Technical Memorandum
Review of the Proposed Montanore Mine
Supplemental Draft Environmental Impact Statement
and
Supporting Groundwater Models

Prepared for Save Our Cabinets, Earthworks, and the Clark Fork Coalition
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Montanore Minerals Corp. (MMC) proposes to construct an underground copper and silver mine and associated facilities near the Cabinet Mountains Wilderness, in the Libby Creek drainage south of Libby MT. The proposed project is called the Montanore Project. The Forest Service (FS) had prepared a draft environmental impact state (DEIS) on the project in 2009, for which I had prepared a letter review (Myers 2009b). The FS prepared a supplemental draft environmental impact statement (SDEIS) to consider changes to the plan and their impacts on the environment. This technical memorandum, prepared on behalf of Save Our Cabinets, Earthworks, and the Clark Fork Coalition, is of that SDEIS and two supporting documents regarding updated numerical modeling studies, Geomatrix (2011) and AMEC (2010).

This technical memorandum focuses on hydrology and water resource issues, including the following:

- Mine dewatering rates
- Conceptual groundwater flow model near the mining area and the Poorman Creek Tailings' facility area
- Groundwater drawdown due to mine dewatering and mine closure
- Changes in surface water flow
- Site Water Balance and Poorman Tailings Impoundment Design
- Monitoring and Mitigation

This review focuses on mine features associated with Alternative 3, the agencies preferred action. The other alternatives had been reviewed in Myers (2009b). Dewatering for the proposed action, alternative 2, is similar to that for alternative 3, was completed in the 2009 DEIS using a 2-d numerical model; Myers (2009b) is reincorporated into this review, by reference, because that model had been reviewed in that letter.

Summary of Major Conclusions and Recommendations

The conceptual flow model for the area is simple, but highly dependent on assumptions. High elevation recharge enters fractured bedrock and flows vertically downward through the fractures. As the fracture size and density decreases, so does the conductivity. Some groundwater continues to flow deeply into fractures which support springs and streams below about 5600 feet above mean sea level (AMSL); some flows laterally to support shallow, ephemeral springs, streams and lakes in the higher elevations. Mining into this bedrock would intersect the fractures at a depth where the conductivity is less than near the surface, which would increase the tendency for the flow to continue downward rather than laterally to the springs. This effectively would create a drain at the bottom of the fracture zone - like pulling the plug on a tub with the water draining downward.

The many faults provide extensive fracture zones which enhance vertical flow and may limit horizontal flow. The Rock Lake fault controls the location of Rock Lake, East Fork Rock Creek, and East Fork Bull River and the springs which provide much of the baseflow to each stream. Modeling completed for the SDEIS simulated the faults as a high conductivity fracture zone surrounded by unfractured bedrock with extremely low conductivity without any data or other verifying justification, even though there is no data to support these assumptions. This artificially minimized the simulated dewatering, drawdown, and impacts to surface water as projected in the SDEIS.

The projected drawdown at all stages of mine development and closure depends on the faults. The conceptualization of Rock Lake Fault in the modeling prevents simulated drawdown from exceeding 10 feet at Rock Lake even though it simulates 1000 feet of drawdown just 1000 feet north of the lake; the fault also prevents simulated drawdown from extending substantially onto the west side of the Cabinets. By preventing drawdown from reaching the high conductivity core of the Rock Lake Fault, the simulated fault artificially protects Rock Lake. If the dewatering draws water from the fault core, it could effectively “pull the drain plug” and substantially empty Rock Lake. Drawdown extends north and south from the Libby adit along the faults, demonstrating how the conceptualization controls the simulated drawdown.

The drawdown affects surface flows wherever the regional water table intersects a stream bottom. Dewatering will change the gradient controlling flow into or from the stream without necessarily causing drawdown at the stream. According to projections, small wilderness streams will essentially be depleted during baseflow and the water table would be drawn below the bottom of Rock Lake, which could potentially lower the water level in that lake substantially more than projected in the SDEISSDEIS.

The conceptualization of the faults in the numerical modeling causes the projected impacts to be grossly underestimated, so more of the project-areastreams will likely be dried than projected. Even the modeler’s uncertainty analysis, while lacking in sophistication, demonstrated that during mine operations the streamflows could decrease by up to 50 percent more than projected using the so-called calibrated model. The effect would be much greater during closure as the mine void fills with water because it is during this period that drawdown is maximized. It is also during this period that drawdown will extend further into the Rock Creek and East Fork Bull River drainage. Headwater stations in the upper part of the East Fork Rock Creek will be completely dried during baseflow conditions after closure when the drawdown reaches its maximum depth.

> *The projected impacts to surface water flows and associated habitat are high, but the range in the potential magnitude of impacts is also high. The proposed monitoring and mitigation will not protect the streams because monitoring would not detect impacts quickly enough for mitigation to prevent the impacts. There is simply no way to mitigate the damages dewatering could cause to wilderness streams, lakes, and springs.*

The minesite water balance is conceptually quite simple. The mine dewatering water will either be used for process water or be treated and discharged to Libby Creek through a percolation pond. During the evaluation and construction phases, the dewatering water, projected at rates up to 480 gallons per minute (GPM), will be discharged through a percolation pond. During operations, dewatering plus up to an additional 1044 gpm is projected to be required for milling the ore. Initially, there will be about 1070 acre-feet stored in the impoundment which could be used in the mill; this is about a year's worth of water required beyond the project dewatering. As the tonnage of ore processes goes up with time, so does the required water. The SDEIS suggests the additional water will come from tailings impoundment runoff, the pumpback wells collecting seepage before it reaches Libby Creek, and recycling. The only consumptive loss will be through evaporation; water from the tails will be recycled to the mill as make-up water. During closure, the dewatering rate will drop to zero and water in the tailings will be diverted to the treatment rate at its maximum capacity, projected to be 500 gpm. As long as the tailings remain wet, there will be seepage. As long as the seepage causes groundwater quality to exceed standards, the pumpback wells will operate and return water to the tailings. Table 17 in the SDEIS provides the agency's guess for these flows.

The water balance misses several important points, or, in part, depends on certain assumptions being true. If the dewatering rate is higher than projected, 480 gpm, there will be excess water in the system. If that occurs, the water treatment system capacity will be exceeded and the discharge to Libby Creek will be higher than projected, and possibly not treated to standards. If the system does not capture as much water from precipitation and runoff in the impoundment as projected, either due to dry years or by underestimating the amount, the system will require make-up water. The SDEIS acknowledges this possibility, but does not analyze the effects of make-up water as part of alternative 3.

The mine site water balance has many uncertainties. The following recommendations apply:

- *The water discharge system should have a larger capacity to accommodate dewatering.*
- *The FS should establish an upper limit for dewatering discharge to avoid damage to surface water habitat.*
- *The SDEIS should estimate a reasonable potential make-up water rate and disclose the impacts to groundwater in the area of the mill using this water would cause.*

The SDEIS has also presented a preferred alternative for a tailings impoundment at Poorman Creek which has not adequately studied. There has been no geotechnical analysis to show the site is even acceptable. This is especially problematic because the mining company had considered this site less acceptable for a tailings impoundment than any other site they had considered.

The estimated seepage from the Poorman tailings facility , 25 gallons per minute, is not much better than a guess because seepage means the liner system will have failed. The estimate of seepage is an acknowledgement of failure before the facility is even built. Similarly, the amount could easily be much higher – if the liner fails in one or two places, it could easily fail in more places. The true amount will never be known because it cannot be measured and even an amount four to six times the projected value would not be noticeable in the impoundment water balance, due to errors in measurement of all of the components. Pumpback wells are proposed to capture this seepage before it reaches Libby Creek; as designed the well will reduce the flow in Libby Creek significantly during operations. The monitoring wells proposed for the facility are spaced too widely to adequately assure that seepage is not reaching Libby Creek.

- *More piezometers should be added to the monitoring wells system downgradient of the pumpback wells to better monitor preferential flow paths.*

Conclusion

The analysis presented in the SDEIS and the review herein demonstrate that the potential risks to streams within the Cabinet Mountains Wilderness are immense, and could be much higher than projected within the SDEIS. Impacts to Libby Creek due to the tailings impoundment and discharge of dewatering water are also potentially high and very uncertain. There is no monitoring that could give adequate warning that the worst potential impacts are imminent.

- ***The mine should not be permitted because the potential impacts to streams are too high.***
- ***The SDEIS has too many assumptions and too little data for the analysis to be considered accurate and for the proposed mitigation to be considered effective.***

Conceptual Flow Model at the Site

A prime aspect of the conceptual flow model is that (1) bedrock at the site has “very low primary permeability”, (2) fractures and structures provide pathways for groundwater movement, and (3) secondary permeability is greater than primary permeability (SDEIS, p 228). These points are correct, but details matter. The details are in the conceptualization of shallow and deep groundwater systems (SDEIS, p 226 and 229) which is linked to the description that shallow bedrock is much “more densely fractured than the deeper bedrock”, and therefore “expected to transmit water more rapidly via secondary porosity” (SDEIS, p 228). “The data indicate that the permeability of the fractured rock decreases with depth and that the permeability of the relatively unfractured rocks between fracture sets is very low” (Id.).

