WRITTEN STATEMENT OF TOM MYERS, PhD
On Behalf of Turner Ranch Properties, LLP and Hillsboro Pitchfork Ranch, LC

Before the Mining and Minerals Division of the New Mexico Energy, Minerals & Natural Resources Department on the Application of New Mexico Copper Corporation for a Permit to Operate the Copper Flat Mine in Sierra County, New Mexico

October 23-24, 2018

On July 18, 2012, New Mexico Copper Corporation (NMCC), a wholly-owned subsidiary of THEMAC Resources Group, Ltd., submitted to the Mining and Minerals Division of the New Mexico Energy, Minerals and Natural Resources Department an application for a permit to operate the Copper Flat Mine in Sierra County, New Mexico, under the New Mexico Mining Act. I respectfully submit this written statement, under section 19.10.9.905.E NMAC, on behalf of Turner Ranch Properties, LLP, which owns the Ladder Ranch, and on behalf of Hillsboro Pitchfork Ranch, LC. Both ranches are located adjacent to the Copper Flat Mine. My written statement discusses my qualifications and presents my comments and critique of the permit application. I will summarize my written statement with oral testimony during the hearing to be held on October 23 and 24, 2018 in Truth or Consequences, New Mexico.

On behalf of Turner Ranch Properties, and Hillsboro Pitchfork Ranch, I appreciate the opportunity to submit this written statement, and to testify before the Division.

The New Mexico Mining Act, and its implementing regulations, requires that "the permit area will be reclaimed to achieve a self-sustaining ecosystem appropriate for the life zone of the surrounding areas following closure unless conflicting with the approved post-mining land use." 19.10.6.603 NMAC. This is a requirement of each reclamation plan. With respect to hydrology a "self-sustaining ecosystem" includes hydrologic and nutrient cycles functioning at levels of productivity sufficient to support biological diversity" (19.10.1.7.R(2) NMAC). The operations "shall be planned and conducted to minimize change to the hydrologic balance in both the permit and potentially affected areas" (19.10.6.603.C(4)). "If not in conflict with the approved post-mining land use, reclamation shall result in a hydrologic balance similar to pre-mining conditions unless non-mining impacts have substantially changed the hydrologic balance (Id.).

The regulations require that a permit application include baseline data on, among other things, surface and ground water. This baseline data must include "a determination of the probable hydrologic consequences of the operation and reclamation, on both the permit and affected areas, with respect to the hydrologic regime, quantity and quality of surface and ground water systems that may be affected by the proposed operations, including the dissolved and suspended solids under seasonal flow conditions" (19.10.6.602.D(13)(g)(v) NMAC).

My statement will focus on the following issues:

- The effects that the pit dewatering and long-term drawdown will have on the hydrologic balance of the groundwater in the area.
- The effect pit dewatering will have on hydric soils and riparian vegetation, primarily in the Grayback Arroyo.
- Long-term water quality in the pit lake, which will violate surface water standards, and will be insufficient for future wildlife and aquatic beneficial uses.
- The failure to consider seepage from waste rock, leaks from the liner beneath the tailings storage facility, and seepage from unlined impacted stormwater ditches.

My statement will also focus on impacts to the Ladder Ranch, which is north and east of the proposed mine, and to the Hillsboro Pitchfork Ranch, which is west and southwest of the proposed mine.

I. QUALIFICATIONS

I have been a self-employed hydrologic consultant since 1993. My primary focus is hardrock mines, mine dewatering, groundwater modeling, natural gas development, and contaminant transport. As part of my consulting work, I have published two studies directly related to contamination caused by mining activities (Myers 2016, 2013).

From 1999 to 2004, I was Executive Director of Great Basin Mine Watch, where I was responsible for reviewing and commenting on mining projects with a focus on groundwater and surface water resources. From 1992 to 1997, I worked as a research assistant at the University of Nevada in Reno, conducting research on riparian area and watershed management, including stream morphology, aquatic habitat, cattle grazing, and low-flow and flood hydrology. From 1990 to 1992, I was a research and teaching assistant at the University of Arizona in Tucson. I conducted research on rainfall and runoff processes and climate models. I also taught the laboratory section for sophomore-level Principles of Hydrology course. From 1988 to 1990, I was a research assistant at the University of Nevada in Reno, where I conducted research on aquatic habitat, stream morphology, and livestock management. From 1983 to 1988, I worked as a hydraulic engineer at the United States Bureau of Reclamation, where I performed hydrology planning studies on a range of topics including flood plains, water supply, flood control, salt balance, irrigation efficiencies, sediment transport, rainfall-runoff modeling, and groundwater balance.

I have a Bachelor of Science degree in civil engineering from the University of Colorado in Boulder, a Master of Science degree in hydrology and hydrogeology from the University of

Nevada in Reno, and a Ph.D. in hydrology and hydrogeology from the University of Nevada in Reno.

II. COMMENTS ON PERMIT APPLICATION

A. Impacts of Dewatering the Pit and Forming the Pit Lake on the Hydrologic Balance

The permit application does not adequately address the probable hydrologic consequences of mining operation and reclamation on nearby surface and ground water systems. The permit application also does not adequately show how the project would maintain the hydrologic balance of the site. The application is therefore deficient and does not fulfill the requirements of the regulations. As will be discussed, the permit application (Velasquez 2017) and the Probable Hydrologic Consequences Report (Jones and Finch 2018) fail to consider the hydrologic balance of the area with respect to the pit.

Figure 1 shows the general hydrogeology of the site. The permit boundary is in the middle on the east side of the small area of crystalline bedrock at the west portion of the area labeled Palomas Basin. The proposed mine is in the Animas Uplift, the north-south strip of sedimentary (blue) and crystalline bedrock.

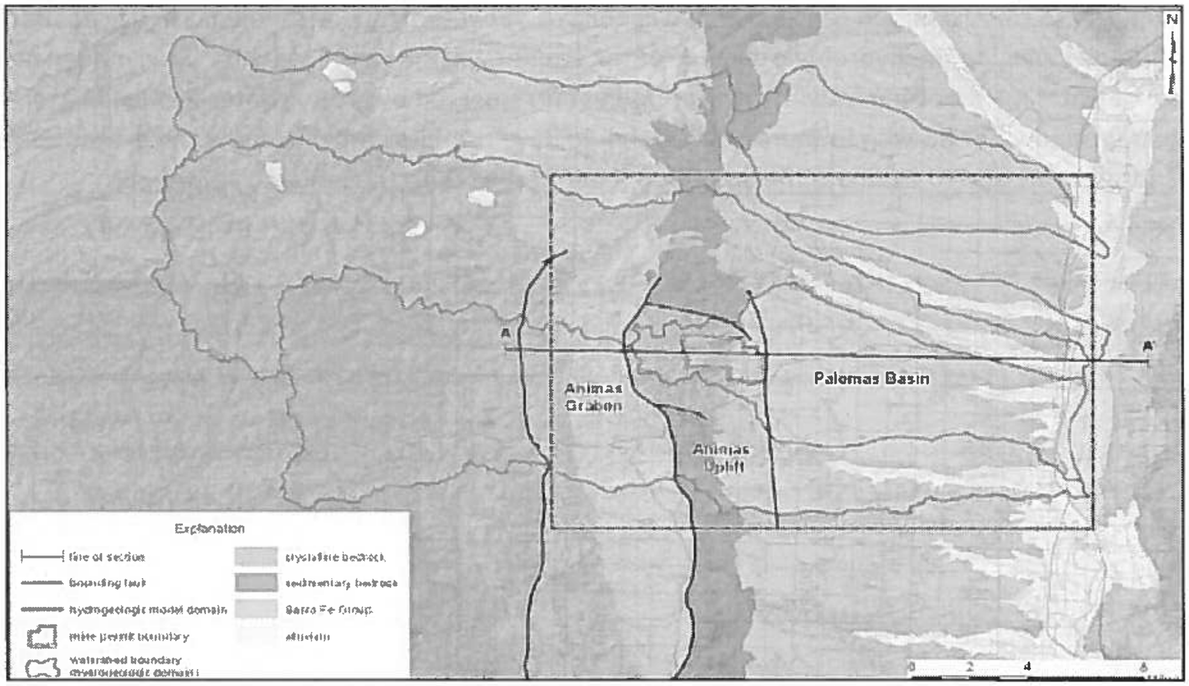


Figure 1: Hydrogeologic zones near the proposed mine. (Source: Figure 4.1 from Jones et al (2014)).

The pit affects the water balance in two related ways. First, drawdown from the proposed pit would have a much larger capture zone than the existing pit. The capture zone is the portion of the aquifer that is drawn to the pit that otherwise would flow west to east. This may be seen by comparing Figure 2 with Figure 3. Figure 2 is the current (2011) potentiometric surface around the mine pit; it shows the groundwater table forms a plateau over the mine area that slopes from west to east as well as being relatively flat in a north-south direction except for a closed contour around the pit at 5450 foot above mean sea level. This contour represents the area that draws water towards the pit, thereby forming a capture zone a little larger than the existing pit lake. North and south of the plateau, the groundwater slopes toward Las Animas Creek and Percha Creek, respectively.

