Appendix A — Synopses of Related Environmental Documents

This appendix includes synopses of related environmental documents for the Stillwater and East Boulder mines.

A.1 Stillwater Mine

A.1.1 Final Environmental Impact Statement, Stillwater Project

Final Environmental Impact Statement, Stillwater Project, Stillwater County, Montana. Prepared by Montana Department of State Lands and USDA Forest Service, Custer National Forest. December 1985.

A.1.1.1 Proposed Action

Stillwater Mining Company proposed to open a platinum-palladium mine within the Stillwater mineral complex. The project would have a 30-year mine life at a daily production rate of 1,000 tons of ore. Underground mining by means of cut-and-fill stoping primarily would be used. Tailings from the milling process would be separated into the sand fraction and the fines fraction. The sand fraction would be backfilled into mining stopes. The fine tailings would be placed in a tailings pond next to the mill. Concentrate from the mill would be trucked to Columbus and shipped by rail to various markets. The project permit area would cover 550 acres.

A.1.1.2 Alternatives Analyzed

In addition to the No Action alternative, several action alternatives were evaluated in detail in the analysis. Production System Alternatives consisted of three alternative tailings disposal locations (including the Hertzler Ranch Site). Mine Portal Arrangement Alternatives were chosen from three arrangements. Electrical Power Supply Alternatives were selected from three options. A public access route to the West Fork Stillwater River was chosen from two possibilities.

A.1.1.3 Environmental Impacts of the Proposed Action

The main areas where issues of concern were identified included: water quality and quantity, reclamation, wildlife, aesthetic values, transportation, surface subsidence, socioeconomic effects, and scenic quality. Water quantity and quality would be affected similarly to the effects from exploration. The mine would probably discharge about the same amount and quality of water as during exploration. Detectable increases in nitrate and total nitrogen concentrations in alluvial ground water would continue downstream of the mine. Water quality of the Stillwater River would be unaffected. Very high flood flows (greater than the 1000-year flood) would encroach on the tailings impoundment, contributing sediment to the Stillwater River. During such a flood, however, the sediment load would be so high from natural sources that the added mine-related sediment would be undetectable.

Reclamation would be affected by soil disturbance and storage. Soils would lose organic matter and this loss would yield a low post-mining water- and nutrient-holding capacity. The decreased capacity would probably result in lower vegetative densities during the initial reclamation years and perhaps some initial revegetation failures. A loss of, or reduction in, soil microorganism populations caused by prolonged storage could result in lower plant species diversity and vigor for several years following initial revegetation. Forage production would increase, primarily from revegetation of 59 acres of previously disturbed lands. Plant diversity would decline from pre-mining levels.

Critical wildlife habitat would not be disturbed. Mule deer and bighorn sheep would lose a small amount of wintering range. These two species could also react to mining activities and noise by withdrawing from nearby areas. The MTFWP believed a herd reduction was imminent and that herd elimination was possible if mining were permitted. Road kills of deer would increase. Population increases in Stillwater County, of which only a portion would be mine-related, would increase housing construction, hunting and other recreation, and poaching by an unknown amount. No threatened or endangered species would be adversely affected by the proposed project.

Aesthetic impacts would be visual (scenic quality) and auditory. The mine and mill would alter the landscape, significantly affecting the visual resources at the mine site. The visual quality objectives would not be met, if at all, until sometime after the completion of reclamation. Noise levels near the mine site would increase considerably. However, because noise decreases rapidly with distance, travelers on County Road 419 would be exposed to only a small increase in noise levels. Residents within 0.5 miles could hear noises associated with the facility.

Transportation effects would include increased traffic volumes on CR 419, CR 420, and CR 78 because of increases in mine-related and household trips. CR 419 and 420 would be most affected by work traffic, and CR 78 by household trips. Increased traffic would result in increased traffic accidents and road maintenance costs. Ranchers, recreationists, and wildlife could be adversely affected by the increased traffic.

Surface subsidence from possible collapse of portions of the mine workings would present minimal long-term risk to the public.

Socioeconomic effects: Area employment and income would both increase. The first year of project construction would add 100 to 150 new jobs to total county employment. If the company proceeded with project development, mill construction would add an additional 150 jobs. During operations the project would employ 200 to 220 people. About 89 jobs would be filled by local residents. The project could increase the population of Stillwater County by 8.1 percent, Absarokee by 24.7 percent, and Columbus by 10.3 percent above the 1995 level without the mine.

A.1.1.4 Decision

The Commissioner of the Department of State Lands and the Supervisor of the Custer National Forest identified a preferred alternative, approved the project, and issued a Record of Decision in 1985.

A.1.2 Preliminary Environmental Review/Environmental Assessment (PER/EA), Stillwater Project East Side Adit Development

Preliminary Environmental Review/Environmental Assessment (PER/EA), Stillwater Project East Side Adit Development. Montana Department of State Lands and Custer National Forest. February 1989.

A.1.2.1 Proposed Action

Stillwater Mining Company proposed to develop the ore reserves on the east side of the Stillwater River in order to reach 1000 tons per day (TPD) of ore production. SMC proposed the development of six adits and one shaft. Ore from the east side development would be trucked to the west side for processing in the existing mill/concentrator. Waste rock not used for construction or other uses would also be trucked to the west side for use in constructing the tailings impoundment dam. Tailings impoundment capacity and design would not change from that approved in 1986.

A.1.2.2 Alternatives Analyzed

Three alternatives were considered in detail. They included the Proposed Action (Alternative 1), the Proposed Action with several agency-identified mitigation measures (Alternative 2), and the No Action Alternative (Alternative 3).

A.1.2.3 Environmental Impacts of Proposed Action

Various impacts were considered capable of being fully mitigated with the implementation of the following measures: (1) two measures to provide traffic reduction; (2) two measures to reduce visual impact; (3) six specific actions to compensate for losses to bighorn sheep habitat; (4) two measures to protect raptors; (5) four measures to monitor ground water quantity and water rights; (6) three measures to protect water quality; and (7) a measure to protect cultural resources.

A.1.2.4 Decision

The decision was made by the Commissioner of the Department of State Lands and the Supervisor of the Custer National Forest to select Alternative 2 and approve the project (Amendment No. 5) with a Finding of No Significant Impacts on March 2, 1989.

A.1.3 Final Environmental Impact Statement, Stillwater Mine Expansion 2000 Tons Per Day, Application to Amend Plan of Operations and Permit No. 00118.

Final Environmental Impact Statement, Stillwater Mine Expansion 2000 Tons Per Day, Application to Amend Plan of Operations and Permit No. 00118. Prepared by Montana Department of State Lands, Montana Department of Health and Environmental Services, and Forest Service. 1992.

A.1.3.1 Proposed Action

SMC proposed to increase the mine production rate up to 730,000 tons per year (2,000 TPD). Included in the proposal was enlargement of the tailings impoundment, expanding waste rock storage, new buildings and berms, etc, on 35 acres, expanding processing facilities capabilities, relocating certain buildings, an incremental addition of 161 additional employees, and an application to change ambient water quality for total dissolved solids, ammonia, nitrates, and metals in both surface and ground water.

A.1.3.2 Alternatives Analyzed

Five alternatives were considered in detail. They were No Action, Proposed Action, Proposed Action with Modified Tailings Impoundment (Partial Approval), Proposed Action with Advanced Water Treatment, and Proposed Action with Modifications to Tailings Impoundment, Waste Rock Storage, and Water Resources.

A.1.3.3 Environmental Impacts of Proposed Action

About 35 acres of new disturbance would occur. Marginal reclamation would occur because of limited replacement soils. Facilities would eliminate vegetative production on 42 acres. Irrigation with nitrate-rich water would increase plant growth. The bighorn sheep herd would continue to be threatened; facilities would eliminate forage on the toe dike. Atmospheric emissions would increase, but permit levels would not be exceeded. Recreational use in area would increase some. Visually, the embankment would be raised 14 feet, the rock armor would be visually uniform, a longer period of time would be necessary to achieve retention of visual quality, and visual screening would be provided by berm on east side. A total employment impact of 232 jobs would occur. Stillwater County's population would increase by 150 people more than projected. Demands would increase for housing, community services, and community facilities. Traffic would double to about 262 vehicles per day.

A.1.3.4 Decision

The agency decision makers approved and permitted the amendment (Amendment No. 8) on September 23, 1992.

A.1.4 Final Environmental Impact Statement, Stillwater Mining Company Underground Valley Crossing and Mine Plan.

Final Environmental Impact Statement, Stillwater Mining Company Underground Valley Crossing and Mine Plan. Application to Amend the Plan of Operations, Permit No. 00118. Prepared by Montana Department of Environmental Quality. February 1996.

A.1.4.1 Proposed Action

In April, 1995, SMC proposed to amend its Operating Permit by proposing to connect the East and West mining areas by means of a haulage drift located at the 4400-foot level of the mine. The haulage drift would be developed beneath the Stillwater River and its floodplain. As part of the proposed amendment, SMC sought approval to mine the ore body at and below the 4400-foot level if and when mineralization was defined.

The project would be conducted in two phases. Phase 1 would include completion of the 4400-foot level haulage drift and the diamond drilling necessary to define the mineralization. Phase 2 would involve implementation of mining below the surface crown pillar. Approval of the proposed amendment would allow SMC to reduce ore and waste handling costs by reducing haul distances to the mill and to crush ore prior to reaching the mill, to access and further delineate additional ore reserves, and to reduce conflict with recreational traffic using County Road 419.

A.1.4.2 Alternatives Analyzed

Three alternatives were considered by DEQ. They were the Proposed Action, No Action alternative, and Proposed Plan with Modifications.

A.1.4.3 Environmental Impacts of Proposed Action

Impacts were analyzed to address the issues of geotechnical stability, increased inflow of ground water to the workings, and water quality of both surface and ground water. Stability analyses indicated the proposed crown pillar thickness (200 ft) was adequate. The long-term stability of the pillar was not considered to be an issue, particularly because SMC proposed to backfill the 4400-ft level haulage way at closure where it would be adjacent to the base of the crown pillar. In addition, all stopes would be backfilled upon completion of mining.

Inflows of ground water were expected to be similar to flows previously observed in the East Side Mine. The predicted rate of inflow to the haulage level

(200 gpm) was not expected to have any impact on flow in the Stillwater River or ground water levels in the valley.

Ground water and surface water quality were not expected to change following implementation of the proposed action. Mine production rates and associated nutrient loading from the mining activities would not be increased by the proposed action and would not exceed the levels analyzed in the SMC 2000 TPD EIS.

A.1.4.4 Decision

The Director of DEQ approved the permit amendment (Amendment No. 9) and the project was permitted in 1996.

A.1.5 Final Environmental Impact Statement Stillwater Mine Revised Waste Management Plan and Hertzler Tailings Impoundment.

Final Environmental Impact Statement Stillwater Mine Revised Waste Management Plan and Hertzler Tailings Impoundment. Prepared by Montana Department of Environmental Quality and USDA Forest Service. October 1998

A.1.5.1 Proposed Action

The proposed action amended operating permit #00118. Specific changes included: a new tailings impoundment on the Hertzler Ranch 7.8 miles northeast of the mine; a system of pipelines along Stillwater County roads 419 and 420 connecting the tailings impoundment to the mine and mill; expanding the waste rock storage areas on the east side of the Stillwater River; relocating the Land Application Disposal (LAD) system from the east side of the Stillwater River to both the Stratton Ranch and the Hertzler Ranch; and removing the 2000 tons per day restriction on processing ore.

A.1.5.2 Alternatives Analyzed

Four alternatives were analyzed: Alternative A — No Action, Alternative B — Proposed Action, Alternative C — Modified Centerline Expansion of the Nye Impoundment and a smaller Hertzler impoundment, Alternative D — Modified Centerline Expansion of the Nye impoundment plus a new impoundment and waste rock storage facility on the east side of the Stillwater River.

A.1.5.3 Environmental Impacts of Proposed Action

Key issue areas included water quality and quantity, wildlife, fisheries, air quality, socioeconomics, tailings impoundment stability, aesthetics, transportation and reclamation. Ground water quality would be affected by localized increases in nitrates. Surface water quantities would experience short-term increases in runoff. Surface water quality would experience minor degradation but no standards would be violated. Nitrate levels in the Stillwater River would increase, but would not violate any standard. Approximately 1.5 acres of wetlands (Waters of the U.S.) would be affected by the pipeline route, but these effects would be mitigated through in-kind reclamation. Air quality would experience slight increases in particulate matter, especially during construction. Vegetation and wildlife habitat communities on 678 acres would be changed from the current agricultural mixture of species to a different mixture after reclamation. Fish reproduction in the Stillwater River could be affected from increases in sedimentation over the short-term.

Socioeconomic effects would include approximately 424 new residents, including 34 new school students, 45 new jobs created, and a continuation of tax payments by SMC for an additional 30 years. Visual intrusion by new facilities would not violate visual quality objectives on Forest lands. Construction noise would be created at all new facilities. Transportation effects would increase the AADT on Stillwater County roads 419 and 420 from 803 to 906. Construction of the pipeline corridors would disrupt traffic on the roads in the short-term. No direct effects would occur to cultural resources.

A.1.5.4 Decision

The Director of DEQ and Supervisor of the CNF approved the permit amendment and Operating Plan revision, respectively, and the Proposed Action with mitigation measures was permitted in 1998.

A.2 East Boulder Mine

A.2.1 Final Environmental Impact Statement, East Boulder Mine Project.

Final Environmental Impact Statement, East Boulder Mine Project. Prepared by Montana Department of State Lands, USDA Forest Service, and Montana Department of Health and Environmental Services. 1992.

A.2.1.1 Proposed Action

The East Boulder Mine Project consists of an underground mine, a surface mill and support complex, a tailings impoundment and ancillary facilities located in Sweet Grass County about 30 miles south of Big Timber, MT. The majority of surface facilities would be in the East Boulder River valley.

A.2.1.2 Alternatives Analyzed

Seven alternatives were analyzed including: 1 – No Action, 2 – Proposed Action, 3 – Modified tailing impoundment configuration, 4 – Alternative access road and power line, 5 – Alternative power supply corridor systems, 6 – Water treatment options, 7 – Proposed Action with modifications, and 8 – Twin production adits instead of one adit.

A.2.1.3 Environmental Impacts of Proposed Action

Issue areas were identified as socioeconomics, transportation, surface and ground water, air quality and noise, wildlife, fisheries and vegetation, recreation and visuals, land use, geology, reclamation, health and safety, and the permitting procedure. Population growth was expected to occur in Big Timber as a result of increased employment at the mine. About 170 persons in the first year and up to 600 workers maximum would be employed. Indirect employment was expected to increase, as is the student population. Demands for housing and community services were expected to increase. Estimated tax revenues resulting from the project increase, but would lag behind the increase in need for services. Transportation effects would include increases in traffic, road maintenance, and a reduction in traffic safety for residents. Potential impacts to surface waters include sediment runoff to streams and water quality degradation from turbidity and nutrients or chemical loading. Impacts to ground water quality could occur from improper disposal of process waters, impoundment leakage, and chemical spills. Air quality would be decreased due to increased particulate and gaseous emissions. Noise would be generated at all facilities. Vegetation and wildlife habitat would be disturbed on 233 acres (most of which is timbered), and disturbance to wildlife would increase from increased traffic and area access. Fisheries could be affected by sediment loading, changes in water quality, changes in fish passages, and in fishing pressure.

Impacts to fishing and hunting quality and dispersed recreation would result. Visual effects on line and color in foreground views would result from construction of facilities, especially the tailings impoundment. Effects on land use would result from increased noise and traffic, and to the timber management by the USFS. Geological impacts would include changing landforms, creating a tailings impoundment, and the depletion of the mineral resources.

A.2.1.4 Decision

The decision-makers of DEQ, DHES and the Supervisor of the GNF approved the mine operating permit application (Plan of Operations), and the Proposed Action with mitigation measures was permitted in 1992.

Appendix B — Monitoring Plan for Boe Ranch LAD System Agency-Mitigated Alternative 3C

If the Boe Ranch LAD System Agency-Mitigated Alternative 3C is selected and approved by the agencies, the additional components listed in this appendix would be included in the Stillwater Mining Company's (SMC's) monitoring plan. Although the monitoring program under the Boe Ranch LAD System Proposed Action Alternative 2C would indicate effects on ground water from land application disposal (LAD), it would not provide data to evaluate the health of the soil resource beneath the LAD area. Selection of the Agency-Mitigated Alternative 3C would minimize the potential for direct adverse short-term and long-term effects from the accumulation of nitrogen and salts in Boe Ranch soils. The agencies' additional monitoring requirements and action plans would ensure that nitrogen and salts problems do not develop over the life of the Boe Ranch LAD system.

Under the Agency-Mitigated Alternative 3C, SMC would monitor the weather, soil quality, soils saturation, LAD application rate, vegetation, and water quality at the Boe Ranch LAD area. The monitoring plan would include threshold conditions and levels that, if exceeded, would trigger changes in LAD operation. SMC would propose to the agencies six to 12 months prior to the construction of the Boe Ranch LAD system a monitoring plan that includes these additional components. The agencies would review and approve the plan prior to implementation. Additional baseline soil, vegetation, water, and climate data would have to be collected before LAD is implemented at the Boe Ranch.

B.1. Monitoring

B.1.1 Weather

SMC would establish a complete weather station at the Boe Ranch site to collect baseline climate information at least one year before LAD is initiated and during operations. The agencies and SMC would jointly locate this station. Data from the station would be used to develop water budgets and to plan irrigation schedules for the Boe Ranch LAD System. Precipitation, wind speed, and weather predictions would be used with soil moisture data to determine the appropriate amount and rate of water to be applied through the LAD system. These data would be used to prevent surface runoff, over-irrigation (*i.e.,* saturation) of soils, salinization of soils, and to maximize plant uptake of nitrogen. The agencies suggest that SMC use a real-time system capable of electronically relaying this information immediately to SMC.

B.1.2 Soils

The following sections provide conceptual details of the proposed monitoring plan for soils.

B.1.2.1 Soils Mapping and Physical Characteristics

To facilitate the proper location of lysimeters, moisture probes, and soils sampling sites, the variability of soils within each proposed center pivot and adjacent control site(s) would be assessed through an Order II soil survey. The Order II soil survey would describe the gradation and range of soil properties and clearly depict each soil unit on an appropriately-scaled map. The survey would also include the following soil parameters:

- Thickness of horizons
- Porosity
- Texture
- Coarse fragment content
- Moisture content
- Bulk density
- Estimate of field capacity
- Depth to water table
- Existing surficial cracks and fill slope bulges

All future soils information would be consistently presented and coupled with the Order II soil survey and map. The location and dimensions of any changes in existing or new major surficial cracks and fill slope bulges would be identified and mapped.

B.1.2.2 Baseline Soils Quality Data

Baseline soils samples would be collected according to soil types and horizons, down to a depth of at least five feet or to the lithic contact. Samples would be collected using standard sample collection and handling quality assurance/quality control procedures. Each sample would be analyzed for:

- Nitrite plus Nitrate nitrogen (NO_2^- + NO_3^-)
- Ammonium (NH^+_4)
- Total Kjeldahl Nitrogen (TKN)
- Total Organic Carbon (TOC)
- Sodium Adsorption Ratio (SAR)
- Saturated Paste Extract Electrical Conductivity (EC) and pH

These data would be used to assess the health and condition of LAD area soils, identify major and critical soil types, and assist in developing irrigation schedules.

B.1.2.3 Operational Soils Monitoring

SMC would submit, six to 12 months prior to the construction of the Boe Ranch LAD system, a detailed plan for the location, installation, and monitoring schedule of lysimeters and moisture probes. The plan would include SMC's proposed schedule and criteria for application of LAD. Soils data would be collected within and downgradient of the proposed LAD areas and established in similar reference areas not influenced by the LAD. These locations would represent the major soil units within each area covered by the center pivots and, if present, critical units that have the most limitations or would most likely be affected by operation of the LAD system (*e.g.*, high-permeability, large coarse rock fragment content, potential for mass wasting). These locations would accurately reflect the variability in landscape and soils, position relative to prevailing winds, probable drift from the pivots, and potential for surface runoff and shallow subsurface interflow. At least one soil moisture probe (or array) would be located beneath each center pivot.

The soil profiles would be sampled by soil horizon. All lysimeters, moisture probes, and soil sampling sites would be permanently staked for identification on the ground, and delineated on a map for regular monitoring during and after the life of the LAD.

The weather station, array of lysimeters, soil moisture probes, and soil sampling sites are intended to provide data for the accurate estimation of evapotranspiration (ET), uptake of nitrogen by native and introduced plant species, attenuation and export of nitrogen and salts, and the annual loading of nitrogen and salts to the ground water. Considerable variation in ET rates would occur over the 30-year period of LAD operation. Daily soil water monitoring would be conducted, so irrigation would be optimized to control percolation of LAD water below the root zone. Soil moisture probes would be calibrated to the soil's moisture characteristics and have the capability of defining moisture content throughout the soil profile. The agencies suggest that SMC use a real-time system capable of electronically relaying this information immediately to SMC.

B.1.2.4 LAD Application Rate and Soil Water

Denitrification (net loss of nitrogen from the system) is negligible at moisture levels below about two-thirds of the water-holding capacity but is appreciable in flooded soils (Stevenson 1982). To facilitate the gaseous loss of nitrogen from soil, the LAD irrigation rate would be adjusted to maintain 65 to 80 percent of saturation in the top 12 to 18 inches of the soil profile. Optimal soil moisture content would facilitate denitrification through maximization of soil moisture residence time in the root zone.

To maximize plant nitrogen uptake and minimize the potential for runoff and nitrogen leaching below the root zone, SMC would adjust daily the LAD water application rate based on addition to soil water from precipitation and depletion of soil water by ET.

A daily water budget would be constructed to track water moving into and out of the effective root zone. The water budget would be solved in terms of daily soil moisture depletion. The amount of irrigation applied per day would be less than or equal to the amount of soil moisture depleted the previous day. Daily water budgets would be based on:

- Soil moisture readings
- Predicted or actual rainfall
- Depth of root zone (*i.e.,* soil reservoir water storage capacity)
- Soil field capacity
- Status of SMC's water balance
- Amount of LAD evaporated
- Amount of LAD delivered to soil
- Soil salts monitoring
- Ground water monitoring

LAD water application rates would be reduced with precipitation and when actual ET is low. LAD water application rates would increase when there is no precipitation and actual ET is high.

The volume of water collected in all lysimeters would be measured and noted weekly. Samples would be regularly collected according to standard sample collection and handling procedures for the following analyses:

- $NO_2^- + NO_3^-$
- NH^+_4
- TKN
- Chloride
- Sulfate
- EC
- pH

The results of these analyses would be compared with ground water quality data to evaluate nitrogen utilization by plants and the effect of deep percolate on ground water. SMC could apply at greater than these rates if a problem with the water balance or soil salinity develops as long as water quality levels are below the threshold action levels established for the site.

B.1.3 Ground Water, Seeps, and Springs

SMC would propose a monitoring network that encompasses the full extent of the Boe Ranch LAD system to the East Boulder River. This network would be placed to ensure identification of water quality changes due to application of LAD and any leaks from the LAD storage pond.

Pairs of monitoring wells consisting of a shallow, glacial-layer well and a bedrock well would be located upgradient, within, and downgradient of the LAD area.

The monitoring wells would be used to indicate whether an increasing trend of nitrogen or salts was occurring as a result of LAD.

Prior to the construction of the Boe Ranch LAD system, SMC would document the location and flow rate of seeps and springs downgradient of the Boe Ranch LAD area. SMC would propose for agency review and approval a list of seeps and springs to monitor. During the irrigation season, SMC would periodically perform visual inspections for new seeps and surface runoff caused by LAD and make appropriate adjustments to LAD application rates. SMC would document new seep location(s) using GPS coordinates, estimate the flow rate of the seep(s), and report the formation of new seeps to the agencies.

Monitoring wells and selected seeps and springs would be sampled at least three times annually (spring: March to April, summer: July to September, and fall/winter: November to January), according to standard sample collection and handling quality assurance/quality control procedures, and analyzed for the following parameters.

- $NO_2^- + NO_3^-$
- NH^+_4
- TKN
- Common ions (Ca, Mg, K, Na, Cl, SO_4, carbonate, bicarbonate, and hardness)
- EC
- pH

If newly identified seeps have sufficient volume to sample, they would also be sampled for these parameters.

B.1.4 LAD Storage Pond, Mason Ditch, and East Boulder River

The volume of water in the LAD storage pond would be measured and used in SMC's overall water balance calculations. SMC would include in its LAD operation plans contingencies for those times when a positive (excess) water budget exists due to precipitation or high water inflows at the East Boulder Mine.

The Mason Ditch and the East Boulder River would be sampled at least three times annually (spring: March to April, summer: July to September, and fall/winter: from November to January), according to standard sample collection and handling quality assurance/quality control procedures, and analyzed for the following parameters.

- Flow rate
- $NO_2^- + NO_3^-$
- NH^+_4
- TKN
- Common ions (Ca, Mg, K, Na, Cl, SO_4, carbonate, and bicarbonate)
- EC
- pH

The results of the Mason Ditch monitoring would allow the agencies to determine its effect on the quality of ground water flowing from the land application area to the East Boulder River. Flow information for both the Mason Ditch and the East Boulder River would be necessary to interpret the effect of land application on ground and surface water.

B.1.5 Vegetation

Vegetation would be sampled periodically to document plant community compositional changes and health over time. SMC would include vegetation management in its plan submitted to the agencies for review and approval.

B.1.6 Mass Wasting

SMC would not use center pivot 10 (P10) because of mass wasting concerns. CES (2008) recommends undertaking additional investigation to assess the soils' ability to absorb the design flow LAD capacity near center pivot P9. The agencies would recommend the same level of sampling near P4.

SMC would submit a plan that would identify conditions that favor slumping or mass wasting around center pivots P4, P9, and P10. In this plan, SMC would consider the effect of deep percolate (soil water) on slope stability within the Boe Ranch LAD area. SMC would perform regular slope stability inspections during operation of the LAD system and provide in its plan operational adjustments that could be made if conditions were identified that favor slumping or mass wasting around the center pivots or storage pond. A geotechnical specialist would look for visible signs of slope movement, soil failures, and other indications of deep-set slope instability annually for a period of three years. The need for further annual geotechnical inspections would be reviewed at that time.

The location and dimensions of major surficial cracks and fill slope bulges identified in the baseline survey would be monitored and any changes would be reported to the agencies. This information would be used to determine if surface cracks and fill slope bulges were the result of LAD activities. Surficial fractures that progressively widen and elongate, or surface cracks located above a prominent, recently-observed surface bulge would be considered an indication of slope failure. If the potential for instability raises concerns for public safety or the environment, SMC would develop corrective plans.

B.2. LAD Storage Pond High-Hazard Action Plan

SMC would prepare an Operations and Maintenance Plan and an Emergency Preparedness Plan for the high-hazard Boe Ranch LAD storage pond for review and approval by the Montana Department of Environmental Quality (DEQ). DEQ would consult with the Montana Department of Natural Resources and Conservation (DNRC) to ensure that the plans met the requirements of the Montana Dam Safety Act. SMC would also prepare a conceptual plan for reducing the volume of water in the LAD storage pond to less than 50 acre-feet at closure to eliminate the high-hazard classification. These plans would have to be submitted six to 12 months before the LAD storage pond is constructed.

B.3. LAD Pipeline Monitoring and Spill Contingency Plan

SMC would prepare for agency review and approval a Pipeline Monitoring and Spill Contingency Plan (PMSCP) for operation of the LAD supply pipeline from the East Boulder Mine. The plan would be submitted for approval by DEQ and the Gallatin National Forest (GNF) six to 12 months before the pipeline and LAD system are constructed.

B.4. Threshold Conditions, Action Levels, and Reporting

The primary concerns associated with the land application of mine water are the accumulation of nitrates and salts in soil and subsequent transport through ground water to the East Boulder River. The following threshold action or trigger levels would address these concerns.

The threshold action level for nitrogen in ground water would be 2 mg/L total inorganic nitrogen (nitrogen) above the ambient nitrogen concentration. This action level would identify over-application of LAD in wells upgradient of the LAD storage pond. The agencies may choose to select a seep as an alternate monitoring site to evaluate the application of LAD. The threshold action level for EC in ground water would be an increase of 20 percent above the baseline conditions. This action level would identify over-application of LAD in wells upgradient of the LAD storage pond. The agencies may choose to select a seep as an alternate monitoring site to evaluate the application of LAD.

If either of these threshold action levels were exceeded, SMC would immediately notify the agencies and take the appropriate measures to address the exceedance(s). SMC would identify in its plan several potential measures that would reduce nitrogen and salts loading from LAD. Potential action/contingency measures may include but are not limited to the following:

- Interseed with vegetation that is compatible with the surrounding ecosystem, adapted to local climatic conditions, and able to sequester larger amounts of nitrogen or tolerate the salts load.
- Mechanically remove aboveground plant biomass and standing litter in accessible areas.
- Manage livestock to facilitate the net removal of nitrogen.
- Periodically burn vegetation if it can be implemented safely under controlled conditions.
- Reduce the hydraulic load delivered to the LAD area to prevent seeps, erosion, and mass wasting.
- Reduce the nitrogen and salts load delivered to the LAD area. The adit and tailings waters should be monitored annually for EC and total dissolved solids (TDS) to provide advance warning of any salinity increase. Such monitoring would allow SMC to implement adaptive management actions to avoid concentrating salts in LAD area soils and vegetation when the tailings waters are disposed of at closure. SMC would supplement the frequency of its monitoring of salts in adit and tailings waters and make efforts to reduce the salts load and concentrations annually. SMC would include in each annual report the measures imple-

mented and the resulting reductions in salts concentrations achieved during the past year.

- Improve nitrogen removal efficiency of the BTS.
- Implement a salts removal treatment system at the East Boulder Mine.
- Redesign portions of the LAD system to allow regular mechanical removal of plant biomass.

Some of these action/contingency plans may not be feasible at the Boe Ranch or would have other effects that may negate the benefits. Regardless of the action/contingency plans implemented, SMC would be required to perform monitoring and assessment of the LAD system to see if operational changes could be made that could influence monitoring results. Some additional actions include:

- If either of the following triggers occur that may be reasonably attributed to the Boe Ranch LAD area, SMC would evaluate the extent of mining-related impacts on periphyton and macroinvertebrates for two additional, consecutive, late summer sampling events to establish whether a trend exists: annual chlorophyll A measurements indicate impairment (greater than 150 mg/m^3) based on the MDEQ narrative standard (Suplee et al 2009), or in-stream total inorganic nitrogen exceeds 1 mg/L downstream of the Boe Ranch LAD.SMC would submit to the agencies the results of monitoring at the end of the first two LAD seasons. If monitoring shows little effect, reporting may be changed to annual. Also, if monitoring suggests some constituents are not appearing in ground water after the first five years of operation of the Boe Ranch LAD facility, SMC may provide written documentation and request that those parameters be dropped from monitoring.

SMC would monitor the flow rate of the East Boulder River during operations. If the flow in the East Boulder River downstream of the Mason Ditch irrigation diversion drops below 3 cubic feet per second (cfs), SMC would have to dispose of some of the nitrogen load at the East Boulder Mine.

SMC would have to implement additional monitoring and mitigating measures if soil SAR concentrations in the Boe Ranch LAD area downgradient monitoring well increase two units above the Boe Ranch LAD storage pond water SAR concentrations.

If the LAD supply pipeline leaks or ruptures, SMC would sample the discharge and report to the agencies as directed in the PMSCP. A cleanup plan would have to be submitted in the PMSCP.

If the LAD storage pond develops a leak as indicated by downgradient ground water monitoring wells, a leak response plan would have to be submitted for agency review and approval.

Appendix C — Agency Water Quality & Quantity Analyses

The analyses and technical memoranda published as draft in this appendix have been revised in response to public comment. The final revised spreadsheets and memoranda are found in Appendix E.

Appendix D — Boe Ranch Supporting Data

This appendix contains maps and tables used in the agencies' effects analysis for the Boe Ranch LAD System Proposed Action Alternative 2C and the Boe Ranch LAD System Agency-Mitigated Alternative 3C.

Table 15. Average Hydraulic Flow Capacity and Management Summary- Operations or Closure

Alternative	Site	Average Flow Capacity [1] Growing Season gpm	Winter gpm	Total LAD Capacity gpm	Percolation Pond gpm	Total Flow gpm	Max N-Load lb N/d	Maximum Volume in Boe Ranch Storage Pond MG	Comments
No Action - 1C	**East Boulder Mine**								
	LAD 6	**14**	**45**	**24**	**21**	**45**	**2.7**	**N/A**	**Phase Ia, No LAD April, May or October**
	LAD 6, 3 Upper	25	81	44	37	81	4.9	N/A	Winter Snowmaking, Summer LAD
	LAD 6, 3 Upper, 4	36	117	64	53	117	7.0	N/A	Winter Snowmaking, Summer LAD
	LAD 6, 3 Upper/Lower, 4	57	117	72	45	117	7.0	N/A	Add Summer Only Area 3 Lower
	LAD 6, 2, 3 Upper/Lower, 4	68	117	77	43	117	7.0	N/A	All East Boulder LAD Sites
	LAD 6, 2, 3 Upper/Lower, 4	68	117	77	660	737	73.5	N/A	Full Permitted Flow, Additional N Treatment Needed for East Boulder Discharge
Proposed Action - 2C	**Boe Ranch**								
	Upper Boe Ranch	**166**	**166**	**166**	**0**	**166**	**N/A**	**46**	**Phase Ib, No East Boulder LAD**
	Upper Boe Ranch + East Boulder Mine	243	243	243	0	243	1.8	50	If Boe Ranch and all East Boulder LAD Areas are constructed
Agency-Mitigated Action - 3C	**Boe Ranch**								
	Upper Boe Ranch	**162**	**162**	**162**	**0**	**162**	**N/A**	**45**	**Phase Ib, No East Boulder LAD**
	Upper Boe Ranch + East Boulder Mine	239	239	239	0	239	1.8	49	If Boe Ranch and all East Boulder LAD Areas are constructed

NOTES:

Capacities developed from monthly water balances created to illustrate possible water management practices. Winter LAD capacity based on East Boulder Mine Snowmaking Test (SMC, 2004) and 68 inches snow accumulation at 40% snow water equivalent. Growing season flow based on vegetation ET according to Montana Guidelines. Storage Pond capacity is 108 million gallons. Storage pond allows steady flows year round without percolation pond use.

