Final
Supplemental Environmental Impact Statement
Golden Sunlight Mine Pit Reclamation

July 2007

Montana Department of Environmental Quality
and
U.S. Bureau of Land Management

Mission Statement

The Bureau of Land Management is responsible for the stewardship of our public lands. It is committed to manage, protect, and improve these lands in a manner to serve the needs of the American people for all times. Management is based upon the principles of multiple use and sustained yield of our nation's resources within a framework of environmental responsibility and scientific technology. These resources include recreation; rangelands; timber; minerals; watershed; fish and wildlife; wilderness; air; and scenic, scientific, and cultural values.

The Department of Environmental Quality's mission is to protect, sustain, and improve a clean and healthful environment to benefit present and future generations.

Cover Photos

The top two photographs were taken in June 2000 and July 2003 showing the view of the East Waste Rock Dump Offload Area during mining and after reclamation. The center photo is an aerial view of the pit taken by Tom Weitz in August 2004. The lower two photographs on the front cover were taken in May 2000 and June 2003 showing the view of the West Waste Rock Dump during mining and after reclamation. Photos are courtesy of GSM and Spectrum Engineering.

United States Department of the Interior
Bureau of Land Management
Butte Field Office

State of Montana
Department of Environmental Quality

July 2007

Final
Supplemental Environmental Impact Statement
Golden Sunlight Mine
Pit Reclamation

State of Montana
Department of Environmental Quality
PO Box 200901
Helena, MT 59620

U.S. Department of the Interior
Bureau of Land Management
Butte Field Office
106 North Parkmont
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July 2007

Dear Reader:

Enclosed for your review is the Final Supplemental Environmental Impact Statement (SEIS) for Pit Reclamation at the Golden Sunlight Mine (GSM).

To comply with the June 27, 2002, judgment of the Montana First Judicial District Court, the Montana Metal Mine Reclamation Act, and other applicable state and federal laws, rules, and regulations, the Montana Department of Environmental Quality (DEQ) and the U.S. Bureau of Land Management (BLM) have prepared this SEIS to evaluate pit reclamation alternatives at GSM for DEQ Operating Permit No. 00065 and BLM Plan of Operations #MTM-82855. Under the Proposed Action (the Partial Pit Backfill With In-Pit Collection Alternative), GSM would partially backfill the open pit and install wells in the backfill material to collect groundwater. The Final SEIS analyzes the potential impacts of the Proposed Action (Partial Pit Backfill With In-Pit Collection) as well as the potential impacts of alternatives: 1) No Pit Pond (no action); 2) Partial Pit Backfill With Downgradient Collection; and 3) Underground Sump. The Final SEIS addresses issues and concerns raised during the public meetings conducted in Whitehall on January 31, 2005, Helena on March 14, 2005, and Butte on March 24, 2005, as well as the public comments received from December 16, 2004, until April 12, 2005. All new information and analysis supplied during the comment period and developed in response to comments received were used to prepare the Final SEIS. The operating permit is available for review at the DEQ office in Helena and at the BLM office in Butte.

DEQ and BLM have identified the Underground Sump Alternative as the preferred alternative. The final decision will be made in the Record of Decision that will be prepared no sooner than 30 days after the Notice of Availability of the Final SEIS is published in the Federal Register.

The Final SEIS contains public comments and responses and changes to the Draft SEIS.

The agencies appreciate the public's involvement in preparing the Final SEIS. Additional copies are available upon request from DEQ or on the DEQ web site at www.deq.mt.gov. A copy of the Record of Decision will be sent to everyone who receives the Final SEIS.

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Final Supplemental
Environmental Impact Statement

Golden Sunlight Mine Pit Reclamation
Jefferson County, Montana

July 2007

Lead Agencies: United States Department of the Interior, Bureau of Land Management, Butte Field Office, and State of Montana, Department of Environmental Quality, Environmental Management Bureau.

Cooperating Agencies: None.

Participating Agencies/Governments: United States Environmental Protection Agency.

Contact for Further Information: R. David Williams, Bureau of Land Management, Butte Field Office, 106 North Parkmont, Butte, MT 59701 (406/533-7655) and Greg Hallsten, Montana Department of Environmental Quality, P.O. Box 200901, Helena, MT 59620-0901 (406/444-3276).

Abstract: This Final SEIS supplements the April 1998 Final EIS, *Environmental Impact Statement Amending and Adopting the Draft Environmental Impact Statement - Golden Sunlight Mine*. The Final SEIS analyzes impacts associated with final pit reclamation. The Final SEIS analyzes four alternatives, including No Action and the Proposed Action. Major issues include pit reclamation, acid rock drainage, and groundwater and surface water quality. The preferred alternative at this time is the Underground Sump Alternative.

Dates: A Record of Decision will be prepared no earlier than 30 days following the date the Environmental Protection Agency publishes the Notice of Availability of the Final SEIS in the Federal Register. A copy of the Record of Decision will be sent to everyone who receives the Final SEIS.

SUMMARY

PURPOSE AND NEED

Golden Sunlight Mines, Inc. (GSM) conducts open pit mining and mineral processing on private and public lands under Operating Permit No. 00065, issued by the Montana Department of Environmental Quality (DEQ) in 1972, and Plan of Operations #MTM82855, issued by the Bureau of Land Management (BLM) in 1982. A major mine expansion permitted in 1998 was challenged in the Montana First Judicial District Court (District Court). The District Court ruled, based on the record before the court, that GSM's reclamation plan must include backfilling the pit and ordered DEQ to implement partial pit backfilling in accordance with the procedures of the Metal Mine Reclamation Act (MMRA). BLM notified DEQ that backfilling the pit may result in "unnecessary or undue degradation of public lands" and that BLM must prepare a supplemental review pursuant to the National Environmental Policy Act (NEPA) and approve the modification to the reclamation plan. On October 24, 2002, DEQ, acting pursuant to the June 27, 2002, District Court judgment, ordered GSM to submit a modified partial pit backfill plan. The plan was to take into consideration current conditions at the mine site and address compliance with the Montana Water Quality Act. GSM submitted a proposed partial pit backfill plan on December 2, 2002. The purpose and need for action is to determine the mine pit reclamation plan to meet the requirements of MMRA and the Water Quality Act. The Supplemental Environmental Impact Statement (SEIS) evaluates the potential impacts of the backfill plan and alternatives pursuant to NEPA and the Montana Environmental Policy Act (MEPA).

What has changed in the Summary since the DSEIS?

The Summary provides a synopsis of the entire SEIS. Based on additional data and public comments, the following changes have been made:

- The overall groundwater capture needed from two dewatering well systems to meet groundwater standards at the mixing zone boundary for the Partial Pit Backfill With Downgradient Collection Alternative was changed from 95% to 96% capture efficiency.
- The volumes of soil cover needed in the four alternatives were updated.
- The pit discharge rate was changed from 16 gpm to between 27 and 42 gpm for the Partial Pit Backfill With Downgradient Collection Alternative and from 32 gpm to between 25 and 27 gpm for the No Pit Pond and Underground Sump alternatives.
- The groundwater collection and treatment rate was changed from 121 to 79 to 145 gpm for the Partial Pit Backfill With Downgradient Collection Alternative.
- All text, figures and tables were revised from data provided by GSM and various consultants.
- Text was corrected based on references.

ISSUES

A Notice of Intent (NOI) to prepare the SEIS was published in the Federal Register on May 7, 2003. The NOI invited scoping comments to be sent to DEQ and BLM through June 7, 2003. On July 1, 2003, a press release was issued to area newspapers, State of Montana Newslinks Service, and major interest groups. A public scoping meeting was held near the mine in Whitehall, Montana, on July 16, 2003.

Technical Issues

Technical issues for final mine pit reclamation include the design and constructability of the alternatives, pit highwall stability and maintenance, backfill maintenance, the effects of subsidence in the underground workings, operational and maintenance requirements of the groundwater/effluent management system, storm water management maintenance requirements, soil cover maintenance requirements, water treatment plant operating and sludge management requirements, and the flexibility of the alternative for implementing new technologies in the future.

Environmental Issues

Environmental issues for final mine pit reclamation include impacts to groundwater quality and quantity, the risk of violation of groundwater quality standards and impairment of beneficial uses of the Jefferson River alluvial aquifer, impacts to surface water quality and quantity, the risk of violation of surface water quality standards and impairment of beneficial uses of the Jefferson River and Slough, surface disturbance, hazards to wildlife, and the amount of disturbed land left unrevegetated.

Socioeconomic Issues

Socioeconomic issues include worker and public safety, mining and reclamation employment, tax revenue, access to future mineral reserves and resources, land use after mining, aesthetics, and the future burdens on society and GSM.

Project Economics Issues

Project economics issues include the costs of reclamation.

ALTERNATIVES ANALYZED IN DETAIL

No Pit Pond Alternative (No Action)

Under the No Pit Pond Alternative, the bottom 100 feet of the pit would be backfilled with crusher reject waste rock to create a backfill sump. The backfill would serve as a

flat working surface on which to station two to three dewatering wells and other components of a collection system. The dewatering system would collect water in the sump and pump it to a permanent water treatment plant. By maintaining the groundwater level as low as possible in the crusher reject, no water would be allowed to pond in the pit bottom. Protection for the pumping facilities and workers would be provided by building one or more berms around the perimeter of the 1.3-acre working area to trap rocks that might fall from the pit highwall. A 3-foot soil cover system would be placed over the crusher reject.

Partial Pit Backfill With In-Pit Collection Alternative (Proposed Action)

Under this alternative, the pit would be backfilled with 100 feet of crusher reject and then waste rock from the East Waste Rock Dump Complex to create a free-draining surface at the 5,350-foot elevation. The upper pit highwall would be cast blasted and contoured to 2H:1V slopes. A 3-foot soil cover system would be placed over the graded area and revegetated. Eleven dewatering wells would be installed through the backfill to bedrock to maintain the pit as a hydrologic sink, and the water would be pumped to a permanent water treatment plant.

Partial Pit Backfill With Downgradient Collection Alternative

This alternative is a variation of the Partial Pit Backfill With In-Pit Collection Alternative. The pit would be backfilled, and the pit highwall would be reduced, as in the Partial Pit Backfill With In-Pit Collection Alternative. The pit would not be maintained as a hydrologic sink by installing wells inside the backfilled area. Instead, a system of wells would be operated outside of and down gradient from the pit to intercept contaminated groundwater after it has left the pit. The system would include an estimated 31 or more new downgradient capture wells, existing wells in the Tailings Impoundment No. 1 capture and monitoring system, and 10 new monitoring wells.

Underground Sump Alternative

The Underground Sump Alternative is similar to the No Pit Pond Alternative, except no backfill would be placed in the pit, and the underground workings would be improved and maintained as a sump for pit dewatering.

ALTERNATIVES CONSIDERED AND DISMISSED FROM DETAILED ANALYSIS

Partial Pit Backfill Without Collection Alternative

The Partial Pit Backfill Without Collection Alternative was developed to evaluate the possibility of avoiding long-term pit water collection and treatment. Reclamation would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative and the Partial Pit Backfill With Downgradient Collection Alternative; however, wells would not

be installed. Natural attenuation and mixing of contaminated pit groundwater with ambient groundwater would be relied on to meet groundwater quality standards at the mixing zone boundary. This alternative was not considered in detail because compliance with groundwater quality standards could not be reliably assured without downgradient or in-pit collection of contaminated groundwater. It would not meet the purpose and need.

Partial Pit Backfill With Amendment Alternative

The Partial Pit Backfill With Amendment Alternative was developed to try to avoid the need for long-term pit water collection and treatment. Reclamation would be the same as under the Partial Pit Backfill With In-Pit Collection and Partial Pit Backfill With Downgradient Collection alternatives, except lime would be added to the waste rock to increase the pH of the water that would collect in the backfill. This alternative was not considered in detail because analysis indicated that without downgradient groundwater capture, compliance with groundwater quality standards for arsenic, selenium, sulfate, and zinc could not be reliably assured. It would not meet the purpose and need.

Pit Pond Alternative

The possibility of creating a pit pond with biologic treatment was analyzed. The objective would be to design a pond that could sustain aquatic life and provide beneficial uses once it was developed. In the Pit Pond Alternative, the pit would be allowed to fill with precipitation, groundwater, and runon water. The water would be treated in the pit with microbes, nutrients, etc. This alternative would have no clear advantage over the Underground Sump Alternative. Without further technical review, any pond concept could only be considered by the agencies on a trial basis. Consequently, this alternative was dismissed. It would not meet the purpose and need.

SUMMARY OF IMPACTS

Table 1 summarizes and compares the impacts of each alternative considered.

MITIGATION MEASURES

Mitigation measures for the mining operations at GSM were identified in the 1997 Draft EIS, Chapter IV, Section IV.P. Only mitigation and monitoring that could be implemented to mitigate potential impacts from the pit reclamation alternatives being evaluated in this SEIS. These twenty-three measures are presented in this SEIS in Chapter 4, Section 4.8.

PREFERRED ALTERNATIVE

The rules and regulations implementing MEPA and NEPA (ARM 17.4.617 and 40 CFR 1502.14, respectively) require that the agencies indicate a preferred alternative in the Draft SEIS, if any, and in the Final SEIS prepared for the project. The preferred alternative is not a final decision; it is an indication of the agencies' preference at this time. The final decision will be made in the Record of Decision that will be prepared no sooner than 30 days after the Notice of Availability of the Final SEIS is published in the Federal Register. The agencies' preference considers all information that has been received and reviewed relevant to the proposed project, and all comments received on the Draft SEIS. The preferred alternative at this time is the Underground Sump Alternative with visual and other mitigations described in Section 4.8.3.2.

Rationale for the Preferred Alternative

Under all alternatives, the probability of highwall failure is low, and there would be no threats to public safety or the environment outside the pit. Some wildlife habitat would be provided. However, only the Underground Sump and No Pit Pond alternatives provide adequate assurance that pollution of the Jefferson River in violation of water quality laws would not occur. These alternatives would provide sufficient control of pit seepage through evaporation and collection. Sufficient control of pit seepage to protect groundwater and surface water quality cannot be reliably assured under the other alternatives because of the problems associated with drilling and operating wells in the 875 feet of reactive backfill and with effectively capturing seepage in or down gradient of the pit.

With the imposition of the visual mitigations described in Section 4.8.3.2 of the Draft SEIS, the Underground Sump and No Pit Pond alternatives also mitigate post-reclamation visual contrasts between the pit and adjacent lands.

The Underground Sump Alternative would pose less risk to workers monitoring and operating the water capture system from rock raveling from the highwall than would the No Pit Pond Alternative. Under the No Pit Pond Alternative, the workers would perform these functions while exposed to raveling and sloughing from a 1,775-foot highwall. Under the Underground Sump Alternative, much of the work would be performed underground. In addition, the Underground Sump Alternative would require less maintenance than the No Pit Pond Alternative, because the most of the collection system would not be susceptible to damage from rock raveling from the highwall.

BLM is mandated by the Federal Land Policy and Management Act (PL 94-579) and subsequent 43 CFR 3809 surface management regulations to manage federal lands so as to prevent unnecessary or undue degradation of the public lands. The preferred alternative prevents unnecessary or undue degradation of the land by maximizing the amount of mine impacted water collected and treated, limiting the potential for mine impacted water to escape collection, and limiting the potential for water quality violations at the mixing zone boundary.

Table S - 1. Summary Comparison of Impacts Under the Proposed Action and Alternatives

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Technical Issues				
Design & constructability of the alternative				
Proven design	Backfilling with 111,000 cubic yards of crusher reject to a depth of 100 feet is a proven design. Dewatering this volume of material to a depth of 100 feet is a proven design.	Backfilling with 33 million cubic yards of acidic waste rock and cast blasting and dozing the highwall to a 2H:1V slope is technically feasible. Dewatering waste rock backfill from a depth of up to 875 feet has not been proven.	Similar to Partial Pit Backfill With In-Pit Collection Alternative. Pumping out of downgradient drainages in natural geologic formations up to 200 feet deep is done regularly, but the objective of overall 96 percent capture may not be achievable.	Not applicable. Maintaining hydrologic connection between the pit bottom and an underground sump 25 to 75 feet below the pit and pumping from the sump have been done successfully at GSM and other mines.
Design & constructability of the alternative				
Ability to construct the alternative at GSM	Problems with constructing this alternative would be minimal.	There would be more problems developing and implementing this alternative than the No Pit Pond Alternative because of the larger volume and depth of backfill needed, the amount of cast blasted material, and the problems drilling dewatering wells in up to 875	There would be more problems developing and implementing this alternative than the No Pit Pond Alternative because of the larger volume and depth of acidic backfill needed and the amount of cast blasted material required. Installing dewatering wells in downgradient drainages in natural geologic	GSM has developed and maintained an underground mine, including an underground sump connected to the open pit.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
		feet of unconsolidated waste rock in order to maintain the pit as a hydrologic sink.	formations up to 200 feet deep has been done successfully at GSM.	
Pit highwall				
Pit highwall stability	Some portions of the pit highwall would be subject to raveling, talus formation, erosion, and limited sloughing. The overall stability of the pit highwall would be expected to increase over the long term as the rock materials achieve a more stable configuration.	No pit highwall would remain exposed. Backfilling the pit would eliminate pit highwall raveling and sloughing. Cast blasting would enhance the inherent stability of the pit highwall by reducing the slope to 2H:1V. The long-term stability of the pit highwall would be greater than the No Pit Pond Alternative.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative.
Pit highwall maintenance requirements	Raveling and sloughing of the highwall would require periodic maintenance to re-establish the 5,700-foot-elevation safety bench, clear the access road, haul more backfill to create a new working surface in the pit bottom, and move rock to re-establish safety berms. This could occur more than once over the long term.	No highwall maintenance would be needed.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative. Depending on the location of highwall raveling and sloughing, access to the 4,550-foot portal and the underground dewatering system could be lost. The 5,700-foot safety bench and access to the 4,550-foot portal would have to be re-established.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Backfill				
Backfill maintenance requirements	Settling in 100 feet of crusher reject would be limited to 10 feet. Repairs would be needed to bring the crusher reject back to grade.	Up to 150 feet of settling could occur in the 875 feet of backfill, with 60 to 75 percent of the settling occurring during the backfilling operation. Repairs would be needed to bring the acidic backfill back to grade. Settling in the acidic backfill would affect storm water diversions on the 2H:1V slopes.	Up to 200 feet of settling could occur in the 875 feet of backfill after it is inundated with groundwater. Sixty to seventy-five percent of settling would occur during the backfilling operation. The remaining settling would occur over about 61 years during saturation to the 5,260-foot elevation. Repairs would be needed to bring the backfill back to grade. Settling in the backfill would affect storm water diversions on the 2H:1V slopes.	Not applicable.
	Raveling and sloughing of the highwall would require periodic maintenance to re-establish the working surface and drill new wells.	The highwall would not ravel or slough.	The highwall would not ravel or slough.	Not applicable.
Underground workings				
Impacts to pit facilities due to subsidence related to underground mining	Localized failures of the walls and ceiling over time could result in subsidence, especially in seep and fault areas where chemical weathering would be increased. Subsidence could cause settling in the 100 feet of crusher reject, affecting the dewatering wells in the crusher reject.	Same as the No Pit Pond Alternative. Subsidence could cause settling in up to 875 feet of backfill, affecting the dewatering wells in the backfill.	Similar to the Partial Pit Backfill With In-Pit Collection Alternative, except the dewatering wells down gradient of the pit would not be affected.	Same as the No Pit Pond Alternative, except localized failures of ceiling and walls in seep and fault areas could occur over time, affecting access to the dewatering system in the underground workings.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Groundwater/ effluent management system				
Operation requirements (number of wells)	Two to three wells would be constructed through the acidic pit crusher reject about 100 feet deep to the bedrock contact.	Eleven wells would be constructed through the acidic pit backfill up to 875 feet deep to the bedrock contact. Wells would need to be replaced frequently due to corrosion.	An additional 31 capture wells and 10 monitoring wells would be constructed down gradient from the pit. This number of wells may not be enough to ensure compliance with groundwater quality standards at the mixing zone boundary.	No wells would be constructed. Drill holes would be used to direct pit water to the underground sump.
Maintenance of capture points	Settlement of the 100 feet of crusher reject could cause separation, buckling, or shearing of well casings. About 60 to 75 percent of settlement would occur during the backfill operation and 25 to 40 percent over a longer period after backfilling is complete.	Settlement effects on well casings would be more severe than under the No Pit Pond Alternative.	Wells would be constructed outside of the pit and would not be subject to acidic backfill settling.	There would be no backfill to settle and no wells to damage. Rock fall from ceiling and walls of the underground workings could damage the dewatering system.
	Corrosion of the well casings, pumps, electrical components, monitoring equipment and pipelines from the acidic water in the backfill would cause periodic need for repair and replacement of dewatering system components.	Same as the No Pit Pond Alternative.	Short-term buffering by the aquifer and mixing with ambient groundwater would limit corrosion of pumps and screens, providing for longer pump life. After the buffering capacity of the aquifer is used up in a few tens of years, water quality would be similar to the No Pit Pond and Partial Pit Backfill With In-Pit Collection alternatives.	Corrosion would be similar to the No Pit Pond Alternative.
	Highwall raveling and	Not applicable.	Not applicable.	Similar to the No Pit Pond

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	sloughing could damage dewatering wells, monitoring equipment, powerlines, and pipelines.			Alternative, except the collection system would not be damaged as much.
	Pumping rates of 25 to 27 gpm at a lift of up to 200 feet would not be a problem. Pumping stations would be used to finish getting the water out of the pit.	Lower pumping rates and the 875-foot lift compared to the No Pit Pond Alternative would cause more pump failure and may cause the need to allow the water table to rebound for pumping efficiency. No pumping stations would be needed.	Similar to the No Pit Pond Alternative. Multiple wells up to 200 feet deep would pump a total of 79 to 145 gpm.	Similar to the No Pit Pond Alternative, except the lift would increase by 75 feet.
	Not applicable.	Not applicable.	Not applicable.	Access to the underground would be needed. Sloughing could bury the 4,550-foot elevation portal blocking access to the dewatering system needed for maintenance.
Storm water runon/runoff management				
Maintenance requirements (drainage channels off 2H:1V slopes)	Diversions on the upper pit highwall would route water away from the pit. Settling of diversions constructed on unconsolidated materials and accumulations of sediment and material sloughed from above would impair diversions' function. Periodic cleaning and	Same as the No Pit Pond Alternative, except there would be diversions on the pit backfill.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	repairs would be needed. Eventually, portions of the diversions would need to be reconstructed completely.			
	Not applicable.	Diversions would be constructed on the 2H:1V slopes created by highwall reduction. Settling in the backfill could cause depressions where surface water could accumulate, infiltrate, and saturate the soil cover resulting in erosion on the face of the reclaimed slopes. Maintenance requirements for diversions would be the same as for the No Pit Pond Alternative, except there would be more diversions to maintain.	Maintenance requirements would be similar to the Partial Pit Backfill With In-Pit Collection Alternative. More settlement would occur due to saturation of the backfill.	Not applicable.
Soil cover				
Soil cover maintenance requirements (erosion, revegetation)	A 3-foot soil cover would be placed and revegetated on the pit floor, pit benches, and roads, totaling 53 acres. A total of 290,400 cubic yards of soil cover material, from existing sources, would be necessary.	A 3-foot soil cover would be placed and revegetated on the backfilled pit and reduced highwall, totaling 272 acres. A total of 1,541,800 cubic yards of soil cover material, resulting in an additional disturbance of 31 acres, would be necessary	Similar to the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative, except there would be 1.3 fewer acres to maintain in the pit. A total of 285,600 cubic yards of soil cover material, from existing sources, would be necessary.
	Eroded areas would need to be repaired, resoiled, and reseeded. Noxious	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	weeds would have to be controlled.			
	The backfill surface would need to be regraded as the crusher reject settles. Rocks that ravel or slough from the highwall onto revegetated areas would need to be removed. Depending on the volume of rock, releveling with more fill, regrading, resoiling, and reseeding of reclaimed surfaces may be needed.	Backfill would settle up to 150 feet. More acidic backfill would have to be placed, graded, resoiled, and revegetated.	Backfill would settle up to 200 feet.	There would be no backfill needing cover maintenance.
	In localized areas, highwall seeps could saturate the soil cover with acidic water, contaminating soils and impairing revegetation success. The seep would have to be located and dewatered, contaminated soil would have to be replaced with clean soil, and the area would have to be revegetated.	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.
Water treatment				
Additional sludge management requirements	Between 25 and 27 gpm of pit water would need treatment.	Between 27 and 42 gpm of pit water would need treatment.	Between 79 and 145 gpm of groundwater would be collected and treated trying to capture 96 percent of the 27 to 42 gpm of pit discharge to meet water quality standards.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	The sludge management requirements would be similar to or less than estimated in the 1997 Draft EIS.	Weathering would continue to produce oxidation byproducts in the unsaturated backfill. Pumping would limit saturation of the backfill and impacts from jarosite dissolution. More sludge would be produced per gallon of treated water than under the No Pit Pond Alternative, so sludge management requirements would be similar to those estimated in the 1997 Draft EIS.	Weathering would continue to produce oxidation byproducts in the unsaturated backfill. Jarosite in the saturated portion of the backfill would, for a time, prevent reducing conditions from developing and allow further production of acid. Jarosite is stable under oxidizing conditions and unstable under reducing conditions. The presence of jarosite in the pit backfill would only influence the redox conditions until it all dissolves. Jarosite would likely dissolve and release metals in the saturated portion of the backfill. Once jarosite completely dissolves, reducing conditions would likely develop in the saturated portion of the backfill. The flow from the unsaturated portion of the backfill above the water table would contribute low pH water with high metals concentrations to the pit discharge for hundreds of years. There is limited natural attenuation capacity along the primary and secondary flow paths from the pit. The sludge management requirements would be about the same as the Partial Pit Backfill With In-	The water produced in the underground workings would be comparable to the water quality in the No Pit Pond Alternative. Because there would be no backfill, jarosite, adsorbed metals, and other oxidation byproducts would remain relatively immobile in the waste rock dump complex. There would be minimal additional sludge.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
			Pit Collection Alternative because the chemical mass would be about the same.	
Additional operating requirements	There would be no additional water treatment operating requirements. The water treatment system in the SEIS is the same as that evaluated in the 1997 Draft EIS, and there would be less pit water to treat.	Same as the No Pit Pond Alternative.	The water treatment plant could require additional operating cost due to the increased water quantity treated under this alternative. The total amount of water would be less than the permitted treatment plant capacity.	Same as the No Pit Pond Alternative.
Flexibility for future improvements				
Potential for utilization of new technologies	New technology, such as *in-situ* water treatment, would be easier to apply in the less than 600,000 cubic yards of crusher reject and raveled and sloughed highwall rock under the No Pit Pond Alternative than it would be in the larger volumes of backfill under the partial pit backfill alternatives.	New technology, such as *in-situ* water treatment, would be harder to apply in 47 million cubic yards of pit backfill than under the No Pit Pond Alternative. Because of the problems with maintaining wells in acidic waste rock in the deeper backfill, this alternative offers less potential for utilization of new technologies. It would be harder to redesign the dewatering system in up to 875 feet of backfill.	Similar to the Partial Pit Backfill With In-Pit Collection Alternative, except that *in-situ* water treatment would be more difficult because of the lack of wells in the backfill. If treatment were attempted outside of the pit, a dispersed plume may be more challenging to track, contain, and treat *in-situ*.	New technology, such as *in-situ* water treatment, would be easier to apply in the open water of an underground sump than in backfill.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Environmental Issues				
Impacts to groundwater quality and quantity				
Risk of impacts to groundwater quality and quantity in permit area	The pit would be maintained as a hydrologic sink and between 25 and 27 gpm of pit water would be collected and treated before being discharged. No impacts to groundwater quality from pit outflows are expected. The groundwater level around the pit would be permanently drawn down. This would result in minor reductions in the flows of springs that are hydrologically connected to the pit.	Same as the No Pit Pond Alternative, except 27 to 42 gpm would be collected and treated. Same as the No Pit Pond Alternative.	The pit would not be a hydrologic sink. Two groundwater capture systems in Rattlesnake Gulch, each operating at an efficiency of 87.5 percent or greater would be required to meet DEQ-7 water quality standards at the mixing zone boundary for the toxic and carcinogenic parameters modeled. The groundwater standard for iron would be exceeded. This level of capture efficiency may not be achievable. Based on their experience, the agencies believe a maximum capture efficiency of 80% per system is potentially achievable. The groundwater level around the pit would rebound so that the flows of springs that are hydrologically connected to the pit could be increased. Because of the higher pit groundwater elevation, ARD water from the pit could move along secondary flow paths in	Same as the No Pit Pond Alternative, except that water would be pumped from the underground sump and treated. Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
			the bedrock and Bozeman Group aquifers where it is more difficult to detect and collect. Groundwater quality would likely be degraded up gradient of the collection wells where groundwater is already affected by ARD from natural mineralization and may eventually be impacted from a small portion of the East Waste Rock Dump Complex. The potential for creating new springs or affecting water quality of existing springs is higher than under the other alternatives.	

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Risk of violation of groundwater standards at permit boundary and impacts to beneficial uses of the Jefferson River alluvial aquifer	Groundwater quality standards would be met at the mixing zone boundary. Beneficial uses of the Jefferson River alluvial aquifer would not be affected.	Compliance with water quality standards at the mixing zone boundary may not be achievable.	Two groundwater capture systems in Rattlesnake Gulch, each operating at an efficiency of 87.5 percent or greater would be required to meet DEQ-7 human health standards at the mixing zone boundary for the toxic and carcinogenic parameters modeled. The DEQ-7 standard for iron would be exceeded. The required capture efficiency may not be achievable. Based on their experience, the agencies believe a maximum capture efficiency of 80% per system is potentially achievable. With two systems each operating at 80 percent capture efficiency, DEQ-7 human health water quality standards for nickel, and copper would be exceeded at the permit boundary and within the Jefferson River alluvial aquifer. Nondegradation criteria for groundwater quality in the JRA aquifer fail for arsenic, cadmium, copper, iron and nickel at all levels of groundwater capture efficiencies modeled, up to and including 96% combined capture efficiency.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Impacts to surface water quality and quantity				
Impacts to springs, wetlands	The groundwater level around the pit would be permanently drawn down resulting in minor reductions in the flows of springs that are hydrologically connected to the pit.	Same as the No Pit Pond Alternative.	The groundwater level around the pit would rebound so that the flows of springs that are hydrologically connected to the pit would remain the same or increase. New springs or seeps could be created that would be impacted by ARD from the pit. Discharges of ARD at existing springs around the pit area could increase.	Same as the No Pit Pond Alternative.
Risk of violation of surface water standards and impacts to beneficial uses of the Jefferson River and Slough	There would be no pit discharge. There would be no risk of violation of surface water standards and impacts to beneficial uses in the Jefferson River and Slough.	Same as the No Pit Pond Alternative.	The risk of contaminants reaching the Jefferson River or Slough and affecting surface water quality and beneficial uses is greater than for alternatives that maintain the pit as a hydrologic sink. Two groundwater capture systems in Rattlesnake Gulch, each operating at an efficiency of 87.5 percent or greater would be required to meet DEQ-7 surface water quality standards. At this capture efficiency, the chronic aquatic life standards were met in the Jefferson River Slough for the parameters modeled. Based on their experience, the agencies believe a maximum capture efficiency of 80% per	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
			system is potentially achievable. At this efficiency, the chronic aquatic life standard for aluminum would be exceeded in the Jefferson River Slough over the entire predicted range. Nondegradation criteria for surface water quality in the Slough fail for aluminum, copper and iron at all levels of groundwater capture efficiencies modeled, up to and including 96% combined capture efficiency. Control of pit seepage along secondary pathways may be difficult. There is little attenuation capacity in the Tertiary debris flow/colluvial aquifer.	
Reclamation plan changes				
Surface disturbance	No new pit disturbance.	56 acres of new pit disturbance and 31 acres of new soil salvage disturbance.	Same as the Partial Pit Backfill With In-Pit Collection Alternative, except 2 additional acres would be disturbed for downgradient wells.	Same as the No Pit Pond Alternative.
Hazards to wildlife	There would be no additional hazards to wildlife.	There would be fewer hazards to wildlife than under the No Pit Pond Alternative because the highwall would be eliminated.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Total remaining unrevegetated acres	158 acres	2 acres of access roads	2 acres of access roads	159 acres
Socioeconomic Issues				
Safety				
Risk to workers (reclamation and construction)	The safety risk to reclamation workers would be increased while crusher reject is being hauled down the steep roads into the pit, because of the potential for truck accidents.	The safety risk to reclamation workers would be the same as under the No Pit Pond Alternative while 100 feet of crusher reject is being hauled down the steep roads into the pit. The rest of the backfilling would be by end dumping acidic waste rock from the pit rim, a standard method used during mining that has less risk than hauling loaded trucks to the bottom of the pit. Cast blasting and dozing to reduce the pit highwall would present risks to workers.	Similar to the Partial Pit Backfill With In-Pit Collection, except separate placement of crusher reject in the bottom of the pit would not be required.	Less than the No Pit Pond Alternative. Backfill would not be hauled into the pit.
	Workers would be below a highwall of up to 1,875 feet high with the risk of injury from rock falls.	Workers installing, operating, and maintaining the dewatering system would not be working below a highwall and would not be at risk of injury from rock falls.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Workers would be exposed to rock falls from the walls and ceiling of the underground workings as well as from the highwall. Overall risk would be less than the No Pit Pond Alternative.
Risk to workers (long-term maintenance)	Workers in the pit would be exposed to the 1,775-foot pit highwall raveling and sloughing. Long-term access would be needed to	Workers would not be exposed to pit highwall raveling and sloughing. Long-term access to the pit bottom would not be	Similar to the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative, except workers would be exposed to rock falls from the walls and ceiling of the underground workings as

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	the pit bottom for monitoring and maintenance of the pit haul road, the 5,700-foot elevation pit safety bench, and the dewatering system.	required. The risk to worker safety in this alternative would be less than the No Pit Pond Alternative and would be similar to the risk of work currently conducted on the waste rock dump complexes.		well as from the 1,875-foot highwall. Overall risk would be less than the No Pit Pond Alternative.
Risk to public safety	Access restrictions on general public use would be maintained and would consist of signs, berms, and fencing around the pit area, but there would still be a risk to public safety from the pit highwall.	Same as the No Pit Pond Alternative, except there would be no risk to public safety from the pit highwall.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.
Mining employment				
Potential employment from mining Stage 5B	750 person years	750 person years. Premature closure would reduce this by 150 person years per year.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.
Reclamation employment				
Reclamation employment opportunities	123 person years	308 person years	308 person years	124 person years
Revenue from taxes				
Potential tax revenues from mining Stage 5B	$8,087,000	Same as the No Pit Pond Alternative, except premature closure would reduce this to $60,000.	Same as the No Pit Pond Alternative, except that premature closure would reduce this tax revenue.	$8,087,000
Potential tax revenues from pit backfill	$319,500	$806,000	$911,000	$322,000

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Mineral reserves and resources				
Access to future mineral reserves/ Resources	If the pit were to be enlarged for additional mining in the future, it would take 1.5 months to remove the 600,000 cubic yards of crusher reject, soil, and highwall rock. Time is based on the 2002 mining rate of 405,000 cubic yards per month.	If the pit were to be enlarged for additional mining in the future, it could take 116 months to remove the 47 million cubic yards of backfill and soil.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	If the pit were to be enlarged for additional mining in the future, it would take 0.5 month to remove the 200,000 cubic yards of raveled and sloughed highwall rock and soil.
	The pit would have to be dewatered before it could be enlarged. The additional time required to dewater the pit would be minimal.	The pit would have to be dewatered. The additional time required to dewater the pit would be the same as the No Pit Pond Alternative.	Because the water table would rebound, more of the acidic backfill would have to be dewatered as mining proceeded. The time required to dewater the pit would be longer than the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative.
Land use after mining				
Suitability of land use after mining	The land use after mining would be wildlife habitat. About 60 acres would be revegetated. About 158 acres of mule deer habitat would be lost. Limited raptor and bat habitat would be developed in the upper highwall.	The land use after mining would be wildlife habitat. About 272 acres would be revegetated. Up to 2 acres of habitat would be lost for access roads. Raptor and bat habitat would not be developed.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Aesthetics				
Visual contrast with adjacent lands	Portions of the highwalls and benches would remain visible. Overall visual contrasts would be reduced to a level where they are noticeable, but not dominant in the landscape, following successful reclamation and revegetation. Landscape modifications would be consistent with the suggested VRM Class III rating for the area.	The reclaimed 2H:1V slopes covering the pit highwall and the reclaimed slopes of the waste rock dump complexes would still be visible, but the overall contrasts would be reduced under this alternative.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.
Potential future burden				
Potential future burden on society	The consequence of failure of this alternative would be the creation of a pit pond below the 5,050-foot elevation. No impacts to groundwater and minimal impacts to springs would occur.	The consequence of failure of this alternative would be uncontrolled discharges of ARD-impacted groundwater from the backfilled pit, which could adversely impact springs and beneficial uses of the Jefferson River alluvial aquifer.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Potential for future liabilities for GSM	No water would leave the pit. If the dewatering system failed, it could be re-established on the regraded pit bottom through 200 feet of crusher reject and sloughed highwall rock more easily than through up to 875 feet of acidic backfill. Continued safe access to the dewatering system for operation and maintenance would be more difficult than the partial pit backfill alternatives because of highwall rock raveling and sloughing onto safety benches and access roads.	No water would leave the pit. If the dewatering system failed, it could be re-established by drilling new wells. Drilling and maintaining wells in up to 875 feet of acidic backfill would be problematic. Safe access to the dewatering system for operation and maintenance would not be a problem because there would be no highwall.	The potential for water quality degradation outside of the pit would be increased. From 27 to 42 gpm of untreated water would escape the pit. If either of the two groundwater capture systems failed to achieve at least 87.5 percent efficiency, groundwater standards for nickel and copper would be exceeded at the edge of the mixing zone.	No water would leave the pit. Removing water from the underground sump would be easier than pumping out of waste rock backfill or crusher reject. If the dewatering system failed, it could be re-established more easily than under the partial pit backfill alternatives. Continued safe access to the dewatering system for operation and maintenance, because of wall and ceiling rock sloughing in the underground workings, would be less risky than the No Pit Pond Alternative.
	Removing water from 100 feet of crusher reject would not be a problem. Dewatering system components would fail regularly from crusher reject settling and corrosion.	Removing water from up to 875 feet of acidic backfill would be difficult. Dewatering system components would fail more often than under the No Pit Pond Alternative.	The quality of the water collected down gradient of the pit would be partially attenuated and mixed with regional groundwater, but consistently achieving 87.5 percent capture for two pumping systems may not be achievable. Based on their experience, the agencies believe a maximum capture efficiency of 80% per system is potentially achievable. Dewatering system components would not fail as regularly due to settling and corrosion.	Dewatering system components would not fail as regularly due to corrosion.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Project Economics Issues				
Costs				
Reclamation costs	$1,168,000	$55,355,000	$55,357,000	$1,260,000

Chapter 1

Purpose and Need for Action

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Chapter 1

Purpose of and Need for Action

1.1 INTRODUCTION

This Supplemental Environmental Impact Statement (SEIS) has been prepared to update site-specific information and evaluate reclamation alternatives for the GSM open pit after mining is completed. This document supplements the 1998 Final Environmental Impact Statement (EIS) prepared for a proposed expansion of mining operations at the Golden Sunlight Mine (GSM) (DEQ and BLM, 1998a). Reclamation alternatives for the GSM pit were evaluated in a Draft EIS issued in 1997 (DEQ and BLM, 1997) and the 1998 Final EIS; however, some important conditions have changed since that time, resulting in an agency decision to prepare this SEIS.

As required by the National Environmental Policy Act (NEPA) and the Montana Environmental Policy Act (MEPA), this SEIS identifies the Proposed Action, defines and evaluates alternatives to that action, and identifies potential environmental impacts of the Proposed Action and alternatives. The Proposed Action evaluated in this document is a pit backfill proposal modified by the agencies' comments and GSM's responses to those comments (See GSM, December 2002; DEQ/BLM, January 14, 2003; GSM, April 23, 2003; DEQ/BLM, June 16, 2003; GSM, August 8, 2003; DEQ/BLM, August 27, 2003; GSM, September 17, 2003; DEQ/BLM, November 18, 2003; GSM, December 19, 2003) including the revised acreages submitted as part of GSM's 2004 Annual Report (GSM, 2005). The Proposed Action involves partially backfilling the pit when mining operations cease at GSM. In this document, the Proposed Action is referred to as the "Partial Pit Backfill With In-Pit Collection" Alternative.

What has changed in Chapter 1 since the DSEIS?

Chapter 1 explains the purpose of the SEIS and the need for the Proposed Action. Based on additional data and public comments, the following changes have been made:

- The GSM 2004, 2005, and 2006 Annual Reports were used to update all figures.
- Figure 1-3 was added to show land ownership.
- Certain references used in the Final SEIS were added to Table 1-2. Both those and other references were also added to the reference section in Chapter 7.
- For other issues that BLM must consider and mitigate to, references to sections in the SEIS were noted.
- All text, figures and tables were revised from data provided by GSM and various consultants.
- Text was corrected based on references.

MEPA and NEPA policies are intended to ensure that governmental agencies make informed and deliberate decisions, while expanding the public right to participate in those decisions. Agencies are required to carry out these policies through the use of a systematic, interdisciplinary analysis on actions that affect the human environment. DEQ and BLM determined that, under MEPA and NEPA regulations and in accordance with the procedures set forth in the Metal Mine Reclamation Act (MMRA), it was necessary for the agencies to conduct an analysis to thoroughly investigate potential environmental impacts of a modified proposal to partially backfill the GSM open pit (GSM, 2002). The revised pit reclamation plan was submitted by GSM on December 2, 2002, as ordered by DEQ on October 24, 2002. This SEIS represents that required additional systematic analysis. The purpose of this SEIS is to evaluate the potential environmental impacts associated with the Proposed Action and alternative pit reclamation plans at the mine.

This SEIS follows the Council on Environmental Quality's (CEQ) recommended document organization (40 Code of Federal Regulations (CFR) 1502.10). Chapter 1 presents the purpose and need for the Proposed Action. Chapter 2 describes and compares the Proposed Action and alternatives, and identifies the agencies' Preferred Alternative. Chapter 3 describes the affected environment. Chapter 4 presents the environmental consequences associated with the Proposed Action and alternatives, including direct, indirect, and cumulative impacts, and describes agency mitigations to reduce or minimize impacts. Chapter 5 presents information on consultation and coordination. Chapter 6 presents the names of those who submitted public comment during the scoping period. Chapter 7 contains the list of preparers, references and glossary. Copies of supporting documents are on file in the administrative record in the Montana Department of Environmental Quality (DEQ) office in Helena, and at the U.S. Department of the Interior, Bureau of Land Management (BLM) Field Office in Butte, Montana.

1.2 PURPOSE OF AND NEED FOR ACTION

The purpose of and need for action is to provide for effective, legally compliant, environmentally sound and safe mine pit reclamation at the Golden Sunlight Mine, considering changes in condition that have occurred since the Final EIS was issued in 1998 and additional information developed through research and evaluation completed since 1998. Action is needed due to the continued operations at GSM (conducted under the approved operating permit (as amended)), changes in the MMRA, and requirements imposed by the District Court decision (all described in more detail in Section 1.4.3, Background and History).

In the years since the FEIS was completed, the pit design has changed, underground mining has been approved, and large portions of the waste rock dump complexes have been reclaimed. These differences are due to mining operations that have taken place, which are in accordance with GSM's approved operating permit and agency-approved minor revisions to that permit. Also, additional research and evaluation have provided more information pertaining to the geology, hydrology and geochemistry of the mine area.

State standards for final reclamation have been amended by the legislature.

1.3 OBJECTIVES

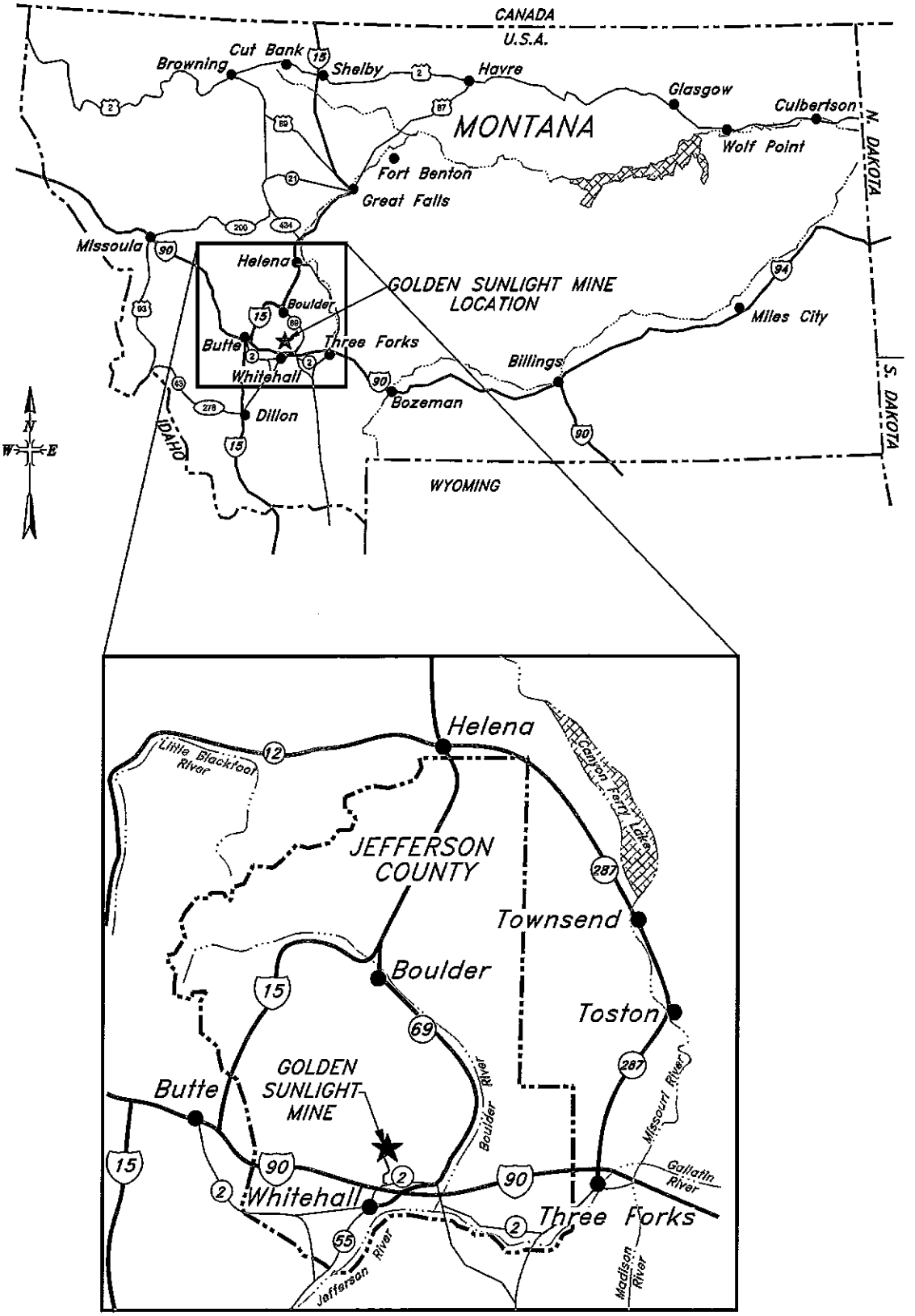
The objectives of the analyses included in this SEIS are as follows:

- Comply with the June 2002 judgment of the Montana First Judicial District Court (District Court) to implement the partial pit backfill reclamation plan at GSM in accordance with the procedures set forth in MMRA;
- Evaluate the partial pit backfill plan and reasonable alternatives as required by MEPA and NEPA;
- Evaluate the partial pit backfill plan and alternatives and develop a pit reclamation plan that will comply with existing federal, state, and local laws, including the 2003 amendments to MMRA;
- Provide the public with an opportunity to comment on the SEIS for reclamation of the pit as required by MEPA and NEPA;
- Provide the regulatory agencies' decision makers with the best available scientific information on which to base their decision as required by MEPA and NEPA;
- Minimize adverse impacts to existing, approved reclamation plans for the rest of the mine site and long-term water treatment plans; and
- Protect long-term water quality.

1.4 PROJECT LOCATION AND RELEVANT HISTORY

1.4.1 Project Location

GSM is located approximately 5 miles northeast of Whitehall, Montana (Figure 1-1). Access to the site is via State Highway 2 East, located adjacent to Interstate 90. Existing mining operations are located in: Sections 19, 20, 28, 29, 30, 32, and 33 of Township 2 North, Range 3 West; Section 6 in Township 1 North, Range 3 West; and Sections 24 and 25 in Township 2 North, Range 4 West in Jefferson County, Montana.



GENERAL LOCATION MAP

Figure 1-1 GenLoc BW.dwg

FIGURE 1-1

1.4.2 Mineral and Surface Ownership

Golden Sunlight Mines, Inc. is the owner and operator of the existing and proposed operations. The corporate address is: Golden Sunlight Mines, Inc., 453 Montana Highway 2 East, Whitehall, Montana, 59759.

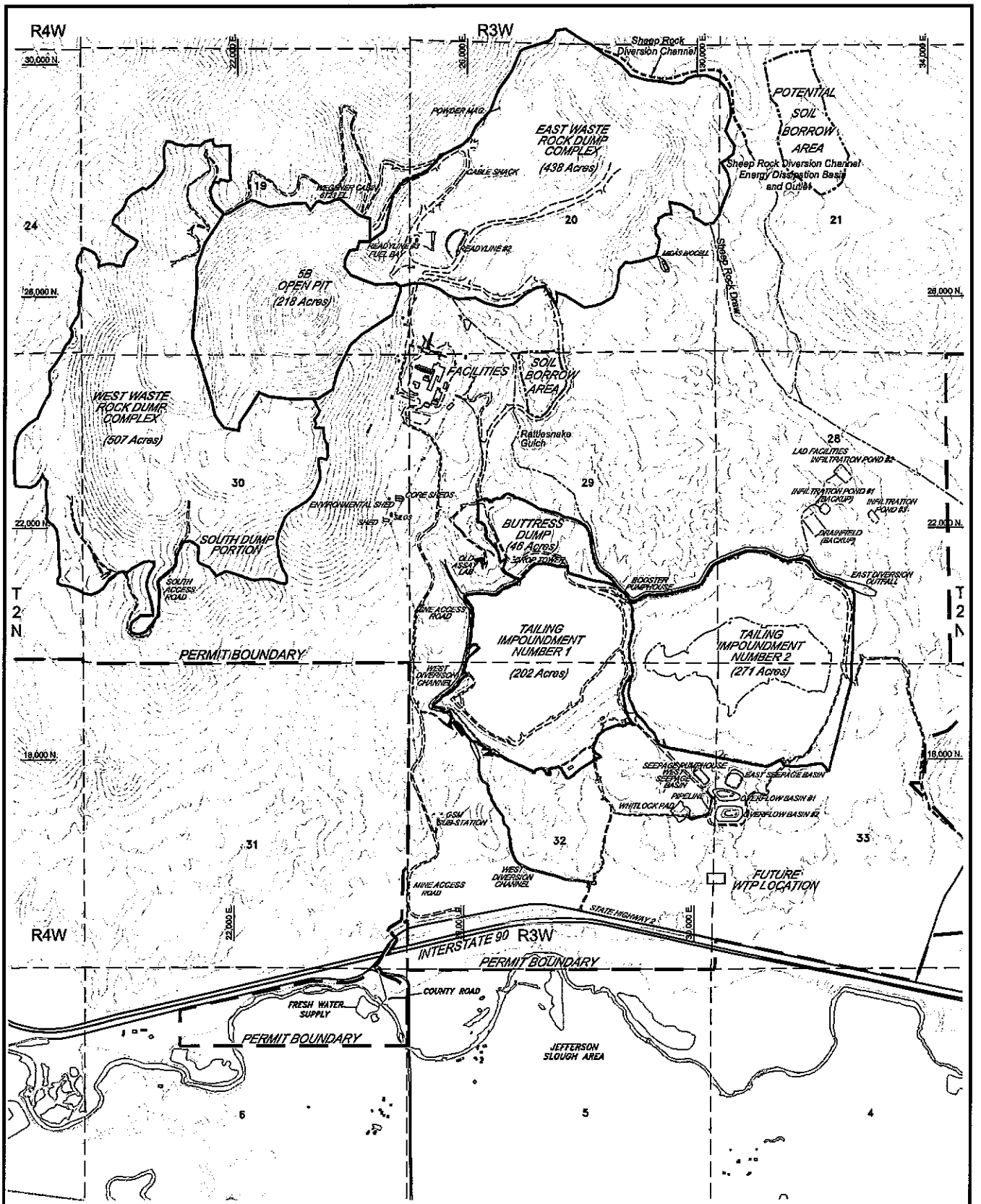
GSM is a subsidiary of Barrick Gold U.S. Inc., 136 East South Temple, Suite 1300, Salt Lake City, Utah 84111. Barrick Gold U.S. Inc. is an indirect, wholly-owned subsidiary of Barrick Gold Corporation, a public company, whose address is BCE Place, Canada Trust Tower, 161 Bay Street, Suite 3700, P.O. Box 212, Toronto, Canada M5J 2S1. Barrick Gold Corporation stock is traded on the New York Stock Exchange and other exchanges around the world.

GSM mines and processes gold-bearing ore using facilities located on private lands (both fee simple and patented mining claims) controlled by GSM, on unpatented mining claims located on federal lands administered by BLM, and on Montana state school trust land under mineral lease by GSM. The mine facilities are shown on Figure 1-2. The land ownership is shown on Figure 1-3.

1.4.3 Background and History

GSM is a conventional truck and shovel open pit mine. Approximately 1/6 of the excavated material is ore and 5/6 is waste rock. The ore is milled using a vat cyanide leach process at the mine site, while the waste rock is placed in large dump complexes. Following processing, the mill slurry goes to the tailings impoundment where tailings settle out and the water is pumped back and reused in the process circuit.

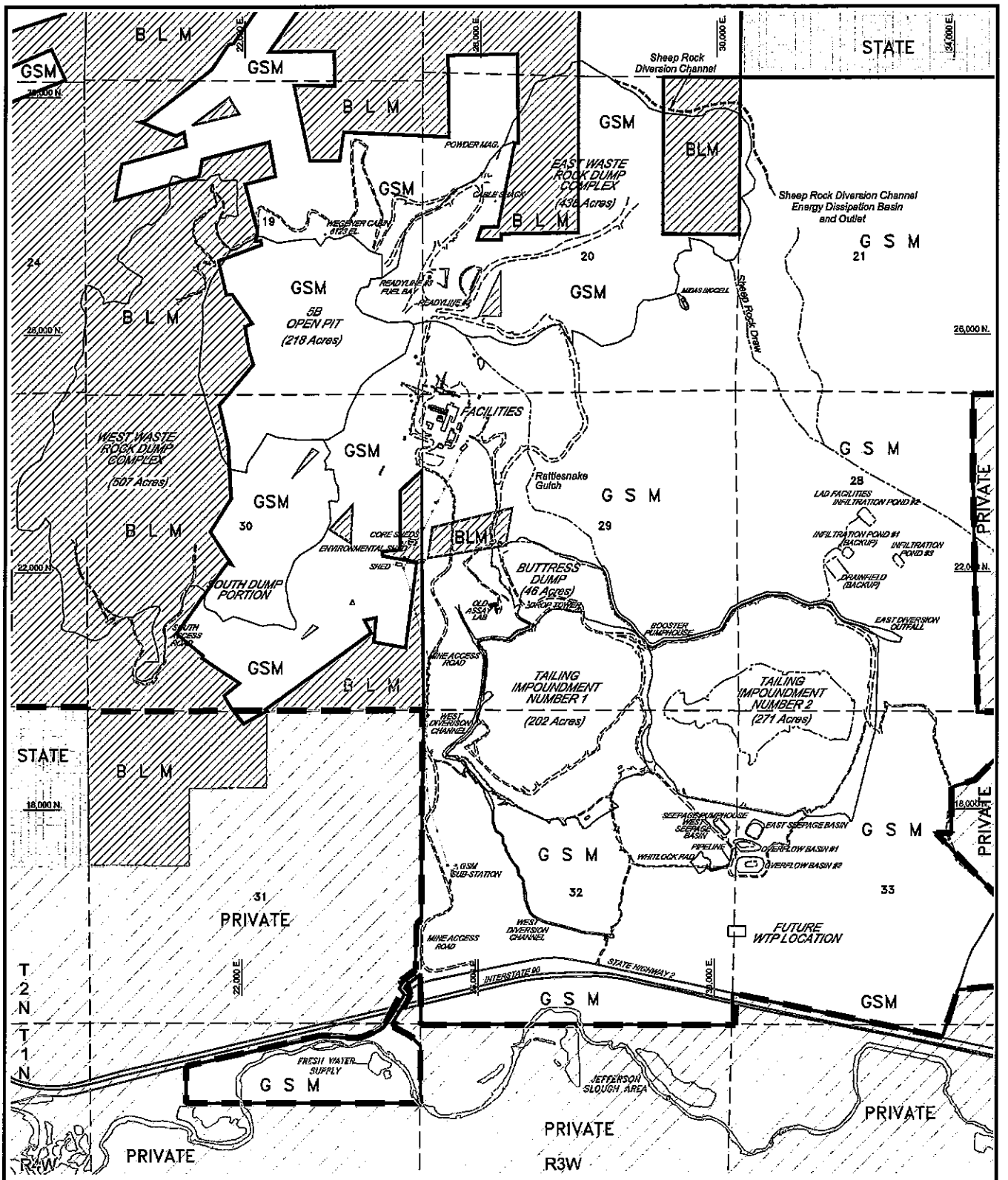
The GSM pit extends below the natural water table. The workings are kept dry by pumping out groundwater and surface water that enter the pit. Two bedrock wells are installed within the perimeter of the pit to intercept groundwater and assist in dewatering. At GSM, the collected water, which is naturally slightly acidic and increases in acidity by contact with sulfide rock in the pit, is pumped to an on-site treatment facility where the acidity is neutralized and metals are removed before the water is used in the milling process or discharged.



MINE FACILITIES AS OF DECEMBER 2006

Figure 1-2 Facilities.dwg

FIGURE 1-2



LAND OWNERSHIP

Figure 1-3 Ownership.dwg Rev. 1/2006

FIGURE 1-3

The vast majority of waste rock at GSM has potential to create "acid rock drainage" (ARD), because it contains sulfides that can easily generate acids upon exposure to air and water. The ARD potential has been characterized by testing conducted during the mine's lifetime (GSM 1982 to 2006 Annual Reports; Dollhopf, 1989; and as listed in Appendix OP-6 in GSM, 2004a). ARD has a low pH and contains concentrations of heavy metals (e.g., copper, cadmium, and nickel) above water quality standards. Reclamation of waste rock to reduce ARD is an important issue. Closure plans detail the reclamation, water treatment, and monitoring activities to which GSM is committed after operations cease (GSM, 1995b and 2004). GSM has approved reclamation and closure plans in place. GSM's reclamation bond is $63,355,020 with the stipulation that the bond would be incrementally increased over the life of the mine based on the amount of new disturbance each year. GSM has posted a total bond of $54,380,000 to cover reclamation, water treatment, and closure costs. GSM is currently bonded for 2,619.55 acres of disturbance. Through December 31, 2006, GSM has disturbed 2,236 acres and reclaimed 1,072 acres (2006 GSM Annual Report).

GSM conducts mining and mineral processing activities under DEQ Operating Permit No. 00065 and BLM Plan of Operations #MTM82855. The Montana Department of State Lands (DSL, now DEQ) issued GSM's Operating Permit on June 27, 1975. BLM issued GSM's Plan of Operations in 1982. An amendment for a major expansion was authorized in April 1981 after an EIS was written (DSL, 1981). The amendment authorized a new operating plan, including construction of mill support facilities, Tailings Impoundment No. 1, and Pit Stages 1, 2, and 3. The next seven permit amendments addressed relatively minor modifications to GSM's operations.

From 1985 through 1987, additional ore reserves were identified that would extend the mine life to at least the year 2003. In March 1988, GSM applied for an amendment to increase the size of the pit by adding two more mine stages (Pit Stages 4 and 5), and construct a second tailings impoundment (GSM, 1995a). Amendment 008 was authorized on July 1, 1990, following preparation of an Environmental Assessment (EA) (DEQ and BLM, 1990). As a result of the amendment, GSM's reclamation bond was increased from $1,750,000 to $23,915,000.

In 1992, five environmental groups (National Wildlife Federation, Montana Environmental Information Center, Mineral Policy Center, Gallatin Wildlife Association, and Sierra Club) brought legal action against the State of Montana and GSM. The plaintiff groups alleged that GSM's reclamation plan was insufficient and violated MMRA and the Montana Constitution, and that an EIS should have been prepared rather than an EA. On September 1, 1994, the District Court ruled that the statutory exemption of open pits from reclamation requirements was unconstitutional and that an EIS should have been prepared. A judgment was entered in 1995 whereby GSM would submit a revised reclamation plan and DEQ would prepare an EIS with BLM acting as co-lead.

In 1995, the Montana Legislature amended MMRA to provide standards for reclamation of open pits. In part, the amendment required reclamation to specified conditions "to the

extent feasible". The enacting legislation contained a Statement of Intent that listed the factors that the Legislature intended DEQ to consider in determining feasibility.

At that time, GSM decided to seek another permit amendment. The amendment would enable GSM to replace the previously planned waste rock dump area, lost due to ground movement in 1994, by expanding its existing waste rock dump complexes in the northeast and west sides of the operating permit area. The amendment also would allow GSM to expand the pit, extend the mine life, modify its reclamation plans, and extend the operating permit boundary.

GSM submitted the amendment application in July 1995 (GSM, 1995b). The EIS process began in October 1995. DEQ and BLM authorized an Interim Mine Plan so that GSM could continue mining and waste rock disposal during preparation of the EIS. Amendment 009 was issued in April 1997 for placement of waste rock at an expanded Interim Mine Plan Dump location. For the next three years, GSM operated under the Interim Mine Plan.

The Draft EIS was completed in November 1997 (DEQ and BLM, 1997b). The Final EIS was completed in April 1998 (DEQ and BLM, 1998a), and the Record of Decision (ROD) was signed in June of 1998 (DEQ and BLM, 1998b). DEQ and BLM authorized Amendment 010, which extended the life of active mining through Stage 5B, on July 9, 1998.

In the 1998 ROD, DEQ and BLM applied the factors set out in the Legislature's Statement of Intent and selected the No Pit Pond Alternative for reclamation of the pit. In its February 16, 2000, Memorandum and Order Decision, the District Court found that DEQ erred by using the factors in the Statement of Intent and by not choosing the Partial Backfill Alternative. The District Court also found, "Today, the record before the Court reveals that the major environmental and reclamation concerns at Golden Sunlight Mine, specifically, the open pit and the highwall, are best capable of being reclaimed by means of the partial pit backfill alternative. In addition, the record shows that partial pit backfill reclamation will provide comparable utility and stability with other disturbed lands. Furthermore, partially backfilling the pit can significantly reduce acid mine drainage."

In 2000, the Legislature again amended the open pit reclamation provisions of MMRA. Shortly thereafter, DEQ reexamined its previous decision imposing the No Pit Pond Alternative, determining that it met the requirements of the 2000 legislative amendment. The plaintiffs again challenged DEQ's decision.

The District Court held in March 2002 that the 2000 amendments to MMRA were unconstitutional because they did not comply with the Montana constitutional mandate that "all lands disturbed by the taking of natural resources shall be reclaimed." In its ruling, the District Court quoted the language listed above. The District Court then stated "that record has not changed." The District Court subsequently ordered DEQ to

immediately begin implementation of the partial pit backfill reclamation plan at GSM in accordance with the procedures set forth in MMRA.

In 2003, the Montana Legislature again amended the law pertaining to the reclamation of open pits and made the amendment applicable to the GSM operation. Subsection 82-4-336(9) now provides that:

> "(c) The use of backfilling as a reclamation measure is neither required nor prohibited in all cases. A department decision to require any backfill measure must be based on whether and to what extent the backfilling is appropriate under the site-specific circumstances and conditions in order to achieve the standards described in subsection (9)(b)."

Subsection 82-4-336(9)(b) provides that the highwall and pit must be reclaimed to a condition:

> (i) of stability structurally competent to withstand geologic and climatic conditions without significant failure that would be a threat to public safety and the environment;
> (ii) that affords some utility to humans or the environment;
> (iii) that mitigates post-reclamation visual contrasts between reclamation lands and adjacent lands; and,
> (iv) that mitigates or prevents undesirable offsite environmental impacts.

Under the Partial Backfill Alternative evaluated in the 1998 Final EIS and not selected in the 1998 ROD, the backfill material for the pit would have come from both the East and the West Waste Rock Dump complexes. Virtually all of the West Waste Rock Dump Complex is located on land owned by the U. S. and managed by BLM. The location of waste dumps on BLM managed federal lands are shown on Figure 1-3. Portions of the pit and the East Waste Rock Dump Complex are also BLM-managed federal lands. On September 6, 2002, BLM notified DEQ that the Partial Backfill Alternative may result in "unnecessary or undue degradation of public lands", and that, before GSM can be required to reclaim under the Partial Backfill Alternative on federal land, BLM must prepare a supplemental review pursuant to NEPA and approve the modification to the reclamation plan. DEQ agrees with BLM that a limited analysis of the potential environmental effects from groundwater exiting the backfilled pit from the Partial Backfill Alternative was completed in the 1997 DEIS.

On October 24, 2002, DEQ, acting pursuant to the June 27, 2002, District Court judgment, ordered GSM to submit a modified partial pit backfill plan to meet the requirements of MMRA, its implementing rules, and the judgment of the District Court. The plan was to take into consideration current conditions at the mine site and address compliance with the Montana Water Quality Act. GSM submitted a proposed partial pit backfill plan on December 2, 2002 (GSM, 2002).

The proposed partial pit backfill plan addresses the following site conditions at the mine that have changed since the 1998 ROD was issued:

- GSM has implemented a modified pit design resulting in a different pit configuration than was used in the 1998 evaluations;
- The original Partial Backfill Alternative, which was evaluated in 1997, called for a large portion of fill material to be obtained from the West Waste Rock Dump Complex. That waste rock dump has since been reclaimed;
- GSM has mined underground under the pit, which could affect backfill operations;
- Additional technical information and evaluation was required to assess the waste rock backfill effects on compliance with the Montana Water Quality Act; and
- GSM has received numerous permit revisions to allow minor modifications to GSM's operations. These revisions cover a variety of activities such as road building, well construction, research projects, and water disposal.

In order to meet the requirements of the October 24, 2002 Order, GSM submitted a Partial Pit Backfill With In-Pit Collection Plan. This is analyzed as the Proposed Action in this SEIS (see Section 1.5). This SEIS is tiered to the 1997 Draft EIS and the 1998 Final EIS.

1.4.4 Current Approved Plan

The 1998 ROD approved the No Pit Pond Alternative as modified by the Return Diversion Alternative (Map II-2, 1997 Draft EIS). The ROD contains various stipulations that were applied to the permit in order to implement the amendment.

As approved in 1998, the pit would be mined to the 4,700-foot elevation. Minor revision 03-001 to deepen the pit to the 4,650-foot elevation was approved by the agencies in 2003 (DEQ and BLM, 2003). The pit design would essentially remain as it is currently permitted (Figure 2-1). Mining operations would continue at least until 2007.

After mining operations cease, GSM would have to implement its closure plan (GSM, 1995b, 2004). The current approved reclamation plan for the pit would involve placing about 475,000 cubic yards (713,000 tons) of waste rock back into the pit to bring the pit bottom to the 4,800-foot elevation (1998 ROD, Stipulation 010-8; Figure II-3, 1997 Draft EIS; DEQ bond calculation, 1998). In addition, 26 acres of pit roads and benches that could be accessed would be covered with soil and revegetated. The remainder of the pit would be left open and not be backfilled.

A waste rock sump in the backfill would collect all water that enters the pit. Water collected in the sump would be pumped from two dewatering wells to the permanent water treatment plant as needed, treated and discharged (Figure 1-2). The dewatering system would maintain the groundwater level as low as possible in the backfill,

preventing the formation of a pit pond and maintaining the pit as a hydrologic sink. According to the 1997 Draft EIS Chapter IV, Section IV.B.6.b, approximately 102 gpm would need to be pumped out regularly to keep the water level as low as possible.

The above-described pit reclamation plan was approved in 1998 by the regulatory agencies. This decision has been legally challenged, as explained in Section 1.4.3.

1.5 PROPOSED ACTION

As ordered by DEQ, GSM provided the details of a modified Partial Pit Backfill With In-Pit Collection Plan, which is the Proposed Action in this SEIS (GSM, 2002). The Proposed Action includes reclaiming the pit by partially backfilling it to the level at which surface water would freely drain from the pit ("daylight level") on the east side of the pit and covering the highwall (Figure 2-4). The current operating permit allows mining through Stage 5B, which was estimated in the 1998 Final EIS to last through 2006. Groundwater and surface water that would naturally flow into the pit would be collected, pumped, and treated at the water treatment facility (Figure 1-2). See Chapter 2 for details of this alternative.

The major differences from the Partial Backfill Alternative (Figure II-4, 1997 Draft EIS) evaluated in the 1997 Draft EIS are:

- Based on the current approved mine designs, the pit configuration has been modified, including the bottom elevation and the elevation of the eastern key cut, the low point on the pit rim where the haul road enters the pit. The elevation of the key cut is 5,350 feet, and, therefore, the pit would have to be backfilled to this level to allow surface water to drain away from the pit area after reclamation. The final pit depth would be the 4,525-foot elevation as proposed or at least the 4,650-foot elevation approved by DEQ in minor revision 03-001, which affects the quantity of backfill material required;
- No waste rock material would be removed from the West Waste Rock Dump Complex;
- Cast blasting and dozing would be used to reduce the upper pit highwall rather than hauling all backfill material from the West Waste Rock Dump Complex;
- Before backfilling the pit to the key cut, 100 feet of crusher reject would be placed in the pit to the 4,625-foot elevation to aid in collecting water for pumping; and,
- A 3-foot soil cover system approved for the waste rock dump complexes is proposed for the cover on the backfill material.

1.6 REGULATORY AUTHORITY RULES AND RESPONSIBILITIES

1.6.1 Applicable Regulatory Requirements

1.6.1.1 Introduction

Table 1-1 lists the permits, licenses, and reviews that are required at GSM. The air quality permit would not require modification because the mining and milling rates would not change. Consultation with the Montana State Historic Preservation Office (SHPO) regarding cultural resources was conducted by BLM. GSM's updated Storm Water Pollution Prevention Plan has been approved by DEQ.

Table 1 - 1. Mine Permits, Licenses, and Reviews

Granting Agency	Permit/Approval
BLM, Butte Field Office	Administering Federal Land Policy and Management Act and NEPA to prevent unnecessary or undue degradation.
U.S. Fish & Wildlife Service (USFWS)	Review under the Endangered Species Act.
Environmental Protection Agency (EPA)	SEIS review under the Clean Air Act.
U.S. Army Corps of Engineers	Permit under Section 404 of the Clean Water Act.
DEQ	Administering MMRA and MEPA; requiring bonding for reclamation of disturbed lands and water treatment; ensuring compliance with state water, air, and hazardous waste regulations; and issuing water discharge and air quality permits.
Montana State Historic Preservation Office (SHPO)	Review under the National Historic Preservation Act and 36 CFR 800 regarding protection of cultural/historic resources.
Jefferson County Disaster & Emergency Relief Coordinator	Review of Floodplain and Emergency Operations Plans regarding uncontrolled releases of hazardous substances.
Jefferson County Weed District	Review for control and prevention of noxious weed infestations.

1.6.1.2 Montana Department of Environmental Quality

DEQ administers MEPA, MMRA, the Montana Hazardous Waste Act, the Clean Air Act of Montana, and the Montana Water Quality Act. DEQ is responsible for investigating

the environmental impacts associated with pit reclamation at GSM in accordance with MEPA and the EIS process, and for evaluating compliance with MMRA.

1.6.1.3 U.S. Bureau of Land Management

BLM manages federally owned lands under its jurisdiction and federally owned minerals. GSM's use of public land must conform to BLM's surface management regulations (43 CFR, Subpart 3809) to prevent unnecessary or undue degradation as well as various federal statutes, including NEPA, the Mining and Mineral Policy Act of 1970, the General Mining Laws, and the Federal Land Policy and Management Act of 1976. BLM must review plans for development on BLM-administered land. The Proposed Action was evaluated for conformance with BLM's Headwaters Resource Management Plan (RMP) Butte and Lewistown Districts (BLM, 1984). Livestock grazing, wildlife habitat, recreation, and mineral resource development are land uses identified in the RMP as appropriate for the project area.

In addition to the requirements of MEPA, the NEPA process was followed during the preparation of the SEIS to ensure:

- Adequate provisions are included to prevent unnecessary or undue degradation of public lands and to protect the non-mineral resources on public lands.
- Measures are included to provide for reclamation of disturbed areas.
- BLM's NEPA Handbook (H-1790, Appendix 5) requires that all EISs address certain Critical Elements of the Human Environment. Any elements that do not occur within the GSM permit area and would not be affected are indicated in Issues Considered but Not Studied in Detail (Section 1.7.3), and those elements are not discussed further in the SEIS.

This elimination of non-significant issues follows the CEQ guidelines as stated in 40 CFR 1500.4. Conformance with the Headwaters Resource Area RMP is ensured and compliance with applicable substantive state and federal laws is achieved through following the CEQ guidelines. BLM is responsible for Section 106 consultation with SHPO in regard to the following on BLM lands:

- The eligibility of cultural resources located on BLM lands within and near the permit area; and,
- The effect of approval of the Proposed Action on eligible cultural resources.

Critical elements of the human environment that BLM must consider and mitigate impacts to, if necessary, include:

- Areas of critical environmental concern (Section 1.7.3.10);
- Prime or unique farm lands (Section 1.7.3.11);
- Floodplains (Section 1.7.3.12);

- Native American religious concerns (Section 1.7.3.9);
- Threatened or endangered species (Section 1.7.3.3);
- Solid or hazardous wastes (Section 1.7.3.6);
- Drinking water/groundwater quality (Section 1.7.2.2.1.1);
- Wetlands/riparian zones (Section 1.7.3.1);
- Wild and scenic rivers (Section 1.7.3.13);
- Wilderness (Section 1.7.3.14);
- Environmental Justice (Section 1.7.3.15); and,
- Invasive, non-native species (Section 1.7.3.16).

All of the issues listed above were considered, although some were not considered in detail as described in this document.

1.6.1.4 Participating Agencies

The lead agency for preparation of the SEIS is DEQ, with BLM acting as co-lead. BLM consulted with USFWS, pursuant to the Endangered Species Act, and SHPO, pursuant to the National Historic Preservation Act, during the preparation of this SEIS.

EPA will review this SEIS pursuant to the federal Clean Air Act, and also participated in the Multiple Accounts Analysis (MAA) process (Robertson GeoConsultants, 2003).

1.6.2 Decisions to Be Made

The DEQ Director and the BLM Field Manager will use the SEIS to decide which pit reclamation alternative to implement and what mitigation measures, if any, to add to the selected alternative.

1.6.3 Relationship to Other Environmental Planning Documents

Numerous documents were reviewed in the development of the Draft and Final SEIS, some of which are not listed in Chapter 7. The MEPA/NEPA and other documents pertinent to GSM that influenced the Draft and Final SEIS are listed in Table 1-2.

Table 1 - 2. Related Environmental and Planning Documents

Document Title	Author	Date
Operating Permit No. 00065	DSL	April 24, 1975
Cultural Resource Class III Inventory Report Number 80-MT-070-075-11,12	Miller, B., BLM	August 6, 7, 1980
Environmental Impact Statement for Amendment 001	DSL	April 1981
Section 32 Tailing Disposal Facility, Golden Sunlight Project, Vol. I. Report Submitted to Golden Sunlight Mine	Sergent, Hauskins & Beckwith, Geotechnical Engineers	September 14, 1981
Cultural Class III Inventory Report Number 82-MT-070-075-14	Taylor, J., BLM	1982
Cultural Class III Inventory Report Number 83-MT-070-075-01, 09	Taylor, J., BLM	1982, 1983
Golden Sunlight Mines, Inc. Annual Reports	GSM	1990-2004
Hydrogeologic Evaluation, Tailing Disposal Facility, Golden Sunlight Project, Whitehall, Montana	Sergent, Hauskins & Beckwith, Geotechnical Engineers	October 24, 1985
Cultural Class III Inventory Report Number 85-MT-070-075-25	Taylor, J., BLM	1985
Cultural Resource Investigation and Assessment of the Golden Sunlight Mine	Herbort, D., State of Montana Land Exchange	1985
Hydrogeologic Evaluation, Tailing Disposal Facility, Golden Sunlight Project, Whitehall, Montana	Sergent, Hauskins & Beckwith, Geotechnical Engineers	August 5, 1986
Hydrogeologic Evaluation, Golden Sunlight Project, Whitehall, Montana	Sergent, Hauskins & Beckwith, Geotechnical Engineers	April 23, 1987
Investigation of Golden Sunlight Mine's Tailings Pond Leak and Alleged Impact to Downgradient Domestic Water Supplies	DSL	May 15, 1987
Site Visit Report, Rock Waste Dump and Midas Slump	Seegmiller International Mining Geotechnical Consultants	1987, 1988

Document Title	Author	Date
Results of an Investigation of the High Nitrate Values in Wells Surrounding the Golden Sunlight Mine	DSL	1988
Final Design Development Report, East Tailing Disposal Facility, Golden Sunlight Mine Vol. II. Submitted to Golden Sunlight Mine	Sergent, Hauskins & Beckwith, Geotechnical Engineers	July 19, 1988
Soil Survey of the Golden Sunlight Mine Proposed Expansion Area	Ottersberg, B.	1988
Hydrogeologic Evaluation, Golden Sunlight Project, Whitehall, Montana	Sergent, Hauskins & Beckwith, Geotechnical Engineers	February 10, 1989
Hydrogeologic Evaluation to Support Environmental Assessment, Golden Sunlight Project, Whitehall, Montana	Sergent, Hauskins & Beckwith, Geotechnical Engineers	February 27, 1989
Assessment of Potential Acid Producing Characteristics of Geologic Material From the Golden Sunlight Mine	Dollhopf, D.	1989
Relationship of the Golden Sunlight Mine To the Great Falls Tectonic Zone	Foster, F. and Chadwick, T.	1990
Should Pits be Filled? Oregon Geology, Volume 52, No. 4, pp. 82-83	Throop, A.	1990
Assessment of Water Quality Impacts – Report to MDHES	Hydrometrics	1990
Cultural Resource Inventory for the Golden Sunlight Mine Expansion Area	Peterson, R.R., Western Cultural Resource Management, Inc	1991
Geology and General Overview of the Golden Sunlight Mine	Foster, F.	1991
Jefferson County Montana 1993 Comprehensive Plan	Jefferson County Planning Board	1993
Golden Sunlight Mines, Inc. Tailings Impoundment No. 1 Post-Closure Settlement.	Knight Piesold Ltd.	1993
A Fluid Inclusion, Stable Isotope, and Multi- Element Study of the Golden Sunlight Deposit. M.S. Thesis, Iowa State University	Paredes, M.M.	1994
Soil Baseline Study, Golden Sunlight Mine	Houlton, H.M. and Noel, R.D., Westech Technology and Engineering	1994-1995

Document Title	Author	Date
Class 1 Paleontologic Literature and Locality Search for the Golden Sunlight Mine Expansion Project	Lindsey, K.D., Western Cultural Resource Management	September 20, 1994
Report from F. Foster of GSM to S. Olsen of DSL and J. Owings of BLM, Regarding Ground Movement Remediation	Foster, F.	December 23, 1994
Class III Cultural Resource Inventory of Approximately 3,277 Acres for Golden Sunlight Mine	Peterson and Mehls	1994
Investigation and Evaluation of the Earth Block Movements at the Golden Sunlight Mine. Reports submitted to Golden Sunlight Mine on various dates	Golder, Associates Ltd.	January 10, 1995-April 4, 1996
Golden Sunlight Mines, Inc. Hard Rock Mining Permit Application and Plan of Operations for an Amendment to Operating Permit 00065	GSM	Five volumes dated August 25, 1995 with five revisions to May 23, 1996
Summary of the Geology and Environmental Programs at the Golden Sunlight Mine	Foster, F. and Smith, T.	1995
Baseline Vegetation Inventory, Phase 2, GSM Permit Area	Westech	1995
Final Summary of Reclamation Monitoring Program for Waste Rock Facilities and Recommendations for Final Reclamation	Schafer and Associates	1995
Evidence for a Magmatic Hydrothermal to Epithermal Origin for the Golden Sunlight Gold-Silver Telluride Deposit	Spry, P.G., Paredes, M.M., Foster, F., Truckle, J., and Chadwick, T.	1995
Hydrogeologic Investigation of the Golden Sunlight Pit. Golden Sunlight Mine, Jefferson County, Montana	Hydrometrics	1995 (revised 1996)

Document Title	Author	Date
Predictive Modeling of Moisture Movement in Engineering Soils Covers for Acid Generating Mine Waste. M.S. Thesis, University of Saskatchewan	Swanson, D.A.	1995
Interim Dump Plan (approved by DEQ and BLM in 1995 & 1997)	GSM	(two minor revisions in 1995 and 1997)
Cultural Resource Inventory of 340 Acres and Testing/ Evaluation of Eight Sites for Golden Sunlight Mine Land Exchange	Peterson, R.R., Western Cultural Resource Management, Inc	1996
Formation of Ferricretes from Acid Rock Drainage at Golden Sunlight Mines, Jefferson County, Montana. M.S. Thesis in Geoscience, Montana Tech of the University of Montana, Butte	Taylor, E.	May 1997
Report on Water Quality Trends in No. 1 Impoundment Area	Hydrometrics	1997
Review of Documents Concerning Research at Golden Sunlight Mine	Bennett, J.W.	1997
Draft Environmental Impact Statement Golden Sunlight Mine	DEQ and BLM	November 1997
Water Quality Regulatory Compliance and Application for Source Specific Groundwater Mixing Zone, Golden Sunlight Mines	GSM	January 1998
Final EIS Amending and Adopting the Draft Environmental Impact Statement for Golden Sunlight Mine	DEQ and BLM	April 1998
Record of Decision for the Proposed Mine Expansion Golden Sunlight Mine Permit Amendments 008 and 010 to Operating Permit 00065	DEQ and BLM	June 1998
Golden Sunlight Mine West Waste Rock Pile Hydrologic Monitoring and Reclamation Study – Final Monitoring Report. In GSM 2000 Annual Report, Volume II, Appendix AR-00-1.3.	Schafer Limited	April 16, 2001
Golden Sunlight Mines, Inc. Operating and Reclamation Plan. A Summary of the Golden Sunlight Mine Operations	GSM	2001

Document Title	Author	Date
and Environmental Programs		
Pit Hydrogeology Investigation	URS Corp.	December 4, 2001
Preliminary Report of Environmental Risks of Proposed Backfilling of Golden Sunlight Pit	Hydrologic Consultants, Inc. (prepared for GSM)	November 26, 2002
Golden Sunlight Mines, Inc. Partial Pit Backfill Plan as Ordered by Montana Dept. of Environmental Quality on October 24, 2002	GSM	December 2, 2002
DEQ Internal Memo – Comments with respect to geochemistry - Golden Sunlight Mine (GSM) Revised Partial Pit Backfill Plan, Dec. 1, 2002	Laura Kuzel, DEQ	December 23, 2002
DEQ Internal Memo – Comments with respect to water quality– Golden Sunlight Mines, Inc. Partial Pit Backfill Plan As Ordered by DEQ on Oct. 24, 2002	George Furniss, DEQ	December 30, 2002
DEQ/BLM Deficiency Review of GSM Partial Pit Backfill Plan	DEQ and BLM	January 14, 2003
Environmental Data Compilation for the Open Pit Area and Potential Pit Backfill Material	Kathy Gallagher	March 21, 2003
Response to DEQ/BLM Deficiency Review of GSM Partial Pit Backfill Plan	GSM	April 23, 2003
Pit Highwall Seeps	Kathy Gallagher	May 28, 2003
Preliminary SAP Mineralogy Result Summary	Telesto	June 3, 2003
DEQ/BLM Second Deficiency Review of GSM Partial Pit Backfill Plan	DEQ/BLM	June 16, 2003
Memorandum on Stepan Spring Water Quality	Kathy Gallagher	June 30, 2003
Response to DEQ/BLM Second Deficiency Review of GSM Partial Pit Backfill Plan	GSM	August 8, 2003
DEQ/BLM Third Deficiency Review of GSM Partial Pit Backfill Plan	DEQ/BLM	August 27, 2003
Response to DEQ/BLM Third Deficiency Review of GSM Partial Pit Backfill Plan	GSM	September 17, 2003

Document Title	Author	Date
Amendments to Operating Permit 00065, particularly Amendment 008	GSM	Various dates
Geotechnical Report for the Reclamation Alternatives for the Golden Sunlight Mine Pit Technical Memo	Telesto	September 2003
Water Balance Model Technical Memo	Telesto	October 2003
Hydrologic Conceptual Model Technical Memo	Telesto	October 2003
Pit Backfill Geochemistry Technical Memo	Telesto	October 2003
Feasibility Assessment Technical Memo	Telesto	October 2003
GSM SEIS Hydrology Support Document	HydroSolutions	October 2003
Pit Analog Study	Kathy Gallagher and Laura Kuzel	October 2003
History of Failures at the GSM Pit	Telesto	November 2003
DEQ/BLM Fourth Deficiency Review of GSM Partial Pit Backfill Plan	DEQ/BLM	November 18, 2003
Response to DEQ/BLM Fourth Deficiency Review of GSM Partial Pit Backfill Plan	GSM	December 19, 2003
DEQ/BLM Current Permit and Bond Status for Operating Permit 00065	DEQ/BLM	January 20, 2004
DEQ/BLM Completeness Letter of GSM Partial Pit Backfill Plan	DEQ/BLM	February 17, 2004
Bio Fouling Potential in Backfill Wells	Telesto	February 20, 2004
Golden Sunlight Mines, Inc. 2003 Annual Permit Report	GSM	June 2004
Review of Draft Supplement Environmental Impact Statement	Brawner Eng.	February 2005
Golden Sunlight Mines, Inc. 2004 Operating and Reclamation Plan	GSM	March 2005
Post-Closure Pit Slope Stability Mineral Hill Pit	Golder Associates	April 2005
Proposed Management Options for Golden Sunlight Mine Pit	Engineering Management Support	April 8, 2005
Visual Resource Evaluation Technical Memorandum	Telesto	April 11, 2005

Document Title	Author	Date
Mineralogical Analysis and Hydraulic Conductivity Measurements Technical Memorandum	Telesto	June 16, 2005
Summary of Geotechnical, Hydrological, and Geochemical options, Partial Pit Backfill	Telesto	2005
Data Report on Geologic Structure West Wall Mineral Hill Pit	Golder Associates	August 1, 2005
Water Balance Model Update Technical Memorandum	Telesto	March 9, 2006
Hydrology Support Document Update Golden Sunlight Mine Pit Reclamation Final SEIS	HydroSolutions	May 12, 2006
Golden Sunlight Mines, Inc. 2005 Annual Permit Report	GSM	July 2006
Golden Sunlight Mines, Inc. 2006 Annual Permit Report	GSM	June 2007
Jefferson River Alluvial Aquifer and Jefferson River Slough Mixing Evaluation For the Golden Sunlight Mine FSEIS	HydroSolutions	July 10, 2007

1.7 PUBLIC PARTICIPATION PROCESS

1.7.1 Scoping

The scoping process is used to identify all issues relevant to the Proposed Action and to help develop alternatives to the Proposed Action. Efforts were made during preparation of this SEIS to involve members of the public and other agencies to define the issues and the scope of analyses.

A Notice of Intent (NOI) to prepare the SEIS was published in the Federal Register on May 7, 2003. The NOI invited scoping comments to be sent to DEQ and BLM through June 7, 2003. On July 1, 2003, a press release was issued to area newspapers, State of Montana Newslinks Service, and major interest groups. A public scoping meeting was held near the mine in Whitehall, Montana, on July 16, 2003. Approximately 165 members of the public attended the meeting and public comments were recorded. As a result of the public scoping process, 75 comment letters were received by DEQ and BLM. Issues and concerns raised at the meeting and contained in the written comments were summarized for consideration in preparation of the SEIS. DEQ and BLM also attended a public informational meeting sponsored by the Whitehall Community Transition Advisory Committee in Whitehall on September 9, 2003, to update local residents on SEIS progress.

1.7.2 Multiple Accounts Analysis Process and Issues Studied in Detail

In an effort to systematize issue evaluation and alternative development and to involve the various agencies and stakeholder groups, DEQ and BLM decided to use the Multiple Accounts Analysis (MAA) process (Robertson GeoConsultants, 2003). The MAA process was developed for evaluation of land management alternatives as a means of comparing alternatives by weighing benefits and costs. It is particularly useful when projects are controversial, because it allows for multi-stakeholder/multi-disciplinary teams to attempt reaching consensus by having opponents and proponents of the project work together. It also aids the consideration of possible reclamation measures, evaluation of the effectiveness of the reclamation alternatives, and revision of the alternatives to optimize their effectiveness.

During the MAA process, representatives from each of the agencies and stakeholder groups participated in a technical working group (TWG) to produce and evaluate alternatives. In this case, the TWG consisted of two representatives each from BLM, DEQ, GSM and its technical consultants, EPA, and, collectively, the five plaintiffs in the District Court action. Spectrum Engineering and its subcontractor, Robertson GeoConsultants, directed the TWG and the MAA process. The TWG met on May 16, June 18 to 19, July 2, and August 4 to 5, 2003. In addition to these meetings, two subgroups met to address the primary concerns including hydrology and geochemistry. Although the MAA was not formally completed, it did provide valuable input on alternatives and environmental impacts.

A local rancher attended the fourth MAA meeting and provided input from a public stakeholder viewpoint to the process.

An evaluation was performed to distinguish potentially significant issues from non-significant issues. Potentially significant issues are evaluated in detail in Chapter 4 of this environmental review, and rationale is presented in Section 1.7.3 for issues that were initially considered but then eliminated from detailed study. All issues identified through public input or identified through analysis are presented and summarized individually. While discussion of all identified issues is necessary for full disclosure of impacts under MEPA and NEPA, the issues do not necessarily correspond with, or are co-extensive to, the agencies' selection criteria under applicable federal and state law.

A number of concerns associated with the 1997 Draft EIS Partial Backfill Alternative that, prior to this SEIS, had not been raised or for which new information has become available have been identified. The issues studied in detail are presented in Table 1-3. Issues identified in Section 1.7.3 are not studied in detail in this SEIS because the issues have not changed since the 1998 Final EIS and no new data are available.

Table 1 - 3. Issues Studied In Detail

ISSUE GROUP	ISSUE	INDICATOR
Technical	Design & constructibility of the alternative	Proven design (done successfully at other places?)
Technical	Design & constructibility of the alternative	Ability to construct the alternative at GSM
Technical	Pit highwall	Pit highwall stability
Technical	Pit highwall	Pit highwall maintenance requirements
Technical	Backfill	Backfill maintenance requirements
Technical	Underground workings	Impacts to pit facilities due to subsidence related to underground mining
Technical	Groundwater/effluent management system	Operation requirements (number of wells)
Technical	Groundwater/effluent management system	Maintenance of capture points
Technical	Storm water runon/runoff Management	Maintenance requirements (drainage channels off 2H:1V slopes)
Technical	Soil Cover	Soil cover maintenance requirements (erosion, revegetation)
Technical	Water treatment	Additional sludge management requirements
Technical	Water treatment	Additional operating requirements
Technical	Flexibility for future Improvements	Potential for utilization of new technologies
Environmental	Impacts to groundwater quality and quantity	Risk of impacts to groundwater quality and quantity in permit area
Environmental	Impacts to groundwater quality and quantity	Risk of violation of groundwater standards at permit boundary and impacts to beneficial uses of the Jefferson River alluvial aquifer
Environmental	Impacts to surface water quality and quantity	Impacts to springs, wetlands
Environmental	Impacts to surface water quality and quantity	Risk of violation of surface water standards and impacts to beneficial uses of the Jefferson River and Slough
Environmental	Reclamation plan changes	Surface disturbance
Environmental	Reclamation plan changes	Hazards to wildlife
Environmental	Reclamation plan changes	Total remaining unrevegetated acres
Socioeconomic	Safety	Risk to workers (reclamation and construction)
Socioeconomic	Safety	Risk to workers (long-term maintenance)
Socioeconomic	Safety	Risk to public safety
Socioeconomic	Mining employment	Potential employment from mining Stage 5B
Socioeconomic	Reclamation employment	Reclamation employment opportunities
Socioeconomic	Revenue from taxes	Potential tax revenues from mining Stage 5B
Socioeconomic	Revenue from taxes	Potential tax revenues from pit backfill
Socioeconomic	Mineral reserves and	Access to future mineral reserves/resources

	Resources	
Socioeconomic	Land use after mining	Suitability of land use after mining
Socioeconomic	Potential future burden	Potential future burden on society
Socioeconomic	Aesthetics	Visual contrast with adjacent lands
Socioeconomic	Potential future burden	Potential for future liabilities for GSM
Project Economics	Costs	Reclamation costs

Only those resources described as being affected in Chapter 3 or related to significant issues described in Chapter 1 are studied in detail in Chapter 4.

1.7.2.1 Technical Issues

1.7.2.1.1 Design and Constructibility of the Alternative

1.7.2.1.1.1 Proven Design

In engineering projects, the design and constructibility of the components are fundamental to the success of the project. Whether the components of the alternatives are considered proven within the mining and reclamation industries must be considered.

1.7.2.1.1.2 Ability to Construct the Alternative at GSM

Whether the components of the alternatives can be constructed as designed at GSM must be determined and risks and uncertainties evaluated.

1.7.2.1.2 Pit Highwall

1.7.2.1.2.1 Pit Highwall Stability

The highwall of a pit is designed to remain sufficiently stable to permit the extraction of minerals during operations with the minimum amount of waste rock removal. As such, a highwall typically is not designed to remain completely stable for an indefinite period of time after closure. Over the long term, natural processes, such as chemical and physical weathering and/or localized seepage, could change rock characteristics in the pit highwall causing periodic raveling and sloughing as the highwall gradually evolves to a more stable configuration over time.

The potential for larger geologic failures, such as slide failures or wedge failures especially from earthquakes, which might cause large and sudden movements of material in the pit highwall, also exists in open pits and must be analyzed.

If backfill materials are introduced into the pit, highwalls that are covered across the pit from highwall to highwall will be more stable than pits that are not backfilled. After construction and as the backfill itself weathers and gradually becomes saturated, some settlement of the backfill could occur. Portions of the highwall not covered on the 2

horizontal:1 vertical (2H:1V) slopes could still weather at a slower rate behind backfill materials.

1.7.2.1.2.2 Pit Highwall Maintenance Requirements

As discussed in the previous section, the pit highwall in alternatives that do not require backfill will continue to ravel over time. The amount of maintenance required to operate and maintain a pit dewatering system, access to the pit, reclamation covers, and storm water systems must be addressed because of pit highwall stability concerns.

1.7.2.1.3 Backfill

1.7.2.1.3.1 Backfill Maintenance Requirements

As discussed in Pit Highwall Stability, there are stability concerns with the backfill itself over time. The amount of maintenance required to operate and maintain a pit dewatering system depends on the amount of backfill, settling, weathering, chemical composition of the waste rock, and degree of saturation.

1.7.2.1.4 Underground Workings

1.7.2.1.4.1 Impacts to Pit Facilities Due to Subsidence Related to Underground Mining

Subsidence of underground workings over time may cause impacts to dewatering system function, worker safety, and future access to the pit and underground workings.

1.7.2.1.5 Groundwater/Effluent Management System

1.7.2.1.5.1 Operation Requirements (Number of Wells)

The potential risk of contamination to groundwater is more important than to surface water at GSM. The risk to the overall groundwater system is affected by many factors.

The disturbances in the mineralized zone caused by mining and related activities at GSM have exposed a large volume of sulfides to the atmosphere, thereby accelerating the natural weathering processes and releasing more metals and sulfur (as sulfate) into water. This ARD, or acid rock drainage, is the largest environmental concern, or potential impact, as a result of mineral extraction at GSM.

Nearly all of the materials that have been mined at GSM 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 mine 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.

Plans for the prevention or control of groundwater degradation must be evaluated with respect to short- and long-term utility and effectiveness. Due to potential impacts to groundwater and a limited potential impact to surface water resources, confidence that the controls chosen will work when implemented and continue to work far into the future is required.

Conceptually, capturing or treating contaminated water before it flows from the pit would eliminate the concern over flow paths from the pit and would limit the amount of water requiring treatment. If the alternative selected depends on wells for dewatering, the number of wells required and their depths will influence the manageability and dependability of the system as well as cost. As increasing amounts of backfill are placed inside the pit, operational limitations of managing wells in the acidic waste rock backfill could occur. Operating dewatering systems in hundreds of feet of backfill complicates water collection in backfilled pits. Operation of wells in acidic backfill or native materials around the pit needs to be addressed in various alternatives.

Alternatives that rely on capturing and treating impacted groundwater in order to protect the surrounding water resources will either need to control the water level in the pit or have the capacity to intercept a high percentage of the water escaping the pit. Backfilling the pit could complicate the collection system and make groundwater collection less certain. Issues related to pit dewatering include installing and maintaining dewatering systems safely in the acidic waters.

Safety issues differ between open pits and backfilled pits. Safety for workers is an issue in open pits.

Settling and compaction effects on dewatering systems were not evaluated previously in the 1997 Draft EIS. Issues related to flowpath control in a backfilled pit have been identified with and without in-pit dewatering systems:

- The backfill in the pit may not be completely free draining and could include zones of relatively low permeability;
- The non-homogeneous nature of the backfill could make it difficult to reduce water levels evenly and maintain a hydrologic sink; and,
- The presence of backfill could make it difficult to fully determine the flow paths of groundwater and the chemical reactions that are occurring.

1.7.2.1.5.2 Maintenance of Capture Points

Some problems with maintenance of capture points in the backfilled pit are discussed above. Attempting to manage a collection system located at the bottom of an open pit or in the existing underground workings accessed through the pit could also present long-term management and safety problems. There is a chance of deterioration of the pit highwall and subsidence of the underground workings over time. Although practices

would be used to minimize hazards to workers and damage to equipment, maintaining access could be problematic.

Relying on capture of pit outflows at distances downgradient of the pit may introduce a larger degree of uncertainty and risk concerning the effectiveness of capturing all contaminated groundwaters and could require collection of a greater volume of groundwater. Maintenance of capture points needs to be addressed in all alternatives.

If capture systems cannot be maintained, contaminated groundwater could reach the Jefferson River alluvial aquifer.

1.7.2.1.6 Storm Water Runon/Runoff Management

1.7.2.1.6.1 Maintenance Requirements

The maintenance requirements for the storm water drainage channels off the reclaimed 2H:1V slopes caused by settling of the backfill must be evaluated.

1.7.2.1.7 Soil Cover

1.7.2.1.7.1 Soil Cover Maintenance Requirements

Reclamation of over 1,072 acres of disturbed land has been completed since the 1998 Final EIS (GSM 2006 Annual Report). This reclamation has resulted in a shortfall of stockpiled soil for reclamation activities. Although an adequate volume of soil exists for reclamation activities under the No Pit Pond Alternative in the 1997 Draft EIS, Chapter IV, Section IV.C.6.a, backfilling the pit would result in additional soil requirements. Additional disturbance would be needed to obtain adequate soil under the modified backfill plans. Maintenance of the reclamation cover, erosion, and revegetation must be addressed for all alternatives.

1.7.2.1.8 Water Treatment

1.7.2.1.8.1 Additional Sludge Management Requirements

In the 1997 Draft EIS, Appendix C, the sludge from the water treatment plant would be deposited in cells in Tailings Impoundment No. 2 and reclaimed. The amount of additional sludge from treating pit water for each alternative must be evaluated.

1.7.2.1.8.2 Additional Operating Requirements

The dewatering systems needed for each alternative will affect the operating requirements of the water treatment plant and must be evaluated.

1.7.2.1.9 Flexibility for Future Improvements

1.7.2.1.9.1 Potential for Utilization of New Technologies

Flexibility for implementing improved water collection and treatment systems in the future must be evaluated. The potential for future improvements and utilization of new technologies must be considered for each alternative.

1.7.2.2 Environmental Issues

1.7.2.2.1 Impacts to Groundwater Quality and Quantity

1.7.2.2.1.1 Risk of Impacts to Groundwater Quality and Quantity in Permit Area

Groundwater flow direction has been mapped through previous studies using monitoring wells of various depths. Approximately 30 wells in the pit area are monitored quarterly. Groundwater flows into the pit from underneath and from all sides, with the steepest gradient on the north side. Understanding this flow system will be critical to the identification of potential impacts of reclamation alternatives.

Over time, the waste rock that is placed in the pit could be chemically and physically altered, causing pore waters with elevated concentrations of naturally occurring contaminants. The changing physical properties of the materials may affect flow patterns and the changing chemistry of the effluent has the potential to impact downgradient groundwater. The ability to capture groundwater in various pit reclamation alternatives will affect the potential for additional impacts to groundwater in the permit area.

1.7.2.2.1.2 Risk of Violation of Groundwater Standards at Permit Boundary and Impacts to Beneficial Uses of the Jefferson River Alluvial Aquifer

If additional groundwater is impacted in the permit area from the open pit, then the potential to violate water quality standards at the permit boundary and impact beneficial uses in the Jefferson River alluvial aquifer must be evaluated.

1.7.2.2.2 Impacts to Surface Water Quality and Quantity

1.7.2.2.2.1 Impacts to Springs, Wetlands

Control of poor quality water both in and out of the pit is needed in order to prevent impacts to adjoining aquifers and possibly downgradient surface water.

One of the risks that has been identified is the potential development of seeps in areas outside of a backfilled pit. Natural ARD seeps, likely controlled by fractures in the

mineralized bedrock, occur at the mine site. After mining, if the groundwater table rebounds to a static condition, fracture controlled flow to surface seeps could increase or develop again. Those reclamation alternatives that include backfill and/or 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 loading at existing seeps, than those that do not include backfill. On the other hand, those alternatives that maintain the pit as a hydrologic sink could minimize the risk of seep development, but would lead to flow reductions in local springs.

Although drainages within the mine boundary are ephemeral and there are no perennial streams within the mine boundary, surface water contamination from mine operations is potentially an issue at GSM. There are historic springs and seeps within the GSM permit area that could be impacted by mine or reclamation operations. Several of these springs or seeps (Bunkhouse, Rattlesnake, Stepan, and Stepan Original springs) produce acid drainage, much of which is from regional naturally mineralized areas and may not be impacted by GSM. Many seeps discharge from the pit highwall. The quantity and quality of water from the seeps varies seasonally. If pit water cannot be captured, it could influence surface water quality and quantity in the historic seeps and the small wetlands associated with them and/or at new discharge points.

1.7.2.2.2.2 Risk of Violation of Surface Water Standards and Impacts to Beneficial Uses of the Jefferson River and Slough

The 1997 Draft EIS, Section IV.B addressed impacts to seeps and springs that might be dewatered if the open pit is maintained as a hydrologic sink. The SEIS must analyze impacts to seeps and springs in backfill alternatives that may or may not allow the water table to rebound and discharge from the pit. The SEIS must analyze impacts to seeps and springs from all alternatives. The potential impacts of flow from the backfilled pit to the Jefferson River/Slough must also be analyzed.

1.7.2.2.3 Reclamation Plan Changes

1.7.2.2.3.1 Surface Disturbance

Cast blasting the upper highwall occurring under partial pit backfill alternatives would result in additional disturbance. Some waste rock and soil would have to be hauled to areas around the pit where access has been cut off. In order to access the top of the northwest highwall of the pit with equipment, additional acreage would be disturbed to construct haul roads and other features.

1.7.2.2.3.2 Hazards to Wildlife

Potential hazards to wildlife that need to be addressed include birds landing in or ingesting poor quality water or acid salts in the pit, wildlife using water impacted by pit seepage, and wildlife falling off the highwall or pit benches.

1.7.2.2.3.3 Total Remaining Unrevegetated Acres

Impacts to vegetation caused by additional surface disturbance in each alternative as well as the amount of land left unrevegetated must also be evaluated.

1.7.2.3 Socioeconomic Issues

1.7.2.3.1 Safety

1.7.2.3.1.1 Risk to Workers (Reclamation and Construction)

Pit haul roads are steep and there are safety issues associated with operating haul trucks down pit haul roads to implement any backfill alternative. GSM currently does not have a written policy regarding fully loaded haul trucks traveling down haul roads into the pit. Waste rock would have to be dumped from the top or trucks would only be partially loaded, resulting in a longer and more expensive project. The engineering and safety issues associated with the alternatives will be evaluated. Policies would be developed to ensure the safety of workers involved in haulage activities and other pit personnel.

1.7.2.3.1.2 Risk to Workers (Long-Term Maintenance)

Safety and security of personnel and equipment that are required to be in the pit for maintenance of the dewatering system need to be addressed for alternatives that leave the pit open.

In some alternatives, the pit would be maintained in approximately the same configuration left by mining. In these cases, the pit has cliff-like configurations that could be hazardous. Stability of the highwall could deteriorate over time, producing raveling and sloughing. Some limited instability could also be associated with the backfill options, as sloughing could occur along the recontoured pit highwall as the result of chemical weathering, freeze-thaw disturbance, and the buildup of groundwater in localized areas.

1.7.2.3.1.3 Risk to Public Safety

Under all open pit options, access restrictions on general public use would need to be maintained.

1.7.2.3.2 Mining Employment

1.7.2.3.2.1 Potential Employment from Mining Stage 5B

The number of jobs impacted with or without mining Stage 5B needs to be analyzed for backfill alternatives. Some alternatives may preserve the potential for future mining and possibly provide employment associated with continued mineral exploration.

1.7.2.3.3 Reclamation Employment

1.7.2.3.3.1 Reclamation Employment Opportunities

A certain number of jobs with or without mining Stage 5B will be created or maintained during the reclamation construction period. The amount of employment will depend on the alternative chosen. In general, alternatives with higher backfill requirements will provide more short-term socioeconomic benefits inside the county. For alternatives requiring more long-term monitoring and management, a small number of jobs will be sustained indefinitely.

1.7.2.3.4 Revenue from Taxes

1.7.2.3.4.1 Potential Tax Revenues from Mining Stage 5B

As long as the mining company or a successor controls the property, the water treatment plant and other property will remain on the county tax base. Under some alternatives, continued revenue from taxes due to mining would be generated. Under a partial pit backfill alternative, there is a possibility that these taxes would not be accrued if Stage 5B did not proceed to completion.

1.7.2.3.4.2 Potential Tax Revenues from Pit Backfill

Regardless of whether Stage 5B is completed, backfilling will produce short-term jobs and revenues. The impacts of backfilling on revenues will be addressed in each alternative.

1.7.2.3.5 Mineral Reserves and Resources

1.7.2.3.5.1 Access to Future Mineral Reserves/Resources

GSM has indicated that precious metal mineralization extends beyond the planned limits of the open pit floor and highwall. GSM believes that if these resources are buried due to backfilling requirements, the cost of recovering minerals in the future may be so high that the resource is completely lost. Future access to minerals for each alternative needs to be evaluated.

1.7.2.3.6 Land Use After Mining

1.7.2.3.6.1 Suitability of Land Use After Mining

The potential for each reclamation alternative to achieve the land use after mining must be evaluated.

1.7.2.3.7 Aesthetics

1.7.2.3.7.1 Visual Contrast with Adjacent Lands

The alternatives in the SEIS are similar to those evaluated in the 1997 Draft EIS. The mitigation of visual contrast between reclaimed lands and adjacent undisturbed lands must be evaluated for each alternative.

1.7.2.3.8 Potential Future Burden

1.7.2.3.8.1 Potential Future Burden on Society

Closed mining operations with long-term management requirements represent a potential liability on society. Bonds are posted to address that risk. The future burden on society in each alternative must be evaluated.

1.7.2.3.8.2 Potential for Future Liabilities for GSM

For all alternatives, it is anticipated that pit water treatment would be required indefinitely. GSM has a water treatment plan and has posted bond with DEQ for long-term water treatment. Facilities used to collect, treat, release and monitor surface water and groundwater will need to be maintained, upgraded, rebuilt and/or replaced. Volumes of water needing treatment vary with each alternative.

Some alternatives may rely on mixing and partial attenuation of impacted water to produce a less degraded water chemistry. This could limit long-term management requirements, but may in turn increase risk and liability for the company.

Long-term water treatment represents the site management that the company will control. This represents a liability to the company. Alternatives that do not achieve complete control of pit water increase the liability for GSM or some other future party.

1.7.2.4 Project Economics Issues

1.7.2.4.1 Reclamation Costs

Some level of backfilling could eliminate any reasonable likelihood of realizing a positive return on investment for GSM. Reclamation costs must be evaluated as an impact to GSM.

1.7.3 Issues Considered but Not Studied in Detail

Issues not studied in detail and the rationale for their exclusion are discussed below.

1.7.3.1 Wetlands

Wetland issues were addressed in the 1997 Draft EIS, Chapter IV, Section IV.D. Approximately 56 to 58 more acres would be disturbed under the partial pit backfill alternatives to build haul roads and to cast blast the upper highwall. Thirty-one acres would be disturbed to salvage soil. No new wetlands would be disturbed in these acres.

1.7.3.2 Wildlife and Fisheries

Wildlife and fisheries issues associated with the permit area were evaluated in the 1997 Draft EIS, Chapter IV, Section IV.E. No new impacts to wildlife or fisheries have been identified in the 87 to 89 acres that would be disturbed under the partial pit backfill alternatives in addition to those disclosed in previous reviews. The potential for each reclamation alternative to achieve the wildlife habitat land use after mining is evaluated in the SEIS in Section 4.3, Environmental Issues.

1.7.3.3 Threatened, Endangered, and Candidate Species

Issues associated with threatened, endangered, and candidate species were addressed in the 1997 Draft EIS, Chapter IV, Section IV.F. Approximately 87 to 89 more acres would be disturbed under the partial pit backfill alternatives to build haul roads, cast blast the upper highwall, and install dewatering and monitoring wells and access roads. No new impacts from the disturbance would affect threatened, endangered, or candidate species or their habitats. The agencies concluded no additional evaluation was required.

1.7.3.4 Air Quality

Fugitive dust emissions from mine traffic are expected for partial pit backfill alternatives due to the large amount of backfill anticipated to be transported to the pit. In addition, mine vehicle exhaust emissions are also expected. Potential changes in ambient air quality (Montana and National Ambient Air Quality Standards) and impacts on visibility could occur.

Air quality impacts were evaluated in the 1997 Draft EIS, Chapter IV, Section IV.G. Air quality from hauling waste rock has not been affected beyond the permit boundary during operations. The amount of traffic generating dust and emissions would be similar to historical mine operations. Therefore, the agencies have concluded that no impacts above those analyzed in previous environmental reviews would occur.

1.7.3.5 Aesthetic Resources

1.7.3.5.1 Noise

Noise impacts were evaluated in the 1997 Draft EIS, Chapter IV, Section IV.I. Noise impacts have been minimal beyond the permit boundary during operations. The amount of mine activity generating noise would be similar to mine operations historically. The agencies have concluded that no impacts above those analyzed in previous environmental reviews would occur.

1.7.3.6 Solid and Hazardous Materials and Wastes

Solid and hazardous materials and wastes were addressed in the 1997 Draft EIS, Chapter IV, Section IV.K. No additional materials or waste have been identified that would be generated under the alternatives in addition to impacts disclosed in previous reviews.

1.7.3.7 Cultural Resources

Cultural resource issues were addressed in the 1997 Draft EIS, Chapter IV, Section IV.L. Cultural resources consist of prehistoric and historic archaeological deposits; structures of historic or architectural importance; and traditional ceremonial, ethnographic, and burial sites. Cultural resources are nonrenewable resources, which are afforded protection by federal, state, and local laws, ordinances, and guidelines.

Several previous archaeological surveys have been conducted in the vicinity (Table 1-2). Reports detailing the results of intensive archaeological evaluations conducted in the GSM area are on file at the BLM Butte Field Office and at the SHPO office in Helena. The only cultural resource that might be affected by pit reclamation is a historic cabin near the north highwall. Should an alternative involving cast blasting be selected, there would be an adverse impact to this historic property, which would require mitigation.

1.7.3.8 Paleontological Resources

Paleontological resource issues were addressed in the 1997 Draft EIS, Chapter IV, Section IV.A. No additional impacts to paleontological resources have been identified in the 87 to 89 acres that would be disturbed under the partial pit backfill alternatives in addition to impacts disclosed in previous reviews. The chances of finding a paleontological resource in the pit area geology are minimal.

1.7.3.9 Native American Concerns

Native American concerns were addressed in the 1997 Draft EIS, Chapter IV, Section IV.M. The 87 to 89 acres of disturbance under the partial pit backfill alternatives would not impact any Native American traditional use sites. No new Native American

concerns have been identified in new disturbance areas under the partial pit backfill alternatives. No additional evaluation was required.

1.7.3.10 Areas of Critical Environmental Concern

No areas of critical environmental concern would be affected by any of the alternatives.

1.7.3.11 Prime or Unique Farmlands

No prime or unique farmlands would be affected by any of the alternatives.

1.7.3.12 Floodplains

No floodplains would be affected by any of the alternatives.

1.7.3.13 Wild and Scenic Rivers

No wild or scenic rivers would be affected by any of the alternatives.

1.7.3.14 Wilderness

No wilderness areas would be affected by any of the alternatives.

1.7.3.15 Environmental Justice

As required by Executive Order 12898, Federal *Actions to Address Environmental Justice in Minority Populations and Low-Income Populations,* the alternatives were evaluated for issues relating to the social, cultural, and economic well being, and health of minorities and low-income groups. None of these environmental justice issues was identified. The socioeconomic impacts of any of the alternatives would not affect minority or low-income groups disproportionately.

1.7.3.16 Invasive Non-Native Species

Non-native noxious weed species were evaluated in the 1997 Draft EIS, Chapter IV, Section IV.D. The county noxious weed list designates noxious weeds for Montana under the County Weed Control Act 7-22-2101(5), MCA. Seven species on this list were identified in the GSM study area during previous inventories: *Cirsium arvense* (Canada thistle), *Cardaria draba* (whitetop or hoarycress), *Centaurea maculosa* (spotted knapweed), *Euphorbia esula* (leafy spurge), *Linaria dalmatica* (dalmatian toadflax), *Hyocyamus niger* (henbane), and *Cynoglossum officinale* (hounds tongue). In general, these species have been confined to areas of recent and historic disturbance, e.g., roadsides, abandoned roads and homesteads, and drainage bottoms affected by fluvial events and livestock impacts.

Noxious weeds have been actively controlled by GSM since 1984 on areas within the mine permit boundary and on nearby property owned by the mine (GSM 1990 to 2006 Annual Reports). A weed control plan was submitted to the Jefferson County Weed Control Board in 1993. The primary concern has been spotted knapweed because of its widespread occurrence and the potential for infestation in areas of disturbed, dry rocky soils. Dalmatian toadflax has also become a concern. The small areas infested with whitetop are generally limited to ephemeral drainage bottoms and near the Jefferson Slough. Leafy spurge is very limited, also occurring primarily near the Jefferson Slough.

The control of noxious weeds is an important element of successful final reclamation. GSM will continue to monitor and control harmful weeds during operations and closure. The methods of monitoring and controlling invasive non-native species of vegetation would not vary by alternative. The 87 to 89 acres of new disturbance under the partial pit backfill alternatives would increase the area needing weed control. No additional evaluation was required.

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Chapter 2

Description of Alternatives

2.1 INTRODUCTION

GSM operates an open pit gold mine and mineral processing facility at the south end of Bull Mountain near Whitehall, Montana. Bull Mountain forms a north-south trending topographic divide ranging in elevation from approximately 5,000 to 6,500 feet in the mine area. The open pit lies just east of the topographic divide and currently occupies an area with 218 acres of total disturbance. This will not increase in size through Stage 5B.

As described in Section 1.4.3, the mine and facilities would normally be reclaimed under reclamation plans that have been approved by DEQ and BLM. However, portions of the statute relied on to select the method of pit closure in the 1998 ROD were ruled unconstitutional by the District Court. In its June 2002 judgment, the District Court ordered DEQ to begin implementation of a partial pit backfill reclamation plan in accordance with the procedures set forth in MMRA. To comply with the court order, and because pit designs have changed and new technical data are available to reevaluate potential environmental impacts of closure by partial pit backfilling, DEQ and BLM have determined that an SEIS is required.

What has changed in Chapter 2 since the DSEIS?

Chapter 2 describes the alternatives, their development and impact. The preferred alternative is also outlined. Based on additional data and public comments, the following changes have been made:

- GSM 2004 Annual Report was used to update all figures.
- GSM's 2006 Annual Report was used to update some acreages.
- Another soil borrow source was identified.
- The rationale for the less than 10 percent of pit water likely flowing south along Range Front Fault and other secondary flow paths was explained.
- The pit water balance was updated to reflect recent data (Telesto, 2006).
- Table 2-2 was changed to match Table 1 in the Summary.
- All text, figures and tables were revised from data provided by GSM and various consultants.
- Text was corrected based on references.

This chapter includes:

- A description of the mine plan and modifications that affect the ultimate configuration of the open pit;
- The process used to formulate the pit closure alternatives evaluated in this SEIS;
- Descriptions of the alternatives that have been considered;
- A summary of the reclamation impacts projected for each of the alternatives considered; and,
- The agencies' Preferred Alternative.

A range of alternatives was developed as a result of the scoping process. All reasonable alternatives were explored and objectively evaluated. Although some of the alternatives were eliminated from detailed study, descriptions of all alternatives are included in this chapter. The Partial Backfill Alternative described in the 1998 Final EIS and subsequently updated to reflect current conditions and modifications (GSM, 2002) is the Proposed Action. The No Pit Pond Alternative described in the 1998 Final EIS and the 1998 ROD serves as the No Action Alternative. Five additional alternatives or variations of these alternatives were studied in this SEIS. Two of the five alternatives were evaluated in detail.

GSM was permitted for 2,964 acres of disturbance (1997 Draft EIS, Table II-22)(GSM 2006 Annual Report). Based on minor revisions permitted since 1998, GSM's approved area for disturbance is 3,002.5 acres. GSM is currently bonded for 2,619.55 acres of disturbance. GSM's permit area is 6,125 acres.

Table 2-1 compares the permitted disturbance at GSM with the proposed disturbance at the end of Stage 5B mining (GSM 2006 Annual Report). GSM's current actual disturbance is 2,236 acres. A new disturbance map was developed and was used to prepare the figures in the SEIS. The numbers reported in Table 2-1 are based on the latest acreage determination and are considered the most accurate. Because these numbers were developed from new site maps and surveys, the numbers do not match the table in the GSM 2002 Annual Report or the 1997 Draft EIS, Table II-22. The disturbance categories were modified to better reflect actual disturbance. Some acreages were moved from one disturbance category to another.

GSM has completed 1,066 acres of reclamation within the disturbance boundary as of December 31, 2006. Table 2-1 details the completed reclamation. At the end of Stage 5B, a total of 560 acres of BLM land would have been disturbed.

Table 2 - 1. Summary of GSM's Permitted Disturbance and Reclaimed Areas

Disturbance Category	Disturbance at End of Stage 5B (Acres)	Reclaimed as of December 31, 2004 (Acres)	1997 Draft EIS Permitted Disturbance (Acres)
West and South Waste Rock Dump Complex	507	507	616
East Waste Rock Dump Complex	438	106	536
East Waste Rock Dumps Misc.	88	46	134
Buttress Waste Rock Dump & Road	66	51	266
Open Pit	218	7	254
Open Pit Area	68	0	82
Facilities	90	4	35
Tailings Impoundments	578	268	865
Stockpiles & Borrow Areas, Roads, and Miscellaneous	183	83	176
TOTAL	**2,236**	**1,072**	**2,964**

Source: GSM 2006 Annual Report Table AR-05-7.1 and 1997 Draft EIS Table II-22.

2.2 MINE PLANNING

2.2.1 Pit Development and Waste Rock Dump Complexes

Mining at GSM is accomplished with conventional open-pit methods that consist of drilling, blasting, loading, and hauling. Waste rock has been extracted and hauled to dump complexes located at the east, west, and south sides of the pit. All waste rock from current mining activities is placed in the East Waste Rock Dump Complex. The bottom of the pit is currently at an elevation of 4,650 feet, 700 feet below the lowest point on the eastern rim of the pit. Figure 1-2 shows the entire mine and facilities area.

Since mining began in 1982, pit development has occurred in stages, which have progressively deepened and expanded the pit. Pit Stages 1 through 5A have been completed. Development of the Stage 5B Pit to the 4,650-foot elevation has been approved by the agencies. In September 2003, GSM decided to begin mining Stage 5B and is now proposing an ultimate pit bottom elevation of 4,525 feet. The agencies will evaluate this change of pit depth in this SEIS. Figure 2-1 shows the ultimate pit

configuration upon completion of the Stage 5B Pit. The mill was shut down in December 2003. Main prestripping of waste rock for Stage 5B was performed throughout 2004. The mill reopened December 31, 2004 (Shannon Dunlap, GSM, personal communication, 2006).

GSM has already reclaimed substantial portions of the waste rock dumps totaling 654 acres (Table 2-1). The West Waste Rock Dump Complex, which includes the South Dump, is totally reclaimed. In addition, 106 acres of the East Waste Rock Dump Complex and 41 acres of the Buttress Dump have been reclaimed (Table 2-1). Reclamation of the rest of the East Waste Rock Dump Complex began again in 2006 (GSM 2006 Annual Report)

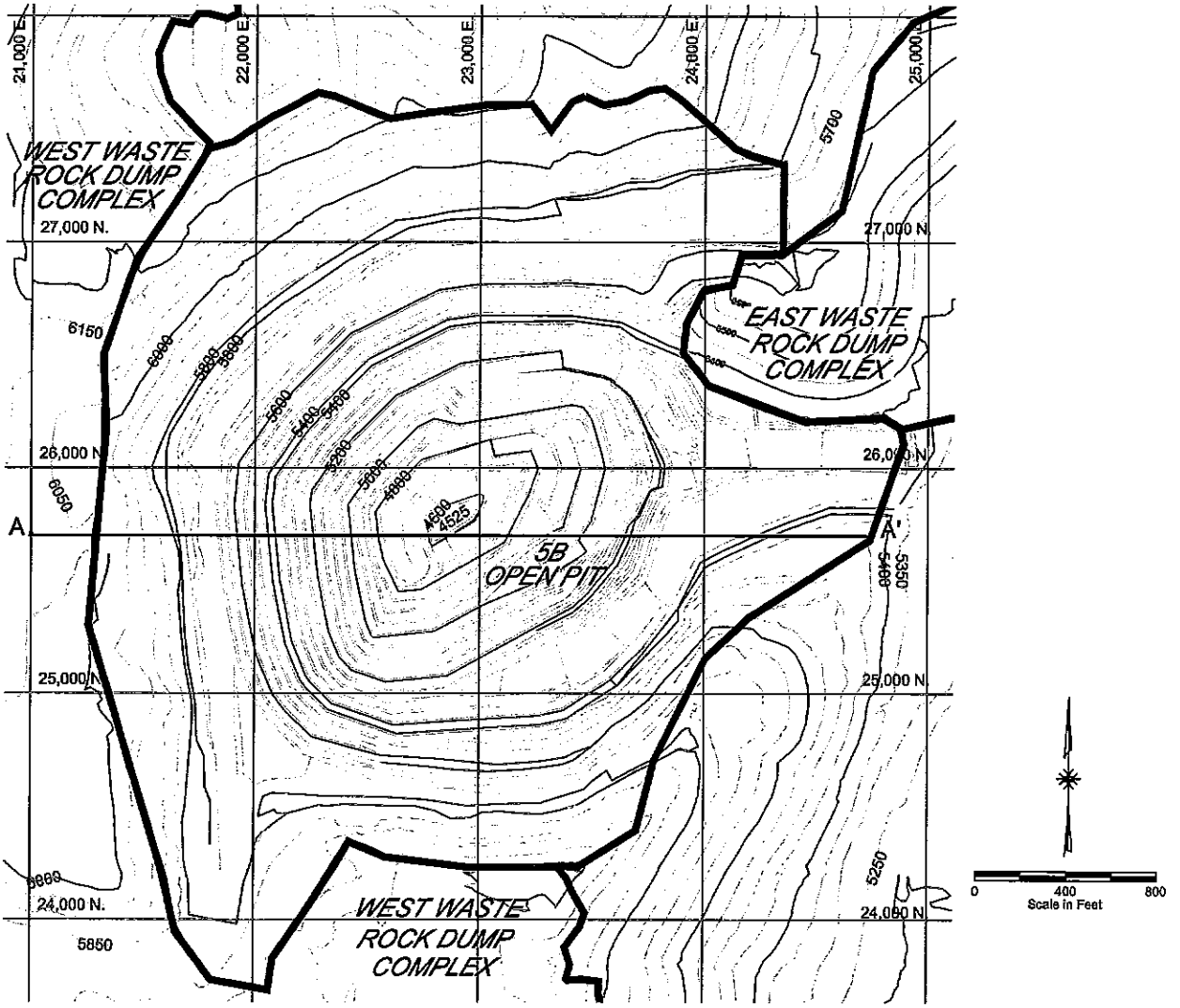
2.2.2 Underground Operation

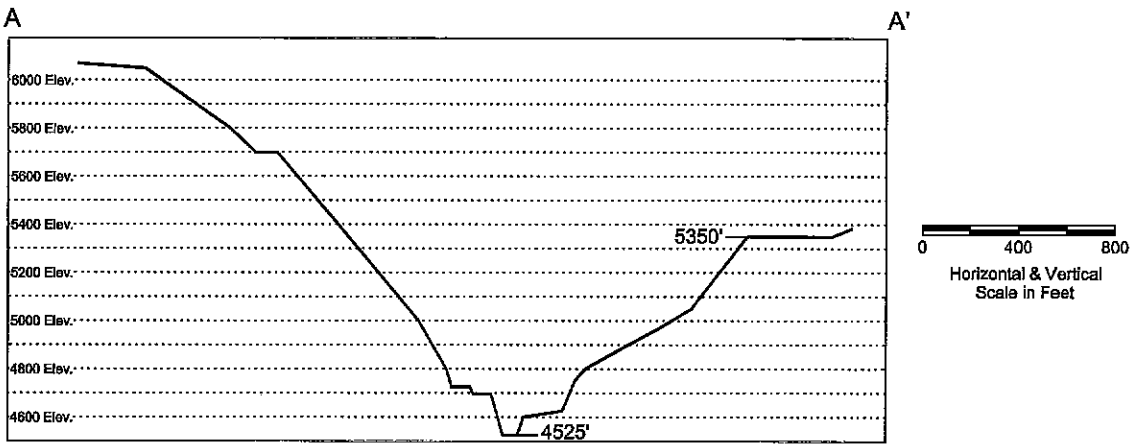
In addition to the open pit mining, GSM has operated a small underground mine with an average production of about 1,000 tons per day (see Figure 2-2). Small, high-grade ore pockets below and adjacent to the pit were mined in the underground workings. The mine portal is located within the open pit at an elevation of 4,857 feet. Portal construction began in July 2002. Development of the first stope, an excavation used in the mining of ore, began in August 2002. Three additional stopes were developed. Mining extracted ore between the elevations of 4,900 feet and 4,400 feet. The workings consist of 3,000 feet of development drifts and the stopes from which ore was extracted. This phase of underground mining was completed by the end of January 2004. The Agencies approved a phase II underground mining plan on August 28, 2006 to allow three new portals. This additional work includes development of 12,000 feet of drifting; additional sumps, raises, and drill stations; and, mining up to 800,000 tons of ore at a rate up to 1,500 tons per day.

2.2.3 Pit Dewatering

Controlling the accumulation of precipitation in the pit and the movement of groundwater through the pit highwall is an important aspect of the pit development plan. Mine dewatering is conducted at GSM to dewater the ore and waste rock actively being mined, to keep the pit floor and underground workings dry, and to release pore pressures in the open pit highwalls. Dewatering operations are monitored by recording pumping rates and collecting water samples for chemical analyses.

Prior to 2002, in-pit sumps were used for dewatering. In July 2002, GSM installed a dewatering well in the bottom of the pit. The well was constructed to a depth of approximately 118 feet (bottom elevation 4,748 feet). Until July 2003, when it was removed by mining, this well was pumped routinely to keep the water level below the pit floor. Based on data collected from a flowmeter installed on the dewatering line, water inflow to the pit during that period averaged 27 to 30 gpm.





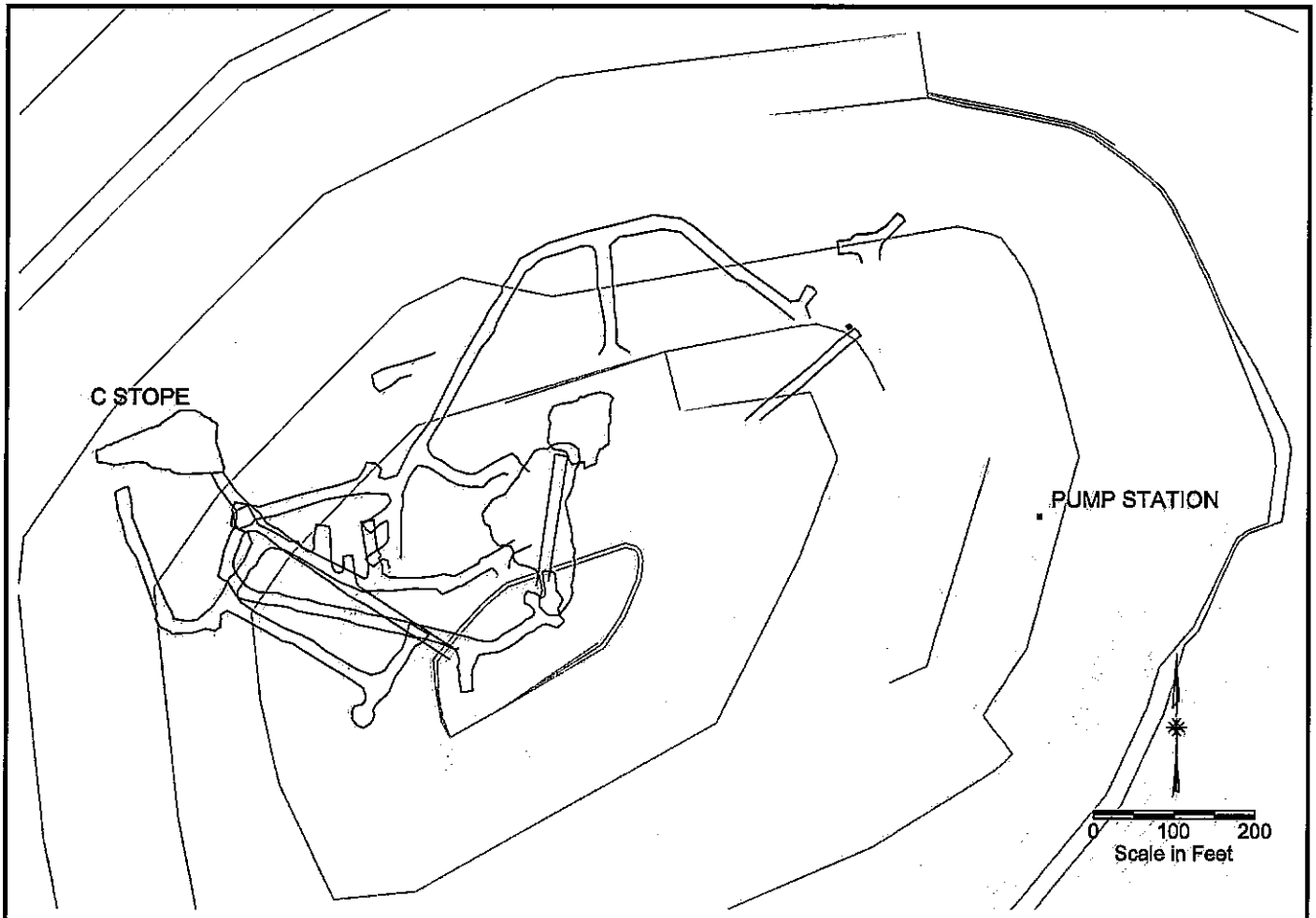
Ultimate Pit Floor Elevation = 4525 Feet

All Alternatives

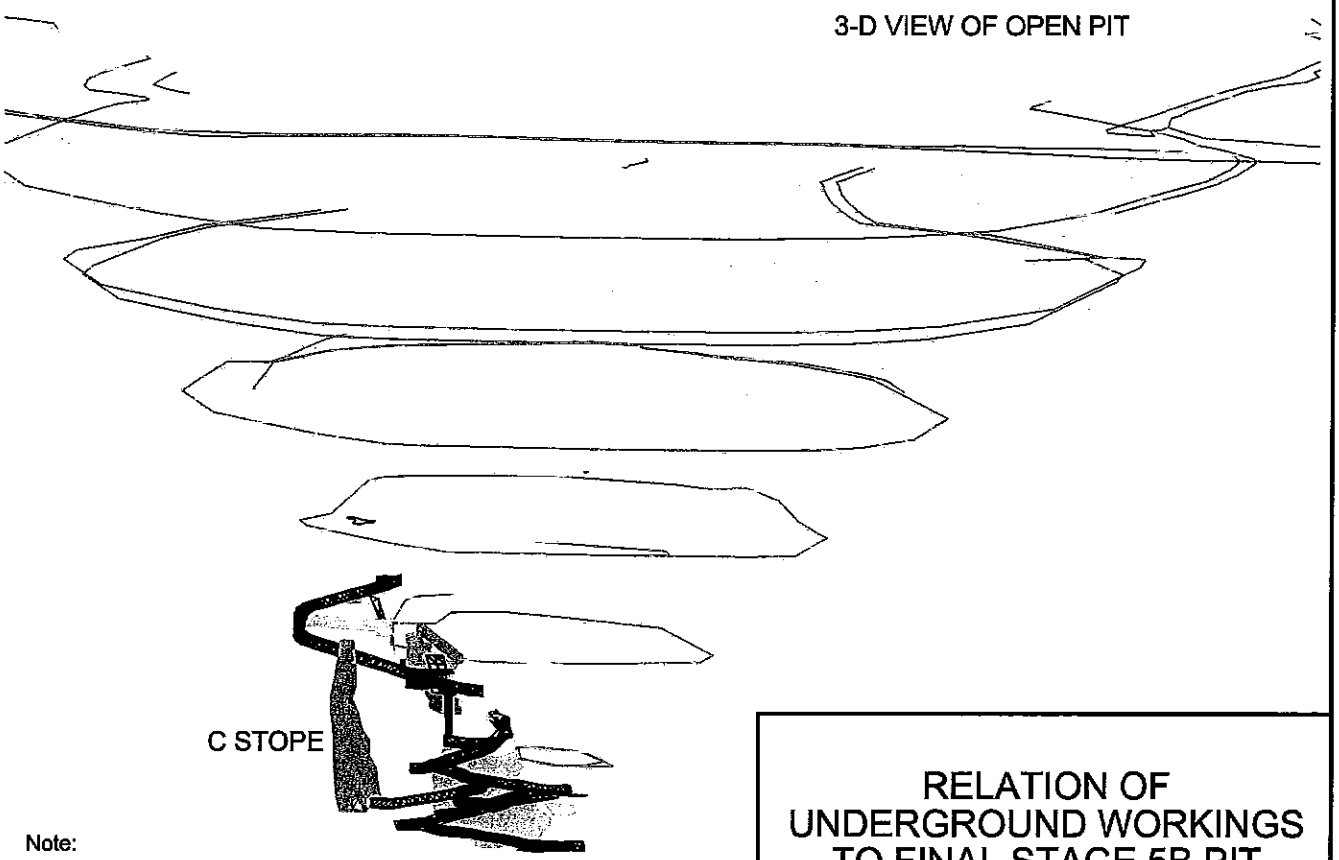
STAGE 5B PIT EXPANSION MINE PLAN

FIGURE 2-1

Figure 2-1 expand-5b.dwg



3-D VIEW OF OPEN PIT



Note:
Major portion of underground workings will be mined out during Stage 5B including the 4857 Portal.

RELATION OF UNDERGROUND WORKINGS TO FINAL STAGE 5B PIT

FIGURE 2-2

Figure 2-2-rev4-04-underground.dwg Rev. 1/2007

Two vertical highwall wells (PW-48 and PW-49) within the pit are regularly pumped to intercept groundwater from the Corridor Fault area before it enters the pit (see Figure 3-2 for location of the Corridor Fault and Figure 3-5 for locations of the wells). These highwall wells produce a combined flow of approximately 18.2 gpm (Telesto, 2006). Horizontal drains in the pit highwall are incorporated into the dewatering system as required to maintain safe operations. The workings inside the underground mine continue to produce less than 5 gpm (estimated at 1 to 2 gpm).

The pit dewatering system constructed during underground mining used a sump in the underground workings to drain and collect pit water. Water in the pit flowed into the underground workings through drill holes connecting the bottom of the pit with the underground workings. The underground mine has a sump with an approximate 500,000-gallon capacity at an elevation between about 4,450 and 4,500 feet. Any water that collected in other areas of the underground workings was pumped to this sump. Water was pumped from the underground sump through a 3-inch high-density polyethylene (HDPE) line to the 4,700-foot booster station. From the 4,700-foot booster station, water was pumped to the 4,850-foot booster station, and then to the 5,000-foot bench booster station through 4-inch HDPE lines. Finally, the water was pumped out of the pit from the 5,000-foot bench booster station to a lined holding pond below the mill. Up to 15,750,000 gallons of water were pumped out of the pit annually.

When Phase I underground mining ceased at the end of January 2004, water started collecting in the pit bottom and underground workings. This water flowed to the underground workings through drill holes connecting the pit bottom with the underground workings. A dewatering well was installed from a pit bench to the underground workings to accommodate dewatering activities during mining of the upper benches of the Stage 5B pit. The existing booster pumps and piping continue to be used for dewatering activities. As mining of the Stage 5B pit progresses, the dewatering well may need to be relocated to another area of the pit. The underground workings can contain a volume of 20 million gallons of water before the water table reaches the pit bottom at the 4,650-foot elevation. As of the end of 2006, there was no water in the bottom of the pit. GSM began pumping for Phase II underground mining again in July, 2006.