Figure 3 shows the simulated post-mining (ca 2030) drawdown around the larger proposed pit. Drawdown does not represent the capture zone because not the entire drawdown cone is drawn to the pit. Drawdown on the water table where it initially slopes away from the pit only decreases the gradient for flow away from the pit. Portions of the aquifer that experience drawdown could still have a gradient away from the pit. Superimposing the drawdown in Figure 3 with the potentiometric surface in Figure 2 shows the capture zone. It is not possible to show the actual postmining capture zone prior to expansion of the pit, but it is apparent the capture zone would be much larger than currently exists. For example, the position of the 100-foot contour indicates that drawdown (Figure 3) will extend beyond the permit boundary in an area the potentiometric surface is flat, other than the existing capture zone as described above (Figure 2). This expanded capture zone will pull groundwater from farther away in the aquifer, thereby changing the hydrologic balance of the aquifer. Less flow will pass the area influenced by dewatering. Consequently, the water bodies currently fed by groundwater flow will have less groundwater flowing to them. NMCC should have used its model to show the extent of the capture zone and to estimate the amount of water drawn into the influence of the pit.

Figure 2: Potentiometric surface around the mine site in 2011 (Source: Figure 5.1 from Jones et al (2014)). The closed contour around the mine pit is 5450 feet above mean sea level.

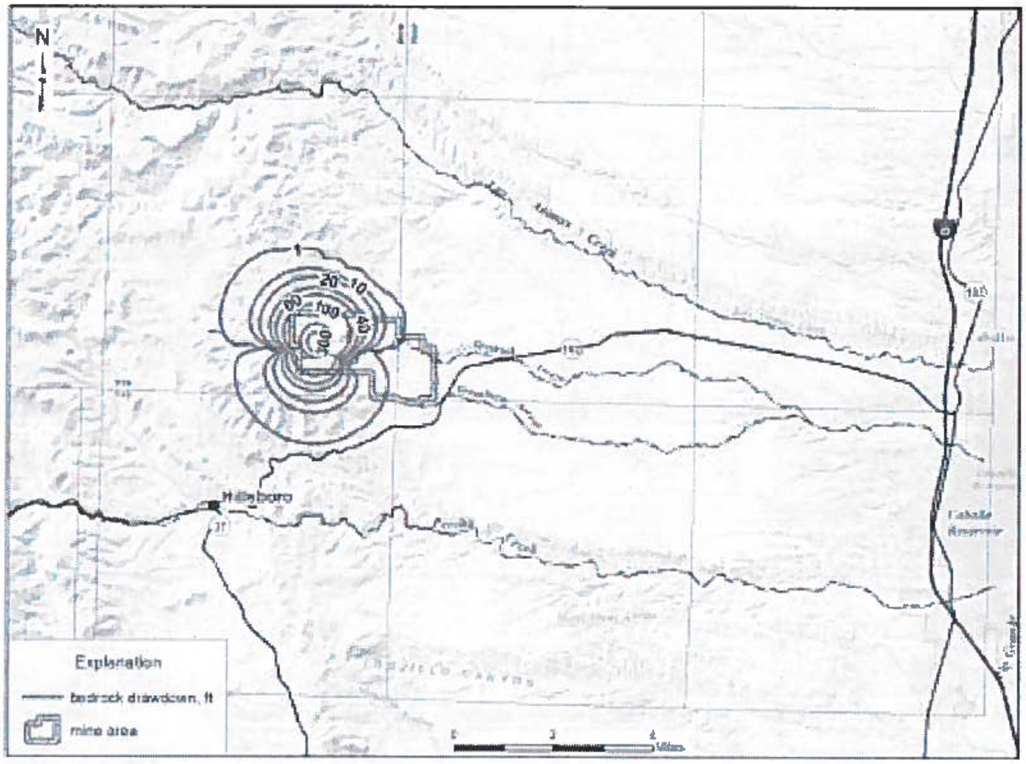


Figure 3: Projected post-mining drawdown in the crystalline bedrock around the proposed pit at the Copper Flat Mine (Source: Figure 3.1 from Jones and Finch (2018))

Second, evaporation from the pit lake is water lost to the aquifer, the hydrologic balance of the region. Evaporation from the existing pit could be considered the baseline, which Jones et al (2014, p 13) estimates at 20 acre-feet per year (af/y), although the actual rate varies with the size of the lake. Projections for evaporation from the future pit lake are about 93 af/y; about 57 af/y of the evaporative loss comes from rainfall and surface runoff, and 36 af/y of the evaporative loss comes from groundwater inflow (Jones and Finch 2018, p 28). This represents a loss of 73 af/y from the hydrologic balance of the area.

Further, dewatering the pit and the development of the pit lake in the long-term will affect flows to and in Las Animas Creek and Percha Creek by diverting flow that would otherwise be toward those creeks. The 2011 potentiometric surface (Figure 2) shows a groundwater plateau from the project area to the west, with steep contours both north and south from the plateau. These contours reflect a flow gradient away from the general west to east flow path and towards the streams. The plateau may be due to the lower conductivity of the crystalline bedrock (monzonite and andesite) near the proposed pit (Figure 1) which diverts groundwater both north and south. That groundwater flow currently supports springs which feed the two creeks, including springs in the Las Animas Creek canyon and in tributary canyons. Dewatering will cause drawdown (Figure 3), which will reduce the flow gradient to those springs and divert groundwater flow away from the north and south by drawing it toward the pit. This may be seen by superimposing the drawdown (Figure 3) on the preexisting potentiometric surface (Figure 2). If the andesite/monzonite near the pit has a higher conductivity than that assumed by Jones et al (2014), the drawdown could extend farther to the north and affect the flows in the springs and Las Animas Creek even more.

Dewatering drawdown will affect the groundwater level at wells on both the Ladder and Hillsboro Pitchfork Ranches. Figure 3 shows that at the end of mining the drawdown would extend across permit boundaries into private and public land north, west, and south of the project. Figure 4 shows that groundwater would be drawn toward the pit from up to two miles south and north of the pit. Drawdown would be 60 feet at the southwest corner of the project boundary and would exceed one foot at up to 1.5 miles of the permit boundary onto the Hillsboro Pitchfork Ranch. This would possibly affect the Rodgers Well and Grayback Well on the Hillsboro Pitchfork Ranch. Drawdown exceeds 100 feet at the north project boundary and would also exceed 1 foot for up to the 1.5 miles beyond the permit boundary and into the Ladder Ranch. This would likely affect the Myers Well, John Cross Well, and Evans Well. As noted in the previous paragraph, a conductivity higher than assumed by Jones et al (2014) would allow the drawdown to affect even more wells further into the Ladder Ranch.

NMCC has done nothing to minimize this loss. The most obvious way to minimize the loss would be to backfill the pit, to eliminate the evaporative loss.

B. Dewatering the Pit Will Decrease Groundwater Flow in the Grayback Arroyo

Dewatering the pit will affect groundwater flow in the Grayback Arroyo. Neither Velasquez (2017) nor Jones and Finch (2018) considered this effect. However, JSAI (2013) observes that in the center of the mine permit area (between the waste rock/mill site area and well GWQ-3), groundwater from the low-permeability andesite discharges to the alluvium along Grayback Arroyo (JSAI, 2013, p 9). JSAI explains that existing groundwater levels in the andesite are higher than those in the alluvium under the Grayback Arroyo, based primarily on observations at well GWQ-5R, and groundwater thus discharges into the alluvium (See Figure 4). The hydraulic gradient flattens downgradient of well GWQ-3 where the alluvium recharges the underlying Santa Fe Group sediments. As depicted in Figure 4, the groundwater contours show crenulations toward Grayback Arroyo, which demonstrate the discharge from andesite to the alluvium.

Well GWQ-5R is just south of Grayback Arroyo in the middle of Figure 4. It is within the 1 to 10-foot drawdown contour shown on Figure 3. Lowering the water level in the andesite would decrease or reverse the gradient for flow to the arroyo and remove a source of water to the alluvium in the arroyo. and affect riparian vegetation and hydric soils that existing within the arroyo.

The reduction of flow in Grayback Arroyo will tend to dry out hydric soils and thus adversely affect riparian vegetation and wildlife in the arroyo. These effects are contrary to the requirements of the regulations.