Abbreviations: gpm = gallons per minute, MG = million gallons, lb N/d = pounds nitrogen per day, ET = evapotranspiration, LAD = land application disposal, Max = maximum.

1 Flows computed as gallons per minute for the season or year for comparison with SMC Water Management Plan (SMC, 1998b) = total gallons per year ÷ 1440 minutes per day ÷ days per season or year. Adit flow assumed stable. Growing Season = Jun - Oct (153 days) and is conservative using the high range precipitation. Winter = Nov - Mar (151 days).

2 LAD and Percolate Pond discharge vary on a daily basis. Max. N-Load is the maximum average daily nitrogen load at the East Boulder Mine site assuming the first 250 gpm are treated 5 mg N/L with any flow additional at 10 mg/L. Actual treatment performance shown to provide less than 5 mg/L.

3 Phases represent the Phased development of LAD in the Boe Ranch Alternative (Knight-Piésold. 2002.Stillwater Mining Company East Boulder Project, Water Management Plan Appendix K, Boe Ranch LAD Alternative, Revision 3 (Ref # 31333/18-1). Knight Piesold, Inc. Vancouver, B.C. Canada, updated April 2002.)

Table 17. Summary of Projected LAD Deep Percolation Losses- Soil Water Volume - All Alternatives (1C, 2C, 3B, and 3C)

Location	Site Type	Predicted LAD Percolate Loss								Soil AWC[2]
		Winter	Summer	Total	Leaching Reqm't[1]	Winter	Summer	Total	Leaching Reqm't[1]	
		inches per acre				inches per acre				
Operations		**Low Precipitation**				**High Precipitation**				
East Boulder Mine	Summer Only	2.6	0.3	**2.9**	**1.6**	7.0	1.1	**8.1**	**1.1**	5.7
	Winter & Summer	29.7	0.4	**30.1**	**5.5**	34.1	1.1	**35.2**	**4.9**	5.7
Boe Ranch	Boe Ranch LAD	2.6	0.3	**2.9**	**1.6**	7.0	1.1	**8.1**	**1.1**	7.8
	Boe Ranch Evaporators[3]	0.0	0.0	**0.0**	**0.0**	0.0	0.0	**0.0**	**0.0**	N/A
	Boe Ranch Snow[4]	15.1	0.0	**15.1**	**3.8**	21.8	0.0	**21.8**	**3.7**	7.8
Closure - Proposed Action Alternative 2B[5]		**Low Precipitation**				**High Precipitation**				
East Boulder Mine	Summer Only	2.6	0.3	**2.9**	**1.8**	7.0	1.1	**8.1**	**1.1**	5.7
	Winter & Summer (LAD 6)	29.7	0.4	**30.1**	**6.9**	34.1	1.1	**35.2**	**6.3**	5.7
Closure - Agency Mitigated Action Alternative 3B[5]		**Low Precipitation**				**High Precipitation**				
East Boulder Mine	Summer Only	2.6	0.3	**2.9**	**1.7**	7.0	1.1	**8.1**	**1.1**	5.7
	Winter & Summer (LAD 6)	29.7	0.4	**30.1**	**6.4**	34.1	1.1	**35.2**	**5.8**	5.7
Closure - Proposed Action 2C		**Low Precipitation**				**High Precipitation**				
Boe Ranch	Boe Ranch LAD	2.6	0.3	**2.9**	**1.9**	7.0	1.1	**8.1**	**1.4**	7.8
	Boe Ranch Evaporators[3]	0.0	0.0	**0.0**	**N/A**	0.0	0.0	**0.0**	**0.0**	N/A
	Boe Ranch Snow[4]	15.1	0.0	**15.1**	**4.5**	21.8	0.0	**21.8**	**4.4**	7.8
Closure - Agency Mitigated Action 3C		**Low Precipitation**				**High Precipitation**				
Boe Ranch	Boe Ranch LAD	2.6	0.3	**2.9**	**1.8**	7.0	1.1	**8.1**	**1.3**	7.8
	Boe Ranch Evaporators[3]	0.0	0.0	**0.0**	**N/A**	0.0	0.0	**0.0**	**N/A**	N/A
	Boe Ranch Snow[4]	15.1	0.0	**15.1**	**4.3**	21.8	0.0	**21.8**	**4.2**	4.3

NOTES:

Estimated deep percolation volumes for LAD at East Boulder Mine and Boe Ranch. Based on MT LAD Guidelines operations in summer, approximately 68 inches depth for snowmaking in winter. Summer Flow is May or June - October. Snow melt is assumed April and May. Winter snowmaking is November through March. Predictions are for average Low and average High precipitation years (Knight-Piesold, 2000).

Abbreviations: LAD = land application disposal; Reqm't = requirement; gpm = gallons per minute.

1 Leaching requirement computed from average electrical conductivity of applied mine water. Represents amount of deep percolation needed to prevent salts accumulation and maintain soil salinity less than 2 mmhos/cm (Ayers and Westcot, 1985).

2 Soil available water holding capacity shown for perspective compared to leaching requirement and deep percolation.

3 Evaporators operate over the pond so there is no percolate loss or load to be calculated.

4 Deep percolation from snowmelt includes natural and artificial snow and assumes 30% of artifical snow will runoff into storage pond.

5 Alternative 3B is in place because there were no plans under no action for East Boulder Mine Closure. Includes up to 18 months to empty Tailings Impoundment (51 gpm) + adit flow to LAD and percolation pond up to 250 gpm.

Appendix E — *Revised* Agency Water Quality & Quantity Analyses

This appendix contains the spreadsheets that have been revised in response to comment and four agency technical memorandums. These revised spreadsheets form the basis for the agencies' water quality and quantity analyses and effects disclosure.

Two technical memoranda have been revised and two new memoranda were written to respond to comments received on the DEIS.

- Revised projected nitrogen concentration decline in adit water when operations cease;
- Revised projected nitrogen loading estimates to the Stillwater River from the shaft at post-closure;
- New potentials for acid generation and metals mobility from ore, tailings, and waste rock;
- New in-stream nutrient criteria.

TECHNICAL MEMORANDUM

February 16, 2012

To: Kristi Ponozzo, MEPA Specialist, MDEQ
Pat Pierson, NEPA Coordinator, Custer and Gallatin National Forests, USFS

From: Lisa M. Boettcher C.P.G., Reclamation Specialist, MDEQ LB

Re: ***Revised*** Projection of Nitrogen Concentration Decline in Adit Water at the Stillwater Mining Company Mines at Nye (Stillwater Mine) and Big Timber (East Boulder Mine), Montana

What has been revised since the DEIS:

- Comments received during the comment period on nitrogen speciation are addressed in detail.
- Data from the decline of nitrogen concentration during the interim shutdown at the Troy Mine, Troy, Montana have been added.
- Further clarification of how the nitrogen decline curve would be used to determine the length of time that water treatment would be needed at closure.
- Tables that contained raw data (Table 1), annually-averaged nitrate data (Table 2), and extrapolated nitrogen concentrations in untreated adit water at closure (Table 3), are displayed graphically in figures 2, 3, and 4, respectively. These tables have been deleted from this technical memorandum.

This memo describes the analysis performed to project the decline of nitrogen concentrations in adit water from workings that do not flood during closure and post-closure at the Stillwater and East Boulder mines. Other calculations have been made with respect to flooded workings and are included in the Appendix E, March 2012 revised technical memorandum discussing Projection of Post-closure Water Quality and Nitrogen Loading from the Stillwater Mine Shaft, Stillwater Mining Company, Nye, Montana. However, it should be clarified that these memos do not address the need for treatment prior to disposal of undiluted tailings waters by percolation or land application.

Adit water would discharge from both mines following closure (*i.e.,* post-closure). If the concentrations of nitrogen in discharged waters during closure could be projected accurately, the agencies could then identify the length of time that treatment of adit water would be needed. The agencies could also identify whether there is potential for, and the duration of, post-closure untreated water quality effects.

The Stillwater Mine changed its mining plan and suspended blasting in the east-side workings in 2002. As a result of the suspension of blasting, the nitrogen concentration has declined in east-side adit water from 10.3 mg/L to less than 0.2 mg/L. The agencies believe that this 10-year decline in nitrogen concentrations measured in the east-side adit water would be representative of the rate of decline in concentrations that would occur during closure and continue into the post-closure period.

The agencies have used these nitrogen concentration data to construct a mathematical model of the post-2002 decline and used the model to project the concentrations of nitrogen in adit water that could be expected at closure and post-closure. The agencies have used standard regression analysis to develop a nitrogen decline curve. This type of analysis describes the nature of the relationship between the two variables of interest: nitrogen concentration in adit water and time. It is used to predict the value of the concentration of nitrogen in mg/L with time.

The assumptions underlying this analysis are:

- There is adequate similarity of characteristics (*e.g.* geology, hydrogeology, chemical composition of ore and waste rock, operations methodology, housekeeping practices, adit water background quality, tailings water quality, etc.) between the Stillwater and East Boulder mines that a direct comparison between the mines can be made;

- The nitrogen concentration decline observed by the ramping down and suspension of activity on the East Side of the Stillwater Mine is directly comparable to what can be expected at the Stillwater and East Boulder mines during closure; and

- The decline in nitrogen concentrations would continue at similar rates throughout closure and post-closure.

Background

Nitrogen (N) compounds in mine waters originate from blasting agents used during mine development and production of ore. Blasting residue from incomplete detonations or spilled explosives contains concentrations of nitrogen that can dissolve into adit water. Nitrogen is measured in tailings supernatant waters at about the same concentration as untreated adit water. Tailings supernatant water that migrates through the tailings mass to the underdrain undergoes a reduction in concentration from an average of about 56 mg/L to 1.7 mg/L. Species are reduced in underdrain water from nitrate to ammonia (2009 through 2011 data, SMC Annual Reports). Nitrogen concentrations are reduced in mine waste waters when treated in SMC's biological treatment systems (BTS) and during land application disposal. After treatment at the Stillwater Mine BTS, the ammonia-nitrogen and total Kjeldahl nitrogen (TKN)-nitrogen concentrations in adit water are nearly non-detectable concentrations (usually less than 0.1 mg/L). The nitrate+nitrite-N concentrations in treated adit water are consistently less than 3 mg/L. Nitrite is a short-lived nitrogen species, is at very low to non-detectable concentrations in SMC's mine waters, and will not be discussed further. Nitrogen concentrations in mine waters could become a water quality concern at post-closure when treatment would not be occurring.

Nitrogen Speciation

The agencies used nitrate data measured in adit water collected during operations and after blasting ceased on Stillwater Mine's east side to calculate the rate that nitrogen concentration would decline in adit water during closure and post-closure. The agencies believe that this rate of decline would be applicable to both mines and could be used to determine the length of time necessary to treat water at closure, and project the concentration of nitrogen in adit water at the beginning of the post-closure period.

Commenters noted that East Boulder adit water contains about 10 percent more ammonia than Stillwater's adit water, and questioned the applicability of the nitrogen decline curve constructed by the agencies to East Boulder adit water. Concerns included the potential effect that a higher percentage of ammonia would have on the rate of nitrogen decline and length of water treatment at closure. To project the time needed for water treatment, the agencies intended that the total inorganic nitrogen concentration would be used as the initial concentration on the curve, rather than only the nitrate species in adit water.

The agencies agree that ammonia is a different species of nitrogen with different geochemical characteristics from nitrate. The characteristic most worthy of note is that ammonia is more volatile than nitrate, which means that ammonia dissolved in water tends to move into the air instead of remaining in the water. Nitrate tends to remain in water. During biological treatment, ammonia is oxidized by microbes to nitrite then nitrate before being converted to nitrogen gas. There are few, if any, published data that address microbial oxidation of ammonia in underground mine waters. Most of the published literature refers to ammonia from fertilizer that oxidizes to nitrite and nitrate in soil and wetlands, or in biological treatment systems, and is not directly applicable to the quality of waters resulting from underground mining. Data have become available from the Troy Mine shutdown that are useful to project how different species of nitrogen compounds would decline after blasting ceases.

Data Evaluation: Troy Mine

Data were collected during the Troy Mine shutdown, which began in late 1992 and continued through 2004. The operational data at the mine, collected from 1982 through 1992, indicate that the nitrogen species in Troy Mine adit water were half ammonia, half nitrate ($1NH_3:1NO_3$). In comparison, the East Boulder adit water has a lower ratio of about one-third ammonia, two-thirds nitrate ($1NH_3:2NO_3$). When blasting ceased at the Troy Mine in October 1992, the average nitrate concentration during operations of about 22 mg/L declined to less than 5 mg/L by July 1993 (Figure 1). Over that nine-month time frame, the average ammonia concentration declined from 11 mg/L to less than 1 mg/L (Clum 2011). It should be noted that the change in nitrogen concentration was slightly greater for ammonia than for nitrate. These data indicate that both nitrogen species in mine adit water reduce quickly to very low concentrations once blasting ceases.

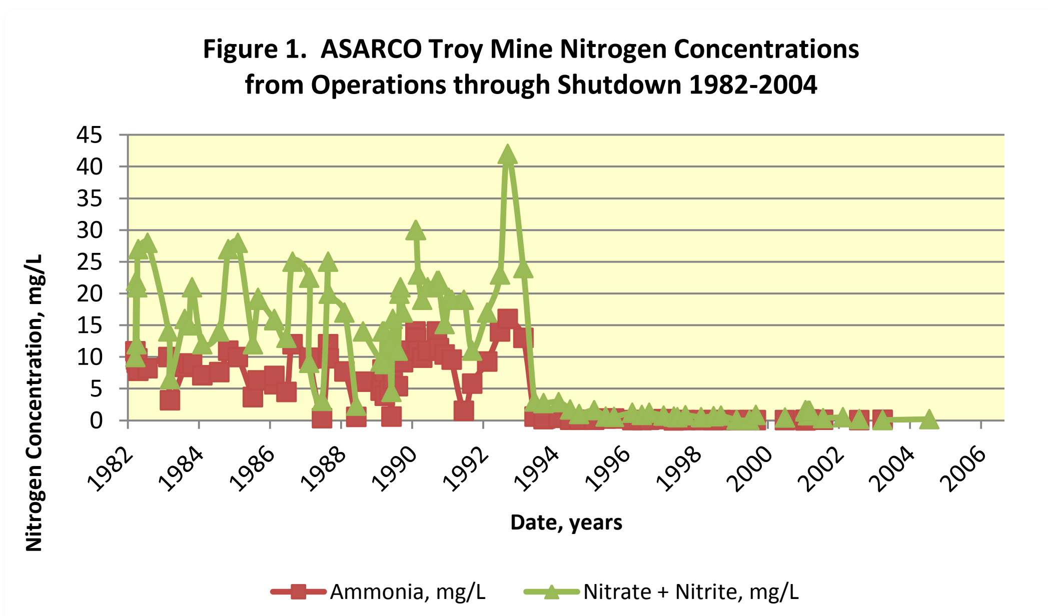

Figure 1 is a plot of the nitrate+nitrite and ammonia concentrations measured in adit water from the Troy Mine 1992 through 2004 shutdown. The ammonia concentration in Troy Mine adit water was about half that of nitrate+nitrite during operations, and both species reduced to <5 mg/L within nine months of shutdown.

The agencies recognize that there are significant differences between the Troy and SMC mines: mining method, workings magnitude and configuration, hydrology, climate, ore geology, ratio of nitrogen species in adit water, and mode of backfill. Differences aside, these data confirm that once blasting ceases, nitrogen concentrations in adit water, regardless of nitrogen species, quickly decline.

<u>*Data Evaluation:* East Boulder Mine</u>

SMC has noted reductions in nitrogen concentrations in adit waters when blasting ceased at the East Boulder Mine. Samples of untreated adit water and riser (tunnel) water were collected during two shutdown periods. The first occurred during a brief holiday shutdown December 23 through 25, Christmas 2001. During this time, no blasting occurred. The nitrogen (nitrate+nitrite as N) concentration in untreated adit water decreased from 17 mg/L to 3 mg/L over three days (Stillwater Mining Company 2002).

The second decrease in nitrogen levels occurred during the 2008 layoff shutdown, November 18 through December 1, 2008. During this time, no blasting occurred. Grab samples of riser water were taken and the nitrogen (nitrate+nitrite as N) concentrations in untreated adit water decreased from 5.7 mg/L to as low as 0.23 mg/L over this period (SMC 2008 data obtained from M. Wolfe) (Figure 2). These data indicate an overall 66-percent decline in the concentration of nitrogen over a two-week period.

These two occurrences, although not statistically significant, provide support that when operational blasting ceases and closure begins, a substantial decline in the nitrogen concentration of untreated adit water would occur over a short time frame.

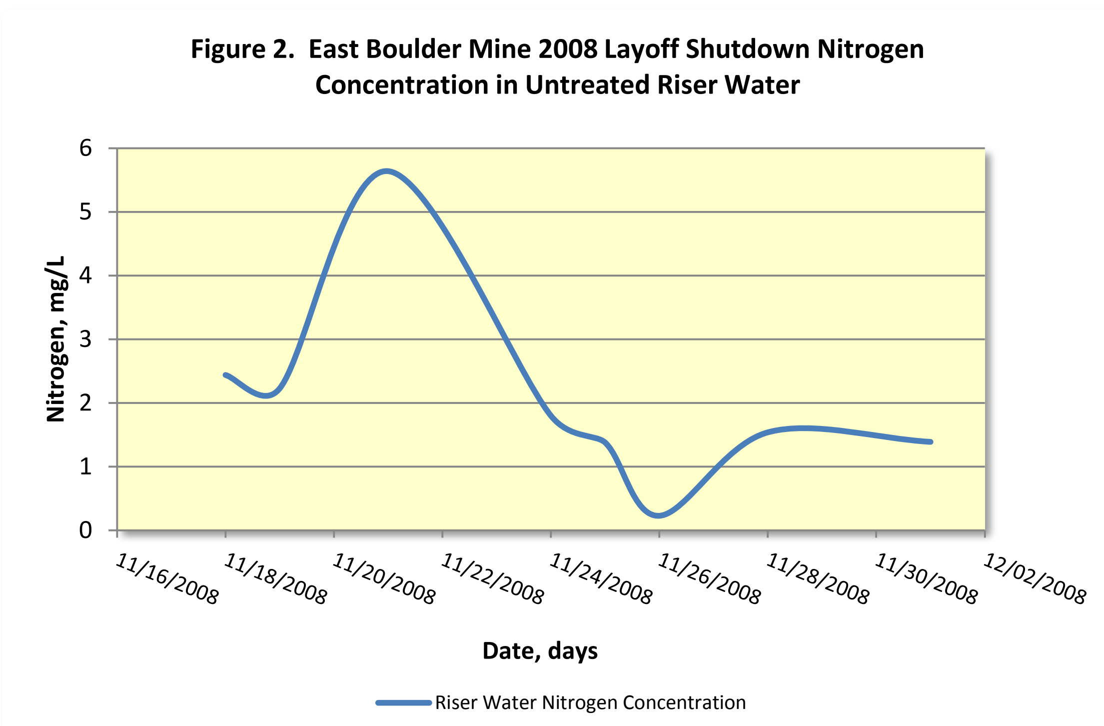

Figure 2 is a plot of the data from the two week 2008 Layoff Shutdown that occurred at the East Boulder Mine. The highest concentration was 5.7 mg/L on November 21, and the lowest concentration was 0.23 mg/L on November 26, 2008. These data represent a 66-percent decline in the concentration of nitrogen over a two-week period.

Data Evaluation: Stillwater Mine

SMC has collected nitrogen (nitrate+nitrite-nitrogen, total ammonia-nitrogen, and TKN-nitrogen) data from untreated adit water flowing from the east-side workings of the Stillwater Mine since 1989. These data were collected during operations and collection continued after the suspension of blasting in 2002 through the present. SMC collected samples from the east side at frequencies that varied from twice-annually to near-daily.

The nitrogen concentration in untreated east-side adit water reached a maximum of 10.3 mg/L in 2000 and declined to less than 0.2 mg/L since September 2007 (Figure 3). Figure 3 shows that

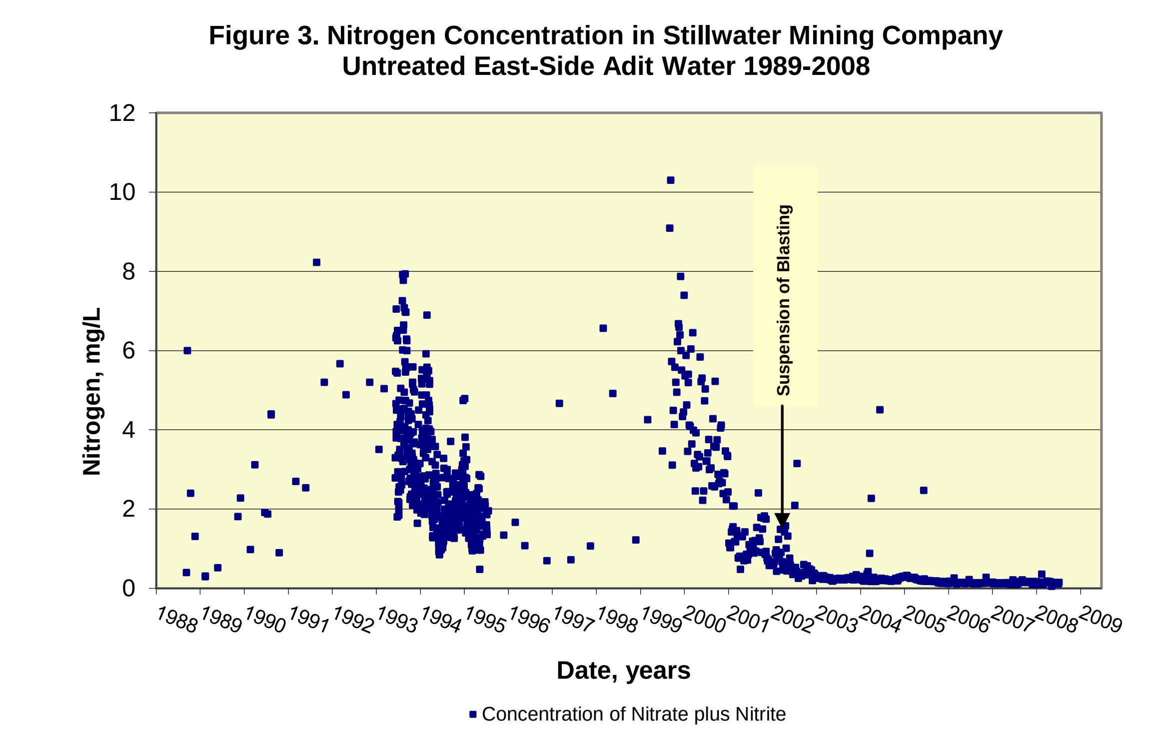

Figure 3 is a scatter plot of the concentrations of nitrogen in untreated adit water from the east-side workings from 1989 through 2008. The highest concentration was 10.3 mg/L in April 2000. The approximate date that blasting was suspended on Stillwater Mine's east side is indicated on the figure.

the concentration of nitrogen in untreated adit water increased from less than 2 mg/L in 1989 to about 8 mg/L in 1993, then decreased to generally less than 2 mg/L through 1997. There are several factors that may be responsible for this decline in nitrogen concentration: 1) a change in the mine plan that altered the amount of production and development from the east side to the west side; 2) the completion of the tunnel beneath the Stillwater River connecting the east-side to the west-side workings that may have rerouted adit water; and 3) the continual progress SMC has made to upgrade its housekeeping and blast hole loading procedures to reduce waste.

Beginning in 1998, the nitrogen concentration increased again, reaching the highest concentration of 10.3 mg/L in April 2000. The nitrogen concentration then decreased, likely a result of the ramping down of east-side production until mid-2002 when blasting on the east side was suspended. The nitrogen concentrations continued to decline after the suspension of blasting and have been less than 0.2 mg/L from fall 2007 through 2010. The agencies are satisfied that the dataset is sufficient to draw conclusions regarding the trend of nitrogen in adit water.

Method: Projecting the Decline of Nitrogen Concentration

To make predictions of the nitrogen concentrations at closure, the agencies fit an exponential decay curve to SMC's raw east-side water quality data. An exponential decay curve is a mathematical model that shows how the amount of a quantity, which in this instance is nitrogen, decreases with time. The agencies chose an exponential decay curve to model the decrease because the quantity of nitrogen in SMC's adit water was seen to decay by a fixed percent at regular intervals of time.

The agencies then determined how accurately the decay curve could predict subsequent nitrogen concentrations. A high degree of accuracy would be required to project the nitrogen concentrations at closure. Statistical methods were used to measure the accuracy of the decay curve. The coefficient of determination, R^2, is the statistical metric the agencies used to measure the accuracy of the decay curve model.

A model curve that can exactly predict subsequent data has an R^2 coefficient equal to one. For example, if the first value of a data set is 438, the second value is 279, and the third value is 105, a model curve that has an R^2 coefficient equal to one will predict 279 as the second value and 105 as the third. Such a model curve would be very accurate at predicting subsequent values. If, however, a model curve cannot predict subsequent data accurately, the R^2 coefficient will be close to zero. In other words, this means that a model curve with an R^2 of 0.10 could not accurately predict the correct second and third data values. Most R^2 values reflect varying levels of success in predicting subsequent values and have values between one and zero (Box *et al* 1978,).

When the agencies fit an exponential decay curve to the raw water quality data collected by SMC since 1999, many of the data points did not fall on the curve. If the data are sufficiently variable that many points do not fall on the curve, the R^2 coefficient will have a value closer to zero than one. The best fit exponential decay curve for all of the raw data from 2000 to present had an R^2 coefficient of 0.48. This R^2 coefficient value indicated that the initial decay curve did not successfully predict all of the subsequent data points. This initial decay curve did not have the necessary degree of accuracy and is not adequate to project the concentration of nitrogen at closure.

If the variability in the data were smoothed, more of the points would fall on the exponential decay curve model and provide a better fit of the data. A better fit would increase the success for predicting subsequent nitrogen concentrations. A method was needed that would preserve the integrity of the data yet reduce its variability. Data smoothing is typically used on a dataset to extract real trends and identify patterns (National Institute of Standards and Technology 2012). The agencies assumed that there was no small scale "structure" within the data causing the variability in the data. That is, it was assumed that the variability in the data is random and not a result of a specific undefined process or phenomenon. To smooth the data, the agencies chose to calculate the annual average nitrogen concentration for each year.

This data smoothing approach solved two problems: it reduced the number of data points to be plotted, thus increasing the accuracy of the curve fit to these data, and it preserved the time-dependence of the data (x-intercepts), giving equal weight to each year, regardless of the number of samples collected per year (annually-averaged). Recall that SMC collected samples between 1989 and 2009 at frequencies that varied from twice-annually to near-daily. This technique has resulted in an over-emphasis of the data collected in some years compared to other years. Figure 4 is a plot of the annually averaged nitrogen concentrations in untreated adit water from the Stillwater Mine east-side workings from 1989 to 2008. It is visually apparent that this data-smoothing technique was effective in preserving the trend of the raw data set shown in Figure 3.

The agencies reviewed the annually-averaged data and identified an exponential decay trend that began in the year 2000 and extended through 2008. The agencies interpreted the break in the slope of the data at year 2000 to correspond with the ramping down of production prior to suspension of blasting at Stillwater Mine's east side in 2002. It is reasonable to expect that a ramping down of production would occur at both the Stillwater and East Boulder mines as closure is approached. Based on the shape of the plotted data, the agencies chose these data to model the reduction in nitrogen concentration during closure.

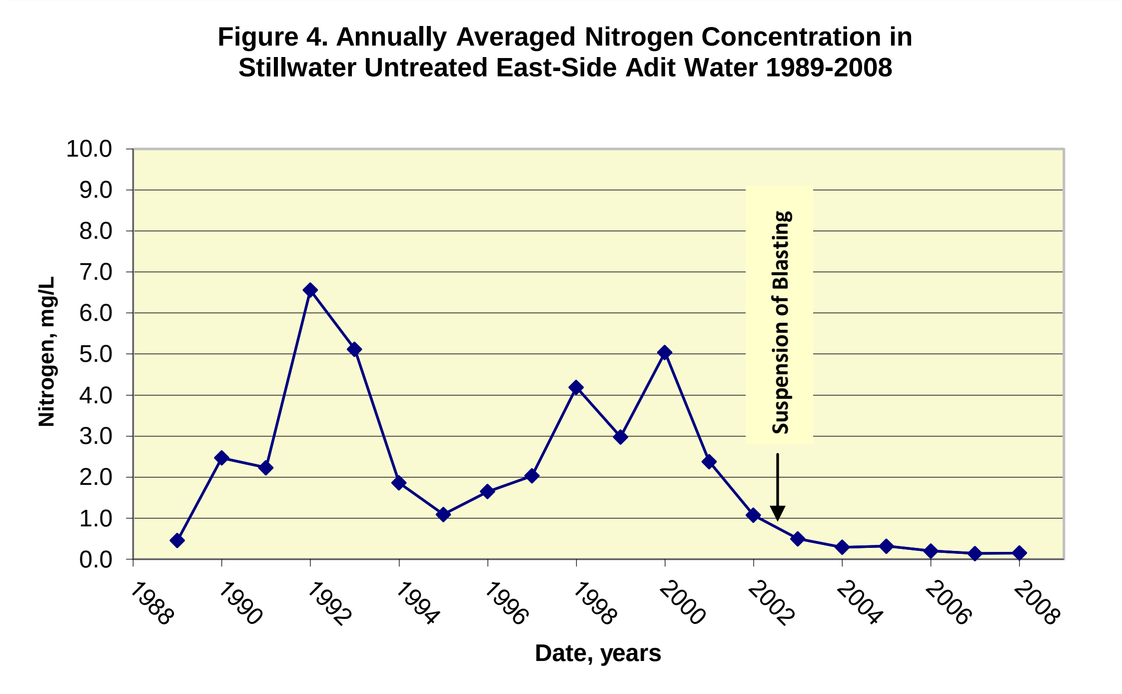

Figure 4 is a plot of the annually averaged concentrations of nitrogen in untreated adit water from the east-side workings from 1989 through 2008. The approximate date that blasting was suspended on Stillwater Mine's east side is indicated on the figure. The data used to generate the decline curve are from 2000 to 2008.

The agencies fit an exponential decay curve $y = 3.9801\, e^{-0.0348x}$ to the annually-averaged data from 2000 to 2008, where x is the time in months and y is the nitrogen concentration in mg/L. The coefficient of determination (R^2) calculated for the exponential decay curve model was 0.93, indicating excellent predictability of subsequent nitrogen concentrations within this annually-averaged data set. This exponential decay curve model derived from the east-side data could be used to calculate the future rate of nitrogen decay in untreated adit water from the west side.

Closure Nitrogen Decline Curve Calculation

The agencies reviewed SMC's current operational concentration of nitrogen in untreated adit water from the west-side workings and assumed that nitrogen concentrations would be similar at the end of mine life. The 2009 through 2011 untreated adit water concentrations average 40 to 45 mg/L nitrogen, whereas the highest concentration on the east-side workings from 1989 to 2009 was about 10 mg/L. The agencies extrapolated the exponential decay curve model to match the expected maximum concentration of untreated adit water prior to the ramping down of production, *i.e.,* about 40 to 45 mg/L nitrogen. The equation for the decay curve is then $y = 37.456\, e^{-0.0348x}$ where x is the time in months and y is the nitrogen concentration in mg/L (Figure 5). The modeled closure nitrogen decline curve has an R^2 value of 0.97, indicating that the fit of the values used to extrapolate this curve are similar to the fit of the annually-averaged data curve.

