | 27 | 161 | 188 |
| Other Utilities (Electric, Communications, Federal Aviation Administration) | 1,176 | 2 | 1,178 |
| **Subtotal** | **5,276** | ***314*** | **5,*590*** |
| **Other Development and Actions** | | | |
| BLM Fuels Reduction Projects[11] | 5,641 | 900 | 6,541 |
| Wildfires[12] | 351,220 | 0 | 351,220 |
| Recreation[13] | 0 | 0 | 0 |
| Livestock[14] | 10 | 53 | 63 |
| Wildlife | 0 | 0 | 0 |
| Agriculture Development[15] | 9,750 | 0 | 9,750 |
| BCI Additional Irrigation Pivots at Dean Ranch[16] | 0 | 640 | 640 |
| Lodge at Pine Valley[17] | 30 | 0 | 30 |
| Crescent Valley Water Supply | 2 | 0 | 2 |
| BCI Cottonwood Infiltration Basins[16] | 104 | 0 | 104 |
| BCI Bank Enabling Agreement (BEA) Project Plans[18] | 0 | 46,929 | 46,929 |
| **Subtotal** | **366,757** | **48,522** | **415,279** |
| **Total** | **393,*691*** | **51,*730*** | **445,*421*** |

## Table 2-3 Surface Disturbance Associated with Past and Present Actions and RFFAs

**FOOTNOTES:**

[1] ***Disturbance acreage from BCI's Goldrush Mine Plan of Operations, Table 4-1 (BCI 2018); total disturbance of 1,724 acres less existing disturbance of 622 acres equals new disturbance of 1,102 acres. Existing disturbance is included in the disturbance for BCI's HC/CUEP and West Pine Valley exploration projects.***

[2] Historic mining- and exploration-related disturbance first began in 1862, prior to the promulgation of surface land management laws and regulations governing mining activities on public lands (e.g., Federal Land Policy and Management Act of 1976 and 40 CFR 3809). Since there were no laws or regulatory programs in place at that time, there were no regulatory or administrative approvals granted. Therefore, the identified disturbance acreage does not include all historic mining-related disturbance in the area.

[3] Includes gold and barium/barite mines.

[4] Plans and notices outside of the general Crescent Valley area have not been quantified.

[5] The approved plan provides for surface exploration activities and development of twin declines for underground exploration (BLM 2016b).

[6] BCI's Robertson Exploration Project boundary is located immediately north of, and partially within, the CGM Operations Area as shown in **Figure 2-13**.

[7] Includes projects by Barrick Cortez Exploration, Nu Legacy Gold, and 777 Minerals Inc.

[8] ROW runs from the Lodge at Pine Valley to the southeast boundary of the CGM Operations Area.

[9] BCI facility located in T28N, R47E, Section 18 SESE just north of the CGM Operations Area; ROW N-092170.

[10] Surface disturbance associated with the towns of Crescent Valley and Beowawe is assumed to be 640 and 160 acres, respectively, with approximately 100 acres of private developed land peripheral to the towns.

[11] Inclusive of acreage associated with the Crescent Valley Wildland Urban Interface Fire Defense System, Tonkin Hazardous Fuels Reduction Project, and Red Hills Hazardous Fuels Reduction Project. Of the total acreage, planned prescribed burns would affect up to 2,537 acres of pinyon-juniper woodland, and 800 acres of pinyon-juniper woodland would be thinned. Also includes future treatment of 900 acres of encroaching pinyon-juniper woodland for enhancement of greater sage-grouse habitat in the approved HC/CUEP Plan of Operation (BLM 2016a,b).

[12] Reflects acreage of vegetation affected by wildland fires from 1998 through 2017 within the vegetation cumulative effects study area (CESA). The acreage is inclusive of approximately 19,681 acres of fire-affected pinyon-juniper woodland.

[13] Surface disturbance associated with recreation activities has occurred; however, the acreages have not been quantified.

[14] Existing livestock-related surface disturbance is associated with water developments. The surface disturbance associated with the livestock RFFAs is based on 0.5 acre per water development activity and 43 acres for fencing and cattle guards. The 4,313 acres previously identified for RFFA activities (BLM 2015a) inadvertently included acreage of surface occupancy. Livestock-related activities outside of the Carico Lake Allotment have not been quantified.

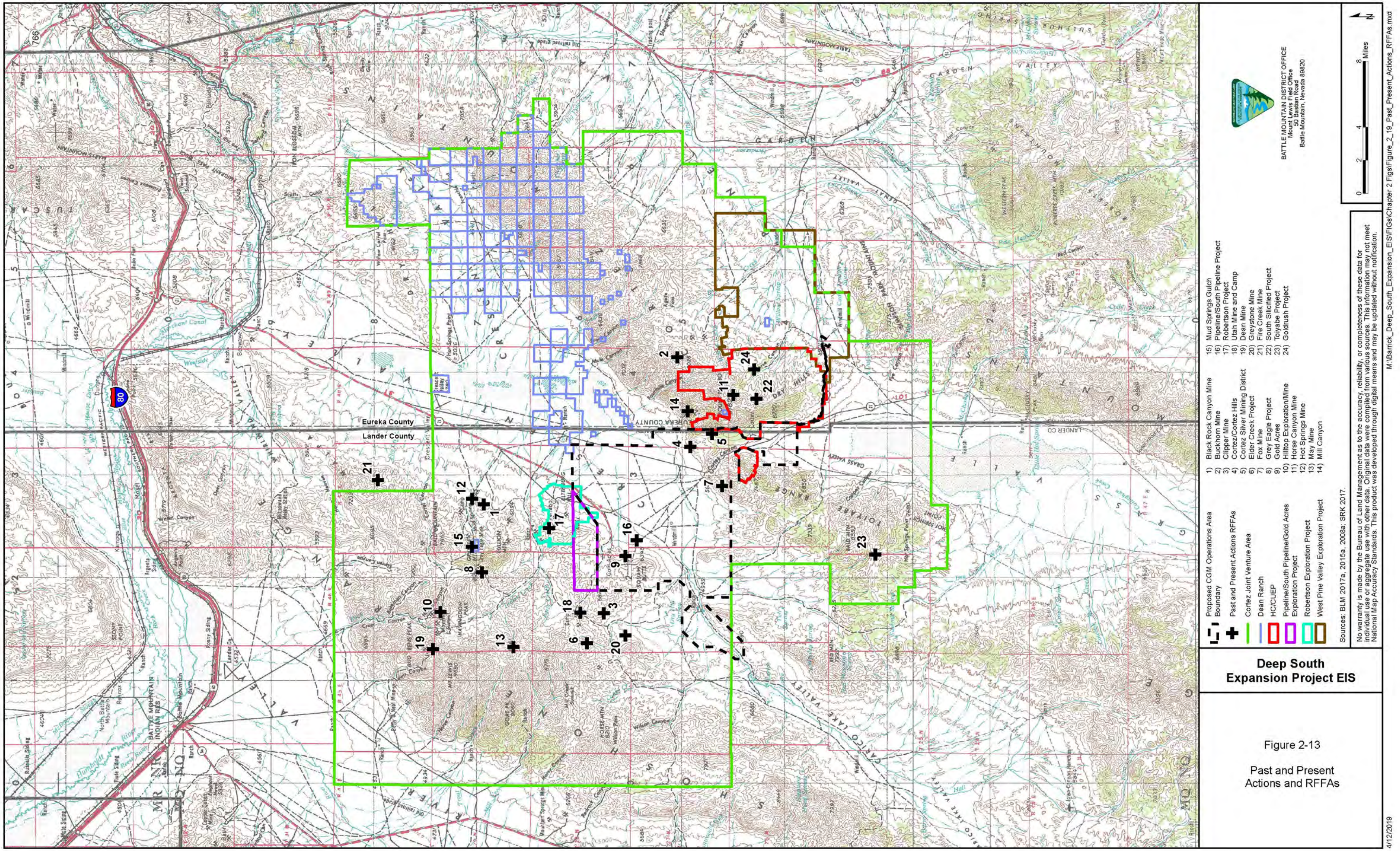
[15] Surface disturbance associated with agricultural development is based on the acreage under irrigation and assumes that a change in vegetation and habitat equates to surface disturbance. Acreage values were based on a February 15, 1998, special hydrographic abstract for Hydrographic Basin No. 054 from the Nevada Division of Water Resources. These values are based on permitted or authorized use of water and may not reflect actual use in a given year.

[16] Surface disturbance located on private (Barrick-owned) land outside of the CGM Operations Area.

[17] This facility is located on the JD Ranch Road approximately 4 miles west of State Route 278 at the BCI-owned JD Ranch.

[18] Includes 37,006 acres for the BEA Public Lands Project Plan and 9,929 acres for the BEA Private Lands Project Plan. Conservation actions that would be implemented to restore and enhance greater sage-grouse habitat would include tree removal, seeding and planting, establishment of fuel breaks, and improving wet meadows (Barrick 2018).

Source: ***BCI 2018;*** BLM 2017a,b, 2015a, 2008a; ESRI World Imagery 2017; U.S. Census Bureau 2017.




Deep South Expansion Project EIS

Figure 2-13

Past and Present Actions and RFFAs

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# 3.0 Geology and Minerals

## 3.1 Affected Environment

The project study area for direct and indirect impacts to geology and minerals encompasses the area within the CGM Operations Area boundary and proposed disturbance outside of the boundary. The CESA encompasses the project study area and includes surface disturbance associated with past and present actions and RFFAs within a 30-mile radius of the proposed project.

### 3.1.1 Physiographic and Topographic Setting

The project study area is located within the Great Basin section of the Basin and Range physiographic province characterized by a series of generally north-trending mountain ranges separated by broad alluvial filled basins. The mountain ranges in the Basin and Range province are bounded by steep range-front faults where vertical movement on these faults has uplifted the mountain blocks relative to the valleys. Faulting associated with development of the Basin and Range province began approximately 14 million years ago and continues to the present (McCormack and Hays 1996). Continual erosion off the uplifted mountain blocks has resulted in thick accumulations of unconsolidated to poorly consolidated sediments in the valley (or basin) areas.

The physiographic features in the project study area and CESA are shown in **Figure 3-1**. The proposed project encompasses portions of southern Crescent Valley, northern Carico Lake Valley, northern Grass Valley, and western Pine Valley. The project study area is flanked by the Cortez Mountains to the east and Shoshone Range to the west. Elevations range from 7,480 feet above mean sea level (amsl) at the summit of Mount Tenabo, located just east of the project study area, to approximately 4,700 feet amsl in Crescent Valley. Consistent with the Basin and Range province of central Nevada, Crescent, Carico Lake, Grass, and Pine valleys are elongate north-northeast trending basins with broad gently sloping valley floors bounded by high mountain ranges that locally extend up to approximately 10,000 feet amsl.

Overall, Crescent Valley is approximately 45 miles long and 20 miles wide and is bordered on the west by the Shoshone Range, on the east by the Cortez Mountains, and on the north by the Humboldt River. Carico Lake Valley is approximately 43 miles long and as much as 15 miles wide and is bounded on the west by the Shoshone Range and on the east by the Toiyabe Range. Grass Valley is a closed topographic basin approximately 40 miles long and 18 miles wide bounded on the west and north by the Toiyabe Range and on the east by the Simpson Park Mountains. Pine Valley is approximately 55 miles long and up to 30 miles wide and is bounded on the west by the Cortez Mountains, on the south by the Simpson and Roberts mountains, on the east by the Sulphur Springs and Pinon ranges, and on the north by the Humboldt River.

### 3.1.2 Regional Geologic Setting

The regional geologic conditions and description of the mapped units are presented in **Figures 3-2** and **3-3**, respectively. Paleozoic sedimentary rocks form the regional basement throughout the study area and have undergone a complex history of sedimentation and deformation. During the early Paleozoic Era, marine clastic and carbonate rocks were deposited in a shallow sea that represented the western continental margin of North America. These marine clastic rocks (referred to as the Western Assemblage) were deposited in the deep water to the west, while carbonate rocks (referred to as the Eastern Assemblage) were deposited in the shallow water to the east (Stewart 1980). The formations associated with the Western Assemblage are predominantly siliceous with very little carbonate, while formations associated with the Eastern Assemblage are predominately carbonate (Gilluly and Masursky 1965).

During the Late Devonian and Early Mississippian geologic periods, sedimentary deposition was interrupted, and the Paleozoic sediments were uplifted, folded, and faulted during a tectonic period referred to as the Antler Orogeny. The Roberts Mountains Thrust, a system of low angle thrust faults that has caused major deformation of the Paleozoic rocks, is the main expression of the Antler Orogeny apparent in the region today. Movement along the Roberts Mountains Thrust resulted in the displacement of the Western Assemblage up to approximately 90 miles eastward over the Eastern Assemblage (Roberts et al. 1967; Stewart 1980). As a result, the Western Assemblage occurs in the upper plate of the thrust, while the Eastern Assemblage occurs in the lower plate of the thrust (Gilluly and Masursky 1965).

The Eastern Assemblage is believed to occur as basement rocks beneath the alluvium in Crescent Valley (Geomega Inc. [Geomega] 2006) and underlies all other stratigraphic units in eastern and central Nevada. In the project vicinity, the Eastern Assemblage is exposed in the Cortez and Gold Acres windows shown in **Figure 3-4**. These “windows” refer to areas where uplift and erosion has removed the upper plate (Western Assemblage) exposing the lower plate (Eastern Assemblage) rocks. The Cortez window is a 2- to 3-mile-wide, north-south trending zone that extends from the margin of Crescent Valley near the Cortez Complex, south through the Cortez Hills Complex, and into the upper Grass Valley area (**Figure 3-4**). The Cortez window appears to be a continuation of the Gold Acres window located to the northwest. The Gold Acres window occurs in the Shoshone Range, is buried beneath the alluvial fill in Crescent Valley, and presumably is offset by the Crescent fault near the Cortez Complex (Gilluly and Masursky 1965; McCormack and Hays 1996).

Several intrusive bodies outcrop in the southern Cortez Mountains and northern Toiyabe Range within the project vicinity (**Figure 3-4**) (Geomega 2006; Gilluly and Masursky 1965). Aeromagnetic studies indicate that intrusives underlie most of the Cortez Mountains; however, except for local exposures, the intrusions generally are not exposed at the surface (Geomega 2006; Muffler 1964).

In the northern Toiyabe Range, the basement rocks are covered by up to 8,000 feet of Tertiary-age, rhyolitic and dacitic ash flows and volcanic debris that is known as the Caetano Tuff (**Figure 3-4**). The Caetano Tuff accumulated in a deep rift (Geomega 2006; Stewart and McKee 1977) and contains minor interbeds of water-laid tuff and pebble conglomerate derived from the nearby Paleozoic rocks (Gilluly and Masursky 1965). Tertiary basalt and andesite flows occur at the eastern end of the Toiyabe Range and east of the proposed project in the Cortez Mountains, where the basalt flows are up to 200 feet thick.

During the late Tertiary and Quaternary periods, continual uplift and erosion of the mountains have partially filled the basins with unconsolidated to poorly consolidated silt, sand, gravel, and boulders. The boundary between the mountains and the valley margins generally is covered by coalescing alluvial fan deposits, whereas the centers of the valleys are dominated by finer grained alluvium deposited by ephemeral streams and in playas (Stewart 1980; Stewart and McKee 1977). Alluvial sediments filling Crescent Valley are estimated to be up to approximately 10,000 feet thick (Gilluly and Masursky 1965). The estimated combined thickness of the Cenozoic volcanic rocks and basin fill deposits are approximately 15,000 feet for both Crescent and Pine Valleys, 9,000 feet for Grass Valley, and 6,000 feet for Carico Lake Valley (Heilweil and Brooks 2011).