Water removed from the pit is either sprayed over blasted rock to control dust or is pumped to the lined holding pond below the mill and then to the water treatment facility in the mill. The water from the highwall dewatering wells is either: 1) mixed with treatment plant discharge and directed to the land application disposal (LAD) infiltration basin, 2) sent to the lined pond below the mill for treatment at the water treatment plant, or 3) pumped to Tailings Impoundment No. 2 for reuse as process water.

2.2.4 Plan Modifications

Since the 1997 Draft EIS, various modifications to GSM's mine plan have been made and approved. The following changes are considered important to the reevaluation of reclamation alternatives:

- The ultimate pit floor, which was projected to be at an elevation of 4,700 feet in the 1997 Draft EIS, is currently permitted to an elevation of 4,650 feet.
- An underground mine has been developed that accessed the ore zone through a portal in the pit highwall at the 4,857-foot elevation.
- The key cut on the pit rim where the haul road enters the pit will be left at an elevation of 5,350 feet rather than cutting the road down to an elevation of 5,200 feet as previously approved.

GSM has begun mining the Stage 5B Pit, which is currently permitted to be mined to an elevation of 4,650 feet. Up to 18 months of waste rock stripping was required to develop the Stage 5B ore zone for mining. A total of 25,000,000 cubic yards (37,500,000 tons) of waste rock and 6,267,000 cubic yards (9,400,000 tons) of ore would be removed during the life of the existing designated Stage 5B pit (GSM, 2003d). A total of 218 acres are inside the current open pit. This is 36 acres less than presented in the 1997 Draft EIS, Table II-22. The difference is due to a revised pit design, modified mining methods since the 1997 Draft EIS, and disturbance accounting changes in April 2004 (Table 2-1). The outline shown on Figure 2-1 is 218 acres. Waste rock from mining the Stage 5B Pit will be placed at various locations on the currently permitted East Waste Rock Dump Complex (Figure 2-5). The footprint of the East Waste Rock Dump Complex will remain 438 acres out of a permitted 670 acres (Table 2-1).

In the modified Partial Pit Backfill Alternative required by DEQ, GSM proposed to mine Stage 5B to the 4,525-foot elevation (GSM, 2002). The 5B pit expansion would add 4 to 5 years to the current mine life. Figure 2-1 shows the proposed topography for the pit at completion of the Stage 5B Pit development. Under this plan, the perimeter would not change from the existing pit configuration. The agencies will evaluate the change of pit depth in the SEIS. In Chapter 4, all reclamation alternatives, including the No Action Alternative, have been evaluated assuming the Stage 5B Pit would be fully developed to 4,525 feet. This allows the agency decision makers to evaluate whether to apply the proposed pit changes to any of the alternatives, including the No Action Alternative.

2.3 DEVELOPMENT OF ALTERNATIVES

The action under review is reclamation of the open pit. This section provides a brief description of how the various reclamation alternatives were developed for evaluation in this document. Because several of the alternatives have a long history of environmental review and litigation associated with them, historical background has been included in Section 1.4.3.

2.3.1 1998 EIS Record of Decision

The ROD for the 1998 Final EIS selected the No Pit Pond Alternative. This alternative required the bottom 100 feet of the pit (from an elevation of 4,700 feet to 4,800 feet) to be backfilled with unspecified waste rock from the East Waste Rock Dump Complex.

The backfill would be used as a sump to prevent a pond from forming in the pit. Two to three wells in the backfill would be used for pit dewatering coupled with water treatment. The top of the backfill would provide a working surface of 7.4 acres where personnel could install and maintain the dewatering system. Worker and dewatering system protection would be provided by building one or more berms around the perimeter of the working area to trap rocks that might ravel from the highwall.

The major focus of the No Pit Pond Alternative was the avoidance of groundwater degradation by pumping water out of the backfill to maintain the groundwater level near 4,700 feet. Another objective was to prevent exposure of wildlife to contaminated water after closure. Maintaining the pit as a hydrologic sink and capturing all pit water inflows would achieve these objectives. Slopes less than 2H:1V, major pit roads, and the pit bottom would have been covered with 2 feet of oxidized waste rock, 2 feet of soil, and revegetated. Twenty-six out of the 254 pit acres would have been revegetated. The rest of the pit was to be reclaimed as highwalls and talus slopes. In the 1998 Final EIS, DEQ and BLM concluded that the No Pit Pond Alternative would substantially achieve those objectives. It is the currently approved reclamation plan for the pit. This plan has been modified to reflect current conditions at the mine and constitutes the No Action Alternative that has been reevaluated in this SEIS.

2.3.2 1997 Draft EIS Partial Backfill Alternative

As described in Section 1.4.3, in a June 2002 judgment, the District Court ordered DEQ to begin implementation of the partial pit backfill reclamation plan, which had been evaluated in the 1997 Draft EIS, in accordance with MMRA. The 1997 Draft EIS Partial Backfill Alternative projected an ultimate pit floor elevation of 4,700 feet. As conceptually described, the Partial Backfill Alternative would require the GSM pit to be backfilled. The ultimate pit would be backfilled to the low point on the rim of 5,200 feet. The upper pit highwall would be reclaimed to 2H:1V slopes by hauling, end dumping, and dozing waste rock. Backfilling would have consisted of two activities:

- Hauling, end dumping, and dozing 34,700,000 to 36,700,000 cubic yards (52,000,000 to 55,000,000 tons) of waste rock material from the East Waste Rock Dump Complex to backfill the pit and cover the lower highwall; and,
- Hauling, end dumping, and dozing approximately 21,000,000 to 22,000,000 cubic yards (31,000,000 to 33,000,000 tons) of waste rock material from the West Waste Rock Dump Complex to complete covering of the highwall.

The backfilled area would be graded to a free-draining surface. All acid producing rock within the pit would be covered with two feet of oxidized waste rock. Then that surface would be covered with two feet of soil. The entire pit area of 254 acres would be revegetated.

Pit dewatering coupled with water treatment would be required. The wells would be installed through the backfill in order to maintain the pit as a hydrologic sink. However,

the agencies believe technical feasibility and potential effectiveness of these measures were not evaluated adequately in the 1997 Draft EIS.

The Partial Pit Backfill With In-Pit Collection Alternative described in this SEIS is presented as the Proposed Action to comply with the District Court's 2002 order. Under this alternative, some changes to the 1997 Draft EIS Partial Backfill Alternative are being evaluated:

- The elevation of the floor of the pit would be changed from 4,700 feet to 4,525 feet;
- Waste rock would be hauled from the East Waste Rock Dump Complex. No backfill would be obtained from the reclaimed West Waste Rock Dump Complex;
- The pit would be backfilled to a minimum elevation of 5,350 feet, which is the low point elevation on the eastern pit rim;
- Portions of the upper pit highwall would be cast blasted and dozed to achieve the 2H:1V slopes, increasing the total pit disturbance area by 56 acres (8.9 acres south of pit, 42.2 acres north and west of pit, and 4.9 acres of roads around the top rim of the pit) from 218 acres to 274 acres (Figure 2-4); and,
- The reclamation cover would be a 3-foot-thick layer of soil with more than 45 percent rock fragments amended in the surface, instead of two feet of oxidized waste rock covered with two feet of soil. This is the currently approved reclamation cover plan for all waste rock dump complexes at GSM (DEQ/BLM, 2002 and 2003).

2.3.3 Determination of Range of Alternatives

DEQ and BLM used comments received during the scoping process described in Section 1.7.1 and previous environmental documents prepared on the mine to determine the range of alternatives. To assist the agencies in determining the range of alternatives to be evaluated in this SEIS, DEQ and BLM initiated an Multiple Accounts Analysis process in May 2003. BLM, DEQ, EPA, GSM, and the environmental groups that are plaintiffs in the District Court action each sent two technical personnel to form a technical working group (TWG) to produce and evaluate alternatives using the MAA process (Robertson GeoConsultants, 2003).

As the process evolved, the TWG modified alternatives based on technical discussions and evaluation of accepted practices. Between meetings, proposed modifications were evaluated by various experts and the TWG was supplied with these supplemental analyses. During this process, public comment from a scoping meeting conducted in Whitehall was incorporated into the process. A local rancher also attended the fourth MAA meeting.

During the evaluation, the TWG identified and evaluated the following seven alternatives:

1. No Pit Pond (No Action) (includes in-pit water collection);
2. Partial Pit Backfill With In-Pit Collection (Proposed Action);
3. Partial Pit Backfill Without Collection;
4. Partial Pit Backfill With Downgradient Collection;
5. Partial Pit Backfill With Amendment;
6. Underground Sump (with underground water collection sump); and,
7. Pit Pond (with pump and treatment).

The agencies have identified 13 technical issues, 7 environmental issues, 12 socioeconomic issues, and 1 project economics issue as having importance for pit reclamation (Table 1-4). These are defined in Section 1.7.2 with additional explanation found in the Technical Memorandum describing the MAA process (Robertson GeoConsultants, 2003).

DEQ and BLM reviewed the results of the MAA process during preparation of this SEIS. While the MAA was not formally completed, the agencies determined that the range of alternatives identified satisfies the requirements of MEPA and NEPA and the District Court's 2002 order. Selection of the Preferred Alternative was based on data, studies, and analyses pertaining to these alternatives, which are described in Chapter 4, and the mandates of the laws, rules, and regulations administered by the agencies.

2.4 ALTERNATIVES CONSIDERED FOR DETAILED STUDY

2.4.1 Introduction

Seven alternatives were developed and evaluated. Three of the alternatives were dismissed from detailed consideration in the SEIS due to environmental or technical concerns (see Section 2.5). Four alternatives were studied in detail. These include:

- The No Pit Pond (No Action) Alternative, presented in the 1997 Draft EIS and selected as the Preferred Alternative in the 1998 ROD, as modified per current mine conditions (GSM, 2002);
- The Partial Pit Backfill With In-Pit Collection Alternative (Proposed Action), presented in the 1997 Draft EIS as the Partial Backfill Alternative as modified by GSM (GSM, 2002);
- The Partial Pit Backfill With Downgradient Collection Alternative developed to address the concerns with in-pit pumping associated with the Partial Pit Backfill With In-Pit Collection Alternative; and,
- The Underground Sump Alternative developed to address concerns with in-pit pumping and the potential burial of mineral resources and reserves associated with the partial pit backfill alternatives.

2.4.2 No Pit Pond Alternative (No Action)

As described in the 1998 ROD, DEQ and BLM selected the No Pit Pond Alternative in order to maintain the pit as a hydrologic sink, thus preventing any contaminated water from leaving the pit and moving into the regional groundwater system. Because the agencies also wanted to prevent a pit pond from forming, the bottom 100 feet of the pit would be backfilled with unspecified waste rock from the East Waste Rock Dump Complex to create a backfill sump. The backfill would serve as a flat working surface on which to station two to three dewatering wells and other components of a collection system. The dewatering system would collect water in the sump and pump it to a permanent water treatment plant. By maintaining the groundwater level as low as possible in the backfill, no water would be allowed to pond in the pit bottom. Protection for the pumping facilities and workers would be provided by building one or more berms around the perimeter of the 7.4-acre working area to trap rocks that might fall from the pit highwall. A 4-foot reclamation cover system would be placed over the backfill.

Since the ROD was issued in June 1998, changes have been made to the planned pit configuration to enhance safety, improve the waste-to-ore ratio, and target ore zones. Modifications common to all alternatives are outlined in Section 2.2.4. Additional planning and investigation to implement this pit closure plan has also continued. The changes affecting the No Pit Pond Alternative are as follows:

- The pit would be backfilled from an ultimate pit bottom elevation of 4,525 feet to an elevation of 4,625 feet instead of 4,700 feet to 4,800 feet;
- The flat working surface on top of the pit backfill would decrease to 1.3 acres from the previously planned 7.4 acres;
- Crusher reject waste rock materials (see Section 2.4.2.2) would be used for the sump backfill;
- The reclamation cover system would consist of 3 feet of soil, instead of 2 feet of oxide rock covered with 2 feet of soil; and,
- During reclamation, accessible pit roads, benches, and other areas within the pit would be resoiled and revegetated (consisting of 1.3 acres of pit floor working surface, 7 acres already reclaimed, and 52 acres of miscellaneous and pit roads), leaving approximately 158 acres (218 acres less 60 acres) of pit area unrevegetated. The area inside the perimeter of the pit would be 218 acres instead of 254 acres (see previous discussion in Section 2.2.4) projected in the 1997 Draft EIS (Table II-22).

2.4.2.1 Underground Mine Closure

The underground sump in the underground mine would not be closed until the end of mining because it would be used as part of a dewatering system for Stage 5B. Portions of the pit that break through into the underground mine pose a hazard to workers and would be backfilled. The current mine plan for the 5B Pit includes mining a safe distance from the underground stopes, backfilling the stopes, and then mining through the stopes (Shannon Dunlap, GSM, personal communication, June 21, 2004). GSM

started backfilling the stopes in 2006. Three stopes have been backfilled to date (Shannon Dunlap, GSM, personal communication, 2006). Because the underground workings have encountered less than 5 gpm of water, the water from the underground mine is not expected to alter the final water management system.

2.4.2.2 Stage 5B Pit Backfill Plan

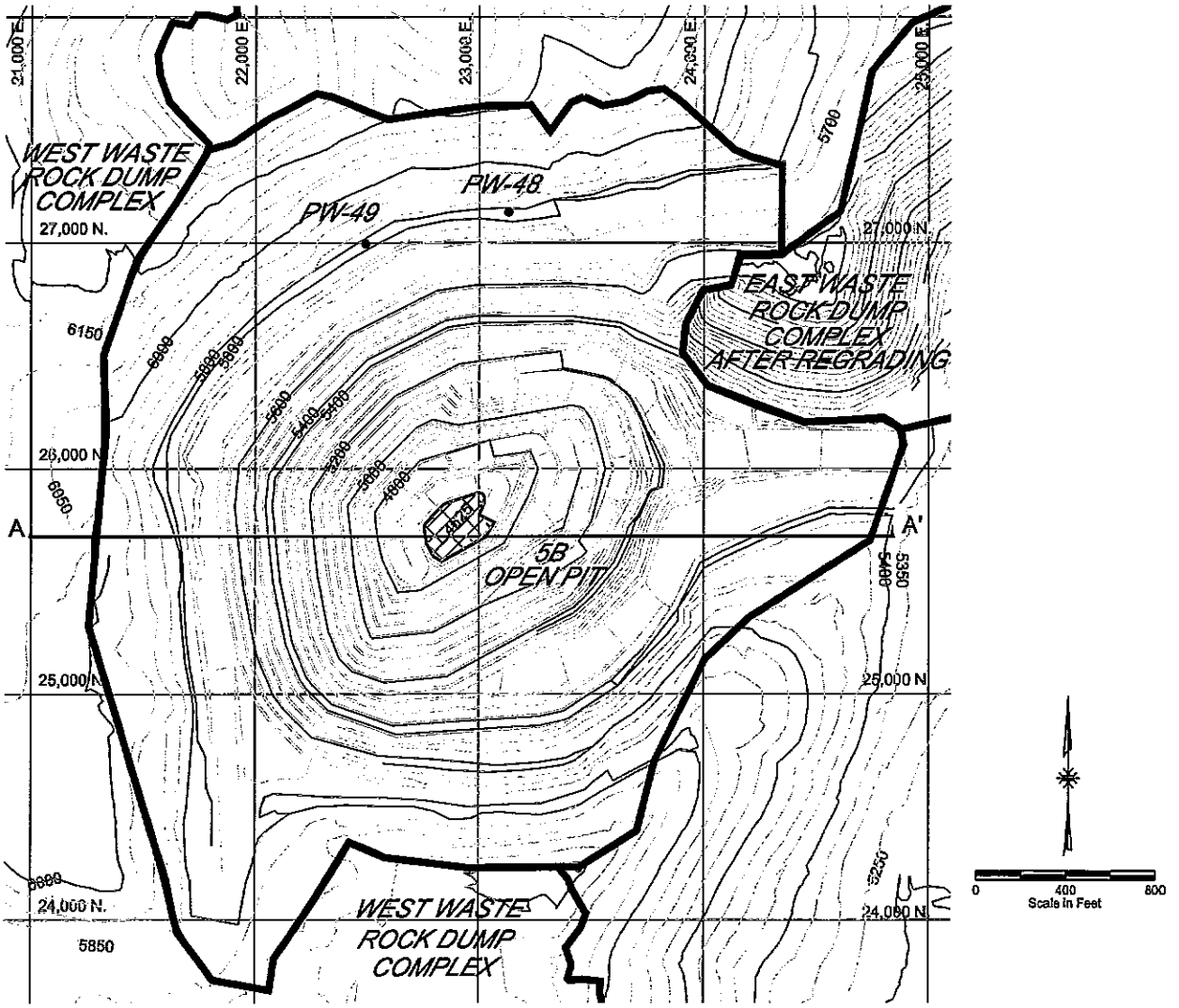
The lower portion of the Stage 5B Pit would be backfilled with 100 feet of crusher reject waste rock to provide a flat working area of 1.3 acres on which to station dewatering wells and other collection equipment. A 3-foot-thick layer of soil would be placed as a cover over the crusher reject. Approximately 111,000 cubic yards (167,000 tons) of crusher reject and 6,400 cubic yards of soil would be required. This limited amount of crusher reject would provide a sump to absorb precipitation and pit groundwater, thereby preventing a pond from forming in the bottom of the pit. Figure 2-3 shows the final topography (plan view) of the proposed backfilled Stage 5B Pit, as well as a cross-section of this pit configuration after backfilling and dewatering well locations.

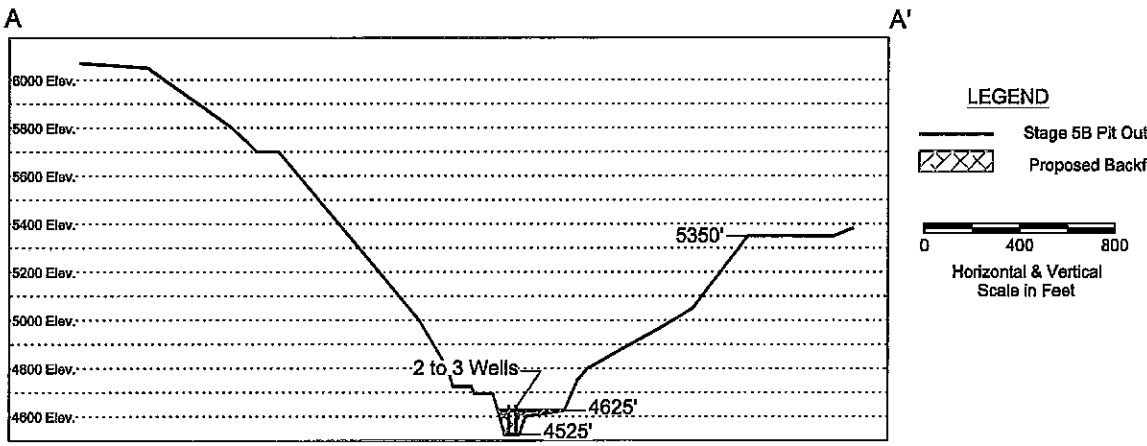
Backfill material was identified as waste rock in the 1997 Draft EIS, Section II.B.6.b. There are two potential on-site sources of waste rock for the backfill (GSM, 2002). One source of material is stockpiled mixed oxidized and waste rock that is stored for reclaiming waste rock disposal areas. Another source is the crusher reject material. Due to the screening process, this material is fairly uniform in size and could provide a good material for sump construction. This is the material proposed for backfilling under this alternative.

The reclamation cover being considered in the various alternatives that use pit backfill is different than the approved cover that was described in the 1997 Draft EIS. The approved cover consists of 2 feet of oxide rock overlain by 2 feet of soil. The proposed modified cover consists of 3 feet soil. This cover has been previously approved by the agencies for use on 2H:1V slopes on the East Waste Rock Dump Complex (DEQ and BLM, 2003). No additional disturbance would be necessary to obtain the soil for the No Pit Pond Alternative cover requirements.

2.4.2.3 Dewatering and Water Treatment

Additional information on the conceptual design of the dewatering system is presented in Section 2.2.3. Based on the 1997 Draft EIS, Section IV.B.6.b analysis, pit dewatering for the No Pit Pond Alternative was expected to require removal of 102 gpm. Current analyses predict that between 25 and 27 gpm would require perpetual removal (Telesto, 2003a). The pit dewatering system would consist of two to three dewatering wells constructed through the crusher reject to the bedrock contact. The wells would not be over 100 feet deep. Well casings would be constructed of polyvinyl chloride (PVC). Stainless steel submersible pumps equipped with electronic sensors would be installed to maintain optimum drawdown of the water table.





No Pit Pond Alternative would have two to three dewatering wells through the 100 feet of backfill from the 4525 to 4625 elevation

No Pit Pond (No Action) Alternative

FINAL NO PIT POND CONFIGURATION

FIGURE 2-3

Figure 2-3 5b-backfill-xsec.dwg

Existing and newly constructed dewatering horizontal drains in the pit highwall would be used at closure. Based on additional hydrogeologic evaluations at the time of closure, horizontal drains drilled from the floor of the pit into target zones behind the pit highwall may also be utilized (GSM, 2002). The horizontal drains would be constructed by drilling 4-inch to 6-inch-diameter boreholes, into which 2-inch to 4-inch-diameter PVC pipes would be inserted. The PVC pipes would be perforated within the targeted dewatering zones and then sealed off from the remainder of the open boreholes to minimize the formation of acid. The horizontal drains would be used in combination with the two vertical pit highwall dewatering wells, PW-48 and PW-49 (Figure 2-3), but would not require individual pumps. Instead, the discharge lines would be manifolded into a common conveyance that would report to a collection/pumping station. The discharge would be routed by pipeline to the permanent water treatment plant with other pit water. The pit highwall wells would be utilized as necessary for dewatering and to maintain or improve highwall stability.

A dewatering monitoring program would be implemented to monitor progress of the dewatering, evaluate the effectiveness of the system, and document the volume and quality of water pumped from the pit.

2.4.2.4 Stability and Safety Concerns

The No Pit Pond Alternative was analyzed for stability and safety in the 1997 Draft EIS, Chapter IV, Section IV.A.6. A new pit design has been implemented since then with different pit highwall angles and blasting techniques. Previous pit slopes were mined at 45 degrees in sediments and 49 degrees in breccia. The steeper pit highwall has been mined at 53 degrees in sediments and 60 degrees in breccia. These steeper slopes have been made possible by using pre-split and controlled blasting techniques within 50 feet of the pit highwall and scaling of the pit highwall with an excavator or by hand. Controlled blasting results in a pit highwall where joints, fractures and the highwall rock are less disturbed, compared to the previous blasting methods used at GSM. As a result, not only is a steeper pit highwall possible, but the highwall is stronger and safer. There is considerably less broken and fractured rock left on the highwall as a result of controlled blasting and scaling. No major pit highwall failures were predicted in the 1998 Final EIS. Pit highwall dewatering wells and horizontal drains would continue to be operated as required to release pore pressures in the open pit highwall to minimize the potential for minor pit highwall failure. Additional information regarding pit highwall stability is included in Section 4.2.1.2.

Abrupt pit perimeters would be bermed and fenced. Public safety after mining would be ensured through fences, locked gates, warning signs, and on-site maintenance personnel.

Personnel that would monitor the site for safety and security would include persons on site for operating water treatment facilities and long-term monitoring activities, including the dewatering system, reclamation cover system, surface water diversions, and noxious weeds.

2.4.2.5 Surface Water Management

As part of the final reclamation of the site, GSM would construct berms and surface water diversions to minimize surface water entering the open pit. Storm water diversions would be constructed around the pit capable of handling a 100-year, 1-hour storm event. Most storm water would be diverted away from the pit; less than 1 percent would enter the pit (Telesto, 2003a). Surface water that enters the pit would evaporate or infiltrate into the crusher reject and be removed by the dewatering system.

2.4.2.6 Reclamation Requirements

Open pit reclamation activities that would be completed under this alternative (GSM, 2002) are:

- Portions of the underground mine would be closed during and at the completion of Stage 5B.
- The pit would be backfilled with 100 feet of crusher reject from the 4,525 to the 4,625-foot elevation.
- Berms would be constructed on the pit bottom to protect workers from rocks raveling and sloughing off the highwall.
- GSM has proposed using a 3-foot layer of soil, as currently approved for the waste rock dumps, for reclaiming the 1.3-acre flat working surface in the pit bottom.
- Major benches that have sufficient width to allow machinery access, which are not likely to become buried with rubble from the pit highwall over time, and pit haul roads would be capped with the 3-foot-thick soil cover and revegetated (53 acres, 7 acres already reclaimed, 60 acres total).
- In addition, 68 acres of miscellaneous associated disturbance (outside the pit) would be reclaimed under the existing reclamation plan. One hundred fifty-eight acres would be left unrevegetated in the pit.
- A two- to three-well dewatering system would be constructed.
- Abrupt pit perimeters would be bermed and fenced.
- Trees would be planted around the pit perimeter.
- Oxidized benches containing enough fine material to support plant life would be seeded and planted with trees where safety allows.
- Berms and storm water diversions would be constructed around the pit perimeter capable of handling a 100-year, 1-hour thunderstorm event.
- Warning signs would be placed around the pit perimeter.
- Dewatering wells and horizontal drains would be installed based on additional hydrologic evaluations at closure.

- Two horizontal excavations would be constructed for bats. A number of large and small raptor cavities would be constructed in the oxidized portion of the upper highwall. The exact location and configuration of the raptor cavities and bat excavations would be determined near the end of mine life when stable portions of the pit with suitable aspects can be most accurately identified.

The following table summarizes the pit backfill quantity requirements as well as cover soil, revegetation and dewatering needs of this alternative:

COMPONENT	Quantity	Units
Sump Material	111,000	cubic yards
Pit Backfill	0	cubic yards
Cover Soil [1]	290,400	cubic yards
Dewatering System	2-3	Wells
Backfill Depth (4,525-4,625)	100	Feet
Pit Area Revegetation [2]	60	Acres
Area Unrevegetated	158	Acres

[1]Cover soil is for 60 pit acres at 3-foot thickness on a flat surface.
[2]Includes 53 acres of pit roads and benches, 7 acres already reclaimed, and a 1.3-acre flat working surface in the pit bottom.

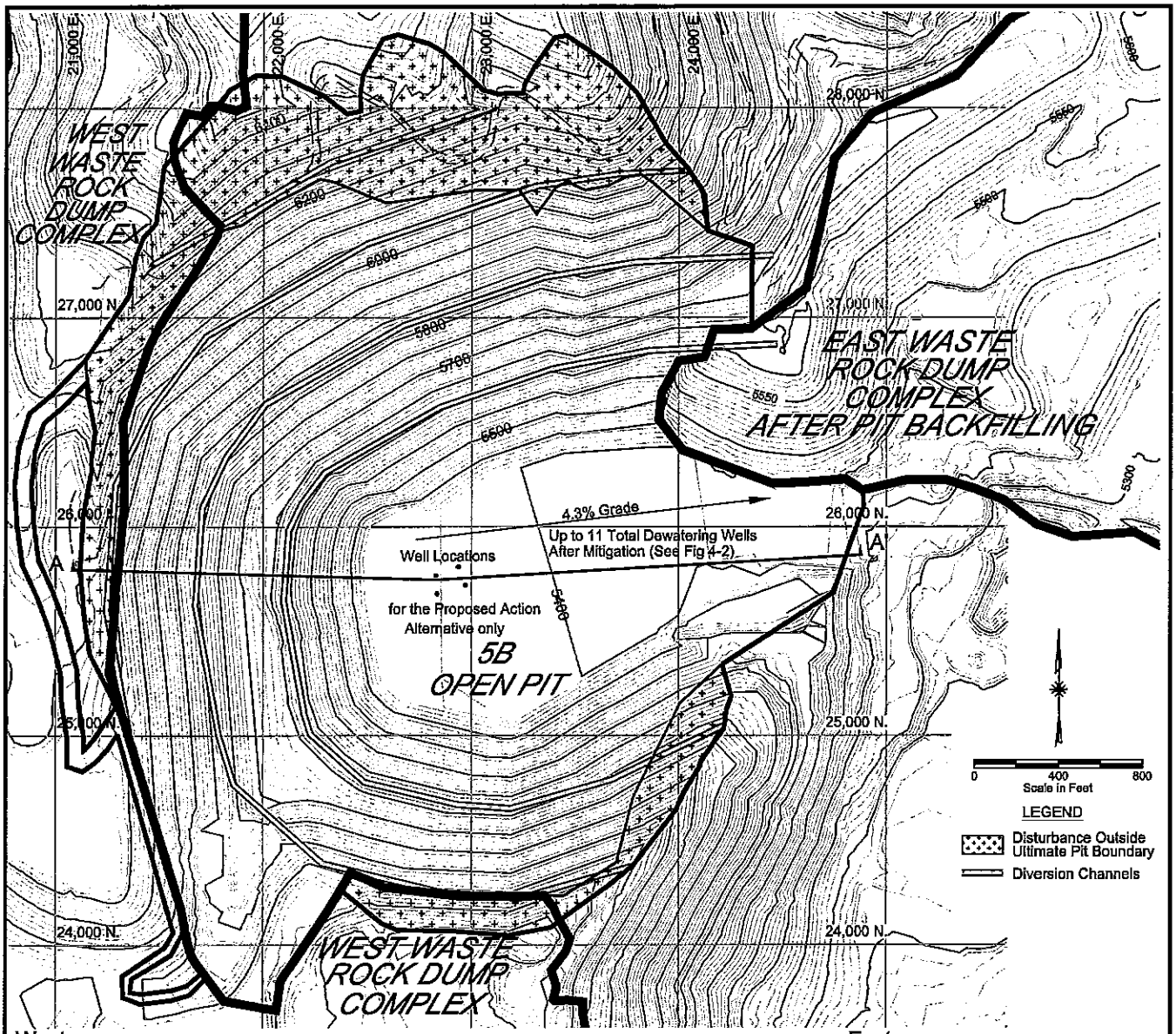
2.4.3 Partial Pit Backfill With In-Pit Collection Alternative (Proposed Action)

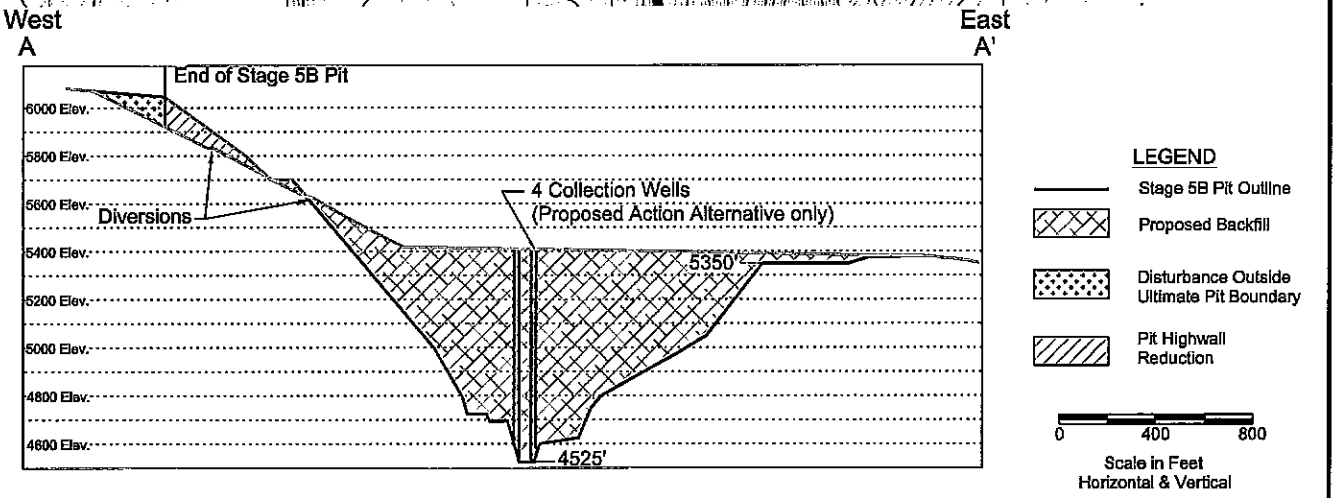
This updated version of the Partial Backfill Alternative analyzed in the 1997 Draft EIS incorporates current site conditions and several modifications submitted by GSM (GSM, 2002). As conceptually described in the 1997 Draft EIS, Chapter II, Section II.B.7, this alternative involves backfilling the GSM pit to a free-draining elevation on the east rim of the pit with previously excavated waste rock and recontouring the upper pit highwall to 2H:1V slopes. The entire area would be graded to a free-draining surface. A 4-foot reclamation cover system was to be placed over the graded area and revegetated. Four pit dewatering wells installed through the backfill coupled with water treatment would be required to maintain the pit as a hydrologic sink. Additional details of the 1997 Draft EIS Partial Backfill Alternative are presented in this SEIS Section 2.3.2.

The configuration of the Stage 5B pit design has changed to enhance safety, improve the waste-to-ore extraction ratio, and target ore zones. Modifications common to all alternatives are outlined in Section 2.2.4. In addition, the West Waste Rock Dump Complex has been reclaimed, and the reclamation cover system has been modified on the waste rock dump complexes to a 3-foot soil cover.

The original plan presented in the 1997 Draft EIS, Chapter II, Section II.B.7 has been modified. Changes include the following:

- The elevation of the floor of the pit would be lowered to an elevation of 4,525 feet to recover more ore from the Stage 5B Pit.
- Crusher reject would be used to backfill the lower 100 feet of the pit from 4,525 to 4,625 feet to act as a sump for the dewatering system.
- To allow surface water on the backfilled area to drain freely, the pit would be backfilled to a minimum elevation of 5,350 feet, which is the current low point elevation of the eastern pit rim.
- Waste rock would be hauled from the East Waste Rock Dump Complex. No backfill would be obtained from the reclaimed West Waste Rock Dump Complex.
- Cast blasting and dozing would be utilized to reduce the upper portion of the pit highwall to a 2H:1V slope rather than hauling all backfill material.
- Pit highwall reduction to 2H:1V slopes using cast blasting and dozing and the construction of soil haul roads would increase the pit disturbance area by 56 acres (Figure 2-4).
- Four dewatering wells would be used to maintain the pit as a hydrologic sink.
- The reclamation cover would be changed to a 3-foot-thick layer of soil with greater than 45 percent rock fragments amended into the surface instead of two feet of oxidized waste rock covered with two feet of soil as currently approved for all 2H:1V waste rock facilities at the mine.





Partial Pit Backfill with In-Pit Collection Alternative would have four 800-875 foot dewatering wells drilled to approximately the 4525-foot elevation. Up to eleven total dewatering wells are required after mitigation. (See Figure 4-2)

Partial Pit Backfill with Downgradient Collection Alternative would have no in-pit wells.

Partial Pit Backfill Alternatives

FINAL PARTIAL PIT BACKFILL CONFIGURATION

FIGURE 2-4

Figure 2-4 PPB-backfill-xsec.dwg

2.4.3.1 Underground Mine Closure

Underground mine closure would be the same as for the No Pit Pond Alternative (Section 2.4.2.1).

2.4.3.2 Stage 5B Pit Backfill

After the Stage 5B Pit is mined to a bottom elevation of 4,525 feet and portions of the underground mine are closed, the pit would be backfilled to establish a free-draining surface. About 111,000 cubic yards (167,000 tons) of crusher reject waste rock would be placed in the bottom of the pit to act as a sump for the dewatering system. This waste rock would need to be hauled by truck down into the pit.

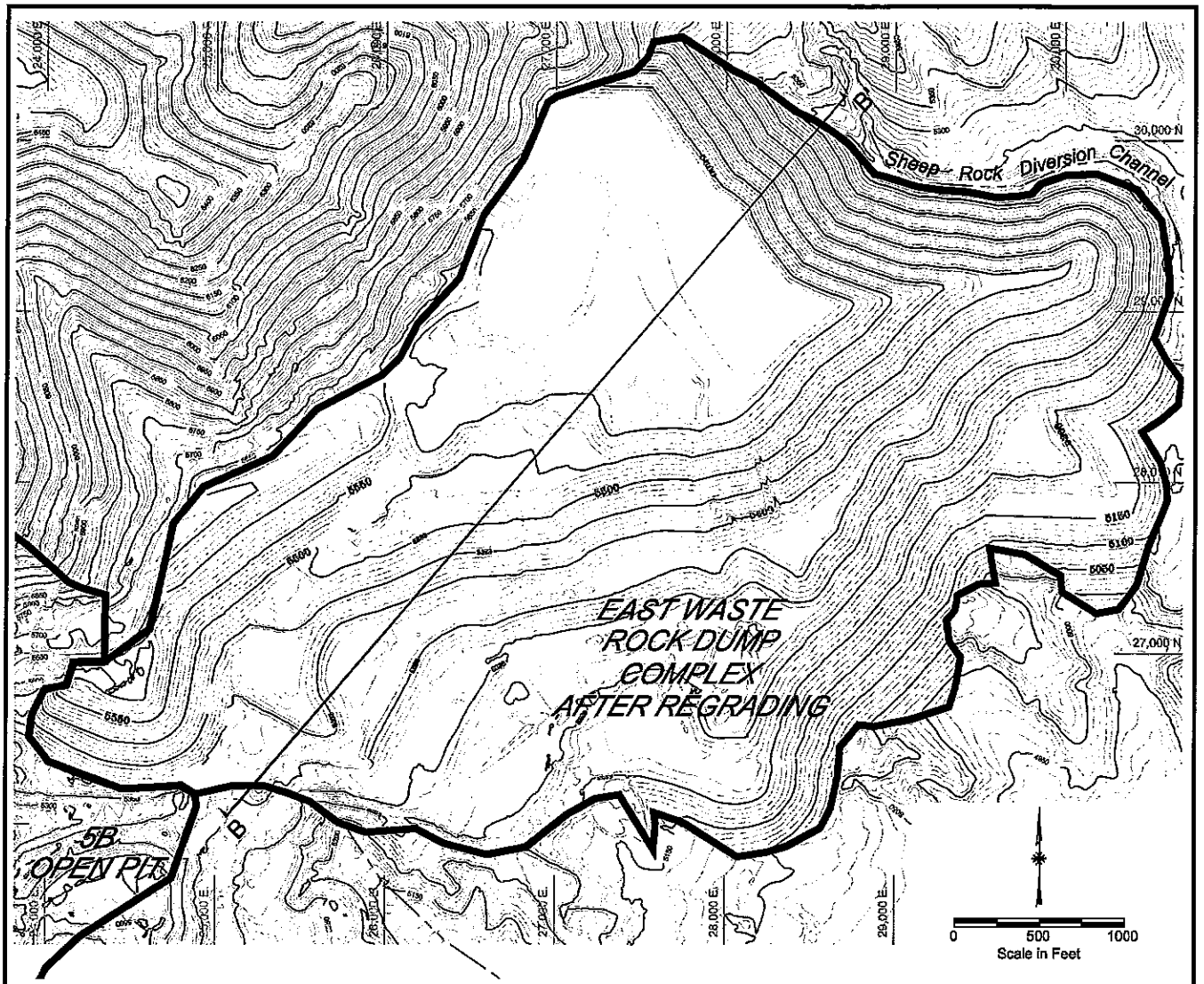
A total of approximately 33,200,000 cubic yards (50,000,000 tons) of additional waste rock would then be hauled from the East Waste Rock Dump Complex to backfill the pit to create a sloping surface with an average elevation of 5,400 feet (Figure 2-4). This waste rock would be dumped into the pit from the 5,400-foot elevation. After reclamation is completed, surface drainage would exit the pit backfill at an elevation of 5,350 feet.

Waste rock for backfilling the pit would not be hauled from the reclaimed West Waste Rock Dump Complex. GSM would reduce the pit highwall above the 5,400-foot elevation to 2H:1V slopes by employing cast blasting and dozing. Approximately 11,900,000 cubic yards (17,850,000 tons) of pit highwall material and 56 acres of additional disturbance in the pit area would be needed to recontour these slopes and develop roads for soil distribution (Figure 2-4). Storm water diversions would be installed every 200 vertical feet down the backfill slope to minimize erosion and to intercept runoff. The benches would be constructed similarly to those constructed for the waste rock dumps. Drainage diversions on the benches would be sloped to collect runoff and route it off the backfill material. The final pit configuration after backfilling the Stage 5B Pit is shown in Figure 2-4, which includes both plan and cross-sectional views.

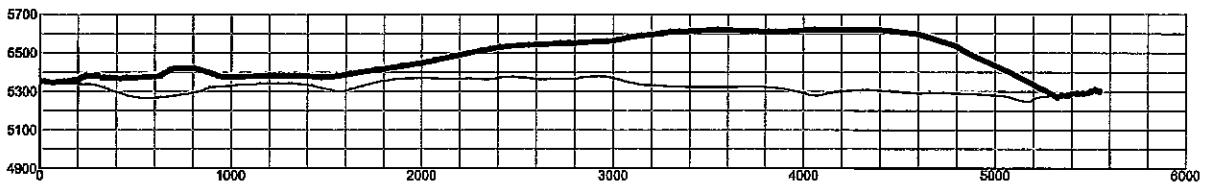
The topography of the East Waste Rock Dump Complex after mining under the Stage 5B Pit plan is shown in both plan and cross-sectional views on Figure 2-5. Figure 2-6 shows the final configuration of the East Waste Rock Dump Complex after removing 33,200,000 cubic yards of material for backfilling from a 222-acre area. The East Waste Rock Dump Complex and Buttress Waste Rock Dump are permitted to hold up to 146,000,000 cubic yards (219,000,000 tons) based on the mine design at that time (1998 ROD) (Figure 1-2). In December 2003, the East Waste Rock Dump Complex contained approximately 76,700,000 cubic yards (114,750,000 tons), while the buttress dump contained approximately 2,000,000 cubic yards (3,000,000 tons). Between December 2003 and December 2005, 34,000,000 tons were placed in the East Waste Rock Dump Complex. Another 7,000,000 to 10,000,000 tons of waste rock would be added through the end of Stage 5B mining (Shannon Dunlap, GSM, personal

communication, 2006). The East Waste Rock Dump Complex is permitted for 670 acres of disturbance. The ultimate East Waste Rock Dump Complex disturbance will be 438 acres. A total of 106 acres of the dump complex are already reclaimed. After Stage 5B mining is completed, GSM estimates that the East Waste Rock Dump Complex would contain 104,000,000 to 106,000,000 cubic yards (156,000,000 to 159,000,000 tons), depending on ore grade (GSM, 2002). The Partial Pit Backfill With In-Pit Collection Alternative would remove 33 percent of the total volume in the East Waste Rock Dump Complex into the pit. None of the backfilling operations would reduce the current footprint of the dump of 438 acres. This varies from the 1997 Draft EIS, Chapter II, Section II.B.7.b, which would have used 30 to 32 percent of the total permitted volume and would have completely removed 82 acres of the dump complex.

About 1,541,800 cubic yards of soil material would be required to cover the pit areas to be revegetated with a 3-foot-thick reclamation cover. The cover is described in Section 2.3.2. Two sources of cover material were considered. One source of cover material is an area northeast of the East Waste Rock Dump Complex that has been used as a soil borrow area (GSM, 2002). Another potential borrow area with more rock fragments has been identified by GSM north of Tailings Impoundment No. 2 (GSM, 2003c). The proposed source includes a 47-acre soil borrow source identified north of Tailings Impoundment No. 1. A portion of the area (about 16 acres) has been permitted for disturbance. The remaining 31 acres of this area would be permitted for a soil borrow source (Figure 1-2) (Shannon Dunlap, GSM, personal communication, 2006). After the earthwork and soil placement are complete, the surfaces would be revegetated using the approved seed mix.



B CROSS SECTION B'



LEGEND

Pre-Mining Topography

Regraded Topography

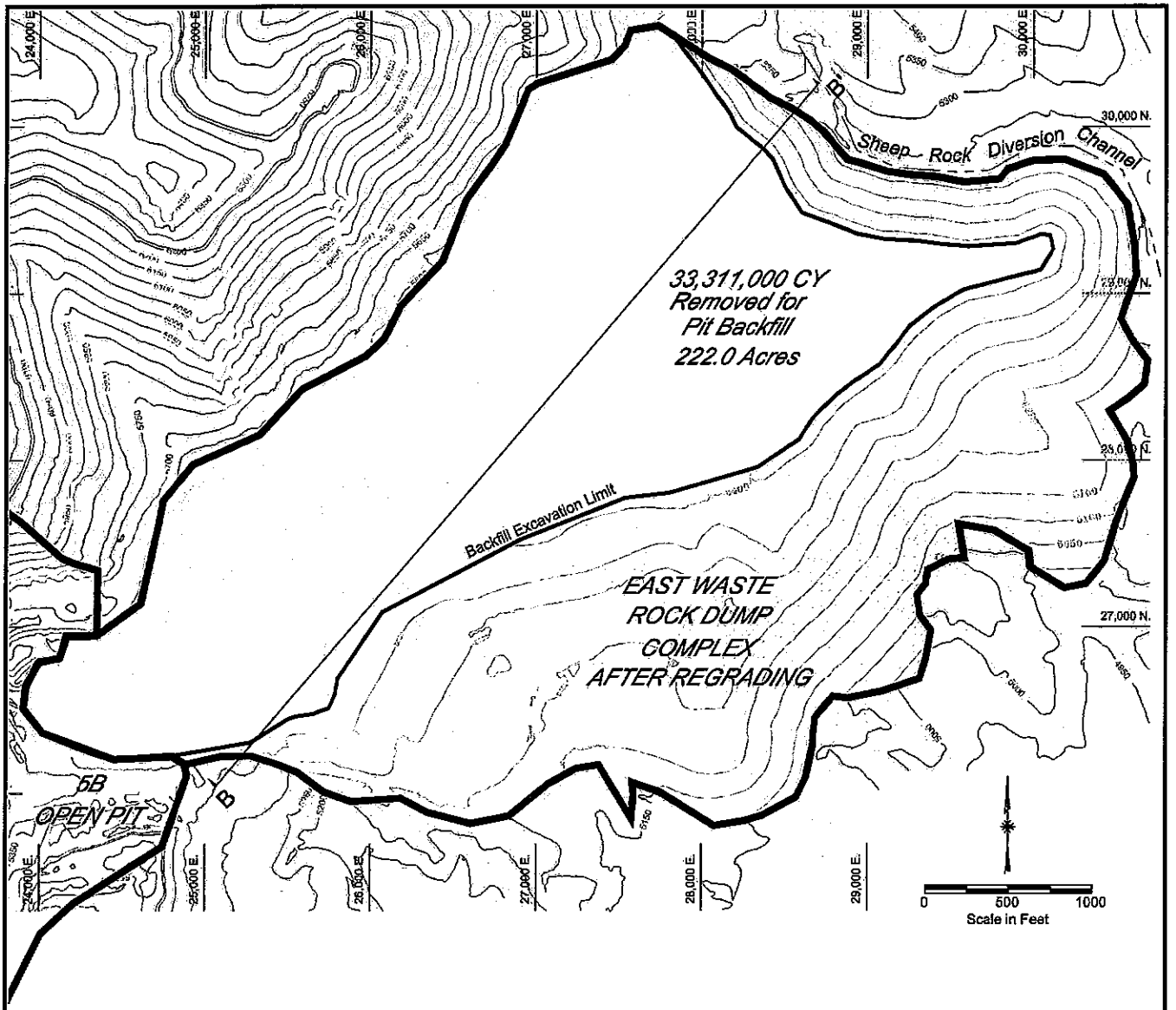
0 500 1000
Horizontal & Vertical
Scale in Feet

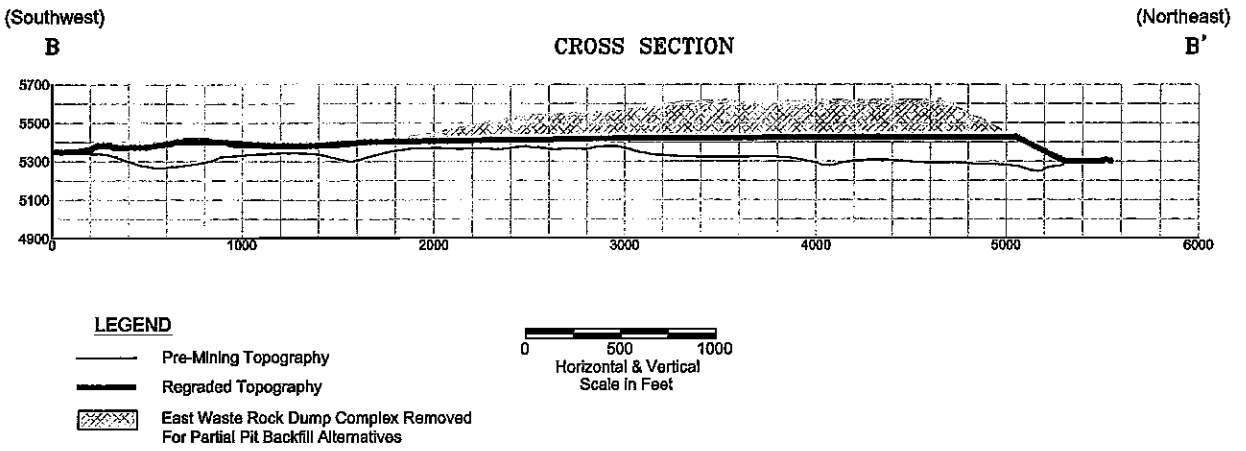
No Pit Pond & Underground Sump Alternatives

EAST WASTE ROCK DUMP COMPLEX TOPOGRAPHY AFTER REGRADING

FIGURE 2-5

Figure 2-5 Rockdump-xsec.dwg





Partial Pit Backfill Alternatives

EAST WASTE ROCK DUMP COMPLEX TOPOGRAPHY AFTER PARTIAL PIT BACKFILL AND REGRADING

FIGURE 2-6

Figure 2-6 PPB rockdump-xsec.dwg

2.4.3.3 Dewatering and Water Treatment

For the Partial Pit Backfill With In-Pit Collection Alternative, the 10-year time-weighted average water balance indicated that the pumping rate would be on the order of 27 to 42 gpm (Telesto, 2006). The dewatering system would consist of four dewatering wells constructed through the pit backfill to the bedrock contact. This backfill would be non-homogeneous and the permeability would be variable. The wells would be drilled at an average surface elevation of 5,400 feet and would extend down into the sump backfill at the bottom of the pit. Consequently, wells up to 875 feet would be required.

Boreholes would be 10 to 12 inches in diameter and would be lined with 6-inch diameter stainless steel casing. The bottom of the casing would be slotted in the saturated zone between the 4,525- and 4,625-foot elevation. A stainless steel submersible pump equipped with electronic sensors to maintain optimum drawdown would be installed in each well. The pumps would be connected to 3-inch diameter PVC discharge lines. The discharge lines would be manifolded into a common conveyance and routed by pipeline to the permanent water treatment plant prior to being discharged back into the ground near the water treatment plant via percolation ponds, LAD, or other approved methods. Special corrosion resistant pumps and stainless steel casings would be required to extend the life of the wells and ancillary equipment.

2.4.3.4 Stability and Safety Concerns

The highwall would be stabilized with backfill up to the 5,400-foot elevation and with cast blasted highwall rock above that elevation in the Partial Pit Backfill With In-Pit Collection Alternative. No major pit highwall failures were predicted in the 1997 Draft EIS, Chapter IV, Section IV.A.7 for the Partial Backfill Alternative. Public access to the permit area would continue to be prohibited in selected areas due to concerns about the safety and security of maintenance personnel and equipment that would remain in the area. Public safety after mining would be ensured through fences, locked gates, and warning signs.

2.4.3.5 Surface Water Management

As part of the final reclamation of the site, GSM would construct berms and surface water diversions around the pit perimeter to prevent over 99 percent of surface water from entering the area of the backfilled pit (Telesto, 2003a). Limited surface water that infiltrates into the pit backfill would be removed by four dewatering wells. Surface water diversions would be installed on benches approximately every 200 vertical feet down the slope of the reduced highwall to minimize erosion and intercept runoff (Figure 2-4). The benches would be constructed similar to those constructed for the waste rock dump complexes. Diversions would be sloped to collect runoff and route it off the reclaimed pit area. The storm water diversions would be constructed following the existing approved plan for this type of structure.

2.4.3.6 Reclamation Requirements

Of the 274 acres of disturbance (218 acres of the pit area plus 56 acres of highwall layback), 272 acres in the pit backfill, pit highwall reduction areas, and haul roads would be covered with 3 feet of soil and revegetated. The same 3-foot soil cover approved for waste rock dump complex reclamation would be used. Outside the pit area, reclamation requirements would be the same as the No Pit Pond Alternative, except at the East Waste Rock Dump Complex. The footprint of the East Waste Rock Dump Complex would remain the same as approved in the 1998 ROD. About 33 percent of the dump's volume would be removed for backfill. No acreage would be completely off-loaded. After placement of reclamation covers, the regraded areas would be fertilized and seeded with an approved seed mix.

The following table summarizes the pit backfill quantity requirements as well as cover soil, revegetation and dewatering needs of this alternative:

COMPONENT	Quantity	Units
Sump Material	111,000	cubic yards
Pit Backfill	33,200,000	cubic yards
Cast Blasting & Dozer Rehandle @ 20%	11,900,000	cubic yards
Cover Soil [1]	1,541,800	cubic yards
Diversion Structures	18,600	linear feet
Roadwork	5,550	linear feet
Dewatering System	4	Wells
Backfill Depth (4,525-5,400)	875	Feet
Pit Area Revegetation [2]	290	Acres
Area Unrevegetated	0	Acres

[1]Cover soil is for 53 acres of flat surface at 3 feet of cover soil and 239 slope acres (plan view adjusted for 2H:1V slope) at 40 inches of cover soil.
[2]This includes 218 plan view acres of the pit plus 56 acres of highwall layback plus 18 acres to adjust plan view acres to 2H:1V slope acres minus 2 acres of access roads.

2.4.4 Partial Pit Backfill With Downgradient Collection Alternative

This alternative is a variation of the Partial Pit Backfill With In-Pit Collection Alternative. These alternatives backfill the pit to a free-draining surface at approximately the 5,350-foot elevation and reduce the pit highwall above that elevation to 2H:1V slopes. The main difference is that instead of attempting to maintain the backfilled pit as a hydrologic sink by installing wells inside the backfilled area and pumping to remove contaminated groundwater, a system of wells would be operated outside and down gradient from the pit to intercept contaminated groundwater from the pit. The conceptual system would include an estimated 26 or more new capture wells, existing wells in the Tailings Impoundment No. 1 capture and monitoring system, and at least 10 new monitoring wells (Figure 2-7).

2.4.4.1 Underground Mine Closure

Underground mine closure would be the same as described for the Partial Pit Backfill With In-Pit Collection Alternative (see Section 2.4.3.1 above).

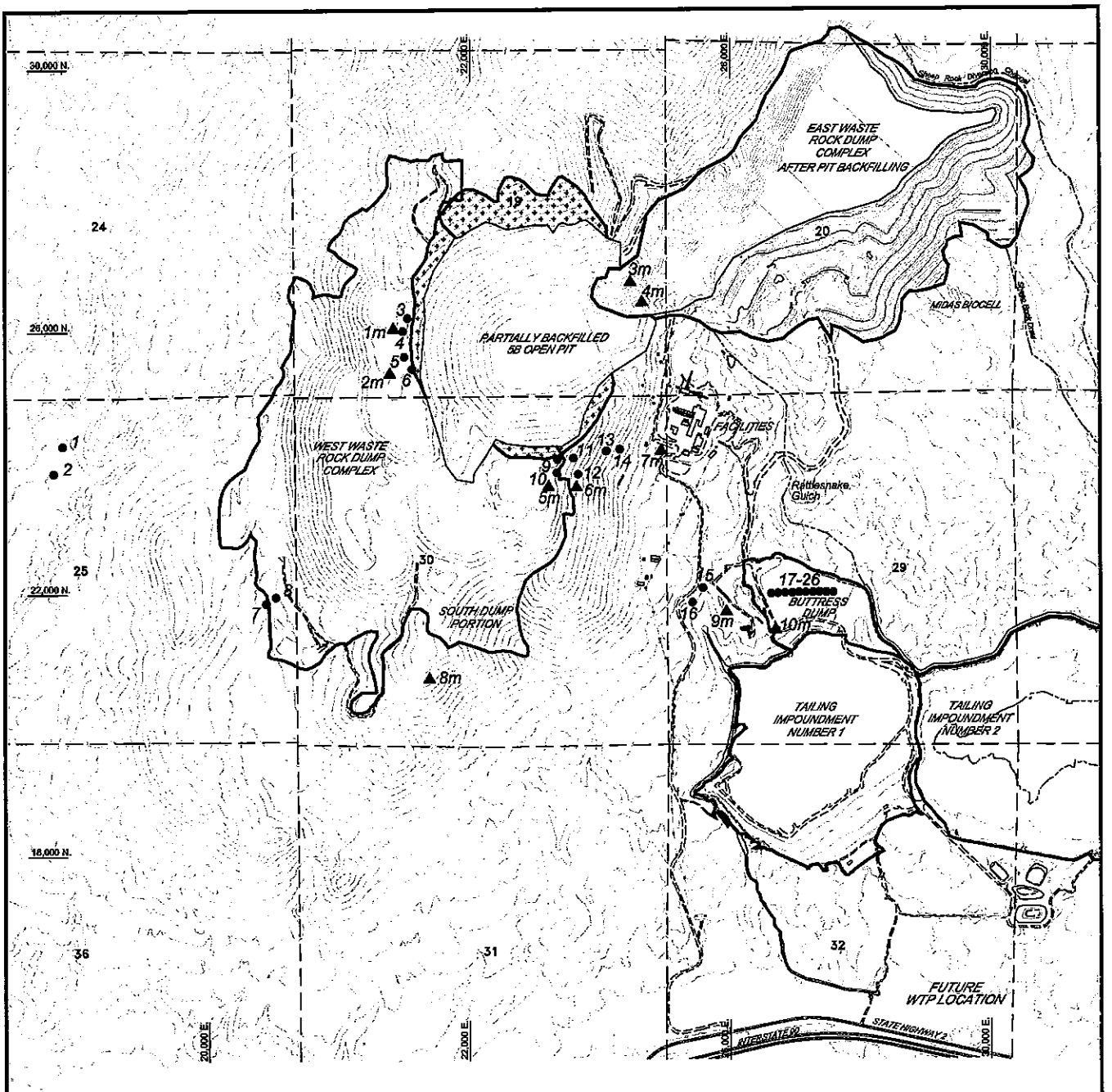
2.4.4.2 Stage 5B Pit Backfill

The backfill plan would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative (see Section 2.4.3.2 above) except that the crusher reject sump would not be constructed in the bottom of the pit.

2.4.4.3 Dewatering and Water Treatment

The Partial Pit Backfill With Downgradient Collection Alternative would rely on a combination of natural attenuation, mixing with ambient groundwater, and collection and treatment to prevent contaminated pit groundwater from impacting groundwater outside of a permitted mixing zone. This alternative would not collect any water inside the perimeter of the pit. The groundwater level in the pit backfill would be allowed to rise and would discharge along natural flowpaths leading to the regional groundwater system down gradient from the pit. Contaminated groundwater from the pit, estimated at 27 to 42 gpm, would mix with ambient groundwater, estimated to range from 52 to 103 gpm, and the resulting combined flow would be collected in a series of 26 or more new capture wells plus the existing wells in the Tailings Impoundment No. 1 south pump back system (Telesto, 2006). These wells would be located down gradient from the pit. Up to 145 gpm of captured water would be pumped to the water treatment plant for treatment prior to release (HSI, 2003; Telesto, 2006).

Conceptual new well locations are shown on Figure 2-7. A hydrogeologic study would be conducted to locate the wells, and GSM would have to submit an application to modify the approved mixing zone.



LEGEND

- New Dewatering Well (1-26)
- ▲ New Monitoring Well (1m-10m)
- Highwall Reduction Area

0 1200 2400
Scale in Feet

Partial Pit Backfill With Downgradient Collection Alternative

POTENTIAL DOWNGRADIENT DEWATERING WELL LOCATIONS

FIGURE 2-7

Figure 2-7 Downgradient_wells.dwg

2.4.4.4 Stability and Safety Concerns

The only difference between this alternative and the Partial Pit Backfill With In-Pit Collection Alternative is that the elevation of the saturated zone in the pit would not be controlled. Highwall stability and safety concerns, as described in Section 2.4.3.4, under both partial pit backfill alternatives would be the same.

2.4.4.5 Surface Water Management

The surface water management plan under this alternative is the same as under the Partial Pit Backfill With In-Pit Collection Alternative (see Section 2.4.3.5 above). Surface water that infiltrates into the pit backfill would be allowed to escape the pit area as groundwater and would be collected down gradient in capture wells.

2.4.4.6 Reclamation Requirements

Reclamation requirements under this alternative are the same as for the Partial Pit Backfill With In-Pit Collection Alternative (see Section 2.4.3.6).

The following table summarizes the pit backfill quantity requirements as well as cover soil, revegetation and dewatering needs of this alternative:

COMPONENT	Quantity	Units
Sump Material	0	cubic yards
Pit Backfill	33,311,000	cubic yards
Cast Blasting & Dozer Rehandle @ 20%	11,900,000	cubic yards
Cover Soil [1]	1,541,800	cubic yards
Diversion Structures	18,600	linear feet
Roadwork	5,550	linear feet
Dewatering System	26+	Wells
Backfill Depth (5,400-4,525)	875	Feet
Pit Area Revegetation [2]	290	Acres
Area Unrevegetated	0	Acres

[1]Cover soil is for 53 acres of flat surface at 3 feet of cover soil and 239 acres of 2H:1V slope at 40 inches of cover soil (slope adjusted).
[2]This includes 218 plan view acres of the pit plus 56 acres of highwall layback plus 18 acres to adjust plan view acres to 2H:1V slope acres minus 2 acres of access roads.

2.4.5 Underground Sump Alternative

The Underground Sump Alternative is similar to the No Pit Pond Alternative described in Section 2.4.2, except no backfill would be placed in the pit and the underground workings would be improved and maintained for continual pit dewatering.

2.4.5.1 Underground Mine Closure

An underground sump pit dewatering system has been employed at GSM during two phases of underground mining beginning in July 2003. During Stage 5B mining, if water collects in the pit bottom, it would be drained into the underground workings through drill holes that intercept the underground workings from the bottom of the pit. Water collected in the underground sump would then be pumped out of the pit to the water treatment plant. Under the Underground Sump Alternative, after the Stage 5B Pit is finished, modifications would be made to the underground workings to improve their function as a continuing underground sump. At closure, water collected in the underground sump would continue to be pumped to the water treatment plant.

The portal enters the pit highwall at an elevation of 4,857 feet. The first phase of underground mining ended in January 2004. The second phase of underground mining was approved in August 2006. The underground mine consists of approximately 3,000 feet of development drifts and various stopes from which ore was removed. GSM started backfilling the stopes from the first phase of underground mining in 2006. Three stopes have been backfilled to date (Shannon Dunlap, GSM, personal communication, 2006). The current mine plan for the 5B Pit includes mining a safe distance from the underground stopes, backfilling the stopes where practicable, and then mining through the stopes (Shannon Dunlap, GSM, personal communication, June 21, 2004). Major portions of the underground workings, including the phase one portal, would be mined out during Stage 5B mining. The second phase of underground will add 12,000 feet of underground development and additional portal sites at elevations of 4875 feet, 4840 feet, and 4,620 feet. About 320 feet of additional underground development and a new portal at the 4,550-foot elevation would be required to prepare the underground mine for permanent use in the dewatering system (Section 2.4.5.3).

2.4.5.2 Stage 5B Pit Backfill

Under the Underground Sump Alternative, no backfill would be placed in the bottom of the pit.

2.4.5.3 Dewatering and Water Treatment

After closure of the pit, precipitation could collect in the pit by falling directly into the pit and by infiltrating into the fractured highwall and flowing to the pit bottom as is occurring during active mining. A groundwater dewatering system would be designed and constructed to maintain the groundwater level below the final 4,525-foot pit bottom

elevation. At least initially, the two vertical highwall wells (PW-48 and PW-49) would also be operated (Figure 2-7).

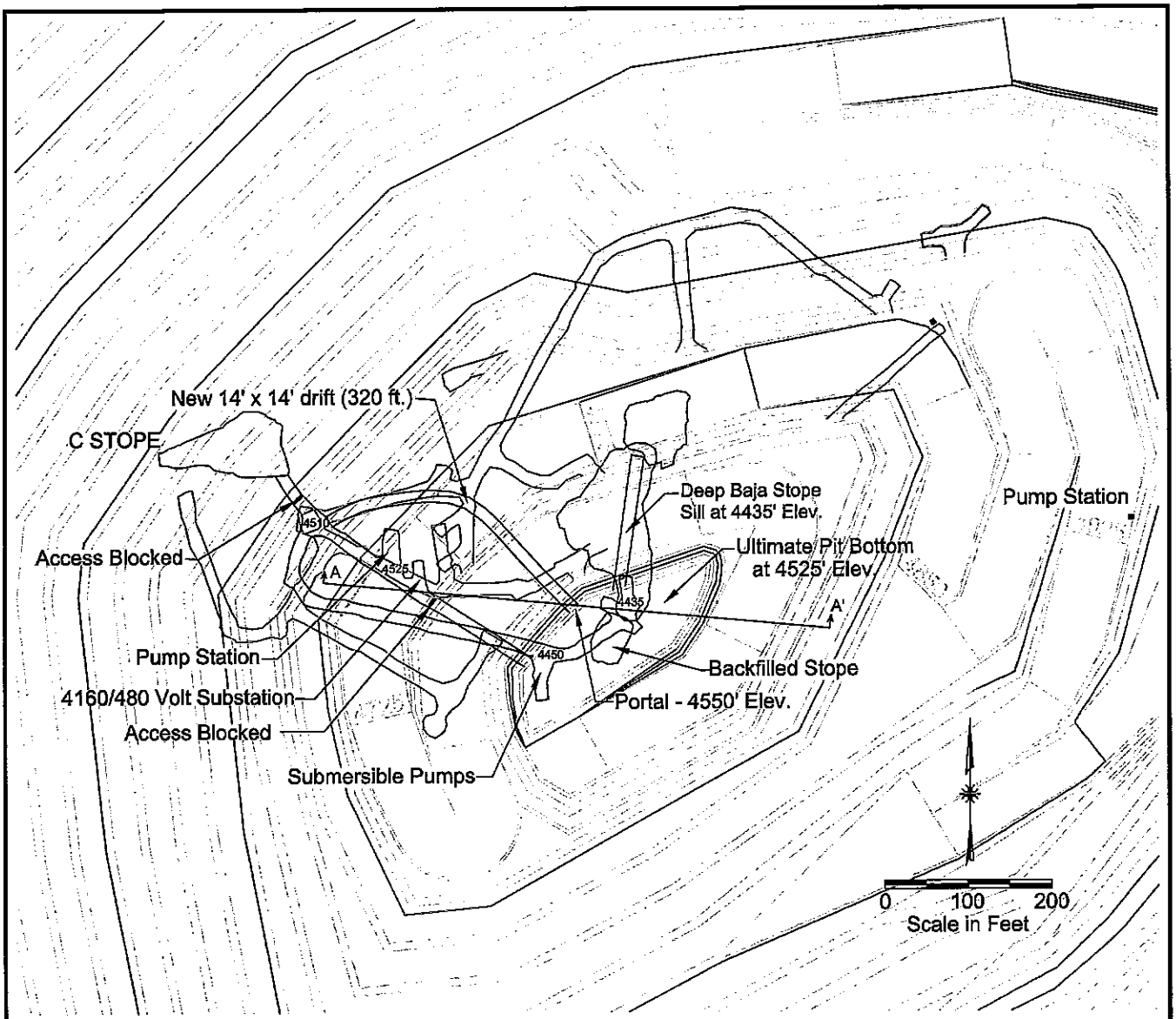
Access to the underground workings would be through the new 4,550-foot-elevation portal. The dewatering system would use the existing 14-foot-wide by 14-foot-high underground access tunnel between the 4,450-foot elevation and the 4,500-foot elevation as a sump, which has a total of 500,000 gallons of surge capacity. Submersible pumps at the 4,450-foot elevation would feed station pumps located in a cross-cut at the 4,525-foot elevation. At least one booster pump station at approximately the 5,000-foot bench would be required to provide the necessary lift to carry water out of the pit. Pumps and fittings would be stainless steel, and pipe would be HDPE pipe with sufficient wall thickness to contain the pressure developed within the dewatering system.

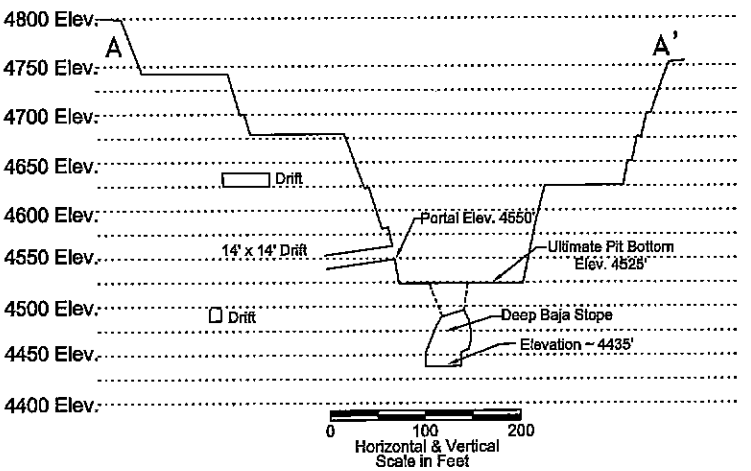
In order to dewater the GSM pit using the underground workings as a permanent sump, the following development and construction work would be required (GSM, personal communication, 2003):

- Installation of a 4,160-volt power line into the pit bottom at the 4,550-foot elevation;
- Construction of a portal at the 4,550-foot elevation in the Stage 5B Pit;
- Construction of 320 feet of 14-foot-wide by 14-foot-high access tunnel to meet the existing underground workings;
- Installation and upgrade of ground support in 1,000 feet of underground workings;
- Installation of an auxiliary fan and 900 feet of fiberglass ventilation duct;
- Blockage of the existing underground road in two locations;
- Installation of a substation to drop voltage from 4,160 to 480 volts;
- Installation of submersible pumps at the 4,450-foot elevation;
- Installation of centrifugal station pumps at the 4,525-foot elevation; and,
- Distribution of 480-volt power to pumps and fan.

Figure 2-8 shows the conceptual dewatering system for the Underground Sump Alternative after completion of Stage 5B.

Submersible pumps equipped with electronic sensors would be installed to maintain optimum drawdown of the water table. The discharge lines would be manifolded into a common conveyance pipe that would carry the water to the water treatment plant. Based on the proposed pit bottom at the 4,525-foot elevation, the submersible pumps would be placed approximately 75 feet below the pit bottom to provide an emergency underground storage capacity of approximately 4,000,000 gallons. Once the system is tested and on line, water would be pumped regularly to maintain the water level below the pit bottom.





EXAGGERATED VIEW
OF BOTTOM 300 FEET
OF PIT

Note:
The 4857 Portal will be mined out during Stage 5B.

See Figure 2.4 for Complete Pit Cross Section.

Underground Sump Alternative

UNDERGROUND SUMP DEWATERING PLAN AFTER STAGE 5B

FIGURE 2-8

Figure 2-8 Pumpstation.dwg

Data collection from the active pit dewatering program indicates that 25 to 27 gpm of water would have to be removed from the underground workings on an annual basis (GSM, personal communication, 2003; Telesto, 2006).

The quality of water extracted from the underground workings is expected to be similar to that observed for the current seeps. Based on the corrosion calculations conducted in support of the SEIS, pump system components made from plastic and stainless steel would be required (Gallagher, 2003b; Telesto, 2003e).

2.4.5.4 Surface Water Management

Surface water would be managed the same under this alternative as under the No Pit Pond Alternative described in Section 2.4.2.5.

2.4.5.5 Stability and Safety Concerns

Pit highwall stability and safety concerns for workers needing access to the 4,550-foot-elevation portal under the Underground Sump Alternative would be nearly the same as under the No Pit Pond Alternative described in Section 2.4.2.4. In addition, the underground workings and dewatering system would have to be maintained.

2.4.5.6 Reclamation Requirements

The reclamation requirements under the Underground Sump Alternative would be nearly the same as under the No Pit Pond Alternative, except no backfill would be placed in the pit bottom as a sump.

The following table summarizes the pit backfill quantity requirements as well as cover soil, revegetation and dewatering needs of this alternative:

COMPONENT	Quantity	Units
Sump Material	0	cubic yards
Pit Backfill	0	cubic yards
Cover Soil [1]	285,600	cubic yards
Diversion Structures	0	linear feet
Wells	0	Wells
Underground Entry	320	Feet
Backfill Depth (4,525)	0	Feet
Pit Area Revegetation [2]	59	Acres
Area Unrevegetated [3]	159	Acres

[1]Cover soil is for 59 pit acres at 3-foot thickness on flat surfaces.
[2]This includes 52 acres of pit roads, floor and benches and 7 acres already reclaimed.
[3]This includes 218 pit acres disturbed less 59 acres revegetated.

2.5 ALTERNATIVES CONSIDERED AND DISMISSED FROM DETAILED ANALYSIS

2.5.1 Introduction

Seven alternatives were developed and evaluated. Three of the alternatives were dismissed from detailed consideration in the SEIS due to environmental or technical concerns. Although the alternatives were dismissed, many technical analyses were completed for these alternatives and can be found in the Technical Memoranda prepared in support of the SEIS (Telesto, 2003a, 2003b, 2003c, 2003d, 2003e, 2003f, 2004; HSI, 2003; Robertson GeoConsultants, 2003; Gallagher, 2003c). The three dismissed alternatives are described below.

2.5.2 Partial Pit Backfill Without Collection Alternative

Like the Partial Pit Backfill With In-Pit Collection Alternative and the Partial Pit Backfill With Downgradient Collection Alternative, this alternative would backfill the pit to a free-draining surface at approximately the 5,350-foot elevation and reduce the pit highwall above that elevation to 2H:1V slopes. However, the Partial Pit Backfill Without Collection Alternative was developed to evaluate the possibility of avoiding long-term pit water collection and treatment. Under the Partial Pit Backfill Without Collection Alternative, wells would not be installed through the backfill and water would not be collected and treated. Natural attenuation and mixing of contaminated pit groundwater with ambient groundwater would be relied on to meet groundwater quality standards at the mixing zone boundary. This alternative would rely on the concept that over time waste rock used to backfill the pit would become less permeable than the surrounding rock. As a result, less water would flow through the pit. Consequently, maintaining the backfilled pit as a hydrologic sink might not be necessary and pit water treatment may not be necessary.

Currently, GSM has a site-wide mixing zone extending to the southern permit boundary for contaminated water from the waste rock dump complexes, Tailings Impoundment No. 1, and the water treatment plant's percolation pond (1998 Final EIS, Appendix 1, Figure 1). Pit discharge is not included in the mixing zone, so GSM would have to apply for a mixing zone modification to accommodate discharge from the pit. The current mixing zone boundary was used for the evaluation of this alternative.

After backfilling, the groundwater level in the pit would slowly rise, saturating the backfill. The pit would no longer be maintained as a hydrologic sink, and eventually the groundwater within the backfill would establish a hydrologic equilibrium with the natural groundwater system around the pit. Based on the water balance performed for the SEIS, seepage of groundwater from the pit backfill would begin approximately 21 years after mining ceases (Telesto, 2006). An equilibrium pit groundwater elevation of 5,260 feet was predicted to be reached approximately 61 years following the cessation of

mining (Telesto, 2003a and 2006). The discharge rate from the pit was predicted to be from 27 to 42 gpm.

As the groundwater level rose in the pit backfill, it would migrate into fractures, faults and other geologic structures in the bedrock forming the pit highwall. When the groundwater rose, it would seep east along and across the structures, beneath the low point on the eastern rim of the pit, into the Tertiary debris flow (Tdf)/colluvial aquifer (URS, 2001). This is identified in Section 3.3.1.4 as the primary pit flowpath (HSI, 2003). The Tdf/colluvial aquifer is a buried gravel deposit forming a continuous pathway from the east side of the Range Front Fault, through Rattlesnake Gulch, where it blends with alluvial gravel deposits beneath Tailings Impoundment No. 1, reaching to the Jefferson River alluvial aquifer (Chapter 3, Section 3.3.1.5; and HSI, 2003). The existence and extent of the Tdf/colluvial aquifer flow path was mapped from geologic data in a number of detailed studies conducted by GSM and its consultants for a variety of purposes since 1985 (SHB, 1985 and Golder, 1995a) (see Figure 3-8). The pit flow path connecting to the Tdf/colluvial aquifer was evaluated for this SEIS (HSI, 2003).

Analysis of the geology and hydrogeology of the pit and surrounding bedrock indicated that secondary flow paths consisting of faults, fractures and other geologic structures could also provide pathways for seepage from a backfilled pit (HSI, 2003). These structures exit the pit in all directions. These same structures provide the pathways for the seeps and springs discharging into the pit during mining (Gallagher, 2003b). They are called secondary because:

- Their extent and continuity outside the pit may be limited or not completely mapped;
- Their hydrologic connection to existing surface water or groundwater features may be indirect; or,
- Their importance is inferred primarily by association with ferricrete deposits or high yield wells, which provide indirect evidence of a pathway.

The agencies assumed that less than 10 percent of the pit water would likely flow south along the Range Front Fault and other secondary flow paths. The 10 percent estimate is an assumption based on the consensus of several scientists working on this SEIS. The rationale for the less than 10 percent estimate is as follows:

The Sunlight Vein, Sunlight and Range Front faults, and the Corridor Fault create complex fault zones located on the eastern side of the pit. As water exits the pit, it would flow both along and out of these structures. Water that reaches Tertiary debris flow sediments will migrate into the primary flow path. The tendency for groundwater to flow preferentially either through any structures or into the Tertiary sediments is controlled by the relative ability of the materials to transmit water.

Studies have produced potentiometric maps that have included the Range Front Fault (Golder, 1995a; HSI, 2003; URS, 2001). All maps indicate that groundwater flows in a

southeasterly direction. Water that crosses the fault zones will migrate into the Tertiary sediments. Water that stays in the fault zones would likely migrate southward. The hydraulic gradient between monitoring well PW-12, which is located on the east side of the fault near the east entrance to the pit, and PW-4, which likely intersects the Range Front Fault to the south, is approximately 0.013 foot/foot (*i.e.*, a vertical drop of 13 feet for every 1,000 feet of movement along the flow path) (Figure 3-8). The hydraulic gradient between PW-12 and PW-8 is approximately 0.037 ft/ft.

Considering these gradients, the transmissivity of the Sunlight and Range Front faults would have to be substantially greater than that of the surrounding rocks, or the faults would have to have relatively continuous impermeable zones acting as hydraulic barriers, in order for preferential flow to occur along the fault. Evidence of both is present in the pit area. There is a permeability contrast across the Sunlight and Range Front faults, evidenced by an abrupt change in groundwater level of 130 feet from the bedrock aquifer to the Tdf/colluvial aquifer (URS, 2001). This permeability contrast suggests either that the fault is acting as a hydraulic barrier or that there is a permeability contrast between rock types (URS, 2001). Geologic evidence in PW-64 indicates the permeability contrast in the Range Front Fault in this vicinity results from differences in rock types rather than structures. This conclusion supports contrasting permeability measurements in the bedrock and Tdf/colluvial aquifers (GSM, 1995; Hydrometrics, 1995). Hydraulic barriers are also present in the pit area as indicated by the change in oxidation state across the Wegner Fault, an early stage of range front faulting. The complex nature of the faulting along the range front strongly suggests that the presence of both permeability contrasts and impermeable zones have and will continue to influence the direction of groundwater flow.

Pit seep monitoring indicates that, between 1995 and 2001, GSM identified two seeps on the south pit highwall (Gallagher, 2003). The maximum measurable flow observed from these seeps was 0.75 gpm, with the majority of measurements recorded as "wet." The flow from seeps on the south highwall is expected to be 1 to 3 gpm. The observed flows occurred under the influence of a large hydraulic gradient created by the dewatered pit. If the hydraulic gradient is reversed in a backfilled pit such that groundwater moves out of the pit along structural pathways, the magnitude of the gradient away from the pit would likely be less than the gradient toward the pit. Potential outflows from the pit along the south highwall would likely be substantially less than 4.2 gpm.

Flow in fractured bedrock is complex and predicting where groundwater will flow is difficult. The majority of water would flow out of the pit via the Tdf/colluvial aquifer. It is estimated that a maximum of 4.2 gpm would flow out of a saturated pit via secondary flow paths in a variety of structures and locations. This is 10 percent of the total pit outflow under the Partial Pit Backfill With Downgradient Collection Alternative.

A groundwater mixing model was developed for the primary pit flow path from the pit to the Jefferson River alluvial aquifer (Telesto, 2003e). The model included mixing with ambient groundwater in the Tdf/colluvial aquifer and from precipitation. Due to the

naturally acidic groundwater and coarse texture of the Tdf/colluvial aquifer beneath Rattlesnake Gulch, attenuation is probably minimal, and thus was not included in the model. This analysis indicated that primary groundwater quality standards for cadmium, copper, nickel and zinc, and secondary standards for sulfate and manganese would be exceeded at the current mixing zone boundary at the Jefferson River alluvial aquifer (Telesto, 2003e). Thus, compliance with groundwater quality standards could not be achieved without capture and treatment.

Analysis found that groundwater in a backfilled pit would also migrate along secondary pathways such as faults, fractures, and other geologic structures in the bedrock (HSI, 2003). There is no natural attenuation capacity, or ability to reduce the metals concentrations, available in the bedrock (Schafer and Associates, 1996). If collection and treatment are added to remedy this deficiency, this alternative becomes the same as the Partial Pit Backfill With Downgradient Collection Alternative. Consequently, this alternative was dismissed because compliance with groundwater quality standards could not be reliably assured without downgradient or in-pit collection of contaminated groundwater.

The reclamation requirements for the Partial Pit Backfill Without Collection Alternative would be the same as the Partial Pit Backfill With Downgradient Collection Alternative.

2.5.3 Partial Pit Backfill With Amendment Alternative

The Partial Pit Backfill With Amendment Alternative was developed to try to avoid the need for long-term pit water collection and treatment. Like the Partial Pit Backfill With In-Pit Collection and Partial Pit Backfill With Downgradient Collection alternatives, this alternative would backfill the pit to a free draining surface at approximately the 5,350-foot elevation and would reduce the pit highwall above that elevation to 2H:1V slopes. In this alternative, the chemical and the physical properties of the backfill would be conditioned to minimize groundwater flow and to prevent the generation of ARD through in-situ neutralization. The addition and mixing of sufficient lime to the acidic waste rock could increase the pH of the pore water, providing a less favorable environment for pyrite oxidation and/or minimizing metals mobility. Lime would be a mixture of calcium carbonate and calcium oxide mixed to DEQ specifications for lime amendment for waste rock (DSL, 1990). The goal would be to minimize the contaminant load that would be generated and transported in seepage from the pit, allowing compliance with applicable groundwater quality standards at the mixing zone boundary.

In this case, all material used to backfill the pit to a free-draining surface (33,300,000 cubic yards) would be hauled into the pit, placed in 2-foot lifts, and amended with lime at the rate of 200 tons of lime per 1,000 tons of waste rock backfill. This amendment rate would have about twice the neutralization potential needed for the waste rock backfill. Cast blasted and other backfill placed above the daylight level would not be amended.

The amended backfill would be constructed in lifts in the following sequence:

- Waste rock would be hauled from the East Waste Rock Dump Complex down into the pit;
- Waste rock would be dumped and spread in 2-foot-thick lifts;
- Lime would be hauled into the pit;
- Lime would be spread evenly over the top of the active backfill lift;
- Lime would be ripped into the backfill; and,
- The amended backfill would be compacted.

Backfill above the daylight level would be placed as described in the Partial Pit Backfill With In-Pit Collection Alternative. Compaction of the backfill placed below the free-draining grade would reduce the permeability of the backfill, which would restrict groundwater movement into and through the amended waste rock. A relatively low permeability plug of amended waste rock would be constructed within the pit.

Evaluation of this alternative revealed potential problems. Evidence was not found of cases where lime amendment of strongly ARD-generating rock or waste material was completely successful in controlling ARD production over a long period of time (Gallagher, 2003c). Some of the problems with lime amendment of ARD material could include:

- Lime amendment of ARD-impacted soils has been shown to be effective in surface reclamation, but not in a mass of waste rock as large as the GSM pit backfill.
- The chemical benefits of lime amendment may be short-lived, since some of the potentially reactive lime tends to become encapsulated by secondary mineral deposits of gypsum and hydroxides, rendering it ineffective in maintaining a non-acidic pH.
- The precipitation of secondary minerals from neutralization reactions would occur, but could not be counted on to form a complete low-permeability plug throughout the waste rock backfill.
- Locally, the formation of low permeability layers in the amended material due to plugging of pore spaces by iron hydroxide precipitates could lead to perching of groundwater recharge and ineffectual in-situ treatment by the amendment (Sonderegger and Donovan, 1984).
- Even if lime amendment would effectively maintain a nearly neutral pH, some contaminants, such as arsenic, selenium, sulfate and zinc, would remain mobile or could become more mobile under these conditions and would be available for groundwater transport out of the pit.
- The incorporation of the lime with the waste rock by ripping is not a perfect mixing process, resulting in many localized spots of ARD generation, which may be mobilized by groundwater (Dollhopf, 1990; Spectrum Engineering, 1996).

A pit backfill analog study did not find any cases, successful or unsuccessful, of mine reclamation programs using amended pit backfill (Kuzel, 2003; Gallagher, 2003c). Most

mines do not have enough backfill history to draw any conclusions. Since the evidence did not support the premise that ARD production and migration from amended backfill could be controlled, seepage of ARD from the backfilled pit could occur. The process through which ARD from a backfilled pit migrates down the primary and secondary groundwater flow paths is described in Section 3.3.7.2. Analysis indicated that, without downgradient groundwater capture, compliance with groundwater quality standards for arsenic, selenium, sulfide, and zinc could not be reliably assured (Telesto, 2003e).

A safety risk was identified for construction workers attempting to implement this alternative because all backfill material below the daylight level would have to be hauled down into the pit via a steep road rather than being end dumped at the 5,400-foot elevation. While the addition of lime would neutralize the acidic quality of the mine waters for some period of time, it would also increase the mobility of other problem metals such as arsenic and zinc, potentially resulting in other environmental consequences (Gräfe et al., 2004). Due to the groundwater quality risk associated with this alternative and the high level of uncertainty, it was dismissed from further consideration.

The reclamation requirements for the Partial Pit Backfill With Amendment Alternative would be the same as the Partial Pit Backfill With Downgradient Collection Alternative, except that about 10,000,000 tons of lime would be needed. This lime would have to be mined or purchased from regional suppliers and hauled to the site.

2.5.4 Pit Pond Alternative

The possibility of creating a pit pond with biologic treatment was analyzed. The objective would be to design a pond that could sustain aquatic life and provide beneficial uses once it was developed. In the Pit Pond Alternative, the pit would passively fill with precipitation, groundwater, and runon water flowing into the pit. The design objectives would be to construct a pit pond that would remain as stable as possible year-round and to treat the water in the pit with microbes, nutrients, etc. As presently understood, a steady-state pit pond 110 feet deep would have a pool elevation of approximately 4,635 feet and would have roughly 30,000,000 gallons of storage (Telesto, 2003a).

The physical and chemical evolution of the pit pond would be monitored as the filling occurred. Depth profiles for temperature and electrical conductivity would be determined from sampling stations in the pit pond. The sample locations would be chosen to determine the effect of acid water on the electrical conductivity profile. During winter months, the freezing and thawing of the pond surface would be monitored. Samples would also be collected for various chemical analyses. Climate data would be collected with an on-site weather station. These data would be used to assist in modeling efforts and planning.

Design of the pit pond would involve applying scientific knowledge and engineering concepts to develop a final closure plan. Design work would consist of reducing

uncertainties involved with the pit pond and gaining an understanding of the mechanisms that would operate in the pit pond. Some test work has been completed on this concept. But, the necessary work required to propose an in-situ treated pit pond is not complete at this time. As a result, a contingency to pump and treat water would be needed to drain the pond as in the Underground Sump Alternative.

Due to the lack of detailed studies to support such an action and the current uncertainties of success associated with a pit pond, the in-situ treatment concept could not be fully developed. Consequently, the pit pond concept was modified to incorporate a minimal pit pond with pumping and external water treatment.

2.5.4.1 Pit Pond With Pump and Treatment Alternative

The Pit Pond With Pump and Treatment Alternative is a no pit backfill option that has the objective of creating a pond of water inside the pit. The quality and level of the water allowed to accumulate in the pit would be managed by pumping from the pond in the pit as it forms, treating this water in the water treatment plant, and then recirculating treated water back into the pond to keep the water quality at an acceptable level. Because this concept would need to be tested in practice, a fully functional contingent underground sump collection and removal system would have to be made available to empty the pond and treat the water in case this alternative failed to provide adequate groundwater protection, as in the Underground Sump Alternative.

The pumping capacity would be designed to accommodate 65 gpm of water from the pit. Pumps could be stationed on a floating barge or inside the underground workings. If it became necessary to dewater all of the underground workings, a portable submersible pump could be advanced down the underground workings. In any case, some modification of the underground mine would be necessary to accommodate the pit pond. This might include constructing a new portal at an alternative elevation. Also, portable substations, fans, and pumping equipment would need to be removed from the sections of underground workings that would be below the pond elevation. HDPE pipes would be left in place.

Under the pump and treat concept, the water level in the pit would be kept as low as possible. Although a design water level was not determined for this concept, it would be well below the elevation of 4,635 feet, the point where evaporation would keep the pond at a steady state. If treated water from all sources was returned to the pit, it would take approximately five to six years for the water level to reach the steady-state elevation of approximately 4,635 feet (Telesto, 2003e).

The water quality of the pond would initially be similar to that observed for the current seeps. If water were left in the pond for long periods of time, evaporation would concentrate constituents. Thus, a pumping rate that balances inflows and evapoconcentration effects would be desired, but this would depend on the chosen treatment option. This pumping rate could be adjusted to meet a certain water quality

desired for the treatment plant. Based on the corrosion calculations completed, pump system components made from plastic and stainless steel would be required.

Under the Pit Pond Alternative, the pit would remain a hydrologic sink above the pond elevation without the potential problems associated with constructing and operating a pumping system in acid producing backfill. However, even under this alternative, wells and drains in the highwall might still be used to target dewatering zones.

A water balance calculated for the pond was similar to that calculated for the No Pit Pond Alternative (Telesto, 2003a). Based on the water balance, the pond elevation would be well below the 5,050-foot elevation, which is the lowest contact with the Sunlight Fault and the point where water would be expected to begin escaping from the pit. No seepage out of the pit would be expected if the pond elevation were at the 4,635-foot level (Telesto, 2003a and 2003e).

There were concerns with this alternative which could not be addressed without actual field experimentation, data collection and additional technical analysis, including:

- The treated water returned to the pit could re-acidify.
- The equilibrium pit water level could fluctuate seasonally and annually and with cycles in weather.
- The continuing influx of acid salts from highwall runoff and the concentration effect from evaporation could affect the ability to maintain a treated pool.
- Given the uncertainties with the water chemistry and treatment capacity, applicable water quality standards might not be met.
- A contingency plan to improve the underground workings to dewater the pit would be needed.

Precipitation and groundwater that come into contact with the pit rock quickly acidify and become ARD. However, no studies have been performed on the interaction between treated water and the pit rock. The filling of a pit by groundwater would be a dynamic process involving the specific geometry of the pit, uncertain water chemistry, and rates of change in several other parameters.

Slope stability analyses show that the highwall would not be susceptible to mass failures under the conditions imposed by this alternative. Highwall stability would be the same as for the Underground Sump Alternative or No Pit Pond Alternative.

Reclamation requirements would be the same as for the Underground Sump Alternative.

The Pit Pond With Pump and Treatment Alternative has no clear advantage over the Underground Sump Alternative. At this point, without further technical review, any pond concept could only be considered by the agencies on a trial basis. Consequently, this alternative was dismissed.

2.6 RELATED FUTURE ACTIONS

Related future actions and impacts are discussed in Cumulative Impacts Section 4.7.

2.7 WATER TREATMENT AND CONTROL APPLICABLE TO ALL ALTERNATIVES

2.7.1 Collection and Treatment of Contaminated Groundwater

A water treatment system design was analyzed in the 1997 Draft EIS, Appendix A and approved in the 1998 ROD. Although quantities of water and the degree of contamination may vary between alternatives, all options require long-term measures to collect and treat contaminated groundwater, which either flows through or originates in the area of the mined-out pit. All alternatives carried forward in this SEIS have provisions for a capture system with pumps and pipes to collect water and convey it to the treatment plant. The projected reliability and effectiveness of the groundwater capture systems vary among the alternatives.

The 1997 Draft EIS, Chapter IV, Sections IV.B.7.b and IV.B.6.b estimated that 50 to 102 gpm of pit water would need to be captured and treated. In the SEIS, projected collection and treatment rates range from 25 to 42 gpm for alternatives involving capture within the pit (Telesto, 2006). Capture rate requirements for the Partial Pit Backfill With Downgradient Collection Alternative would be higher, due to the collection of an additional 52 to 103 gpm of ambient groundwater. The collection rate for the Partial Pit Backfill With Downgradient Collection Alternative would be in the range of 79 to 145 gpm (Telesto, 2006).

2.7.2 Water Treatment Plant

In all alternatives, water treatment would be required. The water treatment facility has already been permitted. In addition, GSM has posted a bond with the agencies for long-term water treatment. Although water treatment facilities with capacity to treat approximately 100 gpm currently exist in the mill building, GSM intends to replace this facility with a new water treatment plant after the mine closes. As reported in the 1997 Draft EIS, Map I-2, the new treatment plant would be located south of Tailings Impoundment No. 2 and would be designed to treat 102 gpm from the pit area (Figure 2-7).

2.7.3 Surface Water Management

GSM manages storm water runoff on site with lined and unlined diversions that route water around mine facilities, and with berms and swales that promote infiltration of runoff into the ground. All alternatives would employ provisions to divert surface water around the pit area, whether it is backfilled to a free-draining configuration or left open. Diversions constructed on acid-producing materials would be lined.

As part of the final reclamation of the site, GSM would construct permanent storm water controls. Erosion and sedimentation controls would be designed and implemented where necessary. The erosion and sedimentation control plan would consist of settling ponds and a network of associated collection and diversion channels (GSM, 1995b).

2.7.4 Monitoring

The water resources monitoring program currently in place (GSM 2006 Annual Report) would be modified at the end of mining, in coordination with DEQ and BLM. Facility-specific monitoring includes:

- Tailings Impoundment No. 1 seepage containment systems;
- Tailings Impoundment No. 1 and No. 2 area wells;
- Pit and waste rock dump complex area wells and seeps;
- Springs and surface water;
- Private residence wells; and,
- Diversion inspections.

Reclamation monitoring includes:

- Cover thickness evaluation;
- Revegetation success monitoring, including noxious weeds;
- Erosion monitoring; and,
- Steam vent monitoring.

2.7.5 Permanent Remediation Staff

All of the alternatives that have been evaluated require perpetual site staffing to monitor, operate, and maintain the water capture and treatment facilities, diversions and other erosion controls, revegetation success, weed control, etc. The permanent staff would range from 2 to 5 employees, depending on the alternative selected.

2.7.6 Return Diversion

The 1998 ROD approved the No Pit Pond Alternative in combination with the Return Diversion Alternative for the East Waste Rock Dump Complex. The diversion has already been constructed. Hence, the Return Diversion Alternative will be common to any of the pit closure alternatives.

Under the Return Diversion Alternative, Sheep Rock Creek is being diverted around the east end of the East Waste Rock Dump Complex and then reconnected with the unnamed tributary to the north on the east side of the dump (Figures 1-2 and 2-5).

2.8 SUMMARY OF IMPACTS FOR ALTERNATIVES

A detailed evaluation of impacts resulting from the Proposed Action and alternatives is provided in Chapter 4. Table 2-2 summarizes and compares the impacts of each alternative considered.

Table 2 - 2. Summary Comparison of Impacts Under the Proposed Action and Alternatives

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Technical Issues				
Design & constructability of the alternative				
Proven design	Backfilling with 111,000 cubic yards of crusher reject to a depth of 100 feet is a proven design. Dewatering this volume of material to a depth of 100 feet is a proven design.	Backfilling with 33 million cubic yards of acidic waste rock and cast blasting and dozing the highwall to a 2H:1V slope is technically feasible. Dewatering waste rock backfill from a depth of up to 875 feet has not been proven.	Similar to Partial Pit Backfill With In-Pit Collection Alternative. Pumping out of downgradient drainages in natural geologic formations up to 200 feet deep is done regularly, but the objective of overall 96 percent capture may not be achievable Based on their experience, the agencies believe a maximum capture efficiency of 80% per system is potentially achievable.	Not applicable. Maintaining hydrologic connection between the pit bottom and an underground sump 25 to 75 feet below the pit and pumping from the sump have been done successfully at GSM and other mines.
Design & constructability of the alternative				
Ability to construct the alternative at GSM	Problems with constructing this alternative would be minimal.	There would be more problems developing and implementing this alternative than the No Pit Pond Alternative because of the larger volume and depth of backfill needed, the amount	There would be more problems developing and implementing this alternative than the No Pit Pond Alternative because of the larger volume and depth of acidic backfill needed and the amount of cast blasted material	GSM has developed and maintained an underground mine, including an underground sump connected to the open pit.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
		of cast blasted material, and the problems drilling dewatering wells in up to 875 feet of unconsolidated waste rock in order to maintain the pit as a hydrologic sink.	required. Installing dewatering wells in downgradient drainages in natural geologic formations up to 200 feet deep has been done successfully at GSM.	
Pit highwall				
Pit highwall stability	Some portions of the pit highwall would be subject to raveling, talus formation, erosion, and limited sloughing. The overall stability of the pit highwall would be expected to increase over the long term as the rock materials achieve a more stable configuration.	No pit highwall would remain exposed. Backfilling the pit would eliminate pit highwall raveling and sloughing. Cast blasting would enhance the inherent stability of the pit highwall by reducing the slope to 2H:1V. The long-term stability of the pit highwall would be greater than the No Pit Pond Alternative.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative.
Pit highwall maintenance requirements	Raveling and sloughing of the highwall would require periodic maintenance to re-establish the 5,700-foot-elevation safety bench, clear the access road, haul more backfill to create a new working surface in the pit bottom, and move rock to re-establish safety berms. This could occur more than once over the long term.	No highwall maintenance would be needed.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative. Depending on the location of highwall raveling and sloughing, access to the 4,550-foot portal and the underground dewatering system could be lost. The 5,700-foot safety bench and access to the 4,550-foot portal would have to be re-established.
Backfill				
Backfill maintenance requirements	Settling in 100 feet of crusher reject would be	Up to 150 feet of settling could occur in the 875 feet of	Up to 200 feet of settling could occur in the 875 feet of backfill	Not applicable.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	limited to 10 feet. Repairs would be needed to bring the crusher reject back to grade.	backfill, with 60 to 75 percent of the settling occurring during the backfilling operation. Repairs would be needed to bring the acidic backfill back to grade. Settling in the acidic backfill would affect storm water diversions on the 2H:1V slopes.	after it is inundated with groundwater. Sixty to seventy-five percent of settling would occur during the backfilling operation. The remaining settling would occur over about 61 years during saturation to the 5,260-foot elevation. Repairs would be needed to bring the backfill back to grade. Settling in the backfill would affect storm water diversions on the 2H:1V slopes.	
	Raveling and sloughing of the highwall would require periodic maintenance to re-establish the working surface and drill new wells.	The highwall would not ravel or slough.	The highwall would not ravel or slough.	Not applicable.
Underground workings				
Impacts to pit facilities due to subsidence related to underground mining	Localized failures of the walls and ceiling over time could result in subsidence, especially in seep and fault areas where chemical weathering would be increased. Subsidence could cause settling in the 100 feet of crusher reject, affecting the dewatering wells in the crusher reject.	Same as the No Pit Pond Alternative. Subsidence could cause settling in up to 875 feet of backfill, affecting the dewatering wells in the backfill.	Similar to the Partial Pit Backfill With In-Pit Collection Alternative, except the dewatering wells down gradient of the pit would not be affected.	Same as the No Pit Pond Alternative, except localized failures of ceiling and walls in seep and fault areas could occur over time, affecting access to the dewatering system in the underground workings.
Groundwater/ effluent management system				
Operation	Two to three wells would	Four wells would be	An additional 26 capture wells	No wells would be

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
requirements (number of wells)	be constructed through the acidic pit crusher reject about 100 feet deep to the bedrock contact.	constructed through the acidic pit backfill up to 875 feet deep to the bedrock contact. Wells would need to be replaced frequently due to corrosion.	and 10 monitoring wells would be constructed down gradient from the pit. This number of wells may not be enough to ensure compliance with groundwater quality standards at the mixing zone boundary.	constructed. Drill holes would be used to direct pit water to the underground sump.
Maintenance of capture points	Settlement of the 100 feet of crusher reject could cause separation, buckling, or shearing of well casings. About 60 to 75 percent of settlement would occur during the backfill operation and 25 to 40 percent over a longer period after backfilling is complete.	Settlement effects on well casings would be more severe than under the No Pit Pond Alternative.	Wells would be constructed outside of the pit and would not be subject to acidic backfill settling.	There would be no backfill to settle and no wells to damage. Rock fall from ceiling and walls of the underground workings could damage the dewatering system.
	Corrosion of the well casings, pumps, electrical components, monitoring equipment and pipelines from the acidic water in the backfill would cause periodic need for repair and replacement of dewatering system components.	Same as the No Pit Pond Alternative.	Short-term buffering by the aquifer and mixing with ambient groundwater would limit corrosion of pumps and screens, providing for longer pump life. After the buffering capacity of the aquifer is used up in a few tens of years, water quality would be similar to the No Pit Pond and Partial Pit Backfill With In-Pit Collection alternatives.	Corrosion would be similar to the No Pit Pond Alternative.
	Highwall raveling and sloughing could damage dewatering wells, monitoring equipment, power lines, and pipelines.	Not applicable.	Not applicable.	Similar to the No Pit Pond Alternative, except the collection system would not be damaged.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	Pumping rates of 25 to 27 gpm at a lift of up to 200 feet would not be a problem. Pumping stations would be used to finish getting the water out of the pit.	Pumping rates of 27 to 42 gpm and the 875-foot lift compared to the No Pit Pond Alternative would cause more pump failure and may cause the need to allow the water table to rebound for pumping efficiency. No pumping stations would be needed.	Similar to the No Pit Pond Alternative. Multiple wells up to 200 feet deep would pump a total of 79 to 145 gpm.	Similar to the No Pit Pond Alternative, except the lift would increase by 75 feet.
	Not applicable.	Not applicable.	Not applicable.	Access to the underground would be needed. Sloughing could bury the 4,550-foot elevation portal blocking access to the dewatering system needed for maintenance.
Storm water runon/runoff management				
Maintenance requirements (drainage channels off 2H:1V slopes)	Diversions on the upper pit highwall would route water away from the pit. Settling of diversions constructed on unconsolidated materials and accumulations of sediment and material sloughed from above would impair diversions' function. Periodic cleaning and repairs would be needed. Eventually, portions of the diversions would need to be reconstructed	Same as the No Pit Pond Alternative, except there would be diversions on the pit backfill.	Same as the No Pit Pond Alternative.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	completely. Not applicable.	Diversions would be constructed on the 2H:1V slopes created by highwall reduction. Settling in the backfill could cause depressions where surface water could accumulate, infiltrate, and saturate the soil cover resulting in localized erosion on the face of the reclaimed slopes. Maintenance requirements for diversions would be the same as for the No Pit Pond Alternative, except there would be more diversions to maintain.	Maintenance requirements would be similar to the Partial Pit Backfill With In-Pit Collection Alternative. More settlement would occur due to saturation of the backfill.	Not applicable.
Soil cover				
Soil cover maintenance requirements (erosion, revegetation)	A 3-foot soil cover would be placed and revegetated on the pit floor, pit benches, and roads, totaling 53 acres. A total of 290,400 cubic yards of soil cover material, from existing sources, would be necessary. Eroded areas would need to be repaired, resoiled, and reseeded. Noxious weeds would have to be controlled.	A 3-foot soil cover would be placed and revegetated on the backfilled pit and reduced highwall, totaling 272 acres. A total of 1,541,800 cubic yards of soil cover material, resulting in an additional disturbance of 31 acres, would be necessary Same as the No Pit Pond Alternative.	Similar to the Partial Pit Backfill With In-Pit Collection Alternative. Same as the No Pit Pond Alternative.	Similar to the No Pit Pond Alternative, except there would be 1.3 fewer acres to maintain in the pit. A total of 285,600 cubic yards of soil cover material, from existing sources, would be necessary. Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	The backfill surface would need to be regraded as the crusher reject settles. Rocks that ravel or slough from the highwall onto revegetated areas would need to be removed. Depending on the volume of rock, regrading, resoiling, and reseeding of reclaimed surfaces may be needed.	Backfill would settle up to 150 feet. More acidic backfill would have to be placed, graded, resoiled, and revegetated.	Backfill would settle up to 200 feet.	There would be no backfill needing cover maintenance.
	No highwalls would be covered with soil.	In localized areas, highwall seeps could saturate the soil cover with acidic water, contaminating soils and impairing revegetation success. The seep would have to be located and dewatered, contaminated soil would have to be replaced with clean soil, and the area would have to be revegetated	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.
Water treatment				
Additional sludge management requirements	Between 25 and 27 gpm of pit water would need treatment.	Between 27 and 42 gpm of pit water would need treatment.	Between 79 and 145 gpm of groundwater would be collected and treated trying to capture 96 percent of the 27 to 42 gpm of pit discharge to meet water quality standards.	Same as the No Pit Pond Alternative.
	The sludge management requirements would be	Weathering would continue to produce oxidation byproducts	Weathering would continue to produce oxidation byproducts	The water produced in the underground workings would

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	similar to or less than estimated in the 1997 Draft EIS.	in the unsaturated backfill. Pumping would limit saturation of the backfill and impacts from jarosite dissolution. More sludge would be produced per gallon of treated water than under the No Pit Pond Alternative, so the sludge management requirements would be similar.	in the unsaturated backfill. Jarosite in the saturated portion of the backfill would, for a time, prevent reducing conditions from developing and allow further production of acid. Jarosite is stable under oxidizing conditions and unstable under reducing conditions. The presence of jarosite in the pit backfill would only influence the oxidation-reduction conditions until it all dissolves. Jarosite would likely dissolve and release metals in the saturated portion of the backfill. Once jarosite completely dissolves, reducing conditions would likely develop in the saturated portion of the backfill. The flow from the unsaturated portion of the backfill above the water table would contribute low pH water with high metals concentrations to the pit discharge for hundreds of years. There is limited natural attenuation capacity along the primary and secondary flow paths from the pit. The sludge management requirements would be about the same as the Partial Pit Backfill With In-Pit Collection Alternative because the chemical mass would be about	be comparable to the water quality in the No Pit Pond Alternative. Because there would be no backfill, jarosite, adsorbed metals, and other oxidation byproducts would remain relatively immobile in the waste rock dump complex. There would be minimal additional sludge.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
			the same.	
Additional operating requirements	There would be no additional water treatment operating requirements. The water treatment system in the SEIS is the same as that evaluated in the 1997 Draft EIS, and there would be less pit water to treat.	Same as the No Pit Pond Alternative.	The water treatment plant could require additional operating cost due to the increased water quantity treated under this alternative. The total amount of water would be less than the permitted treatment plant capacity.	Same as the No Pit Pond Alternative.
Flexibility for future improvements				
Potential for utilization of new technologies	New technology, such as *in-situ* water treatment, would be easier to apply in the less than 600,000 cubic yards of crusher reject and raveled and sloughed highwall rock under the No Pit Pond Alternative than it would be in the larger volumes of backfill under the partial pit backfill alternatives.	New technology, such as *in-situ* water treatment, would be harder to apply in 47 million cubic yards of pit backfill than under the No Pit Pond Alternative. Because of the problems with maintaining wells in acidic waste rock in the deeper backfill, this alternative offers less potential for utilization of new technologies. It would be harder to redesign the dewatering system in up to 875 feet of backfill.	Similar to the Partial Pit Backfill With In-Pit Collection Alternative, except that *in-situ* water treatment would be more difficult because of the lack of wells in the backfill. If treatment were attempted outside of the pit, a dispersed plume may be more challenging to track, contain, and treat *in-situ*.	New technology, such as in-situ water treatment, would be easier to apply in the open water of an underground sump than in backfill.
Environmental Issues				
Impacts to groundwater quality and quantity				
Risk of impacts to groundwater quality	The pit would be maintained as a hydrologic	Same as the No Pit Pond Alternative, except 27 to 42	The pit would not be a hydrologic sink. Two	Same as the No Pit Pond Alternative, except that water

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
and quantity in permit area	sink and between 25 and 27 gpm of pit water would be collected and treated before being discharged. No impacts to groundwater quality from pit outflows are expected.	gpm would be collected and treated.	groundwater capture systems in Rattlesnake Gulch, each operating at an efficiency of 87.5 percent or greater would be required to meet DEQ-7 water quality standards at the mixing zone boundary for the toxic and carcinogenic parameters modeled. The	would be pumped from the underground sump and treated.
	The groundwater level around the pit would be permanently drawn down. This would result in minor reductions in the flows of springs that are hydrologically connected to the pit.	Same as the No Pit Pond Alternative.	standard for iron would be exceeded. This level of capture efficiency may not be achievable. Based on their experience, the agencies believe a maximum capture efficiency of 80% per system is potentially achievable. The groundwater level around the pit would rebound so that the flows of springs that are hydrologically connected to the pit could be increased. Because of the higher pit groundwater elevation, ARD water from the pit could move along secondary flow paths in the bedrock and Bozeman Group aquifers where it is more difficult to detect and collect. Groundwater quality would likely be degraded up gradient of the collection wells where groundwater is already affected	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
			by ARD from natural mineralization and may eventually be impacted from 1-3 gpm of the East Waste Rock Dump Complex seepage in Rattlesnake Gulch. The potential for creating new springs or affecting water quality of existing springs is higher than under the other alternatives.	
Risk of violation of groundwater standards at permit boundary and impacts to beneficial uses of the Jefferson River alluvial aquifer	Groundwater quality standards would be met at the mixing zone boundary. Beneficial uses of the Jefferson River alluvial aquifer would not be affected.	Compliance with water quality standards at the mixing zone boundary may not be achievable long-term.	Two groundwater capture systems in Rattlesnake Gulch, each operating at an efficiency of 87.5 percent or greater would be required to meet DEQ-7 human health standards at the mixing zone boundary for the toxic and carcinogenic parameters modeled. The DEQ-7 standard for iron would be exceeded. The required capture efficiency may not be achievable. Based on their experience, the agencies believe a maximum capture efficiency of 80% per system is potentially achievable. With two systems each operating at 80 percent capture efficiency, DEQ-7 human health water quality standards for nickel, and copper would be exceeded at the permit boundary and within the Jefferson River alluvial	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
			aquifer. Nondegradation criteria for groundwater quality in the JRA aquifer fail for arsenic, cadmium, copper, iron and nickel at all levels of groundwater capture efficiencies modeled, up to and including 96% combined capture efficiency.	
Impacts to surface water quality and quantity				
Impacts to springs, wetlands	The groundwater level around the pit would be permanently drawn down resulting in minor reductions in the flows of springs that are hydrologically connected to the pit.	Same as the No Pit Pond Alternative.	The groundwater level around the pit would rebound so that the flows of springs that are hydrologically connected to the pit would remain the same or increase. New springs or seeps could be created that would be impacted by ARD from the pit. Discharges of ARD at existing springs around the pit area could increase.	Same as the No Pit Pond Alternative.
Risk of violation of surface water standards and impacts to beneficial uses of the Jefferson River and Slough	There would be minimal pit discharge. There would be no risk of violation of surface water standards and impacts to beneficial uses in the Jefferson River and Slough.	Same as the No Pit Pond Alternative.	The risk of contaminants reaching the Jefferson River or Slough and affecting surface water quality and beneficial uses is greater than for alternatives that maintain the pit as a hydrologic sink. Two groundwater capture systems in Rattlesnake Gulch, each operating at an efficiency of 87.5 percent or greater would be required to meet DEQ-7	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
			surface water quality standards At this capture efficiency, the chronic aquatic life standards were met in the Jefferson River Slough for the parameters modeled. Based on their experience, the agencies believe a maximum capture efficiency of 80% per system is potentially achievable. At this efficiency, the chronic aquatic life standard for aluminum would be exceeded in the Jefferson River Slough over the entire predicted range. Nondegradation criteria for surface water quality in the Slough fail for aluminum, copper and iron at all levels of groundwater capture efficiencies modeled, up to and including 96% combined capture efficiency. Control of pit seepage along secondary pathways may be difficult. There is little attenuation capacity in the Tertiary debris flow/colluvial aquifer.	
Reclamation plan changes				
Surface disturbance	No new pit disturbance.	56 acres of new pit disturbance and 31 acres of	Same as the Partial Pit Backfill With In-Pit Collection	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
		new soil salvage disturbance.	Alternative, except 2 additional acres would be disturbed for downgradient wells.	
Hazards to wildlife	There would be no additional hazards to wildlife.	There would be fewer hazards to wildlife than under the No Pit Pond Alternative because the highwall would be eliminated.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.
Total remaining unrevegetated acres	158 acres	2 acres of access roads	2 acres of access roads	159 acres
Socioeconomic Issues				
Safety				
Risk to workers (reclamation and construction)	The safety risk to reclamation workers would be increased while crusher reject is being hauled down the steep roads into the pit, because of the potential for truck accidents.	The safety risk to reclamation workers would be the same as under the No Pit Pond Alternative while 100 feet of crusher reject is being hauled down the steep roads into the pit. The rest of the backfilling would be by end dumping acidic waste rock from the pit rim, a standard method used during mining that has less risk than hauling loaded trucks to the bottom of the pit. Cast blasting and dozing to reduce the pit highwall would present risks to workers.	Similar to the Partial Pit Backfill With In-Pit Collection, except separate placement of crusher reject in the bottom of the pit would not be required.	Less than the No Pit Pond Alternative. Backfill would not be hauled into the pit.
	Workers would be below a highwall of up to 1,875 feet high with the risk of injury from rock falls.	Workers installing, operating, and maintaining the dewatering system would not be working below a highwall	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Workers would be exposed to rock falls from the walls and ceiling of the underground workings as well as from the

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
		and would not be at risk of injury from rock falls.		1,875-foot highwall. Overall risk would be less than the No Pit Pond Alternative.
Risk to workers (long-term maintenance)	Workers in the pit would be exposed to the 1,775-foot pit highwall raveling and sloughing. Long-term access would be needed to the pit bottom for monitoring and maintenance of the pit haul road, the 5,700-foot elevation pit safety bench, and the dewatering system.	Workers would not be exposed to pit highwall raveling and sloughing. Long-term access to the pit bottom would not be required. The risk to worker safety in this alternative would be less than the No Pit Pond Alternative and would be similar to the risk of work currently conducted on the waste rock dump complexes.	Similar to the Partial Pit Backfill With In-Pit Collection Alternative.	Similar to the No Pit Pond Alternative, except workers would be exposed to rock falls from the walls and ceiling of the underground workings as well as from the highwall. Overall risk would be less than the No Pit Pond Alternative.
Risk to public safety	Access restrictions on general public use would be maintained and would consist of signs, berms, and fencing around the pit area, but there would still be a risk to public safety from the pit highwall.	Same as the No Pit Pond Alternative, except there would be no risk to public safety from the pit highwall.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.
Mining employment				
Potential employment from mining Stage 5B	750 person years	750 person years. Premature closure would reduce this by 150 person years per year.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.
Reclamation employment				
Reclamation employment opportunities	123 person years	308 person years	308 person years	124 person years
Revenue from taxes				
Potential tax	$8,087,000	Same as the No Pit Pond	Same as the No Pit Pond	$8,087,000

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
revenues from mining Stage 5B		Alternative, except that premature closure would reduce this tax revenue.	Alternative, except that premature closure would reduce this tax revenue.	
Potential tax revenues from pit backfill	$319,500	$806,000	$911,000	$322,000
Mineral reserves and resources				
Access to future mineral reserves/ Resources	If the pit were to be enlarged for additional mining in the future, it would take 1.5 months to remove the 600,000 cubic yards of crusher reject, soil, and highwall rock. Time is based on the 2002 mining rate of 405,000 cubic yards per month. The pit would have to be dewatered before it could be enlarged. The additional time required to dewater the pit would be minimal.	If the pit were to be enlarged for additional mining in the future, it could take 116 months to remove the 47 million cubic yards of backfill and soil. The pit would have to be dewatered. The additional time required to dewater the pit would be the same as the No Pit Pond Alternative.	Same as the Partial Pit Backfill With In-Pit Collection Alternative. Because the water table would rebound, more of the acidic backfill would have to be dewatered as mining proceeded. The time required to dewater the pit would be longer than the Partial Pit Backfill With In-Pit Collection Alternative.	If the pit were to be enlarged for additional mining in the future, it would take 0.5 month to remove the 200,000 cubic yards of raveled and sloughed highwall rock and soil. Similar to the No Pit Pond Alternative.
Land use after mining				
Suitability of land use after mining	The land use after mining would be wildlife habitat. About 60 acres would be revegetated. About 158 acres of mule deer habitat would be lost. Limited	The land use after mining would be wildlife habitat. About 272 acres would be revegetated. Up to 2 acres of habitat would be lost for access roads. Raptor and	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
	raptor and bat habitat would be developed in the upper highwall.	bat habitat would not be developed.		
Aesthetics				
Visual contrast with adjacent lands	Portions of the highwalls and benches would remain visible. Overall visual contrasts would be reduced to a level where they are noticeable, but not dominant in the landscape, following successful reclamation and revegetation. Landscape modifications would be consistent with the suggested VRM Class III rating for the area.	The reclaimed 2H:1V slopes covering the pit highwall and the reclaimed slopes of the waste rock dump complexes would still be visible, but the overall contrasts would be reduced under this alternative.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.
Potential future burden				
Potential future burden on society	The consequence of failure of this alternative would be the creation of a pit pond below the 5,050-foot elevation. No impacts to groundwater and minimal impacts to springs would occur.	The consequence of failure of this alternative would be uncontrolled discharges of ARD-impacted groundwater from the backfilled pit, which could adversely impact springs and beneficial uses of the Jefferson River alluvial aquifer.	Same as the Partial Pit Backfill With In-Pit Collection Alternative.	Same as the No Pit Pond Alternative.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Potential for future liabilities for GSM	No water would leave the pit. If the dewatering system failed, it could be re-established on the regraded pit bottom through 200 feet of crusher reject and sloughed highwall rock more easily than through up to 875 feet of acidic backfill. Continued safe access to the dewatering system for operation and maintenance would be more difficult than the partial pit backfill alternatives because of highwall rock raveling and sloughing onto safety benches and access roads.	No water would leave the pit. If the dewatering system failed, it could be re-established by drilling new wells. Drilling and maintaining wells in up to 875 feet of acidic backfill would be problematic. Safe access to the dewatering system for operation and maintenance would not be a problem because there would be no highwall.	The potential for water quality degradation outside of the pit would be increased. From 27 to 42 gpm of untreated water would escape the pit. If either of the two groundwater capture systems failed to achieve at least 87.5 percent efficiency, groundwater standards for nickel and copper would be exceeded at the edge of the mixing zone.	No water would leave the pit. Removing water from the underground sump would be easier than pumping out of waste rock backfill or crusher reject. If the dewatering system failed, it could be re-established more easily than under the partial pit backfill alternatives. Continued safe access to the dewatering system for operation and maintenance, because of wall and ceiling rock sloughing in the underground workings, would be less risky than the No Pit Pond Alternative.
	Removing water from 100 feet of crusher reject would not be a problem. Dewatering system components would fail regularly from crusher reject settling and corrosion.	Removing water from up to 875 feet of acidic backfill would be difficult. Dewatering system components would fail more often than under the No Pit Pond Alternative.	The quality of the water collected down gradient of the pit would be partially attenuated and mixed with regional groundwater, but consistently achieving 87.5 percent capture for two pumping systems may not be achievable. Based on their experience, the agencies believe a maximum capture efficiency of 80% per system is potentially achievable. Dewatering system components would not fail as regularly due to settling and corrosion.	Dewatering system components would not fail as regularly due to corrosion.

	No Pit Pond (No Action)	Partial Pit Backfill With In-Pit Collection (Proposed Action)	Partial Pit Backfill With Downgradient Collection	Underground Sump
Project Economics Issues				
Costs				
Reclamation costs	$1,168,000	$55,355,000	$55,357,000	$1,260,000

2.9 PREFERRED ALTERNATIVE

The rules and regulations implementing MEPA and NEPA (ARM 17.4.617 and 40 CFR 1502.14, respectively) require that the agencies indicate a preferred alternative in the Draft SEIS, if one has been identified, and in the Final SEIS prepared for the project. The preferred alternative is not a final agency decision; it is an indication of the agencies' preference at this time. The agencies' preference considers all information that has been received and reviewed relevant to the proposed project, and all comments received on the Draft SEIS. The preferred alternative at this time is the Underground Sump Alternative with visual and other mitigations described in Section 4.8.3.2.

2.9.1 Rationale for the Preferred Alternative

Under all alternatives, no highwall failure that would be a threat to public safety or the environment outside the pit would occur and some wildlife habitat would be provided. However, only the Underground Sump and No Pit Pond alternatives provide adequate assurance that pollution of the Jefferson River alluvial aquifer in violation of water quality laws will not occur. These alternatives would provide almost complete control of pit seepage through evaporation and collection. Sufficient control of pit seepage to protect groundwater and surface water quality cannot be reliably assured under the partial pit backfill alternatives, because of the problems associated with drilling and operating wells in the 875 feet of reactive backfill and with effectively capturing seepage in or down gradient of the pit.

With the imposition of the visual mitigations described in Section 4.8.3.2, the Underground Sump and No Pit Pond alternatives also mitigate post-reclamation visual contrasts between the pit and adjacent lands.

The Underground Sump Alternative would pose less risk to workers monitoring and operating the water capture system from rock raveling from the highwall than would the No Pit Pond Alternative. Under the No Pit Pond Alternative, the workers would perform these functions while exposed to highwall raveling and sloughing. Under the Underground Sump Alternative, much of the work would be performed underground. In addition, the Underground Sump Alternative collection system would require less maintenance than the No Pit Pond Alternative because it would not be susceptible to damage from rock raveling from the highwall.

BLM is mandated by the Federal Land Policy and Management Act (PL 94-579) and subsequent 43 CFR 3809 surface management regulations to manage federal lands so as to prevent unnecessary or undue degradation of the public lands. The preferred alternative avoids unnecessary or undue degradation of the land by maximizing the amount of mine impacted water collected and treated, limiting the potential for mine impacted water to escape collection, and limiting the potential for water quality violations at the mine's mixing zone boundary.

Chapter 3

Affected Environment

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Chapter 3

Affected Environment

3.1 INTRODUCTION

The Affected Environment was described in the 1997 Draft EIS, Chapter III. This chapter updates the existing resource conditions at or near GSM that would be affected by the pit reclamation alternatives. Resources that would not be affected by the alternatives evaluated are not discussed in detail. These resources are vegetation, aquatics, fisheries, noise, and air quality.

3.2 GEOLOGY AND GEOTECHNICAL

The 1997 Draft EIS, Section III.A.2, included a detailed discussion of the regional and local geology of the mine site, as well as geotechnical aspects of block movement within the Tertiary and Quaternary sediments east of the pit. The SEIS includes a short summary of regional geology, focusing on the geology of the pit area and portions of the East Waste Rock Dump Complex overlying Rattlesnake Gulch. This provides a basis for understanding the geological influence on potential flow paths of contaminated groundwater from these facilities. The geotechnical portion of the SEIS updates long-term pit highwall stability analyses.

What has changed in Chapter 3 since the DSEIS?

Chapter 3 describes the affected area around GSM. Based on additional data and public comments, the following changes have been made:

- The GSM 2004 Annual Report was used to update all figures. The GSM 2006 Annual Report was used to update some acreage numbers.
- The net pit inflow rate was changed from 16 gpm to between 25 and 27 gpm based on the updated water balance for the No Action Alternative (No Pit Pond Alternative.
- The Jefferson River alluvium was described in more detail.
- Information on the 2004 earthquake and its effects on the area are provided.
- Additional tasks completed to provide technical information for the SEIS on the Water Resources and Geochemistry were listed.
- Additional information on springs was provided.
- Table 3-1 was updated to include Sunlight and Arkose Valley springs information.
- Information on the groundwater divide on the east side of the pit was added.
- Additional wildlife species found or that may be found near the area were listed.
- All text, figures and tables were revised from data provided by GSM and various consultants.
- Text was corrected based on references.

The geology of the open pit is the same as that discussed in the 1997 Draft EIS, even though GSM proposes to mine to the 4,525-foot elevation. The Water Resources and Geochemistry Section 3.3 will discuss any changes in the geology of the pit highwall and backfill that might affect water quality from that analyzed in the 1997 Draft EIS, Section III.B.

3.2.1 Geology

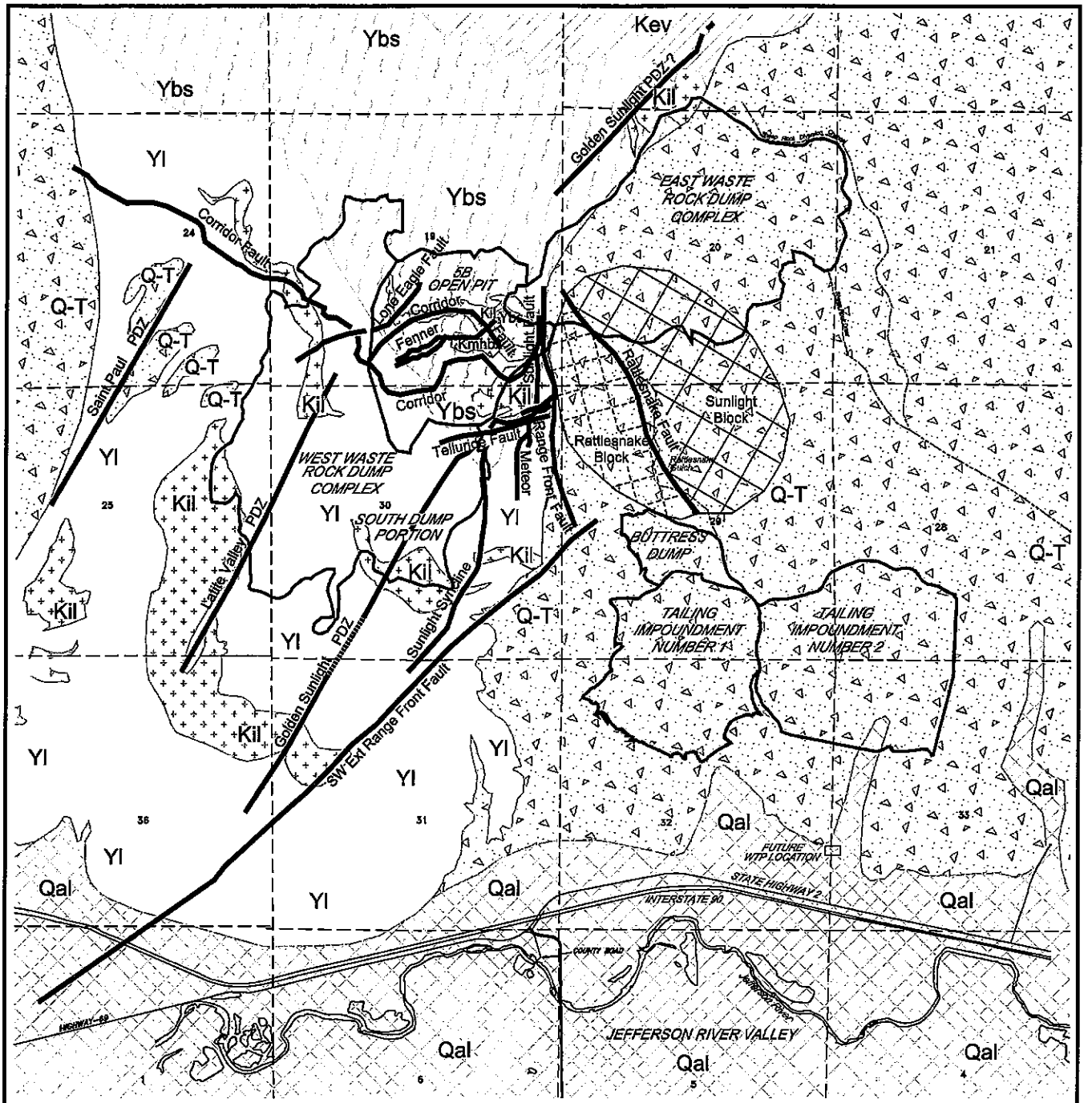
3.2.1.1 Regional Geology and Geologic Structures

GSM is located on the southern flank of Bull Mountain. Figure 3-1 shows a general map of the surficial geology in the vicinity of the mine. Bull Mountain is composed of ancient sedimentary rock that was deposited in a shallow sea during late Precambrian time approximately 1.4 billion years ago. The Precambrian rock types in the vicinity of the mine include sandstone, siltstone, and shale. These rock units are part of the Precambrian Belt Supergroup, and also have been referred to as the LaHood, Greyson, and Newland formations, and the Bull Mountain Shale.

A period of mountain building or tectonic activity known as the Laramide Orogeny occurred approximately 70 to 85 million years ago during the Cretaceous. In the vicinity of the mine, regional compression of the earth's crust created folded blocks of rock followed by extension that resulted in high-angle (near vertical) faults. Precambrian rocks were penetrated by igneous intrusions and overlain by volcanic materials during this period. Cretaceous intrusive rocks in the vicinity of the mine include latite porphyry and numerous smaller lamprophyre dikes.

After the Laramide Orogeny, the landscape was relatively stable. During this time, residual (in-place) weathering of the rock surface was the dominant geologic process. During the Tertiary Period, tectonic activity continued in the form of relaxation of compression, or extension of the earth's crust. This formed the shallow basin east of Bull Mountain, which filled with Tertiary and Quaternary sediments. Part of this sediment-filled valley is now the site of the facility buildings, tailings impoundments, and the East Waste Rock Dump Complex. The geology of the sediments that underlie these facilities, particularly as it influences groundwater flow paths, is the focus of discussion in the following section. Local volcanic activity also is evident by the presence of Eocene (44-million-year-old) basalt, which is exposed near Tailings Impoundment No. 1.

The Precambrian sedimentary rocks in the vicinity of the mine are hydrothermally altered and contain sulfide minerals. When these sulfide minerals are exposed to water and air, they can produce metal-bearing, acidic iron sulfate solutions. These solutions are ARD.



LEGEND

	Qal	Quaternary Alluvial Deposits
	Q-T	Quaternary and Tertiary Deposits
	Kil	Cretaceous Latite
	Kev	Cretaceous Elkhorn Volcanics
	Kmbx	Cretaceous Mineral Hill Breccia
	Ybs	Precambrian Bull Mountain Shale
	Yl	Precambrian LaHood Formation
		Fault
	PDZ	Principal Deformation Zone

Source: 1997 Draft EIS (Map III-1), Golder
1995 (Fig. 4) Chadwick (1996)
1998 MBMG Website Geology Maps

0 1500 3000
Scale in Feet

GENERALIZED SURFACE GEOLOGY

Figure 3-1rev-SurfaceGeology.dwg Rev2/2006

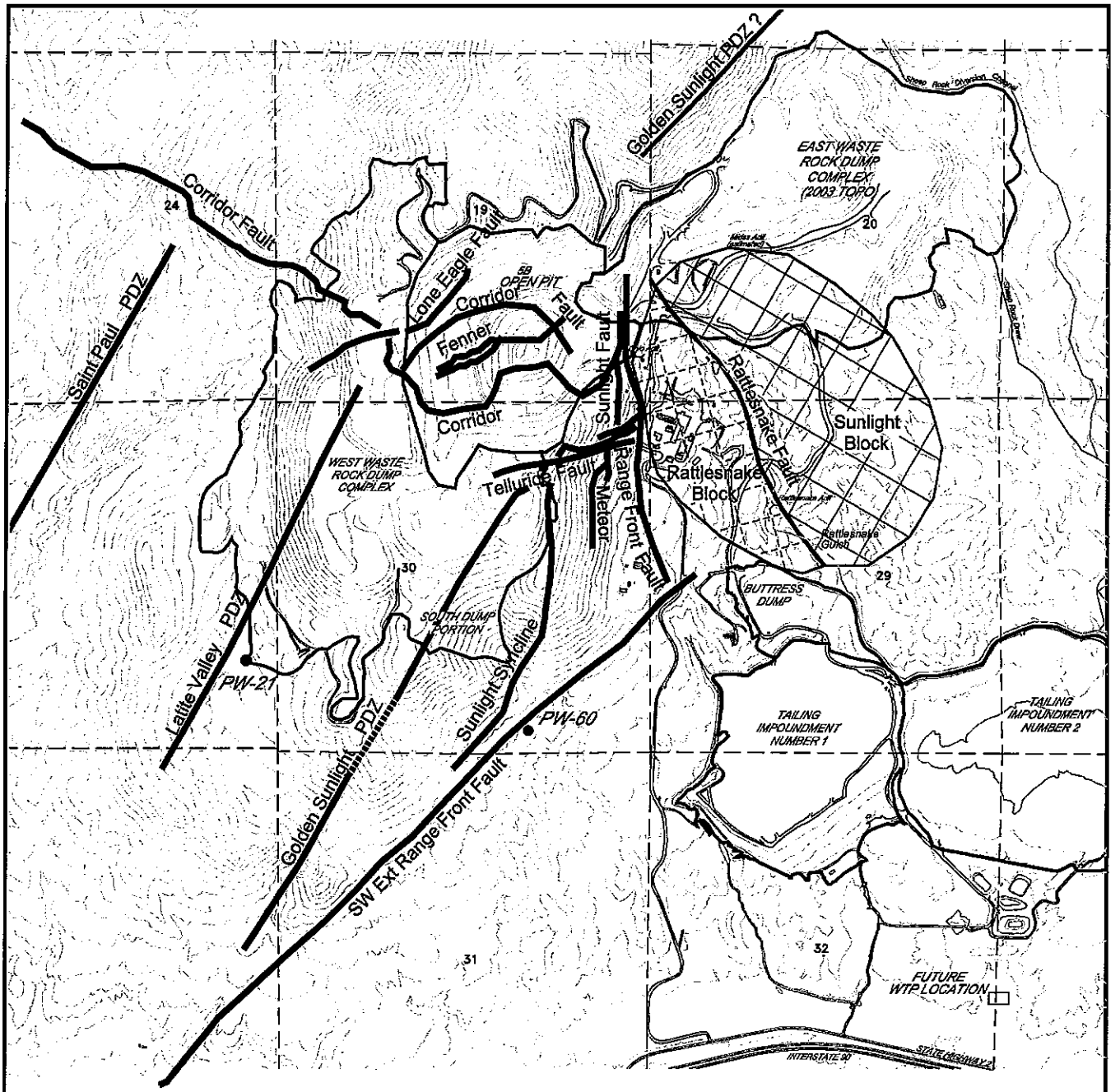
FIGURE 3-1

Pyrite is by far the most abundant sulfide mineral. The average abundance of pyrite in GSM ore is between 3 and 5 percent. The average abundance of pyrite in the waste rock is between 0.5 and 2 percent. Concentrations of up to 20 percent occur, but are not typical. The relatively fine texture of this pyrite enhances the surface area available for ARD generation. Other metallic minerals occur in minor amounts and vary in accordance with zoning in the ore body. Water treatment constituents of concern in ARD include aluminum, arsenic, cadmium, copper, manganese, nickel, pH, sulfate, and zinc. With the exception of aluminum, the other metals are predominantly associated with sulfide complexes and oxides.

3.2.1.2 Bull Mountain Geology and Geologic Structures

The open pit is centered on a breccia pipe in the Precambrian host rocks. The pit cuts through and is bounded by a highly complex series of east and northeast trending high-angle faults (Foster and Chadwick, 1990; Foster, et al., 1993; Foster and Smith, 1995). The Range Front Fault is a major north-south high-angle slip fault that separates the Precambrian and Cretaceous rocks of the upland from the late Tertiary valley fill sediments. The Corridor Fault is a lens-shaped zone up to several hundred feet thick of low-angle faulting that dips approximately 16 degrees to the northeast (Hydrometrics, 1995). The major geologic structures in the vicinity of the pit are shown in Figure 3-2.

The breccia pipe contains disseminated gold-bearing sulfide mineralization that extends more than 100 feet into wallrock in silicified fractures. The pipe is an irregular 700-foot-diameter oval, which plunges 35 degrees to the west-southwest. Individual fragments in the breccia range from less than 1 inch to greater than 30 feet in size and consist of all local rock types except for the late intruding lamprophyre dikes. A low-grade porphyry molybdenum system is located in and adjacent to the mine, as is a zone of massive sulfides in Precambrian rocks. 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 pyrite and minor telluride minerals in the breccia matrix and surrounding rock. Superimposed across the breccia pipe and into the surrounding highwall rock are northeast trending gold-quartz veins that may contain pyrite, galena, sphalerite, and barite.



LEGEND

PDZ Principal Deformation Zone

Fault

NOTE: Refer to Figure 3-5 Spring and Monitoring Well Locations for complete location of all wells.