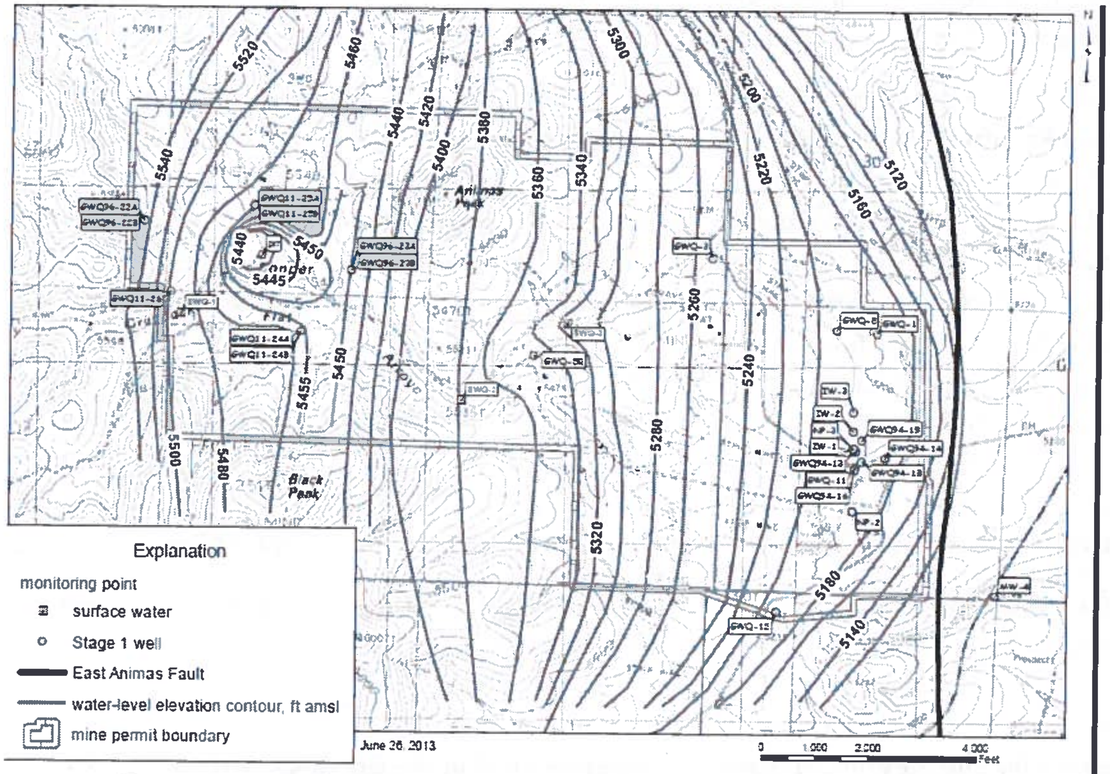


Figure 5. Water-level elevation contour map for Stage 1 Abatement Plan, 2nd Quarter 2013, Copper Flat Mine, Sierra County, New Mexico.

Figure 4: Water level contour map and the location of monitoring wells for the Stage 1 Abatement Plan. (Source: Figure 5 from JSAI (2013))

C. Impacts of the Groundwater Pumping on the Hydrologic Balance

The permit application proposes that projected water supply pumping remove almost 74,000 af of groundwater over 25 years including for construction, startup, operations, rapid fill, and reclamation. The majority would be used for production during the 11.5 years of operation, with production pumping exceeding 6000 af/y and 2200 af for six months during rapid fill (Jones and Finch 2018, Table 2.2). The production pumping would occur from wells in the Santa Fe Aquifer about six miles east of the proposed mine. The 60-foot drawdown on Figure 5 encircles the production wells, which are not shown. The permit application does not adequately address the probable hydrologic consequences of the pumping on surface and ground water systems and is therefore deficient.

The pumping will upset the balance of groundwater flow in the Palomas Basin and discharge into the Caballo Reservoir. Figure 5 shows the extensive drawdown at the end of mining that would occur in the Santa Fe Group, the source for the production water. The extent of the drawdown shows that production pumping will affect groundwater flow over a large area, with the north-south dimension of the 10-foot drawdown being about 10 miles. Pumping will draw primarily from aquifer storage, with the rate of removal as high as 6000 af/y, declining to less than 3000 af/y by the twelfth year, the end of mining (Figure 6). By that time, the pumping will be drawing about 600 af/y from north Palomas Graben aquifer (see the area north of the Palomas Basin in Figure 1), and it will reduce the flow from the Palomas Basin by more than 3000 af/y (Figure 6). The reduction in discharge from the basin will continue for decades, although its substantial effects will last for about 30 years beyond the end of mining (as the discharge reduces to less than 10% of its previous amount). The continued reduction beyond the end of mining is due to groundwater entering storage to replenish the deficit caused by pumping, the drawdown.

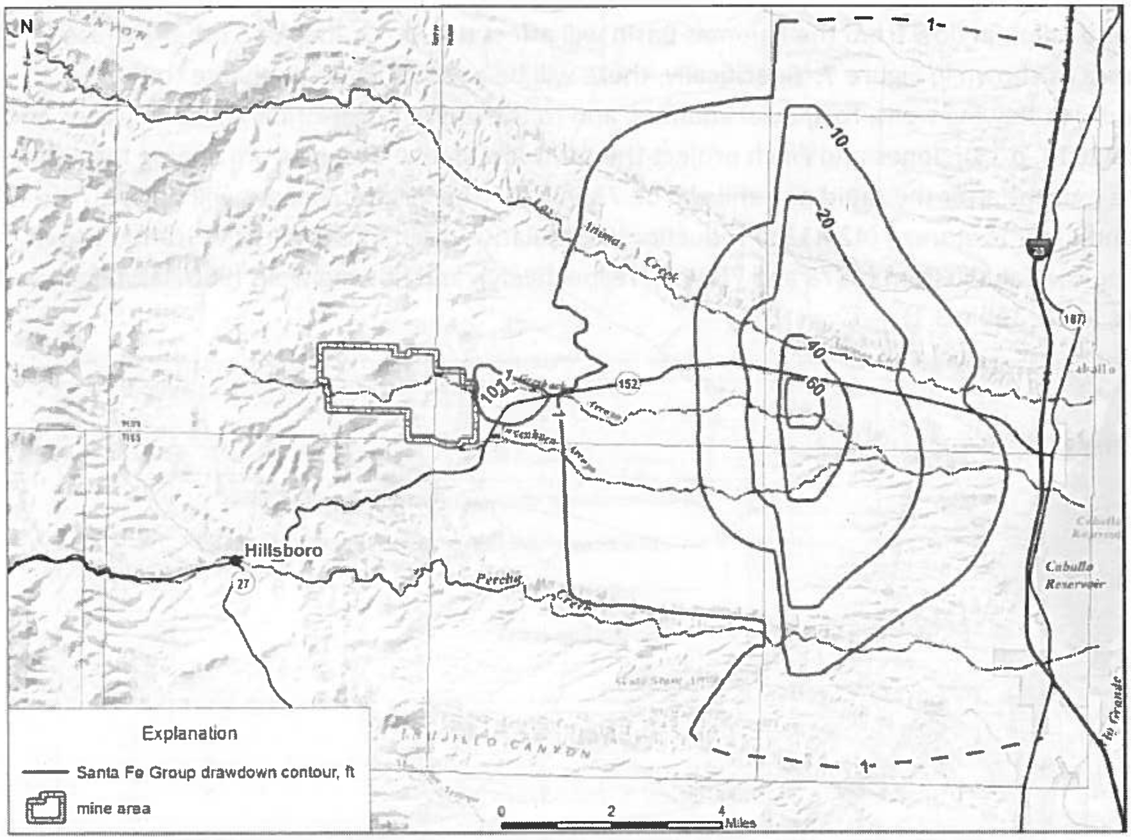


Figure 5: End of mining drawdown in the Santa Fe Group aquifer due to mine operations. (Source: Figure 3.1 from Jones and Finch (2018))

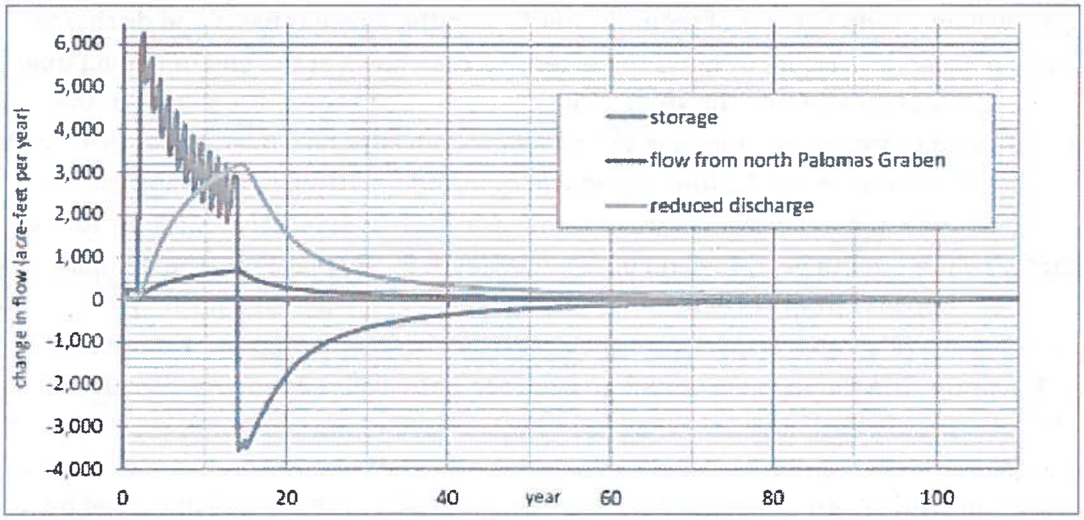


Figure 6: Projected source of water pumped. (Source: Figure 3.2 from the Jones and Finch (2018))

The reduction in flow from the Palomas Basin will affect the Rio Grande and other surface sources as shown in Figure 7. Specifically, there will be a reduction in discharge to the Rio Grande, to flowing wells, to alluvial aquifers, and to the Animas Creek riparian zone (Jones and Finch 2018, p 13). Jones and Finch project the total cumulative change from mining through three months after the rapid pit refill will be 73,987 af. The largest changes will be to groundwater in storage (42,813 af reduction), cumulative discharge to the Rio Grande above and below Caballo Dam (8878 and 7504 af, respectively), and flowing wells (9007 af) (Finch and Jones 2018, Table 3.1).