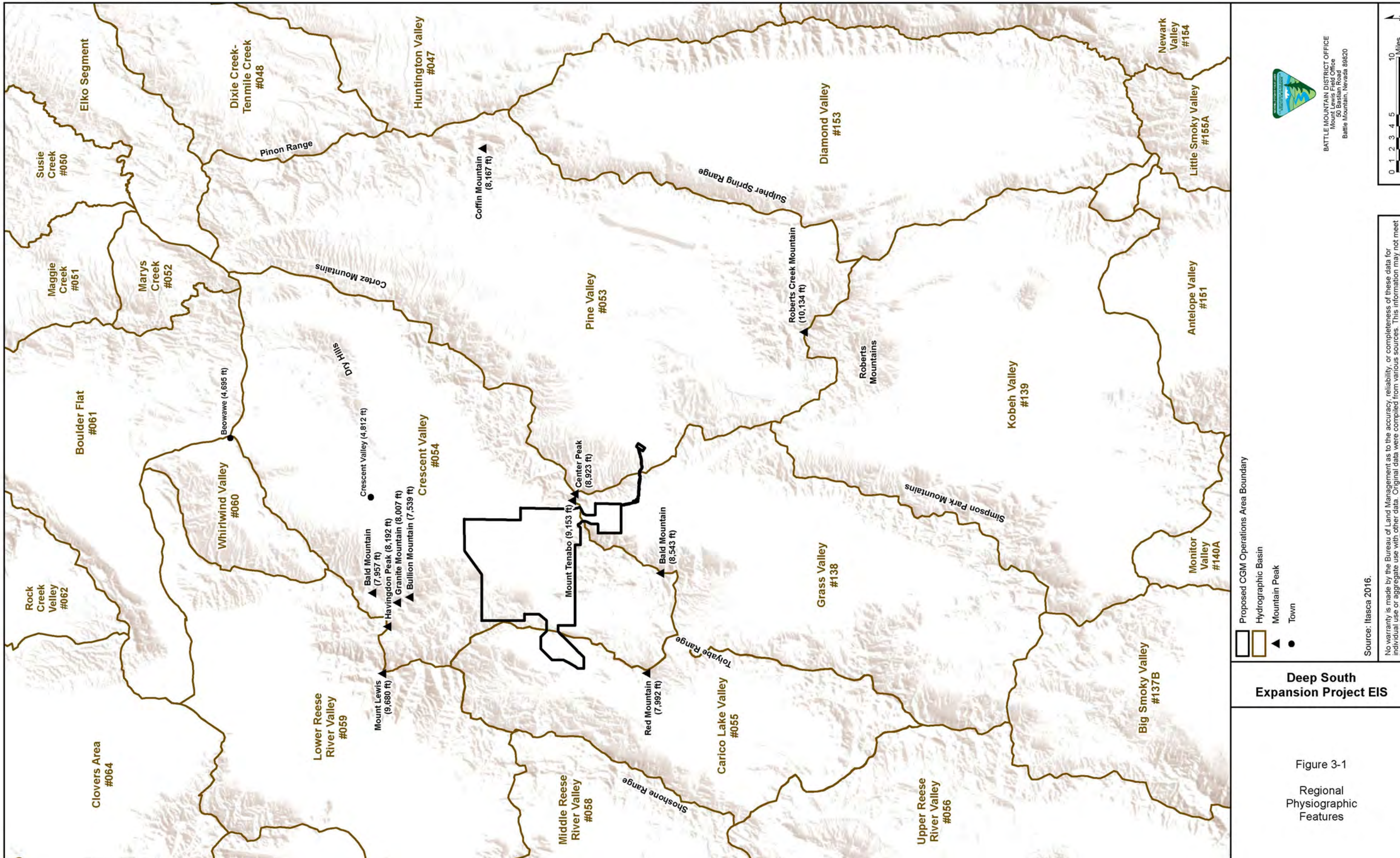
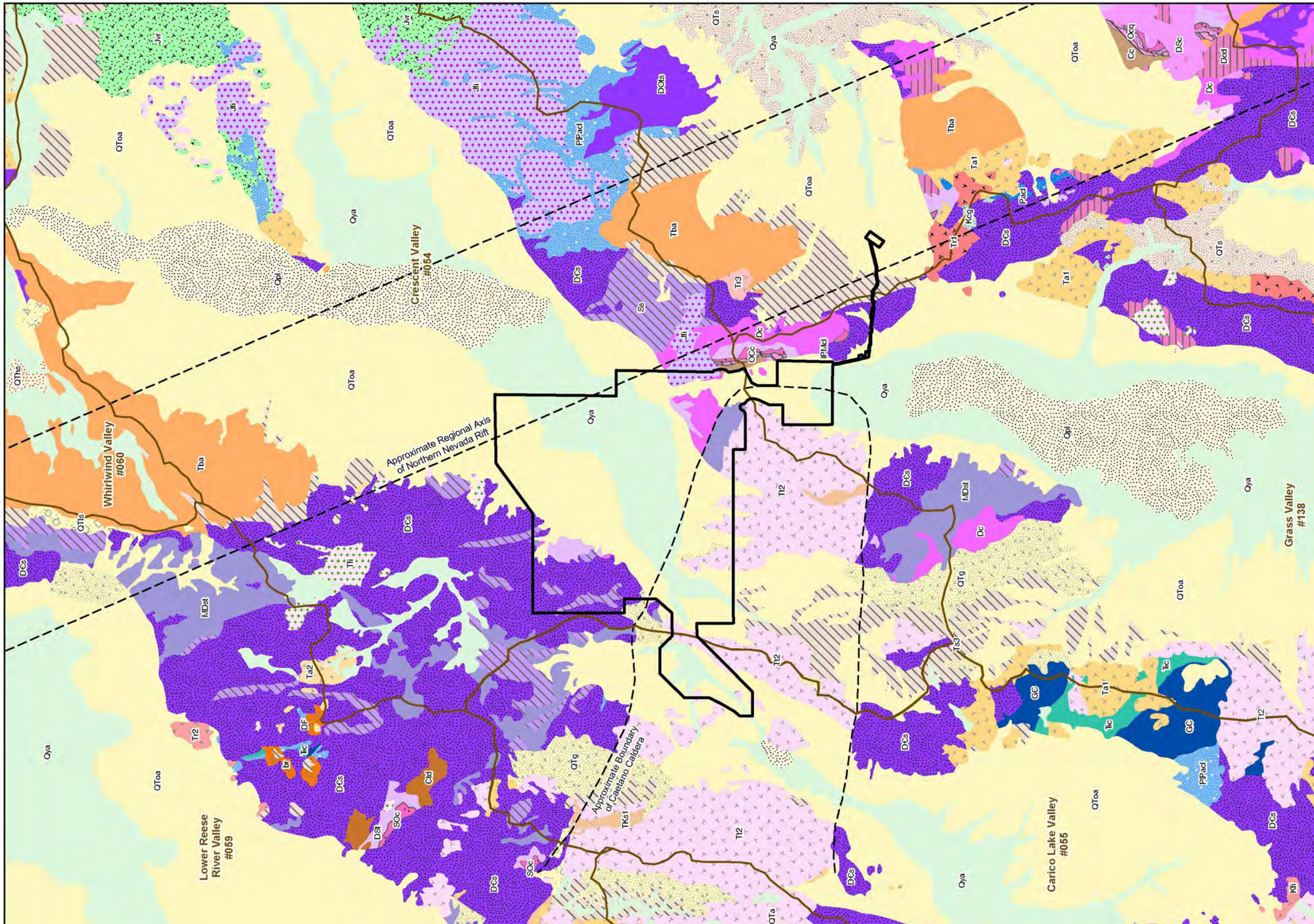



Figure 3-1

Regional Physiographic Features




Proposed CGM Operations Area Boundary

Hydrographic Basin

**Note:** See **Figure 3.1-3** for legend and description of geology layers.

Source: Itasca 2016.

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Figure 3-2

Regional Geology

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| Symbol | Geologic Age | Units | Description |
|---|---|---|---|
| Qya | Quaternary | Younger alluvium | Younger alluvium of valley floors and lower slopes of mountain ranges |
| Qpl | Quaternary | Playa deposits | Playa, lake bed, and flood plain deposits, mostly silt and clay |
| QThs | Holocene to Pliocene | Hot spring travertine, sinter, and tufa | Calcareous and siliceous sinter and tufa deposits |
| QTls | Holocene to Pliocene | Undifferentiated colluvium and talus | Landslide deposits, colluvium, and talus |
| QTg | Pleistocene and Pliocene | Gravels | Older gravels |
| QToa | Pleistocene and Pliocene | Older alluvium | Older alluvium and alluvial fan deposits |
| QTs | Holocene to Pliocene | Sedimentary deposits undivided | Tuffaceous limestone, siltstone, sandstone, and conglomerate |
| QTa | Holocene to Pliocene | Andesite flows and breccias | Andesite flows and breccias |
| Tba | Miocene and Oligocene | Andesite and basalt flows undivided | Andesite and basalt flows |
| Ts3 | Pliocene and Miocene | Tuffaceous sedimentary rocks undivided | Younger tuffaceous sedimentary rocks |
| Tr3 | Miocene | Volcanic rocks undivided | Younger rhyolitic flows and shallow intrusive rocks |
| Ta2 | Lower Miocene and Oligocene | Andesite and intermediate flows and breccias | Andesite flows and breccias and other related rocks of intermediate composition |
| Tt2 | Lower Miocene and Oligocene | Volcanic rocks undivided | Intermediate silicic ash flow tuff |
| Tr2 | Lower Miocene and Oligocene | Volcanic rocks undivided | Intermediate rhyolitic flows and shallow intrusive rocks |
| TKs1 | Lower Oligocene to upper Cretaceous | Sheep Pass Formation | Conglomerate, lacustrine, and tuffaceous sedimentary rocks |
| Ta1 | Lower Oligocene to middle Eocene | Volcanic rocks undivided | Older andesite and intermediate flows and breccias |
| Tr1 | Lower Oligocene to middle Eocene | Volcanic rocks undivided | Older rhyolitic flows and shallow intrusive rocks |
| Tfi | Miocene to Eocene | Felsic phaneritic intrusive rocks | Felsic phaneritic intrusive rocks |
| Kfi | Cretaceous | Felsic phaneritic intrusive rocks | Granodiorite, granite, and related rocks |
| Jfi | Jurassic | Intrusive rocks undivided | Older felsic phaneritic intrusive rocks |
| Jvr | Upper Jurassic | Volcanic rocks undivided | Rhyolite flows, tuffs, and volcaniclastic rocks |
| Kcg | Cretaceous | Newark Canyon Formation | Siltstone, shale, conglomerate, and limestone |
| TRc | Carnian to Spathian | Sedimentary rocks undivided | Limestone, dolomite, shale, sandstone, and conglomerate |
| Dc | Upper and middle Devonian | Sedimentary rocks undivided | Limestone and minor dolomite |
| Dcd | Middle and lower Devinian | Nevada Formation | Dolomite, sandstone, and limestone |
| DSc | Lower Devanian and Silurian | Lone Mountain Dolomite | Dolomite |
| SOc | Lower Silurian to middle Ordovician | Hanson Creek Formation | Dolomite, limestone, and shale |
| Ocq | Middle ordovician | Eureka Quartzite | Quartzite |
| OꞒc | Middle Ordovician to upper Cambrian | Pogonip Group | Limestone, dolomite, and quartzite |
| Ꞓc | Cambrian | Hamburg Dolomite and undifferentiated limestone and dolomite | Dolomite, limestone, and shale |
| GC | Permian to upper Devonian | Golconda Terrane | Basinal, volcanogenic, terrigenous clastic, and minor carbonate rocks |
| Pacl | Permian | Garden Valley Formation | Sandstone, siltstone, limestone, conglomerate, and carbonaceous limestone |
| PIPacl | Permian to middle Pennsylvanian | Brock Canyon Formation | Conglomerate, sandstone, siltstone, and limestone |
| IPMcl | Middle Pennsylvanian to lower Mississippian | Diamond Peak and Chainman Formations | Shale, siltstone, sandstone, and conglomerate |
| DF | Upper Devonian | Dutch Flat Terrane | Feldspathic sandstone, shale, and turbiditic limestone |
| MDst | Lower Mississippian and Devonian | Slaven Chert | Shale, graywacke, siltstone, chert, conglomerate, and limestone |
| DSt | Lower Devonian to Silurian | Roberts Mountains Formation | Platy limestone, dolomite, and chert |
| DOts | Devonian to Ordovician | Vinini Formation | Calcareous shale, siltstone, chert, quartzite, and greenstone |
| DꞒs | Devonian to upper Cambrian | Valmy Formation | Shale, chert, quartzite, greenstone, and limestone |
| Ss | Silurian | Elder Sandstone | Feldspathic sandstone, siltstone, shale, and chert |
| Ꞓtd | Cambrian | Crane Canyon sequence in Toiyabe Range, Dunderburg Shale | Phyllite, schist, shale, thin-bedded limestone, chert, and siltstone |
| br | Tertiary to Jurassic | Mixed breccias | Mixed breccias including volcanic, thrust, jasperoid, and landslide megabreccia |

Figure 3-3

Regional Geologic Map Units

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Source: Crafford 2007; Itasca 2016.

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### 3.1.3 Regional Structures

Several major faults and fault zones occur within the project region as shown in **Figure 3-4**. These include the Roberts Mountains Thrust fault, Cortez fault, and Crescent Valley fault.

The Roberts Mountains Thrust fault is a major regional low-angle fault zone, as discussed above. In the project vicinity, the thrust fault zone is exposed at the surface at the head of Cortez Canyon. The fault zone dips gently toward the southwest throughout the area. The Cortez fault bounds the western margin of the Cortez Mountains and eastern margin of Grass Valley. The Cortez fault is part of the Cortez rift, a system of north to northwest–trending faults that extends from central Oregon into southern Nevada. The Cortez rift is characterized by right-lateral movement that occurred prior to 8 million years ago. The Cortez fault was reactivated during basin and range faulting during the late Tertiary. This fault has experienced an estimated 15,000 feet of horizontal (right-lateral) displacement and 3,800 feet of vertical displacement (McCormack and Hays 1996).

The Crescent fault is located along the eastern margin of Crescent Valley and truncates the northwest boundary of the Cortez Mountains and Toiyabe Range in the project vicinity. The Crescent fault is a steeply dipping normal fault with predominant vertical offset typical of range-front faults of the Basin and Range province. Vertical displacement along the Crescent fault is estimated be on the order of 10,000 feet (Gilluly and Masursky 1965). Other Basin and Range faults in the region include a buried fault located along the western margin of Crescent Valley (and bounding the east flank of the Shoshone Range), and an unnamed range-front fault that bounds the western margin of Grass Valley at the foot of the Toiyabe Range. Block fault movement along the Crescent, Cortez, and other unnamed range-front faults formed during extensional faulting that began in the region during the late Tertiary period (approximately 14 million years ago) and continues to the present (McCormack and Hays 1996).

### 3.1.4 Site Geology

The geology of the CGM Operations Area is shown in the geologic map and cross-sections provided in **Figures 3-4** and **3-5**, respectively. A generalized stratigraphic column of the mapped geologic units in the project area is presented in **Figure 3-6**.

#### 3.1.4.1 Gold Acres Complex

The Gold Acres Complex occurs within the Gold Acres Window and is situated along west margin of Crescent Valley and eastern flank of the Shoshone Range. Historically, the majority of the ore mined in the Gold Acres Complex has occurred in the western edge of the window within the Roberts Mountains Formation. Specifically, in brecciated chert and limestone that occurs within an imbrecated thust zone situated immediately below the Roberts Mountains Thrust (U.S. Geological Survey [USGS] 2017).

#### 3.1.4.2 Pipeline Complex

At the Pipeline Complex, the generalized geology of the Pipeline Pit Complex consists of carbonaceous siltstones that are part of the Roberts Mountains Formation that are overlain by basin fill sediments. The thickness of the basin fill sediments in the pit complex ranges from approximately 30 feet to over 700 feet. The alluvial/bedrock contact dips gradually towards the east at less than 10 degrees. The ore is hosted in the sheared and altered siltstone (USGS 2017).

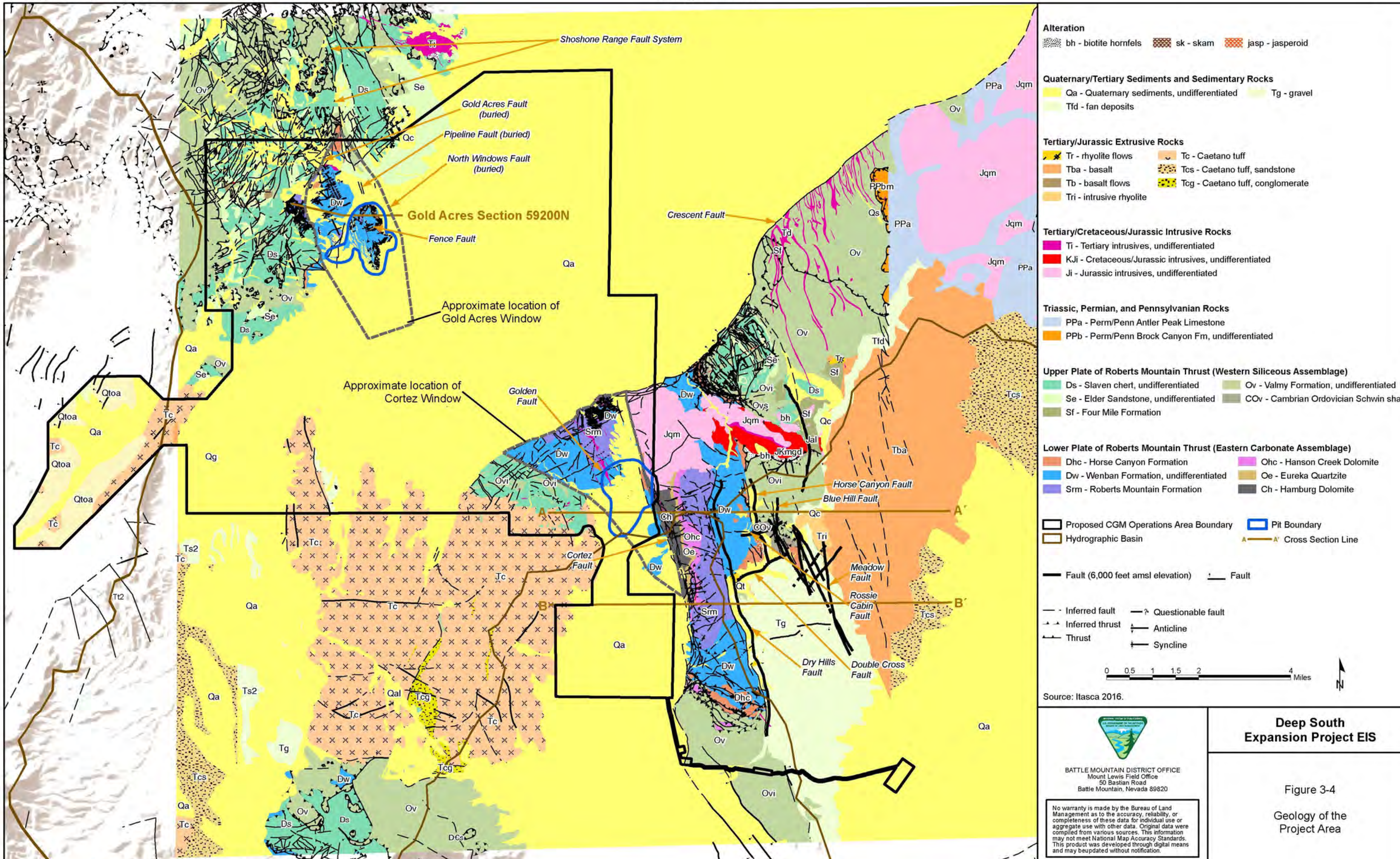
Alteration
bh - biotite hornfels
sk - skarn
jasp - jasperoid
Quaternary/Tertiary Sediments and Sedimentary Rocks
Qa - Quaternary sediments, undifferentiated
Tg - gravel
Tfd - fan deposits
Tertiary/Jurassic Extrusive Rocks
Tr - rhyolite flows
Tc - Caetano tuff
Tba - basalt
Tcs - Caetano tuff, sandstone
Tb - basalt flows
Tcg - Caetano tuff, conglomerate
Tri - intrusive rhyolite
Tertiary/Cretaceous/Jurassic Intrusive Rocks
Ti - Tertiary intrusives, undifferentiated
KJi - Cretaceous/Jurassic intrusives, undifferentiated
Ji - Jurassic intrusives, undifferentiated
Triassic, Permian, and Pennsylvanian Rocks
PPa - Perm/Penn Antler Peak Limestone
PPb - Perm/Penn Brock Canyon Fm, undifferentiated
Upper Plate of Roberts Mountain Thrust (Western Siliceous Assemblage)
Ds - Slaven chert, undifferentiated
Ov - Valmy Formation, undifferentiated
Se - Elder Sandstone, undifferentiated
COv - Cambrian Ordovician Schwin shale
Sf - Four Mile Formation
Lower Plate of Roberts Mountain Thrust (Eastern Carbonate Assemblage)
Dhc - Horse Canyon Formation
Ohc - Hanson Creek Dolomite
Dw - Wenban Formation, undifferentiated
Oe - Eureka Quartzite
Srm - Roberts Mountain Formation
Ch - Hamburg Dolomite
Proposed CGM Operations Area Boundary
Pit Boundary
Hydrographic Basin
Cross Section Line
Fault (6,000 feet amsl elevation)
Fault
Inferred fault
Questionable fault
Inferred thrust
Anticline
Thrust
Syncline
0 0.5 1 1.5 2 4 Miles
N
Source: Itasca 2016.
Shoshone Range Fault System
Gold Acres Fault (buried)
Pipeline Fault (buried)
North Windows Fault (buried)
Gold Acres Section 59200N
Fence Fault
Approximate location of Gold Acres Window
Approximate location of Cortez Window
Golden Fault
Cortez Fault
Crescent Fault
Horse Canyon Fault
Blue Hill Fault
Meadow Fault
Rossie Cabin Fault
Dry Hills Fault
Double Cross Fault
A
A'
B
B'
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Figure 3-4
Geology of the Project Area

