Comparison of Predicted and Actual Water Quality at Hardrock Mines

The reliability of predictions in Environmental Impact Statements

APPENDIX B

CONTENTS

1 GREENS CREEK, ALASKA

1.1 GENERAL INFORMATION

Location: Tongass National Forest – Chatham Area, AK
Ownership: Kennecott Minerals (70%), Hecla Mining Co (30%)
Commodity: Gold, Silver, Lead, Zinc
Operation Type: Underground, Floatation Gravity
Years of Operation: 1984 to present
Jurisdiction: U. S. Forest Service
Disturbed Acres: 170
Bond Amount: $26,170,000
NEPA Documents Available: 1983 EIS (New Project), 1988 EA (General Operations Changes), 1992 EA (Waste Rock Expansion), 2003 EIS (Tailings Disposal)

1.2 WATER QUALITY SUMMARY

Water quality monitoring has been conducted in the mine project area since 1978. In the 1983 EIS, they acknowledged the potential for degradation of surface and/or groundwater through acid mine drainage, heavy metal and trace element leachates, based on the richly mineralized ore body containing various sulfide bearing minerals. They predicted insignificant water quality impacts based on high dilution ratios in Greens Creek and at the Chatham Strait marine discharge site. In 1988, further testing of tailings and waste rock were conducted. Results indicated that parts of the ore body were confirmed acid producers, but the tailings samples indicated low acid production and leaching potential. Mitigations to prevent acid generation of tailings includes grading, compacting and sealing the dry tailings to reduce water percolation through the tailings pile; contouring the surface and constructing surface drainage interception ditches; and finally, sealing with soil and revegetating. The addition of chemical buffering agents and segregation of high sulfur bearing tailings would be employed if necessary. In 1992, they conducted leach tests on waste rock and determined again that the waste rock was not expected to generate acidic leachate. Zinc is the major element of concern and they are employing ion exchange treatment to reduce metals levels before seepage water from springs enters the sediment pond. They again predicted that adverse effects from seepage would be low because of the diversion of seeps around the waste rock pile and the lack of oxygen within the waste rock pile. In the 2003 EIS, they did more extensive geochemical testing and modeling of tailings and waste rock. Results of the "Mass Load" Predictive Model, predicted that the tailings would remain alkaline for at least 500 years, but Static test results found that acid production in tailings would occur between 10 – 30 years and Intrinsic Oxidation Rate and Kinetic tests found that it would take about 25 years for the ANP to be depleted in part of the tailings. IOR test determined that tailings acidification risk would be minimal, however, "the data upon which this analysis is based are variable, and the underlying assumptions have a high degree of uncertainty making this estimate subject to error." Based on the results of the Static, Kinetic, and IOR tests, they predict that they will have 10 – 30 years before acid generation within the tailings impoundment, which would provide ample time for application of site closure technologies to mitigate the acid drainage risk.

Info from the EIS's for the above paragraph and their references:

1983 EIS: This project has the potential for degradation of surface and/or groundwater through acid mine drainage, heavy metal and trace element leachates, but no mention of any geochemical testing was found in the document (iii) (1-7). Orebody is a small, richly mineralized, silver-gold-lead-zinc-copper deposit hosted in sedimentary rocks of marine origin. Main metal-bearing minerals include: pyrite, sphalerite, galena, chalcopyrite, and tetrahedrite tennantite series, and native gold (3-32). Impacts to groundwater would be insignificant. Some minor amounts of groundwater might originate from the mine area wastepiles. This groundwater would have increased concentrations of TDS and sulfate, but effects on Greens Creek would not be measurable due to high dilution ratios (greater than 1:68) (4-5). Effects of the Chatham Strait discharge location on marine water quality is considered to be insignificant

(4-37). Because of the stable chemical nature of the tailings, it was estimated that no significant increase in levels of metal ions would occur (4-4, refers to FEIS 1983 pg 4-24)

1988 EA: Tests included total sulfur, sulfide sulfur determinations, static tests and column leach tests (4-9). Results of acidification tests indicated that the Black and White Orebody components did not have acid production potential while the Massive component was a confirmed acid producer. The tailings sample was not found to have acid production potential (4-3). Preliminary tests carried out on representative tailings samples indicate that acid production and acid leaching potential are low. Mitigations to prevent acid generation of tailings includes grading, compacting and sealing the dry tailings to reduce water percolation through the tailings pile; and contouring the surface and constructing surface drainage interception ditches; and finally, sealing with soil and revegetating (4-9). If additional leach testing of mill tailings or tailings pile seepage water monitoring indicates that the tailings pile could become acidic, more intensive mitigation measures such as addition of chemical buffering agents and segregation of high sulfur bearing tailings would be employed (4-9, 4-10).

1992 EA: Preliminary leach test findings indicate that a small portion of the waste rock has a slight potential to generate acid, however a greater portion has an alkaline neutralization potential. Net effect is that the waste rock is not expected to generate acidic leachate (54). Water quality monitoring has been conducted in the mine project area since 1978. Zinc is the primary metal of concern, because it is the metal seen in the highest concentrations (56). The potential for infiltration through waste rock sites to affect groundwater after closure of waste rock disposal sites would be low due to low permeability after capping and revegetation (66). Construction of a wastewater treatment plant for destruction of cyanide at mill site and wastewater treatment plant in tailings area is underway (49). They are using ion exchange treatment to reduce metals levels before seepage water from springs enters the sediment pond (reported 30% effective in removing Zn) (61). Dissolved zinc or other metals in waste rock site runoff water infiltrating the soil would bind with organic and inorganic components in the soil and would be converted into stable, less harmful inorganic sulfide, oxide, and carbonate compounds by bacterial and chemical actions and would have a low potential to cause adverse effects to groundwater due to their form and immobility. Springs and seeps surfacing directly above or from under a waste rock site are not expected to affect surface or groundwater. In the event that seeps or springs pick up metals or other contaminants from the waste rock, additional water diversion may be required or seepage would be collected and treated to meet applicable discharge permit requirements. The potential for adverse effects from seepage would be low because the diversion of seeps around the waste rock pile and the lack of oxygen within the waste rock pile will not promote metals leaching (66).

2003 EIS: Geochemical tests on samples of phyllite from the mine indicate that these rocks may become acidic after several years of weathering (3-18, 3-19). Third party review of water quality data and waste rock/ tailings management in 1999 – 2000 concluded that no trends in increasing metal and sulfate levels or acidity were evident (3-27). Static ABA test results on tailings indicate that they have the potential to become acidic, however due to the abundance of calcium carbonate and dolomite in the samples, a long period of weathering, an estimated 10 – 33 years would have to occur prior to development of acidic conditions, which would provide ample time for application f site closure technologies to mitigate the acid drainage risk (Appendix A, pg 24). Intrinsic Oxidation Rate analysis predicts that during the operating period, the ANP would be fully dissolved in a portion of the tailings after about 25 years, which is consistent with the lag time predicted from kinetic tests. Initial occurrence of acidity would likely be confined to a thin upper veneer of material, and would not be expected to change the pH of tailings seepage and therefore the tailings acidification risk is considered minimal. The analysis of kinetics of pyrite oxidation in the Kennecott tailings suggests that enough ANP will be retained even in the surficial tailings to maintain neutral pH for hundreds of years after closure. Intrinsic Oxidation Rate test determined that tailings acidification risk would be minimal, however, the data upon which this analysis is based are variable, and the underlying assumptions have a high degree of uncertainty making this estimate subject to error (Appendix A, pg 30). Based on model assumptions, the tailings are expected to remain alkaline for at least 500 years (Appendix A, pg 85).

1.3 EIS SUMMARY

1.3.1 1983 EIS Summary

Geology/Mineralization: Weakly metamorphosed equivalents of shale, siltstone, limestone, and abundant volcanic products underly the project area. These are overlain by younger unconsolidated alluvium, glacial debris, clays, and talus. Orebody is a small, richly mineralized, silver-gold-lead-zinc-copper deposit hosted in sedimentary rocks of marine origin. Main metal-bearing minerals include: pyrite, sphalerite, galena, chalcopyrite, and tetrahedrite tennantite series, and native gold.
Climate: Coastal Marine
Annual Precipitation/ Evaporation:
Proximity to Surface Water: Two small drainages flow through the Mine Service Area.
Proximity to Groundwater: Groundwater exists near ground surface. Relatively small quantities of groundwater exist in bedrock formations. There is no regional aquifer system in mining area. Large quantities of shallow groundwater are present in the lower elevation muskeg areas due to high precipitation and slow drainage due to silty clay layer under muskegs.
Predictive Tests and Models:
Constituents of Concern:
Acid Drainage and Metal Leaching Potential: This project has the potential for degradation of surface and/or groundwater through acid mine drainage and through heavy metal and trace element leachates, and the addition of reagent chemicals.
Water-Quality Impact Potential:
Mitigations: Precipitation, runoff, and snowmelt on the mine service area and mine portal areas would be intercepted, collected and directed to the tailings pond for treatment and eventual marine disposal. Tailings ponds engineered to withstand 100 yr/180 day storm events.
Predicted Water-Quality Impacts: Impacts to groundwater would be insignificant. Some minor amounts of groundwater might originate from the mine area wastepiles. This groundwater would have increased concentrations of TDS and sulfate, but effects on Greens Creek would not be measurable due to high dilution ratios (greater than 1:68). No significant impacts predicted for development of mine services area, mill, cannery, or seepage from Cannery Muskeg tailings pond due to extremely low seepage rates. Increases in stream temperature can be expected in Streams 1 and 2 (in Mine Service Area) during low flows of July and August and a slight temperature increase may be observed in upper Greens Creek near the project area, however, it would be expected to recover quickly and not cause a significant impact. Effects of the Chatham Strait discharge location on marine water quality is considered to be insignificant. During construction, overflow from the sedimentation pond would be discharged into Greens Creek.

1.3.2 1988 EA SUMMARY

Geology/Mineralization:
Climate:
Annual Precipitation/ Evaporation:
Koppen Classification: Region – C, **Temperature –** b, **Precipitation** - f
Proximity to Surface Water:
Proximity to Groundwater:
Predictive Tests and Models: Acidification tests performed by B.C. Research 1982. Tests included total sulfur assays, sulfide sulfur determinations, modified biological tests and column leach tests.
Constituents of Concern:
Acid Drainage and Metal Leaching Potential: Results of acidification tests indicated that the Black and White Orebody components did not have acid production potential while the Massive component was a confirmed acid producer. The tailings sample was not found to have acid production potential. The acid leaching potential is low.
Water-Quality Impact Potential:
Mitigations:

Predicted Water-Quality Impacts: Because of the stable chemical nature of the tailings, it was estimated that no significant increase in levels of metal ions would occur.

1.3.3 1992 EA SUMMARY

Geology/Mineralization:
Climate:
Annual Precipitation/ Evaporation:
Proximity to Surface Water:
Proximity to Groundwater: Water at soil surface in low lying areas, and varying in depth up to 50 feet at site 15E water quality monitoring well.
Predictive Tests and Models: Standard Method 1312 Synthetic Precipitation Leach Test. Infiltration test conducted on waste rock piles.
Constituents of Concern: Zinc is the primary metal of concern. Lead, Copper, Nickel and Manganese also mentioned.
Acid Drainage and Metal Leaching Potential: Preliminary leach test findings indicate that a small portion of the waste rock has a slight potential to generate acid, however a greater portion has an alkaline neutralization potential. Net effect is that the waste rock is not expected to generate acidic leachate. Leach test concentrations of Zn ranged from 0.5 to 1.3 mg/L compared to an average of 1.65 mg/L at Waste area monitoring site. Other metal concentrations were low in the test sources.
Water-Quality Impact Potential: The potential for infiltration through waste rock sites to affect groundwater after closure of waste rock disposal sites would be low due to low permeability after capping and revegetation.
Mitigations: Sediment settling ponds would be used as the primary means to treat runoff collected from the site before it is discharged. Wastewater treatment plant is being used for destruction of cyanide at the mill site and wastewater treatment plant in the tailings area. Ion exchange treatment is being used to reduce metals levels before seepage water from springs enters the sediment pond (reported 30% effective in removing Zn.
Predicted Water-Quality Impacts: Dissolved zinc or other metals in waste rock site runoff water infiltrating the soil would bind with organic and inorganic components in the soil and would be converted into stable, less harmful inorganic sulfide, oxide, and carbonate compounds by bacterial and chemical actions.

1.3.4 2003 EIS SUMMARY

Geology/Mineralization: The primary rock types include quartz schist, carbon rich argillite, phyllite, each of which contains traces of pyrite. Argillite contains small amounts of pyrite, high volume of dolomite and lesser amounts of calcite but enriched in zinc. Phyllite contains more pyrite than dolomite.
Climate: Coastal Marine
Annual Precipitation/ Evaporation: 53 inches/ low evaporation rate.
Proximity to Surface Water: Since construction of the tailings facility, the headwaters of Tributary Creek are small seeps and numerous small channels flowing through muskeg to the south of the tailings (there is lots of surface water on the site). Treated effluent is discharged directly to Hawk Inlet through a submerged diffuser. Wetlands also exist on the site**.**
Proximity to Groundwater: No known regional aquifer, but there are numerous small-scale aquifers and groundwater flow systems such as manmade fill (tailings), peat, sand and gravel, till and fractured bedrock on the site.
Predictive Tests and Models: Static ABA tests, Shake Flask Tests, paste pH, and Kinetic Column Tests. "Tailings Water Quality (Mass Load*) Predictive Model. Water quality assessment stochastic model was developed specifically for this EIS to predict changes in water chemistry through time based on the conceptual understanding of chemical and physical processes. Stochastic Model also predicts water quantity flowing out of tailings pile and combines with quantity and quality of potential receiving waters to predict resulting water quality.
Constituents of Concern: Zinc is primary element of concern.
Acid Drainage and Metal Leaching Potential: Static testing of Greens Creek deposit tailings indicates there is the potential for acid generation but not for years (10 to 33 yrs) due to abundance of calcium carbonate and dolomite.

Oxidation of tailings may cause some metals contained in the tailings to become soluble, particularly Zn even in alkaline pH, resulting in elevated Zn concentrations in water leaching through of running off tailings.
Water-Quality Impact Potential:
Mitigations: All contact water at the facility is collected and treated in a water treatment facility to remove Zn and other metals. Up-gradient surface water is diverted around the tailings pile. During operations, all contact water will continue to be collected, treated, and discharged into Hawk Inlet under the NPDES permit. They are using alkaline amendments and various polymers as a means of slowing acid generation and metals release in potentially acid generating waste rock.
Predicted Water-Quality Impacts: Given that no water that exceeds AWQS will be discharged from the tailings pile and other parts of the mine are not expected to impact groundwater, and there are no other projects to affect groundwater quality, it is not predicted that there will be cumulative impacts to groundwater quality. Effects on water quality in Hawk Inlet drainage are considered minor (negligible) where tailings effluent is discharged directly (without treatment) to surface water or groundwater without dilution, or diluted (without treatment) with surface water or groundwater prior to discharge to receiving waters. Impacts to surface water quality in the three receiving drainages will be minor… total cumulative impacts to surface water … is predicted to be negligible. Predicted lag time for acid generation in tailings is 20 to 50 years.

1.4 MONITORING AND COMPLIANCE INFORMATION

According to the 1992 EA, actual runoff from the waste rock piles was reported to have an average zinc concentration of 1.65 mg/l.

The hydrology and geochemistry evaluation in the 2003 EIS contains some site water chemistry information that can be used to verify the previous and existing water quality predictions. Tailings facility water had relatively neutral pH (7.8 to 8.0), increased sulfate concentrations (1800 to 2000 mg/l) and low metals concentrations (0.01 mg/l zinc) in the tailings saturated zone. However, underdrain water quality showed some moderate acidity (pH 6.5 to 6.7), generally lower sulfate concentrations (800 to 2000 mg/l) and higher zinc concentrations (1-2 mg/l) and in the tailings unsaturated zone new tailings showed lowered pH (5.8 to 6.6) and increased sulfate (2300 to 2400 mg/l) with higher zinc concentrations (.1 – 3.6 mg/l) and additionally significantly increased copper, lead and selenium. Old unsaturated tailings showed a neutral pH (7.5) but high concentrations of sulfate (17,000 mg/l) along with increased concentrations of metals (zinc and magnesium).

According to the 2003 EIS, groundwater quality monitoring wells monitored from 1988 to 2000 have not indicated increasing metal and sulfate levels or acidity so far, although anomalously high sulfate concentrations are noted. Surface water quality monitoring similarly indicates no impacts to surface water quality although some evidence of increased cadmium, copper, mercury and zinc greater than Alaska Water Quality Standards were noted in the late 1980’s and 1990. However, the EIS contradicts itself by acknowledging that lower pH, higher sulfate, and increased zinc concentrations are evident in some smaller streams. The EIS speculates that the increased concentrations are due to high sulfide material (tailings or waste rock) lying outside the tailings pile capture area.

Table 1.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Greens Creek Mine, Alaska.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater and Surface Water	Tailings	• 1983 EIS: Increased concentrations of sulfate and TDS in groundwater but no impact to surface water and marine waters due to mitigation • 1988 EA: Testing indicates no potential for acid drainage • 2003 EIS: Tailings have long-term potential for acid drainage	• 1983 EIS: Surface water and marine water dilution adequate to meet standards • 2003 EIS: acid drainage to be mitigated by short-term capture of tailings solution and long-term by reclamation and closure • grade and cap tailings	• 1983 EIS: No impacts to surface water or marine water predicted • 2003 EIS: No impacts from acid drainage for at least 500 years	• 2003 EIS: Old unsaturated tailings leachate, new tailings leachate, and underdrain water quality all show evidence of acidity and increased sulfate and Zn and in some cases Cu, Pb, Mg and Se • 2003 EIS: Surface water quality monitoring indicates some evidence of lower pH and increased Cd, Cu, Hg, sulfate and Zn due to high sulfide material (tailings or waste rock) lying outside the tailings pile capture area
	Waste Rock	• 1992 EA: Some waste rock has the potential to be acid drainage producing but a greater portion is acid drainage neutralizing, with a prediction of no net acid drainage generation from waste rock. • 1992 EA: Zinc concentrations for waste rock leachate predicted to be high (0.5 – 1.3 mg/l) and other metals concentrations low.	• 1983 EIS: Surface water and marine water dilution adequate to meet standards. • 1992 EA: Mixing of waste rock to neutralize acid drainage potential 2003 EIS: Backfilling of waste rock into underground mine	• 1983 EIS: No impacts to surface water or marine water predicted • 1992 EA: No impacts to surface water or marine water predicted	• 1992 EA: Actual runoff from the waste rock piles was reported to have an average zinc concentration of 1.65 mg/l. • 2003 EIS: lower pH, higher sulfate, and increased zinc concentrations are evident in some smaller streams possibly due to high sulfide material (tailings or waste rock) lying outside the tailings pile capture area

2 BAGDAD, ARIZONA

2.1 GENERAL INFORMATION

Location: Yavapai County, AZ
Ownership: Phelps Dodge Corp.
Commodity: Copper, Molybdenum
Operation Type: Open Pit, Floatation Gravity, Dump Leach
Years of Operation: Historic, still operating
Jurisdiction: Bureau of Land Management
Disturbed Acres: 4,424
Bond Amount: $12,735,170
NEPA Documents Available: 1996 EIS (Expansion)

2.2 WATER QUALITY SUMMARY

The 1986 EIS reports that the majority of rock types on the site are not acid-producing, except for the mineralized ore body. Based on results of geochemical testing (ABA, Total Sulfur and Pyritic Sulfur) there is minimal acid-generating potential from waste rock due to limited volume of pyrite. There is some acid water reported to be entering the pit but they have installed horizontal dewatering wells to limit the quantity of water entering the pit, therefore lowering potential for sulfide ore oxidation. They have reduced the potential adverse impacts to surface water from the tailings impoundment by the design of the tailings facilities and because tailings water is expected evaporate off the surface of the facility. They also plan to use toe channels and underdrains around South waste rock dump to prevent the percolation of surface water through the facility which would minimize infiltration into the aquifer. No water quality impacts are expected as a result of the mitigations.

Info from the EIS's for the above paragraph and their references:

Rock Types: Granodiorite, Quartz Monzonite, Gabbro, Quartz Monzonite Porphyry, Gila Conglomerate, Sanders Basalt, and Alluvium (39-40 and Table 5, pg 42). Oxide and sulfide copper mineralization occurs primarily in the Late Cretaceous quartz monzonite and quartz monzonite ore body (40). Two types of groundwater on site: in fractured bedrock, and in alluvium (49). Ephemeral streams on project site flow only after significant rainfall events (52). Burro Creek has some small perennial reaches (static pools) from surfacing groundwater (52). Estimate the mine is about 2.0 - 2.5 miles from Burro Creek (see map pg 9 and 53). Depth to groundwater ranges from 10-300 ft below ground surface (49). Depth to groundwater is decreasing with pit dewatering by ~400 ft (50). Flow direction is to the west, towards Burro Creek (50). Seeps into pit are due to artesian influence (118). Geochemical tests include ABA, Total Sulfur, and Pyritic Sulfur (Tables 5 and 6, pgs 42, 43). Constituents of concern mentioned include arsenic, fluoride, lead (52) elevated metals and sulfate (118). Majority of rock types are not acid-producing, except mineralized ore body (40, 43 Tables 5, 6). There is minimal acid-generating potential from waste rock due to limited volume of pyrite (119). Majority of exposed rock in pit has low acid-generating potential. Currently, there is very little acid drainage into the pit (52). Potential adverse groundwater impacts from tailings water would be minimal (118). Water chemistry, groundwater conditions upon pit closure detailed in Aquifer Protection Permit Application (Woodward-Clyde Consultants 1995) (119). Potential adverse impacts to surface water are low due to construction design of tailings facilities (119). The majority of the tailings water would evaporate off the surface of the facility (118). Use toe channels and underdrains around South waste rock dump to prevent the percolation of surface water through the facility to minimize infiltration into aquifer (118). Promote surface runoff by using grading and a cap (119). Storm water diversions implemented to reduce pollutant contact (Table 26, pg 138). Horizontal Dewatering Wells limits water quantity entering the pit, therefore lowering potential for sulfide ore oxidation (52). The proposed South waste rock disposal facility is not expected to adversely impact groundwater quality (118). No impacts to water quality of Francis Creek, Burro Creek , or Big Sandy River are expected (Table 26, page 138).

2.3 EIS SUMMARIES

2.3.1 1996 EIS SUMMARY

Geology/Mineralization: Rock Types include Granodiorite, Quartz Monzonite, Gabbro, Quartz Monzonite Porphyry, Gila Conglomerate, Sanders Basalt, and Alluvium. Oxide and sulfide copper mineralization occurs primarily in the Late Cretaceous quartz monzonite and quartz monzonite ore body.
Climate: Arid
Annual Precipitation: 8-10 inches
Koppen Classification: Region – B/C, **Temperature –** a, **Precipitation** - w
Proximity to Surface Water: Two types of groundwater on site: in fractured bedrock, in alluvium. Ephemeral streams on project site flow only after significant rainfall events. Burro Creek has some small perennial reaches (static pools) from surfacing groundwater which is approximately 2 to 2.5 miles from the site.
Proximity to Groundwater: Depth to groundwater ranges from 10-300 feet. Flow direction is to the west, towards Burro Creek. Depth to groundwater is decreasing with pit dewatering by ~400 ft. Seeps into pit are due to artesian influence.
Predictive Tests and Models: Total Sulfur, Pyritic Sulfur, ABA
Constituents of Concern: There are background exceedances of arsenic, fluoride, lead, and elevated metals and sulfate.
Acid Drainage and Metal Leaching Potential: The majority of rock types on the site are not acid-producing, except for the mineralized ore body. There is minimal acid-generating potential from waste rock due to the limited volume of pyrite. The majority of exposed rock in pit has low acid-generating potential. Currently there is very little acid drainage into the pit.
Water-Quality Impact Potential: Potential adverse groundwater impacts from tailings water would be minimal. Potential adverse impacts to surface water are low due to construction design of tailings facilities.
Mitigations: The majority of the tailings water would evaporate off the surface of the facility. Use toe channels and underdrains around South waste rock dump. Horizontal Dewatering Wells limits water quantity, therefore lowering potential for sulfide ore oxidation to prevent the percolation of surface water through the facility to minimize infiltration into aquifer. Promote surface runoff by using grading and a cap. Stormwater diversions implemented to reduce pollutant contact.
Predicted Water-Quality Impacts: The proposed South Waste Rock disposal facility is not expected to adversely impact groundwater quality. No impacts to water quality of Francis Creek, Burro Creek, or Big Sandy River are expected.

2.4 MONITORING AND COMPLIANCE INFORMATION

Years Monitoring Data Available: 1991 to 2004
Number Surface Water Monitoring Locations:
Number Groundwater Monitoring Locations: No information obtained.
Baseline Water Quality:
Violations:.

- **Possible Mining-Related Exceedences (*** *denotes samples exceeding relevant standards)*

Surface Water Monitoring Sites-

- In May-June of 1991, a Cypress-Bagdad tailings impoundment failed and discharged to Copper Creek. Contamination with mercury, phenolics, ammonia, copper, and a low pH occurred in Boulder and Copper Creeks, resulting in a fish kill. Boulder Creek was diverted around the spill, and Cypress Bagdad cleaned up the contamination.
- In 1991, samples taken from Boulder Creek in the reach from Wilder-Burro Creek, 360 yards from Copper Creek, exceeded water quality standards for arsenic and mercury. Arsenic concentrations ranged from 0.012-0.017 mg/l, and mercury concentrations were 0.0013 mg/l.
- In 1991, samples taken from the seepage pools below Copper creek, near Boulder Creek in the Wilder-Burro Creek reach, exceeded standards for arsenic, copper , pH, and turbidity. Arsenic concentrations ranged from 0.01-0.67 mg/l.* Copper concentrations ranged from 1.0-17.45 mg/l.*

pH levels ranged from 6.09-6.43 SU.* One sample exceeded for turbidity, with a concentration of 63 NTU.*

- In 1992, arsenic, beryllium, copper, and lead exceeded standards, again in Boulder Creek. Arsenic concentrations ranged from 0.010-15.0 mg/l. Beryllium concentrations ranged from 0.008-0.110 mg/l. Copper concentrations were 0.155 mg/l Lead concentrations were 0.130 mg/l.
- In sediment samples taken in/near Boulder Creek in 1992, arsenic, beryllium, lead, and molybdenum exceeded standards. Arsenic concentrations ranged from 920-2300 mg/kg. Beryllium concentrations ranged from 0.5-3.9 mg/kg. Lead concentrations ranged from 100-1500 mg/kg., and molybdenum concentrations ranged from 200-740 mg/kg.
- From 1998-2002, 43 samples were taken in 24 samplings from Boulder Creek. One of 21 arsenic samples exceeded drinking water standards, with concentrations ranging from 0.01-0.052 mg/l. One of thirteen lead samples exceeded drinking water standards, with concentrations ranging from 0.005-0.034 mg/l. One of 14 mercury samples exceeded aquatic life standards, with concentrations ranging from less than 0.0002-0.0072 mg/l. One of four selenium samples exceeded aquatic life standards, with concentrations ranging from 0.001-0.003 mg/l.
- From 1998-2002, there were 17 sampling events for Burro Creek in the reach from Francis Creek to Boulder Creek. One of 17 samples exceeded the chronic aquatic life standard for copper, with concentrations ranging from 0.01-0.02 mg/l. Mercury also exceeded the aquatic life standard in one of one sampling events, with concentrations ranging from less than 0.0002-0.0005 mg/l.
- From 1998-2002, 51 samples were taken in 18 sampling events in Burro Creek, in the reach from Boulder Creek to Black Canyon. One of 19 samples for turbidity exceeded the standard, with concentrations ranging from 1-65 NTU. Mercury exceeded aquatic life standards in three of three, and two of 26 events, with concentrations from less than 0.0002-0.0008 mg/l.
- From 1998-2000, in Butte Creek, from its headwaters to Boulder Creek, there were eight sampling events. Mercury exceeded aquatic life standards in two of two, and one of seven events, with concentrations ranging from 0.0002-0.001 mg/l. Selenium exceeded aquatic life standards in one of four events, with concentrations ranging from less than 0.001-0.008 mg/l.

From US EPA, 1997: DAMAGE CASES AND ENVIRONMENTAL RELEASES FROM MINES AND MINERAL PROCESSING SITES:

- In May 1991, seepage of pregnant leach solution from the Copper Creek Leaching System was discovered in a receiving pool in Boulder Creek. Studies indicated that instead of being contained by the Copper Creek Flood Basin, the heavily contaminated solution seeped under the dam. The concentration of total copper in samples collected in the pool in Boulder Creek were as high as 76.4 mg/l. Out of 18 samples collected from the pool during the month that the seepage was discovered, every sample exceeded background levels by more than 0.5 mg/l of total copper, the State's Agricultural Livestock Watering Standard for total recoverable copper. No information was available in the files reviewed that clearly documented the source of the infiltration; however, several documents referred to "repairs" to various HDPE liners. It was not clear from information in the files precisely which units were lined, when they were lined, or the capacity or dimensions of the units.
- On March 29, 1993, US EPA issued a Finding of Violation and Order against Cyprus. On September 13, 1996, the US Department of Justice brought civil action against Cyprus for discharging contaminated water in violation of the Clean Water Act and Arizona law. The civil action cited discharges from tailings ponds, pipelines, leach dumps, other facilities, and a sewage treatment plant. The largest discharges cited, however, came from the mine's Copper Creek Leaching Basin. In a Consent Decree, Cyprus agreed to pay a civil penalty totaling $760,000.
- Of 143 samples of water collected from January 1992 until October 1993, all of which were collected from sumps installed in the alluvial gravels of Boulder Creek downgradient from the facility, not one sample showed any elevation above background concentrations of copper. The cutoff wall was credited with reducing total copper concentrations in shallow groundwater 400 feet downgradient of the wall from 7.2 mg/l before the wall was constructed to 0.8 mg/l afterwards. ADEQ personnel concluded in an internal 1995 memorandum that the overall effectiveness of the remedial measures undertaken by Cyprus was amply demonstrated by the consistently low concentrations of copper

measured in sumps downgradient of the wall and the consistently within-standard copper values achieved in the receiving pool. As of November 1996, the available water quality enforcement files did not contain any more information regarding how Cyprus is managing its PLS pond and other structures.

Table 2.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Bagdad Mine, Arizona.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Surface Water	Tailings	1996 EIS: • Potential for acid drainage and other impacts indicated in testing. • Existing water quality does not indicate impacts. • Background water quality indicates natural exceedances.	1996 EIS: • Facility design to prevent groundwater and surface water impacts. o Stormwater diversions o Grade and cap surface o Leachate collection	1996 EIS: • No impacts to water quality of Francis Creek, Burro Creek, or Big Sandy River are predicted.	WQ Monitoring (1998-2002): • Boulder Creek: exceedances for arsenic, lead, mercury, and selenium • Burro Creek: exceedances for copper and mercury Butte Creek: exceedances for mercury and selenium

3 RAY, ARIZONA

3.1 GENERAL INFORMATION

Location: Pinal County, AZ
Ownership: ASARCO
Commodity: Silver, Copper
Operation Type: Open pit, Floatation Gravity, Dump Leach (SXEW)
Years of Operation: Historic, still operating
Jurisdiction: Bureau of Land Management
Disturbed Acres: 6,231
Bond Amount: $784,826
NEPA Documents Available: 1999 EIS (Land Exchange)

3.2 WATER QUALITY SUMMARY

There is no information provided to determine whether acid drainage could potentially be a problem at this site. Nothing in the geology describes the type of deposit, whether it is an oxide or sulfide deposit. They clearly state that "it is not possible at this time to describe specific details concerning water quality impacts because a mine plan has not been developed."

Info from the EIS's for the above paragraph and their references:
Climate is arid and precipitation rates are low (3-2) with depth to groundwater exceeding 200 feet (3-25). Mineral Creek flows through the Ray Mine (3-21) and suffers from a number of elevated constituents (which were not listed), therefore it is substantially impaired for the uses of full body contact, livestock watering and wildlife (3-22, 3-23). It is not possible at this time to describe specific details concerning water quality impacts because a mine plan has not been developed (4-16).

3.3 EIS SUMMARIES

3.3.1 1999 EIS SUMMARY

Geology/Mineralization: The oldest rocks in this region are metamorphic rocks of Precambrian Age Pinal Schist. The Pinal Schist was intruded by Precambrian granite and diabase. Locally, upper Precambrian sedimentary rocks of the Apache Group rest unconformably on the eroded surface of the Pinal Schist. The Apache Group is separated from Paleozoic limestones and quartzites by another erosional surface. During the Laramide, compressional deformation caused folding of strata and basement thrusting in the Ray Complex region. Deformation was accompanied by metamorphism and plutonism associated with the emplacemant of many large porphyry copper deposits. Erosion during the last several million years has exposed the older formation.
Climate: Arid
Annual Precipitation/ Evaporation: 8.4 – 17 inches/
Koppen Classification: **Region –** B/C, **Temperature –** a, **Precipitation –** w
Proximity to Surface Water: Mineral Creek flows through the Ray Mine.
Proximity to Groundwater: Depths to groundwater ranges from approx. 200-400 ft. Casa Grande area showed depths to water ranging from 470-560 ft.
Predictive Tests and Models:
Constituents of Concern: Mineral Creek suffers from a number of elevated constituents (which were not listed), therefore it is substantially impaired for the uses of full body contact, livestock watering and wildlife.
Acid Drainage and Metal Leaching Potential:
Water-Quality Impact Potential:
Mitigations:

Predicted Water-Quality Impacts: It is not possible at this time to describe specific details concerning water quality impacts because a mine plan has not been developed.

3.4 MONITORING AND COMPLIANCE INFORMATION

Years Monitoring Data Available: 1990 to 1994.
Number Surface Water Monitoring Locations:
Number Groundwater Monitoring Locations: No information obtained.
Baseline Water Quality:
Violations:.
Possible Mining-Related Exceedences:
Mine Water Supply Wells:
Groundwater Monitoring Wells:
Surface Water Monitoring Sites:

- Due to a Ray mine spill in 1990, total dissolved solids (1140 mg/l) and copper concentrations exceeded standards in the Gila River, from San Pedro to Mineral Creek, an 18.2-mile stretch of surface water. Heavy rains caused solution ponds, as well as their back up holding ponds, to overflow, causing the release.
- In 1990, a Ray mine spill caused copper to exceed drinking water standards by 8 times in a 14.3 mile reach of the Gila River, from Mineral Creek to the Donnelly Wash. The same 14.3-mile stretch was affected by high arsenic, total dissolved solids, and turbidity. In 1991-1992, the same reach showed elevated copper in the sediment.
- Due to a 1990 Ray Mine spill, a 49.5-mile reach of the Gila River, from Box O Wash to Queen Creek, was impacted, as reflected by TDS concentrations.
- The Ray tailings spill in 1990 affected a 17.3-mile stretch of Mineral Wash, from the headwaters to the Gila River, with copper and ammonia.
- In Mineral Creek, from its headwaters to the Gila River, arsenic, copper, and turbidity exceeded aquatic standards from 1990-1992. Arsenic concentrations ranged from 0.019-0.021 mg/l. Copper concentrations ranged from 0.19-9.24 mg/l. Turbidity measured 850 NTU.
- In 1994, elevated levels of copper and zinc were discovered in sediment in Mineral Creek, from the headwaters to the Gila River.
- An Arizona Department of Environmental Quality (ADEQ) complaint investigation, from 1991-1994 in Mineral Creek, from the headwaters to the Gila River, revealed that at multiple sites sampled around Ray Mine and Gibson Mine, uses were impaired by arsenic, beryllium, copper, low pH, and zinc.
- ADEQ monitoring of Mineral Creek in 1993 showed that, in 11 samples, uses were impaired by copper, beryllium, and turbidity.
- An EPA copper mine study in 1992 showed that 2 sites in Mineral Creek had uses impaired by copper and low pH.

Table 3.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Ray Mine, Arizona.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater and Surface Water	Tailings	1999 EIS: • No information provided	1999 EIS: • All affected water to flow towards the open pit capture zone	1999 EIS: • Impacts to groundwater and surface water predicted, but details cannot be described because a detailed mine plan has not been developed.	WQ Monitoring: • Prior to the 1999 EIS significant impacts to surface water and groundwater were identified as a result of tailings spills, leaking PLS and other sources

4 AMERICAN GIRL, CALIFORNIA

4.1 GENERAL INFORMATION

Location: San Bernardino County
Ownership: Viceroy Gold Corporation (75%) and MK Gold Company (25%)
Commodity: Gold, Silver
Operation Type: Open Pit, heap and vat leach
Years of Operation: 1992 - 2001
Jurisdiction: BLM (3,645 acres) and private land (265 acres)
Disturbed Acres: unknown
Bond Amount: $1,605,000
NEPA Documents Available: 1998 EA/EIR; 1994 EIS/EIR
NPDES Permit: None

4.2 EIS SUMMARIES

4.2.1 1998 EA/EIR

Proposed Project: New Project-Open pit and underground mining, milling, and heap leach processing
Geology/Mineralization: Gold ore is in quartz/magnetite stringers in metasedimentary and igneous rock.
Climate: Arid desert
Annual Precipitation/ Evaporation: Annual precipitation is 3 to 4 inches per year, and evaporation in nearby cities is 100 to 119 inches annually
Koppen Classification: Region – B, **Temperature –** a, **Precipitation –** w
Proximity to Surface Water: All the surface drainages in the area are ephemeral, with flows occurring only during and following major precipitation events.
Proximity to Groundwater: Groundwater in the vicinity of the proposed heap leach pad occurs from 80-240 feet below the ground surface.
Predictive Tests and Models: No field or laboratory tests were performed. A water quantity model was performed to predict the amount of drawdown in the groundwater table.
Constituents of Concern: None identified.
Acid Drainage and Contaminant Leaching Potential: No information was provided on acid drainage potential, contaminant leaching potential, or constituents of concern.
Potential Water-Quality Impacts (before mitigations): A background groundwater quality evaluation showed that TDS, chloride, and fluoride concentrations exceeded drinking water standards. Two potential groundwater impacts were identified: drawdown of groundwater in the alluvial deposits due to withdrawal for operations, which could influence surrounding groundwater users, and groundwater quality influences resulting from the heap leach operations. The proposed mine was determined to have no identifiable impact on surface water resources, because surface waters flows only during major precipitation events.
Mitigations: The heap leach pad will be lined. Ore processing (mill and heap leach) operations will be operated as zero discharge facilities. Inflow of groundwater to mine pits/underground areas will be consumed in zero-discharge project operations (dust control, process water, etc.), which will avoid seepage of contaminated water into groundwater. Diversion ditches above the mining areas will channel water around active mining and waste rock disposal areas. Sediment traps will be installed, if required, during construction.
Predicted Water-Quality Impacts (after mitigations): There should be no impact to groundwater with proper installation and operation of the lined pad facility. Even if leachate from the pad bypasses the liner, groundwater impacts would be minimal, as the leachate would reach the saturated zone after a long travel time, allowing the leachate to be naturally attenuated. The American Girl Canyon Project will have no identifiable impact on groundwater quality, and other alternatives would have no impact as well. The proposed alternative will have no identifiable impact on surface water resources, as surface waters flow only during major precipitation events. In the

underground test adit, the first inflows were encountered at an elevation of about 510 above msl, just above the base of the proposed open pits. Therefore, the pit is not expected to contain permanent water after mining.
Discharges: No information was provided on discharges to groundwater or surface water.

4.2.2 1994 EIS/EIR

Proposed Project: Proposed surface and underground mine
Geology/Mineralization: Mineralization has a strong quartz-magnetite association and is characterized by irregular stringer zones containing the two minerals. High grade zones may occur as semi-massive lenses up to several feet thick. Gold occurs within the magnetite-quartz stringers or is disseminated in the surrounding wall rock.
Climate: Arid desert
Annual Precipitation/ Evaporation: Average on-site precipitation is 2.14 inches, and at Yuma station, annual evaporation is 97.66. No evaporation data were collected on site. Average on-site precipitation is 2.14 inches, and at Yuma station, annual evaporation is 97.66. No evaporation data were collected on site.
Koppen Classification: Region – B, **Temperature –** a, **Precipitation –** w
Proximity to Surface Water: All surface drainages in the area are ephemeral. Flash flooding and sediment-laden flow are common and result in shifting of drainage channel positions.
Proximity to Groundwater: Groundwater in the vicinity of the proposed project occurs in the alluvium of Tumco and American Girl Washes, and in the unconsolidated deposits underlying Pilot Knob Mesa. The depth to groundwater was variable. The bedrock groundwater table was generally 100 ft deep in the American Girl Wash. Exploration holes drilled to depths of 500-600 ft bgs have significantly lower water levels. Groundwater in the vicinity of the existing leach pad and open-pit occurs at a depth ranging from 35-240 ft bgs. The Padre Madre Wash had drill holes completed to depths of at least 200 ft below the base of the canyon floor and they were dry. Tumco Wash had exploration holes were dry to the 500 ft elevation with some seeps and inflows below this elevation. Water has been encountered in exploration holes at depths of 700 ft. Depths to groundwater in the Pilot Knob Mesa range from 200-400 ft.
Predictive Tests and Models: Geochemical testing of waste materials from the Padre Madre and American Girl Canyon mine operations have shown little potential to generate acid or leach metals or other constituents at concentrations of concern for waste characterization or water quality. Waste Extraction Test (WET) results for the Oro Cruz tailings would be classed as a Class C (inert) waste. The Oro Cruz tailings and spent ore would not be acid generating (total sulfur less than 0.01%). EPA Method 1312 (SPLP) tests showed that the Oro Cruz tailings would not leach metals or other constituents of concern to surface water or groundwater.
Constituents of Concern: None identified.
Acid Drainage and Contaminant Leaching Potential: Due to the degree of oxidation of the ore and waste rock, acid generation would not be significant.
Potential Water-Quality Impacts (before mitigations): The Proposed Oro Cruz operations may impact groundwater by accidental leakage of solutions from the American Girl Canyon heap leach facility. A potential impact of mine waste material and exposed mineralized areas would be the leaching of constituents from these materials into surface water. The depths of open-pit mining in the proposed Cross and Queen pits would generally be above the levels of groundwater encountered in Oro Cruz exploration holes. Groundwater inflows into the mine pits would be non-existent or limited to minor seeps.
Mitigations: Processing facilities would continue to be regulated as a zero discharge site by the RWQCB requirements.
Predicted Water-Quality Impacts (after mitigations): Oro Cruz tailings and spent ore would not leach metals or other constituents of concern for contamination of groundwater. The impact to groundwater quality from the leach pad would not be significant. Surface water quality data are unavailable due to the ephemeral nature of the streams. The impact of Oro Cruz operations on surface water quality would not be significant. The depths of open-pit mining in the proposed Cross and Queen pits would generally be above the levels of groundwater encountered in Oro Cruz exploration holes. Groundwater inflows into the mine pits would be non-existent or limited to minor seeps.
Discharges: No information was provided on discharges to groundwater or surface water.

4.3 MONITORING AND COMPLIANCE INFORMATION

The information on actual water quality conditions was based on a phone call with Michelle Ochs from the Regional Water Quality Control Board (RWQCB) in Palm Desert, California in September 2004. The American Girl Mine has completed mining operations, and the RWQCB rescinded their permit in 2004. The groundwater wells have been abandoned and completely reclaimed after five years of post-closure monitoring (every six months). No water quality problems have been encountered, but after shut down, they had one sampling with elevated copper concentrations in groundwater. The RWQCB required monitoring for an additional five years, and no problems were encountered during this period. Groundwater monitoring was required for TDS, pH, copper, total cyanide, sulfate, arsenic, gold, silver, mercury, iron, nitrate, and selenium.