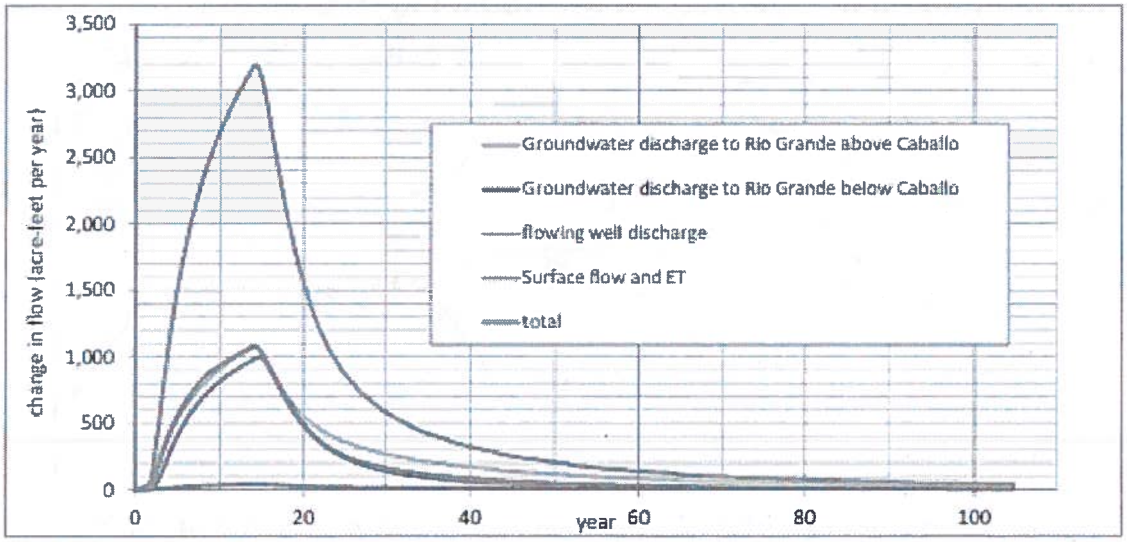


Figure 7: Projected reductions in discharge (Source: Figure 3.3 from the PHCC (Jones and Finch 2018))

The permit application does not discuss the overall effect the loss of this flow would have on the Rio Grande system. Jones and Finch show the discharge from the Palomas Basin to Lower Las Animas Creek, to Lower Percha Creek, and to the Rio Grande will be 4263, 840, and 11,850 af/y, respectively (Jones et al, 2014, Table 3.5). There is an additional 2420 af/y discharge from the Animas Uplift and Animas Graben mostly to the upper portions to the creeks (Id.). The current average discharge to the Rio Grande system from the project area is 19,373 af/y. The total loss to surface flow and evapotranspiration (Figure 7) will peak at more than 3000 af/y, which is about 15% of the discharge to surface water. This reduction will have a significant impact on the flows in the river system.

NMCC apparently has obtained a water lease from the Jicarilla Apache Nation to offset the losses to the river caused by its production pumping. The permit application provides few details on this offset, except that NMCC would "provide sufficient water arriving at Caballo Dam to offset the groundwater-flow model-computed effects" (Jones and Finch 2018, p 16). This implies that water would be provided without regard to season or annual differences due to climate, since the model (Jones et al 2014) was based on steady state climate conditions without consideration of seasonal impacts. There would be no verification of the effects on the Rio Grande system, which could vary from the model results due to travel time and assumptions that go beyond the calibration of the model.

One important assumption discussed in the permit application is that the production pumping will not affect shallow groundwater levels in the alluvium beneath Las Animas Creek (Jones and Finch 2018, section 3.1.7). Because the transmissivity in the Santa Fe Group is high in the area of production pumping, the groundwater level is below the alluvial aquifer, Jones and Finch therefore assume the Santa Fe Group is not in contact with groundwater in the alluvium. They project that drawdown in the regional water table due to production water pumping will not affect shallow aquifers due to this lack of hydrologic connection. The problem with this assumption is the production wells are up to a mile south of the alluvial area (Jones and Finch 2018, Figure 3.6). They do not consider whether water within the Palomas Graben (in which the wells are located) would draw from Las Animas Creek or its alluvium. Production pumping could draw much more directly, and quickly, from Las Animas Creek.

Thus, it is probable that there will be effects on the Rio Grande, resulting in reduced flow, that NMCC has not accurately modeled. Moreover, the water proposed to offset the reduced flow will not actually replace the flow due to delay in groundwater flow. The only way to minimize effects on the Rio Grande would be to measure the decreased discharge to the Caballo Reservoir, both from surface water and groundwater. Based on these measurements, NMCC should have to obtain offset water.

Pumping the production wells will also decrease the discharge from flowing artesian wells along the lower Animas Creek and Percha Creek (Jones and Finch 2018, p 17, 18). The pre-mining discharge is 2030 af/y and production pumping would reduce that to 1054 af/y, as shown in

Figure 7. Of the initial total, the discharge to wells along Las Animas Creek is 1750 af/y (Jones and Finch 2018, p 17). Much of the well discharge is to unlined ponds which serve as irrigation reservoirs. The ponds and irrigated field areas equal 3.9 and 125.8 acres, respectively, which results in a total evaporative loss of 703 af/y (Jones and Finch 2018, Table 3.3). Jones and Finch assert that discharge not evaporated from ponds or irrigated fields contributes to "shallow groundwater systems along Animas Creek and Percha Creek" (Id.), rather than contributing to streamflow. However, shallow groundwater would reach the Caballo Reservoir because there is no substantial riparian zone along the lower part of Animas Creek (Figure 7) that would cause an evaporative loss from the shallow groundwater. At present, approximately 1327 af/y (the amount that discharges from the wells that is not evaporated from the irrigated fields) would reach the Caballo Reservoir. Reducing the discharge from the flowing wells would reduce this discharge to the reservoir. If the evaporative loss remains constant, the flow that reports to shallow groundwater would decrease to 351 af/y, or approximately 1000 af/y less than at present. The permit application fails to account for this reduction in flow to the reservoir. it. It is also not specified as a loss to be offset by the lease of water from the Jicarilla Apache Nation.

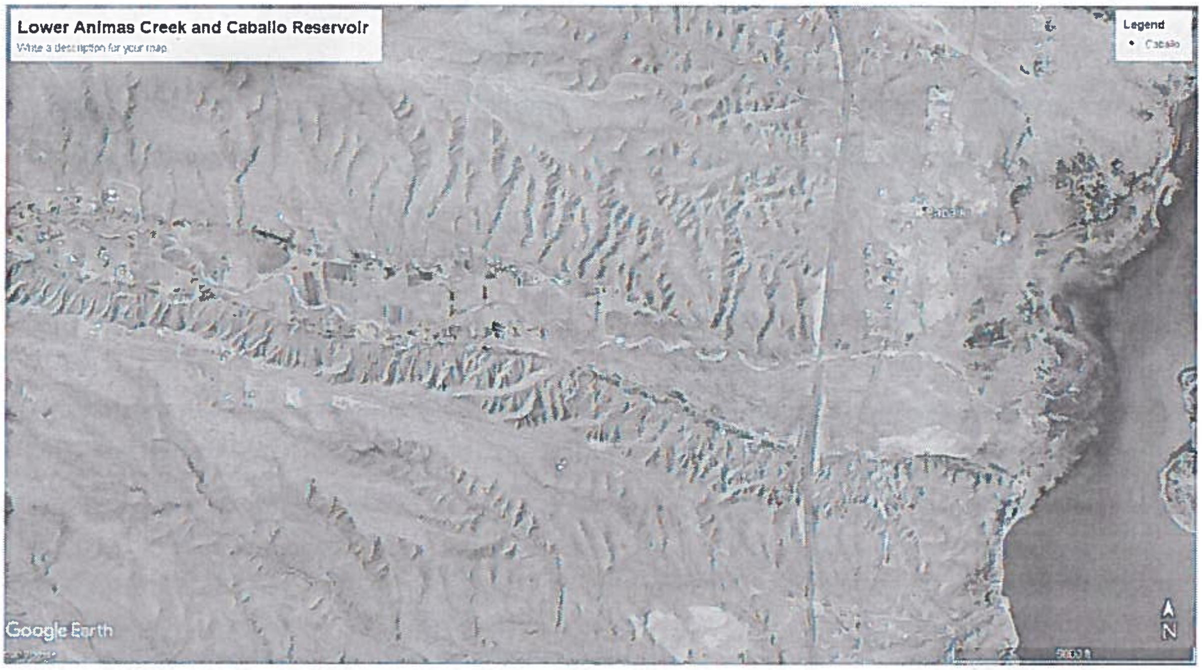


Figure 8: Google Earth image of lower Animus Creek, showing lack of riparian vegetation.

.D. The Pit Lake Will Violate Surface Water Quality Standards

The post-mining land use in the mine area will be the same as for the pre-mining use, which is mining, grazing, recreation, and wildlife habitat (Velasquez 2017, p 2-62). Reclamation is intended to return the land use from mining to the other uses (Id.). In the pit, "the pit walls created by mining and the pit lake that will form over time upon mine closure will provide enhanced avian wildlife habitat and a water source for transient wildlife (Velasquez 2017, p 2-62, -63). Therefore, the pit lake water quality must be suitable for transient wildlife.