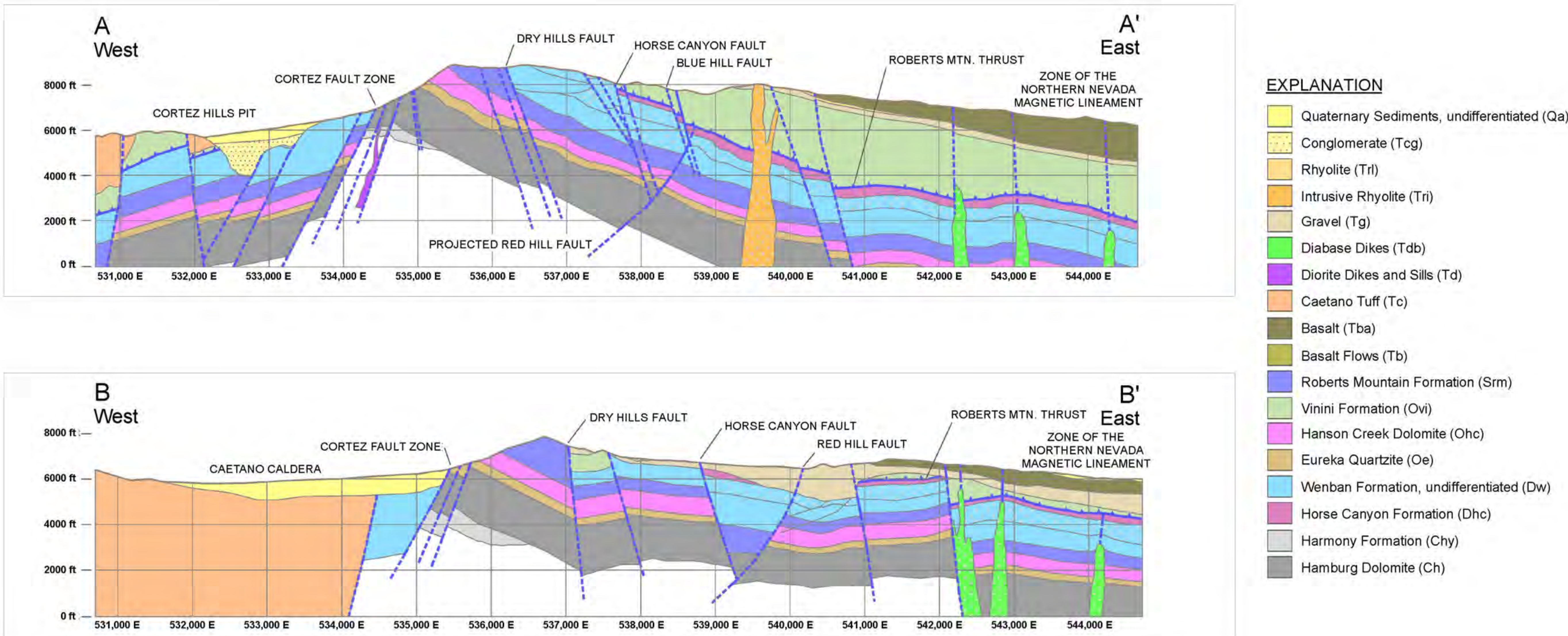


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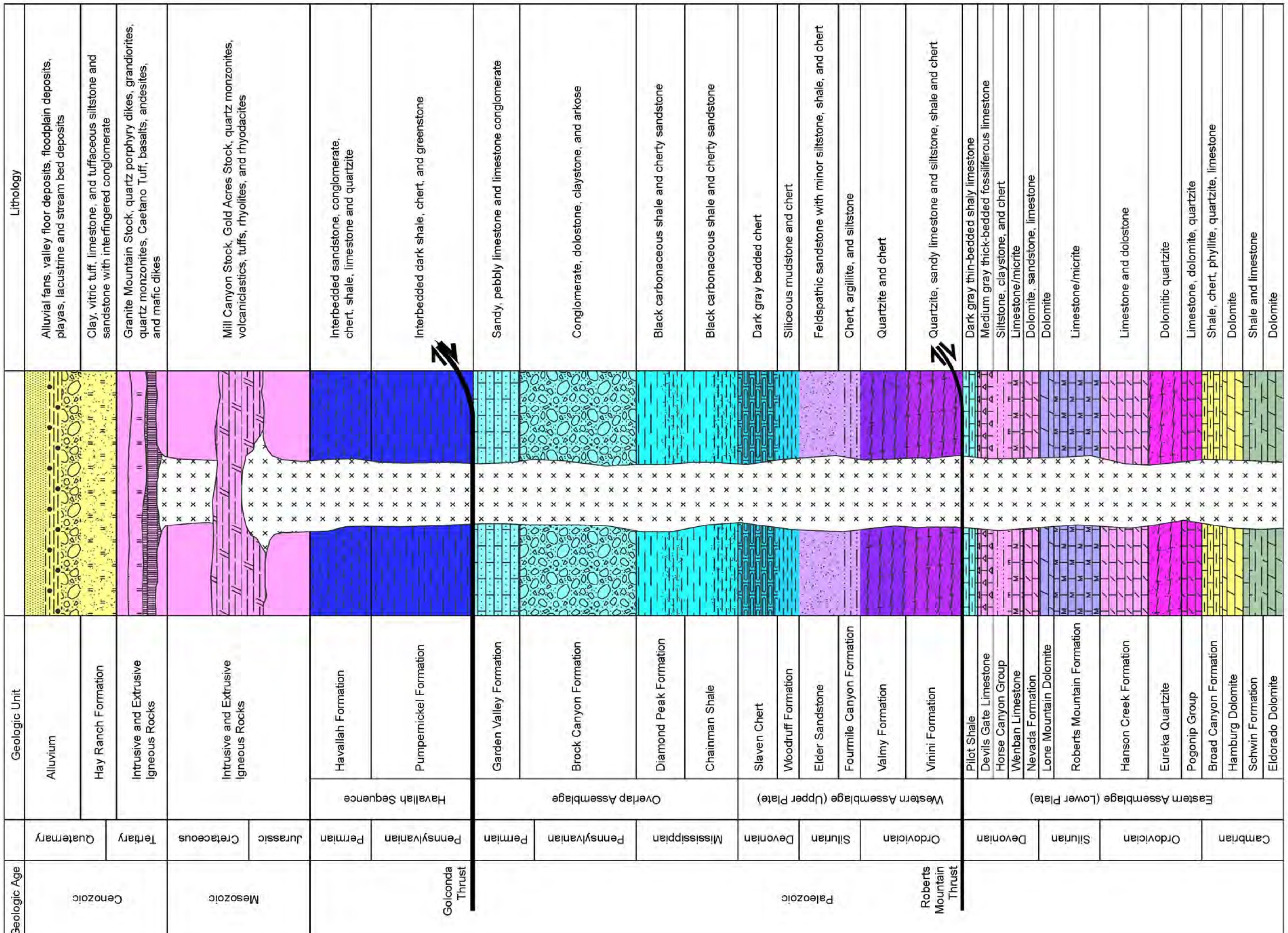
Figure 3-5

Geologic Cross-sections through Cortez Hills and Western Pine Valley

**Note:** See **Figure 3.1-4** for cross-section locations.

Source: Itasca 2016.

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Source: Itasca 2016.

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Figure 3-6

Generalized Stratigraphic Column

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#### 3.1.4.3 Cortez and Cortez Hills Complexes

The Cortez and Cortez Hills complexes occur in a feature known as the Cortez window where the upper plate rocks (Western Assemblage) have been removed, and the lower plate (Eastern Assemblage) rocks are exposed or concealed beneath surficial deposits. In the vicinity of the Cortez Pit, the gold ore occurs where limestone was faulted, brecciated, and folded along the margin of a Tertiary intrusive (USGS 2017).

The Cortez Hills Pit encompasses two separate deposits, including the Cortez Hills deposit hosted in Paleozoic lower plate limestones and the Pediment deposit hosted in Tertiary conglomerate. The Cortez Hills deposit occurs in the northern portion of the pit within the lower plate sequence and includes (from oldest to youngest) the Hamburg Dolomite, Eureka Quartzite, Hanson Creek Formation, Roberts Mountains Formation, Wenban Limestone, and Pilot Shale. The Paleozoic rocks are mantled by Tertiary and Quaternary alluvial and colluvial sediments.

The Pediment deposit occurs in the southern portion of the Cortez Hills Pit. The Pediment deposit is hosted in a thick wedge of Tertiary conglomerate. The conglomerate ranges up to 1,000 feet thick and overlies the Wenban Limestone and other Paleozoic basement rocks in the Cortez window. The Tertiary conglomerate can be subdivided into two subunits differentiated by clast composition: a lower siltstone unit and an upper limestone unit. The siltstone conglomerate consists of heterolithic clasts, whereas the limestone subunit is monolithic. BCI geologists believe that these conglomerates formed by mass wasting of material exposed in the adjacent Cortez Mountains in the Mount Tenabo area. The core recovered from exploration borings in the study area indicates that both subunits of the conglomerate generally are cemented and relatively unfractured (Geomega 2006). The eastern edge of the conglomerate unit is bounded by thermally altered limestone and/or marble, which gradually transitions into unaltered lower plate carbonate rocks (primarily Wenban Limestone) (Geomega 2006). The conglomerate generally is covered by unmineralized alluvial fan and colluvial sediments that range from 10 to greater than 150 feet thick.

### 3.1.5 Mineralization and Mineral Resources

Historically, the Crescent Valley area has been a producer of gold, silver, barite, sulfur, turquoise, and lesser amounts of copper, lead, and arsenic. Valley alluvium has been mined intermittently as a source of gravel for road construction. Most of the mineral production has come from gold and barite mining operations.

The study area occurs within an area that has experienced extensive mineral exploration and development activities over the past 156 years. The earliest mining dates back to 1862 with the discovery of high-grade silver in the Cortez and Mill Canyon areas. Open-pit mining began at the Gold Acres Complex in 1950, at the Cortez Complex in 1969, at the Pipeline Complex in 1996, and at the Cortez Hills Complex in 2008. Gold mineralization in the four mining complexes is described in the previous section. Additional information on the mineralization is summarized below.

The ore deposit at the Gold Acres Complex is characterized as a sediment-hosted, disseminated gold deposit that occurs on the east flank of the Shoshone Range. The ore occurs in the Roberts Mountains Formation within a window of the Roberts Mountains thrust fault. The host rock consists of an intensely sheared, fault-bounded zone of silicified carbonaceous rock with disseminated pyrite surrounded by skarn. Minor gold mineralization also occurs in the skarn and in chert, greenstone, sandstone, and shale sequence of the Devonian Slaven Formation to Ordovician Valmy Formation that occur in the upper plate of the

Roberts Mountains Thrust. Gold occurs as disseminated submicron native gold. The gold is associated with pyrite, molybdenite, scheelite, sphalerite, galena and pyrrhotite (USGS 2017).

As described by Foo et al. (1996), the geology in the Pipeline Pit Complex consists of Quaternary alluvium overlying Paleozoic bedrock. The Quaternary alluvium consists of unconsolidated mixtures of sand, silt, gravel, and cobbles. The alluvium-bedrock surface dips gently (less than 10 degrees) toward the east. Ore within the deposit primarily is hosted within silty carbonates associated with the Roberts Mountains Formation and Wenban Limestone. Gold occurs as submicroscopic disseminated grains within all alteration types. Sphalerite and pyrite are the only sulfide minerals identified in the deposit and occur as fine disseminations (less than 2 percent) along bedding planes and fractures and open-space fillings.

In the Cortez Pit, gold mineralization occurs primarily within the Roberts Mountains Formation. The mineralization is structurally controlled and concentrated along fault intersections, particularly where north northwest trending high-angle faults intersect with low-angle tabular shear zones (McCormack and Hays 1996). Quartz and pyrite are common minerals in the ore zone. Gold is associated with arsenic, antimony, mercury, barium, and silver (BLM 1994).

The Cortez Hills deposit structurally is controlled and characterized by consistent gold grades. Gold deposition generally occurs at structural intersections, and the mineralized zone plunges in a west southwest direction. The ore is hosted within silty limestone and in brecciated, marble altered limestone. Sulfide minerals that occur in the deposit are most commonly rhombohedral pyrite (iron sulfide) grains and include less frequent occurrences of local realgar (arsenic sulfide) veinlets plus finely disseminated pyrite (iron sulfide). A deeper refractory gold horizon occurs at depth below the base of the Cortez Hills Pit and has been intersected by underground mine operations. These refractory horizons apparently are controlled by low-angle structures in the upper section of the Roberts Mountains Formation. Within the Pediment deposit (located in the southern portion of the Cortez Hills Pit), gold occurs in altered and oxidized rock fragments within a siltstone conglomerate. The siltstone rock fragments in the Pediment deposit apparently were derived from erosion and mass wasting of the Roberts Mountains Formation located in the Cortez Mountains, immediately east of the project.

Geothermal resources occur within the CESA as described in the Deep South Expansion Project Supplemental Ennvironmental Report – Water Resources and Geochemistry (BLM 2019a). The potential for oil and gas reserves in the CESA is low (Garside et al. 1988). Based on BLM Battle Mountain District drilling records, fewer than 30 test wells have been drilled within the area, the majority of which have occurred in the Pine Valley area.

## 3.1.6 Faulting and Seismicity

### 3.1.6.1 Faulting

The study area is located in a region that is characterized by active and potentially active faults and a relatively high level of historic seismicity. For the purpose of this assessment, an active fault is defined as a fault that shows evidence of displacement during the Holocene period (last 10,000 years); a potentially active fault is a fault that shows evidence of surface displacement during the late Quaternary period (last 150,000 years). Surface fault rupture typically occurs along active fault traces.

Historically, surface displacement along faults occurred in Nevada during major earthquakes in 1869, 1903, 1915, 1932, and three events in 1954 (Stewart 1980). All of these events occurred along a north trending zone called the Nevada Seismic Belt located west of the study area (**Figure 3-7**). The closest historic surface displacement to the study area was in 1915, located approximately 52 miles to the west of the study area along the west flank of the Tobin Range.

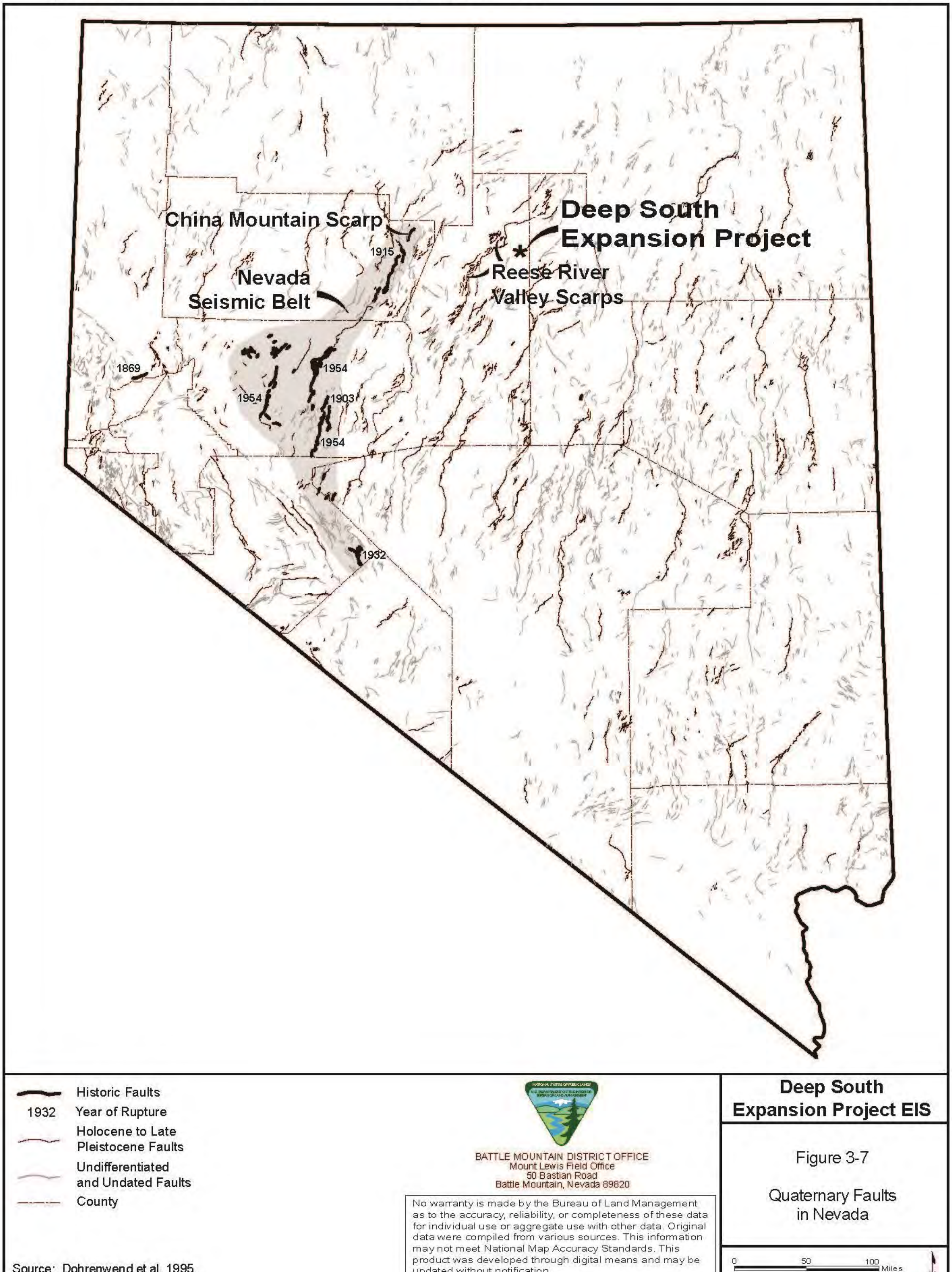


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Figure 3-7

Quaternary Faults
in Nevada

Several active and potentially active faults occur in the vicinity of the study area including: 1) the Crescent fault, located approximately 0.5 mile north of the CGM Operations Area; 2) the Cortez fault, that crosses near the eastern boundary of the CGM Operations Area; and 3) an unnamed, shorter, east-west fault located in the Toiyabe Range, approximately 2 miles southwest of the CGM Operations Area (**Figure 3-4**) (Dohrenwend and Moring 1991).

#### 3.1.6.2 Seismicity

The study area is located in a region that has experienced considerable seismic activity in historic time. A search of the USGS historical earthquake records up through June 1, 2018, identified 10 earthquake events greater than or equal to 4.0 Richter Magnitude have been recorded within a 62-mile (100-kilometer) radius of the project (USGS 2018). **Figure 3-8** shows approximate locations and estimated magnitudes of the recorded seismic events relative to the proposed Deep South Expansion Project. As shown in **Table 3-1**, the largest recorded earthquake to affect the region was a 6.8 Richter Magnitude event located approximately 50 miles west of the study area within the Nevada Seismic Belt. The closest recorded earthquake was an earthquake of magnitude 4.1 on March 18, 1974, approximately 5.8 miles south of the project.