Table 4.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the American Girl Mine, California.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater	Tailings and Spent Ore	• Accidental leakage of solutions from the American Girl Canyon heap leach facility to groundwater	• Zero-discharge processing facilities	• No leaching of contaminants from spent ore to groundwater. Impact to groundwater from leach pad not significant	• None
Surface Water	Mine waste/ ore/exposed mineralized areas	•Leaching of constituents from mine waste/ exposed mineralized areas to surface water	• Zero-discharge processing facilities	• Impact to surface water quality not significant	• None
Pit Water	Open pit walls	• Groundwater inflows into the mine pits would be non-existent or limited to minor seeps.	• Zero-discharge processing facilities	• Groundwater table below bottom of pits	• None

5 CASTLE MOUNTAIN, CALIFORNIA

5.1 GENERAL INFORMATION

Location: San Bernardino County, California
Ownership: Viceroy Gold Corp. (75%), MK Gold Company (25%)
Commodity: Gold, Silver
Operation Type: Open Pit, heap and vat leach
Years of Operation: 1992 - 2001
Jurisdiction: Bureau of Land Management, Needles District
Disturbed Acres: [3,645 VLM + 265 private total – disturbed acres unknown]
Bond Amount: $ 1,605,000
NEPA Documents Available: 1990 EIS (could not obtain document), 1997 EIS (Expansion)
NPDES Permit: None

5.2 EIS SUMMARIES

5.2.1 1997 EIS/EIR SUMMARY

Proposed Project: Mine Expansion Project-increase area of open pit, create an overburden storage site, expand heap leach pad.
Geology/Mineralization: The Castle Mountains, Piute Range, Hackberry, Woods and Northern York Mountains are extrusive Miocene age volcanic rock with lava flows and pyroclastic volcanic ejecta. The Mid Hills and southern New York Mountains have a Cretaceous age intrusive granitic core. Portions of the northern New York Mountains and Vontrigger Hills consist of metamorphosed pre-Cambrian terrain. Recent alluvium has filled Lanfair Valley...with thicknesses of 550-1000 ft of clay-rich Pleistocene age lacustrine deposits. Interbedded with the lake deposits are locally exposed Pleistocene lava flows. No information on rock or mineral type.
Climate: Arid desert
Annual Precipitation/ Evaporation: 8 – 10 inches/yr
Koppen Classification: Region – B, **Temperature –** a, **Precipitation –** w
Proximity to Surface Water: Streams within the basin are ephemeral, with the exception of Piute Spring which flows perennially. A map showing the site and Piute Spring shows that the spring is several miles from the mine site.
Proximity to Groundwater: Potentiometric surface map indicates that the potentiometric surface is highest near the mountains with a slope that becomes more gradual to the southeast. Depth to groundwater is shallowest in the western recharge portion of the basin and becomes deeper toward the east. The general groundwater flow direction is toward the east-southeast. Depths in monitoring wells in the vicinity of the project area in 1990 (the year of the new project EIS) ranged from ~360 - ~750 feet deep.
Predictive Tests and Models: ABA, EPA Method 1312 (EP Toxicity test).
Constituents of Concern: TDS exceeded standard. No metals exceeded standards.
Acid Drainage and Contaminant Leaching Potential: Both the raw ore and leached ore show little to no potential to generate acid. Existing data indicate little potential for acid-producing conditions. Total sulfur was below detection in the overburden. In raw and leached ore, the NP/AP equaled 2.7 and 8.0 respectively. Soluble metals in the ore and overburden are non detectable for most metals. None of the results exceed California Soluble Threshold Limit Concentrations.
Potential Water-Quality Impacts (before mitigations): Due to low metal concentrations, the extremely dry site environment, and the net neutralizing potential of the ore and waste rock, the geochemistry of materials that would be mined would not pose a threat to surface or groundwater quality. Because of the low soluble metals concentrations and the high NP:AP ratio of ore and overburden that would remain in the mine pit walls, it is expected that the quality of any water that could collect in the mine pits would be good. This water would be suitable for wildlife use.
Mitigations: Lined heap leach pads. Sealed drainage/collection facilities to transport/ contain leaching solution. Diked leach pads to confine and control drainage from the leach piles. Neutralization/ rinsing of heap leach piles and decommissioning/ removal of solution storage facilities at project completion. Leakage detection/ monitoring system

for the leach pads, emergency solution storage and storm water storage basins. If a pit lake forms, it will be monitored monthly for conformation to state/ federal water quality standards. Should any pit lake constituent exceed a federal or state MCL, the pit will be backfilled above the high water level. Construct storage basins with adequate freeboard to preclude entry of storm water into the system.

Predicted Water-Quality Impacts (after mitigations): Due to low metal concentrations, the extremely dry site environment, and the net neutralizing potential of the ore and waste rock, the geochemistry of materials that would be mined would not pose a threat to surface or groundwater quality. Quarterly stream samples taken for water quality analysis show water quality at Piute Spring is consistent. Because of the low soluble metals concentrations and the high NP:AP ratio of ore and overburden that would remain in the mine pit walls, it is expected that the quality of any water that could collect in the mine pits would be good. This water would be suitable for wildlife use.

5.3 MONITORING AND COMPLIANCE INFORMATION

Based on a phone call with Michelle Ochs of the Palm Desert Regional Water Quality Control Board on September 30, 2004, the Castle Mountain, or Viceroy, Mine is in the process of closure and is still monitoring groundwater for TDS, total and free cyanide, and arsenic. Groundwater at the site is approximately 600 ft deep, and there is no surface water near the mine. The Regional Board tests for heap leach impacts to groundwater from the pads and the ponds, with an emphasis on cyanide.

Table 5.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Castle Mountain Mine, California.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater and surface water	Heap leach facility	• No threat to surface water or groundwater quality due to dry site environment and low potential to generate acid and metals	• Lined heap leach pad, leachate collection systems, leach pad dikes; rinsing and neutralization upon closure	• Same as potential	• None to date
Pit Water	Open Pit	• Good pit water quality due to low potential for acid generation and metals leaching; suitable for wildlife use.	• Monitoring; backfilling if standards exceeded	• Same as potential	• None to date

6 JAMESTOWN (CALIFORNIA GOLD PROJECT), CALIFORNIA

6.1 GENERAL INFORMATION

Location: Tuolumne County, California
Ownership: Sonora Mining Corporation
Commodity: Gold
Operation Type: Open pit, vat leach
Years of Operation: 1987 - 1994
Jurisdiction: ??
Disturbed Acres: ??
Bond Amount: $?? (insurance policy is for ~$3,000,000 (RWQCB, 10/04))
NEPA Documents Available: 1983 New Project EIS/EIR, 1986 Supplemental EIS/EIR (not reviewed yet), 1989 Supplemental EIS/EIR (not reviewed yet), 1991 Draft Subsequent (Expansion) EIS/EIR
NPDES Permit: None

6.2 EIS SUMMARIES

6.2.1 1983 EIS/EIR SUMMARY

Proposed Project: Application for a County Surface Mining and Reclamation Conditional use permit.
Geology/Mineralization: Deformed metamorphic sedimentary and volcanic rocks of Paleozoic and Mesozoic age. These include the Calaveras formation of Carboniferous age, the Amador group of late or middle Jurassic age and the Mariposa formation of late Jurassic age. The Mother Lode ore zone is a quartz-rich, mineralized ore zone. Rock units in the mine site area may be generally categorized as a slate assemblage (phyllite) on the Paleozoic age hanging wall and serpentinitic assemblages on the Mesozoic footwall separated by the ore zone. The Punch Bowl tailings site is underlain by the footwall rocks or the Mother Lode, which include igneous gabbro and metasedimentary schists (green schist) and serpentine.
Climate: Arid (warm dry days and relatively cool nights with usually clear skies and very little rainfall in summer).
Annual Precipitation/ Evaporation: Average precipitation is 33 inches (with 90% falling in winter); evaporation exceeds precipitation.
Koppen Classification: Region – C, **Temperature –** a, **Precipitation –** s
Proximity to Surface Water: Woods Creek is a tributary of the Tuolumne River. Woods Creek and Sullivan Creek are the only intermittent to perennial drainages in the project area. The tailings and plant sites are bounded by the Montezuma Ditch (irrigation supply), which flows year-around. Several surface water bodies are located within the tailings site.
Proximity to Groundwater: Depth to groundwater in the project area ranges from 30 to about 200 feet. Bottom of proposed pit will be approx. 200 ft below the channel bed of Woods Creek.
Predictive Tests and Models: Short-term leach test (WET test).
Constituents of Concern: barium, arsenic, chromium (from tailings leachate)
Acid Drainage and Contaminant Leaching Potential: NA
Potential Water-Quality Impacts (before mitigations): *Groundwater* - The most important potential groundwater impact is the long-term migration of leachate generated from the tailings site. *Surface Water* - Dissolved constituents derived from the stockpiles may be passed through the sedimentation ponds and eventually discharge to surface water. Accidental damage to tailings pipe could release chemical constituents (e.g., barium, arsenic, chromium) to surface water. *Pit Water* - Surface mine pits will be allowed fill with water. The precise water quality of these ponds cannot be determined at this time, but would presumably be of similar or lower quality than the pre-mining groundwater due to the effects of oxidation and evaporation.
Mitigations: Tailings embankment designed as zero discharge system but tailings water may potentially seep from the pond into surface water.
Predicted Water-Quality Impacts (after mitigations): Same as potential water quality impacts.

6.2.2 1991 EIS/EIR SUMMARY

Proposed Project: Increase daily ore production rates; mine all four deposits concurrently; deepen the Harvard Pit; eliminate limitations on removal of overburden and aggregate byproducts; add four overburden storage areas, expand one overburden storage area; change the processing reagent from thiourea to cyanide, though no on-site processing has taken place to date; expand the tailings management facility; revise the detention pond designs.
Geology/Mineralization: Deformed metamorphic sedimentary and volcanic rocks of Paleozoic and Mesozoic age. These include the Calaveras formation of Carboniferous age, the Amador group of late or middle Jurassic age and the Mariposa formation of late Jurassic age. The Mother Lode ore zone is a quartz-rich, mineralized ore zone. Rock units in the mine site area may be generally categorized as a slate assemblage (phyllite) on the Paleozoic age hanging wall and serpentinitic assemblages on the Mesozoic footwall separated by the ore zone. The Punch Bowl tailings site is underlain by the footwall rocks or the Mother Lode, which include igneous gabbro and metasedimentary schists (green schist) and serpentine.
Climate: Arid (warm dry days and relatively cool nights with usually clear skies and very little rainfall in summer).
Annual Precipitation/ Evaporation: Average precipitation is 33 inches (with 90% falling in winter); evaporation exceeds precipitation.
Koppen Classification: Region – C, **Temperature –** a, **Precipitation –** s
Proximity to Surface Water: Woods Creek is a tributary of the Tuolumne River. Woods Creek and Sullivan Creek are the only intermittent to perennial drainages in the project area. The tailings and plant sites are bounded by the Montezuma Ditch (irrigation supply), which flows year-around. Several surface water bodies are located within the tailings site.
Proximity to Groundwater: Depth to groundwater in the project area ranges from 30 to about 200 feet. Bottom of proposed pit will be approx. 200 ft below the channel bed of Woods Creek.
Predictive Tests and Models: Short-term leach test **(C**AMWET test) performed on flotation tailings, thiourea tailings, and representative rock and soil samples.
Constituents of Concern: None identified.
Acid Drainage and Contaminant Leaching Potential: Chemical analysis of overburden material indicates that the overburden is non-hazardous, non-toxic, and non-acid generating. CAMWET testing performed on flotation tailings, thiourea tailings, and representative rock and soil samples indicates that the mine tailings will not contain contaminants that need to be controlled.
Potential Water-Quality Impacts (before mitigations): *Groundwater* - Overall groundwater quality may be impacted by to some degree by the quality of water in the abandoned pits. Because of the potentially sediment-laden surface inflows, the exposure of mineralized rock on the mine faces, and the potential effects of evaporation, the impoundment water may contain concentrations of total dissolved solids higher than is currently present in the bedrock groundwater systems. *Surface Water* - Overburden storage areas could potentially impact the quality of surface waters within Woods Creek, its tributaries, and additional streams downgradient. Potential impacts to the quality of adjacent surface water bodies from crushing are considered to be significant. Solution could potentially seep from the tailings facility into the surface water flow. CAMWET testing of soil and rock samples indicate that no contaminants are expected to originate from the overburden and tailings areas that would need to be controlled.
Mitigations: *Groundwater* - Zero discharge tailings embankment. Potential impact of a cyanide discharge can be lowered below a level of significance with the incorporation of a cyanide destruction process and a roughly 20:1 dilution of CIL circuit tailings with flotation tailings. *Surface Water* - Zero discharge tailings embankment. Proper handling and containment of organic reagent used in flotation process, as well as spill prevention, control, and counter measures plan would reduce potential for adverse impacts to the surrounding environment. Erosion control structures for the tailings management facility. All water to be discharged into surface water will be monitored and will meet the acceptable levels of the specified parameters. Cyanide destruction circuit in the mill for the carbon-in-leach process tailings. Monitoring for cyanide in carbon-in-leach circuit tailings prior to discharge to tailings facility.
Predicted Water-Quality Impacts (after mitigations): *Groundwater* - Dewatering operations could potentially impact both mine wells and privately owned wells in the area. Potential groundwater impact is similar to what naturally occurs when groundwater passes through the mineralized zone, and because CAMWET testing on representative rock indicated that there should be no contaminants requiring control, potential impacts to groundwater

are considered to be below a level of significance. *Surface Water* - All water to be discharged into surface water will be monitored and will meet the acceptable levels of the specified parameters.

6.2.3 1985 REPORT OF WASTE DISCHARGE

Mineralization: Hydrothermal solutions have added large volumes of silica and carbonate and minor quantites of sulfides to ultrabasic intrusive rocks, sediments and volcanics. Mineralization occurs in all three lithologies.
Testing:_ Waste Extraction Tests were performed on four samples (ore, thiourea tailings, cyanide tailings, froth flotation tailings). Potential Acidity with Peroxide test, described in EPA 670/274-070, pg 48-49. Neutralization potential was tested using the procedure by Grube, pg 50-51 of the above citation.
Contaminant Leaching Potential: Composite head sample (ore): no exceedences of standards in extract. Sample C (thiourea tailings): Exceedences of As (18 and 19 µg/l). Sample D (cyanide tailings): Exceedences of As (15, 16 µg/l), TDS (551, 550 mg/l). Sample Test #20 Tail (froth flotation tails): 1 exceedence of As (15 µg/l). Generally all concentrations were low.
Acid Drainage Potential: NP/AP ratios: Ore = 6.8, thiourea tailings = 2.8; cyanide tailings = 3.1, froth tails = no acid generated. Additional ore and waste rock samples (one ore and 5 waste rock) all had NP/AP values of 3.5:1 to 47:1.
Zero Discharge Facilities: It is the intent of Sonora Mining Corporation to operate the Jamestown Mine (Harvard and Crystalline pits) as a closed system with the exception of some seasonal surface runoff from the east side of the property which will be closely monitored (1-1).

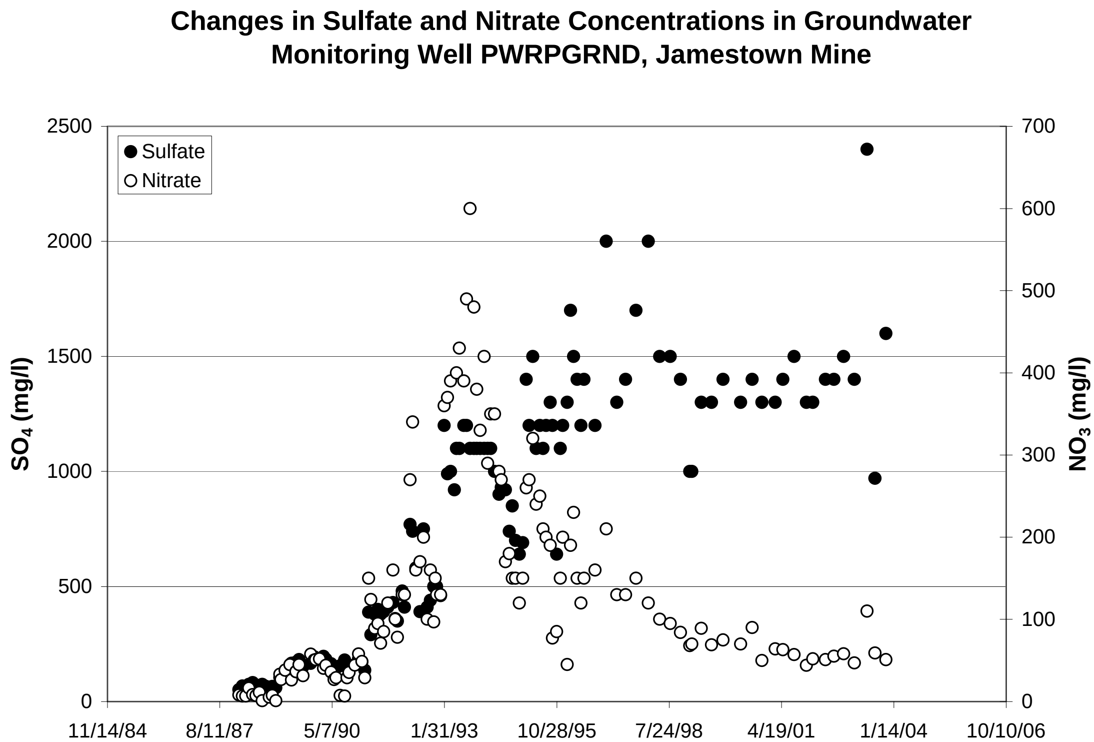
6.3 MONITORING AND COMPLIANCE INFORMATION

Years Monitoring Data Available: January 1988 – May 2003 (Groundwater and pit water)
Number Surface Water Monitoring Locations: 1 open pit location (Harvard Pit); no stream monitoring points available
Number Groundwater Monitoring Locations: 27 locations; depths from 0.77 to 186 ft bgs
Baseline Water Quality: Groundwater monitoring data show that sulfate and nitrate concentrations were low (sulfate ~50-70 mg/l; nitrate <1 mg/l) before mining impacts began
Violations: ~1996/1997 – notice of violation; ~1988, clean up and abatement, then revised and reissued. A list of violations for groundwater affected by the waste rock and tailings management facilities and associated history may be available from the RWQCB in Sacramento.
Lawsuits: (information provided by Mr. Ross Atkinson, RWQCB, in an in-person interview on 10/15/04) Before closure, Sonora Mining Company sold much of the land at the mine to Tuolumne County, and the county indemnified the mine (the city thought it was getting a great deal on a piece of developable property). The county sold the Harvard Pit to an individual (Mr. Wilson), with associated liability. The mine had been paying for insurance to remediate the mine; the insurance was transferred to the city and they cancelled it (~$3 million of insurance). The county had a report of waste discharge performed and assumed that the tailings were level C (inert) wastes (Level A = hazardous waste; Level B = designated waste, which requires placement in a waste management unit; Level C = inert waste, e.g., construction debris), but the tailings and the waste rock were impacting groundwater, so they are group B wastes. The RWQCB said it was not able to reclassify the wastes as class C and asked the county to close the property, and the county said no. The RWQCB wrote orders to Tuolumne County, referred to the attorney general's office, and that then brought in all previous parties, including Sonora Mining Company and foreign companies related to Sonora Mining. The California Regional Board has sued Tuolumne County under the Porter Cologne Act and the California Water Code. The lawsuit was filed in ~1999 and is still ongoing (has not yet gone to trial).
Possible Mining-Related Exceedences:

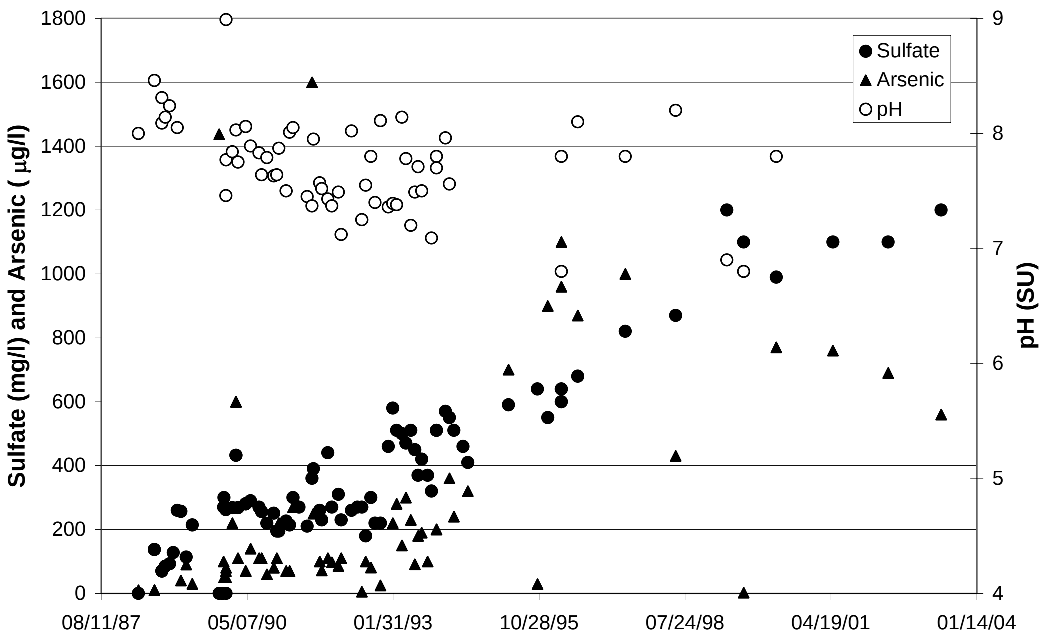
Mine Water Supply Wells: No information obtained/available
Groundwater Monitoring Wells: Exceedences of sulfate, nitrate, and arsenic drinking water standards in some groundwater monitoring wells (sulfate concentrations have been steadily increasing since ~ 1990; nitrate concentrations increased from ~1990 to ~1997 and then decreased) that are downgradient of the waste rock and tailings management facilities (see graphs below).
Open Pit: Sulfate and nitrate concentrations exceed standards in the Harvard Pit (see graphs below).
Surface Water Monitoring Sites: No information obtained/available

Monitoring Comments: Not all constituents identified as constituents of concern (barium, arsenic, chromium - from tailings leachate testing) were determined in groundwater samples. Cyanide was also not determined in groundwater samples.

6.4 GRAPHS OF SELECTED GROUNDWATER AND PIT WATER MONITORING DATA



Changes in Sulfate and Arsenic Concentrations and pH over Time in the Harvard Pit, Jamestown Mine



Changes in Sulfate and Nitrate Concentrations in Monitoring Well RSMW9, Jamestown Mine

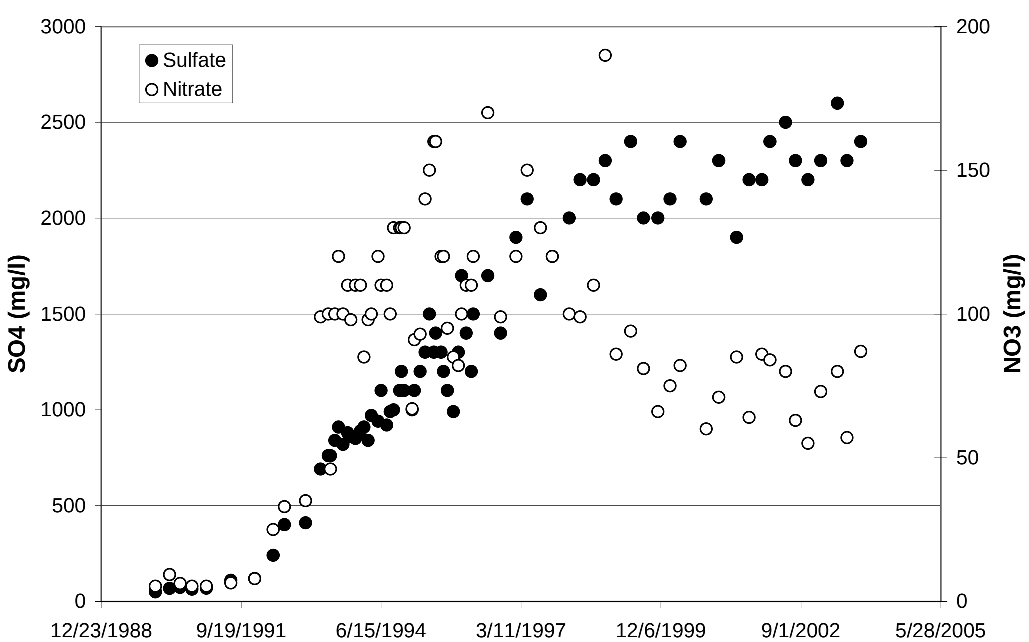


Table 6.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Jamestown Mine, California.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater and Surface Water	Tailings	• 1983 EIS/EIR: migration of leachate identified to groundwater and surface water • 1991 EIS/EIR: Testing indicates no potential for acid drainage or other contaminants • 1991 EIS/EIR: Seepage with high TDS could seep into groundwater and/or surface water	• 1983 EIS/EIR and 1991 EIS/EIR: Facility design to prevent groundwater and surface water impacts. • Embankment design (zero discharge) • Compact tailings subsurface (no liner) • Grade and cap surfaces	• 1983 EIS/EIR: Predicted impacts same as potential impacts • 1991 EIS/EIR: Potential impacts to groundwater and surface water are expected to be insignificant	WQ Monitoring: Groundwater affected by tailings and waste rock and sulfate, nitrate, TDS and arsenic. Concentrations have increased significantly and exceed drinking water standards.
	Waste Rock	• 1983 EIS/EIR: migration of leachate identified to groundwater and surface water via sedimentation ponds • 1983 EIS/EIR: water quality from stockpiles would be of similar or lower quality than the pre-mining groundwater • 1991 EIS/EIR: Testing indicates no potential for acid drainage or other contaminants • 1991 EIS/EIR: Waste rock could affect surface water quality	• 1983 EIS/EIR: No mitigations identified • 1990 EIS/EIR: No mitigations identified		
Groundwater and Pit Water	Open Pit	• 1983 EIS/EIR: water quality in pit ponds would be of similar or lower quality than the pre-mining groundwater • 1991 EIS/EIR: groundwater quality may be impacted by to some degree by the quality of water in the abandoned pits	• 1983 EIS/EIR: No mitigations identified • 1990 EIS/EIR: No mitigations identified	• 1983 EIS/EIR: Predicted impacts same as potential impacts • 1991 EIS/EIR: Potential impacts to groundwater and surface water are expected to be insignificant	WQ Monitoring: Groundwater affected by open pit and sulfate and arsenic. Concentrations have increased significantly and exceed drinking water standards. pH values have decreased from 8.5 to 6.8.

7 MCLAUGHLIN, CALIFORNIA

7.1 GENERAL INFORMATION

Location: Napa, Sonoma, and Yolo Counties, California
Ownership: Homestake Mining Company
Commodity: Gold
Operation Type: Open pit, vat leach
Years of Operation: 1985 - 2002
Jurisdiction: BLM, Ukiah District
Disturbed Acres: 803
Bond Amount: $12,228,964
NEPA Documents Available: 1983 New Project EA/EIR
NPDES Permit: Minor, # CA0081477: 3 locations, recently changed to a general stormwater permit for the mine site.

7.2 EIS SUMMARIES

7.2.1 1983 NEW PROJECT EIS

Proposed Project: Open pit mine, construction of crushing and grinding area, waste rock dump, low grade ore storage area, slurry pipeline, and power lines.
Geology/Mineralization: Marine sediments from the east (Great Valley sequence, including the Knoxville Formation) were placed in contact with the Franciscan Assemblage during subduction, which caused the formation of numerous faults and serpentenite to be exuded along the fault planes.
Climate: No information on general type.
Annual Precipitation/ Evaporation: Annual precipitation is 30 inches.
Koppen Classification: Region – C, **Temperature –** a, **Precipitation –** s.
Proximity to Surface Water: All streams in the project area are intermittent. Distance to perennial surface water bodies is unclear.
Proximity to Groundwater: Groundwater within the bedrock fractures is localized and does not constitute a regional aquifer system. It is found at depths varying from 3.5 feet to over 200 feet below ground surface throughout the project area.
Predictive Tests and Models: Static (similar to NAG – uses hydrogen peroxide) and short-term leach (deionozed water extraction test; California Waste Extraction Procedure), and paste pH. Modeling of impacts to surface water (Hunting Creek) quality (model not specified).
Constituents of Concern: Copper, manganese, total dissolved solids.
Acid Drainage and Contaminant Leaching Potential: Ninety-two% of the waste rock has been determined to be either neutralizing or itself neutral. Comparison of the (tailings) extract analysis concentrations with the health-based Soluble Threshold Limit Concentration (STLC) based on the WET test shows that the estimated concentration of copper exceeds the STLC which could cause the tailings to be considered hazardous. In addition to high copper values, the tailings extract also had lead, arsenic, silver, and cyanide concentrations in excess of water quality standards.
Potential Water-Quality Impacts (before mitigations): *Groundwater* - Permanent degradation of groundwater quality is expected due to tailings seepage. *Surface Water* - There are three types of surface water quality impacts that may potentially occur (from the waste rock dumps): (1) increased sedimentation from runoff, (2) increased total dissolved solids from leachate, and (3) increased heavy metal concentrations from acidic leachate. Potential water quality decreases in Hunting Creek from waste rock leachate. *Pit Water* - Quality of water accumulated in the pit is expected to be of poor quality, with high concentrations of heavy metals and major ions including arsenic, cadmium, iron, lead, manganese, mercury, nickel, boron, sodium, chloride, and sulfate.
Mitigations: *Groundwater* – monitoring. Underdrains for waste rock piles. *Surface Water* - Sediment basins to protect streams and numerous erosion/sedimentation controls. Potentially acid generating rock will be surrounded by

alkaline material during waste rock disposal. Lime will be added to sediment ponds if acidic conditions are encountered during mining. *Pit Water* – None.

Predicted Water-Quality Impacts (after mitigations): *Groundwater* - Proposed tailings facility would allow 40 gpm of seepage to local groundwater underlying the reservoir. This impact would be long term, resulting in permanent degradation of the local groundwater and potentially of the shallow groundwater flowing toward Hunting Creek. Existing groundwater data in the tailings area show poor quality water with long residence times, and very low permeabilities. Therefore, although the proposed action and alternatives would lead to permanent degradation of localized groundwater, local water supply would not be impacted, because the groundwater regime in Quarry Valley has not been found to be connected to a regional aquifer system, and the dam foundation would penetrate to less permeable material. Possible release of TDS from waste rock dump, but it will be collected in the underdrains, the diversion ditches, or in the sediment impoundment. *Surface Water* - Modeling indicated that arsenic, nickel, zinc, silver, iron, and copper concentrations would be lower than drinking water standards in Hunting Creek. Manganese was predicted to slightly exceed its standard. There would be no impact to surface water quality under normal operation of the mill facilities. *Pit Water* - The quality of water accumulated in the pit is expected to be of poor quality, with high concentrations of heavy metals and major ions including arsenic, cadmium, iron, lead, manganese, mercury, nickel, boron, sodium, chloride, and sulfate. Predominance of alkaline producing materials in the rocks would likely produce alkaline pH conditions in the mine pit water and would tend to reduce metals leached from the rocks. Pit water would not reach surface streams, and no impacts on the quality of Hunting, Davis, or Knoxville creeks are anticipated.

7.3 MONITORING AND COMPLIANCE INFORMATION

Years Monitoring Data Available: 1982 to present

Number Surface Water Monitoring Locations: Putah Creek: PC-01, PC-02; Hunting Creek (Hunting Creek is downgradient of West Waste Rock Storage Area and the tailings impoundment): HC-05 (upstream; HC-05R is the NPDES upstream receiving stream monitoring location), HC-09, HC-10 (downstream; HC-10R is the NPDES downstream receiving stream monitoring location), HC-11; Knoxville Creek: KC-03 (downgradient of East Waste Rock Disposal Area and mine); Davis Creek: DC-05, DC-06 (Davis Creek goes through the mine site and is diverted around mining operations).

Number Springs and Seeps Monitoring Sites: Two adits – 1400KA, 1550KA; five springs – 1420BS, 1450BS, 1550KS, 1560KS, 1570KS.

Number Groundwater Monitoring Locations: N-Series Wells (process and tailings impoundment): N-01, N-02, N-02A, N-05, N-06, N-07, N-08A, N-08B, N-09, N-10A, N-11, N-12. S-Series Wells (mine and waste rock area): S-01 (near pit), S-02 (near pit), S-03, S-04, S-05, S-06, S-07, S-08. Davis Creek Reservoir Area: S-10. Waste Rock Underdrain Monitoring and Pump-Back Systems: S-11, S-12, S-13 (these monitor waste rock underdrain flows that are collected and pumped back to the open pit).

Open Pit Monitoring Location: MP-1.

Baseline Water Quality: Hydraulic conductivity is so low and existing water quality is so poor that groundwater on site is considered usable. Waste discharge reports recognized this, and the mine got an exclusion for groundwater on the site. The mine does groundwater monitoring, but enforcement by RWQCB is difficult because of the exclusion (RWQCB, 10/14/04). Baseline water quality data is from 1982 through June 1986. The water quality standards at the site are no increase over background (calculated using water quality data from 1982 through June 1986 – mine evaluates trends compared to baseline concentrations). Precipitation exceeds evaporation at the McLaughlin Mine.

Violations: None. Some "upset events" were reported to RWQCB over the years that most likely related to waste rock or tailings pipes being temporarily broken. If concentrations exceed standards chronically (for long periods of time), an enforcement action is issued, but if not, no enforcement action is issued. The mine has a regulatory exclusion for groundwater at the site, so no groundwater enforcement actions can be brought by RWQCB.

Possible Mining-Related Exceedences: (see graphs below)

Mine Water Supply Wells: NA

Groundwater Monitoring Wells: The N-Series wells (downgradient of tailings impoundment) show increases and exceedences of TDS (see graph: up to 12,000 mg/l), chloride, nitrate (upt o ~37 mg/l), and sulfate from ~1984 to ~1992, with increases of copper (up to 280 µg/l), and other metals during the same period. This period also coincides with lower well water levels. Some of the S-Series wells that are downgradient of waste rock dumps show increasing concentrations of sulfate (in excess of SDWA standards, up to 5,000 mg/l - see graph for well S-06), boron, TDS, calcium, iron, manganese, and other constituents from ~1985 to ~1998. Zinc concentrations increased after this timeframe (up to 1.7 mg/l; see graph for well S-06).

Surface Water Monitoring Sites: Hunting Creek downstream location (HC-10) and Knoxville Creek (KC-03) show exceedences of sulfate (up to ~900 mg/l) that look like they could be related to mine activity (see graphs), but no violations were ever received. Hunting Creek (HC-10 and HC-10R) also shows occasional and sometime large exceedences of arsenic and nickel (up to ~2.5 mg/l, with one peak of 8 mg/l; see graphs), but it is unclear if this is a baseline condition. Occasional large exceedences of zinc, copper, mercury, manganese (up to 0.61 mg/l), lead, iron, chromium, and arsenic occur in a number of these and the other surface water monitoring locations downgradient of the mine. Sulfate in Hunting Creek and shows steady increases after mining began.

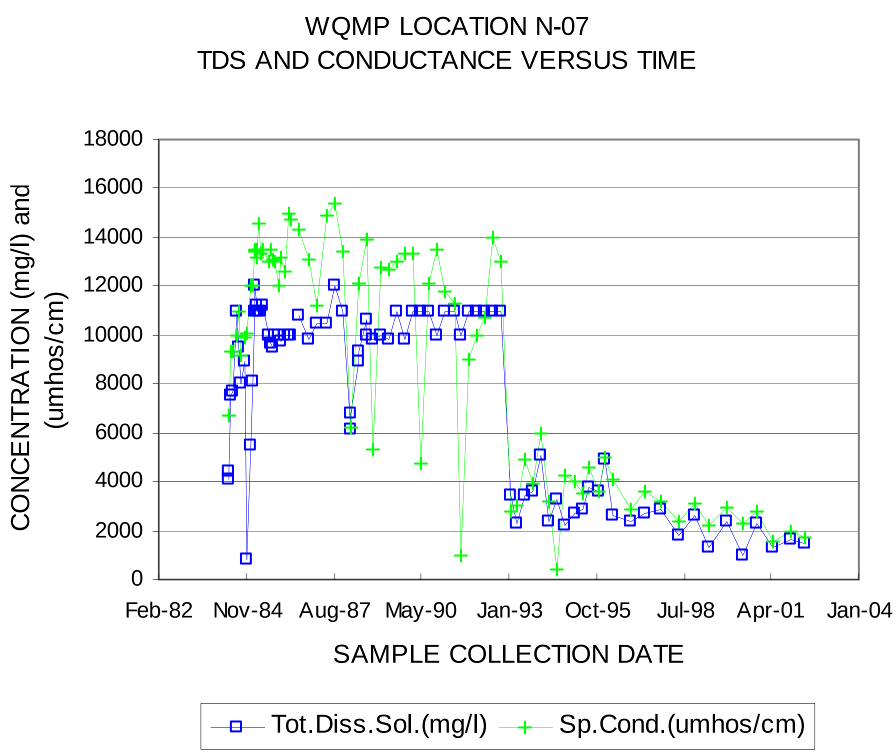
Open-Pit Locations: The open pit also receives pump-back water from the waste rock dumps, so water chemistry may also reflect waste rock drainage/leachate. Only one sample of pit water was available (collected Nov. 2003). Pit water exceeds secondary drinking water standards for pH (5.08), TDS, chloride, sulfate (11,000 mg/l), iron, and manganese (56 mg/l) (see Table B10.1 below). There are also elevated concentrations of boron (15 mg/l), copper, (0.32 mg/l), and zinc (3.3 mg/l). If pit water discharges to surface water, the elevated concentrations of copper, nickel, and zinc could cause exceedences of standards for the protection of aquatic life.

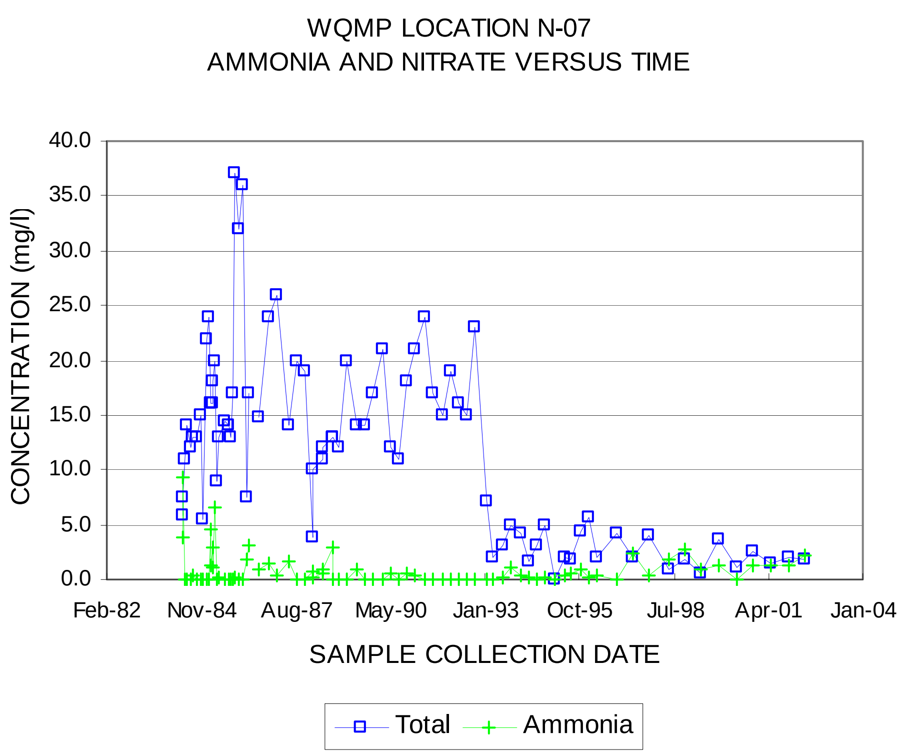
Table 7.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the McLaughlin Mine, California.

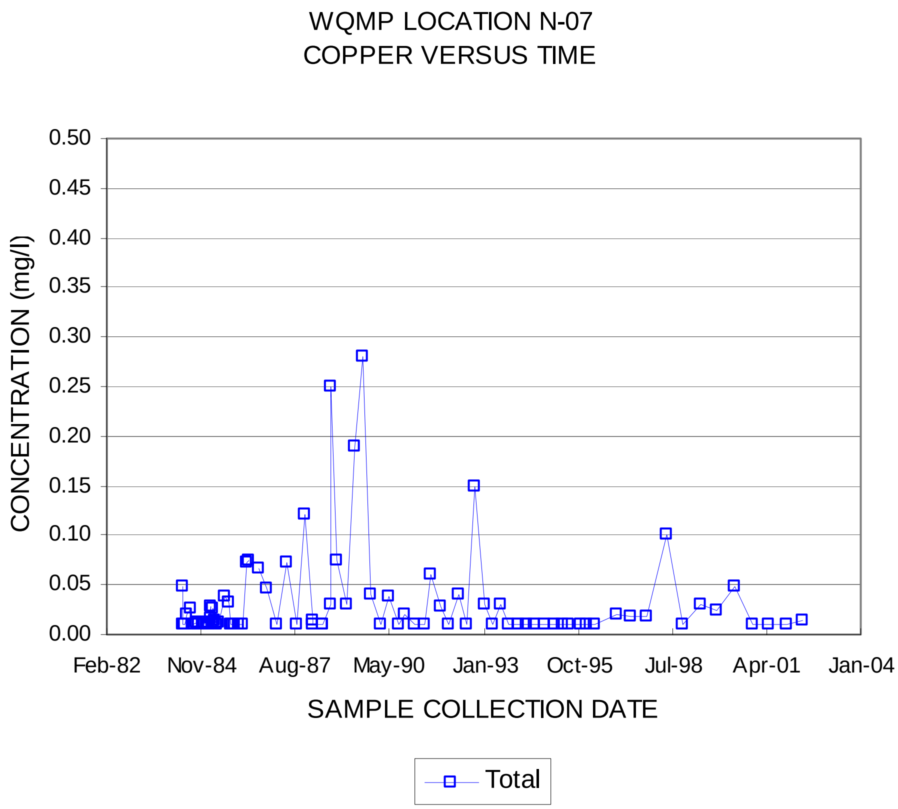
Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater	Tailings	• 1983 EA/EIR: Permanent degradation of groundwater is expected due to tailings seepage	• 1983 EA/EIR: Monitoring only	• 1983 EA/EIR: groundwater will not be impacted outside the existing poor quality confined aquifer	WQ Monitoring: Downgradient wells show increases and exceedances of TDS, Cl, nitrate, and sulfate from ~1984 to ~1992, with increases of Cu, and other metals during the same period
	Waste Rock	• 1983 EA/EIR: Possible release of TDS could occur from waste rock dump	• 1983 EA/EIR: leachate will be collected in the underdrains, the diversion ditches, or in the sediment impoundment. o Segregation and blending of PAG waste rock.	• 1983 EA/EIR: groundwater will not be impacted outside the existing poor quality confined aquifer	• WQ Monitoring: Downgradient wells show increasing concentrations of sulfate (in excess of SDWA standards), B, TDS, Ca, Fe, Mn, and other constituents from ~1985 to ~1998. Zn concentrations increased after 1998
Surface Water	Tailings	• 1983 EA/EIR: no impact to surface water quality	• 1983 EA/EIR: no mitigations identified	• 1983 EA/EIR: no impact to surface water quality	WQ Monitoring: Downstream surface monitoring locations show exceedances of sulfate, and occasionally large exceedances of As, Cr, Cu, Pb, Mn, Hg, Fe, and Zn
	Waste Rock	• 1983 EA/EIR:: surface water quality impacts may potentially occur from waste rock o increased sedimentation from runoff o increased total dissolved solids from leachate o increased heavy metal concentrations from acidic leachate	• 1983 EA/EIR: Lime will be added to sediment ponds if acidic conditions develop o Segregation and blending of PAG waste rock	• 1983 EA/EIR: Manganese was predicted to slightly exceed its standard	
Pit Water	Open Pit	• 1983 EA/EIR: pit is expected to be of poor quality	• 1983 EA/EIR: alkaline pH conditions in the mine pit water and would tend to reduce metals leached	• 1983 EA/EIR: pit water not expected to reach surface streams	WQ Monitoring: Pit water exceeds secondary drinking water standards for pH (low), TDS, Cl, sulfate, Fe and Mn

7.4 GRAPHS OF SELECTED WATER QUALITY MONITORING RESULTS FOR GROUNDWATER AND SURFACE WATER

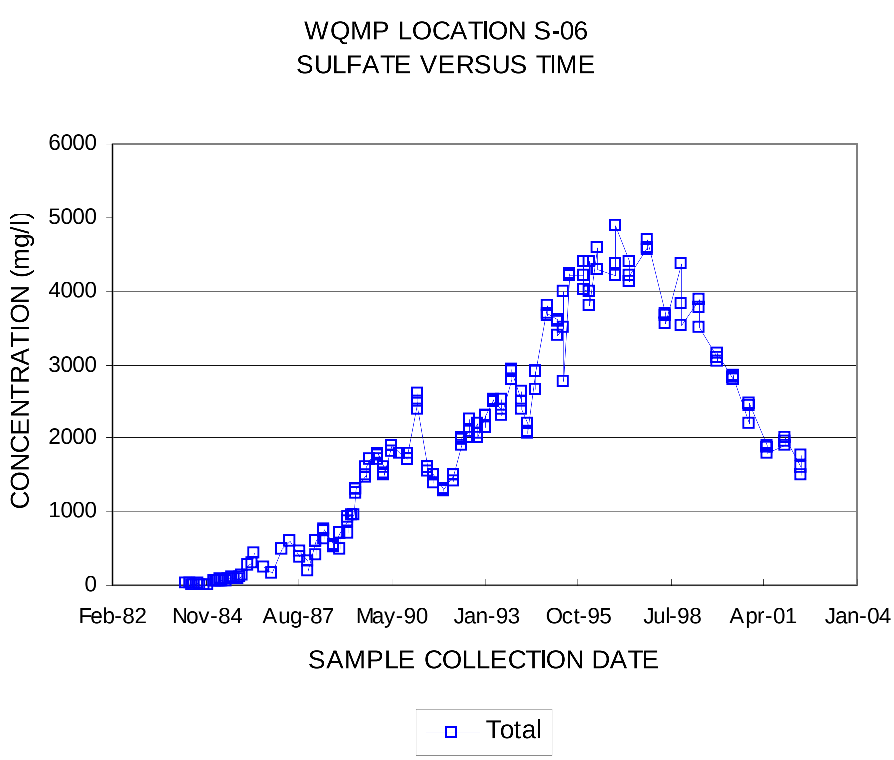
Process and Tailings Impoundment Monitoring Wells:

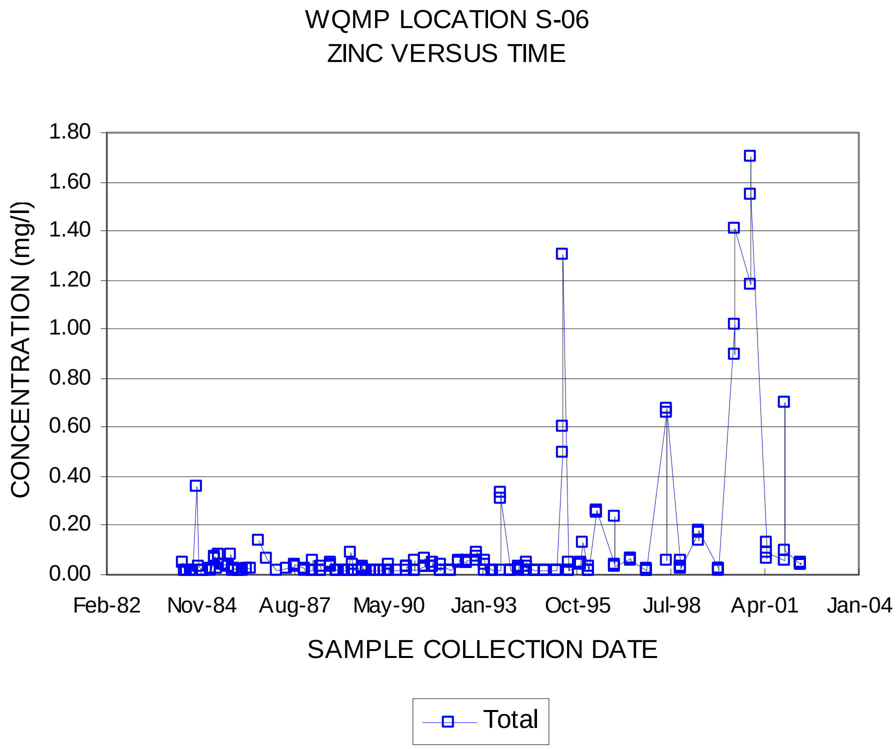




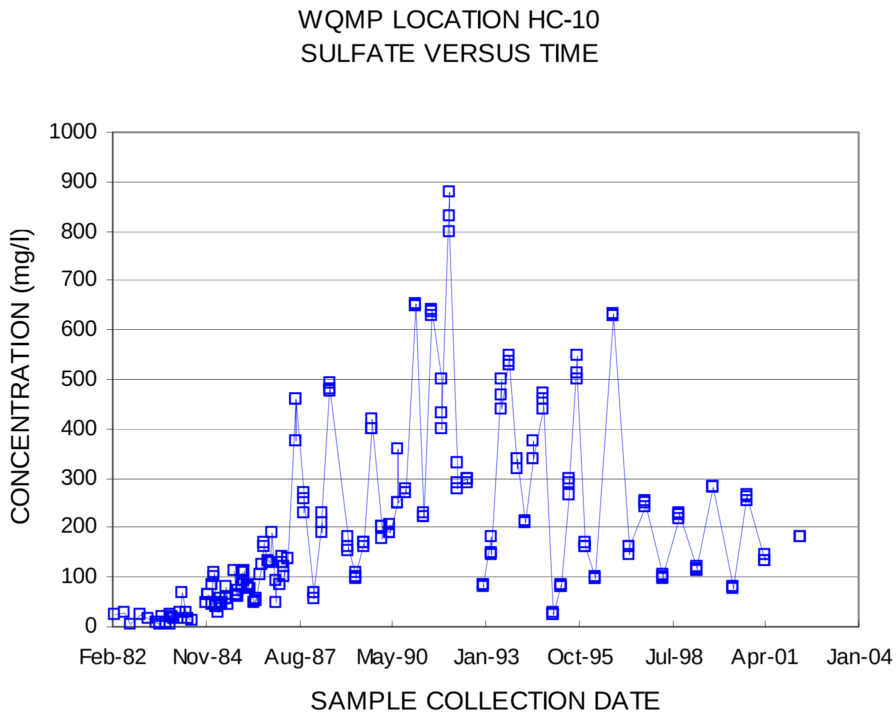


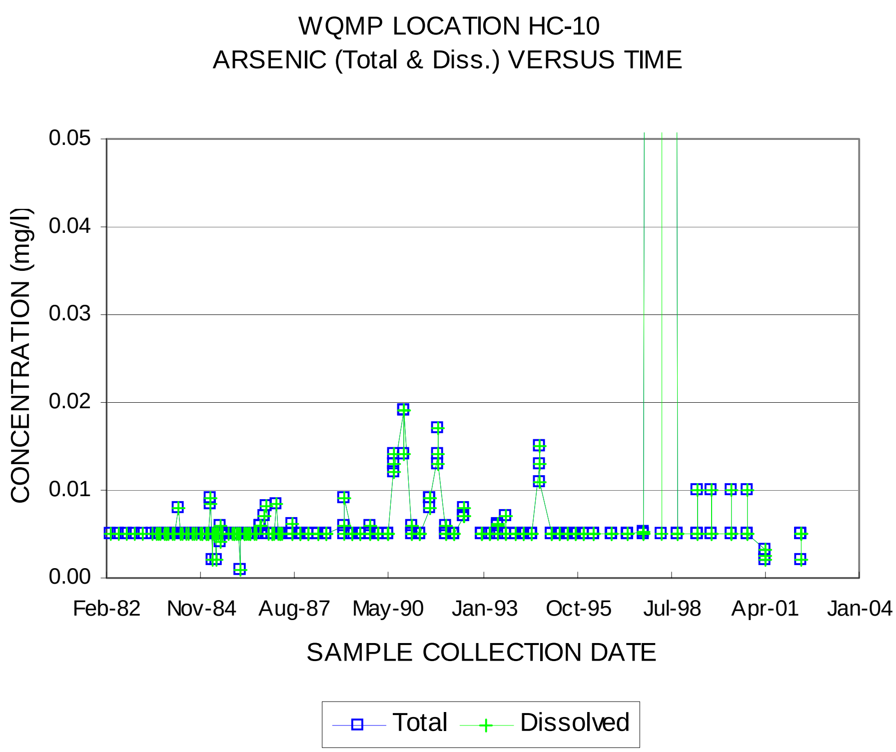
Waste Rock Monitoring Wells:

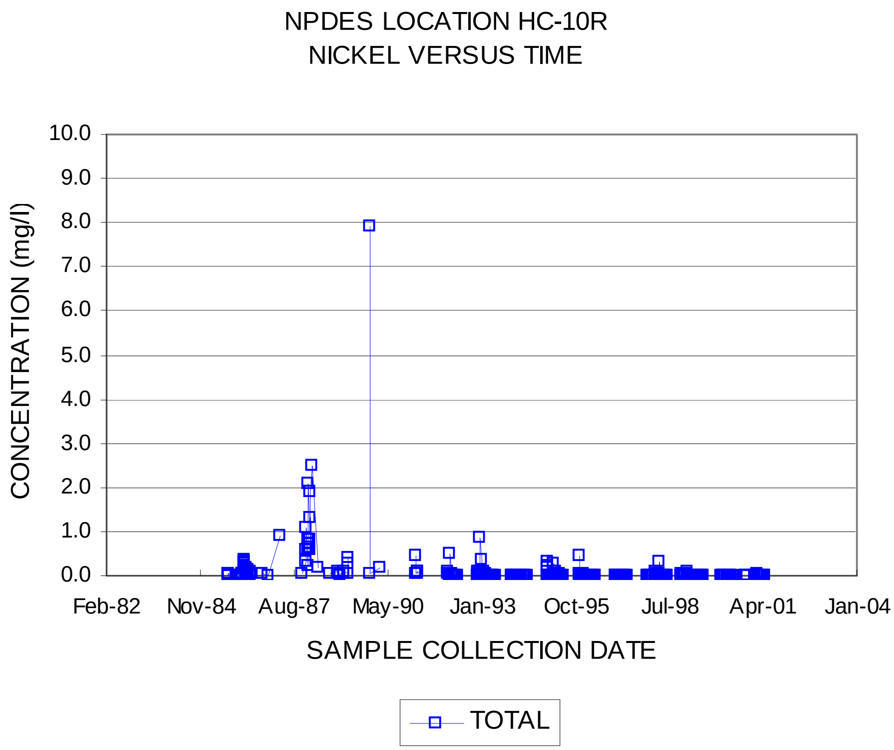



WQMP LOCATION S-06
ZINC VERSUS TIME
CONCENTRATION (mg/l)
1.80
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
Feb-82
Nov-84
Aug-87
May-90
Jan-93
Oct-95
Jul-98
Apr-01
Jan-04
SAMPLE COLLECTION DATE
Total

Hunting Creek Downstream of the Mine:







Knoxville Creek Downstream of Mine and East Waste Rock Dump:

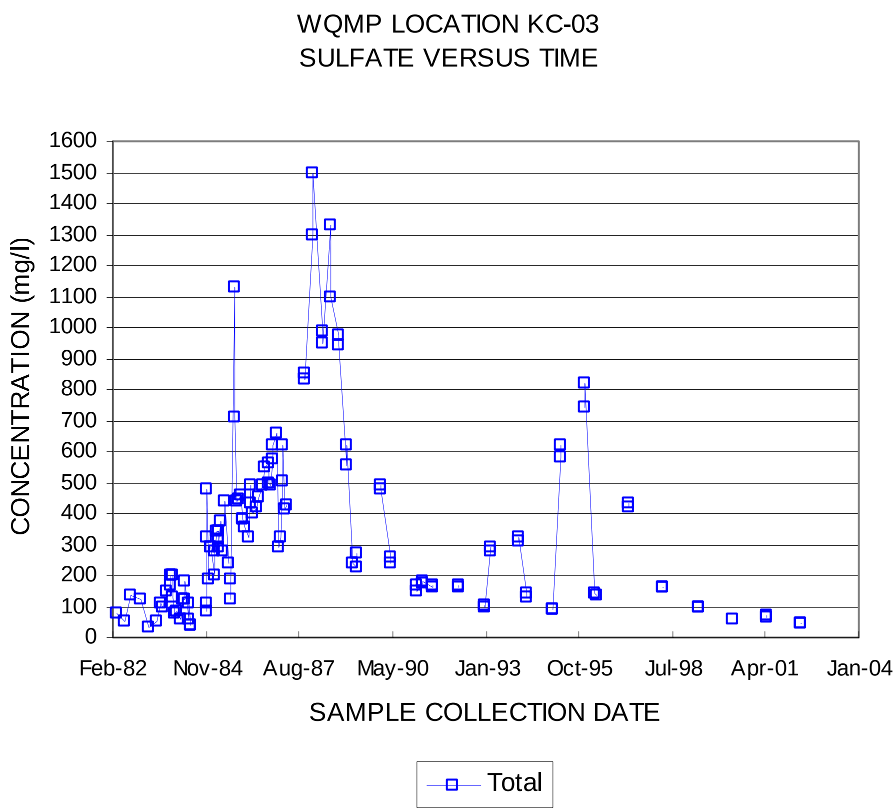


Table 7.2 Water Quality Data for the McLaughlin Open Pit Sampling Location, MP-1, November 17, 2003 (only available date).

Parameter	Concentration
Specific Conductance (µmhos/cm)	4,750
pH (SU)	5.08
Alkalinity (mg/l $CaCO_3$)	14.0
Hardness (mg/l $CaCO_3$)	19,000
TDS (mg/l)	14,000
Sodium (mg/l)	270,000
Chloride (mg/l)	270
Nitrate (mg/l as N)	1.2
Ammonia (mg/l as N)	4.3
Sulfate (mg/l)	11,000
Total/dissolved Arsenic (µg/l)	7.0/4.99
Total/dissolved Boron (ug/l)	15,000/14,000
Total/dissolved Chromium (µg/l)	9.99/9.99
Total/dissolved Copper (µg/l)	320/310
Total/dissolved Lead (µg/l)	4.9/4.9
Total/dissolved Iron (µg/l)	1,500/1,400
Total/dissolved Manganese (µg/l)	56,000/62,000
Total/dissolved Mercury (µg/l)	0.210.0.220
Total/dissolved Nickel (µg/l)	25,000/35,000
Total/dissolved Zinc (µg/l)	3,300/3,400

8 MESQUITE, CALIFORNIA

8.1 GENERAL INFORMATION

Location: Imperial County
Ownership: Newmont Gold Company
Commodity: Gold and Silver
Operation Type: open pit, heap leach
Years of Operation: 1985 to present
Jurisdiction: BLM, El Centro District
Disturbed Acres: 3,655 acres
Bond Amount: $3,048,081 (last updated in 1998)
NEPA Documents: 1984 EIR/EA; 1987 Expansion EIR/EIS (not obtained); 2002 EIR/EIS
NPDES Permit: None

8.2 EIS SUMMARIES

8.2.1 1984 EIR/EA

Proposed Project: New Project
Geology/Mineralization: Ore association and geology; geochemical testing and modeling: Alluvium covers a majority of the site. Older rocks include Miocene/Oligocene nonmarine silts, sand, and angular gravel, with a considerable amount of gypsum, and Mesozoic and Precambrian igneous and metamorphic rocks in the northern part of the site.
Climate: Arid desert
Annual Precipitation/ Evaporation: From a rain gauge 14 miles away, annual precipitation ranged from 1.17 to7.42 inches. Annual rainfall in the Amos basin probably ranges from 3 inches on the valley floor to 5.5 inches in the higher mountains. Mean annual pan evaporation is 137 inches, mean annual lake evaporation is 96 inches.
Koppen Classification: Region – B, **Temperature –** a, **Precipitation –** w
Proximity to Surface Water: The Coachella Canal, approximately 15 miles southwest of the project area, is the closest perennial surface water feature, drainages on site flow only during infrequent thunderstorms.
Proximity to Groundwater: Groundwater occurs in alluvial deposits, and, to a limited extent, in fractures and joint systems in bedrock in the Chocolate Mountains. Average depth to groundwater near the proposed Mesquite mine is 200 ft below ground surface. Depth to groundwater becomes as shallow as 145 ft. just south of highway 78.
Predictive Tests and Models: Static acid-base potential tests were performed on overburden and leached ore.
Constituents of Concern: None identified.
Acid Drainage and Contaminant Leaching Potential: Overburden and leached ore residue have sufficient neutralizing capacity to prevent any formation of acidic leachate.
Potential Water-Quality Impacts (before mitigations): Background groundwater quality in the region had exceedences of fluoride in most wells and chloride, sulfate, iron, manganese, and arsenic in alluvial wells. Bedrock wells exceeded for iron, manganese, arsenic, and mercury. The only potential significant environmental impact to groundwater would be from percolated surface waters containing chemicals used in ore processing, accidental fuel spillage, spillage of reagents or chemicals, breakage of solution pipelines, or leachate from waste dumps. Low soil moisture and depth to groundwater present a secondary defense against contamination. Surface water in the Imperial Valley typically has high TDS values, around 990 mg/l. Surface water quality in the project area could be affected by the presence of suspended solids in runoff, hazardous materials accumulated in the processing plant area, or by any accidental escape of leach solution from the processing system. There will most likely be pit lakes because pit bottoms will be 400-500 ft deep
Mitigations: Proposed mitigations include: impermeable liners for leach pads; immediate application of calcium hypochlorite to any spilled/released cyanide on exposed soil; containment area around reagent building; sumps in

process building to collect spilled materials; collection and storage for runoff from the heap leach facility; rinsing of heap leach pads upon completion of the leaching; and impervious barriers under areas exposed to toxic chemicals.
Predicted Water-Quality Impacts (after mitigations): As a result of implementing the proposed project design and all solution containment measures, no significant adverse impact on groundwater quality is expected. The proposed project design includes measures to prevent any adverse impacts on surface water quality, including the prevention of contamination from the use of dilute cyanide leach solution.
Discharges: No information was provided on discharges to groundwater or surface water.

8.2.2 2002 EIR/EIS

Proposed Project: Expansion (2000 Draft, 2002 Final)
Geology/Mineralization: Gold ore occurs in gneiss and granitic basement rock in essentially free or native forms. It is concentrated in microfractures in minute sizes and amounts. Minor amounts of silver ore are found disseminated in microfractures of gneiss and granitic basement rock.
Climate: Arid desert
Annual Precipitation/ Evaporation: Annual precipitation is 3 inches/yr, and evaporation is ~80 in/yr.
Koppen Classification: Region – B, **Temperature –** a, **Precipitation –** w
Proximity to Surface Water: The closest perennial surface water feature is the Coachella Canal, located approximately 15 miles southwest of the site.
Proximity to Groundwater: The groundwater flow direction is generally from northeast to southwest, following the surface contours. Prior to mining, groundwater depths ranged from about 200 to 300 feet deep.
Predictive Tests and Models: Static acid-base accounting, whole rock analysis for metals, and 20-week kinetic tests were performed. From whole rock analysis, arsenic, selenium and silver, bismuth, thallium were identified as potential constituents of concern. A hydrologic/hydraulic evaluation of runoff was conducted using HEC-1. Pit water quantity and quality modeling was conducted by Baker Consultants.
Constituents of Concern: arsenic, selenium and silver, bismuth, thallium
Acid Drainage and Contaminant Leaching Potential: Rock types encountered in the Rainbow and north half sections were typically net neutralizing. The kinetic tests were inoculated with *Thiobacillus ferrooxidans* and showed no acid generation or any indication that acid would form. The kinetic tests indicated that even the most sulfidic members of the hornblende biotite gneiss and mafic gneiss rock units are not likely to generate acid. Soluble metals concentrations in the overburden/interburden were generally low.
Potential Water-Quality Impacts (before mitigations): Ore processing operations could leak or spill processing fluids if they are not properly designed, constructed and operated. Petroleum products could impact groundwater if a substantial leak were to occur. Infiltrating precipitation could carry soluble constituents from the overburden/interburden to groundwater. Increased runoff could occur from road surfaces during infrequent large storms, but roads cover only small fraction of the site. The potential exists for minor hydrocarbon leaks/spills from equipment. Water quality in the existing pit lake is generally alkaline (pH 8.3 - 8.9), slightly to moderately saline (total alkalinity 258 - 334 mg/L of $CaCO_3$, TDS 1,400 - 3,600 mg/L) and low in dissolved trace metals. Initially, the pit water chemistry will be similar to the existing pit water, with TDS in the 1,500-400 mg/l range. At equilibrium, TDS is expected to reach 5,000-10,000 mg/l. Long term pit chemistry will be the same as the existing pits.
Mitigations: Proposed mitigations for the expansion include: heap leach pad liner and leak detection system; monitoring; storage of bulk petroleum products above ground in designated areas with secondary containment, with monitoring for leaks. Best Management Practices will minimize stormwater-related pollution and include monitoring and inspection protocols to gauge their effectiveness. Ore processing facilities will have run-on controls and will be operated in a manner that protects against release of process fluids or other constituents that may adversely affect surface water quality.
Predicted Water-Quality Impacts (after mitigations): Groundwater quality was evaluated over 5 years for pH, specific conductance, temperature, total dissolved solids, arsenic, copper, iron, sulfate and nitrate/nitrite. None of the parameters showed trends of adverse change in water quality. There are no known groundwater quality impacts from the 15 years of activity that have occurred at the Mesquite Mine to date. Modeling indicates that for the out-of-pit configuration, groundwater would not flow through any of the mine pits, so the build up of dissolved constituents in the pit lakes will not affect water quality away from the mine pits. With petroleum containment and monitoring in

place, fuels and oil use at the site are not expected to impact groundwater quality. Because soluble metals concentrations in waste rock are generally low and the material is not acid generating, and because of the low annual precipitation, waste rock would not have a significant impact on groundwater quality. With heap leach pad operation requirements in place, significant effects to surface water quality are not expected. The likelihood of spills is small, and they would be easily removed. Long term pit chemistry will be the same as the existing pits.
Discharges: No information was provided on discharges to groundwater or surface water.

8.3 MONITORING AND COMPLIANCE INFORMATION

The information on actual water quality conditions is based on a phone call with Michelle Ochs of the RWQCB in Palm Desert, California, in September 2004. The Mesquite Mine is still conducting leaching operations but is otherwise shut down. There was one unreported spill in early 2003/late 2002, and a violation was written by the RWQCB. However, this was a very minor spill. Quarterly reporting is required for TDS, total and free cyanide, pH, sulfate, arsenic, gold, silver, copper, iron, and nitrate. No major problems, for example with cyanide, have occurred.

Table 8.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater	• Heap leach facility • Waste rock	• Ore processing fluids, fuel or chemical spills, pipeline breaks, waste rock leachate (1984) • Leaks or spills of ore solution, petroleum leaks, leachate from waste rock (2002)	• Leach pad liners, calcium hypochlorite applied to cyanide spills, rinse pads after mining (1984) • Heap leach pad liner/leak detection, monitoring, storage of petroleum products in areas with secondary containment, leak monitoring (2002)	• No impact to groundwater (1984) • No impacted predicted because existing groundwater quality unchanged and fuels/oil containment/monitoring. Waste rock would no have significant impact. (2002)	• Spill occurred, but no impacts to groundwater occurred.
Surface Water	• Heap leach facility	• Erosion of soils, processing plant materials, ore solution leachate (1984) • Runoff from roads, fuel spills	• Reagent containment and sumps, heap leach runoff controls (1984) • Stormwater BMPs, monitoring, heap leach run-on controls (2002)	• No impact to surface water quality (1984) • No significant surface water quality effects expected from heap leach pad or spills (2002	• Spill occurred, but no impacts to surface water occurred.
Pit Water	• Open pit	• Pit lakes will exist (1984) • Long-term pit chemistry same as existing pits (2002)	• None	• No information (1984) • Long-term pit chemistry expected to be same as existing pits.	• None

9 ROYAL MOUNTAIN KING, CALIFORNIA

9.1 GENERAL INFORMATION

Location: Copperopolis, California (Calaveras County)
Ownership: Meridian Gold, Inc.
Commodity: Gold and silver
Operation Type: Open pit, vat leach
Years of Operation: 1990 - 1994
Jurisdiction: Calaveras County, private land
Disturbed Acres: 650
Bond Amount: $3,303,000
NEPA Documents Available: 1987 New Project EIS/EIR
NPDES Permit: None

9.2 EIS SUMMARIES

9.2.1 1987 NEW PROJECT EIS/EIR

Proposed Project: Open pit mines in three areas, overburden dumps, processing plant.
Geology/Mineralization: Project area is underlain in the southwestern portion by slate with inter-lensed greenstones, and in the northeastern portions by greenstones. A serpentine dike outcrops along the footwall of the Hodson fault. Mineralized quartz veins have developed along WNW trending thrust faults.
Climate: Mesothermal Forest Climate/Mediterranean Warm Summer
Annual Precipitation/ Evaporation: Annual precipitation is 26 inches.
Koppen Classification: Region – C, **Temperature –** a, **Precipitation –** s
Proximity to Surface Water: Littlejohns and Underwood creeks, which flow through the project area, will be diverted in their entirety around the project area. No statements about whether these are perennial or ephemeral drainages.
Proximity to Groundwater: NA
Predictive Tests and Models: NA
Constituents of Concern: NA
Acid Drainage and Contaminant Leaching Potential: Based on static test results, it is apparent that there is no net acid forming potential associated with the overburden materials. No information on contaminant leaching potential.
Potential Water-Quality Impacts (before mitigations): Waste management units will contain chemicals and reagents that have the potential to contaminate the groundwater system.
Mitigations: Run-off from mine surfaces, haul roads, and stockpile management units due to precipitation will be managed in accordance with standard erosion control procedures.
Predicted Water-Quality Impacts (after mitigations): No information.

9.2.2 PREDICTIONS CONDUCTED BY DONALD R. BAKER FOR MERIDIAN MINERALS, COMPANY, 1988 (NOT PART OF EIR)

Tests Conducted: Total Threshold Limit Concentrations (TTLC) on tailings and waste rock (compare to results from a total digestion of sample); Soluble Threshold Limit Concentrations (STLC) on waste rock (compare to results from WET test); Deionized Water Extraction (DI) test on waste rock.
Results: Tailings leachate composite total digestion values were elevated for antimony, arsenic, beryllium, cadmium, chromium, cobalt, copper, lead, mercury, molybdenum, nickel, selenium, silver, vanadium, and zinc (>10 to 100 times MCL/SMCL values). Total digestion and WET test values for waste rock leachate were elevated for antimony, arsenic, beryllium (total digestion only), cadmium (total digestion only), chromium, cobalt, copper, lead, mercury

(total digestion only), nickel, silver (total digestion only), vanadium (total digestion only), and zinc. Deionized water extract concentrations for waste rock were elevated for arsenic.

9.2.3 1987 REPORT OF WASTE DISCHARGE

Mineralization: Three different types of ore will be mined in the project. The Skyrocket ore body, which comprises roughly 59% of the total reserves, is a carbonaceous deposit. Mountain King, which comprises 30% of ore reserves, is predominantly unoxidized. Gold Knoll, the remaining 11% of reserves, is a mix of oxidized and unoxidized ore.
Testing: There will be three sources of solid waste generated on the property: overburden, flotation tailings, and leached concentrate (heap leach) residues. Each type of waste was subjected to: acid-base accounting (hot hydrogen peroxide oxidation); total metal content; short-term leach (WET, DI water extract); sulfuric-acid extractable metal concentration for samples with acid-forming potential; and bioassay studies on all wastes except overburden.

Contaminant Leaching Potential: High

Overburden: Deionized water extractions on waste rock material showed several exceedences of drinking water standards: arsenic concentrations exceeded standards by over 10X the new standard, selenium concentrations in one sample were elevated but did not exceed the drinking water standard. Total chromium exceeded the drinking water standard by less than a factor of two. For the WET test results, leachate concentrations in all four types of overburden exceeded the new drinking water standard for arsenic, by factors of 2-26, and chromium concentrations also exceeded drinking water standards in all four waste rock types, from a factor of 3-1.5, nickel also exceeded drinking water standards in all four samples, with concentrations ranging between 4 and 7 times the standard.
Flotation Tailings: All four tailings lithologies (one from each pit, as well as a composite) showed drinking water exceedences for the WET test leachate for As, Ba, Cr (total), Pb, and Ni; the detection limit for Hg was too high to conduct comparisons. There was also a single exceedence (from the Mountain King Pit) for Se. In the Deionized water extraction, there was one drinking water exceedence for Se from the Mountian King Pit, and one exceedence of the new As standard, also from the Mountain King pit. As levels were equal to the new drinking water standard in the Gold Knoll pit sample.
Flotation Tailings Solution: Arsenic exceeded the new drinking water standard in all four floatation tailings samples by a factor of 2-3. Lead was elevated, but did not exceed. Nickel exceeded in the Mountain King pit sample.
Leached Concentrates (Heap leach): Arsenic concentrations in the heap leach concentrates were high enough to classify this material as hazardous waste, according to TTLC. In the deionized water extraction of the leached concentrates, antimony concentrations exceeded the drinking water standard by more than a factor of ten in all four samples (each pit, as well as a composite sample.) Arsenic concentrations exceeded the new standard in all four samples, by factors of under 2 to almost 3. Pb detection limit exceeds current std. Hg exceeded the dtandard in the Gold Knoll Pit sample. Ni exceeds by less than a factor of two in the Sky Rocket sample, and is at the standard in the composite sample. In addition, the extraction procedure utilizing citric acid (WET test) predicted elevated concentrations of Sb, As, Pb, and Ni from all samples. The Pb levels in the Mountain King pit samples were high enough compared to the STLC to merit classifying this as a hazardous waste. Extractions using H_2SO_4 produced results similar to the DI water extraction.
Leach Transport Solution: The Leach Transport Solution would exceed, by over a factor of one hundred, the drinking water standards for the following constituents: As (new standard), Cu, cyanide. The following constituents exceeded by a factor of ten or more: Hg, TDS, Ni. Constituents that exceed by less than ten times included: Pb, Ag, SO_4, Zn. The following constituents had detection limits higher than their respective water quality standard: Cd, Cr, Ag, Tl.
Acid Drainage Potential: All overburden lithologies and flotation tailings samples had excess neutralization potential. Ratios were in the neighborhood of 40:1 or higher, indicating that acid generation is unlikely. However, acid generation potential was high in the leached concentrates from the leaching circuit, with NP:AP ratios ranging from 1:3 to 1:12.
Water Quality Impact Potential:
Groundwater: The floor of the tailings impoundment will not require an engineered lining. Both the solids and the liquid in the slurry have been tested extensively and do not present any potential for having an adverse impact on the environment. In addition, the rocks underlying the tailings impoundment are of a low permeability.

Zero Discharge Facilities: There will be no discharge from the flotation mill.

9.3 MONITORING AND COMPLIANCE INFORMATION

Years Monitoring Data Available: 1987 - 2004
Number Surface Water Monitoring Locations: 11 stream locations (6 in Littlejohns Creek), 1 stock water pond
Number Seep Monitoring Points: 5
Number Open-pit Monitoring Locations: 2 – Skyrocket Pit and North Pit (surface of lakes)
Number Groundwater Monitoring Locations: Flotation Tailings Reservoir (FTR): GWM-02, GWM-30, FTR/LCRS; Leached Concentrate Residue Facility (LCRF, heap leach): GWM-04, -06, -15, -24, -25, LCRD/LCRS, LCRD/SPINE, PWP/LCRS, PWP/SPINE; Overburden Disposal Sites (ODS): Gold Knoll ODS – GWM-11, -12, -21, -26, -31, -33, -34, PZ-1, PZ-4; West ODS – GWM-09, -10, -16, -19, -20, -32.
Baseline Water Quality: Mine area has been mined for centuries, so background is difficult to determine. There are some artesian salt springs n the marine deposits, but not all groundwater is salty. Before RMK, all creeks on site were intermittent, and now they run year-round. Skyrocket Pit outlet flows to Littlejohns Creek. Mine claims that elevated groundwater concentrations are background levels, but RWQCB disagrees. Some of the groundwater is very salty, but the chemical signature from the waste rock piles is still apparent. The RWQCB proved, using Piper diagrams, that the groundwater had changed over time from mining activity (RWQCB interview, 10/15/04).
Violations: 29 violations from January 1993 to August 2004, between 9 and 12 of them are related to water quality or quantity problems, remainder related to inadequacies in reports, etc. The State Water Control Board (not the RWQCB) vacated the 2003 cease and desist order, agreeing with the mine that it was too complex, and the Board was not sure the mine could comply with the order. If the order had been kept, the mine would be in violation of it all the time. The RWQCB feels that the financial assurance is too low because it doesn't include foreseeable releases.
Lawsuits: Water Keepers of Northern California, Delta Keepers (Bill Jennings) is suing Royal Mountain King for discharges to Littlejohns Creek (from Skyrocket Pit) and for the presence of elevated arsenic, ammonia, and cyanide in groundwater. Lawsuit requests a cease and desist order and containment.
Possible Mining-Related Exceedences:

Mine Water Supply Wells: NA

Groundwater Monitoring Wells: Tailings wells (GWM-02, GWM-30): exceedences of drinking water standards for chloride, nitrate, nickel, selenium, sulfate, TDS, manganese. Heap leach area wells (PWP/LCRS, GWM-24): exceedence of drinking water standards for antimony, arsenic, chromium, manganese, copper, nickel, nitrate, selenium, sulfate, TDS, total and WAD cyanide (see graph). Waste rock wells (GWM-10, -11, -12, -21): exceedence of drinking water standards for nitrate, TDS, sulfate, arsenic, (up to 1,400 µg/l; see graph), chloride, selenium.

Surface Water Monitoring Sites: (only have temporal data for SWM-08, unnamed drainage to Clover Creek) exceedence of drinking water standards for nitrate, sulfate, TDS, arsenic.

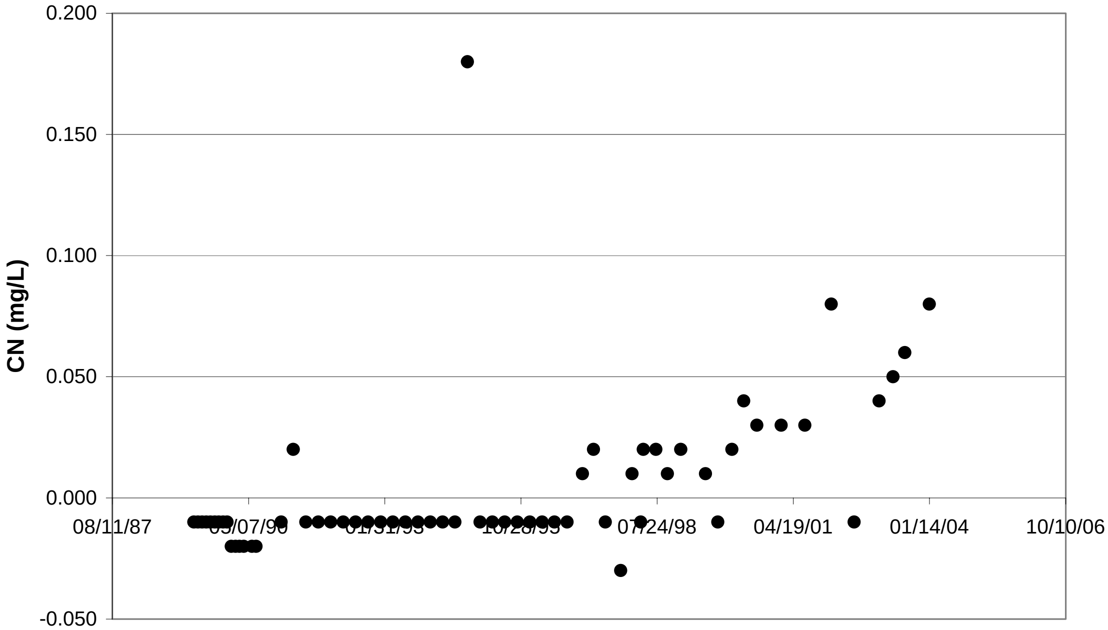
Pit Water Monitoring Sites: Exceedence of sulfate and TDS SMCL values in North Pit; exceedence of arsenic, sulfate, TDS, and chloride drinking water standards in Skyrocket Pit.

Table 9.1 Summary of Sources, Potential Impacts, Mitigations, and Predicted Impacts Related to Actual Water Quality Impacts at the Royal Mountain King Mine, California.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater	Tailings	• 1987 EIS/EIR: potential impacts not assessed • 1987 RWD: Tailings solids and slurry do not present any potential for adverse impact to the environment. Tailings not considered hazardous.	• 1987 RWD: tailings impoundment will not require an engineered lining; rocks underlying impoundment have low permeability.	• 1987 EIS/EIR: Waste management units will contain chemicals and reagents that have the potential to contaminate the groundwater system RWD: Rocks underlying tailings impoundment have low permeability.	WQ Monitoring: Tailings wells show exceedences of drinking water standards for chloride, nitrate, nickel, selenium, sulfate, TDS, manganese.
	Waste Rock	• 1987 EIS/EIR: no net acid forming potential associated with the overburden materials • 1987 RWD: Waste rock not considered hazardous.	• 1987 EIS/EIR: none identified other than stormwater controls		• WQ Monitoring: Waste rock wells show exceedances of drinking water standards for nitrate, TDS, sulfate, arsenic, chloride, selenium.
	Leached Flotation Concentrate	• 1987 EIS/EIR: potential impacts not assessed • 1987 RWD: Arsenic and lead concentrations in the heap leach concentrates were high enough to classify them as hazardous waste.	• 1987 EIS/EIR: none identified		• WQ Monitoring Leached flotation concentrate disposal area wells show exceedence of drinking water standards for Sb, As, Cr, Mn, Cu, nickel, nitrate, Se, sulfate, TDS, total and WAD cyanide

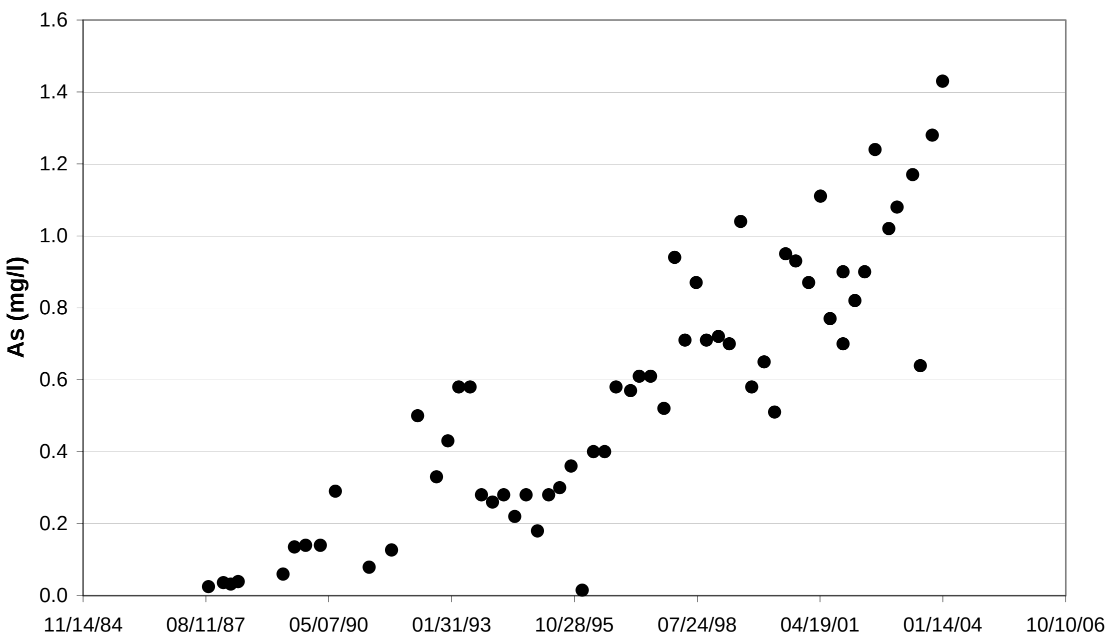
9.4 GRAPHS OF WATER QUALITY MONITORING DATA FOR SELECTED GROUNDWATER LOCATIONS AT THE ROYAL MOUNTAIN KING MINE, CALIFORNIA.

Total Cyanide Concentrations 1987-2004, Heap Leach Monitoring Well GMW-24, Royal Mountain King Mine



(values <0 are below detection)

Arsenic Concentrations in Waste Rock Monitoring Well GWM-12, 1987 - 2004, Royal Mountain King Mine



10 GROUSE CREEK, IDAHO

10.1 GENERAL INFORMATION

Location: Custer County, ID
Ownership: Sunbeam Mining Corporation
Commodity: Gold
Operation Type: Open Pit, Vat Leach
Years of Operation: 1985 - ? (currently closed)
Jurisdiction: U.S. Forest Service
Disturbed Acres: 524
Bond Amount: $7,038,945
NEPA Documents: 1984 EIS (New Project), 1992 EIS (Expansion)

10.2 WATER QUALITY SUMMARY

In the 1984 Final EIS they acknowledged the presence of acid drainage on site emanating from the Sunnyside Mine adit, but still predicted that the potential for generating significant acid drainage from the mine or waste dumps would be minimal. They stated that the proposed open pit would not be subject to the same conditions as the Sunbeam mine and that very little sulfide material was available within the ore body, even though in the geological description of the site material “pyrite casts as much a 2 mm in size” and "finely disseminated pyrite” were identified within the deposit. Weather tests (not defined in the report) indicated that the pH of mine run samples drainage was stable but no results were presented within the report.
Then in 1992, the Grouse Creek Final EIS provided a more detailed geological description indicating the presence numerous sulfide bearing minerals. Further geochemical testing was performed on ore and waste rock and they found that the Sunbeam pit waste rock and ore had a moderate potential for acid generation. Since static tests resulted in a low potential for acid generation from the Grouse Pit, they decided to backfill Sunbeam Pit with Grouse Creek neutralizing materials and install French drains under the waste dump and route potential acid drainage it into diversion ditches or to the tailings impoundment. As a mitigation measure, the addition of lime to the ore during processing would be implemented to neutralize potential acid generation from the tailings. Through continued monitoring and geochemical testing, “the Sunbeam and Grouse Creek mine wastes and ores are not expected to have a deleterious effect on water quality, if mitigation measures are successful.” If mitigations are not successful, acid drainage will be treated at a water treatment plant in perpetuity or until discharge meets WQ standards.

Info from the EIS’s for the above paragraph and their references:

In the1984 EIS, the geology is described as fracture zones in the Challis Volcanics of Sunbeam Mountain which are host to gold and silver mineralization and comprises two primary ore zones (3-2). Dike consists of quartz, plagioclase feldspar, pyrite casts as much as 2 mm in size, clay, joints coated with goethite and hematite. Intrusive rhyolite hydrothermally altered to illite, sericite (muscovite), chlorite and pyrophyllite, contains iron oxide staining (goethite, jarosite) with finely disseminated pyrite (Appendix D, pg 2).
Acidic water (pH range of 3.3 to 3.9) from the Sunnyside Mine adit on the study site indicates the potential for acid drainage from the mineral ore body and/or overburden rocks and materials (3-14). Potential for generating significant acid drainage from mine, or waste dumps is minimal. Very little sulfide material is available within the ore body. Weather tests have indicated that the pH of the drainage of mine-run samples is stable. The acid drainage that has been reported from the abandoned Sunbeam mine portal (pH 3.2) may be as a result of an isolated sulfide-bearing strata within the mine area itself that is exposed to localized oxidation conditions due to variation in the water table within the mine area. The proposed open pit will not be subject to the same conditions that can cause the formation of acid drainage (4-15). The potential for generating significant acid mine drainage from the mine site or waste dump is minimal (4-15).
Mitigations: All ore would be agglomerated with lime and/ or portal cement which would reduce acid generation (4-15).

In the 1992 EIS the geology is described as deposits contain gold, native silver, electrum, miargyrite, pyrargyrite, proustite, acanthite, argentite, pyrite, chalcopyrite, and trace amounts of polybasite, galena, chalcocite, tetrahedrite, covellite, rutile, and bornite. Hydrous iron oxide (goethite, limonite, and lepidocrosite) constitute one to nine percent of the raw ore by volume. Mineralization is generally located in: narrow zones of intensely fractured mineralized and brecciated rock found along faults and fracture planes; irregular zones or lobes on highly altered, intensely fractured mineralized rock developed at and adjacent to the intersection of fault or fracture structures; disseminated low-grade ore (3-4). Tests conducted include: Acid Base Potential Analysis, Sulfur, EP toxicity analysis (indicator of heavy metal leachate potential under low to moderate pH=4.5 conditions (3-4 to 3-7). Acid Base Potential (ABP) analysis indicates there is a low potential for acid generation from the Grouse Pit. The ABP analysis from the Sunbeam pit waste rock and ore indicates there is a moderate potential for acid generation and subsequent acid drainage (3-4), (4-9). The most noticeable impacts would be caused by infiltration of potential acid drainage from the waste dump, potentially resulting in metal mobilization by lowering the pH of the groundwater in isolated areas near waste dump. French drains under waste dump will collect potential acid drainage and route it into diversion ditches or to tailings impoundment. Other potential areas of acid drainage would be from the Sunbeam mine pit where acidic water could drain out of pit area and seep into the ground. Neutralization of any potential acid producing conditions in the Sunbeam mine pot would be accomplished through backfill of mine waste from the Grouse pit with high neutralization potential. The addition of lime to the ore during processing neutralizes potential acid generation from the tailings (4-20). The best indication of potential acid production from the waste dump is shown in the existing drainage emanating from the old Sunbeam adit (pH from 3.0 – 4.5). Acid drainage from the adit is diluted in Jordan Creek which pH ranges from 6.1 – 7.5 (4-10). By backfilling with Grouse Creek neutralizing materials, and continued monitoring and geochemical testing, the Sunbeam and Grouse Creek mine wastes and ores are not expected to have a deleterious effect on water quality, if mitigation measures are successful (4-11).