One hundred years after the end of mining, the pit lake would have sulfate and total dissolved solids (TDS) concentrations of 4353 and 6786 mg/l, respectively, for the unreclaimed pit (SRK 2018, Table 5-4) and 3258 and 5239 mg/l, respectively, for a reclaimed pit (SRK 2018, Table 6-4). The reclaimed pit would have had 2200 af of water pumped into it over six months after the end of mining. Figures 9 and 10 show the projected future sulfate and TDS concentrations with time, respectively, for the reclaimed and unreclaimed pit. The pit lake water quality would violate surface water standards as shown in Table 1 for several metals.

Velasquez (2017, p 4-24, -25) compares these predicted pit lake water contaminant concentrations with those at the existing pit lake to suggest the future condition will be an improvement with respect to the hydrologic balance and therefore in compliance with the Mining Act (19.10.6.603.C(4) NMAC). They even claim long-term evapoconcentration of the water will not cause the pit lake to be out of compliance. Even if the premise of comparison with the existing pit lake is accepted, the conclusion that evapoconcentration would not cause standards to eventually be violated is wrong because the concentration of sulfate and TDS will increase in perpetuity because the chemistry would be conservative, meaning no removal of salts from the pit lake. Figures 9 and 10 show that the predicted concentrations would continue to increase with time.

It is not appropriate to compare the future pit lake with the existing pit lake because they are so different in size. The existing pit lake volume is about 70 af, with a surface area of 5.2 acres (SRK 2018, p 14). The future pit lake volume would be about 2200 af, when filled to elevation 4894 above mean sea level (Jones and Finch 2018, p 28). The future pit lake would be 31 times larger than the existing pit lake.

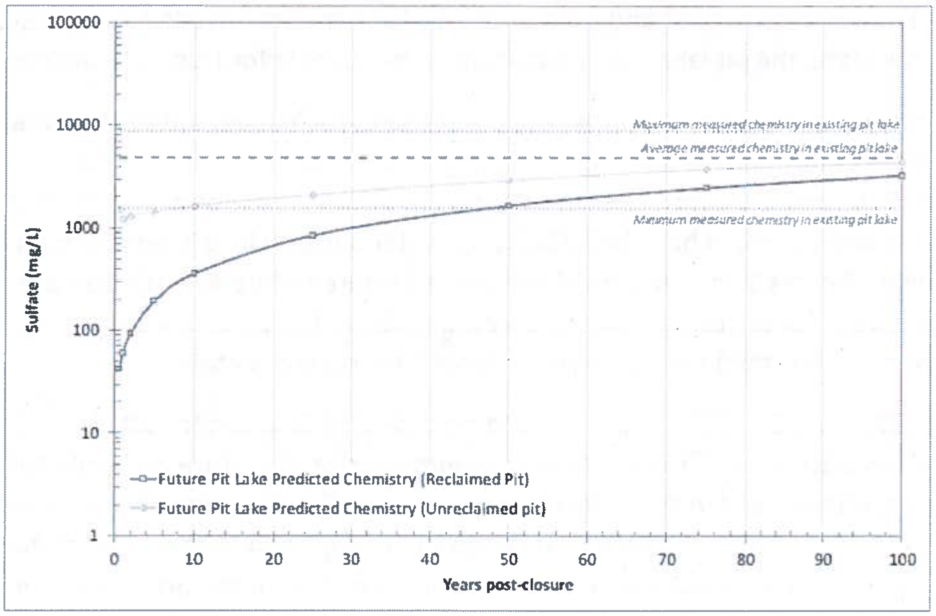


Figure 6-15: Time-series Plot of Predicted Sulfate for the for the Reclaimed Pit Model

Figure 9: Time series plot of predicted sulfate for the future pit lake, for reclaimed and unreclaimed conditions. (Source: Figure 6-15 from SRK (2018)).

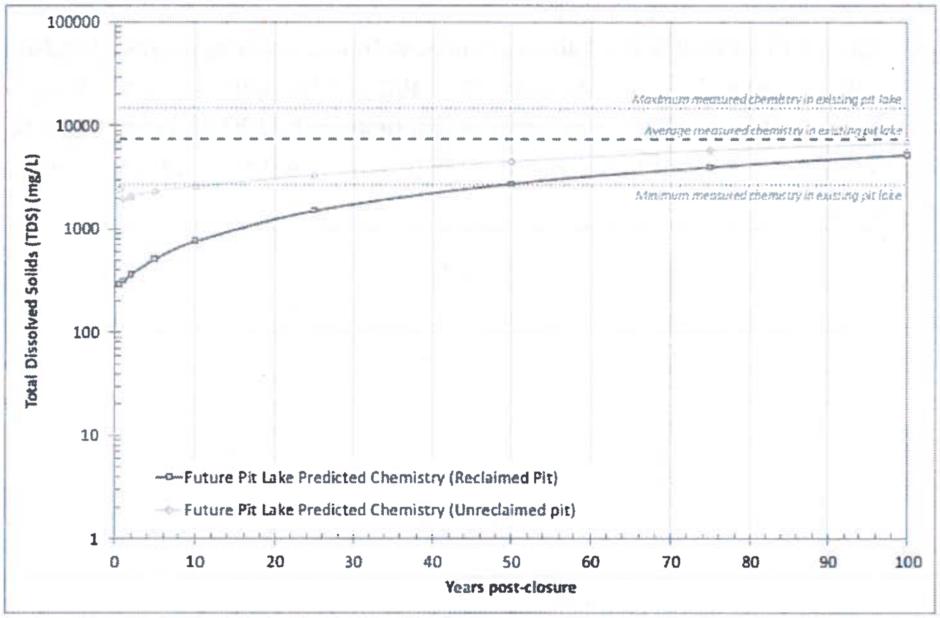


Figure 6-16: Time-series Plot of Predicted TDS for the for the Reclaimed Pit Model

Figure 10: Time series plot of predicted total dissolved solids for the future pit lake, for reclaimed and unreclaimed conditions. (Source: Figure 6-16 from SRK (2018)).

Table 1: Comparison of the pit lake water quality at 100 years with current surface water quality standards. Warmwater aquatic life standards show chronic and acute standards. All units are µg/l. (Source: Draft Environmental Impact Statement)

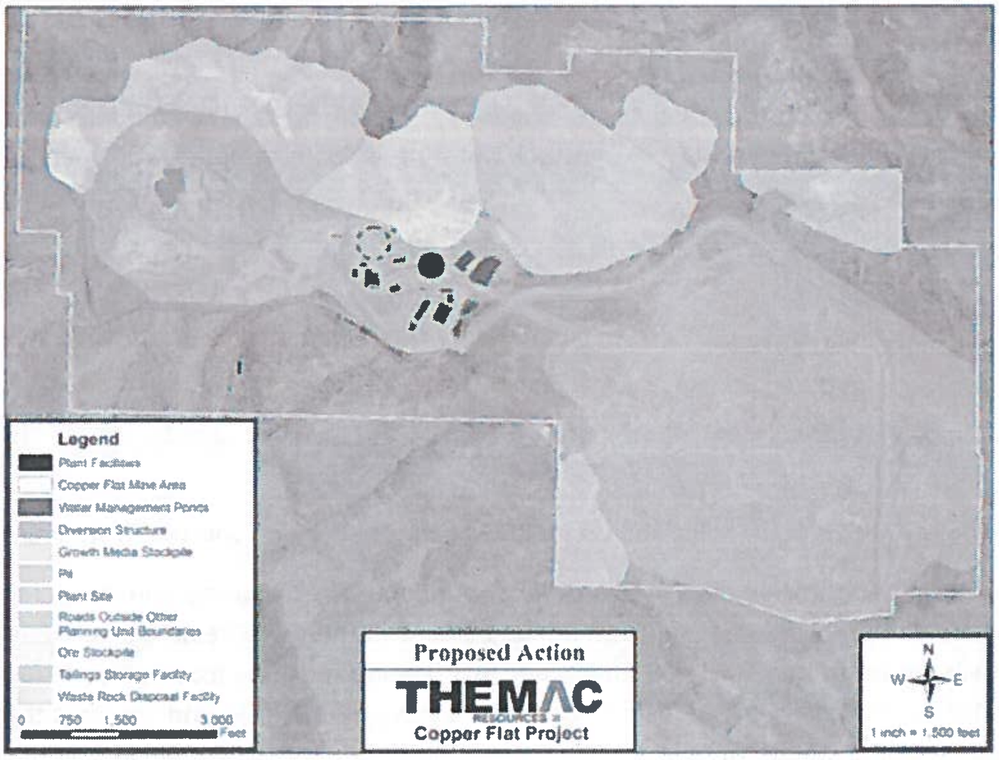
Parameter	Warmwater aquatic life (chronic /acute)	Livestock watering	Wildlife habitat	Pit lake at 100 years
Cadmium	1.22/5.38	50		15
Mercury		10	0.7	0.9
Lead	11/280	100		49
Manganese	2618/4738			8230
Zinc	428/564			920
Selenium	5/20		5	33

E. The Tailings Storage Facility and Waste Rock Stockpiles will be a Source of Contamination

The permit application does not consider contamination emanating from mine facilities because it simply assumes seepage will be minor and there will be no leaks. Neither Velasquez (2017) nor Jones and Finch (2018) provide justification for these assumptions. Jones and Finch (2018) estimate very minor leakage based on a few pinhole leaks and assumes that andesite underlying the waste rock will essentially eliminate seepage. A pinhole leak generally describes defects in a liner, which have been shown to have a median size of 1 square centimeter with 86.5% of observed defects having an effective diameter less than 17.8 millimeters. Other sources, such as unlined mine-impacted stormwater ditches are ignored. This section considers these potential contaminant sources.