Recharge enters the rock and flows downward but the increasingly less permeable rock diverts it laterally to the springs (SDEIS, p 229). The weathering (SDEIS, p 228) affects primary permeability, but the continuing vertical flow depends on fractures that have their origin in seismicity and long-term fluid flow. These fractures exist, and transmit water, as demonstrated by their being water intercepted in fractures intersected by the adits. The Heidelberg adit encountered flow from fractures within 700 feet (horizontal) from the surface. That the total discharge from that adit varies more than twofold (SDEIS, p. 228) demonstrates how seasonal recharge controls the flow in this level. Springs would drain a fracture zone just upgradient from their outlet which captures groundwater to flow to the outlet. It is difficult to know or estimate the amount of water that continues to flow vertically downward (because spring flow can at least be observed) through fractures, and the original recharge cannot be measured. The bifurcation of the recharge means that there are two different discharge points, so it is more difficult to determine recharge by setting it equal to estimated discharge.

Faults also exert control over the flow, because they can be conduits and/or barriers (p 226 & 228). However, there is little data available on the hydrogeology of the faults in the project area. “The hydraulic characteristics of major structures, such as the Rock Lake fault, **have not been investigated**” (p 228, emphasis added). Even the concept that fault conductivity decreases with depth is referenced only to a thesis (SDEIS, p 228). Therefore, neither the agencies nor the mining company have any data on the most important hydrogeologic structure in the system. The modeling simulations are therefore based on assumed properties that have not been verified with data. The results of that modeling are little better than educated guesswork. Also, it is not a “conservative assumption that mapped faults near the mine area have greater permeability than the surrounding bedrock” (SDEIS, p 228), rather it is accepted as fact that could affect flow, both pre-, during, and post-mining more than realized in this SDEIS. **This SDEIS is grossly deficient in baseline hydrogeologic data**.

Springs become perennial below the elevation range of 5400 to 5600 feet. The description that a water table occurs at about 500 feet below ground surface under the ridges (SDEIS, p 229) is probably accurate but the depth probably also varies seasonally. The water table then slopes to the perennial springs. A gradient along this water table therefore controls the spring discharge.

Rock Lake fault underlies Rock Lake and generally Rock Creek upstream from the lake. The hydraulic connection between lake and fault is not known, but groundwater levels near the lake intersect the lake water level suggesting there is a connection. An agency survey indicated that a bedrock spring, SP-31, discharging from the fault system “accounted for 100 percent of the flow in the stream” (SDEIS, p 230) during a dry period in 2007. They indicate that “bedrock groundwater appeared to be the sole source of water to Rock Lake” (Id.) during this period, but the description does not provide an actual estimate of the inflow beyond the suggestion that streamflow equaled 2 cfs before it entered Rock Creek Meadows. Guerreri and Furniss (2004) indicate that Rock Lake has substantial groundwater inflow and outflow, and that during late summer and fall, the groundwater inflow/outflow components of the water budget exceed the surface water inflow and outflow. The surface water section (SDEIS, p 262) mentions a water balance but does not provide it

The SDEIS does not discuss the hydrogeology of Cliff or Copper Lakes, other than to mention their presence in glacial cirque basins (DSGES, p 197). The SDEIS has added no additional information about Rock Lake or Libby Lake, even though the EPA had requested such information in their comment letter (EPA 2009). Guerreri and Furniss (2004) present data that proves that Cliff Lake has groundwater inflow and outflow indicating that it is hydraulically connected to the groundwater system, but that Copper Lake is perched.

Projections of Hydrologic Consequences of the Proposed Mine

From a hydrologic perspective, the proposed mine's environmental effects would be caused by dewatering the adits and mine void and by the construction of mine facilities, most specifically the tailings impoundment, that interrupt the natural recharge. The mine causes drawdown due to dewatering which affects the groundwater discharge to streams and springs. Discharge of dewatering water to Libby Creek during some of the phases increases flow in that creek. Pumpback of groundwater below the tailings impoundment is discharged into Libby Creek upstream, also affecting the flow in that creek.

The next sections discuss first the distribution of drawdown around the study area and the effects that drawdown and discharge has on base flow. The changes in base flow also affect the stream water quality, which is considered in the third section. The fourth section deals with cumulative effects, which includes a discussion of the impacts caused by operating both the Montanore and Rock Creek Mines.

Effects of Dewatering and Drawdown

The SDEIS reviews drawdown caused by developing, dewatering, and closing the mine void as part of alternative 3 because there would be little difference among the alternatives (SDEIS p 234 and p 260). The SDEIS presents drawdown and flow reduction estimates for the exploration, operations, closure, and post-closure phases; additionally there is a cumulative impacts post-closure analysis. I review the details of the groundwater modeling and report in the next section.

The mining company projected dewatering rates using the 3-d numerical model (Geomatrix 2011). The simulated rates are generally less than 500 gpm, with a few intermediate peaks to 800 gpm (SDEIS, p 239-240). The short-term simulated variability should be given little credence because it is an artifact of the modeling; boundary conditions that simulate dewatering change the head level over a section of the mine void instantaneously so the rapid change in head would cause short-term changes in the simulated flow.

> *The projected rates should be considered very uncertain and quite likely a low estimate by as much as threefold.*

The primary drawdown map, for maximum drawdown (DEIS, Figure 71), shows the effect of the Rock Lake Fault, and all faults. Geomatrix uses several assumptions in developing the model that are not supported by data. They simulated the faults as a vertical high conductivity zone, up to 300 feet wide, bounded on both sides with low permeability zones. The conductivity values in the bounding low conductivity zones are lower than in the remaining bedrock between the faults (Geomatrix 2011, p. 12, 13). Thus, the model simulates the faults as a high conductivity zone isolated from the surrounding bedrock; the conductivity in the fault core appears to be four orders of magnitude higher than in the zones surrounding the core (Geomatrix, 2011, Figures 20-23); the bulk bedrock between the faults is an order of magnitude more conductive than the bedrock surrounding the fault core. Water reaches the high conductivity zone from the surface, through which this conceptualization does not extend; model layers 1 and 2 do not include the low conductivity fault boundary. This conceptualization would have little effect on the calibration because there are few observed head values within the fault zone and no underground flow measurements along the fault trace. The conductivity of the high-conductivity zone could be any value without significantly affecting the head distribution around the model domain, and therefore not affecting the overall calibration (see the section below reviewing Geomatrix (2011)).

Rock Lake Fault, using this configuration, bounds the proposed mine void, which is in model layer 6. The low-conductivity zone artificially minimizes the connection between the mine void and the fault, and therefore the effects that dewatering would have on water levels within the fault zone. Geomatrix Figure 33 shows the 10-foot drawdown just touching the north edge of the lake but less than 1000 feet north of the lake's edge the drawdown is 1000 feet, which reflects the Rock Lake Fault. The SDEIS notes that "[w]ater levels over the mine void nearest Rock Lake would permanently remain greater than 100 feet below pre-mine conditions" (SDEIS, p 257). Regardless of the exact depth the groundwater is drawn beneath the lake, the natural groundwater exchange with Rock Lake will be broken.

Geomatrix's uncertainty analysis (Geomatrix 2011, p 34 – 35) only reinforces the concerns about how faults were modeled. Removing the low conductivity barriers between high conductivity core and bulk bedrock media had little effect on the steady state calibration. Removing the low conductivity zone is a conceptual change which could only be analyzed by recalibrating the model.

Regardless, without the low conductivity zones assumed in the model, simulated dewatering rates were 11 to 35 percent higher than determined with the calibrated model. Streamflow reductions were even greater, with the largest effect occurring in the wilderness stations, based on simulations reported to the end of operations. Reductions in flow at both the outlet from Rock Lake and the East Fork Bull River were almost doubled, with the outflow from Rock Lake being more than halved and the flow at the upper EFBR station being reduced by more than a third.

> *Although imprecise, Geomatrix's uncertainty analysis demonstrates how the SDEIS grossly underpredicts the effects of dewatering and mine closure are on dewatering rates and discharge to the streams.*

The projected drawdown extending along the faults demonstrates the control the simulated faults, which assume a low conductivity barrier, have on the predicted effects of the project. Geomatrix (2011) Figure 26 shows projected drawdown at the end of the exploration phase, which affects only the areas around the Libby Adit. The drawdown extends north and south along the faults with of course no discernible drawdown at all near the proposed mine void. Geomatrix Figure 28 for the construction phase shows 10 feet of drawdown all around the Libby Adit; the entire adit is a drain in the model, but the bulk bedrock releases water and experiences drawdown much slower than in the faults. Continuing to the end of mining and complete construction of the mine void, the drawdown above the void is just 100 feet but that along the Libby Adit has reached 500 feet near the faults (Geomatrix Figure 29). Once dewatering ceases and the adit is plugged, drawdown along the adit recovers but near the mine void increases. The long time period for the 1000 feet of drawdown at the void to manifest reflects the low conductivity above the void; the relative quick recovery in the faults near the adit further reflect the high conductivity in the faults (Geomatrix Figures 33 and 34). These drawdown figures graphically demonstrate how faults control the drawdown throughout the mine domain, including the way the simulated fault artificially protects the flow around Rock Lake. All of these figures therefore demonstrate that the conceptualization that Geomatrix used in the groundwater model controls the projected drawdown, and may limit its effects.