10.3 EIS SUMMARIES

10.3.1 1984 EIS

Geology/Mineralization: Bedrock consists of Paleozoic meta-sedimentary and Mesozoic quartz monzonite rocks, overlain with Tertiary extrusives called the Challis Volcanics (tuff, rhyolite, and andesite). Quarternary deposits found in study area valleys consist of morainal debris and terrace (outwash) gravels and recent unconsolidated alluvium (includes clay, gray volcanic sandstone and mudstone, rhyolite fragments, geothite-rich limonite. Fracture zones in the Challis Volcanics of Sunbeam Mountain are host to gold and silver mineralization which comprises two primary ore zones. Dike consists of quartz, plagioclase
feldspar; pyrite casts as much as 2 mm in size, clay, joints coated with goethite and hematite. Intrusive rhyolite hydrothermally altered to illite, sericite (muscovite), chlorite and pyrophyllite, contains iron oxide staining (goethite, jarosite) with finely disseminated pyrite.
Climate: Long, harsh winters and cool, dry summers
Annual Precipitation/ Evaporation: approximately 30 inches/
Koppen Classification: Region – D, **Temperature –** a, **Precipitation –** s
Proximity to Surface Water: Project area is located within the Jordan Creek Basin area with Pinyon Creek and several smaller unnamed streams flowing through the study site. A pond in Pinyon Basin also exists on the site and has been determined a wetland area.
Proximity to Groundwater: Greatly influenced by geologic features. Surface and subsurface soils in the study area contain significant amounts of clay which can inhibit infiltration. Large quantities of groundwater occur in the alluvium below stream courses which include Jordan Creek, Pinyon Creek, and the unnamed tributaries. Static water levels in 4 Pilot Plant area monitoring wells measured over a period of 2 years ranged from about 8 to 29 feet. Groundwater levels in Pinyon Basin ranged from 0.5 to 22 feet below ground surface.
Predictive Tests and Models: Weather tests (undefined in EIS)
Constituents of Concern: Cyanide
Acid Drainage and Metal Leaching Potential: Acidic water (pH range of 3.3 to 3.9) from the Sunnyside Mine adit on the study site indicates the potential for acid drainage from the mineral ore body and/or overburden rocks and

materials. Potential for generating significant acid drainage from mine, or waste dumps is minimal. Very little sulfide material is available within the ore body. Weather tests have indicated that the pH of the drainage of mine-run samples is stable. The acid drainage that has been reported from the abandoned Sunbeam mine portal (pH 3.2) may be as a result of an isolated sulfide-bearing strata within the mine area itself that is exposed to localized oxidation conditions due to variation in the water table within the mine area. The proposed open pit will not be subject to the same conditions that can cause the formation of acid drainage.
Water-Quality Impact Potential: The potential for significant groundwater degradation is minimal. The potential for cyanide entering groundwater in sufficient quantities to do real harm is very minimal, but does exist. The potential for generating significant acid mine drainage from the mine site or waste dump is minimal. Water quality changes in surface streams predicted to be short duration. Potential impacts to surface water include changes in the chemical makeup, turbidity/sedimentation, and biological quality (changes in temp., dissolved oxygen levels, and other characteristics which affect the water's ability to support fish and other aquatic vegetation and wildlife. Potential groundwater impacts include dewatering of the Pinyon Basin (which includes the wetland) and chemical changes from liquid pollutants and dissolved solids.
Mitigations: Groundwater will be monitored continuously for changes in pH and for free and residual cyanide. Will continue to sample and monitor groundwater for pH, Alkalinity, Hardness, NH_4, NO_3, free Chlorine, Cl-, CN-, Mo, Cu, Pb, Ag, Fe, Se, Co, Mn, P, Hg, SO_4, As. All constructed drainages and stormwater settling ponds will meet the projected 50 year, 24 hr storm event. Spillways designed for 100 yr storm event. Will use sediment collection ponds, silt fences, brush barriers, straw mulching, matting and netting to stabilize exposed surfaces. Will continue to sample and monitor surface water every 3 months for Temp., SC, DO, pH, Turbidity (weekly), Alkalinity, Hardness, NH_4, NO_3, free Chlorine, Cl-, CN-, Mo, TSS, and for Cu, Pb, Ag, Fe, Se, Co, Mn, P, Hg, SO_4, As. Groundwater flow into pits will be routed to sediment catchment ponds and settled prior to discharge into Pinyon Creek diversion or Jordan Creek. Cyanide destruction circuit is designed to provide a separate unit process for chlorine and caustic (lime, etc.) addition and treatment. All ore would be agglomerated with lime and/ or portal cement which would reduce acid generation.
Predicted Water-Quality Impacts: No information.

10.3.2 1992 EIS

Geology/Mineralization: Eocene age volcanic rocks composed mainly of volcanic flows and ash deposits (include rhyolitic and andesitic flows, tuffs, and dikes; hydrothermally altered pyroclastic flows; and volcaniclastic and lacustrine sediments). Basement rock in the Project study area consist of partially altered sedimentary rocks and granitic rocks (consist mainly of quartzites and shales, particularly quartz monzonite and granodiorite). Ore bodies range in character from well-defined fracture-filling veins to pervasive low-grade mineralization. Deposits contain gold, native silver, electrum, miargyrite, pyrargyrite, proustite, acanthite, argentite, pyrite, chalcopyrite, and trace amounts of polybasite, galena, chalcocite, tetrahedrite, covellite, rutile, and bornite. Quartz and clay are the main non-metaliferous materials, with lesser amounts of feldspar and mica. Hydrous iron oxide (goethite, limonite, and lepidocrosite) constitute one to nine percent of the raw ore by volume. Mineralization is generally located in: narrow zones of intensely fractured mineralized and brecciated rock found along faults and fracture planes; irregular zones or lobes on highly altered, intensely fractured mineralized rock developed at and adjacent to the intersection of fault or fracture structures; disseminated low-grade ore.
Climate: Long, cold winters with heavy snowfall and relatively short, mild summers.
Annual Precipitation/ Evaporation: 27 inches/ evaporation slightly exceeds precipitation.
Koppen Classification: Region – D, **Temperature –** a, **Precipitation –** s
Proximity to Surface Water: Jordan Creek flows approximately 1200 feet to the east of the Sunbeam Pit and flows south where it discharges into Yankee Fork River. The confluence of Jordan Creek and Yankee Fork River is approximately 2300 ft from the tailings impoundment. Other tributaries to Jordan Creek include Washout Creek, Montana Gulch, Grouse Creek, and Red Rock Creek.
Proximity to Groundwater: Groundwater is found at depths ranging from the ground surface in areas of springs to more than 100 ft in upland areas. Groundwater is typically found at relatively shallow depths in lowland areas and at deeper depths in bedrock deposits of upland areas. Generally the flow of groundwater mirrors the topography, moving from upland areas to lowland areas.

Predictive Tests and Models: ABP testing, Sulfur, EP toxicity analysis
Constituents of Concern: Lead, Arsenic, Cyanide. Potential impacts would occur if blasting residuals, such as ammonium or nitrates, were to accumulate in the waste rock material, but with complete combustion little or no residual remains.
Acid Drainage and Metal Leaching Potential: Acid Base Potential (ABP) analysis indicates there is a low potential for acid generation from the Grouse Pit. The ABP analysis from the Sunbeam pit waste rock and ore indicates there is a moderate potential for acid generation and subsequent acid drainage.
Water-Quality Impact Potential: Infiltration of potential acid drainage from the waste dump, potentially resulting in metal mobilization by lowering the pH of the groundwater in isolated areas near waste dump. Other potential areas of acid drainage would be from the Sunbeam mine pit where acidic water could drain out of pit area and seep into the ground. Leakage through the tailings impoundment liner is expected to be minimal due to fine particle size of tailings. There is a low risk of significant groundwater contamination at the Bonanza Flat impoundment, which could potentially affect water quality in the West Fork and Yankee Fork rivers. Estimate significant groundwater contamination to be low. Leakage from the tailings impoundment liner could potentially affect surface water quality. Sunbeam Pit has a higher potential than Grouse Pit to produce acid rock drainage following reclamation due to high sulfide-bearing rock. Grouse Pit is not expected to be acidic because of the relatively high amounts of calcium carbonate in the rocks.
Mitigations: French drains under waste dump will collect potential acid drainage and route it into diversion ditches or to tailings impoundment. Composite liner system for tailings impoundment used to minimize leakage. Surface water diversion ditches designed to carry 100 yr 24 hr storm event. Mine runoff captured and contained in tailings impoundment, or routed through sediment ponds. Underdrains installed under waste rock dump and tailings impoundment to capture subsurface flows for process water. Backfill the Sunbeam pit with waste rock from Grouse Creek. Waste rock with acid generating potential is segregated, and blended with neutralizing waste rock, placed in low permeability zones, used in mine pit backfilling, reclaimed to reduce possibility of acid drainage. Construction of a composite cap incorporating a synthetic liner and soil cover. Continued monitoring and characterization of waste and ore to determine neutralization requirements. Ferrous sulfate used to detoxify discharged tailings (keep WAD CN- below 50 ppm). If acid drainage mitigation not successful, it will be treated at a water treatment plant in perpetuity or until discharge meets WQ standards.
Predicted Water-Quality Impacts: Not expected to have a deleterious effect on water quality if mitigations are successful. Most noticeable impacts would be caused by infiltration of potential acid drainage from waste dump, potentially resulting in metal mobilization from lowering pH. Acid drainage could potentially form in Sunbeam pit and enter groundwater. Overall potential for significant groundwater contamination to occur is estimated to be low. Because alternative requires larger waste dump with more sulfide-bearing waste rock, there is a higher potential risk for future acid drainage from waste dumps, but is predicted to be insignificant. If acid drainage occurs, the effects could be long-term. Due to mitigations surface water quality not expected to be significantly affected. No impacts from blasting expected due to complete combustion of (ANFO). Adverse effects to water quality from impoundment liner leakage are unlikely due to underdrain and collection system. Post-reclamation Grouse Pit water not expected to be acidic due to relatively high amounts of carbonate in rocks.

10.4 MONITORING AND COMPLIANCE INFORMATION

Hecla experienced financial difficulties at the same time that water quality issues became noticeable. In 2000 the Grouse Creek Mine was declared a Forest Service CERCLA site, and in 2002 an Engineering Evaluation/Cost Analysis (EE/CA) for Non-time Critical Removal Action was performed at the Grouse Creek Mine Site. The following information was taken from the EECA.

Hecla Mining Company has been monitoring water quality since 1987. In 1995 cyanide was detected in both surface water and groundwater monitoring stations. Cyanide detection in wells below the South Embankment indicated that contaminated water was moving through the underlying materials below the tailings impoundment. Cyanide was periodically detected in Jordan Creek below the constructed wetlands. Since 1999, cyanide (total and WAD) concentrations have decreased in Jordan Creek. Since 2001, cyanide (WAD) concentrations have mostly been below detection limits (0.002 mg/l).

Chemicals of Potential Concern identified in tailings pore water included aluminum, copper, arsenic, selenium, silver, zinc, cyanide, ammonia and mercury. Constituents that exceeded acute water quality criteria for protection of aquatic life included aluminum, copper, arsenic, selenium, silver, zinc, and cyanide. Sampling data showed trends toward generally improving tailings impoundment water quality when the EE/CA was written. WAD cyanide concentrations were decreasing and were predicted to decline to less than 0.0025 mg/l by April 2002. Ammonia concentrations were declining steadily in tailings impoundment water and were predicted to be below 25 mg/l in 2003 and below 20 mg/l in 2004. Silver concentrations were declining, and concentrations at most sampling sites currently are below the detection limit (0.0005 mg/l). Copper concentrations have declined to an average of 0.04 mg/l since Fall 2000, and mercury concentrations have been below the detection limit of 0.0002 mg/l. Total nitrate concentrations have been increasing steadily, possibly due to metabolism of ammonia by microbial biomass.

Some contamination of groundwater is still evident at the site. However, since 2001, all contaminants of concern entering the Yankee Fork receiving water were below detection limits. Detectable cyanide (WAD and Total) concentrations were last measured in Jordan Creek in June 2000.

Table 10.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Grouse Creek Mine, Idaho.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater and Surface Water	Tailings and Waste Rock	• 1984 EIS: acid drainage observed but geochemical tests indicated minimal acid drainage potential • 1992 SEIS: Moderate acid drainage potential; low risk of significant groundwater contamination but potential impact to surface water from tailings	• 1984 EIS: stormwater controls and water monitoring • 1992 SEIS: stormwater controls and groundwater capture and treatment during operations; reclamation with buffering rock; composite liner system for tailings impoundment; French drains under waste rock dumps	• 1984 EIS: no impacts to water quality • 1992 SEIS: no impacts to water quality; adverse water quality effects from impoundment leakage unlikely due to underdrain and collection system	• EE/CA: tailings impoundment leakage into groundwater resulted in CN in groundwater and surface water. Tailings pore water exceeds standards for Al, Cu, As, Se, Ag, Zn, CN.

11 THOMPSON CREEK, IDAHO

11.1 GENERAL INFORMATION

Location: Custer County, ID
Ownership: Thompson Creek Mining Co.
Commodity: Molybdenum
Operation Type: Open Pit, Floatation Gravity
Years of Operation: 1983, still operating
Jurisdiction: Bureau of Land Management and U.S. Forest Service
Disturbed Acres: 2,110
Bond Amount: $11,305,703
NEPA Documents Available: 1980 EIS (New Project), 1999 EIS (Plan of Operations Changes)

11.2 WATER QUALITY SUMMARY

The 1980 FEIS stated concern about precipitation water leaching materials in toxic concentrations from the waste rock and tailings impoundment and the contaminated water reaching the groundwater, but leach tests concluded that the mine tailings and waste rock contained sufficient buffering capacity to neutralize potential acid that could be generated. They assumed that these conditions will continue beyond 20 years and assumed that no adverse impacts to Thompson Creek and the local groundwater systems due to potential leaching of trace metals would occur. The 1999 SEIS was produced to minimize adverse environmental impacts from the potential to generate acid drainage in the tailings facility and waste rock dumps. Geochemical testing of the material in the tailings embankment, the tailings beach, material within the impoundment, and waste rock samples (metasedimentary and intrusive type waste) all have the potential to generate acid. They predicted that as long as the whole tailings and pyrite concentrates were kept in a saturated, oxygen-free condition they would not generate acid drainage. Since the overall neutralization potential of the dump materials exceed the acid potential by a factor of 1.5 to 3.1 respectively which suggests that acid produced in the dumps would be neutralized if acid and neutralizing materials were well mixed and oxidation and neutralization reactions proceeded at similar rate. They modeled the acid generating potential over 100 years for both waste rock and tailings and noted that "there is increasing uncertainty due to the lack of information describing a number of processes controlling long-term oxygen diffusion and sulfide oxidation rates in tailings. This is new information that was not considered in the 1980 EIS. "The current mine plan of operations is not designed to control acid drainage in tailings and waste rock facilities." In the 1999 Final SEIS they are still predicting that no cumulative effects associated with surface water quality in Squaw and Thompson Creeks based on the fact that there is no apparent surface water degradation from the historic mining activities, inactive sites or any other mine facilities. They suggest that it is possible that pit water quality will be characteristic of acid mine drainage and high in metals such as molybdenum, iron and manganese, however, indications are that the pit will act as a sink, dewatering the surrounding groundwater system. For these reasons and based on existing information, no cumulative impacts on the quality of the local groundwater (or surface water) systems are predicted at this time.

Info from the EIS's for the above paragraph and their references:

The project is expected to have a moderate effect on the quality of surface and groundwaters. Infiltration from the tailings impoundment over the life of the project will result in increased concentrations of iron, manganese, and zinc in the local groundwater and Bruno Creek which exceed EPA drinking water standards, however, because of dilution with Squaw Creek water, the infiltration would not cause iron or zinc concentrations in Squaw Creek below Bruno Creek to exceed EPA drinking water standards (1980, 5-10, 5-11). The mine pit, waste dumps and settling ponds would only cause minor changes in the quality of the local groundwater system and Thompson Creek. No water quality effects are expected from drainage of ore storage areas (1980, S-4). There is concern about precipitation water leaching materials in toxic concentrations from the waste rock and tailings impoundment and the contaminated water reaching the groundwater (1980, 5-9) but leach tests showed that the lowest pH anticipated was 6.6 and effluent from waste dumps will not contain significant levels of toxic materials. Acid consumption tests on the low-grade ore indicated that its natural buffering capacity is sufficient to neutralize the potential acid that would be generated. The results of leach tests indicated that the effluent from the waste dumps will not contain significant levels of toxic materials. It is probable that these conditions will continue after 20 years. Considering these factors, no adverse impacts to Thompson Creek and the local groundwater systems due to potential leaching of trace metals are anticipated during the periods of construction, operation and abandonment of the project. Also effluent from the waste dumps would have minimal impacts on general water quality of surface and groundwaters in the vicinity of the waste dumps (1980, 5-10).

The 1999 SEIS was produced to minimize adverse environmental impacts from the potential to generate acid drainage in the tailings facility and waste rock dumps. Testing of samples from the waste rock and tailings indicates a potential for acid drainage. This is new information that was not considered in the 1980 EIS (1999, 1-2). The current mine plan of operations is not designed to control acid drainage in tailings and waste rock facilities. Tests performed include the following: Static ABA, Total and pyritic sulfur, TCLP, and Kinetic tests (1-4) (3-3 to 3-6) and Whole rock analysis (3-5).

The 1980 FEIS concluded that the mine tailings and waste rock contained sufficient buffering capacity to neutralize potential acid that could be generated. In the 1999 SEIS it was determined that material in the tailings embankment, the tailings beach and material within the impoundment have the potential to generate acid drainage. Geochemical testing of waste rock samples determined that a portion of metasedimentary and intrusive type waste rocks have the potential to generate acid while the volcanic rock does not (1999, 4-2). The saturated whole tailings and pyrite concentrates are not predicted to generate acid drainage as long as the saturated, oxygen-free condition in the impoundment is maintained (1999, 4-4). The potential for oxidation and release of acid drainage from the impoundment interior is considered negligible because saturated conditions will effectively exclude oxygen (4-5). They modeled the acid generating potential over 100 years for both waste rock and tailings and noted that “there is increasing uncertainty due to the lack of information describing a number of processes controlling long-term oxygen diffusion and sulfide oxidation rates in tailings” (4-8).

The overall neutralization potential of the dump materials exceed the acid potential by a factor of 1.5 to 3.1 respectively which suggests that acid produced in the dumps would be neutralized if acid and neutralizing materials were well mixed and oxidation and neutralization reactions proceeded at similar rates (4-8). While there are historic mining impacts in the area, there is no evidence that existing or reasonably foreseeable actions are causing or will cause cumulative impacts to Bruno or Squaw Creeks’ groundwater, but will be further assessed through implementation of the monitoring plan (4-22).

Although the concentrations of some constituents in the effluent from the waste rock dumps are higher than groundwater significance criteria, it has not been established that effluent is entering groundwater in quantities that are causing, or will cause exceedances of established groundwater criteria, therefore, effluent concentrations are not characterized as having predicted effects on groundwater (4-22). It is possible that pit water quality will be characteristic of acid mine drainage and high in metals such as molybdenum, iron and manganese, however, pit water cannot be predicted until further studies are completed. Indications are that the pit will act as a sink, dewatering the surrounding groundwater system. For these reasons and based on existing information, no cumulative impacts on the quality of the local groundwater (or surface water) systems are predicted at this time (4-23).

11.3 EIS SUMMARIES

11.3.1 1980 EIS

Proposed Project: New Project.

Geology/Mineralization: Bedrock consists of Paleozoic sedimentary rocks (vary in sequences of argillite, quartzite, limestone, dolomite and shale) intruded by Cretaceous igneous rocks known as the Idaho batholith which is overlain by a series of Tertiary volcanic rocks called the Challis volcanics. The primary sedimentary rocks from oldest to youngest are the Saturday Mountain, Copper Basin and Wood River Formations. The sedimentary rocks have been intruded by a biotite granodiorite-quartz monzonite stock (the Idaho Batholith). The most common rock in the area is

andesite and smaller portions of tuff and breccia. In some areas of intrusion, contact metamorphism has occurred, creating silicification and hornfelsing of the argillite.
Koppen Classification: Region – D, **Temperature –** a, **Precipitation –** s
Annual Precipitation/ Evaporation: Precipitation increases with elevation increase and wet in winter, dry in summer
Proximity to Surface Water: The major stream channels in the claim area are Squaw and Thompson Creeks which are tributary to the Salmon River. Other creeks within the boundary of the claim area include Buckskin Creek, Pat Hughes Creek, Bruno Creek, and an unnamed creek. Tailings Impoundment will be built on Bruno Creek.
Proximity to Groundwater: Groundwater levels range from flowing artesian in wells near Bruno Creek to greater than 1200 ft below ground surface in the mine area. Relatively small amounts of groundwater are contained within the surface soils and decomposed bedrock. Groundwater in the alluvium is in direct connection with surface water within the stream courses. The direction of water flow is generally to the south. Argillaceous sediments of the Copper Basin and Saturday Mountain formations are the primary sedimentary bedrock aquifers in the claim area.
Predictive Tests and Models: Several laboratory tests were performed on waste rock (characterize leachate, acid potential and quantity). Laboratory bench leach tests were conducted.
Constituents of Concern: Iron, Manganese, Zinc, Nitrate, total Kjeldahl Nitrogen, total organic carbon, and total volatile solids, TDS, total alkalinity and hardness.
Acid Drainage and Metal Leaching Potential: Leachate tests (using low-grade ore) indicate that the effluent from the waste dumps will not contain significant levels of toxic materials and will not be overly acidic and the lowest pH anticipated is 6.6.
Water-Quality Impact Potential: There is concern that water infiltrating waste dumps will leach materials in toxic concentrations from waste rock and that these will reach groundwater. Infiltration from tailings impoundment may exceed EPA DW standards for Fe, Mn, NO3, kjeldahl N, total organic C, total volatile solids, TDS, total alkalinity, hardness and Zn concentrations and could cause Bruno Creek to exceed criteria during low flow. There is concern that water infiltrating waste dumps will leach materials in toxic concentrations from waste rock and that these will reach surface water.
Mitigations: Tailings impoundment constructed across Bruno Creek and is designed as a "closed" water system. Seepage below and through impoundment is collected in a seepage control system. Monitoring system will be established downstream of tailings impoundment to monitor the effects it may have on Bruno and Squaw Creeks. Settling ponds will be constructed to capture water from Buckskin, Pat Hughes, and Unnamed Creeks near waste dumps.
Predicted Water-Quality Impacts: There is concern about precipitation water leaching materials in toxic concentrations from the waste rock and tailings impoundment and the contaminated water reaching the groundwater but leach tests showed that the lowest pH anticipated was 6.6 and effluent from waste dumps will not contain significant levels of toxic materials. A portion of impoundment seepage is expected to escape the seepage control system and reach Bruno Creek as subsurface flow (as much as 1,000 gpm in early years to much less than 100 gpm in later years (due to reduction in permeability as tailings increase). Seepage from the settling pond embankments is expected to be minimal. Moderate effects are predicted on groundwater quality. Infiltration from tailings impoundment could cause Bruno Creek to exceed criteria during low flow. Moderate effects are predicted on surface water quality.

11.3.2 1999 EIS SUMMARY

Proposed Project: Modification of Plan of Operations for waste rock and tailings impoundment
Geology/Mineralization: Thompson Creek intrusive complex (granodiorite stock) intruded into the Copper Basin Formation (carbonaceous siltite, argillite, and limestone). Subsequent intrusive pulses emplaced quartz monzonite core within the intrusive body. Host rocks composed of andesite and latite flows, agglomerates, and lithic tuffs. Molybdenum ore deposit is a result of mineralization within a granodiorite-quartz monzonite composite intrusive stock. Contact metamorphism of carbonate sedimentary rock resulted in metasediments (tactite and calc-silicate hornfels). Mineralization and associated alteration have occurred both with intrusive stock and sedimentary host rock, and associated with magmatic metasomatized and hydrothermal alteration. Sillicification and pyrite mineralization are present within argillite and granodiorite-quartz monzonite stock. Other existing minerals include muscovite,

biotite, K-feldspar, and pyrite. Pyrite mineralization is most common in metasomatized argillite. Intrusive stock is abundant in quartz, Na-Ca alumino silicates (oligoclase), Ca/Al silicates (plagioclase), K alumino silicates (orthoclase), minor mafic constituents (biotite), and pyritic sulfide and other sulfur compounds (molybdenite and pyrrhotite)

Climate:

Annual Precipitation/ Evaporation: averages 12 - 13 inches

Proximity to Surface Water: Bruno Creek flows through the tailings impoundment.

Proximity to Groundwater: Boreholes showed pre-mining groundwater levels ranged from 7,100 to 8,000 feet in elevation. Groundwater is typically found in shallow alluvial/colluvial systems located in valley bottoms, and in deeper fracture/fault controlled bedrock systems. No mention of depth to groundwater except for discharge of groundwater to surface water in the local Creeks and numerous springs and seeps mentioned. Surface and groundwater hydrologically connected in creeks.

Predictive Tests and Models: Static ABA, Total and pyritic sulfur, TCLP, and Kinetic tests, and whole rock analysis. PYROX model for prediction of sulfide oxidation rates.

Constituents of Concern: Constituents of concern identified through Kinetic testing include: Cadmium, copper, iron, lead, and zinc for Squaw Creek plus selenium and sulfate along with all of the above for Thompson Creek.

Acid Drainage and Metal Leaching Potential: The results of static (ABA) and kinetic testing concluded that under certain conditions (exposure to air and water) the tailings produced at the site will become acid producing. Approx. 21% of the waste rock piles have the potential to produce acid drainage while the other 79% of the waste rock contains only trace or no amounts of pyrite and that the material has significant acid neutralizing capacity. In 1988 visual signs of acid drainage were observed in the mine pit and face of the tailings embankment. The saturated whole tailings and pyrite concentrates are not predicted to generate acid drainage as long as the saturated, oxygen-free condition in the impoundment is maintained.

Water-Quality Impact Potential: Potential impacts to water quality in Squaw Creek based on PYROX model shows that the tailings embankment should have excess neutralization capacity at the end of the 100-yr. period and embankment pore water should remain circum-neutral. Pit hydrogeology is only used for discussion of cumulative effects because it does not support quantitative predictions of potential effects to surface or groundwater. Limited information is available on pit groundwater quality. Report "Groundwater Technical Momorandum, VTN 1980" indicated groundwater in the pit and waste rock dump vicinity was alkaline (pH 8 - 9.5) and had elevated Mo and Mn concentrations. Samples of pit water taken in 1989 showed pH 5.4, sulfate = 1028 ppm, and elevated Fe and Mn. Acid generation is dependent on how much of the sulfide bearing material is left in the pit walls. "Final Waste Rock Management Plan" reports that approx. 45% of the intrusives and 40% of the metasediments have the potential to be acid producing but this does not take into account the potential that in mining the ore and surrounding waste rock, most of the potentially acid producing rock may be removed.

Mitigations: Will maintain saturated conditions in tailings impoundment by the use of a seepage return system to prevent acid generation in tailings impoundment. Implementation of a new moitoring plan will further characterize ground and surface water connections and provide data on water quality and changes that may occur in the future.

Predicted Water-Quality Impacts: The saturated whole tailings and pyrite concentrates are not predicted to generate acid as long as the saturated, oxygen-free environment is maintained. No discharge of acid drainage is predicted for Tailings Embankment. Predict no acid generation from waste rock dumps because of neutralizing potential of waste rock exceeding acid potential by 1.5 to 3.1. For Thompson Creek, predicted water quality from PYROX modeling showed metals concentrations within the waste rock dumps would remain constant during the 100 yr period because of excess neutralization capacity in the dumps. No cumulative impacts on local ground or surface water quality are predicted for surface or subsurface discharges from the pit because it will act as a sink for the surrounding groundwater sources.

11.4 MONITORING AND COMPLIANCE INFORMATION

<u>Seeps from Mine Facilities</u>: 1999 EIS: in 1988 visual signs of ARD were observed and confirmed in the tailings embankment and the mine pit; Tailings seepage water quality shows increases in iron, zinc and alkalinity. Source (Dave Chambers?): Monitoring of seepage from the Buckskin and Pat Hughes waste dumps indicates sulfate and selenium levels have been rising since 1991.

Surface Water: 1999 EIS: Data from 1991 – 1995 indicate elevated levels of cadmium, copper, lead, sulfate and zinc in surface water. Downstream sulfate concentrations increased in surface water between 1989 and 1995 from 100 mg/l to 500 mg/l in one case, and from 300 mg/l to 1,000 mg/l in another case.

Table 11.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Thompson Creek Mine, Idaho.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater	Tailings	• 1980 EIS: No acid drainage potential but metals leaching potential • 1999 EIS: acid drainage potential in tailings	• 1980 EIS: dilution and biological activity • 1999 EIS: saturated conditions in the tailings impoundment to result in less acid drainage potential in slimes tailings	• 1980 EIS: water quality will be similar to background levels • 1999 EIS: acid drainage not predicted for at least 100 years	• Acid drainage observed in 1988 and confirmed in the tailings embankment Tailings seepage water had increases in Fe, Zn and alkalinity
	Waste Rock	• 1980 EIS: No acid drainage or contaminant potential • 1999 EIS: acid drainage potential in waste rock	• 1980 EIS: No mitigations identified • 1999 EIS: segregation and blending of PAG waste rock	• 1980 EIS: No impacts predicted • 1999 EIS: No impacts to groundwater predicted	• Buckskin and Pat Hughes waste dump seepage - rising SO_4 and Se levels since 1991
Surface Water	Tailings	• 1980 EIS: No potential for surface water impacts identified	• 1980 EIS: No mitigations identified	• 1980 EIS: No impacts predicted	• Elevated levels of Cd, Cu, Pb, SO_4 and Zn in surface water (1991-1995) • Increasing downstream SO_4 concentrations (100 to 500 and 300 to 1,000 mg/l), 1989 to 1995
	Waste Rock	• 1980 EIS: No potential for surface water impacts identified • 1999 EIS: acid drainage potential in waste rock	• 1980 EIS: No mitigations identified • 1999 EIS: segregation and blending of PAG waste rock	• 1980 EIS: No impacts predicted • 1999 EIS: No significant acid drainage or metals leaching or impacts to surface water are predicted	
Pit Water	Open Pit	• 1980 EIS: No potential for pit water impacts identified • 1999 EIS: pit water quality may be characteristic of acid drainage and have high concentrations of contaminants	• 1980 EIS: No mitigations identified • 1999 EIS: Pit will be terminal sink	• 1980 EIS: No impacts predicted • 1999 EIS: no impacts on local groundwater or surface water	• Visual signs of acid drainage observed/confirmed in mine pit (1988)

12 BEAL MOUNTAIN, MONTANA

12.1 GENERAL INFORMATION

Location: Silver Bow County, MT
Ownership: Pegasus Gold Co.
Commodity: Gold, Silver
Operation Type: Open Pit, Heap Leach
Years of Operation: 1989 - 1998
Jurisdiction: U. S. Forest Service
Disturbed Acres: 429
Bond Amount: $ 6,312,300
NEPA Documents Available: 1988 EA (New Project), 1993 EIS (Expansion)

12.2 WATER QUALITY SUMMARY

In the 1988 EIS, the description of the geology clearly identifies that sulfides of iron, copper, molybdenum and arsenic existed in the rock, occurring as microscopic to visible grains on fractures and veins. However, they stated that silica from the cherty matrix was sealing the sulfides, resulting in low acid production in the existing adit. Geochemical tests for the main Beal and South Beal deposits indicate a low potential for acid formation, however, "the release of sulfates and metals into surface waters is still considered to be a possibility and these substances could become mobile regardless of acid production." "Results of the acid-base testing indicate the waste rock would not generate acidic waters and would not be a significant source of metals." "The development of a noxious leachate from the waste rock dump is unlikely due to the low sulfide content of the waste material and the large acid-buffering capacity of the majority of the waste rock." "Tests on waste rock indicate that even a leachate developed under acidic conditions would be innocuous." Then in the 1993 EIS, they noted that elevated levels of sulfate had been detected at the monitoring stations near the main Beal waste rock facility. "Although the source has not been verified, there is a concern that this could be a precursor to acid drainage." As a result, samples of main Beal waste with higher sulfide content they chose to test a worst-case scenario and static tests showed that the potential for acid generation did exist. Trace element results conducted on four South Beal ore samples indicated trace element/ metal compositions for arsenic, barium, chromium, copper, iron, manganese, and zinc were elevated above background levels, however, leachate extraction tests resulted in no metals concentrations exceeding regulatory limits and they determined that metals mobility should be minimal. They expected sulfates to be released from the South Beal ore, and identified concern about elevated levels of sulfate detected at monitoring stations near main Beal waste rock facility, however, they predicted that the pH of the water would remain neutral. Results of 9 week Leach test indicates that metals mobility should be minimal. No direct discharge of mine pit water is expected to take place due to the use of a closed system, therefore the mine pit would have minimal impact on water quality. Open pit, waste rock dump, and heap are not expected to cause acid drainage, either during operations or after mining.

Info from the EIS's for the above paragraph and their references:

1988 EA: The Beal ore is native gold with nearly equal amounts of gold and silver that occurs as microscopic up to visible grains on fractures and cross-cutting veins. Sulfides are three to eight percent of the rock including pyrrhotite, pyrite, chalcopyrite, with traces of molybdenite and arsenopyrite. The minerals are sulfides of iron, copper, molybdenum and arsenic. The rocks have a rind of clays and/ or iron oxides enclosing fresh sulfides in a cherty matrix. This sealing by silica would account for the low acid production noted in the existing adit (32). Proposed mine lies in the headwaters of German Gulch. Beefstraight, Edwards and Greenland Creek are the major tributaries to German Gulch (33). Groundwater information in the vicinity of the proposed project limited. Baseline inventories by the company indicate typical mountain springs scattered throughout the area. Most are likely tied to a confined aquifer system (34). Constituents of concern include: Arsenic, Cadmium, and Lead (22). Geochemical tests reported include: Whole Rock Analysis, ABA and EP Toxicity (22). Results of acid-base balance testing for eight rock samples showed that all the rock types except one sample had a neutralization potential. Results of the acid-base testing indicate the waste rock would not generate acidic waters and would not be a significant source of metals (22). The development of a noxious leachate from the waste rock dump is unlikely due to the low sulfide content of the waste material and the large acid-buffering capacity of the majority of the waste rock. Tests on waste rock indicate that even a leachate developed under acidic conditions would be innocuous. No direct discharge of mine pit water is expected to take place due to the use of a closed system, therefore the mine pit would have minimal impact on water quality (46). Sulfates are in higher concentrations in the discharge from the adit below the proposed project. Surface and confined aquifers are likely connected (35). The low sulfide content of the dump material and the highly net-buffered capability of the material and the lack of a significant metals source suggest that degradation of water will not occur in the waste rock dump (50). It is anticipated that residual cyanide will be present after rinsing of the pad during reclamation, however natural degradation and dilution by precipitation and mobilization would reduce concentrations, therefore, it is felt that this impact would be minor and probably unpredictable (50).

In the 1993 EIS: A portion of the waste is iron oxide stained quartzite. The deposit contains pyrite, pyrrhotite and iron disulfides (IV-1). Constituents of concern included: Nitrate (III-16), Sulfate (S-2), Cyanide (III-17), increased sediment and TDS (IV-9) and they noted that TDS in the upper reaches of German Gulch had doubled since baseline data was collected (risen from avg. 136 ppm to high of 253 ppm (III-3). Geochemical tests included: Static ABA (Modified Sobek Method) and Kinetic tests (humidity cells) (S-4, II-7, IV-2), EPA Method 1310 tests (E.P. Toxicity) (IV-1), geochemical characterization of all rock types of South Beal to evaluate water quality in the mine area (IV-1), and trace element analysis (IV-1). Elevated levels of sulfate have been detected at the monitoring stations near the main Beal waste rock facility. Although the source has not been verified, there is a concern that this could be a precursor to acid drainage (S-2).

Due to the presence of pyrite, pyrrhotite and iron disulfides associated with the deposit, the potential for acid production exists. Geochemical material characterization tests for the main Beal and South Beal deposits indicate a low potential for acid formation. However, the release of sulfates and metals into surface waters is still considered to be a possibility and these substances could become mobile regardless of acid production (IV-1). Most of Beal waste material consists of quartzite and static testing could not confirm that all quartzite waste would not be acid non-acid producing. Therefore, kinetic testing using humidity cells, was conducted for 15 weeks and the results indicate that the South Beal quartzite waste would not be acid producing (IV-2). Currently sulfate concentrations in springs emanating from below the main Beal waste rock dump are increasing. This could either be due to dissolution of gypsum incorporated in the rock, dissolution of soil amendments, application of a sulfate used for chemical dust abatement, or the oxidation of iron disulfides and the subsequent production of sulfates. Samples of main Beal waste with higher sulfide content were chosen to test a worst-case scenario and static tests showed that the potential for acid generation exists for these samples (IV-3). Trace element analyses performed on three South Beal marble waste samples and two quartzite waste samples indicated slightly elevated concentrations of trace elements/metals in the rock, but the corresponding leachate extraction tests did not indicate any potential for metals release into the environment (IV-2). Trace element results conducted on four South Beal ore samples indicated trace element/ metal compositions for arsenic, barium, chromium, copper, iron, manganese, and zinc were elevated above background levels. Leachate extraction tests resulted in no metals concentrations exceeding regulatory limits and they determined that metals mobility should be minimal (IV-3). Trace element analyses were not done on main Beal spent ore. Static tests results on main Beal spent ore suggest an uncertainty as to whether sulfate release and metals leaching would eventually become a concern. Kinetic tests on the spent ore resulted in sulfate being released for all samples, indicating a possibility for oxidation of iron disulfide. A chemical analysis of humidity cell leachate of the spent ore after the 9th week indicated the possibility of arsenic mobility. The leachates were not analyzed for metals at the end of testing, therefore testing results were inconclusive regarding the potential for metals mobility. No samples tested produced an effluent with a pH lower than 8.13 after 13 weeks, however, the pH trend analysis for the spent ore sample of greater than 2 mm indicated a substantial drop in the last 2 weeks of testing from 8.24 to 6.4 (IV-3). Elevated levels of sulfate detected at monitoring stations near main Beal waste rock facility causing concern that acid drainage could form (S-2). South Beal deposit rocks contain some sulfides, so there is some potential for acid drainage (S-4). Water quality in German Gulch has changed since baseline data were collected, showing that TDS, sulfates and nitrates have increased considerably (S-3). Release of sulfates and metals into surface waters is still considered to be a possibility (IV-1). Addition of main Beal waste rock as backfill material into South Beal pits could provide a new source of potentially acid generating material, but by testing backfill material before placement and segregating acid producing material and by keeping pit floor above water table expected to prevent negative impacts to water (IV-4). Leach pad has a liner and effluent is controlled - results in only minor impacts from arsenic and other metals (IV-5). Addition of South Beal waste rock to the waste rock dump is not expected to produce acid or release contaminated leachate, but could provide neutral material for capping to help isolate potential leachable contaminants (buffer any acidic water that might be produced) (IV-4). LAD system demonstrated that all metal levels, including arsenic, are successfully attenuated prior to discharge (IV-5). They plan to add lime to the waste rock if necessary (IV-7). Currently some monitoring stations have had readings which exceed State Water Quality Standards and are not controlled with the existing Best Management Practices or mitigation Measures. They are undertaking studies to determine the sources of nitrate and sulfate in order to identify additional management practices for control (S-2). Nitrate concentrations have increased in groundwater in the vicinity of the main Beal project relative to background baseline conditions (III-16). Springs discharging below the main Beal waste rock dump indicate that Main Beal waste may contribute sulfates to groundwater (S-4). If water infiltrates backfilled pits, sulfates could be produced and enter groundwater (S-5). Sulfates are expected to be released from South Beal ore, but pH of water is expected to remain neutral (IV-7). Nitrate concentrations have increased in surface water in the vicinity of the main Beal project relative to background baseline conditions (III-16). Concentration of NO3 and SO4 releases from waste rock facilities may continue to increase with the addition of the South Beal waste (S-5). The potential that nitrates discharge to groundwater downgradient of the pits into German Gulch is minimal due to the distance between the pits and the stream. Sulfates are expected to be released from the South Beal ore, but pH of the water is expected to remain neutral. (S-5). Beal mine "would have both long and short-term environmental effects in German Gulch; however, these would not be significant in terms of either aerial extent or severity of impact" (I-2). Results of Leach test (EPA Method 1310) indicates that metals mobility should be minimal (IV-3). The addition of South Beal waste rock to the waste rock dump would not increase the potential for acid rock drainage because South Beal waste is not expected to produce acid or release contaminated leachate. The addition of South Beal marble/neutral waste rock could provide neutral material for capping and help isolate any potentially leachable contaminants (IV-4). There would be minor cumulative effects from the addition of the South Beal ore to the main Beal ore. Static and kinetic results suggest that the main Beal and South Beal ore could release sulfates and metals (IV-5). Open pit, waste rock dump, and heap are not expected to cause acid drainage, either during operations or after mining (I-2).

12.3 EIS SUMMARIES

12.3.1 1988 EA

Proposed Project: New Project
Geology/Mineralization: Metamorphosed continental rocks intruded by a quartz monzonite pluton composed of hornfels, quartzite, metaconglomerate with minerals quartz, diopside, biotite, feldspar and chlorite. The Beal ore is native gold with nearly equal amounts of gold and silver that occurs as microscopic up to visible grains on fractures and cross-cutting veins. Sulphides are three to eight percent of the rock including pyrrhotite, pyrite, chalcopyrite, with traces of molybdenite and arsenopyrite. The minerals are sulfides of iron, copper, molybdenum and arsenic. The rocks have a rind of clays and / or iron oxides enclosing fresh sulfides in a cherty matrix. This sealing by silica would account for the low acid production noted in the existing adit.
Climate: Modified Continental
Annual Precipitation/ Evaporation: 15 - 20 inches, 35 - 40 inches (both precip. mentioned in different parts of the EIS)/
Koppen Classification: Region – D, **Temperature –** a, **Precipitation –** s
Proximity to Surface Water: Proposed mine lies in the headwaters of German Gulch. Beefstraight, Edwards and Greenland Creek are the major tributaries to German Gulch.
Proximity to Groundwater: Groundwater information in the vicinity of the proposed project limited. Baseline inventories by the company indicate typical mountain springs scattered throughout the area. Most are likely tied to a confined aquifer system.
Predictive Tests and Models: Whole Rock Analysis, ABA and EP Toxicity
Constituents of Concern: Arsenic, Cadmium, Lead

Acid Drainage and Metal Leaching Potential: Sulfates are in higher concentrations in the discharge from the adit below the proposed project. Surface and confined aquifers are likely connected. For the parameters tested in the EP toxicity analyses (arsenic, cadmium and lead) the rocks were far below the concentration limits established by the EPA for hazardous waste. Extracted concentrations of copper and zinc were also very low. Results of acid-base balance testing for eight rock samples showed that all the rock types except one sample had a neutralization potential. The one sample had a net acid potential of -0.5 ppt (parts per thousand or tons of calcium carbonate per 1000 tons of rock). Results of the acid-base testing indicate the waste rock would not generate acidic waters and would not be a significant source of metals. The development of a noxious leachate from the waste rock dump is unlikely due to the low sulfide content of the waste material and the large acid-buffering capacity of the majority of the waste rock. Tests on waste rock indicate that even a leachate developed under acidic conditions would be innocuous. The low sulfide content of the dump material and the highly net-buffered capability of the material and the lack of a significant metals source suggest that degradation of water will not occur in the waste rock dump.
Water-Quality Impact Potential: The low sulfide content of the dump material and the highly net-buffered capability of the material and the lack of a significant metals source suggest that degradation of water will not occur in the waste rock dump. Results of the acid-base testing indicate the waste rock would not generate acidic waters and would not be a significant source of metals. The development of a noxious leachate from the waste rock dump is unlikely due to the low sulfide content of the waste material and the large acid-buffering capacity of the majority of the waste rock. Tests on waste rock indicate that even a leachate developed under acidic conditions would be innocuous.
Mitigations: Use diversion structures to direct precipitation around the open pit. All mine pit water would report to a sump located in the mine pit and would be pumped to the barren pond for inclusion in the process water circuit. The integrity of the leach pad liner would be assured through daily monitoring of a blanket drain system beneath the pad. In addition, the ponds would be equipped with a sump and leak detection system. Any cyanide-containing water encountered in either the sumps or underdrain would be pumped to the barren pond for inclusion in the process water circuit. Final reclamation plans for the mine pit include grading the pit floor to be free draining with water to report to German Gulch. Water exiting the final reclaimed pit would pass through a revegetated pit bottom, underlain by limestone and gravels to insure that acidic waters have not been generated. No impoundment of water would take place in the pit. The open pit would continue to act as a groundwater sink.
Predicted Water-Quality Impacts: It is anticipated that residual cyanide will be present after rinsing of the pad during reclamation, however natural degradation and dilution by precipitation and mobilization would reduce concentrations, therefore, it is felt that this impact would be minor and probably unpredictable. The development of a noxious leachate from the waste rock dump is unlikely due to the low sulfide content of the waste material and the large acid-buffering capability of the majority of the waste rock. The low sulfide content of the dump material and the highly net-buffered capability of the material and the lack of a significant metals source suggest that degradation of water will not occur in the waste rock dump. Water in the mine pit sump is expected to contain elevated amounts of nitrogen species (ammonia and nitrate/ nitrite) and solids due to the contact with blasted rock and blasting residue. No direct discharge of mine pit water is expected to take place due to the use of a closed system therefore the mine pit would have minimal impact on water quality. Results of the acid-base testing indicate the waste rock would not generate acidic waters and would not be a significant source of metals. The development of a noxious leachate from the waste rock dump is unlikely due to the low sulfide content of the waste material and the large acid-buffering capacity of the majority of the waste rock. Tests on waste rock indicate that even a leachate developed under acidic conditions would be innocuous. The low sulfide content of the dump material and the highly net-buffered capability of the material and the lack of a significant metals source suggest that degradation of water will not occur in the waste rock dump. Water in the mine pit sump is expected to contain elevated amounts of nitrogen species (ammonia and nitrate/ nitrite) and solids due to the contact with blasted rock and blasting residue. No direct discharge of mine pit water is expected to take place due to the use of a closed system, therefore the mine pit would have minimal impact on water quality.