0 1200 2400

Scale in Feet

MAJOR BEDROCK GEOLOGIC STRUCTURES IN THE VICINITY OF THE PIT

FIGURE 3-2

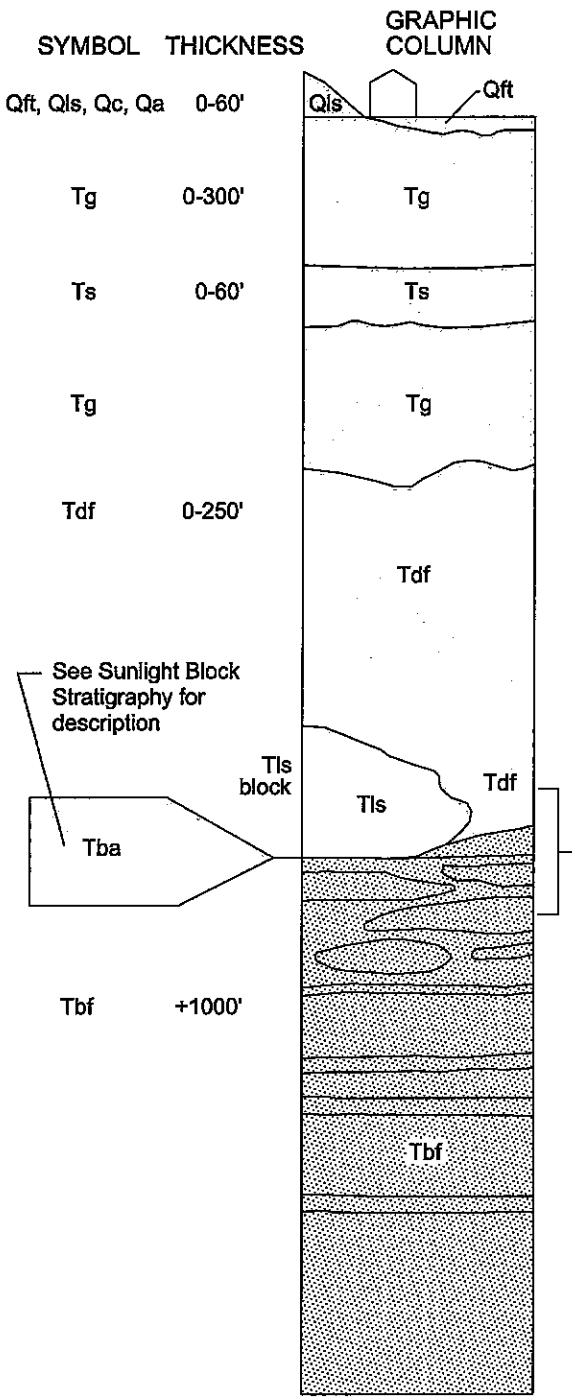
Figure 3-2 geostructures.dwg

3.2.1.3 Tertiary/Quaternary Geology and Geologic Structures

The area east of Bull Mountain contains valley fill Tertiary Bozeman Group sediments up to 1,500 feet thick (Hanneman, 1989). Figures 3-3 and 3-4 show stratigraphic sections from two locations east of Bull Mountain. These rocks and sediments have diverse lithologies, including low permeability clays, moderate permeability sandstone and conglomerate, and carbonate-bearing shales and limestones (1997 Draft EIS, Chapter III, Section A).

The Bozeman Group in the vicinity of the mine has been recognized as having a lower fluvial (stream deposits) facies (Tbf) and alluvial facies (Tba) (Figure 3-3). The fluvial facies generally consists of interbedded medium to high plastic clays and silts, sands and clayey sands. The fluvial facies contains unconsolidated channel sand interlayers, but the bulk of the unit consists of clays, which are interpreted as overbank deposits, exhibiting good lateral continuity (Golder, 1995a). The alluvial facies commonly contains less than 20 percent clay and consists of light brown, lightly calcareous, silty sands and gravels.

Late Tertiary mass-wasting deposits, consisting of landslide (Tls) and debris flow deposits (Tdf), overlie the Bozeman Group sediments unconformably along the east front of Bull Mountain. The mass-wasting deposits are generally confined to the Rattlesnake Block (Golder, 1995a) (Figure 3-3). The debris flow deposits are described as consisting of sandy and silty gravel that is fine to coarse and subrounded to angular, with cobbles and boulders. The debris flow deposits are up to 250 feet thick, massive to bedded, and unconsolidated to well cemented with iron oxide. Associated landslide deposits are composed of more or less intact blocks of latite and other pre-Tertiary bedrock blocks that may be up to 1,500 feet long and 200 feet thick.



DESCRIPTION

Quaternary Sediments - fan terrace gravels (Qft), landslide (Qls), colluvium (Qc), and alluvial (Qa) deposits

Tertiary (?) gravels (Tg); unconsolidated, angular gravels of local derivation; grain supported with more or less sand - silt - clay matrix

Tertiary (?) Sand (Ts); lacustrine beach sand; sheet-like bodies with basin-margin distribution. Well rounded med.-coarse grained quartz-feldspar-biotite sand. Frosted quartz grains, heavy mineral laminae; clean to silty and/or gravelly; unconsolidated.

Tertiary debris flow and landslide deposits (Tdf/Tls) Clay-matrix supported sand to boulder size angular clasts. Massive to well bedded. Semi-consolidated to locally well-cemented with iron oxide. Landslide blocks up to 1500 feet in length, >200' thick.

Common locus of shear (actual position may vary depending on location within block).
Shear is related to Rattlesnake Block movement.

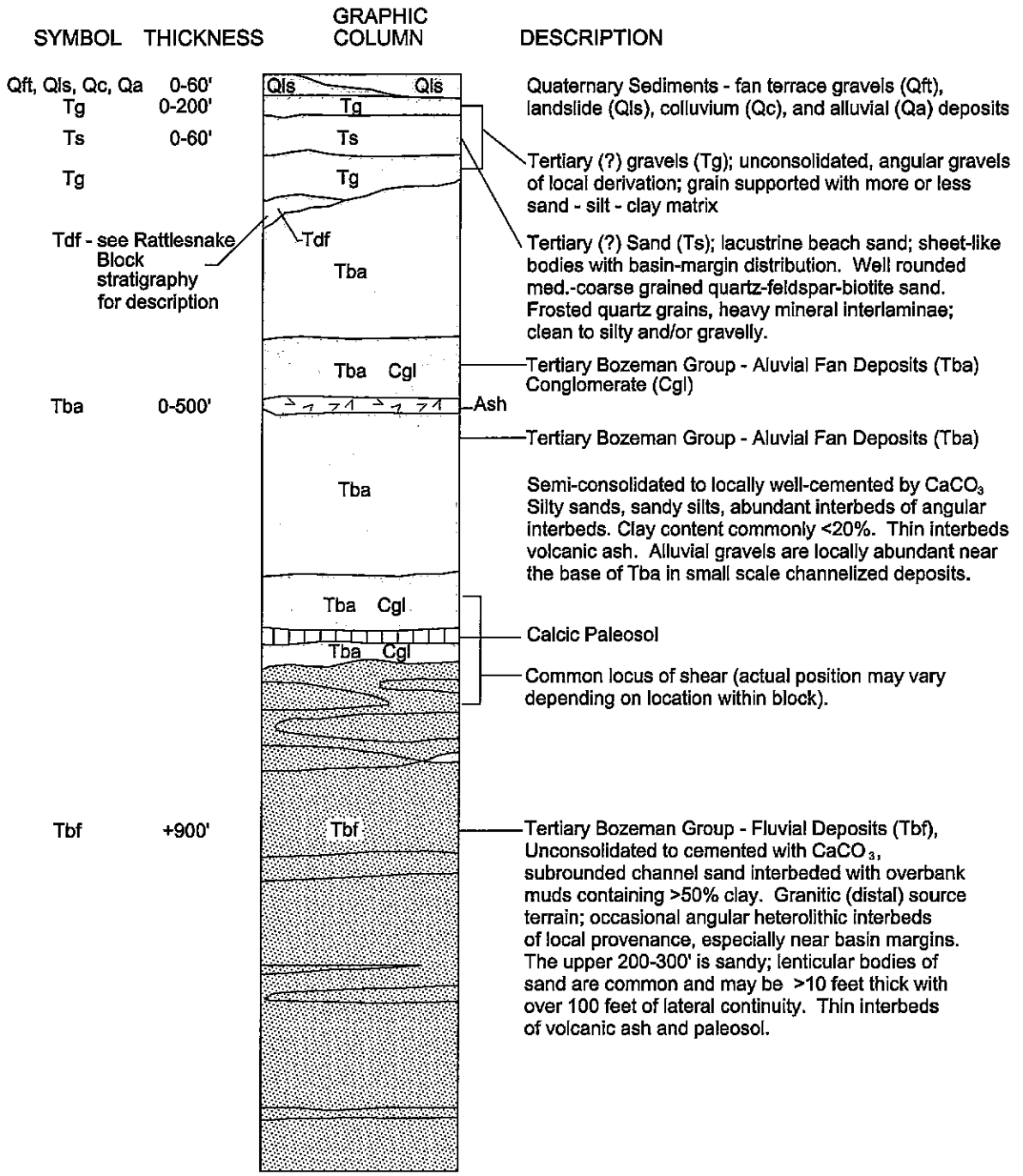
Tertiary Bozeman Group - Fluvial Facies (Tbf) Unconsolidated, subrounded channel sand interbedded with overbank muds containing >50% clay. Granitic (distal) source terrain; occasional angular heterolithic interbeds of local provenance, especially near basin margins.
The upper 200-300' is sandy; lenticular bodies of sand are common and may be >10 feet thick with over 100 feet of lateral continuity. Thin interbeds of volcanic ash.

GEOLOGY: T.H. CHADWICK
SOURCE: GOLDER, 1995a

TYPICAL STRATIGRAPHIC COLUMN FOR RATTLESNAKE BLOCK

FIGURE 3-3

Figure 3-3 column.dwg



GEOLOGY: T.H. CHADWICK
SOURCE: GOLDER, 1995a

TYPICAL STRATIGRAPHIC COLUMN FOR SUNLIGHT BLOCK

FIGURE 3-4

Figure 3-4 column.dwg

Alluvial fan gravels (Tg) and intercalated lacustrine sands (Ts) unconformably overlie the landslide-debris flow complex, with a thickness of as much as 360 feet. Disconformably overlying the Tertiary gravels and sands is a variety of thin Quaternary cover, including fan-terrace gravels, landslide, colluvial and alluvial deposits (Golder, 1995a) (Figure 3-3).

The Jefferson River alluvium is a stream deposit consisting of unconsolidated, permeable alluvium of the river floodplain and the adjacent gravelly terrace deposits (Spectrum Engineering and Gallagher, 2004). This unit follows the flow direction of the Jefferson River (Figure 3-1). At least one of the alluvial terraces is buried by 40 to 80 feet of more recent colluvium and alluvial deposits. It is likely the upper terraces grade into the recent alluvium of the Jefferson River system and are hydrologically connected to some degree. The alluvial deposits consist of unconsolidated gravel, sand, and finer-grained overbank deposits. The well-rounded gravel fraction includes quartzites and volcanics from up-river regions. Angular silicified siltstones and latite appear to be derived from the mine area. Much of the gravel is iron stained. Fragments of ferricrete are present from the Tertiary debris flow deposits. The six borings in the Jefferson River alluvium were distributed both up gradient and down gradient of the Tertiary debris flow deposits. Rock types associated with the mine area were seen in greater abundance in samples from downgradient borings. Samples from the unsaturated portion of the Jefferson River alluvium were calcareous and effervesced in hydrochloric acid, while samples from the saturated portion were non-calcareous and did not effervesce (Spectrum Engineering and Gallagher, 2004).

The Bozeman Group sediments to the east of the pit were the subject of a detailed geotechnical investigation related to block movements that were observed in the mid-1990s (Golder, 1995a). A detailed discussion of the block movements was provided in the 1997 Draft EIS, Chapter III, Section A. Two blocks were identified within the Tertiary sediments that are generally delineated as follows:

- The Rattlesnake Block lies between the Range Front Fault to the west and the Rattlesnake Fault to the east (see Figure 3-3 for stratigraphic section and Figure 3-1 for plan view).
- The Sunlight Block is situated between the Rattlesnake Fault to the west and Midas Draw to the east (see Figure 3-4 for stratigraphic section and Figure 3-1 for plan view).

3.2.1.4 East Waste Rock Dump Complex Geology and Geologic Structures

The East Waste Rock Dump Complex geology was described in detail in the 1997 Draft EIS, Chapter III, Section A and is summarized below. The East Waste Rock Dump Complex lies east of the pit and is located primarily on Tertiary gravels (Tg) and Bozeman Group sediments (Tba) (Figure 3-1). Thirteen percent of the dump complex lies over the Rattlesnake Gulch drainage and could contribute water to groundwater leaving the pit (Figure 3-7).

Bedrock is present below the dump complex at depths ranging from 0 to over 500 feet and is exposed at the surface at elevations above 5,050 feet. Bedrock in this area is composed predominantly of sedimentary rocks (sandstones, limestones, and shales) of Precambrian to Devonian age. The upper bedrock surface is highly weathered and altered to clay in some places. The sedimentary bedrock has been fractured, faulted, and folded, resulting in local variations in bedding orientation. The prevailing strikes of principal faults are north-northeasterly, and their dips are about 60 degrees to the east.

The East Waste Rock Dump Complex site is situated near the northern margin of the valley-fill deposits, with the bedrock surface generally deepening and widening towards the south. Immediately overlying the bedrock surface under much of the East Waste Rock Dump Complex area is a thin layer (0 to 40 feet) of Tertiary gravels, sands, and clays (Tcgl) (also known as the Red Hill Conglomerate) (Figure 3-4). This unit is highly variable in thickness and composition (1997 Draft EIS, Chapter III, Section III.A.2.d).

Bozeman Group sediments that underlie the footprint of the East Waste Rock Dump Complex consist of a thin to moderately thick (10 to 100 feet) bed of the silty alluvial fan facies (Tba), underlain by interbedded Tba and the more clayey fluvial facies (Tbf). Substantial layers of gravel and gravel/clay interbeds also are present within the Tbf/Tba unit. These gravelly layers are interpreted as Tertiary debris flow deposits that were shed off the steep mountain fronts in mass wasting events, as indicated on Figures 3-3 and 3-4. Alluvial fan sediments occur where mountain streams exit onto valley plains or where the stream gradient suddenly decreases. These deposits occur adjacent to the mountain front up to a maximum elevation of approximately 5,200 feet. Fluvial sediments deposited in the valleys by flowing streams are predominant below 4,900 feet in the mine area. The relationship between these deposits is often complex and the deposits are frequently interbedded (1997 Draft EIS, Chapter III, Section III.A.2.d).

3.2.1.5 Ferricrete Deposits

Ferricrete was not discussed in detail in the 1997 Draft EIS. Ferricrete is a term used to describe iron oxide/hydroxide precipitates that are associated with ARD (Taylor, 1997). Ferricrete is a common occurrence both on the surface and at depth at GSM. The importance of ferricrete with respect to the SEIS is that it provides an indication of pre-mining and modern ARD production at the site, and it 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 deposits can be modern, indicating recent or ongoing ARD production, or ancient, indicating prehistoric production of acidic discharge. Taylor (1997) performed a detailed study of the occurrence of ferricrete at or near the surface at GSM and concluded that ferricrete deposition has been an ongoing process, dating back some 11,000 years. Ferricrete deposits have been documented in association with many of the springs located east and south of the GSM pit (Gallagher, 2003a).

A summary of the documented occurrence of ferricrete at GSM was prepared (HSI, 2003). The distribution of ferricrete on the surface is associated mainly with spring discharge emanating from bedrock to the south of the pit. Drill logs presented in Gallagher (2003a) indicate ferricrete is widely distributed in the debris flow deposits between the east flank of Bull Mountain and Rattlesnake Gulch (HSI, 2003). Historic ferricrete deposits do not appear to occur to the east of Rattlesnake Gulch. However, modern ferricrete is likely being created within the East Waste Rock Dump Complex (Taylor, 1997).

Ferricrete deposits have also been documented at depth along the eastern flank of Bull Mountain in monitoring wells, including PW-8, PW-12, PW-47, PW-63 and PW-64 (Figure 3-5), as well as in a gold-bearing hematite deposit that extends down the Rattlesnake Gulch drainage from just east of the pit down to Rattlesnake Spring. These deposits may be indicative of ancient surficial ferricrete deposits that were formed due to ARD emanating from the mineralized bedrock to the west, or they may have resulted from mass-wasting transport of mineralized Tertiary debris flow and landslide rock onto the east flank of Bull Mountain (URS, 2001).

3.2.2 Geotechnical

3.2.2.1 Ground Movements

Ground movements in the mine area are categorized according to three distinct mechanisms of instability:

- Sliding of materials off Bull Mountain on steep, near-surface shear planes;
- Relatively slow movement of massive blocks of valley-fill sediments along deep, low-angle shear surfaces; and,
- Sliding of fault-bounded blocks of bedrock along shear planes due to loss of lateral support.

The first type of ground movement is referred to as a landslide. The second and third types are called earth block slips or landslips (Golder, 1995a). The first two types of ground movement are the result of long-term natural geologic processes. The third type of movement may be caused by human activities, such as pit excavation. All three types can be exacerbated by human activities.

Known features that have moved recently are described in Section III.A.2.b of the 1997 Draft EIS. No ground movements have been documented outside of the pit since the 1998 Final EIS was prepared.

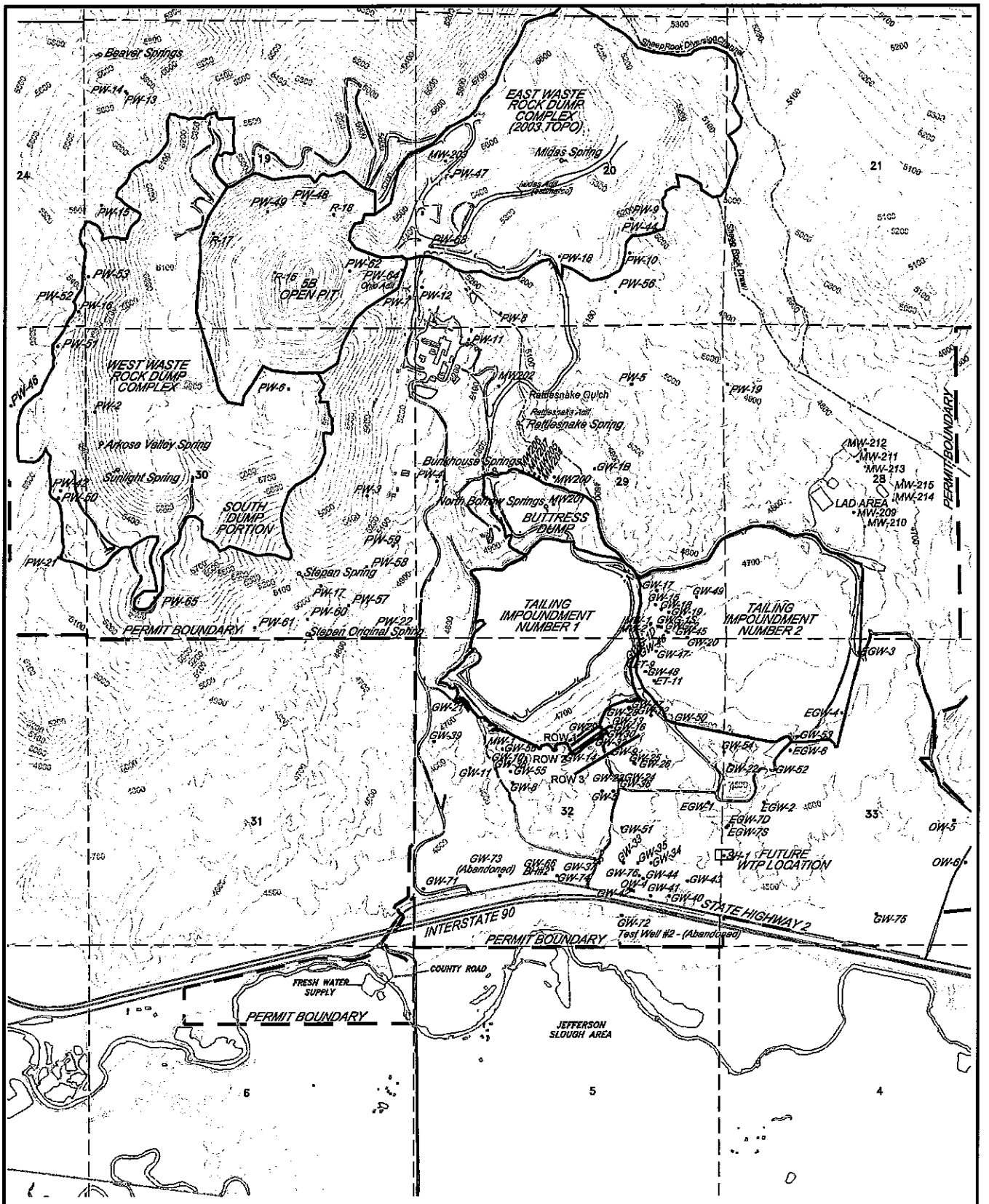
3.2.2.2 Faulting and Seismicity

GSM is located in a region known as the Intermountain Seismic Belt (ISB) (Smith and Sbar, 1974; Stickney and Bartholomew, 1987). The ISB is sharply defined in this area

by historic seismicity along about a 50-mile-wide, northerly trending zone. Ninety-five percent of the earthquake activity in the region occurs within this zone. Most of the historically measured earthquakes in the vicinity of the site are very small and are referred to as micro-earthquakes.

Details on geology in the area of the open pit and East Waste Rock Dump Complex are provided in Sections 3.2.1.2 and 3.2.1.4 of this SEIS and in Section III.A.2.d of the 1997 Draft EIS. Additional details are discussed in Telesto (2003d). This report analyzed the stability of the GSM pit highwall under two reclamation alternatives and examined the factors affecting the long-term aspects of these alternatives. Stability for circular failure was analyzed using SLOPE/W (GEO-SLOPE International, 2001) with the soil and rock mass strength parameters obtained from the laboratory (Golder, 1992a and1992b). The review of the slope stability results for the East Waste Rock Dump Complex shows that the factors of safety ranging from 1.3 to 1.5 are conservative (Golder, 1995a and 1995b). The factor of safety is a calculation defining the relationship of the strength of the resisting force of an element (C) to the demand (D) or stress of the disturbing force where F=C/D. When F is less than 1, failure can occur.

GSM conducted additional studies at the site after a 3.5 magnitude earthquake occurred close to GSM on June 28, 2004 (AMEC, 2004). It was felt at the mine, but no damage was done and no highwall instability occurred. GSM evaluated previous values used in seismic analyses and confirmed these were reasonable and appropriate (Brawner, 2005; Golder, 2005a and 2005b).



SPRING AND MONITORING WELL LOCATIONS IN FACILITIES AREA

FIGURE 3-5

Figure 3-5 springs.dwg Rev. 1/2006

3.2.2.3 Mine Pit Highwall

The main portion of the mine pit is roughly circular in plan view (Figure 2-1). The lowest part of the pit rim on the east side is at approximately the 5,350-foot elevation (Figure 2-3). The main floor of the pit is permitted to an elevation of 4,650 feet. The pit has a crest elevation of approximately 6,400 feet at the northwest side, and the pit is permitted for 336 acres of disturbance (GSM, 2002). The immediate pit area disturbance is 218 acres, based on an April 2004 disturbance accounting using the 2002 aerial photograghs as the base. This disturbance would not expand under the approved Stage 5B mining operations. The SEIS analyzes GSM's proposal to deepen the pit floor to 4,525 feet.

The pit has been redesigned since the 1998 Final EIS as described in Section 2.2.4. The pit highwall is characterized by slopes and benches (Figure 2-3). A 50-foot height between benches was typically used, with some benches being up to 100 feet in height. The width of the benches varies, depending on the desired overall pit highwall slope angle. A minimum bench width of 22 feet is used for 50-foot-high benches. Previously, the angle of the faces between the benches was 45 degrees in sediments and 49 degrees in breccia. Steeper pit highwalls have been made possible (53 degrees in sediments and 60 degrees in breccia) by using presplit and controlled blasting techniques within 50 feet of the pit highwall and scaling of pit highwall with an excavator (see Section 4.2.1.2.1). Controlled blasting results in a pit highwall where structural features, such as faults, bedding planes, joints, fractures, and the highwall rock, are less disturbed compared to the previous mining methods used. There is considerably less broken and fractured rock left on the highwall as a result of controlled blasting and scaling. Whenever the pit highwall is steepened, there is the possibility of intersecting geologic structures that would have been stable at a flatter highwall angle. Controlled blasting has a less detrimental effect on the strength of structural features by reducing disturbance of these structures.

Along the general trend of the northwest pit highwall, there is a series of faults that dip to the southeast and northwest at 70 to 90 degrees. These faults and their intersections with low-angle bedding planes and joints have the potential to generate wedge failures within the pit. The last two wedge failures were on the northwest part of the pit highwall. Slopes along the northwest wall of the pit were flattened as part of the modified pit design in order to mitigate stability problems during the life of the mine due to the unfavorable orientation of these features.

Several factors at GSM indicate that physical or chemical weathering is not likely a factor in highwall stability. The host breccia rock consists predominantly of well-cemented sandstones and shales. Both field observations and petrographic examination indicate that the host rocks are hard with little or no porosity or internal fracturing (Telesto, 2003d). The hydrology of the host rock has been characterized as fracture dominated, which means the diffusion of oxygen or flow of oxygenated water occurs largely in the fractures and not in the host rock matrix. The 0.5 to 2.0 percent

sulfide content of the waste rock has the effect of consuming any available oxygen at the surface of the rock, further limiting the ability for the rocks to chemically weather deeply (Telesto, 2003d).

3.3 WATER RESOURCES AND GEOCHEMISTRY

The 1997 Draft EIS, particularly Chapter IV, was reviewed and a number of data needs were identified with respect to evaluating potential impacts to groundwater leaving the pit area. The following tasks were completed to provide the technical information required for the SEIS:

- A re-analysis of the pit hydrology and pit water balance was conducted based on field data that were not available at that time (Telesto, 2003a & b; Telesto, 2006; HSI, 2006).
- The 1997 Draft EIS, Section III.B.2 relied on groundwater elevation data from 1993 and treated the Precambrian bedrock and Tertiary/Quaternary (T/Q) alluvial aquifers as a single hydrologic unit. For this SEIS, a potentiometric map was prepared using only 2003 data from T/Q wells and springs to better define potential groundwater flow paths within the T/Q sediments away from the pit and the East Waste Rock Dump Complex (HSI, 2003).
- The hydrogeologic and ARD attenuation characteristics of the groundwater flow path from the pit were used to provide a basis for evaluating and comparing alternatives (HSI, 2003).
- The characteristics of the flow path from the East Waste Rock Dump Complex were re-evaluated to ensure that a consistent basis was used for comparing the East Waste Rock Dump Complex and the pit (HSI, 2003 and 2006).
- The pit backfill geochemistry was evaluated in detail (Telesto, 2003c).
- The East Waste Rock Dump Complex mineralogy was characterized (Telesto, 2003h, 2003j, 2005a).

3.3.1 Hydrostratigraphy

The groundwater hydrology of the area was documented in detail in the 1997 Draft EIS, Chapter III, Section B.2, which identified the following hydrogeologic units or aquifers:

- Precambrian fractured bedrock (bedrock aquifer)
- Tertiary Bozeman Group sediments (Bozeman Group aquifer)
- Tertiary to early Quaternary alluvium (T/Q alluvial aquifer)
- Tertiary debris flow/colluvial materials (Tdf/colluvial aquifer)
- Jefferson River alluvium (Jefferson River alluvial aquifer)

3.3.1.1 Bedrock Aquifer

The fractured Precambrian bedrock is the primary hydrogeologic unit that occurs in the pit area and west of the Bull Mountain area (Figure 3-1). As described in Section 3.2.1, the bedrock consists of several different rock types.

Bull Mountain groundwater flow in the bedrock aquifer is controlled by secondary geologic features. The ability of an aquifer to transmit water is defined by its permeability, which is measured in units of length per unit time. The permeability of the bedrock aquifer is a function of the heterogeneous fracture porosity. Depending on the fracture width, spacing, abundance, and orientation, some fracture systems will transmit more water than others. Bedrock permeability varies on a local scale, but when examined on a regional scale, bedrock permeability can be characterized by an average or bulk permeability. Regional analyses yield bulk bedrock permeabilities with values on the order of $1x10^{-6}$ centimeters/second (cm/sec) to $1x10^{-7}$cm/sec, with generally lower values in deeper bedrock (1997 Draft EIS, Chapter III, Section B).

3.3.1.2 Bozeman Group Aquifer

The Bozeman Group aquifer is a hydrogeologic unit that occurs east and south of Bull Mountain where it overlies the bedrock unit. It is comprised of alternating and interfingering layers and lenses of sand, silt, and clay deposited in a fluvial (river or stream) environment. Inspection of drill cuttings has shown fine to coarse-grained sand intermixed within clay and thin sand and gravel lenses. The discrete layers of clay, silt, sand, and fine gravel within the Bozeman Group sediments are discontinuous due to the fluvial depositional environment. The frequency of occurrence of sand and gravel lenses suggests that these lenses are interconnected to some degree, controlling the primary permeability of the unit. The Bozeman Group sediments typically have a low bulk permeability on the order of $2.5x10^{-5}$ to $7x10^{-6}$ cm/sec due to the abundance of silt and clay, but they can locally exhibit relatively high permeability in sand and gravel layers and lenses (1997 Draft EIS, Chapter III, Section B.2.a).

3.3.1.3 Tertiary/Quaternary Alluvial Aquifer

The Tertiary/Quaternary colluvium and alluvium were deposited on the Bozeman Group sediments. This unit consists of locally derived gravels in a silty sand matrix that also may include reworked Bozeman Group sediments and older Tertiary fan terrace deposits consisting of sand, gravel, and clay. Younger alluvial sand and gravel found in modern drainages in the area also are included with this unit, since they share similar textural characteristics with the older deposits. This unit is thickest adjacent to the East Waste Rock Dump Complex area on the east side of Bull Mountain and thins to the south and east. Aquifer tests of the Quaternary alluvium and colluvium indicate permeability in the range of $1x10^{-3}$ to $1x10^{-4}$ cm/sec, with localized values as high as $2x10^{-2}$ cm/sec (Hydrometrics, 1995; SHB, 1981).

3.3.1.4 Tertiary Debris Flow/Colluvial Aquifer

This unit is present locally on the east side of Bull Mountain and is most important in Rattlesnake Gulch in terms of areal extent and saturated thickness. Geologic cross sections indicate that the unit comprises a relatively continuous series of channelized sediments that exist from just east of the open pit to the north end of Tailings Impoundment No. 1 (Golder, 1995a; HSI, 2003). Depending on location, the unit may be exposed at the surface or overlain by recent alluvium and colluvium. The hydraulic conductivity of the unit is estimated to range from $1x10^{-3}$ to $1x10^{-4}$ cm/sec (Golder, 1995a). Saturated thickness within the unit ranges from in excess of 100 feet beneath the mill site to tens of feet where the unit thins and is exposed at the surface. Saturated thickness within the unit has been reduced by the Rattlesnake Gulch groundwater interception wells, which produce approximately 50 gpm (HSI, 2003; Telesto, 2006). This unit appears to convey the majority of groundwater flow in the Rattlesnake Block down Rattlesnake Gulch (Golder, 1995a). Based on data collected by GSM since 1998, the pumping rate from the Rattlesnake Gulch interceptions wells has been approximately 50 gpm, and the pumping rate from the South Pumpback wells in Rattlesnake Gulch has been approximately 30 to 50 gpm, for a combined total of about 100 gpm (S. Dunlap, personal communication, 2006). The East Flank Pumpback wells are outside Rattlesnake Gulch and have been producing a combined total of approximately 50 gpm. Seasonal and annual fluctuations occur.

3.3.1.5 Jefferson River Alluvial Aquifer

The Jefferson River alluvial aquifer is near the southern permit area boundary and consists of unconsolidated gravel, sand, and finer-grained channel and overbank deposits (Figure 3-1). Saturated thickness of the aquifer within the permit boundary is estimated to be approximately 20 feet in lower, recent alluvium (SHB, 1986) and 5 to 15 feet in the upper terraces (Spectrum Engineering and Gallagher, 2004). The majority of inflow to the Jefferson River alluvial aquifer south of GSM is through-flow from the west. Smaller amounts are contributed from the T/Q alluvial aquifer and Tdf/colluvial aquifer at the mine site to the north (SHB, 1986). Most of this groundwater is captured by the Rattlesnake Gulch and South Pumpback capture systems operated by GSM. The Jefferson River alluvial aquifer is in direct contact with the Tdf and alluvial channel aquifer that underlies Tailings Impoundment No. 1 to the north (SHB, 1985; HSI, 2003). The primary direction of groundwater flow in the Jefferson River alluvial aquifer is to the east (SHB, 1985; Spectrum Engineering and Gallagher, 2004). Hydraulic conductivity estimates for the Jefferson River alluvial aquifer are approximately $2x10^{-1}$ cm/sec (SHB, 1986). Pumping rates ranging from 10 to 300 gpm have been reported on drillers' logs filed with the Montana Department of Natural Resources and Conservation (DNRC) (SHB, 1987). A groundwater gradient of 0.0015 has been documented within the Jefferson River alluvial aquifer, with groundwater seepage velocities estimated to be 3.8 to 4.8 feet per day, indicative of a highly permeable groundwater flow system (SHB, 1986; HSI, 2003; Spectrum Engineering and Gallagher, 2004).

3.3.2 Potentiometric Surface in the Tertiary/Quaternary Aquifer

A potentiometric map displays contours of equal elevation of the total hydraulic head and pressure in a particular aquifer with water table or groundwater elevations identified. These maps are routinely used to obtain directions of groundwater flow. In the 1997 Draft EIS, Chapter III, Section B.2.a, groundwater elevation data were used to develop a generalized regional potentiometric map of the mine area for late season 1993 conditions (Chapter III, Figure III-5).

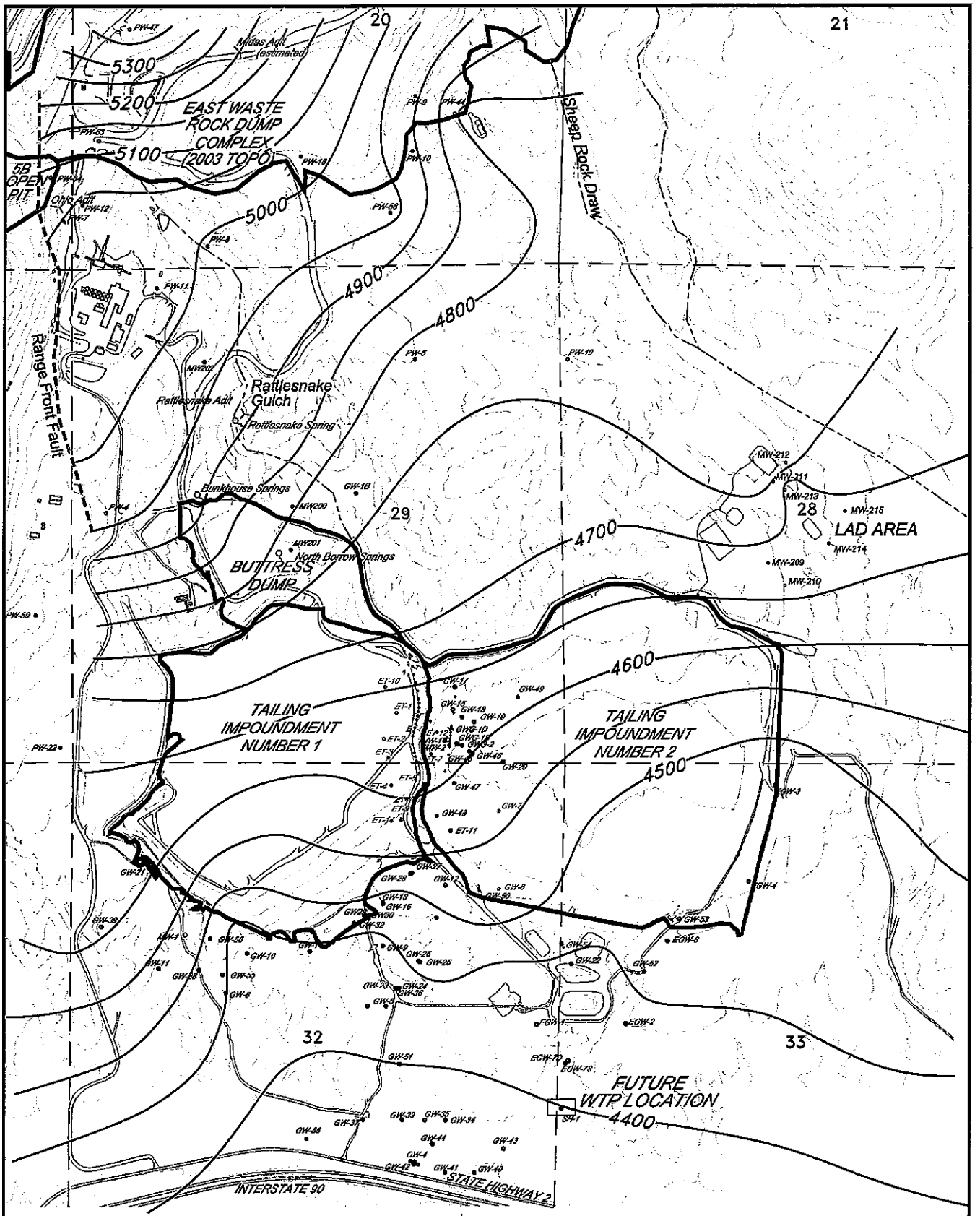
The new potentiometric map (Figure 3-6), which focuses on the Tertiary and Quaternary aquifer system, was constructed for the following reasons:

- To characterize groundwater flow paths in the Tertiary and Quaternary sediments downgradient from the open pit and the East Waste Rock Dump Complex;
- To update the potentiometric map to current site conditions;
- Analyses in this document treat the bedrock aquifer and the Tertiary and Quaternary aquifer as separate hydrologic units.

The new potentiometric map represents groundwater elevations from selected wells that are completed only in the Tertiary and Quaternary aquifer (Figure 3-6). Wells were selected for inclusion in the map based on the geologic map of GSM (GSM, 1996) and a review of well completion details (GSM Annual Reports). Some wells were eliminated from the potentiometric map because they were screened in a perched aquifer, for example, within the tailings impoundments, or very deep in the Bozeman Group sediments, which gives a relatively low head, or they are near the land application disposal (LAD) infiltration pond (HSI, 2003).

In the area between Tailings Impoundment No. 1 and the Jefferson River alluvial aquifer, a saturated sand and gravel channel is incised into the Bozeman Group aquifer (Hydrometrics, 1994; Keats, 2001). Where this sand and gravel aquifer was hydrologically continuous with the upgradient Tdf/colluvial aquifer (Golder, 1995a), data from wells in the Quaternary deposits were utilized so that the uppermost and potentially the most rapid groundwater flow path was addressed.

The Jefferson River alluvial aquifer grades into the T/Q alluvial aquifer on the GSM property several hundred feet north of I-90. Studies by Hydrometrics (1994), Keats (2001-2002), and Spectrum Engineering and Gallagher (2004) indicate that these aquifers are hydrologically connected. Therefore, the potentiometric map included data from wells completed in the Jefferson River alluvial aquifer, including the southernmost GSM monitoring wells along the permit boundary and private water wells in the valley just south of the boundary. Elevations of the private wells were estimated from the United States Geological Survey (USGS) topographic map and adjusted (+91.4 feet) to GSM datum.



LEGEND

Potentiometric Contour Line (50 Foot Interval)

GENERALIZED POTENTIOMETRIC MAP OF THE TERTIARY/QUATERNARY SEDIMENTS EAST OF THE PIT (May - June 2003)

FIGURE 3-6

Figure 3-6 potent.dwg

3.3.3 Groundwater Quality

The 1997 Draft EIS, Chapter III, Section B.2.b described groundwater quality in the GSM project area as highly variable and identified eight regions with distinct water quality characteristics, some of which are related to mine facilities. For the purpose of the SEIS, updated water quality data obtained from GSM's Annual Reports (GSM, 1998-2004; Portage, 2004) for groundwater monitoring wells, springs, and the pit sump (see Figure 3-5 for well and spring locations) were reviewed for trends in acidity (measured in pH standard units) and sulfate concentrations that might indicate changes relevant to the alternatives analyzed. The majority of monitoring wells and springs exhibit stable ranges of pH and sulfate.

The following trends were observed in the data:

- A small number of wells in the bedrock aquifer and the Tdf/colluvial aquifer (PW-8, PW-11, PW-14, and PW-15) show decreases in sulfate concentrations that appear to correlate to decreasing water-level trends (Figure 3-5).
- PW-6, which is located south of the pit in the bedrock aquifer, reflects a decrease in pH from a range of 5-6 to 3 (Figure 3-5). The well also experienced a decreasing water-level trend during this period.
- PW-17, which is located down gradient from Stepan Spring in the bedrock aquifer, had a strong increase in sulfate concentration between 1997 and 2000. Reclamation work in the Stepan Spring area in late 1999 (see discussion in Section 3.3.4) has reversed the sulfate trend in PW-17 (Figure 3-5).
- The pit sump water quality has been monitored from 1999 to present. Water quality decreased substantially in early 2002, coincident with allowing pit water to collect in rubble at the bottom of the pit. The pH range of the pit water decreased from 5-7 to 4-5, and the sulfate concentration increased from approximately 5,000 milligrams/liter (mg/l) to 20,000 mg/l.

3.3.4 Seeps and Springs

Concerns were raised during the MAA process that seeps and springs at GSM may have been affected by mining operations. A detailed analysis of springs in the GSM project area was presented in Chapter III, Section III.B.2.d of the 1997 Draft EIS. A summary of the spring survey with updated water quality information as of December 2002 is presented in Table 3-1 with spring and well locations shown on Figure 3-5.

Most springs and seeps within the area generally discharge only a few gallons per minute, and some can cease flowing during dry seasons when the water table is low or during freezing conditions during winter. The major springs and seeps that have been mapped within and adjacent to the pit area and are currently accessible include Rattlesnake Spring, Bunkhouse Springs, Stepan Spring, and Stepan Original Spring.

Surface seeps existed in the Midas Spring, North Borrow Springs, Sunlight Spring, and Arkose Valley Spring areas (Figure 3-5), but have since been intercepted by drain systems to allow placement of waste rock. The drains were constructed to prevent contact between water and waste rock materials.

Some springs downgradient of the pit area have ARD signatures (low pH, elevated concentrations of sulfate, and trace metals). These include Rattlesnake Spring, Bunkhouse Springs, Stepan Spring, Stepan Original Spring, and North Borrow Springs (Table 3-1). 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 (Gallagher, 2003a). The abundance of 11,000-year-old ferricrete associated with Rattlesnake Spring, Bunkhouse Springs, Stepan Spring, and Stepan Original Spring indicates that ARD discharge is likely to have occurred for thousands of years before mining began. Bunkhouse Springs occurs within Tertiary debris flow deposits and may originate due to the presence of discrete high permeability conduits within the colluvium.

A reclamation project was conducted at the site of Stepan Spring in late 1999 due to a trend of decreasing water quality thought to be related to dump face runoff from the South Dump (Gallagher, 2003d) (Figure 1-2). The reclamation project included:

- Completion of the reclamation of the South Dump and channeling of the historic flow from the toe area;
- Removal of pre-GSM historic mining waste rock and debris;
- Excavation of a channel;
- Placement of a substrate of pebble-sized limestone;
- Placement of a growth medium;
- Creation of benches between the channel and the sides of the gulch;
- Covering areas with limestone armoring; and,
- Placement of straw and seeding the entire area with dryland and wetland species.

The reclamation project resulted in an overall improvement in water quality and a decrease in flow rate from 1999 to 2002 (personal communication (GSM data), Gallagher, June 30, 2003). From 2002 to 2006, the flow rate decreased to intermittent, TDS and Sulfate have increased slightly, and pH has decreased from a range of 5 to 6 to a range of 4 to 5 (Shannon Dunlap, GSM personal communication 2006).

Table 3 - 1. Summary of Springs Downgradient of the Pit

Spring/ Seep Name	Location[1] (shown on Figure 3-5)	Elevation[2] (feet)	Origination[1]	Flow Rate[3] (gpm)	WQ[4]		Other
					pH	Sulfate (ppm)	
Rattlesnake	Southeast of plant site along Rattlesnake Fault	4,940	believed to originate in adit; represents regional system discharge (constant rate)	baseflow 0.2 to 0.6	(3.8-5.3) slightly acidic	309 to 359	represents Bozeman Group aquifer water and upgradient bedrock aquifer (mineralized) water
Bunkhouse	Southwest of Rattlesnake Spring (RS), south end of RS Block	4,930	surface expression of the regional water table in the area	0.6 to 7 (baseflow 1-2)	(4.3-6.8) slightly acidic	598 to 733	receives flow from mineralized zones; reacts to precipitation events
Stepan	Southeast of the South Dump	5,025	represents discharge from mineralized zones in bedrock aquifer	0.2 to 1.4	(2.8-4.7) acidic	1,760 to 9,170	does not receive substantial recharge from drainage area
Stepan Original	1,600 feet southwest of Stepan Spring	4,888	collapsed abandoned adit; represents regional groundwater which has traveled through mineralized zones in bedrock aquifer	0.8 to 2.8	(5.2-6.2) slightly acidic to neutral	1,790 to 2,200	measurement range attributed to inconsistent measurement methods; little variation in flow
Sunlight	Near top of southwest section of West Waste Rock Dump Complex	5,312	possibly related to Latite Valley fault	0 to 6			covered by gravel trench system
Arkose Valley	Near top of southwest section of West Waste Rock Dump Complex, north of Sunlight	5,298	possibly related to Latite Valley fault	Approx < 1			covered by gravel trench system
Buried springs/seeps (engineered systems)							
North Borrow	120 yards north of Tailings Impoundment No. 1 in Rattlesnake Gulch drainage	4,790	created when North Borrow area excavated below shallow water table	8 to 32	(3.9-6.3) slightly acidic	not reported	intercepted by an underdrain; area filled by Buttress Dump expansion

[1] summarized from 1997 Draft EIS text, Chapter III, Section B.2.d

[2] estimated from "Generalized Potentiometric Map of Late Season 1993 Groundwater Conditions in GSM Project Area"; elevations relative to GSM datum; minus 91.4 feet to convert to USGS datum

[3] summarized from GSM Pit Area Spring and Seep Data 1990 to 2002 (Gallagher, 2003b; GSM 2004 Annual Report)

[4] read off graphs in 1997 Draft EIS text, Chapter III, Section B.2.d

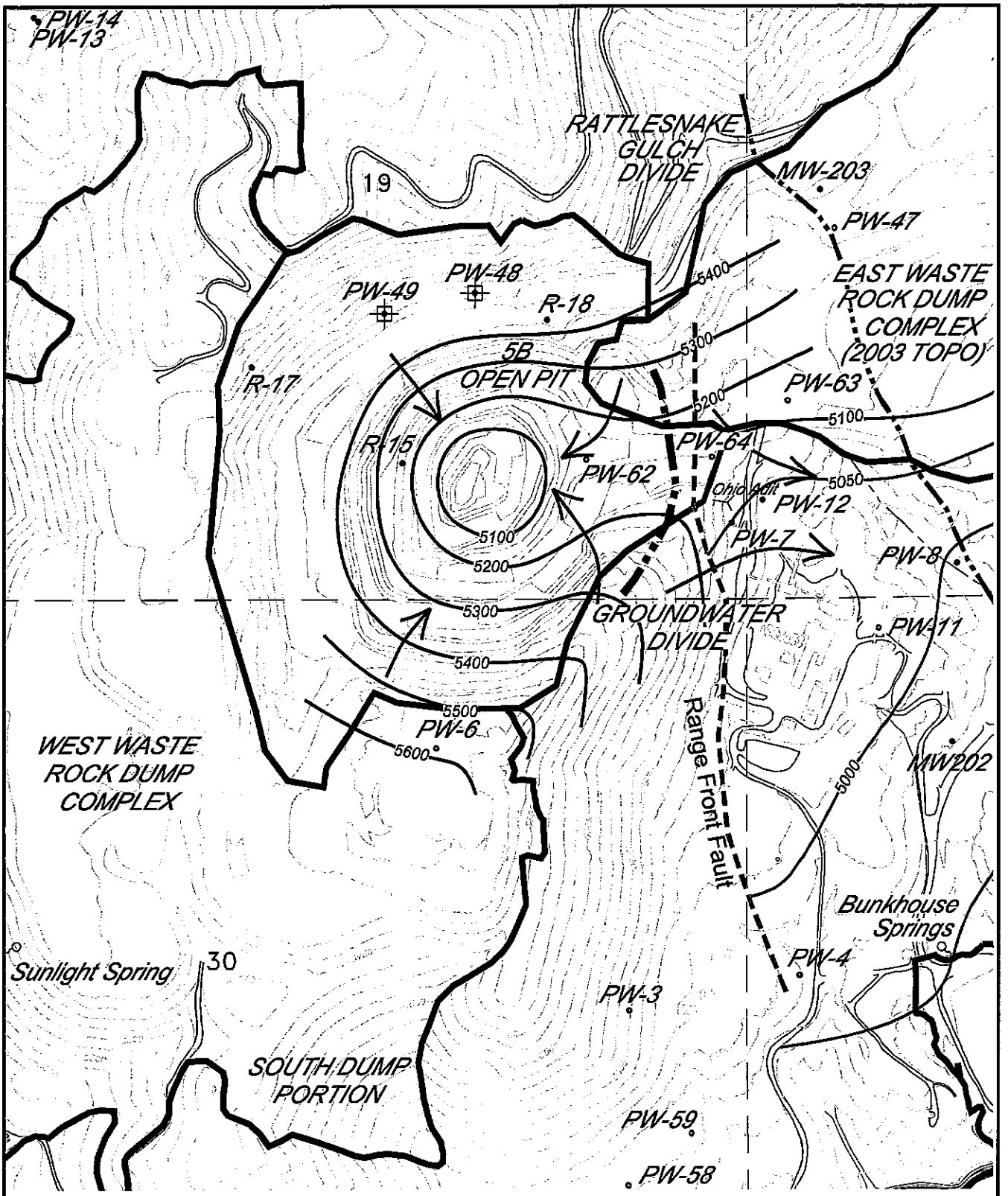
3.3.5 Groundwater in the East Waste Rock Dump Complex

No groundwater is predicted to enter the East Waste Rock Dump Complex from upgradient. The 1997 Draft EIS, Appendix J, Table J-4 predicted that 6 to 10 gpm of water from precipitation and runon would leave the East Waste Rock Dump Complex. Sheep Rock Creek was diverted around the East Waste Rock Dump Complex as part of Amendment 010 approval (1998 ROD).

No flow has been observed from the East Waste Rock Dump Complex and none was predicted for 54 to 433 years (1997 Draft EIS, Appendix J). This value has been adjusted to 33 to 72 years based on technical work for this SEIS as presented in Section 4.3.2.1.1.1.4. No dewatering wells were required as the predicted flow from the East Waste Rock Dump Complex was to be attenuated in the Bozeman Group sediments and mixed with ambient groundwater and would meet groundwater quality standards at the mixing zone boundary (1997 Draft EIS, Appendix B).

3.3.6 Groundwater in the Pit Area

The pit is currently maintained as a hydrologic sink as described in Section 3.3.7.2. A generalized depiction of groundwater elevations in the vicinity of the pit in September 2001 is shown on Figure 3-7. In the 1997 Draft EIS, Chapter II the agencies predicted that 102 gpm (Section II.B.2.b, page 69) of groundwater would need to be pumped and treated under the No Pit Pond Alternative and 47 gpm (Section II.B.7.b, page 100) under the Partial Pit Backfill Alternative. The 1997 Draft EIS, Chapter IV, Section IV.B relied on model simulations of the local pit groundwater system as the primary basis for evaluating impacts to water quantity from pit dewatering (Hydrometrics, 1995). A detailed discussion of the groundwater model configuration and input parameters can be found in Volume 3, Appendix 4.7-1 of GSM's Permit Application (GSM, 1995b). This SEIS uses additional studies, including a pit hydrogeology investigation (URS, 2001), a pit highwall seep study (Gallagher, 2003b; Telesto, 2006), a water balance model of the pit (Telesto, 2003b and 2006), an analysis of well and spring hydrographs (HSI, 2003), and an analysis of groundwater flowpaths from the pit (HSI 2003; HSI 2006; Spectrum Engineering and Gallagher, 2004).



GENERALIZED POTENTIOMETRIC SURFACE OF GSM OPEN PIT AREA

FIGURE 3-7

Figure 3-7 gwflow.dwg Rev. 1/2006

A groundwater divide is located between wells PW-64 and PW-62 (URS, 2001) and is shown near the eastern edge of the pit in Figure 3-7. Recent groundwater elevations in PW-62 and PW-64 have ranged between 5,145 and 5,192 feet, and the groundwater divide is expected to be between those elevations. Groundwater west of the divide flows into the pit; groundwater east of the divide flows eastward into the Tdf/colluvial aquifer.

Faults and fractures control the permeability of the bedrock aquifer in the pit area and act as the conduits of groundwater flow into the pit. During mining, the pit has been continually dewatered from within the pit and from two vertical dewatering wells on the north side of the pit (PW-48 and PW-49 as shown on Figure 3-5). From 1995 through 2001, 43 pit highwall seeps were cataloged by GSM, some of which are probably duplicative, due to the changing pit configuration and seep locations over time (Gallagher, 2003b). The most seepage was found as the pit penetrated the Corridor Fault. In general, while new seeps have been identified as the pit was enlarged and deepened, total flow from seeps has not changed proportionately. At present, most groundwater flows into the pit along the north wall of the pit where the Corridor Fault is intersected. On the south pit highwall, the Sunlight and Fenner faults appear to be secondary sources of groundwater inflow (Figure 3-2).

The 1997 Draft EIS and other previous reports used the term "regional groundwater flow" to describe the majority of groundwater that flows into the pit. Fetter (1980) describes a regional flow system as having its recharge area at the basin divide and discharge area at the valley bottom. Local and intermediate flow systems have shorter flow paths that are influenced by variations in local topography, and may react quickly to precipitation events. Additional analyses indicate that most of the groundwater inflow to the pit is best characterized as intermediate and local groundwater flow (Gallagher, 2003a). Recharge to the pit is generally topographically controlled and is conveyed primarily by structures having higher permeability. Precipitation events were found to be responsible for the largest variations in pit highwall seep flows (Gallagher, 2003b). Precipitation events result in an almost immediate increase in flow (local flow system) from major seeps along the Corridor Fault. A general decay of the flow rate can be observed over time following a precipitation event, indicating influence from the intermediate flow system.

Gallagher's (2003b) spring and seep report also described the geologic structural controls, lithologic controls, and engineering/blasting controls on pit highwall seepage. A disturbed rock zone caused by conventional blasting and mining extends several feet to tens of feet into the pit highwall. This zone tends to funnel pit highwall inflows downward, where the seepage may reach the pit bottom, or may emerge as pit highwall seeps. As described in Section 3.2.2.3, GSM has refined its blasting method in the lower portion of the pit, which has reduced the thickness of the disturbed rock zone.

Based on GSM's experience in dewatering the pit for the past 7 years and a new pit water balance model (Telesto, 2003b and 2006), the total net inflow to the pit (total inflow minus evaporation) is projected to be between 25 and 27 gpm for the No Pit Pond

Alternative. The 1997 Draft EIS, Chapter IV, Section IV.B.2.b projected a maximum total net inflow of 102 gpm for the No Pit Pond Alternative. The difference between the two estimates is due to an earlier underestimation of evaporation, less than predicted pit inflows, and the potential influence of drought. The hydrogeologic and water balance studies performed for the SEIS predict that for a 10-year time-weighted average, the majority (136 gpm) of the inflow to the pit would be direct precipitation and runon, with 22 to 37 gpm entering as groundwater inflow through seepage along faults and fractures, primarily from the Corridor Fault (Telesto, 2006). Faults penetrating the lower portions of the pit yield much less water than the Corridor Fault. The underground mine, which reaches approximately 300 feet (4,400-foot elevation) beneath the current pit bottom, had very small amounts of inflow after fractures drained, and water was imported to maintain underground mining operations.

The new water balance study predicts that for the Stage 5B pit, the majority (132 to 145 gpm) of the water that enters the pit will exit as evaporation (Telesto, 2006). The highwall has a high evaporation potential due to its aspect, color, and large surface area. Most water enters the pit at or above the bottom of the Corridor Fault, and must flow over a large portion of exposed rock in order to reach the bottom of the pit, thus resulting in a large evaporation loss. Some water may also be lost during exothermic reactions with exposed sulfides.

3.3.7 Groundwater Flow Paths

3.3.7.1 Groundwater Flow Path from the East Waste Rock Dump Complex

Groundwater flow beneath the East Waste Rock Dump Complex is to the south, principally in the Tertiary gravels and Tertiary alluvial deposits initially, transitioning into the Tertiary fluvial deposits farther south. Although the bulk permeability of the Bozeman Group aquifer is not high, beds of fine to coarse sandstone and pebbly conglomerate do provide preferential pathways for groundwater movement. Groundwater beneath the 13 percent portion of the East Waste Rock Dump Complex in the Rattlesnake Gulch drainage would likely report to the Tertiary to Quaternary debris flow and alluvial channel deposits in Rattlesnake Gulch.

Below the veneer of Quaternary deposits, typically 80 feet (ranges from 60 to 150 feet) of unsaturated Tertiary sediments underlie the East Waste Rock Dump Complex (HSI, 2003). Saturation is present in the lower portion of the Tertiary gravels and Tertiary alluvial deposits. The earth slip blocks that moved at GSM in 1994 moved on or near the contact of the Tertiary alluvial and Tertiary fluvial deposits (Golder, 1995a). About seventy percent of the East Waste Rock Dump Complex overlies Tertiary deposits. The groundwater flowpath downgradient of the East Waste Rock Dump Complex is principally in Tertiary alluvial and Tertiary fluvial deposits. The potentiometric map of the T/Q alluvial aquifer (Figure 3-6) indicates that this groundwater flow system is hydrologically connected to the Jefferson River alluvial aquifer, approximately 12,500 feet to the south.

The 1997 Draft EIS, Appendix J, Table J-4 predicted that 6 to 10 gpm of water would leave the dump and follow the groundwater flow path from the East Waste Rock Dump Complex to the Jefferson River alluvial aquifer (Figure 3-8). This flow path is interpreted to be hydraulically controlled, that is, dictated by the potentiometric gradient.

About 13 percent of the East Waste Rock Dump Complex at the southwestern tip overlies debris flow deposits that are part of the same sand and gravel flowpath described below for the pit. Groundwater beneath this area migrates south, mixes with other groundwater in the Tdf/colluvial aquifer, and continues to move down gradient in that flow path along Rattlesnake Gulch. The 1997 Draft EIS, Chapter IV, Section IV.B.1.e predicted that 200 gpm of natural groundwater would flow down Rattlesnake Gulch and would have to be collected and treated with Tailings Impoundment No. 1 seepage. GSM drilled the Rattlesnake Gulch dewatering wells above Tailings Impoundment No. 1 in 1994 in association with the Buttress Dump (Figure 3-5). Most of this water is now captured by the wells and does not mix with tailings impoundment seepage. The rest of the groundwater flow is subject to capture by the south pumpback system that collects seepage from Tailings Impoundment No. 1 (Figure 3-5). Evaluations indicate the capture systems are completely or nearly completely capturing all groundwater in the Quaternary alluvial aquifer and the majority of water in the Bozeman Group aquifer. The minor quantity of uncaptured groundwater may reach the Jefferson River alluvial aquifer via coarser units within the Bozeman Group aquifer (Hydrometrics, 1994 and 1997; Keats, 2001 and 2002; Spectrum Engineering and Gallagher, 2004).

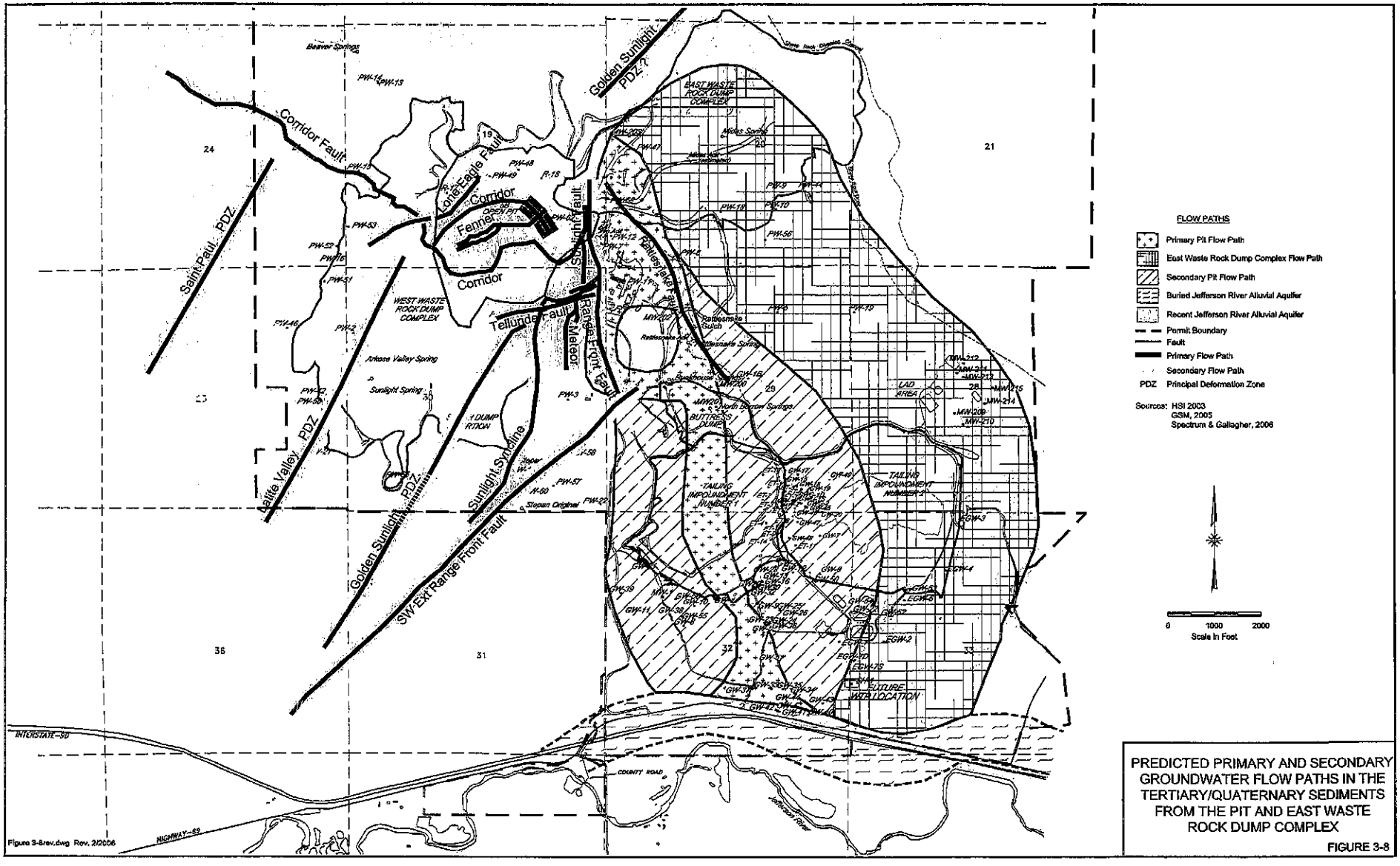


Figure 3-8rev.dwg Rev. 2/2006

PREDICTED PRIMARY AND SECONDARY GROUNDWATER FLOW PATHS IN THE TERTIARY/QUATERNARY SEDIMENTS FROM THE PIT AND EAST WASTE ROCK DUMP COMPLEX

FIGURE 3-8

3.3.7.2 Groundwater Flow Paths from the Pit Area

The open pit is currently maintained as a hydrologic sink by pumping from the bottom of the pit and two vertical highwall dewatering wells (PW-48 and PW-49, Figure 3-5). Under current conditions, almost all of the water entering the pit area is believed to be captured by the pit, and removed by evaporation or pit dewatering activities.

The primary historic flow path out of the pit area was the Corridor Fault, which was encountered at an elevation of approximately 5,250 feet near the northeast corner of the pit (URS, 2001; Gallagher, 2003b; Telesto, 2003b). In addition, other, less permeable structural flow paths exist lower in the pit. The hydrogeologic setting, along with the previous documentation of abundant ferricrete deposits in the T/Q materials immediately below the east and southeast side of the pit, as discussed in Section 3.3.6, provide evidence that the principal groundwater pathway from the pit area would have been via the Corridor Fault east and southeast to subsurface discharge beneath the access road area to the Rattlesnake Gulch drainage.

Some of this flow would be intersected by the Range Front Fault and migrate south to the intersection with the southwest extension of the Range Front Fault where some flow would likely travel along that fault and some flow would likely enter the sediments above Tailings Impoundment No. 1.

As mentioned in Section 3.3.7.1, the 1997 Draft EIS, Chapter IV, Section IV.B.1.e estimated that 200 gpm would flow beneath Tailings Impoundment No. 1, the majority of which would be groundwater flow from the Rattlesnake Gulch drainage area. The 1997 Draft EIS stated that 200 gpm was a conservatively high estimate and predicted that the flow would diminish based on operation of the various pumpback systems near Tailings Impoundment No. 1 and the Rattlesnake Gulch interception wells. Current pumping rates in Rattlesnake Gulch are discussed in Section 3.3.1.4.

A continuous high permeability pathway of Tertiary debris flow deposits from the pit to the north end of Tailings Impoundment No. 1 was mapped (Golder, 1995a). These debris flow deposits would be the potential primary flow path from the pit area if the pit were to become fully saturated (*i.e.* if a pit lake were to form, or if the pit were backfilled and water saturated). The Tertiary debris flow deposits appear to convey the majority of groundwater flow in the Rattlesnake Block (Figures 3-3 and 3-8). The relatively high permeability of these deposits is supported by the 52 gpm average yield of the Rattlesnake interception wells, and the far-reaching drawdown documented on the basis of hydrograph analysis (HSI, 2003).

The Tertiary debris flow gravel channel continues beneath Tailings Impoundment No. 1 and is hydrologically connected to the Jefferson River alluvial aquifer via younger alluvial channel deposits (HSI, 2003; Spectrum Engineering and Gallagher, 2004). This conclusion is supported by examination of numerous well logs and the contaminant migration patterns below the impoundment. Previous hydrogeologic studies by

Hydrometrics (1994 and 1997) used in the 1997 Draft EIS and by Keats (2001 and 2002) have identified this sand and gravel channel. Plotting of drilling logs from all studies demonstrates the continuity of this gravel channel from the pit to the river.

Secondary potential groundwater flow paths in the Tertiary/Quaternary deposits from the pit have been designated on Figure 3-8, based on the potentiometric head patterns. While the Tertiary debris flow channel in Rattlesnake Gulch is clearly the preferential pathway, potentiometric contours indicate that groundwater flow into the Bozeman Group aquifer on either side of the channel is consistent and should be considered as a secondary flow path. The Tertiary fluvial materials have been characterized as having higher clay content, generally lower permeability, and discontinuous sandstone beds (Golder, 1995a). However, GSM's experience in capturing groundwater below Tailings Impoundment No. 1 demonstrates that, once tailings impoundment seepage is introduced to the Bozeman Group aquifer, it moves readily and less predictably than in the alluvial channel sand and gravel deposits (Keats, 2001 and 2002).

Secondary groundwater flow paths from the pit are the principal faults and geologic structures in the bedrock aquifer, other than the Corridor Fault, which is considered a primary flow path. These structures and faults could provide conduits for groundwater transport (Figure 3-2). The principal features of concern are:

- The Range Front Fault east of the pit;
- The east-west trending Telluride Zone and connected Sunlight Fault to the north and Meteor Fault south of the pit;
- The Golden Sunlight Principal Deformation Zone (PDZ) south of the pit;
- The Sunlight Syncline south of the pit (likely the source of Stepan Spring);
- The Latite Valley PDZ southwest of the pit;
- The Fenner Fault, which contributes water to the pit at present but is not mapped outside of the pit;
- The Lone Eagle Fault and potentially connected unnamed faults extending west of the pit; and,
- The Saint Paul PDZ may be connected via mapped faults west of the pit.

As described in Section 3.2.1.5, the extensive ferricrete deposits and gold enrichment along and downgradient of the Range Front Fault suggest that groundwater transport of metalliferous fluids from the area of the pit has occurred in the past. The ferricrete appears to be evidence that discharge along the fault found its way into the Tertiary materials, where it joined the flow paths discussed above.

All the springs on the mine site associated with adits are on or associated with some type of geologic structure or mineralized area (Gallagher, 2003e). Springs are shown on Figure 3-5. Rattlesnake Spring lies on the northwest-trending Rattlesnake Fault. Its water chemistry contains ARD effects indicative of a hydrologic connection to mineralized zones in Bull Mountain. The Arkose Valley Spring is associated with the Latite Valley PDZ. Many small faults and structures surround Bunkhouse Springs and

North Borrow Springs, but these springs do not appear to be related to the faults. South of Bull Mountain, Stepan Spring lies directly over the Sunlight Syncline, suggesting a connection to this geologic structure. The Sunlight Syncline is mapped as a continuous feature from the pit area to Stepan Spring (GSM, 1996). The shape and structure of the syncline funnel ARD from mineralized zones in and south of the pit to Stepan Spring. The thick ferricrete deposits at the spring indicate that ARD transport and deposition have been a long-term occurrence at this location.

Some of the highest yielding wells at GSM lie on faults. PW-60, for example, produces an estimated 40 gpm and lies directly on the unnamed southwest extension of the Range Front Fault (Figure 3-2). PW-21, reported to yield up to 60 gpm, lies on the Latite Valley PDZ. Conversely, no high-yielding wells in the Proterozoic aquifer have been found away from mapped faults. Considering the limited number of monitoring wells installed along faults, and uncertainty of intersecting faults at depth, this apparent association of preferential permeability along faults and other types of geologic structures, although based on limited data, was considered important. Thus, mapped faults which may be traced to the pit area were considered as one of several factors in evaluating hydrologic connection to the pit.

A study of well and spring hydrographs from 1997 to 2003 indicated that the below average precipitation of the 4 to 5 years before the study has likely influenced groundwater levels in all aquifers monitored (HSI, 2003). This obscures any potential of observing indirect evidence of a hydrologic connection from fault-oriented springs and wells to the pit.

3.4 SOILS AND RECLAMATION

The 1997 Draft EIS, Section III.C described the soils within the permit area. Generally, the soils around the pit are on steep slopes and are rocky, shallow, and poorly developed. Soils are salvaged and stockpiled for reclamation purposes. There is a shortfall of stockpiled topsoil for the partial pit backfill alternatives. Additional soils, if needed, would be salvaged from the area permitted for the East Waste Rock Dump Complex and a borrow area north of Tailings Impoundment No. 2 (GSM, 2002). These soils are generally on less steep slopes and are less rocky, deeper, and more developed than the soils around the pit. In addition, a new soil borrow source has been identified north of Tailings Impoundment No. 1, which would require an additional 31 acres of disturbance to salvage enough soil for the pit backfill alternatives. Table 3-2 presents information on the suitability of soils that could be disturbed under the alternatives.

Table 3 - 2. Soil Suitability as Cover

GSM Site Area	Soil Suitability
Western Portion	Soil coarse fragment contents (gravel-, cobble-, and rock-sized geologic materials) are typically somewhat higher in the western portions of the project area. Coarse fragment content has a dual effect on the quality of soils for revegetation purposes. The higher the volume of coarse fragments (assuming the fragments do not readily weather to soil), the less the available water holding capacity of the soil for any given soil texture. For example, a loam soil containing no coarse fragments can store approximately 2.0 inches of water per foot of soil material. A loam soil containing 20 percent coarse fragments can store approximately 1.6 inches of water, while a loam soil containing 50 percent coarse fragments is capable of storing 1.1 inches of water. Conversely, angular coarse fragments occurring on the soil surface decrease the susceptibility of soil to erosion by providing an "armoring effect". The calcium carbonate content and pH buffering capacity of the dominant soils of this area are low.
Eastern Portion	With respect to overall soil characteristics and soil salvage potentials, the soils of this portion of the project area typically overlie less steep slopes, are deeper, have lower coarse fragment contents, and have higher pH values than the soils of the western portion of the project area. These soils have, in part, developed on limestone as well as calcareous loess and have a net buffering capacity due to the calcium carbonate content.

3.5 WILDLIFE

Wildlife resources are addressed in the 1997 Draft EIS, Section III.E. A summary of that information is presented below.

A variety of habitats utilized by resident and migratory wildlife species are found within the general vicinity of the GSM pit. The mule deer is the most common big game species in and around the existing mine site. Several bat species use abandoned mines for roost sites, including winter hibernacula. Bat surveys identified several *Myotis spp.* and big brown bats flying in the vicinity of the mine (GSM, 1995b). A fringed myotis was captured during the surveys and released. Five hibernating big brown bats were observed in one of the four abandoned mines surveyed.

In addition to the named species, long-legged myotis, Yuma myotis, long-eared myotis, and western small-footed myotis are found or may be found in the area (SRK Consulting, 2005).

Twelve raptor species were previously observed in the vicinity of the mine. These species include the bald eagle, golden eagle, turkey vulture, rough-legged hawk, red-tailed hawk, northern harrier, northern goshawk, sharp-shinned hawk, merlin, American kestrel, great-horned owl, and saw-whet owl. An active golden eagle nest was documented in 2003 north of the pit highwall (SRK Consulting, 2005 and Shannon Dunlap, pers. communication, 2006).

3.6 CULTURAL RESOURCES

Cultural resources are addressed in the 1997 Draft EIS, Section III.L.

Cultural resources consist of prehistoric and historic archaeological deposits; structures of historic or architectural importance; and traditional ceremonial, ethnographic, and burial sites. Cultural resources are nonrenewable resources, which are afforded protection by federal, state, and local laws, ordinances, and guidelines.

Several previous archaeological surveys have been conducted in the vicinity (Peterson and Mehls 1994). Reports detailing the results of intensive archaeological evaluations conducted in the GSM area are on file at the BLM Butte Field Office and at the SHPO office in Helena. The only cultural resource that might be affected by pit reclamation is a historic cabin near the north highwall. Should an alternative involving cast blasting be selected, there would be an adverse impact to this historic property, which would require mitigation.

3.7 SOCIOECONOMIC CONDITIONS

Area economy, employment, taxes and income were described in detail in the 1997 Draft EIS, Chapter III, Section III.J, pages 204 through 213. This section updates the data from 1997 to present.

3.7.1 Employment

In 1998, GSM employed 202 full-time personnel, 11 part-time personnel and 39 contractors. As of March, 2006, GSM employed 132 full-time personnel and 17 contractors (Shannon Dunlap, GSM, personal communication, 2006).

Jefferson County is a rural county, with culture and economy historically dependent upon the land. Early economic activities were related to the extraction and utilization of natural resources. The mineral wealth found in the mountains and valleys of western Montana stimulated the county's initial growth. Other activities such as timbering, grazing, and agriculture followed. Natural resource and service industry activities dominate the economy and culture (U.S. Census Bureau, 2000, www.census.com).

The mining sector provides significant contributions to employment in Jefferson County. GSM provided 160 jobs in 2003 accounting for approximately 4.3 percent of total

covered employment. Secondary employment, primarily in the services sector, also is supported in the community by mining jobs at GSM. Table 3-3 shows employment information for Jefferson County and the State of Montana since the 1997 Draft EIS.

Table 3 - 3. Jefferson County and State of Montana Employment and Income

	Jefferson County		Montana	
Population (2001)	10,405		904,433	
Labor Force (2000)	5,183		458,306	
Unemployment Rate (2001)	3.5%		4.1%	
Per Capita Income (1991)	$18,250		$17,151	
Median Household Income (1999)	$41,506		$33,024	
Employment Sector (2000)	**Number Employed**	**Percent of Employment**	**Number Employed**	**Percent of Employment**
Ag/Forestry/Fishing & Hunting/Mining	410	8.4	33,691	7.9
Construction	411	8.4	31,724	7.4
Manufacturing	186	3.8	25,414	6.0
Transportation and Warehousing and Utilities	236	4.8	23,109	5.4
Wholesale Trade	120	2.5	12,937	3.0
Retail Trade	424	8.7	54,468	12.8
Finance/Ins/Real Estate	320	6.5	23,351	5.5
Services	2,034	41.6	195,988	46.1
Public Administration	754	15.4	25,295	5.9
Total, All Industries	**4,895**	**100**	**425,977**	**100**

Note: Source U.S. Census Bureau, 2000, www.census.gov
Note: Services Industry includes professional, scientific, management, administrative and waste management services; educational, health and social services; arts, entertainment, recreation, accommodation and food services; "other services" (except public administration); and information.

3.7.2 Tax Revenues

Table 3-4 provides the specific GSM economic contribution to the State of Montana. Since it began production in 1982, GSM has paid taxes to the state, county, and local communities in the form of the metals mine license tax, the gross proceeds tax, and other taxes. GSM's taxing district includes Whitehall High School and Cardwell Elementary.

Table 3 - 4. Economic Contributions of GSM

	1985	1990	1995	2000	2002	Total Since 1983
Gold Ounces Produced	**96,491**	**97,058**	**89,799**	**212,266**	**111,806**	**2,302,549**
Number of Employees	**146**	**259**	**301**	**92**	**83**	**193 (avg)**
Total Gross Payroll, Payroll Taxes, and Employee Benefits Paid	**$5,872,556**	**$11,934,434**	**$15,157,626**	**$7,679,237**	**$6,296,899**	**$205,977,606**
Total Property Taxes, Gross Proceeds Tax, and Metal Mines License Tax Paid	**$838,632**	**$1,645,634**	**$1,229,379**	**$1,873,003**	**$1,623,460**	**$28,441,051**
Total Purchases	**n/a**	**n/a**	**$35,007,164**	**$21,232,000**	**$27,354,151**	**$337,226,454***
Total Employee Taxes	**$355,098**	**$722,281**	**$3,028,753**	**$1,649,999**	**$1,048,225**	**$32,416,552**

* - Since 1991 only
Source – GSM, personal communication, 2003

The latest Jefferson County and State of Montana revenue figures for fiscal year 1998 and 2002 are shown in Table 3-5. County tax revenues are confined primarily to the property tax, which is assessed based on the total taxable value for the county and the consolidated mill levy (Jefferson County, personal communication, January 6, 2004).

Table 3 - 5. Jefferson County and State of Montana Revenues

Revenue Category	1998		2002		2002 Percent GSM of Total
	GSM	Total County	GSM	Total County	
Property Tax	$551,062	$8,468,801	$309,232	$8,131,529	3.8%
Gross Proceeds Tax	$389,771		$492,362		
Metal Mines License Tax	$847,243		$821,866		

3.8 LAND USE AND ACCESS

Land Use and Access is addressed in the 1997 Draft EIS, Section III.H. A summary of that information is presented below. Today, the primary land uses in the pit area are wildlife habitat and mineral extraction.

The majority of surface land in the current GSM permit area is owned by GSM. The remaining surface lands consist primarily of BLM-administered tracts, with DNRC-administered school trust land in Sections 16 (T2N, R3W) and 36 (T2N, R4W) (Figure 1-3).

The county's current mining operations provide employment and economic benefits for Jefferson County. The county recognizes that mining is a finite activity and it acknowledges the importance of expanding and diversifying the economic base. The Jefferson County Comprehensive Plan also emphasizes the value of "quality of life" issues and preserving environmental and cultural resources (Jefferson County, 1993).

The Jefferson County Comprehensive Plan Map depicts the area around the mine as a "Basic Resource with Development Constraints," meaning that the land is to be protected for agriculture, timber, and mineral resource utilization. Lands with this designation may have development and use constraints including any of the following: public ownership, steep slope, flood susceptibility, poor access, lack of potable water supply, and/or fire suppression capability (Jefferson County, 1993).

GSM applied for a minor revision in December 2003 to leave the mill complex for post mine industrial use by Jefferson County. This change in land use was approved in 2004 and modified in 2005 in Minor Revision 05-005.

3.9 AESTHETIC RESOURCES

Aesthetic resources are addressed in the 1997 Draft EIS, Chapter III, Section III.I.

The BLM Visual Resource Management (VRM) system is designed to help manage the quality of the landscape by minimizing impacts to visual resources resulting from development activities, while maintaining the effectiveness of all BLM resource programs. Through the visual analysis process outlined in BLM Handbook 8410-1, Visual Resource Inventory, rating categories are assigned. The categories describe the relative value by analyzing three components - scenic quality, viewer sensitivity, and distance zone - to provide an assessment of the current visual resources. VRM Classes I to IV are then assigned for the area, with management objectives ranging from maintaining minimal visual disturbance to allowing activities that entail major landscape modifications. The BLM, to date, has not assigned a VRM Classification for the lands around GSM, although the area has generally been managed as a potential VRM Class IV area because of the existing mining disturbances.

A Visual Resource Inventory (VRI) was conducted for the 1997 Draft EIS and is discussed there in Chapter III, Section III.1. The results of the VRI yielded a Class III rating. The study area was defined as the ridgeline encompassing present mining activity and surrounding BLM lands and parts of the surrounding valleys. A Class III rating provides for moderate changes to the existing landscape and activities that may attract the attention, but not dominate the view of the casual observer. Under a Class III rating, areas that currently do not conform to the management objectives would be designated as "Rehabilitation Areas"; these areas would be rehabilitated upon project completion to restore the natural characteristics of the landscape to the extent required for a Class III visual resource rating.

GSM has reclaimed 7 acres in the pit to date. GSM has planted tree seedlings along the upper pit highwall on the west and south sides of the pit. GSM has placed soil on the oxidized upper northwest corner of the pit to determine if revegetation can be successful with a small amount of soil placement.

3.10 SAFETY

Safety is an important issue at Barrick's Golden Sunlight Mine. Safety and Health education and training are key components to Golden Sunlight Mine's safety program.

In January of 2006, Barrick Gold acquired Placer Dome. Barrick's vision and philosophy are as follows:

Barrick's Vision:" *Every person going home safe and healthy every day."*

Barrick's Philosophy: We are committed to performing every job in a safe and healthy manner. Work-related injury or illness is unacceptable and we are committed to the identification, elimination or control of workplace hazards for the protection of ourselves and others. Everyone is responsible for workplace safety. *No job is ever worth doing in an unsafe way. None!*

Barrick's safety and health plan is a dynamic program requiring continuous improvement. The following are the elements of the program:

Core values:

- BEHAVE LIKE AN OWNER
- ACT WITH A SENSE OF URGENCY
- BE A TEAM PLAYER
- CONTINUALLY IMPROVE
- DELIVER RESULTS

Objectives and Strategies:

- Safety Leadership is a Line Management Responsibility;
- Increased Ownership and Participation of "Everyone" – all stakeholders - for Safety and Health;
- Continue to build an incident-free safety and health culture;
- Continuously improve the safety and health programs, systems and resources utilizing "best of industry" practices;
- Develop programs and processes in support of health and wellness.

Priorities for 2007 and 2008:

2007

Continued focus on:

- Leadership and Personal Commitment
- Risk Management
- Contractor Controls
- Health and Wellness

2008

- Training and Competence
- Incident Investigation
- Operational Controls and Procedures

In safety reporting, medical aid injuries are defined as occupational work-related injuries that require medical treatment exceeding a first aid category but do not result in lost time. Lost time injuries are defined as work-related incidents that cause a worker to miss the next regular scheduled shift from work. All injury statistics are reported relative to these definitions.

As of January 1, 2007, GSM employees and contractors had worked 515,665 hours without a lost time accident (LTA). GSM's non-fatal days lost rate for 2006 was 0 compared to a MSHA national average of 1.63.

Chapter 4

Environmental Consequences

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Chapter 4

Environmental Consequences

4.1 INTRODUCTION

The 1997 Draft and 1998 Final EIS discussed impacts associated with pit reclamation alternatives. The information presented in this SEIS supplements those documents.

What has changed in Chapter 4 since the DSEIS?

Chapter 4 describes the environmental consequences of the Proposed Action and three alternatives. Based on additional data and public comments, the following changes have been made:

- Selected analyses in the Final SEIS have been updated since preparation of the Draft SEIS in 2003-2004, as indicated by more recent reference citations.
- The GSM 2004 annual report was used to update all figures. The 2006 annual report was used to update some acreages.
- Information on the 2004 earthquake and its effects on the area is provided.
- Additional wildlife species found or that may be found near the area were listed.
- The groundwater capture needed to meet groundwater standards at the mixing zone boundary for the Partial Pit Backfill With Downgradient Collection Alternative was changed from "95 percent capture efficiency" to "two groundwater capture systems, operating at combined efficiency of approximately 96 percent".
- The volumes of soil cover needed in the four alternatives were updated.
- The pit discharge rate was changed from 16 gpm to between 27 and 42 gpm for the Partial Pit Backfill With Downgradient Collection Alternative and from 32 gpm to between 25 and 27 gpm for the No Pit Pond and Underground Sump alternatives based on a new water balance model.
- The groundwater collection and treatment rate was changed to approximately 145 gpm for the Partial Pit Backfill With Downgradient Collection Alternative.
- The permanent loss of 158-159 acres was changed to 156-158 acres for the No Pit Pond and Underground Sump alternatives.
- Table 4-8 was added to show compliance with DEQ-7 Groundwater Standards and Nondegradation Criteria for the Partial Pit Backfill With Downgradient Collection Alternative for selected parameters.
- Reference was made that the property could be used as a wind farm.
- Measure 2a addresses backfill sources for the partial pit backfill alternatives.
- Measure 15 is now split into three submeasures. Measure 15a is the same as Measure 15 in the Draft SEIS. Measure 15b addresses the installation of an upgradient capture system. Measure 15c addresses the installation of a downgradient capture system near the east edge of the pit. Both Measures 15b and 15c apply to the partial pit backfill alternatives.
- All text, figures and tables were revised from data provided by GSM and various consultants.
- Text was corrected based on references.
- Nondegradation analyses were performed for the Jefferson River Alluvial Aquifer and Jefferson River Slough.

This SEIS addresses potential environmental consequences as a result of the Proposed Action, No Action and two other alternatives presented in Chapter 2. The

most important issue in this SEIS, as determined through scoping, is the potential impact to groundwater. The open pit is the principal facility affected by the actions and alternatives of this SEIS. The East Waste Rock Dump Complex is affected for alternatives involving backfill; waste rock to backfill the pit would be obtained by removing about 33 percent of the volume from the top of the East Waste Rock Dump Complex as shown in Figure 2-6. The footprint of the East Waste Rock Dump Complex would not change.

In addition, 13 percent of the footprint of the East Waste Rock Dump Complex is in the Rattlesnake Gulch drainage. This means that part of the seepage from the dump complex would infiltrate below the dump and mix with ambient groundwater in Rattlesnake Gulch. This groundwater moves down the drainage toward the Jefferson River alluvial aquifer. Most of the seepage from the pit would also move down the Rattlesnake Gulch drainage, if the seepage is not contained within the pit. Hence, the following analysis discusses the alternatives and issues of concern with respect to the pit and the East Waste Rock Dump Complex and associated potential impacts to the environment.

This chapter describes the direct, indirect, and cumulative environmental consequences (both adverse and beneficial) for each of the pit reclamation alternatives. Many impacts are the same regardless of the alternative; however, other impacts are directly dependent on the reclamation measures in a specific alternative.

The impacts are described based upon the change that would occur to the existing resource conditions described in Chapter 3 if the alternative were implemented. The analysis will focus on risks and uncertainties from implementing the various pit reclamation alternatives.

4.1.1 Assumptions

The impact analysis is based upon the following assumptions:

- The Stage 5B pit mining and pit reclamation alternative would be fully implemented as described in Chapter 2.
- Potential mitigation has been built into each alternative as part of the activity that would occur under that alternative. The impacts described for each alternative are, therefore, the residual impacts left after the implementation of mitigating measures.
- Monitoring and maintenance of the water capture and treatment systems would occur under all alternatives as needed to meet the requirements of the Montana Water Quality Act and other permits. The amount of effort required to maintain the systems and the certainty with which compliance is achieved may vary by alternative.
- Consequences of failure of each alternative will be estimated using the best available information. Risks and uncertainties are noted.

4.2 TECHNICAL ISSUES

4.2.1 No Pit Pond Alternative (No Action)

4.2.1.1 Design and Constructibility of the Alternative

Design and constructibility of the No Pit Pond Alternative were not evaluated in the 1997 Draft EIS.

4.2.1.1.1 Proven Design

Under the No Pit Pond Alternative, 100 feet of crusher reject would be placed in the pit as a sump, and two to three 100-foot dewatering wells would be installed to the bedrock contact. It is estimated that from 25 to 27 gpm would be pumped out of the wells (Telesto, 2006).

As described in Section 4.2.1.3 and the pit backfill analog study (Gallagher, 2003c), pits have been backfilled in Montana and elsewhere. Several pits in Montana and other states have been mined below the water table and have been partially backfilled above the water table level. Active dewatering has been conducted in partially backfilled pits.

It is technically feasible to haul backfill and install wells in a pit at closure. Backfilling by hauling to the bottom of the pit and end dumping and dewatering the pit under the No Pit Pond Alternative is a proven design. Backfill maintenance problems after construction of the alternative are described in Section 4.2.1.3.

4.2.1.1.2 Ability to Construct the Alternative at GSM

At closure, GSM would haul the crusher reject between 725 and 825 vertical feet down into the pit from the eastern rim of the pit at the 5,350-foot elevation. GSM's safety policy would require special conditions, such as truck load limits, to be imposed during the backfill operations because of safety concerns with driving fully loaded trucks down the steep pit access road. The 5,700-foot elevation safety bench would have to be maintained. A 1.3-acre working surface would be created on the backfill. A safety berm would be installed on the working surface to protect workers and the dewatering wells.

Two to three dewatering wells would be constructed through the 100 feet of crusher reject to the bedrock contact. Drilling through unconsolidated waste rock is more difficult than drilling through solid rock, but can be done using special equipment. Over 100 feet of backfill have been hauled into pits reclaimed in Montana and elsewhere. Dewatering wells pumping 25 to 27 gpm have been drilled in at least 100 feet of weathered waste rock backfill at GSM and elsewhere (Gallagher, 2003c).

There would be minimal problems developing and implementing the No Pit Pond Alternative at closure as described, because only 111,000 cubic yards (167,000 tons) of crusher reject and two to three wells would be needed. Pit highwall and dewatering well maintenance problems after construction of the alternative are described in Sections 4.2.1.2 and 4.2.1.5, respectively.

4.2.1.2 Pit Highwall

Ground movement in the mine area was analyzed in the 1997 Draft EIS, Chapter IV, Section IV.A.1.a. No ground movement affecting stability in the pit or waste rock dump complex areas have been identified through 2006.

This section addresses both pit highwall stability and pit highwall maintenance requirements for the No Pit Pond Alternative. Additional geotechnical studies on pit highwall stability were conducted for this SEIS (Telesto, 2003d and 2003g). In 2005, GSM conducted reviews of the pit highwall information. The conclusions support the overall stability conclusions found within the Draft SEIS (Brawner, 2005; Golder, 2005). This section will concentrate on observations from 25 years of mining at GSM and on new stability evaluations for the open pit area only.

4.2.1.2.1 Stability Observations at GSM (1981-2006)

During the past 25 years of open pit mining at the site, many slope design studies have been performed (Golder, 1995a-l, 1996a, 1996b; Seegmiller, 1987, 1988; Telesto, 2003d, 2003f). There have been several pit slope failures in connection with on going mining activities. Little information is available for pre-1992 slope failures. The following list provides volume and timeframe estimates for selected post-1992 slides (Telesto, 2003f; Brawner, 2005; Golder, 2005):

- North highwall zone – 600,000 cubic yards in 1995 to 1997.
- Southwest highwall – 500,000 cubic yards in 1999.
- Upper west highwall zone – 200,000 cubic yards in 1999.
- Southeast pit highwall – 10,000 cubic yards in 2001.
- Expanded ramp pit highwall – 50,000 cubic yards (Brawner, July 2002).
- Expanded ramp pit old pit highwall – 10,000 cubic yards (Brawner, September 23, 2003).
- Northwest pit highwall – 310,000 cubic yards on August 31, 2004 where bedding planes that dip into the pit at 30 degrees intersected the Lone Eagle Fault. Movement in the area was being monitored prior to the failure.
- Northwest pit highwall –33,000 to 47,000 cubic yards on June 8, 2005. The slope between the 5,200-foot and 5,450-foot-elevation benches failed and remobilized the failure between the 5,450-foot-elevation bench and the 6,030-foot-elevation highwall crest. The toe of this failure on the 5,200-foot-elevation bench evidently involved the intersection of the Corridor Fault and the Lone Eagle Fault (Golder, 2005).

- Northwest 4925 Wedge - On January 30, 2006, a 47,000 cubic yard wedge mobilized between the 5,200-foot and 4,925-foot elevations due to intersecting high angle structures in the northwest corner of the pit. A catch bench and a rock-fall protection barricade were installed so that mining could continue.
- Switchback Failure - On April 5, 2006, a 133,000 cubic yard highwall failure resulted in the loss of the Number One Switchback from the Main Pit Ramp on the north highwall. The failure was caused when a Lone Eagle type fault intersected a bedding plane fault on the 4,925-foot elevation and was subsequently pressurized by a large precipitation event, 2.7 inches in 24 hours. Consequently, the main ramp was relocated east into the footwall of the Mineral Hill Breccia Pipe.

These failures ranged from small scale bench and multi-bench failures to a large-scale wedge failure of the southwest highwall of the Stage 2 pit. These failures and smaller scale movements were a direct result of mining activities and ceased within days after mining operations moved to different areas of the pit (Paul Buckley, GSM, personal communication, 2003). The largest contributing factors to these failures were conventional blasting, unfavorable structural orientations, such as faults or bedding planes that were exposed by mining, water pressure in joints and fractures, and vibrations from truck hauling, excavating, and dozing.

Highwall failures can be mitigated during operations using a variety of methods as follows:

- Mining to remove the area of concern.
- Flattening of the highwall in the area of concern to reduce the forces tending to cause movement.
- Buttressing the toe of the highwall to reduce forces that tend to cause movement.
- Providing artificial support such as rock bolts and dowels.
- Horizontal drain holes to reduce the hydrostatic pressure which tends to cause movement where unfavorable structural geology exists.

At times during operations, all of these methods or a combination of methods have been used to mitigate the impact of unstable sections of the pit highwall.

One factor influencing pit highwall stability that can potentially be controlled is the impact of blasting. Reducing over break effects (*i.e.*, fracturing and damage to the pit highwall beyond the extent desired for mining) leaves the inherent strength of the rock and geologic structures at the pit highwall in a stronger condition. Therefore, controlling the impact of blasting can be considered a pit highwall stabilization technique.

Pre-splitting is one of several techniques used to control over break. Pre-splitting is similar to blasting techniques used in the rock quarry industry to remove blocks for

building stone. With pre-splitting, a row of holes is drilled along the final excavation line and loaded with a special grade of explosive. These holes are fired prior to the production blast to create a fracture line at the excavation limits. The idea of pre-splitting is to isolate production shots from the remaining rock formation by forming a crack along the designed highwall. Although good over break control results cannot be expected in all geologic formations, a carefully planned blast design can minimize over break in even the most severe conditions.

Pre-splitting works well at GSM (Paul Buckley, GSM, personal communication, 2003). Pre-split blasting techniques have been utilized since January 2001 and would be used throughout the remaining mine life of Stage 5B. Once mining activities for Stage 5B have been completed, approximately 58 percent of the pit highwall would have been mined by pre-split blasting techniques, from the 5,700 bench extending down to the 4,550 bench.

The impact of pit highwall instability during operations would range from minimal to the loss of a substantial portion of the ore reserve. For example, during mining of the Expanded Ramp Pit, two substantial highwall instabilities developed (see above). However, the mitigation for these did not result in the loss of ore reserves, although sections of the pit were redesigned.

Stage 5B would excavate several areas known for unstable ground conditions. However, a diligent slope stability program, including monitoring, geologic mapping, controlled blasting, dewatering, and scaling, would continue to mitigate poor ground conditions as they arise. This would reduce the likelihood of raveling and sloughing impacting long-term operations in the pit bottom. As an added safety measure, the safety bench located at the 5,700-foot elevation would separate the upper north highwall of the pit, where pre-splitting was not used, from the pit bottom. Most of the past failures were caused by, or were associated with, conventional blasting and excavation activities. Such failures would not be expected to occur after mining ceases.

The zones of past pit highwall instability that will remain after completion of the Stage 5B Pit are located above the 5,700-foot safety bench. Monitoring of these zones is on going and no impact from current mining has been recorded.

In summary, past pit highwall instability has been largely attributed to mining activities intersecting unfavorable structures. Characteristically, ground movement has subsided within days after mining operations have moved away from the zone of instability. For this reason, these types of instability and frequency of occurrence would not be typical after closure at GSM, with any pit reclamation alternative being evaluated.

Based on 25 years of observation, the slope failures that have occurred in the non-active mining areas of the GSM pit have been sloughing failures with localized raveling of benches (*i.e.*, the benches lost their blocky shape). Portions of the outside

edges of mine benches have broken off and the intersection between the flat portions of the benches and highwall have filled with these rocks forming talus slopes. The impressions of the benches are still visually evident over most of the pit highwall. These failures have occurred predominantly during the spring and fall months following freeze and thaw cycles, spring melt of accumulated ice and snow on the pit highwall, and following large rainstorm events. These instabilities are typically small-scale and are similar to those observed on mountain slopes along highways.

Experience has indicated that raveling is more common on the newly mined pit highwall and would decrease as the pit highwall matures. On the south side of the pit, the pit highwall movement has been basically dormant for the past 10 years. Much of the north side of the pit, including a zone of instability on the northwest highwall, had been dormant for 6 to 10 years until a failure occurred in 2004 (see above). Both failures were initiated by mining activities in that area. Based on these observations over the mine's life, it is expected that raveling and sloughing would occur over time. The majority of raveling highwall rock would be caught on safety benches resulting in angle of repose surfaces less than 100 feet long and would not cause problems in the bottom of the pit. This type of instability would be slow in movement and progression, although occasionally rocks would fall off safety benches and roll to lower portions of the pit.

After closure, large-scale, multiple-bench wedge failures in the Stage 5B Pit that could destroy dewatering wells would be unlikely (Telesto, 2003d). This prediction is based upon the increase in the competency of the rock that is mined beneath the Corridor Fault and the resulting rock quality due to the improved blasting methods implemented by GSM, which have decreased blast damage to the pit highwall. To further reduce the possibility of a wedge failure, GSM incorporates information regarding local bedding, faulting, and fractures directly into pit designs and excavation. Even with the predicted long-term stability, to be conservative in the following section of this SEIS analysis, the agencies have assumed occasional failures.

4.2.1.2.2 Pit Highwall Stability

The results of the failure modes and effects analysis for the No Pit Pond Alternative in the 1997 Draft EIS, Chapter IV, Section IV.A.6.a indicated that most of the identified modes of failure have a low to very low probability of occurring. Moderately likely failure modes are primarily associated with potential block slip movements in the pit. The only failure mode that would likely occur is occasional localized failures similar to those that can be observed in the highwall today.

For this SEIS, GSM conducted an investigation into pit highwall stability for the pit reclamation alternatives (Telesto, 2003d). The study focused on the Pit Pond Alternative, which has been dismissed in Section 2.5.4, and on the partial pit backfill alternatives. Because of the similarity in geometry between the alternatives, results for the Pit Pond Alternative are directly applicable to the No Pit Pond and Underground Sump alternatives.

For this investigation, rock and soil samples were collected to determine soil classification and geotechnical properties of the rock and soil, using standard industry accepted practices (Telesto, 2003i). The geotechnical properties were then used for modeling the reclamation alternatives for the GSM pit.

Block failure analysis was not conducted because the geology reports for GSM did not indicate the presence of a weak soil layer at the base of the slope, and because most of the pit is constructed in an anticline (*i.e.*, the formations dip away from the pit) (GSM, 1996c). Most high angle faults running through the pit dip into the center of the pit, the Range Front Fault dips steeply away from the pit on the east and the Corridor Fault dips gently towards the east across the upper portion of the pit. These configurations make the possibility of block failure less likely than a circular failure. Damage to a reclamation alternative as a result of massive block failure is unlikely.

Circular failure analysis was chosen to model the potential for massive failure of the pit that would damage or destroy the reclamation alternatives because of the site-specific geology of the pit. Pit highwall stability was modeled to estimate the potential for massive failure in the circular failure mode for each reclamation alternative. SLOPE/W version 5.04, a state of the art model for evaluating slope stability, was used (GEO-SLOPE International, Ltd., 1991; Telesto, 2003d). The relationships between the pit highwall, faults, joints, and bedding angles are conducive to using the circular failure analysis, which overestimates the chance of highwall failures. Circular failure would have to occur across the bedding planes and geologic structures. In circular failure analysis, structures are ignored and the material is treated as unconsolidated. The analysis overestimates the chance of highwall failure because it ignores a fundamental strength component in the analysis (Telesto, personal communication, 2005).

Failure planes typically follow structures. Bedding in much of the pit and a 200-foot-thick latite sill in the northern part of the pit dip away from the pit. However, along portions of the south and west pit highwall, beds dip gently into the pit. Adverse bedding orientation, usually in conjunction with structures or jointing intersections, have only contributed to small slope failures in an area confined to the west and northwest corner of the pit, in a zone in the general vicinity of the Corridor Fault. Historically, failures in the pit have generally been small and have occurred along steep northeast trending faults due to mining activities.

GSM prepared additional stability analyses since the Draft SEIS focusing on the stability of the pit highwall (Golder, 2005). Rock mass stability analyses indicate adequate factors of safety with respect to rock mass failures for the highwall. Failure analyses indicate little potential exists for structurally controlled failures of the highwall, with the exception of the existing failures in the upper west and northwest highwalls (Golder, 2005). In these areas, raveling and small wedge failures could occur. Such failures would be limited in scope and would not damage or destroy the reclamation alternative.

As mentioned in Section 3.2.2.2, stability analyses use factors of safety to estimate the inherent stability of the pit highwall. A factor of safety of 1.0 is considered stable. Factors of safety greater than 1.0 indicate higher pit highwall stability.

The model was run assuming Stage 5B without backfill and with the groundwater level still drawn down below the pit bottom as a result of operational dewatering (Telesto, 2003d). In the No Pit Pond Alternative, the pit would be backfilled with 100 feet of crusher reject from 4,525 feet to 4,625 feet, which would reduce the overall height of the 1,875-foot-high highwall and increase the stability slightly. The water table would be maintained as close to the final pit bottom as possible, which would make it almost as stable as the dewatered Stage 5B Pit. The results of these failure analyses showed that the pit highwall would be stable, and the factors of safety would range from 1.17 (based on higher than anticipated input values) to 1.60 (based on expected analysis input values).

To be on the safe side, the Pit Pond Alternative was analyzed for stability because, with the highest water level and the least amount of backfill, highwall stability problems would be more likely to occur than with the other alternatives. The pit highwall stability for the Pit Pond Alternative following formation of a pit pond decreased from 1.17 to 1.16. A change of less than 0.1 in the overall factor of safety is not important considering the accuracy of this type of analysis. Based on these stability analyses, the factor of safety change would be negligible compared to the dewatered Stage 5B pit. This conclusion agrees with the results for the No Pit Pond Alternative in the 1997 Draft EIS.

The values for the pit highwall are less than the industry-accepted 1.3 short-term and 1.5 long-term factors of safety. However, there is a 97 to 99 percent probability that all the possible strength input parameters would be larger than estimated, resulting in higher factors of safety than calculated in the analysis. Therefore, the expected 1.6 factor of safety value is greater than the 1.3 short-term and 1.5 long-term factors of safety and should be considered as the expected factor of safety for the pit highwall.

Physical and chemical weathering of the pit highwall would not impose an immediate change to the geotechnical analysis presented (Telesto, 2003d). Short-term physical weathering of the highwall appears to be dominated by the effects of blasting, which do not extend far into the highwall, especially below the 5,700-foot safety bench where pre-split blasting has been used. Freezing and thawing would largely control pit highwall physical weathering rates over the long term. Chemical weathering from sulfide oxidation should not extend beyond a thin layer on the exposed surfaces of the highwall and fractures. Exposed sulfide-rich highwall rock in the pit would continue to oxidize through infiltration and percolation of precipitation and seeps regardless of the effectiveness of dewatering. Locally, the oxidation of iron hydroxide might enhance stability through iron oxide cement formation. Thus, physical and chemical weathering would not cause catastrophic failures in the pit highwall (Telesto, 2003d).

In addition to the circular failure analysis, Telesto (2003a) completed an addendum to provide discussion and historical perspective on the possibility of localized pit highwall failures not previously addressed by Telesto (2003d) that would likely occur after closure. The addendum discussed both failures that have occurred during mining operations and failures that can be expected to occur after closure. The addendum discussed the details of the geologic setting and pit slope failures at GSM from 1981 through 2003.

Stability of the highwall after closure in a dewatered pit would greatly depend upon highwall rock integrity. Seeping and fractured areas would generally tend to be less stable unless secondary processes cause cementation of the materials in such zones. Pit highwall slopes would continue to undergo alternating periods of rock raveling and sloughing and quiescence for years after mining has ceased. As the pit highwall is acted on by gravity and the rock fracturing forces of freeze-thaw cycles, the steeper pit highwall would ultimately shed material to form talus slopes at its base, trending to a less steep highwall at the higher elevations. The 1,775-foot pit highwall should achieve equilibrium in 10 or fewer years after closure, with further minor adjustments in wet or above average freeze and thaw cycles and in years with earthquakes.

Seismic effects on stability were evaluated in the 1997 Draft EIS, Chapter IV, Section IV.A.1.a and no adverse effects on highwall stability were identified. No further evaluation of earthquake effects was made for the Draft SEIS. A seismic evaluation, including pseudo-static analysis information, was conducted for the Draft SEIS, which corroborated the 1997 Draft EIS analysis (Telesto, 2003d).

GSM conducted additional studies at the site after a 4.0 magnitude earthquake occurred nearby on June 28, 2004 (AMEC, 2004). It was felt at the mine, but no damage was done and no highwall instability occurred.

Mineralogical, geochemical, and geological data and observations were reviewed and analyzed relevant to the geotechnical evaluation of pit highwall stability at GSM after pit closure (Telesto, 2003d). The highwall stability at GSM has been compared to other sites with similar sulfide content. While the oxidation of sulfide and subsequent generation of acidic pore water can weaken the host rock, the geology and lithology of the host rock must also be considered when making such comparisons or predicting future stability.

Several factors at GSM indicate that physical or chemical weathering would not likely become a factor in highwall stability, as discussed in Section 3.2.2.3. Field and petrographic observations reveal that beyond a thin surface rind (less than 1 mm) of chemical weathering, the interior of the rocks is very fresh with no signs of incipient weathering (Telesto, 2003d). This thin rind can be seen on the rocks exposed to the atmosphere on the pit highwall as well as along natural and conventional blast induced fractures in the pit highwall. A disturbed rock zone caused by conventional blasting and mining can extend several feet to tens of feet into the pit highwall (Gallagher, 2003a; Paul Buckley, GSM, personal communication, 2003). Blast

induced fracturing on the pit highwall may increase physical weathering, but has a limited effect on chemical weathering. Blast induced fractures and the near-surface consumption of oxygen combine to limit the expected extent of chemical weathering. The geotechnical testing of existing mine material indicates an acceptable factor of safety and the data summarized above suggest that future physical and chemical weathering at GSM would not compromise overall highwall stability.

Although a direct analogy between the cause of weathering of the highwall and waste rock exists, a direct correlation between highwall weathering and weathering of the waste rock cannot be inferred (Telesto, 2003c). Waste rock in the dump complexes has weathered at a rapid rate (Herasymuik, 1996). On the highwall, physical weathering is minimized because the rock is left relatively intact after mining. In a few places in the pit where conventional blasting has caused more damage to the highwall, mostly along existing geologic structures, physical weathering has increased and resulted in localized failures. Because the waste rock has undergone a large amount of handling, such as blasting, loading, hauling, dumping, and spreading, more surface area has been created and it is more susceptible to physical and chemical weathering. Larger rock fragments are placed within the dump and, in a relatively short period of time, break down into smaller particle sizes. Because most of the waste rock is either Mineral Hill breccia or from the zone adjacent to the breccia, it generally contains more sulfides than the rock remaining in the highwalls. The oxidation of the larger amount of pyrite in the waste rock dump complexes has accelerated the break down of the acidic rock. This accelerated chemical weathering has not been as pronounced in the pit rock on highwalls or on benches, which have had less physical damage. Thus, the lack of weathering observed on the highwall indicates that the highwall rock weathering rate is not directly correlated to waste rock weathering (Telesto, 2003c).

The 1998 ROD concluded that the highwall would be structurally stable under the No Pit Pond Alternative. Some raveling, talus formation, and limited sloughing of the highwall can be expected over the long term after mine closure. These occurrences would lead to increased stability of the highwall with minimal impact on the environment outside the pit area.

Under the modified No Pit Pond Alternative in this SEIS, the pit bottom would be deepened from 4,650 feet to 4,525 feet as part of Stage 5B. The effect of deepening the pit on highwall stability was evaluated and found to be minimal (Telesto, 2003d). The pit highwall angles, bench widths, and slope angles between benches would be left generally as shown in Figure 2-3. The bottom of the pit would be filled with 100 feet of crusher reject from 4,525 feet to 4,625 feet, reducing the maximum highwall height from 1,875 to 1,775 feet (Figure 2-3). The properties of the crusher reject material are described in detail in the groundwater effluent management system, Section 4.2.1.5.1. Wells would be installed and water would be pumped to prevent a pond from forming. As the groundwater levels surrounding the pit are drawn down during mining and maintained following mining (HSI, 2003), the pit highwall would become more stable overall. This is because the fluid pressures within the rock mass,

which act to destabilize the highwall, would be reduced (Telesto, 2003d). Small localized seeps would continue, especially along the Corridor Fault and other wet areas, largely in response to precipitation events (Gallagher, 2003b). These areas would remain locally unstable and are susceptible to additional chemical and physical weathering and raveling over time.

In summary, under the No Pit Pond Alternative in the 1997 Draft EIS, it would be expected that some portions of the pit highwall would be subject to raveling, talus formation, erosion, and limited sloughing, thus locally altering the configuration of some of the pit highwall. In particular, sloughing may be expected along the northwest area of the pit, where the orientation of existing faults renders the highwall less stable. As sloughing occurs, however, the overall stability of the pit highwall would be expected to increase over the long term as the rock materials achieve a more stable configuration. The combined effect of potential ground movement over time is anticipated to have negligible environmental consequences outside the pit area, but would impact access, maintenance, and dewatering system operation (Telesto, 2003d).

Under the No Pit Pond Alternative in the 1997 Draft EIS, 100 feet of backfill would have been placed to raise the pit bottom from 4,700 feet to 4,800 feet. The volume of backfill needed was estimated to be up to 500,000 cubic yards (750,000 tons) (1997 Draft EIS, Chapter II, Section II.B.6.b; 1998 ROD). The backfill would have created a working surface of 7.4 acres. In this SEIS, 111,000 cubic yards (167,000 tons) of crusher reject would be placed to raise the pit bottom from 4,525 feet to 4,625 feet. This would create a flat, dry working surface of 1.3 acres.

Due to the concerns over potential small-scale failures, a plan for monitoring and mitigation of slope movement of the pit highwall would be developed and implemented after closure. Survey prisms, which are currently used to ensure safe mining operations, would continue to be used to monitor ground movement in susceptible areas after closure. A plan concerning entry into the pit after a storm event or after long periods of absence would also be developed. These plans would help ensure workers' safety and provide a mechanism to maintain pit access.

Another potential cause of failure is surface water runoff from precipitation events. After closure, this potential would be minimized by storm water controls that would prevent an estimated 99 percent of storm water from entering the pit (Telesto, 2003a). This would be accomplished after final slopes are created and before mining is completed if possible. Otherwise, localized failures may occur increasing the amount of rock that ravels and sloughs onto safety benches and the pit bottom.

The term "risk" encompasses the concepts of both the likelihood of failure and the severity of the expected consequences if such events were to occur. An analysis considers both the risk of a failure and uncertainty in estimating the risk. This SEIS explains both the risk and uncertainties in the analyses that were conducted.

Likelihood categories are generally qualitative. However, the use of numerical probability ranges to define the frequency of site specific events can provide additional guidance. Likelihood of failure was evaluated qualitatively for this analysis. In order to assess the impact or consequence of any potential failure on a system, potential receptors must be identified and characterized. Receptors vary at and within each mine site. Key receptors can include human health and safety; the environment; corporate reputation; community relations; government relations; legal consequences; and costs. Likelihood of occurrence and consequence are then evaluated to determine risk.

In the highwall stability analysis for each alternative, the agencies made assumptions of material quantities that could slough or fail over time. Although these quantities are not based on empirical data, as such data do not exist, they do provide a comparative analysis of alternatives. The assumed quantities of material may be subjective; however, the likelihood of such a failure occurring and the consequences of that failure do not change and, therefore, the risk does not change. Technical information prepared for this SEIS was used in evaluating the risk involved with highwall stability issues.

Sloughing of the pit highwall was not as much of a concern in the 1997 Draft EIS because the working area would have been 7.4 acres in size, providing room for raveling and sloughing highwall rock, and the predicted failures would have been small over time. The 1997 Draft EIS and this SEIS analysis concluded that the risk of a large failure was low over time.

To address risk and uncertainty in this SEIS, the agencies have assumed failures would occur over time similar to those that have occurred during operations, as listed in Section 4.2.1.2.1. The agencies have assumed 100,000 cubic yards (150,000 tons) of highwall rock would ravel over time, especially on the northwest highwall, eventually covering the 5,700-foot elevation safety bench and rolling to the bottom of the pit. In addition, the agencies assumed another 100,000 cubic yards would slough into the pit from the northwest portion of the highwall, which would eliminate access to the bottom of the pit, bury the dewatering system, and cover the 1.3-acre working surface. To restabilize the pit, GSM would have to reestablish the safety bench at the 5,700-foot elevation, reopen the access road into the pit, haul more backfill into the pit to create a new larger working surface, and reestablish safety berms and the dewatering system wells. The agencies have assumed this could occur more than once over the long term. The agencies have assumed that, over time, highwall rock and crusher reject in the bottom of the pit would be 200 feet deep and total 600,000 cubic yards (900,000 tons).

As a contingency, if the dewatering system was destroyed or became inaccessible, the agencies would require GSM to submit a plan for development, maintenance, and monitoring of a portal at a suitable elevation to allow access to the underground workings, so that dewatering would still be possible using the underground sump.

Even with these failures, there would be minimal impacts outside of the pit from periodic pit failures over the long term.

4.2.1.2.3 Pit Highwall Maintenance Requirements

As discussed under Pit Highwall Stability above, small-scale highwall instability would continue after closure under the No Pit Pond Alternative, which would affect pit highwall maintenance. Pit highwall maintenance requirements would be higher for alternatives that leave the pit open, such as the No Pit Pond and Underground Sump alternatives.

Highwall safety benches, especially the 5,700-foot safety bench, that are present during mining, would remain in most areas and would catch most rock that ravels after closure. The pit haul road would have to be maintained for access. The highwall safety benches would have to be maintained to protect workers in the pit. The crest of the pit would need to be monitored regularly for tension cracks to identify when movement is occurring and to ensure storm water run-on does not enter the pit.

The agencies have assumed that safety benches would be compromised over time and that as much as 200,000 cubic yards (300,000 tons) of rock would ravel and slough to the bottom of the pit. This would require periodic maintenance to reestablish the 5,700-foot safety bench above the pit floor, clear the access road, haul more backfill to create a new larger working surface, and move rock to reestablish safety berms on the working surface. The agencies have assumed this could occur more than once over the long term, as described in Section 4.2.1.2.2.

Technical reviews, additional analyses (Brawner, 2005; Golder, 2005), and the conclusions in the Draft SEIS confirm that the pit highwall stability conclusions reached in the 1997 Draft EIS remain valid with respect to overall slope stability. Additional analyses of pit highwall raveling and of wedge failure indicated that there is little potential for structurally controlled failures with the exception of the existing failures in the west and northwest walls (Brawner, 2005; Golder, 2005).

Other operational measures that GSM would implement to stabilize the pit in preparation for this reclamation alternative would include the following (Brawner, 2005; Golder, 2005):

- A 100-foot-wide safety bench would be left at the 5,700-foot elevation. Narrower catch benches spaced every 100 vertical feet would also be left to catch rock fall that would occur after mining is completed.
- Wire mesh would be installed over some sections of the west wall failure to mitigate rock fall hazards. Two dowels have been placed to secure a sandstone block. Additional bolts or dowels would be installed. Reinforcement considered critical in the long-term would include appropriate corrosion protection.

- Bench face angles would be reduced in the Lone Eagle Fault Zone, and bench crests would be reduced in local areas of the west highwall in the footwall of the Corridor Fault Zone and along the south wall where there are north-dipping geologic bedding structures.
- Potentially unstable slabs or wedges would be mined out.
- Horizontal drains would be installed around the pit perimeter to reduce water pressure in the pit highwall if seepage is encountered in the lower 300 feet of the Stage 5B pit.
- Drainage interception ditches would be constructed around the open pit to minimize surface water flowing over pit slopes.

Although rock mass stability analyses indicate adequate factors of safety for overall highwall slopes, a long-term stability monitoring and maintenance program would be required for the No Pit Pond and Underground Sump alternatives. Monitoring would concentrate on failure areas on the west and upper northwest highwall areas. The proposed program would include the following (Brawner, 2005; Golder, 2005):

- Regular inspection of the pit by a rock mechanics professional;
- Installation of piezometers to periodically monitor pore water pressures;
- Monitoring of areas where failures have occurred;
- Installation of 8-10 global positioning system monuments on selected locations to monitor movement;
- Monitoring of water levels in wells;
- Restricting access to the pit during and shortly after rainfall events, rapid thaws, and seismic events; and,
- Cleaning catch benches as needed.

4.2.1.3 Backfill

Large open pits have become a common part of modern mining operations. Although pit backfilling has not been required as part of MMRA and/or BLM's Surface Management Regulations, several mines in Montana have used backfilling to some extent. In Montana, some of the larger examples include:

- Montana Resources in Butte
- Beal Mountain south of Gregson
- Basin Creek between Helena and Basin
- Zortman and Landusky in the Little Rockies
- CR Kendall near Hilger
- Treasure Mine northeast of Dillon
- Yellowstone Mine south of Cameron

Some pits have been backfilled in Montana by mining companies as part of regular mining operations when multiple pits were developed at one mining complex and it was a shorter haul distance to deposit waste rock. Some examples include:

- Montana Resources: The East Continental Pit was backfilled as part of the East Waste Rock Dump construction. The Pittsmont Dump was placed in the Continental Pit. The Pittsmont Dump may have to be removed again in future mining operations as ore still remains in the pit.

- Beal Mountain: The Main Beal Pit was partially backfilled during mining of the South Beal deposit. The pit was backfilled above the level of the water table with South Beal waste rock, and the high-sulfide rock in the lower Main Beal Pit highwall was covered with South Beal waste rock and revegetated. The quality of the pit discharge slightly exceeds water quality standards. The US Forest Service is monitoring the water discharging from the Main Beal Pit for water quality changes over time.

- Basin Creek: The Columbia Pit was backfilled during waste rock dump formation. The Paupers Pit was backfilled with the waste rock dump because of waste rock dump stability problems. The backfill is in the water table. The quality of the pit water, as well as local springs in the mineralized area, does not comply with water quality standards. DEQ and EPA are monitoring local springs in the area for potential increased water quality problems from backfilling the pit.

- Zortman and Landusky: Part of the Landusky Gold Bug Pit above the water table was backfilled during mining of adjacent pits.

- CR Kendall: The Haul Road Pit and the South Horseshoe Pit were backfilled with waste rock after the ore was mined out. Also, partial backfill of the Muleshoe and Kendall pits occurred during later mining of adjacent pits. The backfill material is above the water table.

- Yellowstone Mine: The South Main Pit and North Forty Pit were backfilled after the ore was removed and other pits were expanded. There is no water in the pit backfill material.

Other pits have been backfilled as part of reclamation conducted by the agencies after bankruptcy or settlement agreements. Some examples include:

- Zortman and Landusky: At Zortman, most of the pits have been backfilled to a free-draining condition to limit water needing treatment by diverting surface water off the backfill. The water table is beneath the bottom of the Zortman pits. At Landusky, some of the pits were backfilled to a free-draining condition. The water table level is in the backfilled portion of the Landusky pits. Most of the water is drained out of the Landusky pits backfill by an artesian well and the August Tunnel and is collected and treated. The volume of backfill placed into the Landusky Pits was limited by the quantity of non-sulfide waste rock available, plus the goal of capping the backfill as quickly as possible in order to minimize its exposure to precipitation.

Despite the existence of underground tunnels and major shear zones beneath the Landusky pits, contaminant pathways could not be predicted with enough certainty to rely on pumping and treating to contain leachate from the backfill. Instead, restrictions were placed on backfill material quality.

- CR Kendall: Some pits are being considered for backfill based on water issues related to the location of the waste rock dumps in drainage bottoms. The water table is below the bottom of the pits. The feasibility of placing waste rock in the pit would have to be weighed against the advantages of removing it from the drainage bottoms. Water would be difficult to collect in the pits.

4.2.1.3.1 Pit Backfill Analog Study

A survey of existing open pit metal mines in the U.S., Canada and Sweden was performed to provide an "analog" to assist in evaluation of pit closure for those alternatives with partial pit backfill (Kuzel, 2003; Gallagher, 2003c). Information regarding other pit backfill projects was assembled utilizing many of the backfilled mines presented in the 1995 Mine Environment Neutral Drainage Program report (SENES, 1995). A total of 19 mines with potential pit backfills or pit lakes were initially contacted in 2003 (Kuzel, 2003). Information was gathered through telephone interviews and responses to written survey questions. Subsequently, emphasis was placed on mines with similar geology and climate, and that had a history of water quality monitoring (Gallagher, 2003c).

After screening the potential sites, three mines were chosen for more detailed evaluation, the San Luis Mine in southern Colorado, Richmond Hill Mine in the Black Hills of South Dakota, and the underground workings and Berkeley Pit at Butte, Montana (Gallagher, 2003c). None of the sites was a reasonable analog to the GSM pit backfill scenario. For instance, the San Luis Pit has very different geology, the Richmond Hill backfilled pit is unsaturated, the Butte underground consists of saturated underground mine workings rather than a backfilled pit, and the Berkeley Pit is not backfilled.

No backfilled pit of comparable size was found. The San Luis Pit was approximately 100 acres and 140 feet deep. The Richmond Hill Pit was 35 acres and 150 feet deep. A summary of the pit characteristics and findings of the survey is provided in Table 4-1 (Gallagher, 2003c, as updated by the agencies).

Table 4 - 1. Summary of information for Golden Sunlight, San Luis, Richmond Hill and Butte mines[1]

	Partial Pit Backfill With In-Pit Collection Alternative - GSM	San Luis, Colorado	Richmond Hill, South Dakota	Berkeley Pit, Montana	Butte Underground, Montana
Pit size (acres)	218	~100	35	~ 675[2]	About 10,000[3] miles of tunnels
Pit depth (feet)	1,875	140	150	1,780[2]	Up to 1 mile deep
Backfill amount (tons)	50 million	5.78 million	3.5 million	N/A; pit lake ~900 feet deep	10-25 percent gob[4] and slimes
Backfill depth (feet)	775-875	140	<150	None except sloughing	N/A
Geology	Tertiary breccia pipe in Precambrian metasediments	Precambrian biotite-amphibole-quartzo-feldspathic gneiss	Tertiary breccia pipe in Precambrian amphibolites.	Quartz monzonite, quartz, enargite mineralization	Similar to Berkeley Pit with some unique mineralogy within individual mines
% /Type sulfide	Variable-1997 Draft EIS 0.5 to 2 percent pyrite in backfill	Range 0.49 to 5.43 percent as sulfur	Variable – average 1 percent – oxidized / 0-20 percent unoxidized zone pyrite and marcasite	Abundant pyrite, chalcopyrite, enargite	Abundant pyrite, chalcopyrite, bornite, chalcocite, covellite, digenite
Period of Water Quality Data	2002-2003 from in-pit sump	1997 to present	Pit backfilled – 1995; data through 2003	~20 years	~20 years
Saturated/ Unsaturated	< 100 feet Saturated/675-775 feet unsaturated	Both	Unsaturated	Saturated	Saturated (90 percent)
Geochemical testing	See Telesto, 2003c	Sequential Leach and humidity cell	ABA, NAG, whole rock, humidity cells, column leach test, mineralogy	N/A	N/A

Predictions	*Poor quality leachate would form (Table 4-5)*	*Water quality degradation would not be an issue in backfilled pit*	*No water level rebound; no water quality impacts*	*Pit water level predictions; no change in water quality over time assumed in RI/FS[5]; water quality for some constituents has improved over time (Maest, 2003)*	*Water level predictions; no change in water quality over time assumed in RI/FS[5]*
Discharge from pit	*Assumed less than 10% of flow (1.5 gpm)*	*Seeps developed at contact of Rio Seco alluvium and pit backfill material*	*Seeps formed down gradient from unsaturated pit*	*Poor quality pit lake water (hydrologic sink has not reached critical water level); at that point 6.08 million gal/day would be pumped from the pit and treated[2]*	*Improvements in water quality after initial flooding, stable or declines in past several years. All discharges report to the Berkeley Pit hydrologic sink.*

[1] *From Gallagher, 2003c modified by the agencies.*
[2] *Canonie, 1993.*
[3] *Duaime et al., 2004.*
[4] *Gob consists of low-grade ore/high-grade waste rock left in the mine tunnels during mining. The material was deemed uneconomic and therefore, was not brought to the surface. Montana Bureau of Mines and Geology personnel noted the tunnels contained much less than 50 percent gob and more likely 10 to 25 percent, although exact percentage fill is unknown.*
[5] *RI/FS – Superfund Remedial Investigation/Feasibility Study.*

4.2.1.3.2 Backfill Maintenance Requirements

Settling in the 100 feet of crusher reject used for the sump would be 10 feet after a few years, as discussed in Section 4.2.1.5.2 (Telesto, personal communication, September 2004). Some additional settling could occur over the long term after large storm events or during snow melt, if the water level rose in the crusher reject for a short time before it could be pumped back down. Continued chemical weathering of the crusher reject over time would also produce some settling as this acidic rock weathers into smaller-sized particles from pyrite oxidation making it harder to dewater effectively.

Safety benches would have to be maintained to protect workers. Rock raveling off the highwall and escaping the safety benches and/or berms would have to be removed to maintain access. Periodic grading and dozing of the surface of the backfill may be needed to remove rocks that have raveled and sloughed. For information on soil cover maintenance requirements on the backfill working surface, see Soil Cover Section 4.2.1.7.

The agencies have assumed 100,000 cubic yards (150,000 tons) of rock would ravel to the pit bottom over time. As discussed in Section 4.2.1.2.2, the agencies have assumed a 100,000-cubic-yard failure under the No Pit Pond Alternative, which could eliminate access to the bottom of the pit and destroy the dewatering system. If this were to occur, the water table would begin to rebound in the pit backfill. GSM would have to reestablish the safety bench, access, and the safety berm, and haul additional backfill into the pit to stabilize the material on the pit bottom and reestablish a safe, flat, larger working surface. Wells would have to be redrilled. The agencies have assumed this type of failure could occur more than once over the long term.

4.2.1.4 Underground Workings

4.2.1.4.1 Impacts to Pit Facilities Due to Subsidence Related to Underground Mining

The first phase of underground mining ceased in January 2004. The permit for the underground mine indicated that portions of the underground mine that break through into the pit or that might pose a hazard to work in the pit would be backfilled. As of June 2004, no underground workings have been backfilled. The current mine plan for the Stage 5B pit includes mining to a safe distance from the underground stopes as determined by the GSM engineering department, backfilling the stopes, and then mining through the stopes. The stopes would be backfilled by blasting a raise into the stope and backfilling with rock material from the surface. At the end of the open pit mining, the location of the "C" stope would be evaluated to determine if it must be backfilled. However, this stope should be more than 100 feet from the pit highwall. The remaining

stopes would be mined out by the Stage 5B pit (Figure 2-2). Surface subsidence above the underground workings that are not backfilled would not be expected to occur (GSM, 2002a). During underground mining, rock stability was continuously monitored and this monitoring information has not indicated any potential for subsidence or failure.

Based on the rock properties, design of the underground mine, monitoring and maintenance activities, and observations made during mining, subsidence of the underground workings is not expected to be a major problem. No monitoring of the underground workings is proposed for the No Pit Pond Alternative.

Localized failures of overhead rock over time, especially in the stopes, could result in subsidence, especially in seep and fault areas where chemical weathering would be increased. This subsidence could cause the 100 feet of crusher reject to settle affecting the dewatering wells in the backfill. The agencies would require GSM to replace wells that failed for any reason.

4.2.1.5 Groundwater/Effluent Management System

The No Pit Pond Alternative would maintain the pit as a hydrologic sink, keeping the groundwater level in the pit as close as possible to the final pit bottom at the 4,525-foot elevation. Regular pumping would prevent water quality from degrading further over time in the acidic crusher reject. Precipitation, surface runoff, and groundwater seeps that drain into the pit would be removed by two to three dewatering wells and routed to the water treatment plant (GSM, 2002a).

4.2.1.5.1 Operation Requirements (Number of Wells)

The dewatering system would consist of two to three wells constructed through the 100 feet of crusher reject used for pit backfill to the bedrock contact. The permeability of the crusher reject is expected to be in the range of $1x10^{-3}$ cm/sec (Telesto, 2003e). Boreholes would be 10 to 12 inches in diameter and would be lined with 6-inch diameter Schedule 80 PVC casing. The bottom of the casing would be slotted. A stainless steel submersible pump equipped with electronic sensors to maintain optimum drawdown would be installed in each well. The water would be routed by pipeline to the water treatment plant prior to being discharged back into the ground, away from the pit area, in percolation ponds, LAD areas, or by other approved methods.

In addition, GSM would install horizontal drains in the highwall and incorporate these into the dewatering system as required to maintain safe operations. For existing operations, drains are located based on observation. The intent is to eliminate the potential for hydrostatic pressure in the highwall in areas of active mining. At closure, areas of the pit would be evaluated. If areas of the highwall were determined to be susceptible to hydrostatic pressure, additional hydrogeologic evaluations could be necessary to determine if drains were

necessary. GSM personnel would conduct this evaluation, unless additional expertise was deemed necessary. Drains have been used by GSM in areas of active mining (GSM, 2002a). The discharge would drain by gravity to the backfill sump, from which it would be pumped by the wells and transferred by pipeline to the water treatment plant. Dewatering also takes place from two existing vertical highwall wells (PW-48 and PW-49). The highwall wells are located on a pit bench at the 5,800-foot elevation. The wells are located at an elevation above the Stage 5B pit expansion, and therefore will not be affected during mining. Some road maintenance has been required in the past to remove rocks that have raveled down onto the bench. However, walking access for monitoring activities has never been lost. These wells would continue as required to release pore pressures in the open pit highwall to minimize the potential for highwall failure during Stage 5B mining. Figure 3-5 shows the location of the dewatering wells.

The feasibility of pumping from 100 feet of backfill was not investigated in the 1997 Draft EIS. The No Pit Pond Alternative calls for backfilling the bottom 100 feet of the pit with approximately 111,000 cubic yards (167,000 tons) of crusher reject from the 4,525 to 4,625-foot elevation. The crusher reject is expected to have the durability and uniformity to provide an adequate permeability over time. The permeability was estimated at $1x10^{-3}$ cm/sec (Telesto, 2003e). East Waste Rock Dump Complex waste rock has been tested and the permeability is $1x10^{-3}$ to $1x10^{-5}$ cm/sec (Telesto, 2003d). The reduction in permeability is due to chemical weathering of the waste rock.

The acidic water in the backfill would cause corrosion of dewatering system components, as discussed below in Section 4.2.1.5.2. Redundancy would be necessary to ensure continuing operation of the dewatering system. One well can easily handle the anticipated pumping rate of 25 to 27 gpm. While mining Stage 5A, GSM pumped all of the pit inflow, generally from 10 to 30 gpm, from a sump at least 100 feet deep into waste rock in the pit bottom utilizing a single cased well. In order to ensure continuous operation, one additional standby well would be required. A third well would only be required if the one operating well and one standby well were to fail.

4.2.1.5.2 Maintenance of Capture Points

Under the No-Pit Pond Alternative, two to three wells would be used to remove acidic water from 100 feet of crusher reject. Several problems could affect maintenance of these wells over time, including highwall raveling and sloughing, settling, corrosion, scaling, and potential biofouling. The agencies are concerned with maintaining the ability to dewater the backfill, prevent an acidic pond from forming in the bottom of the pit, and prevent discharges from the pit.

As described in Section 4.2.1.2.2, gradual raveling of highwall rock and occasional failures over time would cover the safety bench at the 5,700-foot elevation and would allow some highwall rock to reach the pit bottom. Some of

the rock may overtop the safety berm and make it to the pit floor flat working surface and dewatering system. Damage to the wellheads, monitoring equipment, power lines, pump stations, and/or to the pipelines routing water out of the pit along the access road to the water treatment plant would occur.

The physical integrity of dewatering wells could be threatened due to settlement and consolidation of the 100 feet of pit backfill. Settlement of the backfill could impair the integrity of the well casings due to buckling, separation, or shearing. It could also cause bends or kinks in the casings that, although less severe, may prevent or impair access to the pump for maintenance and operations. About 70 percent of this settlement, 7 feet, would occur during the backfill operation and 30 percent, 3 feet, over a longer period after backfilling is complete (Telesto, personal communication, September 2004). This could affect well casing integrity and require replacement over time.

The corrosion potential of projected pit water quality was evaluated by Telesto (2003e). Three sources of water quality data were evaluated: pit seeps, 2002 to 2003 pit sump water, and the Midas Spring discharge out of the northeastern part of the East Waste Rock Dump Complex. The average pH for these three sources was 3.6, 3.4 and 2.3, respectively. The Langelier Saturation Index (LSI), which is widely applied in the estimation of a water's potential to either corrode or scale equipment, was utilized to evaluate corrosion potential (Grove, 1993). The LSI rating scale ranges from -5 for "severe corrosion", to 0 for "balanced water", to +5 for "severe scaling". The lower and upper 90-percent confidence intervals for the pit seepage and pit sump waters produced LSIs of -7 to -4. The average Midas Spring water quality had a LSI of -7.3.

The corrosion study concluded that the expected water quality from East Waste Rock Dump Complex waste rock would be more corrosive than water quality in the pit sump measured from 2002 to 2003. The crusher reject used in the No Pit Pond Alternative would be similar. The expected LSI (-5 or less) would result in severe corrosion potential if water is not pretreated. Under the No Pit Pond Alternative, no pretreatment is proposed prior to pumping from the pit. Stainless steel pumps would be used, but, because of the low LSI of the backfill water, their life expectancy would be shorter than that of dewatering pumps used in 2002 to 2003 pit backfill dewatering operations. Steel well casings were predicted to have a lifespan of only a few months (Telesto, 2003e). Stainless steel casings would corrode over time as well, although they would last longer.

Acidic water could produce iron hydroxide scaling as well as bacterial biomass, *i.e.*, biofouling. This scaling would plug pumps, pipes, slotted casings, etc. and would shorten the functional life of wells. The low LSI rating for predicted pit water quality indicates scaling would not be a problem. GSM has reported limited problems with scaling over the life of the mine (GSM Annual Reports).

Standard corrosion potential modeling using LSI does not include biofouling potential. Problems from biofouling of wells and pumping equipment are expected to be minimal due to the low pH of the water. Biofouling becomes more of a problem as the pH increases above 4.5 (Cullimore, 1996). The basis for this prediction comes principally from experience at GSM and review of the literature on causes, prevention, and limiting factors (Telesto, 2004).

4.2.1.5.2.1 GSM Experience with Dewatering

Pit reclamation alternatives being considered for pit closure at GSM include long-term pumping of water from wells of various depths. In some alternatives, wells would be installed through the backfill to the bedrock contact and routinely pumped to maintain the water level in the backfilled pit at an acceptable minimum elevation. In another alternative, additional wells would be installed and operated down gradient of the pit. These wells would be similar to existing pumpback wells south of the GSM facilities. For the SEIS, Telesto performed several feasibility analyses regarding well performance based upon projected water quality of the backfill (Telesto, 2003e). The potential effects of biofouling on well performance were also evaluated (Telesto, 2004).

GSM has operated dewatering systems at the mine for a number of years. These systems have been utilized in different scenarios. The following discusses the potential problems that can occur with pumping wells, including corrosion, scaling, and biofouling, and summarizes GSM's experience in operating dewatering systems.

4.2.1.5.2.1.1 Background

Although several factors can affect well performance, the items of greatest concern in the SEIS are settling and corrosion. Depending on pH, scaling and biofouling could be problems. GSM has dealt with each problem in different areas of the site during pumping activities.

The physical integrity of dewatering wells can be threatened due to settlement and consolidation of the material where the well is installed. Settlement can impair the integrity of the well casings due to separation, buckling, or shearing. It can also cause bends or kinks in the casings that may prevent or impair access to pumps for maintenance and operations.

Corrosion can limit the useful life of wells in a number of ways, including enlargement of screen slots, followed by sand pumping; reduction in strength, followed by failure of well screen or casing; deposition of corrosion products, blocking screen openings; and inflow of lower quality water caused by corrosion of the casing (Driscoll, 1986). Corrosion can result from chemical or electrochemical processes. Plastic or stainless steel is typically utilized to reduce corrosion problems in wells.

Scaling can be a major cause of well failure. Water quality chiefly determines the occurrence of scaling (Driscoll, 1995). The kind and amount of dissolved minerals and gasses in water determine their tendency to deposit mineral matter as scale. During pumping, velocity induced pressure changes can disturb the chemical equilibrium of the groundwater and result in the deposition of soluble iron and manganese hydroxides. A coating of iron hydroxide can build up, particularly if pumping is started and stopped intermittently.

Biofouling by iron-fixing bacteria is a common problem in wells worldwide. In general, iron-fixing bacteria gain energy by enzymatically catalyzing the oxidation of ferrous iron to ferric iron. The bacteria then use the energy gained from the oxidation process to reproduce, sometimes exponentially, resulting in a slime-like coating that may contain ferric hydroxides, ferric oxy-hydroxides, and hydrated ferric hydroxides. The slime precipitate can cause plugging of well screens and sand packs, rendering a well practically useless in a short time period. The introduction of iron-fixing bacteria into a well is not always certain. The bacteria may exist in-situ before the well is completed, or they may be carried in on drilling equipment or in drilling fluids that were exposed to the atmosphere prior to drilling. Regardless, iron-fixing bacteria are prevalent in the environment (Driscoll, 1995). Some species prefer circumneutral pH ranges, while others do well in low pH conditions.