The conceptualization of the connection between the lake and groundwater systems, the fault and ore body, and the connection between the mine void and those same groundwater systems, through the fault, controls the projected effect that dewatering has on Rock Lake. If the ore body conductivity is greater than projected, the connection between the mine void and lake would be more direct than currently projected. The modeled conductance of the lake also apparently limits the flow from the lake into the fault and ore body.

The conceptualization of the Rock Lake Fault has also artificially protected features west of the fault from any significant effects of the Montanore Project, although the ten-foot drawdown may extend southwest from St Paul Lake (SDEIS, Figure 71 and Geomatrix Figure 33). Strangely, however, the low conductivity fault border extends only about a mile north or south from the Libby Adit (Geomatrix, 2011, Figures 20-23). The effects of this may be seen on the drawdown maps which show drawdown extending southwest from St Paul Lake.

The SDEIS considers cumulative effects of operating the Rock Creek Mine simultaneously with the Montanore Mine. However, the conceptualized Rock Lake fault effectively prevents the impacts of the two mines from overlapping, except for the SDEISten-foot drawdown southwest of St Paul Lake (Figure 2). Drawdown under Rock Lake does not apparently increase due to the combined effects (Figure 2). The cumulative impact on baseflow in Rock Creek and the East Fork Bull River does exceed that from the Montanore project alone, discussed in the next section. Rock Lake Fault, as conceptualized in the modeling, clearly prevents substantial overlap of the effects of the mine; the two do not combine to increase the impacts anywhere except in the East Fork of the Bull River.

> *The conceptual flow model for the faults, as used in the SDEIS and by Geomatrix in the numerical groundwater modeling, limits the simulated extend of drawdown and minimizes the projected decreases to surface water flow. This conceptualization is utilized, although there is no data to justify it. No credence should be given these projections without much more substantiating data.*

Consistent with the conceptual model as described herein is the possibility for dewatering to affect surface water features higher than 5600 ft amsl, including lakes. As described, water that infiltrates into the bedrock fractures bifurcates with some going to the springs/lakes and some continuing deeper into the bedrock. The modeled decreasing conductivity of the fracture zones with depth controls the proportions. The mine void would encounter these deeper lower conductivity fracture zones. The fractures may no longer fill with water during the snowmelt or high runoff periods.

> *Effectively, removing the deeper, low conductivity portions of the fracture zones is like pulling a plug and allows more of the infiltrating water to flow deeper, not to the springs, to the mine voids. The higher elevation springs, contrary to the assertions in the SDEIS, could go dry for much longer periods.*

Another common impact of drawdown is subsidence. The SDEIS does not mention subsidence, other than to provide a definition in the glossary, Chapter 7. The SDEIS therefore ignores the potential for subsidence.

Effects on Stream Baseflow

Dewatering affects streamflow by decreasing groundwater discharge into the stream or by drawing water from the stream. Groundwater exchange with streams in the model domain was simulated with transfer boundaries, the term used to describe a head-controlled flux boundary in FEFLOW. This allows water to discharge to the streams if the water table is above the stream and to discharge from the stream into the groundwater if the gradient lowers. The simulation is for baseflow only, because baseflow is groundwater discharge to the stream. The model simulates the discharge only in stream reaches connected to the broader regional aquifer in the bedrock; if the groundwater discharging to the stream is perched, the model may not simulate it, although the perched water may be supported seasonally by high water levels in the deeper bedrock.

The SDEIS considers two different flows on the stream – simulated baseflow from the groundwater model and the empirical 7Q2 and 7Q10 values, ostensibly based on measured streamflows. The 7Q2 and 7Q10 refers to the seven-day, 2- or 10-year return interval low flow; in other words it is a flow that occurs for seven consecutive days. There are no gaging stations in these watersheds and neither the agencies nor mining company completed synoptic flow surveys at the proposed monitoring points, so there are not measured streamflow to use for the estimation.

The SDEIS uses a US Geological Survey regression method to estimate 7Q2 and 7Q10 low flows for monitoring points in the headwaters of the streams, most importantly in the E Fork Rock Creek, East Fork Bull River, and Libby Creek. Unfortunately, the higher elevation sites, those that could be most affected by mine dewatering, have a drainage area too small for the USGS regression. There is too little flow data at high elevations to adequately consider the impacts at these elevations.

> *The agencies should collect synoptic flow data at the high elevation sites and compare it to lower elevation flow data to estimate the 7Q2 and 7Q10 flows at those points. Rather than comparing baseflow reductions to the 7Q2 and 7Q10 flows, the percent reduction should be compared to the calibrated flow rates at the monitoring points.*

The SDEIS claims that "baseflow is not a component of the calculated 7Q2 and 7Q10 flows" (SDEIS, p 192, 193) because the USGS equations are based on "drainage area and mean annual precipitation (SDEIS, p 192). These two points do not relate at all, and the SDEIS's claim is simply wrong – drainage area and annual precipitation are probably the two most important controls on baseflow. Another would be geology, which would improve the estimate but the USGS did not include it in its regression relation.

The SDEIS presents the effect on streamflows in two different ways. Section 3.10.4 presents the results of the modeling in Tables 86 through 89. Section 3.11.4 projects the changes to stream baseflow at the 7Q2 and 7Q10 flow rate due to drawdown in Tables 94 through 98. The difference is that Section 3.10.4 considers the changes to the simulated baseflow and section 3.11.4 considers changes to the calculated low flows.

The SDEIS claims the numerical model does not accurately simulate baseflow discharge into headwater streams, which the agencies use as an excuse to downplay the simulations at these points. SDEIS Table 79 shows that the modeled baseflow at the high elevation sites is substantially less than the calculated 7Q2 and 7Q10 flows. The simulated recharge at high elevations may be too low and the conceptualization may not accurately partition the recharge between discharge to the streams and deep recharge. Geomatrix could have used 7Q2 flow rates as calibration targets to improve the estimates and comparisons in the SDEIS.

The important comparison is the change in simulated flux at a point, therefore Tables 86 through 89 provide a better comparison of the impacts due to dewatering. Drawdown removes flow from the streams in comparison to the calibrated baseflow, not the 10Q2 or 10Q7 flows. The model effectively creates its own simulation for comparison. The projected flux changes are based on the steady flux determined from steady state calibration. When considering the drawdown effects on streams, it would useful to consider the percent change in the baseflow (SDEIS Tables 86 through 89) and then estimate the changes in streamflow using the percent change in simulated baseflow and the estimated streamflows.

Mine dewatering could dry the headwaters of streams in the East Fork Rock Creek and the East Fork Bull River (SDEIS Tables 87 and 88) by the end of operations. Further downstream, the baseflow at EFRC-200 during closure decreases by 62 and 51 percent, without and with mitigation, respectively (SDEIS Table 87). At the maximum baseflow change, the surface water discharge from Rock Lake would be reduced to 0 during baseflow conditions (SDEIS Table 88).

Tables 94 through 97 provide the absolute and percent reductions (or increases) in streamflow at various model monitoring points compared with the calculated low flow values (Figure 1). During the construction phase, Libby Creek LB-300 experiences 27 and 79 percent flow increases due to discharge of dewatering water. During operations, the drawdown effect overcomes the discharge and the LB-300 site experiences 6 and 18 percent flow reductions, respectively. The biggest decreases are at the East Fork Rock Creek site, EFRC-200 which have 9 and 21 percent flow reductions. This site is outflow from Rock Lake (Figure 1). During the closure phase, ERFC-200 experiences 26 and 62 percent reductions, respectively, for the 2- and 10-year return interval (Table 96). LB-300 has flow increases of 26 and 74 percent due to discharge of dewatering water. The effect of changes from the operations phase to the closure phase become obvious then with the EFRC-200 site being reduced by 41 and 100 percent at the

2- and 10-year return interval periods (Table 97); LB-300 would have experienced some recovery by this time with water levels rising from the simulated plugging of the Libby Adit.