Figure 11 shows the layout of mine facilities. The proposed tailings storage facility, shown in Figure 11 as the large blue area on the southeast portion of the mine area, lies primarily on Santa Fe Group formation, which has relatively high conductivity (Jones et al 2014). Jones and Finch (2018) account for only the flow through pinhole leaks, estimating a total leak rate of 0.5 gpm over the entire tailings facility. However, leaks resulting from tears and defects in liners, occur frequently, as has been observed at many mine sites (Beck et al 2009, Breitenbach and Smith 2006, Giraud and Bonaparte 1989).

Figure 2-2. Mine Layout – Proposed Action



Source: NMCC 2015

Figure 11: Layout of the proposed Copper Flat Mine. (Source: Draft Environmental Impact Statement

The waste rock piles, shown in orange on Figure 11, lies in the northcentral portion of the site and north of the pit (shown in red), mostly on andesite. The andesite has relatively low conductivity, but not as low as assumed by NMCC (Jones et al 2014, Jones and Finch 2018). Several lines of evidence indicate that the conductivity of the andesite is much higher than 10^{-6} centimeters per second (cm/s), the conductivity that NMCC assumes in its application.

First, NMCC bases its low conductivity estimate primarily on a test at one well (well GWQ 5-R) developed in andesite described in Shomaker (2011). This test is not accurate or representative for several reasons. One is the test was performed on a well bore open interval from 64 to 100 feet below ground surface (bgs) and below the water table. Conditions at this level do not reflect conditions at the ground surface, which are likely much more weathered.

The test was a pressure injection test, known as a standard Lugeon test, which is a geotechnical method commonly used to estimate the permeability of a foundation. Simply described, the test involves collaring an open interval so that water injected into that interval can only flow into the formation surrounding the interval. The flow rate necessary to maintain pressure within the interval with increasing pressure depends on the conductivity of the formation. The conductivity required to maintain an injection rate of 1 liter per minute (LPM) per meter of open interval is a Lugeon unit and equal to 1.3×10^{-5} cm/s. Figure 11, showing the injection rate and applied total head of water, shows that water began to move into the formation at about 200 feet of head and that from about 200 to 320 feet of head the injection rate ranged from about 0.05 to 0.14 gpm. The relatively constant flow between 200 and 320 feet shows that flow was laminar and Darcy's Law applies to the estimate of permeability. The permeability necessary to maintain 0.04 to 0.1 Lugeon units (Figure 12) ranges from 5.2×10^{-7} to 1.3×10^{-6} cm/s.

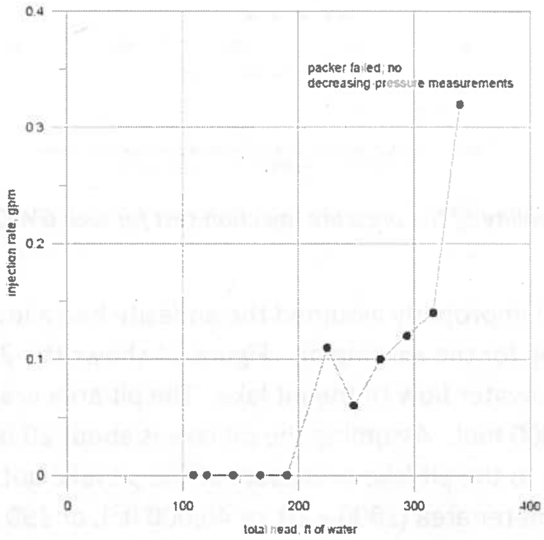


Figure 2 Pressure injection test, New Mexico Copper GWQ 5-R, Zone 1 (64-100 ft), Series 1, August 31, 2011.

Figure 12: Injection rate results of the pressure injection test for well GWQ-5R. (Source: Figure 2 from Shomaker (2011))

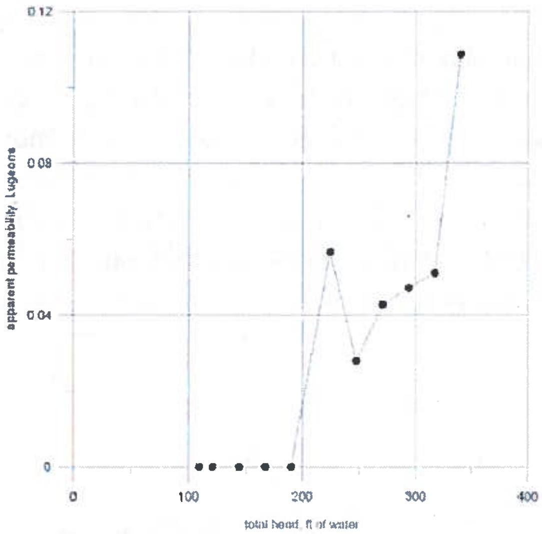


Figure 3. Apparent permeability from pressure injection test, New Mexico Copper GWQ 5-R, Zone 1 (64-100 ft), Series 1, August 31, 2011

Figure 13: Apparent permeability of the pressure injection test for well GWQ-5R (Source: Figure 3 from Shomaker (2011)).

Second, Jones et al (2014) improperly assumed the andesite had a low conductivity based on observed mine dewatering for the existing pit. Figure 14 shows the 2011 potentiometric surface controlling groundwater flow to the pit lake. The pit area is about 500 by 500 feet and the perimeter is about 2000 feet. Assuming the pit lake is about 20 feet deep, the area through which groundwater flows to the pit lake is the sum of the pit lake bottom (500 x 500, or 250,000 ft^2) and the perimeter area (2000 x 20, or 40,000 ft^2), or 290,000 ft^2. The gradient from the east is 0.01 (5 ft in 500 ft), from the west is 0.0333 (10 ft in 300 ft), from the north is 0.025 (10 ft in 400 ft) and from the south is 0.0167 (10 ft in 600 ft). Estimating gradient as the average gradient from four directions, the effective gradient is 0.02125.

For groundwater inflow rates equal to 6 and 10 gpm, K is 0.19 and 0.31 ft/d, respectively, or 6.61×10^{-5} or 1.10×10^{-4} cm/s, respectively. These rates are 66 to 110 times the rate NMCC assumes for the andesite under the waste rock, or 10^{-6} cm/s.

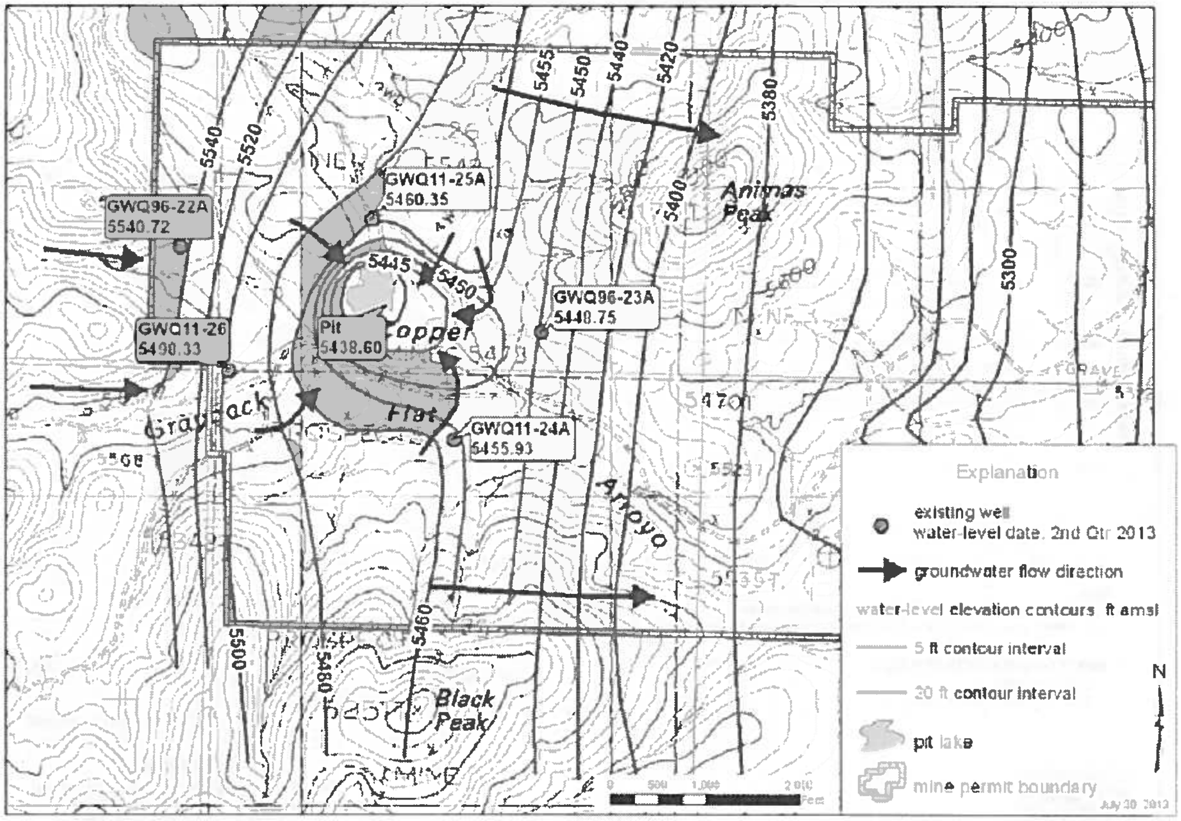


Figure 5.21. Measured pit-area groundwater levels.