12.3.2 1993 EIS SUMMARY

Proposed Project: Expansion – South Beal Pit
Geology/Mineralization: The host rocks for the South Beal deposit are a calcareous impure quartzite and a dense, chalky white, impure calc-silicate marble. The deposit is a single bed about 32 feet thick. The South Beal host and country rocks have been metamorphosed into an assemblage of biotite, diopside, potassium feldspar, chlorite, scapolite, quartz, actinolite-tremolite and hornblende is similar to the assemblage at the main Beal deposit. Igneous rocks peripheral to the deposit include diorite and granodiorite. The rocks associated with the South Beal deposit consist of quartzite/hornfels, marble and a very minor amount of diorite. The quartzite/biotite-hornfels rock makes up about 92% of the total overburden waste rock. Approx. 7% is a fine grained calc-silicate limestone or marble. A portion of the waste is iron oxide stained quartzite. The deposit contains pyrite, pyrrhotite and iron disulfides.
Climate:
Annual Precipitation/ Evaporation:
Koppen Classification: Region – D, **Temperature –** a, **Precipitation –** s
Proximity to Surface Water: German Gulch flows between the Main Beal and South Beal Pits. No springs or seeps known to exist on south side of German Gulch which would be impacted by the proposed South Beal Pits.
Proximity to Groundwater: Groundwater levels range from 25-50 ft below the proposed pit floor.
Predictive Tests and Models: Static ABA, Short Term Leach (EPA Method 1310), Kinetic (15 week humidity cell tests), geochemical characterization, trace element analysis.
Constituents of Concern: Nitrate, Sulfate, Cyanide, increased sediment and TDS.
Acid Drainage and Metal Leaching Potential: Elevated levels of sulfate have been detected at the monitoring stations near the main Beal waste rock facility. Although the source has not been verified, there is a concern that this could be a precursor to acid drainage. Due to the presence of pyrite, pyrrhotite and iron disulfides associated with the deposit, the potential for acid production exists. Geochemical material characterization tests for the main Beal and South Beal deposits indicate a low potential for acid formation. However, the release of sulfates and metals into surface waters is still considered to be a possibility and these substances could become mobile regardless of acid production. Most of Beal waste material consists of quartzite and static testing could not confirm that all quartzite waste would not be acid non-acid producing. Therefore, kinetic testing using humidity cells, was conducted for 15 weeks and the results indicate that the South Beal quartzite waste would not be acid producing. Currently sulfate concentrations in springs emanating from below the main Beal waste rock dump are increasing. This could either be due to dissolution of gypsum incorporated in the rock, dissolution of soil amendments, application of a sulfate used for chemical dust abatement, or the oxidation of iron disulfides and the subsequent production of sulfates. Samples of main Beal waste with higher sulfide content were chosen to test a worst-case scenario and static tests showed that the potential for acid generation exists for these samples. Elevated levels of sulfate have been detected at the monitoring stations near the main Beal waste rock facility. Although the source has not been verified, there is a concern that this could be a precursor to acid drainage. Due to the presence of pyrite, pyrrhotite and iron disulfides, the potential for acid production exists. Geochemical material characterization tests for the main Beal and South Beal deposits indicate a low potential for acid formation. However, the release of sulfates and metals into surface waters is still considered to be a possibility. These substances could become mobile regardless of acid production. Trace element analyses performed on three South Beal marble waste samples and two quartzite waste samples indicated slightly elevated concentration of trace elements/metals in the rock, but the corresponding leachate extraction tests did not indicate any potential for metals release into the environment. Trace element results conducted on four South Beal ore samples indicated trace element/ metal compositions for arsenic, barium, chromium, copper, iron, manganese, and zinc were elevated above background levels. Leachate extraction tests resulted in no metals concentrations exceeding regulatory limits and they determined that metals mobility should be minimal. Trace element analyses were not done on main Beal spent ore. Static tests results suggest an uncertainty as to whether sulfate release and metals leaching would eventually become a concern. Kinetic tests on the spent ore resulted in sulfate being released for all samples, indicating a possibility for oxidation of iron disulfide. A chemical analysis of humidity cell leachate after the 9th week indicated the possibility of arsenic mobility. The leachates were not analyzed for metals at the end of testing, therefore testing results were inconclusive regarding the potential for metals mobility.
Water-Quality Impact Potential: Elevated levels of sulfate detected at monitoring stations near main Beal waste rock facility causing concern that acid drainage could form. South Beal deposit rocks contain some sulfides, so there

is some potential for acid drainage. Release of sulfates and metals into surface waters is still considered to be a possibility. Water quality in German Gulch has changed since baseline data were collected, showing that TDS, sulfates and nitrates have increased considerably. Release of sulfates and metals into surface waters is still considered to be a possibility.

Mitigations: Successful reclamation would minimize any potential for impacts to groundwater from the release of sulfates and would reduce infiltration via use of revegetation and evapotranspiration. Addition of main Beal waste rock as backfill material into South Beal pits could provide a new source of potentially acid generating material, but by testing backfill material before placement and segregating acid producing material and by keeping pit floor above water table expected to prevent negative impacts to water. Leach pad has a liner and effluent is controlled - results in only minor impacts from As and other metals. If iron disulfide oxidation occurs, they would segregate waste to isolate reactive waste and cap it. Addition of South Beal waste rock to the waste rock dump is not expected to produce acid or release contaminated leachate, but could provide neutral material for capping to help isolate potential leachable contaminants (buffer any acidic water that might be produced). LAD system demonstrated that all metal levels, including As, are successfully attenuated prior to discharge. Addition of lime to waste rock will occur if necessary. Pit bottoms will be above the water table. Backfilling and capping will prevent water accumulation in the pits. Pit floors composed of marble bedrock would act to buffer the hydrological system and reduce potential for contaminant leaching. Any water that may accumulate in pits prior to backfilling would be used for irrigation on reclaimed portions of the waste rock facilities or other areas. Use water treatment plant for cyanide destruction. Monitor South Beal heap and waste rock to determine whether it will produce acid drainage and prevent any serious problems by addressing them as necessary. Water quantity would be controlled by LAD of process water in the leach pad.

Predicted Water-Quality Impacts: Currently some monitoring stations have had readings which exceed State Water Quality Standards and are not controlled with the existing Best Management Practices or mitigation Measures. They are undertaking studies to determine the sources of nitrate and sulfate in order to identify additional management practices for control. Impacts to groundwater from mining the South Beal Pits are expected to be minimal because the pits would be open for only two years (one year) and would have a short-term effect on groundwater (would have little if any effect on groundwater). Water table under pits is 25 to 50 ft below the estimated levels of the pit floors, so groundwater would not come in contact with backfilled waste from main Beal. Nitrate concentrations have increased in groundwater in the vicinity of the main Beal project relative to background baseline conditions. Springs discharging below the main Beal waste rock dump indicate that Main Beal waste may contribute sulfates to groundwater. If water infiltrates backfilled pits, sulfates could be produced and enter groundwater. Sulfates are expected to be released from South Beal ore, but pH of water is expected to remain neutral. Concentration of NO3 and SO4 releases from waste rock facilities may continue to increase with the addition of the South Beal waste. The potential that nitrates discharge to groundwater down gradient of the pits into German Gulch is minimal due to the distance between the pits and the stream. Beal mine "would have both long and short-term environmental effects in German Gulch; however, these would not be significant in terms of either aerial extent or severity of impact". Results of Leach test (EPA Method 1310) indicates that metals mobility should be minimal. Open pit, waste rock dump, and heap are not expected to cause acid drainage, either during operations or after mining. Heap is part of a zero discharge circuit and would not release any water to the surface.

12.4 MONITORING AND COMPLIANCE INFORMATION

Groundwater: 1993 EIS: Elevated sulfate levels detected at monitoring stations near main Beal waste rock facility – possible precursor to acid drainage. Increased (compared to baseline) groundwater nitrate concentrations in vicinity of main Beal project. Springs below main Beal waste rock dump indicate it may contribute sulfate to groundwater. This could either be due to dissolution of gypsum incorporated in the rock, dissolution of soil amendments, application of a sulfate used for chemical dust abatement, or the oxidation of iron disulfides and the subsequent production of sulfates.

Surface Water: 1993 EIS: Nitrate concentrations have increased in surface water in vicinity of the main Beal project relative to background baseline conditions. Water quality in German Gulch has changed since baseline data were collected, showing that TDS, sulfates and nitrates have increased considerably. Currently some monitoring stations have had readings which exceed State Water Quality Standards and are not controlled with the existing Best Management Practices or mitigation

Existing Conditions Report

According to the February 2004 Existing Conditions Report (ECR) developed as part of the Engineering Evaluation /Cost Analysis (EE/CA) for this CERCLA site, surface water sampling in German Gulch results showed that concentrations of nitrate (MCL = 10 mg/l) and sulfate were less than 10 mg/l. Total recoverable concentrations of most metals and metalloids (including arsenic and copper) were below chronic aquatic life standards, while total recoverable iron concentrations in German Gulch did exceed secondary MCL values near the mine site. Selenium concentrations were well below the chronic aquatic life standard of 0.005 mg/l. The total concentration of cyanide in German Gulch was 0.008 mg/l, slightly higher than the chronic standard of 0.0052 mg/l. Total recoverable concentrations of copper were below the chronic aquatic standard at all stations in German Gulch in 2003. Selenium concentrations measured in December 2003 were 0.011 mg/l.

Groundwater quality monitoring well data indicated that groundwater in the LAD area exceeded standards for nitrate, iron, and cyanide and had elevated total dissolved solids concentrations. Cyanide was not detected in the LAD area groundwater prior to 2001 when the LAD was initiated. Springs below the LAD area also showed appreciable increases in cyanide and selenium concentrations. Concentrations of selenium, sulfate, nitrate, and total dissolved solids were elevated in seeps sampled at the toe of the waste rock dump.

Geochemical data from both static and kinetic tests indicated that roughly one-third of waste rock and ore mined from the Beal Pit is potentially acid generating, one third is not and the remaining one-third has uncertain potential to generate acid. Geochemical characterization test results from South Beal pit ore and waste rock suggested a low potential for acid drainage from the pit highwalls and waste rock, and a high potential from residual ore. However, the relatively small amount of residual ore is not expected to generate enough acidity to overwhelm the neutralization potential of the surrounding rock.

Static testing of spent ore indicated a high potential for acid generation; however, kinetic tests indicated a low potential for acid generation. Alkalinity and pH values have decreased somewhat following cessation of leaching operations, indicating that the neutralizing capability of the heap is slowly being depleted. Selenium and copper concentrations in the pad appear to be declining.

Water emanating from the toe drain collection system is pumped to a storage pond and has elevated selenium, sulfate and nitrate concentrations and cannot be discharged directly to surface water or groundwater without treatment.

Current leach pad water quality has elevated concentrations of sulfate (2,600 mg/l), selenium (0.38 mg/l), arsenic (0.16 mg/l), iron (4.0 mg/l, copper (0.42 mg/l), total cyanide (9.5 mg/l), and WAD cyanide (0.061 mg/l). Alkalinity values have decreased to about 100 mg/l ($CaCO_3$ equivalent).

From Mine Design, Reclamation, and Closure Conference April 2005 (Poulson, MT):
1998: Pegasus files for bankruptcy
1998-2002: Forest Service and MT DEQ continue reclamation activities in cooperation with bankruptcy trustee
1999: Treated solution kills vegetations, find thiocyaniate in system; surey bond inadequate
2002: Clark Fork Coalition filed lawsuits against Forest Service and MT DEQ
2003: Forest Service enacts CERCLA and enters into a settlement agreement with CRC (Forms RWG)
2003: Mine begins time-critical CERCLA action to treat water and other work and began work on EE/CA to evaluate final closure option.

Table 12.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Beal Mountain Mine, Montana.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater and Surface Water	Leached Ore	• 1988 EA: . Impact from residual cyanide from the leaching process was predicted to be minor and probably undetectable • 1993 EIS: South Beal ore in leach pad could be acid generating but expected to remain neutral	• 1988 EA: solution ponds equipped with sump, leak detection • 1988 EA: leach pad rinsed to address residual cyanide followed by natural degradation, dilution and "mobilization." • 1993 EIS: effluent treated for cyanide and disposed by LAD	• 1988 EA: Water quality impacts from the leach pad would be minor and probably unpredictable • 1993 EIS: only minor impacts from As via LAD 1993 EIS: Heap is part of a zero discharge circuit and would not release any water to the surface.	• 2004 ECR: LAD of leach pad leachate following water treatment resulted in contamination of groundwater exceeding standards for nitrate, iron, cyanide. Exceedence of cyanide concentrations in surface water
	Waste Rock	• 1988 EA: Low acid drainage and metals potential suggests that degradation of water will not occur from the waste rock dump • 1993 EIS: some potential for acid drainage and release of sulfates and metals to water resources	• 1988 EA: No mitigations identified • 1993 EIS: reclamation would minimize any potential for impacts to groundwater from the release of sulfates and reduce infiltration • 1993 EIS: segregation and blending of PAG waste rock with lime added if necessary	• 1988 EA: No impacts predicted • 1993 EIS: Concentration of NO_3 and SO_4 releases from waste rock facilities may continue to increase	• 1993 EIS: Increased SO_4 concentrations in waste rock toe seeps - possible precursor to acid drainage. Increases in TDS, SO_4, NO_3 in German Gulch relative to baseline data. • 2004 ECR: elevated Se, sulfate, nitrate and TDS in seeps below waste rock
Pit Water	Open Pit	• 1988 EA: Mine pit water expected to contain elevated ammonia and nitrate/ nitrite from blasting.	• 1988 EA: Diversion of stormwater and pit water for process use • 1988 EA: pit backfilled, lined with limestone and gravels, free-draining; rock in pit would neutralize contaminants	• 1988 EA: No pit water predicted • 1993 EIS: Predicted impacts would have little if any effect on groundwater.	2004 ECR: water from the open pit toe drains has elevated selenium, sulfate and nitrate and requires capture and treatment

13 BLACK PINE, MONTANA

13.1 GENERAL INFORMATION

Location: Granite County, MT
Ownership: ASARCO
Commodity: Gold, Silver, Copper
Operation Type: Underground, Flotation Gravity
Years of Operation: 1974 - 1989
Jurisdiction: U. S. Forest Service
Disturbed Acres: 429
Bond Amount: $ 8,074,500
NEPA Documents Available: 1981 EA (Preliminary Environmental Review for mine reopening), 2003 EA (Reclamation)

13.2 WATER QUALITY SUMMARY

In 1981 they identified that sulfides and oxides existed at the site, however, no geochemical testing was reported to have taken place anywhere in the EA. They still predicted that impacts to surface water systems in the project area would be minimal and there was no mention of acid drainage in the report. In the reclamation EA of 2003, they identify the site as having "on-going water quality problems" and "acid drainage" from the waste rock dumps. Still no geochemical studies were reported to have been conducted on the waste rock materials and reclamation is in progress. Mitigations such as diversion ditches for storm water and seepage capture systems have been put into place as well as a lined storage pond to help prevent contaminated water from leaving the site. They are pumping collected water back into the underground mine workings.

Info from the EIS's for the above paragraph and their references:

1981 EA: Primary mineral association is hubnerite, tetrahedrite, pyrite, and galena. Secondary mineral association consists of malachite, pyromorphite, oxidized lead, antimony, and native silver (9). Information on the groundwater hydrology of the area is sparse. Test borings in the impoundment area indicate that the groundwater table is approx. 45 feet below ground surface. A total of 30 springs were inventoried in the project area (11). Impacts to surface water systems in the project area will be minimal. The tailings impoundment is designed as a closed cycle system. No planned discharge to surface waters will occur (10). Any leaks in the tailings line system will be detected either by the flow monitoring sensors in the pipeline of the three times-a-day visual inspection (10).

2003 EA: Pyrite, iron staining, and copper bearing minerals can be seen on the surface of the dump and copper staining from mobilization of copper minerals can be seen on rocks, bones, and other debris on the surface of the dump (3). Constituents of concern identified include: sulfates, copper, zinc, iron, cadmium, and low pH (2.6-4.7) (11). There are on-going water quality impacts caused primarily by snowmelt leaching through the waste rock dump and seeping out through the toe of the dump (1). The site has acid rock drainage problems (4). The leachate has flowed downhill across the permit boundary and the acid and high copper content have killed the vegetation in the path of these annual short-term flows (1). Several ephemeral springs and one perennial spring have been located either adjacent to or beneath the waste rock dump and down-slope from the dump in or adjacent to the Combination Soils barren areas. The springs drain into ephemeral drainages that flow into Smart Creek. These springs are acidic (pH ranging between 2.6 and 4.7) and are high in sulfates, copper, zinc, iron and cadmium. These seeps and springs tend to flow during and after snowmelt and large precipitation events although some are perennial (11). Runoff would be collected and pumped back into the mine workings. This would be a temporary measure until interim reclamation of the dump is completed in 2004 (4). ASARCO constructed a seepage control system in 2001 to control offsite migration of acidic waters, which included a network of seepage collection trenches designed to intercept shallow sub-surface water migration. The intercepted water gravity drains to one of two pumping stations and is pumped back into the underground workings. To determine whether the underground mine water was hydraulically connected to the springs and seeps under the waste rock dump, they added NaOH to the mine pool, but no NaOH was detected in the local springs, so they determined that "there is no documented connection between the mine pool and local springs." A shallow trench along the edge of the waste rock dump intercepts stormwater off the face of the dump and shallow seepage, and drains into a temporary stormwater capture pond. This system has shown limited effectiveness under high runoff conditions and some water has been bypassing the system under the lined stormwater pond (13).

13.3 EIS SUMMARIES

13.3.1 1981 EA

Proposed Project: Preliminary Environmental Review (PER) 1981 for re-opening the mine
Geology/Mineralization: Sedimentary rocks in the proposed project area consist primarily of the Newland Formation (impure limestone, calcareous shales, and calcareous argillites) and the Spokane Formation of Algonkian age (red and green shales and red and white quartzites). Ore production has been limited to the quartzites of the Spokane Formation. Four ore bearing quartzite veins have been identified which include: the Combination, Tim Smith, Onyx, and the Upper. Primary mineral association is hubnerite, tetrahedrite, pyrite, and galena. Secondary mineral association consists of malachite, pyromorphite, oxidized lead, antimony, and native silver.
Climate:
Annual Precipitation/ Evaporation:
Koppen Classification: Region – D, **Temperature –** a, **Precipitation –** s
Proximity to Surface Water: The project area is drained by Henderson Creek, Marshall Creek and south Fork Lower Willow Creek which are all tributaries to Flint Creek. Flint Creek is the major drainage in the project area. The proposed tailings area is located on a small tributary of Marshall Creek.
Proximity to Groundwater: Test borings in the impoundment area indicate that the groundwater table is approx. 45 ft below ground surface. A total of 30 springs were inventoried in the project area.
Predictive Tests and Models:
Constituents of Concern:
Acid Drainage and Metal Leaching Potential:
Water-Quality Impact Potential:
Mitigations:
Predicted Water-Quality Impacts: Impacts to surface water systems in the project area will be minimal. No planned discharge to surface waters will occur.
The tailings impoundment is designed as a closed cycle system. No planned discharge to surface waters will occur.

13.3.2 2003 EA SUMMARY

Proposed Project: Reclamation
Geology/Mineralization: The waste rock dump consists primarily of the quartzites and argillites of the Spokane Formation including ore vein material. Pyrite, iron staining, and copper bearing minerals can be seen on the surface of the dump and copper staining from mobilization of copper minerals can be seen on rocks, bones, and other debris on the surface of the dump.
Climate:
Annual Precipitation/ Evaporation: It is estimated that snowmelt in an average year would result in as much as 11 to 13 inches of precipitation that would leave the site within a 2 week period.
Koppen Classification: Region – D, **Temperature –** a, **Precipitation** - s
Proximity to Surface Water: There are no perennial streams near the Combination Mine. The nearest perennial stream is Smart Creek located about 1.25 miles southeast of the toe of the waste rock dump. Several ephemeral springs and one perennial spring have been located either adjacent to or beneath the waste rock dump and downslope from the dump in or adjacent to the barren areas.
Proximity to Groundwater:
Predictive Tests and Models:

Constituents of Concern: sulfates, copper, zinc, iron, cadmium, low pH (2.6 - 4.7).
Acid Drainage and Metal Leaching Potential:
Water-Quality Impact Potential:
Mitigations:
Predicted Water-Quality Impacts: The site has acid rock drainage problems.
Local springs drain into ephemeral drainages that flow into Smart Creek. These springs are acidic (pH ranging between 2.6 and 4.7) and are high in sulfates, copper, zinc, iron and cadmium.

13.4 MONITORING AND COMPLIANCE INFORMATION

According to the 2003 EA, the site has acid rock drainage problems. Springs adjacent to/beneath waste rock dump and combination soils barren areas flow to Smart Creek and are acidic (pH 2.6-4.7), high in sulfate, copper, zinc, iron, cadmium. The 2003 EA was initiated to reduce on-going water quality impacts caused by leachate from the waste rock dump. The leachate also runs overland and has killed vegetation in the area of the flows. In 2001 ASARCO was ordered to construct surface diversions around the toe of the dump and to construct a lined stormwater capture pond and a seepage collection system to capture other contaminated springs in the area. The water is pumped into the underground workings. The capture and pumpback system reduced water quality impacts to a large extent.

Table B.13. Summary of Potential, Predicted and Actual Impacts and Mitigations at the Black Pine Mine, Montana.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater and Surface Water	Waste Rock	• 1981 EA: no potential for ARD or leaching of contaminants was identified • 2003 EA: existing leachate from the waste rock dump contaminating groundwater and springs on site with ARD and metals. • 2004 EA: long-term leachate from the waste rock dump and potential water quality problems from underground mine workings	• 1981 EA: No planned discharge to surface waters will occur • 2003 EA: relocation and improvements to the seepage collection systems below the waste rock dump; consolidation/placement of contaminated materials on top of the waste rock dump; and regrading the waste rock dump from angle of repose to a 3:1 slope. • 2004 EA: reclamation of the waste rock dump with a composite engineered cover; contingency to require more permanent long-term water management measures if the proposed reclamation measures are not effective o capture, pumpback, treatment and disposal.	• 1981 EA: impacts to surface water systems in the project area will be minimal • 2003 EA: reduction of existing water quality impacts is expected • 2004EA: long-term reduction and prevention of future water quality impacts is expected	2000 DEQ: identified existing leachate from the waste rock dump contaminating springs on site showed elevated levels of sulfates, copper, zinc, iron, cadmium, and low pH (2.6 - 4.7).

14 GOLDEN SUNLIGHT, MONTANA

14.1 GENERAL INFORMATION

Location: Jefferson County, MT
Ownership: Placer Dome, Inc. (100%)
Commodity: Gold
Operation Type: Underground, Open Pit, Vat Leach, Floatation
Years of Operation: 1983 to present
Jurisdiction: Bureau of Land Management, Forest Service, Private
Disturbed Acres: 2,967
Bond Amount: $64,089,000
NEPA Documents Available: 1981 EIS (New Project); 1990 EA (Expansion); 1998 EIS (Expansion)

14.2 WATER QUALITY SUMMARY

In 1981, initial tests of the ore confirmed that there was a potential for the ore at Golden Sunlight Mine to be an acid producer, however, these results were dismissed due to the fact that the ore was ground and not mine-run size, and therefore not representative of field conditions. Analysis has shown that the normal operation of the proposed facilities would not result in a significant adverse impact to the areas existing subsurface and surface water resources "Based on the fact that previous historic mining activity and waste dump development on the project area have not resulted in the occurrence of acid mine drainage, and the general lack of a water discharge from existing underground workings at the site, it is reasonable to conclude that the potential for acid mine drainage as a result of the proposed project is minimal." No groundwater or surface water study was performed on the project area prior to permitting, even though one water sample that was collected and analyzed had a pH value of 5.48 and a high concentration of magnesium. In 1990, they acknowledged the existence of acid drainage on site and finally mention the existence of ferricrete deposits in the vicinity. Mitigations included the use of a bactericide prior to seeding or during operations to reduce the rate of pyrite oxidation. Then in 1997, the EIS clearly states that "Pyrite is by far the most abundant metallic mineral ranging from 3 to 5 percent with up to 20 percent can occur in the ore. The relatively fine texture of this pyrite enhances the surface area available for acid drainage generation." They acknowledged that reclaimed waste rock dumps were acid generating and that acid drainage is being produced by the ore stockpile near the mill. They finally acknowledged the presence of natural acid drainage-like solutions from springs in the project area with elevated concentrations of sulfate and trace metals. These springs are considered natural because of the abundant ferricrete associated with them …which indicates that acid drainage has been produced by Bull Mountain for some time and that the rock excavated from the open pit readily forms acid drainage.

Info from the EIS's for the above paragraph and their references:

Results of Acid Production Potential tests confirmed the potential for the ore to be an acid producer, however since the test was conducted on finely ground ore, and not mine-run size ore, they did not consider the test results to be indicative of field conditions. Analysis has shown that the normal operation of the proposed facilities would not result in a significant adverse impact to the areas existing subsurface and surface water resources (1981, 32). "Based on the fact that previous historic mining activity and waste dump development on the project area have not resulted in the occurrence of acid mine drainage, and the general lack of a water discharge from existing underground workings at the site, it is reasonable to conclude that the potential for acid mine drainage as a result of the proposed project is minimal" (1981, 33). Because of the proposed use of finger drains, clay liners, and cutoff trench, and the impervious nature of the underlying sediment, it can be concluded that the threat for seepage of contaminated waters into the area's groundwater system is slight (37). A single water sample taken in August 1980 and analyzed by the Montana Bureau of Mines and Geology in Butte indicate acidic water (pH 5.48) with unusually high Mg, indicating the dominant sulfate was magnesium sulfate (1981, 32).

In the 1990 EA, they acknowledged the existence of acid drainage on site similar to that in the Historic Ohio adit. Waste rock contains 1 to 5 % sulfides, of which 99 % is pyrite with minor amounts of chalcocite, chalcopyrite, bornite, galena, sphalerite and barite. Oxidation of waste rock follows surface topography and is generally limited to within 100 ft of the surface (1990, 14). High sulfur water with low pH and elevated metals were sampled from springs on the site. Ferricretes were mentioned that exist southeast of the mine indicating ancient acid drainage (1990, 25). Mitigations included the use of a bactericide prior to seeding or during operations to reduce the rate of pyrite oxidation (1990, 126). Then in 1997, the EIS clearly states that "Pyrite is by far the most abundant metallic mineral ranging from 3 to 5 percent with up to 20 percent can occur in the ore. The relatively fine texture of this pyrite enhances the surface area available for acid drainage generation" (121). Monitoring of reclaimed dumps shows that waste rock has the geochemical potential to generate acid drainage and that oxidation of sulfide minerals is presently occurring due to infiltration of moisture. Acid drainage is being produced by the ore stockpile near the mill but is being captured in a lined pond and routed to the water treatment plant (141-142). Several springs in the GSM project area have chemical compositions that are strongly influenced by acid drainage-like solutions and some have elevated concentrations of sulfate and trace metals. These springs are considered natural because of the abundant ferricrete associated with them …which indicates that acid drainage has been produced by Bull Mountain for some time and that the rock excavated from the open pit readily forms acid drainage (147). Mitigations and failures: A deficiency in the slurry cut-off wall below Tailings Impoundment No. 1 allowed groundwater and seepage from the impoundment in April 1983. In 1984, several interception/ pump back wells were constructed to collect seepage from Tailings Impoundment No. 1. Additional pump back wells were installed in 1990. Tailings Impoundment No. 2 has a synthetic liner to prevent seepage from the tailings into the underlying materials. Water draining from tailings in Impoundment No. 2 is collected and drains on top of the geomembrane liner, and is conveyed into the reclaim ponds below the impoundment which is then recycled back to the mill. Defects in the liner were detected in 1995 and were repaired (157).

14.3 EIS SUMMARIES

14.3.1 1981 EIS

Proposed Project: New Project
Geology/Mineralization: Brown to gray micaceous siltstone, sandstone, claystone, conglomerate, and fluvial silty clay and gravel deposits.
Climate: Semi arid intermountain
Annual Precipitation/ Evaporation: ranging from 12 to 20 inches/
Proximity to Surface Water: Jefferson Slough is approx. 3/4 mile south of the permit area.
Proximity to Groundwater: Two distinct groundwater regimes exist: perched groundwater and numerous springs of Sunlight Gulch; depth to unconfined water of the Jefferson River floodplain is about 50 to 60 ft.
Predictive Tests and Models: Acid Production Potential Test (ABA)
Constituents of Concern:
Acid Drainage and Metal Leaching Potential: Results of testing confirmed the potential for the ore to be an acid producer. Based on the fact that previous historic mining activity and waste dump development on the project area have not resulted in the occurrence of acid mine drainage, and the general lack of a water discharge from existing underground workings at the site, it is reasonable to conclude that the potential for acid mine drainage as a result of the proposed project is minimal.
Water-Quality Impact Potential: Of major concern should a spill occur to surface drainage systems would be the cyanide and metallocyanide complexes contained in the solution. The major potentials for impact to the existing water resources would include: seepage of chemically contaminated waters from the tailing impoundment into adjacent groundwater systems. It is possible, however, that a drainage system failure, or an irregularity in the underlying soil materials could allow seepage that would typically a high pH with total suspended solids and possible heavy metal content. The presence of significant amounts of heavy metal ions in the seepage would be of a potentially greater concern. The major potentials for impact to the existing water resources would include: a massive failure of the proposed tailing containment system resulting in a surface flow of tailings that could potentially reach the Jefferson Slough. The lack of any perennial surface waters in close proximity of the proposed facilities, should

result in a minimal potential for adverse affects to the area's water resources if cleanup efforts are prompt. Pit water may infiltrate and contribute to the groundwater system. The amount of water trapped would be insignificant compared to the regional groundwater system and any impacts to groundwater quality probably would be undetectable. The infiltration of surface water to the groundwater system would be very localized and should not cause any measurable change in groundwater quality.
Mitigations: Use bentonite slurry cutoff design, blanket drain beneath the dam and finger drains in conjunction with peripheral clay liners along each side of the tailings impoundment. Seepage would be collected in ditches and pumped back to the impoundment
Predicted Water-Quality Impacts: Analysis has shown that the normal operation of the proposed facilities would not result in a significant adverse impact to the areas existing subsurface and surface water resources. Because of the proposed use of finger drains, clay liners, and cutoff trench, and the impervious nature of the underlying sediment, it can be concluded that the threat for seepage of contaminated waters into the area's 1groundwater system is slight.

14.3.2 1990 EA

Proposed Project: Expansion
Geology/Mineralization: A silicious breccia pipe, approx. 700 ft in diameter occurs within the horst and is the primary host for gold mineralization. The oldest rock in the project area consists of coarse arkosic sandstone and argillic shale, calcareous shales, black limestones and thin bedded calcareous, sometimes weakly silicified, siltstones. These are ore hosta and become silicified toward the breccia pipe. younger rocks in the area consist of fine grained sandstone or orthoquartzite, sandy shale, basal breccia, conglomerates, sandstones, shales, calcareous siltstones and fine grained arkosic rocks. Igneous rocks in the immediate vicinity of the mine consist of latite porphyry and lamprophyre intrusives, andesite, andesite porphyry flows, tuffs and agglomerates. The silicious breccia pipe contains disseminated mineralization that extends more than 100 ft into the wallrock in silicified structures. Alteration consists of pyritization, silicification and decarbonization with an alteration mineral assemblage containing silica, pyrite, barite, sericite, chalcopyrite, galena, sphalerite, and molybdenite. Gold occurs as disseminated particles associated with the pyrite in the breccia matrix, auriferous pyrite, and minor telluride minerals. Superimposed across the breccia pipe and into the surrounding wall rock are northeast trending gold-quartz veins that may contain pyrite, galena, sphalerite, and barite. Waste rock contains 1 to 5 % sulfides, of which 99 % is pyrite with minor amounts of chalcocite, chalcopyrite, bornite, galena, sphalerite and barite. Oxidation of waste rock follows surface topography and is generally limited to within 100 ft of the surface
Climate: Semi arid intermountain
Annual Precipitation/ Evaporation: ranging from 10 to 20 inches with an average of 14 inches/ Pan evaporation averaged 45 inches.
Koppen Classification: Region – D, **Temperature –** a, **Precipitation –** s
Proximity to Surface Water: There are no perennial surface water flows within the permit boundary but are small ephemeral drainages that contain water during snowmelt and precipitation events. One major and two minor ephemeral drainages, which would be covered with waste rock, contribute to an unnamed drainage which courses just south of Sheep Rock, then southerly to the Jefferson Slough.
Proximity to Groundwater: Groundwater elevations of the Bedrock Aquifer within the proposed pit area range from 5,300 to 5,470 ft. Depth to groundwater within the Bozeman Group Aquifer is generally less than 100 ft. A line of springs to the north of tailings impoundment 1 is interpreted as a discharge point for a perched system.
Predictive Tests and Models: Acid Production Potential Test (ABA), EP Toxicity, total sulfur and sulfur fractionation, and Laboratory Weathering.
Constituents of Concern: Low pH, elevated levels of metals, nitrates, and high salt concentrations.
Acid Drainage and Metal Leaching Potential: The pH value for waste rock averaged 4.2 (acid generating). All laboratory weathering samples of waste rock produced acid. All samples of unoxidixed mudrock near the breccia ore body produced acid upon laboratory weathering. All samples of oxidized mudrock produced acid upon laboratory weathering. If reclamation does not eliminate available oxygen and water, the tailings may eventually acidify. Waste rock piles would eventually acidify due to convection and diffusion of sulfur compounds from below without a waste rock cap. Acid mine drainage has been observed in the Ohio adit with elevated levels of Cd, Fe, Zn, Ni, and Cu. Water seeping from impoundment II is estimated to be as low as pH 2.4 and would be expected to mobilize metals.

Water-Quality Impact Potential: Plan to extend pit mining down to an elevation of 4,800 ft. which is approx. 225 ft below estimated groundwater table. Ultimate water quality in mine pit is uncertain, but leachate analysis suggests the water would have low pH, elevated levels of metals, nitrates, and high salt concentrations and are expected to be in excess of the natural groundwater conditions.
Mitigations: Engineered mitigations: Impoundment I designed with an amended soil liner and a piping system above the liner to carry tailing seepage through the embankment face to a collection system and returned to the mill circuit. Slurry wall would intercept the majority of seepage from impoundment I.
Predicted Water-Quality Impacts: It is anticipated that seepage to the east and south of impoundment I may occur. In time, a decrease in the effectiveness of the plumbing system for impoundment I is expected. This decrease in efficiency may result in a rise of phreatic levels within impoundment I and drainage through the impoundment bottom or through the embankment face. The EIS prepared for GSM amendment 001 concluded incorrectly that there is no evidence of acid mine drainage in the area. Operation of Impoundment I has influenced the local groundwater quality, flow direction and quantity. Unanticipated site conditions during construction led to two distinct seepage problems for Impoundment I (improper construction of a bentonite slurry cut-off wall led to the escape of tailing effluent and contaminated downgreadient wells with cyanide; and escape of impoundment fluids to the east containing copper concentrations of 65 ppm).

14.3.3 1998 EIS SUMMARY

Proposed Project: Mine Expansion. Expand the pit, waste rock dump areas, and buttress area. Divert Sheep Creek into Conrow Creek to prevent contact with acid generating waste rock.
Geology/Mineralization: Precambrian sedimentary rocks (including sandstone, siltstone and shale - Belt Supergroup. Cretaceous-age latite porphyry intrusions and numerous smaller lamprophyre dikes. Older Paleozoic rocks (Tertiary Bozeman Group sediments) consist of low permeability clays to carbonate-rich shales and limestones with select units exhibiting high acid neutralization potential. The Precambrian sedimentary rocks highly mineralized with sulfide minerals, mostly pyrite. The primary concentration of gold is a 700-ft diameter breccia pipe of late Cretaceous-age. Gold occurs primarily as very fine grains of ore that are disseminated within the breccia pipe and immediately adjacent rocks. Free gold occurs interstitially, as microscopic particles between pyrite grains. Gold-bearing tellurides are present in minor amounts. Pyrite is the most abundant metallic mineral with an average of 3-5 % pyrite in the ore with concentrations up to 20% which can occur, but are not typical.
Climate: Semi arid
Annual Precipitation/ Evaporation: ranging from 13 to 15 inches
Proximity to Surface Water: No perennial streams in the mine area. The Jefferson Slough is approximately 3500 ft from the tailings impoundment.
Proximity to Groundwater: Numerous springs and seeps have been identified throughout the mine site area. These seeps typically flow less than a few hundred feet before infiltrating back into the ground.
Predictive Tests and Models: Static (ABA), Kinetic (Humidity Cell), Mixing Cell Model to predict timeframe for acid drainage impacts.
Constituents of Concern: From pit water, tailings, waste rock seepage/pore water samples: Al, As, Cd, Cu, Zn, pH, SO_4, Ca, Mg, Cr, Fe, Pb, Mn, Ni, Se, Nitrate/Nitrite.
Acid Drainage and Metal Leaching Potential: Test results showed 3-5% and up to 20% pyrite in ore, majority of waste rock materials potentially acid generating, water collected in pit has significant acid drainage potential, tailings will acidify providing a potential for acid drainage. In waste rock pore water several contaminants exceed drinking water standards by 10x or more.
Water-Quality Impact Potential: Acid drainage from waste rock dumps could reach groundwater. Time frame for significant waste rock acid drainage impacts ranges from tens to hundreds of years. Slow movement of wetting front through waste rock and run-on controls limit potential migration of acid drainage to surface water. Pit Pond water would experience acid drainage, but would be treated before being discharged to the groundwater system.
Mitigations: Drains will be installed at the edges of waste rock dumps to reduce the amount of acid drainage that reaches groundwater systems. Engineered limestone drains would collect, channel and partially treat seepage from expanded waste rock dumps on the east side. Monitoring and capture wells will minimize seepage of acid drainage into local groundwater systems. If spring water quality and quantity deteriorates, water would be supplied for wildlife

and livestock use from the water treatment plant, or new sources would be developed. Pumpback wells will capture cyanide plume from Tailings Impoundment No. 1. Collection and treatment of any pit water. Preferred alternative: No pit pond. Chemical precipitation will reduce concentrations of metals and TDS, producing a dense sludge that will then be dewatered and stored in Tailings Impoundment No. 2. Use limestone drains, water treatment plant, and chemical precipitation to mitigate water quality problems. If pit water exceeds standards, mitigation will proceed through increased dewatering.
Predicted Water-Quality Impacts: No groundwater impacts anticipated during active mining. Groundwater down-gradient from East Waste Rock Dump predicted to have limited acid drainage impact (returning to neutral pH within 2,200 to 2,400 feet down-gradient from dump). No impacts to groundwater quality expected down-gradient from East Waste Rock Dump outside proposed mixing zone. Natural neutralization of acid drainage from West Waste Rock Dump expected to be minimal. Because seepage from Tailings Impoundment No. 1 will be collected and treated, potential impacts to water quality are limited to the local cyanide plume associated with Tailings Impoundment No. 1. Over the long-term, potential leakage from the Tailings Impoundment No. 2 HDPE liner is likely to occur, but the main liner under the impoundment is underlain by compacted clay which should contain most small, isolated leaks. Seepage from Tailings Impoundment No.2 and West Waste Rock Complex are expected to require perpetual treatment. No impacts to surface waters are anticipated during active mining operations. No impacts to surface water quality are anticipated down-gradient from the East Waste Rock Dump outside the mines proposed mixing zone. Pit water would be impacted by acid drainage, but would be treated before discharge to groundwater, so no impacts to water quality are anticipated. Pit water is expected to require perpetual treatment.

14.3.4 2005 EIS

Proposed Project: Pit reclamation
Geology/Mineralization: See above for other EISs. Ferricrete deposits are common on the surface and at depth at Golden Sunlight Mine. This provides an indication of the geochemical conditions of potential pit groundwater flow paths, in particular the neutralization capacity of the sediments along a given potential groundwater flow path. Ferricrete at GSM has been dated to 11,000 yrs. Three to 5% pyrite with concentrations of up to 20%; Bozeman Group sediments contain carbonate-rich shales and limestone, but not part of ore body.
Climate: No information
Annual Precipitation/ Evaporation: No information
Koppen Classification: Region – D, **Temperature –** a, **Precipitation –** s
Proximity to Surface Water: The potentiometric map of the T/Q alluvial aquifer indicates that this groundwater flow system is hydrologically connected the the Jefferson River alluvial aquifer, approximately 12,500 feet to the south.
Proximity to Groundwater: Seeps and springs on site. Pit is currently maintained as a hydrologic sink.
Predictive Tests and Models: No information.
Constituents of Concern: No information.
Acid Drainage and Contaminant Leaching Potential: Some springs downgradient of the pit area have ARD signatures, including Rattlesnake Spring, Bunkhouse Springs, Stepan Spring, Stepan Original Spring, and North Borrow Springs. All of these, with the exceptions of Bunkhouse Springs and North Borrow Springs, can be associated with mineralized geologic structures or with abandoned mine adits which interconnect to mineralized zones.
Potential Water-Quality Impacts (before mitigations): *Groundwater*: Because all the mined materials are highly reactive, oxidize quickly and produce acid, seepage from these materials will be acidic with high concentrations of dissolved sulfate and elevated levels of a variety of dissolved metals. Because the open pit extends deep into the groundwater system, water quality problems occurring inside the pit backfilled with ARD generating material could impact downgradient groundwater and adjoining aquifers. Mitigations to prevent groundwater contamination are being examined (1-23). After mining, if the groundwater table rebounds to a static condition, fracture controlled flow to surface seeps could increase and acid springs could develop again. If reclamation alternatives that include backfill and/or that do not maintain the pit as a hydrologic sink are likely to have a greater potential for seep development, or for increased flow or metal loaking in existing seeps, than those that do not include backfill. Maintaining the pit as a hydrologic sink could minimize the risk of seep development. *Surface water*: No information. *Pit water*: Because the open pit extends deep into the groundwater system, water quality problems occurring inside the pit backfilled with

ARD generating material could impact downgradient groundwater and adjoining aquifers. Mitigations to prevent groundwater contamination are being examined.
Mitigations: *Groundwater:* Pumping groundwater would limit saturation of the backfill. Maintain pit as hydrologic sink. *Surface water:* Groundwater would be permanently drawn down resulting in minor reductions in the flows of springs that are hydrologically connected to the pit. *Pit water:* Agencies predicted that 102 gpm of groundwater would need to be pumped and treated under the No Pit Pond Alternative and 47 gpm under the Partial Pit Backfill Alternative. GSM projects 32 gpm (total inflow - evaporation) for the No Pit Pond Alternative taking into account the recent drought conditions.
Predicted Water-Quality Impacts (after mitigations): *Groundwater:* Groundwater quality standards would be met at the permit boundary. *Surface water:* There would be no pit discharge and no risk of violation of surface water standards and impacts to beneficial uses in the Jefferson River and Slough. *Pit water:* Because the open pit extends deep into the groundwater system, water quality problems occurring inside the pit backfilled with ARD generating material could impact downgradient groundwater and adjoining aquifers. Mitigations to prevent groundwater contamination are being examined.
Discharges: No information.

14.4 MONITORING AND COMPLIANCE INFORMATION

1990 EA: Acid mine drainage has been observed in the Ohio adit with elevated levels of Cd, Fe, Zn, Ni, and Cu. Water seeping from impoundment II is estimated to be as low as pH 2.4 and would be expected to mobilize metals. The EIS prepared for GSM amendment 001 concluded incorrectly that there is no evidence of acid mine drainage in the area. Operation of Impoundment I has influenced the local groundwater quality, flow direction and quantity. Unanticipated site conditions during construction led to two distinct seepage problems for Impoundment I (improper construction of a bentonite slurry cut-off wall led to the escape of tailing effluent and contaminated downgradient wells with cyanide; and escape of impoundment fluids to the east containing copper concentrations of 65 ppm).

1998 EIS: Water collected in pit has significant acid drainage potential. In waste rock pore water, several contaminants exceed drinking water standards by 10 times or more. Local cyanide plume associated with Tailings Impoundment No. 1. Seepage from Tailings Impoundment No.2 and West Waste Rock Complex are expected to require perpetual treatment. They acknowledged that reclaimed waste rock dumps were acid generating and that acid drainage is being produced by the ore stockpile near the mill. They finally acknowledged the presence of natural ARD-like solutions from springs in the project area with elevated concentrations of sulfate and trace metals. These springs are considered natural because of the abundant ferricrete associated with them, which indicates that acid drainage has been produced by Bull Mountain for some time and that the rock excavated from the open pit readily forms acid drainage.