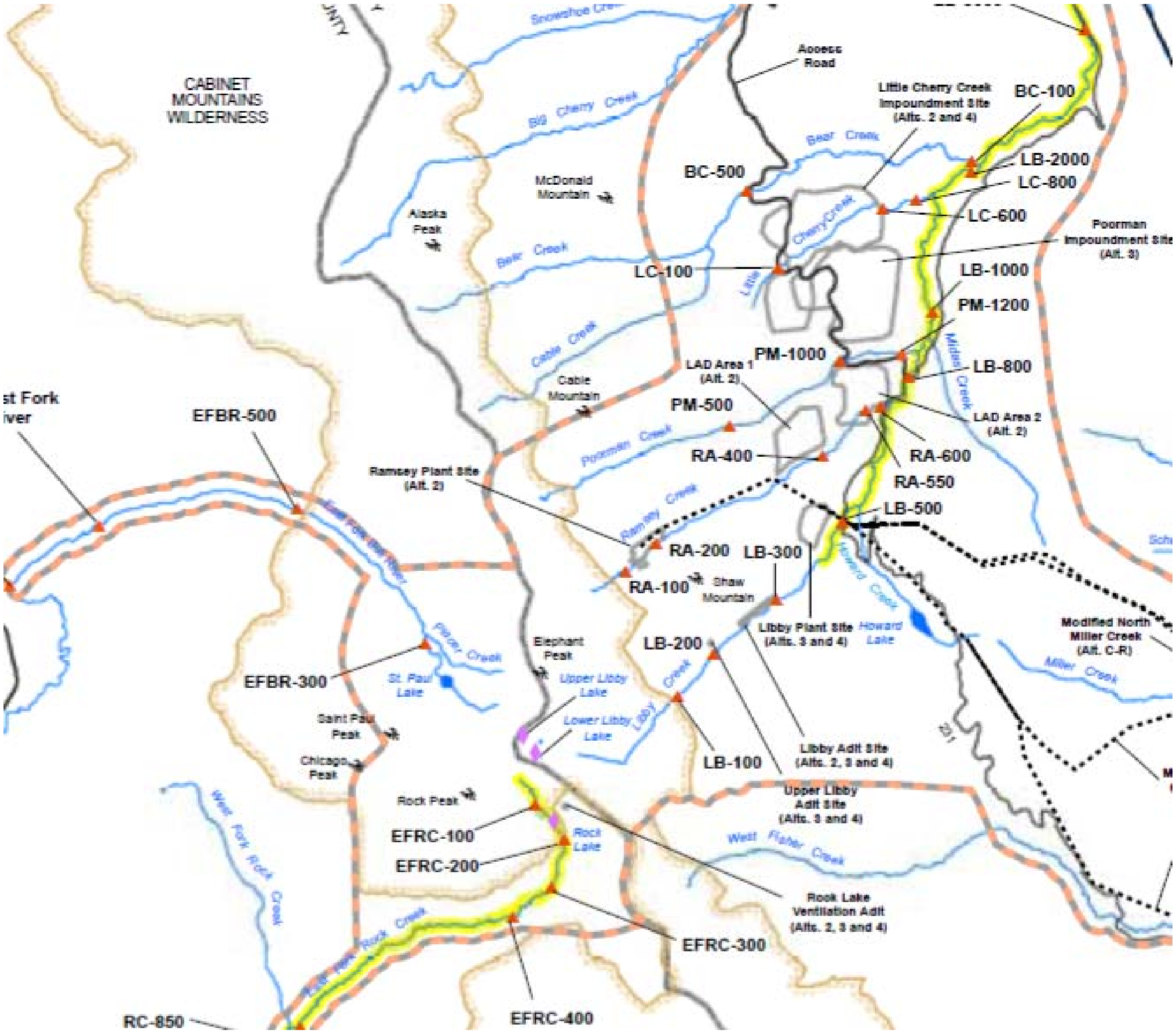

Figure 1: Snapshot from SDEIS Figure 76 showing monitoring points for flow in the streams.

The SDEIS downplays the projected reductions by comparing them to the variability in streamflow measurements (SDEIS, p 274-275). There is nothing wrong with the analysis, other than that it is irrelevant. Streamflow reductions are real whether they are within measurement accuracy or not. Reduced streamflow during winter may mean more of the stream is frozen. Reductions during baseflow may render portions of the stream cross-section not usable as habitat. The threshold for either of these effects is difficult to ascertain.

The biggest problem with the projected flow reductions is they depend on the model conceptualization, as described above. It is very likely that the flow changes in all streams below 5600 ft amsl are underprojected because the conceptualized faults artificially limit the drawdown.

Cumulatively, operating the Montanore and Rock Creek Mines concurrently would affect flow in the East Fork Bull River and Rock Creek more than would either mine individually. However, comparison of

Tables 97 and 102 show that most of the impact comes from the Montanore Mine, because the cumulative decrease at EFBR-500 is 1 and 2 percent more for the 7Q2 and 7Q10 flows without mitigation and 1 and 3 percent more with mitigation; at RC-2000 is 1 percent more for the 7Q2 without mitigation and the 7Q10 with mitigation. This reflects the fact that the Rock Lake fault directly underlies the upper reaches of these two streams and that the modeling, with all of its assumptions, of the Montanore project affects water levels in the fault more than does the Rock Creek Mine. The mines are about 6000 feet apart (Figure 2).

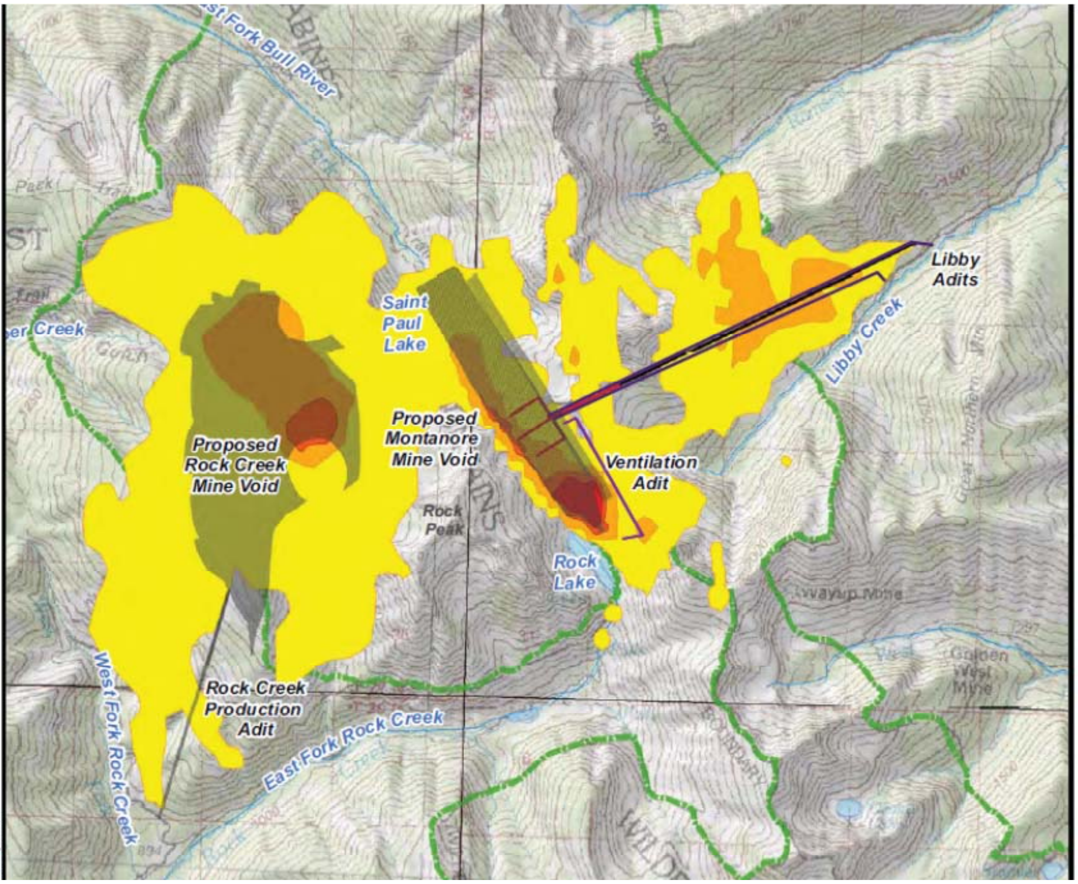

Figure 2: Snapshot from Geomatrix (2011) Figure 36 showing the location of the Montanore and Rock Creek Mine void, and cumulative drawdown for 16 years after the end of mining.

Rock Lake

Rock Lake is a high elevation lake with two distinct flow regimes. During the snowmelt runoff period, there is very high surface water inflow, as a proportion of the lake volume, but once snowmelt ends, groundwater inflow becomes very important. Groundwater inflow and outflow dominate the water budget during the late summer snow-free period (Gurrieri and Furniss 2004). Annual or steady state water balance calculations for such a lake are inaccurate because they ignore critical low flow periods.

Geomatrix (2011) considered only an annual water balance for the lake, to which they compared the effects of dewatering. They dismiss Gurrieri's (2001) estimate for groundwater inflow and outflow by claiming he ignored surface inflow from the sides of the lake, which is not true – Gurrieri (2001) estimated the runoff volume from an October 1999 storm using the Soil Conservation Service synthetic hydrograph method; during the rest of the baseflow period, there would have been little runoff. Geomatrix developed a surface inflow estimate based on flow data "available for a few months between October 7, 1989 and September 20, 1999" (Geomatrix 2011, p F-2); they extrapolated an annual average inflow hydrograph from a gaged site, although they acknowledge a "lack of springtime data" (Id.), the period when most of the runoff occurs. They estimated a net groundwater inflow and reported that groundwater outflow is zero based on the "water balance [showing] net groundwater flow "In"" (Geomatrix 2011, Table F-1). This "net inflow" has been interpreted incorrectly as there being no groundwater outflow, but it merely states there is more inflow than outflow; this is similar to Gurrieri and Furniss (2004) who estimated that groundwater inflow exceeded outflow. Geomatrix did not attempt to estimate a transient water budget for period during which groundwater inflow and outflow would be important, therefore the Geomatrix annual water budget for Rock Lake is not useful; it is not useful to compare the dewatering impacts, which would manifest during baseflow periods, with annual water budgets dominated by snowmelt.

Groundwater inflow and outflow to/from Rock Lake for the July 23-August 10, September 1 through 27, and September 28 through October 21 periods was 430 and 287 af, 122 and 89 af, and 93 and 72 af (Gurrieri and Furniss 2004). That the groundwater interchange decreases from the middle summer to fall period reflects the naturally declining groundwater level.