Figure 14: Groundwater contours for the water table near the existing pit lake. (Source: Figure 5.21 from Jones et al (2014)).

Third, wells developed in andesite show changes in water chemistry that could occur only with substantial movement of groundwater through the formation. Well GWQ96-22, developed in andesite west of the pit, shows a 27% change in TDS and about 50% in sulfate with time (Figure 15). It is not possible to estimate K from this observation, but these changes would not occur if there was not a significant flow of groundwater through the formation.

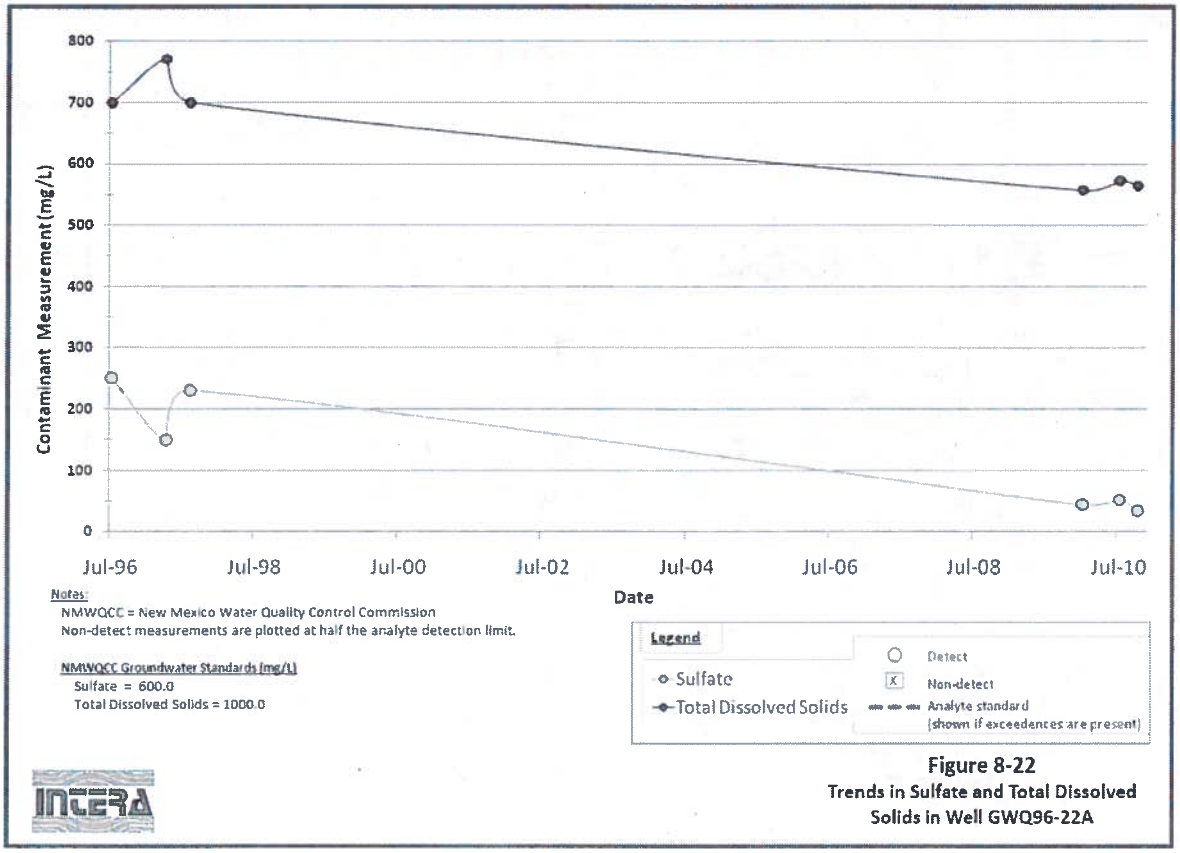


Figure 15: Changes in sulfate and total dissolved solids in well GWQ96-22A. (Source: Figure 8-22 from Intera (2012)).

Fourth, the scale of data collected from the andesite is much too small to draw any conclusions about the site-wide conductivity of the andesite with a significant level of confidence. The observations relied upon to estimate conductivity as less than 10^{-6} cm/s are small-scale. On the other hand, infiltration beneath the waste rock would depend on the average conductivity over about 230 acres. Effective conductivity generally increases as the scale of the measurement becomes larger, from the laboratory scale to the regional scale (Schulze-Makuch et al 1999). Heterogeneities control the scale dependency of K, with preferred flow pathways being more frequently encountered as larger blocks of subsurface are tested; preferred flow pathways could be facies heterogeneities, fractures, or flow conduits. Similar considerations affect contaminant dispersivity, with the same fractures that provide for higher conductivity also providing enhanced contaminant transport as compared with the bulk media (Schulze-Makuck et al 1999).

Fracture flow systems, such as at Copper Flat, have the largest variability of conductivity with measurement volume. Figure 16 shows the relation for a fracture flow media described as a "rock matrix [that] is so tight that only an insignificant amount of flow is transmitted by the matrix” (Schulze-Makuch et al 1999, p 911). The media fractures are both primary fluid pathways and storage locations. As the volume of material considered increases, the chance of including a pathway also increases, which increases the effective K (Figure 16). The assumed K of 10^{-6} cm/s (10^{-8} m/s) corresponds to a tested material volume of about 1 m^3 on Figure 15. The relation of K and tested volume becomes horizontal at about 10^{-5} m/s (equivalent to 10^{-3} cm/s), suggesting that a larger volume could be as much as 1000 times more conductive than NMCC assumes for the andesite. This occurred at a volume of about 500 m^3, which is much larger than the volume likely associated with the area around a bore hole subjected to a pressure test.

Scale effects make it apparent that conductivity from a short-term pressure test that applies very near the borehole is generally less than conductivity from a volume more applicable to conductivity controlling flow and transport beneath the waste rock.

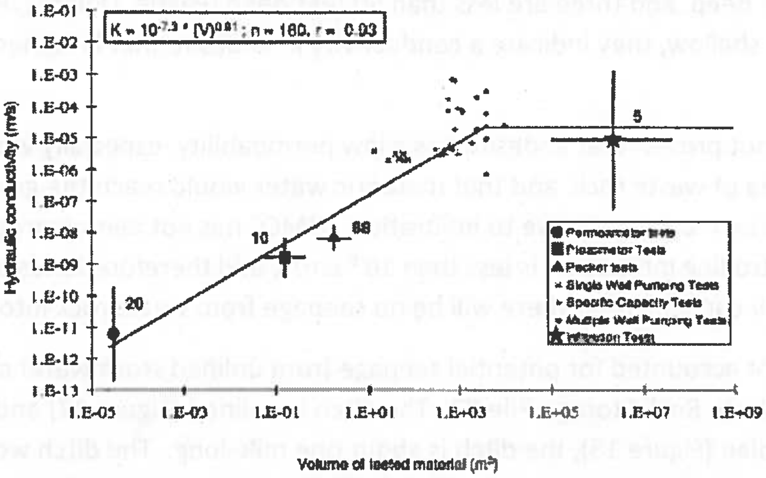


Figure 6. Relationship of hydraulic conductivity to scale of measurement in the Racine Formation of the carbonate aquifer of southeastern Wisconsin. Permeameter, piezometer, packer, and passive infiltration tests were plotted as geometric means with 95% confidence intervals; pumping tests and specific capacity data as single values. Number of observations are given adjacent to means. Passive infiltration tests are derived from the infiltration of Lake Michigan water into the Racine Formation due to the construction of a sewage tunnel. The regression line is derived from all individual values (n = 160) below the infiltration scale. The 95% confidence interval about the slope is 0.91 ± 0.06, and r is the correlation coefficient.

Figure 16: Relation of permeability with the scale of measurement for the Racine Formation of the carbonate aquifer of southeastern Wisconsin. (Source: Figure 6 from Schulze-Makuch et al (1999)).

Seepage through the waste rock would breach the ground surface in a much more uniform rate than would occur during actual rainstorms. During heavy storms, water is available to infiltrate only for a short period so the rainfall rate substantially exceeds the ability of the ground surface to accept infiltration. Flow through waste rock reaches the ground at a lower rate but for a much longer period so it has a much greater chance to enter the ground. If the seepage does not enter the ground directly, it would pond and flow along the ground surface until it reaches an area with a higher permeability that would allow the seepage to enter the ground. The effective conductivity would be an average that accounts for the areas of differing permeability beneath the waste rock.