**Table 3-1 Recorded Earthquakes with Richter Magnitude of 4.0 or Greater Within the Region[1]**

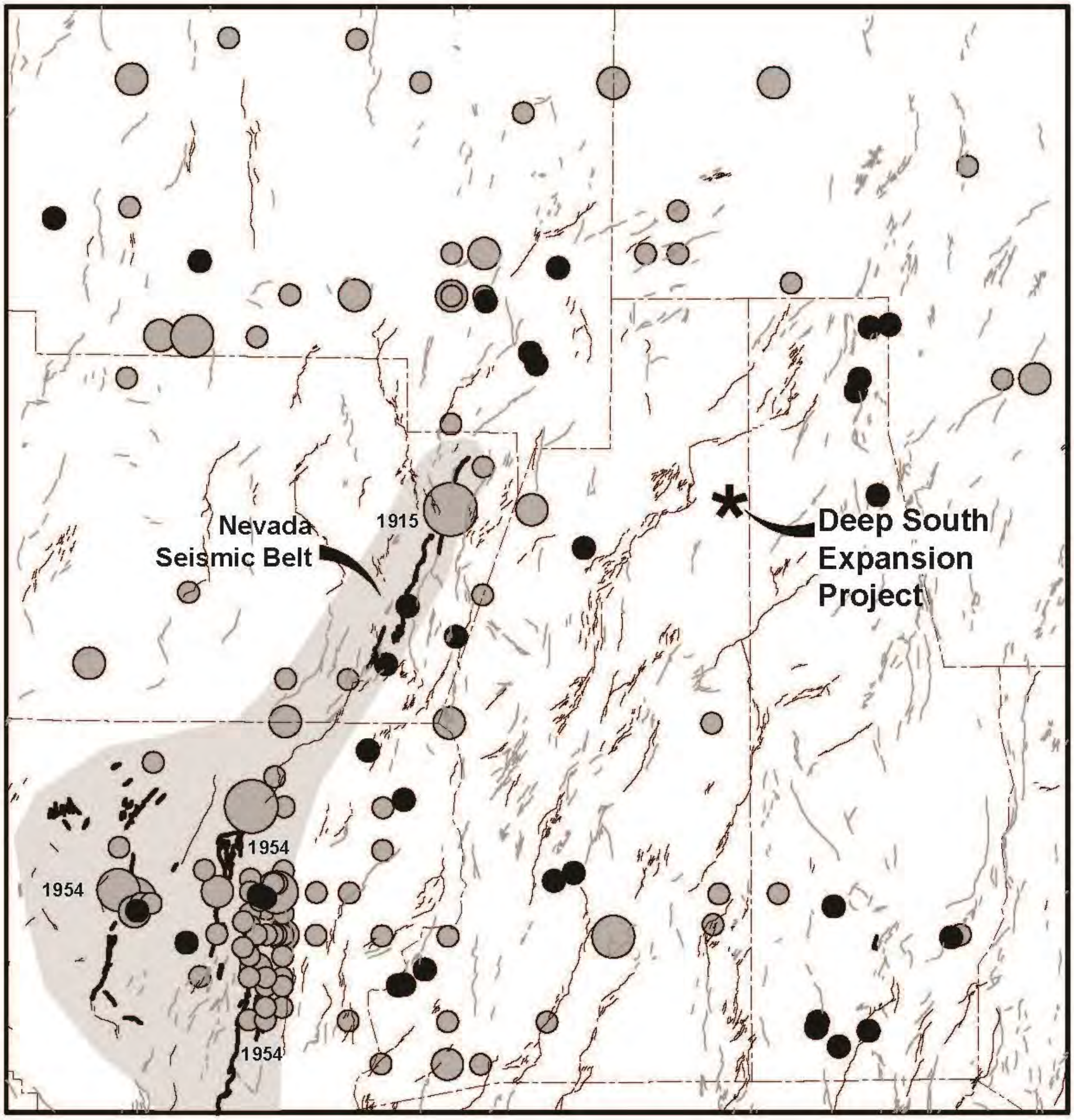
| Year | Month/Day | Location (latitude, longitude) | Approximate Distance from Project Site (miles) | Estimated Richter Magnitude |
|---|---|---|---|---|
| 1915 | 10/03 | 40.26, -177.65 | 50.3 | 6.8 |
| 1974 | 03/18 | 40.17, -116.70 | 5.8 | 4.3 |
| 1974 | 03/18 | 40.20, -116.58 | 8.1 | 4.1 |
| 1978 | 02/14 | 39.62, -117.13 | 48.8 | 4.4 |
| 1978 | 03/05 | 39.79, -117.63 | 57.4 | 4.3 |
| 1978 | 05/23 | 40.87, -117.26 | 50.9 | 4.1 |
| 1979 | 02/13 | 40.92, -116.16 | 59.9 | 4.1 |
| 1987 | 03/05 | 40.78, -116.25 | 43.7 | 4.1 |
| 1992 | 04/06 | 38.59, -117.13 | 50.5 | 4.1 |
| 1997 | 04/17 | 40.40, -116.18 | 29.9 | 4.3 |

[1] Includes earthquakes located within 62 miles (100 kilometers) of the project.

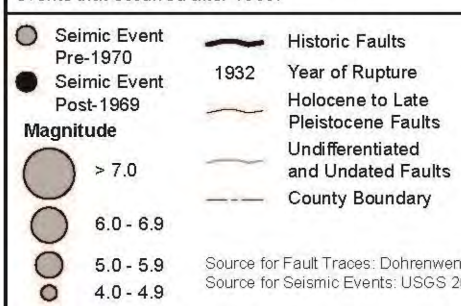
Source: USGS 2018.

### 3.1.7 Ground Subsidence and Earth Fissures

The lowering of groundwater levels associated with ongoing dewatering activities at the Pipeline Pit Complex has resulted in ground subsidence and development of earth fissures in Crescent Valley in the vicinity of the pit. In November 2002, BCI (formerly CGM) personnel discovered large erosional gullies in an area located approximately 1 mile south of the Pipeline Pit Complex that developed in response to a break of a water pipeline. The water pipeline delivered water from the existing pit dewatering system to the existing infiltration basins located south of the mine. The break resulted in a release of approximately 2 million gallons of water. Further evaluation of the erosional gullies indicated that the gullies were formed along earth




**Note:** Due to improvements in the seismic recording network, earthquake epicenters are more accurately located for events that occurred after 1969.




Source for Fault Traces: Dohrenwend et. al. 1995.
Source for Seismic Events: USGS 2018, 2017.

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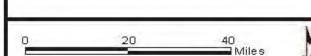
Figure 3-8

Seismic Events



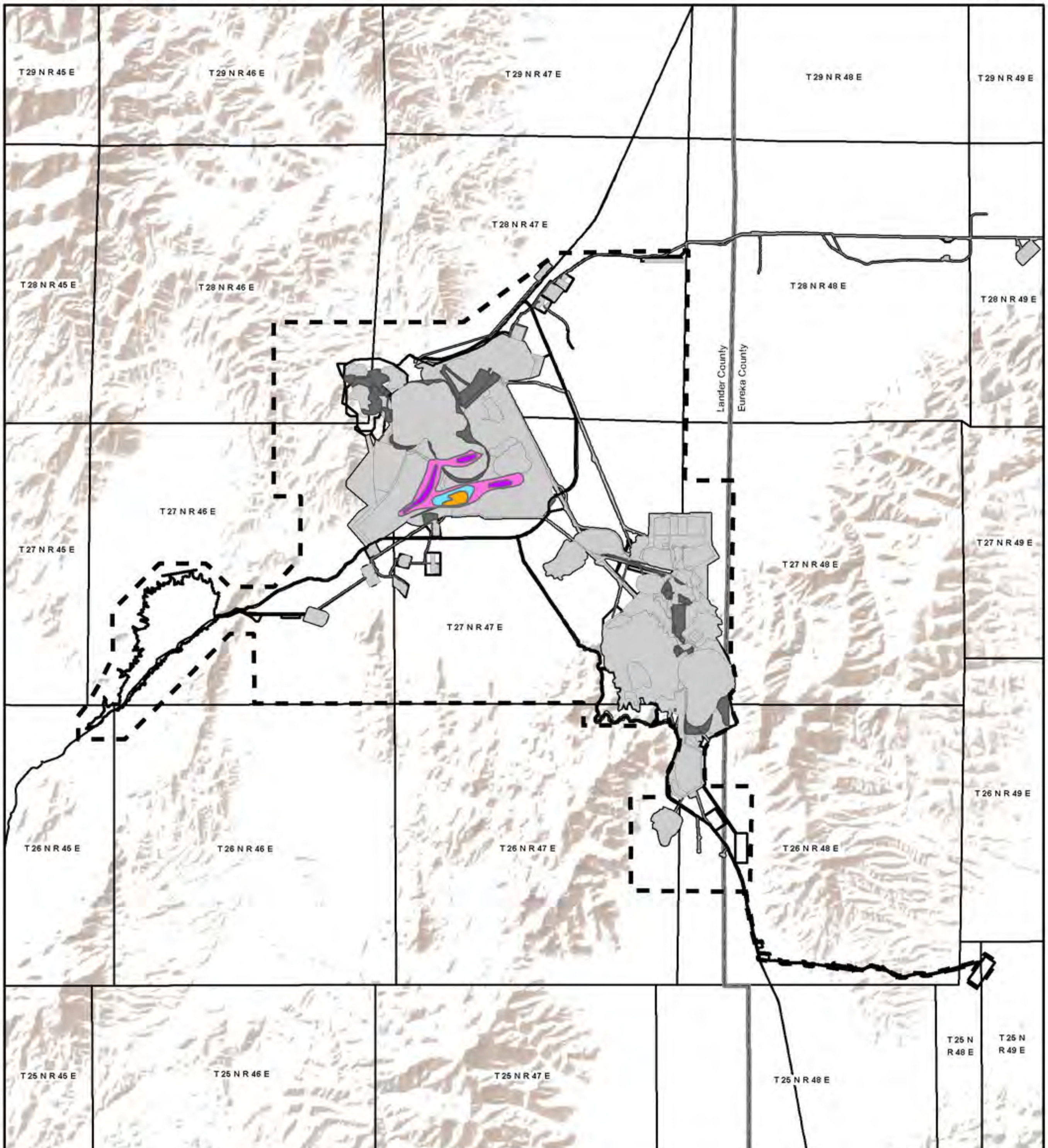
fissures that subsequently were eroded, forming the wider fissure-gullies (AMEC Earth & Environment, Inc. [AMEC] 2003). The fissures were barely discernible by direct observation due to their narrow (0.5-inch) apertures; some fissures were identified indirectly by subtle changes in vegetation and alignment of potholes. However, erosion due to the water release along the fissures resulted in the development of gullies up to 30 feet wide and 15 feet deep. The locations of the identified earth fissures are shown in **Figure 3-9**. The earth fissures are interpreted to have formed by horizontal strains associated with dewatering-induced ground subsidence (AMEC 2003).

In response to the fissures, BCI personnel backfilled the fissure gullies and protected the pipeline from further breaks. In addition, BCI sponsored a study to identify the cause of fissuring, evaluate subsidence in the vicinity of the pit and in southern Crescent Valley, and define areas of potential risk (AMEC 2005, 2003). The results of the study were used to develop a monitoring plan for ground subsidence and earth fissuring associated with mine dewatering and water management activities (CGM 2005). The monitoring plan was submitted to and approved by the BLM. The dewatering-induced subsidence management program is discussed in the Pipeline/South Pipeline Pit Expansion Project Final SEIS (BLM 2004); the major components are summarized in Section 2.3.3, Applicant-committed Environmental Protection Measures, of this report.

The results of the subsidence and earth fissure monitoring are provided in annual reports submitted to the BLM and NDEP (AMEC 2016). As of 2015, survey data are available for 41 monuments distributed across the southern portion of the Pipeline Complex and adjacent areas in southern Crescent Valley. Survey data have been collected at 32 of these monuments since the first quarter of 2004; the remaining nine monuments have been surveyed since the first quarter of 2013. The survey data indicate that most of the monuments have settled less than 1 foot since 2004. However, settlement in nine of the monuments has ranged from 1.0 to 4.2 feet since 2004. The largest settlement has been recorded in survey monuments located south and within 0.5 mile of the south margin of the Pipeline Pit Complex. The survey data also indicate that the majority of the recorded settlement occurred prior to 2010, with relatively minor settlement (typically less than 0.2 foot) between 2010 and 2015.

Quarterly ground inspections conducted since 2012 have identified localized areas of surficial features (i.e., shallow linear depressions, pot holes, an animal borrow, and a vegetation lineament) south of the Pipeline South Area Heap Leach Facility that may be surface expressions of earth fissures at depth. However, these features are not located close to or project under the heap leach facility, and the features have been observed to be relatively static since discovery (AMEC 2016).

A study of interferometric synthetic aperture radar (InSAR) data was conducted for Barrick Gold of North America Inc. to measure the extent and magnitude of land subsidence occurring in Crescent Valley due to mine dewatering at the CGM Operations Area, and evaluate for evidence of land subsidence in the southwestern Pine Valley area (Bell 2013). The InSAR study focused on evaluating subsidence for time periods between 2004 and 2013. For the 2004-2010 period, the InSAR data indicate that in the Pipeline Pit Complex area, the average annual rate of subsidence was generally consistent from year to year at approximately 2.5 inches per year, and the total maximum subsidence was approximately 1.25 feet. This was a period of active dewatering in which groundwater levels steadily declined approximately 350 feet. The aerial extent of the subsidence as defined by the 0.4-inch subsidence contour extends up to approximately 6 miles from the Pipeline Pit Complex in Crescent Valley and into the adjacent flanks of the Cortez Mountains and Toiyabe Range. The InSAR data evaluation did not detect any evidence of land subsidence in the southwest portion of the Pine Valley area for the 2004-2013 period (Bell 2013).




- Proposed CGM Operations Area Boundary
- Proposed New Facilities
- Existing Facilities
- Overlap of Existing and Proposed Facilities
- Visible Windmill Earth Fissure Field
- Region of known earth fissuring, including areas with significant probability of further east - west extension and aperture growth
- Region classification defined below where lineament and numerical analyses result in a higher coincidence level regarding fissure potential
- Region where alluvial basin morphology and past subsidence behavior indicate the presence of conditions favorable for future earth fissure development

Source: Adapted from AMEC 2003.

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Battle Mountain, Nevada 89820



**Deep South Expansion Project EIS**

Figure 3-9

Mapped Earth Fissures

0 1 2 3 4 Miles

The updated calibrated groundwater flow model developed for the project using the MODFLOW-SURFACT (SRK 2017b, 2016b) is summarized in the Deep South Expansion Project Supplemental Environmental Report – Water Resources and Geochemistry (BLM 2019a). Dewatering-induced ground subsidence was simulated using the Interbed-Storage package that was designed for use with MODFLOW (SRK 2017a). Water withdrawn from storage is released through both the expansion of water and compression of the sediments, resulting in a change in storage. The mechanics of subsidence and changes in storage properties in aquifer and aquitard materials are described in Poland (1984). Ground subsidence was simulated for unconsolidated and semi-consolidated basin fill deposits within the model domain.

The observed ground subsidence for the 1996 through 2010 period developed from InSAR data (Bell 2013) was used as calibration targets for the model simulations. A comparison of the observed land subsidence for the 1996 through 2010 period (Bell 2013) and model simulated land subsidence for the 1996 through 2010 period is presented on **Figure 3-10**. Although the observed and simulated subsidence contours are comparable from a regional context, there are differences in magnitude and extent. The differences are likely due in large part to the fact that the InSAR data used by Bell for the 1996 through 2010 period contained a 7-year gap (2000-2007) that resulted in an underestimation of the total subsidence over this period.

For the 1996 through 2010 period, the maximum simulated subsidence is 5.1 feet located 1 mile southeast of the Pipeline Pit Complex. This is the same approximate area where survey data indicate up to 4 feet of subsidence between 2004 and 2010. Overall, the magnitude of the modeled subsidence compares favorably with the measured settlement in the basin fill deposits in the southern part of Crescent Valley (SRK 2017a).

The model-simulated subsidence for the 1996 through 2015 period is shown on **Figure 3-11**. The overall pattern of land subsidence is similar to the 1996 through 2010 period; however, the size of the area encompassed within the 4-inch subsidence contour is 8.5 percent larger (SRK 2017a). The model simulations also predict that subsidence has expanded into northern Grass Valley, south of the Cortez Hills Mine area.

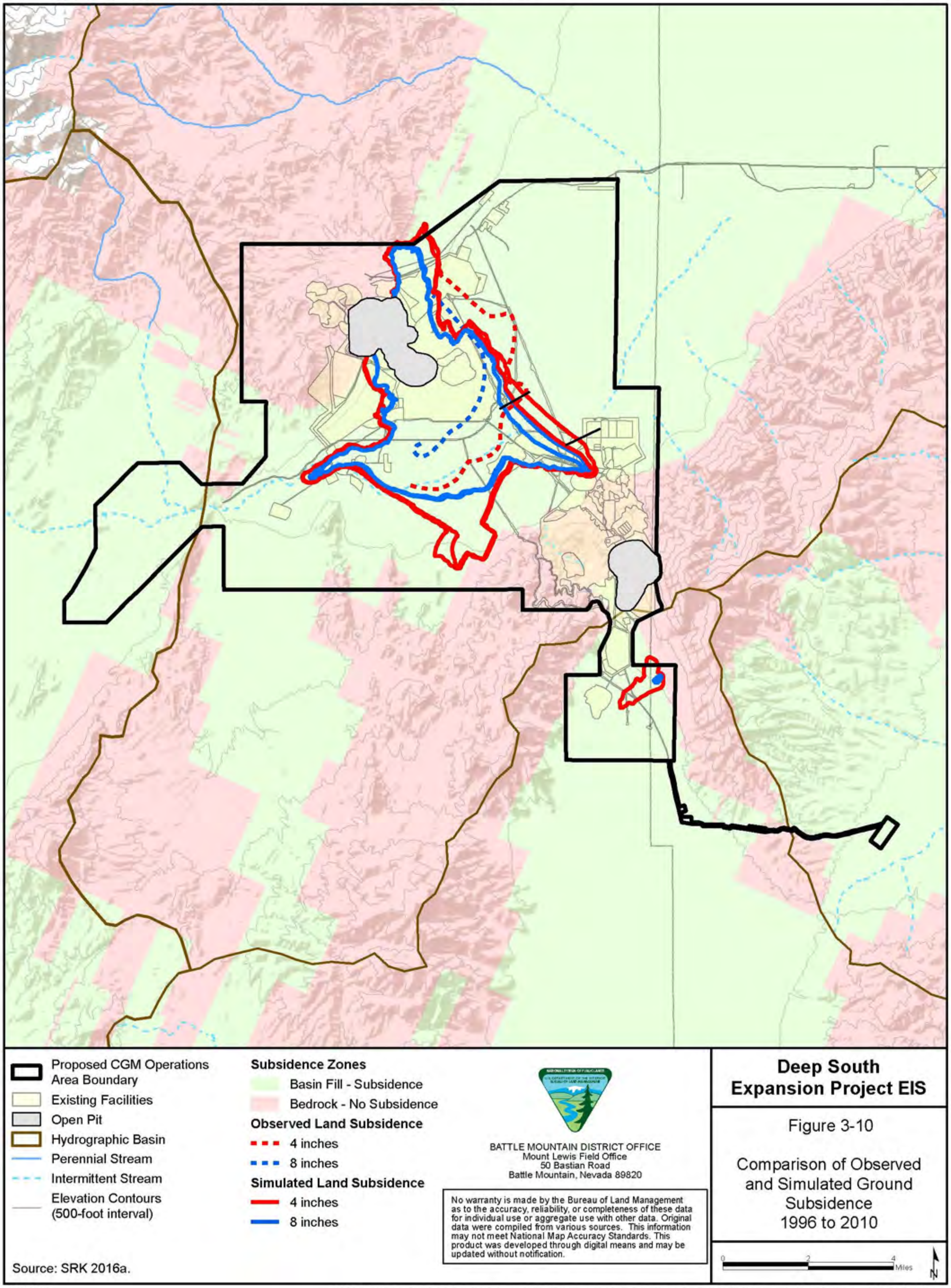
## 3.2 Environmental Consequences

Major issues related to geology and minerals include: 1) geologic hazards created or exacerbated by development of the proposed project; 2) damage to critical facilities caused by seismically induced ground shaking; 3) surface subsidence and ground deformation resulting from the lowering of the groundwater table or from underground mining; and 4) exclusion of future mineral resource availability caused by the placement of facility expansion areas (i.e., waste rock facilities).