The agencies adapted the Geomatrix water balance for Rock Lake (SDEIS, p 262), including the inference there is not groundwater outflow from the lake,SDEISSDEIS against which the SDEIS compares the projected changes in flux to the lake. The SDEIS acknowledges that if Gurrieri (2001) is correct, the "calculated effects on Rock Lake water levels would be somewhat greater than disclosed in this EIS" (SDEIS, p 262). Thus the agencies have rejected a water balance published in an international peer-reviewed journal (Gurrieri and Furniss 2004) which considered critical baseflow period effects in deference to a steady state water balance based on average annual flux components, and acknowledge if the peer-reviewed article is correct, their DSGEIS has underestimated the effects of the mine.

The numerical model simulates effects on Rock Lake in a fashion similar to that on the stream baseflows, as a transfer boundary. The water table would be drawn below the bottom of the lake (SDEIS, p 290) during the post-closure phase for about 135 years. This would eliminate all groundwater inflow to the lake, although lake water would continue to flow through the bottom of the lake to the groundwater. They project that the depletions to the lake would be 1.5, 7.8, 6.0, 53.0, 20.3, 4.0, and 0.0 af/y for the evaluation and construction phase, operations (w/o mitigation), operations (w mitigation), post-closure (w/o mitigation), post-closure (w mitigation), post-closure (steady state, w/o mitigation), and post-closure (steady state w mitigation), respectively (SDEIS, Table 99). Depletions are due to a decrease in inflow from Rock Creek and groundwater drawn directly from the lake. The estimated depletions are far less than the groundwater interchanges estimated by Gurrieri and Furniss (2004), reported in the previous paragraph; the impacts to the Rock Lake water balance are likely to be far greater than disclosed in the SDEIS. The agencs projected maximum change in lake level of 1.22 feet for the post-closure, without mitigation phase condition (SDEIS, Table 99), is likely a gross underestimate. Even though the water table is pulled below the bottom of the lake, the SDEIS projects only a minor decrease in the lake volume.

The predictions discussed for Rock Lake do not comport with the water budget presented for Rock Lake, (Geomatrix 2011, Table F-1), even with all of its problems. Geomatrix shows that groundwater inflow to Rock Lake is 954 af/y. If the water table falls below the lake bottom, this inflow would decrease to zero. This is much higher than the depletions discussed below. Even Geomatrix's water budget indicates that the decrease in groundwater inflow would be about 13 percent of the total inflow to the lake. That is a substantial decrease.

An additional problem with the predicted depletion is that it depends on the conductance the modeler used to control the flow through the bottom of the lake. The value is not calibrated because there are no data to calibrate it to, hence the uncertainty; Geomatrix presents no information regarding this conductance. As conceptualized elsewhere in this review, lowering the water table in the fault zone could create storage into which the lake could drain. At the least, the lake could drain fast enough to maintain a contact with the water table which the model otherwise simulates as falling below the lake level. The impacts on the lake presented in the SDEIS are a very low-end estimate with the actual impacts being potentially much greater.

Effects on Stream Baseflow Water Quality

Dewatering can affect surface water quality in two ways – direct discharge of contaminants or reducing the flow rate so that less dilution occurs. The SDEIS suggests that reductions in bedrock groundwater discharge to high elevation streams may cause the stream to be more dilute and that this could affect the buffering capacity.

Libby Creek could be affected by discharge of groundwater that has been contaminated by seepage from the Poorman Creek tailings. The SDEIS suggests that pumpback wells will prevent this discharge. However, pumpback wells do not capture all of the water they are designed to capture, primarily because some flow will miss the wells due to preferential flow. The second reason is that, as discussed in the water balance section, the actual seepage rate could different from the projected value by several times, and the company would not even know it.

Effectiveness of Mitigation and Monitoring

The SDEIS presents a monitoring plan in Appendix C. It includes monitoring near some of the points that were modeled in the dewatering analysis. There are no groundwater monitoring points near the area to be mined. There are monitoring points near the Libby Adit and around the tailings impoundment. The monitoring plan includes no way to monitor the drawdown near the areas in which the modeling analysis projects up to 1000 feet of drawdown.

The monitoring plan describes data to be collected in a pre-evaluation phase (SDEIS, section C.10.3). This includes survey of springs in the area projected to be affected by drawdown, streamflow measurements, synoptic surveys to identify gain and losing stream reaches, groundwater-dependent wetlands, and lake water balance. This information could have been collected prior to releasing this SDEIS because it would not have been harmful to the Wilderness. Also, data collected to date should have been used in the SDEIS (p C-46).

Monitoring stream flows and lake levels, as proposed, is necessary but not sufficient. The sites and parameters proposed in Table C-8 are comprehensive for monitoring slow changes. No amount of monitoring would really be sufficient because of a threshold effect. The conceptual model described above analogized the mining to pulling a plug on a drain. Contrary to the results of the modeling, which assumes porous media flow, changes could occur rapidly. If the faults do not verify to be as modeled, mining near them could rapidly lower water levels in the faults and quickly drain the fractures higher in the bedrock. Seasonal recharge would short circuit to depth rather than to the upper stream channels and springs. There is no monitoring design that would detect these effects prior to them actually occurring.

The action levels proposed by the agencies are insufficient to protect the lakes or streams. MMI would be required to report with 2 weeks if the “mine and adit inflows greater than 800 gpm occurred over a 2-month period” (SDEIS, p C-69). Considering that the water management system through the tailings impoundment and the capacity of the treatment plant would be only 500 gpm, this flow exceedence would cause a great deal of excess, untreated water. The reporting threshold, 800 gpm, represents almost 26,000,000 gallons, or 80 acre-feet of water. This is the minimum amount of excess that would have been generated under the threshold required by the agencies for reporting. A sixty percent exceedence of the projected dewatering rate for two months is excessive, and the agencies only require that MMI report such an overage within two weeks.

Similarly, there is an action level and similar requirement for reporting to the agencies “excessive tailings water … in excess of what could be managed by storage in the tailings impoundment” (Id.). Excess water in the tailings could be caused by excess dewatering, upwelling from the groundwater, too little storage in the tailings’ pores, too little evaporation, or too much rain. Excess water in an impoundment could lead to a spill or impoundment failure. The SDEIS does not have containment for spills, but should.

> *Excess water from either dewatering or in the tailing impoundment could create a potential spill of contaminated water or impoundment failure. The mine must have action plans that would minimize the chance of such a spill. The action plans must include changed operations, including shutting down if there is excess water. There must also be containment to prevent uncontrolled spills from the tailings area.*

No groundwater wells could be developed within the wilderness. However, they propose to develop piezometers from the dewatering adit to monitor changes in water level caused by dewatering the adit and extending it under the ore body (SDEIS Figure C-6). The proposed data collection should be expanded to include piezometers developed within the high conductivity core of the Rock Lake Fault (it is difficult to determine from Figure C-6 whether this is currently proposed or not). This would help to fine-tune the conceptualization of the fault and help to improve the known location of the fault. The only way a setback as proposed could be useful would be if the location of the fault is well known.

The only mitigation that would minimize these impacts would be prevention – staying as far from the potential drain plugs as possible. There are three proposed mitigations. First is a setback of 100 feet from the Rock Lake Fault (SDEIS, p 253). This assumes the location is accurately known or can be discovered by drilling during mining. It also relies on the 100 feet being very low conductivity, as conceptualized in the model. If this conceptualization is incorrect, and there is no evidence to support it, the setback mitigation would not be effective and the surface water features it is intended to protect would not occur. If the zone around the fault core is just one order of magnitude more conductive, the zone needs to be an order of magnitude wider to provide the same protection. It is disappointing the agencies have not changed this grossly insufficient proposed setback from the 2009 DEIS.

> *The agencies should require a 1000-foot setback from the Rock Lake Fault, to protect Rock Lake and other surface water features connected to the Rock Lake Fault.*

Additionally, two additional types of mitigation may affect the required dewatering and/or the effects of rewatering the mine void. One is the grouting of fractures intersecting the mine void and the second is the construction of bulkheads within the void which would effectively separate the mine void into sections. Simulation of grout involved changing the conductivity in the elements bounding the void, so that the inflow to the void would be decreased. Bulkheads were simulated as low conductivity elements across the void. The mitigation reduced the streamflow decreases, especially during closure, and primarily in Rock Creek. This is because the simulation effectively increased the protection provided by the Rock Lake Fault. The bulkheads also prevented a small transfer of water from the Rock Creek watershed to the East Fork Bull River watershed, which occurs in the unmitigated mine void because the void overlaps the topographic divide (SDEIS, p 331). The SDEIS indicates that there is evidence grouting has worked in the Libby Adit to reduce inflow; the SDEIS should either present the evidence or reference a study regarding it. These two mitigations could decrease the impact caused by dewatering for a period of time, but the effectiveness is very uncertain and depends on the accuracy of the fault conceptualization.