The agencies assume that a planned closure will follow a ramping down of production as closure approaches. In the case of unplanned closure, the mine would have been placed on care and maintenance as a result of an unanticipated event. In either case, explosive use at the mines would diminish or cease at some time prior to the onset of the closure period. Based upon the data obtained during the ramping down of production on the Stillwater Mine's east side, and using equivalent positions on the curves in figures 4 and 5, nitrogen decline curve, the concentration of

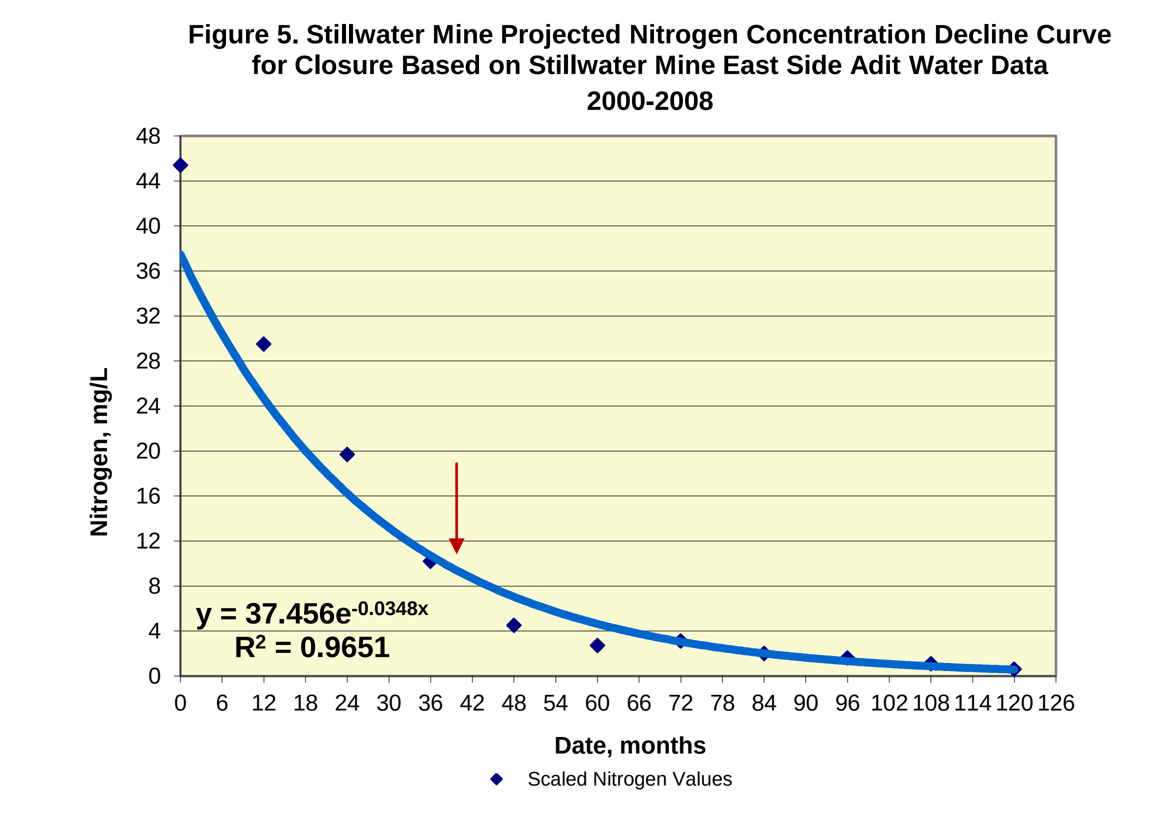

Figure 5 is the projected decline in the nitrogen concentration of untreated adit water at closure based upon data collected from the Stillwater Mine east-side workings from 2000 through 2008. The diamonds are the nitrogen values extrapolated from 2000 to 2008 east-side adit water data to compare with untreated 2009 through 2011 operational nitrogen concentrations. These extrapolated values are inclusive of the period of time in which Stillwater began to ramp down production before blasting was suspended. The curve is the exponential nitrogen decay model based on these data. The equivalence point for the suspension of blasting is indicated with a red arrow.

of adit water is anticipated to reduce about 80 percent from the operational concentration. That is, adit water containing about 45 mg/L nitrogen would reduce to about 9 mg/L when the closure period commences.

In the situation that an unanticipated event for the company would result in unplanned closure, it is the agencies' experience that the explosive use would have ceased, resulting in an extended care and maintenance scenario, the concentration of adit water is anticipated to decrease from the operational 48 mg/L nitrogen to about 4 mg/L going into the closure period.

The closure period for either scenario would continue for 12 to 18 months, depending on the alternative selected and implemented. At the end of closure/beginning of post-closure, the concentration of nitrogen would be less than 7 mg/L for a planned closure and less than 3 mg/L after an extended care and maintenance scenario. Post-closure occurs after reclamation covers are placed on the tailings impoundments and is defined as the time when no further adit or tailings water treatment is needed. Both of these scenarios support the maintenance of the BTS and BTS/Anox systems for up to an 18-month closure period.

How to Use the Nitrogen Decline Curve

Projections for the length of time that adit water treatment at closure would be necessary are based on the nitrogen load (*i.e.,* concentration of nitrogen and adit flow rate). For example, if the untreated concentration of adit water when closure commences at the Stillwater Mine was 9 mg/L at a flow rate of 2,020 gpm, then the resulting nitrogen load would be 218 pounds of nitrogen per day (lbs-N/day), and treatment would be needed until the nitrogen load is less than water quality standards protective of aquatic resources (that is, prevention of nuisance algal growth). At the end of an 18-month closure period, the nitrogen concentration is projected to be about 4 mg/L. At a flow rate of 2,020 gpm, the resulting nitrogen load would be less than the Stillwater Mine MPDES permitted nitrogen load limit of 100 lbs-N/day. In this second example, adit water would not need treatment at closure.

Conclusion

The agencies believe that the decline in nitrogen concentration observed at the east-side workings from 2000 to 2008 is representative of the decline in concentration that would occur at closure for adit water flowing through workings that do not flood at both the Stillwater and East Boulder mines. The agencies used these nitrogen concentration data to construct a mathematical model of the nitrogen decline and to project the concentrations of nitrogen in adit water that could be expected at closure and during post-closure.

The reduction in nitrogen concentration can be represented by the equation $y = 37.456\ e^{-0.0348x}$ where x is the time in months and y is the nitrogen concentration in mg/L (Figure 5). It should be noted for prediction purposes that this model is based on data inclusive of the period when east-side blasting was still occurring but east-side production was ramping down. The time frame projected by this model for the decline of nitrogen concentrations will, therefore, be conservative. These nitrogen concentration projections indicate the maximum time needed from the cessation of blasting at closure for adit water nitrogen levels to decline to a specific concentration. This model also provides nitrogen concentration projections that can be used in concert with adit flow rate to estimate the maximum amount of time adit water treatment would be needed at closure. This technical memorandum assumes that tailings waters would require treatment or dilution prior to disposal by percolation or land application. The biological treatment systems would be needed to treat undiluted tailings waters removed from the impoundments while the reclamation covers are placed, which is 12 to 18 months.

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TECHNICAL MEMORANDUM

March 24, 2012

To: Kristi Ponozzo, MEPA Specialist, Montana DEQ
Pat Pierson, NEPA Coordinator, Custer and Gallatin National Forests, USFS

From: Lisa M. Boettcher, C.P.G. Reclamation Specialist, Montana DEQ LB
Catherine Dreesbach, P.E. Mining Engineer

Re: ***Revised*** Projection of Post-closure Water Quality and Nitrogen Loading from the Stillwater Mine Shaft, Stillwater Mining Company, Nye, Montana

This memo describes the agencies' analysis to estimate post-closure nitrogen loading to the Stillwater River from the discharge of waters flooding the underground workings below the 5,000-foot elevation at the Stillwater Mine, Nye, Montana. This analysis parallels and reviews SMC's analysis (Hydrometrics, Inc. 2004). These calculations are conservative, that is, predict the highest concentrations of nitrogen that may discharge from the shaft based on the assumptions that no denitrification would occur in the underground workings prior to discharge, and that the slimes would fully mix with the ground water flowing into the workings rather than stratify at the bottom of the workings. SMC has documented in-situ denitrification of waters in the LAD storage pond and Hertzler Ranch tailings impoundment underdrain system (Weimer 2012). Based on these data, the agencies expect that denitrification would also occur within the underground workings. Included in this memo are updated end-of-mining volume and backfill projections based on the long-range mine plan provided to the agencies by SMC (SMC 2009).

What has been revised in this memo:

- The calculations have been revised to include the nitrogen concentration of the slimes fraction of the tailings that would be disposed of underground when decommissioning is complete under Alternative 3A.
- Tables 1 and 2 have been combined into one table and reformatted.
- Additional descriptive information has been added to provide clarity.

<u>Calculations for Mined-Out Void</u>

The agencies used the former mine plan provided by SMC to calculate the volumes of backfill and voids in production and development workings at the Stillwater Mine through December 2009 (Table 1). These calculations update the volumes used in the 2004 Hydrometrics, Inc. technical memorandum, and would represent the extent of underground workings and backfill for the short term. These calculations are sufficient to provide documentation to calculate the agencies' 5-year financial assurance requirements. SMC has updated its long-term mine plan and provided data to the agencies so that calculations could be made to extrapolate the underground volume at the projected end of mining (Table 1). The end of mining void and backfill volumes are used to project post-closure nitrogen loading from water filling the workings below the 5,000-foot level for some point in the future.

Ground Water Hydraulics

The rate of ground water inflow to the Stillwater Mine workings in 2011 averaged about 930 gallons per minute (gpm). The upper workings are above 5,000 feet and would not flood post-mining because the regional water table is below this elevation. The shaft is a vertical shaft that extends 1,900 feet beneath the Stillwater River Valley floor through the lower workings. It is used to dewater the lower workings (those below 5,000 feet) (Figure 1, from Hydrometrics, Inc. 2004).

After the underground is decommissioned at closure, the east-side and west-side portals would be plugged with permeable waste rock plugs, and pumping of ground water from the lower workings would cease. Snowmelt and precipitation that infiltrates above the upper workings would flow vertically through open and backfilled areas and fractures to fill the lower workings of the mine. The rate of inflow from the upper workings is estimated to average about 280 gpm at closure (Hydrometrics, Inc. 2004). This inflow rate is expected to continue post-closure. Surrounding ground water would flow laterally into the deeper workings of the mine. Eventually the level of water in the flooding workings would rise to the 4,972-foot elevation of the shaft collar then discharge. Because its elevation is lowest, water would discharge from the shaft collar before discharging from the 4,974-foot east portal or the 5,000-foot west portal (Figure 2, Hydrometrics, Inc. 2004, attached).

While blasting the shaft, SMC grouted any interval having sustained inflow. The grout prevents the flow of water between the alluvial gravels of the Stillwater River and the shaft. Although the alluvial gravels (4,900-foot elevation) are at a lower elevation than the collar of the shaft (4,972-foot elevation), while the grout remains competent, shaft water would not discharge to the Stillwater River alluvium. In the event, however, that water would directly discharge to the alluvium, the loading calculations in this memo remain valid.

The hydrostatic pressure of ground water is dynamic and primarily dependent upon its elevation. The rate of water inflow to the workings and shaft would not be dependent on the total volume of workings, but would depend on the elevation of rising water. As the workings flood, the hydrostatic pressure increases. Initially the rate of flooding is rapid, and as the workings fill, the flooding rate slows. Using the updated end-of-mining backfill and void volumes, SMC estimated that it would take between four and 48 years to fill the maximum projected extent of the workings, depending on ground water inflow rate (SMC 2009).

The agencies assume that there would be no discharge of water to the Stillwater River from the lower workings until the flooded elevation reaches the collar of the shaft. The agencies have confirmed SMC's ground water flow calculations (Hydrometrics, Inc., Inc. 2004), and concur that when the workings are nearly flooded the rate of inflow to the shaft is expected to be 20 to 40 gpm. The water entering the shaft from the lower workings would mix with the projected 280 gpm of inflow from the upper workings and approximately 300 to 320 gpm would discharge from the shaft post-closure. The agencies used the higher 40 gpm inflow rate from the workings and 320 gpm shaft discharge rate for this analysis.

Nitrogen Loading

In the 2004 technical memorandum, Hydrometrics estimated the potential contribution of nitrogen from tailings, waste rock, and paste backfill materials based on column leach tests performed by SMC in 1988 and 2003 (Hydrometrics, Inc. 2004). Hydrometrics constructed a mass balance mixing model to estimate the potential nitrogen concentration and load in mine waters that would discharge from the shaft. Hydrometrics projected flows, and performed surface water mixing calculations and sensitivity analyses to evaluate the influence of individual parameters on the modeling results. This enabled Hydrometrics to assess a maximum nitrogen loading scenario. The agencies have reviewed Hydrometrics' calculations for verification purposes. No measurements of leached salts were taken from the three types of backfill materials. Salts will not be addressed further in this memo.

In this analysis, the agencies assume that the nitrogen concentration in mine water flowing from the upper workings would decrease over time as indicated by the *Revised* Projected Nitrogen Concentration Decline Curve (Appendix E). The agencies agree that water moving through the flooded lower workings would flush nitrogen compounds from the mine. The highest concentration of nitrogen would occur in the first pore volume of mine water through the workings. The nitrogen concentration would decrease in subsequent pore volumes of water flowing through the flooded workings. It is not known how long it would take for one complete pore volume of ground water to flow through the workings and discharge, but is likely to be on the order of decades.

The agencies independently calculated the nitrogen concentration of water discharging from the shaft using the pore volume concentrations estimated by SMC (Hydrometrics, Inc. 2004). The agencies calculated the nitrogen loads for the first and second pore volumes of water flowing through the workings. The first pore volume of mine water would contain the maximum nitrogen concentration, and provides a conservative (worst-case) loading scenario.

<u>Calculations for Nitrogen Loading at Closure</u>

The nitrogen loading calculations that follow are based on the volume of void, volume of backfill, and type of backfill. The ground water inflow rate affects the time to flood the mine.

Concentration of the First Pore Volume

The projected nitrogen concentrations of the first pore volume of water that flood the workings are as follows (Hydrometrics, Inc. 2004):

30 mg/L N_{T1} from tailings backfilled areas
30 mg/L N_{CP1} from cemented paste backfilled areas
112 mg/L N_{WR1} from waste rock backfilled areas
53 mg/L N_S from slimes; concentration from SMC data 2009 to 2011
0.2 mg/L N_V from void (empty) areas, east- and west-side workings, post-closure

where V_P is the pore volume of backfilled areas (tailings, cemented paste, waste rock), V_{Slimes} is the volume of the 18 million gallons of slimes remaining in the tailings impoundment when decommissioning is completed, and V_{Void} is the volume of the void (empty) areas, calculated by the agencies from data provided by SMC (Table 1).

Calculation for Nitrogen Concentration in Water from Flooded Workings (volume of workings up through December 2009):

These calculations project the nitrogen concentration and load that would be expected from the flooded workings if closure at the Stillwater Mine was imminent.

$$= \frac{[V_{P\ Tailings} \times N_{T1} + V_{P\ Cemented\ Paste} \times N_{P1} + V_{P\ Waste\ Rock} \times N_{WR1} + V_{Slimes} \times N_S + (V_{Void\ Workings} - V_{Slimes}) \times N_V]}{(V_{P\ Tailings} + V_{P\ Cemented\ Paste} + V_{P\ Waste\ Rock} + V_{Void\ Workings})}$$

= 35.6 mg/L nitrogen (first pore volume, mining void through December 2009)

Calculation for Nitrogen Concentration in Water Discharged from the Shaft (volume of workings up through 2009):
where V is volumetric flow rate and C is concentration:

$$= \frac{(V_{\text{east-side workings}} \times C_{\text{east-side}} + V_{\text{west-side workings}} \times C_{\text{west-side}} + V_{\text{flooded workings}} \times C_{\text{flooded workings}})}{(V_{\text{east-side workings}} + V_{\text{west-side workings}} + V_{\text{flooded workings}})}$$

$$= \frac{(160 \text{ gpm} \times 0.2 \text{ mg/L} + 120 \text{ gpm} \times 0.2 \text{ mg/L} + 40 \text{ gpm} \times 35.6 \text{ mg/L})}{(160 \text{ gpm} + 120 \text{ gpm} + 40 \text{ gpm})}$$

= 4.6 mg/L nitrogen (first pore volume, mining void through December 2009)

Nitrogen Load$_{1stPV\ 2009}$ = (320 gpm x 4.6 mg/L x 0.012 lbs min L $mg^{-1}gal^{-1}day^{-1}$) = 17.8 lbs/day

The total nitrogen load of 17.8 lbs/day exiting from the shaft is less than the 100 lbs/day MPDES permit load for the Stillwater Mine. A nitrogen load of 17.8 lbs/day would result in a nitrogen concentration of about 0.2 mg/L in the Stillwater River when streamflow is at seven-day, ten-year low flow value ($7Q_{10}$) of 31 cfs.

- To check the sensitivity of this calculation, the agencies recalculated using a nitrogen concentration of 10 mg/L for the 280 gpm from the upper workings and flooded mine voids. The weighted average nitrogen concentration in the flooded workings water would then be 41.4 mg/L. The weighted average concentration of nitrogen in water discharged from the shaft is 13.9 mg/L, and the nitrogen load is 53.5 lbs/day. This load is less than the 100 lbs/day MPDES permit load for the Stillwater Mine and would result in a nitrogen concentration less than 1 mg/L in the Stillwater River.

Calculation for Nitrogen Concentration in Water from Flooded Workings at End-of Mining:
The calculation for the first pore volume nitrogen concentration of flooded workings was repeated using the updated end-of-mining void and backfill volumes. These calculations project the nitrogen concentration and load that would be expected from the flooded workings at full build-out at the end of mining. These volumes were calculated by the agencies from data provided by SMC (Table 1).

$$= \frac{[V_{\text{P Tailings}} \times N_{T1} + V_{\text{P Cemented Paste}} \times N_{P1} + V_{\text{P Waste Rock}} \times N_{WR1} + V_{\text{Slimes}} \times N_S + (V_{\text{Void Workings}} - V_{\text{Slimes}}) \times N_V]}{(V_{\text{P Tailings}} + V_{\text{P Cemented Paste}} + V_{\text{P Waste Rock}} + V_{\text{Void Workings}})}$$

= 25.8 mg/L nitrogen (first pore volume, full projected extent of mine void at end-of-mining)

Calculation for Nitrogen Concentration in Water Discharged from Shaft at End-of Mining:

$$= \frac{(V_{\text{east-side workings}} \times C_{\text{east-side}} + V_{\text{west-side workings}} \times C_{\text{west-side}} + V_{\text{flooded workings}} \times C_{\text{flooded workings}})}{(V_{\text{east-side workings}} + V_{\text{west-side workings}} + V_{\text{flooded workings}})}$$

$$= \frac{(160 \text{ gpm} \times 0.2 \text{ mg/L} + 120 \text{ gpm} \times 0.2 \text{ mg/L} + 40 \text{ gpm} \times 25.8 \text{ mg/L})}{(160 \text{ gpm} + 120 \text{ gpm} + 40 \text{ gpm})}$$

= 4.1 mg/L (first pore volume, full projected extent of mine void at end-of-mining)

Nitrogen Load$_{1stPV\ E\text{-}o\text{-}M}$ = (320 gpm x 4.1 mg/L x 0.012 lbs min L $mg^{-1} gal^{-1} day^{-1}$) = 15.8 lbs/day

The total nitrogen load of 15.8 lbs/day is less than the 100 lbs/day MPDES permit load for the Stillwater Mine. A nitrogen load of 15.8 lbs/day would result in a nitrogen concentration of about 0.2 mg/L in the Stillwater River at the $7Q_{10}$ low streamflow.

- To check the sensitivity of this calculation, the agencies recalculated using a nitrogen concentration of 10 mg/L for the 280 gpm from the upper workings and flooded mine voids. The weighted average nitrogen concentration in the flooded workings water would then be 32.6 mg/L. The weighted average concentration of nitrogen in water discharged from the shaft is 12.8 mg/L, and the nitrogen load is 49.3 lbs/day. This load is less than the 100 lbs/day MPDES permit load for the Stillwater Mine. A nitrogen load less than 100 lbs/day would result in a nitrogen concentration less than 1 mg/L in the Stillwater River.

Concentration of the Second Pore Volume

The projected nitrogen concentrations of the second pore volume of water that floods the Life-of-Mine workings are as follows (Hydrometrics, Inc. 2004):

0.4 mg/L N_{T2} from tailings backfilled areas
0.4 mg/L N_{CP2} from cemented paste backfilled areas
29 mg/L N_{WR2} from waste rock backfilled areas
0.2 mg/L N_V from void (empty) areas

where V_P is the pore volume of backfilled areas (Tailings, Cemented Paste, Waste Rock), and V_{Void} is the volume of the void (empty) areas, calculated by the agencies from data provided by SMC (Table 1).

Calculation for Nitrogen Concentration in Water from Flooded Workings at End-of-mining:

$$= \frac{(V_{P\ Tailings} \times N_{T2} + V_{P\ Cemented\ Paste} \times N_{P2} + V_{P\ Waste\ Rock} \times N_{WR2} + V_{Void\ Workings} \times N_V)}{(V_{P\ Tailings} + V_{P\ Cemented\ Paste} + V_{P\ Waste\ Rock} + V_{Void\ Workings})}$$

= 5.9 mg/L nitrogen concentration (second pore volume, full projected extent of mine void at end of mining)

Calculation for Nitrogen Concentration in Water Discharged from Shaft at End-of-mining:
where V is volumetric flow rate and C is concentration:

$$= \frac{(V_{\text{east-side workings}} \times C_{\text{east-side}} + V_{\text{west-side workings}} \times C_{\text{west-side}} + V_{\text{flooded workings}} \times C_{\text{flooded workings}})}{(V_{\text{east-side workings}} + V_{\text{west-side workings}} + V_{\text{flooded workings}})}$$

$$= \frac{(160 \text{ gpm} \times 0.2 \text{ mg/L} + 120 \text{ gpm} \times 0.2 \text{ mg/L} + 40 \text{ gpm} \times 5.9 \text{ mg/L})}{(160 \text{ gpm} + 120 \text{ gpm} + 40 \text{ gpm})}$$

= 1.6 mg/L nitrogen (second pore volume, full projected extent of mine void at end of mining)

$Nitrogen\ Load_{2ndPV\ 2008}$ = (320 gpm x 1.6 mg/L x 0.012 lbs min L $mg^{-1}gal^{-1}day^{-1}$) = 6.2 lbs/day

The total nitrogen load is 6.2 lbs/day, which is less than the 100 lbs/day MPDES permit load for the Stillwater Mine. A nitrogen load of 6.2 lbs/day would result in a nitrogen concentration less of about 0.1 mg/L in the Stillwater River at the $7Q_{10}$ low streamflow.

Conclusions

This memo provides the basis of the agencies' estimate of post-closure nitrogen loading to the Stillwater River from the flooding of Stillwater Mine workings. This analysis parallels and reviews SMC's analysis (Hydrometrics, Inc. 2004) and includes updated end-of-mining backfill and void projections based on the long-range mine plan provided to the agencies by SMC (SMC 2009).

The highest concentration of nitrogen would occur in the first pore volume of mine water entering the shaft, and is a conservative (worst-case) loading scenario. The nitrogen concentration would decrease in subsequent pore volumes of water flowing through the flooded workings. No estimates have been made of the time it would take for one pore volume of ground water to flow through the workings, but is likely to be on the order of decades.

The nitrogen load in the first pore volume of water that would discharge post-closure from the shaft would be about 18 lbs/day, which is less than the MPDES permit limit of 100 lbs/day. Based upon these calculations, the MPDES permit limit for nitrogen would be met and no treatment of shaft water would be necessary post-closure.

References

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Weimer, R. 2012. Personal communication [*February 27* e-mail to P. Pierson, Custer National Forest, Billings, MT. *RE:* Mine ownership acres]. Environmental Manager, Stillwater Mine, Nye, Montana. 2 pages.

Table 1. *Revised* Underground Workings Void and Backfill Calculations

ASSUMPTIONS: The average development area is not rectangular; tailings mass per foot of development is 16 tons of combined tailings/paste per foot; cemented mass per foot of development is 16 tons of combined mass per foot; waste rock backfill ratio was 24 tons up through December 31, 2009 and 18 to 20 tons thereafter; volume per ton of backfill does not consider any caving; pore volume of the tailings is based on Hydrometrics, Inc. 2004: tailings porosity = 0.4, cemented paste porosity = 0.08, waste rock porosity = 0.4.

all mass is in tons, volume in cubic feet	**Prior to Dec 31, 2009**	**From Jan 1, 2010 to end of mine life**	**Life of Mine**
Mass of tailings placed as backfill	828,235	3,202,941	4,031,176
Mass of cemented paste placed as backfill	828,235	3,202,941	4,031,176
Mass of waste rock placed as backfill	2,484,706	7,606,985	10,091,691
Volume of tailings placed as backfill	16,564,700	64,058,820	80,623,520
Volume of cemented paste placed as backfill	16,564,700	64,058,820	80,623,520
Volume of waste rock placed as backfill	49,694,120	152,139,700	201,833,820
Void volume of tailings placed as backfill	6,625,880	25,623,528	32,249,408
Void volume of cemented paste placed as backfill	1,325,176	5,124,706	6,449,882
Void volume of waste rock placed as backfill	19,877,648	60,855,880	80,733,528
Mined-out development void	14,112,459	54,575,524	68,687,982
Mined-out production void	113,887,541	440,424,476	554,312,018
Volume of development void available for water storage (without backfill; empty mined-out void)	14,112,459	54,575,524	68,687,982
Volume of production void available for water storage (mined-out void with backfill placed)	31,064,021	160,167,136	191,231,158
Total volume available for water storage (development + production + backfill voids)	58,892,725	251,771,250	310,663,975

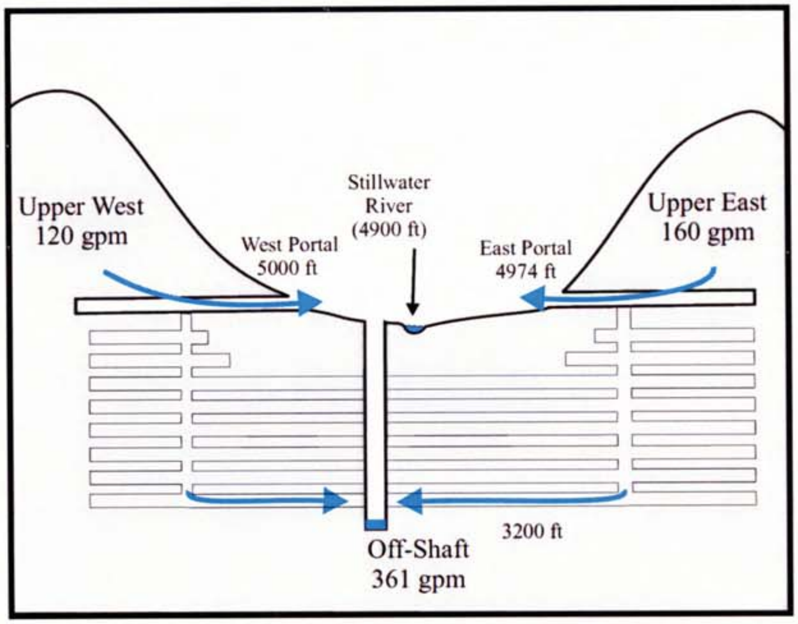

Figure 1.
Flow Schematic
Present Operational Scenario

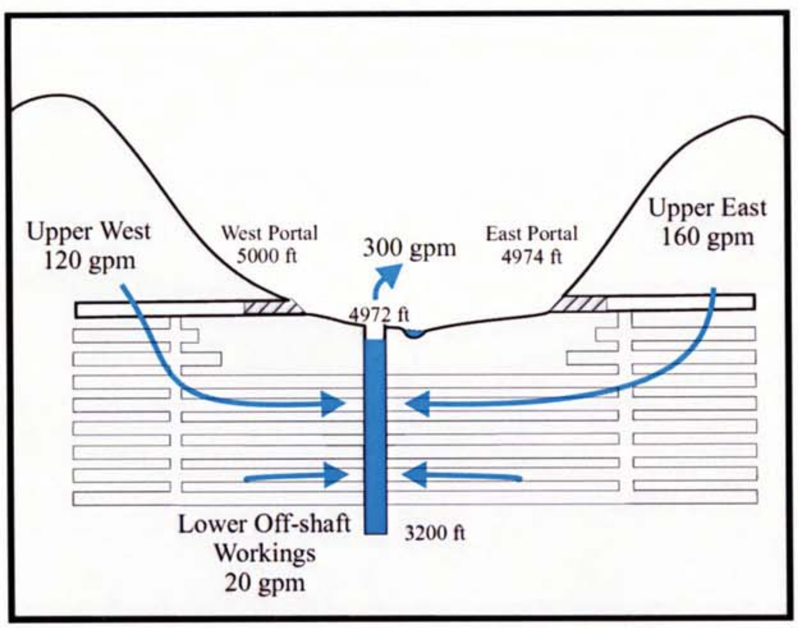

Figure 2.
Flow Schematic
Closure Scenario

K:\project\Nload Schematic2.cdr

TECHNICAL MEMORANDUM

Date: January 3, 2012

To: Kristi Ponozzo, Stillwater Mining Company EIS Project Coordinator, Montana DEQ
Patrick Pierson, Stillwater Mining Company EIS Project Coordinator, Custer National Forest, USFS

From: Lisa M. Boettcher, C.P.G., Reclamation Specialist, Montana DEQ LB

Subject: Potentials for long-term acid rock drainage or metals mobility at the Stillwater Mine near Nye and the East Boulder Mine near Big Timber, Montana

Brief overview

The Environmental Protection Agency (EPA) provided comments regarding the need for the 2010 Stillwater Mining Company's Revised Water Management Plans and Boe Ranch LAD Draft Environmental Impact Statement (DEIS) to address the post-closure potential for acid rock drainage and near-neutral metals mobility from waste rock, tailings, and the adits at the Stillwater Mining Company (SMC) Stillwater and East Boulder mines. This memo compiles the statutory and scientific basis upon which the agencies decided to determine the potential for water quality impacts from metals as nonsignificant, and therefore, only reference their coverage in the DEIS. This memo then addresses the EPA comments using data collected at both mines over a 13- to 25-year period of record and summarizes papers, reports, data and the appropriate water quality criteria so that these data may be evaluated in context.

The potentials for long-term acid rock drainage or metals mobility have been addressed to differing degrees in previous environmental documents to which the 2010 Draft Environmental Impact Statement (DEIS) was tiered and were not raised as significant issues during the agencies' scoping process. Federal guidance related to implementation of the National Environmental Policy Act (NEPA) found at 40 Code of Federal Regulations (CFR) 1500 – 1508 directs federal agencies to identify at an early stage "the significant environmental issues deserving of study and [deemphasize] insignificant issues, narrowing the scope of the environmental impact statement accordingly" [40 CFR 1501.1(d)]. Agencies are directed in this section to "Identify and eliminate from detailed study the issues which are not significant or which have been covered by prior environmental review (Section 1506.3), narrowing the discussion of these issues in the statement to a brief presentation of why they will not have a significant effect on the human environment or providing a reference to their coverage elsewhere" [40 CFR 1501.7(a)(3)].

The Administrative Rules of Montana(ARM) related to determining the scope of an Environmental Impact Statement are similar, directing the agency to identify issues that "are likely to involve significant impacts and that will be analyzed in depth in the EIS" [ARM § 17.4.615 (b)]. Further, the ARM directs agencies to "identify the issues that are not likely to involve significant impacts, thereby indicating that unless the unanticipated effects are discovered during the preparation of the EIS, the discussion of these issues in the EIS will be limited to a brief presentation of the reasons they will not significantly affect the quality of the human environment (c)", and to "identify those issues that have been adequately addressed by prior environmental review, thereby indicating that the discussion of these issues in the EIS will be limited to a summary and reference to their coverage elsewhere (d)" A.R.M § 17.4.615.

The 2010 Draft Environmental Impact Statement (DEIS) lists on page 1-16 the previous environmental analyses that have been prepared for the Stillwater and East Boulder mines. Appendix A of the DEIS contains a synopsis of each of these documents. Chapter 2 of the DEIS identifies the issues and concerns identified based on public and agency input and describes the agencies' scoping process on pages 2-1 and 2-2. The significant issues were identified in Chapter 2.2.1 (pages 2-2 through 2-6), and the issues considered but dismissed were identified in Chapter 2.2.2 (pages 2-7 through 2-14).

EPA Comments
The comments specifically requested that the DEIS provide the following:

1) disclosure of the geochemical characterization of the Stillwater Complex, specifically the sulfide content;
2) summary of the long-term monitoring plan for potential acid generation and leaching of metals post-closure;
3) analysis of the effects of metals on surface and ground water at both mines, operationally and post-closure;
4) disclosure of the operational concentrations of metals in adit and tailings waters at both the Stillwater and East Boulder mines with a comparison of the operational concentrations to applicable water quality standards;
5) documentation of the potential for acid generation and metals mobility based on a large-scale field column (humidity cell) test performed over a period of several years;
6) expansion of the list of metals for long-term monitoring (aluminum, arsenic, cadmium, copper, iron, manganese, mercury, selenium, silver, zinc, platinum, palladium) and inclusion of total hardness, calcium, magnesium, and sulfate for mine drainage and runoff; and
7) evaluation of the effects of the mine during operations on downgradient surface (Nye Creek) and ground water with respect to metals loading.

Agency Responses
Comment 1: *Disclosure of the geochemical characterization of the Stillwater Complex, specifically the sulfide content.*

<u>*Geology*</u>*:* Platinum and palladium are produced from the Stillwater Complex, an ultramafic-to-mafic cumulate (layered crystalline accumulation) intrusive deposit, mined at two surface locations, the Stillwater Mine at Nye and the East Boulder Mine near Big Timber. The sulfide minerals occur almost exclusively within the ore zone and not within waste rock. The Stillwater Complex is an estimated 5,500 m thick, preserved between the intrusive lower contact and the pre-Middle Cambrian unconformity that bound the complex. The complex has been grouped into three main stratigraphic series—the Basal series, the Ultramafic series, and the Banded series. The Basal series, lowermost in the complex is in contact with basement rock and is approximately 150 m thick. The 1,000 m thick ultramafic series is next in sequence and overlain by the Banded series. The Banded series hosts the platinum-palladium deposit. The Banded series makes up more than three-fourths of the exposed thickness of the complex and is subdivided into the Lower, Middle, and Upper series, which is further broken down into lithologic zones.

The Lower Banded Series is subdivided into the *Norite I*, *Gabbro I*, and *Troctolite-Anorthosite I*. *Norite I* consists of plagioclase-bronzite cumulates and can be identified at the base of the section along the entire length of the complex; *Gabbro I* is composed of cumulates containing plagioclase, bronzite, and augite; *Troctolite-Anorthosite I* is a complex succession of olivine-, plagioclase-, bronzite-, and augite-bearing cumulates and pegmatoidal (very coarsely crystalline) rocks. The *Troctolite-Anorthosite I* zone hosts the J-M Reef, which is 1 to 3 m thick and contains the platinum-palladium ore mined by SMC (Kirk et al 2006).

<u>Sulfide occurrence and content</u>: The ore minerals are present as braggite $(Pt_{0.60}Pd_{0.34}Ni_{0.06})_{\Sigma=1.00}S_1$, cooperite $(Pt_{0.98}Pd_{0.01}Ni_{0.03})_{\Sigma=1.02}S_{0.98}$, and are associated with chalcopyrite ($CuFeS_2$), pyrrhotite ($Fe_{1-x}S$), pentlandite $(Fe, Ni)_9S_8$, and minor pyrite (FeS_2). The sulfide minerals are present in small concentrations (0.05 to 1 weight percent) in the ore. The sulfide-bearing rock is, for the most part, mined as ore. The sulfide minerals that pose a risk of acid generation occur almost exclusively in the ore zone so that little risk of acid generation is anticipated from waste rock and the underground workings (Kirk et al 2006). This conclusion is supported by the water monitoring data provided in comments 3 and 4.