Table 14.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Golden Sunlight Mine, Montana: Groundwater and Surface Water.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater and Surface Water	Tailings	• 1983 EIS: Geochemical tests indicate ARD potential but site indications used to suggest low actual potential. • 1983 EIS: Potential for contamination of groundwater from tailings solution containing cyanide. • 1990 EA: Potential for ARD and metals in leachate • 1998 EIS: Short-term tailings leak containing cyanide and other contaminants expected to continue • 1998 EIS: Long-term potential for tailings to go acid	• 1983 EIS: Facility design to prevent groundwater and surface water impacts. o use of finger drains o clay liner o cutoff trench o impervious nature of the underlying sediments • 1990 EA: Capture of contaminated groundwater o Slurry walls and downgradient wells • 1998 EIS: Capture of contaminated groundwater o Slurry walls and downgradient wells o landowner buyouts o replacement water provisions • 1998 EIS: Reclamation cover to decrease long-term potential for impacts from ARD	• 1983 EIS: Risk to groundwater "slight" • 1990 EA: Prevent contamination from becoming more extensive in groundwater and will protect surface water • 1998 EIS: Little or no long-term impact to groundwater from ARD	• 1990 EA: Contamination of cyanide and copper in downgradient wells • 1998 EIS: Continued contamination of cyanide and copper in dowgradient wells • WQ Monitoring: Capture not 100% efficient due to operational problems

Table 14.2 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Golden Sunlight Mine, Montana: Groundwater and Surface Water (cont.) and Pit Water.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater and Surface Water	Waste Rock	• 1983 EIS: Geochemical tests indicate ARD potential but site indications used to suggest low actual potential • 1990 EA: Significant potential for ARD and metals in waste rock leachate • 1998 EIS: Significant potential for impacts from ARD and metals over long-term	• 1983 EIS: No mitigations identified as needed • 1990 EA: Capture of contaminated groundwater o Slurry walls and downgradient wells • 1990 EA: Engineered covers to reduce leachate production • 1998 EIS: Capture of contaminated groundwater o Slurry walls and downgradient wells o installation of drains and other seepage capture devices • 1998 EIS: Reclamation cover to decrease long-term potential for impacts from ARD	• 1983 EIS: Risk from ARD "minimal" • 1990 EA: Mitigations to prevent significant long-term impacts from ARD • 1998 EIS: Mitigations to prevent significant long-term impacts from ARD in surface water	WQ Monitoring: No actual impacts noted to date although springs near east waste rock dump and pore water in all waste rock dumps indicate long-term ARD and metals leaching impacts
Groundwater, Surface Water and Pit Water	Open Pit	• 1983 EIS: Pit not expected to go below groundwater level • 1990 EA: Significant potential for ARD and metals in leachate from open pit • 1998 EIS: Pit water expected to be characteristic of ARD	• 1983 EIS: No mitigations identified as needed • 1990 EA: Capture of contaminated pit water • 1998 EIS: Capture and treatment – no pit lake allowed to form	• 1983 EIS: no impacts to water quality • 1990 EA: Mitigations to prevent significant long-term impacts from ARD • 1998 EIS: Mitigations to prevent significant off-site impacts from ARD	WQ Monitoring: Monitoring of pit water indicates ARD characteristics

15 MINERAL HILL, MONTANA

15.1 GENERAL INFORMATION

Location: Park County, MT
Ownership: TVX Gold Inc. (100%); Homestake Mining Company (1.25% NRS)
Commodity: Gold, Silver
Operation Type: Underground, Vat Leach
Years of Operation: 1989 - 1996
Jurisdiction: Forest Service, Private
Disturbed Acres: 69 (106 including historical disturbed acres)
Bond Amount: $8,537,000
NEPA Documents: 1986 EIS (New Project), 2001 EIS (Reclamation and Closure)

15.2 WATER QUALITY SUMMARY

The 1986 EIS reported that baseline water quality samples were collected in 1981 on a monthly basis at three sites prior to mine startup, one above the site, one adjacent to the project site, and one below the project site. Leachate from batch extraction tests contained elevated cyanide as free cyanide, arsenic and manganese. Continued monitoring after mine startup was required using existing wells, along with additional wells to monitor the unsaturated zone surrounding the tailings impoundment. Information provided by the applicant suggested that the availability of water in the mine workings would limit acid drainage because the lowest proposed working level would be about 62 feet above the only documented source of water and they were not expecting the workings to produce appreciable amounts of water. In the 2001 EIS, they reported that on-site water quality did not meet MT Water Quality Standards and that seepage quantity would be measurable following closure, not as was predicted in 1986. The residual water from the dry tailings and precipitation percolating through the pile did not meet MT WQ Standards and needed to be treated with pH adjustment and RO, prior to release. The mine closure plans required the decommissioning and replacement of the reverse osmosis/ evaporation treatment plant with a passive biological treatment system to treat the 1300 Adit discharge and tailings effluent for arsenic removal, and where possible, pumps would be replaced by gravity-driven systems. They stated that by mixing treated tailings storage facility water with Crevice Adit water to meet applicable groundwater quality standards, there would be no local or cumulative impact to the environment when released to the uplands habitat development site. No impacts to the mine site area groundwater and surface water had been identified during the12 years of pre-mining and operational monitoring. “By reclaiming the site, post-closure impacts should be negligible, and no cumulative impacts are expected.”

Info from the EIS's for the above paragraph and their references:

1986 FEIS: Iron-chemical precipitates, which formed during periods of stability when volcanic activity subsided, contain higher sulfide, gold, arsenic, copper and iron concentrates than the volcanic sediments. Minerals in the gold-bearing zone include arsenopyrite, pyrrhotite, pyrite, chlorite, quartz, and amorphous carbon. Gold ore grades range from a trace to high-grade, nugget-bearing ore (II-2). Baseline water quality samples were collected and analyzed on a monthly basis for three sites in Bear Creek (upstream of the project site, adjacent to the project area, and at the confluence of Bear Creek and the Yellowstone River) beginning in April 1981 for a period of one year (II-11). Continued monitoring using existing wells, along with additional wells and monitoring the unsaturated zone surrounding the tailings impoundment was required to be put in place (III-12). Batch Extraction Leach Test on tailings (III-9). Leachate from batch extraction contained elevated cyanide as free cyanide, arsenic and manganese (III-9) (See table III-4, pg III-10 for results of Batch Test Leachate and Supernatant). Information provided by the applicant suggests that the availability of water in the mine workings would limit acid drainage. The lowest proposed working level is about 62 feet above the only documented source of water and 150 feet above Bear Creek so they are not expecting the workings to produce appreciable amounts of water (III-10, III-11). Two sources of groundwater contamination: Direct seepage from the tailings dump and the production of leachate in mine workings and backfill that could percolate through bedrock fractures to the Bear Creek alluvium. Mitigations to prevent seepage from entering the groundwater system involve the construction of a lined seepage control drainage system (III-10). The availability of water in the mine workings would limit acid drainage. The existing workings do not produce appreciable amounts of water, however, a small seep near a portal at 6,601 feet produces a few gpm. The lowest proposed level is about 62 feet above the only documented source of water so they are not expecting the workings to produce appreciable amounts of water (III-10, III-11). Removal of two historic tailings impoundments would result in a decrease in the loading of cyanide, arsenic, and other heavy metals to the groundwater system and Bear Creek (III-6). Tailings would not be dewatered before backfilling, however slurry would be controlled by ditches in the mine, collected in underground sumps, and pumped back to the mill circuit (II-7, II-8). After reclamation surface water from Bear Creek would be sampled both upstream and downstream from the operation. Special sampling would be done as needed after discharges from sediment control structures, for example. A comprehensive groundwater monitoring program would be developed (I-19).

2001 FEIS: On site water quality does not meet MT Water Quality Standards (16). Treatment of the 1300 Adit water by chemical coprecipitation would reduce arsenic levels in the discharge from an average concentration of 0.506 mg/L to below the background arsenic concentration of 0.036 mg/L, therefore the effluent is anticipated to contain less than 0.02 mh/L arsenic (25). The closure plans include the decommissioning of the reverse osmosis/ evaporation treatment plant with a passive biological treatment system to treat the 1300 Adit discharge and tailings effluent for arsenic removal, and where possible, pumps would be replaced by gravity-driven systems (ES-2). Additional monitoring wells would be installed to verify that mining and reclamation activities have not modified natural trends in groundwater quality (ES-3). The residual water from the dry tailings and any precipitation percolating through the pile are intercepted by drain tiles and transported to a seepage collection pond. This water does not meet MT WQ Standards and is treated with pH adjustment, and RO, prior to release to Bear Creek. Residual drainage from the tailings storage facility would continue for an indefinite time and the current approved plan provides for no water treatment (4). Under this plan, tailings effluent would be treated using a two-stage biological treatment system (aerobic, anaerobic), then effluent would go to a second-stage wet meadow habitat development site (20). It has been apparent since Nov 99 that seepage quantity would be measurable following closure, not as was predicted in 1986 (17). Lateral subsurface flow along the soil/clay layer interface could dissolve metals or other constituents of concern and transport them to the periphery and off the lined area. This potential contamination pathway was not analyzed in the 1986 EIS (17). Seepage water does not meet water quality standards (17). By applying treated tailings storage facility water to the uplands habitat development site, which has been mixed with Crevice Adit water to meet applicable groundwater quality standards, there would be no local or cumulative impact to the environment. No other impacts to the area are proposed that could increase pollutant loads (21). No impacts to the mine site area groundwater and surface water have been identified by the 12 years of pre-mining and operational monitoring. By reclaiming the site, post-closure impacts should be negligible, and no cumulative impacts are expected (29).

15.3 EIS SUMMARIES

15.3.1 1986 EIS SUMMARY

Proposed Project: New Project.
Geology/Mineralization: Ancient, metamorphosed marine sediments host the gold-bearing ore. The thickness of the gold-bearing strata varies from just a few inches to as much as 75 feet thick. Volcanic sediments were metamorphosed and formed massive, quartz-rich horizons bearing minor amounts of gold, sulfides and tungsten (scheelite), within quartz-biotite schists and biotitic quartzites. Minerals in the gold-bearing zone include arsenopyrite, pyrrhotite, pyrite, chlorite, quartz, and amorphous carbon. Gold ore grades range from a trace to high-grade, nugget-bearing ore.
Climate: Long cold winters and short cool summers.
Annual Precipitation/ Evaporation: 18 inches (ranging from 12 to 35.4 inches)/
Koppen Classification: Region – D, **Temperature –** a, **Precipitation** - s
Proximity to Surface Water: Doesn't say in the text. Map observations show existing tailings are approximately 100 feet from Bear Creek.
Proximity to Groundwater: Approximate depth to the water table is 100 to 150 feet. Perched water is found above layers of silts and clays and is most likely associated with seepage from the historic tailings impoundment. There is a perched water table located under a tailings dump that is approximately 100 ft bgs.

Predictive Tests and Models: Batch Extraction Leach Test on tailings, Batch Extraction and Batch Column tests.
Constituents of Concern: Total nitrogen from sewage disposal; arsenic and cyanide from historic tailings; leachate from batch extraction contained elevated cyanide as free cyanide, arsenic and manganese.
Acid Drainage and Metal Leaching Potential: Availability of water in the mine workings would limit acid drainage.
Water-Quality Impact Potential: Information provided by the applicant suggests that the availability of water in the mine workings would limit acid drainage. The lowest proposed working level is about 62 feet above the only documented source of water and 150 feet above Bear Creek so they are not expecting the workings to produce appreciable amounts of water.
Mitigations: Removal and reprocessing of old existing tailings piles. Tailings would not be dewatered before backfilling, however slurry would be controlled by ditches in the mine, collected in underground sumps, and pumped back to the mill circuit.
Predicted Water-Quality Impacts: Sources of water contamination: Direct seepage from the tailings dump and the production of leachate in mine workings and backfill that could percolate through bedrock fractures to the Bear Creek alluvium. Increased sediment loading on Bear Creek expected.

15.3.2 2001 EIS SUMMARY

Proposed Project: Modify Reclamation and Water Management Plans
Geology/Mineralization: No information.
Climate: No information.
Annual Precipitation/ Evaporation: No information.
Koppen Classification: Region – D, **Temperature –** a, **Precipitation –** s
Proximity to Surface Water: After treatment, water is discharged into Bear Creek
Proximity to Groundwater: No information.
Predictive Tests: None.
Constituents of Concern: Nitrate and arsenic. Arsenic is the primary pollutant of concern.
Acid Drainage and Metal Leaching Potential: Lateral subsurface flow along the soil/clay layer interface could dissolve metals or other constituents of concern and transport them to the periphery and off the lined area. This potential contamination pathway was not analyzed in the 1986 EIS. No impacts to the mine site area groundwater and surface water have been identified by the 12 years of pre-mining and operational monitoring.
Mitigations: pH adjustment, settling, two-stage high pressure Reverse Osmosis chambers and evaporation. Tailings effluent would be treated using a two-stage biological treatment system (aerobic, anaerobic), then effluent would go to a second-stage wet meadow habitat development sit. After treatment, water is discharged into Bear Creek.
Predicted Water-Quality Impacts: It has been apparent since Nov 99 that seepage quantity would be measurable following closure, not as was predicted in 1986. Seepage water does not meet water quality standards. By reclaiming the site, post-closure impacts should be negligible, and no cumulative impacts are expected.
Discharges: Discharge to Bear Creek after treatment.

15.4 MONITORING AND COMPLIANCE INFORMATION

2001 EIS: It has been apparent since Nov 99 that there would be seepage in the mine workings following closure, not as was predicted in 1986. Seepage water does not meet water quality standards. Tailings leachate containing cyanide and nitrates as well as manganese, sulfate, arsenic and TDS escape the liner system and caused exceedances by discharging into alluvial aquifer and surface water. Flow from mine workings of approximately 15 gpm which contains arsenic in excess of standards

Table 15.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Mineral Hill Mine, Montana.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater and Surface Water	Tailings	• 1986 EIS: potential for elevated cyanide, arsenic and manganese in tailings leachate to contaminate groundwater • 2001 EIS: potential for cyanide, arsenic, manganes, sulfate, nitrates and TDS in tailings leachate to contaminate alluvial aquifer and surface water	• 1986 EIS: Tailings dewatered and placed in a lined repository • 2001 EIS: capture and treatment of the leachate with discharge to the vadose zone; water balance cover to reduce seepage	• 1986 EIS: no impacts predicted • 2001 EIS: no impacts predicted as long as mitigation is maintained (100 years)	2001 EIS: tailings leachate containing cyanide and nitrates as well as manganese, sulfate, arsenic and TDS escape the liner system and caused exceedances by discharging into alluvial aquifer and surface water
	Underground Workings	• 1986 EIS: potential for ARD from mine workings or backfill to contaminate alluvial aquifer • 2001 EIS: potential for increased flow of approximately 15 gpm which contains arsenic in excess of standards	• 1986 EIS: would not produce appreciable amounts of water • 2001 EIS: water treatment to reduce arsenic to acceptable levels and discharge to groundwater	• 1986: no impacts predicted • 2001 EIS: no impacts predicted as long as mitigation is maintained (100 years)	• 2001 EIS: flow from mine workings of approximately 15 gpm which contains arsenic in excess of standards

16 STILLWATER, MONTANA

16.1 GENERAL INFORMATION

Location: Stillwater County, MT
Ownership: Stillwater Mining Company
Commodity: Platinum, Palladium
Operation Type: Underground, Floatation Gravity, Smelter
Years of Operation: 1986 - present
Jurisdiction: Forest Service, Private
Disturbed Acres: 120
Bond Amount: $7,800,000
NEPA Documents: 1985 EIS (New Project); 1992 EIS (Amend Plan of Operations); 1998 EIS (Revised Waste Management and Hertzler Tailings Impoundment)

16.2 WATER QUALITY SUMMARY

The Stillwater Mine has been conducting a baseline water quality study since 1980 to document the water quality to prior the development of the mine and during on-going mine operations. This is one of the only thorough water quality studies that has been conducted at any mine to date. In the 1985 FEIS, they report that there have been no adverse impacts on the surface waters of the area from exploration activities. Only nitrogen compounds are expected to affect groundwater quality but would not influence algae growth in Stillwater River because of low P concentrations in river. Mitigations set in place to reduce environmental impacts include: Tailings impoundment lined with 36-mil hypalon synthetic liner would prevent seepage from reaching Stillwater River; regularly scheduled water monitoring program; ditches and occasional collection ponds along the slurry pipeline to capture any spills. In the 1992 FEIS, Static testing of ore and waste materials determined that no acid drainage is expected. Proper use of blasting agents and limiting exposure to water has been implemented to reduce nitrates and nitrites in adit water, and clarification is being used to reduce total dissolved solids. In the 1998 FEIS, they reported that groundwater quality remains generally good in the area of the SMC project. Granitic Stillwater Complex is a non-acid generating ore body with low sulfur concentrations. Tests confirm acid-base potential of waste rock to generate acid water is low. They plan to continue annual testing of tailings and waste rock to verify the lack of acid-generating potential of the materials. They are continuing regularly scheduled monitoring of surface water quality, and are denitrifying adit water with anoxic biotreatment cell (ABC). No acid drainage has developed at the site to date, and no impacts to the Stillwater River and surrounding area have been observed.

Info from the EIS's for the above paragraph and their references:

1985 EIS: To date, no adverse impacts on the surface waters of the area have occurred from exploration activities. Stillwater River would not be influenced by percolation pond seepage. Only nitrogen compounds are expected to affect groundwater quality (IV-8). Pond water seepage would be diluted by groundwater and Stillwater River. After dewatering and reclaiming tailings impoundment, tailings not expected to pose a long-term water quality hazard, even if membrane liner deteriorates over time due to low precipitation and high evaporation and plant uptake (IV-9). Even under most severe conditions (high flow and high nitrate concentrations in pond seepage and low flow and high nitrate concentrations in river) excess algal growth in river would not occur (III-13). Additional N compounds would not influence algae growth because of low P concentrations in river (III-14). Mining has increased ammonia, nitrate, and phosphorus concentrations of the mine adit discharge. Nitrate and ammonia concentrations during active mining have averaged more than ten times higher than undisturbed bedrock groundwater concentrations. Phosphorus concentrations are roughly three times nonmining concentrations. Mine water is sent to percolation ponds, where it becomes part of the alluvial groundwater system (III-16). Groundwater is generally of drinking water quality in the bedrock immediately surrounding the platinum-group mineralized zone. Sulfide and metal values are low in this zone (III-18). Monitoring wells installed close to the river show no water exceeding drinking water standards and are considered representative of premining conditions. Three monitoring wells closest to the percolation ponds had higher ammonia and nitrate concentrations than monitoring wells closer to the river. The mine discharge water also contains fairly high amounts of nitrates, which add to the nutrient loading of the underlying groundwater. Dilution of pond seepage water in the alluvial groundwater downstream of the mine is believed to render all but nitrates undetectable from baseline conditions (III-21). Tailings impoundment lined with 36-mil hypalon synthetic liner would prevent seepage from reaching Stillwater River (IV-9). Set up water monitoring program, compliance monitoring for water quality (IV-8). Ditches and occasional collection ponds along slurry pipeline to capture any spills (IV-10).

1992 FEIS: No evidence indicates that present mining operations have increased the concentrations of metals in surface waters (74). Mill and impoundment are zero-discharge (121). Static testing of ore and waste materials was performed. So far no indication exists that this mine would produce acid. To verify continued non-acid-producing status of the Stillwater Mine throughout its life, SMC would develop a testing program using both static and if necessary, kinetic testing which would identify the potential for eventual acid production and attendant metals leaching (52, 154). No Acid Drainage is expected (52, 154). Proper use of blasting agents and limiting exposure to water reduces nitrates and nitrites in adit water (80). Clarification - Ferralyte 8130 Coagulant (flocculating agent) in clarifiers to reduce TDS (80).

1998 FEIS: Groundwater quality remains generally good in the area of the SMC project (3-15). Granitic Stillwater Complex is a non-acid generating ore body with low sulfur concentrations. Tests confirm acid-base potential of waste rock to generate acid water is low (3-12). Groundwater beneath the percolation ponds on the east side of the river has shown higher concentrations of ammonia, nitrate, sulfate and TDS than groundwater elsewhere in the facilities area until of pond seepage in the alluvial groundwater downstream of the mine renders all but nitrates undetectable from baseline conditions (3-19). Seepage from the unlined storage pond would have no significant impact on groundwater quality because of low permeability of underlying glacial material (project less than 2 gpm seepage (4-8). Groundwater wells in the area not expected to be impacted (4-7). Modeling predicts nitrate nitrogen concentrations from Hertzler LAD water to be 0.70 mg/L but are expected to be much lower due to uptake by vegetation, evaporation and higher flow in the Stillwater River (4-8). Alluvial waters along the Stillwater River would not be affected, as it (Hertzler Tailings Impoundment and LAD) is more than one mile to the river (4-7).

Mitigations: HDPE liner and clay liner with an overlying seepage collection system (4-7). Construct stormwater detention ponds to reduce sediment loading during construction phase and from east side waste rock storage site footprint, prior to discharge into river (4-2). Use diversion ditches to divert stormwater around the tailings impoundment. Have adequate freeboard to prevent surface water release during a large storm event (4-6). Continue annual testing of tailings and waste rock to verify the lack of acid-generating potential of the materials. Regularly scheduled monitoring of surface water quality (4-16). Denitrification with anoxic biotreatment cell (ABC) (4-3). Clarifiers or earthen sediment traps to maintain the percolation pond effeciency (4-3).

16.3 EIS SUMMARIES

16.3.1 1985 EIS

Proposed Project: New Project
Geology/Mineralization: The platinum-group metals are located within the Stillwater Complex which is 1 to 5 miles wide and 28 miles long. The mineralized unit dips to the north steeply at about 50-80 degrees. The original intrusion contained iron, nickel, copper and platinum-group minerals which settled out in different levels prior to crystallization. The layer of highest platinum-group mineralization is only 3 to 15 feet wide. Nickel-copper and chromite deposits also occur throughout the complex.
Climate: Mountainous continental
Annual Precipitation/ Evaporation: 20-40 inches, averaging 23.2 inches
Proximity to Surface Water: Stillwater River flows within 1/4 mile of the mine.
Proximity to Groundwater: Depth to groundwater under the mine site ranges from 40 to 90 feet**.** Groundwater is mainly confined to openings (i.e. Joints, faults, shear zones) and amounts are highly variable.
Predictive Tests and Models: No information provided.
Constituents of Concern: Nitrate and total nitrogen.
Acid Drainage and Metal Leaching Potential: No information.

Water-Quality Impact Potential: No information.
Mitigations: Tailings impoundment lined with 36-mil hypalon synthetic liner would prevent seepage from reaching Stillwater River. Set up water monitoring program, compliance monitoring for water quality. Impoundment located outside 100-yr and 1,000-yr flood plains. Ditches and occasional collection ponds along slurry pipeline installed to capture any spills.
Predicted Water-Quality Impacts: Only nitrogen compounds are expected to affect groundwater quality. Even under most severe conditions (high flow and high nitrate concentrations in pond seepage and low flow and high nitrate concentrations in river) excess algal growth in river would not occur. Additional N compounds would not influence algae growth because of low P concentrations in river. Stillwater River would not be influenced by percolation pond seepage.

16.3.2 1992 EIS

Proposed Project: Amended plan of operations and permit.
Geology/Mineralization: The platinum group metals (PGM) found in the Stillwater Complex consists of layers of iron and magnesium-rich igneous rock. The platinum-palladium ore zone is called the J-M Reef and averages 4 ft. in width and is located near the bottom of the complex above the chromite-rich zones. The Stillwater complex also contains chrome, copper, nickel, and iron minerals.
Climate: Modified Continental.
Annual Precipitation/ Evaporation: 20 – 25 inches
Proximity to Surface Water: Stillwater River flows within 1/4 mile of the mine.
Proximity to Groundwater: No information.
Predictive Tests and Models: Static testing of ore and waste materials.
Constituents of Concern: Lead, cadmium, mercury, zinc, iron, copper, nickel sulfides, chromite, TDS, sulfate, nitrates, chromium, ammonia.
Acid Drainage and Metal Leaching Potential: No acid drainage is expected.
Water-Quality Impact Potential: No evidence exists to indicate that present mining operations have increased concentrations of metals in surface waters.
Mitigations: Lined tailings impoundment. Reclamation probably will require filter fabric and geonet plus advanced structural cap of waste rock. Expanded Biological Monitoring Program for Stillwater River. Clarification - Ferralyte 8130 Coagulant (flocculating agent) in clarifiers used to reduce TDS. Proper use of blasting agents and limiting exposure to water reduces nitrates and nitrites in adit water.
Predicted Water-Quality Impacts: Chromium, zinc and to a lesser extent, cadmium are elevated in downgradient wells relative to upgradient wells. Increased TDS, sulfate, nitrate and to a lesser extent, chromium and zinc, reflect the disposing of excess adit water through land application and percolation. No acid drainage is expected.

16.3.3 1998 EIS

Proposed Project: Revised waste management plan and Hertzler Tailings Impoundment
Geology/Mineralization: Ultrabasic rocks, Madison limestone, with gneiss, schist, hornfels, quartz monzonite intrusives, and Colorado Group shale and Montana Group sandstone, siltstone, shale and carbonaceous units.
Climate: No information.
Annual Precipitation/ Evaporation: 18.3 inches/year at the mine site.
Proximity to Surface Water: Stillwater River flows approx. 500 feet to the east of the mine site tailings impoundment. Hertzler Tailings Impoundment more than 1 mile from the river. There are 3 adjudicated springs on site.
Proximity to Groundwater: Depth to water at the Hertzler Ranch ranges from 42 to 76 ft.
Predictive Tests and Models: ABA, Toxicity Characteristic Leaching Procedure, Sequential Saturated Rolling Extractions, Column Leach Extraction
Constituents of Concern: Water discharged from West Side Adit and East Side Adit between March 1990 and June 1997 had exceedences (in either Montana human life or aquatic standards) in dissolved cadmium, copper, manganese, zinc and total recoverable cadmium, copper and lead. Nitrogen in adit discharge water continues to be much higher than natural levels. Dissolved chromium regularly exceed human health standard at all sites in LAD area and slight elevations of SO_4, Cl, P, Cd, Fe, Zn observed downgradient of LAD.

Acid Drainage and Metal Leaching Potential: Low. The Stillwater Complex is a non-acid generating ore body with low sulfur concentrations. Tests confirm acid-base potential of waste rock to generate acid water is low.
Water-Quality Impact Potential: LAD application of adit water may result in soil uptake of Mn, Cd, and Pb and subsequent soil bound copper but is not anticipated to diminish groundwater quality.
Mitigations: HDPE liner and clay liner with an overlying seepage collection system is being used. Regularly scheduled monitoring of groundwater quality by sampling wells on site. Construct stormwater detention ponds to reduce sediment loading during construction phase and from east side waste rock storage site footprint prior to discharge into river. Use diversion ditches to divert stormwater around the tailings impoundment. Have adequate freeboard to prevent surface water release during a large storm event. Continue annual testing of tailings and waste rock to verify the lack of acid-generating potential of the materials. Regularly scheduled monitoring of surface water quality. Water Treatment Plant constructed for denitrification with anoxic biotreatment cell. Use clarifiers or earthen sediment traps to maintain the percolation pond efficiency.
Predicted Water-Quality Impacts: Alluvial waters along the Stillwater River would not be affected, as the Hertzler Tailings Impoundment and LAD is more than one mile to the river.

16.4 MONITORING AND COMPLIANCE INFORMATION

The Stillwater Mine has been collecting surface water and groundwater quality data since 1980 to document the water quality to prior the development of the mine and during on-going mine operations. In 2003, a comprehensive Baseline Water Quality Study (CSP2, 2003) was completed examining the baseline water quality from before mining to present. The results of the study showed that over the approximately 18 years of mine life no noticeable impacts (compliance with Montana non-degradation water quality standards) to water quality in the Stillwater River have occurred due to the operation of the Stillwater Mine with the exception of increased nitrogen concentrations. The increase in concentration averages approximately 0.2 mg/l over the life of the mine with seasonal fluctuations ranging from less than 0.1 mg/l to as high as 0.7 mg/l (the regulatory limit in SMC's MPDES permit is 1.0 mg/l). Stillwater Mining as part of the Good Neighbor Agreement with local conservation organizations has agreed to optimize its water treatment and land application discharge operations and remove 90% more nitrogen than is required by its NPDES permit and reduce maximum concentration increases in groundwater to 2.0 mg/l and in the Stillwater River to 0.2 mg/l.

No acid drainage has developed at the site to date, and no impacts to the Stillwater River and surrounding area have been observed. The company has voluntarily reduced their nitrogen levels to approximately 10% of their allowable discharge.

Existing Water Quality Information from EISs:
1992 EIS: Chromium, zinc and to a lesser extent, cadmium are elevated in downgradient wells relative to upgradient wells. Increased TDS, sulfate, nitrate and to a lesser extent, chromium and zinc, reflect the disposal of excess adit water through land application and percolation.
1998 EIS**:** Water discharged from West Side Adit and East Side Adit between March 1990 and June 1997 had exceedences (in either Montana human life or aquatic standards) in dissolved cadmium, copper, manganese, zinc and total recoverable cadmium, copper and lead. Nitrogen in adit discharge water continues to be much higher than natural levels. Dissolved chromium regularly exceed human health standard at all sites in the Land Application Disposal (LAD) Facility area and slight elevations of SO_4, Cl, P, Cd, Fe, Zn were observed downgradient of LAD. No acid drainage has developed at the site to date, and no impacts to the Stillwater River and surrounding area have been observed.

Table 16.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Stillwater Mine, Montana.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater and Surface Water	Tailings and Waste Rock	• 1985 EIS; no potential for acid drainage or other contaminants except nitrogen • 1992 EIS; potential for Pb, Cd, Hg, Zn, Fe, Cu, Ni, Cr, TDS, Sulfate, nitrogen compounds • 1998 EIS: no potential for acid drainage or metals identified: potential for nitrogen identified	• 1985 EIS; line tailings impoundment • 1992 EIS; line tailings, cap waste rock, reduce explosives usage • 1998 EIS: line tailings impoundment	• 1985 EIS; nitrogen will increase in groundwater but no impacts to surface water quality • 1992 EIS; no impacts to water quality predicted 1998 EIS: no impacts to water quality predicted	1985 – 2004: No discernible impacts to surface water or groundwater other than nitrogen (below standards)
	Discharge Water from Underground Workings	1998 EIS: Water discharged from underground workings exceeds standards for Cd, Cu, Mn, Zn, Pb with high levels of nitrogen. LAD discharge contains elevated levels of Cr, SO_4, Cl, P, Cd, Fe, Zn	• 1998 EIS: water treatment to reduce nitrogen and land application discharge at agronomic rates for nitrogen uptake	• 1998 EIS: Groundwater quality not expected to be diminished and surface water would not be affected	• Adit water (1990 - 1997) exceeded Montana standards for Cd, Cu, Pb, Mn, Zn; N concentrations higher than baseline. Groundwater downgradient of LAD had regular exceedences of Cr and slight elevations of SO4, Cl, P, Cd, Fe, Zn. • Increases in the Stillwater River of N, up to 0.7 mg/l (std = 1.0 mg/l).

17 ZORTMAN AND LANDUSKY, MONTANA

17.1 GENERAL INFORMATION

Location: Phillips County, MT
Ownership: Pegasus Gold Corporation (100%)
Commodity: Gold, Silver
Operation Type: Open Pit, Heap Leach
Years of Operation: 1979 - 1997
Jurisdiction: Bureau of Land Management, Private, Tribal
Disturbed Acres: 1,215
Bond Amount: $70,510,000
NEPA Documents: 1979 EIS (New Project); 1993 EA (Acid Drainage Control); 1996 EIS (Expansion); 2001 SEIS (Reclamation)

17.2 WATER QUALITY SUMMARY

At the initiation of modern mining at Zortman/ Landusky in 1979, regulatory officials believed that acid drainage would not be a significant issue "The proposed mine pits would not mine into the sulfide ore body, but rather the oxide ore body which is not conducive to acid drainage. Acid drainage is therefore, not considered a potential threat from the proposed projects." With the numerous incidences of acid drainage and water quality impacts noted in the early 1990's, an extensive geochemical characterization program was undertaken in the mid to late 1990's. Results of the geochemical tests indicated that the ore, spent ore, and waste rock all contained sulfides and had potential to generate acid. Mitigations such as segregation of acid generating materials from non acid generating materials, capture systems (ponds and pump back wells), water treatment plants, surface water diversion ditches, limestone underdrains, and water monitoring wells were put in place to reduce and monitor impacts to surrounding ground and surface waters. The lack of initial geological evaluation of the sites and geochemical testing were the major downfalls regarding water quality predictions at the Zortman and Landusky sites.

Info from the EIS's for the above paragraph and their references:

At the initiation of modern mining at Zortman/ Landusky in 1979, regulatory officials believed that acid drainage would not be a significant issue "The proposed mine pits would not mine into the sulfide ore body, but rather the oxide ore body which is not conducive to acid drainage. Acid drainage is therefore, not considered a potential threat from the proposed projects." As a result of the formation of acid drainage from pit walls and floors, leach pads and pad foundation, and waste rock piles at both Zortman and Landusky Mines (with pH values ranging from 2.3 – 6.7) as noted in 1993, mine rock characterization, and geochemical testing of over 2000 samples was performed on the ore, spent ore, waste rock and other un-mineralized local rock types (FEIS 1996, 3-18 and 2001, 3-19). Tests performed include: Total Sulfur, Paste pH, Static testing and Kinetic testing. Short term (20 week) and Long Term (72 week) Kinetic tests were performed on spent ore and determined that all spent ore would be acid generating and that blended amendments would not succeed in affecting the acid production significantly, but only delayed acid generation (FEIS 1996 3-23). Then by 2001, certain leach pads had become acidic (I think much sooner than anticipated) (FEIS 2001, 3-19). On Page 3-42 (1996 FEIS), results of 45 week Kinetic tests of rock with sulfur content of 0.2 to 0.8 percent when mixed with metamorphic rock did not produce pH's less than 6.0 and did not produce acid, and they determined that the Tertiary syenite porphyry could be considered suitable for reclamation cover material. Then in the 2001 FEIS (3-20), they state that syenite waste rock containing less than or equal to 0.2% sulfur and of 0 T/kT or greater, does not generate acid in sufficient quantities to affect revegetation, but could affect water quality if this waste is placed where contact with surface water is likely to occur. A geochemical characterization program was conducted in 1999 to 2000 as a result of continued weathering of materials on the site which included widespread surface sampling program and drilling program to test material from within leach pads and dikes (FEIS 2001, 3-14). Static data for trachyte, quartzite, and felsic gneiss indicated that these rock types did have the potential to generate net acid, however kinetic test data was inconclusive. Additional field and lab testing confirms the earlier static testing results, that these rock types are largely acid generating and not suitable for reclamation purposes (FEIS 2001, 3-20). In general, there is very little neutralization potential in the vast majority of material on-site. Nearly all samples with total sulfur contents greater than 0.2% have field pH values less than 5.0, therefore a sulfur cutoff value of 0.2%, as proposed by ZMI in 1993, is not necessarily protective of the environment (FEIS 2001, 3-15). They initially predicted that the utilization of both membrane and clay liners would prevent significant impacts to groundwater quality during normal operations (FEIS 1979, 79-80). Mitigations include the segregation of acid generating rock from non acid generating rock, and backfilling pits with acid generating rock and capping with clay and PVC liners and then revegetating to limit surface water infiltration. Construct limestone underdrains to buffer acidic drainage. Expanded their monitoring program with additional wells and expanded improved pump-back systems. Lined capture ponds, water treatment facilities and interceptor trenches and/ or sumps were developed in the mid 1990's. to deal with acid water.

17.3 EIS SUMMARIES

17.3.1 1979 EIS

Proposed Project: Proposed plan of mining and reclamation.
Geology/Mineralization: Tertiary intrusives are composed mainly of syenite porphyry. Regional deformation resulted in faulting along the edges of the intrusive bodies and tensional fracturing within them. These fracture systems form the loci of the gold-silver mineralization. Oxidation (on both properties) generally persists to the levels of the deepest workings on the property which are 500 ft bgs.
Climate: No information.
Annual Precipitation/ Evaporation: 19.2 inches (at Zortman) and 14.3 inches at Hays/
Koppen Classification: Region – D, **Temperature –** a, **Precipitation -** s
Proximity to Surface Water: Ruby Creek is the major drainage in the Zortman mine area and includes several triburaries (Alder Gulch, Ruby Gulch, Goslin Gulch). Triburaries draining the northeastern side of Zortman mine that flow towards the Milk River are Lodgepole Creek and Beaver Creek. The southern portion of the Landusky mine area is drained entirely by Rock Creek and its tributaries (Sullivan Creek, Mill Gulch, and Montana Gulch. The northern portion of Landusky area is drained by Little Peoples Creek and its tributaries (South Bighorn Creek and King Creek).
Proximity to Groundwater: Local groundwater wells in the area show groundwater levels less than 200 ft.
Predictive Tests and Models: No information.
Constituents of Concern: cyanide, metallocyanide complexes.
Acid Drainage and Metal Leaching Potential: Proposed mine pits would not mine into the sulfide ore body, but rather the oxide ore body which is not conducive to acid drainage formation. Acid drainage is not considered a potential threat from the proposed projects.
Water-Quality Impact Potential: *Groundwater:* A lining failure could occur, in either ther heap or process water pads releasing an unknown amount of solution to the groundwater. In this case, the presence of significant amounts of heavy metal ions in the seepage would be of a potentially great concern. It is proposed that there will be a cumulative effect on the groundwater due to infiltration from both pits. *Surface water*: No information. *Pit water*: No information.
Mitigations: They have implemented a groundwater and surface water monitoring program. Contaminated groundwater detected would be pumped and piped for containment and neutralization in either the barren pond or and emergency storage pond until the source of the leak is detected and repaired. Construct surface runoff holding ponds (10-yr, 24-hr storm even) designed to allow for infiltration and evaporation of captured water. Overflow will flow to existing streams. They have constructed an emergency storage pond capable of storing any overflow from the process ponds in an emergency or in case of pond liner failure. In the event of a process pond discharge, the addition of calcium hypochlorite would effectively destroy the cyanide solution.
Predicted Water-Quality Impacts: Proposed mine pits would not mine into the sulfide ore body, but rather the oxide ore body which is not conducive to acid drainage formation. Acid drainage is not considered a potential threat from the proposed projects. Because of the utilization of both membrane and clay liners it is not anticipated that either operation will have a significant effect on groundwater quality during normal operations. The utilization of berms, ditches and impermeable barriers is expected to prevent deterioration of surface water from the waste ponds. It is proposed that there will be a cumulative effect on the groundwater due to infiltration from both pits. The impact, however, will be small due

to the small area proposed for mining. No water expected to accumulate in pits because pit floors will be sloped and graded to prevent the formation of ponds.

17.3.2 1993 EA

Proposed Project: Supplemental EA Landusky Mine. Operating and Reclamation Plan Modifications ARD Control and Remediation.
Geology/Mineralization: Limestone, Shale, porphyritic intrusions. Iron sulfides: pyrite, pyrrhotite, marcasite.
Climate: No information.
Annual Precipitation/ Evaporation:
Koppen Classification: Region – D, **Temperature –** a, **Precipitation –** s
Proximity to Surface Water: Rock Creek, Mill Gulch and Montana Gulch typically maintain surficial flow year-round within the Landusky mine's permit boundary. Mill Gulch headwaters flow from the toe of the Mill Gulch waste rock dump. Sullivan Gulch flows south for approx. 2000 ft from the 1991 leach pad. Montana Gulch flows south approx. 6000 ft from the 1985 - 1986 leach pad dike.
Proximity to Groundwater: No information
Predictive Tests and Models: Paste pH, total sulfur, ABA, Leachate extraction tests. Long-term leachate extractions in the field.
Constituents of Concern: Exceedences of MCLs for Cd, F, SO_4, Zn, pH, Nitrate, Arsenic.
Acid Drainage and Metal Leaching Potential: Major rock types being mined contain both oxides and sulfides. Acid drainage has developed from waste rock dumps and ore heap retaining dikes. The flow of acidic water from the toe of the dump and observed venting of sulfurous steam from portions of the dump are manifestations of the sulfide oxidation reaction occurring within the dump. Mill Gulch waste dump has generated acid drainage with pH periodically dropping as low as 3.9. Based on field inspections BLM and DSL found that ZMI's approved operating and reclamation plans were not preventing acid drainage.
Water Quality Impact Potential: It is reasonable to assume that sulfide-bearing ore may exist in all leach pads, and thus each pad has the potential to produce acid.
Mitigations: Installation of additional monitoring wells. Properly engineered caps over reclaimed dumps and heap leach pads. Monitoring parameters include: metals, pH, cyanide, common ions, and other indicators of water quality. Pump-back systems would reduce impacts to groundwater by collecting acidified water below Sullivan Park dike and route it into the pump-back system. Slurry cutoff walls below the dike to reduce the volume of acidic water bypassing the contingency pond. Delay perforation of leach pad liners until leach pad materials meet water quality standards. Diversion structures designed to withstand 6-inch, 100-yr, 24-hr storm events. Leach pad underdrains will capture water which is pumped to the contingency pond and is not discharged to surface waters but is directed to the processing circuit.
Predicted Water Quality Impacts: Mill Gulch and upper Sullivan Creek have become acidic as a result of pyrite oxidation in waste rock placed in Mill Gulch Waste Dump, the Sullivan Park dike, and possibly places within the excavated foundation of the 1991 leach pad. Surface water monitoring sites within Sullivan Creek have been impacted by acid drainage from 1991 leach pad with pH between values between 2.6 and 2.8. Any water which collects in the pits infiltrates into groundwater. Groundwater samples downstream of the Sullivan Park dike indicates that sulfate concentrations in the alluvial groundwater near the facility have increased. There are no surface discharges from pits. To date, no leach pad liners have been perforated for reclamation, therefore water within leach pads does not discharge to surface water.

17.3.3 1996 EIS

Proposed Project: Reclamation Plan Modifications and Mine Life Extensions.
Geology/Mineralization: Tertiary syenite porphyries comprise the largest percentage of rock in Zortman pit complex (~64%). Quartz monzonite makes up about 7%. Archaean amphibolites and felsic gneisses make up about 21%, Tertiary monzonite equals about 7%, and about 2% contains quartzite, breccia and Cambrian shale and the final 6% is unclassified. The mineral deposits occur in the altered syenite porphyries, and are associated with high-angle faults or fractures. The most important ore bodies have been within the porphyry-hosted "breccia" dikes. The oxidized portion of the ore bodies

contains the gold and silver concentrate. Iron sulfides are the most abundant species of sulfide mineralization, including the minerals pyrite, marcasite, arsenopyrite, and others.
Climate: Semi-arid continental
Annual Precipitation/ Evaporation: 11 – 40 inches/year precipitation.
Koppen Classification: Region – D, **Temperature –** a, **Precipitation** - s
Proximity to Surface Water: Ruby Creek is the major drainage in the Zortman mine area and includes several tributaries (Alder Gulch, Ruby Gulch, Goslin Gulch). Tributaries draining the northeastern side of Zortman mine that flow towards the Milk River are Lodgepole Creek and Beaver Creek. The southern portion of the Landusky mine area is drained entirely by Rock Creek and its tributaries (Sullivan Creek, Mill Gulch, and Montana Gulch). The northern portion of Landusky area is drained by Little Peoples Creek and its tributaries (South Bighorn Creek and King Creek).
Proximity to Groundwater: Depth to groundwater in the vicinity of the August Pit is about 190 ft bgs. A zone of perched groundwater was encountered between 140-150 ft bgs.
Predictive Tests and Models: Total Sulfur, Paste pH, ABA, Kinetic testing both long term and short term humidity cell for ore and waste rock, Free CN, WAD CN, Total CN, CN amenable to chlorination, Cyanate, Thiocyanate.
Constituents of Concern: cyanides, sulfate, TDS, nitrate, increased metal concentrations.
Acid Drainage and Metal Leaching Potential: Acid drainage is currently being generated from pit walls and floors, leach pads and pad foundations, and waste rock piles. Static tests on Zortman and Landusky ores resulted in strong potential to generate acid. Even with pit backfilling, there is still the potential for groundwater discharge to the north.
Water-Quality Impact Potential: For both mine sites, waste samples having negative NNP's should be considered potentially acid generating. At Landusky, short-term increases in TDS, sulfate and metals concentrations may occur at Sullivan Creek, Mill Gulch, and Montana Gulch due to the lack of diluting water, but loads are expected to be reduced rapidly. Formation of significant volumes of acid drainage contaminated water from spent ore pads is not likely due to the lengthy duration of sampling required to establish acceptable cyanide and metal concentrations and because of the minimal amount of infiltration expected through the enhanced reclamation covers.
Mitigations: They will segregate acid generating waste from non-acid generating waste. Use combination of "water barrier" and "water balance" reclamation covers. Most of the historic mine workings would be removed by extended mining of Zortman pits. Old adits would be bulkheaded where exposed in the pits to minimize oxygen flow and discharge of transient water. Implementation of a water quality improvement plan. Use capture systems and cutoff walls and recovery wells to intercept poor quality surface water. Removal of old existing waste rock dumps and used as backfill material for pits. Backfill the Zortman pit complex with waste rock to an elevation necessary to drain freely into Ruby Gulch and Alder Spur thereby reducing the potential for groundwater discharge to the north. Will use water treatment but the EIS didn't mention what type of threatment.
Predicted Water-Quality Impacts: Downstream surface water quality in many drainages may actually improve due to the enlargement of capture systems and added cutoff walls and recovery wells intercepting poor quality surface water. It is predicted that acid and metal concentrations measured in the toe drain leachates emanating from the bottom ore "toe" of facilities may actually increase or, at best, remain roughly unchanged for the first few years after capping. It is likely that capping would not be as successful at slowing the rate of acid drainage at older, more oxidized facilities due to high Ferric Iron content in low pH environments. Increases in TDS, sulfate and metal concentrations are expected in the short term post-reclamation. Some minor water quality degradation in the form of increases in TDS, sulfate, etc. is expected to occur in surface water and alluvial groundwater surrounding the leach pad due to the exposed large area of bedrock during construction, but it is considered only moderately significant due to the poor quality of the water in the receiving drainage. Some irreversible impacts to the surface water quality are expected in the immediate vicinity of the Goslin Flats leach pad, but these impacts are not expected to be significant because of the current poor quality of the existing water. No impacts to surface or groundwater of Lodgepole Creek is anticipated from the bulkheaded adit drainage as it would be above the final potentiometric surface. Backfilling the open pits with mined material -- either waste rock or spent ore -- is likely to degrade the water quality relative to baseline even if the waters do not become acidic. At both pits the saturated backfill will receive recharge of oxygenated water from the buried pit walls and likely become a source of continued discharge, although sulfide oxidation rates may be slowed because of the consolidation of the backfill material.