Environmental impacts to geology and minerals would be significant if the Proposed Action or other action alternatives result in any of the following:

- Impact to a facility caused by geologic hazards, including landslides and catastrophic slope failures or ground subsidence.
- Structural damage or failure of a facility caused by seismic loading from earthquakes.
- Restriction of future extraction of known mineral resources.
- Alteration of the geologic terrain from a project facility resulting in a geologic hazard.

The impact analysis for geology and mineral resources uses the following qualifiers to describe potential impacts in terms of intensity, duration, and context.

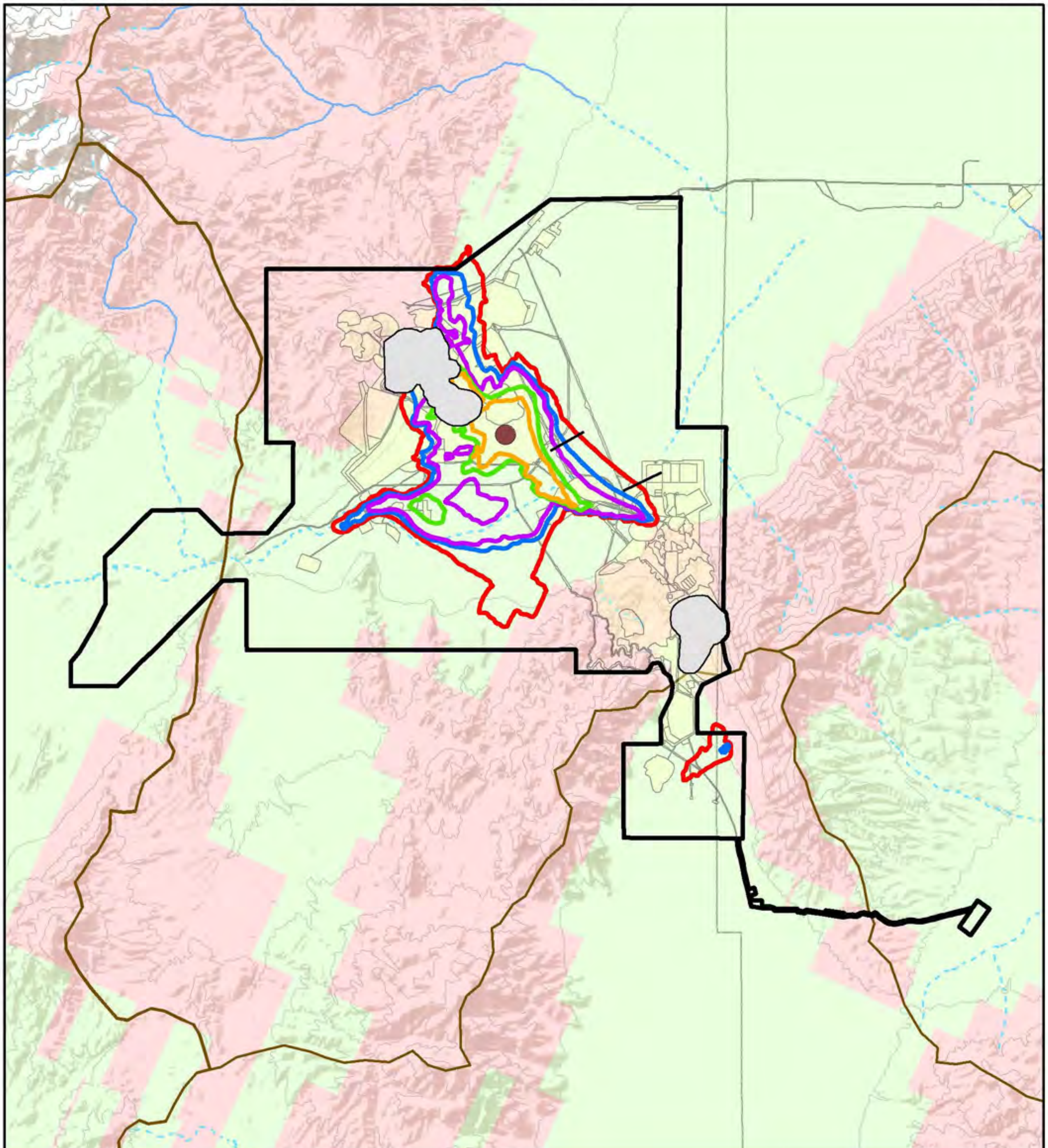



Source: SRK 2016a.

**Deep South Expansion Project EIS**

Figure 3-10

Comparison of Observed and Simulated Ground Subsidence 1996 to 2010



Proposed CGM Operations Area Boundary
Existing Facilities
Open Pit
Hydrographic Basin
Perennial Stream
Intermittent Stream
Elevation Contours (500-foot interval)

Source: SRK 2016a.

**Subsidence Zones**
Basin Fill - Subsidence
Bedrock - No Subsidence

**Simulated Land Subsidence**
4 inches
8 Inches
1 foot
2 feet
3 feet
Maximum Predicted Subsidence (5 feet)

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**Deep South Expansion Project EIS**

Figure 3-11

Simulated Ground Subsidence 1996 to 2015

0 2 4 Miles

Intensity

- Negligible: Effects to geologic or mineral resources would occur; however, they would be so slight as to not be measurable using normal methods.
- Minor: Effects to geologic or mineral resources would occur; however, they would be small and just measurable using normal methods.
- Moderate: Effects to geologic or mineral resources would occur and would be readily detectable.
- Major: Effects to geologic or mineral resources would occur and would be large, measurable, and easily recognized by a human observer.

Duration

- Short-term: Effects lasting up to the duration of construction, operations, and reclamation.
- Long-term: Effects extend after the life of the project and could be permanent.

Context

- Localized: Effects would be limited to the CGM Operations Area.
- Regional: Effects would extend beyond the CGM Operations Area.

### 3.2.1 Proposed Action

Direct impacts of the Proposed Action on geologic and mineral resources would include: 1) the mining of proven and probable ore reserves of approximately 88.5 million tons; 2) the generation and permanent disposal of approximately 442 million tons of waste rock, 59.5 million tons of spent heap leach material, and 16 million tons of tailings material; and 4) the permanent disposal of up to 1.9 million tpy of spent heap leach/tailings material from the processing of additional Arturo Mine oxide ore. These impacts would be moderate, long-term, and localized.

The project would result in the permanent alteration of the landscape on approximately 582 acres of proposed new disturbance. This would include expansion areas for open pits and waste rock facilities that permanently would alter the natural topographic and geomorphic features in the area. In addition, there would be a permanent alternation of the landscape and geomorphic features on a portion of the currently authorized ancillary and mill facility disturbance areas for which a reallocation of use is proposed for open pit and waste rock facility expansion, less proposed reallocation of a portion of the Pipeline Heap Leach/Tailings Facility to ancillary (sum total of approximately 324 acres). Impacts resulting in alteration of the landscape would be major, long-term, and localized. Other temporary facilities (e.g., power line corridors, growth media and ore stockpiles, RIBs, and Rocky Pass Reservoir) that would be reclaimed to pre-mining topography would not permanently alter the natural topography or geomorphic features in the area. Impacts to the topography associated with these temporary facilities would be minor to moderate, short-term, and localized.

#### 3.2.1.1 Geologic Hazards and Geotechnical Considerations

Geotechnical considerations include potential damage to process and storage facilities due to ground movement during both operation and post-closure periods. Potential ground movement includes slope instability under static and earthquake loads, and settlement and ground deformation of foundation materials resulting from groundwater-induced subsidence or settlement over underground mine workings.

Waste Rock Facilities

The Proposed Action includes proposed modifications or expansions of five out-of-pit waste rock facilities, modifications to the currently authorized backfill within a portion of the Pipeline Pit Complex, optional partial backfill of the Cortez Hills Pit, backfill of the northern portion of the Cortez Pit, and complete backfill of the Ada 52 Pit. The modified and expanded waste rock facilities would be engineered, constructed, and reclaimed in a manner similar to the currently authorized waste rock facilities. Slope configurations would be subject to change based on geotechnical review as discussed in the Barrick Cortez Inc. (NVN-067575 (16-1A)) Deep South Expansion Project Amendment to Plan of Operations and Reclamation Permit Application #0093 (BCI 2016).

Piteau Associates (Piteau) (2016b) conducted an assessment of the stability of the proposed expanded and/or modified out-of-pit and in-pit waste rock facilities. The stability analysis was performed on representative cross-sections selected based on the topography of the existing ground surface and reclaimed surface of the facility. The stability analysis used limit equilibrium methods that require input values for slope geometry (including lift height), soil shear strength, soil unit weight, and groundwater conditions. Estimates of soil shear strength and soil unit weight were derived from available information on the material properties of the waste rock and foundation materials compiled from the prior geotechnical evaluations completed for existing waste rock facilities. The analyses conservatively assumed that groundwater could recover to the original ground surface in the out-of-pit waste rock facilities. For the in-pit waste rock facilities, the analysis used the projected fully recovered groundwater elevations. A seismic stability (i.e., pseudostatic) analysis also was performed with an assumed seismic coefficient of 0.09 g, which is equivalent to 50 percent of the estimated design peak ground acceleration that would be generated by an operational basis earthquake (i.e., the earthquake for which the structure is designed to resist and remain operational).

The criteria used for the stability evaluations were based on industry standards for the minimum static and pseudostatic factors of safety for design of waste rock facilities (1.3 static and 1.0 pseudostatic). A factor of safety is used to provide a design margin to ensure that a slope is stable and will not experience critical failure due slumping or sliding. A computed factor of safety greater than or equal to 1.0 implies that the slope will be stable and is strong enough to support the assumed design loads. The results of the slope stability evaluation indicate adequate factors of safety for both static and pseudostatic (i.e., seismic) conditions for all of the analyzed waste rock facility sections where comprised of relatively good quality overburden or waste rock. In these areas, the analysis indicates that lift heights of 500 feet or more appear feasible (Piteau 2016b). However, the report recommends that angle of repose lifts in the Pipeline Pit Complex should not exceed 200 feet in height where the backfill is comprised of predominantly fine-grained overburden soils from the Crossroads Pit (southeast portion of the Pipeline Pit Complex) (Piteau 2016b). Based on the available information regarding site conditions, material properties, and the stability evaluation results, impacts associated with instability of the out-of-pit and in-pit waste rock facilities under static or seismic loading conditions are not anticipated.

Pit Slope Stability

Open pit walls can experience periodic slope instability problems due to weak geologic materials; adversely oriented geologic structures, such as bedding, faults, and jointing; and the presence of groundwater. Impacts associated with potential instability of the pit walls during operation and post-closure are discussed below.

*Gold Acres Pits, Pipeline Pit Complex, and Cortez Pit*

The Proposed Action includes the expansion of the Gold Acres Pit (including development of satellite pits), Pipeline Pit Complex, and Cortez Pit as described in Section 2.3. The pit slope angles generally would range from 1H:1V to 3H:1V; however, in areas of poor rock quality and/or reduced dewatering efficiency, the overall pit slope angles could be reduced. A 200-foot-wide pit adjustment zone around the pit rim would provide for operational flexibility. As described in Section 2.3 some of the pits would be partially backfilled with waste rock prior to closure. Stability analyses for these pit expansions have not been conducted but would be completed prior to mining and would include recommended setbacks for waste rock facilities where appropriate (BCI 2017a). The stability of the open pits at closure would conform to a minimum factor of safety of 1.0 under seismic loading for large scale or deep-seated type failures (BCI 2016). Geotechnical monitoring, consisting of geologic structure mapping, groundwater monitoring, and slope stability analyses, would be conducted during active mining to assist in optimizing final pit designs. Additional management and maintenance activities would occur as mining progresses, based on the actual geologic conditions encountered and verification of pit wall performance. Following mining, pit dewatering operations would cease, and the groundwater levels would rebound. Pit lakes are predicted to develop in the post-mining period in the Pipeline Pit Complex and Cortez Pit as summarized in Section 2.3. During the post-closure period, it is anticipated that the pit slopes would experience raveling and localized failures over time until they reach a long-term stable configuration.

*Cortez Hills Pit*

Under the Proposed Action, the existing Cortez Hills Pit either would be closed without placement of backfill in the pit as currently authorized, or partially backfilled. If partially backfilled, backfill would be placed in the deepest portion of the pit to an elevation of approximately 4,865 feet amsl, with a waste rock fill buttress extending up the east slope of the pit to an approximate elevation of 6,*500* feet amsl as shown on **Figure 2-8**. The final design and backfill elevations would be based on future hydrologic and geotechnical evaluations incorporating information gained during mining as discussed in the the Barrick Cortez Inc. (NVN-067575 (16-1A)) Deep South Expansion Project Amendment to Plan of Operations and Reclamation Permit Application #0093 (BCI 2016).

A potential stability concern previously was identified for the existing Cortez Hills Pit due to the east pit wall intersection of highly sheared bedrock material associated with the Cortez Fault Zone (BLM 2008a). As described in the Cortez Hills Expansion Project Final EIS (BLM 2008a), geotechnical investigations have indicated the weak bedrock material and fault gouge (pulverized rock generated by fault movement) associated with the Cortez Fault Zone ranges from approximately 100 to 500 feet wide and dip steeply toward the west. The pit also is situated in an active seismic area, as described in Section 3.1.6, Faulting and Seismicity. Ground acceleration caused by seismic events could have the potential to trigger failure of pit slopes that would be marginally stable under static conditions. To address this issue, a mitigation measure (GM2) was added to the Cortez Hills Expansion Project Final EIS (BLM 2008a) and incorporated into the Record of Decision (BLM 2008b) as discussed in Section 3.2.3, No Action Alternative. Piteau (2016a) evaluated the long-term stability of the east wall of the existing Cortez Hills Pit following recovery of groundwater levels in the post-mining period and developed slope stabilization measures to minimize the potential risk of slope failure impacts to the property of cultural and religious importance (Mount Tenabo/White Cliffs) located east of the pit. The analysis was conducted using a limit equilibrium stability analysis model to assess the potential for deep-seated, structurally controlled rock mass failures of the final east wall slopes. The stability model incorporated rock mass strength and rock fabric data used for design of the east wall. The projected recovered groundwater levels in the east wall were incorporated into the analysis using a local-scale interpretation of the regional groundwater flow model results that accounted for local structural conditions (Piteau 2016a). A pseudostatic analysis also was conducted to simulate earthquake-loading conditions assuming a peak horizontal ground acceleration of 0.1175 g. The peak ground acceleration used for the analysis represents half of the peak horizontal ground acceleration (0.23 g) generated from an earthquake that has a 1/1,000-year probability of recurrence.

Piteau (2016a) used a minimum factor of safety of 1.3 under static conditions and 1.0 under seismic loading conditions as the design criteria for the post-mining stability of the inter-ramp and overall slopes. Stability analyses were performed on six geotechnical cross-sections through the east wall of the Cortez Hills Pit using the final pit shell design under two scenarios: 1) no backfill placement and 2) partial backfill placement as described above. The results of the stability analyses for the six cross-sections assuming no placement of backfill in the pit indicate calculated factors of safety ranging from 0.96 to 1.21 for static conditions, and 0.79 to 1.00 for the assumed earthquake loading conditions. These results indicate that under the no backfill placement scenario, the stability of the east wall of the existing Cortez Hills Pit does not meet the design criteria for post-mining stability. Thus, the results indicate an unacceptable risk of deep-seated failure in the east wall during the post-closure period after groundwater levels recover. Also, the risk of failure under the no backfill scenario increases during the assumed earthquake loading indicating that a large deep-seated slope failure could be triggered during the assumed design seismic event. However, as described in Section 3.2.3, No Action Alternative, the final design of the Cortez Hills Pit under the currently authorized mine plan is required to meet a minimum factor of safety of 1.3 under static loading and predicted post-closure groundwater conditions for large-scale failures, and 1.0 under seismic loading. Additional discussion regarding the potential long-term stability of the Cortez Hills Pit under the currently authorized mine plan is provided in Section 3.2.3.

For the partial backfill scenario, the backfill design was developed and optimized through an iterative process to determine the minimum backfill required to provide for long-term stability of the east wall of the existing Cortez Hills Pit (i.e., achieve a factor of safety of greater than or equal to 1.3 under static conditions and greater than or equal to 1.0 under the assumed earthquake loading conditions) (Piteau 2016a). The results of the stability analyses of the partial backfill placement design indicate calculated factors of safety ranging from 1.3 to 1.53 for the static conditions, and 1.06 to 1.35 for the assumed earthquake loading conditions. The results of the stability analyses indicate that that partial pit backfill using the backfill dimensions specified in Piteau (2016b) would provide for long-term stability of the east wall of the existing Cortez Hills Pit. Potential impacts associated with long-term slope instability under the partial backfill scenario would likely be minor, long-term, and localized (i.e., would not extend outside of the proposed CGM Operations Area).

BCI has indicated that in the event that partial pit backfill is not placed in the existing Cortez Hills Pit as recommended by Piteau (2016a), other technically sound methods would be used to meet the minimum factor of safety criteria. These methods may include, but would not be limited to, active or passive dewatering techniques (BCI 2016).