Supplemental samples of low grade ore, high grade ore, mineralized dike, and paste backfill (tailings amended with cement and used to backfill stopes), were collected by Kuipers and Associates in 2001 and analyzed for sulfur content, the potential to generate acid, and the potential to mobilize metals. The sulfur content in Stillwater ore ranged from 0.13 to 0.49 weight percent, and in East Boulder ore ranged from 0.13 to 0.24 weight percent. The sulfur content in mineralized dike material at the Stillwater Mine was 0.05 percent and at the East Boulder Mine was 0.08 weight percent. The sulfur content was 0.09 weight percent in Stillwater Mine paste backfill. Samples of tailings and waste rock from both mines were also collected from 2001 to 2004, analyzed, and reported by Kuipers. The sulfur content of Stillwater tailings ranged from 0.05 to 0.08 weight percent, and 0.06 weight percent from a composite of East Boulder tailings. The Stillwater Mine waste rock total sulfur ranged from 0.01 to 0.04 weight percent. The East Boulder Mine waste rock total sulfur ranged from less than detection to 0.16 weight percent (Kuipers and Associates 2006). The total sulfur content of all of these samples, with the exception of the high grade Stillwater ore, was well below the generally accepted threshold of 0.3 weight percent sulfide sulfur for acid generation (Jambor et al 2000).

Further evidence was provided by static tests performed by SMC on gabbronorite (n=15 samples), norite (n=17 samples), troctolite (n=6 samples), and anorthosite (n=9 samples). The neutralization potential varied from 20 to 70 T/kT as calcium carbonate. The acid generation potential for all rock types was equal to or less than 1 and falls within the "not acid-generating" region of the plot (**Figure 1)**. These results confirm that there is very low risk of ARD formation in waste rock mined from the Stillwater complex (Kirk et al 2006).

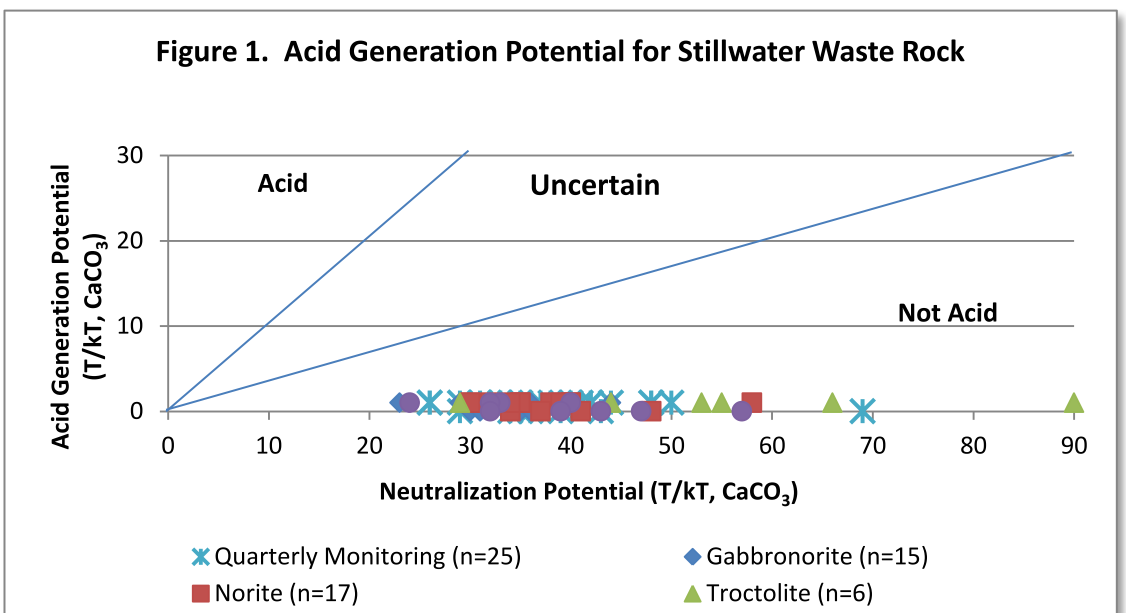

Figure 1. Comparison of neutralization and acid generation potential by waste rock type (after Kirk et al 2006).

<u>Determination of ore and waste rock</u>: Geologists at the mine determine whether a material will be shipped as ore or waste rock based on visual estimates of sulfide content. These estimates are based on experience from mapping the reef production stopes as well as sampling results that are taken regularly to calibrate the geologists' estimates. Geologists do not map development headings on a regular basis because much historical data has been collected to indicate that these rocks do not contain significant sulfides. The probe drill holes are logged and any material that may contain sulfides is sampled (Kirk et al 2006). SMC conducts operational quarterly testing of active waste rock headings to evaluate whether there is any change in rock type or characterization. As an additional management practice, SMC processes an average of 200 tons per day of "reef waste" material. Reef waste is material from the J-M Reef remaining on the edges of the stope or on the hanging wall that could contain sulfides. Processing the reef waste ensures that any rock that may contain sulfides is not disposed of in the east side waste rock storage site (ESWRS) and adds sand inventory for use underground as fill (R. Weimer, personal communication).

<u>Disposal of tailings and waste rock</u>: At the Stillwater Mine, rock that is determined to be waste in production stopes may be shipped to the ESWRS (from the lower west and east sides of the mine), or used underground to gob-fill sublevel extractions (upper west) (Kirk et al 2006). Tailings are components of paste backfill used in production stopes for the underhand cut-and-fill method of mining (with cement additive) or sandfill for overhand mining (without cement additive). Tailings may be stored in the impoundments at the mine or at Hertzler Ranch. Waste rock may also be used at both mines for road and construction materials (Kuipers and Associates 2006). At the East Boulder Mine, waste rock is used exclusively for concurrent construction of the tailings storage facility embankments, with only a fraction of a percent used as gob-fill. The majority of tailings at the East Boulder Mine are used underground as sandfill. The coarser sand fraction remains underground and the fine fraction reports to the surface impoundment (M. Wolfe, personal communication).

<u>Potential for acid generation</u>: SMC has historically collected data on a quarterly basis as part of the waste rock characterization plan to evaluate the potential for acid formation and trace element release. Recently, an operational study was done on 46 samples collected in 2004 and 2005 to correlate recently-mined waste rock with historical waste, based on geological characterization and mining practices (Kirk et al 2006). Based on the geology of the mined rock, mineralogical and whole rock geochemical analyses were used to fingerprint volumetrically significant (>1% by weight) waste lithologies. Five-kilogram samples were collected throughout the mine at multiple locations over a two-year period as part of routine operations, to produce a representative suite of samples for geochemical analysis. Thirty-one samples of waste rock were taken from primary development headings (permanent openings to approach the J-M reef), nine samples were taken from stope accesses (secondary development headings to access the stope), and seven samples were taken from reef waste rock in the stope (ore production) headings.

During the operational study, four rock types were identified as significant waste rock units. All of these rock types may be placed on the ESWRS. These are the rock types, the percentage of rock produced, and the number of samples collected per type: Norite is 54 percent of the waste rock (15 recent operational samples, 30 historical samples); gabbro is 31 percent of the waste rock (16 recent operational samples, 33 historical samples); anorthosite is 13 percent of the waste rock (9 recent samples, 33 historical samples); and troctolite is 2 percent of the waste rock (6 recent samples, 22 historical samples).

Several results were indicated by the analyses of the waste rock in the operational study:

- Total sulfur in all samples is less than 0.05 weight percent, well below the generally accepted threshold of 0.3 weight percent sulfide sulfur for acid generation (Jambor et al 2000).
- Neutralization potential of waste rock ranged from an equivalent of 20 to 70 tons of calcium carbonate per thousand tons of rock. In general, the neutralization potential of troctolite > norite > anorthosite > gabbronorite, and the acid generation potential for all rock types was less than or equal to 1 (**Figure 1)**.
- Historical data show that more than 97 percent of waste rock samples have total sulfur contents of less than 0.3 weight percent, further supporting the conclusion that waste rock mined throughout the history of production at the Stillwater Mine has negligible potential to generate acid.

These results confirm the original conclusion made during the hardrock permitting process that there is very low risk of ARD formation in waste rock mined from the Stillwater complex and suggest that kinetic testing for the oxidation of metal sulfides is unwarranted (Kirk et al 2006).

To fulfill the Hardrock operating permit requirements, both the Stillwater and East Boulder mines have an ongoing monitoring program to characterize waste rock and tailings for the potential to generate acid and leach metals. The Stillwater Mine also characterizes ore for the potential to generate acid and leach metals. Quarterly composite samples are analyzed at an accredited laboratory for neutralization potential, acid potential, and acid/base accounting using the modified Sobeck method; extractable metals have been analyzed historically using the toxicity characteristic leaching procedure (TCLP)(EPA Method 1311) and are currently analyzed by the synthetic precipitation leaching procedure (SPLP)(EPA Method 1312); and total metals are analyzed by EPA Method 6010/6020.

Kuipers and Associates independently evaluated the potential for ore, tailings, and waste rock from both the Stillwater and East Boulder mines to produce acid based on data collected from 2001 to 2004. Supplemental samples were collected in 2005 for separate geochemical analysis. They concluded that ore, tailings, and waste rock from both the Stillwater and East Boulder mines have a very low potential to generate acid (Kuipers and Associates 2006).

Operational data for Stillwater Mine: The parameters pH and sulfate have long been recognized as indicators of acid generation. When oxidation of sulfide occurs, the pH decreases and sulfate concentration increases. The agencies evaluated the long-term trends of pH and sulfate concentration in ground water at the Stillwater Mine and Hertzler Ranch land application disposal facility (LAD), Stillwater adit water, and tailings water from the Stillwater and Hertzler Ranch impoundments. The results are presented below. Please refer to the 2010 DEIS for figures that show the location of facilities and monitoring wells at the Stillwater Mine (Figures 2-3 and 3-1), Hertzler Ranch LAD (Figures 2-3 and 3-1), and the East Boulder Mine (Figure 2-27).

Ground water at the Stillwater Mine: **Figure 2** shows that the trend of pH for the 13-year period of record in downgradient wells is strongly controlled by the fluctuations of pH in upgradient ground water, as represented by MW-10A (west side of the Stillwater River) and MW-T1A (east side of the Stillwater River). The upgradient monitoring well data are displayed with dashed lines. The fluctuations noted in pH appear to be related to seasonality; that is, the slight changes in water quality would be attributed to variation in the level of the water table (higher level in spring and lower level in fall-winter). The overall trend of pH is constant in the upgradient ground water wells MW-10A and MW-

T1A. The monitoring wells located downgradient of the ESWRS (MW-15A and MW-18A) and the Stillwater tailings impoundment on the west side (MW-7A and MW-9A) follow the trend of the upgradient monitoring wells. The pH of ground water at the mine is representative of ambient water quality and is not indicative of acid formation in the ESWRS or tailings impoundment with subsequent infiltration to ground water.

Figure 3 shows the trend of sulfate in ground water at the Stillwater Mine. The concentration of sulfate in upgradient wells MW-10A and MW-T1A (displayed with dashed lines) is nearly constant. The concentrations of sulfate in wells MW-5A, MW-7A, and MW-18A downgradient of the tailings impoundment and the ESWRS fluctuate, but have an overall decreasing trend over the 13-year period of record. These fluctuations in sulfate appear to be related to seasonality and do not appear to reflect the influence of mine water. Monitoring well MW-15A is downgradient of the Stillwater Valley Ranch percolation ponds and the former East Side center pivot north LAD area. The short-term increases in sulfate between 2000 and 2003 are likely a result of seasonal disposal of mine water at the LAD. The increase in 2004 is associated with increased use of the Stillwater Valley Ranch percolation ponds while the Hertzler Ranch LAD storage pond was being constructed. The concentration of sulfate in ground water at MW-15A has since returned to near background concentrations. The sulfate concentration of ground water at the mine is representative of ambient water quality and is not indicative of acid formation in the ESWRS or tailings impoundment with subsequent infiltration to ground water.

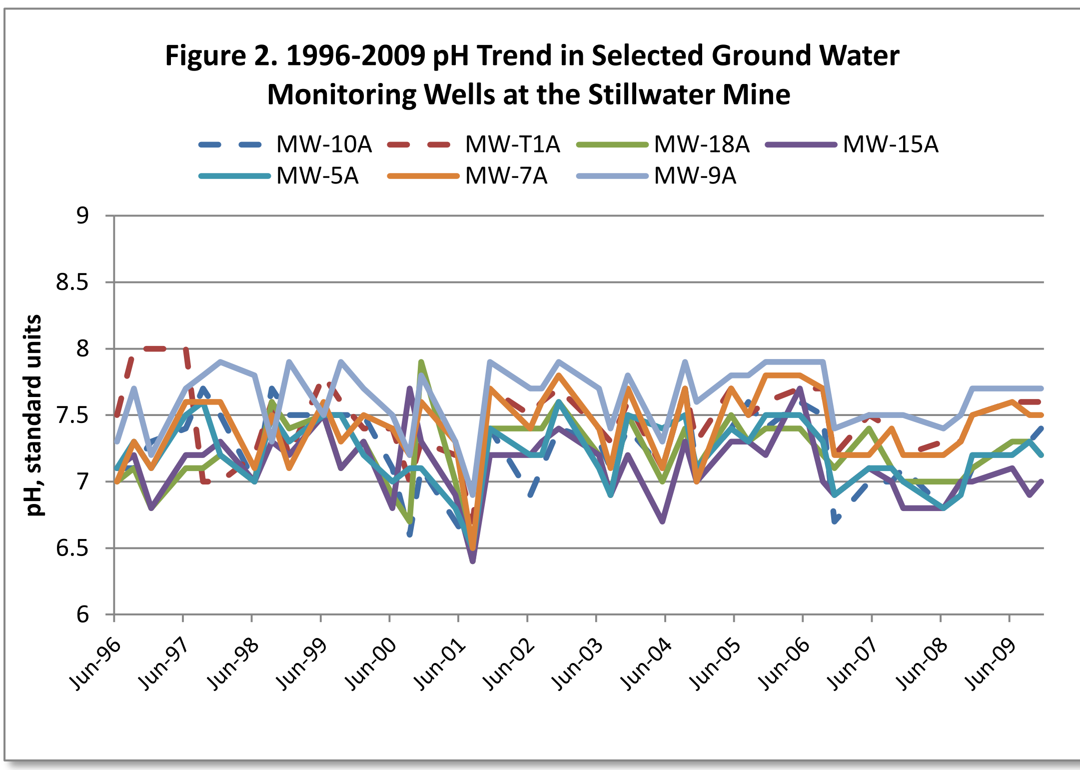

Figure 2. The trend of pH in ground water in selected monitoring wells at the Stillwater Mine. Upgradient wells are displayed with dashed lines. See the text of this memo and 2010 DEIS Figure 3-1 for monitoring well locations.

Ground water at the Hertzler Ranch LAD: The trend of pH in ground water at the Hertzler Ranch LAD is similar to that of Stillwater Mine (SMC database). The pH in upgradient ground water well HMW-5 fluctuates around a constant pH value of about 7.9, and the fluctuation appears to be related to seasonality. The pH of ground water in downgradient monitoring wells HMW-6 and HMW-10 (LAD system compliance well) is strongly controlled by upgradient ground water, and also fluctuates around a constant value of 7.9. Monitoring well HMW-9 has shown the short-term influence of mine water as a result of a 2003 leak from piping, and has a slightly lower pH averaging 7.4 standard units. Ground water in HMW-14 has a slightly higher average pH (8.7) that has been generally constant over time. The higher pH of HMW-14 is likely due to the geologic unit in which the well is screened and does not appear to reflect the influence of mine water.

The sulfate concentrations of upgradient well HMW-5 and downgradient wells HMW-6, HMW-10, and HMW-14, have fluctuated around a constant value of 23 mg/L that appear to be related to seasonality. The average sulfate concentration of monitoring well HMW-9 is 87 mg/L as a result of the 2003 piping leak. The sulfate concentration and pH of ground water at the Hertzler Ranch is strongly controlled by ambient ground water and is not indicative of acid generation from the Hertzler Ranch tailings impoundment with subsequent infiltration to ground water.

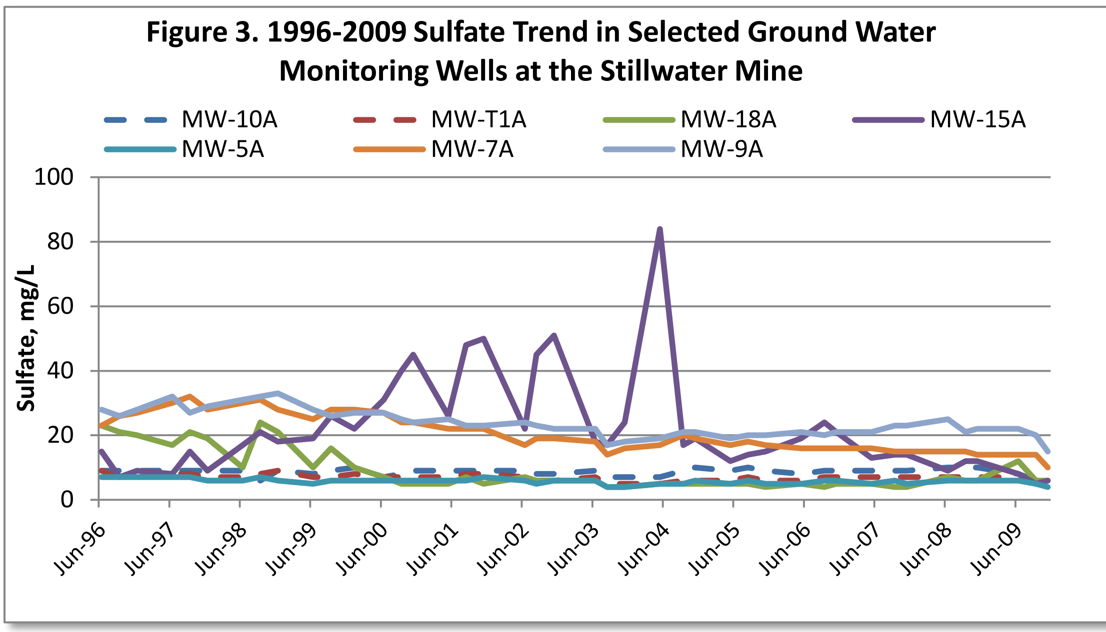

Figure 3. The trend of sulfate concentration in ground water monitoring wells at the Stillwater Mine. Upgradient wells are displayed with dashed lines. See the text of this memo and the 2010 DEIS Figure 3-1 for monitoring well locations.

Stillwater Mine adit water: Stillwater Mine currently produces an average of 650 to 800 gpm (gallons per minute) of adit water. This water is collected underground, used underground to wash down muck piles and cool drilling equipment, or used in the mill. Excess adit water is treated in the biological treatment system (BTS) to remove nitrogen before disposal in the percolation pond or at Hertzler Ranch LAD. **Figure 4** indicates that the concentration of sulfate in adit water at the Stillwater Mine has been constant around a mean of 170 mg/L over the 13-year period of record. The pH of adit water from 1987 to 2004 has been constant around a mean of 7.5. The pH has increased since 2004 about half a standard unit.

The pH spikes noted in figure 4 are likely due to the fact that Stillwater recycles about 55 percent of its tailings in cemented paste backfill or in sandfill of stopes. Paste backfill consists of the coarse tailings fraction mixed with cement and emplaced as slurry. Water that drains from cemented backfill is higher in pH and sulfate concentration than adit water and drains to sumps that collect adit water. The spikes in data may be due to times when sampling events occurred simultaneously with large underground paste pours (R. Weimer personal communication). These pH and sulfate data are not indicative of acid formation underground at the Stillwater Mine.

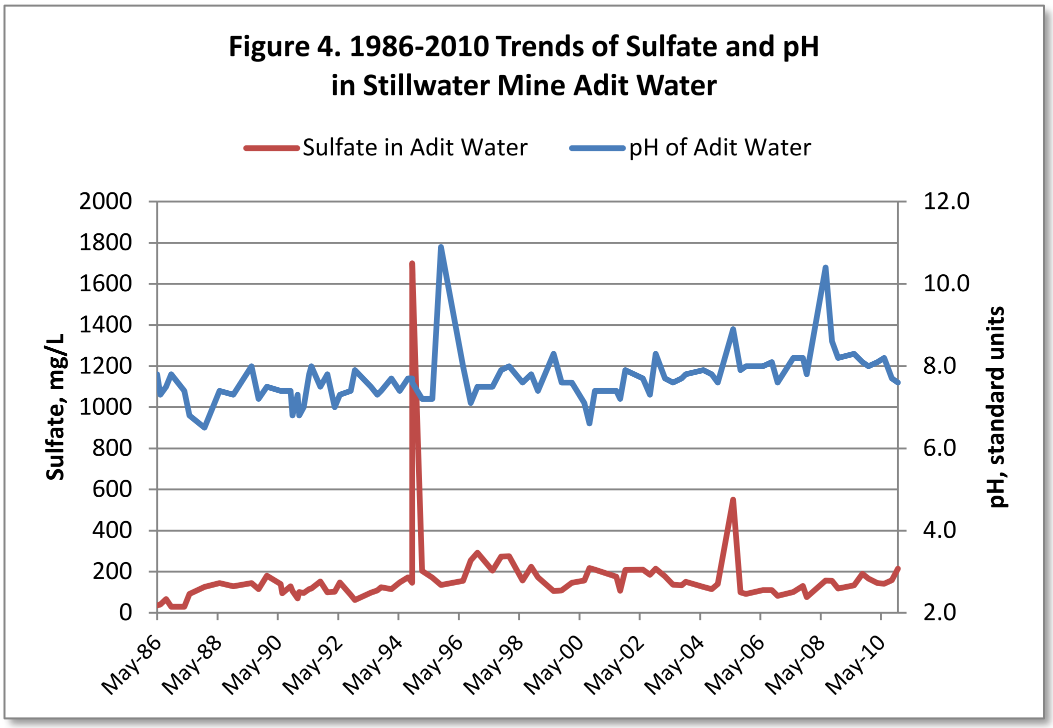

Figure 4. The trends of sulfate and pH in untreated adit water at the Stillwater Mine. The mine currently produces about 650 to 800 gpm of adit water.

Stillwater Mine tailings water: During operations, adit water contributes to the tailings water that is continuously recycled between impoundments, used in the milling process, and used for dust control on the impoundment beaches. Water is routed between the Stillwater and Hertzler Ranch impoundments so that it is combined and homogenized for a consistent quality signature. **Figure 5** displays the concentrations of sulfate and pH in tailings waters. The pH of tailings waters from 1986 to 2004 has fluctuated around a mean of 7.5. Since 2004, the pH of tailings water has increased about half a standard unit, most likely from the use of cemented paste backfill. These pH values are consistent with that of adit water, as would be expected from the routing of water within the mine. The concentration of sulfate in tailings waters gradually increased from 1986 to 2003 as a result of recycling water underground and between impoundments (for water balance). Between 2003 and 2005, the overall sulfate concentration of tailings water declined, likely a result of routing water to Hertzler Ranch to ballast the Stage II tailings impoundment liner, rather than recycling it. The mean sulfate concentration since 2005 (520 mg/L) is consistent with recycled tailings waters prior to ballasting the Stage II impoundment liner. These pH and sulfate concentration data are not indicative of acid formation within the Stillwater or Hertzler Ranch tailings impoundments.

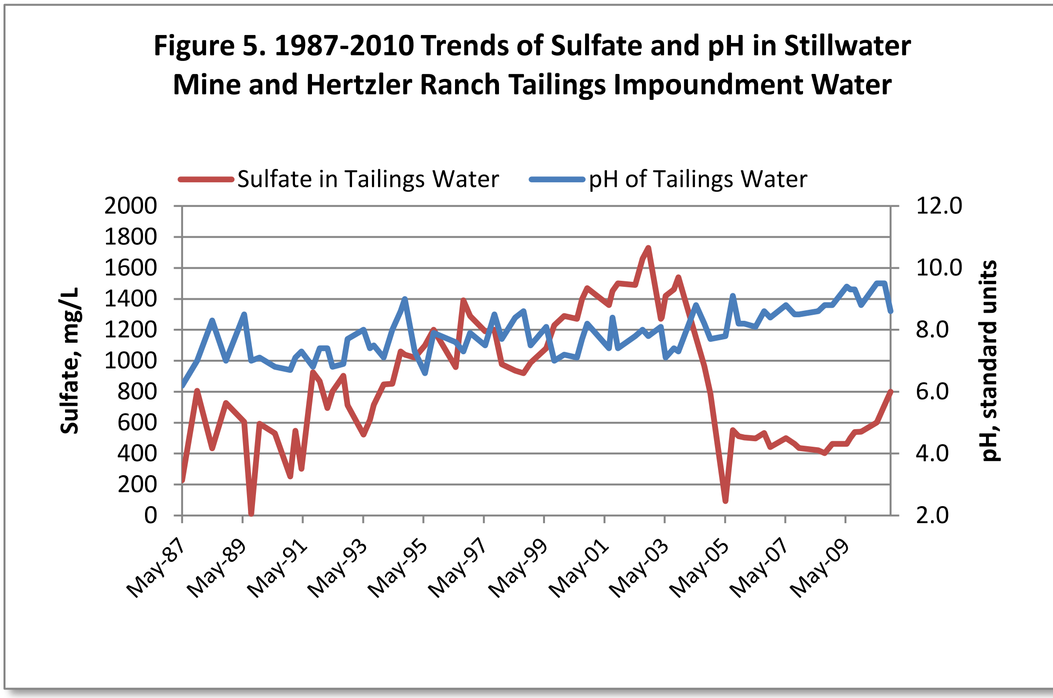

Figure 5. The trends of pH and sulfate in untreated tailings impoundment waters at the Stillwater Mine and Hertzler Ranch. The water from the Hertzler Ranch tailings impoundment is recycled back to the Stillwater impoundment during operations, so the water in both impoundments has the same quality signature.

Operational data for East Boulder Mine: The agencies evaluated the long-term trends of pH and sulfate concentration in ground water, adit water, and tailings water at the East Boulder Mine. The results are presented below.

Ground water at the East Boulder Mine: The East Boulder Mine has a much smaller footprint than the Stillwater Mine, and fewer ground water monitoring wells. The upgradient well, WW-1 is the potable water source for the mine. Monitoring well EBMW-4 is immediately downgradient of the percolation pond, which is the primary method for disposal of treated adit water. Due to annual water table fluctuations beneath the screened interval, a second monitoring well, EBMW-4A was drilled near EBMW-4 at a deeper depth with a longer screen. EBMW-2 is between the tailings impoundment and the East Boulder River. There are seven monitoring wells at the downgradient end of the tailings impoundment used to indicate compliance with the MPDES-permitted percolation pond outfall. Of these seven wells, EBMW-6 and EBMW-7 best represent downgradient water quality and are included in this evaluation.

Figure 6 shows that the pH of upgradient ground water, represented by monitoring well WW-1 (shown by a dotted line), has fluctuated around a mean of 7.8. The pH of ground water in down-gradient monitoring wells EBMW-2, EBMW-4, EBMW-6, and EBMW-7 fluctuates around a mean of 7.8 over the 22-year period of record. The fluctuations noted in pH appear to be related to seasonality; and downgradient water quality appears to be strongly influenced by upgradient water quality.

Figure 7 shows the trend of sulfate in ground water at the East Boulder Mine. The concentration of sulfate in upgradient well WW-1 is generally less than 10 mg/L. The concentration of sulfate in EBMW-2, which is strongly influenced by the East Boulder River, is less than 25 mg/L, with a mean of 15 mg/L.

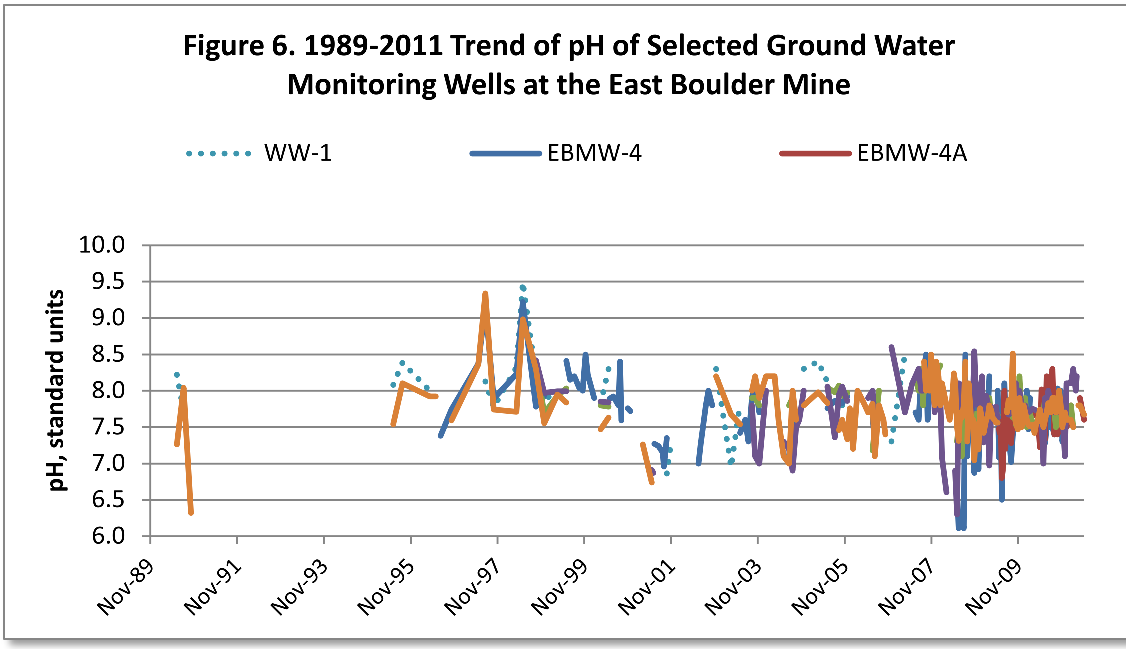

Figure 6. The trend of pH in ground water at the East Boulder Mine. Upgradient well WW-1 is displayed with a dotted line. See the text of this memo and the 2010 DEIS Figure 2-27 for the location of the monitoring wells.

The concentrations of sulfate in monitoring wells EBMW-4 and EBMW-4A downgradient of the percolation pond fluctuate around a mean of about 30 mg/L. The concentrations of sulfate in wells EBMW-6 and EBMW-7 downgradient of the tailings impoundment fluctuate around a mean of about 20 mg/L. The increase in sulfate concentration in MW-4 is due to percolation disposal of treated excess

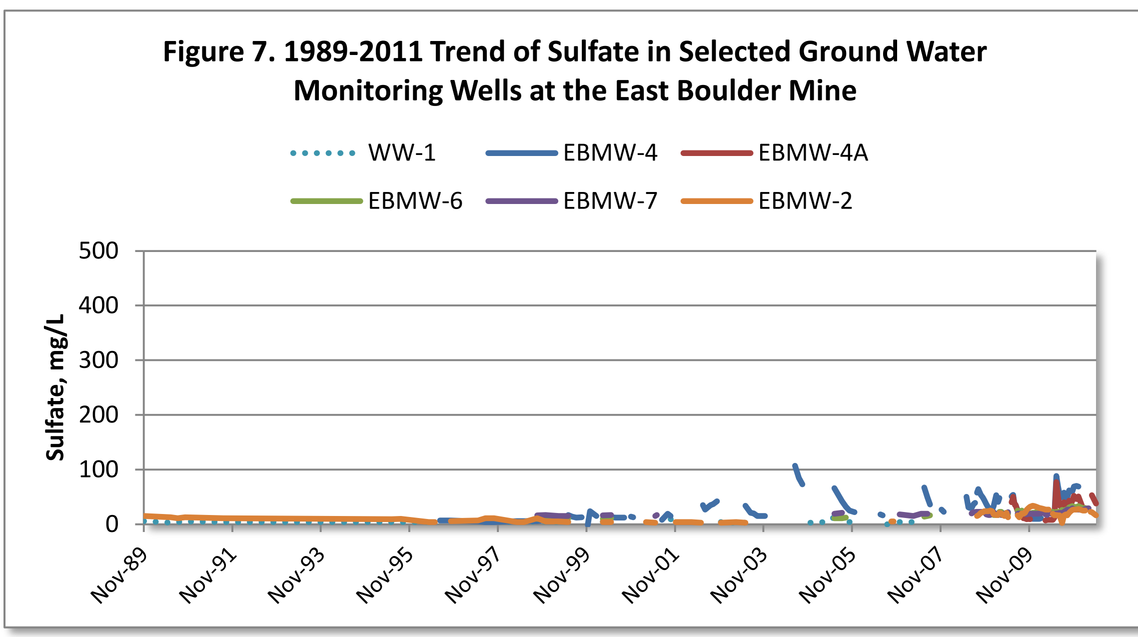

Figure 7. The trend of sulfate in ground water at the East Boulder Mine. Upgradient well WW-1 is displayed with a dotted line. See the text of this memo and the 2010 DEIS Figure 2-27 for the location of the monitoring wells.

mine waters. These pH and sulfate data, in general, reflect ambient water quality and do not indicate acid generation in the tailings impoundment or from waste rock used in construction of mine facilities.