GSM has operated dewatering systems in different scenarios. GSM has operated wells or dewatering systems in the pit highwall, the pit bottom, the underground workings, down gradient of the tailings impoundments, the Midas Spring area, and in waste rock dumps. The following discusses experience in operating each of these systems.

4.2.1.5.2.1.2 Highwall Dewatering Wells

Two vertical highwall wells (PW-48 and PW-49) within the pit have been regularly pumped to intercept groundwater from the Corridor Fault area before it enters the pit. The wells are located on the 5,800-foot-elevation bench of the north highwall. PW-48 was completed to 925 feet (perforated interval 851-925 feet); and PW-49 was completed to 455 feet (perforated interval 415-455 feet). PW-48 and PW-49 were constructed in July 1997, but were not regularly pumped until October 1999. These wells produce a combined flow of approximately 18.2 gpm (Telesto, 2006).

Water quality in PW-49 is typically better than pit water, indicating the well is mostly intercepting intermediate groundwater. However, during high precipitation events, the water quality declines. During 2003, the pH of well PW-49 remained above 5. However, the water is acidic and has high levels of metals, such as iron and manganese.

Some maintenance is required for operating these wells. Flowmeters plug quickly and have to be maintained on a regular basis. Flowmeters are the largest maintenance item related to the highwall wells, as they become plugged with iron and other scale. This most likely is due to iron scale forming on the well screens and casing and then being pumped from the well. Because these wells are not vital to the actual dewatering operation, temporary down time is not typically an issue. The flow rates in these wells have declined over time. The pump had to be pulled from well PW-49 in April 2006. The pump was pulled, the well screen was brushed, and the pump was replaced. However, this did not improve production from the well. Due to the flow significantly decreasing in late 2006, the pump and well casing were pulled out. The bottom 35 feet of the well screen was filled with iron scale, and the pump was ruined. Therefore, it can be shown that scaling can affect well efficiency to a large degree in this system (Shannon Dunlap, personal communication, 2007).

As these two wells are constructed in the bedrock in the pit highwall and the pH of the water is about 5.0, their operation is not indicative of what would be expected to occur in wells installed in backfill material with a pH ranging from 3.0 to 4.3, but could be indicative of potential wells installed in bedrock down gradient of the pit.

4.2.1.5.2.1.3 Pit Dewatering Well

The pit dewatering system used in 2002 to 2003 consisted of a 118-foot-deep dewatering well in about 150 feet of backfill, a 15 horsepower (hp) stainless steel submersible pump, booster station, and associated piping and storage structures in the pit. The dewatering well was constructed in a combination of crusher reject and waste rock previously pushed into the bottom of the pit from higher benches. The well was a HDPE pipe with slots. Water was allowed to collect in the backfill material, and the well was pumped periodically to keep the water down to an acceptable level for underground and open pit mining activities, below the pit bottom. Piping consisted of HDPE and PVC.

The average pH of the water pumped from the pit during 2002-2003 was 3.6. This well was utilized for a period of approximately 10 months.

The largest maintenance issues involved deterioration of PVC pipe sections, float switches, and centrifugal pumps at the booster station due to the low pH of the water. In addition, plastic parts occasionally were affected by heat due to the pumping scheme. When dewatering was occurring on a continuous basis, approximately 20-30 hours per week were spent on the dewatering system maintenance, which included the pit dewatering well and highwall wells. Stainless steel parts did not deteriorate during the active life of this well. No biofouling problems were identified when the pump was removed and the well was mined out. During the 10 months, pumping rates were not reduced from either well screen or pump intake clogging. When the pump was removed, it had

no scale or slime growth on it. In addition to low pH water, another key factor for preventing or minimizing biofouling is to limit the aerobic/anaerobic interface near well screens and pump intakes. By proper well design and pump operation, the water level can be maintained above the screens and water entry velocities kept low, which may limit biofouling. As the hydrology of the system becomes more complicated, this becomes more difficult to accomplish.

Problems were encountered with the lowest portion of the well silting in. This was most likely due to the slot size and the fact that the well was not installed with a gravel pack. The pump was periodically raised in the well casing to alleviate this issue.

Well operating issues that occurred during this time would be expected to recur under the No Pit Pond Alternative. Due to the weathered acidic waste rock being placed in the pit and depth of backfill in the Partial Pit Backfill With In-Pit Collection Alternative, the issues could be compounded. Given the likelihood of elevated iron concentrations in the water to be pumped from the potential backfill, and the "omni-presence" of iron-fixing bacteria, biofouling of backfill wells is possible if the pH rises. Treatment of biologically fouled wells typically includes some type of oxidant (*e.g.*, chlorine, bromine) to break down the cell walls of the bacteria. Oxidants also can precipitate oxides of many metals. Given the high metals concentrations projected in the backfill, the introduction of oxidants could create other problems, such as lower pH in the well and chemical precipitation that could induce further well fouling. Thus, the ability to treat a biologically fouled well may be impaired by the physical and chemical conditions that would be present.

In the event biofouling occurred as determined by production loss or pump/well inspection, there are a number of rehabilitative processes, which could be tried short of constructing new wells. The best would be to high-pressure water jet the screen with subsequent well flushing. Another would be to chemically oxidize any bacterial growth. New methods, which could also be tried, use a combination of treatments such as dispersants, pH modifiers, and disinfecting agents. Biofouling is not expected to be a major problem because of the low pH of the pit water. Biofouling has not been a problem at GSM during operations. Therefore, biofouling is not expected to be a problem in water management after mining.

4.2.1.5.2.1.4 Underground Dewatering

The pit dewatering system used during underground mining from July 2002 to January 2004 consisted of a sump in the underground workings to drain and collect pit water. Water in the pit flowed into the underground workings through drill holes connecting the bottom of the pit with the underground workings. The underground mine had a sump with an approximate 500,000-gallon capacity at an elevation of approximately 4,650 feet. Any water that collected in other areas

of the underground workings was pumped to this sump. Water was pumped from the underground sump through a 3-inch HDPE line to the 4,700-foot booster station. From the 4,700-foot booster station, water was pumped to the 4,850-foot booster station, and then to the 5,000-foot bench booster station through 4-inch HDPE lines. Finally, the water was pumped out of the pit from the 5,000-foot bench booster station, through a 4-inch HDPE line, to a lined holding pond below the mill.

In 2003, the pH of the water pumped from the underground workings ranged from 3 to 4.3. The water contained high levels of metals such as iron and manganese. No corrosion problems occurred with the underground dewatering equipment despite predictions based on the LSI rating. Problems were encountered with the booster pump system, as described for the pit dewatering. The quality of water extracted from the underground workings is expected to be similar to that observed for the pit highwall seeps. Based on previous experience, stainless steel pumps and parts may have a reasonable life expectancy.

Following the cessation of underground mining in January 2004, water collected in the underground workings. This water flowed to the underground workings through drill holes connecting the pit bottom with the underground workings. After the cessation of underground mining, no water was removed from the underground workings through June 2006 (Shannon Dunlap, personal communication, 2006).

Pit dewatering issues that occurred during this time would be expected to be similar to the Underground Sump Alternative and not the No Pit Pond Alternative. However, due to the contact time between the water and the pit rock, the ultimate water quality would not be expected to be good (Table 4-5).

4.2.1.5.2.1.5 Groundwater Pumpback Wells

As of the end of 2005, GSM operated 31 pumpback wells south of the tailings impoundments (Shannon Dunlap, GSM, personal communication, 2006) (Figure 3-5). The four Rattlesnake Gulch wells are also pumped regularly above the Buttress Dump. The pumpback wells have been operated since the mid-1980s and early-1990s; the Rattlesnake Gulch wells have been operated since 1998.

The water quality in the pumpback wells is not similar to the pit area water. The Rattlesnake Gulch well water is naturally acidic, although not to the extent of the pit area water.

Operational monitoring of the pumpback wells ensures efficient operation of the active seepage control system. Flow rates, dynamic and static water level measurements, and regular maintenance are key elements to this monitoring. The pumpback well systems have totalizing flowmeters that are normally

checked twice per month to determine monthly average flow rates. Monitoring wells are associated with each group of pumpback wells. GSM inspects all of the operating pumpback wells daily. Lights, which serve as visual indicators, have been installed on each operating well. If operational checks indicate a deviation from normal operation, maintenance personnel are advised immediately. Proper operation of these wells is important; therefore, any required mechanical/electrical inspection or repair work is done as quickly as possible.

The Rattlesnake Gulch wells were originally plumbed with steel and plastic pipe and fittings. Problems initially developed with pumps and plumbing at least every 3 months. The system has been re-plumbed with Schedule 80 PVC and stainless steel. In addition, the flow rates in these wells have decreased. No major repairs have been required for approximately 3 years on the Rattlesnake Gulch wells. The pumpback wells were originally plumbed with steel pipe. Smaller pumps were installed in all of the wells and all of the plumbing converted to Schedule 80 PVC.

Maintenance of the pumpback system is time consuming but routine. Maintenance activities consist primarily of pump replacement, hour meter repairs, and flowmeter repairs. Corrosion, scaling, and biofouling have not been problems recently. Some silting, sanding, and scaling in pumpback wells was noted in 1993 and 1995 (GSM 1993 and 1995 Annual Reports). Approximately three pumps are replaced per year. As the aquifer continues to be dewatered, well yield decreases, and, in some cases, the wells dry up. As the well yield decreases, smaller pumps must be installed in the wells.

The entire pumpback well system was redone in 2001. GSM completely refurbished the east flank pumpback wells and the south pumpback wells, which included a total of 48 wells. The work consisted of setting up on each well, pulling the original column pipe and pump (2-inch steel pipe, 5 to 7 hp pump), blowing debris from the well using compressed air, and cleaning the screen. Once the well was redeveloped, appropriately sized new pumps were placed in the wells. One-inch PVC pipe was used instead of steel for easier maintenance. Equipment required for the project included a pump truck, air compressor, and associated equipment. Daily monitoring of these wells takes approximately 2 hours per day. Approximately 20 hours per month are typically spent on maintenance activities for these 48 wells.

Operating issues similar to these wells could be expected for the Partial Pit Backfill With Downgradient Collection Alternative.

4.2.1.5.2.1.6 Midas Spring

The Midas Spring capture system is located below an area formerly occupied by a small slump and spring. To prevent groundwater from contacting dump material, a portion of the spring area was previously excavated, and a gravel

drain and piping system was constructed in early 1994 to intercept shallow groundwater and lower the potentiometric surface beneath the dump complex. Acidic discharge from the Midas Spring is captured in a series of drains beneath a portion of the East Waste Rock Dump Complex. The drains route the water to a collection tank/pumping system, where it is then pumped via pipeline to the water treatment holding pond in upper Rattlesnake Gulch. This water is then blended with water pumped from the open pit and treated in a lime-precipitation treatment plant located in the mill complex.

The Midas Spring water is poor quality. The Midas Spring was impacted when it was covered with waste rock (in the East Waste Rock Dump Complex) during the early stages of mining at GSM. This spring also has a unique geologic setting in that it is located in an area with structurally controlled high sulfide mineralization, elevated iron, silver, and copper, deep oxidation, and a surface seep influenced by a landslide/debris flow. Therefore, water from the Midas Spring is considered to represent "worst-case" seepage from waste rock dump material.

Stainless steel submersible pumps used to pump water from the Midas Spring to treatment have to be replaced at least every 6 months. There are times when a pump may only last 2 weeks due to failure of pump and motor components, which are not stainless steel. Pumping of solids most likely also affects the life of these pumps. The manifold lines have to be cleaned at times due to solids building up in the line. In addition, sludge that accumulates in the tank has to be removed periodically.

GSM and EPA conducted a research project on the Midas Spring during which the spring was diverted into a lined pond filled with crushed limestone. The limestone became plugged within a year and a half and the research project was discontinued (GSM Annual Report 2003).

Some of the operating issues with the Midas Spring system could be expected to occur for the Partial Pit Backfill With In-Pit Collection Alternative.

4.2.1.5.2.1.7 Waste Rock Dump Testing

GSM has conducted research and monitoring activities in waste rock dumps for a number of years. Some of this work included installation of monitoring wells and other tubes into waste rock material. The wells were more difficult to install than wells in solid rock formations.

For research conducted on the unsaturated West Waste Rock Dump Complex, several 2-inch steel pipes, up to 175 feet long, were drilled into the weathered waste rock for data collection (Schafer and Associates, 1996). After a few years, acid generated by sulfide oxidation coupled with some shifting in the waste rock resulted in blockage of the deepest pipe. Efforts to clear the pipe were unsuccessful. Shallower PVC pipes were also installed up to approximately 70

feet deep. Schafer and Associates (1996) noted that minor movements of waste rock deformed these access pipes, preventing sample acquisition at several sites during the first year of operation.

Some problems have been encountered with monitoring wells in the West Waste Rock Dump Complex. One well sanded in and another well was damaged during reclamation activities. Another well appears to have a separated casing, but this is unconfirmed. A damaged well in the area near the pit was replaced in 2004 because the well casing separated.

Operating issues encountered during monitoring in waste rock dumps could be expected to occur for the Partial Pit Backfill With In-Pit Collection Alternative.

4.2.1.5.2.2 Dewatering Experience at Other Mines

Mines have not typically been required to dewater backfill, so there are few examples. As documented in Section 4.2.1.3.1, no mines were found with similar amounts of backfill as described in the partial pit backfill alternatives (Gallagher, 2003c). At the San Luis Pit in Colorado, which had a maximum depth of about 140 feet of backfill, about one in five pumps fail due to shifting backfill, which deforms the installations. Precipitation and clogging of well screens in ARD plumes have affected wells at the Climax and Grasberg Mines.

Groundwater has been a concern in the Butte Mining District ever since the early mineshafts encountered water at depths of 20 to100 feet below ground level. To allow underground and open pit mining in the area, the groundwater level was lowered by pumping. Prior to cessation of open pit mining in the Berkeley Pit in 1982, dewatering was occurring at a rate of 4,000 to 5,000 gpm. The pumping system was located in the Kelley Mine Shaft west of the Berkeley Pit from the 1960s to 1982 (Canonie, 1994). Dewatering from underground sumps allowed underground mining in Butte for almost 100 years. Pumping from the underground workings for over 20 years effectively lowered the water table during open pit mining.

Montana Resources has pumped water from a floating barge in the Berkeley Pit to recover copper in the precipitation plant with minimal operational problems (S. Czehura, Montana Resources, personal communication, August 2004).

In summary, several factors could affect maintenance of the dewatering wells under the No Pit Pond Alternative. The agencies would require GSM to install and maintain a remote monitoring system for wells, pumps, pipelines, powerlines, etc. to minimize the need for workers to be in the pit and to ensure water is kept as low as possible in the crusher reject. GSM would have to replace any wells that failed.

4.2.1.6 Storm Water Runon/Runoff Management

Surface water runoff from storms and snow melt would be diverted around the open pit. As part of the final reclamation of the site, GSM would construct permanent storm water controls concurrently with site reclamation. As described in Section 2.4.2.5, storm water diversions designed to carry the flow from a 100-year, 1-hour storm event would be constructed around the pit perimeter to prevent as much surface water as possible from entering the pit. The storm water diversions would be designed and sized, installed to grade, lined with a geosynthetic liner to reduce infiltration into the pit rock under the diversions, covered with 3 feet of soil and/or riprap depending on location and the design flow of the diversion, and revegetated where appropriate.

The only storm water that would enter the pit would be direct precipitation on the pit disturbance area and runoff from areas where diversions would not be possible due to topographic constraints. It is estimated that 99 percent of the storm water around the pit area could be diverted away from the pit (Telesto, 2003a).

4.2.1.6.1 Maintenance Requirements

The maintenance requirements for the diversions would include regular monitoring of the system integrity and gradient to ensure proper function.

Some settling may occur where the diversions are constructed on unconsolidated materials, which would affect the ability of a diversion to route water away from the pit area over time. If the gradient changed from settling resulting in low spots, the diversion would have to be returned to the proper gradient, resoiled and seeded as necessary. Eventually, portions of the diversions would need to be reconstructed completely or at least have sediment accumulations and/or rockfalls from upgradient slopes removed. If 99 percent of storm water cannot be diverted, the amount of water needing treatment would increase.

4.2.1.7 Soil Cover

4.2.1.7.1 Soil Cover Maintenance Requirements

As described in Section 2.4.2.6, GSM has proposed a 3-foot soil cover on the pit floor area, pit benches, and roads, totaling 53 acres of revegetation. Seven acres have already been revegetated within the pit boundary area. Another 68 acres around the pit would be reclaimed with 3 feet of soil and revegetated. Any acreage revegetated in the pit would need to be monitored for rock raveling and sloughing, backfill settling, erosion, and noxious weeds. Highwall rock that has raveled or sloughed would have to be removed, the affected area covered with new soil, and reseeded. Areas that have settled would have to be filled to grade with additional soil. Eroded areas would need to be repaired, resoiled and

reseeded. Noxious weeds would have to be controlled. One hundred fifty-eight acres would not be resoiled in the pit.

As described in Section 4.2.1.3.2, some grading and/or dozing of the backfill surface may be needed if the crusher reject settled. This would affect the soil cover and more soil would have to be placed and reseeded.

As described in Section 4.2.1.2.2, the pit bottom would eventually be covered with rocks raveling off the highwalls and/or highwall rock from sloughing. The soil cover would be covered with the rocks. GSM would have to haul more backfill to reestablish the flat working surface and haul in new soil and reseed the soil.

4.2.1.8 Water Treatment

The 1997 Draft EIS, Chapter IV, Section IV.B.6.e and Appendix A evaluated the water treatment system for all water pumped from the pit. The treatment plant would be a standard lime treatment system located below Tailings Impoundment No. 2 (Figure 1-2). This system would be similar to the operational water treatment plants at GSM and Montana Resources in Butte. The 1998 ROD approved the water treatment plant with a design capacity, including contingencies, of 392 gpm, which included the 65 gpm of pit inflows (54 gpm plus 20 percent contingency) then projected for the No Pit Pond Alternative (Table 4-2). No changes to the treatment system have been proposed since the 1998 ROD. The treated pit water would be disposed of in a percolation pond below Tailings Impoundment No. 2. The revised pit water balance completed for this SEIS identified that 25 to 27 gpm would have to be pumped to the treatment plant under the No Pit Pond Alternative (Telesto, 2006).

The 1997 Draft EIS assumed that the pit would not discharge into surrounding aquifers. Total water collected and treated, with contingencies, included 25 gpm from the East Waste Rock Dump Complex, 200 gpm from Tailings Impoundment No. 1, and 25 gpm from Tailings Impoundment No. 2 in the 1997 Draft EIS, Appendix A, Table 2-1.

Table 4-2 compares 1997 Draft EIS inflows to the water treatment plant with SEIS predictions. In the No Pit Pond Alternative in this SEIS, total water, from all sources needing treatment, would be 250 gpm compared to 392 gpm in the 1997 Draft EIS. The water treatment plant is designed to handle this amount of water. GSM is bonded for 392 gpm as a contingency in case inflows are more than predicted.

Table 4 - 2. Water Treatment Plant Inflows (gpm) for the No Pit Pond Alternative

Facility	1997 Draft EIS[1]	SEIS
Tailings Impoundment No. 1	200	100
Tailings Impoundment No. 2	25	25
West Waste Rock Dump Complex	77	77
East Waste Rock Dump Complex	25	21
Pit	65	25 to 27
TOTAL	392	248 to 250

[1]1997 Draft EIS, Appendix A, Table 2-1; volumes include contingencies.

4.2.1.8.1 Additional Sludge Management Requirements

The new water balance completed for this SEIS concluded that from 25 to 27 gpm from the pit would need to be treated under the No Pit Pond Alternative. The quality of the water assumed to be treated in the 1997 Draft EIS was not as poor as that to be treated under this SEIS (See Section 4.3.3.1.1.2.1 and Table 4-5). More sludge would be produced per gallon of treated water. Because the volume of pit water requiring treatment in the SEIS is approximately one-third of the volume expected in the 1997 Draft EIS, the overall sludge management requirements would be similar to, or less than, those evaluated in the 1997 Draft EIS, Chapter IV, Section IV.B.1.e.

4.2.1.8.2 Additional Operating Requirements

The water treatment system in this SEIS is the same as that evaluated in the 1997 Draft EIS and, as shown in Table 4-2, there would be less water to treat from the pit.

There would be no additional operating requirements under the No Pit Pond Alternative from those analyzed in the 1997 Draft EIS.

4.2.1.9 Flexibility for Future Improvements

The flexibility for future improvements and potential for utilization of new technologies was not evaluated in the 1997 Draft EIS for pit reclamation alternatives. This is an important issue because of the risks and uncertainties associated with backfilling the GSM pit.

4.2.1.9.1 Potential for Utilization of New Technologies

As stated above in Section 4.2.1.5.1, 25 to 27 gpm of water would need to be treated under the No Pit Pond Alternative. The water would be pumped out of 100 feet of backfill. As described in various sections above, this can be done

although it would be more difficult in weathering, unconsolidated, settling, waste rock than native, unweathered rock.

The acidic water would require regular maintenance and replacement of pumps and other dewatering well components, as discussed in Section 4.2.1.5.2.

GSM has evaluated the potential to treat or at least pretreat pit water in-situ. During pumping from the pit sump in 2002-2003, GSM added carbon sources such as alcohol and sugars to the pit in an attempt to pretreat the pit water in the rubble at the bottom of the pit. The test was partially successful in improving pit water quality (GSM 2002 Annual Report). GSM initiated a new test during the mill shutdown (GSM, 2004). This new test was approved by the agencies (DEQ and BLM, 2004). Pretreating the pit water would increase the operational life of dewatering system components by reducing corrosion.

Research has been conducted on treating pit water with carbon sources, microbes, etc. in various locations around the world, for example, the Berkeley Pit in Butte and the Gilt Edge Mine in South Dakota. If an alternative to pumping and treating were developed in the future, it would be easier to pretreat pit water in an open body of water than in waste rock. It is easier to pump and mix carbon sources, microbes, etc. evenly in an open body of water than in saturated waste rock backfill.

If pit water had to be treated in saturated backfill, it would be easier to treat it in the less than 600,000 cubic yards of pit backfill and rock projected to fall to the bottom of the pit over time in the No Pit Pond Alternative than it would be in the much larger volumes of rock placed in the pit under the partial pit backfill alternatives.

4.2.1.9.2 Consequence of Failure of Dewatering System

If the dewatering system failed under the No Pit Pond Alternative, a pit pond would form. Pit water balance studies were completed for the Pit Pond Alternative, which was considered but dismissed in Section 2.5.4. These studies concluded that, for the Pit Pond Alternative without pumping pit water, the water level would rise and stabilize at the 4,635-foot elevation with no discharge. The results of the water balance studies performed for the Pit Pond Alternative can be applied to the No Pit Pond and Underground Sump alternatives.

Under the No Pit Pond Alternative, 25 to 27 gpm would be expected to flow into the pit (Telesto, 2006). Less than 10 percent of the water would leave the pit through fractures.

The principal consequence of failure of this alternative would be the potential creation of an ARD-impacted pit pond. Under the No Pit Pond Alternative, the agencies have assumed that the pit would eventually contain 600,000 cubic

yards (900,000 tons) of backfill and highwall rock that would ravel and slough over time. The additional 600,000 cubic yards of material would raise the pit floor from 4,625 to 4,742 feet. The water level in the backfill would remain below the surface of 4,742 feet because of the increased surface area of the pit floor and evaporation. Water remaining in the backfill would be below the 5,050-foot elevation at which water would begin to seep out of the pit at the colluvium-bedrock contact on the east side of the pit. Since a pond is unlikely to form, no adverse impacts to groundwater outside the pit would be anticipated. Water could be pumped out of the over 200 feet of pit backfill for treatment, if needed.

4.2.2 Partial Pit Backfill With In-Pit Collection Alternative (Proposed Action)

4.2.2.1 Design and Constructibility of the Alternative

4.2.2.1.1 Proven Design

As in the No Pit Pond Alternative, 100 feet of crusher reject would be placed in the bottom of the pit as backfill for use as a sump. Then, under the Partial Pit Backfill With In-Pit Collection Alternative, the rest of the backfill would be hauled to the pit rim and end dumped to an average 5,400-foot elevation. Finally, the upper highwall would be reduced by cast blasting and dozing until the 2H:1V final slope was achieved. Up to 11 dewatering wells from 775 to 875 feet deep would be drilled on the 5,400-foot elevation backfill surface. The wells could be built from the bottom up as stand pipes in leach pads are constructed. However, the backfill would have to be hauled down into the pit and placed in layers, putting workers at greater risk, or it would have to be end dumped from pit margins, putting the standpipes at risk from damage during dumping. These wells would experience the same risks as they would if drilled from the surface, including shearing and crushing from compaction, silting, and corrosion. Replacement wells would need to be drilled from the surface. It is estimated that 27 to 42 gpm would be pumped out of the wells (Telesto, 2006). Seventeen gpm would be routed off the backfill as storm water runoff or would be used up through evapotranspiration (Telesto, 2003a).

As described in the No Pit Pond Alternative, Section 4.2.1.3 and the pit backfill analog study (Gallagher, 2003c), pits have been backfilled in Montana and elsewhere. There are no known instances of pits receiving 875 feet of backfill in Montana or elsewere. Cast blasting is a common mining technique but has had limited use in reclamation. Cast blasting of the upper highwall as a reclamation technique to reduce portions of the highwall has been discussed at GSM, Zortman, and Landusky (William Maehl, personal communication, 2004), and proposed at the McDonald Gold project (Seven Up Pete Joint Venture, 1994).

It is technologically feasible to haul backfill, cast blast highwalls, and install wells in a pit at closure. Backfilling by hauling to the bottom of the pit and end dumping, and by hauling and end dumping from the pit rim, is a proven design. Cast blasting to reduce highwalls has not been used as much in regrading pit slopes but cast blasting is a proven design in and of itself. Dewatering a backfilled pit by installing wells is a proven design in shallow pits; it is not a proven design in pits with up to 875 feet of backfill, especially those with acidic water (HCI, 2002). It is possible to install wells in unsaturated, unconsolidated waste rock, as shown by the two-inch steel casings installed in the West Waste Rock Dump Complex at GSM for data collection (Schafer, 1995a). Monitoring

wells have been constructed in the shallow portions of some of the waste rock dumps, but all these wells have failed over time.

Backfilling and cast blasting are proven designs. It is technically feasible to backfill and cast blast, but the agencies have not documented any other pits the size of the GSM pit that have been backfilled by end dumping and cast blasted to reduce highwalls. Dewatering backfill from this depth has also not been documented (HCI, 2002; Kuzel, 2003; Gallagher, 2003c).

4.2.2.1.2 Ability to Construct the Alternative at GSM

The pit backfill analog study conducted for this SEIS did not find any hardrock mine in which such a large pit was backfilled and allowed to become saturated with groundwater (Gallagher, 2003c). No long-term water quality monitoring records exist at the backfilled mines or flooded underground mines studied sufficient to indicate whether the reclamation goals at those mines were achieved.

As described in the No Pit Pond Alternative, crusher reject would be hauled to fill the bottom 100 feet of the pit. After the 100 feet of crusher reject has been placed under the Partial Pit Backfill With In-Pit Collection Alternative, GSM would start hauling and end dumping waste rock from the pit rim. End dumping would continue to an average elevation of 5,400 feet. Total backfill volume would be 33,300,000 cubic yards (50,000,000 tons). As noted in the pit backfill analog study, attempts were made to identify and describe a backfilled mine pit with a similar depth to GSM's pit. None could be found.

The upper 1,000 feet of the highwall would be reduced by cast blasting and dozing 11,900,000 cubic yards (17,900,000 tons) of highwall rock to create 2H:1V slopes. If cast blasting failed on any portion of the highwall, waste rock could be hauled and end dumped after construction of new access roads. Cast blasting would enhance the overall stability of the pit highwall by reducing the highwall slope, but would disturb an additional 56 acres (Figure 2-4).

Installing dewatering wells at this depth in unconsolidated waste rock backfill and pumping the estimated 27 to 42 gpm of pit groundwater from this depth is more difficult than the same activities in 100 feet of crusher reject and pumping the 25 to 27 gpm under the No Pit Pond Alternative. Four dewatering wells could be installed successfully, although it would be difficult in 775 to 875 feet of backfill (J. Finley, Telesto, personal communication, 2003).

No actual case histories or examples of dewatering wells pumping as little as 27 to 42 gpm in up to 875 feet of weathered waste rock backfill have been found (HCI, 2002; Gallagher, 2003c). Wells of this depth and capacity could be pumped successfully, at least initially, but wells and pumps would need repeated maintenance and replacement, as described in Section 4.2.1.5.2.

There would be more problems developing and implementing the Partial Pit Backfill With In-Pit Collection Alternative than the No Pit Pond Alternative at closure because of the larger volume and depth of backfill needed, the amount of cast blasted material, and the problems drilling dewatering wells up to 875 feet deep in unconsolidated waste rock in order to maintain the pit as a hydrologic sink.

The agencies expect that the dewatering wells would fail repeatedly over time due to settling and corrosion. In addition, it is doubtful that 27 to 42 gpm could be continually pumped from these wells from this depth without allowing time for the water table to rebound in the backfill sump (HCI, 2002). Therefore, water may not be restricted to the lowest level of the pit. Fluctuation in the water table would degrade the quality of the water and increase settling (Telesto, 2003e). The quality of the water in the acidic backfill would result in problems with corrosion. Scaling and biofouling are not expected to be a problem because of the low pH of the pit water. The agencies would require GSM to replace dewatering wells that failed.

Waste rock samples show fairly high permeability for the projected pit backfill, based on 18 field samples from the surface and 5 laboratory samples from depths up to 15 feet (Telesto, 2003d). Sample results were similar to those reported by Herasymuik (1996). They were considered to be representative of the entire East Waste Rock Dump Complex. Herasymuik's maps and cross sections show that his sample pits were dug during re-excavation of the East Waste Rock Dump Complex after the 1994 ground movement. Samples were taken from waste rock dumps less than 6 years old in the unsaturated zone less than 100 feet deep. The applicability of these results to conditions under a much greater thickness of fill, over an indefinite period of time, and under varying degrees of saturation, is uncertain. The analysis shows that permeability would decrease over time due to compaction in up to 875 feet of backfill and accelerated weathering due to rehandling waste rock during backfilling operations (see Section 4.2.2.3.1).

Additional permeability testing of potential backfill material under simulated load conditions (such as that in a backfilled pit) was conducted subsequent to the Draft SEIS (Telesto, 2005). The results indicate that under 450 feet of backfill, the hydraulic conductivity can decrease to 10^{-6} cm/s, and that under 900 feet of backfill, the hydraulic conductivity can decrease to 10^{-7} cm/s (Telesto, 2005). This additional evaluation indicates that control of pit seepage with vertical wells would likely not be reliable.

4.2.2.2 Pit Highwall

The stability analysis for the Partial Backfill Alternative is summarized in Appendix H of the 1997 Draft EIS. The analysis concluded that there would be

no important difference in overall pit highwall stability between an open pit and a partially backfilled pit. The pit highwall under the Partial Pit Backfill With In-Pit Collection Alternative would be slightly more stable in comparison with the No Pit Pond Alternative in this SEIS because of the change in the pit highwall slopes due to cast blasting to achieve overall 2H:1V slopes in the highwall.

4.2.2.2.1 Pit Highwall Stability

Under the Partial Pit Backfill With In-Pit Collection Alternative, the pit from the 4,525-foot to the 5,400-foot elevation would be backfilled with 33,300,000 cubic yards (50,000,000 tons) of waste rock material from the East Waste Rock Dump Complex. Cast blasting and dozing of the upper pit highwall would be used to create the 2H:1V slope on the highwall above 5,400 feet (Figure 2-4 cross section of pit). Cast blasting would enlarge the pit by 56 acres from 218 to 274 acres in order to achieve overall 2H:1V slopes and provide haul routes for pit backfilling and soil replacement (Figure 2-4).

No pit highwall would remain exposed under this alternative. Backfilling the pit under this alternative would eliminate pit highwall raveling and sloughing over time. Cast blasting would also enhance the inherent stability of the pit highwall by reducing the slope to 2H:1V from a current average of 0.8H:1V. Thus, the long-term stability of the pit highwall would be greater than the No Pit Pond Alternative. The agencies assumed in the No Pit Pond Alternative that the highwall would ravel and have occasional failures of up to 100,000 cubic yards over time. The agencies expect that disturbance caused by cast blasting under the Partial Pit Backfill With In-Pit Collection Alternative would be greater than the total acreage disturbed by eventual highwall failures assumed under the No Pit Pond Alternative over time (Section 4.2.1.2.2).

The SEIS's stability conclusions are supported by subsequent technical reviews and additional analyses (Brawner, 2005; Golder, 2005). These studies concluded that, with the pit slopes covered, highwall raveling and other failure modes are not important stability issues under the partial pit backfill alternatives.

4.2.2.2.2 Pit Highwall Maintenance Requirements

The highwall would be covered by backfill, cast blasted highwall rock, and soil. Some physical and chemical weathering would occur over time in the highwall rock, especially in localized seep areas. No highwall maintenance would be needed under the Partial Pit Backfill With In-Pit Collection Alternative.

4.2.2.3 Backfill

4.2.2.3.1 Backfill Maintenance Requirements

As described in Section 4.2.1.5.2, geotechnical testing of the backfill and cast blasted materials showed that settlement would be expected during and after backfilling operations (Telesto, 2003e). The backfilled pit area would be subject to more settlement than a large portion of the waste rock dump complexes because of the thickness of the backfill. Settlement of waste rock used as backfill would be reduced because the waste rock has already weathered in the waste rock dump complex. Some backfilled areas in deep portions of the pit could still settle as much as 150 feet (Telesto, 2003d). Since the backfill material would be composed of mainly gravel and sand sized particles from the waste rock deposits (Herasymuik, 1996) and would be applied in an unsaturated condition, the agencies expect that 60 to 75 percent of settlement will occur during the backfilling process.

Although long-term settlement in the 775 to 875 feet of backfill would not affect pit highwall stability, it is likely that depressions would occur in the backfill material and the cast blasted material on the 2H:1V slopes due to the settlement of the backfill. These depressions would become locations for surface water accumulation and infiltration and could be sites where saturation and instability of the soil cover would be initiated. Monitoring would be needed to watch for settling of the cover. If ponding occurred, more soil would need to be replaced to restore the gradient. Settlement along a storm water diversion could result in erosion on the face of the revegetated slopes. To minimize this impact, monitoring of bench gradients and reestablishment of gradients would be needed over time. For maintenance of soiled and revegetated areas, see Section 4.2.1.7. For maintenance of storm water diversions, see Section 4.2.2.6.1.

If the Partial Pit Backfill With In-Pit Collection Alternative were selected, the agencies would consider requiring GSM to delay final reclamation of the backfill and cast blasted material until monitoring of the backfill indicated that most of the settlement had occurred. Even though 60 to 75 percent of the settling would have occurred, dewatering well failure would continue due to the remaining 25 to 40 percent settling as waste rock in the backfill weathered over time. Dewatering well failure and subsequent saturation of the backfill would lead to up to 50 feet of additional settlement (Telesto, 2003d). In addition, problems of corrosion discussed in Section 4.2.2.5 would still be a problem.

4.2.2.4 Underground Workings

4.2.2.4.1 Impacts to Pit Facilities Due to Subsidence Related to Underground Mining

Impacts due to subsidence in the underground workings would be the same as under the No Pit Pond Alternative. The underground workings and portal monitoring and maintenance plan could not be implemented because access to the underground would be covered with over 500 feet of backfill material.

Localized failures of overhead rock in the underground workings over time could result in subsidence, especially in seep and fault areas where chemical weathering would be increased. This subsidence could cause the backfill to further settle, potentially affecting the dewatering wells in the backfill. The agencies would require GSM to backfill the underground workings remaining after Stage 5B to minimize settlement. The agencies would require GSM to replace wells that failed.

4.2.2.5 Groundwater/Effluent Management System

4.2.2.5.1 Operation Requirements (Number of Wells)

The 1997 Draft EIS, Chapter II, Section II.B.7.b described a pit dewatering system for the Partial Backfill Alternative consisting of a series of wells drilled to depths below the 5,050-foot elevation. In this SEIS, the dewatering system for the Partial Pit Backfill With In-Pit Collection Alternative would consist of up to 11 wells from 775 to 875 feet deep to keep the groundwater level as close as possible to the 4,525-foot pit bottom elevation (Telesto, 2006).

The wells would be drilled until they penetrate the bedrock under the backfill. As described in Section 2.4.3.3, boreholes would be 10 to 12 inches in diameter and would be lined with 6-inch-diameter stainless steel casing. The bottom 200 to 300 feet of the casing would be slotted. The water level would be maintained as low as possible in the backfill. A stainless steel submersible pump equipped with electronic sensors to maintain optimum drawdown would be installed in each well. The water would be routed by pipeline to the water treatment plant prior to being discharged back into the ground, away from the pit area, in percolation ponds, LAD areas, or other approved locations.

The dewatering wells would be subject to settlement and corrosion. Scaling and biofouling are not expected to be a problem because of the low pH of the pit water. The agencies would require GSM to replace wells that failed. The permeability of the backfill would decrease as described in Section 4.2.2.1.2.

4.2.2.5.2 Maintenance of Capture Points

Installation and long-term operation of dewatering wells in backfill under this alternative would be similar to the No Pit Pond Alternative but more problematic. The main differences are:

- Drilling and completing wells through an additional 675 to 775 feet of unconsolidated backfill;
- Effectiveness of pumping from wells in an additional 675 to 775 feet of heterogeneous backfill, some of which would be fine-grained and of lower permeability (Figure 4-1);
- Maintaining the water table as low as possible at similar pumping rates and higher lifts (HCI, 2002);
- Maintaining pump intake openings, slotted casings, and sensors that would be subject to corrosion and silting and sanding;
- Maintaining structural integrity of dewatering wells due to long-term settlement of the additional 675 to 775 feet of backfill; and
- Decreases in permeability, especially in the lower portions of the pit, would reduce the ability to capture groundwater.

Drilling to depths greater than 100 feet within acidic waste rock backfill presents unique problems and challenges. Problematic issues when drilling in poorly consolidated or unconsolidated materials such as backfill include: poor circulation, low recovery, reduced drilling rates, and decreased borehole stability. Telesto Solutions, Inc. completed a drilling program in southern Arizona in a blasted, unconsolidated, brecciated formation similar to conditions that would occur in pit backfill at GSM (J. Finley, Telesto, personal communication, 2003).

During the drilling program, circulation was lost approximately 60 feet below ground surface and all attempts to regain circulation were unsuccessful. In the course of drilling a 400-foot boring, over 1,000 bags of bentonite were added to the drilling fluid in an unsuccessful attempt to regain circulation. Enough chip-seal (cedar fibers and cotton hulls) was used to completely clog the recirculation system on the drilling rig with no effect on recovery of drilling solution or underground geologic material.

Drilling rates averaged approximately 1.5 feet per hour because of the difficulty in drilling through the rubble material and the time required to mix the large quantities of drilling mud. The potential for the bore hole to collapse required drilling with very frequent casing advancement (casing was advanced approximately every 5 to 10 feet) further slowing the drilling rates. Borehole stability was enough of a concern that drilling the rubble material required around-the-clock drilling operations so that borehole collapse would be minimized. Drilling in the breccia formation required approximately three times the amount of hours anticipated by both experienced geologists and drillers, and

approximately 15 times longer than drilling in natural, unconsolidated formations. Drilling through unconsolidated breccia material is not impossible, but difficult and expensive. Installing wells at depths greater than 400 feet would be more difficult.

A screening level feasibility assessment of pumping from a backfilled pit was performed for this SEIS (Telesto, 2003e). The Partial Pit Backfill With In-Pit Collection Alternative was evaluated for its functionality, conformance to industry standards, and construction feasibility. Permeability of the backfill is the principal property determining the effectiveness of dewatering wells. If permeability is too low, groundwater would not move into a well fast enough or from a sufficient region to allow the pump to function properly (HCI, 2002).

All available permeability values for waste rock samples from GSM, consisting of 23 tests (5 laboratory and 18 field tests), were summarized (Telesto, 2003d). The geometric mean of these data was approximately $1x10^{-3}$ cm/sec. The 90th percentile value was approximately $1x10^{-4}$ cm/sec. All samples were from the upper 15 feet of the waste rock dump. Telesto concluded that after backfilling, the permeability could be expected to range from $1x10^{-3}$ to $1x10^{-5}$ cm/sec. Based on this analysis, it was concluded in the Draft SEIS that initially the permeability of the backfill would be adequate for dewatering under this alternative. Additional permeability testing of potential backfill material under simulated load conditions (such as that in a backfilled pit) was conducted subsequent to the Draft SEIS (Telesto, 2005). The results indicate that under 450 feet of backfill, the hydraulic conductivity can decrease to 10^{-6} cm/s, and that under 900 feet of backfill, the hydraulic conductivity can decrease to 10^{-7} cm/s (Telesto, 2005). This additional evaluation indicates that control of pit seepage with vertical wells would likely not be reliable. The analysis shows that the permeability would decrease over time under 875 feet of backfill with variable or incomplete drainage. In addition, cementing of the acidic backfill by oxidation byproducts in the water could eventually create some perched water tables or areas of limited permeability around the wells.

The analysis shows that the 100 feet of crusher reject would be permeable at first but would weather and break down over time. This would limit the ability to pump out water effectively, because of accumulation of fines in the backfill. In addition, the acidic water and waste rock is full of microbes, which accelerate the ARD reaction and could increase potential biofouling, depending on the pH of the water. Acidic water increases corrosion. Scaling, from iron hydroxide formation, and biofouling would not reduce permeability over time because of the low pH of the pit water.

Due to the low flows of 27 to 42 gpm and problems with pumping small amounts of water, the water level could not be steadily maintained at the 4,525-foot elevation. The water level would rebound up in the slotted casing and then be pumped intermittently to effectively pump from that depth. This would increase

the production and flushing of oxidation products as the water level fluctuates in the backfill and not meet the goal of maintaining the water level as low as possible in the crusher reject, which minimizes the flushing of oxidation products.

Based on backfill settlement discussed in Section 4.2.3.3, up to 150 feet of settlement could occur over the deepest part of the pit over several years (Telesto, 2003e). If the water table rebounded because dewatering wells could not effectively pump from 775 to 875 feet deep, this could cause up to an additional 50 feet of settlement in the saturated portion of the backfill over about 100 years.

Corrosion, scaling, and potential biofouling were addressed in the No Pit Pond Alternative Section 4.2.1.5.2. The corrosive nature of the backfill groundwater, along with the settlement of the backfill, could create difficulties in the implementation of the Partial Pit Backfill With In-Pit Collection Alternative. The following measures may lessen the impacts due to settling and corrosion, but not eliminate them:

- Allow time for settlement, which could result in less than 10 percent of the ARD leaving the pit along faults and other flow paths if the water level rose to the 5,050-foot elevation;
- Wait until backfill saturation approaches the design elevation of the dewatering well screens, which would increase the flushing of oxidation byproducts and allow more settlement to occur in the saturated backfill;
- Install additional dewatering wells in case of failure due to settlement and corrosion; and,
- Install shallower wells as an alternate water level control, which would increase the amount of water escaping the pit, flushing of oxidation byproducts, and settlement.

The agencies considered the risks and uncertainties of all these measures. Settlement is the highest risk to well integrity. Some measures would increase the potential for creating more acidic water, which would move out of the pit and have to be captured down gradient. These measures do nothing to reduce corrosion, which is a risk to well failure. These measures do nothing to improve the ability to drill 875-foot wells in unconsolidated waste rock backfill.

If pumping cannot maintain the water level at the 4,525-foot elevation, groundwater within the pit backfill would become more acidic and metal laden than typical pit water. Due to the 775 to 875 feet of backfill and the need for deep wells, control of the groundwater level would be more difficult under the Partial Pit Backfill With In-Pit Collection Alternative than the No Pit Pond Alternative.

As described in Section 4.2.2.3, 150 feet of settling of the 775 to 875 feet of backfill would occur over time. This settling could affect the integrity of the well casings causing casings to separate in the compacting and consolidating material. Settling could also affect pumps, electrical components, monitoring equipment and pipelines requiring periodic repair and replacement. Additional settling would occur if the backfill becomes inundated. Most settlement would occur within the first few years of placement, but 25 to 40 percent would occur over a longer period, after wells would likely be installed, subjecting them to stresses sufficient to buckle or shear the casings requiring complete replacement of wells over time. This could lead to elevated groundwater levels in the backfill, increasing ARD migration out of the pit if the water table rose above the 5,050-foot elevation (Telesto, 2003a).

Up to 11 wells would be required, compared to two to three wells under the No Pit Pond Alternative, to provide adequate capacity to create an effective cone of depression in the 775 to 875 feet of backfill because of reduced permeability. The corrosive nature of the pit backfill groundwater and potential damage to the well casings from settling backfill indicate that redundancy would also be necessary to maintain effective dewatering. Because of the risks and uncertainties, GSM would be required to replace wells that failed.

As described in Section 4.2.1.5.2, corrosion of the screens and pumps, well casings, electrical components, monitoring equipment and pipelines from the acidic crusher reject and acidic water in the backfill would cause periodic need for repair and replacement of dewatering system components. To prevent wells from silting in, wells must be installed with a gravel pack and the pump periodically raised in the well casing.

Other problems with maintenance include trying to maintain pumps at low pumping rates and high lifts and replacing wells and pumps over time. These are more problematic than the No Pit Pond Alternative, which would require less lift and similar pumping rates in the 100 feet of backfill. The only capture points would be the up to 11 dewatering wells. The underground sump could not be used as a contingency in this alternative because the underground workings would be buried under more than 500 feet of backfill.

4.2.2.6 Storm Water Runon/Runoff Management

4.2.2.6.1 Maintenance Requirements

Maintenance requirements for storm water diversions under this alternative would be the same as under the No Pit Pond Alternative.

The storm water runon/runoff system to keep surface water out of the pit under the Partial Pit Backfill With In-Pit Collection Alternative would be similar to the No Pit Pond Alternative except the location would be different due to the 56 acres of new disturbance created by cast blasting. More than 99 percent of the storm water would be diverted away from the pit (Telesto, 2003a).

Benches would be created on the 2H:1V slopes every 200 vertical feet. Storm water diversions would be constructed on the benches and graded to route water out of the pit area. The backfilled surface of the pit would be graded at 4.3 percent to drain surface water out the eastern rim of the pit at the 5,350-foot elevation.

On the 2H:1V slopes, dozer basins would be created as on the waste rock dump complexes to control erosion until vegetation becomes established. Rocky soils containing up to 45 percent coarse fragments would help to limit erosion and sedimentation in storm water diversions.

The analysis shows that 0.5 to 1.1 inches of annual precipitation would infiltrate into the pit backfill as on waste rock dump slopes (HSI, 2003). This is included in the 27 to 42 gpm of pit seepage that would be collected and treated (Telesto, 2006).

The risks and uncertainties for storm water diversions outside of the pit would be the same as under the No Pit Pond Alternative. Settlement in the backfill as described in Section 4.2.2.5.2 could cause depressions, which would become locations for surface water accumulation and infiltration and could be sites where saturation and instability of the soil cover would be initiated. Settlement along a storm water diversion could result in erosion on the face of the reclaimed slopes. To minimize this impact, monitoring of bench gradients and reestablishment of gradients would be needed over time.

4.2.2.7 Soil Cover

4.2.2.7.1 Soil Cover Maintenance Requirements

As described in Section 2.4.3.6, GSM has proposed a 3-foot soil cover on 274 acres to be revegetated in the pit area. Monitoring of backfill settlement would be the same as described in the No Pit Pond Alternative, Section 4.2.1.7, but there would be more settlement because of the depth of the backfill. There would be

no raveling and sloughing affecting the cover. Any acreage revegetated in the pit would need to be monitored for erosion and noxious weeds. Eroded areas would need to be repaired, resoiled and reseeded. Noxious weeds would have to be controlled.

As described in Section 4.2.3.3, some grading and/or dozing of the backfill surface would be needed as the backfill settles. This would affect the soil cover and more soil would have to be placed and reseeded.

GSM has previously constructed soil covers on waste rock dump complexes and tailings impoundments. On waste rock dump complexes, the dump material and covers have not become saturated, and settlement or erosion problems have been limited. GSM monitors storm water diversions on waste rock dumps annually. If settling occurs, the gradient would be re-established as necessary. On Tailings Impoundment No. 1, where the tailings were saturated and are dewatering over time, settlement has resulted in the necessity for maintenance activities (GSM, 2002c). GSM monitors settlement and soil is replaced as needed to prevent ponding on the impoundment surface and to provide drainage off the impoundment surface.

After cast blasting and dozing the pit highwall to a 2H:1V slope, a 3-foot soil cover with 45 percent rock fragments would be placed over the waste rock and revegetated. GSM's consultant concluded that, in the partial backfill alternatives, a drainage layer would be necessary to keep the soil from slumping in saturated areas on steep 2H:1V slopes (Telesto, 2003d). GSM has been successful in reclaiming long steep slopes at the mine site. The agencies have concluded that the subsurface drainage layer to keep soil from slumping in saturated backfill is not needed in either of the partial pit backfill alternatives. The agencies concluded that small localized stability problems would exist for the soil cover if the soil became saturated, especially if the backfill was relatively impermeable in localized areas. Small localized failures could develop because highwall seeps could flow laterally through and saturate the cover. Seep water would be acidic and would contaminate soils and impair revegetation success if allowed to contact the soil cover. To improve soil cover stability in these localized areas after a failure, the seep would be located and dewatered, contaminated soil would be replaced with clean soil, and the area would be revegetated. In highly permeable areas, such as the Corridor Fault, seep areas would be more common.

Steam vent monitoring under the current permit would be modified to include the pit area as well as the waste rock dumps.

4.2.2.8 Water Treatment

The water treatment plan under the Partial Pit Backfill With In-Pit Collection Alternative would be the same as the No Pit Pond Alternative. In the 1997 Draft

EIS, Chapter IV, Section IV.B.7.b, the agencies predicted that up to 50 gpm of pit water would be treated under the Partial Backfill Alternative. Because an estimated 27 to 42 gpm of pit water would be treated under the Partial Pit Backfill With In-Pit Collection Alternative as a result of the new water balance completed for this SEIS (Telesto, 2006), no change in treatment or disposal methods would be needed.

No other pit discharge was assumed in the 1997 Draft EIS for the Partial Backfill Alternative. The water treatment plant approved in the 1998 ROD had a total design capacity of 392 gpm. No changes in treatment plant design capacity would be needed for the Partial Pit Backfill With In-Pit Collection Alternative.

4.2.2.8.1 Additional Sludge Management Requirements

The quality of the water assumed to be treated in the 1997 Draft EIS was not as poor as the water quality projections of pit water to be treated used in this SEIS (see Table 4-5 in Section 4.3.3.1). In addition, the weathering processes observed in the waste rock dump complexes would continue to produce oxidation byproducts in the unsaturated portion of the backfill. Jarosite in the saturated portion of the backfill would prevent reducing conditions from developing, as can sometimes occur within submerged materials because of the lack of oxygen (see Section 4.3.3.1.1.2.1). Jarosite would allow further production of acid. Jarosite is soluble under the foreseeable conditions and would be expected to dissolve slowly adding dissolved ferric iron to the water. Pumping of pit water to maintain the water level at the 4,525-foot elevation would limit saturation of the backfill and impacts from jarosite dissolution.

More sludge would be produced per gallon of treated water compared to the No Pit Pond Alternative, but the volume of pit water to be treated would be about one-third. So the sludge management requirements would be similar to or less than that analyzed in the 1997 Draft EIS.

4.2.2.8.2 Additional Operating Requirements

The water treatment system in this SEIS is the same as that evaluated in the 1997 Draft EIS. There would be less water to treat from the pit, so there would be no additional operating requirements at the water treatment plant.

Up to 11 dewatering wells would be located at the 5,400-foot elevation. If the water could be pumped out of the wells regularly without failure of the pumps due to corrosion, routing water from the 5,400-foot elevation would be easier than from the 4,625-foot elevation under the No Pit Pond Alternative.

If the drought has affected the seepage predictions on this SEIS and more water would need to be treated than expected, the existing permit stipulation based on

Measure W-6, adding capacity to the water treatment plant, approved in the 1998 ROD as Stipulation 010-9 would be adequate.

4.2.2.9 Flexibility for Future Improvements

4.2.2.9.1 Potential for Utilization of New Technologies

It is estimated that 27 to 42 gpm of water from the pit would need to be treated under the Partial Pit Backfill With In-Pit Collection Alternative.

The water would need to be pumped out of 775 to 875 feet of acidic backfill. This may be possible, although it would be more difficult in the weathering, unconsolidated, acidic waste rock. The acidic water would require regular maintenance and replacement of pumps and other dewatering system components. Because of the problems with maintaining wells in waste rock and the difficulty in removing water from the deeper backfill, the partial pit backfill alternatives offer less potential for utilization of new technologies.

The Partial Pit Backfill With In-Pit Collection Alternative would be less able to accommodate future technological improvements in controlling water quality and quantity than the No Pit Pond Alternative. It would be easier to redesign the system in 100 feet of backfill than in 775 to 875 feet of backfill. If necessary, it would be easier to remove 111,000 cubic yards (167,000 tons) than 33,300,000 cubic yards (50,000,000 tons) of backfill and 11,900,000 cubic yards (17,900,000 tons) of cast blasted highwall rock.

As discussed in the No Pit Pond Alternative (Section 4.2.1.9.1), research is being conducted on treating pit water with chemicals, carbon sources, microbes, etc. in various locations around the world. If an alternative to pumping and treating were developed in the future, it would be easier to treat pit water in an open body of water than in backfill.

If pit water had to be treated in backfill, it would be easier to treat it in the 111,000 cubic yards (167,000 tons) of waste rock in the pit under the No Pit Pond Alternative than it would be in the 33,300,000 cubic yards (50,000,000 tons) of waste rock placed in the pit under the partial pit backfill alternatives.

Pit water balance studies completed for this SEIS concluded that for the Pit Pond Alternative, dismissed in Section 2.5.4, the water level would rise and stabilize at the 4,635-foot elevation due to evaporation of water from the highwall and pit pond. The agencies expect that the 27 to 42 gpm of pit inflow would not leave the pit under the Partial Pit Backfill With In-Pit Collection Alternative. If the dewatering system failed with the volume of backfill placed in the pit, the water would eventually begin discharging at the 5,050-foot elevation. It would be easier to implement treatment systems using chemicals, carbon sources, microbes, etc. in an open body of water than in a pit backfilled with waste rock.

4.2.2.9.2 Consequence of Failure

If implementation of this alternative failed for any reason, the water level would rise in the backfill above the 5,050-foot elevation. An estimated 27 to 42 gpm would eventually leave the pit and would have to be captured down gradient as under the Partial Pit Backfill With Downgradient Collection Alternative. Other treatment technologies that could be implemented in the backfilled pit would be limited. If downgradient collection were not installed, eventually groundwater quality standards would be exceeded at the mixing zone boundary. The time that it would take for groundwater standards to be exceeded at the mixing zone boundary would depend on the mode of failure. If failure occurs because groundwater by-passes the deeper portions of the pit where groundwater is to be collected, the time for groundwater standards to be exceeded would be relatively short. If failure occurs because the collection wells in the pit malfunction, then the time available to address failure of this alternative would be greater.

4.2.3 Partial Pit Backfill With Downgradient Collection Alternative

4.2.3.1 Design and Constructibility of the Alternative

4.2.3.1.1 Proven Design

Backfilling and cast blasting under the Partial Pit Backfill With Downgradient Collection Alternative would be the same as for the Partial Pit Backfill With In-Pit Collection Alternative.

The dewatering system design would be more complex, requiring at least 26 dewatering wells, 10 monitoring wells, and 2 acres of new road and pipeline and power line disturbance, but is a proven design. Pumping out of drainages from wells up to 200 feet deep in various geologic formations is done regularly. The water quality down gradient would not cause as much failure of dewatering system components due to corrosion from acidic water as pumping from backfill in the pit under the No Pit Pond and Partial Pit Backfill With In-Pit Collection alternatives. Scaling from iron hydroxide formation and potential biofouling could increase because of the higher pH of the captured water. Limited scaling has occurred at GSM (Section 4.2.1.5.2.1.5).

4.2.3.1.2 Ability to Construct the Alternative at GSM

The volume and depth of backfill and cast blasted material would be the same for both partial pit backfill alternatives.

No wells would be constructed in the backfill under this alternative. At least 26 dewatering wells and 10 monitoring wells would be constructed down gradient of the pit in Rattlesnake Gulch (Figure 2-7).

Installing dewatering wells at GSM in similar geologic materials has been done successfully. Based on GSM's experience in drilling monitoring and pumpback wells, the agencies expect that only a maximum of 80 percent of groundwater in a given capture system would likely be captured in these wells because of uncertainty about flow paths, heterogeneities in the aquifer, and operations and maintenance outages. More wells would probably be needed to attempt capturing a sufficient percentage of the pit discharge. The Tailings Impoundment No. 1 south pumpback system (Figure 3-5) would have to be maintained as well. Two capture systems, operating at a combined capture efficiency of approximately 96 percent, would be required to prevent water quality violations at the mixing zone boundary. The 96 percent capture efficiency may not be achievable based on GSM's experience capturing Tailings Impoundment No. 1 seepage. Based on their experience, the agencies believe a maximum capture efficiency of 80 percent per system is potentially achievable.

GSM has been capturing Tailings Impoundment No. 1 seepage since the 1983 leak of tailings solution through the improperly constructed bentonite slurry cutoff wall. Chronologies of events about the leak and capture systems from 1983 through 2003 have been compiled (GSM 1991 Annual Report: Table 1; Spectrum Engineering, 2004: Appendix A).

Four pumpback wells were constructed in 1983. In 1986,15 pumpback wells were in place. In 1991, 22 more pumpback wells were constructed. As detailed in various Annual Reports, new monitoring wells and pumpback wells have been constructed and old wells have had to be decommissioned or replaced regularly. Wells were refurbished in 1995 and 2001. In 2004, 16 pumpback wells were still being pumped, and a total of 52 monitoring wells and three surface water stations were being sampled to track the leakage from Tailings Impoundment No. 1 (Portage Environmental, 2004).

Various reports have been prepared since 1980 about the impoundment, documenting the problem and addressing agencies' comments about GSM's ability to contain the seepage (SHB, 1980, 1982, 1983, 1985, 1986, 1987, and 1989b; DSL, 1987 and 1988; Hydrometrics, 1991, 1994, 1997; Keats, 2001; HSI, 2003; Spectrum Engineering, 2004; Portage Environmental, 2004). Despite continual upgrading of the wells, some seepage is escaping the south pumpback system. Data suggest slow migration of seepage away from Tailings Impoundment No. 1 (GSM 1998, 1999, and 2000 Annual Reports). There also is a vertical component to the seepage migration as well (GSM 2000 Annual Report).

Keats (2001) concluded the second and third rows of pumpback wells were not completely capturing the seepage. Keats recommended treatment at the source area rather than adding pumpback wells. This was due in part to the difficulty in defining smaller scale contaminant pathways. GSM has tested in-situ injection in the area with DEQ and EPA approval to achieve treatment at the source since the Keats report was completed.

Portage Environmental, Inc. reviewed the GSM monitoring well program in 2004. It summarized the level of contamination in all wells in the report. The majority of wells below the pumpback system still show some cyanide, nitrate, or metal contamination. It is hard to define how much of that is from the 1983 leak or from the continued migration of seepage past the capture systems. The agencies and GSM continue to review sampling results and modify the seepage containment system to prevent violations at the permit boundary.

A new well was constructed in 2004 to identify sources of nitrate that may or may not be related to the mine (Spectrum Engineering, 2004). Another new well drilling program was approved in October 2004 to identify the nitrate source(s) in

the area wells. Each new well placed in the Bozeman Group shows variable geology and the discontinuity of lithologic units within the Group.

The Bozeman Group is a variable aquifer and has been the subject of many studies since 1980. GSM is capturing the majority of the seepage from Tailings Impoundment No. 1, a process that uses a large number of pumpback and monitoring wells (Hydrometrics, 1996) that continue to be necessary. Some seepage continues to escape the pumpback system. Efforts continue to ensure that violations do not occur at the mixing zone boundary.

For this SEIS, modeling indicated that two capture systems achieving an overall capture efficiency of approximately 96 percent would be needed to prevent violations at the mixing zone boundary (HSI, 2006). GSM's experience since 1983 trying to capture Tailings Impoundment No. 1 seepage indicates this may not be achievable. Based on their experience, the agencies believe a maximum capture efficiency of 80 percent per system is potentially achievable

DEQ has been addressing concerns with capture system efficiency at other sites, including the Zortman, Landusky, CR Kendall, and Black Pine mines, and PPL Montana power plants in Colstrip. At Colstrip, PPL Montana continues to have problems containing seepage through a variable Tertiary aquifer. None of these systems capture all seepage.

Containing groundwater in the pit offers a greater degree of control of contaminants than trying to capture contaminants in a variable aquifer closer to the mixing zone boundary. Treatment at the source (*i.e.*, pumping directly from the pit sump) in the No Pit Pond or Underground Sump alternatives is easier to achieve than treating by collection and pumping from downgradient wells. Adding more water to the Rattlesnake Gulch flowpath may accelerate and complicate existing capture system collection efforts.

4.2.3.2 Pit Highwall

4.2.3.2.1 Pit Highwall Stability

Pit highwall stability under this alternative would be similar to the Partial Pit Backfill With In-Pit Collection Alternative.

Stability of the pit highwall would not be affected by the water table rebounding and stabilizing at the 5,260-foot elevation (Telesto, 2003d).

4.2.3.2.2 Pit Highwall Maintenance Requirements

Pit highwall maintenance requirements would be similar to the Partial Pit Backfill With In-Pit Collection Alternative.

Highwall maintenance would be similar to the Partial Pit Backfill With In-Pit Collection Alternative.

4.2.3.3 Backfill

4.2.3.3.1 Backfill Maintenance Requirements

The type of backfill maintenance requirements would be similar for the No Pit Pond and partial pit backfill alternatives. Under this alternative, the backfill would become saturated to the 5,260-foot elevation as the water table rebounded.

As described in Section 4.2.2.5.2, up to 150 feet of settlement would occur over time. Sixty to 75 percent would occur during backfilling. The rest would occur over the long term (Telesto, 2003d). The settlement tests performed on the waste rock specimens were analyzed in a dry condition to mimic end dumping that would occur during backfilling. Following the settlement tests, the specimens were inundated with water to simulate water filling of the pit. This inundation by water added an additional 50 feet average settlement (Telesto, 2003d).

Settlement could extend below the toe of the steep 2H:1V slopes, causing the slope to slough. If the function of the storm water diversions on the benches is affected, gullies would form. One way to mitigate this adverse impact would be to delay installing the drainage controls and soil cover until the backfill has sufficiently stabilized, as described in Section 4.2.2.5.2. According to the consolidation tests conducted using the backfill material, settlement would stop once the backfilled pit has been fully inundated. After inundation of the pit, the settlement could be as much as 167 to 200 feet. During this delay, downgradient dewatering would have to continue. It would take nearly 61 years for saturation of the pit backfill to reach equilibrium at the 5,260-foot elevation.

The maintenance requirements would be more than for the Partial Pit Backfill With In-Pit Collection Alternative due to the additional 50 feet of settling from inundation of the backfill to the 5,260-foot elevation. As for the Partial Pit Backfill With In-Pit Collection Alternative, additional soil would be needed to bring the backfill up to grade and to restore the function of the storm water diversions.

4.2.3.4 Underground Workings

4.2.3.4.1 Impacts to Pit Facilities Due to Subsidence Related to Underground Mining

Impacts due to subsidence in the underground workings under this alternative would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative.

The risks and uncertainties would be similar to the Partial Pit Backfill With In-Pit Collection Alternative.

4.2.3.5 Groundwater/Effluent Management System

The water balance for this SEIS concluded that for the Partial Pit Backfill With Downgradient Collection Alternative, an estimated 27 to 42 gpm would discharge from the backfilled pit (Telesto, 2006). The primary objective of the Partial Pit Backfill With Downgradient Collection Alternative would be to try to avoid pit dewatering completely by letting the pit water table rebound in the backfill and letting the pit effluent discharge into the regional groundwater system. The pit discharge would move down primary and secondary groundwater flow paths, partially attenuate, and mix with ambient groundwater. Approximately 77 to 143 gpm of ambient groundwater, East Waste Rock Dump Complex seepage, and pit discharge would be collected in Rattlesnake Gulch using the existing Rattlesnake Gulch dewatering wells and the Tailings Impoundment No. 1 capture system supplemented with additional wells as described in Section 2.4.4.3 (HSI, 2006).

4.2.3.5.1 Operation Requirements (Number of Wells)

As described in Section 2.4.4.3, at least an additional 26 downgradient capture wells, and 10 monitoring wells would be needed to capture and monitor pit seepage and ambient groundwater. Groundwater quality standards would be met at the mixing zone boundary if 96 percent or greater overall capture efficiency is achieved from two capture systems (HSI, 2006). More wells may be needed as described in Section 4.2.3.1.2. An overall 96 percent capture efficiency may not be achievable based on GSM's experience with Tailings Impoundment No. 1 seepage, as described in Section 4.2.3.1.2. As described in Section 4.3.4.1.2.2.1, as a result of trying to capture an overall 96 percent of the combined pit seepage, East Waste Rock Dump Complex seepage, and ambient groundwater to meet groundwater standards at the mixing zone boundary, an approximate 77 to 143 gpm of groundwater would be collected in the process. The number of wells and the need to collect additional water reflect the uncertainties of effective contaminant collection in the Tdf/colluvial aquifer (the primary pit flowpath), and collection of contaminants in the fractured bedrock aquifer (the secondary pit flowpaths).

4.2.3.5.2 Maintenance of Capture Points

Maintenance of downgradient collection wells would be less problematic than those in acidic backfill. As described above, capturing groundwater at distances down gradient of the pit introduces uncertainty as to the effectiveness of capture of all contaminated groundwater in the heterogeneous Bozeman Group and in fracture flow systems. It also necessitates the collection of a greater volume of groundwater.

The collection wells would need to be monitored and maintained regularly to ensure pumping efficiency. Additional operator time would be needed to access the wells around the pit. The powerlines, pipelines and access roads would also need to be maintained. The well casings in natural geologic formations would not be subject to the settling effects of the backfill. In addition, the pumped water quality could be better for a few years due to short-term buffering by the aquifer and mixing with ambient groundwater, which would limit corrosion and extend pump life. Once the attenuation and buffering capacity of the aquifer is used up (projected to be a few tens of years (HSI, 2003)), then water quality would be similar to the pit water quality. GSM has been maintaining capture wells below the impoundments for many years (Section 4.2.1.5.2.1.5) and the costs of this maintenance are well documented. Bond would be calculated to cover the additional costs of maintaining the complex collection system. Approximately 77 to 143 gpm of ambient groundwater, East Waste Rock Dump Complex seepage, and pit discharge would have to be collected to meet groundwater standards at the mixing zone boundary (HSI, 2006). This may not be achievable, as described in Section 4.2.3.1.2. Based on their experience, the agencies believe a maximum capture efficiency of 80 percent per system is potentially achievable

4.2.3.6 Storm Water Runon/Runoff Management

4.2.3.6.1 Maintenance Requirements

The storm water runon/runoff management maintenance requirements for this alternative would be the same as the Partial Pit Backfill With In-Pit Collection Alternative.

The storm water runon/runoff management maintenance risks and uncertainties for this alternative would be the same as the Partial Pit Backfill With In-Pit Collection Alternative.

4.2.3.7 Soil Cover

4.2.3.7.1 Soil Cover Maintenance Requirements

The soil cover maintenance requirements for this alternative would be greater than the Partial Pit Backfill With In-Pit Collection Alternative due to more settlement in the saturated backfill.

Risks and uncertainties with soil cover maintenance would be the same as the Partial Pit Backfill With In-Pit Collection Alternative.

4.2.3.8 Water Treatment

The water treatment plan under the Partial Pit Backfill With Downgradient Collection Alternative would be the same as all other alternatives. In the

modeling completed for this SEIS, it was estimated that of the from 27 to 42 gpm that would discharge from the pit, 96 percent would need to be collected in the existing pumpback collection systems and at least an additional 26 downgradient wells. The agencies have estimated that approximately 77 to 143 gpm would be collected and treated as a result of trying to capture the combined volume of pit seepage, East Waste Rock Dump seepage, and ambient groundwater needed to prevent water quality impacts at the mixing zone boundary. In the 1998 ROD, the agencies predicted treatment of 102 gpm of pit water under the No Pit Pond Alternative. The present treatment plant design capacity would be adequate (Table 4-2). The additional water would not require a change in treatment or disposal methods. The quality of the water from the saturated pit would be worse because of the geochemical processes associated with weathered acidic, metal laden waste rock backfill of the pit under both saturated and unsaturated conditions.

4.2.3.8.1 Additional Sludge Management Requirements

As mentioned above, with downgradient collection, approximately 77 to 143 gpm would be collected and treated under this alternative to prevent impacts at the mixing zone boundary.

The quality of the water in the backfill would be the same as in the Partial Pit Backfill With In-Pit Collection Alternative. Jarosite in the saturated portion of the backfill would prevent reducing conditions from developing, as can sometimes occur within submerged materials because of the lack of oxygen. Jarosite would allow further production of acid. Metals release would occur during the dissolution of jarosite because ferrous iron usually predominates below the water table. The flow from the unsaturated portion of the backfill above the water table would continue to contribute low pH water with high metals concentrations to the pit discharge for hundreds of years. The rock along the primary and secondary flow paths from the pit has limited natural attenuation capacity, or ability to reduce the metals concentration or increase pH of the groundwater flow (HSI, 2003; Telesto, 2003e). The sludge management requirements would be roughly the same between alternatives with and without pumping because the chemical mass produced is roughly the same (Robertson GeoConsultants, 2003).

4.2.3.8.2 Additional Operating Requirements

Under the Partial Pit Backfill With Downgradient Collection Alternative, 26 more collection wells and 10 more monitoring wells would be needed in the dewatering system than with the Partial Pit Backfill With In-Pit Collection Alternative. This would require more spur pipelines and powerlines to the main pipeline and powerline to transport the captured water to the treatment plant. The agencies have assumed an additional 2 acres would be disturbed for new roads, pipelines, and powerlines to the wells.

The extra wells, pipelines, powerlines and roads would require more monitoring time than the dewatering systems for other alternatives. The collection and monitoring wells under this alternative would not be subject to other problems that the wells in the acidic backfill would be subject to such as settling damage to casings and corrosion. The collection and monitoring wells could be subject to limited problems with corrosion, scaling, and potential biofouling of pumps and screens, etc., due to increased pH of the captured water. The wells would also not be as deep and therefore would not have the problems with high lift out of the deep backfill. The water treatment plant could require additional operating funds due to the increased water quantity (approximately 77 to 143 gpm) that would be collected in the downgradient capture wells, as compared to the other alternatives. The 300 to 366 gpm volume from all sources needing treatment under this alternative would still be less than the 392 gpm water treatment plant capacity approved in the 1998 ROD.

4.2.3.9 Flexibility for Future Improvements

4.2.3.9.1 Potential for Utilization of New Technologies

The potential for utilization of new technologies under this alternative would be similar to the Partial Pit Backfill With In-Pit Collection Alternative except that future backfill water treatment methods that require injection of chemicals, carbon sources, microbes, etc. would be more difficult because of the lack of wells in the backfill. Wells could be installed. If treatment were attempted outside of the pit, a dispersed plume may be more challenging to track and contain.

4.2.3.9.2 Consequence of Failure

If implementation of this alternative failed for any reason, modeling indicates that groundwater quality standards would be exceeded at the mixing zone boundary. This alternative would put contaminated water into groundwater flowpaths that connect to the Jefferson River alluvial aquifer and Jefferson Slough.

4.2.4 Underground Sump Alternative

4.2.4.1 Design and Constructibility of the Alternative

4.2.4.1.1 Proven Design

The pit would not be backfilled under this alternative. Waste rock would remain stored and capped above the water table in the East Waste Rock Dump Complex. Dewatering would occur in an underground sump. This has already been done at GSM during operations. The Colorado Division of Minerals and Geology (CDMG), the Nevada Department of Natural Resources and Conservation (NDNRC), and the Nevada Department of Environmental Protection (NDEP) were contacted regarding dewatering (Kathy Gallagher, GSM consultant, personal communication, 2003). The NDNRC and NDEP could not provide specific methods of dewatering for individual mine sites, merely stating that the majority of mines in Nevada were dewatered. Mines listed by NDEP included Pipeline (Placer Dome America), Gold Quarry (Newmont), Meikle (Barrick Gold Strike), and Robinson (Quadra). Underground operations listed as being dewatered from a sump included Leeville (Newmont), Hollister (Hecla), and Getchell (Placer Dome America). The CDMG data are presented below in Table 4-3.

Table 4 - 3. Examples of mines being dewatered and their dewatering methods

Mine	Limited Backfill	Underground Sumps	Pit Ponds
Berkeley Pit - Butte, Montana		From the 1960s to 1982, Anaconda Company dewatered Berkeley Pit from Kelley Shaft at 4,000-5,000 gpm (Canonie, 1994).	Montana Resources has pumped from the pit lake for process water.
Mayflower Mine - Montana		In 1997 dewatered from sump at 1,582 feet, pump @ 1,200 level .	
Battle Mountain – San Luis Colorado	Controlled dewatering/rinse of pit backfill for indefinite time. Treated and released.		
Homestake - Bulldog, Colorado		Dewatered below lowest adit level to develop sub-adit level. Treated and released.	
Cotter Corp - Schwartzwalder, Colorado		Dewatered below adit level (formerly) to develop sub-adit workings. Treated and released.	
Climax Molyb. Co - Climax, Colorado		Perpetual pumping from main shaft to prevent overflow of groundwater out shaft. Treated and released.	
Gilt Edge, South Dakota			Treated in the pond, pumped from the pond, and discharged.

During stripping of waste rock for Stage 5B, GSM dewatered the mine from 7/27/2006 through 1/16/2007 via an underground sump. Water is drained to the sump through two drill holes from the 4,650-foot elevation. At closure, GSM would have to drill holes from the 4,525-foot elevation to an underground sump to drain water that would collect in the pit bottom.

It is technically feasible to install pumps in the underground workings at closure. During a portion of the underground operation, GSM dewatered the pit and underground working from a sump in the underground, as described in Section 4.2.1.5.2.1.4. Maintaining hydrologic connection between the pit bottom and the underground for dewatering has been successful. Periodic maintenance would be needed to ensure access to the 4,550-foot-elevation portal, to maintain the underground workings, and access to the sump. Pumps would need to be replaced as in other alternatives. Pipelines and powerlines may be damaged periodically by rock falls in the underground workings or from the highwall, but

these are readily observable and can be corrected immediately. In addition, preventive measures, such as covering pipelines with rock after installations, can be routinely implemented to minimize potential impacts.

4.2.4.1.2 Ability to Construct the Alternative at GSM

No crusher reject would be placed in the pit under this alternative. The only work needed to construct this alternative would be to redesign the underground dewatering system and develop the 4,550-foot elevation portal for future access.

The agencies would require GSM to submit a plan for development, maintenance and monitoring of a portal at a suitable elevation to maintain secondary access for dewatering. This would provide long-term access to the dewatering system for repair and maintenance and to provide safety for underground workers.

4.2.4.2 Pit Highwall

4.2.4.2.1 Pit Highwall Stability

Pit highwall stability under this alternative would be essentially similar to the No Pit Pond Alternative.

Under the Underground Sump Alternative, no crusher reject or other material would be backfilled in the bottom portion of the pit. Dewatering of the pit would occur from within the existing underground workings. As the groundwater level in the pit highwall is drawn down during mining and maintained following mining, the pit highwall would remain stable. The portal at the 4,550-foot elevation could be destroyed by the failures described by the agencies under the No Pit Pond Alternative. The agencies would require GSM to submit a plan for development, maintenance, and monitoring of a portal at a suitable elevation to allow secondary access, dewatering in the future, and to protect workers in the pit and underground.

4.2.4.2.2 Pit Highwall Maintenance Requirements

Pit highwall maintenance requirements under this alternative would be similar to the No Pit Pond Alternative.

Depending on the location and nature of highwall raveling and sloughing over time, there is a possibility that access to the 4,550-foot portal and the underground dewatering system could be lost. If this were to occur, portions of the pipelines and powerlines could be lost. The water table would begin to rebound in the underground workings. GSM would have to reestablish the 5,700-foot safety bench and access to the 4,550-foot portal, if possible, and repair any damaged dewatering components. The agencies would require GSM to submit a plan for development, maintenance and monitoring of a portal at a

suitable elevation to maintain secondary access for dewatering. There would be no impacts outside of the pit.

4.2.4.3 Backfill

4.2.4.3.1 Backfill Maintenance Requirements

Not applicable to the Underground Sump Alternative.

4.2.4.4 Underground Workings

4.2.4.4.1 Impacts to Pit Facilities Due to Subsidence Related to Underground Mining

Impacts due to subsidence under this alternative would be similar to the No Pit Pond Alternative except localized failures of overhead rock in seep and fault areas could occur over time affecting access to the dewatering system in the underground workings. A monitoring and maintenance plan would be needed to ensure continued access to repair the dewatering system and to ensure worker safety. The monitoring and maintenance plan would be applied to both the 4,550-foot and contingency portal locations.

4.2.4.5 Groundwater/Effluent Management System

The principal objective of the Underground Sump Alternative would be to maintain the pit as a hydrologic sink, keeping the groundwater level below the final pit bottom at the 4,525-foot elevation.

4.2.4.5.1 Operation Requirements (Number of Wells)

There would be no new wells constructed under this alternative. Some drill holes would be needed to direct pit water to the underground sump. Construction of the underground dewatering system would be completed during the last phase of Stage 5B mining operations. The dewatering system would be designed and constructed to maintain the groundwater level 25 to 75 feet below the final pit bottom elevation of 4,525 feet by pumping from the Deep Baja stope (Figure 2-8). Risks and uncertainties for wells would be less than the No Pit Pond Alternative, since no new wells are required and no wells would be installed in any backfill.

The modeling for this SEIS estimates that from 25 to 27 gpm of water would have to be removed from the underground workings. In addition, the modeling indicates that pumping may not be required from the two existing vertical highwall wells (PW-48 and PW-49), since evaporation and the heat produced by the reaction from sulfide oxidation would likely remove over 75 percent of the volume of this water as it migrated down the highwall. However, at least initially, the

highwall wells would continue to be operated (GSM, 2002a). Operation requirements for the underground dewatering system would be less than the operation requirements for wells under the partial pit backfill alternatives. All water would be collected at one point.

4.2.4.5.2 Maintenance of Capture Points

The only capture point would be the sump in the underground workings. Access to the underground would be needed. The agencies expect that highwall failures over time would bury the 4,550-foot elevation portal. The agencies would require GSM to submit a plan for development, maintenance and monitoring of a portal at a suitable elevation for long-term access. The agencies would bond for maintenance of access and regular repair and replacement of dewatering system components.

4.2.4.6 Storm Water Runon/Runoff Management

4.2.4.6.1 Maintenance Requirements

Storm water management maintenance requirements would be comparable to the No Pit Pond Alternative.

Surface water would be diverted around the open pit. Surface water that drains into the pit would be removed to the underground sump through bore holes drilled to connect the pit with the underground workings. As part of the final reclamation of the site, GSM would construct permanent storm water controls concurrently with site reclamation. These controls would minimize or eliminate surface water inflow from entering the open pit. More than 99 percent of the surface water would be diverted away from the pit (Telesto, 2003a).

Risks and uncertainties would be similar to the No Pit Pond Alternative.

4.2.4.7 Soil Cover

4.2.4.7.1 Soil Cover Maintenance Requirements

This alternative is similar to the No Pit Pond Alternative except there would be 1.3 fewer acres to maintain in the pit. Any rocks off the highwall that escape the safety benches may end up on the soil covered revegetated areas on pit roads and benches. These areas may either need to be cleared or resoiled and reseeded. There would be no backfill material, and therefore no cover on backfill material.

4.2.4.8 Water Treatment

This alternative would be similar to the No Pit Pond Alternative and an estimated 25 to 27 gpm would be pumped from the underground workings (Telesto, 2006). Water quality in the underground sump would be more predictable than water in the backfill.

4.2.4.8.1 Additional Sludge Management Requirements

The 25 to 27 gpm produced in the underground workings would be comparable to the water quality in the No Pit Pond Alternative. The amount of water needing treatment would be less than the 102 gpm used to design the water treatment plant capacity for the No Pit Pond Alternative in the 1997 Draft EIS.

The water quality used in the 1997 Draft EIS was better than the water quality used in this SEIS, so additional sludge would be created. The agencies have concluded that the amount of additional sludge would be minimal and would not produce changes in the sludge management plans at the water treatment plant. Because no waste rock would be removed from the East Waste Rock Dump Complex to be used as backfill, jarosite, adsorbed metals, and other oxidation byproducts would remain relatively immobile in the waste rock dump complex.

4.2.4.8.2 Additional Operating Requirements

Pumping from the underground sump at the 4,450-foot elevation out of the 4,550-foot elevation portal and then to the water treatment plant would result in the need for some additional pipelines and powerlines over those needed for the No Pit Pond Alternative.

The agencies expect that the 4,550-foot elevation portal would be buried by rocks raveling and sloughing off the highwalls over time. GSM would be required to maintain access at a contingency portal location. This would require additional powerlines, pipelines, and maintenance of access roads in the decline to ensure integrity of the dewatering system and provide a secondary escapeway for workers over time. The agencies have assumed the safety risk to workers in the pit is less than in the No Pit Pond Alternative. The risk to workers from using the underground sump for the dewatering system would be less than the risk to workers maintaining the pit dewatering system in the No Pit Pond Alternative below the 1,775-foot highwall on a 1.3-acre working surface.

4.2.4.9 Flexibility for Future Improvements

4.2.4.9.1 Potential for Utilization of New Technologies

The Underground Sump Alternative would have the potential for utilization of new technologies being developed for use in the underground workings to collect or

treat seepage. Access would have to be maintained to the underground workings to implement these new technologies or wells could be drilled into the underground workings. Research is being conducted on treating pit water with carbon sources, microbes, etc. in various locations around the world, including the Berkeley Pit in Butte. It would be easier to implement treatment systems using chemicals, carbon sources, microbes, etc. in an open body of water in the underground sump than in a pit backfilled with waste rock.

The acidic water would cause regular maintenance and replacement of pumps and other dewatering well components, as in other alternatives. Although no waste rock is placed in the pit under this alternative, the water is still expected to be acidic because of its exposure to pit rock containing sulfides and the 200,000 cubic yards (300,000 tons) of rock that ravels and sloughs to the bottom over time.

GSM has researched the potential to treat or at least pre-treat pit water in-situ. During 2002-2003, GSM added carbon sources such as alcohol and sugars to the pit in an attempt to pre-treat the pit water in the rubble at the bottom of the pit. In addition, GSM proposed treating water that is collecting in the underground workings. This new test has been approved by the agencies (DEQ and BLM, 2004). Pretreating the pit water would increase the operational life of dewatering system components by reducing corrosion. Depending on the success of the test, it may cause potential biofouling and scaling. This test was never conducted.

This alternative offers the opportunity to test and potentially treat water either in an open pond, in the event of failure, or in an open water body in the underground workings. The agencies believe the potential for using new technologies is maximized in the Underground Sump Alternative.

4.2.4.9.2 Consequence of Failure

The consequence of failure of a dewatering system in the underground workings in this alternative would be that the underground workings below the pit would flood and the pit would begin to fill with water. The consequence of failure would be similar to the Pit Pond Alternative, which was dismissed in Section 2.5.4. If the Underground Sump Alternative failed, then the No Pit Pond Alternative or a Pit Pond Alternative could be implemented. Under the Pit Pond Alternative, the water table would rise to the 4,635-foot elevation and stabilize. Pit water would be readily observable, and corrective action would be taken before the pit substantially flooded. The revised pit water balance model predicts an inflow range from 25 to 27 gpm (Telesto, 2006). It would take approximately 230 to 262 days for 8.3 million gallons of water in the underground workings to reach the pit bottom elevation of 4,525 feet.

Under the No Pit Pond Alternative, 111,000 cubic yards (167,000 tons) of crusher reject would be backfilled. The agencies have assumed that up to 100,000 cubic yards (150,000 tons) of rock would ravel and slump off the pit highwall over time, and another 100,000 cubic yards (150,000 tons) would slough. Even with this total volume of rock in the bottom of the pit, the water table would not rise above the 5,050-foot elevation where water would begin to discharge from the pit.

The Underground Sump Alternative would be similar to the No Pit Pond Alternative in terms of ravel and slough as well as water table stabilization level. Even with the rock that would ravel and slough to the pit bottom, the water level would stabilize below the 5,050-foot elevation (Telesto, 2003a). If the dewatering system was to fail and a pit pond formed, water could be treated in the pit, pumped to the treatment plant from the pit pond and treated, or the No Pit Pond Alternative could be implemented as a contingency. This alternative offers the most flexibility for future changes in water treatment methods.

4.3 ENVIRONMENTAL ISSUES

4.3.1 Environmental Impacts of Current Mining Operations

4.3.1.1 Waste Rock Impacts to Water Quality and Quantity

Springs around the pit area are shown in Figure 3-5. No impacts to spring water quality during mining operations were identified in the 1997 Draft EIS, Chapter IV, Section IV.B. Since 1998, the only documented change in water quality in pit area springs was to Stepan Spring. Stepan Spring, below the South Dump, showed water quality impairment, which was attributed to waste rock dump runoff (Gallagher, 2003c). This site was reclaimed, with pH and dissolved metals levels improving from 1999 to 2002, although total dissolved solids and sulfate generally remained above levels of 1989 to 1998. From 2003 to 2006, flow from Stepan Spring has diminished to intermittent, and pH has decreased somewhat (see Section 3.3.4). Stepan Original Spring emanates from a collapsed adit and represents regional groundwater that has traveled through mineralized zones (HSI, 2003).

The East Waste Rock Dump Complex buried an intermittent spring, Midas Spring, which may be associated with the buried Midas Adit and possibly associated with the Sunlight slip block discussed by Golder (1995a). Discharge from this spring may be in contact with waste rock, and the earliest measurements in 1990 indicate that it was acidic with elevated sulfate and metals. Midas Spring discharge is captured and conveyed to the water treatment plant.

Rattlesnake Spring and Bunkhouse Springs emerge in Rattlesnake Gulch, a natural drainage filled with debris flow and landslide deposits derived in part from mineralized portions of Bull Mountain. As described in Section 3.3.4, these springs receive flow from mineralized zones, which contain subsurface ferricrete deposits, and are believed to be representative of naturally mineralized groundwater. This analysis identified no definitive water quality trends indicating mining- or waste rock-related impacts (Gallagher, 2003a).

North Borrow Springs, located approximately 120 yards north of Tailings Impoundment No. 1, consists of a broad seepage area with flow rates ranging from 8 to 32 gpm. These springs were created when the North Borrow Area was excavated below the shallow water table. Spring water is now being intercepted by an underdrain system constructed beneath the Buttress Dump. The system conveys water by pipeline to Tailings Impoundment No. 2. The North Borrow Area excavation has been filled with material from the East Waste Rock Dump Complex to form the Buttress Dump. Flows from the underdrain system have been minimal since the Rattlesnake Gulch pumpback system was installed (Shannon Dunlap, GSM, personal communication to HSI, November 1, 2005).

Arkose Valley Spring and Sunlight Spring were both covered by the West Waste Rock Dump Complex after 1986 and do not have any surface expression. In order to lower the local potentiometric surface and prevent contact between water and waste rock, interception and infiltration facilities were constructed at both Arkose Valley Spring and Sunlight Spring in mid-1994. All work was completed prior to expansion of the West Waste Rock Dump Complex over the springs. No discharge or seepage of water has occurred from the West Waste Rock Dump Complex.

Storm water runoff from the waste rock dump complexes has been limited during mine life. Storm water that ran off was captured at the toe of the waste rock dump by berms and percolation ponds. No impacts were noted in downstream monitoring wells (GSM 2006 Annual Report).

4.3.1.2 Pit Impacts to Water Quality and Quantity

4.3.1.2.1 Pit Impacts to Groundwater

As groundwater enters the pit, it flows through zones of broken and disturbed rock, which contains 0.5 to 2.0 percent pyrite (Table 4-1). Atmospheric oxygen and dissolved oxygen in water percolating through the broken rock reacts with the pyrite, which leads to sulfide oxidation and generation of ARD. In addition, during precipitation events, water quality is degraded by the flushing of oxidation by-products, such as acid salts that have accumulated on the pit highwall from evaporation (Gallagher, 2003b) and from heat produced by sulfide oxidation.

As discussed in Section 3.3.3, water collected within the pit has been impacted by ARD during the life of the mine. Most of the seeps and springs emanating from the pit highwall have a pH ranging from 2 to 4 (Gallagher, 2003b). Freshly blasted highwall rock is primarily unoxidized and acid producing (Gallagher, 2003a; Schafer and Associates, 1994, 1996). GSM has conducted research on the pit sump water during operations. Water pumped from the pit sump from 2002 to 2003 had a median pH of approximately 4.5 and an average sulfate concentration of 16,400 mg/l.

Groundwater immediately upgradient of the pit is less affected by sulfide oxidation and is of better quality than pit water. Two vertical highwall dewatering wells (PW-48 and PW-49 as shown on Figure 3-5) located on the 5,800-foot elevation bench on the north highwall have been pumped to intercept groundwater upgradient of the pit. Monitoring results from these wells indicate that, although the water is of better quality than the pit water, it would require treatment to meet water quality standards (GSM, 2002a). The water quality from PW-48 is somewhat lower than PW-49, with median pH of 3.8 and median sulfate of 1,825 mg/l, compared to 5.9 and 1,605 mg/l, respectively for PW-49.

The 1997 Draft EIS, Chapter IV, Section IV.B.1.b indicated that ARD from the pit was not expected to impact local groundwater quality during mining operations. The 1997 Draft EIS concluded that mining would reduce the groundwater level around the pit area during operations. Pumping of water from the pit causes a cone of depression in the potentiometric surface of the bedrock aquifer surrounding the pit such that the net flow is into the pit creating a hydrologic sink (URS, 2001; Hydrometrics, 1995) (Figure 3-5 from GSM, 2002a).

Groundwater flows into the pit from all directions, controlled by geologic structures such as faults, fractures, dikes, and disturbed rock zones. The sources of pit inflows include direct precipitation over the pit, the local and intermediate groundwater systems, underground mine water, and groundwater released from storage (Telesto, 2003a). The groundwater capture zone of the pit extends from as little as 100 to 300 feet east and south of the pit rim to as much as 1,600 feet north of the pit rim (Telesto, 2003a). Hydraulic effects of the pit may extend greater distances from the pit along fracture zones.

As described in Section 3.3.7.2, faults and fractures control the permeability of the bedrock unit in the pit area and act as the conduits of groundwater flow into the pit. From 1995 through 2001, 43 pit highwall seeps were cataloged by GSM, some of which may be duplicative due to the changing pit configuration and seep locations over time (Gallagher, 2003b). The most seepage was found as the pit intersected the Corridor Fault. In general, while new seeps have been identified as the pit was deepened, total flow from seeps has not changed proportionately. Precipitation events were found to be responsible for the largest variations in pit highwall seep flows (Gallagher, 2003b). Gallagher (2003a) also described the geologic structural controls, lithologic controls, and engineering/blasting controls on pit highwall seepage. A disturbed rock zone caused by conventional blasting and mining extends several feet to tens of feet into the pit highwall. This zone tends to funnel pit highwall inflows downward, where the water may reach the pit bottom or emerge as pit highwall seeps.

The pit has been maintained as a hydrologic sink by pumping from the pit since at least 1991, when the first seeps developed during Stage 2 and 3 mining. Dewatering requirements were minimal until late 1991/early 1992 when the pit intercepted the Corridor Fault in the Stage 3 Pit. In July 2002, GSM installed a dewatering well in rubble in the bottom of the pit. The well was constructed to a depth of approximately 118 feet (bottom of hole elevation 4,748 feet). The well was pumped routinely from the end of July 2002 until July 2003 to keep the water level below the pit floor. In July 2003, the well was removed to allow mining of the rubble in the bottom of the pit. Based on pumping records, water inflow to the sump at the bottom of the pit averaged 27 to 30 gpm while the well was in service (see Section 4.2.1.5.2.1.3).

Two highwall dewatering wells (PW-48 and PW-49) have been pumped to intercept groundwater from the Corridor Fault area before it enters the pit. The

combined flow from these wells averaged approximately 18.2 gpm (PW-49 averaged 16 gpm, PW-48 averaged 2 gpm) (Telesto, 2006). In addition to the existing dewatering wells, horizontal drains have been installed and incorporated into the dewatering system as required to maintain safe operations. Less than 5 gpm of groundwater discharged into the underground mine and was collected in the underground sump and pumped out of the underground workings. Pumping did not occur after underground mining ceased in January 2004 through June 2006 (Shannon Dunlap, personal communication, 2006), because no water accumulated in the pit bottom. The underground sump at the 4,450 to 4,500-foot elevation has a 500,000 gallon capacity. Total storage in the underground workings is estimated to be 20,000,000 gallons.

Since the 1997 Draft EIS was published through 2003, water levels in wells near the pit have shown a strong downward trend as a result of regional drought conditions and pit dewatering (HSI, 2003; SEIS Figure 3-6). Water levels in R-18 declined from late 1997 until the monitoring well was mined out in September 1999.

The average annual total pit pumping rates for 2000, 2001, and 2002 were 36.4, 28.2, and 47.8 gpm, respectively (Gallagher, 2003a). The average annual total pit pumping rate for 2003 was 36 gpm (GSM, 2004b). Prior to 2000, monthly average pit pumping rates varied from 12 to 76 gpm (Hydrometrics, 2000). The 1997 Draft EIS, Chapter IV, Section IV.B.1.b reported that the minimum groundwater elevation in the pit in 1993 was approximately 5,400 feet. In 2002, the minimum pit groundwater elevation was approximately 4,700 feet. GSM is permitted to mine the pit to the 4,650-foot elevation, and the pit reached that depth in October 2003.

The hydrograph study found that there was a general decline in bedrock water levels from 1998 through 2003, but that it was difficult to make definitive conclusions regarding the causes (HSI, 2003). A decline in precipitation from 1998 into 2003 was found to have affected groundwater levels in bedrock wells at GSM. However, the general water level declines track with the trend of R-18 reasonably well, indicating that pit dewatering may be responsible for some portion of water level declines in the fractured bedrock aquifer, particularly in PW-14, located about 3,000 feet northwest of the pit (Figure 3-5).

During mine operations and during the 16 to 18-month mill shut down while Stage 5B waste rock was removed, water collecting in the pit bottom is transferred to the underground workings through drill holes that intercept both the underground workings and pit. Water collected in the underground workings can be either sprayed over blasted rock to control dust or pumped to a lined holding pond and then to the water treatment facility. Pumping from the underground had not occurred from 2004 through June 2006 (Shannon Dunlap, GSM, personal communication, 2006). GSM pumped 47,157,900 gallons from

7/27/2006 through 1/16/2007 (Kathy Gallagher, GSM, personal communication, 2007).

The water from the highwall dewatering wells may be mixed with treatment plant discharge and directed to the LAD infiltration basin, a lined pond for treatment, or Tailings Impoundment No. 2.

In summary, mining has caused a decline in the groundwater level around the pit area. This condition would continue through Stage 5B. The regional drought has contributed to the decline in groundwater level (HSI, 2003 and 2006). The regional drought may have also contributed to reduced levels of pit inflow as well as reduced estimates of water needing treatment.

4.3.1.2.2 Pit Impacts to Surface Water

The 1997 Draft EIS, Chapter IV, Section IV.B.1.b reported that discharges at springs and seeps in the vicinity of the pit have the potential to be impacted if the expanding cone of depression from pit dewatering intercepts interconnected hydrogeologic units and groundwater, which otherwise would discharge to the surface as springs. Because of the small (0 gpm to 32 gpm) variable spring flow rates and the complex nature of the hydrostratigraphic units, incremental changes in spring discharge have not been quantified (Table 3-1). The 1997 Draft EIS, Chapter III, Section III.B described the setting and general conditions for each of the known springs around the pit area, including Bunkhouse, Rattlesnake, Stepan, Stepan Original, and St. Paul springs (Figure 3-5). The long-term potential impact to Stepan Spring, identified as most likely to be impacted by pit dewatering, was a reduction in flow. This reduction could bring the flow from the typical range of 0.8 to 2.8 gpm to a range from 0.1 to 1 gpm. Other springs could be expected to have a smaller reduction in flow. If the groundwater cone of depression has not reached equilibrium at the conclusion of mining, long-term impacts to springs from pit dewatering may be somewhat greater than the impacts of current operations, and monitoring and mitigation Measure W-1, approved in the 1998 ROD as Stipulation 010-4, would continue.

The trend of spring flows from 1998 to 2003 was reviewed and all but one spring was found to exhibit at least a slight decline in flow (HSI, 2003). The flow of Rattlesnake Spring increased slightly. Springs having a slight to moderate decline include Bunkhouse, Sheep Rock, Stepan Original, Stepan, and St. Paul. With springs at long distances from the pit, such as St. Paul and Sheep Rock springs, exhibiting as much or more relative decline in flow as those much closer to the pit, it was concluded that the drought had likely been the dominant factor leading to declining spring flows (HSI, 2003). From 1999 through 2003, annual precipitation recorded at the mine has averaged 2.59 inches below normal per year. Onsite precipitation monitoring for 1985 to 2005 averaged 13.89 inches. Precipitation was 10.9 inches in 1999, 11.3 inches in 2000, 9.58 inches in 2001,

11.61 inches in 2002, 13.09 inches in 2003, 13.89 inches in 2004, and 17.58 inches in 2005.

In summary, observations and measurements of springs performed for this analysis generally support the findings of the 1997 Draft EIS regarding impacts of pit dewatering, namely, that there may have been slight reductions in flow in some of the springs closest to the pit, and those with a potential hydrologic connection to the pit, including Rattlesnake Spring, Bunkhouse Springs, Stepan and Stepan Original Springs, Sunlight Spring and Arkose Valley Spring (the last two are covered by the West Waste Rock Dump Complex). However, no flow reductions have been found beyond those associated with drought. Additional spring flow reductions from pit dewatering are anticipated from the continuation of mining operations through Stage 5B.

Monitoring of springs for this analysis has not shown changes in water quality, but drought may have complicated interpretation of data (HSI, 2003).

4.3.2 No Pit Pond Alternative (No Action)

4.3.2.1 Impacts to Groundwater Quality and Quantity

4.3.2.1.1 Risk of Impacts to Groundwater Quality and Quantity in Permit Area

The most important issue related to pit reclamation at GSM is impact to groundwater. The 1997 Draft EIS, Chapter III, Section III.B.2 included a discussion of the regional and local groundwater resources. The 1997 Draft EIS, Chapter III, Section III.A also contained a description of the geochemistry of the ore and waste rock. In the 1997 Draft EIS, Appendix A, Table 1, groundwater quality in the backfilled pit was assumed to be an average of Ohio Adit, Stage 2 pit sump, Stage 3 pit sump, highwall seep, and water treatment plant feed water. In this SEIS, Section 3.3 presents updated geochemical information (Telesto, 2003c). In this SEIS, the projected pit water quality has been updated based on West Waste Rock Dump Complex pore water sampling and other geochemical samples taken from around the site that emanate from similar materials that may be undergoing similar processes as the pit backfill would. This water quality is worse than that used in the 1997 Draft EIS (see Table 4-5 in Section 4.3.3.1).

The 1997 Draft EIS, Chapter IV, Section IV.B relied on numerical groundwater model simulations of the local pit groundwater system conducted in 1995 as the primary basis for evaluating impacts to water quantity from pit dewatering (Hydrometrics, 1995). A detailed discussion of the groundwater model configuration and input parameters can be found in Volume 3, Appendix 4.7-1 of GSM's Permit Application (GSM, 1995b). Additional studies were performed for this SEIS, including a pit hydrogeology investigation (URS, 2001), a pit highwall seep study (Gallagher, 2003b), a new water balance model of the pit (Telesto, 2003a and 2006), an analysis of well and spring hydrographs (HSI, 2003), geotechnical assessment of backfill materials (Telesto, 2005), and an assessment of groundwater flow paths out of the pit (HSI, 2003 and 2006), and are discussed in Section 3.3.6.

Several factors of the pit reclamation plan that could affect groundwater resources include:

- Seepage from 13 percent of the East Waste Rock Dump Complex in Rattlesnake Gulch;
- Geochemistry of the backfill material and the effects on groundwater quality;
- Changes in water quality in the saturated zone in the backfill material;
- Amount of water entering the pit after closure; and,

- Ability to dewater the reclaimed pit.

4.3.2.1.1.1 Impacts from Waste Rock Dump Seepage

Under the No Pit Pond Alternative, up to 500,000 cubic yards (750,000 tons) would have been removed from the top of the East Waste Rock Dump Complex for the backfill sump (1997 Draft EIS, Chapter II, Section II.B.6.b; 1998 ROD). Based on the revised pit design in this SEIS under the No Pit Pond Alternative, 111,000 cubic yards (167,000 tons) of crusher reject would be placed in the pit, and no waste rock would be removed from the waste rock dump.

The 1997 Draft EIS, Appendix J evaluated waste rock dump water quality. A numerical model was developed and simulations performed to assess the ultimate extent and timing of impacts to water quality that could be caused by ARD from the waste rock dumps. The analysis for this SEIS performed a review of the methods and key parameters of the 1997 Draft EIS modeling, assembled updated information where available, applied methods of analysis consistent among the alternatives, and checked for differences in findings or conclusions that could affect the rating or selection among SEIS alternatives (HSI, 2003 and 2006).

4.3.2.1.1.1.1 Estimation of Long-Term ARD Production by Waste Rock Dump Complexes

The long-term quality of water discharge from the toe or base of a waste rock dump is controlled by the flow of water through the waste rock dump materials, the availability of oxygen, and the abundance of sulfide minerals and/or oxidation byproducts in the waste rock. These processes were described in detail in Appendix I of the 1997 Draft EIS. The focus of ARD impact analysis from waste rock dumps is two-fold:

- The hydrology of water infiltration through the waste rock, transport downward to the aquifer, and then down gradient through groundwater aquifers to the mixing zone boundary and receiving surface waters; and,
- The generation, transport and attenuation of the contaminants, principally acidity and metals, contained in the seepage.

The existing reclamation plan provides for covering all 2H:1V slopes on waste rock dump surfaces with 3 feet of cover soil having greater than 45 percent rock content and revegetation. This plan has not been approved for pit reclamation (DEQ and BLM, 2003). The reclamation cover is designed to limit water infiltration, thus minimizing the production and migration of ARD through the waste rock dumps.

As described in the 1997 Draft EIS, Chapter IV, Section IV.C, capping measures aimed at reducing water infiltration rates would reduce pollutant load in the short term. Based on the results from long-term ARD studies conducted at other sites, the rate of ARD generation may be reduced by reclamation, but cannot be eliminated (Bennett, 1997). For a range of potential infiltration rates the long-term ARD load would be expected to be similar. For this reason, ARD impact analysis focuses on the fate and attenuation of contaminants over a range of possible hydrologic conditions, assuming that ARD generation cannot be fully prevented.

4.3.2.1.1.1.2 Water Balance of the East Waste Rock Dump Complex

In the 1997 Draft EIS, Chapter IV, Section IV.B.1.a, three modeling approaches were used to provide an assessment of the water balance within reclaimed dumps at GSM:

- Hydraulic Evaluation Landfill Performance model (HELP) (Schroeder, et. al., 1994);
- A model by Schafer Limited (2001); and
- SOILCOVER model (Swanson, 1995).

These models use soil, climate, vegetation, and other information to establish a water budget. A variety of parameters considered in each model addresses the manner in which water on the waste rock dump surface can be removed by evapotranspiration and runoff. Water that is not removed by evapotranspiration and runoff is available to enter the waste rock dump interior by percolation.

All three model calculations in the 1997 Draft EIS were in general agreement and suggested that infiltration through the reclaimed dump surface would be on the order of 0.25 inch per year, which is about 1.7 percent of the 13.75 inches of annual precipitation incident to the dump surface area. The studies found that infiltration might be as high as 0.5 inch in wet years. Seepage from the East Waste Rock Dump Complex for 0.25 inch of infiltration was estimated to be about 10.5 gpm (Appendix J, 1997 Draft EIS).

Since the 1997 Draft EIS, updated estimates of infiltration on waste rock dumps at GSM became available with the completion of a technical report covering eight years (1992-2000) of hydrologic monitoring and reclamation of the West Waste Rock Dump Complex (Schafer Limited, 2001). Schafer Limited (2001) addressed ARD generation potential, oxygen and water movement, water balance, temperature, and water quality of the West Waste Rock Dump Complex. Although the West Waste Rock Dump Complex is not involved in any of the alternatives or actions in this SEIS, the technical analysis found it to be a surrogate for the East Waste Rock Dump Complex, thus providing a check on the modeling estimates done for the 1997 Draft EIS (Telesto, 2003c).

The average infiltration rate into revegetated portions of the West Waste Rock Dump Complex was 1.1 inches/year (Schafer Limited, 2001). This is greater than the HELP model study in the 1997 Draft EIS, which was 0.25 inch/year (best case) to 0.5 inch/year (expected case) on reclaimed surfaces, and less than 2 inches/year on unreclaimed surfaces (Schafer Limited, 2001). Not all of the infiltration measured in this study led to a continuing saturation of the waste rock dump materials, for the following reasons:

- Oxidation of pyrite consumes 3.5 moles of water for every mole of pyrite oxidized, chemically consuming water which therefore cannot flow out of the dump;
- Ferrihydrite, formed as a by-product of pyrite oxidation, has a greater capacity to retain water than the original pyrite;
- Heat produced by pyrite oxidation causes upward movement of air within the waste rock dump, particularly in winter. Cold dry air is pulled into the toe of the dump and is warmed as it flows through the interior, where it becomes water-saturated before exiting the top of the dump. Water vapor may also be expelled from the waste rock dump via latent heat transport (warm air is capable of greater moisture transport than cold air) and through water vapor transport. Evidence of heat and water vapor movement of these types has been seen at GSM; and,
- The percolation rate is lower than the saturated permeability, therefore not allowing saturated conditions to occur.

The average infiltration rate (1.1 inches/year) was a gross value, while the values used in modeling the East Waste Rock Dump Complex in the 1997 Draft EIS were net values (Schafer Limited, 2001). The difference was attributed to consumption of water by pyrite oxidation, water retention by ferrihydrite, and water loss from the waste rock dump via convective air flow. The processes described above should prevent flux of water through the pile for at least 20 to 50 years. The 1997 Draft EIS analysis in Appendix J provided modeling output graphs (Figures J-3 to J-24) which incorporated "best case", "expected case" and "worst case" ARD scenarios, with infiltration rates of 0.25, 0.50 and 2.0 inches/year, respectively. The 1997 Draft EIS modeling incorporated the range of infiltration measured and is considered a valid estimation of the expected long-term infiltration rate to groundwater through the East Waste Rock Dump Complex.

Beginning in November 2001, GSM sponsored another reclamation cover infiltration monitoring study within the East Waste Rock Dump Complex (Nichol and Wilson, 2003). Continuous monitoring of soil moisture at five different depths within the soil cover and upper portions of the waste rock (23 to 145 cm) indicated that the water movement was generally upward, and that net infiltration had not occurred during 2002. Additional monitoring was performed in 2005 (Shannon Dunlap, GSM, personal communication, 2006).

Evaluation of long-term infiltration estimates for soil covers at GSM found that approximately 0.25 to 0.5 inch/year of net infiltration occurred (Telesto, 2003e). For the purposes of assessing the middle to worst-case hydrologic impacts in this SEIS, a rate of 0.5 inch/year was determined to be the best estimate of net long-term infiltration for reclaimed waste rock dumps, with sensitivity evaluation up to 1.1 inches/year.

Impacts of ARD quality and quantity from the East Waste Rock Dump Complex were reevaluated in this SEIS and were similar to those identified in the 1997 Draft EIS. The following section addresses East Waste Rock Dump Complex ARD from the portion of the dump complex that is in the Rattlesnake Gulch drainage (Figure 3-7).

The methodologies used in the 1997 Draft EIS were reviewed and determined to be a reasonable and generally acceptable basis for the analyses and purposes of this SEIS, with some qualifications (HSI, 2003). These qualifications included:

- Although the methodology for the cell-by-cell ARD transport and attenuation modeling of the 1997 Draft EIS, Appendix J was described, a working version of the model was not available, so an alternate approach was used in this SEIS. Termed "pore volume attenuation," this approach is analogous to determining how much spilled milk (contaminants) a sponge (the aquifer) can absorb before dripping (releasing contaminants). In this methodology, the attenuation capacity (*i.e.*, the ability for a portion of the aquifer to retard or completely restrict the movement of chemical mass) of the aquifer flow path was quantified through geochemical estimations. Attenuation capacity is measured in terms of the mass of a chemical constituent per mass of the aquifer. Knowing the saturated water volume (*i.e.*, pore volume) per mass of aquifer and the concentration of constituents in the pore water, a calculation of how many pore volumes it takes to move an amount of constituents equal to the attenuation capacity was made;
- Only limited information on the calcite content of the Bozeman Group aquifer could be found, indicating calcite levels of less than 5 percent (the content used in the 1997 Draft EIS). The pore volume method eliminated the need for direct use of this parameter;
- The correlation of metals to predicted sulfate concentrations, as used in the 1997 Draft EIS analysis, was acknowledged to be simplistic, and not sensitive to differences among the alternatives. Again, the pore volume method eliminated the specific need for this correlation; and,
- This SEIS evaluation used updated values for some of the parameters in the fate and transport equations of Appendix J, and revised some of the 1997 Draft EIS predictions to be consistent with this information.

The 1997 Draft EIS, Appendix J, provided a discussion of the limitations and assumptions of the ARD fate and transport modeling. These also apply to this SEIS analysis, and can be summarized as follows:

- The model simplified complex hydrogeological and geochemical processes;
- There is some degree of error within the model predictions due to uncertainty in the model input parameters;
- The model is intended to characterize, compare, and contrast the types of possible impacts, not to accurately quantify those impacts; and,
- These impacts may or may not occur depending on future site-specific conditions such as long-term climatic conditions, infiltration rates, and oxidation rates, in addition to other physical conditions which are difficult to quantify such as moisture migration pathways, rate of groundwater movement and flow paths, and subsurface geochemical conditions.

A review was made of the key parameters that are required to be used in the hydrology fate and transport equations (HSI, 2003). Some of the parameters were estimated for the 1997 Draft EIS and were measured in studies specifically at GSM. For example, porosity was estimated to be 26 percent in 1997, but was measured at 4 to 10 percent in two recent studies at GSM. This SEIS evaluation focused on using a consistent approach in the sources and application of parameters among the alternatives. There was some emphasis on defining the "worst case" scenarios for the parameters to ensure that decision makers had information on the sensitivity of the estimates. Table 4-4 provides a comparison of the key modeling parameters from the 1997 Draft EIS, Appendix J, along with updated information and estimates used in this SEIS.

In the 1997 Draft EIS, Chapter IV, Section IV.B.1.a, the potential impacts from the East Waste Rock Dump Complex were evaluated for the Bozeman Group aquifer, upon which most of the waste rock dump rests. This was extended in this SEIS to include the portion of the East Waste Rock Dump Complex that overlies the Tdf/colluvial aquifer of Rattlesnake Gulch. Details of the updated ARD fate and transport model of the East Waste Rock Dump Complex conducted for this SEIS are presented in HSI (2003).

The total time for East Waste Rock Dump Complex seepage in Rattlesnake Gulch to travel through the Tdf/colluvial aquifer was not estimated in the 1997 Draft EIS. In this SEIS, the total time for East Waste Rock Dump Complex seepage from the portion in Rattlesnake Gulch to travel through the Tdf/colluvial aquifer was estimated at 80 to 190 years (HSI, 2003).

Table 4 - 4. Comparison of Key Parameters in ARD Modeling For the East Waste Rock Dump Complex over the Rattlesnake Gulch Drainage, EIS to SEIS[1]

East Waste Rock Dump Complex Parameter	1997 Draft EIS Appendix J	End of Stage 5B	Comments
Waste rock thickness	Up to 300 feet	Up to 300 feet	Approx. 222 acres of East Waste Rock Dump Complex would have up to 100 feet of waste rock removed in the backfill alternatives (about 33% of the volume)
Infiltration	0.25 - 2 inches/year	0.5 - 1.1 inches/year	Revised based on study of the West Waste Rock Dump Complex (Schafer Limited, 2001)
Recharge in undisturbed areas	1.5 inches/year	0.25 - 0.5 inch/year	Golder (1995a) water balance of Sunlight Block
Width of flow path	4,000 feet	3,300 feet	As mapped 2003
Thickness of flow path	Graded from 100 - 300 feet	150 feet	Based on observed depth of constituents below Tailings Impoundment No. 1
Length of flow path in Bozeman Group aquifer	13,200 feet	12,500 feet	Measured from toe of dump
Groundwater base flow rate in the Rattlesnake Gulch drainage	200 gpm	52 - 103 gpm	Flow rate reduced based on HSI 2003
Effective porosity	26%	4% - 10%	Herasymuik, 1996 and Schafer Limited, 2001
Specific retention	8%	5.5%	Schafer and Associates (1995) for the East Waste Rock Dump Complex
Permeability, Bozeman Group aquifer	$1.2x10^{-5}$ cm/sec (vertical); $2.5x10^{-4}$ cm/sec (horizontal)- est.	$2.5x10^{-5}$ cm/sec	Upper estimate of bulk permeability
Amount of calcite	5 percent	Not used directly	Used pore volume attenuation method
Sulfate concentration	30,000 mg/l	Not used directly	Used pore volume attenuation method
Mass of sulfide in dump	0.5 - 2 percent sulfide	Not used directly	Used pore volume attenuation method
Concentration of metals	Correlated from Schafer and Associates (1994)	Not used directly	Used pore volume attenuation method
Impacted aquifers	Bozeman Group aquifer	87 percent Bozeman Group aquifer, seepage of 8-18 gpm; 13 percent Tdf/ colluvial aquifer, seepage of 1-3 gpm	Based on updated aquifer mapping (HSI, 2003)
Thickness of unsaturated zone in Bozeman Group aquifer	200 feet	80 feet	

[1] *From HSI, 2003 as updated by the agencies.*

The 1997 Draft EIS, Chapter IV, Section IV.B.1.e predicted that the base flow captured below Tailings Impoundment No. 1 in Rattlesnake Gulch would be 200 gpm. The agencies assumed the 10.5 gpm of East Waste Rock Dump Complex drainage would report to the Bozeman Group aquifer and be attenuated. Based on this SEIS analysis, there is reduced flow in the Rattlesnake Gulch drainage of 52 to 103 gpm (HSI, 2003). One to three gpm of the East Waste Rock Dump Complex drainage would report to the Tdf/colluvial aquifer. Therefore, the 8 to 18 gpm drainage from the rest of the East Waste Rock Dump Complex that overlies the Bozeman Group aquifer is within the range of the 1997 Draft EIS analysis and mitigation Measure W-4, Stipulation 010-7 in the 1998 ROD. It is also within the contingency volume of water to be treated from the East Waste Rock Dump Complex under the No Pit Pond Alternative.

A Dynamic Systems Model (DSM) was utilized (Telesto, in HSI, 2003) to predict the water quality impact of seepage from the portion of the East Waste Rock Dump Complex expected to reach the Tdf/colluvial aquifer. Based on the expected average net infiltration rate of 0.5 to 1.1 inches/year on the East Waste Rock Dump Complex, the long-term seepage rate to existing aquifers after reclamation from the East Waste Rock Dump Complex was estimated at 7 to 17 gpm. The portion of this seepage expected to reach the Tdf/colluvial aquifer would be about 1 to 3 gpm. The GSM Attenuation Study (Telesto, in HSI, 2003) indicated that a solution of mixed Tdf/colluvial aquifer groundwater and East Waste Rock Dump Complex seepage would have 13 to 15 pore volumes of attenuation capacity in the Tdf/colluvial aquifer, at the net infiltration rate of 0.5 inch/year. Given the anticipated range of flows in the Tdf/colluvial aquifer (52 to 103 gpm), attenuation of exchangeable metals could be expected for 35 to 63 years. Some contaminants such as sulfate, arsenic, and zinc have little affinity for attenuation and would not be removed in transport. Because the water flow rate from net infiltration through the East Waste Rock Dump Complex is small compared to the entire flow through the aquifer, the time required to fill the attenuation capacity of the aquifer is directly proportional to the mass load into the aquifer. A net infiltration rate through the pile of 1.1 inches/year would increase the mass loading by roughly 2.2 times. Thus, the attenuation capacity would be exhausted approximately 2.2 times faster, and the resulting range would be from 16 to 29 years.

The results of the updated long-term fate and transport evaluation of the East Waste Rock Dump Complex led to the following conclusions about impacts to groundwater quality and quantity in the permit area:

- The 1997 Draft EIS said 10.5 gpm would seep from the East Waste Rock Dump Complex. Long-term hydrologic monitoring and reclamation studies at GSM indicate that the best estimate of average long-term net infiltration rate to reclaimed rock dumps is 0.5 inch/year,

with the gross infiltration rate of 1.1 inches/year, yielding seepage rates from the East Waste Rock Dump Complex of 11 to 25 gpm (Schafer Limited, 2001; Telesto 2003e). Eight to eighteen gpm would travel down the main waste rock flow path; and,

- Based on updated hydrogeologic data, the thickness of the unsaturated zone of the Bozeman Group rocks beneath the East Waste Rock Dump Complex is typically 80 feet, compared to the 200 feet used in the 1997 Draft EIS. This shortens the time for breakthrough of ARD to the Bozeman Group aquifer.

It is possible to estimate the rate at which pyrite and other sulfide minerals are oxidizing by monitoring the internal temperature of the dump (Harries and Ritchie, 1987). Monitoring conducted on the West Waste Rock Dump Complex showed that the unreclaimed portion of the complex had a higher average temperature than the reclaimed portion (Schafer and Associates, 1994). The data indicated that the cover provided no definitive control on oxidation rates (Bennett, 1997).

Water is consumed geochemically during the oxidation of sulfide minerals in the waste rock dump complexes. Additionally, the oxidation of sulfide minerals raises the internal temperature of the dumps and appears to produce a chimney-like effect where cool air is drawn in the sides of the waste rock dumps and hotter, moister air exits through the top. This effect ensures a continued supply of oxygen for sulfide oxidation, but also can act to remove water from the dump interior in the form of water vapor. As much as 5 inches of water per year were reported to be removed by this convective mechanism (1997 Draft EIS, Chapter IV, Section IV.B.1.a). To be more protective of groundwater quality, modeling for the 1997 Draft EIS and this SEIS assumed that no water was removed by this convective mechanism. The agencies expect that the convective mechanism would eventually stop and water would exit the dump as seepage.

4.3.2.1.1.1.3 Long-Term Monitoring and Mitigation for Unanticipated East Waste Rock Dump Complex Seepage

As pointed out in the 1997 Draft EIS, Chapter IV, Section IV.B.1.a, it is possible that ARD-contaminated groundwater could travel through high conductivity preferential flow paths down gradient from the East Waste Rock Dump Complex. In addition, the water infiltration rate through the waste rock dumps could be higher than estimated, resulting in a greater flow rate of ARD than anticipated. As a contingency, potential monitoring and mitigation measures to control and contain unanticipated ARD in groundwater under the No Pit Pond Alternative are required by Stipulation 010-7 that was approved in the 1998 ROD. Table 4-2 shows the water treatment plant was designed to treat up to 25 gpm of East Waste Rock Dump Complex seepage. Appendix B, Section 6.0 of the 1997 Draft EIS, contains a GSM commitment to further hydrogeologic investigation of the waste rock dump complexes to identify optimum monitoring sites and to aid in the

design of groundwater capture systems if needed as contingencies for waste rock dump seepage. In addition, GSM has committed to construct additional monitoring wells along the waste rock dump perimeters as part of the long-term monitoring plan. A final mixing zone compliance monitoring plan will include additional wells along the approved mixing zone boundaries as identified in consultation with DEQ. As a result of this SEIS re-evaluation, no additional mitigation measures are needed.

4.3.2.1.1.1.4 Summary of East Waste Rock Dump Complex Seepage Impacts to Water Quality and Water Quantity

No impacts to groundwater quality from the portion of the East Waste Rock Dump Complex in Rattlesnake Gulch are anticipated during active mining operations through Stage 5B. The 1997 Draft EIS predicted that groundwater under the East Waste Rock Dump Complex would first experience ARD impacts in 54 to 433 years. An updated evaluation in this SEIS of the 1997 Draft EIS modeling was conducted using combinations of middle to worst-case parameters. The updated modeling predicts that groundwater under the East Waste Rock Dump Complex would first experience ARD impacts in 33 to 72 years (HSI, 2003).

4.3.2.1.1.2 Impacts from Pit Seepage

4.3.2.1.1.2.1 Impacts to Water Quality

Water quality in the pit under the No Pit Pond Alternative would be characteristic of ARD, similar to that produced by mining operations. Only 111,000 cubic yards (167,000 tons) of crusher reject would be used to create the sump in the bottom of the pit. This sump would prevent a pond from forming in the bottom of the pit (Figure 2-3 showing pit after backfilling).

Acidic backfill in the sump could affect pit water quality. The 1998 ROD did not specify a source of backfill material. There are two potential on-site sources of suitable backfill material (GSM, 2002a). One possible source of material is stockpiled mixed waste rock that was originally intended for reclamation of the waste rock dump complexes. Mixed waste rock consists of both sulfide and oxide waste rock. Another potential source is crusher reject material, which is proposed for use by GSM. Due to the screening process, this material is fairly uniform in size, with an average size of 2 inches or smaller, which would provide a relatively high porosity. Testing of these backfill sources was performed by GSM for this SEIS under a sampling and analysis plan approved by the agencies (Telesto, 2003g, 2003h; GSM, 2003a). The acid-base accounting tests found that the mixed waste and crusher reject both had negative net neutralization potential (NNP). The mixed oxide material had a NNP of -12, and the crusher reject had a NNP of -113. A negative NNP indicates the amount of lime needed to neutralize acidity in the waste rock. These materials had no neutralization

potential and pH values from leaching tests ranged from 4.4 to 7.4. In a pit backfill setting, both materials would generate ARD. The pit produces water in pH ranges similar to those from the leaching tests. The agencies assume that crusher reject would not change the quality of water needing treatment.

The agencies considered the use of other rock materials for the sump and concluded that they would decompose or become cemented in the saturated zone relatively quickly and would be no better than the waste rock or crusher reject for use as sump material over time.

In the 1997 Draft EIS, Appendix A, Table 1, groundwater quality in the backfilled pit was assumed to be an average of Ohio Adit, Stage 2 pit sump, Stage 3 pit sump, highwall seepage, and water treatment plant feed water. Pit sump monitoring by GSM in 2002 and 2003 has provided water quality data for the pit waste rock (GSM, 2002a; Telesto, 2003a). In 2002-2003, field pH ranged from 3.6 to 5.7, TDS ranged from 13,000 to 28,000 mg/l, sulfate from 9,370 to 20,400 mg/l, and dissolved copper from 0.7 to 12.2 mg/l (GSM, 2003e, 2004b). Other dissolved metals were also elevated. GSM's experience with pit water has shown that regular pumping from the pit sump or well reduces water quality degradation, primarily by limiting contact time with waste rock. Some of the water quality data in this period may not be representative because GSM conducted field experiments involving additions of organic carbon to the pit sump (Shannon Dunlap, GSM, personal communication, 2003).

Under the No Pit Pond Alternative, regular pumping would remove pit water from the crusher reject sump and send it to the water treatment plant. Regular pumping would maintain the pit as a sink, with a cone of depression in the potentiometric surface centered on the pit, similar to that which presently exists (Figure 3-5 in GSM, 2002a). No impacts to groundwater or surface water outside the pit would be anticipated because groundwater would not flow out of the pit. This agrees with conclusions in the 1997 Draft EIS.

If ARD inflows to the pit exceed the expected rates or the quality changes, Measure W-6 approved in the 1998 ROD as Stipulation 010-9 would apply. This measure provides for a re-evaluation of the water treatment plant capacity 2 years prior to mine closure, with modifications to the existing plant, or new treatment processes added for specific facilities, as may be required. Increased flows to the pit are not expected, based on observations during underground mining at GSM.

4.3.2.1.1.2.2 Impacts to Water Quantity

The No Pit Pond Alternative, in the 1997 Draft EIS, Chapter IV, Section IV.B.6, considered impacts associated with pumping water from the pit sump and focused on the quantity of water to treat and discharge. A pit water balance model was developed with the information available at that time (Hydrometrics 1995), which accounted for total inflows and outflows (see 1997 Draft EIS, Table IV-5). That model found that complete dewatering of the pit to the projected 4,700-foot-elevation pit floor at that time would require removal of approximately 102 gpm. Consequently, the 1997 Draft EIS concluded that water treatment requirements would have been greater under the No Pit Pond Alternative as compared to the Partial Backfill Alternative at that time, which would have required treatment of 50 gpm (1997 Draft EIS, Chapter IV, Section IV.B.7.b).

Based on GSM's experience in dewatering the pit and a new pit water balance model, lower pit water inflows are projected for the No Pit Pond Alternative (Telesto, 2006). The new model was calibrated to pumping records and predicts that pit dewatering would require perpetual removal of about 25 to 27 gpm. The hydrogeologic and water balance studies performed for this SEIS have shown that most of the water enters the pit through seepage from the Corridor Fault and through other faults in the upper half of the pit (Gallagher, 2003b; Telesto, 2003a). Faults penetrating the lower portions of the pit do not yield as much water. The underground mine, which is approximately 250 feet (4,400-foot elevation) beneath the pit bottom has less than 5 gpm of inflow, based on visual observation during mining activities. Water was imported to maintain underground mining operations (HSI, 2003). Therefore, standard hydrogeologic modeling, which predicts that pit inflows would continue to increase as the pit deepens, does not apply. The new studies also found that most pit inflows were related to direct precipitation on the pit and that more water is lost through evaporation than was previously suspected. The amount of water lost as a result of being heated and expelled as steam or warm vapor from the reaction of sulfides with water and oxygen (sulfide oxidation) was not quantified.

As stated in Section 4.3.2.2.2.2, the agencies have concluded that maintaining the pit as a hydrologic sink under the No Pit Pond Alternative would provide almost complete control of the ARD produced by the pit at its source and eliminate the risk of water quality impacts outside the pit.

4.3.2.1.1.2.3 Summary of Pit Impacts to Water Quality and Water Quantity

The analysis of this SEIS generally supports the findings of the 1997 Draft EIS for the No Pit Pond Alternative, except that the long-term pumping rate would be from 25 to 27 gpm, instead of 102 gpm. The impacts to water quantity from the open pit after closure would likely be limited to possible reductions in flows of springs close to and hydrologically connected to the pit, *i.e.*, Stepan, Stepan

Original, Rattlesnake, and Bunkhouse springs, as a result of pit dewatering. Even if drought conditions have reduced pumping rate predictions, the water treatment plant would be built to treat the 102 gpm analyzed in 1997.

Because the pit would be maintained as a local groundwater sink and all pit water would be collected and routed to the water treatment plant before being discharged, no impacts to groundwater quality from pit outflows are anticipated long term.

Potential additional water quantity impacts from the No Pit Pond Alternative would likely be limited to possible reductions in the bedrock aquifer groundwater level. The groundwater level around the pit would be permanently drawn down. This is an unavoidable impact of controlling all groundwater flow out of the pit by maintaining the pit as a hydrologic sink. This could result in reductions of flows from springs around the pit as described in Section 4.3.2.2.1.2.

4.3.2.1.2 Risk of Violation of Groundwater Standards at Permit Boundary and Impacts to Beneficial Uses of the Jefferson River Alluvial Aquifer

4.3.2.1.2.1 Impacts from Waste Rock Dump Seepage

The Tdf/colluvial aquifer groundwater and the East Waste Rock Dump Complex seepage would migrate down gradient and mix with 99 gpm in the Jefferson River alluvial aquifer, the portion of flow within the GSM mixing zone. Following exhaustion of the attenuation capacity, the Dynamic Systems Model indicated that this mixed groundwater would not exceed groundwater quality standards for any of the metals and trace elements modeled (arsenic, cadmium, copper, nickel, selenium, and zinc) (HSI, 2003 and 2006). The predicted nickel concentration, ranging from 52 to 78 percent of the standard (0.1 mg/l), came closest to violating water quality standards (HSI, 2006). The evaluation indicated that the results were sensitive to the initial concentrations in the Tdf/colluvial aquifer and to the mixing rate. In comparison, the 1997 EIS, Chapter IV, Section IV.B.1.a found that long-term impacts to groundwater in the vicinity of the waste rock dumps would likely occur. The ARD fate and transport analysis provided in the 1997 Draft EIS, Appendix J indicated that full chemical neutralization of ARD would occur within 2,200 to 4,400 feet downgradient of the toe of the dump, within GSM's mixing zone. Thus, no impacts were predicted to groundwater outside the GSM permit boundary, or to the Jefferson River alluvial aquifer.

For this SEIS analysis, Telesto (2003c) evaluated data from West Waste Rock Dump Complex lysimeters, the 2002 to 2003 pit sump, highwall test pads, and springs and seeps. Because the pit would be backfilled with crusher reject, chemistry of porewater from the West Waste Rock Dump Complex was deemed to be most representative. Concentrations of constituents in the pit sump water

are comparable, if not slightly more concentrated, than the West Waste Rock Dump Complex pore waters.

The 1997 Draft EIS, Appendix J stated that uncertainties regarding the model inputs and the simulation itself allow for only a low to moderate level of confidence in the model predictions of specific ARD concentrations and travel times to various locations down gradient of the waste rock dumps. This limitation also holds for the updated evaluation presented in this SEIS. The assumptions are provided in Table 4-4.

The results of the updated long-term fate and transport evaluation of the East Waste Rock Dump Complex led to the following conclusions:

- Combining updated middle to worst case hydrogeologic parameters in the fate and transport equations, and in the absence of any attenuation, the total time of travel from the top of the East Waste Rock Dump Complex to the Jefferson River alluvial aquifer via the Bozeman Group aquifer was shortened from a range of 960 to 1,300 years in the 1997 Draft EIS to 245 to 575 years. The differences reflect updated information available since the 1997 DEIS: a) a lower effective porosity of the East Waste Rock Dump Complex; b) the thinner layer of unsaturated Bozeman Group aquifer beneath the dump; c) a smaller depth of mixing; and d) a slightly shorter length and width of the flow path within the Bozeman Group aquifer (Table 4-4);
- This SEIS analysis indicates that 1 to 3 gpm of the East Waste Rock Dump Complex discharge would enter the Tdf/colluvial aquifer in Rattlesnake Gulch. Using updated information and combining the worst case hydrogeologic parameters in the fate and transport equations, and, in the absence of any attenuation, the timeframe to breakthrough from the top of the East Waste Rock Dump Complex to the Jefferson River alluvial aquifer via the Tdf/colluvial aquifer in Rattlesnake Gulch is estimated to be 80 and 250 years for non-attenuated and attenuated contaminants respectively (HSI, 2003);

- The attenuation analysis in the 1997 Draft EIS, Figure 5-1 in Appendix B, which predicted that no ARD contaminants would move beyond 2,200 to 4,400 feet down gradient of the East Waste Rock Dump Complex, was checked with a straight pore-volume attenuation analysis based on the ARD Attenuation Study (Schafer and Associates, 1994). This approach indicates that 1.4 pore volumes of attenuation could be expected along the East Waste Rock Dump Complex flow path and that ARD breakthrough beyond the permit boundary could occur in the range of 280 to 700 years. Groundwater capture would be required to prevent migration beyond the permit boundary;
- Mitigation measures, including additional groundwater monitoring, capture and treatment at the East Waste Rock Dump Complex, were approved in the 1998 ROD and incorporated into the permitted mixing zone for the East Waste Rock Dump Complex. Mitigation Measure W-4, Stipulation 010-7 in the 1998 ROD, responded to the issue of potential ARD releases that are premature or have greater than expected flows. This measure requires monitoring of groundwater at the mixing zone boundary and establishment of additional capture wells as a contingency under the GSM operating permit; and,
- The volume of seepage from the East Waste Rock Dump Complex predicted in this SEIS is within the contingency volume identified in the 1997 Draft EIS for the water treatment plant.

4.3.2.1.2.2 Impacts from Pit Seepage

Table 4-5 compares the projected pit water quality for this SEIS and the 1997 Draft EIS to Montana Groundwater Quality Standards. Table 1 of Appendix A of the 1997 Draft EIS presented estimated groundwater quality in the backfilled pit. Water quality was based on an average of values from the Ohio Adit, Stage 2 pit sump, Stage 3 pit sump, highwall seepage, and water treatment plant feed water.

The No Pit Pond Alternative would provide almost complete control of pit discharges by maintaining the pit water level as close as possible to the 4,525-foot elevation. There would be no risk of violation of groundwater standards and beneficial uses in the Jefferson River alluvial aquifer.

4.3.2.2 Impacts to Surface Water Quality and Quantity

4.3.2.2.1 Impacts to Springs, Wetlands

4.3.2.2.1.1 Impact from Waste Rock Dump Seepage

As discussed in Section 4.3.1.1, no impacts to surface water quality and quantity from the portion of the East Waste Rock Dump Complex in Rattlesnake Gulch are anticipated during active mining operations through Stage 5B. Rattlesnake

Spring is already affected by naturally acidic groundwater. This SEIS analysis found that the East Waste Rock Dump Complex could contribute 1 to 3 gpm of ARD to Rattlesnake Gulch, which could affect water quality and quantity in the spring, possibly impacting its use for wildlife in the future. Mitigation of impacts to wildlife use of springs is required by Measure W-1, which was approved in the 1998 ROD as Stipulation 010-4.

4.3.2.2.1.2 Impacts from Pit Seepage

Impacts to springs outside the pit could be expected due to dewatering. This is similar to the conclusion reached in the 1997 Draft EIS, Chapter IV, Section IV.B.6.b. Stepan Spring has the greatest potential for reduced flows resulting from active pit dewatering. The Stepan Original Spring has less potential for reduced flows than Stepan Spring, but is more likely to have reduced flow than Rattlesnake Spring and Bunkhouse Springs. Rattlesnake Spring and Bunkhouse Springs have a potential for reduced flow, but any reduction in flow is expected to be minimal since no impact from pit dewatering has been documented, and these springs occur in the T/Q alluvial aquifer.

As stated in the 1997 Draft EIS, Chapter IV, Section IV.B.6, accurate quantification of incremental changes in spring discharge is not possible. It is anticipated that change in groundwater levels and impacts to spring flow would be somewhat greater under the No Pit Pond Alternative in this SEIS than the No Pit Pond Alternative in the 1997 Draft EIS due to the groundwater level being reduced from 4,700 to 4,525-foot elevation. Long-term potential to reduce spring flows would be as predicted in the 1997 Draft EIS. Mitigation of long-term impacts to downgradient springs requires a monitoring and spring enhancement plan. GSM maintains a spring monitoring program, including flow rates and water quality (GSM, 2002a), as required by Measure W-1 approved as Stipulation 010-4 in the 1998 ROD. This mitigation measure is adequate for the No Pit Pond Alternative.

The hydrograph analysis indicated that the groundwater cone of depression around the pit may not have reached equilibrium with the pit dewatering (HSI, 2003). The cone of depression can be expected to increase until equilibrium is achieved. This could take tens of years (HSI, 2003). Associated long-term impacts to springs could be somewhat greater than the operational impacts, as described in Section 4.3.1.2.1.

Table 4 - 5. Projected Pit Backfill Water Quality
Bolded numbers exceed the DEQ-7 standards (all in mg/L except pH, s.u.)

Constituent	SEIS Project Pit Backfill Chemistry Porewater Quality[1, 4]	1997 Draft EIS Pit Water Quality[2]	Montana Groundwater Quality Standards[3]
pH	2.23[5]	2.7	--
TDS	--	15,698	--
Calcium (Ca)	412	408	--
Magnesium (Mg)	530	1,199	--
Sodium (Na)	82	59	--
Potassium (K)	6	15	--
Sulfate (SO_4)	22,400	10,240	--
Nitrate+Nitrite as N (NO_3 + NO_2-N)	--	10.9	--
Aluminum (Al)	1,410	292	--
Arsenic (As)	**0.056**	**0.411**	.01
Cadmium (Cd)	**0.138**	**0.641**	.005
Chromium (Cr)	0.988	0.009	.1
Copper (Cu)	**55.88**	**75.9**	1.3
Iron (Fe)	**508**	**1,170**	.3
Lead (Pb)	0.01	**0.274**	.015
Manganese (Mn)	**37.78**	**126**	.05
Mercury (Hg)	0.001	0.000	.002
Nickel (Ni)	**13.03**	**5.84**	.1
Selenium (Se)	**0.0563**	0.015	.05
Silver (Ag)	--	0.000	.1
Zinc (Zn)	**21.33**	**90.4**	2

[1] *Concentrations are representative of the 75th percentile of the West Waste Rock Dump Complex pore water from Shafer Limited, 2001.*
[2] *1997 Draft EIS, Appendix A, Table 1.*
[3] *DEQ-7, February 2006 (note that iron and manganese have only secondary standards).*
[4] *SEIS data from Telesto, 2003c.*
[5] *Concentrations are representative of the 25th percentile of the West Waste Rock Dump Complex pore water from Shafer Limited, 2001.*

4.3.2.2.2 Risk of Violation of Surface Water Standards and Impacts to Beneficial Uses of the Jefferson River and Slough

The Montana Water Quality Act defines impacts to beneficial uses as impacts to public water supplies, wildlife, fish and aquatic life, agriculture, industry, livestock, and recreation. Known beneficial uses in the vicinity of GSM are shown on Map IV-2 of the 1997 Draft EIS, Chapter IV, Section IV.B. A review of beneficial uses relative to this SEIS evaluation follows.