17.3.4 2001 EIS

Proposed Project: Reclamation.
Geology/Mineralization: Same as 1996 EIS.
Climate: Semi-arid continental
Annual Precipitation/ Evaporation: average precipitation for 2000 was 16.39 inches; annual evaporation was 38-43 inches
Koppen Classification: Region – D, **Temperature –** a, **Precipitation –** s
Proximity to Surface Water: Rock Creek is approx. 600 ft from Landusky 87/91 leach pad
Proximity to Groundwater: Zortman mine historic mine adits encountered significant groundwater at the 600 - 700 ft level. Landusky groundwater is at about 500 - 550 ft. Surface water and groundwater closely tied together at site. At Landusky mine, pit infiltration discharges to Gold Bug adit, August drain, artesian well WS-3 and springs and seeps in Swift Gulch.
Predictive Tests and Models: They refer to tests that were conducted in the 1996 EIS (Total Sulfur, Paste pH, ABA, Kinetic testing both long term and short term humidity cell for ore and waste rock, Free CN, WAD CN, Total CN, CN amenable to chlorination, Cyanate, Thiocyanate). Since then, a geochemical characterization program was conducted in 1999 and 2000. New tests conducted include paste pH, paste TDS, ABA.
Constituents of Concern: Sulfate, pH, Fe, Al, Zn, As, Cu, Cd, arsenic.
Acid Drainage and Contaminant Leaching Potential: They expect water to become acidic and pH to drop and sulfate concentrations to increase.
Water-Quality Impact Potential: *Groundwater*: Potential for infiltration to impact deeper groundwater at higher elevations is low due to surface water/groundwater interaction at higher elevations. *Surface and pit water*: No information.
Mitigations: *Groundwater*: Thick reclamation covers would reduce the sulfate and metals loads entering Lodgepole Creek by one-half. The use of water barrier liners and reclamation covers would significantly reduce impacts to groundwater quality in the Ruby Gulch drainage. *Surface Water*: The majority of surface water within the drainages of Zortman mine is collected at the capture system. Removal of a significant volume of acid generating waste rock from Alder Gulch waste rock dump would significantly reduce existing contaminant loads. Removal of the east lobe of the August #2 waste rock dump would eliminate a significant portion of the contaminant source in King Creek and would reduce the total sulfate and metal loads, improving the surface water quality. By buttressing the Sullivan Gulch, the L91 leach pad dike face, covering the surface to reduce infiltration, this would result in a slightly improved surface water quality by reducing total sulfate and metals loads. An estimated 22.5 to 52.5 gpm of water may be bypassing the current capture systems and entering the Montana Gulch drainage. By excavating a surface drainage channel water quality could be improved by diluting contaminants with added clean water. *Pit Water*: Backfill the pits and use reclamation cover to decrease overall infiltration rates.
Predicted Water-Quality Impacts: *Groundwater:* Despite the differences in total sulfate and metal loads in groundwater within the drainages of Zortman mine, downgradient water quality predictions showed a wide range of possible concentrations that vary little between alternatives. Since modeling cannot accurately predict if the water quality standards would be exceeded, continued monitoring and provisions for supplemental capture and treatment would be used to prevent significant impacts to water quality. Landusky mine pits (portions of Queen Rose and Suprise pits and the reclaimed Big Horn ramp) have been partially backfilled with highly acid generating material. In the long term, removing the east lobe of this dump would have a positive impact on groundwater quality in King Creek. In Sullivan Gulch, the L91 leach pad dike, leach pad foundation and underdrain were constructed of acid-generating rock. Only a small portion of water is bypassing the capture system (0.15 to 0.55 gpm) which contains elevated concentrations of contaminants. By buttressing the dike face, covering the surface to reduce infiltration, this would result in a slightly improved groundwater quality by reducing total sulfate and metals loads. Mill Gulch groundwater total sulfate and metals loads are predicted to decrease from existing conditions due to reduced infiltration through the leach pad. Concentrations of most contaminants from the Landusky Mine are going to increase over time. Pit backfill is expected to increase loads of contaminants in the short term due to the disturbance of acid generating material, the re-establishment of flowpaths and mobilization of 'soluble oxidation products.' *Surface Water*: In the short term, there would be no improvement in the surface water quality in Alder Spur. At Landusky mine, Infiltration of precipitation through the pit floor and backfill presently results in poor water quality entering Swift Gulch. In the short term, the total sulfate and metals loads in Swift Gulch would be

moderately reduced, however, the quality of infiltration water would decrease as the pit backfill reaches geochemical maturity. Since the material at Zortman is close to geochemical maturity (not likely to get worse), and capture system bypass volumes are predicted to be relatively small, the downgradient impacts would be minimal. It is likely long-term water quality would be acceptable where acid generating backfill is placed in drainages with existing capture systems. In the long-term, water quality impacts at Landusky are still developing. Water currently at the bottom of the L87/91 leach pad is not acidic, it is predicted that over time, the spent ore on this pad would be a significant source of acid generation. Water quality impacts in the northern drainages would increase due to the acid generating nature of the material placed as pit backfill in the headwaters of these drainages. Concentrations of most contaminants from the Landusky Mine are going to increase over time. *Pit Water*: Pit backfill is expected to increase loads of contaminants in the short term due to the disturbance of acid generating material, the re-establishment of flowpaths and mobilization of soluble oxidation products.

17.4 MONITORING AND COMPLIANCE INFORMATION

1993 EA: Acid drainage has developed from waste rock dumps and ore heap retaining dikes. The flow of acidic water from the toe of the dump and observed venting of sulfurous steam from portions of the dump are manifestations of the sulfide oxidation reaction occurring within the dump. Mill Gulch waste dump has generated acid drainage with pH values periodically dropping as low as 3.9. Based on field inspections BLM and DSL found that ZMI's approved operating and reclamation plans were not preventing acid drainage. Mill Gulch and upper Sullivan Creek have become acidic as a result of pyrite oxidation in waste rock placed in Mill Gulch Waste Dump, the Sullivan Park dike, and possibly places within the excavated foundation of the 1991 leach pad. Surface water monitoring sites within Sullivan Creek have been impacted by acid drainage from 1991 leach pad with pH values between 2.6 and 2.8. Groundwater samples downstream of the Sullivan Park dike indicate that sulfate concentrations in the alluvial groundwater near the facility have increased.

1996 EIS: Acid drainage is currently being generated from pit walls and floors, leach pads and pad foundations, and waste rock piles.

Table 17.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Zortman Landusky Mine, Montana.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater and Surface Water	Heap Leach Piles, Open Pit, and Waste Rock Dumps	• 1979 EIS: only oxide ore and no potential identified other than cyanide • 1993 EA: potential for impacts from acid drainage including pH, sulfate, Cd, F, Zn, As, and nitrate. • 1996 EIS: strong potential to generate acid drainage and high TDS, sulfate and metals values • 2001 EIS: high potential to generate acid drainage with pH, sulfate, metals, metalloids, cyanide and nitrate.	• 1979 EIS: only oxide ore to be mined; stormwater controls and liners to prevent cyanide seepage • 1993 EA: reclamation caps (water barrier); groundwater capture and treatment for acid drainage and cyanide, stormwater controls. • 1996 EIS: waste segregation; water balance and water barrier reclamation covers; groundwater and surface water capture and treatment for cyanide, nitrate, acid drainage, metals and other contaminants • 2001 EIS: waste consolidation; reclamation covers, water capture and treatment in perpetuity	• 1979 EIS: no water quality impacts predicted • 1993 EA: no additional water quality impacts predicted • 1996 EIS: reduced water quality impacts predicted • 2001 EIS: Contaminants to increase over time but surface water quality expected to meet standards. Concentrations of most contaminants from the Landusky Mine are going to increase over time. Pit backfill expected to increase loads of contaminants in the short term due to the disturbance of acid generating material, the re-establishment of flowpaths and mobilization of 'soluble oxidation products'	1993 EA: acid drainage from waste rock dumps and heap leach retaining dikes. Surface water impacted by acid drainage with pH 2.6-2.8. Increased sulfate in groundwater • 1996 EIS: multiple +100-yr storm events; extensive groundwater and surface water contamination with acid drainage and metals/metalloids, nitrate, cyanides • 2001 EIS: acid drainage with metals, metalloids, nitrate, cyanide common throughout groundwater and in surface water

18 FLORIDA CANYON MINE

18.1 GENERAL INFORMATION

Location: Pershing County, NV
Ownership: Florida Canyon Mining Co.
Commodity: Gold
Years of Operation: 1986-Present
Disturbed Acres: 2,149
Bond Amount: $16,936,130
NEPA Documents: 1986 New Project EA (not obtained), 1995 Expansion EA (not obtained), 1997 Expansion and Reclamation EIS, 1999 Expansion EIS (not obtained).

18.2 EIS SUMMARIES

18.2.1 1997 EIS

Proposed Project: Expansion and Reclamation EIS
Geology/Mineralization: Oldest exposed rocks are from the Triassic Koipato group, composed of (from oldest to youngest) the Limerick Greenstone, the Rochester Rhyolite, and the Weaver Rhyolite. These are volcanic flows, tuffs, and tuffaceous sedimentary rocks. These are overlain by the Star Peak Group, which is composed of the Prida and Natchez Pass formations. Prida rocks grade upward from coarse clastics to carbonates to siltstones to sandstones. The Natchez Pass formation is mainly massive carbonates. Triassic age Grass Valley formation is metamorphosed and hydrothermally altered siltstone forming slate, phyllite and argillite; unconsolidated Quaternary-age alluvium and lacustrine deposits are also present.
Gold mineralization is hosted in argillites and siltstones of the Grass Valley formation, associated with quartz-veining as auriferous pyrite and free gold. Trace pyrite and marcasite in are found in the host rock. Gold mineralization is often related to fissure filling veins or vein swarms of quartz, which often contains pyrite (or limonite after pyrite) and locally marcasite. Silicic, hematitic, and alunite alteration are present.
Climate: Semi-arid.
Precipitation: 14 inches annually.
Evaporation: 50-60 inches annually.
Proximity to Surface Water: There are no perennial streams or springs within the project area. The closest surface water body is the Rye Patch reservoir, located approximately 1.5-2 miles west of the project area.
Proximity to Groundwater: Pre-mining water levels below the heap leach pad were approximately 400 feet below ground surface. Water levels in the alluvial aquifer just west of the pit range from 0-250 feet below ground surface.
Predictive Tests: Static testing (ABA), Whole Rock Analysis, Short term leach testing (MWMP), Kinetic testing (humidity cell and column leach testing), and petrographic analyses.
Constituents of Concern Identified: Whole rock analyses revealed that As is elevated in most rock types, Cd is elevated in the alluvium, and Sb is somewhat elevated in altered silicic rocks. Meteoric Water Mobility Procedure tests showed exceedences in some samples for the following constituents: Al, As, Fe, Pb, Hg, Tl, TDS.
Predictive modeling: MODFLOW groundwater modeling. HELP, OPUS, and UNSAT2 were used to model waste rock seepage.
Acid Drainage Potential: Low. The only rock with potential to generate acid is unoxidzed sulfide rock, which makes up only 0.2% of mined rock from pit. Kinetic tests of rocks with ANP:AGP ratios less than one produced leachate with pH between 5.75 and 7.47, indicating the rock was not acid generating.
Metal Leaching Potential: The following constituents showed exceedences of drinking water standards in some MWMP tests: Al, As, Fe, Pb, Hg, Tl, TDS .
Groundwater Quality Impact Potential: Groundwater in some wells already exceeds drinking water standards for As, Al, Cd, Cl, MN, SO4, TDS, F, and Ni. Groundwater may be impacted by seepage from the heap leach facility, waste rock dumps, and by release of constituents from the pit backfill material. There is potential for dissolution of constituents from the backfill into the groundwater to degrade groundwater quality.

Surface Water Quality Impact Potential: No information.
Pit Water Quality Impact Potential: Partial backfilling of the mine pit above the water table. This will prevent the formation of a pit lake.
Predicted Groundwater Quality Impacts: No impacts to groundwater quality are expected as a result of backfilling of the pit with waste rock. Water quality impacts from waste rocks dumps are not expected due to low seepage rate, low AGP, natural attenuation properties of alluvium, depth to groundwater, and waste rock management plan. Contamination of groundwater by leach solution is not expected.
Predicted Surface Water Quality Impacts: Water quality impacts from potentially acid generating rock are not expected due to segregation of acid generating rock from other waste rock.
Predicted Pit Water Quality Impacts: Partial backfilling of the mine pit above the water table. This will prevent the formation of a pit lake.
Zero discharge facilities: Heap leach facility.

18.3 MONITORING AND COMPLIANCE INFORMATION

Years Monitoring Data Available: 1999-2003
Number Surface Water Monitoring Locations: 0
Number Groundwater Monitoring Locations: 24. Some of these pertain to an expansion not constructed, and thus aren't reported. Others are recent additions, so that in monitoring reports there are fewer wells.
Baseline Water Quality: Groundwater in some wells already exceeds drinking water standards for As, Al, Cd, Cl, MN, SO4, TDS, F, and Ni. It appears that this is due to aquifer properties, not mining activities, and that wells screened in differing aquifers have different qualities. (From the DEIS).
Violations: In 1999, Florida Canyon Mining Inc. was issued a Finding of Alleged Violation (FOAV) by the Nevada Department of Environmental Protection (NDEP) for flow rates in the leakage detection system which exceed the limits stipulated in the Water Pollution Control Permit (WPCP). FCMI hired Vector Engineering to investigate the problem, who determined that the anomalously high flows were due to a pipe failure. FCMI and Vector state that the liners underneath the leach pad were not compromised, and that the violation did not result in environmental degradation. The leakage detection system is not required by NDEP, and will not be monitored in the future, since it no longer functions as designed.

In addition, routine sampling of monitoring well MW-16 during the second quarter of 2000 showed that a number of constituents were elevated. Constituents exceeding Federal or state MCL's were: Cl (694 mg/l), Hg (0.185 mg/l), NO_3 (21.8 mg/l), TDS (1940), and WAD CN (0.225 mg/l). MW-16 was sampled weekly following the discovery of these drinking water exceedences, and the implemented pumping regime has resulted in lower concentrations of each constituent elevated over drinking water MCL's. There have been occasional spikes in constituent concentrations, but on the whole the trend is toward compliance. As of December 28th 2000, Hg had fallen to 0.0300mg/l, NO3 had fallen to 5.0 mg/l, and WAD CN was not detected. Cl and TDS were last sampled during the 4th quarter, and were measured at 86.2 mg/l and 499 mg/l, respectively. As of those sampling dates, only Hg exceeded the federal MCL. Sampling continued through 2001, and concentrations continued to drop, but occasional spikes were still noted. In the weekly sampling during quarter 4, no WAD CN exceedences occurred and only one NO3 exceedence occurred, but Hg exceeded in every sample save two, one of which was at the MCL. In 2002, Cl, NO3, TDS, and WAD CN are below MCL's in every quarter. Hg, however, exceeds in every quarterly and weekly sampling. In the 2003 4th quarter report there is no mention of MW-16 or it's contamination. I did not find an FOAV document in Nevada that related to MW-16.

Possible Mining-Related Exceedences:

Mine Water Supply Wells:

- Not monitored.

Groundwater Monitoring Wells:

- MW-7, MW-16, and MW-17 show frequent low level exceedences for Al, As (new standard), Cd, Cl, Fe, Mn, TDS. There are occasional exceedences for Ni as well. These wells are flagged in the 1997 DEIS as being of poorer quality, though it isn't completely clear that this is a pre-mining condition.

- During the first quarter of 1999 wells MW-12, MW-13, MW-14, and MW-17 Ni is at or above the drinking water MCL of 0.01 mg/l.
- From 2000-2003, wells MW-8, MW-11, MW-12, MW-13, and MW-14 show frequent, low level exceedences for As and Al. As exceedences remain below a factor of 2; Al exceedences are less frequent, and usually exceed the lower limit of 0.05 mg/l. There are occasional exceedences of the higher (0.2 mg/l) limit, but these also are by less than a factor of two. The above wells also show scattered exceedences of the Fe, Cl, and TDS. Exceedences for these constituents are generally below a factor of three, though one Fe exceedence is by almost a factor of five.
- In 2003, a number of new monitoring wells were added, comparable in quality to MW-7, MW-16, and MW-17. These wells are MW-B, MW-C, MW-H, MW-L, MW-N, MW-P, MW-Q, MW-R, MW-S, MW-T, MW-U. Exceedences of the drinking water standard for As, Cl, Mn, TDS are very frequent, and exceedences of the drinking water standard for Al, Fe and Ni occur occasionally. As exceedences range from less than a factor of two up five times the MCL. Cl exceedences are all less than three times the lower standard. Mn exceedences are all less than three times the higher standard (0.1 mg/l). TDS all are by less than three times the standard. Al is elevated only once, and only to the level of the standard. Ni exceedences are by less than a factor of two. Fe exceedences are by less than a factor of three (lower standard-0.3 mg/l).

Surface Water Monitoring Sites:

- No surface water monitoring sites

Table 18.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Florida Canyon Mine, Nevada.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater	Leach Pads	1997 EIS: • Seepage from the heap leach facility. • Background water quality indicates natural exceedances.	1997 EIS: Facility design to prevent groundwater impacts (zero discharge with leak detection with pumpback of leaks if detected	1997 EIS: No impacts to groundwater predicted	WQ Monitoring: Contamination of groundwater with cyanide and other constituents noted and partially mitigated with leak pumpback system
	Waste Rock, Open Pit, or baseline conditions	1997 EIS: Water quality would be same as pre-mining (background water quality indicates natural exceedances).	1997 EIS: • Backfill pit to prevent formation of pit lake. • Segregation/disposal of PAG rock in the waste rock dumps	1997 EIS: No impacts to groundwater predicted.	WQ Monitoring: Exceedances of drinking water standards noted in various monitoring wells which could be attributed to waste rock and open pit leachate or baseline conditions.

19 JERRITT CANYON, NEVADA

19.1 GENERAL INFORMATION

Location: Elko County, NV
Ownership: Independence Mining Company
Commodity: Gold and Silver
Operation Type: Open pit heap leach and underground vat leach
Years of Operation: 1980 to present
Jurisdiction: USDA Forest Service, R4 Humboldt-Toiyabe Forest
Disturbed Acres: 3,411
Bond Amount: $7,153,932
NEPA Documents: 1980 New Project EIS; 1994 Expansion EIS
NPDES Permit: None

19.2 EIS SUMMARIES

19.2.1 1980 EIS

Proposed Project: Construct and operate an open pit mine, a cyanidation mill and tailings disposal pond.
Geology/Mineralization: The western siliceous facies contains quartzite, chert, and other sedimentary rock types. The eastern carbonate facies contains limestone, dolomitic limesone, and lesser amounts of quartzite and chert. Mineralization occurs in the eastern facies. Gold occurs both as oxide ores and unoxidized carbonaceous ores.
Climate: No information.
Annual Precipitation/ Evaporation: Annual precipitation is 19.6 in/yr.
Koppen Classification: Region – B/C/D, **Temperature –** a, **Precipitation** - s
Proximity to Surface Water: No information provided (see 1994 EIS).
Proximity to Groundwater: Test drilling at the tailings disposal area encountered perched groundwater at depths of 8 to70 ft. Thirty-two springs were mapped in the Jerritt Canyon project area.
Predictive Tests and Models: Leach tests on waste rock samples. No predictive modeling was performed.
Constituents of Concern: Baseline surface water samples had elevated nitrate, anomalous values for zinc, and exceedences of the drinking water standards for mercury and chromium.
Acid Drainage and Contaminant Leaching Potential: No information on acid drainage potential was provided. There is a potential for some leaching of some heavy metals and other toxic substances from the waste rock into surface water and groundwater. Leach tests on waste rock samples show only minimum potential for leaching of contaminants from waste rock.
Potential Water-Quality Impacts (before mitigations): *Groundwater* **-** There is a potential for some leaching of some heavy metals and other toxic substances from the waste rock into surface water and groundwater. Leach tests on waste rock samples show only minimum potential for leaching of contaminants from waste rock. *Surface Water* – There is the possibility of a release of toxic materials to streams due to spills of hazardous materials, or breakage of the tailings pipeline.
Mitigations: *Groundwater* - Tailings disposal pond will be lined to provide an impervious barrier to vertical movement. Horizontal seepage of liquids will be controlled by dam embankment design. *Surface Water and Pit Water* - Diversion ditches will direct flow around the mine pit and back into natural drainages. Groundwater flowing into the pits will be used for dust control, and at times, excess water may be discharged to Jerritt Canyon.
Predicted Water-Quality Impacts (after mitigations): Increased suspended solids expected in affected stream drainages due to increased erosion. The mill and tailings pond is in the headwater of a very small watershed and should have negligible effects on water quality.

19.2.2 1994 EIS

Proposed Project: Expansion of gold mining facilities, construction of four open pits mines and associated waste rock dumps, soil stockpiles, ore stockpiles, haul roads, and support facilities.
Geology/Mineralization: The overlying Snow Canyon formation contains carbonaceous siltstones and shale with lesser amounts of dolomitic siltstone, cherts, altered mafic lavas and dikes. The Roberts Mountains formation underlies the Snow Canyon formation, with the Roberts Mountain Thrust separating them. The Roberts Mountain formation is composed of weakly pyritic laminated calcareous and carbonaceous siltstone. The underlying Hansen formation contains limestone and dolomite with chert. Gold mineralization is disseminated and occurs in the Roberts Mountains and Hanson Creek formations. Gold is in both oxidized and unoxidized carbonaceous ores. Antimony, silver, mercury, manganese, and barite occur in project area.
Climate: No information.
Annual Precipitation/ Evaporation: Annual precipitation is 12 to 26 in/yr. Eighty percent of the precipitation is lost through evaporation.
Koppen Classification: Region – B/C/D, **Temperature –** a, **Precipitation -** s
Proximity to Surface Water: Jerritt and Burns Creeks have intermittent and perennial (mostly intermittent) reaches within Project area. Twenty-three springs and eight seeps were identified in the project area.
Proximity to Groundwater: Regional groundwater table is 700 feet deep. In addition, there are lenses of perched or semi-perched groundwater on the site. There are also seeps and springs on site, which are likely fed by the perched/semi-perched groundwater.
Predictive Tests and Models: Static (ABA) and kinetic (modified humidity cell procedure [Schafer, 1994] and column leach tests) tests; MWMP tests on waste rock. No predictive modeling was performed.
Constituents of Concern: Arsenic, selenium, nitrate, and sulfate (from MWMP tests on waste rock).
Acid Drainage and Contaminant Leaching Potential: Low acid generation potential for waste rock derived from Roberts Mountains and Hanson Cr formations. Snow Canyon formation has moderate potential to generate acid. Waste rock from unoxidized strongly altered intrusive is acid-forming, but would make up less than 2% of the waste rock in the waste rock dumps. Several MWMP test waste rock samples had elevated arsenic, selenium, nitrate, and sulfate concentrations that were all less than 10 times drinking water standards.
Potential Water-Quality Impacts (before mitigations): *Groundwater* - Groundwater quality may be affected if waste rock and pits generate acid and mobilize metals and other compounds. Spring and seep water quality may be affected by contact with waste rock dumps, or by contact with pit walls. *Surface Water* – There is potential for acid drainage from waste rock, ore stockpiles, or pits to affect waterways and for an increase in sedimentation from roads, pits, and waste rock dumps. *Pit Water* - Saval, Steer, and Burns Basin pits (proposed project) will lie above the regional groundwater table and not accumulate water. The New Deep deposit will be mined using underground techniques, so no pit lake will form. No existing pit has encountered the regional groundwater table.
Mitigations: Selective handling and isolation of acid-forming waste rock; capping, contouring, or drainage control to reduce infiltration; blending and dilution of acid-generating materials; sediment control/capture structures.
Predicted Water-Quality Impacts (after mitigations): No impacts to surface water or groundwater are predicted (NDEP standards will be met) due to the implementation of the waste rock characterization and handling program and plugging of the underground workings. No pit lake is predicted to form. Temporary increases in sedimentation are expected, which would be reduced to below pre-mining levels following closure.

19.3 MONITORING AND COMPLIANCE INFORMATION

Years Monitoring Data Available: 1997-1998; 2000-2003
Number Surface Water Monitoring Locations: 21: Two Jerrit Canyon Creek sites, two Mill Creek sites, four Burns Creek sites, two Stump Creek sites, three Winters Creek sites, one Snow Canyon site, four Foreman Creek sites, and three spring sites.
Number Groundwater Monitoring Locations: Seven groundwater monitoring wells, and four water supply well.
Baseline Water Quality: Unknown.

Violations: A Finding of Alleged Violation (FOAV) was issued on March 5th, 1991 due to a CN plume in the groundwater, caused by seepage from the tailings pond. A seepage collection system was installed and operating by October 1991, and pumps tailings seepage back to the tailings facility.

Possible Mining-Related Exceedences:

Mine Water Supply Wells (WW-3, WW-4, WW-5, WW-6):

- Most metals concentrations peaked in 2000, particularly in WW-4.. Metals of concern included Al, As, Cu, and Pb. Elevated metals concentrations were limited to 2000, and were not recorded in later sampling.

Groundwater Monitoring Wells:

- GW-9, GW-24, GW-46, and JCM-20A showed exceedences for Cl and TDS, with values peaking at 30,000 mg/l (TDS) and 12,000 mg/l (Cl) in well GW-9. Exceedences of over 10X were common for these constituents, with exceedences occurring constantly between 1993 and 2004, aside from GW-46, which is first mentioned in the 2003 annual report GW-9 also had SO4 exceedences from 93-04, though these exceedences were by less than a factor of 2. These wells also showed occasional As fluctuations, but they rarely exceeded by even a factor of two. These wells are in the area affected by tailings seepage. The tailings impoundment is being gradually evaporated down to eliminate seepage.
- Some other wells showed very slight (less than a factor of two) exceedences for Cl and TDS.

Surface Water Monitoring Sites-

- Surface water monitoring sites BC-3, JC-2, MC-2, showed occasional, slight exceedences of As (new 0.01 mg/L standard) by a factor of 2 or less. Surface water monitoring sites SHE-10 and STC-10 each show a single exceedence of the old As standard, by less than a factor of two. Exceedences did not recur in later samplings. High As values are common in the area, and monitoring will show occasional exceedences. As long as exceeding concentrations are solitary, no action is taken.
- Surface water monitoring sites JC-2, MC-2, and SC show occasional, slight (less than a factor of 2) exceedences for TDS. SC also shows occasional, low (less than 2X) exceedences for SO_4.
- Surface water monitoring site SHE-10 shows a steady increase in TDS and SO_4 concentrations from 2001-2004, with exceedences of over 10X for both by early 2004 This is probably related to the waste rock disposal pile, and may also be affected by the reclamation measures mandated by the USFS.
- Surface water monitoring sites BC-3, STC-10, and SHE-10, all show slight pH exceedences, with values peaking in the low 9's. This may be due to the intermittent nature of the creek.

Table 19.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Jerritt Canyon Mine, Nevada.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater and Surface Water	Tailings	• 1980 EIS: No information provided for groundwater. Possibility of release of toxic materials to streams due to breakage of the tailings pipeline.	• 1980 EIS: Tailings located in headwaters of small water shed will protect water quality • 1980 EIS: Facility design to prevent groundwater impacts o Tailings disposal pond will be lined o Horizontal seepage controlled by embankment design.	• 1980 EIS: No impacts predicted • 1991 EA: Six pumpback wells are not effective at preventing migration of plume from impoundment	Water Quality Monitoring • 1991: Cyanide plume detected from tailings pond and seepage collection installed • 1993-2004: Groundwater monitoring wells downgradient of the tailing impoundment show exceedances for Cl and TDS consistently from 1993 –2004.
	Waste Rock	• 1980 EIS: Minimum potential for some leaching of some heavy metals and other toxic substances in the waste rock into surface and groundwater • 1994 EIS: Groundwater and surface water quality may be affected by acid drainage and other constituents in waste rock	• 1980 EIS: No information provided • 1994 EIS: Waste rock mitigations include: o Segregation and blending of PAG waste rock. o 1994 EIS: Capping, contouring and drainage controls o 1994 EIS: Waste rock characterization and handling (segregation, cap, contour, drainage) program	• 1980 EIS: Minimum impacts predicted • 1994 EIS: No impacts to groundwater or surface water predicted	Water Quality Monitoring • 2001-2004: Surface monitoring shows a steady increase in TDS and SO_4 concentrations downstream from waste rock piles from 2001-2004 with most recent data indicating exceedances of standards by 10X
	Open Pit	• 1980 EIS: No information • 1994 EIS: Groundwater and surface water quality may be affected by acid drainage and other constituents in pit walls	1980 EIS: Divert surface water flow around pit and groundwater from pit used for dust control or discharged	• 1980 EIS: No impacts predicted • 1994 EIS: No pit lakes predicted to form	

20 LONE TREE, NEVADA

20.1 GENERAL INFORMATION

Location: Humboldt County, Nevada
Ownership: Newmont Mining Co. (previously owned by Santa Fe Pacific Gold Corporation)
Commodity: Gold and silver
Years of Operation: 1991 to present
Operation Type: Open pit, heap leach, vat leach
Disturbed Acres: Permitted disturbance = 3,547; Actual disturbance = 2,691
Land Management/Ownership Status: 861 acres BLM; 2,686 private
Bond Amount: $8,375,000
NEPA Documents: 1995/1996 Draft/Final Expansion EIS
NPDES Permit: Minor, # NV0021962.

20.2 EIS SUMMARIES

20.2.1 1996 EIS

Proposed Project: Expansion of open pit; continuation of mine dewatering and discharge facility; expansion of tailing impoundment facility; and the overburden disposal facility.
Geology/Mineralization: Mississippian, Pennsylvanian and Permain sandstone, limestone, chert, shale, siltstone, mudstone, basalt, argillite (Havallah Formation); Ordivician argillite, quartzite and chert (Valmy Formation); and Permian siltstone/sandstone and arenite; pyrite deposition along the faults (Edna Mountain Formation). Marine sedimentary rocks host the gold mineralization, including only one carbonate unit, a sandy limestone. The Wayne Zone of the Havallah, Valmy, and Edna Mountain Formation has the highest concentration of gold. The Lone Tree deposit is composed of mineralized breccias, veins, and shear zones. The deposit contains oxide ore to 600 ft. below ground surface, shallower on east side of pit.
Climate: Warm, dry summers and cool, moist winters. *??*
Annual Precipitation/Evaporation: 6 to 8 in/yr precipitation; 36 to 42 in/yr evaporation.
Koppen Classification: Region – B/C/D, **Temperature –** a, **Precipitation** - s
Proximity to Surface Water: Two miles south of the Humboldt River. Excess mine water is discharged to canals, then the Herrin Slough, then the Humboldt River at a point ~11 mi. NW of the mine.
Proximity to Groundwater: Ranges from less than 10 to almost 200 feet below ground surface.
Predictive Tests and Models: Static (ABA), Kinetic (humidity cell tests), and short-term leach tests (MWMP). Also conducted a mixing experiment using acid leachate from Lone Tree rocks and Wayne Zone groundwater. Modeling included water quantity and water quality modeling: MINEDW, a proprietary computer program to predict three-dimensional groundwater flow, and hydrogeochemical modeling of pit lake water by PTI (assumed proprietary).
Constituents of Concern: arsenic, iron, sulfate, and total dissolved solids (mine discharge water; antimony, arsenic, cadmium, nickel, fluoride, sulfate (pit lake); and arsenic, copper, cyanide, iron, and sulfate (tailings).
Acid Drainage Potential: Static testing, humidity cell testing, and meteoric water mobility procedure testing indicate that Lone Tree overburden stockpiles will have excess neutralization potential (only 7% classified as acid-producing, based on static tests). Though static testing indicated that tailings are potentially acid generating, kinetic testing indicates they are not. Sulfides are encapsulated in silica; humidity cells tests on overburden suggest silicate buffering important.
Contaminant Leaching Potential: Moderate to high. In DEIS, MWMP extracts for tailings material exceeded drinking water MCLs for pH, sulfate, copper, iron, lead (<10x) and cyanide and arsenic (>10x). In FEIS (correction), MWMP tailings extract exceeded MCL's for arsenic, iron, lead, copper, pH, sulfate, and total dissolved solids (by <10x, so considered benign). WAD cyanide exceeded drinking water standard by ~25x, but still considered benign because standard is for total cyanide. MWMP tests on overburden material indicate the potential to mobilize arsenic, chloride, iron, and manganese, but concentrations are below ten times the MCL and are considered benign.

Potential Water-Quality Impacts (before mitigations): *Groundwater* - Pit lake water will mix with groundwater after steady state groundwater levels are reached; due to natural attenuation, no groundwater exceedences are expected. *Surface Water* - Water pumped from the ground and discharged into the Humboldt River is generally of good quality, except for recently increased concentrations of arsenic, iron, and sulfate in mine discharge water (DEIS). FEIS states that iron, copper, and lead have exceeded aquatic life criteria in mine discharge water. *Pit Lake* - Pit lake water quality predicted to be acidic and exceed the arsenic standard initially but become neutral after 10 years and not exceed for arsenic; cadmium predicted to exceed for one year; nickel, fluoride, and antimony for 25+ years; sulfate until 10 years. Nickel and fluoride predicted to exceed their respective limits by less than 10x and antimony by over 10x. In long term, pit water would show exceedences of 1-10x for aluminum, antimony, arsenic, fluoride, total dissolved solids, and pH; thallium predicted to exceed by >10x in long term.
Mitigations: Springs that are adversely affected would be mitigated by piping in water from another source, drilling into a deeper (unaffected) aquifer, improving existing spring sites to enhance water yield, or developing/improving other nearby springs to offset loss of flow. Sixty wells proposed for monitoring water levels and/or quality. Residual sludge in the bottom of the process ponds would be tested (TCLP), and treated if it fails, before burial. Waste rock exhibiting acid-generation potential would be placed in the interior of the dump and be surrounded with acid neutralizing material. Benches would be constructed to maximize precipitation retention and minimize surface runoff. Diversion ditches to prevent surface runoff from entering mine pit areas. Upon cessation of mining, the pit would be allowed to fill - neutralization is not proposed. Reclamation activities include diversion channels to minimize runoff into pit, fencing, and posting warning signs to identify potential safety hazards. Cooling pond proposed to keep discharge water within 2^{o}C of Humboldt River water. Water treatment proposed to reduce arsenic in dewatering water before discharge.
Predicted Water-Quality Impacts (after mitigations): *Groundwater* - Pit lake water will mix with groundwater after steady state groundwater levels are reached; due to natural attenuation, no groundwater exceedences are expected. Overlapping groundwater drawdown from Marigold, Getchell, and Pinson mines (but Lone Tree has highest pumping rate). Potential discharge of acid water from overburden, tailings, leach pads, ore stockpiles, but overburden mixing, encapsulation, monitoring, and mitigation programs will mitigate potential impacts. *Surface Water* - Discharge of mine water to Humboldt River would increase total dissolved solids and trace elements, but no significant water quality impacts (only minor impacts) would occur to the Humboldt River. *Pit Water* – See Potential Water-Quality Impacts.

20.3 MONITORING AND COMPLIANCE INFORMATION

Years Monitoring Data Available: 1998-2002
Number Surface Water Monitoring Locations: No information on surface water quality available from NDEP (information on water discharged to surface water – see below).
Number Groundwater Monitoring Locations: Sixteen. Eleven monitoring wells and five production wells.
Baseline Water Quality: No information.
Violations: None found in BMRR.
Possible Mining-Related Exceedences:

Mine Water Supply Wells:

- Production well WW-13 exceeded the secondary standards for F and Mn in 1998 and 2000. Both concentrations were less than twice the standard.
- In 2002 production well SS-14 exceeded the new drinking water standard for As (10 µg/l). The concentration was 1.3 times the new standard.

Groundwater Monitoring Wells

Heap leach monitoring wells:

- As exceedences (of the new standard) were fairly common in wells MO15-1A, MO15-2A, MO15-3. The highest exceedence was by a factor of two. The monitoring reports submitted to NDEP/BMRR from Newmont refer to these wells as 'Heap Leach.'
- Monitoring well MO15-2A recorded exceedences of the drinking water standard for Al in the fourth quarters of 1999 and 2000. The concentration in 1999 was 1.05 mg/l, and was 0.07 mg/l in 2000. The standard for Al is 0.05 to 0.2 mg/l.

- Monitoring well MO15-2A recorded an exceedence of the drinking water standard for Fe by less than a factor of two in the fourth quarter of 1999.
- Monitoring well MO15-3 recorded TDS exceedences from the second quarter of 1999 through the third quarter of 2000. Concentrations exceeded only slightly in 1999, (512 mg/l; 500 mg/l is the standard) but rose to 740 mg/l before dropping again.

Tailings monitoring wells:

- The tailings impoundment experienced a major leak in November, 2000, but the leak was not detected below the vadose zone.
- Exceedences of the secondary drinking water MCL for F (2.0 mg/l) were frequent in the tailings monitoring wells, S23MW1 through S23MW5, from 1999-2001. The primary MCL (4.0 mg/l) was not exceeded.
- Tailings monitoring wells (S23MW1-5) also showed frequent exceedences of the drinking water standard for Mn (50 µg/l) from 1999-2001, all less than twice the MCL.
- Tailings monitoring wells showed occasional exceedences for Fe and TDS from 1999-2002. TDS exceedences were more common from 2000-20002, and Fe exceedences were more common in 1999 and 2000. Concentrations were less than 1.2 times the standard. All Fe exceedences were by less than a factor of three.
- Some tailings monitoring wells had As concentrations that were at the level of the new standard in 2000 and 2002.

Surface Water Monitoring Sites:

- Between 1998 and 2002, dewatering water discharged into the Humboldt River exceeded standards frequently for pH, total dissolved solids, fluoride, boron and un-ionized ammonia.

Table 20.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Lone Tree Mine, Nevada.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impact
Groundwater	Heap Leach	1996 EIS: No estimates of potential impacts to water quality.	1996 EIS: No specific mitigation provided.	1996 EIS: No estimates of predicted water quality.	WQ Monitoring: possible exceedances of As, Al, Fe, and TDS
	Tailings	1996 EIS: No potential for acid drainage. Moderate to high potential for As, Cu, CN, Fe, and sulfate	1996 EIS: No specific mitigation provided.	1996 EIS: No estimates of predicted water quality.	WQ Monitoring: possible exceedances of secondary drinking water MCLs from 1999-2002 for fluoride, iron, manganese, and TDS
	Waste Rock	1996 EIS: No estimates of potential impacts to water quality.	1996 EIS: Overburden mixing and segregation	1996 EIS: No estimates of predicted water quality.	WQ Monotoring: No exceedances indicated.
	Open Pit	1996 EIS: Pit lake water quality acidic initially, but after 10 yr neutral; would exceed standards for As, Cd, Ni, F, Sb (by >10x), Tl (by >10x), and SO_4 at different times.	1996 EIS: Diversions to prevent runoff from entering pits.	1996 EIS: Groundwater downgradient from mine pit would approach baseline quality of regional groundwater, not expected to exceed MCLs	
Surface Water	Pit Dewatering	1996 EIS: Fe, Cu, and Pb are the only parameters that exceeded aquatic life criteria in mine discharge water.	1996 EIS: Affected springs mitigated by: piping in water, drilling into a deeper aquifer, improving existing springs to enhance yield, or developing/improving nearby springs to offset loss. Monitoring.	1996 EIS: No significant impacts would occur, but discharge to Humboldt River would increase total dissolved solids and trace elements.	Water pumped from the ground and discharged into the Humboldt River Discharge exceeds permit limits for TDS, B, F, pH, and NH_3.

21 ROCHESTER, NEVADA

21.1 GENERAL INFORMATION

Location: Pershing County, NV
Ownership: Coeur Rochester, Inc.
Commodity: Silver, Base metals
Years of Operation: 1986/Historic - Present
Disturbed Acres: 1,447
Bond Amount: $8,435,268
NEPA Documents: May 2001 EA; June 2003 EA.

21.2 EIS SUMMARIES

21.2.1 2001 EA

Proposed Project: develop a satellite open pit mine to mine a silver deposit 1.5 miles southwest of the Rochester project**.**
Geology/Mineralization: The oldest rocks in the area are from the Koipato group, which include the Limerick, Rochester Rhyolite and Weaver Formations. (Rock unit age is not mentioned.) The Rochester Rhyolite is composed of altered felsite with tuffaceous lenses. The Weaver Formation is similar, and unconformably overlies the Rochester Rhyolite. There is also a Cretaceous granodior intrusive that cauts through the Weaver Formation in the project area.
Climate: No information.
Precipitation: 13.88 inches per year, on average.
Evaporation: 53 inches per year.
Proximity to Surface Water: All streams in the project area are ephemeral.
Proximity to Groundwater: No springs in the project area. Pit depth will be at least 140 feet higher than the water table.
Predictive Tests: Acid-Base Accounting, Meteoric Water Mobility Procedure, Whole Rock Analysis.
Constituents of Concern identified: Sb, As, Fe, Pb, Hg, Ag
Predictive modeling: None.
Acid Drainage Potential: Low. Rocks in the project area generally have low sulfur content and low neutralizing potential. Only tw of twenty-six Acid-Base Accounting samples showed potential to generate acid.
Metal Leaching Potential: Comparison of results of ICP analyses of non-ore samples and similar unmineralized rock suggest that As, Pb, Hg, and Ag may occur in elevated concentrations in the rock and therefore may produce leachate at rates resulting in elevat concentrations in discharge water. Meteoric Water Mobility Procedure results show that under short term leaching conditions, Sb, Fe, and Hg may occur in elevated concentrations in discharge water from the non-ore material.
Groundwater Quality Impact Potential: No info in 2001 EA. Future developments at the Coeur operations or Relief Canyon operations could generate long-term impacts to groundwater (from 2003 EA).
Surface Water Quality Impact Potential: Due to historic mining in the area, the current site includes abandoned tailings material waste dumps, and leach pads that are likely to have an impact on surface water quality (2001 EA). There is a potential for increased sedimentation from the surface disturbance associated with the Proposed Action. There is potential for acid rock drainage from the present actions (2003 EA).
Pit Water Quality Impact Potential: The water table is 140 feet below the proposed pit bottom, so no pit lake is expected to form
Groundwater Mitigations:
Surface Water Mitigations:
Predicted Groundwater Quality Impacts: The proposed action is considered unlikely to degrade groundwater resources.
Predicted Surface Water Quality Impacts: The proposed action is considered unlikely to further degrade baseline surface water quality, since a part of the proposed action includes reclamation of the abandoned pre-Coeur workings.
Predicted Pit Water Quality Impacts: The water table is 140 feet below the proposed pit bottom, so no pit lake is expected to for
Zero discharge facilities: No information.

21.2.2 2003 EA

Proposed Project: Expansion to the Rochester and Packard mines.
Geology/Mineralization: Same as above for the Packard mine. Same as above for the Rochester mine, except that the Limerick formation is exposed in the project area. Alluvium is also present in the Rochester mine area. Higher grade mineralization is found in the brittle rhyolite zones.
Climate: No information.
Annual Precipitation/ Evaporation: No information.
Koppen Classification: Region – B/C/D, **Temperature –** a, **Precipitation –** s. **Proximity to Surface Water:** All of the drainages at the site are ephemeral.
Proximity to Groundwater: Several seasonal springs occur within the project area (3-5). Depths in the discontinuous alluvial/colluvium/weathered bedrock aquifer range from less than a foot to upwards of 20 feet (3-5). The potentiometric surface in the bedrock aquifer ranges from above the surface to a depth of approximately 400 feet. No information given on the actual depth to water in the deep bedrock aquifer, howerever.
Predictive Tests and Models: Whole rock analysis, ABA, MWMP, kinetic tests (257 samples, total, in all tests).
Constituents of Concern: Fe, Al, Cu, pH in rock from the Weaver Tuff (MWMP) (1-8, 1-9). Pb, pH, Cd, Zn in the Rochester Rhyolite (MWMP).
Acid Drainage and Metal Leaching Potential: 10-20% of non-ore material to be mined below the 6,600 ft. level has the potential to generate acid (1-8). Acid generating potential of material mined above the 6,600 ft. level was characterized in 1995, but information is not presented in this EA. Only one of the seven Weaver tuff samples released metals. The sample of the Weaver clastic unit, which contained two percent total sulfur released sulfate, as well as well as 1.2 mg/l of Fe, 0.2 mg/l of Al, 0.12 mg/l of Cu, and the final pH was 4.0 (1-8, 1-9). Of the five Rochester Fm samples, one sample did not release detectable metals. One sample released lead at 0.044 mg/l, with a pH of 4.9. One of the samples release Cd in excess of the drinking water standard, and two samples showed elevated concentratons of Zn and Cd, and one of the two had a pH of 5.6. Background water quality problems due to historic mining. Shallow groundwater has high TDS and SO4.
Water-Quality Impact Potential: *Groundwater*: Future developments at the Coeur operations or Relief Canyon operations could generate long-term impacts to groundwater. *Surface Water*: There is a potential for increased sedimentation from the surface disturbance associated with the Proposed Action (4-2). There is potential for acid rock drainage from the present actions.
Mitigations: Part of the proposed action includes reclamation of the existing project, as well as some of the abandoned pre-Coeur mine workings.
Predicted Water-Quality Impacts: *Groundwater*. Chemical composition of any water recharging the groundwater system from infiltration through the rock disposal sites would not be expected to substantially differ from the current groundwater chemistry. *Surface Water*: The proposed action is considered unlikely to further degrade baseline water quality, since a part of the proposed action includes reclamation of the project as well as some of the abandoned pre-Coeur mine workings.