East Boulder Mine adit water: East Boulder Mine currently produces, on average, 150 gpm of adit water. This water is collected underground, treated as needed to remove nitrogen, and routed for reuse underground to cool drilling equipment and wash down muck piles, used in the mill, or disposed of by percolation. During the period 1998 through 2002, the East Boulder Mine underwent a phase of underground construction. During this time, the three-mile adit was bored, shops were constructed, and these areas were coated with shotcrete. An acid neutralizing circuit was added to the East Boulder Mine biological treatment system (BTS) to adjust pH and protect the denitrifying bacteria. **Figure 8** portrays the pH and concentration of sulfate in untreated adit water. The sulfate concentration has fluctuated since 2003, but its nine-year trend is generally constant around a mean of 130 mg/L. The pH of adit water during the construction phase was about 9.5, but since 2002 has averaged about 7.8 standard units. The East Boulder Mine produces much less water than the Stillwater Mine, so the pH and sulfate content of adit water would strongly reflect the influence of shotcrete (pH) and sandfill (sulfate) in the underground workings. The East Boulder Mine does not use cemented paste backfill (M. Wolfe, personal communication). These data are not indicative of acid generation in the underground workings.

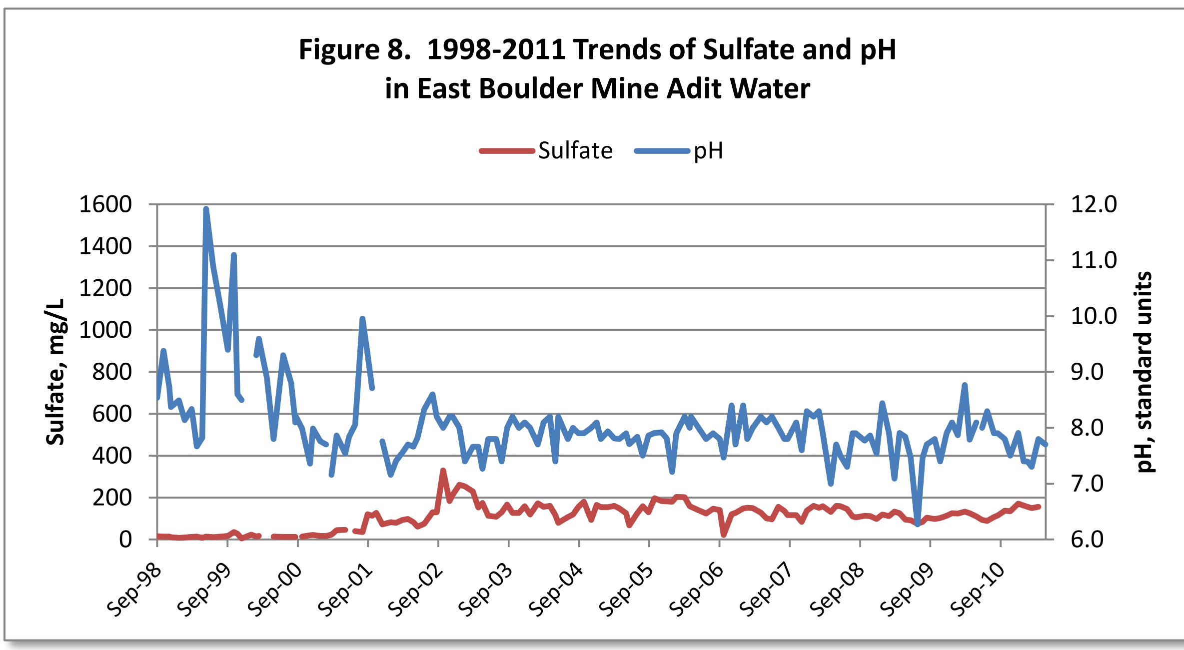

Figure 8. The trends of sulfate and pH in untreated adit water at the East Boulder Mine. The mine produces about 150 gpm of adit water.

East Boulder Mine Tailings water: Water is collected from the tailings impoundment as supernatant and underdrain (also called subdrain) water. The underdrain is a system of gravel and pipe finger drains installed above the liner to collect water that has migrated through the tailings mass. At the East Boulder Mine, approximately 80 gpm of tailings water is collected from the underdrain and recycled with supernatant water. The pH and sulfate concentrations of tailings water are presented in **Figure 9**.

The pH of the tailings waters has fluctuated around a mean of about 8.3. The sulfate concentration of the tailings waters since 2003 has averaged about 260 mg/L. These data are not indicative of acid formation in the East Boulder tailings impoundment.

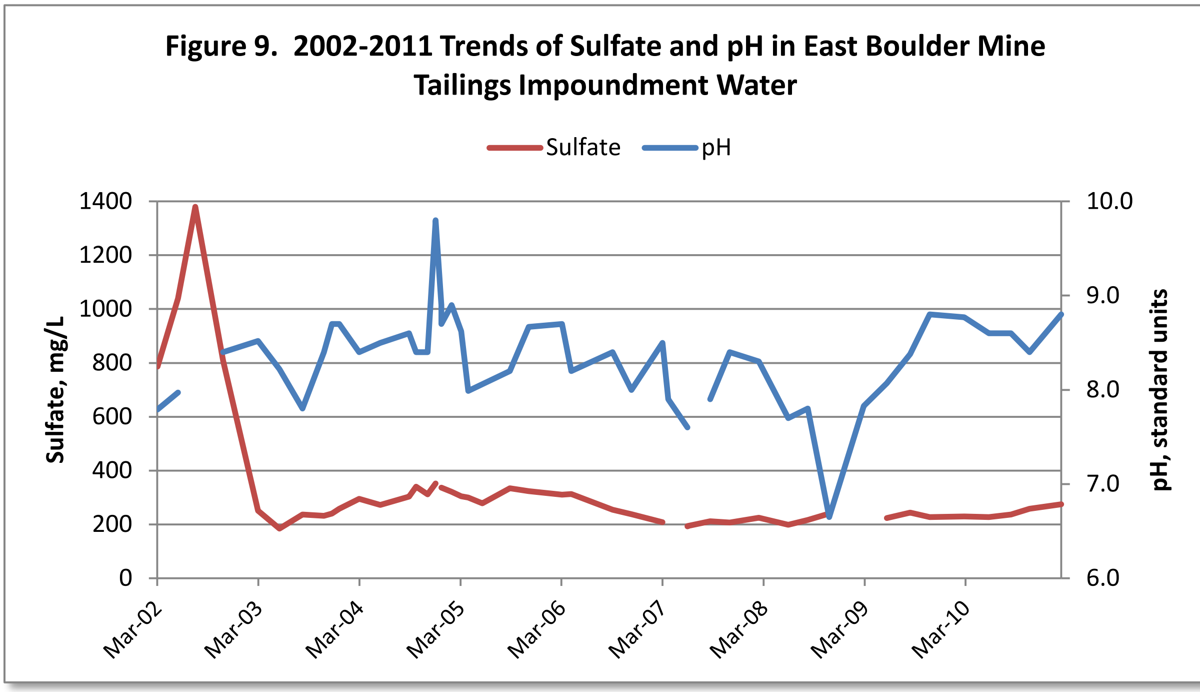

Figure 9. The trends of sulfate and pH in tailings impoundment water at the East Boulder Mine.

<u>Conclusion</u>: Current and historical geochemical data for waste rock, tailings, and ore at both mines indicate a very low potential to generate acid. SMC conducts operational quarterly testing of active waste rock headings to evaluate whether any changes are discernable in rock type or characterization (R. Weimer, personal communication). SMC has an ongoing quarterly operational monitoring program to characterize ore, waste rock, and tailings for the potential to generate acid (hardrock permit plans of operations). The ground water quality at both mines and the Hertzler Ranch LAD is strongly influenced by the ambient ground water signature and is not indicative of impacts resulting from acid generation in waste rock or from the tailings impoundments. The quality of adit and tailings waters, based on pH and sulfate concentrations, is not indicative of acid generation in the underground or in the tailings impoundments.

These data suggest that static and kinetic testing is unwarranted post-closure. Geologic interpretation of the Stillwater Complex J-M Reef, comparisons of geology and rock type/composition between the Stillwater and East Boulder Mines, probe holes drilled in advance of the heading/footwall underground, exploration drilling from the surface along the length of the deposit, and extensive surface mapping all attest to the remarkable consistency of this Pt-Pd deposit (R. Weimer, personal communication). Due to this consistency, no change in rock type or mineralogy is anticipated. If the rock types, geochemical data, and water quality data remain consistent with current and historical data, the potential for generation of acid is extremely low, and the agencies would not require additional static or kinetic testing.

Comment 2: *Summary of the long-term monitoring plan for potential acid generation and leaching of metals post-closure.*

<u>Potential for acid generation</u>: Based on the data provided in response to Comment 1, if the rock types, geochemical data, and water quality data remain consistent with operational and historic data, the potential for generation of acid is extremely low. These data suggest that monitoring for acid generation is unwarranted post-closure. The agencies will require water quality monitoring during closure.

<u>Potential for metals leaching-- geochemical data</u>: Leaching tests are used at hard rock mines to evaluate whether metals might be leached from waste rock or tailings that could infiltrate soil and potentially discharge to ground water. SMC has an ongoing quarterly operational monitoring program to characterize ore (Stillwater Mine only), waste rock, and tailings for the potential to generate acid and leach metals.

Under the Good Neighbors Agreement (GNA), Kuipers and Associates performed an independent review of quarterly geochemical data collected from 2001 to 2005 by both mines (whole rock and leachable metals by TCLP and SPLP). The TCLP had initially been used by SMC at Stillwater Mine to evaluate metals mobility and is a more aggressive leaching analysis performed on whole rock. The fixed pH 5 of the extraction solution used in the TCLP is lower than any pH measurement recorded for the site and the results obtained, therefore, are conservative in assessing metals mobility from the site.

EPA has suggested that a less aggressive leaching test such as SPLP could be applied to mineral processing wastes, and may be more appropriate than TCLP (EPA 1995). In their independent review of the leaching data from both mines, Kuipers and Associates recommended that "Stillwater Mine modify the Waste Rock Characterization Plan to analyze ore, tailings, and waste rock samples for SPLP extractable metals instead of TCLP extractable metals" (Kuipers and Associates 2006). The SPLP is less aggressive, designed to evaluate the mobility of organic and inorganic contaminants by simulating the effect of acid rain on land disposed wastes. SMC now uses the SPLP test at both Stillwater and the East Boulder mines on a quarterly basis to evaluate metals mobility.

A third test, the Meteoric Water Mobility Procedure (MWMP), was developed by the Nevada Department of Environmental Protection for mining wastes and is a laboratory analysis described by the American Society of Testing and Materials (ASTM E2242-07). The MWMP test is designed to evaluate the potential for dissolution and mobility of certain constituents from mine waste by leaching with meteoric water (precipitation). SMC performed MWMP leaching analyses on samples obtained from cores of waste rock collected from the ESWRS at the Stillwater Mine (SMC 2009).

In addition to their review of existing data, Kuipers and Associates collected supplemental samples from the Stillwater and East Boulder mines in 2001 to analyze for sulfur content, the potential to generate acid, total metals concentration, and the potential to mobilize metals using the SPLP analyses (reported in Kuipers and Associates 2006). The Stillwater Mine's highest concentration laboratory metals leaching results for waste rock, tailings, and ore are listed in **Table 1** (Kuipers and Associates 2006 and SMC 2009). It should be noted that three leaching procedures were used to provide the results listed in Table 1. All of the laboratory SPLP and MWMP leachable metals results for waste rock and tailings are less than ground water quality criteria. Two TCLP leachable metals detections (from a tailings sample) exceeded MT DEQ Circular 7 ground water criteria.

Table 1. **Stillwater Mine Maximum Laboratory Leachate Concentrations from Mine Waste compared to Ground Water Criteria** (from Kuipers and Associates 2006 and SMC 2009).

Parameter (all values mg/L)	**Laboratory Metals Leaching Maximum Results from Stillwater Mine Waste Rock, Tailings, and Ore***						**MT DEQ Circular 7 Ground Water Criteria**
	Waste Rock		**Tailings**		**Ore**		
	MWMP 2009 n=37	SPLP 2006 n=11	SPLP 2006 n=1	TCLP 2006 n=15	SPLP 2006 n=1	SPLP 2006 n=6	
Cadmium	<0.0001	<0.0001	<0.0001	**0.5**	<0.0001	<0.1	0.005
Chromium	0.029	<0.01	<0.01	<1	<0.01	<0.5	0.100
Copper	0.0175	<0.01	<0.01	<0.5	<0.01	<0.5	1.3
Iron	<0.06	NA	NA	NA	NA	NA	0.300
Lead	<0.003	0.0007	0.0002	<0.5	0.0004	<0.5	0.015
Manganese	0.007	NA	NA	<5	NA	NA	0.050
Mercury	<0.0002	0.0003	<0.0002	<0.05	<0.0002	<0.02	0.002
Nickel	0.031	<0.01	<0.01	**0.9**	<0.01	<0.5	0.1
Zinc	0.011	0.01	0.01	<5[€]	0.01	<0.5	2.000

* The maximum, and therefore, most conservative, laboratory result is listed in the table. [€]For tailings, four TCLP samples were analyzed for zinc. Abbreviations: **n**= the number of samples analyzed; **MWMP**-Meteoric Water Mobility Procedure; **SPLP**-Synthetic Precipitation Leaching Procedure; **TCLP**- Toxic Characteristic Leaching Procedure; **NA**-not analyzed; **mg/L** milligrams per liter; **<** indicates a non-detectable result at the detection level listed. **Bold values** indicate an exceedance of ground water quality criterion.

The East Boulder Mine's highest laboratory metals leaching results for waste rock, tailings, and ore are listed in **Table 2** (Kuipers and Associates 2006). It should be noted that only the SPLP leaching procedure was used to provide the results listed in Table 2. All of the laboratory SPLP leachable metals results are less than MT DEQ Circular 7 ground water quality criteria.

Table 2. **East Boulder Mine Maximum Laboratory Leachate Concentrations from Mine Waste compared to Ground Water Criteria.**

Parameter (all values mg/L)	**Laboratory Metals Leaching Maximum Results from SMC East Boulder Mine Waste Rock, Tailings, and Ore***			**MT DEQ Circular 7 Ground Water Criteria**
	Waste Rock SPLP 2006* n=5	**Tailings** SPLP 2006* n=1	**Ore** SPLP 2006* n=1	
Cadmium	<0.0001	<0.0001	<0. 0001	0.005
Chromium	<0.01	<0.01	<0.01	0.100
Copper	<0.01	<0.01	<0.01	1.3
Iron	NA	NA	NA	0.300
Lead	0.0002	<0.0001	<0.0001	0.015
Manganese	NA	NA	NA	0.050
Nickel	<0.01	<0.01	<0.01	0.1
Zinc	0.02	0.01	<0.01	2.000

* Maximum detectable concentration is listed in table (Kuipers and Associates 2006). Bold values indicate an exceedance of ground water quality criterion. Abbreviations: **SPLP**-Synthetic Precipitation Leaching Procedure; **NA**-not analyzed; **mg/L** milligrams per liter; **<** indicates a non-detectable result at the detection level listed.

<u>Conclusion</u>: Geochemical characterization data collected by SMC from 2001 through 2005 as part of the ongoing operational monitoring program, and reviewed by Kuipers and Associates under the GNA, indicate that ore, tailings, and waste rock have a very low potential to generate acid and leach metals (Kuipers and Associates 2006). Based on these data and SMC's ongoing operational monitoring program, if the rock types and geochemical data remain consistent with operational and historical data, the potential for leaching of metals is extremely low. These data suggest that metals leachability testing is unwarranted during post-closure.

Comment 3: *Disclosure of the operational concentrations of metals in adit and tailings waters at both the Stillwater and East Boulder mines with a comparison of the operational concentrations to applicable water quality standards.*

The agencies have compared the concentrations of metals in adit and tailings waters at both the Stillwater and East Boulder mines to MT DEQ Circular 7 ground water criteria. These are the appropriate criteria because the mines currently discharge mine waters to percolation ponds or LAD systems that infiltrate to ground water. These data are tabulated below.

The agencies have also compared the concentrations of metals in adit and tailings waters from both mines to the respective MPDES permit direct discharge effluent limits. Please note that the operational data are obtained using dissolved metals analyses. The MPDES permit would require total recoverable metals analyses of any direct-discharged waters. Dissolved and total recoverable metals analyses produce very different results, and as such, are not directly comparable. Conceding this primary difference in analytical technique, there is merit in comparing the order of magnitude of operational dissolved metals concentrations with MPDES permit surface water total recoverable metals effluent limits to estimate the potential effect that direct discharge of untreated (for metals) adit or tailings waters might have on surface water.

<u>Potential for metals loading—Stillwater Mine operational waste water quality data</u>: **Table 3** lists the median metals quality of the operational waste water at the Stillwater Mine in comparison to the ground water quality criteria. Both the operational waste water data and the MT DEQ Circular 7 ground water criteria are dissolved analyses. None of the operational wastewater streams violate DEQ Circular 7 metals criteria for ground water and are generally at least one order of magnitude less than the metals criteria. These data indicate that discharge of Stillwater Mine untreated adit or tailings waters at the mine percolation ponds or Hertzler Ranch LAD would not result in metals contamination of ground water.

<u>Potential for metals loading—Stillwater Mine surface water effluent limits</u>: For comparison purposes, **Table 4** lists the Montana Pollution Discharge Elimination System (MPDES) permit effluent limits for the Stillwater Mine that SMC would have to meet if treated mine waters were directly discharged to the Stillwater River. Although Stillwater Mine has a permitted outfall (001) for direct discharge to the Stillwater River, this outfall has not been constructed and is not used by the mine. Please note that the discharged water would require total recoverable metals analysis. SMC currently treats for nitrogen then land applies (discharges to ground water) most of its mine waters at the Hertzler Ranch LAD System (discharge to ground water) and the remainder is disposed of in the percolation ponds (discharge to ground water) at the Stillwater Mine. Conceding the difference between analytical methodologies, all of the adit and tailings waters are approximately equal to, or less than, the MPDES

average monthly and instantaneous maximum metals limits for direct discharge to surface water without treatment for metals.

Table 3. **Stillwater Mine Operational Waste Water Quality Data compared to Ground Water Criteria.**

Parameter (all values mg/L)	**MT DEQ Circular 7 Ground Water Criteria**	**Adit Waters**[€]		**Tailings Waters**[€]		**Hertzler Ranch Tailings Underdrain**[€] 2003-2008
		East Side SMC-9 2001-2010	**West Side SMC-3** 2001-2010	**Stillwater SMC-4** 2000-2010	**Hertzler Ranch** 2001-2009	
Cadmium	0.005	<0.0001	<0.0001	<0.0001	<0.0001	0.0001
Chromium	0.100	0.010	0.001	<0.01	0.0012	<0.001
Copper	1.3	<0.001	<0.001	0.003	0.003	0.001
Iron	0.300	<0.01	<0.01	0.025	0.025	0.256
Lead	0.015	<0.003	<0.003	<0.003	<0.003	<0.003
Manganese	0.050	<0.005	0.0065	<0.003	0.007	1.26
Mercury	0.002	<0.00001	NA	NA	NA	NA
Nickel	0.1	<0.01	NA	NA	NA	NA
Silver	0.100	<0.0005	NA	NA	NA	NA
Zinc	2.000	<0.01	<0.01	<0.01	0.015	0.015

[€] Median concentration reported from the SMC database for the period indicated. **Bold values** indicate an exceedance of ground water quality criterion. Abbreviations: **mg/L** milligrams per liter; **<** indicates a non-detectable result at the detection level listed; **NA**—not analyzed.

Table 4. **Comparison of Stillwater Mine MPDES Permit Metals Effluent Limits for Direct Discharge to the Stillwater River to Stillwater Waste Water Metals Quality Data.**

MPDES Permit MT0024716 Stillwater Mine Outfall 001 to Stillwater River Effluent Limits (expires 2013)			**Stillwater Mine Adit Water**[€]		**Tailings Waters**[€] Stillwater and Hertzler Impoundments
Parameter (all values in mg/L)	**Average Monthly Limit**	**Instantaneous Maximum Limit**	**East Side SMC-9** 2001-2010	**West Side SMC-3** 2001-2010	**Stillwater SMC-4** 2000-2010
Cadmium	<0.00008	<0.00008	<0.0001	<0.0001	<0.0001
Chromium	0.174	0.350	0.010	0.001	<0.01
Copper	0.012	0.025	<0.001	<0.001	0.003
Iron	6.1	12.23	<0.01	<0.01	0.025
Lead	0.000545	0.01398	<0.003	<0.003	<0.003
Manganese	0.35	0.53	<0.005	0.0065	<0.003
Mercury	0.00005	0.00008	<0.00001	NA	NA
Nickel	0.048	0.100	<0.01	NA	NA
Zinc	0.027	0.055	<0.01	<0.01	<0.01

[€] Median dissolved metals concentration of the data for the date range indicated, from the SMC database. **Bold values** indicate an exceedance of ground water quality criterion. Abbreviations: **NA**—not analyzed; **<** indicates a non-detectable result at the detection level listed. Please note that the MPDES permit effluent limits would require a total recoverable metals analysis and the operational data are dissolved metals analyses.

Potential for metals loading—East Boulder Mine operational waste water metals data: **Table 5** lists the metals quality of the operational waste waters at the East Boulder Mine in comparison to the ground water quality criteria. None of the operational waste waters violate MT DEQ Circular 7 metals ground water criteria and most values are at least one order of magnitude less than the metals criteria. These data indicate that metals contamination of ground water would not result from discharge of East Boulder Mine adit or tailings waters.

Table 5. **East Boulder Mine Operational Metals Waste Water Quality Data compared to Ground Water Criteria.**

Parameter (all values mg/L)	**MT DEQ Circular 7 Ground Water Criteria**	**East Boulder Mine Operational Waste Stream Metals Data**	
		Adit Water€ 1998-2011	**Tailings Waters**€ 1998-2011
Arsenic	0.010	<0.003	<0.003
Barium	1.000	0.005	<0.2
Beryllium	0.004	<0.001	<0.001
Cadmium	0.005	<0.0001	<0.0001
Chromium	0.100	<0.001	<0.001
Copper	1.3	<0.001	0.002
Iron	0.300	0.04	0.025
Lead	0.015	<0.003	<0.002
Manganese	0.050	0.022	0.005
Mercury	0.002	<0.005	<0.005
Nickel	0.1	<0.02	<0.02
Selenium	0.050	0.002	0.005
Silver	0.1	<0.003	<0.003
Zinc	2.000	<0.02	<0.01

€Median dissolved metals concentration of the data for the date range indicated, from the SMC database. **Bold values** indicate an exceedance of ground water quality criterion. Abbreviations: **mg/L** milligrams per liter; **<** indicates a non-detectable result at the detection level listed; **NA**—not analyzed.

Potential for metals loading —East Boulder Mine surface water effluent limits: For comparison purposes, **Table 6** lists the MPDES permit effluent limits for the East Boulder Mine that SMC would have to meet if treated mine waters were directly discharged to the East Boulder River. Although East Boulder Mine has a permitted outfall (001) for direct discharge to the East Boulder River, this outfall has not been constructed and is not used by the mine. SMC currently percolates (discharges to ground water) mine waters that have been treated for nitrogen at the East Boulder Mine. Conceding the difference between analytical methodologies, all of the adit and tailings waters are approximately equal to, or less than, the MPDES average monthly and instantaneous maximum metals limits for direct discharge to surface water without treatment for metals.

Conclusion: Geologic interpretation of the Stillwater Complex J-M Reef, comparisons of geology and rock type/composition between the Stillwater and East Boulder Mines, probe holes drilled in advance of the heading/footwall underground, exploration drilling from the surface along the length of the deposit, and extensive surface mapping all attest to the remarkable consistency of this Pt-Pd deposit (R. Weimer, personal communication). Due to this consistency, no change in rock type or mineralogy is anticipated

Table 6. **Comparison of East Boulder Mine MPDES Permit Metals Effluent Limits for Direct Discharge to the East Boulder River to East Boulder Waste Water Metals Quality Data**

MT0026808 East Boulder Mine Outfall 001 to East Boulder River Effluent Limits (administratively extended since 2005)			**East Boulder Mine**[€]	
Parameter (mg/L)	**Average Monthly Limit**	**Instantaneous Maximum**	**Adit Water** 1998-2011	**Tailings Waters** 1998-2011
Cadmium	0.0014	0.0021	<0.0001	<0.0001
Chromium	0.05	0.075	<0.001	<0.001
Copper	0.008	0.012	<0.001	0.002
Iron	0.43	0.65	0.04	0.025
Lead	0.001	0.0015	<0.003	<0.002
Manganese	0.19	0.28	0.022	0.005
Nickel	0.024	0.036	<0.02	<0.02
Zinc	0.03	0.045	<0.02	<0.01

[€] Median concentration reported from SMC database; dissolved metals analysis. All values in **mg/L** milligrams per liter; **<** indicates a non-detectable result at the detection level listed; **NA**—not analyzed; Please note that the MPDES permit effluent limits would require a total recoverable metals analysis.

that would result in an adverse change in the quality of adit or tailings water over time. The results of SMC's operational monitoring program, in concert with historical data, suggest that SMC's disposal of adit and tailings waters would not cause loading of metals at a rate that would cause contamination of or degrade surface and ground water. The agencies believe that the current operational monitoring program, the MT DEQ ground water quality metals criteria, and the requirements of the MPDES permit are adequate to protect surface and ground water quality.

Comment 4: *Analysis of the effects of metals on surface and ground water at both mines, operationally and post-closure.*

In general, hardrock waste rock storage facilities, tailings impoundments, and LAD facilities have the potential to leach metals to ground water and surface runoff. The agencies have reviewed the ground water quality data up- and downgradient of the tailings impoundments and surface waste rock storage areas at both mines, and at the Hertzler Ranch LAD to determine whether metals have affected surface and ground water quality at the mines operationally. The agencies have also evaluated whether metals would affect surface and ground water quality at the mines post-closure.

Potential for metals loading—Stillwater Mine ground water quality data: Monitoring well MW-10A is upgradient of all facilities, including the Stillwater Tailings impoundment, on the west side of the Stillwater River. Monitoring well MW-T1A is upgradient of the ESWRS on the east side of the Stillwater River. Monitoring wells MW-15A and MW18A monitor the uppermost aquifer downgradient of the ESWRS. Monitoring wells MW-5A, MW-7A, and MW-9A monitor the uppermost aquifer downgradient of the Stillwater Tailings Impoundment. Please refer to Figures 2-3 and 3-1 in the 2010 DEIS for the location of these monitoring wells. **Table 7** lists the highest concentrations of metals in ground water monitoring wells up- and downgradient of the Stillwater Mine ESWRS and the Stillwater Tailings impoundment. The period of record is listed per monitoring well and extends through the 2009 Annual

Water Resources Monitoring Report (SMC 2010). All of the ground water metals data to date meet ground water quality criteria. It should be noted that detection limits have improved since ground water sampling began at the mine and current detection limits are lower than ground water criteria.

Table 7. **Stillwater Mine Operational Ground Water Quality[€] Up- and Downgradient of the East Side Waste Rock Storage and Stillwater Tailings Impoundment.**

Parameter (all values mg/L)	**MT DEQ Circular 7 Ground Water Criteria**	**Stillwater Mine Upgradient Monitoring Wells**		**East Side Waste Rock Storage[a] Downgradient Monitoring Wells**		**West Side Stillwater Tailings Impoundment[¥] Downgradient Monitoring Wells**		
		MW-10A West Side 1986-2009	**MW-T1A** East Side 1988-2009	**MW-18A** 1994-2009	**MW-15A** 1990-2009	**MW-5A** 1987-2009	**MW-7A** 1986-2009	**MW-9A** 1986-2009
Cadmium	0.005	<0.005	<0.005	0.002	0.001	<0.005	<0.005	<0.005
Chromium	0.100	<0.02	<0.05	0.007	0.008	<0.02	0.03	0.04
Copper	1.3	<0.01	<0.01	<0.001	<0.01	<0.01	<0.01	0.01
Iron	0.300	0.2	<0.03	0.08	0.08	0.16	0.16	0.06
Lead	0.015	<0.02	<0.02	<0.003	<0.001	<0.02	<0.01	<0.02
Manganese	0.050	0.03	<0.02	<0.01	<0.02	0.01	<0.02	<0.02
Mercury	0.002	NA	NA	NA	NA	NA	NA	NA
Nickel	0.1	NA	NA	NA	NA	NA	NA	NA
Zinc	2.000	0.04	0.02	0.04	0.04	<0.09	0.12	2.21

[€] Maximum concentration reported from SMC database. [a]The East Side Waste Rock Dump was placed on top of the former chromite tailings piles from the Mouat Chromite Mine. [¥]The tailings impoundment was placed on top of former mill facility for the Mouat Chromite Mine. **Bold values** indicate an exceedance of ground water quality criterion. Abbreviations: **<** indicates a non-detectable result at the detection level listed; **NA**—not analyzed.

<u>Potential for metals loading—Hertzler Ranch LAD ground water quality data:</u> The Hertzler Ranch LAD system is used for disposal of excess water produced at the Stillwater Mine. The facilities at the Hertzler Ranch as of 2011 include seven center pivots, a LAD water storage pond, and the Hertzler Ranch tailings impoundment. In 2010, 216 million gallons of water was disposed of using the LAD system. Ground water monitoring well HMW-5 is upgradient of the center pivots, LAD storage pond, and Hertzler Ranch tailings impoundment. Monitoring wells HMW-9 and HMW-14 are downgradient of the LAD storage pond and tailings impoundment, respectively. HMW-6 is located beneath the center pivots, and HMW-10 is the compliance well located downgradient of the pivots, storage pond, and tailings impoundment. Please refer to Figure 3-1 in the 2010 DEIS for the location of these monitoring wells. **Table 8** lists the highest concentrations of metals in ground water monitoring wells up- and downgradient of the Hertzler Ranch LAD facilities. The period of record is listed per monitoring well and extends through the 2009 Annual Water Resources Monitoring Report (SMC 2010). All of the ground water quality metals data to date meet ground water quality criteria.

<u>Potential for metals loading—East Boulder Mine ground water quality data</u>: **Table 8** lists the highest concentrations of metals in up- and downgradient ground water monitoring wells at the East Boulder Mine. The period of record is listed per monitoring well and extends through the first quarter 2011 (East Boulder Mine water quality database). With the exception of iron and manganese in the upgradient well WW-1 and in EBMW-2 located between the tailings impoundment and the East Boulder River, ground water quality metals criteria are met. Similar concentrations of iron and manganese were not

detected in wells downgradient of the percolation pond and tailings impoundment. There is no evidence that ground water quality has been adversely affected by metals from the East Boulder Mine.

Table 8. **Hertzler Ranch Metals Water Quality Up- and Downgradient of the LAD Center Pivots, LAD Storage Pond and the Hertzler Ranch Tailings Impoundment.**

Parameter (all values mg/L)	**MT DEQ Circular 7 Ground Water Criteria**	**Hertzler Ranch LAD System Metals Ground Water Quality Data**				
		Upgradient Monitoring Well€	**Hertzler Tailings Impoundment and LAD Pond Downgradient Monitoring Wells** €		**Hertzler Ranch LAD Downgradient Monitoring Wells**€	
		HMW-5 1995-2009	**HMW-9** 1996-2009	**HMW-14** 1999-2009	**HMW-6** 1996-2009	**HMW-10** Compliance Well 1996-2009
Cadmium	0.005	0.0011	0.0009	0.0004	0.0007	0.0007
Chromium	0.100	0.001	0.006	0.004	0.002	0.002
Copper	1.3	0.003	0.005	0.003	0.002	0.002
Iron	0.300	0.19	0.03	0.07	0.02	0.03
Lead	0.015	<0.003	0.003	<0.003	<0.003	0.005
Manganese	0.050	0.037	0.032	0.045	0.01	0.007
Mercury	0.002	NA	NA	NA	NA	NA
Nickel	0.1	NA	NA	NA	NA	NA
Zinc	2,000	0.02	0.03	<0.01	0.04	0.03

€ Maximum concentration of the data for the date range indicated, from the SMC database. **Bold values** indicate an exceedance of ground water quality criterion. Abbreviations: **<** indicates a non-detectable result at the detection level listed; **NA**—not analyzed.

Post-closure potential for metals loading:

East Boulder Mine post-closure adit discharge: Post-closure, the East Boulder Mine workings would be free-draining and its stopes would not flood. The East Boulder underground sandfill would not become saturated to potentially leach constituents that could affect water quality. The quality of adit water post-closure is expected to approach that of ambient ground water, and would not adversely affect ground water quality (DEQ and USFS 2010).

Stillwater Mine post-closure off-shaft discharge to the Stillwater River: Four to eleven years after closure, ground water that fills the underground workings would begin to discharge from the off-shaft (a vertical shaft that extends 1,900 feet beneath the Stillwater River Valley floor through the lower workings that would be used to dewater workings below 5,000 feet). The discharge from the off-shaft is estimated to be 320 gallons per minute (gpm) which is about 0.7 cubic feet per second (cfs) to the Stillwater River (DEQ and USFS 2010).

To put this post-closure discharge in perspective, the lowest monthly streamflow over a 10-year period for the Stillwater River at SMC-11 occurred in 2006 at 84 cfs, which is about 37,700 gpm. The estimated discharge from the off-shaft is 0.8 percent of the 2006 low streamflow value. The average low monthly Stillwater River streamflow is 140 cfs (about 62,900 gpm) (SMC database). The estimated discharge from the off-shaft is 0.5 percent of the average low streamflow value. These streamflow and volumetric data indicate that adit water discharging from the off-shaft post-closure would be at such a low volume as to not be discernable (that is, 8/1,000 and 5/1,000 parts, respectively).

As discussed in the response to comment 3, the concentrations of metals in adit and tailings waters are approximately equivalent to, or less than, the 2008 MPDES permit effluent limits and would not cause contamination of or degrade surface water. These data indicate that adit water discharging from the off-shaft post-closure would not adversely affect aquatic life in the Stillwater River.