It is also probable that the effectiveness of the mitigations may not last forever. The SDEIS presents no data concerning the longevity of either grout or bulkheads. The head experienced by the grout could be substantial. Grout is not designed to eliminate flow, so the continuing flow around and through the pores near the grout could dissolve or erode it with time. There would be a head drop across the bulkheads, which are designed to prevent flow from the Rock Creek to East Fork Bull River watershed (SDEIS, p 253-254), so there would likely be a constant gradient for flow across the bulkhead. If the concrete is more impervious than the surrounding bedrock, groundwater would flow through small natural fractures around the bulkhead; with time, these fractures could erode and the bulkheads fail. The SDEIS should not rely on mitigations that will fail with time; the mitigations, if they do work as designed, would just extend the time to maximum impact rather than prevent it.

Proposed monitoring of the tailings impoundment could be improved by mapping preferential flow zones. At the Poorman site, they propose at least seven monitoring wells, four of them nested pairs in shallow and deep flow paths, along the downgradient side of the impoundment between the pumpback wells and Libby Creek. The SDEIS notes that monitoring would also be required for preferential flow paths that "were encountered during the construction of the impoundment or installation of monitoring wells" (SDEIS, p C-56). This is a good requirement, if MMI actually looks for them. Depth to bedrock is variable and generally less than a couple hundred feet (AMEC 2010); fracture zones could be preferential flow paths, as suggested at the Little Cherry Creek tailings site (SDEIS, p 234). The till covering the bedrock has been fluvially reworked; there could be higher conductivity pathways not immediately obvious on the geology maps. There should also be a requirement or a standard that requires the mining company to actually look for preferential flow paths and to install the appropriate monitoring well so that contaminants do not miss the wells.

During operations, these wells would be used to assess whether the pumpback wells are doing their job, as proposed. They would compare the "measured water level … with predicted drawdown … to determine whether full capture had been established" (SDEIS, p C-65). While matching water levels would seem to be necessary, it does not prove full capture because it is simply a point on the drawdown cone.

- *With wells spaced 1000 feet apart, the monitoring data would merely verify drawdown at a point, not the shape of the drawdown cones. The monitoring wells are clearly insufficient*
- *After the pumpback wells have operated for a while and the monitoring wells have collected water levels, the model of the tailings impoundment should be verified. The model should then be recalibrated and the pumpback system reconsidered.*

Mine Site Water Balance and the Tailings Impoundment

The minesite water balance for alternative 3, SDEIS Table 17, is actually quite simple. Mine dewatering water will either be used for process water or be treated and discharged to Libby Creek through a percolation pond. During the evaluation and construction phases, the dewatering water, projected at rates up to 480 gallons per minute (GPM), will be discharged through a treatment plant and percolation pond. During operations, dewatering plus up to an additional 1044 gpm is projected to be required for milling the ore. The additional water comes from precipitation and runoff in the tailings impoundment, of which the SDEIS projects there will be about 1070 af stored in the impoundment at the beginning of operations, or about a year's worth of process water. This would be used in the mill. As the tonnage of ore processed goes up with time, so does the required water. The additional water will come from tailings impoundment runoff, the pumpback wells collecting seepage before it reaches Libby Creek, and recycling. The only consumptive loss will be through evaporation, so water from the tails will be recycled to the mill as make-up water. During closure, the dewatering rate will drop to zero and water in the tailings will be diverted to the treatment rate at its maximum capacity, projected to be 500 gpm. As long as the tailings remain wet, there will be seepage. As long as the seepage causes groundwater quality to exceed standards, the pumpback wells will operate and return water to the tailings.

SDEIS Table 17 should be presented with annual time steps, rather than grouping longer periods such as years 6 to 10, or 11 to 15. Substantial differences in the components occur among those periods, as listed in the previous paragraph. A yearly basis would help show how the components transition.

The water balance misses at least two important points, or in part depends on certain assumptions being true, as follows.

- *If the dewatering rate is higher than projected, 480 gpm, there will be excess water in the system. This would exceed the water treatment system capacity and potentially cause discharge to Libby Creek to be higher than projected, and possibly not treated to standards.*
- *If the system does not capture as much water from precipitation and runoff in the impoundment or the dewatering rate is lower than projected, either due to dry years or by underestimating the amount, the system will require make-up water. The SDEIS acknowledges this possibility, but states only that make-up would come from a well field north of the seepage collection pond (SDEIS, p 244). It would be preferable for makeup water to come from the pumpback wells. The SDEIS should analyze potential make-up wells.*

Seepage from the tailings impoundment is an important aspect of the water balance analysis. The projection for the Poorman site is that seepage will be 25 gpm. This is water that seeps from the tails and gets past the seepage collection system, which is tantamount to a leak detection system. For years 6-10, 11-15, and 16-24, respectively, the seepage collection system sends 498, 815, and 1044 gpm to the mill (SDEIS, Table 17), which means the analysis has determined that most of the seepage from the tails are collected by the seepage collection system. The projection is that very little water will actually seep past the liners. Because a leak is a failure in construction of a design that was intended not to leak, the uncertainty around the estimate could be huge. A significant leak could vastly increase the amount required to be captured by the pumpback wells.

Also, the SDEIS proposes no method for actually measuring the discharge to groundwater. Because the expected seepage is within the measurement error for the other components of the system, it would be impossible to detect the leak from other water balance components. The amount could easily be two- or threefold higher. This would render the groundwater quality analysis in SDEIS Table 108 completely wrong. The concentration in groundwater could easily be twice that projected, based on the amounts of natural groundwater flux used to calculate the concentrations.

The tailings generated for the Poorman site as proposed in alternative 3 will be drier, which may “affect the ability to use the [tailings] impoundment as a reservoir to maintain a water balance” (SDEIS, p 49). MMC would “reevaluate[d] the water balance and the tailings deposition plan” (Id.) as part of the final design. This is a huge oversight in the SDEIS because the water balance controls the potential contamination from the mine site. An alternative water storage site would be the “seepage collection pond” (Id.), although the SDEIS does not analyze the effect of this or whether it would be large enough merely by assuming “that all collected water would be returned to the impoundment” (Id.). The SDEIS considers this pond only by assuming that precipitation within it would be gathered to use in the mill (Table 17, SDEIS).

The tails deposited at the Poorman site in alternative 3 would be thickened, meaning the density would exceed 55 percent (SDEIS, p 46). Considering that the water balance assumes water released from the tails, the SDEIS should specify the density and not just state they would be greater than 55 percent.

The SDEIS was submitted without a detailed design for the Poorman tailings impoundment, although that is the preferred action. The SDEIS presents only a conceptual design and that site information "would be collected during field exploration programs during the design phase". They have not even completed a seepage analysis on the Poorman tailings impoundment (SDEIS, p 225), rather they have relied on estimates from the Little Cherry Creek site to arrive at the 25 gpm estimate (AMEC 2010, p 9). Considering that MMI (2005, p 211) had considered that the Poorman site was not a viable site for a tailings impoundment, this is especially problematic. This is another reason why this SDEIS is premature – there is much additional information to be collected and presented in the NEPA documents.

Review of Dewatering Model (Geomatrix 2011)

The first step in developing a numerical groundwater model is development of a conceptual model describing the flow paths and fluxes around the model domain. A conceptual model inherently combines assumptions with the measured water budget components. The model presented by Geomatrix depends exceptionally on the description of shallow and deep groundwater flow and the properties of the Rock Lake fault.

Geomatrix quotes from Guerrieri (2001) to note that "groundwater flow occurs mostly in local flow systems" and "[w]hen surface water bodies are isolated from the underlying groundwater system by low conductivity rock units at intervening depths,…, much of the recharge would continue to follow the pre-mining path…" (Geomatrix, p 3). Neither point is inaccurate, but the emphasis on how the geology may protect the hydrology from dewatering rather than on an objective discussion of the overlap of the water table with the springs and lakes. Geomatrix presents no data to prove that shallow systems are disconnected from the deeper systems; because recharge at high elevation recharges both shallow and deep systems, it is not possible to assume the shallow system is completely perched. It is likely that decreasing bedrock conductivity causes recharge to flow laterally to high elevation springs but also that fractures in those bedrock layers allows groundwater to flow to depth; the proportion flowing in each direction is unknown. Because the rock is very tight except where fractured, each fracture system may be treated in isolation. Each system may be quite limited in volume, which suggests they would fill with water seasonally. Recharge into the fracture system may occasionally (seasonally) overflow to the spring systems. Mine dewatering that affects the fracture systems would decrease the seasonal carry-over so that more recharge is required to fill the system and cause spring flow. If the mining effectively opens the bottom of the fracture system, the systems may drain and effectively never fill. This type of system is too detailed for the numerical model to simulate with its porous media assumptions, which include annual average recharge. Isolated fracture systems, which control the flow and discharge to springs and lakes, cannot be simulated with a regional 3-d model.

Assuming the model simulates flow into the adit and void accurately, the dewatering estimates should be accurate within the range of the variability in the parameters controlling that flow. The modeling strategy, or predictive scenarios (section 5), is not inaccurate. The mining schedule (Geomatrix Table 5) may be input in too much detail, because it will likely change, but that detail should not affect the results. The accuracy of the projected effects of that dewatering on the resources in the remaining model domain depends on how well they are conceptualized and calibrated. There is no description of how the boundary used to simulate the mine void dewatering is calibrated, which increases the uncertainty around the projected dewatering rate. Increased conductivity would require increased dewatering, and would also increase the rate that the void fills after mining ceases and the extent that drawdown affects the surface.