21.3 MONITORING AND COMPLIANCE DATA

Years Monitoring Data Available: 2000-2003
Number Surface Water Monitoring Locations: 3
Number Groundwater Monitoring Locations: 17
Baseline Water Quality: Well WI-17 has been contaminated by a leak in the Stage I heap leach for some time.
Violations:
1988- At around noon on December 27th 1987, Coeur-Rochester experienced a release of process solution from the E Pregnant Pond. According to Rochester, the release occurred while solution levels in the two pregnant ponds (East and were being equalized. Fluid in the East pregnant pond did not drain down uniformly, which caused an exposed corner o float pontoon (which the floating suction is mounted on) to contact the liner and puncture it. This caused pregnant solu rain into American Canyon for 12-18 hours at a rate of 5-10 gpm.

In a letter dated December 31st, 1987, Harry Van Drielen of NDEP wrote to Coeur "It is the conclusion of this offi that cause of the discharge is unlikely to recur and that the mitigation of adverse consequences upon the environment is appropriate and comprehensive. Coeur-Rochester has satisfied the conditions in the permit, and administrative action towa fines or other penalties is unwarranted." However, the United States EPA issued a Notice of Violation to Coeur-Rochester June 30th, 1988, for violating the Clean Water Act by discharging pregnant solution to American Canyon. The EPA conclu the NOV by stating that "NDEP has 30 days in which to respond to the enclosed notice by taking appropriate enforcement action against Coeur-Rochester for the above mentioned violation… If NDEP does not take appropriate enforcement actio within that time, EPA will take whatever action against Coeur Rochester it deems appropriate."

On July 20th, 1988, NDEP issued an FOAV to Coeur-Rochester for the December 27th, 1987, pregnant solution release. It does not appear that NDEP pursued a monetary settlement.

1999- At roughly 12:00am on the morning of November 29th, 1998, a low-pressure alarm was activated on the Stage IV (heap leach pad) pipeline. An operator went to investigate the alarm, and discovered a broken pipeline at approximately 1:00am. The control room was notified, and the valves were closed and pumping was stopped. It is estimated that discharg occurred for 70-80 minutes. This resulted in the displacement of 200 ton of ore off the liner, causing 19,400 gallons of pro solution containing 45.3 lbs. of CN to be released to the environment. Of this, 5000 gallons of process solution containing 11.7 lbs. of CN was discharged off site to American Canyon, an intermittent drainage.

A dike was installed in American Canyon to stop solution flows, and affected soil was treated by H_2O_2 to degrade cyanide. Displaced ore was moved back to containment. Soil samples and solution collected from monitoring wells indicat that due to the frozen ground (which limited infiltration) and the prompt response of Rochester, no long term environment damage has resulted or will result from the spill. Rochester accepted a settlement agreement from NDEP for $10,625.00 to bring the matter to a close.

2003- On April 27th, 2003, NDEP issued Rochester an FOAV for CN exceedences discovered during quarterly monitori by Rochester. Contamination due to a leak in the Stage I heap leach pad had been present in the valley fill alluvium for a number of years. Do we have data for this – enough to make a graph? The violation was issued in response to the discover CN exceedences in MW-16, a monitoring well screened in the shallow bedrock below the site. Contamination had been previously confined to the alluvium. A settlement for $7,500 was assessed by NDEP and paid by Rochester. MW-16 will b pumped to limit the spread of the contaminant plume. Due to the low permeability of the bedrock, pumping is not expecte be very effective. For the same reason, however, the contaminant plume is of fairly limited extent and moves slowly.

Other Mining Related Exceedences:

Groundwater monitoring wells:

Wells downgradient of the Stage I heap leach pad:

- **WI-16**, shallow bedrock aquifer- This well has shown exceedences of Arsenic, Nitrate and WAD Cyanide. W Cyanide levels exceeding the MCL were discovered in the third quarter of 2002, and again in the first and thir quarters of 2003. The contamination was from the Stage I heap leach pad. Previously, contamination from the Stage I heap leach pad had been confined to the shallow alluvial aquifer (WI-17). Discovery of a plume in WI- a shallow bedrock well, led to an FOAV issued on April 27th, 2003.
- **WI-17**, shallow alluvial aquifer- Contamination in this well from the leaking Stage I heap leach pad has been established for quite some time. Constituents exceeding the MCL include NO3, WAD CN, Cd, Hg. Exceeden for WAD CN, Cd, and Hg were sporadic, while NO2/NO3 exceedences occurred in more than half the sample taken between 2000 and 2003. WAD CN, Cd, and Hg exceedences were by less than a factor of two, while NO2/NO3 concentrations peaked at just over seven times the drinking water MCL.
- **WI-19**, shallow alluvial aquifer- Arsenic values in WI-19 exceed the MCL in almost all samplings taken from 2000-2003. WI-19 is located between the process ponds, and downgradient of the Stage I heap leach pad. Rochester believed that the N. Barren pond was leaking, and may have caused the Arsenic exceedences. The Stage I heap leach pad may be contributing as well.
- **WI-1**, is near South American, and monitors the Stage I Heap Leach pad in a different drainage than America Canyon. In the first quarter of 2001, lead exceeded the MCL by under a factor of two in WI-1. Since Rocheste a base metals/Silver mine, elevated lead could be an indication of process solution contamination. There have been a few 'blips' in this area that could indicate leakage is occurring, but, if any leakage is occurring, it is mi

- **WI-29** exceeded the MCL for NO2/NO3 in all quarters it was sampled in 2000. This well is downgradient leaking Stage I heap leach pad, and the contamination is probably from the same plume that is affecting Ar Canyon Springs, and wells WI-16 and WI-17.
- **MW-30** is downgradient of the Stage I heap leach pad, as well as the solution ponds. In the third quarter o lead exceeded the MCL by less than a factor of two, and mercury exceeded the MCL by a factor of 6.5. In fourth quarter of 2003, mercury exceeded by a factor of 24.5. Rochester believes that this was due to leaka the N. Barren pond, which was re-lined in late 2004 as a result. The leaking Stage I heap leach pad may be contributing to this contamination as well.

Surface Water Monitorin Sites downgradient of the Stage I heap leach pad:

- **American Canyon Springs** recorded a number of NO2/NO3 exceedences from 2000-2003. Though it isn exactly clear what this contamination is related to, it is almost certainly not a natural condition. Rochester it is due to their septic field. However, American Canyon Springs is also downgradient of the leaking Stag leach pad, and the N. Barren pond, which was re-lined in late 2004.

Wells monitoring Stage IV heap leach pad:

- **MW-25** is downgradient of the Stage IV heap leach pad, and exceeded the MCL for Lead during the secon quarter of 2001. There has been some indication (slightly elevated, though not exceeding Cyanide values) Stage IV heap leach pad is leaking to its underdrain system, but not the groundwater.

Wells and surface water downgradient of the solution ponds:

- **WI-19**, shallow alluvial aquifer- Arsenic values in WI-19 exceed the MCL in almost all samplings taken fr 2000-2003. WI-19 is located between the process ponds, and downgradient of the Stage I heap leach pad. Rochester believed that the N. Barren pond was leaking, and may have caused the Arsenic exceedences. T Stage I heap leach pad may be contributing as well.
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- **American Canyon Springs** recorded a number of NO2/NO3 exceedences from 2000-2003. Though it isn exactly clear what this contamination is related to, it is almost certainly not a natural condition. Rochester it is due to their septic field. However, American Canyon Springs is also downgradient of the leaking Stag leach pad, and the N. Barren pond, which was re-lined in late 2004.

Table 21.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Rochester Mine, Nevada.

Resource	Potential Impacts	Mitigations	Predicted Impacts	Actual Impact
Groundwater	2003 EA: Future developments at the Coeur operations or Relief Canyon operations could generate long-term impacts to groundwater.	No info.	2001 EA: The proposed action is considered unlikely to degrade groundwater resources. 2003 EA: Water recharging the groundwater system from infiltration through Rock Disposal Sites not expected to differ from the current groundwater chemistry.	Leaks from the Stage I heap leach pad and the N. Barren pond have resulted in numerous exceedences in groundwater monitoring wells. Exceeding constituents include WAD Cyanide, mercury, cadmium, nitrate, and arsenic.
Surface Water and Springs	2001 EA: Due to historic mining, current site includes abandoned tailings, waste dumps, and leach pads that are likely to have an impact on t surface water quality. 2003 EA: There is a potential for increased sedimentation from surface disturbance associated with Proposed Action. There is potential for ARD from the present actions (2003)	2001 EA: Diversion ditches, as well as other sediment control measures. 2003 EA: Part of the proposed action includes reclamation of the Project, as welll as some of the abandoned pre-Coeur mine workings.	2001, 2003 EA: The proposed action is unlikely to further degrade baseline water quality, since part of the proposed action includes reclamation of project as well as some abandoned pre-Coeur mine workings.	Contamination of American Canyon (intermittent drainage) by process solution release of Nov. 29th, 1998. Exceedences of nitrate and arsenic in American Canyon Springs from heap leach pad and process solution ponds.

22 ROUND MOUNTAIN, NEVADA

22.1 GENERAL INFORMATION

Location: Nye County, Nevada.
Ownership: Round Mountain Gold Corporation
Commodity: Gold, Silver
Years of Operation: 1977-Present
Disturbed Acres: 4,542 permitted, 4,431 actual.
Bond Amount: $41,702,744
NEPA Documents: 1977 New Project EA (not reviewed), 1987 Expansion EA (not reviewed), 1992 Expansion EA (not reviewed), 1996 Expansion EIS

22.2 EIS SUMMARIES

22.2.1 1996 EIS

Proposed Project: Expansion of the existing operation to improve recovery of gold and build ancillary facilities (new primary crusher; a power line; fresh water, reclaim water, and tailings pipelines; and a septic system)
Geology/Mineralization: Gold occurs mostly as electrum (Au + Ag - free gold is milled and sent to flotation). Mineralization in Paleozoic sedimentary rocks and Cretaceous granitic rocks occurs mostly along faults and fracture zones. The primary host of mineralizations is the Tertiary Round Mountain tuff, in which gold occurs in quartz-carbonate and quartz-pyrite veins.
Climate: Dry.
Precipitation: 8 inches
Evaporation: 50-56 inches
Proximity to Surface Water: Ephemeral streams exist in the project area.
Proximity to Groundwater: 310-425 feet under the North heap leach pad offload, and 180 feet below S-2 leach pad offload.
Predictive Tests: MWMP for leach pad offload materials (spent ore). TCLP and MWMP tests for tailings. NNP (sulfide sulfur and carbonate carbon) and humidity cell tests for pit walls. Soil attenuation tests for leachate from leach offload piles.
Constituents of Concern identified:
Predictive Modeling: MODFLOW for groundwater flow into the pit. CE-THERM-R1 for thermal stratification and overturn of the pit lake. Quantitative models for wall rock loading, groundwater inflow, surface runoff to the pit, and MINTEQA2 for geochemistry of the pit lake. Davis-Ritchie model was used to calculate the thickness of the oxidized zone in the wall rock.
Acid Drainage Potential: Spent ore has the potential to generate elevated pH values. Forty percent of samples from the pit wall had potential to generate acid, but it is highly unlikely pit water will be acidic. In the long run, pit water is predicted to exceed the drinking water standard (high) for pH.
Metal Leaching Potential: Spent ore has the potential to leach Sb, As, Se, CN, and occasionally Fe, Hg, Ni, NO3, F, as well as generating elevated pH's. According to the EPA's Toxicity Characteristics Leaching Procedure, tailings do not exhibit hazardous properties. Meteoric Water Mobility Procedure tests indicate that carbon-in-leach tailings could leach Fe, Pb, Mn, TDS, SO4 in concentrations in excess of MCLs; carbon-in-leach tailings, however, would be only 5-10% of total tailings, and the tailings facility is designed as a zero discharge facility. Ultimately, pit water is predicted to exceed DW standards for Al, As, F, Mg, Hg, Ni, pH (high) TDS, SO4, and Zn.
Groundwater Quality Impact Potential: Geochemical test results suggest that some exceedences could potentially occur if water were to seep through the leach offload piles and discharge directly into a protected surface water source or groundwater aquifer. MWMP test average concentrations on spent ore show

exceedences of over 10X for As, and less than 10X for Sb, Se and CN. pH is also higher than allowed. If, after cessation of mine processing operations, seepage of tailings solution is still occurring through the underdrain system, the seepage would create a potential impact to groundwater.
Surface Water Quality Impact Potential: Potential exists for stormwater runoff to mobilize metals and CN from the spent ore materials. MWMP test average concentrations on spent ore show exceedences of over 10X for As, and less than 10X for Sb, Se and CN. pH is also higher than allowed.
Pit Water Quality Impact Potential: Excavation of the pit will expose sulfide minerals in the ultimate pit surface to atmospheric oxygen, and the resulting oxidation, particularly of pyrite, will form sulfuric acid and will potentially mobilize metals.
Predicted Groundwater Quality Impacts: Modelling indicates the pit will not discharge to groundwater, and thus is not expected to affect groundwater resources. Significant impacts to surface or groundwater quality from leach offload piles are not anticipated due to attenuation in soils. Minimal impacts to groundwater quality from tailings facilities due to management and design. Any metals and WAD CN potentially mobilized by snowmelt or rainfall that runs off the piles or seeps through the piles and later infiltrates the alluvial soils would be rapidly attenuated in the upper soil column. This indicates significant impacts to groundwater from the leach offload piles are not expected.
Predicted Surface Water Quality Impacts: Potential for mine facilities to degrade ground or surface water during the life of the mine are minimal. No discharge is expected from the mine pit, and thus pit water is not expected to degrade surrounding waters.
Predicted Pit Water Quality Impacts: Pit water would exceed MCLs (in the long term) for Al, As, F, Mg, Ni, Zn, TDS, pH (>9) and Hg, by less than ten times. Modeling of final groundwater levels and flow rates and predicted precipitation and evaporation rates suggest that the pit lake will have no net outflow to either ground or surface waters.
Zero discharge facilities: Mill and tailings facility.

22.3 MONITORING AND COMPLIANCE INFORMATION

Years Monitoring Data Available: 1999-2003
Number Surface Water Monitoring Locations: 0
Number Groundwater Monitoring Locations: 10
Baseline Water Quality: The Round Mountain Mine Fact Sheet flags Fe, NO3, F, As, and Cd levels as high in one or more wells.
Violations: No Finding of Alleged Violation (FOAV) documents for the Round Mountain Mine, but there was information on a hydrocarbon pollution/remediation in 2001, as well as a hole in the reusable leach pad liner. The hydrocarbon contamination was a pile of barrels on the ground over contaminated soil, which were removed and disposed of by a contracted company. The leach pad had an asphalt liner, which was punctured when a loader dug into it during unloading. Contaminated material was excavated, and the liner was repaired.
Possible Mining-Related Exceedences:
Mine Water Supply Wells:

- No data.

Groundwater Monitoring Wells:

- Most of the monitoring wells at Round Mountain are sampled for Profile I and III constituents yearly, which includes pH, As, F, TDS, and WAD CN.
- Monitoring wells recorded a number of exceedences of the secondary standards. Constituents with Secondary Standards that showed exceedences include Al F, Fe, Mn, and TDS. Al exceedences occurred in the pit dewatering water. Fe exceedences occurred in MW-106 and the pit dewatering water. Exceedences of the secondary standard for Mn occurred in wells MW-101, MW-105, and MW-106, and the pit dewatering water. TDS exceedences were recorded in MW-2 and the pit dewatering water. In addition to exceeding the secondary standard, F also exceeded the drinking water MCL at a number of sampling locations.

- Arsenic exceedences, of both the old and new standards, were very common, and are mentioned as a background condition in the Round Mountain Mine Fact Sheet (4/21/1997).
- Though they were not flagged as a baseline condition in the Fact Sheet, wells MW-101, DMW-1, DMW-2 recorded exceedences of the Sb MCL during every quarter it was sampled for from 1999-2002. Wells MW-101 and DMW-2 recorded exceedences in 2003, as well. All concentrations were by less than a factor of two (the document states that the Sb standard is .146 mg/l).
- Monitoring well MW-4 was sampled only during the first quarter of 1999, and Pb exceeded by less than a factor of two.
- High pH values have been measured in wells MW-101 and DMW-1. These wells are near one another, and near a range front fault where geothermal waters upwell. High pH values are likely due to the geothermal waters.

Surface Water Monitoring Sites-

- No surface water monitoring sites.

Table 22.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Round Mountain Mine, Nevada.

Resource	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater	Test results suggest some exceedences could occur if water were to seep through leach offload piles, discharge directly to a protected groundwater aquifer. MWMP tests show exceedences of over 10X for As, and less than 10X for Sb, Se and CN. pH is also higher than allowed. If, after cessation of mine operations, seepage of tailings is still occurring through underdrain, seepage would creat potential impact to groundwater.	Tailings facility designed for zero discharge. Backfill and reclaim the tailings seepage collection pond after underdrain seepage has ceased.	No discharge from pit, so no impact to GW. Significant impacts to groundwater quality from leach offload piles not anticipated due to attenuation in soils. Minimal impact to groundwater quality from tailings facilities due to management, design. Any metals, WAD CN mobilized by snowmelt or rainfall that runs off piles/seeps through piles and infiltrates alluvial soils would be attenuated in upper soil column.	Exceedences of secondary standards for Al F, Fe, Mn, pH (high), and TDS and primary drinking water standards for arsenic, antimony, and lead all appear to be related to baseline conditions. No mining-related exceedences are evident.

23 RUBY HILL, NEVADA

23.1 GENERAL INFORMATION

Location: Eureka County, NV
Ownership: Homestake Mining Co.
Commodity: Gold
Years of Operation: 1997 – 2002; DEIS for reopening filed in 2005
Disturbed Acres: 696
Bond Amount: $7,071,200
NEPA Documents: 1997 EIS

23.2 EIS SUMMARIES

23.2.1 1997 EIS

Proposed Project: New project.
Geology/Mineralization: Oxide ore hosted in limestone, with some sulfide species present.
Climate: No information
Precipitation/Evaporation: 13 inches precipitation/year; evaporation exceeds precipitation.
Proximity to Surface Water: Exact surface water proximity not mentioned, but there are no springs or perennial streams within the project area.
Proximity to Groundwater: Groundwater depth below the project area is 300 ft deep at the NW corner of the project area, and 500-600 feet deep at the SE corner of the project area.
Predictive Tests: Whole Rock Analysis, ABA, MWMP, Humidity Cell, Synthetic Precipitation Leach Test-EPA method 1312
Constituents of Concern: As, Al, Sb, TDS;
Acid Drainage and Metal Leaching Potential: Low for acid drainage: average ANP:AGP was 813 for alluvial material, and 955 for oxidized limestone samples. Moderate for contaminant/metals leaching: meteoric water mobility procedure (MWMP) on alluvial material and oxidized limestone resulted in occasional drinking water exceedences for Al, As, Sb, and TDS. EPA method 1312 leach tests showed exceedences for Al, As, and pH (high).
Water-Quality Impact Potential: Modeling indicates low potential for groundwater degradation. Increased erosion is the only noted surface water quality concern.
Predicted Water-Quality Impacts: No impacts to surface or groundwater expected, due to the nature of the rocks, as well as the distance to water. Pit will be above regional water table, so no pit lake expected.

23.3 MONITORING AND COMPLIANCE INFORMATION

Years Monitoring Data Available: 1997-2003
Number Surface Water Monitoring Locations: None.
Number Groundwater Monitoring Locations: Seven monitoring wells and two water supply wells.
Baseline Water Quality:

- Water in monitoring wells often exceeded the dw standard for As, with monitoring wells 1 and 5 (MW-1 and MW-5) consistently exceeding the new (0.010 mg/l) standard by over 10X. Other wells showed frequent low level exceedences of the new standard. Hand-written notes in the margins of monitoring reports by BMRR personnel refer to high As concentrations as ‘background’ conditions. pH exceedences (high) were fairly regular for MW-1. One or two pH exceedences (high) were recorded in wells MW-4 and MW-6 as well. A communication (dated March 14th, 2002) from Sharon Meyer (Homestake Mining co.) to Miles Shaw (BMRR) provides a graph that shows As and pH exceedences in these wells prior to mining. Exceedences date as early as September of 1995, and the FEIS is from January of 1997.

Violations:

- None in the violations file at BMRR.

Possible Mining Related Exceedences:

Groundwater Monitoring Wells:

- Nitrate concentrations in well MW-4 were frequently elevated (~8 mg/l), though no exceedences were recorded.
- There were lead exceedences (less than twice the drinking water standard) during the 4th quarter of 1997 and the 1st quarter of 1998 in MW-4, though no problems were recorded after this point. Since the exceedence did not recur, it did not result in any action.

Table 23.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Ruby Hill Mine, Nevada.

Resource	Potential Impacts	Mitigations	Predicted Impacts	Actual Impact
Groundwater	Low potential for degradation from leaching of arsenic and aluminum, according to the Horizontal Plane Source Model. Partial backfilling of pit (preferred alternative) would increase potential chemical impacts.	Zero discharge heap leach with a leakage detection/collection system; rinsing of heap leach during closure followed by a land application of rinse water.	Contamination of groundwater by leach solution not expected. Cumulative impacts from the waste rock and leach residue are not expected to occur.	None. Any exceedences related to baseline conditions.

24 TWIN CREEKS, NEVADA

24.1 GENERAL INFORMATION

Location: Humboldt County, Golconda, Nevada
Ownership: Newmont Mining Corporation (formerly owned by Santa Fe Pacific Gold Corporation)
Commodity: Gold and silver
Operation Type: Open pit heap and vat leach
Years of Operation: 1988 to present (The Twin Creeks Mine is the combination of the Rabbit Creek and Chimney Creek Mines. Those mines began operations in about 1988.)
Jurisdiction: BLM, Winnemucca District and private
Disturbed Acres: 4,549 acres on private land and 8,898 acres on BLM lands for a total disturbance of 13,447 acres
Bond Amount: $
NEPA Documents Available: 1996 Expansion EIS
NPDES Permit: Minor

24.2 EIS SUMMARIES

24.2.1 1996 EIS

Proposed Project: Pit expansion, additional milling, overburden/interburden storage areas, flotation and tailings; additional heap leach facility; expanded dewatering system and water disposal facilities; diversion of Rabbit Creek and tributaries.
Geology/Mineralization: Ordovician Valmy Formation: shales, basalt flows, sills and basaltic tuffs; Permo-Pennsylvanian Etchart Formation: interbedded limestone, dolomite and sandy limstone; and Mississippian Leviathan greenstone: altered basalts and basaltic tuffs with cherty interbeds. Gold mineralization occurs in the Paleozoic sedimentary rocks (Valmy Formation and Leviathan greenstone (South Pit) and Etchart limestone and Leviathan greenstone (Vista Pit)). Arsenic-mercury mineralization occurs mostly in oxidized ore, but there is some sulfide ore in the South Pit deposit. Sulfide minerals associated with gold mineralization include pyrite, stibnite, realgar, and orpiment.
Climate: Semi-arid
Annual Precipitation/ Evaporation: 9 to 12 in/yr precipitation; 40 to 45 in/yr evaporation, with pit evaporation estimated at 42 in/yr
Koppen Classification: Region – B/C/D, **Temperature –** a, **Precipitation –** s
Proximity to Surface Water: Kelly and Rabbit creeks are within the project area. A small portion of Kelly Creek is perennial on the mine site. Kelly and Rabbit creeks drain to the Humboldt River, but are largely ephemeral.
Proximity to Groundwater: Depth to groundwater is >~100 ft bgs over most of the mine site. In 1995, the pit floor was ~400 ft below the pre-mining water table.
Predictive Tests and Models: Static (ABA), kinetic (20-wk humidity cell; 46 pit wall rock samples), mineralogy, and short-term leach tests (MWMP). Hydrologic modeling included MINEDW (proprietary) for groundwater dewatering. Mass balance modeling was used to predict final pit lake elevation. CE-THERM-R1 was used to predict pit evaporation. DE-QUAL-W2 was used for modeling limnologic processes. Geochemical modeling included MINTEQA2 for predicting pit water chemistry and the Davis-Ritchie model for predicting the thickness of the oxidized zone in the pit walls over time.
Constituents of Concern: Total dissolved solids, aluminum, antimony, arsenic, beryllium, cadmium, chloride, chromium, copper, iron, lead, manganese, mercury, nickel, nitrate, selenium, silver, sulfate, thallium, and zinc (based on MWMP leachate results for waste rock, pit wall rock, and tailings, and humidity cell tests for pit wall rock).

Acid Drainage and Contaminant Leaching Potential: Pit wall rock NNP:range = -350-+671t/kt; avg.=+162; ~91% of rocks in proposed final pit surface would not be acid generating (have positive net neutralization potential values). Sulfide ore stockpiles: 31 samples, NNP weighted average =-67 t/kt. No mentioned acid-base accounting testing of heap leach material. Juniper and Sage mill tailings are net acid neutralizing; Mule Canyon mine ore is potentially acid generating. Waste rock (based on MWMP tests) leachate could exceed drinking water standards for total dissolved solids, beryllium, cadmium, selenium, zinc (of 1 – 10x), and for aluminum, antimony, arsenic, iron, manganese, mercury, nickel, sulfate, and thallium (of >10x). Kinetic testing of some pit samples showed net acid-generating potential and ability to release arsenic, sulfate, iron, aluminum, cadmium, and chromium. Rocks with higher NNP released more antimony. Elevated nitrate in MWMP tests. Tailings MWMP leachate concentrations exceeded drinking water standards for arsenic, antimony, cadmium, chromium, copper, iron, lead, mercury, silver, and selenium; tailings filtrate had elevated concentrations of zinc and chloride.

Potential Water-Quality Impacts (before mitigations): *Groundwater* - Infiltrating dewatering water has the potential to flush soluble salts, including chloride and nitrate, from the shallow alluvium to groundwater. There is minimal potential for impacts to water quality from the heap leach facility. No significant impacts to groundwater quality are expected from the sulfide ore stockpiles or tailings due to low precipitation, groundwater depth, and natural attenuation. *Surface Water* – Dewatering water discharged to Rabbit Creek has shown occasional exceedences of total dissolved solids (by 1-10x) and arsenic (>10x). *Pit Water* – Antimony and arsenic concentrations are predicted to exceed drinking water standards by over 10x for the life of the pit. Thallium concentrations are predicted to exceed drinking standards by 1-10x for the life of the pit. Aluminum concentrations would be exceeded in the north lobe of the pit for the first 27 years, but after the pit lakes merged it would no longer exceed. Total dissolved solids concentration in steady state pit water would exceed standard by 1-10x.

Mitigations: *Groundwater* - Basal layer of acid neutralizing material would be placed underneath waste rock. Waste rock would be placed over tailings, and thus seepage would be collected and discharged to process facilities, evaporated, or treated prior to discharge. Tailings facilities are designed with liners, subdrains, collection ponds, and pumback systems to prevent migration of tailings waters into groundwater systems. Groundwater would be monitored to prevent infiltration of mine water, with mitigation measures to follow if infiltration is detected. Heap leach pads are designed with synthetic liner and leak detection system and will be operated as a zero-discharge facility; solution ponds are double-lined with leak detection systems. A bioremediation facility will treat hydrocarbon-contaminated soil. *Surface Water* - Water treatment plant for dewatering water. The connection between Jake Creek and the regional groundwater system will be evaluated, followed by monitoring for water quantity and quality. Diversion structures will be inspected to ensure proper function and combat soil loss. Drainage structures will be stabilized after completion of mining. *Pit Water* - Pit water quality will be monitored.

Predicted Water-Quality Impacts (after mitigations): *Groundwater* - Mine dewatering would lower regional groundwater elevation, infiltration would increase water levels in re-infiltration pond area by up to 70 feet, even though stream flow increase is not expected. Pit water is not expected to discharge to groundwater, so no impacts to downgradient groundwater are expected. Tailings facilities are designed with liners, subdrains, collection ponds, and pumback systems to prevent migration of tailings waters into groundwater systems. *Surface Water* - Drawdown would potentially reduce baseflow in perennial streams and springs, including Little Humboldt River and Jake Creek. Potential for adverse effects to water quality from sludge disposal is considered minimal. Limited or no impact is expected to occur from bioremediation facilities. Water discharged to Rabbit Creek has shown occasional exceedences of total dissolved solids and arsenic. *Pit Water* – Drinking water standards predicted to be exceeded for antimony and arsenic (>10x) and thallium (1 - 10x) for the life of the pit. Aluminum concentrations are predicted to exceed standards in the north lobe of the pit for the first 27 years, but after the pit lakes merged it would no longer exceed. Steady state pit would exceed standard for TDS (1-10x). No net outflow from the pit to groundwater or surface water is expected.

24.3 MONITORING AND COMPLIANCE INFORMATION

24.3.1 MONITORING AND COMPLIANCE DATA: TWIN CREEKS (NORTH)

Years Monitoring Data Available: 2000-2003
Number Surface Water Monitoring Locations: 0
Number Groundwater Monitoring Locations: Seven groundwater monitoring wells.
Baseline Water Quality: Elevated As appears to be a background condition at the Twin Creeks Mine site. Monitoring reports submitted to the Nevada Bureau of Mining Regulation and Reclamation refer to As levels as background, and this was confirmed by Bob Carlson of the BMRR in a phone conversation on 1/25/05..
Violations: A violation was issued to the Chimney Creek Mine (operated by Gold Fields Operating Co.) in 1990 for constructing a minor modification to the heap leach pad without first obtaining a permit modification. The Chimney Creek and Twin Creek mines were combined in the mid-1990's.
Though no Finding of Alleged Violation (FOAV) was issued, there are documents relating to a mercury spill in the Juniper Mill. It resulted from a mechanical failure in the mill. Contaminated soil was excavated and run through the mill.
In addition, there is documentation of a remediation plan for an area of hydrocarbon contaminated soils at the mine site, but again, no FOAV was issued.
Possible Mining-Related Exceedences:

Mine Water Supply Wells:

- Not monitored. *Possibly monitored as part of NPDES permit.*

Groundwater Monitoring Wells:

- A number of monitoring wells, including GW-1A, GW-2A, GW-3A, GW-4, GW-5, GW-6, and GW-7 had As levels consistently elevated over the new (2006) or old MCL's. This appears to be a baseline condition for the site. (See above category, Baseline Water Quality).
- With the exception of arsenic levels, groundwater is generally of good quality. In the four years for which we have monitoring data, there are only two other exceedences; one is a slight TDS exceedence (515 mg/l) during the 3rd quarter of 2000 in GW-6, and the other is an exceedence of the lower standard for Al, by less than a factor of three.

Surface Water Monitoring Sites:

- Did not obtain files for the NPDES discharge.

24.3.2 MONITORING AND COMPLIANCE DATA: TWIN CREEKS (SOUTH)

Years Monitoring Data Available: 2001-2003
Number Surface Water Monitoring Locations: 0
Number Groundwater Monitoring Locations: 2001-2002: 5; 2003: 8 groundwater monitoring wells and 26 vadose wells.
Baseline Water Quality: Elevated As appears to be a background condition at the Twin Creeks Mine site. Monitoring reports submitted to the Nevada Bureau of Mining Regulation and Reclamation refer to As levels as background, and this was confirmed by Bob Carlson of the BMRR in a phone conversation on 1/25/05.
Violations: Twin Creeks was cited in 1994 for various 'poor housekeeping' practices discovered during a Water Pollution Control Permit Compliance Inspection. These included an open-ended concrete pipe located East of the mill that was 'discharging fluid onto the ground surface'; poor containment of stored hydrochloric acid, including leaking seals, puddles of acid on the floor, and a full/overflowing bucket being used to contain overflow from a tank; hydrocarbon pollution from the truck wash in an 'evap pond'; a non-permitted lined pond to contain process solution at the tailings booster pumps, where process solution escapes containment and contacts the ground.
Possible Mining-Related Exceedences:

Mine Water Supply Wells:

- Not monitored.

Groundwater Monitoring Wells:

Tailings impoundment monitoring wells:

- Cyanide was detected in monitoring well MW-2 in October 1995, from seepage in the Pinon tailings impoundment. Seepage is believed to have occurred when the supernatant pool was filled to deeply, which may have resulted in seepage through the tailings embankment in excess of the collection pipe's capacity, NDEP evaluated and characterized seepage fluids in the vadose zone below the facility and plugged well MW-2 because they believed it was acting as a conduit. The well was replaced with monitoring well MW-2R-1. Vadose zone wells (VW wells) were added to monitor seepage from the tailings impoundment. No violation was issued, as CN concentrations did not exceed maximum contaminant level.
- Elevated As appears to be a background condition at the Twin Creeks Mine site. Monitoring reports submitted to the Nevada Bureau of Mining Regulation and Reclamation refer to As levels as background, and this was confirmed by Bob Carlson of the BMRR in a phone conversation on 1/25/05. Wells showing occasional or persistent As exceedences include MW-4, MW-6, MW-1, MW-2R1, and MW-3.
- In addition to the aforementioned CN and As, there have been occasional exceedences of secondary standards as well. MW-2R1 occasionally exceeded the secondary standard for TDS from 2001-2003, though no concentration exceeded the higher (1000 mg/l) standard. In addition, MW-1 and MW-3 both showed occasional exceedences of the secondary standard for Al and Mn, from 2002-2003. MW-3 also exceeded the secondard standard for Fe once during 2002.

Vadose Zone Monitoring Wells (Tailings seepage)

- The vadose zone monitoring wells that were added during 2003 to monitor seepage from the tailings impoundment. (VW-1 through VW-26) tend to be of poorer quality and display multiple exceedences. TDS, SO_4, and Cl show exceedences in almost all vadose zone wells, typically in all four quarters of 2003. TDS typically exceeds the higher MCL by a factor of 1-2.5, with the highest exceedence just over a factor of 3. SO4 exceedences are usually less than twice the upper standard, and in some cases only the lower standard is exceeded. VW-23 and VW-24 do not exceed secondary MCL's for SO_4. Cl exceeds the upper standard in all wells but VW-23, in which the lower standard is exceeded. Cl exceedences are usually around twice the upper standard, and peak around 2.5 times the upper standard.
- All vadose zone well samples exceeded the MCL for Nitrate, by as much as a factor of four.
- In addition to the above issues, some vadose wells also showed contaminant concenctrations exceeding MCL's or Secondary Standards for CN, Al, Sb, As, Mg, Fe, Hg, and Mn.

Surface Water Monitoring Sites:

- Did not obtain files for the NPDES discharge.

Table 24.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Twin Creeks Mine, Nevada.

Resource	Source	Potential Impacts	Mitigations	Predicted Impacts	Actual Impacts
Groundwater	Tailings impound-ment	Infiltrating dewatering water could flush soluble salts, including chloride and nitrate, from shallow alluvium to groundwater. Low potential for impacts from heap leach. No significant impacts from sulfide ore stockpiles or tailings.	Layer of acid-neutralizing material underneath overburden storage. Overburden placed over tailings, seepage collected and discharged to process facilities, evaporated, or treated prior to discharge. Tailings facilities have liners, subdrains, collection ponds, and pumback systems. Heap leach pads have liner and leak detection, as well as double lined solution ponds with leak detection. Monitoring.	Dewatering would lower groundwater elevation, infiltration would increase levels in reinfiltration pond area up to 70 feet; stream flow increase not expected. Pit water not expected to discharge to GW, so no impacts. Tailings facilities have liners, subdrains, collection ponds, and pumback systems.	The Pinon tailings impoundment formed a leak which caused a perched zone with poor water quality including high concentrations of WAD cyanide, As, TDS and other constituents.
Surface Water	Dewate-ring water	Drawdown would potentially reduce baseflow in perennial streams and springs, including Little Humboldt River and Jake Creek.	Evaluation of connection between Jake Creek and groundwater system, followed by monitoring. Inspection of diversion structures to ensure function and combat soil loss. Stabilization of drainage structures after mining.	Potential for impacts from sludge disposal is considered minimal. Limited/no impact expected from bioremediation facilities.	Water discharged to Rabbit Creek has shown occasional exceedances (by 1-10X) of total dissolved solids and arsenic (over 10x).

25 FLAMBEAU, WISCONSIN

25.1 GENERAL INFORMATION

Location: Rusk County, WI
Ownership: Kennecott
Commodity: Copper
Years of Operation: 1991-1995
Disturbed Acres: ?
Bond Amount: ?
NEPA Documents Available: 1990 New Project EIS

25.2 EIS SUMMARIES

25.2.1 1990 EIS

Proposed Project: New Project
Geology/Mineralization: Precambrian volcanic rock, Cambrian sandstone, and Pleistocene glacial deposits. The orebearing deposits were formed on an ocean floor as a result of volcanic violent explosions and metal-sulfur rich brines more than 1.8 billion years ago. Dominant rock types within the mineralized horizon are quartz-rich sediments and volcanic ash, massive sulfide, semi-massive sulfide, and chert. Economically valuable minerals are chalcocite, bornite, and chalcopyrite, with trace gold and silver. The upper gossan cap is 30 feet thick. High-grade supergene copper (chalcocite, bornite in pyrite/chert) is below this to a maximum depth of 225 ft. Lower grade copper sulfide minerals are present below the supergene-enriched zone.
Climate: Temperate continental characterized by moderately warm summers and long cold winters.
Precipitation: Average is 31 inches per year, with a range from 21 to 45 inches.
Evaporation: No information.
Proximity to Surface Water: The proposed mine site is located ~15 miles above the confluence of the Flambeau and Chippewa Rivers. Three intermittent streams on site. Meadowbrook Creek, a perennial tributary to Flambeau River, is 0.5 miles south of the project area.
Proximity to Groundwater: Usually less than 20 ft. Groundwater in the proposed mine site flows west toward the Flambeau River.
Predictive Tests: Wet/dry leach test (HCT?) and a second leach test of continued saturation of materials. Whole rock analysis, including sulfur, of waste rock (5 samples) and topsoil, till, sandstone, and saprolite. Acid production test performed on waste rock.
Constituents of Concern identified: Based on leach tests and geochemical modeling, iron, manganese, and sulfate.
Predictive modeling: Geochemical model of backfilled waste leachate.
Acid Drainage Potential: Tests indicate that waste rock with sulfur content of 2% or less would not be expected to produce acid. The matrix of the enriched horizon was made up of pyrite and chert. No indication of amount of high sulfur material.
Metal Leaching Potential: Leach tests: Cu, Fe, Mn, sulfate in groundwater in backfilled pit.
Groundwater Quality Impact Potential: Waste rock from the mining operation would have the potential to leach contaminants to groundwater.
Surface Water Quality Impact Potential: Waste rock from the mining operation would have the potential to leach contaminants to surface waters.
Pit Water Quality Impact Potential: Pit backfill will eliminate pit waters. Predicted leachate concentration (from 1990 EIS) in pit backfill is 0.014 mg/l copper, 0.32 mg/l iron, 0.725 mg/l manganese, 1,360 mg/l sulfate.
Groundwater Mitigations: High sulfur waste stockpiles and ore crushing/loading areas would be lined to prevent seepage. Worst case leakage would leak into mine pit, where water would be treated before discharge.

Surface Water Mitigations: Settling ponds will collect runoff from low sulfur waste stockpiles for treatment prior to discharge to the Flambeau River. The ponds are unlined, but seepage to groundwater would flow mostly to the open pit.
Pit Water Mitigations: Backfilling to eliminate possibility of a pit lake. Liming of backfill.
Other Mitigations: Water from the open pit, and water from the high sulfur waste rock pile would be routed through the wastewater treatment plant before being discharged to the Flambeau River.
Predicted Groundwater Quality Impacts: Slightly increased levels of TDS, hardness, SO4, Fe, and Mn might be expected from leachate infiltration of groundwater. Contaminants would flow into adjacent mine pit, where it would be treated prior to discharge to Flambeau River. High sulfur waste stockpile, ore crushing and loading areas would be lined using a geomembrane; no impacts to groundwater quality expected. Settling ponds would collect runoff from low sulfur waste stockpiles and seep into groundwater at a rate of at least 5,000-6,000 gallons/day; could cause increase in contaminant concentrations in the groundwater near the ponds. Most groundwater under the ponds would flow into the pit, limiting the potential zone of contamination.
Predicted Surface Water Quality Impacts: Surface water impacts could include increased soil erosion and discharge of sediment (increased turbidity) to the river. Discharge into the Flambeau River will not cause the concentration of any substances in the river to exceed the most stringent applicable water quality standard. The groundwater drawdown may affect additional acreage. A small amount of contaminants from the settling ponds may be transported in the groundwater to the Flambeau River, but would not measurably affect the river water quality. After closure, discharge of contaminants would not likely be measurable in the Flambeau River due to dilution by the large river flow.
Predicted Pit Water Quality Impacts: Pit backfilling will eliminate pit waters. Predicted leachate concentration (from 1990 EIS) in pit backfill is 0.014 mg/l copper, 0.32 mg/l iron, 0.725 mg/l manganese, 1,360 mg/l sulfate.
Zero discharge facilities: None noted.
Discharges: WPDES discharge to surface water.

25.3 MONITORING AND COMPLIANCE INFORMATION

Years Monitoring Data Available: 2000-2003
Number Surface Water Monitoring Locations: 1
Number Groundwater Monitoring Locations: 4
Baseline Water Quality:
Violations:
Possible Mining-Related Exceedences:

Groundwater/Pit Backfill Monitoring Wells:

- Four monitoring wells in the backfilled pit show exceedences of drinking water MCL's or Secondary Standards for manganese (2.9 – 37 mg/l), iron (0.15 – 12 mg/l), sulfate (320 – 1,700 mg/l), pH (6.1 – 6.7), and TDS (810 – 3,400 mg/l).
- Samples taken from a location between the river and the pit show exceedences for manganese (3.1 – 4.2 mg/l), iron (2.8 – 7.4 mg/l), sulfate (350 – 460 mg/l), pH (5.9 – 6.2), and TDS (810 – 1,100 mg/l).

Surface Water Locations:

- Although concentrations in surface water up and downgradient of the mine showed no temporal water quality trends, a report from the Great Lakes Indian Fish and Wildlife Commission stated that water parameters measured have changed from those measured during mine operation, and that the change makes it impossible to compare during- and post-mining water quality (Coleman, 2004). In addition, the report states that the downstream sample site SW-2 is above the discharge point for surface water coming from the southeast portion of the mine site and therefore may not capture all releases from the mine.

Sources:

Coleman, J. 2004. Memorandum from John Coleman, Great Lakes Indian Fish and Wildlife Commission, to Neil Kmiecik, Biological Services Director. Re: Report on the status of the Flambeau Mine, February 22, 2004.

Lehrke, S., 2004. Memorandum from Stephen Lehrke, Foth & Van Dyke, to Jana Murphy, Flambeau Mining Company. Re: Flambeau MiningCompany – 2003 Annual Rerpot Groudnwater and Surface Water Trends. January 1, 2004.

Table 25.1 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Flambeau Mine, Wisconsin: Pit Backfill Leachate and Groundwater.

Resource	Source	Potential Impact	Mitigations	Predicted Impact	Actual Impact
Pit Backfill Leachate	Pit backfill	Pit backfill will eliminate pit waters.	Backfilling to eliminate possibility of a pit lake. Liming of backfill.	Pit backfill will eliminate pit waters. Predicted leachate concentration in pit backfill was 0.014 mg/l copper, 0.32 mg/l iron, 0.725 mg/l manganese, and 1,360 mg/l sulfate.	Four monitoring wells in the backfilled pit show exceedances of drinking water standards for Fe, Mn, pH, SO_4, and TDS. One in-pit well shows continued increasing or elevated concentrations of Fe, SO_4, TDS, and Mn; other wells show decreasing concentrations.
Groundwater	Pit backfill	Waste rock from the mining operation would have the potential to leach contaminants to groundwater.	High sulfur waste stockpiles and ore crushing/ loading areas lined. Treatment of mine water before discharge; Liming of backfill. Settling ponds to collect runoff from low sulfur stockpiles.	Slightly increased TDS, hardness, SO_4, Fe, Mn may be expected from leachate infiltration. No impacts from high sulfur stockpile, ore crushing areas. Worst-case leakage would leak into mine pit, where water would be treated before discharge. Groundwater under ponds flows to pit, limiting contamination.	Samples taken from a well between the river and the pit show exceedances of drinking water standards for Fe (2.8-7.4 mg/l), Mn (3.1-4.2 mg/l), pH (5.9-6.2), SO_4 (250-460 mg/l), and TDS (810-1,100 mg/l).

Table 25.2 Summary of Potential, Predicted and Actual Impacts and Mitigations at the Flambeau Mine, Wisconsin: Surface Water.

Surface Water and Springs	Pit backfill and mine operations	Waste rock from the mining operation would have the potential to leach contaminants to surface waters.	Settling ponds collect runoff from low sulfur stockpiles for treatment prior to discharge. Ponds unlined, but seepage to groundwater would flow mostly to pit. Contaminant flow to pit treated prior to discharge to river.	Increased erosion and discharge to river possible. Discharge will not cause concentration of any substance to exceed standards. Contaminants from ponds may be transported to river, wouldn't affect water quality. Post-closure discharge of contaminants not measurable in river due to dilution.	No observable changes in surface water quality, but sample locations may not capture all releases from mine.