Table 9. **East Boulder Mine Operational Ground Water Quality Up- and Downgradient of the East Boulder Percolation Pond and Tailings Impoundment.**

Parameter (all values mg/L)	**MT DEQ Circular 7 Ground Water Criteria**	**East Boulder Mine Metals Ground Water Quality Data**[€]					
		Upgradient Monitoring Well	**Monitoring Wells Downgradient of the Percolation Pond**		**Monitoring Wells Downgradient East Boulder Tailings Impoundment**		
		WW-1 1989-2011	**EBMW-4** 1996-2010	**EBMW-4A** 2009-2011	**EBMW-2** 1989-2011	**EBMW-6** 1998-2011	**EBMW-7** 1998-2011
Arsenic	0.010	<0.005	0.003	<0.01	<0.005	NA	<0.001
Barium	1.0	<0.01	<0.1	0.016	NA	NA	0.017
Beryllium	0.004	<0.005	NA	NA	NA	NA	<0.001
Cadmium	0.005	0.001	0.0006	<0.0001	<0.001	0.0002	<0.0003
Chromium	0.10	<0.02	0.005	0.004	0.017	0.01	0.001
Copper	1.3	0.034	0.012	0.002	0.004	0.003	0.003
Iron[a]	0.300	**1.74**	0.05	0.05	**1.69**	0.03	<0.03
Lead	0.015	<0.01	<0.003	<0.002	<0.01	<0.003	<0.003
Manganese[a]	0.050	**0.052**	0.007	0.01	**0.071**	0.01	0.006
Mercury	0.002	<0.001	<0.0001	NA	<0.001	NA	<0.0001
Nickel	0.100	<0.03	<0.02	<0.01	<0.03	0.02	<0.001
Selenium	0.050	<0.005	<0.0001	NA	<0.005	NA	<0.001
Silver	0.1	<0.005	<0.001	NA	<0.05	NA	<0.001
Zinc	2.000	0.43	0.04	<0.01	0.04	0.43	0.02

[€] Maximum concentration reported from SMC database. **Bold values** indicate an exceedance of the ground water quality criterion. [a] Secondary maximum contaminant level. Abbreviations: **mg/L** milligrams per liter; **<** indicates a non-detectable result at the detection level listed; **NA**—not analyzed.

Post-closure seepage through the reclamation covers: A post-closure discharge would occur from each of the three tailings impoundments: Stillwater Mine, Hertzler Ranch, and East Boulder Mine. Precipitation that infiltrates through the reclamation cover and mixes with tailings waters would eventually overflow the liners and discharge as seepage through the cover. The rate of seepage for each impoundment was estimated based on precipitation, evaporation, and impoundment size (cover thickness was not considered as a conservative assumption) (DEQ and USFS 2010). Because the tailings waters from all impoundments meet DEQ Circular 7 criteria without dilution from precipitation, and the volume of ground water available for dilution is much greater than the volume of surface water, ground water will not be discussed further with respect to this post-closure discharge. The specifics for each impoundment and its discharge to surface water are discussed separately below.

Stillwater Mine tailings impoundment: Seepage is estimated to discharge post-closure from the Stillwater Mine tailings impoundment at about 10 gpm (0.02 cfs) (DEQ and USFS 2010). As discussed in the response to comment 3, the concentrations of metals in tailings waters are approximately equivalent to, or less than, the 2008 MPDES permit effluent limits and ground water quality metals criteria. The quality of the seepage through the cover would be more dilute than tailings water quality because infiltrating precipitation would mix with tailings waters prior to seepage through the cover and discharge to ground water or the Stillwater River (DEQ and USFS 2010).

As also discussed in the response to comment 3, the lowest monthly Stillwater River streamflow averages 140 cfs (about 62,900 gpm). The estimated discharge from seepage through the reclamation cover is 0.02 percent of the average low streamflow value. These streamflow and volumetric data indicate that seepage through the cover discharging post-closure to the Stillwater River at its lowest average streamflow rate would be at such a small volume as to not be discernable (that is, 2/10,000 parts), and would not adversely affect aquatic life in the Stillwater River.

Hertzler Ranch tailings impoundment: Seepage is estimated to discharge post-closure from the Hertzler Ranch tailings impoundment at about 18 gpm (0.04 cfs) (DEQ and USFS 2010). As previously discussed, the concentrations of metals in tailings waters are approximately equivalent to, or less than, the MPDES permit effluent limits and ground water quality metals criteria. The quality of the seepage through the cover would be more dilute than tailings water quality because infiltrating precipitation would mix with tailings waters prior to seepage through the cover and discharge to ground water or the Stillwater River (DEQ and USFS 2010).

As discussed in the previous section, the lowest monthly Stillwater River streamflow averages 140 cfs (about 62,900 gpm). The estimated discharge from seepage through the Hertzler Ranch reclamation cover is 0.03 percent of the average low streamflow value. These streamflow and volumetric data indicate that seepage through the cover discharging post-closure to the Stillwater River at its lowest average streamflow rate would be at such a small volume as to not be discernable (that is, 3/10,000 parts), and would not adversely affect aquatic life in the Stillwater River.

East Boulder Mine tailings impoundment: Seepage is estimated to discharge post-closure from the East Boulder tailings impoundment ranging from an average of 7 gpm to a peak of 124 gpm (0.02 to 0.3 cfs) (DEQ and USFS 2010). The 10-year lowest streamflow downstream of the East Boulder Mine at EBR-004/4A occurred during the winter months and was about 4.5 cubic feet per second (cfs), which is about 2,020 gpm. The summer low streamflow averages about 15 cfs (about 6,730 gpm). As previously discussed, the concentrations of metals in tailings waters are approximately equivalent to, or less than, the MPDES permit effluent limits and ground water quality metals criteria. The quality of the seepage through the cover would be more dilute than tailings water quality because infiltrating precipitation would mix with tailings waters prior to seepage through the cover and discharge to ground water or the East Boulder River (DEQ and USFS 2010). The estimated average discharge from seepage through the East Boulder reclamation cover is 0.3 percent of the 10-year lowest streamflow value, and 0.1 percent of average low streamflow. Peak seepage discharge rates would typically occur in late spring or early summer when streamflow is highest (May through July streamflow maintains at least 50 cfs on average), and would equate to a maximum of 0.6 percent of spring streamflow. These streamflow and volumetric data indicate that seepage through the cover discharging post-closure to the East Boulder River at its lowest average streamflow rate would be about 3/1,000 parts, and would not adversely affect aquatic life in the East Boulder River.

<u>Conclusion</u>: Geologic interpretation of the Stillwater Complex J-M Reef, comparisons of geology and rock type/composition between the Stillwater and East Boulder Mines, probe holes drilled in advance of the heading/footwall underground, exploration drilling from the surface along the length of the deposit, and extensive surface mapping all attest to the remarkable consistency of this Pt-Pd deposit (R. Weimer, personal communication). Due to this consistency, no change in rock type or mineralogy is anticipated

that would result in an adverse change in the quality of adit or tailings water over time. The operational quality of adit and tailings waters from the Stillwater Mine, Hertzler Ranch LAD, and East Boulder Mine during the entire period of record (13 to 23 years) indicate that these mine waters meet or are less than applicable surface (MPDES) and ground water (MT DEQ Circular 7) metals criteria. Discharges of these waters would not adversely affect the quality of surface and ground water during operations or post-closure.

Comment 5: *Documentation of the potential for acid generation and metals mobility based on a large-scale field column (humidity cell) test performed over a period of several years.*

Waste rock has been used in construction of the tailings impoundments at both the Stillwater (1985) and East Boulder (2005) mines, and as such, these locations represent in-situ, large-scale field column tests for metals leachability. Waste rock has been disposed of in the location of the Stillwater Mine ESWRS since 1997, and constitutes a 14-year large-scale field column test. The location for the ESWRS was sited on top of native soils and historic chrome tailings in an effort to reclaim the historic tailings. The early waste rock was not compacted and the thickness of the pile was comparatively "thin" so that precipitation falling on the waste rock could readily flow through and infiltrate to ground water. If metals would have leached from the waste rock to infiltrate to ground water, those metals concentrations would have been captured in the datasets presented in Table 7 for the Stillwater Mine and in Table 9 for the East Boulder Mine.

In 2006, as a voluntary effort, SMC performed an in-situ test of the ESWRS to evaluate the potential for metals mobility and acid generation within the waste rock disposal area. SMC located and drilled four sonic core holes through the ESWRS based on annual records of waste rock placement, to maximize spatial distribution and the length of time that waste rock was in place. The 80- to 100-foot long cores were used to evaluate the potential effects of waste rock on water quality by determining: whether a "wetting front" from precipitation existed at depth within the pile; nitrogen concentration with depth and leaching (nutrient mobility); and acid/base accounting and metals leachability information on weathered rock at depth.

Sonic drilling technology allows drilling of rock using high-frequency, resonant energy to advance the drill bit, precluding the need and use of water in the drilling process. The cores were advanced until native soils or chrome tailings were encountered at the base of the ESWRS. Moisture readings were taken from the cores and samples were collected for nutrient and metals mobility and acid/base accounting analysis.

Infiltration of precipitation is necessary to mobilize leachable constituents from the waste rock or facilitate acid generation. The infiltration rate of precipitation depends on particle-size distribution of the waste, compaction, surface texture and geometry of the waste pile, moisture content of the waste, and the rate and duration of precipitation. SMC contours the ESWRS surface to facilitate runoff and compacts the waste rock in 3-foot lifts. When waste rock placement is complete, topsoil is placed and the dump surface is vegetated. The Stillwater Mine is in an area of net evaporation, having 13.2 inches of precipitation and 29.8 inches of evaporation (SMC 2009).

Moisture readings from the 37 samples collected at the ESWRS indicate that the moisture content is drying from the average 5 percent of "just mined" material to an in-situ moisture content averaging 2.35 percent. The maximum moisture measurement was 4.66 percent. The data did not indicate any consistent trend in moisture content with depth in any of the boreholes. No "wetting front" of precipitation was present to mobilize nutrients or metals from waste rock (SMC 2009).

The potential to mobilize residual nitrogen from the dump was evaluated. Nitrogen is a conservative parameter, and would leach from the ESWRS given the necessary conditions. The concentrations of nitrate+nitrite from the 37 samples ranged from 1.66 to 42.2 mg/L with a mean concentration of 17.8 mg/L (SMC 2009). No trend was evident in the concentrations of nitrogen with depth in any of the boreholes, indicating that nutrients have not been mobilized by precipitation within the ESWRS.

Acid/base accounting results were consistent with historic and recently collected operational data (Kirk et al 2006 and SMC 2009). The neutralization potential varied from 21 to 48 T/kT as calcium carbonate. The acid generation potential for all waste rock was less than 1 and falls within the "not acid-generating" region of the acid generation potential plot (**Figure 10**). The pyrite sulfur content was ≤0.02 weight percent, an order of magnitude less than the 0.3 weight percent sulfide sulfur threshold for acid production (Jambor et al 2000). The chrome tailings underlying the ESWRD were sampled in 1994 and had less than detectable TCLP results for all metals analyzed (SMC 2009).

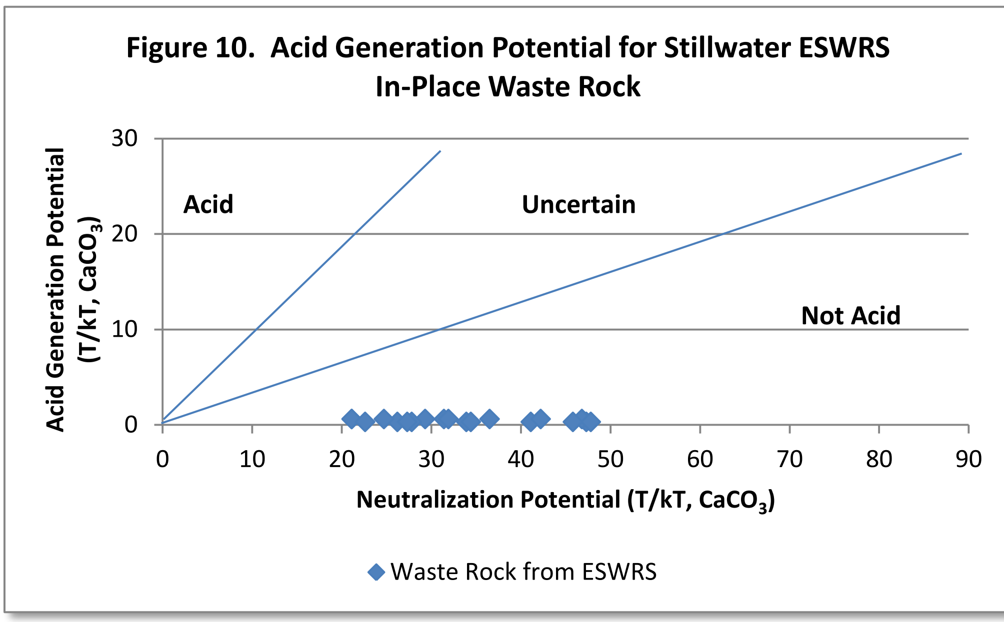

Figure 10. The acid generation potential for waste rock from drill cores taken from the ESWRS. The cores were taken from waste rock that had been placed in the ESWRS between 1997 and 2006.

The core samples produced leachable metals concentrations at or below the detection limit for all samples analyzed using the MWMP: beryllium; bismuth; cadmium; cobalt; gallium; iron; lead; lithium; mercury; phosphorous; scandium; silver; thallium; tin; and titanium. **Table 10** lists the leachable metals results for those parameters that had detectable concentrations and compares those results to ground water metals criteria. Only one detectable concentration was above the human health ground water standard for arsenic (SMC 2009). Given the fact that all other MWMP leaching arsenic results were at least an order of magnitude lower, the agencies believe that the exceedance is not consistent with other data, and as such, may be a remnant from the chrome tailings or an outlier.

Conclusion: The geochemical data collected from waste rock disposed of between 1997 and 2006 in the ESWRS indicate a very low potential to generate acid, leach metals, leach nitrogen, or adversely impact surface or ground water quality. Ground water quality data downgradient of the ESWRS, the Stillwater tailings impoundment, and the East Boulder tailings impoundments reflect the signature of upgradient water quality. Ground water at both mines is very high quality, with low sulfate concentrations, neutral pH, and metals concentrations near or below detection limits.

Geologic interpretation of the Stillwater Complex J-M Reef, comparisons of geology and rock type/composition between the Stillwater and East Boulder Mines, probe holes drilled in advance of the heading/footwall underground, exploration drilling from the surface along the length of the deposit, and extensive surface mapping all attest to the remarkable consistency of this Pt-Pd deposit (R. Weimer, personal communication). Due to this consistency, no change in rock type or mineralogy is anticipated that would result in an adverse change in the quality of adit or tailings water over time.

The agencies are satisfied that ESWRS core sampling performed by SMC provides data equivalent to a large-scale field column humidity cell test performed over a period of at least nine years. The agencies would not require another such test if the rock types, quarterly operational geochemical data, and water quality data remain consistent with current and historical data.

Table 10. **Field-scale Metals Leachability Results from the Stillwater East Side Waste Rock Storage.**

Parameter	**Number of Detectable Results**	**Laboratory Metals Leachability Results from Field-Scale Stillwater ESWRS** (mg/L)		**MT DEQ 7 Ground Water Quality Criteria** (mg/L)
		Lowest MWMP Detectable Result	Highest MWMP Detectable Result	
Aluminum	2	0.108	0.109	NC
Antimony	2	0.00697	0.0401	0.006
Arsenic	10	0.0033	**0.0167**	0.01
Boron	37	0.15	0.33	NC
Chromium	37	0.0013	0.029	0.1
Copper	27	0.001	0.0175	1.3
Manganese	2	0.005	0.007	0.05
Molybdenum	22	0.009	0.031	NC
Nickel	3	0.011	0.031	0.1
Selenium	6	0.001	0.0013	0.05
Strontium	34	0.007	0.046	4.0
Vanadium	5	0.0052	0.0074	NC
Zinc	1	0.011	0.011	2.0

* The analysis results are from 2009 SMC Waste Rock Core Analysis Report. Abbreviations**: MWMP**-Meteoric Water Mobility Procedure; **NC** - no criterion promulgated; **mg/L** milligrams per liter. **Bold values** indicate an exceedance of ground water quality criterion.

Comment 6: *Expansion of the list of metals for long-term monitoring (aluminum, arsenic, cadmium, copper, iron, manganese, mercury, selenium, silver, zinc, platinum, palladium), and inclusion of total hardness, calcium, magnesium, and sulfate for mine drainage and runoff.*

The list of metals that SMC operationally monitors at the Stillwater and East Boulder mines is based upon the whole rock analysis of its ores and waste rock, the efficiency of its beneficiation process, the potential of waste streams to contact contaminants, and the regulatory requirements of the agencies. At the Stillwater Mine, SMC monitors for cadmium, chromium, copper, iron, lead, manganese, nickel, and zinc. Please refer to tables 1, 3, 4, 7, and 8. Please also see the extensive list of metals analyzed at the Stillwater Mine ESWRS for metals mobility in the response to Comment 5. At the East Boulder Mine, SMC monitors for arsenic, barium, beryllium, cadmium, copper, iron, lead, manganese, mercury, nickel, selenium, silver, and zinc. Please refer to tables 2, 5, 6, and 9.

<u>Conclusion</u>*:* The agencies are satisfied with the adequacy of the current list of metals and, given the remarkable consistency of the geochemistry and mineralogy of the deposit, would not require the analysis of additional metals unless there was a change in the geochemistry of the rock encountered or other regulatory reason to expand the list of analytes.

Comment 7: *Evaluation of the effects of the mine during operations on downgradient surface (Nye Creek) and ground water with respect to metals loading.*

To evaluate whether the Stillwater Mine has had effects on surface water downgradient of mine facilities, specifically Nye Creek, the agencies analyzed total recoverable metals concentration data collected between 1997 and 2009 from upstream (SMC-7) and downstream (SMC-7D) monitoring stations along the creek. The statistics of the two data sets were calculated and the mean and median total recoverable metals concentrations are listed in **Table 11**. The two data sets appear similar, but the statistics are slightly different.

To further evaluate whether there is a difference between the up- and downstream sample results, the distribution of differences of sample proportions was calculated. If two values are the same, when subtracted, the result is zero. If two sample populations are the same, when the differences between values in the populations are calculated, the mean of those differences would be zero. It follows then that, if the Stillwater Mine is affecting the quality of Nye Creek, the downstream total recoverable metals concentrations would be different from upstream water quality, and that difference would not equal zero. If there is no difference in concentrations between up- and downstream sample results, the mean of the differences of the concentrations would equal zero, indicating that the Stillwater Mine is not affecting the quality of Nye Creek.

Table 11. **1997-2009 Comparison of Surface Water Quality between Upper and Lower Nye Creek Downgradient of the Stillwater Mine.**

Parameter	Upper and Lower Nye Creek Water Quality				
	Mean Concentration (total recoverable, mg/L)		Mean of Differences between samples[€]	Median Concentration (total recoverable, mg/L)	
	SMC-7 Upstream	SMC-7D Downstream		SMC-7 Upstream	SMC-7D Downstream
Cadmium	0.0001	0.001	0.00	<0.0001	<0.0001
Chromium	0.010	0.012	0.00	0.010	0.011
Copper	0.002	0.003	0.00	<0.001	0.002
Iron	0.04	0.21	**0.16**	0.03	0.065
Lead	<0.003	<0.003	0.00	<0.003	<0.003
Manganese	<0.005	0.010	0.00	<0.005	<0.005
Zinc	0.01	0.04	0.00	<0.01	<0.01

[€] **Bold values** indicate a statistical difference between upstream and downstream samples.

The distribution of differences of sample proportions was calculated for the metals cadmium, chromium, copper, iron, lead, manganese, and zinc (sample size varied from 12 to 38). The means of the differences for cadmium, chromium, copper, lead, manganese, and zinc were equal to zero, indicating that there is no statistical difference between samples and Stillwater Mine is not affecting the quality of Nye Creek. The mean of the differences for iron, however, was not equal to zero, indicating that there is a statistical difference in iron concentration between the up- and downstream sampling locations. Because iron is the only metal that has a statistical difference between up- and downstream concentrations, and if the mine was affecting downstream water quality, several parameters would show mine influence, the difference in iron is likely attributable to a naturally-occurring geological source in the stream at the SMC-7D location. Please also see the response to comment 3.

Conclusion: There is no evidence that the Stillwater Mine has an adverse effect on the quality of water in Nye Creek.

For the reasons stated above, and barring an unforeseen change in the geochemistry/mineralogy of the J-M Reef or a regulatory reason to revisit this decision, the agencies have dismissed these seven issues regarding the potential for water quality impacts from metals and the potential for acid generation.

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TECHNICAL MEMORANDUM

Date: March 7, 2012

To: Kristi Ponozzo, MEPA Coordinator, Montana DEQ
Pat Pierson, NEPA Coordinator, Custer and Gallatin National Forests, USFS

From: Lisa M. Boettcher C. P.G., Reclamation Specialist, Montana DEQ LB

Re: EPA comment regarding appropriate criteria for nutrients at the Stillwater and East Boulder Mines

The Environmental Protection Agency (EPA) commented that "in-stream nitrogen levels less than 1 mg/L may promote creation of conditions which produce undesirable aquatic life. EPA is concerned that the current [Montana Pollution Discharge Elimination System] MPDES permit nitrogen loads based on the 1 mg/L in-stream nitrogen standard have potential to create aquatic conditions that may not be consistent with the narrative water quality standard. It is our understanding that Montana is developing numeric criteria for nitrogen in surface waters within the next year that may be lower than 1 mg/L total nitrogen. We encourage reevaluation of MPDES permit nitrogen loads based on the current scientific findings regarding nitrogen levels that are protective of beneficial uses in future MPDES permitting."

The MPDES permits for both mines set effluent discharge limits based on the $7Q_{10}$ streamflow[1] that would result in in-stream concentrations of 1 mg/L total nitrogen (TN[2]) at the Stillwater Mine (Stillwater River) and 1 mg/L total inorganic nitrogen (TIN[2]) at the East Boulder Mine (East Boulder River). For the Stillwater Mine, the MPDES statement of basis states on page 19, "The limit was based on an increase in background concentration from 0.4 mg/L to 1.0 mg/L (in the Stillwater River) at the $7Q_{10}$ of 31.1 cfs. It is believed that an increase of nitrogen to 1 mg/L would not [affect] the environment if phosphorus was limited to no increase." Stillwater Mine collects macroinvertebrate, periphyton, and diatom data to confirm that the nitrogen limit of 100 lb/day TN and "no increase" in total phosphorus (TP) do not create undesirable aquatic life in the Stillwater River. For the East Boulder Mine, the MPDES statement of basis states on page 16, "The Final Environmental Impact Statement (FEIS) competed in 1992 concluded that an increase in the [in-stream] nitrogen concentration to 1.0 mg/L at the $7Q_{10}$ would not cause undesirable or harmful algal growth." The rationale continues on page 19, "The agencies' environmental analysis of the East Boulder Project (FEIS 1992), recommended that the total nitrogen concentration not exceed 1.0 mg/L based on site-specific factors… boulder-cobble dominated substrate; high-gradient erosive environment; downstream dilution sources; the phosphorus-limiting condition of the East Boulder River; and lack of downstream lakes, reservoirs, or other nutrient-sensitive bodies." The concentration of TP is limited by the MPDES permit at the East Boulder Mine to 0.001 mg/L above the average background value of 0.02 mg/L. SMC has a bioassessment monitoring program in place to ensure that discharges from the East Boulder Mine do not create undesirable aquatic life in the East Boulder River. The Stillwater Mine MPDES permit expires October 31, 2013, and the East Boulder Mine MPDES permit expired July 31, 2005 and has been administratively extended.

MDEQ Water Quality Standards Section has prepared a preliminary technical analysis to address total nutrient concentrations that could represent an undesirable biological impact for streams in Montana

[1] The $7Q_{10}$ streamflow is the lowest streamflow over 7 consecutive days in a 10-year period.
[2] TIN is the nitrate+nitrite and inorganic ammonia concentration that is a component of TN, which also includes organically-bound nitrogen and organic ammonia-nitrogen species.

during the growing season from July 1 through September 30 (Suplee *et al*. 2008, Suplee and Suplee 2011a). The analysis is not yet complete and has not been developed sufficiently to begin the rulemaking process. The technical analysis seeks to determine seasonal criteria that would be generally applied on an ecoregion level, but would be further subject to reach-specific factors that affect algal growth.

EPA has indicated that TN and TP are the minimum acceptable nutrient criteria for evaluating the potential for nuisance algal growth (Suplee *et al*. 2008). Significant increases in algal growth may not occur in response to increases in TN concentration if phosphorus concentrations are sufficiently low that they limit algal growth when nitrogen is already present in surplus (Allan 1995, Steinman and Mulholland 1996). Light is also considered an important factor in increased eutrophication of Montana streams (Suplee *et al*. 2008). In streams with heavy canopy cover, systems can become "light limited" and can attenuate algal growth. However it should be noted that light is not a valid limiting factor for those reaches of the Stillwater or East Boulder rivers that would be affected by the closure of the mines. High flow events also affect algal growth by scouring algae from the streambed by high stream velocities alone, or the combination of stream velocity and bedload movement (Suplee *et al* 2008). The effects of scouring depend on the timing, magnitude, and frequency of the high flow event. How these site-specific factors would combine with nutrient concentrations to affect algal assemblages in stream reaches adjacent to the Stillwater and East Boulder mines and the Hertzler Ranch LAD system have not been quantified.

The TN and TP concentrations in the preliminary technical analysis were developed on an ecoregion basis (Suplee *et al*. 2008). The Stillwater and East Boulder mines are on the edge of the Middle Rockies Ecoregion 17, and the Hertzler Ranch and proposed Boe Ranch LAD systems are within the Northwestern Glaciated Plains Ecoregion 42 (NRIS). The preliminary technical analysis indicates that for the Middle Rockies Ecoregion 17, a TN concentration of 0.320 mg/L and a TP concentration of 0.048 mg/L could be appropriate numeric criteria for the Montana Board of Environmental Review to consider for adoption. The preliminary technical analysis indicates that for the Northwestern Glaciated Plains Ecoregion 42, a TN concentration of 1.311 mg/L and a TP concentration of 0.020 mg/L could be appropriate numeric criteria for the Montana Board of Environmental Review to consider for adoption (Suplee *et al*. 2008, Suplee and Suplee 2011). These TN and TP concentrations are based on maintaining in-stream chlorophyll *a* concentrations to less than 150 mg/m^2 as identified by MDEQ's nuisance algae public-perception survey. Nuisance algal levels were defined quantitatively in this survey using a benthic algae metric (*i.e.*, chlorophyll *a* density per unit area of stream bottom; Suplee et al. 2009). Further, it has been documented that elevated TN and TP can lead to significant seasonal dissolved oxygen decreases along a stream, which would be harmful to fish (Suplee and Suplee 2011b).

The agencies analyzed concentrations of nutrients and salts in surface and ground water that would result from the disposal of a range of adit flow rates and the dewatering of three tailings impoundments during capping at closure. Projected in-stream nitrogen concentrations have been disclosed in the 2010 Draft Environmental Impact Statement (DEIS). The agencies used the $7Q_{10}$ streamflow cited in the respective MPDES permits when calculating receiving stream concentrations. The $7Q_{10}$ streamflow would provide the least dilution for the mine waters discharged (*i.e.*, result in the highest concentration of a constituent in the stream) and as such, is generally conservative. The agencies' analyses show that the nitrogen concentration in the respective surface waters during the growing season from July 1 through September 30 would meet the respective MPDES limits of 1 mg/L TN or TIN in-stream concentrations for all of the agency-mitigated alternatives. The MPDES TN and TIN limits are less than the preliminary technical analysis Northwestern Glaciated Plains Ecoregion TN concentration, but greater than the Middle Rockies Ecoregion TN concentration. The MPDES permit limits in-stream phosphorus concentration increases between July 15 and October 15 to 0.001 mg/L for the East Boulder Mine and sets a load of no more than 1.1 lbs/day (based on non-degradation) for the Stillwater Mine. These permit limits are less than the preliminary technical analysis TP concentrations for both ecoregions.

The long-term statistics for average in-stream chlorophyll *a*, total Kjeldahl nitrogen (TKN), nitrite+nitrate ($NO_2 + NO_3$), and TP concentrations in the Stillwater River adjacent to the Stillwater Mine have been compiled for the period 1998 to 2009 (Environ 2010b) and are listed in Table 1. These data show that the in-stream chlorophyll *a* concentrations in the Stillwater River are at least an order of magnitude less than the 150 mg/m^2 reference threshold identified by MDEQ's nuisance algae public-perception survey (Suplee et al. 2009). The long-term average Stillwater River in-stream nitrogen concentrations are approximately equal to or less than the preliminary technical analysis Middle Rockies Ecoregion TN concentration of 0.320 mg/L and TP concentration of 0.048 mg/L. These data indicate that nutrient discharges from the Stillwater Mine do not cause nuisance algal growth in the Stillwater River, and the MPDES permit limits for TN and TP are protective of the beneficial use of this stream.

Table 1. **Stillwater River nutrients and chlorophyll *a* concentrations upstream, adjacent to, and downstream of the Stillwater Mine and the Hertzler Ranch LAD** (after Environ 2010b).

Period of Record: 1998-2009	**SMC-J** (upstream of mine)	**SMC-2** (adjacent to mine)	**SMC-11** (downstream of mine)	**DEQ Preliminary Technical Analysis Nutrient Total Concentration[2] Middle Rockies Ecoregion**	**WFSC** (upstream of Hertzler Ranch LAD)	**SMC-13** (downstream of Hertzler Ranch LAD)	**DEQ Preliminary Technical Analysis Nutrient Total Concentration[2] Northwestern Glaciated Plains Ecoregion**
N Chlorophyll *a* Long-term mean[1] (mg/m^2) 95% UCL	110 12.9 15.4	80 12.7 14.4	131 11.6 15.8	150	100 16.2 18.8	97 17.1 20.1	150
TKN mean[3] (mg/L)	0.15	0.10	0.25	0.320	0.10	0.20	1.311
$NO_2 + NO_3$ mean[3] (mg/L)	0.09	0.2	0.12		0.17	0.088	
Total P mean[3] (mg/L)	0.010	0.009	0.011	0.048	0.011	0.014	0.020

[1] Long-term summary statistics show **N** - number of samples, arithmetic mean, and **UCL** upper 95% confidence limit for entire chlorophyll *a* database of non-transformed replicate samples from August 1 through September during the 1998-2009 monitoring period.
[2] TN and TP concentrations from the preliminary technical analysis by ecoregion (Suplee *et al*. 2008); chlorophyll *a* concentrations from MDEQ's nuisance algae public-perception survey (Suplee et al. 2009).
[3] Long-term summary statistics show the arithmetic mean for nutrients for the 2000-2009 monitoring period.
Abbreviations: **TKN** – total Kjeldahl nitrogen; **$NO_2 + NO_3$** - nitrite+ nitrate; **P** – phosphorus; **LAD-** Land Application Disposal facility.

The East Boulder River, like many streams in Montana (Bahls 2004), has been affected since 2003 by proliferation of the nuisance organism *Didymosphenia geminata.* The proliferation began above the mine at the confluence of the Dry Fork, and spread up- and downstream. *D. geminata* is a stalked, filamentous diatom that increases the chlorophyll *a* concentration in a stream, so between the years 2005 and 2009, visual estimates of in-stream algal growth of *D. geminata* were made rather than samples taken for chlorophyll *a* concentrations. The in-stream 2009 chlorophyll *a* concentrations (arithmetic mean) in the East Boulder River adjacent to the East Boulder Mine are listed in Table 2. The proliferation of *D. geminata* compromised the condition of the benthic substrate (sediment on the bed of the stream that aquatic organisms live on) and resulted in a decline of benthic integrity (lower bioassessment scores indicating reduced overall aquatic health). Recent surveys indicate the East Boulder River is returning to pre-proliferation levels. The 2009 95% upper confidence level values of in-stream chlorophyll *a* concentration in the East Boulder River are one-third that of the 150 mg/m^2 reference threshold identified by MDEQ's nuisance algae public-perception survey (Environ 2009a, Suplee et al. 2009). The long-term (2000-2009) average East Boulder River in-stream nitrogen and phosphorus concentrations are lower than the preliminary technical analysis Middle Rockies Ecoregion TN concentration of 0.320 mg/L and TP concentration of 0.048 mg/L. These data indicate that discharges of nutrients from the East Boulder Mine do not cause nuisance algal growth in the East Boulder River, and the MPDES permit limits for TIN and TP are protective of the beneficial use of this stream.

According to the reopener provisions of the MPDES permits described in the Administrative Rules of Montana, ARM 17.30.1361 (2) (b): "permits may be modified during their terms if…the department has received new information …indicating that cumulative effects on the environment are unacceptable, or (c) the standards or requirements on which the permit was based have been changed by amendment or judicial decision after the permit was issued." Consequently, the 1.0 mg/L TN or TIN limit for ambient surface waters currently in the MPDES permits could be modified by MDEQ at any time if nuisance algal growth attributable to the mines is observed or lower numeric standards for nutrients are adopted.

Table 2. **East Boulder River nutrients and 2009 chlorophyll *a* concentrations with 2000-2009 nutrient levels upstream, adjacent to, and downstream of the East Boulder Mine** (after Environ 2010a).

Period of Record: 2000-2009	**EBR-002 (upstream)**	**EBR-003 (adjacent)**	**EBR-004 (downstream)**	**DEQ Preliminary Technical Analysis Nutrient Concentration**[2]
$NO_2 + NO_3$ mean[1] (mg/L)	0.06	0.06	0.05	0.320
Total N mean[1] (mg/L)	0.44	0.29	0.23	
Total P mean[1] (mg/L)	0.02	0.01	0.01	0.048
Chlorophyll *a* 2009 mean (mg/m^2) 95% UCL	18.3 58.4	17.4 36.6	21.4 45.1	150
percent algal cover[3,4] study area average by year	100% (2005) 91% (2006) 75% (2007) 45% (2008) 32% (2009)			

[1] Long-term summary statistics show the arithmetic mean for nutrients for the 2000-2009 monitoring period.