Geomatrix (p 16) downplays the ability of their model to “accurately predict impacts to the uppermost reaches of these streams where baseflows are low and variable”. These are streams for which understanding the impacts is most important. If there is little data, more should be collected. Wells cannot be drilled in the wilderness, but the springs and streams offer data which has not been fully utilized. Each spring could be considered a head target in the calibration if that spring can be assumed part of the water table being modeled. The point at which a stream becomes perennial is also a head observation. The method for estimating baseflow for ungaged streams, described in the SDEIS, could be used to estimate additional discharge points and flow rates.

The largest impacts, relative to flow rate, will occur to upper reaches of Rock Creek, Libby Creek, and East Fork Bull River. Figures 3 and 4 are snipped from Geomatrix Figures 27 and 33, respectively, which should be referred to for the legends. Figure 3 shows the Rock Creek EFRC-50 and Rock Creek at Wilderness Boundary in darker red, Libby Creek at wilderness boundary in darker purple, and the East Fork Bull River in dark green. These, and the other reaches and other streams, have been modeled as transfer boundaries with the discharge to them controlled by gradient and a conductance (which the report does not specify) in model layer 1. These could be calibrated to flows estimated for these streams. The mine is in model layer 6, so the drawdown must propagate through five layers to affect the streams by inducing recharge from or reducing discharge to the stream. The vertical conductivity of these layers controls the rate at which the drawdown occurs. Baseflow changes occur when the gradient at the stream change; if the gradient changes from positive to negative, the stream will change from receiving discharge to recharging the aquifer. At high elevations where there is no baseflow, this could not occur since there would be no water in the stream to flow into the aquifer; recharge may occur from these streams during runoff periods.

The figures show clearly the simulated drawdown occurs directly under the reaches EFBR-300 and EFRC-50. The time of maximum impact is 16 years after mining ceases because the drawdown continues to expand as the mine void fills with water. EFRC-50 goes essentially dry but discharge to EFBR-300 decreases by less than 20% at this time; drawdown at EFBR-300 appears to range from 10 to 100 ft while at EFRC-50 it appears to exceed 100 ft. Not knowing the initial gradient, it is difficult to verify or even understand the modeled changes in flow; in particular, the gradient controlling flow to the upper end of the E Frk Bull River must initially be high if drawdown from 10 to 100 feet causes less than 20% flow reduction.

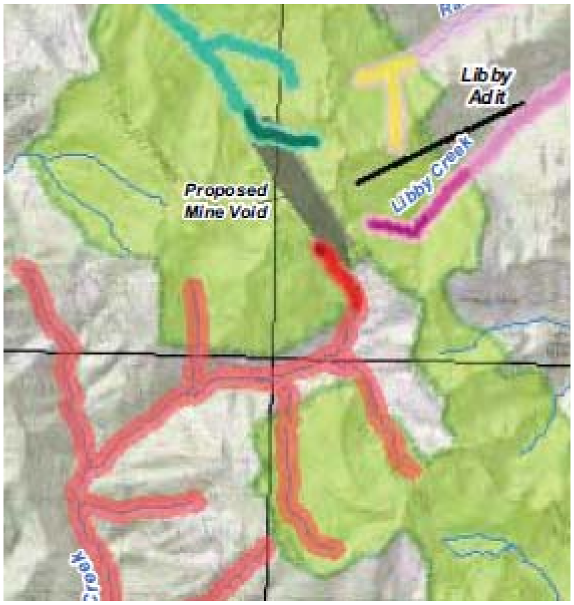

Figure 3: Snapshot from Geomatrix Figure 27.

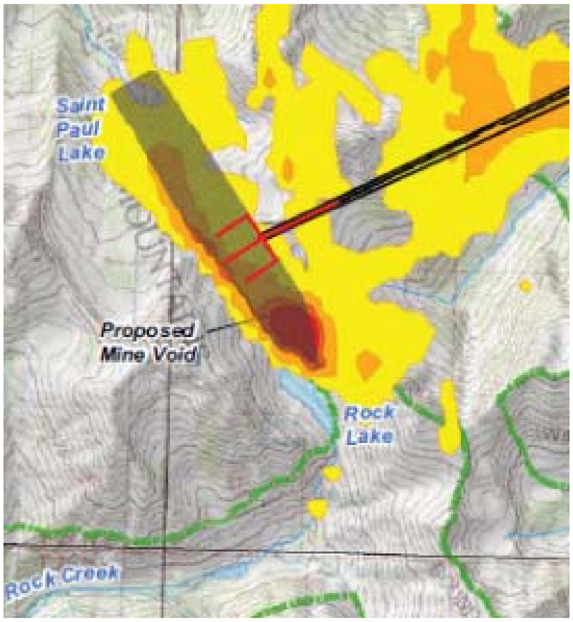

Figure 4: Snapshot from Geomatrix Figure 33.

Geomatrix is correct in stating that fractures that are not connected to others can contain water that may drain but not be a long-term source of flow (Geomatrix, p. 3). However, they present or utilize no site-specific data for the Montanore project regarding connectivity. Considering that most of the fracture zones are apparently related to faults, the fracture zone would likely be more extensive than suggested by the statement.

Geomatrix suggests that historic flow rates into the Libby Adit "typically decrease with depth" (Geomatrix,p. 3). They convert the location within the adit into depth of overburden (Geomatrix, Figure 4) to suggest that inflow decreases with increasing depth. Geomatrix has not proven that the decrease is not simply caused by different geologic formations being intersected by the adit or by a lucky fracture. SDEIS Figure 62 shows the first 8000 feet or so is Prichard formation. That the mining company found two fracture zones in the first 5300 feet that produced significant water followed by several in the next 7000 feet not producing water does not prove that lithostatic pressure in this instance caused the lack of flow. It may be an exaggeration to state that 'the upper 600 feet of bedrock yields 50 percent of the water" (*Id.*).

It is correct that, in general, the permeability of fractured rock decreases with depth (Geomatrix, p. 4). Geomatrix however has no data to support any conceptualization that faults, including the Rock Lake Fault, are barriers to flow. They present no information about gouge or other fines in the fault (Caine et al 1999), nor do they present any hydrologic data showing a significant head drop across the fault, which would be expected if a fault was a flow impediment.

The models considered the faults as areas with higher conductivity in the fault than around it: "Both models used hydraulic conductivities for faults higher than the surrounding rock and decreased hydraulic conductivity with depth" (SDEIS, p 226). This conceptualization would emulate a preferential flow zone. There is no indication that a lower horizontal conductivity is used to prevent flow across the fault. The flow in a high conductivity zone would have only a limited connection to flow in much lower conductivity rock around the fault. Drawdown on one side would pull water from the fault zone without lowering the water table within it. The previous section provided much more review of the modeling of faults.

Recharge

Geomatrix does not present the derivation of their recharge estimate (Geomatrix, Table 1), other than to state that "AMEC developed a steady-state groundwater balance…when the system receives the least stress…" (Geomatrix, p. 4). This reference and the derivation should be included because recharge drives a groundwater model. Table 1 suggests that recharge approximates the estimated outflow which includes mostly discharge as baseflow and a small amount of interbasin underflow and evapotranspiration. The estimate averages to 4.6 in/y of recharge over 371 square miles from an average 44 in/y precipitation (p. 7). This rate is low compared to methods widely used in more arid regions (Maxey and Eakin, 1949; Flint et al, 2004). 44 in/y is higher than the range considered for the M-E method, but for greater than 20 in/y the method yields 25% of the annual precipitation as recharge. However, setting recharge equal to discharge for a specific study area is the best way to make the estimate (Myers 2009a; Cherkauer 2004), therefore 4.6 in/y may be reasonable. The geology in the project area has a low conductivity and most precipitation runs off rather than becoming recharge. Interbasin flow from the area is not measured, nor measurable. The main point here is that the recharge estimate may be very uncertain.

However, even if the areal average is accurate, Geomatrix method of distributing it around the domain is not reasonable. They set the recharge equal to two percent of PRISM precipitation if the ground slope exceeds 30 percent and equal to 14 percent if the ground slow is less than 30 percent. Slope definitely affects runoff which in turn affects recharge, but their method ignores soils and geology; there would be little recharge for precipitation landing on a rock outcrop regardless of the slope. Their simple criterion leads to large changes in the recharge across the area – the most ludicrous is the near 1.0 in/y just west of the mountain crest on some steep slopes and 11 in/y adjacent to it on the flatter ridge tops (Geomatrix, Figure 9). Figure 9 shows a broad area of low recharge east of the crest (and "proposed mine void") although Geomatrix Figure 10 shows a variety of geologic formations.

Setting recharge high based simply on the ground-surface slope could also cause the modeler to overestimate conductivity. Forcing recharge into the ground can cause simulated heads to be too high if the conductivity is low, so the calibration process changes the conductivity to allow the recharge into the ground. This could lead to zones of high and low conductivity in the same formation for no reason other than the ground slope.

Conductivity

Geomatrix should not call setting permeability in the faults higher than the surrounding bedrock a "conservative assumption" (p 7) because it simply is not. It may be correct, but that just means it is accurate, not conservative.