4.3.2.2.2.1 Impacts from Waste Rock Dump Seepage

There are no close public water sources down gradient of the East Waste Rock Dump Complex. Domestic wells are located approximately 4,000 feet down gradient from Tailings Impoundment No. 2. The nearest downgradient surface water fishery is the Jefferson Slough. An area of GSM's property along the Jefferson River Slough is leased for cattle grazing. Acreage adjacent to the Jefferson Slough is being cultivated. There are no known industrial uses outside of the existing mine operations, or recreational beneficial use of the water resource that would be impacted by ARD from the waste rock dump complexes.

Because of limited surface water availability, springs at the mine site provide local wildlife habitat. The 1997 Draft EIS, Chapter III, Section III.B.2.d reported that Rattlesnake Spring, located approximately 3,100 feet down gradient of the East Waste Rock Dump Complex, was believed to receive flow from the Bozeman Group aquifer, potentially in part from the abandoned Rattlesnake Adit (Lazuk, 1996). At the surface, Rattlesnake Spring emerges from Tdf/colluvial aquifer (GSM, 1993; Golder,1995a). Bunkhouse Springs is approximately 3,400 feet down gradient of the East Waste Rock Dump Complex and occurs within the Tdf/colluvial aquifer.

The 1997 Draft EIS, Chapter IV, Section IV.E.1.a stated that, because these springs are used by wildlife for watering, impacts to wildlife associated with reduced water quality could occur, and that impacts are less likely to occur in Rattlesnake Spring, because of the ARD attenuation effects that are anticipated in the Bozeman Group aquifer. As discussed in Section 3.3.4 of this SEIS, the gravel deposits from which both of these springs discharge are extensively altered by ferricrete deposits indicative of prehistoric metal-rich groundwater transport and deposition of oxidation byproducts from sulfide mineralized zones in Bull Mountain. Rattlesnake Spring and Bunkhouse Springs have been acidic, with pH typically 4 to 5, and elevated metals concentrations for the monitoring record, going back to 1993 for Rattlesnake Spring. As indicated in Section 3.3.4, these springs have been affected by groundwater from naturally mineralized deposits.

This SEIS analysis found that the primary groundwater flow path from the East Waste Rock Dump Complex is through the Bozeman Group aquifer east of these springs (HSI, 2003). One to three gpm of seepage from the East Waste Rock Dump Complex could find its way into the Rattlesnake Gulch drainage and potentially impact Rattlesnake Spring. This could lead to further decline in pH and increases in metal concentrations. Impacts to Bunkhouse Springs would not be expected due to its location west of Rattlesnake Gulch.

In summary, the only beneficial use expected to be impacted by ARD migration down gradient of the portion of the East Waste Rock Dump Complex overlying the Tdf/colluvial aquifer in Rattlesnake Gulch, within the limits of the permitted mixing zone, is Rattlesnake Spring, which is used by wildlife. The spring has been acidic since monitoring began due to prehistoric deposition of oxidation byproducts within the aquifer, and any additional impacts to the Rattlesnake Spring may not be attenuated. Adverse impacts to other beneficial uses are not anticipated for the No Pit Pond Alternative. Mitigation of impacts to beneficial uses, namely, springs used by wildlife, within the mixing zone boundaries was required by Measure W-1, which was approved as Stipulation 010-4 in the 1998 ROD, that requires monitoring for changes in spring water quantity and quality.

The 1997 Draft EIS, Chapter IV, Section IV.B.1.a concluded that there would be no risk of violation of water quality standards and impacts to beneficial uses of the Jefferson River and Slough from ARD from the East Waste Rock Dump Complex under the No Pit Pond Alternative. This SEIS analysis supports that conclusion.

4.3.2.2.2.2 Impacts from Pit Seepage

Under the No Pit Pond Alternative through Stage 5B, water inflows to the pit are expected to be similar to present conditions averaging 25 to 27 gpm (Telesto, 2006). Groundwater inflows to the pit are not expected to increase even though the pit would be deepened from the 4,650-foot to the 4,525-foot elevation during Stage 5B. Monitoring has shown that pit inflows have not been increasing as the pit was deepened. The volume of water intercepted by the underground mine, which was 250 feet beneath the bottom of the pit, was typically less than 5 gpm, based on visual observation.

The agencies have concluded that the No Pit Pond Alternative would provide almost complete control of pit discharges by maintaining the pit water level as close as possible to the 4,525-foot elevation. Therefore, there would be no risk of violation of groundwater standards and beneficial uses in the Jefferson River and Slough.

4.3.2.3 Reclamation Plan Changes

The 1997 Draft EIS, Chapter IV, Section IV.C addressed the soil impacts that are common to all alternatives for the approved reclamation plan for the areas in the pit to be revegetated. The approved plan includes covering major benches that have sufficient width to allow machinery access with 2 feet of pH neutral, oxide, non-acid producing waste rock plus 2 feet of stockpiled soil for a total of 4 feet of growth medium (1997 Draft EIS, Chapter II, Section II.B).

GSM reclaimed the south portion of the West Waste Rock Dump Complex in 1998-2000 following the approved reclamation plan. The stockpiled oxide waste rock turned out to be slightly acid producing and had to be amended with lime. After the reclamation was completed, the agencies and GSM concluded that it would be better to come up with alternate materials if possible rather than amend the acidic waste rock with lime.

In the fall of 1999, GSM started reclaiming the West Waste Rock Dump Complex. Evaluations of the stockpiled oxide waste rock that was to be used identified that these materials were slightly acid producing.

As a result, GSM investigated alternative materials and proposed a modification of the approved waste rock dump reclamation coversoil system on August 22, 2000 (GSM, 2000). The proposed change was to place 3 feet of non-acid producing stockpiled soil over the acid producing sulfide waste rock rather than the previously approved coversoil system. The agencies evaluated the proposal and approved the change based on characteristics of the west side soils (DEQ and BLM, 2001).

The agencies did not approve the change for the East Waste Rock Dump Complex without further characterization of the east side soil stockpiles (DEQ and BLM, 2001a). GSM did further studies in 2001 and applied to modify the approved reclamation coversoil system for the East Waste Rock Dump Complex and the pit acres to be revegetated (GSM, 2001). GSM reapplied to place 3 feet of non-acid producing stockpiled soil over the acid producing sulfide waste rock rather than the approved 48-inch coversoil system. The agencies evaluated the proposal and approved the change (DEQ and BLM, 2002, 2003). For 2H:1V slopes, the agencies required that the east side soils be amended with rock to raise the coarse fragment content to greater than 45 percent.

The agencies did not approve the change for the pit areas to be revegetated, because of a shortfall of soils stockpiled on the east side and the amount of 2H:1V slopes that would be revegetated in a partial pit backfill alternative (DEQ and BLM, 2003). The changes in the coversoil system for the pit acres to be revegetated are evaluated in this SEIS.

The potential reclamation plan changes that would occur from the 1997 Draft EIS are as follows:

- Volumes of soil needed for reclamation capping;
- Composition and thickness of layers of soil cover;
- Amount of surface disturbance;
- Hazards to wildlife; and,
- Amount of unrevegetated acres.

Table 4-6 summarizes the volume of soil needed for pit reclamation in the alternatives. As of December 31, 2006, there were 2,236 total acres of disturbance within the GSM permit boundary (Table 2-1). Of that total, 1,072 acres have been reclaimed through 2006 (GSM 2006 Annual Report). The reclamation of all other associated disturbance (tailings ponds, facilities, roads, etc.) is not shown in Table 4-6. The associated disturbance around the pit was addressed under the 1997 Draft EIS and is common to all pit reclamation alternatives under consideration.

Table 4 - 6. Soils Comparison by Alternative for Pit Reclamation

Reclamation Plan	Additional New Pit Disturbance/ Pit Soil Cover Area (Acres)	Cover Soil Source	Cover Soil Required for Pit Closure Area (Cubic Yards)	Pit Acres Left Unrevegetated
No Pit Pond Alternative	0 / 53	Stockpiles	290,400	158
Partial Pit Backfill With In-Pit Collection Alternative	56/ 292[1]	Stockpiles plus soil borrow area	1,541,800	0
Partial Pit Backfill With Downgradient Collection Alternative	58 / 292[1]	Stockpiles plus soil borrow area	1,541,800	0
Underground Sump Alternative	0 / 52	Stockpiles	285,600	159

[1] Actual pit disturbance after reclamation would be 274 acres (218 plus 56 cast blasted). The 292 acres listed in the table under the partial pit backfill alternatives represent the total acres that need to be soiled and revegetated on 2H:1V slopes. The 2H:1V slopes increase the total acres by 18.

GSM has proposed a coversoil system consisting of 3 feet of soil for the pit acres to be revegetated in all alternatives. On 2H:1V slopes, the soil would be

amended with rock to raise the coarse fragment content to more than 45 percent as is approved for the East Waste Rock Dump Complex (GSM, 2002a).

GSM would either use borrow soil meeting the rock fragment requirement or blend coversoil with more rocky potentially acidic waste rock to increase the rock content from 30 percent to greater than 45 percent. The waste rock would have a net acid generating pH value greater than 4.5 to meet quality criteria approved for the East Waste Rock Dump Complex in Minor Revision 01-004 (DEQ and BLM, 2002 and 2003). A sample frequency of one sample per 10,000 tons would be used for soil testing to determine acid producing potential. GSM estimates that approximately 15 percent of the stockpiled waste rock would be used to raise the rock content of the calcareous coversoil to greater than 45 percent. Non-acid generating coversoil may be available from borrow areas.

GSM would test mixtures of the calcareous soils and the potential acidic waste rock materials to develop a recipe to produce the more than 45 percent rock content needed in the surface soils on 2H:1V slopes. GSM would verify that the resultant mixture would have a net neutralizing potential at a 3:1 ratio above the acid generating potential. After placement, GSM would verify net neutralizing potential again by sampling a 100 by 100-foot grid on the final surface. Verification of no impacts to plant growth with this plan would be addressed by a qualified third party technical specialist.

GSM would amend the surface soils with agency-approved organic amendments. GSM would try to achieve an average 1.0 percent organic matter content in the upper 4 inches of the replaced coversoils after organic matter addition. GSM would sample the organic matter content on a 100 by 100-foot grid on the regraded coversoil slopes. GSM has to document that the proper application rate has been calculated, applied, and incorporated as best as possible. GSM is concerned that, because of the 2H:1V slope, the organic matter would not be incorporated completely. Some would be lost to wind and water erosion. The agencies believe that some loss is acceptable. Any organic matter would enhance the establishment of microbes in the soil.

The 3-foot coversoil is intended to minimize infiltration into the waste rock by storing water within the cover material during wet periods and allowing water to be removed by evapotranspiration from the cover during drier periods. Cover thickness over about 18 inches in this climate would result in negligible increases in infiltration rate (Prodgers, 2000). The amount of water infiltrating through 18 inches or 3 feet would be similar and within the range used for water balance estimations (*i.e.*, 0.25 to 0.5 inch/year, or 2 to 4 percent of average annual precipitation) (Telesto, 2003a).

While the net infiltration through 18 inches or 3 feet is estimated to be similar, the durability of the covers may be different. Based on the experience with cover placement and maintenance on the West Waste Rock Dump Complex, it is

anticipated that the 3-foot coversoil with more than 45 percent coarse fragments would adequately resist erosion, particularly on slopes (DEQ and BLM, 2001a, 2003). This design has been approved for the East Waste Rock Dump Complex.

GSM has provided soil analyses for the proposed borrow site north of Tailings Impoundment No. 2 (GSM, 2002a). The agencies would require further testing to verify that the rock size and characteristics are adequate for use on 2H:1V slopes. An amendment to add rock fragments would be required if necessary. The agencies have concluded that the 3-foot coversoil system with the required rock content and characteristics approved for 2H:1V slopes on the waste rock dump complexes would be adequate to revegetate waste rock backfilled into the pit under any of the alternatives.

4.3.2.3.1 Surface Disturbance

GSM's permit area is 6,125 acres. GSM was permitted for 2,964 acres of disturbance (1997 Draft EIS, Table II-22) (GSM 2006 Annual Report). GSM's approved area for disturbance is 3,002.5 acres, which was acquired through minor revisions to the permit (GSM 2004 Annual Report). GSM is bonded for 2,619.8 acres of disturbance.

Table 2-1 compares the permitted disturbances at GSM with the proposed disturbances at the end of Stage 5B mining. GSM's 2006 actual disturbance was 2,236 acres. The numbers reported in Table 2-1 do not match the 1997 Draft EIS, Table II-22 because of updated mapping (GSM 2004 Annual Report). GSM has completed 1,072 acres of reclamation within the disturbance boundary. Table 2-1 details the completed reclamation.

The 1997 Draft EIS, Table II-22 estimated the pit disturbance area would be 254 acres. GSM's reclamation bond included covering with the 4-foot coversoil system and revegetation of 26 acres of pit area. The total pit disturbance area was permitted to be 336 acres of which 108 acres would be revegetated.

This SEIS estimates the pit disturbance area would be 218 acres. GSM proposes a 3-foot coversoil system and revegetation of 60 acres of the pit area. The total pit disturbance area, including the perimeter disturbance, would be 286 acres of which 128 acres would be revegetated. Seven acres in the pit area have been reclaimed with a 4-foot coversoil system. Under the No Pit Pond Alternative, GSM would revegetate another 53 acres (7 acres already reclaimed) with the 3-foot coversoil system, requiring 290,400 cubic yards of soil. None of the total 60 acres to be reclaimed would be on 2H:1V slopes and would not require rock amendments. Some soil placed inside the pit below the highwall is at risk of being lost or possibly mixed with acidic highwall rock as the pit highwall gradually sloughs to more stable configurations. The amount of soil that would be lost would be minimal. The soil loss would be an unavoidable impact of

revegetating areas next to the highwall. GSM has enough soil stockpiled to reclaim the pit acres.

4.3.2.3.2 Hazards to Wildlife

A total of 2,236 acres was disturbed as of 2006, and Stage 5B mining is not expected to result in additional disturbance (GSM, 2002a). No additional pit area disturbance would be created under this alternative. The pit would only be backfilled with 111,000 cubic yards (167,000 tons) of crusher reject. This would leave almost 1,775 feet of acid-producing highwall exposed. Because there would be no further pit surface disturbance, there would be no additional hazards to wildlife beyond those analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.e. If the pit cannot be dewatered for some reason and a lake forms in the pit, an additional hazard to wildlife would develop from exposure to contaminated water.

4.3.2.3.3 Total Remaining Unrevegetated Acres

In the 1997 Draft EIS, based on Chapter II, Section II.B.6.b and Table II-14, 228 out of 254 acres in the pit would be left unrevegetated. In this SEIS, of the 218 pit acres, 158 acres would be left unrevegetated. The difference is due to the reconfiguration of the pit since 1998.

4.3.3 Partial Pit Backfill With In-Pit Collection Alternative (Proposed Action)

4.3.3.1 Impacts to Groundwater Quality and Quantity

4.3.3.1.1 Risk of Impacts to Groundwater Quality and Quantity in Permit Area

4.3.3.1.1.1 Impacts from Waste Rock Dump Seepage

In the 1997 Draft EIS, Chapter II, Section II.B.7.b, 34,700,000 to 36,700,000 cubic yards (52,000,000 to 55,000,000 tons), or 30 to 32 percent of the total East Waste Rock Dump Complex volume would have been removed for backfill under the Partial Backfill Alternative. Approximately 20,500,000 to 22,000,000 cubic yards (30,800,000 to 33,000,000 tons) or 15 to 16 percent of the West Waste Rock Dump Complex would have been removed to cover the upper highwall. The West Waste Rock Dump Complex footprint would not have been reduced. In the 1997 Draft EIS, Chapter IV, Section IV.B.7, the East Waste Rock Dump Complex footprint would have been reduced by 82 acres.

In this SEIS, the partial pit backfill alternatives would remove 33,300,000 cubic yards (50,000,000 tons) or 33 percent of the total East Waste Rock Dump Complex volume at the end of Stage 5B. The footprint area would remain the same (GSM, 2002a), so the spatial dimension of potential impacts from the East Waste Rock Dump Complex would remain similar (Figure 2-6). To cover the upper highwall, 11,900,000 cubic yards (17,900,000 tons) of pit highwall material would be cast blasted to create the 2H:1V slopes. No West Waste Rock Dump Complex waste rock would be removed for backfill.

The topography of the East Waste Rock Dump Complex after mining Stage 5B is shown in plan and cross-section views on Figure 2-5, and the final configuration of the East Waste Rock Dump Complex after removing material for backfilling is shown on Figure 2-6.

Waste rock water quality would not change under the Partial Pit Backfill With In-Pit Collection Alternative. Impacts to long-term water quality under this alternative would be similar to those of the No Pit Pond Alternative, except that the East Waste Rock Dump Complex would achieve a saturated condition sooner, since the maximum thickness of waste rock would be reduced from 300 feet to 100 feet (Figure 2-6). Overall, the potential ARD impacts from the East Waste Rock Dump Complex under this alternative would be the same as under the No Pit Pond Alternative.

Since the thickness of the East Waste Rock Dump Complex would be reduced from approximately 300 feet to 100 feet in the thickest area, the time it would

take for the remaining waste rock to become wet to the point ARD exits the dump would be less. There would be less geochemical uptake of water, and the drying effect of convective air movement that occurs in waste rock dumps would be diminished. The average time until seepage begins would reduce from a range of 50 to 200 years (1997 Draft EIS, Chapter IV, Section IV.B.1.a), to 11 to 24 years (HSI, 2003: Table 6-2). This is based on a 100-foot thickness of waste rock. The downward migration of the 1 to 3 gpm seepage from the base of the East Waste Rock Dump Complex down the Rattlesnake Gulch drainage would be similar to that described for the No Pit Pond Alternative.

4.3.3.1.1.1.1 Long-Term Monitoring and Mitigation for Unanticipated East Waste Rock Dump Complex Seepage

Impacts to, and mitigation measures for, groundwater resources and beneficial uses of water would be the same as for the No Pit Pond Alternative.

4.3.3.1.1.1.2 Summary of East Waste Rock Dump Complex Impacts to Water Quality and Water Quantity

No impacts to groundwater quality from the portion of the East Waste Rock Dump Complex in Rattlesnake Gulch are anticipated during active mining operations through Stage 5B. The 1997 Draft EIS predicted that groundwater under the East Waste Rock Dump Complex would first experience ARD impacts in 54 to 433 years. An updated evaluation in this SEIS of the 1997 Draft EIS modeling was conducted using combinations of middle to worst-case parameters (HSI, 2003). The updated modeling predicts that groundwater under the East Waste Rock Dump Complex would first experience ARD impacts in 33 to 72 years. The water treatment plant has been designed to handle 25 gpm of seepage from the East Waste Rock Dump Complex as a contingency (1997 Draft EIS, Appendix A, Table 2-1).

4.3.3.1.1.2 Impacts from Pit Seepage

4.3.3.1.1.2.1 Impacts to Water Quality

Under the Partial Pit Backfill With In-Pit Collection Alternative, the pit would be backfilled from 4,525 feet to an average elevation of 5,400 feet. The pit highwall would be reduced to 2H:1V slopes by cast blasting and dozing. The backfilled pit would be graded at 4.3 percent to create a free-draining surface (Figure 2-4) and a 3-foot soil cover would be placed over the entire backfilled pit and reduced highwall and revegetated. Four wells would be installed through the backfill to the bedrock contact to maintain the pit as a hydrologic sink. As under the No Pit Pond Alternative, pit dewatering coupled with water treatment would be required.

The principal objective of this alternative would be similar to the No Pit Pond Alternative and would be to maintain the pit as a hydrologic sink and keep the

groundwater level as close as possible to the pit bottom elevation of 4,525 feet. If successful, this would control the ARD produced by the pit at its source and eliminate the risk of water quality impacts from pit groundwater seepage outside the pit.

The first 100 feet of crusher reject would be the same as for the No Pit Pond Alternative. Above this, approximately 33,200,000 cubic yards (50,000,000 tons) of waste rock from the East Waste Rock Dump Complex would be backfilled to an average 5,400-foot elevation. The backfill from the waste rock dumps would be trucked to the pit and end dumped.

The mechanics of end dumping and cast blasting would create segregated fine and coarse zones, based on observations at GSM from offloading a portion of the East Waste Rock Dump Complex in 1994. Each truck load would create a single segregated cell with larger material on the bottom and fines on top. There would be sorting within the dumping zone with fines higher in the section. The backfill timeframe allows rain events to redistribute fines in the pit creating less permeable lenses. The process of weight compaction and weathering would produce fines that could move into the lower portions of the backfill, including the crusher reject, which is the pumping zone.

Over time, the crusher reject would develop reduced permeability and may lose its ability to function as a sink to maintain collection of pit seepage. These effects would occur in any alternative that includes pit backfill, including the No Pit Pond Alternative. The effect would be more pronounced in the partial pit backfill alternatives because there would be a much greater volume of backfill, and backfill would consist of less uniformly graded material. Cast-blasting and dozing would create the 2H:1V final highwall slope. Slope breaks and surface water diversions off the slopes and backfill area are described in Section 2.4.3.5. Figure 4-1 shows the potential stratification of the pit backfill after pit backfilling. The final pit configuration after backfilling the pit is shown in Figure 2-4 in both a plan view and cross-sectional view.

In the 1997 Draft EIS, Appendix A, Table 1, groundwater quality in the backfilled pit was assumed to be an average of the Ohio Adit, Stage 2 pit sump, Stage 3 pit sump, highwall seepage, and water treatment plant feed water. A re-evaluation of the projected chemistry of pit water in the Partial Pit Backfill With In-Pit Collection Alternative was performed (Table 4-5) (Telesto, 2003c). If successful, dewatering would maintain the groundwater level in the backfill as close as possible to the 4,525-foot pit bottom elevation. The majority of the backfill would remain above the saturated zone, and geochemical reactions characteristic of an unsaturated environment would predominate. Oxidation of sulfide minerals in the unsaturated zone in the backfilled pit would proceed as in the reclaimed waste rock dump complexes, and the water chemistry would be similar to the pore water chemistry observed in the West Waste Rock Dump Complex (Table 4-5)

(Telesto, 2003c). The poor water quality would be expected to occur for hundreds to thousands of years.

Table 4-5 lists the estimated quality of pit water under the Partial Pit Backfill With In-Pit Collection Alternative, which corresponds to West Waste Rock Dump Complex pore waters (Telesto, 2003c). Because the geochemical processes in an unsaturated backfill scenario would be similar to those in the existing waste rock dumps, the water quality from the unsaturated pit backfill would be the same as in the waste rock dumps. The agencies expect that this water quality would develop in any waste rock used for backfill. Table 4-5 lists the water quality used in the 1997 Draft EIS and Montana groundwater quality standards for comparison.

The concentrations listed in Table 4-5 are intended as indicators of probable backfill water quality and the values listed are not intended to represent a chemically balanced water. The potential exists that some constituents could be slightly higher and others slightly lower than indicated. Placement of the waste rock material in the backfilled pit would result in low-pH, elevated metal-bearing groundwater from initiation of groundwater contact with the backfill for hundreds to thousands of years (Telesto, 2003c).

Jarosite is a byproduct of sulfide oxidation and can be characterized as a ferric-hydroxide sulfate mineral. In the unsaturated zone of the backfill, jarosite would be expected to continue to form because the geochemical processes in the unsaturated backfill would be no different than those in the waste rock dumps. In the saturated zone, assuming that oxygen flux is limited, jarosite would likely start to dissolve (Telesto, 2003c). As long as it is present, it would keep the redox potential (*i.e.*, the activity of electrons) in the range that would sustain low pH and high ferric iron activity and could promote the continued oxidation (*i.e.*, the loss of electrons) of pyrite. This process is exhibited in the Berkeley Pit (Maest, 2004). The pit is not anoxic, even below the chemocline, due to the presence of ferric iron. This shows that redox potential is not only a function of oxygen concentrations and that simply saturating a material to limit oxygen does not automatically raise the redox potential and limit metals solubility. There are other redox buffers in the system besides oxygen, including ferric iron ions.

In regard to the quantity of jarosite, it was observed to be prevalent in all samples that were examined through mineralogical analyses (Telesto, 2003j). Mineralogical analyses showed that of the clay sized particles, jarosite was present in major amounts (more than 50 percent by weight). Other lines of evidence suggest that it is prevalent also. For example, the consistency of waste rock samples evaluated using field methods suggested that a high clay content exists in the waste rock. Grain size distribution testing indicates that the clay-sized fraction is very small. Thus, the results of field-testing methods (*i.e.*, texture, amount of cementing) were influenced by the physical properties of jarosite by which the sieve analyses were not influenced (Telesto, 2003j). It is

important to note that jarosite dissolution is not instantaneous and jarosite will influence the redox potential of the pore water. This conclusion only relates to the continued geochemical reactivity of the saturated backfill. The unsaturated portion of the backfill would remain geochemically reactive in a manner consistent with the observations and measurements from the existing waste rock.

The predicted water quality of groundwater in a backfilled pit would fall within the range of concentrations found in ARD sources, such as the West Waste Rock Dump Complex pore water, the Midas Spring, the 2002-2003 pit sump, and the passivation test pads (Telesto, 2003c). GSM has experimented with passivation, which involves sealing pit walls to limit oxidation (GSM 2004 Annual Report).

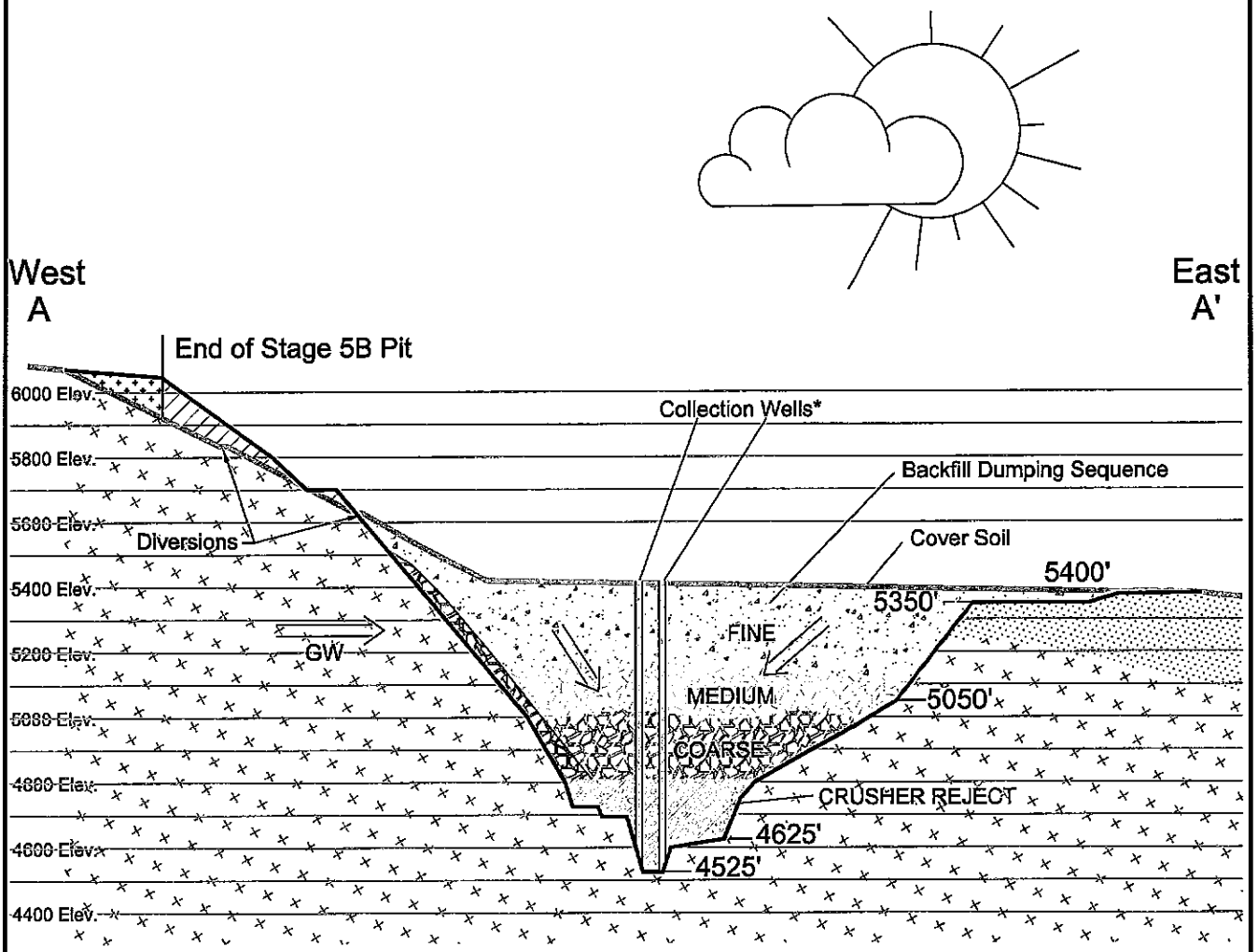
In particular, the pit sump water quality data have specific pertinence because the measured water quality from July 2002 to July 2003 documented the geochemical reactions occurring in a small scale version of the pit backfill (see Section 4.3.2.1.1.2.1). Waste rock that would have been directed to the East Waste Rock Dump Complex was allowed to fill in the bottom of the pit. A well was placed in the backfill and pumped almost continuously to maintain dewatering of the pit. Organic carbon (*e.g.*, methanol and other easily degradable forms) was injected into the pit sump material to attempt to limit the oxidation of sulfide material. This may have affected measured water quality. The concentrations of contaminants in the pit sump water are similar to the West Waste Rock Dump Complex pore water, even with organic carbon additions (Telesto, 2003c).

Based on conversations with agency representatives and consultants regarding the San Luis, Richmond Hill, and Butte underground mines and Berkeley Pit, none of the sites have an adequate period of record to make substantial conclusions on the ultimate water quality response to pit backfilling and pit/mine flooding (Gallagher, 2003c).

An independent evaluation of water quality in the Butte underground mines found that, while the Berkeley Pit water quality has not improved since the pit began filling in 1982, pH increased somewhat and cadmium decreased in the Kelley mine shaft, and dissolved copper decreased on the Belmont mine shaft, in correlation with the rising water levels (Maest, 2003). Other constituents experienced smaller reductions or no reduction in concentration since flooding began. Monitoring of the pit and underground water noted large variation in water chemistry throughout the underground workings. The period of record was not long enough to account for future geochemical processes that may reverse the observed improvements. Major elements and metals could remain elevated for an extended period of time, and it would be important to have control over water in the pit (*e.g.*, through draining via workings), so that treatment could be performed if required (Maest, 2003).

Water quality in the saturated portion of the backfill in the GSM pit would be expected to be acidic and elevated in metal concentrations. Based on the limited data reviewed in the Butte underground mines, which are not backfilled, it is possible that concentrations of some metals in the saturated portion of the backfilled GSM pit water would decrease "naturally" over the first five to ten years. Other metals and sulfate could remain elevated for an extended period of time. It is conceivable that ARD would be generated in the saturated backfill until the sulfides have reacted completely. Thereafter, the products of oxidation would be reduced and mobilized.

The pit backfill analog study conducted for this SEIS did not find any hardrock mine in the U.S. or Canada in which such a large pit was backfilled and allowed to become saturated with groundwater (Kuzel, 2003; Gallagher, 2003c). No long-term water quality monitoring records exist at the backfilled mines or flooded underground mines studied sufficient to indicate whether the reclamation goals at those mines were achieved.



LEGEND

- Stage 5B Pit Outline
- Regraded Surface
- Colluvium
- Generalized Bedrock
- Disturbance Outside Ultimate Pit Boundary
- Pit Highwall Reduction
- Water Flow Direction (GW)

0 400 800

Scale in Feet
Horizontal & Vertical

See Figure 2-4 for Cross Section A - A' Location

Backfill Permeability (Telesto, 2005)
Under 450 ft backfill, 10^{-6} CM/SEC
Under 900 ft backfill, 10^{-7} CM/SEC

*Collection Wells Needed For Partial Pit Backfill with In-Pit Collection Alternative Only

(Telesto - Feasibility Assessment, 2003e)

Partial Pit Backfill Alternatives

CONCEPTUAL STRATIFICATION OF PIT BACKFILL

Figure 4-1.dwg

FIGURE 4-1

4.3.3.1.1.2.2 Impacts to Water Quantity

The potential impacts to water quantity by the open pit and reclamation alternatives in the 1997 Draft EIS were evaluated with a numerical groundwater model and a water balance study (GSM's Permit Application Appendix 4.7-1, Hydrometrics, 1995). In the 1997 Draft EIS, Chapter IV, Table IV-5, the water balance accounted for surface water recharge from snowmelt, direct precipitation, runoff, and groundwater inflow. The 1997 Draft EIS, Chapter IV, Section IV.B.2.b estimated the total inflow to the pit from surface water and groundwater sources would be 102 gpm. The 1997 Draft EIS, Chapter II, Section II.B.7.b indicated that backfilling under the Partial Backfill Alternative would reduce the amount of water needing treatment from 102 to approximately 50 gpm. Fifty-two gpm of storm water runoff would report off the reclaimed surface of the pit area or be lost to evapotranspiration.

In contrast, this SEIS concludes that backfilling would change the amount of water needing treatment from 25 to 27 gpm for the No Pit Pond Alternative to between 27 and 42 gpm for the Partial Pit Backfill With In-Pit Collection Alternative (Telesto, 2006). Seventeen gpm would report off the reclaimed surface of the pit area as storm water runoff or be lost to evapotranspiration (Telesto, 2003a). The ratio of water pumped for treatment compared to that which runs off is about the same as in the 1997 Draft EIS, with the difference in values between these studies attributable to the updated water balance calculations performed for this SEIS (Telesto, 2003a).

The water balance for this SEIS was based on calibration to 2003 records of pit water inflows and outflows. Average annual precipitation during that period has been reduced due to drought. The amount of water needing treatment could be somewhat higher in the future. The agencies assume that the total amount from the pit needing treatment would not exceed the 50 gpm indicated in the 1997 Draft EIS.

Cast blasting would increase pit disturbance by 56 acres to reduce the slope to 2H:1V. This could increase the amount of water infiltrating into the upgradient groundwater system, which would enter the Corridor Fault. This new disturbance would be covered with a 3-foot soil cover and revegetated. This soil cover would minimize infiltration, potentially balancing the increased water produced by 56 acres of new disturbance that could report to the pit.

4.3.3.1.1.2.3 Migration of Perched Groundwater

The potential for perched water migration across the pit was not analyzed for the Partial Backfill Alternative in the 1997 Draft EIS. The potential development of perched groundwater conditions in a backfilled pit was investigated for this SEIS (Telesto, 2003e). The development of perched groundwater conditions with

cross-pit migration hinges on whether a low permeability layer would exist from compaction or be created by oxidation byproducts below the level of the seepage. In the backfilled pit, the concern would be for the poor quality perched water to migrate into bedrock and avoid capture in the pit dewatering system.

Seeps have been identified in the highwall of the pit, and some are observed to flow continuously throughout the year, particularly those associated with the Corridor Fault (Gallagher, 2003b). If the pit is backfilled, these seeps would be buried, but would continue to flow, possibly creating perched water within the backfill materials and potential problems with localized small failures if they saturate the backfill and soil cover on the upper slopes.

Sulfide oxidation byproducts are colloidal in nature and effectively could seal pore space over time reducing permeability below seeps to $1x10^{-5}$ cm/sec or less (G. Furniss, DEQ, personal communication, 2004). As oxygenated water continues to emerge from the seeps and react with backfill, an impermeable layer of reaction products would spread outward across the backfill and would prevent the water from seeping downward in the backfill. Water could bypass the capture system and report to groundwater above the 5,050-foot elevation. This would be in addition to the 10 percent seepage from fractures assumed by the agencies below the 5,050-foot elevation.

For the Draft SEIS, hydraulic conductivity estimates for the backfill material ranged from 10^{-3} to 10^{-5} cm/s (Telesto, 2003e). Pit flow analysis conducted for the Draft SEIS predicts that hydraulic conductivity values of 10^{-6} cm/s or less would result in perching of groundwater within the backfill that would lead to horizontal, rather than vertical groundwater flow, thus permitting seepage to leave the pit without being captured by the wells (Telesto, 2003e).

Additional permeability testing of potential backfill material under simulated load conditions (such as that in a backfilled pit) was conducted subsequent to the Draft SEIS by Telesto (2005). The results indicate that, under 450 feet of backfill, the hydraulic conductivity can decrease to 10^{-6} cm/s, and that under 900 feet of backfill, the hydraulic conductivity can decrease to 10^{-7} cm/s (Telesto, 2005). This additional evaluation indicates that control of pit seepage with vertical wells would likely not be reliable. A different approach using directionally drilled dewatering wells would be no more effective than vertical dewatering wells because of the low hydraulic conductivity of the backfill and difficulty of predicting where groundwater flow paths could develop. If this alternative is selected, the agencies could bond for Measure 3, to identify secondary flow paths from the pit, and Measure 15a (see Section 4.8.2.1), to maintain operation of the Rattlesnake Gulch and Tailings Impoundment No. 1 pump back wells.

As noted in the pit backfill analog study completed for this SEIS, both the San Luis and Richmond Hill mines developed unexpected seepage of groundwater down gradient from the pits. This was unexpected at the Richmond Hill mine

because the pit was above the water table, so the source of the seepage was probably perched water in the backfill. The specific source of the seepage is not known but is suspected to be related to the pit (Gallagher, 2003c). The seep is impacted by ARD and must be captured and treated.

Permeability of the backfill could decrease over time due to compaction and weathering, as described in Section 4.2.2.1.2.

4.3.3.1.1.2.4 Summary of Pit Impacts to Water Quality and Quantity

As with the No Pit Pond Alternative, the Partial Pit Backfill With In-Pit Collection Alternative is intended to maintain the pit as a hydrologic sink and treat the groundwater in the permanent water treatment plant. If the Partial Pit Backfill With In-Pit Collection Alternative were to perform as intended over the long term, the impacts would be similar to the No Pit Pond Alternative.

4.3.3.1.2 Risk of Violation of Groundwater Standards at the Permit Boundary and Impacts to Beneficial Uses of the Jefferson River Alluvial Aquifer

4.3.3.1.2.1 Impacts from Waste Rock Dump Seepage

Impacts from the 1 to 3 gpm of seepage from the East Waste Rock Dump Complex in Rattlesnake Gulch would be the same as the No Pit Pond Alternative.

4.3.3.1.2.2 Impacts from Pit Seepage

If the groundwater capture systems described in Section 4.3.4.1.2.2 were able to be successfully operated over the long term, the impacts to groundwater in the Jefferson River alluvial aquifer would be similar to the No Pit Pond Alternative because the pit would be maintained as a hydrologic sink. There is a greater risk of groundwater excursions from the pit due to the potential for perched groundwater zones in the backfill as described in Section 4.3.3.1.1.2.3.

As a consequence of long-term failure of the dewatering system under this alternative, water would rise above the 5,050-foot elevation and reach a steady state at 5,260 (Telesto, 2003a) and discharge from the pit as it would under the Partial Pit Backfill With Downgradient Collection Alternative (see Section 4.2.2.9.2). Twenty-seven to forty-two gpm of pit seepage would reach groundwater and move down Rattlesnake Gulch toward the Jefferson River alluvial aquifer along with the 1 to 3 gpm of seepage from the East Waste Rock Dump Complex in Rattlesnake Gulch. A groundwater capture system like that for the Partial Pit Backfill with Downgradient Collection Alternative would be required to capture pit seepage, and impacts to groundwater in the Jefferson River alluvial aquifer would be the same as for that alternative.

4.3.3.2 Impacts to Surface Water Quality and Quantity

4.3.3.2.1 Impacts to Springs, Wetlands

4.3.3.2.1.1 Impacts from Waste Rock Dump Seepage

Impacts from waste rock dump seepage would be the same as the No Pit Pond Alternative.

4.3.3.2.1.2 Impacts from Pit Seepage

The 1997 Draft EIS, Chapter IV, Section IV.B.7.b concluded that spring flows outside the pit area under the Partial Backfill Alternative would be reduced because the pit would be maintained as a hydrologic sink. Impacts to the flow of springs and wetlands from pit dewatering under the Partial Pit Backfill With In-Pit Collection Alternative would be the same as the No Pit Pond Alternative. Under both, pit water elevations would be maintained as low as possible between 4,525 and 4,625 feet in elevation. As indicated in Section 4.2.2.5.2, under the Partial Pit Backfill With In-Pit Collection Alternative, groundwater levels in the backfilled pit could rise if operation or maintenance problems developed because of dewatering system failures. This could be caused by problems with well casings and pumps from settlement and corrosion of pumps and screens. The agencies would bond for additional wells to be installed to ensure that the water level would not rise above the 5,050-foot elevation. If the water level can be kept close to the 4,525-foot elevation, the impacts would be similar to the No Pit Pond Alternative.

The 1997 Draft EIS, Chapter IV, Sections IV.B.1.b and IV.B.7.b did not predict that, under the Partial Backfill Alternative, there would be any impacts to the water quality of springs from pit discharge. With the backfilled pit maintained as a hydrologic sink under the Partial Pit Backfill With In-Pit Collection Alternative, there also would be no water quality impacts to springs. However, if operational and maintenance problems led to loss of hydrologic control of pit groundwater allowing water levels to rise above the 5,050-foot elevation, ARD-affected water from the pit could reach existing springs or create new ones. In this case, Measure W-1 approved in the 1998 ROD as Stipulation 010-4, would be required to monitor, treat or augment spring discharge.

Measure W-1 was designed to respond to the identification and replacement of reduced discharge or reduced water quality at springs and seeps. It allows for establishment of a monitoring and sampling program frequent enough to detect spring responses to seasonal variations and pit dewatering. Mitigation includes improving collection and interception of spring waters, supplying replacement water, and enhancing water resources for wildlife and livestock. Measure W-1 would have to be modified to cover increased flows from springs under this alternative.

4.3.3.2.2 Risk of Violation of Surface Water Standards and Impacts to Beneficial Uses of the Jefferson River and Slough

4.3.3.2.2.1 Impacts from Waste Rock Dump Seepage

Impacts from the 1 to 3 gpm of seepage from the East Waste Rock Dump Complex in Rattlesnake Gulch would have similar impacts to those for the No Pit Pond Alternative described in Section 4.3.2.2.2.1.

4.3.3.2.2.2 Impacts from Pit Seepage

If the groundwater capture systems described in Section 4.3.4.1.2.2 were able to be successfully operated over the long term, the impacts to surface water in the Jefferson River Slough would be similar to the No Pit Pond Alternative because the pit would be maintained as a hydrologic sink. There is a greater risk of groundwater excursions from the pit due to the potential for perched groundwater zones in the backfill as described in Section 4.3.3.1.1.2.3.

As a consequence of long-term failure of the dewatering system under this alternative, water would rise above the 5,050-foot elevation and reach a steady state at 5,260 (Telesto, 2003a) and discharge from the pit as it would under the Partial Pit Backfill With Downgradient Collection Alternative (see Section 4.2.2.9.2). Twenty-seven to forty-two gpm of pit seepage would reach groundwater and move down Rattlesnake Gulch toward the Jefferson River alluvial aquifer along with the 1 to 3 gpm of seepage from the East Waste Rock Dump Complex in Rattlesnake Gulch. A groundwater capture system like that for the Partial Pit Backfill with Downgradient Collection Alternative would be required to capture pit seepage, and impacts to groundwater in the Jefferson River Slough would be the same as for that alternative.

4.3.3.3 Reclamation Plan Changes

4.3.3.3.1 Surface Disturbance

The 1997 Draft EIS, Chapter II, Section II.B.7.b estimated that all 254 acres in the pit would be reclaimed with the 4-foot coversoil system under the Partial Backfill Alternative. The Stage 5B pit disturbance area in this SEIS would be 218 acres. The pit would increase by 56 acres to 274 acres due to new haul roads and cast blasting the upper highwall. In this SEIS under the Partial Pit Backfill With In-Pit Collection Alternative, GSM would reclaim all 274 pit acres with the 3-foot coversoil system (Figure 2-4). About 239 of these acres would be on 2H:1V slopes and would require coversoil rock amendments.

Table 4-6 indicates that 1,541,800 cubic yards of soil would be needed to revegetate the pit disturbance in this alternative. GSM does not have enough

soil stockpiled to revegetate the pit acres. GSM has approved soil borrow areas from which to obtain soil. One source of cover material is the area northeast of the East Waste Rock Dump Complex, where soil had been obtained in the past. The haul for this material would include approximately 8,250 feet of flat grade and 1,920 feet of 10 percent grade for covering the lower portions of the backfilled pit. In order to haul material to the upper portions of the cast blasted backfill, the haul would consist of a total of 15,280 feet of flat grade and 8,955 feet of 10 percent grade. Additional haul roads would be required to haul soil to cover the reduced highwall.

Under Minor Revision 03-003, GSM is permitted an additional 8 acres of disturbance for a borrow area for the Tailings Impoundment No. 2 embankment construction. This additional area could be utilized for cover material (GSM, 2003c). Thirty-one acres of additional disturbance would be required. From the existing borrow area to the pit, the haul would include 2,700 feet of 6 percent grade and 3,250 feet of 3 percent grade. The haul route would be over existing roads for covering the lower portions of the backfilled pit. In order to haul material to the upper portions of the cast blasted backfill, the haul would consist of a total of 16,250 feet of 6 percent grade as shown on Figure 2-4.

4.3.3.3.2 Hazards to Wildlife

The total mine disturbance permitted is 3,002.5 acres (GSM 2006 Annual Report). GSM has indicated that 2,236 acres would be disturbed through Stage 5B (GSM, 2004 Annual Report). Additional pit disturbance of 56 acres would be created under this alternative. Even with the additional pit area disturbance, there would be fewer hazards to wildlife than under the No Pit Pond Alternative because the highwall would be eliminated. There would be no hazard to wildlife from exposure to acidic pit water.

4.3.3.3.3 Total Remaining Unrevegetated Acres

In the 1997 Draft EIS and this SEIS, no pit disturbance acres would be left unrevegetated in this alternative, except roads to the dewatering system.

4.3.4 Partial Pit Backfill With Downgradient Collection Alternative

4.3.4.1 Impacts to Groundwater Quality and Quantity

4.3.4.1.1 Risk of Impacts to Groundwater Quality and Quantity in Permit Area

4.3.4.1.1.1 Impacts from Waste Rock Dump Seepage

Waste rock removed for backfill material under this alternative would be the same as the Partial Pit Backfill With In-Pit Collection Alternative, except that no crusher reject would be used. The impacts of this alternative on groundwater resources and geochemistry of seepage from the East Waste Rock Dump Complex would be the same as the Partial Pit Backfill With In-Pit Collection Alternative except 1 to 3 gpm of seepage would travel down Rattlesnake Gulch with between 27 and 42 gpm of pit seepage (Telesto, 2003a, 2006).

4.3.4.1.1.1.1 Long-Term Monitoring and Mitigation for Unanticipated East Waste Rock Dump Complex Seepage

Long-term monitoring and mitigation for unanticipated East Waste Rock Dump Complex seepage would be the same as for the No Pit Pond Alternative and all other alternatives.

4.3.4.1.1.1.2 Summary of East Waste Rock Dump Complex Seepage Impacts to Water Quality and Water Quantity

Impacts to groundwater under this alternative would be essentially the same as the No Pit Pond Alternative and all other alternatives except 1 to 3 gpm of East Waste Rock Dump Complex seepage would migrate down Rattlesnake Gulch with between 27 and 42 gpm of pit seepage.

4.3.4.1.1.2 Impacts from Pit Seepage

The Partial Pit Backfill With Downgradient Collection Alternative would not maintain the pit as a hydrologic sink. Instead, the water table would be allowed to rebound and reach a steady state at the 5,260-foot elevation. Groundwater leaving the pit would be collected from wells located down gradient of the pit. At least 10 new monitoring wells and 26 additional groundwater capture wells may be required to intercept contaminated water. More wells may be needed based on hydrogeologic studies completed to identify flow paths. The wells would be installed in the T/Q alluvial and bedrock aquifers in drainages and along faults at various depths (Figure 2-7). This alternative would rely on a combination of partial attenuation, mixing with ambient groundwater, and collection to prevent

contaminated pit seepage from impacting groundwater outside of a permitted mixing zone.

For the Final SEIS, pit outflow was varied based on a revised pit water balance model (Telesto, 2006). The revised pit water balance model utilized new data collected by GSM subsequent to preparation of the Draft SEIS, and predicts a range of pit seepage values rather than a single estimate, as was reported for the Draft SEIS. The range of pit seepage values better represents the predictability of a natural system with numerous variables.

The conceptual model of pit inflow was reviewed and modified to include two baseflow components: baseflow that occurs beneath the Corridor Fault, and baseflow that occurs above and within the Corridor Fault (Telesto, 2006). The maximum baseflow above and within the Corridor Fault is estimated to be 30 gpm, based on the maximum potential recharge area for the pit. The baseflow from beneath the Corridor Fault was held constant at 2 gpm. For the Final SEIS, the total baseflow rate (*i.e.*, baseflow below, within, and above the Corridor Fault) was varied from 17 to 32 gpm. With this input range, the estimated rates of pumping for the Partial Pit Backfill With In-Pit Collection Alternative for the Final SEIS range from 27 gpm to 42 gpm, compared to 14.5 gpm for the Draft SEIS. The estimated rates of seepage from the pit for the Partial Pit Backfill With Downgradient Collection Alternative for the Final SEIS range from 27 gpm to 42 gpm, compared to about 16 gpm for the Draft SEIS.

Complex capture well systems would be required for this alternative. The fractured and faulted bedrock geology around the GSM pit may make it difficult to locate the seepage and to construct wells adequate to capture enough seepage. Collected water would be treated in the water treatment system and released in a percolation pond below Tailings Impoundment No. 2. Although some attenuation would help prevent impacts outside of the mixing zone in the short term, the available capacity is limited for effective, long-term attenuation along the primary pit outflow groundwater flow path. Attenuation would be limited because of historic flows of ARD along the flow path as indicated by ferricrete deposits in the area (HSI, 2003, 2006).

The geochemical conditions and evolution of groundwater quality in a backfilled pit were described by Telesto (2003c). The waste rock in the East Waste Rock Dump Complex has had 1 to 20 years to weather the sulfide by taking on oxygen and water. Wetting of the sulfide causes a heat-producing reaction, which drives the water off as steam. As a result, the waste rock is covered with oxidation byproducts, such as acid salts. Placing this weathered waste rock in the pit as backfill and allowing it to become saturated would mobilize these oxidation byproducts.

The waste rock placed in the unsaturated, oxidizing environment in the pit backfill would continue sulfide oxidation even though the chimney effect present in the

waste rock dump complexes would not be present in the backfilled pit. The accumulating groundwater in the backfill prior to pit outflow would have a chemical composition similar to that of the unsaturated zone with potentially higher concentrations due to the dissolution of the oxidation products. The oxidation of sulfide would be driven by both oxygen and ferric iron in the unsaturated zone above the water table in the pit and would be driven by ferric iron in the saturated zone.

Over the long term, the oxidation state of the deeper portion of the saturated backfill would decline due to the limited circulation of oxygen and reduction in the rate of sulfide oxidation (Telesto, 2003c). Until the existing amount of jarosite (ferric iron oxide) is dissolved and flushed from the system, it is likely that little change would be noticeable. Based on the water balance and rate of groundwater circulation through the pit, the pit discharge water quality until the backfill is saturated would likely resemble that listed in Table 4-5. As groundwater moves through the saturated backfill, water quality would gradually change. The time for circulation of one pore volume through the pit varies with the depth of the pit flowpath, with shallow groundwater requiring about 28 years and the deep pit flowpath requiring about 78 years (Telesto, 2006).

The ultimate quality of the groundwater discharging from the pit would be influenced by the rates of groundwater circulation through various depths of the pit backfill, ARD input from the unsaturated backfill via recharge, and the locations and elevations of the various pathways by which groundwater would leave the pit. The geochemical evaluation (Telesto, 2003c) indicated that production of ARD-impacted pit water would occur for hundreds to thousands of years.

Hydrogeologic evaluations indicated that most of the 27 to 42 gpm discharge from a backfilled pit would occur to the east, from the Sunlight/Range Front Fault and across and along the Corridor Fault from the 5,050 to 5,260-foot elevation (Telesto, 2003a). Some seepage would be expected to leave the pit through subsurface geologic structures directly connected to the deeper saturated portions of the pit backfill (see Section 3.3.7 for a flow path discussion).

The 1997 Draft EIS, Chapter IV, Section IV.B.7.b indicated that groundwater from a backfilled pit would exit through the colluvium at the east side of the pit (Hydrometrics, 1995). An evaluation of the groundwater flow paths through a backfilled pit was performed for this SEIS using a two-dimensional (cross-section) flow net analysis with existing hydrologic boundary conditions (Telesto, 2003e and 2006). Flow time through the pit would range from 28 to 78 years, from top to bottom of the pit, respectively. Most water that migrated through the deep portion of the pit would eventually flow out of the pit at a higher elevation (*i.e.*, out the Corridor Fault or similar flow path).

The flow net generated from the model indicated that precipitation recharge, which would migrate through the unsaturated portion of the pit, makes up approximately 25 percent of the total pit outflow. Another 25 percent of the pit outflow would contact a zone of waste rock that fluctuates between unsaturated and saturated conditions. Thus, roughly half of the pit discharge would be directly influenced by sulfide oxidation processes in the unsaturated zone of the backfill and would continue to transport ARD. The remaining half of the pit discharge will not likely contact unsaturated waste rock, but would be affected by the dissolution of sulfide oxidation products remaining in the deeper backfill. It is projected that it would be on the order of hundreds of years before the existing sulfide oxidation products are flushed from the upper portions of the backfill. Additionally, the remaining jarosite could maintain redox conditions that produce ARD beyond the hundreds of years time frame. (Telesto, personal communication, September 2004).

The combination of rinsing accumulated ARD products and continued oxidation in both the saturated zone and unsaturated zone would result in the discharge of low-pH, metal-bearing groundwater for at least hundreds of years. The water chemistry provided in Table 4-5 is appropriate for describing the probable composition of groundwater discharge from the pit for this period. Beyond the initial saturation period, while the quality of groundwater in the permanently saturated zone may be improved over that derived from the unsaturated zone, the overall quality of the actual discharge may or may not improve, as approximately 4 gpm or 10 to 15 percent of the pit discharge is derived from rain and snow melt recharge through the unsaturated backfill (Telesto, 2003e).

As documented in the 1997 Draft EIS, Chapter III, Section III.B.2.b, Table III-1, the quality of groundwater in the Tdf/colluvial aquifer is impacted by natural mineralization. Table III-1 indicated that the groundwater in Rattlesnake Gulch had a geometric mean pH of 4.3, sulfate of 731 mg/l, aluminum of 6.5 mg/l, copper of 0.43 mg/l, zinc of 0.54 mg/l, and nickel of 13.03 mg/l based on GSM monitoring wells PW-47, PW-63, PW-12 and PW-8 (shown on Figure 3-5). Much of the Tdf/colluvial aquifer has an alkalinity of 30 mg/l or less. The water quality data for the inputs to the pit flow path model were updated through 2004 and revised to use the appropriate sources (HSI, 2006).

The water balance indicated a pit discharge of from 27 to 42 gpm, having a pH of 2.2, sulfate of 22,400 mg/l, aluminum of 1,410 mg/l, copper of 55.9 mg/l, zinc of 21.3 mg/l, and nickel of 13.03 mg/l (Telesto, 2003a and 2003c). Groundwater discharge of a backfilled pit to the Tdf/colluvial aquifer in Rattlesnake Gulch would cause some additional deterioration of water quality, including increasing acidity and dissolved metals concentrations. Mixing the pit effluent of from 27 to 42 gpm with the expected range of 52 to 103 gpm of groundwater of upper Rattlesnake Gulch would result in an approximate average 7- to 15-fold increase in sulfate concentration and a 6- to 12-fold increase in copper concentration, assuming no chemical or physical reactions of these contaminants (HSI, 2006).

The basis of these estimates is provided in Table 4-7. Other metals would also increase in concentration. Upper Rattlesnake Gulch lies within GSM's permitted mixing zone. The mixing zone does not include the pit as a source of discharge.

The natural properties of the Tdf/colluvial aquifer to attenuate ARD contaminants from the additional chemical mass contributed to the existing mixing zone by groundwater discharge from the backfilled pit and the 1 to 3 gpm seepage from the East Waste Rock Dump Complex were evaluated (Telesto, 2003e). The analysis included acid/base reactions, silicate dissolution, sorption, ion exchange, oxidation-reduction reactions, and mixing.

Unlike the Bozeman Group aquifer, samples of the Tdf/colluvial aquifer do not include identified calcareous zones or carbonate cementation (SHB, 1981-1989; Golder, 1995). The lack of visual identification of carbonates indicates they constitute less than a few percent of the Tdf/colluvial aquifer material.

For the Final SEIS, samples of the Tdf/colluvial and Jefferson River alluvial aquifers were obtained from drilling performed in 2003-2005 and submitted for laboratory analysis of calcite. X-ray diffraction (XRD) and energy dispersive spectrometry (EDS) analysis, and scanning electron microscope (SEM) imaging were performed on nine samples from the saturated zone of the Tdf/colluvial and Jefferson River alluvial aquifers (Mogk, 2005). There was no evidence of the presence of calcite. The XRD results have a sensitivity level of about plus or minus 0.1 percent.

Table 4 - 7. Estimated Impacts to Groundwater Quality in the Tdf/Colluvial Aquifer From Pit Effluent

	Higher Estimated Groundwater Flow Rate In Tdf/Colluvial Aquifer SULFATE		Lower Estimated Groundwater Flow Rate In Tdf/Colluvial Aquifer SULFATE		
Discharge of Pit to Tdf	27	gpm	42	gpm	Telesto, 2006
Flow Rate in Tdf	103	gpm	52	gpm	Rattlesnake Wells 98-03
Mixed Rate	130	gpm	94	gpm	
Sulfate in Pit	22,400	mg/l	22,400	mg/l	Telesto, 2003c
Sulfate in Tdf	695	mg/l	695	mg/l	Avg. PW-8,11,12 63, 2003-05
Mixed Sulfate	5,203	mg/l	10,393	mg/l	
Change	**750**	%	**1500**	%	

COPPER					COPPER
Discharge of Pit to Tdf	27	gpm	42	gpm	Telesto, 2006
Flow Rate in Tdf	103	gpm	52	gpm	Rattlesnake Wells 98-03
Mixed Rate	130	gpm	94	gpm	
Copper in Pit	56	mg/l	56	mg/l	Telesto, 2003c
Copper in Tdf	2.129	mg/l	2.129	mg/l	Avg. PW-8,11,12 63, 2003-05
Mixed Copper	13.32	mg/l	26020	mg/l	
Change	**630**	%	**1,230**	%	

Limited neutralization potential could be provided by silicate dissolution for groundwater solutions with a pH below about 2.5 (Telesto, 2003c). The kinetics of acid neutralization by silicate dissolution are relatively slow. While this process is known to occur in the East Waste Rock Dump Complex, which is unsaturated and has relatively slow reaction kinetics, silicate dissolution is not expected to be an important factor for pit seepage in the Tdf/colluvial aquifer where groundwater flux is relatively rapid and contact time minimal (Telesto, 2003c).

Of the attenuation processes considered, ion exchange and sorption reactions are the ones likely to play a major role in attenuation of metals and acidity from GSM pit discharge. Based on the geologic descriptions of the Tdf/colluvial aquifer, it was assumed that the clay content included 1 percent smectite clay, 3 percent kaolinite clay, and 2 percent iron oxide cementation (Telesto, 2003e). A cation exchange capacity (CEC) was assigned for each of the clay and material types found in the Tdf/colluvial aquifer based on published data. CEC is the amount of exchangeable cations that a soil can adsorb at pH 7.0 (U.S. Department of Agriculture, 2003). CEC is a measure of the net negative charge of a soil and is related to the organic matter content and kind and amount of clay present in the soil. The effective CEC of the Tdf/colluvial aquifer was estimated to be 3.15 milliequivalents per 100 grams (HSI, 2003). This means that 3.15 milliequivalents (millimoles of a constituent divided by its valence state) of a constituent can become associated with 100 grams of clay particles in the Tdf/colluvial aquifer.

These calculations tend to overestimate the attenuation that would likely occur, because the calculations assumed that all of the constituents have an equal likelihood of sorbing to the available material and that the clays and iron oxides are uniformly distributed within the Tdf/colluvial aquifer and in full contact with the water. This is not the case in natural systems (HSI, 2003).

A mass balance calculation to determine the ion exchange capacity of the Tdf/colluvial aquifer was performed using the CEC value and the aquifer volumes presented above (Telesto, 2003e; HSI, 2003). The mass balance calculated the total mass of constituents that the aquifer could capture by the cation exchange

process and balanced that against the mass flux through the aquifer. The mass balance calculation was performed for two scenarios:

- Existing 103 gpm of Tdf/colluvial aquifer groundwater mixed with 1 to 3 gpm East Waste Rock Dump Complex drainage that would impact the aquifer. This is the condition that would prevail whether pit seepage occurred or not (such as in the No Pit Pond Alternative); and,
- Taking the 104 to 106 gpm of water and mixing the expected 27 to 42 gpm of pit seepage under the Partial Pit Backfill With Downgradient Collection Alternative.

As discussed in HSI (2003, 2006) and Telesto (2003a and 2003e), the 1 to 3 gpm of seepage from the East Waste Rock Dump Complex would be expected to occur prior to, or concurrent with discharge from the backfilled pit. Therefore, the waste rock dump seepage was factored into the baseline condition for Rattlesnake Gulch that would exist at the time the pit seepage would impact the Tdf/colluvial aquifer.

The Tdf/colluvial aquifer was divided into relatively uniform segments based on the detailed hydrogeologic data available from previous GSM studies (Golder, 1995; Hydrometrics, 1994, 1995, 1997; Keats, 2001, 2002). Rates of recharge to the aquifer segments were made to match the flow rates in the Tdf/colluvial aquifer indicated by the geometry, hydraulic gradient and physical properties of the aquifer. The final pit water balance model predicts the average outflow from the pit to be 27 to 42 gpm (Telesto, 2006). The analysis in the Draft SEIS indicated that, while a portion of pit outflows may exit the pit through other bedrock flow paths, this flow could rejoin the groundwater system of Rattlesnake Gulch, given the existing hydraulic heads and groundwater flow directions on the south side of the pit (Figure 3-6).

Dilution was accounted for by mixing the 27 to 42 gpm of pit effluent with the rate of discharge in successive segments of the Tdf/colluvial aquifer from the pit. Pit seepage would eventually mix with the 99 gpm flow of the Jefferson River alluvial aquifer within the GSM permit boundary.

A hydrogeologic characterization of the Tdf/colluvial aquifer was performed (Table 6-4 in HSI, 2003). A mixing model was developed (Telesto, 2003e). Recharge was added to mixing cells to balance the predicted range of groundwater flow within the aquifer (52 to 103 gpm) and a water chemistry of monitoring well MW-200, mid-way along the Tdf/colluvial aquifer flow path (Figure 3-5). As discussed in Section 4.3.2.1.1.1.2, the portion of the East Waste Rock Dump Complex overlying the Tdf/colluvial aquifer in Rattlesnake Gulch was predicted to contribute approximately 1 to 3 gpm of ARD seepage to groundwater in the range of 33 to 87 years in the future (HSI, 2003). This period overlaps the anticipated timing of discharge from the pit (21 to 61 years), thereby providing a

higher baseline concentration of these parameters than 2005 conditions (Telesto, 2006).

The downgradient groundwater collection for the Partial Pit Backfill With Downgradient Collection Alternative would be accomplished by a series of existing wells and at least 26 additional capture wells near or slightly west and south of the Rattlesnake Gulch interception wells (HSI, 2003). These include 10 within the throat of Rattlesnake Gulch, near the existing capture wells, and 16 on secondary bedrock pathways. The 16 capture wells on bedrock pathways included two at each of the eight bedrock structure locations identified in Section 2.4.4.3 and Figure 2-7. At least 10 new wells would be needed to intercept groundwater with an estimated average of 80 percent recovery efficiency across the 800-foot-wide Tdf/colluvial aquifer in the vicinity of the Rattlesnake Gulch interception wells. An evaluation of the Tailings Impoundment No. 1 south pumpback system indicated that contaminant capture efficiency can exceed 96 percent with intensive groundwater interception and monitoring (HSI, 2003, 2006). The agencies have concluded that 96 percent capture efficiency may not be achievable in the complex hydrogeologic setting in the secondary bedrock pathways, based on GSM's experience as described in Section 4.2.3.1.2. Based on their experience, the agencies believe a maximum capture efficiency of 80 percent per system is potentially achievable.

The pit would discharge under this alternative. Groundwater quality would likely deteriorate upgradient of the collection wells in an area where groundwater is already impacted by ARD from natural mineralization and by future seepage from the portion of the East Waste Rock Dump Complex that overlies Rattlesnake Gulch. The pit discharge of 27 to 42 gpm was not included in the 1998 Final EIS, Appendix 1 mixing zone analysis.

In contrast to the Partial Pit Backfill With In-Pit Collection Alternative, this alternative would allow the pit groundwater level to rebound and discharge down gradient. During backfilling over 3 years, groundwater could not be collected in the sump in the underground workings. Access to the underground would be lost as soon as backfilling operations were initiated. During and after backfilling, the groundwater level in the pit would slowly rise, saturating the backfill. Eventually, the groundwater within the backfill would establish a hydrologic steady state with the natural groundwater system around the pit. The 1997 Draft EIS, Chapter IV, Section IV.B.7.b predicted that the water table under the Partial Backfill Alternative would rise to the 5,050-foot elevation and begin to discharge to the Tdf/colluvial aquifer (Hydrometrics, 1995). The discharge rate estimated in the 1997 Draft EIS was 50 gpm. New information was analyzed for this SEIS to update this prediction.

Seepage of groundwater from the pit backfill would begin approximately 21 years after mining ceases, when the groundwater level reached the 5,050-foot elevation (Telesto, 2006). At this point, only about 26 percent of the backfill

would be saturated. A steady state pit groundwater elevation of 5,260 feet would be reached approximately 61 years following the cessation of mining, when 67 percent of the backfill would be saturated (Telesto, 2003a). The discharge rate from the pit would be 27 to 42 gpm.

As discussed in Section 3.3.6, a local groundwater divide exists near the eastern rim of the pit between wells PW-62 and PW-64 (Figure 3-7). From this point, the groundwater potentiometric gradient declines toward the hydrologic sink maintained in the pit to the west, and it declines abruptly to the Range Front Fault and the Tdf/colluvial aquifer to the east (see Figure 3-7). In a backfilled pit without water level control, groundwater levels are predicted to reach a steady state at the 5,260-foot elevation (Telesto, 2003a), which is between 68 and 115 feet above the groundwater divide which has existed during open pit mining. Although the Corridor Fault is believed to be relatively permeable, the pit backfill would continue to weather, forming oxidation byproducts and becoming less permeable over time. It requires a hydraulic head to move groundwater through the backfill to the fault to discharge from the pit.

Under the Partial Pit Backfill With Downgradient Collection Alternative, groundwater would saturate over 67 percent of the backfilled pit, and the water level would encounter the Corridor Fault at an elevation between 5,150 feet on the north side of the pit and 5,250 feet on the east side of the pit (Telesto, 2003a). Because the hydraulic head on the north side of the pit is higher than the water levels in the pit, the majority of the flow from the pit to the Corridor Fault is expected to occur near the east side of the pit.

Due to its large size and orientation, the Corridor Fault was identified in Section 3.3.7.2 as the primary pit flow path crossing through the pit and connecting with the Range Front Fault (HSI, 2003). The thick Quaternary gravel and debris flow deposits east of the Range Front Fault on the eastern rim of the pit, as mapped by Chadwick (1992), are hydrologically connected to the Tdf/colluvial aquifer in the upper Rattlesnake Gulch (URS, 2001; HSI, 2003). The majority of pit outflow is expected to migrate through the Corridor Fault and be conveyed to the Tdf/colluvial aquifer along and across the Range Front Fault (Gallagher, 2003a; HSI, 2003; Telesto, 2003a; URS, 2001).

As described in Section 3.3.1.4, the Tdf/colluvial aquifer is a buried gravel deposit forming a continuous groundwater pathway from the east edge of the pit and south through Rattlesnake Gulch, where it blends with the T/Q alluvial aquifer beneath Tailings Impoundment No. 1, reaching to the Jefferson River alluvial aquifer (HSI, 2003). The existence and extent of this flow path was mapped from geologic data in a number of detailed studies since 1982 (HSI, 2003). A map of the groundwater flow paths from the pit is provided in Figure 3-8 (HSI, 2003).

The 1997 Draft EIS, Chapter IV, Section IV.B.1.e predicted that the groundwater base flow captured below Tailings Impoundment No. 1 in Rattlesnake Gulch would be 200 gpm. New analyses based on additional information were conducted for this SEIS (HSI, 2003). The quantity of groundwater flow through the buried Tdf/colluvial aquifer in upper Rattlesnake Gulch north of Tailings Impoundment No. 1 has been estimated from existing data. The flow rate estimated with channel geometry data from Golder (1995a), geometric mean permeability from Golder (1995a) and SHB (1987) of 3.6 feet/day, and the new potentiometric map (HSI, 2003) indicates the ambient discharge would be a maximum of 103 gpm. The existing interception wells located in the upper portion of Rattlesnake Gulch above the Tailings Impoundment No. 1 produced a combined average of 50 gpm from 1998 through mid-2005 (Shannon Dunlap, GSM, personal communication, 2006).

4.3.4.1.1.2.1 Impacts to Water Quality

The Partial Pit Backfill With Downgradient Collection Alternative is the only alternative studied in detail that would not maintain the pit as a hydrologic sink. Overall groundwater capture efficiency of 96 percent or greater would be required to meet DEQ-7 water quality standards at the mixing zone boundary for the toxic and carcinogenic parameters modeled (HSI, 2006). The groundwater standard for iron, which is a secondary (harmful) standard would not be met at 96 percent capture efficiency (HSI, 2006, 2007). Groundwater discharging from the pit along the primary flow path would be captured by a series of wells in upper Rattlesnake Gulch and the existing Tailings Impoundment No. 1 South Pumpback system (Figure 3-5). Continued dewatering in the Rattlesnake Gulch drainage is an unavoidable impact of the groundwater capture system. Ninety-six percent capture efficiency may not be achievable, as described in Section 4.2.3.1.2. Based on their experience, the agencies believe a maximum capture efficiency of 80 percent per system is potentially achievable.

Degradation of groundwater quality would likely occur upgradient of the collection wells in an area where groundwater is already impacted by ARD from natural mineralization (see Table 4-7) and may eventually be impacted by the portion of the East Waste Rock Dump Complex in Rattlesnake Gulch. Although this area is within the permitted GSM mixing zone, pit sources are not included. As discussed below in Section 4.3.4.1.2,2 the water quality modeling and mixing evaluation indicated that degradation of groundwater would also occur in the Jefferson River Alluvial Aquifer at levels that would fail the nonsignificance criteria of ARM 17.30.715 (HSI, 2007),

The higher pit groundwater elevation under this alternative could lead to migration of ARD water from the pit along secondary flow paths in the bedrock aquifer and Bozeman Group aquifer where it is more difficult to detect and collect. As provided in mitigation Measure W-10 in the 1998 Final EIS, additional hydrogeologic studies and monitoring, along with at least 26 groundwater capture

wells, would be needed to attempt to comply with applicable standards. Some seepage would still escape the capture system. This SEIS suggests augmenting the existing monitoring well network with at least 10 additional monitoring wells.

The pit backfill analog study conducted for this SEIS did not find any hardrock mine in the U. S. or Canada in which such a large pit was backfilled and allowed to become saturated with groundwater (Gallagher, 2003c). No long-term water quality monitoring records exist at the backfilled mines or flooded underground mines studied sufficient to indicate whether the reclamation goals at those mines were achieved.

4.3.4.1.1.2.2 Impacts to Water Quantity

This alternative poses a greater risk than the Partial Pit Backfill With In-Pit Collection Alternative by creating new springs or having seeps impacted by ARD from the pit or increased discharges of ARD at existing springs around the pit area. Such new or increased sources of contaminants would be within GSM's established mine-wide mixing zone. Pit sources are not approved and would trigger a permitting review by the DEQ.

4.3.4.1.1.2.3 Summary of Pit Impacts to Water Quality and Quantity

The Partial Pit Backfill With Downgradient Collection Alternative does not maintain the pit as a hydrologic sink. It relies on the success of pumpback wells to capture and treat the groundwater in the permanent water treatment plant. Ninety-six percent capture efficiency is required, but may not be achievable, to avoid a violation of a water quality standard (HSI, 2006). Based on their experience, the agencies believe a maximum capture efficiency of 80 percent per system is potentially achievable.

4.3.4.1.2 Risk of Violation of Groundwater Standards at the Permit Boundary and Impacts to Beneficial Uses of the Jefferson River Alluvial Aquifer

4.3.4.1.2.1 Impacts from Waste Rock Dump Seepage

Impacts from 1 to 3 gpm of seepage from the East Waste Rock Dump Complex in Rattlesnake Gulch under this alternative would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative.

4.3.4.1.2.2 Impacts from Pit Seepage

4.3.4.1.2.2.1 Impacts to Water Quality

The alternatives analyzed in the1997 Draft EIS did not include a scenario in which the pit would be permitted to freely discharge without being maintained as

a hydrologic sink. In addition, the 1997 Draft EIS, Chapter IV, Section IV.B.1.a found that there would be no impacts to the Jefferson River alluvial aquifer at any future time due to seepage from the waste rock dumps. The 1997 Draft EIS did not specifically analyze the rate of flow or attenuation potential of the Jefferson River alluvial aquifer.

Any uncaptured water originating from the pit would eventually migrate to the Jefferson River alluvial aquifer at the southern limit of the GSM permit area through the Tdf/colluvial aquifer and Quaternary alluvial aquifer occupying lower Rattlesnake Gulch, or the underlying Bozeman Group aquifer (Hydrometrics, 1994,1997; Keats, 2001, 2002). The Jefferson River alluvial aquifer consists of the stream deposits laid down by the Jefferson River. Based on the drill holes and monitoring wells installed by GSM in 2004 and 2005, the alluvial aquifer probably consists of two or more sand and gravel terraces which are hydrologically connected (Spectrum Engineering and Gallagher, 2005). The width of the Jefferson River alluvial aquifer is approximately 1,000 feet, from its northern limit to the closest point on the Jefferson River Slough within the GSM permit boundary (Figure 3-6). Geologic logs of GSM and private wells indicate that the saturated thickness of coarse sand, gravel and cobbles averages about 20 feet in the area along Interstate 90 and the Jefferson River Slough (HSI, 2003). Based on Jefferson River alluvial aquifer properties from previous studies, it is estimated that approximately 99 gpm of groundwater flows through the Jefferson River alluvial aquifer within the GSM permit boundary (HSI, 2003). The hydrologic and water quality parameters of the Jefferson River alluvial aquifer are provided in HSI (2003, 2006).

The water quality data for the inputs to the pit flow path model were updated through 2004 and revised to use the appropriate sources (HSI, 2006). New hydrogeologic and water quality data on the Jefferson River alluvial aquifer became available from GSM studies conducted after the Draft SEIS.

The Tdf/colluvial aquifer would have the theoretical capacity to attenuate 1.9 to 2.8 pore volumes of mixed pit discharge and ambient groundwater before the exchange capacity of the aquifer materials would reach a steady state with the groundwater (HSI, 2003). Since the 1 to 3 gpm of seepage from the portion of the East Waste Rock Dump Complex in Rattlesnake Gulch may reach the Tdf/colluvial aquifer first, little or no attenuation capacity may remain for the pit-impacted groundwater. With the 87.5 percent groundwater capture efficiency by the upper Rattlesnake Gulch collection system that would be required for this alternative, the Tdf/colluvial aquifer below this row of wells would only have 10 to 20 years of attenuation capacity (HSI, 2003, 2006). Since the exchange process is reversible, metals that were sorbed onto the aquifer materials could be remobilized by additional ARD seepage. Therefore, over the long term, the Tdf/colluvial aquifer would not attenuate ARD, and only mixing and collection would reliably serve to mitigate potential impacts.

A mass water balance was calculated using between 27 and 42 gpm of pit seepage, obtained from the revised pit water balance (Telesto, 2006), 52 to 103 gpm of ambient groundwater in Rattlesnake Gulch, and 1 to 3 gpm of seepage from the portion of the East Waste Rock Dump overlying Rattlesnake Gulch. A total of 80 to 148 gpm of contaminated groundwater would migrate down the Tdf/colluvial aquifer.

The analysis provided results for a range of capture efficiencies due to the variation in potential hydrogeologic conditions and operations. Bulk capture efficiencies over 95 percent have been estimated in an evaluation of cyanide capture below Tailings Impoundment No. 1 South Pumpback system for a single short period of time (Hydrometrics, 1994; HSI, 2003). This level of capture efficiency for a mixture of pit effluent and native groundwater would be less likely due to longer, more complex and heterogeneous flow paths along the Tdf/colluvial aquifer, and the potential for migration through adjacent bedrock aquifers. The lower capture efficiencies, a lack of long-term attenuation capacity in the flow paths (HSI, 2003, 2006), and the possibility of not identifying discrete flow paths (Keats, 2001) result in a greater risk of violating water quality standards at the mixing zone boundary. Keats (2001) concluded the second and third rows of pumpback wells were not completely capturing the seepage. Keats recommended treatment at the source area rather than adding pumpback wells. This was due in part to the difficulty in defining smaller scale contaminant pathways. Based on experience at GSM, capture efficiencies of 80 percent could be achieved for the individual groundwater collection systems included in Measure 15a (see Section 4.8.2.1).

This SEIS analysis indicates that the continued operation of the South Pumpback system would be needed to attempt control of contaminants from the tailing impoundment, naturally mineralized groundwater and potentially other future sources. Long-term downgradient monitoring would be required to assure continued compliance.

The primary pit flowpath model for the Draft SEIS predicted that two groundwater collection systems operating at 80 percent would achieve groundwater standards at the mixing-zone boundary. The dynamic systems model developed for the Draft SEIS predicted that two groundwater collection systems operating at 80 percent capture efficiency would result in an overall capture efficiency of 95 percent. This was based on an assumption of two capture systems in series without any intervening recharge occurring between the two capture systems. As a result of agency review and comments, the primary pit flowpath dynamic systems model was modified for the Final SEIS to better represent groundwater capture and recharge along the flowpath (HSI, 2006). The dynamic systems model modification accounted for natural recharge between the two systems, meaning that capture efficiency must slightly increase to capture sufficient contaminant mass so water quality standards are not exceeded. As a result, two capture systems operating at 80 percent capture efficiency give an overall

capture efficiency of approximately 92 percent. For the Final SEIS, the rate of seepage from the pit to the primary pit flow path was varied from 27 to 42 gpm, as predicted in the revised water balance model (Telesto, 2006).

The revised primary pit flowpath modeling conducted for the Final SEIS indicates that nickel especially, and cadmium, copper, arsenic, and zinc are the most critical parameters with respect to meeting groundwater standards in the Jefferson River alluvial aquifer at the mixing-zone boundary (HSI, 2006, 2007). Table 4-8 summarizes the DSM findings, and Table 4-2 depicts nickel concentrations under different groundwater capture scenarios and pit seepage rates.

Table 4-8. Ability to Meet DEQ-7 Groundwater Standards and Nondegradation Criteria in Jefferson River Alluvial Aquifer with the Partial Pit Backfill With Downgradient Collection Alternative for Selected Parameters.

Parameter	DEQ-7 GW Stds mg/l	No Capture of Pit Seepage	One Downgradient Capture System at 80% Efficiency	Two Downgradient Capture System, each at 80% Efficiency for a total of 92% (Measure 15a, Section 4.8.2.1)
Predicted Pit Seepage		27 – 42 gpm	27-42 gpm	27-42 gpm
Arsenic	0.01	DEQ-7 standard exceeded. Nondegradation criteria failed.	DEQ-7 standard met. Nondegradation criteria failed.	DEQ-7 standard met. Nondegradation criteria failed.
Cadmium	0.005	DEQ-7 standard exceeded. Nondegradation criteria failed.	DEQ-7 standard exceeded. Nondegradation criteria failed.	DEQ-7 standard met. Non degradation criteria failed.
Copper	1.3	DEQ-7 standard exceeded. Nondegradation criteria failed.	DEQ-7 standard exceeded. Nondegradation criteria failed.	DEQ-7 standard met. Nondegradation criteria failed.
Nickel	0.1	DEQ-7 standard exceeded. Nondegradation criteria failed.	DEQ-7 standard exceeded. Nondegradation criteria failed.	DEQ-7 standard exceeded. Nondegradation criteria failed.
Selenium	0.05	DEQ-7 standard met. Nondegradation criteria failed.	DEQ-7 standard met, Nondegradation criteria failed	DEQ-7 standard met. Nondegradation criteria met.
Zinc	2	DEQ-7 standard exceeded. Nondegradation criteria failed.	DEQ-7 standard met. Nondegradation criteria failed.	DEQ-7 standard met. Nondegradation criteria failed.

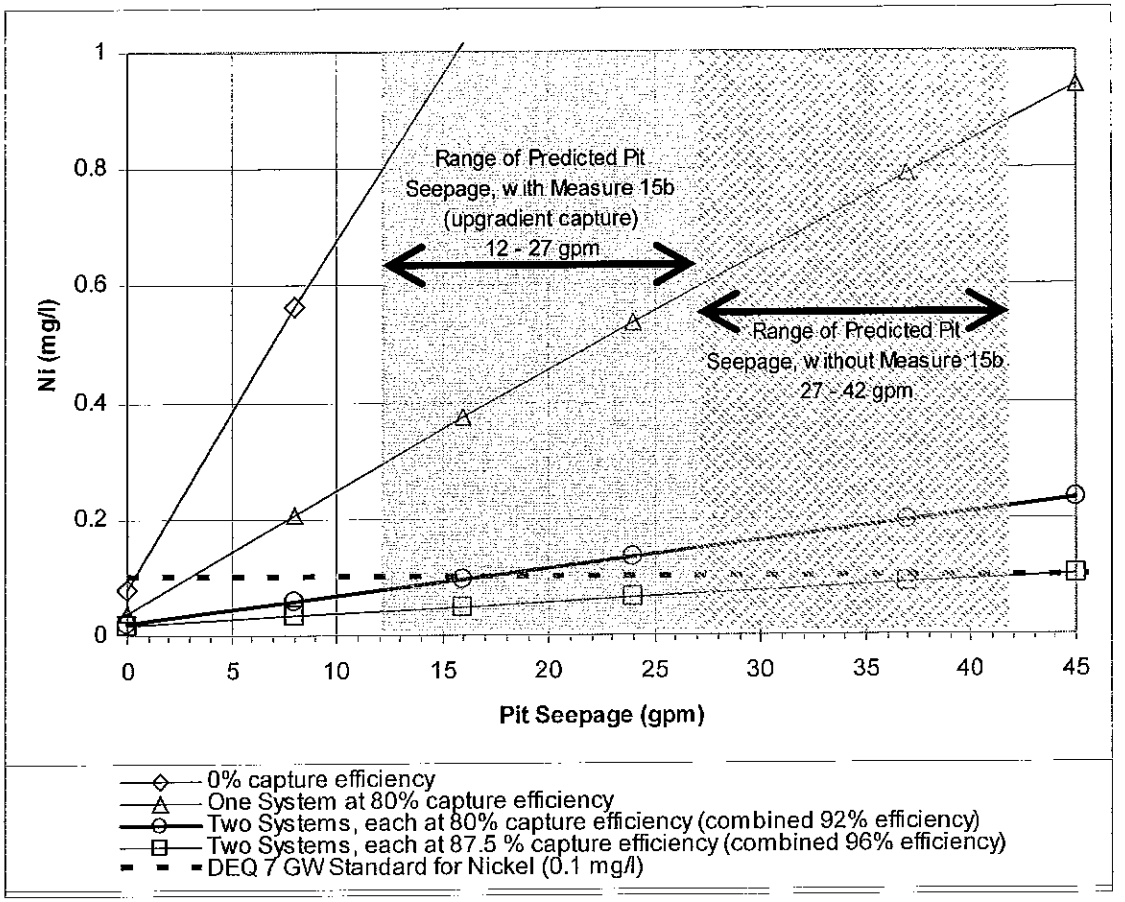


Figure 4-2. Predicted nickel concentration at the mixing zone boundary for various groundwater capture scenarios and pit seepage rates; the gray boxes represent the predicted ranges of pit seepage with and without upgradient capture.

The results of the primary pit flowpath modeling are summarized in the following points with respect to DEQ-7 groundwater quality standards and Nondegradation criteria (17.30.715 ARM). Mitigation measures discussed below are described in Section 4.8.2.1.

- If no pit seepage were captured, DEQ-7 groundwater standards for cadmium, copper, iron, nickel and zinc would be exceeded over the entire predicted range of pit seepage, and arsenic would be exceeded over a portion of the predicted range. Nondegradation criteria would fail for arsenic, cadmium, copper, iron, nickel and zinc over the entire predicted range of pit seepage, and selenium would fail over a portion of the predicted range.

- With one down-gradient collection system operating at 80 percent efficiency, DEQ-7groundwater standards for cadmium, copper, iron and nickel would be exceeded over the entire predicted range of pit seepage. Nondegradation criteria would fail for arsenic, cadmium, copper, iron, nickel and zinc over the entire predicted range of pit seepage, and selenium would fail over a portion of the predicted range.
- With mitigation Measure 15a (two collection systems, each operating at 80 percent capture efficiency), DEQ-7 groundwater standards for nickel and iron would be exceeded over the entire predicted range of pit seepage. Nondegradation criteria would fail for arsenic, cadmium, copper, iron and nickel over the entire predicted range of pit seepage, and zinc would fail over a portion of the predicted range.
- To meet DEQ-7 groundwater standards with only Measure 15a, the capture efficiency of individual capture systems would have to be approximately 87.5 percent each, resulting in an combined 96 percent capture efficiency (HSI, 2006). At 96% capture, nondegradation criteria for arsenic, cadmium, copper, iron and nickel would fail over the entire predicted range of pit seepage (HSI, 2007). Based on their experience, the agencies believe a maximum overall capture efficiency of 80% per system is potentially achievable (equivalent to 92% combined efficiency of two systems in mixing evaluation of HSI, 2006, 2007).
- With mitigation Measure 15a operating at a combined capture efficiency of 92% and mitigation Measure 15b (15 gpm of up-gradient groundwater capture) the DEQ-7 groundwater standard for nickel would be exceeded over a portion of the predicted pit seepage range (see Figure 4-2), and the groundwater standard for iron would be exceeded over the entire predicted range.
- With Measures 15a and 15b in place, additional capture systems would be required if pit seepage rates exceed 16 to 18 gpm. Implementing Measure 15c (near-pit downgradient groundwater collection) may further reduce pit seepage. However, for reasons discussed in Section 4.8.2.1 (and HSI, 2006), measure 15c would not be likely to reduce pit seepage sufficiently to meet DEQ-7 groundwater standards over the entire predicted range of pit seepage.

Based on the updated analysis for the FSEIS (HSI, 2006, 2007; Telesto, 2006), the agencies concluded that even with all identified mitigation measures (Section 4.8.2.1), compliance with DEQ-7 groundwater standards for metals in the JRA Aquifer could not be expected over the entire predicted range of pit seepage. Based on the water quality modeling and mixing evaluations (HSI, 2006, 2007) the agencies also concluded that degradation of groundwater would occur in the Jefferson River Alluvial Aquifer at levels that would fail the nonsignificance criteria of ARM 17.30.715. The consequences of failure of the groundwater capture system are discussed in Section 4.2.3.9.2.

Contingency measures for additional groundwater capture, such as Measure W-4 approved in the 1998 ROD as Stipulation 010-7, would be necessary for implementation of this alternative in the absence of the Tailings Impoundment No.1 south pumpback system. Measure W-4 requires monitoring of groundwater at the mixing zone boundary and establishment of additional capture wells as a contingency under the GSM operating permit. If the pit is allowed to discharge under this alternative, groundwater quality would likely deteriorate up gradient of the collection wells in an area where groundwater is already impacted by ARD from natural mineralization and would be impacted by seepage from the portion of the East Waste Rock Dump Complex that overlies Rattlesnake Gulch. The pit discharge of between 27 and 42 gpm was not included in the 1998 Final EIS, Appendix 1 mixing zone analysis.

Secondary groundwater flow paths were not identified in the 1997 Draft EIS. As the groundwater level rises in the pit backfill under this alternative to the 5,260-foot elevation, the agencies expect that 10 percent of the 27 to 42 gpm of pit discharge, or 2.7 to 4.2 gpm, would also migrate into fractures, faults and other geologic structures in the bedrock forming the pit highwall (HSI, 2003). Many of these structures provide the pathways for the seeps and springs discharging into the pit during mining (Gallagher, 2003b). The additional flow pathways are called "secondary" because their extent and continuity outside the pit may be limited or incompletely mapped, their hydrologic connection to existing surface water or groundwater features may be indirect, or their importance is inferred primarily by association with ferricrete deposits or high-yield wells, which provide indirect evidence of a pathway.

The Precambrian LaHood Formation, which is the bedrock hosting the ore body, has little to no natural attenuation capacity (Schafer and Associates, 1994). This rock, where mineralized, has produced acidity and metals naturally. Thus, any ARD migrating out of a saturated backfilled pit through bedrock structures would not likely be attenuated within the bedrock aquifer and may encounter mineralized zones, which could further deteriorate water quality.

Due to the uncertainty of secondary groundwater flow paths in the fractured bedrock, groundwater monitoring along known, hydrologically important geologic structures would be a component of this alternative. A review of the existing groundwater monitoring well network in the bedrock aquifer surrounding the pit was performed (HSI, 2003). A summary of the pertinent geologic structures, along with the degree of existing monitoring and recommendations for monitoring wells, is provided in Table 4-9. It indicates that at least 10 monitoring wells on geologic structures and other pathways would be required for this alternative. The potential locations of these wells are shown on Figure 2-7.

Groundwater capture wells on secondary pathways would be a contingency. The wells would not be installed until monitoring indicated a need. Based on previous studies of groundwater capture in bedrock (Hydrometrics, 1995) and experience

in drilling wells at GSM, it is estimated that at least two capture wells would initially be required for each structure with evidence of ARD migration. Testing and monitoring would be required to determine whether two wells achieved sufficient capture efficiency. More wells may be needed based on hydrogeologic studies.

Appendix B in the 1997 Draft EIS provided an analysis in support of a source-specific groundwater mixing zone for GSM. It included an assessment of groundwater capture in the fractured bedrock south of the pit around the West Waste Rock Dump Complex. This assessment concluded that capture efficiencies of 80 percent or greater were theoretically achievable in the fractured bedrock. A capture efficiency of 80 percent resulted in meeting all water quality standards for all metals except copper. An efficiency of 85 percent would result in compliance for copper. This is potentially achievable within the possible range of capture efficiencies. As noted in the 1997 Draft EIS, Appendix B, additional hydrogeologic characterization or capture wells may be required to meet these efficiencies.

Table 4 - 9. Anticipated Monitoring Sites for Groundwater Flow Paths out of a Saturated Pit

Flow Path[1]	Existing Monitoring Locations	Additional No. of Monitoring Wells	Comments
Primary Pit Flow Path			
Corridor Fault	None	2	Suggested locations are north of the key cut at the northeast corner of the pit rim
Range Front Fault	PW-4, PW-58, PW-59, PW-60	1	Suggested location is at or near mine parking lot, designed to intersect the fault
Tertiary Debris Flow Channel	PW-8, PW-11, PW-12, PW-63, MW-202, MW-200, Rattlesnake Spring, Bunkhouse Springs	0	Includes wells north of Tailings Impoundment No. 1 with the exception of the Rattlesnake Gulch interception wells
Secondary Pit Flow Paths			
Bozeman Group Aquifer	EFPB-21	2	Assumes EFPB-21 well would be available. Suggested locations are near the Old Assay Lab and the Buttress Dump

Sunlight Syncline	Stepan Spring, PW-17	1	Suggested location is east of PW-6 well near intersection of Sunlight Syncline and Telluride Zone
Sunlight PDZ	None	2	One suggested location is east of PW-6 well near intersection of Sunlight PDZ and Telluride Zone, a second location to the southeast
Telluride Zone	PW-6	0	Would be covered by wells for Sunlight Syncline and Sunlight PDZ
Latite Valley PDZ	PW-21 and Arkose Valley /Sunlight Springs Trench Drain	2	Suggest at least two additional monitoring wells to be located on the west ridge of pit near intersection of Latite Valley PDZ/Fenner Fault/Lone Eagle Fault
Fenner Fault	None	0	See Latite Valley PDZ
Lone Eagle Fault	None	0	See Latite Valley PDZ
St Paul Gulch PDZ	St Paul Gulch Spring	0	Spring monitoring should continue

[1] As modified from HSI (2003). See Figure 3-1 for fault locations and Figure 2-7 for monitoring well locations.

4.3.4.1.2.2.2 Impacts to Water Quantity

Appendix B and Appendix L of the 1997 Draft EIS evaluated groundwater capture efficiency from fractures in the bedrock aquifer using a flow rate consisting of 12 gpm of ambient groundwater flux plus 5 gpm of net seepage to groundwater from the West Waste Rock Dump Complex, for a total of 17 gpm flux at the capture wells. This SEIS reviewed the 1997 Draft EIS and applied this evaluation to the capture of seepage from a backfilled pit with downgradient collection. The rate of groundwater flux through secondary bedrock flow paths (faults, fractures and other geologic structures) from a backfilled pit not maintained as a hydrologic sink was estimated to be roughly 10 percent of the total pit outflow of 16 gpm, or 1.6 gpm, based on best professional judgment. The SEIS analysis of the groundwater impacts from a backfilled pit with downgradient collection found that an additional 1.6 gpm could be expected at downgradient capture wells in the bedrock aquifer. This additional flow is relatively minor and is adequately encompassed within the range of variability inherent in the capture analysis of the 1998 Final EIS.

The Partial Pit Backfill With Downgradient Collection Alternative would result in 1.6 gpm of pit seepage along secondary flow paths around the pit due to the higher hydraulic head in the pit relative to the groundwater elevations surrounding the pit (HSI, 2003).

Following implementation of the Partial Pit Backfill With Downgradient Collection Alternative, the presence of new or increased pit seepage would be determined through review of monitoring results and trends in conjunction with other relevant information. Evidence of both increased quantity and/or decreased quality of groundwater seepage or existing springs could trigger an agency review of the need for an MPDES permit or permit modification and applicability of Effluent Limitation Guidelines.

Measure W-10, Stipulation 010-13 in the 1998 ROD, would be modified to include additional hydrogeologic studies and monitoring, along with groundwater capture wells east and south as well as west of the pit. Wells installed as a result of these studies would attempt to offset this problem of complying with applicable standards. Existing and additional conceptual monitoring well locations are suggested in this SEIS for bonding purposes (Figure 2-7 and Table 4-8). More wells would be needed due to the uncertainty of hitting groundwater flow paths.

Secure funding and infrastructure are required to collect and treat contaminated water in perpetuity. The principal consequence of failure of this alternative would be undetected or uncaptured discharges of ARD-impacted groundwater from the backfilled pit, which could adversely impact springs and beneficial uses of the Jefferson River alluvial aquifer. In the worst case with no pumping and collection of pit seepage, 16 gpm could reach the Jefferson River alluvial aquifer compared to no discharge expected in the alternatives that maintain the pit as a hydrologic sink.

4.3.4.2 Impacts to Surface Water Quality and Quantity

4.3.4.2.1 Impacts to Springs, Wetlands

4.3.4.2.1.1 Impacts from Waste Rock Dump Seepage

The impacts to springs and wetlands from waste rock dump seepage would be the same as the No Pit Pond Alternative.

4.3.4.2.1.2 Impacts from Pit Seepage

The 1997 Draft EIS, Chapter IV, Section IV.B.1.b concluded that some spring flows could be reduced because the pit would remain a hydrologic sink. The potential impacts to springs discussed under the No Pit Pond and Partial Pit Backfill With In-Pit Collection alternatives in this SEIS were also primarily related to diminishing spring flows with the pit maintained as a hydrologic sink. Under

the Partial Pit Backfill With Downgradient Collection Alternative, the pit would not be maintained as a sink. After approximately 123 years, groundwater in the pit would reach steady state with the surrounding groundwater system at an elevation of 5,260 feet (Telesto, 2003a). Under this alternative, the potential adverse impacts to springs would be related to an increase in quantity of flow and a decrease in water quality. Of the eight bedrock geologic structures identified as possible groundwater flow paths from a saturated pit, six are associated with springs or seeps (see Section 3.3.4, and HSI, 2003). Figure 3-5 shows all the springs around the pit.

Stepan, Stepan Original, Sunlight, Arkose Valley, and Midas springs are situated around the pit and are associated with faults or synclines, or with abandoned mine Adits, which are also on geologic structures. Rattlesnake, Bunkhouse and North Borrow springs are situated where discharge from a backfilled pit along the primary flow path could adversely impact the quality and quantity of these springs prior to the point of initial capture in Rattlesnake Gulch. The former Midas Spring is a seasonal discharge that occurs in an active slump area (DEQ and BLM, 1998) and was buried by the East Waste Rock Dump Complex (See Section 4.2.1.5.2.1.6). The source of the spring is uncertain but may originate from the abandoned Midas Adit. It may become acidified within the adit and by contact with waste rock in the dump. It is captured and conveyed to treatment.

Some springs, including Rattlesnake, Bunkhouse, Stepan, and Stepan Original have been slightly to strongly acidic and contain some elevated metal concentrations (Table 3-1). This water quality is due to natural mineralization, but possibly affected by historic underground mining. These springs also have ferricrete deposits, which are indicative of long-term deposition of iron and other minerals by groundwater discharge before mining began in the area (HSI, 2003).

In addition, potential impacts could occur to springs having better water quality than that located in the pit, including the Sunlight and Arkose Valley springs. These two springs are on the Latite Valley PDZ, a geologic structure that has four of five indicators of a possible groundwater flow path from a saturated pit (HSI, 2003).

The potential impacts to these springs would likely include increased acidity with eventual increased concentrations of dissolved metals, such as aluminum, cadmium, copper, iron, manganese, nickel, zinc, and other constituents, such as sulfate and total dissolved solids. The flows and quality of springs having hydrologic connections to the pit did not noticeably decrease during operations, even with the drought (HSI, 2003). These flows could increase and their water quality decrease somewhat from levels experienced during mining due to the recovery of groundwater levels and hydraulic head in the pit under this alternative. This alternative is more likely to increase discharges of ARD at existing springs around the pit area, or create new springs or seeps impacted by ARD from the pit, than alternatives that maintain the pit as a hydrologic sink.

There is a reasonable likelihood that, under the Partial Pit Backfill With Downgradient Collection Alternative, one or more existing springs could be adversely impacted by the discharge from a backfilled pit. These potential water quality impacts could trigger an MPDES permitting review by DEQ. There is an additional potential for the creation of new springs or seeps around the backfilled pit in locations where the hydraulic head in the pit is greater relative to the groundwater elevations in possible groundwater pathways from fractures and old mine workings (HSI, 2003). Such new springs would also be subject to an MPDES permitting review by DEQ.

Measure W-1, Stipulation 010-4 in the 1998 ROD, would be modified to monitor for increased discharges from existing springs and seeps and for new springs and seeps. Any change to springs and seeps quantity and/or quality, and their associated source of contaminants, would be subject to an MPDES permitting review by DEQ. For bonding purposes, the agencies have assumed that one existing spring, Stepan Spring, would have a 15 percent increase in flow that would have to be collected and treated, and that one new spring discharging 1.5 gpm would develop and would be collected and treated under an MPDES permit. The assumed flow rate changes are based on existing spring information for the area and are strictly assumptions for analysis purposes.

4.3.4.2.2 Risk of Violation of Surface Water Standards and Beneficial Uses of the Jefferson River and Slough

4.3.4.2.2.1 Impacts from Waste Rock Dump Seepage

Impacts from 1 to 3 gpm of seepage from the East Waste Rock Dump Complex in Rattlesnake Gulch under this alternative would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative.

4.3.4.2.2.2 Impacts from Pit Seepage

Pit seepage under this alternative would be more likely to reach the Jefferson River alluvial aquifer and the Jefferson River and Slough. Pit seepage would be allowed to leave the pit and reach the Tdf/colluvial aquifer, where it would be partially captured by two lines of capture wells and other wells on flow paths (Table 4-8). Two groundwater capture systems, a new one in Rattlesnake Gulch (see Figure 4-5) and the Tailings Impoundment No. 1 south pumpback system, would be used to try to capture this seepage. The point of control of the pit seepage would be much closer to the Jefferson River alluvial aquifer. There is little attenuation capacity in the Tdf/colluvial aquifer. High capture efficiencies are not reliably assured, as described in Section 4.2.3.1.2. At 92% combined capture efficiency, the DEQ-7 surface water standard for aluminum would be exceeded in the Jefferson Slough (HSI, 2006, 2007). In addition, as described in Chapter 6, Response to Comment #58, nondegradation criteria for the Slough fail

for aluminum, copper and iron. Control of potential pit seepage along secondary pathways is another complication. The risk of contaminants reaching the Jefferson River Slough or Jefferson River is greater than for alternatives that maintain the pit as a hydrologic sink.

4.3.4.3 Reclamation Plan Changes

4.3.4.3.1 Surface Disturbance

Surface disturbance for the Partial Pit Backfill With Downgradient Collection Alternative would be similar to the Partial Pit Backfill With In-Pit Collection Alternative, except 2 additional acres would be disturbed for downgradient collection wells, access roads, pipelines, and powerlines (Table 4-6). The number of acres on 2H:1V slopes requiring coversoil rock amendments under this alternative would be the same as the Partial Pit Backfill With In-Pit Collection Alternative.

4.3.4.3.2 Hazards to Wildlife

Hazards to wildlife under this alternative would be similar to the Partial Pit Backfill With In-Pit Collection Alternative, except that there is a greater potential for impacts to springs down gradient of the pit.

4.3.4.3.3 Total Remaining Unrevegetated Acres

There would be no remaining unrevegetated pit acres under this alternative.

4.3.5 Underground Sump Alternative

Under this alternative, the underground workings beneath the pit would be adapted to be used as a sump for removing water from the pit and routing it to the water treatment plant after closure. The design of the underground collection system is discussed in Section 2.4.5.3. The pit would be maintained as a hydrologic sink, similar to the No Pit Pond Alternative and Partial Pit Backfill With In-Pit Collection Alternative. The ultimate pit design would be the same as the other alternatives, except no material would be backfilled into the bottom of the pit. A new portal would be developed at the 4,550-foot elevation to replace the 4,857-foot portal, which was eliminated during Stage 5B mining. Only rock raveling off the highwall over time and highwall rock from assumed failures would accumulate on the pit bottom, as described in Section 4.2.4.9.1.

Compared to other alternatives, groundwater and precipitation entering the pit would encounter the least amount of acidic rock in the lower pit, which is estimated by the agencies to be 200,000 cubic yards (300,000 tons) over the long term, prior to being captured and sent to treatment. Unlike the No Pit Pond Alternative, a staging area for pumping facilities would not be required inside the pit. Underground access would, however, still need to be maintained. As a contingency against failures, which could destroy the 4,550-foot-elevation portal, the agencies would require GSM to submit a plan for development, maintenance and monitoring of a portal at a suitable alternative elevation. If the 4,550-foot-elevation portal is inaccessible, GSM would have to submit a plan for a secondary escape way and access to the underground workings. Additional details on the design of this alternative may be found in Section 2.4.5.

4.3.5.1 Impacts to Groundwater Quality and Quantity

4.3.5.1.1 Risk of Impacts to Groundwater Quality and Quantity in Permit Area

4.3.5.1.1.1 Impacts from Waste Rock Dump Seepage

Impacts to groundwater resources associated with the East Waste Rock Dump Complex seepage are generally the same as were described for the No Pit Pond Alternative.

This alternative would result in the largest amount of waste rock in the final East Waste Rock Dump Complex. Based on the relative mass of waste rock, the difference between this alternative and the No Pit Pond Alternative is only about 0.1 percent.

4.3.5.1.1.1.1 Long-Term Monitoring and Mitigation for Unanticipated East Waste Rock Dump Complex Seepage

Long-term monitoring and mitigation under this alternative would be the same as the No Pit Pond Alternative and all other alternatives.

4.3.5.1.1.1.2 Summary of East Waste Rock Dump Complex Seepage Impacts to Water Quality and Water Quantity

Impacts to groundwater under this alternative would be essentially the same as the No Pit Pond Alternative and all other alternatives.

4.3.5.1.1.2 Impacts from Pit Seepage

4.3.5.1.1.2.1 Impacts to Water Quality

Water-related impacts from the pit under this alternative would be similar to those for the No Pit Pond Alternative. Since no waste rock would be placed in the pit, groundwater and precipitation entering the pit would have contact ultimately with 200,000 cubic yards (300,000 tons) of acid-producing rock.

Water quality in the pit under the Underground Sump Alternative would be similar to the No Pit Pond Alternative. Under the Underground Sump Alternative, pumping regularly would remove pit water from the underground sump and send it to the water treatment plant. The regular pumping would minimize changes in groundwater quality and maintain the pit as a sink, with a cone of depression in the potentiometric surface centered on the pit similar to that which presently exists, but 25 to 75 feet deeper. No ARD impacts to groundwater quality outside the pit would be anticipated. If ARD pumped from the pit exceeds the expected rates, mitigation Measure W-6 approved in the 1998 ROD as Stipulation 010-9 would provide for additional water treatment plant capacity to treat the additional flows.

4.3.5.1.1.2.2 Impacts to Water Quantity

A pit water balance model was developed in the 1997 Draft EIS, Table IV-5, which accounted for total inflows and outflows (Hydrometrics, 1995). That model found that complete dewatering of the pit to the 4,700-foot pit floor permitted at that time would require removal of approximately 102 gpm.

The revised SEIS water balance model is described under the No Pit Pond Alternative, Section 4.3.2.1. This SEIS model was calibrated to recent pumping records to predict pit dewatering under the Underground Sump Alternative. Average inflow under the Underground Sump Alternative is expected to be the same as that of the No Pit Pond Alternative. Although the pumping level in the

underground sump would be 25 to 75 feet deeper than in the No Pit Pond Alternative, the rate of groundwater inflow from the underground workings would be minimal (H. Bogert, GSM, personal communication, 2004).

This SEIS has generally found that the water-related impacts of this alternative would be similar to those predicted in the 1997 Draft EIS, Chapter IV, Section IV.B.6 for the No Pit Pond Alternative, except that the long-term pumping rate from the pit sump is projected to be from 25 to 27 gpm, instead of the 102 gpm predicted in the 1997 Draft EIS.

Potential water resource impacts from the Underground Sump Alternative would be limited to possible additional reductions in the bedrock groundwater level and the flows of springs hydrologically connected to the pit, as a result of the continued pit dewatering. This is an unavoidable impact of maintaining the pit as a hydrologic sink.

4.3.5.1.1.2.3 Summary of Pit Impacts to Water Quality and Quantity

Under this alternative, 25 to 27 gpm would be pumped out of the underground sump and treated. Water quality would be similar to that predicted in Table 4-5. Pumping from the underground workings would provide complete control of the predicted pit water discharge. It would be relatively easy to pump from the underground sump as long as access is maintained. The agencies would require a contingency portal location for secondary access to ensure continued pumping and worker safety. As long as access to the underground is maintained, it is relatively easy to repair, replace, and maintain the dewatering system under this alternative. If the predicted pit flows were twice as much as predicted, the dewatering system could easily be upgraded and routed to the water treatment plant. GSM proposed to test in-situ treatment of the water in the underground sump during the 2004-2005 mill shutdown (GSM, 2004). The testing program was never fully implemented due to accessing the pit bottom during mining operations. The wells were installed, lime was placed in the underground, and some chemicals were initially added. Testing was not completed nor is it planned as the pit dewatering has lowered the water below the pumps in the test wells (Shannon Dunlap, personal communication, 2007). Pretreatment of the water in the sump may be possible and has been done at GSM (Shannon Dunlap, GSM, personal communication, 2006). It is anticipated that pit water quality would be slightly better under the Underground Sump Alternative than under the partial pit backfill alternatives because of less contact with reactive rock.

4.3.5.1.2 Risk of Violation of Groundwater Standards at Permit Boundary and Impacts to Beneficial Uses of the Jefferson River Alluvial Aquifer

4.3.5.1.2.1 Impacts from Waste Rock Dump Seepage

The impacts from waste rock dump seepage would be the same as under all the other alternatives.

4.3.5.1.2.2 Impacts from Pit Seepage

The pit would be maintained as a hydrologic sink under this alternative with no additional risk to the Jefferson River alluvial aquifer. If ARD from the pit exceeds the expected rates, provisions such as mitigation Measure W-6 approved in the 1998 ROD as Stipulation 010-9 would provide for additional permanent water treatment plant capacity to treat the additional flows. No untreated water would migrate toward the Jefferson River alluvial aquifer. Water treatment plant effluent would be discharged below Tailings Impoundment No. 2 and would migrate to the Jefferson River alluvial aquifer.

The principal consequence of failure of this alternative would be the creation of an ARD-impacted pit pond. In the Pit Pond Alternative, which was dismissed in Section 2.5.4, the water level in the pit would have risen to the 4,635-foot elevation. Under the Underground Sump Alternative, no backfill would be placed in the pit and 200,000 cubic yards (300,000 tons) of highwall rock would ravel and slough over time. The additional 200,000 cubic yards of material would raise the pit lake a maximum of 32 feet, to approximately the 4,667-foot elevation. This is below the 5,050-foot elevation at which water would begin to seep out of the pit. Since control of water from a pit pond can be accomplished by direct pumping and treating, no adverse impacts to groundwater outside the pit would be anticipated. In addition, water in a pit pond could be more easily pretreated before pumping to the water treatment plant.

4.3.5.2 Impacts to Surface Water Quality and Quantity

4.3.5.2.1 Impacts to Springs, Wetlands

4.3.5.2.1.1 Impacts from Waste Rock Dump Seepage

The impacts to springs and wetlands from waste rock dump seepage would be the same as the No Pit Pond Alternative.

4.3.5.2.1.2 Impacts from Pit Seepage

Under the Underground Sump Alternative, pit water elevations would be maintained within the underground sump, with the pumping level ranging from

4,450 to 4,500-foot elevation. This would be 25 to 75 feet deeper than the water level that would be maintained under the No Pit Pond and Partial Pit Backfill With In-Pit Collection alternatives. Long-term impacts to springs would be similar to those that are predicted under the No Pit Pond Alternative, Section 4.3.2.2.1.2, except that the water table may be further reduced by the 25 to 75-foot deeper cone of depression.

If the groundwater system has not reached equilibrium at the conclusion of mining Stage 5B, long-term impacts to springs from pit dewatering may be somewhat greater than impacts during mining operations and predictions from the 1997 Draft EIS and this SEIS. GSM maintains a spring monitoring program, including flow rates and water quality (GSM, 2002a). Continued monitoring and mitigation measures similar to mitigation Measure W-1 approved in the 1998 ROD as Stipulation 010-4, which requires spring flow and water quality monitoring, would be required.

4.3.5.2.2 Risk of Violation of Surface Water Standards and Impacts to Beneficial Uses of the Jefferson River and Slough

4.3.5.2.2.1 Impacts from Waste Rock Dump Seepage

Impacts from waste rock dump seepage on surface water quality and quantity would be the same as under the No Pit Pond Alternative.

4.3.5.2.2.2 Impacts from Pit Seepage

Impacts from pit seepage under this alternative would be the same as the No Pit Pond Alternative, which predicted no impacts to the Jefferson River and Slough in the 1997 Draft EIS and this SEIS.

4.3.5.3 Reclamation Plan Changes

4.3.5.3.1 Surface Disturbance

Surface disturbance for the Underground Sump Alternative would be similar to the No Pit Pond Alternative. About 285,600 cubic yards of stockpiled soil would be used to revegetate the 52 acres to be reclaimed (7 acres already reclaimed) of pit disturbance.

4.3.5.3.2 Hazards to Wildlife

Hazards to wildlife under this alternative would be the same as the No Pit Pond Alternative.

4.3.5.3.3 Total Remaining Unrevegetated Acres

About 159 acres of the pit disturbance area would be left unrevegetated.

4.4 SOCIOECONOMIC ISSUES

4.4.1 Introduction

Analyses for this SEIS are based on the assumption that GSM would complete Stage 5B, which should extend operations through 2008 (GSM, 2002a). Selection of a pit closure alternative might directly affect the economics on which future mining decisions are based. Moreover, after this mine has been shut down, the type of pit closure that is implemented could have a continued impact on the prospects for future development of the potential remaining mineral resource.

The proposed action in the 1998 Final EIS provided for mining operations to continue through 2006. No increase in work force was expected. Because GSM was in operation and no new work force was required, no changes were expected with regard to population, housing, schools, water supply, waste water treatment, solid waste disposal, fire protection, law enforcement, health care, or community recreation. Tax revenue and other economic benefits would be discontinued at the end of the mine life at the end of 2006.

This SEIS took a more detailed look at the socioeconomic issues. This included evaluating issues such as cultural resources, noise, safety, aesthetics, employment opportunities, revenue from taxes, mineral resources/reserves, and future burden on society and the company (Robertson GeoConsultants, 2003).

Initiation of mining the Stage 5B pit in October 2003 increased mine employment. Underground mining added contractor personnel to the total work force.

4.4.2 No Pit Pond Alternative (No Action)

4.4.2.1 Safety

The topography of the mine area would differ depending on the reclamation alternative that is implemented and would affect safety. The No Pit Pond Alternative has limited backfill, and the pit would be maintained in about the same configuration left by mining. The highwall would have cliff-like configurations that would be hazardous. Stability of the highwall could degrade over time producing periodic raveling and sloughing as described in Section 4.2.1.2.2.

4.4.2.1.1 Risk to Workers (Reclamation and Construction)

After Stage 5B is completed, reclamation and construction of the dewatering system would begin. In the 1997 Draft EIS, Chapter IV, Section IV.N.6 under the

No Pit Pond Alternative, in order to provide safe access to the floor of the pit for construction and operation of the dewatering system, the pit would have been partially backfilled with waste rock from the 4,700-foot to the 4,800-foot elevation, creating a flat working surface of 7.4 acres. In this SEIS under the No Pit Pond Alternative, in order to provide safe access to the floor of the pit for construction and operation of the dewatering system, the pit would be partially backfilled with crusher reject from the 4,525-foot to the 4,625-foot elevation (GSM, 2002a).

This partial backfilling of the pit would allow creation of a flat working area of approximately 1.3 acres (300 feet by 225 feet). Although the area is smaller than the area in the 1997 Draft EIS, the pit highwall at this elevation is more stable than envisioned in 1997 due to the pre-split blasting techniques employed. In addition, there would remain a 70-foot-wide safety bench at the 5,700-foot elevation above three sides of the working area for additional protection. Additional protection would be provided by building one or more berms around the perimeter of the working area to trap incidental rocks that may fall from the highwall. The agencies would require the road leading down to the working area from the 4,875-foot elevation to be widened where possible, depending on the final pit configuration, by extending the road to the south over a portion of the 4,800-foot-elevation area and away from the highwall toe.

Under the No Pit Pond Alternative, trucks loaded with crusher reject would have to drive down the 8 to 12-percent-grade pit haul road to deposit the backfill in the bottom of the pit. Hauling 111,000 cubic yards (167,000 tons) of crusher reject down the pit haul road would expose drivers to an increased hazard for up to 3 months. Because of this risk, GSM's safety policy would require trucks to be operated partially loaded.

Operating bulldozers to level the backfill and drilling equipment to install the dewatering wells below the pit highwall would expose workers to some risk. Although pit safety benches would be maintained to minimize hazards to workers, operating equipment below unstable areas would be a concern.

The safety risk to reclamation workers under the No Pit Pond Alternative is increased while backfill is being hauled down the steep roads into the pit, because the potential for truck accidents would be increased mainly from brake failures. In addition, the workers would be below a highwall of up to 1,875 feet increasing the risk of injury from rock falls.

The Mine Safety and Health Administration (MSHA) tracks mine related injuries and reports national average non-fatal, days lost (NFDL) accident rates. These numbers for surface metal mines have ranged from 1.79 to 2.82 NFDLs per year from 1993 through 2006 (www.msha.gov). No attempt was made to assign lost time accidents by alternative. The longer reclamation takes, the higher the likelihood of having NFDLs or even a death. Under the No Pit Pond Alternative,

reclamation would take 23 person years to complete, and total mine reclamation and construction would take about 123 person years to complete.

4.4.2.1.2 Risk to Workers (Long-Term Maintenance)

Under the No Pit Pond Alternative, workers in the pit would be exposed to pit highwall raveling and sloughing hazards from the 1,775-foot highwall. The No Pit Pond Alternative would require long-term access to the pit bottom for monitoring and maintenance of the pit haul road, 5,700-foot-elevation pit safety bench, and the dewatering system.

4.4.2.1.3 Risk to Public Safety

Access restrictions on general public use would be maintained under the No Pit Pond Alternative. Access restrictions would consist of signs, berms, and fencing around the pit area, but there would still be a risk to public safety because of the pit highwall.

4.4.2.2 Mining Employment

4.4.2.2.1 Potential Employment from Mining Stage 5B

The 1997 Draft EIS, Chapter IV, Section J.2.a predicted employment and potential tax revenues for mining the Stage 5 pit. Table 4-10 summarizes employment opportunities and potential tax revenues of the alternatives in this SEIS through the end of Stage 5B compared with the projections from the 1997 Draft EIS.

Table 4 - 10. Total Mining Employment and Economic Benefits of GSM Through Stage 5B

ITEM	1997 Draft EIS Projection (1997-2011)	SEIS Projection (1997-2009)	Current (1997-2005)
Average Number of Employees (1997 thru 2011)	96 (average)	119	138
Salaries	60,111,200	82,918,724	69,124,605
Payroll Taxes	4,872,000	16,583,745	6,680,835
Benefits	11,038,850	33,167,490	16,427,905
Revenue from Taxes Paid (Property, Gross Proceeds, Metals Mine License, State)	21,523,400	19,125,719	13,770,841
Purchases of Goods and Services, Inside and Outside of Montana	386,516,279	367,117,592	252,178,212
Total	484,061,729	518,913,270	358,182,398

Under the No Pit Pond Alternative, GSM would be expected to complete mining and reclamation tasks within a period of 10 years. The continued operation of the mine under Stage 5B would provide employment for mine personnel. No new work force would be expected from current levels. No new changes induced by the project are anticipated with respect to population, housing, schools, water supply, wastewater treatment, solid waste disposal, fire protection, law enforcement, health care, or community recreation.

Since 1983 when major mining development was initiated at GSM, employment has ranged from 74 to 301 employees. As of May 2006, GSM employed a total of 157 persons with an additional 22 contractor personnel. GSM has maintained a policy of hiring from the local area when possible since inception of operations. The number of employees needed to complete Stage 5B mining would vary by year. There is also a multiplier effect for secondary employment opportunities. This effect results in other indirect employment opportunities.

Upon completion of Stage 5B mining and mine closure under all alternatives, there would be an immediate staff reduction. When employment terminates, workers would find other jobs locally or relocate, depending on job availability. Workers remaining in the area would continue to make demands on community services and could increase the demand on assistance programs.

The community of Whitehall would experience impacts from closure of the mine. Typically, approximately 65 percent of the GSM workforce resides in the

Whitehall area. It is estimated that as of June 2004, 10 percent of the town's population is employed full time at the mine (104 people out of a population of 1,044). If a typical family of three is assumed, approximately 30 percent of the population would be estimated to be dependent on GSM employment. In addition, mining jobs support secondary employment in the services sector and other industries (Table 4-10).

The anticipated mining employment opportunities from mining Stage 5B under the No Pit Pond Alternative are 750 person years.

4.4.2.3 Reclamation Employment

4.4.2.3.1 Reclamation Employment Opportunities

After mining ceases, a reduced labor force would be employed for a period of up to 3 years to complete reclamation and to prepare the site for long-term water treatment. About 2 years would be required to decommission the facilities, place 100 feet of crusher reject in the pit bottom, and reclaim other disturbed areas. The predicted employment opportunities during reclamation under the No Pit Pond Alternative are 123 person years. Only about 23 person years of this total would be attributable to pit closure tasks. Following pit closure, dewatering and water treatment would continue indefinitely, requiring a full time staff of less than ten. Reclamation would end about 2010. After reclamation is complete, continued employment would occur at a reduced level to maintain the site, provide monitoring, and operate the dewatering and water treatment systems. Under the No Pit Pond Alternative, about two to five employees would be needed indefinitely.

4.4.2.4 Revenue from Taxes

4.4.2.4.1 Potential Tax Revenues from Mining Stage 5B

Estimates of tax revenue were made for the completion of mining of Stage 5B, which included property tax, metalliferous mines license tax, gross proceeds tax, and state payroll tax. No federal taxes were included. Payroll tax was estimated on averages for employee salaries for the number of person years estimated for the mining employment section above. The estimated tax revenue from Stage 5B mining under the No Pit Pond Alternative would be $8,087,000.

In 2002, GSM paid $821,866 in metal mine license tax, $492,362 in gross proceeds tax, and $309,232 in other property taxes. The total tax payment was $1,623,460.

In 2003, GSM paid $1,217,076 in metal mine license tax, $412,675 in gross proceeds tax, and $215,115 in other property taxes. The total tax payment was $1,844,866. Comparable tax payments would be expected during the years that

Stage 5B is mined, except during the waste rock stripping when no gold was produced.

The socioeconomic impacts from closure and reclamation would be the loss of tax payments. Taxes based on production would end with the completion of mineral processing. Property taxes would gradually decrease with the decommissioning of facilities, but would be maintained indefinitely at some level on the land and the dewatering and water treatment system.

4.4.2.4.2 Potential Tax Revenues from Pit Backfill

After Stage 5B mining is completed, the only taxes paid by GSM during reclamation would be property taxes. Estimates of potential tax revenue for reclamation activities include property tax and state payroll tax. No federal taxes were included. The estimated tax revenue from reclamation under the No Pit Pond Alternative would be $319,500.

4.4.2.5 Mineral Reserves and Resources

4.4.2.5.1 Access to Future Mineral Reserves/Resources

Precious metal mineralization extends beyond the planned limits of the open pit floor and highwall for Stage 5B (GSM, 2002a). There might be additional resources that have not been identified by exploration activities. The minerals may not be considered feasible to mine under current economic conditions and technology. Changes in external conditions, such as fluctuating metals prices and improvements in technology, may result in revised open pit designs, which could increase the amount of economically extractable ore some time in the future. If these resources are buried due to backfilling requirements, the cost of recovering them in the future may be so high that the resource would be unavailable. Although it is technically possible to remove the backfill material, it may not be economically feasible to remove the remaining gold.

A mineral resource is defined as a concentration or occurrence of natural, solid, and inorganic material in or on the earth's crust in such form and quantity and of such grade or quality that it has reasonable prospects for economic extraction. The definitions utilized by Barrick for reporting conform to Canadian Institute of Mining, Metallurgy and Petroleum definition of these terms as of the effective date of estimation, as required by National Instrument 43-101 of the Canadian Securities Administrators.

One of the purposes of MMRA is to prevent foreclosure of future access to mineral resources not fully developed by current mining operations (82-4-302(1)(f), MCA). However, MMRA does not direct DEQ to adopt pit reclamation alternatives that would allow future access to unmined reserves. The degree of future accessibility of the remaining gold-bearing mineralization would in part

determine the future mining potential for the remainder of the resource. That accessibility would be influenced by the pit reclamation plan chosen.

Three factors of the pit reclamation plan that could affect future mining potential include:

- Amount of backfill placed in the pit;
- Amount of highwall rock that would ravel and slough into the pit over time; and
- Ability to dewater the saturated portion of the backfill.

Under the No Pit Pond Alternative, the pit would be backfilled from 4,525 to 4,625 feet. About 111,000 cubic yards (167,000 tons) of backfill and 290,400 cubic yards of soil would have to be removed from 60 acres if the pit were enlarged for additional mining in the future. In addition, as described in Section 4.2.1.2.2, the agencies expect some highwall rock to ravel and slough into the pit over time, some of which would have to be removed.

The agencies have assumed 100,000 cubic yards (150,000 tons) of highwall rock would ravel over time. In addition, another 100,000 cubic yards would slough into the pit as a mass failure of the highwall, which would bury the dewatering system. The 5,700-foot safety bench would have to be reestablished for access and safety. This would produce an unknown volume of highwall rock. More backfill would have to be hauled into the pit to create a new flat working surface and reestablish the dewatering system wells. As a result, soil cover and 200 feet of highwall rock and backfill or a minimum of 600,000 cubic yards (900,000 tons) would have to be removed before mining could begin again.

The pit would have to be dewatered before enlarging the pit in the future. The dewatering system needed to dry out the saturated backfill would already be in place, but may be destroyed as the mine is expanded. Because only the bottom 200 feet of the pit would be filled with waste rock, the time required to dewater the pit for continued mining would be less than the partial pit backfill alternatives. During 2002 mining, an average of 405,333 cubic yards (608,000 tons) of waste rock and ore was removed from the bottom of the pit per month. Assuming a similar mining rate, it would take 1.5 months to remove 600,000 cubic yards.

Because of the limited amount of rock that would have to be removed, the waste-to-ore ratio would not increase substantially. In addition, the time required to dewater the pit would be minimal. This alternative would have a limited impact on future recovery of mineral resources. Under this alternative, the potential would remain for continued exploration and possible future mining with minimal implementation problems.

4.4.2.6 Land Use After Mining

4.4.2.6.1 Suitability of Land Use after Mining

Land uses of the permit area before mining consisted of wildlife habitat, livestock grazing, agriculture, timber, recreation, and industrial use, as discussed in Section 3.8. Within the area of the open pit, the steep terrain limited activities such as livestock grazing and precluded other agriculture land uses. So, prior to construction of the open pit mine, this area was used for wildlife habitat, limited livestock grazing, and mining. Because timber is sparse in this area, timber harvesting has not been impacted. The only recreation activities that likely could have occurred in the area in the past were hunting and hiking, which were dependent on the permission of the previous owner.

Land use after mining was judged in terms of the suitability of the alternative to achieve that land use. In all cases, that land use would be a reclaimed mine with monitoring, maintenance, water treatment, and wildlife habitat. Under the No Pit Pond Alternative, 60 acres in the pit would be revegetated as mule deer habitat, and 158 acres would be reclaimed as steep cliffs. GSM would also develop a small portion of the highwall in the pit to provide bat and raptor habitat on the upper oxidized highwall, as described and evaluated in the 1997 Draft EIS, Chapter IV, Section IV.E and described in this SEIS in Section 2.4.2.6. Observations at other mines suggest that the following species could use the GSM highwall at the conclusion of mining: golden eagle, red-tailed hawk, great horned owl, common raven, rock wren, fringed myotis, long-legged myotis, Yuma myotis, long-eared myotis, and western small-footed myotis, all BLM sensitive species (SRK, 2005). Mines at which these observations were made include several non-ARD pits (REN, Dee Gold, Sunshine, Marigold, Bald Mountain, and Robertson) and several having ARD potential (Gold Quarry, Reona, Gold Hole, and Coeur Rochester) (G. Back, SRK, personal communication, 2005). No conclusions were made on whether any nests were in sulfide material.

Under the No Pit Pond Alternative, additional disturbance of lands would not occur. The pit area would be maintained as a hydrologic sink with the pit bottom being used to capture and collect contaminated water. A fence, signs, and berms would be constructed around the open pit to discourage large mammals including humans from entering the area. The industrial usage at the bottom of the pit and the fence would not preclude bats and raptors from using the upper oxidized pit highwall and mule deer from using the revegetated areas within the pit.

Approximately 5 acres of existing disturbance would be used for the dewatering system and access roads in the pit. Hunting and other recreational activities around the pit and in other operational areas would be prohibited. The primary land use impact under this alternative would be the permanent loss of 158 acres of mule deer habitat.

4.4.2.7 Aesthetics

Visual resources impacts were evaluated in the 1997 Draft EIS, Chapter IV, Section IV.I.

4.4.2.7.1 Visual Contrast With Adjacent Lands

The impact the No Pit Pond Alternative would have on visual resources was evaluated in the 1997 Draft EIS, Section IV.I. It was determined that, for the pit under this alternative, visual contrasts would be reduced to a level where they would be noticeable but not dominant in the landscape, following successful reclamation and revegetation. Landscape modifications for the area would be consistent with a Class III rating according to the BLM's visual resource management system.

A high degree of visual contrast would relate to a poor aesthetic value. As stated in the MMRA with regard to open pits and rock faces, the reclamation plan must provide sufficient measures for reclamation to a condition that mitigates visual contrasts between reclamation lands and adjacent lands.

Since the 1997 Draft EIS evaluation, the design of the pit highwall and the scope of the proposed reclamation plans have changed with respect to this issue. The one notable change in the pit design is the elevation at which the haul road enters the pit at the low point on the pit rim. The plan was to cut a 32-acre notch out of this section of the pit highwall and lower the road by 150 feet. The existing configuration eliminates the need for the notch and hides more of the pit from view from all vantage points below the pit rim.

Recontouring and revegetating portions of the pit would reduce the visual contrast with adjacent undisturbed lands. GSM has proposed to revegetate 60 acres in the 218-acre pit, of which 15 acres would be visible. The measures that would be used to reduce visual contrast under the No Pit Pond Alternative include planting trees around the pit perimeter where possible, and, where safety allows, seeding and planting trees on final oxidized benches containing enough fine material to support plant life (GSM, 2002). The raveling and sloughing of pit highwalls over time would reduce visual contrast.

To further reduce visual contrast, the agencies would require GSM to seed and plant trees on additional safely accessible areas in the pit above the 5,700-foot safety bench (see Section 4.8.3.2). The agencies would also require GSM to extend the East Waste Rock Dump Complex across the mouth of the pit to tie into the natural slope and partially screen the view of the highwall (see Section 4.8.3.2).

4.4.2.8 Potential Future Burden

4.4.2.8.1 Potential Future Burden on Society

Operation and maintenance of reclaimed mines involves infrastructure used to collect, treat and release the impacted water, divert clean water, and maintain covers, etc. Over time, some facilities would need to be upgraded, rebuilt or replaced. Monitoring programs would be required. While all activities after mining would be the responsibility of GSM and would be bonded, site management may become the responsibility of another private or agency custodian. The long-term nature of these requirements at GSM suggests a risk to society to inherit the burden if the responsible party fails in its obligations.

The complexity of the dewatering and water collection systems and the uncertainty of collecting all pit water would be the largest potential burden on society under any alternative. Under the No Pit Pond Alternative, these systems for the pit area would consist of two to three 100-foot-deep wells, a powerline, and a pipeline to the water treatment plant. Pit highwall failures expected over time would increase the depth of the wells needed to 200 feet.

The principal consequence of failure of long-term implementation of the No Pit Pond Alternative would be creation of an ARD-impacted pit pond below the 5,050-foot elevation, as described in Section 4.2.1.9.2. Below this elevation, less than 10 percent of the water would not flow out of the pit. No impacts to groundwater outside the pit would be anticipated. The risk of this alternative to create a future burden on society is low because water resource impacts to seeps and springs would be minimal. Beneficial uses of the Jefferson River alluvial aquifer would not be impacted, as described in Section 4.3.2.1.2.2.

In addition, future treatment technologies could easily be implemented. Pit water would be completely controlled.

4.4.2.8.2 Potential for Future Liabilities for GSM

The complexity of the alternative pit reclamation plan could affect GSM's ability to comply with the operating permit requirements and water quality standards. Liabilities from the alternatives would be based on the potential for water quality degradation related to the amount of backfill, complexity of the dewatering system, and continued access to the dewatering system for operation and maintenance.

Under the No Pit Pond Alternative in both the 1997 Draft EIS and this SEIS, there would be no water quality degradation outside of the pit. The water level, even with backfill and pit highwall rock that has raveled and sloughed to the pit bottom over time, would not reach the 5,050-foot elevation. Therefore, no untreated water would leave the pit. In addition, if the dewatering system failed for any

reason, it could be re-established on the regraded pit bottom through the expected 200 feet of backfill and highwall rock more easily than under an alternative with up to 875 feet of backfill. Continued safe access to the dewatering system for operation and maintenance under the No Pit Pond Alternative would be more difficult than the partial pit backfill alternatives because of highwall rock raveling and sloughing onto access roads and the changing condition of the roads. Removing water from the backfill would be easier because of the agency-assumed 600,000-cubic-yard volume of material from which the water would be pumped and the depth of the wells in the 200 feet of rock in the pit bottom. GSM contends it could comply with groundwater quality standards under the No Pit Pond Alternative (GSM, personal communications, 2003).

4.4.3 Partial Pit Backfill With In-Pit Collection Alternative (Proposed Action)

4.4.3.1 Safety

4.4.3.1.1 Risk to Workers (Reclamation and Construction)

The Partial Pit Backfill With In-Pit Collection Alternative would backfill the pit to a free-draining elevation of 5,350 feet and would reduce all of the pit highwall above this elevation to 2H:1V slopes. All of the 254 pit acres would be covered with 3 feet of soil and revegetated (Table 4-6).

Risk to workers could arise from a number of activities.

- Hauling 111,000 cubic yards (167,000 tons) of crusher reject to the bottom of the pit for the sump under the Partial Pit Backfill With In-Pit Collection Alternative would be the same as for the No Pit Pond Alternative.
- Hauling and end dumping 33,200,000 cubic yards (50,000,000 tons) of waste rock from the edge of the pit that is hundreds of feet deep would expose drivers to limited hazards for 50 to 80 months. This activity is similar to end dumping used to create the waste rock dump complexes.
- Drilling and cast blasting 11,900,000 cubic yards (17,900,000 tons) of pit highwall and dozing blasted materials down to create 2H:1V slopes would expose workers to fall and rollover hazards for about 30 to 36 months.
- Constructing roads on steep slopes and hauling soil along narrow benches and spreading soil on long 2H:1V slopes would expose workers to hazards for 10 to 12 months.

The safety risk to reclamation workers would be the same as under the No Pit Pond Alternative while 100 feet of crusher reject is being hauled down the steep roads into the pit because of the potential for truck accidents, especially from brake failures. After placement of the sump material to the 4,625-foot elevation, pit backfilling to the average elevation of 5,400 feet would be accomplished by end dumping waste rock from the pit rim. This is the standard method used during mining to create waste rock dumps and has less risk than hauling loaded trucks to the bottom of the pit.

Cast blasting and dozing would be used to reduce the pit highwall to a 2H:1V slope above the 5,400-foot elevation. Operating bulldozers to create the final slopes would have risk similar to that of reducing the slopes of waste rock dumps. All of the highwall would be eliminated. Workers installing, operating,

and maintaining the dewatering system would not be working in a pit below a 1,775-foot highwall and would not be at risk of injury from rock falls.

Pit reclamation would take 108 person years. Total reclamation and construction would take about 308 person years to complete.

4.4.3.1.2 Risk to Workers (Long-Term Maintenance)

Under the Partial Pit Backfill With In-Pit Collection Alternative, long-term access to the pit bottom would not be required. Worker safety over the long term relates primarily to monitoring and maintenance of the reclaimed pit slopes and benches and the dewatering system. The risk to worker safety in this alternative would be less than the No Pit Pond Alternative and would be similar to work conducted on the reclaimed portions of the waste rock dump complexes.

4.4.3.1.3 Risk to Public Safety

Access restrictions on general public use would be maintained under the Partial Pit Backfill With In-Pit Collection Alternative. Access restrictions would consist of signs, berms, and fences, and there would be less risk to public safety because the pit highwall would be eliminated.

4.4.3.2 Mining Employment

4.4.3.2.1 Potential Employment from Mining Stage 5B

Impacts associated with mine operation under the Partial Pit Backfill With In-Pit Collection Alternative would be the continued economic benefits of employment and income provided by the mine and county and state tax revenues throughout the mine's projected life span to 2008. The anticipated mining employment opportunities from mining Stage 5B under the Partial Pit Backfill With In-Pit Collection Alternative would be 750 person years.

GSM has indicated that it may not be able to continue mining if a partial pit backfill alternative is selected (GSM, 2002a). Manpower requirements fluctuate on a routine basis during mining. Under this alternative, for each year lost by premature mine closure, mining employment would be reduced by approximately 150 person years, depending on the state of mining. There would be a loss of GSM's 139 full time and 42 contract jobs under this alternative (GSM, personal communication, September 2004).

4.4.3.3 Reclamation Employment

4.4.3.3.1 Reclamation Employment Opportunities

At the termination of mining, decommissioning of the facilities, partial backfilling of the pit, and reclamation of other disturbed areas would require an additional 3 years. The predicted employment opportunities during reclamation under the Partial Pit Backfill With In-Pit Collection Alternative would be 308 person years. About 108 person years of this total would be attributable to pit closure tasks. Following pit closure, dewatering and water treatment would continue indefinitely requiring a full time staff of approximately ten. Periodic requirements to repair settling and erosion damage, as well as repair and replace dewatering wells, would provide opportunities for other area service providers.

4.4.3.4 Revenue from Taxes

4.4.3.4.1 Potential Tax Revenues from Mining Stage 5B

The tax revenues from completing Stage 5B would be $8,087,000, the same as the No Pit Pond Alternative. GSM has indicated that mining may cease if partial pit backfilling is required. Under this alternative, for each year lost by premature mine closure, tax revenues would be reduced by $1,605,400. If GSM closes, property tax revenue would be $12,000 per year.

4.4.3.4.2 Potential Tax Revenues from Pit Backfill

Estimates of potential tax revenue for reclamation activities, primarily backfilling, include property tax and state payroll tax totaling $806,000 over a 3-year period. No federal taxes were included.

4.4.3.5 Mineral Reserves and Resources

4.4.3.5.1 Access to Future Mineral Reserves/Resources

Under the Partial Pit Backfill With In-Pit Collection Alternative, the pit would be backfilled from 4,525 feet to an average depth of 5,400 feet. A total of 111,000 cubic yards (167,000 tons) of crusher reject material, 33,200,000 cubic yards (50,000,000 tons) of backfill, 11,900,000 cubic yards (17,900,000 tons) of waste rock covering the highwall, and 1,541,800 cubic yards of soil would have to be removed from 274 acres if the pit was enlarged in the future.