[2] TN and TP concentrations from the preliminary technical analysis for the Middle Rockies Ecoregion (Suplee *et al*. 2008); chlorophyll *a* concentrations from MDEQ's nuisance algae public-perception survey (Suplee et al. 2009).

[3] Visual estimates of macroscopic growth of filaments and the diatom *Didymosphenia geminata* are unavailable prior to 2005. "While always present at sites EBR-001 and downstream to EBR-004, *D. geminata* demonstrated considerable growth between the August-September 2003 and August-September 2004 sampling events…" (AdventEnviron 2005)

[4] Long-term summary statistics show the study area average based on visual estimates of macroscopic growth of filaments and the diatom *Didymosphenia geminata.* Abbreviations: **$NO_2 + NO_3$** - nitrite+ nitrate; **N** – nitrogen; **P** – phosphorus.

In summary, data collected to date indicate that the TP concentrations in the Stillwater and East Boulder rivers are about 20 percent of those concentrations identified by the technical analysis as necessary to limit algal growth (Suplee 2008). The long-term average in-stream TN or TIN concentrations are approximately equal to or less than the preliminary technical analysis Middle Rockies Ecoregion TN concentration. In-stream TN or TIN MPDES permit limit concentrations of 1 mg/L are not anticipated to increase algal growth to the extent that it would be considered "nuisance" algae. The preliminary technical analysis could provide appropriate numeric criteria for the Montana Board of Environmental Review to consider for adoption;

however, the analysis is not yet complete and has not been developed sufficiently to begin the rulemaking process. The technical analysis seeks to determine seasonal criteria that would be generally applied on an ecoregion level, but these criteria would be further subject to reach-specific factors that affect algal growth. To address the uncertainty regarding the response of area streams to increased nutrients, SMC performs aquatic monitoring at both mines as part of the Hardrock Operating Permit requirements. In the absence of a numeric standard, if subsequent monitoring indicates nuisance algal growth has developed as a result of mine effluent discharge, then SMC's MPDES nitrogen effluent limit would be adjusted to become more restrictive in order to comply with the narrative standard.

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Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Revised **Stillwater 2,020 gpm** **CLOSURE scenarios**		**No Action** **Alternative 1A**	Proposed Action Alternative 2A	Agency-Mitigated Alternative 3A

No Action Alternative 1A Option 1, 2,020 gpm: *Tailings waters would be evaporated over the tailings mass. Disposal of 370 gpm (24 hr) untreated east side adit water would be at the Stillwater Mine east side percolation ponds. Disposal of 1,650 gpm (24 hr) treated west side adit water and 105 MG Hertzler Ranch LAD storage pond treated adit water would be at the Hertzler Ranch LAD area. The closure time frame was not specified.*

NOTE: This option exceeds the hydraulic load at Hertzler Ranch LAD.

No Action Alternative 1A Option 2, 2,020 gpm : *Tailings waters would be evaporated over the tailings mass. Disposal of 370 gpm (24 hr) untreated east side water would be at the Stillwater Mine percolation ponds. Disposal of 105 MG of Hertzler Ranch LAD storage pond treated adit water and 1,650 gpm (24 hr) of treated west side adit water would be at the Hertzler Ranch LAD area. The closure time frame was not specified.*

Stillwater Mine	criteria			
Nitrogen load to Stillwater River at Stillwater Mine, lbs/day	100	**81**		
Closure Nitrogen load to ground water, days 1-365, lbs/12-mo		**329**		
Nitrogen concentration in ground water below Stillwater Mine, mg/L	7.5	**meets MPDES Nitrogen load**		
Nitrogen concentration in Stillwater River below Stillwater Mine, mg/L	1	**meets MPDES Nitrogen load**		
EC in ground water at Stillwater Mine, µmhos/cm	1,000	**715**		
TDS in Stillwater River below Stillwater Mine, mg/L		**123**		
Hertzler Ranch LAD				
Nitrogen concentration in ground water below Hertzler Ranch LAD, mg/L	7.5	**0.6**		
Closure Nitrogen load to ground water at Hertzler Ranch LAD, lbs/12-mo		**3,590**		
Nitrogen concentration in Stillwater River below Hertzler Ranch LAD, mg/L	1	**0.4**		
EC in ground water at Hertzler Ranch LAD, µmhos/cm	1,000	**869**		
TDS in Stillwater River below Hertzler Ranch LAD, mg/L		**116**		

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Revised **Stillwater 2,020 gpm CLOSURE scenarios**		No Action Alternative 1A	**Proposed Action Alternative 2A**	Agency-Mitigated Alternative 3A

Proposed Action Alternative 2A, Option 1, 2,020 gpm: *The 370 gpm (24-hr) of untreated east-side adit water would be disposed of in the Stillwater Mine east-side percolation ponds. Up to 250 gpm (24-hr) Stillwater Tailings waters would be mixed and treated with 1,650 gpm (24-hr) west-side adit water and routed to 105 MG Hertzler Ranch LAD storage pond for disposal with 201 MG untreated Hertzler Ranch tailings waters. The closure time frame would be 12 months.*

NOTE: This option exceeds the hydraulic load at Hertzler Ranch LAD.

Proposed Action Alternative 2A Option 2, 2,020 gpm: The *370 gpm (24-hr) of untreated east-side adit water would be disposed in the Stillwater Mine east-side percolation ponds. Up to 250 gpm (24-hr) (53 MG) Stillwater tailings waters would be mixed and treated with 1,650 gpm (24-hr) west-side adit water and routed to the Stillwater Mine percolation ponds. Up to 201 MG of untreated Hertzler Ranch tailings waters would be routed to the Hertzler Ranch LAD storage pond containing 105 MG of treated adit water for disposal at the Hertzler Ranch LAD area. The closure time frame would be 12 months.*

Stillwater Mine	criteria	No Action Alternative 1A	Proposed Action Alternative 2A	Agency-Mitigated Alternative 3A
Nitrogen load to Stillwater River at Stillwater Mine, lbs/day	100		**95**	
Closure Nitrogen load to ground water, days 1-365, lbs/12-mo			**12,645**	
Nitrogen concentration in ground water below Stillwater Mine, mg/L	7.5		**meets MPDES Nitrogen load**	
Nitrogen concentration in Stillwater River below Stillwater Mine, mg/L	1		**meets MPDES Nitrogen load**	
EC in ground water at Stillwater Mine, µmhos/cm	1,000		**734**	
TDS in Stillwater River below Stillwater Mine, mg/L			**123**	
Hertzler Ranch LAD				
Nitrogen concentration in ground water below Hertzler Ranch LAD, mg/L	7.5		**2.9**	
Closure Nitrogen load to ground water at Hertzler Ranch LAD, lbs/12-mo			**17,363**	
Nitrogen concentration in Stillwater River below Hertzler Ranch LAD, mg/L	1		**0.7**	
EC in ground water below Hertzler Ranch LAD, µmhos/cm	1,000		**985**	
TDS in Stillwater River below Hertzler Ranch LAD, mg/L			**126**	

NOTE: Under this scenario a temporary exceedance of the 1,000 µmhos/cm Beneficial Use EC criterion for ground water would occur in the vicinity of the assumed Hertzler Ranch tailings impoundment seep (1,290 µmhos/cm) and beneath the upper LAD area (1,276 µmhos/cm) but the Beneficial Use criterion would be met at the down-gradient compliance point, HMW-10.

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Revised **Stillwater 2,020 gpm CLOSURE scenarios**		No Action Alternative 1A	Proposed Action Alternative 2A	**Agency-Mitigated Alternative 3A**

Agency-Mitigated Alternative 3A Option 1, 2,020 gpm: Stillwater Mine first season*: The 370 gpm (24 hr) of untreated east-side adit water would be disposed in the Stillwater Mine percolation ponds days 1-90, then routed underground on day 91. The 250 gpm (24 hr) of Stillwater tailings waters would be mixed and treated with 1,650 gpm (24 hr) of west-side adit water and routed to the Stillwater Mine percolation ponds days 1- 90 , then routed underground on day 91 until the Stillwater tailings impoundment is dewatered.*

Hertzler Ranch first season*: Up to 260 gpm (24 hr) of the untreated 201 MG Hertzler Ranch tailings waters would be routed to the 105 MG of treated adit waters in Hertzler Ranch LAD storage pond, and the mixed adit and tailings waters would be disposed at the Hertzler Ranch LAD area. Hertzler Ranch second season: Any excess water that cannot be disposed the first year would be land applied at Hertzler Ranch. The closure time frame would be 18 months.*

Stillwater Mine	criteria	No Action Alternative 1A	Proposed Action Alternative 2A	Agency-Mitigated Alternative 3A
Nitrogen load to Stillwater River at Stillwater Mine, lbs/day	100			**95**
Closure Nitrogen load to ground water, days 1-548, lbs/18-mo				**7,966**
Nitrogen concentration in ground water below Stillwater Mine, mg/L	7.5			**meets MPDES Nitrogen load**
Nitrogen concentration in Stillwater River below Stillwater Mine, mg/L	1			**meets MPDES Nitrogen load**
EC in ground water at Stillwater Mine, µmhos/cm	1,000			**771**
TDS in Stillwater River below Stillwater Mine, mg/L				**133**
Hertzler Ranch LAD				
Nitrogen concentration in ground water below Hertzler Ranch LAD, mg/L	7.5			**4.5**
Closure Nitrogen load to ground water at Hertzler Ranch LAD, lbs/18-mo				**54,450**
Nitrogen concentration in Stillwater River below Hertzler Ranch LAD, mg/L	1			**0.9**
EC in ground water below Hertzler Ranch LAD, µmhos/cm	1,000			**986**
TDS in Stillwater River below Hertzler Ranch LAD, mg/L				**126**

NOTE: Under this scenario a temporary exceedance of the 1,000 µmhos/cm Beneficial Use EC criterion for ground water would occur in the vicinity of the assumed Hertzler Ranch tailings impoundment seep (1,276 µmhos/cm) and beneath the upper LAD area (1,131 µmhos/cm) but the Beneficial Use criterion would be met at the down-gradient compliance point, HMW-10.

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Revised Stillwater 1,302 gpm **CLOSURE scenarios**		**No Action Alternative 1A**	Proposed Action Alternative 2A	Agency-Mitigated Alternative 3A

***No Action Alternative 1A Option 1, 1,302 gpm**: The tailings waters would be evaporated over the tailings mass. Disposal of 370 gpm (24 hr) untreated east side adit water would be at the Stillwater Mine east side percolation ponds. Disposal of 932 gpm (24 hr) treated west side adit water and 105 MG of treated west side adit water stored in the Hertzler Ranch LAD storage pond waters would be at the Hertzler Ranch LAD area. The closure time frame was not specified.*

Stillwater Mine	criteria			
Nitrogen load to Stillwater River at Stillwater Mine, lbs/day	100	**0.9**		
Closure Nitrogen load to ground water, days 1-365, lbs/12-mo		**324**		
Nitrogen concentration in ground water below Stillwater Mine, mg/L	7.5	**meets MPDES Nitrogen load**		
Nitrogen concentration in Stillwater River below Stillwater Mine, mg/L	1	**meets MPDES Nitrogen load**		
EC in ground water at Stillwater Mine, µmhos/cm	1,000	**191**		
TDS in Stillwater River below Stillwater Mine, mg/L		**53**		
Hertzler Ranch LAD				
Nitrogen concentration in ground water below Hertzler Ranch LAD, mg/L	7.5	**0.6**		
Closure Nitrogen load to ground water at Hertzler Ranch LAD, lbs/12-mo		**3,590**		
Nitrogen concentration in Stillwater River below Hertzler Ranch LAD, mg/L	1	**0.4**		
EC in ground water below Hertzler Ranch LAD, µmhos/cm	1,000	**869**		
TDS in Stillwater River below Hertzler Ranch LAD, mg/L		**116**		

Revised Stillwater 1,302 gpm **CLOSURE scenarios**		No Action Alternative 1A	**Proposed Action Alternative 2A**	Agency-Mitigated Alternative 3A

***Proposed Action Alternative 2A Option 1, 1,302 gpm:** The 370 gpm (24-hr) of untreated east-side adit water would be disposed in the Stillwater Mine percolation ponds. The 932 gpm (24-hr) west-side adit water would be mixed and treated with 600 gpm (24-hr) Sillwater tailings waters and routed to Hertzler Ranch LAD storage pond containing 105 MG of treated adit water and 201 MG of Hertzler Ranch tailings waters. All these waters would be disposed at the Hertzler Ranch LAD area. The time frame for disposal is 12 months.*

This option is hydraulically infeasible with 201 MG supernatant plus tailings mass waters at the Hertzler Ranch LAD.

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Revised Stillwater 1,302 gpm CLOSURE scenarios		No Action Alternative 1A	**Proposed Action Alternative 2A**	Agency-Mitigated Alternative 3A

Proposed Action Alternative 2A Option 2, 1,302 gpm: *The 370 gpm (24-hr) of untreated east-side adit water would be routed with 932 gpm (24-hr) treated west-side adit water and 600 gpm (24-hr) Sillwater tailings waters for disposal in the Stillwater Mine percolation ponds. No waters at the mine at closure would be routed to Hertzler Ranch LAD. The 105 MG of stored treated adit water in the Hertzler Ranch LAD storage pond and 201 MG of Hertzler Ranch tailings waters would be disposed of at the Hertzler Ranch LAD area. The time frame for disposal is 12 months.*

Stillwater Mine	criteria	No Action Alternative 1A	Proposed Action Alternative 2A	Agency-Mitigated Alternative 3A
Nitrogen load to Stillwater River at Stillwater Mine, lbs/day	100		**77**	
Closure Nitrogen load to ground water, days 1-365, lbs/12-mo			**4,299**	
Nitrogen concentration in ground water below Stillwater Mine, mg/L	7.5		**meets MPDES Nitrogen load**	
Nitrogen concentration in Stillwater River below Stillwater Mine, mg/L	1		**meets MPDES Nitrogen load**	
EC in ground water at Stillwater Mine, µmhos/cm	1,000		**377**	
TDS in Stillwater River below Stillwater Mine, mg/L			**68**	
Hertzler Ranch LAD				
Nitrogen concentration in ground water below Hertzler Ranch LAD, mg/L	7.5		**2.9**	
Nitrogen concentration in Stillwater River below Hertzler Ranch LAD, mg/L	1		**0.7**	
EC in ground water below Hertzler Ranch LAD, µmhos/cm	1,000		**985**	
TDS in Stillwater River below Hertzler Ranch LAD, mg/L			**126**	

NOTE: The EC of ground water at Hertzler Ranch temporarily exceeds the 1,000 µmhos/cm Beneficial Use EC criterion for ground water in the vicinity of the assumed Hertzler Ranch tailings impoundment seep (1,267 µmhos/cm) and beneath the upper LAD area (1,129 µmhos/cm) but the Beneficial Use criterion would be met at the down-gradient compliance point, HMW-10.

Revised Stillwater 1,302 gpm CLOSURE scenarios		No Action Alternative 1A	Proposed Action Alternative 2A	**Agency-Mitigated Alternative 3A**

Agency-Mitigated Alternative 3A Option 1, 1,302 gpm: Stillwater Mine first season *The 370 gpm (24 hr) untreated east-side adit water would be disposed at east-side percolation ponds days 1-90. From day 91 on, all untreated east-side and 932 gpm (24 hr) west-side adit water would be routed to the underground workings. Days 1-41, the 932 gpm (24 hr) west side adit water would be mixed and treated with 600 gpm (24 hr) Stillwater tailings waters and routed to Hertzler Ranch LAD storage pond. From day 42 on, the Stillwater tailings impoundment would be dewatered and treated west side adit waters would be routed to the Hertzler Ranch LAD storage pond.*

Hertzler Ranch first LAD season days 1-41: *The mixed and treated 400 gpm (24 hr) of west side adit water and 600 gpm Stillwater tailings waters would be routed to the Hertzler Ranch LAD storage pond containing 105 MG of treated adit water. Days 42-90 up to 396 gpm (24 hr) of untreated Hertzler Ranch tailings waters would be routed to the Hertzler Ranch LAD storage pond and disposed at the Hertzler Ranch LAD area.*

Hertzler Ranch second LAD season*: Any excess water that could not be disposed the first year due to high precipitation, unforeseen circumstances where Stillwater would be unable to fulfill its obligations, etc. would be land applied at Hertzler Ranch. The time frame would be up to 18 months.*

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Hertzler Ranch LAD: The hydraulic load of disposal of treated adit and tailings waters plus 201 MG of Hertzler Ranch tailings water and 105 MG LAD storage pond waters exceeds the hydraulic capacity of the Hertzler Ranch LAD system. The adit and Stillwater tailings waters need to be managed at the Stillwater Mine.

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Revised **Stillwater 1,302 gpm CLOSURE scenarios**		No Action Alternative 1A	Proposed Action Alternative 2A	**Agency-Mitigated Alternative 3A**

Agency-Mitigated Alternative 3A Option 2, 1,302 gpm: Stillwater Mine first season: *The 370 gpm (24 hr) untreated east-side adit water would be disposed of at the east-side percolation ponds days 1-90. From day 91 on, all untreated east-side and west-side adit water would be routed to the underground workings. Days 1-56, the 932 gpm (24 hr) west-side adit water would be mixed and treated with 600 gpm (24 hr) Stillwater tailings waters and would be routed to the east-side percolation ponds. The Stillwater tailings impoundment would be dewatered on Day 56. Some west-side adit water may be routed through the BTS to maintain the microbes through the second LAD season, or routed to the Hertzler Ranch and used to*

Hertzler Ranch first LAD season days 1-120: *Untreated Hertzler Ranch tailings waters would be routed to the Hertzler Ranch LAD storage pond and disposed of at the Hertzler Ranch LAD area. Additional treated west-side adit water may be needed to flush salts from soil for an extended first season or be placed in the LAD storage pond for application the second LAD*

Hertzler Ranch second LAD season*: Any excess water that could not be disposed the first year due to high precipitation, unforeseen circumstances where Stillwater would be unable to fulfill its obligations, etc. would be land applied at Hertzler Ranch. The time frame would be up to 18 months.*

Stillwater Mine	criteria	No Action Alternative 1A	Proposed Action Alternative 2A	Agency-Mitigated Alternative 3A
Nitrogen load to Stillwater River at Stillwater Mine, lbs/day	100			**47 to 63**
Closure Nitrogen load to ground water, days 1-548, lbs/18-mos				**4,950**
Nitrogen concentration in ground water below Stillwater Mine, mg/L	7.5			**meets MPDES Nitrogen load**
Nitrogen concentration in Stillwater River below Stillwater Mine, mg/L	1			**meets MPDES Nitrogen load**
EC in ground water at Stillwater Mine, µmhos/cm	1,000			**496 to 810**
TDS in Stillwater River below Stillwater Mine, mg/L				**85 to 115**
Hertzler Ranch LAD				
Closure Nitrogen load to ground water, days 1-548, lbs/18-mos				**54,450**
Nitrogen concentration in ground water below Hertzler Ranch LAD, mg/L	7.5			**4.5**
Nitrogen concentration in Stillwater River below Hertzler Ranch LAD, mg/L	1			**0.9**
EC in ground water below Hertzler Ranch LAD, µmhos/cm	1,000			**985**
TDS in Stillwater River below Hertzler Ranch LAD, mg/L				**126**

NOTE: Under this scenario a temporary exceedance of the 1,000 µmhos/cm Beneficial Use EC criterion for ground water would occur in the vicinity of the assumed Hertzler Ranch tailings impoundment seep (1,268 µmhos/cm) and beneath the upper LAD area (1,129 µmhos/cm) but the Class I Beneficial Use criterion would be met at the down-gradient compliance point, HMW-10.

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Revised **East Boulder 737 gpm CLOSURE scenarios**	**No Action Alternative 1B**	Proposed Action Alternative 2B	Agency-Mitigated Alternative 3B

No Action Alternative 1B Option 1, 737 gpm: *The Boe Ranch LAD system is not built and this analysis assumes that LAD areas 2, 3-Upper, and 4 have been built to manage water at East Boulder Mine. East Boulder tailings waters are evaporated over the tailings mass; 737 gpm (24 hr) treated adit water is land applied at LAD areas 2, 3-Upper, 4, and 6 at East Boulder Mine. The closure period for this alternative is not specified, but for the purposes of analysis, was assumed to occur in 12 months.*

NOTE: The hydraulic load of 737 gpm (24 hr) would exceed the capacity of the 0.7 MG storage pond and the disposal capability of the East Boulder Mine LAD areas 2, 3-Upper, 4 and 6. Additional water management measures would be necessary in both summer and winter. No time frame for the evaporation of tailings waters at closure was specified. The current volume of water in the tailings impoundment (98 MG) is more than double the original estimated volume (40 MG). An extended length of time would be necessary to evaporate the tailings waters.

No Action Alternative 1B Option 2, 737 gpm: *The Boe Ranch LAD system is not built and this analysis assumes that LAD areas 2, 3-Upper, and 4 have been built to manage water at East Boulder Mine. East Boulder tailings waters are evaporated over the tailings mass; 737 gpm (24 hr) treated adit water is land applied at LAD areas 2, 3-Upper, 4, and 6 at East Boulder Mine, and the excess waters are percolated. Summer and winter disposal scenarios were evaluated separately. Summer scenario: 725 gpm treated adit water would be land applied at LAD areas 2, 3-Upper, 4, and 6, and 12 gpm (24 hr) treated adit water would be percolated. Winter scenario: 285 gpm treated adit water would be disposed using snowmaking at LAD areas 3-Upper, 4, and 6, and 452 gpm (24 hr) treated adit water would be percolated. The closure period for this alternative is not specified, but for the purposes of analysis, all disposal of water was assumed to occur in 12 months.*

	criteria	No Action Alternative 1B	Proposed Action Alternative 2B	Agency-Mitigated Alternative 3B
Closure commences in summer using LAD				
Nitrogen load at East Boulder Mine, lbs/day summer	30	**0.7**		
Closure Nitrogen load to ground water, days 1-365, lbs/12-mos		**84**		
Nitrogen concentration in ground water at East Boulder Mine, mg/L summer	7.5	**meets MPDES Nitrogen load**		
Nitrogen concentration in East Boulder River at East Boulder Mine, mg/L	1	**0.6**		
EC in ground water at East Boulder Mine, µmhos/cm summer	1,000	**994**		
TDS in East Boulder River at East Boulder Mine, mg/L summer		**199**		
Closure commences in winter using snowmaking				
Nitrogen load at East Boulder Mine, lbs/day winter	30	**2.2**		
Closure Nitrogen load to ground water, days 1-365, lbs/12-mo		**293**		
Nitrogen concentration in ground water at East Boulder Mine, mg/L winter	7.5	**meets MPDES Nitrogen load**		
Nitrogen concentration in East Boulder River at East Boulder Mine, mg/L winter	1	**0.7**		
EC in ground water at East Boulder Mine, µmhos/cm winter	1,000	**822**		
TDS in East Boulder River at East Boulder Mine, mg/L winter		**191**		

NOTE: No time frame for the evaporation of tailings waters at closure was specified. The current volume of water in the tailings impoundment (98 MG) is more than double the original estimated volume (40 MG). An extended length of time would be necessary to evaporate the tailings waters.

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

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Revised Summary of Projected Water Quality by Alternative

Revised **East Boulder 737 gpm CLOSURE scenarios**		No Action Alternative 1B	**Proposed Action Alternative 2B**	Agency-Mitigated Alternative 3B
Proposed Action Alternative 2B Option 1, 737 gpm: *The Boe Ranch LAD system is not built and this analysis assumes up to 737 gpm (24 hr) adit water and 263 gpm (24 hr) East Boulder tailings waters would be treated in the BTS/Anox system for nitrogen then preferentially disposed at the mine percolation pond. The time frame for closure is 12 months. Days 1-120, treated adit plus tailings waters would be percolated. Days 121-365, treated adit water would be percolated.*				
East Boulder Mine	criteria			
Nitrogen load at East Boulder Mine, lbs/day	30		**3.5 to 15.6**	
Closure Nitrogen load to ground water days 1-365, lbs			**4,414**	
Nitrogen concentration in ground water below East Boulder Mine, mg/L	7.5		**meets MPDES Nitrogen load**	
Nitrogen concentration in East Boulder River below East Boulder Mine, mg/L	1		**meets MPDES Nitrogen load**	
EC in ground water at East Boulder Mine, µmhos/cm	1,000		**681 to 767**	
TDS in East Boulder River at East Boulder Mine, mg/L			**190 to 229**	

Proposed Action Alternative 2B Option 2, 737 gpm: *The Boe Ranch LAD system is not built and this analysis assumes up to 737 gpm (24 hr) adit and 263 gpm (24 hr) are disposed at the mine LAD areas. This analysis assumes that all East Boulder LAD areas 2, 3-Upper, 4, and 6, are constructed and operating to manage the adit water. For this option, no percolation would be used. Summer and winter disposal scenarios were evaluated separately. The time frame for closure would be 12 months.*

NOTE: For a closure scenario that commences in either summer or winter, there is insufficient hydraulic capacity at the East Boulder Mine LAD areas to manage the hydraulic load of 737 gpm (24 hr) treated adit and 263 gpm (24 hr) treated tailings waters. Additional water disposal methods must be used such as percolation.

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

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Revised Summary of Projected Water Quality by Alternative

Revised **East Boulder 737 gpm CLOSURE scenarios**		No Action Alternative 1B	**Proposed Action Alternative 2B**	Agency-Mitigated Alternative 3B

Proposed Action Alternative 2B Option 3, 737 gpm: *The Boe Ranch LAD system is not built and this analysis assumes up to 737 gpm (24 hr) adit and 263 gpm (24 hr) are disposed maximizing the East Boulder Mine LAD areas with contingency disposal at the percolation pond. This analysis assumes that all East Boulder LAD areas 2, 3-Upper, 4, and 6, are constructed and operating to manage the adit water. Summer and winter disposal scenarios were evaluated separately. The time frame for closure would be 12 months.*

	criteria	No Action Alternative 1B	Proposed Action Alternative 2B	Agency-Mitigated Alternative 3B
Closure commences in summer using LAD				
Nitrogen load at East Boulder Mine, lbs/day summer	30		**6.1**	
Closure Nitrogen load to ground water days 1-365, lbs			**1,162**	
Nitrogen concentration in ground water at East Boulder Mine, mg/L summer	7.5		**meets MPDES Nitrogen load**	
Nitrogen concentration in East Boulder River at East Boulder Mine, mg/L	1		**0.9**	
EC in ground water at East Boulder Mine, µmhos/cm summer	1,000		**685 to 892**	
TDS in East Boulder River at East Boulder Mine, mg/L summer			**191 to 261**	
Closure commences in winter using snowmaking				
Nitrogen load at East Boulder Mine, lbs/day winter	30		**21**	
Closure Nitrogen load to ground water days 1-365, lbs			**1,822**	
Nitrogen concentration in ground water at East Boulder Mine, mg/L winter	7.5		**meets MPDES Nitrogen load**	
Nitrogen concentration in East Boulder River at East Boulder Mine, mg/L winter	1		**1.0**	
EC in ground water at East Boulder Mine, µmhos/cm winter	1,000		**685 to 729**	
TDS in East Boulder River at East Boulder Mine, mg/L winter			**174 to 191**	

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Revised **East Boulder 737 gpm CLOSURE scenarios**		No Action Alternative 1B	Proposed Action Alternative 2B	**Agency-Mitigated Alternative 3B**
Agency-Mitigated Alternative 3B Option 1, 737 gpm: *The Boe Ranch LAD system and the East Boulder LAD areas 2, 3-Upper, and 4 are not built. The 737 gpm of treated adit waters plus 263 gpm treated tailings waters would be disposed in the East Boulder Mine percolation pond as in Proposed Action Alternative 2B, but over an 18-month closure time frame.*				
East Boulder Mine	criteria			
Nitrogen load at East Boulder Mine, lbs/day	30			**11.1**
Closure Nitrogen load to ground water, days 1-548, lbs/18-mo				**3,791**
EC in ground water at East Boulder Mine, µmhos/cm	1,000			**767**
TDS in East Boulder River at East Boulder Mine, mg/L				**229**

Agency-Mitigated Alternative 3B Option 2, 737 gpm: *The Boe Ranch LAD system is not built. All approved mine LAD areas would be constructed. The 737 gpm (24 hr) adit and 263 gpm (24 hr) treated East Boulder tailings waters would be preferentially disposed at the East Boulder LAD areas 2, 3-Upper, and 4. Summer and winter closure scenarios are evaluated separately. The closure time frame would be 18 months.*

NOTE: The hydraulic load of 737 gpm adit water plus 263 gpm tailings waters exceeds the capacity of the approved East Boulder Mine LAD areas in summer and winter and cannot be managed solely by land application at the East Boulder Mine. Some excess water would need to be percolated.

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Revised **East Boulder 737 gpm CLOSURE scenarios**		No Action Alternative 1B	Proposed Action Alternative 2B	**Agency-Mitigated Alternative 3B**
Agency-Mitigated Alternative 3B Option 3, 737 gpm: *The Boe Ranch LAD system is not built. All approved mine LAD areas would be constructed. The 737 gpm (24 hr) adit and 263 gpm (24 hr) treated East Boulder tailings waters would be preferentially disposed at the East Boulder LAD areas 2, 3-Upper, and 4, and excess waters would be discharged to the East Boulder Mine percolation pond. Days 1-120, treated adit plus tailings waters would be LAD and the excess water percolated. Days 121-335, treated adit plus tailings waters would be percolated. Days 336-548, treated adit water would be percolated. Summer and winter closure scenarios are evaluated separately. The closure time frame would be 18 months.*				
Closure commences in summer using LAD	criteria			
Nitrogen load at East Boulder Mine, lbs/day summer	30			**4.7 to 11.1**
Closure Nitrogen load to ground water, days 1-548, lbs/18-mos				**3,119**
Nitrogen concentration in ground water at East Boulder Mine, mg/L summer	7.5			**meets MPDES Nitrogen load**
Nitrogen concentration in East Boulder River at East Boulder Mine, mg/L summer	1			**0.4 to 0.8**
EC in ground water at East Boulder Mine, µmhos/cm summer	1,000			**682 to 892**
TDS in East Boulder River at East Boulder Mine, mg/L summer				**190 to 243**
Closure commences in winter using snowmaking				
Nitrogen load at East Boulder Mine, lbs/day winter	30			**3.5 to 9.5**
Closure Nitrogen load to ground water, days 1-548, lbs/18-mos				**3,702**
Nitrogen concentration in ground water at East Boulder Mine, mg/L winter	7.5			**meets MPDES Nitrogen load**
Nitrogen concentration in East Boulder River at East Boulder Mine, mg/L winter	1			**0.4 to 0.8**
EC in ground water at East Boulder Mine, µmhos/cm winter	1,000			**681 to 811**
TDS in East Boulder River at East Boulder Mine, mg/L winter				**170 to 235**

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Revised **East Boulder 150 gpm CLOSURE scenarios**		**No Action Alternative 1B**	Proposed Action Alternative 2B	Agency-Mitigated Alternative 3B
No Action Alternative 1B Option 1, 150 gpm: *The Boe Ranch LAD system is not built; East Boulder Mine LAD areas 2, 3-Upper, 4 are not built; East Boulder tailings waters are evaporated over the tailings mass; 150 gpm (24 hr) treated adit water is land applied at LAD Area 6 at East Boulder Mine. Summer and winter disposal scenarios were evaluated separately.*				
Closure commences in summer using LAD	criteria			
Nitrogen load at East Boulder Mine, lbs/day summer	30	**0.7**		
Total summer closure Nitrogen load to ground water, days 1-365, lbs/12-mo		**2,250**		
Nitrogen concentration in ground water at East Boulder Mine, mg/L summer	7.5	**meets MPDES Nitrogen load**		
Nitrogen concentration in East Boulder River at East Boulder Mine, mg/L	1	**0.8**		
EC in ground water at East Boulder Mine, µmhos/cm summer	1,000	**617**		
TDS in East Boulder River at East Boulder Mine, mg/L summer		**133**		
Closure commences in winter using snowmaking				
Nitrogen load at East Boulder Mine, lbs/day winter	30	**0.7**		
Total summer closure Nitrogen load to ground water, days 1-365, lbs/12-mo		**2,250**		
Nitrogen concentration in ground water at East Boulder Mine, mg/L winter	7.5	**meets MPDES Nitrogen load**		
Nitrogen concentration in East Boulder River at East Boulder Mine, mg/L winter	1	**0.8**		
EC in ground water at East Boulder Mine, µmhos/cm winter	1,000	**617**		
TDS in East Boulder River at East Boulder Mine, mg/L winter		**133**		

Revised **East Boulder 150 gpm CLOSURE scenarios**		No Action Alternative 1B	**Proposed Action Alternative 2B**	Agency-Mitigated Alternative 3B
Proposed Action Alternative 2B Option 2, 150 gpm: *The Boe Ranch LAD system is not constructed. This analysis assumes up to 150 gpm (24 hr) treated adit water plus 350 gpm (24 hr) would be percolated at East Boulder Mine percolation pond. The time frame for closure would be 12 months.*				
Nitrogen load at East Boulder Mine, lbs/day	30		**0.7 to 16.8**	
Closure Nitrogen load to ground water, days 1-365, lbs/12-mo			**3,386**	
EC in ground water at East Boulder Mine, µmhos/cm	1,000		**378 to 700**	
TDS in East Boulder River at East Boulder Mine, mg/L			**102 to 176**	

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

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Revised Summary of Projected Water Quality by Alternative

Revised **East Boulder 150 gpm CLOSURE scenarios**		No Action Alternative 1B	Proposed Action Alternative 2B	**Agency-Mitigated Alternative 3B**
Agency-Mitigated Alternative 3B Option 1, 150 gpm: *The Boe Ranch and LAD areas 2, 3-Upper, 4 are not built. This analysis assumes up to 150 gpm treated adit water plus 350 gpm treated tailings waters would be disposed at the East Boulder Mine percolation pond. The closure time frame would be 18 months.*				
Nitrogen load at East Boulder Mine, lbs/day	30			**0.7 to 10.8**
Closure Nitrogen load to ground water, days 1-548, lbs/18-mo				**2,346**
EC in ground water at East Boulder Mine, µmhos/cm	1,000			**445 to 700**
TDS in East Boulder River at East Boulder Mine, mg/L				**105 to 176**
Agency-Mitigated Alternative 3B Option 2, 150 gpm: *The Boe Ranch and LAD areas 2, 3-Upper, 4 are not built. This analysis assumes up to150 gpm treated adit water plus 350 gpm treated tailings waters would be disposed at the East Boulder Mine LAD Area 6. No percolation would be used. The closure time frame would be 18 months.*				
NOTE: There is insufficient hydraulic capacity at the East Boulder Mine LAD Area 6 to manage the hydraulic load of 150 gpm (24 hr) treated adit and 350 gpm (24 hr) treated tailings waters. Additional water disposal methods must be used such as percolation.				
Agency-Mitigated Alternative 3B Option 3, 150 gpm: *The Boe Ranch and LAD areas 2, 3-Upper, 4 are not built. This analysis assumes up to 150 gpm treated adit water plus 350 gpm treated tailings waters would be preferentially disposed at the East Boulder Mine LAD Area 6, with excess waters disposed at the mine percolation pond. Closure commencing in summer and winter were evaluated separately. The closure time frame would be 18 months.*				
Closure commences in summer using LAD	criteria			
Nitrogen load at East Boulder Mine, lbs/day summer	30			**5.7 to 10.8**
Total summer closure Nitrogen load to ground water, days 1-548				**1,741**
Nitrogen concentration in ground water at East Boulder Mine, mg/L summer	7.5			**meets MPDES Nitrogen load**
Nitrogen concentration in East Boulder River at East Boulder Mine, mg/L summer	1			**0.3 to 0.9**
EC in ground water at East Boulder Mine, µmhos/cm summer	1,000			**764 to 939**
TDS in East Boulder River at East Boulder Mine, mg/L summer				**168 to 181**
Closure commences in winter using snowmaking				
Nitrogen load at East Boulder Mine, lbs/day winter	30			**0.7 to 7.2**
Total winter closure Nitrogen load to ground water, lbs/18 mos				**1,923**
Nitrogen concentration in ground water at East Boulder Mine, mg/L winter	7.5			**meets MPDES Nitrogen load**
Nitrogen concentration in East Boulder River at East Boulder Mine, mg/L winter	1			**0.5 to 0.9**
EC in ground water at East Boulder Mine, µmhos/cm winter	1,000			**494 to 936**
TDS in East Boulder River at East Boulder Mine, mg/L winter				**112 to 179**

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Revised **Boe Ranch 737 gpm OPERATIONS scenarios**	**No Action Alternative 1C**	Proposed Action Alternative 2C	Agency-Mitigated Alternative 3C

No Action Alternative 1C OPERATIONS, 737 gpm: *the Boe Ranch LAD system is not constructed. There would be no effect from LAD at the Boe Ranch. Not Revised.*

Revised **Boe Ranch 737 gpm OPERATIONS scenarios**	No Action Alternative 1C	**Proposed Action Alternative 2C**	Agency-Mitigated Alternative 3C

Proposed Action Alternative 2C OPERATIONS Option 1, 737 gpm: *Preferential disposal of all 737 gpm (24 hr) adit water would occur at the Boe Ranch LAD at agronomic rates with contingency disposal of treated adit water at the East Boulder Mine percolation pond.*

NOTE: During the 120 day LAD season, the hydraulic load of 737 gpm (24 hr) adit water can be managed at Boe Ranch LAD if all 10 pivots are operating at agronomic rates as proposed by SMC. However, the LAD storage pond would fill the first 95 days of winter and excess adit waters would have to managed at the East Boulder Mine percolation ponds and by winter snowmaking. During the following LAD season, the hydraulic load of 737 gpm (24 hr) could be managed at Boe Ranch LAD, but no capacity would exist to dewater the LAD storage pond.