The conductivity distribution reflects the recharge over large sections of the domain. Figures 18 through 22 demonstrate several north-south K trends that do not reflect the mapped geology on Figure 10. The text has described the bedrock as having a low K, but these recharge-driven K zones have K varying over two orders of magnitude. The geologic mapping does not justify the K-zonation show on the K maps (Geomatrix Figures 18 through 23).

The combined recharge and K distribution biases the model to cause groundwater to flow in certain directions and protects certain areas from drawdown. One area with potential bias is just north of the proposed mine void. Geomatrix Figure 18 shows an almost triangular area north of the mine void colored orange for conductivity (K) equal to 4.0 or 4.5 E-4 cm/s; although there are other areas with this K, it is one of the highest K areas in layer 1. It adjoins a huge area to the east with the lowest K, 5E-5 cm/s which coincides with the lowest recharge. This region follows through to layer 5 being one of the highest K zones in the bedrock. This region connects with the E Frk Bull River, as well. Because it coincides with high recharge, it limits the drawdown to the north and assures that flow to the East Fork Bull River is not impacted that much. This also manifests in Geomatrix's uncertainty analysis, in which they found less than 20% variability in flow to that river (p. 32).

Calibration

There were 115 head targets used for steady state calibration (p. 9), but most were clustered around the edge of the domain far from the mine area, or clustered near mine facilities (just three near the area to be dewatered) (Figure 13). Contrary to Geomatrix's claim they "are not spatially biased," Figure 13 shows extreme spatial clustering of positive or negative residuals. Along the southwest edge of the model near the Clark Fork, there are 19 negative and just 4 positive residuals (Figure 13). Further northwest along the river is a string of positive residuals. Only near the mine facilities are the residuals relatively balanced. Additionally, large extents of the model domain in the northwest and southeast have no observations and the model is therefore essentially unconstrained.

Transient calibration with short-term pump tests does not provide useful information, because the stresses are a very small proportion of what will occur in the future. The transient calibration using the observed flows to the Libby adit could be useful, but the report does not adequately explain the calibration. The comparison of simulated with observed dewatering suggests the calibration was designed to calibrate the conductance around the boundary representing the adit. However, there would be no control on the heads near the adit. The calibrated conductance would correspond with a simulated gradient, but there is no data to test whether the simulated gradient is correct. Geomatrix could have imposed specified flux boundaries and calibrated the change in head, if there were data available. Geomatrix Figure 13 does not provide a very good fit; for more than half of the period, the simulated dewatering was 20 percent or more less than the observed; this could bias future projections downward. There is very little confidence that the transient calibration provided an accurate calibration.

Geomatrix uncertainty analysis (section 6) was unusual – not designed to really estimate the uncertainty in the calibration of the model. It is highly unlikely that all of the geologic formations would have conductivity an order of magnitude higher or lower than calibrated. It is more likely that some formations have higher and some formations lower values. As completed, the uncertainty analysis in section 6 adds no understanding to the projections made for dewatering the proposed mine.

A preferable uncertainty analysis would be to determine the sensitivity of the model to each parameter zone. The modeler would vary the K of each zone individually across a range up to an order magnitude and compare the relevant test statistic with the variation in the K. This would show which parameters are most sensitive (and might help the modeler to improve the model).

For this model, the biggest uncertainty may be the rate that water enters the adit and the mine void, which is controlled by the gradient at the boundary and a specified conductance. The conductance would represent the “skin” resistance and conductivity in the rock next to the void. The best way to estimate the effect of uncertainty on the dewatering rate would be to vary the conductance and/or the K of the element next to the mine void boundary.

Review of Tailings Impoundment Model (AMEC 2010)

AMEC (2010) is a technical memorandum describing a MODFLOW-based groundwater model conceptualized and calibrated to simulate groundwater flow through the proposed tailings impoundment sites. They used the model to simulate a pumpback system designed to capture seepage from the Poorman Creek Tailings Impoundment. The design was an "optimization" in which they attempted to minimize the number of wells and pumping rate necessary to capture all of the seepage.

The report describes that "glacial lacustrine deposits act as a confining unit across much of the site" (p 2) because they have a low conductivity and that glaciofluvial and colluvial units have moderate and high "permeability", respectively. No references or pump-test results are provided to support these contentions. They describe the bedrock as low to moderate conductivity.

They correctly describe flow as to the east except on the ridges, and that all of the flow discharges into Libby Creek due to a bedrock constriction (p 2). This is probably an oversimplification because, if the bedrock does have moderate conductivity, some flow likely continues within or enters the bedrock. Additionally, there remains a small alluvial aquifer beneath the stream so some flow would likely remain in that aquifer. It is also possible that some flow would discharge north to Little Cherry Creek, especially due to a potential mound forming due to seepage under the impoundment. AMEC's assumption would have the effect of underestimating the flux through the system, because the only way for groundwater to exit the domain is through Libby Creek.

The discharge to all streams is considered to be 4.9 cfs, or 3550 af/y; this target was apparently based on simulated flows from Geomatrix (2011) (AMEC, p 6). AMEC used the recharge rate used for the regional model (described in the previous section) of 14 percent of rainfall. There is no reference given for this value and the comments made above regarding recharge in the Geomatrix model pertain here as well. The total recharge therefore equals 1570 af/y, so the interbasin flow to the domain from the west and south would be 1980 af/y. AMEC should determine whether this is reasonable based on recharge and watershed area draining to this point.

AMEC simulated the stream boundaries and inflow to the model domain with head-controlled flux boundaries (RIVER and general head boundaries). Recharge and wells were a specified flux. They used the parameter zone method to simulate geologic formations. They adjusted conductivity parameter zone values to make the fluxes and heads match. The parameter zones (AMEC, Figure 3) in general match the apparent geologic formations (AMEC, Attachment 1). However, the modelers subdivided the zones in ways not justified by the geology; the report should explain the justification. The following are some specifics.

- Layer 3 is the bedrock layer. There is no justification for brown-colored zone with K=0.5 ft/d mostly under the tailings impoundment, surrounded by K=0.06 ft/d. The high conductivity zone would allow seepage from the tailings impoundment to circulate into layer 3 at this point. It would act effectively as a drain for the tailings seepage on the downgradient end of the impoundment. It would effectively collect the seepage for the pumpback wells to capture.

- Very high conductivity along Libby Creek drains the model so that flow into the creek occurs easily. The high K value was probably necessary to allow vertical flow into the creek. The conductivity in this zone being so excessively high suggests the flow around the creek is poorly conceptualized.
- The green bedrock in layers 1 and 2 near the confluence of Little Cherry and Libby Creek does coincide with Precambrian bedrock on Attachment 1. Presumably this is an outcrop of the deeper bedrock, but weathering where it is exposed would have increased the conductivity which should allow some leakage from the model.
- The light-blue K=12.5 zone splits the much lower conductivity zone in layer1 and especially in layer 2. The zone on the north end of the impoundment serves as a drain for the tails water. That there are up to 5 wells completed in that zone shows that the zone conveniently helps to simulate capture of the simulated tails seepage.

AMEC calibrated the model in steady state mode so that discharge to the stream matched the measured value and so that the simulated water level observations closely matched the observed. However, considering how well constrained the model is with flux boundaries, it is surprising the simulated discharge to the streams, 4.1 cfs, is 16 percent less than targeted rate. It suggests the calibration was completed too quickly, possibly leading to some of the errors outlined above.

AMEC simulates the tailings impoundment by replacing the natural recharge with the expected 25 gpm spread across the site, which is about 40 af/y. In alternative 3, the tailings impoundment would cover up to 1272 acres (SDEIS, Table S-1). The seepage rate reduces recharge to less than 0.4 in/y, from 4.6 or 5.8 in/y, depending on the recharge zone; at 4.6 in/y, the total natural recharge under the tails would be about 488 af/y. The impoundment, if it works as conceptualized, would reduce the recharge on its footprint by 448 af/y. This would cause a significant drawdown itself. The drawdown figure (AMEC Figure 7) is unclear as to whether this is included.

The model boundaries are obviously too close to the impoundment; this is especially true for the upgradient side. As the recharge reduces from natural to the lower tailings seepage rate under the impoundment, the groundwater level would also be lowered. This lowering of the water table would increase the effective gradient at the boundary. If the increase is small, it may be acceptable. However, the boundary is effectively an unlimited water supply in the model. If the drawdown draws more flow from the boundary than would realistically occur, it may inappropriately minimize the drawdown under the impoundment. This would decrease the reduction in simulated discharge to Libby Creek. The drawdown map (AMEC, Figure 7) shows that drawdown approaches the boundary, but the report does not indicate whether the flux across the boundary increases.

A similar issue applies on the east at Libby Creek; the model boundary is too close. Drawdown at the creek appears to exceed 10 feet.

That the model simulates a decrease in flow to the creek equal to the pumping rate (AMEC, p 9) indicates that they have not adjusted the natural recharge under the tailings impoundment. The decreased recharge must affect the flows to the creek as well. AMEC should present a full water balance accounting from the model with pumping to show where the excess flow goes. If the model continues to simulate the natural recharge under the tailings in addition to the seepage, it inappropriately minimizes the effect the project has on the creek. In addition to the pumping for the pumpback wells, the flow to the creek would also be decreased by the decreased recharge.

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