<u>Underground Mining</u>

The Proposed Action includes expansion of underground mining operations as described in Section 2.3. The underground expansion would increase the depth of mining from the currently authorized elevation of 3,800 feet amsl to 2,500 feet amsl. Underground workings are expected to encounter mineralized and altered rock with poor rock quality. The mining methods currently used for the existing underground operations would continue under the Proposed Action. Most of these methods include replacement of mined ore with cemented backfill or waste rock. The cemented backfill or waste rock placement is designed to provide support for the walls to allow for subsequent mining in adjacent areas. Although cemented backfill or waste rock would be placed in mined-out areas, it is anticipated that there would be areas within the underground workings that would not be backfilled. In the post-closure period, localized rock collapse would be likely to occur over open workings and result in the development of localized ground deformation/subsidence-type features within the boundaries of the proposed Cortez Hills Pit. The declines are expected to have localized long-term collapse; however, they are unlikely to impact surface features due to the strength and thickness of the overlying rock in relation to the dimensions of the underground openings (SRK 2016c). Impacts associated with potential surface deformation/subsidence as a result of underground mining would likely be minor, long-term, and localized.

Rocky Pass Reservoir

The proposed Rocky Pass Reservoir would require construction of a 60-foot-high earth fill embankment (with a maximum pool depth of 55 feet) to impound up to 21,200 acre-feet of excess dewatering water as described in the Barrick Cortez Inc. (NVN-067575 (16-1A)) Deep South Expansion Project Amendment to Plan of Operations and Reclamation Permit Application #0093 [BCI 2016]. AKANA (2015) conducted a preliminary evaluation of the 60-foot-high earth fill embankment that included stability and seepage analyses. Geotechnical exploration and laboratory testing data for material properties of the foundation, abutments, and embankment fill was not available for this preliminary evaluation. Therefore, the stability and seepage analyses were based on assumed properties for the native foundation and abutments and embankment fill materials. The evaluation assumed embankment slopes of 2.5H:1V for the feasibility study. The results of the preliminary slope stability evaluation indicate adequate factors of safety under static and seismic (pseudostatic) loading conditions. In addition, under the Nevada Revised Statute 535, BCI would need to acquire a dam safety permit from the State of Nevada, State Engineer office since the dam would be greater than 20 feet in height. The goal of the state dam safety program is to avoid dam failure and prevent loss of life and destruction of property. As part of the dam safety program, the State Engineer office would be responsible for reviewing the dam application and dam design, performing on-site inspection as the dam is constructed, reviewing as-built drawings and quality assurance/quality control reports, and periodic inspections of the dam during the operational period. Considering the preliminary feasibility evaluation and state dam safety requirements, impacts associated with instability of the embankment under static or seismic loading conditions are not anticipated. Potential impacts associated with the construction and operation of the Rocky Pass Reservoir would be minor, long-term, and localized.

Dewatering-induced Surface Subsidence

The predicted drawdown and potential impacts to water resources associated with the dewatering activities under the Proposed Action are addressed in the Deep South Expansion Project Supplemental Environmental Report – Water Resources and Geochemistry (BLM 2019a). The dewatering required for the Proposed Action would increase the areal extent and magnitude of drawdown compared to current conditions. This additional dewatering would lower groundwater levels in both fractured bedrock and basin fill sediments. The load born by the basin sediments as a result of groundwater removal and the associated lowering of groundwater levels would increase and result in compaction of the basin sediments, causing subsidence of the ground surface. Ground subsidence also can result in the development of cracks at the surface that are known as earth fissures. As discussed in Section 3.1.7, Ground Subsidence and Earth Fissures, the lowering of groundwater levels associated with past dewatering activities at the Pipeline Pit Complex in Crescent Valley has resulted in ground subsidence in the region surrounding the mine and development of earth fissures immediately south of the Pipeline Pit Complex (**Figure 3-9**).

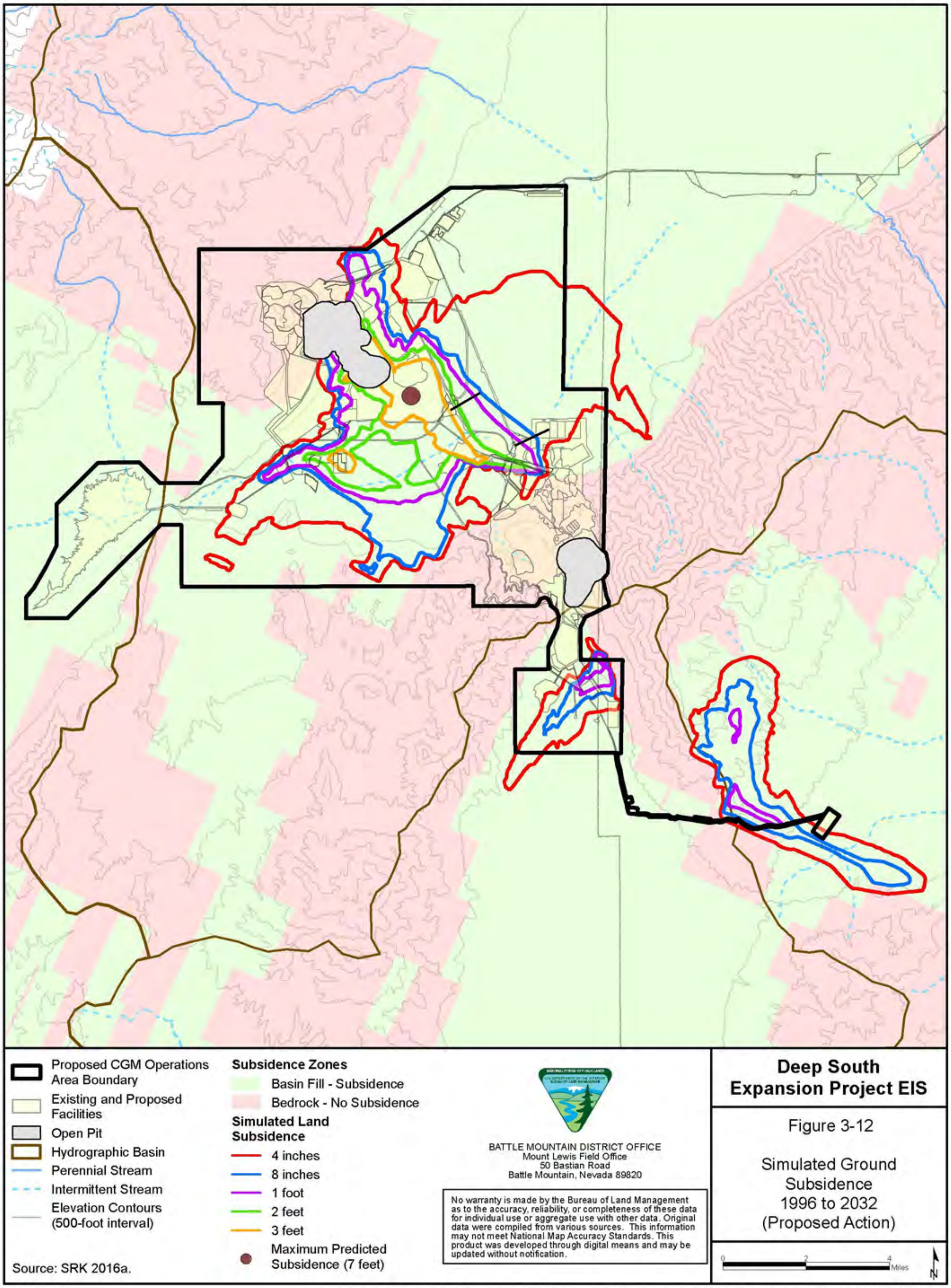
The projected increase in ground subsidence from the Proposed Action dewatering activities was estimated using the updated calibrated groundwater flow model and the MODFLOW Interbed-Storage package as described in Section 3.1.7, Ground Subsidence and Earth Fissures. The predicted total subsidence resulting from the historic dewatering activities to date combined with the proposed future dewatering activities under the Proposed Action (i.e., 1996 through 2032) is shown in **Figure 3-12**. This model simulation reflects backfill Scenario 3 for the Pipeline Pit Complex. The simulations for backfill scenarios 1 and 2 are provided in cumulative subsidence report (SRK 2017a) and as indicated, the subsidence predictions for all three Pipeline Pit Complex backfill scenarios are nearly identical.

The subsidence modeling results predict that the maximum subsidence under the Proposed Action would occur southeast of the Pipeline Pit Complex. The area affected by 4 inches or more of subsidence would extend 5.2 miles to the east and 4.9 miles to the south from the Pipeline Pit Complex in Crescent Valley. Compared to the predictions for the end of mining under the No Action Alternative (1996 through 2024) (**Figure 3-13**), the areal extent of the areas predicted to experience 4 inches or more of subsidence would increase by 24 percent in Crescent Valley, 16 percent in Grass Valley, and 44 percent in Pine Valley (SRK 2017a). Major facilities within this predicted Proposed Action subsidence area include the same facilities as under the No Action Alternative (i.e., Pipeline Heap Leach/Tailings Facility, Pipeline South Area Heap Leach Facility, and the Pipeline/South Pipeline Waste Rock Facility) plus the Cortez West Waste Rock Facility and the historic tailings impoundments located in the northern portion of the Cortez Complex. Impacts associated with dewatering induced subsidence are anticipated to be negligible to minor, long-term, and regional.

The predicted additional subsidence as a result of dewatering activities under the Proposed Action could expand the development of earth fissures. If undetected and unmitigated, earth fissures potentially could damage existing solution-bearing facilities such as leach pads, process ponds, and tailings facilities. Earth fissures and subsidence also could disrupt stormwater control features and RIB facilities. BCI's current operations include a monitoring plan for subsidence and related earth fissure development near the Pipeline Complex (CGM 2005). Also, as discussed in Section 2.3.3, Applicant-committed Environmental Protection Measures, BCI currently implements management and mitigation measures (in addition to monitoring) to address possible earth fissuring in the Pipeline Complex area. Continued implementation of these measures would mitigate significant impacts associated with subsidence-related earth fissure development in the vicinity of the Pipeline Complex. However, considering the uncertainty associated with the subsidence predictions and fissure development, there is a potential for damage to facilities resulting from future earth fissure development in the vicinity of the Cortez and Cortez Hills complexes. Potential impacts anticipated from earth fissure development would be minor to moderate, long-term, and localized. Therefore, the dewatering-induced subsidence monitoring plan and management activities would need to be expanded to mitigate potential significant impacts associated with subsidence-related earth fissure development in the vicinity of the Cortez and Cortez Hills complexes, and in northern Grass Valley and western Pine Valley.

#### 3.2.1.2 Blasting

Conventional drilling and blasting techniques would continue to be used to facilitate the proposed surface and underground mining. Extensive research has been conducted by the U.S. Bureau of Mines (USBM) to quantify the effects of blasting on a variety of structures (Siskind et al. 1980). This research led to the development of acceptable vibration standards and techniques to predict and control blast vibrations that reduce the risk of off-site damage.




Source: SRK 2016a.

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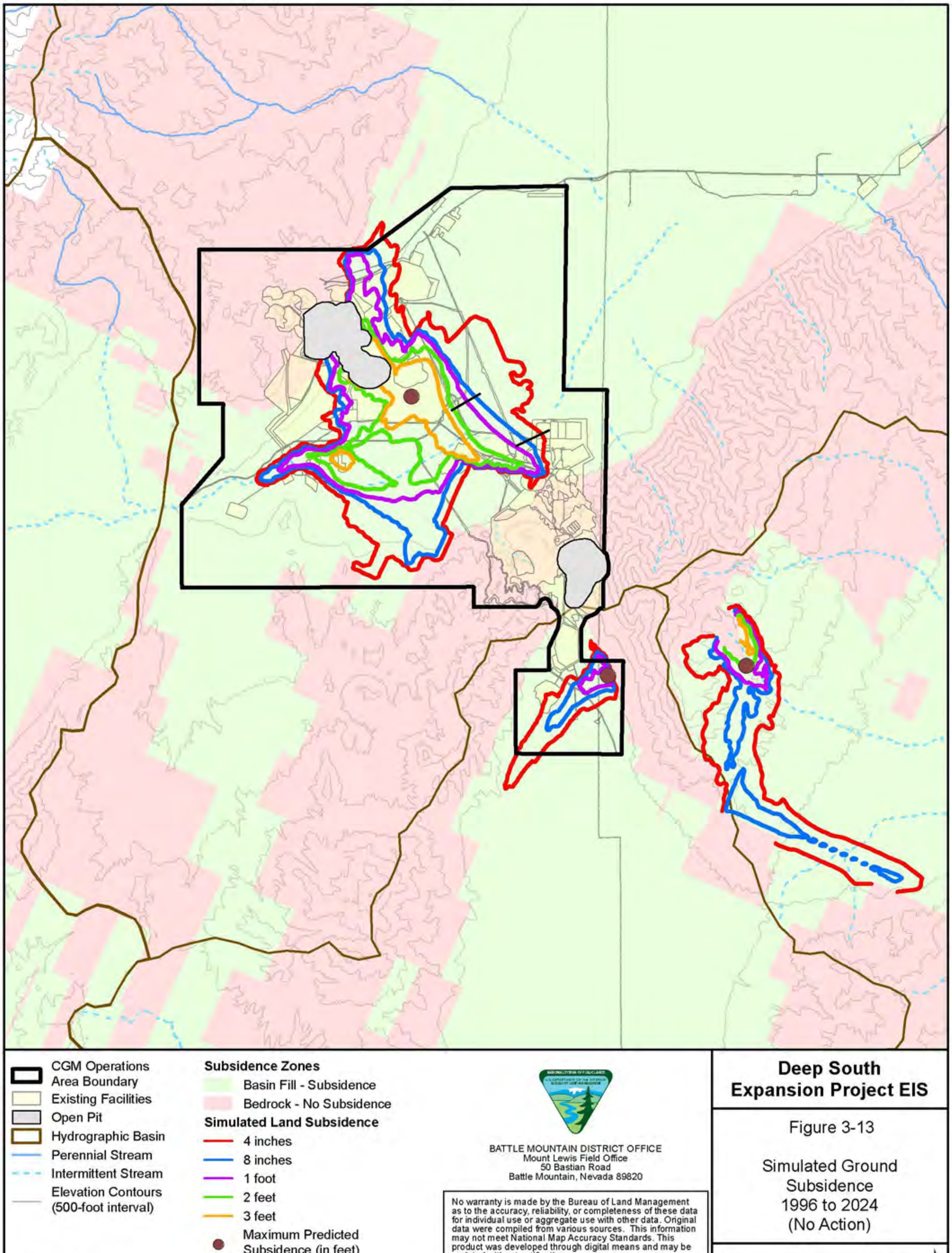
**Deep South Expansion Project EIS**

Figure 3-12

Simulated Ground Subsidence 1996 to 2032 (Proposed Action)




Source: SRK 2016a.

**Deep South Expansion Project EIS**

Figure 3-13

Simulated Ground Subsidence 1996 to 2024 (No Action)

Blasting vibrations in the project area are monitored with blasting seismographs. The seismographs measure the rate of movement in three separate planes to determine the velocity of vibration. The monitored vibrations are recorded as the peak particle velocity (PPV) in inches per second. The PPV is the maximum speed at which a particle in the ground is moving relative to its inactive state. Historical seismograph data from the project area indicate that the PPVs are unlikely to exceed thresholds of 1.0 inch per second at 1,000 feet (site-to-source), 0.25 inch per second at 2,000 feet, and 0.1 inch per second at 3,000 feet (BCI 2017b).

Information collected by the USBM documented damage to various types of residential structures from blasting vibration (Siskind et al. 1980). The USBM results established a minimum safe vibration threshold for residential structures of 0.5 inch per second. Below this threshold, blasting vibration is unlikely to result in cracking or other structural damage. The historical blasting seismograph data for the site indicates that vibrations that exceed the 0.5 inch per second threshold are restricted to areas within a site-to-source distance of up to approximately 1,500 feet. Therefore, blasting vibrations are not expected to damage any residential type structures located at distances of greater than 1,500 feet from the blast locations.

### 3.2.2 Gold Acres Pit Partial Backfill Alternative

Under the Gold Acres Pit Partial Backfill Alternative, potential impacts to geology and mineral resources would be the same as described for the Proposed Action, with the following exception. Under this alternative, the project would result in the permanent alteration of the natural topographic and geomorphic features on approximately 510 acres of proposed new disturbance for open pits and waste rock facilities and approximately 308 acres of currently authorized disturbance proposed for reallocation to open pits and waste rock facilities. The impacts associated with the permanent alteration of the natural topographic and geomorphic features would be major, long-term, and localized.

### 3.2.3 No Action Alternative

Under the No Action Alternative, the proposed Deep South Expansion Project would not be developed and the related potential impacts to geologic and mineral resources would not occur. Existing mining and processing operations and reclamation activities in the current CGM Operations Area, as described in Section 2.4.2, No Action Alternative, would continue to operate under the terms of current permits and approvals as authorized by the BLM and State of Nevada. Potential impacts to geologic and mineral resources previously were analyzed in the Pipeline/South Pipeline Project Final SEIS (BLM 2004) and earlier NEPA documents for the site (BLM 2000, 1996), as well as the Cortez Underground Exploration Project Environmental Assessment (BLM 2006), Cortez Hills Expansion Project Final EIS (BLM 2008a), and subsequent Environmental Assessments (BLM 2015, 2014).

A potential stability concern previously was identified for the existing Cortez Hills Pit due to the east pit wall intersection of highly sheared bedrock material associated with the Cortez Fault Zone (BLM 2008a). As described in the Cortez Hills Expansion Project Final EIS (BLM 2008a), geotechnical investigations have indicated the weak bedrock material and fault gouge (pulverized rock generated by fault movement) associated with the Cortez Fault Zone ranges from approximately 100 to 500 feet wide and dip steeply toward the west. The pit also is situated in an active seismic area, as described in Section 3.1.6, Faulting and Seismicity. Ground acceleration caused by seismic events could have the potential to trigger failure of pit slopes that would be marginally stable under static conditions.

Under the No Action Alternative (i.e., currently authorized mine plan), the Cortez Hills Pit would not be backfilled. However, the pit design would meet or exceed the following design criteria as specified in the Cortez Hills Expansion Project Final EIS (BLM 2008a):

- Minimum factor of safety of 1.2 based on static loading conditions and target operating groundwater conditions;
- Minimum factor of safety of 1.3 under static loading conditions and predicted post-closure groundwater conditions for large-scale failures that extend towards the properties of cultural and religious importance (PCRI) boundary east of the pit; and
- Minimum factor of safety of 1.0 under pseudostatic (i.e., seismic) loading and the predicted post-closure groundwater conditions.

In addition, Mitigation Measure GM2 was included in the Cortez Hills Expansion Project Final EIS (BLM 2008a) and incorporated into the Record of Decision (BLM 2008b) to address the potential for slope failures in the east wall of the Cortez Hills Pit in the post-closure period. Mitigation Measure GM2 requires that the results of pit slope monitoring, geotechnical data collection, modifications to pit design, and development of corrective actions be provided in an annual report to the BLM for the life of the project. Mitigation Measure GM2 also requires that the final pit slope be designed to conform to a minimum factor of safety of 1.0 under seismic loading for potential failure surfaces that could extend to the PCRI boundary located east of the pit crest. Other measures to address long-term stability of the east wall of the Cortez Hills Pit (e.g., slope buttressing) would be evaluated as mining progresses and provided in the final closure plan based on the results of pit slope monitoring, geotechnical data collection, and stability analysis (BLM 2008a,b).