Revised **Boe Ranch 737 gpm OPERATIONS scenarios**	No Action Alternative 1C	**Proposed Action Alternative 2C**	Agency-Mitigated Alternative 3C

Proposed Action Alternative 2C OPERATIONS Option 2, 737 gpm: *During the LAD season days 1-120, up to 164 gpm (24 hr) treated adit water plus 579 gpm (24 hr) stored pond water is applied at Boe Ranch LAD at agronomic rates, and 573 gpm (24 hr) is disposed at the East Boulder Mine percolation pond. The remainder of the year (days 121-365), 283 gpm (24 hr) treated adit water can be routed to the Boe Ranch LAD storage pond and up to 454 gpm (24 hr) would be disposed of at the East Boulder Mine percolation pond.*

	criteria	No Action Alternative 1C	Proposed Action Alternative 2C	Agency-Mitigated Alternative 3C
East Boulder Mine				
Nitrogen load East Boulder Mine, lbs/day	30		**2.2 to 2.7**	
Nitrogen concentration in ground water below East Boulder Mine, mg/L	7.5		**meets MPDES Nitrogen load**	
Nitrogen concentration in East Boulder River below East Boulder Mine, mg/L	1		**meets MPDES Nitrogen load**	
EC in ground water below East Boulder Mine, µmhos/cm	1,000		**858 to 866**	
TDS in East Boulder River below East Boulder Mine, mg/L			**224 to 236**	
Boe Ranch LAD				
Nitrogen concentration in ground water below Boe Ranch, mg/L	7.5		**0.1**	
Nitrogen concentration in East Boulder River below Boe Ranch, mg/L (2.0 cfs flow)	1		**0.1**	
Nitrogen concentration in East Boulder River below Boe Ranch, mg/L (5.0 cfs flow)	1		**0.1**	
EC in ground water below Boe Ranch, µmhos/cm	2,500		**1,103**	
TDS in East Boulder River below Boe Ranch, mg/L (2.0 cfs flow)			**425**	
TDS in East Boulder River below Boe Ranch, mg/L (5.0 cfs flow)			**318**	

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Revised **Boe Ranch 737 gpm OPERATIONS scenarios**		No Action Alternative 1C	Proposed Action Alternative 2C	**Agency-Mitigated Alternative 3C**

Agency-Mitigated Alternative 3C OPERATIONS Option 1, 737 gpm: *To operationally address the hydraulic volume of 737 gpm adit water and dewater the Boe Ranch LAD storage pond annually, only 284 gpm (24 hr) treated adit water with 579 gpm (24 hr) Boe Ranch LAD stored waters could be land applied at Boe Ranch LAD with 7 pivots operating on 166 acres at greater than agronomic rates as is done at Hertzler Ranch LAD. The remaining 453 gpm (24 hr) adit water must be managed seasonally at the East Boulder Mine LAD areas (293 gpm 24 hr summer rate, 205 gpm 24 hr winter rate) and percolation pond (160 gpm 24-hr summer rate, 248 gpm 24-hr winter rate).*

East Boulder Mine	criteria	No Action Alternative 1C	Proposed Action Alternative 2C	Agency-Mitigated Alternative 3C
Nitrogen load East Boulder Mine, lbs/day	30			**0.8 to 2.2**
Nitrogen concentration in ground water below East Boulder Mine, mg/L	7.5			**meets MPDES Nitrogen load**
Nitrogen concentration in East Boulder River below East Boulder Mine, mg/L	1			**meets MPDES Nitrogen load**
EC in ground water below East Boulder Mine, µmhos/cm	1,000			**904 to 950**
TDS in East Boulder River below East Boulder Mine, mg/L				**323**
Boe Ranch LAD				
Nitrogen concentration in ground water below Boe Ranch, mg/L summer	7.5			**0.3**
Nitrogen concentration in East Boulder River below Boe Ranch, mg/L (2.0 cfs flow)	1			**0.2**
Nitrogen concentration in East Boulder River below Boe Ranch, mg/L (5.0 cfs flow)	1			**0.1**
EC in ground water below Boe Ranch, µmhos/cm summer	2,500			**1,070**
TDS in East Boulder River below Boe Ranch, mg/L				**328**

Boe Ranch 150 gpm OPERATIONS scenarios		**No Action Alternative 1C**	Proposed Action Alternative 2C	Agency-Mitigated Alternative 3C

No Action Alternative 1C, 150 gpm: *the Boe Ranch LAD system is not constructed. There would be no effect from LAD at the Boe Ranch. Not Revised.*

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Boe Ranch 150 gpm OPERATIONS scenarios	No Action Alternative 1C	**Proposed Action Alternative 2C**	Agency-Mitigated Alternative 3C

Proposed Action Alternative 2C OPERATIONS Option 2, 150 gpm: *During the LAD season days 1-120, up to 150 gpm (24 hr) treated adit water plus 301 gpm (24 hr) stored pond water would be applied at Boe Ranch LAD at agronomic rates. No water would be disposed at the East Boulder Mine percolation pond. The remainder of the year (days 121-365), 150 gpm (24 hr) treated adit water would be routed to the Boe Ranch LAD storage pond. The capacity of the Boe Ranch LAD storage pond would be adequate to store eight months of treated adit water (52 MG).*

days 1-120 East Boulder Mine			**no disposal at the East Boulder Mine days 1-120**	
LAD season days 1-120 Boe Ranch LAD				
Nitrogen concentration in ground water below Boe Ranch, mg/L	7.5		**0.1**	
Nitrogen concentration in East Boulder River below Boe Ranch, mg/L (2.0 cfs flow)	1		**0.1**	
Nitrogen concentration in East Boulder River below Boe Ranch, mg/L (5.0 cfs flow)	1		**0.1**	
EC in ground water below Boe Ranch, µmhos/cm	2,500		**1,072**	
TDS in East Boulder River below Boe Ranch, mg/L (2.0 cfs flow)			**432**	
TDS in East Boulder River below Boe Ranch, mg/L (5.0 cfs flow)			**328**	
Days 121-365 Boe Ranch LAD			**adit water stored; no disposal occurs**	

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Revised **Boe Ranch 150 gpm OPERATIONS scenarios**		No Action Alternative 1C	Proposed Action Alternative 2C	**Agency-Mitigated Alternative 3C**
Agency-Mitigated Alternative 3C OPERATIONS Option 1, 150 gpm: *During the LAD season days 1-120, up to 150 gpm (24 hr) treated adit water plus 301 gpm (24 hr) stored pond water would be applied at Boe Ranch LAD at greater than agronomic rates. No water would be disposed at the East Boulder Mine percolation pond. The remainder of the year (days 121-365), 150 gpm (24 hr) treated adit water would be routed to the Boe Ranch LAD storage pond. The capacity of the Boe Ranch LAD storage pond would be adequate to store eight months of treated adit water (52 MG).*				
days 1-365 East Boulder Mine LAD season days 1-120 Boe Ranch LAD				**no disposal at the East Boulder Mine**
Nitrogen load East Boulder Mine, lbs/day	30			**meets MPDES Nitrogen load**
Nitrogen concentration in ground water below East Boulder Mine, mg/L	7.5			**meets MPDES Nitrogen load**
Nitrogen concentration in East Boulder River below Boe Ranch, mg/L (5.0 cfs flow)	1			**0.1**
EC in ground water below Boe Ranch, µmhos/cm summer	2,500			**1,070**
TDS in East Boulder River below Boe Ranch, mg/L (2.0 cfs flow)				**432**
TDS in East Boulder River below Boe Ranch, mg/L (5.0 cfs flow)				**328**
days 121-365 water storage occurs at the Boe Ranch				**no disposal at the Boe Ranch LAD days 121-365**

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Revised **Boe Ranch 737 gpm CLOSURE scenarios**	**No Action Alternative 1C**	Proposed Action Alternative 2C	Agency-Mitigated Alternative 3C

No Action Alternative 1C Option 1, 737 gpm: *The Boe Ranch LAD system is not built and this analysis assumes that LAD areas 2, 3-Upper, and 4 have been built to manage water at the East Boulder Mine. The East Boulder tailings waters are evaporated over the tailings mass. The 737 gpm (24 hr) treated adit water is land applied at LAD areas 2, 3-Upper, 4, and 6 at East Boulder Mine. Summer and winter disposal scenarios were evaluated separately. The results of this analysis are equivalent to the No Action Alternative 1B, Option 1, 737 gpm. No time frame was given for closure.*

Revised **Boe Ranch 737 gpm CLOSURE scenarios**	No Action Alternative 1C	**Proposed Action Alternative 2C**	Agency-Mitigated Alternative 3C

Proposed Action Alternative 2C Option 1, 737 gpm: *The Boe Ranch LAD system is built. The East Boulder tailings impoundment would be dewatered at 263 gpm (24 hr) and treated with 737 gpm (24 hr) adit water through the BTS/Anox system. Based on the hydraulic load calculations, only 743 gpm (24 hr) can be disposed of at the Boe Ranch LAD. During the LAD season, days 1-120, up to 164 gpm (24 hr) of treated adit and tailings waters plus 579 gpm (24 hr) stored pond water would be applied at the Boe Ranch LAD at agronomic rates. The remaining 833 gpm (24 hr) would be disposed at the East Boulder Mine (293 gpm would be routed to LAD Area 6, and 540 gpm would be routed to the percolation pond.) For the remainder of closure (days 121-365), 737 gpm (24 hr) treated adit water would be disposed at the East Boulder Mine percolation pond. The time frame for closure would be 12 months.*

East Boulder Mine	criteria		
Nitrogen load East Boulder Mine, lbs/day	30	**3.5 to 15.6**	
Closure Nitrogen load to ground water, lbs/12-mos		**3,635**	
Nitrogen concentration in ground water below East Boulder Mine, mg/L	7.5	**meets MPDES Nitrogen load**	
Nitrogen concentration in East Boulder River below East Boulder Mine, mg/L	1	**meets MPDES Nitrogen load**	
EC in ground water below East Boulder Mine, µmhos/cm	1,000	**655 to 830**	
TDS in East Boulder River below East Boulder Mine, mg/L		**184 to 242**	
Boe Ranch LAD			
Nitrogen concentration in ground water below Boe Ranch, mg/L summer	7.5	**0.1**	
Closure Nitrogen load to ground water, lbs/12-mos		**1,391**	
Nitrogen concentration in East Boulder River below Boe Ranch, mg/L (2.0 cfs flow)	1	**0.1**	
Nitrogen concentration in East Boulder River below Boe Ranch, mg/L (5.0 cfs flow)	1	**0.1**	
EC in ground water below Boe Ranch, µmhos/cm summer	2,500	**1,088**	
TDS in East Boulder River below Boe Ranch, mg/L (2.0 cfs flow)		**421**	
TDS in East Boulder River below Boe Ranch, mg/L (5.0 cfs flow)		**316**	

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

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Revised Summary of Projected Water Quality by Alternative

Revised **Boe Ranch 737 gpm CLOSURE scenarios**		No Action Alternative 1C	Proposed Action Alternative 2C	**Agency-Mitigated Alternative 3C**

Agency-Mitigated Alternative 3C, Option 1, 737 gpm: *At closure, SMC would treat 737 gpm adit water and 263 gpm tailings waters in the BTS. The closure time frame would be 18 months.* ***Days 1-120:*** *SMC would maximize disposal of 284 gpm treated adit and tailings waters with 579 gpm (24 hr) stored waters at the Boe Ranch LAD area at greater than agronomic rates. SMC would dispose of the remaining 716 gpm at the East Boulder Mine. LAD Area 6 would receive 293 gpm and the excess 423 gpm would be routed to the East Boulder Mine percolation pond during the first 120 day summer LAD season in the 18-month closure period.*

Days 121-365: *After day 120, the tailings impoundment would be closed and only 737 gpm of treated adit water would need disposal during the rest of the 18-month closure period. From days 121-365, up to 284 gpm would be routed to the Boe Ranch LAD storage pond, and 453 gpm would be disposed at the East Boulder Mine percolation pond.*

Days 366-548: *During the second year 120 day LAD season, 284 gpm would be routed and disposed at greater than agronomic rates with 579 gpm stored waters in the Boe Ranch LAD storage pond. After the second year LAD season, all 737 gpm of treated adit water would be disposed at the East Boulder Mine percolation pond.*

East Boulder Mine	criteria	No Action Alternative 1C	Proposed Action Alternative 2C	Agency-Mitigated Alternative 3C
Nitrogen load East Boulder Mine, lbs/day	30			**2.2 to 4.9**
Total Nitrogen load to ground water at East Boulder Mine during closure, lbs/18 mos				**2,330**
Nitrogen concentration in ground water below East Boulder Mine, mg/L	7.5			**meets MPDES Nitrogen load**
Nitrogen concentration in East Boulder River below East Boulder Mine, mg/L	1			**meets MPDES Nitrogen load**
EC in ground water below East Boulder Mine, µmhos/cm	1,000			**867 to 1,063**
TDS in East Boulder River below East Boulder Mine, mg/L				**207 to 268**
Boe Ranch LAD				
Nitrogen concentration in ground water below Boe Ranch, mg/L summer	7.5			**0.1 to 0.3**
Total Nitrogen load to ground water at Boe Ranch LAD during closure, days 1-486				**604**
Nitrogen concentration in East Boulder River below Boe Ranch, mg/L (2.0 cfs flow)	1			**0.1 to 0.2**
Nitrogen concentration in East Boulder River below Boe Ranch, mg/L (5.0 cfs flow)	1			**0.1**
EC in ground water below Boe Ranch, µmhos/cm summer	2,500			**1,062 to 1,083**
TDS in East Boulder River below Boe Ranch, mg/L (2.0 cfs flow)				**426 to 432**
TDS in East Boulder River below Boe Ranch, mg/L (5.0 cfs flow)				**323 to 327**

Boe Ranch 150 gpm CLOSURE scenarios		**No Action Alternative 1C**	Proposed Action Alternative 2C	Agency-Mitigated Alternative 3C

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

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Revised Summary of Projected Water Quality by Alternative

No Action Alternative 1C Option 1, 150 gpm: *The Boe Ranch LAD system is not built and this analysis assumes that East Boulder Mine LAD areas 2, 3-Upper, and 4 have not been built at the East Boulder Mine. The East Boulder tailings waters are evaporated over the tailings mass. The 150 gpm (24 hr) treated adit water is land applied at LAD Area 6 at East Boulder Mine. Summer and winter disposal scenarios were evaluated separately. The results of this analysis are equivalent to the No Action Alternative 1B, Option 1, 150 gpm. No time frame was given for closure. Not revised.*

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Revised **Boe Ranch 150 gpm CLOSURE scenarios**		No Action Alternative 1C	**Proposed Action Alternative 2C**	Agency-Mitigated Alternative 3C
Proposed Action Alternative 2C Option 1, 150 gpm: *Days 1-120 Up to 150 gpm (24 hr) adit water would be mixed and treated with 286 gpm tailings waters and routed to the Boe Ranch LAD storage pond. The 436 gpm (24 hr) mixed, treated adit and tailings waters would mix with 52 MG of treated stored water in the LAD storage pond, then land applied at Boe Ranch LAD at agronomic rates 743 gpm (24 hr rate). Days 121-365: During the rest of the 12-month closure period, the 150 gpm (24 hr) would be routed to the East Boulder Mine percolation pond.*				
days 1-120 East Boulder Mine			**no disposal at the East Boulder Mine**	
LAD season days 1-120 Boe Ranch LAD				
Nitrogen concentration in ground water below Boe Ranch, mg/L	7.5		**0.1**	
Total Nitrogen load to ground water at Boe Ranch LAD during closure, days 1-120			**1,391**	
Nitrogen concentration in East Boulder River below Boe Ranch, mg/L (2.0 cfs flow)	1		**0.1**	
Nitrogen concentration in East Boulder River below Boe Ranch, mg/L (5.0 cfs flow)	1		**0.1**	
EC in ground water below Boe Ranch, µmhos/cm	2,500		**1,088**	
TDS in East Boulder River below Boe Ranch, mg/L (2.0 cfs flow)			**421**	
TDS in East Boulder River below Boe Ranch, mg/L (5.0 cfs flow)			**316**	
days 121-365 East Boulder Mine				
Nitrogen load East Boulder Mine, lbs/day	30		**0.7 to 7.3**	
Total Nitrogen load to ground water at Boe Ranch LAD during closure, days 121-365			**916**	
Nitrogen concentration in ground water below East Boulder Mine, mg/L	7.5		**meets MPDES Nitrogen load**	
Nitrogen concentration in East Boulder River below East Boulder Mine, mg/L	1		**meets MPDES Nitrogen load**	
EC in ground water below East Boulder Mine, µmhos/cm	1,000		**408 to 599**	
TDS in East Boulder River below East Boulder Mine, mg/L			**150 to 238**	

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

Appendix E DEQ 2012
Revised Summary of Projected Water Quality by Alternative

Revised **Boe Ranch 150 gpm CLOSURE scenarios**		No Action Alternative 1C	Proposed Action Alternative 2C	**Agency-Mitigated Alternative 3C**

Agency-Mitigated Alternative 3C, Option 1, 150 gpm: SMC would treat 436 gpm (150 gpm adit water and 350 gpm of tailings waters) at closure to empty the East Boulder Mine tailings impoundment. The Boe Ranch LAD storage pond would contain 52 MG of treated adit waters on the first day of the 120-day LAD season. SMC would land apply water for disposal at greater than agronomic rates. After the first 120-day LAD season, 150 gpm of treated adit water would be routed to the Boe Ranch LAD storage pond for disposal during the second LAD season in the 18-month closure period. The 150 gpm of treated adit water would be disposed at the East Boulder Mine days 487 to 548 of the 18-month closure period.

	criteria	No Action Alternative 1C	Proposed Action Alternative 2C	Agency-Mitigated Alternative 3C
days 1-120 East Boulder Mine				**no disposal at the East**
LAD season days 1-120 Boe Ranch LAD				
Nitrogen concentration in ground water below Boe Ranch, mg/L summer	7.5			**0.5**
Nitrogen concentration in East Boulder River below Boe Ranch, mg/L (2.0 cfs flow)	1			**0.3**
Nitrogen concentration in East Boulder River below Boe Ranch, mg/L (5.0 cfs flow)	1			**0.2**
EC in ground water below Boe Ranch, µmhos/cm summer	2,500			**1,190**
TDS in East Boulder River below Boe Ranch, mg/L (2.0 cfs flow)				**466**
TDS in East Boulder River below Boe Ranch, mg/L (5.0 cfs flow)				**344**
days 121-365 East Boulder Mine				**no disposal at the East Boulder Mine**
Second year LAD season days 366-486 Boe Ranch LAD				
Nitrogen concentration in ground water below Boe Ranch, mg/L summer	7.5			**0.5**
EC in ground water below Boe Ranch, µmhos/cm summer	2,500			**796**
TDS in East Boulder River below Boe Ranch, mg/L (2.0 cfs flow)				**291**
TDS in East Boulder River below Boe Ranch, mg/L (5.0 cfs flow)				**238**
days 366-548 East Boulder Mine				
Nitrogen load East Boulder Mine, lbs/day	7.5			**0.7**
Total Nitrogen load to ground water at East Boulder Mine during closure, days 1-548				**45**
Nitrogen concentration in ground water below East Boulder Mine, mg/L	1			**meets MPDES Nitrogen load**
Nitrogen concentration in East Boulder River below East Boulder Mine, mg/L	1			**meets MPDES Nitrogen load**
EC in ground water below East Boulder Mine, µmhos/cm	1,000			**922**
TDS in East Boulder River below East Boulder Mine, mg/L				**378**

Note: These concentrations are projected values based on best available data.
TDS Total Dissolved Solids; EC Electrical Conductivity;
MG Million gallons

2012 Stillwater Mine Water Management Plan Final EIS
Formatting Key for the *Revised* Spreadsheet Analyses

What has changed for the FEIS

- The cell values that were revised are highlighted in mauve.
- Anchor cell values are highlighted in green and minor adjustments in the calculations were made so that these values are used in subsequent calculations.
- Redundant listings of input data have been removed and calculations adjusted accordingly to reduce the length of the spreadsheets.
- Revisions to text other than corrections of typographical errors are indicated in a navy blue font.
- Updated data/input values with citations are listed in navy blue font.
- Values that were revised as a result of comment include
  - Supernatant volumes
  - Nitrogen concentration of treated adit and tailings waters
  - Updated ambient concentrations of nitrogen and salts in ground water to better reflect current operating conditions
  - Average concentrations of adit and tailings waters recalculated to consider the last three years of data (2009 to 2011)

Electronic Microsoft Excel™ spreadsheets contain the formulas used to make the calculations for this environmental analysis. The pdf files included in this document do not contain the formulas. Every effort has been made to minimize error. For a summary of these results, please see the *Revised* Summary of Water Quality by Alternative Table, also found in Appendix E. This key will make the most sense if used by the reader while reviewing a printed or electronic spreadsheet.

- ***Title:*** The initial line shown in orange is the title of the spreadsheet. The spreadsheets are named by alternative and labeled “Nitrogen Calculations” for the analysis of total inorganic nitrogen or “Salts Calculations” for the analysis of salts. Two spreadsheets have been constructed for each alternative. All spreadsheets contain analyses of what the agencies considered reasonable, non-prescriptive options for the management of water at closure, and indicate whether the analysis is also applicable to operations or post-closure. Several options are listed on a given spreadsheet. Headers assist the reader in tracking which option is being evaluated.

- ***Assumptions made:*** Beneath the orange title box is a yellow box with blue text that describes the overarching assumptions for the calculations made in that spreadsheet. These overarching assumptions are consistent for each constituent (nitrogen or salts) and location (Stillwater Mine and Hertzler Ranch LAD system, East Boulder Mine, and Boe Ranch LAD System), regardless of the alternative.

- ***Options analyzed:*** The green boxes indicate which option has been analyzed for the calculations that follow. For some of the analyses, several options were evaluated. The options analyzed were not intended to be prescriptive, but are reasonable representations of the alternative. Often, there are multiple options possible for each alternative. The options analyzed provide a reasonable estimate of projected water quality and quantity impacts for the alternative, if chosen and implemented. In all options, the analysis is sequenced: first, the hydraulic capacity of the treatment and disposal systems is evaluated, then the nitrogen load/concentration or the salts as measured by electrical conductivity (ground water) and total dissolved solids (surface water).

- ***Adit water flow rate:*** Each spreadsheet analyzes the current operational and upper-most expected adit flow rate for each alternative. These are intended to give a range of potential water quality and quantity impacts.

- ***Hydraulic and loading analyses:*** The headers for each section are color-coded. The hydraulics analyses headers and conclusions are labeled pale blue, the loading analyses and results are pale green, the ground water headers and results are medium blue, and the surface water headers and results are aqua. As stated above, anchor cells are shown in green, and cell values that were changed are highlighted in mauve.

- ***Conclusions:*** Conclusions regarding the option analyzed are in yellow boxes. The adit flow rate analyzed is highlighted in purple. Red text is used where a hydraulic loading capacity or a contaminant standard or recommendation has been exceeded. Please note that for salts, the appropriate unit to determine compliance with ground water beneficial use standards is micromhos/centimeter (µmhos/cm) (electrical conductivity). Although both total dissolved solids and electrical conductivity values are calculated in the spreadsheets, the applicable projected concentration is highlighted in color.

- ***Option analyzed:*** Next to the headers for each section in grey boxes are descriptions of that portion of the option analyzed. Some options have been split into specific timeframes due to hydraulic or contaminant load sequencing.

- ***Input values and references:*** Below each of the headers are the specific input values used for that portion of the analysis. The values that were used in the calculations are listed in black text and have a descriptor. For the first analysis, and for subsequent analyses where space permits, a citation for the source of the data is listed to the right in blue text. In an effort to reduce the length of the spreadsheets, the citations for the data are not always located across from the value used, especially where there are several iterations of calculations. For the FEIS, input values are listed once in the spreadsheet and subsequent redundant values have been removed.

- ***Activity-specific flow rate:*** Both 12-hour and 24-hour flow rates were used, and are designated in the units column. This convention was necessary as some activities, such as adit flow and tailings impoundment dewatering rates, would occur over a 24-hour period, and other activities, such as land application, would occur over a 12-hour period. The volume calculations have been adjusted to reflect whether a 12-hour or 24-hour flow rate was used. For example, to calculate a volume based on a 12-hour rate, 720 minutes per day rate was used. To calculate a volume based on a 24-hour rate, 1,440 minutes per day rate was used. Similarly, loading calculations use the conversion factor 0.012 for a 24-hour gallon per minute rate, while the same calculation for a 12-hour gallon per minute pumping rate uses the conversion factor 0.006.

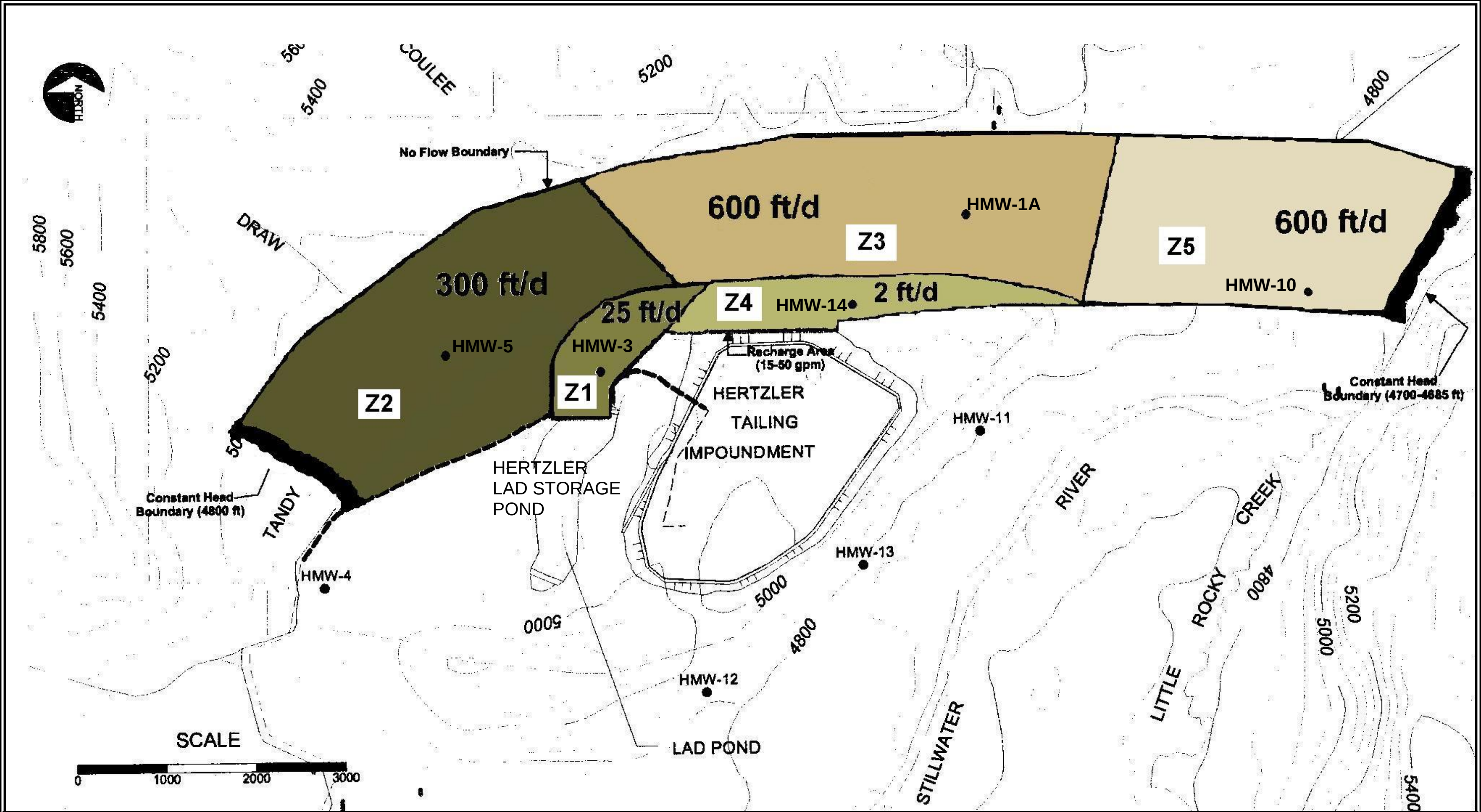
- ***Conversion factors:*** Standard conversion factors (weight, volume, time, loading) have been used.

- ***Significant figures:*** Minimal digits were displayed in an effort to address concerns relating to the precision of these calculations and the degree of accuracy inherently attributed to numbers with expansive extensions to the right of the decimal point. While not strictly adhering to the rules of significant figures, care has been taken to display digits appropriate to the calculation made.

- ***Plant uptake and snowmaking credits:*** The vegetation uptake of nitrogen during land application of mine waste waters has been quantified during tests at the Hertzler Ranch LAD system and snowmaking at the East Boulder Mine, so factors based upon the results of those tests have been applied to the appropriate calculations.

- ***Limitations:*** Please note that these calculations are reasonable projections of changes that can be expected in ground and surface water quality from the disposal of waste waters from SMC's mines. While spreadsheet modeling is valuable to provide good predictions within ground and surface water systems, it does have some limitations. These limitations are most apparent under the following circumstances: when aquifers are highly heterogeneous, which causes differences in permeability and the behavior of ground water; when a three-dimensional approach is needed (these models are two-dimensional); or when the contaminant concentration changes (is attenuated) due to interactions with soil, microbes, or ground and surface water. These types of situations are more accurately represented by a complex (potentially three-dimensional) model. Spreadsheet models are best used in situations such as this analysis, where the salts and nitrogen are conservative (that is, they do not degrade or are otherwise attenuated in the ground water system), temporal relationships are generally known, and for simple ground water or stream flow mixing calculations. These spreadsheet models do not provide temporal estimates, so the agencies have relied upon trends in water quality monitoring data.

L.M.B.



HERTZLER RANCH LAD GROUND WATER ZONES FIGURE

Stillwater Mine System Coordinates 532,000 N, 926,125 E

Appendix C

DEQ 2009

adapted from Hydrometrics 2003 Hertzler LAD Holding Pond Seepage Analysis Figure 4 Numerical Model Layout