Fifth, NMCC fails to consider the conductivity at several water supply wells developed in andesite that apparently produce more groundwater would occur if the conductivity was as low as assumed by NMCC. Table 2 in JSAI (2011) is a list of wells in the project area. It includes seven wells developed in andesite and listed as supply wells, including wells GWQ-4, GWQ-6(N), GWQ-6(S), Pague, Dolores, Paxton Wells, and LRG-4156. They would be supply wells only if they had sufficient conductivity to provide enough groundwater to pump. These wells are all less than 150 feet deep, and three are less than 50 feet deep (Pague, Dolores, Paxton Well). Because they are shallow, they indicate a conductivity in andesite that is higher near the ground surface.

Thus, NMCC has not proven that andesite has a low permeability, especially when considered over the large area of waste rock, and that meteoric water would reach the ground surface at a rate which would be more conducive to infiltration. NMCC has not demonstrated the andesite permeability controlling infiltration is less than 10^{-6} cm/s, and therefore Jones and Finch (2018) cannot reasonably conclude that there will be no seepage from waste rock into the ground.

NMCC has also not accounted for potential seepage from unlined stormwater conveyance ditches around Waste Rock Storage Pile #3. The ditch is unlined (Figure 17) and based on scaling from the plan (Figure 18), the ditch is about one mile long. The ditch would capture water running from the waste rock. The water would have contacted waste rock, and therefore could convey contaminants. Because the ditch is unlined, the impacted water could enter the groundwater beneath the waste rock pile, especially wherever the ditch crosses a conductive zone.

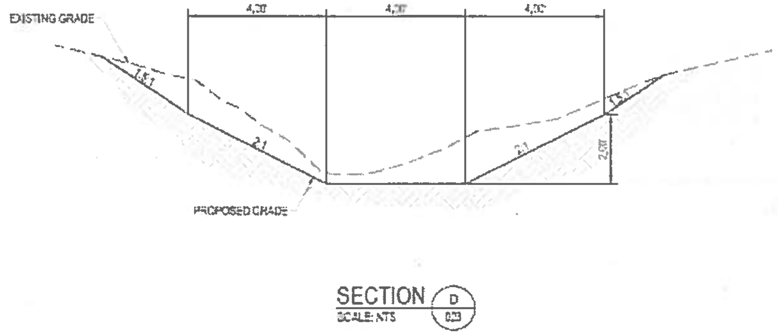


Figure 17: Cross-section of stormwater conveyance ditch near Waste Rock Storage Pile #3. (Copper Flat Project, Impoundment Design Report, 2015)

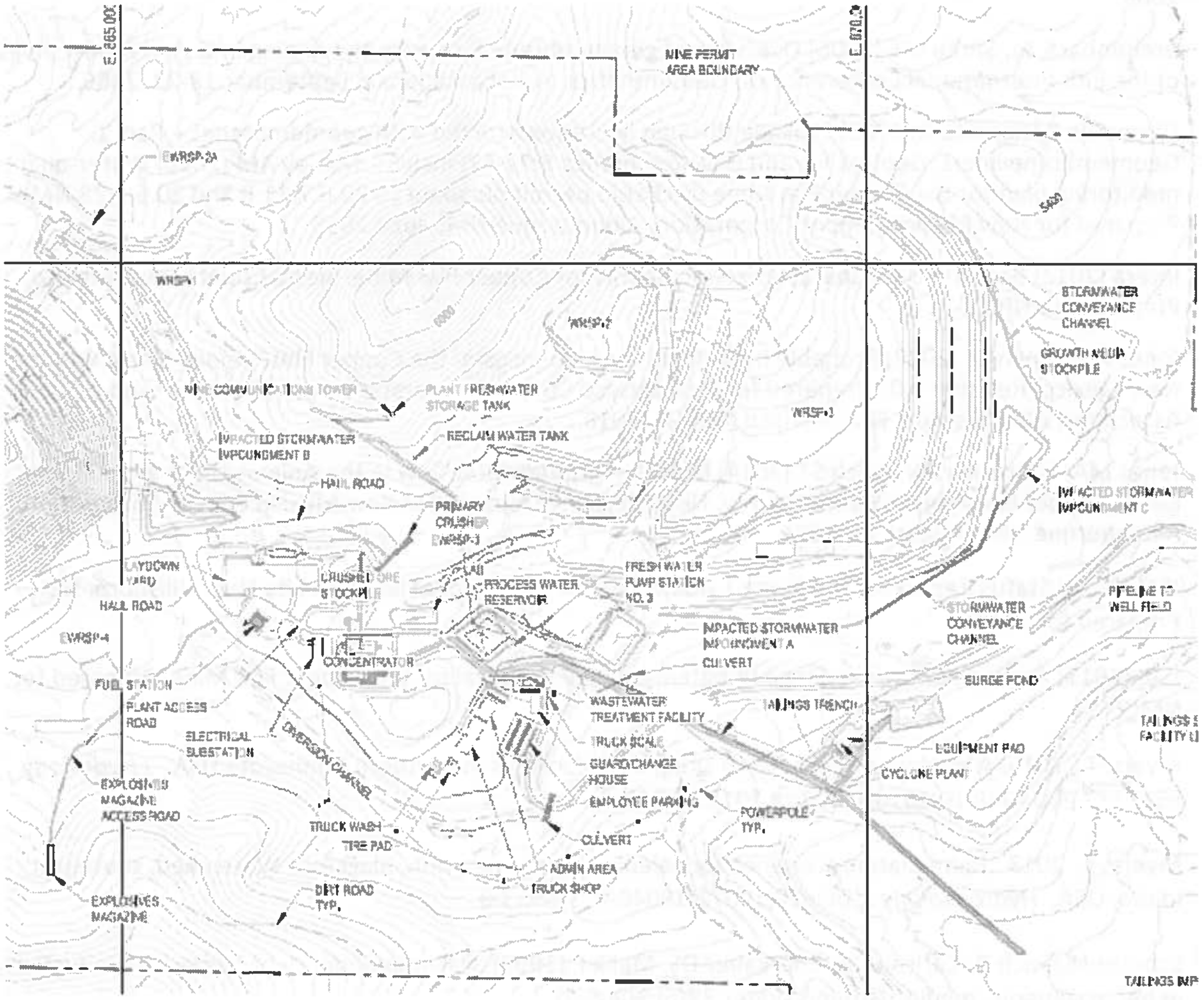


Figure 18: Waste rock storage pile #3 in the north portion of proposed mine,and stormwater conveyance channel. (Source: Figure 11J-1, Copper Flat Project, Impoundment Design Report, 2015)

I declare under penalty of perjury that the foregoing is true and correct.

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References

Beck A, Smith ME, Sample K (2009) Geomembranes for tailing impoundments. The Mining Record, June 2009.

Breitenbach AJ, Smith ME (2006) Overview of geomembrane history in the mining industry. Proceedings of the Eith International Conference on Geosynthetics, Yokohama Japan, September 18-22, 2006.

Giroud JP, Bonaparte R (1989) Leakage through liners constructed with geomembranes – Part 1. Geomembrane liners. Geotextiles and Geomembranes 8:27-67Finch ST, McCoy AM (2016) Water-quality monitoring plan for the Copper Flat Mine discharge permit pursuant to 20.6.7.11.R and 20.6.7.28 NMAC. Prepared for New Mexico Copper Corporation, Albuquerque NM. June 2016

Intera (2012) Baseline Data Characterization Report for Copper Flat Mine, Sierra County, New Mexico. Prepared for NMCC

Jones MA, Finch ST (2018) Probable hydrologic consequences of the Copper Flat Project, Sierra County, New Mexico, Revision 1.0. Prepared for New Mexico Copper Corporation. John Shomaker and Associates, Albuquerque, NM. Revised May 22, 2018.

Jones MA, Shomaker JW, Finch ST (2014) Model of groundwater flow in the Animas Uplift and Palomas Basin, Copper Flat Project, Sierra County, New Mexico. Prepared for New Mexico Copper Corporation, Albuquerque NM. August 15, 2014.

JSAI (2013) Status Report for the Stage 1 Abatement at the Copper Flat Mine Site Near Hillsboro, NM. Prepared for NMCC

JSAI (2011) Amendment to the Stage I Abatement Plan Proposal for the Copper Flat Mine. Prepared for NMCC

Myers, T., 2016. A modeling approach to siting mine facilities in northern Minnesota USA. *J Hydrology* 533: 277-290. Doi: 10.1016/j.jhydrol.2015.12.020

Myers, T., 2013. Remediation scenarios for selenium contamination, Blackfoot Watershed, southeast Idaho, USA. *Hydrogeology J.* DOI 10.1007/s10040-013-0953-8

Schulze-Makuch D, Carlson DA, Cherkauer DS, Malik P (1999) Scale dependency of hydraulic conductivity in heterogeneous media. Ground Water 37(6):904-920

SRK Consulting (2018) Predictive Geochemical Modeling of Pit Lake Water Quality at the Copper Flat Project, New Mexico. Reno NV

Velasquez Environmental Services (Velasquez) (2017) New Mexico Copper Corporation, New Mine Permit No. S1027RN, Updated Mining Operation and Reclamation Plan for its Copper Flat Mine, Submitted to New Mexico Mining and Minerals Division Pursuant to 19.10.6.602.D.(15) and 19.10.6.603 NMAC. Revision 1, July 2017