With implementation of the design criteria and Mitigation Measure GM2, the slopes in the currently authorized Cortez Hills Pit would be designed with reasonable factors of safety with respect to potential large-scale type failures that could extend outside the project boundary and towards the PCRI boundary during the post-closure period. Therefore, large-scale failures that could extend outside of the CGM Operations Area boundary and into the PCRI area, or impact the White Cliffs, are not anticipated during operation or closure (BLM 2008a).

The predicted drawdown and potential impacts to water resources associated with current dewatering activities under the No Action Alternative are addressed in the Deep South Expansion Project Supplemental Environmental Report – Water Resources and Geochemistry (BLM 2019a). The No Action Alternative dewatering scenario for groundwater modeling includes continued dewatering and mining at the Crossroads Pit (southeast portion of the Pipeline Pit Complex) through 2023, and continued dewatering and mining of the Cortez Hills underground mine through 2021 (SRK 2017a). Ongoing dewatering required for these currently permitted operations would increase the areal extent and magnitude of groundwater drawdown compared to current conditions. This additional dewatering would lower groundwater levels in both fractured bedrock and the basin sediments. As mine dewatering lowers the groundwater levels and water is expelled from the basin fill sediments, the load born by the sediments would increase and result in compaction of the sediment causing subsidence of the ground surface. Ground subsidence also can result in the development of cracks at the surface that are known as earth fissures.

As discussed in Section 3.1.7, Ground Subsidence and Earth Fissures, the lowering of groundwater levels associated with past dewatering activities at BCI's operations in Crescent Valley has resulted in ground subsidence in the region surrounding the Pipeline Complex and the development of earth fissures (**Figure 3-9**). The predicted total subsidence resulting from the historic dewatering activities to date combined with the projected future dewatering activities under the No Action Alternative (i.e.,1996 through 2024) are shown in **Figure 3-13**. The subsidence analysis indicates that the maximum subsidence would be up to approximately 7.1 feet and would occur southeast of the Pipeline Pit Complex. The area predicted to be affected by 4 inches or more of ground subsidence extends up to approximately 3.7 miles to the east and 4.8 miles to the south of the Pipeline Pit Complex perimeter (SRK 2017a). Major facilities within this predicted subsidence area include the Pipeline Heap Leach/Tailings Facility, Pipeline South Area Heap Leach Facility, and the Pipeline/South Pipeline Waste Rock Facility.

Additionally, the subsidence areas are predicted to expand (compared to the 1996 to 2015 predictions provided in **Figure 3-11**) in northern Grass Valley, and a new subsidence area is predicted to develop in basin fill sediments along the western margin of Pine Valley.

The predicted additional subsidence under the No Action Alternative could expand the development of earth fissures. Considering the uncertainty associated with the subsidence predictions and fissure development, there is a potential for damage to facilities resulting from future earth fissure development in southern Crescent Valley. If undetected and unmitigated, earth fissures potentially could damage existing solution-bearing facilities such as leach pads, process ponds, and tailings facilities. Subsidence or earth fissures also could disrupt stormwater control features. Potential damage to facilities from subsidence-related fissure development would be considered a significant impact. BCI's current operations include a monitoring plan for subsidence and related earth fissure development near the Pipeline Complex (CGM 2005). Based on the monitoring results, mitigation measures are implemented to address possible earth fissuring in this area. Continued implementation of these measures should detect and mitigate significant impacts associated with subsidence and earth fissure development. Impacts associated with dewatering-inducted subsidence are anticipated to be negligible to minor, long-term, and regional.

## 3.3 Cumulative Impacts

The CESA for geology and minerals is shown in **Figure 3-14**. The past and present actions and RFFAs in this area are identified in **Table 2-3**; the distribution of primary actions within the CESA are shown in **Figure 2-13**. Mineral production in these areas has included gold, silver, barite, sulfur, turquoise and lesser amounts of copper, lead, and arsenic. Most of the mineral production has come from gold and barite mining operations. In addition, the basin fill material has been mined intermittently as a source of gravel for road construction.

### 3.3.1 Proposed Action

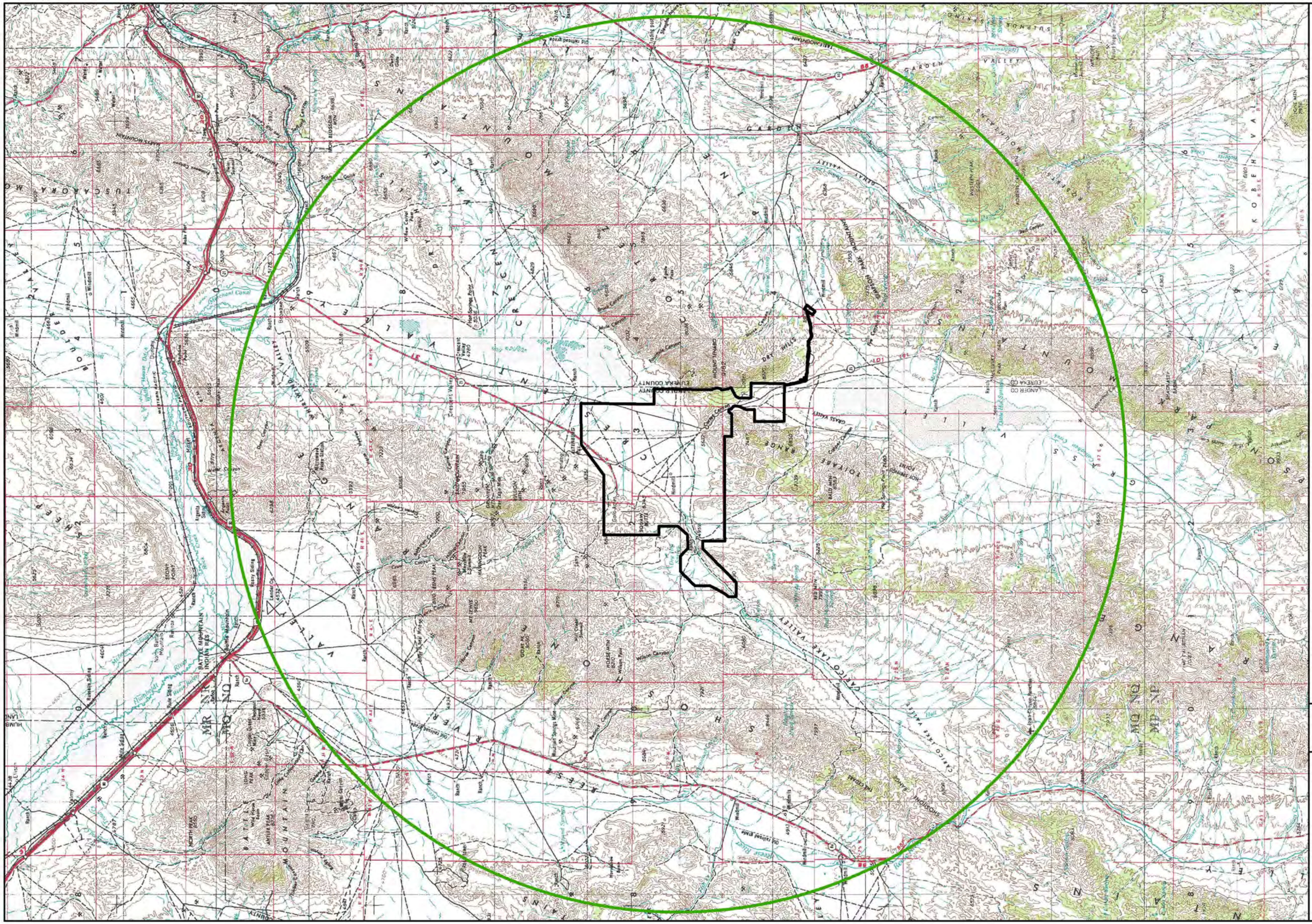
Surface mining activity affects geology and mineral resources by excavating, modifying, or covering natural topographic and geomorphic features and by removing mineral deposits. Mining disturbance in the CESA has included exploration (drilling, trenching, sampling, and road construction), open-pit and underground mining, and construction of waste rock, heap leaching, ore milling and processing, and tailings disposal facilities. For the purpose of this evaluation, "disturbed" area (or geologic disturbance) is defined to include mine components such as open pits, waste rock areas, leach pads, and tailings impoundments that permanently alter the natural topographic and geomorphic features in the area, even if reclaimed. In addition to mining, other developments in the region include agricultural development and utilities/community development. Large portions of the area also have been affected by wildfires (**Table 2-3**). For the purposes of this evaluation, agricultural, utility, and community development, and wildfires are not considered to result in a geologic disturbance as defined above.

Based on available information, past, present, and reasonably foreseeable future mining-related activities have, or would, result in approximately 20,*718* acres of disturbance (excluding disturbance associated with exploration) within the CESA; an unquantifiable portion of which has, or would, result in a permanent alteration of the natural topography. Of the 4,380 total acres of new disturbance that would occur under the Proposed Action, the project incrementally would increase the permanent alteration of topography (as open pit and waste rock facilities) in the CESA on approximately 582 acres of proposed new disturbance, with the additional incremental increase in permanent alternation on approximately 324 acres of currently authorized disturbance proposed for reallocation to open pits and waste rock facilities.

As discussed in Section 3.1.7, Ground Subsidence and Earth Fissures, the lowering of groundwater levels associated with existing dewatering activities at BCI's existing operations in the CGM Operations Area has resulted in ground subsidence in the region surrounding the Pipeline Complex and the development of earth fissures. Additional dewatering required for the Proposed Action incrementally would increase the areal extent and magnitude of groundwater drawdown compared to current conditions and result in an increase in subsidence in the southern portion of Crescent Valley and northern portion of Grass Valley, with subsidence expanding into western Pine Valley. The total cumulative subsidence from the past, present, and projected future dewatering activities was predicted using the MODFLOW Interbed-Storage package as summarized in Section 3.1.7 and described in detail in the cumulative effects subsidence report completed for the project (SRK 2017a). The cumulative ground subsidence predictions are based on estimated effects associated with all mine dewatering and water management activities that occurred historically in the CGM Operations Area (1996 through 2015) combined with the assumed future dewatering and water management activities associated with the following (SRK 2017a):

- Continued mining of the Crossroads Pit (southeast portion of the Pipeline Pit Complex) from 2016 through 2024;
- Continued mining of the Cortez Hills underground mine from 2016 through 2021;
- Mining of the Cortez Pit from 2020 through 2022;
- Mining of the proposed Cortez Hills underground mine expansion area from 2022 through 2032; and
- Mining of the potential future Goldrush underground mine from 2022 through 2043 (including initiation of dewatering for the West Access Declines in 2018).

The Goldrush Project is identified as a RFFA (Section 2.5) that would be located in western Pine Valley Hydrographic Area and consist of a*n* underground mine operation with an approximate *18*-year mine life that would require mine dewatering. The predicted cumulative subsidence resulting from the historic dewatering activities to date combined with the projected future dewatering activities (i.e., 1996 to 2043) is shown in **Figure 3-15**. As noted in Section 3.2.1, Proposed Action, this model simulation reflects backfill Scenario 3 for the Pipeline Pit Complex. (Predictions for backfill scenarios 1 and 2 are provided in the SRK [2017a] report and indicate that considering model uncertainty, the subsidence predictions for all three Pipeline Pit Complex backfill scenarios are essentially the same.) The subsidence modeling results predict that the maximum subsidence (7.1 feet) would occur southeast of the Pipeline Pit Complex. The area affected by 4 inches or more of subsidence would extend 5.8 and 4.9 miles to the east and south, respectively, from the Pipeline Pit Complex in Crescent Valley (SRK 2017a). Compared to the predictions for the end of mining under the Proposed Action (**Figure 3-12**), the areal extent of the subsidence areas predicted to experience 4 inches or more of subsidence would increase by 16 percent in Crescent Valley,



Proposed CGM Operations Area Boundary

Geology and Minerals CESA

BATTLE MOUNTAIN DISTRICT OFFICE
Mount Lewis Field Office
50 Bastian Road
Battle Mountain, Nevada 89820

0 1 2 3 4 5 10 Miles

No warranty is made by the Bureau of Land Management as to the accuracy, reliability, or completeness of these data for individual use or aggregate use with other data. Original data were compiled from various sources. This information may not meet National Map Accuracy Standards. This product was developed through digital means and may be updated without notification.

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**Deep South Expansion Project EIS**

Figure 3-14

Geology and Minerals CESA

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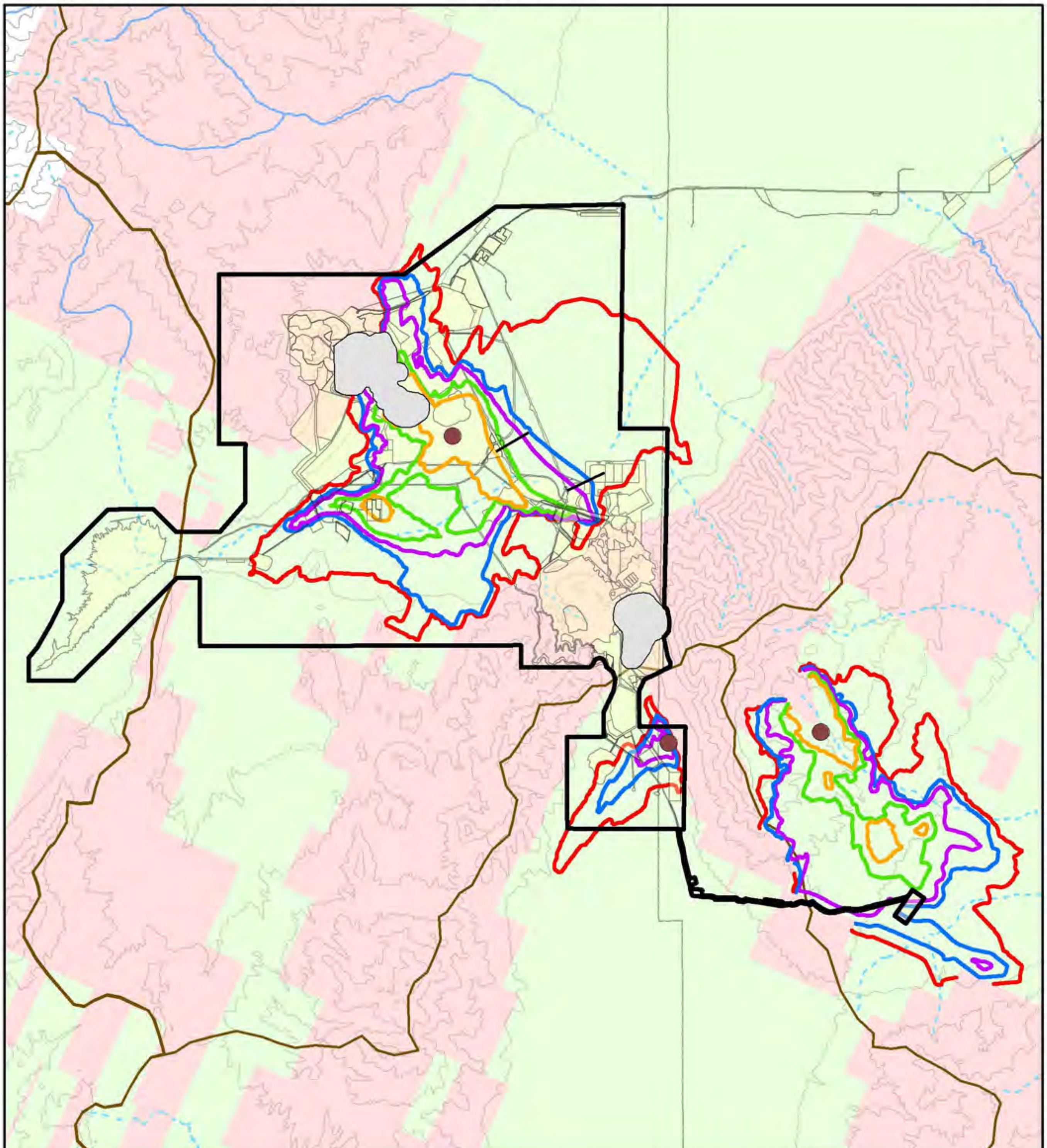

Proposed CGM Operations Area Boundary
Existing and Proposed Facilities
Open Pit
Hydrographic Basin
Perennial Stream
Intermittent Stream
Elevation Contours (500-foot interval)

**Subsidence Zones**
Basin Fill - Subsidence
Bedrock - No Subsidence

**Simulated Land Subsidence**
4 inches
8 inches
1 foot
2 feet
3 feet
Maximum Predicted Subsidence (in feet)

BATTLE MOUNTAIN DISTRICT OFFICE
Mount Lewis Field Office
50 Bastian Road
Battle Mountain, Nevada 89820

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**Deep South Expansion Project EIS**

Figure 3-15

Simulated Ground Subsidence 1996 to 2043 (Cumulative Scenario)

0 2 4 Miles

N

Source: SRK 2017b.

13 percent in Grass Valley, and 29 percent in Pine Valley (SRK 2017a). Major facilities within the cumulative subsidence area include the same facilities within the predicted Proposed Action subsidence area (i.e., Pipeline Heap Leach/Tailings Facility, Pipeline South Area Heap Leach Facility, Pipeline/South Pipeline Waste Rock Facility, Cortez West Waste Rock Facility, and the historic tailings impoundments located in the northern portion of the Cortez Complex).

The subsidence analysis indicates that the maximum cumulative subsidence would occur southeast of the existing Pipeline Pit Complex. This additional subsidence could expand the development of earth fissures. If undetected and unmitigated, earth fissures potentially could damage solution-bearing facilities such as existing leach pads, process ponds, and tailings facilities. Current BCI operations include implementation of a monitoring plan and mitigation measures for subsidence and related earth fissure development near the Pipeline Complex (CGM 2005), as previously discussed for the Proposed Action.

### 3.3.2 Gold Acres Pit Partial Backfill Alternative

Cumulative impacts to geology and minerals under the Gold Acres Pit Partial Backfill Alternative would be the same as described for the Proposed Action, with the following exception. Under this alternative, the project incrementally would contribute to the alteration of the natural topographic and geomorphic features on approximately 510 acres of proposed new disturbance for open pits and waste rock facilities and approximately 308 acres of currently authorized disturbance proposed for reallocation to open pits and waste rock facilities.

## 3.4 Monitoring and Mitigation Measures

**Issue**: The current “Monitoring Plan for Ground Subsidence and Related Earth Fissure Development near the Pipeline Mine” was approved in January 2004 and revised in 2008. The plan is designed to monitor for ground subsidence and earth fissure development in southern Crescent Valley within proximity to the Pipeline Complex. The monitoring results are provided in annual reports that, when necessary, include recommendations for modifications to the monitoring plan and site specific recommendations to reduce the potential enlargement of identified earth fissures by limiting surface water infiltration and erosion. The 2015 annual monitoring report (AMEC 2016) includes recommendations for excavation, backfilling, and capping of earth fissures. Updated subsidence simulations for the Proposed Action and cumulative dewatering scenarios predict that the area affected by dewatering-induced ground subsidence would continue to expand through the end of mining and affect broader areas within Crescent Valley (including the northern portion of the Cortez Complex), as well as northern Grass Valley south of the Cortez Hills Complex and western Pine Valley.