The pit would have to be dewatered while removing the backfill and enlarging the pit in the future. The dewatering system needed to dry out the saturated sump material would already be in place, but would be destroyed while removing the backfill. The new dewatering system would have to be implemented in stages as part of the expanded mining operations as is done for regular mining operations

below the water table. It is expected the time required to dewater the pit would be longer than the No Pit Pond Alternative. Dewatering a pit backfilled with weathered waste rock could be as difficult as dewatering solid rock because of the amount of fine, cemented material in the weathered waste rock backfill. When the East Waste Rock Dump Complex was partially off-loaded after the 1994 ground movement, the waste rock had weathered into finer material. Ripping of the unsaturated waste rock was needed because of cementation and compaction (Herasymuik, 1996). GSM reported that some of the material required blasting. The agencies expect the same process would occur in the backfilled pit.

In order to re-open the pit after reclamation is completed under the Partial Pit Backfill With In-Pit Collection Alternative, a mining company would have to remove 47,000,000 cubic yards of backfill and soil, which includes the amount needed to re-establish the 5,700-foot pit safety bench and to gain access to mineralization below the former pit floor.

Because this amount of rock and soil would have to be removed, this alternative would increase the waste-to-ore strip ratio more than the No Pit Pond Alternative. This would affect the potential for future mining activity more than the No Pit Pond Alternative. Under this alternative, the potential for continued exploration and possible future mining could be limited. The backfill would not be as difficult to remove as solid rock. Assuming a mining rate similar to that used by GSM in 2002, removal of this volume of material could take about 10 years at 405,000 cubic yards per month. Part of the backfill material would be wet, including areas near preferential flow from seeps into the pit. During the years of backfill removal, more could saturate and removal could be more difficult.

4.4.3.6 Land Use After Mining

4.4.3.6.1 Suitability of Land Use After Mining

Under the Partial Pit Backfill With In-Pit Collection Alternative, nearly the entire pit area would be reclaimed to its primary pre-mining land use as wildlife habitat. This alternative would require the disturbance of an additional 56 acres of land on the steep hillsides around the perimeter of the pit from cast blasting and constructing haul roads to haul soil (Figure 2-4). The additional disturbance would be revegetated within a period of about 3 years. The intent of the reclamation plan for the pit disturbance area would be to establish a sustainable plant cover in all areas.

Approximately 1 to 2 acres would be required for the dewatering system and access roads in the reclaimed pit area and would have little utility as wildlife habitat. All other areas would be available for wildlife habitat. Due to the presence of maintenance personnel and equipment in the pit, hunting would be

prohibited in most areas. With removal of pit hazards, recreational activities outside the pit, such as hiking, and hunting could be permitted.

Under the Partial Pit Backfill With In-Pit Collection Alternative, 274 acres would be revegetated as mule deer habitat. GSM would not develop raptor and bat habitat on the upper highwall because there would be no highwall.

4.4.3.7 Aesthetics

4.4.3.7.1 Visual Contrast with Adjacent Lands

The 1997 Draft EIS, Chapter IV, Section IV.I evaluated the impact the Partial Backfill Alternative would have on aesthetics. It was determined that backfilling the pit to a daylight level and revegetating the upper pit slopes would partially restore the pit area and would decrease the contrasting forms, lines, and colors of the pit benches and highwall visible from key observation points. In addition, hauling waste rock material from the East Waste Rock Dump Complex to backfill the pit would reduce the height of some of the benches in the dump.

In this SEIS, the Partial Pit Backfill With In-Pit Collection Alternative would be similar to the Partial Backfill Alternative in the 1997 Draft EIS. The reclaimed 2H:1V slopes covering the pit highwall and the reclaimed slopes of the waste rock dump complexes would still be visible, but the overall contrasts would be reduced under this alternative.

4.4.3.8 Potential Future Burden

4.4.3.8.1 Potential Future Burden on Society

The complexity of the dewatering and water collection systems and the uncertainty of collecting all pit water would be the largest potential burden on society in the long term. Under the Partial Pit Backfill With In-Pit Collection Alternative, these systems would consist of up to 11 wells up to 875 feet deep, an access road, a powerline, and a pipeline to the water treatment plant.

Funding and infrastructure are required to collect and treat contaminated water after closure. The consequence of failure of this alternative due to technical or financial reasons is uncontrolled discharges of ARD-impacted groundwater from the backfilled pit, which could adversely impact springs (Section 4.3.4.2.1.2) and beneficial uses of the Jefferson River alluvial aquifer, as described in Section 4.3.4.1.2 for the Partial Pit Backfill With Downgradient Collection Alternative. Downgradient capture wells, as described in Section 4.2.3.5.1 for the Partial Pit Backfill With Downgradient Collection Alternative, would be needed as a contingency if the dewatering system failed. Unlike the No Pit Pond Alternative, if implementation of the dewatering system failed, an estimated 27 to 42 gpm of seepage would eventually leave the pit and migrate into the regional groundwater

system, as described in Section 4.3.4.1.2.2.1 for the Partial Pit Backfill With Downgradient Collection Alternative.

4.4.3.8.2 Potential for Future Liabilities for GSM

Under the Partial Pit Backfill With In-Pit Collection Alternative, the potential for water quality degradation outside of the pit would be increased if the dewatering system failed. The water table would be kept as close as possible to the 4,525-foot elevation by pumping. Untreated water escaping the pit would be the same as under the No Pit Pond Alternative. If the dewatering system failed due to backfill settling and damage to wells, they could be re-established by drilling new wells in the deeper backfill and replacing the pumps. Completion of these wells would be problematic. Safe access to the dewatering system for operation and maintenance would not be a problem because there would be no pit or highwall.

Removing water from up to 875 feet of backfill would be more difficult because of the 47,000,000 cubic yards of backfill material from which the water would be pumped and the 875-foot depth of the wells. Pumps and other dewatering system components would fail regularly from backfill settling and corrosion, as described in Section 4.2.1.5.2. This alternative may create a larger liability for the company in the future because of the uncertainty of pit water quality and complete collection of the water in the pit (GSM, 2002a).

4.4.4 Partial Pit Backfill With Downgradient Collection Alternative

The socioeconomic impacts of the Partial Pit Backfill With Downgradient Collection Alternative are nearly identical to those of the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.1 Safety

4.4.4.1.1 Risk to Workers (Reclamation and Construction)

Under the Partial Pit Backfill With Downgradient Collection Alternative, separate placement of sump material in the bottom of the pit would not be required. All pit backfilling to the average elevation of 5,400 feet would be accomplished by hauling and end dumping waste rock from the East Waste Rock Dump Complex from the pit rim. This is the standard method used during mining to create waste rock dumps and has less risk than hauling loaded trucks to the bottom of the pit.

The pit highwall would be reduced to a 2H:1V slope above the 5,400-foot elevation as described in the Partial Pit Backfill With In-Pit Collection Alternative and the risk to worker safety would be the same. Dewatering wells and collection facilities would be constructed outside the perimeter of the backfilled pit. This would be safer for maintenance workers after mining. Reclamation and construction activities would be the same as the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.1.2 Risk to Workers (Long-Term Maintenance)

Under the Partial Pit Backfill With Downgradient Collection Alternative, long-term access to the pit bottom would not be required. Worker safety over the long term relates primarily to monitoring and maintenance of the reclaimed pit slopes and benches and the dewatering system. The risk to worker safety in this alternative would be less than the No Pit Pond Alternative and essentially similar to the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.1.3 Risk to Public Safety

Access restrictions and risk to public safety would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.2 Mining Employment

4.4.4.2.1 Potential Employment from Mining Stage 5B

Employment and income impacts associated with mine operation under the Partial Pit Backfill With Downgradient Collection Alternative would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.3 Reclamation Employment

4.4.4.3.1 Reclamation Employment Opportunities

Employment and income impacts associated with pit reclamation under the Partial Pit Backfill With Downgradient Collection Alternative would be essentially the same as under the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.4 Revenue from Taxes

4.4.4.4.1 Potential Tax Revenues from Mining Stage 5B

Revenue from taxes associated with mine operations under the Partial Pit Backfill With Downgradient Collection Alternative would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.4.2 Potential Tax Revenues from Pit Backfill

Revenue from taxes associated with pit reclamation under the Partial Pit Backfill With Downgradient Collection Alternative would be the same as under the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.5 Mineral Reserves and Resources

4.4.4.5.1 Access to Future Mineral Reserves/Resources

This alternative has an additional impact on access to future mineral reserves and resources compared to the Partial Pit Backfill With In-Pit Collection Alternative. In the Partial Pit Backfill With Downgradient Collection Alternative, the backfill would not be dewatered and the water table would rebound. More of the backfill would have to be dewatered as mining proceeds as described in the Partial Pit Backfill With In-Pit Collection Alternative. The agencies assume that a similar dewatering system as used in the Partial Pit Backfill With In-Pit Collection Alternative would have to be installed to dewater to facilitate removal of the backfill. Since there would be no sump material in the bottom of the pit, the dewatering might be less effective. Because there would be no previous dewatering activities, the time required to install the dewatering system and dewater the pit may be longer than the Partial Pit Backfill With In-Pit Collection

Alternative. In addition, it may be harder to dewater backfilled, weathered waste rock than the original pit rock.

In order to re-open the pit after reclamation is completed under the Partial Pit Backfill With Downgradient Collection Alternative, a mining company would have to remove 47,000,000 cubic yards of backfill and soil, which includes the amount needed to re-establish pit benches for access and safety. This would increase the waste-to-ore strip ratio. Up to 735 feet of the backfill would be saturated.

4.4.4.6 Land Use After Mining

4.4.4.6.1 Suitability of Land Use After Mining

The suitability of land use after mining under the Partial Pit Backfill With Downgradient Collection Alternative would be essentially the same as under the Partial Pit Backfill With In-Pit Collection Alternative. Collection of contaminated water outside the pit area would require a large number of wells and a more complex collection and conveyance system. This would increase the size of the industrial usage area by 2 acres. In addition, seeps of poor quality water could develop in the area between the pit and the capture wells. The agencies have assumed one new seep would develop as described in Section 4.3.4.2.1.2. The presence of poor quality water and the spread-out nature of the industrial usage areas could impact wildlife usage. Mine operations have had minimal impact on mule deer.

4.4.4.7 Aesthetics

4.4.4.7.1 Visual Contrast with Adjacent Lands

Impacts to visual resources would be the same as the Partial Pit Backfill With In-Pit Collection Alternative.

4.4.4.8 Potential Future Burden

4.4.4.8.1 Potential Future Burden on Society

The complexity of the dewatering and water collection systems and the uncertainty of collecting all pit water would be the largest potential burden on society. Under the Partial Pit Backfill With Downgradient Collection Alternative, these systems would consist of at least 26 capture wells, at least 10 monitoring wells of various depths, and multiple pipelines to the water treatment plant. More wells may be needed based on hydrogeologic studies.

Secure funding and infrastructure are required to collect and treat contaminated water after closure. The principal consequence of failure of this alternative would be undetected or uncaptured discharges of ARD-impacted groundwater from the

backfilled pit, which could adversely impact springs and beneficial uses of the Jefferson River alluvial aquifer. Total pit seepage of 27 to 42 gpm would reach the regional groundwater system compared to less than 4.2 gpm in the alternatives that maintain the pit as a hydrologic sink. Ninety-six percent of the seepage would have to be collected to prevent water quality impacts at the mixing zone boundary, as described in Section 4.3.4.2.2. Ninety-six percent capture efficiency may not be achievable, as described in Section 4.2.3.1.2. Based on their experience, the agencies believe a maximum capture efficiency of 80 percent per system is potentially achievable.

4.4.4.8.2 Potential for Future Liabilities for GSM

Under the Partial Pit Backfill With Downgradient Collection Alternative, the potential for water quality degradation outside of the pit would be increased. The water table would not be kept below the 5,260-foot elevation equilibrium level by pumping. Therefore, from 27 to 42 gpm of untreated water would escape the pit. Multiple wells would be located down gradient of the pit area to try to capture contaminated groundwater leaving the pit. If the dewatering system failed to capture 96 percent of the groundwater, groundwater standards for some constituents would be exceeded at the edge of the mixing zone (Telesto, 2003e, 2006).

The quality of the water collected down gradient of the pit would be partially attenuated and mixed with regional groundwater. Pumps and other dewatering system components would not fail as regularly due to settling and corrosion. Scaling and biofouling could increase because the water would be collected down gradient of the pit and have a higher pH. Experience at GSM has shown this not to be a problem. Complete capture of pit seepage would not be possible. Ninety-six percent capture efficiency may not be achievable, as described in Section 4.2.3.1.2. Based on their experience, the agencies believe a maximum capture efficiency of 80 percent per system is potentially achievable.

4.4.5 Underground Sump Alternative

The socioeconomic impacts of the Underground Sump Alternative are nearly identical to those of the No Pit Pond Alternative. The principal difference is that pit closure would be confined to reestablishing access, adapting the underground workings, and preparing the underground sump.

4.4.5.1 Safety

4.4.5.1.1 Risk to Workers (Reclamation and Construction)

The Underground Sump Alternative would have less potential for safety liabilities than the No Pit Pond Alternative as it requires workers to maintain access into the pit and to the 4,550-foot-elevation portal, and to maintain the underground workings. Most dewatering equipment would be stationed inside the underground workings. Rock hazards in the underground workings would be added to the risk from highwall rock hazards. However, the agencies agree that the risk of working on the pit floor would be greater than the risk of working in the underground workings.

The lowest stope in the underground workings would be used as a sump in the dewatering system for Stage 5B. During Stage 5B, most of the underground workings would be mined out. After Stage 5B is completed, access to the underground workings would be reestablished by developing a portal at the 4,550-foot elevation. The operational dewatering system in the underground workings would be redesigned for long-term use as described in Section 2.4.5.3. Under the Underground Sump Alternative, workers would re-enter the underground workings to evaluate wall and ceiling stability. Dewatering system construction workers would be exposed to rock falls from the walls and ceiling. Wall and ceiling stability would be monitored and repairs made as needed to ensure worker safety and the integrity of the dewatering system. The agencies would require GSM to develop a long-term plan to stabilize and maintain the ceiling and walls of the underground workings, especially the stopes, where necessary to ensure employee safety.

Pit reclamation and construction under the Underground Sump Alternative would take 24 person years and complete mine reclamation would take about 124 person years.

4.4.5.1.2 Risk to Workers (Long-Term Maintenance)

Risk to worker safety over the long term would be less than the No Pit Pond Alternative. The risks of working underground are less than the risks of working in the bottom of the pit.

4.4.5.1.3 Risk to Public Safety

Access restrictions to the pit area on general public use would be the same as under the No Pit Pond Alternative.

4.4.5.2 Mining Employment

4.4.5.2.1 Potential Employment from Mining Stage 5B

Employment and income impacts associated with mine operation under the Underground Sump Alternative would be the same as under the No Pit Pond Alternative.

4.4.5.3 Reclamation Employment

4.4.5.3.1 Reclamation Employment Opportunities

Employment and income impacts associated with pit reclamation under the Underground Sump Alternative would be essentially the same as under the No Pit Pond Alternative.

4.4.5.4 Revenue from Taxes

4.4.5.4.1 Potential Tax Revenues from Mining Stage 5B

Revenue from taxes associated with mine operation under the Underground Sump Alternative would be the same as under the No Pit Pond Alternative.

4.4.5.4.2 Potential Tax Revenues from Pit Backfill

Revenue from taxes associated with pit reclamation under the Underground Sump Alternative would be essentially the same as under the No Pit Pond Alternative.

4.4.5.5 Mineral Reserves and Resources

4.4.5.5.1 Access to Future Mineral Reserves/Resources

Under the Underground Sump Alternative, no backfill would be placed in the pit. The 200,000 cubic yards (300,000 tons) of pit highwall rock that would ravel or slough over time would have to be removed as part of the future mining plan. The pit bottom would remain dry except after precipitation events while water is infiltrating into the underground workings. A dewatering system would be in place removing pit water from the underground workings. The overall impacts to access to future mineral reserves and resources would be similar to the No Pit Pond Alternative, and 111,000 cubic yards (167,000 tons) less material would have to be removed, adding little to the waste-to-ore strip ratio.

4.4.5.6 Land Use After Mining

4.4.5.6.1 Suitability of Land Use After Mining

Suitability of land use after mining would be the same as the No Pit Pond Alternative.

4.4.5.7 Aesthetics

4.4.5.7.1 Visual Contrast with Adjacent Lands

Impacts to visual resources would be the same as the No Pit Pond Alternative.

4.4.5.8 Potential Future Burden

4.4.5.8.1 Potential Future Burden on Society

For the Underground Sump Alternative, the dewatering system would consist of an underground sump, a powerline, and a series of pumps and pipelines to the water treatment plant. The Underground Sump Alternative would have no water leaving the pit bottom to the regional groundwater system even though the pit water table would be lowered 25 to 75 feet compared to the No Pit Pond Alternative.

The consequence of failure of a dewatering system in the underground workings in this alternative would be that the underground workings below the pit would flood and the pit would begin to fill with water after a period of time. The consequence of failure would be similar to the Pit Pond Alternative, which was dismissed in Section 2.5.4, and the No Pit Pond Alternative. Under the Pit Pond Alternative, the water table would rise to the 4,635-foot elevation and stabilize. Under the Underground Sump Alternative, the agencies expect that up to 200,000 cubic yards (300,000 tons) of rock would ravel and slough off the pit highwall over time. Even with the 200,000 cubic yards (300,000 tons) of rock in the pit bottom, the water level would stabilize below the 5,050-foot elevation. No water would leave the pit. If the dewatering system failed and a pit pond formed, water could be treated in the pit, pumped to the treatment plant from the pit pond, or the No Pit Pond Alternative could be implemented as a contingency. The agencies believe this alternative offers the most flexibility for future changes in water treatment methods.

4.4.5.8.2 Potential for Future Liabilities for GSM

Under the Underground Sump Alternative, the potential for water quality degradation outside of the pit would be limited. The water level, with pit highwall rock that has sloughed to the pit bottom over time, would not reach the 5,050-foot elevation. No untreated water would leave the pit.

In addition, if the dewatering system failed for any reason, it could be re-established in the underground workings more easily than under the partial pit backfill alternatives. Continued safe access to the dewatering system for operation and maintenance under the Underground Sump Alternative would be less difficult than the No Pit Pond Alternative, as described in Section 4.4.5.1.2.

Raveling and sloughing of the highwall would require construction of a new portal at a higher elevation to maintain access to the underground sump and a secondary escape way over time. Removing water from the underground sump would be easier than pumping out of backfill. GSM contends that this alternative would have the least liability in the future (GSM, personal communication, 2003).

4.5 PROJECT ECONOMICS

4.5.1 Reclamation Costs

The estimated capital and operating costs for GSM to complete the pit reclamation by alternative are presented in Table 4-11.

Cost assumptions are based on $1.30 per cubic yard for earthwork, 22 cents per cubic yard for cast blasting, and 27 cents per yard for dozing the blasted material. Revegetation is based on a cost of $385 per acre, and the 53 acres of pit and associated pit reclamation common to all alternatives are included. The backfill costs were produced for alternative comparison purposes. The partial pit backfill alternatives do have costs for repairing future settling. This cost is hard to predict, but 15 percent has been added to the total cost of these alternative closure plans. These costs were estimated for presenting a relative comparison of alternatives.

Table 4 - 11. Reclamation Costs[1] by Alternative

COST CATEGORY	ALTERNATIVE			
	No Pit Pond	**Partial Pit Backfill With In-Pit Collection**	**Partial Pit Backfill With Downgradient Collection**	**Under-ground Sump**
Haul and Place Backfill in the Sump	$288,000	$288,000	$0	$0
Haul and Place Backfill in the Pit to Free Drain	$0	$43,160,000	$43,290,000	$0
Cast Blast the Highwall	$0	$2,618,000	$2,618,000	$0
Dozer Push the Highwall	$0	$643,000	$643,000	$0
Haul and Place Soil Cover on Revegetated Acres	$378,000	$3,469,000	$3,469,000	$371,000
Construct Storm Water Diversion Structures	$0	$335,000	$335,000	$0
Construct/Reclaim Additional Roads/Miscellaneous Disturbance	$0	$83,000	$83,000	$0
Revegetation	$20,000	$112,000	$112,000	$20,000
Dewatering System Installation	$28,000	$310,000	$470,000	$780,000
QA/QC, Supervision, Miscellaneous, Taxes, Insurance	$77,000	$4,337,000	$4,337,000	$82,000
TOTAL COST	$791,000	$55,355,000	$55,357,000	$1,253,000

[1] Costs (in 2003 dollars) based on GSM experience and SEIS contractor experience at Zortman/Landusky mines. Agency costs would be higher.

4.6 REGULATORY RESTRICTIONS ANALYSIS

In 1995, the Montana Legislature amended MEPA to require Montana state agencies to evaluate in their environmental documents any regulatory restrictions proposed to be imposed on the use of private property (Section 75-1-201(1)(b)(iv)(D), MCA). Alternatives and mitigation measures designed to make the project meet minimum environmental standards with implementation methods specifically required by federal or state laws and regulations are excluded from evaluation under the Implementing Guidelines for Section 75-1-201(1)(b)(iv)(D), MCA. Alternatives and mitigation measures that are court mandated also are excluded; these measures are a result of court interpretation of the minimum environmental standards of existing federal and state statutes.

A regulatory restrictions analysis was performed in the 1997 Draft EIS, Chapter IV, Section IV.N. Included was consideration of the No Pit Pond Alternative and Partial Backfill Alternative, which are similar to the alternatives evaluated in this SEIS. The costs for pit reclamation have been updated and are shown in Table 4-11.

4.6.1 No Pit Pond Alternative (No Action)

The total cost of implementation of the No Pit Pond Alternative is approximately $791,000. This is $54,564,000 less than the cost of the Proposed Action, the Partial Pit Backfill With In-Pit Collection Alternative. All of the mitigations in the No Pit Pond Alternative listed in Section 4.8 would be required to comply with applicable laws and regulations.

4.6.2 Partial Pit Backfill With In-Pit Collection Alternative (Proposed Action)

The total cost of implementation of the Partial Pit Backfill With In-Pit Collection Alternative is approximately $55,355,000. All of the mitigations in the Partial Pit Backfill With In-Pit Collection Alternative listed in Section 4.8 would be required to comply with applicable laws and regulations.

4.6.3 Partial Pit Backfill With Downgradient Collection Alternative

This alternative is a variation on the Partial Pit Backfill With In-Pit Collection Alternative. The total cost of implementation of the Partial Pit Backfill With Downgradient Collection Alternative is approximately $55,357,000. This is virtually the same cost as the Proposed Action, the Partial Pit Backfill With In-Pit Collection Alternative. All of the mitigations in the Partial Pit Backfill With Downgradient Collection Alternative listed in Section 4.8 would be required to comply with applicable laws and regulations.

4.6.4 Underground Sump Alternative

The total cost of implementation of the Underground Sump Alternative is approximately $1,253,000. This is $54,102,000 less than the cost of the Proposed Action, the Partial Pit Backfill With In-Pit Collection Alternative. All of the mitigations in the Underground Sump Alternative listed in Section 4.8 would be required to comply with applicable laws and regulations.

4.7 CUMULATIVE IMPACTS

Cumulative impacts are defined as the impacts that result from the incremental effect of an action, decision, or project when analyzed with respect to other past, present, and reasonably foreseeable future actions. The cumulative impacts of GSM's expansion were analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O. The pit reclamation alternatives evaluated in this SEIS would not add to the cumulative impacts evaluated in 1997.

4.7.1 Past, Present, and Reasonably Foreseeable Future Actions

The agencies have updated the following sections with new information from 1997 through 2006.

4.7.1.1 Montana Tunnels Mine

Montana Tunnels Mining, Inc. (Montana Tunnels) operates a zinc, lead, silver, and gold mine located 45 miles north of GSM, in central Jefferson County, near Jefferson City. Montana Tunnels has revised its mine plan since 1997 and is still operating. A major expansion is anticipated if permitting is approved. The agencies received the application in July 2004 and are preparing an EIS. The new plan would allow active mining to continue through 2011. Mining could continue past this point, either by continuing the open pit operation or by developing an underground mine. If mining continues until at least 2011, potential impacts from the project would be minimal during closure, as GSM would be completing closure during the same time period and the initial layoffs from the mine closure would have already occurred. If closure of the mines were to be initiated concurrently, unemployment in the region could be compounded. Cumulative impacts to tax revenue losses for the county also could occur if the closures coincided. Details of potential concurrent closure of the two mines were evaluated in a Montana Tunnels environmental assessment (DEQ and BLM, 2002).

4.7.1.2 Ash Grove Cement

Ash Grove Cement Co. (Ash Grove) continues to operate quarries to supply limestone, silica, and shale for its cement plant in Montana City. No major changes have occurred since 1998. DEQ has approved a permit consolidation plan to combine Ash Grove's six individual permits into one permit for ease of administration by DEQ and Ash Grove.

4.7.1.3 Montana Resources Continental Pit

Montana Resources in Butte, which operates a copper and molybdenum mine, reopened in November 2003 after a 3-year shut down due to low metal prices and high energy prices. Potential cumulative impacts to regional mining employment are not expected, as Montana Resources intends to continue mining. No cumulative impacts to local government finance are anticipated due to the mine's location in a different county. No new cumulative impacts to other resources would be anticipated due to its distance from GSM.

4.7.1.4 Graymont Limestone Mine and Processing Plant

Graymont Western US, Inc. (formerly Continental Lime, Inc.) continues to operate a limestone mine and kiln producing hydrated lime near Townsend. Graymont is the supplier of lime for pH control in the mill at GSM. Graymont's quarry site is located on lands included in the Montana Army National Guard's (MTARNG) Limestone Hills Training Area. MTARNG has applied for a withdrawal covering the training area to ensure that training activities can continue. MTARNG and BLM are coordinating on preparation of a Legislative Environmental Impact Statement. Graymont plans to expand quarry activities farther to the south in the training range. The overall scope of mining activities would not change, and no new cumulative impacts would be anticipated beyond the additional disturbance.

4.7.1.5 Beal Mountain Mine

Pegasus Gold Corporation went bankrupt in 1998. DEQ and the U.S. Forest Service have been reclaiming the Beal Mountain Mine near Gregson since then. The Forest Service is conducting response activities at the site under the Comprehensive Environmental Response, Compensation and Liability Act with input from a technical working group, including DEQ.

4.7.1.6 Exploration Activity at GSM and Other Locations

GSM conducted limited exploration drilling in 2005 and is in the process of reviewing past exploration data. Once the review of existing and new data is complete, exploration targets could be generated (GSM, personal

communication, 2005). An underground mine was developed and completed in January 2004. The Agencies approved a phase two underground mining plan on August 28, 2006 to allow three new portals. A portion of this additional work includes 12,000 feet of core holes to define known exploration targets below the 5B Pit. The cumulative impacts of potential future mining activities cannot be estimated, although GSM contends there is a large mineral resource remaining after mining Stage 5B. Cumulative impacts of exploration activities are not expected to occur, as there is no planned expansion of mining activities outside of current and permitted disturbances. All disturbance related to past exploration activities has been reclaimed. No other mining companies in the area have proposed exploration activities.

4.7.2 Jefferson Local Development Corporation Use of GSM Facilities After Mining

The agencies have reviewed a proposal from GSM to change the land use on a portion of its operating permit area to a light industrial park. Part of the facilities and land would be made available to Jefferson County. This change in land use and donation to the county would lessen impacts at mine closure. The agencies approved the change in October 2004. GSM has also had discussions involving use of the property for a wind farm.

4.7.3 Past, Present, and Reasonably Foreseeable Future Impacts

The agencies have updated the following sections with new information since 1997.

4.7.3.1 Geology, Minerals, and Paleontology

The cumulative impacts on geology, minerals, and paleontology analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.a would not change as a result of implementing any of the alternatives in this SEIS, even though 56 to 58 additional acres would be disturbed under the partial pit backfill alternatives and the pit would be deepened by 125 feet.

4.7.3.2 Water Resources

The cumulative impacts on water resources analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.b would not change as a result of implementing the No Pit Pond, Partial Pit Backfill With In-Pit Collection, or Underground Sump alternatives, because the updated water balance model shows that less water would need to be treated. The Partial Pit Backfill With Downgradient Collection Alternative would add contaminated water to the groundwater system outside of the pit area, which could also affect surface water quality, as described in Section 4.3.4.2.2.2. Dewatering with downgradient collection wells would lower the

regional groundwater level, further affecting groundwater and surface water around the pit area. This is an unavoidable impact of using a groundwater collection system.

4.7.3.3 Soils and Reclamation

The cumulative impacts on soils and reclamation analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.c would not change as a result of implementing the No Pit Pond and Underground Sump alternatives, because the quantity of soil used would not increase. For the partial pit backfill alternatives, cast blasting to reduce the highwall and construction of additional haul roads to transport backfill material and soil would cause additional disturbance. Soil would be stripped from 56 to 58 acres as a result of cast blasting and haul road construction. Soil salvage would be as deep as possible. Any unsalvageable soil would be lost. Soil would also be salvaged from 31 acres northeast of Tailings Impoundment No. 2 to cover the backfill.

Some soil would be wasted on reclaimed areas where highwall rock would ravel and slough or in areas where backfill settled.

4.7.3.4 Vegetation and Wetlands

The cumulative impacts on vegetation and wetlands analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.d would not change as a result of implementing the No Pit Pond and Underground Sump alternatives, because disturbance area would not increase. For the partial pit backfill alternatives, cast blasting to reduce the highwall, construction of additional haul roads to transport backfill material and soil, and installation of new downgradient wells would disturb about 56 to 58 acres. Native vegetation would be lost. Predominantly non-native vegetation communities would be established after the disturbance is revegetated. In addition, native vegetation would be destroyed on soil borrow areas. Soil would also be salvaged from 31 acres northeast of Tailings Impoundment No. 2 to cover the backfill. The borrow areas would be reclaimed with predominantly non-native vegetation. No new wetlands would be disturbed under any of the alternatives.

4.7.3.5 Wildlife and Fisheries Resources

The cumulative impacts on wildlife and fisheries resources analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.e would not change as a result of implementing any of the alternatives in this SEIS, because fewer acres would be disturbed and fewer acres would be reclaimed as highwalls. Wildlife habitat impacts are evaluated under Land Use After Mining sections in each alternative.

4.7.3.6 Threatened, Endangered, and Candidate Species

The cumulative impacts on threatened, endangered, and candidate species analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.f would not change as a result of implementing any of the alternatives in this SEIS, even though 87 to 89 new acres would be disturbed in the partial pit backfill alternatives, because there are still no threatened, endangered, or candidate species on the mine site.

4.7.3.7 Air Quality

The cumulative impacts on air quality analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.g would not change as a result of implementing any of the alternatives in this SEIS, because there would be less disturbance and no change in mining rate.

4.7.3.8 Land Uses and Plans

The cumulative impacts on land uses and plans analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.h would not change as a result of implementing any of the alternatives in this SEIS, because there have been no changes in land uses or plans.

4.7.3.9 Aesthetic Resources

4.7.3.9.1 Visual Resources

The cumulative impacts on visual resources analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.i would not change as a result of implementing any of the alternatives in this SEIS, because fewer acres would be disturbed and fewer acres would be reclaimed as highwall. A mitigation has been added that would produce more reclamation of the upper pit highwalls to reduce visual contrast in the No Pit Pond and Underground Sump alternatives. Another mitigation has been added to extend the East Waste Rock Dump Complex across the pit mouth to obscure part of the pit highwall.

4.7.3.9.2 Noise

The cumulative impacts on noise analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.i would not change as a result of implementing any of the alternatives in this SEIS, because there would be no new sources of noise or increases in mining activity.

4.7.3.10 Socioeconomic Resources

The cumulative impacts on socioeconomic resources analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.j would not change as a result of implementing any of the alternatives in this SEIS unless GSM closed prematurely, then the impacts of closure would occur sooner.

4.7.3.11 Hazardous Materials and Wastes

The cumulative impacts associated with hazardous materials use and storage at the site, analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.k, would not change as a result of implementing any of the alternatives in this SEIS.

4.7.3.12 Cultural Resources

The cumulative impacts on cultural resources analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.l could change as a result of implementing any of the partial pit backfill alternatives in this SEIS. A cabin located near the highwall could be damaged or destroyed when the highwall is cast blasted.

4.7.3.13 Native American Concerns

The cumulative impacts on Native American concerns analyzed in the 1997 Draft EIS, Chapter IV, Section IV.O.3.m would not change as a result of implementing any of the alternatives in this SEIS, because no cultural resources would be disturbed.

4.8 AGENCY MITIGATION MEASURES

Mitigation measures for the mining operations at GSM were identified in the 1997 Draft EIS, Chapter IV, Section IV.P. Only mitigation and monitoring that could be implemented to mitigate potential impacts from the pit reclamation alternatives being evaluated in this SEIS are discussed in this section.

4.8.1 Technical Issues

4.8.1.1 Pit Highwall

Issue: Pit highwall stability under alternatives that do not require partial pit backfilling.

Measure 1: A plan for monitoring and mitigating raveling and sloughing of the pit highwall would be developed and implemented after closure. Survey prisms currently used to ensure safe mining operations would continue to be used after closure during activities in the pit to monitor ground movement in potentially susceptible areas. A plan concerning entry into the pit after storm events, spring thaws, or after long periods of absence would also be developed.

Horizontal drains and highwall dewatering wells would be maintained and new ones installed where necessary to relieve hydrostatic pressure in the highwall and capture groundwater before it enters the pit.

Effectiveness: These measures have been proven to be effective during the past 25 plus years of mining at GSM. These plans would help ensure workers' safety and provide for a mechanism to help maintain pit access. The wells would help reduce the amount of pit water that would have to be handled.

Application: This measure would apply to the No Pit Pond Alternative and the Underground Sump Alternative.

4.8.1.2 Backfill

Issue: Backfill maintenance.

Measure 2: Backfilled areas would be monitored for settling. If ponding occurred, more soil would be placed to restore the gradient. Gradients would be monitored for settlement along storm water diversions that could result in erosion on the face of the revegetated slopes. Storm water diversion gradients on the backfill would be reestablished as needed and any erosion damage would be repaired.

Small localized failures could develop because highwall seeps could flow laterally through and saturate the cover. Seep water would be acidic and would contaminate soils and impair revegetation success if allowed to contact the soil cover. To improve soil cover stability in these localized areas after a failure, the seep would be located and dewatered, contaminated soil would be replaced with clean soil, and the area would be revegetated.

GSM would backfill the underground workings remaining after Stage 5B to minimize settlement in the partial pit backfill alternatives. The lowest stope in the underground workings would be maintained as a contingency dewatering sump in the No Pit Pond Alternative.

Effectiveness: There would be less need for backfill maintenance, and there would be fewer dewatering well failures because of backfill settlement. Localized failures of overhead rock in the underground workings over time could result in subsidence, especially in seep and fault areas where chemical weathering would be increased. This subsidence could cause the backfill to further settle, potentially affecting the dewatering wells in the backfill.

Application: This measure would apply to all alternatives except the Underground Sump Alternative.

Issue: Backfill source.

Measure 2a: Backfill would be obtained from along the northeastern edge of the East Waste Rock Dump Complex, instead of from the top. The original Sheep Rock drainage would be uncovered, and 67 acres of waste rock dump would be removed and placed back into the pit (Figure 4-3). The return diversion around the East Waste Rock Dump Complex would be blocked and reclaimed. This measure applies to both partial pit backfill alternatives. The final configuration of the East Waste Rock Dump under the Underground Sump and No Pit Pond alternatives is shown on Figure 4-4.

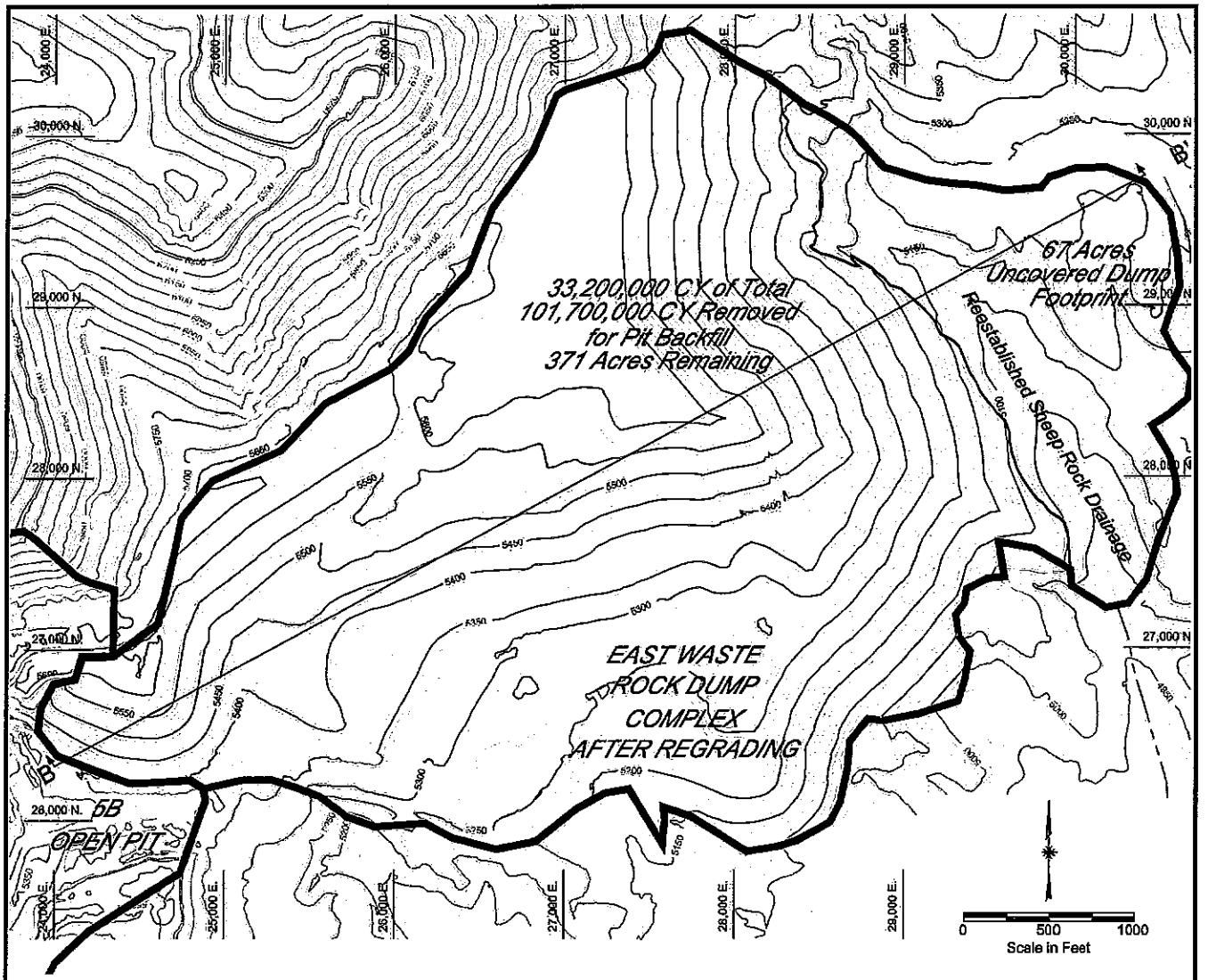
Effectiveness: This measure would reduce the footprint of the East Waste Rock Dump Complex by 67 acres and re-establish the Sheep Rock drainage.

Application: This measure would apply to the partial pit backfill alternatives.

4.8.1.3 Groundwater Effluent Management System

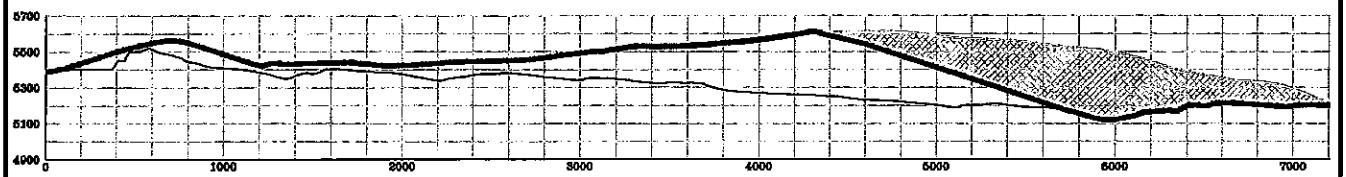
Issue: Identification of secondary flow paths from the pit.

Measure 3: This is a modification of Measure W-10 from the 1997 Draft EIS, Chapter IV, Section IV.P, which was approved as Stipulation 010-13 in the 1998 ROD.



CROSS SECTION

(Southwest) B — (Northeast) B'



LEGEND

- Pre-Mining Topography
- Regraded Topography
- East Waste Rock Dump Complex Removed For Partial Pit Backfill Alternatives

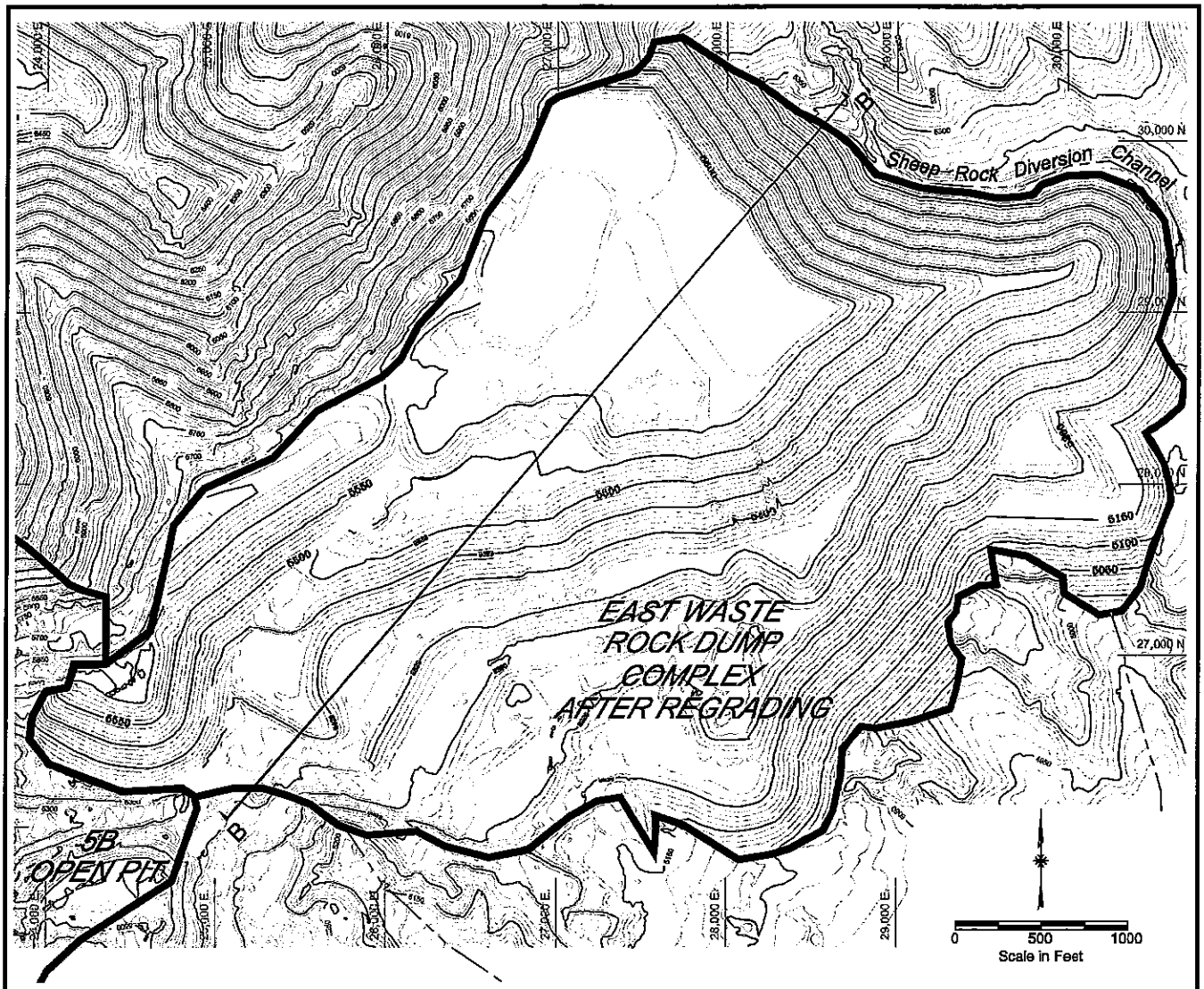
0 500 1000
Horizontal & Vertical Scale in Feet

Partial Pit Backfill Alternatives

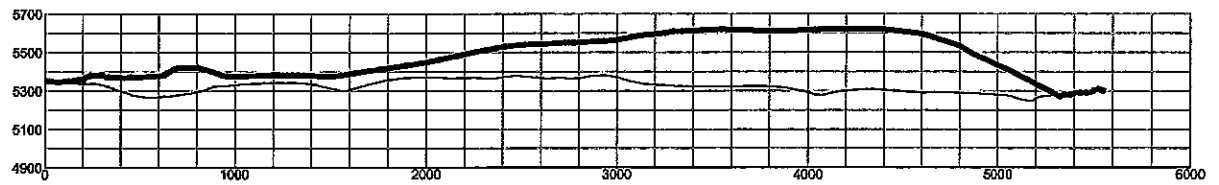
REGRADED EAST WASTE ROCK DUMP COMPLEX TOPOGRAPHY AFTER PARTIAL PIT BACKFILL AFTER MITIGATION

FIGURE 4-3

Figure 4-3 mitig PPB rockdump-xsec.dwg



B CROSS SECTION B'



LEGEND

Pre-Mining Topography

Regraded Topography

0 500 1000
Horizontal & Vertical
Scale in Feet

No Pit Pond & Underground Sump Alternatives

REGRADED EAST WASTE ROCK DUMP COMPLEX TOPOGRAPHY AFTER MITIGATION

FIGURE 4-4

Figure 4-4 mitig Rockdump-xsec.dwg

A hydrogeologic investigation would be conducted down gradient of the pit to identify geologic structures that could act as secondary groundwater flow paths east, west, and south of the pit for purposes of monitoring and future groundwater capture of pit seepage. The study would be comprised of geologic mapping, test well drilling, and aquifer testing. The results of the study would be used to determine optimum groundwater monitoring locations and to design a groundwater capture system to minimize impacts to beneficial water uses from pit seepage.

Groundwater capture wells would be installed on secondary pathways when monitoring indicates a need. Based on previous studies of groundwater capture in bedrock and experience in drilling wells at GSM, it is estimated that at least two capture wells would initially be required for each structure with evidence of ARD migration. Testing and monitoring would be required to determine whether two wells achieved sufficient capture efficiency. Existing and potential monitoring and capture well locations are listed in Table 4-12 and shown on Figure 4-5 in the SEIS.

Effectiveness: A hydrogeological investigation to identify secondary flow paths down gradient of the pit would increase the efficiency of the proposed groundwater capture systems. Wells installed as a result of this study would reduce the problem of complying with applicable groundwater quality standards and would protect springs and beneficial uses of the Jefferson River alluvial aquifer.

Application: This measure would apply to the Partial Pit Backfill With Downgradient Collection Alternative.

Issue: Dewatering system damage from highwall raveling and sloughing.

Measure 4: As a contingency in case the dewatering system were damaged, destroyed, or became inaccessible, the agencies would require GSM to submit a plan for development, maintenance, and monitoring of a portal at a suitable elevation to allow access to the underground workings, so that dewatering would still be possible using an underground sump. If the 4,550-foot-elevation portal became inaccessible, GSM would have to establish a third portal.

Effectiveness: This contingency would allow dewatering to continue to keep the water table from rebounding if the dewatering system is damaged or destroyed and cannot be reestablished.

Application: This measure would apply to the No Pit Pond Alternative and the Underground Sump Alternative.

Issue: Access to the dewatering system in the pit.

Measure 5: Highwall safety benches, especially the 5,700-foot safety bench, and safety berms around the pit floor working surface would be maintained to catch rock that ravels and sloughs from the highwall after closure. The pit haul road would be maintained for access. Rock raveling and sloughing from the highwall and escaping the safety benches and berms would be removed. For the No Pit Pond Alternative, the working surface on the pit floor would be graded to remove the rocks, filled with more waste rock to re-level the working area, and resoiled if necessary.

Effectiveness: Maintenance of safety benches, berms, haul road, and the working area in the pit bottom would ensure that the dewatering system in the pit would be accessible, and worker safety would be ensured.

Application: This measure would apply to the No Pit Pond Alternative and the Underground Sump Alternative.

Issue: Dewatering system monitoring.

Measure 6: GSM would install and maintain a remote monitoring system for wells, pumps, pipelines, powerlines, etc., to ensure water is captured efficiently.

A dewatering monitoring system performance program would be implemented to monitor progress of the dewatering, evaluate the effectiveness of the system, and document the volume and quality of water pumped from the pit, underground sump, and capture wells.

Effectiveness: A remote monitoring system would ensure the proper functioning of the dewatering system while protecting workers by not requiring them to visit dewatering system components frequently. The system performance program would track the efficiency of the dewatering system and identify potential for improvement.

Application: This measure would apply to all alternatives.

Issue: Dewatering system failures.

Measure 7: Dewatering wells, pumps, access roads, powerlines, and pipelines would be repaired or replaced as needed to maintain dewatering system operations.

Effectiveness: Maintaining dewatering system components in good order would protect groundwater quality.

Application: This measure would apply to all alternatives.

Issue: Failure of the dewatering system in the Partial Pit Backfill With Downgradient Collection Alternative.

Measure 8: If the Partial Pit Backfill With Downgradient Collection Alternative were selected and the downgradient capture system does not prevent impacts at the mixing zone boundary, dewatering wells would be installed in the backfilled pit as in the Partial Pit Backfill With In-Pit Collection Alternative (see Figure 4-5 for well locations).

Effectiveness: This measure would minimize the potential for pit discharge.

Application: This measure would apply to the Partial Pit Backfill With Downgradient Collection Alternative.

Issue: Access to the underground workings.

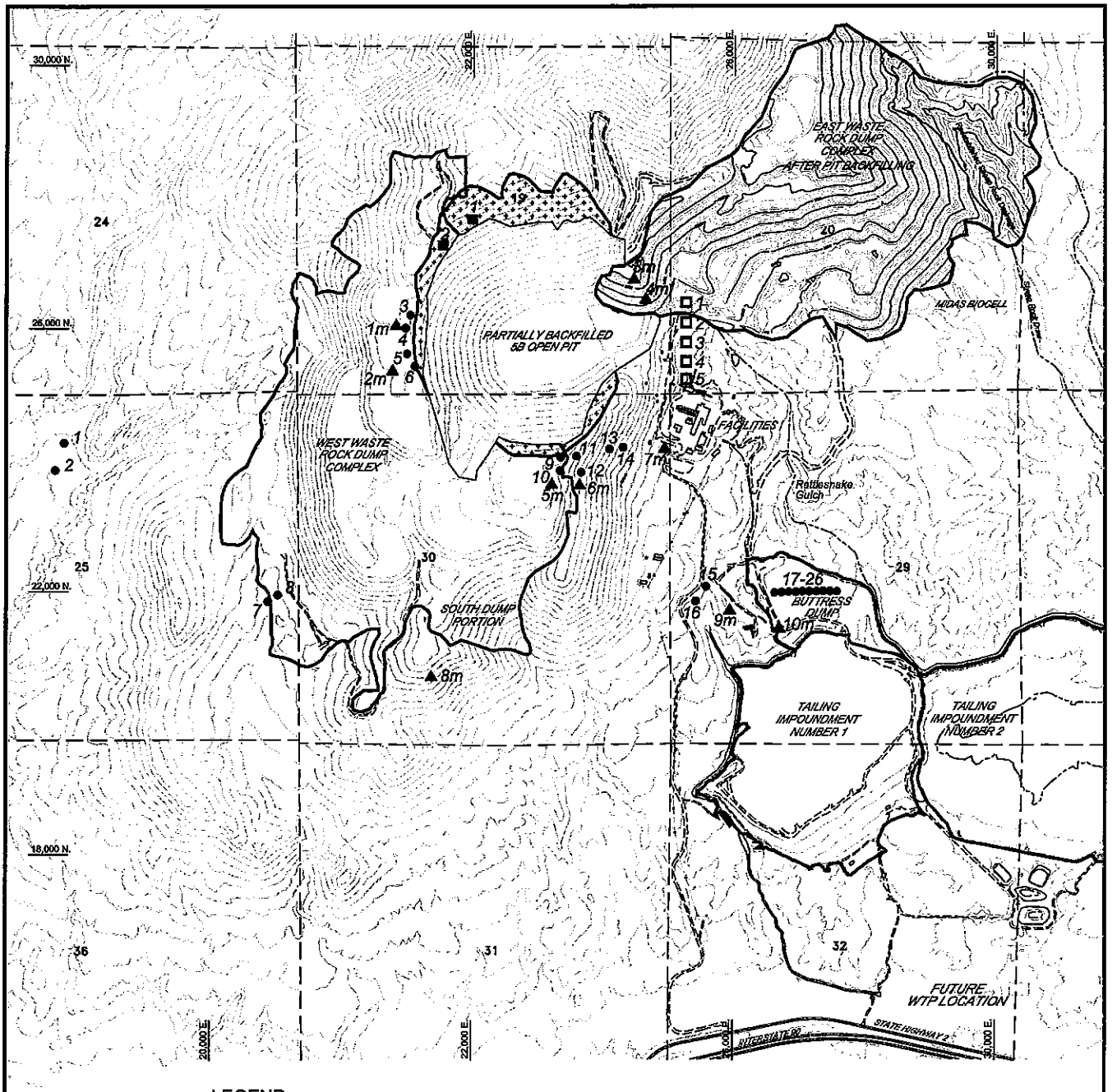
Measure 9: Access to the underground would be needed for a primary or contingency pit dewatering system. The agencies expect that the 4,550-foot elevation portal to the underground workings would be buried by rocks raveling off the highwalls and mass failures over time. The agencies would require GSM to submit a plan for development, monitoring, and maintenance of a new portal at a suitable elevation for access long term. The agencies would bond for maintenance of access and regular repair and replacement of dewatering system components.

This would require additional powerlines, pipelines, and maintenance of access roads in the underground workings to ensure integrity of the dewatering system and provide secondary access for workers. Monitoring of the underground workings would be required to ensure the integrity of the walls and ceiling.

A monitoring and maintenance plan would be needed to ensure continued access to repair the dewatering system and to ensure worker safety. The monitoring and maintenance plan would be applied to both the 4,550-foot and contingency portal locations. If the 4,550-foot-elevation portal became inaccessible, GSM would have to establish a third portal.

Effectiveness: Secondary portals would provide access to the underground workings, a backup dewatering system, and an escape way for workers.

Application: This measure would apply to the No Pit Pond Alternative and the Underground Sump Alternative.



LEGEND

- ■ New Upgradient Well (1-2)
- □ New Near Pit Well (1-5)
- ● New Dewatering Well (1-26)
- ▲ New Monitoring Well (1m-10m)
- Highwall Reduction Area

0 1200 2400
Scale in Feet

Partial Pit Backfill With Downgradient Collection Alternative

POTENTIAL DOWNGRADIENT DEWATERING WELL LOCATIONS AFTER MITIGATION

FIGURE 4-5

Figure 4-5 mitig Downgradient_wells.dwg

4.8.1.4 Storm Water Runon/Runoff Management

Issue: Storm water diversion maintenance.

Measure 10: Storm water diversions would be monitored regularly for integrity and gradient. If the gradient changed from settling resulting in low spots, the diversion would be returned to the proper gradient, resoiled, and seeded as necessary. Eventually, portions of the diversions would need to be reconstructed completely or at least have sediment accumulations and/or rockfalls from upgradient slopes removed.

Effectiveness: The maintenance requirements for the storm water diversions would ensure the ability of the diversions to route water away from the pit area over time.

Application: This measure would apply to all alternatives.

4.8.1.5 Soil Cover

Issue: Monitoring and testing of soils affected by steam venting at the waste rock dump complexes and the reclaimed pit area and tracking number and size of vents on all reclaimed surfaces over acid-producing materials.

Measure 11: This would replace Measure S-1 from the 1997 Draft EIS, Chapter IV, Section IV.P, which was approved as Stipulation 010-14 in the 1998 ROD.

A program would be implemented for the continued monitoring of existing waste rock dump complexes and pit surfaces that are reclaimed over acid-producing materials to further assess the impacts, if any, that steam venting may have on reapplied soil or establishing vegetation. The program would consist of GSM and/or agency reclamation specialists annually monitoring the number, location, and size of steam vents and extent of modified plant communities surrounding vent locations. If detrimental effects to establishing vegetation communities are observed on more than 0.1 percent of the total reclaimed area covering acid-producing materials, GSM would be required to: 1) rock armor vent locations to prevent erosion and spreading of vent locations, 2) sample and test soils at vent locations, and 3) prepare a detailed plan to further reduce the expansion of steam vents and minimize potential impacts to reclamation success. Soil parameters to be tested would correspond to those which appear to have given rise to the change in vegetation communities. At a minimum, soil pH and ABA would be evaluated for each sample collected. The general cost for such a program would be included in a post-mine maintenance bond.

Effectiveness: This would be an effective means of assessing and mitigating the changes occurring, if any, through time to reapplied soil materials and vegetation communities as a result of steam venting. The results of testing would be directly applicable to assessing whether steam venting had a negative effect on establishing vegetation communities.

Application: This measure would apply to all alternatives.

Issue: Pit reclamation maintenance.

Measure 12: Any acreage revegetated in the pit would be monitored for rock raveling and sloughing, backfill settling, erosion, and noxious weeds. Rock that has raveled or sloughed on revegetated areas would be removed or covered with new soil. Areas that have settled would be filled to grade with additional soil. Eroded areas would be repaired, resoiled, and reseeded. Noxious weeds would be controlled.

Effectiveness: This measure would ensure that revegetated areas are maintained, and storm water is diverted out of the pit.

Application: This measure would apply to all alternatives.

Issue: Reclamation soil rock content for 2H:1V slopes.

Measure 13: GSM would perform further testing to verify that soils from the proposed borrow site east of Tailings Impoundment No. 2 has the rock size and characteristics that are adequate for use on 2H:1V slopes. An amendment to add rock fragments would be required if necessary.

Effectiveness: This measure would ensure that soil placed on 2H:1V slopes in the pit would be protected from erosion.

Application: This measure would apply to all alternatives.

4.8.1.6 Water Treatment

Issue: Total of combined inflows to permanent water treatment plant exceeds the capacity of the plant.

Measure 14: This is Measure W-6 from the 1997 Draft EIS, Chapter IV, Section IV.P, which was approved as Stipulation 010-9 in the 1998 ROD.

The capacity of the permanent water treatment plant would be reevaluated and incorporated into the final design within 2 years prior to projected mine closure. At that time, the actual rate and quality of pit inflow during peak flow and low flow

periods, and the total rate and quality of groundwater captured in the tailing area will be better known.

Based on the degree of uncertainty of the rate of inflow from future sources, a contingency measure of up to 25 percent additional flow would be incorporated into the treatment plant capacity, and a contingency to provide storage for up to 6 months of anticipated water inflow would be included. This would provide for time to modify the plant if needed for unanticipated future inflows.

Alternatively, a new, additional water treatment facility would be constructed to address treatment of a specific source or sources. This supplemental water treatment facility would be built at the time such sources are identified. This alternative measure may be considered for treatment of waste rock dump ARD, because the time frame before ARD impacts are anticipated to occur is longer than a reasonable design life of the permanent water treatment plant that will be built at the end of mining.

Effectiveness: Sufficient additional water treatment capacity, whether added to the permanent water treatment plant design or as an additional separate facility, would provide for treatment of unanticipated inflows.

Application: This measure would apply to all alternatives.

4.8.2 Environmental Issues

4.8.2.1 Impacts to Groundwater Quality and Quantity

Issue: Compliance with groundwater standards down gradient of the pit.

Measure 15 from the Draft SEIS has been broken into three parts, based on public comments.

Measure 15a: The Rattlesnake Gulch dewatering wells and Tailings Impoundment No. 1 south pumpback system wells would be operated together to try to achieve at least a 96 percent capture efficiency of groundwater in the Tdf/colluvial aquifer down gradient of the pit to achieve compliance with groundwater standards for nickel and the other metals. If monitoring shows that an overall 96 percent capture is not being achieved, more wells would be installed.

Effectiveness: This measure would minimize impacts to the Jefferson River alluvial aquifer, but it cannot be guaranteed that sufficient wells can be installed to prevent water quality violations.

Application: This measure would apply to the Partial Pit Backfill With Downgradient Collection Alternative.

Measure 15b: Two capture wells would be installed up gradient of the pit to reduce the volume of groundwater entering the pit from the Corridor Fault by at least 15 gpm.

Effectiveness: Upgradient capture wells would reduce the rate of groundwater seepage to the pit by 15 gpm, reducing the expected pit seepage to the Tdf/colluvial aquifer from 27 to 42 to 12 to 27 gpm. If Measure 15a achieves only 92% overall capture efficiency, groundwater standards would be met at the mixing zone boundary if pit seepage rates are less than 16 to 18 gpm under the Partial Pit Backfill With Downgradient Collection Alternative.

Application: Upgradient capture would apply to the partial pit backfill alternatives.

Measure 15c: Five wells would be installed near the eastern edge of the pit in upper Rattlesnake Gulch to capture some of the pit seepage (see Figure 4-6 for well locations). The targets of the capture wells would be the Tdf/colluvial aquifer and the Corridor Fault. A detailed hydrogeologic characterization of the area directly east of the pit would be required to identify the most effective zones for capture.

Table 4 - 12. New Capture Well Locations

Flow Path	Location	No. of Wells	Comments
Corridor Fault	Up Gradient of pit	2	
Tdf/colluvial Aquifer	Down gradient of pit	5	Near east edge of pit in upper Rattlesnake Gulch

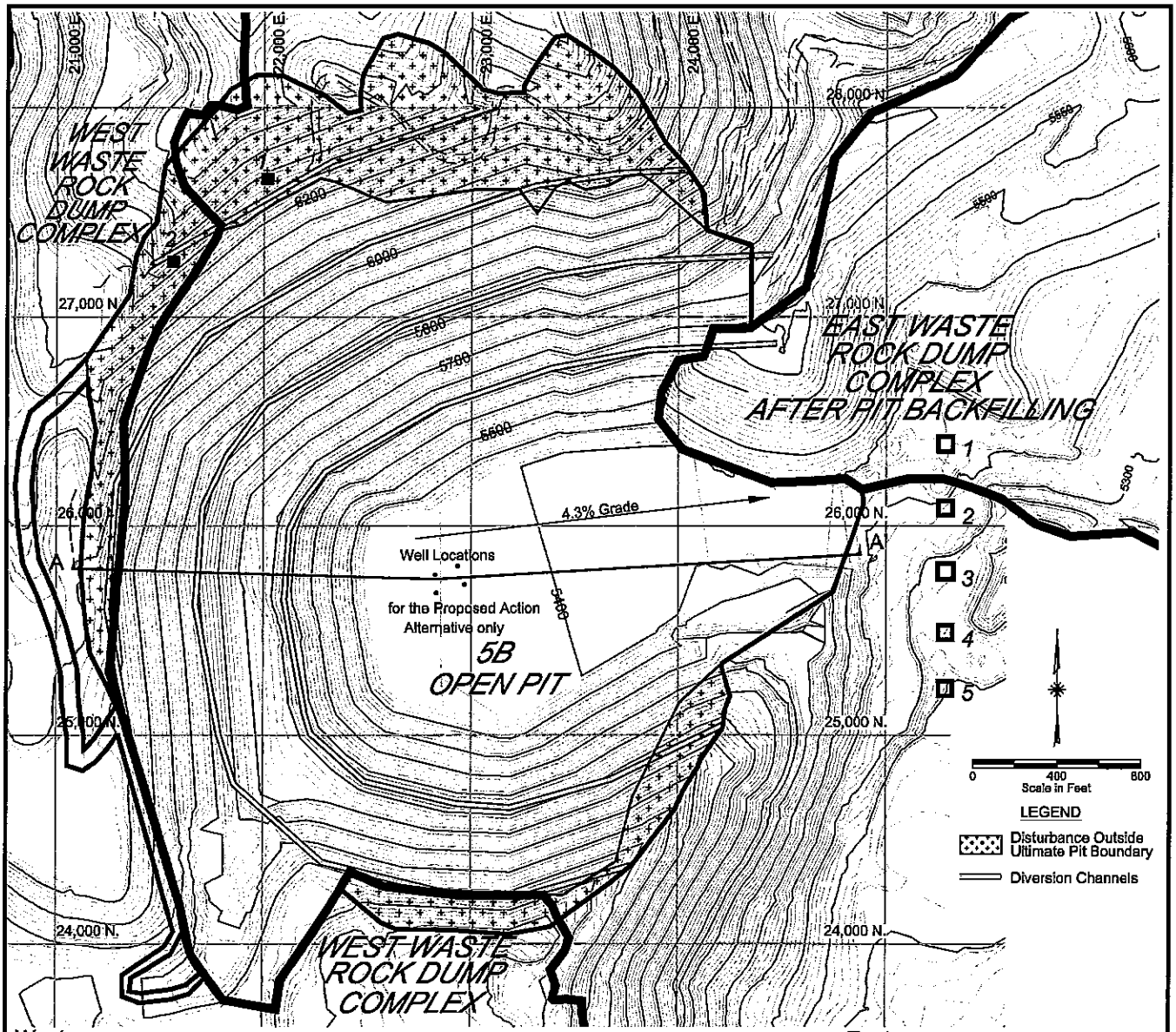
Effectiveness: This measure would reduce some of the water entering the aquifer from the pit. Its effectiveness would be limited because:

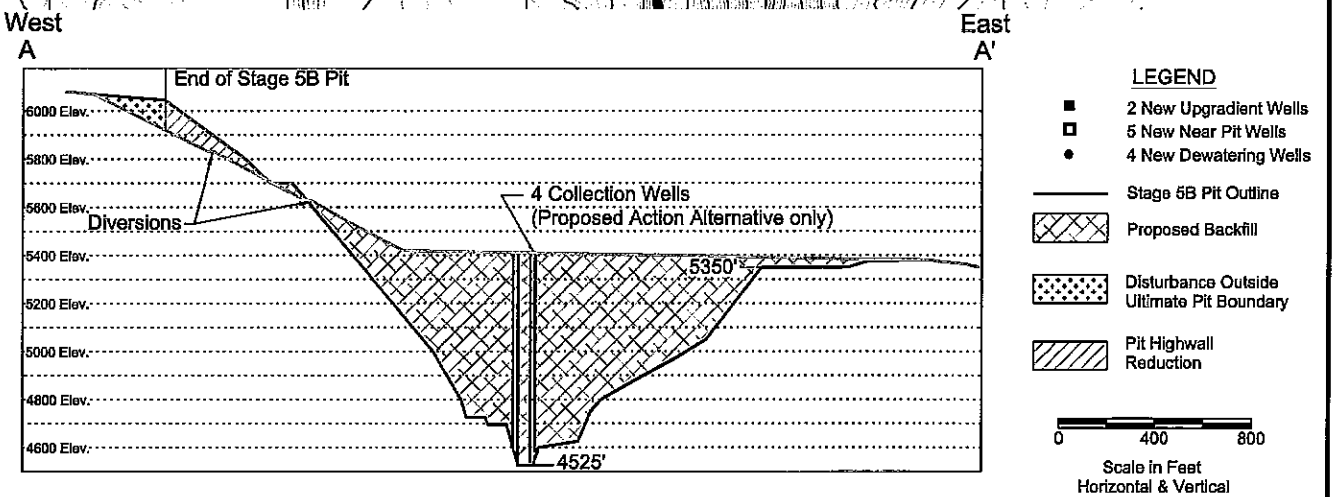
- This is a structurally complex aquifer. Groundwater flow is less predictable than in the sedimentary deposits in Rattlesnake Gulch. Groundwater flow could be in fractured rock and might by-pass the Tdf/colluvial aquifer adjacent to the pit;
- The Tdf/colluvial aquifer at this location is deeper and more heterogeneous and has multiple flow paths, making capture more difficult than at the current location of the Rattlesnake Gulch capture system; and
- The groundwater gradient is high. The large groundwater gradient results in less saturated thickness and faster groundwater velocities, making capture in wells more difficult.

Application: This measure would apply to the Partial Pit Backfill With Downgradient Collection Alternative.

Issue: Impacts to beneficial uses in the Jefferson River alluvial aquifer.

Measure 16: Water would be discharged from the permanent water treatment plant back to the aquifer as recharge, or to discharge as surface water in order to minimize impacts to downgradient beneficial uses.





Partial Pit Backfill with In-Pit Collection Alternative would have four 800-875 foot dewatering wells drilled to approximately the 4525-foot elevation. Up to eleven total dewatering wells would be required for mitigation.

Partial Pit Backfill with Downgradient Collection Alternative would have no in-pit wells.

Partial Pit Backfill Alternatives

FINAL PARTIAL PIT BACKFILL CONFIGURATION AFTER MITIGATION

FIGURE 4-6

Figure 4-6 mitig PPB-backfill-xsec.dwg

Effectiveness: This measure would minimize impacts to beneficial uses of water down gradient of the groundwater capture system in the Jefferson River alluvial aquifer or the Jefferson River and Slough.

Application: This measure would apply to all alternatives.

Issue: Modification of the groundwater mixing zone to include pit discharge.

Measure 17: Pit discharge was not included in the groundwater mixing zone statement of basis in the 1998 Final EIS, Appendix 1. The flow paths from the pit are within the permitted GSM mixing zone. GSM would have to submit an application to modify the approved mixing zone. DEQ would modify the 1998 Statement of Basis for the mixing zone.

Effectiveness: The mixing zone analysis and the statement of basis modification would ensure compliance with groundwater quality standards at the mixing zone boundary.

Application: This measure would apply to the Partial Pit Backfill With Downgradient Collection Alternative.

4.8.2.2 Impacts to Surface Water Quality and Quantity

Issue: Identification and replacement of altered discharge or reduced water quality at springs and seeps.

Measure 18: This is a modification of Measure W-1 from the 1997 Draft EIS, Chapter IV, Section IV.P, which was approved as Stipulation 010-4 in the 1998 ROD.

A monitoring program would be established to quantify discharge and water quality at springs in the project area and to identify any reductions or increases in flow or changes in water quality. Data would be collected often enough to detect spring response to seasonal variations and pit dewatering.

Mitigation of reduced discharge at springs would be accomplished by further development of the affected spring or by diverting water from the permanent water treatment plant to provide water for wildlife and livestock use. Further development of the spring would involve improving collection and storage of spring discharge and/or expanding the interception area of the spring at the water table.

Mitigation would be required if spring discharge increased by more than 15 percent of the baseline spring flow or if water quality declined. If flow increased

or water quality decreased, the spring water would be collected and routed to the water treatment plant for treatment and disposal.

Mitigation of reduced water quality would be accomplished by establishing additional water sources for wildlife and livestock use. Treated water from the permanent water treatment plant would be discharged as surface water for wildlife and livestock use.

Any change in the quantity and/or quality of springs and seeps, and their associated source of contaminants, would be subject to an MPDES permitting review by DEQ. For bonding purposes, under the Partial Pit Backfill With Downgradient Collection Alternative, the agencies have assumed that one existing spring, Stepan Spring, would have a 15 percent increase in flow that would have to be collected and treated, and that one new spring discharging 1.5 gpm would develop and would be collected and treated under an MPDES permit.

Effectiveness: This measure would document variations in spring discharge and spring water quality and provide data to determine if changes in spring flows or water quality occur during and after mining. This measure also would provide continued surface water sources at the mine site, reducing impacts to wildlife and livestock.

Application: This measure would apply to all alternatives.

Issue: ARD release from waste rock dump complexes or the pit area that is either premature because of transport along preferential, discrete flow paths and/or of greater flow rate than modeled performance because of higher than expected infiltration.

Measure 19: This is Measure W-4 from the 1997 Draft EIS, Chapter IV, Section IV.P, which was approved as Stipulation 010-7 in the 1998 ROD.

If the data from existing monitoring wells and/or spring flows indicate that changes in water quality are occurring which are likely to exceed applicable regulatory requirements, the following mitigation measures would be employed:

a) If water quality impacts are detected in monitoring wells at the mixing zone boundary down gradient from the East Waste Rock Dump Complex, localized capture of groundwater may be needed to contain ARD transport along preferential, discrete flow paths that were not anticipated by the ARD fate and transport model (see the 1997 Draft EIS, Appendix J). A groundwater capture system similar to the system described in Appendix A for the West Waste Rock Dump Complex would be installed. Capture of discrete plumes from the East Waste Rock Dump Complex would not require a well system as extensive as that needed for the West Waste Rock Dump Complex. The contingency design in the 1997 Draft EIS, Appendix A that provides for treatment of approximately 20

percent of the predicted flux on the east side is considered adequate for this mitigation measure;

b) ARD-impacted seeps may emerge at the toes of the waste rock dumps where preferential drainage paths occur within the dumps that lead to discrete "perched" saturated zones at their base. Shallow groundwater capture systems such as toe drains around the peripheries of the waste rock dumps would be installed to supplement the primary, deep capture well system; or

c) *In-situ* treatment systems would be installed in the shallow ("perched") aquifer zones, including the alluvial materials over bedrock on the west side, and/or the colluvial/alluvial materials in Rattlesnake Gulch or at other locations down gradient of the East Waste Rock Dump Complex. One example of this type of emerging technology is a funnel and gate approach which incorporates groundwater barriers that "funnel" the identified contaminant plume(s) through constrained location(s) within the shallow aquifer. *In-situ* reaction walls, such as limestone-filled trenches, are installed at these "gate" locations. The reaction walls provide essentially "semipervious" barriers which allow water to pass but "filter" the dissolved metals or other contaminants.

Effectiveness: The supplemental groundwater capture systems described would allow interception of contaminated groundwater that bypasses the primary capture well system. ARD-impacted groundwater could bypass the capture wells along shallow perched flow paths around the peripheries of all the dumps, or move through high conductivity preferential flow paths down gradient from the East Waste Rock Dump Complex. The supplemental systems described would provide for capture of these potential ARD sources before the contaminated water migrates down gradient to beneficial uses, or to sensitive receptors, such as the Jefferson River.

Application: These measures would apply to all alternatives.

4.8.3 Socioeconomic Issues

4.8.3.1 Safety

Issue: Worker safety within the pit.

Measure 20: A 70-foot-wide safety bench at the 5,700-foot elevation would be left around three sides of the pit for additional protection. One or more berms would be constructed around the perimeter of the working area on the pit bottom in the No Pit Pond Alternative to trap incidental rocks that may fall from the highwall. The access road leading down to the working surface on the pit bottom from the 4,875-foot elevation would be widened by extending the road to the south over a portion of the 4,800-foot-elevation area and away from the highwall toe.

The agencies would require the development of secondary portals at suitable elevations in the pit as secondary escape ways as needed.

The agencies would require GSM to install and maintain a remote monitoring system for wells, pumps, pipelines, powerlines, etc., to minimize the need for workers to be in the pit.

Effectiveness: These measures would provide additional protection to workers in the pit, but there would continue to be hazards associated with working in the pit.

Application: This measure would apply to the No Pit Pond Alternative and the Underground Sump Alternative.

4.8.3.2 Aesthetics

Issue: Visual contrast with adjacent lands.

Measure 21: About 37 acres in the pit would be treated with the following measures to reduce the visual contrast with adjacent lands, if the work can be accomplished safely:

- End dumping and/or cast blasting would occur along the upper portion of the northwest and west highwalls, and these areas would be seeded and possibly planted with trees.
- Dozer work would be completed on the area of the west highwall that sloughed in 2005 or another appropriate area, and this area would be seeded and possibly planted with trees.
- Soil sampling on the old slide area on the northwest highwall would be completed, and this area would be seeded and possibly planted with trees.

- Soil would be placed on the highwall bench above the 5,700-foot safety bench, and the area would be seeded and planted with trees if it is safe to do so.
- Trees would be planted where possible on the 5,700- and 5,400-foot safety benches.

Effectiveness: Sharp lines and forms in the pit would be softened. Pit highwall rock weathering and vegetation over the long term would blend with the color and texture of the natural landscape. Portions of the highwalls and benches would remain visible. Overall visual contrasts would be reduced to a level where they are noticeable but not dominant in the landscape, following successful reclamation and revegetation. Landscape modifications would be consistent with the suggested VRM Class III rating for the area.

Application: This measure would apply to the No Pit Pond Alternative and the Underground Sump Alternative.

Measure 22: The East Waste Rock Dump Complex would be extended back across the mouth of the pit to tie into the natural slope and partially screen the view of the northeast corner of the pit highwall.

Effectiveness: Views of the northwest portion of the pit highwall would be partially obscured.

Application: This measure would apply to the No Pit Pond Alternative and the Underground Sump Alternative.

4.8.4 Other Issues

Issue: Cultural resource protection.

Measure 23: GSM would prepare and execute a mitigation plan for the cabin located near the highwall, if it is threatened by cast blasting.

Effectiveness: A mitigation plan would ensure that the cabin is protected, or that historical data are properly collected and recorded before it is damaged or destroyed.

Application: This measure would apply to the Partial Pit Backfill With In-Pit Collection Alternative and the Partial Pit Backfill With Downgradient Collection Alternative.

4.9 UNAVOIDABLE ADVERSE IMPACTS

Unavoidable adverse impacts were addressed in the 1997 Draft EIS, Chapter IV, Section IV.Q. That analysis included evaluating unavoidable impacts that could result from expansion of mining activities, as well as reclamation activities. Implementation of the potential mitigation measures identified in the 1997 Draft EIS was to reduce most adverse impacts that were identified. This SEIS updates that analysis.

4.9.1 Technical Issues

The technical issues described and evaluated in this section relate primarily to stability, maintainability, and operating requirements of engineered structures and water management facilities as they relate to pit reclamation. The technical issues were evaluated in conjunction with the environmental and socioeconomic issues. The evaluation of the other issues assumed that the issues in the technical section function as designed and constructed. The success of the technical issues directly affects other issues.

Unavoidable impacts related to the technical issues include impacts associated with the pit highwall, groundwater effluent management system, storm water runon/runoff management, soil cover, water treatment, and flexibility for future improvements.

In alternatives that do not include large amounts of backfilling, it is expected that some portions of the pit highwall would be subject to raveling and limited sloughing, which are unavoidable. This movement could result in impacts to the dewatering system and pose safety concerns for workers in the pit. Limited environmental impacts would occur outside of the pit as a result of raveling and sloughing over time.

In regard to the groundwater effluent management system, the Partial Pit Backfill With In-Pit Collection Alternative would include a large amount of backfill and would encounter additional problems with pumping water from the pit. Due to the amount of backfill required and the characteristics of the backfill material, problems with operating and maintaining properly functioning wells and ensuring water can be effectively captured in backfill with low permeability are unavoidable. It cannot be reliably assured that these systems would function as designed. If the dewatering system fails, environmental impacts to regional groundwater could occur outside of the pit.

Storm water runon/runoff management activities would be required regardless of the alternative selected. The need for managing storm water diversions over acid producing waste would result in long-term maintenance needs.

The alternatives would result in the need for 3 feet of soil for covering the acid generating waste rock on 52 to 292 acres in the pit (Table 4-6), depending on the alternative. As needed, this soil would be removed from borrow areas on the mine site.

A small volume of soil would be lost to erosion during salvage and reapplication activities and following seeding until vegetation becomes established. The partial pit backfill alternatives are subject to settlement after reclamation, which could result in some limited soil loss and soil additions to reestablish grades. Under the No Pit Pond and Underground Sump alternatives, some soil on reclaimed areas in the pit would be lost adjacent to highwalls by raveling and sloughing rock.

Water treatment would be required regardless of the alternative chosen. GSM is bonded for long-term water treatment and this is unavoidable. Water treatment would result in the need to manage discharge water and sludge generated by treatment activities.

Opportunities exist for improvements to existing water management practices and plans in the future that could reduce contamination and provide lower cost treatment alternatives. Partial pit backfill alternatives could reduce the possibility of continued research and development of these opportunities within the pit backfill.

4.9.2 Environmental Issues

Unavoidable impacts related to environmental issues include impacts to groundwater quality and quantity, surface water quality and quantity, and reclamation plan changes.

Under the alternatives that maintain the pit as a hydrologic sink, dewatering the pit has reduced groundwater levels in the pit vicinity during operation. Continued pumping of groundwater for treatment, as part of reclamation, would result in lower groundwater levels for as long as pumping continues. The reduced groundwater levels could impact discharges from local seeps and springs. Intercepted pit water is removed from the local hydrologic system. During operation, this water is used in the processing circuit. Following mine closure and reclamation, most of this water would be returned to the local groundwater system in another drainage down gradient of the water treatment plant after treatment to avoid recontamination of that water in the flow path below the pit.

The Partial Pit Backfill With In-Pit Collection Alternative would include a large amount of backfill and would encounter problems with pumping water and maintaining the pit as a hydrologic sink. If the dewatering system fails, contaminated groundwater would flow along a path projected in the Partial Pit Backfill With Downgradient Collection Alternative.

Under the Partial Pit Backfill With Downgradient Collection Alternative, the regional groundwater system in the pit would return to the level before mining. The water table down gradient of the pit would be drawn down around the capture wells. This is an unavoidable impact of downgradient dewatering using a groundwater capture system.

The Partial Pit Backfill With Downgradient Collection Alternative would result in contaminated groundwater leaving the pit and entering the local groundwater system. This water would impact the groundwater quality to the point of collection. If collection is not 96 percent effective adverse impacts would result at the mixing zone boundary.

No direct adverse impacts to wetlands have been identified. Indirect hydrologic impacts could occur to area springs under all alternatives.

There are 156 to 158 acres of pit area under the No Pit Pond Alternative and Underground Sump Alternative that would be reclaimed as highwall and not revegetated.

Reclamation for all of the alternatives requires diversion of surface water flows around waste rock dump complexes and the pit.

No changes from the unavoidable adverse impacts discussed for the waste rock dump complexes in the 1997 Draft EIS, Chapter IV, Section IV.Q are expected as a result of the reclamation plans evaluated in this SEIS.

4.9.3 Socioeconomic Issues

Unavoidable adverse impacts related to socioeconomic issues include impacts to mining employment, tax revenues, mineral reserves and resources, and land use after mining. Impacts to mining employment and tax revenues would occur if GSM decides to stop mining Stage 5B if a partial pit backfill alternative is selected.

No unavoidable adverse impacts to access to future mineral reserves and resources have been identified for the No Pit Pond Alternative and the Underground Sump Alternative. The Partial Pit Backfill With In-Pit Collection Alternative and the Partial Pit Backfill With Downgradient Collection Alternative would place 47,000,000 cubic yards of waste rock and soil back into the pit. This backfill material would bury the remaining potential mineral resource and would potentially make it uneconomic for future open pit extraction of ore by increasing waste-to-ore strip ratios.

Long-term loss of 156 to 158 acres of native wildlife habitat for species such as mule deer would occur under the No Pit Pond and Underground Sump

alternatives. The alternatives that would result in the largest loss of mule deer habitat would also result in a small gain of habitat for other wildlife species, such as raptors and bats.

Unavoidable adverse impacts for land use include areas disturbed by mining activity and the loss of grazing resources in the Bull Mountain Allotment and Hill and Wilkerson Allotment.

4.10 SHORT-TERM USE VERSUS LONG-TERM PRODUCTIVITY

The 1997 Draft EIS, Chapter IV, Section IV.R addressed short-term use versus long-term productivity. This SEIS only addresses changes to productivity that would occur as a result of pit reclamation alternatives. Short term is defined as the life of GSM through closure and reclamation (2011). Long term is defined as the future beyond reclamation. Many of the impacts associated with all alternatives would be short term and would cease following successful reclamation.

Soil and vegetation short-term productivity would be reduced on the 56 to 58 acres of new disturbance under the partial pit backfill alternatives. Assuming revegetation is successful, and soil development and vegetation succession occur, long-term soil productivity would be restored. The permanent loss of 156 to 158 acres of native vegetation and wildlife habitat under the No Pit Pond and Underground Sump alternatives would be partially offset by productivity of the acreage revegetated with predominantly non-native species.

Noxious weeds are increasing in areas around the mine and across Montana. Regardless of control efforts, noxious weeds will increase on the pit disturbed area for all alternatives, affecting long-term productivity of desirable species. Plant community composition would be altered by the noxious weeds and control activities. This is an unavoidable impact of noxious weed presence and control.

4.11 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The 1997 Draft EIS, Chapter IV, Section IV.S addressed irreversible and irretrievable commitments of resources. This SEIS only addresses changes to irreversible and irretrievable commitments of resources that would occur as a result of pit reclamation alternatives. Irreversible is a term that describes the loss of future options. It applies primarily to the effects of use of nonrenewable resources, such as minerals or cultural resources, or to those factors, such as soil productivity, that are renewable only over long periods of time. Irretrievable is a term that applies to the loss of production, harvest, or use of natural resources. For example, livestock forage production from an area is lost irretrievably while an area is serving as a mining area. The production lost is

irretrievable, but the action is not irreversible. If the use changes and the mine is reclaimed, it is possible to resume forage production. Irreversible and irretrievable impacts under all alternatives are similar to those analyzed in the 1997 Draft EIS.

One irreversible loss addressed in this SEIS involves the ability to adapt to future technologies. Prevention and treatment technologies for ARD are continually evolving and becoming more effective. For alternatives involving partial pit backfilling, the ability to adapt to future changes in technology may be limited.

The partial pit backfill alternatives would restrict access to future reserves and limit the potential for future mining and recovery of remaining mineral resources and reserves. This agrees with conclusions of the National Resource Council Report by Committee on Hard Rock Mining on Federal Lands, 1999, National Academy Press, Washington, D.C., that backfilling pits does limit the potential for future mining and recovery of remaining mineral resources and reserves.

4.12 ENERGY REQUIREMENTS AND CONSERVATION POTENTIAL

Energy for Stage 5B and the reclamation alternatives would be essentially the same as listed in the 1997 Draft EIS, Chapter IV, Section IV.T.

The Partial Pit Backfill With In-Pit Collection Alternative and the Partial Pit Backfill With Downgradient Collection Alternative would have increased diesel fuel consumption for grading slopes to 2H:1V and backfilling waste rock from the East Waste Rock Dump Complex into the pit. The life-of-project diesel fuel consumption increases from the 13,000,000 gallons for Stage 5B and the No Pit Pond Alternative to 22,000,000 gallons for the two partial pit backfill alternatives. Pumping from the underground workings under the Underground Sump Alternative would add a very minimal amount of electrical demand.

Chapter 5

Consultation and Coordination

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Chapter 5

Consultation and Coordination

5.1 AGENCIES, ORGANIZATIONS, AND INDIVIDUALS CONSULTED

In the course of preparation of the Draft and Final SEISs for the Golden Sunlight Mine (GSM), the DEQ and BLM communicated with and received input from federal, state, and local agencies, elected representatives, environmental and citizens groups, companies, and individuals. This list of agencies, organizations, and individuals includes those individuals present at the Public Scoping and the Whitehall Community Transition Advisory Committee meetings held in Whitehall, and the MAA meetings.

5.2 PUBLIC PARTICIPATION

5.2.1 Scoping Meeting

A public scoping meeting was held on July 16, 2003 at the Middle School in Whitehall, Montana. A total of 164 people signed in at the meeting, and there were approximately another 30 who declined to sign the register. The meeting commenced with an explanation of the meeting's purpose presented by DEQ. The General Manager of GSM spoke on the history of the mine. This was followed by a presentation by the agencies of the seven alternatives being actively studied in preparation of the SEIS.

Twenty-six attendees at the public scoping meeting made statements, all against partial pit backfill at GSM. Representatives of BLM and DEQ answered questions raised by participants of the meeting.

A total of 76 comments have been received, 71 letters or e-mails, and five comment forms completed during the public meeting. There were a total of 120 signatures on the comments, and 12 comments were on form letters. Of the 76 comments received, 73 expressed strong opinions against partial pit backfill. Seven letters were from local, state, or federal representatives.

What has changed in Chapter 5 since the DSEIS?

Chapter 5 lists all those who consulted on the SEIS and how public participation took place. The following changes have been made:

- Information on the DSEIS meetings held in 2005 are listed.
- The information on the timeframe for public comments is listed.
- The mailing list for the FSEIS is listed.

5.2.2 Whitehall Community Transition Advisory Committee

On September 9, 2003, another public meeting was held at the Whitehall Middle School, called by the Whitehall Community Transition Advisory Committee, a locally based stakeholder group interested in the future and reclamation of GSM. This meeting again showed the interest of the local and surrounding communities in the process. Both DEQ and BLM representatives attended the meeting.

A total of 117 people attended the meeting. Similar to the Public Scoping Meeting, the persons making statements at this meeting were strongly against the partial pit backfill approach to GSM reclamation.

5.2.3 MAA Process

To assist the agencies in determining the range of alternatives to be evaluated in the SEIS, DEQ and BLM initiated a Multiple Accounts Analysis (MAA) process. The MAA process is described in detail in Robertson GeoConsultants (2003) and summarized in Section 1.7.2.

5.2.4 Draft SEIS Public Meetings

Public meetings were held in Whitehall on January 31, 2005, with 17 speakers, Helena on March 14, 2005, with 13 speakers, and Butte on March 24, 2005, with 7 speakers. The meetings were conducted by DEQ and BLM to solicit input on the GSM Draft SEIS.

5.2.5 Draft SEIS Public Comments

The public comment period ran from December 16, 2004, until April 12, 2005. There were 169 groups or individuals who provided public comment on the Draft SEIS. These 169 entities provided 392 comments. The responses to these public comments are found in Chapter 6.

5.3 PERSONS AND ORGANIZATIONS RECEIVING THE SEIS

Agencies, organizations, and individuals who received copies of the Final SEIS are listed below:

Businesses/Organizations
- Alliance for the Wild Rockies
- AngloGold North America
- Atlatl
- Bighorn Environmental Sciences
- Buka Environmental
- Butte Local Development Corp.
- Cardwell Store and RV Park
- Center for Environmental Programs
- Center for Urban Affairs & Policy
- Clark Fork Coalition
- Continental Divide Trail
- Cortez Gold Mine
- CURE
- Earthworks
- Fickler Oil Company
- Gallatin Wildlife Association
- Genesis Inc. Troy Mine
- Golden Sunlight Mine
- Gouch, Shanahan, Johnson & Waterman
- International Union of Oper. Engineers
- J. Kuipers Engineering
- JLDC
- LR Huckaba Ranch
- McCloskey Auto Electric
- Mineral Policy Center
- Montana Contractors' Association, Inc.
- Montana Mining Association
- Montana Petroleum Association
- Montana Resources
- Montana River Action
- Montana Wildlife Federation
- Mountain Labs
- MSE-TA
- MT Environmental Information Center
- National Wildlife Federation
- Northern Plains Resource Council
- O'Keefe Drilling
- Pacific Blasting
- People for the West
- Pintler Audubon Society
- Smith Construction
- Smith Contracting
- Western Mining Action Project
- Western Environmental Trade Assoc.

Colleges and Universities
- Montana State University – Bozeman
- Montana Tech of the University of Montana - Butte

Libraries
- Boulder Community Library
- Bozeman Public Library
- Butte Public Library
- John Gregory Memorial Library
- Lewis and Clark County Library
- Montana State Library
- Montana State University Library
- Montana Tech Library

Congressional Offices
- U.S. Representative Denny Rehberg
- U.S. Senator Max Baucus
- U.S. Senator Jon Testor

Montana Legislators
- Representative Art Noonan
- Representative Diane Rice
- Representative George Groesbeck
- Representative Jim Keane
- Representative Scott Mendenhall
- Senator Steve Gallus
- Senator Terry Murphy
- Senator Dan Harrington
- Senator Bill Tash

Local Governments
- Butte Chamber of Commerce

County Agencies
- Butte Silver Bow County Commission
- Gallatin County Commission
- Jefferson County Commission
- Jefferson Valley Conservation District
- Madison-Jefferson County Extension Office

Tribal Entities
- The Confederated Salish and Kootenai Tribes of the Flathead Nation
- Crow Indian Reservation
- Shoshone-Bannock Tribes

Federal Government
- Bureau of Indian Affairs
- Bureau of Land Management
- Bureau of Reclamation
- Department of Energy
- Department of Interior
- Environmental Protection Agency
- Fish and Wildlife Service
- Library of Congress
- Mineral Management Service
- National Park Service
- Office of Environmental Policy & Compliance
- Office of Surface Mining
- US Geological Survey National Center
- US Government Printing Office

State of Montana
- Department of Commerce
- Department of Environmental Quality
- Department of Natural Resources and Conservation
- Environmental Quality Council
- Hard Rock Impact Board
- Montana Chamber of Commerce
- Montana Fish, Wildlife and Parks
- Office of the Governor
- State Historic Preservation Office

Individuals
- Joe and Laurie Adams
- James Anderson
- Paul Babcock
- Eric Ball
- Joe Bardswich
- Ike Bassett
- Dana Bauer
- Henry Bogert
- Steve Bundrock
- Shane and Kari Chatriand
- Randy Cline
- Bill and Bernadette Conner
- Gary and Faith Cooper
- Roberta Coppinger
- Joe Davis
- Mary Davis
- Bob Dedominic
- Kenneth Dodd
- Jim Ellerton
- Jessie Felsheim
- Meryl and Lacy Fitzpatrick
- Jerry Fleege
- Larry Fulford
- Donald Gillespie
- Jerry Gray
- Dick and Mary Gustin
- Jerry Hanley

Individuals (Cont.)

Amber Henson
Clifford Hoopes
J.R. Huchohe
Amber Jones
Trenton Jones
Rick Jonlan
Doc Jordan
Jim Keane
Joe Kenworthy
Jerr Lamb
Victor Lazar
Roxann Lincoln
Robert Lonback
John Magnus
Tamara Mar
Robert Marks
Bret Martinell
Glenn Marx
Antone Matule
Michael McCarthy
James McComber
Phillip Mulholland
Eric Nelson
Jerry Ocheskey
Kenneth Paulsen
Dan Poff
Don Powers
Janice Prinkki
Dean Pryor
Henry Reed
Paul Richards
Edward Ruppel
Ellie Safratowich
Tom Salvagni
Betty Salvagni
Darrell Scharf
June Severance
Bill and Barbara Seybert
Debbie Bowman Shea
Ed Simon
Bob and Connie Sims
Richard Smith
Bruce Stredwick
Bob and Barb Sunderland
Norman and Michelle Tebay
Jim Tinger
Charles Van Patten
Dan Walker
B. Warthen
Kerry and Cassie Weightman
Eric Williams
Mark Williams
Ken Wilson

Chapter 6

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Chapter 6

6.1 INTRODUCTION

Chapter 6 contains the public comments received on the Draft Supplemental EIS (DSEIS) and the agencies' responses to those comments. BLM and DEQ considered and responded to all comments in preparing the Final GSM FSEIS.

Public meetings were held in Whitehall on January 31, 2005, Helena on March 14, 2005, and Butte on March 24, 2005. The meetings were conducted by DEQ and BLM to solicit input on the GSM DSEIS. Each of the public meetings had public speakers talk on issues and opinions concerning the GSM DSEIS. The speakers listed in Table 6-1 are listed in the order in which they spoke at the particular meeting.

The public comment period went from December 16, 2004, until April 12, 2005. The comments contained herein request clarification, more discussion, give new information, question analytical techniques, suggest new alternatives, or are a positive/negative response to the recommended alternative.

This section describes the paraphrased comments received in written format, and then lists the commenters' letter number in parentheses following the comment. These comments may have been paraphrased, or otherwise updated for ease in preparing this document.

Similar comments have been grouped together, where possible, to create comment statements that capture the idea of two or more commenters. Comment statements may not be exact quotes of anyone or any one organization. Comments are grouped in the order in which they are numbered for this document.

What has changed in Chapter 6 since the DSEIS?

Chapter 6 was not included in the DSEIS. The chapter is a result of the documentation received from the public during the comment period:

- Table 6-1 lists the public meeting speakers.
- Table 6-2 is a log of the individuals making public comments.
- Comments 1-392 are comments received by the public and the agencies' responses to those comments.

Table 6-1 - Public Meeting Speakers

Whitehall Public Meeting 17 Speakers January 31, 2005	Helena Public Meeting 13 Speakers March 14, 2005	Butte Public Meeting 7 Speakers March 24, 2005
Tom Lythgoe	Bob Sims	Ken Weber
Ken Weber	Tom Salvagni	Ed Handl
Chuck Notbohm	Tim Mulligan	Tom Salvagni
Ed Handl	Scott Mendenhall	Peter Bogy
Elaine Mann	Roger Stover	Tom Harrington
Roger Stovers	Tom Lythgoe	Rick Jordan
Bob Sims	Tom Harrington	
Kelly Weber	Ken Weber	
Mark Briggs	Ed Handl	
Phil Mulholland	Peter Bogy	
Mark Isto	Webb Brown	
Joe Davis	Angela Janacaro	
Tom Harrington		
Tammy Johnson		
Joe Bardswich		
Tom Salvagni		

Table 6-2 is a list of commenters and their corresponding letter or form designation number. These letter numbers are shown at the end of the particular paraphrased comment statement to identify the person or organization that made the comments. Numbers in parentheses (following the Letter Number) are the numbers of pages in the original comments, whether hand written or typed.

Table 6-2 - Log of Public Comments

Letter Number	Name of Commenter
1(2)	Sarah M. Reum
2(2)	Kipp Keim
3(2)	Thomas A. Dale
4(2)	Wayne Severance

Letter Number	Name of Commenter
5(2)	June Severance
6(2)	Gwen M. Quesnell
7(2)	Delbert O. Hunt
8(2)	John F. Childs
9(2)	Robert Nimmick
10(2)	Darrell Scharf
11(2)	Miles Page
12(2)	Tanika Page
13(2)	Nina K. Olson
14(2)	John A. Olson
15(2)	Lynn R. Jensen
16(2)	Alan R. Jensen
17(2)	Ramona Fiack
18(2)	Delbert Fiack
19(2)	Susan Fulford
20(2)	Larry L. Fulford
21(2)	Donald R. Gillespie
22(2)	Bonna G. Gillespie
23(2)	Rachel E. Monforton
24(2)	Tom Monforton
25(2)	Pat H. Irwin
26(2)	Dave Chapman
27(2)	Mabel Ferch
28(2)	Bernard J. Ferch
29(2)	Kenneth R. Dodd
30(2)	Clifford J. Hoopes
31(2)	Patricia L. Hoopes
32(2)	Rory Lamp / Bill Upton (Nevada Dept. of Wildlife)
33	Jerry Hanley
34	Patsy Ballard
35	Larry Feight & Family
36	Rick Bishop (Bishop Insurance Agency)

Letter Number	Name of Commenter
37	Bonnie Brown (Jefco Real Estate)
38	Wanda Freman
39	James L. Loomis
40	Dr. Kathy Meyer (Whitehall Chiropractic)
41	Dana Bauer
42	Paul Richards
43	Andy Johnson
44	Kurt Ehlert (Tractor & Equipment Co.)
45	Lee Ebeling, P. E. (Lacy & Ebeling Engineering Inc.)
46	Jim Smitham (Butte Local Development Corporation)
47	Angela Janacaro (Montana Mining Association)
48	Delbert Hunt
49	Mary Whittinghill (Montana Taxpayers Association)
50(2)	Scott Mendenhall (House Representative for District 77)
51	Ken S. Eurick
52(2)	Tim Mulligan
53(2)	Roger W. Rohr (Tractor & Equipment Co.)
54	Mark Nelson
55	Ken Holkan
56	Clint Clements
57	Mike Ferguson
58	Jason Johnson
59	Cindy Larsen (Whitehall Chamber of Commerce)
60	Terry Basnett
61	Joe Nicholls
62	Steve Streadwick
63	David Bonko
64	William Turner
65	Scott Conner
66	Richard Flowers
67	Bob Sunderland
68	George Smith

Letter Number	Name of Commenter
69	Lance Hugulet
70	Donna L. Heikkinen
71	Robert V. Shaw
72	David Soennichsen
73	Dick Coughlin
74	Scott Parker
75(2)	Kevin R. Johnson (Montana Bentonite, LLC)
76	Justin Wentland
77	Sam Freese
78	Mark Janacaro
79	Paul Smith
80	Mike Wall
81	Tom Nicholson
82	Jack & Olive Smith
83	William D. Todd
84	Tim O'Donnell
85	Frank Sholey
86	Rodney Mills
87	Jay McCarthy
88	Jim Loomis, Jr.
89	Thomas Kinghorn
90	Robert Carpenter
91	Martin L. Johnson
92(4)	Tom Salvagni
93	Ray Panisko
94	Harry Parker
95	Greg Powers
96	Jeremy Bennett
97	Ken Hugulet
98	Tom Powers
99	Gary White

Letter Number	Name of Commenter
100	Brock Hassler
101	Ray Fitzpatrick
102	Wyatt Hartmann
103	Bret Martinell
104	David Lambrecht
105	Nina K. Olson
106	Don Drake
107	Brian Alley
108	Patrick J. Flowers (Mont. Fish, Wildlife & Parks Supervisor for Region #3)
109	Eric Johnson
110(4)	Edward L. Handl, P. E. (Atlatl Inc.)
111	Leita Beardsley
112(2)	Laura Skaer (Executive Director for the Northwest Mining Association)
113	Joe Dillon
114	Harold Sant
115	John Patritti
116	Sam Graham
117	Tom Peters
118	Kelly Stolp
119	Rick Henderson
120	Bill Chase
121	Ken Bahr
122	Tim Hockenberry
123	Bob Cronholm
124	Chris M. Nelson
125	John Perigo
126	Jim Chiotti
127	Tom & Twila Harrington
128	Tom Harrington (Whitehall Community Transition Advisory Committee Chairman)

Letter Number	Name of Commenter
129	Pat Connors
130	Gordon Lyons
131	Shawn McGurk
132	Don Powers
133	Richard A. Smith
134	Kerry Weightman
135	John Von Bergen
136	Dan Masica
137	Ryan Brackett
138	Brian Friesz
139	Dean Schroeder
140	Tim Near
141(2)	Tomas E. Lythgoe, Chuck Notbohm, Ken Weber (Jefferson County Commission)
142	Don Drake
143	Tomas E. Lythgoe
144(2)	Philip S. Mulholland (Mine Geologist)
145	Patricia Lewis (Jefferson Local Development Corporation)
146	Cory Vollmer (AFFCO)
147	Mark Briggs
148	Rick Johnston
149	Dan Donner
150	Greg Mills
151	Dave Vossler
152	Gary O'Farrell
153	Rich Johnson
154	Jeff Coleman
155	Douglas M. Hardison
156	Shane Albracht
157	Larry Downing
158	Justin Hanninen

Letter Number	Name of Commenter
159	Rich Prodgers
160	Tim & Andrea Mulligan
161	Bob Sims
162	B. Sachau/Jean Public
163	Bill Tash (Montana State Senator for District 36)
164(3)	Betty Salvagni
165	Merle Olson
166	Lonna Johnson
167(7)	Larry Svoboda (U. S. Environmental Protection Agency)
168(29)	Plaintiffs Representatives (David K. W. Wilson, Jr., Thomas M. France, and James R. Kuipers, PE)
169(48)	Golden Sunlight Mine

6.2 INDIVIDUAL COMMENTS AND RESPONSES

6.2.1 Public Interest Group Form Comments

The first six comments are from forms provided by a public interest group to the public for responding to the DSEIS and the public meetings held in early 2005. The 31 respondents indicated whether they agreed, disagreed, or had no opinion on six comments printed on the form. Each comment is repeated here and the responses are summarized by response number from Table 6.2.

Comments 7 through 19 are from these 31 respondents in written form.

1. COMMENT:
The preferred alternative – recommended by the Montana Department of Environmental Quality and the Bureau of Land Management – should be authorized and implemented. This alternative, the Underground Sump Alternative, is the best reclamation plan for ensuring environmental protection and water quality.

The 31 commenters listed below made the following response to the above statement:

Agree	Disagree	No Opinion	Not Marked
1-21, 23-28, 30-31	-	-	22, 29

RESPONSE:
Thank you for your comment.

2. **COMMENT:**
Worker safety is a critical part of any EIS and Record of Decision. The agencie's preferred alternative, the Underground Sump Alternative, provides the highest level of safety to workers in the future. It does this by utilizing the underground workings and by further reducing worker exposure to falling rock.

The 31 commenters listed below made the following response to the above statement:

Agree	Disagree	No Opinion	Not Marked
1-21, 23-28, 30-31	-	-	22, 29

RESPONSE:
Thank you for your comment.

3. **COMMENT:**
While "backfilling" the pit may be supported by some as the proper thing to do, it is not. Backfilling actually increases the chance of worker injury, brings undue costs, increases unnecessary fuel consumption, reduces air quality, and most importantly, increases the risk to water quality, including in the Jefferson River. Backfilling is simply the poorest choice for reclaiming this pit.

The 31 commenters listed below made the following response to the above statement

Agree	Disagree	No Opinion	Not Marked
1-16, 18-21, 23-28, 30-31	-	17	22, 29

RESPONSE:
Thank you for your comment. The agencies disagree that the chance of worker injury would increase. See Section 4.4.3.1.1.

4. COMMENT:
It appears that there are additional mineral resources in the vicinity of the pit. Backfilling will likely preclude future development of those mineral resources, or at the very least make it difficult, cumbersome and environmentally more difficult to access. The Underground Sump alternative, however, helps keep future options open – for both mining and proper water management.

The 31 commenters listed below made the following response to the above statement:

Agree	Disagree	No Opinion	Not Marked
1-3, 5-21, 23-28, 30-31	-	-	4, 22, 29

RESPONSE:
Thank you for your comment.

5. COMMENT:
As noted in the DSEIS, the Underground Sump Alternative provides "Flexibility for future improvements," which is currently being researched in several locations. This is particularly relevant regarding technologies being developed for water treatment such as microbes, carbon sources, etc. The ability to use such technologies in the future will be much greater in an open body of water (including underground) than in soggy backfill material. This alternative provides similar flexibility in other aspects of reclamation also.

The 31 commenters listed below made the following response to the above statement:

Agree	Disagree	No Opinion	Not Marked
1-28, 30-31	-	-	29

RESPONSE:
Thank you for your comment.

6. COMMENT:
As the BLM has indicated, backfilling the pit may result in "unnecessary or undue degradation of public lands" and should be avoided. The Underground Sump

Alternative provides the best solution for public lands, private lands, the environment, water quality, nearby communities and the State of Montana.

The 31 commenters listed below made the following response to the above statement:

Agree	Disagree	No Opinion	Not Marked
1-28, 30-31	-	-	29

RESPONSE:
Thank you for your comment.

In addition to submitting circled responses (comments 1-6), the following is the paraphrased comment made by 5 of the 31 commenters.

7. COMMENT:
The Underground Sump Alternative is common sense, addresses all the long term issues, and was developed by experts, so let's put this issue to rest and not let the Environmental Extremists (backfill options) shut down the mining industry in Montana. (2, 3, 5, 10, 25)

RESPONSE:
Thank you for the comment.

6.2.2 Other Individual Written Comments

This section describes the paraphrased comments received in written format, and then lists the commenters' letter number in parentheses following the comment.

8. COMMENT:
GSM is sitting in limbo waiting on a decision that should have been cleared up years ago. I support your recommended alternative, the Underground Sump. Those who seem to challenge the mine at every turn, say that by not backfilling the pit, GSM is defying the Montana Constitution. That is ridiculous. The law clearly states that backfill decisions should be made on a case by case basis. I think the DSEIS is clear and concise as to what each alternative would accomplish. Either of the no backfill alternatives is far and away better for our environment than the backfill alternatives.

I very much desire clean water and a nice town to live in. This is our community, and frankly, I don't know why the environmentalists can't leave us alone. They prefer alternatives that would poison the water, take away jobs, reduce worker safety, and reduce tax revenue for the schools, city, county, and the state of Montana. (32-34, 36-39, 45-51 54, 56, 57, 59, 62, 70, 71, 84, 92, 96-100, 104, 107,

118, 121, 123, 124, 128, 133, 138, 139, 141, 142, 144, 145, 147, 148, 152, 153, 155-158, 164-166)

RESPONSE:
Thank you for the comment.

9. **COMMENT:**
My family and I live just southeast of the mine by about 2.5 miles. I am completely opposed to any option that backfills the pit, with the potential to contaminate my well. My family and I will live with the results of this decision long after the mine is gone. I already know that mine operations affect my well, and here is why. My well is 200 feet deep, and over the years I have installed and changed an iron filter on a monthly basis. When the mine stopped mining ore this past time and went to the next phase of stripping, the iron filter contaminants were greatly reduced. I am not employed by GSM. I have records for my well. (35)

RESPONSE:
Thank you for the information.

10. **COMMENT:**
Numerous debates on the GSM and its reclamation have occurred over many years. As some groups argue for backfilling the pit, it seems other mines have tried this with great expense and less than successful environmental results. I am writing in support of the recommended option, the Underground Sump Alternative. This is the best of all the alternatives.

The decision as to how to handle this reclamation problem needs to be made in the best interest of all and not just a limited few who come here to push their agenda and then go home and don't really care about the true impacts of this decision. (40, 41, 53, 58, 60, 61, 63-68, 72, 75-77, 81-83, 86, 87, 89, 93-95, 101-103, 105, 111, 112, 116, 117, 119, 120, 122, 125-127, 129-132, 134, 135, 137, 140, 146, 154, 161, 163)

RESPONSE:
Thank you for the comment.

11. **COMMENT:**
The Montana Constitution mandates complete reclamation of all pits and highwalls to original contour. The Constitution also requires all poisoned waters be thoroughly purified and all final contours be revegetated with natural species requiring no water or fertilizer additions. (42)

RESPONSE:
The Montana Constitution does not require the reclamation of all pits and highwalls to original contour. Article IX, Section 2, of the Montana Constitution requires all lands disturbed by the taking of natural resources to be reclaimed and delegates to the Montana Legislature the authority to provide effective requirements and standards for the reclamation of lands disturbed.

The Montana Legislature has enacted the Metal Mine Reclamation Act to fulfill its obligations under Article IX of the Montana Constitution. The Metal Mine Reclamation Act requires open pits and rock faces to be reclaimed to a condition 1) of structural stability competent to withstand geologic and climatic conditions without significant failure that would be a threat to public safety and the environment; 2) that affords some utility to humans or the environment; 3) that mitigates post-reclamation visual contrasts between reclamation lands and adjacent lands; and 4) that mitigates or prevents undesirable offsite impacts. The Metal Mine Reclamation Act neither requires nor prohibits use of backfilling as a reclamation measure. Rather, DEQ is required to base its decision to require any backfill measure on whether and to what extent backfilling is appropriate under site-specific circumstances and conditions to achieve the standards previously discussed. DEQ is applying these standards in selecting the reclamation alternative.

MMRA requires compliance with the Montana Water Quality Act to protect water quality. MMRA does not require the use of native species in revegetation, but GSM is planting mostly native species.

12. COMMENT:
I support the recommended alternative for the GSM FSEIS. Sustainable development would require leaving the pit open, so that future generations could take advantage of lower quality ores that have already been exposed. The people who have sued regarding the backfilling of the pit, and then didn't bother to show up at the public meetings, are just showing that their suit is frivolous. GSM should be allowed to sue them for recovery of funds used to address these frivolous issues, and also for damages caused by their continuous delaying tactics. (43, 44, 49, 85, 88)

RESPONSE:
Thank you for the comment.

13. COMMENT:
If the GSM is forced to implement one of the backfill alternatives and not the one supported by science and the experts, and as a result, my property and water are contaminated by ARD, etc.; who do I come after? Surely, not those who are pushing for these backfill alternatives that will most likely cause this to happen. (52, 160)

RESPONSE:
Thank you for the comment. The agencies will make their decision based on science and the legal standards set forth in the Montana Metal Mine Reclamation Act. Your legal question regarding liability is outside the scope of the SEIS.

14. COMMENT:
I am writing to show my support for the Underground Sump Alternative. It is very difficult to get a good paying job with benefits that can help support a family. I believe that either of the backfill alternatives would cause GSM to close and cause many unemployed workers as well as cutting tax revenues for our schools, city, county, and state. (55, 73, 74, 78, 90, 109, 113, 115, 136, 149-151)

RESPONSE:
Thank you for the comment.

15. COMMENT:
I support the Underground Sump Alternative because it takes care of the environment as well as the local, county, and state economies. Workers spend their checks, pay their taxes, employers buy goods, services, and pay their taxes. If one could track all the dollars, the economic impact of GSM would be staggering! The mine has paid over 200 million dollars in wages and benefits to its employees and have paid over 30 million dollars in taxes. (69, 79, 114)

RESPONSE:
Thank you for the comment.

16. COMMENT:
I am a lifelong Montana resident and an avid outdoorsman. What I have learned over the years is that without a good paying job, I can't participate in these activities. My point is, I'm tired of hearing that tourism is Montana's future. It is not the future! Can all Montanans make a living and support a family in a small town waiting tables, cleaning motel rooms, being a teller at a quick stop, or selling Montana trinkets on the street corner? I don't think so! Without the higher paying jobs like mining, our economy can't survive over the long run. The well-to-do folks from the east or west coasts can still be a part of the state economy, but not the whole economy! Support the recommended alternative. (91)

RESPONSE:
Thank you for the comment.

17. COMMENT:

As an avid outdoorsman, I would like to add a few other items to the decision. Let me list a few other things GSM has done over the past few years to aid in environmental improvements and help for the community.

A: Donated 20 acres of land to the Montana Dept. of Fish, Wildlife, and Parks for the construction of a family fishing pond. This will hopefully come to fruition in the near future.

B: Has consolidated more than 500 acres of wetlands in the Piedmont Swamp area near the Jefferson River.

C: Has purchased more than 600 acres of elk calving grounds in the Bull Mountains.

D: Carefully manages the Candlestick Ranch, enhancing the public's access and recreational opportunities.

E: Purchased computers and musical instruments for local schools.

F: Given college scholarships.

G: Purchased medical equipment.

H: Helped start the community endowment foundation.

I: Put a roof on the school.

J: Purchased weight equipment.

K: Helped with the library expansion.

L: Is working on economic development projects to help mitigate eventual mine closure.

M: Helped with a turkey stocking program.

How much have the plaintiffs spent, in "on the ground" improvements in our area? Please implement the Underground Sump Alternative. (106, 143)

RESPONSE:

Thank you for the comment. Your question is outside the scope of the SEIS.

18. COMMENT:

My staff (MT FW&P) has reviewed the SEIS for reclamation of the GSM. Given our responsibilities, we support the selection of an alternative that provides the most effective reclamation of the mine site over the long term, while taking care of the long term water protection and monitoring program. We hope the bond will cover these water protection and water monitoring expenses over the life of this site. My staff doesn't feel qualified to fully evaluate these alternatives. However, we trust that your chosen alternative will accomplish these two long term goals. (108)

RESPONSE:
Thank you for the comment. The bond will cover the cost of water protection and monitoring.

19. COMMENT:
As professionals, working with the Jefferson County Commissioners and others, I support the Underground Sump Alternative (USA). Here are 9 solid technical reasons why the MDEQ and BLM should continue on the FSEIS using this recommended alternative.

1. The Underground Sump Alternative (USA) is the optimum choice when considering all factors from the numerous, comprehensive, multi-disciplinary scientific studies summarized in DSEIS.
2. This is the only alternative which will not expose additional rock to additional saturated pit conditions. This should render all other options unacceptable.
3. This Alternative will best preserve remaining mineral resources so that economics or technology might make them reserves in the future.
4. The USA would allow for future developments in science, technology, research, and the creative human spirit. In addition to the technology in the mining or economic world mentioned in number 3 above, who knows what use we may find for an open pit?
5. The USA does not require the re-handling of millions of tons of rock and the problems associated with those alternatives. These problems include dust emissions, extra fossil fuel usage with associated green-house gases, and much greater worker safety issues.
6. The preferred alternative will allow GSM the greatest chance of a longer productive life.
7. The USA provides the most simple and straightforward long term water quality plan. Considering the myriad of technical problems associated with the other alternatives, the USA should have the highest probability of resulting in a trouble free, sustainable, environmentally protective operation on a continuous basis.
8. The recommended alternative will have the lowest static groundwater level in the future. This should allow plenty of time for repairs or replacements of pumping system parts should the need arise. This is, by far, the best alternative for long term groundwater protection.
9. The final solid reason for choosing the USA is allowing technology advancements in pumping or water treatment options. These changes can be implemented much easier in an open pit than in any of the backfill options. (110, 159)

RESPONSE:
Thank you for the comment.

6.3 ENVIRONMENTAL PROTECTION AGENCY COMMENTS AND RESPONSES

Letter Number 167, as listed in Table 6.2 above, is from the Denver office of the EPA. EPA's three page cover letter and four pages of comments were broken down in Comments 20 through 32.

20. COMMENT:
EPA's review of the DSEIS found improvements to the information available and in the understanding of hydrology and hydrogeology in the project area compared to the previous EIS. EPA has remained neutral throughout this process regarding whether the GSM pit should be backfilled. EPA will only support alternatives that protect Montana's natural resources. Based on our review of the DSEIS, we believe that adverse impacts to receiving water quality could be avoided with or without pit backfill. Importantly, the DSEIS indicates that pit backfill alternatives could adversely affect the Jefferson River alluvial aquifer. EPA believes that with improved mitigation, water management and model assumptions that more accurately reflect what is known of the project area, adverse impacts from pit backfill to water quality might be avoided. In our attached Detailed Comments, we will provide specific recommendations for improvement of the analysis for the FSEIS that we expect will lead to a more conclusive assessment of the potential impacts of the alternatives. (167)

RESPONSE:
Additional mitigation, water management, and water modeling assumptions are analyzed in the FSEIS in Table 4-8. The agencies' responses to specific concerns raised by EPA regarding mitigation, water management and water modeling assumptions are addressed in responses to Comments 26 through 29.

21. COMMENT:
EPA actively participated in the Multiple Accounts Analysis (MAA) process that brought multi-agency expertise together to identify and analyze the basic alternatives. In hindsight, MAA may not be the best tool for analyzing a project with essentially only two alternatives (backfill vs. no backfill). However, bringing the interested parties together was important and effective in many ways. The process raised the participants' understanding of the project site, the mine, and the technical, socio-economic and environmental factors to be considered in this decision. Bringing together this group of experts resulted in thorough identification of the challenges faced by each alternative, improved modeling, and developed a shared understanding of the array of issues covered in this EIS. The MAA successfully identified the basic alternatives for analysis, and successfully eliminated a number of infeasible alternatives from detailed study. (167)

RESPONSE:
Thank you for the comment.

22. COMMENT:
This MAA was conducted in a tight timeframe relative to most MAA's. The MAA is typically run as an iterative process that allows for alternatives to be improved over time to attempt to avoid identified weaknesses. In this case, the MAA was largely forced to stay with the basic alternatives (a single iteration), and there was not sufficient time to revise alternatives or to reanalyze the impacts of alternatives under different mitigation packages. For example, at several times during the MAA process, EPA commented that a pit backfill alternative could include both in-pit collection and down-gradient collection. EPA and others also suggested possible mitigation measures to reduce the potential for impacts to water quality. The process, unfortunately, was prematurely ended by the lead agencies before many of these measures could be evaluated by the group. We encourage the lead agencies to re-engage the participants to assess the potential for mitigation to avoid adverse impacts, to look for solutions to technical challenges, and to assess the model input variables for representativeness. This analysis could then be included in the FSEIS and would be available to the decision makers. By honing the analysis in this way, the decision makers can have improved confidence in the impact predictions in the FSEIS. (167)

RESPONSE:
Additional mitigation, water management, and water modeling assumptions are analyzed in the FSEIS, and impacts from pit backfill to water quality have been addressed in the FSEIS in Table 4-8. The agencies' responses to specific concerns raised by EPA regarding mitigation, water management and water modeling assumptions are addressed in responses to Comments 26 through 29. The agencies have decided not to re-engage the MAA process.

23. COMMENT:
Based primarily on the need for perpetual treatment to meet water quality standards under all alternatives, and on the lack of consideration of potential mitigation to reduce risks to water quality primarily in the pit backfill alternatives, EPA has issued a rating on this DSEIS of EC-2 (Environmental Concerns - Needs Information). The "EC" rating indicates that the EPA review has identified environmental impacts that should be avoided in order to fully protect the environment. Corrective measures may require changes to the proposed alternative, or application of mitigation measures or actions that can reduce these impacts. The "2" indicates that EPA has identified additional information, data, analyses or discussion should be included in the Final EIS. A full description of EPA's EIS rating system is enclosed. (167)

RESPONSE
There are additional mitigation measures added to the analysis in Chapter 4 under each alternative. All supplemental new information since publication of the DSEIS is reviewed and addressed in the FSEIS.

24. COMMENT:

EPA recognizes the substantial difference in cost among the alternatives. We recognize the lead agencies have many complex factors to consider in making the decision on whether to backfill the pit. EPA will support any alternative that proves sustainable in protecting Montana's natural resources and that complies with applicable laws and regulations for protecting environmental resources.

RESPONSE

Thank you for the comment.

25. COMMENT:

A great deal of energy was expended in understanding the basic alternatives analyzed in this EIS. The Multiple Accounts Analysis (MAA) participants were engaged to find the strengths and weaknesses of each alternative. The MAA process was unfortunately halted before the group could employ their collective expertise and creativity to seek solutions for the weaknesses identified. This is particularly true of the pit-backfill alternatives where little time was invested by the MAA group to solve the identified issues that potentially detract from backfill alternatives. We are not suggesting that every challenge has a feasible option for reducing or eliminating that problem, or that every problem deserves an in-depth attempt to resolve. However, for problems that ultimately lead to a projection that environmental standards could be violated, we believe a serious effort to avoid those problems is worth the investment. EPA is concerned that a full and thorough analysis of mitigation measures appropriate for the pit-backfill alternatives was not completed. (167)

RESPONSE:

Thank you for the comment. Analysis of additional mitigation measures for the pit backfill alternatives has been included in the FSEIS in Chapter 4.

26. COMMENT:

The environmental challenges with pit backfill are primarily tied to the ability to protect ground water in the Jefferson River alluvial aquifer from adverse impacts. There are three basic ways to successfully protect water resources with this project:

A. Control (reduce) the amount of water entering the pit;

B. Collect the water after it has entered the pit; or

C. Collect the water down gradient, after it has been discharged from the pit.

The DSEIS includes alternatives that begin to assess in-pit and down-gradient water collection. There is no alternative that includes measures to prevent ground water from entering the pit. There is also no alternative that combines the three approaches. To understand whether water resources can feasibly and reliably be protected while backfilling the GSM pit, it seems critical that all three water control methods are fully assessed, perhaps most efficiently in a single alternative.

Perhaps the next step in the feasibility assessment of pit backfill should be to determine how much up-gradient ground water and/or pit water (including water collected as it leaves the pit) would have to be collected in order protect water quality given the predicted capture efficiency of the Rattlesnake Gulch collection wells. At that point, a group of experts could be assembled to determine whether there is a combination of up-gradient collection and in-pit collection that could capture that amount of water.

The following factors appear to make an integrated approach to water management more feasible:

A. The majority of the 15 gpm of ground water that enters the pit comes in via a single fault, the Corridor Fault.
B. Most (up to 90 percent) of the water that enters the backfill is predicted to exit to the east from the Sunlight/Range Front Fault and along the Corridor Fault.

This opens the possibility that water management in these select areas could sufficiently reduce the volume of water leaving the pit to protect water quality in the Jefferson Aquifer.

For water leaving the pit, it is unclear why the down-gradient collection alternative proposes collecting that water down in Rattlesnake Gulch rather than as soon as it leaves the pit. The DSEIS states (p. 1-24), "Relying on capture of pit outflows at distances down gradient of the pit may introduce a larger degree of uncertainty and risk concerning the effectiveness of capturing all contaminated groundwaters and could require collection of a greater volume of groundwater." We, therefore, recommend that near-pit collection be addressed in the FSEIS. If near-pit collection proves feasible, even in part, it would be a benefit to water quality because the pit effluent would be captured without the need to capture and treat dilution water as well. EPA recommends the FSEIS include an analysis of cost and engineering feasibility related to capturing this discharge immediately east of the point of discharge from the pit.

RESPONSE:

The agencies appreciate EPA's specific recommendations. As described in the agencies' response to Comment 28, the pit water balance has been updated based on additional data obtained since the DSEIS. The expected pit seepage rate has been revised from an estimated 16 gpm for the DSEIS, to a range of 27 to 42 gpm for the FSEIS (Telesto, 2006). The reasons for this revision are described in the response to Comment 28.

The agencies have performed additional evaluation of EPA's three suggested water control methods in the partial pit backfill alternatives. Mitigation Measure 15 has been expanded to include 3 sub-components (Section 4.8.2.1). Measure 15a is the same as Measure 15 as presented in the DSEIS, which comprises downgradient capture at two locations. Measures 15b and 15c incorporate upgradient collection

wells (Measure 15b) and new wells near the eastern edge of the pit in the Upper Rattlesnake collection system (Measure 15c). The agencies have concluded that these measures could be applied to any alternative as mitigation measures.

Upgradient Capture (Measure 15b)
Capture of groundwater prior to entering the pit would reduce the total volume of water that enters the pit, and would reduce the seepage volume that would have to be pumped from the pit under the Partial Pit Backfill With In-Pit Collection Alternative, or collected down gradient under the Partial Pit Backfill With Downgradient Collection Alternative. The DSEIS identified the Corridor Fault as the primary source of groundwater inflow to the pit. This would be the main target of an upgradient capture system. GSM currently operates two dewatering wells, PW-48 and PW-49, in the north highwall of the pit. The combined pumping rate from PW-48 and PW-49 has averaged approximately 18.2 gpm (Telesto, 2006). The existing wells would be covered during construction of either of the partial pit backfill alternatives. Similar wells could be constructed after completion of the partial pit backfill alternatives, and that 15 gpm could be captured upgradient of the pit, based on the recent experience of GSM and the hydrogeology of the pit area.

Implementing upgradient capture mitigation Measure 15b for the Partial Pit Backfill With Downgradient Collection Alternative would reduce the rate of groundwater seepage that enters the Tdf/colluvial aquifer by 15 gpm, thus reducing the expected seepage range from 27 to 42 gpm to 14 to 29 gpm. The effects of the reduced seepage rates on predicted groundwater quality in the Jefferson River alluvial aquifer are discussed in Comment 28 and in Section 4.8.2.1.

In-Pit Collection
The agencies considered additional mitigation measures to improve collection of water in the backfilled pit, but did not find any capable of overcoming the technical limitations and uncertainties associated with this approach. Collecting water after it has entered the pit was evaluated in the DSEIS under the Partial Pit Backfill With In-Pit Collection Alternative. The analysis indicated that complete control of pit seepage cannot be guaranteed because of problems associated with drilling and operating wells in 875 feet of backfill that is corrosive and subject to settling.

For the DSEIS, hydraulic conductivity estimates for the backfill material ranged from 10^{-3} to 10^{-5} cm/s (Telesto, 2003e). Pit flow analysis conducted for the DSEIS predicted that hydraulic conductivity values of 10^{-6} cm/s or less would result in perching of groundwater within the backfill that would lead to horizontal, rather than vertical groundwater flow, thus permitting seepage to leave the pit without being captured by the wells (Telesto, 2003e). The agencies discounted the horizontal flow potential because perching would not be continuous across the backfilled pit (Figure 4-1).

Additional permeability testing of potential backfill material under simulated load conditions, such as that in a backfilled pit, was conducted subsequent to the DSEIS (Telesto, 2005). The results indicate that under 450 feet of backfill, the hydraulic

conductivity can decrease to 10^{-6} cm/s, and that under 900 feet of backfill, the hydraulic conductivity can decrease to 10^{-7} cm/s (Telesto, 2005). This additional evaluation indicates that collection of pit seepage using vertical wells cannot be reliably assured. The number of wells was increased from four to up to 11 to offset this potential problem (Section 4.2.2.5.2).

The Partial Pit Backfill With In-Pit Collection Alternative would have 100 feet of crusher reject in the bottom of the pit. The backfill from the waste rock dumps would be trucked into the pit in several areas. The mechanics of end dumping and cast blasting would create segregated fine and coarse zones, based on observations at GSM from offloading a portion of the East Waste Rock Dump Complex in 1994 (Figure 4-1). Each truck load would create a single segregated cell with larger material on the bottom and fines on top. There would be some zonation within the dumping zone with fines higher in the section. The several dump areas would create different broad zones. The process of weight compaction and weathering would produce fines that could move into the lower portions of the backfill with water, including the crusher reject, which is the pumping zone. Over time, the crusher reject would develop reduced permeability and may lose its ability to function as a sink to maintain collection of pit seepage (Section 4.2.2.1.2). These effects would occur in any alternative that includes pit backfill, including the No Pit Pond Alternative. The effect would be more pronounced in the partial pit backfill alternatives because there would be a much greater volume of backfill, and backfill would consist of less uniformly graded material.

Directionally drilled dewatering wells could be more effective than vertical dewatering wells. Directional wells would be drilled through bedrock into the crusher reject in the bottom of the pit. Directional wells in bedrock would avoid damage due to settling in the backfill and would be subject to settling and corrosion only near the bottom of the casing in the crusher reject. The low hydraulic conductivity of the backfill would still limit movement of water into the crusher reject and the wells (see also the response to Comment 27).

A mitigation option was considered to build the wells from the bottom up as the backfill was placed instead of waiting to drill through all the backfill. This is commonly done on valley fill heap leach pads. The collection wells are built from the bottom up as each lift of waste rock is placed. End dumping from 775 to 875 feet would damage the wells. The agencies dismissed this measure because the wells would still fail from corrosion and would have to be drilled through the backfill.

The agencies have concluded that pumping water out of the backfilled pit using vertical or directionally drilled wells would be difficult. If the Partial Pit Backfill With In-Pit Collection Alternative is selected, the agencies would bond for Measure 3 to identify flow paths, Measure 15a to maintain the two pump back well systems, Measure 15b to install upgradient capture wells, and Measure 15c to add new wells in the Upper Rattlesnake Gulch collection system and/or on secondary bedrock pathways because complete capture of seepage within the pit cannot be reliably assured (Section 4.8.2.1). This would be equivalent to permitting the Partial Pit Backfill With Downgradient Collection Alternative.

Downgradient Collection (Measure 15c)
The agencies have evaluated Measure 15c to collect water immediately down gradient in Upper Rattlesnake Gulch after it has discharged from the pit (see Section 4.2.3.1.2). This measure could be applied to the partial pit backfill alternatives. Up to five new wells would be installed near the eastern edge of the pit in an attempt to capture some of the pit seepage (Figure 4-5). The target of the capture wells would be the Tdf/colluvial aquifer just east of the pit, and if possible, the Corridor Fault. The agencies would require a detailed hydrogeologic characterization of the area directly east of the pit to identify the most effective zones for capture. However, the capture of water in this area is expected to be less effective than Measure 15a (capture in Rattlesnake Gulch and the South Pumpback System) and Measure 15b (upgradient capture) for the following reasons:

- Groundwater flow into this structurally complex aquifer could be in fractured rock, which might locally by-pass the Tdf/Colluvial aquifer adjacent to the pit and is less predictable than in the sedimentary deposits in Rattlesnake Gulch;
- The Tdf/colluvial aquifer at this location is deeper and more heterogeneous and has multiple channels (flow paths), making capture much more difficult than at the current location of the Rattlesnake Gulch capture system;
- Groundwater gradients have been documented to be high (*e.g.*, 130 foot drop across the fault separating bedrock from the colluvial/alluvial materials) due to permeability contrasts between the rock units (URS, 2001). The large groundwater gradient results in less saturated thickness and faster groundwater velocities, making capture in wells more difficult; and,
- Thorough evaluation of the effectiveness of Measure 15c could not be done until the alternative was constructed, and pit seepage began to leave the pit.

Implementing Measure 15c would result in a reduction of pit seepage into the primary pit flowpath. Due to the reasons listed above, the agencies have determined that the probability of achieving effective capture of pit seepage with Measure 15c is less than with Measures 15a and 15b, and that Measure 15c would not be relied upon as a primary mitigation measure for the Partial Pit Backfill With Downgradient Collection Alternative.

27. COMMENT:
EPA questions whether there may be methods available to increase the reliability of in-pit collection. It is possible that engineering solutions could overcome or limit the predicted difficulties with drilling and maintaining wells in backfill. For example, directional drilling might allow wells to be drilled primarily in bedrock rather than in backfill. There may also exist engineering solutions to problems like lensing, settling, etc. These issues were not a significant focus of the MAA, and it is not clear in the DSEIS that effort was expended to try to overcome these challenges after the MAA process was halted. (167)

RESPONSE:
See the response to Comment 26 about the ability to collect water in the pit backfill under the Partial Pit Backfill With In-Pit Collection Alternative. Engineered solutions to compensate for in-pit collection difficulties were discussed during the MAA process, and no engineered solutions were identified.

The Partial Pit Backfill With Amendment Alternative was dismissed, as described in the DSEIS. The analysis in the DSEIS indicated a risk that water contaminated with arsenic and zinc would have to be collected down gradient of the pit to ensure compliance with water quality standards.

The agencies considered directional drilling in bedrock for installing dewatering wells into the crusher reject under the backfill or an underground sump. Directional drilling methods commonly used in the oil and gas industry could be used at GSM. Directionally drilled wells would be subject to deformation of the portion of the backfill due to settlement of the backfill and corrosion for the portion of the well in the backfill. The pump and pump riser piping would also be subject to corrosion. For these reasons, directionally drilled dewatering wells would fail less frequently than vertical dewatering wells, but the magnitude and consequence of the failure would likely be the same. These wells may be more easily repaired than wells installed through the backfill.

The agencies also considered directional drilling through bedrock and collecting water in an underground sump below the backfilled pit. There would be no problems with settlement. Corrosion would be less of a problem. The low hydraulic conductivity of the backfill would limit movement of water into the underground sump. If the Partial Pit Backfill With In-Pit Collection Alternative, with an underground sump instead of crusher reject, is selected, the agencies would bond for Measure 3 to identify flow paths, Measure 15a to maintain the two pump back well systems, Measure 15b to install upgradient capture wells, and Measure 15c to add new wells in the Upper Rattlesnake Gulch collection system and/or on secondary bedrock pathways because complete capture of seepage within the pit cannot be guaranteed. This would be equivalent to permitting the Partial Pit Backfill With Downgradient Collection Alternative.

In summary, directionally drilled wells offer some advantages over vertical wells, but also have some disadvantages. The agencies have concluded that collecting water up gradient and down gradient of the pit would be more effective in controlling seepage from a backfilled pit.

28. COMMENT:
EPA has a number of questions and concerns related to the estimate of necessary pit-effluent capture efficiency. The FSEIS should identify the key assumptions that led to the estimate of necessary capture efficiency (*e.g.,* attenuation rate, dilution,

percent of effluent in the preferential pathway, etc.). The FSEIS should also discuss the sensitivity of the model to each of these variables or assumptions. By understanding these assumptions, reviewers have an opportunity to suggest opportunities for mitigation that could reduce risk, or to suggest why the assumptions may not be accurate. Depending on sensitivity of these variables, the analysis in the DSEIS may significantly overstate the risk to groundwater quality from pit effluent. The hydrogeologic evaluation of the preferential flow path for pit effluent is critical to the prediction of whether pit effluent will adversely affect the Jefferson River alluvial aquifer, yet that evaluation was fairly minimal and was based on large assumptions and sparse data. The analysis included in the DSEIS does not include any modeling to simulate ground-water flow and contaminant transport along this flow path. The sediments which comprise this pathway have characteristics that are not indicative of a high permeability pathway (*i.e.*, large radius cone of depression = low permeability). The water quality data from Tailings Impoundment No. 1 leakage do not indicate that any contamination from the impoundment has ever reached the Jefferson River – even though the impoundment leaked for some time – indicating some attenuation capacity. EPA recommends the FSEIS take a hard look at the assumptions that went into the hydrogeologic evaluation of the preferential flow path and make corrections where necessary to reflect what is known of this pathway. That analysis should include any mitigation identified that could reduce the necessary capture efficiency (*i.e.*, up-gradient ground water collection, in-pit collection, near-pit effluent collection, etc.) or that could increase the likelihood that effluent will be captured. (167)

RESPONSE:
EPA expresses concern with the estimate of necessary pit-effluent capture efficiency. The DSEIS cites references for the assumptions. The ranges of potential values used for evaluating impacts are shown in Table 6-3. The agencies have reviewed the assumptions upon which analyses that were presented in the DSEIS were based. Assumptions for the FSEIS are compared to the assumptions for the DSEIS in Table 6-3.

As indicated in Table 6-3, the groundwater flow in the Tdf/colluvial aquifer, inflow from the East Waste Rock Dump Complex, and groundwater flow in the Jefferson River alluvial aquifer were varied in the DSEIS to evaluate sensitivity of the impact evaluations to attenuation and capture efficiency.

For the FSEIS, pit outflow was varied based on a revised pit water balance model (Telesto, 2006). The revised pit water balance model utilized new data collected by GSM subsequent to preparation of the DSEIS, and predicts a range of pit seepage values rather than predicting a single estimate, as was reported for the DSEIS. The range of pit seepage values better represents the predictability of a natural system with numerous variables.

The water quality data for the inputs to the pit flow path model were updated through 2004 and revised to use the appropriate sources (HSI, 2006). New hydrogeologic

and water quality data on the Jefferson River alluvial aquifer and buried channel aquifer became available from GSM studies conducted since the DSEIS (Spectrum Engineering and Kathy Gallagher, 2004; HSI, 2006)).

Geologic data available for the DSEIS indicated little to no calcite was present in the primary pit flow path to attenuate ARD. For the FSEIS, samples of the Tdf/colluvial and Jefferson River alluvial aquifers were obtained from drilling performed in 2003-2005 and submitted for laboratory analysis of calcite (Mogk, 2005). X-ray diffraction (XRD) and energy dispersive spectrometry (EDS) analysis, and scanning electron microscope (SEM) imaging was performed on nine samples from the saturated zone of the Tdf/colluvial and Jefferson River alluvial aquifers (Mogk, 2005). There was no evidence of the presence of calcite. The XRD results have a sensitivity level of about plus or minus 0.1 percent.

A related analysis of geologic logs from seven new drill holes in the Jefferson River alluvial aquifer and five borings in the Upper Rattlesnake Gulch drainage revealed the presence of iron oxides and associated red staining of sediments throughout the primary pit flow path. These data further supported the pre-historic migration of iron-rich fluids along this pathway (Spectrum Engineering and Kathy Gallagher, 2004; HSI, 2006)).

The analysis for the FSEIS incorporates the following:

- Modification of the projected pit inflow and outflow rates;
- Added sensitivity analysis for water quality inputs to the dynamic systems model (DSM);
- Narrowed uncertainty of some key parameters, including the calcite content of the Rattlesnake Gulch drainage flow path (Tables 4-4 and 6-3); and
- Confirmation of the primary pit effluent flow path as a prehistoric feature conveying iron-rich groundwater into the Jefferson River alluvial aquifer.

The amount of hydrogeologic data supporting the evaluation of the Rattlesnake Gulch drainage flow path for pit effluent is adequate. The area down gradient of the pit has been studied extensively as described in HSI (2003 and 2006). The sources used by HSI include: Golder, 1995a, Fig. 13; Keats, 2001 and 2002; SHB, 1982 to 1989; and GSM well logs. A total of 114 monitoring wells and borings from within or near the Rattlesnake Gulch drainage flow path and were used to delineate the flow path. Data from the wells and borings were used to develop a groundwater flow analysis. Water balances and other calculations were used to verify the flow analysis.

Flow path modeling was performed using a Dynamic Systems Model to evaluate groundwater flow and mixing from all water sources affecting the system. Contaminant sources and transport, including travel time, attenuation mechanisms, mixing, and dilution processes, along the flow path were documented in HSI (2003,

2006) and Telesto (2003e). Attenuation mechanisms were addressed, and the potential amount and duration of ARD attenuation predicted. The modeling effort for the DSEIS was appropriate for the aquifer setting and attenuation mechanisms involved. The agencies have updated the modeling for the FSEIS based on new data that became available between preparation of the DSEIS and the FSEIS (Section 4.3.4.1.2.2.1 and HSI 2006, Telesto 2006).

A high permeability pathway is defined relative to the surrounding material. The hydraulic conductivity in the pathway should be one-half to one order of magnitude higher than in the surrounding material to be considered a high permeability pathway. The analysis for the DSEIS (HSI, 2003) found that the hydraulic conductivity, using geometric mean data, of the identified primary flow path aquifers and the surrounding Tertiary-age materials was 3.5 ft/day to 0.07 ft/day, respectively, giving a difference of about one and one-half orders of magnitude (HSI, 2003). Previous studies have reported that the Tdf/colluvial aquifer has a hydraulic conductivity two to three orders of magnitude greater than that of the Bozeman Group aquifer (SHB, 1987, Hydrometrics, 1995). These hydraulic conductivities are obtained from field tests performed at GSM. The agencies disagree with the assertion that a large radius cone of depression equals low permeability. The size of a cone of depression is primarily a function of the hydraulic conductivity of the aquifer, boundary conditions, and recharge/discharge to the aquifer (for illustrations, see Driscoll, 1988). In an aquifer without recharge and boundary restrictions, the higher the hydraulic conductivity, the wider the radius and shallower the depth of the cone of depression will be. Recharge of the aquifer decreases the radius of the cone of depression. Restrictions in aquifer geometry lead to non-circular and deeper areas of drawdown. The Tdf/colluvial aquifer has definite boundaries, which limit the size and shape of the cone of depression and create a preferential flow pathway.

Tailings Impoundment No. 1 has leaked cyanide. Leakage from Tailings Impoundment No. 1 was never detected in the Jefferson River and Slough. This is not due to the attenuation capacity of the Bozeman Formation, but rather to other factors such as GSM's installation of capture wells soon after leak detection and the continual monitoring and upgrading of the complex capture system.

The primary flowpath from the pit is the Tdf/colluvial aquifer, which does not contain calcite (HSI, 2006). Metals would not be attenuated by long term, irreversible mechanisms. The point of compliance is not the Jefferson River, but rather the Jefferson River alluvial aquifer at the edge of the approved groundwater mixing zone. The agencies have concluded that monitoring and upgrading of the capture system would have to continue to prevent impacts from metals to the Jefferson River alluvial aquifer at the mixing zone boundary. For a discussion of mitigations reviewed to increase capture efficiency, see response to Comment 26.

Table 6-3. Summary of Key Parameters, Sources and Assumptions Used to Estimate Groundwater Capture Efficiency in the Tdf/Colluvial Aquifer

Parameter	Estimated Value	Sources & Assumptions
Groundwater Baseflow to Pit	DSEIS: 2 gpm	Calibrated Pit Water Balance (Telesto, 2003e).
	FSEIS: 17 to 32 gpm	Revised Calibrated Pit Water Balance (Telesto, 2006).
Pit Outflow	DSEIS: 16 gpm	Calibrated Pit Water Balance (Telesto, 2003e).
	FSEIS: 27 to 42 gpm	Revised Calibrated Pit Water Balance (Telesto, 2006).
East Waste Rock Dump Complex Inflow	1 to 3 gpm	Water Balance of East Waste Rock Dump Complex (FSEIS Section 4.3.2.1.1.1.2).
Baseflow-Recharge in Upper Rattlesnake Gulch	52 to 103 gpm	Impacts of Pit Seepage Analysis (FSEIS Section 4.3.4.1.1.2).
Quality of Baseflow Recharge to Tdf/colluvial Aquifer	See HSI, 2003, Table 5-9	Monitoring well MW-202 quality best represents shallow groundwater in the Tdf/colluvial aquifer.
Quality of East Waste Rock Dump Complex and Pit Effluent	See Telesto, 2003e, Tables 4 and 5, App. G.	Based on evaluations for 1998 FEIS, Appendix B, and pore water chemistry from West Waste Rock Dump Complex.
Cation Exchange Capacity	3.15 meq/100 g	Geologic descriptions of Tdf/colluvial aquifer: 1% smectite clay, 3% kaolinite clay and 2% iron oxides.
Calcite Content	DSEIS: 1.8 to 59%	DSEIS: back-calculation required for attenuation 1.8 to 59% based on acid potential of East Waste Rock Dump Complex and pit effluent.

	FSEIS: No detectable calcite	FSEIS: X-ray diffraction analysis: no detectable calcite in Tdf/colluvial & Jefferson River alluvial aquifers samples (Mogk, 2005; HSI, 2006).
Jefferson River Alluvial Aquifer Groundwater Baseflow	99 to 2500 gpm	Darcy Law flux based on monitoring well logs and water level measurements.
Jefferson River Alluvial Aquifer Water Quality	DSEIS: HSI, 2003, Table 5-9,	Water quality data from Jefferson River alluvial aquifer wells.
	FSEIS: Revised Jefferson River Alluvial Aquifer Water Quality	Water quality based on results of GSM well installations and hydrogeologic characterization completed in 2003-2004 (Spectrum Engineering and Kathy Gallagher, 2004; HSI, 2006).
Capture Efficiencies	80 to 99.99%	Based on analysis in HSI (2003 and 2006) and GSM's operational experience.

The agencies' review of new and existing data resulted in a number of changes in the pit water balance model (Telesto, 2006) and the primary pit flowpath model (HSI, 2006). The revised modeling efforts are described below and in Sections 4.3.4.1.1.2 and 4.3.4.1.2.2.1.

Pit Water Balance Model Revisions

In response to comments to the DSEIS, the agencies reviewed the pit water balance model and concluded that applying a range of possible groundwater baseflow to the predictive modeling for closure alternatives would better represent the level of certainty to which groundwater inflows to the pit, and thus pit outflows, can be known. The conceptual model of pit inflow was reviewed and modified to include two baseflow components: baseflow that occurs beneath the Corridor Fault, and baseflow that occurs above and within the Corridor Fault (Telesto, 2006).

Production records indicate that the highwall dewatering wells, PW-48 and PW-49, which produce from the Corridor Fault, have been pumped at a fairly constant rate 18.2 gpm (Telesto, 2006). Because the flow rates from PW-48 and PW-49 do not decrease during prolonged dry periods, and do not increase during prolonged wet periods, the combined minimum water rate produced from those wells of 15 gpm represents the minimum rate of baseflow that occurs above, and within the Corridor Fault. The maximum baseflow above and within the Corridor Fault is estimated to be 30 gpm, based on the maximum potential recharge area for the pit (Telesto,

2006). The baseflow from beneath the Corridor Fault was held constant at 2 gpm. For the FSEIS, the total baseflow rate (*i.e.*, baseflow below, within, and above the Corridor Fault) was varied from 17 to 32 gpm (Telesto, 2006). With this input range, the estimated rates of pumping for the Partial Pit Backfill With In-Pit Collection Alternative for the FSEIS range from 27 to 42 gpm, compared to 15 gpm for the DSEIS. The estimated rates of seepage from the pit for the Partial Pit Backfill With Downgradient Collection Alternative for the FSEIS range from 27 to 42 gpm, compared to 16 gpm for the DSEIS.

Primary Pit Flowpath Model Revisions
The agencies reviewed the flow path model that was applied for the DSEIS. As a result of the review, a number of modifications were made for the FSEIS, as described in HSI (2006). In the DSEIS, seepage from the pit into the primary pit flow path was modeled at a constant rate of 16 gpm for the Partial Pit Backfill With Downgradient Collection Alternative. For the FSEIS, seepage from the pit into the primary flow path was modeled as a variable, ranging from 0 to 45 gpm, enveloping the pit seepage range predicted by the updated water balance of 27 to 42 gpm. By modeling over that range, the agencies can evaluate the effects of uncertainty related to pit seepage, and can better evaluate the need for, and effects of, various mitigation measures.

The analysis presented in the DSEIS provided results for a range of capture efficiencies. Based on experience at GSM, the agencies have concluded that capture efficiencies of 80 percent could be realistically achieved for the individual groundwater collection systems included in Measure 15 of the DSEIS (Measure 15a of the FSEIS). The primary pit flowpath model for the DSEIS predicted that two groundwater collection systems operating at 80 percent would achieve groundwater standards at the mixing-zone boundary (Section 4.3.4.1.2.2.1). The DSEIS predicted that two groundwater collection systems operating at 80 percent capture efficiency would result in an overall capture efficiency of 95 percent. This was based on a calculation that did not account for recharge that would occur between the two capture systems. As a result of agency review, the primary pit flowpath Dynamic Systems Model was modified for the FSEIS to better represent groundwater capture and recharge along the flowpath (HSI, 2006). The result of the modification of the DSM is that two capture systems operating at 80 percent capture efficiency would result in an overall capture efficiency of approximately 92 percent.

The revised primary pit flowpath modeling conducted for the FSEIS indicates that nickel, cadmium, copper, zinc and iron are the most critical parameters with respect to meeting groundwater standards in the Jefferson River alluvial aquifer at the mixing-zone boundary (HSI, 2006, 2007). Of the DEQ-7 toxic and carcinogenic parameters, nickel is the most critical parameter for meeting DEQ-7 groundwater standards (see Figure 4-2). Meeting the DEQ-7 standard for iron, which is a harmful (non-toxic) parameter, is also problematic. The results of the updated pit water balance model (Telesto, 2006) and of the primary flow path modeling (HSI, 2006)

are incorporated into the updated analysis summarized in Section 4.3.4, the Partial Pit Backfill With Downgradient Alternative.

Based on the updated analysis for the FSEIS (HSI, 2006, 2007; Telesto, 2006), the agencies concluded that even with all identified mitigation measures (Section 4.8.2.1), compliance with DEQ-7 groundwater standards for metals in the JRA Aquifer could not be expected over the entire predicted range of pit seepage.

29. COMMENT:

The DSEIS includes a projection of potential mineral reserves remaining after completion of Stage 5B as "over 1,500,000 ounces remaining in the known resource (p. 4-127)." In the same section, the DSEIS states that "one of the purposes of the Montana Metal Mine Reclamation Act is to prevent foreclosure of future access to mineral resources not fully developed by current mining operations." The DSEIS goes on to describe the substantial additional time and cost of removing any pit-backfill should pit expansion be necessary for future mine expansion. The DSEIS appears to assume that access to future mineral reserves or resources would have to happen by expanding the pit (p. 4-135), although some of the existing mining has been accomplished via underground workings. The DSEIS does not make a case for why mining beyond 5B would necessitate pit expansion, and why underground mining via a portal outside the pit could not happen. In summary, the DSEIS does not provide a rationale for why future access to mineral resources could not be accomplished with underground workings. Given the amount of overburden that would have to be removed to further expand the pit, it may be possible that underground mining would prove an economic advantage over pit expansion. The FSEIS should address this issue and assess the feasibility of access reserves beyond 5B while the pit remains backfilled.

Some additional information in the FSEIS could help the situation. The known configuration and depth of the breccia pipe and ore body below 5B should be discussed, as well as the amount of additional overburden that would have to be removed to expand the pit beyond Stage 5B. The time and cost of removing that overburden should be included and compared to those same costs in Stage 5B. The FSEIS could assume that the next pit expansion would be of the same scale as the 5B operation. Those costs could then be compared to costs and mineral recovery rates associated with constructing an underground access to the reserves from outside the pit.

The pit-backfill alternatives include the statement that "premature closure" would reduce tax revenue from mining Stage 5B (p. 2-53). This conclusion appears to be based on a statement from GSM that they "may" cease mining 5B if pit backfill is required (p. 4-153). Given that GSM will have expended the resources to remove the overburden to access the mineral resources in 5B by the time this decision is made, the assumption that mining 5B would halt should be re-evaluated in the FSEIS. The FSEIS should include sufficient information to support this assumption,

or should revise the estimated tax revenue to reflect that 5B is likely to be completed under all alternatives.

All alternatives will require perpetual water treatment from both the waste rock dump effluent and pit water collection or effluent in order to meet water quality standards. There is no foreseeable technology that would eventually preclude the need for treatment of this water. It is, therefore, critical that the lead agencies pay close attention to the long-term operation and maintenance requirements and costs for the capture and treatment systems as the final closure plan is developed. (167)

RESPONSE

Foreclosure of future mining is not a decision criterion under MMRA. The agencies did not consider foreclosure of future mining in selecting the preferred alternative. Evaluating the potential for underground mining is outside the scope of the SEIS. The cost of removing backfill and the loss of tax revenue from not mining Stage 5B will not be factors in the decision under MMRA. Conditions at GSM have changed since the DSEIS was published. Whether to continue mining is a decision for GSM and Barrick. GSM makes decisions based on information that is not available to the agencies. The agencies accept GSM's statement that partial pit backfill may cause mining to cease at any time during mine operations. The decision in the FSEIS may still impact future mining at GSM. The agencies have weighed the long-term operation and maintenance requirements of water treatment carefully in their evaluation of alternatives.

In the DSEIS, the agencies tried to design alternatives that would meet water quality standards if implemented properly. The agencies considered long-term operation and maintenance requirements and costs for the capture and treatment systems. The analysis indicated that as system complexity increases, the potential for long-term failure and the subsequent risk to water quality increases, as discussed in Section 4.2 for each alternative under Consequence of Failure. The Underground Sump Alternative in the DSEIS was selected because it would provide almost complete control of pit seepage even without a collection system. The Underground Sump and No Pit Pond alternatives were the only alternatives that would provide adequate assurance that pollution of the Jefferson River alluvial aquifer in violation of water quality laws would not occur. The Underground Sump Alternative would be safer for workers (Section 4.4.5.1.2) and require less maintenance than the No Pit Pond Alternative (Section 4.4.2.1.2).

30. COMMENT:

In the Underground Sump Alternative, we found a lack of information or clarity regarding the portal to access the sump. The DSEIS lacked information on the expected longevity of the access portal. The DSEIS states that "agencies would require GSM to submit a plan for development, maintenance and monitoring" of an alternate portal (p. 4-56). More certainty regarding who would actually be responsible for the cost and development of the alternate portal, as well as the

means of financial assurance, should be added to the FSEIS and Record of Decision. (167)

RESPONSE:
A conceptual plan for the 4,550-foot-elevation access portal was developed and analyzed in the FSEIS in Sections 2.4.5.1 and 4.2.4.1.2 and 4.2.4.2.2. In case of highwall raveling and slumping, a new access portal would be developed at the 4,750-foot elevation to access the underground workings. The new portal would be located in the northeast portion of the pit highwall 200 feet higher than the 4,550-foot-elevation portal assumed in the Underground Sump Alternative. The agencies assume the new access portal would be similar in design to the old underground portal developed by GSM beginning in July 2002, which was approved by the agencies under Minor Revision 02-001 on May 23, 2002. Underground access would be developed from the portal to the underground pump station, as described in Section 2.4.5.3. The only differences would be the need for additional pump stations and a longer adit to tie into the old underground workings.

Regular maintenance of the portal would be required annually to ensure safe access and to maintain pumping operations. Periodic underground maintenance would include scaling, clearing roadways, and occasional bolting as needed. This maintenance is designed to prevent failure. The portal is assumed to last 30 years for bonding purposes. The agencies have assumed portal failure on a regular basis, and bond would be posted to cover the costs of reopening or redeveloping the access portal. GSM would be responsible for the cost and development of the alternate portal, as well as the means of financial assurance. This information has been added to Section 4.2.4.2.2.

The portal would provide underground access. Secondary access after closure from the underground pump station would not be required by MSHA. GSM and the agencies would install secondary access to ensure worker safety. The secondary escapeway would also have to be maintained. GSM would be bonded for this maintenance.

31. COMMENT:
EPA found no mention of techniques to stabilize the highwall as a component of the no-backfill alternatives. For example, it may be possible that reducing the volume of ground water seepage into the pit (*i.e.,* through up-gradient collection) may increase highwall stability and improve worker safety. (167)

RESPONSE:
MMRA Section 82-4-336(9)(b)(i) requires open pit stability structurally competent to withstand geologic and climatic conditions without significant failure that would be a threat to public safety and the environment. Sections 4.2.1.2.1 and 4.2.1.2.2 of the DSEIS discuss highwall stability. The agencies concluded the highwall would be stable with a low probability of a large-scale failure. The agencies assumed raveling and sloughing over time. The conclusion was that, even with assumed failures,

there would be minimal impacts outside of the pit from periodic pit failures over the long term, which would prevent undesirable offsite environmental impacts. Section 4.2.1.2.3 describes pit highwall maintenance requirements. GSM removes overburden from weak areas, diverts storm water flow, has MSHA-required safety benches, horizontal drains, and buttresses. The agencies have developed a Mitigation Measure 15b that would require upgradient wells to reduce the volume of groundwater seepage into the pit (see response to Comment 26).

32. COMMENT:

The FSEIS should provide some information on how drains would be re-established into the sump should they fail (*e.g.*, due to highwall slumping into the pit). (167)

RESPONSE:

In the event that highwall sloughing closes the drains between the pit bottom and the underground sump, the drain holes would be reestablished. Bond would be posted to cover this work. Section 4.2.4.2.2 describes maintenance required to keep the pit safely accessible, and Mitigation Measures 4 and 9 address this work.

6.4 PLAINTIFFS' COMMENTS AND RESPONSES

Letter Number 168, as listed in Table 6.2 above, contains the plaintiffs' comments. These comprise Comments 34 through 61.

33. COMMENT:

Since the 1998 EIS the mine has continued with the planned pit 5B expansion as well as developed underground workings towards the pit bottom in order to access deeper higher grade ores. Significant reclamation of the West Waste Rock Dumps and a portion of the East Waste Rock Dumps have occurred although the mine was aware that resolution of the pit backfill issue might affect such reclamation by requiring removal of materials located in those dumps back into the pit as backfill.

Under the Court's 2002 Judgment, DEQ ordered GSM to provide the details of a modified Partial Pit Backfill with In-Pit Collection Plan, which is the Proposed Action in the DSEIS. In total, six other alternatives in addition to the above alternative are identified in the DSEIS.

1. No Pit Pond (No Action) (includes in-pit water collection);
2. Partial Pit Backfill With In-Pit Collection (Proposed Action);
3. Partial Pit Backfill Without Collection;
4. Partial Pit Backfill With Downgradient Collection;
5. Partial Pit Backfill With Amendment;
6. Underground Sump (with underground water collection sump); and,
7. Pit Pond (with pump and treatment).

The Partial Pit Backfill With Downgradient Collection alternative should have been identified as the preferred alternative (had additional mitigation been considered and included), because it is the alternative that is best designed to meet the Court's order. This conclusion is based upon the following:

- It is a proven design and the alternative can be constructed at GSM.
- Backfilling the pit would address highwall stability concerns and no highwall maintenance would be required.
- Backfill maintenance requirements could be approximately equal to pit highwall maintenance requirements.
- Groundwater capture and treatment is assumed – agencies cite 95 percent capture risk (where 5 percent of the water may not be captured and potentially reaches surface water). However, the overall risk is the same, if not less, than for other permitted facilities at GSM (*e.g.*, West Waste Rock Dump estimated at less than 95 percent in 1997 EIS).
- All alternatives would require maintenance and operation, including water treatment, in perpetuity and there is not a significant difference between alternatives in terms of total water treatment capacity and design when the combined loads from the entire mine site are considered.

- Groundwater quality within the mixing zone would be degraded but if treated with the same assumptions as for the other facilities at the mine site should not impact beneficial uses of the Jefferson River alluvial aquifer.
- Impacts to springs/seeps in the area should be minimal as most are naturally acidic and mineralized and potential for impacts to surface water is directly related to groundwater capture efficiency.

Risk to public safety would be minimized by the partial backfill and public access and post-mining land use would be possible.

DEQ's preferred alternative identified in the DSEIS would leave the pit highwalls in their present unstable and hazardous condition. This represents a far greater risk to human health and safety than the pit backfill alternative. Similarly, the preferred alternative in the DSEIS would essentially condemn any realistic future post-mining land use other than future mining and result in a *de facto* removal of those lands from public use. The pit backfill alternative, if properly designed and performed, will eliminate, to the extent practically feasible, the hazard to human health and welfare as well as restore the land to a productive post-mining land use.

Why were additional mitigation measures not considered in the DSEIS, in order to meet the Court ordered plan, including:

- additional means to capture contaminated groundwater in the pit area including drilling of collection wells outside the pit backfill material using directional drilling or other means;
- driving an adit under the backfilled pit into the existing underground workings from outside the pit in stable ground; and,
- additional means to prevent down gradient migration of contamination if preferential flow paths are discovered such as slurry walls or other devices to enhance capture efficiency? (168)

RESPONSE:
Historically, GSM has reclaimed waste rock dumps as they were completed; including the West Waste Rock Dump Complex, the south portion of the West Waste Rock Dump Complex, the Buttress Waste Rock Dump, and the off-loaded portion of the East Waste Rock Dump Complex. GSM reclaimed the waste rock dumps in accordance with approved reclamation plans.

The DSEIS addresses each of the bullet items:

- The agencies agree that the Partial Pit Backfill With Downgradient Collection Alternative is a proven design and could be constructed at GSM. See Sections 4.2.3.1.1 and 4.2.3.1.2.
- The agencies agree that backfilling the pit would eliminate pit highwall raveling and sloughing and no highwall maintenance would be required for the partial pit backfill alternatives. See Sections 4.2.2.2.1 and 4.2.2.2.2.

- The agencies agree that backfill maintenance requirements could be approximately equal to pit highwall maintenance requirements, except the backfilled pit area would be subject to additional settling due to saturation of the backfill material. See Section 4.2.3.3.1.
- The agencies disagree that the overall risk of violation of surface water quality standards and beneficial uses to the Jefferson River and Slough is the same, if not less than, for the West Waste Rock Dump Complex. In the Statement of Basis for the Proposed Mixing Zone in Appendix 1 of the 1998 Final EIS, for the West Waste Rock Dump Complex, the agencies assumed 50 percent capture efficiency for the toe drains and 82 percent capture efficiency for pumpback wells on the west flank of the dump complex. If these capture efficiencies are achieved, water quality standards would be met at the mixing zone boundary. Implementation of required mitigation Measure W-10, which specifies a hydrogeologic investigation on the west side, would be necessary to ensure that the required capture efficiencies are achieved. Ninety-five percent capture efficiency is not needed to prevent violation of surface water quality standards and beneficial uses on the west side.
- The agencies agree that all alternatives would require maintenance and operation, including water treatment in perpetuity, and there is little difference between alternatives in terms of total water treatment capacity and design when the combined loads from the entire mine site are considered. As discussed in Section 4.2.3.8.2, the 300 to 366 gpm volume from all sources needing treatment under the Partial Pit Backfill With Downgradient Collection Alternative would be less than the 392 gpm water treatment plant capacity approved in the 1998 Record of Decision.
- Groundwater quality within the mixing zone would be of lower quality but would comply with water quality standards at the mixing zone boundary and not impact beneficial uses of the Jefferson River alluvial aquifer, if over 95 percent of pit seepage is captured. The pit seepage flow path does not have the attenuation capacity of the East Waste Rock Dump Complex flow path and requires higher capture efficiency than needed for the West Waste Rock Dump Complex, as indicated in the fourth bullet above. The same assumptions do not apply to the pit seepage flow path.
- Under all alternatives, impacts to springs/seeps in the area should be minimal. For the partial pit backfill alternatives, the agencies have assumed in the analysis (Section 4.3.4.2.1.2) that one spring would increase in flow by 15 percent and one new spring would develop. Under the other alternatives, the agencies have predicted one spring would have decreased flows (Section 4.3.2.2.1.2).
- The agencies agree that risk to public safety would be minimized and public access would be similarly limited under all alternatives. See Section 4.4.4.1.3. The suitability for post-mining land use is addressed in Sections 4.4.4.5 and 4.4.4.6 for the backfill alternatives and in Sections 4.4.2.6 and 4.4.5.6 for the other alternatives.

All of the mitigation measures listed rely on capturing the ground water after it has been impacted by pit backfill. The little or no backfill alternatives collect pit water before it exits the pit and enters the groundwater system. There are fewer limitations and uncertainties associated with water collection in the pit with little or no backfill than with water capture outside of the pit.

With regard to additional mitigation measures:

- The agencies have addressed additional means to capture contaminated groundwater in the pit area including drilling of dewatering wells outside the pit backfill material using directional drilling in the response to Comment 26.
- The agencies have considered driving an adit under the backfilled pit into the existing underground workings from outside the pit in stable ground. Driving an adit is technically feasible. Topography, historic landslides, and reclaimed waste rock dumps limit potential external portal sites to the area south of the existing GSM administration building. A portal site near the existing GSM core shed would be the most efficient balance of elevation and ramp length. A ramp driven at -15 percent grade would extend 4,500 feet from the portal to the underground sump (H. Bogart, GSM, personal communication, 2006). Access beginning from any site further down the slope would be longer. Access beginning from any site further up the slope would be steeper or longer. The portal would be excavated from an excavation in weathered bedrock, and the ramp would cross the Range Front Fault, the Telluride Fault, and the Sunlight Fault before reaching the pump station. Ground conditions are unknown in this area. Power cables, ventilation ductwork, and discharge waterlines would hang from the roof. Periodic underground maintenance would include scaling, clearing roadways, and occasional bolting as needed. It would require more maintenance and have a higher safety risk than maintaining the limited amount of tunneling in the Underground Sump Alternative in the existing pit. The portal would provide underground access. Secondary access from the underground pump station after closure would not be required by MSHA. GSM and the agencies would install secondary access to ensure worker safety. The secondary escapeway would also have to be maintained. GSM would be bonded for this maintenance.
- The agencies have considered additional means, such as slurry walls or other devices to enhance capture efficiency and to prevent downgradient migration of contamination if preferential flow paths are discovered. Slurry walls have been used successfully as a containment measure, sometimes alone and sometimes in combination with pumps and drains. A slurry wall was used in the original design of GSM's Tailing Impoundment No. 1. This system consisted of a bentonite slurry cutoff wall, a collection pond, an underdrain system, and a row of pumpback wells upstream of the cutoff wall. The slurry wall was intended to limit downgradient groundwater flow immediately below the tailings embankment (SHB, 1985). The consulting engineering report stated, "Errors during construction of the bentonite slurry wall resulted in portions of the wall not being fully keyed into the relatively impermeable Bozeman Formation." This design flaw resulted in the documented 1983 cyanide release from the impoundment. Based on this experience and

considerably more site-specific information, there is evidence that slurry walls are not the appropriate mitigation strategy. The Bozeman Group is now known to consist of permeable deposits (Spectrum Engineering and Kathy Gallagher, 2004).

The analysis of Partial Pit Backfill With Downgradient Collection Alternative in the DSEIS included mitigation measures so that water quality standards were met at the mixing zone boundary within the Jefferson River alluvial aquifer. For the FSEIS, Mitigation Measures 15b and 15c are discussed in Section 4.8.2.1. The results of the analysis have not changed the agencies' rationale for the preferred alternative.

34. COMMENT:

Existing and Future Contamination from Other Sources - Section 1.4.2 in the DSEIS contains a discussion on acid drainage potential from the GSM pit and reclamation of waste rock to reduce ARD and mentions water treatment and bonding. The section should provide additional information addressing the amount of groundwater which is already planned for capture from the existing mine facilities (including duration, flow, contaminant load) and bonding related to those requirements in order to provide for later comparison to additional potential requirements, if any, resulting from pit backfilling. For example, the text could be revised to include the language "In addition to reclamation of waste rock and tailings impoundments, it is presently predicted that up to 350 gpm of metals contaminated water will be captured and treated in perpetuity from the waste rock piles, tailings impoundments and open pit, at a cost of $25M" (figures not exact).

RESPONSE:

The amount of groundwater planned for collection from the existing mine facilities is discussed under water treatment in Section 4.2.1.8 for the No Pit Pond Alternative and for each of the other alternatives in Sections 4.2.2.8, 4.2.3.8, and 4.2.4.8. These sections also discuss duration (*i.e.*, in perpetuity), flow, and relative chemical mass. Bond is not set until an alternative is selected for permitting and will be shown in the Record of Decision. Estimates of reclamation costs for GSM for each alternative are listed in Table 4-11.

35. COMMENT:

In addressing changed site conditions (p. 1-8 – 1-9), the DSEIS mentions "Additional technical information and evaluation was required to assess the waste rock backfill effects on compliance with the Montana Water Quality Act." If additional information was required to assess the waste rock backfill effects, then why is the same or similar additional information not required to assess the waste rock (and tailings) at the GSM site in their existing locations and their effects on compliance with the Montana Water Quality Act? If important new information has been developed concerning geochemistry and geohydrology for the mine site, why is it not equally important to also evaluate their effect on compliance with applicable regulations, and allow for a comparison of the mine site as a whole, including the existing waste rock

piles and tailings impoundments in their present locations, with that of the pit backfill proposal?

Please provide additional information in the FSEIS on the existing requirements for contaminated water capture and treatment and the bonding requirements for the same. Please explain why additional information similar to that performed for the pit backfill proposal has not been required and applied to the existing rock piles and tailings which appear to have far greater potential for impacts? (168)

RESPONSE:
This SEIS evaluates impacts of pit reclamation alternatives. The agencies utilized new and available information for other mine facilities, for example three studies of Tailing Impoundment No. 1 by Keats (2001, 2002a, 2002b), the waste rock cover monitoring report by Nichol and Wilson (2003), and the West Waste Rock Pile Hydrologic Monitoring and Reclamation Report by Schafer Limited (2001). Therefore, the agencies do not agree that additional information was not applied to existing rock dumps and tailings impoundments, or that additional information is needed to assess waste rock and tailings in their existing locations and their effects on compliance with applicable regulations in the SEIS. The purpose of the SEIS is to supplement the technical analyses in the 1998 EIS, especially those components that needed to be evaluated to address pit reclamation. In completing the SEIS, the technical team reviewed and performed additional analyses on other components of the mine site as needed. The waste rock dumps were analyzed in this SEIS as part of the additional analysis completed based on the removal of waste rock and placement in the pit. The impacts on water quality from all waste rock dumps and tailings impoundments were addressed in the 1998 Final EIS, Appendix 1 for the mixing zone. As indicated above, the SEIS did evaluate new information for the East Waste Rock Dump Complex and Tailings Impoundment No. 1. The water balance for the East Waste Rock Dump Complex was completed for the SEIS in Section 4.3.2.1.1.1.2. No new impacts were identified, but the attenuation capacity would be depleted sooner and the amount of seepage would increase though not above the 1998 prediction including contingencies (Table 4-2). The amount of water predicted to need treatment from capture systems around Tailings Impoundment No. 1 was updated with actual water pumping records from GSM. See Section 3.3.7.2.

The agencies review annual monitoring reports from GSM and continually apply adaptive management to respond to changes in water quality and quantity. For example, the agencies worked with GSM in 2004 to drill additional wells to try to identify sources of nitrate in groundwater below the tailings impoundment. Under the Metal Mine Reclamation Act, DEQ can revise the reclamation plan at any time during mine life if significant environmental problems arise. The bond is reviewed annually and every 5 years under the Act.

36. COMMENT:

Reduction of Pit Highwall - According to the SEIS (p. 1-10) in describing the pit backfill alternatives "Cast blasting and dozing would be used to reduce the upper pit highwall rather than hauling all backfill material from the West Waste Rock Dump Complex." The previous paragraph states that "No waste rock material would be removed from the West Waste Rock Dump." The second paragraph should be revised to reflect a reduction in the material that cast blasting would result in hauling from the East Waste Rock Dump Complex. This is an example where the "proponent's" proposal should have been reconsidered since, later in the DSEIS, it is used to prejudice the discussion of the pit backfill alternative by connecting safety issues to the proposal. If public safety issues actually continue to exist following backfilling, then the design (*e.g.*, cast blasting at the top of the pit) should be reconsidered so as to ensure the result of backfilling meets the intended requirements of ensuring the health and safety of the public. We have no doubt that such a design can be determined (by grading of the top portions following cast blasting for example) to be safe if the agencies desire such an outcome.
Please explain why further consideration of designs to avoid public safety concerns was not considered for the pit backfill alternative? (168)

RESPONSE:

The suggested revision for page 1-10 is not needed because the cast blasted material is intended to replace any backfill that might be hauled from the West Waste Rock Dump Complex. The agencies concur that the backfill alternatives are safer than alternatives with little or no backfill. See response to Comment 33 for a discussion of public safety in the SEIS.

37. COMMENT:

Multiple Accounts Analysis Process and Issues Studied in Detail - Section 1.7.2 of the DSEIS is entitled "Multiple Accounts Analysis Process and Issues Studied in Detail." This implies that the MAA process was conducted to completion, when, in fact, it was stopped at a critical juncture in the technical/scientific process and was largely a failed effort in terms of discussion, timing, participation and utilization.

I served in the role of a technical expert and official MAA participant representing the Plaintiffs in the MAA process conducted by Spectrum Engineering on behalf of Montana DEQ and BLM with the cooperation of the Golden Sunlight Mine and Environmental Protection Agency.

Throughout the MAA process, I observed a strong bias by DEQ, BLM, and GSM representatives towards the development of technical facts and information intended solely to support those alternatives which would not involve pit backfilling. That bias is present throughout the DSEIS in that it fails to address obvious shortcomings with mitigations or changes to the alternatives or to compare them to existing conditions at the GSM mine site.

The conduct of the MAA was underscored by the attempt to achieve a result in an unrealistically short time frame. The process was initiated in May 2003 and prematurely concluded in August 2003, purportedly so that the DSEIS could be completed in September 2003 (it in fact was completed in November 2004). As such, the process was rushed to a premature conclusion that apparently has been embraced by BLM and DEQ and used in the SEIS as a final product. It did not represent a collaborative effort and any result should be noted in the SEIS as representing the viewpoint of only certain parties (and not representing Plaintiffs' view).

As noted (p. 1-10), a local rancher attended the fourth MAA meeting and provided input from a "public stakeholder" viewpoint to the process. The same rancher, who was not an official participant, with the apparent consent of DEQ, BLM and GSM, conducted public meetings using the preliminary MAA and representing it as a final and conclusive result. The rules of conduct of the MAA process require that only technically competent persons be allowed to participate, yet DEQ and BLM allowed an unqualified person to disrupt the process and present highly biased and unfounded views at a critical juncture in the process, essentially eliminating any chance of progress and development of meaningful results. This action tainted the entire MAA process and brings into question its relevance and usefulness in this circumstance.

Please accurately describe the MAA process, or eliminate from the SEIS any discussion and implication that the process resulted in any particular recommendation? (168)

RESPONSE:
The title does not imply that the MAA was conducted to completion. A draft report was prepared (Robertson GeoConsultants, 2003) and is described in detail in Section 1.7.2. Although the MAA was not formally completed, it was useful in defining issues, developing alternatives, and providing additional technical information to use in the analyses.

38. COMMENT:
Proven Design - According to the SEIS (p. 1-21), "Whether the components of the alternatives are considered proven within the mining industry must be considered." The use of the mining industry as a measure of "proof" is questionable. The mining industry is often times the last industry to adopt progressive practices and in many cases disclaims proof offered by other industries in order to avoid adoption of best management practices and other alternatives. For example, in 1996 the mining industry claimed that water treatment to treat acid drainage and metals was not a "proven" technology and therefore Montana's non-degradation water quality discharge standards could not be met. Today, just nine years later, ten of 13 major mines presently being regulated by DEQ are treating or have proposed to treat their water to meet regulatory standards. For this reason, the SEIS should not restrict

itself to those alternatives that the mining industry (in this case represented solely by GSM) does not consider proven, but rather should consider any alternatives that have been successfully used in other similar or equivalent applications.

Please explain why only technologies espoused by the mining industry are considered appropriate in the DSEIS? (168)

RESPONSE:
The agencies disagree that only technologies espoused by industry were considered. Proven design is discussed throughout the DSEIS, including Sections 4.2.1.1.1, 4.2.2.1.1, 4.2.3.1.1, and 4.2.4.1.1. The agencies have considered alternatives that have been successfully used in other similar or equivalent applications.

39. COMMENT:
Pit Highwall Stability - According to the SEIS (p. 1-22), an unreclaimed pit highwall "typically is not designed to remain completely stable for an indefinite period of time after closure..." and "gradually evolves to a more stable configuration over time." We agree with this statement, and it clearly suggests that future failures of the pit highwalls are likely if not certain. However, according to the DSEIS (p. 2-14), "GSM has not proposed any other specific measures to maintain or improve pit highwall stability after closure. No major pit highwall failures were predicted in the 1998 Final EIS."

It should be noted that it is difficult if not impossible to accurately predict the stability of pit highwalls. For example, pit highwall failures that have occurred at the Berkeley Pit in Butte, and at Montana Tunnels near Wickes, and elsewhere throughout the U.S. have never been "predicted." The nature of geotechnical stability makes accurate prediction difficult if not impossible as is evidence that no failure has ever been predicted beforehand, and only failures that have actually occurred can be accurately assessed (and then with some difficulty).

The last paragraph of this discussion in the SEIS is confusing and appears to attempt to suggest that pit backfilling will not result in highwall stability. This appears to be an attempt to bias the SEIS by balancing pit wall instability in an unbackfilled condition (100 percent certain to be unstable), with instability in the pit wall in a backfilled condition (1 percent or less probability on a comparative basis). DEQ must explain what is meant in this paragraph and consider whether it is appropriate or necessary to include in the DSEIS given the context of the intended discussion in this section (purpose and need). The need to address pit highwall stability is obvious, but the potential consequence should be provided in context in the appropriate discussion (Chapter 4).

Please explain what allows for more accurate prediction in this case and why the inevitability of pit highwall failures is not more fully recognized in the DSEIS as a

likely consequence of not backfilling the open pit? Please explain in the DSEIS what the Montana DEQ's and the public taxpayer's liability will be in the event of a pit highwall failure that results in a human death, injury, or property damage. (168)

RESPONSE:
A discussion of pit highwall stability is presented in Sections 4.2.1.2.2, 4.2.2.2.1, 4.2.3.2.1, and 4.2.4.2.1 for each alternative in the DSEIS. Pit highwall stability failure modes and effects analyses were conducted for the 1997 Draft EIS. Additional pit highwall stability analyses were conducted (Brawner, 2005; Golder, 2005). Copies of these reports are in the Administrative Record.

Three potential failure modes were identified with respect to long term pit highwall stability: 1) raveling; 2) slope failure; and 3) wedge failure in the upper west highwall Grayson Formation sedimentary rocks. Results indicate that an adequate Factor of Safety (FOS) exists for both non-backfilled and backfilled pit scenarios. A combination of engineering design and operational procedures were outlined to manage the pit highwall after closure. The agencies reviewed these design and operational procedures and have developed additional mitigations to enhance highwall stability as referenced in the Comment 130 Response.

GSM is currently maintaining pit highwall stability under operational conditions caused by continuous stress to the highwall from vibration of moving equipment and blasting. Stability would increase at closure because these stresses would be removed.

The agencies addressed the risk to public safety in Sections 4.4.2.1.3, 4.4.3.1.3, 4.4.4.1.3, and 4.4.5.1.3. Liability in the event of a pit highwall failure that results in a human death, injury, or property damage is outside the scope of the SEIS. Post-closure operations would be bonded for long-term operation and maintenance, which would include highwall monitoring and reestablishing catch benches. Secondary access to underground workings would not be required by MSHA in the Underground Sump Alternative to protect worker safety as discussed in responses to Comments 30 and 33, but the agencies would require GSM to provide secondary access.

40. COMMENT:
Operation Requirement - According to the DSEIS (p. 1-23), "The potential risk of contamination to groundwater is more important than that to surface water at GSM."

What is the intent of this statement given that the Montana WQA primarily regulates surface water and that elsewhere in the DSEIS an emphasis on potential harm to surface water is emphasized in comparison of the alternatives? (168)

RESPONSE:
The citation is a general statement of the relative potential for impacts to groundwater and surface water. Since groundwater occurs beneath or around all of the GSM facilities, the risk of contamination to groundwater is more important than the risk to surface water in the form of springs, which occur infrequently within the GSM permit boundary. Impacts to groundwater are discussed in Sections 4.3.2.1, 4.3.3.1, 4.3.4.1, and 4.3.5.1. Impacts to surface water are discussed in Sections 4.3.2.2, 4.3.3.2, 4.3.4.2, and 4.3.5.2. Groundwater in the mixing zone has been impacted during operations. Contamination of springs during mine operations has not been conclusively shown. The agencies have assumed minimal impacts to surface water quality and quantity in the various alternatives. No contamination of the Jefferson River alluvial aquifer outside the mixing zone is predicted except for the Partial Pit Backfill With Downgradient Collection Alternative.

41. COMMENT:
Maintenance of Capture Points - According to the DSEIS (p. 1-24), "Relying on capture of pit outflows at distances down gradient of the pit may introduce a larger degree of uncertainty and risk concerning the effectiveness of capturing all contaminated groundwater and could require collection of a greater volume of groundwater." The present in-perpetuity mitigation program for capture of leachate outflows from waste rock dumps and tailing impoundments down gradient of those facilities similarly introduces a degree of uncertainty and risk concerning the effectiveness of capturing all contaminated groundwater and requires collection of significant volumes of groundwater.

How would the maintenance, safety, settling and compaction issues be different for the pit backfill alternative versus the same issues for the existing facilities where downgradient capture has been determined adequate? (168)

RESPONSE:
The agencies acknowledge that there is always a degree of uncertainty and risk associated with the performance of groundwater capture systems. However, the analysis in the DSEIS demonstrates that capturing pit effluent down gradient of the pit poses a larger degree of uncertainty and risk than capturing groundwater beneath the pit as planned in the Underground Sump Alternative. Maintenance of capture wells below the tailings impoundments and waste rock dumps would not be subject to settling and compaction as would wells in pit backfill. Safety for workers maintaining wells in the backfilled pit would be the same as for workers maintaining capture systems down gradient of tailings impoundments and waste rock dumps.

42. COMMENT:
Soil Cover Maintenance Requirements - According to the DSEIS (p. 1-24), previous reclamation has led to a shortfall of stockpiled soil for future reclamation

activities such as pit backfilling. This implies that previous approaches taken in reclamation have used an excess of topsoil, or otherwise not generated or identified additional suitable growth medium, for reclamation of the open pit. The lack of readily available cover soil, while an issue, should not be viewed as a negative aspect against pit backfilling because it represents a lack of foresight by the agencies and the operators which they have purposefully exercised since the 1998 Final EIS was issued.

Suitable growth medium has been located for past reclamation requirements and the ability to locate and use similar growth medium and therefore minimize this consideration in pit backfilling should be discussed in the SEIS. (168)

RESPONSE:
All reclamation activities at GSM have been conducted following approved reclamation plans. Section 1.7.2.1.7.1 of the DSEIS states that an adequate soil volume exists for reclamation activities under the No Pit Pond Alternative in the 1997 Draft EIS, but backfilling would result in additional soil requirements. This additional soil borrow source has been identified in the FSEIS in Section 4.3.2.3.

43. COMMENT:
Risk of Impacts to Groundwater Quality and Quantity in Permit Area -
According to the DSEIS (p. 1-25), "Over time, the waste rock that is placed in the pit could be chemically and physically altered, causing pore waters with elevated concentrations of naturally occurring contaminants. The changing physical properties of the materials may affect flow patterns, and the changing chemistry of the effluent has the potential to impact down gradient groundwater. The ability to capture groundwater in various pit reclamation alternatives will affect the potential for additional impacts to groundwater in the permit area." The same waste rock material that presently or in the future will be located in the East Waste Rock Dump similarly could be chemically and physically altered increasing contaminant concentrations, changing flow patterns, and impacting down gradient groundwater.

RESPONSE:
Rehandling waste rock to backfill the pit would cause some additional physical alteration that would not occur if the waste rock is left in the dumps. The agencies have predicted water quality in the unsaturated zone of the backfilled pit would be the same as pore water quality in the waste rock dumps. Part of the backfill in the pit would be saturated (see Section 4.3.3.1.1.2.1). This would not be true of waste rock in the dumps. The agencies have predicted that water quality in the saturated zone would decrease due to jarosite dissolution. The agencies disagree that, for waste rock dumps, contaminant concentrations would increase, flow paths would change, and downgradient groundwater would be impacted more than predicted in the DSEIS and 1997 Draft EIS.

44. COMMENT:
Telesto (2003) concludes that current waste rock pore water is a good approximation of pit backfill pore water chemistry. Although pore water in the upper, unsaturated portion of the backfilled pit could have low pH and elevated metals concentrations, like the waste rock pore water, it is unlikely that pore water in the lower, saturated portion of the pit would have as low of a pH or as high concentrations of metals as current waste rock pore water. The cover and the saturation with water will decrease the amount of oxygen in the backfill and consequently reduce the rate of sulfide oxidation and acid drainage production. (168)

RESPONSE:
The agencies disagree that it is unlikely that pore water in the lower, saturated portion of the pit would have as low pH or as high concentrations of metals as waste rock pore water (see Section 4.3.3.1.1.2.1).

The saturated portion of the backfill would transition from oxidizing conditions immediately after placement and during groundwater filling in the pit backfill to reducing conditions when hydrologic steady-state conditions develop either under active water level management or for flow through conditions.

The saturated portion of pit backfill will be affected by ferric iron oxidation of pyrite and from dissolution of jarosite. The oxidation rate should diminish with time because of the low oxygen content of the groundwater and low oxygen diffusion in water. Lower oxidation rates do not automatically translate into higher pH. The pit backfill must contain sufficiently reactive materials to buffer the acidity produced with a decreased oxidation rate or the inflowing groundwater must carry sufficient alkalinity to buffer acidity it comes in contact with. As the backfilled pit fills with water, the solid phase oxidation products that formed from geochemical reactions in the unsaturated zone would probably dissolve due to the lower oxidation-reduction state of the saturated zone. The flushing of reaction products from both the unsaturated zone and saturated zone would continue for hundreds to thousands of years, because of the low groundwater recharge and flow rate (Telesto, 2003c).

Further, other metals that exist in the waste rock material that are more mobile in different pH conditions may be liberated or remain mobile with a changed pH condition in the saturated zone unless drastic pH rises could be achieved. For example, soluble nickel will remain in solution until the pH of the solution is increased to values on the order of 9 or 10. It is unlikely that simple saturation of a previously oxidized and metal laden waste would remove metals or change concentrations to a point that water quality could be considered non-degraded.

45. COMMENT:
Current waste rock pore water chemistry was used to model transport of seepage from a backfilled pit to the Jefferson River alluvium (HSI, Inc., 2003). The model should be rerun (for downgradient transport in aquifer) using backfill pore water with a higher pH and lower metals concentrations, at least as a sensitivity analysis. (168)

RESPONSE:
The agencies disagree that the model should be rerun using backfill pore water with a higher pH and lower metals concentrations, at least as a sensitivity analysis. See response to Comment 35.

46. COMMENT:
Telesto (2003) also concludes that a reduction in oxygen in waste rock in the pit would dissolve jarosite, release acidity and ferric iron, and keep the pH of pore water in a backfilled pit depressed. However, the pore water pH will increase because the rate of pyrite oxidation would decrease. Using Figure 1 in Telesto (2003), if only oxidation potential drops, the solution would enter the aqueous ferrous sulfate field, which is the reduced ferrous, not the oxidized ferric, iron. If the oxidation potential drops and pH goes up even slightly, the solution would enter the goethite field, and ferric iron would precipitate as a solid. It seems more likely, then, that under reducing conditions, if jarosite did dissolve, that aqueous ferrous sulfate and ferric hydroxide would form. (168)

RESPONSE:
The agencies disagree. Figure 1 in Telesto (2003) depicts solid or aqueous phases at equilibrium with the solution chemistry and does not consider reaction kinetics. As oxidation potential drops, the solution would tend to remain at the equilibrium boundary between jarosite and aqueous ferrous sulfate, which is a surrogate for the ferrous/ferric iron boundary, until all of the jarosite has reacted. During the time that the oxidation potential is buffered by the jarosite dissolution reaction, the activities of ferric and ferrous iron would be equal, which means that ferric iron would be available for activating further sulfide oxidation.

Jarosite stability and expected changes in backfill water chemistry are discussed in responses to Comments 47 and 48.

47. COMMENT:
The percentages of jarosite in the waste rock material were never quantified (Telesto, 2003; Personal Communication, Jim Finley, October 2003). Too much is being made of the presence of jarosite. Jarosite is only listed as being present in minor quantities in one whole rock waste rock sample and in trace quantities in another whole rock waste rock sample. Looking only at the clay fraction, jarosite was present in major quantities in 8 of 11 samples, but the clay fraction is only a

small portion of the whole rock material (data table provided by Jim Finley, Telesto Solutions, Inc., October 2003). (168)

RESPONSE:
The agencies disagree. The formation and dissolution of jarosite and its control over solution chemistry can be profound. X-ray diffraction (XRD) is a semi-quantitative mineral identification technique with a detection limit of approximately 1 percent for crystallized material. Assuming 1 percent would be present in the backfill, the estimated total quantity of jarosite is 44,750,000 tons. The amount of jarosite corresponds to approximately 8.1×10^{10} moles of jarosite. In addition, jarosite would continue to be produced by sulfide oxidation reactions within the unsaturated zone of the backfill. On a quantitative basis, the amount of jarosite in the backfill is a key component controlling the overall backfilled pit geochemistry. XRD does not identify amorphous secondary minerals that are undoubtedly present. Typically in acid generating waste materials, these include iron sulfates as well as other phases.

48. COMMENT:
It is possible that there would be a flush of low-pH, metal-rich leachate from the backfilled pit for some time (possibly tens of years after the lower pit is saturated and discharge from the backfilled pit occurs). However, if a capture system is in place, which it should be, this "first flush" could be captured and treated. Golden Sunlight Mine is prepared to commit to in-perpetuity pumping/capture and treating for a water-filled pit. However, in the long-term (tens to hundreds of years), it is more prudent to backfill the pit, with a contingency for capturing and treating discharge because the chances for improved water quality are higher in a backfilled pit. In addition, from hydrologic calculations, flow from a backfilled pit would be quite low (~25 gpm) and could potentially be diluted or neutralized to the point where discharge to the Jefferson River would not impair aquatic life. This possibility was not adequately tested by transport modeling performed on pit backfill leachate transport (HSI, 2003). (168)

RESPONSE:
The flushing of contaminants in sufficient concentrations to pose risks to groundwater and surface water quality will occur for a period much longer than tens of years, based on the geochemical evaluation performed for the DSEIS and cited therein (Telesto, 2003c). The geochemical evaluation found that the combination of rinsing and continued oxidation in both the saturated zone (from ferric iron) and unsaturated zone (from oxygen and ferric iron) will result in production of low pH, metal-bearing ground water for 100s to 1000s of years because of the large total mass of pyrite that would be placed in the pit. The combination of the long-term geochemical reaction rates in the pit and the low ground water flow rate from a backfilled pit (Telesto, 2003c) means that the process of flushing reaction products will continue for 100s to 1000s of years. The ambient baseline quality of groundwater in the debris flow aquifer of Rattlesnake Gulch provides further evidence that the mineralization naturally found at the GSM has produced low pH,

and metal-enriched groundwater since ancient times. Therefore, the agencies conclude that the analysis in the DSEIS sufficiently modeled the flushing of contaminants from a backfilled pit and their transport in primary and secondary flow paths (see Section 4.3.4.1.1.2).

49. COMMENT:

The backfill analogue study (Gallagher, 2003) was reportedly focusing on 1) initial predictions of water quality at the analogue sites; 2) comparison of predicted to actual conditions; and 3) water quality trends over time. While the first two are points were addressed and are instructive, the third point is more important and relevant to our charge for the Golden Sunlight Mine and was addressed at only one site (Butte underground workings and pit lake chemistry, Maest, 2003).

The conclusion of the backfill analogue study was that "none of the sites have an adequate period of record to make substantial conclusions on the ultimate water quality response to pit backfilling and pit/mine flooding." Because long-term water quality data was only provided for one site, this conclusion is not warranted. Water quality for the Butte underground workings shows improvement in water quality over time. While conditions in the underground are not directly comparable to a completely backfilled open pit, the decrease in oxygen and the filling with water are similar, and these conditions will drive redox reactions in a backfilled pit.

Water quality data over time for the San Luis Mine were provided to DEQ, yet these were not presented in the memorandum (the data disks could not be located, but copies could have been secured again from the agency). I have had conversations with Harry Posey and others at the Colorado Division of Mines and Geology, and they have informed me that water quality in seeps discharging from the backfilled pit were initially high in manganese and sulfate but that concentrations have decreased over time, and water quality in the adjacent Rito Seco Creek has improved. While it was difficult to adequately summarize and present water quality data over time for all backfilled pits in the time allotted for the study, more time should have been provided to evaluate and summarize the available long-term water quality data.

Rather than the conclusion reached in the backfill analogue study, based on the two examples with water quality data over time (Butte and the San Luis mine), it would be reasonable to conclude that water quality in backfilled open pits, while poor initially, should if anything improve somewhat over time as the backfill becomes saturated. The decrease in available oxygen over time should decrease the rate of pyrite oxidation, which should raise the pH and begin to immobilize metals roughly in the order of their hydrolysis constants.

Why will the pore water chemistry of the pit backfill not be as deleterious as suggested by the DSEIS? Please explain why the DSEIS and Telesto's hydrology models do not evaluate similar phenomena and potential impacts in the East Waste

Rock Dump as well as other mine features such as the West Waste Rock Dump and tailing impoundments on a comparative basis? (168)

RESPONSE:
The agencies disagree that the underground workings at Butte are a representative analog for a backfilled pit situation (Gallagher, 2003). The wallrock in the flooded Butte underground workings has been oxidized a few millimeters. Submerging unoxidized rocks would limit the oxidation of pyrite by oxygen, but not by ferric iron. The water quality data suggest that initial flooding of the underground workings removed a flush of products. Water quality has improved as those products were removed and as water has continued to circulate through the workings. A similar set of hydrogeochemical processes cannot be assumed for the backfilled pit scenario at GSM.

Another backfilled pit is the Whistle Mine in Ontario (Knight Piesold, 1998). Lime amended waste rock was backfilled into a pit and water quality samples collected. The intent was that the water quality would meet discharge quality over time. Even though the pH increased to near neutral due to lime amendment, it was unsuccessful in achieving discharge water quality standards, in particular for nickel due to the need for a pH near 9 or 10 to precipitate nickel. Collection and treatment continues.

The agencies disagree with the assessment of the San Luis Mine. Telesto has been working at the San Luis Mine from 1999 to 2006. There is no seepage from the backfilled pit at the San Luis Mine because the groundwater level in the backfilled pit has been actively controlled at an elevation such that groundwater cannot flow from the pit. The backfilled pit water chemistry was better because the backfill had been rinsed of oxidation products during storage. The San Luis Mine waste rock has less sulfide than the GSM waste rock. Waste rock with neutralizing capacity was used as backfill at the San Luis Mine. The zone of groundwater fluctuation occurs within the high neutralizing capacity material and not in sulfide-bearing waste rock. Because of the lower sulfide content and material with neutralizing capacity, the groundwater in the backfilled pit at the San Luis Mine has always had neutral pH with low metal concentrations.

The agencies do not dispute that pit effluent may improve over time; however, the improvement would be limited. See the response to Comment 48 for a discussion of the change in pit water quality over time.

Two measures influence the interpretation and projection of water chemistry associated with sulfide oxidation: 1) the total mass of sulfide present and 2) the rate of reaction. The total mass of sulfide can be used to evaluate the balance between potential acidity generated and potential neutralization capacity. The rate of reaction constrains the period over which the solution chemistry is influenced by sulfide oxidation. In the case of in-pit neutralization, the evaluation must consider both measures.

The rate of reaction does not normally affect the chemistry of water unless the neutralization reactions involve rapidly reacting carbonate minerals that are in contact with the pyrite. In the presence of rapidly reacting carbonate minerals, the sulfide oxidation rate can be balanced. The acidity and metals released during the oxidation process are neutralized and immobilized assuming an equivalent amount of neutralizing material is present. If the principal neutralization reaction is aluminosilicate weathering, as is the case at GSM, then the issue of relative rates of reaction would dictate the solution chemistry.

As the purpose of the SEIS was to evaluate pit reclamation alternatives, other facilities were not modeled, unless the information was necessary for the analyses. See response to Comment 35.

50. COMMENT:

Risk to Public Safety - According to the DSEIS (p. 1-29), "Under all open pit options, access restrictions on general public use would need to be maintained." An alternative should be developed and considered that would address and remove access restrictions over the long-term. In order for the pit backfill alternative or, any other reclamation alternative for that matter, to be effective and result in a clean and healthy environment it must result in the achievement of public safety. If 2H:1V slopes can achieve safe conditions on the waste rock piles where access restrictions are not envisioned long-term, then similarly it should be possible to achieve similarly safe conditions with pit backfilling at the same 2H:1V slopes.

Please explain if the same standard of performance is applied to the pit backfilling slopes as to the waste rock slopes why access restrictions to public use would need to be maintained? (168)

RESPONSE:

The risks to worker safety would be similar for 2H:1V slopes on pit backfill and waste rock dumps (see Section 4.4.3.1.2.). Please see Figure 1-3 to clarify land ownership and public access issues. Since much of the pit area land is privately owned, the mine would not allow public access with any of the alternatives to provide an additional measure for public safety (Shannon Dunlap, GSM, personal communication, 2006).

51. COMMENT:

Reclamation Costs - According to the DSEIS (p. 1-30), "Some level of backfilling could eliminate any reasonable likelihood of realizing a positive return on investment for GSM. Reclamation costs must be evaluated as an impact to GSM." This ignores previous rulings by the Montana District Court in a February, 2000 decision that "there is nothing in the constitution or the MMRA which allows a reclamation decision to be based on a threshold determination of whether a mine operator will make a profit."

Why does the DSEIS evaluate reclamation costs as an impact given the Court's ruling?

RESPONSE:

MEPA requires the agencies to disclose the economic impact of the alternatives on GSM (see Section 4.5.1 and Table 4-11). Economics are not considered in making a decision under MMRA.

52. COMMENT:

Alternatives Evaluated in Detail - According to the DSEIS (p. 2-1), "The Partial Backfill Alternative described in the 1998 Final EIS and subsequently updated to reflect current conditions and modifications (GSM, 2002) is the Proposed Action Alternative. The No Pit Pond Alternative described in the 1998 Final EIS and the 1998 ROD serves as the No Action Alternative. Five additional alternatives or variations of these alternatives were studied in the SEIS. Two of the five alternatives were evaluated in detail." Section 2.4.1 (p. 2-10) suggests four alternatives were studied in detail.

Why were all seven of the alternatives not evaluated in detail? How can an accurate analysis be performed if all alternatives are not developed in equal detail? Why were the alternatives not modified to identify appropriate mitigations as issues were identified where practical? (168)

RESPONSE:

The MAA process developed reasonable alternatives for analyses. Although three preliminary potential alternatives were dismissed, many technical analyses were completed for these alternatives in supporting documents for the preparation of the SEIS. Section 2.5 of the DSEIS provides the rationale for dismissing alternatives.

53. COMMENT:

Stage 5B Pit Backfill - According to the DSEIS (p. 2-19), "The Partial Pit Backfill With In-Pit Collection Alternative would remove 33 percent of the total volume in the East Waste Rock Dump Complex into the pit. None of the backfilling operations would reduce the current footprint of the dump of 438 acres. This varies from the 1997 Draft EIS, Chapter II, Section II.B.7.b, which would have used 30 to 32 percent

of the total permitted volume and would have completely removed 82 acres of the dump complex."

Why was the Proposed Action changed to result in no reduction of the dump complex footprint? (168)

RESPONSE:
The agencies have changed the partial pit backfill alternatives based on the comment. As part of mitigation Measure 2A (see Section 4.8.1.2), waste rock would be removed to restore Sheep Rock Draw. Under this conceptual design, 67 acres of the dump footprint would be uncovered and Sheep Rock Draw would be placed back in its original channel (see revised Figure 2-5). The return diversion approved in the 1998 ROD would be reclaimed.

54. COMMENT:
Stability and Safety Concern - According to the DSEIS (p. 2-22) in discussing the Partial Backfill option, "Public access to the permit area would continue to be prohibited in selected areas due to concerns about the safety and security of maintenance personnel and equipment that would remain in the area."

Please explain how public access represents a hazard to maintenance personnel and equipment? Please explain why mitigations (*i.e.*, design modifications) were not identified to address those hazards rather than restrict public access? Please explain why the same hazards do not exist elsewhere on reclaimed (*e.g.*, reclaimed slopes on waste rock dumps) areas of the mine? (168)

RESPONSE:
See response to Comment 50.

55. COMMENT:
Hydrologic Conceptual Model and Feasibility Assessment - The DSEIS relies upon several studies by Telesto including a Hydrologic Conceptual Model and a Feasibility Assessment which address potential flows from the pit to groundwater and surface water as well as the transport and fate of potential contaminants of concern which might be present in those flows.

A number of the assumptions or initial conditions for the modeling of ARD transport from the pit will overestimate concentrations reaching the Jefferson River (HSI, Inc., 2003). For example, no basis is provided for the use of 5 percent infiltration (pg. 4); the EIS (1998) used 11.5 percent of annual precipitation. The lower infiltration will bias concentrations high because of lower dilution. (168)

RESPONSE:
The use of 5 percent of annual precipitation for recharge in the DSEIS is explained in Section 6.2.2 – Groundwater Travel Times in the Bozeman and Debris Flow Aquifers" on page 58 of the HSI (2003) report. This section discusses methods of calculating groundwater flux. This section states: "In the (sic) Appendix J study (1998 Final EIS), a recharge rate of 1.5 inches per year (about 11.5 percent of the annual precipitation) was used over Bull Mountain. Golder (1995a) arrived at a groundwater recharge estimate of 0.25 inches/yr (about 2 percent of annual precipitation) in their assessment of the water balance of the Sunlight Slip Block at GSM. Accordingly, a mid-range value of 5 percent of annual precipitation (0.69 inches/yr) was assigned for this evaluation."

Throughout the arid western U.S., it is recognized that a typical recharge rate for natural areas as well as revegetated areas is on the order of 5 percent (Maxey-Eakin, 1949). During the MAA process, the general consensus was that recharge would be around 5 percent and definitely not larger than 10 percent.
Increasing the recharge rate would not result in dilution of the water chemistry from the backfilled pit. It is nearly impossible to dilute pH, and the geochemistry of the backfill solid phases would dictate the chemistry of water for long periods of time – see responses to Comments 44 and 48. It would result in more poor quality water requiring higher ground water capture efficiency.

56. COMMENT:
Similarly, the assumption that 100 percent of flow from pit would be through Rattlesnake Gulch does not comport with flow path study results. Some flow from the pit should be routed through other faults and features in a rerun of the model. Assuming that 100 percent of the flow is through Rattlesnake Gulch will overestimate concentrations reaching the Jefferson River because this path does not go through the neutralizing Bozeman formation. Using a discharge from the pit of 103 gpm will overestimate concentrations in groundwater and in the Jefferson River. In the MAA meetings, flows of 10 or 25 to 50 gpm were mentioned as being more reasonable. (168)

RESPONSE:
In the DSEIS, the discharge from the pit was predicted to be 16 gpm (Telesto, 2003a), not 103 gpm as mentioned in the comment above. As described in the Response to Comment 28, the revised pit water balance model (Telesto, 2006) predicts the average outflow from the pit to be 27 to 42 gpm. The analysis in the DSEIS indicated that a portion of pit outflows through other bedrock flow paths could rejoin the groundwater system of Rattlesnake Gulch given the existing hydraulic heads and groundwater flow directions on the south side of the pit (see DSEIS Figure 3-6). For the FSEIS, the pit effluent flow rate down Rattlesnake Gulch was evaluated for a range of flows from 0 to 45 gpm (Figure 4-2). The 103 gpm referred to in the comment is the estimated upper end of the diluting flow in Rattlesnake Gulch from the naturally occurring groundwater in that aquifer. The diluting flows used in the DSEIS assessment were 52 to 103 gpm. To estimate impacts to the

Jefferson River alluvial aquifer, this range was used in the SEIS (see Section 4.3.4.1.1.2).

57. COMMENT:
The model should be rerun using more realistic ranges of outflows from the pit, infiltration rates, and percentages of flow through Rattlesnake Gulch. These sensitivity analyses should be included in the EIS. (168)

RESPONSE:
The pit hydrologic flow and water balance model (see Telesto, 2003a) rates of flow through Rattlesnake Gulch were based on 1) five years of weekly to bi-weekly readings from the Rattlesnake Gulch groundwater capture system (52 gpm), and 2) the groundwater flux through upper Rattlesnake Gulch calculated with Darcy's Law and the aquifer geometry, gradient and hydraulic conductivity obtained from GSM studies (103 gpm) (Golder, 1995; SHB, 1989). Sensitivity analysis was performed and presented in the DSEIS in Section 4.3.4.1.1.2 and in Table 4-7. See Tables 6-13 and 6-14 in the Hydrology Supplement Report (HSI, 2003), which contain analyses that included sensitivity to variations in the rate of flow through Rattlesnake Gulch (52-103 gpm), the contribution from the East Waste Rock Dump Complex (1-3 gpm), and rates of groundwater capture efficiency (80 - 99.99 percent). Technical experts involved in the MAA process commented on the values used in the analysis.

58. COMMENT:
It is most likely that zinc would be the contaminant of concern for the Jefferson River because concentrations are high in waste rock pore water, zinc is not easily immobilized by adsorption or precipitation, and zinc is an aquatic toxin. However, the analysis did not take the pit discharge through to the Jefferson River. The model takes the pit backfill discharge to the Jefferson River alluvium but not through it. What would dilution be in the alluvium? Also, what would predicted concentrations be in the Jefferson River, and, given the measured hardness, would this exceed or come close to exceeding ambient water quality criteria for protection of aquatic biota? (168)

RESPONSE:
The DSEIS analysis of Partial Pit Backfill With Downgradient Collection was based on evaluating compliance with water quality standards within the mixing zone. Most of the southern permit boundary falls in the Jefferson River alluvial aquifer or other alluvial deposits on the north side of the Jefferson River Slough. The Jefferson River alluvial aquifer receives water from the primary pit effluent groundwater pathway, in the southeast corner of Section 32 where the permit boundary crosses I-90. In response to the above comment, the agencies performed additional water quality analysis that carried the results of the DSEIS groundwater mixing model to the Jefferson River Slough and compared the results to DEQ7 surface water

standards (HSI, 2006, 2007) and to Non-Degradation of Water Quality rules (ARM 17.30.715) (HSI, 2007).

With two systems operating at 87.5 percent efficiency (combined efficiency of 96%), the analysis indicates that aluminum would be slightly below the chronic aquatic limit, and that chronic limits for cadmium and copper could be exceeded at low hardness conditions (25 mg/l per DEQ-7). The DEQ-7 standard for iron would be exceeded (HSI, 2006). As above, application of criteria for determining non-significant changes in water quality under ARM 17.30.715 failed for aluminum, copper, and iron (HSI, 2007).

Based on their experience, the agencies believe a maximum capture efficiency of 80 percent per system is potentially achievable. With two groundwater capture systems operating at 80 percent efficiency (combined efficiency of 92%), the analysis indicates that chronic aquatic standard for aluminum and iron would be exceeded at 188 mg/l hardness (based on a 3/8/2006 measurement from the Jefferson River Slough near the GSM property boundary), and that for low hardness conditions (25 mg/l per DEQ-7), chronic limits for aluminum, cadmium and copper would be exceeded (HSI, 2006). Application of criteria for determining non-significant changes in water quality under ARM 17.30.715 failed for aluminum, copper, and iron (HSI, 2007). Aluminum and copper are classified as "toxic" parameters, and iron as "harmful" according to Circular DEQ7.

59. COMMENT:

HSI (2003) assumes that no ARD attenuation or dilution would occur in the Rattlesnake Gulch aquifer and no attenuation or dilution (because recharge and dilution to individual fault zones cannot be reliably made with the available information) would occur in the Precambrian bedrock surrounding the pit. These assumptions will overestimate predicted concentrations traveling from a backfilled pit to the Jefferson River alluvium and do not appear to be supported by any available data (especially the assumption of no dilution). With a small amount of discharge coming from a backfilled pit, even small amounts of dilution, adsorption, and neutralization will help improve water quality.

Please address the comments provided above and explain the worst-case basis for Telesto's assumptions? Please explain why similar worst case assumptions should not be applied to all other mine features (waste rock piles and tailings) in a comparative analysis? Please explain why the potential for similar flow paths and potential for contamination of surface water was not similarly evaluated for the West Waste Rock Dump Complex in previous EISs or this DSEIS? Please explain why attenuation and other phenomena which were applied in previous analysis to suggest reduced impacts to surface water are not used in Telesto's analysis? (168)

RESPONSE:
The analysis did not overestimate the potential impacts of the Partial Pit Backfill With Downgradient Collection Alternative. The agencies agree that small amounts of attenuation may improve the quality of migrating pit effluent, which is why the DSEIS analysis evaluated several types of attenuation (Telesto, 2003e; HSI, 2003).

Attenuating mechanisms included: 1) dilution, 2) neutralization, 3) ion exchange, and 4) sorption (HSI, 2003; Appendix G). As described in the responses to Comments 28 and 57, the projected outflow from the pit was diluted with a range of potential flows in Rattlesnake Gulch from 52 to 103 gpm (HSI, 2003). The potential attenuation along the flow path was incorporated into the analysis.

The DSEIS analysis indicated that attenuation by ion exchange would last 10 to 20 years (see Section 4.3.4.1.2.2.1, and HSI, 2003). The exchange process is reversible, meaning that this attenuation mechanism may not be protective of water quality in the long term.

The DSEIS analysis of dilution and attenuation in geologic materials surrounding the pit was based on site-specific data. A column leaching study of ARD attenuation indicated that the dominant geologic materials in the pit effluent flow path offered essentially no attenuation or neutralization capacity (Schafer & Associates, 1994).

Analysis of attenuation mechanisms performed for the FSEIS demonstrated the absence of calcite in the primary pit effluent flow path, confirming the lack of neutralization potential (Mogk, 2005).

Some dilution by recharge would occur within the bedrock (HSI, 2003). Reasonable estimates of recharge and dilution in individual fault zones cannot be made with available information. Recharge waters migrate through the same rock that imparts the water quality characteristics to the existing groundwater. The bedrock groundwater around the pit is generally acidic (for example, that from highwall wells PW-48 and PW-49), and therefore would not serve to substantially improve the quality of migrating pit effluent. The agencies' conclusions about dilution and attenuation are consistent with site-specific data.

The agencies evaluated all GSM facilities potentially affected by the Proposed Action and alternatives, including the East Waste Rock Dump Complex. The DSEIS reviewed previous attenuation studies, and applied reasonably consistent contaminant fate, transport and attenuation assessments to potential discharge from both the pit and the East Waste Rock Dump Complex (see Section 4.3.2.1.1.1, and HSI, 2003, Section 6.0). The analysis of the East Waste Rock Dump Complex used middle to worst case estimates of recharge of 0.25 to 0.5 inches per year (see Section 4.3.2.1.1.1.2). The ARD modeling parameters compared to the 1997 Draft EIS were provided in Table 4-4, and included information sources. See response to Comment 35 for discussion of analysis of other mine facilities.

Flow paths and potential for contamination of surface water were evaluated for the West Waste Rock Dump Complex in the 1997 Draft EIS in Appendix J and in the 1998 Final EIS in Appendix 1.

60. COMMENT:

Rationale for Selection - We disagree with the rationale for selection stated in the SEIS (p. 2-56) as has been discussed in other comments herein and as follows: There is a significantly higher risk of a highwall failure that threatens public and worker safety with the no backfill alternatives. The agencies' reliance on analysis that is intended to address catastrophic pit-highwall failures versus failures of a variety of mechanisms that are sure to occur over time is short-sighted and relies on a concept that suggests the GSM pit walls are inherently more stable than other similar pit walls.

If only the Underground Sump and No Pit Pond Alternatives provide adequate assurance that pollution of the Jefferson River alluvial aquifer will not occur (assumedly by increasing risk of capture to greater than 95 percent), then why have past decisions not been made on a similar basis (in which event the No Action Alternative should have been chosen in 1992 as not mining was the only alternative that could assure greater than 95 percent capture of contamination from the tailings impoundments and waste rock dumps)? What uniquely makes effective capture of seepage in or down gradient of the pit more difficult than capture of seepage from the waste rock dumps and tailings impoundments?

The pit backfill alternatives would minimize the risk to workers monitoring the site post-reclamation and would similarly minimize public safety and access issues. Please address the agencies' rationale for the preferred alternative given that the pit backfill alternative would result in the above advantages and most likely not result in any impacts to surface water quality if the appropriate mitigations are applied? (168)

RESPONSE

Pit highwall stability for the various alternatives is addressed in the response to Comment 39.

Capture of seepage in the pit or down gradient of the pit, waste rock dump complexes, and tailings impoundments is addressed in the response to Comment 33. The mixing zone was analyzed in the 1997 Draft EIS, Appendix J, and the 1998 Final EIS, Appendix 1. Ninety-five percent capture efficiency from the waste rock dumps and tailings impoundments is not needed to comply with water quality standards at the mixing zone boundary.

The comment assumes that the alternatives not selected in the DSEIS achieved less than 95 percent capture of pit-contaminated groundwater. All alternatives were designed to achieve the degree of groundwater capture sufficient to protect water quality of the Jefferson River alluvial aquifer, if implemented properly. The partial pit

backfill alternatives carry some risk and uncertainty, as discussed in Sections 4.2.2.9.2 and 4.2.3.9.2. The greater the reliance on capture systems under the partial pit backfill alternatives, the more likely there would be impacts to water quality in the Jefferson River alluvial aquifer. The agencies believe that the decision in the 1998 ROD also achieved the applicable water quality standards based on the information available at the time.

The DSEIS described the main pit groundwater flow path, the Tdf/colluvial aquifer, which would funnel most of the pit effluent down a relatively high permeability pathway with little or no attenuation capacity directly to the Jefferson River alluvial aquifer. The cyanide leak in 1983 from Tailings Impoundment No. 1, which followed a portion of this pathway, demonstrated to GSM and the agencies that this pathway posed risks to groundwater quality and the ability to meet water quality standards. The waste rock dump complexes have a different hydrologic setting and are not directly recharged by groundwater, as is the pit. Effluent from waste rock dump complexes has not yet developed. An evaluation of cover systems on the waste rock dump complexes and tailings impoundments found that no infiltration to waste rock dumps is expected if good vegetation cover is established, and that the presence of poor vegetation cover would be sufficient to prevent infiltration to the tailing impoundments (Junqueira and Wilson, 2005). To be conservative, the agencies assumed in the DSEIS that some precipitation would infiltrate the reclamation covers. Taken together, this information supports the analysis and selection of the preferred alternative made in the DSEIS.

The agencies have considered additional mitigations as a result of public comments on the DSEIS. See response to Comment 26. Public safety and access issues are addressed in the responses to Comment 33 and 50.

61. COMMENT:

Comparison to Similar Proposals - It is notable that the agencies approved complete and partial backfill at the Zortman and Landusky Mines in the 2001 Reclamation and Closure EIS. In all cases, they were able to identify proposed mitigations, including amendment of potentially acid generating materials together with capping of those materials and downstream capture and treatment of any deleterious constituents to the point where, in their opinion, no environmental harm would occur. In those cases where the proposed mitigations have failed (*e.g.* Swift Gulch where ongoing contamination is occurring), the agencies have yet to employ the identified mitigations (capture of groundwater flowing from the August Little Ben Pit to Swift Gulch or capture and treatment of the water in Swift Gulch itself), but, if they do so, should be successful at addressing the existing water quality impacts. The agencies apparently had no problem in that case approving those actions without having any greater certainty, and perhaps even less, of the outcome at Zortman and Landusky than they do for the GSM pit backfill proposal.

Please explain how this decision differs from that of the Montana DEQ and BLM in the Zortman and Landusky EIS? (168)

RESPONSE:
The geometry of the pit at GSM is fundamentally different than that of the Zortman and Landusky mines. The proposed reclamation measures at GSM differ accordingly. The Zortman and Landusky mine pit floors were located above the water table and collected storm water, which then infiltrated and percolated down to the water table. This contaminated groundwater has the potential to flow toward adjacent streams. This water is then captured and pumped to a treatment facility.

In contrast, the GSM pit extends deep beneath the water table and can be maintained as a sink with a hydraulic gradient toward the pit rather than away from it. There is not sufficient non-acid generating waste rock available at GSM for use as backfill. Placement of waste rock into the pit would increase contaminant loading to groundwater when the water table rebounds into the backfill. The Zortman and Landusky and GSM pit reclamation plans are consistent in that both would minimize placement of acid generating waste rock within or near groundwater.

For the Zortman and Landusky mines, alternatives were selected with the minimal amount of backfill needed to achieve free-draining conditions so runoff had less opportunity to infiltrate the underlying sulfide zone and become contaminated. This material was generally oxide in nature, with little potential to contribute to degradation. Most of this material was used to cover the sulfide-rich highwall segment and was judged to be a net benefit to source control (Wayne Jepson personal communication, 2001).

Other alternatives for the Zortman and Landusky mines with considerably greater amounts of backfill (up to 20 times the amount used) were analyzed and dismissed because they involved placement of millions of tons of sulfide waste rock at inherently riskier locations. The environmental controls and mitigation that would have been necessary for the Zortman and Landusky SEIS Alternatives Z4, Z5, L5, or L6 simply could not be developed with enough certainty to be protective of the environment.

Avoiding placement of sulfide material near groundwater was a goal of the reclamation plan. Limestone waste was used as the lowest layer of backfill in the Landusky August Pit because this pit floor was located near the water table. To the extent possible, backfilling of the Landusky pits was performed using waste rock that is not likely to generate acid drainage. This was done to avoid placing an additional source of contaminants within the pit. The quantities of backfill included in the selected alternative balanced the goals of routing storm water out of the pits and avoiding the placement of acid generating rock into the pits. The Zortman and Landusky SEIS was very clear in stating that "the nature of the backfilled material and its placement can increase environmental risks to surface and groundwater" and the Landusky preferred "Alternative L4 would avoid the potential negative impacts on the drainages to the north of the mine that would occur with the use of spent ore from the L87/91 leach pad as backfill." Landusky alternatives were rejected because

additional backfill would have negative consequences on groundwater. By limiting backfill in the August-Little Ben Pit to non-acid generating material sources, the flow of water was able to be controlled and rerouted from originally flowing north back to the south where it can be captured and treated.

The reference to the situation in Swift Gulch proves the point that backfilling with acid-generating material even above the water table greatly increases the risk of contamination. The Zortman and Landusky SEIS itself predicted that, in Swift Gulch, the agency-selected alternative would decrease the contaminant load by 36 percent. The Zortman and Landusky SEIS also predicted that Alternative L5, with five times the backfill of the selected alternative, would increase the contaminant load by an estimated 66 percent. Alternative L6, with 15 times the backfill of the selected alternative would increase the contaminant load by an estimated 227 percent. Selecting alternatives that increase the risk of contamination in a location where the technical performance of capture and collection systems is in doubt, was determined to be undesirable at the Landusky Mine. That same logic is applicable to pit reclamation at GSM.

In summary, the pit backfill plans at Zortman and Landusky reduce impacts to the environment because non-acid generating material was used as backfill in order to reduce the quantity of contaminated infiltration reaching the water table. Pit backfill at GSM would increase negative impacts to the environment because acid generating material would be used as backfill and increase the quantity of contaminated infiltration reaching the water table.

6.5 GOLDEN SUNLIGHT MINE COMMENTS AND RESPONSES

Letter Number 169 as listed in Table 6.2 above is from the Golden Sunlight Mine. Their comments were broken down in Comments 62-391.

62. COMMENT:
Throughout the sections, GSM believes the term "acidic" should be added to references to both backfill and waste rock (including "material"), *e.g.*, "acidic backfill." (169)

RESPONSE:
The agencies disagree. The word "acidic" is used as necessary in the FSEIS.

63. COMMENT:
GSM believes the document should clearly state that there was minimal analysis of the potential environmental impacts from the Partial Pit Backfill Alternative in the 1997 DEIS. (169)

RESPONSE:
The agencies agree. The FSEIS states in the fourth to last paragraph of Section 1.4.3 that "DEQ agrees with BLM that a limited analysis of the potential environmental effects from groundwater exiting the backfilled pit from the Partial Backfill Alternative was completed in the 1997 DEIS."

64. COMMENT:
Page 3, Alternatives Considered But Dismissed, Partial Pit Backfill Without Collection, 2nd to last line and Partial Pit Backfill with Amendment Alternative, last line and Page 4, Preferred Alternative, Rationale for Selection, 1st Paragraph, 8th line - GSM believes it would be more appropriate to replace "guaranteed" with "reliably assured."

RESPONSE:
The agencies agree. These changes have been made.

65. COMMENT:
Page 3, Alternatives Considered But Dismissed, Pit Pond Alternative, 1st line -: Replace "mitigation" with "treatment." (169)

RESPONSE:
The agencies agree. This wording has been changed.

66. COMMENT:
Page 6, Table 1, Design & Constructability of the Alternative: Proven Design for No Pit Pond – the pit would be backfilled with 100 ft of crusher reject. (169)

RESPONSE:
The agencies agree and this wording has been changed.

67. COMMENT:
Partial Pit Backfill with Downgradient Collection – GSM suggests modifying the 2nd paragraph to "Pumping out of...., but the objective of overall 95 percent capture..." Also, secondary known and unknown flowpaths (*e.g.*, faults, fractures) would further reduce the reliability of the capture system (HSI, 2003). (169)

RESPONSE:
The agencies agree and this has been changed.

68. COMMENT:
This alternative should also include a statement that construction of a soil cover and its associated subsurface drainage layer on a long 2H:1V slope is difficult. (169)

RESPONSE:
This has already been addressed. GSM's consultant concluded that, in the partial backfill alternatives, a drainage layer would be necessary to keep the soil from slumping in saturated areas on steep 2H:1V slopes (Telesto 2003d). GSM has already been successful in reclaiming long steep slopes at the mine site. The agencies have concluded in Sections 4.2.2.7.1 and 4.2.3.7.1 that the subsurface drainage layer referred to in the comment to keep soil from slumping in saturated backfill is not needed in either of the partial pit backfill alternatives. Small localized failures could develop if the cover is saturated. GSM would be required to locate the seep and dewater it. Contaminated soil would be replaced with clean soil and the area revegetated. See mitigation Measure 2 in Section 4.8.1.2.

69. COMMENT:
Page 7, Table 1, Backfill, Backfill maintenance requirements - GSM suggests the agencies review the settlement numbers presented in the document. Consolidation testing presented in Appendix C of the Feasibility Assessment by Telesto (2003e) showed a 13 to 15 percent settlement of placed material will likely occur. Most of this settlement will occur during placement of the materials and soon (a few years) after final surface reclamation. Testing also showed that under saturating conditions, an additional 6 to 8 percent settlement could occur. No mention of the potential for settlement ranging up to 150 to 200 feet could be found in these documents for the No Pit Pond, Partial Pit Backfill with In-Pit Collection, and Partial Pit Backfill with Downgradient Collection Alternatives, respectively. Yet, these numbers are cited throughout the document. GSM suggests the agencies review their calculations and present the rationale for these values. (169)

RESPONSE:
The agencies acknowledge that the Telesto report (2003e) never mentions actual footages and uses percentages. The DEQ converted the percentages to feet of settlement so that the average reader could relate to the amount of settlement possible.

70. COMMENT:
Page 8, Table 1, continuation of Backfill Maintenance Requirements, Partial Pit Backfill with In-Pit Collection (Proposed Action), 2nd paragraph - GSM believes the agencies should discuss hydrostatic pressure in the highwall cover. While this information is briefly, and possibly inaccurately, presented on page 4-42, it is an important component of the stability analyses for the alternatives. (169)

RESPONSE:
See response to Comment 68.

71. COMMENT:
Page 8, Table 1, Underground Workings, Impacts to pit facilities due to subsidence - Based on the previous underground mining operations conducted at GSM, localized rock falls occurred in stopes but no subsidence was evident. GSM believes there is no evidence to suggest that there would be subsidence in the underground workings that would impact the open pit. However, any potential impacts could affect all backfill alternatives. (169)

RESPONSE:
Thank you for your comment. The change is not necessary. The SEIS assumed a long-term conservative analysis.

72. COMMENT:
Page 8, Table 1, Groundwater Effluent Management System, Operation requirements: Partial Pit Backfill With In-Pit Collection - Change "regularly" to "frequently due to corrosion." (169)

RESPONSE:
The agencies agree and this has been changed.

73. COMMENT:
Page 9, Table 1, Groundwater Effluent Management. System, Maintenance of capture points, 2nd paragraph regarding corrosion - Partial Pit Backfill With In-Pit Collection - We do not agree that the corrosion impacts for this alternative will be the same as for the No Pit Pond Alternative. Evaluations indicate corrosion will be a significant issue for the Partial Pit Backfill With In-Pit Collection wells, much more so than wells in 100 feet of backfill (Telesto, 2003e). These wells will likely need to be replaced frequently, and this should be noted in the summary. (169)

RESPONSE:
All wells would be in acidic conditions, subject to corrosion and subject to replacement. The only question is the timing of the replacement. The agencies do not believe this needs to be noted.

74. **COMMENT:**
Page 9, Table 1, Groundwater Effluent Management System, Maintenance of capture points, 2nd paragraph regarding corrosion - Underground Sump - Since the pumping system for the Underground Sump Alternative would not require wells to be completed in backfill, corrosion to wells is not applicable in this case. (169)

RESPONSE:
The agencies disagree. All pumping system components would be in acidic conditions, subject to corrosion and subject to replacement. The only difference is the lack of wells.

75. **COMMENT:**
Page 10 - 11, Table 1, Groundwater Effluent Management System, Maintenance of capture points, Access - Underground Sump - The first sentence "Access to the underground would be needed" is adequate for this description. We suggest deleting the remainder of this discussion since it describes mitigation. (169)

RESPONSE:
The agencies disagree. The remainder of the text was left in the document.

76. **COMMENT:**
Page 11, Table 1, Stormwater Runon/Runoff Management Maintenance requirements: Partial Pit Backfill With In-Pit Collection - Since the diversions for this alternative are engineered and require special construction unlike the stormwater diversions outside the pit, the maintenance requirements would not be the same as those for the No Pit Pond Alternative. Maintenance would be more involved and costly. (169)

RESPONSE:
The storm water diversions for the partial pit backfill alternatives would be constructed the same as diversions on the 2H:1V waste rock dump slopes. It may be more costly due to the total length of diversions maintained but the requirement should not change. The agencies do not believe additional wording is required.

77. **COMMENT:**
Page 11, Table 1, Soil cover maintenance requirements - For alternatives with cast blasted and reclaimed highwalls, hydrostatic pressure from the highwall seeps will result in damage to soil covers as described in Telesto, 2003d. This document makes specific references to the maintenance and monitoring of the phreatic surface

and drainage properties of the cover constructed on the 2H:1V slope. These maintenance issues are of high concern due to the low factor of safety (1.01) calculated for the stability of the cover placed on the 2H:1V slope under static conditions. GSM believes this information should be included. (169)

RESPONSE:
The agencies believe this has been addressed. See response to Comment 68.

78. COMMENT:
Page 11, Table 1, Soil cover maintenance requirements - GSM suggests adding information regarding the soil borrow requirements and associated disturbance for each alternative. (169)

RESPONSE:
The agencies agree and Table S-1 and Table 2-2 have been modified to include soil borrow requirements and acres of disturbance for each alternative under the soil cover maintenance requirements (erosion, revegetation) row:

No Pit Pond (No Action) column - A total of 290,400 cubic yards of soil cover material, from existing sources, would be necessary.

Partial Pit Backfill With In-Pit Collection (Proposed Action) - A total of 1,541,800 cubic yards of soil cover material, resulting in an additional disturbance of 31 acres, would be necessary.

Partial Pit Backfill With Downgradient Collection - No change, same as Partial Pit Backfill With In-Pit Collection.

Underground Sump - A total of 285,600 cubic yards of soil cover material, from existing sources, would be necessary.

79. COMMENT:
Page 12, Table 1, Soil cover maintenance requirements - Since the surface of the partial pit backfill alternatives will consist of 292 acres of revegetated surface versus 1 acre for the No Pit Pond Alternative, we do not agree that the impacts from highwall seeps to vegetation will be the same for all alternatives. If this impact were to occur, it would have a much larger impact in the partial pit backfill alternatives. (169)

RESPONSE:
The agencies believe this has been addressed. Any highwall seeps should be localized and create minimal disturbance. See response to Comment 68.

80. COMMENT:
Page 12, Table 1, Water Treatment, Additional sludge management requirements, 2nd paragraph under discussion of the Partial Pit Backfill With Downgradient Collection - Regarding the statement "Jarosite in the saturated portion of the backfill would prevent reducing conditions from developing and allow further production of acid. Metals would be released during the dissolution of jarosite" – Jarosite is stable under oxidizing conditions and unstable under reducing conditions. However, the presence of jarosite in the pit backfill will only influence the redox conditions until it all dissolves. Jarosite will likely dissolve and release metals in the saturated portion of the backfill. Once jarosite completely dissolves, reducing conditions will likely develop in the saturated portion of the backfill. This is described in Section 4.3.3.1.1.2.1 and should be clarified in Table 1. (169)

RESPONSE:
The agencies agree with this comment. The text in Table S-1 and Table 2-2, under Partial Pit Backfill With Downgradient Collection, is altered to read, "Weathering would continue to produce oxidation byproducts in the saturated backfill. Jarosite in the saturated portion of the backfill would, for a time, prevent reducing conditions from developing and allow further production of acid. Jarosite is stable under oxidizing conditions and unstable under reducing conditions. The presence of jarosite in the pit backfill would only influence the redox conditions until it all dissolves. Jarosite would likely dissolve and release metals in the saturated portion of the backfill. Once jarosite completely dissolves, reducing conditions would likely develop in the saturated portion of the backfill. The flow from the unsaturated portion of the backfill above the water table would contribute low pH water with high metal concentrations to the pit discharge for hundreds of years. There is limited natural attenuation capacity along the primary and secondary flow paths from the pit. The sludge management requirements would be about the same as the Partial Pit Backfill With In-Pit Collection Alternative because the chemical mass would be about the same."

81. COMMENT:
Page 14, Table 1, Impacts to groundwater quality and quantity, Risk of impacts to groundwater quality - No Pit Pond - This alternative would not result in pit outflows. (169)

RESPONSE:
The agencies agree that pit outflows would be minor to non-existent and have concluded impacts from pit outflow would be minimal. No change is necessary.

82. COMMENT:
Page 15, Table 1, Impacts to groundwater quality and quantity, Risk of violation of groundwater to the Jefferson River Alluvium, Partial Pit Backfill With Downgradient Collection - The following wording is suggested for the first sentence - "Groundwater

quality standards would be met at the permit boundary if the 95 percent or greater capture efficiency is achieved, and then beneficial uses of the Jefferson River alluvial aquifer would not be affected." (169)

RESPONSE:

The referenced sentence has been changed to read as follows: "Two groundwater capture systems in Rattlesnake Gulch, each operating at an efficiency of 87.5 percent or greater would be required to meet water quality standards at the mixing zone boundary. Beneficial uses of the Jefferson River alluvial aquifer would not be affected."

83. COMMENT:

Page 18, Table 1, Mineral reserves and resources, Access to future mineral reserves, Partial Pit Backfill With Downgradient Collection - This alternative would not be the same as the Proposed Action since the backfill material would be saturated. The backfill material would have to be dewatered and would have to drain prior to excavation. Due to the time that would be required for the pore spaces to drain adequately, in GSM's opinion it is questionable whether the pit would be mineable under this scenario. (169)

RESPONSE:

The agencies disagree. The pit could still be mined, though perhaps at a higher overburden stripping price.

84. COMMENT:

Page 19, Table 1, Mineral reserves and resources, Access to future mineral reserves..., 1st paragraph, Partial Pit Backfill With In-Pit Collection - It is unclear why the statement "...though is would likely take less than that" is included. The value of 116 months was based on operational information and experience that 405,000 cubic yards of backfill could be removed per month. This was the standard used to evaluate all alternatives and should be no different for this alternative. (169)

RESPONSE:

The agencies agree. This phrase has been deleted.

85. COMMENT:

Page 19, Table 1, Land Use After Mining, Suitability of land use after mining - NPP - GSM suggests deleting "limited" from the third sentence since the entire highwall would be available as habitat, and it is the entire highwall which provides the topographic relief features desired by raptors. (169)

RESPONSE:

The agencies disagree with the comment. Limited development of bat and raptor habitat in the upper highwall, as described in Sections 2.4.2.6 and 4.4.2.6.1 and the

1997 Draft EIS Chapter IV, Section IV.E, is part of the existing permit and the No Action Alternative.

86. COMMENT:
Page 1-1, Section 1.1, 1st paragraph, 2nd sentence - We believe the primary purpose of the SEIS is to evaluate reclamation alternatives for the GSM open pit after mining is completed. Therefore, the following change in wording is suggested: "This Supplemental Environmental Impact Statement (SEIS) has been prepared to evaluate reclamation alternatives for the GSM pit after mining is completed. As part of this process, site-specific data have also been updated where relevant." (169)

RESPONSE:
The agencies do not believe this wording is necessary.

87. COMMENT:
Page 1-2, Section 1.2, 1st full paragraph, 7th line - The Proposed Action involves "partially" backfilling the pit and this should be noted. (169)

RESPONSE:
The agencies agree and this has been changed.

88. COMMENT:
Page 1-2, Section 1.3, 4th and 5th bulleted items - Please add text stating these items are required under NEPA and MEPA. (169)

RESPONSE:
The agencies agree and this has been changed.

89. COMMENT:
Page 1-2, Section 1.3, 5th bulleted item - Please note that the best "available" scientific data were used. (169)

RESPONSE:
The agencies agree and this has been noted.

90. COMMENT:
Page 1-3, Section 1.4.2, 2nd paragraph - Please note that the address for Placer Dome U.S. is 1125 Seventeenth Street, Suite 2310 (not Suite 310). (169)

RESPONSE:
This address correction has been made to reflect Barrick ownership and address.

91. COMMENT:
Page 1-3, Section 1.4.2, 3rd paragraph - We request that a land status map be added to the document for clarification of private, state, and federal land ownership in the mine area. (169)

RESPONSE:
The agencies agree and Figure 1-3 has been added to include ownership in relation to major mine facilities.

92. COMMENT:
Page 1-3, Section 1.4.3, 1st paragraph - Add to the second sentence: "As is typical for precious metal mines, approximately 1/6..." (169)

RESPONSE:
The agencies do not think this change needs to be added to the text.

93. COMMENT:
Page 1-3, Section 1.4.3, 2nd paragraph, 4th line - Please note that the collected water is naturally "slightly" acidic. (169)

RESPONSE:
The agencies agree and this has been changed.

94. COMMENT:
Page 1-6, 1st paragraph, 1st line - GSM suggests modifying the first sentence to indicate the "vast majority" of waste rock at GSM has potential to create acid rock drainage. (169)

RESPONSE:
The agencies agree and this has been changed.

95. COMMENT:
Page 1-6, 1st paragraph, 5th line - Please add the following text following the term heavy metals: (*e.g.*, copper, cadmium, and nickel). (169)

RESPONSE:
The agencies agree and this has been changed.

96. COMMENT:
Page 1-6, 1st paragraph, last line - The discussion in this paragraph incorrectly leads the reader to assume that GSM is under bonded. Please note in the last line that the $54+ million is the bond required for the existing disturbance and water treatment activities and a significant portion of the work covered by this bond has been completed. (169)

RESPONSE:
This last sentence has been clarified as follows: "GSM has posted a total bond of $54,380,000 to cover reclamation, water treatment, and closure costs. GSM is currently bonded for 2,619.55 acres of disturbance. Through December 31, 2006, GSM has disturbed 2,236 acres and reclaimed 1,072 acres (2006 GSM Annual Report)."

97. COMMENT:
Page 1-8, 3rd paragraph (below 2nd numbered list), 4th line - Please include a land status map and reference this figure following the information about the location of waste dumps on BLM managed federal land. (169)

RESPONSE:
See response to Comment 91.

98. COMMENT:
Page 1-9, 1st paragraph under bulleted list, 1st line - GSM "submitted" a partial pit backfill plan as ordered by DEQ, but did not propose this alternative in their submittal. Please change "propose" to "submitted" in the first line. (169)

RESPONSE:
The agencies agree and this has been changed.

99. COMMENT:
Page 1-11, Table 1-1 - Please replace the existing text with the following text in the Permit/Approval description for BLM: "Approval of Plan of Operations to prevent unnecessary or undue degradation under the Federal Land Policy and Management Act and the 43 CFR Subpart 3809 Regulations." (169)

RESPONSE:
The agencies partially agree and this has been changed as follows: "Administering FLPMA and NEPA to prevent unnecessary or undue degradation."

100. COMMENT:
Page 1-11, Table 1-1 - Should the DNRC be listed in this table? (169)

RESPONSE:
The DNRC does not need to be listed because it has no regulatory jurisdiction over the pit reclamation plan.

101. COMMENT:
Page 1-11, Section 1.6.1.3, 3rd line - Please add "to prevent unnecessary or undue degradation" after "(43 CFR, Subpart 3809)." (169)

RESPONSE:
The agencies agree and this has been added.

102. COMMENT:
Page 1-12, last set of bulleted items - Please refer to the section numbers for each bulleted item. (169)

RESPONSE:
The agencies agree and this has been added as follows:

- Areas of critical environmental concern (Section 1.7.3.10);
- Prime or unique farm lands (Section 1.7.3.11);
- Floodplains (Section 1.7.3.12);
- Native American religious concerns (Section 1.7.3.9);
- Threatened or endangered species (Section 1.7.3.3);
- Solid or hazardous wastes (Section 1.7.3.6);
- Drinking water/groundwater quality (Section 1.7.2.2.1.1);
- Wetlands/riparian zones (Section 1.7.3.1);
- Wild and scenic rivers (Section 1.7.3.13);
- Wilderness (Section 1.7.3.14);
- Environmental Justice (Section 1.7.3.15);
- Invasive, non-native species (Section 1.7.3.16).

103. COMMENT:
Page 1-13, Table 1-2 - GSM suggests adding the 1981 EIS and other pertinent documents completed between 1975 and 1980 to this table. (169)

RESPONSE:
The agencies agree and the following documents have been added:

Document Title	Author	Date
Operating Permit No. 00065	DSL	April 24, 1975
Environmental Impact Statement for Amendment 001	DSL	April 1981
Assessment of Potential Acid Producing Characteristics of Geologic Material From the Golden Sunlight Mine	Dollhopf, D.	1989
Assessment of Water Quality Impacts – report to MDHES	Hydrometrics	1990

Also note that the reference date for Parades, M.M. has been changed to 1994.

104. COMMENT:
Page 1-19, Section 1.7.2, second paragraph - GSM believes the agencies should note the MAA process was not successfully concluded to the satisfaction of all parties involved. Although the MAA provided valuable input to the NEPA document regarding alternatives and consequences, Section 1.7.2 may leave the reader with the impression the MAA process was concluded with the approval of all involved. This impression is repeated in several sections of the SEIS (*e.g.*, 2.3.3, 4.1, 4.4.1, and 5.1). However, it was the professional opinion of the consultant conducting the MAA that the Draft Consensus MAA is representative of the majority of the participants in the Technical Working Group. While a true consensus was not reached for the pit reclamation alternatives at GSM, the MAA process clearly defined alternatives and issues. (169)

RESPONSE:
A draft report was prepared (Robertson GeoConsultants, 2003) and is described in detail in Section 1.7.2. Although the MAA was not formally completed, it was useful in defining issues, developing alternatives, and providing additional technical information to use in the analyses. The following changes have been made in the text:

Section 1.7.2, end of the second paragraph, add: "Although the MAA was not formally completed, it did provide valuable input on alternatives and environmental impacts."

Section 2.3.3, fifth paragraph, at the beginning of the second sentence, add: "While the MAA was not formally completed, the agencies determined ..."

Section 4.1, second paragraph, second sentence, delete: "including the MAA process ..."

Section 4.4.1, third paragraph, first sentence is changed: "This SEIS took a more detailed look ...". The last sentence of the paragraph is deleted.

105. COMMENT:
Page 1-20, 1st full paragraph, last line - Please clarify the term "co-extensive." (169)

RESPONSE:
Co-extensive means having the same limits, boundaries, or scope. MEPA and NEPA require the agencies to disclose and analyze issues that are identified during scoping. Decisions made under the applicable federal and state laws are not necessarily governed by these issues. Instead, the decisions are made within the authority of the applicable law.

106. COMMENT:
Page 1-21, Section 1.7.2.1.1.1, last line - Please modify this sentence to read "...within the mining and reclamation industries..." (169)

RESPONSE:
The agencies agree and this has been added.

107. COMMENT:
Page 1-23, section 1.7.2.1.5.1, 5th paragraph - Please add the following text to the end of the first sentence in this paragraph: "but this applies only if the capture can be reliably achieved." (169)

RESPONSE:

The agencies disagree and do not believe this wording is necessary.

108. COMMENT:
Page 1-24, Section 1.7.2.1.7.1 - Also note that adequate soil cover exists for the Underground Sump Alternative. (169)

RESPONSE:
The agencies do not believe this change is necessary.

109. COMMENT:
Page 1-27, Section 1.7.2.3.1.1, 2nd sentence - This statement should be modified to reflect that GSM currently does not have a written policy regarding fully loaded haul truck traffic down pit haul roads. However, policies would be developed to ensure the safety of workers involved in haulage activities and other pit personnel. (169)

RESPONSE:
The agencies agree and this has been changed.

110. COMMENT:
Page 1-29, Section 1.7.2.3.5.1 - Please modify the term "contends" as follows: "GSM has indicated that precious metal mineralization..." "GSM believes that if these resources are buried..." Please also see the comment concerning Page 4-127, Section 4.4.2.5.1 and Page 4-128 for information regarding GSM mineral resources. (169)

RESPONSE:
The agencies agree and this has been modified as suggested.

111. COMMENT:
Page 1-29, Section 1.7.2.3.7.1 - Since no quantification will be completed, please remove the term "amount of" from the 2nd line. (169)

RESPONSE:
The agencies have reworded this sentence from "The amount of visual contrast..." to "The mitigation of visual contrast..."

112. COMMENT:
Page 1-29, Section 1.7.2.3.8.2, 2nd paragraph - It is unclear how relying on mixing and partial attenuation could limit "long-term management requirements." Please clarify this as GSM does not believe this is true. (169)

RESPONSE:
The agencies disagree. Mixing and attenuation of pit effluent would occur under the Partial Pit Backfill With Downgradient Collection Alternative. Since the groundwater is naturally acidic and contains contaminants and attenuation has been shown in the DSEIS analysis to be limited, there would be little or no reduction in long-term management of pit effluent, capture systems, or water treatment.

113. COMMENT:
Page 1-30, 1st paragraph, last line - Please note that "Alternatives that do not achieve complete control of pit water increase the liability for GSM, the State of Montana, the community, and some other future party." (169)

RESPONSE:
The agencies disagree. The issue is future liability for GSM.

114. COMMENT:
Page 2-1, Section 2.1, 2nd paragraph, last sentence - GSM believes that the primary purpose of the SEIS is to evaluate reclamation alternatives for the GSM open pit after mining is completed. We suggest the following wording change: "Completion of a SEIS was determined to be necessary by the DEQ and BLM to evaluate potential environmental impacts by implementing a partial pit backfill alternative. This evaluation also takes into consideration new technical information gathered for assessing impacts of the partial pit backfill alternative and changes to pit designs from minor revisions granted since the 1998 EIS." (169)

RESPONSE:
The agencies do not believe this wording needs to be added.

115. COMMENT:
Page 2-3, Section 2.2.2, last full sentence - There is potential for additional underground mining. Therefore, GSM suggests modifying the last sentence to read "This phase of underground mining was completed by the end of January 2004." (169)

RESPONSE:
The agencies agree and this wording has been changed.

116. COMMENT:
Page 2-6, last paragraph, last sentence - This sentence implies that treatment plant discharge is mixed with water from the dewatering wells and run through the treatment plant again, which is incorrect. We believe it should read: "The water from the highwall dewatering wells is either: 1) mixed with treatment plant discharge and directed to the land application disposal (LAD) infiltration basin, 2) sent to the lined pond below the mill for treatment at the water treatment plant, or 3) pumped to Tailing Impoundment No. 2 for reuse as process water." (169)

RESPONSE:
The agencies agree and this wording has been changed.

117. COMMENT:
Page 2-7, Section 2.2.4, last paragraph in the section, 1st line - GSM believes that DEQ "required," rather than "requested" a modified partial pit backfill plan. (169)

RESPONSE:
The agencies agree and this wording has been changed.

118. COMMENT:
Page 2-7, Section 2.2.4, last paragraph in the section, 2nd line - GSM suggests modifying the last part of this line to read: "The 5B pit expansion would add 4 to 5 years to the current mine life." (169)

RESPONSE:
The agencies agree and this wording has been changed.

119. COMMENT:
Page 2-7, Section 2.2.4, last paragraph in the section and Page 2-7, Section 2.2.4, last paragraph in the section, last full sentence - Page 2-3, 2nd paragraph says that "GSM has decided to begin mining the Stage 5B and is now proposing an ultimate pit bottom of 4,525 ft. The agencies will evaluate this change of pit depth in the SEIS." How will the ultimate decision about approval of mining to this depth be addressed (*e.g.*, ROD, Preferred Alternative description, etc.)? (169)

RESPONSE:
The ultimate decision will be addressed in the ROD.

120. COMMENT:
Page 2-8, Section 2.3.2, 1st paragraph - GSM believes the agencies should describe the level of evaluation of the partial pit backfill alternative in the 1997 Draft EIS. GSM does not believe the environmental impacts of the alternative were fully evaluated in the 1997 DEIS. (169)

RESPONSE:
The agencies agree. See response to Comment 63.

121. COMMENT:
Page 2-9, 4th bulleted item - GSM suggests noting that, before this could be implemented, a determination of land status would be necessary. (169)

RESPONSE:

The agencies disagree. The change is not necessary.

122. COMMENT:
Page 2-9, Section 2.3.3, 1st paragraph - This discussion implies the alternatives were developed by comments at the scoping meeting and from information in previous environmental documents, and the MAA process only refined these previously identified alternatives. Since many of the alternatives were defined by the Technical Working Group during the MAA process, this should be noted. (169)

RESPONSE:
The agencies do not believe this wording is required.

123. COMMENT:
Page 2-9, Section 2.3.3, 2nd paragraph - The Technical Working Group (TWG) didn't really identify "deficiencies," the alternatives were discussed and modified based on the discussion of technical issues. Perhaps more accurate wording would be "As the process evolved, the TWG modified alternatives based on technical discussions and evaluation of accepted practices." (169)

RESPONSE:
The agencies agree. This wording has been changed.

124. COMMENT:
Page 2-10, Section 2.4.1, last bulleted item - GSM suggests this item be modified to read: "...and the potential loss of mineral resources and reserves associated with burial activities of the backfill alternatives." (169)

RESPONSE:
The agencies do not believe this wording is required.

125. COMMENT:
Page 2-11, Section 2.4.2.1, 1st paragraph, 1st sentence - Since use of the underground sump is ongoing, GSM suggests modifying this sentence to read "....the underground sump in the underground mine will not be closed until the end of mining because it will be used as part of the dewatering system for Stage 5B." (169)

RESPONSE:
The agencies do not believe this wording is required.

126. COMMENT:
Page 2-11, Section 2.4.2.1, 1st paragraph: 2nd sentence - GSM suggests the following wording change for clarity: "Portions of the pit that break through into the underground mine posing a hazard to workers would be backfilled." (169)

RESPONSE:
The agencies agree and this wording has been changed.

127. COMMENT:
Page 2-12, Section 2.4.2.2, 2nd paragraph, 5th line - Add a sentence indicating crusher reject is also acid-generating as defined by testing for the SEIS. (169)

RESPONSE:
The agencies do not believe this wording is required.

128. COMMENT:
Page 2-12, Section 2.4.2.2, 3rd paragraph - GSM suggests noting that no additional disturbance would be necessary for the No Pit Pond Alternative cover requirements. (169)

RESPONSE:
The agencies agree and this wording has been added.

129. COMMENT:
Page 2-14, Section 2.4.2.3, 1st paragraph, 1st line - This discussion cites Section 2.2.3, which describes actual dewatering activities at the mine. It is unclear what is meant by "additional information on the conceptual design of the dewatering system..." There is nothing conceptual about the information in Section 2.2.3. (169)

RESPONSE:
The agencies do not believe changes are required.

130. COMMENT:
Page 2-14, Section 2.4.2.4, 2nd to last line and page 2-22, Section 2.4.3.4, 1st paragraph, 5th line - GSM contracted C.O. Brawner Engineering Ltd. (Brawner) to conduct a post-closure geotechnical assessment of the open pit to support previous work conducted for the SEIS. The objectives of this assessment were to assist GSM in reviewing the geotechnical assumptions used by the agencies in preparation of the DSEIS and provide technical comment/opinion using existing geotechnical information. A copy of the report generated is attached to these comments. GSM believes that some of the technical analyses and conclusions can be utilized by the agencies to corroborate the analyses included in the DSEIS.

In addition, GSM contracted with Golder Associates to conduct a review of the DSEIS information and conduct additional stability analyses. Golder's analyses included an evaluation of raveling, overall slope failure, and wedge failure in the upper west wall. The Golder Associates (April, 2005) report is submitted with these comments and also corroborates the conclusions presented in the DSEIS. (169)

RESPONSE:
The agencies agree and have made the following text modifications.

In Section 2.4.2.4, the text in the first paragraph has been modified:

"...as a result of controlled blasting and scaling. ~~GSM has not proposed any other specific measures to maintain or improve pit highwall stability after closures.~~ No major ... in Section 4.2.1.2."

In response to comments on the DSEIS, GSM proposed operational measures to stabilize the pit highwall and a long-term monitoring and maintenance program based on technical reviews and additional analyses (Brawner, 2005; Golder, 2005). The following text modifications have been made at the end of Section 4.2.1.2.3. and apply to Section 4.2.4.2.2.

"Technical reviews, additional analyses (Brawner, 2005; Golder, 2005), and the conclusions in the DSEIS confirm that the pit highwall stability conclusions reached in the 1997 Draft EIS remain valid with respect to overall slope stability. Additional analyses of pit highwall raveling and of wedge failure indicated that there is little potential for structurally controlled failures with the exception of the existing failures in the upper west and northwest walls (Brawner, 2005; Golder, 2005).

"Other operational measures that GSM would implement to stabilize the pit in preparation for this reclamation alternative would include the following (Brawner, 2005; Golder, 2005):

- A 100-foot-wide safety bench would be left at the 5,700-foot elevation. Narrower catch benches spaced every 100 vertical feet would also be left to catch rock fall that would occur after mining is completed.
- Wire mesh would be installed over some sections of the west wall failure to mitigate rock fall hazards. Two dowels have been placed to secure a sandstone block. Additional bolts or dowels would be installed. Reinforcement considered critical in the long term would include appropriate corrosion protection.
- Bench face angles would be reduced in the Lone Eagle Fault Zone, and bench crests would be reduced in local areas of the west highwall in the footwall of the Corridor Fault Zone and along the south wall where there are north-dipping geologic bedding structures.
- Potentially unstable slabs or wedges would be mined out.
- Horizontal drains would be installed around the pit perimeter to reduce water pressure in the pit highwall if seepage is encountered in the lower 300 feet of the Stage 5B pit.
- Drainage interception ditches would be constructed around the open pit to minimize surface water flowing over pit slopes.

"Although rock mass stability analyses indicate adequate factors of safety for overall highwall slopes, a long-term stability monitoring and maintenance program would be required for the No Pit Pond and Underground Sump alternatives. Monitoring would concentrate on failure areas on the west and upper northwest highwall areas. The proposed program would include the following (Brawner, 2005; Golder, 2005):

- Regular inspection of the pit by a rock mechanics professional;
- Installation of piezometers to periodically monitor pore water pressures;
- Monitoring of areas where failures have occurred;
- Installation of 8-10 global positioning system monuments on selected locations to monitor movement;
- Monitoring of water levels in wells;
- Restricting access to the pit during and shortly after rainfall events, rapid thaws, and seismic events; and,
- Cleaning catch benches as needed."

In Section 2.4.3.4, the text in the first paragraph has been modified:

"...for the Partial Backfill Alternative." ~~GSM has not proposed any specific measures to maintain or improve pit highwall stability after closure~~.

In response to comments on the DSEIS, GSM proposed operational measures to stabilize the pit highwall and a long-term monitoring and maintenance program based on technical reviews and additional analyses (Brawner, 2005; Golder, 2005). The following text modifications have been made at the end of Section 4.2.2.2.1 and apply to Section 4.2.3.2.1.

"The SEIS's stability conclusions are supported by subsequent technical reviews and additional analyses (Brawner, 2005; Golder, 2005). These studies concluded that with the pit slopes covered, highwall raveling and other failure modes are not important stability issues under the partial pit backfill alternatives."

131. COMMENT:
Page 2-15, Section 2.4.2.6, first bulleted item - GSM suggests changing the term "would" to "may" for accuracy. (169)

RESPONSE:
The agencies do not believe this wording is required.

132. COMMENT:
Page 2-16, first bulleted item - GSM suggests changing the word "trees" to "seedlings" for accuracy. (169)

RESPONSE:
The agencies do not believe this wording is required.

133. COMMENT:
Page 2-17, 2nd bulleted item - Text previously identifies that crusher reject would be used for the lower 100 feet of backfill. (169)

RESPONSE:
The agencies agree and this wording has been modified.

134. COMMENT:
Page 2-17, last bulleted item - GSM suggests adding "as currently approved for all waste rock facilities at the mine" to the end of this sentence. (169)

RESPONSE:
The agencies agree and have added the words "as currently approved for all 2H:1V waste rock facilities at the mine." to the end of the sentence.

135. COMMENT:
Page 2-22, 1st paragraph - At the time the backfill plan was submitted, the most likely source was the area northeast of the East Waste Rock Dump. However, since that time, another potential soil source has been identified north of Tailing Impoundment No. 1 and a portion of the area was permitted for disturbance. The remainder of this area would be required to be permitted for a borrow source. (169)

RESPONSE:
The agencies agree and Section 2.4.3.2 has been modified to address all borrow sources as follows: "The proposed source includes a 47-acre soil borrow source

identified north of Tailings Impoundment No. 1. A portion of the area (about 16 acres) has been permitted for disturbance. The remaining 31 acres of this area would be permitted for a soil borrow source (Figure 1-2) (Shannon Dunlap, GSM, personal communication, 2006)."

136. COMMENT:
Page 2-22, Section 2.4.3.3, 1st paragraph - Telesto's 2003a document does not state that the average predicted pumping rate is 20 gpm. The first sentence of the paragraph should be struck along with the "However," at the beginning of the second sentence, to make this statement correct. The differences in predicted pumping rates for the various alternatives range from approximately 15 to 30 gpm. (169)

RESPONSE:
The agencies agree. The text has been modified to read as follows: "For the Partial Pit Backfill With In-Pit Collection Alternative, the 10-year time-weighted average water balance indicated that the pumping rate would be on the order of 27 to 42 gpm (Telesto, 2006). The dewatering system..."

137. COMMENT:
Page 2-23, Section 2.4.3.5, 2nd line - GSM suggests changing the term "remove" to "prevent" for accuracy. (169)

RESPONSE:
The agencies agree and this wording has been modified.

138. COMMENT:
Page 2-23, Section 2.4.3.6, 1st paragraph - GSM suggests the agencies include a statement indicating the amount of additional disturbance for the soil borrow areas. (169)

RESPONSE:
The agencies agree and Section 2.4.3.2 has been modified as addressed in response to Comment 135.

139. COMMENT:
Page 2-24, Section 2.4.4.3, 1st paragraph, 7th line - In order to more accurately describe the system, GSM suggests the following wording: "Contaminated groundwater from the pit, estimated at 16 gpm, would mix with ambient groundwater and the entire 121 gpm would be collected in a series of 26 or more new capture wells..." (169)

RESPONSE:
The agencies agree and this wording has been modified and updated as follows: "Contaminated groundwater from the pit, estimated at 27 to 42 gpm, would mix with ambient groundwater, estimated to range from 52 to 103 gpm, and the resulting

combined flow would be collected in a series of 26 or more new capture wells plus the existing wells in the Tailings Impoundment No. 1 south pump back system (Telesto, 2006)."

140. COMMENT:
Page 2-26, Section 2.4.4.4, 1st paragraph - GSM suggests describing the effects of hydrostatic pressure in the soil cover on slopes for the partial pit backfill alternatives. As described in the Geotechnical Report (Telesto, 2003d), "...pressure head build up could occur in the lower stages of the resloped highwall under the partial pit backfill alternative, especially if the permeability of the blasted highwall material and waste rock backfill drops below the 10^{-4} cm/sec range. Thus for soil cover stability to be maintained in the long-term, the flow through the soil cover and a pressure head build up would not be allowed." (169)

RESPONSE:
The agencies believe this has been addressed. See response to Comment 68.

141. COMMENT:
Page 2-27, Section 2.4.5.1, 2nd paragraph, 4th line - GSM suggests the following wording: "The current mine plan for the 5B Pit includes mining a safe distance from the underground stopes, backfilling the stopes where practicable, and then mining through the stopes." (169)

RESPONSE:
The agencies agree and the wording has been changed.

142. COMMENT:
Page 2-28, 1st line and 3rd bulleted item - GSM suggests changing the term "road" to "ramp." (169)

RESPONSE:
The agencies do not believe this wording change is necessary.

143. COMMENT:
Page 2-28, last paragraph - Based on actual collected data for a short time period, the flow rate of water pumped from the pit/underground workings has averaged about 30 gpm, not between 30-47 gpm. GSM requests this value be changed for accuracy. (169)

RESPONSE:
The agencies agree and the wording has been changed.

144. COMMENT:
Page 2-29, Figure 2-8 - Since the Underground Sump is the preferred alternative, we recommend a figure showing how the components of the dewatering system function be included in this section. (169)

RESPONSE:
The agencies disagree. Figure 2-8 is adequate to show the dewatering system in conceptual detail.

145. COMMENT:
Page 2-30, 1st paragraph - GSM suggests a reference to the pit seep water quality discussion be included in this paragraph. (169)

RESPONSE:
The agencies agree. Reference to Gallagher (2003b) has been added to the text.

146. COMMENT:
Page 2-31, Section 2.5.2, 2nd paragraph - GSM suggests deleting the term "site-wide" as the facilities covered under the mixing zone are delineated within the sentence and do not represent every facility at the site. (169)

RESPONSE:
The term site-wide mixing zone is appropriate because the areal extent of the mixing zone encompasses the majority of the mine permit area.

147. COMMENT:
Page 2-32, 1st paragraph, 8th line – HSI (2003) does not include any statements about the debris flow blending with alluvial gravel deposits beneath Tailings Impoundment No. 1, but describes the lithology as follows: "In the area between Tailing Impoundment No. 1 and the Jefferson River Alluvium, saturated sand and gravel overlies the Bozeman Formation Aquifer. This material has been classified as Quaternary in age (Keats...)." (169)

RESPONSE:
The agencies believe this has been addressed. On page 40 of HSI (2003), the authors state, "A likely explanation is that the gravel channel is time-transgressive, being Tertiary where it has remained buried in the northern Rattlesnake drainage, and reworked during the Quaternary lower in the drainage where it surfaces and blends with the natural drainage channel of lower Rattlesnake Gulch."

148. COMMENT:
Page 2-32, 1st paragraph below bulleted list - GSM believes the agencies should include the rationale for using the assumption that less than 10 percent of the pit water would flow south along the Range Front Fault. (169)

RESPONSE:
The agencies agree. The agencies stated in the DSEIS that "less than 10 percent of the pit water would likely flow south along the Range Front Fault and other secondary flow paths." The 10 percent estimate is an assumption based on the consensus of several scientists working on this SEIS. The rationale for the 10 percent estimate is as follows:

The Sunlight Vein, Sunlight and Range Front faults, and the Corridor Fault create complex fault zones located on the eastern side of the pit. As water exits the pit, it would flow both along and out of these structures. Water that reaches Tertiary debris flow sediments will migrate into the primary flow path. The tendency for groundwater to flow preferentially either through any structures or into the Tertiary sediments is controlled by the relative ability of the materials to transmit water.

Studies have produced potentiometric maps that have included the Range Front Fault (Golder, 1995a; HSI, 2003; URS 2001). All maps indicate that groundwater flows in a southeasterly direction. Water that crosses the fault zones would migrate into the Tertiary sediments. Water that stays in the fault zones would likely migrate southward. The hydraulic gradient between monitoring well PW-12, which is located on the east side of the fault near the east entrance to the pit, and PW-4, which likely intersects the Range Front Fault to the south, is approximately 0.013 foot/foot (*i.e.*, a vertical drop of 13 feet for every 1,000 feet of movement along the flow path) (Figure 3-8). The hydraulic gradient between PW-12 and PW-8 is approximately 0.037 ft/ft.

Considering these gradients, the transmissivity of the Sunlight and Range Front faults would have to be substantially greater than that of the surrounding rocks, or the faults would have to have relatively continuous impermeable zones acting as hydraulic barriers, in order for preferential flow to occur along the fault. Evidence of both is present in the pit area. There is a permeability contrast across the Sunlight and Range Front faults, evidenced by an abrupt change in groundwater level of 130 feet from the bedrock aquifer to the Tdf/colluvial aquifer (URS, 2001). This permeability contrast suggests either that the fault is acting as a hydraulic barrier or that there is a permeability contrast between rock types (URS, 2001). Geologic evidence in PW-64 indicates the permeability contrast in the Range Front Fault in this vicinity results from differences in rock types rather than structures. This conclusion supports contrasting permeability measurements in the bedrock and Tdf/colluvial aquifers (GSM, 1995; Hydrometrics, 1995). Hydraulic barriers are also present in the pit area as indicated by the change in oxidation state across the Wegner Fault, an early stage of range front faulting. The complex nature of the faulting along the range front strongly suggests that the presence of both permeability contrasts and impermeable zones have and will continue to influence the direction of groundwater flow.

Pit seep monitoring indicates that, between 1995 and 2001, GSM identified two seeps on the south pit highwall (Gallagher, 2003). The maximum measurable flow observed from these seeps was 0.75 gpm, with the majority of measurements

recorded as "wet." The flow from seeps on the south highwall is assumed to be 1 to 3 gpm. The observed flows occurred under the influence of a large hydraulic gradient created by the dewatered pit. If the hydraulic gradient is reversed in a backfilled pit such that groundwater moves out of the pit along structural pathways, the magnitude of the gradient away from the pit would likely be less than the gradient toward the pit. Potential outflows from the pit along the south highwall would likely be substantially less than 4.2 gpm.

Flow in fractured bedrock is complex and predicting where groundwater will flow is difficult. The majority of water would flow out of the pit via the Tdf/colluvial aquifer. It is assumed that a maximum of 4.2 gpm would flow out of a saturated pit via secondary flow paths in a variety of structures and locations. This is 10 percent of the total pit outflow under the Partial Pit Backfill With Downgradient Collection Alternative.

149. COMMENT:
Page 2-33, 1st paragraph, 6th line and page 2-34, 1st paragraph below bulleted list, last line - GSM believes that "guaranteed" should be replaced with "reliably assured." (169)

RESPONSE:
The agencies agree and the wording has been changed.

150. COMMENT:
Page 2-33, Section 2.5.3, 1st paragraph, 3rd to last line - The reference to DEQ, 1990 should be replaced with "DSL, 1990" as noted in the references. (169)

RESPONSE:
The agencies agree and the change has been made.

151. COMMENT:
Page 2-34, 1st full paragraph - Note that Laura Kuzel's mine backfill information and summary table contained in Appendix 1 of the analog study only noted that the Flambeau Mine was ultimately amended with lime. However, the wording in the SEIS suggests there was an analysis of lime amended waste material. This is not the case. Please remove the reference to the analog study. (169)

RESPONSE:
The agencies do not believe the wording implies that there was an analysis of lime amended waste material.

152. COMMENT:
Page 2-34, 5th bulleted item - GSM suggests replacing the term "under these conditions" in the 3rd line with "under higher pH conditions." (169)

RESPONSE:
The agencies do not believe this wording change is necessary.

153. COMMENT:
Page 2-35, 1st partial paragraph, 1st line - Regarding the statement that "...the addition of lime would neutralize the acidic quality of the mine water for some period of time..." - Zinc and arsenic mobility decreases as acidic solutions approach circum-neutral pH values. Arsenic mobility may increase if pH values increase significantly above circum-neutral pH values (*e.g.*, pH>10); however, zinc will precipitate from solution at these extremely elevated pH values. A reference should be included supporting this statement or it should be deleted. (169)

RESPONSE:
The following reference has been added to the text: (Gräfe, Markus, Maarten Nachtegaal, and Donald R. Sparks, 2004).

154. COMMENT:
Page 2-35, Section 2.5.4, 1st paragraph, 1st line - GSM believes the term "biological treatment" is more accurate than "biologic mitigation." (169)

RESPONSE:
The agencies agree and the wording has been changed.

155. COMMENT:
Page 2-36, 1st paragraph, 3rd line - GSM suggests adding "Thus, this is not a reclamation alternative with proven design and reliability" after the first sentence. (169)

RESPONSE:
The agencies disagree and this change has not been made.

156. COMMENT:
Page 2-37, 1st paragraph, last sentence - GSM suggests the agencies note that the 4,635-foot pond elevation was determined by Telesto (2003a and 2003e). (169)

RESPONSE:
The agencies agree and this change has been made.

157. COMMENT:
Page 2-38, Section 2.7.1, 2nd paragraph, last sentence - GSM believes the range presented for the Partial Pit Backfill with Downgradient Collection Alternative is incorrect. The analysis shows that 16 gpm of pit water would mix with ambient water for a total of approximately 121 gpm. Since no collection system is proposed at the pit discharge, then there would always be more than 16 gpm for collection. GSM

suggests this statement be modified to read: "The collection rate...would be approximately 121 gpm." There is no reference in HSI (2003) indicating any range of this type, therefore the reference should be removed. (169)

RESPONSE:
The agencies agree that no specific mention of the 16 to 121 gpm range was made in HSI (2003) and the reference has been removed. The text has been changed to read: "The collection rate for the Partial Pit Backfill With Downgradient Collection Alternative would be in the range of 79 to 145 gpm (Telesto, 2006)."

158. COMMENT:
Pages 2-40 through 2-55, Table 2-2 - See comments for the Summary Table presented above. (169)

RESPONSE:
All edits have been checked and all acreages have been revised based on the 2004 GSM Annual Report as follows:

Section 1.7.2.1.7.1, line 1
Section 2.1, page 2-2, 3rd paragraph, line 1
Table 2-1, page 2-2
Section 2.2.1, 3rd paragraph, line 3
Section 3.3.5, 1st paragraph, line 7
Section 4.3.2.3, page 4-84, last paragraph, line 2
Section 4.3.2.3.1, page 4-87, line 1
Section 4.9.2, 6th paragraph, line 1
Section 4.9.3, 3rd paragraph, line 1
Section 4.10, 2nd paragraph, line 4

159. COMMENT:
Page 3-1, Section 3.1, 1st paragraph - Since this section describes the existing environment for all alternatives, GSM suggests the following re-wording of the 3rd sentence - "Resources that would not be affected by the alternatives evaluated are not discussed in detail." (169)

RESPONSE:
The agencies agree and this wording has been changed.

160. COMMENT:
Page 3-1, Section 3.2.1.1, 1st paragraph - While it is true "the Precambrian rock types in the vicinity of the mine include sandstone, siltstone, and shale," these are meta-sediments. Please modify the description to include this information. (169)

RESPONSE:
The agencies do not believe this level of detail is necessary. The agencies recognize the distinction between sedimentary and metasedimentary rocks in that

sedimentary rocks are weak and porous while the induration / metamorphism of metasedimentary rocks makes them much stronger and not as porous or not porous at all. Disseminated flow would dominate in sediments and fracture flow in metasediments. Sediments have much less ability to maintain highwall stability than metasediments.

161. COMMENT:
Page 3-8, Section 3.2.1.3, 2nd paragraph on page - This paragraph describes the Jefferson River Quaternary alluvial deposits as shown on Figure 3-1. The map only shows the recent Jefferson River Alluvium (JRA) as "Qal" on the map. The part of the JRA we have been most concerned about is the buried channel north of I-90 (HSI, 2003). It may be useful to add an additional sentence indicating that buried JRA sediments also extend north of I-90 and are an important component of the analysis. (169)

RESPONSE:
The agencies revised Figure 3-1 to reflect information concerning the extent of the Jefferson River alluvium deposits north of Interstate 90 obtained by GSM during installation of monitoring wells in 2003 and 2004 (Gallagher, 2005). The following has been added to the above-referenced section of the FSEIS to describe the alluvium:

"The Jefferson River alluvium is a stream deposit consisting of unconsolidated, permeable alluvium of the river floodplain and the adjacent gravelly terrace deposits (Spectrum Engineering and Kathy Gallagher, 2004). This unit follows the flow direction of the Jefferson River (Figure 3-1). At least one of the alluvial terraces is buried by 40 to 80 feet of more recent colluvium and alluvial deposits. It is likely the upper terraces grade into the recent alluvium of the Jefferson River system and are hydrologically connected to some degree. The alluvial deposits consist of unconsolidated gravel, sand, and finer-grained overbank deposits. The well-rounded gravel fraction includes quartzites and volcanics from up-river regions. Angular silicified siltstones and latite appear to be derived from the mine area. Much of the gravel is iron stained. Fragments of ferricrete are present from the Tertiary debris flow deposits. The six borings in the Jefferson River alluvium were distributed both up gradient and down gradient of the Tertiary debris flow deposits. Rock types associated with the mine area were seen in greater abundance in samples from downgradient borings. Samples from the unsaturated portion of the Jefferson River alluvium were calcareous and effervesced in hydrochloric acid, while samples from the saturated portion were non-calcareous and did not effervesce (Gallagher, personal communication, 2006)."

162. COMMENT:
Page 3-8, Section 3.2.1.4, 1st paragraph - Since the term "perched" is often associated with groundwater, a better term might be "located." (169)

RESPONSE:
The agencies agree and the wording has been modified.

163. COMMENT:
Page 3-8, Section 3.2.1.4, 2nd paragraph - Again, GSM suggests indicating the rocks are meta-sediments. (169)

RESPONSE:
The agencies do not believe this level of detail is necessary.

164. COMMENT:
Page 3-9, Section 3.2.1.5, 2nd paragraph, 2nd line - GSM suggests the following changes: - "Ferricrete deposits can be modern... indicating prehistoric natural production of acidic discharge." (169)

RESPONSE:
The agencies do not believe this level of detail is necessary.

165. COMMENT:
Page 3-10, 1st paragraph, 6th line - "These deposits may be indicative of ancient deposits that were formed due to ARD naturally emanating from ..." (169)

RESPONSE:
The agencies do not believe this level of detail is necessary.

166. COMMENT:
Page 3-10, Section 3.2.2.2, 1st paragraph - GSM conducted additional studies on faulting and seismic activity at the site within the past year. In 2004, work was initiated due to a moderate magnitude earthquake that occurred close to the GSM on June 28, 2004. A copy of the report from AMEC is included with these comments. Additionally, in 2005, C.O. Brawner Engineering and Golder Associates evaluated previous values used in seismic analyses and confirmed these were reasonable and appropriate. These reports may also contain information that would be of use for Chapter 3. (169)

RESPONSE:
Thank you for the comments and reports. The following text has been added at the end of Section 3.2.2.2.

"GSM conducted additional studies at the site after a 4.0 magnitude earthquake occurred close to GSM on June 28, 2004 (AMEC, 2004). It was felt at the mine, but no damage was done and no highwall instability occurred.

GSM evaluated previous values used in seismic analyses and confirmed these were reasonable and appropriate (Brawner, 2005; Golder, 2005a, 2005b)."

167. COMMENT:
Page 3-13, Section 3.2.2.3, 2nd paragraph - GSM suggests indicating the rocks are meta-sediments. (169)

RESPONSE:
The agencies do not believe this level of detail is necessary. See the response to Comment 160.

168. COMMENT:
Page 3-13, Section 3.3, Title - This section title indicates geochemistry data will be described. A lot of new geochemical data were collected for the SEIS. GSM suggests including this new information in this section. (169)

RESPONSE:
The agencies agree. The following has been added to the bulleted list under Section 3.3:

- The pit backfill geochemistry was evaluated in detail (Telesto, 2003c).
- The East Waste Rock Dump Complex mineralogy was characterized (Telesto, 2005a).

169. COMMENT:
Page 3-13, Section 3.3, 1st bullet in this section - GSM suggests rewording this sentence as follows: "A re-analysis of the pit hydrology... was conducted based on data that were not available at the time the 1997 Draft EIS was written." (169)

RESPONSE:
The agencies do not believe this wording is necessary.

170. COMMENT:
Page 3-15, Section 3.3.1.4, 1st paragraph - The Golder (1995a) cross-sections show the landslide/debris flow deposits north of the tailing impoundment, but the surficial geology map shows the deposits extend further south. The general geology map in the SEIS doesn't even show the landslide/debris flow sediments. GSM suggests more carefully delineating these sediments since they are an important flowpath. (169)

RESPONSE:
As indicated in surface geology maps of the GSM area (Golder, 1995a; GSM 1996c), the portion of the Tertiary landslide/debris flow deposit which is expressed at the surface is relatively minor, and specifically delineating this on Figure 3-1 would not enhance the understanding of the geology as presented. The vast majority of this deposit is buried by other surficial deposits. As discussed in Section 3.3.7.2, the primary pit flowpath is comprised primarily of the Tertiary landslide/debris flow deposit, which is mapped on Figure 3-8.

171. COMMENT:
Page 3-15, Section 3.3.1.5, 1st paragraph - Again, Figure 3-1 does not really show the Jefferson River Alluvium we are describing in this section. Since it is another important flowpath, suggests producing a better map for the final document. (169)

RESPONSE:
See response to Comment 170.

172. COMMENT:
Page 3-18, Section 3.3.4, 2nd paragraph, 2nd line - GSM suggests also noting that the springs also cease to flow during freezing conditions during winter. (169)

RESPONSE:
The agencies agree and this wording has been added.

173. COMMENT:
Page 3-18, Section 3.3.4, 2nd paragraph - 4th line - North Borrow, Sunlight, and Arkose Valley springs should be added to the list of springs at the bottom of page. (169)

RESPONSE:
North Borrow, Sunlight and Arkose Valley springs were not included in the DSEIS because they have been buried by mining activities. The agencies agree that they should be mentioned and the paragraph now reads:

"The major springs and seeps that have been mapped within and adjacent to the pit area and are currently accessible include Rattlesnake Spring, Bunkhouse Springs, Stepan Spring, and Stepan Original Spring. Surface seeps existed in the Midas Spring, North Borrow Springs, Sunlight Spring, and Arkose Valley Spring areas (Figure 3-5), but have since been intercepted by drain systems to allow placement of waste rock piles. The drains were constructed to prevent contact between water and waste rock materials."

174. COMMENT:
Page 3-21, Section 3.3.5, 1st paragraph, 7th line - GSM suggests changing the text to indicate 106 acres (not 76.8 acres) of the EWRD have been reclaimed, as this is the latest reported value. (169)

RESPONSE:
The agencies agree and the GSM 2006 Annual Report has been used to update all acreages. See Comment 158 for a list of changes made.

175. COMMENT:
Page 3-26, 1st paragraph, last sentence - Since the capture system is very effective (Keats, 2001), GSM suggests modifying this sentence as follows: "Evaluations

indicate the capture systems are capturing the majority of water. The minor quantity of uncaptured groundwater..." (169)

RESPONSE:
The agencies agree and this wording has been modified as follows: "Evaluations indicate the capture systems are completely or nearly completely capturing all groundwater in the Quaternary alluvial aquifer and the majority of water in the Bozeman Group aquifer. The minor quantity of uncaptured groundwater may reach the Jefferson River alluvial aquifer via coarser units within the Bozeman Group aquifer (Hydrometrics, 1994, 1997; Keats, 2001, 2002; Spectrum Engineering and Kathy Gallagher, 2004)."

176. COMMENT:
Page 3-27, 1st paragraph, 7th line - There is a reference to 50 gpm. However, on page 3-26, the number is 52 gpm. (169)

RESPONSE:
The agencies used both numbers in the 1997 Draft EIS. They are essentially the same and do not need to be changed.

177. COMMENT:
Page 3-27, 3rd paragraph, 2nd to last line - This paragraph contains the first reference to the "Tertiary fluvial sandstone aquifer." This aquifer is not discussed in the stratigraphy section. (169)

RESPONSE:
The agencies agree. The aquifer that the text is referring to is the Bozeman Group aquifer. The phrase "Tertiary fluvial sandstone aquifer" has been replaced with "Bozeman Group aquifer."

178. COMMENT:
Page 3-28, Section 3.4, 1st paragraph, 4th line - GSM suggests noting in this discussion that, because of the shortfall of stockpiled topsoil for the partial pit backfill alternatives, additional disturbance will be necessary. (169)

RESPONSE:
The agencies agree. The following sentence has been added after the seventh sentence. "In addition, a new soil borrow source has been identified north of Tailings Impoundment No. 1, which would require an additional 31 acres of disturbance to salvage enough soil for the pit backfill alternatives." See responses to Comments 42 and 135.