**Mitigation Measure GM1**: The current “Monitoring Plan for Ground Subsidence and Related Earth Fissure Development near the Pipeline Mine” (CGM 2005) would be revised to expand the area of subsidence and earth fissure monitoring to include the area within the maximum extent of the 4-inch subsidence contour projected at the end of mining under the Proposed Action as defined in the subsidence prediction report (SRK 2017a), and to extend the period of monitoring through the life of the project (approximately 2032) or as approved by the BLM and NDEP. The focus of the monitoring would be to provide an assessment of cumulative ground surface settlement and identify and map any observed earth fissure development in the vicinity of the mine facilities, with emphasis on lined facilities that contain process solutions (e.g., leach pads, process ponds, and tailings facilities), as well as stormwater control features and RIB facilities. BCI would continue to provide the monitoring results in annual reports and would work with the BLM and NDEP, as necessary, to develop and implement appropriate site-specific measures to minimize the risk of damage to critical mine facilities.

**Effectiveness**: Implementation of this measure would extend the monitoring period and provide for development of site-specific measures to mitigate any identified earth fissures within the broader area predicted to be affected by mine dewatering-induced subsidence. This expansion of the monitoring area is anticipated to be effective at tracking subsidence, identifying earth fissures, and developing and implementing site-specific measures, as necessary, to minimize the risk of damage to critical mine facilities.

## 3.5 Residual Adverse Effects

Residual adverse effects to geology and mineral resources as a result of the proposed project would include the permanent removal of approximately 88.5 million tons of ore from within the CGM Operations Area and the permanent alteration of the landscape on a total of approximately 906 acres as a result of the proposed expansion of open pits and waste rock facilities.

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# 4.0 References

## Chapter 1.0 Introduction

Barrick Cortez Inc. (BCI). 2016. Barrick Cortez Inc. (NVN-067575 (16-1A)) Deep South Expansion Project Amendment to Plan of Operations and Reclamation Permit Application #0093. Submitted to BLM Mount Lewis Field Office, Battle Mountain, Nevada, and Nevada Division of Environmental Protection, Carson City, Nevada. October 2016.

## Chapter 2.0 Alternatives Including the Proposed Action

***Barrick Cortez Inc. (BCI). 2018. Barrick Cortez Inc. Goldrush Mine Plan of Operations and Reclamation Permit Application. Submitted to BLM Mount Lewis Field Office, Battle Mountain, Nevada, and Nevada Division of Environmental Protection, Carson City, Nevada. December 2018.***

Barrick Cortez Inc. (BCI). 2016. Barrick Cortez Inc. (NVN-067575 (16-1A)) Deep South Expansion Project Amendment to Plan of Operations and Reclamation Permit Application #0093. Submitted to BLM Mount Lewis Field Office, Battle Mountain, Nevada, and Nevada Division of Environmental Protection, Carson City, Nevada. October 2016.

Barrick Gold of North America (Barrick). 2018. Bank Enabling Agreement 2017 Annual Report. February 2018.

Bureau of Land Management (BLM). 2017a. Bureau of Land Management's Land & Mineral Legacy Rehost 2000 System - LR2000. Internet website: http://www.blm.gov/lr2000/. Accessed January 27, 2017.

Bureau of Land Management (BLM). 2017b. GIS Shapefiles for Wildfire Affected Areas in Nevada. May 30, 2017.

Bureau of Land Management (BLM). 2016a. Environmental Assessment Barrick Gold Exploration, Inc. Horse Canyon/Cortez Unified Exploration Project Plan of Operations (NVN-066621 [16-1A]) and Reclamation Permit No. 0159 Plan Amendment – Twin Declines for Underground Exploration. Battle Mountain District Office, Mount Lewis Field Office. Battle Mountain, Nevada. July 20, 2016.

Bureau of Land Management (BLM). 2016b. Decision Environmental Assessment Barrick Gold Exploration, Inc. Horse Canyon/Cortez Unified Exploration Project Plan of Operations (NVN-066621 [16-1A]) and Reclamation Permit No. 0159 Plan Amendment – Twin Declines for Underground Exploration. Mount Lewis Field Office, Battle Mountain, Nevada. September 9, 2016. On file, Bureau of Land Management, Mount Lewis Field Office, Battle Mountain, Nevada.

Bureau of Land Management (BLM). 2015a. Environmental Assessment Barrick Cortez Inc. (NVN-067575 [14-1A]) Amendment 3 to Plan of Operations and Reclamation Permit Application. Battle Mountain District Office, Mount Lewis Field Office, Battle Mountain, Nevada. July 2015.

Bureau of Land Management (BLM). 2015b. Decision/Finding of No Significant Impact Barrick Cortez Inc. Amendment to the Plan of Operations Approval Determination of Required Financial Guarantee. Mount Lewis Field Office, Battle Mountain, Nevada. September 11, 2015.

Bureau of Land Management (BLM). 2014a. Environmental Assessment for Barrick Cortez Inc. (NVN-67575 [11-3A]) 2011 Amendment to Plan of Operations and Reclamation Permit Application Proposed North Waste Rock Facility Realignment/Rangeland Fence Addition/Stockpile Relocation/Ancillary Addition. Battle Mountain District, Mount Lewis Field Office, Battle Mountain, Nevada. February 2014.

Bureau of Land Management (BLM). 2014b. Decision/Finding of No Significant Impact Cortez Gold Mines Project Amendment to the Plan of Operations Approval Determination of Required Financial Guarantee. Mount Lewis Field Office, Battle Mountain, Nevada. February 24, 2014.

Bureau of Land Management (BLM). 2011a. Cortez Hills Expansion Project Final Supplemental Impact Statement. Battle Mountain District Office, Battle Mountain, Nevada. January 2011.

Bureau of Land Management (BLM). 2011b. Cortez Hills Expansion Project Record of Decision and Plan of Operations Amendment Approval. Battle Mountain District Office, Battle Mountain, Nevada. March 2011.

Bureau of Land Management (BLM). 2008a. Cortez Hills Expansion Project Final Impact Statement. Battle Mountain District Office, Battle Mountain, Nevada. September 2008.

Bureau of Land Management (BLM). 2008b. Cortez Hills Expansion Project Record of Decision and Plan of Operations Amendment Approval. BLM Battle Mountain District, Battle Mountain, Nevada. November 2008.

Bureau of Land Management (BLM). 2004. Pipeline/South Pipeline Pit Expansion Project Final Supplemental Environmental Impact Statement. Battle Mountain Field Office, Battle Mountain, Nevada. December 2004.

ESRI World Imagery. 2017. GIS Application for Satellite Imagery. May 17, 2017.

SRK Consulting, (U.S.) Inc. (SRK). 2017. Deep South Expansion Project – Cumulative Effects, Groundwater Flow Modeling Report. Prepared for Barrick Cortez Inc. March 2017.

SRK Consulting, Inc. (SRK). 2014. Barrick Cortez Inc. Noxious Weed Management Plan. Prepared for Barrick Cortez Inc. July 2014.

U.S. Census Bureau. 2017. TIGER/Line Shapefile, Roads-Lander County. Internet website: ftp://ftp2.census.gov/geo/tiger/TGRGDB13/. November 11, 2009. Accessed May 17, 2017.

## Chapter 3.0 Geology and Minerals

AKANA. 2015. Technical Memorandum. Water Storage Reservoir Scoping Study, Akana Project No. 15-138. Task 4 Deliverable – Dam Conceptual Design Alternatives. Submitted to Barrick Cortez, Inc. Crescent Valley, Nevada. September 22, 2015.

AMEC Foster Wheeler Environment & Infrastructure, Inc. (AMEC). 2016. 2015 Annual Ground Subsidence and Earth Fissure Monitoring Report. Pipeline/South Pipeline Project, Lander County, Nevada. April 2016.

AMEC Earth & Environmental, Inc. (AMEC). 2005. In: Synthetic Aperture Radar (SAR) Evaluation for Ground Subsidence and Earth Fissure Monitoring 2004. Pipeline/South Pipeline Project, Cortez Gold Mines, Lander County, Nevada. July 28, 2005. In: Bureau of Land Management (BLM). 2008a. Cortez Hills Expansion Project Final Impact Statement. Battle Mountain District Office, Battle Mountain, Nevada. September 2008.

AMEC Earth & Environmental, Inc. (AMEC). 2003. Preliminary Report Ground Subsidence and Earth Fissure Evaluation, Pipeline/South Pipeline Project, Cortez Gold Mines, Lander County, Nevada. In: Bureau of Land Management (BLM). 2008a. Cortez Hills Expansion Project Final Impact Statement. Battle Mountain District Office, Battle Mountain, Nevada. September 2008.

Barrick Cortez Inc. (BCI). 2017a. Supplemental geotechnical data provided by S. Schoen, BCI, to D. Koontz, AECOM, in response to an AECOM data requested. March 6, 2017.

Barrick Cortez Inc. (BCI). 2017b. Email submittal from S. Schoen, BCI, to K. Hurrell, BLM, D. Gregory, AECOM, and D. Koontz, AECOM, regarding blasting-related vibration. August 1, 2017.

Barrick Cortez Inc. (BCI). 2016. Barrick Cortez Inc. (NVN-067575 [16-1A]) Deep South Expansion Project Amendment to Plan of Operations and Reclamation Permit Application #0093. Submitted to BLM Mount Lewis Field Office, Battle Mountain, Nevada and Nevada Division of Environmental Protection, Carson City, Nevada. October 2016.

Bell, J. W. 2013. InSAR Studies in the Crescent Valley Area Final Technical Report to Barrick Gold of North America. Nevada Bureau of Mines and Geology University of Nevada, Reno. December5, 2013.

Bureau of Land Management (BLM). 2019a. Deep South Expansion Project Supplemental Environmental Report – Water Resources and Geochemistry. Prepared in Support of: File Number: NVN-067575 (16-1A) DOI-BLM-NV-B010-2016-0052 EIS. Battle Mountain District Office, Mount Lewis Field Office, Battle Mountain, Nevada. 2019.

Bureau of Land Management (BLM). 2015. Environmental Assessment Barrick Cortez Inc. (NVN-067575 [14-1A]) Amendment 3 to Plan of Operations and Reclamation Permit Application. Battle Mountain District Office, Mount Lewis Field Office, Battle Mountain, Nevada. July 2015.

Bureau of Land Management (BLM). 2014. Environmental Assessment for Barrick Cortez Inc. (NVN-67575 [11-3A]) 2011 Amendment to Plan of Operations and Reclamation Permit Application Proposed North Waste Rock Facility Realignment/Rangeland Fence Addition/Stockpile Relocation/Ancillary Addition. Battle Mountain District, Mount Lewis Field Office, Battle Mountain, Nevada. February 2014.

Bureau of Land Management (BLM). 2008a. Cortez Hills Expansion Project Final Impact Statement. Battle Mountain District Office, Battle Mountain, Nevada. September 2008.

Bureau of Land Management (BLM). 2008b. Cortez Hills Expansion Project Record of Decision and Plan of Operations Amendment Approval. BLM Battle Mountain District, Battle Mountain, Nevada. November 2008.

Bureau of Land Management (BLM). 2006. Cortez Mine Underground Exploration Project Environmental Assessment. Battle Mountain Field Office, Battle Mountain, Nevada. February 2006.

Bureau of Land Management (BLM). 2004. Pipeline/South Pipeline Pit Expansion Project Final Supplemental Environmental Impact Statement. NVN-067575(01-1A); NV063-EIS01-70. Battle Mountain Field Office, Battle Mountain, Nevada. December 2004.

Bureau of Land Management (BLM). 2000. South Pipeline Project Final Environmental Impact Statement. NV64-93-001P(96-2A); NV063-EIS98-014. Battle Mountain Field Office, Battle Mountain, Nevada. February 2000.

Bureau of Land Management (BLM). 1996. Cortez Pipeline Gold Deposit Final Environmental Impact Statement - Volume 1. U.S. Department of the Interior, Bureau of Land Management, Battle Mountain District, Shoshone - Eureka Resource Area. January 1996.

Bureau of Land Management (BLM). 1994. Cortez Pipeline Gold Deposit Draft Environmental Impact Statement. Battle Mountain District. Shoshone-Eureka Resource Area, Battle Mountain, Nevada. July 1994.

Cortez Gold Mines (CGM). 2005. Monitoring Plan for Ground Subsidence and Related Earth Fissure Development near the Pipeline Mine. Unpublished report submitted to BLM. July 7, 2005. In: Bureau of Land Management (BLM). 2008. Cortez Hills Expansion Project Final Impact Statement. Battle Mountain District Office, Battle Mountain, Nevada. September 2008.

Crafford, A. E J. 2007. Geologic Map of Nevada: U.S. Geological Survey Data Series 249.

Dohrenwend, J. C. and B. C. Moring. 1991. Reconnaissance Photogeologic Map of Young Faults in the Winnemucca 1º by 2º Quadrangle, Nevada. U.S. Geological Survey Miscellaneous Field Studies Map MF-2175, 1:250,000.

Dohrenwend, J. C., B. A. Schell, C. M. Menges, B. C. Moring, and M. A. McKittrick. 1995. Reconnaissance Photogeologic Map of Young (Quaternary and Late Tertiary) Faults in Nevada. USGS Open-File Report 95-xxxl, 38:1 sheet at scale 1:1,000,000. In: Bureau of Land Management (BLM). 2008a. Cortez Hills Expansion Project Final Impact Statement. Battle Mountain District Office, Battle Mountain, Nevada. September 2008.

Foo, S. T., R. C. Hays, Jr., and J. K. McCormack. 1996. Geology and Mineralization of the South Pipeline Gold Deposit, Lander County, Nevada. In: A. R. Coyner, and P. L. Fahey, editors. Geology and Ore Deposits of the American Cordillera: Reno, Geological Society of Nevada Symposium 1995 Proceedings, p. 95-109. In: Bureau of Land Management (BLM). 2008a. Cortez Hills Expansion Project Final Impact Statement. Battle Mountain District Office, Battle Mountain, Nevada. September 2008.

Garside, L. J., R. H. Hess, K. L. Fleming, and B. S. Weimer. 1988. Oil and Gas Developments in Nevada. Nevada Bureau of Mines and Geology Bulletin 104. 8 pp.

Geomega Inc. (Geomega). 2006. Cortez Hills Expansion Project Baseline Characterization Report. In: Bureau of Land Management (BLM). 2008. Cortez Hills Expansion Project Final Impact Statement. Battle Mountain District Office, Battle Mountain, Nevada. September 2008.

Gilluly, J. and H. Masursky. 1965. Geology of the Cortez Quadrangle Nevada. U.S. Geological Survey 24 Bulletin 1175. 117 p.

Heilweil, V. M. and L. E. Brooks, editors. 2011. Conceptual Model of the Great Basin Carbonate and Alluvial Aquifer System: U.S. Geological Survey Scientific Investigations Report 2010-5193. 191 p.

Itasca Denver, Inc. (Itasca). 2016. Barrick Cortez Four-Basin (Carico Lake Valley, Crescent Valley, Grass Valley, and Pine Valley) Groundwater Flow Model Report. January 2016.

McCormack, J. C. and R. C. Hays. 1996. Crescent Valley: A Model for Reconstruction of District Mineralization in the Basin and Range. In: A. R. Coyner, and P. L. Fahey, editors. Geology and Ore Deposits of the American Cordillera: Reno, Geological Society of Nevada Symposium 1995 Proceedings, p. 635-646. In: Bureau of Land Management (BLM). 2008a. Cortez Hills Expansion Project Final Impact Statement. Battle Mountain District Office, Battle Mountain, Nevada. September 2008.

Muffler, L. J. P. 1964. Geology of the Frenchie Creek Quadrangle North-Central Nevada. U.S. Geological Survey Bulletin 1179. 99 p.

Piteau Associates USA, Ltd. 2016a. Memorandum: Stability Analysis Results for the Post-Closure Cortez Hills East Wall. March 22, 2016.

Piteau Associates USA, Ltd. 2016b. Memorandum: Slope Stability Assessment – Pipeline and CHOP Waste Rock Facilities. February 2, 2016, revised May 6, 2016.

Poland, J. F. 1984. Guidebook to Studies of Land Subsidence Due to Ground-water Withdrawal. Prepared for the International Hydrological Programme, Working Group 8.4. UNESCO Studies and Reports in Hydrology.

Roberts, R. J., K. M. Montgomery, and R. E. Lehner. 1967. Geology and Mineral Resources of Eureka County, Nevada. Prepared cooperatively by the United States Geological Survey. Nevada Bureau of Mines and Geology Bulletin 64. 152 p.

Siskind. D. E., M. S. Stagg, J. W.Kopp, and C. H. Dowding. 1980. Structure Response and Damage Produced by Ground Vibration from Surface Mine Blasting. Bureau of Mines. Report of Investigations 8507.

SRK Consulting, Inc. (SRK). 2017a. Deep South Expansion Project – Cumulative Effects, Subsidence Report. Prepared for Barrick Cortez Inc. March 2017.

SRK Consulting, Inc. (SRK). 2017b. Deep South Expansion Project – Cumulative Effects, Groundwater Flow Modeling Report. Prepared for Barrick Cortez Inc. March 2017.

SRK Consulting Inc. (SRK). 2016a. Technical Memorandum: Results of Land Subsidence Predictions in Pipeline and Cortez/Cortez Hills Complexes for the Deep South Expansion Project. August 2016.

SRK Consulting, Inc. 2016b. Groundwater Flow Model Report Deep South Expansion Project Crescent Valley, Nevada. Prepared for Barrick Cortez, Inc. August 2016.

SRK Consulting, Inc. (SRK). 2016c. Cortez Hills Underground Mine Closure Plan. Prepared for Barrick Cortez, Inc. December 2016.

Stewart, J. H. 1980. Geology of Nevada: A Discussion to Accompany the Geologic Map of Nevada. Prepared in cooperation with the United States Geological Survey. Nevada Bureau of Mines and Geology Special Publication 4. 136 p.

Stewart, J. H. and E. H. McKee. 1977. Geology and Mineral Deposits of Lander County, Nevada, Part 1, Geology. Prepared in cooperation with the United States Geological Survey. Nevada Bureau of Mines and Geology Bulletin 88. 106 p.

U.S. Geological Survey (USGS). 2018. Earthquake Hazards Program – Search Earthquake Catalog. Internet website: https://earthquake.usgs.gov/earthquakes/search/. Accessed June 4, 2018.

U.S. Geological Survey (USGS). 2017. Mineral Resources Data System (MRDS), Online spatial data system accessed to review available geologic and mineral data online for the Gold Acres (ID 10310461), Pipeline/South Pipeline (ID 10310340), and Cortez Mine (ID 10310410) Deposits. Internet website: https://mrdata.usgs.gov/mrds/. Accessed August 10, 2017.