179. COMMENT:
Page 3-30, continuation of Section 3.5 - GSM suggests incorporating the information from the 1997 Draft EIS concerning all bat and raptor species into this section.

Additional and supporting information compiled and analyzed by Gary Back, Ph.D. (SRK Consulting, 3/14/05), is attached for use as a reference for the FSEIS. (169)

RESPONSE:
The agencies have tiered to the 1997 Draft EIS information on bats and raptors in Section 3.5. Changes have been made to Section 3.5 as follows:

"In addition to the named species, long-legged myotis, Yuma myotis, long-eared myotis, and western small-footed myotis are found or may be found in the area (SRK Consulting, 2005)."

"Twelve raptor species were previously observed in the vicinity of the mine. These species include the bald eagle, golden eagle, turkey vulture, rough-legged hawk, red-tailed hawk, northern harrier, northern goshawk, sharp-shinned hawk, merlin, American kestrel, great-horned owl, and saw-whet owl. An active golden eagle nest was documented in 2003 north of the pit highwall (SRK Consulting, 2005 and Shannon Dunlap, personal communication, 2006)".

180. COMMENT:
Page 3-34, Section 3.10, 1st paragraph, 2nd line - All work practices are conducted following GSM's Safety Manual and various safety policies and procedures. (169)

RESPONSE:
The agencies agree. This wording has been changed.

181. COMMENT:
Page 3-34, Section 3.10, bulleted list - GSM suggests changing the wording to indicate the Critical Incident Initiative is a Placer Dome policy, not just GSM. (169)

RESPONSE:
The agencies do not believe this change is required in light of the mine now operating under the Barrick Safey Manual.

182. COMMENT:
Page 4-1, Section 4.1 - There should be a discussion of the organization of the section, *i.e.,* discuss the division of technical and environmental impacts. Also in a previous discussion it is noted the technical and environmental impacts assessed in the MAA generally could not be separated for analysis. Clarification would be helpful since the agencies separated the technical and environmental impacts for the Chapter 4 environmental consequences section. (169)

RESPONSE:
The agencies disagree. Table 1-3 lists the issues studied in detail by category and Section 1.7.2 explains each issue.

183. COMMENT:
Page 4-1, Section 4.1, 2nd paragraph, 2nd sentence - GSM suggests adding the following text to this sentence: "This means that part of the seepage (estimated to be a minor 1 to 3 gpm) from the dump complex...(HSI, 2003)." (169)

RESPONSE:
The agencies disagree and do not believe this wording is required.

184. COMMENT:
Page 4-1, Section 4.1, last paragraph - GSM agrees the analysis should focus on risks and uncertainties. (169)

RESPONSE:
Thank you for the comment.

185. COMMENT:
Page 4-2, 2nd bulleted item, 4th line - GSM suggests modifying the term "ease" with either "certainty" or "technical feasibility." (169)

RESPONSE:
The agencies agree that "certainty" would be a more appropriate word for this sentence and this change has been made to the third bullet in Section 4.1.1.

186. COMMENT:
Page 4-3, Section 4.2.1.1 - While the 1997 DEIS did not specifically have a section called "Design and Constructability of the Alternative," GSM believes the alternative was adequately evaluated at that time. Note the agencies indicate the No Pit Pond is a proven technology in a subsequent paragraph. (169)

RESPONSE:
Comment noted.

187. COMMENT:
Page 4-3, Section 4.2.1.1.1, 2nd paragraph & Page 4-33, Section 4.2.2.1.1, 2nd paragraph - The analog study did not specifically determine how backfill was placed in the pits. Therefore, the reference to "end dumping" is not necessarily true. (169)

RESPONSE:
The agencies agree. References to end dumping have been removed from the text.

188. COMMENT:
Page 4-4, Section 4.2.1.2.1 - GSM suggests moving the majority of this discussion to Chapter 3 since it describes the history of pit failures and the existing

environment. Only the information concerning the No Pit Pond and pit highwall stability analysis should be included in this section. (169)

RESPONSE:
The agencies believe this discussion is best left together in Section 4.2.1.2.1.

189. COMMENT:
Page 4-4, Section 4.2.1.2.1, 1st paragraph, 2nd sentence - GSM suggests rewording this discussion for clarity as follows: "There have been several pit slope failures in connection with on-going mining activities. Little information is available for pre-1992 slope failures. The following list provides volume and timeframe estimates for selected post-1992 slides (Telesto, 2003f):" (169)

RESPONSE:
The agencies agree and this wording has been changed and updated with "(Brawner, 2005; Golder, 2005)" and added to Section 4.2.1.2.1.

190. COMMENT:
Page 4-5, 3rd paragraph below bulleted list - GSM suggests the following changes to this paragraph for accuracy: "...With pre-splitting, a row of holes is drilled along the final excavation line and loaded with a special grade of explosive. These holes are fired prior to the production blast to create a fracture line at the excavation limits. The idea of pre-splitting is to isolate production shots from the remaining rock formation by forming a crack along the designed highwall. Although..." (169)

RESPONSE:
The agencies agree and this change has been made to Section 4.2.1.2.1.

191. COMMENT:
Page 4-5, last paragraph, 1st sentence - GSM suggests rewording this sentence for clarity to read: "The expected range of potential impacts of pit highwall instability during operations will range from remote and minimal to the loss of a substantial portion of the ore reserve." However, it should also be noted that GSM would not be mining the 5B pit if there was a high probability of "loss of a substantial portion of the ore reserve." (169)

RESPONSE:
The agencies disagree and do not believe this wording is required.

192. COMMENT:
Page 4-6, 4th paragraph, 2nd sentence beginning on 3rd line - GSM suggests modifying the second sentence of this paragraph to include: "Portions of the outside edges of mine benches have broken off..." (169)

RESPONSE:
The agencies agree and this wording has been modified in Section 4.2.1.2.1.

193. COMMENT:
Page 4-6, 5th paragraph, 5th line - GSM believes this statement should be modified to indicate both failures were initiated by on-going mining activities in that area. (169)

RESPONSE:
The agencies agree and this wording change has been made in Section 4.2.1.2.1.

194. COMMENT:
Page 4-7, 1st paragraph, last sentence - GSM believes the agencies should provide the rationale for the assumption that "occasional failures" will occur and suggest the agencies change the wording to: "occasional localized failures similar to those that can be observed in the highwall today." (169)

RESPONSE:
The agencies agree and this wording has been modified in Section 4.2.1.2.1.

195. COMMENT:
Page 4-7, Section 4.2.1.2.2 - GSM agrees that the pit wall will be stable and modes of significant failure have a very low probability of occurring. GSM has conducted additional studies to corroborate this fact. Studies conducted by C.O. Brawner Engineering and Golder Associates are attached, as part of GSM's comments.

Overall – The first paragraph states that the 1997 Draft EIS found that block slip movements into the pit are moderately likely. In addition, Section 4.2.1.2.1 states that a large scale wedge failure occurred within the Stage 2 pit. However, the fourth paragraph of referenced section states that block failure analyses were not conducted for the current SEIS. This appears to be inconsistent and needs to be further clarified in the text.

Although the text does present reasons why block failure analyses were not conducted, specific reference to the purpose of the current analysis should be presented. The second paragraph of Section 4.2.1.2.2 should specifically state that the current failure analysis was conducted to assess the potential for massive failures of the pit that would damage or destroy the reclamation alternatives and that, for the reasons presented in the following paragraphs of the section, massive block failures having such an effect are highly unlikely and thus were not considered.

In addition, the third sentence of paragraph 5 states "although the major formation dip is away from the pit, there are low lying bedding planes and joint faces that do dip into the pit especially on the northwest side." This sentence should be qualified with an explanation that these bedding planes and joint faces are located such that

they are not expected to result in a massive block failure that would damage or destroy the reclamation alternatives. (169)

RESPONSE:
Thank you for your comments. These studies are now part of the Administrative Record. The clarifications mentioned have been made to the text as follows:

Section 4.2.1.2 Pit Highwall. The following sentence has been added in front of the last sentence of this section: "In 2005, GSM conducted reviews of the pit highwall information. The conclusions support the overall stability conclusions found within the DSEIS (Brawner, 2005; Golder, 2005)."

Section 4.2.1.2.1 Stability Observations at GSM (1981-2005). The following has been added as part of the last sentence of the first paragraph before the bulleted list: "... (Brawner, 2005; Golder, 2005)."

A new bullet has been added to the list as follows:

- " Northwest pit highwall – Around 50,000 to 70,000 tons on June 8, 2005. The slope between the 5,200-foot and 5,450-foot-elevation benches failed and remobilized the failure between the 5,450-foot-elevation bench and the 6,030-foot-elevation highwall crest. The toe of this failure on the 5,200-foot-elevation bench evidently involved the intersection of the Corridor Fault and the Lone Eagle Fault (Golder, 2005)."

Section 4.2.1.2.2 Pit Highwall Stability. This section has been modified in several places.

The following sentences replace the first two sentences of the fifth paragraph:

"Circular failure analysis was chosen to model the potential for massive failure of the pit that would damage or destroy the reclamation alternatives because of the site-specific geology of the pit. Pit highwall stability was modeled to estimate the potential for massive failure in the circular failure mode for each reclamation alternative..."

The following sentences have been added at the end of the fourth paragraph:

"Most high angle faults running through the pit dip into the center of the pit, the Range Front Fault dips steeply away from the pit on the east and the Corridor Fault dips gently towards the east across the upper portion of the pit. These configurations make the possibility of block failure less likely than a circular failure. Damage to a reclamation alternative as a result of massive block failure is unlikely."

The following has been added as a new eighth paragraph:

"GSM prepared additional stability analyses since the DSEIS focusing on the stability of the pit highwall (Golder, 2005). Rock mass stability analyses indicate adequate factors of safety with respect to rock mass failures for the highwall. Failure analyses indicate little potential exists for structurally controlled failures of the

highwall, with the exception of the existing failures in the upper west and northwest highwalls (Golder, 2005). In these areas, raveling and small wedge failures could occur. Such failures would be limited in scope and would not damage or destroy the reclamation alternative."

196. COMMENT:
Page 4-7, Section 4.2.1.2.2 2nd paragraph, 2nd line - GSM requests the agencies delete the term "proposed" from "proposed pit reclamation alternatives." (169)

RESPONSE:
The agencies agree and the word "proposed" has been removed.

197. COMMENT:
Page 4-7, Section 4.2.1.2.2 2nd paragraph, last sentence - GSM suggests defining the meaning of, and purpose for, a "margin of safety." It should be explained how this applies to block and circular failures. (169)

RESPONSE:
The text has been modified and the phrase "and include a margin of safety" has been removed.

198. COMMENT:
Page 4-7, Section 4.2.1.2.2 4th paragraph - GSM contracted with Golder Associates to conduct a review of the SEIS information and conduct additional stability analyses. This report, "Post-Closure Slope Stability, Mineral Hill Pit, Golden Sunlight Mine," (April, 2005), is attached. Additionally, C.O. Brawner Engineering conducted an evaluation of geotechnical assumptions utilized in the SEIS. This report is also included with this submittal. (169)

RESPONSE:
Thank you for your comment. See responses to Comments 39, 130, 166, and 195.

199. COMMENT:
Page 4-7, Section 4.2.1.2.2 5th paragraph, last sentence - GSM suggests adding information on why circular failure analysis overestimates the chance of highwall failures. (169)

RESPONSE:
The agencies agree. The text after the fourth sentence in the fifth paragraph has been modified as follows:

"Circular failure would have to occur across the bedding planes and geologic structures. In circular failure analysis, structures are ignored and the material is treated as unconsolidated. The analysis overestimates the chance of highwall

failure because it ignores a fundamental strength component in the analysis (Telesto, personal communication, 2005)."

"Failure planes typically follow structures. Bedding in much of the pit and a 200-foot-thick latite sill in the northern part of the pit dips away from the pit. However, along the south and southwest pit highwall, beds dip gently into the pit. Adverse bedding orientation, usually in conjunction with structural or jointing intersections, has only contributed to small slope failures in an area confined to the west and northwest corner of the pit, in a zone in the general vicinity of the Corridor Fault. Historically, failures in the pit have generally been small and have occurred along steep northeast trending faults due to mining activities."

200. COMMENT:
Page 4-8, 3rd paragraph - This paragraph should be clarified. The lower factor of safety was determined by using all of the minimum strength values. This lower value changed slightly, while the value for the expected case did not change. Telesto's technical memorandum stated that a factor of safety change of 0.021 will most likely occur with the addition of a pit lake. However, a change of less than 0.1 in the overall factor of safety is typically beyond the accuracy of this analysis, and therefore the addition of a pit lake is not significant. (169)

RESPONSE:
The agencies disagree that additional clarification is needed. The text has not been changed.

201. COMMENT:
Page 4-9, 3rd paragraph - GSM suggests adding a sentence indicating there has been no known change in earthquake effects since the EIS was completed. However, a seismic evaluation including pseudo-static analyses information are included in the appendices of Telesto's Geotechnical Evaluation (2003d). Telesto's discussion is corroborated by the enclosed C.O. Brawner Engineering and Golder Associates (2005) reports. Both of these reports address seismicity and pit slope factors of safety associated with seismic events. (169)

RESPONSE:
Thank you for the additional studies. The agencies have replaced the last sentence with the following text and added a new paragraph to Section 4.2.1.2.1: "A seismic evaluation, including pseudo-static analyses information, was conducted for the DSEIS, which corroborated the 1997 Draft EIS analysis (Telesto, 2003d).

GSM conducted additional studies at the site after a 4.0 magnitude earthquake occurred close to GSM on June 28, 2004 (AMEC, 2004). It was felt at the mine, but no damage was done and no highwall instability occurred."

202. COMMENT:
Page 4-10, last paragraph, sentence beginning at the end of the 9th line - For clarification, the backfill will be used as a sump from which to install and pump wells. The placement of the backfill, in and of itself, does not keep the pit pond from forming. (169)

RESPONSE:
The agencies agree. The paragraph has been modified as follows: "The properties of the crusher reject material are described in detail in the groundwater effluent management system, Section 4.2.1.5.1. Wells would be installed and water would be pumped to prevent a pond from forming."

203. COMMENT:
Page 4-11, 3rd paragraph, 2nd sentence beginning on the 3rd line - Inclinometers are not used in the pit, therefore, GSM suggests removing "Inclinometers and" and beginning the sentence with "Survey prisms, which are..." (169)

RESPONSE:
The change has been made.

204. COMMENT:
Page 4-11: 5th paragraph, last sentence - The words "attempts to" should be removed. (169)

RESPONSE:
The agencies agree. These words have been removed.

205. COMMENT:
Page 4-12, 3rd full paragraph and Page 4-13, 2nd full paragraph - GSM suggests the agencies provide rationale for their assumption that 100,000 cubic yards of material will ravel from the highwall and another 100,000 cubic yards of material will slough and be deposited in the bottom of the pit. (169)

RESPONSE:
The agencies made a conservative estimate. As stated in the draft, this estimate was made "to address risk and uncertainty."

206. COMMENT:
Page 4-12, last paragraph above Section 4.2.1.2.3 - GSM believes this paragraph should be moved to the discussion on the underground workings alternative. (169)

RESPONSE:
The agencies disagree. This paragraph falls under contingencies for pit highwall stability and potential failure.

207. COMMENT:
Page 4-13 – 4-14, Pit Highwall Maintenance Requirements section - One element not discussed is the need to regularly monitor the crests of the pit for tension cracks. The need is two fold: 1) to know when movement is occurring and, 2) to insure storm water run-on does not have a clear path into the highwalls. (169)

RESPONSE:
The agencies agree and a new paragraph has been added in Section 4.2.1.2.3 between the second and third paragraphs:

"The crest of the pit would need to be monitored regularly for tension cracks to know when movement is occurring and to ensure storm water run-on does not enter the pit."

208. COMMENT:
Page 4-13 to 4-14, Section 4.2.1.3 - GSM believes this section incorrectly implies that complete or nearly complete backfilling is extremely common in Montana, and elsewhere in the U.S. Although some backfilling has occurred at several mines, these activities were often due to sequential mining and were generally not at the scale proposed in the Partial Pit Backfill alternatives described for GSM. These alternatives include massive backfilling, including placing 33,311,000 cubic yards of material back in the pit and cast blasting and dozer rehandling of an additional nearly 12,000,000 cubic yards of material. This quantity of material is far in excess of any backfill project in Montana or elsewhere. GSM suggests the agencies expand the discussion to include the limited thickness and type of backfilling that has occurred at the referenced sites. Examples include:

Beal Mountain: The Main Beal Pit was developed on a hillside, with the tallest highwall reaching approximately 550 feet. The pit was sequentially backfilled to the elevation of German Gulch and drains to this creek and contains between 130 to 240 feet, depending on location within the pit, of backfill from the Main Beal and South Beal pits. Backfilling the pit with non-acid generating material was a requirement of the permit to extend the pit below the water table.

Basin Creek: The Columbia Pit was a small side hill cut that was approximately 100 feet deep at the deepest point. This side hill cut was sequentially backfilled to original contour during mining from the nearby Paupers Pit complex. The Paupers Pit complex was located on a ridge line, with depths ranging from 100 to 250 feet dependent upon topography. This pit was filled to original contour with waste rock from the dump. The lower approximately 20 feet of the Paupers Pit was mined below the water table.

Zortman and Landusky: In the first section describing the pits backfilled during operations, it should be noted that the Suprise and Queen Rose Pits were also partially backfilled during mining of the August Pit. For the second section, backfilling during reclamation, for Zortman pits: The South Alabama pit, which is not

a true pit since one end is open, was already free-draining. Twenty (20) feet of leach pad material (225,725 cubic yards) was placed in this 0 to 250 foot deep pit. The OK-Ruby Pit Complex has between 10 and 240 feet (2,029,000 cubic yards) of fill followed by 6-inches of tailing, a liner, 6-inches of tailing and 18-inches of topsoil. Maximum pit depth for the pit complex was 240 feet. Backfill in the Mint Pit ranges from 10 to 50 feet thick (334,000 cubic yards). For Landusky Pits: The August-Little Ben Pit was backfilled with 5-feet of limestone from the South Goldbug Pit limestone stockpile followed by an average of 54 feet (1,666,700 cubic yards) of backfill from the L85/86 leach pad, for a total of 59 feet of backfill. The backfill was capped with a foot of compacted clay and two-feet of topsoil. The pit averaged 274 feet deep. The Suprise and Queen Rose were regraded and sideslopes covered, but no new fill was installed in the bottom of the pits. The pits are capped with two-feet of topsoil over a GCL liner.

CR Kendall: The Muleshoe and North Muleshoe Pits were mined first with most of the waste utilized for roads and infrastructure or stockpiled in waste rock dumps. Later the Muleshoe and North Muleshoe Pits were partially and sequentially backfilled to a depth of 160 feet (1,600,000 cubic yards), as part of the expansion of the pits. The South Horseshoe and Horseshoe Pits were mined next, with the South Horseshoe completed first. The South Horseshoe Pit was completely backfilled to a depth of 200 feet (234,000 cubic yards) with Horseshoe Pit waste, allowing the re-establishment of Little Dog Creek drainage. The Horseshoe Pit was partially backfilled to a maximum depth of 100 feet (173,000 cubic yards), using waste from the pit itself during expansion activities. The Barnes-King and Haul Road Pits were mined last. The small Haul Road pit was sequentially and completely backfilled to a depth of 180 feet (160,000 cubic yards) with rocky waste from the Barnes-King Pit, which was not backfilled. Finer textured waste from the Barnes-King Pit was stored for later re-use as reclamation material in the Kendall Pit.

Yellowstone Mine: This Luzenac-operated mine produces talc ore. The pits are all above the water table. The South Main Pit was partially backfilled with 200 feet (2,053,000 cubic yards) of dolomite (with minor amounts of volcanic ash) waste rock. The North Forty Pit is open at the east end. The western end of this "pit" was completely backfilled and backfill thickness decreased towards the east. The Pit was filled with the dolomite waste rock to an average thickness of 220 feet (4,335,000 cubic yards). The North Forty Pit will be covered by the North Dump.

The initial bulleted list of mines (page 4-13) includes Montana Tunnels. Representatives from this mine indicate material was used to buttress the east side of the pit and also to build ramps, but the pit was not backfilled as suggested by this section.

As described above, none of the backfill scenarios in Montana (or elsewhere as described in the Analog study) are similar to the partial pit backfill alternative for the Golden Sunlight Mine, which involves backfilling the pit, which is well below the water table, up to 875 feet deep.

The FSEIS should also recognize that the National Research Council/National Academy of Sciences has addressed the subject of backfilling in its report on "Hardrock Mining on Federal Lands" (1999), prepared at the request of the U.S. Congress. That report "was unable to find a basis to establish a general presumption either for or against backfilling in all cases." Id. at 82. It recognized that the NRC/NAS had addressed this subject in 1979 and found that restoration to approximate original contour was "generally not technically feasible for non-coal minerals, or has limited value because it is impractical, inappropriate, or economically unsound . . . ." Id. The 1999 NRC/NAS report stated that it had "no strong basis to contradict . . ." the 1979 conclusion on backfilling. Id. The 1999 NRC/NAS Report noted that in some cases backfilling can cause "the degradation of groundwater quality if the backfill material is leached or chemically transformed as a result of geochemical conditions in the backfilled pit or underground workings." Id. The 1999 NRC/NAS Report found further that the circumstances in which backfilling was "most likely to be viable" included sequential mining plans, *i.e.*, "mining areas where multiple ore bodies allow mining and backfilling to proceed without double handling of material." Id. at 83. In BLM's final rulemaking to modify the 43 C.F.R. Subpart 3809 regulations, dated November 21, 2000, BLM removed a proposed "presumption" in favor of pit backfilling in response to the discussion in the 1999 NRC/NAS report. 65 Fed. Reg. at 70,051 (Nov. 21, 2000). BLM stated that a site specific review would be required to determine the appropriate amount of backfilling, taking into consideration economic, environmental and safety concerns. Id. See 43 C.F.R. § 3809.420(c)(7)(i). (169)

RESPONSE:
Backfilling is common in Montana. The agencies appreciate the review of each of these mines but feel this is too much detail for inclusion. Montana Tunnels has been removed from the bulleted list of mines on page 4-13 as suggested in the comment. BLM will address the appropriate amount of backfilling in the Record of Decision.

209. COMMENT:
Pages 4-16 and 4-17, Section 4.2.1.3.1, Table 4-1 - This table contains a number of errors. Please make sure the footnotes are superscript for the pit size (675 acres) and depth (1,780 foot) numbers for the Berkeley Pit. The Butte Underground number should also be 10,000 (based on 2004 Bureau studies) and the 3 should be a footnote. (169)

RESPONSE:
All errors noted in this table have been fixed.

210. COMMENT:
Pages 4-16 and 4-17, Section 4.2.1.3.1, Table 4-1 - Delete the word "average" in the Partial Pit Backfill Alternative, %/Type sulfide column – a range is presented. (169)

RESPONSE:
The word "average" has been removed from the table.

211. COMMENT:
Pages 4-16 and 4-17, Section 4.2.1.3.1, Table 4-1 - In addition to the items listed in the first bullet, check all footnotes to make sure they are superscript. (169)

RESPONSE:
All footnotes for this table have been corrected.

212. COMMENT:
Pages 4-16 and 4-17, Section 4.2.1.3.1, Table 4-1 - The description in the Predictions row for the Berkeley pit is partially incorrect. Maest (2003) also noted no improvement in pit water quality, so that verbiage should be removed. Fix the footnote (5) in this cell and in the Butte Underground cell. Ann Maest noted that some constituents were improving in the Butte Underground, but saying "water quality improving with age" is incorrect. In her memo, she noted that some constituents were improving. (169)

RESPONSE:
The agencies agree. The phrase has been modified: "water quality for some constituents have improved over time (Maest, 2003)." The superscript in footnote "5" has been corrected in the table.

213. COMMENT:
Please indicate under San Luis and Geology that the backfill material was acidic. (169)

RESPONSE:
The agencies do not believe this change is necessary as acidity was not mentioned for any of the mines in the table.

214. COMMENT:
Page 4-18, Section 4.2.1.3.2, 1st paragraph, last sentence - GSM believes this discussion is contrary to the information presented in Telesto (2003e), and the discussion on page 4-20 which indicates the crusher reject "is expected to have the durability and uniformity to provide an adequate permeability over time." Also, the last two paragraphs in this section may be best suited for Section 4.2.1.2.3. (169)

RESPONSE:
The agencies have made a conservative assumption that the material would weather over time, reducing permeability in the crusher reject. The last two paragraphs do not need to be moved.

215. COMMENT:
Page 4-18, Section 4.2.1.3.2, 3rd paragraph, second sentence - In referenced Section 4.2.1.2.2, it states the agencies expect 200,000 cubic yards of ravel and slough. Also see GSM comment (re: Page 4-12, 3rd paragraph) regarding including rationale for the agency assumption. (169)

RESPONSE:
The agencies made a conservative estimate. As stated in Section 4.2.1.2.2, this estimate was made to address risk and uncertainty.

216. COMMENT:
Page 4-18, Section 4.2.1.4.1, 9th line - GSM suggests including the location of the "C" stope on Figure 2-2, as referenced. (169)

RESPONSE:
The agencies agree. This stope location has been included on Figure 2-2.

217. COMMENT:
Page 4-19, Section 4.2.1.5.1, 1st paragraph, 2nd sentence - GSM suggests indicating the crusher reject is expected to have the durability and uniformity to provide adequate permeability over time. (169)

RESPONSE:
The agencies disagree and this change has not been made. See response to Comment 215.

218. COMMENT:
Page 4-20, 2nd full paragraph, first line - GSM believes adequate data exist to more firmly state that "the acidic pit backfill groundwater would cause corrosion..." (169)

RESPONSE:
The agencies agree and this wording modification has been made in the last paragraph of Section 4.2.1.5.1.

219. COMMENT:
Page 4-20, Section 4.2.1.5.2, 1st paragraph, last sentence - The analyses show that no water would discharge from the pit under the No Pit Pond Alternative even if the dewatering system failed. Therefore, the agencies should not state this concern for this alternative. (169)

RESPONSE:
The agencies have assumed that a negligible amount of water, less than 10 percent of 25 to 27 gpm, could discharge from the pit through secondary pathways.

220. COMMENT:
Page 4-21, 1st full paragraph and Page 4-27, Section 4.2.1.5.2.1.6 - GSM believes that the discussion of the Midas Spring presented in Section 4.2.1.5.2.1.6 should be included in Chapter 3. The first major discussion of the spring is on Page 4-21. (169)

RESPONSE:
The agencies disagree. As mentioned in Section 3.3.4 of the SEIS, a detailed analysis of springs was presented in Section III.B.2.d of the 1997 Draft EIS.

221. COMMENT:
Page 4-21, 2nd full paragraph, 5th line - GSM believes it is unlikely the water in the pit sump under the No Pit Pond Alternative would be "pretreated." (169)

RESPONSE:
Comment noted.

222. COMMENT:
Page 4-21, 2nd full paragraph, last sentence - Telesto (2003e) noted that steel casing, not stainless steel casing, would have a lifespan of only a few months. However, stainless steel casing would corrode as well over time, although it would probably last more than a few months. (169)

RESPONSE:
The agencies agree and the text in Section 4.2.1.5.2 at the end of the fifth paragraph has been modified as follows: "Steel well casings were predicted to have a life span of only a few months (Telesto, 2003e). Stainless steel casings would corrode over time as well, although they would last longer."

223. COMMENT:
Page 4-21, 3rd full paragraph, last sentence - While GSM has had limited problems with scaling of pumps, pipes, and slotted casing over the mine life, scale has presented problems for flowmeters as noted on 4-23. (169)

RESPONSE:
Thank you for your comment.

224. COMMENT:
Page 4-23, 1st full paragraph, 4th line - GSM has only installed a few monitoring wells in portions of the waste rock dumps with shallow waste rock. These wells have all failed (PW-2, PW-16, PW-47 and PW-63). No dewatering wells have ever been installed in the dumps. (169)

RESPONSE:
Thank you for your comment.

225. COMMENT:
Page 4-23, Section 4.2.1.5.2.1.2, 1st paragraph, 3rd sentence beginning on 3rd line - GSM believes the agencies are describing PW-49 rather than PW-48 in this sentence. (169)

RESPONSE:
The first paragraph in the section is correct. The second paragraph first sentence has been modified to read that "Water quality in PW-49 is typically better than pit water..."

226. COMMENT:
Page 4-23, Section 4.2.1.5.2.1.2, 2nd paragraph, 2nd line - Note that in several documents we have modified the term "regional" to "intermediate," as described on page 3-23. (169)

RESPONSE:
The agencies agree. The text has been changed.

227. COMMENT:
Page 4-24, Section 4.2.1.5.2.1.3, 1st paragraph - The well was drilled approximately 185 feet, at an angle. There was approximately 150 feet of rock material that had accumulated in the bottom of the pit from mining activities on upper benches. The text states a well depth of 118 feet in several locations. Please clarify. (169)

RESPONSE:
The text has been changed in Section 4.2.1.5.2.1.3 as follows: "The pit dewatering system used in 2002 to 2003 consisted of a 118-foot-deep dewatering well in about 150 feet of backfill..."

228. COMMENT:
Page 4-24, Section 4.2.1.5.2.1.3: 4th paragraph - This paragraph discusses silting in of wells. GSM believes this information should also be included in the Partial Pit Backfill with In-Pit Collection Alternative discussion. (169)

RESPONSE:
The second to the last paragraph of Section 4.2.2.5.2 regarding well maintenance requirements has been modified as follows: "To prevent wells from silting in, wells must be installed with a gravel pack and the pump periodically raised in the well casing."

229. COMMENT:
Page 4-25, 1st paragraph, last sentence - GSM believes the last sentence should be reworded as follows: "Therefore, biofouling is not expected to be a problem in water management after mining." (169)

RESPONSE:
The agencies agree. This wording has been changed in the last paragraph of Section 4.2.1.5.2.1.3.

230. COMMENT:
Page 4-26, Section 4.2.1.5.2.1.5: 2nd paragraph - GSM believes the agencies should indicate that Rattlesnake Gulch groundwater is "naturally" acidic. (169)

RESPONSE:
The agencies disagree. Some of the groundwater in Rattlesnake Gulch may be from old mine workings.

231. COMMENT:
Page 4-26, Section 4.2.1.5.2.1.5: 5th paragraph, 1st sentence - Maintenance of the pumpback system is time consuming, but is routine rather than "complex." (169)

RESPONSE:
The wording of this sentence has been changed in the fifth paragraph of the section.

232. COMMENT:
Page 4-27, Section 4.2.1.5.2.1.6, last paragraph of section - GSM believes this statement belongs in the Partial Pit Backfill with In-Pit Collection discussion. (169)

RESPONSE:
The agencies disagree. Section 4.2.1.5.2.1 describes GSM's experience with dewatering. The agencies have summarized in each subsection which problems would affect different alternatives.

233. COMMENT:
Page 4-28, 3rd full paragraph - GSM suggests moving this paragraph to the Partial Pit Backfill with In-Pit Collection Alternative discussion. (169)

RESPONSE:
The agencies disagree. See response to Comment 232.

234. COMMENT:
Page 4-28, Section 4.2.1.5.2.2 - This section appears to be incomplete. Mines are dewatered all over the world, including the United States. It is not clear why the Berkeley Pit and Butte Underground dewatering experience are included in this

section, other than to say that pumping from non-backfilled underground sumps is successful. The No Pit Pond Alternative section is likely not the place for this discussion. GSM suggests keeping discussion of the environmental consequence for a particular alternative only in the section for that particular alternative. The No Pit Pond alternative section includes various discussions regarding the other alternatives. (169)

RESPONSE:
The agencies presented a short summary of dewatering at other mines in Section 4.2.1.5.2.2. The summary highlights the problems adequately. The discussion of the Berkeley Pit and Butte Underground in this section is appropriate. Section 4.2.1.5.2.1 describes GSM's experience with dewatering. The agencies have summarized in each subsection which problems would affect different alternatives.

235. COMMENT:
Page 4-29, Section 4.2.1.6, 1st paragraph, 4th line - GSM suggests noting that the design is for a 100-year, 1-hour storm event. (169)

RESPONSE:
The agencies agree and have made this change.

236. COMMENT:
Page 4-29, Section 4.2.1.6.1, 2nd paragraph, 1st line - GSM believes that under the No Pit Pond Alternative, no diversions will be constructed on unconsolidated material. Therefore, this sentence is incorrect. This sentence may be more appropriate for the Partial Pit Backfill with In-Pit Collection Alternative. (169)

RESPONSE:
The agencies believe some fill and diversions may be required in this alternative.

237. COMMENT:
Page 4-29, Section 4.2.1.7.1, 2nd sentence - For clarity, GSM suggests the following wording: "Seven acres have already been revegetated within the pit boundary area." (169)

RESPONSE:
The agencies agree with this change. The text has been modified.

238. COMMENT:
Page 4-30, Section 4.2.1.8, 1st paragraph - It is unclear why the Berkeley Pit water treatment plant is referenced here. GSM has operated a water treatment plant, using the same method, for years.

The text states that based on the 1997 EIS, 102 gpm would be pumped to the WTP from pit seepage, while the table on the next page only shows 65 gpm. The 1997

Draft EIS, Volume 2, Appendix A, Table 2-1 shows 54 gpm from the pit would require treatment and the 65 gpm is the "with contingencies" value. The agencies should clarify the differences in the table and text. (169)

RESPONSE:
The third sentence has been modified as follows: "This system would be similar to the operational water treatment plants at GSM and the Berkeley Pit in Butte. The 1998 ROD approved the water treatment plant with a design capacity, including contingencies, of 392 gpm, which included the 65 gpm of pit inflows (54 gpm plus 20 percent contingency) then projected for the No Pit Pond Alternative (Table 4-2)."

239. COMMENT:
Page 4-30, Section 4.2.1.8, 3rd paragraph - GSM suggests modifying the second sentence as follows: "In the No Pit Pond Alternative in this SEIS, total water, from all sources needing treatment would be 260 gpm..."

GSM believes it should also be noted that the mine is already bonded for water treatment of 392 gpm. (169)

RESPONSE:
The agencies agree. The text has been modified as follows: "In the No Pit Pond Alternative in this SEIS, total water, from all sources needing treatment, would be 250 gpm. The change is the result of new water balance modeling since the DSEIS..."

The last sentence of the paragraph has been modified as follows: "GSM is currently bonded for 392 gpm ..."

240. COMMENT:
Page 4-31, Table 4-2 - The agencies may want to consider additional text to explain the differences in the numbers in this table. Also, there appears to be considerable inconsistencies between this table and text throughout subsequent Chapter 4. GSM suggests the agencies reconcile the discussions with information presented in this table. (169)

RESPONSE:
See response to Comment 238.

241. COMMENT:
Page 4-31, Section 4.2.1.8.1, 1st paragraph - Note that the volume of water destined for treatment described in the 1997 Draft EIS was all water from the mine site, not just pit water. While the SEIS predicted water quality from the pit backfill is expected to be worse, the quality of the total volume will not be much different. (169)

RESPONSE:
The agencies do not believe the text needs to be changed.

242. COMMENT:
Page 4-31, Section 4.2.1.8.1, 2nd paragraph - GSM believes this sentence should be revised to indicate that under this alternative, pit water requiring treatment is only about 1/3 of the volume previously predicted in the 1997 DEIS. The sentence now sounds like only 1/3 of the pit water would be treated. (169)

RESPONSE:
The agencies agree. The text in the above-referenced paragraph has been deleted and the following sentence has been added to the first paragraph of Section 4.2.1.8.1: "Because the volume of water requiring treatment in the SEIS is approximately one-third of the volume assumed in the 1997 Draft EIS, the overall sludge management requirements would be similar to, or less than, those evaluated in the 1997 Draft EIS, Chapter IV, Section IV.B.1.e."

243. COMMENT:
Page 4-31, Section 4.2.1.9 - GSM believes this discussion should contain a reference to the discussions on flexibility for future improvements and potential utilization of new technologies in this document. (169)

RESPONSE:
The agencies disagree and do not believe this discussion is necessary.

244. COMMENT:
Page 4-32, Section 4.2.1.9.2, last paragraph - GSM suggests adding that water could also be easily pumped out of the pit for treatment. (169)

RESPONSE:
The agencies agree and the text has been modified as follows: "Water could be pumped out of the 100 to 200 feet of pit backfill for treatment, if needed."

245. COMMENT:
Page 4-33, Section 4.2.2.1.1, 2nd paragraph - GSM suggests the following addition after the first sentence: "However, there are no known instances of pits of this depth receiving 875 feet of backfill in Montana or elsewhere." (169)

RESPONSE:
The agencies agree and the text has been modified as follows: "There are no known instances of pits receiving 875 feet of backfill in Montana or elsewhere."

246. COMMENT:
Page 4-33, Section 4.2.2.1.1, 3rd paragraph, 6th line - GSM suggests adding the following text: "...it is not a proven design in deep backfilled pits, such as is discussed in the DEQ proposed action, especially..." (169)

RESPONSE:
The agencies disagree and have not made this change.

247. COMMENT:
Page 4-33, Section 4.2.2.1.1, 3rd paragraph, last sentence - This sentence does not seem especially relevant in its current form. It may be useful to reword the sentence as follows: "It is possible to install casing in unsaturated, unconsolidated waste rock, as shown by the two-inch steel casing installations in the West Waste Rock Dump at GSM for data collection purposes (Schafer, 1995a). Monitoring wells have been constructed in the shallow portions of some of the waste rock dumps, but all these wells failed over time." (169)

RESPONSE:
The agencies agree. The text has been modified as follows: "It is possible to install wells in unsaturated, unconsolidated waste rock, as shown by the two-inch steel casings installed in the West Waste Rock Dump Complex at GSM for data collection purposes (Schafer, 1995a). Monitoring wells have been constructed in the shallow portions of some of the waste rock dumps, but all these wells have failed over time."

248. COMMENT:
Page 4-33, Section 4.2.2.1.1, 4th paragraph - GSM suggests striking the first sentence. (169)

RESPONSE:
The agencies disagree.

249. COMMENT:
Page 4-34, Section 4.2.2.1.2, 1st full paragraph, 5th sentence beginning on the 6th line - GSM suggests revising the wording of the sentence starting with "GSM is larger than the pits reviewed..." to "As noted in the analog study, attempts were made to identify and describe a backfilled mine pit with a similar depth to GSM's pit, however, none could be found." (169)

RESPONSE:
The agencies agree. The text in the second paragraph of the section has been modified by replacing the sentence with the following: "As noted in the pit backfill analog study, attempts were made to identify and describe a backfilled mine pit with a similar depth to GSM's pit. None could be found."

250. COMMENT:
Page 4-34, 4th full paragraph, end of the 4th line - GSM suggests changing the word "regular" to "frequent." (169)

RESPONSE:
The agencies agree. In the fifth paragraph of the section, the word "regular" has been changed to "repeated" based on the Telesto (2003e) report that states that wells would require frequent replacement due to consolidation. In addition, steel well casings would last only a few months so PVC casing and stainless steel pumps would be required. Telesto also states for this alternative, pumps would have to be replaced more frequently that current pit sump pumps.

251. COMMENT:
Page 4-34, last partial paragraph, 5th line - GSM suggests adding the following text after the sentence ending "...which is the agencies' goal" – "Therefore implementation of this alternative cannot reasonably assure this goal can be achieved." (169)

RESPONSE:
The agencies disagree and this wording change has not been made.

252. COMMENT:
Page 4-35, Section 4.2.2.2.1, 2nd paragraph, 2nd and 3rd sentences - The statement regarding long-term stability of the pit wall under the Partial Pit Backfill alternative should be qualified to indicate that if there is a rise in phreatic surface, the stability becomes comparable to the No Pit Pond alternative and thus would be similarly stable, not more stable. Telesto (2003d) evaluated the pit wall stability and found the expected factor of safety (FOS) for the pit highwall after completion of the 5B expansion to be 1.603. The expected FOS for the partial pit backfill alternatives would be 1.841 with the rise in phreatic surface. (169)

RESPONSE:
The agencies do not believe this change is necessary.

253. COMMENT:
Page 4-36, Section 4.2.2.3.1, 3rd paragraph, 1st sentence - GSM does not believe that delaying reclamation for a number of years to allow for backfill settlement would fulfill the mine's requirements under the MMRA. (169)

RESPONSE:
The agencies disagree. Settlement is part of mine closure.

254. COMMENT:
Page 4-37, Section 4.2.2.4.1, 1st paragraph - GSM does not believe the underground workings and portal maintenance plan are relevant to this alternative. (169)

RESPONSE:
The agencies disagree and no change has been made.

255. COMMENT:
Page 4-37, Section 4.2.2.4.1, 2nd paragraph, end of 3rd sentence, last line - GSM believes the agencies should recognize that the existing mine plan for the underground workings provides for some backfilling, but not complete backfill. There is no basis for imposing the requirement for complete backfilling of the underground. (169)

RESPONSE:
The agencies disagree and no change has been made.

256. COMMENT:
Page 4-37, Section 4.2.2.4.1, 2nd paragraph, last sentence - GSM believes this would occur continuously and indefinitely into the future, and therefore suggests adding "this would occur continuously and indefinitely into the future" to the end of the last sentence. (169)

RESPONSE:
The agencies disagree and no additional wording has been added.

257. COMMENT:
Page 4-37, Section 4.2.2.5.1, 3rd paragraph, 1st sentence - GSM suggests rewriting this sentence as follows: "The dewatering wells would be subject to short-term and long-term shearing and crushing caused by settlement, as well as short-term and long-term corrosion due to the acidic backfill." (169)

RESPONSE:
The agencies disagree and see no need to rewrite this sentence.

258. COMMENT:
Page 4-37, Section 4.2.2.5.1, 3rd paragraph, last sentence - To be consistent with previous information, GSM suggests rewording this sentence as follows: "The agencies believe the permeability of the backfill would decline as described in Section..." (169)

RESPONSE:
This sentence in the last paragraph of the section has been reworded to say: "The permeability of the backfill would decrease as described in Section..."

259. COMMENT:
Page 4-38, Section 4.2.2.5.2, 4th bulleted item - GSM suggests modifying "corrosion" with "short-term and long-term." (169)

RESPONSE:
The agencies disagree and the text has not been modified.

260. COMMENT:
Page 4-38, Section 4.2.2.5.2, 5th bulleted item - GSM suggests adding "short-term and" before "long-term" in this sentence. (169)

RESPONSE:
The agencies disagree and the text has not been modified.

261. COMMENT:
Page 4-39, 2nd full paragraph, first sentence - Dr. Robert Sterrett of Engineering Management Support, Inc. (EMSI) provided an opinion regarding declines in permeability in his report to GSM (4/8/05). His report is enclosed with this submittal to be included as GSM's comment. He states that "Under the partial backfill scenario, the mineral jarosite will form and such formation will reduce the permeability of the waste rock. Also, the weathering of the silicate minerals will likely produce clays that would further reduce the permeability. Although existing geotechnical testing has not shown decreases in permeability, the waste rock materials are relatively young (no more than 20 years) and full development of jarosite cementation and clay formations have not occurred...jarosite and clay formation are time dependent. Furthermore, it is a known and accepted fact that consolidation of millions of tons of waste rock stacked to a depth of 875 feet will result in a reduction in permeability." (169)

RESPONSE:
The agencies do not disagree with Dr. Sterrett's comment. Addition of his comments to the text does not change the meaning of the paragraph or add to its content. The paragraph already notes the effects of weathering and compaction under 875 feet of backfill on permeability.

262. COMMENT:
Page 4-39, last partial paragraph, last line and Page 4-40, 3rd paragraph below bullets, 2nd and 3rd lines - GSM suggests changing the term "could" to "can be expected to," which is warranted by the Telesto (2003e) corrosion analysis. (169)

RESPONSE:
The agencies do not believe this change is necessary.

263. COMMENT:
Page 4-40, 1st bulleted item - GSM suggests clarifying this description with the amount of time required for settlement (Telesto noted 35 years for water to reach the 5,050-foot level and over 100 years for equilibrium at 5,250 feet) as well as the requirements under the MMRA for reclamation. (169)

RESPONSE:
The agencies considered several measures to lessen the impacts due to settling and corrosion in Section 4.2.2.5.2. The agencies concluded these measures would be of limited use in reducing settlement in the long term. The time required for water to reach the two elevations is discussed in Section 4.3.4.1.1.2. No change is necessary.

264. COMMENT:
Page 4-40, 3rd paragraph under bullets, lines 5 and 9 - GSM suggests changing the terms "could" to "would," as warranted by the analysis. (169)

RESPONSE:
The agencies have changed the first reference of "could" to "would" in the second paragraph after the second set of bullets in the section.

265. COMMENT:
Page 4-40, last paragraph, last sentence - GSM suggests rewording this sentence for clarity and accuracy to: "Because wells will fail over the short- and long-term, GSM would be required to frequently and continually replace wells. This would lead to additional risk and uncertainty." (169)

RESPONSE:
The agencies do not believe this wording needs to be changed.

266. COMMENT:
Page 4-41, 1st paragraph, 3rd line - GSM suggests adding "and frequent" after "periodic." (169)

RESPONSE:
The agencies do not believe this wording needs to be changed.

267. COMMENT:
Page 4-41, Section 4.2.2.6.1, 1st paragraph and section in general - Because of the large area of cover, GSM does not agree that the maintenance requirements for storm water diversions are the same as for the No Pit Pond. There is significantly more maintenance involved with the Partial Pit Backfill alternatives to control stormwater and runoff than with the No Pit Pond alternative as described in the last paragraph on this page. (169)

RESPONSE:
The agencies disagree. The maintenance requirements per linear foot of storm water diversion are the same. There would be more linear feet of storm water diversions to maintain in the partial pit backfill alternatives. The total manpower and equipment time required for maintenance would be different but the requirements per linear foot would be the same.

268. COMMENT:
Page 4-41, Section 4.2.2.6.1, last paragraph - GSM suggests classifying outside the pit and inside the pit impacts separately. (169)

RESPONSE:
The agencies do not believe this is required.

269. COMMENT:
Page 4-42, Section 4.2.2.7.1 - GSM believes the agencies should expand on Telesto's information regarding cover soil stability in this discussion, as the discussion on this page does not accurately reflect the results of the evaluation presented in Telesto (2003d). Page 4-42 states that "small, localized stability problems would exist for the soil cover if the soil became saturated, especially if the backfill was relatively impermeable in localized areas." Telesto (2003d) notes that "the factor of safety for infinite slope failure of the soil cover material is essentially 1.0 (failed) if flow through the cover occurs." Telesto's report does not specifically address "small, localized" stability problems.

GSM suggests noting that additional soil borrow disturbance is required under this alternative. (169)

RESPONSE:
In the fourth paragraph of this section, the agencies have deleted "The soil cover was analyzed for stability (Telesto, 2003d)." The agencies have deleted "Analyses showed" and inserted: "GSM's consultant concluded that, in the partial backfill alternatives, a drainage layer would be necessary to keep the soil from slumping in saturated areas on steep 2H:1V slopes (Telesto, 2003d). GSM has been successful in reclaiming long steep slopes at the mine site. The agencies have concluded that the subsurface drainage layer to keep soil from slumping in saturated backfill is not needed in either of the partial pit backfill alternatives. The agencies concluded...". See response to Comment 68 about cover soil stability.

See responses to Comments 42 and 135 for a discussion of the soil borrow area disturbance.

270. COMMENT:
Page 4-44, Section 4.2.2.9.1, 2nd paragraph, 2nd sentence beginning on 1st line - GSM suggests replacing "This can be done although" with "This may be achievable on a short-term basis, although..." (169)

RESPONSE:
The agencies do not believe this wording needs to be changed.

271. COMMENT:
Page 4-46, Section 4.2.3.1.1, 2nd paragraph - GSM suggests moving the 3rd and 4th sentences to the Environmental Issues section. (169)

RESPONSE:
The agencies do not believe these sentences need to be moved.

272. COMMENT:
Page 4-46, Section 4.2.3.1.2, 3rd paragraph - The last sentence of this paragraph, as well as many other locations throughout the document, states that 95 percent capture efficiency may not be achievable based on GSM's experience capturing Tailings Impoundment No. 1 seepage. It may be more correct to indicate that there is substantial risk and uncertainty associated with meeting the required 95 percent capture efficiency. (169)

RESPONSE:
The agencies believe the wording is okay as stated.

273. COMMENT:
Page 4-47, 1st full paragraph, last sentence - Portage lists 52 monitoring wells for Tailings Impoundment No. 1 plus three surface water stations, therefore the sentence should be modified to state "...and a total of 55 monitoring wells and surface water stations are being sampled..." (169)

RESPONSE:
The agencies agree. The text has been modified in the fourth paragraph of the section as follows: "...and a total of 52 monitoring wells and three surface water stations were being sampled..."

274. COMMENT:
Page 4-47, 2nd full paragraph, 2nd sentence starting in 5th line - GSM suggests striking the sentence beginning "Despite continual upgrading..." The most current evaluation is by Donna Keats, with her results presented in paragraph 3 on page 4-47. (169)

RESPONSE:
The agencies do not believe this wording needs to be changed.

275. COMMENT:
Page 4-47, last partial paragraph, 2nd sentence - GSM suggests modifying this sentence for clarity, *e.g.*, "GSM is capturing the majority of the seepage from Tailings Impoundment No. 1, a process that requires a number of pumpback and monitoring wells." The current wording suggests that a large number of additional wells are needed, which would not be correct. (169)

RESPONSE:
The agencies agree that the sentence requires clarification. The sentence in the ninth paragraph of Section 4.2.3.1.2 has been changed and now reads: "GSM is capturing the majority of the seepage from Tailings Impoundment No. 1, a process that uses a large number of pumpback and monitoring wells (Hydrometrics, 1996) that continue to be necessary."

276. COMMENT:
Page 4-48, 3rd full paragraph - GSM suggests moving this paragraph to the Environmental Issues section. (169)

RESPONSE:
The agencies disagree that the paragraph needs to be moved.

277. COMMENT:
Page 4-50, Section 4.2.3.5.1, 1st paragraph, 1st sentence - The wells described are not all located in Rattlesnake Gulch. Please modify the text to reflect the accurate well locations. (169)

RESPONSE:
The agencies agree. The text has been modified as follows: "...26 downgradient capture wells and 10 monitoring wells would be needed to capture and monitor pit seepage and ambient groundwater."

278. COMMENT:
Page 4-50, Section 4.2.3.5.1, 1st paragraph, 3rd line - GSM suggests replacing the term "impacts" with "impacts that would constitute water quality violations." (169)

RESPONSE:
The agencies agree. Section 4.2.3.5.1, first paragraph, second sentence has been changed to read: "Groundwater quality standards would be met at the mixing zone boundary if 96 percent or greater overall capture efficiency is achieved from two capture systems (HSI, 2006)."

279. COMMENT:
Page 4-50, Section 4.2.3.5.1, 2nd paragraph, 1st line - Since the reference is to a later section, it may be useful to provide some of the relevant information in this paragraph. (169)

RESPONSE:
The agencies disagree. No changes are needed.

280. COMMENT:
Page 4-51, Section 4.2.3.7.1 - GSM believes that since there would be more backfill maintenance due to settlement there would also be more soil cover maintenance with this alternative. (169)

RESPONSE:
The agencies agree. The text has been modified as follows: "The soil cover maintenance requirements for this alternative would be greater than the Partial Pit Backfill With In-Pit Collection Alternative due to more settlement in the saturated backfill."

281. COMMENT:
Page 4-54, Section 4.2.4.1.1, 2nd sentence beginning on 1st line - For consistency, GSM suggests modifying this sentence as follows: "Acidic waste rock containing sulfides would remain stored and capped..." (169)

RESPONSE:
The agencies agree. The text has been modified as follows: "Waste rock would remain stored and capped above the water table in the East Waste Rock Dump Complex."

282. COMMENT:
Page 4-55, 2nd paragraph beneath table, last sentence - GSM suggests adding the following information to the end of the sentence: "...but these are readily observable and can be corrected immediately. In addition, preventive measures, such as covering pipelines with rock after installations, are routinely implemented to minimize potential impacts." (169)

RESPONSE:
The agencies agree. This wording has been added to the second paragraph below Table 4.3.

283. COMMENT:
Page 4-57, Section 4.2.4.5.1, 1st paragraph - GSM suggests adding a statement indicating that the risks and uncertainties for wells would be less than the No Pit Pond Alternative since no new wells are required and no wells would be installed in any backfill. (169)

RESPONSE:
The agencies agree. The text has been modified as follows: "Risks and uncertainties for wells would be less than the No Pit Pond Alternative since no new wells are required and no wells would be installed in any backfill."

284. COMMENT:
Page 4-57, Section 4.2.4.6.1, last paragraph/sentence - GSM suggests adding "which are minimal" to the end of this sentence. (169)

RESPONSE:
The agencies do not believe this is necessary.

285. COMMENT:
Page 4-59, Section 4.2.4.9.1, 2nd paragraph - GSM suggests moving this paragraph to an appropriate section since it is not associated with the potential for utilization of new technologies.

RESPONSE:
The agencies do not believe this is necessary.

286. COMMENT:
Page 4-59, Section 4.2.4.9.1, 4th paragraph - GSM suggests indicating that this alternative offers the "best and only" opportunity to test and potentially treat water either in an open pond or in an open water body in the underground workings. (169)

RESPONSE:
The agencies disagree. This paragraph will remain unchanged.

287. COMMENT:
Page 4-59, Section 4.2.4.9.2, 1st paragraph - GSM suggests adding the following sentence to the end of this paragraph: "However, any such failure would be readily observable and corrective action would be taken before the pit substantially flooded." Please note that it would take approximately 180 days for water in the underground to reach the ultimate pit bottom (4,525 feet) if the inflow rate was 32 gpm (8.3 million gallons of water). (169)

RESPONSE:
The agencies agree. Text has been inserted at the end of the first paragraph: "Pit water would be readily observable, and corrective action would be taken before the pit substantially flooded. The revised pit water balance model predicts an inflow range from 25 to 27 gpm (Telesto, 2006). It would take approximately 230 to 262 days for 8.3 million gallons of water in the underground workings to reach the pit bottom elevation of 4,525 feet."

288. COMMENT:
Page 4-59, Section 4.2.4.9.2, 2nd paragraph (carries over to page 4-60) - GSM believes this paragraph is not relevant to this section and should be moved to the appropriate section. (169)

RESPONSE:
The agencies disagree. The second paragraph summarizes the No Pit Pond Alternative so it can be contrasted with the Underground Sump Alternative in the third paragraph.

289. COMMENT:
Page 4-60, last paragraph - GSM suggests moving the 3rd and 4th sentences to the Environmental Issues section. (169)

RESPONSE:
The agencies do not believe this is necessary.

290. COMMENT:
Page 4-61, Section 4.3.1.1, 1st paragraph, 5th line - The reference should be changed to (Gallagher, 2003c). (169)

RESPONSE:
The agencies agree. This reference has been changed.

291. COMMENT:
Page 4-61, Section 4.3.1.1, 3rd paragraph - There is no mention of the North Borrow Spring in this section. (169)

RESPONSE:
The agencies agree. The following paragraph has been added to Section 4.3.1.1:

"North Borrow Springs, located approximately 120 yards north of Tailings Impoundment No. 1, consists of a broad seepage area with flow rates ranging from 8 to 32 gpm. These springs were created when the North Borrow Area was excavated below the shallow water table. Spring water is now being intercepted by an underdrain system constructed beneath the Buttress Dump. The system conveys water by pipeline to Tailings Impoundment No. 2. The North Borrow Area excavation has been filled with material from the East Waste Rock Dump Complex to form the Buttress Dump. Flows from the underdrain system have been minimal since the Rattlesnake Gulch pumpback system was installed (Shannon Dunlap, GSM, personal communication to HSI, November 1, 2005)."

292. COMMENT:
Page 4-61, Section 4.3.1.1, 4th paragraph - The following information should be added to this paragraph: In order to lower the local potentiometric surface and

prevent contact between water and acidic waste rock, interception/infiltration facilities were constructed at both the Arkose Valley and Sunlight Springs in mid-1994. (169)

RESPONSE:
The agencies agree and the text in the fifth paragraph of the section has been modified as follows: "In order to lower the local potentiometric surface and prevent contact between water and waste rock, interception and infiltration facilities were constructed at both Arkose Valley Spring and Sunlight Spring in mid-1994."

293. COMMENT:
Page 4-61, Section 4.3.1.1, 4th paragraph - Sunlight Spring: A thin layer of fine-grain material was excavated in the Sunlight Spring area. Coarse gravel and perforated PVC pipe were then placed within the drainage for approximately 400 feet. The coarse gravel was to promote re-infiltration of surface discharge, and the pipe was placed to intercept and convey water from beneath the West Dump, if ever needed. The pipe is presently capped and all water remains as groundwater. The coarse gravel and pipe were covered by filter fabric, then by two feet of sand material, followed by a HDPE liner. The HDPE liner was then covered with two additional feet of sand and 5 to 8 feet of adjacent soil material. (169)

RESPONSE:
The agencies do not believe this information needs to be added.

294. COMMENT:
Page 4-61, Section 4.3.1.1, 4th paragraph – Arkose Spring: Construction in the Arkose Spring area was identical to the Sunlight Spring, but did not include initial excavation. The gravel, PVC, filter fabric, sand, HDPE, and soil mitigation measures were implemented in the same sequence and generally with the same thickness as in the Sunlight Spring. (169)

RESPONSE:
The agencies do not believe this information needs to be added.

295. COMMENT:
Page 4-61, Section 4.3.1.1, 4th paragraph - All work was completed prior to expansion of the West Dump over the area occupied by the springs. (169)

RESPONSE:
The agencies agree and the text in the fifth paragraph of the section has been added as follows: "All work was completed prior to expansion of the West Waste Rock Dump Complex over the springs."

296. COMMENT:
Page 4-62, 2nd full paragraph, 4th line - GSM (2002a) does not state that PW-48 and PW-49 have relatively good water quality for a sulfide mineralized zone. This document notes that "data show that pit water is generally of poor quality." PW-48 and PW-49 are included in the "pit water" category. (169)

RESPONSE:
The agencies partially agree. The third paragraph in Section 4.3.1.2.1 has been modified as follows: "Monitoring results from these wells indicate that, although the water is of better quality than the pit water, it would require treatment to meet water quality standards."

297. COMMENT:
Page 4-63, 1st full paragraph, 3rd and 4th lines - GSM suggests including additional information regarding dewatering activities from 1992 to 2002. The paragraph currently gives the reader the impression there were no dewatering activities for that 10-year period. (169)

RESPONSE:
The agencies disagree. This additional information is not necessary.

298. COMMENT:
Page 4-63, 1st full paragraph, 6th line – The well constructed in the bottom of the pit was 185 feet deep (see previous comment). (Note that 118 feet is cited on page 2-6 also.) (169)

RESPONSE:
The agencies disagree. See response to Comment 227.

299. COMMENT:
Page 4-63, 1st full paragraph, last line - GSM suggests referring the reader to the appropriate section for information on difficulties in operating the pit sump well. (169)

RESPONSE:
The reference to Section 4.2.1.5.2.1.3 was included in the seventh paragraph of this section.

300. COMMENT:
Page 4-68, top partial paragraph - GSM cannot find the statement attributed to Telesto (2003c) in that document. While it may be true that acid generation may be reduced by reclamation, but cannot be eliminated, GSM suggests the agencies provide an accurate reference to this conclusion. (169)

RESPONSE:
The agencies agree. This reference has been changed to "(Bennett, 1997)" in the second paragraph after the bullets in Section 4.3.2.1.1.1.1.

301. COMMENT:
Page 4-72, last partial paragraph, 4th line - GSM suggests adding "net" in front of "infiltration" for consistency with the rest of the text. (169)

RESPONSE:
The agencies agree. This change has been made in the second paragraph after Table 4-4.

302. COMMENT:
Page 4-74, Section 4.3.2.1.1.1.4 - The numbers provided in this section are incorrect and should be clarified. For the SEIS, HSI (2003) updated all of the ARD fate and transport modeling information for the East Waste Rock dump. All of the information should be discussed for clarity. For instance, the reference that the updated evaluation indicates ARD impacts in 33 to 72 years from the EWRD. HSI (2003) states this is the predicted time to wet the EWRD. The numbers provided for the 1997 EIS evaluation appear to indicate the total predicted travel time from the EWRD through the Bozeman aquifer. If this is the case, the two numbers are not comparable. In addition, the numbers generated for the SEIS are middle to worse case ranges. Comparison of these values to the 1997 EIS values should be clarified to ensure the reader is not confused by the comparison. (169)

RESPONSE:
The agencies agree that the comparison in the DSEIS is incorrect. Section 4.3.2.1.1.1.4 has been modified to read as follows: "The 1997 Draft EIS predicted that groundwater under the East Waste Rock Dump Complex would first experience ARD impacts in 54 to 433 years. An updated evaluation in this SEIS of the 1997 Draft EIS modeling was conducted using combinations of middle to worst-case parameters. The updated modeling predicts that groundwater under the East Waste Rock Dump Complex would first experience ARD impacts in 33 to 72 years (HSI, 2003)."

303. COMMENT:
Page 4-75, 2nd paragraph, 1st sentence - Based on the analysis completed for the SEIS (Telesto, 2003e), GSM believes the agencies should replace "could" with "would." (169)

RESPONSE:
The agencies do not believe this is necessary.

304. COMMENT:
Page 4-76, Section 4.3.2.1.1.2.2, 2nd paragraph, last sentence - GSM believes this amount is the same as the 75 percent of water that would be removed by evaporation described on page 4-57. (169)

RESPONSE:
The agencies disagree. The amount of water lost as a result of sulfide oxidation would be in addition to that lost through evaporation. Evaporation estimates were based on pan evaporation measurements at the mine (Telesto 2003a). Any evaporation from the heat of sulfide oxidation is over and above the predicted evaporation in the model.

305. COMMENT:
Page 4-76, 3rd paragraph, 1st sentence and Page 4-83, Section 4.3.2.2.2.2, 2nd paragraph, 1st sentence - GSM believes the agencies have presented compelling evidence throughout the document to change the word "assumed" to "concluded" in this section. (169)

RESPONSE:
The agencies partially agree. The text has been modified in the last paragraph of Section 4.3.2.1.1.2.2 as follows: "...the agencies have concluded that maintaining the pit as a hydrologic sink under the No Pit Pond Alternative would provide almost complete control of the ARD..."

The text has been modified in the last paragraph of Section 4.3.2.2.2.2 as follows: "The agencies have concluded that the No Pit Pond Alternative would provide almost complete control of pit discharges..."

306. COMMENT:
Page 4-78, 1st full paragraph - GSM believes that a number of conservative assumptions were used for the predictions and suggests the agencies include the assumptions or a reference to the discussion of the model. (169)

RESPONSE:
As stated in the first bullet after the cited paragraph, the analysis of seepage from the East Waste Rock Dump Complex was based on middle to worst case assumptions. The assumptions used in the SEIS, in comparison to those of the 1997 EIS, were provided in Table 4-4. A reference to Table 4-4 has been added to the third paragraph in Section 4.3.2.1.2.1.

307. COMMENT:
Page 4-78, 1st bulleted item - GSM believes the rationale for differences between the SEIS and 1997 DEIS travel time values should be incorporated so the reader is not confused. (169)

RESPONSE:
The first bullet in Section 4.3.2.1.2.1 has been modified to describe the differences between the 1997 DEIS and the SEIS in the values of parameters that affect the travel times as follows: "The differences reflect updated information available since the 1997 DEIS: a) a lower effective porosity of the East Waste Rock Dump Complex; b) the thinner layer of unsaturated Bozeman Group aquifer beneath the dump; c) a smaller depth of mixing; and d) a slightly shorter length and width of the flow path within the Bozeman Group aquifer (Table 4-4)."

308. COMMENT:
Page 4-78, 3rd bulleted item, last sentence - While it is unlikely that GSM would forego capture activities until contamination reached the permit boundary, it may be useful to clarify that groundwater contamination would not reach the permit boundary for 280 to 700 years. (169)

RESPONSE:
The agencies do not believe this wording needs to be clarified.

309. COMMENT:
Page 4-82, most of discussion - It is unclear how the discussion relates to "Risk of Violation of Surface Water Standards and Impacts to Beneficial Uses of the Jefferson River and Slough." The information contained in the discussion mostly relates to wildlife. Should this be discussed in a separate "impacts to wildlife" section? Also, the impact to wildlife should be more clearly stated, both adverse and beneficial. (169)

RESPONSE:
The agencies disagree. Wildlife is a beneficial use under the Water Quality Act and discussion of impacts to that beneficial use is appropriate to this section.

310. COMMENT:
Page 4-84, 4th bulleted item - GSM suggests replacing the term "hazards" to "impacts." (169)

RESPONSE:
The agencies do not believe this language needs to be changed.

311. COMMENT:
Page 4-85, Table 4-6 - It is unclear why this soils comparison table for all alternatives is contained in the No Pit Pond Alternative discussion. (169)

RESPONSE:
The agencies do not believe a change is warranted.

312. COMMENT:
Page 4-85, 2nd paragraph, 1st sentence - GSM suggests changing the term "would" to "may have to" since all current data show no amendment of the coversoil will be necessary. (169)

RESPONSE:
The agencies do not believe a change is warranted.

313. COMMENT:
Page 4-85, 2nd paragraph, after last sentence - GSM suggests showing potential borrow areas on one of the maps. (169)

RESPONSE:
The agencies agree. The potential borrow areas are shown on Figure 1-2.

314. COMMENT:
Page 4-86, first full sentence in top partial paragraph - GSM suggests changing the word "relevant" to "qualified." (169)

RESPONSE:
The agencies agree. The word "relevant" has been changed to "qualified."

315. COMMENT:
Page 4-86, Section 4.3.2.3.1, 1st paragraph, 2nd sentence - For clarity, GSM suggests adding to the beginning of the sentence: "Through minor revisions, GSM's currently approved..." (169)

RESPONSE:
The agencies agree. The second sentence has been modified to read "GSM's currently approved area for disturbance is 3,002.25 acres, which was acquired through minor revisions to the permit (GSM 2006 annual report)."

316. COMMENT:
Page 4-87, Section 4.3.2.3.2 - While GSM understands the MAA Group designated various surface disturbances as a potential hazard to wildlife and rated them accordingly, GSM believes the SEIS should evaluate the impacts to wildlife, both positive and negative. Therefore, GSM suggests changing the section name here and in every alternative section to "Impacts to Wildlife," and providing a discussion of both positive and negative impacts. For instance, a benefit to the No Pit Pond Alternative will be the creation of raptor nesting areas and bat roosts. This section does not allow for any discussion of benefits to wildlife by alternative. Please also see SRK Consulting (3/14/05) for additional information concerning raptors and bat habitat. (169)

RESPONSE:
The agencies disagree that the title of this section needs to be changed. The impacts to wildlife were addressed in the 1997 Draft EIS in Chapter IV.E and IV.F on pages 325-334. See response to Comment 85.

317. COMMENT:
Page 4-88, 2nd to last paragraph, 5th line - Page 4-88 should be corrected to state the thickness of waste rock would be reduced from 300 feet to 100 feet, as is discussed on the first paragraph of page 4-89 and shown in Figure 2-6. (169)

RESPONSE:
The agencies agree. This change has been made.

318. COMMENT:
Page 4-89, Section 4.3.3.1.1.2.1, 2nd paragraph, last sentence and Page 4-90, 2nd paragraph, 3rd sentence - GSM suggests adding "which the agencies have determined is unlikely" to the end of these sentences. (169)

RESPONSE:
The agencies do not believe this change is necessary.

319. COMMENT:
Page 4-92, 2nd full paragraph, 3rd line - The passivation test pads should not be included in the list of existing ARD sources. These pads were constructed in the pit and have been removed by mining. (169)

RESPONSE:
The agencies have rewritten this sentence in the ninth paragraph of Section 4.3.3.1.1.2.1 to read "...within the range of concentrations found in ARD sources..."

320. COMMENT:
Page 4-93, 2nd paragraph - GSM suggests the agencies modify this paragraph to be consistent with the analysis conducted: "Water quality in the saturated portion of the backfill in the GSM pit would be acidic and elevated in metals concentrations. Based on the limited data reviewed in the Butte underground mines, which are not backfilled, and were flooded rapidly, it is possible that concentrations of some metals in the saturated portion of the backfilled GSM pit water would decrease "naturally" over time. Other metals and sulfate can be expected to remain elevated for an extended period of time. ARD would be generated in the saturated backfill until the sulfides have reacted completely."

GSM has enclosed an evaluation by Dr. Donald Runnells (3/25/05), a renowned mining geochemist, as part of our comments. Dr. Runnells has experience at several partially backfilled open-pits including the San Luis gold mine in Colorado, the Midnite uranium mine in Washington, and the Blackbird cobalt/copper mine in

Idaho. He notes that "at each of these three sites, the specific conditions are different, including the geologic environment, the type of wallrock, the mineralogy, the type of mineralization and alteration, and the hydrology. However, none has been successful in restoring the quality of water to acceptable levels, and all three of these partially backfilled mines require on-going active treatment of groundwater." (169)

RESPONSE:
Thank you for your comment. The agencies do not believe that addition of the suggested text would add to the section.

321. COMMENT:
Page 4-94, 2nd full paragraph, last sentence - The water balance analyses were conducted on the entire area, including the additional 56 acres. Although the cover minimizes infiltration, the agencies have assumed some infiltration. Therefore, there is additional water from the 56 acres that affects the water balance. The last sentence does not make sense in this context. (169)

RESPONSE:
The agencies disagree and no change has been made.

322. COMMENT:
Page 4-95, partial first paragraph, after last line - GSM suggests the agencies provide information on the consequence of formation of the impermeable layer (*e.g.*, "Therefore, water would by-pass the capture system and report to groundwater."). (169)

RESPONSE:
The agencies agree. The following sentence has been added to the end of the fourth paragraph in Section 4.3.3.1.1.2.3: "Water could bypass the capture system and report to groundwater."

323. COMMENT:
Page 4-95, Section 4.3.3.1.1.2.4 - GSM believes the analysis clearly indicates it is highly unlikely the Partial Pit Backfill with In-Pit Collection Alternative will perform as intended. Additionally, the analysis describes the development of perched water systems and decreases in permeability. Therefore, we believe the impacts would be more severe for this alternative than for the No Pit Pond Alternative. (169)

RESPONSE:
The agencies disagree and no change is required.

324. COMMENT:
Page 4-96, 1st full paragraph (paragraph above Section 4.3.3.2) - GSM believes the impacts should be more clearly stated. For instance, if flow is captured there is no

impact to groundwater at the permit boundary. However, if flow is not captured, violations to water quality standards in the Jefferson River alluvial aquifer will occur. (169)

RESPONSE:
The agencies do not believe the wording needs to be changed.

325. COMMENT:
Page 4-96, Section 4.3.3.2.1.2, 1st paragraph, 8th and 9th lines and 2nd paragraph, 7th line - GSM suggests changing "could" to "would."

RESPONSE:
The agencies do not believe the wording needs to be changed.

326. COMMENT:
Page 4-96, Section 4.3.3.2.1.2, 2nd paragraph, 7th line - GSM suggests adding "as is likely" after the "5,050-foot elevation." (169)

RESPONSE:
The agencies do not agree. No change is necessary.

327. COMMENT:
Page 4-97, Section 4.3.3.2.2.1 - GSM suggests more clearly defining the impact to water quality. (169)

RESPONSE:
The last sentence of Section 4.3.3.2.2.1 has been changed to read as follows: "Impacts from the 1 to 3 gpm of seepage from the East Waste Rock Dump Complex in Rattlesnake Gulch would be similar impacts to those for the No Pit Pond Alternative described in Section 4.3.2.2.2.1."

328. COMMENT:
Page 4-97, Section 4.3.3.2.2.2, 4th line - GSM suggests adding "secondary" before "bedrock pathways." (169)

RESPONSE:
The agencies agree. This has been modified.

329. COMMENT:
Page 4-97, Section 4.3.3.2.2.2, end of paragraph - GSM suggests adding a statement to the end of this paragraph indicating this alternative leads to a non-mitigable risk of violation of surface water standards. (169)

RESPONSE:
The agencies do not agree. No updates are required.

330. COMMENT:
Page 4-100, Section 4.3.4.1.1.2, 3rd sentence beginning on 3rd line - Since the analysis has indicated difficulties in adequately collecting downgradient water, GSM suggests modifying the wording of this sentence to "Groundwater leaving the pit would be attempted to be collected from wells..." or "Groundwater leaving the pit would be collected from wells located downgradient of the pit to the extent capture can be accomplished." (169)

RESPONSE:
The agencies do not believe this change is required.

331. COMMENT:
Page 4-100, Section 4.3.4.1.1.2, 4th sentence beginning on 4th line - GSM suggests modifying this sentence as follows: "At least 10 new monitoring wells... may be required to attempt to intercept contaminated water..." (169)

RESPONSE:
The agencies do not believe this change is required.

332. COMMENT:
Page 4-101, first line - GSM suggests modifying the first full sentence as follows: "The fractured and faulted bedrock geology around the GSM pit..." (169)

RESPONSE:
The agencies agree. The second sentence of the fourth paragraph in Section 4.3.4.1.1.2 has been modified as follows: "The fractured and faulted bedrock geology around the GSM pit..."

333. COMMENT:
Page 4-103, first sentence - GSM suggests modifying this sentence as follows: "The water balance analysis indicated that the expected future pit discharge of 16 gpm would exhibit the following water quality parameters: a pH of 2.2, sulfate of 22,400 mg/l..." (169)

RESPONSE:
The agencies do not believe this change is warranted.

334. COMMENT:
Page 4-105, last paragraph, 6th line - GSM believes the agencies should provide a rationale for assuming the 10 percent and state that there is significant uncertainty with the assumption. (169)

RESPONSE:
The agencies disagree. See response to Comment 148.

335. COMMENT:
Page 4-106, 1st full paragraph, 2nd line - GSM suggests changing "at least 26 capture wells" to "an additional 26 capture wells." (169)

RESPONSE:
The agencies have modified this sentence in Section 4.3.4.1.1.2 to read: "...by a series of existing wells and at least 26 additional capture wells..."

336. COMMENT:
Page 4-106, 1st full paragraph, 9th line - GSM's experience does not indicate a maximum 80 percent pumpback efficiency. Since this was the agencies assumption, it may be useful to explain this assumption in the text. Also, the 10 well requirement was based on HSI (2003) analysis, not necessarily GSM's experience. (169)

RESPONSE:
The agencies modified the text in the ninth paragraph after Table 4-7 in Section 4.3.4.1.1.2 as follows: "At least 10 new wells would be needed to intercept groundwater with an estimated average of 80 to 90 percent recovery efficiency..." The agencies evaluated the Partial Pit Backfill With Downgradient Collection Alternative with various capture efficiencies ranging from 80 percent to 99.99 percent (HSI, 2003).

337. COMMENT:
Page 4-106, 1st full paragraph, after 2nd to last sentence on 2nd to last line - GSM suggests adding: "Therefore, groundwater standards may be exceeded." Also, it does not appear that GSM's groundwater capture experience is described in Section 4.2.2.1.2. (169)

RESPONSE:
The agencies do not believe this wording is necessary. Groundwater capture experience is described in Section 4.2.1.5.2.1.5. The reference has been changed.

338. COMMENT:
Page 4-107, 1st full and 2nd paragraphs - GSM believes the referenced paragraphs would be modified to more accurately represent information presented by both Telesto and HSI (2003).

Section 3.3.6 does not discuss a localized groundwater divide nor is this divide designated on Figure 3.7. The average reader would not be able to identify this feature. The elevation is not referenced in any supporting document and should be

deleted from this discussion. Please note also that Figure 3-5 in the SEIS shows PW-64 (if you know where it is), but there are no elevations on the map. Figure 3-5 of HSI (2003) neither shows groundwater elevations nor includes PW-64. Note also that Telesto (2003a) uses 5,050 as the first discharge elevation as this is the contact between the pit and the Sunlight Fault. Telesto (2003a) states: "In an effort to be conservative and account for the high degree of uncertainty in the flow path and interconnectivity of fractures that are not intimately tied to the Corridor Fault, Telesto has assumed that groundwater may start to flow from the pit once the pit water elevation reaches 5,050 feet. The reasoning behind the 5,050 feet elevation is that the Sunlight Fault intersects and outcrops within the eastern portion of the pit at this elevation. At an elevation of 5,250 feet, the Corridor Fault outcrops at its lowest point on the east side of the pit (the lowest expected point on the Corridor Fault is at 5,150 feet, but this occurs on the upgradient side of the pit and therefore will not convey water out of the pit)..." (169)

RESPONSE:
The agencies agree that these paragraphs require additional clarification. A discussion of the groundwater divide has been added to Section 3.3.6 that provides support for the text in the above-referenced paragraphs. The reference to a specific elevation of the groundwater divide has been corrected in the thirteenth paragraph after Table 4-7 and now reads: "As discussed in Section 3.3.6, a local groundwater divide exists near the eastern rim of the pit between wells PW-62 and PW-64 (Figure 3-7). ... In a backfilled pit without water level control, groundwater levels are predicted to reach a steady state at the 5,260-foot elevation (Telesto, 2003a), which is between 68 and 115 feet above the current groundwater divide elevation..."

The second full paragraph now reads:
"Under the Partial Pit Backfill With Downgradient Collection Alternative, groundwater would saturate over 67 percent of the backfilled pit, and the water level would encounter the Corridor Fault at an elevation between 5,150 feet on the north side of the pit and 5,250 feet on the east side of the pit (Telesto, 2003a). Because the hydraulic head on the north side of the pit is higher than the water levels in the pit, the majority of flow from the pit to the Corridor Fault is expected to occur near the east side of the pit."

A new paragraph has been added in Section 3.3.6 as follows:
"A groundwater divide is located between wells PW-64 and PW-62 (URS, 2001) and is shown near the eastern edge of the pit in Figure 3-7. Recent groundwater elevations in PW-62 and PW-64 have ranged between 5,145 and 5,192 feet, and the groundwater divide is expected to be between those elevations. Groundwater west of the divide flows into the pit; groundwater east of the divide flows eastward into the Tdf/colluvial aquifer."

Figure 3-5 has been modified to make the labels larger and more legible. Figure 3.7 has been modified to include the groundwater divide.

339. COMMENT:
Page 4-108, Section 4.3.4.1.1.2.1 - It might be useful to include a paragraph with the expected change in water quality parameters. (169)

RESPONSE:
The changes in water quality from the Partial Pit Backfill With Downgradient Collection Alternative were provided (HSI, 2003). For the FSEIS, the agencies added a summary of these changes to Section 4.3.4.1.1.2.1, indicating which parameters either exceeded or came close to Montana water quality standards based on the results of the updated Dynamic Systems Modeling. These results are as shown in Table 4-8.

Table 4-8: Ability to Meet DEQ-7 Groundwater Standards with the Partial Pit Backfill With Downgradient Collection Alternative for Selected Parameters.

Parameter	DEQ-7 GW Stds mg/l	No Capture of Pit Seepage	One Downgradient Capture System at 80% Efficiency	Two Downgradient Capture Systems, each at 80% Efficiency (Measure 15a)
Predicted Pit Seepage		27 – 42 gpm	27 – 42 gpm	27 – 42 gpm
Arsenic	0.01	DEQ-7 groundwater standard met	DEQ-7 groundwater standard met	DEQ-7 groundwater standard met
Cadmium	0.005	DEQ-7 groundwater standard exceeded over entire predicted pit seepage range	DEQ-7 groundwater standard exceeded over entire predicted pit seepage range	DEQ-7 groundwater standard met
Copper	1.3	DEQ-7 groundwater standard exceeded over entire predicted pit seepage range	DEQ-7 groundwater standard exceeded over entire predicted pit seepage range	DEQ-7 groundwater standard met
Nickel	0.1	DEQ-7 groundwater standard exceeded over entire predicted pit seepage range	DEQ-7 groundwater standard exceeded over entire predicted pit seepage range	DEQ-7 groundwater standard exceeded over entire predicted pit seepage range
Selenium	0.05	DEQ-7 groundwater standard met	DEQ-7 groundwater standard met	DEQ-7 groundwater standard met
Zinc	2	DEQ-7 groundwater standard exceeded over entire predicted pit seepage range	DEQ-7 groundwater standard met	DEQ-7 groundwater standard met

340. COMMENT:
Page 4-108, Section 4.3.4.1.1.2.1, 2nd paragraph, last sentence - GSM suggests modifying the last part of this sentence as follows: "...and DEQ review of the permit would, if permitted by substantial law, be triggered." (169)

RESPONSE:
The agencies do not believe this wording needs to be added.

341. COMMENT:
Page 4-109, Section 4.3.4.1.1.2.2: - GSM believes the Partial Pit Backfill with Downgradient Collection Alternative poses a greater risk than all the other alternatives for creating new ARD-impacted springs or seeps, not just the Partial Pit Backfill with In-Pit Collection Alternative. (169)

RESPONSE:
The agencies do not believe this wording needs to be added because the No Pit Pond Alternative and the Underground Sump Alternative would not create new springs or seeps.

342. COMMENT:
Page 4-109, Section 4.3.4.1.1.2.3 - GSM believes the agencies should add that this alternative would result in intentional contamination of groundwater upgradient from the capture systems. (169)

RESPONSE:
The agencies do not agree and no change has been made.

343. COMMENT:
Page 4-109, Section 4.3.4.1.1.2.3, last sentence - GSM suggests adding "to avoid violations of water quality standards," after "required" in this sentence. (169)

RESPONSE:
The agencies agree. The last sentence in Section 4.3.4.1.1.2.3 has been modified to add the words "...to avoid a violation of a water quality standard (HSI, 2006)."

344. COMMENT:
Page 4-110, 1st full paragraph, 3rd line - GSM suggests adding "Darcy Law Groundwater Flux" to the glossary. (169)

RESPONSE:
The agencies agree. This has been added to the glossary.

345. COMMENT:
Page 4-110, last paragraph - The importance of the second sentence is unclear. The text suggests degradation could change the classification. GSM does not believe this is correct. (169)

RESPONSE:
The agencies agree that this statement is not relevant to the discussion in this section and it was stricken. Changes in water quality would not change the groundwater classification, although it could trigger corrective actions.

346. COMMENT:
Page 4-111, 1st full paragraph - GSM suggests incorporating information into this paragraph indicating that no conclusive data resulted from the in-situ work. Therefore, it is not known how long the downgradient collection wells would be needed. (169)

RESPONSE:
The agencies agree that no conclusive information resulted from GSM's in-situ testing. The text of Section 4.3.4.1.2.2.1 has been modified as follows: "GSM has been conducting studies of reclamation and in-situ treatment methods to prevent contaminants from Tailings Impoundment No. 1 from migrating to groundwater (GSM 2004 annual report). The agencies have not found conclusive results from these studies suggesting that downgradient control of contaminants using the existing pumpback systems may not be needed in the foreseeable future."

347. COMMENT:
Page 4-111, 2nd full paragraph, 3rd sentence beginning on the 6th line - Since impacts to groundwater from the East Waste Rock Dump Complex have not yet been identified and are not predicted to occur for many years, GSM suggests wording this sentence as follows: "If the pit...where groundwater is already impacted by ARD from natural mineralization and by future predicted seepage from the 13 percent..." (169)

RESPONSE:
The agencies agree. This sentence in the third paragraph after 4-2 in Section 4.3.4.1.2.2.1 has been changed to read: "If the pit...where groundwater is already impacted by ARD from natural mineralization and would be impacted by seepage from the portion..."

348. COMMENT:
Page 4-111, 2nd full paragraph, last sentence - GSM suggests deleting this sentence since it is not related to impacts, but describes other regulatory processes that may be invoked. (169)

RESPONSE:
The agencies do not agree and this sentence will remain.

349. COMMENT:
Page 4-114, Section 4.3.4.1.2.2.2, 1st paragraph, 9th line - GSM believes the agencies should provide a rationale for assuming 10 percent of flow from the pit through secondary pathways and state that there is significant uncertainty with the assumption. Also, in this instance, please cite the source of the "professional judgment." (169)

RESPONSE:
The agencies believe this is adequate. This is a conservative approach. See response to Comment 149.

350. COMMENT:
Page 4-114, Section 4.3.4.1.2.2.2, last complete paragraph, last sentence - GSM suggests deleting this sentence since it is not related to impacts, but describes other regulatory processes that may be invoked. (169)

RESPONSE:
The agencies disagree and this will remain in the text.

351. COMMENT:
Page 4-115, Section 4.3.4.2.1.2, 2nd paragraph (partial), last full sentence - GSM suggests referring the reader to Section 4.2.1.5.2.1.6 which describes the interception system for the Midas Spring. The discussion on page 4-115 implies the spring was just covered with the waste rock dump. (169)

RESPONSE:
The agencies agree. The reference to Section 4.2.1.5.2.1.6 has been added to the sentence in Section 4.3.4.2.1.2.

352. COMMENT:
Page 4-116, 1st full sentence - GSM suggests deleting "beneath the dump" at the end of this sentence.

RESPONSE:
The agencies agree and have deleted "beneath the dump" and added "...in the dump..." at the end of the sentence in the second paragraph of Section 4.3.4.2.1.2.

353. COMMENT:
Page 4-116, 2nd full paragraph - Due to the engineered drains constructed in mid-1994 (see previous comment), neither the Arkose Valley nor Sunlight Springs

currently have a surface expression. As reported in Table 3-1, none of the site springs have "good water quality." (169)

RESPONSE:
The agencies have modified the 4th paragraph in Section 4.3.4.2.1.2 to read "In addition, potential impacts could occur to springs having better water quality than found in the pit." The agencies have added Arkose Valley and Sunlight springs to Table 3-1 as follows:

Spring/Seep Name	Location	Elevation (feet)	Origination	Flow Rate** (gpm)	WQ**		Other
Sunlight	Near top of southwest section of West Waste Rock Dump Complex	5,312	possibly related to Latite Valley fault	0 to 6			covered by gravel trench system
Arkose Valley	Near top of southwest section of West Waste Rock Dump Complex, north of Sunlight	5,298	possibly related to Latite Valley fault	approx <1			covered by gravel trench system

354. COMMENT:
Page 4-117, Section 4.3.4.2.2.2, 12th line - GSM suggests changing "guaranteed" to "reasonably assured." (169)

RESPONSE:
The agencies agree. This wording change has been made.

355. COMMENT:
Page 4-117, Section 4.3.4.3.2 and Page 4-122, Section 4.3.5.3.2 - GSM suggests changing "Hazards" in the title and first line to "Impacts" to provide a more neutral assessment of both the positive and negative impacts.

RESPONSE:
The agencies disagree. This change has not been made.

356. COMMENT:
Also, GSM believes the impacts to wildlife under this alternative are greater than the Partial Pit Backfill with In-Pit Collection due to the potential impacts to springs and seeps. (169)

RESPONSE:
The agencies agree. The text in Section 4.3.4.3.2 has been changed to read: "Hazards to wildlife under this alternative would be similar to the Partial Pit Backfill

With In-Pit Collection Alternative, except that there is a greater potential for impacts to springs down gradient of the pit."

357. COMMENT:
Page 4-118, Section 4.3.5, 1st paragraph, 1st line - GSM suggests deleting "adapted to" from this sentence to merely state the "underground workings beneath the pit would be used as a sump for removing water from the pit." (169)

RESPONSE:
The agencies do not believe this change is necessary.

358. COMMENT:
Page 4-120, Section 4.3.5.1.1.2.3, 2nd sentence and last sentence - GSM believes these statements are contradictory. The last sentence states the water quality will be better, while the second sentence notes it will be similar to water quality predicted for the backfilled pit. (169)

RESPONSE:
The last sentence of Section 4.3.5.1.1.2.3 has been modified as follows: "It is anticipated that pit water quality would be slightly better..."

359. COMMENT:
Page 4-120, Section 4.3.5.1.1.2.3, 2nd to last sentence - GSM believes this statement should be modified to indicate the fact that pretreatment of water in an open sump is possible and has been done at GSM and other mine sites. This statement should reflect the agencies evaluation of the validity of this type of treatment and not GSM's "contention." (169)

RESPONSE:
The agencies agree. The second to the last sentence in Section 4.3.5.1.1.2.3 has been modified to read: "Pretreatment of the water in the sump may be possible and has been done at GSM (Shannon Dunlap, personal communication, 2006."

360. COMMENT:
Page 4-121, top partial paragraph, 2nd line - It is unclear why the pit water elevation would rise above the 4,635 foot level even with the assumed value of pit sloughing. (169)

RESPONSE:
The agencies have added text to the fourth sentence of the second paragraph in Section 4.3.5.1.2.2 to explain that the pit water elevation would rise as a result of displacement of water by the sloughed material as follows: "...200,000 cubic yards (300,000 tons) of highwall rock would ravel and slough over time. The additional 200,000 cubic yards of material would raise the pit lake a maximum of 32 feet to

approximately the 4,667-foot elevation. This is below the 5,050-foot-elevation at which water would begin to seep out of the pit."

361. COMMENT:
Page 4-122, Section 4.3.5.3.1, 2nd sentence - GSM believes this sentence should be reworded since it sounds like the referenced 52 acres is additional disturbance for this alternative. However, this acreage is common to the Underground Sump and No Pit Pond alternatives. (169)

RESPONSE:
The agencies agree. The word "additional" has been dropped and the sentence will read "...would be used to revegetate the 52 acres to be reclaimed..."

362. COMMENT:
Page 4-124, 1st full paragraph, last sentence - GSM believes the agencies should state the road will be widened where possible at this elevation, depending on the final pit configuration. (169)

RESPONSE:
The agencies agree. The last sentence of the second paragraph in Section 4.4.2.1.1 has been modified as follows: "The agencies would require the road leading down to the working area from the 4,875-foot elevation to be widened where possible, depending on the final pit configuration, by extending the road to the south over a portion of the 4,800-foot-elevation area and away from the highwall toe."

363. COMMENT:
Page 4-124, 4th full paragraph, last line and Page 4-125, Section 4.4.2.1.2, 2nd line - The highwall is defined as 1,875 feet and 1,775 ft in the respective sections. (169)

RESPONSE:
The agencies disagree. The highwall is 1,875 feet high before the 100 feet of fill is placed in the bottom and is 1,775 feet high after it is placed.

364. COMMENT:
Page 4-125, last line on page - GSM is unclear about the origin of this time frame and the starting point of the 10 year period.

RESPONSE:
The agencies have assumed 10 years to complete reclamation of the site.

365. COMMENT:
Page 4-127, 1st partial paragraph - GSM suggests adding "monitoring" to the post-reclamation activities. (169)

RESPONSE:
The agencies agree. The second to the last sentence of Section 4.4.2.3.1 has been reworded to say "...at a reduced level to maintain the site, provide monitoring, and operate the dewatering..."

366. COMMENT:
Page 4-127, Section 4.4.2.5.1 - GSM believes the last sentence on page 4-127 should be modified to read "Placer Dome reported 235,000 measured and indicated mineral resources (in ounces) at Golden Sunlight in their 2003 annual report." (169)

RESPONSE:
The agencies agree. The third sentence in the first paragraph of Section 4.4.2.5.1 has been changed to read "Placer Dome reported 448,000 measured and indicated mineral resources in ounces at GSM in their 2004 Annual Report." No resource numbers were reported in the 2005 Annual Report.

367. COMMENT:
Page 4-128, 1st partial paragraph, 6th line - GSM suggests changing "contends" to "believes." (169)

RESPONSE:
The agencies agree and this wording has been changed in the first paragraph of Section 4.4.2.5.1.

368. COMMENT:
Page 4-129, Section 4.4.2.6.1, 2nd paragraph - GSM requests the agencies review the information presented in SRK (3/14/05) enclosed with this submittal. In this memo, Dr. Gary Back reviews species utilizing mine pit highwalls at other western U.S. mines. He also evaluates species in the GSM area likely to utilize the highwall and recommends enhancements for wildlife use. (169)

RESPONSE:
Thank you for the comment. The following text has been added to the second paragraph of Section 4.4.2.6.1: "Observations at other mines suggest that the following species could use the GSM highwall at the conclusion of mining: golden eagle, red-tailed hawk, great horned owl, common raven, rock wren, fringed myotis, long-legged myotis, Yuma myotis, long-eared myotis, western small-footed myotis, and all BLM sensitive species (SRK Consulting, 2005). Mines at which these observations were made include several non-ARD pits (REN, Dee Gold, Sunshine, Marigold, Bald Mountain, and Robertson) and several having ARD potential (Gold Quarry, Reona, Gold Hole, and Coeur Rochester) (G. Back, SRK Consulting, personal communication, 2005). No conclusions were made on whether any nests were in sulfide material."

369. COMMENT:
Page 4-130, 1st full paragraph, last sentence - GSM suggests modifying this sentence to indicate that while 158 acres of habitat may be lost to some species, such as mule deer, that this loss will be partially offset by the addition of bat and raptor habitat provided by the highwall. (169)

RESPONSE:
The agencies partially agree. The last sentence in Section 4.4.2.6.1 has been reworded to say "...would be the permanent loss of 158 acres of mule deer habitat."

370. COMMENT:
Page 4-130, Section 4.4.2.7.1 - Additional visual analyses have been conducted by Telesto (4/11/05) and ENSR (2/7/05). These assessments are included with this submittal as part of GSM's comments. (169)

RESPONSE:
Thank you for your comment and the additional study information. The additional information does not change the conclusions in the SEIS.

371. COMMENT:
Page 4-132, 2nd to last line - GSM believes this sentence should be modified to note that "The analysis shows groundwater quality standards could be met under the No Pit Pond Alternative." This is not just a "contention" by the company. The analysis by Telesto (2003a) showed that water levels would only rise to 4,635 feet, well below the elevation of 5,050 feet assumed for significant outflow. In addition, the water would be pumped out, essentially eliminating the risk for water quality degradation outside the pit. (169)

RESPONSE:
The agencies do not believe the wording in the last paragraph of Section 4.4.2.8.2 requires changing.

372. COMMENT:
Page 4-133, Section 4.4.3.1.1, bulleted list - The number of months to implement this alternative appears too high. GSM previously estimated this alternative would take approximately 3 years to complete, operating 24 hours per day, 7 days per week. The numbers should be confirmed. (169)

RESPONSE:
The agencies used the GSM supplied number of 405,000 cubic yards per month to calculate the number of months. A 24-hours-per-day, 7-days-per-week schedule would shorten the overall time to implement this alternative from the 50 to 80 months down to 36 to 48 months. This does not affect the overall evaluation and no changes have been made.

373. COMMENT:
Page 4-135, Section 4.4.3.5.1, 2nd paragraph, 7th line - GSM believes it would be harder to dewater a backfilled pit than solid rock due to the challenges described in the analysis. Therefore, GSM suggests the agencies change the term "as difficult" to "more difficult." (169)

RESPONSE:
The agencies believe the wording is correct as stated.

374. COMMENT:
Page 4-137, last line and Page 4-138, first line - It is unclear to GSM how the untreated water escaping the pit would be the same for both the Partial Pit Backfill with In-Pit Collection Alternative and the No Pit Pond Alternative since no water would escape the pit under the No Pit Pond Alternative even if the dewatering system failed. (169)

RESPONSE:
The agencies believe the wording in the first paragraph of Section 4.4.3.8.2 is correct as stated.

375. COMMENT:
Page 4-138, last paragraph, 5th line - GSM believes the analysis has clearly shown the impacts to a dewatering system under this alternative. GSM suggests modifying the sentence to read "It has been demonstrated that this alternative would create a larger liability..." (169)

RESPONSE:
The agencies agree. The last sentence in Section 4.4.3.8.2 has been modified to read "This alternative may create a larger liability..."

376. COMMENT:
Page 4-140, Section 4.4.4.5.1, 1st and 2nd sentences - These sentences contradict one another. The first states the impact to access to future mineral resources would be the same for the both the Partial Pit Backfill Alternatives. The second sentence then states the backfill alternative with downgradient collection has an "additional impact." The analysis indicates there would be greater impacts to access to future mineral resources with the Partial Pit Backfill with Downgradient Collection Alternative and this should be stated. Please clarify. (169)

RESPONSE:
The agencies agree. The first sentence in Section 4.4.4.5.1 has been deleted.

377. COMMENT:
Page 4-140, Section 4.4.4.5.1, 10th line - GSM suggests clarifying the statement regarding "reversing" the alternative. (169)

RESPONSE:
The agencies agree. The sentence in the first paragraph of Section 4.4.4.5.1 has been reworded to read: "The agencies assume that a similar dewatering system as used in the Partial Pit Backfill With In-Pit Collection Alternative would have to be installed to dewater, which would facilitate removal of the backfill."

378. COMMENT:
Page 4-142, Section 4.4.4.8.2, 2nd paragraph, last sentence - GSM suggests also noting the company does not believe that it is in the best interest of the State of Montana to intentionally degrade groundwater. (169)

RESPONSE:
The agencies do not believe this sentence needs to be changed.

379. COMMENT:
Page 4-143, Section 4.4.5.1.1, 2nd paragraph, last sentence - GSM suggests modifying this sentence to read: "The agencies would require GSM to develop a long-term plan to stabilize and maintain the ceiling and walls of the underground workings, especially the stopes, where necessary to ensure employee safety." For example, only areas that require entry by maintenance personnel may need to be maintained. (169)

RESPONSE:
The agencies agree and this has been changed.

380. COMMENT:
Page 4-145, Section 4.4.5.8.1, 1st sentence - GSM believes the design for the Underground Sump Alternative was proposed, not assumed. (169)

RESPONSE:
The agencies agree. The first sentence in Section 4.4.5.8.1 has been changed to read: "For the Underground Sump Alternative, the dewatering system would consist of an underground..."

381. COMMENT:
Page 4-146, 1st full paragraph above Section 4.5, 4th line - GSM believes the analysis shows this alternative has the least liability and the agencies should indicate this is an agency position not a company contention. (169)

RESPONSE:
The agencies believe the wording is correct as stated.

382. COMMENT:
Page 4-147, Table 4-10 - Based on the tables in Chapter 2 that list the cover soil volumes required for each alternative, the costs for hauling and placing soil cover on revegetated acres for the No Pit Pond would be similar to, but slightly more than, the Underground Sump Alternative. (169)

RESPONSE:
The agencies agree. Table 4-10 has been changed to Table 4-11. The 3-foot-thick cover soil volume of 290,400 cubic yards listed under the No Pit Pond Alternative in Section 2.4.2.6 for 60 acres is correct. The cover soil volume of 290,400 cubic yards listed under the Underground Sump Alternative in Section 2.4.5.6 for 59 acres is incorrect. This volume has been changed to 285,600 cubic yards. In Table 4-11 the "Haul and Place Soil Cover on Revegetated Acres" row has been changed to $378,000 for the No Pit Pond Alternative and $371,000 for the Underground Sump Alternative.

The "TOTAL COSTS" row has been changed accordingly. A footnote has been added to indicate that these costs are based on 2003 dollars prior to the increase in diesel fuel prices.

383. COMMENT:
Page 4-150, Section 4.7.1.6 - It should be noted that although GSM does not have an ongoing exploration program, we are in the process of reviewing past exploration data. Once this review is complete, exploration targets could be generated. Based on the current knowledge, this does not change the cumulative impacts analysis.

RESPONSE:
The agencies agree. The first sentence in Section 4.7.1.6 has been deleted and replaced with the following: "GSM conducted limited exploration drilling in 2005 and is in the process of reviewing past exploration data. Once the review of existing and new data is complete, exploration targets could be generated (GSM, personal communication, 2005)."

384. COMMENT:
Page 4-151, Section 4.7.2, 2nd line - GSM suggests noting this will be a "light industrial park." (169)

RESPONSE:
The agencies agree and this wording change has been made.

385. COMMENT:
Page 4-151, Section 4.7.2, 3rd line - GSM believes the term "donated" should be replaced with "made available." (169)

RESPONSE:
The agencies agree and this wording has been changed.

386. COMMENT:
Page 4-151, Section 4.7.2 - GSM also suggests adding a sentence such as "GSM has also had discussions involving use of the property for a wind farm." (169)

RESPONSE:
The agencies agree and this sentence has been added to Section 4.7.2.

387. COMMENT:
Page 4-154, Section 4.8.1.2, 3rd paragraph - Backfilling of the underground is currently only required as specifically discussed in the EA, since evaluations show the underground would be stable without complete backfilling. An evaluation would be required to determine if this work could be completed, if necessary. (169)

RESPONSE:
The agencies believe the wording is correct as stated.

388. COMMENT:
Page 4-164, 1st bulleted item - GSM suggests modifying this sentence to indicate "...these areas would be seeded and possibly planted with tree seedlings." (169)

RESPONSE:
The agencies believe the wording is correct as stated in Measure 21 in Section 4.8.3.2.

389. COMMENT:
Page 4-164: Measure 22 - Please see the attached 2005 visual evaluations from Telesto (4/11/05) and ENSR (2/7/05), submitted as part of GSM's comments. (169)

RESPONSE:
See response to Comment 370.

390. COMMENT:
Page 4-167, Section 4.9.3, 3rd paragraph, last line - GSM believes the term "small" should be removed as no scale of reference is provided. The entire highwall area will provide habitat for raptors and bats. (169)

RESPONSE:
The entire highwall would be available for wildlife habitat. The agencies believe bats and raptors would use the oxidized portions of the upper highwall.

391. COMMENT:

Page 4-168, Section 4.11, last paragraph - GSM suggests striking the word "contends" and noting that the National Resource Council Report by Committee on Hard Rock Mining on Federal Lands, 1999, National Academy Press, Washington D.C., concluded that backfilling pits does limit the potential for future mining and recovery of remaining mineral resources and reserves. (169)

RESPONSE:

The agencies disagree. The third paragraph in Section 4.11 has been edited as follows: "GSM contends that the partial pit backfill alternatives would limit the potential for future mining and recovery of remaining mineral resources and reserves. This agrees with conclusions of the National Resource Council Report by Committee on Hard Rock Mining on Federal Lands, 1999, National Academy Press, Washington, D.C., that backfilling pits does limit the potential for future mining and recovery of remaining mineral resources and reserves."

Chapter 7
Preparers and References

7.1 LIST OF PREPARERS _____ 7-1
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Chapter 7

Preparers and References

7.1 LIST OF PREPARERS

The Draft and Final SEISs were prepared by an interdisciplinary team from Montana Department of Environmental Quality (DEQ), the Bureau of Land Management (BLM), and Spectrum Engineering, Inc., a third-party consulting firm working under the direction of the two agencies. DEQ, BLM, and Spectrum Engineering personnel (consisting of Spectrum Engineering, Timberline Resources, HydroSolutions, and Robertson GeoConsultants) were involved in the production of the Draft and Final SEISs. Their responsibilities and qualifications are listed below.

What has changed in Chapter 7 since the DSEIS?

Chapter 7 provides a list of the preparers of the SEIS, references used in the SEIS and a glossary of terms found in the SEIS. Based on additional data and public comments, the following changes have been made:

- Additional information on the preparers of the SEIS were added.
- References were updated and/or added based on new documents provided.
- Additional definitions were added to the glossary.
- Text was corrected based on references.

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7.3 GLOSSARY

Acid Generating Potential	A material's potential to generate acid and produce acid drainage. Analytical tests used to assess acid generating potential are either static or kinetic.
Acidity	The state, quality, or degree of being acid.
Acid Neutralizing Potential	The measure of a neutralizing material theoretically available to neutralize potential acid generated by ore or waste rock.
Acid Rock Drainage (ARD)	Water from pits, underground workings, waste rock, and tailings containing free sulfuric acid. The formation of acid drainage is primarily due to the weathering of iron pyrite and other sulfur-containing minerals. Acid drainage can mobilize and transport heavy metals which are often characteristic of metal deposits.
Adit	A horizontal or nearly horizontal access opening into an underground mine.
Aerobic/Anaerobic Interface	Zone in a soil or other porous media where the concentration of oxygen is detected to drop from a positive to a zero value.
Alluvium, alluvial	Unconsolidated fine to coarse material, deposited by flowing water.
Ambient	The baseline condition of a resource.
Amphibole	Any of a group of complex silicate minerals that contain calcium, sodium, magnesium, aluminum, and iron ions or a combination of them.
Amphibolite	A metamorphic rock composed chiefly of amphibole with minor plagioclase and little quartz.
Analog	Something that is similar to something else.

Angle of Repose	The angle at which a loose pile of earth or rock will stand when left to itself, usually between 30° and 39°.
Aquifer	A stratum of permeable rock, sand, etc., which contains water. Water source for a well.
Archaeology	The science that investigates the history of peoples by the remains belonging to the earlier periods of their existence.
Armoring	A protective covering.
Artesian Well	A well drilled through impermeable strata to reach water capable of rising to the surface under its own pressure.
Attenuate, Attenuation	To lessen, decrease, reduce in concentration.
Backfill	Any material placed back in the pit or that would have to be removed from the pit.
Barite	A heavy yellow, white, or colorless crystalline mineral of barium sulfate that is used in paint and is the chief source of barium chemicals.
Basalt	A hard, dense, dark volcanic rock, rich in iron and magnesium.
Basin Divide	A ridge dividing two drainage basins.
Bedding Plane	A planar or nearly planar surface which visibly separates successive layers of stratified rock.
Bedrock	The solid rock that underlies gravel, soil, or other superficial material.
Belt Supergroup	A thick succession of Precambrian rocks found in Montana and nearby states and provinces.
Benchmark	A surveyor's mark made on a stationary object of previously determined position and elevation and used as a reference point in surveys.
Beneficial Use	Public use of water, including but not limited to agricultural, domestic, fish and wildlife,

	industrial, irrigation, mining, municipal, power, water leasing, and recreation.
Berm	A horizontal, earthen structure, often constructed on exposed slopes, which increases slope stability, redirects the flow of water or other materials, or provides a place for sloughing material to collect.
Biofouling	The undesirable accumulation of microorganisms on pump and well components.
Biotite	A dark-brown or dark-green to black mica, which forms in igneous and metamorphic rocks.
Block Failure/Block Slip	A very general term that refers to a slope failure where the failing material consists of blocks of rock. The failure surface may also consist of a stepped path around blocks rather than a single plane.
Bond	A sum of money which, under contract, one party pays another party under conditions that, when certain obligations are met, the money is then returned (such as after mining reclamation occurs).
Bore Hole	A circular small-diameter hole made by a drill to a desired depth.
Bornite	A copper-iron sulfide mineral; important ore of copper.
Borrow Area	An area which provides a source of earthen construction material such as sand, gravel or topsoil for use in construction or reclamation.
Breccia	Rock composed of angular fragments embedded in a fine-grained matrix.
Buffer	A substance that minimizes change in the acidity of a solution when an acid or base is added to the solution.

Calcareous	Composed of, containing, or characteristic of calcium carbonate, calcium, or limestone; chalky.
Calcite	A common crystalline form of natural calcium carbonate, $CaCO_3$, that is the basic constituent of limestone, marble, and chalk.
Calcium Carbonate	See calcite.
Candidate Species	Plant or animal species under consideration by the United States Fish and Wildlife Service listing as threatened or endangered under the Endangered Species Act.
Cap	Barren rock and/or soil covering for reclaimed areas.
Capture Point	Well for removing groundwater.
Cation Exchange Capacity	The amount of positively charged ions a soil can hold expressed in milliequivalents per 100 grams (meq/100g) of soil.
Cemented	Describes rock or soil particles held together by secondary substances like silica, calcite, or oxides.
CFR	Code of Federal Regulations. A codification of the general and permanent rules published in the Federal Register by the executive departments and agencies of the federal government.
Chalcopyrite	A copper iron sulfide ($CuFeS_2$); an important ore of copper.
Chemical Weathering	Process by which chemical reactions transform rocks or minerals into new chemical combinations stable at the earth's surface.
Chimney Effect	Convective air movement in waste rock dumps by which air is warmed and rises and is replaced by cooler air.

Circular Failure	Any slope failure where the failure surface has a circular shape.
Clean Water Act	Federal Water Pollution Control Act, as amended.
Colloidal	Pertaining to fine particles suspended in a liquid or gas.
Colluvium/Colluvial	Consisting of a mixture of soils and angular fragments of rock that have accumulated at the foot and on slopes of mountainsides under the influence of gravity.
Column Leach Test	A procedure for measuring the concentrations of constituents that can be rinsed from a material. The materials are placed in a cylindrical shaped apparatus (i.e. column) and fluid, usually distilled water, is passed through the materials. The effluent is collected and analyzed for concentration of constituents.
Compaction	An increase in the density of something; the act of crushing together.
Cone of Depression	The geometry or shape of an inverted cone on the water table or artesian pressure surface caused by the pumping of a well. The cone of depression will disappear over time when well pumping ceases.
Confidence Interval	A statistical range with a specified probability that a given parameter lies within the range.
Conglomerate	A rock consisting of rounded pebbles and gravel embedded in a finer-grained matrix.
Contrast	The effect of differences in the form, line, color, or texture of a landscape's features.
Conventional Blasting	Also called production blasting. Blast holes are drilled on a square or equilateral triangular grid. No particular design changes are made near the pit wall to improve the strength of the wall.

Corrosion	A state of deterioration in metals caused by oxidation or chemical action.
County Tax Base	Private property that is taxed by a county government.
Covellite	A dark blue sulfide of copper (CuS); an important ore of copper.
Cretaceous	The geologic period at the end of the Mesozoic Era; the span of time between approximately 136 and 65 million years ago.
Cross Section	A drawing showing a vertical section through a feature.
Crusher Reject	Crushed and screened waste rock of uniform size.
Cultural Resources	Remains of human activity, occupation, or endeavor as reflected in sites, buildings, artifacts, ruins, etc.
Darcy's Law	Is a generalized relationship for flow in porous media. It shows that the volumetric flow rate is a function of the flow area, elevation, fluid pressure and a proportionality constant. It may be stated in several different forms depending on the flow conditions. Since its discovery, it has been found valid for any Newtonian fluid. Likewise, while it was established under saturated flow conditions, it may be adjusted to account for unsaturated and multiphase flow.
Daylight Level	The lowest point on the rim of an open pit.
Debris Flow	A mass of unsorted rock fragments, soil, and mud which has flowed downhill by gravity.
Decarbonization	The act of removing carbon from something.
Decay	To break down into component parts.
Devonian	The geologic period between approximately 405 million and 345 million years ago.

Dewatering	The act of removing water.
Diffusion	The process whereby particles of liquids, gases, or solids intermingle and move from a region of higher to one of lower concentration.
Digenite	A copper sulfide mineral.
Distal	Located far from a point of reference.
Downgradient	At a lower point of elevation in relation to any fixed point with regard to the direction of drainage or flow.
Drawdown	Vertical distance that a water elevation is lowered or the pressure head is reduced due to the removal of water from the same system.
Drift	A mine passage; the nearly horizontal opening driven along a vein or ore body.
Drill Log	A written record kept by drillers or geologists of materials encountered while drilling a hole.
Dynamic Systems Model	A computer tool that allows time-dependent calculations of many physical processes within a certain environment (i.e., system).
Effluent	Something that flows out, like water seeping from the pit or treated water leaving the water treatment plant.
Enargite	An iron-black mineral containing sulfur, arsenic, copper, and often silver.
Endangered species	Any species of animal or plant that is in danger of extinction throughout all or a significant portion of its range. Plant or animal species identified by the Secretary of the Interior as endangered in accordance with the 1973 Endangered Species Act.
Enrichment	Concentration of valuable constituents in an ore by mechanical or chemical weathering.

Environment	The physical, biological, and social conditions that exist within an area, including land, air, water, minerals, flora, fauna, social and economic values, and objects of historical, aesthetic, or cultural significance. The sum of all external conditions that affect an organism or community and ultimately determine its form and survival.
Environmental Assessment (EA)	A public document for which a federal or state agency is responsible that serves to: 1) Provide sufficient evidence and analysis for determining whether to prepare an environmental impact statement or a finding of no significant impact; 2) Aid an agency's compliance with the National or Montana Environmental Policy Act (NEPA or MEPA) when no environmental impact statement is necessary; 3) Facilitate preparation of an environmental impact statement when one is necessary.
Environmental Impact Statement (EIS)	An analytical document prepared under the National Environmental Policy Act (NEPA) and Montana Environmental Policy Act (MEPA) that evaluates potential impacts to the environment of a Proposed Action and its possible alternatives. An EIS is developed for use by decision makers to weigh the environmental consequences of a potential decision.
Eocene	A geological epoch of the Tertiary Period; approximately 58 million to 40 million years ago.
Ephemeral (streams)	Flowing in response only to direct precipitation or snow melt.
Erosion	The group of processes whereby earth or rock material is loosened and/or dissolved and removed from any part of the earth's surface.
Ethnographic	Pertaining to the branch of anthropology that deals with the scientific description of specific human cultures.

Evaporate, Evaporation	To change into vapor.
Evapotranspiration	Loss of water by evaporation from the soil and transpiration from plants.
Expanded Ramp Pit	This refers to a particular open pit at Golden Sunlight Mines. This was the last pit stage mined before the current Stage 5B Pit. It consisted of mining an old haul road and an extension that was recovered by removing an old pit highwall instability.
Facies	The aspect and characteristics of a sedimentary rock unit, usually reflecting the conditions of its origin.
Factor of Safety	A calculation defining the relationship of the strength of the resisting force of an element (C) to the demand (D) or stress on the disturbing force where F=C/D. When F is less than 1, failure can occur.
Failure Modes and Effects Analysis	An estimate of how an engineered structure might fail, the likelihood of failure, and the kind and intensity of the possible impacts.
Fault	A fracture or fracture zone along which there has been displacement of the sides relative to one another parallel to the fracture.
Fee Simple	Private ownership of real estate in which the owner has the right to control, use, and transfer the property at will.
Ferricrete	Surficial sands and gravel cemented into a hard mass by iron oxide derived from the oxidation of sulfide minerals into solutions of iron salts.
Floodplain, 100-year	That portion of a river valley, adjacent to the river channel, built of sediments and inundated with water at least once every 100 years.
Flow Path	The route by which groundwater moves.

Fluid Pressure	A force that is equal in all directions.
Fluvial	Of or relating to a stream or river.
Free Draining	Allowing water to flow off a surface.
Freeze and Thaw Cycle	Alternating episodes of freezing and thawing.
Fugitive Emissions	Those air emissions, such as road dust, which could not reasonably pass through a stack, chimney, vent, or other functionally equivalent opening.
Galena	A gray mineral, lead sulfide (PbS); the principal ore of lead.
Gallons Per Minute (gpm)	A measurement of flow per minute. Seepage volumes are sometimes annualized to show what the steady flow in gpm would be if spread out over the entire year.
Geochemistry, Geochemical	The study of the chemical composition of, and actual or possible chemical changes in, the crust of the earth.
Geology	The science that relates to the earth, the rocks of which it is composed, and the changes that the earth has undergone or is undergoing.
Geosynthetic	Polymeric products used with soil, rock or other material as a liner or barrier to contain material or prevent erosion.
Geotechnical	Pertaining to the application of scientific methods and engineering principles to the acquisition, interpretation, and use of knowledge of materials of the earth's crust for the solution of engineering problems. It embraces the fields of soil mechanics and rock mechanics, and many of the engineering aspects of geology, geophysics, hydrology, and related sciences.
Gneiss, Feldspathic	A metamorphic rock with prominent bands of feldspar and other minerals.

Ground Movement	General term for displacement of blocks of near-surface material by earthquakes or slow movement in response to gravity or other stresses.
Ground Support	The application of mechanical support techniques to improve stability of rock or soil slopes. These techniques include, rock bolts, rock anchors, shotcrete, wire mesh, buttresses, and retaining walls.
Groundwater	Water found beneath the land surface in the zone of saturation below the water table.
Habitat	A specific set of physical conditions that surround a single species, a group of species, or a large community. In wildlife management, the major components of habitat are considered to be food, water, cover, and living space.
Haul Road	A road used by large trucks to haul ore and overburden from an open pit mine to other locations.
Hazardous Waste	A waste or combination of wastes that, because of its quantity, concentration, or physical, chemical, or infectious characteristics, may: (i) cause or significantly contribute to an increase in mortality or an increase in serious irreversible or incapacitating reversible illness; or (ii) pose a substantial present or potential hazard to human health or the environment when improperly treated, stored, transported, or disposed of or otherwise managed.
Hematite	A black or blackish-red to brick-red mineral, ferric oxide (Fe_2O_3); an important ore of iron.
Hibernacula	Caves or other structures used by bats for hibernation.

Highwall	The unexcavated face of exposed waste and ore in an open pit mine (same as pit wall).
Highwall Angle	The angle from horizontal at which the unexcavated face of exposed overburden in an open pit mine is standing.
Host Rock	Unmineralized rock in which an ore deposit occurs.
Humidity Cell	A geochemical test for obtaining bulk mineral reaction rates under controlled laboratory conditions.
Hydraulic	Conveyed or moved by means of water or other fluids, or pertaining to fluid in motion, or movement or action caused by water.
Hydraulic Conductivity	The capacity of a rocks or sediments to transmit water. Governed by the size and shape of pores, the interconnection between pores, and the physical properties of the fluid.
Hydraulic Gradient	In an aquifer, the rate of change of total head per unit of distance of flow at a given point and in a given direction.
Hydrogeology/Hydrogeologic	The branch of geology that deals with the occurrence, distribution, and effect of ground water.
Hydrograph Analysis	Analysis of a chart showing stage, flow velocity, or some other characteristic of water with respect to time.
Hydrologically Connected	Water-bearing rocks and sediment and water bodies that are directly connected, such as surface water bodies and groundwater and wetlands and surface water.
Hydrologic Sink	An area that captures groundwater.
Hydrology	The science that relates to the water of the earth.

Hydrostatic Pressure	Force exerted by water at any given point in a body of water at rest.
Hydrostratigraphy	The science of the arrangement of rock strata and their interrelation to water.
Impact	Influence or effect; a modification of the environment.
Impoundment	A body of water formed by the accumulation of water in a reservoir or other storage area.
Inclinometer	An instrument used by surveyors to measure an angle of inclination or elevation.
Infiltration	The movement of water or some other fluid into the soil through pores or other openings.
Interbedded rocks.	Interlayering of different kinds of sedimentary
Intercalated	Material introduced between layers of a different kind of material, for example thin layers of shale between thick layers of sandstone.
Interfingering	Intergradation of different kinds of rocks through a vertical succession of thin interlocking or overlapping wedge-shaped layers.
Intermittent Stream	A stream that runs water in most months, but does not contain water year-round.
Intrusive Rock/Intrusion	Igneous rock formed within surrounding rock as a result of magma intrusion.
Ion Exchange	A reversible chemical reaction between an insoluble solid and a solution during which ions may be interchanged.
Iron Hydroxide	An oxide characterized by the linkage of iron with the hydroxide ion.
Iron Oxide	Any of various oxides of iron, such as ferric oxide or ferrous oxide.

Irretrievable	Applies to losses of production, harvest, or commitment of renewable natural resources. For example, some or all of the timber production from an area is irretrievably lost during the time an area is used as a winter sports site. If the use changes, timber production can be resumed. The production lost is irretrievable, but the act is not irreversible.
Irreversible	Applies primarily to the use of nonrenewable resources, such as minerals or cultural resources, or to those factors that are renewable only over long time spans, such as soil productivity. Irreversible also includes loss of future options.
Jarosite	An ocher-yellow mineral, a hydrous sulfate of iron and potash.
Joint	A usually planar fracture surface in rock without relative displacement of the opposite sides.
Kaolinite	A clay mineral consisting of aluminum silicate ($Al_2Si_2O_5(OH)_4$); main source of kaolin.
Key Cut	The low point on the pit rim where the haul road enters the pit.
Key Observation Point (KOP)	Selected points from which a BLM visual resource assessment is conducted. KOPs are typically along commonly traveled routes, critical viewpoints (*e.g.,* communities, crossings, or observation areas), or at typical or representative viewing points.
Lacustrine	Of or relating to lakes. Found in, living, or growing in or along the edges of lakes.
Laminae	Narrow beds of rock.
Lamprophyre	Any of several intermediate igneous rocks composed of feldspar and ferromagnesium

	minerals that typically occur as dikes and minor intrusions.
Land Application Disposal (LAD)	The disposal of excess solution by spray irrigation over a large area where evaporation and plant uptake utilize the water. LAD is also a treatment method for some contaminants such as residual amounts of cyanide, which breaks down when exposed to oxygen and sunlight or nitrates which are used in plant growth.
Landform	A term used to describe the many types of land surfaces that exist as the result of geologic activity and weathering, e.g., plateaus, mountains, plains, and valleys.
Laramide Orogeny	A period of mountain building and deformation of the earth's crust in the western U.S., which occurred from the late Cretaceous into the early Tertiary periods.
Latite	A porphyritic volcanic rock having plagioclase and potassium feldspar present in nearly equal amounts of visible crystals, little or no quartz, and a finely crystalline to glassy groundmass; the extrusive equivalent of monzonite.
Leachate	A solution containing contaminants picked up as the liquid passes through soil or rock.
Lead Agency	The public agency(s) that has (have) the principal responsibility for carrying out or approving a project.
Lenticular	Lens shaped.
Lithology	The gross physical character or composition of a rock or rock formation.
Loam	Soil composed of a mixture of sand, clay, silt, and organic matter.
Locus of Shear	The geometrical plane or point along which shearing is taking place.

Loess	A buff to gray windblown deposit of fine-grained, calcareous silt or clay.
Manifold	A pipe or chamber having multiple apertures for making connections.
Marcasite	A mineral with the same composition as pyrite, FeS_2, but differing in crystal structure.
Mass Balance	Calculations used to estimate the amount of mass flux into, out of, and stored within a confined volume (*e.g.*, a pond or pit).
Mass Flux	The per unit area of mass transfer or movement.
Mass Movement/Failure	A general term that refers to failure of a large mass of material.
Mass Load, Mass Loading	The summation of mass metal flux into a region.
Matrix	Fine-grained material surrounding the larger particles in a sedimentary rock.
Median	The middle value in a series of numbers or data points.
Metalliferous	Containing metal.
Metal Loading	The summation of the mass flux of metals into a region.
Metamorphose	To change rock by naturally occurring heat and pressure in the earth's crust.
Metasediment	A rock resulting from the metamorphism of a sedimentary rock.
Migratory	Periodically moving from place to place.
Milliequivalent	One thousandth of a gram equivalent of a chemical.

Mineralized Zone, Mineralization	Process by which minerals are introduced into a rock, resulting in an economically valuable or potentially valuable deposit.
Mineral Reserve	A concentration or occurrence of natural, solid, inorganic, or fossilized organic material in or on the earth's crust in such form and quantity and of such grade or quality that it has reasonable prospects for economic extraction.
Minor Revision	A change in a mine permit that increases the permitted area by less than 10 acres or less than 5 percent, adds less than 10 acres of new disturbance, or will not significantly affect the human environment.
Mitigation	Actions to avoid, minimize, reduce, eliminate, replace, or rectify the impact of a management practice or activity.
Mixing Zone	An area established in a permit where water quality standards may be exceeded to allow for initial effluent dilution.
Model, Modeling	A schematic description of a system, theory, or phenomenon that accounts for its known or inferred properties and may be used for further study of its characteristics.
Molybdenite	Molybdenum sulfide, MoS_2; the principal ore of molybdenum.
Monitoring Well	A well used to track groundwater quality or quantity.
Monzonite	An intrusive igneous rock composed chiefly of plagioclase and orthoclase, with small amounts of other minerals.
Multiple Accounts Analysis (MAA)	Multiple Accounts Analysis provides the means by which evaluators can select the most suitable, or advantageous, alternative from a list of alternatives by weighting the relative benefits.
National Environmental	An Act passed in 1969 declaring a

Policy Act (NEPA)	national policy which will encourage productive and enjoyable harmony between humankind and the environment, to promote efforts which will prevent or eliminate damage to the environment and biosphere and stimulate the health and welfare of humanity, to enrich the understanding of the ecological systems and natural resources important to the Nation, and to establish a Council on Environmental Quality. A principal component of NEPA is the requirement to conduct EAs and EISs.
Neutralization	Reduction in acidity.
Non-homogeneous	Not uniform in structure or composition.
100-year Storm	A large storm predicted to occur about once every 100 years.
Noxious Weeds	Introduced plants that are officially recognized as undesirable by the state and county governments.
Ore	A mineral or an aggregate of minerals from which a commodity can be profitably mined or extracted.
Overbank Deposit	Mud or sand deposited beyond the banks of a stream by flooding.
Over-break	The impact of blasting damages the rocks beyond the location of the designed pit highwall.
Overburden	Loose or consolidated rock material that overlies a mineral deposit and must be removed prior to mining.
Oxidation, Oxidize	The process of combining with oxygen; or the process by which electrons are removed from atoms or ions.
Oxide	A mineral compound of oxygen with one or more metallic elements; or a binary compound of oxygen with some other element or with a radical.

Oxygenated Water	Water containing dissolved oxygen gas.
Paleontology	The science that deals with the life of past geological ages through the study of the fossil remains of organisms.
Paleozoic	Span of time from end of Precambrian to beginning of Mesozoic Era, ranging from about 570 million to 250 million years ago.
Particulate(s)	Minute, separate particles, such as dust or other air pollutants.
Passivation	A patented process using potassium permanganate sprayed on pit highwalls and waste rock to prevent pyrite oxidation.
Patented	A mining claim owned by legal title.
Partial Pit Backfill	Partial filling of the pit but not attempting to mound the fractured rock to the original configuration of the mountain.
Percolation Pond	An unlined pond that allows water to seep through the bottom.
Perennial Stream	A stream that flows at all times of the year.
Permeability	The property or capacity of a porous rock, sediment, or soil for transmitting a fluid.
Petrographic	Of the description and classification of rocks.
pH	The measure of the acidity or alkalinity of a solution in terms of hydrogen ion concentration.
Physical (Mechanical) Weathering	Breakdown of rock into smaller fragments by physical means like freezing and thawing, as opposed to chemical processes.
Pit Backfilling	Process of placing waste rock back into the pit from which it came.

Pit Highwall	Steep rock surfaces bordering a pit after removal of ore and waste. Same as pit wall.
Plaintiff	The party that brings a law suit against another party.
Plan View	Diagram showing features as seen from above; map view.
Pore Pressure	The hydrostatic pressure of the water in the pore space of a soil.
Pore Water	Water found in the pores of rock.
Porosity	The ratio of the volume of all the pores in a material to the volume of the whole.
Porphyry	Igneous rock containing relatively large conspicuous crystals, especially feldspar, in a fine-grained matrix.
Portal	Horizontal entrance to an underground mine.
Potentiometric Surface	The surface to which water in an aquifer would rise by hydrostatic pressure.
Precambrian	About 90 percent of geologic time; all time which precedes Paleozoic.
Precipitate	To cause a solid substance to be separated from a solution.
Preferential Flowpath	The most likely direction of groundwater flow.
Pre-split Blasting	A smooth blasting method in which cracks for the final contour are created by blasting prior to the drilling of the rest of the holes for the blast pattern.
Principal Deformation Zone	The principal axis of distorted rocks along a fault or other structural feature.
Proterozoic	The period of Earth's history that began 2.5 billion years ago and ended 543 million years ago; a subdivision of Precambrian time.

Pumpback System	A series of wells designed to capture groundwater and return it to some specific location.
Pyrite	A common brass-colored sulfide mineral, FeS_2; also known as "fool's gold."
Quaternary	The second period of the Cenozoic era, following the Tertiary; began 2 to 3 million years ago and extends to the present.
Raise	A mine opening driven vertically from a lower to higher level.
Ramp	A sloping mine excavation.
Raptor	Bird of prey.
Raveling	Any small-scale localized failure of the highwall.
Receptor	Someone or something that receives a stimulus, such as noise.
Reclamation	To return a disturbed area to an approved post-mining land use.
Recontouring, Regrading	Reshaping irregular piles or dumps of rock or earth to a desired shape or form.
Record of Decision (ROD)	A document separate from, but associated with, an Environmental Impact Statement that publicly and officially discloses the responsible official's decision on the proposed action.
Redox Potential	The tendency for transfer of electrons from one compound to another. The donor is oxidized, the acceptor reduced.
Region	A large tract of land generally recognized as having similar character and physiographic types.
Right-of-Way	Strip of land over which a power line, access road, or maintenance road has a legal right to pass.

Riparian	A type of ecological community that occurs adjacent to streams and rivers and is directly influenced by water. It is characterized by certain types of vegetation, soils, hydrology, and fauna, and requires free or unbound water or conditions more moist than normally found in the area.
Riprap	A layer of large, broken rock placed together irregularly to prevent erosion of embankments, causeways, or other surfaces.
Risk	The possibility of suffering harm or loss; danger.
Rock Bolt	Steel bolt with one flanged end and one expanding end; placed in a pre-drilled hole to control rock movement.
Runoff	Precipitation or snow melt that is not retained on the site where it falls, not absorbed by the soil; natural drainage away from an area.
Safety Bench	Wide bench in an open pit mine designed to catch falling or sliding rocks and debris and provide protection to workers and features below.
Safety Berm	Rock or earthen barrier along a bench or road, designed to keep vehicles and workers away from a dangerous edge.
Salvaged	Recovered or saved, such as soil that is picked up for future use in reclamation.
Saturated, Inundated	Soaked, filled, or loaded to capacity.
Scaling	Development of hard, brittle, cement like deposits, usually due to the precipitation of calcium and magnesium carbonates.
Scaling	The plucking down of loose rocks adhering to the solid face after a shot or round of shots has been fired.

School Trust Land	State land set aside specifically as a source of income to public schools in Montana and managed by the Montana Department of Natural Resources and Conservation.
Scoping	A term used to identify the process for determining the scope of issues related to a Proposed Action and for identifying significant issues to be addressed in an environmental impact statement.
Sedimentary	A type of rock resulting from consolidation of loose sediment that has accumulated in layers.
Seismicity	The likelihood of an area being subjected to earthquakes; the phenomenon of earth movements.
Sericite	A fine-grained potassium mica occurring in silky scales having a fibrous structure; a common alteration product of other silicate minerals.
Shear Zone	A body of rock broken by numerous, closely spaced, nearly parallel fractures.
Silicate Dissolution	The act of dissolving minerals composed of silica (e.g., quartz).
Slip Block	A body of rock or land which has slid away from its original position along a low-angle surface; usually bounded by near-vertical breaks.
Slope Acre	An acre of land in plan view adjusted for degree of slope.
Slough	A backwater or isolated bend of a stream.
Slough	Any large-scale mass failure of the highwall.
Sludge	Semisolid material precipitated in a water treatment plant.
Slurry	A thin mixture of water and finely ground ore.

Smectite	A group of clay minerals, often greenish.
Soil Development	The development of an unconsolidated layer of weathered rock which lies upon bedrock and is a medium for plant growth.
Sorption, Sorbing	The process in which one substance takes up or holds another by either absorption or adsorption.
Species	A group of individuals of common ancestry that closely resemble each other structurally and physiologically and in nature interbreed producing fertile offspring.
Sphalerite	The primary ore of zinc, occurring in usually yellow-brown or brownish-black crystals or cleavage masses, essentially zinc sulfide with some cadmium, iron, and manganese.
Stakeholder	One who has a share or an interest in something.
Steady State	A stable condition that does not change over time or in which change in one direction is continually balanced by change in another.
Stipulation	A condition attached to a mine's operating permit.
Stockpiled	Set aside for future use.
Stope	Any excavation underground to remove the ore, other than the development work. The outlines of a stope are determined either by the limits of the ore body or by raises.
Stratigraphy, Stratigraphic	Form, arrangement, geographic distribution, chronologic succession, classification, and relationships of rock strata.
Subsidence	Settling caused by the collapse of an underground mine.
Sulfate	A chemical compound containing SO_4.

Sulfide	A mineral composed of sulfur combined with a metal or semi-metal, for example pyrite and bornite.
Sump	The bottom of a shaft or any other place in a mine that is used as a collecting point for drainage water.
Supplemental EIS	A supplemental analytical document prepared under the National Environmental Policy Act (NEPA) and Montana Environmental Policy Act (MEPA) that portrays potential impacts to the environment of a Proposed Action and its possible alternatives. A SEIS is developed for use by decision makers to weigh the environmental consequences of a potential decision.
Surficial Geology	Of or relating to the geology of the surface of the earth.
Survey Prism	Device used to monitor movement of slip blocks or other features.
Syncline	A fold in rocks in which the rock layers dip inward from both sides toward the axis.
Tailings	The non-economic constituents of processed ore material that remain after the valuable minerals have been removed from raw materials by milling.
Talus	Heaps of coarse debris at the foot of cliffs and steep slopes resulting from weathering processes and gravity transport.
Tectonic Zone	Large-scale structural feature of the upper part of the earth's crust characterized by present or past seismic movements.
Telluride	A binary compound of tellurium usually with an element or radical, such as gold or silver. Metal tellurides are sometimes regarded as alloys.

Tertiary	A geologic period; the span of time between about 65 and 3 to 2 million years ago.
Texture	The composition of soil in terms of the relative proportions of sand, silt, and clay, such as loam.
Threatened species	Any species likely to become endangered within the foreseeable future throughout all or a significant part of its range.
Topographically Controlled	Constrained by the shape of the land surface.
Tributary	A stream flowing into a larger stream or other body of water.
Uncertainty	The estimated amount or percentage by which an observed or calculated value may differ from the true value.
Unconformably, Disconformably	Characterized by a substantial break or gap in the geologic record.
Unnecessary or Undue Degradation	Under BLM regulations: conditions, activities, or practices that: (1) Fail to comply with one or more of the following: the performance standards in Sec. 3809.420, the terms and conditions of an approved plan of operations, operations described in a complete notice, and other federal and state laws related to environmental protection and protection of cultural resources; (2) Are not "reasonably incident" to prospecting, mining, or processing operations as defined in Sec. 3715. 0-5 of this chapter; or (3) Fail to attain a stated level of protection or reclamation required by specific laws in areas such as the California Desert Conservation Area, Wild and Scenic Rivers, BLM-administered portions of the National Wilderness System, and BLM-administered National Monuments and National Conservation Areas.
Unpatented	A mining claim controlled by staking and assessment work, not by full legal ownership.

Unsaturated	Not soaked, filled, or loaded to capacity
Upgradient	At a higher point of elevation in relation to any fixed point with regard to the direction of drainage or flow.
Vat Cyanide Leach Process	Recovery of gold and other metals by soaking a concentrate milled from ore in a cyanide solution contained in a cylindrical vertical vat.
Visual Contrast	Noticeable visual difference between the natural landscape and adjacent reclaimed areas.
Visual Resource Inventory	A BLM system of determining visual values in an area by inventorying existing scenic quality, sensitivity level, and distance zones. Inventory classes of one through four are assigned.
Visual Resource Management	A BLM system of analyzing the potential visual impacts of a proposed project or activity by assessing the visual contrasts that would be created between a project and the existing landscape. The major features of form, line, color, and texture are evaluated.
Volcanic	Activities, structures, or rock types produced by a volcano.
Waste-to-Ore Ratio	Number of units of waste rock which must be removed to allow mining of a unit of ore.
Waste Rock	Rock that is removed to access precious metal-bearing ore, but does not contain enough mineral to be mined and processed at a profit.
Waste Rock Dump	Storage area for waste rock.
Water Balance	An account of all the inflows and outflows for a given basin with no net change in storage. Factors include precipitation, evapotranspiration, streamflow, water use, and any transfers of groundwater out of the basin.

Water Holding Capacity	The amount of water stored in a soil after the large (macro) pores have drained. Dependent upon soil texture and organic matter content.
Water Quality Standards	Limits on water pollutants designed to protect human health, aquatic life, and beneficial uses, as listed in DEQ's Circular DEQ-7.
Watershed	The entire land area that contributes water to a particular drainage system or stream.
Water Table	The level below which the ground is completely saturated with water.
Weathered Waste Rock	Waste material which has been subjected to chemical and mechanical weathering after being moved to dumps.
Wedge Failure	Any failure where the planes which failure is occurring along have a wedge shaped geometry.
Well Completion Details	A record of the depth and manner in which a water or monitoring well has been constructed and equipped.
Wetlands	Areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions. BLM Manual 1737, Riparian- Wetland Area Management, includes marshes, shallow swamps, lakeshores, bogs, muskegs, wet meadows, estuaries, and riparian areas as wetlands.
Working Surface	An area leveled off to provide a place to work, as the bottom of an open pit.

7.4 ACRONYMS AND ABBREVIATIONS

AGP	Acid Generating Potential
ARD	Acid Rock Drainage
ARM	Administrative Rules of Montana
BLM	U.S. Bureau of Land Management
CEC	Cation Exchange Capacity
CEQ	Council on Environmental Quality
CFR	Code of Federal Regulations
cm/sec	centimeter per second
cy	cubic yard
DEQ	Montana Department of Environmental Quality
DNRC	Montana Department of Natural Resources and Conservation
DSL	Montana Department of State Lands
DSM	Dynamic Systems Model
EA	Environmental Assessment
EIS	Environmental Impact Statement
EPA	U.S. Environmental Protection Agency
g	gram
gpm	gallons per minute
GPS	Global Positioning System
GSM	Golden Sunlight Mine
HDPE	High-density Polyethylene
HSI	HydroSolutions Inc
hp	horsepower
ISB	Intermountain Seismic Belt
KOP	Key Observation Point
LAD	Land Application Disposal
LSI	Langelier Saturation Index
LTA	Lost Time Accident
MAA	Multiple Accounts Analysis
MBMG	Montana Bureau of Mines and Geology
MCA	Montana Code Annotated
MEPA	Montana Environmental Policy Act
meq	millequivalent
mg/l	milligram per liter
MMRA	Montana Metal Mine Reclamation Act
MSHA	Mine Safety and Health Administration
MTARNG	Montana Army National Guard
NEPA	National Environmental Policy Act
NNP	Net Neutralizing Potential
NOI	Notice of Intent
PDZ	Principal Deformation Zone
ppm	parts per million
PVC	Polyvinyl Chloride
RMP	Resource Management Plan

ROD	Record of Decision
SEIS	Supplemental Environmental Impact Statement
SHPO	Montana State Historic Preservation Office
T/Q	Tertiary/Quaternary
Tba	Tertiary Bozeman Group alluvial facies
Tbf	Tertiary Bozeman Group fluvial facies
Tdf	Tertiary debris flow
TDS	Total Dissolved Solids
Tg	Tertiary alluvial fan gravels
Tls	Tertiary land slide
Ts	Tertiary lacustrine sands
TWG	Technical Working Group
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VRI	Visual Resource Inventory
VRM	Visual Resource Management
WTP	Water Treatment Plant

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